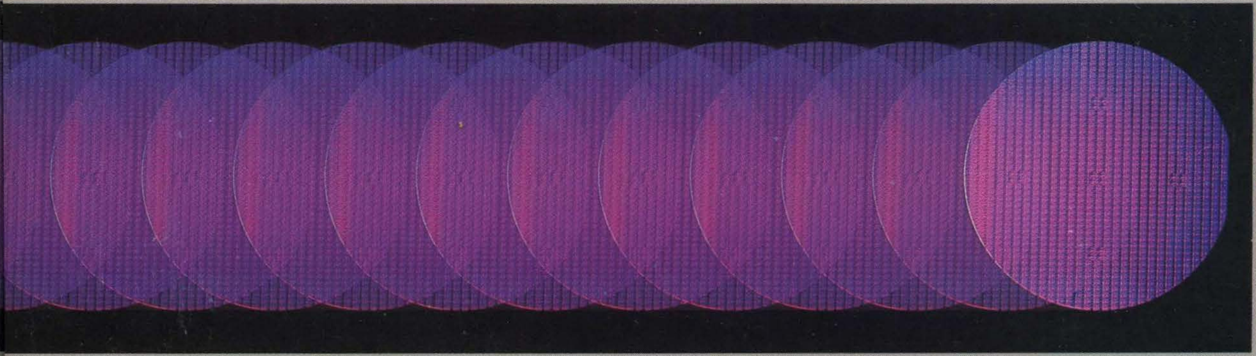
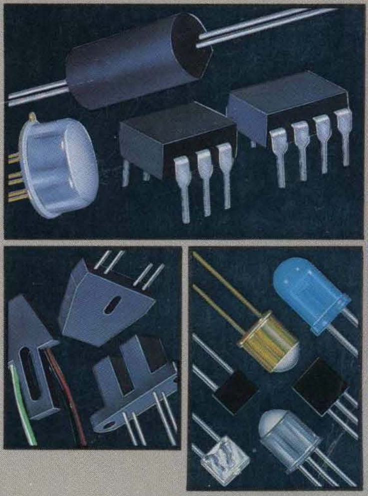
Optoelectronics Division
TRW Electronic
Components Group



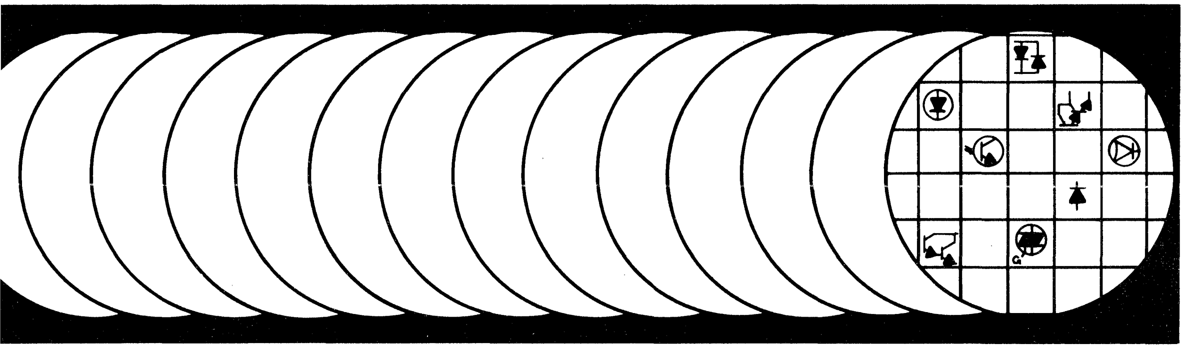
Optoelectronics Data Book



Leadership Through Technology

Optoelectronics Division
TRW Electronic
Components Group
Optoelectronics Data Book

Optoelectronics Division
TRW Electronic Components Group
1207 Tappan Circle
Carrollton, TX 75006



Optoelectronics Data Book

Leadership Through Technology

A Company Called TRW

TRW is a diversified company that provides high technology products and services through 90,000 employees in 300 locations, worldwide. Nearly 15,000 of its people are scientists and engineers.

Accomplishments over the past twenty-five years include the building of more than 175 spacecraft, including Pioneer 10, the first to leave our solar system. Recent achievements in the area of electronic components include the first commercial usage of one-micron geometry for very large scale integrated circuitry, resistor networks made from non-noble hybrid materials, optoelectronic integrated circuitry, self-aligning fiber optic connectors, and laser-scribed capacitors.

TRW Means Quality

Quality is a theme that extends throughout the entire TRW organization. As a broadly diversified manufacturer, TRW's commitment to producing only the highest quality products spans many industries. In the automotive industry, for example, the percentage of parts made by TRW in the renowned Mercedes Benz is higher than in any other vehicle. Titanium engine valves perfected by TRW are used in racing engines everywhere. Another example is the aircraft industry, where TRW is a premier supplier of jet engine compressor blades, variable pitch propellers, precision bearings, fuel pumps, engine components, and electronic components for both commercial and military aircraft. In the safety and quality conscious aviation industry, TRW's rich tradition of excellence extends back to Lindbergh's transatlantic flight. The Spirit of St. Louis used engine valves developed by the Thompson Products Company, which later became TRW. Producing quality products has been an important part of TRW's past and remains an integral part of its present and future objectives. That is why TRW means quality.

TRW Electronic Components Group

TRW Electronic Components Group offers more than 300 product lines, perhaps the most extensive selection of electronic components available from any one manufacturer. These lines include both standard and custom products to meet the needs of industrial, consumer, and defense markets. TRW components find applications in computer, telecommunication, aerospace, medical instrumentation, home entertainment, and automotive equipment.

Worldwide Sales/Distributor Organization

The Optoelectronics Division, as a part of the Electronics Components Group, is served by 70 locations of sales offices in the United States, Canada, and Puerto Rico. In addition, the Optoelectronics Division has a nationwide organization of factory trained field application engineers available to provide applications and specification assistance. An extensive network of sales representatives and distributors in Europe and the Far East has been established by TRW in order to provide the highest level of service in each country. This network functions under the direction of a sales headquarters in Guildford, England.

TRW Electronic Components Group Members

Capacitor Division
Connector Division
Cylindrical Connector Division
Daut + Rietz GmbH Co. KG
Electronic Assemblies Division
LSI Products Division
Motor Division
Optoelectronics Division
Resistive Products Division
RF Devices Division

Tomorrow is taking shape at A Company Called TRW.

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TRW

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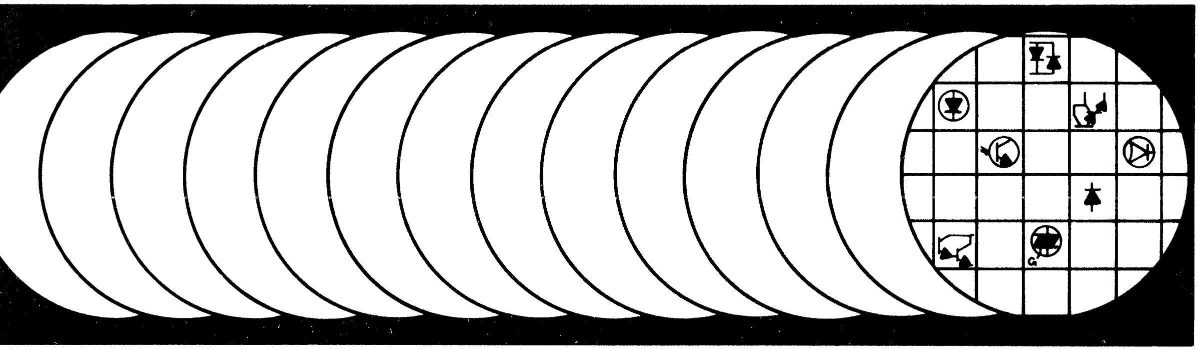
*See Power Semiconductor Literature.



Product Selection Guide

Product Selection Guide

Emitters

Part No.	Case Style	Beam Angle	Symbol	Min.	Max.	Output	at Rated I_{IF}	Max. V_F at Rated I_F	Max. I_R at Rated V_R	Page No.
OP123	Hermetic Pill Lensed	15	$E_{e(APT)}$	.40	—	mW/cm²	50 mA	1.50 V @ 50 mA	100 μA @ 2.0 V	4
OP124	Hermetic Pill Lensed	15	$E_{e(APT)}$	1.00	—	mW/cm²	50 mA	1.50 V @ 50 mA	100 μA @ 2.0 V	4
OP130	Hermetic TO-46 Lensed	18	P_O	1.00	—	mW	100 mA	1.75 V @ 100 mA	100 μA @ 2.0 V	6
OP131	Hermetic TO-46 Lensed	18	P_O	3.0	—	mW	100 mA	1.75 V @ 100 mA	100 μA @ 2.0 V	6
OP132	Hermetic TO-46 Lensed	18	P_O	4.0	—	mW	100 mA	1.75 V @ 100 mA	100 μA @ 2.0 V	6
OP133	Hermetic TO-46 Lensed	18	P_O	5.0	—	mW	100 mA	1.75 V @ 100 mA	100 μA @ 2.0 V	6
OP130W	Hermetic TO-46	50	P_O	1.00	—	mW	100 mA	1.75 V @ 100 mA	100 μA @ 2.0 V	6
OP131W	Hermetic TO-46	50	P_O	3.0	—	mW	100 mA	1.75 V @ 100 mA	100 μA @ 2.0 V	6
OP132W	Hermetic TO-46	50	P_O	4.0	—	mW	100 mA	1.75 V @ 100 mA	100 μA @ 2.0 V	6
OP133W	Hermetic TO-46	50	P_O	5.0	—	mW	100 mA	1.75 V @ 100 mA	100 μA @ 2.0 V	6
OP140SL	Plastic Lateral	40	$E_{e(APT)}$	.020	—	mW/cm²	20 mA	1.60 V @ 20 mA	100 μA @ 2.0 V	8
OP140SLA	Plastic Lateral	40	$E_{e(APT)}$	.40	—	mW/cm²	20 mA	1.60 V @ 20 mA	100 μA @ 2.0 V	8
OP140SLB	Plastic Lateral	40	$E_{e(APT)}$	.30	.55	mW/cm²	20 mA	1.60 V @ 20 mA	100 μA @ 2.0 V	8
OP140SLC	Plastic Lateral	40	$E_{e(APT)}$	.20	.40	mW/cm²	20 mA	1.60 V @ 20 mA	100 μA @ 2.0 V	8
OP140SLD	Plastic Lateral	40	$E_{e(APT)}$	.100	.30	mW/cm²	20 mA	1.60 V @ 20 mA	100 μA @ 2.0 V	8
OP160SL	Plastic T-1 Lensed	16	$E_{e(APT)}$	.050	—	mW/cm²	20 mA	1.60 V @ 20 mA	100 μA @ 2.0 V	10
OP160SLA	Plastic T-1 Lensed	16	$E_{e(APT)}$	1.95	—	mW/cm²	20 mA	1.60 V @ 20 mA	100 μA @ 2.0 V	10
OP160SLB	Plastic T-1 Lensed	16	$E_{e(APT)}$	1.40	2.2	mW/cm²	20 mA	1.60 V @ 20 mA	100 μA @ 2.0 V	10
OP160SLC	Plastic T-1 Lensed	16	$E_{e(APT)}$	.85	1.60	mW/cm²	20 mA	1.60 V @ 20 mA	100 μA @ 2.0 V	10
OP160SLD	Plastic T-1 Lensed	16	$E_{e(APT)}$	.28	.95	mW/cm²	20 mA	1.60 V @ 20 mA	100 μA @ 2.0 V	10
OP160W	Plastic T-1	85	P_O	.50	—	mW	20 mA	1.60 V @ 20 mA	100 μA @ 2.0 V	12
OP161SL	Plastic T-1 Lensed	16	$E_{e(APT)}$	.050	—	mW/cm²	20 mA	1.60 V @ 20 mA	100 μA @ 2.0 V	14
OP161SLA	Plastic T-1 Lensed	16	$E_{e(APT)}$	1.95	—	mW/cm²	20 mA	1.60 V @ 20 mA	100 μA @ 2.0 V	14
OP161SLB	Plastic T-1 Lensed	16	$E_{e(APT)}$	1.40	2.2	mW/cm²	20 mA	1.60 V @ 20 mA	100 μA @ 2.0 V	14
OP161SLC	Plastic T-1 Lensed	16	$E_{e(APT)}$	.85	1.60	mW/cm²	20 mA	1.60 V @ 20 mA	100 μA @ 2.0 V	14
OP161SLD	Plastic T-1 Lensed	16	$E_{e(APT)}$	.28	.95	mW/cm²	20 mA	1.60 V @ 20 mA	100 μA @ 2.0 V	14
OP168F	Plastic Custom	104	$E_{e(APT)}$	.20	—	mW/cm²	20 mA	1.60 V @ 20 mA	100 μA @ 2.0 V	16
OP168FA	Plastic Custom	104	$E_{e(APT)}$	.48	—	mW/cm²	20 mA	1.60 V @ 20 mA	100 μA @ 2.0 V	16
OP168FB	Plastic Custom	104	$E_{e(APT)}$	.43	.79	mW/cm²	20 mA	1.60 V @ 20 mA	100 μA @ 2.0 V	16
OP168FC	Plastic Custom	104	$E_{e(APT)}$	.34	—	mW/cm²	20 mA	1.60 V @ 20 mA	100 μA @ 2.0 V	16
OP169SL	Plastic Custom	46	$E_{e(APT)}$	.020	—	mW/cm²	20 mA	1.60 V @ 20 mA	100 μA @ 2.0 V	18
OP169SLC	Plastic Custom	46	$E_{e(APT)}$	.195	—	mW/cm²	20 mA	1.60 V @ 20 mA	100 μA @ 2.0 V	18
OP169SLD	Plastic Custom	46	$E_{e(APT)}$	.116	.24	mW/cm²	20 mA	1.60 V @ 20 mA	100 μA @ 2.0 V	18
OP223	Hermetic Pill Lensed	18	$E_{e(APT)}$	1.00	—	mW/cm²	50 mA	1.80 V @ 50 mA	100 μA @ 2.0 V	20
OP224	Hermetic Pill Lensed	18	$E_{e(APT)}$	3.5	—	mW/cm²	50 mA	1.80 V @ 50 mA	100 μA @ 2.0 V	20
OP231	Hermetic TO-46 Lensed	18	$E_{e(APT)}$	1.50	—	mW/cm²	100 mA	2.0 V @ 100 mA	100 μA @ 2.0 V	22
OP232	Hermetic TO-46 Lensed	18	$E_{e(APT)}$	2.0	4.5	mW/cm²	100 mA	2.0 V @ 100 mA	100 μA @ 2.0 V	22
OP233	Hermetic TO-46 Lensed	18	$E_{e(APT)}$	3.0	—	mW/cm²	100 mA	2.0 V @ 100 mA	100 μA @ 2.0 V	22
OP231W	Hermetic TO-46	50	$E_{e(APT)}$	1.50	—	mW/cm²	100 mA	2.0 V @ 100 mA	100 μA @ 2.0 V	22
OP232W	Hermetic TO-46	50	$E_{e(APT)}$	3.5	7.0	mW/cm²	100 mA	2.0 V @ 100 mA	100 μA @ 2.0 V	22
OP233W	Hermetic TO-46	50	$E_{e(APT)}$	5.0	—	mW/cm²	100 mA	2.0 V @ 100 mA	100 μA @ 2.0 V	22
OP240SL	Plastic Lateral	40	$E_{e(APT)}$	.050	—	mW/cm²	20 mA	1.80 V @ 20 mA	100 μA @ 2.0 V	24
OP240SLA	Plastic Lateral	40	$E_{e(APT)}$	.60	—	mW/cm²	20 mA	1.80 V @ 20 mA	100 μA @ 2.0 V	24
OP240SLB	Plastic Lateral	40	$E_{e(APT)}$	.40	1.20	mW/cm²	20 mA	1.80 V @ 20 mA	100 μA @ 2.0 V	24
OP240SLC	Plastic Lateral	40	$E_{e(APT)}$	.20	.86	mW/cm²	20 mA	1.80 V @ 20 mA	100 μA @ 2.0 V	24
OP260SL	Plastic T-1 Lensed	16	$E_{e(APT)}$	.54	—	mW/cm²	20 mA	1.80 V @ 20 mA	100 μA @ 2.0 V	26
OP260SLA	Plastic T-1 Lensed	16	$E_{e(APT)}$	2.7	—	mW/cm²	20 mA	1.80 V @ 20 mA	100 μA @ 2.0 V	26
OP260SLB	Plastic T-1 Lensed	16	$E_{e(APT)}$	1.65	4.7	mW/cm²	20 mA	1.80 V @ 20 mA	100 μA @ 2.0 V	26
OP260SLC	Plastic T-1 Lensed	16	$E_{e(APT)}$	.54	3.3	mW/cm²	20 mA	1.80 V @ 20 mA	100 μA @ 2.0 V	26
OP268FA	Plastic Custom	104	$E_{e(APT)}$	.56	—	mW/cm²	20 mA	1.80 V @ 20 mA	100 μA @ 2.0 V	28
OP268FB	Plastic Custom	104	$E_{e(APT)}$	.48	.96	mW/cm²	20 mA	1.80 V @ 20 mA	100 μA @ 2.0 V	28
OP268FC	Plastic Custom	104	$E_{e(APT)}$	.40	—	mW/cm²	20 mA	1.80 V @ 20 mA	100 μA @ 2.0 V	28

Emitters (continued)

Part No.	Case Style	Beam Angle	Symbol	Min.	Max.	Output	at Rated I_{IF}	Max. V_F at Rated I_F	Max. I_R at Rated V_R	Page No.
OP269	Plastic Custom	46	$E_{e(APT)}$	.30	—	mW/cm²	20 mA	1.80 V @ 20 mA	100 µA @ 2.0 V	30
OP269SLA	Plastic Custom	46	$E_{e(APT)}$	.45	—	mW/cm²	20 mA	1.80 V @ 20 mA	100 µA @ 2.0 V	30
OP269SLB	Plastic Custom	46	$E_{e(APT)}$	.35	.70	mW/cm²	20 mA	1.80 V @ 20 mA	100 µA @ 2.0 V	30
OP290A	Plastic T-1 ¾ Lensed	50	$E_{e(APT)}$	210	—	mW/cm²	1.50 A	4.0 V @ 1.50 A	10 µA @ 5.0 V	32
OP290B	Plastic T-1 ¾ Lensed	50	$E_{e(APT)}$	180	300	mW/cm²	1.50 A	4.0 V @ 1.50 A	10 µA @ 5.0 V	32
OP290C	Plastic T-1 ¾ Lensed	50	$E_{e(APT)}$	150	—	mW/cm²	1.50 A	4.0 V @ 1.50 A	10 µA @ 5.0 V	32
OP291A	Plastic T-1 ¾ Lensed	50	$E_{e(APT)}$	16.0	—	mW/cm²	100 mA	2.0 V @ 100 mA	100 µA @ 2.0 V	32
OP291B	Plastic T-1 ¾ Lensed	50	$E_{e(APT)}$	13.0	26	mW/cm²	100 mA	2.0 V @ 100 mA	100 µA @ 2.0 V	32
OP291C	Plastic T-1¾ Lensed	50	$E_{e(APT)}$	10.0	—	mW/cm²	100 mA	2.0 V @ 100 mA	100 µA @ 2.0 V	32
OP292A	Plastic T-1¾ Lensed	50	$E_{e(APT)}$	2.7	—	mW/cm²	20 mA	1.75 V @ 20 mA	10 µA @ 5.0 V	32
OP292B	Plastic T-1¾ Lensed	50	$E_{e(APT)}$	2.2	4.4	mW/cm²	20 mA	1.75 V @ 20 mA	10 µA @ 5.0 V	32
OP292C	Plastic T-1¾ Lensed	50	$E_{e(APT)}$	1.70	—	mW/cm²	20 mA	1.75 V @ 20 mA	10 µA @ 5.0 V	32
OP293A	Plastic TO-46 Lensed	60	$E_{e(APT)}$	16.0	—	mW/cm²	100 mA	2.0 V @ 100 mA	100 µA @ 2.0 V	36
OP293B	Plastic TO-46 Lensed	60	$E_{e(APT)}$	13.0	20	mW/cm²	100 mA	2.0 V @ 100 mA	100 µA @ 2.0 V	36
OP293C	Plastic TO-46 Lensed	60	$E_{e(APT)}$	10.0	—	mW/cm²	100 mA	2.0 V @ 100 mA	100 µA @ 2.0 V	36
OP295A	Plastic T-1¾ Lensed	15	$E_{e(APT)}$	44	—	mW/cm²	1.50 A	4.0 V @ 1.50 A	10 µA @ 5.0 V	32
OP295B	Plastic T-1¾ Lensed	15	$E_{e(APT)}$	33	77	mW/cm²	1.50 A	4.0 V @ 1.50 A	10 µA @ 5.0 V	32
OP295C	Plastic T-1¾ Lensed	15	$E_{e(APT)}$	22	—	mW/cm²	1.50 A	4.0 V @ 1.50 A	10 µA @ 5.0 V	32
OP296A	Plastic T-1¾ Lensed	15	$E_{e(APT)}$	3.6	—	mW/cm²	100 mA	2.0 V @ 100 mA	100 µA @ 2.0 V	32
OP296B	Plastic T-1¾ Lensed	15	$E_{e(APT)}$	2.6	6.6	mW/cm²	100 mA	2.0 V @ 100 mA	100 µA @ 2.0 V	32
OP296C	Plastic T-1¾ Lensed	15	$E_{e(APT)}$	1.60	—	mW/cm²	100 mA	2.0 V @ 100 mA	100 µA @ 2.0 V	32
OP297A	Plastic T-1¾ Lensed	15	$E_{e(APT)}$	.70	—	mW/cm²	20 mA	1.75 V @ 20 mA	10 µA @ 5.0 V	32
OP297B	Plastic T-1¾ Lensed	15	$E_{e(APT)}$	.50	1.30	mW/cm²	20 mA	1.75 V @ 20 mA	10 µA @ 5.0 V	32
OP297C	Plastic T-1¾ Lensed	15	$E_{e(APT)}$	.30	—	mW/cm²	20 mA	1.75 V @ 20 mA	10 µA @ 5.0 V	32
OP298A	Plastic TO-46 Lensed	25	$E_{e(APT)}$	3.6	—	mW/cm²	100 mA	2.0 V @ 100 mA	100 µA @ 2.0 V	36
OP298B	Plastic TO-46 Lensed	25	$E_{e(APT)}$	2.8	4.4	mW/cm²	100 mA	2.0 V @ 100 mA	100 µA @ 2.0 V	36
OP298C	Plastic TO-46 Lensed	25	$E_{e(APT)}$	2.0	—	mW/cm²	100 mA	2.0 V @ 100 mA	100 µA @ 2.0 V	36
OP298D	Plastic TO-46 Lensed	25	$E_{e(APT)}$	2.0	4.4	mW/cm²	100 mA	2.0 V @ 100 mA	100 µA @ 2.0 V	36

Product Selection Guide

Sensors

Part No.	Case Style	Output Type	Min.	Max.	$I_{C(ON)}$	at Rated V_{CE} and E_e	Min. $V_{(BR)CEO}$ at Rated I_C	Max. I_{CEO} at Rated V_{CE}	Page No.
OP300	Hermetic Pill Lensed	Photodarlington	.80	—	mA	5.0 V and 1.00 mW/cm²	15.0 V @ 100 μA	1.00 μA @ 10.0 V	44
OP301	Hermetic Pill Lensed	Photodarlington	.80	2.4	mA	5.0 V and 1.00 mW/cm²	15.0 V @ 100 μA	1.00 μA @ 10.0 V	44
OP302	Hermetic Pill Lensed	Photodarlington	1.80	5.4	mA	5.0 V and 1.00 mW/cm²	15.0 V @ 100 μA	1.00 μA @ 10.0 V	44
OP303	Hermetic Pill Lensed	Photodarlington	3.6	12.0	mA	5.0 V and 1.00 mW/cm²	15.0 V @ 100 μA	1.00 μA @ 10.0 V	44
OP304	Hermetic Pill Lensed	Photodarlington	7.0	21	mA	5.0 V and 1.00 mW/cm²	15.0 V @ 100 μA	1.00 μA @ 10.0 V	44
OP305	Hermetic Pill Lensed	Photodarlington	14.0	—	mA	5.0 V and 1.00 mW/cm²	15.0 V @ 100 μA	1.00 μA @ 10.0 V	44
OP500	Plastic T-1 Lensed	Phototransistor	4.0	—	mA	5.0 V and 20 mW/cm²	30 V @ 100 μA	100 nA @ 15.0 V	46
OP500SLA	Plastic T-1 Lensed	Phototransistor	40	—	mA	5.0 V and 20 mW/cm²	30 V @ 100 μA	100 nA @ 15.0 V	46
OP500SLB	Plastic T-1 Lensed	Phototransistor	25	50	mA	5.0 V and 20 mW/cm²	30 V @ 100 μA	100 nA @ 15.0 V	46
OP500SLC	Plastic T-1 Lensed	Phototransistor	17.0	35	mA	5.0 V and 20 mW/cm²	30 V @ 100 μA	100 nA @ 15.0 V	46
OP500SLD	Plastic T-1 Lensed	Phototransistor	10.0	24	mA	5.0 V and 20 mW/cm²	30 V @ 100 μA	100 nA @ 15.0 V	46
OP500SR	Plastic T-1 Lensed	Phototransistor	.080	—	mA	5.0 V and .13 mW/cm²	30 V @ 1.00 mA	100 nA @ 10.0 V	48
OP500SRA	Plastic T-1 Lensed	Phototransistor	.64	—	mA	5.0 V and .13 mW/cm²	30 V @ 1.00 mA	100 nA @ 10.0 V	48
OP500SRB	Plastic T-1 Lensed	Phototransistor	.32	.96	mA	5.0 V and .13 mW/cm²	30 V @ 1.00 mA	100 nA @ 10.0 V	48
OP500SRC	Plastic T-1 Lensed	Phototransistor	.160	.48	mA	5.0 V and .13 mW/cm²	30 V @ 1.00 mA	100 nA @ 10.0 V	48
OP500SRD	Plastic T-1 Lensed	Phototransistor	.080	.24	mA	5.0 V and .13 mW/cm²	30 V @ 1.00 mA	100 nA @ 10.0 V	48
OP500W	Plastic T-1	Phototransistor	.50	—	mA	5.0 V and 20 mW/cm²	30 V @ 100 μA	100 nA @ 15.0 V	50
OP501	Plastic T-1 Lensed	Phototransistor	4.0	—	mA	5.0 V and 20 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	52
OP501SLA	Plastic T-1 Lensed	Phototransistor	40	—	mA	5.0 V and 20 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	52
OP501SLB	Plastic T-1 Lensed	Phototransistor	25	50	mA	5.0 V and 20 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	52
OP501SLC	Plastic T-1 Lensed	Phototransistor	17.0	35	mA	5.0 V and 20 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	52
OP501SLD	Plastic T-1 Lensed	Phototransistor	10.0	24	mA	5.0 V and 20 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	52
OP501SR	Plastic T-1 Lensed	Phototransistor	.080	—	mA	5.0 V and .13 mW/cm²	30 V @ 1.00 mA	100 nA @ 10.0 V	54
OP501SRA	Plastic T-1 Lensed	Phototransistor	.64	—	mA	5.0 V and .13 mW/cm²	30 V @ 1.00 mA	100 nA @ 10.0 V	54
OP501SRB	Plastic T-1 Lensed	Phototransistor	.32	.96	mA	5.0 V and .13 mW/cm²	30 V @ 1.00 mA	100 nA @ 10.0 V	54
OP501SRC	Plastic T-1 Lensed	Phototransistor	.160	.48	mA	5.0 V and .13 mW/cm²	30 V @ 1.00 mA	100 nA @ 10.0 V	54
OP501SRD	Plastic T-1 Lensed	Phototransistor	.080	.24	mA	5.0 V and .13 mW/cm²	30 V @ 1.00 mA	100 nA @ 10.0 V	54
OP508FA	Plastic Custom	Phototransistor	3.6	—	mA	5.0 V and 20 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	56
OP508FB	Plastic Custom	Phototransistor	1.20	8.4	mA	5.0 V and 20 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	56
OP508FC	Plastic Custom	Phototransistor	.50	—	mA	5.0 V and 20 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	56
OP509	Plastic Custom	Phototransistor	.50	—	mA	5.0 V and 1.00 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	58
OP509SLC	Plastic Custom	Phototransistor	.30	—	mA	5.0 V and 1.00 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	58
OP509SLD	Plastic Custom	Phototransistor	.17.0	.50	mA	5.0 V and 1.00 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	58
OP530	Plastic T-1 Lensed	Photodarlington	5.0	—	mA	5.0 V and .50 mW/cm²	15.0 V @ 1.00 mA	100 nA @ 10.0 V	60
OP538F	Plastic Custom	Photodarlington	1.00	—	mA	5.0 V and 1.00 mW/cm²	15.0 V @ 1.00 mA	225 nA @ 10.0 V	62
OP538FA	Plastic Custom	Photodarlington	4.0	—	mA	5.0 V and 1.00 mW/cm²	15.0 V @ 1.00 mA	225 nA @ 10.0 V	62
OP538FB	Plastic Custom	Photodarlington	3.2	7.2	mA	5.0 V and 1.00 mW/cm²	15.0 V @ 1.00 mA	225 nA @ 10.0 V	62
OP538FC	Plastic Custom	Photodarlington	2.4	—	mA	5.0 V and 1.00 mW/cm²	15.0 V @ 1.00 mA	225 nA @ 10.0 V	62
OP550	Plastic Lateral	Phototransistor	.50	—	mA	5.0 V and 20 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	64
OP550SLA	Plastic Lateral	Phototransistor	22	—	mA	5.0 V and 20 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	64
OP550SLB	Plastic Lateral	Phototransistor	15.0	28	mA	5.0 V and 20 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	64
OP550SLC	Plastic Lateral	Phototransistor	12.0	19	mA	5.0 V and 20 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	64
OP550SLD	Plastic Lateral	Phototransistor	4.5	14.5	mA	5.0 V and 20 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	64
OP560	Plastic Lateral	Photodarlington	.50	—	mA	2.0 V and 1.00 mW/cm²	30 V @ 1.00 mA	100 nA @ 10.0 V	70
OP560A	Plastic Lateral	Photodarlington	24	—	mA	2.0 V and 1.00 mW/cm²	30 V @ 1.00 mA	100 nA @ 10.0 V	70
OP560B	Plastic Lateral	Photodarlington	12.0	26	mA	2.0 V and 1.00 mW/cm²	30 V @ 1.00 mA	100 nA @ 10.0 V	70
OP560C	Plastic Lateral	Photodarlington	4.0	—	mA	2.0 V and 1.00 mW/cm²	30 V @ 1.00 mA	100 nA @ 10.0 V	70
OP593A	Plastic TO-18 Lensed	Phototransistor	3.0	—	mA	5.0 V and 1.50 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	72
OP593B	Plastic TO-18 Lensed	Phototransistor	2.0	4.0	mA	5.0 V and 1.50 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	72
OP593C	Plastic TO-18 Lensed	Phototransistor	1.00	—	mA	5.0 V and 1.50 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	72
OP598A	Plastic TO-18 Lensed	Phototransistor	7.5	—	mA	5.0 V and 1.50 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	72
OP598B	Plastic TO-18 Lensed	Phototransistor	5.0	10.0	mA	5.0 V and 1.50 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	72

Sensors (continued)

Part No.	Case Style	Output Type	Min.	Max.	$I_{C(ON)}$	at Rated V_{CE} and E_e	Min. $V_{(BR)CEO}$ at Rated I_C	Max. I_{CEO} at Rated V_{CE}	Page No.
OP598C	Plastic TO-18 Lensed	Phototransistor	2.5	–	mA	5.0 V and 1.50 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	72
OP600	Hermetic Pill Lensed	Phototransistor	.50	–	mA	5.0 V and 20 mW/cm²	50 V @ 100 μA	25 nA @ 10.0 V	76
OP601	Hermetic Pill Lensed	Phototransistor	.50	3.0	mA	5.0 V and 20 mW/cm²	50 V @ 100 μA	25 nA @ 10.0 V	76
OP602	Hermetic Pill Lensed	Phototransistor	2.0	5.0	mA	5.0 V and 20 mW/cm²	50 V @ 100 μA	25 nA @ 10.0 V	76
OP603	Hermetic Pill Lensed	Phototransistor	4.0	8.0	mA	5.0 V and 20 mW/cm²	50 V @ 100 μA	25 nA @ 10.0 V	76
OP604	Hermetic Pill Lensed	Phototransistor	7.0	22	mA	5.0 V and 20 mW/cm²	50 V @ 100 μA	25 nA @ 10.0 V	76
OP640	Hermetic Pill Lensed	Phototransistor	.50	–	mA	5.0 V and 20 mW/cm²	25 V @ 100 μA	100 nA @ 10.0 V	76
OP641	Hermetic Pill Lensed	Phototransistor	.50	3.0	mA	5.0 V and 20 mW/cm²	25 V @ 100 μA	100 nA @ 10.0 V	76
OP642	Hermetic Pill Lensed	Phototransistor	2.0	5.0	mA	5.0 V and 20 mW/cm²	25 V @ 100 μA	100 nA @ 10.0 V	76
OP643	Hermetic Pill Lensed	Phototransistor	4.0	8.0	mA	5.0 V and 20 mW/cm²	25 V @ 100 μA	100 nA @ 10.0 V	76
OP644	Hermetic Pill Lensed	Phototransistor	7.0	22	mA	5.0 V and 20 mW/cm²	25 V @ 100 μA	100 nA @ 10.0 V	76
OP800	Hermetic TO-18 Lensed	Phototransistor	.50	–	mA	5.0 V and 5.0 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	78
OP801	Hermetic TO-18 Lensed	Phototransistor	.50	3.0	mA	5.0 V and 5.0 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	78
OP802	Hermetic TO-18 Lensed	Phototransistor	2.0	5.0	mA	5.0 V and 5.0 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	78
OP803	Hermetic TO-18 Lensed	Phototransistor	4.0	8.0	mA	5.0 V and 5.0 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	78
OP804	Hermetic TO-18 Lensed	Phototransistor	7.0	22	mA	5.0 V and 5.0 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	78
OP805	Hermetic TO-18 Lensed	Phototransistor	15.0	–	mA	5.0 V and 5.0 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	78
OP800W	Hermetic TO-18	Phototransistor	.30	–	mA	5.0 V and 5.0 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	80
OP801W	Hermetic TO-18	Phototransistor	.50	3.0	mA	5.0 V and 5.0 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	80
OP802W	Hermetic TO-18	Phototransistor	2.5	–	mA	5.0 V and 5.0 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	80
OP830	Hermetic TO-18 Lensed	Photodarlington	15.0	–	mA	5.0 V and .50 mW/cm²	15.0 V @ 100 μA	1.00 μA @ 10.0 V	86
OP830W	Hermetic TO-18	Photodarlington	4.0	–	mA	5.0 V and .50 mW/cm²	15.0 V @ 100 μA	1.00 μA @ 10.0 V	88
OP841	Hermetic TO-18 Lensed	Phototransistor	.50	–	mA	5.0 V and 5.0 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	90
OP842	Hermetic TO-18 Lensed	Phototransistor	2.0	–	mA	5.0 V and 5.0 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	90
OP843	Hermetic TO-18 Lensed	Phototransistor	5.0	–	mA	5.0 V and 5.0 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	90
OP844	Hermetic TO-18 Lensed	Phototransistor	7.0	–	mA	5.0 V and 5.0 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	90
OP845	Hermetic TO-18 Lensed	Phototransistor	15.0	–	mA	5.0 V and 5.0 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	90
OP841W	Hermetic TO-18	Phototransistor	.30	–	mA	5.0 V and 5.0 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	92
OP842W	Hermetic TO-18	Phototransistor	1.00	–	mA	5.0 V and 5.0 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	92
OP843W	Hermetic TO-18	Phototransistor	1.50	–	mA	5.0 V and 5.0 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	92
OP844W	Hermetic TO-18	Phototransistor	2.0	–	mA	5.0 V and 5.0 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	92
OP845W	Hermetic TO-18	Phototransistor	2.5	–	mA	5.0 V and 5.0 mW/cm²	30 V @ 100 μA	100 nA @ 10.0 V	92

B

Photologic™ Devices

Part No.	Case Style	Output Circuit	Min./Max. V_{CC}	Max. I_{CC} at V_{CC}=5.25 V	Min./Max. $E_eT(+)$	Max. Propagation Delay (t_{PLH}, t_{PHL})	Page No.
OPL550	Plastic Lateral	Buffer, Totem-Pole	4.5/5.5 V	15.0 mA @ 0 or 3.0 mW/cm²	.25/2.4 mW/cm²	5.0 μs	66
OPL550SLB	Plastic Lateral	Buffer, Totem-Pole	4.5/5.5 V	15.0 mA @ 0 or 3.0 mW/cm²	.65/1.90 mW/cm²	5.0 μs	66
OPL550SLA	Plastic Lateral	Buffer, Totem-Pole	4.5/5.5 V	15.0 mA @ 0 or 3.0 mW/cm²	.25/1.40 mW/cm²	5.0 μs	66
OPL550-OC	Plastic Lateral	Buffer, Open-Collector	4.5/5.5 V	15.0 mA @ 0 or 3.0 mW/cm²	.25/2.4 mW/cm²	5.0 μs	66
OPL550SLB-OC	Plastic Lateral	Buffer, Open-Collector	4.5/5.5 V	15.0 mA @ 0 or 3.0 mW/cm²	.65/1.90 mW/cm²	5.0 μs	66
OPL550SLA-OC	Plastic Lateral	Buffer, Open-Collector	4.5/5.5 V	15.0 mA @ 0 or 3.0 mW/cm²	.25/1.40 mW/cm²	5.0 μs	66
OPL551	Plastic Lateral	Inverter, Totem-Pole	4.5/5.5 V	15.0 mA @ 0 or 3.0 mW/cm²	.25/2.4 mW/cm²	5.0 μs	66
OPL551SLB	Plastic Lateral	Inverter, Totem-Pole	4.5/5.5 V	15.0 mA @ 0 or 3.0 mW/cm²	.65/1.90 mW/cm²	5.0 μs	66
OPL551SLA	Plastic Lateral	Inverter, Totem-Pole	4.5/5.5 V	15.0 mA @ 0 or 3.0 mW/cm²	.25/1.40 mW/cm²	5.0 μs	66
OPL551-OC	Plastic Lateral	Inverter, Open-Collector	4.5/5.5 V	15.0 mA @ 0 or 3.0 mW/cm²	.25/2.4 mW/cm²	5.0 μs	66
OPL551SLB-OC	Plastic Lateral	Inverter, Open-Collector	4.5/5.5 V	15.0 mA @ 0 or 3.0 mW/cm²	.65/1.90 mW/cm²	5.0 μs	66
OPL551SLA-OC	Plastic Lateral	Inverter, Open-Collector	4.5/5.5 V	15.0 mA @ 0 or 3.0 mW/cm²	.25/1.40 mW/cm²	5.0 μs	66
OPL800	Hermetic TO-18 Lensed	Buffer, Totem-Pole	4.8/5.2 V	15.0 mA @ 0 or 1.00 mW/cm²	–/3.0 mW/cm²	5.0 μs	82
OPL800-OC	Hermetic TO-18 Lensed	Buffer, Open-Collector	4.8/5.2 V	15.0 mA @ 0 or 1.00 mW/cm²	–/3.0 mW/cm²	5.0 μs	82
OPL801	Hermetic TO-18 Lensed	Inverter, Totem-Pole	4.8/5.2 V	15.0 mA @ 0 or 1.00 mW/cm²	–/3.0 mW/cm²	5.0 μs	82
OPL801-OC	Hermetic TO-18 Lensed	Inverter, Open-Collector	4.8/5.2 V	15.0 mA @ 0 or 1.00 mW/cm²	–/3.0 mW/cm²	5.0 μs	82

Product Selection Guide

Photodiodes

Part No.	Case Style	Output Type	Min.	Max.	I_L	at Rated V_R and E_e	Min. $V_{(BR)R}$ at Rated I_R	Max. I_D at Rated V_R	Page No.
OP900	Hermetic Pill Lensed	Photodiode	8.0	—	μA	10.0 V and 20 mW/cm²	100 V @ 100 μA	10.0 nA @ 10.0 V	94
OP913	Hermetic TO-5 Lensed	Photodiode	120	—	μA	5.0 V and 5.0 mW/cm²	32 V @ 100 μA	25 nA @ 10.0 V	96
OP913W	Hermetic TO-5	Photodiode	40	—	μA	5.0 V and 5.0 mW/cm²	32 V @ 100 μA	25 nA @ 10.0 V	96

Optically Coupled Isolators

Part No.	Case Style	Output Type	Min. CTR @ Rated V_{CE} and I_F	Min. Isolation Voltage	Min. $V_{(BR)CEO}$ at Rated I_C	Max. I_{CEO} at Rated V_{CE}	Page No.
3N243	Hermetic TO-72	Phototransistor	15% @ 10.0 V and 10.0 mA	1000 VDC	30 V @ 1.00 mA	100 nA @ 10.0 V	166
3N244	Hermetic TO-72	Phototransistor	30% @ 10.0 V and 10.0 mA	1000 VDC	30 V @ 1.00 mA	100 nA @ 10.0 V	166
3N245	Hermetic TO-72	Phototransistor	60% @ 10.0 V and 10.0 mA	1000 VDC	30 V @ 1.00 mA	100 nA @ 10.0 V	166
4N22A	Hermetic TO-5	Phototransistor	25% @ 5.0 V and 10.0 mA	1000 VDC	35 V @ 1.00 mA	100 nA @ 20 V	170
4N23A	Hermetic TO-5	Phototransistor	60% @ 5.0 V and 10.0 mA	1000 VDC	35 V @ 1.00 mA	100 nA @ 20 V	170
4N24A	Hermetic TO-5	Phototransistor	100% @ 5.0 V and 10.0 mA	1000 VDC	35 V @ 1.00 mA	100 nA @ 20 V	170
4N25	6 Pin P-DIP	Phototransistor	20% @ 10.0 V and 10.0 mA	2500 VDC	30 V @ 1.00 mA	50 nA @ 10.0 V	172
4N26	6 Pin P-DIP	Phototransistor	20% @ 10.0 V and 10.0 mA	1500 VDC	30 V @ 1.00 mA	50 nA @ 10.0 V	172
4N27	6 Pin P-DIP	Phototransistor	10% @ 10.0 V and 10.0 mA	1500 VDC	30 V @ 1.00 mA	50 nA @ 10.0 V	172
4N28	6 Pin P-DIP	Phototransistor	10% @ 10.0 V and 10.0 mA	500 VDC	30 V @ 1.00 mA	100 nA @ 10.0 V	172
4N29	6 Pin P-DIP	Photodarlington	100% @ 10.0 V and 10.0 mA	2500 VDC	30 V @ 100 μA	100 nA @ 10.0 V	174
4N30	6 Pin P-DIP	Photodarlington	100% @ 10.0 V and 10.0 mA	1500 VDC	30 V @ 100 μA	100 nA @ 10.0 V	174
4N31	6 Pin P-DIP	Photodarlington	50% @ 10.0 V and 10.0 mA	1500 VDC	30 V @ 100 μA	100 nA @ 10.0 V	174
4N32	6 Pin P-DIP	Photodarlington	500% @ 10.0 V and 10.0 mA	2500 VDC	30 V @ 100 μA	100 nA @ 10.0 V	174
4N33	6 Pin P-DIP	Photodarlington	500% @ 10.0 V and 10.0 mA	1500 VDC	30 V @ 100 μA	100 nA @ 10.0 V	174
4N35	6 Pin P-DIP	Phototransistor	100% @ 10.0 V and 10.0 mA	3500 VAC	30 V @ 1.00 mA	50 nA @ 10.0 V	176
4N36	6 Pin P-DIP	Phototransistor	100% @ 10.0 V and 10.0 mA	2500 VAC	30 V @ 1.00 mA	50 nA @ 10.0 V	176
4N37	6 Pin P-DIP	Phototransistor	100% @ 10.0 V and 10.0 mA	1500 VAC	30 V @ 1.00 mA	50 nA @ 10.0 V	176
4N38	6 Pin P-DIP	Phototransistor	20% @ 1.00 V and 20 mA	1500 VDC	80 V @ 1.00 mA	50 nA @ 60.0 V	178
4N38A	6 Pin P-DIP	Phototransistor	20% @ 1.00 V and 20 mA	2500 VDC	80 V @ 1.00 mA	50 nA @ 60.0 V	178
CNY17/1	6 Pin P-DIP	Phototransistor	40% @ 5.0 V and 10.0 mA	4000 VDC	70 V @ 1.00 mA	50 nA @ 10.0 V	102
CNY17/2	6 Pin P-DIP	Phototransistor	63% @ 5.0 V and 10.0 mA	4000 VDC	70 V @ 1.00 mA	50 nA @ 10.0 V	102
CNY17/3	6 Pin P-DIP	Phototransistor	100% @ 5.0 V and 10.0 mA	4000 VDC	70 V @ 1.00 mA	100 nA @ 10.0 V	102
CNY17/4	6 Pin P-DIP	Phototransistor	160% @ 5.0 V and 10.0 mA	4000 VDC	70 V @ 1.00 mA	100 nA @ 10.0 V	102
OPI102	Hermetic TO-5	Phototransistor	25% @ 5.0 V and 10.0 mA	1000 VDC	35 V @ 1.00 mA	100 nA @ 20 V	106
OPI103	Hermetic TO-5	Phototransistor	100% @ 5.0 V and 10.0 mA	1000 VDC	35 V @ 1.00 mA	100 nA @ 20 V	106
OPI110	Plastic Axial	Phototransistor	12.5 % @ 5.0 V and 16.0 mA	10,000 VDC	30 V @ 100 μA	200 nA @ 20 V	108
OPI110A	Plastic Axial	Phototransistor	25% @ 5.0 V and 16.0 mA	10,000 VDC	30 V @ 100 μA	200 nA @ 20 V	108
OPI110B	Plastic Axial	Phototransistor	50% @ 5.0 V and 16.0 mA	10,000 VDC	30 V @ 100 μA	200 nA @ 20 V	108
OPI110C	Plastic Axial	Phototransistor	100% @ 5.0 V and 16.0 mA	10,000 VDC	30 V @ 100 μA	200 nA @ 20 V	108
OPI113	Plastic Axial	Photodarlington	50% @ 2.0 V and 16.0 mA	10,000 VDC	15.0 V @ 1.00 mA	100 nA @ 15.0 V	108
OPI120	Hermetic Axial	Phototransistor	20% @ 5.0 V and 10.0 mA	15,000 VDC	25 V @ 1.00 mA	100 nA @ 10.0 V	110
OPI123	Hermetic Axial	Photodarlington	50% @ 2.0 V and 10.0 mA	15,000 VDC	20 V @ 1.00 mA	100 nA @ 10.0 V	110
OPI130	Hermetic TO-5	Photodarlington	200% @ 2.0 V and 5.0 mA	1000 VDC	25 V @ 1.00 mA	100 nA @ 10.0 V	118
OPI140	Hermetic TO-72	Phototransistor	15% @ 10.0 V and 10.0 mA	1000 VDC	30 V @ 1.00 mA	50 nA @ 10.0 V	120
OPI150	Hermetic Axial	Phototransistor	10% @ 5.0 V and 10.0 mA	50,000 VDC	30 V @ 1.00 mA	100 nA @ 10.0 V	122
OPI153	Hermetic Axial	Photodarlington	25% @ 5.0 V and 20 mA	50,000 VDC	15.0 V @ 1.00 mA	500 nA @ 10.0 V	122
OPI210	Surface Mount	Phototransistor	50% @ 5.0 V and 10.0 mA	1000 VDC	35 V @ 100 μA	100 nA @ 20 V	124
OPI211	Surface Mount	Phototransistor	200% @ 5.0 V and 10.0 mA	1000 VDC	35 V @ 100 μA	100 nA @ 20 V	124
OPI1264	Plastic Axial	Phototransistor	12.5% @ 5.0 V and 10.0 mA	10,000 VDC	32 V @ 1.00 mA	100 μA @ 10.0 V	116
OPI1264A	Plastic Axial	Phototransistor	25% @ 5.0 V and 10.0 mA	10,000 VDC	32 V @ 1.00 mA	100 μA @ 10.0 V	116
OPI1264B	Plastic Axial	Phototransistor	50% @ 5.0 V and 10.0 mA	10,000 VDC	32 V @ 1.00 mA	200 nA @ 20 V	116
OPI1264C	Plastic Axial	Phototransistor	100% @ 5.0 V and 10.0 mA	10,000 VDC	32 V @ 1.00 mA	200 nA @ 20 V	116
OPI2100	6 Pin P-DIP	Phototransistor	150% @ 5.0 V and 10.0 mA	4000 VDC	30 V @ 1.00 mA	50 nA @ 5.0 V	126

Optically Coupled Isolators (continued)

Part No.	Case Style	Output Type	Min. CTR @ Rated V_{CE} and I_F	Min. Isolation Voltage	Min. $V_{(BR)CEO}$ at Rated I_C	Max. I_{CEO} at Rated V_{CE}	Page No.
OPI2150	6 Pin P-DIP	Phototransistor	2% @ 5.0 V and 10.0 mA	1500 VDC	20 V @ 1.00 mA	100 nA @ 10.0 V	128
OPI2151	6 Pin P-DIP	Phototransistor	10% @ 5.0 V and 10.0 mA	1500 VDC	30 V @ 1.00 mA	100 nA @ 10.0 V	130
OPI2152	6 Pin P-DIP	Phototransistor	20% @ 5.0 V and 10.0 mA	1500 VDC	30 V @ 1.00 mA	50 nA @ 10.0 V	132
OPI2153	6 Pin P-DIP	Phototransistor	50% @ 5.0 V and 10.0 mA	1500 VDC	30 V @ 1.00 mA	50 nA @ 10.0 V	134
OPI2154	6 Pin P-DIP	Phototransistor	10% @ .50 V and .50 mA	1500 VDC	30 V @ 1.00 mA	50 nA @ 10.0 V	136
OPI2155	6 Pin P-DIP	Phototransistor	20% @ .50 V and 1.00 mA	2500 VDC	30 V @ 1.00 mA	50 nA @ 10.0 V	136
OPI2250	6 Pin P-DIP	Phototransistor	2% @ 5.0 V and 10.0 mA	2500 VDC	20 V @ 1.00 mA	100 nA @ 10.0 V	128
OPI2251	6 Pin P-DIP	Phototransistor	10% @ 5.0 V and 10.0 mA	2500 VDC	30 V @ 1.00 mA	100 nA @ 10.0 V	130
OPI2252	6 Pin P-DIP	Phototransistor	20% @ 5.0 V and 10.0 mA	2500 VDC	30 V @ 1.00 mA	50 nA @ 10.0 V	132
OPI2253	6 Pin P-DIP	Phototransistor	50% @ 5.0 V and 10.0 mA	2500 VDC	30 V @ 1.00 mA	50 nA @ 10.0 V	134
OPI2254	6 Pin P-DIP	Phototransistor	10% @ .50 V and .50 mA	1500 VDC	30 V @ 1.00 mA	50 nA @ 10.0 V	136
OPI2255	6 Pin P-DIP	Phototransistor	20% @ .50 V and 1.00 mA	2500 VDC	30 V @ 1.00 mA	50 nA @ 10.0 V	136
OPI2500	6 Pin P-DIP	AC Phototransistor	12.5% @ .40 V AND 16.0 mA	1500 VDC	30 V @ 1.00 mA	50 nA @ 10.0 V	138
OPI2501	6 Pin P-DIP	AC Phototransistor	20% @ 10.0 V and 10.0 mA	1500 VDC	30 V @ 1.00 mA	50 nA @ 10.0 V	138
OPI3150	6 Pin P-DIP	Photodarlington	300% @ 2.0 V and 10.0 mA	1500 VDC	30 V @ 100 μA	100 nA @ 10.0 V	150
OPI3151	6 Pin P-DIP	Photodarlington	300% @ 2.0 V and 10.0 mA	1500 VDC	30 V @ 100 μA	100 nA @ 10.0 V	152
OPI3152	6 Pin P-DIP	Photodarlington	300% @ 5.0 V and 10.0 mA	1500 VDC	55 V @ 100 μA	100 nA @ 10.0 V	154
OPI3153	6 Pin P-DIP	Photodarlington	500% @ 5.0 V and 1.00 mA	1500 VDC	25 V @ 1.00 mA	100 nA @ 10.0 V	154
OPI3250	6 Pin P-DIP	Photodarlington	300% @ 2.0 V and 10.0 mA	2500 VDC	30 V @ 100 μA	100 nA @ 10.0 V	150
OPI3251	6 Pin P-DIP	Photodarlington	300% @ 2.0 V and 10.0 mA	2500 VDC	30 V @ 100 μA	100 nA @ 10.0 V	152
OPI3252	6 Pin P-DIP	Photodarlington	300% @ 5.0 V and 10.0 mA	2500 VDC	55 V @ 100 μA	100 nA @ 10.0 V	154
OPI3253	6 Pin P-DIP	Photodarlington	500% @ 5.0 V and 1.00 mA	2500 VDC	25 V @ 1.00 mA	100 nA @ 10.0 V	154
OPI6000	6 Pin P-DIP	Phototransistor	20% @ 5.0 V and 10.0 mA	1500 VDC	300 V @ 1.00 μA	100 nA @ 200 V	158
OPI6100	6 Pin P-DIP	Phototransistor	10% @ 5.0 V and 10.0 mA	1500 VDC	200 V @ 1.00 μA	100 nA @ 100 V	158
OPI7002	Plastic Custom	Phototransistor	20% @ 10.0 V and 5.0 mA	6000 VDC	30 V @ 1.00 mA	100 nA @ 10.0 V	160
OPI7010	Plastic Custom	Phototransistor	100% @ 10.0 V and 5.0 mA	6000 VDC	30 V @ 1.00 mA	100 nA @ 10.0 V	160
OPI7320	Plastic Custom	Photodarlington	200% @ 5.0 V and 5.0 mA	6000 VDC	30 V @ 1.00 mA	100 nA @ 10.0 V	160
OPI7340	Plastic Custom	Photodarlington	400% @ 5.0 V and 5.0 mA	6000 VDC	30 V @ 1.00 mA	100 nA @ 10.0 V	160

Triac Driver Couplers

Part No.	Case Style	Type	Max. LED Trigger Current	Peak Blocking Current Max. @ Rated V_{DRM}	Peak On-State Voltage @ Rated I_{TM}	Isolation Voltage	Holding Current, Either Direction	Page No.
OPI3009	6 Pin P-DIP	Zero Current	30 mA @ 3.0 V	100 nA @ 250 V(1)	3 V @ 100 mA	2500 VDC	100 μA	142
OPI3010	6 Pin P-DIP	Zero Current	15.0 mA @ 3.0 V	100 nA @ 250 V(1)	3 V @ 100 mA	2500 VDC	100 μA	142
OPI3011	6 Pin P-DIP	Zero Current	10.0 mA @ 3.0 V	100 nA @ 250 V(1)	3 V @ 100 mA	2500 VDC	100 μA	142
OPI3012	6 Pin P-DIP	Zero Current	5.0 mA @ 3.0 V	100 nA @ 250 V(1)	3 V @ 100 mA	2500 VDC	100 μA	142
OPI3020	6 Pin P-DIP	Zero Current	30 mA @ 3.0 V	100 nA @ 400 V(1)	3 V @ 100 mA	2500 VDC	100 μA	144
OPI3021	6 Pin P-DIP	Zero Current	15.0 mA @ 3.0 V	100 nA @ 400 V(1)	3 V @ 100 mA	2500 VDC	100 μA	144
OPI3022	6 Pin P-DIP	Zero Current	10.0 mA @ 3.0 V	100 nA @ 400 V(1)	3 V @ 100 mA	2500 VDC	100 μA	144
OPI3023	6 Pin P-DIP	Zero Current	5.0 mA @ 3.0 V	100 nA @ 400 V(1)	3 V @ 100 mA	2500 VDC	100 μA	144
OPI3030	6 Pin P-DIP	Zero Voltage	30 mA @ 3.0 V	100 nA @ 250 V(1)	3 V @ 100 mA	2500 VDC	200 μA	146
OPI3031	6 Pin P-DIP	Zero Voltage	15.0 mA @ 3.0 V	100 nA @ 250 V(1)	3 V @ 100 mA	2500 VDC	200 μA	146
OPI3032	6 Pin P-DIP	Zero Voltage	10.0 mA @ 3.0 V	100 nA @ 250 V(1)	3 V @ 100 mA	2500 VDC	200 μA	146
OPI3033	6 Pin P-DIP	Zero Voltage	5.0 mA @ 3.0 V	100 nA @ 250 V(1)	3 V @ 100 mA	2500 VDC	200 μA	146
OPI3040	6 Pin P-DIP	Zero Voltage	30 mA @ 3.0 V	100 nA @ 400 V(1)	3 V @ 100 mA	2500 VDC	200 μA	148
OPI3041	6 Pin P-DIP	Zero Voltage	15.0 mA @ 3.0 V	100 nA @ 400 V(1)	3 V @ 100 mA	2500 VDC	200 μA	148
OPI3042	6 Pin P-DIP	Zero Voltage	10.0 mA @ 3.0 V	100 nA @ 400 V(1)	3 V @ 100 mA	2500 VDC	200 μA	148
OPI3043	6 Pin P-DIP	Zero Voltage	5.0 mA @ 3.0 V	100 nA @ 400 V(1)	3 V @ 100 mA	2500 VDC	200 μA	148

Product Selection Guide

High Technology Couplers

Part No.	Case Style	Output Type	Max. V_F at Rated I_F	Min. CTR at Rated V_{CE} and I_F	Isolation Voltage	Max. V_{OL} at Rated I_{OL}	Bandwidth	Page No.
OPI125	Hermetic Axial	Photologic™	1.50 V @ 10.0 mA	Buffer, Totem-Pole Output	15,000 VDC	.40 V @ 13.0 mA	250 K-baud	112
OPI126	Hermetic Axial	Photologic™	1.50 V @ 10.0 mA	Buffer, Open-Collector Output	15,000 VDC	.40 V @ 13.0 mA	250 K-baud	112
OPI127	Hermetic Axial	Photologic™	1.50 V @ 10.0 mA	Inverter, Totem-Pole Output	15,000 VDC	.40 V @ 13.0 mA	250 K-baud	112
OPI128	Hermetic Axial	Photologic™	1.50 V @ 10.0 mA	Inverter, Open-Collector Output	15,000 VDC	.40 V @ 13.0 mA	250 K-baud	112
OPI2502	8 Pin P-DIP	Phototransistor	1.70 V @ 16.0 mA	15% @ 4.5 V and 16.0 mA	3000 VDC	.40 V @ 2.4 mA	2 MHz, R=100	184
OPI2630	8 Pin P-DIP	Dual Logic Gate	1.75 V @ 10.0 mA	700%, R=100 and 5.0 mA	3000 VDC	.60 V @ 13.0 mA	5 MHz, R=100	140
OPI8012	8 Pin P-DIP	Photologic™	1.50 V @ 10.0 mA	Buffer, Totem-Pole Output	1500 VDC	.40 V @ 13.0 mA	250 K-baud	162
OPI8013	8 Pin P-DIP	Photologic™	1.50 V @ 10.0 mA	Buffer, Open-Collector Output	1500 VDC	.40 V @ 13.0 mA	250 K-baud	162
OPI8014	8 Pin P-DIP	Photologic™	1.50 V @ 10.0 mA	Inverter, Totem-Pole Output	1500 VDC	.40 V @ 13.0 mA	250 K-baud	162
OPI8015	8 Pin P-DIP	Photologic™	1.50 V @ 10.0 mA	Inverter, Open-Collector Output	1500 VDC	.40 V @ 13.0 mA	250 K-baud	162
OPI8137	8 Pin P-DIP	Logic Gate	1.75 V @ 10.0 mA	700%, R=100 and 5.0 mA	3000 VDC	.60 V @ 13.0 mA	2.5 MHz, R=100	188
4N45	8 Pin P-DIP	Photodarlington	1.70 V @ 1.00 mA	250%, V=1.00 V and 1.00 mA	3000 VDC	1.00 V @ 2.5 mA	–	180
4N46	8 Pin P-DIP	Photodarlington	1.70 V @ 1.00 mA	500%, V=1.20 V and 1.00 mA	3000 VDC	1.00 V @ 2.5 mA	–	180
6N135	8 Pin P-DIP	Phototransistor	1.70 V @ 1.00 mA	7% @ 4.5 V and 16.0 mA	3000 VDC	.40 V @ 1.10 mA	2 MHz, R=100	184
6N136	8 Pin P-DIP	Phototransistor	1.70 V @ 1.00 mA	19% @ 4.5 V and 16.0 mA	3000 VDC	.40 V @ 2.4 mA	2 MHz, R=100	184
6N137	8 Pin P-DIP	Logic Gate	1.75 V @ 10.0 mA	700%, R=100 and 5.0 mA	3000 VDC	.60 V @ 13.0 mA	5 MHz, R=100	188
6N138	8 Pin P-DIP	Phototransistor	1.70 V @ 1.60 mA	300% @ 4.5 V and 1.60 mA	3000 VDC	.40 V @ 4.8 mA	–	192
6N139	8 Pin P-DIP	Phototransistor	1.70 V @ 1.60 mA	500% @ 4.5 V and 1.60 mA	3000 VDC	.40 V @ 24 mA	–	192

Reflective Assemblies

Part No.	Output Type	Max. V_F at Rated I_F	Min. $V_{(BR)CEO}$ at Rated I_C	Max. I_{CEO} at Rated V_{CE}, I_F=0	Min. On-State Collector Current at Rated V_{CE} and I_F	Page No.
OPB125A	Photodarlington	1.70 V @ 50 mA	25 V @ 100 μA	1.00 μA @ 10.0 V	2.0 mA @ 5.0 V and 40 mA, d=0.20 in. (5.08 mm)	212
OPB253A	Phototransistor	1.70 V @ 50 mA	25 V @ 100 μA	100 nA @ 10.0 V	25 μA @ 5.0 V and 40 mA, d=0.20 in. (5.08 mm)	214
OPB703A	Phototransistor	1.70 V @ 40 mA	30 V @ 100 μA	100 nA @ 10.0 V	200 μA @ 5.0 V and 40 mA, d=0.20 in. (5.08 mm)	216
OPB706A	Phototransistor	1.70 V @ 20 mA	30 V @ 100 μA	100 nA @ 5 V	500 μA @ 5.0 V and 20 mA, d=0.05 in. (1.27 mm)	218
OPB706B	Phototransistor	1.70 V @ 20 mA	30 V @ 100 μA	100 nA @ 5 V	350 μA @ 5.0 V and 20 mA, d=0.05 in. (1.27 mm)	218
OPB706C	Phototransistor	1.70 V @ 20 mA	30 V @ 100 μA	100 nA @ 5 V	200 μA @ 5.0 V and 20 mA, d=0.05 in. (1.27 mm)	218
OPB707A	Photodarlington	1.70 V @ 20 mA	15.0 V @ 100 μA	250 nA @ 5 V	25 μA @ 5.0 V and 20 mA, d=0.05 in. (1.27 mm)	218
OPB707B	Photodarlington	1.70 V @ 20 mA	15.0 V @ 100 μA	250 nA @ 5 V	17.0 μA @ 5.0 V and 20 mA, d=0.05 in. (1.27 mm)	218
OPB707C	Photodarlington	1.70 V @ 20 mA	15.0 V @ 100 μA	250 nA @ 5 V	10.0 μA @ 5.0 V and 20 mA, d=0.05 in. (1.27 mm)	218
OPB708	Phototransistor	1.70 V @ 40 mA	30 V @ 100 μA	100 nA @ 15 V	10.0 mA @ 5.0 V and 40 mA, d=0.15 in. (3.81 mm)	222
OPB709	Photodarlington	1.70 V @ 40 mA	15.0 V @ 100 μA	250 nA @ 10.0 V	10.0 mA @ 5.0 V and 40 mA, d=0.15 in. (3.81 mm)	222
OPB710	Phototransistor	1.50 V @ 50 mA	30 V @ 100 μA	100 nA @ 5 V	150 mA @ 5.0 V and 40 mA, d=0.25 in. (6.35 mm)	226
OPB711	Phototransistor	1.70 V @ 20 mA	30 V @ 100 μA	100 nA @ 10 V	350 μA @ 5.0 V and 40 mA, d=0.080 in. (2.03 mm)	230
OPB712	Photodarlington	1.70 V @ 20 mA	15.0 V @ 100 μA	250 nA @ 10 V	20 mA @ 5.0 V and 40 mA, d=0.08 in. (2.03 mm)	230
OPB730	Photodarlington	1.50 V @ 50 mA	30 V @ 100 μA	250 nA @ 5 V	1.00 mA @ 5.0 V and 40 mA, d=0.25 in. (6.35 mm)	226

Slotted Optical Switches

Part No.	Slot Width Inches (mm)	Sensor Aperture Inches (mm)	V_F at Rated I_F	I_{CEO} at Rated V_{CE}, I_F=0, E_e=0	Min. On-State Collector Current at Rated V_{CE} and I_F	*Page No.
CNY36	0.120 (3.05)	–	1.70 V @ 20 mA	100 nA @ 10.0 V	200 μA @ 10.0 V and 20 mA	238
OPB804	0.155 (3.94)	–	1.70 V @ 20 mA	100 nA @ 10.0 V	500 μA @ 10.0 V and 20 mA	240
OPB806	0.125 (3.18)	–	1.70 V @ 20 mA	100 nA @ 10.0 V	400 μA @ .50 V and 20 mA	242
OPB813S3	0.125 (3.18)	0.003 (0.076)×0.04 (1.02)	1.70 V @ 20 mA	100 nA @ 10.0 V	75 μA @ 10.0 V and 20 mA	244
OPB813S5	0.125 (3.18)	0.005 (0.127)×0.04 (1.02)	1.70 V @ 20 mA	100 nA @ 10.0 V	250 μA @ 10.0 V and 20 mA	244
OPB813S7	0.125 (3.18)	0.007 (0.178)×0.04 (1.02)	1.70 V @ 20 mA	100 nA @ 10.0 V	350 μA @ 10.0 V and 20 mA	244
OPB816	0.125 (3.18)	–	1.70 V @ 20 mA	100 nA @ 10.0 V	500 μA @ 10.0 V and 20 mA	246
OPB817	0.125 (3.18)	–	1.70 V @ 20 mA	100 nA @ 10.0 V	1.00 mA @ 10.0 V and 10 mA	246
OPB818	0.20 (5.08)	–	1.70 V @ 20 mA	100 nA @ 10.0 V	100 μA @ 10.0 V and 20 mA	248
OPB820	0.08 (2.03)	–	1.70 V @ 20 mA	100 nA @ 10.0 V	500 μA @ 10.0 V and 20 mA	250
OPB820S5	0.08 (2.03)	0.005 (0.127)×0.04 (1.02)	1.70 V @ 20 mA	100 nA @ 10.0 V	170 μA @ 10.0 V and 20 mA	250
OPB820S7	0.08 (2.03)	0.007 (0.178)×0.04 (1.02)	1.70 V @ 20 mA	100 nA @ 10.0 V	300 μA @ 10.0 V and 20 mA	250
OPB820S12	0.08 (2.03)	0.012 (0.305)×0.04 (1.02)	1.70 V @ 20 mA	100 nA @ 10.0 V	400 μA @ 10.0 V and 20 mA	250
OPB821	0.08 (2.03)	–	1.70 V @ 20 mA	100 nA @ 10.0 V	500 μA @ 10.0 V and 20 mA	252
OPB821S5	0.08 (2.03)	0.005 (0.127)×0.04 (1.02)	1.70 V @ 20 mA	100 nA @ 10.0 V	170 μA @ 10.0 V and 20 mA	252
OPB821S7	0.08 (2.03)	0.007 (0.178)×0.04 (1.02)	1.70 V @ 20 mA	100 nA @ 10.0 V	300 μA @ 10.0 V and 20 mA	252
OPB821S12	0.08 (2.03)	0.012 (0.305)×0.04 (1.02)	1.70 V @ 20 mA	100 nA @ 10.0 V	400 μA @ 10.0 V and 20 mA	252
OPB822S	0.10 (2.54)	2) 0.01 (0.254)×0.08 (2.03)	1.70 V @ 20 mA	100 nA @ 10.0 V	250 μA @ 10.0 V and 20 mA	254
OPB822SD	0.10 (2.54)	2E–2S) 0.01 (0.254)×0.08 (2.03)	1.70 V @ 20 mA	100 nA @ 10.0 V	100 μA @ 10.0 V and 20 mA	254
OPB823A	0.125 (3.18)	–	1.70 V @ 20 mA	100 nA @ 10.0 V	200 μA @ 10.0 V and 20 mA	256
OPB824A	0.125 (3.18)	–	1.70 V @ 20 mA	100 nA @ 10.0 V	500 μA @ 10.0 V and 20 mA	256
OPB825	0.160 (4.06)	–	1.70 V @ 20 mA	100 nA @ 10.0 V	500 μA @ 10.0 V and 20 mA	258
OPB825A	0.160 (4.06)	–	1.70 V @ 20 mA	100 nA @ 10.0 V	500 μA @ 10.0 V and 20 mA	258
OPB825B	0.160 (4.06)	–	1.70 V @ 20 mA	100 nA @ 10.0 V	500 μA @ 10.0 V and 20 mA	258
OPB826S	0.10 (2.54)	2) 0.01 (0.254)×0.04 (1.02)	1.70 V @ 20 mA	100 nA @ 10.0 V	250 μA @ 10.0 V and 20 mA	260
OPB826SD	0.10 (2.54)	2E–2S) 0.01 (0.254)×0.04 (1.02)	1.70 V @ 20 mA	100 nA @ 10.0 V	100 μA @ 10.0 V and 20 mA	260
OPB835	0.15 (3.81)	–	1.70 V @ 20 mA	100 nA @ 10.0 V	1.50 μA @ 10.0 V and 20 mA	264
OPB836	0.10 (2.54)	–	1.70 V @ 20 mA	100 nA @ 10.0 V	1.00 mA @ 10.0 V and 20 mA	266
OPB837	0.125 (3.18)	0.01 (0.254)×(1.52)	1.70 V @ 20 mA	100 nA @ 10.0 V	500 μA @ 10.0 V and 20 mA	268
OPB847	0.10 (2.54)	0.025 (0.635)×0.06 (1.52)	1.70 V @ 20 mA	100 nA @ 10.0 V	4.0 mA @ 10.0 V and 20 mA	270
OPB848	0.10 (2.54)	0.025 (0.635)×0.06 (1.52)	1.70 V @ 20 mA	100 nA @ 10.0 V	1.00 mA @ 10.0 V and 20 mA	270
OPB860/870	0.125 (3.18)	See Datasheet	1.70 V @ 20 mA	100 nA @ 10.0 V	500 μA @ 10.0 V and 20 mA	272
OPB861/871	0.125 (3.18)	See Datasheet	1.70 V @ 20 mA	100 nA @ 10.0 V	1.00 mA @ 5.0 V and 10.0 mA	272
OPB862/872	0.125 (3.18)	See Datasheet	1.70 V @ 20 mA	100 nA @ 10.0 V	1.80 mA @ .40 V and 20 mA	272
OPB863/873	0.125 (3.18)	See Datasheet	1.70 V @ 20 mA	100 nA @ 10.0 V	200 μA @ 10.0 V and 20 mA	272
OPB880/890	0.125 (3.18)	See Datasheet	1.70 V @ 20 mA	100 nA @ 10.0 V	500 μA @ 10.0 V and 20 mA	276
OPB881/891	0.125 (3.18)	See Datasheet	1.70 V @ 20 mA	100 nA @ 10.0 V	1.00 mA @ 5.0 V and 10.0 mA	276
OPB882/892	0.125 (3.18)	See Datasheet	1.70 V @ 20 mA	100 nA @ 10.0 V	1.80 mA @ .40 V and 20 mA	276
OPB883/893	0.125 (3.18)	See Datasheet	1.70 V @ 20 mA	100 nA @ 10.0 V	200 μA @ 10.0 V and 20 mA	276
OPB947	0.10 (2.52)	–	1.70 V @ 20 mA	ICC=15.0 mA @ 5.25 V	Buffer, Totem-Pole	280
OPB948	0.10 (2.52)	–	1.70 V @ 20 mA	ICC=15.0 mA @ 5.25 V	Buffer, Open-Collector	280
OPB960/970	0.125 (3.18)	See Datasheet	1.70 V @ 20 mA	ICC=15.0 mA @ 5.25 V	Buffer, Totem-Pole	284
OPB961/971	0.125 (3.18)	See Datasheet	1.70 V @ 20 mA	ICC=15.0 mA @ 5.25 V	Buffer, Open-Collector	284
OPB962/972	0.125 (3.18)	See Datasheet	1.70 V @ 20 mA	ICC=15.0 mA @ 5.25 V	Inverter, Totem-Pole	284
OPB963/973	0.125 (3.18)	See Datasheet	1.70 V @ 20 mA	ICC=15.0 mA @ 5.25 V	Inverter, Open-Collector	284
OPB980/990	0.125 (3.18)	See Datasheet	1.70 V @ 20 mA	ICC=15.0 mA @ 5.25 V	Buffer, Totem-Pole	290
OPB981/991	0.125 (3.18)	See Datasheet	1.70 V @ 20 mA	ICC=15.0 mA @ 5.25 V	Buffer, Open-Collector	290
OPB982/992	0.125 (3.18)	See Datasheet	1.70 V @ 20 mA	ICC=15.0 mA @ 5.25 V	Inverter, Totem-Pole	290
OPB983/993	0.125 (3.18)	See Datasheet	1.70 V @ 20 mA	ICC=15.0 mA @ 5.25 V	Inverter, Open-Collector	290
OPB10100	0.125 (3.18)	See Datasheet	1.70 V @ 20 mA	100 nA @ 10.0 V	100 μA @ 10.0 V and 20 mA	296
OPB10120	0.125 (3.18)	See Datasheet	1.70 V @ 20 mA	100 nA @ 10.0 V	100 μA @ 10.0 V and 20 mA	296
OPB10510	0.125 (3.18)	See Datasheet	1.70 V @ 20 mA	ICC=15.0 mA @ 5.25 V	Buffer, Totem-Pole	300

B

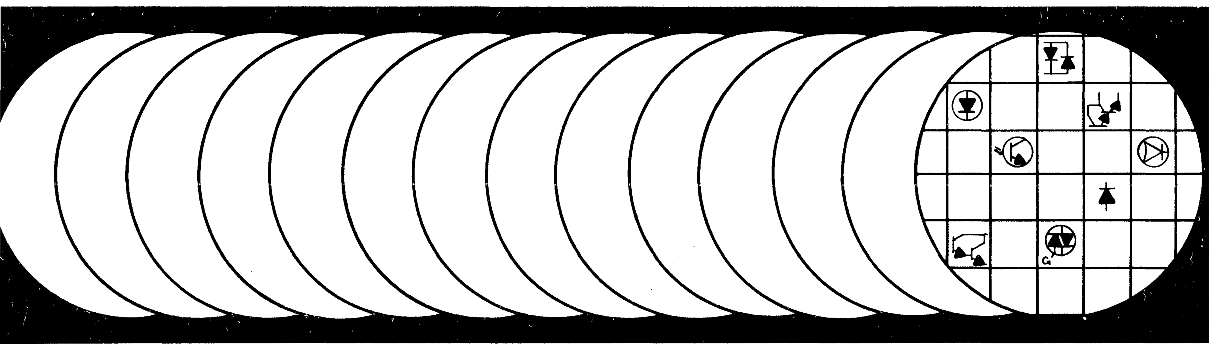
Slotted Optical Switches (continued)

Part No.	Slot Width Inches (mm)	Sensor Aperture Inches (mm)	V_F at Rated I_F	I_{CEO} at Rated V_{CE}, I_F=0, E_e=0	Min. On-State Collector Current at Rated V_{CE} and I_F	Page No.
OPB10511	0.125 (3.18)	See Datasheet	1.70 V @ 20 mA	ICC=15.0 mA @ 5.25 V	Buffer, Open-Collector	300
OPB10512	0.125 (3.18)	See Datasheet	1.70 V @ 20 mA	ICC=15.0 mA @ 5.25 V	Inverter, Totem-Pole	300
OPB10513	0.125 (3.18)	See Datasheet	1.70 V @ 20 mA	ICC=15.0 mA @ 5.25 V	Inverter, Open-Collector	300
OPB10530	0.125 (3.18)	See Datasheet	1.70 V @ 20 mA	ICC=15.0 mA @ 5.25 V	Buffer, Totem-Pole	300
OPB10531	0.125 (3.18)	See Datasheet	1.70 V @ 20 mA	ICC=15.0 mA @ 5.25 V	Buffer, Open-Collector	300
OPB10532	0.125 (3.18)	See Datasheet	1.70 V @ 20 mA	ICC=15.0 mA @ 5.25 V	Inverter, Totem-Pole	300
OPB10533	0.125 (3.18)	See Datasheet	1.70 V @ 20 mA	ICC=15.0 mA @ 5.25 V	Inverter, Open-Collector	300
OPB10130	0.125 (3.18)	See Datasheet	1.70 V @ 20 mA	100 nA @ 10.0 V	100 μA @ 10.0 V and 20 mA	296

Matched Pairs

Part No.	Case Style	V_F at Rated I_F	I_R at Rated V_R	Min. $I_{C(ON)}$ at Rated V_{CE} and I_F	$V_{(BR)CEO}$ at Rated I_C	I_{CEO} at Rated V_{CE}, E_e=0	Page No.
OPS660	Plastic T-1 Lensed	1.60 V @ 20 mA	100 μA @ 2.0 V	.50 mA @ 5.0 V and 20 mA	30 V @ 1.00 μA	100 nA @ 10.0 V	306
OPS661	Plastic T-1 Lensed	1.60 V @ 20 mA	100 μA @ 2.0 V	1.00 mA @ 5.0 V and 20 mA	30 V @ 1.00 μA	100 nA @ 10.0 V	306
OPS662	Plastic T-1 Lensed	1.60 V @ 20 mA	100 μA @ 2.0 V	5.0 mA @ 5.0 V and 20 mA	30 V @ 1.00 μA	100 nA @ 10.0 V	306
OPS690	Plastic Lateral	1.60 V @ 20 mA	100 μA @ 2.0 V	100 μA @ 10.0 V and 20 mA	30 V @ 1.00 μA	100 nA @ 10.0 V	308
OPS691	Plastic Lateral	1.60 V @ 20 mA	100 μA @ 2.0 V	500 μA @ 10.0 V and 20 mA	30 V @ 1.00 μA	100 nA @ 10.0 V	308
OPS692	Plastic Lateral	1.60 V @ 20 mA	100 μA @ 2.0 V	1.00 mA @ 10.0 V and 20 mA	30 V @ 1.00 μA	100 nA @ 10.0 V	308
OPS693	Plastic Lateral	1.60 V @ 20 mA	100 μA @ 2.0 V	2.0 mA @ 10.0 V and 20 mA	30 V @ 1.00 μA	100 nA @ 10.0 V	308

Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958



C

Infrared Emitting Diodes

Infrared Emitting Diodes

TRW remains unchallenged as the industry's most complete high quality source for infrared emitters. The latest state-of-the-art solution grown epitaxial techniques are used to produce the high quality GaAs and GaAlAs diode material required to make TRW infrared emitting diodes. This precision processing ensures high junction emission efficiency and long operating life with minimal degradation. The added benefit of over 16 years of mounting, bonding, and packaging experience makes TRW the undisputed technological leader in the design and production of infrared emitting diodes.

Leadership in Manufacturing Technology

When engineers are asked which product features they value most in TRW's electronic components, the answers most often given are quality and reliability. Assuring high quality is a philosophy that begins at product conception, is carried through the design phase and heavily emphasized during every step in the manufacture of TRW infrared emitting diodes.

Production begins in the Optoelectronic Division's own wafer processing area located in Carrollton, Texas. A GaAlAs or GaAs melt is added to high purity GaAs wafers at precisely controlled temperatures. As cooling takes place, the crystalline structure begins to grow. Partially into the growth, at exactly the right temperature, the material changes from "N"-type to "P"-type and the diode junction is formed. To complete the process, excess starting material is removed and metallization layers are added for electrical contacts. The individual diode chips are then sliced from the wafer. Application Bulletin 114, printed in this data book, discusses these materials in additional detail.

The infrared emitting diode is then carefully mounted in a specially designed reflective "well" as shown in Figure 1. Depending upon the device type, conductive epoxy or soldering is used to attach the chip to the lead frame or header. Gold wire is bonded to the top contact pad ("N"-type material) using TRW's specially developed techniques designed to minimize stress or possible damage to the delicate chip material. A refractive index matching silicone overcoat is then added to "ruggedize" the entire assembly and improve optical efficiency. Hermetic parts are then weld-sealed and Optokleer™ type parts are sent for plastic encapsulation and lens formation. After assembly, 100 percent of the devices are electrically tested and placed in bin ranges in order to guarantee compliance with the electrical limits specified in TRW data sheets. Prior to final release for shipment, TRW's outgoing quality control department independently retests samples from each lot.

Output Specifications Designed for Engineering Convenience

The outputs of the vast majority of TRW emitters are specified using apertured radiant incidence, $E_{e(APT)}$, expressed in milliwatts per square centimeter. This method, also known as on-axis intensity measurement, provides the best accuracy and convenience for the design engineer. Production testing consists of measuring 100% of the energy passing through a specified diameter aperture orthogonal to the optical axis, and at a specified distance from the device. For TRW devices, the distance chosen for this measurement is equivalent to the typical operating distance from emitter to sensor. Most specifications for compatible photosensors describe output current at a specified radiant intensity, also expressed in milliwatts per square centimeter. Therefore, the design of close proximity transmissive emitter/sensor assemblies can be done more accurately, and with a minimum of optical calculations and specification conversions.

Infrared emitter manufacturers use three methods of specifying output limits on infrared emitters. These are Radiant Power Output (P_O), Radiant Intensity (I_e) and Apertured Radiant Incidence [$E_{e(APT)}$]. Radiant Power Output, P_O, sometimes called Total Power, is strictly interpreted as a measure of the total energy emitted from the device. TRW has interpreted this to include only the energy useful to most customers. Therefore, side and backward emissions are not measured. As a benchmark for comparison among devices, TRW devices are conservatively rated. For example, the P_O reading for the useful portion of the OP295A radiation pattern is 60 percent higher when a parabolic reflector is used to capture normally unused side emissions as opposed to TRW's more conservative rating method. When making P_O comparisons among manufacturers, the design engineer should always investigate the methods of measurement.

Radiant Intensity, I_e, is usually expressed in milliwatts per steradian. This method attempts to account for usable energy, where the peak intensity falls within an included angle centered around the optical axis. Through some moderately complex geometrical calculations, the energy falling on the sensor can be roughly estimated if the sensor is on or close to the optical axis and if the distance from emitter to sensor is known. However, most infrared emitters cannot accurately be modeled as a point source at the close proximity used in many applications (less than four inches); therefore, this method has the potential to result in serious design errors. Additionally, it is more cumbersome than TRW's direct approach of characterizing emitters in terms of apertured radiant incidence.

TRW Application Bulletin 118, appearing later in this data book addresses the issues summarized above in additional detail.

Diode Material Selection

Gallium arsenide (GaAs) and gallium aluminum arsenide (GaAlAs) each have specific advantages when used in the manufacture of TRW infrared emitters. GaAs emits energy at 930±15 nanometers while GaAlAs emits at 875±20 nanometers. As temperature increases, these peaks shift upward by 0.26 and 0.20 nanometers per degree centigrade, respectively. Due to the spectral matching with photosensitive silicon, which exhibits a sensitivity maximum of 850 nanometers, as shown in Figure 2, (the second peak is caused by a fractional wave sensor overcoat), GaAlAs has the advantage of more efficient coupling. The sensor is better able to "see" the energy emitted by GaAlAs. In addition, at equivalent forward currents, GaAlAs is typically a more efficient emitter of infrared.

GaAs is considered to be less susceptible to output degradation than GaAlAs. Figure 3 shows typical percentage changes in output versus time for GaAs and GaAlAs operating at the absolute maximum forward current rating of $I_F = 100$ mA, on a TO-46 header. While the effects of degradation on both materials are insignificant at normal operating currents (10-20 mA), GaAs is, nevertheless, the preferable choice of material in applications where high operating currents or temperatures are expected and long term reliability is critical.

GaAs offers the second advantage of having lower forward voltage characteristics than GaAlAs. If large numbers of devices are to be placed in series or if power supply voltage is limited, the selection of GaAs over GaAlAs devices may be the best design choice.

Package Selection

The two broad classifications of package types are plastic and hermetic. Each offers its own distinct advantages. In many demanding environments, hermetic packaging may be mandatory. It has excellent resistance to water and other solvents, while offering the broadest operating temperature range and resistance to thermal shocks. Plastic packaging, in addition to a cost advantage over hermetic packaging, exhibits excellent optical properties due to TRW's exclusive Optokleer™ processing techniques. Overall emission efficiency is also superior because optical interfaces are minimized. Finally, resistance to mechanical shock and vibration is excellent because both chip and bond wire are fully encased in supportive material. Application Bulletin 119 compares these package types.

Special Product Capability

In addition to the standard products shown, TRW leads the industry in custom product capability. Special bin selections or custom package designs may be the solution to your unique application problem. Call your local TRW office for more information.

Figure 1.
Infrared Emitting Diode Radiation

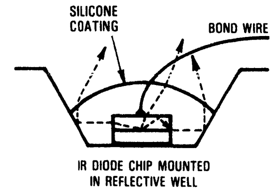
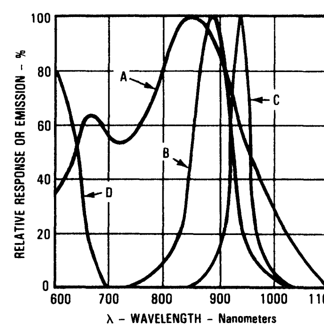
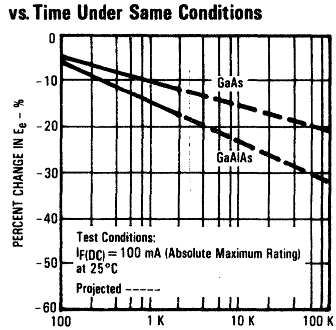


Figure 2.
Photosensor Spectral Response vs. GaAlAs and GaAs



Test Conditions (LED):
$T_A = T_J = 25°C$, $I_F = 100$ mA, DC = 0.1%, PW = 100 μs
Peak Wavelength – λ_p: (A) XSTR – 850±30 nm
(B) LED GaAlAs – 875±20 nm
(C) LED GaAs – 930±15 nm
(D) Human Eye Response

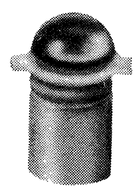
Figure 3.
Percent Change in GaAs and GaAlAs IR Emitters Mounted in Metal TO-46 Package vs. Time Under Same Conditions

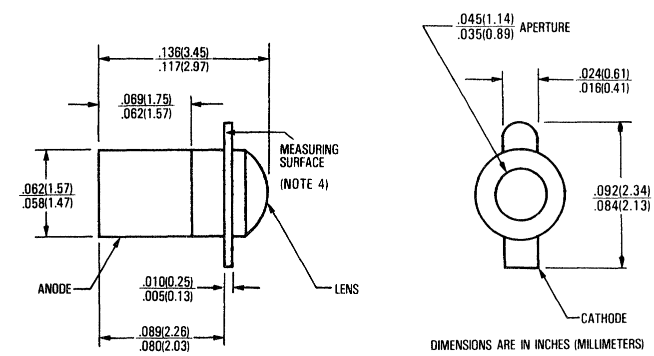


Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5030
January 1985

GaAs Hermetic Infrared Emitting Diodes
Types OP123, OP124





DIMENSIONS ARE IN INCHES (MILLIMETERS)

Features
- Miniature hermetically sealed "pill" package
- Ideal for direct mounting to PC boards[1]
- High power output
- Mechanically and spectrally matched to the OP600 phototransistor and the OP300 photodarlington

Description
The OP123 and OP124 series are high intensity gallium arsenide infrared emitting diodes mounted in miniature "pill" type hermetically sealed packages. This package style is intended for direct mounting into PC boards.

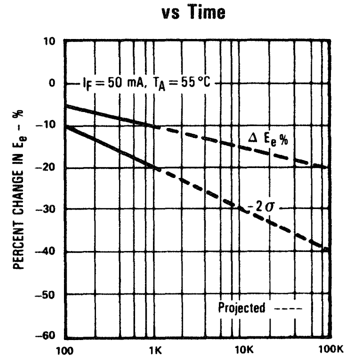
The OP123 and OP124 series are high intensity gallium arsenide infrared emitting diodes mounted in miniature "pill" type hermetically sealed packages. This package style is intended for direct mounting into PC boards. The devices are mechanically and spectrally matched to the OP600 and OP300 series photosensors. For additional information on spectral emission, please refer to the OP600 data sheet.

Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)
Reverse Voltage .... 2.0 V
Continuous Forward Current .... 100 mA
Storage Temperature Range .... −65°C to +150°C
Operating Temperature Range .... −65°C to +125°C
Lead Soldering Temperature (for 5 sec. with soldering iron)[2] .... 240°C
Power Dissipation .... 150 mW[3]

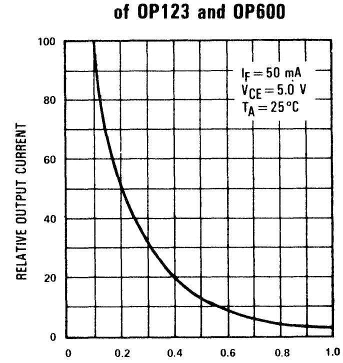
Notes:
(1) Refer to Application Bulletin 111 which discusses proper techniques for soldering pill-type devices into PC boards.
(2) RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering.
(3) Derate linearly 1.00 mW/°C above 25°C.
(4) $E_{e(APT)}$ is measured using a 0.031" (0.787 mm) diameter apertured sensor placed 0.50" (12.7 mm) from the measuring surface. $E_{e(APT)}$ is not necessarily uniform within the measured area.

Typical Performance Curves

Percent Changes in Radiant Intensity vs Time



Coupling Characteristics of OP123 and OP600

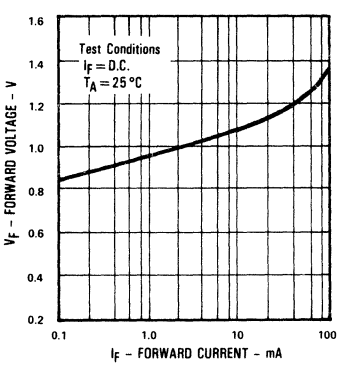


Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

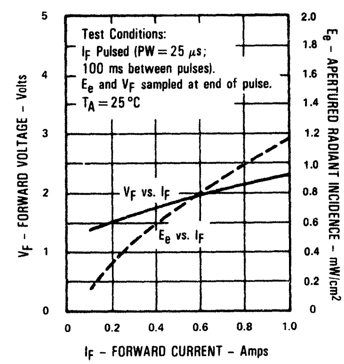
Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$E_{e(APT)}$ [4]	Apertured Radiant Incidence OP123 OP124	0.40 1.00			mW/cm^2	$I_F = 50$ mA, Aperture = 0.031″ Dia.@ Distance = 0.50″ [4]
V_F	Forward Voltage			1.50	V	$I_F = 50$ mA
I_R	Reverse Current			100	μA	$V_R = 2.0$ V
λ_p	Wavelength at Peak Emission		930		nm	$I_F = 50$ mA
B	Spectral Bandwidth Between Half Power Points		50		nm	$I_F = 50$ mA
$\Delta\lambda_p/\Delta T$	Spectral Shift with Temperature		+0.30		nm/°C	I_F = Constant
θ_{HP}	Emission Angle at Half Power Points		36		Deg.	$I_F = 50$ mA
t_r	Output Rise Time		1200		ns	$I_{F(PK)} = 50$ mA, PW = 10.0 μs, D.C. = 10.0%
t_f	Output Fall Time		550		ns	

Typical Performance Curves

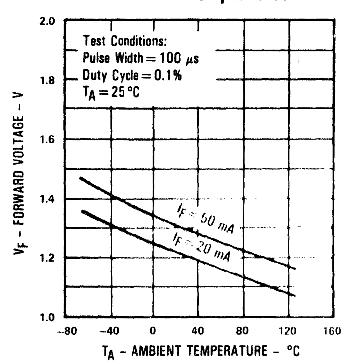
Forward Voltage vs Forward Current



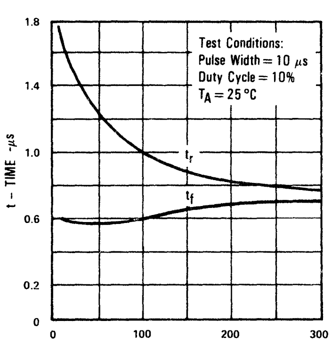
Forward Voltage and Radiant Incidence vs Forward Current



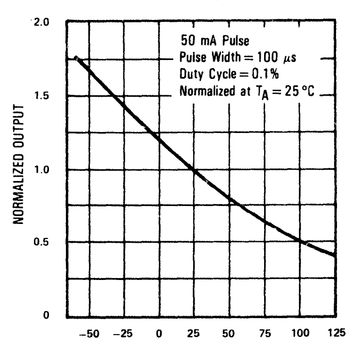
Forward Voltage vs Ambient Temperature



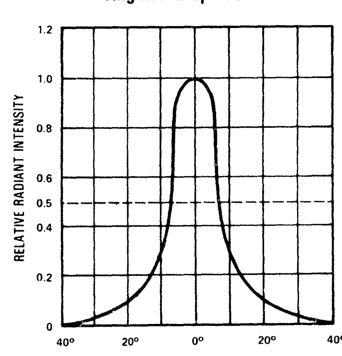
Rise Time and Fall Time vs Forward Current



Normalized Power Output vs Ambient Temperature



Relative Radiant Intensity vs Angular Displacement



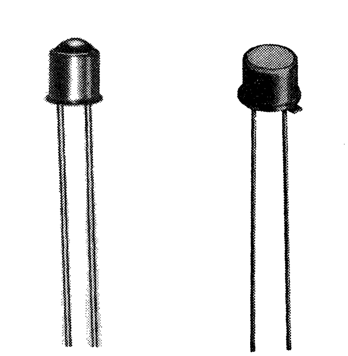
TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958

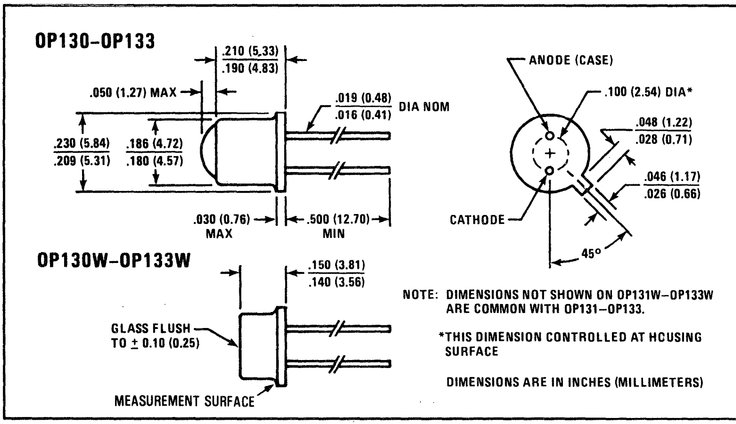
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5035
January 1985

GaAs Hermetic Infrared Emitting Diodes
Types OP130, OP131, OP132, OP133, OP130W, OP131W, OP132W, OP133W



OP130 OP130W



Features
- Reliability significantly improved
- TO 46 hermetically sealed packages
- Designer specified to apertured power with ranges designed to satisfy most applications
- Mechanically and spectrally matched to OP800/OP800W and OP593/OP598 phototransistors or OP830/OP830W photodarlingtons

Description
The OP130 series are high intensity gallium arsenide infrared emitting diodes mounted in hermetic TO-46 housings. They have lensed cans providing a relatively narrow beam angle. The narrow beam angle and the specified radiant intensity allow ease of design in beam interrupt applications in conjunction with the OP800 or OP598 series. The GaAs LED offers improved reliability in degradation due to improved processing techniques. (See percent change in I_e versus Time.)

The OP130W series are wide beam angle GaAs LEDs specified for ease of design in applications where radiant intensity over a broad area is required or when an accessory lens is being used. They are mechanically and spectrally matched to the OP800W and OP830W series.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

Reverse Voltage	2.0 V
Continuous Forward Current	100 mA
Peak Forward Current (Pulse Width = 2 μsec., 0.1% Duty Cycle)	10.0 A
Storage and Operating Temperature Range	−65°C to +150°C
Lead Soldering Temperature (1/16 in. [1.6 mm] from case for 5 sec. with soldering iron)[1]	240°C
Power Dissipation	200 mW[2]

Notes:

(1) RMA flux is recommended. Duration can be extended to 10 seconds max. when flow soldering.

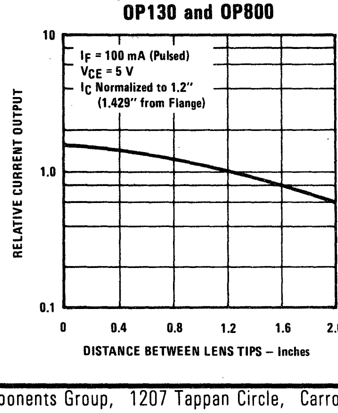
(2) Derate linearly 1.6 mW/°C above 25°C.

(3) $E_{e(APT)}$ is a measurement of the average radiant intensity within the cone formed by the measurement surface, a radius of 1.429" (36.30 mm) measured from the lens side of the tab to the sensing surface and a sensing surface of 0.250" (6.35 mm) in diameter forming a 10° cone. (See Dimensional Drawing.) On the OP133W series, a radius of 0.466" (11.84 mm) measured from the lens side of the tab to the sensing surface and a sensing surface of 0.250" (6.35 mm) in diameter forms a 30° cone.

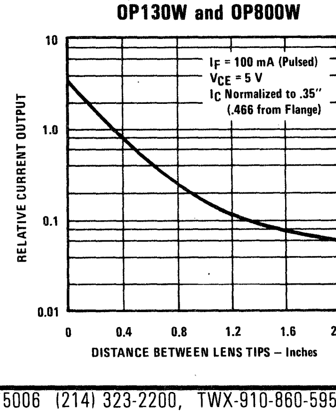
(4) Measurement made with 100 μs pulse measured at the trailing edge of the pulse with a duty cycle of 0.1% and an I_F = 100 mA.

Typical Performance Curves

Coupling Characteristics of OP130 and OP800



Coupling Characteristics of OP130W and OP800W



Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
$E_{e(APT)}$	Apertured Radiant Incidence	OP130, OP130W		0.30		mW/cm^2	$I_F = 100$ mA [3] [4]
		OP131, OP131W		0.50		mW/cm^2	$I_F = 100$ mA [3] [4]
		OP132, OP132W		1.00		mW/cm^2	$I_F = 100$ mA [3] [4]
		OP133, OP133W		1.50		mW/cm^2	$I_F = 100$ mA [3] [4]
P_O	Radiant Power Output	OP130, OP130W	1.0			mW	$I_F = 100$ mA [4]
		OP131, OP131W	3.0			mW	$I_F = 100$ mA [4]
		OP132, OP132W	4.0			mW	$I_F = 100$ mA [4]
		OP133, OP133W	5.0			mW	$I_F = 100$ mA [4]
V_F	Forward Voltage			1.5	1.75	V	$I_F = 100$ mA [4]
I_R	Reverse Current				100	μA	$V_R = 2$ V
λ_p	Wavelength at Peak Emission			930		nm	$I_F = 100$ mA [4]
B	Spectral Bandwidth Between Half Power Points			60		nm	$I_F = 100$ mA [4]
θ_{HP}	Emission Angle at Half Power Points	OP130—OP133		18		Deg.	$I_F = 100$ mA [4]
		OP130W—OP133W		50		Deg.	$I_F = 100$ mA [4]
t_r	Output Rise Time			1000		ns	$I_{F(PK)} = 100$ mA, PW $= 10$ μs, D.C. $= 10\%$
t_f	Output Fall Time			600		ns	

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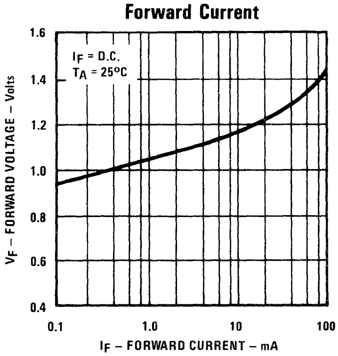
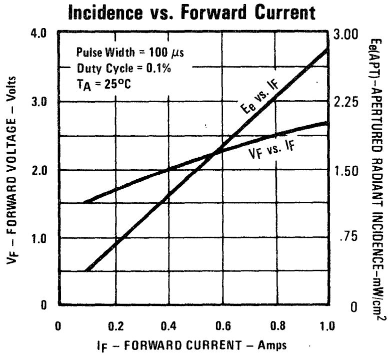
Typical Performance Curves

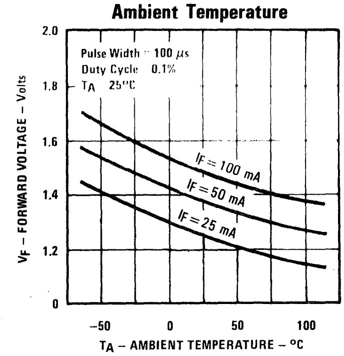
Forward Voltage vs. Forward Current



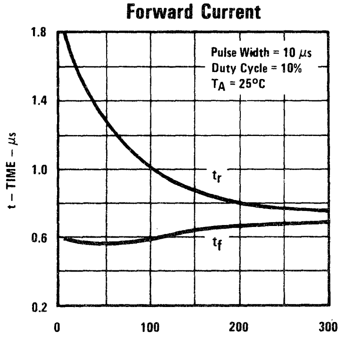
Forward Voltage and Radiant Incidence vs. Forward Current



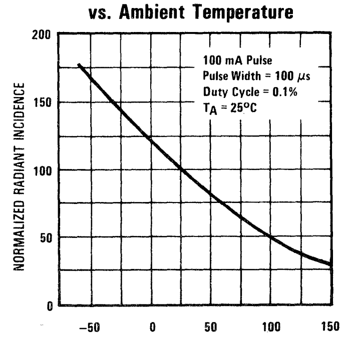
Forward Voltage vs. Ambient Temperature



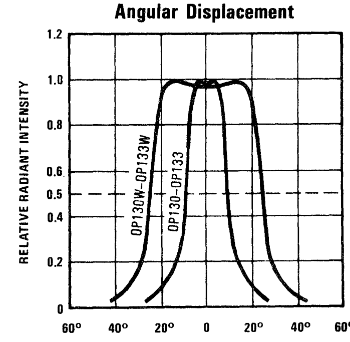
Rise and Fall Time vs. Forward Current



Normalized Radiant Incidence vs. Ambient Temperature



Relative Radiant Intensity vs. Angular Displacement



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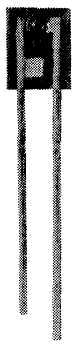
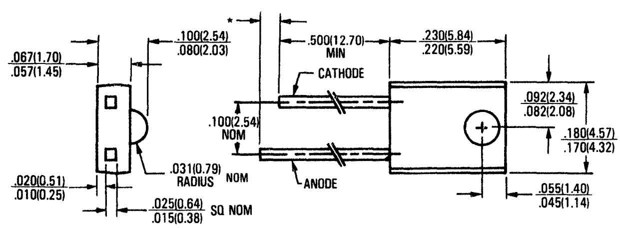
Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958

Product Bulletin 5039
January 1985

GaAs Plastic Infrared Emitting Diodes
Types OP140SL, OP140SLD, OP140SLC, OP140SLB, OP140SLA





DIMENSIONS ARE IN INCHES (MILLIMETERS).

* FOR IDENTIFICATION PURPOSES, ANODE IS .060(1.52) NOM. LONGER THAN CATHODE LEAD..

Features
- Selected to specific on-line intensity and radiant intensity ranges
- Low cost, miniature plastic side-looking package
- Mechanically and spectrally matched to the OP550 series of phototransistors and the OP560 series of photodarlingtons

Description
The OP140SL series devices are high intensity gallium arsenide infrared emitting diodes mounted in clear plastic side looking packages. TRW engineers originated the side-looking or "lateral" package for use in PC board mounted slotted switches or as an easy mount PC board interrupter. The OP140SL series provides a broad range of intensity selection.

The OP140SL series devices are mechanically and spectrally matched to OP550 and OP560 series photosensors. Please refer to photosensor data sheets for additional spectral characterization data.

The OP140SL is equivalent to TRW's earlier part number OP140.

Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)

Reverse Voltage	2.0 V
Continuous Forward Current	50 mA
Peak Forward Current (Pulse Width = 1 μsec., 300 pps)	3.0 A
Storage and Operating Temperature Range	−40°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)(1)	240°C
Power Dissipation	100 mW(2)

Notes:

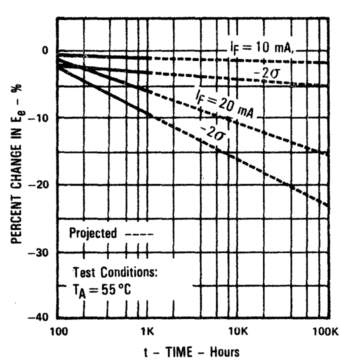
(1) RMA flux is recommended. Duration can be extended to 10 seconds max. when flow soldering.

(2) Derate linearly 1.33 mW/°C above 25°C.

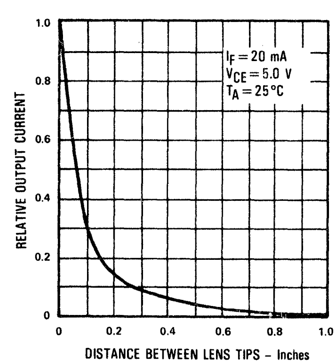
(3) $E_{e(APT)}$ is a measurement of the average apertured radiant incidence upon a sensing area 0.180" (4.57 mm) in diameter perpendicular to and centered on the mechanical axis of the lens, and 0.653" (16.6 mm) from the lens tip. $E_{e(APT)}$ is a measurement of the average radiant intensity within the cone formed by the above conditions. $E_{e(APT)}$ is not necessarily uniform within the measured area.

Typical Performance Curves

Percent Changes in Radiant Intensity vs Time



Coupling Characteristics of OP140SL and OP550



Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
P_O	Radiant Power Output	OP140SL		0.50		mW	$I_F = 40$ mA
$E_{e(APT)}$[3]	Apertured Radiant Incidence	OP140SL	0.020			mW/cm²	$I_F = 20$ mA
		OP140SLD	0.100		0.30	mW/cm²	$I_F = 20$ mA
		OP140SLC	0.20		0.40	mW/cm²	$I_F = 20$ mA
		OP140SLB	0.30		0.55	mW/cm²	$I_F = 20$ mA
		OP140SLA	0.40			mW/cm²	$I_F = 20$ mA
V_F	Forward Voltage				1.60	V	$I_F = 20$ mA
I_R	Reverse Current				100	μA	$V_R = 2.0$ V
λ_P	Wavelength at Peak Emission			930		nm	$I_F = 20$ mA
B	Spectral Bandwidth Between Half Power Points			50		nm	$I_F = 20$ mA
$\Delta\lambda_P/\Delta T$	Spectral Shift with Temperature			+0.30		nm/°C	I_F = Constant
θ_{HP}	Emission Angle at Half Power Points			40		Deg.	$I_F = 20$ mA
t_r	Output Rise Time			1550		ns	$I_{F(PK)} = 20$ mA, PW = 10.0 μs, D.C. = 10.0%
t_f	Output Fall Time			550		ns	

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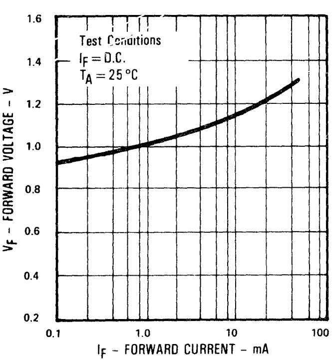
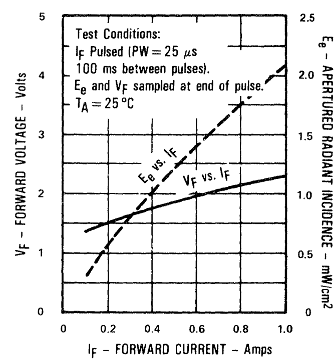
Typical Performance Curves

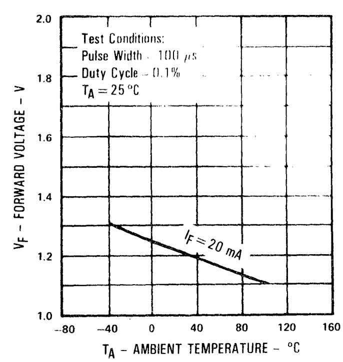
Forward Voltage vs Forward Current



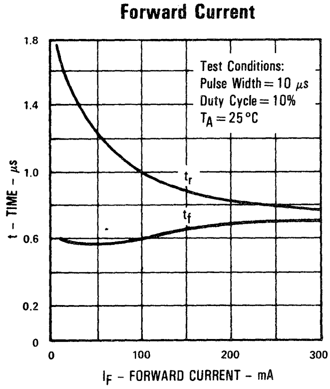
Forward Voltage and Radiant Incidence vs Forward Current



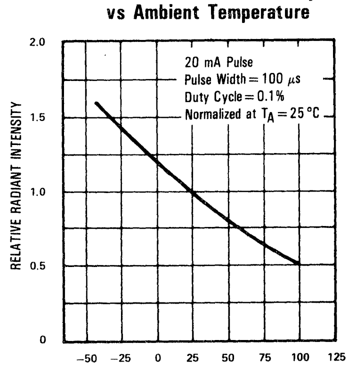
Forward Voltage vs Ambient Temperature



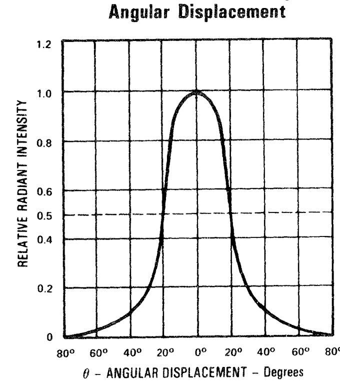
Rise Time and Fall Time vs Forward Current



Relative Radiant Intensity vs Ambient Temperature



Relative Radiant Intensity vs Angular Displacement



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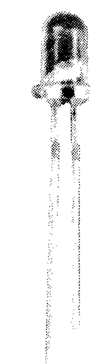
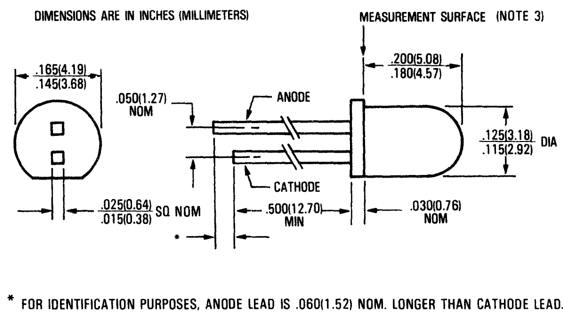
Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958

Product Bulletin 5042
January 1985

GaAs Plastic Infrared Emitting Diodes
Types OP160SL, OP160SLD, OP160SLC, OP160SLB, OP160SLA





Features
- Selected to specific on-line intensity ranges
- Low cost, miniature, plastic end-looking T-1 package
- Mechanically and spectrally matched to the OP500–OP500SL series phototransistors and the OP530 photodarlington

Description
The OP160SL series devices are gallium arsenide infrared emitting diodes mounted in clear plastic end-looking packages. The OP160SL series allows a broad range of intensity selection. The narrow radiation pattern provides high on-axis intensity for excellent coupling efficiency with an OP500 or OP500SL series T-1 phototransistor. For additional information on spectral emission characteristics, please refer to the OP500 data sheet.

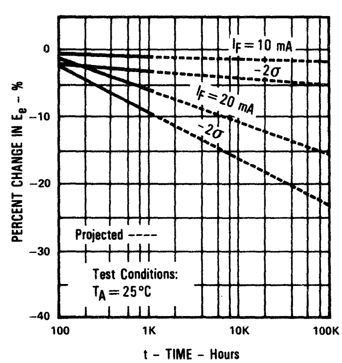
Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)

Reverse Voltage	2.0 V
Continuous Forward Current	50 mA
Peak Forward Current (Pulse Width = 1 μsec., 300 pps)	3.0 A
Storage and Operating Temperature Range	−40°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)[1]	240°C
Power Dissipation	100 mW[2]

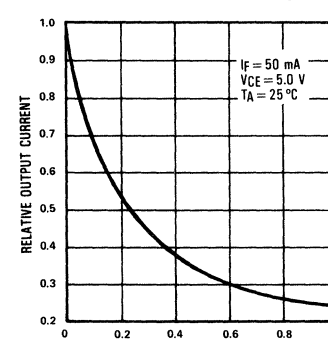
Notes:
(1) RMA flux is recommended. Duration can be extended to 10 seconds max. when flow soldering.
(2) Derate linearly 1.33 mW/°C above 25°C.
(3) $E_e(APT)$ is a measurement of the average apertured radiant incidence upon a sensing area 0.081" (2.06 mm) in diameter perpendicular to and centered on the mechanical axis of the lens, and 0.590" (14.99 mm) from the measurement surface. $E_e(APT)$ is not necessarily uniform within the measured area.

Typical Performance Curves

Percent Changes in Radiant Intensity vs Time



Coupling Characteristics of OP160SL and OP500



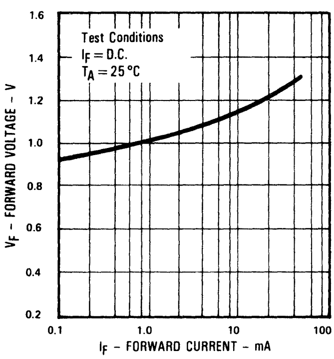
Types OP160SL, OP160SLD, OP160SLC, OP160SLB, OP160SLA

Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

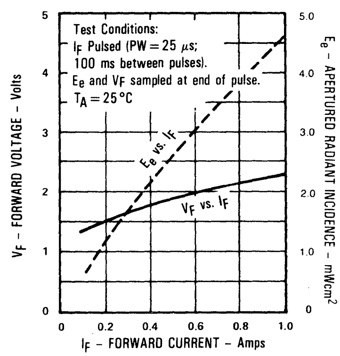
Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
P_O	Radiant Power Output	OP160	0.50			mW	$I_F = 20$ mA
E_e(APT)[3]	Apertured Radiant Incidence	OP160SL	0.05			mW/cm^2	$I_F = 20$ mA
		OP160SLD	0.28		0.95	mW/cm^2	$I_F = 20$ mA
		OP160SLC	0.85		1.60	mW/cm^2	$I_F = 20$ mA
		OP160SLB	1.40		2.2	mW/cm^2	$I_F = 20$ mA
		OP160SLA	1.95			mW/cm^2	$I_F = 20$ mA
V_F	Forward Voltage				1.60	V	$I_F = 20$ mA
I_R	Reverse Current				100	μA	$V_R = 2.0$ V

Typical Performance Curves

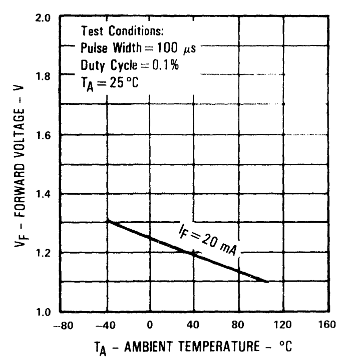
Forward Voltage vs Forward Current



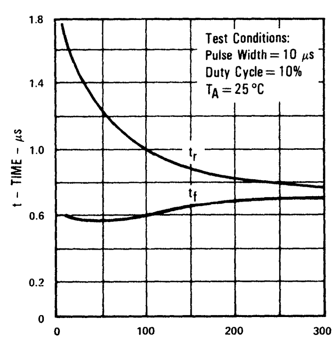
Forward Voltage and Radiant Incidence vs Forward Current



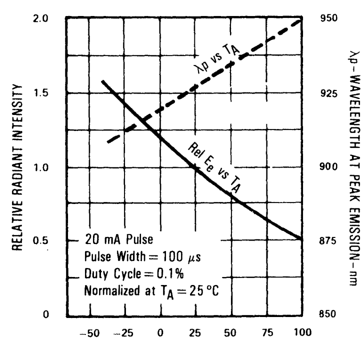
Forward Voltage vs Ambient Temperature



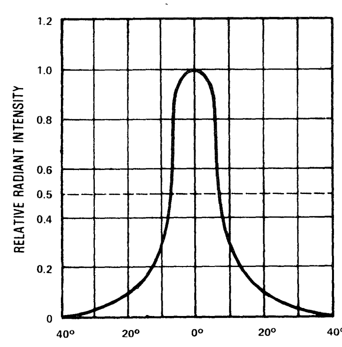
Rise Time and Fall Time vs Forward Current



Relative Radiant Intensity and Wavelength at Peak Emission vs Ambient Temperature



Relative Radiant Intensity vs Angular Displacement



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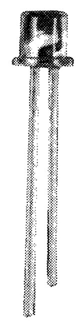
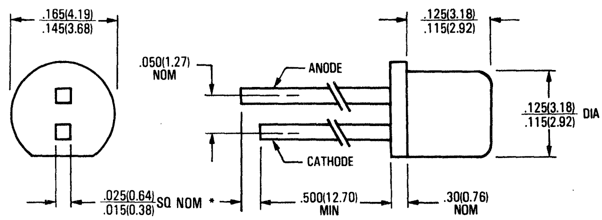
Product Bulletin 5045
January 1985

GaAs Plastic Infrared Emitting Diode
Type OP160W



DIMENSIONS ARE IN INCHES (MILLIMETERS)



* FOR IDENTIFICATION PURPOSES, ANODE LEAD IS .060(1.52) NOM. LONGER THAN CATHODE LEAD.

Features

- Flat lensed for wide radiation angle
- Low cost, miniature, plastic end-looking package
- Mechanically and spectrally matched to the OP500W phototransistor

Description

The OP160W is a gallium arsenide infrared emitting diode molded in a clear plastic, flat lensed, mini-axial package. The flat lens allows a radiation half angle of 40° measured from the optical axis to the half power point. The OP160W is mechanically and spectrally matched to the OP500W phototransistor. For additional information on spectral emission characteristics, please refer to the OP500W data sheet.

This package is a T-1 style in all respects except for the length of the plastic package. It is most useful where relatively even illumination over a broad area is required.

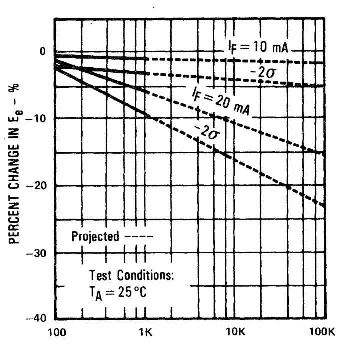
Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

Continuous Forward Current .... 50 mA
Peak Forward Current (Pulse Width = 1 μsec, 300 pps) .... 3.0 A
Reverse Voltage .... 2.0 V
Storage and Operating Temperature Range .... −40°C to +100°C
Lead Soldering Temperature Range (1/16 Inch [1.6 mm] from Case for 5 sec. with soldering iron)[1] ... 240°C
Power Dissipation .... 100 mW[2]

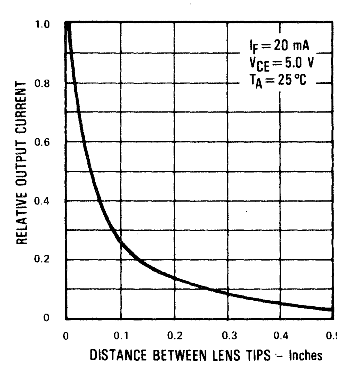
Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering.
(2) Derate linearly 1.33 mW/°C above 25°C.

Typical Performance Curves

Percent Changes in Power Output vs Time



Coupling Characteristics of OP160W and OP500W



Type OP160W

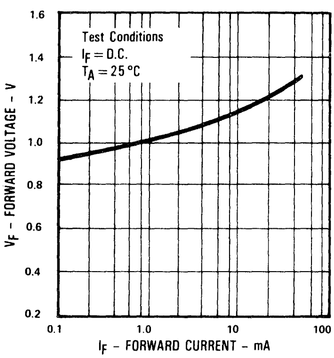
Electrical Characteristics (TA = 25°C unless otherwise noted)

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
P_O	Radiant Power Output	0.50			mW	$I_F = 20$ mA
V_F	Forward Voltage			1.60	V	$I_F = 20$ mA
I_R	Reverse Current			100	μA	$V_R = 2.0$ V

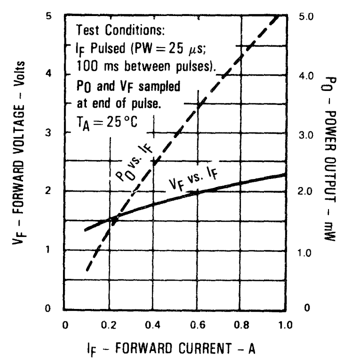
C

Typical Performance Curves

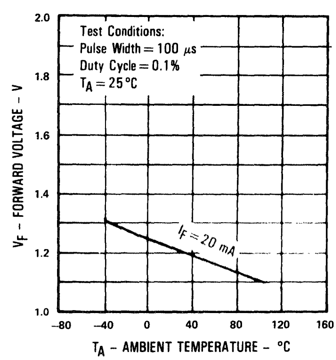
Forward Voltage vs Forward Current



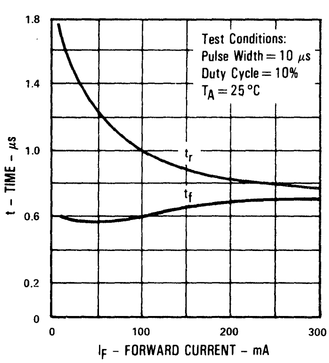
Forward Voltage and Power Output vs Forward Current



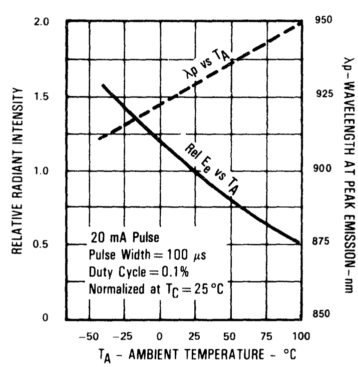
Forward Voltage vs Ambient Temperature



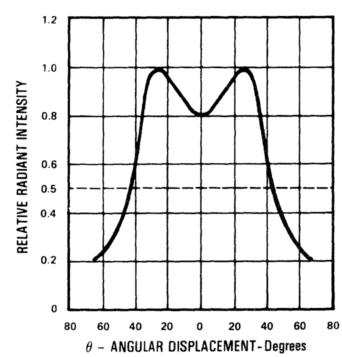
Rise Time and Fall Time vs Forward Current



Normalized Power Output and Wavelength at Peak Emission vs Ambient Temperature



Relative Radiant Intensity vs Angular Displacement



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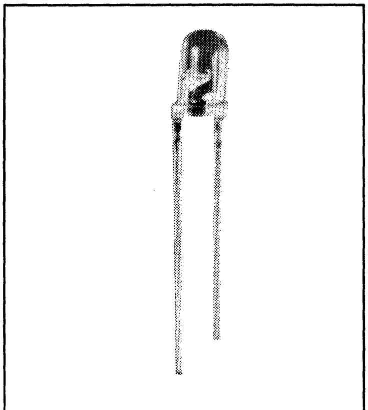
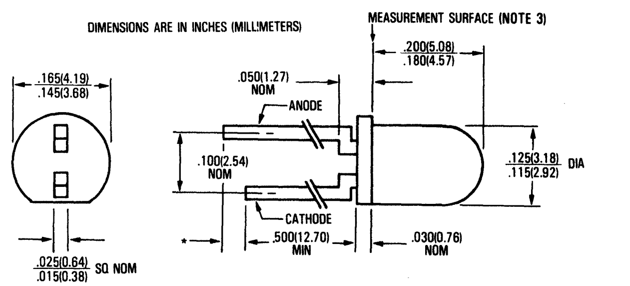
GaAs Plastic Infrared Emitting Diodes
Types OP161SL, OP161SLD, OP161SLC, OP161SLB, OP161SLA





* FOR IDENTIFICATION PURPOSES, ANODE LEAD IS .060(1.52) NOM. LONGER THAN CATHODE LEAD.

Features

- 0.100 inch (2.54 mm) lead spacing for standard socket mounting
- Low cost, plastic miniature end-looking T-1 package
- Mechanically and spectrally matched to the OP501 phototransistor series

Description

The OP161SL series devices are gallium arsenide infrared emitting diodes molded in clear plastic, mini-axial packages. The lensing effect of the package allows a radiation half angle of 8° measured from the optical axis to the half power point. Lead spacing is 0.100″ (2.54 mm) to allow mounting in standard sockets. These devices are mechanically and spectrally matched to the OP501 and OP501SL series of phototransistors. For additional information on spectral emission characteristics, please refer to the OP501 data sheet.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

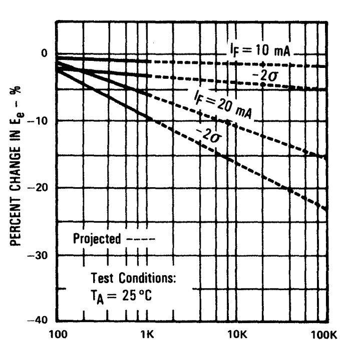
Continuous Forward Current	50 mA
Peak Forward Current (Pulse Width = 1 μsec, 300 pps)	3.0 A
Reverse Voltage	2.0 V
Storage and Operating Temperature Range	−40°C to +100°C
Lead Soldering Temperature Range (1/16 Inch [1.6 mm] from Case for 5 sec. with soldering iron)(1)	240°C
Power Dissipation	100 mW(2)

Notes:

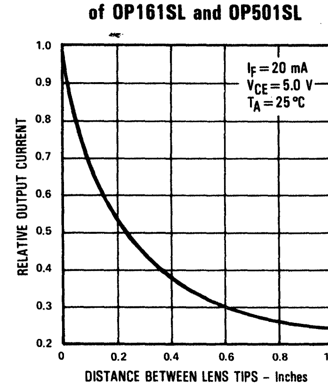
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering.
(2) Derate linearly 1.33 mW/°C above 25°C.
(3) E_e(APT) is a measurement of the average apertured radiant incidence upon a sensing area 0.081″ (2.06 mm) in diameter perpendicular to and centered on the mechanical axis of the lens, and 0.590″ (14.99 mm) from the measurement surface. E_e(APT) is not necessarily uniform within the measured area.

Typical Performance Curves

Percent Changes in Radiant Intensity vs Time



Coupling Characteristics of OP161SL and OP501SL



Types OP161SL, OP161SLD, OP161SLC, OP161SLB, OP161SLA

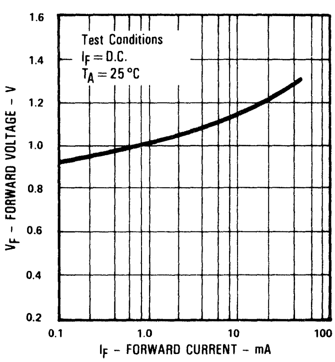
C

Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

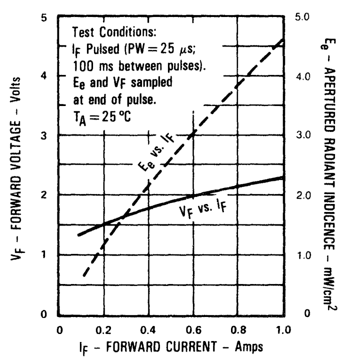
Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
P_O	Radiant Power Output	OP161	0.50			mW	$I_F = 20$ mA
$E_e(APT)^{(3)}$	Apertured Radiant Incidence	OP161SL	0.05			mW/cm^2	$I_F = 20$ mA
		OP161SLD	0.28		0.95	mW/cm^2	$I_F = 20$ mA
		OP161SLC	0.85		1.60	mW/cm^2	$I_F = 20$ mA
		OP161SLB	1.40		2.2	mW/cm^2	$I_F = 20$ mA
		OP161SLA	1.95			mW/cm^2	$I_F = 20$ mA
V_F	Forward Voltage				1.60	V	$I_F = 20$ mA
I_R	Reverse Current				100	μA	$V_R = 2.0$ V

Typical Performance Curves

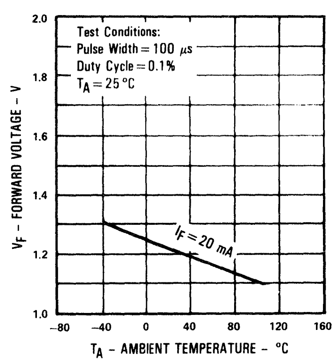
Forward Voltage vs Forward Current



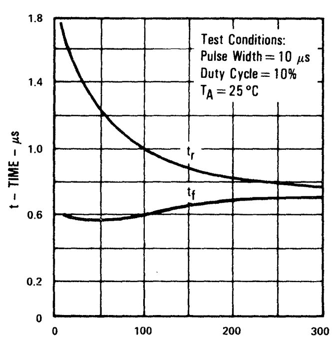
Forward Voltage and Radiant Incidence vs Forward Current



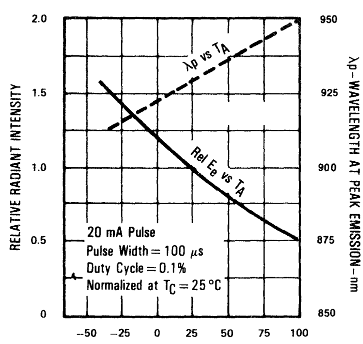
Forward Voltage vs Ambient Temperature



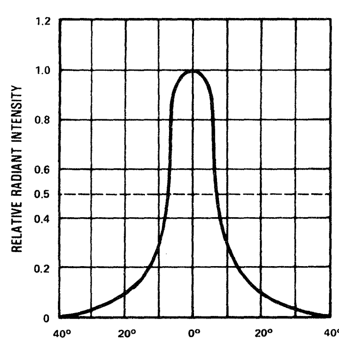
Rise Time and Fall Time vs Forward Current



Relative Radiant Intensity and Wavelength at Peak Emission vs Ambient Temperature



Relative Radiant Intensity vs Angular Displacement



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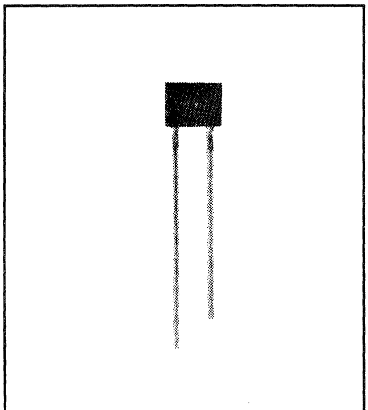
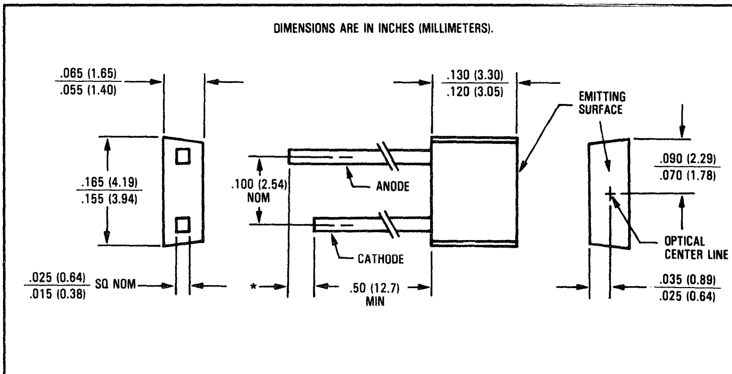
GaAs Plastic Infrared Emitting Diodes
Types OP168F, OP168FC, OP168FB, OP168FA





*FOR IDENTIFICATION PURPOSES, ANODE LEAD IS .06 (1.52) NOM. LONGER THAN CATHODE LEAD.

Features
- Flat lensed for wide radiation angle
- Easily stackable on 0.100 inch (2.54 mm) hole centers
- Mechanically and spectrally matched to the OP508F series phototransistor and the OP538F series of photodarlingtons

Description
The OP168F series are gallium arsenide infrared emitting diodes molded in an "end emitting" miniature black plastic package. This device has a wide radiation angle due to its flat emitting surface. Small size and 0.100 (2.54 mm) lead spacing allow considerable design flexibility.

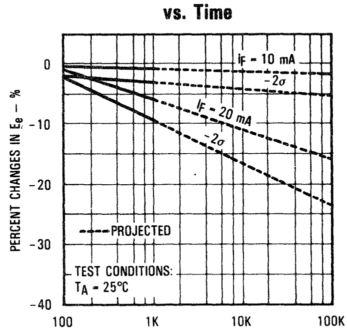
Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

Continuous Forward Current	50 mA
Peak Forward Current (Pulse Width = 1 μsec, 300 pps)	3.0 A
Reverse Voltage	2.0 V
Storage and Operating Temperature Range	−40°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)[1]	240°C
Power Dissipation	100 mW[2]

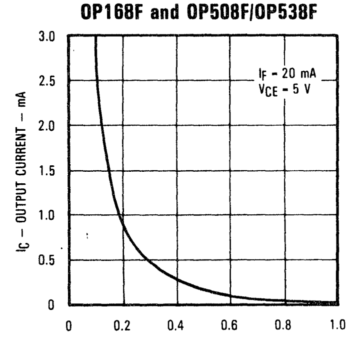
Notes:
(1) RMA flux is recommended. Duration can be extended to 10 seconds max. when flow soldering.
(2) Derate linearly 1.33 mW/°C above 25°C.
(3) $E_{e(APT)}$ is a measurement of the average apertured radiant energy incident upon a sensing area 0.081" (2.06 mm) in diameter perpendicular to and centered on the mechanical axis of the "emitting surface" and 0.400" (10.16 mm) from the measurement surface. $E_{e(APT)}$ is not necessarily uniform within the measured area.

Typical Performance Curves

Percent Changes in Radiant Intensity vs. Time



Coupling Characteristics of OP168F and OP508F/OP538F



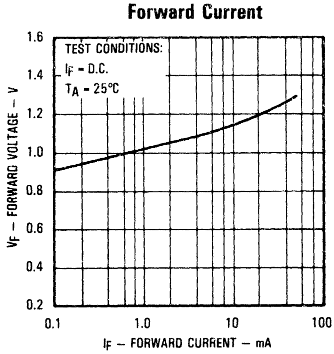
Types OP168F, OP168FC, OP168FB, OP168FA

Electrical Characteristics (T_A = 25°C unless otherwise noted)

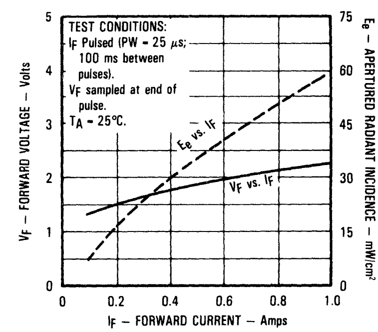
Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$E_{e(APT)}$ [3]	Apertured Radiant Incidence OP168F	0.20			mw/cm²	I_F = 20 mA
	OP168FC	0.34			mW/cm²	I_F = 20 mA
	OP168FB	0.43		0.79	mW/cm²	I_F = 20 mA
	OP168FA	0.48			mW/cm²	I_F = 20 mA
V_F	Forward Voltage			1.60	V	I_F = 20 mA
I_R	Reverse Current			100	μA	V_R = 2.0 V
λp	Wavelength at Peak Emission		930		nm	I_F = 20 mA
B	Spectral Bandwidth Between Half Power Points		50		nm	I_F = 20 mA
$\Delta\lambda p/\Delta T$	Spectral Shift with Temperature		+0.20		nm/°C	I_F = Constant
θ_{HP}	Emission Angle at Half Power Points		104		Deg.	I_F = 20 mA
t_r	Output Rise Time		1550		ns	$I_{F(PK)}$ = 20 mA, PW = 10.0 μs, D.C. = 10.0%
t_f	Output Fall Time		580		ns	

Typical Performance Curves

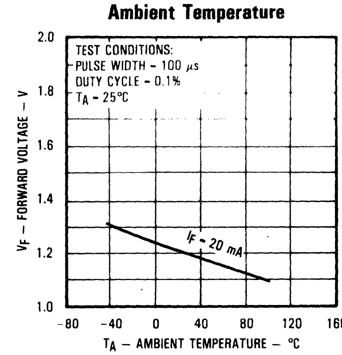
Forward Voltage vs. Forward Current



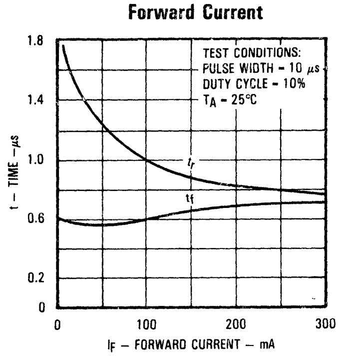
Forward Voltage and Radiant Incidence vs. Forward Current



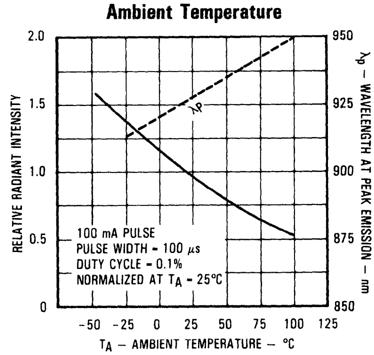
Forward Voltage vs. Ambient Temperature



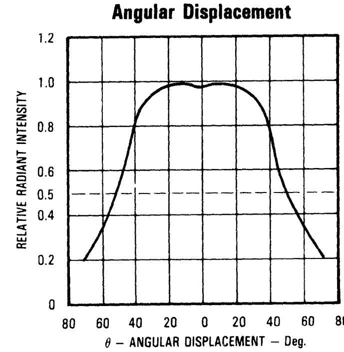
Rise Time and Fall Time vs. Forward Current



Relative Radiant Intensity and Wavelength at Peak Emission vs. Ambient Temperature



Relative Radiant Intensity vs. Angular Displacement



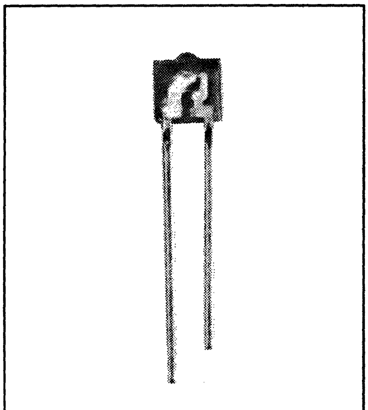
TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

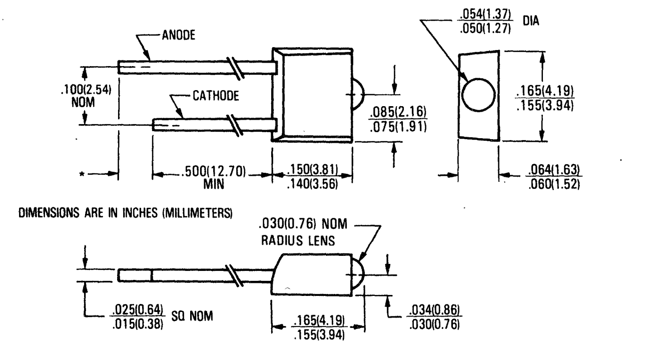
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5054
January 1985

TRW

GaAs Plastic Infrared Emitting Diodes
Types OP169SL, OP169SLD, OP169SLC





*FOR IDENTIFICATION PURPOSES, ANODE LEAD IS .060(1.52) NOM. LONGER THAN CATHODE LEAD.

Features
- Integral lens for narrow beam angle
- Easily stackable on 0.100 inch (2.54 mm) hole centers
- Mechanically and spectrally matched to the OP509 phototransistor series

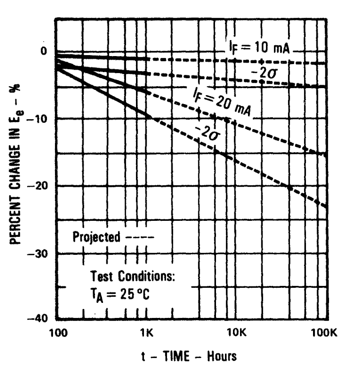
Description
The OP169SL series are gallium arsenide infrared emitting diodes molded in "end-emitting" miniature clear packages. The molded lens insures improved uniformity of lens magnification from unit to unit. The OP169SL series provides a broad range of on-line and radiant intensities and has considerable design flexibility due to its small size. These devices are mechanically and spectrally matched to the OP509 series of phototransistors. For additional information on spectral emission characteristics, please refer to the OP509 data sheet.

Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)
Continuous Forward Current .... 50 mA
Peak Forward Current (Pulse Width = 1 μsec, 300 pps) .... 3.0 A
Reverse Voltage .... 2.0 V
Storage and Operating Temperature Range .... −40°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from Case for 5 sec. with soldering iron)[1] .... 240°C
Power Dissipation .... 100 mW[2]

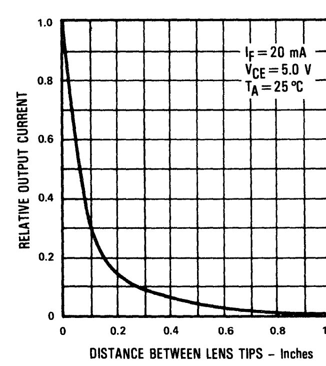
Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering.
(2) Derate linearly 1.33 mW/°C above 25°C.
(3) $E_{e(APT)}$ is a measurement of the average apertured radiant incidence upon a sensing area 0.180" (4.57 mm) in diameter perpendicular to and centered on the mechanical axis of the lens, and 0.653" (16.6 mm) from the lens tip. $E_{e(APT)}$ is a measurement of the average radiant intensity within the cone formed by the above conditions. $E_{e(APT)}$ is not necessarily uniform within the measured area.

Typical Performance Curves

Percent Changes in Radiant Intensity vs Time



Coupling Characteristics of OP169SL and OP509



Types OP169SL, OP169SLD, OP169SLC

Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
P_O	Radiant Power Output	OP169SL		0.20		mW	$I_F = 20$ mA
$E_{e(APT)}$[3]	Apertured Radiant Incidence	OP169SL OP169SLD OP169SLC	0.020 0.116 0.195		0.24	mW/cm² mW/cm² mW/cm²	$I_F = 20$ mA $I_F = 20$ mA $I_F = 20$ mA
V_F	Forward Voltage				1.60	V	$I_F = 20$ mA
I_R	Reverse Current				100	μA	$V_R = 2.0$ V
λp	Wavelength at Peak Emission			930		nm	$I_F = 20$ mA
B	Spectral Bandwidth Between Half Power Points			50		nm	$I_F = 20$ mA
$\Delta\lambda p/\Delta T$	Spectral Shift with Temperature			+0.30		nm/°C	I_F = Constant
θ_{HP}	Emission Angle at Half Power Points			46		Deg.	$I_F = 20$ mA
t_r	Output Rise Time			1550		ns	$I_{F(PK)} = 20$ mA, PW = 10.0 μs, D.C. = 10.0%
t_f	Output Fall Time			580		ns	

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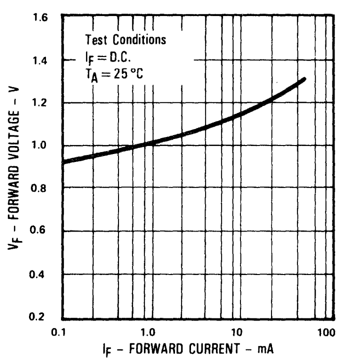
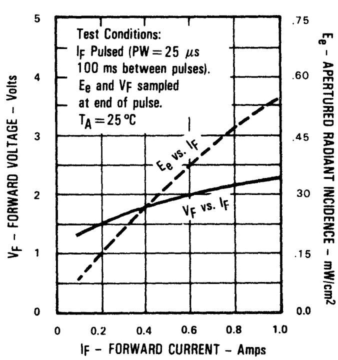
Typical Performance Curves

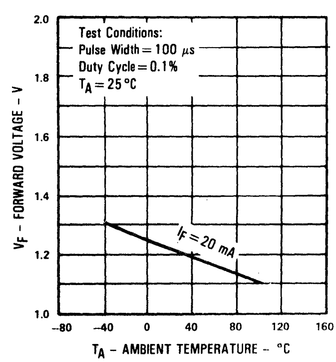
Forward Voltage vs Forward Current



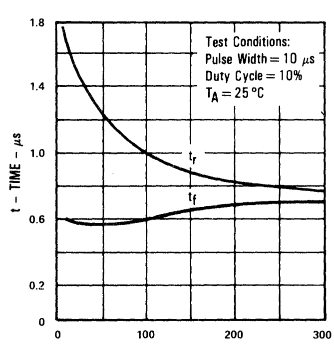
Forward Voltage and Radiant Incidence vs Forward Current



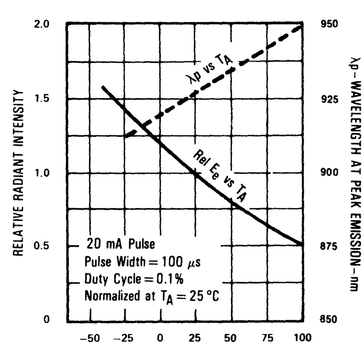
Forward Voltage vs Ambient Temperature



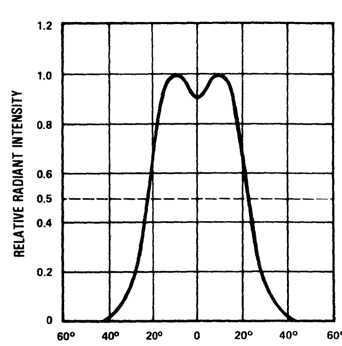
Rise Time and Fall Time vs Forward Current



Relative Radiant Intensity and Wavelength at Peak Emission vs Ambient Temperature



Relative Radiant Intensity vs Angular Displacement



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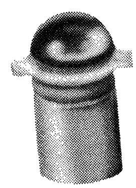
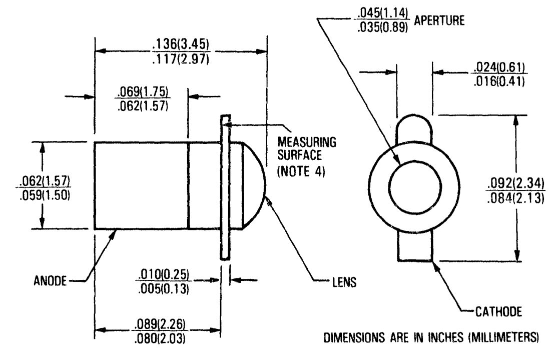
Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958

Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5057
January 1985

GaAlAs Hermetic Infrared Emitting Diodes
Types OP223, OP224





Features

- Up to 2.5 times the power output of the GaAs equivalent at the same drive current
- Miniature hermetically sealed "pill" package
- Ideal for direct mounting to PC boards[1]
- Mechanically and spectrally matched to the OP600 phototransistor and the OP300 photodarlington

Description

The OP223 and OP224 series are gallium aluminum arsenide infrared emitting diodes mounted in miniature "pill" type hermetically sealed packages. This package style is intended for direct mounting into PC boards. Gallium aluminum arsenide features a significant increase over the radiated output of gallium arsenide at the same forward current. Also, with a wavelength centered at 875 nanometers, it more closely matches the spectral responce of silicon phototransistors. Please refer to the OP600 data sheet for additional spectral emission information.

Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)

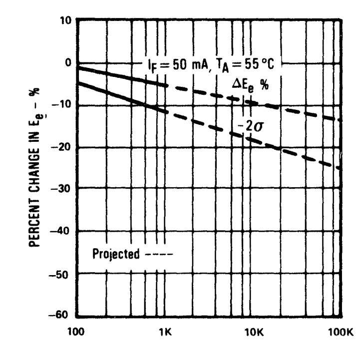
Reverse Voltage .... 2.0 V
Continuous Forward Current .... 50 mA
Storage Temperature Range .... −65°C to +150°C
Operating Temperature Range .... −65°C to +125°C
Soldering Temperature (for 5 sec. with soldering iron)[2] .... 240°C
Power Dissipation .... 150 mW[3]

Notes:

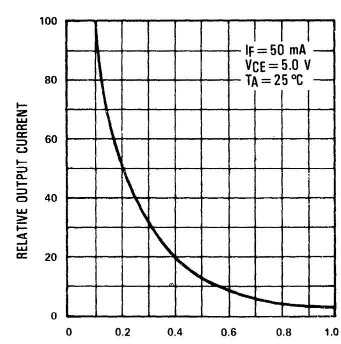
(1) Refer to Application Bulletin 111 which discusses proper techniques for soldering pill-type devices into PC boards.
(2) RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering.
(3) Derate linearly 1.00 mW/°C above 25°C.
(4) $E_e(APT)$ is measured using a 0.031" (0.787 mm) diameter apertured sensor placed 0.50" (12.7 mm) from the mounting plane. This corresponds to an included cone angle of 0.003 sr. $E_e(APT)$ is not necessarily uniform within the measured area.

Typical Performance Curves

Percent Changes in Radiant Intensity vs Time



Coupling Characteristics of OP223 and OP600



Types OP223, OP224

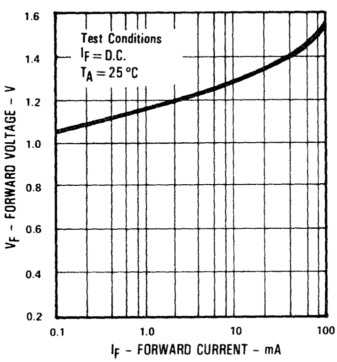
Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
P_O	Radiant Power Output	OP223		0.80		mW	$I_F = 50$ mA
		OP224		3.0		mW	$I_F = 50$ mA
$E_e(APT)$[4]	Apertured Radiant Incidence	OP223	1.00			mW/cm^2	$I_F = 50$ mA
		OP224	3.5			mW/cm^2	$I_F = 50$ mA
V_F	Forward Voltage				1.80	V	$I_F = 50$ mA
I_R	Reverse Current				100	μA	$V_R = 2.0$ V
λ_p	Wavelength at Peak Emission			875		nm	$I_F = 50$ mA
B	Spectral Bandwidth Between Half Power Points			80		nm	$I_F = 50$ mA
$\Delta\lambda_p/\Delta T$	Spectral Shift with Temperature			+0.18		nm/°C	I_F = Constant
θ_{HP}	Emission Angle at Half Power Points			36		Deg.	$I_F = 50$ mA
t_r	Output Rise Time			475		ns	$I_{F(PK)} = 50$ mA, PW = 10.0 μs, D.C. = 10.0%
t_f	Output Fall Time			250		ns	

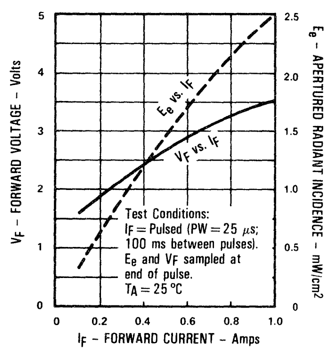
C

Typical Performance Curves

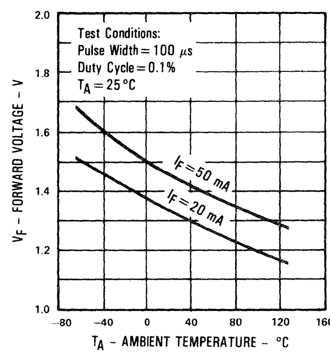
Forward Voltage vs Forward Current



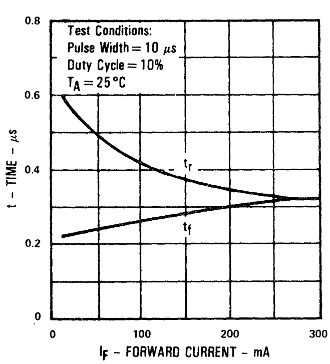
Forward Voltage and Radiant Incidence vs Forward Current



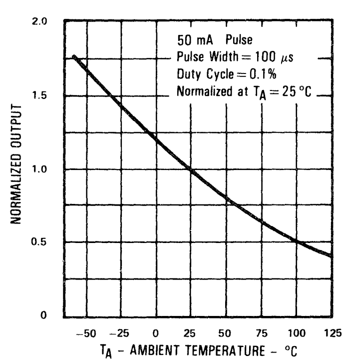
Forward Voltage vs Ambient Temperature



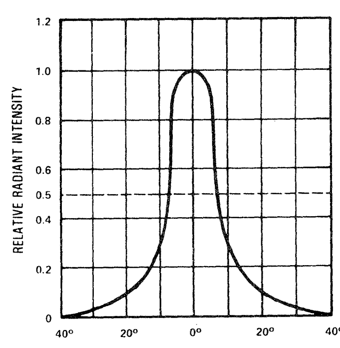
Rise Time and Fall Time vs Forward Current



Normalized Power Output vs Ambient Temperature



Relative Radiant Intensity vs Angular Displacement

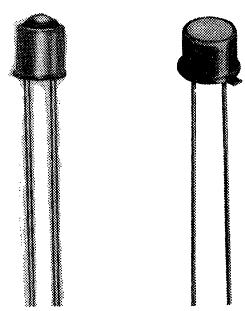


TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

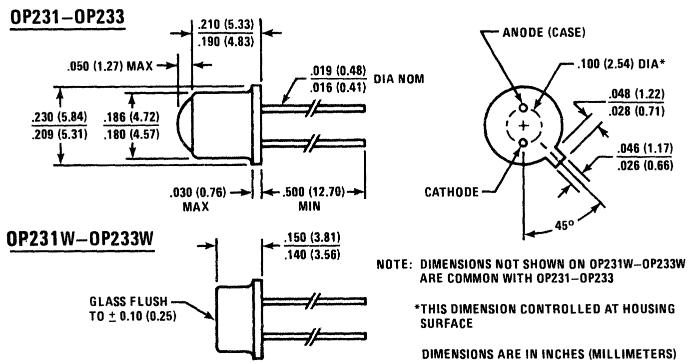
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5061
January 1985

GaAlAs Hermetic Infrared Emitting Diodes
Types OP231, OP232, OP233, OP231W, OP232W, OP233W



OP231 OP231W



Features

- Solid metal header for better thermal characteristics
- TO-46 hermetically sealed package
- Mechanically and spectrally matched to OP800, OP593, and OP598 phototransistors
- Designer specified to apertured power in ranges to satisfy most applications

Description

The OP231/OP231W series are gallium aluminum arsenide infrared emitting diodes mounted in hermetic TO-46 housings. Gallium aluminum arsenide features higher radiated output than gallium arsenide at the same forward current. Also, with a wavelength centered at 875 nanometers, it more closely matches the spectral response of silicon phototransistors. The OP231 series have lensed cans providing a narrow beam angle (18° between half power points). The OP231W series have flat window cans providing a wide beam angle (50° between half power points). The narrow beam angle and the specified radiant intensity of the OP231 series allow ease of design in beam interrupt applications in conjunction with the OP800 or OP598 series photosensor. The wide beam angle and the specified radiant intensity of the OP231W series allows ease of design where the radiant intensity over a broader area is required or when designing for an accessory lens or irradiating more than one sensor.

Please refer to application bulletins 119 through 121 for additional design information and reliability (degradation) data.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

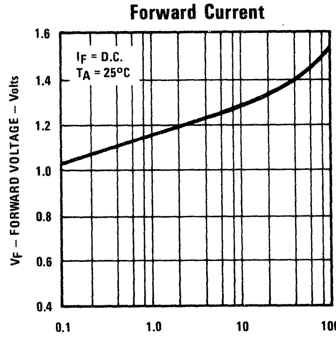
Reverse Voltage . . . . 2.0 V
Continuous Forward Current . . . . 100 mA
Peak Forward Current (Pulse Width = 1 μsec, 0.1% Duty Cycle) . . . . 10.0 A
Storage and Operating Temperature Range . . . . −65°C to +150°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)[1] . . . . 240°C
Power Dissipation . . . . 200 mW[2]

Notes:

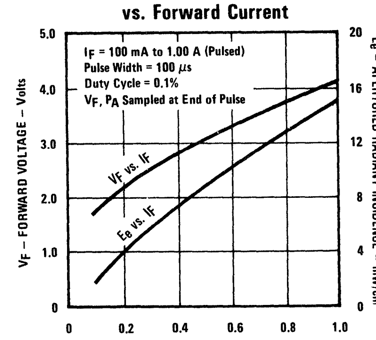
(1) RMA flux is recommended. Duration can be extended to 10 seconds max. when flow soldering.
(2) Derate linearly 1.60 mW/°C above 25°C.
(3) $E_{e(APT)}$ is a measurement of the average radiant intensity within the cone formed by the measurement surface. On the OP231 series this cone is outlined by a radius of 1.429" (36.30 mm) measured from the lens side of the tab to the sensing surface and a sensing surface of 0.250" (6.35 mm) in diameter forming a 10° cone. On the OP231W series this cone is outlined by a radius of 0.466" (11.84 mm) measured from the lens side of the tab to the sensing surface and a sensing surface of 0.250" (6.35 mm) in diameter forming a 30° cone. $E_{e(APT)}$ is not necessarily uniform within the measured area.
(4) Measurement made with 100 μs pulse measured at the trailing edge of the pulse with a duty cycle of 0.1% and at I_F = 100 mA.

Typical Performance Curves

Forward Voltage vs. Forward Current



Forward Voltage and Radiant Incidence vs. Forward Current



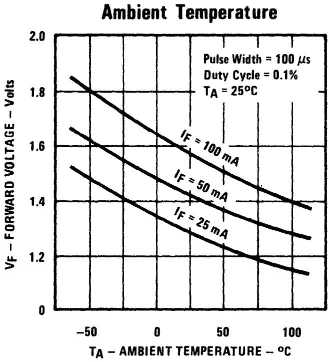
Types OP231, OP232, OP233, OP231W, OP232W, OP233W

Electrical Characteristics (T_A = 25°C unless otherwise noted)

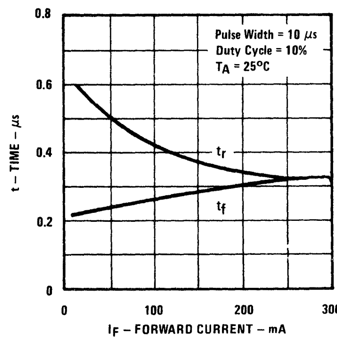
Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
$E_{e(APT)}$	Apertured Radiant Incidence	OP231, OP231W	1.50			mW/cm²	I_F = 100 mA[3] [4]
		OP232	2.0		4.5	mW/cm²	I_F = 100 mA[3] [4]
		OP232W	3.5		7.0	mW/cm²	I_F = 100 mA[3] [4]
		OP233	3.0			mW/cm²	I_F = 100 mA[3] [4]
		OP233W	5.0			mW/cm²	I_F = 100 mA[3] [4]
P_O	Radiant Power Output	OP231, OP231W		8.0		mW	I_F = 100 mA[3] [4]
		OP232, 232W		10.0		mW	I_F = 100 mA[3] [4]
		OP233, OP233W		12.0		mW	I_F = 100 mA[3] [4]
V_F	Forward Voltage				2.0	V	I_F = 100 mA[4]
I_R	Reverse Current				100	μA	V_R = 2.0 V
λp	Wavelength at Peak Emission			875		nm	I_F = 100 mA[4]
B	Spectral Bandwidth Between Half Power Points			80		nm	I_F = 100 mA[4]
θ_{HP}	Emission Angle at Half Power Points	OP231, OP232, OP233		18.0		Deg.	I_F = 100 mA[4]
		OP231W, OP232W, OP233W		50.0		Deg.	I_F = 100 mA[4]
t_r	Output Rise Time			450		ns	$I_{F(PK)}$ = 100 mA, PW = 10 μs, D.C. = 10%
t_f	Output Fall Time			250		ns	

Typical Performance Curves

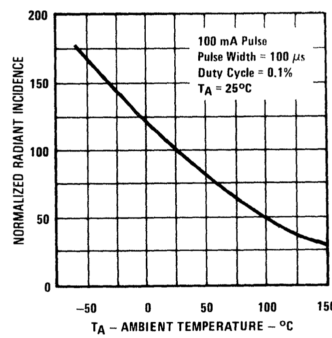
Forward Voltage vs. Ambient Temperature



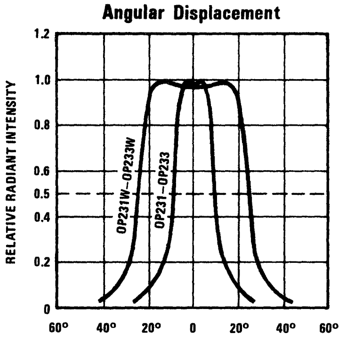
Rise Time and Fall Time vs. Forward Current



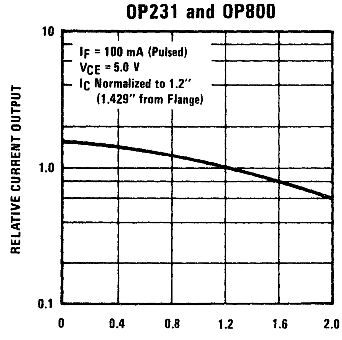
Normalized Radiant Incidence vs. Ambient Temperature



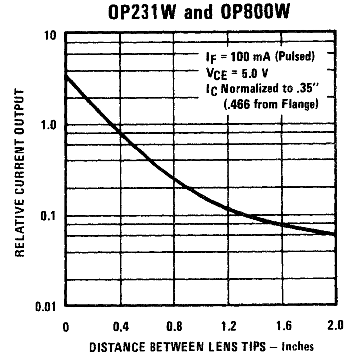
Relative Radiant Intensity vs. Angular Displacement



Coupling Characteristics of OP231 and OP800



Coupling Characteristics of OP231W and OP800W



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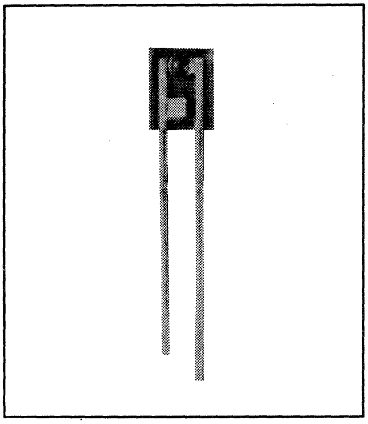
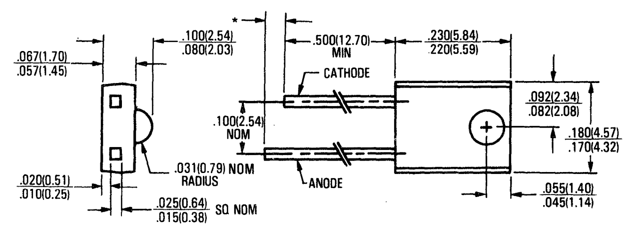
GaAlAs Plastic Infrared Emitting Diodes
Types OP240SL, OP240SLC, OP240SLB, OP240SLA





DIMENSIONS ARE IN INCHES (MILLIMETERS).

* FOR IDENTIFICATION PURPOSES, ANODE LEAD IS .060(1.52) NOM. LONGER THAN CATHODE LEAD.

Features

- Up to 2.5 times the radiant intensity of the GaAs equivalent at the same drive current
- Selected to specific on-line intensity and radiant intensity ranges
- Mechanically and spectrally matched to the OP550 series of phototransistors and the OP560 series of photodarlingtons

Description

The OP240SL series consist of gallium aluminum arsenide infrared emitting diodes mounted in low cost, clear plastic side-looking packages. Gallium aluminum arsenide features a significant increase in the radiated output of gallium arsenide at the same forward current. Also, with a wavelength centered at 875 nanometers, it more closely matches the spectral response of silicon phototransistors. For additional information on spectral emission characteristics, please refer to the OP550 data sheet.

The OP240SL is equivalent to TRW's earlier part number OP240.

Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)

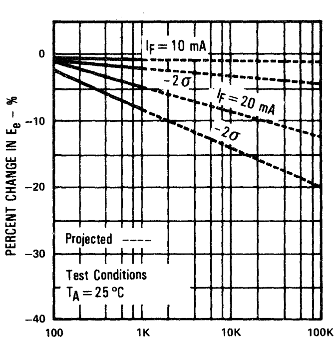
Reverse Voltage .... 2.0 V
Continuous Forward Current .... 50 mA
Peak Forward Current (Pulse Width = 1 μsec., 300 pps) .... 3.0 A
Storage and Operating Temperature Range .... −40°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)[1] .... 240°C
Power Dissipation .... 100 mW[2]

Notes:

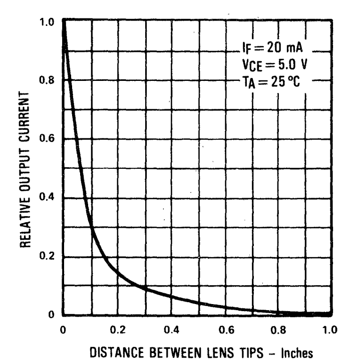
(1) RMA flux is recommended. Duration can be extended to 10 seconds max. when flow soldering.
(2) Derate linearly 1.33 mW/°C above 25°C.
(3) $E_{e(APT)}$ is a measurement of the average apertured radiant incidence upon a sensing area 0.180" (4.57 mm) in diameter perpendicular to and centered on the mechanical axis of the lens, and 0.653" (16.6 mm) from the lens tip. $E_{e(APT)}$ is a measurement of the average radiant intensity within the cone formed by the above conditions. $E_{e(APT)}$ is not necessarily uniform within the measured area.

Typical Performance Curves

Percent Changes in Radiant Intensity vs Time



Coupling Characteristics of OP240SL and OP550



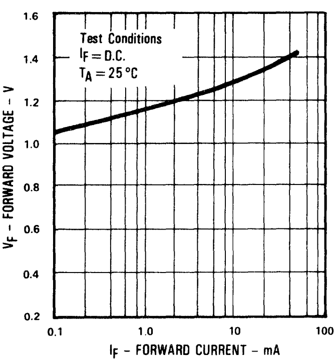
Types OP240SL, OP240SLC, OP240SLB, OP240SLA

Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

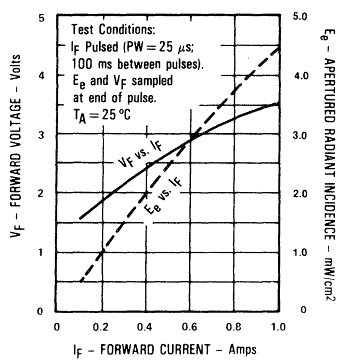
Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
P_O	Radiant Power Output	OP240SL		1.0		mW	$I_F = 40$ mA
$E_{e(APT)}$[3]	Apertured Radiant Incidence	OP240SL	0.050			mW/cm²	$I_F = 20$ mA
		OP240SLC	0.20		0.86	mW/cm²	$I_F = 20$ mA
		OP240SLB	0.40		1.20	mW/cm²	$I_F = 20$ mA
		OP240SLA	0.60			mW/cm²	$I_F = 20$ mA
V_F	Forward Voltage				1.80	V	$I_F = 20$ mA
I_R	Reverse Current				100	μA	$V_R = 2.0$ V
λp	Wavelength at Peak Emission			875		nm	$I_F = 20$ mA
B	Spectral Bandwidth Between Half Power Points			80		nm	$I_F = 20$ mA
$\Delta\lambda p/\Delta T$	Spectral Shift with Temperature			+0.18		nm/°C	$I_F =$ Constant
θ_{HP}	Emission Angle at Half Power Points			40		Deg.	$I_F = 20$ mA
t_r	Output Rise Time			550		ns	$I_{F(PK)} = 20$ mA, PW = 10.0 μs, D.C. = 10.0%
t_f	Output Fall Time			225		ns	

Typical Performance Curves

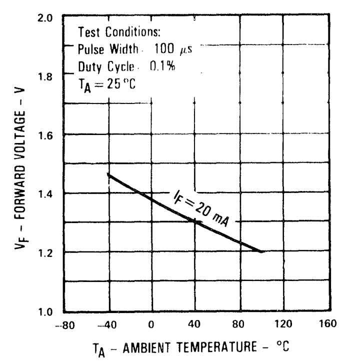
Forward Voltage vs Forward Current



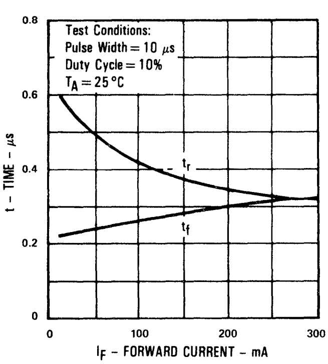
Forward Voltage and Radiant Incidence vs Forward Current



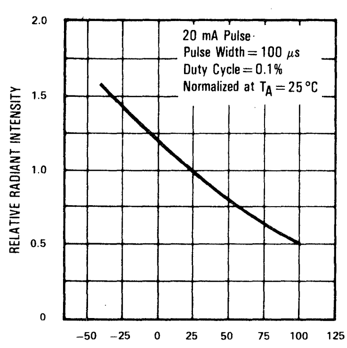
Forward Voltage vs Ambient Temperature



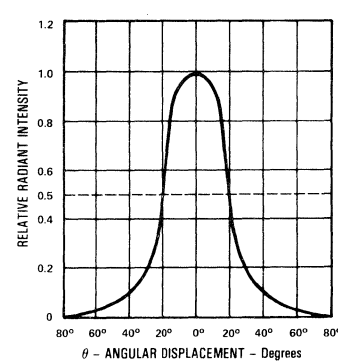
Rise Time and Fall Time vs Forward Current



Relative Radiant Intensity vs Ambient Temperature



Relative Radiant Intensity vs Angular Displacement



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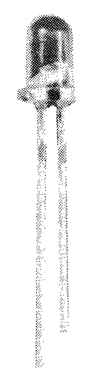
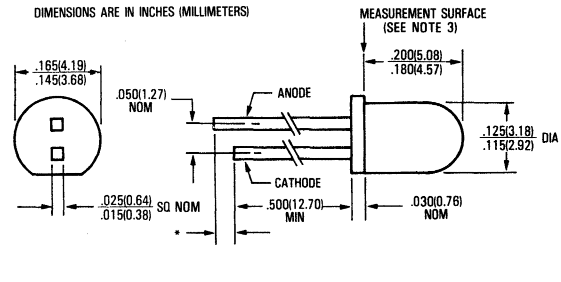
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5066
January 1985

GaAlAs Plastic Infrared Emitting Diodes
Types OP260SL, OP260SLC, OP260SLB, OP260SLA





* FOR IDENTIFICATION PURPOSES, ANODE LEAD IS .060(1.52) NOM. LONGER THAN CATHODE LEAD.

Features

- Up to 1.6 times the radiant intensity of the GaAs equivalent at the same drive current
- Selected to specific on-line intensity ranges
- Mechanically and spectrally matched to the OP500–OP500SL series of phototransistors and the OP530 photodarlington
- Narrow beam T-1 package for high coupling efficiency

Description

The OP260SL series are gallium aluminum arsenide infrared emitting diodes mounted in low cost, clear plastic end-looking packages. Gallium aluminum arsenide features a significant increase in the radiated output of gallium arsenide at the same forward current. Also, with a wavelength centered at 875 nanometers, it more closely matches the spectral response of silicon photosensors. For additional information on spectral emission characteristics, please refer to the OP500 data sheet.

Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)

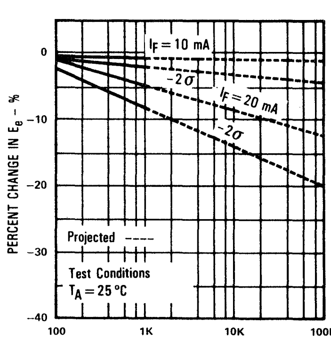
Reverse Voltage .... 2.0 V
Continuous Forward Current .... 50 mA
Peak Forward Current (Pulse Width = 1 μsec., 300 pps) .... 3.0 A
Storage and Operating Temperature Range .... −40°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)[1] .... 240°C
Power Dissipation .... 100 mW[2]

Notes:

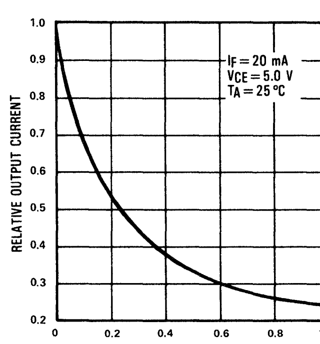
(1) RMA flux is recommended. Duration can be extended to 10 seconds max. when flow soldering.
(2) Derate linearly 1.33 mW/°C above 25°C.
(3) $E_e(APT)$ is a measurement of the average apertured radiant incidence upon a sensing area 0.081″ (2.06 mm) in diameter perpendicular to and centered on the mechanical axis of the lens, and 0.590″ (14.99 mm) from the measurement surface. $E_e(APT)$ is not necessarily uniform within the measured area.

Typical Performance Curves

Percent Changes in Radiant Intensity vs Time



Coupling Characteristics of OP260SL and OP500



Types OP260SL, OP260SLC, OP260SLB, OP260SLA

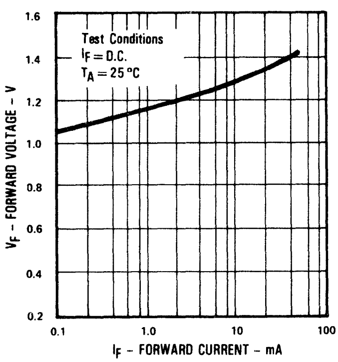
Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
P_O	Radiant Power Output	OP260	1.00			mW	$I_F = 20$ mA
$E_e(APT)$[3]	Apertured Radiant Incidence	OP260SL	.54			mW/cm^2	$I_F = 20$ mA
		OP260SLC	.54		3.3	mW/cm^2	$I_F = 20$ mA
		OP260SLB	1.65		4.7	mW/cm^2	$I_F = 20$ mA
		OP260SLA	2.7			mW/cm^2	$I_F = 20$ mA
V_F	Forward Voltage				1.80	V	$I_F = 20$ mA
I_R	Reverse Current				100	μA	$V_R = 2.0$ V

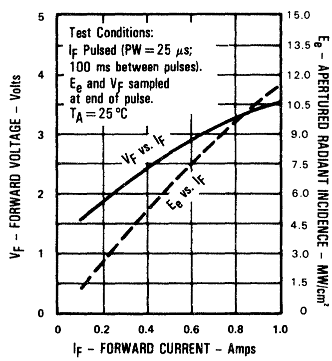
C

Typical Performance Curves

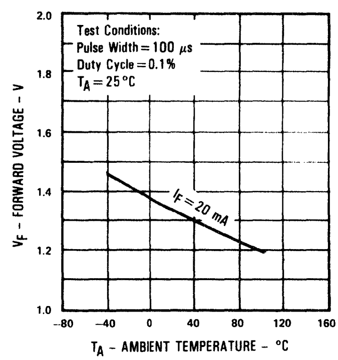
Forward Voltage vs Forward Current



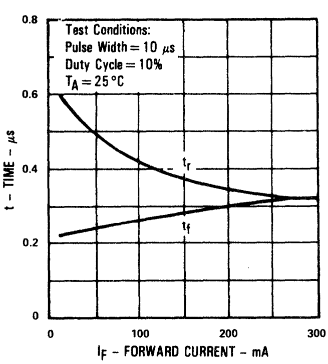
Forward Voltage and Radiant Incidence vs Forward Current



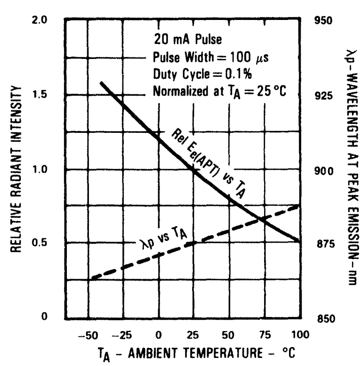
Forward Voltage vs Ambient Temperature



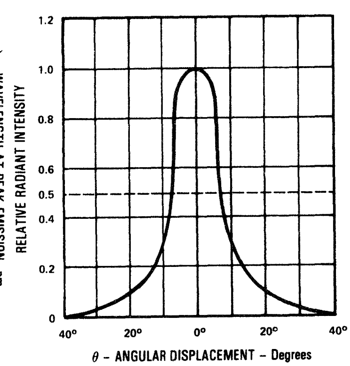
Rise Time and Fall Time vs Forward Current



Relative Radiant Intensity and Wavelength at Peak Emission vs Ambient Temperature



Relative Radiant Intensity vs Angular Displacement



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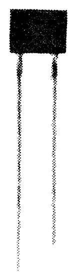
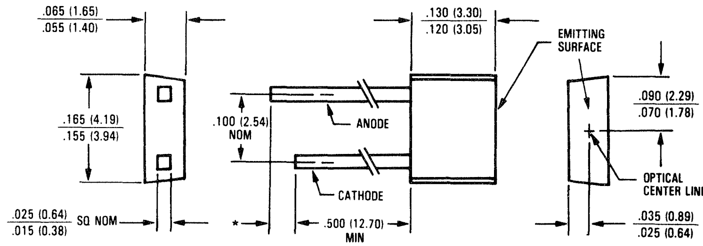
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5067
January 1985

GaAs Plastic Infrared Emitting Diodes
Types OP268FC, OP268FB, OP268FA



DIMENSIONS ARE IN INCHES (MILLIMETERS).



*FOR IDENTIFICATION PURPOSES, ANODE LEAD IS .06 (1.52) NOM. LONGER THAN CATHODE LEAD.

Features
- Flat lensed for wide radiation angle
- Easily stackable on 0.100″ (2.54 mm) hole centers
- Mechanically and spectrally matched to the OP508F series phototransistor and the OP538F series of photodarlingtons

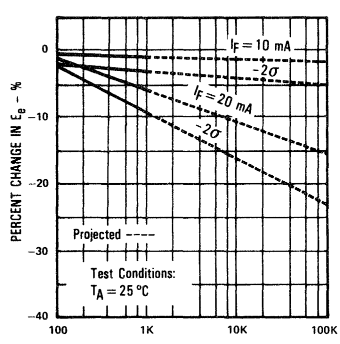
Description
The OP268F series contains a gallium aluminum arsenide infrared emitting diode mounted in an "end-emitting" miniature black plastic package. This device has a wide radiation angle due to its flat emitting surface. Small size and 0.100″ (2.54 mm) lead spacing allow considerable design flexibility.

Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)
Continuous Forward Current .... 50 mA
Peak Forward Current (Pulse Width = 1 μsec., 300 pps) .... 3.0 A
Reverse Voltage .... 2.0 V
Storage and Operating Temperature Range .... −40°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)[1] .... 240°C
Power Dissipation .... 100 mW[2]

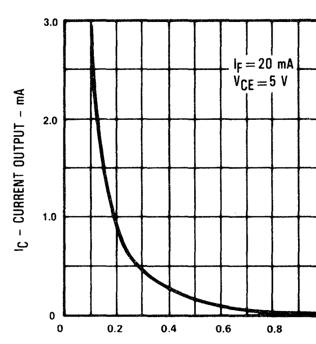
Notes:
(1) RMA flux is recommended. Duration can be extended to 10 seconds max. when flow soldering.
(2) Derate linearly 1.33 mW/°C above 25°C.
(3) $E_{e(APT)}$ is a measurement of the average apertured radiant energy incident upon a sensing area 0.081″ (2.06 mm) in diameter perpendicular to and centered on the mechanical axis of the "emitting surface" and 0.400″ (10.16 mm) from the measurement surface. $E_{e(APT)}$ is not necessarily uniform within the measured area.

Typical Performance Curves

Percent Changes in Radiant Intensity vs Time



Coupling Characteristics of OP268F and OP508F/OP538F

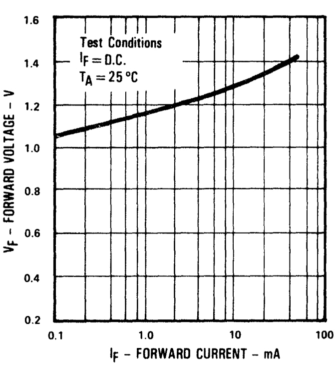


Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

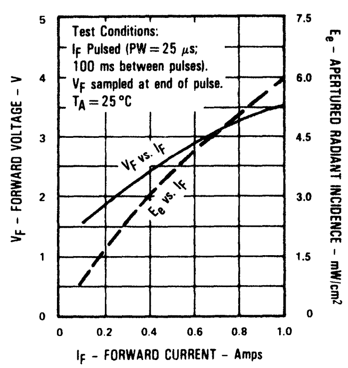
Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
$E_e(APT)$[3]	Apertured Radiant Incidence	OP268FC	.40			mW/cm²	$I_F = 20$ mA
		OP268FB	.48		.96	mW/cm²	$I_F = 20$ mA
		OP268FA	.56			mW/cm²	$I_F = 20$ mA
V_F	Forward Voltage				1.80	V	$I_F = 20$ mA
I_R	Reverse Current				100	μA	$V_R = 2.0$ V
λp	Wavelength at Peak Emission			875		nm	$I_F = 20$ mA

Typical Performance Curves

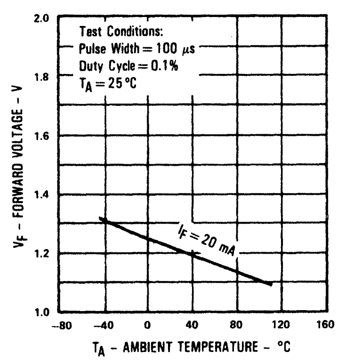
Forward Voltage vs Forward Current



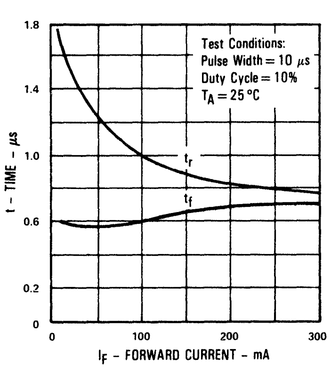
Forward Voltage and Radiant Incidence vs Forward Current



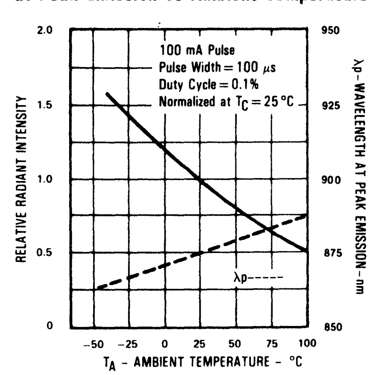
Forward Voltage vs Ambient Temperature



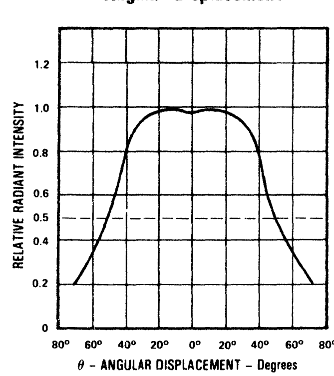
Rise Time and Fall Time vs Forward Current



Relative Radiant Intensity and Wavelength at Peak Emission vs Ambient Temperature



Relative Radiant Intensity vs Angular Displacement



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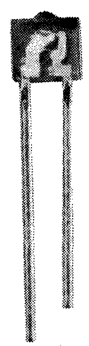
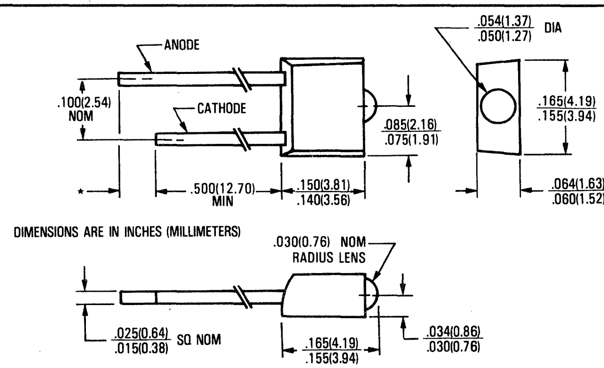
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5068
January 1985

GaAlAs Plastic Infrared Emitting Diodes
Types OP269SLC, OP269SLB, OP269SLA





* FOR IDENTIFICATION PURPOSES, ANODE LEAD IS .060(1.52) NOM. LONGER THAN CATHODE LEAD.

Features
- Integral lens for narrow beam angle
- Easily stackable on 0.100 inch (2.54 mm) hole centers
- Mechanically and spectrally matched to the OP509 phototransistor series

Description
The OP269SL series are gallium aluminum arsenide infrared emitting diodes molded in "end-looking" miniature clear packages. The molded lens insures improved uniformity of lens magnification from unit to unit. The OP269SL series provides a broad range of on-line and radiant intensities and has considerable design flexibility due to its small size. These devices are mechanically and spectrally matched to the OP509 phototransistor series. The wavelength at peak emission for this series is 875 nm. For additional information on spectral emission characteristics, please refer to the OP509 data sheet.

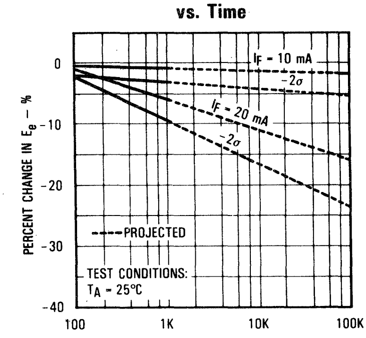
Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

Continuous Forward Current .... 50 mA
Peak Forward Current (Pulse Width = 1 μsec, 300 pps) .... 3.0 A
Reverse Voltage .... 2.0 V
Storage and Operating Temperature Range .... −40°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from Case for 5 sec. with soldering iron[1] .... 240°C
Power Dissipation .... 100 mW[2]

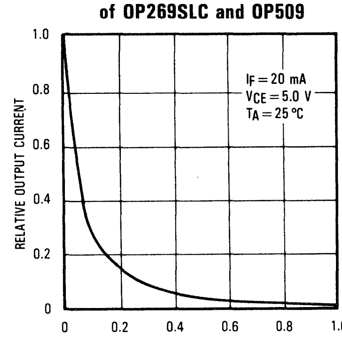
Notes:
(1) RMA flux is recommended. Duration can be extended to 10 seconds max. when flow soldering.
(2) Derate linearly 1.33 mW/°C above 25°C.
(3) $E_{e(APT)}$ is a measurement of the average apertured radiant incidence upon a sensing area 0.180" (4.57 mm) in diameter perpendicular to and centered on the mechanical axis of the lens, and 0.653" (16.6 mm) from the lens tip. $E_{e(APT)}$ is a measurement of the average radiant intensity within the cone formed by the above conditions. $E_{e(APT)}$ is not necessarily uniform within the measured area.

Typical Performance Curves

Percent Changes in Radiant Intensity vs. Time



Coupling Characteristics of OP269SLC and OP509



Types OP269SLC, OP269SLB, OP269SLA

Electrical Characteristics (T_A = 25°C unless otherwise noted)

Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
$E_{e(APT)}$[3]	Apertured Radiant Incidence	OP269SLC	0.30			mW/cm^2	I_F = 20 mA
		OP269SLB	0.35		0.70	mW/cm^2	I_F = 20 mA
		OP269SLA	0.45			mW/cm^2	I_F = 20 mA
V_F	Forward Voltage				1.80	V	I_F = 20 mA
I_R	Reverse Current				100	μA	V_R = 2.0 V

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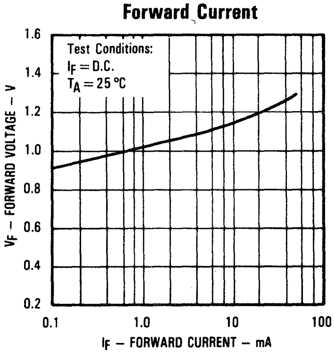
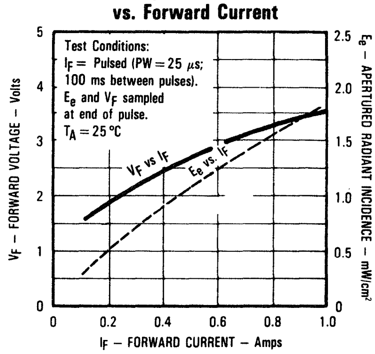
Typical Performance Curves

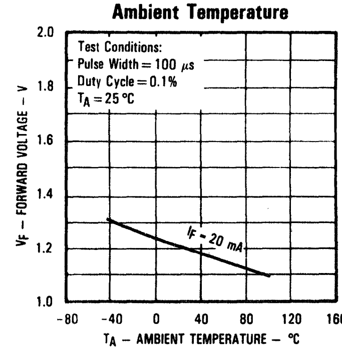
Forward Voltage vs. Forward Current



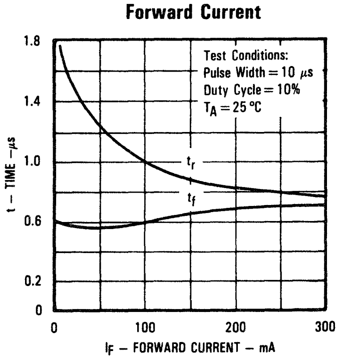
Forward Voltage and Radiant Incidence vs. Forward Current



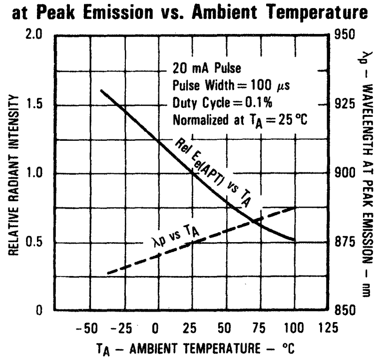
Forward Voltage vs. Ambient Temperature



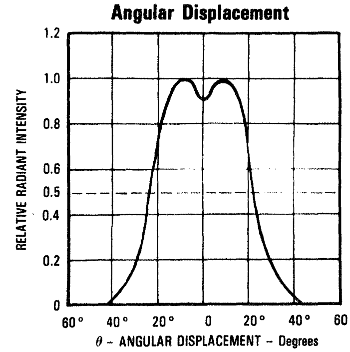
Rise Time and Fall Time vs. Forward Current



Relative Radiant Intensity and Wavelength at Peak Emission vs. Ambient Temperature



Relative Radiant Intensity vs. Angular Displacement



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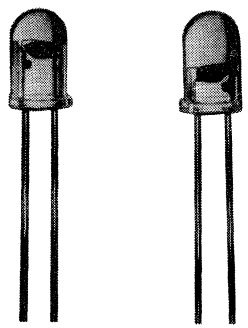
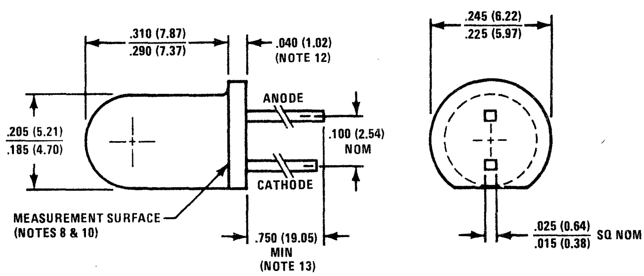
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5069
January 1985

GaAlAs Plastic Infrared Emitting Diodes
Types OP290C, B, A–OP292C, B, A, OP295C, B, A–OP297C, B, A



OP290, OP291 OP295, OP296
OP292 SERIES OP297 SERIES



DIMENSIONS ARE IN INCHES (MILLIMETERS)

Features
- 1.7 times the irradiance level of GaAs at the same drive current
- 50° (OP290, OP291, OP292) or 15° (OP295, OP296, OP297) emission angle
- 3 output ranges for each type
- Superior optical and thermal consistency
- Designer specified and characterized
- U.L. Recognized, File Number S2047

Description
The OP290, OP291, OP292, OP295, OP296, and OP297 are gallium aluminum arsenide infrared emitting diodes mounted in lensed plastic, end looking T – 1 3/4 packages. The OP290 and OP295 are specified under pulse conditions to 1.5 amps and can be used up to 5 amps. The OP291 and OP296 are specified under pulse conditions to 100 mA and are intended for use as low cost plastic replacements for TO-46 hermetic units. The OP292 and OP297 are specified under pulse conditions to 20 mA and are intended for use in low current applications. The wavelength is centered at 875 nm and closely matches the spectral response of silicon phototransistors. Each of the six unit types are categorized into three ranges of apertured power output. They are also completely characterized for ease of system design. The units utilize the Optokleer™ lens processing which ensures mechanically controlled chip centering and minimum optical discontinuities in the package. The blue, non-absorbing dye is added to the device for identification and does not affect the device performance. Silver-copper lead frames are used in order to offer excellent thermal characteristics.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

Reverse Voltage — OP290/OP295	5.0 V
OP291/OP296	2.0 V
OP292/OP297	5.0 V
Continuous Forward Current	150 mA[1]
Peak Forward Current — OP290/OP295 — Pulse Width = 25 μs	5.0 A
OP291/OP296 — Pulse Width = 100 μs	2.0 A
OP292/OP297 — Pulse Width = 100 μs	1.00 A
Maximum Duty Cycle — OP290/OP295 — Pulse Width = 25 μs @ 5 A	1.25%[2]
Storage and Operating Temperature Range	−40°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. w/soldering iron)[3]	240°C
Power Dissipation	333 mW[4][5][6]

Notes:

(1) Derate linearly 1.67 mA/°C above 25°C (Free-Air). When used with heat sink (see Note 5) derate linearly 2.07 mA/°C above 62.5°C (Normal use).
(2) Refer to graph of Maximum Peak Pulse Current vs. Pulse Width.
(3) RMA flux is recommended. Duration can be extended to 10 seconds max. when flow soldering.
(4) Measured in Free-Air. Derate linearly 3.33 mW/°C above 25°C.
(5) Mounted on 1/16" (1.6 mm) thick PC board with each lead soldered through 80 mil square lands 0.250" (6.35 mm) below flange of device. Derate linearly 5.33 mW/°C above 62.5°C.
(6) Immersed in silicone fluid simulating infinite heat sink. Derate linearly 11.1 mW/°C above 95°C.
(7) Measurement is taken at the end of a single 100 μs pulse. Heating due to increased pulse rate or pulse width will cause a decrease in reading.
(8) $E_{e(APT)}$ is a measurement of the average apertured radiant energy incident upon a sensing area 0.250" (6.35 mm) in diameter perpendicular to and centered on the mechanical axis of the lens and 0.500" (12.7 mm) from the measurement surface. $E_{e(APT)}$ is not necessarily uniform within the measured area.
(9) Typical total Power Out (P_O) @ I_F = 20 mA pulsed on all units is 3.6 mW, @ I_F = 100 mA is 19 mW, and @ I_F = 1.5 A is 240 mW.
(10) $E_{e(APT)}$ is a measurement of the average apertured radiant energy incident upon a sensing area 0.250" (6.35 mm) in diameter perpendicular to and centered on the mechanical axis of the lens and 1.429" (36.3 mm) from the measurement surface. $E_{e(APT)}$ is not necessarily uniform within the measured area.
(11) Measured at the end of a 10 msec. voltage soak.
(12) This dimension is held to within ±0.005" on the flange edge and may vary ±0.020" in the area of the leads.
(13) Cathode lead is 0.050" shorter than anode lead.

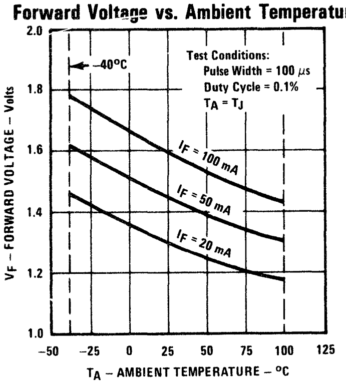
Types OP290C, B, A–OP292C, B, A, OP295C, B, A–OP297C, B, A

Electrical Characteristics (T_A = 25°C unless otherwise noted)

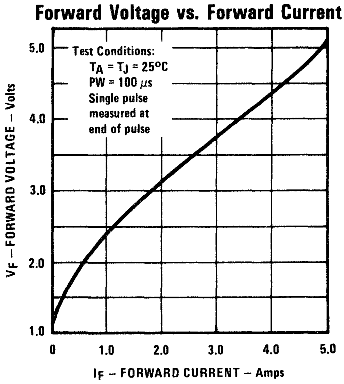
Symbol	Parameter		Min.	Max.	Units	Test Conditions
$E_{e(APT)}$	Apertured Radiant Incidence*	OP290C	150		mW/cm²	I_F = 1.50 A[7][8][9]
		OP290B	180	300	mW/cm²	I_F = 1.50 A[7][8][9]
	*OP290 series is measured into a 30° cone	OP290A	210		mW/cm²	I_F = 1.50 A[7][8][9]
	with the aperture 0.5″ from the device	OP291C	10.0		mW/cm²	I_F = 100 mA[7][8][9]
	measurement surface.	OP291B	13.0	26	mW/cm²	I_F = 100 mA[7][8][9]
		OP291A	16.0		mW/cm²	I_F = 100 mA[7][8][9]
	*OP295 series is measured into a 10° cone	OP292C	1.70		mW/cm²	I_F = 20 mA[7][8][9]
	with the aperture 1.429″ from the device	OP292B	2.2	4.4	mW/cm²	I_F = 20 mA[7][8][9]
	measurement surface.	OP292A	2.7		mW/cm²	I_F = 20 mA[7][8][9]
		OP295C	22		mW/cm²	I_F = 1.50 A[7][9][10]
		OP295B	33	77	mW/cm²	I_F = 1.50 A[7][9][10]
		OP295A	44		mW/cm²	I_F = 1.50 A[7][9][10]
		OP296C	1.60		mW/cm²	I_F = 100 mA[7][9][10]
		OP296B	2.6	6.6	mW/cm²	I_F = 100 mA[7][9][10]
		OP296A	3.6		mW/cm²	I_F = 100 mA[7][9][10]
		OP297C	0.30		mW/cm²	I_F = 20 mA[7][9][10]
		OP297B	0.50	1.30	mW/cm²	I_F = 20 mA[7][9][10]
		OP297A	0.70		mW/cm²	I_F = 20 mA[7][9][10]
V_F	Forward Voltage	OP290/295		4.0	V	I_F = 1.50 A[7]
		OP291/296		2.0	V	I_F = 100 mA[7]
		OP292/297		1.75	V	I_F = 20 mA[7]
I_R	Reverse Current	OP290/292/295/297		10.0	μA	V_R = 5.0 V[11]
		OP291/296		100	μA	V_R = 2.0 V[11]

Typical Performance Curves

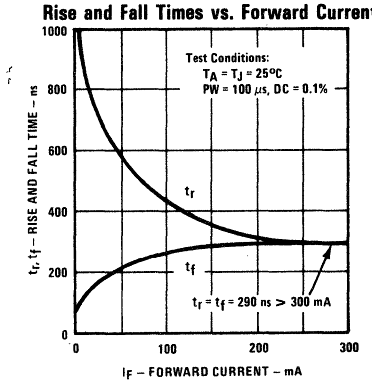
Forward Voltage vs. Ambient Temperature



Forward Voltage vs. Forward Current



Rise and Fall Times vs. Forward Current



Thermal Parameters

Type Units	R_{THJA} (°C/W) Free Air(1)	Normal(2)	Infinite Heat Sink(3)	C_{TH} (10^{-5} Ws/°C)	τ_{TH} (10^{-2} s)	K
All	300	188	90	1.42	0.263	0.008

Refer to Application Bulletin 105 for use of these constants.

Notes to Thermal Parameters

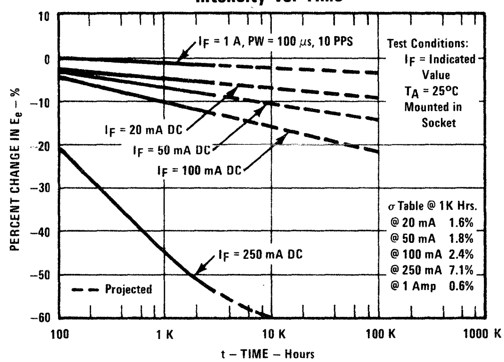
(1) Heat transfer minimized by holding unit in still air with minimum heat transferred through leads by conduction.

(2) Unit mounted in double sided printed circuit board ≈ 0.250 inches (6.35 mm) below plastic. The land areas are 0.080 inches square. This simulates normal use.

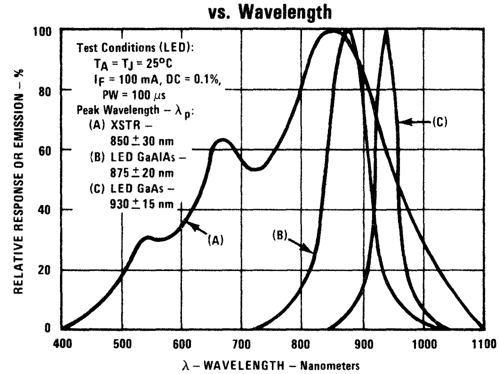
(3) Unit immersed in circulating silicone fluid holding T_{CASE} = 25°C. This simulates an infinite heat sink.

Typical Performance Curves

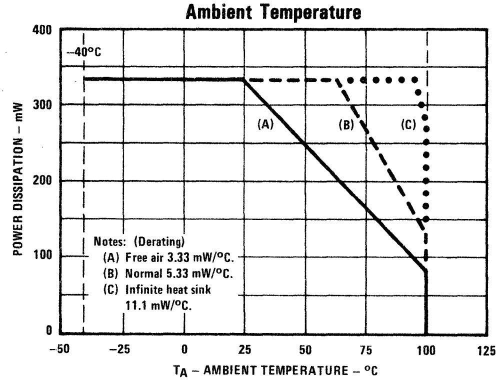
Percent Change in Radiant Intensity vs. Time



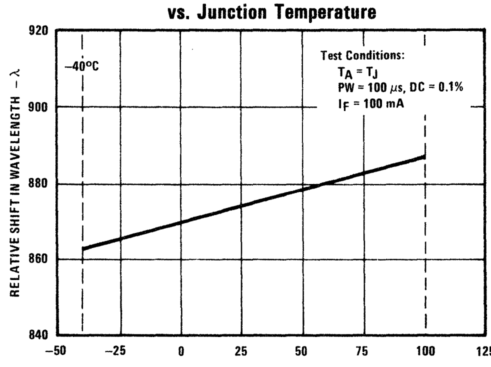
Spectral Response and Emission vs. Wavelength



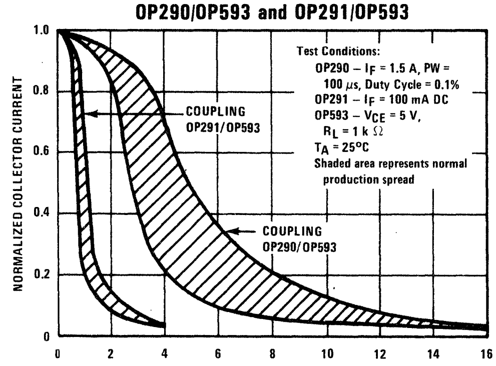
Power Dissipation vs. Ambient Temperature



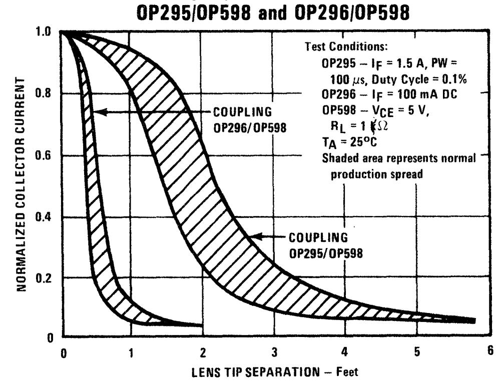
Shift in Peak Wavelength vs. Junction Temperature



Coupling Characteristics of OP290/OP593 and OP291/OP593

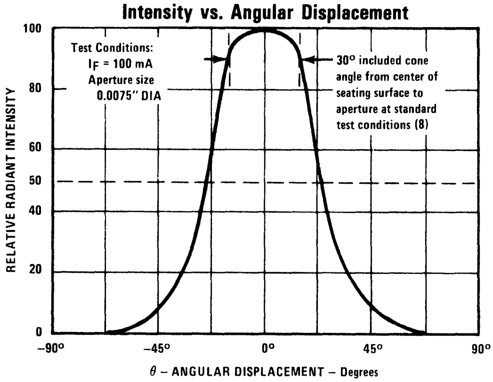


Coupling Characteristics of OP295/OP598 and OP296/OP598

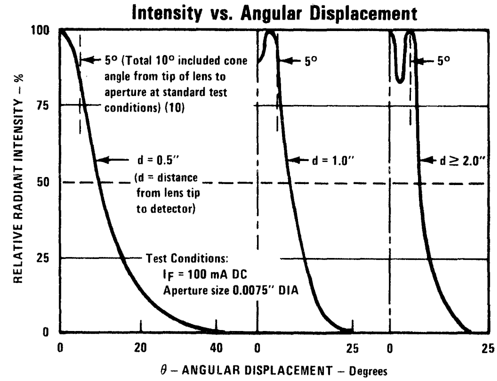


Typical Performance Curves

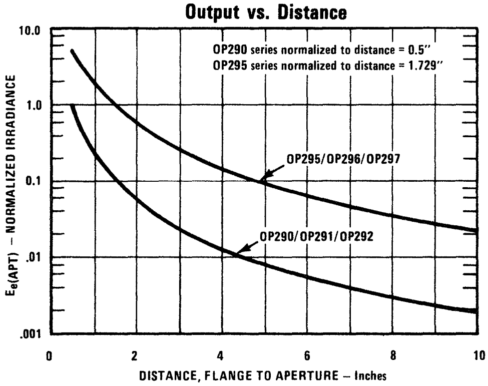
OP290/OP291/OP292 Relative Radiant Intensity vs. Angular Displacement



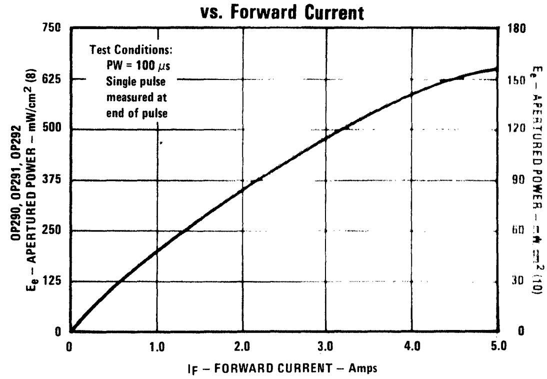
OP295/OP296/OP297 Relative Radiant Intensity vs. Angular Displacement



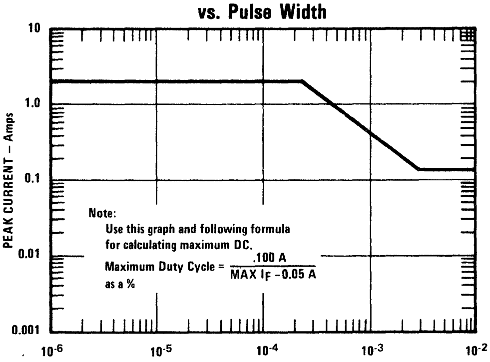
Percent Change in Apertured Power Output vs. Distance



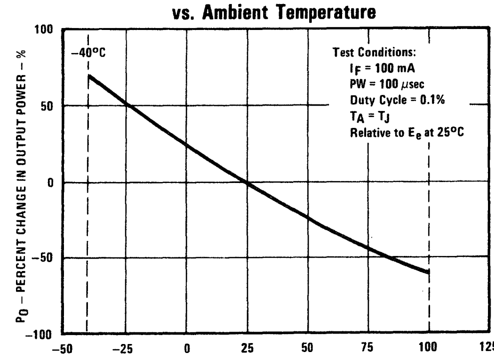
Power Output or Radiant Incidence vs. Forward Current



Maximum Peak Pulse Current vs. Pulse Width



Percent Change in Power Output vs. Ambient Temperature

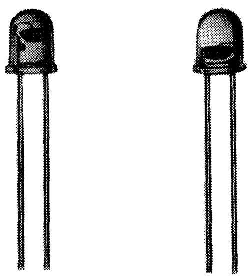


TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

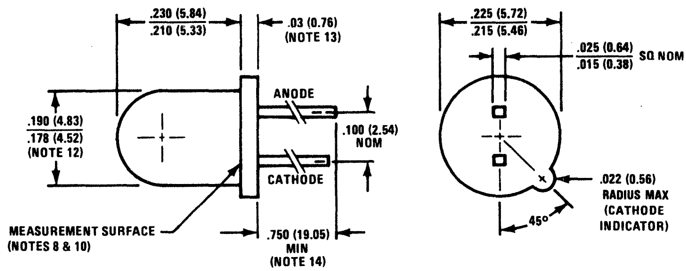
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5072
January 1985

GaAlAs Plastic Infrared Emitting Diodes
Types OP293C, B, A, OP298D, C, B, A



OP293 SERIES **OP298 SERIES**



DIMENSIONS ARE IN INCHES (MILLIMETERS)

Features
- Low cost plastic replacement for TO-46
- Superior optical consistency and thermal rating compared to hermetic TO-46
- Mechanically and spectrally matched to OP593/OP598 series phototransistors
- U.L. Recognized, File Number S2047
- Improved spectral matching for 1.7 times the effective energy transfer of GaAs at the same irradiance level
- 1.7 times the irradiance level of GaAs at the same drive current

Description
The OP293/OP298 series are gallium aluminum arsenide infrared emitting diodes mounted in a plastic lensed TO-46 outline housing. Gallium aluminum arsenide, with a wavelength centered at 875 nanometers, closely matches the spectral response of silicon phototransistors. The units utilize the Optokleer™ lens processing which ensures mechanically controlled chip centering and minimum optical discontinuities in the package. The blue, non-absorbing dye is added to the device for identification and does not affect the device performance. In addition, the silver-copper lead frame offers better thermal characteristics than its hermetic counterpart. The OP293 series have a lensed outline with a broad emission angle of 60° included between half power points. The OP298 series have a lensed outline providing a beam angle of 25° for better coupling efficiency over longer distance.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

Reverse Voltage	2.0 V
Continuous Forward Current	150 mA(1)
Peak Forward Current (Pulse Width = 250 μsec)	2.0 A
Maximum Duty Cycle (Pulse Width 250 μsec @ 2 A)	5.0%(2)
Storage and Operating Temperature Range	−40°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from Case for 5 sec. with soldering iron)(3)	240°C
Power Dissipation (Free-Air)	333 mW(4)
Power Dissipation (Normal Use)	333 mW(5)
Power Dissipation (Infinite Heat Sink)	333 mW(6)

Notes:
(1) Derate linearly 1.67 mA/°C above 25°C (Free-Air). When used with heat sink (see Note 5) derate linearly 2.07 mA/°C above 62.5°C (Normal use).
(2) Refer to graph of Maximum Peak Pulse Current vs. Pulse Width.
(3) RMA flux is recommended. Duration can be extended to 10 seconds max. when flow soldering.
(4) Measured in Free-Air. Derate linearly 3.33 mW/°C above 25°C.
(5) Mounted on 1/16″ (1.6 mm) thick PC board with each lead soldered through 80 mil square lands 0.250″ (6.35 mm) below flange of device. Derate linearly 5.33 mW/°C above 62.5°C.
(6) Immersed in silicone fluid simulating infinite heat sink. Derate linearly 11.1 mW/°C above 95°C.
(7) Measurement is taken at the end of a single 100 μs pulse. Heating due to increased pulse rate or pulse width will cause a decrease in reading.
(8) $E_{e(APT)}$ is a measurement of the average apertured radiant energy incident upon a sensing area 0.250″ (6.35 mm) in diameter perpendicular to and centered on the mechanical axis of the lens and 0.420″ (10.7 mm) from the measurement surface. $E_{e(APT)}$ is not necessarily uniform within the measured area.
(9) Typical total Power Out (P_O) @ I_F = 100 mA pulsed on OP293C and OP298C = 13 mW; OP293B and OP298B = 18 mW; OP293A and OP298A = 22 mW.
(10) $E_{e(APT)}$ is a measurement of the average apertured radiant energy incident upon a sensing area 0.250″ (6.35 mm) in diameter perpendicular to and centered on the mechanical axis of the lens and 1.429″ (36.30 mm) from the measurement surface. $E_{e(APT)}$ is not necessarily uniform within the measured area.
(11) Measured after voltage has been applied for 10 msec.
(12) For press fit, drill 0.184 ±0.001″ diameter hole.
(13) This dimension is held to within ±0.005″ on the flange edge and may vary ±0.020″ in the area of the leads.
(14) Cathode lead is 0.050″ shorter than anode lead.

Types OP293C, B, A, OP298D, C, B, A

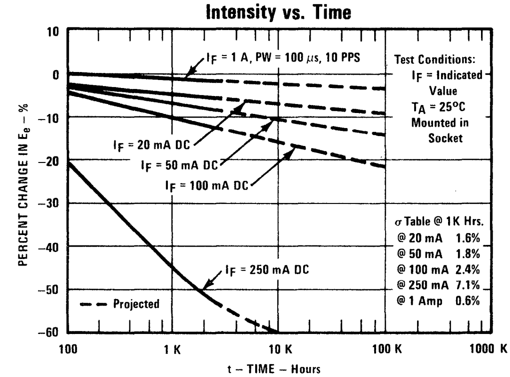
Electrical Characteristics (T_A = 25°C unless otherwise noted)

Symbol	Parameter		Min.	Max.	Unit	Test Conditions
$E_{e(APT)}$	Apertured Radiant Incidence*	OP293C	10.0		mW/cm²	I_F = 100 mA[7][8][9]
		OP293B	13.0	26	mW/cm²	I_F = 100 mA[7][8][9]
	*OP293 is measured with a 30° cone angle	OP293A	16.0		mW/cm²	I_F = 100 mA[7][8][9]
	at 0.420″ and OP298 is measured with a 10°	OP298D	1.80	4.8	mW/cm²	I_F = 100 mA[7][9][10]
	cone angle at 1.429″.	OP298C	1.80		mW/cm²	I_F = 100 mA[7][9][10]
		OP298B	2.4	4.8	mW/cm²	I_F = 100 mA[7][9][10]
		OP298A	3.0		mW/cm²	I_F = 100 mA[7][9][10]
V_F	Forward Voltage			2.0	V	I_F = 100 mA[7]
I_R	Reverse Current			100	μA	V_R = 2.0 V[11]

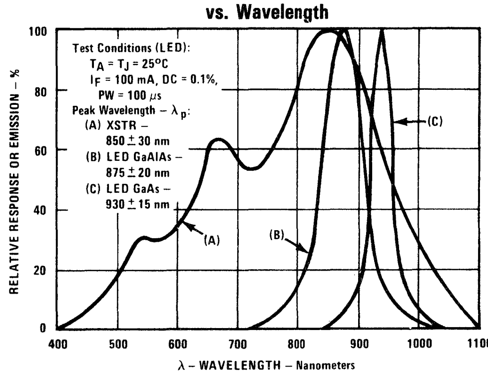
C

Typical Performance Curves

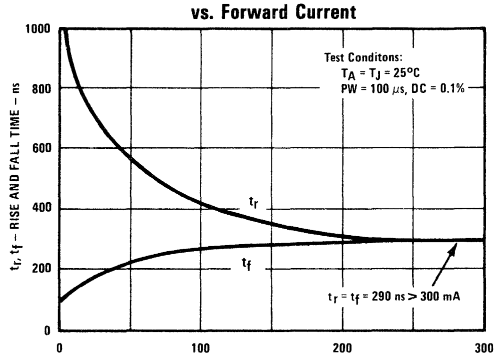
Percent Change in Radiant Intensity vs. Time



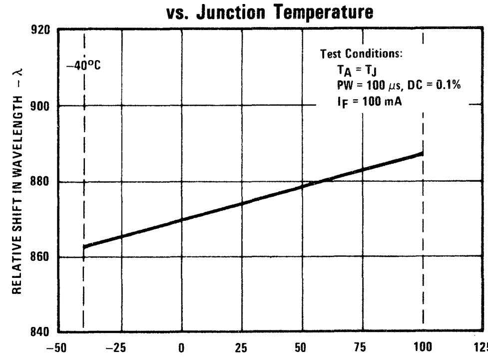
Spectral Response and Emission vs. Wavelength



Rise and Fall Time vs. Forward Current

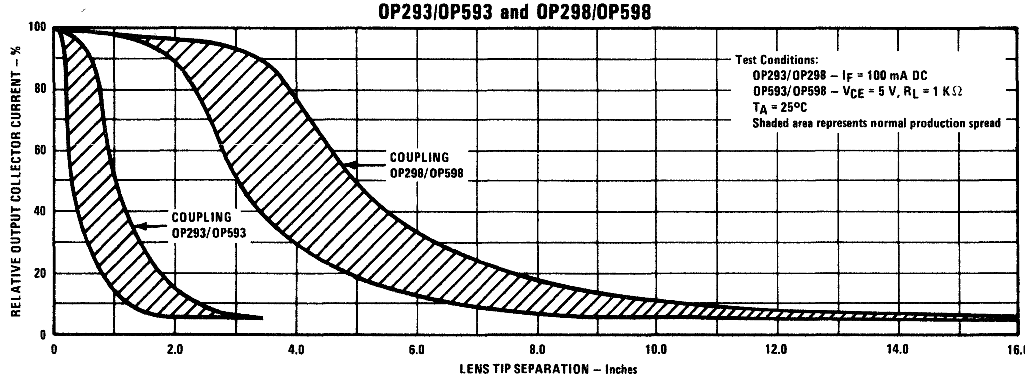


Shift in Peak Wavelength vs. Junction Temperature

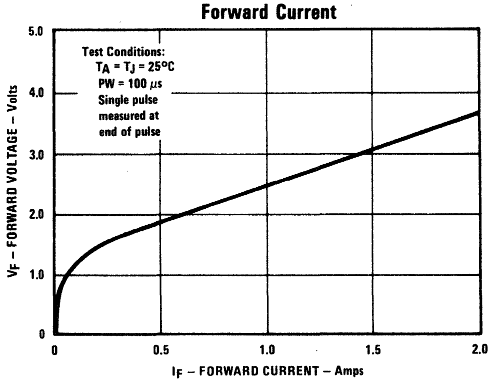


Typical Performance Curves

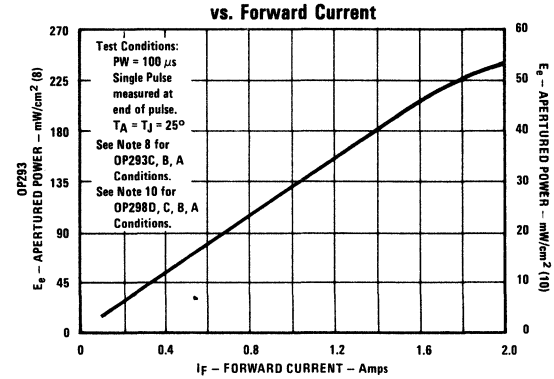
Coupling Characteristics of OP293/OP593 and OP298/OP598



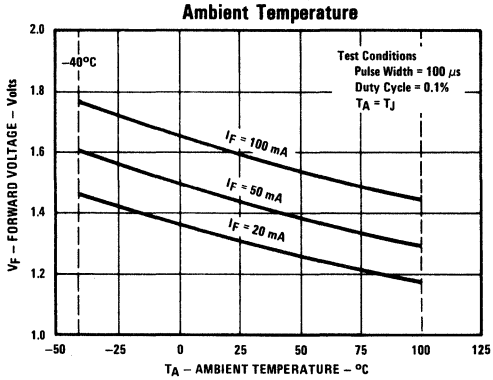
Forward Voltage vs. Forward Current



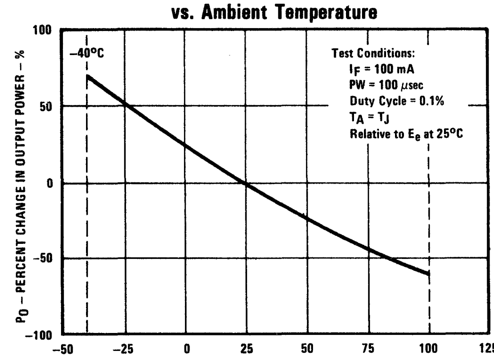
Apertured Power OP293/OP298 vs. Forward Current



Forward Voltage vs. Ambient Temperature



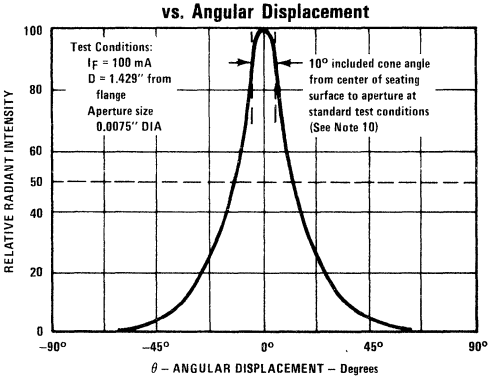
Percent Change in Power Output vs. Ambient Temperature



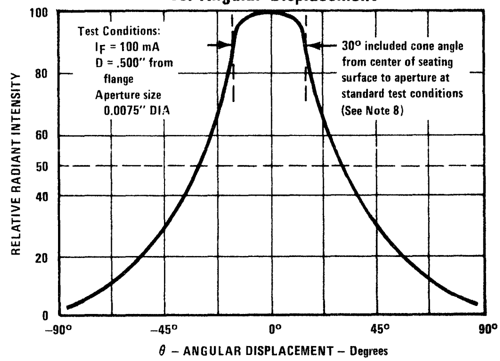
C

Typical Performance Curves

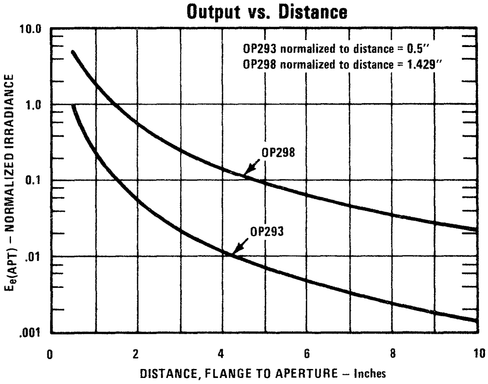
OP298 – Relative Radiant Intensity vs. Angular Displacement



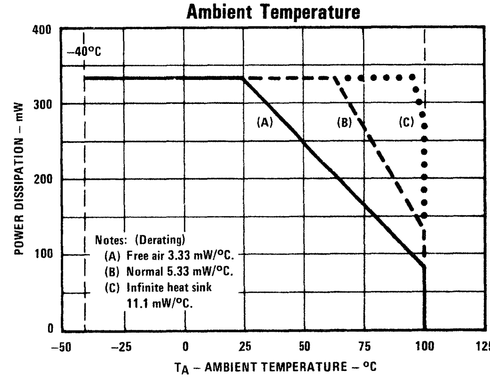
OP293 – Relative Radiant Intensity vs. Angular Displacement



Percent Change in Apertured Power Output vs. Distance



Power Dissipation vs. Ambient Temperature



Thermal Parameters

Type Units	R_{THJA} (°C/W)			C_{TH}	τ_{TH}	K
	Free Air(1)	Normal(2)	Infinite Heat Sink(3)	(10^{-5} Ws/°C)	(10^{-2} s)	
All	300	188	90	1.42	0.263	0.008

Notes:

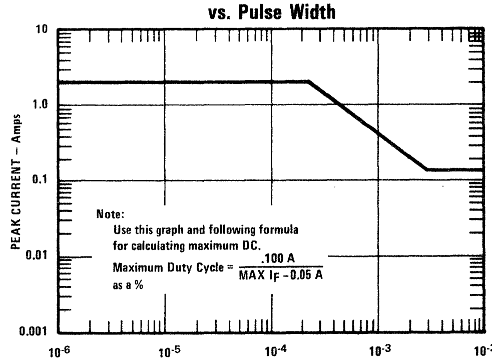
(1) Heat transfer minimized by holding unit in still air with minimum heat transferred through leads by conduction.

(2) Unit mounted in double sided printed circuit board 0.250 inches (6.35 mm) below plastic. The land areas are 0.080 inches square. This simulates normal use.

(3) Unit immersed in circulating silicone fluid holding T_{CASE} @ 25°C. This simulates an infinite heat sink.

Refer to Application Bulletin 105 for use of these constants.

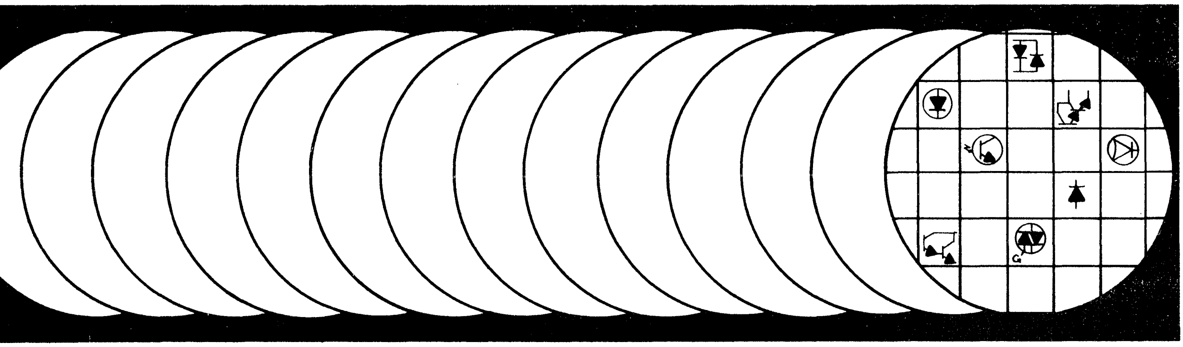
Maximum Peak Pulse Current vs. Pulse Width



TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958

TRW



D

Photosensors

Photosensors

The TRW line of photosensors includes four basic infrared-sensitive device types: photodiodes, phototransistors, photodarlingtons and Photologic™ sensors. Each basic type is available in a variety of case styles. For every infrared emitter made by TRW, except the T-1¾ package,[1] there is a mechanically and spectrally matched sensor. Case styles include several sizes of hermetic devices, and an even wider variety of plastic encapsulated types. Optokleer™ plastic versions of the popular hermetic TO-18 part are also available, offering improved optical design and drop-in replacement at substantial cost savings.

Selecting the Right TRW Sensor

Important factors to consider when selecting the right device for an application are: the operating speed needed, available infrared energy, and the required output current. Depending on the required balance of these design factors, TRW offers a choice of several appropriate types of photosensors.

Photodiodes

PN junction silicon photodiodes have the fastest operating speed of all the photosensors in the TRW product family. Rise and fall times of 100 nanoseconds are typical for these devices. However, light current (I_C) for these devices tends to be low; therefore, additional amplification is almost always required. Nevertheless, where speed considerations predominate, photodiodes are the best option. Figure 3 illustrates typical circuit requirements for the photoconductive and photovoltaic modes of operation.

Photologic™ Devices

Photologic™ is a term TRW uses to refer to complex integrated circuitry combined with a high speed, high sensitivity photodiode on a single silicon chip. Photologic™ devices offer the speed advantage of photodiodes along with a Schmitt trigger and amplifier to directly drive up to eight TTL loads. Medium speed data rates to 250 K-baud are possible with typical output rise and fall times of 25 nanoseconds. These devices are excellent choices where speed, accuracy and logic interface are required. Typical examples include high speed motion encoding, modulated (pulsed) long distance beam interrupt applications, such as touch screens, and track ball type devices for video games or "mouse" applications for computer accessories.

Phototransistors and Photodarlingtons

Phototransistors and photodarlingtons are TRW's most widely used photosensor types. For most traditional applications, NPN silicon phototransistors offer the best value in terms of output current, sensitivity, speed, reliability and quality. Devices with minimum on-state collector currents ranging up to 40 mA are available, while output rise and fall times of 60-100 microseconds ($R_L = 5\ K\Omega$) are typical. TRW phototransistors are 100 percent tested and specified at light levels which range upwards from 1.00 mW/cm^2 with collector-to-emitter voltage (V_{CE}) set at 5.0 volts.

Photodarlingtons offer the higher sensitivity and gain needed for many applications; however, rise and fall times are slower. When switching time is not critical, the choice of a photodarlington can offer improved sensing reliability and reduce the need for additional signal amplification.

TRW Leadership in Advanced Photosensor Design

TRW scientists and engineers continue to advance the state of the art in Photologic™ monolithic optoelectronic IC's, a product originally conceived and developed by TRW. The next generation of Photologic™ devices will include substantially increased sensitivity, making longer beam distances possible and offering even higher reliability at lower irradiance levels. Direct TTL and CMOS compatibility will also be featured with increased sink/source capability. Supply voltage requirements will be more flexible than before due to an on-chip voltage regulator designed by TRW. And finally, the new Photologic™ devices will offer a choice of two hysteresis ratios ($E_{eT(+)}/E_{eT(-)}$) of 2 and 1.4. With these new advancements, TRW continues its leadership role in advanced photosensor design.

Spectral Matching for Improved Coupling Efficiency

TRW photosensors are spectrally matched to the TRW line of infrared emitting diodes. Figure 1 shows the spectral response curve for TRW phototransistors, photodarlingtons, and junction photodiodes. The output peak wavelengths for both GaAs and GaAlAs lie very close to the silicon sensitivity peak of about 850 nanometers. The secondary silicon sensivity peak at approximately 670 nanometers is caused by a quarter wave overcoat used for enhanced optical coupling and even further improved spectral matching.

Controlling Ambient Light

The spectral response of silicon extends into the visible light range. This makes the sensors vulnerable to ambient light; particularly from tungsten sources (or the sun) where red light is present. TRW offers devices in black plastic (see OP508F) to reduce ambient light noise. In addition, many of TRW's slotted optical switches shield the sensor in a polycarbonate housing designed to control ambient light. External light filters or controlled modulation of the LED and/or sensor may also be used to reduce the noise from ambient light. As another alternative, most photographic shops can supply infrared passing gelatin filters for laboratory experimentation. For production use, several types of plastic are commercially available with varying degrees of infrared and visible light transmitivity (e.g., polysulfone and polycarbonate).

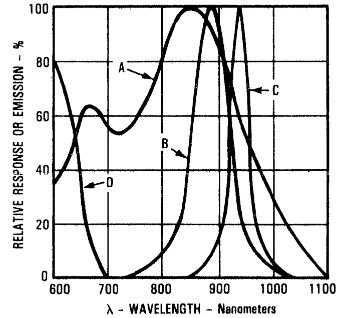
Product Specifications Written for Easy Design

The product specifications in this book were written with ease of design in mind. Emitter output and sensor response levels are specified in terms of milliwatts per square centimeter at separation distances typical for most applications. In addition, as shown in Figure 2, phototransistor collector current versus collector-to-emitter voltage curves are provided for stepped levels of photocurrent (measured in mW/cm²). These curves allow the design-in process to be very analogous to the design of a simple transistor amplifier or switching circuit. The application notes appearing in the back of this catalog also provide additional information.

Custom Design and Selection for Unique Applications

While the TRW line is the industry's broadest, a unique application requirement may result in the need for custom selection or package design. Call your local TRW sales office or TRW Optoelectronics Division for more information.

Figure 1. Photosensor Spectral Response



Test Conditions (LED):
$T_A = T_J = 25°C$, $I_F = 100$ mA, DC = 0.1%, PW = 100 μs
Peak Wavelength – λ_p: (A) XSTR – 850±30 nm
(B) LED GaAlAs – 875±20 nm
(C) LED GaAs – 930±15 nm
(D) Human Eye Response

Figure 2. Collector Current vs Collector to Emitter Voltage

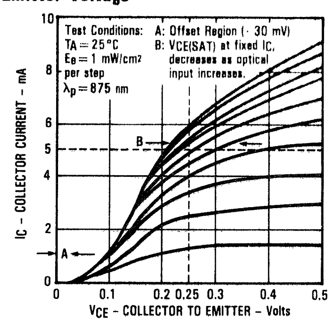
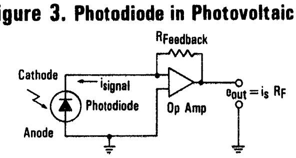
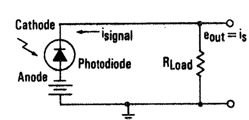


Figure 3. Photodiode in Photovoltaic Mode

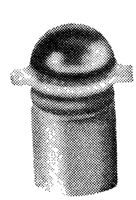


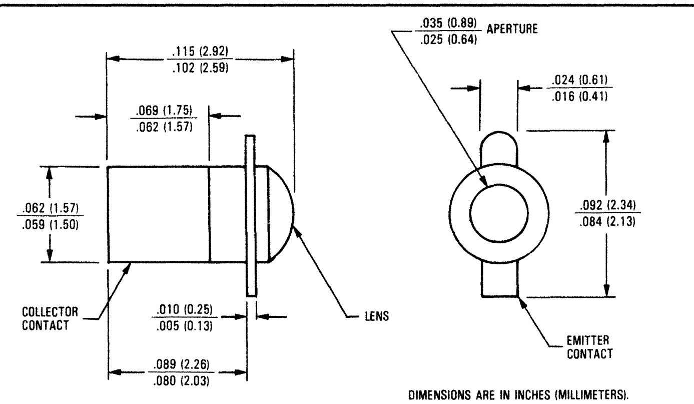
Photodiode in Photoconductive Mode



(1) TRW's Optokleer™ high output T-1¾ emitters are designed for long distance remote control applications. These applications require a large area PIN diode as sensing element.

NPN Silicon Photodarlingtons
Types OP300, OP301, OP302, OP303, OP304, OP305





Features
- Miniature hermetically sealed package
- High current gain
- Ideal for direct mounting in PC boards[1]

Description
The OP300 through OP305 each consist of an NPN silicon photodarlington mounted in a miniature glass lensed, hermetically sealed, "Pill" package. The lensing effect of the package allows an acceptance half angle of 18° measured from the optical axis to the half power point. Photodarlingtons are normally used in applications where light signal levels are low and more current gain is needed than is possible with phototransistors. This series is mechanically and spectrally matched to the OP123/124 and OP223/224 series of infrared emitting diodes.

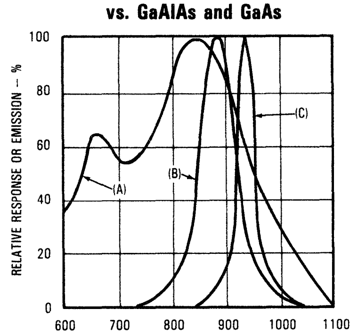
Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

Collector-Emitter Voltage	15.0 V
Emitter-Collector Voltage	5.0 V
Storage Temperature Range	−65°C to +150°C
Operating Temperature Range	−65°C to +85°C
Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)[2]	240°C
Power Dissipation	50 mW[3]

Notes:
(1) Refer to Application Bulletin 111 which discusses proper techniques for soldering Pill type devices into PC boards.
(2) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(3) Derate linearly 1.0 mW/°C above 25°C.
(4) Junction temperature maintained at 25°C.
(5) Light source is an unfiltered tungsten bulb operating at CT = 2870°K or equivalent infrared source.

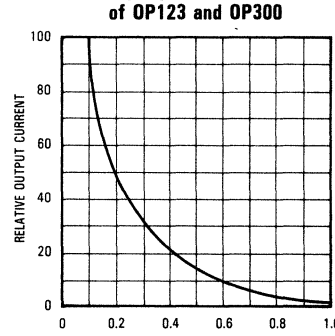
Typical Performance Curves

Spectral Response of OP300-OP305 vs. GaAlAs and GaAs



Test Conditions (LED): $T_A = T_J$ = 25°C, I_F = 100 mA, DC = 0.1%, PW = 100 μs
Peak Wavelength - λp: (A) XSTR – 850 ± 30 nm, (B) LED GaAlAs – 875 ± 20 nm, (C) LED GaAs – 930 ± 15 nm

Coupling Characteristics of OP123 and OP300

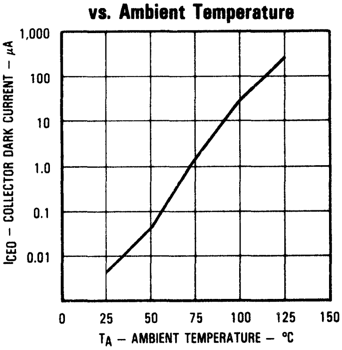


Electrical Characteristics (T_A = −40°C to +70°C unless otherwise noted)

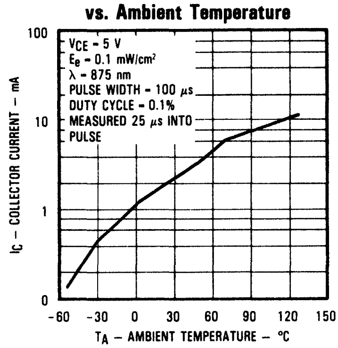
Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
$I_{C(ON)}$[4]	On-State Collector Current	OP300	0.80			mA	V_{CE} = 5.0 V, E_e = 1.00 mW/cm²[2][5]
		OP301	0.80		2.4	mA	V_{CE} = 5.0 V, E_e = 1.00 mW/cm²[2][5]
		OP302	1.80		5.4	mA	V_{CE} = 5.0 V, E_e = 1.00 mW/cm²[2][5]
		OP303	3.6		12.0	mA	V_{CE} = 5.0 V, E_e = 1.00 mW/cm²[2][5]
		OP304	7.0		21.0	mA	V_{CE} = 5.0 V, E_e = 1.00 mW/cm²[2][5]
		OP305	14.0			mA	V_{CE} = 5.0 V, E_e = 1.00 mW/cm²[2][5]
I_{CEO}	Collector Dark Current				1.00	μA	V_{CE} = 10.0 V, E_e = 0
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage		15.0			V	I_C = 100 μA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage		5.0			V	I_E = 100 μA
$V_{CE(SAT)}$[4]	Collector-Emitter Saturation Voltage	OP300, 301			1.10	V	I_C = 0.40 mA, E_e = 1.00 mW/cm²[2][5]
		OP302, 304, 305			1.10	V	I_C = 1.00 mA, E_e = 1.00 mW/cm²[2][5]

Typical Performance Curves

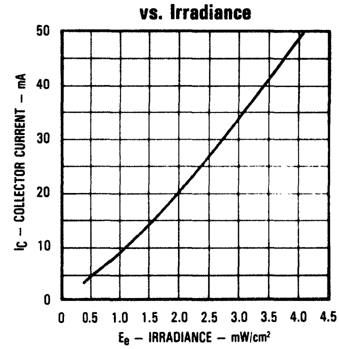
Collector Dark Current vs. Ambient Temperature



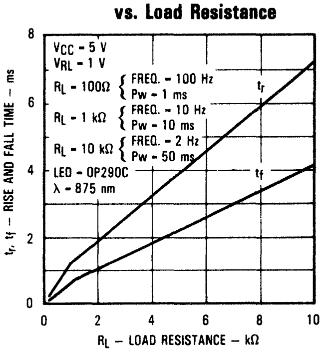
Collector Current vs. Ambient Temperature



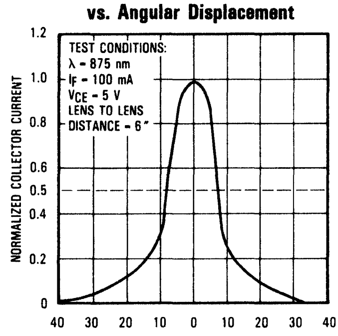
Collector Current vs. Irradiance



Rise and Fall Time vs. Load Resistance



Normalized Collector Current vs. Angular Displacement

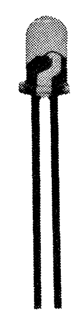


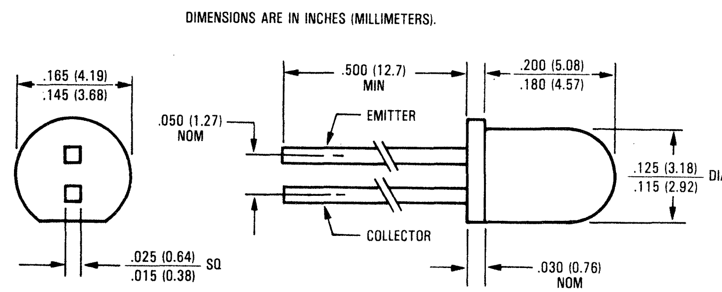
TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5093
January 1985

NPN Silicon Phototransistors
Types OP500, OP500SLD, OP500SLC, OP500SLB, OP500SLA





Features
- Wide range of collector currents
- Lensed for high sensitivity
- Low cost plastic package

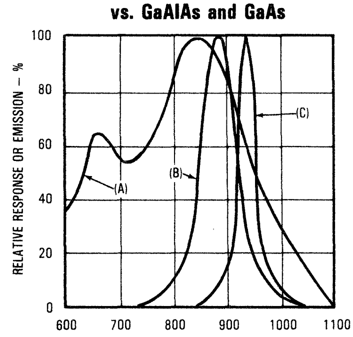
Description
The OP500 and OP500SLD through SLA each consist of an NPN silicon phototransistor mounted in a lensed, clear plastic, end looking package. The lensing effect of the package allows an acceptance half angle of 8° measured from the optical axis to the half power point. This series is mechanically and spectrally matched to the OP160SL and OP260SL series of infrared emitting diodes.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)
Collector-Emitter Voltage .... 30 V
Emitter-Collector Voltage .... 5.0 V
Storage and Operating Temperature Range .... −40°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)[1] .... 240°C
Power Dissipation .... 100 mW[2]

Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(2) Derate linearly 1.33 mW/°C above 25°C.
(3) Junction temperature maintained at 25°C.
(4) Light source is an unfiltered tungsten bulb operating at CT = 2870°K or equivalent infrared source.
(5) To calculate typical collector dark current in μA, use the formula $I_{CEO} = 10^{(0.040\,T_A - 3.4)}$ where T_A is ambient temperature in °C.

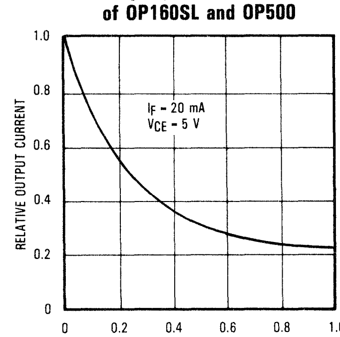
Typical Performance Curves

Photosensor Spectral Response vs. GaAlAs and GaAs



Test Conditions (LED): $T_A = T_J$ = 25°C, I_F = 100 mA, DC = 0.1%, PW = 100 μs
Peak Wavelength – λp: (A) XSTR – 850 ± 30 nm, (B) LED GaAlAs – 875 ± 20 nm, (C) LED GaAs – 930 ± 15 nm

Coupling Characteristics of OP160SL and OP500



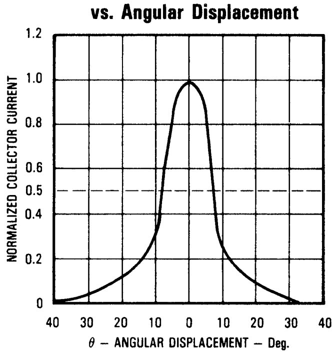
Electrical Characteristics (T_A = 25°C unless otherwise noted)

Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
$I_{C(ON)}$[3]	On-State Collector Current	OP500	4.0			mA	V_{CE} = 5.0 V, E_e = 20 mW/cm[2(4)]
		OP500SLD	10.0		24	mA	V_{CE} = 5.0 V, E_e = 20 mW/cm[2(4)]
		OP500SLC	17.0		35	mA	V_{CE} = 5.0 V, E_e = 20 mW/cm[2(4)]
		OP500SLB	25		50	mA	V_{CE} = 5.0 V, E_e = 20 mW/cm[2(4)]
		OP500SLA	40			mA	V_{CE} = 5.0 V, E_e = 20 mW/cm[2(4)]
$\Delta I_C/\Delta T$	Relative I_C Changes with Temperature			1.00		%/°C	V_{CE} = 5.0 V, E_e = 1.00 mW/cm², λ = 875 nm
I_{CEO}[5]	Collector Dark Current				100	nA	V_{CE} = 15.0 V, E_e = 0
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage		30			V	I_C = 100 μA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage		5.0			V	I_E = 100 μA
$V_{CE(SAT)}$[3]	Collector-Emitter Saturation Voltage				0.40	V	I_C = 0.50 mA, E_e = 20 mW/cm[2(4)]

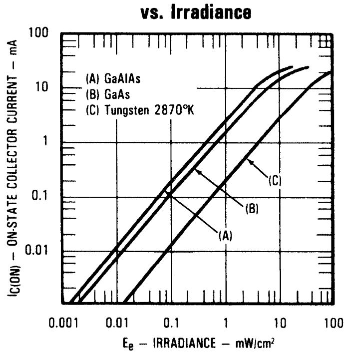
D

Typical Performance Curves

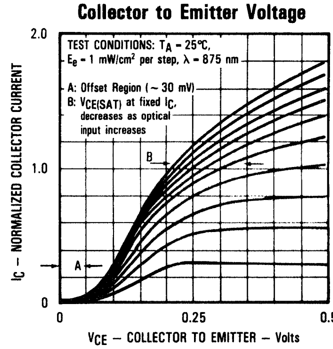
Normalized Collector Current vs. Angular Displacement



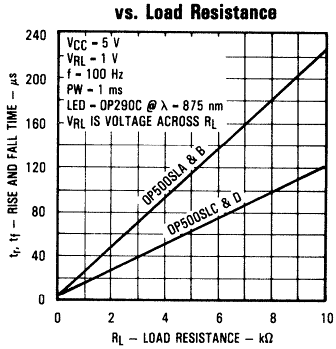
On-State Collector Current vs. Irradiance



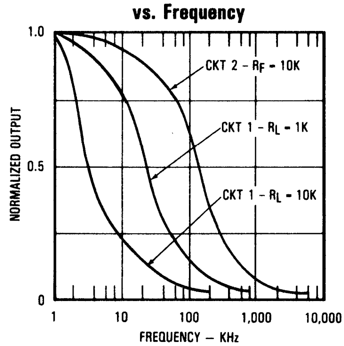
Normalized Collector Current vs. Collector to Emitter Voltage



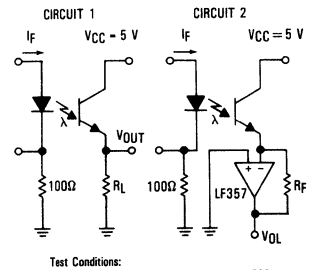
Rise and Fall Time vs. Load Resistance



Normalized Output vs. Frequency



Switching Time Test Circuit



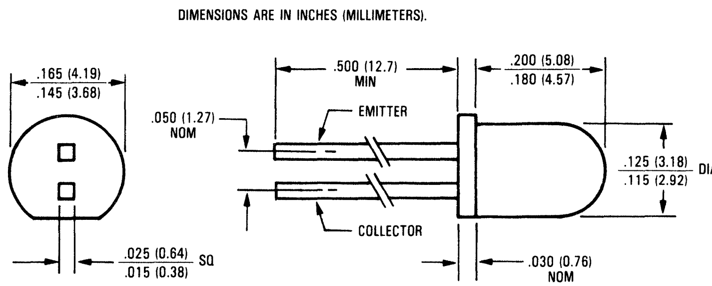
Test Conditions:
Light source is pulsed LED with t_r and t_f ≤ 500 ns.
I_F is adjusted for V_{OUT} = 1 Volt.

TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5094
January 1985

Infrared Selected NPN Silicon Phototransistors
Types OP500SR, OP500SRD, OP500SRC, OP500SRB, OP500SRA



Features
- Tested using infrared for close correlation to TRW infrared emitters
- Wide range of collector currents
- Lensed for high sensitivity
- Low cost plastic package

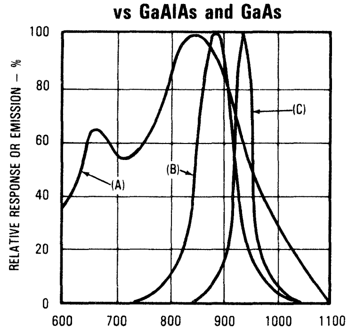
Description
The OP500SR and OP500SRD through SRA each consist of an NPN silicon phototransistor mounted in a lensed, clear plastic, end-looking package. The lensing effect of the package allows an acceptance half angle of 8° measured from the optical axis to the half power point. The series is 100% factory tested using infrared for close correlation to TRW GaAs or GaAlAs emitters and the most accurate design-in possible. This series is mechanically and spectrally matched to the OP160SL and OP260SL series of infrared emitting diodes.

Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)
Collector-Emitter Voltage .... 30 V
Emitter-Collector Voltage .... 5.0 V
Storage and Operating Temperature Range .... −40°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)[1] .... 240°C
Power Dissipation .... 100 mW[2]

Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(2) Derate linearly 1.33 mW/°C above 25°C.
(3) Junction temperature maintained at 25°C.
(4) Light source is an unfiltered GaAs LED with a peak emission wavelength of 930 nm and a radiometric intensity level which varies less than 10% over the entire lens surface of the phototransistor being tested.
(5) To calculate typical collector dark current in μA, use the formula $I_{CEO} = 10^{(0.040\,T_A - 3.4)}$ where T_A is ambient temperature in °C.

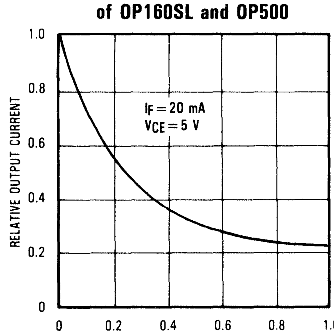
Typical Performance Curves

Photosensor Spectral Response vs GaAlAs and GaAs



Test Conditions (LED): $T_A = T_J = 25°C$, $I_F = 100$ mA, DC = 0.1%, PW = 100 μs
Peak Wavelength – λp: (A) XSTR – 850 ±30 nm,
(B) LED GaAlAs – 875 ±20 nm,
(C) LED GaAs – 930 ±15 nm

Coupling Characteristics of OP160SL and OP500



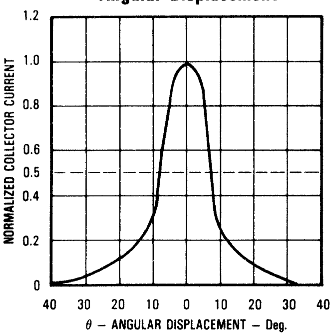
Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
$I_{C(ON)}$ [3]	On-State Collector Current	OP500SR	0.080			mA	$V_{CE} = 5.0$ V, $E_e = 0.130$ mW/cm² [4]
		OP500SRD	0.080		0.24	mA	$V_{CE} = 5.0$ V, $E_e = 0.130$ mW/cm² [4]
		OP500SRC	0.160		0.48	mA	$V_{CE} = 5.0$ V, $E_e = 0.130$ mW/cm² [4]
		OP500SRB	0.32		0.96	mA	$V_{CE} = 5.0$ V, $E_e = 0.130$ mW/cm² [4]
		OP500SRA	0.64			mA	$V_{CE} = 5.0$ V, $E_e = 0.130$ mW/cm² [4]
$\Delta I_C/\Delta T$	Relative I_C Changes with Temperature			1.00		%/°C	$V_{CE} = 5.0$ V, $E_e = 1.00$ mW/cm², $\lambda = 930$ nm
I_{CEO} [5]	Collector Dark Current				100	nA	$V_{CE} = 10.0$ V, $E_e = 0$
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage		30			V	$I_C = 100$ μA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage		5.0			V	$I_E = 100$ μA
$V_{CE(SAT)}$ [3]	Collector-Emitter Saturation Voltage				0.50	V	$I_C = 50$ μA, $E_e = 0.130$ mW/cm² [4], $\lambda = 930$ nm

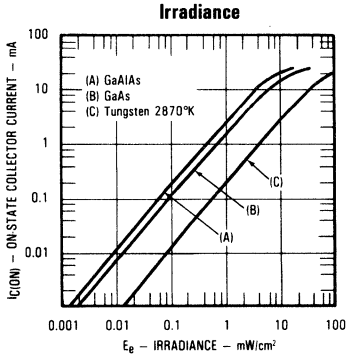
D

Typical Performance Curves

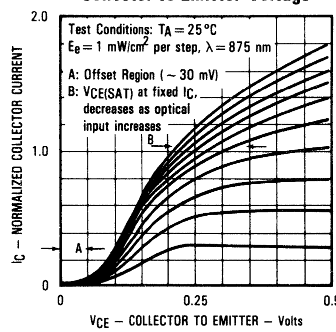
Normalized Collector Current vs Angular Displacement



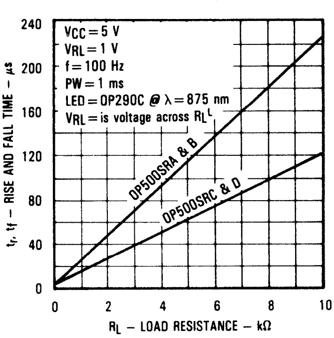
On-State Collector Current vs Irradiance



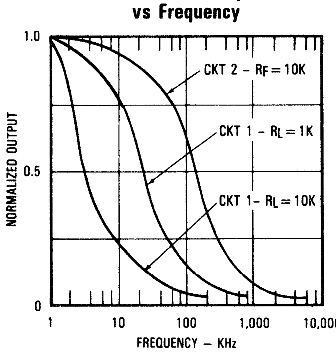
Normalized Collector Current vs Collector-to-Emitter Voltage



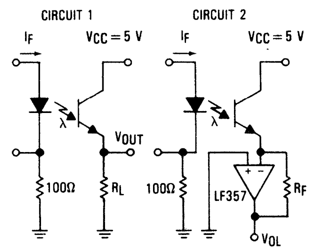
Rise and Fall Time vs Load Resistance



Normalized Output vs Frequency



Switching Time Test Circuit



Test Conditions:
Light source is pulsed LED with t_r and $t_f \leq 500$ ns.
I_F is adjusted for $V_{OUT} = 1$ Volt.

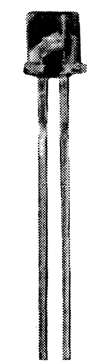
TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

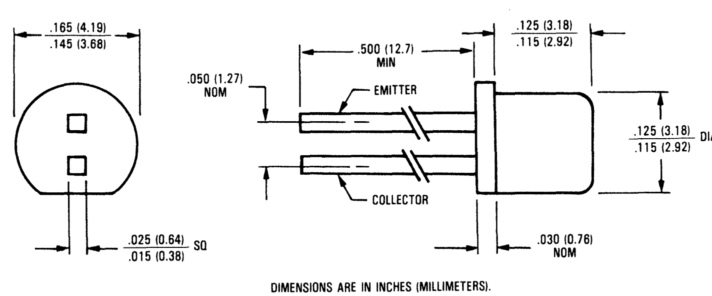
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5095
January 1985

TRW

NPN Silicon Phototransistor
Type OP500W





DIMENSIONS ARE IN INCHES (MILLIMETERS).

Features
- Flat lensed for wide acceptance angle
- .050″ lead spacing
- Low cost plastic miniature plastic end-looking T-1 package.

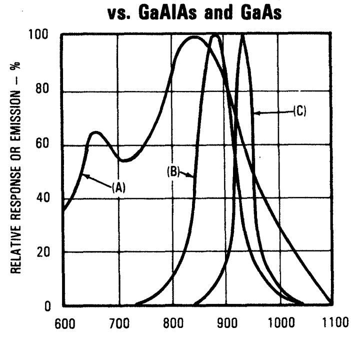
Description
The OP500W consists of an NPN silicon phototransistor mounted in a flat lensed, clear plastic, end-looking package. The flat lens allows an acceptance half angle of 45° measured from the optical axis to the half power point. The OP500W is mechanically and spectrally matched to the OP160W infrared emitting diodes.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)
Collector-Emitter Voltage .... 30 V
Emitter-Collector Voltage .... 5.0 V
Storage and Operating Temperature Range .... −40°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)[1] .... 240°C
Power Dissipation .... 100 mW[2]

Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(2) Derate linearly 1.33 mW/°C above 25°C.
(3) Junction temperature maintained at 25°C.
(4) Light source is an unfiltered tungsten bulb operating at CT = 2870°K or equivalent infrared source.
(5) To calculate typical collector dark current in µA, use the formula $I_{CEO} = 10^{(0.040\ T_A - 3.4)}$ where T_A is ambient temperature in °C.

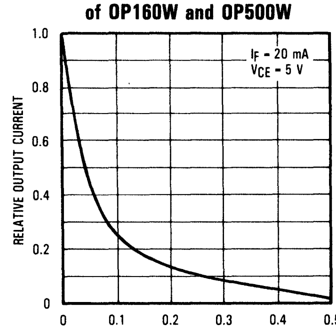
Typical Performance Curves

Photosensor Spectral Response vs. GaAlAs and GaAs



Test Conditions (LED): T_A = T_J = 25°C, I_F = 100 mA, DC = 0.1%, PW = 100 µs
Peak Wavelength – λp: (A) XSTR – 850 ± 30 nm, (B) LED GaAlAs – 875 ± 20 nm, (C) LED GaAs – 930 ± 15 nm

Coupling Characteristics of OP160W and OP500W



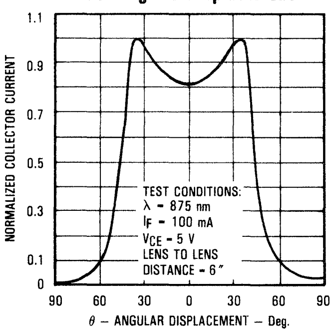
Type OP500W

Electrical Characteristics (T_A = 25°C unless otherwise noted)

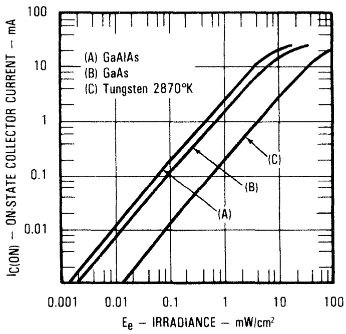
Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_{C(ON)}$[3]	On-State Collector Current	0.50			mA	V_{CE} = 5.0 V, E_e = 20 mW/cm²[4]
$\Delta I_C/\Delta T$	Relative I_C Changes with Temperature		1.00		%/°C	V_{CE} = 5.0 V, E_e = 1.00 mW/cm², λ = 875 nm
I_{CEO}[5]	Collector Dark Current			100	nA	V_{CE} = 15.0 V, E_e = 0
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	30			V	I_C = 100 μA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	5.0			V	I_E = 100 μA
$V_{CE(SAT)}$[3]	Collector-Emitter Saturation Voltage			0.40	V	I_C = 250 μA, E_e = 20 mW/cm²[4]

Typical Performance Curves

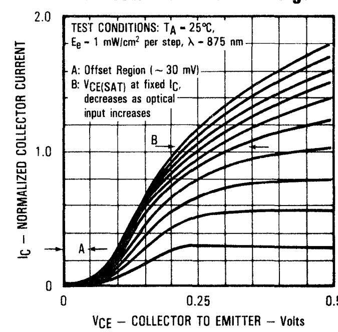
Normalized Collector Current vs. Angular Displacement



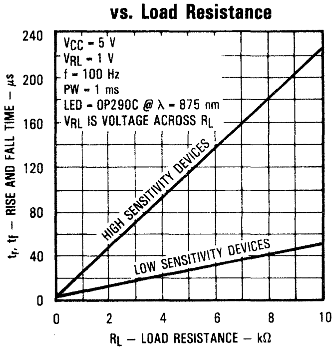
On-State Collector Current vs. Irradiance



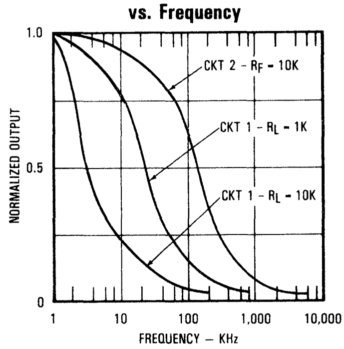
Normalized Collector Current vs. Collector to Emitter Voltage



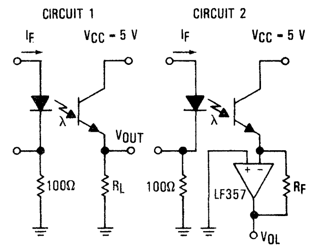
Rise and Fall Time vs. Load Resistance



Normalized Output vs. Frequency



Switching Time Test Circuit

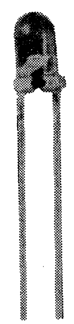


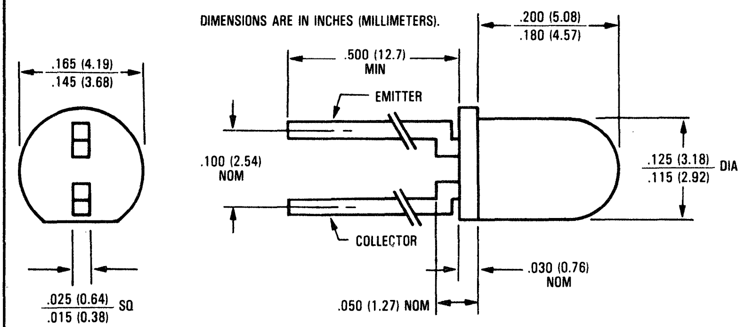
Test Conditions:
Light source is pulsed LED with t_r and $t_f \leq$ 500 ns.
I_F is adjusted for V_{OUT} = 1 Volt.

Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5097
January 1985

NPN Silicon Phototransistors
Types OP501, OP501SLD, OP501SLC, OP501SLB, OP501SLA





Features
- 0.100″ (2.54 mm) lead spacing
- Wide range of collector currents
- Lensed for high sensitivity

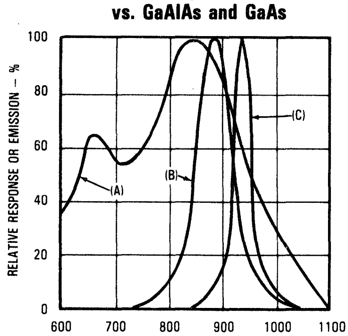
Description
The OP501 and OP501SLD through SLA each consist of an NPN silicon phototransistor mounted in a lensed, clear plastic, end looking package. The lensing effect of the package allows an acceptance half angle of 8° measured from the optical axis to the half power point. This series is identical to the OP500 except for lead spacing. It is mechanically and spectrally matched to the OP160SL and OP161SL series of infrared emitting diodes.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)
Collector-Emitter Voltage .... 30 V
Emitter-Collector Voltage .... 5.0 V
Storage and Operating Temperature Range .... −40°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)(1) .... 240°C
Power Dissipation .... 100 mW(2)

Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(2) Derate linearly 1.33 mW/°C above 25°C.
(3) Junction temperature maintained at 25°C.
(4) Light source is an unfiltered tungsten bulb operating at CT = 2870°K or equivalent infrared source.
(5) To calculate typical collector dark current in μA, use the formula $I_{CEO} = 10^{(0.040 T_A - 3.4)}$ where T_A is ambient temperature in °C.

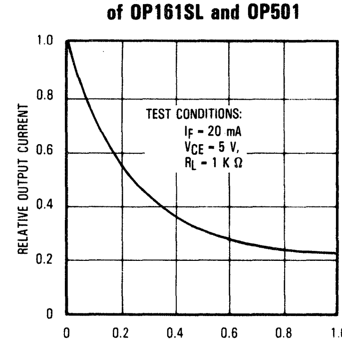
Typical Performance Curves

Photosensor Spectral Response vs. GaAlAs and GaAs



Test Conditions (LED): $T_A = T_J$ = 25°C, I_F = 100 mA, DC = 0.1%, PW = 100 μs
Peak Wavelength – λp: (A) XSTR – 850 ± 30 nm, (B) LED GaAlAs – 875 ± 20 nm, (C) LED GaAs – 930 ± 15 nm

Coupling Characteristics of OP161SL and OP501



Types OP501, OP501SLD, OP501SLC, OP501SLB, OP501SLA

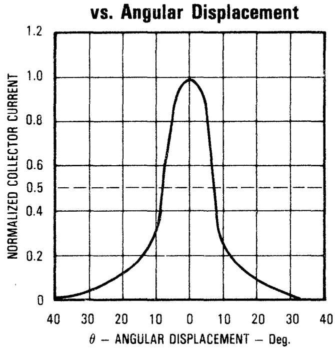
Electrical Characteristics (T_A = 25°C unless otherwise noted)

Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
$I_{C(ON)}$[3]	On-State Collector Current	OP501	4.0			mA	V_{CE} = 5.0 V, E_e = 20 mW/cm²[2][4]
		OP501SLD	10.0		24	mA	V_{CE} = 5.0 V, E_e = 20 mW/cm²[2][4]
		OP501SLC	17.0		35	mA	V_{CE} = 5.0 V, E_e = 20 mW/cm²[2][4]
		OP501SLB	25		50	mA	V_{CE} = 5.0 V, E_e = 20 mW/cm²[2][4]
		OP501SLA	40			mA	V_{CE} = 5.0 V, E_e = 20 mW/cm²[2][4]
$\Delta I_C/\Delta T$	Relative I_C Changes with Temperature			1.00		%/°C	V_{CE} = 5.0 V, E_e = 1.00 mW/cm², λ = 875 nm
I_{CEO}[5]	Collector Dark Current				100	nA	V_{CE} = 10.0 V, E_e = 0
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage		30			V	I_C = 100 μA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage		5.0			V	I_E = 100 μA
$V_{CE(SAT)}$[3]	Collector-Emitter Saturation Voltage				0.40	V	I_C = 500 μA, E_e = 20 mW/cm²[2][4]

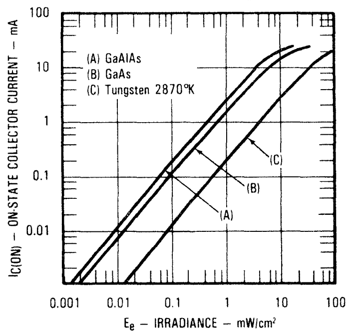
D

Typical Performance Curves

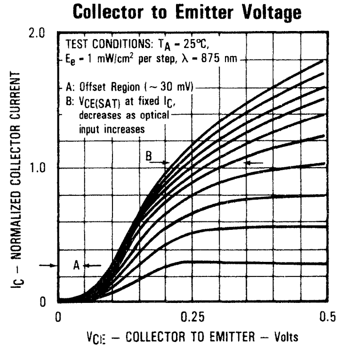
Normalized Collector Current vs. Angular Displacement



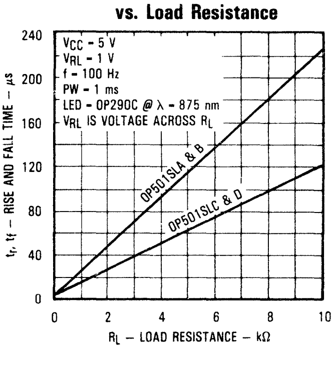
On-State Collector Current vs. Irradiance



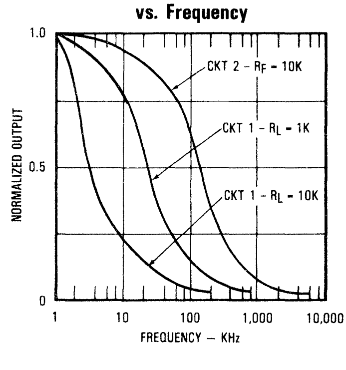
Normalized Collector Current vs. Collector to Emitter Voltage



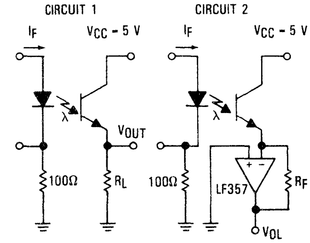
Rise and Fall Time vs. Load Resistance



Normalized Output vs. Frequency



Switching Time Test Circuit



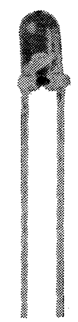
Test Conditions:
Light source is pulsed LED with t_r and $t_f \leq$ 500 ns.
I_F is adjusted for V_{OUT} = 1 Volt.

TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

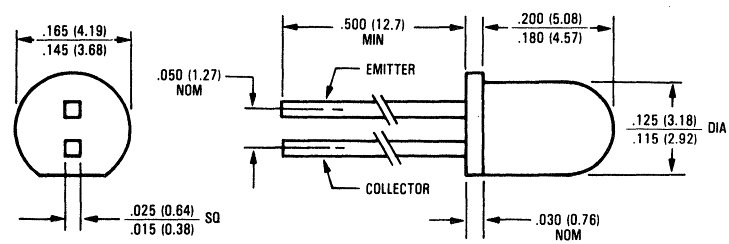
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5098
January 1985

Infrared Selected NPN Silicon Phototransistors
Types OP501SR, OP501SRD, OP501SRC, OP501SRB, OP501SRA



DIMENSIONS ARE IN INCHES (MILLIMETERS).



Features
- Tested using infrared for close correlation to TRW infrared emitters
- 0.100″ (2.54 mm) lead spacing
- Wide range of collector currents
- Lensed for high sensitivity

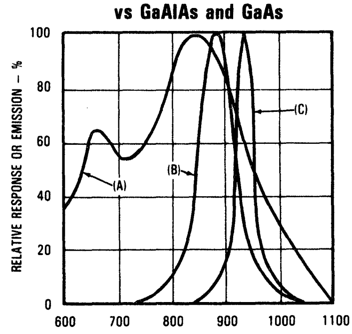
Description
The OP501SR and OP501SRD through SRA each consist of an NPN silicon phototransistor mounted in a lensed, clear plastic, end-looking package. The lensing effect of the package allows an acceptance half angle of 8° measured from the optical axis to the half power point. This series is identical to the OP500 except for lead spacing. The series is 100% factory tested using infrared for close correlation to TRW GaAs or GaAlAs emitters and the most accurate design-in possible. This series is mechanically and spectrally matched to the OP160SL and OP260SL series of infrared emitting diodes.

Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)
Collector-Emitter Voltage .... 30 V
Emitter-Collector Voltage .... 5.0 V
Storage and Operating Temperature Range .... −40°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)[1] .... 240°C
Power Dissipation .... 100 mW[2]

Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(2) Derate linearly 1.33 mW/°C above 25°C.
(3) Junction temperature maintained at 25°C.
(4) Light source is an unfiltered GaAs LED with a peak emission wavelength of 930 nm and a radiometric intensity level which varies less than 10% over the entire lens surface of the phototransistor being tested.
(5) To calculate typical collector dark current in μA, use the formula $I_{CEO} = 10^{(0.040\ T_A - 3.4)}$ where T_A is ambient temperature in °C.

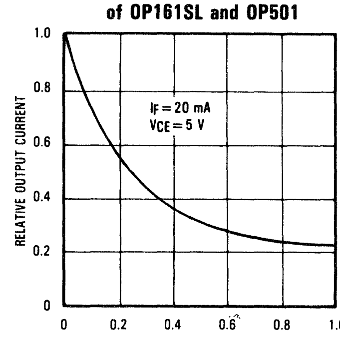
Typical Performance Curves

Photosensor Spectral Response vs GaAlAs and GaAs



Test Conditions (LED): $T_A = T_J = 25°C$, $I_F = 100$ mA, DC = 0.1%, PW = 100 μs
Peak Wavelength – λ_p: (A) XSTR – 850 ±30 nm, (B) LED GaAlAs – 875 ±20 nm, (C) LED GaAs – 930 ±15 nm

Coupling Characteristics of OP161SL and OP501



Types OP501SR, OP501SRD, OP501SRC, OP501SRB, OP501SRA

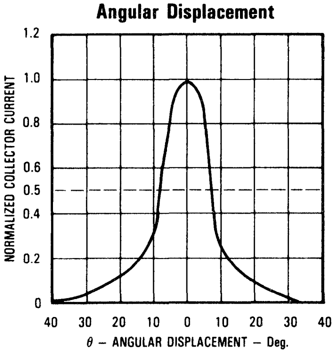
Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
$I_{C(ON)}$ (3)	On-State Collector Current	OP501SR	0.080			mA	$V_{CE} = 5.0$ V, $E_e = 0.130$ mW/cm² (4)
		OP501SRD	0.080		0.24	mA	$V_{CE} = 5.0$ V, $E_e = 0.130$ mW/cm² (4)
		OP501SRC	0.160		0.48	mA	$V_{CE} = 5.0$ V, $E_e = 0.130$ mW/cm² (4)
		OP501SRB	0.32		0.96	mA	$V_{CE} = 5.0$ V, $E_e = 0.130$ mW/cm² (4)
		OP501SRA	0.64			mA	$V_{CE} = 5.0$ V, $E_e = 0.130$ mW/cm² (4)
$\Delta I_C/\Delta T$	Relative I_C Changes with Temperature			1.00		%/°C	$V_{CE} = 5.0$ V, $E_e = 1.00$ mW/cm², $\lambda = 930$ nm
I_{CEO} (5)	Collector Dark Current				100	nA	$V_{CE} = 10.0$ V, $E_e = 0$
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage		30			V	$I_C = 100$ μA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage		5.0			V	$I_E = 100$ μA
$V_{CE(SAT)}$ (3)	Collector-Emitter Saturation Voltage				0.50	V	$I_C = 50$ μA, $E_e = 0.130$ mW/cm² (4), $\lambda = 930$ nm

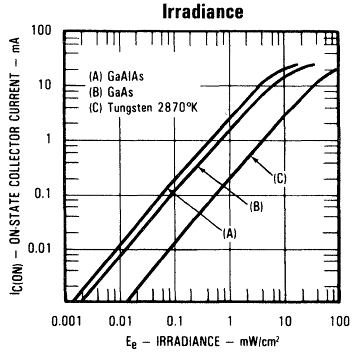
D

Typical Performance Curves

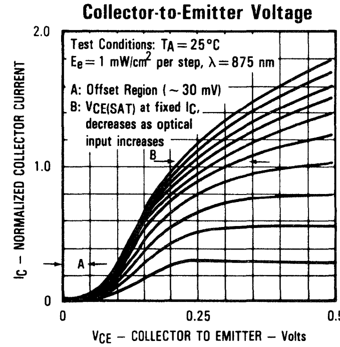
Normalized Collector Current vs Angular Displacement



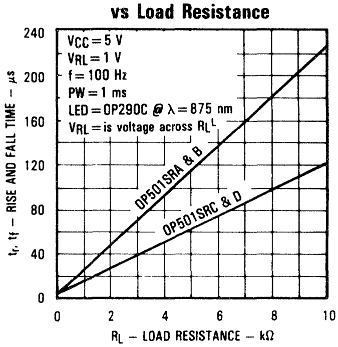
On-State Collector Current vs Irradiance



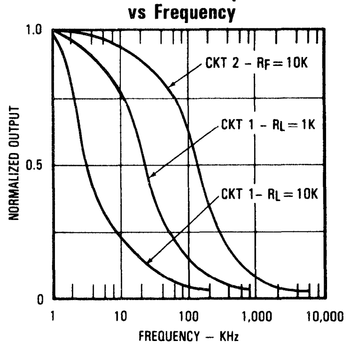
Normalized Collector Current vs Collector-to-Emitter Voltage



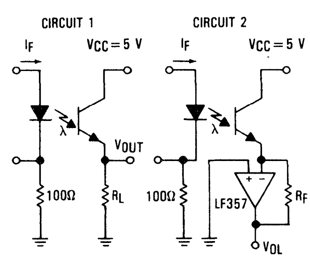
Rise and Fall Time vs Load Resistance



Normalized Output vs Frequency



Switching Time Test Circuit



Test Conditions:
Light source is pulsed LED with t_r and $t_f \leq 500$ ns.
I_F is adjusted for $V_{OUT} = 1$ Volt.

TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958

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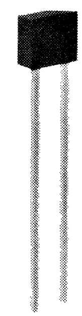
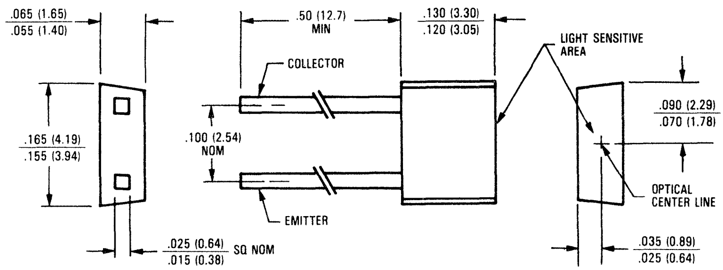
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5112
January 1985

NPN Silicon Phototransistors
Types OP508FC, OP508FB, OP508FA





DIMENSIONS ARE IN INCHES (MILLIMETERS).

Features
- Flat lensed for wide acceptance angle
- Can be mounted on 0.100″ (2.54 mm) hole centers
- Low cost plastic package
- Mechanically and spectrally matched to the OP168F and OP268F infrared emitting diodes.

Description
The OP508F series consist of NPN silicon phototransistors mounted in flat, black plastic, end looking packages. The flat sensing surface allows an acceptance half angle of 60° measured from the optical axis to the half power point. The black plastic package significantly reduces ambient light noise. These devices can be mounted on 0.100″ (2.54 mm) hole centers making them an ideal low cost alternate to hermetic pill discretes.

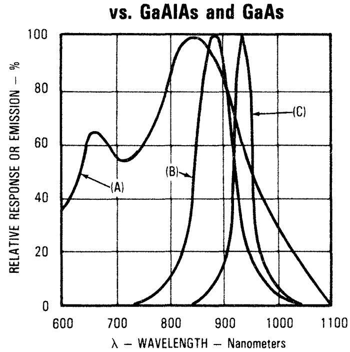
Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

Collector-Emitter Voltage . . . . 30 V
Emitter-Collector Voltage . . . . 5.0 V
Storage and Operating Temperature Range . . . . −40°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)[1] . . . . 240°C
Power Dissipation . . . . 100 mW[2]

Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(2) Derate linearly 1.33 mW/°C above 25°C.
(3) Junction temperature maintained at 25°C.
(4) Light source is an unfiltered tungsten bulb operating at CT = 2870°K or equivalent infrared source.
(5) To calculate typical collector dark current in μA, use the formula $I_{CEO} = 10^{(0.040\ T_A - 3.4)}$ where T_A is ambient temperature in °C.

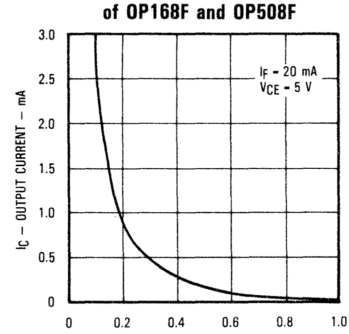
Typical Performance Curves

Photosensor Spectral Response vs. GaAlAs and GaAs



Test Conditions (LED): $T_A = T_J$ = 25°C, I_F = 100 mA, DC = 0.1%, PW = 100 μs
Peak Wavelength − λp: (A) XSTR — 850 ± 30 nm, (B) LED GaAlAs — 875 ± 20 nm, (C) LED GaAs — 930 ± 15 nm

Coupling Characteristics of OP168F and OP508F



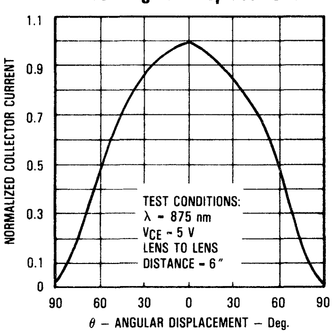
Types OP508FC, OP508FB, OP508FA

Electrical Characteristics (T_A = 25°C unless otherwise noted)

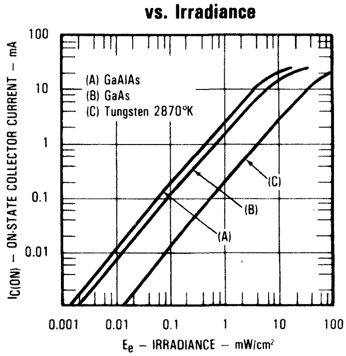
Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
$I_{C(ON)}$	On-State Collector Current	OP508FC	0.50			mA	V_{CE} = 5.0 V, E_e = 20 mW/cm²(2)(4)
		OP508FB	1.20		8.4	mA	V_{CE} = 5.0 V, E_e = 20 mW/cm²(2)(4)
		OP508FA	3.6			mA	V_{CE} = 5.0 V, E_e = 20 mW/cm²(2)(4)
$I_C/\Delta T$	Relative I_C Changes with Temperature			1.00		%/°C	V_{CE} = 5.0 V, E_e = 1.00 mW/cm², λ = 875 nm
I_{CEO}(5)	Collector Dark Current				100	nA	V_{CE} = 10.0 V, E_e = 0
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage		30			V	I_C = 100 μA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage		5.0			V	I_E = 100 μA
$V_{CE(SAT)}$(3)	Collector-Emitter Saturation Voltage				0.40	V	I_C = 1.00 mA, E_e = 20 mW/cm²(2)(4)

Typical Performance Curves

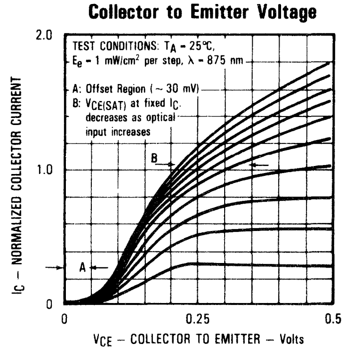
Normalized Collector Current vs. Angular Displacement



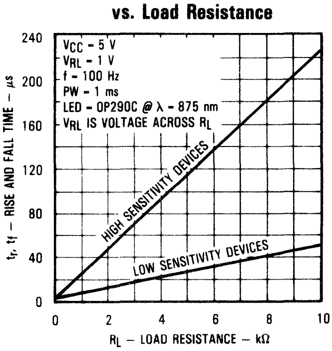
On-State Collector Current vs. Irradiance



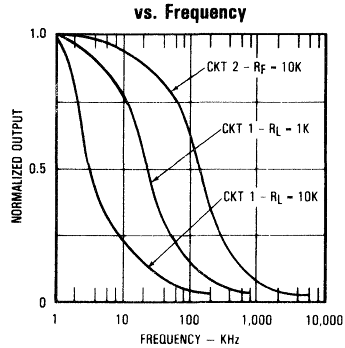
Normalized Collector Current vs. Collector to Emitter Voltage



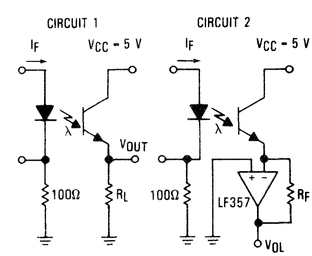
Rise and Fall Time vs. Load Resistance



Normalized Output vs. Frequency



Switching Time Test Circuit



Test Conditions:
Light source is pulsed LED with t_r and $t_f \leq$ 500 ns.
I_F is adjusted for V_{OUT} = 1 Volt.

TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

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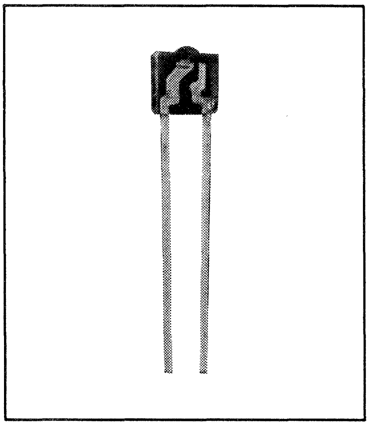
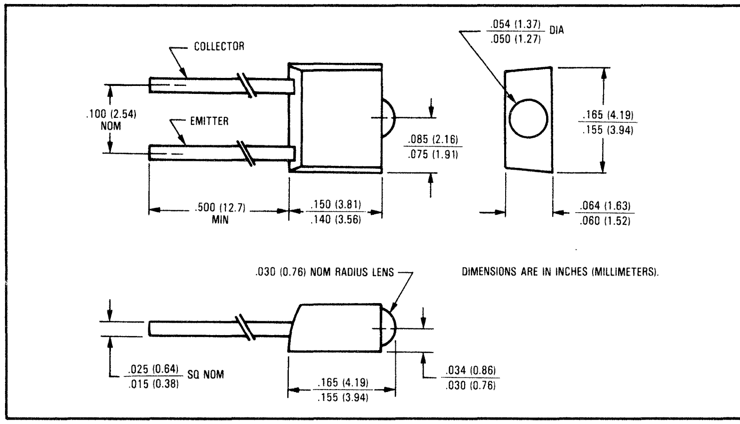
NPN Silicon Phototransistors
Types OP509, OP509SLD, OP509SLC





Features
- Lensed for high sensitivity
- Can be mounted on 0.100″ (2.54 mm) hole centers
- Low cost plastic package
- Mechanically and spectrally matched to the OP169SL and OP269SL series of infrared emitting diodes

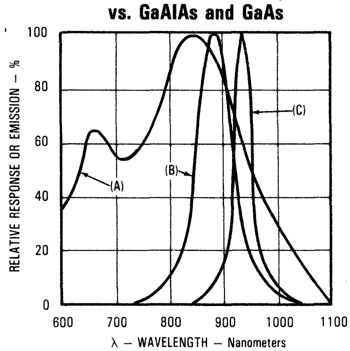
Description
The OP509, OP509SLD, and OP509SLC each consist of an NPN silicon phototransistor mounted in a lensed, clear plastic, end looking package. The lensing effect of the package allows an acceptance half angle of 25° measured from the optical axis to the half power point.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)
Collector-Emitter Voltage . . . . . 30 V
Emitter-Collector Voltage . . . . . 5.0 V
Storage and Operating Temperature Range . . . . . −40°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)[1] . . . . . 240°C
Power Dissipation . . . . . 100 mW[2]

Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(2) Derate linearly 1.33 mW/°C above 25°C.
(3) Junction temperature maintained at 25°C.
(4) Light source is an unfiltered tungsten bulb operating at CT = 2870°K or equivalent infrared source.
(5) To calculate typical collector dark current in μA, use the formula $I_{CEO} = 10^{(0.040\,T_A - 3.4)}$ where T_A is ambient temperature in °C.

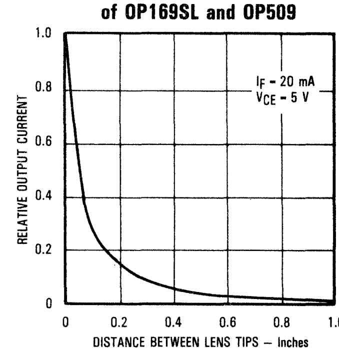
Typical Performance Curves

Photosensor Spectral Response vs. GaAlAs and GaAs



Test Conditions (LED): $T_A = T_J$ = 25°C, I_F = 100 mA, DC = 0.1%, PW = 100 μs
Peak Wavelength – λp: (A) XSTR – 850 ± 30 nm, (B) LED GaAlAs – 875 ± 20 nm, (C) LED GaAs – 930 ± 15 nm

Coupling Characteristics of OP169SL and OP509



Types OP509, OP509SLD, OP509SLC

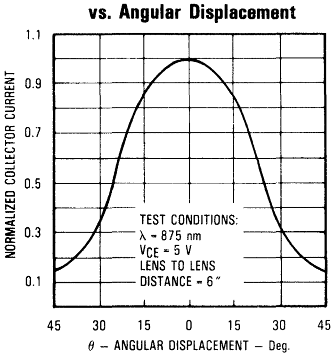
Electrical Characteristics (T_A = 25°C unless otherwise noted)

Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
$I_{C(ON)}$[3]	On-State Collector Current	OP509	0.050			mA	V_{CE} = 5.0 V, E_e = 1.00 mW/cm²[4]
		OP509SLD	0.170		0.50	mA	V_{CE} = 5.0 V, E_e = 1.00 mW/cm²[4]
		OP509SLC	0.30			mA	V_{CE} = 5.0 V, E_e = 1.00 mW/cm²[4]
$\Delta I_C/\Delta T$	Relative I_C Changes with Temperature			1.00		%/°C	V_{CE} = 5.0 V, E_e = 1.00 mW/cm², λ = 875 nm
I_{CEO}[5]	Collector Dark Current				100	nA	V_{CE} = 10.0 V, E_e = 0
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage		30			V	I_C = 100 μA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage		5.0			V	I_E = 100 μA
$V_{CE(SAT)}$[3]	Collector-Emitter Saturation Voltage				0.40	V	I_C = 250 μA, E_e = 5.0 mW/cm²[4]

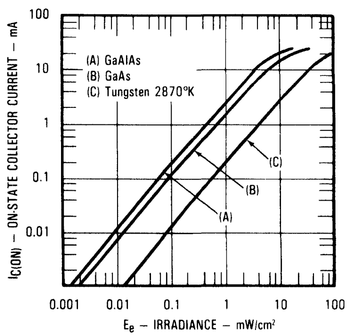
D

Typical Performance Curves

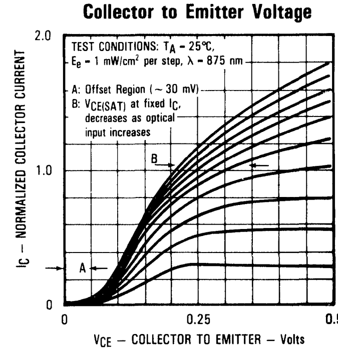
Normalized Collector Current vs. Angular Displacement



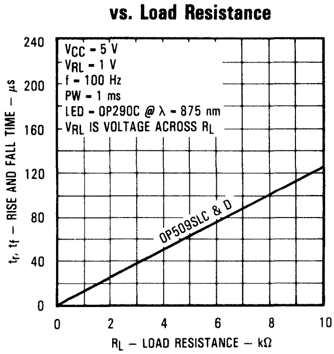
On-State Collector Current vs. Irradiance



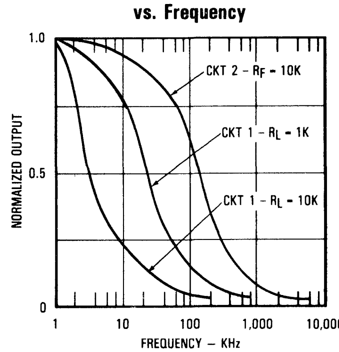
Normalized Collector Current vs. Collector to Emitter Voltage



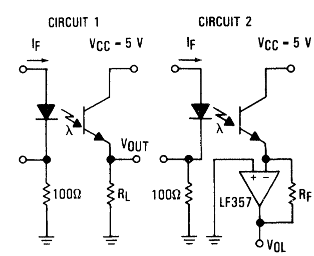
Rise and Fall Time vs. Load Resistance



Normalized Output vs. Frequency



Switching Time Test Circuit



Test Conditions:
Light source is pulsed LED with t_r and t_f ≤ 500 ns.
I_F is adjusted for V_{OUT} = 1 Volt.

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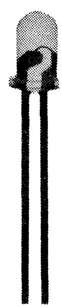
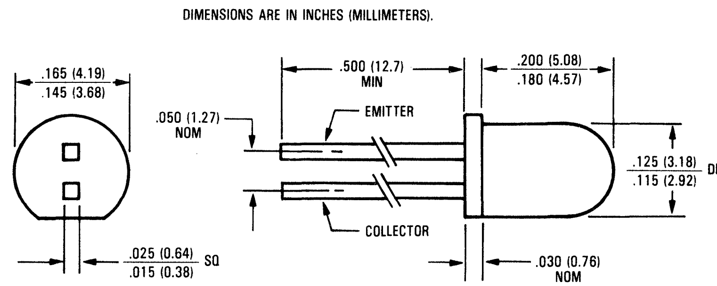
TRW Electronic Components Group

Product Bulletin 5116
January 1985

NPN Silicon Photodarlington
Type OP530





Features
- Lensed for high sensitivity
- High current gain
- Low cost plastic package

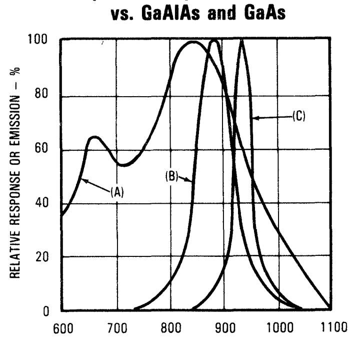
Description
The OP530 consists of an NPN silicon photodarlington mounted in a lensed, clear plastic, end looking package. The lensing effect allows an acceptance half angle of 8° measured from the optical axis to the half power point.
Photodarlington devices are normally used in applications where light signal levels are low and more current gain is needed than is possible with phototransistors. The OP530 is mechanically and spectrally matched to the OP160SL and OP260SL series of infrared emitting diodes.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)
Collector-Emitter Voltage . . . . 15.0 V
Emitter-Collector Voltage . . . . 5.0 V
Storage and Operating Temperature Range . . . . −40°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)[1] . . . . 240°C
Power Dissipation . . . . 100 mW[2]

Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(2) Derate linearly 1.33 mW/°C above 25°C.
(3) Junction temperature maintained at 25°C.
(4) Light source is an unfiltered tungsten bulb operating at CT = 2870°K or equivalent infrared source.

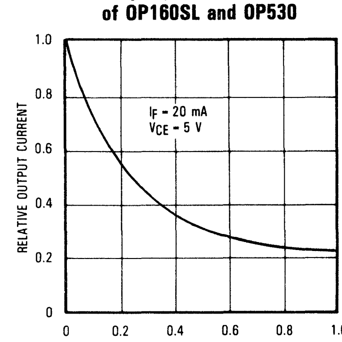
Typical Performance Curves

Spectral Response of OP530 vs. GaAlAs and GaAs



Test Conditions (LED): $T_A = T_J$ = 25°C, I_F = 100 mA, DC = 0.1%, PW = 100 μs
Peak Wavelength − λp: (A) XSTR − 850 ± 30 nm, (B) LED GaAlAs − 875 ± 20 nm, (C) LED GaAs − 930 ± 15 nm

Coupling Characteristics of OP160SL and OP530



Type OP530

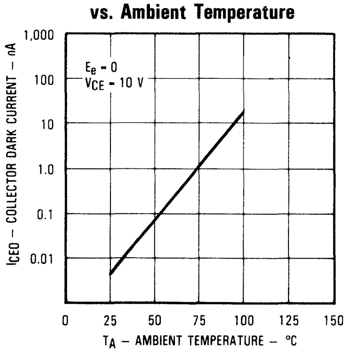
D

Electrical Characteristics (T_A = 25°C unless otherwise noted)

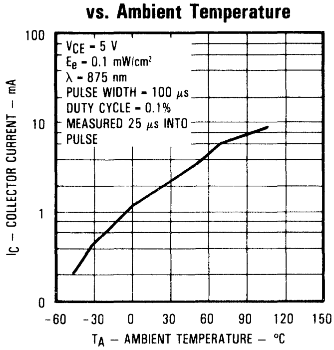
Symbol	Parameter	Min.	Max.	Units	Test Conditions
$I_{C(ON)}$[3]	On-State Collector Current	5.0		mA	V_{CE} = 5.0 V, E_e = 0.50 mW/cm²[(4)]
I_{CEO}	Collector Dark Current		100	nA	V_{CE} = 10.0 V, E_e = 0
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	15.0		V	I_C = 1.00 mA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	5.0		V	I_E = 100 μA
$V_{CE(SAT)}$[3]	Collector-Emitter Saturation Voltage		1.10	V	I_C = 2.5 mA, E_e = 0.50 mW/cm²[(4)]

Typical Performance Curves

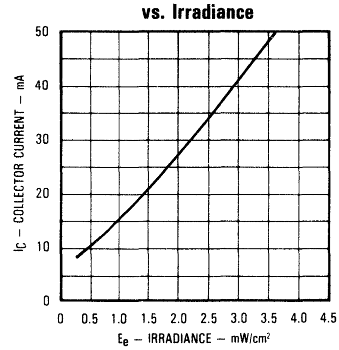
Collector Dark Current vs. Ambient Temperature



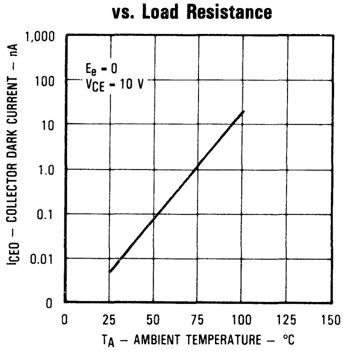
Collector Current vs. Ambient Temperature



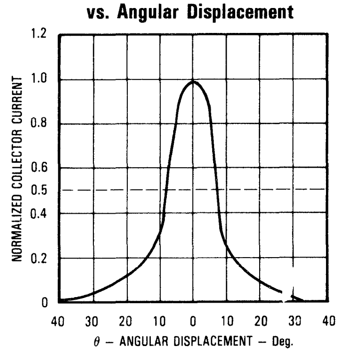
Collector Current vs. Irradiance



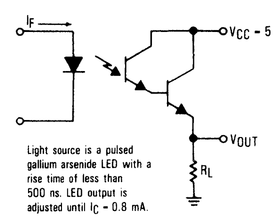
Rise and Fall Time vs. Load Resistance



Normalized Collector Current vs. Angular Displacement



Switching Time Test Circuit



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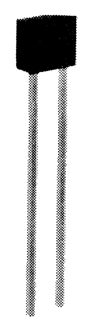
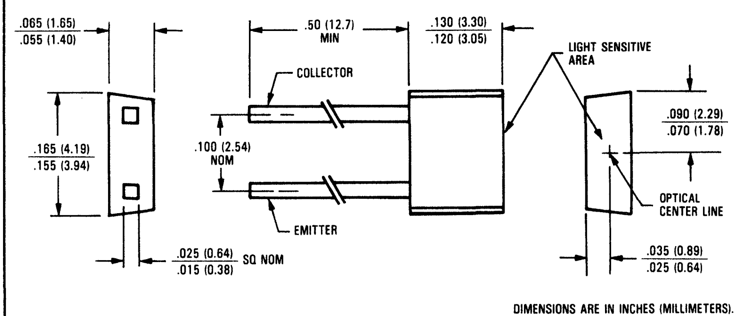
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5118
January 1985

NPN Silicon Photodarlington
Types OP538F, OP538FC, OP538FB, OP538FA





Features
- Flat lensed for wide acceptance angle
- Can be mounted on 0.100″ (2.54 mm) hole centers
- Low cost plastic package
- Mechanically matched to the OP168F and OP268F infrared emitting diodes

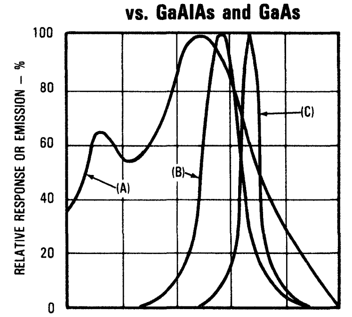
Description
The OP538F series consists of NPN silicon photodarlingtons mounted in flat lensed, black plastic, end looking packages. The flat sensing surface allows an acceptance half angle of 65° measured from the optical axis to the half power point. The black plastic package significantly reduces ambient light noise. These devices can be mounted on 0.100″ (2.54 mm) hole centers making them an ideal low cost alternative to hermetic pill discretes.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)
Collector-Emitter Voltage . . . . . 15.0 V
Emitter-Collector Voltage . . . . . 5.0 V
Storage and Operating Temperature Range . . . . . −40°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)[1] . . . . . 240°C
Power Dissipation . . . . . 100 mW[2]

Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(2) Derate linearly 1.33 mW/°C above 25°C.
(3) Light source is an unfiltered tungsten bulb operating at CT = 2870°K or equivalent infrared source.
(4) Due to high gain of photodarlington, a load resistor should be used to avoid thermal runaways.

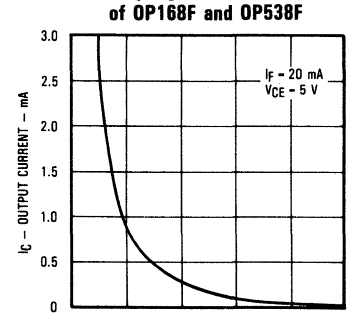
Typical Performance Curves

Photosensor Spectral Response vs. GaAlAs and GaAs



Test Conditions (LED): $T_A = T_J = 25°C$, $I_F = 100$ mA, DC = 0.1%, PW = 100 μs
Peak Wavelength – λp: (A) XSTR – 850 ± 30 nm, (B) LED GaAlAs – 875 ± 20 nm, (C) LED GaAs – 930 ± 15 nm

Coupling Characteristics of OP168F and OP538F



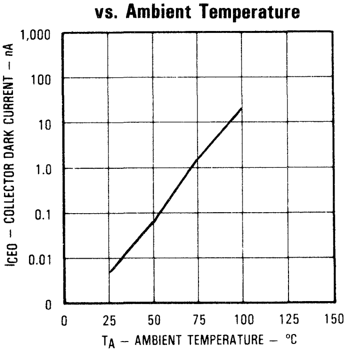
Types OP538F, OP538FC, OP538FB, OP538FA

Electrical Characteristics (T_A = 25°C unless otherwise noted)

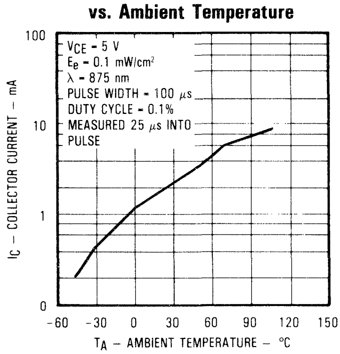
Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
$I_{C(ON)}$[4]	On-State Collector Current	OP538F	1.00			mA	V_{CE} = 5.0 V, E_e = 1.00 mW/cm²[2][3]
		OP538FC	2.4			mA	V_{CE} = 5.0 V, E_e = 1.00 mW/cm²[2][3]
		OP538FB	3.2		7.2	mA	V_{CE} = 5.0 V, E_e = 1.00 mW/cm²[2][3]
		OP538FA	4.0			mA	V_{CE} = 5.0 V, E_e = 1.00 mW/cm²[2][3]
I_{CEO}	Collector Dark Current				225	nA	V_{CE} = 10.0 V, E_e = 0
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage		15.0			V	I_C = 1.00 mA, E_e = 0
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage		5.0			V	I_E = 100 μA, E_e = 0
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage				1.00	V	I_C = 0.50 mA, E_e = 1.00 mW/cm²[2][3]

Typical Performance Curves

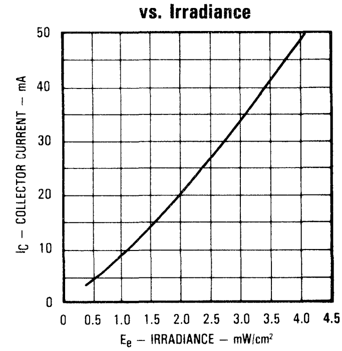
Collector Dark Current vs. Ambient Temperature



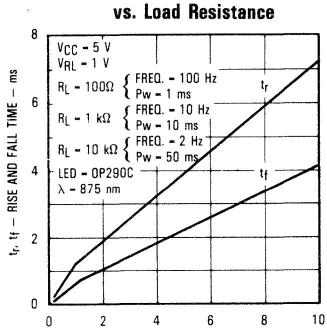
Collector Current vs. Ambient Temperature



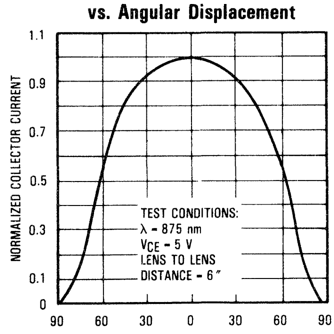
Collector Current vs. Irradiance



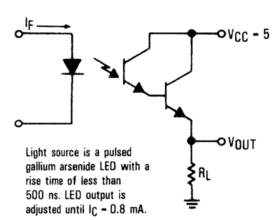
Rise and Fall Time vs. Load Resistance



Normalized Collector Current vs. Angular Displacement



Switching Time Test Circuit



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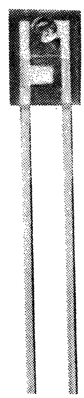
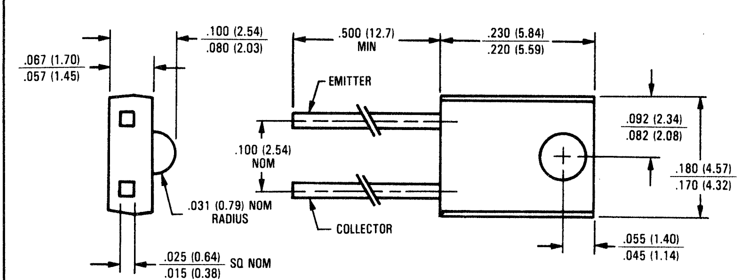
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5119
January 1985

NPN Silicon Phototransistors
Types OP550, OP550SLD, OP550SLC, OP550SLB, OP550SLA





DIMENSIONS ARE IN INCHES (MILLIMETERS).

Features
- Wide range of collector currents
- Lensed for high sensitivity
- Low cost plastic package

Description
The OP550 and OP550SLD through SLA each consist of an NPN silicon phototransistor mounted in a lensed, clear plastic, side looking package. The lensing effect of the package allows an acceptance half angle of 28° measured from the optical axis to the half power point. This series is mechanically and spectrally matched to the OP140SL and OP240SL series of infrared emitting diodes.

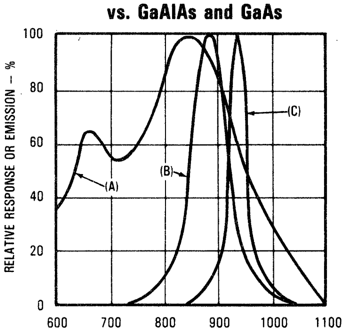
Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

Collector-Emitter Voltage	30 V
Emitter-Collector Voltage	5.0 V
Storage and Operating Temperature Range	−40°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)[1]	240°C
Power Dissipation	100 mW[2]

Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(2) Derate linearly 1.00 mW/°C above 25°C.
(3) Junction temperature maintained at 25°C.
(4) Light source is an unfiltered tungsten bulb operating at CT = 2870°K or equivalent infrared source.
(5) To calculate typical collector dark current in μA, use the formula $I_{CEO} = 10^{(0.040\,T_A - 3.4)}$ where T_A is ambient temperature in °C.

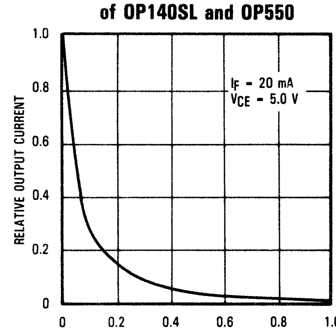
Typical Performance Curves

Photosensor Spectral Response vs. GaAlAs and GaAs



Test Conditions (LED): $T_A = T_J = 25°C$, $I_F = 100$ mA, DC = 0.1%, PW = 100 μs
Peak Wavelength – λp: (A) XSTR – 850 ± 30 nm, (B) LED GaAlAs – 875 ± 20 nm, (C) LED GaAs – 930 ± 15 nm

Coupling Characteristics of OP140SL and OP550



Types OP550, OP550SLD, OP550SLC, OP550SLB, OP550SLA

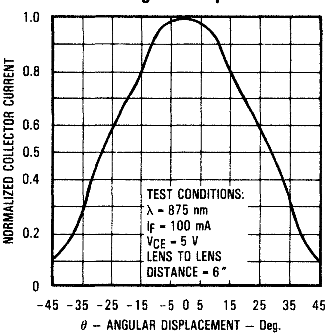
Electrical Characteristics (T_A = 25°C unless otherwise noted)

Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
$I_{C(ON)}$[3]	On-State Collector Current	OP550	0.50			mA	V_{CE} = 5.0 V, E_e = 20 mW/cm²[(4)]
		OP550SLD	4.5		14.5	mA	V_{CE} = 5.0 V, E_e = 20 mW/cm²[(4)]
		OP550SLC	12.0		19.0	mA	V_{CE} = 5.0 V, E_e = 20 mW/cm²[(4)]
		OP550SLB	15.0		28	mA	V_{CE} = 5.0 V, E_e = 20 mW/cm²[(4)]
		OP550SLA	22			mA	V_{CE} = 5.0 V, E_e = 20 mW/cm²[(4)]
$\Delta I_C/\Delta T$	Relative I_C Changes with Temperature			1.00		%/°C	V_{CE} = 5.0 V, E_e = 1.00 mW/cm², λ = 875 nm
I_{CEO}[5]	Collector Dark Current				100	nA	V_{CE} = 10.0 V, E_e = 0
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage		30			V	I_C = 100 μA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage		5.0			V	I_E = 100 μA
$V_{CE(SAT)}$[3]	Collector-Emitter Saturation Voltage				0.40	V	I_C = 250 μA, E_e = 20 mW/cm²[(4)]

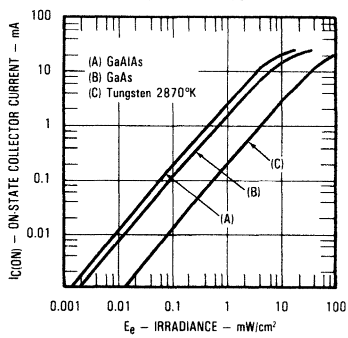
D

Typical Performance Curves

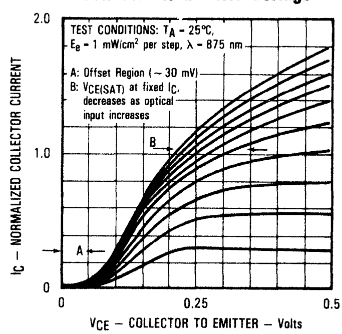
Normalized Collector Current vs. Angular Displacement



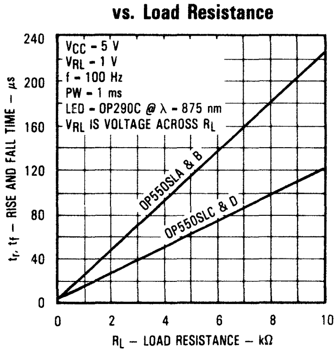
On-State Collector Current vs. Irradiance



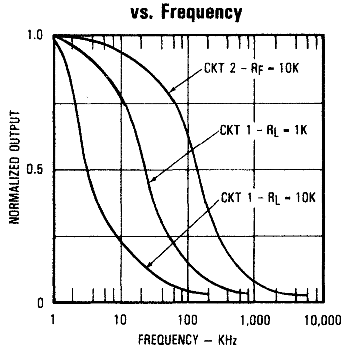
Normalized Collector Current vs. Collector to Emitter Voltage



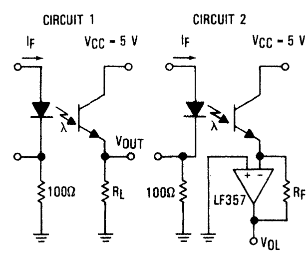
Rise and Fall Time vs. Load Resistance



Normalized Output vs. Frequency



Switching Time Test Circuit



Test Conditions:
Light source is pulsed LED with t_r and $t_f \leq$ 500 ns.
I_F is adjusted for V_{OUT} = 1 Volt.

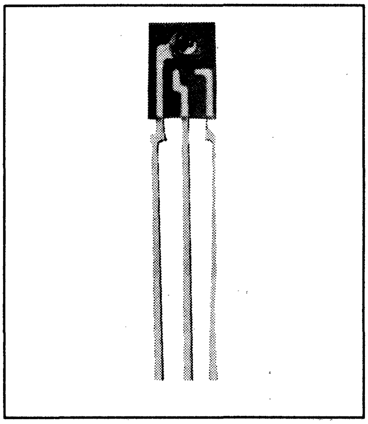
TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

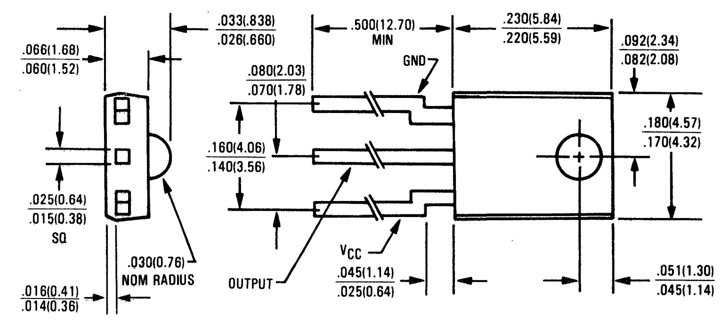
Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958

Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5154
January 1985

Photologic™ Plastic Sensors
Types OPL550, OPL550-OC, OPL551, OPL551-OC, SLB, SLA





DIMENSIONS ARE IN INCHES (MILLIMETERS)

Features
- Four output options
- High noise immunity
- Direct TTL/LSTTL interface
- Low cost plastic side looking package
- Mechanically and spectrally matched to OP140SL and OP240SL series LEDs
- Data rates to 250 K-baud

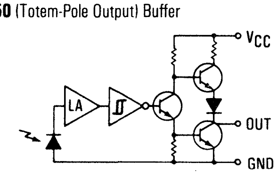
Description
The OPL550, OPL550-OC, OPL551, and OPL551-OC contain a monolithic integrated circuit which incorporates a photodiode, a linear amplifier and a Schmitt trigger on a single silicon chip. The devices feature TTL/LSTTL compatible logic level output which can drive up to 8 TTL loads without additional circuitry. Also featured are medium speed data rates to 250 K-baud with typical rise and fall times of 25 nsec. The Schmitt trigger's hysteresis characteristics provide high immunity to noise on input and V_{CC}. The Photologic™ chip is encapsulated in a molded plastic package which has an integral lens for enhanced optical coupling. These devices are mechanically and spectrally matched to the OP140SL and OP240SL infrared emitting diodes.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)
Supply Voltage, V_{CC} (not to exceed 3 seconds) .... +10.0 V
Storage Temperature Range .... −40°C to +100°C
Operating Temperature Range .... −40°C to +85°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron) .... 240°C[1]
Power Dissipation .... 85 mW[2]
Duration of Output Short to V_{CC} or Ground (OPL550, OPL551) .... 1.00 sec.
Duration of Output Short to V_{CC} (OPL550-OC, OPL551-OC) .... 1.00 sec.
Voltage at Output Lead (OPL550-OC, OPL551-OC) .... 35 V
Low Level Output Current .... 16.0 mA
High Level Output Current (OPL550, OPL551) .... 1.00 mA
Irradiance .... 25 mW/cm²

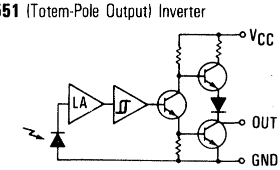
Notes:
(1) RMA flux is recommended. Duration can be extended to 10 seconds max. when flow soldering.
(2) Derate linearly 4.25 mW/°C above 80°C.

Schematics

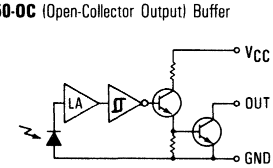
OPL550 (Totem-Pole Output) Buffer



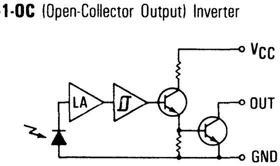
OPL551 (Totem-Pole Output) Inverter



OPL550-OC (Open-Collector Output) Buffer



OPL551-OC (Open-Collector Output) Inverter



Electrical Characteristics (−40°C to +85°C unless otherwise noted)

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
V_{CC}	Operating Supply Voltage	4.5		5.5	V	
	Peak-to-Peak V_{CC} Ripple Necessary to Cause False Triggering of Output		2.0		V	V_{CC} = 5.0 VDC f = DC to 50 MHz
$E_{eT(+)}$	Positive-Going Threshold Irradiance					
	OPL550, OPL550-OC, OPL551, OPL551-OC	.25		2.4	mW/cm²	V_{CC} = 5.0 V
	OPL550SLA, OPL550-OCSLA, OPL551SLA, OPL551-OCSLA	.25		1.40	mW/cm²	V_{CC} = 5.0 V
	OPL550SLB, OPL550-OCSLB, OPL551SLB, OPL551-OCSLB	.65		1.90	mW/cm²	V_{CC} = 5.0 V
$E_{eT(+)}/E_{eT(-)}$	Hysteresis Ratio	1.50	2.0	3.0		
I_{CC}	Supply Current		8.0	15.0	mA	V_{CC} = 5.5 V, E_e = 0 or 3.0 mW/cm²

OPL550 (Buffer, Totem-Pole)

V_{OH}	High Level Output Voltage	2.4	3.3		V	V_{CC} = 4.5 V, I_{OH} = −800 μA, E_e = 3.0 mW/cm²
V_{OL}	Low Level Output Voltage		.25	0.40	V	V_{CC} = 4.5 V, I_{OL} = 12.8 mA, E_e = 0
I_{OS}	Short Circuit Output Current	−20	−55	−100	mA	V_{CC} = 5.5 V, E_e = 3.0 mW/cm², Output = GND

OPL550-OC (Buffer, Open-Collector)

I_{OH}	High Level Output Current		1.00	100	μA	V_{CC} = 4.5 V, V_{OH} = 30 V, E_e = 3.0 mW/cm²
V_{OL}	Low Level Output Voltage		.25	0.40	V	V_{CC} = 4.5 V, I_{OL} = 12.8 mA, E_e = 0

OPL551 (Inverter, Totem-Pole)

V_{OH}	High Level Output Voltage	2.4	3.3		V	V_{CC} = 4.5 V, I_{OH} = −800 μA, E_e = 0
V_{OL}	Low Level Output Voltage		.25	0.40	V	V_{CC} = 4.5 V, I_{OL} = 12.8 mA, E_e = 3.0 mW/cm²
I_{OS}	Short Circuit Output Current	−20	−55	−100	mA	V_{CC} = 5.5 V, E_e = 0, Output = GND

OPL551-OC (Inverter, Open-Collector)

I_{OH}	High Level Output Current		1.00	100	μA	V_{CC} = 4.5 V, V_{OH} = 30 V, E_e = 0
V_{OL}	Low Level Output Voltage		.25	0.40	V	V_{CC} = 4.5 V, I_{OL} = 12.8 mA, E_e = 3.0 mW/cm²

OPL550, OPL551

t_r, t_f	Output Rise Time, Output Fall Time		25	70	ns	V_{CC} = 5.0 V, T_A = 25°C, E_e = 0 or 3.0 mW/cm² f = 10.0 kHz, D.C. = 50%, R_L = 8 TTL Loads
t_{PLH}, t_{PHL}	Propagation Delay, Low-High, High-Low		2.5	5.0	μs	

OPL550-OC, OPL551-OC

t_r, t_f	Output Rise Time, Output Fall Time		25	70	ns	V_{CC} = 5.0 V, T_A = 25°C, E_e = 0 or 3.0 mW/cm² f = 10.0 kHz, D.C. = 50%, R_L = 360 Ω
t_{PLH}, t_{PHL}	Propagation Delay, Low-High, High-Low		2.5	5.0	μs	

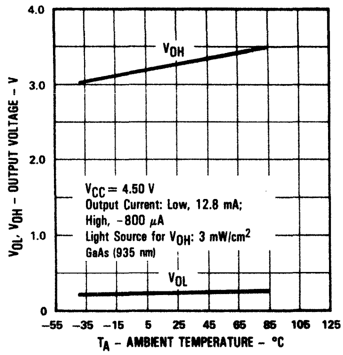
Note: (1) Irradiance measurements are made with λ_i = 935 nm, through an aperture .020 × .060, centered on the lens, parallel to the leads, and flush +.005 to the lens surface.

D

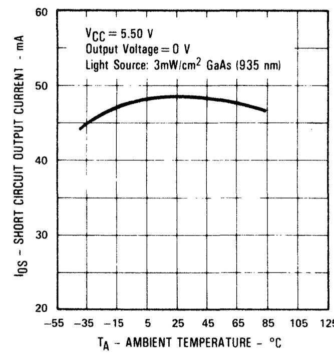
Typical Performance Curves

OPL550, OPL551

Output Voltage vs. Ambient Temperature

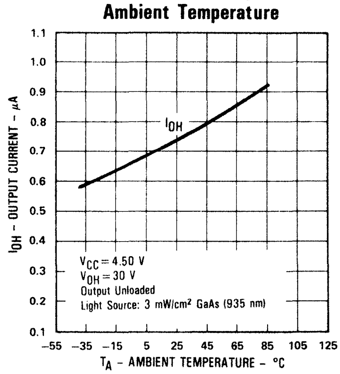


Short Circuit Output Current vs. Ambient Temperature

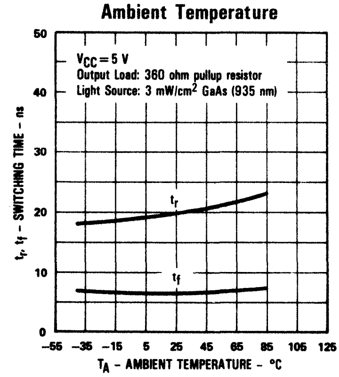


OPL550-OC, OPL551-OC

Output Current (High) vs Ambient Temperature

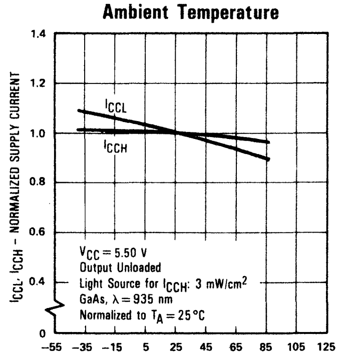


Rise Time and Fall time vs Ambient Temperature



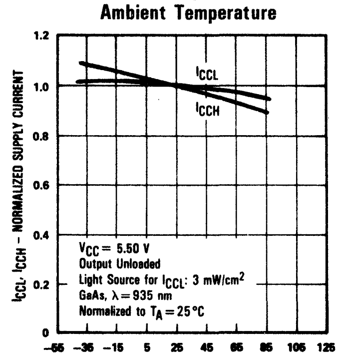
OPL550, OPL550-OC

Normalized Supply Current vs Ambient Temperature

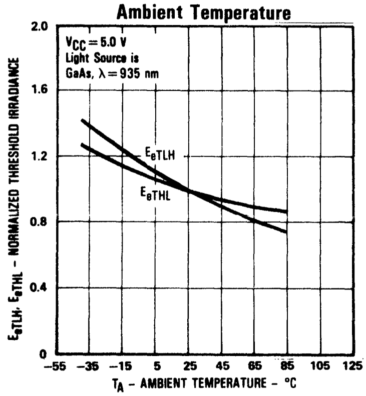


OPL551, OPL551-OC

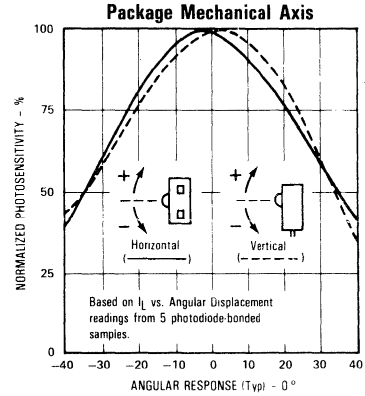
Normalized Supply Current vs Ambient Temperature



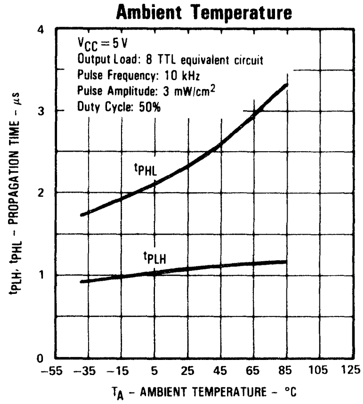
Normalized Threshold Irradiance vs Ambient Temperature



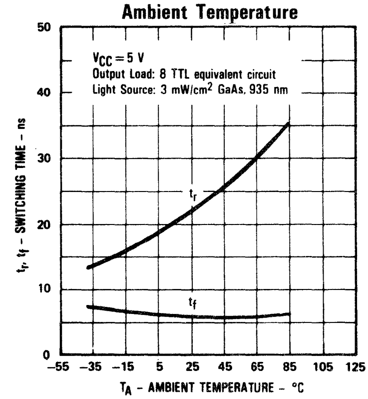
Angular Displacement from Package Mechanical Axis



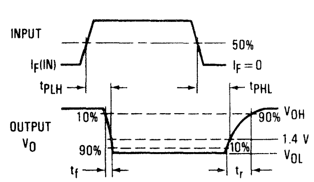
Propagation Time vs Ambient Temperature



Rise Time and Fall time vs Ambient Temperature

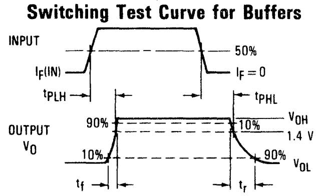


Switching Test Curve for Inverters



LED: f = 10 kHz, D.C. = 50%

Switching Test Curve for Buffers



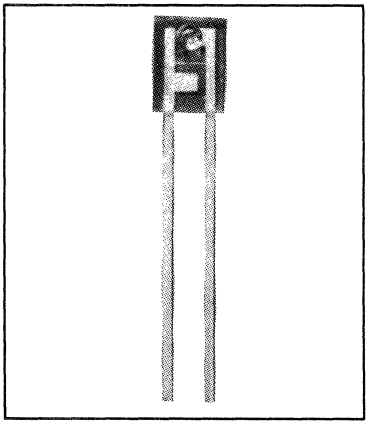
LED: f = 10 kHz, D.C. = 50%

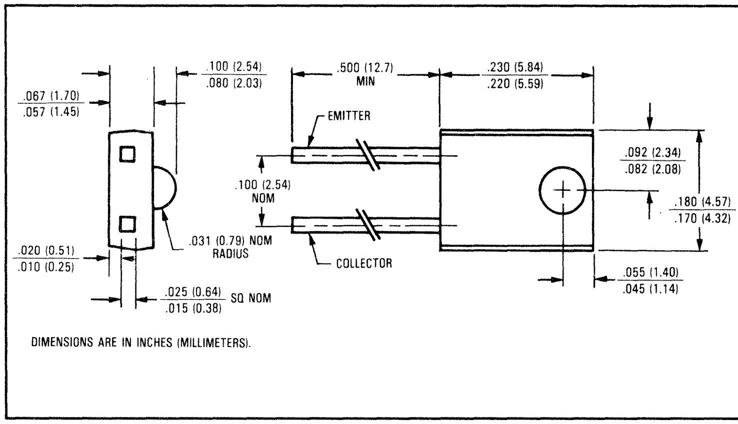
TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5122
January 1985

NPN Silicon Photodarlington
Types OP560, OP560C, OP560B, OP560A





Features
- Lensed for high sensitivity
- High current gain
- Low cost plastic package
- Mechanically and spectrally matched to the OP140SL and OP240SL series of infrared emitting diodes

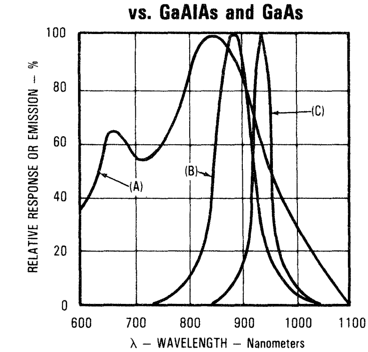
Description
The OP560 series consists of NPN silicon photodarlingtons mounted in lensed, clear plastic, side looking packages. The lensing effect allows an acceptance half angle of 28° measured from the optical axis to the half power point. Photodarlington devices are normally used in applications where light signal levels are low and more current gain is needed than is possible with phototransistors.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)
Collector-Emitter Voltage . . . . 15.0 V
Emitter-Collector Voltage . . . . 5.0 V
Storage and Operating Temperature Range . . . . −40°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)[1] . . . . 240°C
Power Dissipation . . . . 100 mW[2]

Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(2) Derate linearly 1.33 mW/°C above 25°C.
(3) Junction temperature maintained at 25°C.
(4) Light source is an unfiltered tungsten bulb operating at CT = 2870°K or equivalent infrared source.
(5) Due to high gain of photodarlington, a load resistor should be used to avoid thermal runaways.

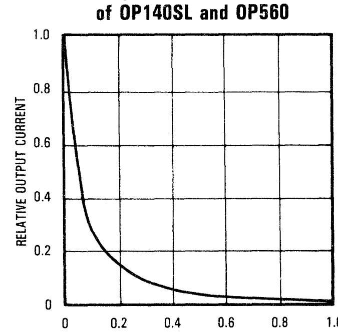
Typical Performance Curves

Photosensor Spectral Response vs. GaAlAs and GaAs



Test Conditions (LED): $T_A = T_J = 25°C$, $I_F = 100$ mA, DC = 0.1%, PW = 100 μs
Peak Wavelength – λp: (A) XSTR – 850 ± 30 nm, (B) LED GaAlAs – 875 ± 20 nm, (C) LED GaAs – 930 ± 15 nm

Coupling Characteristics of OP140SL and OP560



Types OP560, OP560C, OP560B, OP560A

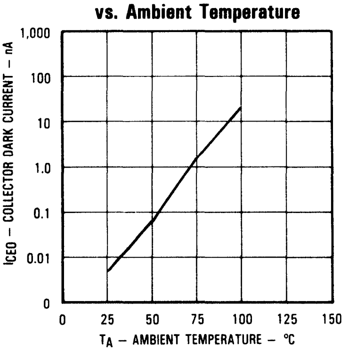
Electrical Characteristics (T_A = 25°C unless otherwise noted)

Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
$I_{C(ON)}$[3][5]	On-State Collector Current	OP560	0.50			mA	V_{CE} = 2.0 V, E_e = 1.00 mW/cm²[2][4]
		OP560C	4.0			mA	V_{CE} = 2.0 V, E_e = 1.00 mW/cm²[2][4]
		OP560B	12.0		36	mA	V_{CE} = 2.0 V, E_e = 1.00 mW/cm²[2][4]
		OP560A	24			mA	V_{CE} = 2.0 V, E_e = 1.00 mW/cm²[2][4]
I_{CEO}	Collector Dark Current				100	nA	V_{CE} = 10.0 V, E_e = 0
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage		15.0			V	I_C = 1.00 mA, E_e = 0
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage		5.0			V	I_E = 100 μA, E_e = 0
$V_{CE(SAT)}$[3]	Collector-Emitter Saturation Voltage				1.10	V	I_C = 0.40 mA, E_e = 1.00 mW/cm²[2][4]

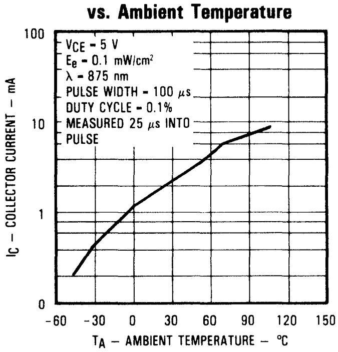
D

Typical Performance Curves

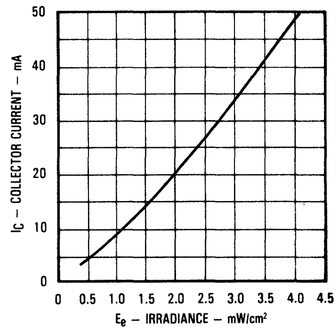
Collector Dark Current vs. Ambient Temperature



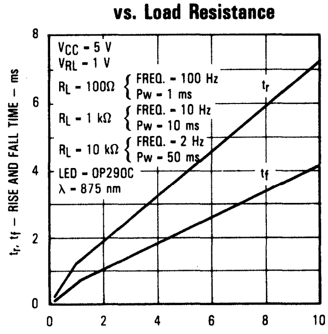
Collector Current vs. Ambient Temperature



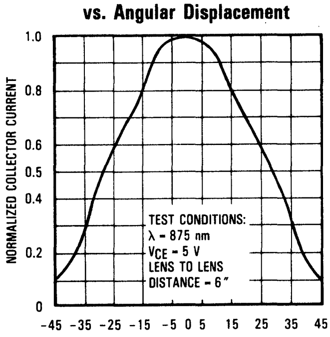
Collector Current vs. Irradiance



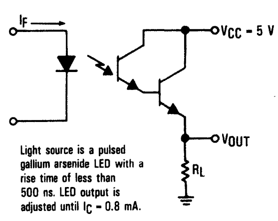
Rise and Fall Time vs. Load Resistance



Normalized Collector Current vs. Angular Displacement



Switching Time Test Circuit



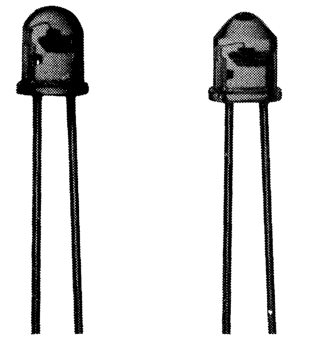
TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958

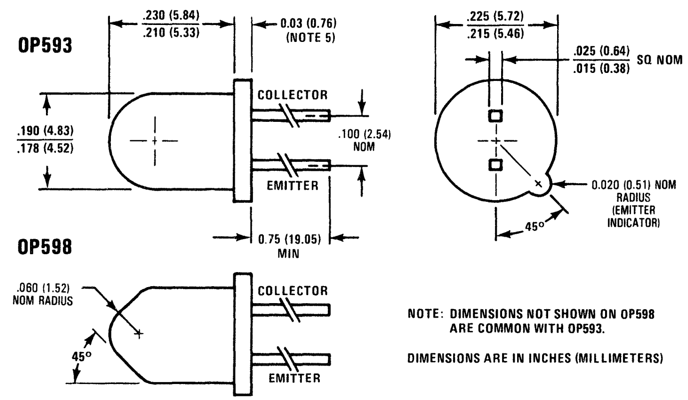
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5125
January 1985

NPN Plastic Silicon Phototransistors
Types OP593C, OP593B, OP593A, OP598C, OP598B, OP598A



OP593 OP598



NOTE: DIMENSIONS NOT SHOWN ON OP598 ARE COMMON WITH OP593.

DIMENSIONS ARE IN INCHES (MILLIMETERS)

Features
- Low cost plastic replacement for TO-18
- Superior optical consistency
- Mechanically and spectrally matched to OP293/OP298 LEDs
- Three collector current ranges
- Designer characterized and specified

Description
The OP593/OP598 series consist of an NPN silicon phototransistor mounted in a lensed plastic TO-18 outline package. The plastic housing offers lower cost, more consistent optical qualities than its hermetic counterpart, and response characteristics that make it a close spectral and mechanical match to the OP293/OP298 series.

The OP593 series have a lensed outline with a broad reception angle of 130° between the half power points.

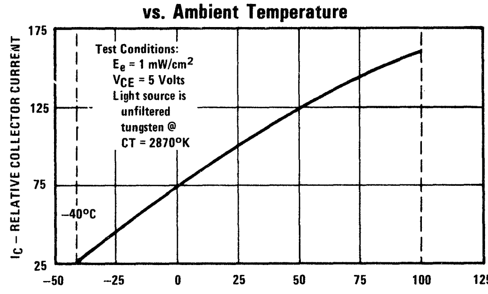
The OP598 series have a lensed outline providing an included angle between half power points of 25°.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

Collector-Emitter Voltage 30V
Emitter-Collector Voltage 5.0V
Continuous Collector Current . . . . . 50 mA
Storage Temperature Range . . . . . −40°C to +100°C
Operating Temperature Range . . . . . −40°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron) . . . . . 240°C[1]
Power Dissipation . . . . . 250 mW[2]

Notes:
(1) RMA flux is recommended. Duration can be extended to 10 seconds max. when wave soldering.
(2) Derate linearly 3.33 mW/°C.
(3) Junction temperature maintained at 25°C.
(4) V_{CE} = 5V. Light source is an unfiltered GaAlAs emitting diode operating at peak emission wavelength of 875 nm and $E_{e(APT)}$ of 1.5 mW/cm² average within a .250″ dia. aperture.
(5) This dimension is held to within ±0.005″ on the flange edge and may vary up to ±0.020″ in the area of the leads.

Normalized Collector Current vs. Ambient Temperature



Electrical Characteristics (T_A = 25°C unless otherwise noted)

Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
$I_{C(ON)}$	On-State Collector Current	OP593C	1.00			mA	See Notes (3), (4)
		OP593B	2.0		4.0	mA	See Notes (3), (4)
		OP593A	3.0			mA	See Notes (3), (4)
		OP598C	2.5			mA	See Notes (3), (4)
		OP598B	5.0		10.0	mA	See Notes (3), (4)
		OP598A	7.5			mA	See Notes (3), (4)
I_{CEO}	Collector Dark Current				100	nA	V_{CE} = 10.0 V, E_e = 0
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage		30			V	I_C = 100 μA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage		5.0			V	I_E = 100 μA
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage				0.40	V	I_C = 0.40 mA, E_e = 5.0 mW/cm²(3)(4)

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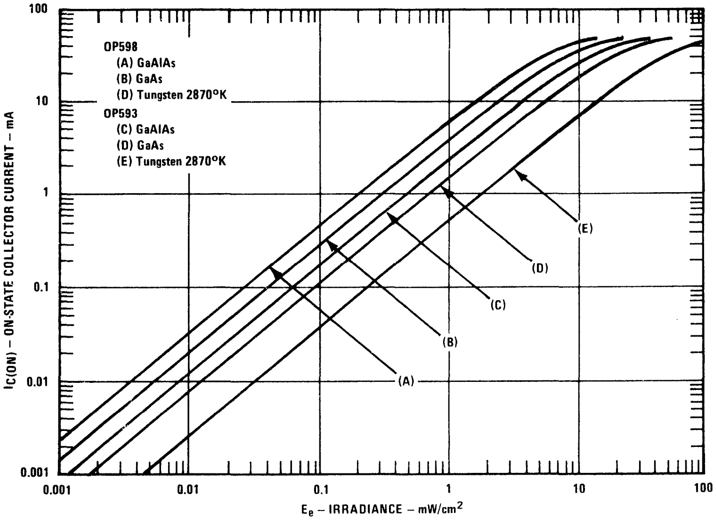
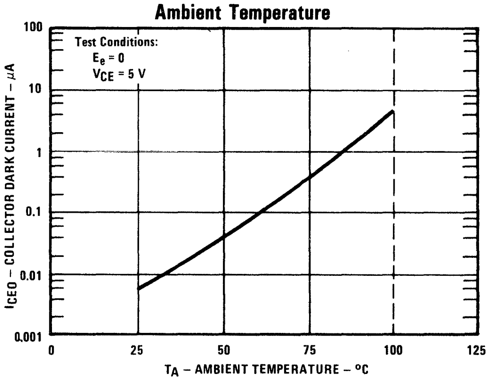
Typical Performance Curves

On-State Collector Current vs. Irradiance

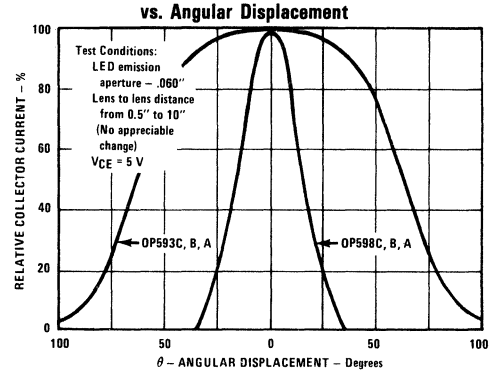


Typical Performance Curves

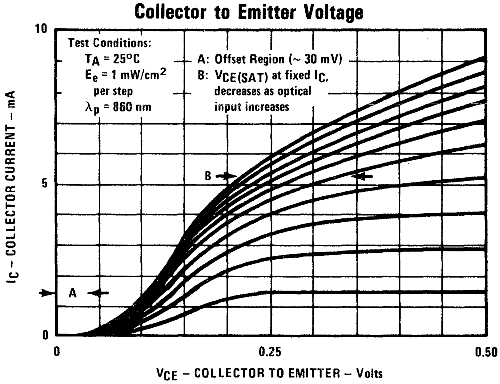
Collector Dark Current vs. Ambient Temperature



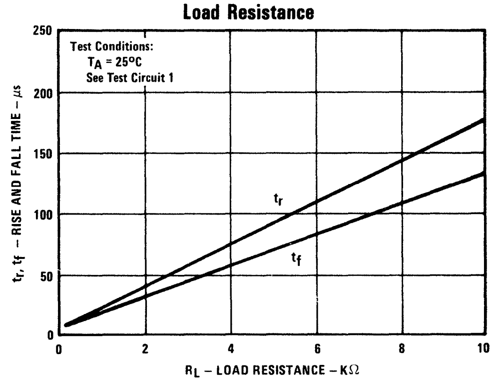
Relative Collector Current vs. Angular Displacement



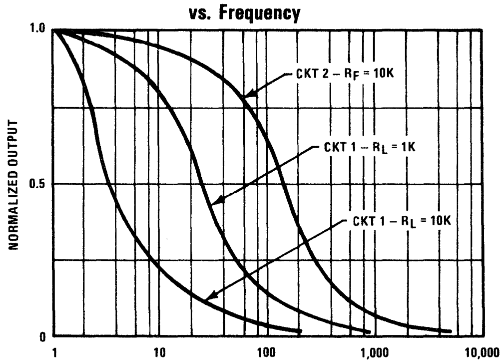
Collector Current vs. Collector to Emitter Voltage



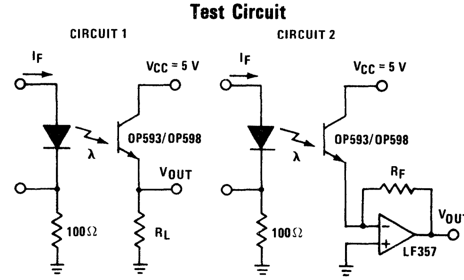
Rise and Fall Time vs. Load Resistance



Normalized Output vs. Frequency



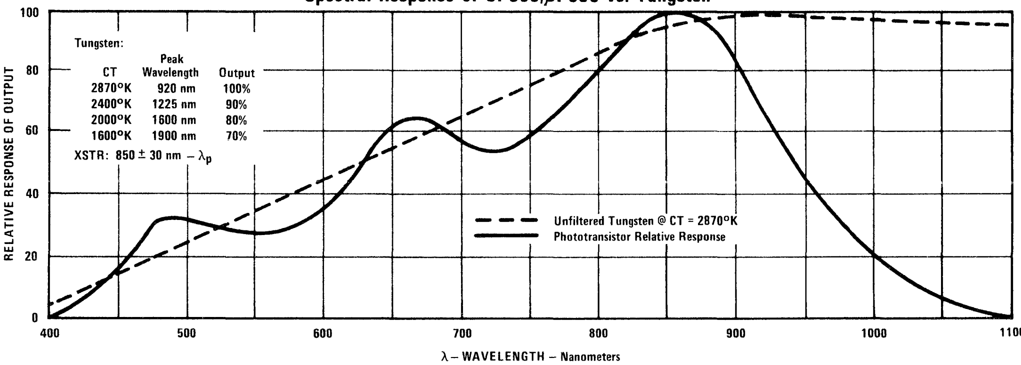
Switching Time Test Circuit



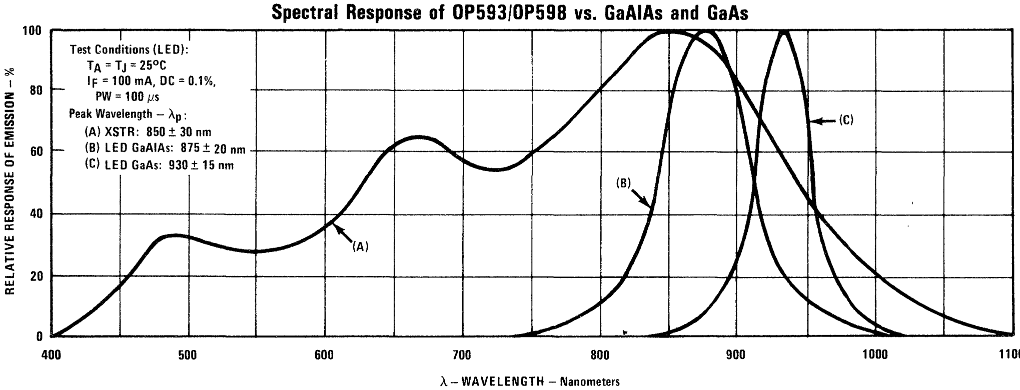
Test Conditions:
Light source is pulsed LED with t_r and $t_f \leq 500$ ns.
I_F is adjusted for $V_{OUT} = 1$ Volt.

Typical Performance Curves

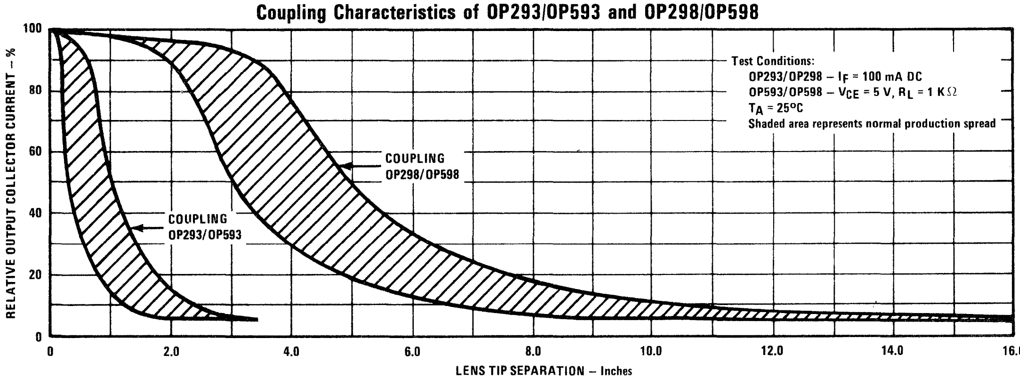
Spectral Response of OP593/OP598 vs. Tungsten



Spectral Response of OP593/OP598 vs. GaAlAs and GaAs



Coupling Characteristics of OP293/OP593 and OP298/OP598



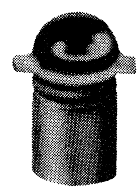
D

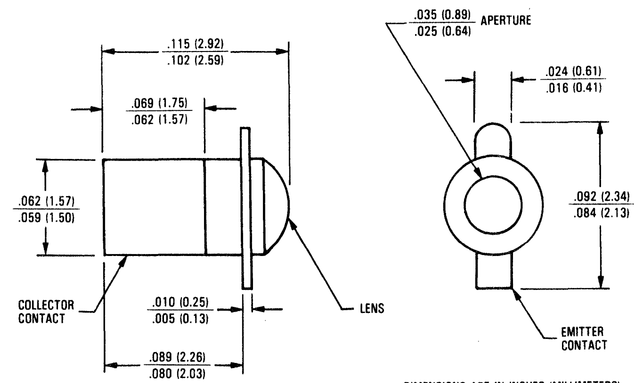
TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5131
January 1985

NPN Silicon Phototransistors
Types OP600-OP604, OP640-OP644





DIMENSIONS ARE IN INCHES (MILLIMETERS).

Features
- Miniature hermetically sealed package
- Wide range of collector currents
- Ideal for direct mounting in PC boards[1]

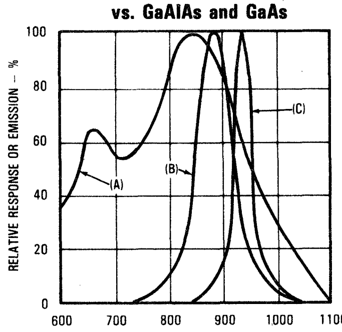
Description
The OP600 through OP604 and OP640 through OP644 each consist of an NPN silicon phototransistor mounted in a miniature glass lensed, hermetically sealed, "Pill" package. The lensing effect allows an acceptance half angle of 18° measured from the optical axis to the half power point. Except for breakdown voltages and leakage the OP600 series and OP640 series are identical. They are also mechanically and spectrally matched to the OP123 and OP223 series of infrared emitting diodes.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)
Collector-Emitter Voltage — OP600-OP604 .... 50 V
OP640-OP641 .... 25 V
Emitter-Collector Voltage — OP600-OP604 .... 7.0 V
OP640-OP641 .... 5.0 V
Storage Temperature Range .... −65°C to +150°C
Operating Temperature Range .... −65°C to +125°C
Soldering Temperature (for 5 seconds with soldering iron)[2] .... 240°C
Power Dissipation .... 50 mW[3]

Notes:
(1) Refer to Application Bulletin 111 which discusses proper techniques for soldering Pill type devices to PC boards.
(2) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(3) Derate linearly 0.5 mW/°C above 25°C.
(4) Junction temperature maintained at 25°C.
(5) Light source is an unfiltered tungsten bulb operating at CT = 2870°K or equivalent infrared source.

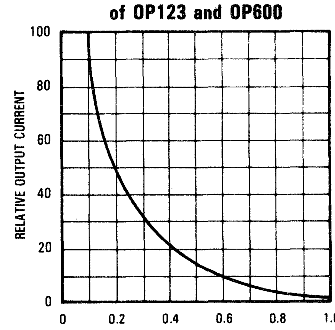
Typical Performance Curves

Photosensor Spectral Response vs. GaAlAs and GaAs



Test Conditions (LED): $T_A = T_J$ = 25°C, I_F = 100 mA, DC = 0.1%, PW = 100 μs
Peak Wavelength - λp: (A) XSTR — 850 ± 30 nm, (B) LED GaAlAs — 875 ± 20 nm, (C) LED GaAs — 930 ± 15 nm

Coupling Characteristics of OP123 and OP600



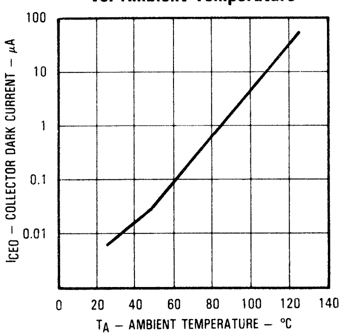
Electrical Characteristics (T_A = 25°C unless otherwise noted)

Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
$I_{C(ON)}$[4]	On-State Collector Current	OP600-OP640	0.50			mA	V_{CE} = 5.0 V, E_e = 20 mW/cm²[5]
		OP601-OP641	0.50		3.0	mA	V_{CE} = 5.0 V, E_e = 20 mW/cm²[5]
		OP602-OP642	2.0		5.0	mA	V_{CE} = 5.0 V, E_e = 20 mW/cm²[5]
		OP603-OP643	4.0		8.0	mA	V_{CE} = 5.0 V, E_e = 20 mW/cm²[5]
		OP604-OP644	7.0		22	mA	V_{CE} = 5.0 V, E_e = 20 mW/cm²[5]
I_{CEO}	Collector Dark Current	OP600-OP604			25	nA	V_{CE} = 10.0 V, E_e = 0
		OP640-OP644			100	nA	V_{CE} = 10.0 V, E_e = 0
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	OP600-OP604	50			V	I_C = 100 μA
		OP640-OP644	25			V	I_C = 100 μA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	OP600-OP604	7.0			V	I_E = 100 μA
		OP640-OP644	5.0			V	I_E = 100 μA
$V_{CE(SAT)}$[4]	Collector-Emitter Saturation Voltage				0.40	V	I_C = 0.40 mA, E_e = 20 mW/cm²[5]
t_r	Rise Time			2.5		μs	V_{CC} = 5.0 V, I_C = 0.80 mA
t_f	Fall Time			2.5		μs	R_L = 1.00 kΩ, See Test Circuit

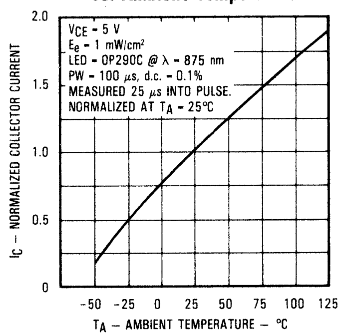
D

Typical Performance Curves

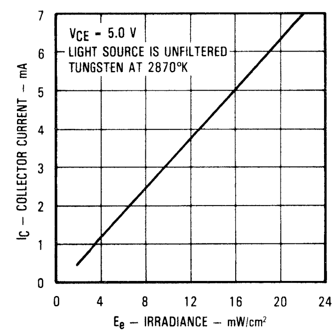
Collector Dark Current vs. Ambient Temperature



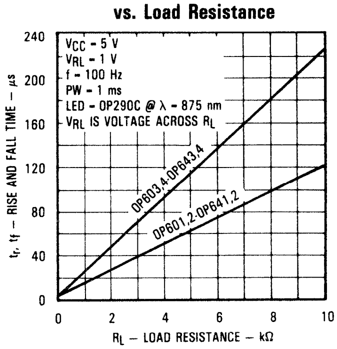
Normalized Collector Current vs. Ambient Temperature



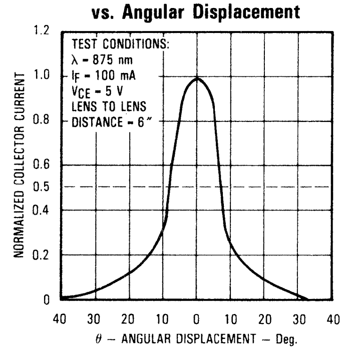
Collector Current vs. Irradiance



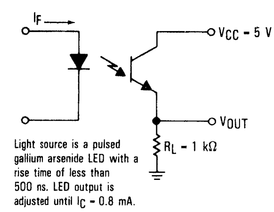
Rise and Fall Time vs. Load Resistance



Normalized Collector Current vs. Angular Displacement



Switching Time Test Circuit



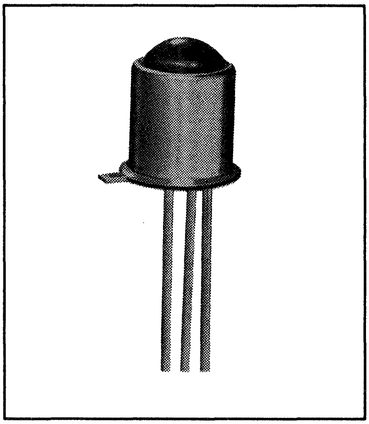
TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

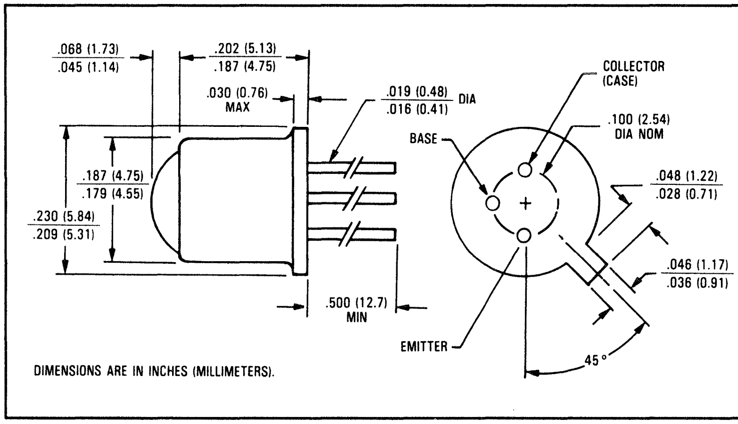
Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958

Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5136
January 1985

NPN Silicon Phototransistors
Types OP800, OP801, OP802, OP803, OP804, OP805





Features
- Lensed for high sensitivity
- Wide range of collector currents
- TO-18 hermetically sealed package

Description
The OP800 through OP805 each consist of an NPN silicon phototransistor mounted in a lensed, hermetically sealed, TO-18 package. TO-18 packages offer high power dissipation, and superior hostile environment operation. The lensing effect allows an acceptance half angle of 10° measured from the optical axis to the half power point. The base lead is bonded to enable conventional transistor biasing. This series is mechanically and spectrally matched to the OP130 and OP231 series of infrared emitting diodes.

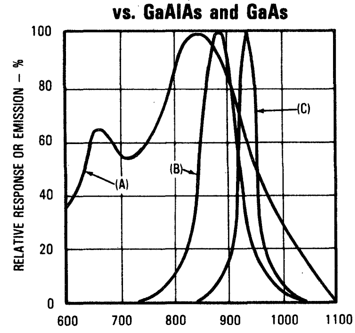
Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

Collector-Base Voltage	30 V
Collector-Emitter Voltage	30 V
Emitter-Base Voltage	5.0 V
Emitter-Collector Voltage	5.0 V
Storage Temperature Range	−65°C to +150°C
Operating Temperature Range	−65°C to +125°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)[1]	240°C
Power Dissipation	250 mW[2]

Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(2) Derate linearly 2.5 mW/°C above 25°C.
(3) Junction temperature maintained at 25°C.
(4) Light source is an unfiltered tungsten bulb operating at CT = 2870°K or equivalent infrared source.

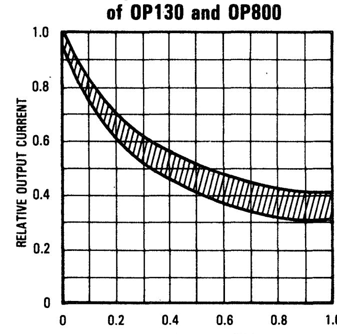
Typical Performance Curves

Spectral Response of OP800-OP805 vs. GaAlAs and GaAs



Test Conditions (LED): $T_A = T_J = 25°C$, $I_F = 100$ mA, DC = 0.1%, PW = 100 μs
Peak Wavelength – λp: (A) XSTR – 850 ± 30 nm, (B) LED GaAlAs – 875 ± 20 nm, (C) LED GaAs – 930 ± 15 nm

Coupling Characteristics of OP130 and OP800



Types OP800, OP801, OP802, OP803, OP804, OP805

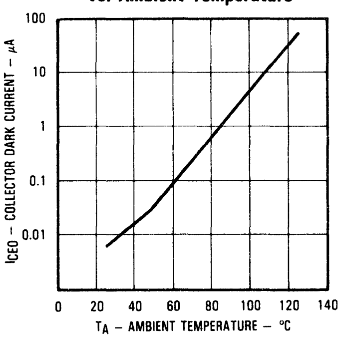
Electrical Characteristics (T_A = 25°C unless otherwise noted)

Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
$I_{C(ON)}$[3]	On-State Collector Current	OP800	0.50			mA	V_{CE} = 5.0 V, E_e = 5.0 mW/cm²[4]
		OP801	0.50		3.0	mA	V_{CE} = 5.0 V, E_e = 5.0 mW/cm²[4]
		OP802	2.0		5.0	mA	V_{CE} = 5.0 V, E_e = 5.0 mW/cm²[4]
		OP803	4.0		8.0	mA	V_{CE} = 5.0 V, E_e = 5.0 mW/cm²[4]
		OP804	7.0		22	mA	V_{CE} = 5.0 V, E_e = 5.0 mW/cm²[4]
		OP805	15.0			mA	V_{CE} = 5.0 V, E_e = 5.0 mW/cm²[4]
I_{CEO}	Collector Dark Current				100	nA	V_{CE} = 10.0 V, E_e = 0
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage		30			V	I_C = 100 μA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage		5.0			V	I_E = 100 μA
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage				0.4	V	I_C = 0.40 mA, E_e = 5.0 mW/cm²[4]
t_r	Rise Time			2.0		μs	V_{CC} = 5.0 V, I_C = 0.80 mA
t_f	Fall Time			2.0		μs	R_L = 100Ω, See Test Circuit

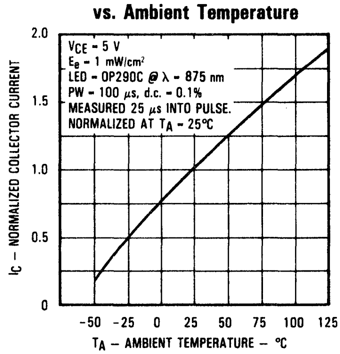
D

Typical Performance Curves

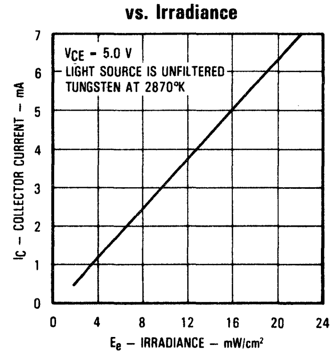
Collector Dark Current vs. Ambient Temperature



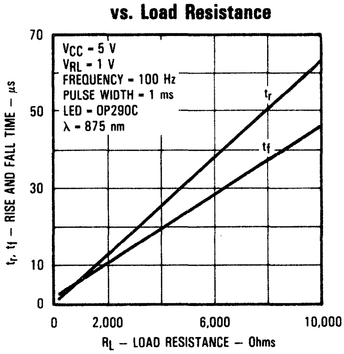
Normalized Collector Current vs. Ambient Temperature



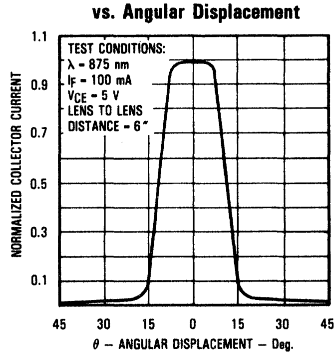
Collector Current vs. Irradiance



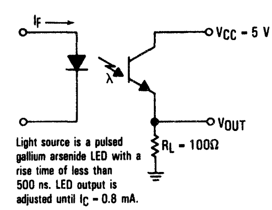
Rise and Fall Time vs. Load Resistance



Normalized Collector Current vs. Angular Displacement



Switching Time Test Circuit



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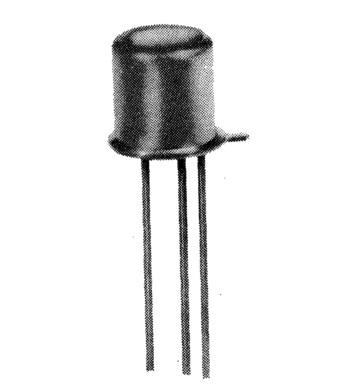
Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958

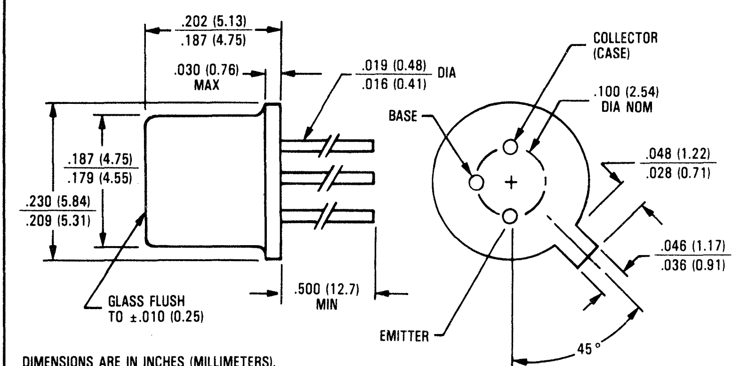
Printed in U.S.A.

Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5138
January 1985

NPN Silicon Phototransistors
Types OP800W, OP801W, OP802W





Features

- Flat lensed for wide acceptance angle
- Three collector current ranges
- TO-18 hermetically sealed package

Description

The OP800W, OP801W, and OP802W each consist of an NPN silicon phototransistor mounted in a flat lensed, hermetically sealed TO-18 package. TO-18 packages offer high power dissipation and superior hostile environment operation. The flat lens allows an acceptance half angle of 40° measured from the optical axis to the half power point. The base lead is bonded to enable conventional transistor biasing. This series is mechanically and spectrally matched to the OP130W and OP231W series of infrared emitting diodes.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

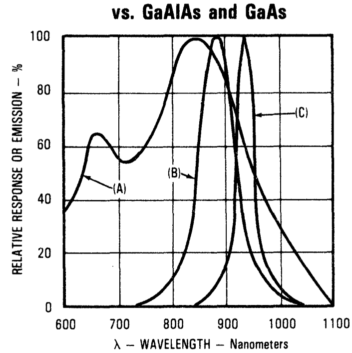
Collector-Emitter Voltage .... 30 V
Emitter-Collector Voltage .... 5.0 V
Storage Temperature Range .... −65°C to +150°C
Operating Temperature Range .... −55°C to +125°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)[1] .... 240°C
Power Dissipation .... 250 mW[2]

Notes:

(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(2) Derate linearly 2.5 mW/°C above 25°C.
(3) Junction temperature maintained at 25°C.
(4) Light source is an unfiltered tungsten bulb operating at CT = 2870°K or equivalent infrared source.

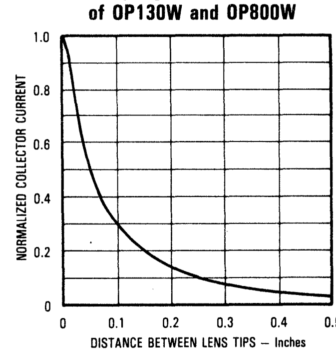
Typical Performance Curves

Photosensor Spectral Response vs. GaAlAs and GaAs



Test Conditions (LED): $T_A = T_J$ = 25°C, I_F = 100 mA, DC = 0.1%, PW = 100 μs
Peak Wavelength − λp: (A) XSTR − 850 ± 30 nm, (B) LED GaAlAs − 875 ± 20 nm, (C) LED GaAs − 930 ± 15 nm

Coupling Characteristics of OP130W and OP800W



Types OP800W, OP801W, OP802W

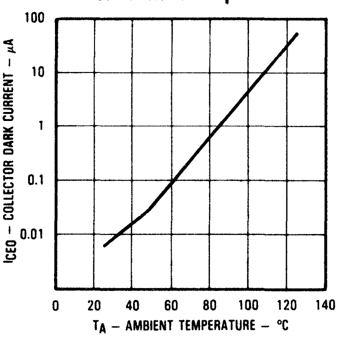
Electrical Characteristics (T_A = 25°C unless otherwise noted)

Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
$I_{C(ON)}$[3]	On-State Collector Current	OP800W	0.30			mA	V_{CE} = 5.0 V, E_e = 5.0 mW/cm²[2][4]
		OP801W	0.50		3.0	mA	V_{CE} = 5.0 V, E_e = 5.0 mW/cm²[2][4]
		OP802W	2.5			mA	V_{CE} = 5.0 V, E_e = 5.0 mW/cm²[2][4]
I_{CEO}	Dark Current				100	nA	V_{CE} = 10.0 V, E_e = 0
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage		30			V	I_C = 100 μA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage		5.0			V	I_E = 100 μA
$V_{CE(SAT)}$[3]	Collector-Emitter Saturation Voltage				0.40	V	I_C = 0.40 mA, E_e = 5.0 mW/cm²[2][4]
t_r	Rise Time			2.0		μs	V_{CC} = 5.0 V, I_C = 0.80 mA
t_f	Fall Time			2.0		μs	R_L = 100Ω, See Test Circuit

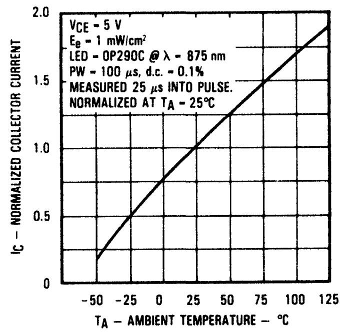
D

Typical Performance Curves

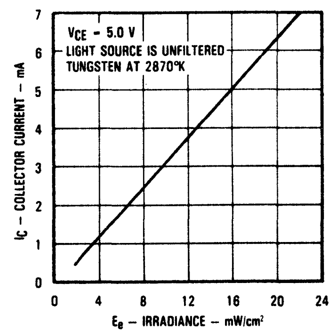
Collector Dark Current vs. Ambient Temperature



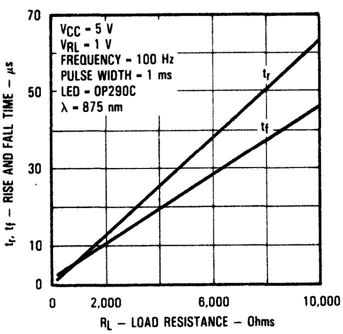
Normalized Collector Current vs. Ambient Temperature



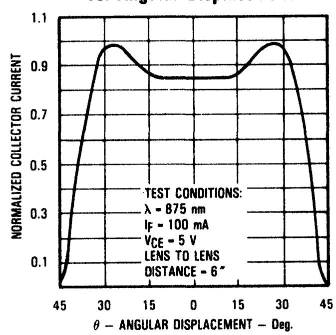
Collector Current vs. Irradiance



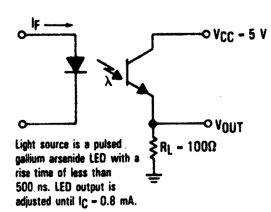
Rise and Fall Time vs. Load Resistance



Normalized Collector Current vs. Angular Displacement



Switching Time Test Circuit



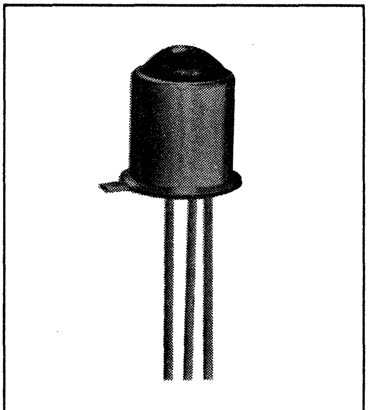
TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

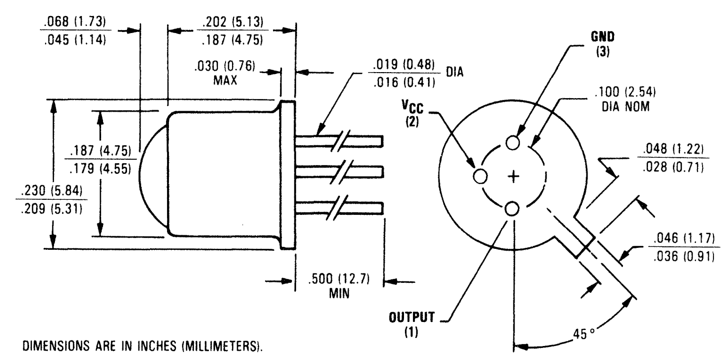
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5156
January 1985

TRW

Photologic™ Hermetic Sensors
Types OPL800, OPL800-OC, OPL801, OPL801-OC





Features
- Four output options
- High noise immunity
- Direct TTL/LSTTL interface
- TO-18 hermetic package
- Mechanically and spectrally matched to the OP130 and OP231 Series LEDs
- Data rates to 250 Kbaud

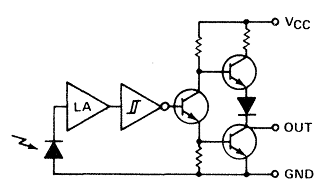
Description
The OPL800, OPL800-OC, OPL801, and OPL801-OC each incorporate a photodiode, a linear amplifier, and a Schmitt trigger on a single silicon chip. The devices feature TTL/LSTTL compatible logic level output which can drive up to 8 TTL loads without additional interface circuitry. Also featured are medium speed data rates to 250 Kbaud with typical rise and fall times of 25 nsec. The Schmitt trigger's hysteresis characteristics provide high immunity to noise on input and V_{CC}. The Photologic™ chip is mounted on a standard TO-18 header which is hermetically sealed in a lensed metal can. These devices are mechanically and spectrally matched to GaAs and GaAlAs infrared emitting diodes.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)
Supply Voltage, V_{CC} (not to exceed 3 seconds) .... +10.0 V
Storage Temperature Range .... −65°C to +150°C
Operating Temperature Range .... −55°C to +110°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. w/soldering iron) .... 240°C[1]
Power Dissipation .... 85 mW[2]
Duration of Output Short to V_{CC} or Ground — OPL800, OPL801 .... 1.00 sec.
Duration of Output Short to V_{CC} — OPL800-OC, OPL801-OC .... 1.00 sec.
Voltage at Output Lead — OPL800-OC, OPL801-OC .... 35 V

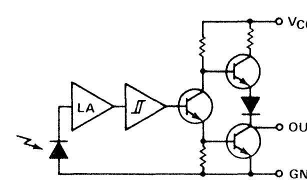
Notes:
(1) RMA flux is recommended. Duration can be extended to 10 seconds max. when flow soldering.
(2) Derate linearly 2.0 mW/°C above 25°C.
(3) Light measurements are made with λ = 935 nm.

Schematics

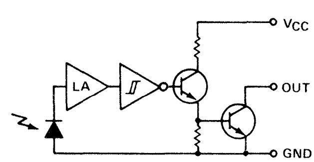
OPL800 (Totem-Pole Output) Buffer



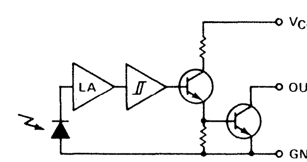
OPL801 (Totem-Pole Output) Inverter



OPL800-OC (Open Collector Output) Buffer



OPL801-OC (Open Collector Output) Inverter



Electrical Characteristics (−40°C to +70°C unless otherwise noted)

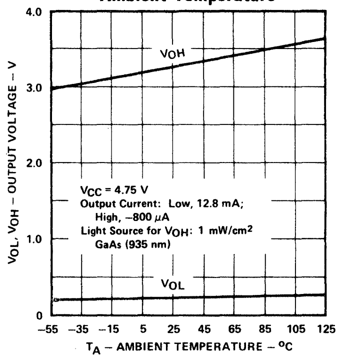
Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions[3]
V_{CC}	Operating Supply Voltage	4.8		5.2	V	
	Peak-to-Peak V_{CC} Ripple Necessary to Cause False Triggering of Output		2.0		V	V_{CC} = 5.0 VDC, f = DC to 50 MHz
$E_{eT(+)}$	Positive-Going Threshold Irradiance		0.50	2.0	mW/cm²	V_{CC} = 5.0 V
$E_{eT(-)}$	Negative-Going Threshold Irradiance		0.25		mW/cm²	
$E_{eT(+)}/E_{eT(-)}$	Hysteresis Ratio		2.0			
I_{CC}	Supply Current			20	mA	V_{CC} = 5.2 V, E_e = 0 or 2.0 mW/cm²
OPL800 (Buffer, Totem-Pole)						
V_{OH}	High Level Output Voltage	2.4			V	V_{CC} = 4.8 V, I_{OH} = −800 μA, E_e = 2.0 mW/cm²
V_{OL}	Low Level Output Voltage			0.40	V	V_{CC} = 4.8 V, I_{OL} = 12.8 mA, E_e = 0
I_{OS}	Short Circuit Output Current	−30		−120	mA	V_{CC} = 5.2 V, E_e = 2.0 mW/cm², Output = GND
OPL800-OC (Buffer, Open Collector)						
I_{OH}	High Level Output Current			100	μA	V_{CC} = 4.8 V, V_{OH} = 30 V, E_e = 2.0 mW/cm²
V_{OL}	Low Level Output Voltage			0.40	V	V_{CC} = 4.8 V, I_{OL} = 12.8 mA, E_e = 0
OPL801 (Inverter, Totem-Pole)						
V_{OH}	High Level Output Voltage	2.4			V	V_{CC} = 4.8 V, I_{OH} = −800 μA, E_e = 0
V_{OL}	Low Level Output Voltage			0.40	V	V_{CC} = 4.8 V, I_{OL} = 12.8 mA, E_e = 2.0 mW/cm²
I_{OS}	Short Circuit Output Current	−30		−120	mA	V_{CC} = 5.2 V, E_e = 0, Output = GND
OPL801-OC (Inverter, Open Collector)						
I_{OH}	High Level Output Current			100	μA	V_{CC} = 4.8 V, V_{OH} = 30, E_e = 0
V_{OL}	Low Level Output Voltage			0.40	V	V_{CC} = 4.8 V, I_{OL} = 12.8 mA, E_e = 2.0 mW/cm²
OPL800, OPL801						
t_r, t_f	Output Rise Time, Output Fall Time			70	ns	V_{CC} = 5.0 V, T_A = 25°C, E_e = 0 or 1.00 mW/cm²
t_{PLH}, t_{PHL}	Propagation Delay, Low-High, High-Low			5.0	μs	f = 10.0 kHz, DC = 50%, R_L = 8 TTL Loads
OPL800-OC, OPL801-OC						
t_r, t_f	Output Rise Time, Output Fall Time			70	ns	V_{CC} = 5.0 V, T_A = 25°C, E_e = 0 or 1.00 mW/cm²
t_{PLH}, t_{PHL}	Propagation Delay, Low-High, High-Low			5.0	μs	f = 10.0 kHz, DC = 50%, R_L = 360 Ω

D

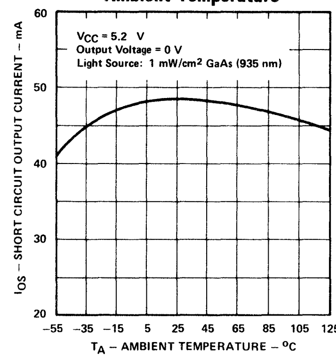
Typical Performance Curves

OPL800, OPL801

Output Voltage vs. Ambient Temperature

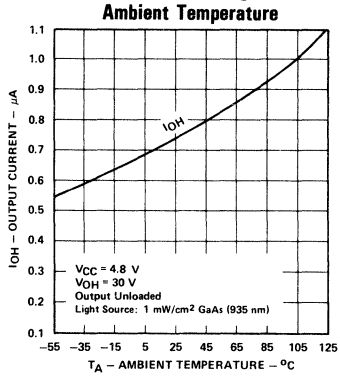


Short Circuit Output Current vs. Ambient Temperature

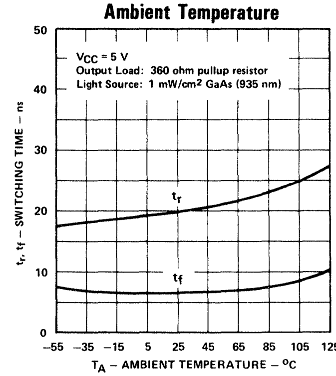


OPL800-OC, OPL801-OC

Output Current (High) vs. Ambient Temperature

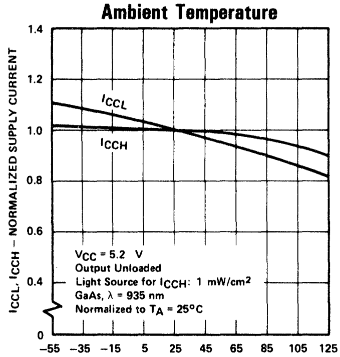


Rise Time and Fall Time vs. Ambient Temperature



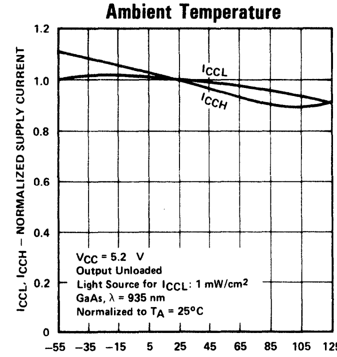
OPL800, OPL800-OC

Normalized Supply Current vs. Ambient Temperature



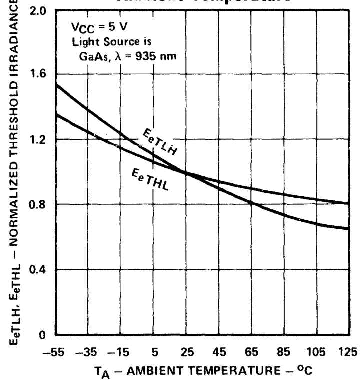
OPL801, OPL801-OC

Normalized Supply Current vs. Ambient Temperature

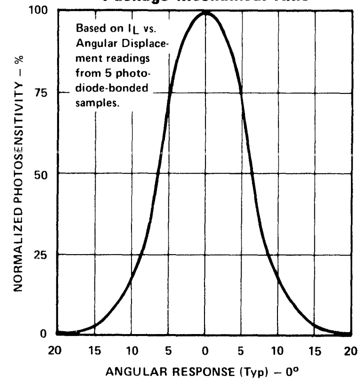


Typical Performance Curves

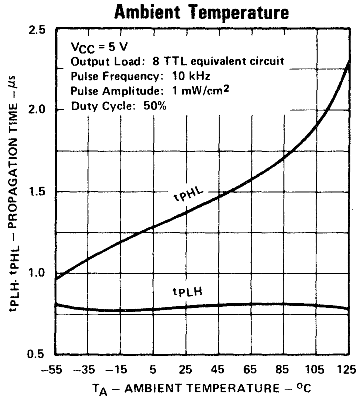
Normalized Threshold Irradiance vs. Ambient Temperature



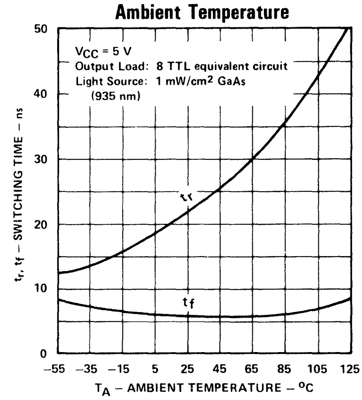
Angular Displacement from Package Mechanical Axis



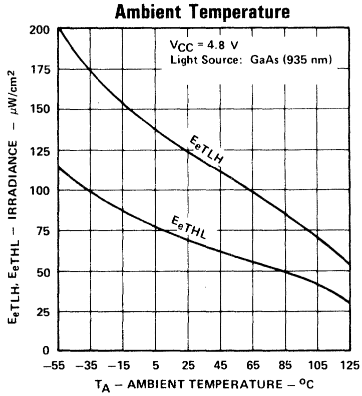
Propagation Time vs. Ambient Temperature



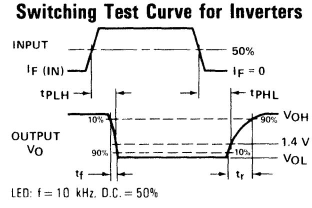
Rise Time and Fall Time vs. Ambient Temperature



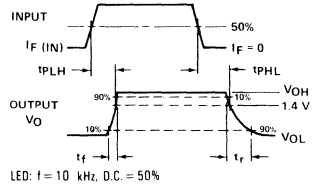
Trigger Irradiance vs. Ambient Temperature



Switching Test Curve for Inverters



Switching Test Curve for Buffers



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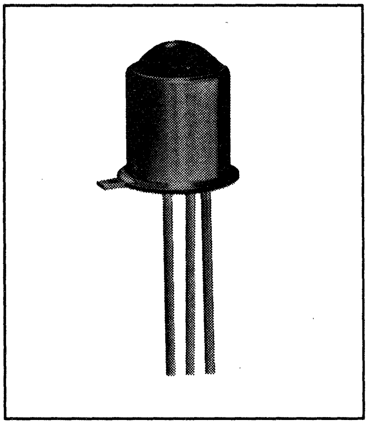
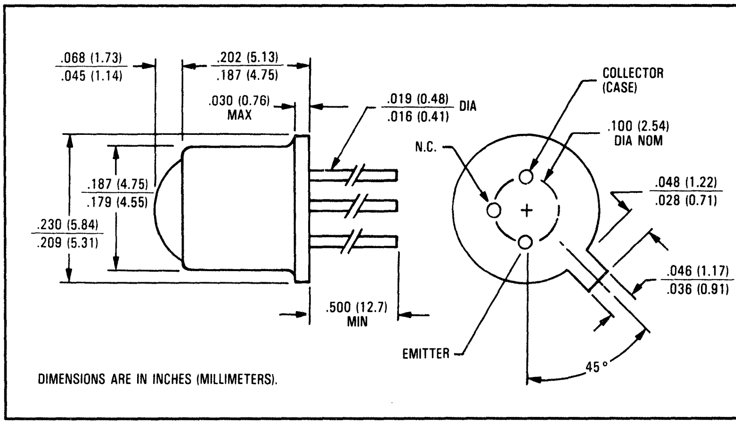
NPN Silicon Photodarlington
Type OP830





Features
- Lensed for high sensitivity
- High current gain
- TO-18 hermetically sealed package

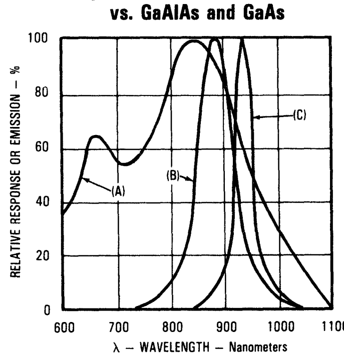
Description
The OP830 consists of an NPN silicon photodarlington mounted in a lensed, hermetically sealed, TO-18 package. The lensing effect allows an acceptance half angle of 10° measured from the optical axis to the half power point. Photodarlington devices are normally used in applications where light signal levels are low and more current gain is needed than is possible with phototransistors. The OP830 is mechanically and spectrally matched to the OP130 and OP231 series of infrared emitting diodes.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)
Collector-Emitter Voltage .... 15.0 V
Emitter-Collector Voltage .... 5.0 V
Storage Temperature Range .... −65°C to +150°C
Operating Temperature Range .... −55°C to +125°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)[1] .... 240°C
Power Dissipation .... 50 mW[2]

Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(2) Derate linearly 2.0 mW/°C above 25°C.
(3) Junction temperature maintained at 25°C.
(4) Light source is an unfiltered tungsten bulb operating at CT = 2870°K or equivalent infrared source.

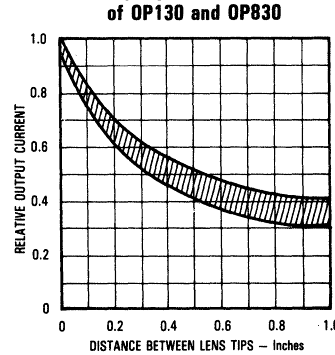
Typical Performance Curves

Spectral Response of OP830 vs. GaAlAs and GaAs



Test Conditions (LED): $T_A = T_J = 25°C$, I_F = 100 mA, DC = 0.1%, PW = 100 μs
Peak Wavelength - λp: (A) XSTR – 850 ± 30 nm, (B) LED GaAlAs – 875 ± 20 nm, (C) LED GaAs – 930 ± 15 nm

Coupling Characteristics of OP130 and OP830



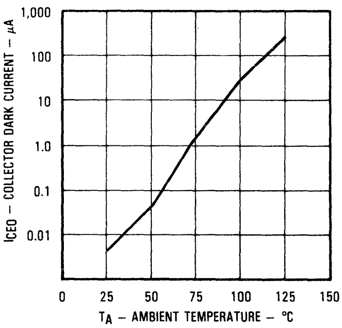
Type OP830

Electrical Characteristics (T_A = 25°C unless otherwise noted)

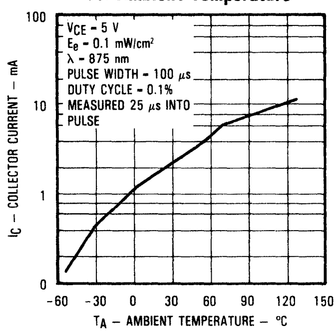
Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_{C(ON)}$[3]	On-State Collector Current	15.0			mA	V_{CE} = 5.0 V, E_e = 0.50 mW/cm²[2][4]
I_{CEO}	Collector Dark Current			1.00	μA	V_{CE} = 10.0 V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	15.0			V	I_C = 100 μA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	5.0			V	I_E = 100 μA
$V_{CE(SAT)}$[3]	Collector-Emitter Saturation Voltage			1.20	V	I_C = 1.00 mA, E_e = 0.50 mW/cm²[2][4]

Typical Performance Curves

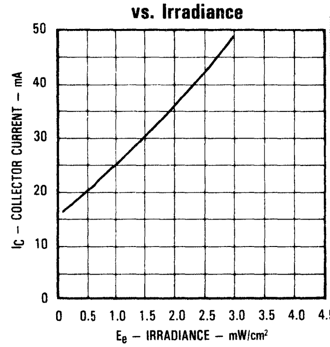
Collector Dark Current vs. Ambient Temperature



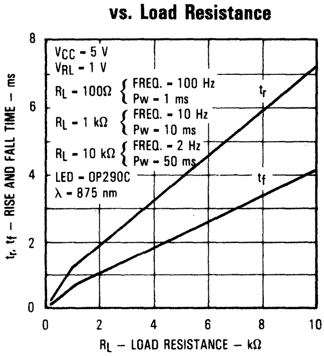
Collector Current vs. Ambient Temperature



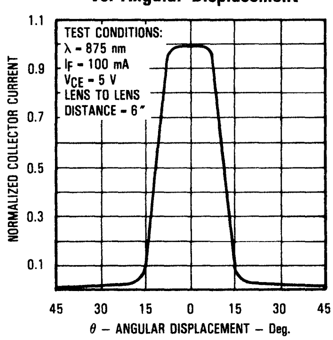
Collector Current vs. Irradiance



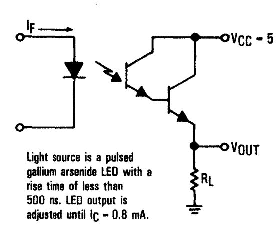
Rise and Fall Time vs. Load Resistance



Normalized Collector Current vs. Angular Displacement



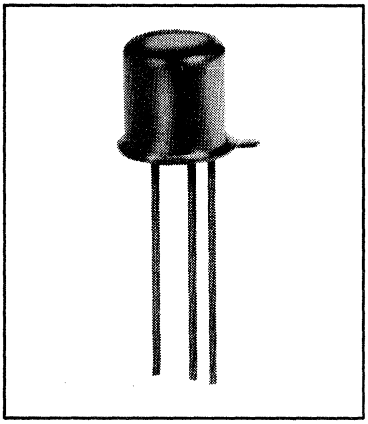
Switching Time Test Circuit

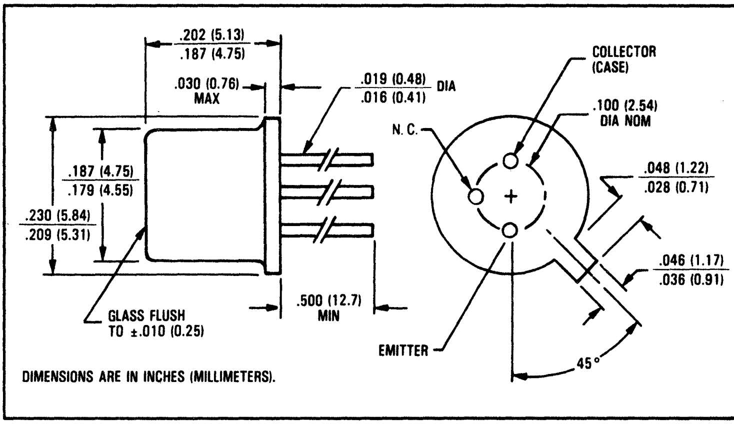


Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5142
January 1985

NPN Silicon Photodarlington
Type OP830W





Features
- Flat lensed for wide acceptance angle
- High current gain
- TO-18 hermetically sealed package

Description
The OP830W consists of an NPN silicon photodarlington mounted in a flat lensed, hermetically sealed, TO-18 package. The flat lens allows an acceptance half angle of 40° measured from the optical axis to the half power point. Photodarlington devices are normally used in applications where light signal levels are low and more current gain is needed than is possible with phototransistors. The OP830W is mechanically and spectrally matched to the OP130W and OP231W series of infrared emitting diodes.

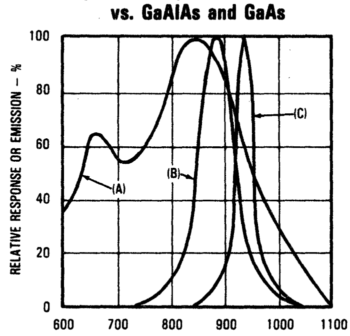
Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

Collector-Emitter Voltage . . . . . . 15.0 V
Emitter-Collector Voltage . . . . . . 5.0 V
Storage Temperature Range . . . . . . −65°C to +150°C
Operating Temperature Range . . . . . . −55°C to +125°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)[1] . . . . . . 240°C
Power Dissipation . . . . . . 50 mW[2]

Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(2) Derate linearly 2.0 mW/°C above 25°C.
(3) Junction temperature maintained at 25°C.
(4) Light source is an unfiltered tungsten bulb operating at CT = 2870°K or equivalent infrared source.

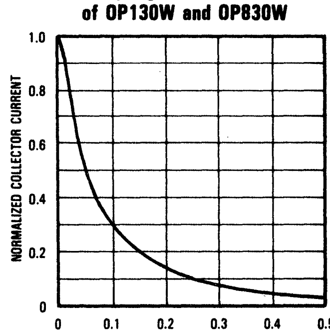
Typical Performance Curves

Spectral Response of OP830W vs. GaAlAs and GaAs



Test Conditions (LED): $T_A = T_J = 25°C$, I_F = 100 mA, DC = 0.1%, PW = 100 μs
Peak Wavelength – λp: (A) XSTR – 850 ± 30 nm, (B) LED GaAlAs – 875 ± 20 nm, (C) LED GaAs – 930 ± 15 nm

Coupling Characteristics of OP130W and OP830W



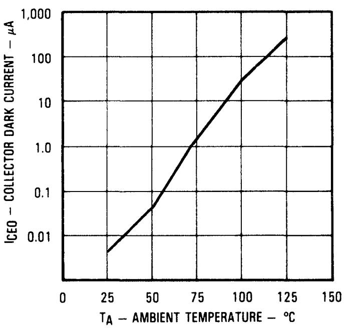
Type OP830W

Electrical Characteristics (T_A = 25°C unless otherwise noted)

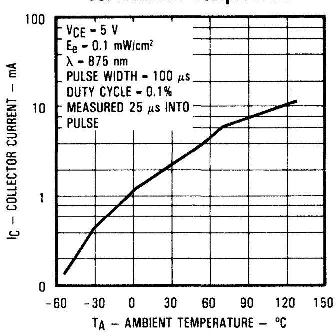
Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_{C(ON)}$[3]	On-State Collector Current	4.0			mA	V_{CE} = 5.0 V, E_e = 0.50 mW/cm²[2][4]
I_{CEO}	Collector Dark Current			1.00	μA	V_{CE} = 10.0 V
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	15.0			V	I_C = 100 μA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	5.0			V	I_E = 100 μA
$V_{CE(SAT)}$[3]	Collector-Emitter Saturation Voltage			1.20	V	I_C = 1.00 mA, E_e = 0.50 mW/cm²[2][4]

Typical Performance Curves

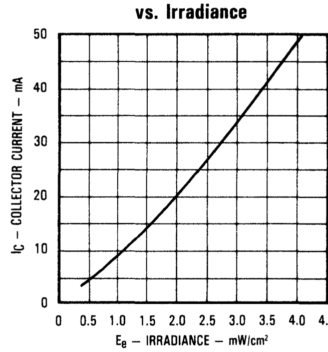
Collector Dark Current vs. Ambient Temperature



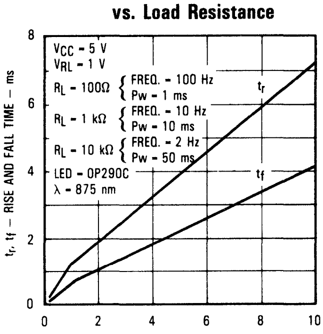
Collector Current vs. Ambient Temperature



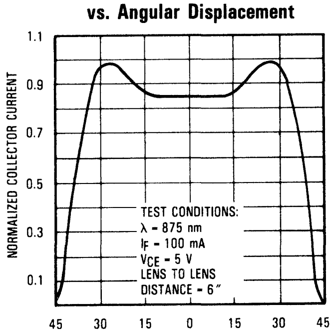
Collector Current vs. Irradiance



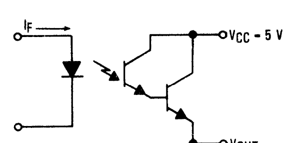
Rise and Fall Time vs. Load Resistance



Normalized Collector Current vs. Angular Displacement



Switching Time Test Circuit



Light source is a pulsed gallium arsenide LED with a rise time of less than 500 ns. LED output is adjusted until I_C = 0.8 mA.

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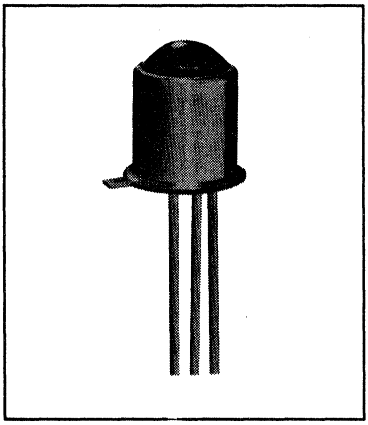
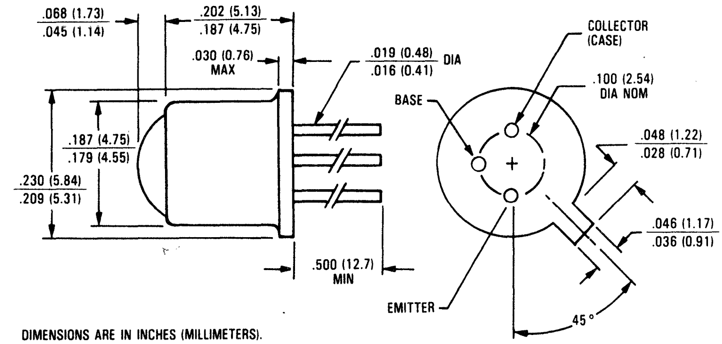
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5144
January 1985

NPN Silicon Phototransistors
Types OP841, OP842, OP843, OP844, OP845





Features

- Collector currents are binned to minimums only
- Lensed for high sensitivity
- TO-18 hermetically sealed package

Description

The OP841 through OP845 each consist of an NPN silicon phototransistor mounted in a lensed, hermetically sealed, TO-18 package. The lensing effect allows an acceptance half angle of 10° measured from the optical axis to the half power point. The base lead is bonded to enable conventional transistor biasing. Except for minor differences in collector current ranges and minimum range binning only, this series is identical to the OP800 series and is mechanically and spectrally matched to the OP130 and OP231 series of infrared emitting diodes.

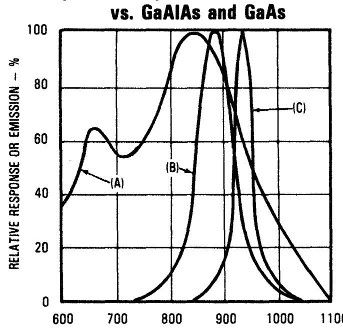
Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

Collector-Base Voltage .... 30 V
Collector-Emitter Voltage .... 30 V
Emitter-Base Voltage .... 5.0 V
Emitter-Collector Voltage .... 5.0 V
Storage Temperature Range .... −65°C to +150°C
Operating Temperature Range .... −65°C to +125°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)[1] .... 240°C
Power Dissipation .... 250 mW[2]

Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(2) Derate linearly 2.5 mW/°C above 25°C.
(3) Junction temperature maintained at 25°C.
(4) Light source is an unfiltered tungsten bulb operating at CT = 2870°K or equivalent infrared source.

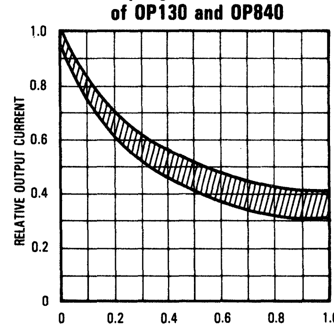
Typical Performance Curves

Spectral Response of OP841-OP845 vs. GaAlAs and GaAs



Test Conditions (LED): $T_A = T_J = 25°C$, I_F = 100 mA, DC = 0.1%, PW = 100 μs
Peak Wavelength – λp: (A) XSTR – 850 ± 30 nm, (B) LED GaAlAs – 875 ± 20 nm, (C) LED GaAs – 930 ± 15 nm

Coupling Characteristics of OP130 and OP840



Electrical Characteristics (T_A = 25°C unless otherwise noted)

Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
$I_{C(ON)}$[3]	On-State Collector Current	OP841	0.50			mA	V_{CE} = 5.0 V, E_e = 5.0 mW/cm²[2][4]
		OP842	2.0			mA	V_{CE} = 5.0 V, E_e = 5.0 mW/cm²[2][4]
		OP843	5.0			mA	V_{CE} = 5.0 V, E_e = 5.0 mW/cm²[2][4]
		OP844	7.0			mA	V_{CE} = 5.0 V, E_e = 5.0 mW/cm²[2][4]
		OP845	15.0			mA	V_{CE} = 5.0 V, E_e = 5.0 mW/cm²[2][4]
I_{CEO}	Collector Dark Current				100	nA	V_{CE} = 10.0 V, E_e = 0
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage		30			V	I_C = 100 μA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage		5.0			V	I_E = 100 μA
$V_{CE(SAT)}$[3]	Collector-Emitter Saturation Voltage				0.40	V	I_C = 0.40 mA, E_e = 5.0 mW/cm²[2][4]
t_r	Rise Time			2.0		μs	V_{CC} = 5.0 V, I_C = 0.80 mA
t_f	Fall Time			2.0		μs	R_L = 100Ω, See Test Circuit

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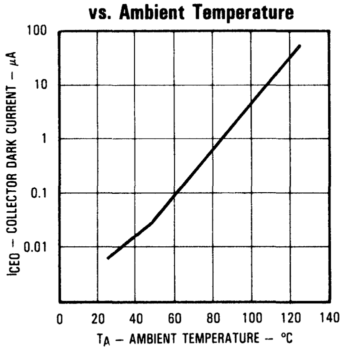
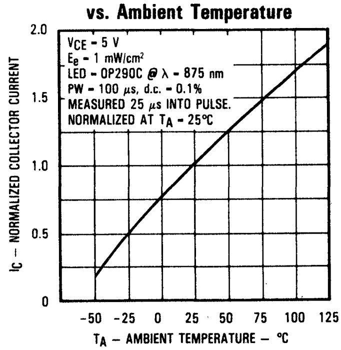
Typical Performance Curves

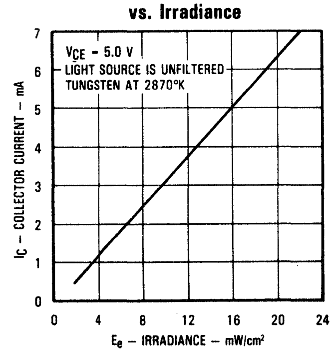
Collector Dark Current vs. Ambient Temperature



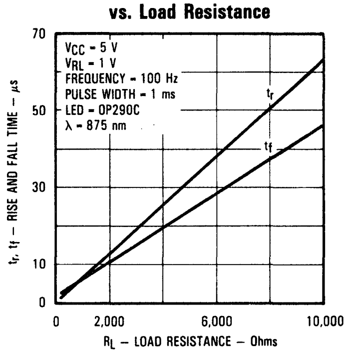
Normalized Collector Current vs. Ambient Temperature



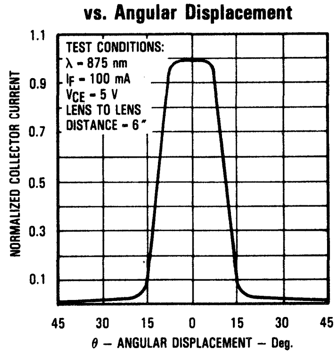
Collector Current vs. Irradiance



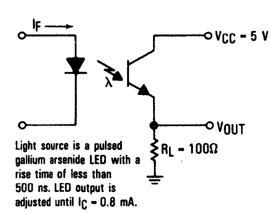
Rise and Fall Time vs. Load Resistance



Normalized Collector Current vs. Angular Displacement



Switching Time Test Circuit



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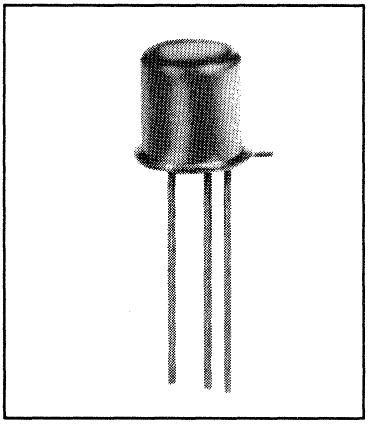
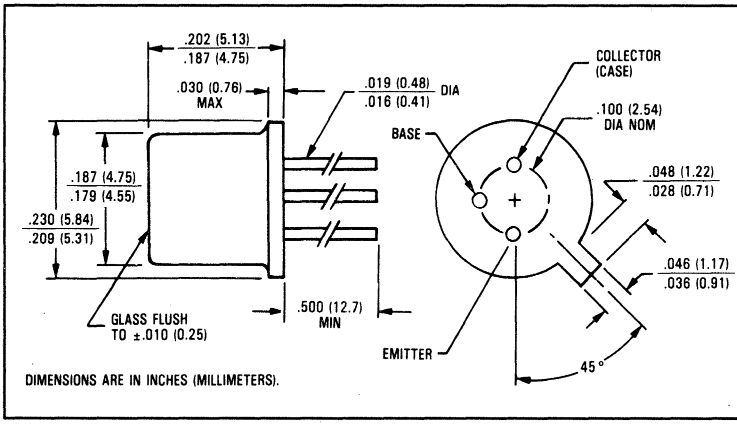
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5146
January 1985

NPN Silicon Phototransistors
Types OP841W, OP842W, OP843W, OP844W, OP845W





Features
- Collector currents specified as minimums
- Flat lensed for wide acceptance angle
- TO-18 hermetically sealed package

Description
The OP841W through OP845W each consist of an NPN silicon phototransistor mounted in a flat lensed, hermetically sealed, TO-18 package. The flat lens allows an acceptance half angle of 40° measured from the optical axis to the half power point. The base lead is bonded to enable conventional transistor biasing. Except for minor differences in collector current ranges and minimum range binning only, this series is identical to the OP800W series and is mechanically and spectrally matched to the OP130W and OP231W series of infrared emitting diodes.

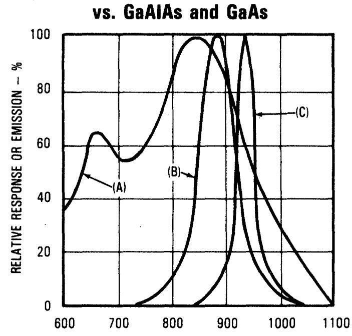
Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

Collector-Base Voltage	30 V
Collector-Emitter Voltage	30 V
Emitter-Base Voltage	5.0 V
Emitter-Collector Voltage	5.0 V
Continuous Collector Current	50 mA
Storage Temperature Range	−65°C to +150°C
Operating Temperature Range	−65°C to +125°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)[1]	240°C
Power Dissipation	250 mW[2]

Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(2) Derate linearly 2.5 mW/°C above 25°C.
(3) Junction temperature maintained at 25°C.
(4) Light source is an unfiltered tungsten bulb operating at CT = 2870°K or equivalent infrared source.

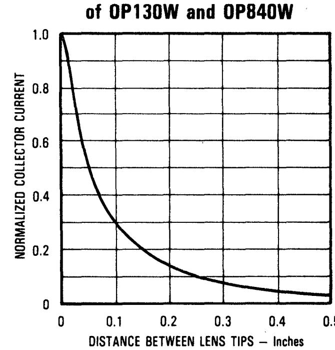
Typical Performance Curves

Spectral Response ofOP841W-OP845W vs. GaAlAs and GaAs



Test Conditions (LED): $T_A = T_J$ = 25°C, I_F = 100 mA, DC = 0.1%, PW = 100 μs
Peak Wavelength – λp: (A) XSTR – 850 ± 30 nm, (B) LED GaAlAs – 875 ± 20 nm, (C) LED GaAs – 930 ± 15 nm

Coupling Characteristics of OP130W and OP840W



Types OP841W, OP842W, OP843W, OP844W, OP845W

Electrical Characteristics (T_A = 25°C unless otherwise noted)

Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
$I_{C(ON)}$[3]	On-State Collector Current	OP841W	0.30			mA	V_{CE} = 5.0 V, E_e = 5.0 mW/cm²[2(4)]
		OP842W	1.00			mA	V_{CE} = 5.0 V, E_e = 5.0 mW/cm²[2(4)]
		OP843W	1.50			mA	V_{CE} = 5.0 V, E_e = 5.0 mW/cm²[2(4)]
		OP844W	2.0			mA	V_{CE} = 5.0 V, E_e = 5.0 mW/cm²[2(4)]
		OP845W	2.5			mA	V_{CE} = 5.0 V, E_e = 5.0 mW/cm²[2(4)]
I_{CEO}	Collector Dark Current				100	nA	V_{CE} = 10.0 V, E_e = 0
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage		30			V	I_C = 100 μA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage		5.0			V	I_E = 100 μA
$V_{CE(SAT)}$[3]	Collector-Emitter Saturation Voltage				0.40	V	I_C = 0.40 mA, E_e = 5.0 mW/cm²[2(4)]
t_r	Rise Time			2.0		μs	V_{CC} = 5.0 V, I_C = 0.80 mA
t_f	Fall Time			2.0		μs	R_L = 100Ω, See Test Circuit

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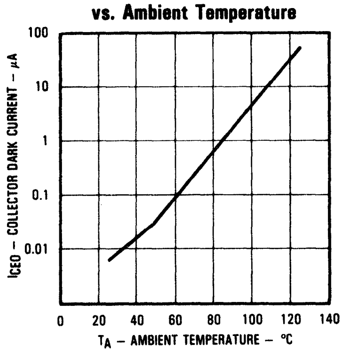
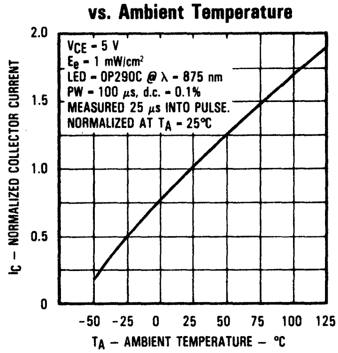
Typical Performance Curves

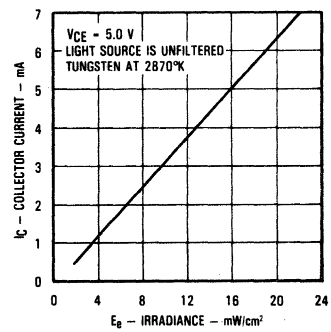
Collector Dark Current vs. Ambient Temperature



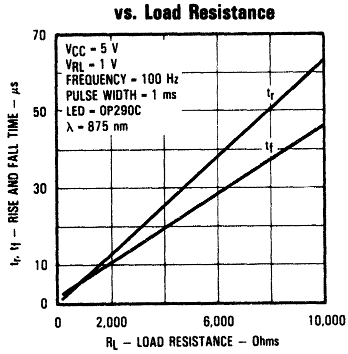
Normalized Collector Current vs. Ambient Temperature



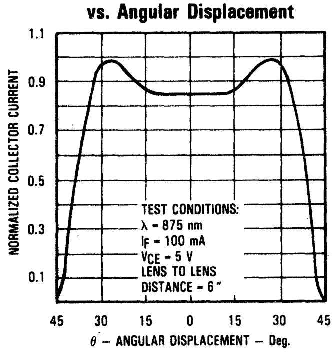
Collector Current vs. Irradiance



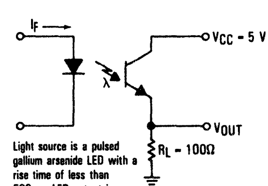
Rise and Fall Time vs. Load Resistance



Normalized Collector Current vs. Angular Displacement



Switching Time Test Circuit



Light source is a pulsed gallium arsenide LED with a rise time of less than 500 ns. LED output is adjusted until I_C = 0.8 mA.

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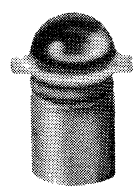
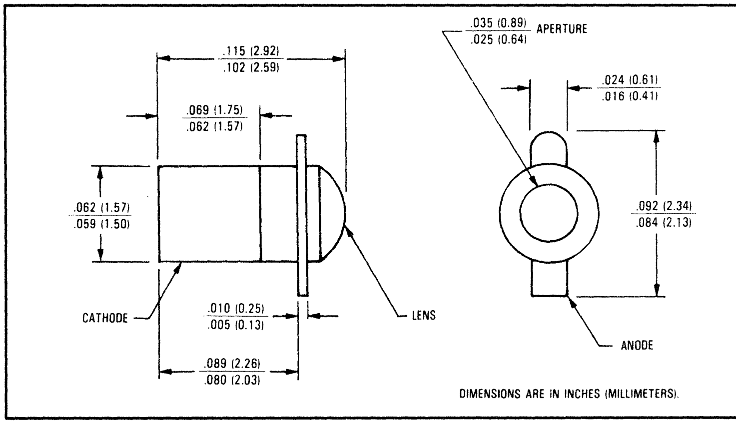
PN Junction Silicon Photodiode
Type OP900





Features
- Miniature hermetically sealed package
- Fast switching speed
- Ideal for direct mounting to PC boards

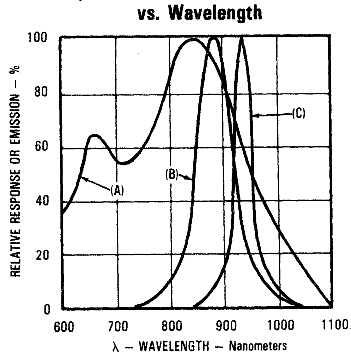
Description
The OP900 consists of a PN junction silicon photodiode mounted in a miniature, glass lensed hermetically sealed "Pill" package. The lensing effect allows an acceptance half angle of 18° measured from the optical axis to the half power point. This device can also be used in a photovoltaic mode.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)
Reverse Voltage .... 100 V
Storage Temperature Range .... −65°C to +150°C
Operating Temperature Range .... −65°C to +125°C
Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)[1] .... 240°C
Power Dissipation .... 50 mW[2]

Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(2) Derate linearly 0.5 mW/°C above 25°C.
(3) Junction temperature maintained at 25°C.
(4) Light source is an unfiltered tungsten bulb operating at CT = 2870°K or equivalent infrared source.

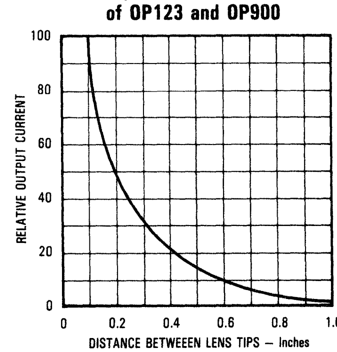
Typical Performance Curves

Spectral Response and Emission vs. Wavelength



Test Conditions (LED): $T_A = T_J$ = 25°C, I_F = 100 mA, DC = 0.1%, PW = 100 μs
Peak Wavelength – λp: (A) XSTR – 850 ± 30 nm, (B) LED GaAlAs – 875 ± 20 nm, (C) LED GaAs – 930 ± 15 nm

Coupling Characteristics of OP123 and OP900



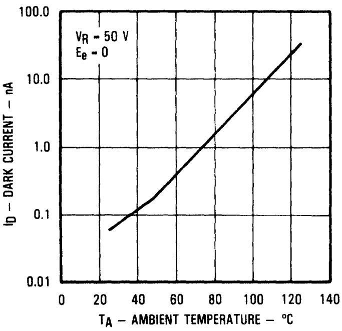
Type OP900

Electrical Characteristics (T_A = 25°C unless otherwise noted)

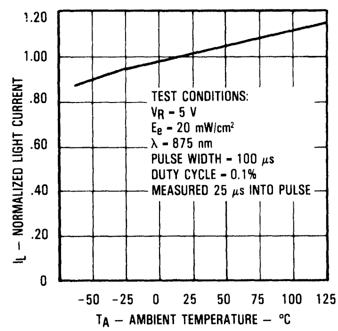
Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
I_L[3]	Light Current	8.0	14.0		μA	V_R = 10.0 V, E_e = 20 mW/cm^2[4]
I_D[3]	Dark Current			10.0	nA	V_R = 10.0 V, E_e = 0
$V_{(BR)R}$	Reverse Voltage Breakdown	100	150		V	I_R = 100 μA
t_r	Rise Time		100		ns	V_R = 50 V, I_L = 8.0 μA
t_f	Fall Time		100		ns	R_L = 1.00 kΩ, See Test Circuit

Typical Performance Curves

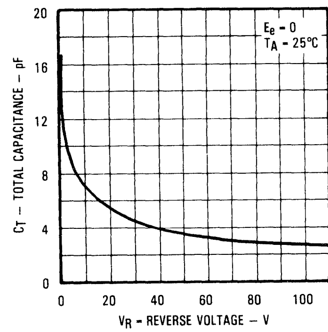
Dark Current vs. Ambient Temperature



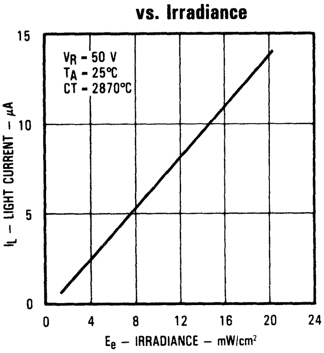
Normalized Light Current vs. Ambient Temperature



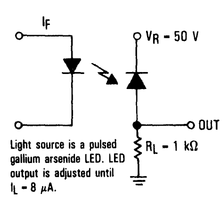
Total Capacitance vs. Reverse Voltage



Light Current vs. Irradiance



Switching Time Test Circuit



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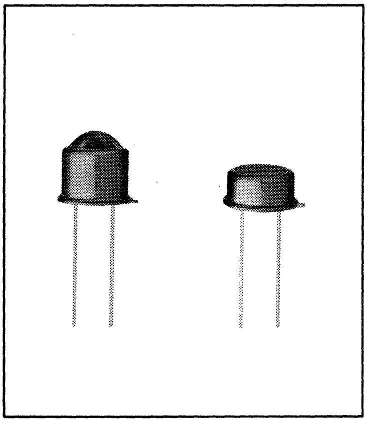
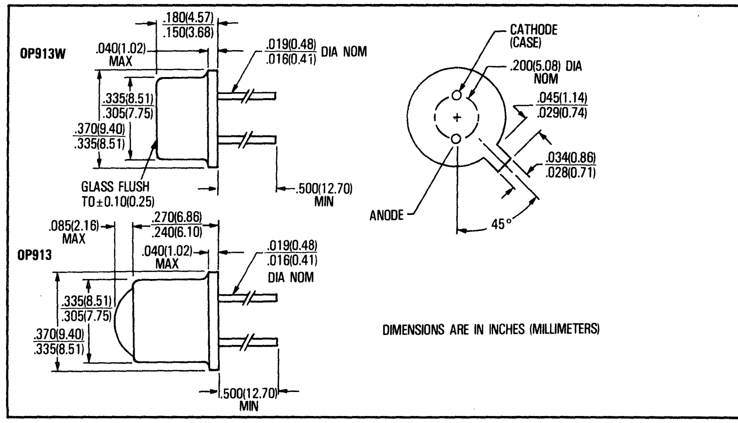
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5151
January 1985

PIN Silicon Photodiodes
Types OP913, OP913W





Features
- Large active area chip
- Fast switching time
- Lensed for high sensitivity
- TO-5 hermetically sealed package

Description
The OP913 and OP913W each consist of a PIN silicon photodiode mounted in a two leaded, TO-5 hermetically sealed package. The lensing effect of the OP913 allows an acceptance angle of 10° measured from the optical axis to the half power point. The flat lens of the OP913W allows an acceptance half angle of 30°. The large active area chip makes very low level detection possible. Both devices can be used in the photovoltaic mode.

Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)
Reverse Voltage . . . . 32 V
Storage Temperature Range . . . . −65°C to +150°C
Operating Temperature Range . . . . −55°C to +125°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)(1) . . . . 240°C
Power Dissipation . . . . 150 mW(2)

Notes:
(1) RMA flux is recommended. Duration can be extended to 10 seconds max. when flow soldering.
(2) Derate linearly 1.5 mW/°C above 25°C.
(3) Junction temperature maintained at 25°C.
(4) Light source is an unfiltered tungsten bulb operating at CT = 2870°K or equivalent infrared source.
(5) At any particular wavelength, the flux responsivity, R_Θ, is the ratio of the diode photocurrent to the radiant flux producing it. R_Θ is related to quantum efficiency by:

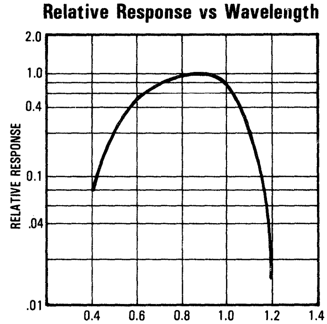
$$R_\Theta = \eta q \left(\frac{\lambda}{1240}\right)$$

Where ηq is the quantum efficiency in electrons per photon and λ is the wavelength in nanometers. Thus, at 900 nm, 0.6 A/W corresponds to a quantum efficiency of 83%.
(6) NEP is the radiant flux, at a specified wavelength, required for unity signal to noise ratio normalized for bandwidth.

$$NEP = \frac{I_N/\sqrt{\Delta f}}{R_\Theta}$$ where $I_N/\sqrt{\Delta f}$ is the bandwidth normalized shot noise.

NEP calculation is made using responsivity at peak sensitivity wavelength, with spot noise measurement at 1000 Hz in a noise bandwidth of 6 Hz. $(\lambda, f, \Delta f) = (\lambda p, 1000\ Hz, 6\ Hz)$.

Typical Performance Curves
Relative Response vs Wavelength



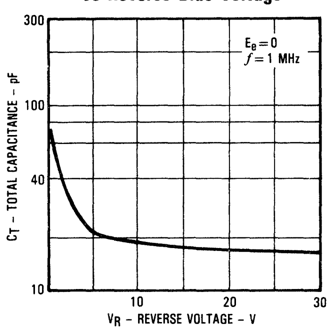
Types OP913, OP913W

Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

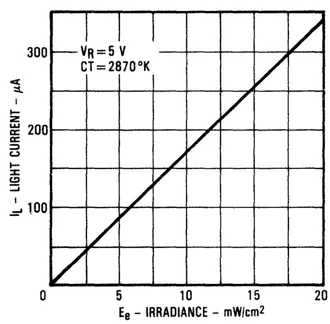
Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
I_L [3]	Reverse Light Current	OP913 OP913W	120 40	240 55		μA μA	$V_R = 5.0$ V, $E_e = 5.0$ mW/cm² [4] $V_R = 5.0$ V, $E_e = 5.0$ mW/cm² [4]
I_D [3]	Reverse Dark Current				25	nA	$V_R = 10.0$ V, $E_e = 0$ [4]
V_{OC}	Open Circuit Voltage	OP913 OP913W		400 300		mV mV	$E_e = 5.0$ mW/cm² [4] $E_e = 5.0$ mW/cm² [4]
I_{SC}	Short Circuit Current	OP913 OP913W	120 40			μA μA	$E_e = 5.0$ mW/cm² [4] $E_e = 5.0$ mW/cm² [4]
BV_R	Reverse Breakdown Voltage		32			V	$I_R = 100$ μA
C_T	Total Capacitance	OP913 OP913W			150 150	pF pF	$V_R = 0$, $E_e = 0$, f = 1.00 mHz $V_R = 0$, $E_e = 0$, f = 1.00 mHz
t_{on}, t_{off}	Turn-on Time, Turn-off Time	OP913 OP913W		50 50		ns ns	$V_R = 10.0$ V, $R_L = 1$ KΩ $V_R = 10.0$ V, $R_L = 1$ KΩ

Typical Performance Curves

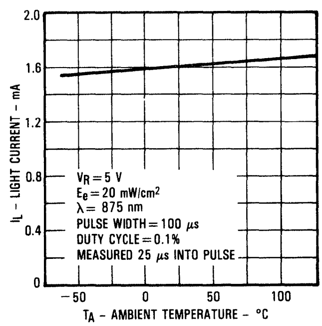
Total Capacitance vs Reverse Bias Voltage



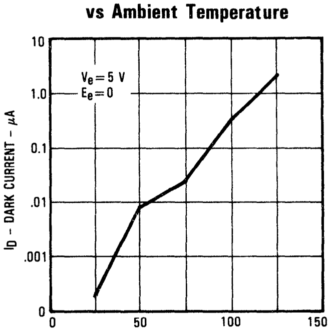
Light Current vs Irradiance



Light Current vs Ambient Temperature



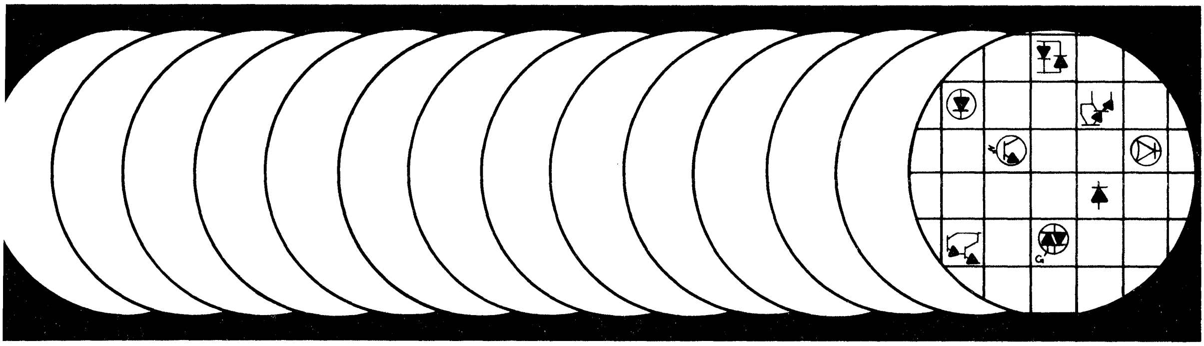
Dark Current vs Ambient Temperature



D

TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958



E

Optically Coupled Isolators

Optically Coupled Isolators

Optically coupled isolators, also called optocouplers, are used to isolate one electrical system from another in an electronic circuit. They allow direct circuit control with complete electrical isolation of input from output. These isolators are considered the best, most cost effective devices to eliminate associated differential ground, ground loop and EMI/RFI problems.

An optically coupled isolator consists of an IRED (infrared emitting diode) connected to the input circuit, optically coupled to a silicon photosensor at the output circuit. Both IRED and photosensor are housed in a single package with a light-conducting medium between them.

Optically coupled isolators are used in control and computer networks to isolate electrical "spikes" in one part of the circuit from transmission to another part. These isolators are especially useful in appliances and manually controlled electronic equipment to guard the operator against direct electrical contact with the line voltage. They can also serve as replacements for DC transformers or mechanical relays. With over twelve years of experience in the design and manufacture of optically coupled isolators, TRW is a market leader in high technology and specialty couplers. TRW led the industry by obtaining the first VDE approved IR optoisolator. The product line now contains several UL and VDE approved types, as well as types approved by BASEEFA (Great Britain) for operation in flammable atmospheres.

The TRW product line is broad and can meet a wide variety of unique applications. The line consists of:

- **Standard couplers** with phototransistor or photodarlington output, with current transfer ratios (CTR) as high as 500 percent, and with input current as low as 0.5 mA.
- **Specialty couplers** available in several styles of hermetic packages, with isolation voltages up to 50,000 VDC, with guaranteed CTRs up to 700 percent, and with input currents as low as 5 mA.
- **Triac Drivers** with zero current and zero voltage switching modes, with guaranteed LED trigger currents as low as 5 mA, and with an isolation voltage of ±2500 volts.
- **High technology** couplers with TTL-compatible Photologic™ output, with isolation voltages up to 15,000 VDC, and with the ultimate in speed—up to 5 MHz—available in single and dual channel versions.

Standard Optically Coupled Isolators

TRW's standard optocoupler line features the 6 pin P-DIP style case. These optocouplers are especially useful in applications requiring high voltage and noise isolation. Among such applications are computer and telephone interconnections, and level shifting and interfacing between logic families and low input current line receivers. When the application is networking among multiple hardware units, optically coupled isolators should be designed in for ground loop elimination and electrical protection.

TRW standard optocouplers contain either a gallium arsenide (GaAs) or gallium aluminum arsenide (GaAlAs) IRED as input, and a silicon (Si) phototransistor sensor (NPN type) as output. The coupling medium between the IRED and sensor is a high dielectric silicone gel. The infrared light emitted from the IRED has a wavelength of 930 nm for the GaAs IRED and 875 for the GaAlAs IRED. Both are spectrally matched with the photosensor peak spectral response, centered at 850 nm, in order to assure optimum DC transfer characteristics.

The key design parameters of an optically coupled isolator are the current transfer ratio (CTR), which is a measure of the output current for a given input current, and the isolation voltage, which is the amount of voltage that can be applied between input and output without causing arcing or breakdown. The CTR for TRW's standard optocouplers range from 2 to 500 percent. The isolation voltages range as high as 4000 VDC. Specialty couplers and custom products have CTRs and isolation voltages that often exceed these ranges.

Specialty Optocouplers

TRW's leadership in optoisolator technology and manufacture began 12 years ago when engineers developed the company's first infrared optoisolator using hermetic devices. Today, this product, the OPI120, remains one of the more popular of TRW's line of specialty couplers.

The specialty coupler line offers a wide selection of case types and electrical variations. Isolation voltages range from 1000 VDC in hermetic TO-5 and TO-72 packages, to 50 KV DC, made possible by TRW's development of an optical waveguide and custom package using hermetic discretes. Some of the line's most cost effective parts are the OPI1264A, B, and C types, which offer 10 KV electrical isolation in a popular axial package design. Choices of CTRs of 25, 50 or 100 percent are available with phototransistor output.

The OPI102, and OPI103, and JEDEC registered 3N and 4N types are hermetically packaged in TO-5 and TO-72 metal cans. CTRs range from 15 to 100 percent, and the parts feature phototransistor output for easy design-in to most circuits. The Hi-Rel and Military parts section of this data book contain descriptions of JAN and JANTX versions of many of these specialty coupler products.

Triac Driver Couplers

Opticaly coupled triac drivers are a practical, cost effective method of electrically isolating appliances and microprocessor equipment. They find use in appliance timing controls, lighting control systems, solenoid switching, motor controls and other solid state relay applications.

TRW's line of optically coupled triac drivers consists of four series, the OPI3009 and OPI3020, which switch at or near zero load **current**, and the OPI3030 and OPI3040, which switch at or near zero load **voltage**. Maximum triac voltage can be either 200 V or 400 V (for use with 115 or 220 VAC). Most important, trigger current selections span a range of 30 mA down to 5 mA. TRW's leadership in improving sensitivity to a 5 mA maximum trigger current level has resulted in making these the most sensitive triac drivers available today.

TRW triac drivers are characterized to have maximum immunity to high frequency AC line noise. Their commutating dV/dt of 100 V/μsec minimizes the chance that the devices will be triggered unintentionally by voltage spikes or other AC line noise. In addition, TRW's zero voltage crossing devices eliminate the need for snubber networks which require additional components and associated PC board space. Fewer components for the circuits mean increased reliability. Finally, TRW's optically coupled triac drivers can lower noise generation and suppress inrush current to protect inductive or resistive loads (e.g., lamp filaments).

Application Bulletin 110, printed in this data book, discusses the design considerations needed to use optically coupled triac drivers correctly, with special attention to appliances.

High Technology or Photologic™ Couplers

TRW's development of Photologic™ advanced IC photosensors has also led to the design of high technology couplers with 250 K-Baud TTL capability. The OPI8012, OPI8013, OPI8014 and OPI8015 are 6 pin P-DIP Photologic™ optocouplers. They represent four types of output: buffer totem-pole, buffer open-collector, inverter totem-pole, and inverter open-collector. If high voltage electrical isolation is required, the OPI125 through OPI128 series of parts provides these same output options with 15,000 VDC isolation in a hermetic axial-leaded package.

The TRW line of high technology couplers also includes the popular JEDEC registered 6N types. The 6N135 and 6N136 parts provide speeds of up to 2 MHz. The 6N138 and 6N139 offer CTRs of 300 and 500 percent, respectively. The top-of-the-line 6N137 offers state-of-the-art speeds of 5 MHz with logic gate output, and a 700 percent CTR. Part number OPI2630 is a dual channel version of this product, while the OPI8137 is a less costly version of the 6N137 for use where speed is slightly less critical.

Custom Optoisolator Capability

In some critical applications, standard electrical characteristics or package types simply will not work. TRW has extensive experience in designing and manufacturing custom optoisolators to meet the most demanding application requirements.

Leadership in Advanced Coupler Research

TRW's Optoelectronics Division has recently patented surface mount optoisolators, OPI210 and OPI211, symbols of the Division's leadership through optoisolator technology. The 6N137 high technology optocoupler, described above offers the ultimate in speed (5 MHz). Current research and development efforts at TRW are aimed at surpassing this achievement.

Projects currently in progress at the Division's research and development laboratories include operating speed improvements, increased photosensor functionality, input sensitivity enhancements, and innovations in package designs, such as new surface mount products. TRW continues to lead the industry in state-of-the-art optically coupled isolators.

Applications

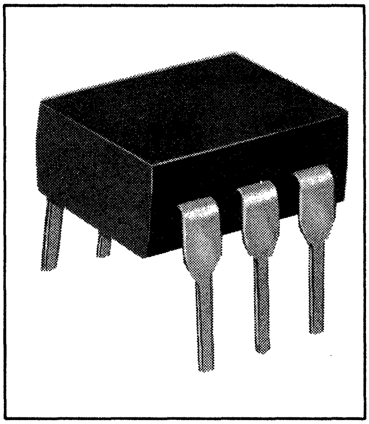
- AC Voltage Sensing
- Computer Peripherals
- Current Sensing
- Data Transmission
- Ground Loop Elimination
- Home Appliances
- Industrial Controls
- Instrument I/O Isolation
- Level Shifting
- Line Receivers
- Line Voltage Status Indicators
- Logic Interface
- Microprocessor Interface
- Motor or Light controls
- Network Isolation
- Polarity Sensing
- Solid State Relays
- Switching Power Supply
- Telephone Ring Detection
- Telephone Switching

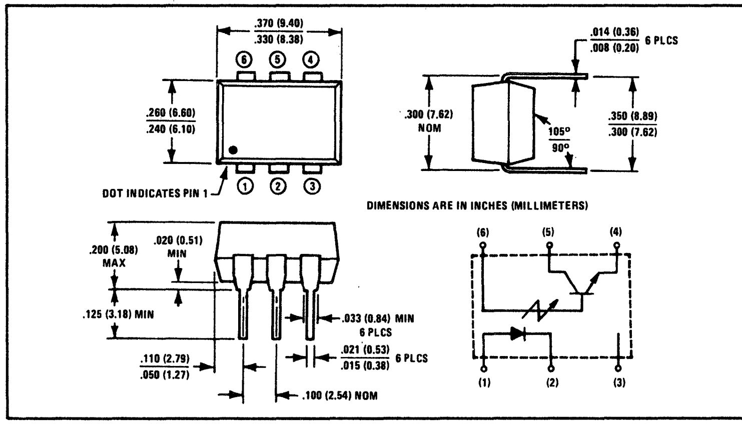
E

Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5196
January 1985

Optically Coupled Isolators
Types CNY17/1, CNY17/2, CNY17/3, CNY17/4





Features
- 4000 VDC isolation voltage
- Tightly controlled min-max CTR limits
- Low cost plastic package
- UL recognized, File No. E58730
- Fast switching speed

Description
The CNY17/1, CNY17/2, CNY17/3, and CNY17/4 are optically coupled isolators consisting of an infrared emitting diode coupled to an NPN silicon phototransistor and mounted in a standard six pin dual in-line package.

This series was originally numbered using Roman numerals, and may still appear on many prints and documents using the numbering system CNY17/I through CNY17/IV.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)
Input-to-Output Isolation Voltage .... ±4000 VDC[1]
Operating Temperature Range .... −55°C to +100°C
Storage Temperature Range .... −55°C to +150°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron) .... 260°C[2]

Input Diode
Reverse DC Voltage .... 3.0 V
Peak Forward Current (1 μsec pulse width, 330 pps) .... 3.0 A
Continuous Forward Current .... 60 mA
Power Dissipation .... 100 mW[3]

Output Sensor
Collector-Emitter Voltage .... 70 V
Emitter-Collector Voltage .... 7.0 V
Power Dissipation .... 150 mW[4]

Notes:
(1) Measured with input leads shorted together and output leads shorted together.
(2) RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering.
(3) Derate linearly 1.33 mW/°C above 25°C.
(4) Derate linearly 2.0 mW/°C above 25°C.

Electrical Characteristics (T_A = 25°C unless otherwise noted)

Symbol	Parameter		Min.	Max.	Units	Test Conditions
Input Diode						
V_F	Forward Voltage			1.65	V	I_F = 60 mA
I_R	Reverse Current			10.0	μA	V_R = 3.0 V
Phototransistor						
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage		70		V	I_C = 1.00 mA
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage		70		V	I_C = 100 μA
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage		7.0		V	I_E = 100 μA
I_{CEO}	Dark Current	CNY17/1, CNY17/2		50	nA	V_{CE} = 10.0 V
		CNY17/3, CNY17/4		100	nA	V_{CE} = 10.0 V
Coupled						
CTR	Current Transfer Ratio	CNY17/1	40	80	%	I_F = 10.0 mA, V_{CE} = 5.0 V, See Fig. 1, 2, 3
		CNY17/2	63	125	%	I_F = 10.0 mA, V_{CE} = 5.0 V
		CNY17/3	100	200	%	I_F = 10.0 mA, V_{CE} = 5.0 V
		CNY17/4	160	320	%	I_F = 10.0 mA, V_{CE} = 5.0 V
$V_{CE(SAT)}$	Saturation Voltage			0.40	V	I_F = 10.0 mA, I_C = 2.5 mA, See Fig. 1
V_{ISO}	Isolation Voltage		4000		VDC	See Note 1

E

Thermal Behavior Data

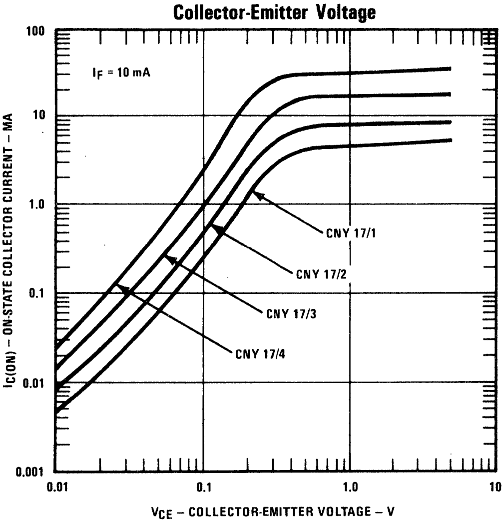
R_{THJA} — Thermal resistance, junction to ambient air
R_{THJX} — Thermal resistance, junction to some mounting surface
τ_{TH} — Thermal time constant
K — Thermal rating factor

R_{THJA} or X °C/W	τ_{TH} 10^{-2} sec	K	Condition
750	1.70	0.008	Free air
500	1.70	0.008	Mounted in standard DIP socket.
450	1.70	0.008	Mounted in 1/16" (1.6 mm) thick double sided PC board.

See Application Note 111 for information on proper soldering technique.

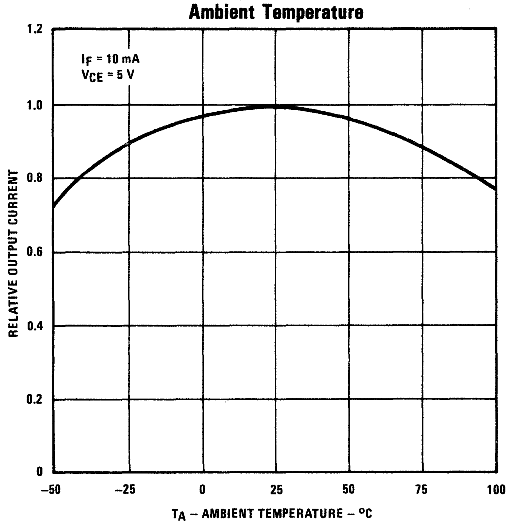
Typical Performance Curves

On-State Collector Current vs. Collector-Emitter Voltage

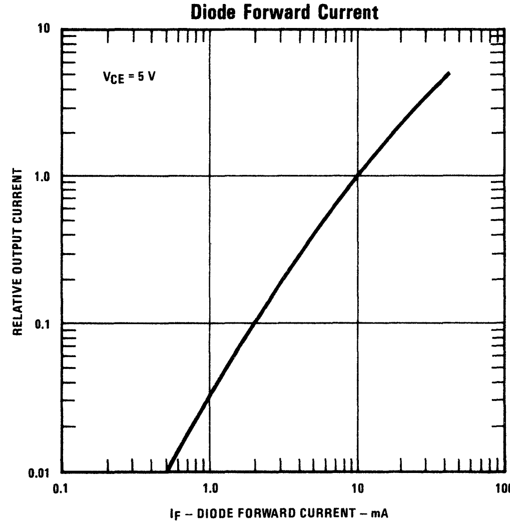


Typical Performance Curves

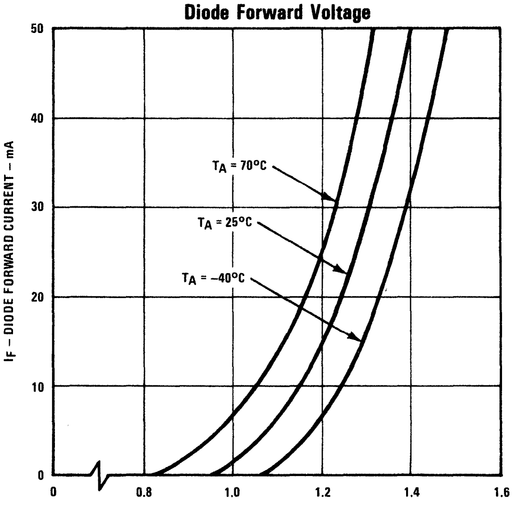
Relative Output Current vs. Ambient Temperature



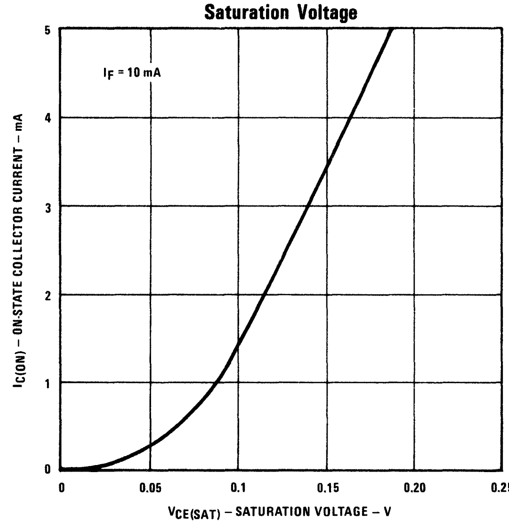
Relative Output Current vs. Diode Forward Current



Diode Forward Current vs. Diode Forward Voltage

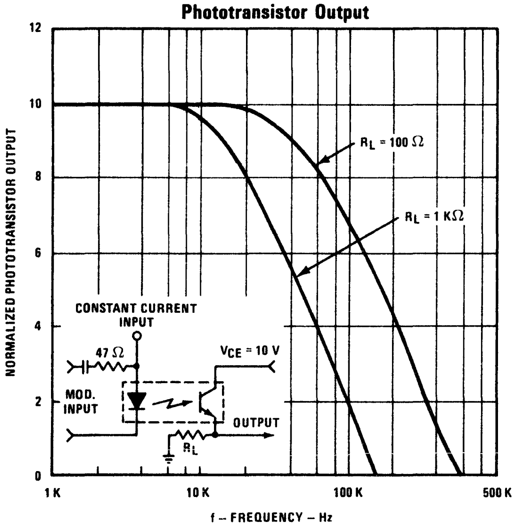


On-State Collector Current vs. Saturation Voltage

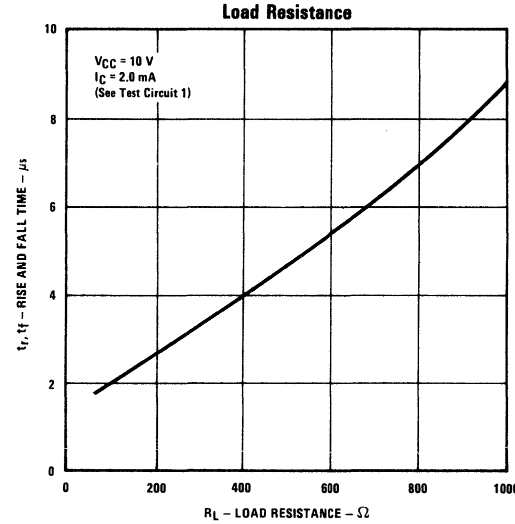


Typical Performance Curves

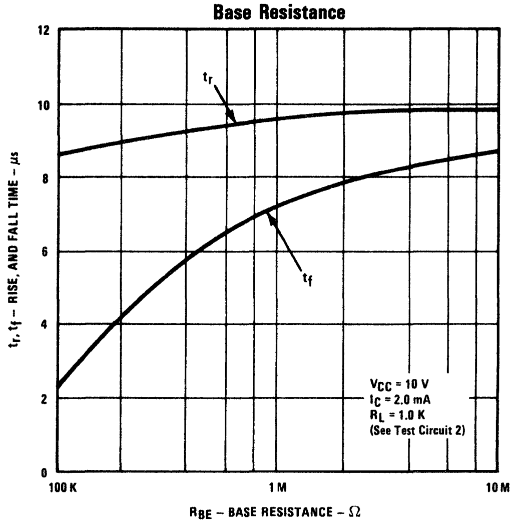
Frequency vs. Phototransistor Output



Rise and Fall Time vs. Load Resistance

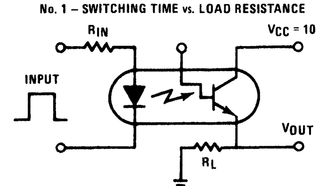


Delay, Rise, and Fall Time vs. Base Resistance

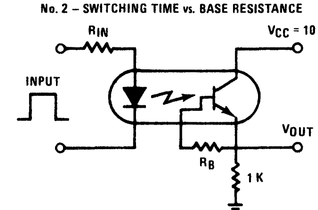


Switching Time Test Circuits

No. 1 – SWITCHING TIME vs. LOAD RESISTANCE



No. 2 – SWITCHING TIME vs. BASE RESISTANCE



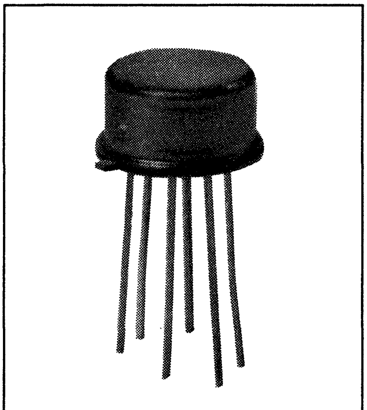
NOTE: Rise Time (t_r) is time required for collector current to increase from 10% to 90% of its final value. Fall Time (t_f) is time required for the collector current to decrease from 90% to 10% of its initial value. Delay Time (t_d) is the time from input pulse leading edge to point where collector current reaches 10% of its final value.

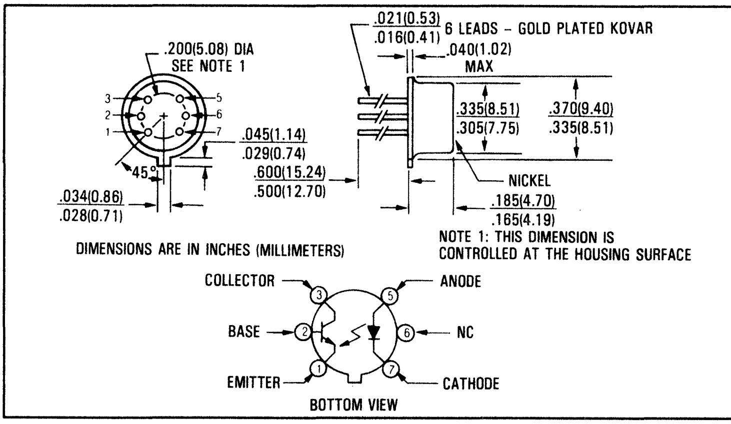
Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958

Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5179
January 1985

Optically Coupled Isolators
Types OPI102, OPI103





Features
- High DC current transfer ratio
- TO-5 hermetically sealed package
- 1000 volt isolation
- Base lead is provided for conventional transistor biasing

Description
The OPI102 and OPI103 are optically coupled isolators consisting of a gallium arsenide infrared emitting diode and an NPN silicon phototransistor mounted in a hermetically sealed TO-5 package. TO-5 packages offer high power dissipation, ease of heat sinking and superior hostile environment operation.

Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)
Input-to-Output Isolation Voltage .... ±1000 VDC(1)
Storage and Operating Temperature Range .... −55°C to +125°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron) .... 240°C(2)

Input Diode
Forward DC Current (65°C or below) .... 40 mA(3)
Reverse Voltage .... 2.0 V

Output Sensor
Continuous Collector Current .... 50 mA
Collector-Emitter Voltage .... 35 V
Collector-Base Voltage .... 35 V
Emitter-Base Voltage .... 4.0 V
Power Dissipation .... 300 mW(4)

Notes:
(1) Measured with input leads shorted together and output leads shorted together.
(2) RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering.
(3) Derate linearly 0.67 mA/°C above 65°C.
(4) Derate linearly 3.0 mW/°C above 25°C.
(5) Measured with input and output leads shorted together.

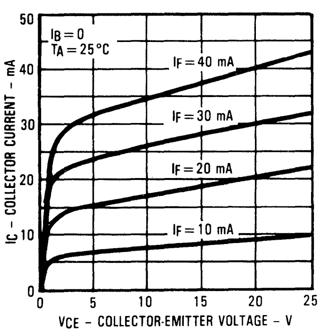
Types OPI102, OPI103

Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

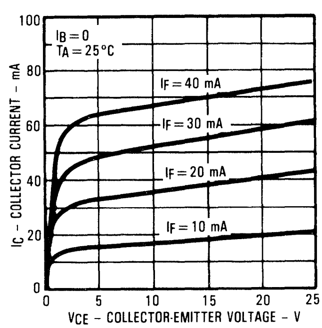
Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
Input Diode							
V_F	Forward Voltage				1.30	V	$I_F = 10.0$ mA
I_R	Reverse Current				100	μA	$V_R = 2.0$ V
Output Sensor							
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage		35.0			V	$I_C = 1.00$ mA, $I_B = 0$, $I_F = 0$
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage		35.0			V	$I_C = 100$ μA, $I_B = 0$, $I_F = 0$
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage		4.0			V	$I_E = 100$ μA, $I_B = 0$, $I_F = 0$
I_{CEO}	Collector-Emitter Dark Current				100	nA	$V_{CE} = 20$ V, $I_B = 0$, $I_F = 0$
h_{FE}	Forward Current Gain	OPI102		300			$V_{CE} = 5.0$ V, $I_C = 10.0$ mA, $I_F = 0$
		OPI103		500			$V_{CE} = 5.0$ V, $I_C = 10.0$ mA, $I_F = 0$
Coupled							
$I_{C(ON)}$	On-State Collector Current	OPI102	2.50			mA	$V_{CE} = 5.0$ V, $I_F = 10.0$ mA, $I_B = 0$
		OPI103	10.0			mA	$V_{CE} = 5.0$ V, $I_F = 10.0$ mA, $I_B = 0$
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage	OPI102			0.30	V	$I_C = 2.5$ mA, $I_F = 20$ mA
		OPI103			0.30	V	$I_C = 10.0$ mA, $I_F = 20$ mA
R_{IO}	Input-to-Output Resistance		10^{11}			Ω	$V_{IO} = \pm 1.00$ kV (See Note 5)
C_{IO}	Input-to-Output Capacitance			2.5		pF	$V_{IO} = 0$, $f = 1.00$ MHz (See Note 5)
t_r	Output Rise Time			5.0		μs	$V_{CC} = 10.0$ V, $I_F = 10.0$ mA
t_f	Output Fall Time			5.0		μs	$R_L = 100\Omega$ (See Test Circuit)

Typical Performance Curves

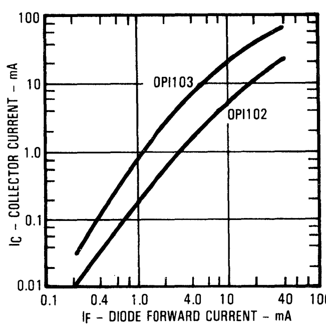
Collector Current vs Collector-Emitter Voltage (OPI102)



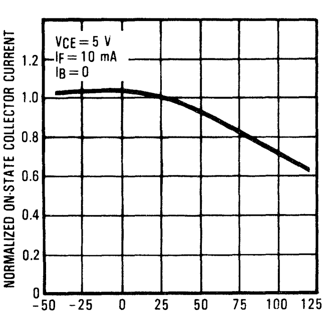
Collector Current vs Collector-Emitter Voltage (OPI103)



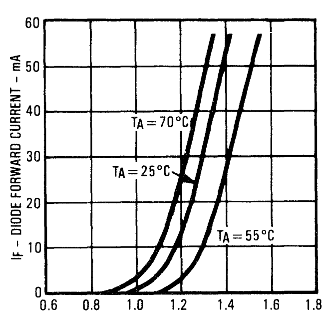
Collector Current vs Diode Forward Current



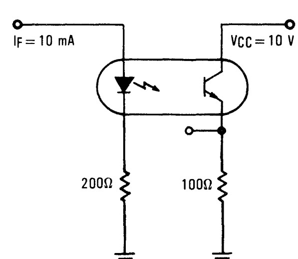
Normalized On-State Collector Current vs Free-Air Temperature



Diode Forward Current vs Diode Forward Voltage



Test Circuit

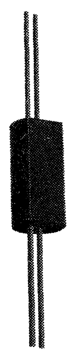


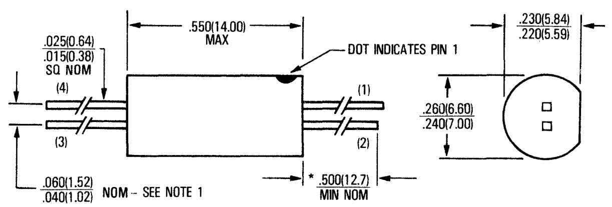
TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5182
January 1985

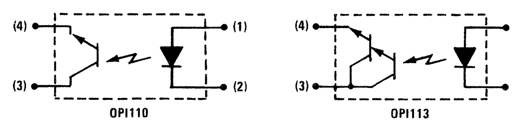
Optically Coupled Isolators
Types OPI110, OPI110C, OPI110B, OPI110A, OPI113





NOTE 1: THIS DIMENSION IS CONTROLLED AT THE HOUSING SURFACE.

DIMENSIONS ARE IN INCHES (MILLIMETERS).



*CATHODE LEAD. OTHER LEADS ARE .06(1.52) NOM. LONGER.

Features
- 10 kV electrical isolation
- Phototransistor or photodarlington output option
- Low cost plastic housing
- VDE approved
- UL Recognized File Number E58730[6]
- BASEEFA Approved File Number SFA/19/104/01

Description
The OPI110 series and the OPI113 are optically coupled isolators, each containing a gallium arsenide infrared emitting diode and an NPN silicon phototransistor (OPI110 series) or photodarlington (OPI113) sealed in a precast opaque housing. This series is designed for applications requiring high voltage isolation between input and output.

Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)
Input-to-Output Isolation Voltage . . . . . ±10 kVDC[1]
Storage Temperature Range . . . . . −40°C to 100°C
Operating Temperature Range . . . . . −40°C to +85°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron) . . . . . 240°C[2]

Input Diode
Forward DC Current . . . . . 40 mA[3]
Reverse DC Voltage . . . . . 2.0 V
Power Dissipation . . . . . 50 mW[4]

Output Photosensor
Collector-Emitter Voltage (OPI110) . . . . . 30 V
(OPI113) . . . . . 15.0 V
Emitter-Collector Voltage . . . . . 5.0 V
Power Dissipation . . . . . 100 mW[5]

Notes:
(1) Measured with input diode leads shorted together and output leads shorted together. Typical input/output capacitance is .06.
(2) RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering.
(3) Derate linearly 0.73 mA/°C above 25°C.
(4) Derate linearly 0.91 mW/°C above 25°C.
(5) Derate linearly 1.82 mW/°C above 25°C.
(6) UL recognition is for 3500 VAC, 1 minute only.

Types OPI110, OPI110C, OPI110B, OPI110A, OPI113

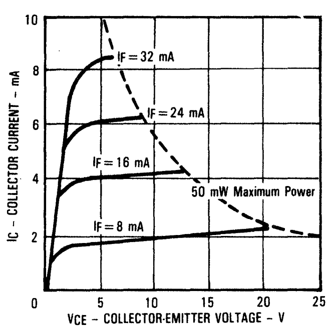
Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

Symbol	Parameter		Min.	Max.	Units	Test Conditions
Input Diode						
V_F	Forward Voltage	OPI110		1.60	V	$I_F = 20$ mA
		OPI113		1.60	V	$I_F = 20$ mA
I_R	Reverse Current			100	μA	$V_R = 2.0$ V
Output Photosensor						
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	OPI110	30		V	$I_C = 100$ μA
		OPI113	15		V	$I_C = 1.00$ mA, $I_F = 0$
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	OPI110	5.0		V	$I_E = 100$ μA, $I_F = 0$
		OPI113	5.0		V	$I_E = 100$ μA, $I_F = 0$
I_{CEO}	Collector-Emitter Dark Current	OPI110		100	nA	$V_{CE} = 15$ V, $E_e = 0$
		OPI113		100	nA	$V_{CE} = 10.0$ V, $E_e = 0$
Coupled						
I_C/I_F	DC Current Transfer Ratio	OPI110	12.5		%	$I_F = 10.0$ mA, $V_{CE} = 5.0$ V
		OPI110A	25		%	$I_F = 10.0$ mA, $V_{CE} = 5.0$ V
		OPI110B	50	125	%	$I_F = 10.0$ mA, $V_{CE} = 5.0$ V
		OPI110C	100		%	$I_F = 10.0$ mA, $V_{CE} = 5.0$ V
		OPI113	50		%	$I_F = 5.0$ mA, $V_{CE} = 2.0$ V
$V_{CE(SAT)}$	Collector Saturation Voltage	OPI110		0.40	V	$I_F = 10.0$ mA, $I_C = 1.60$ mA
		OPI113		0.80	V	$I_F = 10.0$ mA, $I_C = 5.0$ mA
I_{CEO}	Collector-Emitter Dark Current	OPI110		200	nA	$V_{CE} = 20$ V, $I_F = 0$
		OPI113		100	nA	$V_{CE} = 10.0$ V, $I_F = 0$
V_{ISO}	Isolation Voltage		10.0		kVDC	(See Note 1)

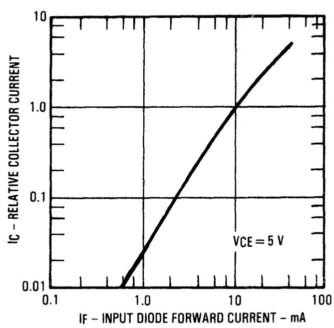
E

Typical Performance Curves (OPI110 Only)

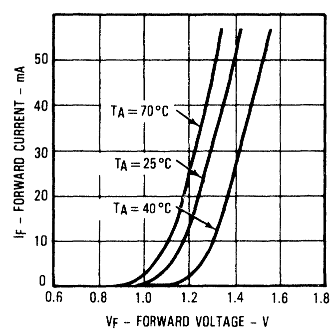
Collector Current vs Collector-Emitter Voltage



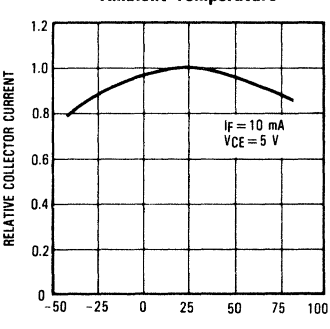
Relative Collector Current vs Diode Forward Current



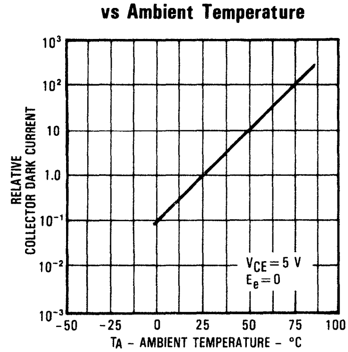
Diode Forward Current vs Diode Forward Voltage



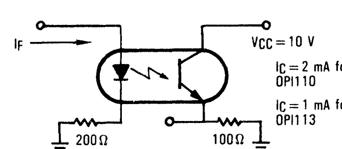
Relative Collector Current vs Ambient Temperature



Relative Collector Dark Current vs Ambient Temperature



Switching Time Test Circuit



t_r and t_f for OPI110 are typically 4 μs.
t_r and t_f for OPI113 are typically 40 μs.
The input waveform is supplied by a generator with the following characteristics: $Z_{OUT} = 50\Omega$, $t_r \leq 15$ ns, duty cycle ≅ 1%, pulse width = 100 μs.

TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958

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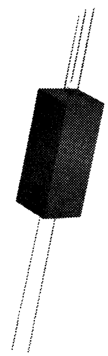
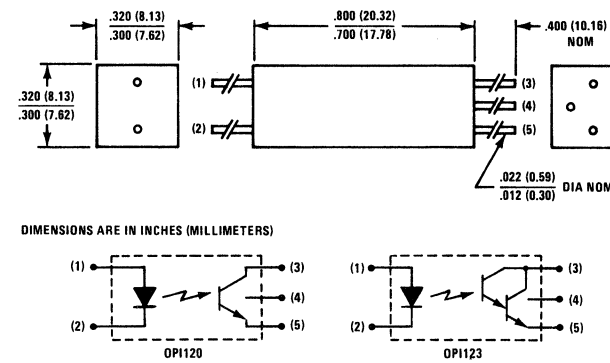
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5184
January 1985

Optically Coupled Isolators
Types OPI120, OPI123





Features
- 15 kV electrical isolation
- Phototransistor or photodarlington output option
- Hermetically sealed LED and photosensor
- Base contact is bonded for conventional transistor biasing

Description
The OPI120 and OPI123 are optically coupled isolators each containing a gallium arsenide infrared emitting diode and an NPN silicon phototransistor (OPI120) or photodarlington (OPI123) sealed in a high dielectric plastic housing. LED and sensors are in hermetically sealed packages. This series is designed for applications requiring high voltage isolation between input and output.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

Input-to-Output Isolation Voltage	±15 kVDC(1)
Storage Temperature Range	−55°C to +125°C
Operating Temperature Range	−55°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)(2)	240°C
Input Diode	
Forward DC Current	150 mA(3)
Reverse DC Voltage	3.0 V
Power Dissipation	200 mW(4)
Output Photosensor	
Collector-Emitter Voltage — OPI120	25 V
OPI123	20 V
Emitter-Collector Voltage	5.0 V
Collector-Base Voltage — OPI120	25 V
OPI123	30 V
Power Dissipation	250 mW(5)

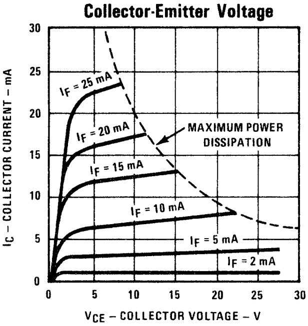
Notes:
(1) Measured with input leads shorted together and output leads shorted together in air with a maximum relative humidity of 50%. If suitably encapsulated or oil immersed, the isolation voltage is increased to at least 25 kV.
(2) RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering.
(3) Derate linearly 2.0 mA/°C above 25°C.
(4) Derate linearly 2.67 mW/°C above 25°C.
(5) Derate linearly 3.33 mW/°C above 25°C.

Electrical Characteristics (T_A = 25°C unless otherwise noted)

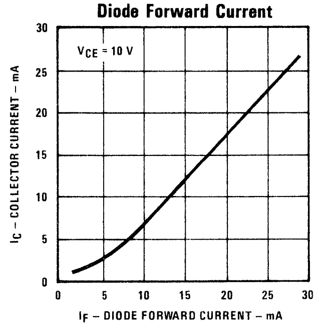
Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
Input Diode							
V_F	Forward Voltage	OPI120			1.50	V	I_F = 30 mA
		OPI123			1.50	V	I_F = 10.0 mA
I_R	Reverse Current	OPI120			100	μA	V_R = 3.0 V
		OPI123			10.0	μA	V_R = 3.0 V
Output Photosensor							
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	OPI120	25			V	I_C = 1.00 mA
		OPI123	20			V	I_C = 1.00 mA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage		5.0			V	I_E = 100 μA
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	OPI120	25			V	I_C = 100 μA
		OPI123	30			V	I_C = 100 μA
I_{CEO}	Collector-Emitter Dark Current				100	nA	V_{CE} = 10.0 V
Coupled							
I_C/I_F	DC Current Transfer Ratio	OPI120	20	70		%	I_F = 10.0 mA, V_{CE} = 5.0 V
		OPI123	50			%	I_F = 10.0 mA, V_{CE} = 2.0 V
$V_{CE(SAT)}$	Saturation Voltage	OPI120			0.5	V	I_F = 30 mA, I_C = 1.00 mA
		OPI123			1.20	V	I_F = 5.0 mA, I_C = 1.00 mA
V_{ISO}	Isolation Voltage		15.0			kV	See Note 1
t_r	Output Rise Time	OPI120		2.0		μs	V_{CC} = 10.0 V, I_C = 2.0 mA, R_L = 100Ω
t_f	Output Fall Time	OPI120		2.0		μs	See Test Circuit
t_r	Output Rise Time	OPI123		40		μs	V_{CC} = 10.0 V, I_C = 1.00 mA, R_L = 100Ω
t_f	Output Fall Time	OPI123		40		μs	See Test Circuit

Typical Performance Curves (OPI120 Only)

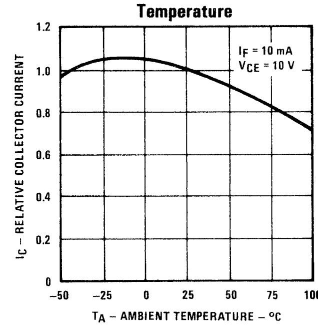
Collector Current vs. Collector-Emitter Voltage



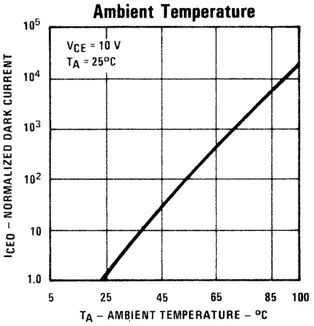
Collector Current vs. Diode Forward Current



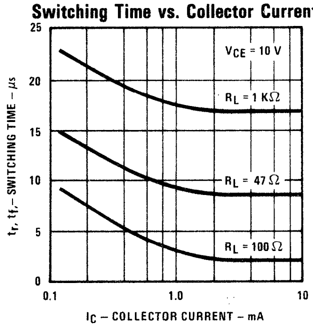
Relative Collector Current vs. Temperature



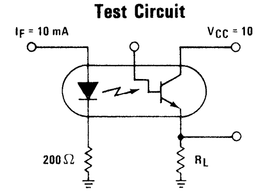
Normalized Dark Current vs. Ambient Temperature



Switching Time vs. Collector Current



Test Circuit



The input waveform is supplied by a generator with the following characteristics: Z_{OUT} = 50Ω, $t_r \leq$ 15 ns. Duty cycle ≈ 1%, pulse width ≈ 100 μs.

TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

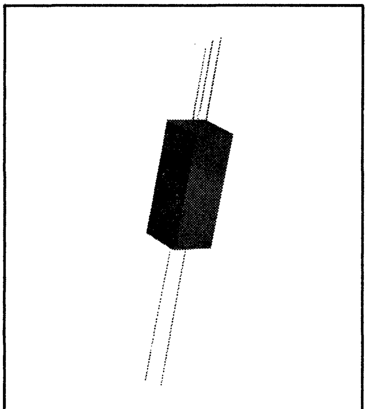
Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958

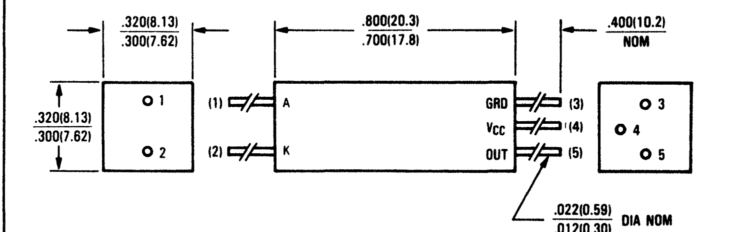
Printed in U.S.A.

Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5186
January 1985

Photologic™ Optically Coupled Isolators
Types OPI125, OPI126, OPI127, OPI128





DIMENSIONS ARE IN INCHES (MILLIMETERS)

Features
- Four output options
- 15 kV input-to-output isolation voltage
- Direct TTL/LSTTL interface
- High noise immunity
- Data rates to 250 KBaud
- Hermetically sealed

Description
The OPI125, OPI126, OPI127, and OPI128 each contain a gallium arsenide infrared emitting diode coupled to a monolithic integrated circuit which incorporates a photodiode, a linear amplifier and a Schmitt trigger on a single silicon chip. The devices feature TTL/LSTTL compatible logic level output which can drive up to 8 TTL loads directly without additional circuitry. Also featured are medium speed data rates to 250 KBaud with typical rise and fall times of 25 nsec. Both the infrared emitting diode and the Photologic™ sensor are in hermetically sealed packages for maximum long term stability and are mounted in a high dielectric plastic housing.

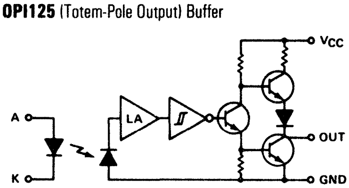
Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)

Input-to-Output Isolation Voltage	±15 kVDC(1)
Supply Voltage, V_{CC} (not to exceed 3 seconds)	+10.0 V
Storage Temperature Range	−55°C to +100°C
Operating Temperature Range	−55°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)(2)	240°C
Total Device Power Dissipation	400 mW(3)
Input Diode Power Dissipation	250 mW(4)
Output Photologic Power Dissipation	200 mW(5)
Duration of Output Short to V_{CC} or Ground (OPI125, OPI127)	1.00 sec.
Duration of Output Short to V_{CC} (OPI126, OPI128)	1.00 sec.
Voltage at Output Lead (OPI126, OPI128)	35 V
Diode Input — Forward D.C. Current	25 mA
Diode Input — Reverse D.C. Voltage	2.0 V

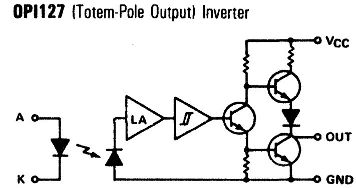
Notes: **(1)** Measured with input diode leads shorted together and output leads shorted together. **(2)** RMA flux is recommended. Duration can be extended to 10 seconds max. when flow soldering. **(3)** Derate linearly 5.33 mW/cm² above 25°C. **(4)** Derate linearly 3.33 mW/cm² above 25°C. **(5)** Derate linearly 2.67 mW/cm² above 25°C.

Schematics

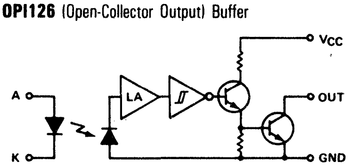
OPI125 (Totem-Pole Output) Buffer



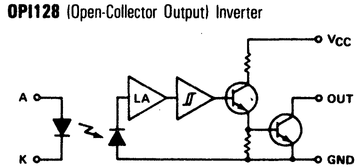
OPI127 (Totem-Pole Output) Inverter



OPI126 (Open-Collector Output) Buffer



OPI128 (Open-Collector Output) Inverter



Electrical Characteristics (−40°C to +70°C unless otherwise noted)

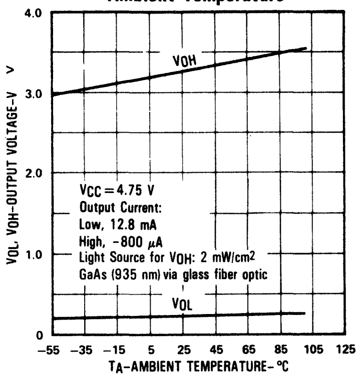
Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
Diode Input						
V_F	Forward Voltage			1.50	V	$I_F = 10.0$ mA, $T_A = 25°C$
I_R	Reverse Current			100	μA	$V_R = 2.0$ V, $T_A = 25°C$
$I_{F(+)}$	LED Positive-Going Threshold Current			7.5	mA	$V_{CC} = 5.0$ V
$I_{F(+)}/I_{F(-)}$	Hysteresis Ratio		2.0			
Photologic™ Output						
V_{CC}	Operating Supply Voltage	4.8		5.2	V	
I_{CC}	Supply Current			20	mA	$V_{CC} = 5.2$ V, $I_F = 0$ or 7.5 mA
OPI125 (Buffer, Totem-Pole)						
V_{OL}	Low Level Output Voltage			0.40	V	$V_{CC} = 4.8$ V, $I_{OL} = 13.0$ mA, $I_F = 0$ mA
V_{OH}	High Level Output Voltage	2.4			V	$V_{CC} = 4.8$ V, $I_{OH} = -800$ μA, $I_F = 7.5$ mA
I_{OS}	Short Circuit Output Current	−30		−120	mA	$V_{CC} = 5.2$ V, $I_F = 7.5$ mA, Output = GND
OPI126 (Buffer, Open-Collector)						
V_{OL}	Low Level Output Voltage			0.40	V	$V_{CC} = 4.8$ V, $I_{OL} = 13.0$ mA, $I_F = 0$ mA
I_{OH}	High Level Output Current			100	μA	$V_{CC} = 4.8$ V, $V_{OH} = 30$ V, $I_F = 7.5$ mA
OPI127 (Inverter, Totem-Pole)						
V_{OL}	Low Level Output Voltage			0.40	V	$V_{CC} = 4.8$ V, $I_{OL} = 13.0$ mA, $I_F = 7.5$ mA
V_{OH}	High Level Output Voltage	2.4			V	$V_{CC} = 4.8$ V, $I_{OH} = -800$ μA, $I_F = 0$ mA
I_{OS}	Short Circuit Output Current	−30		−120	mA	$V_{CC} = 5.2$ V, $I_F = 0$ mA, Output = GND
OPI128 (Inverter, Open-Collector)						
V_{OL}	Low Level Output Voltage			0.40	V	$V_{CC} = 4.8$ V, $I_{OL} = 13.0$ mA, $I_F = 7.5$ mA
I_{OH}	High Level Output Current			100	μA	$V_{CC} = 4.8$ V, $V_{OH} = 30$ V, $I_F = 0$ mA
OPI125, OPI127						
t_r, t_f	Output Rise Time, Output Fall Time		70		ns	$V_{CC} = 5.0$ V, $T_A = 25°C$, $I_F = 0$ or 10.0 mA, f = 10.0 kHz, D.C. = 50%, $R_L = 8$ TTL Loads
t_{PLH}, t_{PHL}	Propagation Delay, Low-High, High-Low		5		μs	
OPI126, OPI128						
t_r, t_f	Output Rise Time, Output Fall Time		70		ns	$V_{CC} = 5.0$ V, $T_A = 25°C$, $I_F = 0$ or10.0 mA, f = 10.0 kHz, D.C. = 50%, $R_L = 360\Omega$
t_{PLH}, t_{PHL}	Propagation Delay, Low-High, High-Low		5		μs	

E

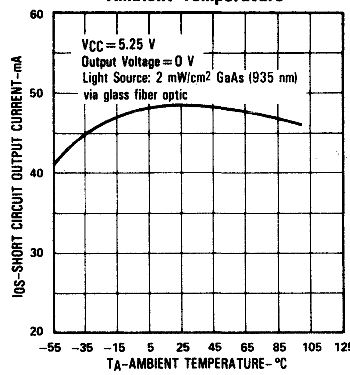
Typical Performance Curves

OPI125, OPI127

Output Voltage vs. Ambient Temperature

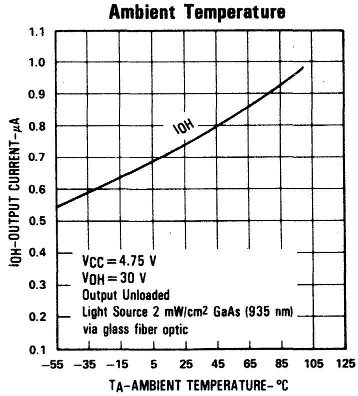


Short Circuit Output Current vs. Ambient Temperature

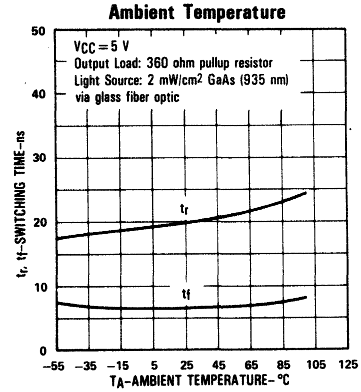


OPI126, OPI128

Output Current (High) vs Ambient Temperature

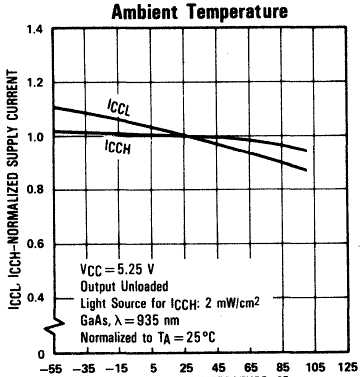


Rise Time and Fall time vs Ambient Temperature



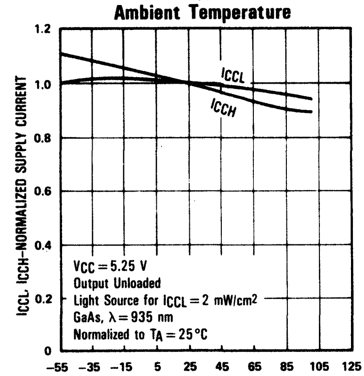
OPI125, OPI126

Normalized Supply Current vs Ambient Temperature



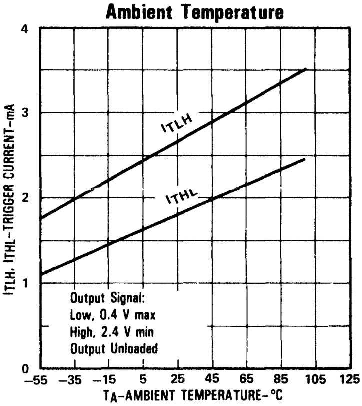
OPI127, OPI128

Normalized Supply Current vs Ambient Temperature

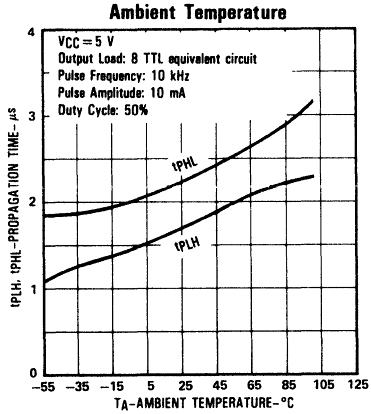


Typical Performance Curves

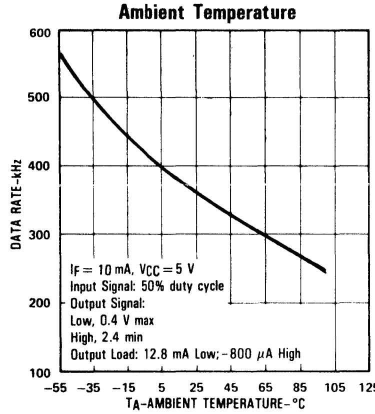
Trigger Current vs Ambient Temperature



Propagation Time vs Ambient Temperature

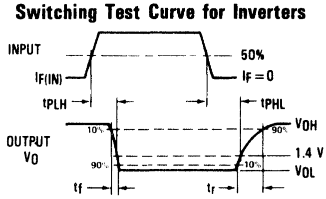


Data Rate vs Ambient Temperature



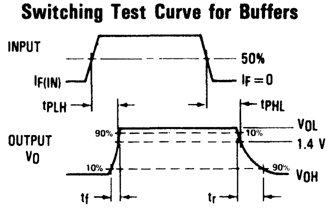
E

Switching Test Curve for Inverters



LED: f = 1kHz, D.C. = 50%

Switching Test Curve for Buffers



LED: f = kHz, D.C. = 50%

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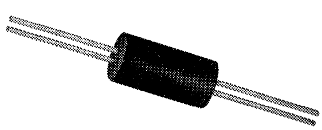
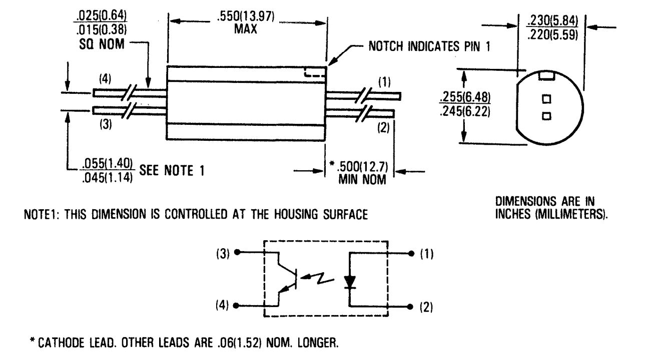
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5194
January 1985

Optically Coupled Isolators
Types OPI1264, OPI1264C, OPI1264B, OPI1264A





Features
- 10 kV electrical rating
- High current transfer ratio
- Low cost plastic module
- VDE approved File No. 30 431

  VDE rated for:
  Surface leakage current: Group III (KB > 600)
  Creeping distance ≥ 12 mm
  Air path ≥ 15 mm
- UL recognized File No. E58730 (6)

Description
The OPI1264, OPI1264A, OPI1264B, and OPI1264C are a family of optically coupled isolators, each consisting of a gallium arsenide, infrared emitting diode, coupled to an NPN silicon phototransistor sealed in a precast opaque housing. This series is designed for applications requiring high voltage isolation between input and output.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)
Input-to-Output Isolation Voltage .... ±10.0 kVDC(1)
Operating Temperature Range .... −40°C to +85°C
Storage Temperature Range .... −40°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron) .... 240°C(2)

Input Diode
Forward DC Current .... 40 mA(3)
Reverse DC Voltage .... 2.0 V
Power Dissipation .... 50 mW(4)

Output Phototransistor
Collector-Emitter Voltage .... 30 V
Emitter-Collector Voltage .... 5.0 V
Power Dissipation .... 100 mW(5)

Notes:
(1) Measured with input diode leads shorted together and output leads shorted together. Typical input/output capacitance is .06 pf.
(2) RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering.
(3) Derate linearly 0.73 mA/°C above 25°C.
(4) Derate linearly 0.91 mW/°C above 25°C.
(5) Derate linearly 1.82 mW/°C above 25°C.
(6) UL recognition is for 3500 VAC, 1 minute, only.

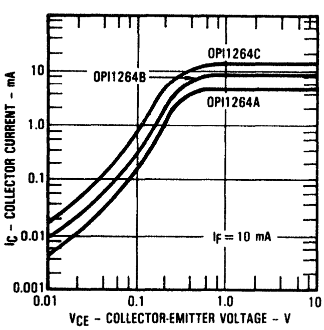
Types OPI1264, OPI1264C, OPI1264B, OPI1264A

Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

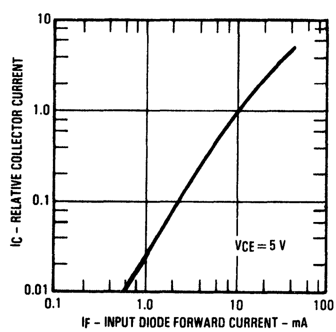
Symbol	Parameter	Min.	Max.	Units	Test Conditions
Input Diode					
V_F	Forward Voltage		1.60	V	$I_F = 20$ mA
I_R	Reverse Current		100	μA	$V_R = 2.0$ V
Output Phototransistor					
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	30		V	$I_C = 100$ μA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	5.0		V	$I_E = 100$ μA
I_{CEO}	Collector-Emitter Dark Current		100	nA	$V_{CE} = 15$ V, $E_e = 0$
Coupled					
I_C/I_F	DC Current Transfer Ratio OPI1264	12.5		%	$I_F = 10.0$ mA, $V_{CE} = 5.0$ V
	OPI1264A	25		%	$I_F = 10.0$ mA, $V_{CE} = 5.0$ V
	OPI1264B	50	125	%	$I_F = 10.0$ mA, $V_{CE} = 5.0$ V
	OPI1264C	100		%	$I_F = 10.0$ mA, $V_{CE} = 5.0$ V
V_{ISO}	Isolation Voltage	10,000		V	(See Note 1)
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage		0.40	V	$I_F = 10.0$ mA, $I_C = 1.60$ mA
I_{CEO}	Collector-Emitter Dark Current		200	nA	$V_{CE} = 20$ V, $I_F = 0$

Typical Performance Curves

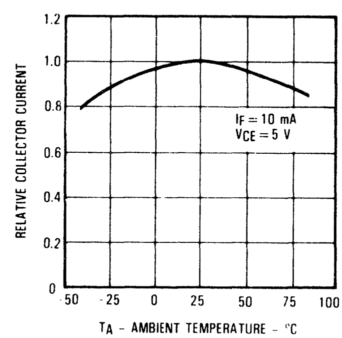
Collector Current vs Collector-Emitter Voltage



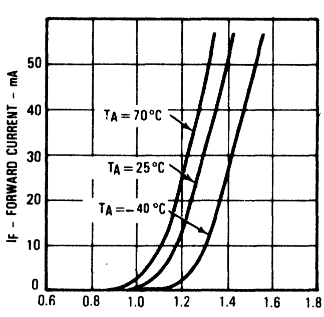
Relative Collector Current vs Diode Forward Voltage



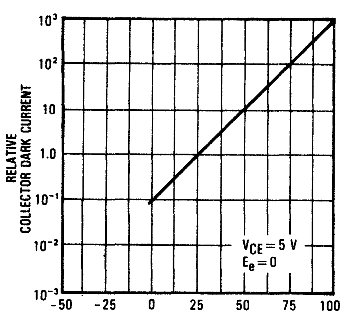
Relative Collector Current vs Ambient Temperature



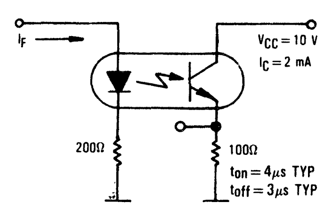
Diode Forward Current vs Diode Forward Voltage



Collector Dark Current vs Ambient Temperature



Switching Time Test Circuit



The input waveform is supplied by a generator with the following characteristics: $Z_{OUT} = 50\Omega$, $t_r \leq 15$ ns, duty cycle ≈ 1%, pulse width ≈ 100 μs.

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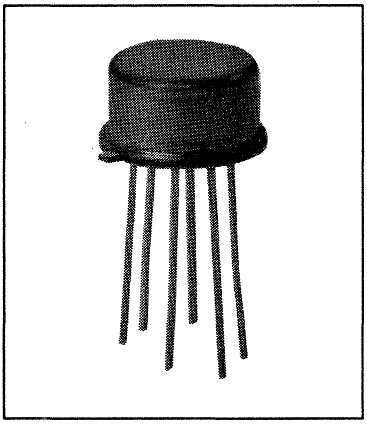
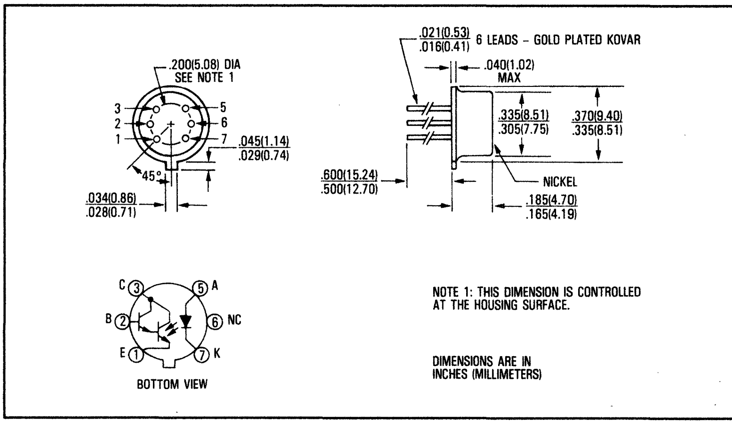
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5188
January 1985

Optically Coupled Isolator
Type OPI130





Features
- Photodarlington output
- TO-5 hermetically sealed package
- 1000 volt isolation
- Base lead is provided for conventional transistor biasing

Description
The OPI130 is an optically coupled isolator consisting of a gallium arsenide infrared emitting diode and an NPN silicon photodarlington mounted in a hermetically sealed TO-5 package. TO-5 packages offer high power dissipation, ease of heat sinking and superior hostile environment operation.

Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)

Input-to-Output Isolation Voltage .... ±1000 VDC[1]
Storage Temperature Range .... −65°C to +150°C
Operating Temperature Range .... −55°C to +125°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron) .... 240°C[2]

Input Diode
Forward DC Current (65°C or below) .... 40 mA[5]
Reverse Voltage .... 2.0 V
Power Dissipation .... 60 mW[3]

Output Sensor
Continuous Collector Current .... 50 mA[5]
Collector-Emitter Voltage .... 25 V
Collector-Base Voltage .... 25 V
Emitter-Base Voltage .... 5.0 V
Power Dissipation .... 300 mW[4]

Notes:
(1) Measured with input leads shorted together and output leads shorted together.
(2) RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering.
(3) Derate linearly 0.6 mW/°C above 25°C.
(4) Derate linearly 3.0 mW/°C above 25°C.
(5) Derate linearly to 125°C free-air temperature at the rate of 0.67 mA/°C.

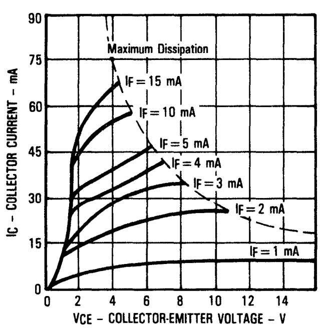
Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
Input Diode						
V_F	Forward Voltage			1.30	V	$I_F = 10.0$ mA
I_R	Reverse Current			100	μA	$V_R = 2.0$ V
Output Photodarlington						
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	25			V	$I_C = 1.00$ mA, $I_B = 0$, $I_F = 0$
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	25			V	$I_C = 100$ μA, $I_E = 0$, $I_F = 0$
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	5.0			V	$I_E = 100$ μA, $I_C = 0$, $I_F = 0$
I_{CEO}	Collector-Emitter Dark Current			100	nA	$V_{CE} = 10.0$ V, $I_B = 0$, $I_F = 0$
			800		μA	$V_{CE} = 10.0$ V, $I_B = 0$, $I_F = 0$, $T_A = 100°C$
h_{FE}	DC Current Gain		12000			$V_{CE} = 5.0$ V, $I_C = 10.0$ mA, $I_F = 0$
Coupled						
$I_{C(ON)}$	On-State Collector Current	10.0			mA	$V_{CE} = 2.0$ V, $I_F = 5.0$ mA, $I_B = 0$
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage			1.00	V	$I_C = 1.00$ mA, $I_F = 5.0$ mA
I_{IO}	Leakage, Input-to-Output			10.0	nA	$V_{IO} = \pm 1.00$ kV (See Note 1)
R_{IO}	Input-to-Output Resistance	10^{11}	10^{12}		Ω	$V_{IO} = \pm 1.00$ kV (See Note 1)
C_{IO}	Input-to-Output Capacitance		3.0		pF	$V_{IO} = 0$, f = 1.00 MHz (See Note 1)
t_r	Output Rise Time		50		μs	$V_{CC} = 20$ V, $I_F = 5.0$ mA
t_f	Output Fall Time		50		μs	$R_L = 100Ω$ (See Test Circuit)

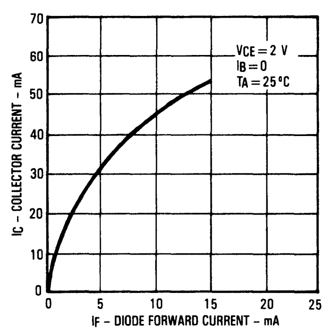
E

Typical Performance Curves

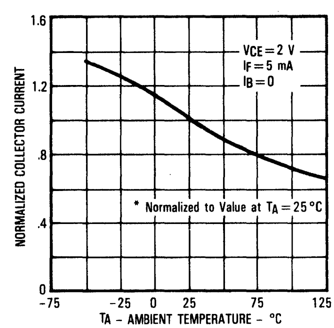
Collector Current vs Collector-Emitter Voltage



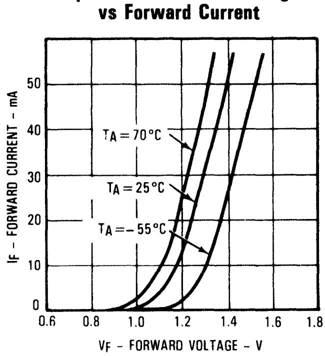
Collector Current vs Diode Forward Voltage



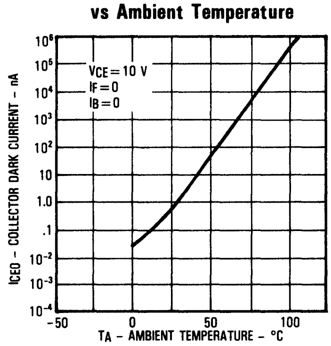
Normalized Collector Current vs Ambient Temperature



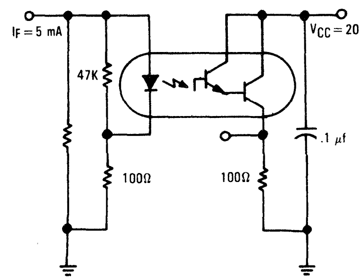
Input Diode Forward Voltage vs Forward Current



Collector Dark Current vs Ambient Temperature



Test Circuit



The input waveform is supplied by a generator with the following characteristics: $Z_{OUT} = 50Ω$, $t_r \leq 15$ ns, duty cycle ≈ 1%, pulse width ≈ 100 μs.

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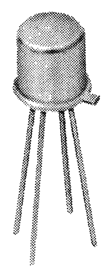
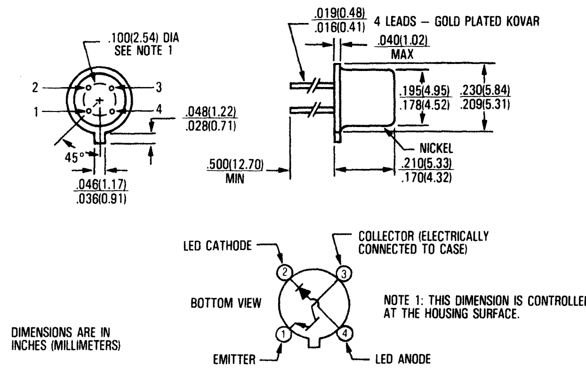
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5190
January 1985

Optically Coupled Isolator
Type OPI140





Features
- TO-72 hermetically sealed package
- 1000 volt isolation
- Withstands HTRB at 125°C, $V_{CE}=20$ volts

Description
The OPI140 is an optically coupled isolator consisting of a gallium arsenide infrared emitting diode and an NPN silicon photosensor mounted in a hermetically sealed TO-72 package. TO-72 packages offer high power dissipation, ease of heat sinking and superior hostile environment operation.

Absolute Maximum Ratings ($T_A=25°C$ unless otherwise noted)

Input-to-Output Isolation Voltage	±1000 VDC[1]
Storage Temperature Range	−65°C to +150°C
Operating Temperature Range	−55°C to +125°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)	240°C[2]
Input Diode	
Forward DC Current	40 mA
Reverse DC Voltage	3.0 V
Power Dissipation	60 mW[3]
Output Phototransistor	
Collector-Emitter Voltage	30 V
Emitter-Colledtor Voltage	7.0 V
Continuous Collector Current	30 mA
Power Dissipation	200 mW[4]

Notes:
(1) Measured with input leads shorted together and output leads shorted together.
(2) RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering.
(3) Derate linearly 0.6 mW/°C above 25°C.
(4) Derate linearly 2.0 mW/°C above 25°C.

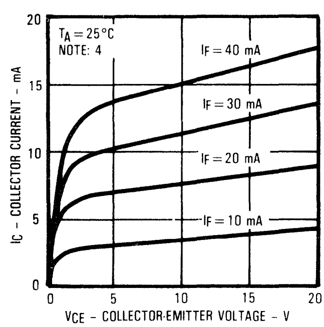
Type OPI140

Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

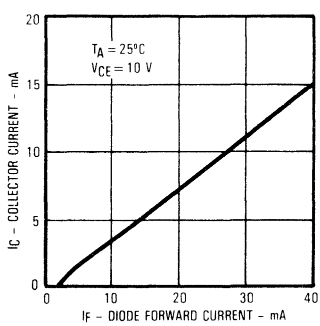
Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
Input Diode						
V_F	Forward Voltage			1.50	V	$I_F = 40$ mA
I_R	Reverse Current			10.0	μA	$V_R = 3.0$ V
Output Phototransistor						
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	30			V	$I_C = 1.00$ mA, $I_F = 0$
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	7.0			V	$I_E = 100$ μA, $I_F = 0$
I_{CEO}	Collector-Emitter Dark Current			50	nA	$V_{CE} = 10.0$ V, $I_F = 0$
Coupled						
$I_{C(ON)}$	On-State Collector Current	1.50			mA	$V_{CE} = 10.0$ V, $I_F = 10.0$ mA
$V_{CE(SAT)}$	Saturation Voltage			0.50	V	$I_F = 40$ mA, $I_C = 1.60$ mA
I_{IO}	Leakage, Input-to-Output			10.0	nA	$V_{IO} = \pm 1.00$ KVDC. (See Note 1)
R_{IO}	Input-to-Output Resistance		10^{11}		Ω	$V_{IO} = 500$ V (See Note 1)
t_r	Output Rise Time		2.0		μs	$V_{CC} = 10.0$ V, $I_C = 1.00$ mA
t_f	Output Fall Time		2.0		μs	$R_L = 100\Omega$ (See Test Circuit)

Typical Performance Curves

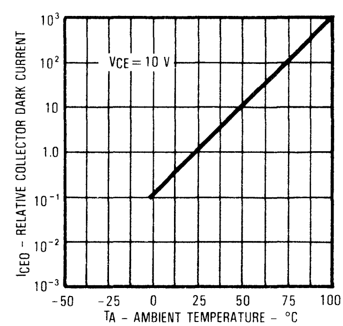
Collector Current vs Collector-Emitter Voltage



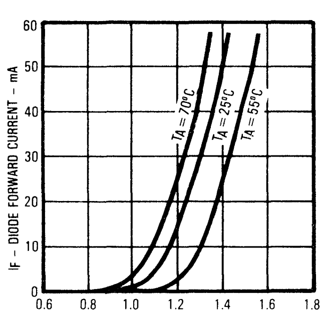
Collector Current vs Diode Forward Voltage



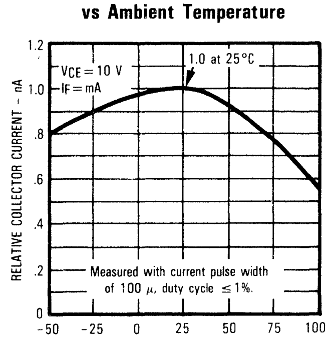
Collector Dark Current vs Ambient Temperature



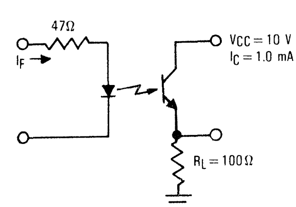
Diode Forward Voltage vs Diode Forward Current



Relative Collector Current vs Ambient Temperature



Test Circuit



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Optoelectronics Division
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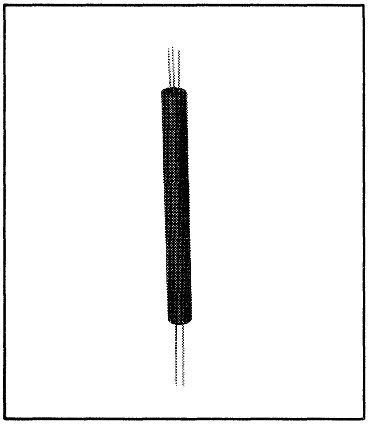
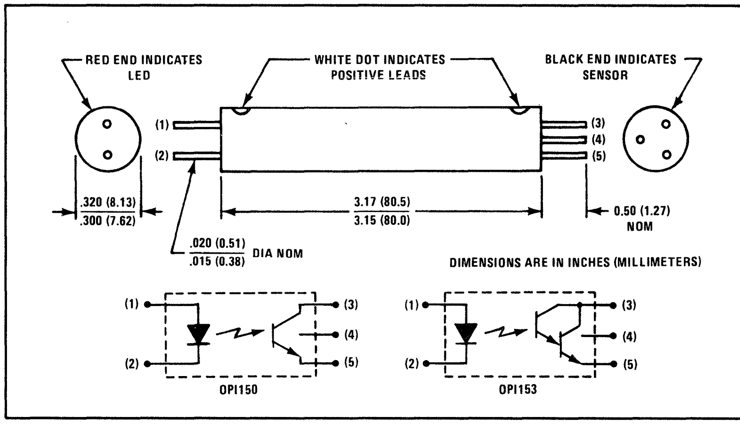
Product Bulletin 5192
January 1985

Optically Coupled Isolators
Types OPI150, OPI153





Features
- 50 kV electrical isolation
- Phototransistor or photodarlington output option
- Hermetically sealed LED and photosensor
- Base contact is bonded for conventional transistor biasing

Description
The OPI150 and OPI153 each contain a gallium arsenide infrared emitting diode and an NPN silicon phototransistor (OPI150) or photodarlington (OPI153) optically coupled by means of a light pipe and mounted in a high dielectric plastic housing. LED and sensors are in hermetically sealed packages. This series is designed for applications requiring very high isolation between input and output.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

Input-to-Output Isolation Voltage	±50 kV(1)
Storage Temperature Range	−40°C to +85°C
Operating Temperature Range	−40°C to +85°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)(2)	240°C
Input Diode	
Reverse Voltage	3.0 V
Continuous Forward Current	50 mA
Power Dissipation	200 mW(3)
Output Photosensor	
Collector-Emitter Voltage — OPI150	30 V
OPI153	15.0 V
Emitter-Collector Voltage — OPI150	5.0 V
OPI153	5.0 V
Collector-Base Voltage — OPI150	30 V
OPI153	20 V
Power Dissipation — OPI150	250 mW(4)
OPI153	250 mW(4)

Notes:

(1) Measured with input leads shorted together and output leads shorted together.
(2) RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering.
(3) Derate linearly 3.33 mW/°C above 25°C.
(4) Derate linearly 4.17 mW/°C above 25°C.

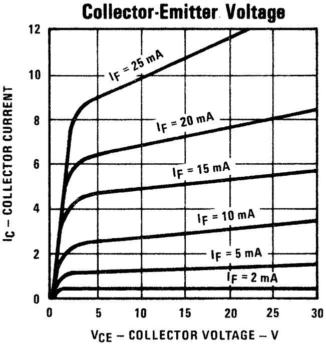
Electrical Characteristics (T_A = 25°C unless otherwise noted)

Symbol	Parameter		Min.	Max.	Units	Test Conditions
Input Diode						
V_F	Forward Voltage	OPI150		1.50	V	I_F = 50 mA
		OPI153		1.60	V	I_F = 50 mA
I_R	Reverse Current			100	μA	V_R = 3.0 V
Output Photosensor						
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	OPI150	30		V	I_C = 1.00 mA
		OPI153	15.0		V	I_C = 1.00 mA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage		5.0		V	I_F = 100 μA
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	OPI150	30		V	I_C = 100 μA
		OPI153	20		V	I_C = 100 μA
I_{CEO}	Collector-Emitter Dark Current	OPI150		100	nA	V_{CE} = 10.0 V
		OPI153		500	nA	V_{CE} = 10.0 V
I_{CBO}	Collector-Base Dark Current	OPI150		50	nA	V_{CB} = 10.0 V
Coupled						
I_C/I_F	DC Current Transfer Ratio	OPI150	10.0		%	V_{CE} = 5.0 V, I_F = 10.0 mA
		OPI153	25		%	V_{CE} = 5.0 V, I_F = 20 mA
$I_{CB(ON)}$	On-State Photodiode Current	OPI150	10.0		μA	V_{CB} = 5.0 V, I_F = 20 mA
$V_{CE(SAT)}$	Saturation Voltage	OPI150		0.50	V	I_F = 16.0 mA, I_C = 1.00 mA
		OPI153		1.20	V	I_F = 30 mA, I_C = 2.0 mA

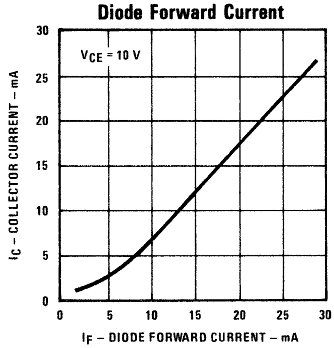
E

Typical Performance Curves (OPI150 Only)

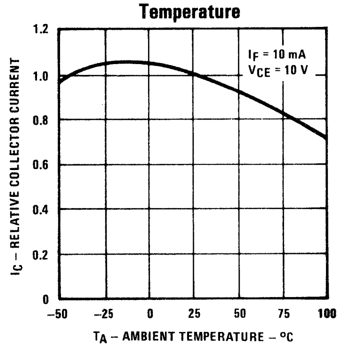
Collector Current vs. Collector-Emitter Voltage



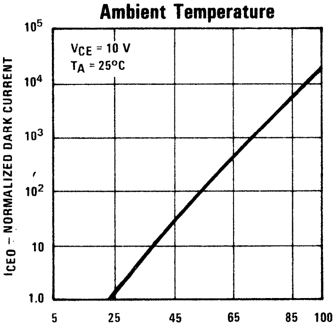
Collector Current vs. Diode Forward Current



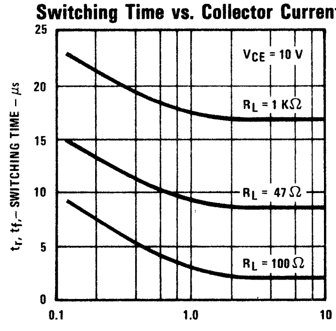
Relative Collector Current vs. Temperature



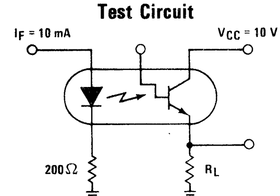
Normalized Dark Current vs. Ambient Temperature



Switching Time vs. Collector Current



Test Circuit



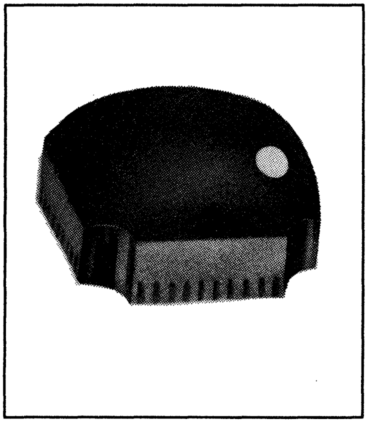
The input waveform is supplied by a generator with the following characteristics: Z_{OUT} = 50Ω, $t_r \leq$ 15 ns. Duty cycle ≈ 1%, pulse width ≈ 100 μs.

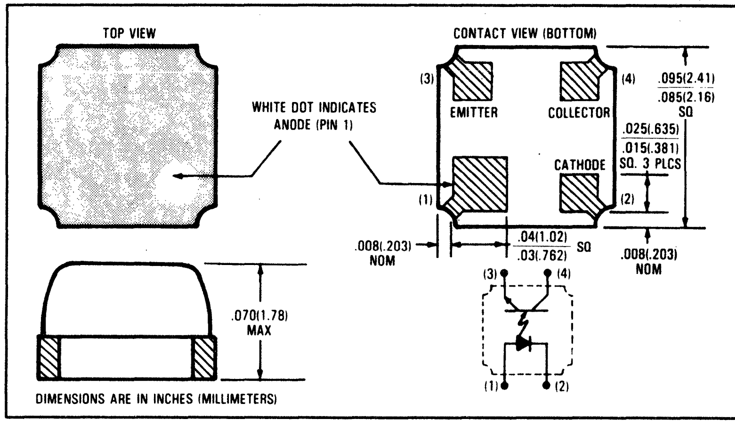
TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5193
January 1985

Surface Mount Optically Coupled Isolators
Types OPI210, OPI211





Features
- Micro miniature package—ideal for hybrid applications
- TTL, DTL compatible
- High DC current transfer ratio
- Four bonding pads for attaching to hybrid substrates
- 1 KV electrical isolation
- High efficiency gallium aluminum arsenide emitter

Description
The OPI210 and OPI211 are optically coupled isolators each consisting of a gallium aluminum arsenide LED and a silicon phototransistor mounted and coupled on a thick film ceramic substrate. These solid-state optocouplers are ideal for hybrid applications. Four thick film bonding pads make electrical connections easy.

The OPI210 and OPI211 are identical except for the DC current transfer ratio. Both were designed with high reliability in mind and are ideally suited for use in MIL-STD-883 hybrid applications.

Device mounting may be achieved using silver or gold filled epoxies. The OPI210 and OPI211 are sensitive to some hybrid cleaning processes. Consult factory for details.

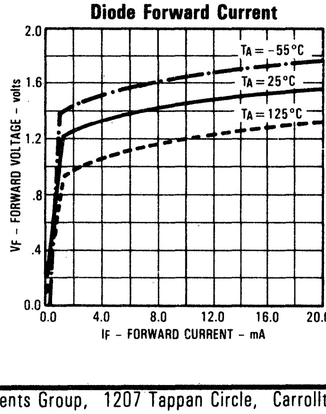
Absolute Maximum Ratings (T_A=25°C unless otherwise noted)

Input-to-Output Isolation Voltage	±1000 VDC(1)
Storage Temperature Range	−65°C to +150°C
Operating Temperature Range	−55°C to +125°C
Input Diode	
Forward DC Current (65°C or below)	20 mA
Peak Forward Current (1 μs pulse, 300 pps)	1.00 A
Reverse Voltage	3.0 V
Power Dissipation	30 mW(2)
Output Transistor	
Collector-Emitter Voltage	35 V
Emitter-Collector Voltage	7.0 V
Continuous Collector Current	40 mA
Power Dissipation	200 mW(3)

Notes: **(1)** Measured with input diode bond pads shorted together and output bond pads shorted together. **(2)** Derate linearly between 65°C and 125°C free air temperature at the rate of 3.0 mW/°C. **(3)** Derate linearly to 125°C free air temperature at the rate of 2.0 mW/°C.

Typical Performance Curves

Diode Forward Voltage vs Diode Forward Current



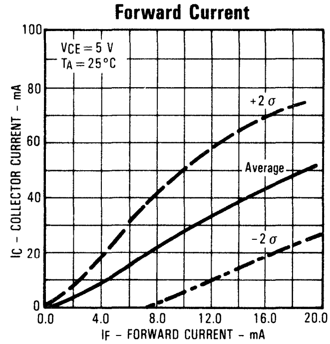
Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
Input Diode						
V_F	Forward Voltage			1.50	V	$I_F = 10.0$ mA
I_R	Reverse Current			100	μA	$V_R = 2.0$ V
Output Phototransistor						
$V_{(BR)CEO}$	Collector-to-Emitter Breakdown Voltage	35			V	$I_C = 100$ μA, $I_F = 0$
$V_{(BR)ECO}$	Emitter-to-Collector Breakdown Voltage	7.0			V	$I_E = 100$ μA, $I_F = 0$
I_{CEO}	Collector-Emitter Dark Current			100	nA	$V_{CE} = 20$ V, $I_F = 0$
Coupled						
I_C/I_F	DC Current Transfer Ratio OPI210	50			%	$I_F = 10.0$ mA, $V_{CE} = 5.0$ V
	OPI211	200			%	$I_F = 10.0$ mA, $V_{CE} = 5.0$ V
$V_{CE(SAT)}$	Collector-to-Emitter Saturation Voltage			0.30	V	$I_C = 10.0$ mA, $I_F = 20$ mA
t_r	Output Rise Time			15.0	μs	$V_{CC} = 10.0$ V, $R_L = 100\Omega$
t_f	Output Fall Time			15.0	μs	Pulse width = 100 μs, duty cycle = 1%

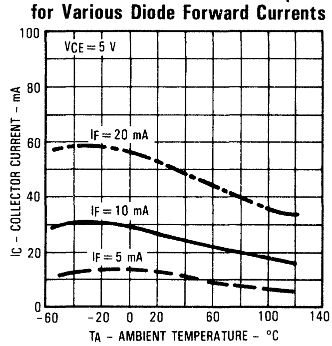
E

Typical Performance Curves

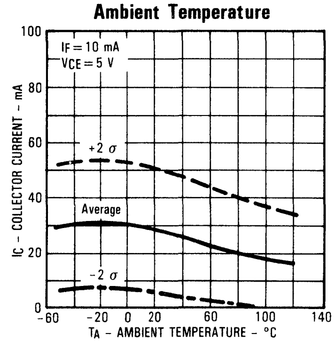
Collector Current vs Forward Current



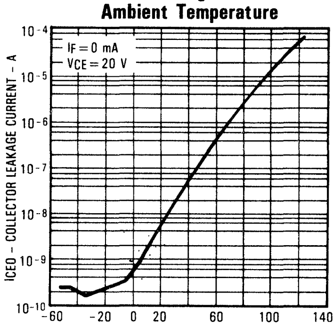
Collector Current vs Ambient Temperature for Various Diode Forward Currents



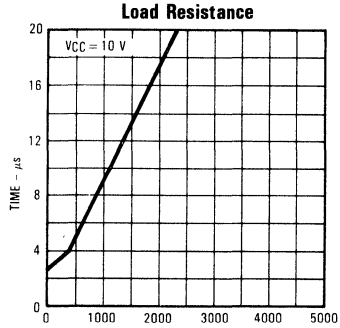
Collector Current vs Ambient Temperature



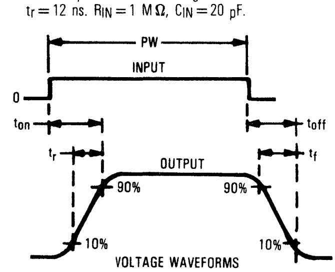
Collector Leakage Current vs Ambient Temperature



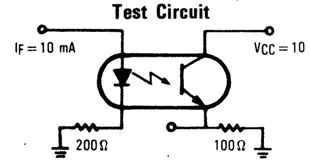
Rise and Fall Time vs Load Resistance



The output waveform is monitored on an oscilloscope with the following characteristics: $t_r = 12$ ns. $R_{IN} = 1$ MΩ, $C_{IN} = 20$ pF.



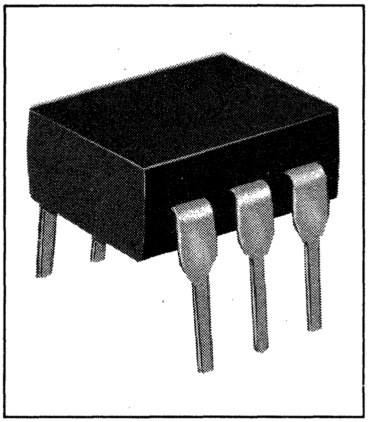
Test Circuit

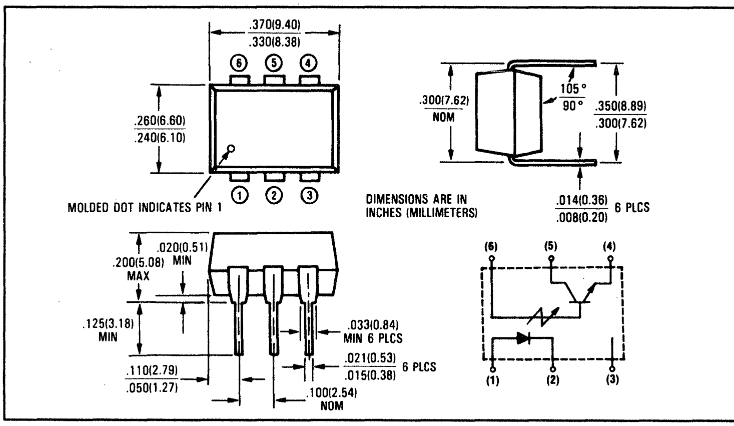


The input waveform is supplied by a generator with the following characteristics: $Z_{OUT} = 50\Omega$, $t_r \leq 15$ ns, duty cycle ≈ 1%, pulse width ≈ 100 μs.

Product Bulletin 5198
January 1985

Optically Coupled Isolators
Type OPI2100





Features
- 4 kV isolation
- High current transfer ratio
- Direct interface with up to 10 TTL loads
- UL recognized File No. E58730

Description
The OPI2100 consists of a gallium arsenide infrared emitting diode and an NPN silicon phototransistor mounted in a standard plastic six pin dual-in-line package. This device is designed to directly drive from 1 to 10 TTL loads and has very good output sinking characteristics at low sink current.

Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)
Input-to-Output Isolation Voltage . . . ±4000 VDC(1)
Storage Temperature Range . . . −55°C to +150°C
Operating Temperature Range . . . −55°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)(2) . . . 260°C

Input Diode
Forward DC Current . . . 60 mA
Peak Forward Current (1 μs pulse, 300 pps) . . . 3.0 A
Reverse Voltage . . . 6.0 V
Power Dissipation . . . 100 mW(3)

Output Transistor
Collector-Emitter Voltage . . . 30 V
Collector-Base Voltage . . . 30 V
Emitter-Collector Voltage . . . 6.0 V
Power Dissipation . . . 150 mW(4)

Notes:
(1) Measured with input diode leads shorted together and output leads shorted together.
(2) RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering.
(3) Derate linearly 1.33 mW/°C above 25°C.
(4) Derate linearly 2.0 mW/°C above 25°C.

Type OPI2100

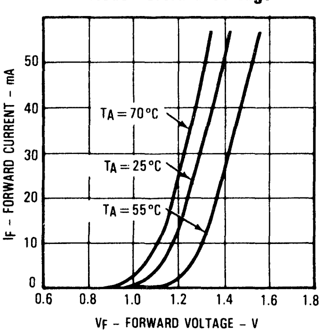
Electrical Characteristics ($T_A = 25°C$ unless otherwise noted).

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
Input Diode						
V_F	Forward Voltage			1.40	V	$I_F = 40$ mA
I_R	Reverse Current			10.0	µA	$V_R = 6.0$ V
Output Phototransistor						
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	30			V	$I_C = 1.00$ mA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	6.0			V	$I_C = 100$ µA
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	30			V	$I_C = 10.0$ µA
I_{CEO}	Collector-Emitter Dark Current			50	nA	$V_{CE} = 5.0$ V
h_{FE}	DC Current Gain		100			$V_{CE} = 5.0$ V, $I_C = 10.0$ mA
Coupled						
I_C/I_F	DC Current Transfer Ratio	150			%	$V_{CE} = 5.0$ V, $I_F = 10.0$ mA
I_C/I_F	DC Current Transfer Ratio	50			%	$V_{CE} = .60$ V, $I_F = 3.2$–32 mA
$V_{CE(SAT)}$	Saturation Voltage			0.60	V	$I_C = 16.0$ mA, $I_F = 32$ mA

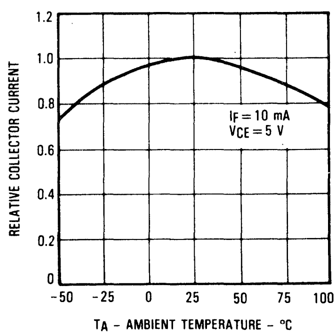
E

Typical Performance Curves

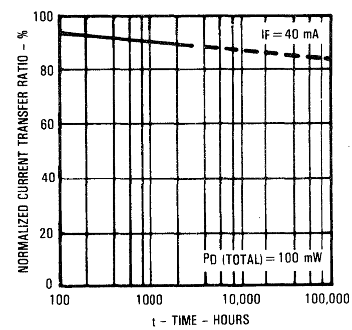
Diode Forward Current vs Diode Forward Voltage



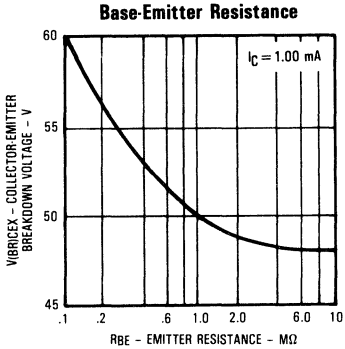
Relative Collector Current vs Ambient Temperature



Normalized Current Transfer Ratio vs Time



Collector-Emitter Breakdown Voltage vs Base-Emitter Resistance

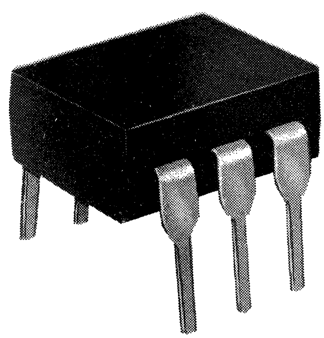


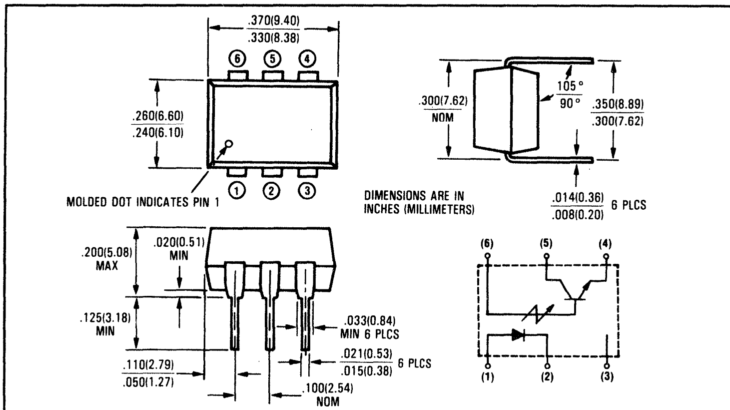
TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5201
January 1985

Optically Coupled Isolators
Types OPI2150, OPI2250





Features
- 1500 or 2500 volt isolation
- High current transfer ratio
- Low cost 6 pin dual-in-line package
- UL recognized File No. E58730

Description
The OPI2150 and OPI2250 each consist of a gallium arsenide infrared emitting diode coupled to an NPN silicon phototransistor mounted in a six pin dual-in-line package. The OPI2150 and OPI2250 are identical except for input-to-output isolation voltage.

Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)

Input-to-Output Isolation Voltage OPI2150 .... ±1500 VDC(1)
OPI2250 .... ±2500 VDC(1)
Storage Temperature Range .... −55°C to +150°C
Operating Temperature Range .... −55°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)(2) .... 260°C

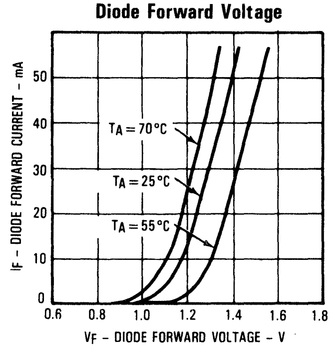
Input Diode
Forward DC Current .... 60 mA
Peak Forward Current (1 μs pulse, 300 pps) .... 3.0 A
Reverse Voltage .... 3.0 V
Power Dissipation (25°C) .... 100 mW(3)

Output Transistor
Power Dissipation .... 150 mW(4)
$B_{(BR)CEO}$ .... 20 V
$V_{(BR)CBO}$ .... 30 V
$V_{(BR)ECO}$ .... 5.0 V

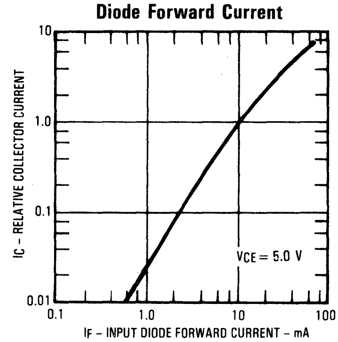
Notes: **(1)** Measured with input diode leads shorted together and output leads shorted together. **(2)** RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering. **(3)** Derate linearly 1.33 mW/°C above 25°C. **(4)** Derate linearly 2.0 mW/°C above 25°C.

Typical Performance Curves

Diode Forward Current vs Diode Forward Voltage



Relative Collector Current vs Diode Forward Current

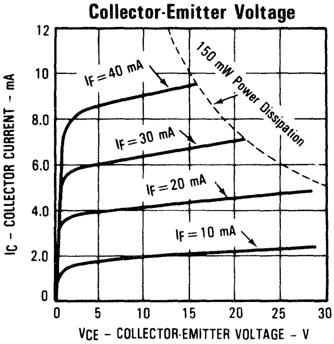


Electrical Characteristics (TA = 25°C unless otherwise noted)

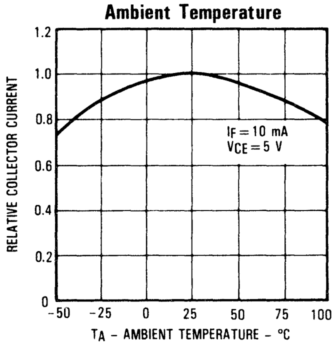
Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
Input Diode						
V_F	Forward Voltage			1.50	V	$I_F = 10.0$ mA
$V_{(BR)R}$	Reverse Breakdown Voltage	2.0			V	$I_R = 100$ μA
I_R	Reverse Current			100	μA	$V_R = 2.0$ V
Output Phototransistor						
$V_{(BR)CEO}$	Collector-to-Emitter Breakdown Voltage	20			V	$I_C = 1.00$ mA
$V_{(BR)ECO}$	Emitter-to-Collector Breakdown Voltage	5.0			V	$I_E = 10.0$ μA
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	30			V	$I_C = 10.0$ μA
I_{CEO}	Collector-Emitter Dark Current		10.0	100	nA	$V_{CE} = 10.0$ V
I_{CBO}	Collector-Base Dark Current			50	nA	$V_{CB} = 10.0$ V
C_{CE}	Capacitance Collector-to-Emitter		8.0		pF	$V_{CE} = 0$
h_{FE}	DC Current Gain		150			$V_{CE} = 5.0$ V, $I_C = 100$ μA
Coupled						
I_C/I_F	DC Current Transfer Ratio	2.0	5.0		%	$I_F = 10.0$ mA, $V_{CE} = 5.0$ V
$V_{CE(SAT)}$	Collector-to-Emitter Saturation Voltage			0.40	V	$I_F = 50$ mA, $I_C = 1.00$ mA
V_{ISO}	Isolation Voltage OPI2150 OPI2250	1500 2500			VDC VDC	See Note 1
R_{IO}	Input-to-Output Resistance	10^{11}			Ω	$V_{IO} = 500$ V, See Note 1
C_{IO}	Input-to-Output Capacitance		2.0		pF	f = 1.00 MHz, See Note 1
t_r	Output Rise Time		2.0		μs	$V_{CC} = 10.0$ V $I_C = 2.0$ mA
t_f	Output Fall Time		2.0		μs	$R_L = 100$Ω, See Test Circuits

Typical Performance Curves

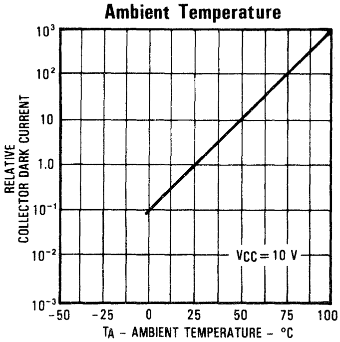
Collector Current vs Collector-Emitter Voltage



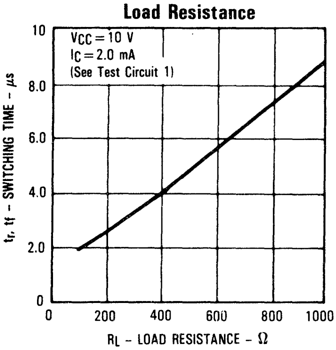
Relative Collector Current vs Ambient Temperature



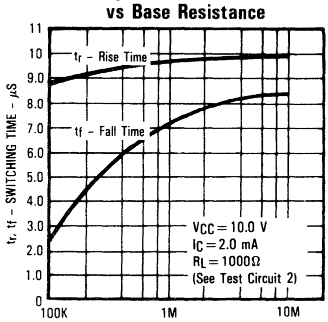
Relative Collector Dark Current vs Ambient Temperature



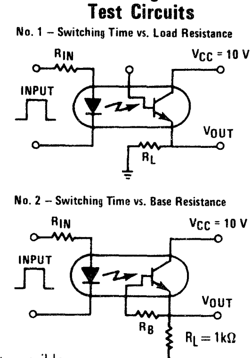
Rise and Fall Time vs Load Resistance



Delay, Rise, and Fall Time vs Base Resistance



Switching Time Test Circuits



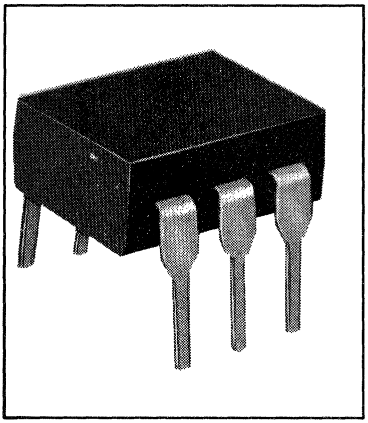
TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

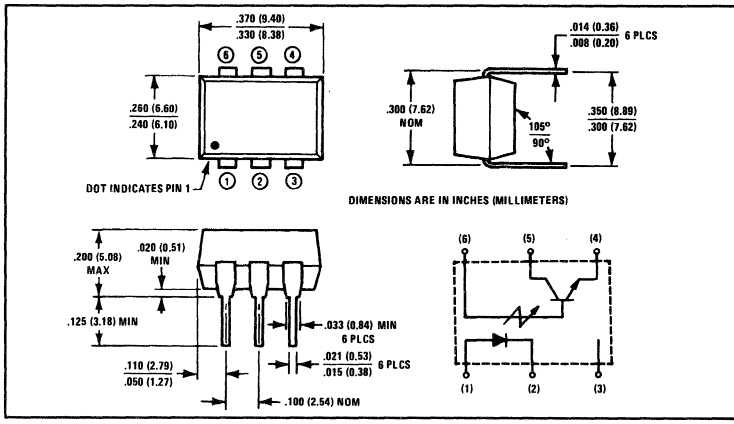
Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958

Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5202
January 1985

Optically Coupled Isolators
Types OPI2151, OPI2251





Features
- 1500 or 2500 volt isolation
- High current transfer ratio
- Low cost 6 pin dual-in-line package
- UL recognized File No. E58730

Description
The OPI2151 and OPI2251 each consist of a gallium arsenide infrared light emitting diode coupled to an NPN silicon phototransistor mounted in a six pin dual-in-line package. The OPI2151 and OPI2251 are identical except for input-to-output isolation voltage.

Absolute Maximum Ratings (T_A=25°C unless otherwise noted)

Input-to-Output Isolation Voltage OPI2151 .... ±1500 VDC(1)
OPI2251 .... ±2500 VDC(1)
Storage Temperature Range .... −55°C to +150°C
Operating Temperature Range .... −55°C to +150°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)(2) .... 260°C

Input Diode

Forward DC Current .... 60 mA
Peak Forward Current (1 μs pulse width, 300 pps) .... 3.0 A
Reverse Voltage .... 3.0 V
Power Dissipation (25°C) .... 100 mW(3)

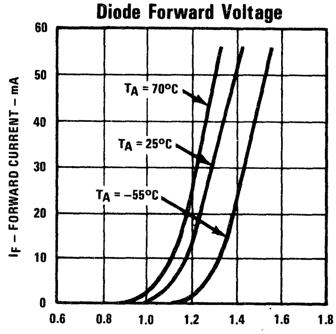
Output Transistor

Power Dissipation .... 150 mW(4)
$B_{(BR)CEO}$ .... 30 V
$V_{(BR)CBO}$ .... 30 V
$V_{(BR)ECO}$ .... 5.0 V

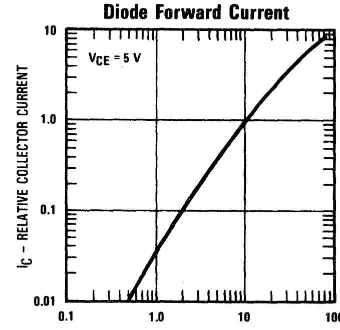
Notes: **(1)** Measured with input diode leads shorted together and output leads shorted together. **(2)** RMA rosin flux is recommended. Duration can be extended to 10 sec. max. when flow soldering or using a solder pot. **(3)** Derate linearly 1.33 mW/°C above 25°C. **(4)** Derate linearly 2.0 mW/°C above 25°C.

Typical Performance Curves

Diode Forward Current vs Diode Forward Voltage



Relative Collector Current vs Diode Forward Current



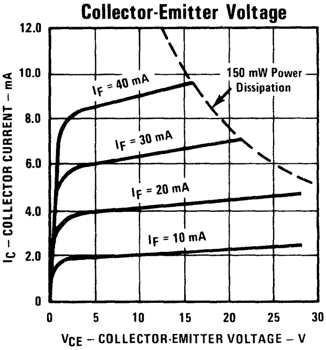
Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
Input Diode						
V_F	Forward Voltage			1.50	V	$I_F = 10.0$ mA
$V_{(BR)R}$	Reverse Breakdown Voltage	3.0 V			V	$I_R = 10.0$ μA
I_R	Reverse Current			10.0	μA	$V_R = 3.0$ V
Output Phototransistor						
$V_{(BR)CEO}$	Collector-to-Emitter Breakdown Voltage	30			V	$I_C = 1.0$ mA
$V_{(BR)ECO}$	Emitter-to-Collector Breakdown Voltage	5.0			V	$I_E = 100$ μA
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	30			V	$I_C = 100$ μA
I_{CEO}	Collector-Emitter Dark Current		5.0	100	nA	$V_{CE} = 10.0$ V
I_{CBO}	Collector-Base Dark Current			20	nA	$V_{CB} = 10.0$ V
C_{CE}	Capacitance Collector-to-Emitter		8.0		pF	$V_{CE} = 0$
h_{FE}	DC Current Gain		150			$V_{CE} = 5.0$ V, $I_C = 100$ μA
Coupled						
I_C/I_F	DC Current Transfer Ratio	10.0	20		%	$I_F = 10.0$ mA, $V_{CE} = 5.0$ V, $I_B = 0$
$V_{CE(SAT)}$	Collector-to-Emitter Saturation Voltage			0.40	V	$I_F = 10.0$ mA, $I_C = 250$ μA, $I_B = 0$
V_{ISO}	Isolation Voltage OPI2151 OPI2251	1500 2500			VDC VDC	See Note 1
R_{IO}	Input-to-Output Resistance	10^{11}			Ω	$V_{IO} = 500$ V, See Note 1
C_{IO}	Input-to-Output Capacitance		2.0		pF	f = 1.00 MHz, See Note 1
t_r	Output Rise Time		2.0		μs	$V_{CC} = 10.0$ V, $I_C = 2.0$ mA
t_f	Output Fall Time		2.0		μs	$R_L = 100Ω$, See Test Circuit

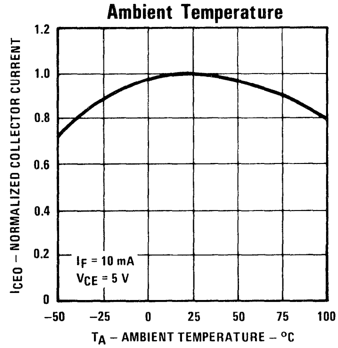
E

Typical Performance Curves

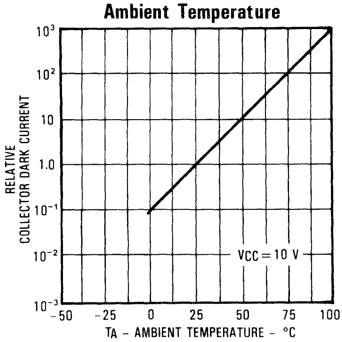
Collector Current vs Collector-Emitter Voltage



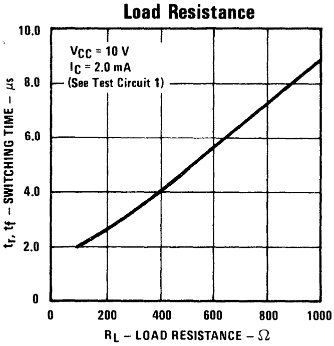
Relative Collector Current vs Ambient Temperature



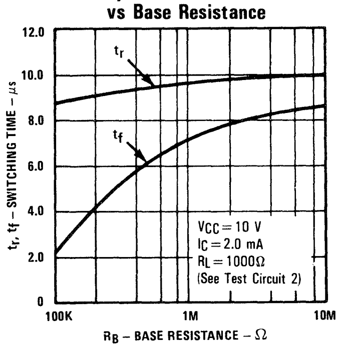
Relative Collector Dark Current vs Ambient Temperature



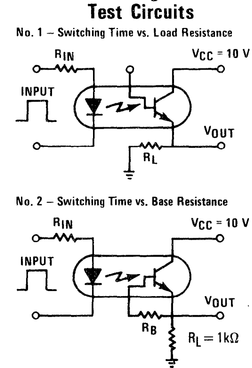
Rise and Fall Time vs Load Resistance



Delay, Rise, and Fall Time vs Base Resistance



Switching Time Test Circuits



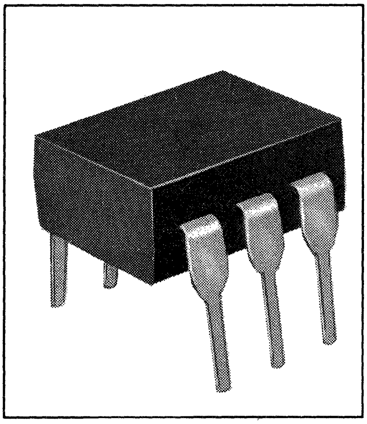
TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

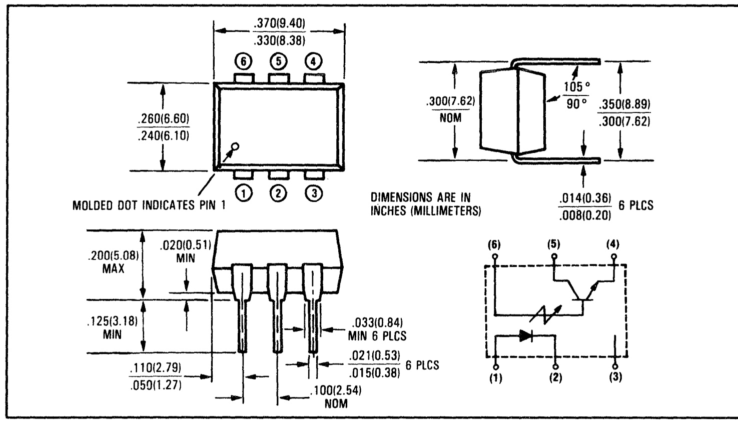
Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958

Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5204
January 1985

Optically Coupled Isolators
Types OPI2152, OPI2252





Features
- 1500 or 2500 volt isolation
- High current transfer ratio
- Low cost 6 pin dual-in-line package
- UL recognized File No. E58730

Description
The OPI2152 and OPI2252 each consist of a gallium arsenide infrared light emitting diode coupled to an NPN silicon phototransistor mounted in a six pin dual-in-line package. The OPI2152 and OPI2252 are identical except for input-to-output isolation voltage.

Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)

Input-to-Output Isolation Voltage OPI2152 . . . . . ±1500 VDC(1)
OPI2252 . . . . . ±2500 VDC(1)
Storage Temperature Range . . . . . −55°C to +150°C
Operating Temperature Range . . . . . −55°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)(2) . . . . . 260°C

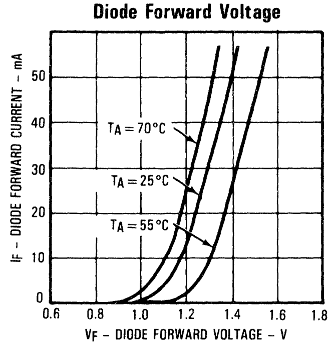
Input Diode
Forward DC Current . . . . . 60 mA
Peak Forward Current (1 μs pulse, 300 pps) . . . . . 3.0 A
Reverse Voltage . . . . . 3.0 V
Power Dissipation (25°C) . . . . . 100 mW(3)

Output Transistor
Power Dissipation . . . . . 150 mW(4)
$B_{(BR)CEO}$ . . . . . 30 V
$V_{(BR)CBO}$ . . . . . 50 V
$V_{(BR)ECO}$ . . . . . 5.0 V

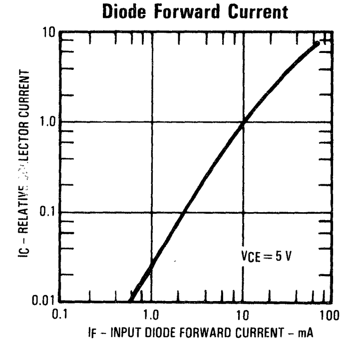
Notes: (1) Measured with input diode leads shorted together and output leads shorted together. **(2)** RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering. **(3)** Derate linearly 1.33 mW/°C above 25°C. **(4)** Derate linearly 2.0 mW/°C above 25°C.

Typical Performance Curves

Diode Forward Current vs Diode Forward Voltage



Relative Collector Current vs Diode Forward Current



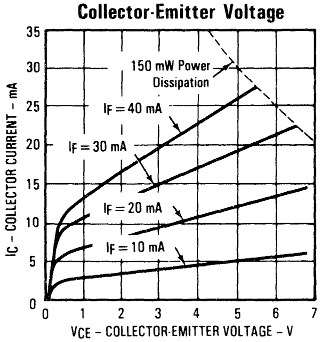
Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
Input Diode						
V_F	Forward Voltage			1.50	V	$I_F = 10.0$ mA
$V_{(BR)R}$	Reverse Breakdown Voltage	3.0			V	$I_R = 10.0$ μA
I_R	Reverse Leakage Current			10.0	μA	$V_R = 3.0$ V
Output Phototransistor						
$V_{(BR)CEO}$	Collector-to-Emitter Breakdown Voltage	30			V	$I_C = 1.00$ mA
$V_{(BR)ECO}$	Emitter-to-Collector Breakdown Voltage	5.0			V	$I_E = 10.0$ μA
$V_{(BR)CBO}$	Collector-to-Base Breakdown Voltage	50			V	$I_C = 10.0$ μA
I_{CEO}	Collector-Emitter Dark Current		5.0	50	nA	$V_{CE} = 10.0$ V
I_{CBO}	Collector-Base Dark Current			20	nA	$V_{CB} = 10.0$ V
C_{CE}	Capacitance Collector-to-Emitter		8.0		pF	$V_{CE} = 0$
h_{FE}	DC Current Gain		250			$V_{CE} = 5.0$ V, $I_C = 100$ μA
Coupled						
I_C/I_F	DC Current Transfer Ratio	20	40		%	$I_F = 10.0$ mA, $V_{CE} = 5.0$ V
$V_{CE(SAT)}$	Collector-to-Emitter Saturation Voltage			0.40	V	$I_F = 10.0$ mA, $I_C = 500$ μA
V_{ISO}	Isolation Voltage OPI2152 OPI2252	1500 2500			VDC VDC	See Note 1
R_{IO}	Input-to-Output Resistance	10^{11}			Ω	$V_{IO} = 500$ V, See Note 1
C_{IO}	Input-to-Output Capacitance		2.0		pF	f = 1.00 MHz, See Note 1
t_r	Output Rise Time		2.0		μs	$V_{CC} = 10.0$ V, $I_C = 2.0$ mA
t_f	Output Fall Time		2.0		μs	$R_L = 100\Omega$, See Test Circuit

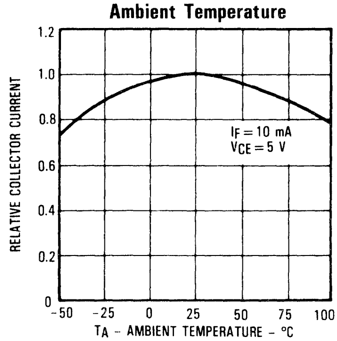
E

Typical Performance Curves

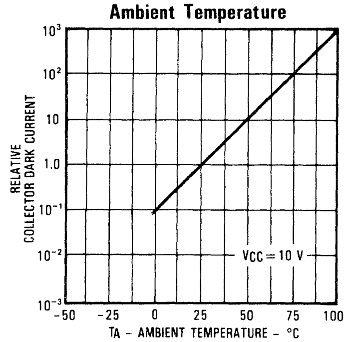
Collector Current vs Collector-Emitter Voltage



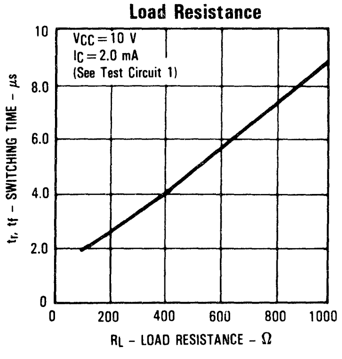
Relative Collector Current vs Ambient Temperature



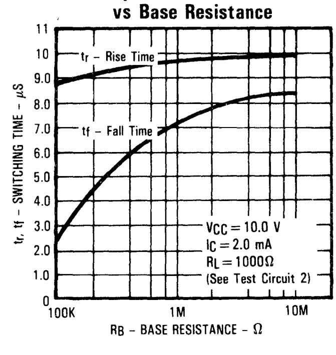
Relative Collector Dark Current vs Ambient Temperature



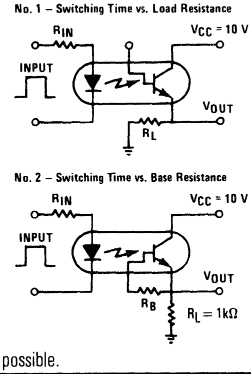
Rise and Fall Time vs Load Resistance



Delay, Rise, and Fall Time vs Base Resistance



Switching Time Test Circuits



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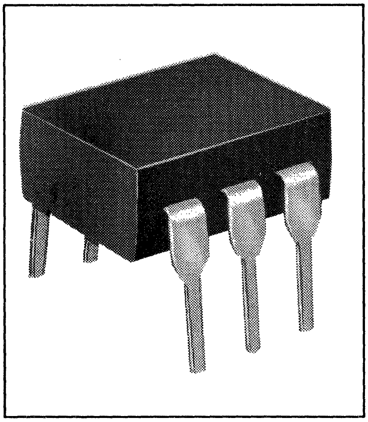
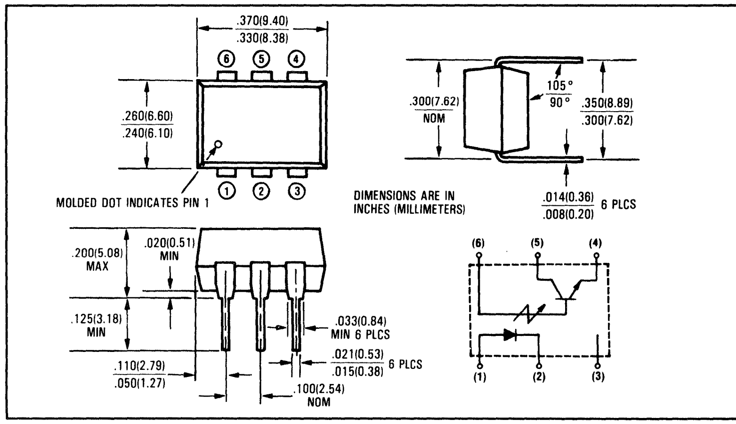
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5206
January 1985

Optically Coupled Isolators
Types OPI2153, OPI2253





Features
- 1500 or 2500 volt isolation
- High current transfer ratio
- Low cost 6 pin dual-in-line package
- UL recognized File No. E58730

Description
The OPI2153 and OPI2253 each consist of a gallium arsenide infrared light emitting diode coupled to an NPN silicon phototransistor mounted in a six pin dual-in-line package. The OPI2153 and OPI2253 are identical except for input-to-output isolation voltage.

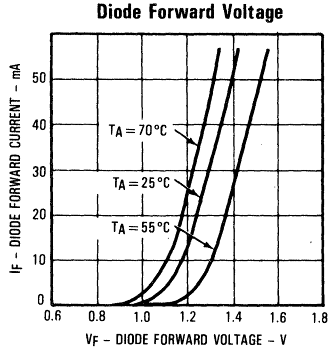
Absolute Maximum Ratings (T_A=25°C unless otherwise noted)

Input-to-Output Isolation Voltage OPI2153	±1500 VDC(1)
OPI2253	±2500 VDC(1)
Storage Temperature Range	−55°C to +150°C
Operating Temperature Range	−55°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)(2)	260°C
Input Diode	
Forward DC Current	60 mA
Peak Forward Current (1 μs pulse width, 300 pps)	3.0 A
Reverse Voltage	3.0 V
Power Dissipation (25°C)	100 mW(3)
Output Transistor	
Power Dissipation	150 mW(4)
$B_{(BR)CEO}$	30 V
$V_{(BR)CBO}$	50 V
$V_{(BR)ECO}$	5.0 V

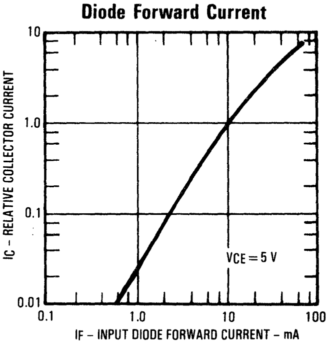
Notes: (1) Measured with input diode leads shorted together and output leads shorted together. **(2)** RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering. **(3)** Derate linearly 1.33 mW/°C above 25°C. **(4)** Derate linearly 2.0 mW/°C above 25°C.

Typical Performance Curves

Diode Forward Current vs Diode Forward Voltage



Relative Collector Current vs Diode Forward Current



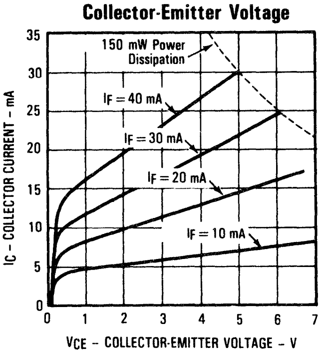
Electrical Characteristics (TA = 25°C unless otherwise noted)

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
Input Diode						
V_F	Forward Voltage			1.40	V	$I_F = 16.0$ mA
$V_{(BR)R}$	Reverse Breakdown Voltage	3.0			V	$I_R = 10.0$ μA
I_R	Reverse Leakage Current			10.0	μA	$V_R = 3.0$ V
Output Phototransistor						
$V_{(BR)CEO}$	Collector-to-Emitter Breakdown Voltage	30			V	$I_C = 1.00$ mA
$V_{(BR)ECO}$	Emitter-to-Collector Breakdown Voltage	5.0			V	$I_E = 100$ μA
$V_{(BR)CBO}$	Collector-to-Base Breakdown Voltage	50			V	$I_C = 100$ μA
I_{CEO}	Collector-Emitter Dark Current		5.0	50	nA	$V_{CE} = 10.0$ V
I_{CBO}	Collector-Base Dark Current			20	nA	$V_{CB} = 10.0$ V
C_{CE}	Capacitance Collector-to-Emitter		8.0		pF	$V_{CE} = 0$
h_{FE}	DC Current Gain		350			$V_{CE} = 5.0$ V, $I_C = 100$ μA
Coupled						
I_C/I_F	DC Current Transfer Ratio	50	80		%	$I_F = 10.0$ mA, $V_{CE} = 5.0$ V
$V_{CE(SAT)}$	Collector-to-Emitter Saturation Voltage			0.40	V	$I_F = 10.0$ mA, $I_C = 2.0$ mA
V_{ISO}	Isolation Voltage OPI2153 OPI2253	1500 2500			VDC VDC	See Note 1
R_{IO}	Input-to-Output Resistance	10^{11}			Ω	$V_{IO} = 500$ V, See Note 1
C_{IO}	Input-to-Output Capacitance		2.0		pF	f = 1.00 MHz, See Note 1
t_r	Output Rise Time		2.0		μs	$V_{CC} = 10.0$ V, $I_C = 2.0$ mA
t_f	Output Fall Time		2.0		μs	$R_L = 100Ω$, See Test Circuit 1

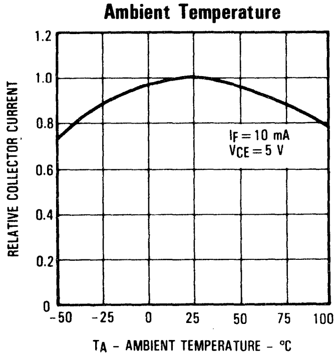
E

Typical Performance Curves

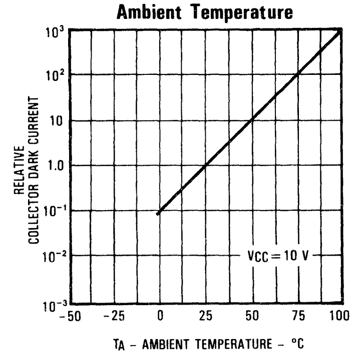
Collector Current vs Collector-Emitter Voltage



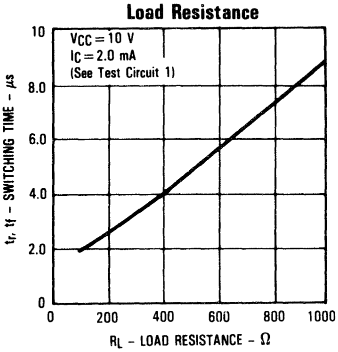
Relative Collector Current vs Ambient Temperature



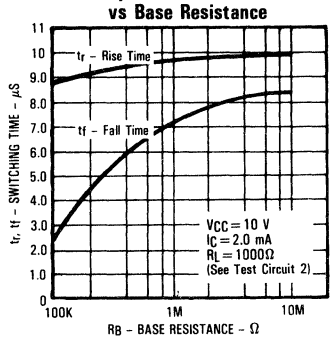
Relative Collector Dark Current vs Ambient Temperature



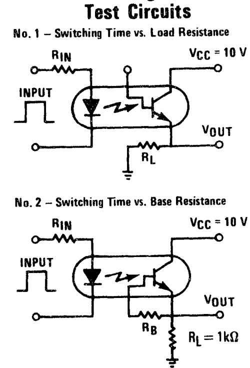
Rise and Fall Time vs Load Resistance



Delay, Rise, and Fall Time vs Base Resistance



Switching Time Test Circuits



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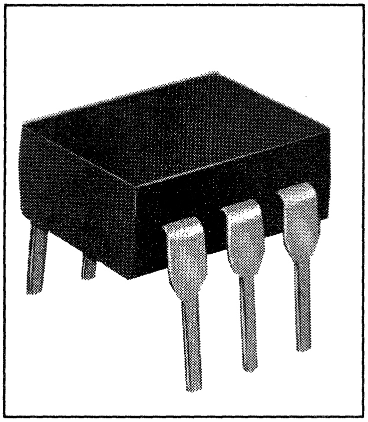
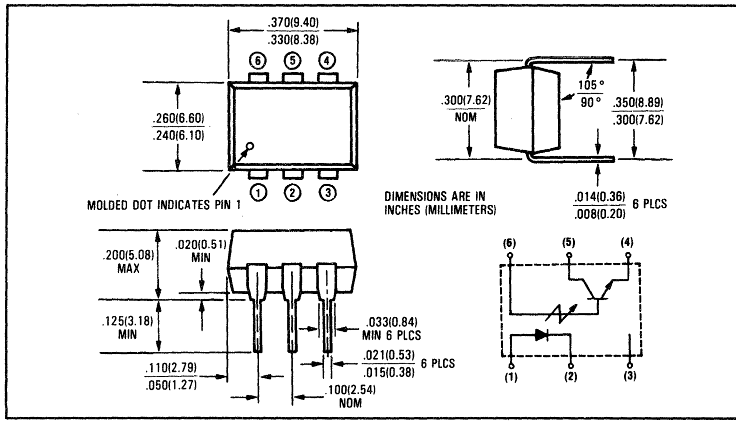
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5208
January 1985

Optically Coupled Isolators
Types OPI2154, OPI2155, OPI2254, OPI2255





Features
- 1500 and 2500 volt isolation
- Very low LED drive current
- UL recognized File No. E58730

Description
The OPI2154, OPI2155, OPI2254, and OPI2255 each consist of a gallium arsenide infrared emitting diode and an NPN silicon phototransistor mounted in a standard plastic six pin dual-in-line package. This series is designed to provide electrical isolation at low operating currents.

Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)
Input-to-Output Isolation Voltage OPI2154, OPI2155 .... ±1500 VDC(1)
OPI2254, OPI2255 .... ±2500 VDC(1)
Storage Temperature Range .... −55°C to +150°C
Operating Temperature Range .... −55°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)(2) .... 260°C

Input Diode
Forward DC Current .... 60 mA
Peak Forward Current (1 μs pulse, 300 pps) .... 3.0 A
Reverse Voltage .... 3.0 V
Power Dissipation .... 100 mW(3)

Output Transistor
Collector-Emitter Voltage .... 30 V
Collector-Base Voltage .... 30 V
Emitter-Collector Voltage .... 5.0 V
Power Dissipation .... 150 mW(4)

Notes:
(1) Measured with input diode leads shorted together and output leads shorted together.
(2) RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering.
(3) Derate linearly 1.33 mW/°C above 25°C.
(4) Derate linearly 2.0 mW/°C above 25°C.

Types OPI2154, OPI2155, OPI2254, OPI2255

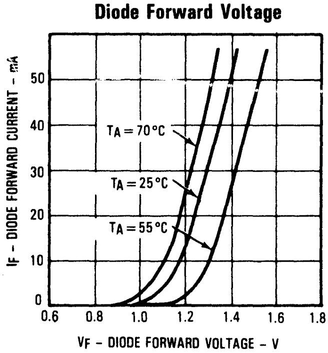
Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
Input Diode						
V_F	Forward Voltage			1.50	V	$I_F = 10.0$ mA
I_R	Reverse Current			10.0	μA	$V_R = 3.0$ V
Output Phototransistor						
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	30			V	$I_C = 1.00$ mA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	5.0			V	$I_E = 100$ μA
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	30			V	$I_C = 100$ μA
I_{CEO}	Collector-Emitter Dark Current			50	nA	$V_{CE} = 10.0$ V
C_{CE}	Collector-Emitter Capacitance		8.0		pF	$V_{CE} = 0$
h_{FE}	DC Current Gain		500			$V_{CE} = 5.0$ V, $I_C = 100$ μA
Coupled						
I_C/I_F	DC Current Transfer Ratio					
	OPI2154, OPI2254	10.0			%	$V_{CE} = .50$ V, $I_F = .50$ mA
	OPI2155, OPI2255	20			%	$V_{CE} = .50$ V, $I_F = 1.00$ mA
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage			.35	V	$I_F = 5.0$ mA, $I_C = 1.00$ mA

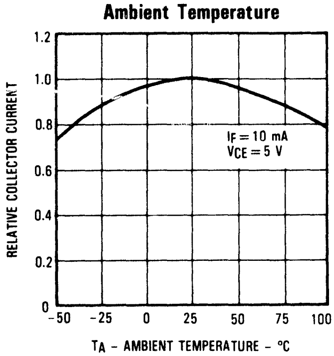
E

Typical Performance Curves

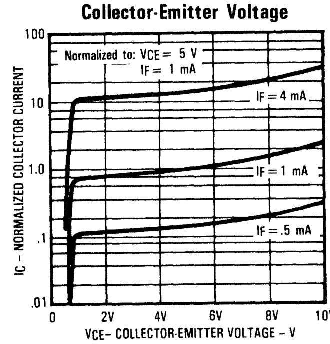
Diode Forward Current vs Diode Forward Voltage



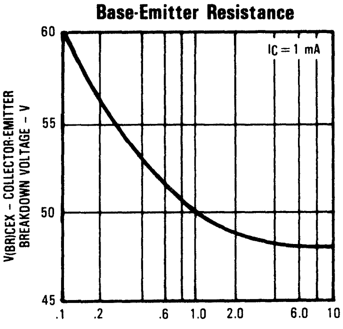
Relative Collector Current vs Ambient Temperature



Normalized Collector Current vs Collector-Emitter Voltage



Collector-Emitter Breakdown Voltage vs Base-Emitter Resistance



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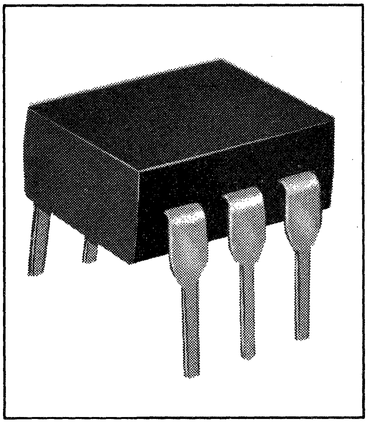
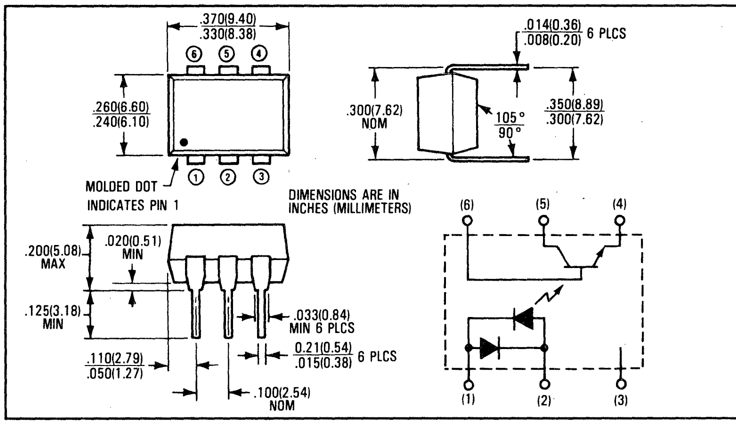
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5209
January 1985

Optically Coupled Isolators
Types OPI2500, OPI2501





Features

- Two inverse parallel LEDs for AC to logic interfacing
- Low cost six pin dual-in-line package

Description

The OPI2500 and OPI2501 are bi-directional optically coupled isolators consisting of two gallium arsenide infrared emitting diodes connected in inverse parallel and an NPN silicon photo-transistor mounted in a standard plastic six pin dual-in-line package. This device is intended for applications where the input to the LEDs is AC.

Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)

Input-to-Output Isolation Voltage .... ±1500 VDC[1]
Storage Temperature Range .... −55°C to +150°C
Operating Temperature Range .... −55°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 3 sec. with soldering iron)[2] .... 260°C

Input Diode

Forward DC Current .... ±60 mA
Peak Forward Current (1 μs pulse width, 300 pps) .... ±3.0 A
Power Dissipation .... 100 mW[3]

Output Phototransistor

$V_{(BR)CEO}$ .... 30 V
$V_{(BR)CBO}$ .... 70 V
$V_{(BR)ECO}$ .... 5.0 V
Power Dissipation OPI2500 .... 150 mW[4]
OPI2501 .... 300 mW[5]

Notes:

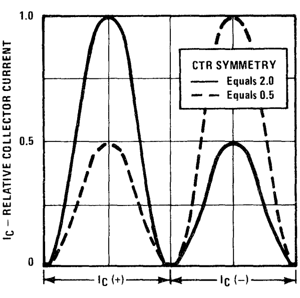
(1) Measured with input leads shorted together and phototransistor leads shorted together.
(2) RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering or using a solder pot.
(3) Derate linearly 1.33 mW/°C above 25°C.
(4) Derate linearly 2.0 mW/°C above 25°C.

Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

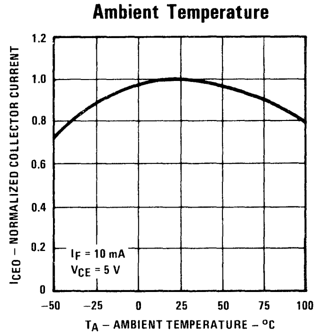
Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
Input Diode							
V_F	Forward Voltage				1.50	V	$I_F = 10.0$ mA
Output Phototransistor							
$V_{(BR)CEO}$	Collector-to-Emitter Breakdown Voltage		30			V	$I_C = 1.00$ mA
$V_{(BR)ECO}$	Emitter-to-Collector Breakdown Voltage		5.0			V	$I_E = 10.0$ μA
$V_{(BR)CBO}$	Collector-to-Base Breakdown Voltage		70			V	$I_C = 10.0$ μA
I_{CEO}	Collector-Emitter Dark Current			5.0	50	nA	$V_{CE} = 10.0$ V
C_{CE}	Capacitance Collector-to-Emitter			8.0		pF	$V_{CE} = 0$
h_{FE}	DC Current Gain			250			$V_{CE} = 5.0$ V, $I_C = 100$ μA
Coupled							
I_C/I_F	DC Current Transfer Ratio	OPI2500	12.5	20		%	$I_F = \pm 10.0$ mA, $V_{CE} = 5.0$ V
		OPI2501	20.0			%	$I_F = \pm 10.0$ mA, $V_{CE} = 5.0$ V
$I_{C(+)}/I_{C(-)}$	CTR Symmetry (OPI2501 only)		0.5		2.0	(ratio)	$I_F = \pm 10.0$ mA, $V_{CE} = 10.0$ V
$V_{CE(SAT)}$	Collector-to-Emitter Saturation Voltage				0.50	V	$I_F = \pm 10.0$ mA, $I_C = 1.00$ mA
V_{ISO}	Isolation Voltage		1500			V	See Note 1
R_{IO}	Input-to-Output Resistance		10^{11}			Ω	$V_{IO} = 500$ V. See Note 1
C_{IO}	Input-to-Output Capacitance			2.0		pF	f = 1.00 MHz. See Note 1
t_r	Output Rise Time			2.0		μs	$V_{CC} = 10.0$ V, $I_C = 2.0$ mA
t_f	Output Fall Time			2.0		μs	$R_L = 100\Omega$. See Test Circuit

Typical Performance Curves

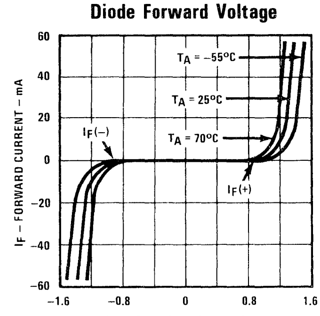
Relative Output Current Wave Form



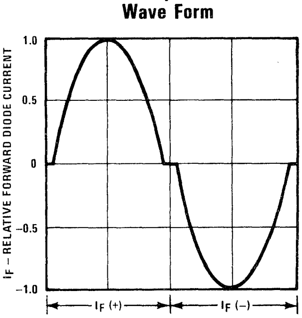
Normalized Collector Current vs Ambient Temperature



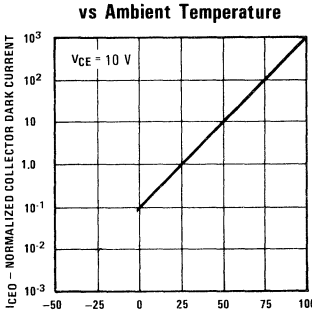
Diode Forward Current vs Diode Forward Voltage



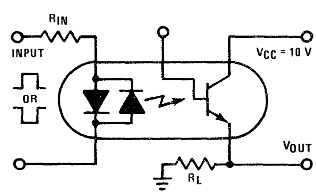
Relative Input Current Wave Form



Normalized Collector Dark Current vs Ambient Temperature



Switching Time Test Circuit



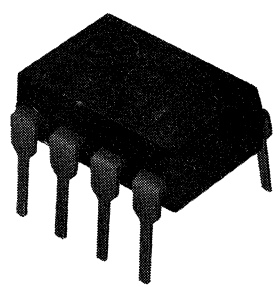
Note: Rise Time (t_r) is time required for collector current to increase from 10% to 90% of its final value. Fall Time (t_f) is time required for the collector current to decrease from 90% to 10% of its initial value.

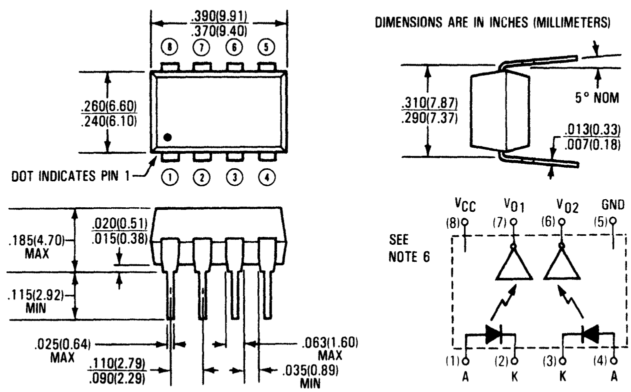
TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5211
January 1985

Optically Coupled Isolator
Type OPI2630





Features

- Guaranteed performance over temperature
- Low input current required
- 3000 VDC isolation voltage
- DTL/TTL compatible 5V supply
- Ultra high speed
- 8 pin P-DIP package

Description

The OPI2630 consists of twin emitting diodes optically coupled to a pair of photodiodes amplified by high gain linear amplifiers. Each amplifier drives a Schottky clamped open collector output transistor. The net result is a dual DTL/TTL compatible, temperature, current and voltage compensated optoisolator. Very high speeds are possible with this design.

The OPI2630 is designed for use where common mode signals must be rejected, such as in-line receivers and floating power supplies, motors, and their machine control systems. The OPI2630 also eliminates ground loops between system interfaces; for example, between a computer and peripheral equipment. In addition, high density, dual channel packaging allows increased board density and convenience.

Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)

Input-to-Output Isolation Voltage .... ±3000 VDC
Operating Temperature Range .... 0°C to +70°C
Storage Temperature Range .... −55°C to +125°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 3 sec. with soldering iron)[1] .... 260°C

Input Diode (Each Channel)

Average Forward Current .... 15.0 mA
Reverse DC Voltage .... 5.0 V
Peak Forward Current (1 ms duration) .... 30 mA

Output IC

Supply Voltage – V_{CC} .... 7.0 V (1 min. max.)
Output Current – I_O (each channel) .... 16.0 mA
Output Voltage – V_O (each channel) .... 7.0 V
Output Collector Power Dissipation .... 60 mW

Notes:

(1) RMA flux is recommended. Duration can be extended to 10 seconds max. when flow soldering.
(2) The t_{PLH} propagation delay is measured from the 3.75 mA point on the trailing edge of the input pulse to the 1.5V point on the trailing edge of the output pulse.
(3) The t_{PHL} propagation delay is measured from the 3.75 mA point on the leading edge of the input pulse to the leading edge of the output pulse.
(4) Each channel.
(5) Measured between pins 1, 2, 3, and 4 shorted together, and pins 5, 6, 7, and 8 shorted together.
(6) A .01 μF bypass capacitor should be connected between pins 5 and 8

Caution: This component is susceptible to damage from electrostatic discharge. Normal static prevention procedures should be used in handling.

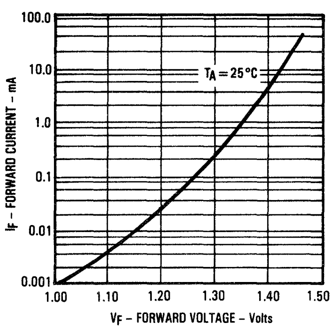
Electrical Characteristics ($T_A = 0°C$ to $70°C$ unless otherwise noted)

Symbol	Parameter	Min.	Max.	Units	Test Conditions
I_{OH}	High Level Output Current (4)		250	μA	$V_{CC} = 5.5$ V, $V_O = 5.5$ V, $I_F = 250$ μA
V_{OL}	Low Level Output Voltage (4)		0.6	V	$V_{CC} = 5.5$ V, $I_F = 5.0$ mA, $I_{OL(sinking)} = 13.0$ mA
I_{CCH}	High Level Supply Current		30	mA	$V_{CC} = 5.5$ V, $I_F = 0$ mA, (Both Channels)
I_{CCL}	Low Level Supply Current		36	mA	$V_{CC} = 5.5$ V, $I_F = 10.0$ mA (Both Channels)
V_F	Input Forward Voltage (4)		1.75	V	$I_F = 10.0$ mA, $T_A = 25°C$
I_R	Input Reverse Current (4)		10.0	μA	$V_R = 5.0$ V, $T_A = 25°C$
I_{I-O}	Input-Output Insulation Leakage Current (5)		1.0	μA	Relative Humidity = 45%, t = 5 s, $V_{I-I} = 500$ V
t_{PLH}	Propagation Delay Time to High Output Level (2)		75	ns	$R_L = 350Ω$, CL = 15 pF, $I_F = 7.5$ mA, $T_A = 25°C$, $V_{CC} = 5.0$ V
t_{PHL}	Propagation Delay Time to Low Output Level (3)		75	ns	$R_L = 350Ω$, CL = 15 pF, $I_F = 7.5$ mA, $T_A = 25°C$, $V_{CC} = 5.0$ V

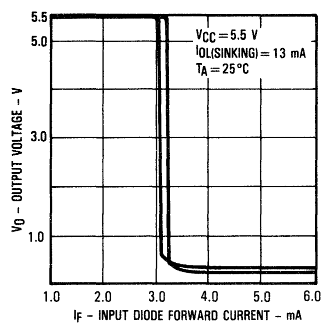
E

Typical Performance Curves

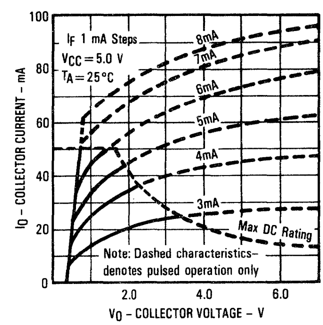
Diode Forward Current vs Forward Voltage



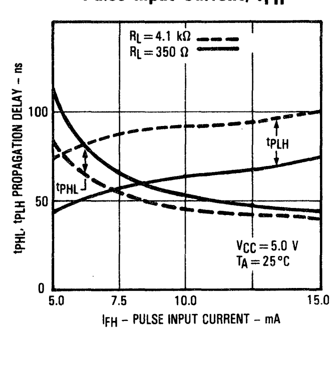
Output Voltage vs Input Diode Forward Current



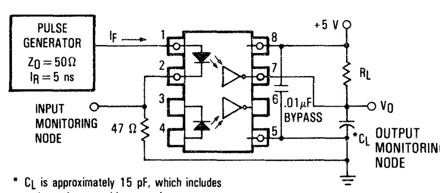
OPI2630 Transfer Characteristics



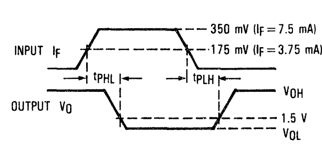
Propagation Delay, t_{PHL} and t_{PLH} vs Pulse Input Current, I_{FH}



Test Circuit for T_{PHL} and T_{PLH}



* C_L is approximately 15 pF, which includes probe and stray wiring capacitance.



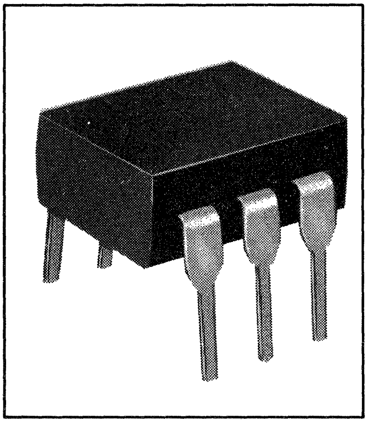
TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

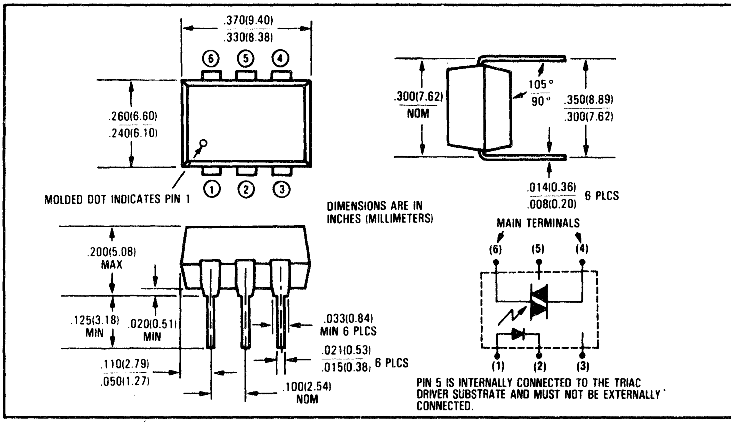
Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958

Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5212
January 1985

Optically Coupled Triac Drivers
Type OPI3009, OPI3010, OPI3011, OPI3012





Features
- For 120 VAC operation
- 2500 VDC minimum electrical isolation
- Low LED trigger current to latch output
- UL recognized File No. E58730

Description
The OPI3009, OPI3010, OPI3011, and OPI3012 each consist of a gallium arsenide or gallium aluminum arsenide infrared emitting diode and a monolithic integrated circuit containing a photodiode and a bidirectional switch, mounted in a standard plastic six pin dual-in-line package. This series is intended to interface electronic controls with power triacs to control resistive and inductive loads as in motors, solenoids, and appliances.

Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)

Input-to-Output Isolation Voltage .... ±2500 VDC(1)
Storage Temperature Range .... −40°C to +150°C
Operating Temperature Range .... −40°C to +85°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)(2) .... 260°C
Total Device Power Dissipation .... 400 mW(3)

Input Diode

Forward DC Current .... I_F .... 60 mA
Reverse DC Voltage .... V_R .... 3.0 V
Power Dissipation .... P_D .... 100 mW(4)

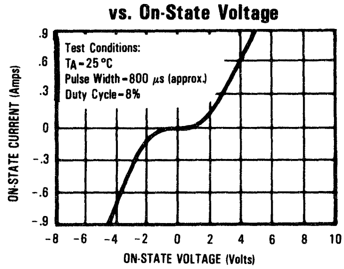
Output Photosensor

Off-State Terminal Voltage .... V_{DRM} .... 250 V
On-State RMS Current ... $I_{T(RMS)}$ ... [Full Cycle 50-60 Hz] ... $T_A = 25°C$ .... 100 mA
... $T_A = 70°C$ .... 50 mA
Peak Non-Repetitive Surge Current (PW = 10 ms, duty cycle = 10%) .... I_{TSM} .... 1.20 A
Power Dissipation .... P_D .... 350 mW(5)

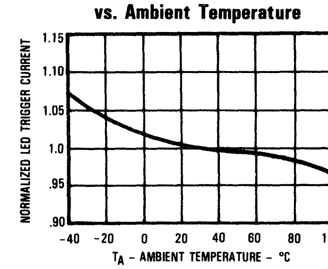
Notes:
(1) Measured with input diode leads shorted together and output leads shorted together.
(2) RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering.
(3) Derate 7.27 mW/°C above 25°C.
(4) Derate 1.82 mW/°C above 25°C.
(5) Derate 6.36 mW/°C above 25°C.

Typical Performance Curves

On-State Collector Current vs. On-State Voltage



Normalized LED Trigger Current vs. Ambient Temperature



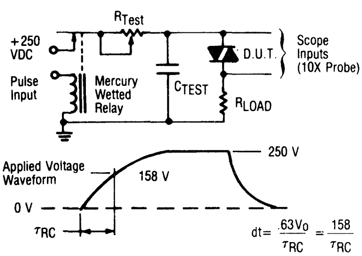
Types OPI3009, OPI3010, OPI3011, OPI3012

Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
Input Diode						
V_F	Forward Voltage		1.20	1.50	V	$I_F = 10.0$ mA
			1.40	1.70	V	$I_F = 30$ mA
I_R	Reverse Current		.0100	10.0	μA	$V_R = 3.0$ V
Output Photosensor						
I_{DRM}	Peak Blocking Current, Either Direction		10.0	100	nA	$V_{DRM} = 250$ V. Must be applied within dV/dt rating
V_{TM}	Peak On-State Voltage, Either Direction		1.75	3.0	V	$I_{TM} = 100$ mA
dV/dt	Critical Rate of Rise of Off-State-Voltage		15.0		V/μs	$R_L = 2.5$ kΩ
dV/dt	Critical Rate of Rise of Commutating Voltage		.140		V/μs	$R_L = 1.00$ kΩ
Coupled						
I_{FT}	LED Trigger Current Required to Latch Output in Either Direction					
	OPI3009		15.0	30	mA	Main Terminal Voltage = 3.0 V
	OPI3010		10.0	15.0	mA	Main Terminal Voltage = 3.0 V
	OPI3011		7.5	10.0	mA	Main Terminal Voltage = 3.0 V
	OPI3012		3.5	5.0	mA	Main Terminal Voltage = 3.0 V
I_H	Holding Current, Either Direction		100		μA	

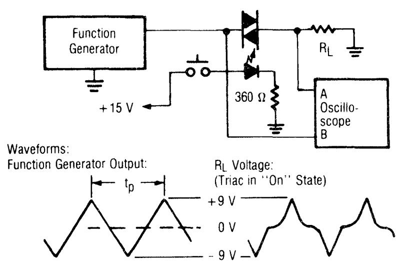
Typical Performance Curves

Static dV/dt Test Circuit



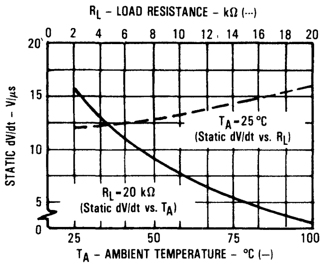
- The relay provides a high speed repeated pulse to the D.U.T.
- 10X probes are used to allow high speeds and voltages.
- The worst case condition for static dV/dt is established by triggering the D.U.T. with a normal input (LED) current, then removing this current. The variable R_{TEST} allows the dV/dt to be increased until the D.U.T. continues to trigger in response to the applied voltage pulse, even after the LED current has been removed. The dV/dt is then decreased until the D.U.T. stops triggering. τ_{RC} is measured at this point and recorded.

Commutating dV/dt Test Circuit

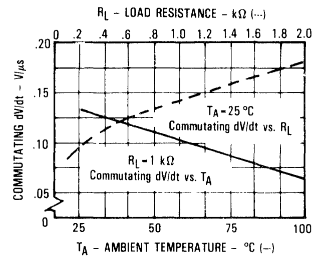


- 10X probes are used to allow high speeds.
- Frequency is increased until the triac stays "on" after being triggered by pushbutton. Frequency is then decreased until triac turns "off." t_p is measured at this point and recorded.
- Commutating dV/dt = $36/t_p$.

Static dV/dt vs. Ambient Temperature and Load Resistance



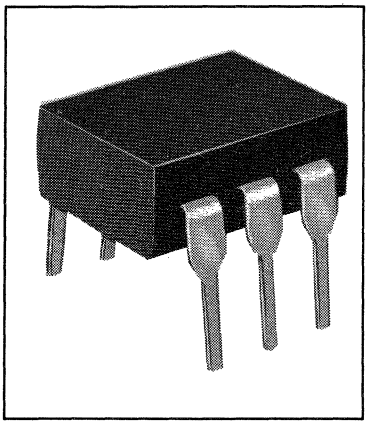
Commutating dV/dt vs. Ambient Temperature and Load Resistance

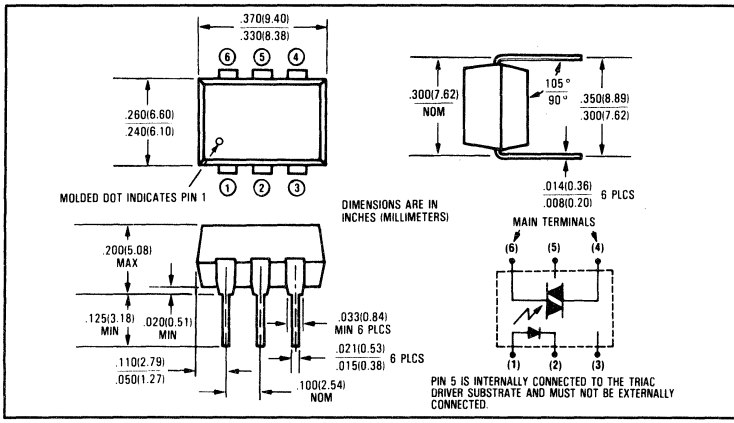


Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5214
January 1985

Optically Coupled Triac Drivers
Types OPI3020, OPI3021, OPI3022, OPI3023





Features
- For 220 VAC operation
- 2500 VDC minimum electrical isolation
- Low LED trigger current to latch output
- UL recognized File No. E58730

Description
The OPI3020, OPI3021, OPI3022, and OPI3023 each consist of a gallium arsenide or gallium aluminum arsenide infrared emitting diode and a monolithic integrated circuit containing a photodiode and a bidirectional switch, mounted in a standard plastic six pin dual-in-line package. This series is intended to interface electronic controls with power triacs to control resistive and inductive loads as in motors, solenoids, and appliances.

Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)
Input-to-Output Isolation Voltage . . . . . . ±2500 VDC[1]
Storage Temperature Range . . . . . . −40°C to +150°C
Operating Temperature Range . . . . . . −40°C to +85°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)[2] . . . . . . 260°C
Total Device Power Dissipation . . . . . . 400 mW[3]

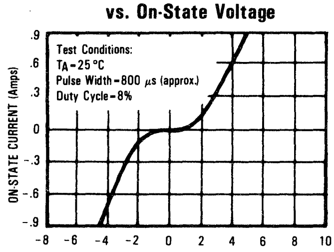
Input Diode
Forward DC Current . . . . . . I_F . . . . . . 60 mA
Reverse DC Voltage . . . . . . V_R . . . . . . 3.0 V
Power Dissipation . . . . . . P_D . . . . . . 100 mW[4]

Output Photosensor
Off-State Terminal Voltage . . . . . . V_{DRM} . . . . . . 400 V
On-State RMS Current . . . I_T(RMS) . . . [Full Cycle] . . . $T_A = 25°C$ . . . . . . 100 mA
[50-60 Hz] . . . $T_A = 70°C$ . . . . . . 50 mA
Peak Non-Repetitive Surge Current (PW = 10 ms, duty cycle = 10%) . . . . . . I_{TSM} . . . . . . 1.20 A
Power Dissipation . . . . . . P_D . . . . . . 350 mW[5]

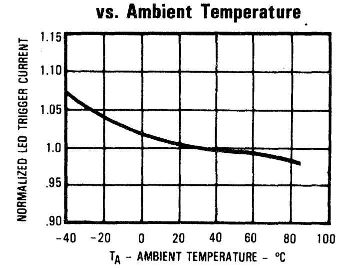
Notes:
(1) Measured with input diode leads shorted together and output leads shorted together.
(2) RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering.
(3) Derate 7.27 mW/°C above 25°C.
(4) Derate 1.82 mW/°C above 25°C.
(5) Derate 6.36 mW/°C above 25°C.

Typical Performance Curves

On-State Collector Current vs. On-State Voltage



Normalized LED Trigger Current vs. Ambient Temperature



Types OPI3020, OPI3021, OPI3022, OPI3023

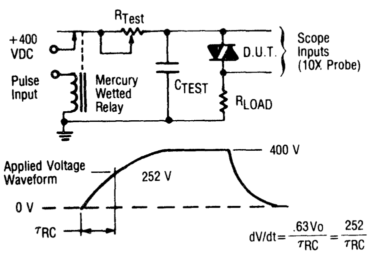
Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
Input Diode						
V_F	Forward Voltage		1.20	1.50	V	$I_F = 10.0$ mA
			1.40	1.70	V	$I_F = 30$ mA
I_R	Reverse Current		.0100	100	μA	$V_R = 3.0$ V
Output Photosensor						
I_{DRM}	Peak Blocking Current, Either Direction		10.0	100	nA	$V_{DRM} = 400$ V. Must be applied within dV/dt rating
V_{TM}	Peak On-State Voltage, Either Direction		1.75	3.0	V	$I_{TM} = 100$ mA
dV/dt	Critical Rate of Rise of Off-State-Voltage		15.0		V/μs	$R_L = 1$ kΩ
dV/dt	Critical Rate of Rise of Commutating Voltage		.140		V/μs	$R_L = 4$ kΩ
Coupled						
I_{FT}	LED Trigger Current Required to Latch Output in Either Direction					
	OPI3020		15.0	30	mA	Main Terminal Voltage = 3.0 V
	OPI3021		10.0	15.0	mA	Main Terminal Voltage = 3.0 V
	OPI3022		7.5	10.0	mA	Main Terminal Voltage = 3.0 V
	OPI3023		3.5	5.0	mA	Main Terminal Voltage = 3.0 V
I_H	Holding Current, Either Direction		100		μA	

E

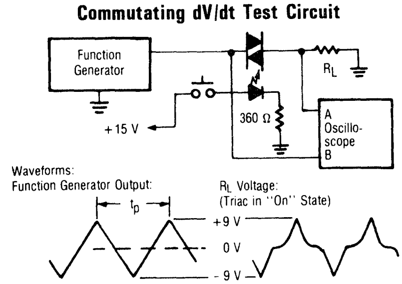
Typical Performance Curves

Static dV/dt Test Circuit



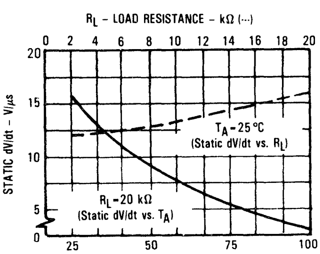
- The relay provides a high speed repeated pulse to the D.U.T.
- 10X probes are used to allow high speeds and voltages.
- The worst case condition for static dV/dt is established by triggering the D.U.T. with a normal input (LED) current, then removing this current. The variable R_{TEST} allows the dV/dt to be increased until the D.U.T. continues to trigger in response to the applied voltage pulse, even after the LED current has been removed. The dV/dt is then decreased until the D.U.T. stops triggering. τ_{RC} is measured at this point and recorded.

Commutating dV/dt Test Circuit

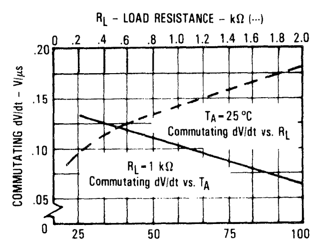


- 10X probes are used to allow high speeds.
- Frequency is increased until the triac stays "on" after being triggered by pushbutton. Frequency is then decreased until triac turns "off." t_p is measured at this point and recorded.
- Commutating dV/dt = $36/t_p$.

Static dV/dt vs. Ambient Temperature and Load Resistance



Commutating dV/dt vs. Ambient Temperature and Load Resistance



TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

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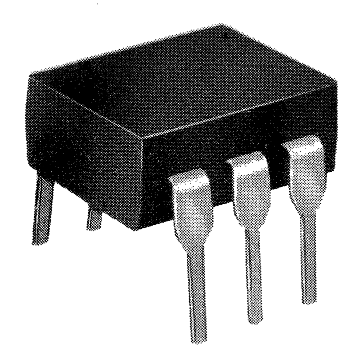
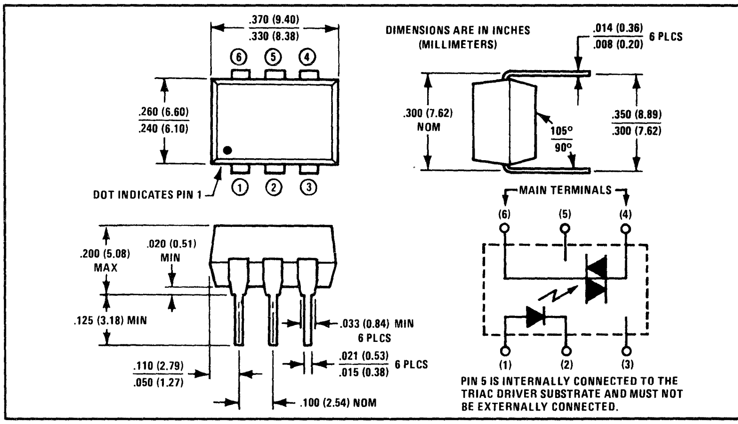
TRW Electronic Components Group

Product Bulletin 5216
January 1985

TRW

Zero Voltage Crossing Optically Coupled Triac Drivers
Types OPI3030, OPI3031, OPI3032, OPI3033





Features
- For 120 VAC operation
- 2500 VDC minimum electrical isolation
- Low LED trigger current to latch output
- Zero voltage crossing for reduced EMI and line noise, and improved static dV/dt
- UL recognized File No. E58730

Description
The OPI3030, OPI3031, OPI3032, and OPI3033 each contain a gallium arsenide or gallium aluminum arsenide infrared emitting diode and a monolithic integrated circuit containing a photodiode and a zero voltage bidirectional triac driver, mounted in a standard plastic six pin dual-in-line package. Required LED drive currents are 30 mA, 15 mA, 10 mA, and 5 mA, respectively. This series is intended to be used for low power DC controlling of power triacs which in turn control resistive, inductive, or capacitance loads powered from 120 VAC. Zero voltage crossing ensures that the devices will not turn on until the line voltage reduces to 15 volts, typical.

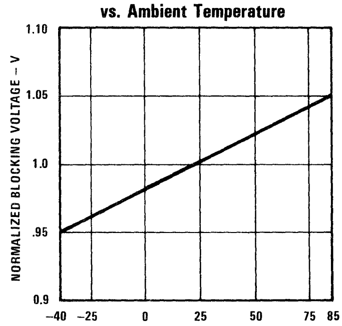
Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

Input-to-Output Isolation Voltage		±2500 VDC(1)
Storage Temperature Range		−40°C to +150°C
Operating Temperature Range		−40°C to +85°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)(2)		260°C
Total Device Power Dissipation		400 mW(3)
Input Diode		
Forward DC Current	I_F	60 mA
Reverse DC Voltage	V_R	3.0 V
Power Dissipation	P_D	100 mW(4)
Output Photosensor		
Off-State Terminal Voltage	V_{DRM}	250 V
On-State RMS Current ..... I_T(RMS) ..... [Full Cycle, 50-60 Hz]	...T_A = 25°C	100 mA
	...T_A = 70°C	50 mA
Peak Non-Repetitive Surge Current (PW = 10 ms, duty cycle = 10%)	I_{TSM}	1.20 A
Power Dissipation	P_D	350 mW(5)

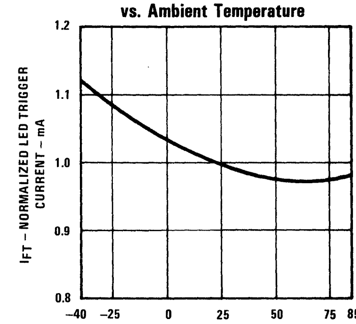
Notes: (1) Measured with input diode leads shorted together and output leads shorted together. **(2)** RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering. **(3)** Derate 6.67 mW/°C above 25°C. **(4)** Derate 1.67 mW/°C above 25°C. **(5)** Derate 5.83 mW/°C above 25°C.

Typical Performance Curves

Blocking Voltage vs. Ambient Temperature



Normalized Trigger Level vs. Ambient Temperature



Types OPI3030, OPI3031, OPI3032, OPI3033

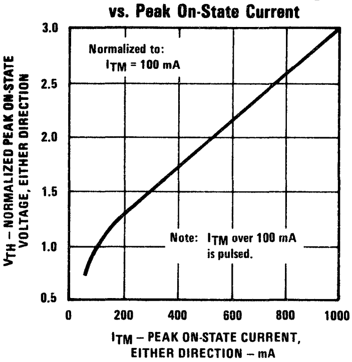
Electrical Characteristics (T_A = 25°C unless otherwise noted)

Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
Input Diode							
V_F	Forward Voltage			1.20	1.50	V	I_F = 10.0 mA
I_R	Reverse Current				100	μA	V_R = 6.0 V
Output Photosensor							
I_{DRM}	Peak Blocking Current, Either Direction			10.0	100	nA	V_{DRM} = 250 V. Must be applied within dV/dt rating.
V_{TM}	Peak On-State Voltage, Either Direction			1.75	3.0	V	I_{TM} = 100 mA Peak
dV/dt	Critical Rate of Rise of Off-State Voltage			100		V/μs	
Coupled							
I_{FT}	LED Trigger Current Required to Latch	OPI3030		15.0	30	mA	Main Terminal Voltage = 3.0 V
	Output in Either Direction (Rated I_{FT})	OPI3031		10.0	15.0	mA	Main Terminal Voltage = 3.0 V
		OPI3032		7.5	10.0	mA	R_L = 150 kΩ
		OPI3033		3.5	5.0	mA	R_L = 150 kΩ
I_H	Holding Current, Either Direction			200		μA	
V_{ISO}	Isolation Voltage		2500			VDC	See Note (1)
$V_{I(TH)}$	Zero Voltage Crossing Inhibit Voltage Threshold			15.0	25	V	I_{FT} = Rated I_{FT}. MT1, MT2 voltage above which the device will not trigger.
$I_{R(I)}$	Leakage Current in Inhibit State	OPI3030 & OPI3031		100	300	μA	I_{FT} and MT1, MT2 voltage as rated. Device in
		OPI3032 & OPI3033		100	200	μA	off-state.

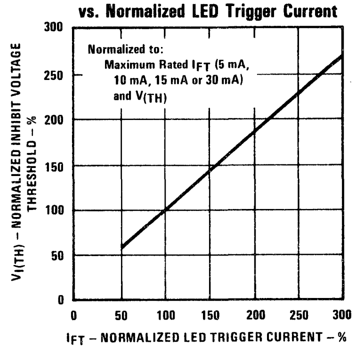
E

Typical Performance Curves

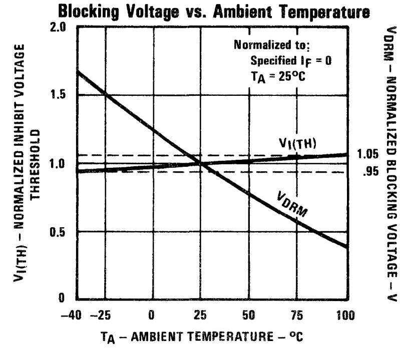
Normalized Peak On-State Voltage vs. Peak On-State Current



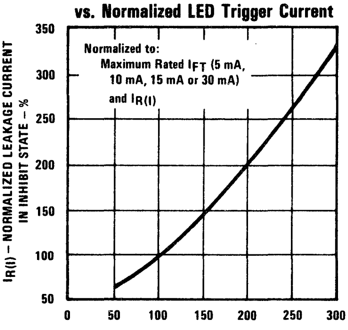
Normalized Inhibit Voltage Threshold vs. Normalized LED Trigger Current



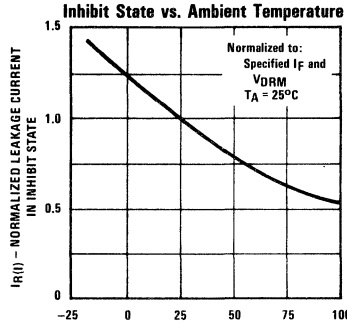
Normalized Inhibit Voltage Threshold and Blocking Voltage vs. Ambient Temperature



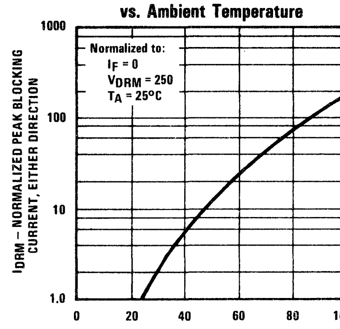
Normalized Leakage Current In Inhibit State vs. Normalized LED Trigger Current



Normalized Leakage Current In Inhibit State vs. Ambient Temperature



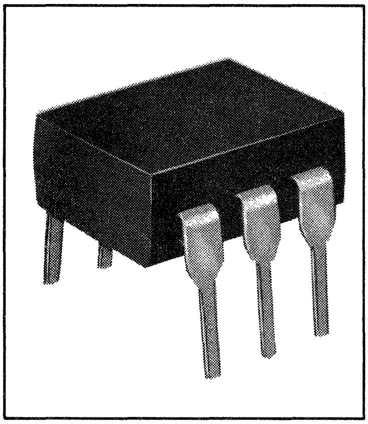
Normalized Peak Blocking Current vs. Ambient Temperature

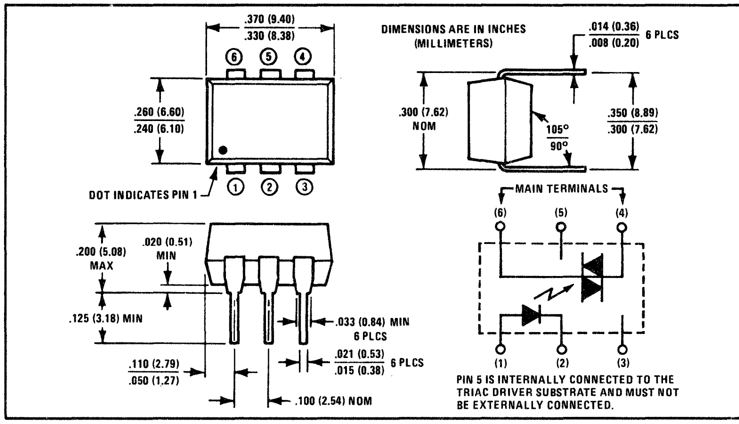


Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5218
January 1985

Zero Voltage Crossing Optically Coupled Triac Drivers
Types OPI3040, OPI3041, OPI3042, OPI3043





Features
- For 220 VAC operation
- 2500 VDC minimum electrical isolation
- Zero voltage crossing for reduced EMI and line noise, and improved static dV/dt
- UL recognized File No. E58730

Description
The OPI3040, OPI3041, OPI3042, and OPI3043 each contain a gallium arsenide or gallium aluminum arsenide infrared emitting diode and a monolithic integrated circuit containing a photodiode and a zero voltage bidirectional triac driver, mounted in a standard plastic six pin dual-in-line package. Required LED drive currents are 30 mA, 15 mA, 10 mA, and 5 mA, respectively. This series is intended to be used for low power DC controlling of power triacs which in turn control resistive, inductive, or capacitance loads powered from 220 VAC. Zero voltage crossing ensures that the devices will not turn on until the line voltage reduces to 15 volts, typical.

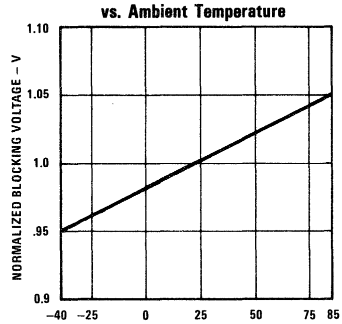
Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

Input-to-Output Isolation Voltage		±2500 VDC[1]
Storage Temperature Range		−40°C to +150°C
Operating Temperature Range		−40°C to +85°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)[2]		260°C
Total Device Power Dissipation		400 mW[3]
Input Diode		
Forward DC Current	I_F	60 mA
Reverse DC Voltage	V_R	3.0 V
Power Dissipation	P_D	100 mW[4]
Output Photosensor		
Off-State Terminal Voltage	V_{DRM}	400 V
On-State RMS Current ..... I_T(RMS) ..... [Full Cycle, 50-60 Hz] ... T_A = 25°C		100 mA
On-State RMS Current ..... I_T(RMS) ..... [Full Cycle, 50-60 Hz] ... T_A = 70°C		50 mA
Peak Non-Repetitive Surge Current (PW = 10 ms, duty cycle = 10%)	I_{TSM}	1.20 A
Power Dissipation	P_D	350 mW[5]

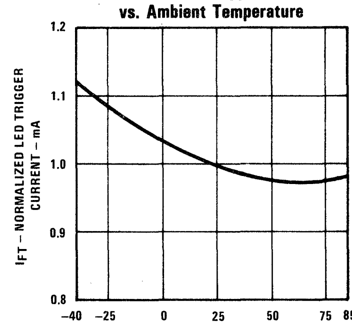
Notes: (1) Measured with input diode leads shorted together and output leads shorted together. **(2)** RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering. **(3)** Derate 6.67 mW/°C above 25°C. **(4)** Derate 1.67 mW/°C above 25°C. **(5)** Derate 5.83 mW/°C above 25°C.

Typical Performance Curves

Blocking Voltage vs. Ambient Temperature



Normalized Trigger Level vs. Ambient Temperature



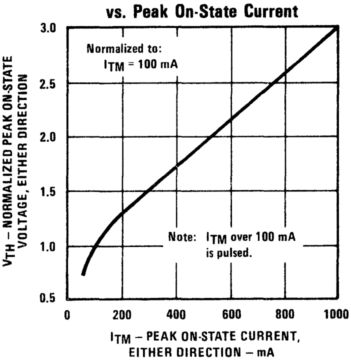
Types OPI3040, OPI3041, OPI3042, OPI3043

Electrical Characteristics (T_A = 25°C unless otherwise noted)

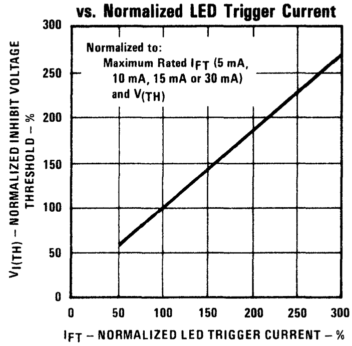
Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
Input Diode							
V_F	Forward Voltage			1.20	1.50	V	I_F = 10.0 mA
I_R	Reverse Current				100	μA	V_R = 6.0 V
Output Photosensor							
I_{DRM}	Peak Blocking Current, Either Direction			10.0	100	nA	V_{DRM} = 400 V. Must be applied within dV/dt rating.
V_{TM}	Peak On-State Voltage, Either Direction			1.75	3.0	V	I_{TM} = 100 mA Peak
dV/dt	Critical Rate of Rise of Off-State Voltage			100		V/μs	
Coupled							
I_{FT}	LED Trigger Current Required to Latch	OPI3040		15.0	30	mA	Main Terminal Voltage = 3.0 V
	Output in Either Direction (Rated I_{FT})	OPI3041		10.0	15.0	mA	Main Terminal Voltage = 3.0 V
		OPI3042		7.5	10.0	mA	R_L = 150 kΩ
		OPI3043		3.5	5.0	mA	R_L = 150 kΩ
I_H	Holding Current, Either Direction			200		μA	
V_{ISO}	Isolation Voltage		2500			VDC	See Note (1)
$V_{I(TH)}$	Zero Voltage Crossing Inhibit Voltage Threshold			15.0	40	V	I_{FT} = Rated I_{FT}. MT1, MT2 voltage above which the device will not trigger.
$I_{R(I)}$	Leakage Current in Inhibit State	OPI3040 & OPI3041		100	300	μA	I_{FT} and MT1, MT2 voltage as rated. Device in off-state.
		OPI3042 & OPI3043		100	200	μA	

Typical Performance Curves

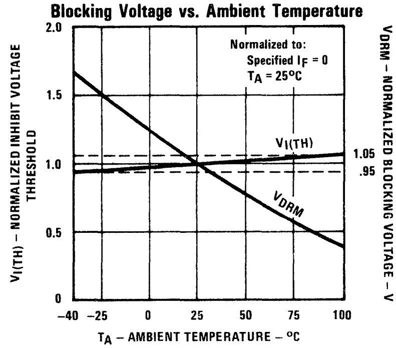
Normalized Peak On-State Voltage vs. Peak On-State Current



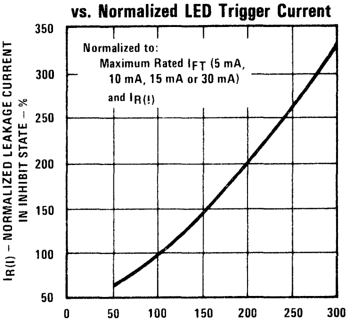
Normalized Inhibit Voltage Threshold vs. Normalized LED Trigger Current



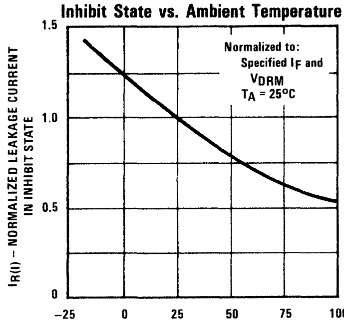
Normalized Inhibit Voltage Threshold and Blocking Voltage vs. Ambient Temperature



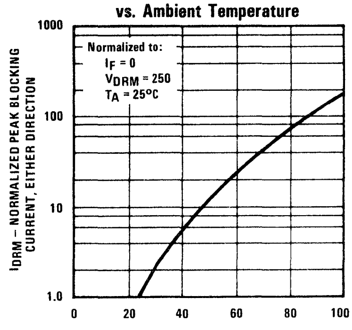
Normalized Leakage Current In Inhibit State vs. Normalized LED Trigger Current



Normalized Leakage Current In Inhibit State vs. Ambient Temperature



Normalized Peak Blocking Current vs. Ambient Temperature



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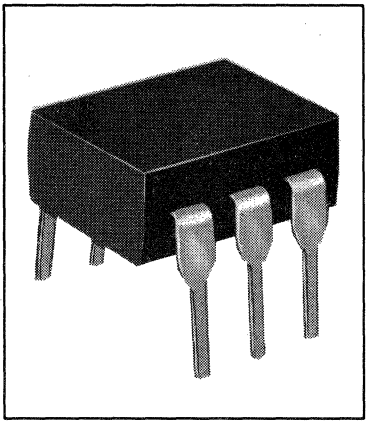
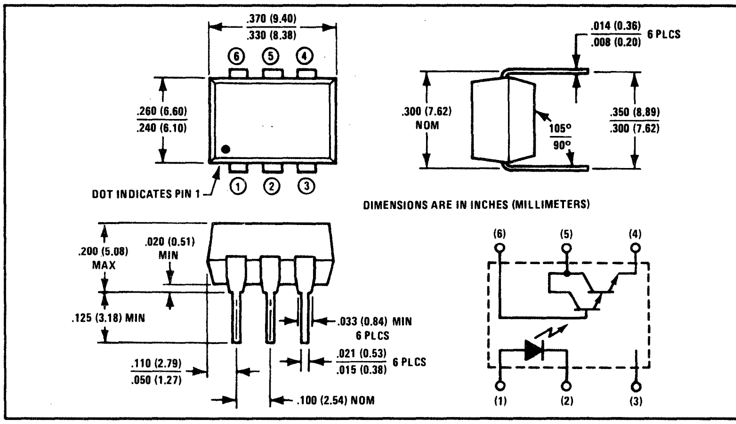
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5221
January 1985

Optically Coupled Isolators
Types OPI3150, OPI3250





Features

- Photodarlington output
- High current transfer ratio
- 2500 or 1500 volt isolation ratings
- UL recognized File No. E58730

Description

The OPI3150 and OPI3250 are optically coupled isolators each consisting of a gallium arsenide infrared emitting diode and an NPN silicon photodarlington mounted in a standard plastic six pin dual-in-line package. Except for isolation voltage, the OPI3150 and OPI3250 are identical.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

Input-to-Output Isolation Voltage — OPI3150 .... ±1500 VDC(1)
OPI3250 .... ±2500 VDC(1)
Storage Temperature Range .... −55°C to +150°C
Operating Temperature Range .... −55°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)(2) .... 260°C

Input Diode

Forward DC Current .... 60 mA
Peak Forward Current (1 μs pulse width, 330 pps) .... 3.0 A
Reverse DC Voltage .... 3.0 V
Power Dissipation .... 100 mW(3)

Output Transistor

Collector-Emitter Voltage .... 30 V
Collector-Base Voltage .... 30 V
Emitter-Collector Voltage .... 5.0 V
Power Dissipation .... 150 mW(4)

Notes:

(1) Measured with input diode leads shorted together and output leads shorted together.
(2) RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering.
(3) Derate linearly 1.33 mW/°C above 25°C.
(4) Derate linearly 2.0 mW/°C above 25°C.

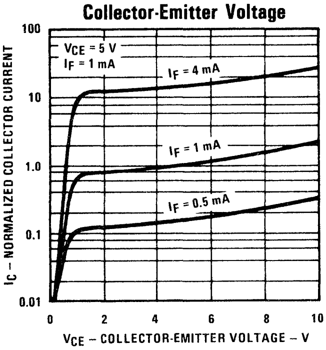
Types OPI3150, OPI3250

Electrical Characteristics (T_A = 25°C unless otherwise noted)

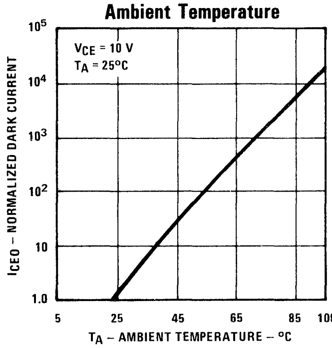
Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
Input Diode						
V_F	Forward Voltage		1.50		V	I_F = 10.0 mA
I_R	Reverse Current		100		μA	V_R = 3.0 V
Output Photodarlington						
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	30			V	I_C = 100 μA, I_B = 0
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	30			V	I_C = 100 μA, I_E = 0
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	5.0			V	I_E = 100 μA, I_B = 0
I_{CEO}	Collector-Emitter Dark Current			100	nA	V_{CE} = 10.0 V, I_B = 0
Coupled						
I_C/I_F	DC Current Transfer Ratio	300			%	I_F = 10.0 mA, V_{CE} = 2.0 V
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage		1.00		V	I_F = 10.0 mA, I_C = 10.0 mA, I_B = 0
t_r	Output Rise Time			3.0	μs	V_{CC} = 10.0 V, I_C = 10.0 mA, R_L = 100Ω
t_f	Output Fall Time			25	μs	See Test Circuit

Typical Performance Curves

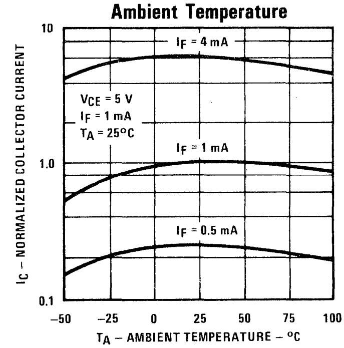
Normalized Collector Current vs. Collector-Emitter Voltage



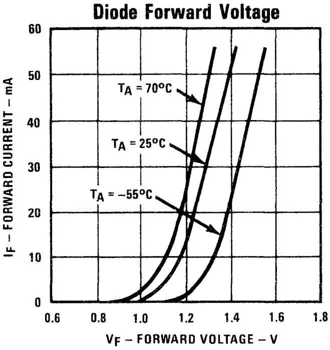
Normalized Dark Current vs. Ambient Temperature



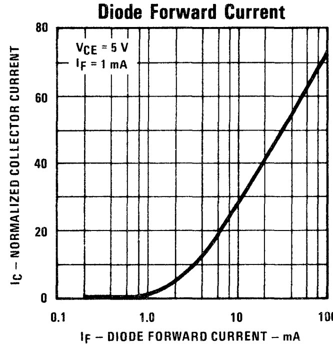
Normalized Collector Current vs. Ambient Temperature



Diode Forward Current vs. Diode Forward Voltage

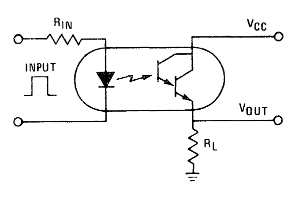


Normalized Collector Current vs. Diode Forward Current



Switching Time Test Circuit

SWITCHING TIME VS. LOAD RESISTANCE



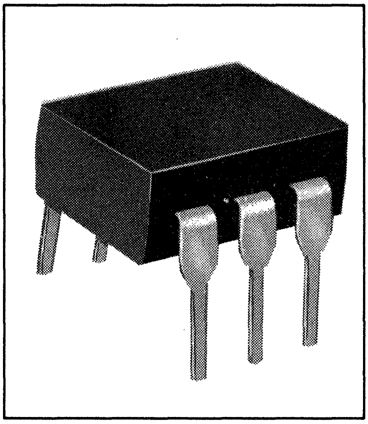
NOTE: Rise Time (t_r) is time required for collector current to increase from 10% to 90% of its final value. Fall Time (t_f) is time required for the collector current to decrease from 90% to 10% of its initial value.

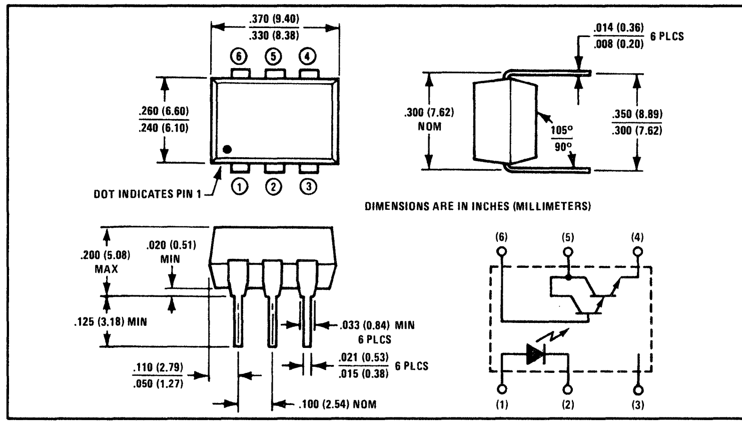
Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958

Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5222
January 1985

Optically Coupled Isolators
Types OPI3151, OPI3251





Features
- Photodarlington output
- High current transfer ratio
- 2500 or 1500 volt isolation ratings
- UL recognized File No. E58730

Description
The OPI3151 and OPI3251 are optically coupled isolators each consisting of a gallium arsenide infrared emitting diode and an NPN silicon photodarlington mounted in a standard plastic six pin dual-in-line package. Except for isolation voltage, the OPI3151 and OPI3251 are identical.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

Input-to-Output Isolation Voltage — OPI3151	±1500 VDC(1)
OPI3251	±2500 VDC(1)
Storage Temperature Range	−55°C to +150°C
Operating Temperature Range	−55°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)(2)	260°C
Input Diode	
Forward DC Current	60 mA
Peak Forward Current (1 μs pulse width, 330 pps)	3.0 A
Reverse DC Voltage	3.0 V
Power Dissipation	100 mW(3)
Output Transistor	
Collector-Emitter Voltage	30 V
Collector-Base Voltage	30 V
Emitter-Collector Voltage	5.0 V
Power Dissipation	150 mW(4)

Notes:
(1) Measured with input diode leads shorted together and output leads shorted together.
(2) RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering.
(3) Derate linearly 1.33 mW/°C above 25°C.
(4) Derate linearly 2.0 mW/°C above 25°C.

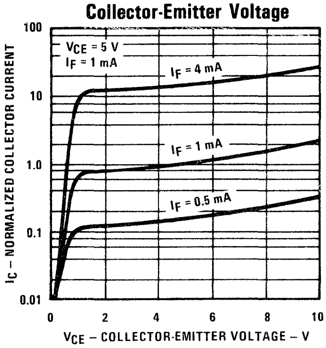
Electrical Characteristics (T_A = 25°C unless otherwise noted)

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
Input Diode						
V_F	Forward Voltage			1.50	V	I_F = 10.0 mA
I_R	Reverse Current			100	μA	V_R = 3.0 V
Output Photodarlington						
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	30			V	I_C = 100 μA,
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	30			V	I_C = 100 μA,
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	5.0			V	I_E = 100 μA,
I_{CEO}	Collector-Emitter Dark Current			100	nA	V_{CE} = 10.0 V
Coupled						
I_C/I_F	DC Current Transfer Ratio	300			%	I_F = 10.0 mA, V_{CE} = 1.00 V
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage			1.00	V	I_F = 10.0 mA, I_C = 30 mA, I_B = 0
t_r	Output Rise Time		3.0		μs	V_{CC} = 10.0 V, I_C = 10.0 mA, R_L = 100Ω
t_f	Output Fall Time		25		μs	See Test Circuit

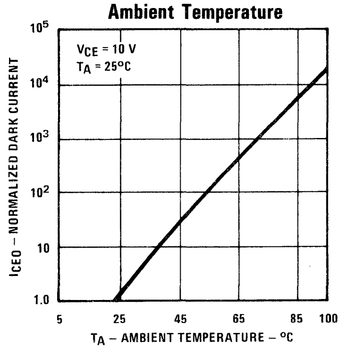
E

Typical Performance Curves

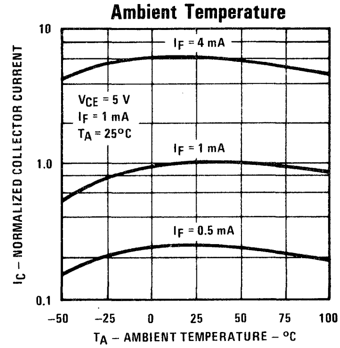
Normalized Collector Current vs. Collector-Emitter Voltage



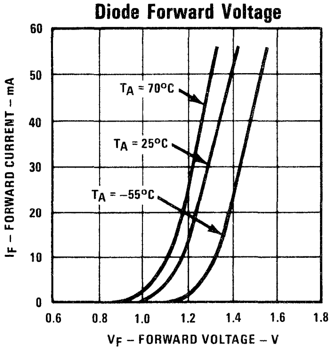
Normalized Dark Current vs. Ambient Temperature



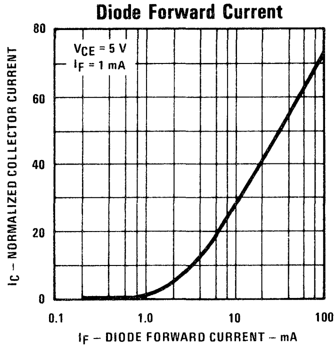
Normalized Collector Current vs. Ambient Temperature



Diode Forward Current vs. Diode Forward Voltage

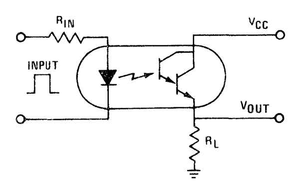


Normalized Collector Current vs. Diode Forward Current



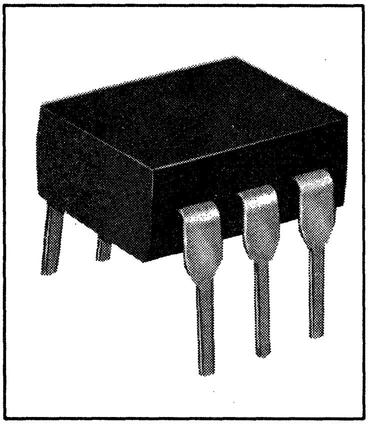
Switching Time Test Circuit

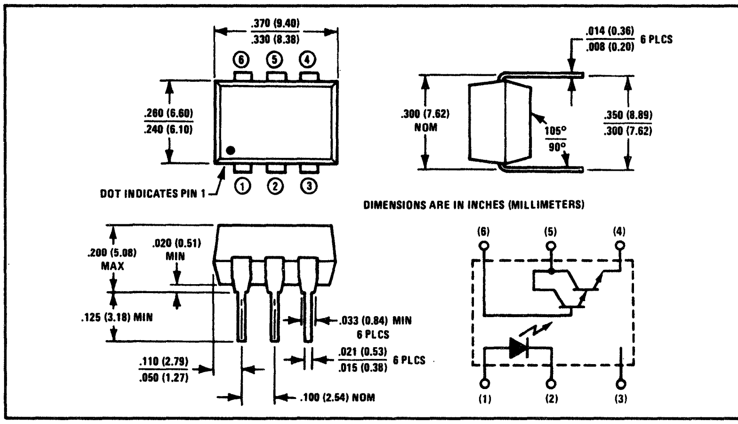
SWITCHING TIME VS. LOAD RESISTANCE



NOTE: Rise Time (t_r) is time required for collector current to increase from 10% to 90% of its final value. Fall Time (t_f) is time required for the collector current to decrease from 90% to 10% of its initial value.

Optically Coupled Isolators
Types OPI3152, OPI3252





Features
- Photodarlington output
- High current transfer ratio
- 2500 or 1500 volt isolation ratings
- UL recognized File No. E58730

Description
The OPI3152 and OPI3252 are optically coupled isolators each consisting of a gallium arsenide infrared emitting diode and an NPN silicon photodarlington mounted in a standard plastic six pin dual-in-line package. Except for isolation voltage, the OPI3152 and OPI3252 are identical.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

Input-to-Output Isolation Voltage — OPI3152 .... ±1500 VDC(1)
OPI3252 .... ±2500 VDC(1)
Storage Temperature Range .... −55°C to +150°C
Operating Temperature Range .... −55°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)(2) .... 260°C

Input Diode

Forward DC Current .... 60 mA
Peak Forward Current (1 µs pulse width, 330 pps) .... 3.0 A
Reverse DC Voltage .... 3.0 V
Power Dissipation .... 100 mW(3)

Output Transistor

Collector-Emitter Voltage .... 55 V
Collector-Base Voltage .... 55 V
Emitter-Collector Voltage .... 5.0 V
Power Dissipation .... 150 mW(4)

Notes:
(1) Measured with input diode leads shorted together and output leads shorted together.
(2) RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering.
(3) Derate linearly 1.33 mW/°C above 25°C.
(4) Derate linearly 2.0 mW/°C above 25°C.

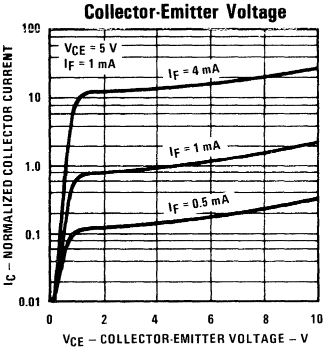
Electrical Characteristics (T_A = 25°C unless otherwise noted)

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
Input Diode						
V_F	Forward Voltage			1.50	V	I_F = 10.0 mA
I_R	Reverse Current			100	μA	V_R = 3.0 V
Output Photodarlington						
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	55			V	I_C = 100 μA, I_B = 0
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	55			V	I_C = 100 μA, I_E = 0
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	5.0			V	I_E = 100 μA, I_B = 0
I_{CEO}	Collector-Emitter Dark Current			100	nA	V_{CE} = 10.0 V, I_B = 0
Coupled						
I_C/I_F	DC Current Transfer Ratio	300			%	I_F = 10.0 mA, V_{CE} = 5.0 V
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage			1.00	V	I_F = 50 mA, I_C = 50 mA, I_B = 0
t_r	Output Rise Time		3.0		μs	V_{CC} = 10.0 V, I_C = 10.0 mA, R_L = 100Ω
t_f	Output Fall Time		25		μs	See Test Circuit

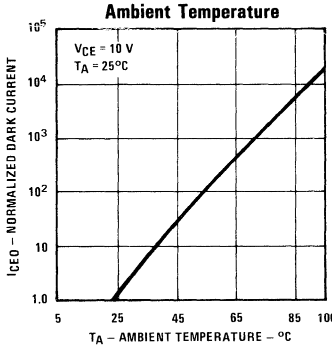
E

Typical Performance Curves

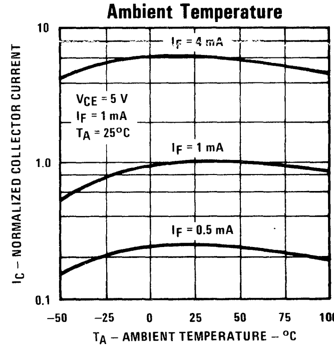
Normalized Collector Current vs. Collector-Emitter Voltage



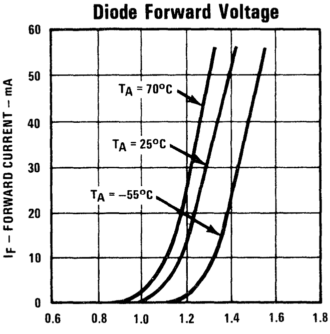
Normalized Dark Current vs. Ambient Temperature



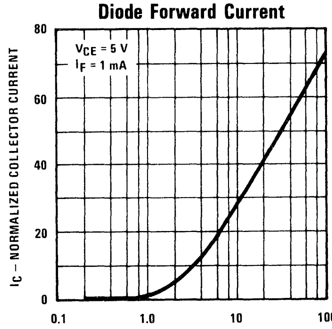
Normalized Collector Current vs. Ambient Temperature



Diode Forward Current vs. Diode Forward Voltage

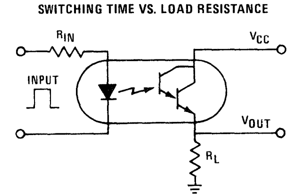


Normalized Collector Current vs. Diode Forward Current



Switching Time Test Circuit

SWITCHING TIME VS. LOAD RESISTANCE



NOTE: Rise Time (t_r) is time required for collector current to increase from 10% to 90% of its final value. Fall Time (t_f) is time required for the collector current to decrease from 90% to 10% of its initial value.

TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

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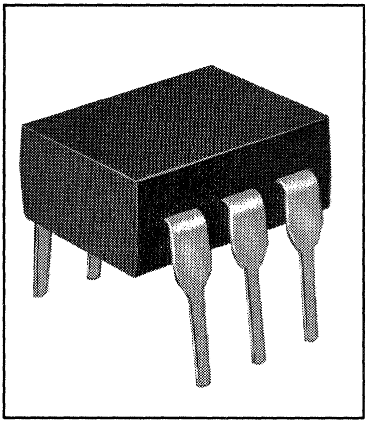
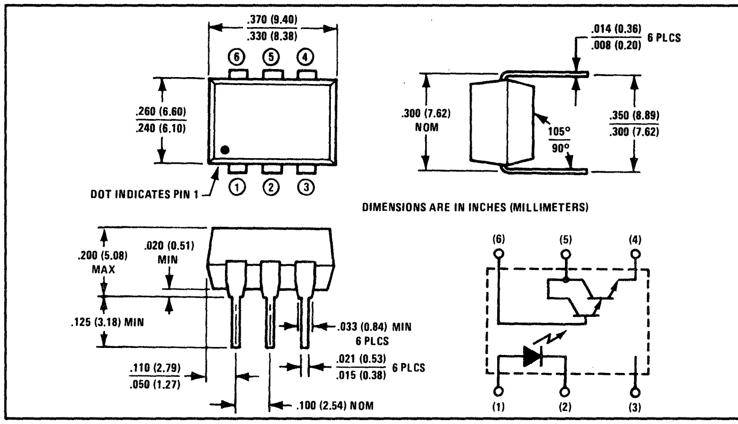
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5226
January 1985

Optically Coupled Isolators
Types OPI3153, OPI3253





Features
- Photodarlington output
- High current transfer ratio
- 2500 or 1500 volt isolation ratings
- UL recognized File No. E58730

Description
The OPI3153 and OPI3253 are optically coupled isolators each consisting of a gallium arsenide infrared emitting diode and an NPN silicon photodarlington mounted in a standard plastic six pin dual-in-line package. Except for isolation voltage, the OPI3153 and OPI3253 are identical.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

Input-to-Output Isolation Voltage — OPI3153	±1500 VDC(1)
OPI3253	±2500 VDC(1)
Storage Temperature Range	−55°C to +150°C
Operating Temperature Range	−55°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)(2)	260°C
Input Diode	
Forward DC Current	60 mA
Peak Forward Current (1 μs pulse width, 330 pps)	3.0 A
Reverse DC Voltage	3.0 V
Power Dissipation	100 mW(3)
Output Transistor	
Collector-Emitter Voltage	25 V
Collector-Base Voltage	30 V
Emitter-Collector Voltage	5.0 V
Power Dissipation	150 mW(4)

Notes:
(1) Measured with input diode leads shorted together and output leads shorted together.
(2) RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering.
(3) Derate linearly 1.33 mW/°C above 25°C.
(4) Derate linearly 2.0 mW/°C above 25°C.

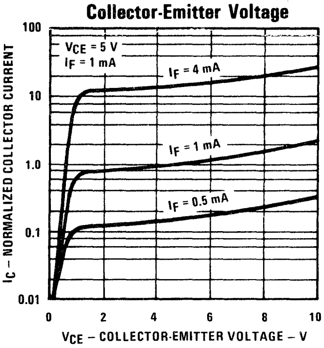
Electrical Characteristics (T_A = 25°C unless otherwise noted)

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
Input Diode						
V_F	Forward Voltage			1.50	V	I_F = 10.0 mA
I_R	Reverse Current			100	μA	V_R = 3.0 V
Output Photosensor						
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	25			V	I_C = 1.00 mA
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	30			V	I_C = 100 μA,
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	5.0			V	I_E = 100 μA,
I_{CEO}	Collector-Emitter Dark Current			100	nA	V_{CE} = 10.0 V
Coupled						
I_C/I_F	DC Current Transfer Ratio	500			%	I_F = 1.00 mA, V_{CE} = 5.0 V
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage			1.00	V	I_F = 1.00 mA, I_C = 1.00 mA
t_r	Output Rise Time		3.0		μs	V_{CC} = 10.0 V, I_C = 10.0 mA, R_L = 100Ω
t_f	Output Fall Time		25		μs	See Test Circuit

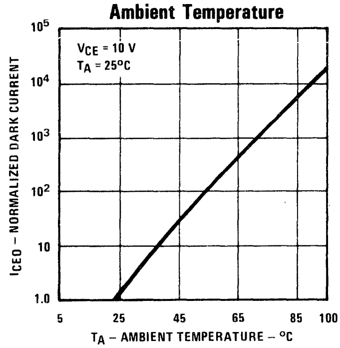
E

Typical Performance Curves

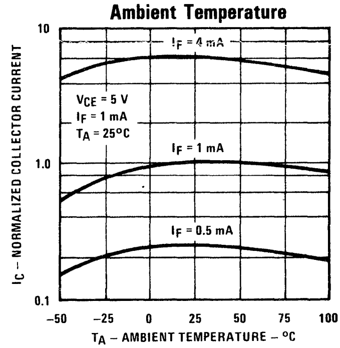
Normalized Collector Current vs. Collector-Emitter Voltage



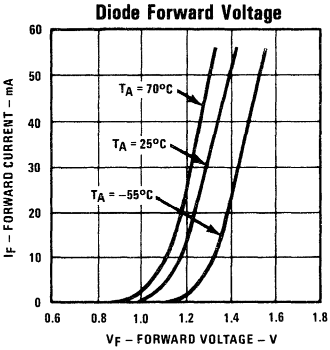
Normalized Dark Current vs. Ambient Temperature



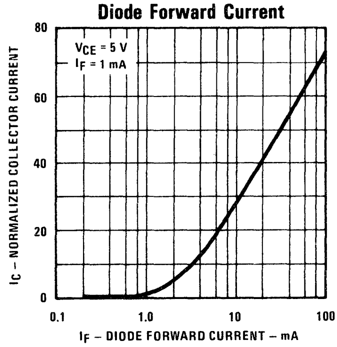
Normalized Collector Current vs. Ambient Temperature



Diode Forward Current vs. Diode Forward Voltage

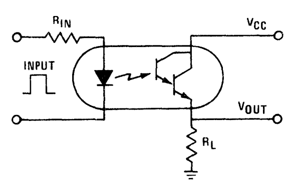


Normalized Collector Current vs. Diode Forward Current



Switching Time Test Circuit

SWITCHING TIME VS. LOAD RESISTANCE



NOTE: Rise Time (t_r) is time required for collector current to increase from 10% to 90% of its final value. Fall Time (t_f) is time required for the collector current to decrease from 90% to 10% of its initial value.

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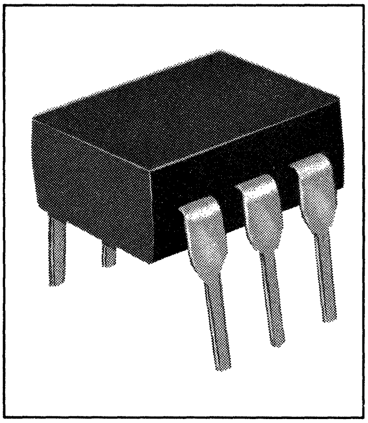
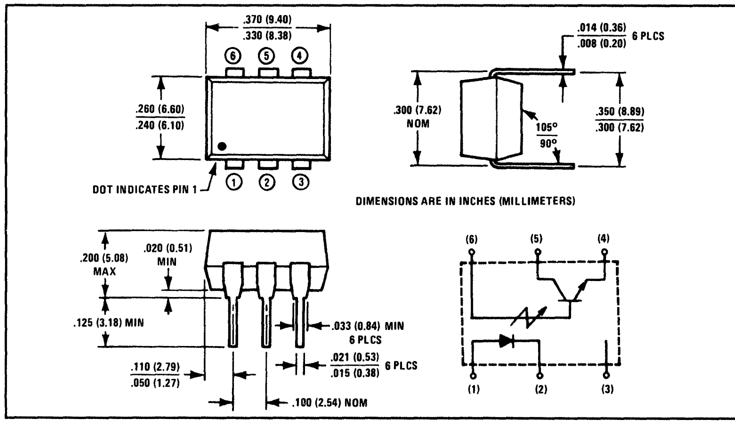
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5228
January 1985

Optically Coupled Isolators, High $V_{(BR)CEO}$
Types OPI6000, OPI6100





Features
- 300 V collector-emitter breakdown voltage
- Low cost 6 pin dual-in-line package
- UL recognized File No. E58730

Description
The OPI6000 and OPI6100 are optically coupled isolators each consisting of a gallium arsenide infrared emitting diode and an NPN silicon phototransistor mounted in a standard plastic six pin dual-in-line package. This series is intended for applications where high collector-emitter breakdown voltages are required.

Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)

Input-to-Output Isolation Voltage		±1500 VDC(1)
Storage Temperature Range		−55°C to +150°C
Operating Temperature Range		−55°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)(2)		260°C
Input Diode		
Forward DC Current		60 mA
Peak Forward Current (1 μs pulse width, 300 pps)		3.0 A
Reverse Voltage		3.0 V
Power Dissipation		100 mW(3)
Output Phototransistor		
$B_{(BR)CEO}$	OPI6000	300 V
	OPI6100	200 V
$V_{(BR)CBO}$	OPI6000	300 V
	OPI6100	200 V
$V_{(BR)ECO}$		7.0 V
Power Dissipation		300 mW(4)

Notes:
(1) Measured with input diode leads shorted together and output leads shorted together.
(2) RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering.
(3) Derate linearly 1.33 mW/°C above 25°C.
(4) Derate linearly 4.0 mW/°C above 25°C.

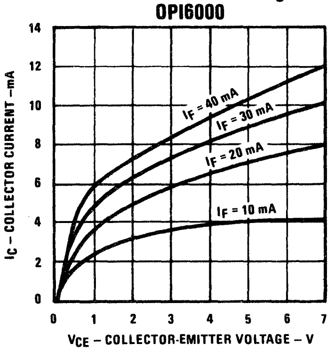
Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
Input Diode							
V_F	Forward Voltage				1.50	V	$I_F = 10.0$ mA
I_R	Reverse Current				10.0	μA	$V_R = 3.0$ V
Output Phototransistor							
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage (See Note 1)	OPI6000	300			V	$I_C = 1.00$ mA
		OPI6100	200				
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage		7.0			V	$I_E = 100$ μA
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	OPI6000	300			V	$I_C = 100$ μA, $I_F = 0$
		OPI6100	200				
I_{CEO}	Collector Dark Current	OPI6000			100	nA	$V_{CE} = 200$ V, $R_{BE} = 1.00$ MΩ
		OPI6100			100	nA	$V_{CE} = 100$ V, $R_{BE} = 1.00$ MΩ
Coupled							
I_C/I_F	DC Current Transfer Ratio	OPI6000	20			%	$I_F = 10.0$ mA, $V_{CE} = 5.0$ V
		OPI6000	10.0			%	$I_F = 10.0$ mA, $V_{CE} = 5.0$ V
$V_{CE(SAT)}$	Collector-to-Emitter Saturation Voltage				0.40	V	$I_F = 10.0$ mA, $I_C = 0.50$ mA
V_{ISO}	Isolation Voltage		1500			VDC	See Note 1
R_{IO}	Input-to-Output Resistance		10^{11}			Ω	$V_{IO} = 500$ V, See Note 1
C_{IO}	Input-to-Output Capacitance			2.0		pF	f = 1.00 MHz, See Note 1
t_{on}	Turn On Time			4.0		μs	$V_{CC} = 10.0$ V, $R_L = 100$ Ω
t_{off}	Turn Off Time			2.5		μs	$I_F = 2.0$ mA, See Test Circuit

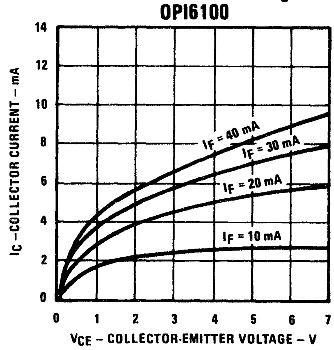
E

Typical Performance Curves

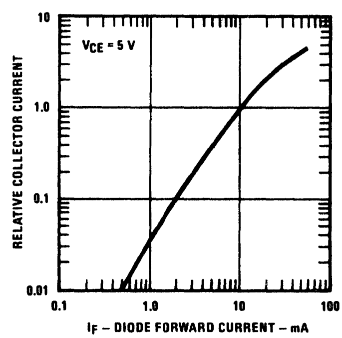
Collector Current vs Collector-Emitter Voltage OPI6000



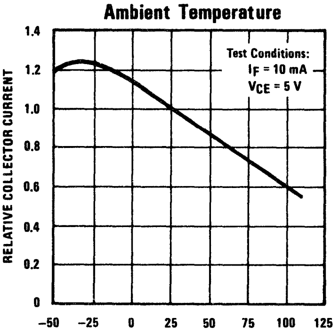
Collector Current vs Collector-Emitter Voltage OPI6100



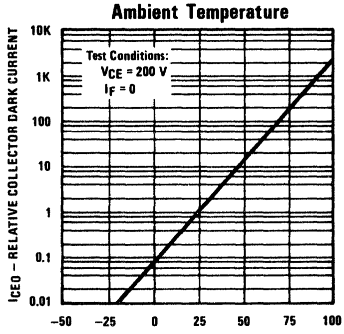
Relative Collector Current vs Diode Forward Current



Relative Collector Current vs Ambient Temperature

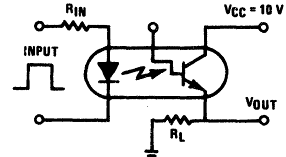


Relative Collector Dark Current vs Ambient Temperature



Switching Time Test Circuit

Switching Time vs Load Resistance



Note: Rise Time (t_r) is time required for collector current to increase from 10% to 90% of its final value. Fall Time (t_f) is time required for the collector current to decrease from 90% to 10% of its initial value.

TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

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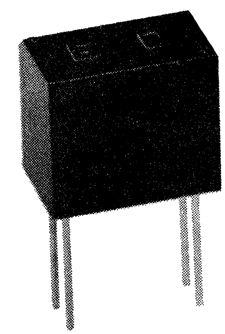
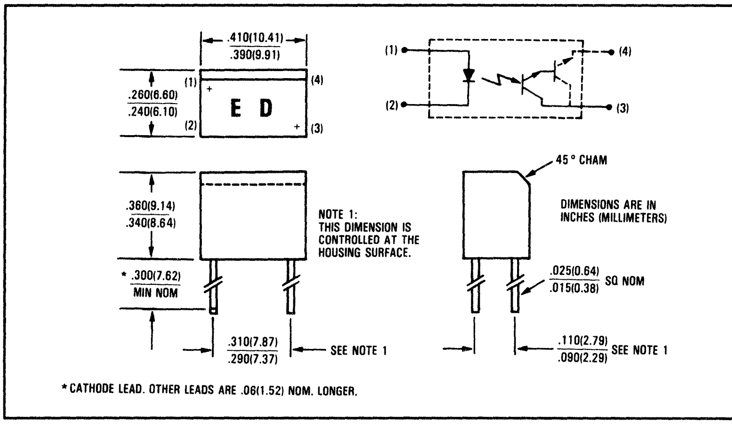
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5231
January 1985

Optically Coupled Isolators
Types OPI7002, OPI7010, OPI7320, OPI7340





Features
- 6 kV electrical isolation
- Low cost plastic housing
- UL recognized File No. E58730

Description
The OPI7002, OPI7010, OPI7320, and OPI7340 each consist of an infrared emitting diode coupled to an NPN silicon phototransistor (OPI7002, OPI7010) or photodarlington (OPI7320, OPI7340). The LED and sensor are encased in a black low-cost plastic housing. Pin spacing is compatible with standard dual-in-line packages.

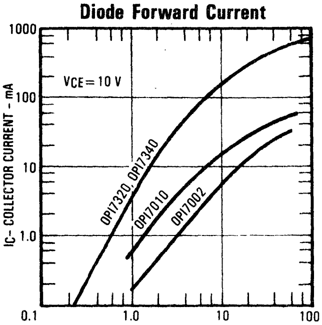
Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)

Input-to-Output Isolation Voltage	±6 kVDC(1)
Storage Temperature Range	−40°C to +85°C
Operating Temperature Range	−40°C to +85°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)(2)	240°C
Input Diode	
Forward DC Current	50 mA
Peak Forward Current (1 μs pulse width, 300 pps)	3.0 A
Reverse Voltage	2.0 V
Power Dissipation	100 mW(3)
Output Photosensor	
Collector-Emitter Voltage — OPI7320 & OPI7340	15.0 V
OPI7002 & OPI7010	30 V
Emitter-Collector Voltage	5.0 V
Power Dissipation	100 mW(3)

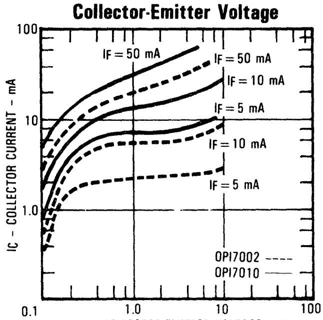
Notes: (1) Measured with input diode leads shorted together and output leads shorted together. **(2)** RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering. **(3)** Derate linearly 1.33 mW/°C above 25°C.

Typical Performance Curves

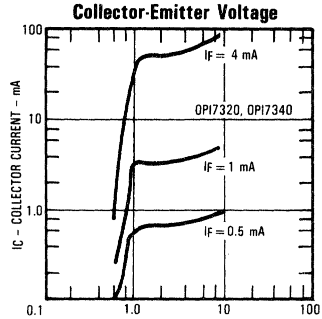
Collector Current vs Diode Forward Current



Collector Current vs Collector-Emitter Voltage



Collector Current vs Collector-Emitter Voltage



Types OPI7002, OPI7010, OPI7320, OPI7340

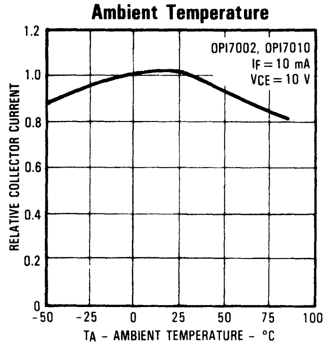
Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
Input Diode						
V_F	Forward Voltage			1.70	V	$I_F = 10.0$ mA
I_R	Reverse Current			100	μA	$V_R = 2.0$ V
Output Sensor						
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage OPI7320, OPI7340 OPI7002, OPI7010	15 30			V V	$I_C = 1.00$ mA, $I_F = 0$ $I_C = 100$ μA, $I_F = 0$
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	5.0			V	$I_E = 100$ μA, $I_F = 0$
I_{CEO}	Collector Dark Current			100	nA	$V_{CE} = 10.0$ V, $I_F = 0$
Coupled						
I_C/I_F	DC Current Transfer Ratio OPI7002 OPI7010 OPI7320 OPI7340	20 100 200 400			% % % %	$V_{CE} = 5.0$ V, $I_F = 10.0$ mA $V_{CE} = 5.0$ V, $I_F = 5.0$ mA
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage OPI7002, OPI7010 OPI7320, OPI7340			.40 1.00	V V	$I_F = 10.0$ mA, $I_C = 0.50$ mA $I_F = 5.0$ mA, $I_C = 2.0$ mA
V_{ISO}	Isolation Voltage	6000			VDC	See Note 1
t_{on}	Turn-On-Time OPI7002, OPI7010 OPI7320, OPI7340		4.0 150		μs μs	$V_{CE} = 10.0$ V, $I_{CE} = 10.0$ mA, $R_L = 100Ω$
t_{off}	Turn-Off-Time OPI7002, OPI7010 OPI7320, OPI7340		3.0 125		μs μs	$V_{CE} = 10.0$ V, $I_{CE} = 10.0$ mA, $R_L = 100Ω$
C_{IO}	Capacitance Input-to-Output		0.20		pF	$V_{IO} = 0$, f = 1 MHz, See Note 1

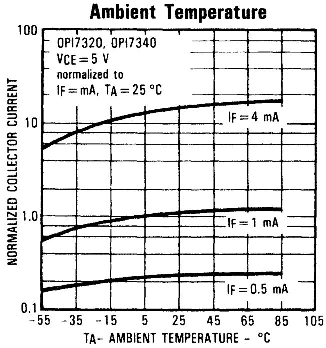
E

Typical Performance Curves

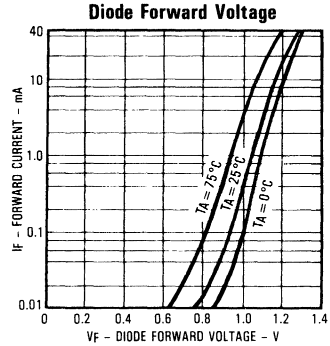
Relative Collector Current vs Ambient Temperature



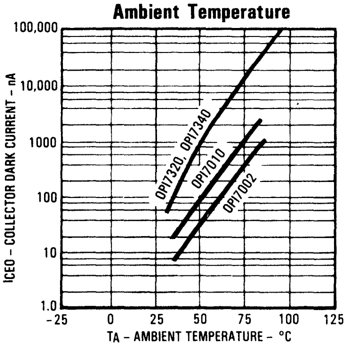
Normalized Collector Current vs Ambient Temperature



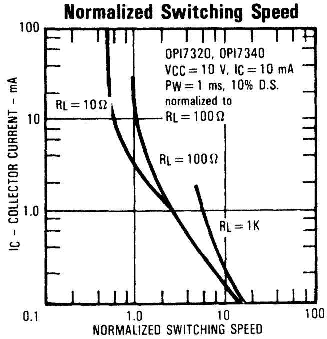
Diode Forward Current vs Diode Forward Voltage



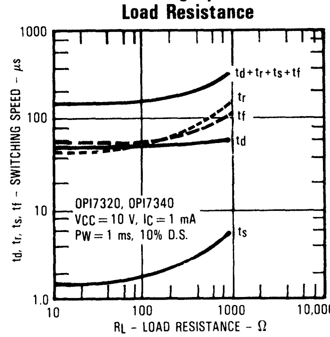
Collector Dark Current vs Ambient Temperature



Collector Current vs Normalized Switching Speed



Switching Speed vs Load Resistance



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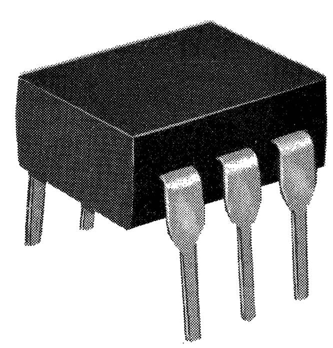
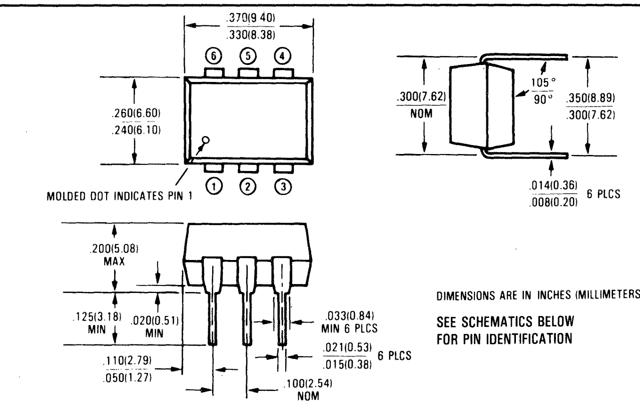
TRW Electronic Components Group

Product Bulletin 5232
January 1985

Photologic™ Optically Coupled Isolators
Types OPI8012, OPI8013, OPI8014, OPI8015





Features

- Four output options
- Low cost P-DIP package
- Direct TTL/LSTTL interface
- High noise immunity
- Data rates to 250 KBaud
- UL recognized File No. E58730

Description

The OPI8012, OPI8013, OPI8014, and OPI8015 each contain a gallium arsenide infrared emitting diode coupled to a monolithic integrated circuit which incorporates a photodiode, a linear amplifier and a Schmitt trigger on a single silicon chip. The devices feature TTL/LSTTL compatible logic level output which can drive up to 8 TTL loads directly without additional circuitry. Also featured are medium speed data rates to 250 KBaud and typical rise and fall times of 25 nsec. The devices are designed for industrial environments and have built-in hysteresis for high immunity to noise on input and V_{CC}.

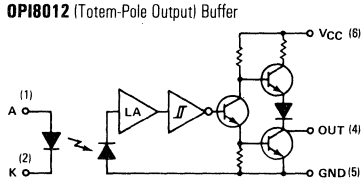
Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)

Input-to-Output Isolation Voltage	1500 V Peak(1)
Supply Voltage, V_{CC}	+10 V
Storage Temperature Range	−55°C to +150°C
Operating Temperature Range	−55°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)(2)	260°C
Total Device Power Dissipation	250 mW(3)
Input Diode Power Dissipation	100 mW(4)
Output Photologic Power Dissipation	200 mW(5)
Duration of Output Short to V_{CC} or Ground (OPI8012, OPI8014)	1.00 sec.
Duration of Output Short to V_{CC} (OPI8013, OPI8015)	1.00 sec.
Voltage at Output Lead (OPI8013, OPI8015)	35 V
Diode Input: Forward D.C. Current	25 mA
Diode Input: Reverse D.C. Voltage	3.0 V

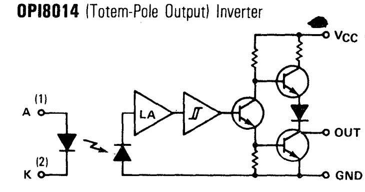
Notes: **(1)** Measured with input diode leads shorted together and output leads shorted together. **(2)** RMA flux is recommended. Duration can be extended to 10 seconds max. when flow soldering. **(3)** Derate linearly 3.33 mW/cm² above 25°C. **(4)** Derate linearly 1.33 mW/cm² above 25°C. **(5)** Derate linearly 2.67 mW/cm² above 25°C.

Schematics

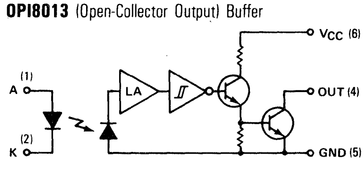
OPI8012 (Totem-Pole Output) Buffer



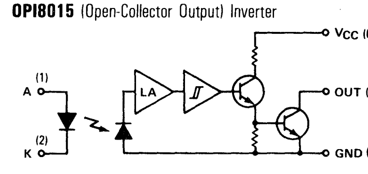
OPI8014 (Totem-Pole Output) Inverter



OPI8013 (Open-Collector Output) Buffer



OPI8015 (Open-Collector Output) Inverter



Types OPI8012, OPI8013, OPI8014, OPI8015

Electrical Characteristics (−40°C to +70°C unless otherwise noted)

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
Diode Input						
V_F	Forward Voltage			1.50	V	$I_F = 10.0$ mA, $T_A = 25°C$
I_R	Reverse Current			10.0	μA	$V_R = 3.0$ V, $T_A = 25°C$
$I_{F(+)}$	LED Positive-Going Threshold Current			10.0	mA	$V_{CC} = 5.0$ V,
$I_{F(+)}/I_{F(-)}$	Hysteresis Ratio		2.0			
Photologic™ Output						
V_{CC}	Operating Supply Voltage	4.8		5.2	V	
I_{CC}	Supply Current			15.0	mA	$V_{CC} = 5.2$ V, $I_F = 0$ or 10.0 mA
OPI8012 (Buffer, Totem-Pole)						
V_{OL}	Low Level Output Voltage			0.40	V	$V_{CC} = 4.8$ V, $I_{OL} = 13$ mA, $I_F = 0$ mA
V_{OH}	High Level Output Voltage	2.4			V	$V_{CC} = 4.8$ V, $I_{OH} = -800$ μA, $I_F = 10.0$ mA
I_{OS}	Short Circuit Output Current	−30		−100	mA	$V_{CC} = 5.2$ V, $I_F = 10.0$ mA, Output = GND
OPI8013 (Buffer, Open-Collector)						
V_{OL}	Low Level Output Voltage			0.40	V	$V_{CC} = 4.8$ V, $I_{OL} = 13$ mA, $I_F = 0$ mA
I_{OH}	High Level Output Current			100	μA	$V_{CC} = 4.8$ V, $V_{OH} = 30$ V $I_F = 10.0$mA
OPI8014 (Inverter, Totem-Pole)						
V_{OL}	Low Level Output Voltage			0.40	V	$V_{CC} = 4.8$ V, $I_{OL} = 13$ mA, $I_F = 10.0$ mA
V_{OH}	High Level Output Voltage	2.4			V	$V_{CC} = 4.8$ V, $I_{OH} = -800$ μA, $I_F = 0$ mA
I_{OS}	Short Circuit Output Current	−30		−100	mA	$V_{CC} = 5.2$ V, $I_F = 0$ mA, Output = GND
OPI8015 (Inverter, Open-Collector)						
V_{OL}	Low Level Output Voltage			0.40	V	$V_{CC} = 4.8$ V, $I_{OL} = 13$ mA, $I_F = 10.0$ mA
I_{OH}	High Level Output Current			100	μA	$V_{CC} = 4.8$ V, $V_{OH} = 30$ V, $I_F = 0$ mA
OPI8012, OPI8014						
t_r, t_f	Output Rise Time, Output Fall Time			25	ns	$V_{CC} = 5.0$ V, $T_A = 25°C$, $I_F = 10.0$ mA, Square Wave f = 10.0 kHz, D.C. = 50%, $R_L = 8$ TTL Loads
t_{PLH},t_{PHL}	Propagation Delay, Low-High, High-Low			10.0	μs	
OPI8013, OPI8015						
t_r, t_f	Output Rise Time, Output Fall Time			25	ns	$V_{CC} = 5.0$ V, $T_A = 25°C$, $I_F = 10.0$ mA, Square Wave f = 10.0 kHz, D.C. = 50%, $R_L = 360\Omega$
t_{PLH},t_{PHL}	Propagation Delay, Low-High, High-Low			10.0	μs	

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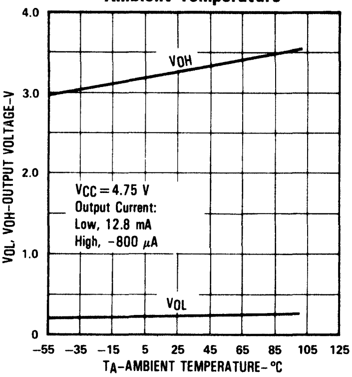
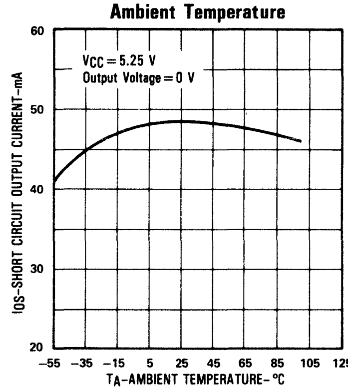
Typical Performance Curves

OPI8012, OPI8014

Output Voltage vs. Ambient Temperature

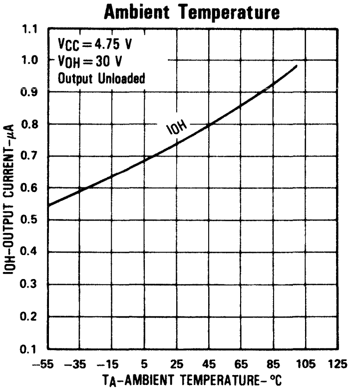


Short Circuit Output Current vs. Ambient Temperature

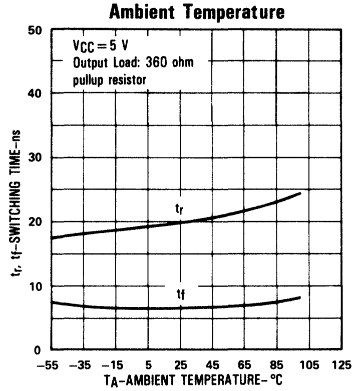


OPI8013, OPI8015

Output Current (High) vs Ambient Temperature

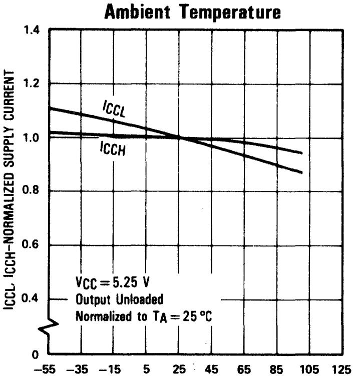


Rise Time and Fall time vs Ambient Temperature



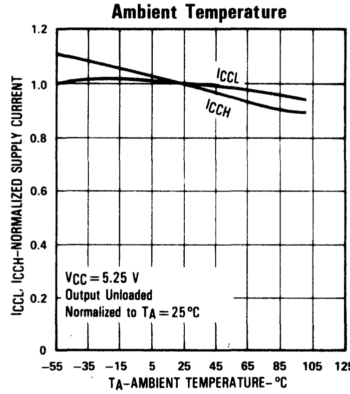
OPI8012, OPI8013

Normalized Supply Current vs Ambient Temperature



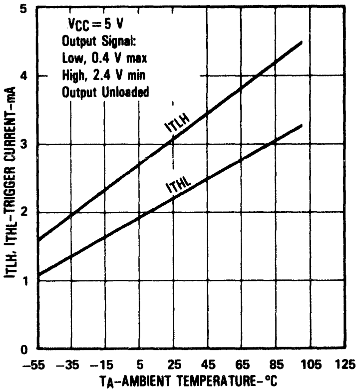
OPI8014, OPI8015

Normalized Supply Current vs Ambient Temperature

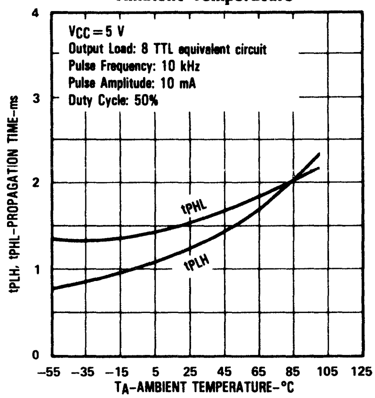


Typical Performance Curves

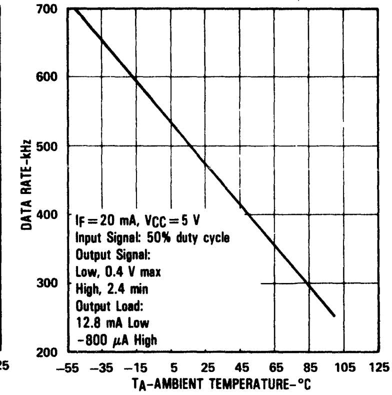
Trigger Current vs Ambient Temperature



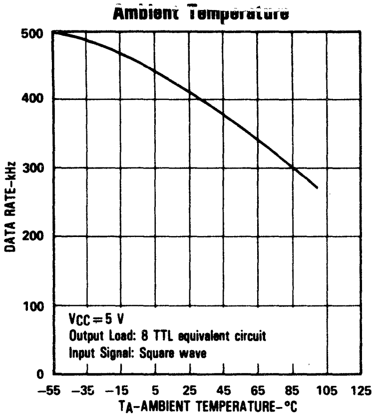
Propagation Time vs Ambient Temperature



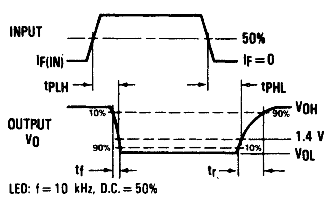
Data Rate vs Ambient Temperature



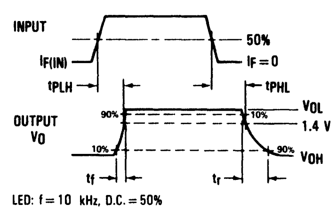
Data Rate vs Ambient Temperature



Switching Test Curve for Inverters



Switching Test Curve for Buffers



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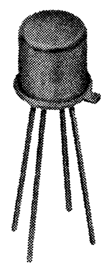
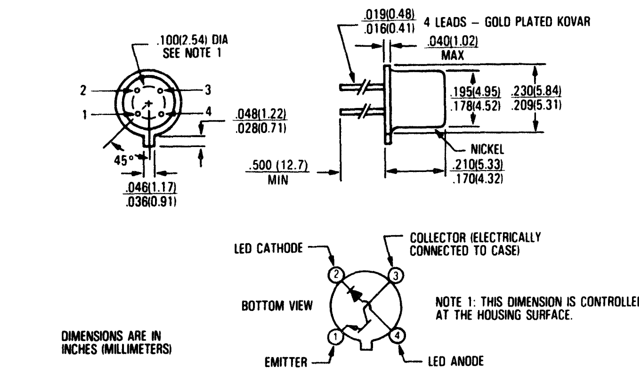
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5234
January 1985

Optically Coupled Isolators
Types 3N243, 3N244, 3N245





Features
- TO-72 hermetically sealed package
- 1 kVDC electrical isolation

Description
The 3N243, 3N244, and 3N245 are JEDEC registered optically coupled isolators each consisting of a gallium arsenide infrared emitting diode and an NPN silicon phototransistor mounted in a hermetically sealed TO-72 package.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

Input-to-Output Isolation Voltage	±1.00 kVDC(1)
Storage Temperature Range	−55°C to +150°C
Operating Temperature Range	−55°C to +125°C
Lead Soldering Temperature (1/16 in. [1.6 mm] from case for 5 sec. with soldering iron)	240°C(2)
Input Diode	
Forward DC Current	40 mA
Reverse Voltage	2.0 V
Power Dissipation	60 mW(3)
Output Phototransistor	
Continuous Collector Current	30 mA
Collector-Emitter Voltage	30 V
Emitter-Collector Voltage	5.0 V
Power Dissipation	200 mW(4)

Notes:
(1) Measured with input leads shorted together and output leads shorted together.
(2) RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering.
(3) Derate linearly 0.6 mW/°C above 25°C.
(4) Derate linearly 2.0 mW/°C above 25°C.
(5) The input waveform is supplied by a generator with the following characteristics: Z_{OUT} = 50Ω, $t_r \leq$ 15 ns, duty cycle ≈ 1%.

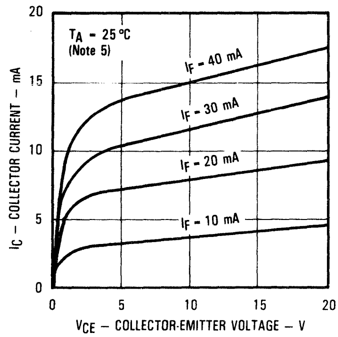
Types 3N243, 3N244, 3N245

Electrical Characteristics (T_A = 25°C unless otherwise noted)

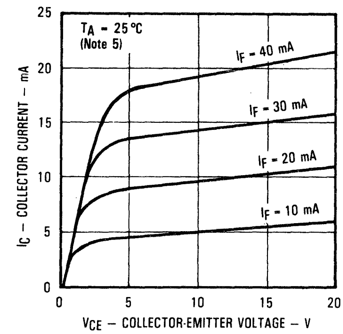
Symbol	Parameter	3N243			3N244			3N245			Units	Test Conditions
		Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.		
Input Diode												
V_F	Forward Voltage	0.80		1.30	0.80		1.30	0.80		1.30	V	I_F = 10.0 mA
		1.00		1.50	1.00		1.50	1.00		1.50	V	I_F = 10.0 mA, T_A = −55°C
		0.70		1.20	0.70		1.20	0.70		1.20	V	I_F = 10.0 mA, T_A = 100°C
I_R	Reverse Current			100			100			100	µA	V_R = 2.0 V
Output Phototransistor												
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	30			30			30			V	I_C = 1.00 mA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	5.0			5.0			5.0			V	I_E = 100 µA
I_{CEO}	Collector Dark Current			100			100			100	nA	V_{CE} = 10.0 V
				100			100			100	µA	V_{CE} = 10.0 V, T_A = 100°C
Coupled												
$I_{C(ON)}$	On-State Collector Current	1.50			3.0			6.0			mA	I_F = 10.0 mA, V_{CE} = 10.0 V
		0.30			0.80			1.50			mA	I_F = 3.0 mA, V_{CE} = 10.0 V,
		0.50			1.00			1.50			mA	I_F = 10.0 mA, V_{CE} = 10.0 V, T_A = −55°C
		0.50			1.00			1.50			mA	I_F = 10.0 mA, V_{CE} = 10.0 V, T_A = 100°C
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage			0.30							V	I_F = 20 mA, I_C = 1.50 mA
							0.30				V	I_F = 20 mA, I_C = 3.0 mA
										0.30	V	I_F = 20 mA, I_C = 6.0 mA
I_{IO}	Leakage, Input-to-Output			100			100			100	nA	V_{IO} = ±1.00 kVDC. See Note 1.
C_{IO}	Capacitance, Input-to-Output			5.0			5.0			5.0	pF	V_{IO} = 0 V, f = 1.00 MHz. See Note 1.
t_r	Output Rise Time			10.0			10.0			10.0	µs	V_{CC} = 10.0 V, I_F = 10.0 mA,
t_f	Output Fall Time			10.0			10.0			10.0	µs	R_L = 100Ω. See Test Circuit.

Typical Performance Curves

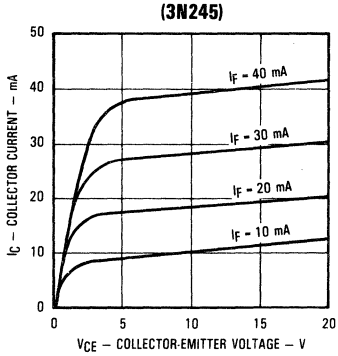
Collector Current vs. Collector-Emitter Voltage (3N243)



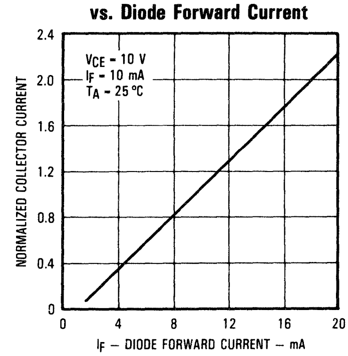
Collector Current vs. Collector-Emitter Voltage (3N244)



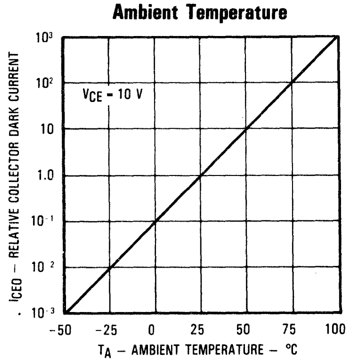
Collector Current vs. Collector-Emitter Voltage (3N245)



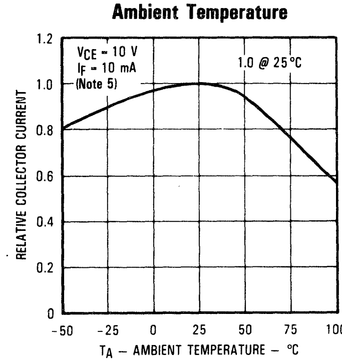
Normalized Collector Current vs. Diode Forward Current



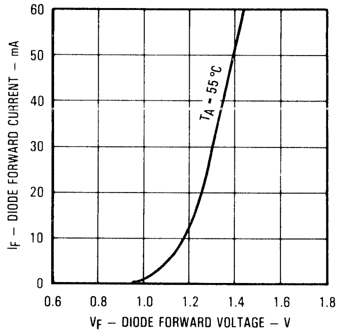
Collector Dark Current vs. Ambient Temperature



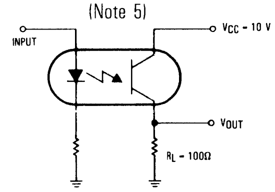
Relative Collector Current vs. Ambient Temperature



Diode Forward Current vs. Diode Forward Voltage



Switching Time Test Circuit
(Note 5)



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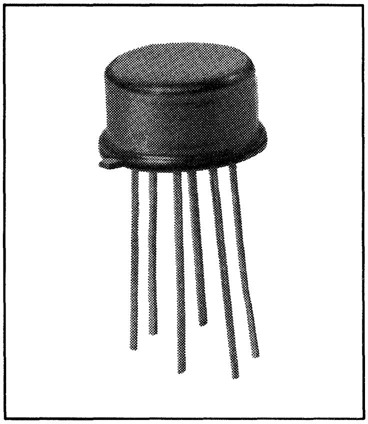
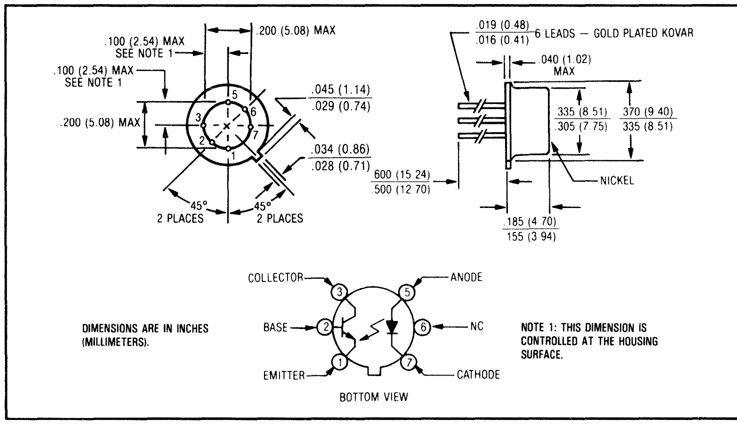
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5236
January 1985

Optically Coupled Isolators
Types 4N22A, 4N23A, 4N24A

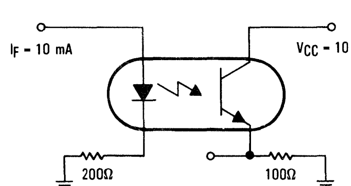




Features
- High DC current transfer ratio
- TO-5 hermetically sealed package
- 1 kV electrical isolation
- Base contact is provided for conventional transistor biasing

Description
The 4N22A, 4N23A, 4N24A are JEDEC registered optically coupled isolators each consisting of a gallium arsenide infrared emitting diode and an NPN silicon phototransistor mounted in a hermetically sealed TO-5 package. TO-5 packages offer high power dissipation, ease of heat sinking and superior hostile environment operation. The suffix "A" denotes that the collector is electrically isolated from the can.

Test Circuit



The input waveform is supplied by a generator with the following characteristics: Z_{OUT} = 50Ω, $t_r \leq$ 15 ns, duty cycle ≈ 1%, pulse width ≈ 100 μs.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)
Input-to-Output Isolation Voltage .... ±1 kVDC(1)
Storage and Operating Temperature Range .... −55°C to +125°C
Lead Soldering Temperature (1/16 in. [1.6 mm] from case for 5 sec. with soldering iron) .... 240°C(2)

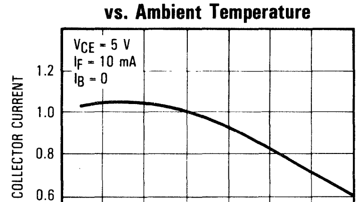
Input Diode
Forward DC Current (65°C or below) .... 40 mA
Reverse Voltage .... 2.0 V
Power Dissipation .... 60 mW(3)

Output Phototransistor
Continuous Collector Current .... 50 mA
Collector-Emitter Voltage .... 35 V
Collector-Base Voltage .... 35 V
Emitter-Base Voltage .... 4.0 V
Power Dissipation .... 300 mW(4)

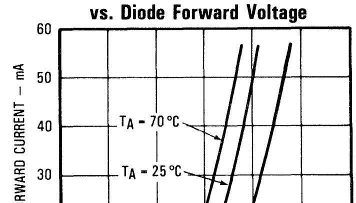
Notes: (1) Measured with input leads shorted together and output leads shorted together. **(2)** RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering. **(3)** Derate linearly 0.67 mW/°C above 25°C. **(4)** Derate linearly 3.0 mW/°C above 25°C.

Typical Performance Curves

Normalized Collector Current vs. Ambient Temperature



Diode Forward Current vs. Diode Forward Voltage



Types 4N22A, 4N23A, 4N24A

Electrical Characteristics (T_A = 25°C unless otherwise noted)

Symbol	Parameter	4N22A			4N23A			4N24A			Units	Test Conditions
		Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.		
Input Diode												
V_F	Forward Voltage	1.00		1.50	1.00		1.50	1.00		1.50	V	I_F = 10.0 mA, T_A = −55°C
		0.80		1.30	0.80		1.30	0.80		1.30	V	I_F = 10.0 mA
		0.70		1.20	0.70		1.20	0.70		1.20	V	I_F = 10.0 mA, T_A = 100°C
I_R	Reverse Current			100			100			100	µA	V_R = 2.0 V
Output Phototransistor												
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	35			35			35			V	I_C = 1.00 mA, I_B = 0, I_F = 0
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	35			35			35			V	I_C = 100 µA, I_E = 0, I_F = 0
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	4.0			4.0			4.0			V	I_E = 100 µA, I_C = 0, I_F = 0
I_{CEO}	Collector-Emitter Dark Current			100			100			100	nA	V_{CE} = 20 V, I_B = 0, I_F = 0
				100			100			100	µA	V_{CE} = 20 V, I_B = 0, I_F = 0 T_A = 100°C
Coupled												
$I_{C(ON)}$	On-State Collector Current	0.150			0.20			0.40			mA	V_{CE} = 5.0 V, I_F = 2.0 mA
		1.00			2.5			4.0				V_{CE} = 5.0 V, I_F = 10.0 mA, T_A = −55°C
		2.5	6.0		6.0	9.0		10.0	15.0		mA	V_{CE} = 5.0 V, I_F = 10.0 mA
		1.00			2.5			4.0			mA	V_{CE} = 5.0 V, I_F = 10.0 mA, T_A = 100°C
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage			0.30							V	I_C = 2.5 mA, I_F = 20 mA
							0.30					I_C = 5.0 mA, I_F = 20 mA
										0.30		I_C = 10.0 mA, I_F = 20 mA
R_{IO}	Resistance, Input-to-Output	10^{11}			10^{11}			10^{11}			Ω	V_{IO} = ±1.00 kV. See Note 1.
C_{IO}	Capacitance, Input-to-Output			5.0			5.0			5.0	pF	V_{IO} = 0, f = 1.00 MHz. See Note 1.
t_r	Output Rise Time			15.0			15.0			20	µs	V_{CC} = 10.0 V, I_F = 10.0 mA,
t_f	Output Fall Time			15.0			15.0			20	µs	R_L = 100Ω. See Test Circuit.

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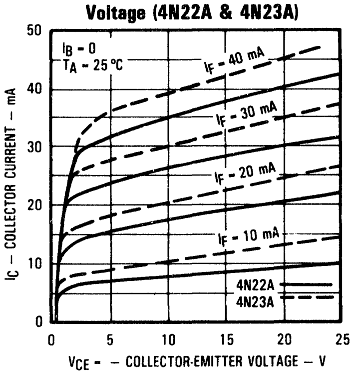
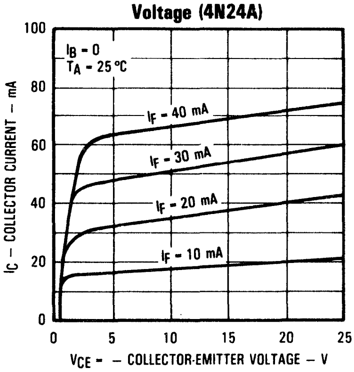
Typical Performance Curves

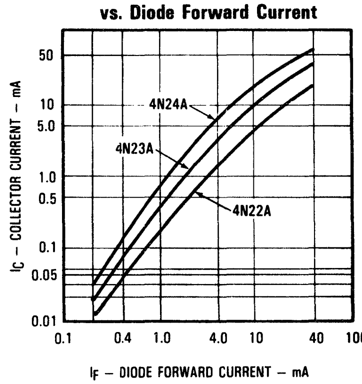
Collector Current vs. Collector-Emitter Voltage (4N22A & 4N23A)



Collector Current vs. Collector-Emitter Voltage (4N24A)



Collector Current vs. Diode Forward Current



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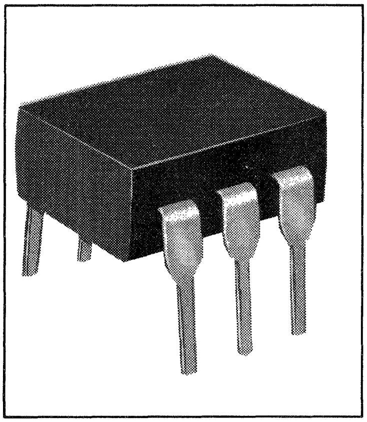
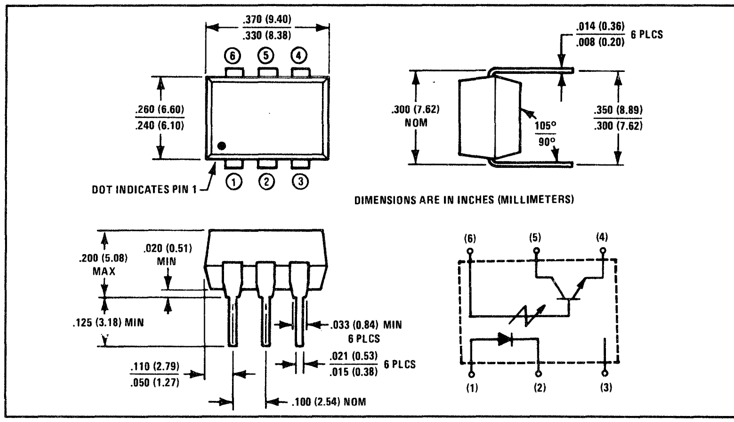
TRW Electronic Components Group

Product Bulletin 5240
January 1985

Optically Coupled Isolators
Types 4N25, 4N26, 4N27, 4N28





Features

- 2500, 1500 or 500 volt isolation ratings
- Low cost 6 pin dual-in-line package
- UL recognized File No. E58730

Description

The 4N25, 4N26, 4N27 and 4N28 are JEDEC registered optically coupled isolators each consisting of a gallium arsenide infrared emitting diode and an NPN silicon phototransistor mounted in a standard plastic six pin dual-in-line package.

Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)

Input-to-Output Isolation Voltage 4N25 .... ±2500 VDC(1)
4N26, 4N27 .... ±1500 VDC(1)
4N28 .... ±500 VDC(1)
Storage Temperature Range .... −55°C to +150°C
Operating Temperature Range .... −55°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)(2) .... 260°C
Total Device Power Dissipation .... 250 mW(3)

Input Diode

Forward DC Current .... 60 mA
Peak Forward Current (1 μs pulse width, 300 pps) .... 3.0 A
Reverse Voltage .... 3.0 V
Power Dissipation .... 100 mW(4)

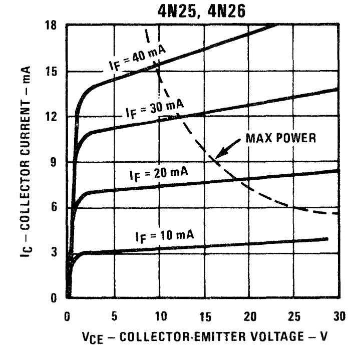
Output Phototransistor

$V_{(BR)CEO}$ .... 30 V
$V_{(BR)CBO}$ .... 70 V
$V_{(BR)ECO}$ .... 7.0 V
Power Dissipation .... 150 mW(5)

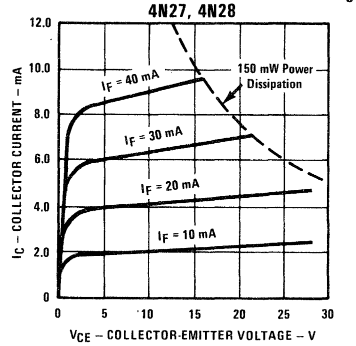
Notes: (1) Measured with input diode leads shorted together and output leads shorted together. **(2)** RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering. **(3)** Derate linearly 3.3 mW/°C above 25°C. **(4)** Derate linearly 1.33 mW/°C above 25°C. **(5)** Derate linearly 2.0 mW/°C above 25°C.

Typical Performance Curves

Collector Current vs Collector-Emitter Voltage 4N25, 4N26



Collector Current vs Collector Emitter Voltage 4N27, 4N28



Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
Input Diode							
V_F	Forward Voltage				1.50	V	$I_F = 10.0$ mA
$V_{(BR)R}$	Reverse Breakdown Voltage		3.0			V	$I_R = 100$ µA
I_R	Reverse Current				100	µA	$V_R = 3.0$ V
Output Phototransistor							
$V_{(BR)CEO}$	Collector-to-Emitter Breakdown Voltage		30			V	$I_C = 1.00$ mA
$V_{(BR)ECO}$	Emitter-to-Collector Breakdown Voltage		7.0			V	$I_E = 100$ µA
$V_{(BR)CBO}$	Collector-to-Base Breakdown Voltage		70			V	$I_C = 100$ µA
I_{CEO}	Collector-Emitter Dark Current	4N25, 4N26, 4N27 4N28		5.0	50 100	nA nA	$V_{CE} = 10.0$ V
I_{CBO}	Collector-Base Dark Current				20	nA	$V_{CB} = 10.0$ V
C_{CE}	Capacitance, Collector-to-Emitter			8.0		pF	$V_{CE} = 0$
h_{FE}	DC Current Gain			150			$V_{CE} = 5.0$ V, $I_C = 100$ µA
Coupled							
I_C/I_F	DC Current Transfer Ratio	4N25, 4N26 4N27, 4N28	20 10.0			% %	$I_F = 10.0$ mA, $V_{CE} = 10.0$ V,
V_{ISO}	Isolation Voltage	4N25 4N26, 4N27 4N28	2500 1500 500			VDC VDC VDC	See Note 1
R_{IO}	Input-to-Output Resistance		10^{11}			Ω	$V_{IO} = 500$ V, See Note 1
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage				0.50	V	$I_F = 50$ mA, $I_C = 2.0$ mA
C_{IO}	Input-to-Output Capacitance			2.0		pF	f = 1.00 MHz, See Note 1
t_r	Output Rise Time			2.0		µs	$V_{CC} = 10.0$ V, $I_C = 2.0$ mA
t_f	Output Fall Time			2.0		µs	$R_L = 100Ω$, See Test Circuits

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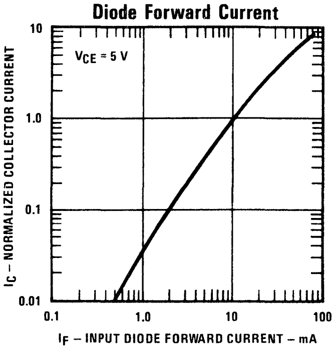
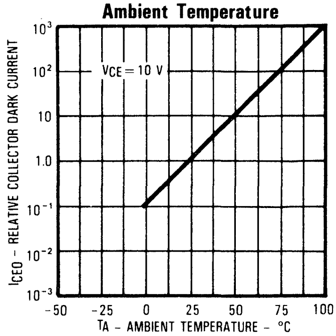
Typical Performance Curves

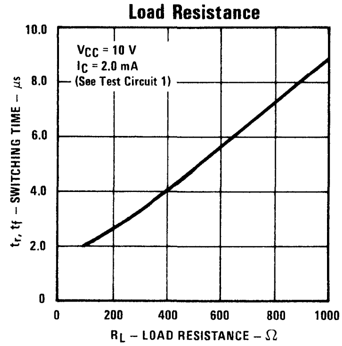
Relative Collector Current vs Diode Forward Current



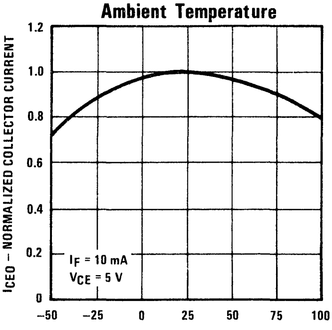
Relative Collector Dark Current vs Ambient Temperature



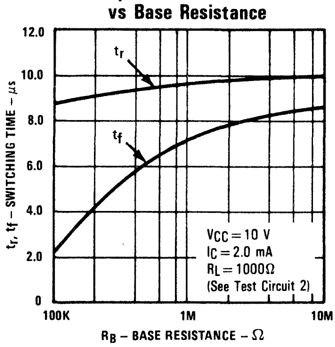
Rise and Fall Time vs Load Resistance



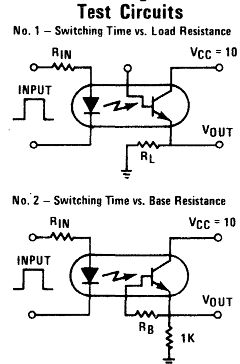
Relative Collector Current vs Ambient Temperature



Delay, Rise, and Fall Time vs Base Resistance



Switching Time Test Circuits



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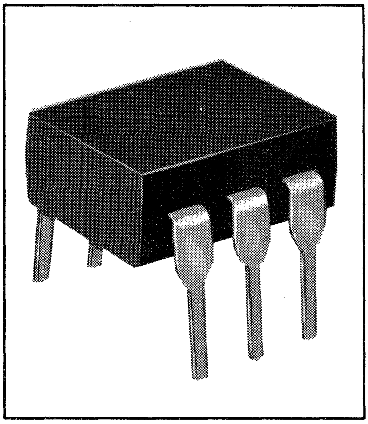
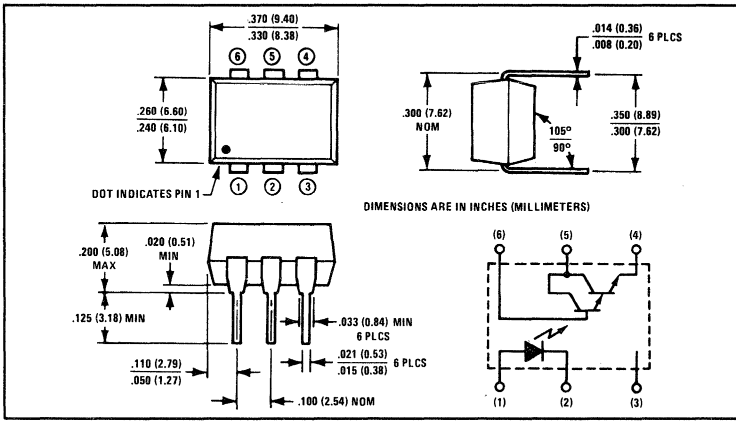
TRW Electronic Components Group

Product Bulletin 5242
January 1985

Optically Coupled Isolators
Types 4N29, 4N30, 4N31, 4N32, 4N33





Features
- Photodarlington output
- High current transfer ratio
- 2500 or 1500 volt isolation ratings
- UL recognized File No. E58730

Description
The 4N29, 4N30, 4N31, 4N32, and 4N33 are JEDEC registered optically coupled isolators each consisting of a gallium arsenide infrared emitting diode and an NPN silicon photodarlington mounted in a standard plastic six pin dual-in-line package.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

Input-to-Output Isolation Voltage — 4N30, 4N31, 4N33 .... ±1500 VDC(1)
4N29, 4N32 .... ±2500 VDC(1)
Storage Temperature Range .... −55°C to +150°C
Operating Temperature Range .... −55°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)(2) .... 260°C

Input Diode
Forward DC Current .... 60 mA
Peak Forward Current (1 μs pulse width, 330 pps) .... 3.0 A
Reverse DC Voltage .... 3.0 V
Power Dissipation .... 100 mW(3)

Output Photodarlington
Collector-Emitter Voltage .... 30 V
Collector-Base Voltage .... 30 V
Emitter-Collector Voltage .... 5.0 V
Power Dissipation .... 150 mW(4)

Notes:
(1) Measured with input leads shorted together and output leads shorted together.
(2) RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering.
(3) Derate linearly 1.33 mW/°C above 25°C.
(4) Derate linearly 2.0 mW/°C above 25°C.

Types 4N29, 4N30, 4N31, 4N32, 4N33

Electrical Characteristics (T_A = 25°C unless otherwise noted)

Symbol	Parameter	Min.	Max.	Units	Test Conditions
Input Diode					
V_F	Forward Voltage		1.50	V	I_F = 10.0 mA
I_R	Reverse Current		100	μA	V_R = 3.0 V
Output Photodarlington					
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	30		V	I_C = 100 μA,
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	30		V	I_C = 100 μA,
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	5.0		V	I_E = 100 μA,
I_{CEO}	Collector-Emitter Dark Current		100	nA	V_{CE} = 10.0 V
Coupled					
I_C/I_F	DC Current Transfer Ratio 4N29, 4N30	100		%	I_F = 10.0 mA, V_{CE} = 10.0 V
	4N31	50		%	
	4N32, 4N33	500		%	
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage 4N29, 4N30, 4N32, 4N33		1.00	V	I_F = 8.0 mA, I_C = 2.0 mA, I_B = 0
	4N31		1.20	V	
t_{on}	Turn-On Time		5.0	μs	V_{CC} = 10.0 V, I_C = 50 mA, I_F = 200 mA
t_{off}	Turn-Off Time 4N29, 4N30, 4N31		40	μs	
	4N32. 4N33		100	μs	

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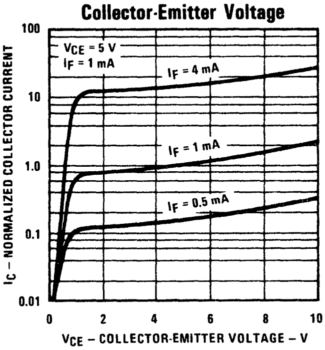
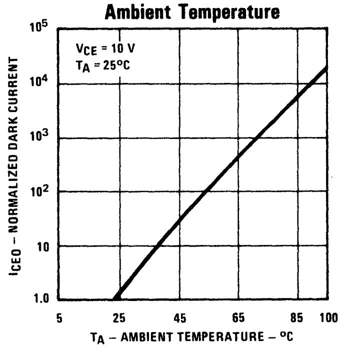
Typical Performance Curves

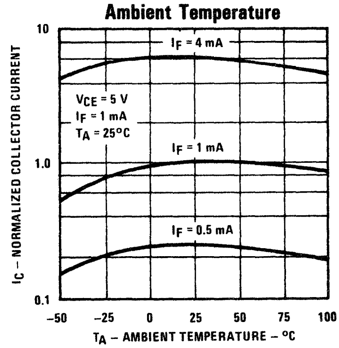
Normalized Collector Current vs. Collector-Emitter Voltage



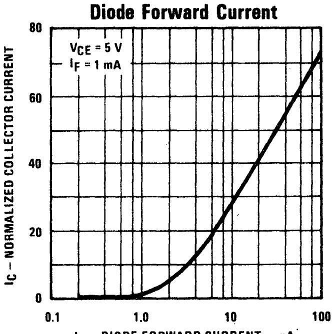
Normalized Dark Current vs. Ambient Temperature



Normalized Collector Current vs. Ambient Temperature



Normalized Collector Current vs. Diode Forward Current



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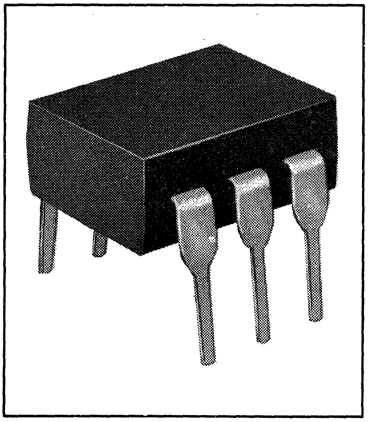
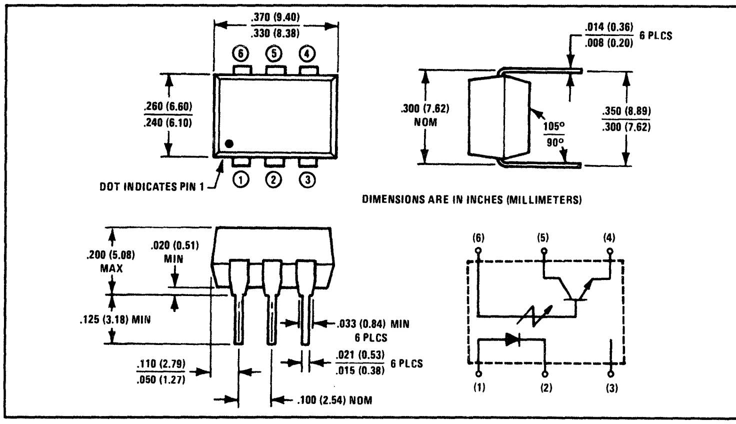
TRW Electronic Components Group

Product Bulletin 5244
January 1985

Optically Coupled Isolators
Types 4N35, 4N36, 4N37,





Features

- 2500, 1750 or 1050 V_{RMS} isolation ratings
- High current transfer ratio
- Low cost 6 pin dual-in-line package
- UL recognized File No. E58730

Description

The 4N35, 4N36, and 4N37 are JEDEC registered optically coupled isolators each consisting of a gallium arsenide infrared emitting diode and an NPN silicon phototransistor mounted in a standard plastic six pin dual-in-line package. Except for isolation voltages, the devices are identical.

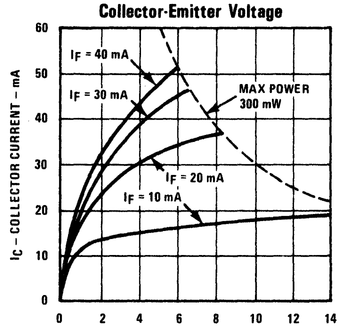
Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

Input-to-Output Isolation Voltage	4N35	2500 V_{RMS}	3500 VAC(1)
	4N36	1750 V_{RMS}	2500 VAC(1)
	4N37	1050 V_{RMS}	1500 VAC(1)
Storage Temperature Range			−55°C to +150°C
Operating Temperature Range			−55°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)(2)			260°C
Total Device Power Dissipation			400 mW(3)
Input Diode			
Forward DC Current			60 mA
Peak Forward Current (1 μs pulse width, 300 pps)			3.0 A
Reverse Voltage			6.0 V
Power Dissipation			100 mW(4)
Output Transistor			
$V_{(BR)CEO}$			30 V
$V_{(BR)CBO}$			70 V
$V_{(BR)ECO}$			7.0 V
Power Dissipation			300 mW(5)

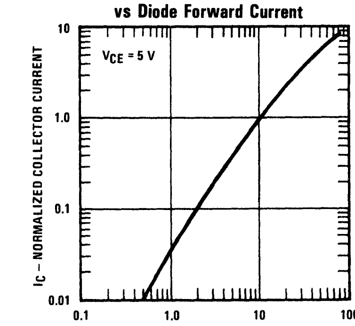
Notes: (1) Measured with input diode leads shorted together and output leads shorted together. **(2)** RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering. **(3)** Derate linearly 4.0 mW/°C above 25°C. **(4)** Derate linearly 1.33 mW/°C above 25°C. **(5)** Derate linearly 4.0 mW/°C above 25°C.

Typical Performance Curves

Collector Current vs Collector-Emitter Voltage



Normalized Collector Current vs Diode Forward Current

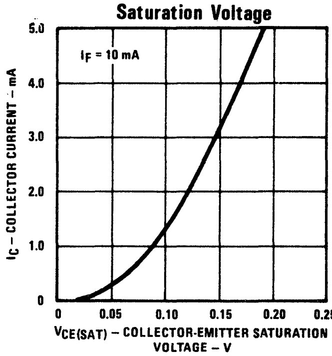


Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

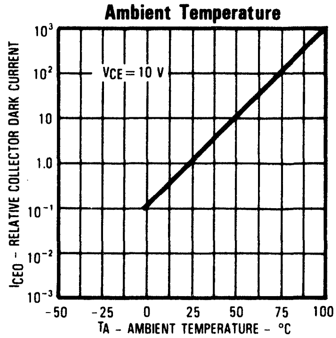
Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
Input Diode						
V_F	Forward Voltage	0.70 0.80 0.90		1.40 1.50 1.70	V V V	$I_F = 10.0$ mA, $T_A = 100°C$ $I_F = 10.0$ mA, $T_A = 25°C$ $I_F = 10.0$ mA, $T_A = -55°C$
$V_{(BR)R}$	Reverse Breakdown Voltage	6.0			V	$I_R = 10.0$ μA
I_R	Reverse Current			10.0	μA	$V_R = 6.0$ V
Output Phototransistor						
$V_{(BR)CEO}$	Collector-to-Emitter Breakdown Voltage	30			V	$I_C = 1.00$ mA
$V_{(BR)ECO}$	Emitter-to-Collector Breakdown Voltage	7.0			V	$I_E = 100$ μA
$V_{(BR)CBO}$	Collector-to-Base Breakdown Voltage	70			V	$I_C = 100$ μA
I_{CEO}	Collector-Emitter Dark Current		5.0	50 500	nA μA	$V_{CE} = 10.0$ V, $T_A = 25°C$ $V_{CE} = 30$ V, $T_A = 100°C$
I_{CBO}	Collector-Base Dark Current			20	nA	$V_{CB} = 10.0$ V, $I_E = 0$
Coupled						
I_C/I_F	DC Current Transfer Ratio	100 40 40			% % %	$T_A = 25°C$, $V_{CE} = 10.0$ V, $I_F = 10.0$ mA $T_A = 100°C$, $V_{CE} = 10.0$ V, $I_F = 10.0$ mA $T_A = -55°C$, $V_{CE} = 10.0$ V, $I_F = 10.0$ mA
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage			.30	V	$I_F = 10.0$ mA, $I_C = 0.50$ mA, $I_B = 0$
V_{ISO}	Isolation Voltage 4N35 4N36 4N37	2500 1750 1050			V_{RMS} V_{RMS} V_{RMS}	See Note 1
R_{IO}	Input-to-Output Resistance	10^{11}			Ω	$V_{IO} = 500$ V, See Note 1
C_{IO}	Input-to-Output Capacitance		2.5		pF	f = 1.00 MHz, See Note 1
t_r t_f	Output Rise Time Output Fall Time		3.5 3.5	10.0 10.0	μs μs	$V_{CC} = 10.0$ V, $I_C = 2.0$ mA $R_L = 100\Omega$, See Test Circuit

Typical Performance Curves

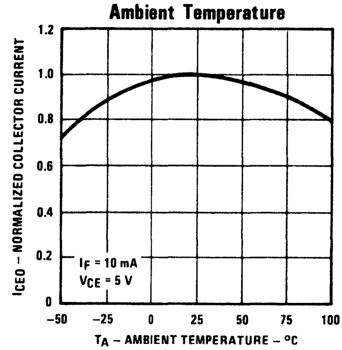
Collector Current vs Saturation Voltage



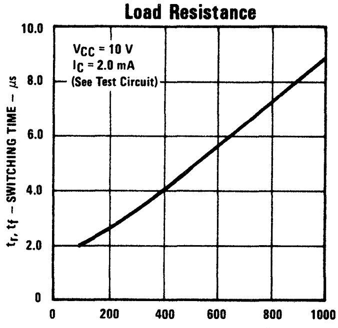
Relative Collector Dark Current vs Ambient Temperature



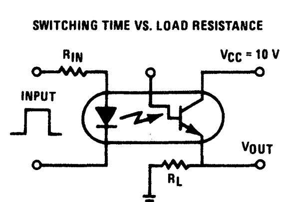
Relative Collector Current vs Ambient Temperature



Rise and Fall Time vs Load Resistance



Switching Time Test Circuit



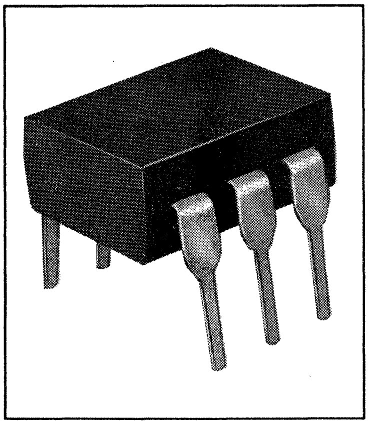
TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

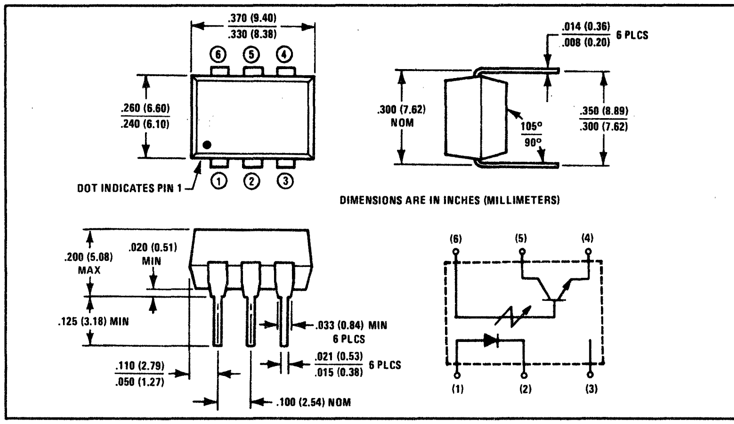
Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958

Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5246
January 1985

Optically Coupled Isolators
Types 4N38, 4N38A





Features
- 1500 and 2500 volt isolation
- High breakdown voltages
- UL recognized File No. E58730

Description
The 4N38 and 4N38A are JEDEC registered optically coupled isolators each consisting of a gallium arsenide infrared emitting diode and an NPN silicon phototransistor mounted in a standard plastic six pin dual-in-line package. This series is designed with higher than standard breakdown voltages for use in circuitry where increased power supply voltages are used. The 4N38 and 4N38A are identical except for input-to-output isolation voltage (see Absolute Maximum Ratings).

Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)

Input-to-Output Isolation Voltage 4N38	±1500 VDC(1)
4N38A	1775 VAC & ±2500 VDC(1)
Storage Temperature Range	−55°C to +150°C
Operating Temperature Range	−55°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)(2)	260°C
Total Device Power Dissipation	250 mW(3)
Input Diode	
Forward DC Current	80 mA
Peak Forward Current (1 μs pulse, 300 pps)	3.0 A
Reverse Voltage	3.0 V
Power Dissipation	150 mW(4)
Output Phototransistor	
Collector-Emitter Voltage	80 V
Collector-Base Voltage	80 V
Emitter-Collector Voltage	7.0 V
Power Dissipation	150 mW(4)

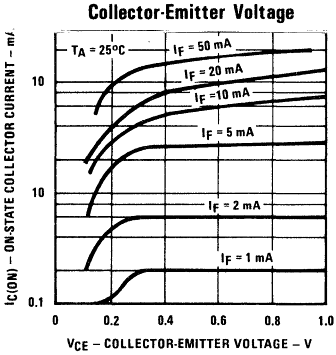
Notes:
(1) Measured with input diode leads shorted together and output leads shorted together.
(2) RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering.
(3) Derate linearly 3.33 mW/°C above 25°C.
(4) Derate linearly 2.0 mW/°C above 25°C.

Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

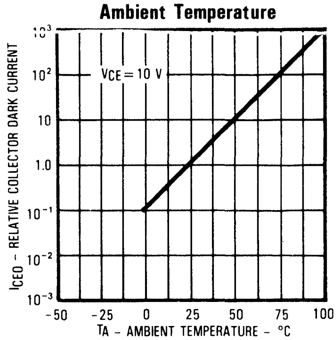
Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
Input Diode						
V_F	Forward Voltage			1.50	V	$I_F = 10.0$ mA
I_R	Reverse Current			100	μA	$V_R = 3.0$ V
Output Phototransistor						
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	80			V	$I_C = 1.00$ mA
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	80			V	$I_C = 1.00$ μA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	7.0			V	$I_E = 100$ μA
I_{CEO}	Collector-Emitter Dark Current			50	nA	$V_{CE} = 60$ V
I_{CBO}	Collector-Base Dark Current			20	nA	$V_{CB} = 60$ V
Coupled						
I_C/I_F	DC Current Transfer Ratio	20			%	$V_{CE} = 1.00$ V, $I_F = 20$ mA
$V_{CE(SAT)}$	Collector-to-Emitter Saturation Voltage			1.00	V	$I_F = 20$ mA, $I_C = 4.0$ mA
t_{on}	Turn-on-Time		5.0		μs	$V_{CC} = 10.0$ V, $I_C = 2.0$ mA
t_{off}	Turn-off-Time		5.0		μs	$R_L = 100\Omega$, See Test Circuit

Typical Performance Curves

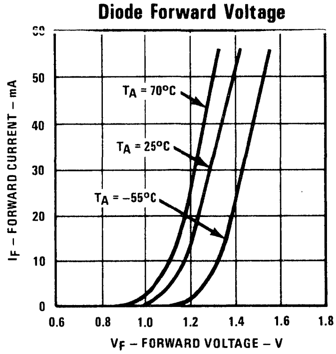
On-State Collector Current vs Collector-Emitter Voltage



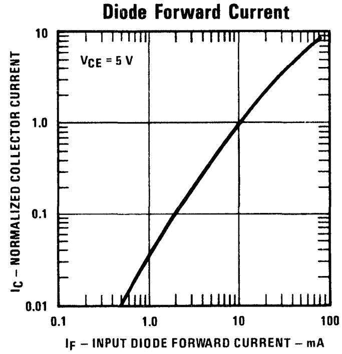
Relative Collector Dark Current vs Ambient Temperature



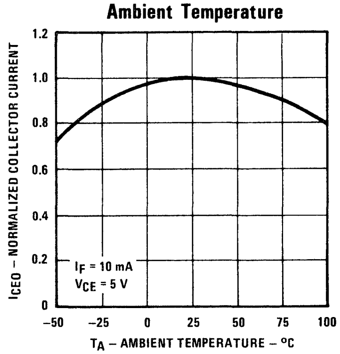
Diode Forward Current vs Diode Forward Voltage



Relative Collector Current vs Diode Forward Current

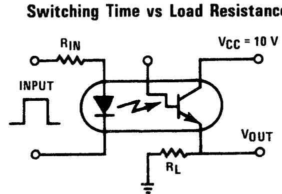


Relative Collector Current vs Ambient Temperature



Switching Time Test Circuit

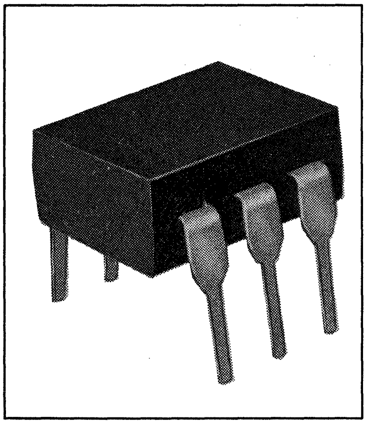
Switching Time vs Load Resistance

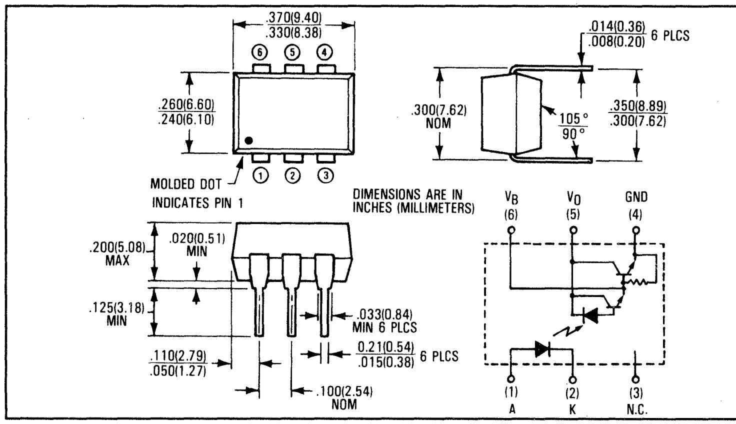


Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5248
January 1985

Low Input Current, High Gain Optically Coupled Isolators
Types 4N45, 4N46





Features

- 1000% typical current transfer ratio
- 0.50 mA LED drive current
- 3000 VDC isolation voltage
- External connection to second stage base
- U.L. recognized, File No. E58730

Description

The 4N45 and 4N46 each consist of a gallium aluminum arsenide infrared emitting diode coupled to a high gain photodetector IC mounted in a standard plastic six pin DIP.

High performance over specified temperature range is made possible by an integrated emitter-base bypass resistor which shunts the photodiode and first stage leakage currents to ground.

The high current transfer ratio at very low LED drive current allows broad flexibility in circuit design as well as a wide margin for the effects of CTR degradation over time.

The 4N45 has a 250% minimum CTR at 1 mA LED drive current. The 4N46 has a 350% minimum CTR at 0.5 mA drive current making it ideal for such applications as MOS, CMOS and low power logic interfacing.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

Input-to-Output Isolation Voltage	±3000 VDC(1)
Storage Temperature Range	−55°C to +125°C
Operating Temperature Range	−40°C to +70°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 10 seconds)	260°C
Input Diode	
Average Input Current	20 mA(3)
Peak Input Currrent (1 ms pulse width, 50% duty cycle)	40 mA
Peak Input Transient Current (≤ 1 μs pulse width, 300 pps)	1.00 A
Input Reverse Breakdown Voltage	5.0 V
Input Power Dissipation	35 mW(4)
Output Photodetector	
Output Current	60 mA(5)
Emitter-Base Reverse Voltage (Pins 4 & 6)	0.50 V
Output Voltage (Pins 5 & 4) 4N45	−0.50 V to 7.0 V
4N46	−0.50 V to 20 V
Output Power Dissipation	100 mV(6)

Notes:

(1) Measured with input leads shorted together and output leads shorted together.
(2) RMA flux is recommended. Duration can be extended to 10 seconds max. when flow soldering.
(3) Derate linearly 0.40 mA/°C above 50°C.
(4) Derate linearly 0.70 mW/°C above 50°C.
(5) Derate linearly 0.80 mA/°C above 25°C.
(6) Derate linearly 1.50 mW/°C above 25°C.

Types 4N45, 4N46

Electrical Characteristics ($T_A = 0°C$ to $70°C$, unless otherwise noted)

Symbol	Parameter	Device	Min.	Typ.**	Max.	Units	Test Conditions
Input Diode							
V_F*	Input Forward Voltage			1.20	1.70	V	$I_F = 1.00$ mA, $T_A = 25°C$
BV_R*	Input Reverse Breakdown Voltage		5.0	59		V	$I_R = 10.0$ μA, $T_A = 25°C$
$\frac{\Delta V_F}{\Delta T_A}$	Temperature Coefficient of Forward Voltage			-1.80		mV/°C	$I_F = 1.00$ mA
Coupled							
CTR*	Current Transfer Ratio	4N45	250	1000		%	$I_F = 1.00$ mA, $V_O = 1.00$ V
		4N45	200	500		%	$I_F = 10.0$ mA, $V_O = 1.20$ V
		4N46	350	1300		%	$I_F = 0.50$ mA, $V_O = 1.00$ V
		4N46	500	1100		%	$I_F = 1.00$ mA, $V_O = 1.20$ V
		4N46	200	700		%	$I_F = 10.0$ mA, $V_O = 1.20$ V
V_{OL}	Logic Low Output Voltage	4N45		0.89	1.00	V	$I_F = 1.00$ mA, $I_{OL} = 2.5$ mA
		4N45		0.94	1.20	V	$I_F = 10.0$ mA, $I_{OL} = 20$ mA
		4N46		0.89	1.00	V	$I_F = 0.50$ mA, $I_{OL} = 1.75$ mA
		4N46		0.93	1.00	V	$I_F = 1.00$ mA, $I_{OL} = 5.0$ mA
		4N46		0.94	1.20	V	$I_F = 10.0$ mA, $I_{OL} = 20$ mA
I_{OH}	Logic High Output Current	4N45		0.001	250	μA	$I_F = 0$, $V_O = 5.0$ V
		4N46		0.001	100	μA	$I_F = 0$, $V_O = 18.0$ V
C_{IN}	Input Capacitance			60		pF	$f = 1.00$ MHz, $V_F = 0$
$I_{I\text{-}O}$*	Input-Output Insulation Leakage Current				1.00	μA	45% Relative Humidity $T_A = 25°C$, $t = 5.0$ sec, $V_{I\text{-}O} = 3000$ VDC
$R_{I\text{-}O}$	Input-Output Resistance			10^{12}		Ω	$V_{I\text{-}O} = 500$ VDC
$C_{I\text{-}O}$	Input-Output Capacitance			0.60		pF	$f = 1.00$ MHz

Switching Specifications ($T_A = 25°C$)

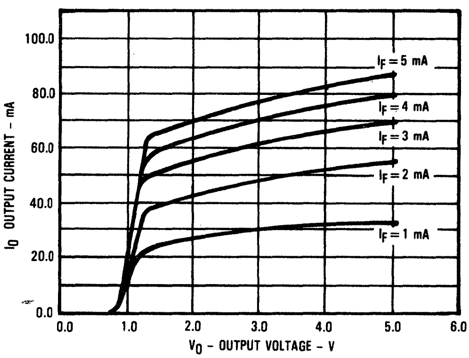
Symbol	Parameter	Device	Min.	Typ.**	Max.	Units	Test Conditions
t_{PHL}	Propagation Delay Time to Logic Low at Output			80		μs	$I_F = 1.00$ mA, $R_L = 10.0$ kΩ
t_{PHL}*	Propagation Delay Time to Logic Low at Output			2.5	50	μs	$I_F = 10.0$ mA, $R_L = 220$ Ω
t_{PHL}	Propagation Delay Time to Logic High at Output			1500		μs	$I_F = 1.00$ mA, $R_L = 10.0$ kΩ
t_{PHL}*	Propagation Delay Time to Logic High at Output			52	500	μs	$I_F = 10.0$ mA, $R_L = 220$ Ω
CM_H	Common Mode Transient Immunity at Logic High Level Output			500		V/μs	$I_F = 0$, $R_L = 10.0$ kΩ, $V_{cm} = 10.0$ $V_{p\text{-}p}$
CM_L	Common Mode Transient Immunity at Logic Low Level Output			-500		V/μs	$I_F = 1.00$ mA, $R_L = 10.0$ kΩ, $V_{cm} = 10.0$ $V_{p\text{-}p}$

* All Min-Max ratings are JEDEC Registered. ** All typicals are at $T_A = 25°C$

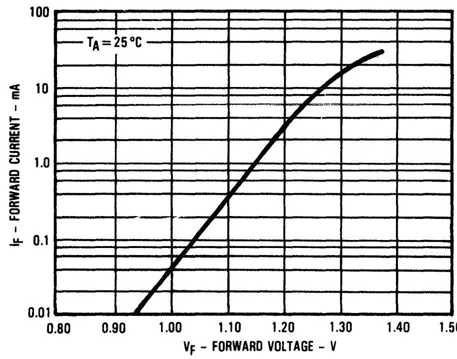
E

Typical Performance Curves

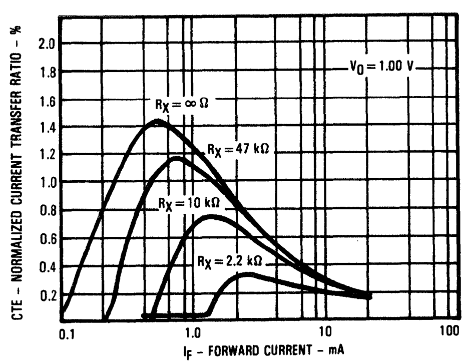
Output Current vs Output Voltage



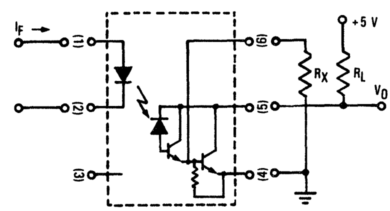
Forward Current vs Forward Voltage



Forward Diode Current vs CTR for Different External Base Resistors

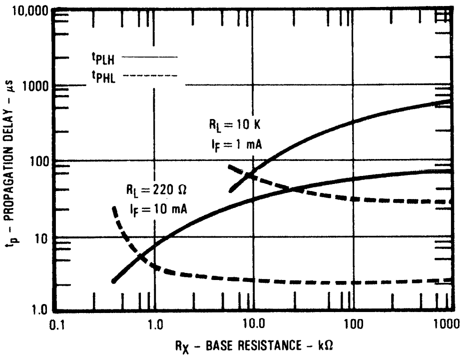


Circuit Diagram – External Base Resistor – R_X

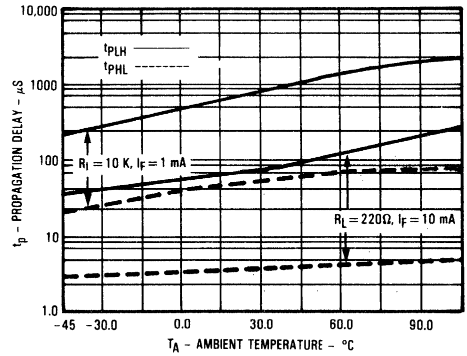


Typical Performance Curves

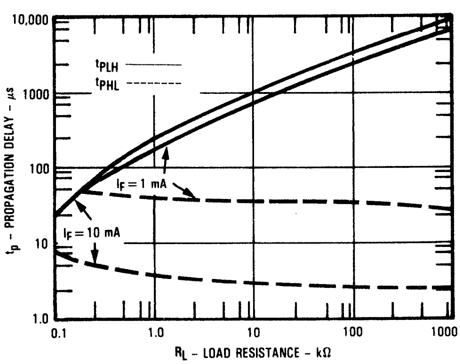
Propagation Delay vs Base Resistance



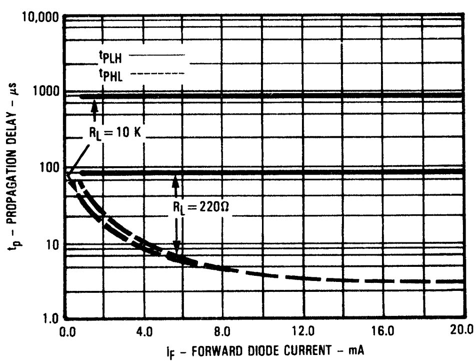
Propagation Delay vs Ambient Temperature



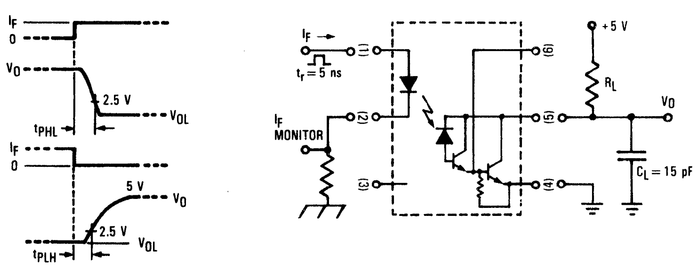
Propagation Delay vs Load Resistance



Propagation Delay vs Forward Diode Current



Switching Time Test Circuit

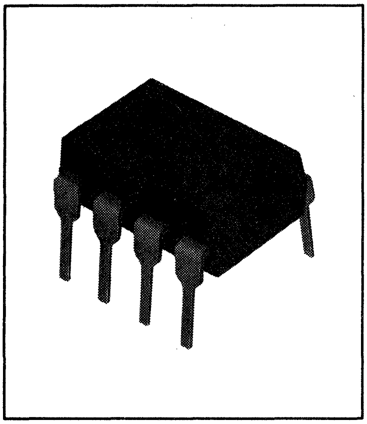


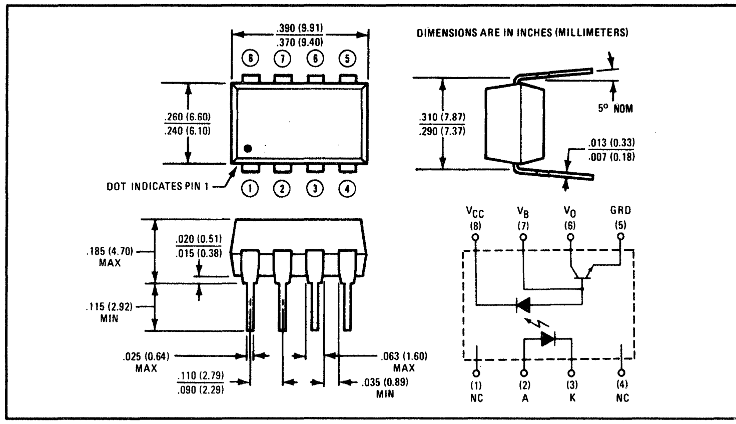
E

Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5252
January 1985

High Speed Optocouplers
Types 6N135, 6N136, OPI2502





Features
- High speed — 1 megabit/second
- TTL compatible
- High common mode transient immunity
- Wide bandwidth
- Open collector output
- U.L. Recognized, File No. E58730

Description
TRW's 6N135 and 6N136 JEDEC registered optocouplers are high speed devices consisting of GaAsP emitters and integrated photodetectors. The circuitry of each device consists of a photodiode driving an open collector transistor, inherently faster than a phototransistor. The OPI2502 is a high speed non-JEDEC part.

The 6N135 has a minimum current transfer ratio of 7% when driven with 16 mA and is compatible with TTL/CMOS or TTL/LSTTL as well as wide-band analog circuitry.

The 6N136, with a CTR of 19% minimum, can be driven from a TTL driver at 16 mA and will provide sufficient output to drive a single TTL load with a 5.6 kΩ pull-up resistor.

Pins 2 through 7 are compatible with the configuration of standard 6-pin DIP devices with phototransistor and photodarlington outputs. By supplying 1.5 to 15 volts bias to pin 8 the 6N135/6N136 optocouplers offer improved speed performance for existing circuits.

Absolute Maximum Ratings (No derating required up to 70°C)

Storage Temperature	−55°C to +125°C
Operating Temperature	−55°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 10 seconds)	260°C
Average Input Current — I_F	25 mA[1]
Peak Input Current — I_F (50% duty cycle, 1 ms pulse width)	50 mA[2]
Peak Transient Input Current — I_F ($\leq$ 1 μs pulse width, 300 pps)	1.0 A
Reverse Input Voltage — V_R	5.0 V
Input Power Dissipation	45 mW[3]
Average Output Current — I_O	8.0 mA
Peak Output Current	16.0 mA
Emitter-Base Reverse Voltage	5.0 V
Supply and Output Voltage — V_{CC}, V_O	−0.5 V to 15 V
Base Current — I_B	5.0 mA
Output Power Dissipation	100 mW[4]

Caution: This component is susceptible to damage from electrostatic discharge. Normal static prevention procedures should be used in handling.

Notes:
(1) Derate linearly above 70°C free-air temperature at a rate of 0.8 mA/°C.
(2) Derate linearly above 70°C free-air temperature at a rate of 1.6 mA/°C.
(3) Derate linearly above 70°C free-air temperature at a rate of 0.9 mA/°C.
(4) Derate linearly above 70°C free-air temperature at a rate of 2.0 mA/°C.
(5) CM_H is the maximum allowable dv/dt on the leading edge of a common mode pulse to assure that the output will not switch from high to low.
(6) CM_L is the maximum negative dv/dt allowable on the trailing edge of a common mode pulse to assure that the output will not switch from low to high.
(7) Test condition represents 1 TTL unit load with 5.6 kΩ pull-up resistor.
(8) Test condition represents 1 LSTTL unit load with a 6.1 kΩ pull-up resistor.
(9) Device considered a two-terminal device: pins 1, 2, 3 and 4 shorted together and pins 5, 6, 7 and 8 shorted together.

Applications
- Line receivers
- High speed logic isolation–TTL/TTL, TTL/LTTL, TTL/CMOS, TTL/LSTTL
- Improved speed as replacement for 6-pin DIP isolators
- Improved linearity in analog circuit ground isolation

Electrical Characteristics Over recommended temperature ($T_A = 0°C$ to $70°C$), unless otherwise noted)

Symbol	Parameter	Device	Min.	Typ.**	Max.	Units	Test Conditions	Figure
CTR*	Current Transfer Ratio	6N135	7.0	19.0		%	$I_F = 16.0$ mA, $V_O = 0.40$ V, $V_{CC} = 4.5$ V $T_A = 25°C$	1, 2
		6N136	19.0	25		%		
		OPI2502	15.0		22	%		
CTR		6N135	5.0	15.0		%	$I_F = 16.0$ mA, $V_O = 0.50$ V, $V_{CC} = 4.5$ V	
		6N136	15.0	23		%		
V_{OL}	Logic Low Output Voltage	6N135		0.100	0.40	V	$I_F = 16.0$ mA, $I_O = 1.10$ mA, $V_{CC} = 4.5$ V	
		6N136 OPI2502		0.100	0.40	V	$I_F = 16.0$ mA, $I_O = 2.4$ mA, $V_{CC} = 4.5$ V	
I_{OH}*	Logic High Output Current			3.0	500	nA	$I_F = 0$ mA, $V_O = V_{CC} = 5.5$ V, $T_A = 25°C$	6
				0.010	1.00	µA	$I_F = 0$ mA, $V_O = V_{CC} = 15.0$ V, $T_A = 25°C$	
I_{OH}					50	µA	$I_F = 0$ mA, $V_O = V_{CC} = 15.0$ V	
I_{CCL}	Logic Low Supply Current			40		µA	$I_F = 16.0$ mA, V_O = Open, $V_{CC} = 15.0$ V	
I_{CCH}*	Logic High Supply Current			0.020	1.00	µA	$I_F = 0$ mA, V_O = Open, $V_{CC} = 15.0$ V, $T_A = 25°C$	
I_{CCH}					2.0	µA	$I_F = 0$ mA, V_O = Open, $V_{CC} = 15.0$ V,	
V_F*	Input Forward Voltage			1.50	1.70	V	$I_F = 16.0$ mA, $T_A = 25°C$	3
$\frac{\Delta V_F}{\Delta T_A}$	Temperature Coefficient of Forward Voltage			-1.80		mV/°C	$I_F = 16.0$ mA	
BV_R*	Input Reverse Breakdown Voltage		5.0			V	$I_R = 10.0$ µA, $T_A = 25°C$	
C_{IN}*	Input Capacitance			42		pF	f = 1.00 MHz, $V_F = 0$	
I_{IO}*	Input-Output Insulation Leakage Current				1.00	µA	45% Relative Humidity, t = 5.0 sec $V_{IO} = 3000$ Vdc, $T_A = 25°C$ (Note 9)	
R_{IO}	Input-Output Resistance			10^{12}		Ω	$V_{IO} = 500$ Vdc (Note 9)	
C_{IO}	Input-Output Capacitance			0.50		pF	f = 1.00 MHz (Note 9)	
h_{FE}	Transistor DC Current Gain			150		—	$V_O = 5.0$ V, $I_O = 3.0$ mA	

Switching Specifications ($T_A = 25°C$) $V_{CC} = 5.0$ V, $I_F = 16.0$ mA, unless otherwise specified

t_{PHL}	Propagation Delay Time to Logic Low at Output	6N135*		0.50	1.50	µs	$R_L = 4.1$ kΩ (Note 8)	5, 9
		6N136* OPI2502		0.20	0.80	µs	$R_L = 1.90$ kΩ (Note 7)	
t_{PLH}	Propagation Delay Time to Logic High at Output	6N135*		0.40	1.50	µs	$R_L = 4.1$ kΩ (Note 8)	5, 9
		6N136* OPI2502		0.30	0.80	µs	$R_L = 1.90$ kΩ (Note 7)	
CM_H	Common Mode Transient Immunity at Logic High Level Output	6N135		1000		V/µs	$I_F = 0$ mA, $V_{CM} = 10.0$ $V_{p\text{-}p}$, $R_L = 4.1$ kΩ (Notes 6, 8)	10
		6N136 OPI2502		1000		V/µs	$I_F = 0$ mA, $V_{CM} = 10.0$ $V_{p\text{-}p}$, $R_L = 1.90$ kΩ (Notes 6, 7)	10
CM_L	Common Mode Transient Immunity at Logic Low Level Output	6N135		-1000		V/µs	$V_{CM} = 10.0$ $V_{p\text{-}p}$, $R_L = 4.1$ kΩ (Notes 5, 8)	10
		6N136 OPI2502		-1000		V/µs	$V_{CM} = 10.0$ $V_{p\text{-}p}$, $R_L = 1.90$ kΩ (Notes 5, 7)	10

*JEDEC Registered Data
**All typicals at $T_A = 25°C$ and $V_{CC} = 5.0$ V, unless otherwise noted.

E

Typical Performance Curves

Figure 1. Output Current vs Output Voltage

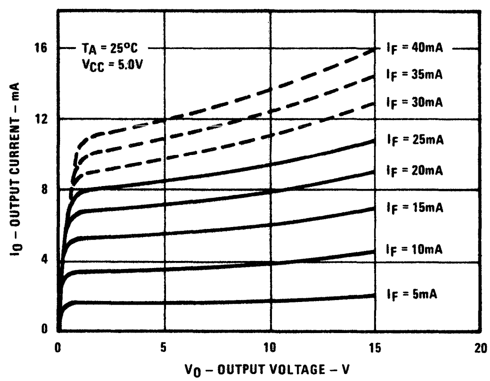


Figure 2. Current Transfer Ratio vs Forward Current

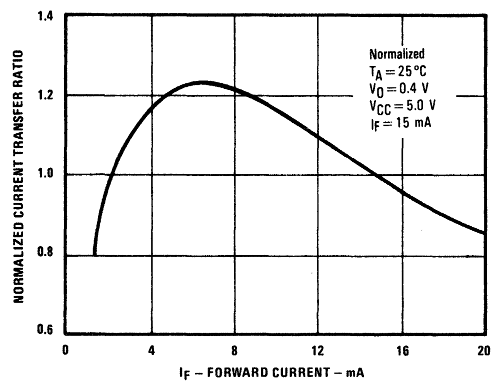


Figure 3. Forward Current vs Forward Voltage

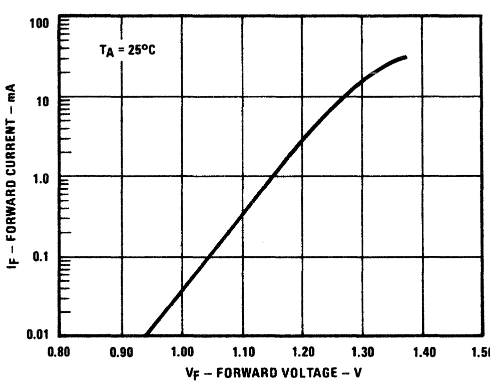


Figure 4. Current Transfer Ratio vs Temperature

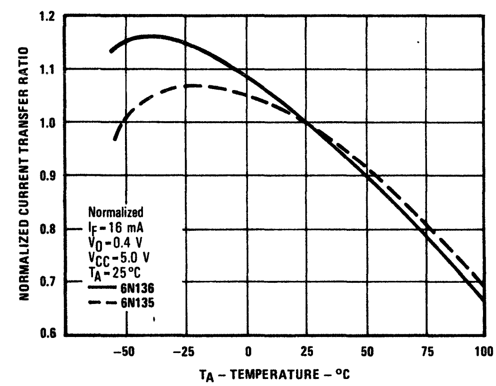


Figure 5. Propagation Delay vs Temperature

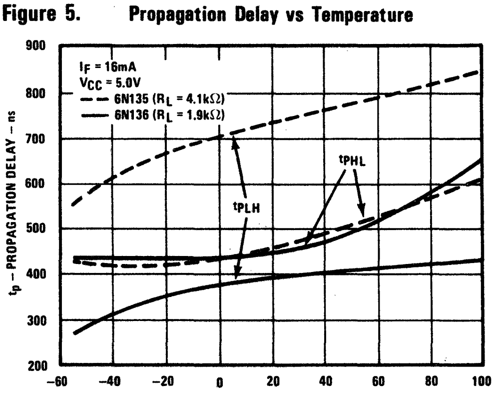


Figure 6. Logic High Output Current vs Temperature

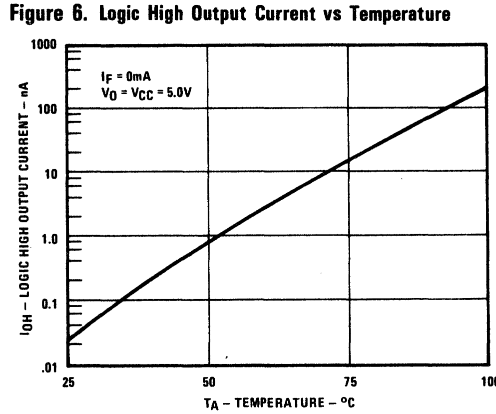


Figure 7. Small Signal Current Transfer Ratio vs Quiescent Input Current

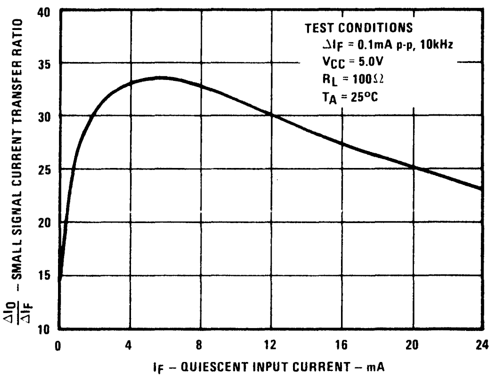


Figure 8. Frequency Response

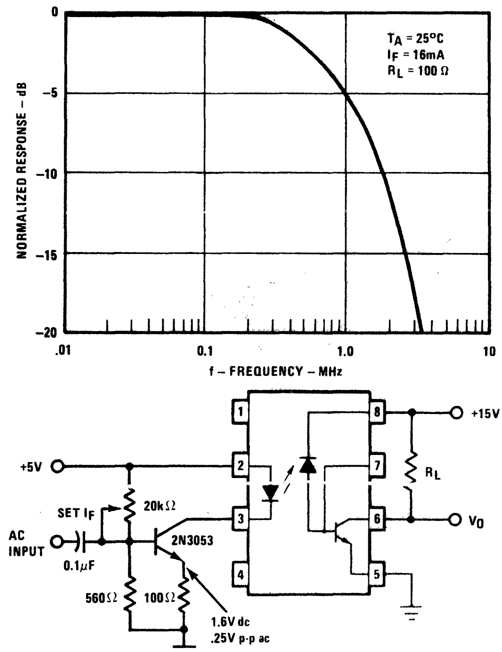
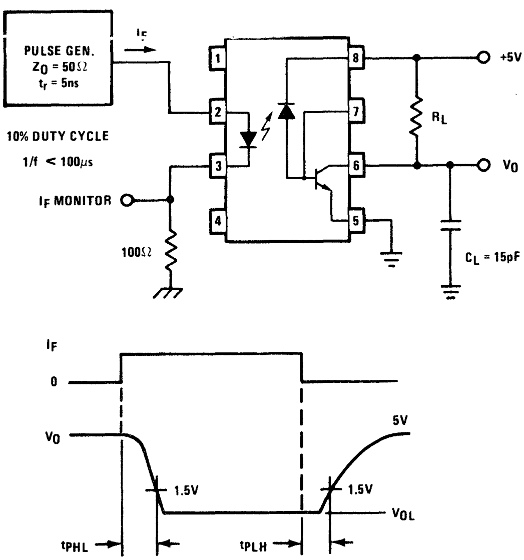
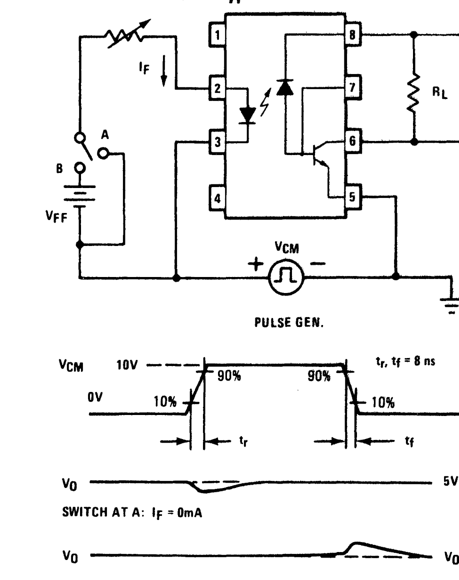


Figure 9. Switching Test Circuit*



*JEDEC Registered Data.

Figure 10. Test Circuit for Transient Immunity and Typical Waveforms



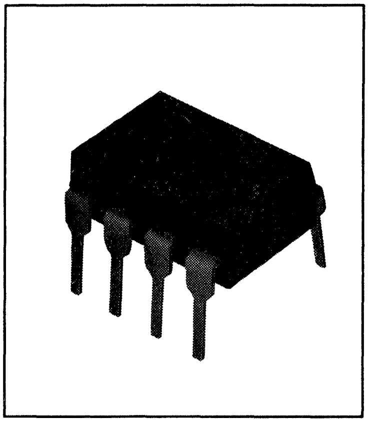
E

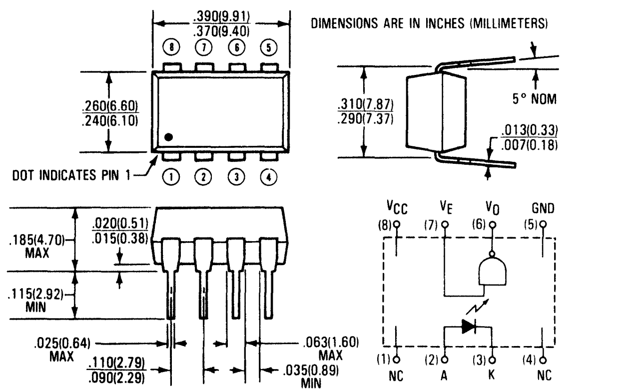
Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958

Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5254
January 1985

Optically Coupled Logic Gate
Types 6N137, OPI8137





Features
- LSTTL/TTL compatible
- Extremely high speed
- Low input current requirement
- High common mode rejection
- Guaranteed over temperature
- 3000 VDC isolation
- U.L. Recognized, File No. E58730

Description
The 6N137 and OPI8137 optocoupler combine a GaAsP photon emitting diode with a unique integrated detector. Photons are collected in the detector by a photodiode and amplified by a high gain linear amplifier that drives a Schottky clamped open collector output transistor. The circuit is temperature, current and voltage compensated.

The unique design produces maximum DC and AC circuit isolation between input and output while providing LSTTL/TTL circuit compatibility. Isolator parameters are guaranteed from 0°C to 70°C, so that a minimum input current of 5 mA will sink an eight gate fan-out (13 mA) at the output with 5 volt V_{CC} applied to the detector. Isolation and coupling are achieved with typical propagation delays of 45 ns for the 6N137 and 90 ns for the OPI8137. The enable input provides gating of the detector with input sinking and sourcing requirements compatible with LSTTL/TTL interfacing and a typical propagation delay of 25 ns.

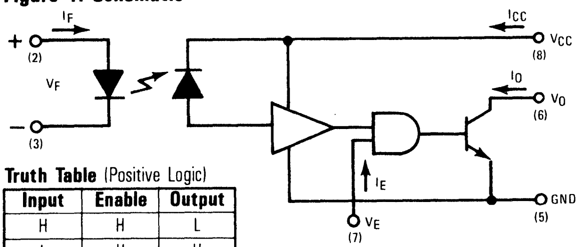
Absolute Maximum Ratings* (No derating required up to 70°C)

Storage Temperature	−55°C to +125°C
Operating Temperature	0°C to +70°C
Lead Solder Temperature (1/16 inch [1.6 mm] from case for 10 seconds)	260°C
Peak Forward Input Currrent ($\leq$ 1 msec duration)	40 mA
Average Forward Input Current	20 mA
Reverse Input Voltage	5.0 V
Enable Input Voltage (not to exceed V_{CC} by more than 500 mV)	5.5 V
Supply Voltage – V_{CC} (1 minute maximum)	7.0 V
Output Current – I_O	50 mA
Output Collector Power Dissipation	85 mW
Output Voltage – V_O	7.0 V

* JEDEC Registered Data

Applications
The device is designed for use in high speed digital interfacing applications where common mode signals must be rejected. Elimination of ground loops can be accomplished in system interfaces such as between a computer and a peripheral memory, printer, controller, etc.

Figure 1. Schematic



Truth Table (Positive Logic)

Input	Enable	Output
H	H	L
L	H	H
H	L	H
L	L	H

Note:
A .01 to 0.1 μF bypass capacitor must be connected between pins 8 and 5.

Recommended Operating Conditions

Symbol	Parameter	Min.	Max.	Units
I_{FL}	Input Current, Low Level Each Channel	0	250	μA
I_{FH}	Input Current, High Level Each Channel	6.3**	15.0	mA
V_{EH}	High Level Enable Voltage	2.0	V_{CC}	V
V_{EL}	Low Level Enable Voltage (Output High)	0	0.80	V
V_{CC}	Supply Voltage, Output	4.5	5.5	V
N	Fan Out (TTL Load)		8	
T_A	Operating Temperature	0	70	°C

Electrical Characteristics Over recommended temperature ($T_A = 0°C$ to $70°C$), unless otherwise noted

Symbol	Parameter	Min.	Typ.***	Max.	Units	Test Conditions	Figure
I_{OH}*	High Level Output Current		2.0	250	μA	$V_{CC}=5.5$ V, $V_O=5.5$ V, $I_F=250$ μA, $V_E=2.0$ V	6
V_{OL}*	Low Level Output Voltage		0.40	0.60	V	$V_{CC}=5.5$ V, $I_F=5.0$ mA, $V_{EH}=2.0$ V I_{OL} (Sinking) = 13.0 mA	2, 3
I_{EH}	High Level Enable Current		−0.80		mA	$V_{CC}=5.5$ V, $V_E=2.0$ V	
I_{EL}*	Low Level Enable Current		−1.20	−2.0	mA	$V_{CC}=5.5$ V, $V_E=0.50$ V	
I_{CCH}*	High Level Supply Current		7.0	15.0	mA	$V_{CC}=5.5$ V, $I_F=0$, $V_E=0.50$ V	
I_{CCL}*	Low Level Supply Current		13.0	18.0	mA	$V_{CC}=5.5$ V, $I_F=10.0$ mA, $V_E=0.50$ V	
I_{IO}*	Input-Output Insulation Leakage Current			1.00	μA	Relative Humidity = 45%, $T_A=25°C$, t = 5.0 sec $V_{IO}=3000$ VDC	
R_{IO}	Input-Output Resistance		10^{12}		Ω	$V_{IO}=500$ V, $T_A=25°C$	
C_{IO}	Input-Output Capacitance		0.60		pF	f = 1.00 MHz, $T_A=25°C$	
V_F*	Input Forward Voltage		1.50	1.75	V	$I_F=10.0$ mA, $T_A=25°C$	5
BV_R*	Input Reverse Breakdown Voltage	5.0			V	$I_R=10.0$ μA, $T_A=25°C$	
C_{IN}	Input Capacitance		60		pF	$V_F=0$, f = 1.00 MHz	
CTR	Current Transfer Ratio		700		%	$I_F=5.0$ mA, $R_L=100Ω$	4

Switching Specifications ($T_A = 25°C$) $V_{CC} = 5$ V

Symbol	Parameter	Min.	Typ.***	Max.	Units	Test Conditions	Figure
t_{PLH}	Propagation Delay Time to High Output Level — 6N137 * OPI8137		45 90	75 150	ns ns	$R_L=350Ω$, $C_L=15.0$ pF, $I_F=7.5$ mA	7, 8
t_{PHL}	Propagation Delay Time to Low Output Level — 6N137 * OPI8137		45 90	75 150	ns ns	$R_L=350Ω$, $C_L=15.0$ pF, $I_F=7.5$ mA	7, 8
t_r, t_f	Output Rise-Fall Time (10-90%)		20, 30		ns	$R_L=350Ω$, $C_L=15.0$ pF, $I_F=7.5$ mA	
t_{ELH}	Propagation Delay Time of Enable from V_{EH} to V_{EL}		40		ns	$R_L=350Ω$, $C_L=15.0$ pF, $I_F=7.5$ mA $V_{EH}=3.0$ V, $V_{EL}=0.50$ V	10
t_{EHL}	Propagation Delay Time of Enable from V_{EL} to V_{EH}		25		ns	$R_L=350Ω$, $C_L=15.0$ pF, $I_F=7.5$ mA $V_{EH}=3.0$ V, $V_{EL}=0.50$ V	10
CM_H	Common Mode Transient Immunity at Logic High Output		50		V/μs	$V_{CM}=10.0$ V, $R_L=350Ω$, $V_{O(min)}=2.0$ V, $I_F=0$ mA (See Note 1)	12
CM_L	Common Mode Transient Immunity at Logic Low Output		−150		V/μs	$V_{CM}=10.0$ V, $R_L=350Ω$, $V_{O(max)}=0.80$ V, $I_F=5.0$ mA (See Note 2)	12

* JEDEC Registered Data. ** Permits 20% CTR degradation. *** All typicals at $T_A=25°C$ and $V_{CC}=5.0$ V, unless otherwise noted.

Notes:
1. CM_H is the maximum allowable dv/dt on the leading edge of a common mode pulse to assure that the output will not switch from high to low.
2. CM_L is the maximum negative dv/dt allowable on the trailing edge of a common mode pulse to assure that the output will not switch from low to high.

Operating Procedures and Definitions

Logic Convention. The 6N137 is defined in terms of positive logic.

Bypassing. A ceramic capacitor (.01 to 0.1 μF) should be connected from pin 8 to pin 5 (Figure 9) to stabilize the operation of the high gain linear amplifier. Failure to provide the bypassing may impair the switching properties. The total lead length between capacitor and coupler should not exceed 20 mm.

Polarities. All voltages are referenced to network ground (pin 5). Current flowing toward a terminal is considered positive.

Enable Input. No external pull-up required for a logic (1), i.e., can be open circuit.

Figure 2. Input-Output Characteristics

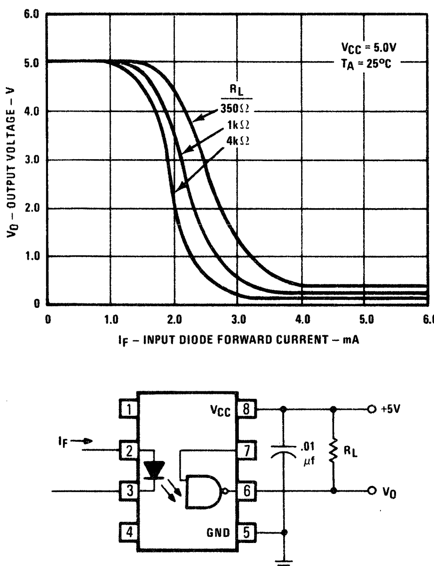


Figure 3. Output Voltage, V_{OL} vs Temperature and Fan-Out

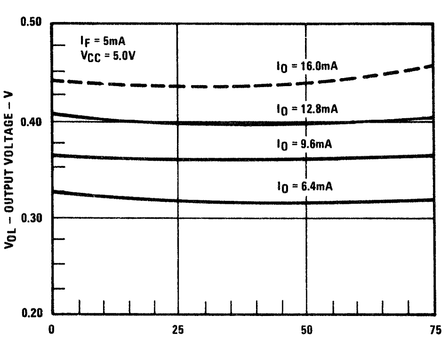


Figure 4. Optocoupler Collector Characteristics

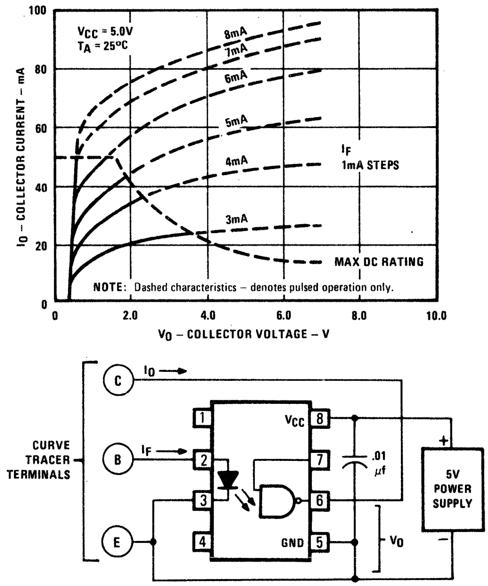


Figure 5. Input Diode Forward Characteristic

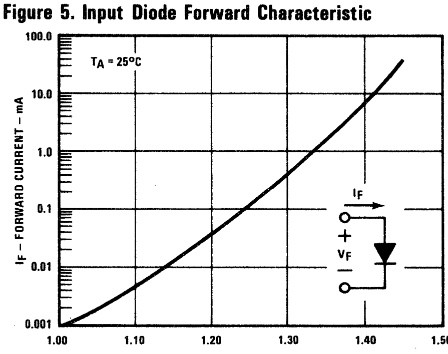


Figure 6. Output Current, I_{OH} vs Temperature (I_F=250 μA)

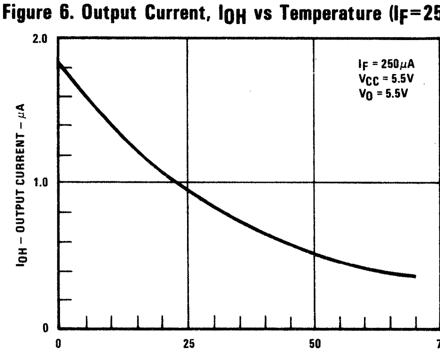


Figure 7. Test Circuit for T_{PHL} and T_{PLH} (6N137 Only)

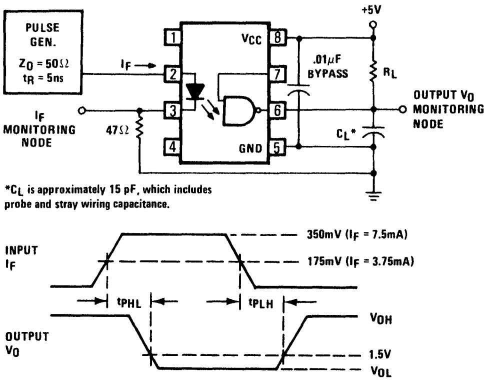


Figure 8. Propagation Delay, t_{PHL} and t_{PLH} vs Pulse Input Current, I_{FH}

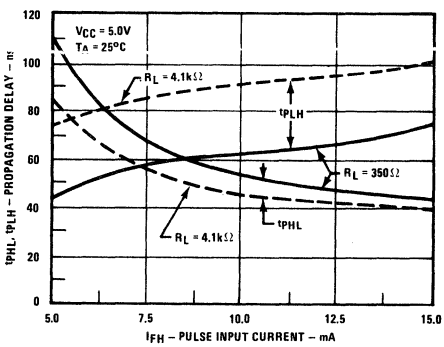


Figure 9. Recommended Printed Circuit Board Layout

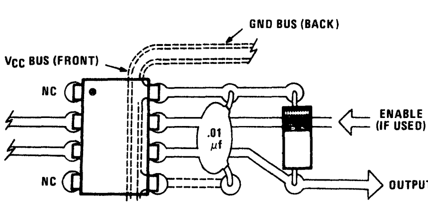


Figure 10. Test Circuit for T_{ELH} and T_{EHL}

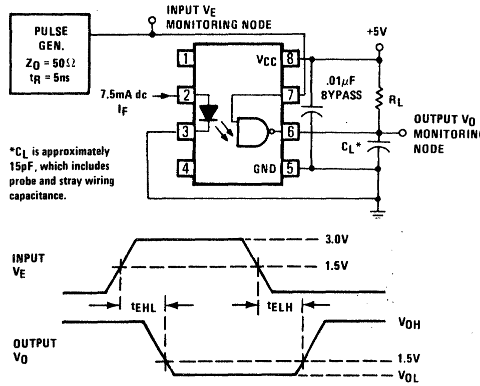


Figure 11. Response Delay Between TTL Gates

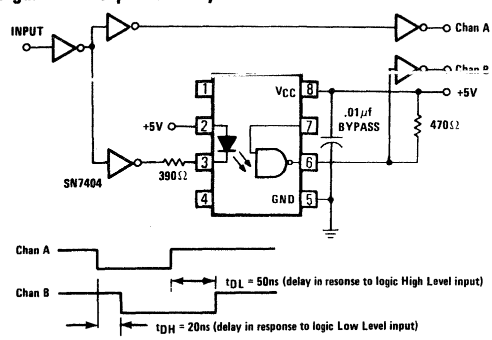
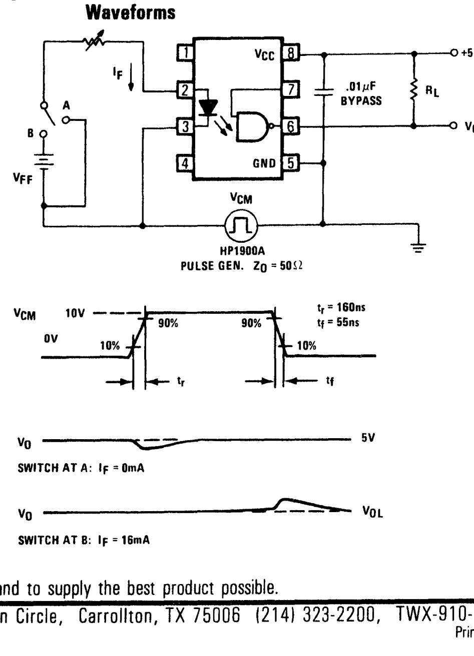
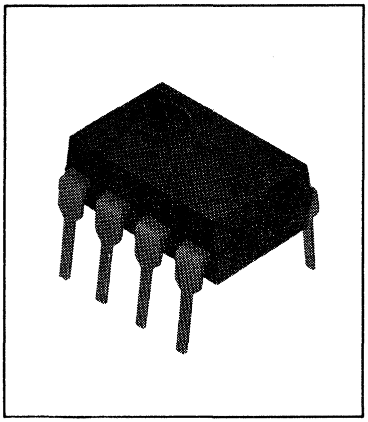
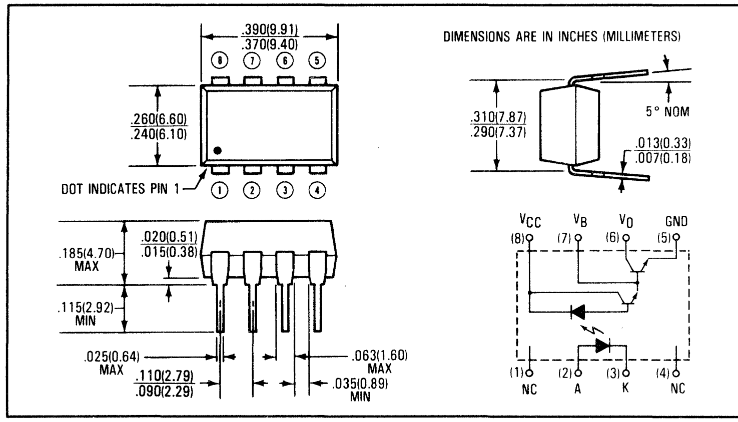


Figure 12. Test Circuit for Transient Immunity and Typical Waveforms



High Gain Optocouplers
Types 6N138, 6N139





Features

- High CTR
- Low drive current required
- TTL compatible
- 3000 V isolation
- High output current
- High common mode rejection
- U.L. Recognized, File No. E58730

Description

GaAsP emitters are coupled with high gain integrated photodetectors to provide good sensitivity at low input currents. A photodiode drives two transistor stages to provide good speed performance with an open collector output capable of interface to TTL. Alternatively, the two collectors can be externally connected for darlington operation.

The 6N139 is suitable for CMOS or LTTL applications with a 400% minimum CTR at 0.5 mA input drive.

The 6N138 is for use in TTL applications with a minimum CTR of 300% at 1.6 mA input. This allows TTL in and TTL out when used with a 2.2 kΩ pull-up resistor.

Absolute Maximum Ratings* (No derating required up to 70°C)

Storage Temperature	−55°C to +125°C
Operating Temperature	0°C to +70°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 10 seconds)	260°C
Average Input Current – I_F	20 mA(1)
Peak Input Currrent – I_F (50% duty cycle, 1 ms pulse width)	40 mA
Peak Transient Input Current – I_F (≤ 1 μs pulse width, 300 pps)	1.00 A
Reverse Input Voltage – V_R	5.0 V
Input Power Dissipation	35 mW(2)
Output Current – I_O	60 mA(3)
Emitter-Base Reverse Voltage	0.50 V
Supply and Output Voltage – V_{CC}, V_O	
6N138	−0.50 V to 7.0 V
6N139	−0.50 V to 18.0 V
Output Power Dissipation	100 mV(4)

* JEDEC Registered Data

Notes:
(1) Derate linearly above 50°C free-air temperature at a rate of 0.4 mA/°C.
(2) Derate linearly above 50°C free-air temperature at a rate of 0.7 mW/°C.
(3) Derate linearly above 25°C free-air temperature at a rate of 0.7 mA/°C.
(4) Derate linearly above 25°C free-air temperature at a rate of 2.0 mW/°C.

Caution: This component is susceptible to damage from electrostatic discharge. Normal static prevention procedures should be used in handling.

Electrical Characteristics Over recommended temperature ($T_A = 0°C$ to $70°C$), unless otherwise noted

Symbol	Parameter	Device	Min.	Typ.**	Max.	Units	Test Conditions	Figure
CTR*	Current Transfer Ratio	6N139	400 500	800 900		%	$I_F = 0.50$ mA, $V_O = 0.40$ V, $V_{CC} = 4.5$ V $I_F = 1.60$ mA, $V_O = 0.40$ V, $V_{CC} = 4.5$ V	3
		6N138	300	600		%	$I_F = 1.60$ mA, $V_O = 0.40$ V, $V_{CC} = 4.5$ V	
V_{OL}	Logic Low Output Voltage	6N139		0.100 0.100 0.20	0.40 0.40 0.40	V	$I_F = 1.60$ mA, $I_O = 6.4$ mA, $V_{CC} = 4.5$ V $I_F = 5.0$ mA, $I_O = 15.0$ mA, $V_{CC} = 4.5$ V $I_F = 12.0$ mA, $I_O = 24$ mA, $V_{CC} = 4.5$ V	
		6N138		0.100	0.40	V	$I_F = 1.60$ mA, $I_O = 4.8$ mA, $V_{CC} = 4.5$ V	
I_{OH}*	Logic High Output Current	6N139		0.050	100	μA	$I_F = 0$ mA, $V_O = V_{CC} = 18.0$ V	
		6N138		0.100	250	μA	$I_F = 0$ mA, $V_O = V_{CC} = 7.0$ V	
I_{CCL}	Logic Low Supply Current			0.20		mA	$I_F = 1.60$ mA, V_O = Open, $V_{CC} = 5.0$ V	
I_{CCH}	Logic High Supply Current			10.0		nA	$I_F = 0$ mA, V_O = Open, $V_{CC} = 5.0$ V	
V_F*	Input Forward Voltage			1.40	1.70	V	$I_F = 1.60$ mA, $T_A = 25°C$	4
BV_R*	Input Reverse Breakdown Voltage		5.0		V		$I_R = 10.0$ μA, $T_A = 25°C$	
$\frac{\Delta V_F}{\Delta T_A}$	Temperature Coefficient of Forward Voltage			−1.80		mV/°C	$I_F = 1.60$ mA	
C_{IN}	Input Capacitance			60		pF	f = 1.00 MHz, $V_F = 0$	
I_{I-O}*	Input-Output Insulation Leakage Current				1.00	μA	45% Relative Humidity, $T_A = 25°C$ t = 5.0 s, $V_{I-O} = 3000$ VDC	
R_{IO}	Input-Output Resistance			10^{12}		Ω	$V_{IO} = 500$ VDC	
C_{IO}	Input-Output Capacitance			0.60		pF	f = 1.00MHz	

Switching Specifications ($T_A = 25°C$)

Symbol	Parameter	Device	Min.	Typ.**	Max.	Units	Test Conditions	Figure
t_{PHL}*	Propagation Delay Time	6N139		5.0 0.20	25 1.00	μs	$I_F = 0.50$ mA, $R_L = 4.7$ kΩ $I_F = 12.0$ mA, $R_L = 270$ Ω	7
		6N138		1.00	10.0	μs	$I_F = 1.60$ mA, $R_L = 2.2$ kΩ	
t_{PLH}*	Propagation Delay Time	6N139		5.0 1.00	60 7.0	μs	$I_F = 0.50$ mA, $R_L = 4.7$ kΩ $I_F = 12.0$ mA, $R_L = 270$ Ω	7
		6N138		4.0	35	μs	$I_F = 1.60$ mA, $R_L = 2.2$ kΩ	
C_{MH}	Common Mode Transient Immunity at Logic High Level Output			500		V/μs	$I_F = 0$ mA, $R_L = 2.2$ kΩ, $R_{CC} = 0$ $\|V_{cm}\| = 10.0$ V_{p-p} (See Note 5)	10
C_{ML}	Common Mode Transient Immunity at Logic Low Level Output			−500		V/μs	$I_F = 1.60$ mA, $R_L = 2.2$ kΩ, $R_{CC} = 0$ $\|V_{cm}\| = 10.0$ V_{p-p} (See Note 6)	10

* JEDEC Registered Data. ** All typicals at $T_A = 25°C$ and $V_{CC} = 5$ V, unless otherwise noted.

Notes:

5. CM_H is the maximum allowable dv/dt on the leading edge of a common mode pulse to assure that the output will not switch from high to low.
6. CM_L is the maximum negative dv/dt allowable on the trailing edge of a common mode pulse to assure that the output will not switch from low to high.

E

Figure 1. 6N139 DC Transfer Characteristics

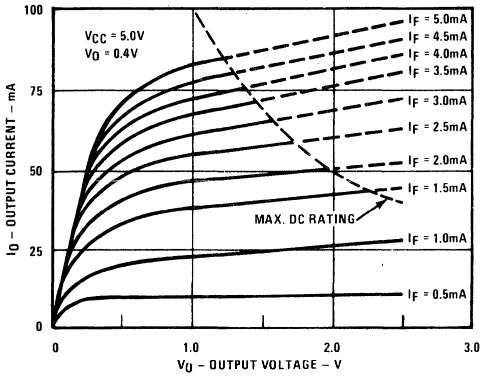


Figure 2. 6N138 DC Transfer Characteristics

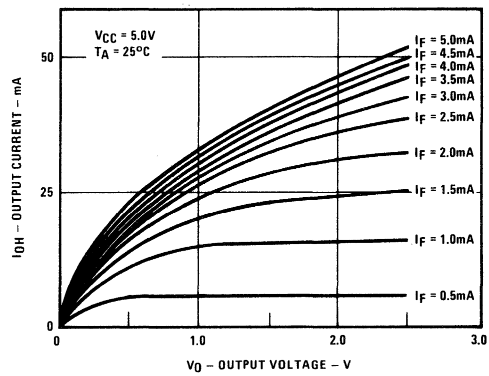


Figure 3. Current Transfer Ratio vs Forward Current

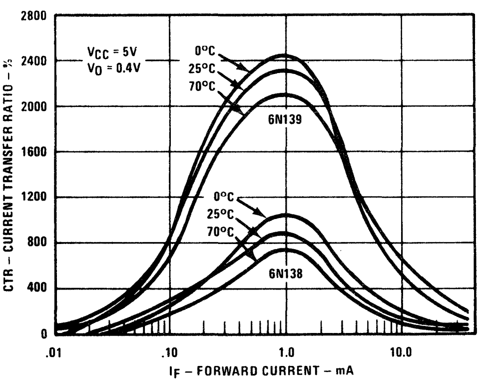


Figure 4. Input Diode Forward Current vs Forward Voltage

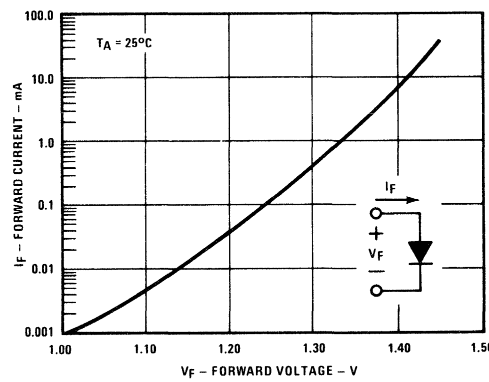


Figure 5. 6N139 Output Current vs Input Diode Forward Current

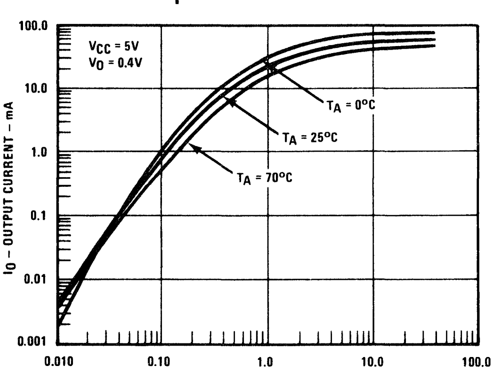


Figure 6. 6N138 Output Current vs Input Diode Forward Current

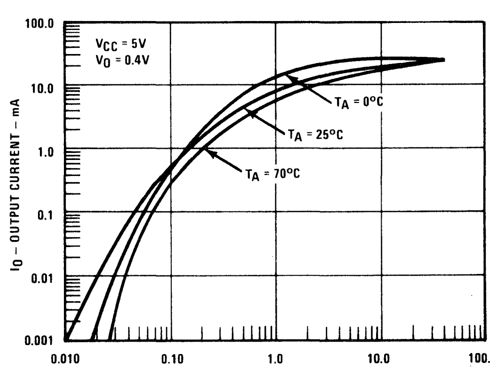


Figure 7. **Propagation Delay vs Temperature**

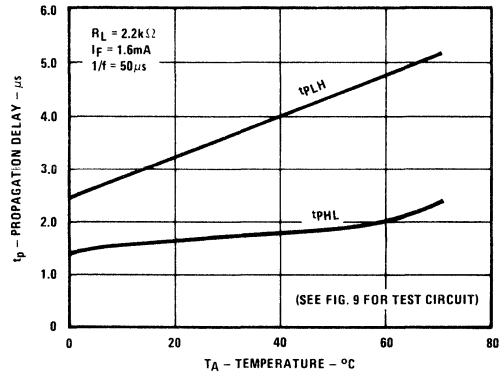


Figure 8. **Non Saturated Rise and Fall Time vs Load Resistance**

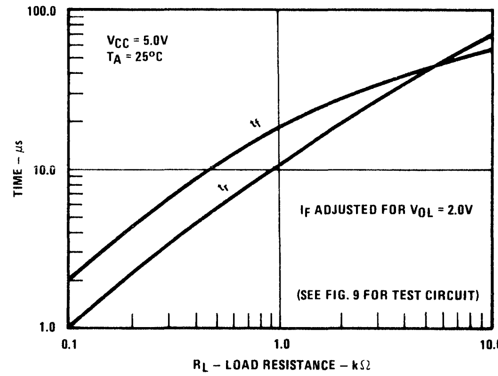
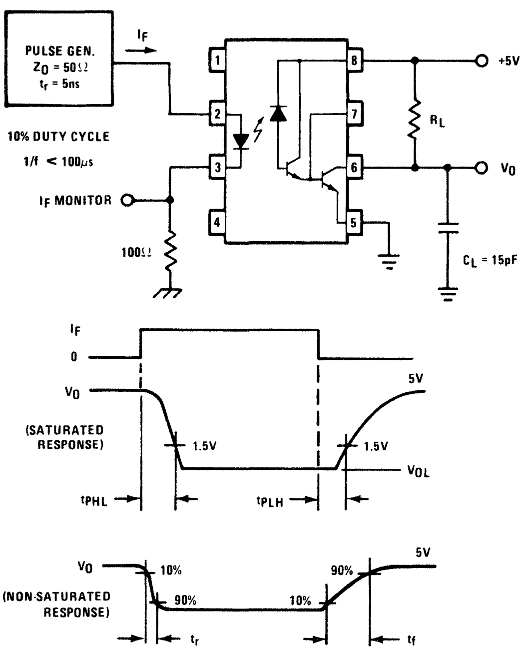
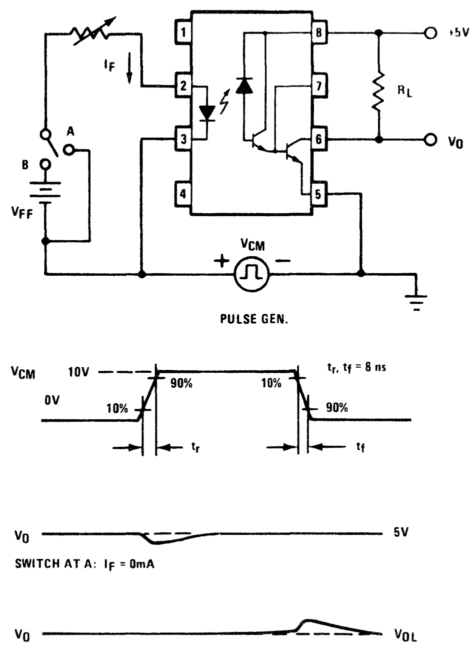


Figure 9. **Switching Time Test Circuit**



*JEDEC Registered Data.

Figure 10. **Test Circuit for Transient Immunity and Typical Waveforms**



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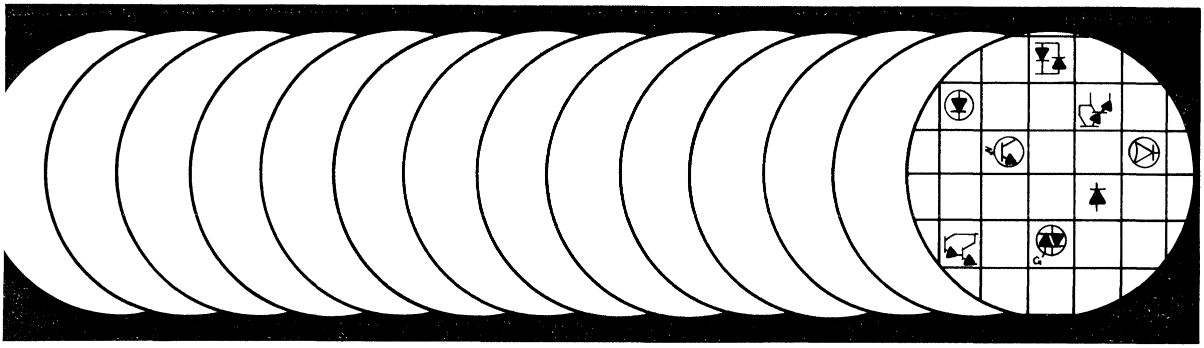
TRW



Emitter and Photosensor Chips

F

Emitter and Photosensor Chips

The Optoelectronics Division of TRW is widely recognized as one of the industry's leading suppliers of high quality gallium arsenide (GaAs) and gallium aluminum arsenide (GaAlAs) infrared emitter chips and silicon photosensor chips. In hybrid or other applications where space forbids use of a discrete optoelectronics component, direct placement of emitter and/or sensor chips may be the best alternative. With over seventeen years of experience, TRW is the technological leader in the design and fabrication of optoelectronic semiconductor chips.

The Optoelectronics Division manufactures emitter and sensor chips in the closely controlled clean rooms of its Carrollton, Texas division headquarters. The building which housed the division at the time of its founding in 1968 was designed and built specifically for the purpose of being used as an infrared semiconductor products fabrication facility. Since that time, capacity has been expanded several times over including the opening of separate emitter and sensor areas and an additional building solely dedicated to wafer fabrication. As recently as 1984, the division invested in an extensive expansion which more than doubled capacity.

Emitter Chips: Material Fabrication

Two basic types of infrared emitting diode chips are offered by TRW: GaAs or GaAlAs. In the early 1970's, Optron (today known as TRW Optoelectronics Division) pioneered in the development of solution grown epitaxial GaAs IREDs. This represented a quantum leap in photon generation efficiency compared to the planar diffused GaAs emitter chips of the 1960's. In the early 1980's, aluminum was added to the GaAs "melt" to produce GaAlAs solution grown epitaxial IREDs. TRW's ability to overcome the technical barriers associated with this new process resulted in a further improvement in device efficiency and the move toward higher energy, shorter wavelength infrared output. The wavelength at peak emission dropped from 935 nm (GaAs) to 875 nm (GaAlAs) which is more closely matched to the 850 nm response peak of most silicon photosensors.

Emitter Chip Selection

GaAs is often chosen for its lower rate of output degradation over time. Throughout their operating lives, crystalline degradation occurs in all III-IV compounds (e.g., GaAs) as micro-flaws propagate due to the combined effects of current and temperature change. Optical efficiency is lowered; hence overall infrared power output drops with time. Heat sinking and careful limiting of operating currents, of course, can have a dramatic effect on the life of the chip. GaAlAs, being slightly more susceptible to the natural degradation phenomenon, is usually the material of choice when the decision centers upon device efficiency and spectral matching.

The metallization area and chip size are important factors in the IRED output capability. TRW offers smaller chips with smaller metallization areas for low current applications. Typically operated in the range of 10–20 mA, many of these devices may be designed with applications demanding up to 100 mA of forward current. The larger chips with bonding areas designed for high current, may be operated at up to five amperes in the pulsed mode.

Photosensor Chips: Material Fabrication

TRW was first to combine complex integrated circuitry and a photosensitive semiconductor on a monolithic chip. The term Photologic™ refers to these photo ICs, developed in the mid 1970's.

TRW photosensors are of the planar diffused type, which means that they are fabricated using the basic photolithographic techniques widely accepted as the standard for silicon processing. Dopants are diffused into selected regions of the wafer to create the electrical properties required by the design specifications. An important TRW addition to the basic process is the optical overcoat or "passivation" covering the photosensitive area. This improves spectral response and enhances optical efficiency.

Photosensor Chip Selection

The basic phototransistor consists of three regions (NPN) with the base (P-type material) acting as receiver of the infrared energy (Figure 2). As such, the bulk of the surface area consists of the base diffusion region or, in other words, the area which was left open in order to absorb P-type impurities into the N-type starting material. In some chips, the base may also be bonded and electrically biased in order to improve device speed and/or sensitivity. In addition, these products may also be used as PN photodiodes by connecting only the base and collector.

Photodarlington chips are, as expected, more complex than the basic phototransistor. Again, the base region for the photosensitive transistor is designed to be as large as possible to maximize the photosensitive area.

Chip Mounting and Bonding Recommendations

Two basic mounting (alloy) methods are recommended for the chip products described herein: eutectic and epoxy. Eutectic scrub mounting is most often used with a metal header type of packaging. Solder preforms are required and are commonly available for this type of work. Conductive epoxy (silver based) is generally used when mounting the chip in a silver plated lead frame. Again, these epoxies are commonly available from a variety of suppliers. Mounting to a hybrid ceramic substrate may be accomplished by either of the above methods.

Thermo-compression bonding (ball bonding) is the recommended method of gold wire attachment. Caution is urged to avoid damage to the delicate chip structure (particularly with GaAs and GaAlAs). The possibility of chip damage should be carefully considered before using ultrasonic, thermo-sonic or other methods. TRW only recommends the use of carefully monitored thermo-compression bonding for gold wire attachment to the metalization area of its IRED chips.

TRW Hybrid Capability

In many cases, an application demands the use of a hybrid circuit, yet in-house engineering resources and equipment may not be available. Having the chips is only a part of the solution. The investment required to develop the complete hybrid in-house may be unrealistic for many customers.

TRW has recently added a state-of-the-art hybrid facility that may be able to meet your specific needs. Specializing in the automated design and fabrication of complex opto custom hybrid circuits, TRW's leading engineers can solve your most demanding application problems. Many satisfied customers have found that the cost of letting TRW do the entire circuit is often less than the "in-house" approach.

TRW, long known as the leader in custom opto assemblies, is now the leader in opto hybrid design and production. For more information, contact your local TRW office or call the Optoelectronics Division.

Chip Services and Availability

TRW chip products described herein can be delivered from stock by the authorized distributor shown below. The various testing, sorting, and packaging services required by hybrid circuit manufacturers are also readily available to TRW customers through our authorized distributor. Whether your needs call for DC electrical tests, visual inspection to military standards, or any other special chip related specification, contact your local TRW sales office or the following distributor.

Chip Supply Company
7725 N. Orange Blossom Trail
Orlando, FL 32910
(305) 298-7100

Figure 1. IRED Chip Fabrication

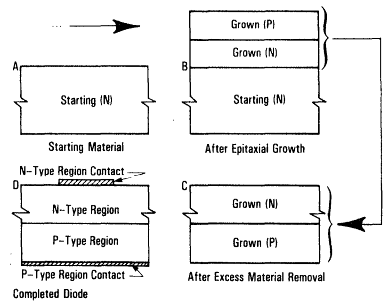
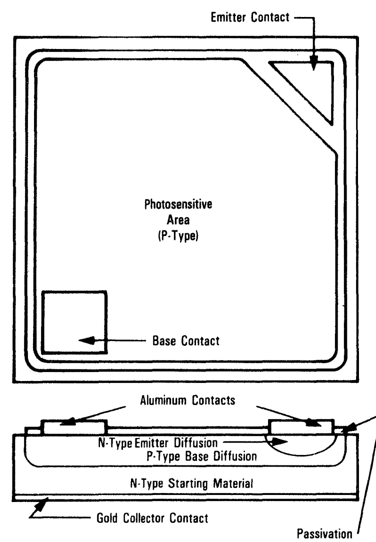


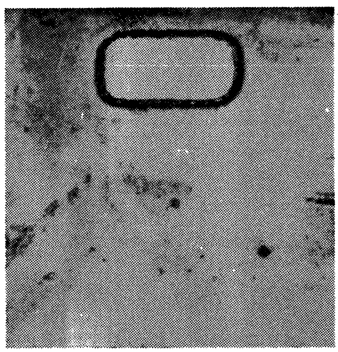
Figure 2. Typical Phototransistor Layout

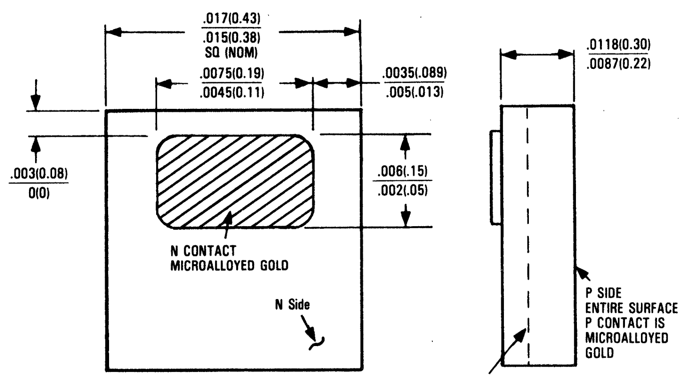


Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5382
January 1985

GaAs Infrared Emitter Chip
Type OPC116





DIMENSIONS ARE IN INCHES (MILLIMETERS).

Features
- High infrared radiation output
- Low degradation
- Microalloyed gold contacts

Description
TRW Optoelectronics Division's infrared emitting diode chips are fabricated by solution epitaxial techniques which provide high efficiency, long operating life, and minimum degradation. Spectral emission is centered at 935 nanometers.

Since TRW has no control over the techniques the customer may use to alloy and bond chips, TRW cannot be held responsible for damage to the chips resulting from such techniques. Nor can TRW warrant the life or any other parameter after the chips have been bonded.

Absolute Maximum Ratings[1] ($T_A = 25°C$ unless otherwise noted)
Storage and Operating Temperature Range .... −55°C to +150°C
Forward DC Current .... 150 mA[2]
Peak Forward Current (1 μs pulse, 300 pps) .... 3.0 A
Power Dissipation .... 200 mW

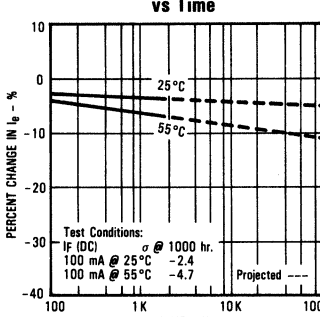
Electrical Characteristics (25°C unless otherwise noted)

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
V_R	Reverse Voltage	2.0			V	$I_R = 10.0\ \mu A$
V_F	Forward Voltage			1.70	V	$I_F = 100$ mA
P_O	Radiant Power Output	2.0			mW	$I_F = 100$ mA

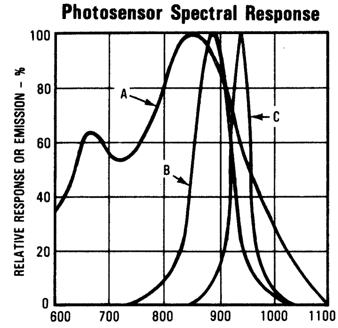
Notes: (1) All maximum ratings are determined with the chip mounted on a dimpled TO-46 header using TRW techniques. **(2)** Maximum operating current is a function of the package in which the chip is housed and the environment in which the assembled package will be used. **(3)** Typical wavelength at peak emission is 935 nm. **(4)** Chips will normally be shipped in a glass vial with cotton packing for protection.

Typical Performance Curves

Percent Change in Power Output vs Time



Photosensor Spectral Response



Test Conditions (LED):
$T_A = T_J = 25°C$, $I_F = 100$ mA, DC = 0.1%, PW = 100 μs
Peak Wavelength – λ_p: (A) XSTR – 850±30 nm
(B) LED GaAlAs – 875±20 nm
(C) LED GaAs – 930±15 nm

TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

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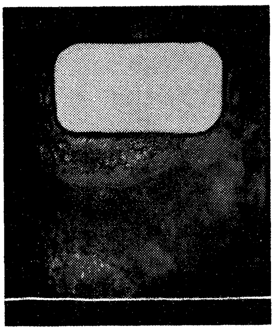
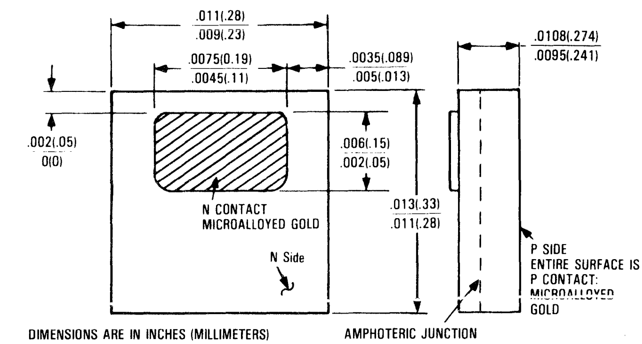
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5381
January 1985

GaAs Infrared Emitter Chip
Type OPC123





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Features
- High infrared radiation output
- Low degradation
- Microalloyed gold contacts

Description
TRW Optoelectronics Division's infrared emitting diode chips are fabricated by solution epitaxial techniques which provide high efficiency, long operating life, and minimum degradation. Spectral emission is centered at 935 nanometers.

Since TRW has no control over the techniques the customer may use to alloy and bond chips, TRW cannot be held responsible for damage to the chips resulting from such techniques. Nor can TRW warrant the life or any other parameter after the chips have been bonded.

Absolute Maximum Ratings(1) ($T_A = 25°C$ unless otherwise noted)

Storage and Operating Temperature Range . . . . . . −55°C to +150°C
Forward DC Current . . . . . . 150 mA(2)
Peak Forward Current (1 μs pulse, 300 pps) . . . . . . 3.0 A
Power Dissipation . . . . . . 200 mW

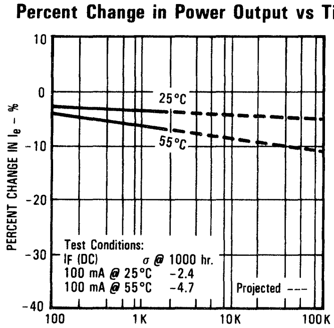
Electrical Characteristics (25°C unless otherwise noted)

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
V_R	Reverse Voltage	2.0			V	$I_R = 10.0$ μA
V_F	Forward Voltage			1.75	V	$I_F = 100$ mA
P_O	Radiant Power Output	2.0			mW	$I_F = 100$ mA

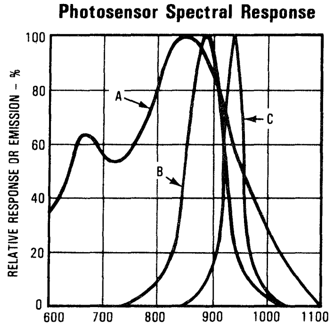
Notes: (1) All maximum ratings are determined with the chip mounted on a dimpled TO-46 header using TRW techniques. **(2)** Maximum operating current is a function of the package in which the chip is housed and the environment in which the assembled package will be used. **(3)** Typical wavelength at peak emission is 935 nm. **(4)** Chips will normally be shipped in a glass vial with cotton packing for protection.

Typical Performance Curves

Percent Change in Power Output vs Time



Photosensor Spectral Response



Test Conditions (LED):
$T_A = T_J = 25°C$, $I_F = 100$ mA, DC = 0.1%, PW = 100 μs
Peak Wavelength – λ_p: (A) XSTR – 850 ± 30 nm
(B) LED GaAlAs – 875 ± 20 nm
(C) LED GaAs – 930 ± 15 nm

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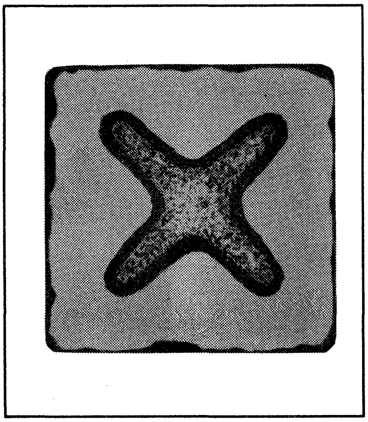
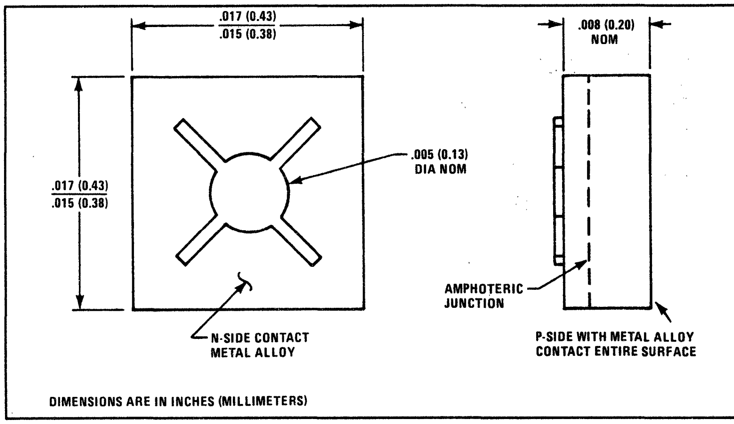
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5386
January 1985

GaAlAs Infrared Emitter Chip
Type OPC216





Features
- High infrared radiation output
- Low degradation
- Microalloyed gold contacts

Description
TRW Optoelectronics Division's infrared emitting diode chips are fabricated by solution epitaxial techniques, which provide high efficiency, long operating life, and minimum degradation. Spectral emission is centered at 875 nanometers.

Since TRW has no control over the techniques the customer may use to alloy and bond chips, TRW cannot be held responsible for damage to the chips resulting from such techniques. Nor can TRW warrant the life or any other parameter after the chips have been bonded.

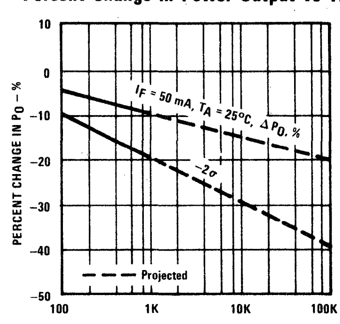
Absolute Maximum Ratings[1] ($T_A = 25°C$ unless otherwise noted)
Storage and Operating Temperature Range . . . . −55°C to +150°C
Forward DC Current . . . . 150 mA[2]
Peak Forward Current (1 μs pulse, 300 pps) . . . . 3.0 A
Power Dissipation . . . . 200 mW

Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
V_R	Reverse Voltage	2.0			V	$I_R = 10\ \mu A$
V_F	Forward Voltage			1.95	V	$I_F = 100$ mA
P_O	Radiant Power Output	4.0			mW	$I_F = 100$ mA[3]

Notes: (1) All maximum ratings are determined with the chip mounted on a dimpled TO-46 header using TRW techniques. **(2)** Maximum operating current is a function of the package in which the chip is housed and the environment in which the assembled package will be used. **(3)** Typical wavelength at peak emission is 875 nm. **(4)** Chips will normally be shipped in a glass vial with cotton packing for protection.

Typical Performance Curves
Percent Change in Power Output vs Time



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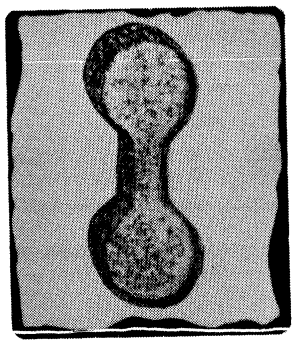
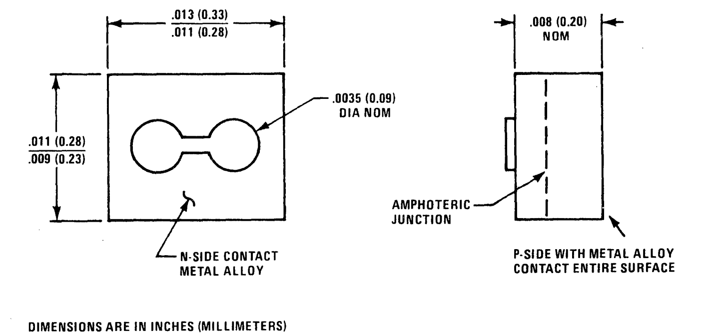
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5387
January 1985

GaAlAs Infrared Emitter Chip
Type OPC230





F

Features
- High infrared radiation output
- Low degradation
- Microalloyed gold contacts

Description
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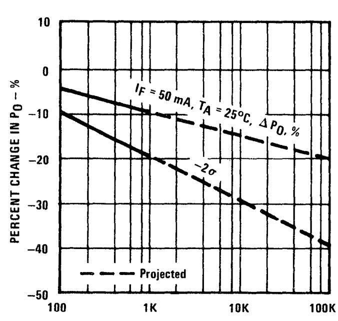
Absolute Maximum Ratings[1] ($T_A = 25°C$ unless otherwise noted)
Storage and Operating Temperature Range . . . . . . −55°C to +150°C
Forward DC Current . . . . . . 150 mA[2]
Peak Forward Current (1 μs pulse, 300 pps) . . . . . . 3.0 A
Power Dissipation . . . . . . 200 mW

Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
V_R	Reverse Voltage	2.0			V	$I_R = 10\ \mu A$
V_F	Forward Voltage			1.95	V	$I_F = 100$ mA
P_O	Radiant Power Output	4.0			mW	$I_F = 100$ mA[3]

Notes: (1) All maximum ratings are determined with the chip mounted on a dimpled TO-46 header using TRW techniques. **(2)** Maximum operating current is a function of the package in which the chip is housed and the environment in which the assembled package will be used. **(3)** Typical wavelength at peak emission is 875 nm. **(4)** Chips will normally be shipped in a glass vial with cotton packing for protection.

Typical Performance Curves
Percent Change in Power Output vs Time



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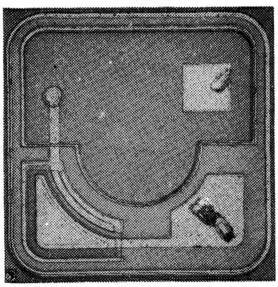
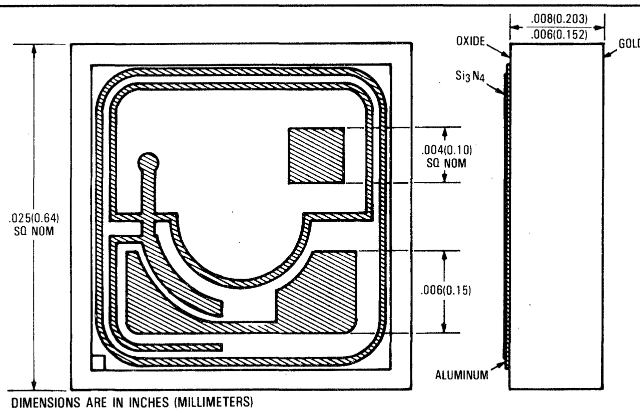
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5398
January 1985

NPN Silicon Photodarlington Chip
Type OPC300R





Features
- High collector current
- Improved current sinking characteristics
- Silicon nitride passivation

Description
TRW Optoelectronics Division photosensor chips are fabricated using the latest silicon planar diffused technology and are silicon nitride passivated for long term stability. All photosensors have an antireflective coating over the active area to ensure maximum absorption of irradiated light. Leads are covered with oxide passivation to protect from mechanical damage.

Since TRW Optoelectronics has no control over the techniques the customer may use to alloy and bond chips, TRW Optoelectronics cannot be held responsible for damage to the chips resulting from such techniques.

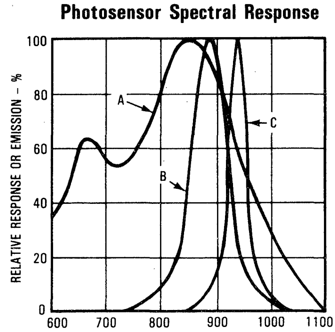
Absolute Maximum Ratings[1] ($T_A = 25°C$ unless otherwise noted)
Storage and Operating Temperature Range . . . . . −65°C to +150°C
Collector-Emitter Voltage . . . . . 30 V
Emitter-Collector Voltage . . . . . 5.0 V
Power Dissipation . . . . . 50 mW[2]

Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	33			V	$I_C = 100\ \mu A$
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	7.0			V	$I_E = 100\ \mu A$
I_{CEO}	Collector Dark Current			100	nA	$V_{CE} = 10.0$ V, $E_e = 0$
I_{CB}	Collector-Base Current		150		nA	$V_{CE} = 5.0$ V, $E_e = 1.00$ mW/cm² (4)
$I_{C(ON)}$	On-State Collector Current	0.50		20	mA	$V_{CE} = 5.0$ V, $E_e = 1.00$ mW/cm² (4)

Notes: **(1)** All maximum ratings are determined with the chip mounted on a TO-18 header using TRW Optoelectronics' techniques. **(2)** Maximum power dissipation is a function of the package in which the chip is housed and the environment in which the assembled package will be used. **(3)** Chips will be shipped in a glass vial with cotton packing for protection. **(4)** Light source is an unfiltered tungsten bulb operating at CT = 2870°K.

Typical Performance Curves
Photosensor Spectral Response



Test Conditions (LED):
$T_A = T_J = 25°C$, $I_F = 100$ mA, DC = 0.1%, PW = 100 μs
Peak Wavelength – λ_p: (A) XSTR – 850±30 nm
(B) LED GaAlAs – 875±20 nm
(C) LED GaAs – 930±15 nm

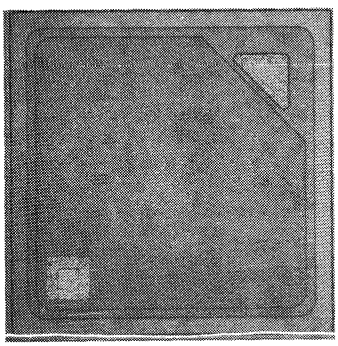
TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

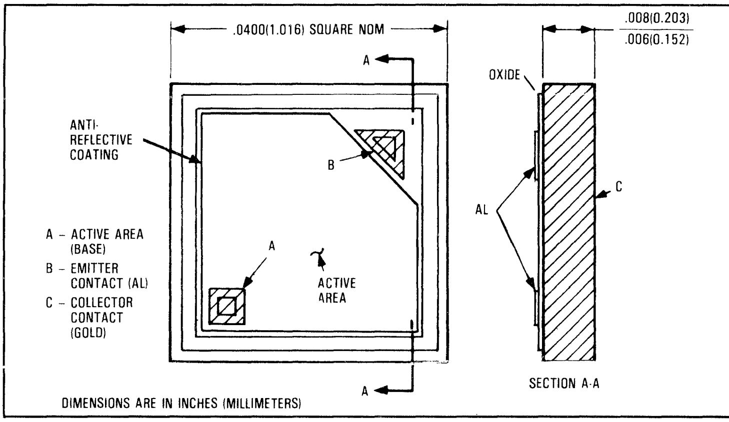
Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958

Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5391
January 1985

NPN Silicon Phototransistor Chip
Type OPC60X





Features
- 2.7 times the active area of OPC600L
- More sensitive at low light levels
- Active area is centered on chip

Description
TRW Optoelectronics Division photosensor chips are fabricated using the latest silicon planar diffused technology and are silicon nitride passivated for long term stability. All photosensors have an antireflective coating over the active area to ensure maximum absorption of irradiated light. Chips can be specially probed to satisfy custom requirements.

Since TRW has no control over the techniques the customer may use to alloy and bond chips, TRW cannot be held responsible for damage to the chips resulting from such techniques.

Absolute Maximum Ratings(1) ($T_A = 25°C$ unless otherwise noted)
Storage and Operating Temperature Range . . . . . −65°C to +150°C
Collector-Emitter Voltage . . . . . 30 V
Emitter-Collector Voltage . . . . . 5.0 V
Power Dissipation . . . . . 50 mW(2)

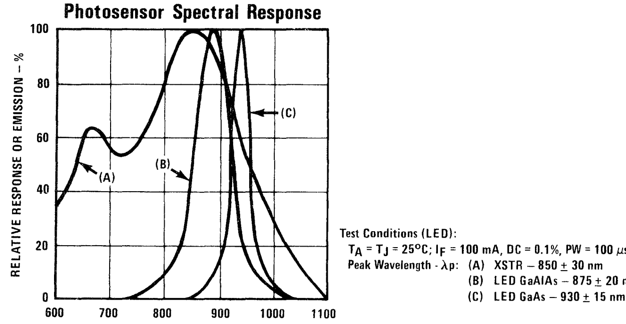
Electrical Characteristics (25°C unless otherwise noted)

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	30			V	$I_C = 100\ \mu A$
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	5.0			V	$I_E = 100\ \mu A$
I_{CEO}	Collector Dark Current			100	nA	$V_{CE} = 10.0$ V, $E_e = 0$
I_L	Light Current	0.8		22	mA	$V_{CE} = 5.0$ V, $E_e = 5.0$ mW/cm^2 (4)(5)
I_{CB}	Collector-Base Current		8.2		μA	$V_{CE} = 5.0$ V, $E_e = 10.0$ mW/cm^2 (4)

Notes: **(1)** All maximum ratings are determined with the chip mounted on a dimpled TO-18 header using TRW techniques. **(2)** Maximum power dissipation is a function of the package in which the chip is housed and the environment in which the assembled package will be used. **(3)** Chips will normally be shipped in a glass vial with cotton packing for protection. **(4)** Light source is an unfiltered tungsten bulb operating at CT = 2870°K. **(5)** I_L not tested. H_{fe} range guarantees I_L.

Typical Performance Curves

Photosensor Spectral Response

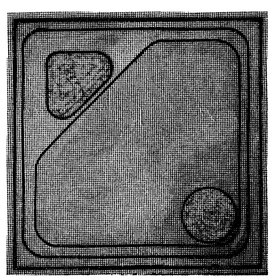


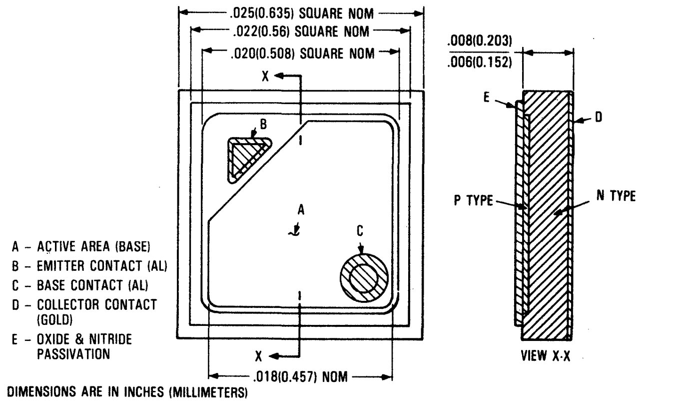
TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958

Product Bulletin 5394
January 1985

NPN Silicon Phototransistor Chip
Type OPC600L





Features
- Active area centered on chip
- Low cost
- Silicon nitride passivation

Description
TRW Optoelectronics Division photosensor chips are fabricated using the latest silicon planar diffused technology and are silicon nitride passivated for long term stability. All photosensors have an antireflective coating over the active area to ensure maximum absorption of irradiated light. Chips can be specially probed to satisfy custom requirements.

Since TRW has no control over the techniques the customer may use to alloy and bond chips, TRW cannot be held responsible for damage to the chips resulting from such techniques.

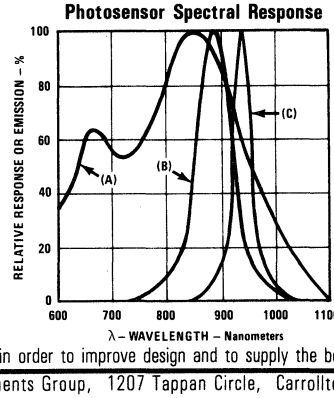
Absolute Maximum Ratings(1) ($T_A = 25°C$ unless otherwise noted)
Storage and Operating Temperature Range .... −65°C to +150°C
Collector-Emitter Voltage .... 30 V
Emitter-Collector Voltage .... 5.0 V
Power Dissipation .... 50 mW(2)

Electrical Characteristics (25°C unless otherwise noted)

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	30			V	$I_C = 100\ \mu A$
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	5.0			V	$I_E = 100\ \mu A$
I_{CEO}	Collector Dark Current			100	nA	$V_{CE} = 10.0$ V, $E_e = 0$
I_L	Light Current	0.80		10.0	mA	$V_{CE} = 5.0$ V, $E_e = 20$ mW/cm^2 (4)(5)
I_{CB}	Collector-Base Current		6.0		μA	$V_{CE} = 5.0$ V, $E_e = 20$ mW/cm^2 (4)

Notes: **(1)** All maximum ratings are determined with the chip mounted on a dimpled TO-18 header using Optoelectronics techniques. **(2)** Maximum power dissipation is a function of the package in which the chip is housed and the environment in which the assembled package will be used. **(3)** Chips will normally be shipped in a glass vial with cotton packing for protection. **(4)** Light source is an unfiltered tungsten bulb operating at CT = 2870°K. **(5)** I_L not tested. H_{fe} range guarantees I_L.

Typical Performance Curves
Photosensor Spectral Response



Test Conditions (LED):
$T_A = T_J = 25°C$; $I_F = 100$ mA, DC = 0.1%, PW = 100 μs
Peak Wavelength - λ_P: (A) XSTR – 850 ± 30 nm
(B) LED GaAlAs – 875 ± 20 nm
(C) LED GaAs – 930 ± 15 nm

TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

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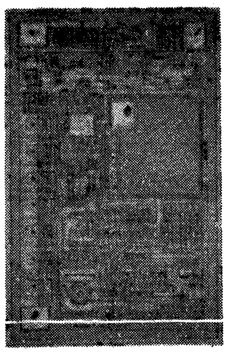
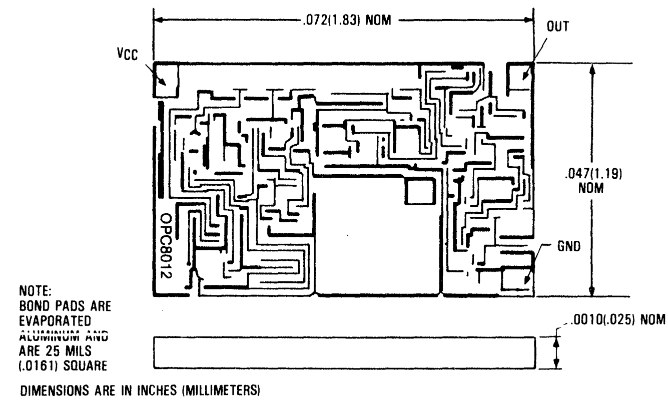
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5409
January 1985

TRW

Photologic™ Chips
Types OPC8012, OPC8013, OPC8014, OPC8015





F

Features
- Open collector or totem-pole output
- Drive up to 8 TTL loads
- Data rates to 250 K baud

Description
The OPC8012 family of photologic chips are bipolar monolithic integrated circuits consisting of a photodiode, a linear amplifier, and a Schmitt trigger on a single silicon chip. Four output options are available, buffer-totem pole (OPC8012), buffer-open collector (OPC8013), inverter-totem pole (OPC8015), and inverter-open collector (OPC8014). Featured is logic level output and up to 12.8 mA of sink current for direct driving of up to 8 TTL loads. The Schmitt trigger provides hysteresis for high immunity to noise on the input.

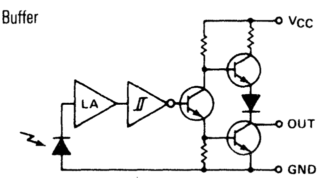
Since TRW Optoelectronics Division has no control over the techniques the customer may use to alloy and bond chips, TRW cannot be held responsible for damage to the chips resulting from such techniques.

Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)
Storage and Operating Temperature Range . . . . −55°C to +125°C
Supply Voltage, V_{CC} . . . . 5.25 V
Junction Temperature . . . . 125°C

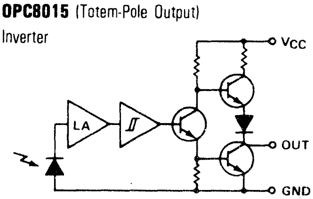
Notes:
(1) Light level sufficient to cause high level output (see Typical $E_{eT}+$). Light source is an unfiltered tungsten bulb operating at CT = 2870°K.
(2) Light level sufficient to cause low level output (see Typical $E_{eT}+$). Light source is an unfiltered tungsten bulb operating at CT = 2870°K.
(3) Chips will normally be shipped in a glass vial with cotton packing for protection.

Block Diagrams

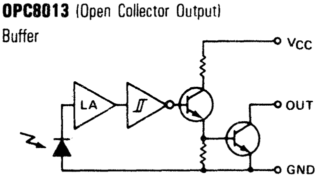
OPC8012 (Totem-Pole Output)
Buffer



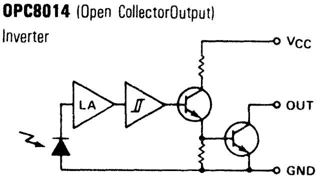
OPC8015 (Totem-Pole Output)
Inverter



OPC8013 (Open Collector Output)
Buffer



OPC8014 (Open CollectorOutput)
Inverter



Types OPC8012, OPC8013, OPC8014, OPC8015

Electrical Characteristics (−40°C to +70°C unless otherwise noted)

Symbol	Parameter	Min.	Typ.	Max.	Unit	Test Conditions
OPC8012 (Buffer-Totem Pole)						
I_{CCH}	High Level Supply Current		8.0	15.0	mA	$V_{CC}=5.2$ V, (See Note 1)
I_{CCL}	Low Level Supply Current	3.0	8.0	13	mA	$V_{CC}=5.2$ V, $E_e=0$
V_{OH}	High Level Output Voltage	2.5	3.2		V	$V_{CC}=4.8$ V, $I_{OH}=-800$ μA (See Note 1)
V_{OL}	Low Level Output Voltage		0.28	400	mV	$V_{CC}=4.8$ V, $I_{OL}=13.8$ mA, $E_e=0$
E_eT+	Trigger Irradiance (Low-High)		1.00		mW/cm2	$V_{CC}=5.0$ V
E_eT+/E_eT-	Hysteresis		2.0			$V_{CC}=5.0$ V
I_{OS}	Short Circuit Output Current	−80	−50	−25	mA	$V_{CC}=5.2$ V, $V_{OUT}=0$, (See Note 1)
OPC8013 (Buffer-Open Collector)						
I_{CCH}	High Level Supply Current		8.0	15.0	mA	$V_{CC}=5.2$ V, (See Note 1)
I_{CCL}	Low Level Supply Current	3.0	8.0	13	mA	$V_{CC}=5.2$ V, $E_e=0$
I_{OH}	High Level Output Current			100	μA	$V_{CC}=4.8$ V, $V_{OH}=35$ V (See Note 1)
V_{OL}	Low Level Output Voltage		0.28	400	mV	$V_{CC}=4.8$ V, $I_{OL}=13.8$ mA, $E_e=0$
E_eT+	Trigger Irradiance (Low-High)		1.00		mW/cm2	$V_{CC}=5.0$ V
E_eT+/E_eT-	Hysteresis		2.0			$V_{CC}=5.0$ V
OPC8014 (Inverter-Open Collector)						
I_{CCH}	High Level Supply Current		3.0	13	mA	$V_{CC}=5.2$ V, $E_e=0$
I_{CCL}	Low Level Supply Current		3.0	15	mA	$V_{CC}=5.2$ V, (See Note 2)
I_{OH}	High Level Output Current			100	μA	$V_{CC}=4.8$ V, $V_{OH}=35$ V $E_e=0$
V_{OL}	Low Level Output Voltage		0.28	400	mV	$V_{CC}=4.8$ V, $I_{OL}=13.8$ mA, (See Note 2)
E_eT+	Trigger Irradiance (Low-High)		1.00		mW/cm2	$V_{CC}=5.0$ V
E_eT+/E_eT-	Hysteresis		2.0			$V_{CC}=5.0$ V
OPC8015 (Inverter-Totem Pole)						
I_{CCH}	High Level Supply Current		3.0	13	mA	$V_{CC}=5.2$ V, $E_e=0$
I_{CCL}	Low Level Supply Current		3.0	15	mA	$V_{CC}=5.2$ V, (See Note 2)
V_{OH}	High Level Output Voltage	2.5	3.2		V	$V_{CC}=4.8$ V, $I_{OH}=-800$ μA, $E_e=0$
V_{OL}	Low Level Output Voltage		0.28	400	mV	$V_{CC}=4.8$ V, $I_{OH}=13.8$ mA, (See Note 2)
E_eT+	Trigger Irradiance (High-Low)		1.00		mW/cm2	$V_{CC}=5.0$ V
E_eT+/E_eT-	Hysteresis		2.0			$V_{CC}=5.0$ V
I_{OS}	Short Circuit Output Current	−80	−50	−25	mA	$V_{CC}=5.2$ V, $V_{OUT}=0$, $E_e=0$

TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

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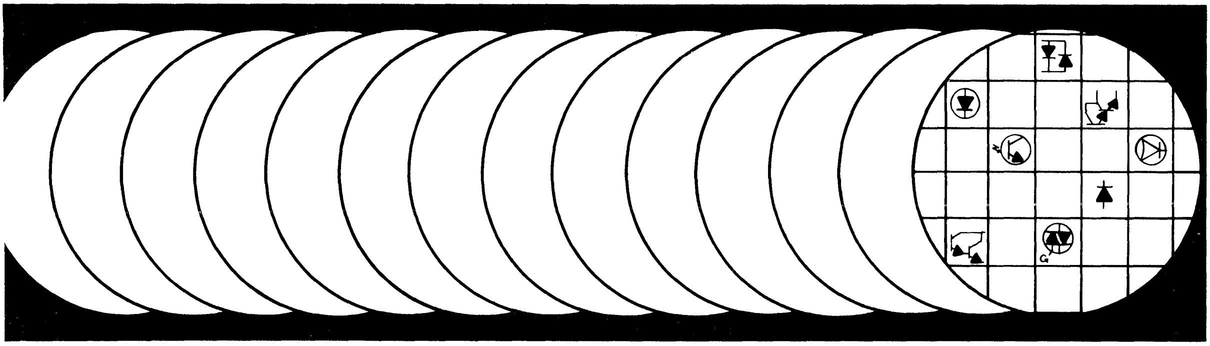
TRW



Reflective Assemblies

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Reflective Assemblies

Reflective assemblies are motion or position sensors that provide non-contact sensing of a reflective surface or a *change* in surface reflectivity. Such an assembly consists of one or more infrared emitting diodes (IRED) and sensors (an NPN silicon phototransistor, photodarlington or Photologic™) in the same housing. The emitter and sensor are positioned on the same side of the assembly, facing the surface to be sensed, which can be a major mounting advantage in certain applications.

(Application Bulletin 113, printed in this data book, presents an in-depth discussion of reflective assemblies and possible design problems involving mounting configurations, reflective surfaces, and sensing circuits. If you have further questions, please contact your local TRW representative, or TRW Optoelectronics Division in Carrollton, Texas.)

An important consideration to keep in mind when using reflective assemblies is that the photosensor will not necessarily "see" infrared radiation in the same way that the human eye sees visible light. For example, a black surface and a white one may, under certain conditions, have similar reflective properties when illuminated with infrared radiation.

TRW's Optoelectronics Division makes two kinds of reflective assemblies: focused and unfocused.

Focused Reflective Assemblies

Best for sensing specular or polished surfaces, focused reflective assemblies are made from discrete devices with convex lenses (see Figure 1). In such assemblies, the emitter and sensor are mounted on converging optical axes.

For the standard focused type, the on-state collector current, $I_{C(ON)}$, peaks when a reflective surface is placed between 0.100 and 0.200 inches (2.5 to 5.0 mm) in front of the reflective assembly. ($I_{C(ON)}$ is the collector current created by the infrared radiation emitted by the IRED and detected by the photosensor from the reflective surface.)

The IRED emits radiation which follows a diverging pattern, not a straight line through its centerline, and the sensor views a converging pattern rather than a straight line through its center.

Unfocused Reflective Assemblies

Best for sensing diffuse or rough surfaces, unfocused reflective assemblies are often made from discrete devices with plano or non-magnifying lenses (see Figure 2). In the standard assembly, the emitter and sensor are usually mounted on parallel optical axes.

For unfocused assemblies, the reflective surface generally must be placed closer to the assembly than when using a focused type. The reason is that $I_{C(ON)}$ peaks when the reflective surface is between 0.040 and 0.080 inches (1.00 to 2.0 mm) from the front of the assembly.

These units are well suited for mounting in sockets or printed circuit boards.

Variations in Signal Level

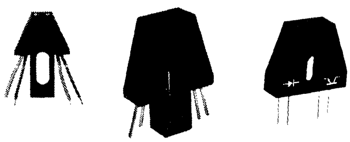
Consideration should be given to possible variations in signal level when designing in reflective assemblies. Such variations may occur for a variety of reasons:

- Inconsistency in placement of reflective surfaces, resulting in variation in distance between the surface and the reflective assembly.
- Variations in the reflective surfaces. In some instances, black and white surfaces can exhibit similar reflective properties.

- Using transmissive materials between the reflective assembly and the reflective surface.
- Variations from assembly to assembly. (Especially where the devices are tested to a minimum limit only.)
- Variation in size is another potential problem area. An optimum sized reflective surface is one in which no increase in $I_{C(ON)}$ is observed when the surface area is increased.
- Variations in signal level can be observed due to spurious illumination from outside sources.

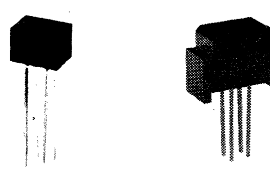
TRW makes reflective assemblies in a wide variety of sizes and shapes for many different applications. The customer can find suitable reflective assemblies to meet a wide variety of specifications. However, many times designers are faced with conditions that prevent the use of standard reflective assemblies, as specified by the manufacturer. Reflective surfaces may be different than specified and the distance between the reflective surface may be greater or closer than that specified, or cannot be consistently maintained. Various mounting requirements may make tighter control impractical and the contrast ratio may have to be improved. In many of these application-specific situations, TRW can design a custom reflective assembly to meet your needs.

Figure 1. Focused Reflective Assemblies



OPB125A, 253A OPB703A OPB708, 709

Figure 2. Unfocused Reflective Assemblies



OPB706, 707 OPB711, 712

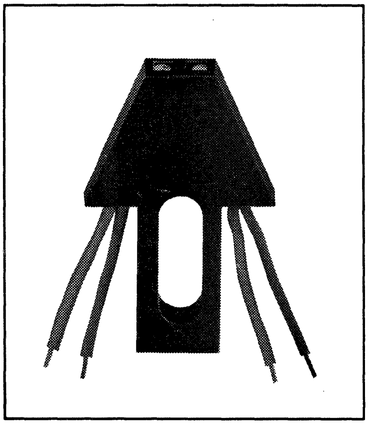
Applications

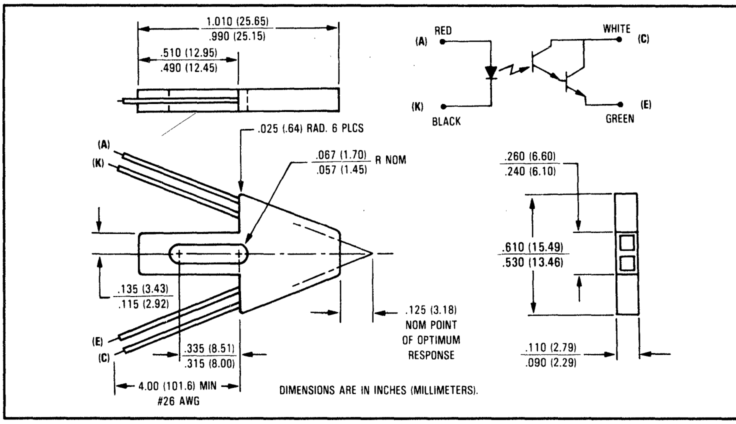
- Measuring surface roughness.
- Sensing the level of liquids.
- Detecting variations in surface locations.
- Detecting presence or absence of paper in office machines.
- Controlling the shutter and/or flash in sophisticated cameras.
- Triggering a high speed print cutting mechanism.
- Plus many other applications in industrial controls, surveillance mechanisms, and elsewhere.

Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5279
January 1985

Reflective Object Sensor
Type OPB125A





Features
- Photodarlington output
- Low profile to facilitate stacking
- Low cost plastic housing
- 4.0 inches (101.6 mm) minimum length lead wire

Description
The OPB125A consists of an infrared emitting diode and an NPN silicon photodarlington mounted side-by-side on converging optical axes, in a black plastic housing. The photodarlington responds to radiation from the LED only when a reflective object passes within its field of view.

OPB125A utilizes an OP123 or OP223 LED and an OP300 family sensor. Leads are #26 AWG, teflon insulation, 4.0" (101.6 mm) minimum length, stripped and tinned.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)
Storage Temperature Range . . . . −40°C to +125°C
Operating Temperature Range . . . . −40°C to +100°C

Input Diode
Forward DC Current . . . . 50 mA
Reverse DC Voltage . . . . 2.0 V
Power Dissipation . . . . 80 mW(1)

Output Photodarlington
Collector-Emitter Voltage . . . . 25 V
Emitter-Collector Voltage . . . . 5.0 V
Power Dissipation . . . . 50 mW(2)

Notes:
(1) Derate linearly 1.07 mW/°C above 25°C.
(2) Derate linearly 0.67 mW/°C above 25°C.
(3) Measured using an Eastman Kodak neutral white test card having 90% diffuse reflectance as a reflecting surface.
(4) Measured using a reflecting surface that has a very black dull surface with optical reflectance qualities comparable to a surface coated with carbon black printer's ink.
(5) Crosstalk (I_{CX}) is the collector current measured with the indicated current in the input diode and with no reflecting surface.
(6) Lower curve is based on a calculated worst case condition rather than the conventional -2σ limit.
(7) d is the distance from the assembly head to the reflective surface.

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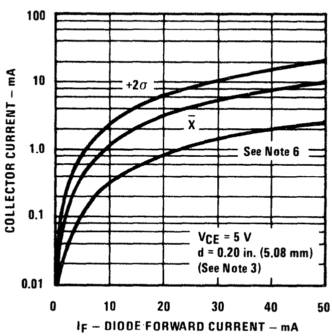
Electrical Characteristics (T_A = 25°C unless otherwise noted)

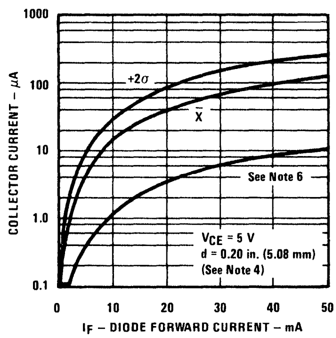
Symbol	Parameter	Min.	Max.	Units	Test Conditions
Input Diode					
V_F	Forward Voltage		1.70	V	I_F = 50 mA
I_R	Reverse Current		100	μA	V_R = 2.0 V
Output Photodarlington					
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	25		V	I_C = 100 μA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	5.0		V	I_E = 100 μA
I_{CEO}	Collector Dark Current		1.00	μA	V_{CE} = 10.0 V, I_F = 0, $E_e \leq$ 0.100 μW/cm²
Combined					
$I_{C(ON)}$	On-State Collector Current	2.0		mA	I_F = 40 mA, V_{CE} = 5.0 V, d = 0.200 in. (5.08 mm)(7). See Note 3.
I_{CX}	Crosstalk		20	μA	I_F = 40 mA, V_{CE} = 5.0 V, No Reflecting Surface. See Note 5.
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage		1.10	V	I_F = 40 mA, I_C = 1 mA, d=0.200(5.08mm)(7)(3).

Typical Performance Curves

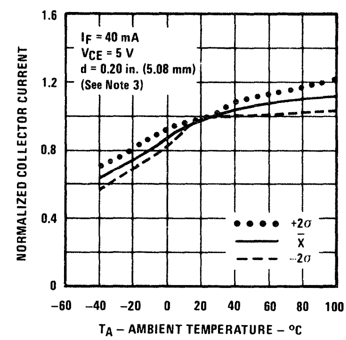
Reflective Surface Collector Current vs. Diode Forward Current



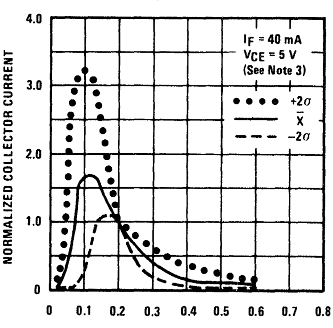
Diffused Surface Collector Current vs. Diode Forward Current



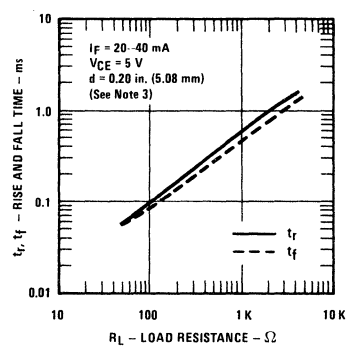
Normalized Collector Current vs. Ambient Temperature



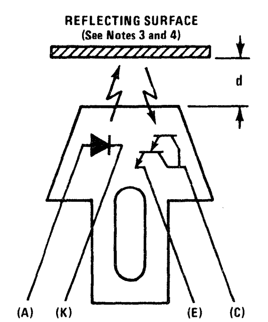
Normalized Collector Current vs. Object Distance



Rise and Fall Time vs. Load Resistance



Test Condition

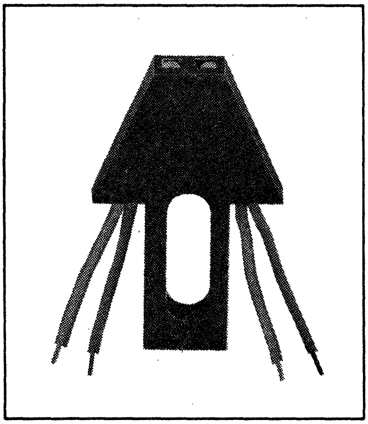


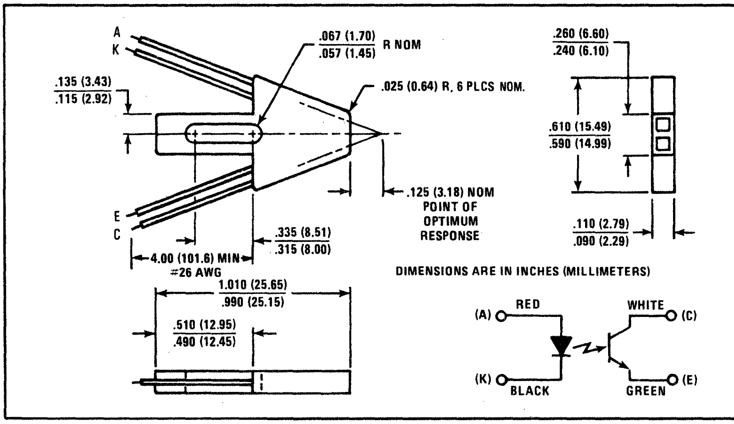
TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958

Product Bulletin 5282
January 1985

Reflective Object Sensor
Type OPB253A





Features

- Phototransistor output
- Low profile to facilitate stacking
- Low cost plastic housing
- 4.0 inches (101.6 mm) minimum length lead wire

Description

The OPB253A consists of an infrared emitting diode and an NPN silicon phototransistor mounted side-by-side on converging optical axes, in a black plastic housing. The phototransistor responds to radiation from the LED only when a reflective object passes within its field of view.

The OPB253A utilizes an OP123 or OP223 LED and an OP600 family sensor. Leads are #26 AWG, teflon insulation, 4.0″ (101.6 mm) minimum length, stripped and tinned.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

Storage Temperature Range . . . . −40°C to +125°C
Operating Temperature Range . . . . −40°C to +100°C

Input Diode

Reverse Voltage . . . . 2.0 V
Continuous Forward Current . . . . 50 mA
Power Dissipation . . . . 80 mW(1)

Output Phototransistor

Collector-Emitter Voltage . . . . 25 V
Emitter-Collector Voltage . . . . 5.0 V
Power Dissipation . . . . 50 mW(2)

Notes:

(1) Derate linearly 1.07 mW/°C above 25°C.
(2) Derate linearly 0.67 mW/°C above 25°C.
(3) Measured using an Eastman Kodak neutral white test card having 90% diffuse reflectance as a reflecting surface.
(4) Crosstalk (I_{CX}) is the collector current measured with the indicated current in the input diode and with no reflecting surface.
(5) Lower curve is based on a calculated worst case condition rather than the conventional -2σ limit.
(6) d is the distance from the assembly head to the reflective surface.

Type OPB253A

Electrical Characteristics (T_A = 25°C unless otherwise noted)

Symbol	Parameter	Min.	Max.	Units	Test Conditions
Input Diode					
V_F	Forward Voltage		1.70	V	I_F = 50 mA
I_R	Reverse Current		100	μA	V_R = 2.0 V
Output Phototransistor					
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	25		V	I_C = 100 μA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	5.0		V	I_E = 100 μA
I_{CEO}	Collector Dark Current		100	nA	V_{CE} = 10.0 V, I_F = 0, $E_e \leq$ 0.1 μW/cm²
Combined					
$I_{C(ON)}$	On-State Collector Current	25		μA	I_F = 40 mA, V_{CE} = 5.0 V, d = 0.20 in. (5.08 mm).[6] See Note 3.
I_{CX}	Crosstalk		2.0	μA	I_F = 40 mA, V_{CE} = 5.0 V. No Reflecting Surface
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage		0.40	V	I_F = 40 mA, I_C = 10.0 μA, d = 0.20 in. (5.08 mm).[6] See Note 3.

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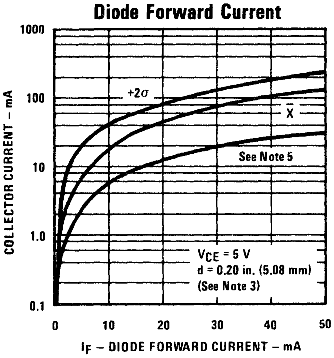
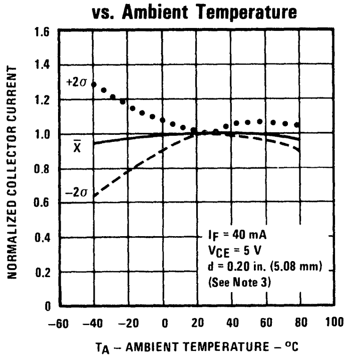
Typical Performance Curves

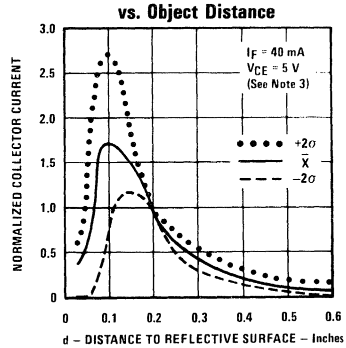
Collector Current vs. Diode Forward Current



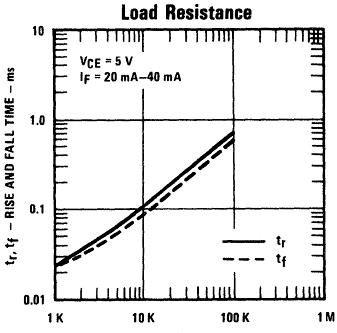
Normalized Collector Current vs. Ambient Temperature



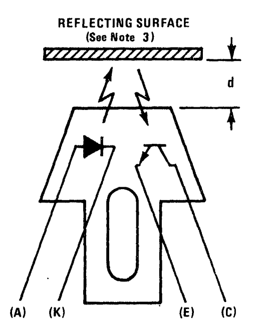
Normalized Collector Current vs. Object Distance



Rise and Fall Time vs. Load Resistance



Test Condition



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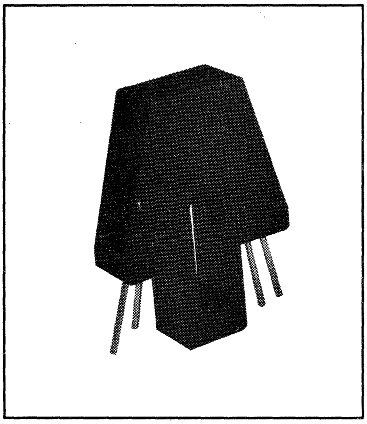
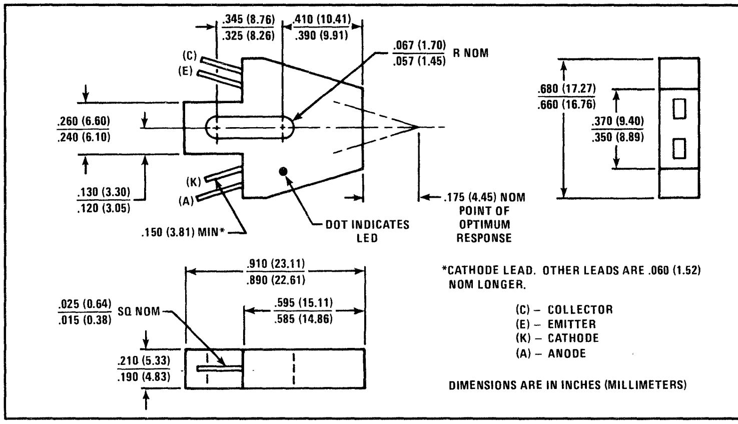
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5284
January 1985

Reflective Object Sensor
Type OPB703A





Features
- Phototransistor output
- High sensitivity
- Low cost plastic housing
- Lensed for dust protection and ambient light filtration

Description
The OPB703A consists of an infrared emitting diode and an NPN silicon phototransistor mounted side-by-side on converging optical axes, in a black plastic housing. A filtering lens in the face of the housing seals the device from dust and dirt and reduces ambient light noise. The photosensor responds to radiation from the LED only when a reflective object passes within its field of view.

OPB703A utilizes an OP160 or OP260 LED and an OP500 family sensor.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)
Storage Temperature Range . . . . −40°C to +85°C
Operating Temperature Range . . . . −40°C to +85°C
Lead Soldering Temperature (1/16 in. [1.6 mm] from case for 5 sec. with soldering iron)[1] . . . . 240°C

Input Diode
Forward DC Current . . . . 40 mA
Reverse DC Voltage . . . . 2.0 V
Power Dissipation . . . . 70 mW[2]

Output Photosensor
Collector-Emitter Voltage . . . . 30 V
Emitter-Collector Voltage . . . . 5.0 V
Power Dissipation . . . . 50 mW[3]

Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering.
(2) Derate linearly 1.27 mW/°C above 25°C.
(3) Derate linearly 0.91 mW/°C above 25°C.
(4) d is the distance from the assembly face to the reflective surface.
(5) Measured using an Eastman Kodak neutral white test card having 90% diffuse reflectance as a reflecting surface.
(6) Measured using a reflecting surface that has a very black dull surface with optical reflectance qualities comparable to a surface coated with carbon black printer's ink.
(7) Lower curve is based on a calculated worst case condition rather than the conventional -2σ limit.

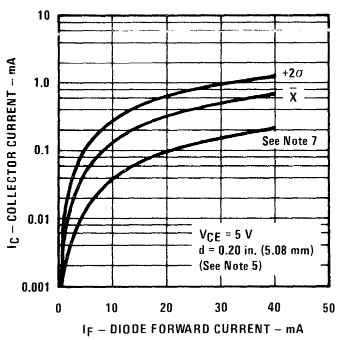
Type OPB703A

Electrical Characteristics (T_A = 25°C unless otherwise noted)

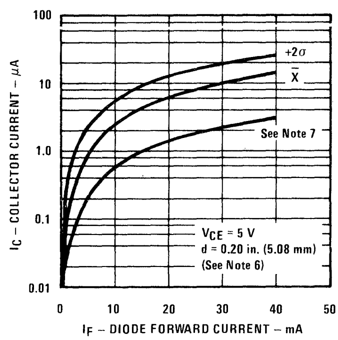
Symbol	Parameter	Min.	Max.	Units	Test Conditions
Input Diode					
V_F	Forward Voltage		1.70	V	I_F = 40 mA
I_R	Reverse Current		100	μA	V_R = 2.0 V
Output Phototransistor					
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	30		V	I_{CE} = 100 μA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	5.0		V	I_{EC} = 100 μA
I_{CEO}	Collector Dark Current		100	nA	V_{CE} = 10.0 V, I_F = 0, E_e = 0
Combined					
$I_{C(ON)}$	On-State Collector Current	200		μA	I_F = 40 mA, V_{CE} = 5.0 V, d = 0.20 in. (5.08 mm)[4][5].
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage		0.40	V	I_F = 40 mA, I_C = 100 μA, d = 0.20 in. (5.08 mm)[4][5]

Typical Performance Curves

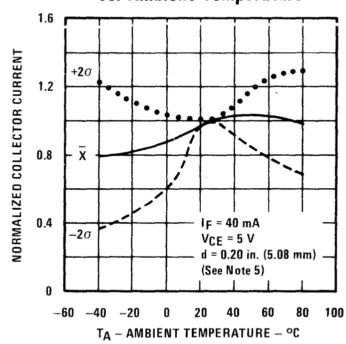
Reflective Surface Collector Current vs. Diode Forward Current



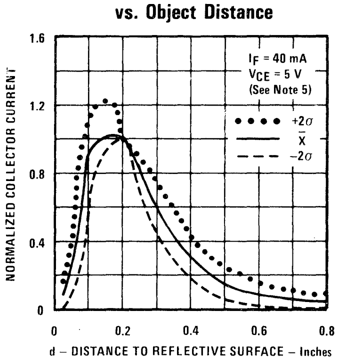
Diffused Surface Collector Current vs. Diode Forward Current



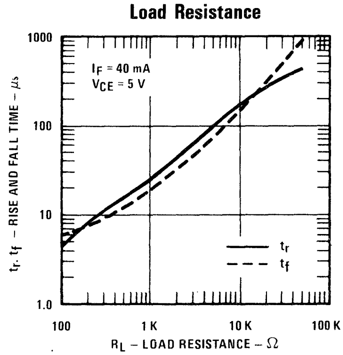
Normalized Collector Current vs. Ambient Temperature



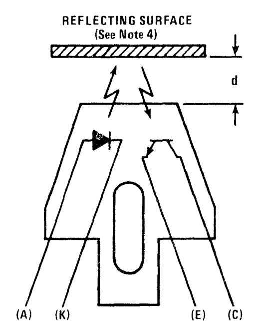
Normalized Collector Current vs. Object Distance



Rise and Fall Time vs. Load Resistance



Test Condition

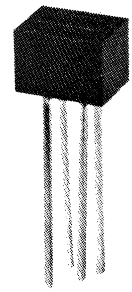


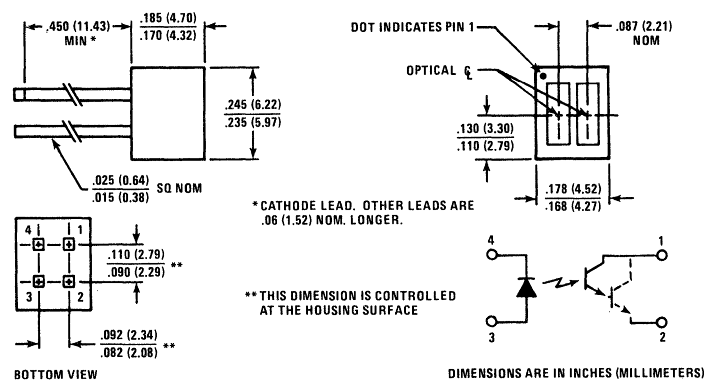
TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5286
January 1985

Reflective Object Sensors
Types OPB706C, B, A, OPB707C, B, A





Features
- Phototransistor (OPB706) or photodarlington (OPB707) output
- Unfocused for sensing diffuse surfaces
- Low cost plastic housing

Description
The OPB706 and OPB707 each consist of an infrared emitting diode and an NPN silicon phototransistor (OPB706) or photodarlington (OPB707) mounted side-by-side on parallel axes in a black plastic housing. Both the emitting diode and photosensor are molded out of black plastic to reduce ambient light noise. The photosensor responds to radiation from the LED only when a reflective object passes within its field of view.

OPB168F or OP268F series emitters are used. The OPB706 utilizes an OP508 type sensor and the OPB707 utilizes an OP538 type photodarlington.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)
Operating Temperature Range . . . . −40°C to +85°C
Storage Temperature Range . . . . −40°C to +85°C
Soldering Temperature (1/16 in. [1.6 mm] from case for 3 sec. with soldering iron)[1] . . . . 240°C

Input Diode
Forward DC Current . . . . 50 mA
Peak Forward Current (Pulse Width = 1 μ sec., 300 pps) . . . . 3.0 A
Reverse DC Voltage . . . . 2.0 V
Power Dissipation . . . . 75 mW[2]

Output Photosensor
Collector-Emitter Voltage — OPB706 . . . . 30 V
OPB707 . . . . 15.0 V
Emitter-Collector Voltage . . . . 5.0 V
Collector DC Current — OPB706 . . . . 25 mA
OPB707 . . . . 125 mA
Power Dissipation — OPB706 . . . . 75 mW[2]
OPB707 . . . . 125 mW[3]

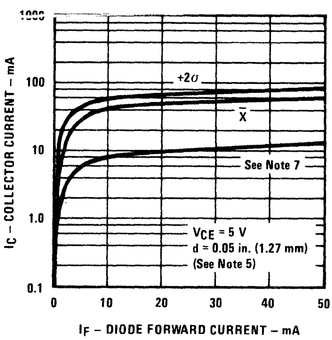
Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering.
(2) Derate linearly 1.36 mW/°C above 25°C.
(3) Derate linearly 2.27 mW/°C above 25°C.
(4) d is the distance from the assembly face to the reflective surface.
(5) Measured using an Eastman Kodak neutral white test card having 90% diffuse reflectance as a reflecting surface.
(6) Crosstalk (I_{CX}) is the collector current measured with the indicated current in the input diode and with no reflecting surface.
(7) Lower curve is based on a calculated worst case condition rather than the conventional -2σ limit.

Electrical Characteristics (T_A = 25°C ambient temperature unless otherwise noted)

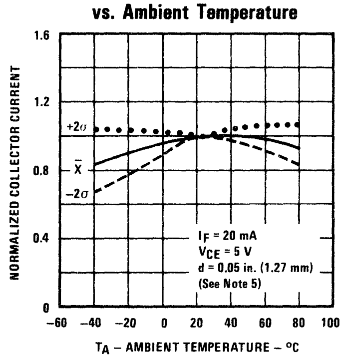
Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
Input Diode							
V_F	Forward Voltage				1.70	V	I_F = 20 mA
I_R	Reverse Current				100	μA	V_R = 2.0 V
Output Phototransistor							
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage		30			V	I_C = 100 μA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage		5.0			V	I_E = 100 μA
I_{CEO}	Collector Dark Current				100	nA	V_{CE} = 5.0 V, I_F = 0, $E_e \leq$ 0.1 μW/cm^2
Combined							
$I_{C(ON)}$	On State Collector Current	OPB706A	500	1000		μA	I_F = 20 mA, V_{CE} = 5.0 V, d = 0.050 in. (1.27 mm)[4][5]
		OPB706B	350	700		μA	
		OPB706C	200	400		μA	
I_{CX}	Crosstalk				200	nA	I_F=20 mA, V_{CE}=5.0 V, Note 6
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage				0.40	V	I_F = 20 mA, I_C = 100 μA, d = 0.050 in. [5][4]

Typical Performance Curves

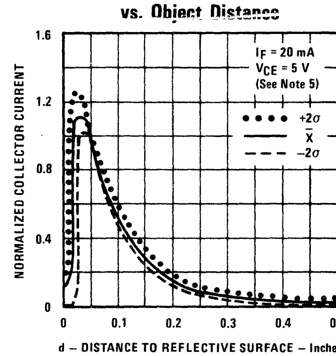
Collector Current vs. Diode Forward Current



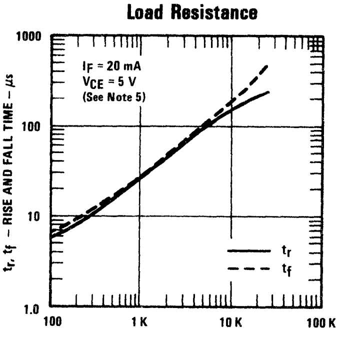
Normalized Collector Current vs. Ambient Temperature



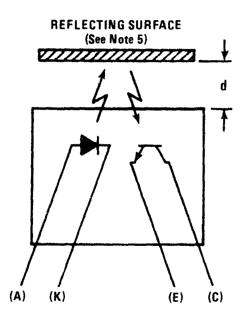
Normalized Collector Current vs. Object Distance



Rise and Fall Time vs. Load Resistance



Test Condition



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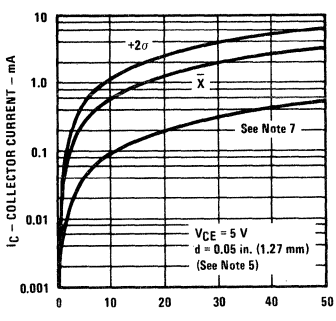
Type OPB707

Electrical Characteristics (T_A = 25°C ambient temperature unless otherwise noted)

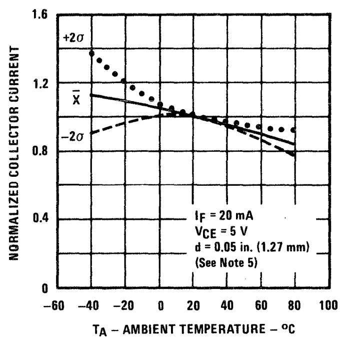
Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
Input Diode							
V_F	Forward Voltage				1.70	V	I_F = 20 mA
I_R	Reverse Current				100	μA	V_R = 2.0 V
Output Photodarlington							
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage		15.0			V	I_C = 100 μA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage		5.0			V	I_E = 100 μA
I_{CEO}	Collector Dark Current				250	nA	V_{CE} = 5.0 V, I_F = 0, $E_e \leq$ 0.1 μW/cm^2
Combined							
$I_{C(ON)}$	On-State Collector Current	OPB707A	25	50		mA	I_F = 20 mA, V_{CE} = 5.0 V, d = 0.050 in. (1.27 mm)[4][5]
		OPB707B	17.0	34		mA	
		OPB707C	10.0	20		mA	
I_{CX}	Crosstalk				10	μA	I_F = 20 mA, V_{CE} = 5.0 V. No Reflecting Surface.[6]
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage				1.10	V	I_F = 20 mA, I_C = 2.0 mA, d = 0.050 in.(1.27mm)[4][5]

Typical Performance Curves

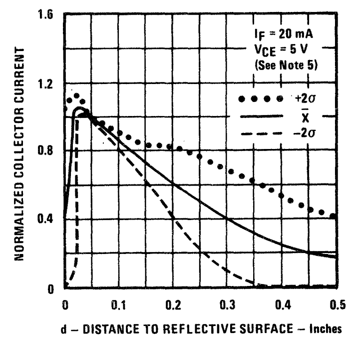
Collector Current vs. Diode Forward Current



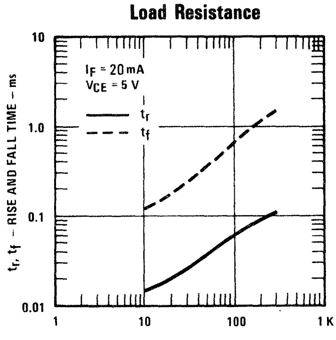
Normalized Collector Current vs. Ambient Temperature



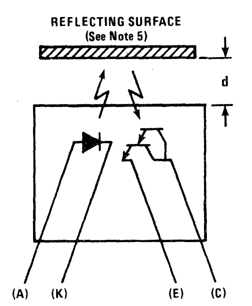
Normalized Collector Current vs. Object Distance



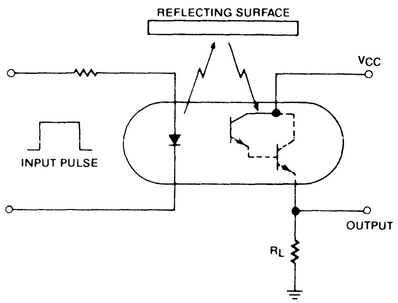
Rise and Fall Time vs. Load Resistance



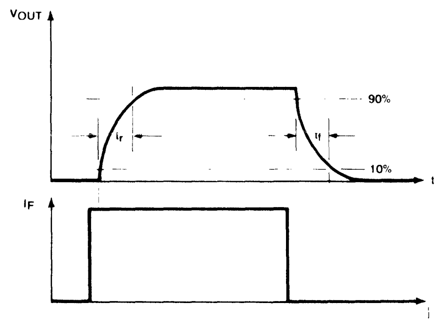
Test Condition



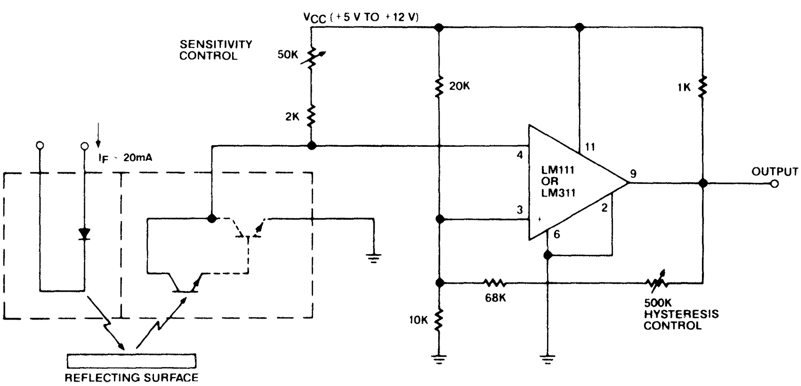
Response Time Test Circuit



Switching Time Waveforms



Typical Interfacing Circuit
Recommended for applications requiring adjustments on both sensitivity and hysteresis.



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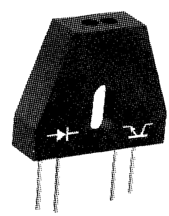
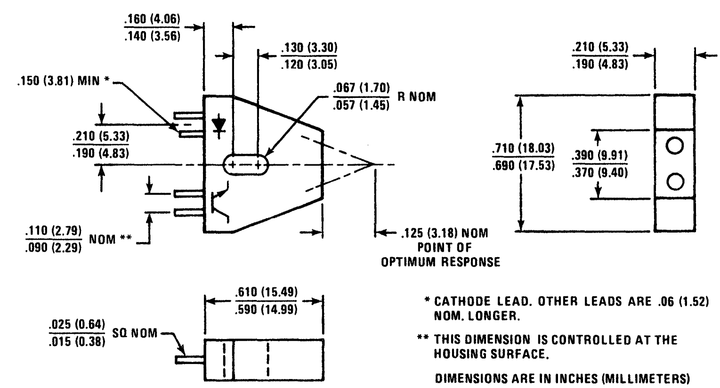
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5288
January 1985

Reflective Object Sensors
Types OPB708, OPB709





Features
- Focused for maximum sensitivity
- Phototransistor (OPB708) or photodarlington (OPB709) output
- Crosstalk does not exceed specified I_{CEO}
- Low cost plastic housing

Description
The OPB708 and OPB709 each consists of an infrared emitting diode and an NPN silicon phototransistor (OPB708) or photodarlington (OPB709) mounded side-by-side on converging optical axes, in a black plastic housing. Maximum sensitivity typically occurs .125 in. from the front of the housing. Housing material is flame retardant ABS which meets UL 94V-0 standards.

The photosensor responds to radiation from the LED only when a reflective object passes within its field of view.

Both parts are constructed using either OP160 or OP260 series LEDs. The OPB708 utilizes an OP500 type phototransistor and the OPB709 uses an OP530 type photodarlington.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

Storage Temperature Range	−40°C to +85°C
Operating Temperature Range	−40°C to +85°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)	240°C(1)
Input Diode	
Reverse Voltage	2.0 V
Continuous Forward Current	40 mA
Power Dissipation	60 mW(2)
Output Photosensor	
Collector-Emitter Voltage — OPB708	30 V
OPB709	15.0 V
Emitter-Collector Voltage	5.0 V
Power Dissipation — OPB708	50 mW(3)
OPB709	125 mW(4)

Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering.
(2) Derate linearly 1.09 mW/°C above 25°C.
(3) Derate linearly 0.91 mW/°C above 25°C.
(4) Derate linearly 2.27 mW/°C above 25°C.
(5) d is the distance from the assembly face to the reflective surface.
(6) Reflective surface is Eastman Kodak neutral white test card with 90% diffuse reflectance as a reflecting surface.
(7) Lower curve is based on a calculated worst case condition rather than the conventional -2σ limit.

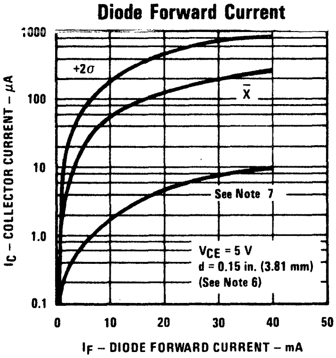
Type OPB708

Electrical Characteristics (T_A = 25°C unless otherwise noted)

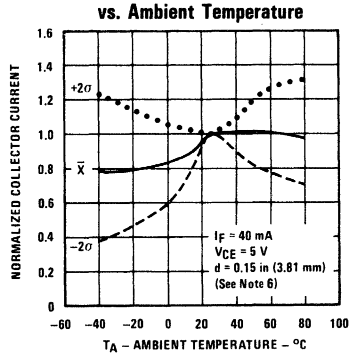
Symbol	Parameter	Min.	Max.	Units	Test Conditions
Input Diode					
V_F	Forward Voltage		1.70	V	I_F = 40 mA
I_R	Reverse Current		100	μA	V_R = 2.0 V
Output Phototransistor					
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	30		V	I_C = 100 μA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	5.0		V	I_E = 100 μA
I_{CEO}	Collector Dark Current		100	nA	V_{CE} = 10.0 V, I_F = 0, E_e = 0
Combined					
$I_{C(ON)}$	On-State Collector Current	10.0		μA	V_{CE} = 5.0 V, I_f = 40 mA, d = 0.150″ (3.81 mm)[5][6]
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage		0.40	V	I_F = 40 mA, I_C = 3.0 μA, d = 0.150″ (3.81 mm)[5][6]

Typical Performance Curves

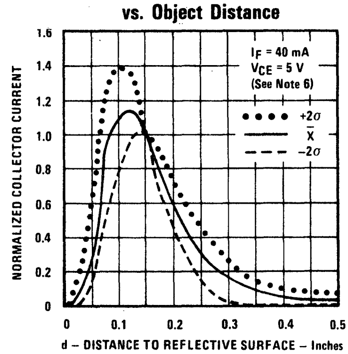
Collector Current vs. Diode Forward Current



Normalized Collector Current vs. Ambient Temperature



Normalized Collector Current vs. Object Distance



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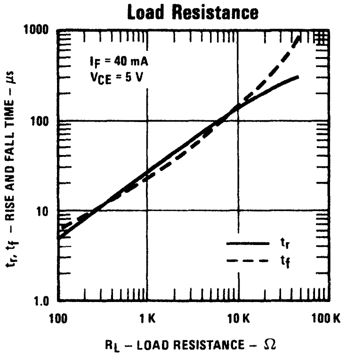
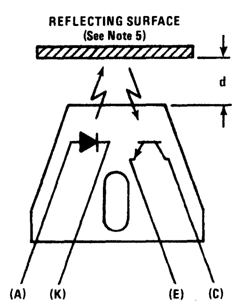
Rise and Fall Time vs. Load Resistance



Test Condition

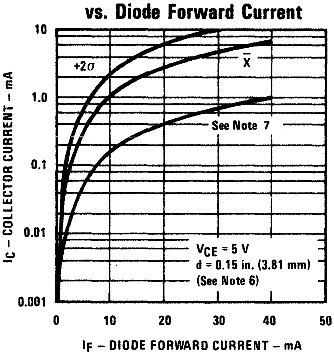


Electrical Characteristics (T_A=25°C unless otherwise noted)

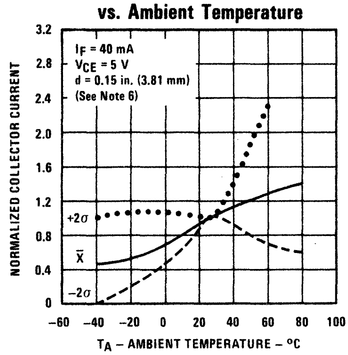
Symbol	Parameter	Min.	Max.	Units	Test Conditions
Input Diode					
V_F	Forward Voltage		1.70	V	I_F=40 mA
I_R	Reverse Current		100	μA	V_R=2.0 V
Output Photodarlington					
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	15.0		V	I_C=100 μA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	5.0		V	I_E=100 μA
I_{CEO}	Collector Dark Current		250	nA	V_{CE}=10.0 V, I_F=0, E_e=0
Combined					
$I_{C(ON)}$	On-State Collector Current	1.00		mA	V_{CE} = 5.0 V, I_f = 40 mA, d = 0.150″ (3.81 mm)(5)(6)
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage		1.10	V	I_F = 40 mA, I_C = 3.0 μA, d = 0.150″ (3.81 mm)(5)(6)

Typical Performance Curves

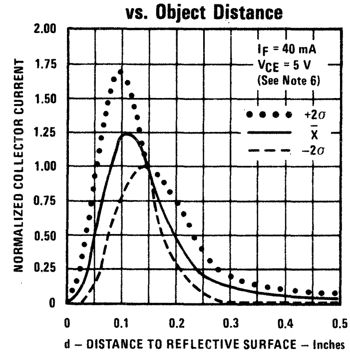
Collector Current vs. Diode Forward Current



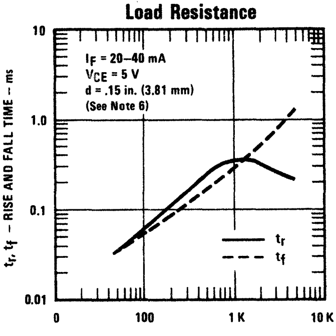
Normalized Collector Current vs. Ambient Temperature



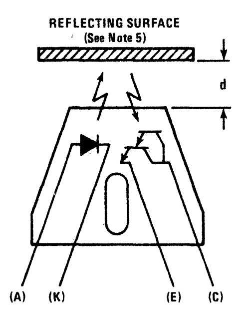
Normalized Collector Current vs. Object Distance



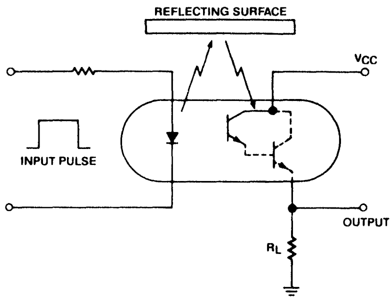
Rise and Fall Time vs. Load Resistance



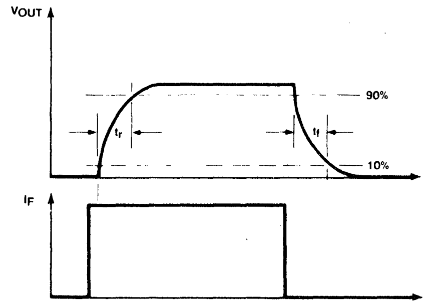
Test Condition



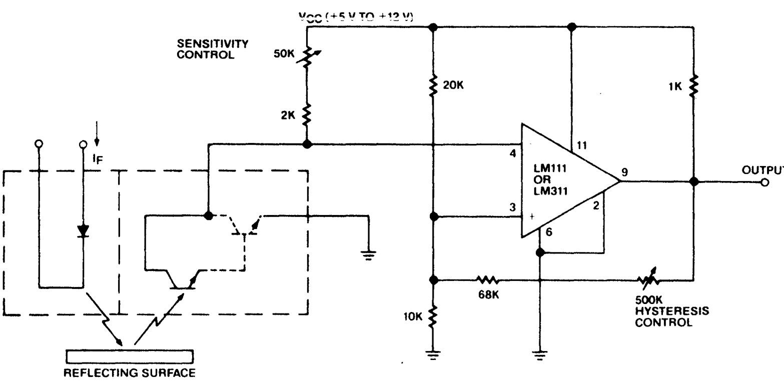
Response Time Test Circuit



Switching Time Waveforms



Typical Interfacing Circuit
Recommended for applications requiring adjustments on both sensitivity and hysteresis.



TRW assumes no responsibility for use of any circuits shown and makes no representation that they are free from patent infringement.

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TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

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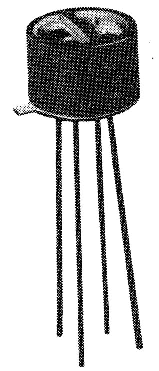
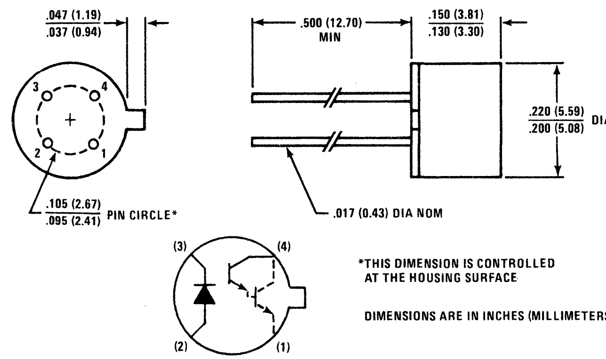
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5290
January 1985

Reflective Object Sensors
Types OPB710, OPB710F, OPB730, OPB730F





Features
- Phototransistor (OPB710/710F) or photodarlington (OPB730/730F) output
- Unfocused for sensing diffuse surfaces
- Mounted on standard TO-72 header
- Available in clear encapsulating epoxy (OPB710/730) or filtered (OPB710F/730F) to reduce the effect of visible or fluorescent light.

Description
The OPB710 and OPB710F each consist of a gallium arsenide infrared emitting diode and an NPN silicon phototransistor. The OPB730 and OPB730F have the same emitting diode but the detector is a photodarlington. The emitting diode and detector are mounted side by side on parallel axes on a standard TO-82 header. A black plastic sleeve is attached and filled with encapsulating epoxy to cover the emitter and detector. The "F" versions have a filter material added to the encapsulate to reduce the effect of ambient light. The package prevents diode emissions from reaching the sensor in front of the lens.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)
Storage Temperature Range . . . . −20°C to +85°C
Operating Temperature Range . . . . 0°C to +70°C
Lead Soldering Temperature (1/16 in. [1.6 mm] from case for 5 sec. with soldering iron) . . . . 240°C[1]

Input Diode
Forward DC Current . . . . 50 mA
Peak Forward Current (1 µs Pulse Width, 300 pps) . . . . 3.0 A
Reverse DC Voltage . . . . 3.0 V
Power Dissipation . . . . 75 mW[2]

Output Photosensor
Collector-Emitter Voltage . . . . 30 V
Emitter-Collector Voltage . . . . 5.0 V
Collector DC Current . . . . 25 mA
Power Dissipation . . . . 150 mW[3]

Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering.
(2) Derate linearly 1.67 mW/°C above 25°C.
(3) Derate linearly 3.3 mW/°C above 25°C.
(4) Measured using as a reflecting surface an Eastman Kodak neutral white test card having 90% diffuse reflectance located 0.250 in. (6.35 mm) from the face of the OPB710/730.
(5) Crosstalk (I_{CX}) is the collector current measured with the indicated current in the input diode and with no reflecting surface. Ambient light is excluded with a black box.

Electrical Characteristics (T_A = 25°C unless otherwise noted)

Symbol	Parameter	Min.	Max.	Units	Test Conditions
Input Diode					
V_F	Forward Voltage		1.50	V	I_F = 50 mA
I_R	Reverse Current		100	μA	V_R = 3.0 V
Output Phototransistor					
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	30		V	I_C = 1.00 mA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	5.0		V	I_E = 100 μA
I_{CEO}	Collector Dark Current		100	nA	V_{CE} = 5.0 V, I_F = 0, $E_e \leq$ 0.100 μW/cm[2]
Combined					
$I_{C(ON)}$	On-State Collector Current	150		μA	I_F = 50 mA, V_{CE} = 5.0 V, d = 0.250 in. (6.35 mm). See Test Condition[(4)]
I_{CX}	Crosstalk		400	nA	I_F = 50 mA, V_{CE} = 5.0 V. No Reflecting Surface.[(6)]

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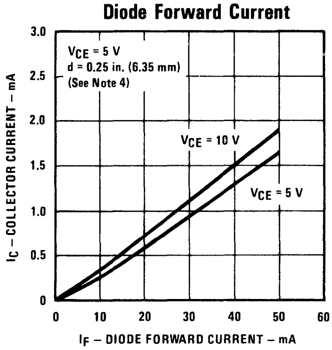
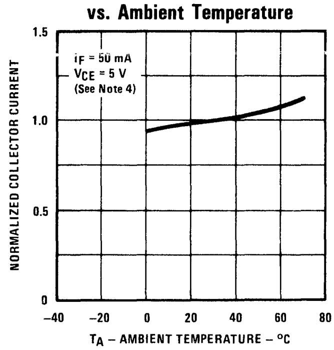
Typical Performance Curves

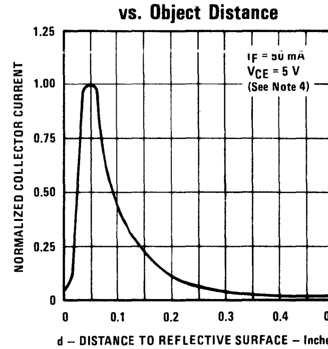
Collector Current vs. Diode Forward Current



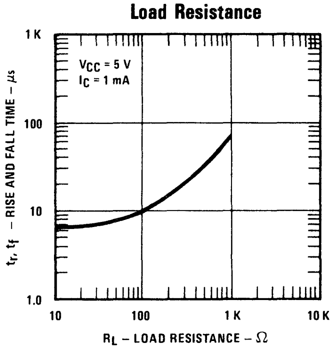
Normalized Collector Current vs. Ambient Temperature



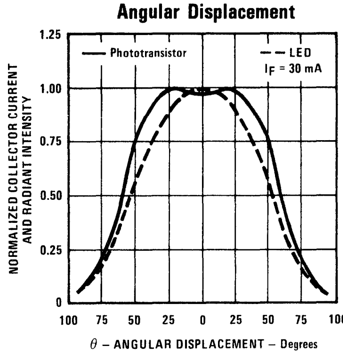
Normalized Collector Current vs. Object Distance



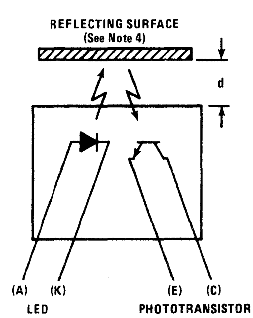
Rise and Fall Time vs. Load Resistance



LED and Phototransistor Angular Displacement



Test Condition

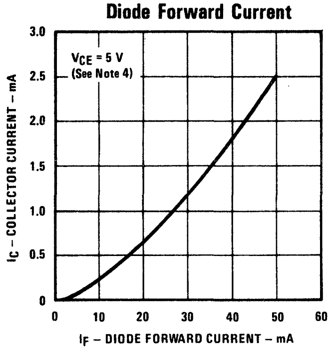


Electrical Characteristics (T_A = 25°C unless otherwise noted)

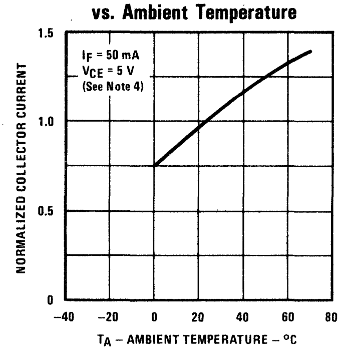
Symbol	Parameter	Min.	Max.	Units	Test Conditions
Input Diode					
V_F	Forward Voltage		1.50	V	I_F = 50 mA
I_R	Reverse Current		100	μA	V_R = 3.0 V
Output Photodarlington					
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	30		V	I_C = 1.00 mA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	5.0		V	I_E = 100 μA
I_{CEO}	Collector Dark Current		250	nA	V_{CE} = 5.0 V, I_F = 0, $E_e \leq$ 0.100 $\mu W/cm^2$
Combined					
$I_{C(ON)}$	On-State Collector Current	1.00		mA	I_F = 50 mA, V_{CE} = 5.0 V, d = 0.250 in. (6.35 mm). See Test Condition[4]
I_{CX}	Crosstalk		500	nA	I_F = 50 mA, V_{CE} = 5.0 V. No Reflecting Surface.[5]

Typical Performance Curves

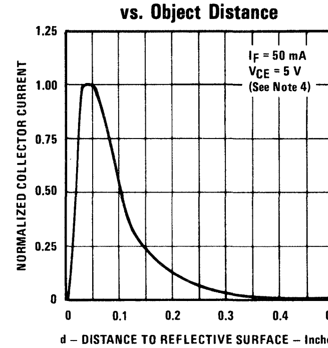
Collector Current vs. Diode Forward Current



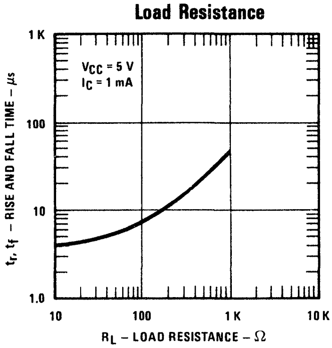
Normalized Collector Current vs. Ambient Temperature



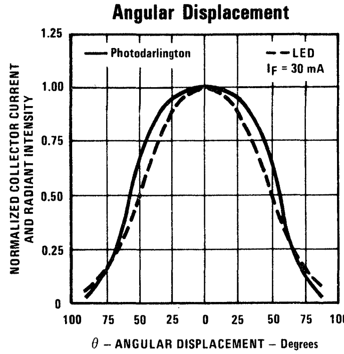
Normalized Collector Current vs. Object Distance



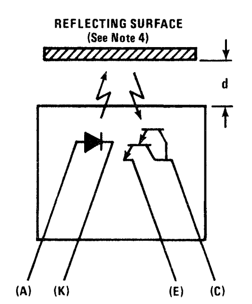
Rise and Fall Time vs. Load Resistance



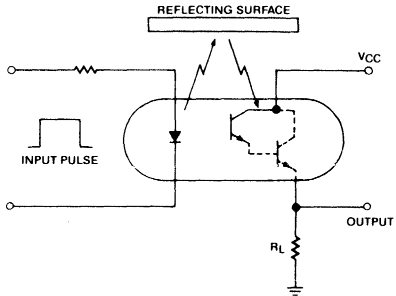
LED and Photodarlington Angular Displacement



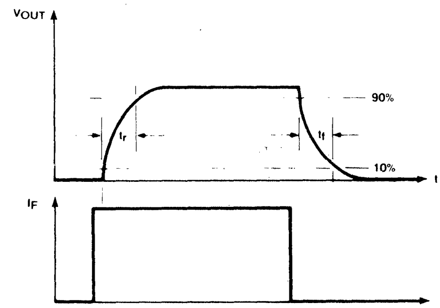
Test Condition



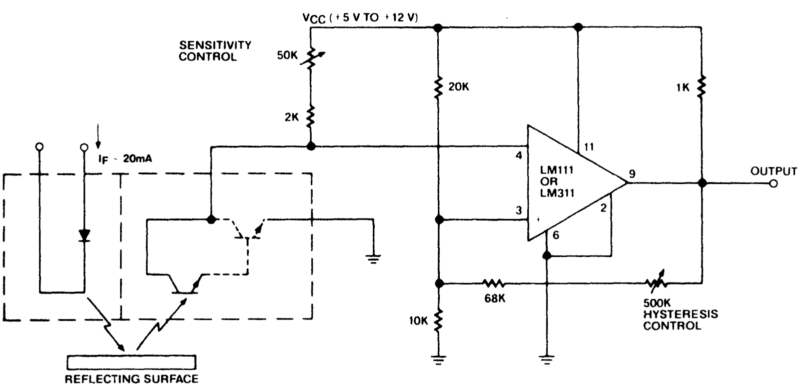
Response Time Test Circuit



Switching Time Waveforms



Typical Interfacing Circuit
Recommended for applications requiring adjustments on both sensitivity and hysteresis.



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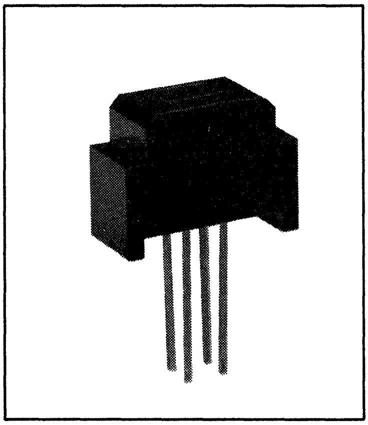
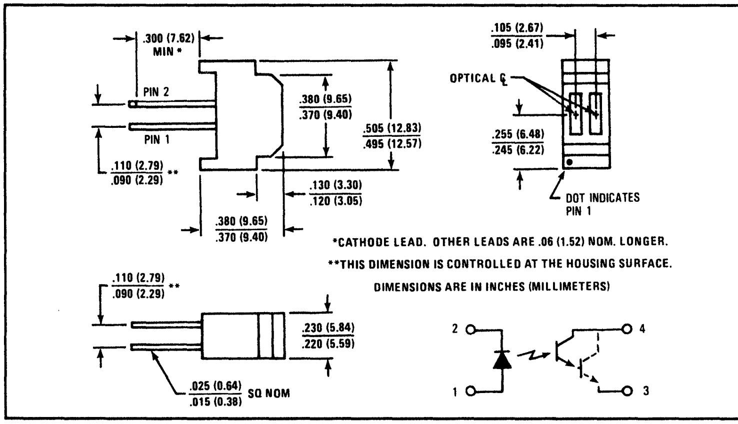
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5292
January 1985

Reflective Object Sensors
Types OPB711, OPB712





Features
- Phototransistor (OPB711) or photodarlington (OPB712) output
- Unfocused for sensing diffuse surfaces
- Low cost plastic housing

Description
The OPB711 and OPB712 each consist of an infrared emitting diode and an NPN silicon phototransistor (OPB711) or photodarlington (OPB712) mounted side-by-side on parallel axes, in a black plastic housing. Both the emitting diode and photosensor are molded out of black plastic to reduce ambient light noise. The photosensor responds to radiation from the LED only when a reflective object passes within its field of view.

The OPB711 utilizes the OP168 or OP268 LED and the OP508 sensor. The OPB712 utilizes the OP168 or OP268 LED and the OP538 photodarlington.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)
Storage and Operating Temperature Range . . . . . . −40°C to +85°C
Lead Soldering Temperature (1/16 in. [1.6 mm] from case for 5 sec. with soldering iron)[1] . . . . . . 240°C

Input Diode
Reverse DC Voltage . . . . . . 2.0 V
Forward DC Current . . . . . . 50 mA
Peak Forward Current (1 μs pulse width, 300 pps) . . . . . . 3.0 mA
Power Dissipation . . . . . . 80 mW[2]

Output Photosensor
Collector-Emitter Voltage — OPB711 . . . . . . 30 V
OPB712 . . . . . . 15.0 V
Emitter-Collector Voltage . . . . . . 5.0 V
Collector DC Current — OPB711 . . . . . . 25 mA
OPB712 . . . . . . 125 mA
Power Dissipation — OPB711 . . . . . . 80 mW[2]
OPB712 . . . . . . 125 mW[7]

Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering.
(2) Derate linearly 1.33 mW/°C above 25°C.
(3) d is the distance from the assembly head to the reflective surface.
(4) Measured using an Eastman Kodak neutral white test card with 90% diffuse reflectance as a reflecting surface.
(5) Crosstalk (I_{CX}) is the collector current measured with the indicated current in the input diode and with no reflecting surface.
(6) Lower curve is based on a calculated worst case condition rather than the conventional -2σ limit.
(7) Derate linearly 2.27 mW/°C above 25°C.
(8) Performance curves are those of the OPB706 (OPB707). These curves represent the response of the OPB711 (OPB712) at the same conditions.

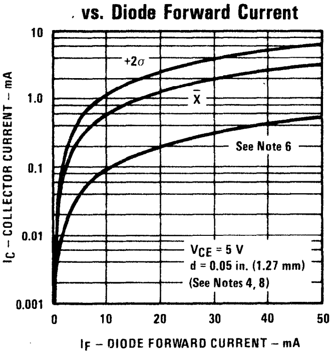
Type OPB711

Electrical Characteristics (T_A = 25°C unless otherwise noted)

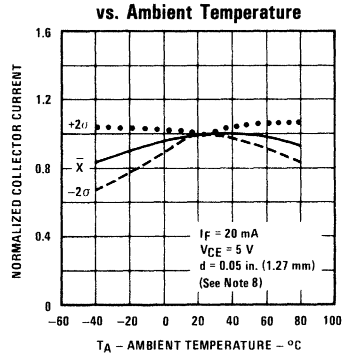
Symbol	Parameter	Min.	Max.	Units	Test Conditions
Input Diode					
V_F	Forward Voltage		1.70	V	I_F = 20 mA
I_R	Reverse Current		100	μA	V_R = 2.0 V
Output Phototransistor					
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	30		V	I_C = 100 μA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	5.0		V	I_E = 100 μA
I_{CEO}	Collector Dark Current		100	nA	V_{CE} = 10.0 V, I_F = 0, $E_e \leq$ 0.100 μW/cm²
Combined					
$I_{C(ON)}$	On-State Collector Current[4]	350		μA	I_F = 20 mA, V_{CE} = 5.0 V, d = 0.080 in. (2.03 mm)[3][4].
I_{CX}	Crosstalk[5]		100	nA	V_{CE} = 5.0 V, I_F = 20 mA. No Reflecting Surface[5].
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage		0.40	V	I_F = 20 mA, I_C = 50 μA, d = 0.080 in.(2.03mm)[3][4]

Typical Performance Curves

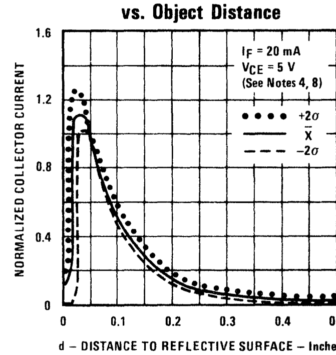
Collector Current vs. Diode Forward Current



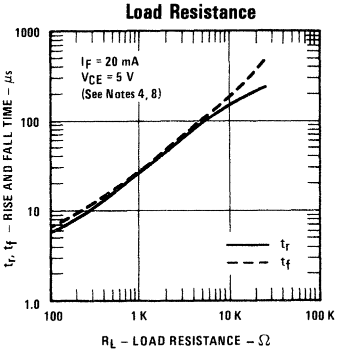
Normalized Collector Current vs. Ambient Temperature



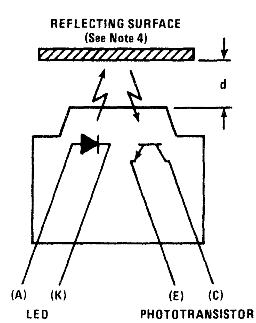
Normalized Collector Current vs. Object Distance



Rise and Fall Time vs. Load Resistance



Test Condition



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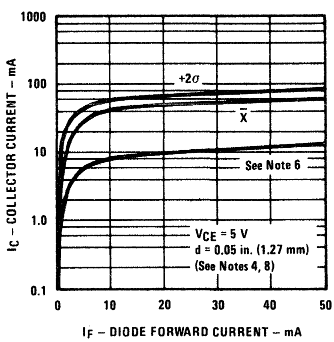
Type OPB712

Electrical Characteristics (T_A = 25°C unless otherwise noted)

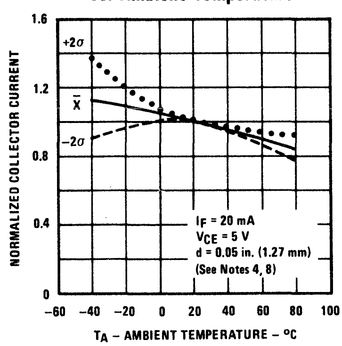
Symbol	Parameter	Min.	Max.	Units	Test Conditions
Input Diode					
V_F	Forward Voltage		1.70	V	I_F = 20 mA
I_R	Reverse Current		100	μA	V_R = 2.0 V
Output Photodarlington					
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	15.0		V	I_C = 100 μA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	5.0		V	I_E = 100 μA
I_{CEO}	Collector Dark Current		250	nA	V_{CE} = 10.0 V, I_F = 0, $E_e \leq$ 0.100 μW/cm²
Combined					
$I_{C(ON)}$	On-State Collector Current	20		mA	I_F = 20 mA, V_{CE} = 5.0 V, d = 0.080 in. (2.03 mm)[3][4]
I_{CX}	Crosstalk[5]		250	nA	V_{CE} = 5.0 V, I_F = 20 mA. No Reflecting Surface[5].
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage		1.10	V	I_F = 20 mA, I_C = 5.0 mA, d = 0.080 in.(2.03mm)[3][4]

Typical Performance Curves

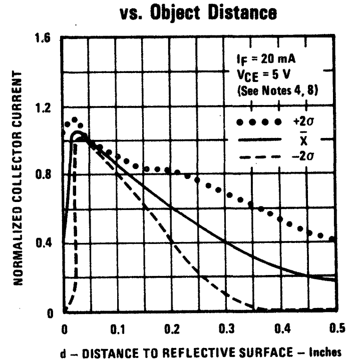
Collector Current vs. Diode Forward Current



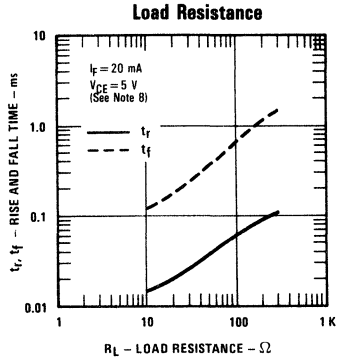
Normalized Collector Current vs. Ambient Temperature



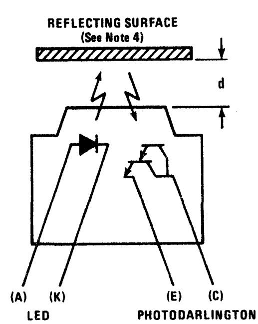
Normalized Collector Current vs. Object Distance



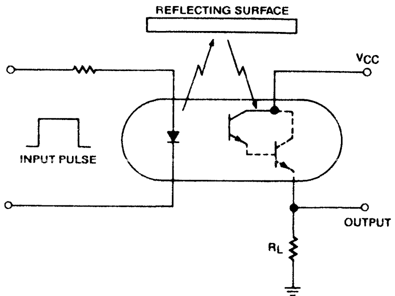
Rise and Fall Time vs. Load Resistance



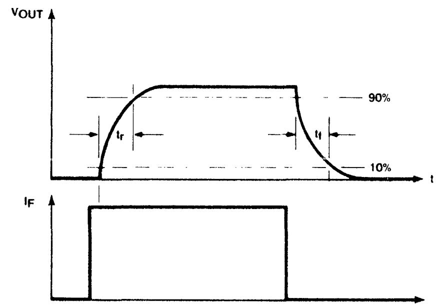
Test Condition



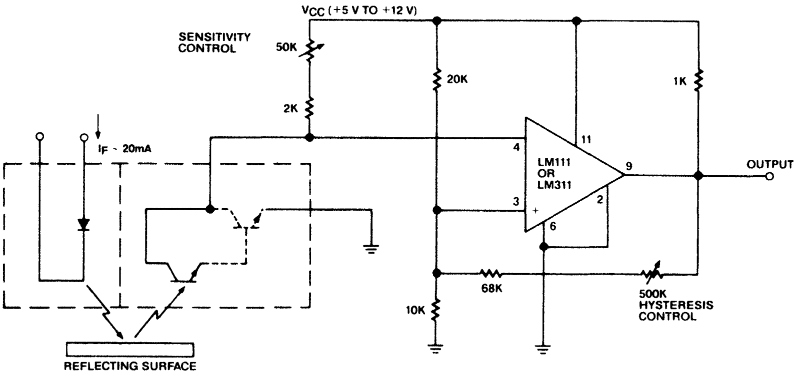
Response Time Test Circuit



Switching Time Waveforms



Typical Interfacing Circuit
Recommended for applications requiring adjustments on both sensitivity and hysteresis.



TRW assumes no responsibility for use of any circuits shown and makes no representation that they are free from patent infringement.

G

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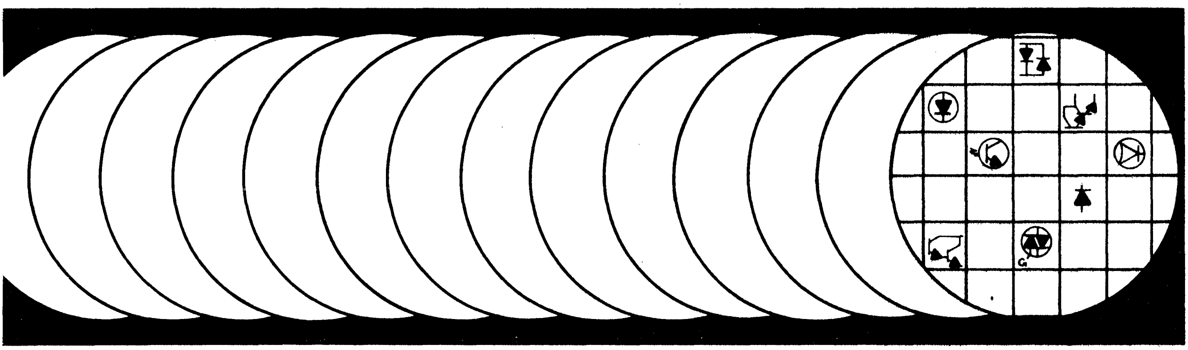
TRW



Slotted Optical Switches

H

Slotted Optical Switches

Slotted optical switches, also known as transmissive assemblies or gap switches, are motion or position sensors. They operate on the principle that an object opaque to infrared light transmission will block light in the path between an infrared emitting diode (IRED) and a photosensor.

Slotted optical switches provide non-contact sensing of linear or rotary motion as in optical encoders. They find a variety of uses in industrial controls, computers peripherals and other instrumentation. They can signal:

- conveyor feed rates
- door positions on disk drives
- end-of-carriage return on data processing printers
- seating of tape cartridges

and they have many more applications.

A TRW slotted switch consists of an IRED and a silicon photosensor, each mounted on opposite sides of a slot in a molded plastic housing . When the gap is open or when material transparent to IR transmission passes through the slot, light reaches the photosensor allowing it to conduct current and the switch is "on." When an object opaque to IR transmission passes through the slot, the IR transmission is blocked, the photosensor does not conduct, and the switch is "off."

The speed of the switch is often an important application consideration. The overall switching time depends on the device chosen to serve as the photosensor. For example, a photo-darlington switches in milliseconds; a phototransistor, in microseconds; and a TRW Photologic™ device (which is a photo-integrated circuit), in the low nanosecond range. In many designs, the mechanical turn-off and turn-on times for the equipment being controlled are much longer than the switching times of the photosensor.

Position Sensors

These sensors are electromechanical devices that detect the position or rate of change of position of a mechanism and translate the monitored information into useful output. A good example is the tachometer, which is a rotary encoder sensing slots in a wheel. The switch produces a pulse for every slot on the wheel. The number of pulses versus time provides a readout of the motor speed.

Standard switches can easily read 0.010 inch widths in etched metal on molded plastic disks. Typically the slots are rectangular in shape. Maximum resolution is achieved by the narrowest of detectable apertures. Designs calling for narrower apertures than 0.010 inches are possible but may require custom designed and higher priced switches.

Application Bulletin 116, printed in this data book, discusses linear and rotary encoders in depth. Application Bulletins 112 and 120 discuss specific TRW interruptive assemblies for encoding and other functions.

Housing Material and Other Considerations

Housings for slotted optical switches do two things: they hold the IRED and photosensor in permanent fixed positions, and they contain mounting holes or other means of attchment to the equipment. The materials most commonly used for TRW slotted optical switch housings are polycarbonate and polysulfone, although other plastics may be used for specific applications. Injection molding techniques are used to form the plastic housing.

If the interruptive assembly is to be used in a high dust and dirt environment, an infrared-transparent polysulfone housing is recommended. Such housings do not contain the mechanical apertures or openings which can collect dust and reduce light transmission. in other applications, the polycarbonate housing, which is opaque to both infrared and visible light, is preferred.

For special applications that require special materials for the housings, TRW can custom design a housing part to match exact specifications.

Options for Selecting A Slotted Optical Switch

Design considerations of speed, resolution, length of optical path, environment, performance and cost impinge upon the proper selection of interruptive assemblies. TRW offers the engineer a wide selection of assemblies to meet exact design requirements. TRW offers slotted optical switches with the following options:

1. Phototransistor, photodarlington or Photologic™ output.
   a. Phototransistor output in various output ranges.
   b. Photologic™ output in four different output variations.
2. Gallium arsenide or gallium aluminum arsenide IREDs.
3. Dual channel devices in side-by-side or over/under configuration for speed, direction of movement and relative position sensing.
4. Various slot widths and depths.
5. Different sensor and emitter lead spacings.
6. Different aperture widths in front of sensor and emitter.
7. Different mounting configurations and housing styles.
8. Housing materials: polycarbonate or polysulfone.
9. Lead wires and connectors: standard leads or 18″ (minimum length) lead wires

Custom Design of Interruptive Assemblies

In cases where unique specifications call for a custom design, TRW can work closely with the customer to produce the optimum interruptive slotted optical switch. Such designs can vary from slight adjustments to standard parts to completely new mechanical configurations.

Typical Applications

- Printers
- Electric watt-hour meters
- Copying machines
- Coin changers
- Disk drives
- Medical equipment
- Paper sorting equipment
- Typewriters
- Amusement games
- Liquid level sensing equipment
- Touch panel applications

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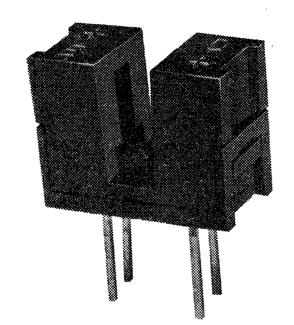
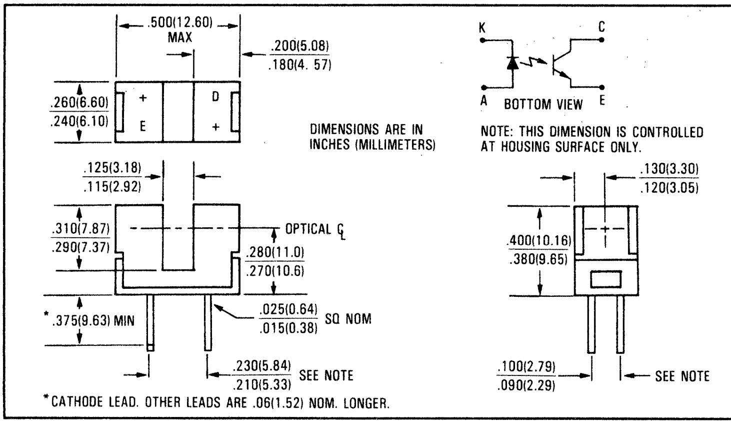
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5312
January 1985

Slotted Optical Switch
Type CNY36

Not recommended for new design. See OPB860 Series





Features
- Non-contact switching
- Printed circuit board mounting
- Compact construction
- Fast switching speed

Description
The CNY36 consists of an infrared emitting diode and an NPN silicon phototransistor mounted in a low cost plastic housing on opposite sides of a 0.120″ (3.05 mm) wide slot. Phototransistor switching takes place whenever an opaque object passes through the slot.

The CNY36 uses an OP140 series emitter and an OP550 series sensor.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)
Storage and Operating Temperature Range . . . . . . −40°C to +85°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron) . . . . . . 240°C(1)

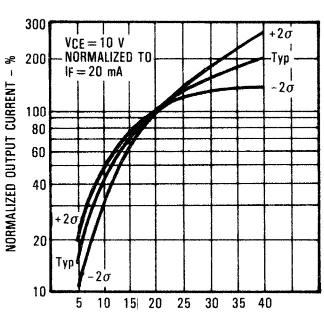
Input Diode
Reverse Voltage . . . . . . 2.0 V
Continuous Forward Current . . . . . . 50 mA
Peak Forward Current (1 μs pulse width, 300 pps) . . . . . . 3.0 A
Power Dissipation . . . . . . 100 mW(2)

Output Phototransistor
Collector-Emitter Voltage . . . . . . 32 V
Emitter-Collector Voltage . . . . . . 5.0 V
Power Dissipation . . . . . . 100 mW(2)

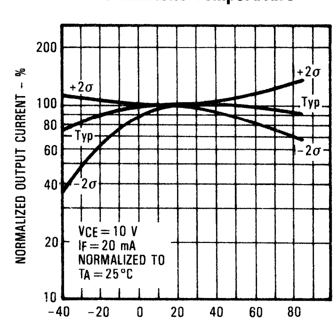
Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(2) Derate linearly 1.33 mW/°C above 25°C.
(3) Methanol or isopropanol alcohols are recommended as cleaning agents. Plastic housing is soluble in chlorinated hydrocarbons and ketones.

Typical Performance Curves

Normalized Output Current vs Forward Current



Normalized Output Current vs Ambient Temperature



Type CNY36

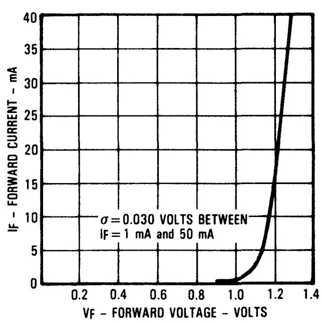
Not recommended for new design.
See OPB860 Series

Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

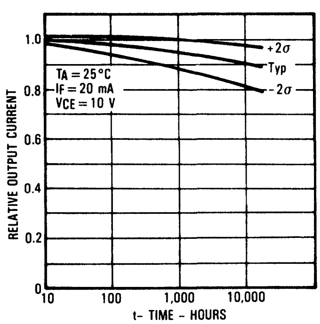
Symbol	Parameter	Min.	Max.	Units	Test Conditions
Input Diode					
V_F	Forward Voltage		1.50	V	$I_F = 20$ mA
I_R	Reverse Current		100	μA	$V_R = 2.0$ V
Output Phototransistor					
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	32		V	$I_C = 1.00$ mA, $E_e = 0$
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	5.0		V	$I_E = 100$ μA, $E_e = 0$
I_{CEO}	Collector-Emitter Dark Current		100	nA	$V_{CE} = 10.0$ V, $I_F = 0$, $E_e = 0$
Coupled					
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage		0.40	V	$I_C = 25$ μA, $I_F = 20$ mA
$I_{C(ON)}$ (3)	Collector Current	200		μA	$V_{CE} = 10.0$ V, $I_F = 20$ mA

Typical Performance Curves

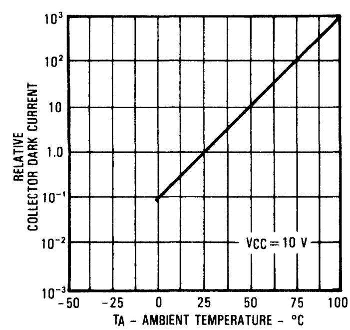
Forward Current vs Forward Voltage Input Diode



Relative Output Current vs Time



Relative Collector Dark Current vs Ambient Temperature



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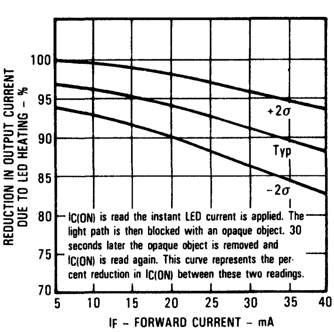
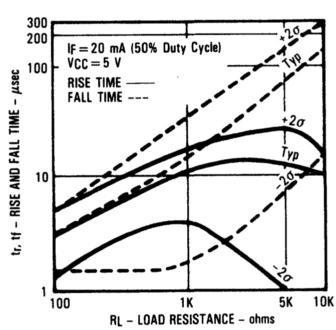
Reduction in Output Current Due to LED Heating vs Forward Current



Rise and Fall Time vs vs Load Resistance

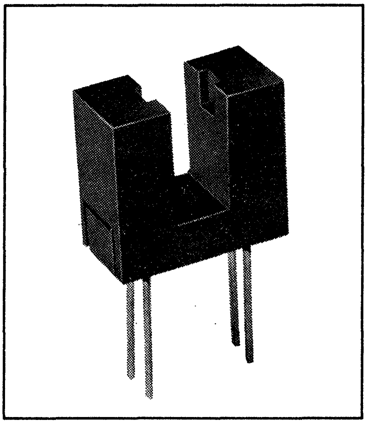


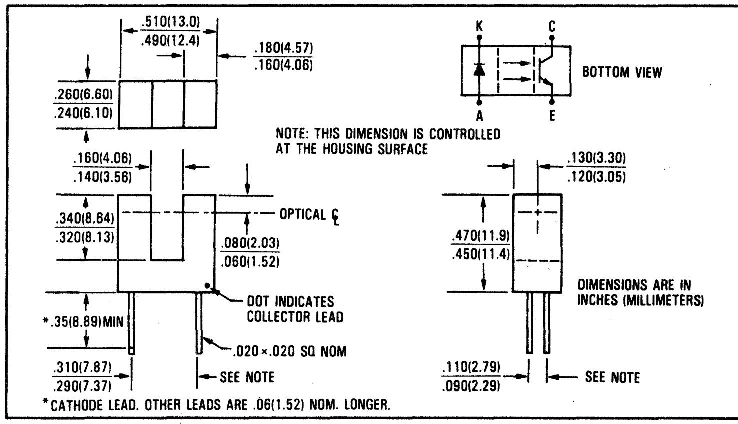
TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5314
January 1985

Slotted Optical Switch
Type OPB804





Features
- Non-contact switching
- Printed circuit board mounting
- Compact construction
- Fast switching speed

Description
The OPB804 consists of an infrared emitting diode and an NPN silicon phototransistor mounted in a low cost plastic housing on opposite sides of a 0.155″ (3.94 mm) wide slot. Phototransistor switching takes place whenever an opaque object passes through the slot.

The OPB804 utilizes either an OP140 or an OP240 series emitter with an OP550 series sensor.

Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)
Storage and Operating Temperature Range . . . . −40°C to +85°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron) . . . . 240°C(1)

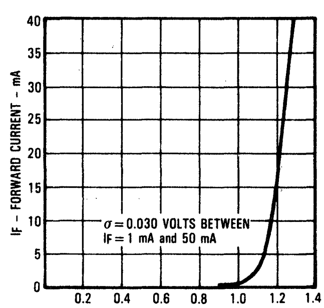
Input Diode
Reverse Voltage . . . . 2.0 V
Continuous Forward Current . . . . 50 mA
Peak Forward Current (1 μs pulse width, 300 pps) . . . . 3.0 A
Power Dissipation . . . . 100 mW(2)

Output Phototransistor
Collector-Emitter Voltage . . . . 30 V
Emitter-Collector Voltage . . . . 5.0 V
Power Dissipation . . . . 100 mW(2)

Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(2) Derate linearly 1.33 mW/°C above 25°C.
(3) Methanol or isopropanol alcohols are recommended as cleaning agents.

Typical Performance Curves

Forward Current vs Forward Voltage Input Diode



Type OPB804

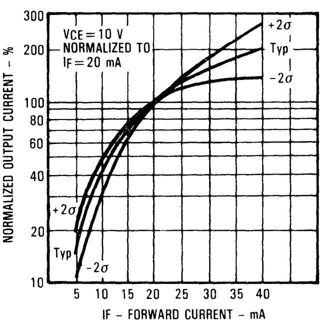
Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

Symbol	Parameter	Min.	Max.	Units	Test Conditions
Input Diode					
V_F	Forward Voltage		1.70	V	$I_F = 20$ mA
I_R	Reverse Current		100	μA	$V_R = 2.0$ V
Output Phototransistor					
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	30		V	$I_C = 1.00$ mA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	5.0		V	$I_E = 100$ μA
I_{CEO}	Collector Dark Current		100	nA	$V_{CE} = 10.0$ V, $I_F = 0$, $E_e = 0$
Coupled					
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage		0.40	V	$I_F = 20$ mA, $I_C = 250$ μA
$I_{C(ON)}$	On-State Collector Current	500		μA	$I_F = 20$ mA, $V_{CE} = 10.0$ V

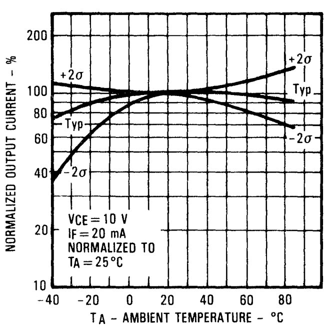
H

Typical Performance Curves

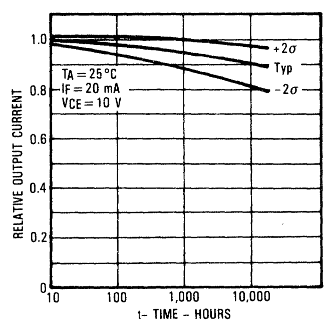
Normalized Output Current vs Forward Current



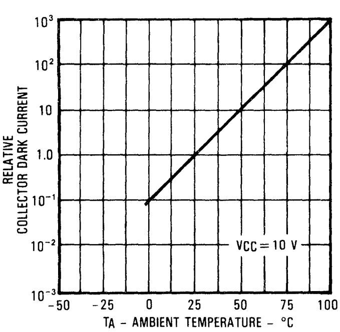
Normalized Output Current vs Ambient Temperature



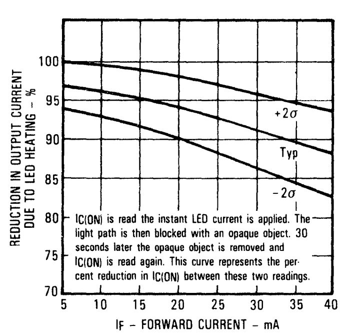
Relative Output Current vs Time



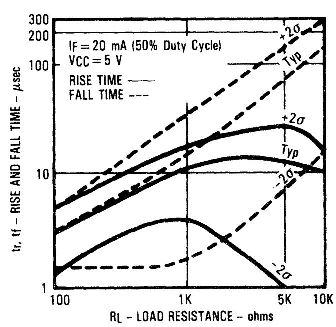
Relative Collector Dark Current vs Ambient Temperature



Reduction in Output Current Due to LED Heating vs Forward Current

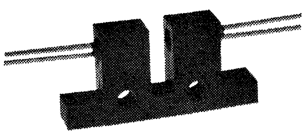


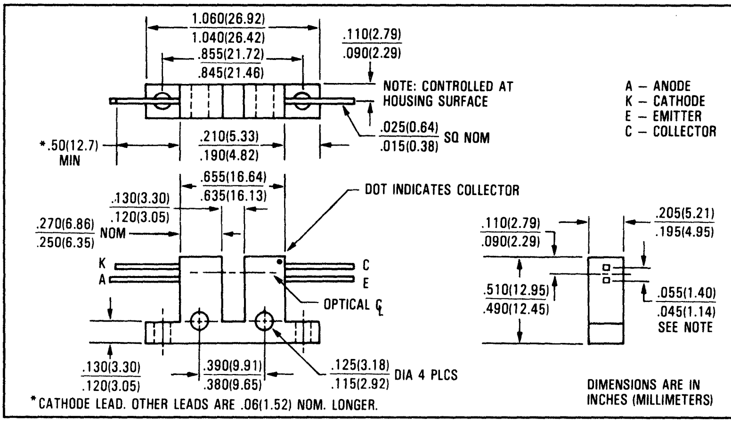
Rise and Fall Time vs Load Resistance



TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

Slotted Optical Switch
Type OPB806





Features
- Non-contact switching
- Base or side mounting
- Fast switching speed

Description
The OPB806 consists of an infrared emitting diode and an NPN silicon phototransistor mounted in a low cost plastic housing on opposite sides of a 0.125″ (3.18 mm) wide slot. Phototransistor switching takes place whenever an opaque object passes through the slot.

The OPB806 utilizes an OP160 or OP260 LED and an OP500 family sensor.

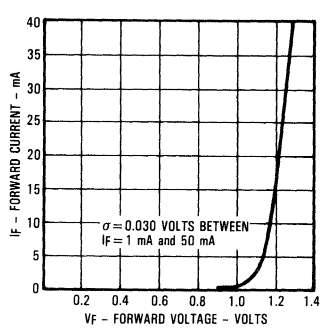
Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)
Storage and Operating Temperature Range . . . . −40°C to +85°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron) . . . . 240°C[1]

Input Diode
Reverse Voltage . . . . 2.0 V
Continuous Forward Current . . . . 50 mA
Peak Forward Current (1 μs pulse width, 300 pps) . . . . 3.0 A
Power Dissipation . . . . 100 mW[2]

Output Phototransistor
Collector-Emitter Voltage . . . . 30 V
Emitter-Collector Voltage . . . . 5.0 V
Power Dissipation . . . . 100 mW[2]

Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(2) Derate linearly 1.33 mW/°C above 25°C.
(3) Methanol or isopropanol alcohols are recommended as cleaning agents.

Typical Performance Curves
Forward Current vs Forward Voltage Input Diode



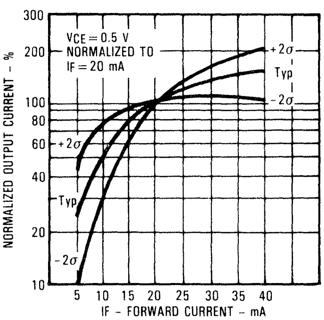
Type OPB806

Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

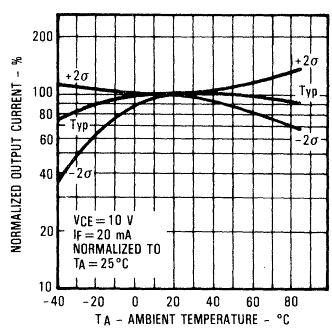
Symbol	Parameter	Min.	Max.	Units	Test Conditions
Input Diode					
V_F	Forward Voltage		1.70	V	$I_F = 20$ mA
I_R	Reverse Current		100	μA	$V_R = 2.0$ V
Output Phototransistor					
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	30		V	$I_C = 100$ μA, H = 0
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	5.0		V	$I_E = 100$ μA, H = 0
I_{CEO}	Collector-Emitter Dark Current		100	nA	$V_{CE} = 10.0$ V, $I_F = 0$, $E_e = 0$
Coupled					
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage		0.50	V	$I_F = 20$ mA, $I_C = 200$ μA
$I_{C(ON)}$	On-State Collector Current	0.40		mA	$V_{CE} = 0.5$ V, $I_F = 20.0$ mA

Typical Performance Curves

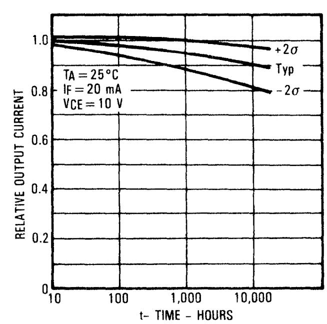
Normalized Output Current vs Forward Current



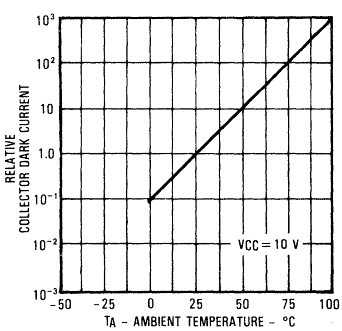
Normalized Output Current vs Ambient Temperature



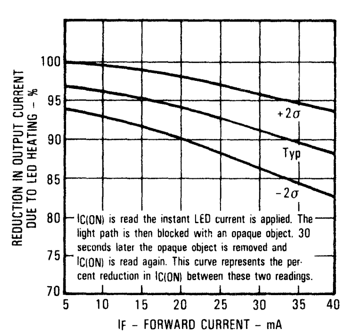
Relative Output Current vs Time



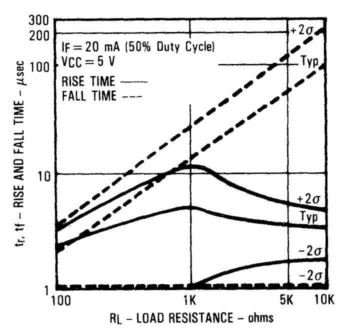
Relative Collector Dark Current vs Ambient Temperature



Reduction in Output Current Due to LED Heating vs Forward Current



Rise and Fall Time vs Load Resistance



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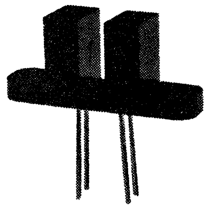
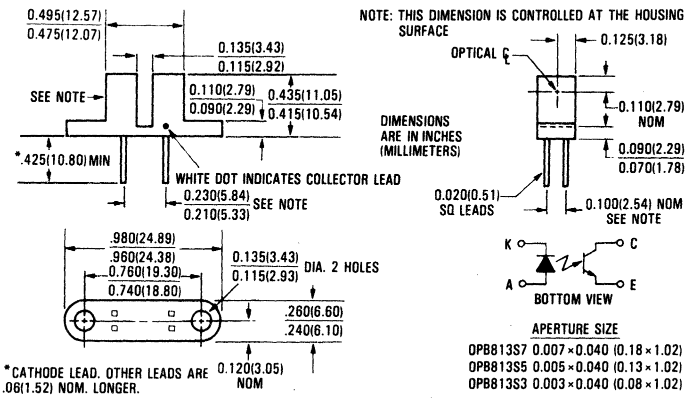
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5319
January 1985

High Resolution Slotted Optical Switches
Types OPB813S7, OPB813S5, OPB813S3





Features
- Non-contact switching
- Four standard aperture sizes
- Completely sealed polysulfone housing
- Fast switching speed

Description
The OPB813S7, OPB813S5 and OPB813S3 each consist of an infrared emitting diode and an NPN silicon phototransistor mounted on opposite sides of a 0.125" (3.18 mm) wide slot. Phototransistor switching takes place whenever an opaque object passes through the slot. The low cost polysulfone housing reduces possible interference from ambient light and provides dirt and dust protection. High resolution position sensing is achieved by using one of four standard aperture sizes.

The OPB813S7, OPB813S5, and OPB813S3 utilize an OP140 or OP240 LED and an OP550 family sensor.

Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)
Storage and Operating Temperature Range . . . . −40°C to +85°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron) . . . . 240°C(1)

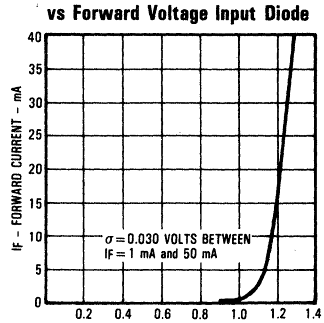
Input Diode
Reverse DC Voltage . . . . 2.0 V
Continuous Forward Current . . . . 50 mA
Peak Forward Current (1 μs pulse width, 300 pps) . . . . 3.0 A
Power Dissipation . . . . 100 mW(2)

Output Phototransistor
Collector-Emitter Voltage . . . . 30 V
Emitter-Collector Voltage . . . . 5.0 V
Power Dissipation . . . . 100 mW(2)

Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(2) Derate linearly 1.33 mW/°C above 25°C.
(3) Plastic housing is soluble in chlorinated hydrocarbons and ketones. Methanol or isopropanol are recommended as cleaning agents.

Typical Performance Curves

Forward Current vs Forward Voltage Input Diode



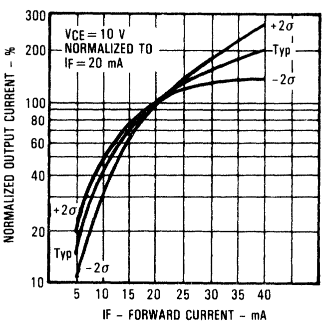
Type OPB813S7, OPB813S5, OPB813S3

Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

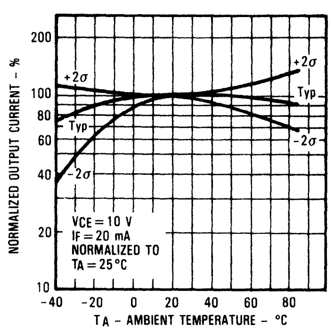
Symbol	Parameter		Min.	Max.	Units	Test Conditions
Input Diode						
V_F	Forward Voltage			1.70	V	$I_F = 20$ mA
I_R	Reverse Current			100	μA	$V_R = 2.0$ V
Output Phototransistor						
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage		30		V	$I_C = 1.0$ mA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage		5.0		V	$I_E = 100$ μA
I_{CEO}	Collector-Emitter Dark Current			100	nA	$V_{CE} = 10.0$ V, $I_F = 0$, $E_e = 0$
Coupled						
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage	OPB813S7		0.40	V	$I_F = 20$ mA, $I_C = 175$ μA
		OPB813S5		0.40	V	$I_F = 20$ mA, $I_C = 125$ μA
		OPB813S3		0.40	V	$I_F = 20$ mA, $I_C = 40$ μA
$I_{C(ON)}$	On-State Collector Current	OPB813S7	350		μA	$I_F = 20$ mA, $V_{CE} = 10$ V
		OPB813S5	250		μA	$I_F = 20$ mA, $V_{CE} = 10$ V
		OPB813S3	75		μA	$I_F = 20$ mA, $V_{CE} = 10$ V

Typical Performance Curves

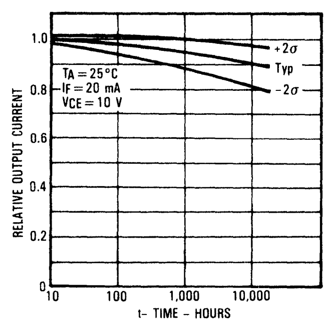
Normalized Output Current vs Input Current



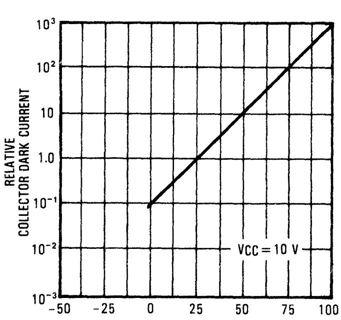
Normalized Output Current vs Ambient Temperature



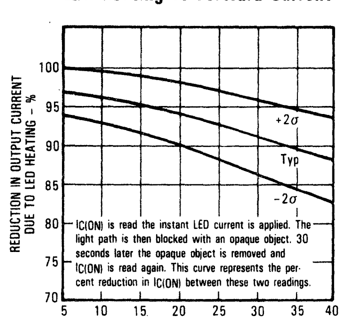
Relative Output Current vs Time



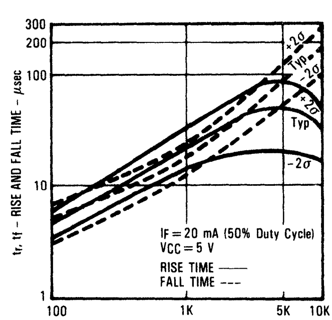
Relative Collector Dark Current vs Ambient Temperature



Reduction in Output Current Due to LED Heating vs Forward Current



Rise and Fall Time vs Load Resistance



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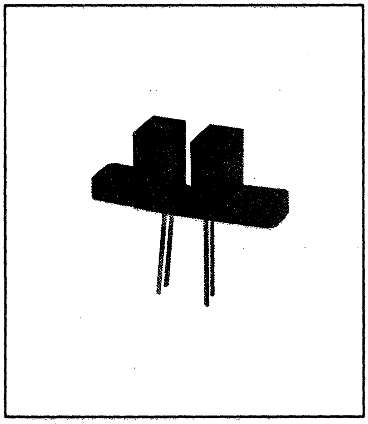
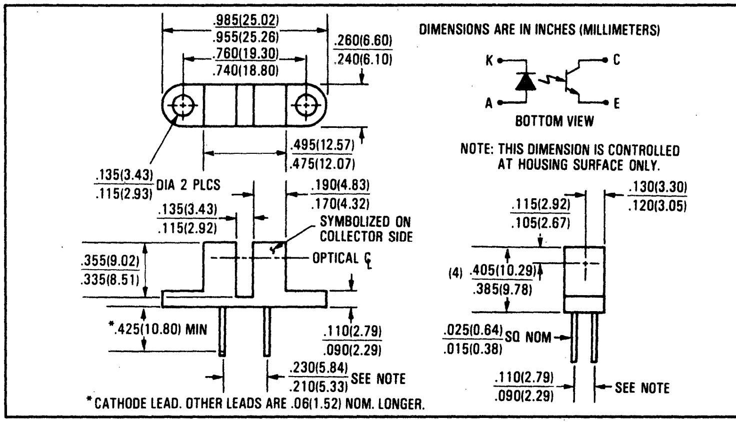
Product Bulletin 5323
January 1985

Slotted Optical Switches
Types OPB816, OPB817





Features
- Non-contact switching
- Low profile
- Fast switching speed

Description
The OPB816 and OPB817 each consist of an infrared emitting diode and an NPN silicon phototransistor mounted in a low cost black plastic housing on opposite sides of a 0.125″ (3.18 mm) wide slot. Phototransistor switching takes place whenever an opaque object passes through the slot.

The OPB816 and OPB817 each utilize either an OP140 or OP240 LED combined with an OP550 family sensor.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

Storage and Operating Temperature Range .... −40°C to +85°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron) .... 240°C[1]

Input Diode

Reverse Voltage .... 2.0 V
Continuous Forward Current .... 50 mA
Peak Forward Current (1 μs pulse width, 300 pps) .... 3.0 A
Power Dissipation .... 100 mW[2]

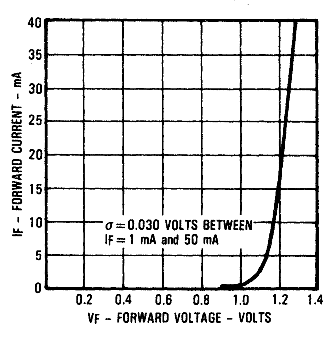
Output Phototransistor

Collector-Emitter Voltage .... 30 V
Emitter-Collector Voltage .... 5.0 V
Power Dissipation .... 100 mW[2]

Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(2) Derate linearly 1.33 mW/°C above 25°C.
(3) Methanol or isopropanol alcohols are recommended as cleaning agents.
(4) The OPB816/OPB817 is a low profile version of the OPB860 type. The OPB860 type is recommended when the extra height is not a factor.

Typical Performance Curves

Forward Current vs Forward Voltage Input Diode

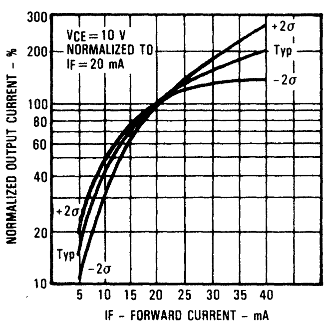


Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

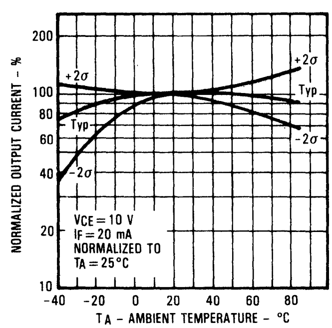
Symbol	Parameter		Min.	Max.	Units	Test Conditions
Input Diode						
V_F	Forward Voltage			1.70	V	$I_F = 20$ mA
I_R	Reverse Current			100	μA	$V_R = 2.0$ V
Output Phototransistor						
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage		30		V	$I_C = 1.00$ mA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage		5.0		V	$I_E = 100$ μA
I_{CEO}	Collector-Emitter Dark Current			100	nA	$V_{CE} = 10.0$ V, $I_F = 0$, $E_e = 0$
Coupled						
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage	OPB816		0.40	V	$I_C = 250$ μA, $I_F = 20$ mA
		OPB817		0.40	V	$I_C = 250$ μA, $I_F = 10.0$ mA
$I_{C(ON)}$	On-State Collector Current	OPB816	500		μA	$V_{CE} = 10.0$ V, $I_F = 20$ mA
		OPB817	1000		μA	$V_{CE} = 10.0$ V, $I_F = 10.0$ mA

Typical Performance Curves

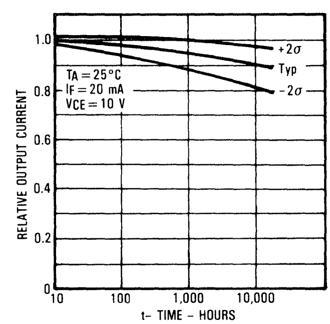
Normalized Output Current vs Forward Current



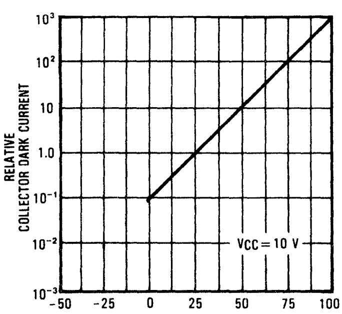
Normalized Output Current vs Ambient Temperature



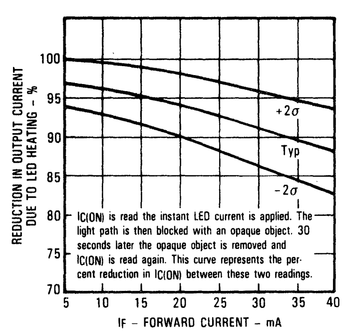
Relative Output Current vs Time



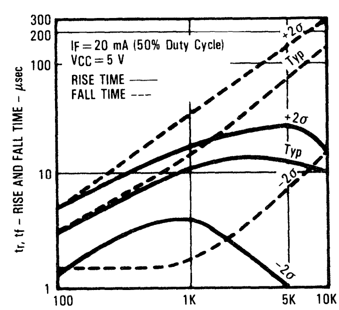
Relative Collector Dark Current vs Ambient Temperature



Reduction in Output Current Due to LED Heating vs Forward Current



Rise and Fall Time vs Load Resistance



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Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958

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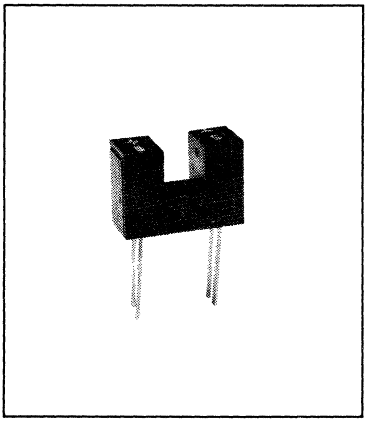
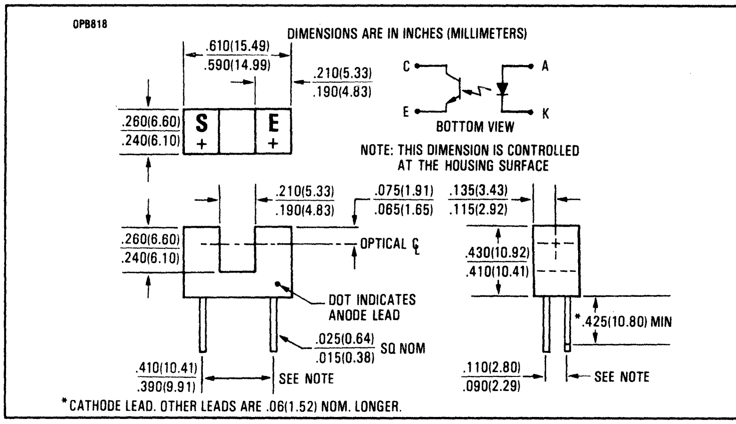
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5324
January 1985

Slotted Optical Switch
Type OPB818





Features
- Non-contact switching
- For direct PC board or dual-in-line socket mounting
- Fast switching speed

Description
The OPB818 consists of an infrared emitting diode and an NPN silicon phototransistor mounted in a low cost black plastic housing on opposite sides of a 0.20″ (5.08 mm) wide slot. Phototransistor switching takes place whenever an opaque object passes through the slot. The OPB818 is designed for direct soldering into PC boards or mounting in standard dual-in-line sockets.

The OPB818 utilizes an OP140 or OP240 LED and an OP550R family sensor.

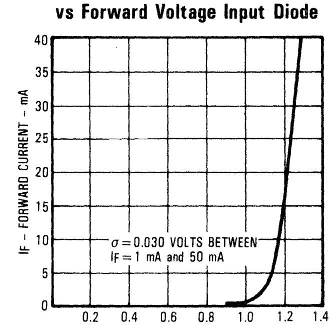
Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)
Storage and Operating Temperature Range . . . . . −40°C to +85°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron) . . . . . 240°C[1]

Input Diode
Reverse Voltage . . . . . 2.0 V
Continuous Forward Current . . . . . 50 mA
Peak Forward Current (1 μs pulse width, 300 pps) . . . . . 3.0 A
Power Dissipation . . . . . 100 mW[2]

Output Phototransistor
Collector-Emitter Voltage . . . . . 30 V
Emitter-Collector Voltage . . . . . 5.0 V
Power Dissipation . . . . . 100 mW[2]

Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(2) Derate linearly 1.33 mW/°C above 25°C.
(3) Methanol or isopropanol alcohols are recommended as cleaning agents.

Typical Performance Curves
Forward Current vs Forward Voltage Input Diode



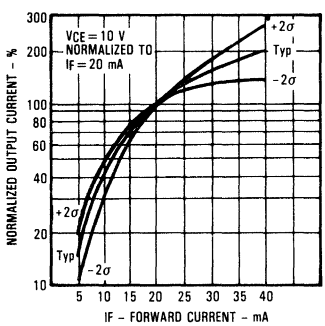
Type OPB818

Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

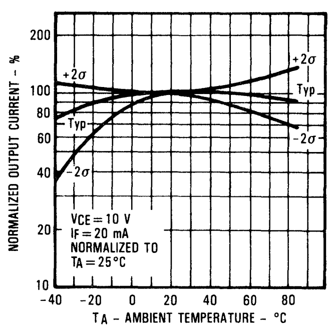
Symbol	Parameter	Min.	Max.	Units	Test Conditions
Input Diode					
V_F	Forward Voltage		1.70	V	$I_F = 20$ mA
I_R	Reverse Current		100	μA	$V_R = 2.0$ V
Output Phototransistor					
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	30		V	$I_C = 1.00$ mA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	5.0		V	$I_E = 100$ μA
I_{CEO}	Collector-Emitter Dark Current		100	nA	$V_{CE} = 10.0$ V, $I_F = 0$, $E_e = 0$
Coupled					
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage		0.4	V	$I_C = 50$ μA, $I_F = 20$ mA
$I_{C(ON)}$	On-State Collector Current	100		μA	$V_{CE} = 10.0$ V, $I_F = 20$ mA

Typical Performance Curves

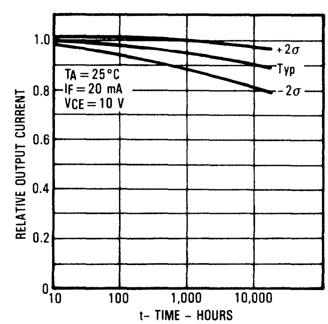
Normalized Output Current vs Forward Current



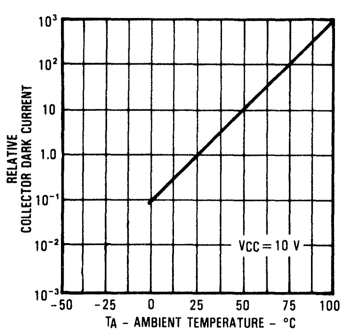
Normalized Output Current vs Ambient Temperature



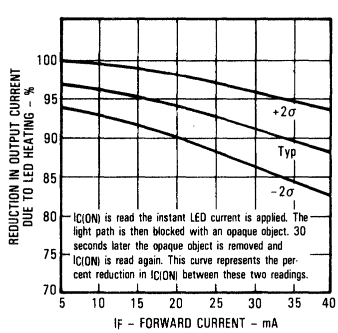
Relative Output Current vs Time



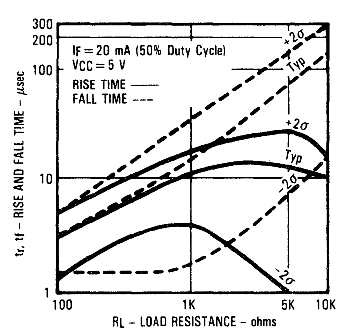
Relative Collector Dark Current vs Ambient Temperature



Reduction in Output Current Due to LED Heating vs Forward Current



Rise and Fall Time vs Load Resistance



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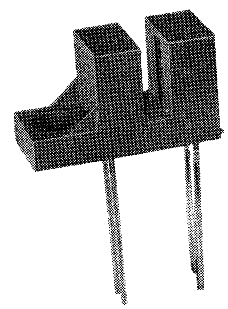
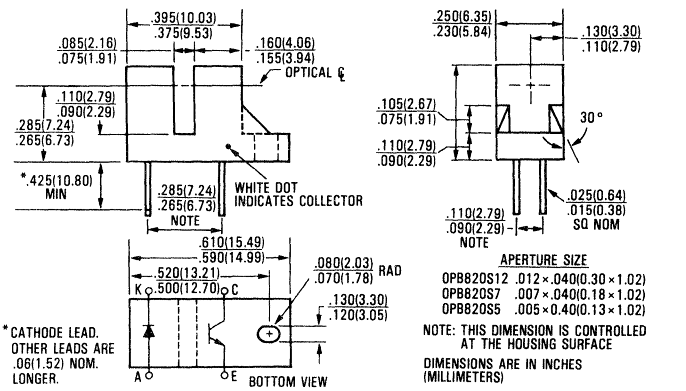
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5328
January 1985

Slotted Optical Switches
Types OPB820, OPB820S12, OPB820S7, OPB820S5





Features
- Non-contact switching
- Three standard aperture sizes for high resolution
- Fast switching speed

Description
The OPB820, OPB820S12, OPB820S7, and OPB820S5 each consist of an infrared emitting diode and an NPN silicon phototransistor mounted in a low cost black plastic housing on opposite sides of a 0.080″ (2.03 mm) wide slot. Phototransistor switching takes place whenever an opaque object passes through the slot. The OPB820 is unapertured. The OPB820S12, OPB820S7, and OPB820S5 each have an aperture in front of the phototransistor for high resolution position sensing.

The OPB820, OPB820S12, OPB820S7, and OPB820S5 utilize an OP140 or OP240 LED and an OP550 family sensor.

Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)
Storage and Operating Temperature Range . . . . −40°C to +85°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron) . . . . 240°C(1)

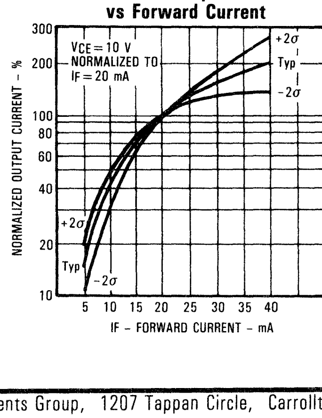
Input Diode
Reverse Voltage . . . . 2.0 V
Continuous Forward Current . . . . 50 mA
Peak Forward Current (1 μs pulse width, 300 pps) . . . . 3.0 A
Power Dissipation . . . . 100 mW(2)

Output Phototransistor
Collector-Emitter Voltage . . . . 30 V
Emitter-Collector Voltage . . . . 5.0 V
Power Dissipation . . . . 100 mW(2)

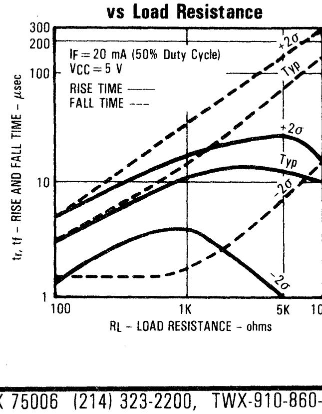
Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(2) Derate linearly 1.33 mW/°C above 25°C.
(3) Methanol or isopropanol alcohols are recommended as cleaning agents.

Typical Performance Curves
OPB820

Normalized Output Current vs Forward Current



Rise and Fall Time vs Load Resistance



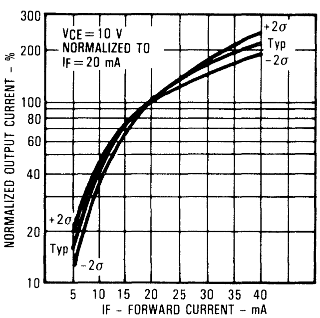
Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

Symbol	Parameter		Min.	Max.	Units	Test Conditions
Input Diode						
V_F	Forward Voltage			1.70	V	$I_F = 20$ mA
I_R	Reverse Current			100	μA	$V_R = 2.0$ V
Output Phototransistor						
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage		30		V	$I_C = 1.00$ mA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage		5.0		V	$I_E = 100$ μA
I_{CEO}	Collector-Emitter Dark Current			100	nA	$V_{CE} = 10.0$ V, $I_F = 0$, $E_e = 0$
Coupled						
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage	OPB820, OPB820S12		0.4	V	$I_C = 250$ μA, $I_F = 20$ mA
		OPB820S7		0.4	V	$I_C = 150$ μA, $I_F = 20$ mA
		OPB820S5		0.4	V	$I_C = 125$ μA, $I_F = 20$ mA
$I_{C(ON)}$	On-State Collector Current	OPB820	500		μA	$V_{CE} = 10.0$ V, $I_F = 20$ mA
		OPB820S12	400		μA	$V_{CE} = 10.0$ V, $I_F = 20$ mA
		OPB820S7	300		μA	$V_{CE} = 10.0$ V, $I_F = 20$ mA
		OPB820S5	170		μA	$V_{CE} = 10.0$ V, $I_F = 20$ mA

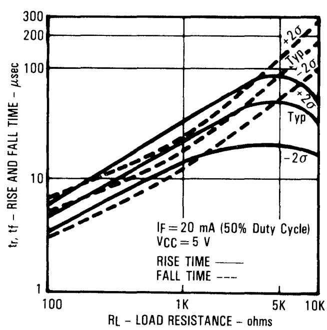
Typical Performance Curves

OPB820S12, OPB820S7, OPB820S5

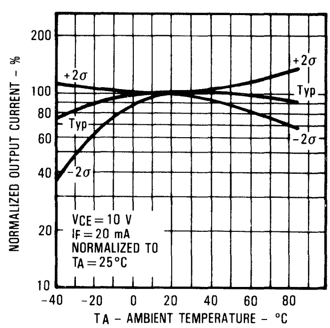
Normalized Output Current vs Input Current



Rise and Fall Time vs Load Resistance

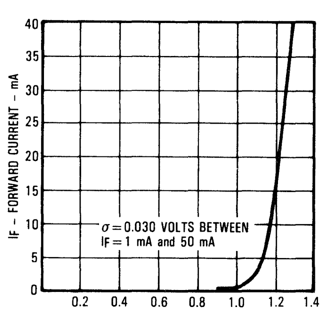


Normalized Output Current vs Ambient Temperature

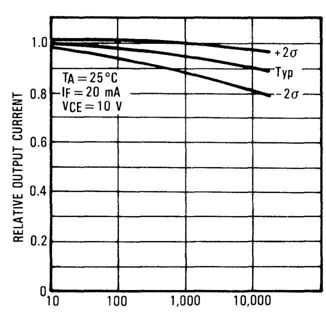


All Assemblies

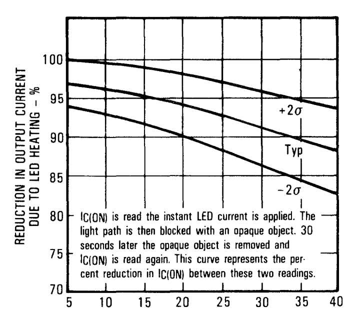
Forward Current vs Forward Voltage Input Diode



Relative Output Current vs Time



Reduction in Output Current Due to LED Heating vs Forward Current



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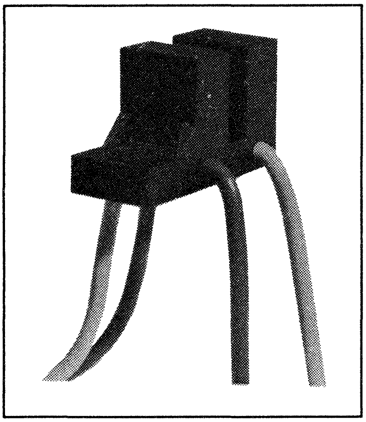
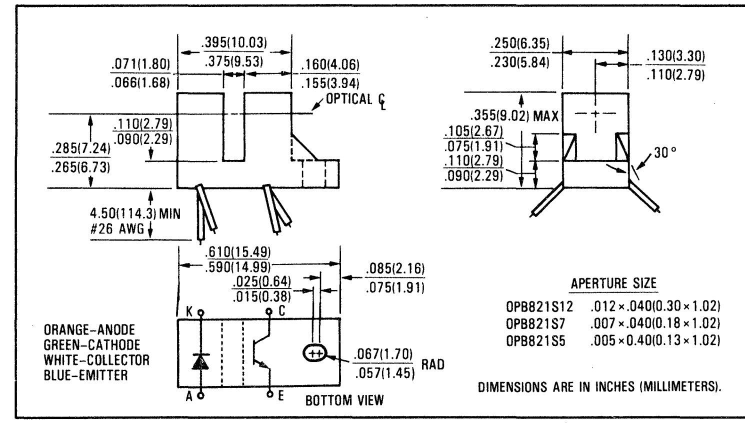
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5331
January 1985

Slotted Optical Switches
Types OPB821, OPB821S12, OPB821S7, OPB821S5





Features
- Non-contact switching
- Three standard aperture sizes for high resolution
- Fast switching speed

Description
The OPB821, OPB821S12, OPB821S7, and OPB821S5 each consist of an infrared emitting diode and an NPN silicon phototransistor mounted in a low cost black plastic housing on opposite sides of a 0.080″ (2.03 mm) wide slot. Phototransistor switching takes place whenever an opaque object passes through the slot. The OPB821 is unapertured. The OPB821S12, OPB821S7, and OPB821S5 each have an aperture in front of the phototransistor for high resolution position sensing. 4.5″ (114.3 mm) minimum length lead wires ease assembly where PC board mounting is not practical.

The OPB821, OPB821S12, OPB821S7, and OPB821S5 utilize an OP140 or OP240 LED and an OP550 family sensor.

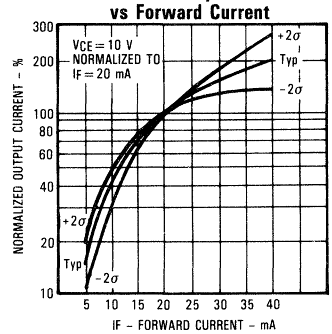
Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)

Storage and Operating Temperature Range	−40°C to +85°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)	240°C[1]
Input Diode	
Reverse Voltage	2.0 V
Continuous Forward Current	50 mA
Peak Forward Current (1 μs pulse width, 300 pps)	3.0 A
Power Dissipation	100 mW[2]
Output Phototransistor	
Collector-Emitter Voltage	30 V
Emitter-Collector Voltage	5.0 V
Power Dissipation	100 mW[2]

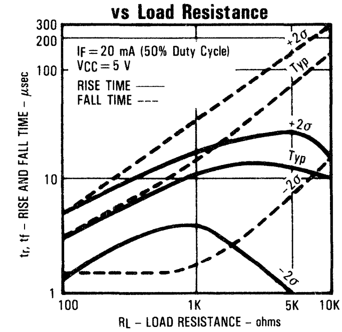
Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(2) Derate linearly 1.33 mW/°C above 25°C.
(3) Methanol or isopropanol alcohols are recommended as cleaning agents.

Typical Performance Curves
OPB821

Normalized Output Current vs Forward Current



Rise and Fall Time vs Load Resistance



Types OPB821, OPB821S12, OPB821S7, OPB821S5

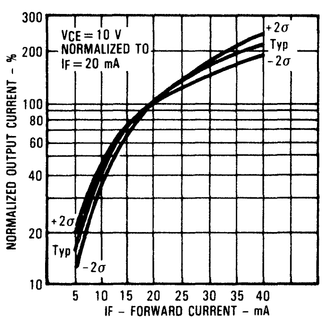
Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

Symbol	Parameter	Min.	Max.	Units	Test Conditions
Input Diode					
V_F	Forward Voltage		1.70	V	$I_F = 20$ mA
I_R	Reverse Current		100	μA	$V_R = 2.0$ V
Output Phototransistor					
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	30.0		V	$I_C = 1.00$ mA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	5.0		V	$I_E = 100$ μA
I_{CEO}	Collector-Emitter Dark Current		100	nA	$V_{CE} = 10.0$ V, $I_F = 0$, $E_e = 0$
Coupled					
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage OPB821, OPB821S12		0.4	V	$I_C = 250$ μA, $I_F = 20$ mA
	OPB821S7		0.4	V	$I_C = 150$ μA, $I_F = 20$ mA
	OPB821S5		0.4	V	$I_C = 125$ μA, $I_F = 20$ mA
$I_{C(ON)}$	On-State Collector Current OPB821	500		μA	$V_{CE} = 10.0$ V, $I_F = 20$ mA
	OPB821S12	400		μA	$V_{CE} = 10.0$ V, $I_F = 20$ mA
	OPB821S7	300		μA	$V_{CE} = 10.0$ V, $I_F = 20$ mA
	OPB821S5	170		μA	$V_{CE} = 10.0$ V, $I_F = 20$ mA

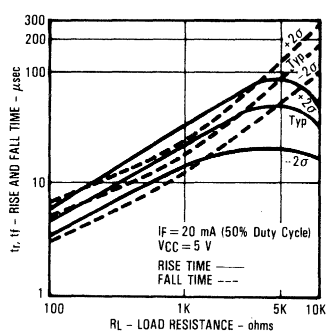
Typical Performance Curves

OPB821S12, OPB821S7, OPB821S5

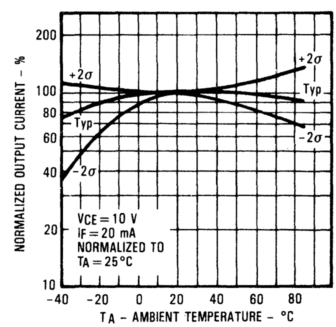
Normalized Output Current vs Input Current



Rise and Fall Time vs Load Resistance

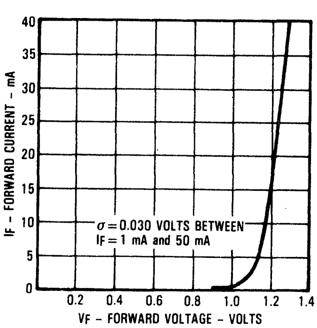


Normalized Output Current vs Ambient Temperature

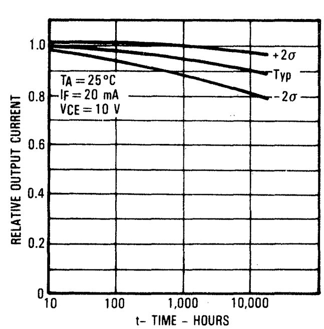


All Assemblies

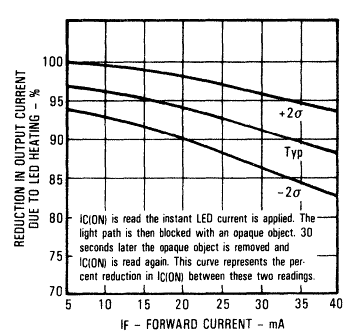
Forward Current vs Forward Voltage Input Diode



Relative Output Current vs Time



Reduction in Output Current Due to LED Heating vs Forward Current



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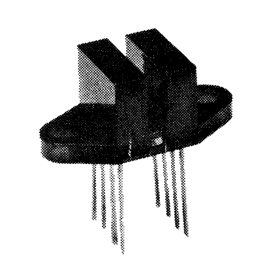
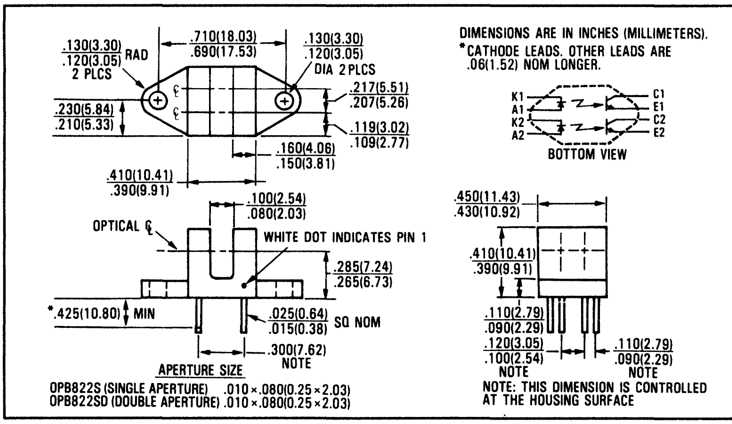
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5332
January 1985

Dual Channel Slotted Optical Switches
Types OPB822S, OPB822SD





Features
- Non-contact switching
- Single or double apertures for high resolution
- Completely sealed polysulfone housing

Description
The OPB822S and OPB822SD each consist of two infrared emitting diodes and two NPN silicon phototransistors mounted in a side-by-side configuration on opposite sides of a 0.100″ (2.54 mm) wide slot. Phototransistor switching takes place whenever an opaque object passes through the device slot. The OPB822S has 0.010″ (.25 mm) by 0.080″ (2.03 mm) apertures in front of both phototransistors. The OPB822SD has the same sized apertures in front of both phototransistors and both LEDs. Dual channels enable direction of travel sensing. The low cost polysulfone housing reduces possible interference from ambient light and provides dust and dirt protection.

The OPB822S and OPB822SD utilize an OP140 or OP240 LED and an OP550 family sensor.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)
Storage and Operating Temperature Range . . . . . −40°C to +85°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron) . . . . . 240°C[1]

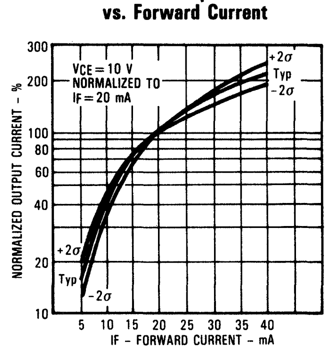
Input Diode(s)
Reverse Voltage . . . . . 2.0 V
Continuous Forward Current . . . . . 50 mA
Peak Forward Current (1 μs pulse width, 300 pps) . . . . . 3.0 A
Power Dissipation . . . . . 100 mW[2]

Output Phototransistor(s)
Collector-Emitter Voltage . . . . . 30 V
Emitter-Collector Voltage . . . . . 5.0 V
Power Dissipation . . . . . 100 mW[2]

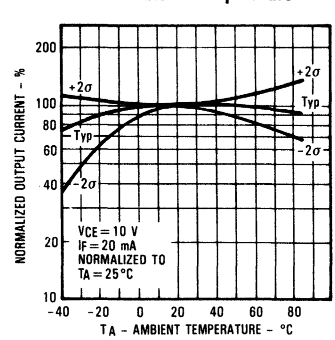
Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(2) Derate linearly 1.33 mW/°C above 25°C.
(3) Plastic housing is soluble in chlorinated hydrocarbons and ketones. Methanol or isopropanol alcohols are recommended as cleaning agents.

Typical Performance Curves

Normalized Output Current vs. Forward Current



Normalized Output Current vs Ambient Temperature

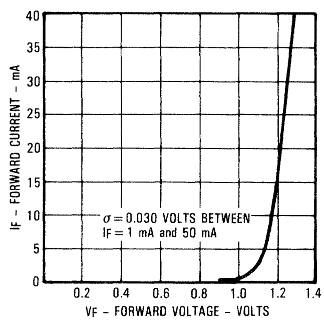


Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

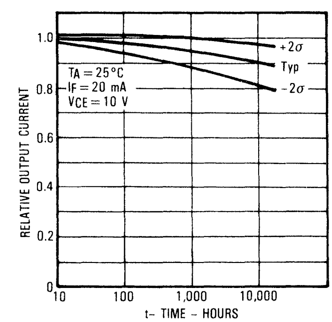
Symbol	Parameter		Min.	Max.	Units	Test Conditions
Input Diode						
V_F	Forward Voltage			1.70	V	$I_F = 20$ mA
I_R	Reverse Current			100	μA	$V_R = 2.0$ V
Output Phototransistor						
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage		30		V	$I_C = 1.0$ mA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage		5.0		V	$I_E = 100$ μA
I_{CEO}	Collector-Emitter Dark Current			100	nA	$V_{CE} = 10.0$ V, $I_F = 0$, $E_e = 0$
Coupled						
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage	OPB822S		0.40	V	$I_C = 125$ μA, $I_F = 20$ mA
		OPB822SD		0.40	V	$I_C = 50$ μA, $I_F = 20$ mA
$I_{C(ON)}$	On-State Collector Current	OPB822S	250		μA	$V_{CE} = 10.0$ V, $I_F = 20$ mA
		OPB822SD	100		μA	$V_{CE} = 10.0$ V, $I_F = 20$ mA

Typical Performance Curves (All Assemblies)

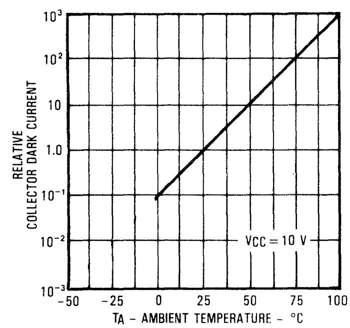
Forward Current vs Forward Voltage Input Diode



Relative Output Current vs Time



Relative Collector Dark Current vs Ambient Temperature



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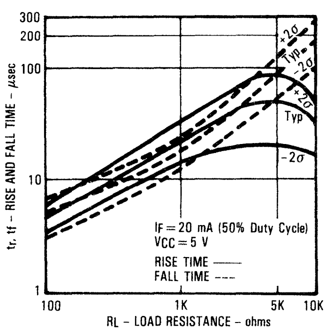
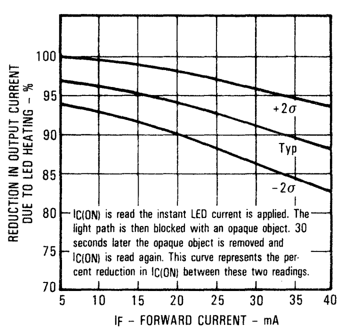
Rise and Fall Time vs Load Resistance



Reduction in Output Current Due to LED Heating vs Forward Current

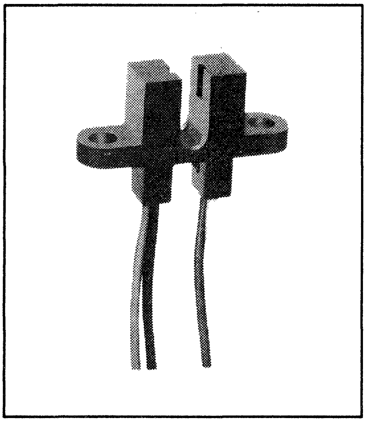


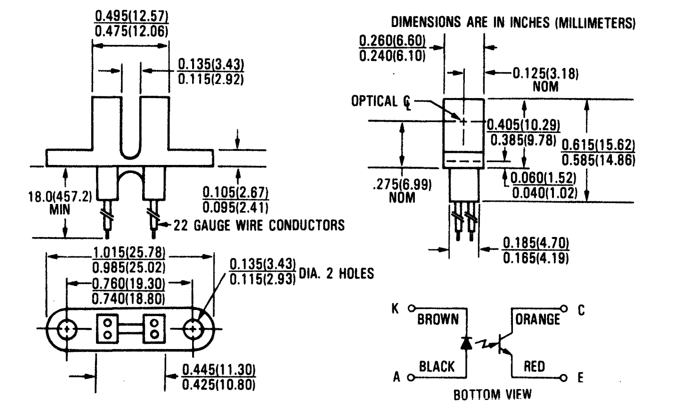
TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5334
January 1985

Slotted Optical Switches
Types OPB823A, OPB824A





Features
- Non-contact switching
- Lead wires for electrical connection
- Fast switching speed

Description
The OPB823A and OPB824A each consist of an infrared emitting diode and an NPN silicon phototransistor mounted in a low cost black plastic housing on opposite sides of a 0.125" (3.18 mm) wide slot. Phototransistor switching takes place whenever an opaque object passes through the slot. 18" (457.2 mm) minimum length lead wires ease assembly where PC board mounting is not practical.

The OPB823A and OPB824A each utilize an OP140 or OP240 type LED and an OP550 family sensor.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)
Storage and Operating Temperature Range . . . . . . −40°C to +85°C[1]

Input Diode

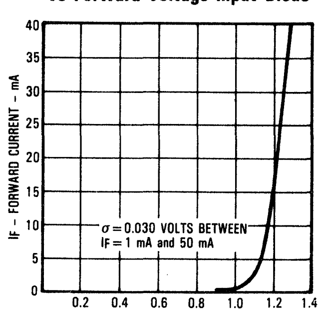
Reverse Voltage . . . . . . 2.0 V
Continuous Forward Current . . . . . . 50 mA
Peak Forward Current (1 μs pulse width, 300 pps) . . . . . . 3.0 A
Power Dissipation . . . . . . 100 mW[2]

Output Phototransistor

Collector-Emitter Voltage . . . . . . 30 V
Emitter-Collector Voltage . . . . . . 5.0 V
Power Dissipation . . . . . . 100 mW[2]

Notes:
(1) Derate linearly 1.33 mW/°C above 25°C.
(2) Junction temperature maintained at 25°C.
(3) Methanol or isopropanol alcohols are recommended as cleaning agents.

Typical Performance Curves
Forward Current vs Forward Voltage Input Diode

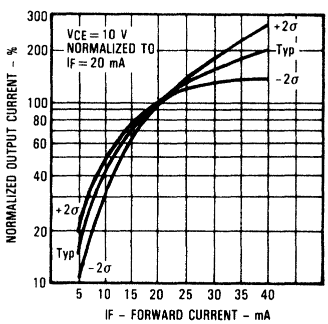


Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

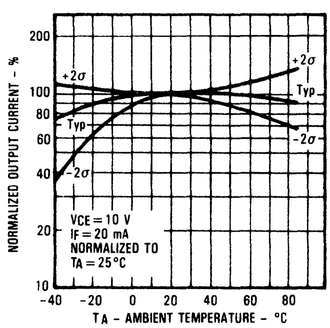
Symbol	Parameter	Min.	Max.	Units	Test Conditions
Input Diode					
V_F	Forward Voltage		1.70	V	$I_F = 20$ mA
I_R	Reverse Current		100	μA	$V_R = 2.0$ V
Output Phototransistor					
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	30.0		V	$I_C = 1.00$ mA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	5.0		V	$I_C = 100$ μA
I_{CEO}	Collector-Emitter Dark Current		100	nA	$V_{CE} = 10.0$ V, $I_F = 0$, $E_e = 0$
Coupled					
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage OPB823A		0.40	V	$I_F = 20$ mA, $I_C = 100$ μA
	OPB824A		0.40	V	$I_F = 20$ mA, $I_C = 250$ μA
$I_{C(ON)}$	On-State Collector Current OPB823A	200		μA	$I_F = 20$ mA, $V_{CE} = 10.0$ V
	OPB824A	500		μA	$I_F = 20$ mA, $V_{CE} = 10.0$ V

Typical Performance Curves

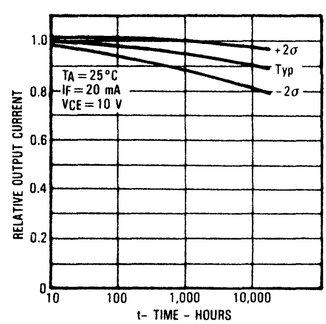
Normalized Output Current vs Forward Current



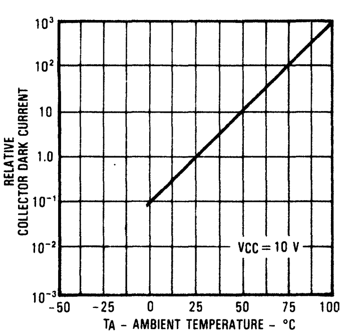
Normalized Output Current vs Ambient Temperature



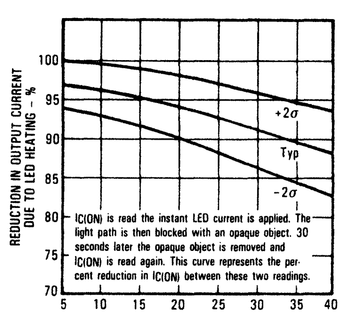
Relative Output Current vs Time



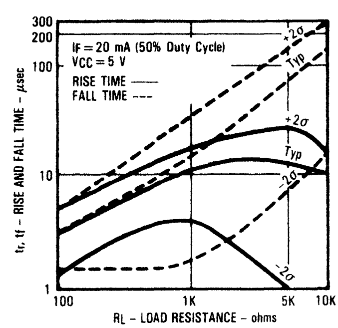
Relative Collector Dark Current vs Ambient Temperature



Reduction in Output Current Due to LED Heating vs Forward Current



Rise and Fall Time vs Load Resistance



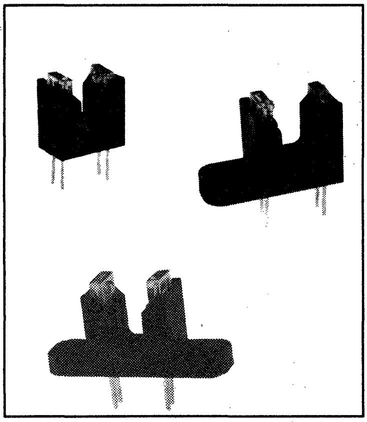
TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

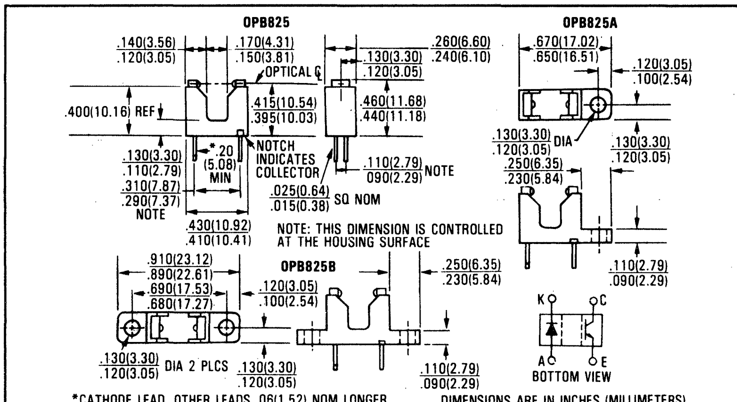
Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958

Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5336
January 1985

Slotted Optical Switches
Types OPB825, OPB825A, OPB825B





*CATHODE LEAD. OTHER LEADS .06(1.52) NOM LONGER. DIMENSIONS ARE IN INCHES (MILLIMETERS).

Features
- Non-contact switching
- Versatile mounting
- Small size
- Fast switching speed

Description
The OPB825, OPB825A, and OPB825B each consist of an infrared emitting diode and an NPN silicon phototransistor mounted in a low cost black plastic housing on opposite sides of a 0.160" (4.06 mm) wide slot. Phototransistor switching takes place whenever an opaque object passes through the slot. The OPB825 has no mounting tabs and is intended for direct insertion into PC boards or dual-in-line sockets. The OPB825A has a single mounting tab on the phototransistor side and the OPB825B has mounting tabs on both sides.

The OPB825, OPB825A and OPB825B utilize an OP140 or OP240 LED and an OP550 family sensor.

Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)
Storage and Operating Temperature Range .... −40°C to +85°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron) .... 240°C[1]

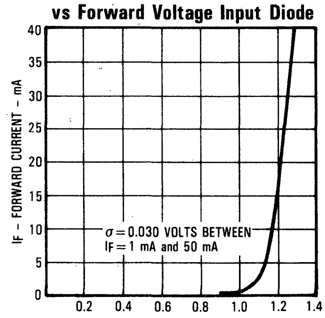
Input Diode
Reverse Voltage .... 2.0 V
Continuous Forward Current .... 50 mA
Peak Forward Current (1 μs pulse width, 300 pps) .... 3.0 A
Power Dissipation .... 100 mW[2]

Output Phototransistor
Collector-Emitter Voltage .... 30 V
Emitter-Collector Voltage .... 5.0 V
Power Dissipation .... 100 mW[2]

Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(2) Derate linearly 1.33 mW/°C above 25°C.
(3) Methanol or isopropanol alcohols are recommended as cleaning agents.

Typical Performance Curves

Forward Current vs Forward Voltage Input Diode

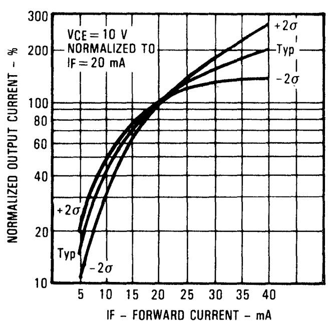


Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

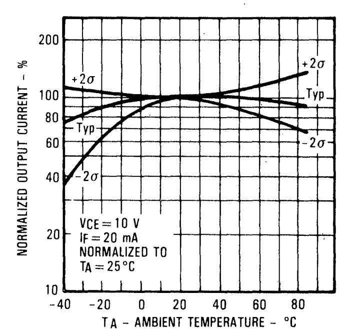
Symbol	Parameter	Min.	Max.	Units	Test Conditions
Input Diode					
V_F	Forward Voltage		1.70	V	$I_F = 20$ mA
I_R	Reverse Current		100	μA	$V_R = 2.0$ V
Output Phototransistor					
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	30		V	$I_C = 1.00$ mA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	5.0		V	$I_E = 100$ μA
I_{CEO}	Collector-Emitter Dark Current		100	nA	$V_{CE} = 10.0$ V, $I_F = 0$, $E_e = 0$
Coupled					
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage		0.40	V	$I_C = 250$ μA, $I_F = 20$ mA
$I_{C(ON)}$	On-State Collector Current	500		μA	$V_{CE} = 10.0$ V, $I_F = 20$ mA

Typical Performance Curves

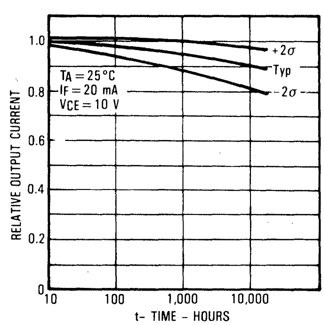
Normalized Output Current vs Forward Current



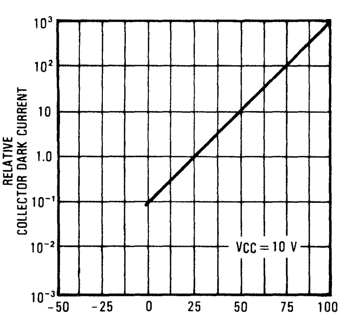
Normalized Output Current vs Ambient Temperature



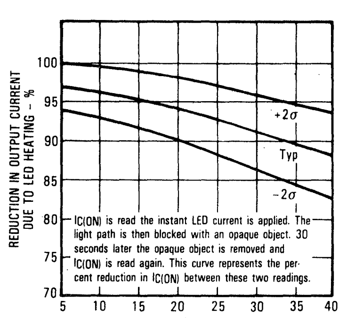
Relative Output Current vs Time



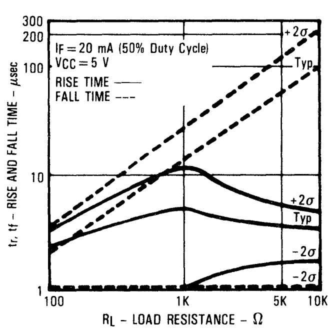
Relative Collector Dark Current vs Ambient Temperature



Reduction in Output Current Due to LED Heating vs Forward Current



Rise and Fall Time vs Load Resistance



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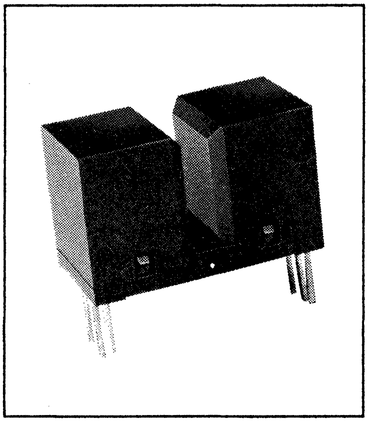
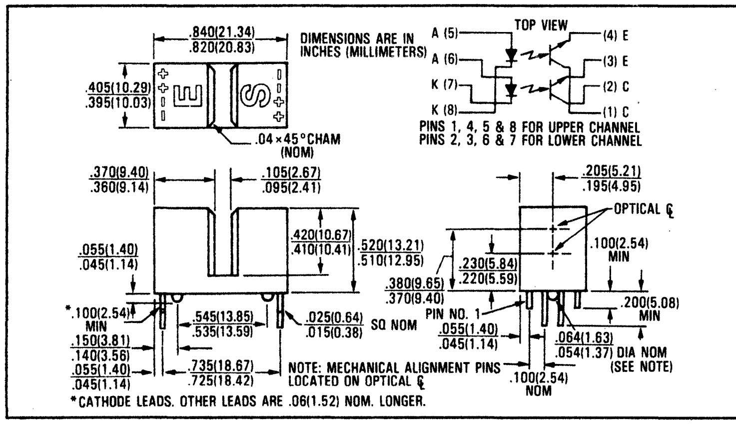
Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958

Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5338
January 1985

Dual Channel Slotted Optical Switches
Types OPB826S, OPB826SD





Features
- Non-contact switching
- Single or double apertures for high resolution
- Completely sealed polysulfone housing

Description
The OPB826S and OPB826SD each consist of two infrared emitting diodes and two NPN silicon phototransistors mounted in an over/under configuration on opposite sides of a 0.100" (2.54 mm) wide slot. Phototransistor switching takes place when an opaque object passes through the slot. The OPB826S has 0.010" (0.25 mm) by 0.040" (1.02 mm) apertures in front of both phototransistors. The OPB826SD has the same sized apertures in front of both phototransistors and both LEDs. Dual channels enable direction of travel sensing. The low cost polysulfone housing reduces possible interference from ambient light and provides dust and dirt protection.

The OPB826S and OPB826SD utilize an OP169 or OP269 type LEDs and OP509 family sensors.

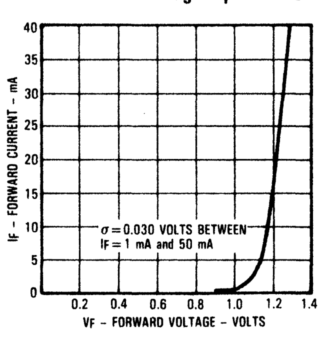
Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)
Storage and Operating Temperature Range .... −40°C to +85°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron) .... 240°C(1)

Input Diode(s)
Reverse Voltage .... 2.0 V
Continuous Forward Current .... 40 mA
Peak Forward Current (1 μs pulse width, 300 pps) .... 3.0 A
Power Dissipation .... 100 mW(2)

Phototransistor(s)
Collector-Emitter Voltage .... 30 V
Emitter-Collector Voltage .... 5.0 V
Power Dissipation .... 100 mW(2)

Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(2) Derate linearly 1.33 mW/°C above 25°C.
(3) Plastic housing is soluble in chlorinated hydrocarbons and ketones. Methanol or isopropanol alcohols are recommended as cleaning agents.

Typical Performance Curves
Forward Current vs Forward Voltage Input Diode



Types OPB826S, OPB826SD

Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

Symbol	Parameter		Min.	Max.	Units	Test Conditions
Input Diode						
V_F	Forward Voltage			1.70	V	$I_F = 20$ mA
I_R	Reverse Current			100	μA	$V_R = 2.0$ V
Output Phototransistor						
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage		30		V	$I_C = 1.00$ mA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage		5.0		V	$I_E = 100$ μA
I_{CEO}	Collector-Emitter Dark Current			100	nA	$V_{CE} = 10.0$ V, $I_F = 0$, $E_e = 0$
Coupled						
$I_{C(ON)}$	On-State Collector Current	OPB826S	250		μA	$V_{CE} = 10.0$ V, $I_F = 20$ mA
		OPB826SD	100		μA	$V_{CE} = 10.0$ V, $I_F = 20$ mA
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage	OPB826S		0.40	V	$I_F = 20$ mA, $I_C = 125$ μA
		OPB826SD		0.40	V	$I_F = 20$ mA, $I_C = 50$ μA
I_{CX_1}	Crosstalk	OPB826S		20	μA	$I_{F_1} = 0$, $I_{F_2} = 20$ mA, $V_{CE} = 10.0$ V
		OPB826SD		10.0	μA	$I_{F_1} = 0$, $I_{F_2} = 20$ mA, $V_{CE} = 10.0$ V
I_{CX_2}	Crosstalk	OPB826S		20	μA	$I_{F_1} = 20$ mA, $I_{F_2} = 0$, $V_{CE} = 10.0$ V
		OPB826SD		10.0	μA	$I_{F_1} = 20$ mA, $I_{F_2} = 0$, $V_{CE} = 10.0$ V

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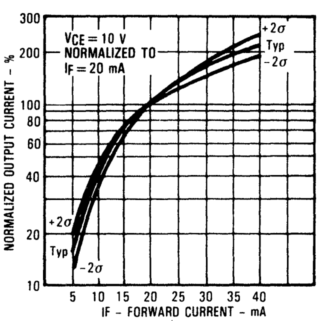
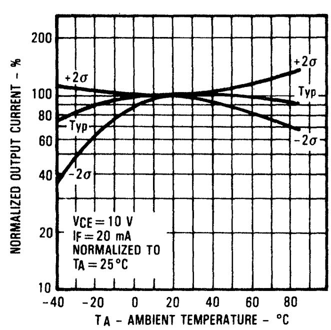
Typical Performance Curves

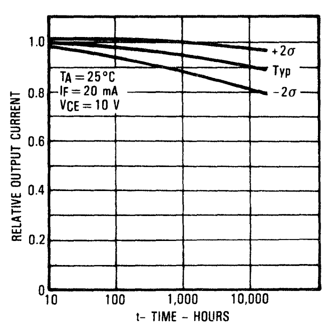
Normalized Output Current vs Input Current



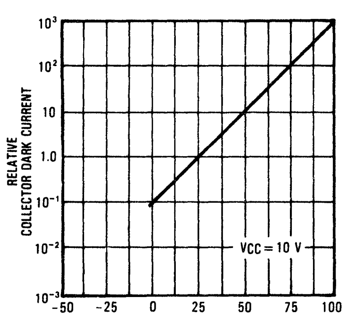
Normalized Output Current vs Ambient Temperature



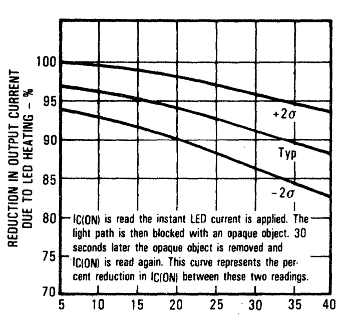
Relative Output Current vs Time



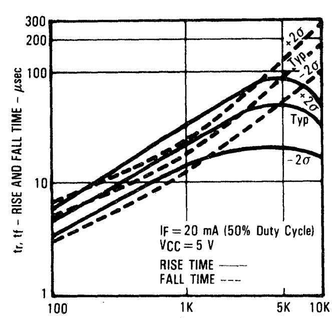
Relative Collector Dark Current vs Ambient Temperature



Reduction in Output Current Due to LED Heating vs Forward Current



Rise and Fall Time vs Load Resistance

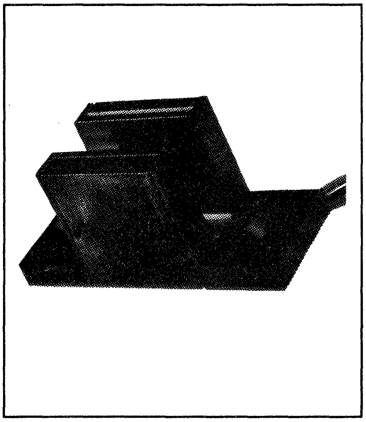


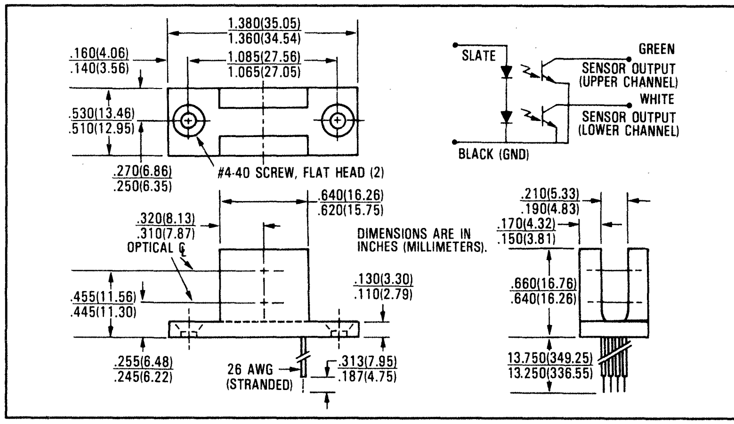
TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5339
January 1985

Dual Channel Slotted Optical Switch
Type OPB831S20





Features
- Non-contact switching
- Sensors apertured for high resolution
- Completely sealed polysulfone housing

Description
The OPB831S20 consists of two infrared emitting diodes and two NPN silicon phototransistors mounted in an over/under configuration on opposite sides of a 0.200″ (5.08 mm) wide slot. Phototransistor switching takes place when an opaque object passes through the slot. A 0.020″ (0.508 mm) by 0.060″ (1.52 mm) aperture is mounted in front of each phototransistor for high resolution position sensing. Dual channels enable direction of travel sensing. The low cost polysulfone housing reduces possible interference from ambient light and provides dirt and dust protection.

The OPB831S20 utilizes OP140 or OP240 type LEDs and OP550 family sensors.

Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)
Storage and Operating Temperature Range . . . . −40°C to +85°C(1)

Input Diodes (See Schematic)

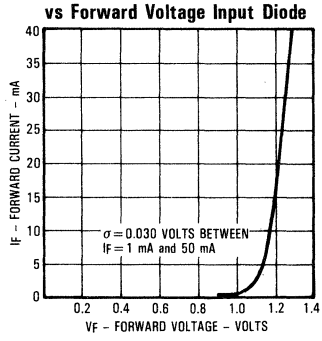
Reverse Voltage . . . . 4.0 V
Continuous Forward Current . . . . 50 mA
Peak Forward Current (1 μs pulse width, 300 pps) . . . . 3.0 A
Power Dissipation . . . . 200 mW(2)

Output Phototransistor(s)

Collector-Emitter Voltage . . . . 30 V
Emitter-Collector Voltage . . . . 5.0 V
Power Dissipation . . . . 100 mW(3)

Notes:
(1) Maximum storage and operating temperature are limited by the temperature rating of the lead wires.
(2) Derate linearly 2.66 mW/°C above 25°C.
(3) Derate linearly 1.33 mW/°C abpve 25°C.
(4) Plastic housing is soluble in chlorinated hydrocarbons and ketones. Methanol or isopropanol alcohols are recommended as cleaning agents.

Typical Performance Curves
Forward Current vs Forward Voltage Input Diode

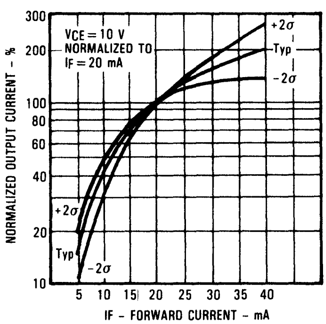


Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

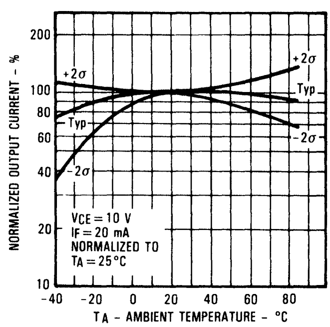
Symbol	Parameter	Min.	Max.	Units	Test Conditions
Input Diode					
V_F	Forward Voltage		3.4	V	$I_F = 40$ mA
I_R	Reverse Current		100	μA	$V_R = 4.0$ V
Output Phototransistor					
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	30		V	$I_C = 100$ μA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	5.0		V	$I_E = 100$ μA
I_{CEO}	Collector-Emitter Dark Current		100	nA	$V_{CE} = 10.0$ V, $I_F = 0$, $E_e = 0$
Coupled					
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage		0.40	V	$I_C = 250$ μA, $I_F = 25$ mA
$I_{C(ON)}$[4]	On-State Collector Current	400		μA	$V_{CE} = 10.0$ V, $I_F = 25$ mA
I_{CX}	Crosstalk		200	μA	$I_F = 25$ mA, $V_{CE} = 2.0$ V

Typical Performance Curves

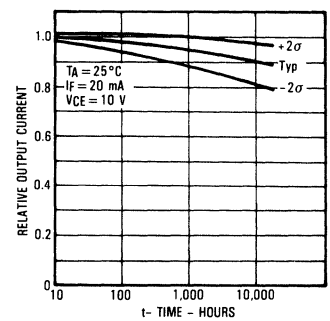
Normalized Output Current vs Forward Current



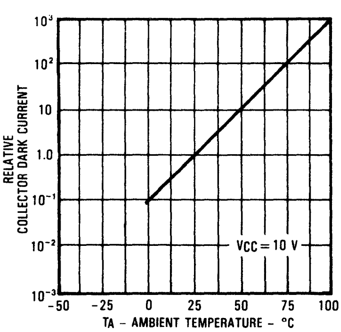
Normalized Output Current vs Ambient Temperature



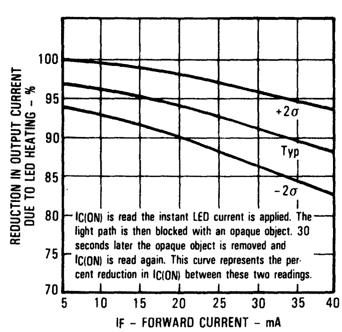
Relative Output Current vs Time



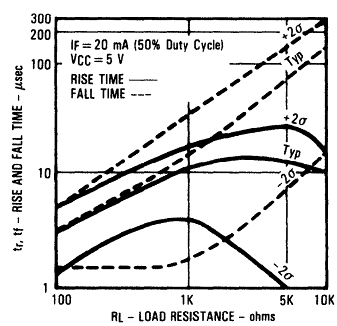
Relative Collector Dark Current vs Ambient Temperature



Reduction in Output Current Due to LED Heating vs Forward Current



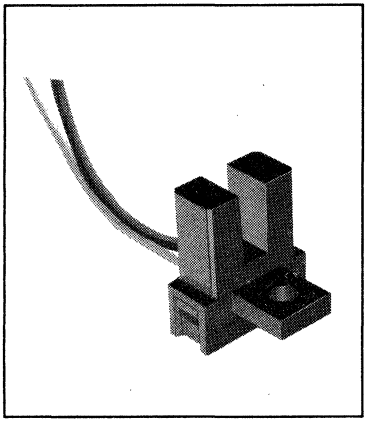
Rise and Fall Time vs Load Resistance

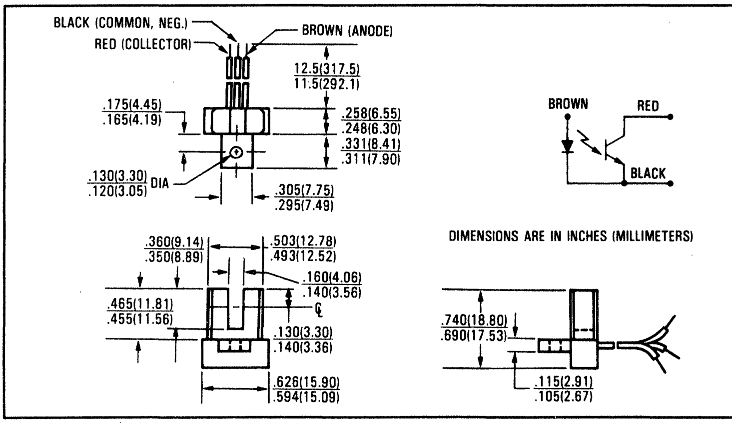


Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5342
January 1985

Slotted Optical Switch
Type OPB835





Features
- Non-contact switching
- Three lead wires for electrical connection
- Completely sealed polysulfone housing
- Fast switching speed

Description
The OPB835 consists of an infrared emitting diode and an NPN silicon phototransistor mounted on opposite sides of a 0.15″ (3.81 mm) wide slot. Phototransistor switching takes place whenever an opaque object passes through the slot. The low cost polysulfone housing reduces possible interference from ambient light and provides dirt and dust protection. 11.5″ (292.1 mm) minimum length lead wires ease assembly where PC board mounting is not practical.

The OPB835 utilizes an OP140 or OP240 LED and an OP550R family sensor.

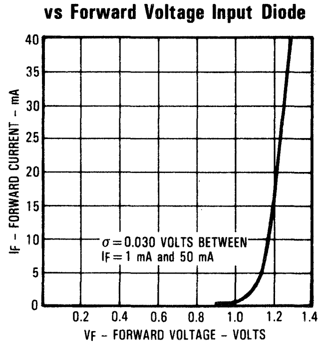
Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)
Storage and Operating Temperature Range . . . . . −40°C to +85°C[1]

Input Diode
Reverse Voltage . . . . . 2.0 V
Continuous Forward Current . . . . . 50 mA
Peak Forward Current (1 μs pulse width, 300 pps) . . . . . 3.0 A
Power Dissipation . . . . . 100 mW[2]

Phototransistor
Collector-Emitter Voltage . . . . . 30 V
Emitter-Collector Voltage . . . . . 5.0 V
Power Dissipation . . . . . 100 mW[2]

Notes:
(1) Maximum storage and operating temperature are limited by the temperature rating of the lead wires.
(2) Derate linearly 1.33 mW/°C above 25°C.
(3) Plastic housing is soluble in chlorinated hydrocarbons and ketones. Methanol or isopropanol alcohols are recommended as cleaning agents.

Typical Performance Curves
Forward Current vs Forward Voltage Input Diode



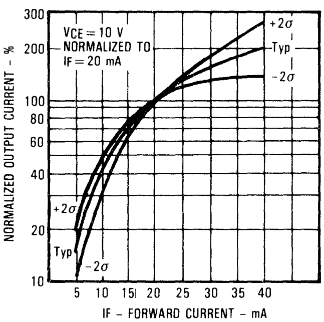
Type OPB835

Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

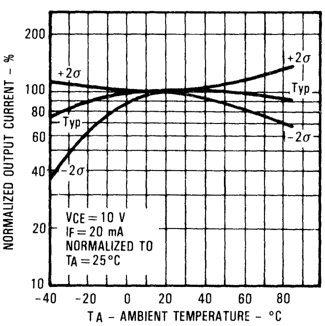
Symbol	Parameter	Min.	Max.	Units	Test Conditions
Input Diode					
V_F	Forward Voltage		1.70	V	$I_F = 20$ mA
I_R	Reverse Current		100	μA	$V_R = 2.0$ V
Output Phototransistor					
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	30		V	$I_C = 1.00$ mA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	5.0		V	$I_E = 100$ μA
I_{CEO}	Collector-Emitter Dark Current		100	nA	$V_{CE} = 10.0$ V, $I_F = 0$, $E_e = 0$
Coupled					
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage		0.40	V	$I_C = 1.50$ mA, $I_F = 20$ mA
$I_{C(ON)}$	On-State Collector Current	1.50		mA	$V_{CE} = 10.0$ V, $I_F = 20$ mA

Typical Performance Curves

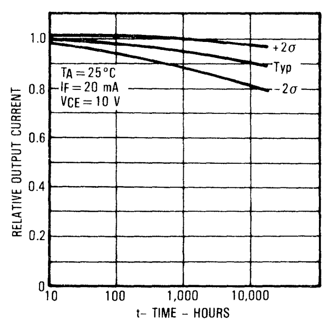
Normalized Output Current vs Forward Current



Normalized Output Current vs Ambient Temperature



Relative Output Current vs Time



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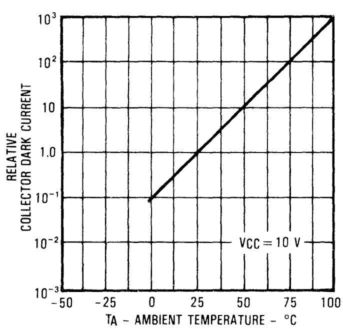
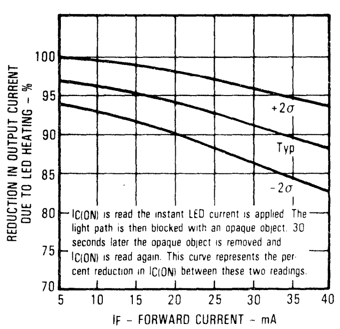
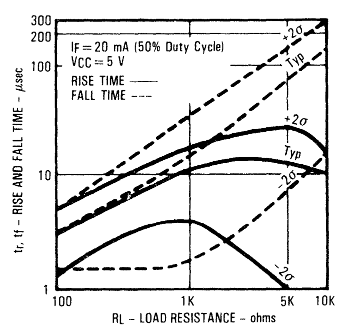
Relative Collector Dark Current vs Ambient Temperature



Reduction in Output Current Due to LED Heating vs Forward Current



Rise and Fall Time vs Load Resistance

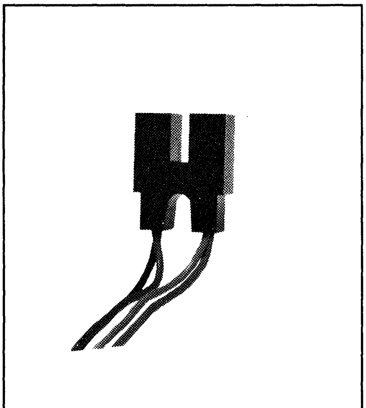


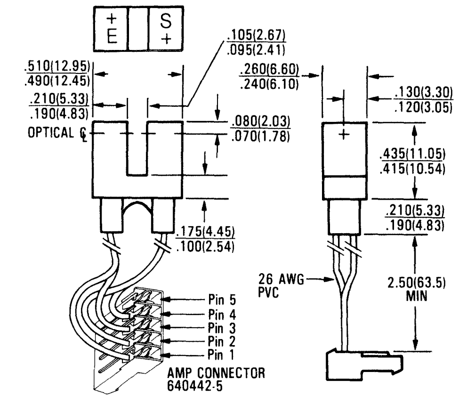
TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

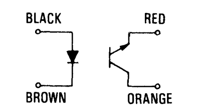
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5344
January 1985

Slotted Optical Switch
Type OPB836







WIRE COLOR	PIN #	
BROWN	1	CATHODE
ORANGE	2	COLLECTOR
BLACK	3	ANODE
RED	4	EMITTER
	5 (OPEN)	

Features
- Non-contact switching
- Wired to standard Amp No. 640442-5 connector
- Completely sealed polysulfone housing
- Fast switching speed

Description
The OPB836 consists of an infrared emitting diode and an NPN silicon phototransistor mounted on opposite sides of a 0.100″ (2.54 mm) wide slot. Phototransistor switching takes place whenever an opaque object passes through the slot. The low cost polysulfone housing reduces possible interference from ambient light and provides dirt and dust protection. A standard Amp No. 640442-5 connector has been attached to the lead wires to ease connection to wire harnesses.

The OPB836 utilizes an OP140 or OP240 type LED and an OP550 family sensor.

Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)
Storage and Operating Temperature Range . . . . . −40°C to +85°C(1)

Input Diode

Reverse Voltage . . . . . 2.0 V

Continuous Forward Current . . . . . 50 mA

Peak Forward Current (1 μs pulse width, 300 pps) . . . . . 3.0 A

Power Dissipation . . . . . 100 mW(2)

Phototransistor

Collector-Emitter Voltage . . . . . 30 V

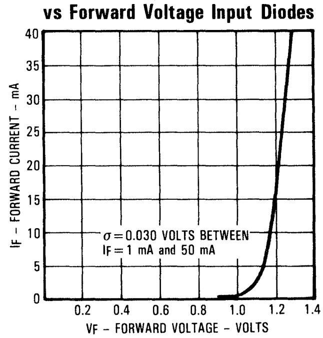
Emitter-Collector Voltage . . . . . 5.0 V

Power Dissipation . . . . . 100 mW(2)

Notes:

(1) Maximum storage and operating temperature are limited by the temperature rating of the lead wires.
(2) Derate linearly 1.33 mW/°C above 25°C.
(3) Plastic housing is soluble in chlorinated hydrocarbons and ketones. Methanol or isopropanol alcohols are recommended as cleaning agents.
(4) Wire color and location in connector govern polarity.

Typical Performance Curves
Forward Current vs Forward Voltage Input Diodes



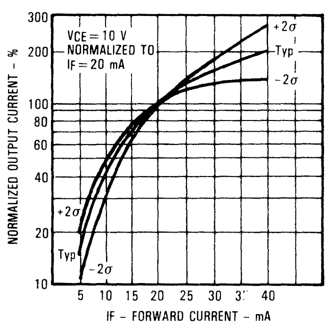
Type OPB836

Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

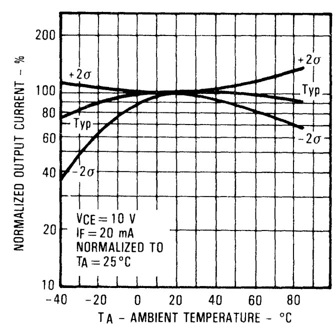
Symbol	Parameter	Min.	Max.	Units	Test Conditions
Input Diode					
V_F	Forward Voltage		1.70	V	$I_F = 20$ mA
I_R	Reverse Current		100	μA	$V_R = 2.0$ V
Output Phototransistor					
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	30		V	$I_C = 1.00$ mA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	5.0		V	$I_E = 100$ μA
I_{CEO}	Collector-Emitter Dark Current		100	nA	$V_{CE} = 10.0$ V, $I_F = 0$, $E_e = 0$
Coupled					
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage		0.40	V	$I_C = 500$ μA, $I_F = 20$ mA
$I_{C(ON)}$	On-State Collector Current	1.00		mA	$V_{CE} = 10.0$ V, $I_F = 20$ mA

Typical Performance Curves

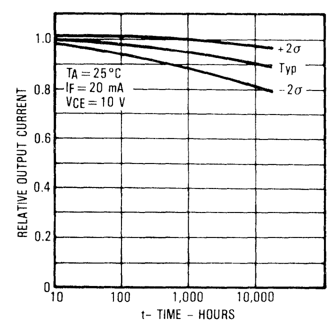
Normalized Output Current vs Forward Current



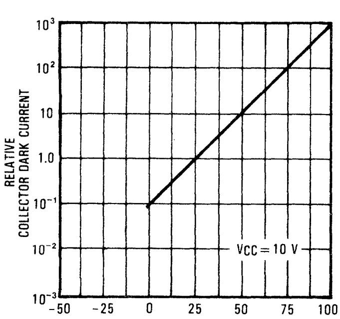
Normalized Output Current vs Ambient Temperature



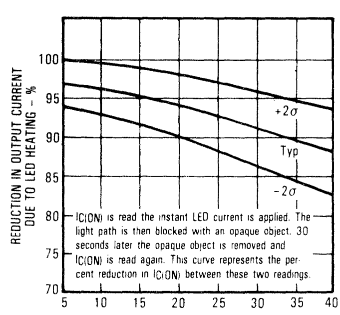
Relative Output Current vs Time



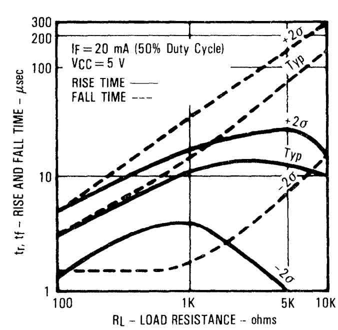
Relative Collector Dark Current vs Ambient Temperature



Reduction in Output Current Due to LED Heating vs Forward Current



Rise and Fall Time vs Load Resistance



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Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958

Optoelectronics Division
TRW Electronic Components Group

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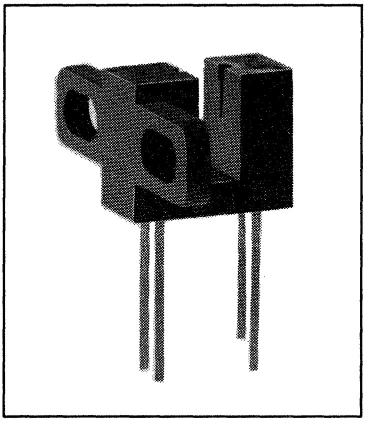
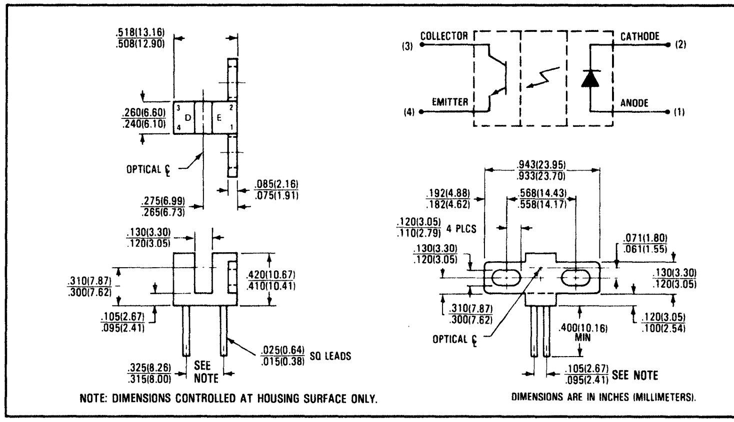
January 1985

Slotted Optical Switch
Type OPB837





Features
- Back mounting tabs
- Compact construction
- Opaque polycarbonate housing
- Non-contact switching
- Fast switching speed

Description
The OPB837 features mounting tabs located on the back of the housing, allowing a mounting variation which is often a useful advantage. Compact construction allows the device to occupy limited space within the user's system. The opaque polycarbonate housing shields the sensor from ambient light other than directly in front of the aperture. This allows the unit to operate in high ambient light levels. Utilizing the optical beam interrup system means non-contact switching at much higher speeds than is possible with mechanical switches. The discrete devices used are the OP140 or OP240 IRLED series, and the OP550 phototransistor series.

These units are particularly useful in counting applications such as tachometers and limit switch applications such as end- or beginning-of-travel sensors.

Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)
Storage and Operating Temperature Range . . . . −40°C to +85°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron) . . . . 240°C[1]

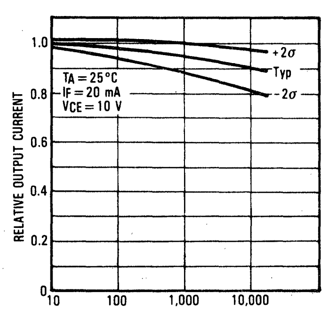
Input Diode
Reverse Voltage . . . . 2.0 V
Continuous Forward Current . . . . 50 mA
Peak Forward Current (1 μs pulse width, 300 pps) . . . . 3.0 A
Power Dissipation . . . . 100 mW[2]

Output Phototransistor
Collector-Emitter Voltage . . . . 30 V
Emitter-Collector Voltage . . . . 5.0 V
Collector DC Current . . . . 30 mA
Power Dissipation . . . . 100 mW[2]

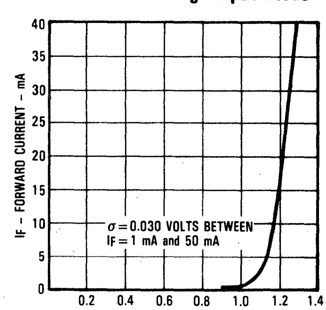
Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(2) Derate linearly 1.33 mW/°C above 25°C.
(3) Methanol or isopropanol alcohols are recommended as cleaning agents. Plastic housing is soluble in chlorinated ketones.

Typical Performance Curves

Relative Output Current vs Time



Forward Current vs Forward Voltage Input Diode



Type OPB837

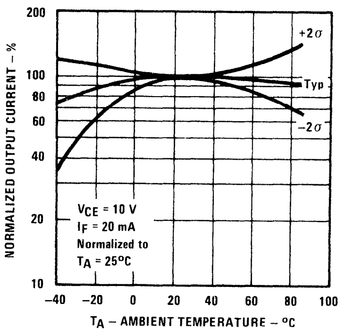
Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

Symbol	Parameter	Min.	Max.	Units	Test Conditions
Input Diode					
V_F	Forward Voltage		1.70	V	$I_F = 20$ mA
I_R	Reverse Current		100	μA	$V_R = 2.0$ V
Output Phototransistor					
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	30		V	$I_C = 1.00$ mA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	5.0		V	$I_E = 100$ μA
I_{CEO}	Collector-Emitter Dark Current		100	nA	$V_{CE} = 10.0$ V
Coupled					
$I_{C(ON)}$	On-State Collector Current	500		μA	$V_{CE} = 10.0$ V, $I_F = 20$ mA
$V_{CE(SAT)}$	Saturation Voltage		0.40	V	$I_C = 250$ μA, $I_F = 20$ mA

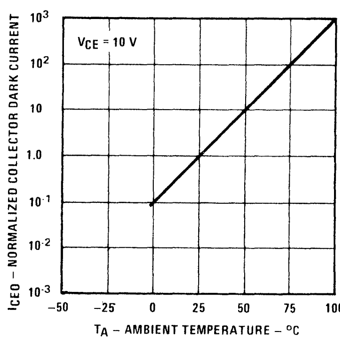
H

Typical Performance Curves

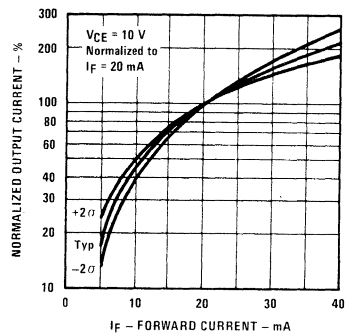
Normalized Output Current vs Ambient Temperature



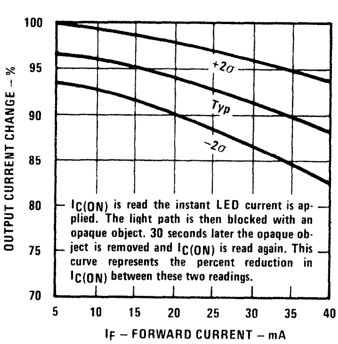
Collector Dark Current vs Ambient Temperature



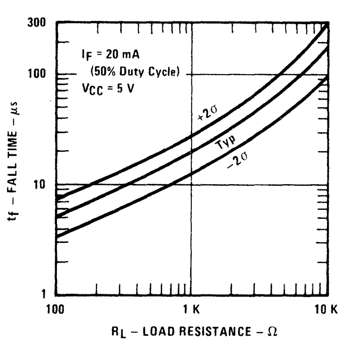
Normalized Output Current vs Forward Current



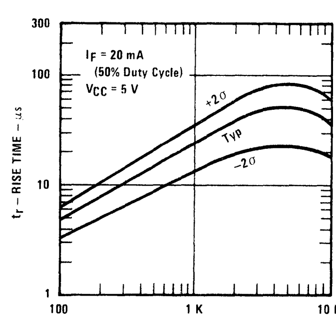
Change in Output Current Due to LED Heating vs Forward Current



Fall Time vs Load Resistance



Rise Time vs Load Resistance

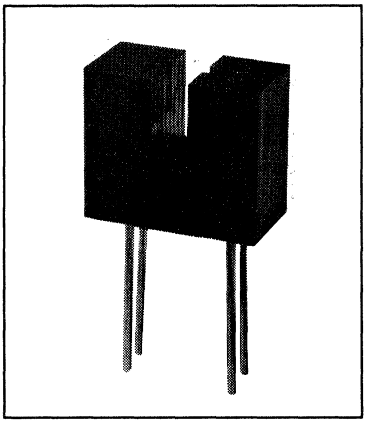


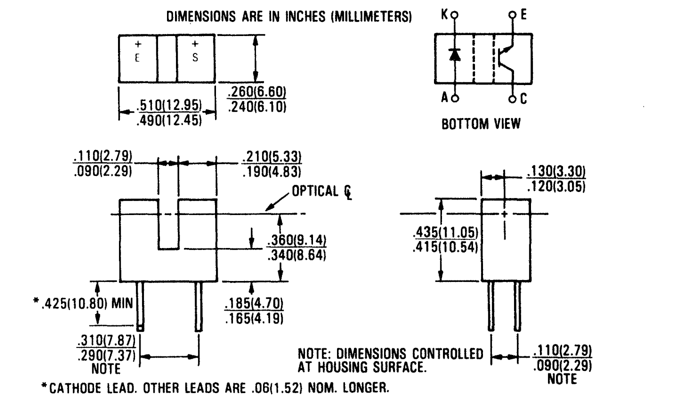
TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958

Printed in U.S.A.

Slotted Optical Switches
Types OPB847, OPB848





Features
- Non-contact switching
- Apertured for high resolution
- Fast switching speed

Description
The OPB847 and OPB848 each consist of an infrared emitting diode and an NPN silicon phototransistor mounted in a low cost black plastic housing on opposite sides of a 0.100" (2.54 mm) wide slot. Phototransistor switching takes place whenever an opaque object passes through the device slot. Both devices have a 0.025" (0.635 mm) by 0.06" (1.52 mm) aperture in front of the phototransistor for high resolution position sensing.

The OPB847 and OPB848 utilize an OP140 or OP240 type LED and an OP550 family sensor.

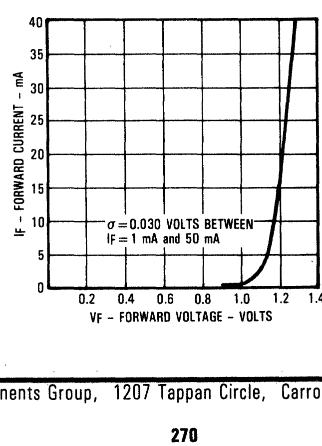
Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)

Storage and Operating Temperature Range	−40°C to +85°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)	240°C[1]
Input Diode	
Reverse Voltage	2.0 V
Continuous Forward Current	50 mA
Peak Forward Current (1 μs pulse width, 300 pps)	3.0 A
Power Dissipation	100 mW[2]
Output Phototransistor	
Collector-Emitter Voltage	30 V
Emitter-Collector Voltage	5.0 V
Power Dissipation	100 mW[2]

Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(2) Derate linearly 1.33 mW/°C above 25°C.
(3) Methanol or isopropanol alcohols are recommended as cleaning agents.

Typical Performance Curves

Forward Current vs Forward Voltage Input Diodes

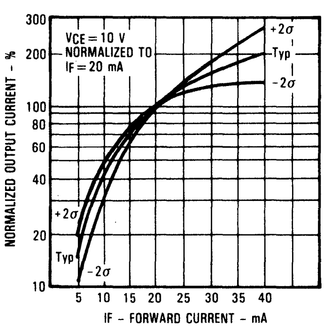


Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

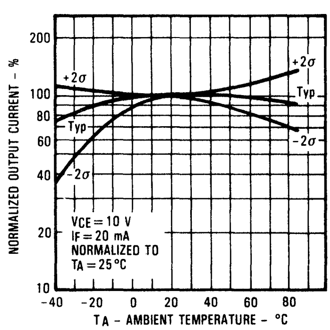
Symbol	Parameter	Min.	Max.	Units	Test Conditions
Input Diode					
V_F	Forward Voltage		1.70	V	$I_F = 20$ mA
I_R	Reverse Current		100	μA	$V_R = 2.0$ V
Output Phototransistor					
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	30		V	$I_C = 1.00$ mA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	5.0		V	$I_E = 100$ μA
I_{CEO}	Collector-Emitter Dark Current		100	nA	$V_{CE} = 10.0$ V, $I_F = 0$, $E_e = 0$
Coupled					
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage OPB847		0.40	V	$I_C = 2.0$ mA, $I_F = 20$ mA
	OPB848		0.40	V	$I_C = 0.50$ mA, $I_F = 20$ mA
$I_{C(ON)}$	On-State Collector Current OPB847	4.0		mA	$V_{CE} = 10.0$ V, $I_F = 20$ mA
	OPB848	1.0		mA	$V_{CE} = 10.0$ V, $I_F = 20$ mA

Typical Performance Curves

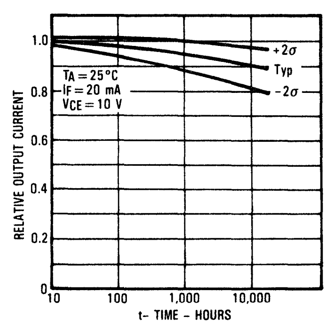
Normalized Output Current vs Forward Current



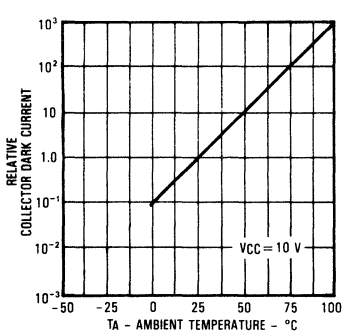
Normalized Output Current vs Ambient Temperature



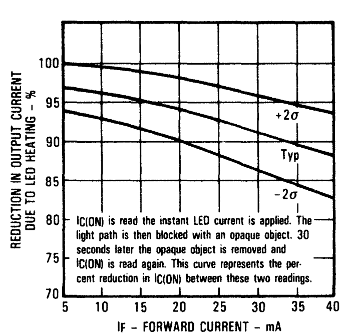
Relative Output Current vs Time



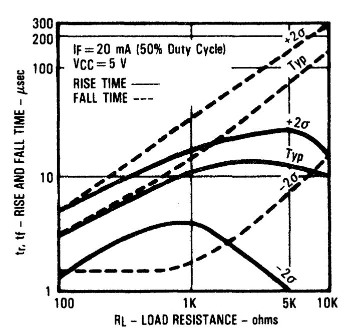
Relative Collector Dark Current vs Ambient Temperature



Reduction in Output Current Due to LED Heating vs Forward Current



Rise and Fall Time vs Load Resistance



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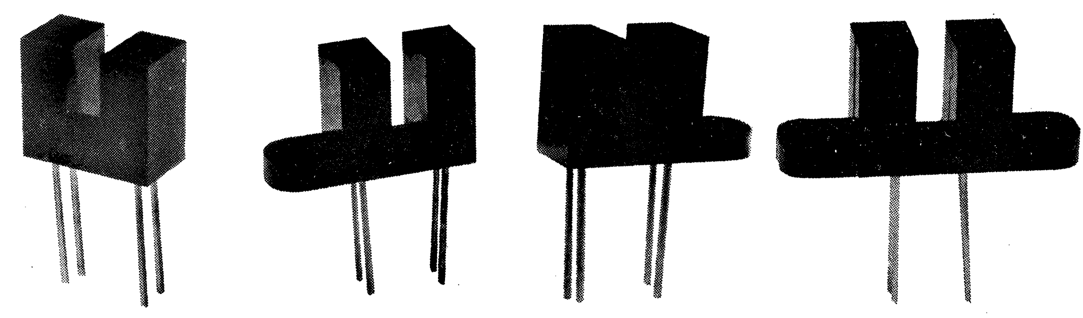
Printed in U.S.A.

Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5350
January 1985

Slotted Optical Switches
Types OPB860 Series, OPB870 Series

Recommended for New Design: The OPB860 series and OPB870 series are recommended new design replacements for the following devices: OPB813 family, OPB816, OPB817, OPB819, OPB825 family, CNY36.



Package N **Package L** **Package P** **Package T**

Features
- Choice of aperture sizes
- Choice of lead spacing
- Choice of mounting configuration
- Choice of minimum $I_{C(ON)}$
- Choice of polycarbonate or polysulfone housing

Description
The all new OPB860/OPB870 series is intended to provide custom design capability in a standard series. Each device consists of an infrared emitting diode and an NPN silicon phototransistor mounted on opposite sides of a 0.125″ (3.18 mm) wide slot. [Options include sensor aperture widths of 0.050″ (1.27 mm) or 0.010″ (0.25 mm); LED aperture width of 0.050″ (1.27 mm) or 0.020″ (0.50 mm); sensor-LED lead spacing of 0.220″ (5.59 mm) or 0.320″ (8.13 mm); minimum $I_{C(ON)}$ of 200 μA, 500 μA, 1000 μA, or 1800 μA;] and polysulfone (OPB860 series) housing for dust and dirt protection, or polycarbonate (OPB870 series) housing for complete opacity to ambient light.

The OPB860 series and OPB870 series both utilize an OP140 or an OP240 LED and an OP550 sensor.

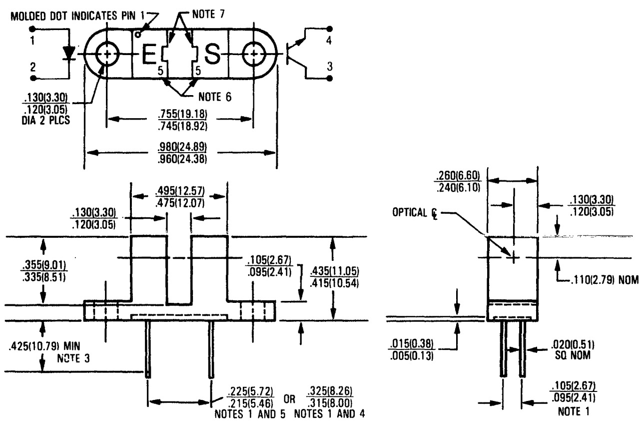
Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

Storage and Operating Temperature Range	−40°C to +85°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)	240°C(1)
Input Diode	
Reverse Voltage	2.0 V
Continuous Forward Current	50 mA
Peak Forward Current (1 μs pulse width, 300 pps)	3.0 A
Power Dissipation	100 mW(2)
Output Phototransistor	
Collector-Emitter Voltage	30 V
Emitter-Collector Voltage	5.0 V
Power Dissipation	100 mW(2)

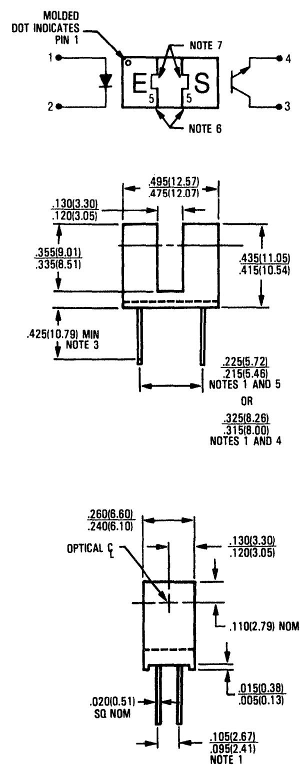
Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(2) Derate linearly 1.33 mW/°C above 25°C.
(3) Junction temperature maintained at 25°C.

Type OPB860 Series, OPB870 Series

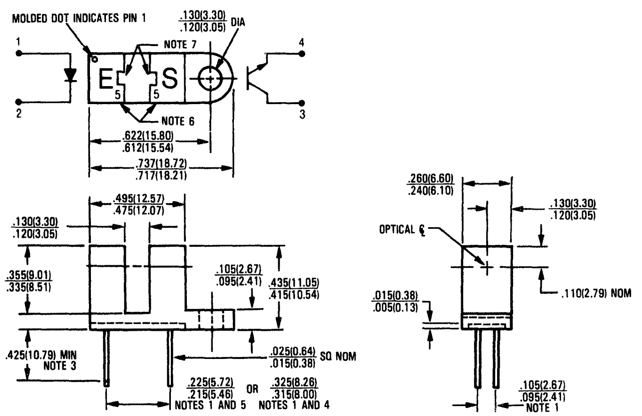
Package Configuration T



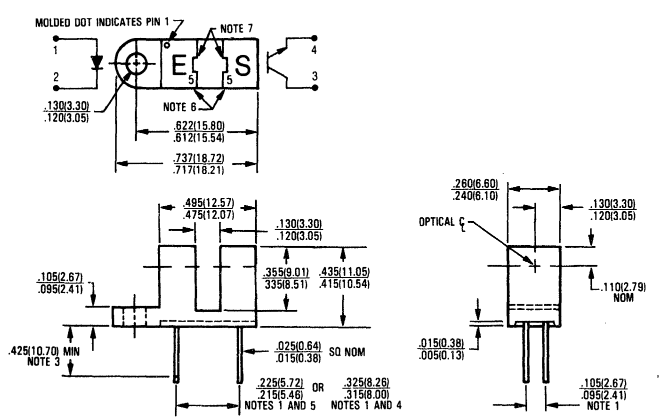
Package Configuration N



Package Configuration P



Package Configuration L



NOTES
1. DIMENSION CONTROLLED AT HOUSING SURFACE ONLY.
2. HOUSINGS SHOWN ARE POLYCARBONATE. HOUSINGS ARE SOLUBLE IN CHLORINATED HYDROCARBONS AND KETONES. METHANOL AND ISOPROPANOL ALCOHOLS ARE RECOMMENDED AS CLEANING AGENTS FOR BOTH TYPES OF HOUSING MATERIAL.
3. CATHODE LEAD. ALL OTHER LEADS ARE .06 (1.52) NOM. LONGER.
4. OPB860, OPB861, OPB862, OPB870, OPB871, OPB872, OPB873
5. OPB865, OPB866, OPB867, OPB875, OPB876, OPB877, OPB878
6. MOLDED NUMBER TO IDENTIFY APERTURE SIZE. SEE PART NUMBER GUIDE.
7. DIMENSIONS OF APERTURE OPENING DEPENDENT ON HOUSING MATERIAL. SEE PART NUMBER GUIDE.

DIMENSIONS ARE IN INCHES (MILLIMETERS).

H

Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

Symbol	Parameter	Min.	Max.	Units	Test Conditions
Input Diode					
V_F	Forward Voltage		1.70	V	$I_F = 20$ mA
I_R	Reverse Current		100	μA	$V_R = 2.0$ V
Output Phototransistor					
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	30		V	$I_C = 1.00$ mA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	5.0		V	$I_E = 100$ μA
I_{CEO}	Collector-Emitter Dark Current		100	nA	$V_{CE} = 10.0$ V
Coupled					
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage				
	Parameter A – OPB860, OPB865, OPB870, OPB875		0.40	V	$I_C = 400$ μA, $I_F = 20$ mA
	Parameter B – OPB861, OPB866, OPB871, OPB876		0.40	V	$I_C = 800$ μA, $I_F = 10.0$ mA
	Parameter C – OPB862, OPB867, OPB872, OPB877		0.40	V	$I_C = 1800$ μA, $I_F = 20$ mA
	Parameter D – OPB873, OPB878		0.40	V	$I_C = 400$ μA, $I_F = 20$ mA
$I_{C(ON)}$[3]	On-State Collector Current				
	Parameter A – OPB860, OPB865, OPB870, OPB875	500		μA	$V_{CE} = 10.0$ V, $I_F = 20$ mA
	Parameter B – OPB861, OPB866, OPB871, OPB876	1000		μA	$V_{CE} = 5.0$ V, $I_F = 10.0$ mA
	Parameter C – OPB862, OPB867, OPB872, OPB877	1800		μA	$V_{CE} = 0.4$ V, $I_F = 20$ mA
	Parameter D – OPB873, OPB878	200		μA	$V_{CE} = 10.0$ V, $I_F = 20$ mA

Part Numbering Guide

OPB 8XX X XX

TRW Assembly Prefix

8 = Phototransistor Output Family

Housing Material Designation
6 = Polysulfone 7 = Polycarbonate

Mechanical and Electrical Specification Variations

- 0 = Electrical parameter A, Lead Spacing .320″ (8.13 mm)
- 1 = Electrical parameter B, Lead Spacing .320″ (8.13 mm)
- 2 = Electrical parameter C, Lead Spacing .320″ (8.13 mm)
- * *3 = Electrical parameter D, Lead Spacing .320″ (8.13 mm)
- 5 = Electrical parameter A, Lead Spacing .220″ (5.59 mm)
- 6 = Electrical parameter B, Lead Spacing .220″ (5.59 mm)
- 7 = Electrical parameter C, Lead Spacing .220″ (5.59 mm)
- 8 = Electrical parameter D, Lead Spacing .220″ (5.59 mm)

* * Available only in polycarbonate housing

Aperture width in front of sensor
5 = .050″ (1.27 mm) *1 = .010″ (.25 mm)
Aperture length is .060″ (1.52 mm)
* Available only with electrical parameter A or D

Aperture width in front of LED
5 = .050″ (1.27 mm) *2 = .020″ (0.50 mm)
Aperture length is .060″ (1.52 mm)
* Available only with electrical parameter D and in a polycarbonate housing

Mounting Configurations
- T = Both mounting tabs
- N = No tabs
- L = Single mounting tab, emitter side
- P = Single mounting tab, sensor side

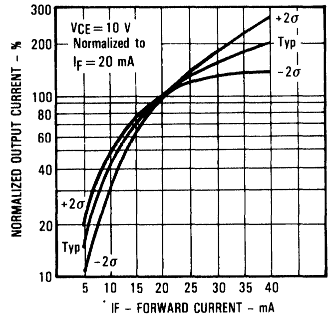
Example

OPB 875 N 51

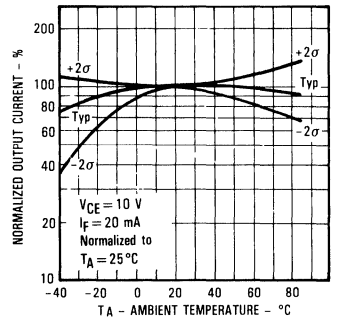
- TRW Assembly Prefix
- Phototransistor Output
- Polycarbonate Housing
- Electrical Paramater A, .220″ (5.59 mm) Lead Spacing
- No mounting tabs
- .050″ (1.27 mm) aperture in front of LED
- .010″ (.25 mm) aperture in front of sensor

Typical Performance Curves

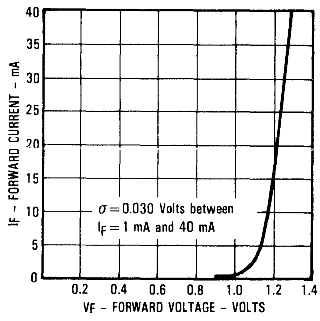
Normalized Output Current vs Forward Current



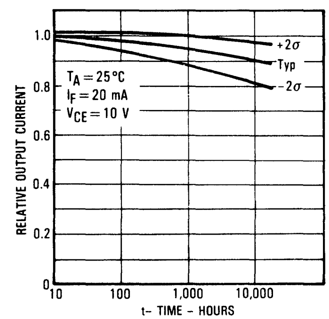
Normalized Output Current vs Ambient Temperature



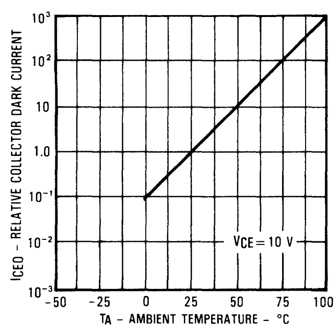
Forward Current vs Forward Voltage Input Diode



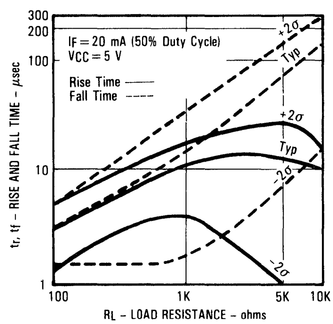
Relative Output Current vs Time



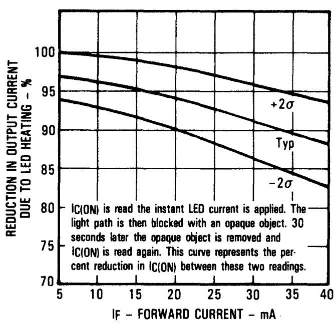
Collector Dark Current vs Ambient Temperature



Rise and Fall Time vs Load Resistance

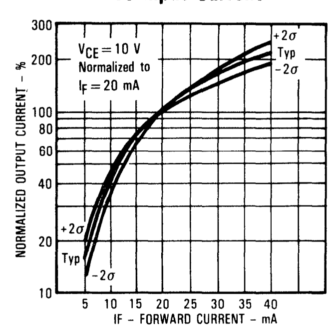


Reduction in Output Current Due to LED Heating vs Forward Current

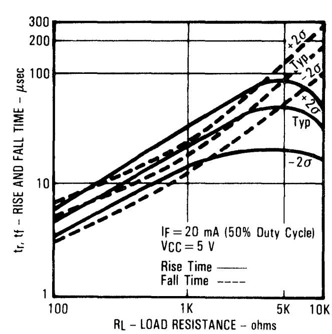


All Part Numbers Ending in "1"

Normalized Output Current vs Input Current



Rise and Fall Time vs Load Resistance



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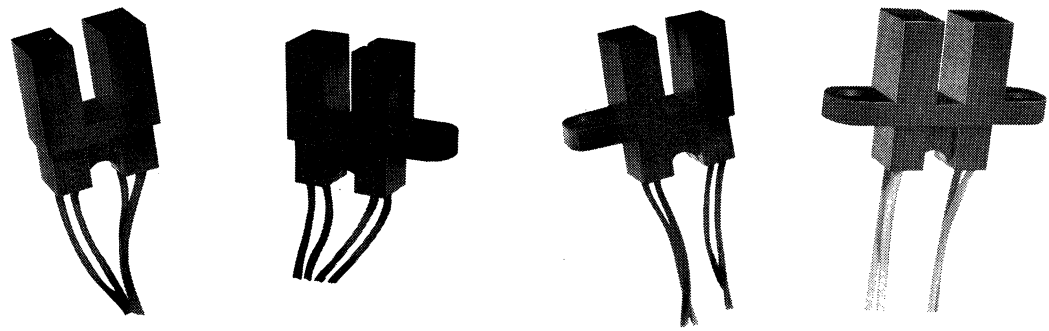
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5351
January 1985

Slotted Optical Switches
Types OPB880 Series, OPB890 Series

Recommended for New Design: The OPB880 series and OPB890 series are recommended new design replacements for the following devices: OPB813 family, OPB816, OPB817, OPB819, OPB825 family, CNY36.



Package N **Package L** **Package P** **Package T**

Features

- Choice of aperture sizes
- Choice of lead spacing
- Choice of mounting configuration
- Choice of minimum $I_{C(ON)}$
- Choice of polycarbonate or polysulfone housing

Description

The all new OPB880/OPB890 series is intended to provide custom design capability in a standard series using 18″ minimum length wire leads with PVC insulation. Each device consists of an infrared emitting diode and an NPN silicon phototransistor mounted on opposite sides of a 0.125″ (3.18 mm) wide slot. Options include sensor aperture widths of 0.050″ (1.27 mm) or 0.010″ (0.25 mm); LED aperture width of 0.050″ (1.27 mm) or 0.020″ (0.50 mm); minimum $I_{C(ON)}$ of 200 μA, 500 μA, 1000 μA, or 1800 μA; and polysulfone (OPB880 series) housing for dust and dirt protection, or polycarbonate (OPB890 series) housing for complete opacity to ambient light.

The OPB880 series and OPB890 series both utilize an OP140 or an OP240 LED and an OP550 sensor.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

Storage and Operating Temperature Range . . . . . −40°C to +85°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron) . . . . . 240°C[1]

Input Diode

Reverse Voltage . . . . . 2.0 V
Continuous Forward Current . . . . . 50 mA
Peak Forward Current (1 μs pulse width, 300 pps) . . . . . 3.0 A
Power Dissipation . . . . . 100 mW[2]

Output Phototransistor

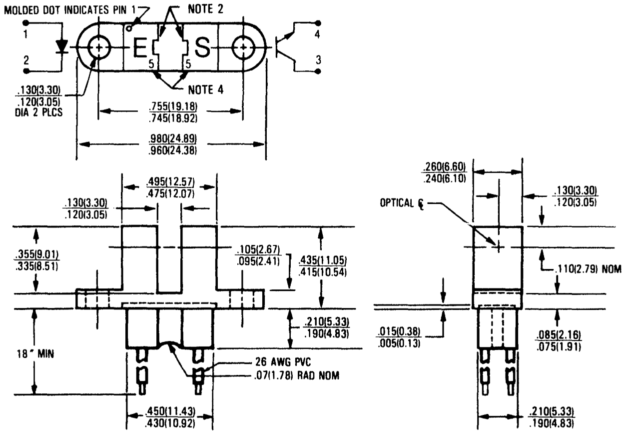
Collector-Emitter Voltage . . . . . 30 V
Emitter-Collector Voltage . . . . . 5.0 V
Power Dissipation . . . . . 100 mW[2]

Notes:

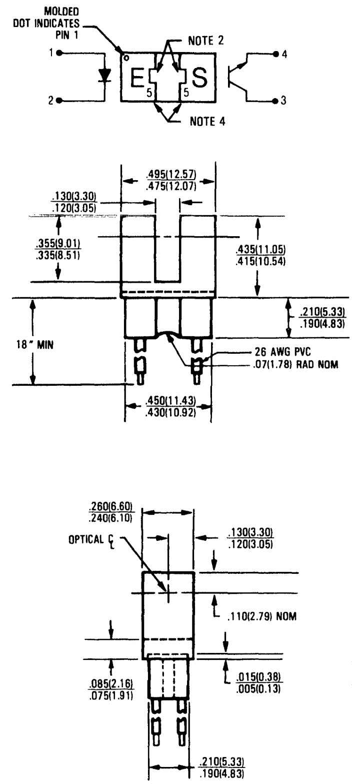
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(2) Derate linearly 1.33 mW/°C above 25°C.

Type OPB880 Series, OPB890 Series

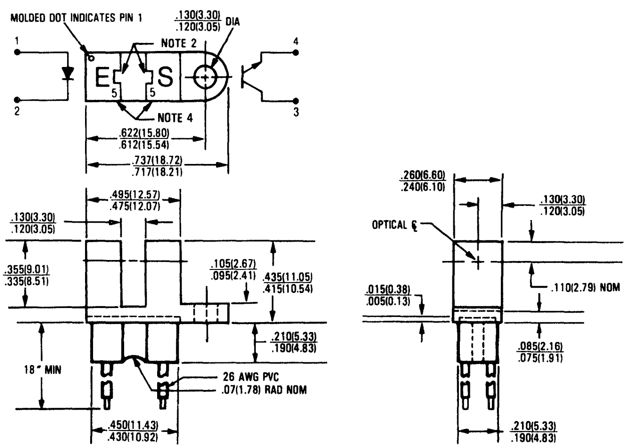
Package Configuration T



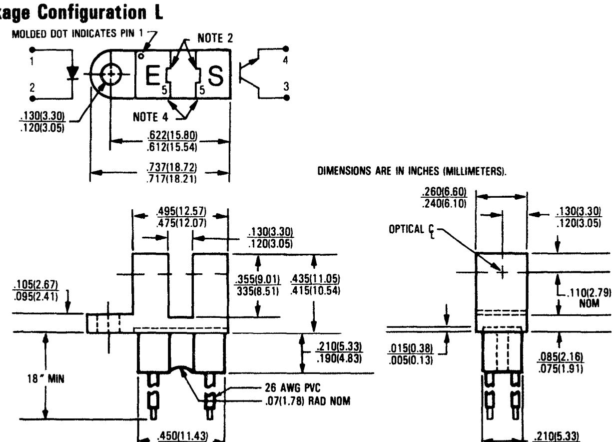
Package Configuration N



Package Configuration P



Package Configuration L



DIMENSIONS ARE IN INCHES (MILLIMETERS).

NOTES:
1. HOUSINGS SHOWN ARE POLYCARBONATE. HOUSINGS ARE SOLUBLE IN CHLORINATED HYDROCARBONS AND KETONES. METHANOL AND ISOPROPANOL ARE RECOMMENDED AS CLEANING AGENTS FOR BOTH TYPES OF HOUSING MATERIAL.
2. DIMENSIONS OF APERTURE OPENING DEPENDENT ON HOUSING MATERIAL.
3. MOLDED NUMBER TO IDENTIFY APERTURE SIZE. SEE PART NUMBER GUIDE.

H

Types OPB880 Series, OPB890 Series

Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

Symbol	Parameter	Min.	Max.	Units	Test Conditions
Input Diode					
V_F	Forward Voltage		1.70	V	$I_F = 20$ mA
I_R	Reverse Current		100	μA	$V_R = 2.0$ V
Output Phototransistor					
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	30		V	$I_C = 1.00$ mA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	5.0		V	$I_E = 100$ μA
I_{CEO}	Collector-Emitter Dark Current		100	nA	$V_{CE} = 10.0$ V
Coupled					
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage Parameter A - OPB880, OPB890, Parameter B - OPB881, OPB891, Parameter C - OPB882, OPB892, Parameter D - OPB893		 0.40 0.40 0.40 0.40	 V V V V	 $I_C = 400$ μA, $I_F = 20$ mA $I_C = 800$ μA, $I_F = 10.0$ mA $I_C = 1800$ μA, $I_F = 20$ mA $I_C = 400$ μA, $I_F = 20$ mA
$I_{C(ON)}$	On-State Collector Current Parameter A - OPB880, OPB890 Parameter B - OPB881, OPB891 Parameter C - OPB882, OPB892 Parameter D - OPB893	 500 1000 1800 200		 μA μA μA μA	 $V_{CE} = 10.0$ V, $I_F = 20$ mA $V_{CE} = 5.0$ V, $I_F = 10.0$ mA $V_{CE} = 0.4$ V, $I_F = 20$ mA $V_{CE} = 10.0$ V, $I_F = 20$ mA

Part Numbering Guide

OPB 8XX X XX

- TRW Assembly Prefix
- 8 = Phototransistor Output Family
- Housing Material Designation
  - 8 = Polysulfone 9 = Polycarbonate
- Mechanical and Electrical Specification Variations
  - 0 = Electrical parameter A
  - 1 = Electrical parameter B
  - 2 = Electrical parameter C
  - ** 3 = Electrical parameter D
  - ** Available in polycarbonate housing only.
- Aperture width in front of sensor
  - 5 = .050" (1.27 mm) * 1 = .010" (.25 mm)
  - Aperture length is .060" (1.52 mm)
  - * Available only with electrical parameter A or D
- Aperture width in front of LED
  - 5 = .050" (1.27 mm) * 2 = .020" (0.50 mm)
  - Aperture length is .060" (1.52 mm)
  - * Available only with electrical parameter D.
- Mounting Configurations
  - T = Both mounting tabs
  - N = No tabs
  - L = Single mounting tab, emitter side
  - P = Single mounting tab, sensor side

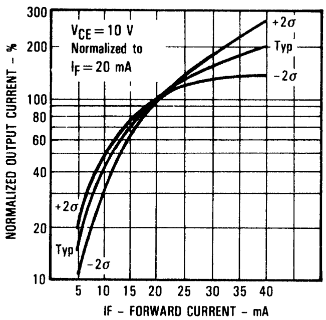
Example

OPB 890 N 51

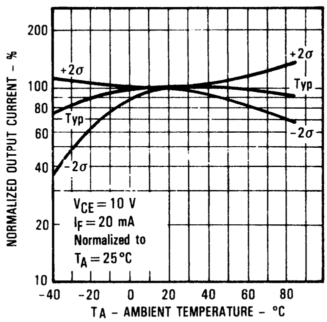
- TRW Assembly Prefix
- Phototransistor Output
- Polycarbonate Housing with wire leads
- Electrical Paramater A .220" (5.59 mm) Lead Spacing
- .010" (.25 mm) aperture in front of sensor
- .050" (1.27 mm) aperture in front of LED
- No mounting tabs

Typical Performance Curves

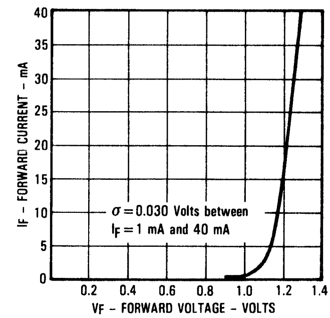
Normalized Output Current vs Forward Current



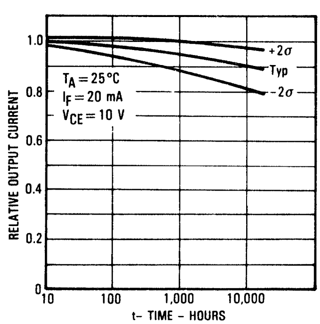
Normalized Output Current vs Ambient Temperature



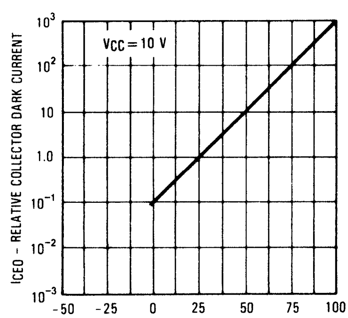
Forward Current vs Forward Voltage Input Diode



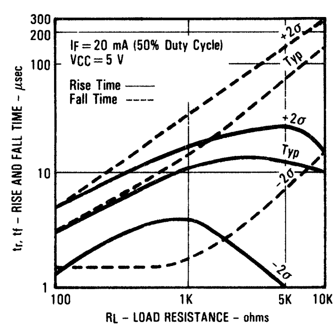
Relative Output Current vs Time



Collector Dark Current vs Ambient Temperature

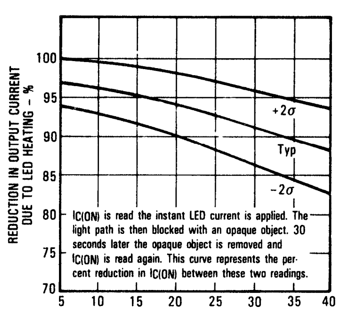


Rise and Fall Time vs Load Resistance



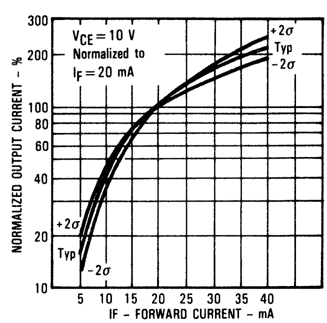
H

Reduction in Output Current Due to LED Heating vs Forward Current

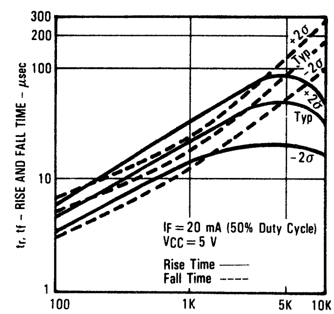


All Part Numbers Ending in "1"

Normalized Output Current vs Input Current



Rise and Fall Time vs Load Resistance

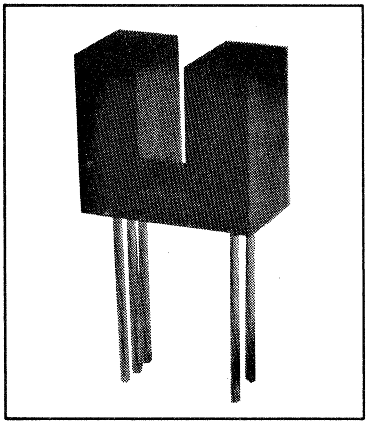


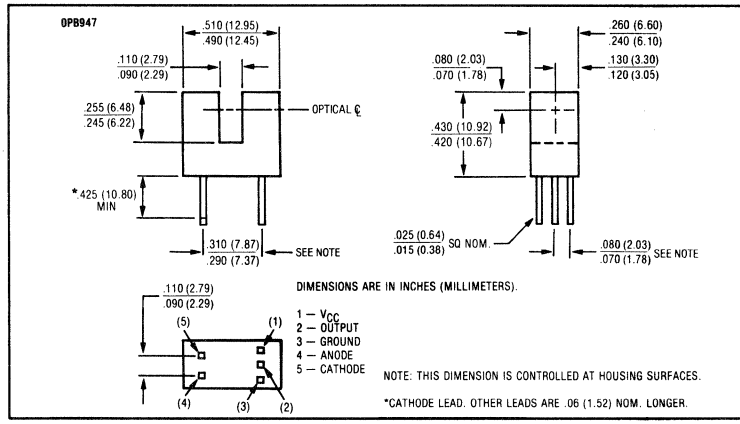
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5358
January 1985

Photologic™ Slotted Switches
Types OPB947, OPB948

NOT RECOMMENDED FOR NEW DESIGN. SEE OPB960 SERIES.





Features

- Two output options
- Low cost plastic housing
- Direct TTL/LSTTL interface
- High noise immunity
- Data rates to 250 Kbaud

Description

The OPB947 and OPB948 each contain an infrared emitting diode coupled to a monolithic integrated circuit, which incorporates a photodiode, a linear amplifier and a Schmitt trigger on a single silicon chip. The devices feature TTL/LSTTL compatible logic level output which can drive up to 8 TTL loads directly without additional circuitry. Also featured are medium speed data rates to 250 Kbaud with typical output rise and fall times of 25 nsec. A 0.025 inch (0.635 mm) aperture in front of the sensor and a 0.05 inch (1.27 mm) aperture in front of the LED allows high resolution motion sensing. The devices are encased in low cost plastic housings which reduce ambient light noise and ease direct soldering to PC boards.

OPB947 and OPB948 each utilize an OP140 or OP240 LED. OPB947 uses an OPL550 type sensor and OPB948 uses an OPL550-OC type sensor.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

Supply Voltage, V_{CC} (not to exceed 3 seconds)	+10.0 V
Storage Temperature Range	−40°C to +85°C
Operating Temperature Range	−40°C to +70°C
Lead Soldering Temperature Range (1/16 inch [1.6 mm] from Case for 5 sec. with soldering iron)	240°C(1)
Total Power Dissipation	300 mW(2)
Input Diode Power Dissipation	100 mW(3)
Output Photologic Power Dissipation	200 mW(4)
Duration of Output Short to V_{CC} or Ground (OPB947)	1.00 sec.
Duration of Output Short to V_{CC} (OPB948)	1.00 sec.
Voltage at Output Lead (OPB948)	35 V
Input Diode Forward DC Current	40 mA
Input Diode Reverse DC Voltage	2.0 V

Notes:

(1) RMA flux is recommended. Duration can be extended to 10 seconds max. when flow soldering.
(2) Derate linearly 4.0 mW/°C above 25°C.
(3) Derate linearly 1.33 mW/°C above 25°C.
(4) Derate linearly 2.67 mW/°C above 25°C.
(5) Normal application would be with light source blocked, simulated by I_F = 0.
(6) Methanol and isopropanol alcohols are recommended as cleaning agents.

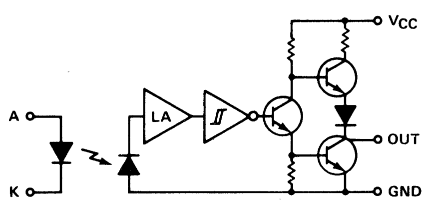
Types OPB947, OPB948

Electrical Characteristics (T_A = −40° to +70°C unless otherwise noted)

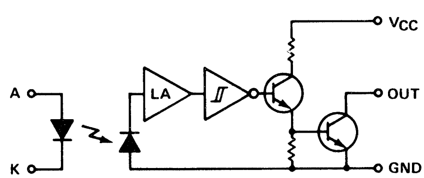
Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
Diode Input						
V_F	Forward Voltage			1.70	V	I_F = 20 mA, T_A = 25°C
I_R	Reverse Current			100	μA	V_R = 2.0 V, T_A = 25°C
$I_{F(+)}$	LED Positive-Going Threshold Current			15.0	mA	V_{CC} = 5.0 V
$I_{F(+)}I_{F(-)}$	Hysteresis Ratio		2.0			
Photologic Output						
V_{CC}	Operating Supply Voltage	4.75		5.25	V	
I_{CC}	Supply Current			15.0	mA	V_{CC} = 5.25 V, I_F = 0[5] or 15.0 mA
OPB947 (Buffer, Totem-Pole)						
V_{OL}	Low Level Output Voltage			0.40	V	V_{CC} = 4.75 V, I_{OL} = 12.8 mA, I_F = 0 mA[5]
V_{OH}	High Level Output Voltage	2.4			V	V_{CC} = 4.75 V, I_{OH} = −800 μA I_F = 15.0 mA
I_{OS}	Short Circuit Output Current	−30		−100	mA	V_{CC} = 5.25 V, I_F = 15.0 mA, Output = GND
OPB948 (Buffer, Open Collector)						
V_{OL}	Low Level Output Voltage			0.40	V	V_{CC} = 4.75 V, I_{OL} = 12.8 mA, I_F = 0 mA[5]
I_{OH}	High Level Output Current			100	μA	V_{CC} = 4.75 V, V_{OH} = 30 V, I_F = 15.0 mA
OPB947 (Buffer, Totem-Pole)						
t_r, t_f	Output Rise Time, Output Fall Time		70		ns	V_{CC} = 5.0 V, T_A = 25°C, I_F = 0[5] or 20 mA
t_{PLH}, t_{PHL}	Propagation Delay, Low-High, High-Low		5.0		μs	f = 10.0 kHz, D.C. = 50%, R_L = 8 TTL Loads
OPB948 (Buffer, Open Collector)						
t_r, t_f	Output Rise Time, Output Fall Time		70		ns	V_{CC} = 5.0 V, T_A = 25°C, I_F = 0[5] or 20 mA
t_{PLH}, t_{PHL}	Propagation Delay, Low-High, High-Low		5.0		μs	f = 10.0 kHz, D.C. = 50%, R_L = 8 TTL Loads

Schematics

OPB947 (Totem-Pole Output) Buffer



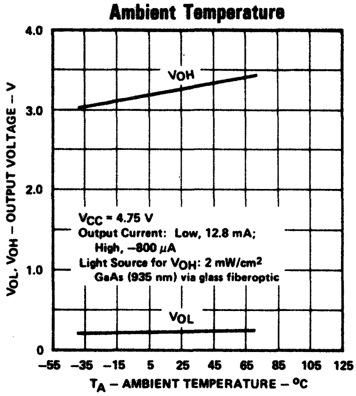
OPB948 (Open Collector Output) Buffer



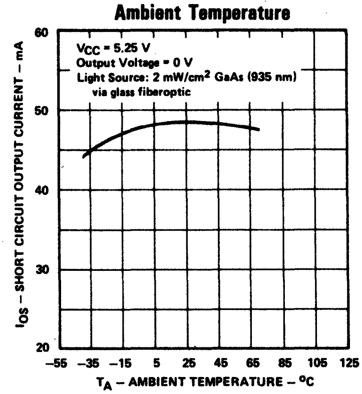
Typical Performance Curves

OPB947

Output Voltage vs. Ambient Temperature

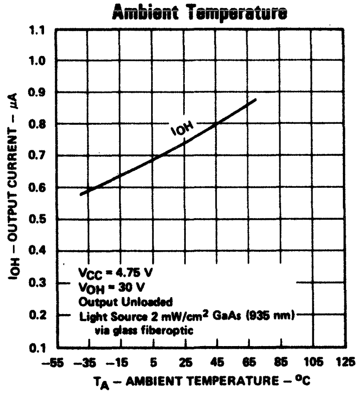


Short Circuit Output Current vs. Ambient Temperature

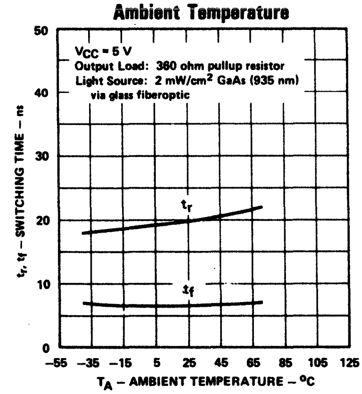


OPB948

Output Current (High) vs. Ambient Temperature

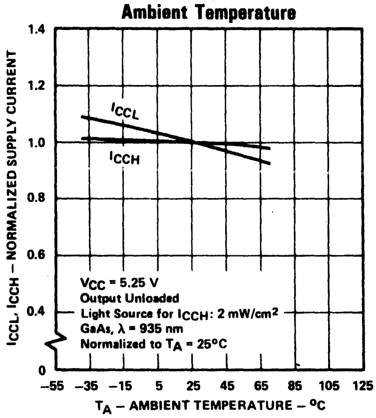


Rise Time and Fall Time vs. Ambient Temperature

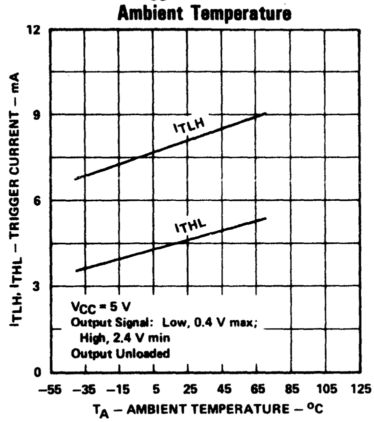


Typical Performance Curves

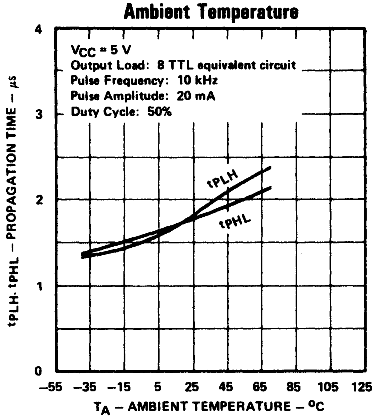
Normalized Supply Current vs. Ambient Temperature



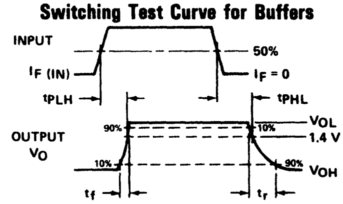
Trigger Current vs. Ambient Temperature



Propagation Time vs. Ambient Temperature



Switching Test Curve for Buffers



LED: f = 10 kHz, D.C. = 50%

H

TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958

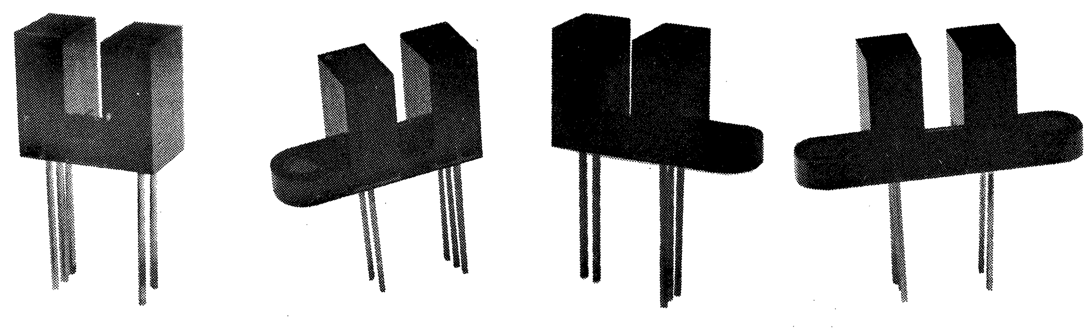
 Printed in U.S.A.

Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5354
January 1985

Photologic™ Slotted Optical Switches
Types OPB960 Series, OPB970 Series

Recommended for New Design: The OPB960 series and OPB970 series are recommended new design replacements for the following devices: OPB913S10, OPB914S10, OPB915S10, OPB916S10, OPB947, OPB948.



Package N **Package L** **Package P** **Package T**

Features

- Choice of aperture
- Choice of mounting configuration
- Choice of output configuration
- Choice of polysulfone or polycarbonate housing
- Data rates to 250 K baud

Description

The all new OPB960/OPB970 series is intended to provide custom design capabilities in a standard series. Each device consists of an infrared emitting diode and a Photologic™ sensor (a monolithic integrated circuit which incorporates a linear amplifier, and a Schmitt trigger) mounted on opposite sides of a 0.125″ (3.18 mm) wide slot. Options include Photologic™ sensor aperture widths of 0.050″ (1.27 mm) or 0.010″ (0.25 mm); and LED aperture widths of 0.050″ (1.27 mm) or 0.020″ (0.51 mm);* four different mounting configurations; buffer-totem pole, buffer-open collector, inverter-totem pole, or inverter-open collector output; and polysulfone (OPB960) housing for dirt and dust protection, or polycarbonate (OPB970) housing for complete opacity to ambient light.

The OPB960/OPB970 series utilizes an OP140 or OP240 LED and Photologic™ plastic sensor.

Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)

Supply Voltage, V_{CC} (not to exceed 3 seconds)	+10.0 V
Storage Temperature Range	−40°C to +85°C
Operating Temperature Range	−40°C to +70°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)	240°C(1)
Input Diode Power Dissipation	100 mW(2)
Output Photologic Power Dissipation	200 mW(4)
Total Device Power Dissipation	300 mW(5)
Voltage at Output Lead (Open Collector Output)	35 V
Diode Forward D.C. Current	40 mA
Diode Reverse D.C. Voltage	2.0 V

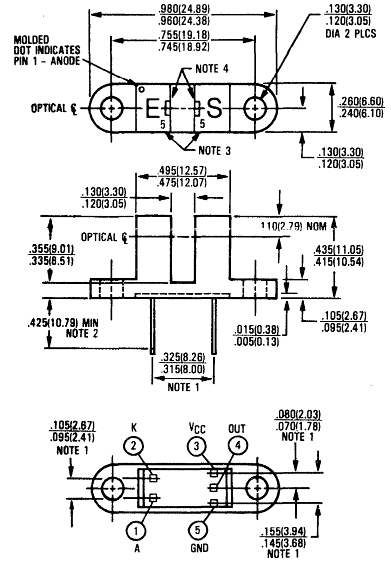
Notes:

(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(2) Derate linearly 1.33 mW/°C above 25°C.
(3) Normal application would be with light source blocked, simulated by $I_F = 0$.
(4) Derate linearly 2.67 mW/°C above 25°C.
(5) Derate linearly 4.0 mW/°C above 25°C.

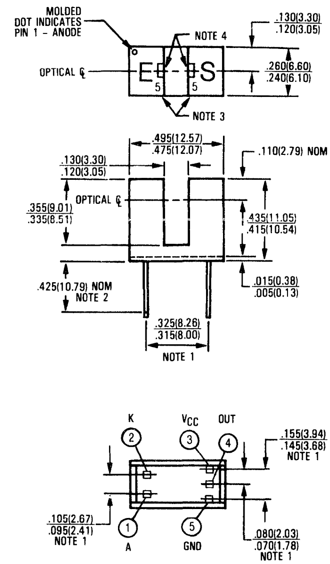
* LED aperture width of .020″ (0.51 mm) is available only with a sensor aperture width of .010″ (0.25 mm) in polycarbonate housing.

Type OPB960 Series, OPB970 Series

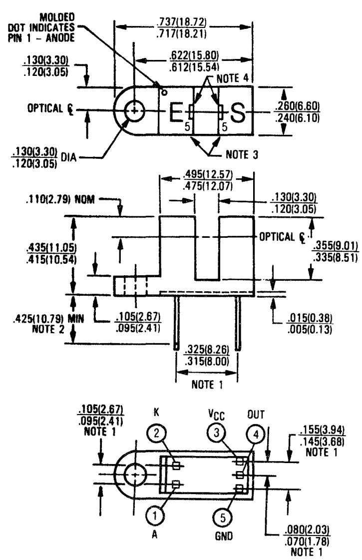
Package Configuration T



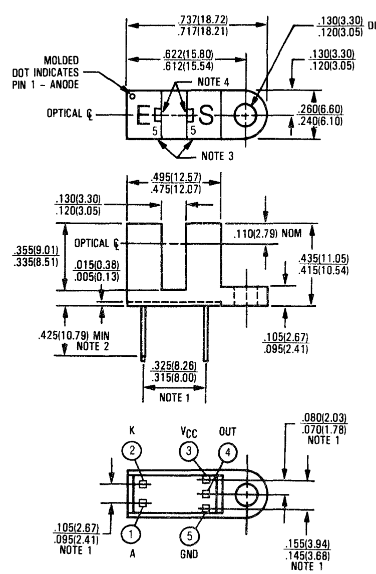
Package Configuration N



Package Configuration L



Package Configuration P



DIMENSIONS ARE IN INCHES (MILLIMETERS)

NOTES:

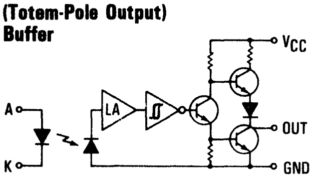
1. THIS DIMENSION IS CONTROLLED AT HOUSING SURFACE.
2. CATHODE LEAD. ALL OTHER LEADS ARE .06 (1.52) NOM. LONGER
3. MOLDED NUMBER TO IDENTIFY APERTURE SIZE. SEE PART NUMBER GUIDE.
4. DIMENSIONS OF APERTURE OPENING DEPENDENT ON HOUSING MATERIAL. SEE PART NUMBER GUIDE. HOUSINGS ARE SOLUBLE IN CHLORINATED HYDROCARBONS AND KETONES. METHANOL AND ISOPROPANOL ARE RECOMMENDED AS CLEANING AGENTS FOR BOTH TYPES OF HOUSING MATERIAL.
5. HOUSINGS SHOWN ARE POLYCARBONATE.

Electrical Characteristics (−40°C to +70°C unless otherwise noted)

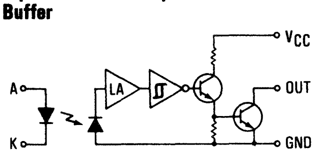
Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
Input Diode						
V_F	Forward Voltage			1.70	V	$I_F = 20$ mA, $T_A = 25°C$
I_R	Reverse Current			100	μA	$V_R = 2.0$ V, $T_A = 25°C$
Output Photologic™						
V_{CC}	Operating Supply Voltage	4.75		5.25	V	
I_{CCL}	Low Level Supply Current:					
	Buffer with Totem-Pole Output			15.0	mA	$V_{CC} = 5.25$ V, $I_F = 0$ mA(3)
	Buffer with Open-Collector			15.0	mA	$V_{CC} = 5.25$ V, $I_F = 0$ mA(3)
	Inverter with Totem-Pole Output			15.0	mA	$V_{CC} = 5.25$ V, $I_F = 15.0$ mA
	Inverter with Open-Collector			15.0	mA	$V_{CC} = 5.25$ V, $I_F = 15.0$ mA
I_{CCH}	High Level Supply Current:					
	Buffer with Totem-Pole			15.0	mA	$V_{CC} = 5.25$ V, $I_F = 15.0$ mA
	Buffer with Open-Collector			15.0	mA	$V_{CC} = 5.25$ V, $I_F = 15.0$ mA
	Inverter with Totem-Pole			15.0	mA	$V_{CC} = 5.25$ V, $I_F = 0$ mA(3)
	Inverter with Open-Collector			15.0	mA	$V_{CC} = 5.25$ V, $I_F = 0$ mA(3)
V_{OL}	Low Level Output Voltage:					
	Buffer with Totem-Pole			0.40	V	$V_{CC} = 4.75$ V, $I_{OL} = 12.8$ mA, $I_F = 0$ mA(3)
	Buffer with Open-Collector			0.40	V	$V_{CC} = 4.75$ V, $I_{OL} = 12.8$ mA, $I_F = 0$ mA(3)
	Inverter with Totem-Pole			0.40	V	$V_{CC} = 4.75$ V, $I_{OL} = 12.8$ mA, $I_F = 15.0$ mA
	Inverter with Open-Collector			0.40	V	$V_{CC} = 4.75$ V, $I_{OL} = 12.8$ mA, $I_F = 15.0$ mA
V_{OH}	High Level Output Voltage:					
	Buffer with Totem-Pole	2.4			V	$V_{CC} = 4.75$ V, $I_{OH} = 800$ μA, $I_F = 15.0$ mA
	Inverter with Totem-Pole	2.4			V	$V_{CC} = 4.75$ V, $I_{OH} = 800$ μA, $I_F = 0$ mA(3)
I_{OH}	High Level Output Current:					
	Buffer with Open-Collector			100	μA	$V_{CC} = 4.75$ V, $V_{OH} = 30$ V, $I_F = 15.0$ mA
	Inverter with Open-Collector			100	μA	$V_{CC} = 4.75$ V, $V_{OH} = 30$ V, $I_F = 0$ mA, $T_A = 25°C$
$I_F(+)$	LED Positive-Going Threshold Current			15.0	mA	$V_{CC} = 5.0$ V
$I_F(+)/I_F(-)$	Hysteresis Ratio		2.0			$V_{CC} = 5.0$ V
I_{OS}	Short Circuit Output Current	−30		−100	mA	$V_{CC} = 5.25$ V, $I_F = 20$ mA, Output = GND
t_r, t_f	Output Rise Time, Output Fall Time		70		ns	$V_{CC} = 5.0$ V, $T_A = 25°C$, $I_F = 0$ or 15.0 mA
t_{PLH}, t_{PHL}	Propagation Delay, Low-High & High-Low		5.0		μs	$R_L = 8$ TTL Loads (Totem-Pole) $R_L = 360\ \Omega$ (Open-Collector)

Schematics

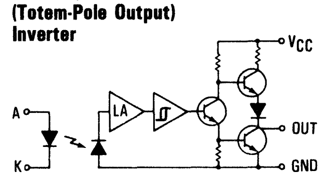
OPB960/OPB970
(Totem-Pole Output)
Buffer



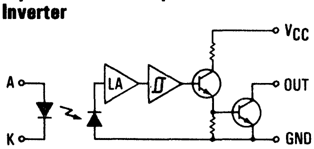
OPB961/OPB971
(Open-Collector Output)
Buffer



OPB962/OPB972
(Totem-Pole Output)
Inverter



OPB963/OPB973
(Open-Collector Output)
Inverter



Part Numbering Guide

OPB 9XX X XX

- TRW Assembly Prefix — OPB
- 9 = Photologic Output Family
- Housing Material Designation
  - 6 = Polysulfone 7 = Polycarbonate
- Photologic Sensor Output Variations
  - 0 = Buffer with Totem Pole Output
  - 1 = Buffer with Open Collector Output
  - 2 = Inverter with Totem Pole Output
  - 3 = Inverter with Open Collector Output
- Mounting Configurations
  - T = Mounting tabs, both sides
  - N = No mounting tabs
  - L = Single mounting tab, emitter side
  - P = Single mounting tab, sensor side
- Aperture width in front of LED
  - 5 = 0.050″ (1.27 mm) * 2 = 0.020″ (0.51 mm)
  - Aperture length is 0.060″ (1.52 mm)
  - * Available only in a polycarbonate housing with a sensor aperture width of 0.010″ (0.25 mm).
- Aperture width in front of sensor
  - 5 = 0.050″ (1.27 mm) 1 = 0.010″ (0.25 mm)
  - Aperture length is 0.060″ (1.52 mm)

Example

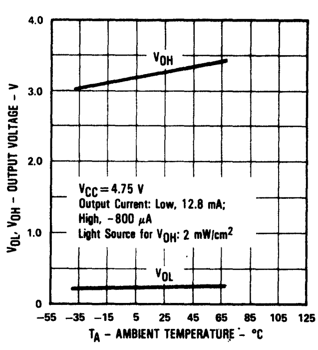
OPB 963 N 51

- TRW Assembly Prefix — OPB
- Photologic Output — 9
- Polysulfone Housing — 6
- Inverter, Open Collector — 3
- No mounting tabs — N
- 0.050″ (1.27 mm) aperture in front of LED — 5
- 0.010″ (0.25 mm) aperture in front of sensor — 1

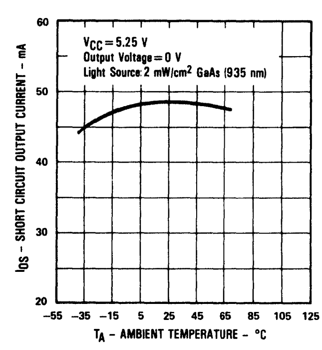
Typical Performance Curves

OPB960, OPB962, OPB970, OPB972

Output Voltage vs Ambient Temperature

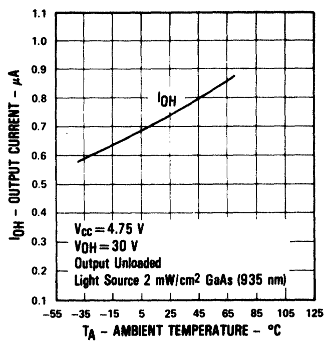


Short Circuit Output Current vs Ambient Temperature

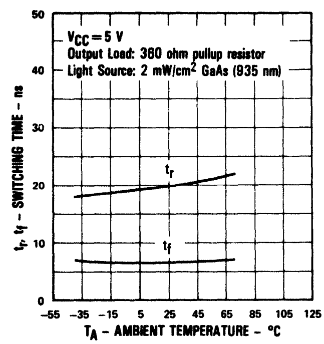


OPB961, OPB963, OPB971, OPB973

Output Current (High) vs Ambient Temperature

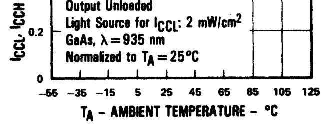


Rise Time and Fall Time vs Ambient Temperature



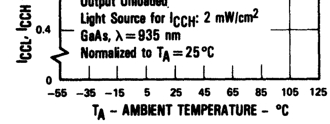
OPB962, OPB963, OPB972, OPB973

Normalized Supply Current vs Ambient Temperature



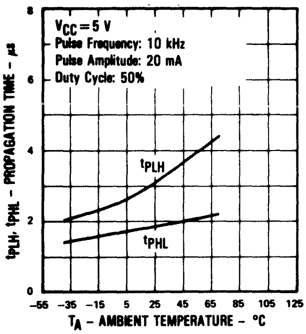
OPB960, OPB961, OPB970, OPB971

Normalized Supply Current vs Ambient Temperature

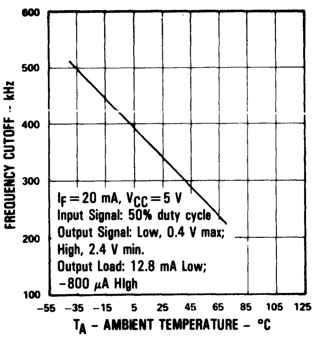


All Assemblies

Propagation Time vs Ambient Temperature

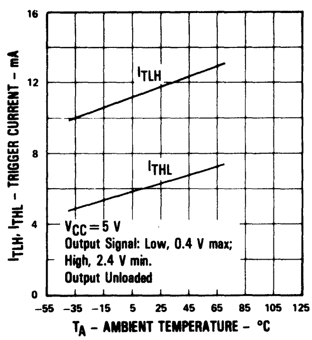


Data Rate vs Ambient Temperature

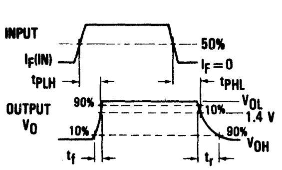


All Assemblies

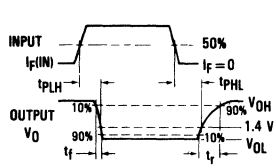
Trigger Current vs Ambient Temperature



Switching Test Curve for Buffers



Switching Test Curve for Inverters



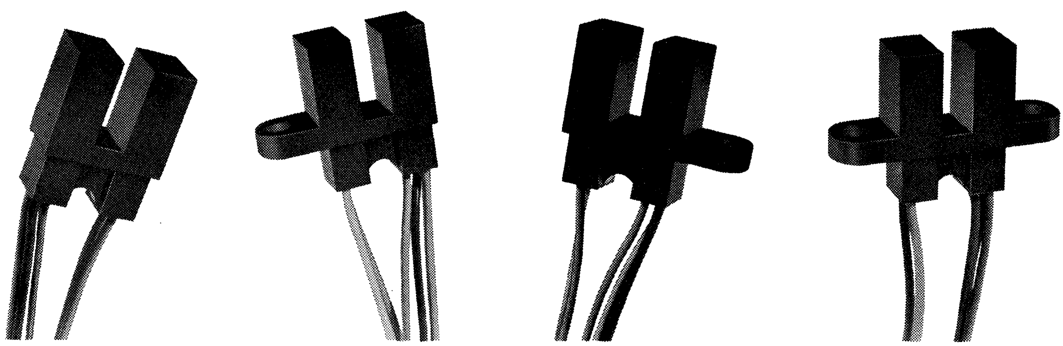
TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5355
January 1985

Photologic™ Slotted Optical Switches
Types OPB980 Series, OPB990 Series

Recommended for New Design: The OPB980 series and OPB990 series are recommended new design replacements for the following devices: OPB913S10, OPB914S10, OPB915S10, OPB916S10, OPB947, OPB948.



Package N　　Package L　　Package P　　Package T

Features

- Choice of aperture
- Choice of mounting configuration
- Choice of output configuration
- Choice of polysulfone or polycarbonate housing
- Data rates to 250 K baud

Description

The all new OPB980/OPB990 series is intended to provide custom design capabilities in a standard series using 18″ minimum length wire leads with PVC insulation. Each device consists of an infrared emitting diode and a Photologic™ sensor (a monolithic integrated circuit which incorporates a linear amplifier and a Schmitt trigger) mounted on opposite sides of a 0.125″ (3.18 mm) wide slot. Options include Photologic™ sensor aperture widths and LED aperture widths, four different mounting configurations; buffer-totem pole, buffer-open collector, inverter-totem pole, or inverter-open collector output; and polysulfone (OPB980) housing for dirt and dust protection, or polycarbonate (OPB990) housing for complete opacity to ambient light.

The OPB980/OPB990 series utilizes an OP140 or an OP240 LED and a Photologic™ plastic sensor.

Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)

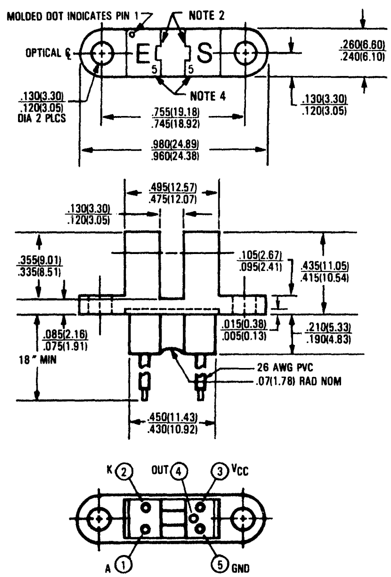
Supply Voltage, V_{CC} (not to exceed 3 seconds) .... +10.0 V
Storage Temperature Range .... −40°C to +85°C
Operating Temperature Range .... −40°C to +70°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron) .... 240°C[1]
Input Diode Power Dissipation .... 100 mW[2]
Output Photologic Power Dissipation .... 200 mW[4]
Total Device Power Dissipation .... 300 mW[5]
Voltage at Output Lead (Open Collector Output) .... 35 V
Diode { Forward D.C. Current .... 40 mA
Diode { Reverse D.C. Voltage .... 2.0 V

Notes:

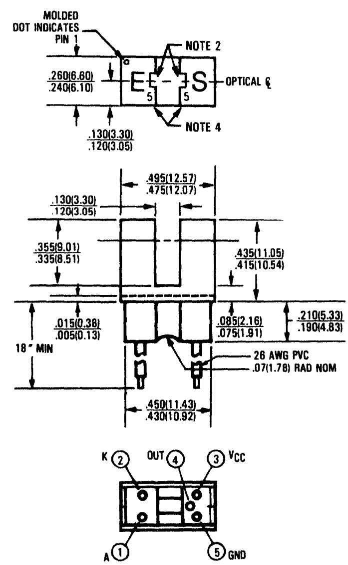
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(2) Derate linearly 1.33 mW/°C above 25°C.
(3) Normal application would be with light source blocked, simulated by $I_F = 0$.
(4) Derate linearly 2.67 mW/°C above 25°C.
(5) Derate linearly 4.0 mW/°C above 25°C.

Types OPB980 Series, OPB990 Series

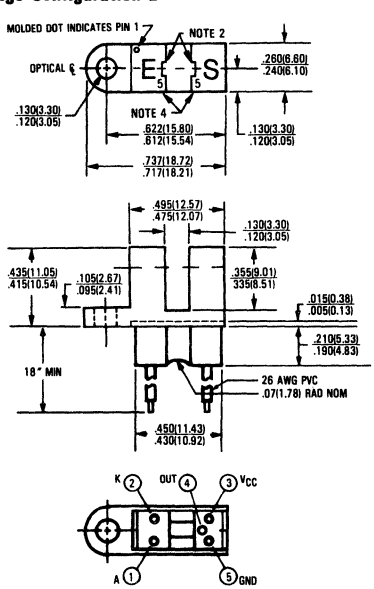
Package Configuration T



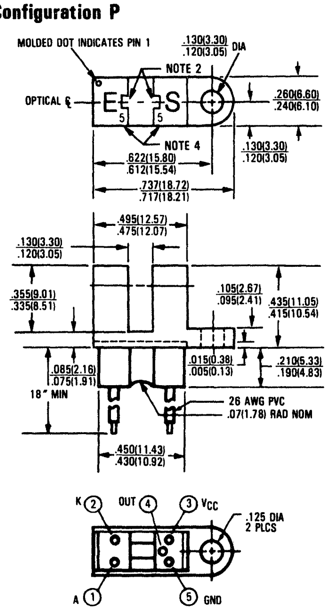
Package Configuration N



Package Configuration L



Package Configuration P



H

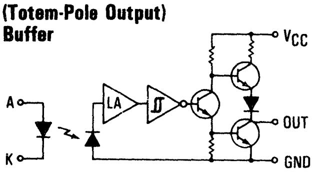
NOTES
1. HOUSINGS ARE SOLUBLE IN CHLORINATED HYDROCARBONS AND KETONES. METHANOL AND ISOPROPANOL ARE RECOMMENDED AS CLEANING AGENTS FOR BOTH TYPES OF HOUSING MATERIAL.
2. DIMENSIONS OF APERTURE OPENING DEPENDENT ON HOUSING MATERIAL. HOUSINGS SHOWN ARE POLYCARBONATE.
3. MOLDED NUMBER TO IDENTIFY APERTURE SIZE. SEE PART NUMBER GUIDE.

Electrical Characteristics (−40°C to +70°C unless otherwise noted)

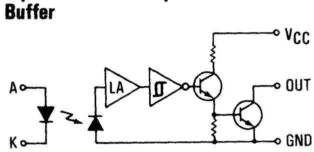
Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
Input Diode						
V_F	Forward Voltage			1.70	V	$I_F = 20$ mA, $T_A = 25°C$
I_R	Reverse Current			100	μA	$V_R = 2.0$ V, $T_A = 25°C$
Output Photologic™						
V_{CC}	Operating Supply Voltage	4.75		5.25	V	
I_{CCL}	Low Level Supply Current: Buffer with Totem-Pole Output Buffer with Open-Collector Inverter with Totem-Pole Output Inverter with Open-Collector			 15.0 15.0 15.0 15.0	 mA mA mA mA	 $V_{CC} = 5.25$ V, $I_F = 0$ mA(3) $V_{CC} = 5.25$ V, $I_F = 0$ mA(3) $V_{CC} = 5.25$ V, $I_F = 15.0$ mA $V_{CC} = 5.25$ V, $I_F = 15.0$ mA
I_{CCH}	High Level Supply Current: Buffer with Totem-Pole Buffer with Open-Collector Inverter with Totem-Pole Inverter with Open-Collector			 15.0 15.0 15.0 15.0	 mA mA mA mA	 $V_{CC} = 5.25$ V, $I_F = 15.0$ mA $V_{CC} = 5.25$ V, $I_F = 15.0$ mA $V_{CC} = 5.25$ V, $I_F = 0$ mA(3) $V_{CC} = 5.25$ V, $I_F = 0$ mA(3)
V_{OL}	Low Level Output Voltage: Buffer with Totem-Pole Buffer with Open-Collector Inverter with Totem-Pole Inverter with Open-Collector			 0.40 0.40 0.40 0.40	 V V V V	 $V_{CC} = 4.75$ V, $I_{OL} = 12.8$ mA, $I_F = 0$ mA(3) $V_{CC} = 4.75$ V, $I_{OL} = 12.8$ mA, $I_F = 0$ mA(3) $V_{CC} = 4.75$ V, $I_{OL} = 12.8$ mA, $I_F = 15.0$ mA $V_{CC} = 4.75$ V, $I_{OL} = 12.8$ mA, $I_F = 15.0$ mA
V_{OH}	High Level Output Voltage: Buffer with Totem-Pole Inverter with Totem-Pole	 2.4 2.4			 V V	 $V_{CC} = 4.75$ V, $I_{OH} = 800$ μA, $I_F = 15.0$ mA $V_{CC} = 4.75$ V, $I_{OH} = 800$ μA, $I_F = 0$ mA(3)
I_{OH}	High Level Output Current: Buffer with Open-Collector Inverter with Open-Collector			 100 100	 μA μA	 $V_{CC} = 4.75$ V, $V_{OH} = 30$ V, $I_F = 15.0$ mA(3) $V_{CC} = 4.75$ V, $V_{OH} = 30$ V, $I_F = 0$ mA, $T_A = 25°C$
$I_{F(+)}$	LED Positive-Going Threshold Current			15.0	mA	$V_{CC} = 5.0$ V
$I_{F(+)}/I_{F(-)}$	Hysteresis Ratio		2.0			$V_{CC} = 5.0$ V
I_{OS}	Short Circuit Output Current	−30		−100	mA	$V_{CC} = 5.25$ V, $I_F = 20$ mA, Output = GND
t_r, t_f	Output Rise Time, Output Fall Time		70		ns	$V_{CC} = 5.0$ V, $T_A = 25°C$, $I_F = 0$ or 15.0 mA $R_L = 8$ TTL Loads (Totem-Pole) $R_L = 360$ Ω (Open-Collector)
t_{PLH}, t_{PHL}	Propagation Delay, Low-High & High-Low		5.0		μs	

Schematics

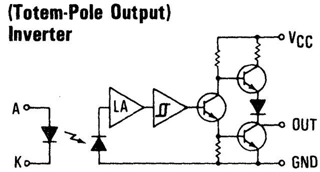
OPB980/OPB990
(Totem-Pole Output)
Buffer



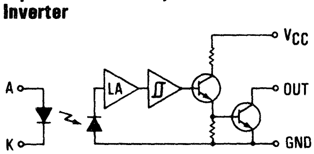
OPB981/OPB991
(Open-Collector Output)
Buffer



OPB982/OPB992
(Totem-Pole Output)
Inverter



OPB983/OPB993
(Open-Collector Output)
Inverter



Part Numbering Guide

OPB 9XX X XX

TRW Assembly Prefix — OPB

9 = Photologic Output Family

Housing Material Designation
8 = Polysulfone 9 = Polycarbonate

Photologic Sensor Output Variations
0 = Buffer with Totem Pole Output
1 = Buffer with Open Collector Output
2 = Inverter with Totem Pole Output
3 = Inverter with Open Collector Output

Aperture width in front of sensor
5 = 0.050″ (1.27 mm) 1 = 0.010″ (0.25 mm)
Aperture length is 0.060″ (1.52 mm)

Aperture width in front of LED
5 = 0.050″ (1.27 mm) *2 = 0.020″ (0.51 mm)
Aperture length is 0.060″ (1.52 mm)
* Available only in a polycarbonate housing with a sensor aperture width of 0.010″ (0.25 mm).

Mounting Configurations
T = Mounting tabs, both sides
N = No mounting tabs
L = Single mounting tab, emitter side
P = Single mounting tab, sensor side

Example

OPB 983 N 51

TRW Assembly Prefix
Photologic Output
Polysulfone Housing
Inverter, Open Collector

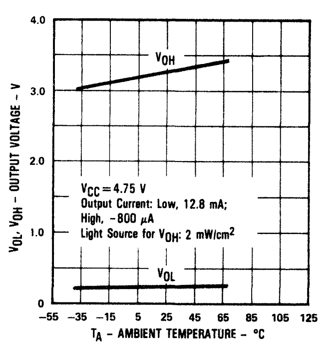
0.010″ (0.25 mm) aperture in front of sensor
0.050″ (1.27 mm) aperture in front of LED
No mounting tabs

H

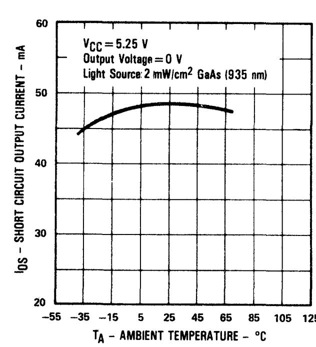
Typical Performance Curves

OPB980, OPB982, OPB990, OPB992

Output Voltage vs Ambient Temperature

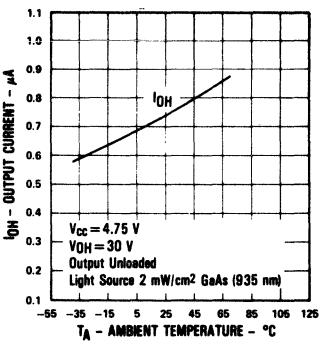


Short Circuit Output Current vs Ambient Temperature

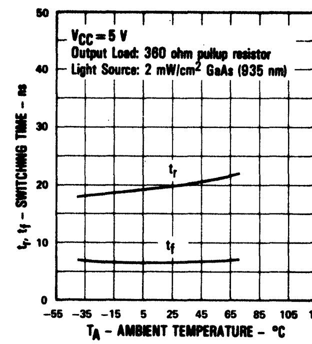


OPB981, OPB983, OPB991, OPB993

Output Current (High) vs Ambient Temperature

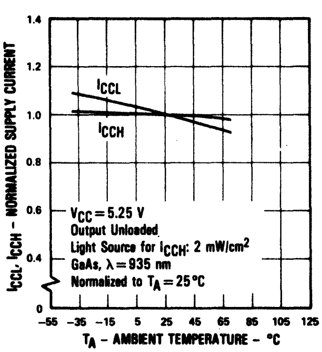


Rise Time and Fall Time vs Ambient Temperature



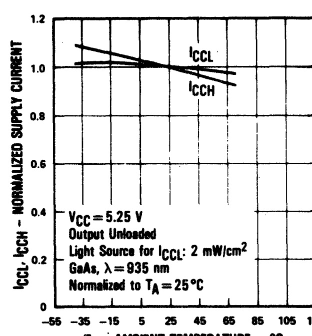
OPB980, OPB981, OPB990, OPB991

Normalized Supply Current vs Ambient Temperature



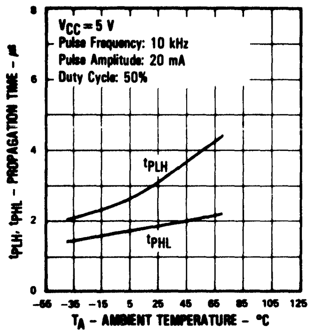
OPB982, OPB983, OPB992, OPB993

Normalized Supply Current vs Ambient Temperature

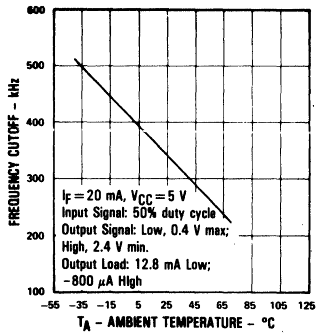


All Assemblies

Propagation Time vs Ambient Temperature

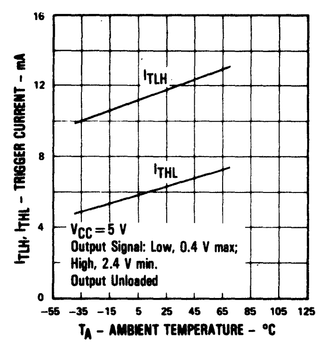


Data Rate vs Ambient Temperature

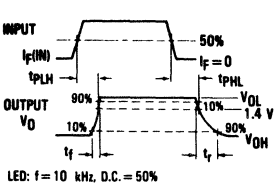


All Assemblies

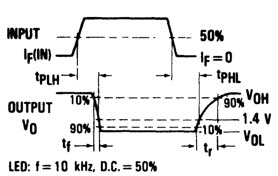
Trigger Current vs Ambient Temperature



Switching Test Curve for Buffers



Switching Test Curve for Inverters

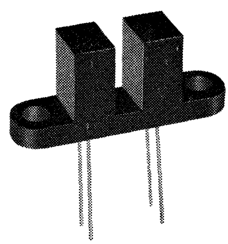


Optoelectronics Division
TRW Electronic Components Group

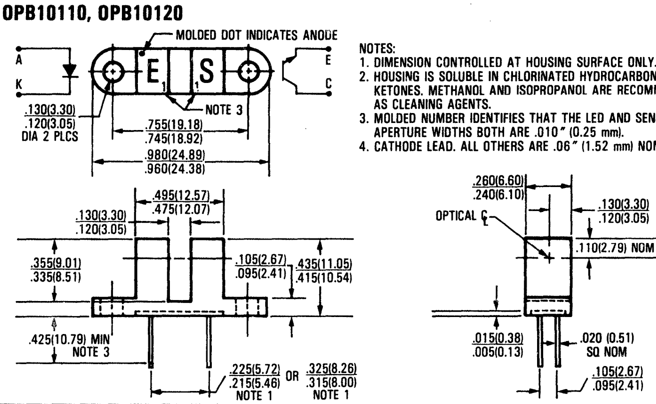
Product Bulletin 5360
January 1985

TRW

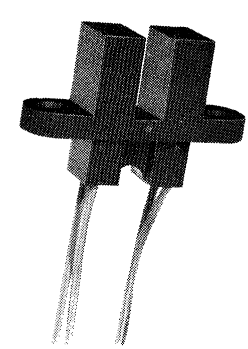
Slotted Optical Switches
Type OPB10100 Series



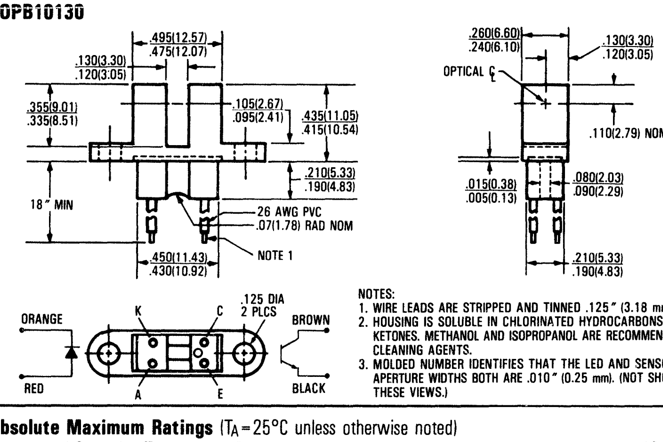
OPB10110, OPB10120



NOTES:
1. DIMENSION CONTROLLED AT HOUSING SURFACE ONLY.
2. HOUSING IS SOLUBLE IN CHLORINATED HYDROCARBONS AND KETONES. METHANOL AND ISOPROPANOL ARE RECOMMENDED AS CLEANING AGENTS.
3. MOLDED NUMBER IDENTIFIES THAT THE LED AND SENSOR APERTURE WIDTHS BOTH ARE .010″ (0.25 mm).
4. CATHODE LEAD. ALL OTHERS ARE .06″ (1.52 mm) NOM.



OPB10130



NOTES:
1. WIRE LEADS ARE STRIPPED AND TINNED .125″ (3.18 mm) MIN.
2. HOUSING IS SOLUBLE IN CHLORINATED HYDROCARBONS AND KETONES. METHANOL AND ISOPROPANOL ARE RECOMMENDED AS CLEANING AGENTS.
3. MOLDED NUMBER IDENTIFIES THAT THE LED AND SENSOR APERTURE WIDTHS BOTH ARE .010″ (0.25 mm). (NOT SHOWN IN THESE VIEWS.)

Features
- Choice of lead spacing or wires
- Polysulfone housing
- High resolution
- Dual flange mounting configuration

Description
The all new OPB10100 series is intended to provide custom design capability in a standard series. Each device consists of an infrared emitting diode and an NPN silicon phototransistor mounted on opposite sides of an 0.125″ (3.18 mm) wide slot. Sensor aperture width of 0.010″ (0.25 mm); LED aperture width of 0.010″ (0.25 mm); sensor-LED lead spacing of 0.320″ (8.13 mm) or 0.220″ (5.59 mm); or 26 ga., 18″ min. wire leads, respectively; minimum $I_{C(ON)}$ of 100 μA; and polysulfone housings for dust and dirt protection.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)
Storage and Operating Temperature Range . . . . . . −40°C to +85°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron) . . . . . . 240°C(1)

Input Diode
Reverse Voltage . . . . . . 2.0 V
Continuous Forward Current . . . . . . 50 mA
Peak Forward Current (1 μs pulse width, 300 pps) . . . . . . 3.0 A
Power Dissipation . . . . . . 100 mW(2)

Output Phototransistor
Collector-Emitter Voltage . . . . . . 30 V
Emitter-Collector Voltage . . . . . . 5.0 V
Power Dissipation . . . . . . 100 mW(2)

Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(2) Derate linearly 1.33 mW/°C above 25°C.
(3) Junction temperature maintained at 25°C.

Type OPB10100 Series

Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

Symbol	Parameter	Min.	Max.	Units	Test Conditions
Input Diode					
V_F	Forward Voltage		1.70	V	$I_F = 20$ mA
I_R	Reverse Current		100	μA	$V_R = 2.0$ V
Output Phototransistor					
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	30		V	$I_C = 1.00$ mA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	5.0		V	$I_E = 100$ μA
I_{CEO}	Collector-Emitter Dark Current		100	nA	$V_{CE} = 10.0$ V
Coupled					
$V_{CE(SAT)}$(3)	Collector-Emitter Saturation Voltage OPB10110, OPB10120, OPB10130		0.4	V	$I_C = 60$ μA, $I_F = 20$ mA
$I_{C(ON)}$(3)	On-State Collector Current OPB10110, OPB10120, OPB10130	100		μA	$V_{CE} = 10.0$ V, $I_F = 20$ mA

Part Numbering Guide

OPB 101 X0

TRW Assembly Prefix — OPB

Polysulfone housing with transistor output, and .010″ (0.25 mm) apertures over both LED and sensor — 101

X0:
10 - .320″ (8.13 mm) lead spacing
20 - .220″ (5.59 mm) lead spacing
30 - 26 ga. PVC, 18″ min. wire leads
Anode — Red
Cathode — Orange
Collector — Brown
Emitter — Black

Example

OPB 101 20

TRW Assembly Product — OPB

20 — .220″ lead spacing

101:
- Polysulfone housing
- Transistor output
- .010″ apertures over LED and sensor.

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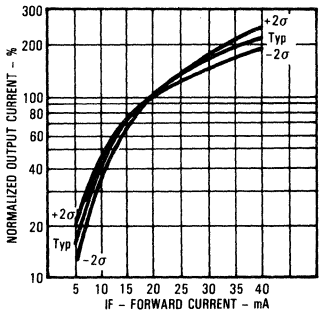
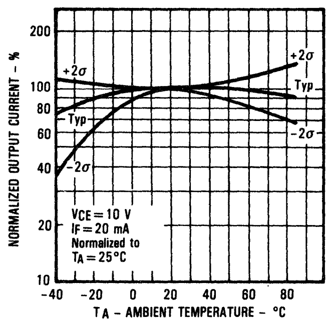
Typical Performance Curves

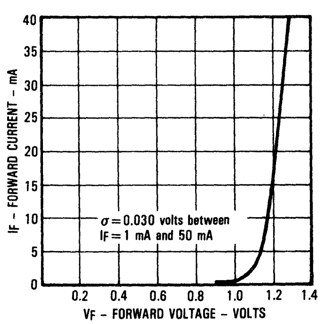
Normalized Output Current vs Forward Current



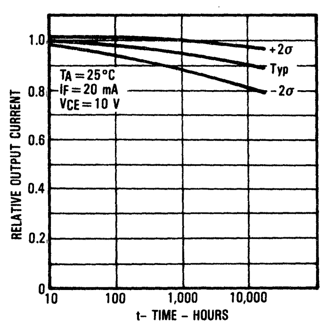
Normalized Output Current vs Ambient Temperature



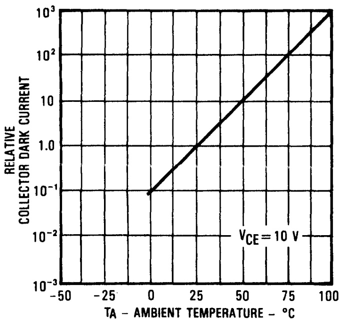
Forward Current vs Forward Voltage Input Diode



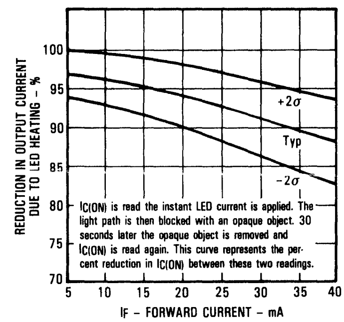
Relative Output Current vs Time



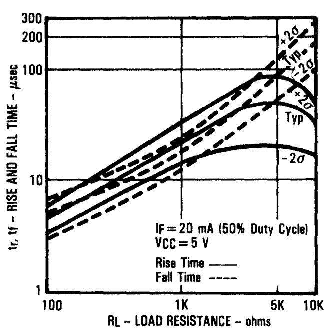
Collector Dark Current vs Ambient Temperature



Reduction in Output Current Due to LED Heading vs Forward Current



Rise and Fall Time vs Load Resistance

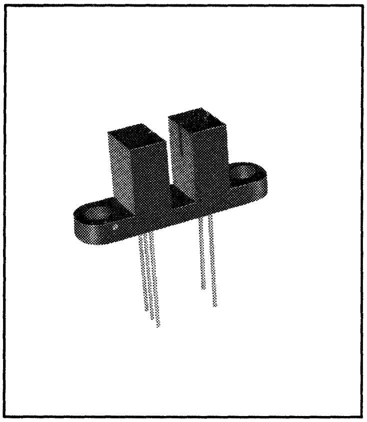


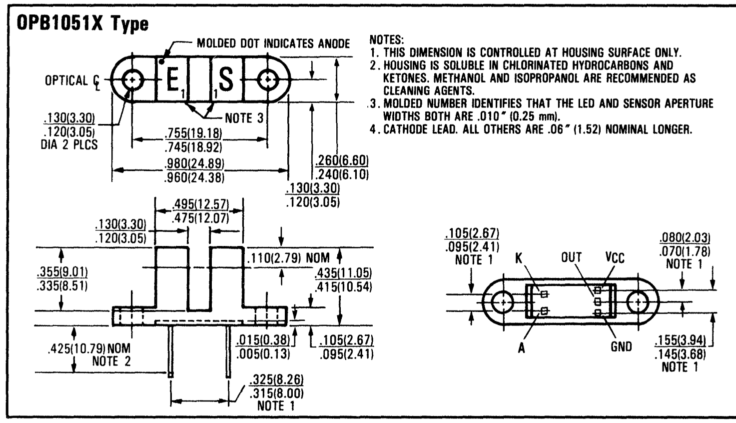
Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958

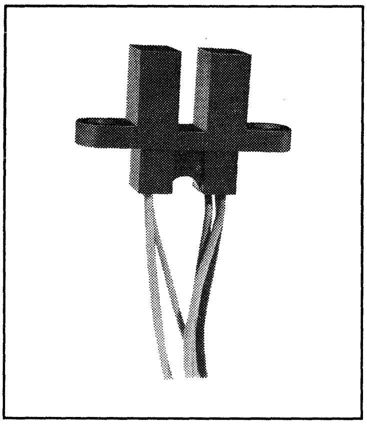
Optoelectronics Division
TRW Electronic Components Group

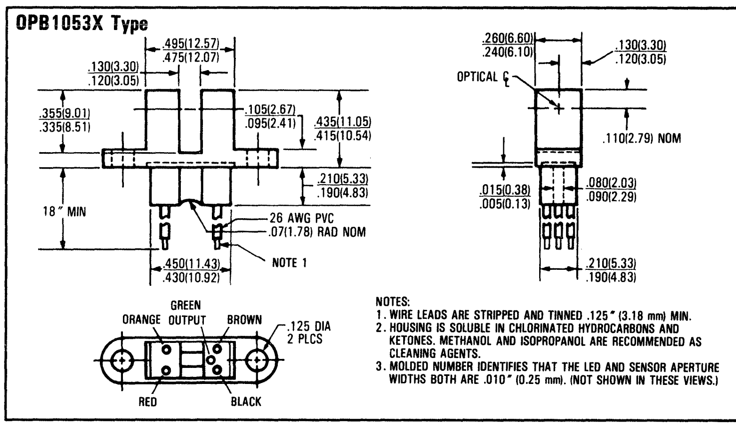
Product Bulletin 5363
January 1985

Photologic™ Slotted Optical Switches
Type OPB10500 Series









Features

- Choice of output configuration
- Polysulfone housing
- Data rates to 250K baud
- High resolution

Description

The all new OPB10500 series is intended to provide custom design capabilities in a standard series. Each device consists of an infrared emitting diode and a Photologic™ integrated circuit mounted on opposite sides of a 0.125″ (3.18 mm) wide slot. Photologic™ sensor/LED aperture width of 0.010″ (0.25 mm); dual flange mounting configuration; buffer totem-pole, buffer open-collector, inverter totem-pole or inverter open-collector output; and polysulfone housing for dirt and dust protection. Available with either discrete leads or wire leads (26 ga., 18″ in length).

Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)

Supply Voltage, VCC (not to exceed 3 seconds)	+10 V
Storage Temperature Range	−40°C to +85°C
Operating Temperature Range	−40°C to +70°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)	240°C[1]
Input Diode Power Dissipation	100 mW[2]
Output Photologc Power Dissipation	200 mW[4]
Total Device Power Dissipation	300 mW[5]
Voltage at Output Lead (Open-Collector Output)	35 V
Diode Forward D.C. Current	40 mA
Diode Reverse D.C. Voltage	2.0 V

Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(2) Derate linearly 1.33 mW/°C above 25°C.
(3) Normal application would be with light source blocked, simulated by $I_F = 0$.
(4) Derate linearly 2.67 mW/°C above 25°C.
(5) Derate linearly 4.0 mW/°C above 25°C.

Electrical Characteristics (−40°C to +70°C unless otherwise noted)

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
Input Diode						
V_F	Forward Voltage			1.70	V	$I_F = 20$ mA, $T_A = 25°C$
I_R	Reverse Current			100	μA	$V_R = 2.0$ V, $T_A = 25°C$
Output Photologic™						
V_{CC}	Operating Supply Voltage	4.75		5.25	V	
I_{CCL}	Low Level Supply Current: Buffer with Totem-Pole Output Buffer with Open-Collector Inverter with Totem-Pole Output Inverter with Open-Collector			 15.0 15.0 15.0 15.0	 mA mA mA mA	 $V_{CC} = 5.25$ V, $I_F = 0$ mA(3) $V_{CC} = 5.25$ V, $I_F = 0$ mA(3) $V_{CC} = 5.25$ V, $I_F = 25$ mA $V_{CC} = 5.25$ V, $I_F = 25$ mA
I_{CCH}	High Level Supply Current: Buffer with Totem-Pole Buffer with Open-Collector Inverter with Totem-Pole Inverter with Open-Collector			 15.0 15.0 15.0 15.0	 mA mA mA mA	 $V_{CC} = 5.25$ V, $I_F = 25$ mA $V_{CC} = 5.25$ V, $I_F = 25$ mA $V_{CC} = 5.25$ V, $I_F = 0$ mA(3) $V_{CC} = 5.25$ V, $I_F = 0$ mA(3)
V_{OL}	Low Level Output Voltage: Buffer with Totem-Pole Buffer with Open-Collector Inverter with Totem-Pole Inverter with Open-Collector			 0.4 0.4 0.4 0.4	 V V V V	 $V_{CC} = 4.75$ V, $I_{OL} = 12.8$ mA, $I_F = 0$ mA(3) $V_{CC} = 4.75$ V, $I_{OL} = 12.8$ mA, $I_F = 0$ mA(3) $V_{CC} = 4.75$ V, $I_{OL} = 12.8$ mA, $I_F = 25$ mA $V_{CC} = 4.75$ V, $I_{OL} = 12.8$ mA, $I_F = 25$ mA
V_{OH}	High Level Output Voltage: Buffer with Totem-Pole Inverter with Totem-Pole	 2.4 2.4			 V V	 $V_{CC} = 4.75$ V, $I_{OH} = 800$ μA, $I_F = 25$ mA $V_{CC} = 4.75$ V, $I_{OH} = 800$ μA, $I_F = 0$ mA(3)
I_{OH}	High Level Output Current: Buffer with Open-Collector Inverter with Open-Collector			 100 100	 μA μA	 $V_{CC} = 4.75$ V, $V_{OH} = 30$ V, $I_F = 25$ mA $V_{CC} = 4.75$ V, $V_{OH} = 30$ V, $I_F = 0$ mA(3), $T_A = 25°C$
$I_{F(+)}$	LED Positive-Going Threshold Current			25	mA	$V_{CC} = 5.0$ V
$I_{F(+)}/I_{F(-)}$	Hysteresis Ratio		2.0			$V_{CC} = 5.0$ V
I_{OS}	Short Circuit Output Current	−30		−100	mA	$V_{CC} = 5.25$ V, $I_F = 25.0$ mA, Output = GND
t_r, t_f	Output Rise Time, Output Fall Time		70		ns	$V_{CC} = 5.0$ V, $T_A = 25°C$, $I_F = 0$ or 25 mA $R_L = 8$ TTL Loads (Totem-Pole) $R_L = 360\ \Omega$ (Open-Collector)
t_{PLH}, t_{PHL}	Propagation Delay, Low-High & High-Low		5.0		μs	

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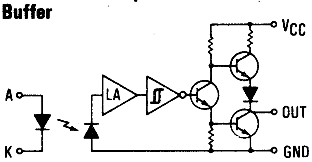
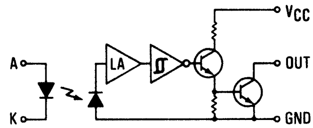
Schematics

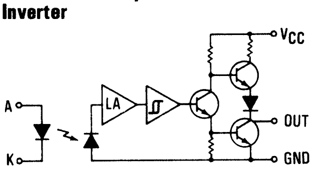
OPB10510/OPB10530
(Totem-Pole Output)
Buffer



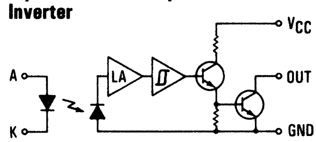
OPB10511/OPB10531
(Open-Collector Output)
Buffer



OPB10512/OPB10532
(Totem-Pole Output)
Inverter



OPB10513/OPB10533
(Open-Collector Output)
Inverter



Part Numbering Guide

OPB 105 X X

- TRW Assembly Prefix — OPB
- Polysulfone housing with Photologic™ output, and .010″ (0.25 mm) apertures over both LED and sensor — 105
- Photologic™ Sensor Output Variations (last X)
  - 0 – Buffer with totem-pole output
  - 1 – Buffer with open-collector output
  - 2 – Inverter with totem-pole output
  - 3 – Inverter with open-collector output
- First X
  - 1 – Discrete leads with .320″ (8.13 mm) spacing
  - 3 – Wire, 26 ga. PVC, 18″ min.
    - Anode — Red
    - Cathode — Orange
    - VCC — Brown
    - Output — Green
    - Emitter — Black

Example

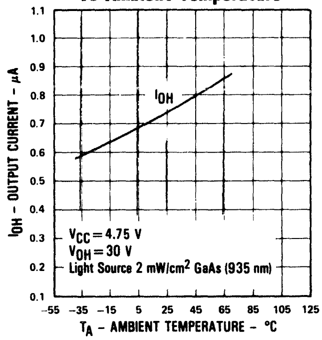
OPB 105 3 2

- TRW Assembly Product — OPB
- 105:
  - Polysulfone housing
  - Photologic™ output
  - .010″ aperture over LED and sensor.
- 3 — 26 Ga. PVC wire, 18″ min. length
- 2 — Inverter with totem pole output

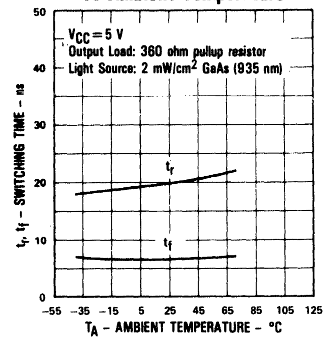
Typical Performance Curves

OPB10511/OPB10513/OPB10531/OPB10533

Output Current (High) vs Ambient Temperature

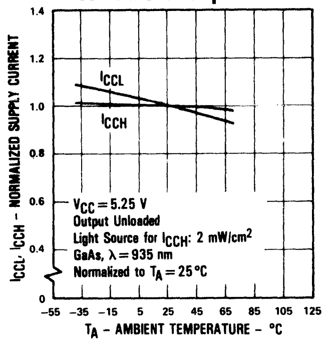


Rise Time and Fall Time vs Ambient Temperature



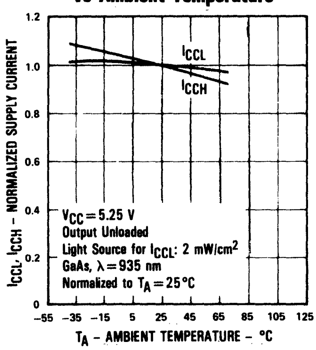
OPB10510/OPB10511/OPB10530/OPB10531

Normalized Supply Current vs Ambient Temperature

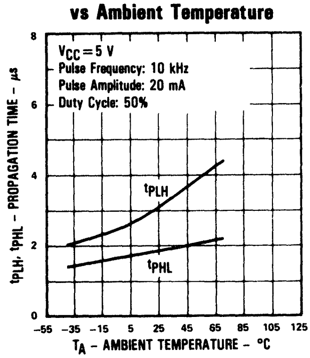


OPB10512/OPB10513/OPB10532/OPB10533

Normalized Supply Current vs Ambient Temperature

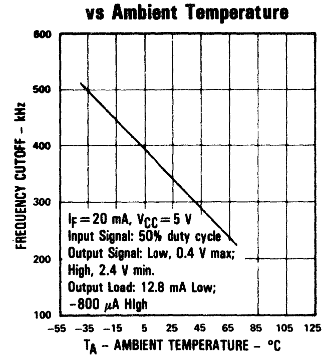


Propagation Time vs Ambient Temperature



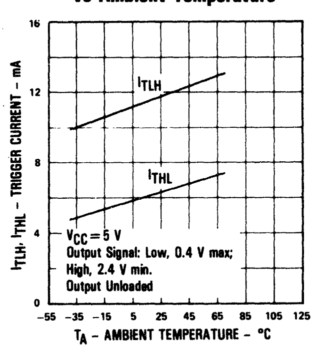
All Assemblies

Data Rate vs Ambient Temperature

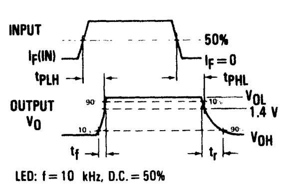


All Assemblies

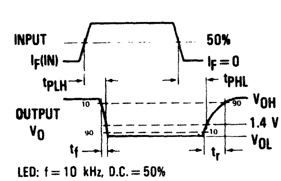
Trigger Current vs Ambient Temperature



Switching Test Curve for Buffers



Switching Test Curve for Inverters



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TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

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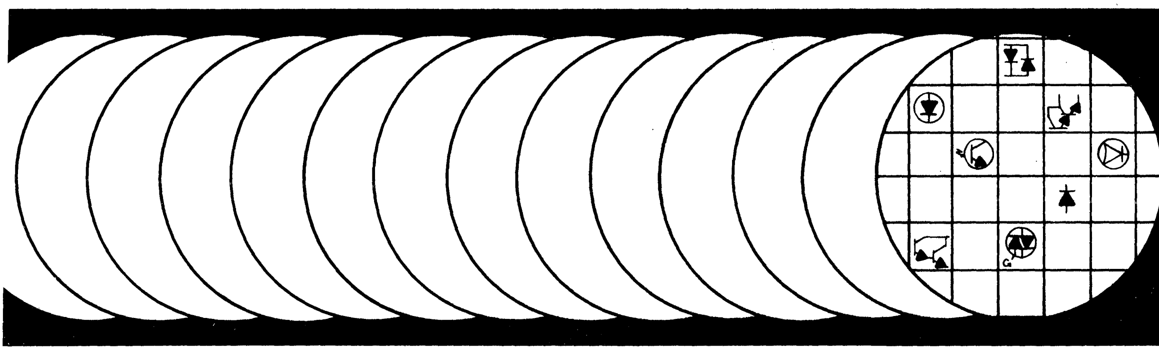
Printed in U.S.A.



Emitter and Photosensor Matched Pairs

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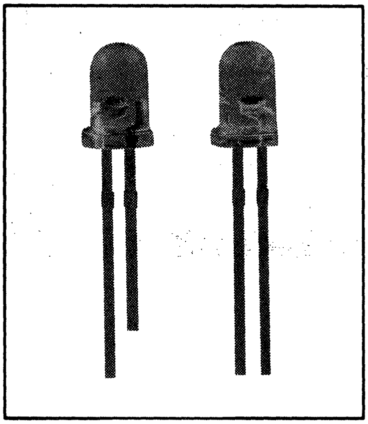
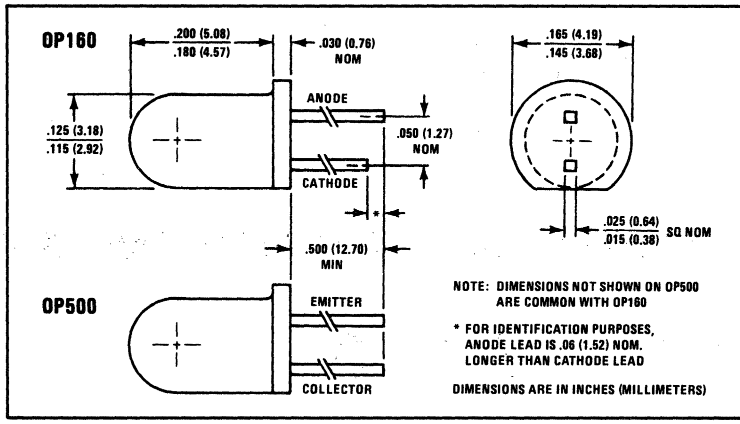
Matched LED and Photosensor Pair
Types OPS660, OPS661, OPS662





Features
- Mini-axial end-looking plastic packages
- High current transfer ratio
- Low cost plastic package
- Three current range selections

Description
The OPS660 series consists of a gallium arsenide infrared emitting diode (OP160) and an NPN silicon phototransistor (OP500) mounted in matched mini-axial end-looking clear plastic T-1 packages. Matched pairs are desirable where the application is unique and the quantity required does not justify assembly tooling costs. The units are offered in three different sensitivity ranges to give the designer more flexibility. If separation between the LED and sensor is greater than two times the specified $I_{C(ON)}$ distance, proper alignment becomes critical. Also, it should be remembered that the sensor is sensitive to ambient light. Although sold as pairs, emitters may be packaged separately from sensors for customer ease of handling.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)
Storage and Operating Temperature Range .... −40°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)(1) .... 240°C

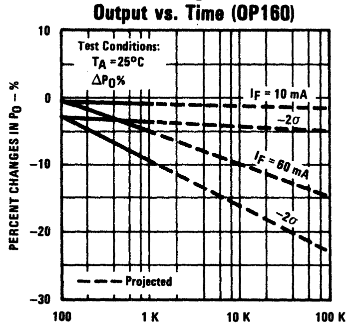
Input Diode
Continuous Forward Current .... 50 mA
Peak Forward Current (1 μs pulse width, 300 pps) .... 3.0 A
Reverse Voltage .... 2.0 V
Power Dissipation .... 100 mW(2)

Output Photosensor
Collector-Emitter Voltage .... 30 V
Emitter-Collector Voltage .... 5.0 V
Power Dissipation .... 100 mW(2)

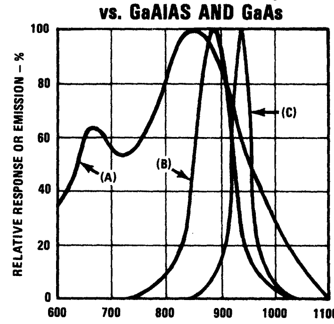
Notes: **(1)** RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering. **(2)** Derate linearly 1.33 mW/°C above 25°C.

Typical Performance Curves

Percent Changes in Power Output vs. Time (OP160)



Photosensor Spectral Response vs. GaAlAS AND GaAs



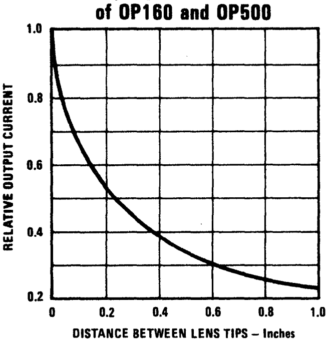
Test Conditions (LED):
$T_A = T_J$ = 25°C; I_F = 100 mA, DC = 0.1%, PW = 100 μs
Peak Wavelength - λp: (A) XSTR – 850 ± 30 nm
(B) LED GaAlAs – 875 ± 20 nm
(C) LED GaAs – 930 ± 15 nm

Electrical Characteristics (T_A = 25°C unless otherwise noted)

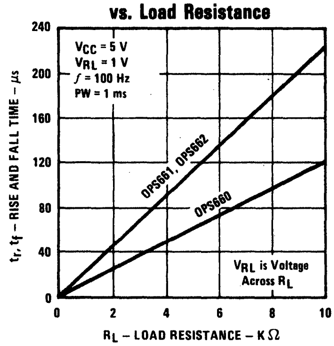
Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
Input Diode							
V_F	Forward Voltage				1.60	V	I_F = 20 mA
I_R	Reverse Current				100	μA	V_R = 2.0 V
Output Photosensor							
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage		30			V	I_C = 100 μA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage		5.0			V	I_E = 100 μA
I_{CEO}	Collector Dark Current				100	nA	V_{CE} = 15.0 V, E_e = 0
$I_{C(ON)}$	On-State Collector Current	OPS660	0.50			mA	V_{CE} = 5.0 V, I_F = 20 mA
		OPS661	1.00		10.0	mA	d = .250" lens tip to lens tip.
		OPS662	5.0			mA	

Typical Performance Curves

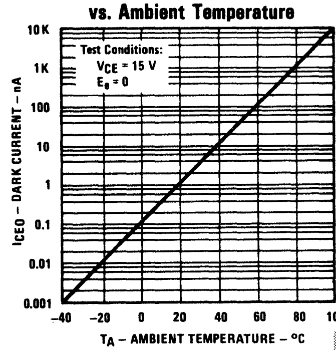
Coupling Characteristics of OP160 and OP500



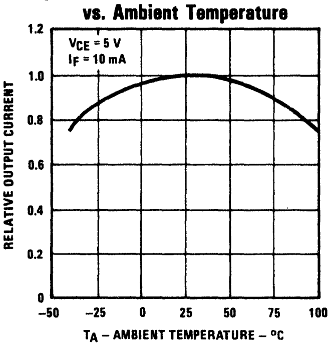
Rise and Fall Time vs. Load Resistance



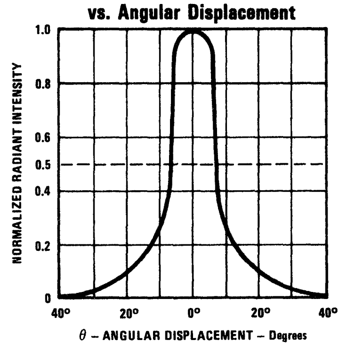
Collector Dark Current vs. Ambient Temperature



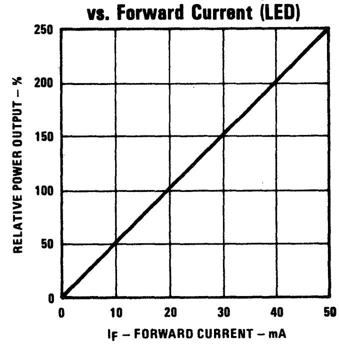
Coupled-Relative Output Collector Current vs. Ambient Temperature



Emission (LED) and Response (Sensor) Normalized Radiant Intensity vs. Angular Displacement



Relative Power Output vs. Forward Current (LED)



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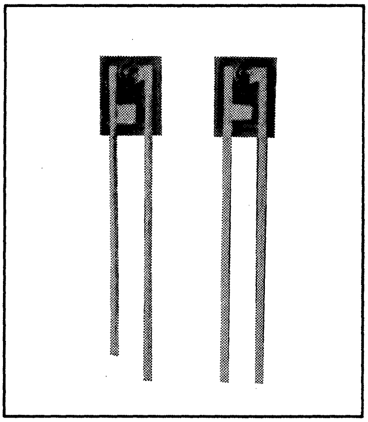
Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958

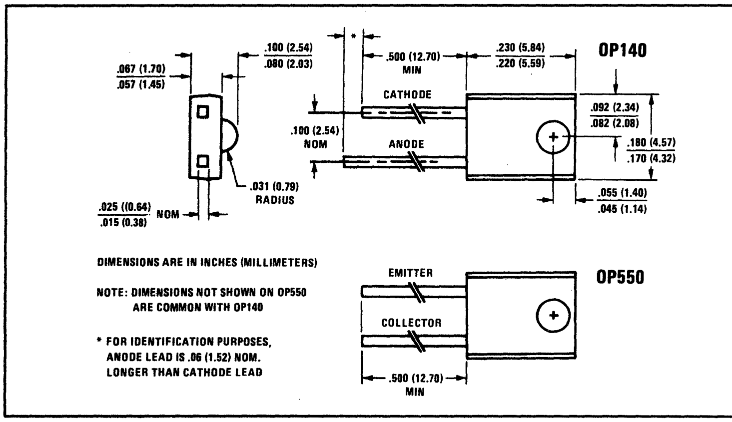
Printed in U.S.A.

Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5415
September 1984

Matched LED and Photosensor Pair
Types OPS690, OPS691, OPS692, OPS693





Features
- Lateral side looking clear plastic package
- High current transfer ratio

Description
The OPS690 through OPS693 each consist of a gallium arsenide infrared emitting diode (OP140) and an NPN silicon phototransistor (OP550) mounted in matched lateral side looking clear plastic packages. Matched pairs are desirable where the application is unique and the quantity required does not justify assembly tooling costs. If separation between the LED and sensor is greater than two times the specified IC(ON) distance, proper alignment becomes critical. Also, it should be remembered that the sensor is sensitivie to ambient light. On-state collector current ranges are guaranteed to a 2.5% AQL. Although sold as pairs, emitters may be packaged separately from sensors for customer ease of handling.

Absolute Maximum Ratings ($T_A = 25°C$ unless otherwise noted)
Storage and Operating Temperature Range . . . . −40°C to +100°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)[1] . . . . 240°C

Input Diode
Reverse Voltage . . . . 2.0 V
Continuous Forward Current . . . . 50 mA
Peak Forward Current (1 μs pulse width, 300 pps) . . . . 3.0 A
Power Dissipation . . . . 100 mW[2]

Output Phototransistor
Collector-Emitter Voltage . . . . 30 V
Emitter-Collector Voltage . . . . 5.0 V
Power Dissipation . . . . 100 mW[2]

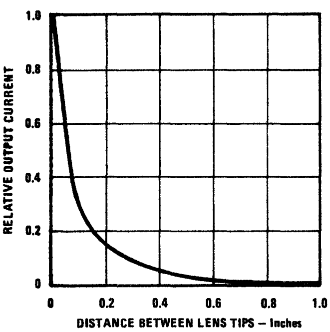
Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(2) Derate linearly 1.33 mW/°C above 25°C.
(3) Distance from lens tip to lens tip is 0.125 inches (3.18mm).

Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

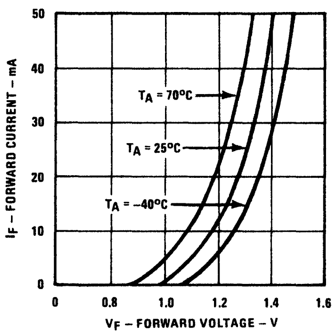
Symbol	Parameter		Min.	Typ.	Max.	Unit	Test Conditions
Input Diode							
V_F	Forward Voltage				1.60	V	$I_F = 20$ mA
I_R	Reverse Current				100	μA	$V_R = 2.0$ V
Output Phototransistor							
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage		30			V	$I_C = 100$ μA, $E_e = 0$
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage		5.0			V	$I_E = 100$ μA, $E_e = 0$
I_{CEO}	Dark Current				100	nA	$V_{CE} = 10.0$ V, $E_e = 0$
Coupled							
$V_{CE(SAT)}$	Saturation Voltage				0.40	V	$I_F = 20$ mA, $I_C = 50$ μA(3)
$I_{C(ON)}$(3)	On-State Collector Current	OPS690	100			μA	$V_{CE} = 10.0$ V, $I_F = 20$ mA(3)
		OPS691	500			μA	
		OPS692	1.00			mA	
		OPS693	2.0			mA	

Typical Performance Curves

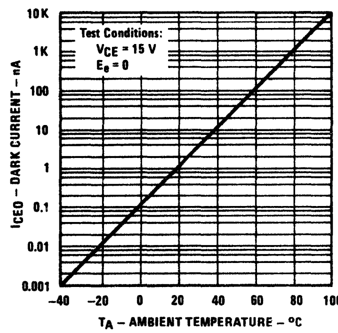
Coupling Characteristics of OP140 and OP550



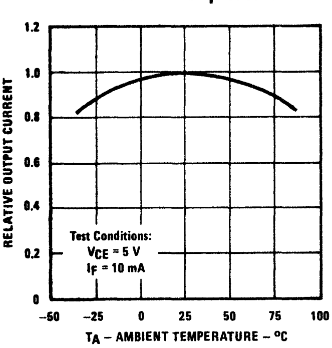
Forward Current vs Forward Voltage



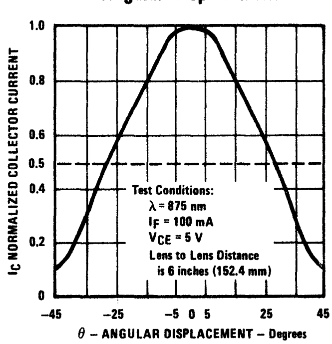
Dark Current vs Free Air Temperature



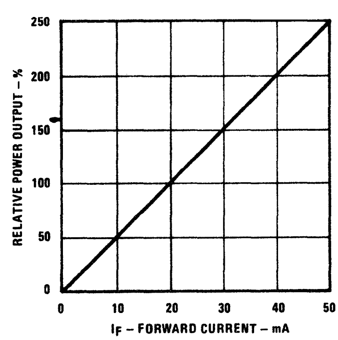
Relative Output Current vs Free Air Temperature



Normalized Collector Current vs Angular Displacement



Relative Power Output vs Forward Current (LED)



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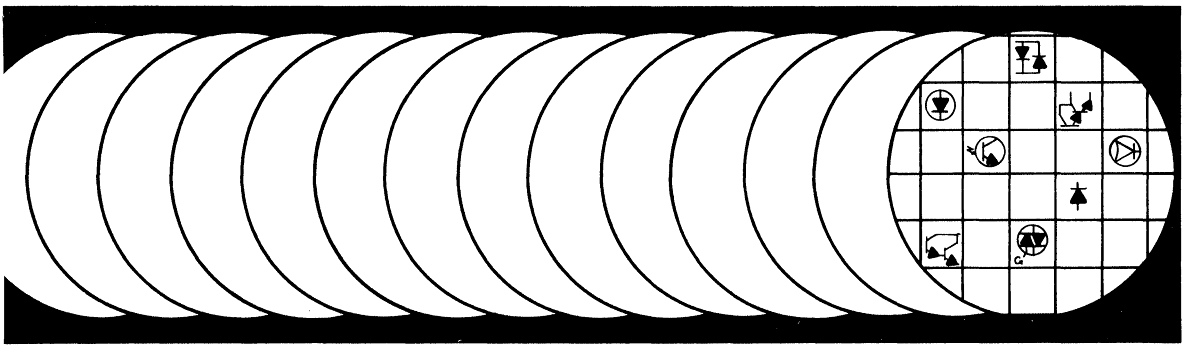
TRW



High Reliability and Military Devices

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High-Reliability and Military Optoelectronic Devices

High-reliability requirements demand that products be able to function under abnormally severe levels of mechanical, environmental, and electrical stress. This challenge has been met by TRW with product designs and process control techniques that ensure high reliability and, thus, long life.

Capabilities

TRW Optoelectronics maintains a well equipped high-reliability lab for conducting electrical, mechanical, and environmental tests. All testing is performed in-house, with engineering, manufacturing, and quality control facilities located within the continental United States.

TRW's calibration system complies with the requirements of MIL-S-45662, which incorporates both MIL-Q-9858 and MIL-I-45208.

High reliability optoelectronic devices from TRW are currently in use in a wide variety of space and defense programs.

Certifications

TRW Optoelectronics Division is a QPL supplier, approved by D.E.S.C. to provide products in accordance with Military Specification MIL-S-19500. Electrical, environmental, and mechanical testing is done by experienced TRW employees based on MIL-STD-750 and MIL-STD-883 test methods and procedures. Military screening to as high as JANTXV is performed.

TRW has certified technicians in many areas such as x-ray and soldering. Any internal soldering, if required, is done in compliance with MIL-S-45743/WS6536.

High-Reliability Couplers

TRW's offering of high-reliability, optically coupled isolators consist of D.E.S.C. qualified devices to MIL-S-19500/486 and components processed to TRW's own military screening program. The 4N22A through 4N24A series of D.E.S.C. qualified couplers are processed to JAN, JANTX, and JANTXV reliability levels per MIL-S-19500/486. (See Figure 1 for details.)

Although the 3N243R through 3N245R series of optically coupled isolators are not military qualified, they are processed to TRW's own military screening program. Each device in the series receives process conditioning which includes a 168-hour power burn-in.

High-Reliability Sensors and Emitters

A large selection of discrete emitters and sensors are offered that are processed to TRW's own military screening program patterned after MIL-S-19500. These devices are identified by "TX" and "TXV" suffixes. Although not military qualified devices, they receive 100% screening that parallels JANTX and JANTXV reliability requirements. (See Figure 2.)

For discrete sensors, the 100% screening includes both a 48-hour, high temperature reverse bias at $T_A = 125°C$ and a 168-hour power burn-in at ambient temperature ($T_A = 25°C$). For emitters, the 100% screening includes a burn-in in the forward direction for 96 or 168 hours, depending on the series.

One of the key advantages of purchasing part types to an in-house hi-rel screening program is that Group B and C lot charges may be avoided, since the manufacturer frequently spreads these costs over large groups of orders. For high-reliability emitters and sensors with "TX" and "TXV" suffixes, generic Group B and C data can be supplied with each order. Customers requiring Group B and C testing on their individual orders can also be accommodated, but these orders have to be run under special part numbers for control purposes.

High-Reliability Assemblies

In addition to the standard discrete optoelectronic components, TRW manufactures a wide variety of standard (off-the-shelf) and custom (built-to-print) assemblies. Most assemblies can be classified into one of two groups: slotted optical switches or reflective assemblies. Slotted optical switches are designed to provide non-contact sensing of linear or rotary motion. Reflective assemblies, in turn, are designed to provide non-contact sensing of reflective surfaces, or a change in surface reflectivity of an object. Both slotted optical switches and reflective assemblies can be purchased to high-reliability requirements.

High reliability assemblies are generally made with plastic housings and hermetically sealed discrete sensors and emitters. Before being placed in the housing, the discrete components are subjected to high-reliability processing. Frequently, this processing on the discrete devices is similar to what is specified on the individual high-reliability sensor and emitter data sheets.

Custom Prints

Sometimes, it is necessary to have special electrical selections, screening requirements, or package configurations that are different from the standard offerings shown in the data sheets. TRW's custom capability is enormous. Assembly and test areas were designed with a great deal of flexibility, which allows the product to be built and tested on an order-to-order basis. The Quality Control Department's environmental testing areas are set up similarly, allowing many orders to be handled, each requiring different tests, screens, and conditions.

Definitions of Common Reliability Terms

Group A: Consists of electrical tests and external visual inspection done on a sample basis by Q.C. At TRW, prior to submittal to Q.C. for Group A inspection, all devices in the lot are 100% electrically tested in manufacturing.

Group B: Consists of tests conducted on a sample basis to verify production lot conformance to package integrity, environmental extremes, and long-term reliability. The Group B samples are normally selected from lots that are manufactured within a six week time period, based on the date of final package sealing.

Group C: Is further environmental testing—similar to Group B, but sample testing is performed on a periodic basis (typically at six month intervals).

High-Rel Processing, 100% Processing, TX Processing: Same as Processing Conditioning.

High Temperature Reverse Bias (HTRB): Devices are reverse biased in a non-conduction mode at a high temperature for a period of time in this test. This test is used primarily to screen out those devices with inferior semiconductor die characteristics, such as poor voltage breakdown or leakage current. Ambient temperature is usually specified somewhere between +100°C to +175°C.

JAN: A prefix assigned to standard JEDEC device types (1N, 2N, 4N, etc.) to denote that they have successfully passed specific military testing requirements (Groups A, B, and C). (See Figure 1.)

JANTX: Next higher product assurance level after JAN. All JANTX units receive process conditioning prior to quality conformance inspection. (See Figure 1.)

JANTXV: Same as JANTX, plus 100% internal visual inspection. (See Figure 1.)

JANS: An ultra-high-reliability version of JAN devices with very strict quality assurance and manufacturing controls imposed. JANS was designed with space applications in mind, and is the highest product assurance reliability level.

MIL-S-19500: Military document that establishes the general requirements for semiconductor devices for JAN, JANTX, JANTXV, and JANS reliability levels. Specific part type requirements and characteristics are specified in detail specifications for a particular series (e.g., 4N22A military series is spelled out in MIL-S-19500/486).

MIL-STD-750: Military specification that depicts electrical, mechanical, and environmental test procedures and methods for discrete semiconductors.

Operating Life: Also known as burn-in, life testing, and power age. Operating the device in a conduction mode (turned on) to simulate what the part will encounter in actual service. As a very common test in process conditioning, operating life is used to screen out those parts with potential short service life.

Process Conditioning: Tests (sometimes referred to as screens) that are performed on 100% of the devices in the lot to assure long-term reliability characteristics. (See Figure 2.)

Qualification (Qual.): All testing performed to qualify a new part, traditionally consisting of Groups A, B, and C. Individual tests or requirements are sometimes added or deleted for qualification.

Qualified Products List (QPL): Semiconductor device types that are qualified under military specification MIL-S-19500 for JAN, JANTX, JANTXV, and JANS procurements.

Quality Conformance Inspection: Those tests performed to verify a given lot's conformance to a military document or a customer's specification. Quality conformance inspection consists of Group A, but may include Group B or C, depending on the requirements for the formulation of these groups of tests.

Figure 1. Simplified JAN Product Flow

JAN
Controlled Lot with Sample Environmental and Life Testing

Commercial Product
↓
Group A, B, C Sample Test
↓
Ship

JANTX
100% Processing Plus Sample Environmental and Life Testing

Commercial Product
↓
100% Processing
↓
Group A, B, C Sample Test
↓
Ship

JANTXV
Same as JANTX Plus 100% Internal Visual Inspection

100% Pre-Cap Visual
↓
100% Processing
↓
Group A, B, C Sample Test
↓
Ship

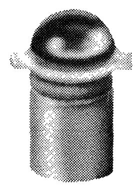
Figure 2. 100% Processing (Typical)

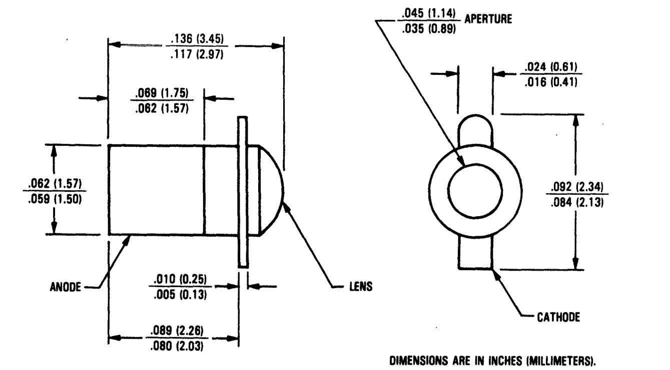
Pre-Cap Visual	
High Temperature Storage	
Temperature Cycle	
Constant Acceleration	
Hermetic Seal	Fine: Gross:
High Temperature Reverse Bias	
Power Burn-in	

Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5058
January 1985

High Reliability GaAlAs Infrared Emitting Diodes
Types OP223TX, OP223TXV, OP224TX, OP224TXV





Features
- High reliability processed to TRW's Military screening program patterned after MIL-S-19500
- Miniature hermetically sealed "pill" package
- Twice the power output of GaAs at the same drive current
- Mechanically and spectrally matched to the OP600 phototransistor and the OP300 photodarlington

Description
The OP223TX, TXV and OP224TX, TXV are high reliability gallium aluminum arsenide infrared emitting diodes mounted in miniature "pill" type hermetically sealed packages. This package style is intended for direct mounting into PC boards.

After electrical testing of manufacturing, all devices are processed to TRW's 100 percent screening program patterned after MIL-S-19500. After completion, Group A sample tests are performed and generic data is supplied for Group B & C inspections.

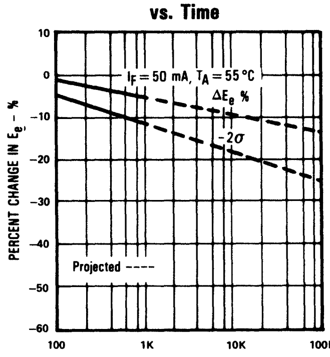
Gallium aluminum arsenide features twice the radiated output of gallium arsenide at the same forward current. Also, with a wavelength centered at 875 nanometers, it more closely matches the spectral response of silicon phototransistors.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)
Reverse Voltage . . . 2.0 V
Continuous Forward Current . . . 100 mA
Storage Temperature Range . . . −65°C to +150°C
Operating Temperature Range . . . −65°C to +125°C
Soldering Temperature (for 5 sec. with soldering iron) . . . 240°C[1]
Power Dissipation . . . 125 mW[2]

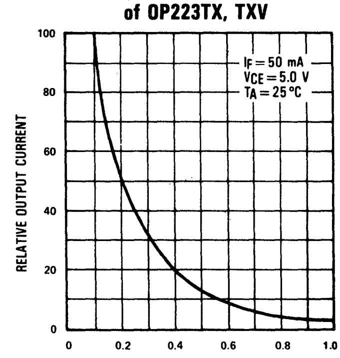
Notes:
(1) RMA flux is recommended. Duration can be extended to 10 seconds max. when flow soldering.
(2) Derate linearly 1.00 mW/°C above 25°C.

Typical Performance Curves

Percent Changes in Radiant Intensity vs. Time



Coupling Characteristics of OP223TX, TXV



Types OP223TX, OP223TXV, OP224TX, OP224TXV

Electrical Characteristics (T_A = 25°C unless otherwise noted)

Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
P_O	Radiant Power Output	OP223TX, TXV	1.00			mW	I_F = 50 mA
		OP224TX, TXV	1.50			mW	I_F = 50 mA
V_F	Forward Voltage		0.80		1.80	V	I_F = 50 mA
I_R	Reverse Current				100	μA	V_R = 2.0 V
λp	Wavelength at Peak Emission			875		nm	I_F = 50 mA
B	Spectral Bandwidth Between Half Power Points			80		nm	I_F = 50 mA
$\Delta\lambda p/\Delta T$	Spectral Shift with Temperature			0.18		nm/°C	I_F = Constant
θ_{HP}	Emission Angle at Half Power Points			36		Deg.	I_F = 50 mA
t_r	Output Rise Time			475		ns	$I_{F(PK)}$ = 50 mA, PW = 10 μs, DC = 10%
t_f	Output Fall Time			250		ns	

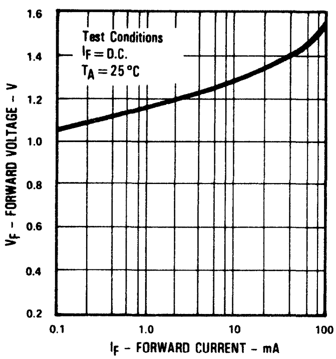
100% Processing

Screen	MIL-STD-750 Method	Conditions	OP223TX OP224TX	OP223TXV OP224TXV
Pre-Cap Visual	—	TRW Opto pre-cap visual	—	100%
High Temperature Storage	1032	T_A = 150°C, t = 24 hrs. min.	100%	100%
Temperature Cycle	1051, Condition F	20 cycles, −65°C to +150°C, 10 min. each extreme	100%	100%
Constant Acceleration	2006	20000 G, Y_1 only	100%	100%
Hermetic Seal	1071	Fine: Condition G or H, 5 × 10^{-7} atm cc/sec Gross: Condition C, Step 2	100%	100%
Power Burn-In*	1038, Condition B	I_F = 50 mA, T_A = 25°C, t = 168 hrs. min.	100%	100%

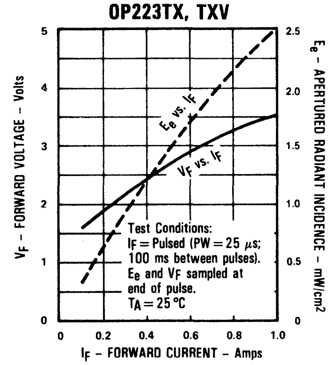
*100% electrically tested to the limits in subgroup 2 of the group A table before and after burn-in. ΔP_O = ±15%; ΔV_F = ±10%; PDA = 10%.

Typical Performance Curves

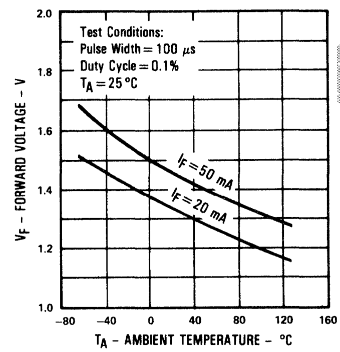
Forward Voltage vs. Forward Current



Forward Voltage and Radiant Incidence vs. Forward Current OP223TX, TXV



Forward Voltage vs. Ambient Temperature



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Group A Inspection—Electrical Tests (performed on each inspection lot after all devices have been subject to the 100% processing requirements)

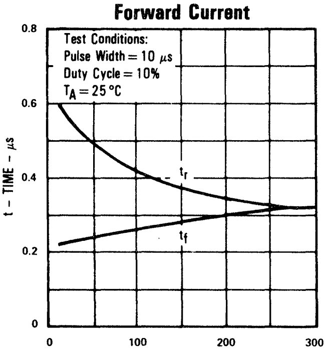
Symbol	Examination or Test	MIL-STD-750 Method	MIL-STD-750 Conditions	LTPD	Limit Min.	Limit Max.	Units
Subgroup 1				5			
	Visual and Mechanical Examination	2071					
Subgroup 2				5			
P_O	Radiant Power Output						
	OP223TX, TXV		$I_F = 50$ mAdc		1.00		mW
	OP224TX, TXV		$I_F = 50$ mAdc		1.50		mW
V_F	Forward Voltage	4011	$I_F = 50$ mAdc		0.80	1.80	Vdc
I_R	Reverse Current	4016	$V_R = 2.0$ V			100	μA
Subgroup 3				5			
V_F	Forward Voltage	4011	$I_F = 50$ mAdc, $T_A = -55°C$		1.00	2.0	Vdc
I_R	Reverse Current	4016	$V_R = 2.0$ Vdc, $T_A = 100°C$			1.00	mA

Group B Inspection (performed on each inspection lot)

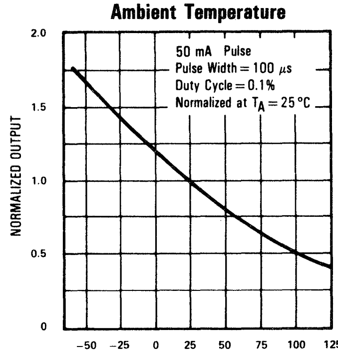
Examination or Test	MIL-STD-750 Method	MIL-STD-750 Conditions	LTPD
Subgroup 1			15
Solderability	2026		
Subgroup 2			10
Thermal Shock (Temperature Cycling)	1051	Condition F, 25 cycles, 10 minutes minimum @ extremes	
Hermetic Seal	1071		
Fine Leak		Condition G or H, 5×10^{-7} atm cc/sec	
Gross Leak		Condition A, C, E or F	
End Points:		Group A, Subgroup 2	
Subgroup 3			5
Steady State Operating Life	1027	$I_F = 50$ mAdc, t = 340 hours, $T_A = 25°C$	
End Points:		Group A, Subgroup 2	
Subgroup 4			
Internal Visual	2075	Per Pre-Seal Criteria	1 device/0 failure
Bond Strength	2037		20 (C = 1)
Subgroup 6			7
High Temperature Life (Non-Operating)	1032	$T_A = 150°C$, t = 340 hours	
End Points:		Group A, Subgroup 2	

Typical Performance Curves

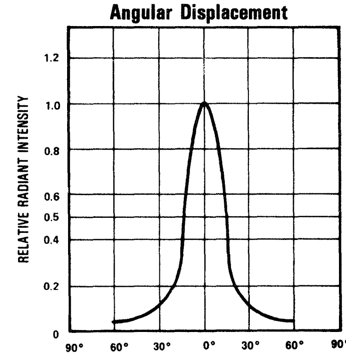
Rise Time and Fall Time vs. Forward Current



Normalized Power Output vs. Ambient Temperature



Relative Radiant Intensity vs. Angular Displacement



Types OP223TX, OP223TXV, OP224TX, OP224TXV

Group C Inspection

Examination or Test	MIL-STD-750 Method	MIL-STD-750 Conditions	LTPD
Subgroup 1			15
Physical Dimensions	2066		
Subgroup 2			10
Thermal Shock (Glass strain)	1056	Test Condition B	
Hermetic Seal Fine Leak Gross Leak	1071	 Condition G or H, max. leak rate = 5×10^{-7} atm cc/sec Condition A, C, E or F	
Moisture Resistance	1021	Omit initial conditioning	
External Visual	2071		
Electrical Measurements		Group A, Subgroup 2	
Subgroup 3			10
Shock	2016	Nonoperating; 1500 G's, 0.5 ms, 5 blows in each orientation; X_1, Y_1, and Z_1	
Vibration, Variable Frequency	2056		
Constant Acceleration	2006	One minute min., in each orientation X_1, Y_1, and Z_1 at 20,000 G's min.	
End Points:		Group A, Subgroup 2	
Subgroup 4			15
Salt Atmosphere	1041		
Subgroup 6			10
Steady-State Operational Life	1026	I_F = 100 mAdc, t = 1,000 hours, T_A = 25°C	
End Points:		Group A, Subgroup 2	

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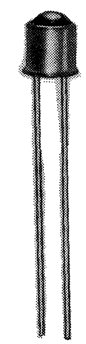
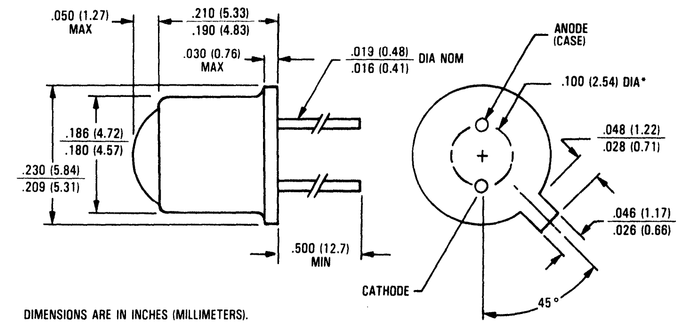
TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5062
January 1985

High Reliability GaAlAs Infrared Emitting Diodes
Types OP231TX, OP231TXV, OP232TX, OP232TXV





DIMENSIONS ARE IN INCHES (MILLIMETERS).
*THIS DIMENSION CONTROLLED AT HOUSING SURFACE.

Features
- High reliability processed to TRW's military screening program patterned after MIL-S-19500
- 1.7 the power output of GaAs at the same drive current
- TO-46 hermetically sealed package
- Mechanically and spectrally matched to OP800, OP593 and OP598 phototransistors
- Specified to apertured power and ranges designed to satisfy most applications

Description
The OP231TX, TXV and OP232TX, TXV are high reliability gallium aluminum arsenide infrared emitting diodes mounted in hermetic TO-46 housings.

After electrical testing by manufacturing, all devices are processed to TRW's 100 percent screening program patterned after MIL-S-19500. After completion, Group A sample tests are performed and generic data is supplied for Group B & C inspections.

The OP231TX, TXV and OP232TX, TXV have lensed cans providing a narrow beam angle (18° between half power points). The narrow beam angle and the specified radiant intensity allow ease of design in beam interrupt applications in conjunction with the OP800 or OP598 series.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

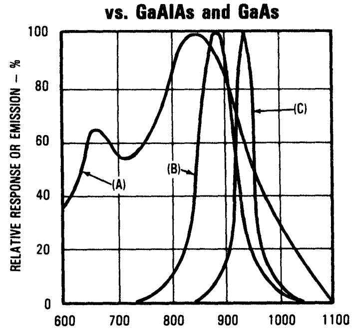
Reverse Voltage	2.0 V
Continuous Forward Current	100 mA
Peak Forward Current (Pulse Width = 1 µsec., 0.1% Duty Cycle)	10.0 A
Storage and Operating Temperature Range	−65°C to +150°C
Lead Soldering Temperature (1/16 inch [1.6 mm] from case for 5 sec. with soldering iron)[1]	240°C
Power Dissipation	200 mW[2]

Notes:

(1) RMA flux is recommended. Duration can be extended to 10 seconds max. when flow soldering.
(2) Derate linearly 1.60 mW/°C above 25°C.
(3) I_e is a measurement of the average radiant intensity within the cone formed by the measurement surface, a radius of 1.429" (36.30 mm) measured from the lens side of the tab to the sensing surface of 0.250" (6.35 mm) in diameter forming a 10° cone. (See Dimensional Drawing.)
(4) Measurement made with 100 µs pulse measured at the trailing edge of the pulse with a duty cycle of 0.1% and an I_F = 100 mA.

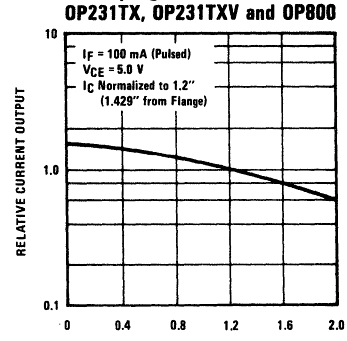
Typical Performance Curves

Photosensor Spectral Response vs. GaAlAs and GaAs



Test Conditions (LED): $T_A = T_J$ = 25°C, I_F = 100 mA, DC = 0.1%, PW = 100 µs
Peak Wavelength – λp: (A) XSTR – 850 ± 30 nm, (B) LED GaAlAs – 875 ± 20 nm, (C) LED GaAs – 930 ± 15 nm

Coupling Characteristics of OP231TX, OP231TXV and OP800



Types OP231TX, OP231TXV, OP232TX, OP232TXV

Electrical Characteristics (T_A = 25°C unless otherwise noted)

Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
P_O	Radiant Power Output	OP231TX, TXV	8.0			mW	I_F = 100 mA[3]
		OP232TX, TXV	10.0			mW	I_F = 100 mA[3]
V_F	Forward Voltage		1.10		2.0	V	I_F = 100 mA[4]
I_R	Reverse Current				10.0	μA	V_R = 2.0 V
λp	Wavelength at Peak Emission			880		nm	I_F = 100 mA[4]
B	Spectral Bandwidth Between Half Power Points			50		nm	I_F = 100 mA[4]
θ_{HP}	Emission Angle at Half Power Points			18.0		Deg.	I_F = 100 mA[4]
t_r	Output Rise Time			450		ns	$I_{F(PK)}$ = 100 mA, PW = 10 μs, DC = 10%
t_f	Output Fall Time			250		ns	

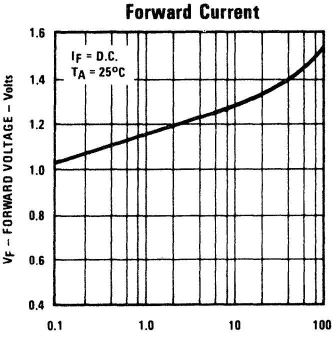
100% Processing

Screen	MIL-STD-750 Method	Conditions	OP231TX OP232TX	OP231TXV OP232TXV
Pre-Cap Visual	—	TRW Opto pre-cap visual	—	100%
High Temperature Storage	1032	T_A = 150°C, t = 24 hrs. min.	100%	100%
Temperature Cycle	1051, Condition F	20 cycles, −65°C to +150°C, 10 min. each extreme	100%	100%
Constant Acceleration	2006	20000 G, Y_1 only	100%	100%
Hermetic Seal	1071	Fine: Condition G or H, 5 × 10^{-7} atm cc/sec Gross: Condition C, Step 2	100%	100%
Power Burn-In*	1038, Condition B	I_F = 100 mA, T_A = 25°C, t = 96 hrs. min.	100%	100%

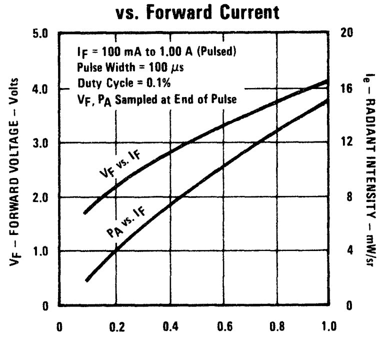
*100% electrically tested to the limits in subgroup 2 of the group A table before and after burn-in. ΔP_O = ±20%; ΔV_F = ±100 mV.

Typical Performance Curves

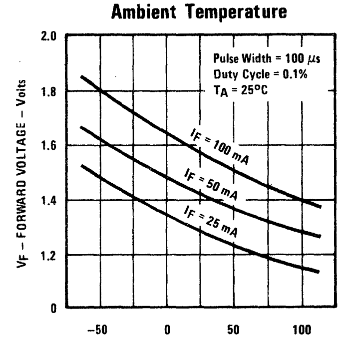
Forward Voltage vs. Forward Current



Forward Voltage and Radiant Incidence vs. Forward Current



Forward Voltage vs. Ambient Temperature



Group A Inspection—Electrical Tests (performed on each inspection lot after all devices have been subject to the 100% processing requirements)

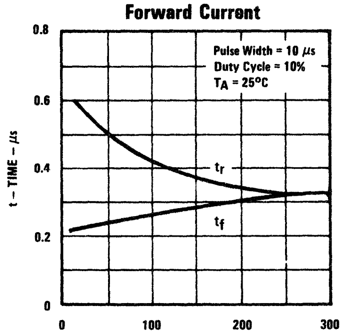
Symbol	Examination or Test	MIL-STD-750 Method	MIL-STD-750 Conditions	LTPD	Limit Min.	Limit Max.	Units
Subgroup 1				5			
	Visual and Mechanical	2071					
Subgroup 2				5			
P_O	Radiant Power Output						
	OP231TX, TXV		I_F = 100 mA		8.0		mW
	OP232TX, TXV		I_F = 100 mA		10.0		mW
V_F	Forward Voltage	4011	I_F = 100 mA		1.10	2.0	V
I_R	Reverse Current	4016	V_R = 2.0 V			10.0	μA

Group B Inspection (performed on each inspection lot)

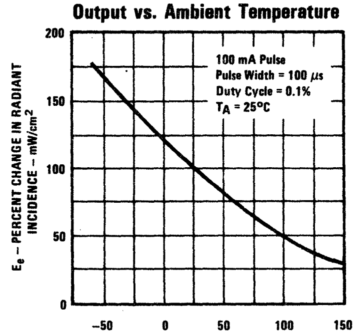
Symbol	Examination or Test	MIL-STD-750 Method	MIL-STD-750 Conditions	LTPD	Limit Min.	Limit Max.	Units
Subgroup 1				15			
	Solderability	2026					
Subgroup 2				10			
	Thermal Shock (Temperature Cycle)	1051	Condition F, 25 cycles, −65°C to +150°C, 10 minutes minimum @ extremes				
	Hermetic Seal	1071					
	Fine Leak		Condition G or H, 5 × 10^{-7} atm cc/sec				
	Gross Leak		Condition A, C, E or F				
	End Point Measurements		Group A, Subgroup 2				
Subgroup 3				5			
	Steady State Operational Life	1027	I_F = 100 mA, T_A = 25°C, t = 340 hours				
	End Point Measurements						
V_F	Forward Voltage	4011	I_F = 100 mA		1.10	2.0	V
I_R	Reverse Current	4016	V_R = 2.0 V			10.0	μA
P_O	Radiant Flux OP231TX, TXV		I_F = 100 mA		6.4		mW
	OP232TX, TXV		I_F = 100 mA		8.0		mW
Subgroup 6				5			
	High Temp. Life (Nonoperating)	1032	T_A = 150°C, t = 340 hours				
	End Point Measurements		Same as in Group B, Subgroup 3				

Typical Performance Curves

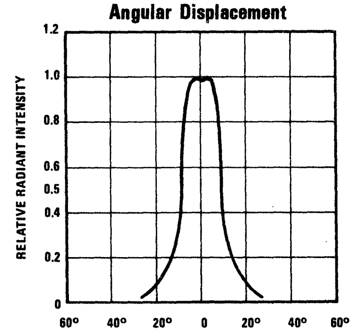
Rise Time and Fall Time vs. Forward Current



Percent Change in Power Output vs. Ambient Temperature



Relative Radiant Intensity vs. Angular Displacement



Types OP231TX, OP231TXV, OP232TX, OP232TXV

Group C Inspection

Symbol	Examination or Test	MIL-STD-750		LTPD	Limit		Units
		Method	Conditions		Min.	Max.	
Subgroup 1				15			
	Physical Dimensions	2066					
Subgroup 2				10			
	Thermal Shock (Glass Strain)	1056	Condition B				
	Terminal Strength	2036	Condition E				
	Hermetic Seal Fine Leak Gross Leak	1071	 Condition G or H, 5×10^{-7} atm cc/sec Condition A, C, E or F				
	Moisture Resistance	1021	Omit initial conditioning				
	External Visual	2071					
	End Point Measurements		Group A, Subgroup 2				
Subgroup 3				10			
	Shock	2016	Nonoperating, 1500 G's, 0.5 ms, 5 blows: X_1, Y_1, Z_1				
	Vibration, Variable Frequency	2056					
	Constant Acceleration	2006	20 KG's, one minute in each orientation: X_1, Y_1, Z_1				
	End Point Measurements		Group A, Subgroup 2				
Subgroup 4				15			
	Salt Atmosphere	1041					
Subgroup 6				$\lambda = 10$			
	Steady State Operational Life	1026	I_F = 100 mA, T_A = 25°C, t = 1000 hours				
	End Point Measurements		Same as in Group B, Subgroup 3				

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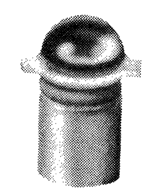
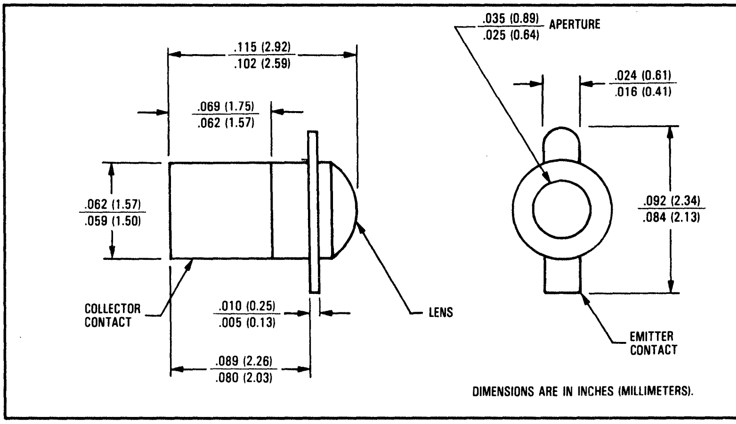
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5132
January 1985

High Reliability NPN Silicon Phototransistors
Types OP602TX/V, OP603TX/V, OP604TX/V





Features
- High reliability processed to TRW's military screening program patterned after MIL-S-19500
- Miniature hermetically sealed package
- Wide range of collector currents
- Ideal for direct mounting in PC boards

Description
Each device in the OP602TX, TXV series consists of a high reliability NPN silicon phototransistor mounted in a miniature glass lensed, hermetically sealed, "Pill" package.

After electrical testing by manufacturing, all devices are processed to TRW's 100 percent screening program patterned after MIL-S-19500. After completion, Group A sample tests are performed and generic data is supplied for Group B & C inspections.

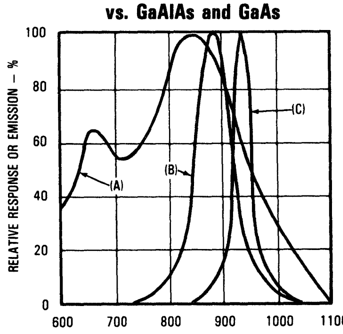
The OP602TX, TXV series have lenses that allow an acceptance half angle of 18° measured from the optical axis to the half power point. The series is also mechanically and spectrally matched to the OP123 and OP233 series of infrared emitting diodes.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)
Collector-Emitter Voltage .... 50 V
Emitter-Collector Voltage .... 7.0 V
Storage Temperature Range .... −65°C to +150°C
Operating Temperature Range .... −65°C to +125°C
Soldering Temperature (for 5 seconds with soldering iron) .... 240°C[1]
Power Dissipation .... 50 mW[2]

Notes:
(1) RMA flux is recommended. Duration can be extended to 10 sec. max. when wave soldering.
(2) Derate linearly 0.5 mW/°C above 25°C.
(3) Junction temperature maintained at 25°C.
(4) Light source is an unfiltered tungsten bulb operating at CT = 2870°K or equivalent source.

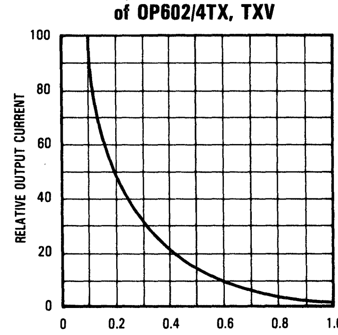
Typical Performance Curves

Photosensor Spectral Response vs. GaAlAs and GaAs



Test Conditions (LED): $T_A = T_J$ = 25°C, I_F = 100 mA, DC = 0.1%, PW = 100 μs
Peak Wavelength – λp: (A) XSTR – 850 ± 30 nm, (B) LED GaAlAs – 875 ± 20 nm, (C) LED GaAs – 930 ± 15 nm

Coupling Characteristics of OP602/4TX, TXV



Electrical Characteristics (T_A = 25°C unless otherwise noted)

Symbol	Parameter		Min.	Typ.	Max.	Units	Test Conditions
$I_{C(ON)}$[3]	On-State Collector Current	OP602TX, TXV	2.0		5.0	mA	V_{CE} = 5.0 V, E_e = 20 mW/cm²[4]
		OP603TX, TXV	4.0		8.0	mA	V_{CE} = 5.0 V, E_e = 20 mW/cm²[4]
		OP604TX, TXV	7.0			mA	V_{CE} = 5.0 V, E_e = 20 mW/cm²[4]
I_{CEO}	Collector Dark Current				25	nA	V_{CE} = 10.0 V, E_e = 0
					100	μA	V_{CE} = 30.0 V, E_e = 0, T_A = +100°C
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage		50			V	I_C = 100 μA, E_e = 0
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage		7.0			V	I_E = 100 μA, E_e = 0
$V_{CE(SAT)}$[3]	Collector-Emitter Saturation Voltage				0.40	V	I_C = 0.4 mA, E_e = 20 mW/cm²[4]
t_r	Rise Time				20.0	μs	V_{CC} = 30 V, I_C = 1.00 mA, R_L = 1.00 kΩ,
t_f	Fall Time				20.0	μs	See Test Circuit

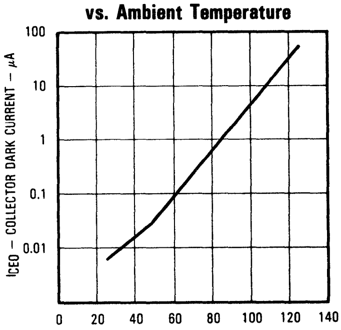
100% Processing

Screen	MIL-STD-750 Method	Conditions	OP602TX OP603TX OP604TX	OP602TXV OP603TXV OP604TXV
Pre-Cap Visual	—	TRW Opto pre-cap visual	—	100%
High Temperature Storage	1032	T_A = 150°C, t = 24 hrs. min.	100%	100%
Temperature Cycle	1051, Condition F	20 cycles, −65°C to +150°C, 10 min. each extreme	100%	100%
Constant Acceleration	2006	20000 G, Y_1 only	100%	100%
Hermetic Seal	1071	Fine: Condition G or H, 5 × 10^{-7} atm cc/sec Gross: Condition C, Step 2	100%	100%
High Temperature Reverse Bias[5]	1039, Condition A	T_A = 125°C, V_{CE} = 30 Vdc, E_e = 0, t = 48 hrs. min.	100%	100%
Power Burn-In[6]	1039, Condition B	P_T = 50 mW min., T_A = 25°C, t = 168 hrs. min.	100%	100%

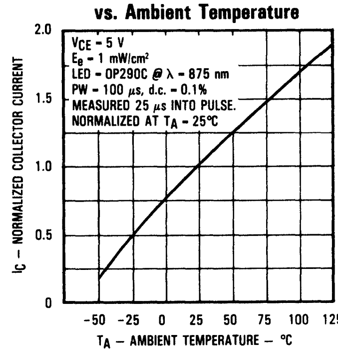
(5) 100% electrically tested to the limits in subgroup 2 of the Group A table before and after HTRB.
(6) 100% electrically tested to the limits in subgroups 2 and 3 of the Group A table before and after burn-in. ΔI_{CEO} = ±100% of initial reading or ±15 nA, whichever is greater; $\Delta I_{C(ON)}$ = ±20%; PDA = 10%.

Typical Performance Curves

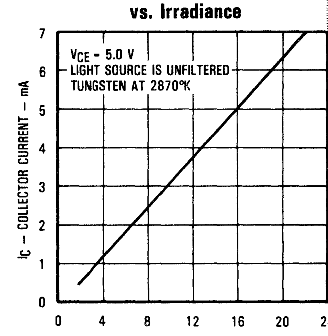
Collector Dark Current vs. Ambient Temperature



Normalized Collector Current vs. Ambient Temperature



Collector Current vs. Irradiance



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Group A Inspection—Electrical Tests (performed on each inspection lot after all devices have been subject to the 100% processing requirements)

Symbol	Examination or Test	MIL-STD-750 Method	MIL-STD-750 Conditions	LTPD	Limit Min.	Limit Max.	Units
Subgroup 1				5			
	Visual and Mechanical Examination	2071					
Subgroup 2				5			
I_{CEO}	Dark Current	3041	V_{CE} = 10.0 Vdc			25	nAdc
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	3011	I_C = 100 μAdc, E_e = 0		50		Vdc
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	3001	I_E = 100 μAdc, E_e = 0		7.0		Vdc
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage		I_C = 0.40 mAdc, E_e[7] = 20 mW/cm^2			0.40	Vdc
$I_{C(ON)}$	On-State Collector Current		V_{CE} = 5.0 Vdc, E_e[7] = 20 mW/cm^2				
	OP602TX, TXV				2.0	5.0	mAdc
	OP603TX, TXV				4.0	8.0	mAdc
	OP604TX, TXV				7.0		mAdc
Subgroup 3				5			
I_{CEO}	Dark Current	3041	V_{CE} = 30 Vdc, E_e = 0, T_A = 100°C			100	μAdc
Subgroup 4				5			
t_r, t_f	Rise and Fall Time		V_{CC} = 30 Vdc, R_L = 1K ohms			20.0	μs

(7) Light source is an unfiltered tungsten lamp operated at a color temperature of 2870°K.

Group B Inspection (performed on each inspection lot)

Examination or Test	MIL-STD-750 Method	MIL-STD-750 Conditions	LTPD
Subgroup 1			15
Solderability	2026		
Subgroup 2			10
Thermal Shock (Temperature Cycle)	1051	No dwell at 25°C, Condition F, 25 cycles, 10 minutes at extremes	
Hermetic Seal	1071		
Fine Leak		Condition G or H, max. leak rate = 5 × 10^{-7} atm cc/sec	
Gross Leak		Condition A, C or E	
End Points:		Group A, Subgroup 2	
Subgroup 3			5
Steady-State Operational Life	1027	P_D = 50 mW, t = 340 hours, T_A = 25°C	
End Points:		Group A, Subgroup 2	
Subgroup 6			5
High Temperature Life (non-operating)	1032	t = 340 hours, T_A = 150°C	
End Points:		Group A, Subgroup 2	

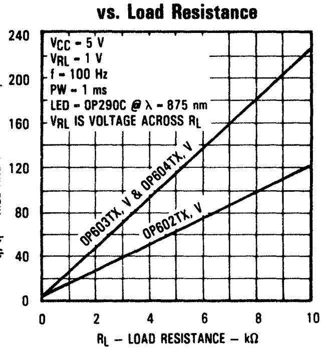
Types OP602TX/V, OP603TX/V, OP604TX/V

Group C Inspection

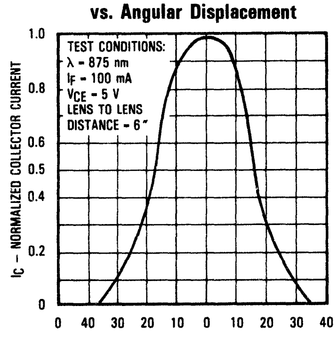
Examination or Test	MIL-STD-750 Method	Conditions	LTPD
Subgroup 1			15
Physical Dimensions	2066		
Subgroup 2			10
Thermal Shock (Glass Strain)	1056	Condition B	
Hermetic Seal	1071		
Fine Leak		Condition G or H, max. leak rate = 5×10^{-7} atm cc/sec	
Gross Leak		Condition A, C or E	
Moisture Resistance	1021	Omit initial conditioning	
External Visual	2071		
End Points:		Group A, Subgroup 2	
Subgroup 3			10
Shock	2016	Non-operating; 1500 G's; 0.5 ms, 5 blows in each orientation; X_1, Y_1, and Z_1	
Vibration, Variable Frequency	2056		
Constant Acceleration	2006	1 minute in each orientation; X_1, Y_1 and Z_1 at 20,000 G's min.	
End Points:		Group A, Subgroup 2	
Subgroup 4			15
Salt Atmosphere	1041		
Subgroup 6			10
Steady-State Operational Life	1026	Power dissipation = 50 mW, t = 1000 hours, T_A = 25°C	
End Points:		Group A, Subgroup 2	

Typical Performance Curves

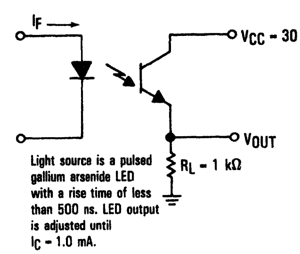
Rise and Fall Time vs. Load Resistance



Normalized Collector Current vs. Angular Displacement



Switching Time Test Circuit



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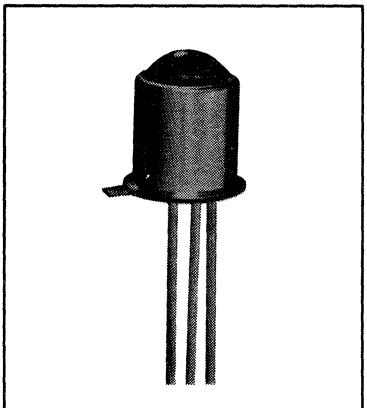
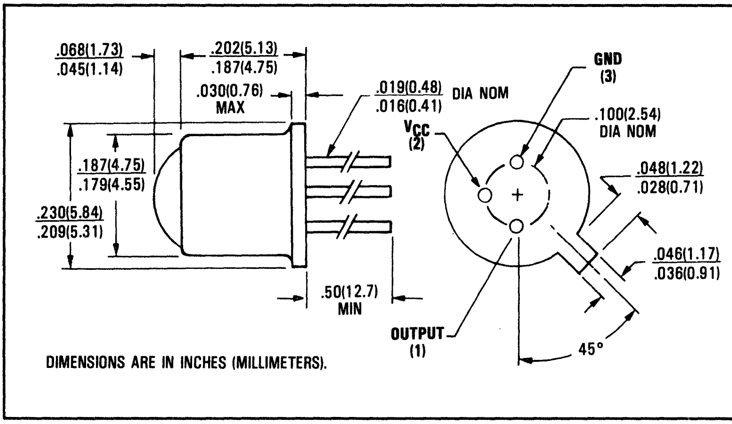
TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5159
January 1985

High Reliability Photologic™ Hermetic Sensors
Type OPL800TXV





Features
- 100% screened and quality conformance tested to TRW's Hi-Rel program patterned after MIL-STD-883 Class B
- Direct TTL/LSTTL interface
- Hermetic, lensed TO-18 package
- Mechanically and spectrally matched to OP130 and OP230 LEDs

Description
The OPL800TXV is a high reliability optoelectronic microcircuit that incorporates a photodiode, linear amplifier, and Schmitt trigger on a single silicon chip. The device features TTL/LSTTL compatible logic level output which can drive up to 8 TTL loads without additional interface circuitry. The photologic chip is mounted on a standard TO-18 header which is hermetically sealed in a lensed metal can. These devices are mechanically and spectrally matched to the OP130 and OP230 infrared emitting diodes. All parts are processed to TRW's 100 percent screening program patterned after Method 5004 of MIL-STD-883 and the Quality Conformance testing in Method 5005 for Class B devices. Complete details of this Hi-Rel program are given on the following pages.

Typical characteristic curves are shown on the commercial OPL800 data sheet.

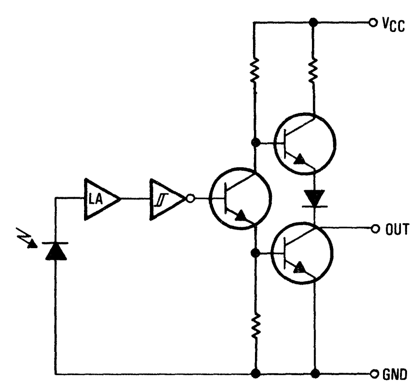
Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

Supply Voltage, V_{CC} (not to exceed 3 seconds) . . . . . +10.0 V
Storage Temperature Range . . . . . −65°C to +150°C
Operating Temperature Range . . . . . −55°C to +110°C
Lead Soldering Temperature (1/16 in. [1.6 mm] from case for 5 sec. with soldering iron) . . . . . 240°C[1]
Power Dissipation . . . . . 250 mW[2]
Duration of Output Short to V_{CC} or Ground . . . . . 1.00 sec.

Notes:
(1) RMA flux is recommended. Duration can be extended to 10 seconds max. when flow soldering.
(2) Derate linearly 2.0 mW/°C above 25°C.
(3) Light measurements are made with λ = 935 nm.

Schematic

OPL800TXV (Totem-Pole Output) Buffer



Type OPL800TXV

100% Processing

Screen	MIL-STD-883 Method	Conditions	OPL800/883B
Internal Visual	2010, Condition B		100%
High Temperature Storage	1008, Condition C	T_A = 150°C, t = 24 hrs. min.	100%
Temperature Cycling	1010, Condition C	10 cycles, −65°C to +150°C, 10 min. each extreme	100%
Constant Acceleration	2001, Condition E	Y_1 orientation, 30 KGs for 1 min.	100%
Hermetic Seal	1014	Fine: Condition A or B, 5 × 10^{-7} atm cc/sec Gross: Condition C, D, or E	100%
Power Burn-In*	1015, Condition B	T_A = 125°C, V_{CC} = 5.25 V, E_e = 0, t = 160 hrs. min.	100%
External Visual Examination	2009		100%

*100% electrically tested to the limits in subgroups 1 & 9 of the group A table before and after burn-in.

Group A Inspection—Electrical Tests (performed on each inspection lot after all devices have been subject to the 100% processing requirements)

Symbol	Examination or Test	MIL-STD-883 Method	MIL-STD-883 Conditions	LTPD	Limit Min.	Limit Max.	Units
Subgroup 1**				5			
I_{CCH}	Supply Current, High	3005	V_{CC} = 5.25 V, E_e = 2.0 mW/cm²			15.0	mA
I_{CCL}	Supply Current, Low	3005	V_{CC} = 5.25 V, E_e = 0			15.0	mA
V_{OL}	Low Level Output Voltage	3007	V_{CC} = 4.75 V, I_{OL} = 12.8 mA, E_e = 0			0.40	V
V_{OH}	High Level Output Voltage	3006	V_{CC} = 4.75 V, I_{OH} = −800 μA, E_e = 2.0 mW/cm²		2.4		V
I_{OS}	Short Circuit Output Current	3011	V_{CC} = 5.25 V, E_e = 2.0 mW/cm², Output = GND		-30	-120	mA
Subgroup 2**			T_A = +125°C	7			
I_{CCH}	Supply Current, High	3005	V_{CC} = 5.25 V, E_e = 2.0 mW/cm²			15.0	mA
I_{CCL}	Supply Current, Low	3005	V_{CC} = 5.25 V, E_e = 0			15.0	mA
V_{OL}	Low Level Output Voltage	3007	V_{CC} = 4.75 V, I_{OL} = 12.8 mA, E_e = 0			0.40	V
V_{OH}	High Level Output Voltage	3006	V_{CC} = 4.75 V, I_{OH} = −800 μA, E_e = 2.0 mW/cm²		2.4		V
Subgroup 3**			T_A = −55°C	7			
I_{CCH}	Supply Current, High	3005	V_{CC} = 5.25 V, E_e = 2.0 mW/cm²			15.0	mA
I_{CCL}	Supply Current, Low	3005	V_{CC} = 5.25 V, E_e = 0			15.0	mA
V_{OL}	Low Level Output Voltage	3007	V_{CC} = 4.75 V, I_{OL} = 12.8 mA, E_e = 0			0.40	V
V_{OH}	High Level Output Voltage	3006	V_{CC} = 4.75 V, I_{OH} = −800 μA, E_e = 2.0 mW/cm²		2.4		V
Subgroup 9**	(Figure 1)			7			
t_r	Rise Time	3004	V_{CC} = 5.0 V, R_L = 8 TTL loads			70	nS
t_f	Fall Time	3004	V_{CC} = 5.0 V, R_L = 8 TTL loads			70	nS
t_{PLH}	Propagation Delay, LOW-HIGH	3003	V_{CC} = 5.0 V, R_L = 8 TTL loads			10.0	μS
t_{PHL}	Propagation Delay, HIGH-LOW	3003	V_{CC} = 5.0 V, R_L = 8 TTL loads			10.0	μS

**Light source is a gallium arsenide light emitting diode with a typical rise time of 500 nanoseconds.

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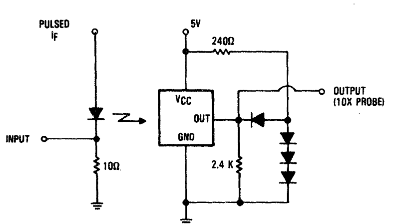
Group B Inspection (performed on each inspection lot)

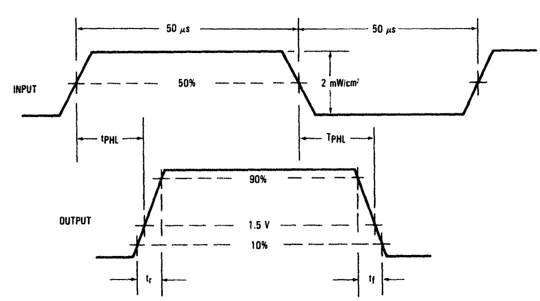
Examination or Test	MIL-STD-883 Method	MIL-STD-883 Conditions	LTPD
Subgroup 1			2 devices no failures
Physical Dimensions	2016		
Subgroup 2			4 devices no failures
Resistance to Solvents	2015		
Subgroup 3			15
Solderability	2003	Soldering temp. = 260°C ± 10°C	
Subgroup 5			15
Bond Strength	2011	Condition C or D	
Subgroup 7			5
Hermetic Seal	1014		
Fine Leak		Condition A or B, 5×10^{-7} atm cc/sec	
Gross Leak		Condition C, D or E	

Group C (Die Related Tests) (performed every 3 months during production)

Examination or Test	MIL-STD-883 Method	MIL-STD-883 Conditions	LTPD
Subgroup 1			5
Steady State Life	1005	V_{CC} = 5.0 V, T_A = 150°C, t = 1000 hrs.	
End Points:		Group A, Subgroup 1	
Subgroup 2			15
Temperature Cycling	1010	Condition C, 10 cycles, −65°C to +150°C, 10 minutes minimum @ extremes, 5 minutes max. transfer time	
Constant Acceleration	2001	Cond. E, 30KG's, Y_1 only for 1 minute	
Hermetic Seal	1014		
Fine Leak		Condition A or B, 5×10^{-7} atm cc/sec	
Gross Leak		Condition C, D or E	
End Points:		Group A, Subgroup 1	

Figure 1: Switching Test Circuit and Waveforms





Type OPL800TXV

Group D (Package Related Tests) (performed every 6 months during production)

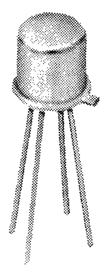
Examination or Test	MIL-STD-883		LTPD
	Method	**Conditions**	
Subgroup 1			15
Physical Dimensions	2016		
Subgroup 2			15
Lead Integrity	2004	Condition B2 (Lead Fatigue)	
Hermetic Seal Fine Leak Gross Leak	1014	 Condition A or B, 5×10^{-7} atm cc/sec Condition C, D or E	
Subgroup 3			15
Thermal Shock	1011	Condition B, 15 cycles, 125°C to −55°C, 5 minutes minimum @ extremes, 10 second maximum transfer time	
Temperature Cycling	1010	Condition C, 100 cycles, −65°C to +150°C, 10 minutes minimum @ extremes, 5 minutes maximum transfer time	
Moisture Resistance	1004		
Hermetic Seal Fine Leak Gross Leak	1014	 Condition A or B, 5×10^{-7} atm cc/sec Condition C, D or E	
End Points:		Group A, Subgroup 1	
Subgroup 4			15
Mechanical Shock	2002	Condition B	
Vibration, Variable Frequency	2007	Condition A	
Constant Acceleration	2001	Condition E, 30 KG's, Y_1 only for 1 minute	
Hermetic Seal Fine Leak Gross Leak	1014	 Condition A or B, 5×10^{-7} atm cc/sec Condition C, D or E	
End Points:		Group A, Subgroup 1	
Subgroup 5			15
Salt Atmosphere	1009	Condition A	
Hermetic Seal Fine Leak Gross Leak	1014	 Condition A or B, 5×10^{-7} atm cc/sec Condition C, D or E	

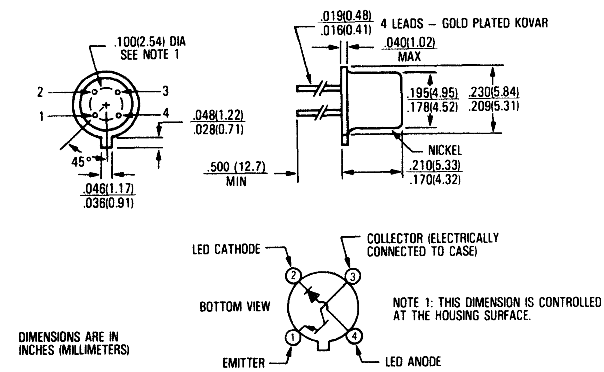
TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5235
January 1985

High Reliability Optically Coupled Isolators
Types 3N243R, 3N244R, 3N245R





Features

- High-Reliability processed to TRW's military screening program patterned after MIL-S-19500/486
- TO-72 hermetically sealed package
- 1 kVDC electrical isolation

Description

The 3N243R, 3N244R, and 3N245R are high-reliability optically coupled isolators, each consisting of a gallium arsenide infrared emitting diode and an NPN silicon phototransistor mounted in a hermetically sealed TO-72 package.

The 3N243R, 3N244R, and 3N245R are identical to the JEDEC registered optically coupled isolators 3N243, 3N244, and 3N245, except that they receive additional high-reliability processing. This processing is patterned after MIL-S-19500 as shown in the accompanying table.

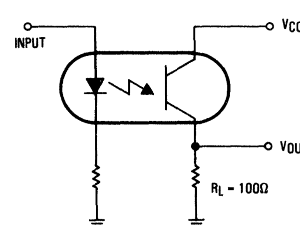
Typical characteristic curves are shown on the commercial 3N243, 3N244, and 3N245 data sheets.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

Input-to-Output Isolation Voltage	±1.00 kVDC[1]
Storage Temperature Range	−55°C to +150°C
Operating Temperature Range	−55°C to +125°C
Lead Soldering Temperature (1/16 in. [1.6 mm] from case for 5 sec. with soldering iron)	240°C[2]
Input Diode	
Forward DC Current	40 mA
Reverse Voltage	2.0 V
Power Dissipation	60 mW[3]
Output Phototransistor	
Continuous Collector Current	30 mA
Collector-Emitter Voltage	30 V
Emitter-Collector Voltage	5.0 V
Power Dissipation	200 mW[4]

Notes:
(1) Measured with input leads shorted together and output leads shorted together.
(2) RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering.
(3) Derate linearly 0.60 mW/°C above 25°C.
(4) Derate linearly 2.0 mW/°C above 25°C.
(5) The input waveform is supplied by a generator with the following characteristics: Z_{OUT} = 50Ω, $t_r \leq$ 15 ns, duty cycle ≅ 1%, pulse width ≅ 100 μs.

Switching Time Test Circuit
(See Note 5)



Types 3N243R, 3N244R, 3N245R

Electrical Characteristics (T_A = 25°C unless otherwise noted)

Symbol	Parameter	3N243R			3N244R			3N245R			Units	Test Conditions
		Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.		
Input Diode												
V_F	Forward Voltage	0.80		1.30	0.80		1.30	0.80		1.30	V	I_F = 10.0 mA
		1.00		1.50	1.00		1.50	1.00		1.50	V	I_F = 10.0 mA, T_A = −55°C
		0.70		1.20	0.70		1.20	0.70		1.20	V	I_F = 10.0 mA, T_A = 100°C
I_R	Reverse Current			100			100			100	μA	V_R = 2.0 V
Output Phototransistor												
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	30			30			30			V	I_C = 1.00 mA
$V_{(BR)ECO}$	Emitter-Collector Breakdown Voltage	5.0			5.0			5.0			V	I_E = 100 μA
I_{CEO}	Collector Dark Current			100			100			100	nA	V_{CE} = 10.0 V
				100			100			100	μA	V_{CE} = 10.0 V, T_A = 100°C
Coupled												
$I_{C(ON)}$	On-State Collector Current	1.50			3.0			6.0			mA	I_F = 10.0 mA, V_{CE} = 10.0 V
		0.30			0.80			1.50			mA	I_F = 3.0 mA, V_{CE} = 10.0 V
		0.50			1.00			1.50			mA	I_F = 10.0 mA, V_{CE} = 10.0 V, T_A = −55°C
		0.50			1.00			1.50			mA	I_F = 10.0 mA, V_{CE} = 10.0 V, T_A = 100°C
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage			0.30							V	I_F = 20 mA, I_C = 1.50 mA
							0.30				V	I_F = 20 mA, I_C = 3.0 mA
										0.30	V	I_F = 20 mA, I_C = 6.0 mA
I_{IO}	Leakage, Input-to-Output			100			100			100	nA	V_{IO} = ±1.00 kVDC. See Note 1.
C_{IO}	Capacitance, Input-to-Output			5.0			5.0			5.0	pF	V_{IO} = 0 V, f = 1.00 MHz. See Note 1.
t_r	Output Rise Time			10.0			10.0			15.0	μs	V_{CC} = 10.0 V, I_F = 10.0 mA,
t_f	Output Fall Time			10.0			10.0			15.0	μs	R_L = 100Ω. See Test Circuit.

100% Processing

Screen	MIL-STD-750 Method	Conditions	3N243R, 3N244R 3N245R
Pre-Cap Visual		TRW Opto pre-cap visual	100%
High Temperature Storage		T_A = 150°C, t = 48 hrs.	100%
Temperature Cycle	1051, Condition B	10 cycles; 15 min. each extreme	100%
Constant Acceleration	2006	20K G, Y_1 only	100%
Power Burn-In	1039, Condition B	V_{CE} = 10 V; P_t = 175-200 mW; T_A = 25°C; I_F = 40 mA, t = 168 hrs. min.	100%
Hermetic Seal	1071	Fine: Condition G or H, 1 × 10^{-8} atm cc/sec Gross: Condition C or D	100%
External Visual Examination	2071		100%

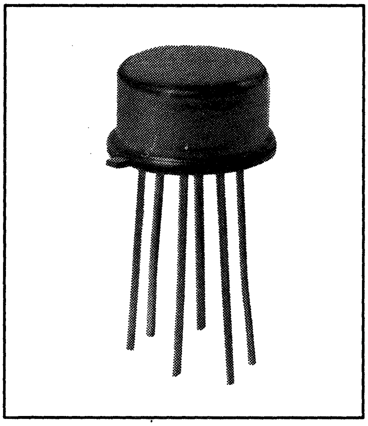
TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

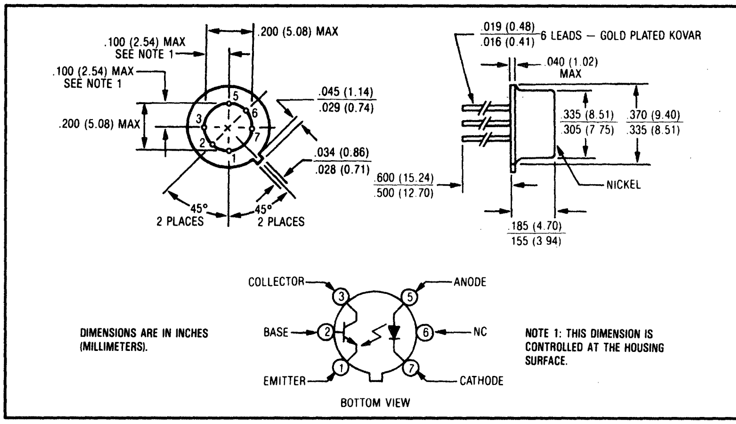
Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958

Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5238
January 1985

Optically Coupled Isolators
Types JAN, JANTX, JANTXV–4N22A, 4N23A, 4N24A





Features
- High-Reliability processed to MIL-S-19500/486
- 1 kV electrical isolation
- Base contact is provided for conventional transistor biasing

Description
The JAN, JANTX, and JANTXV series of 4N22A, 4N23A, and 4N24A are JEDEC registered, DESC qualified, optically coupled isolators. High reliability processing on the devices is performed in accordance with MIL-S-19500/486.

Each device in the series consists of a gallium arsenide infrared emitting diode and a NPN silicon phototransistor mounted in a hermetically sealed TO-5 package. The suffix letter "A" denotes the collector is electrically isolated from the case.

Typical characteristic curves are shown on the commercial 4N22A, 4N23A, and 4N24A data sheets.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

Input-to-Output Isolation Voltage	±1.00 kVDC(1)
Storage and Operating Temperature Range	−65°C to +125°C
Lead Soldering Temperature (1/16 in. [1.6 mm] from case for 5 sec. with soldering iron)	240°C(2)
Input Diode	
Forward DC Current (65°C or below)	40 mA
Reverse Voltage	2.0 V
Peak Forward Current (1 μs pulse width, 300 pps)	1.00 A
Power Dissipation	60 mW(3)
Output Photosensor	
Continuous Collector Current	50 mA
Collector-Emitter Voltage	35 V
Collector-Base Voltage	35 V
Emitter-Base Voltage	4.0 V
Power Dissipation	300 mW(4)

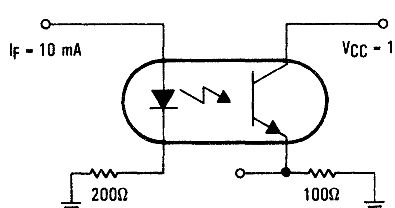
Notes:
(1) Measured with input diode leads shorted together and output leads shorted together.
(2) RMA flux is recommended. Duration can be extended to 10 sec. max. when flow soldering.
(3) Derate linearly 0.67 mW/°C above 65°C.
(4) Derate linearly 3.0 mW/°C above 25°C.
(5) Manufacturing is not required to 100% test.

Types JAN, JANTX, JANTXV–4N22A, 4N23A, 4N24A

Electrical Characteristics (T_A = 25°C unless otherwise noted)

Symbol	Parameter	JAN, JANTX, JANTXV 4N22A Min.	4N22A Max.	4N23A Min.	4N23A Max.	4N24A Min.	4N24A Max.	Units	Test Conditions
Input Diode									
V_F	Forward Voltage	0.80	1.30	0.80	1.30	0.80	1.30	V	I_F = 10.0 mA
		1.00	1.50	1.00	1.50	1.00	1.50	V	I_F = 10.0 mA, T_A = −55°C(5)
		0.70	1.20	0.70	1.20	0.70	1.20	V	I_F = 10.0 mA, T_A = 100°C(5)
I_R	Reverse Current		100		100		100	μA	V_R = 2.0 V
Output Phototransistor									
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	35		35		35		V	I_C = 1.00 mA
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	35		35		35		V	I_C = 100 μA
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	4.0		4.0		4.0		V	I_E = 100 μA
I_{CEO}	Collector Dark Current		100		100		100	nA	V_{CE} = 20.0 V
			100		100		100	μA	V_{CE} = 20.0 V, T_A = 100°C(5)
Coupled									
$I_{C(ON)}$	On-State Collector Current	2.5		6.0		10.0		mA	I_F = 10.0 mA, V_{CE} = 5.0 V
		0.150		0.20		0.40		mA	I_F = 2.0 mA, V_{CE} = 5.0 V
		1.00		2.5		4.0		mA	I_F = 10.0 mA, V_{CE} = 5.0 V, T_A = −55°C(5)
		1.00		2.5		4.0		mA	I_F = 10.0 mA, V_{CE} = 5.0 V, T_A = 100°C(5)
$V_{CE(SAT)}$	Collector-Emitter Saturation Voltage		0.30					V	I_F = 20 mA, I_C = 2.5 mA
					0.30			V	I_F = 20 mA, I_C = 5.0 mA
							0.30	V	I_F = 20 mA, I_C = 10.0 mA
h_{FE}	DC Current Gain	200		300		400			V_{CE} = 5.0 V, I_C = 10.0 mA, I_F = 0 mA
R_{IO}	Resistance, Input-to-Output	10^{11}		10^{11}		10^{11}		Ω	V_{IO} = 1.00 kVDC(1)
I_{IO}	Leakage, Input-to-Output		10.0		10.0		10.0	nA	V_{IO} = ±1.00 kVDC(1)
C_{IO}	Capacitance, Input-to-Output		5.0		5.0		5.0	pF	V_{IO} = 0 V, f = 1.00 MHz(1)
t_r	Output Rise Time		15.0		15.0		20	μs	V_{CC} = 10.0 V, I_F = 10.0 mA,
t_f	Output Fall Time		15.0		15.0		20	μs	R_L = 100Ω. See Test Circuit.

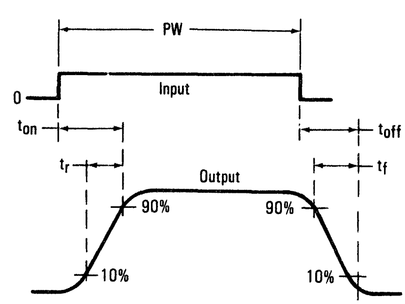
Test Circuit



The input waveform is supplied by a generator with the following characteristics: Z_{OUT} = 50Ω, $t_r \leq$ 15 ns, duty cycle ≈ 1%, pulse width ≈ 100 μs.

Voltage Waveforms

The output waveform is monitored on an oscilloscope with the following characteristics: t_r = 12 ns, R_{IN} = 1 MΩ, C_{IN} = 20 pF.



Simplified JAN Product Flow

JAN	JANTX	JANTXV
Controlled Lot with Sample Environmental and Life Testing	*100% Processing Plus Sample Environmental and Life Testing*	*Same as JANTX Plus 100% Internal Visual Inspection*
Commercial Product ↓ Group A, B, C Sample Test ↓ Ship	Commercial Product ↓ 100% Processing ↓ Group A, B, C Sample Test ↓ Ship	100% Pre-Cap Visual ↓ 100% Processing ↓ Group A, B, C Sample Test ↓ Ship

100% Processing

Screen	MIL-STD-750 Method	Conditions	JANTX4N22A JANTX4N23A JANTX4N24A	JANTXV4N22A JANTXV4N23A JANTXV4N24A
Pre-Cap Visual	2072		–	100%
High Temperature Storage		T_A = 125°C, t = 72 hrs.	100%	100%
Temperature Cycle	1051, Condition B	10 cycles; 15 min. each extreme	100%	100%
Constant Acceleration	2006	20K G, Y_1 only	100%	100%
High Temperature Reverse Bias	1039, Condition A	T_A = 125°C, I_F = 0, V_{CB} = 20 V, t = 96 hrs. min.	100%	100%
Power Burn-In	1039, Condition B	V_{CC} = 20 V; V_{CE} = 10 ± 5 V, P_t = 275 ± 25 mW; T_A = 25°C, I_F = 40 mA, t = 168 hrs. min.	100%	100%
Monitored Temperature Cycle	1051, Condition B	Monitored, 1 cycle, 15 min. each extreme	100%	100%
Hermetic Seal	1071	Fine: Condition G or H 1 × 10^{-7} atm cc/sec Gross: Condition C or D	100%	100%
External Visual Examination	2071		100%	100%

Quality and Reliability Lot Acceptance Testing

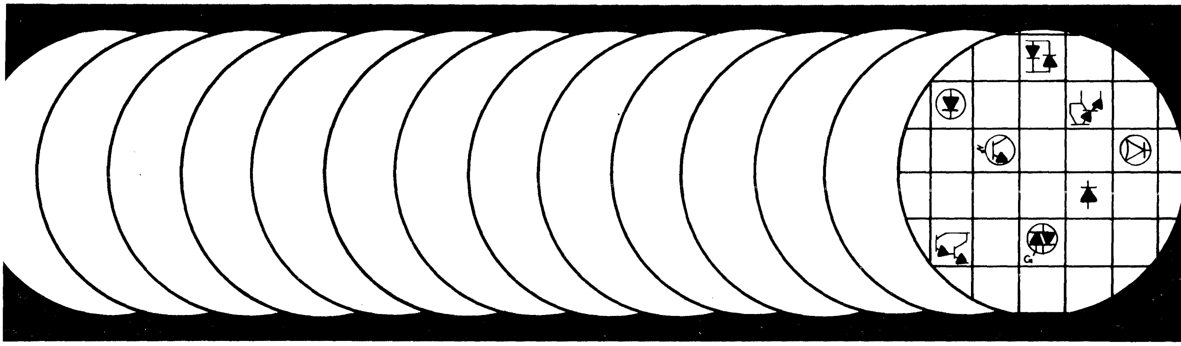
Sub Group	Examination or Test (MIL-S-19500/486A)	MIL-STD-750 Method	Sample Size (Accept on 1 Failure) JAN	JANTX	JANTXV
Electrical Testing					
A1	Visual & Mechanical	2071	38	55	55
A2	Electrical — LED	—	55	77	77
A3	Electrical — Transistor	—	55	77	77
A4	Electrical — Combination	—	55	77	77
A5	Electrical — High Temp.	—	38	55	55
A6	Electrical — Low Temp.	—	38	55	55
Environmental Testing					
B1	Solderability	2026	25	25	25
	Thermal Shock (Temp. Cycle)	1051, Condition B	25	25	25
	Thermal Shock (Glass Strain)	1056, Condition A	25	25	25
	Hermetic Seal	1071, Condition G or H, C or D	25	25	25
	Moisture Resistance	1021	25	25	25
	End Points		25	25	25
B2	Shock	2016	38	38	38
	Vibration, Variable Freq.	2056	38	38	38
	Constant Acceleration	2006	38	38	38
	End Points		38	38	38
B3	High Temperature Isolation	1016	18	18	18
	End Points		18	18	18
C1	Barometric Pressure (reduced)	1001	38	38	38
C2	Physical Dimensions	2066	18	18	18
C3	Resistance to Solvents	MIL-STD-202, Method 215	38	38	38
C4	Terminal Strength	2036, Condition E	38	38	38
C5	Salt Atmosphere (corrosion)	1041	38	38	38
Life Testing					
B4	High Temp. Life (non-operating)	1032	55	77	77
B5	Steady State Operating Life	1027	55	77	77
C6	High Temp. Life (non-operating)	1031	55	77	77
C7	Steady State Operating Life	1026	55	77	77

NOTE: Group C testing is performed once each six months and on one JAN device type.

J

Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958

TRW



Hallogic™ Hall Effect Sensors

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Hallogic™ Hall Effect Sensors

TRW's Optoelectronics Division produces the *only temperature-compensated* Hall effect magnetic sensing device on the market, the Hallogic™ Hall Effect Sensor (the OH360). TRW's Hall effect sensors are superior products that meet the demands of motion sensing in extremely harsh environments such as under-the-hood automotive and heavy industrial machinery applications, including robotics.

Hallogic™ refers to the combination of a Hall element magnetic field sensor with highly refined integrated circuitry on a single, monolithic bipolar silicon chip. Incorporated on the OH360 sensor chip are:

- a Hall element
- a bandgap voltage regulator
- a threshold amplifier (including a linear amplifier and a Schmitt trigger)
- an open-collector output transistor (that can drive ten TTL loads)

The Hall Element

The basic Hall element relies on diverting a magnetic field in order to sense motion. The principle is based on the Hall effect, discovered more than 100 years ago by the American physicist, Edwin Herbert Hall. The Hall effect is the small electrical potential created when a stationary magnetic field is placed perpendicular to a current-carrying semiconductor (see Figure 1).

Most available Hall elements hold current constant and measure voltage, which is then correlated with magnetic field strength. The superior performance of the TRW device is due in part to a fundamental design change which instead provides a constant bias *voltage* and measures the Hall *current*. This method proves more accurate for sensing magnetic field strength when temperature varies. It also provides a better way to interface the Hall element with the complex integrated circuitry of the Hallogic™ sensor, the OH360.

The TRW Hall element then is basically a block of semiconductor material with four contact points. Two contacts (or electrodes) are used to supply a constant bias voltage to the element; the other two are used for the varying current output. If voltage is held constant across the device while a perpendicular magnetic field is applied, the Hall current can be sensed across the output connections. The Hall current is proportional to the strength of the applied magnetic field.

Unprecedented Temperature Stability

Temperature coefficients have been optimized to insure stable electrical characteristics over the temperature range of −55°C to +150°C. For example, TRW guarantees that the magnetic operate point of the OH360 will not drift by more than ±75 gauss over this temperature range. (Most optoelectronic devices are limited to an operating temperature range of −40° to +100°C.)

Other design aspects of the OH360 that enable it to meet TRW's demanding temperature stability objectives are two important circuit areas on the chip, the bandgap regulator and the threshold amplifier:

1. **Bandgap Voltage Regulator:**
   In addition to maintaining a constant output voltage level (no matter what changes occur in input voltge or output current), the TRW Hallogic™ bandgap voltage regulator also serves as an extremely good temperature-compensated voltage source to bias the Hall element. This bandgap voltage regulator enables Hallogic devices to operate with a supply voltage ranging from 4.5 to 24 volts DC, with virtually no drift in magnetic sensitivity (i.e., in the magnetic trigger point).
2. **Threshold Amplifier:**
   The amplifier/detector circuit is a constant-gain type, designed with temperature-compensated trip points at the input to the voltage comparator. The Schmitt trigger output then drives an open-collector transistor with a 50 mA current sinking capability. This open-collector transistor enables the device output to drive up to ten TTL loads directly.

The result of these design features is that the TRW Hallogic™ Hall Effect Sensor is the most temperature-stable Hall effect sensing device available.

Low Power Compensation

Yet another advantage of the OH360 is its low power consumption, which results from no bias current being required by the permanent magnet. The sensor itself draws only 6 mA (typical) of supply current (I_{CC}).

Package Design

TRW uses a very high density plastic to encapsulate the OH360 lead frame and chip. Both the density and the injection molding process result in a dirt and moisture barrier effective enough to pass Military Standard 883. The OH360 easily passes "pressure cooker" and similar moisture and temperature testing procedures to insure a reliable product.

In addition, the lead frame is designed with superior thermal characteristics for maximum reliability at the ten TTL load capability of the device.

The dimensional outline of the package and the precise placement of the Hall element are standard. This design allows for the superior, temperature-compensated TRW device to be specified for instant replacement. A significant upgrade in performance can be achieved without costly redesign and retooling.

Because the Hallogic™ Hall Effect Sensor is smaller than conventional emitter-detector pairs, it will more easily fit into areas with small size constraints.

The OH360 is made by automated production methods. Chip placement, bonding, encapsulation and testing processes are all completed with the precision afforded by the latest, state-of-the-art automated semiconductor manufacturing equipment.

Designed for the Toughest Environments

The result is that the Hallogic™ Hall Effect Sensor is virtually immune to environmental contaminants. It is rugged and suitable for use under severe service conditions. Even in the toughest environment, the Hallogic™ sensor will exhibit excellent magnetic sensitivity to provide reliable, repetitive operations in close tolerance applications. These devices are excellent choices for DC motors, automotive applications, robotic and heavy machinery sensing applications, or for any application in a harsh environment where optoelectronic devices are unsuitable.

TRW Hall Effect Research Center

TRW's Optoelectronics Division, through its Hall Effect Research Center, is continuing to develop products to "leapfrog" over the current available technology. Two particular areas under current investigation are:

1. **Linear Hall Effect Devices:**
   Almost ready for production, these devices will offer the key to low cost, precision current sensing in applications ranging from those for the local power company to home stereo power meters.
2. **Differential Magnetic Comparator (DMC):**
   Slated to enter production in the near future, this ultra sensitive device is designed to sense precise changes in magnetic field strength. It will make possible such industrial and automotive applications as remote gear tooth sensing. (The moving gear tooth would alter the magnetic flux sufficiently to trigger the device. A secondary magnet and sensor assembly would be necessary for this application.)

Complete custom capability and design assistance is available from the TRW Hall Effect Research Center. The Center offers electrical, mechanical and magnetic design, circuit simulation and packaging prototypes. TRW engineers are available to assist in the development of complete Hallogic™ assemblies to be manufactured by TRW to meet the customer's specific applications.

Figure 1. Basic Hall Element

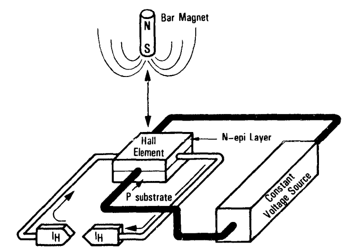
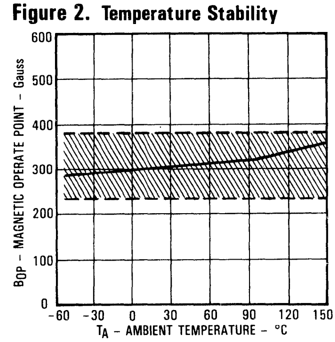


Figure 2. Temperature Stability



Typical Applications

- Appliances
- Automotive OEM
- Automotive aftermarket
- Business machines
- Communications
- Computers/peripherals
- Controls
- Entertainment products
- Industrial and commercial switches
- Instrumentation
- Machinery
- Machine tools
- Military systems and equipment
- Power supplies
- Test equipment

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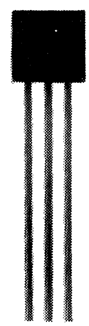
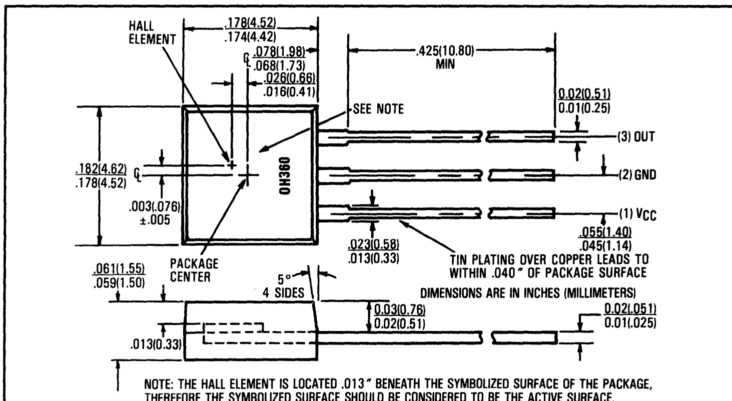
Optoelectronics Division
TRW Electronic Components Group

Product Bulletin 5515
January 1985

Hallogic™ Hall Effect Sensors
Type OH360





Features
- Operates over a broad range of supply voltages
- Excellent temperature stability to operate in harsh environments
- Drive capability up to 10 TTL loads
- Hall element, linear amplifier, and Schmitt trigger on a single Hallogic™ silicon chip

Description
The OH360 contains a monolithic integrated circuit which incorporates a Hall element, a linear amplifier, a threshold amplifier, and a Schmitt trigger on a single silicon chip. Included on-chip is a bandgap voltage regulator to allow operation with a wide range of supply voltages. The device features logic level output and provides up to 30 mA of sink current. This allows direct driving of more than 10 TTL loads, or any standard logic family using power supplies ranging from 4.5 to 24 volts. Output amplitude is constant at switching frequencies from DC to over 200 KHz.

The OH360 is a high performance device capable of operation from −55°C to 150°C. Stability of the magnetic operate and release points is ±75 gauss over this entire temperature range.

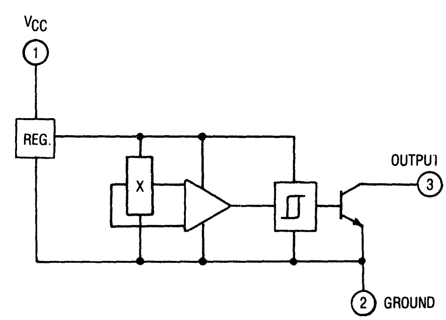
Package size has been kept to a minimum, providing an advantage in applications where space is limited.

Absolute Maximum Ratings (T_A = 25°C unless otherwise noted)

Supply Voltage, V_{CC}	25 V
Storage Temperature Range, T_S	−65°C to +160°C
Operating Temperature Range, T_A	−55°C to +150°C
Temperature Variance in B_{OP} and B_{RP} (−55°C to 150°C)	±75 G
Lead Soldering Temperature (1/8 inch [3.2 mm] from case for 5 sec. with soldering iron)[1]	260°C
Output ON Current, I_{SINK}	50 mA
Output OFF Voltage, V_{OUT}	25 V
Magnetic Flux Density, B	Unlimited

Note:
1. Heat sink leads during hand soldering.

Functional Block Diagram



FUNCTIONAL BLOCK DIAGRAM

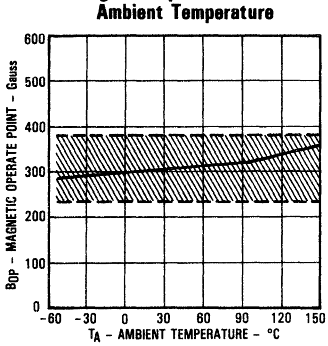
Type OH360

Electrical Characteristics ($T_A = 25°C$ unless otherwise noted)

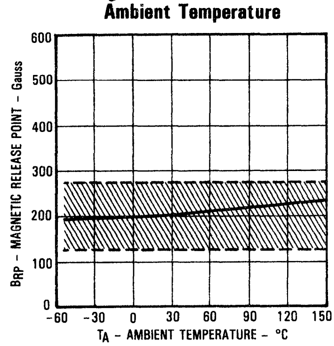
Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
B_{OP}	Magnetic Operate Point (see Rise and Fall Time Tests)	235	360	465	Gauss	$V_{CC} = 14.0$ V
B_{RP}	Magnetic Release Point (see Rise and Fall Time Tests)	120	230	325	Gauss	$V_{CC} = 14.0$ V
B_H	Magnetic Hysteresis	50	130	200	Gauss	$V_{CC} = 14.0$ V
I_{CC}	Supply Current	—	6.0	9.0	mA	$V_{CC} = 24$ V, OUTPUT ON
V_{OL}	Output Saturation Voltage	—	100	300	mV	$V_{CC} = 4.5$ V, $I_{OL} = 30$ mA
I_{OH}	Output Leakage Current	—	0.5	10.0	nA	$V_{CC} = 24$ V, $V_{OUT} = 24$ V
t_r	Output Rise Time	—	0.3	1.00	μS	$R_L = 460\Omega$, $C_L = 20$ pF, $V_{CC} = 14.0$ V
t_f	Output Fall Time	—	0.3	1.00	μS	$R_L = 460\Omega$, $C_L = 20$ pF, $V_{CC} = 14.0$ V

Typical Performance Curves

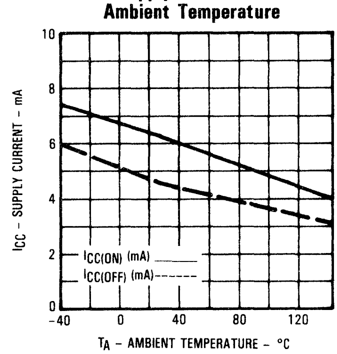
Magnetic Operate Point vs Ambient Temperature



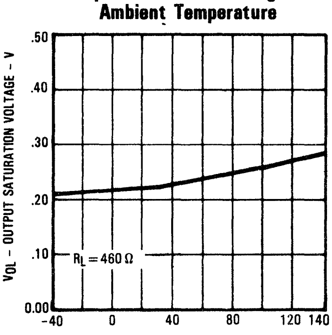
Magnetic Release Point vs Ambient Temperature



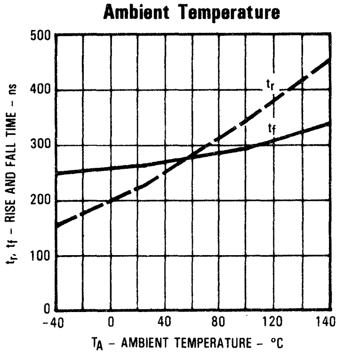
Supply Current vs Ambient Temperature



Output Saturation Voltage vs Ambient Temperature

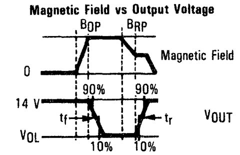


Rise and Fall Time vs Ambient Temperature

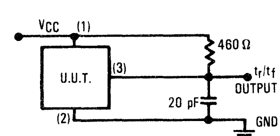


Rise and Fall Time Tests

Magnetic Field vs Output Voltage



Rise and Fall Time Test Circuit



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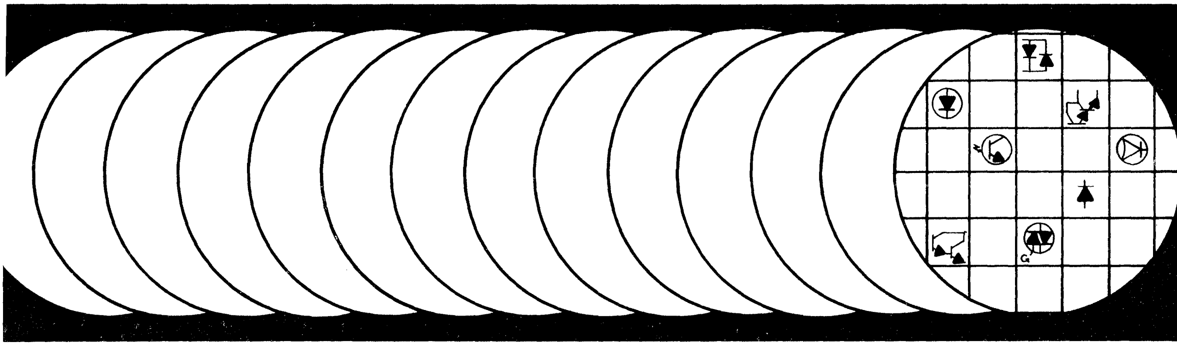
TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958



Application Bulletins

Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958

Optoelectronics Division
TRW Electronic Components Group

Application Bulletin 105
January 1985

Thermal behavior of GaAs LEDs

Table of Contents

Introduction

The output power (P_O) of a GaAs LED is a function of forward current (I_F). As this forward current increases, the output power will also increase. This forward current flowing through the LED generates heat (P_D) which causes the junction temperature (θ_j) of the diode to increase. As the junction temperature increases, the output power decreases.

To obtain optimum operating conditions for a GaAs LED, the knowledge of the different thermal parameters and their influence on the major electro-optical parameters must be known. The purpose of this bulletin is to introduce these thermal parameters to the reader and provide a way to use them. Data will be presented and formulae will be given that will allow readers to determine if their system meets manufacturer's guidelines in both a DC mode and a pulsed mode.

Mathematical assumptions have been made to simplify derivations and provide useful formulae in simple terms; empirical data has verified that the resulting error is less than 5%.

Care should be taken in making use of the information presented. For example:

> A current pulse could be short enough to cause no apparent problem within the presented material. However, it could be of sufficient magnitude and duration to exceed the allowable current density of the bond wire interconnect causing it to fail.

Thermal Parameters

The thermal behavior of a GaAs LED can be considered in a simple way by using the analogy of an electrical circuit. In this circuit, the heat power generator, the temperature differences, the thermal capacitors, and thermal resistors replace the conventional current or voltage generators, voltage differences, capacitors, and resistors respectively. Figure 1 shows this equivalent thermal circuit.

Figure 1—Equivalent Thermal Circuit

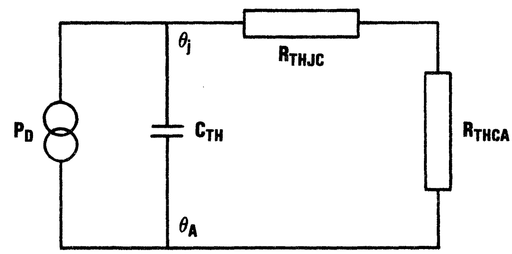


Table 1 defines the various thermal parameters we will be exploring in this bulletin.

Table 1

Table 1
Thermal Parameters

Symbol	Parameter	Units
P_O	Output Power	W
P_D	Dissipated power	W
θ_j	Junction Temperature	°C
θ_A	Ambient Temperature	°C
C_{TH}	Thermal Capacitor	Ws °C^{-1}
R_{THJC}	Junction to Case Thermal Resistance	°CW^{-1}
R_{THCA}	Case to Ambient Air Thermal Resistance	°CW^{-1}
R_{THJA}	Junction to Ambient Air Thermal Resistance	°CW^{-1}
τ_{TH}	Thermal Time Constant ($R_{THJA} \times C_{TH}$)	s
K	Thermal Rating Factor	None
K_{eff}	Effective Duty cycle	None

When forward current (I_F) flows through the GaAs LED, heat or power (P_D) is generated. Most of this heat is generated within:

(a) The upper section of the chip away from the mount area; the "N" area; the cathode.
(b) The mid section of the chip; the junction between the "N" and "P" regions.
(c) The lower section of the chip, the "P" area, the anode.

Heat is also generated in the contact interfaces and the conductors but this is considered negligible. This heat propagates through the chip and the mount surface primarily by thermal conduction. It is then transferred to the ambient air by thermal convection. All of the measurements and data presented in this bulletin were made with the air temperature in the room fairly constant throughout the test period and zero air velocity in the volume surrounding the device except for convection currents. Further, there were no extraneous thermal paths. Normal mounting of the devices in PC boards or adding heat sinks will improve the heat path. This is not considered in this bulletin with the exception of the last four (4) line items in Table 2. R_{THJA} should be considered as R_{THJX} in these cases. Table 2 lists several thermal parameters.

Table 2 – Thermal Parameters of TRW GaAs LEDs

GaAs LED Type	R_{THJA} (°CW^{-1})	C_{TH} (10^{-5}Ws°C^{-1})	τ_{TH} (10^{-2}s)	K
OP123/124, OP223/224	980	1.6	1.5	0.008
OP131-133(W), OP231-233(W)	490	3.0	1.5	0.008
1N6264/5	490	3.0	1.5	0.008
OP140/240	740	4.3	2.0	0.008
OP160/260	740	5.3	3.9	0.008
OP168	840	5.3	3.9	0.008
OP290/295 C, B, A	188	1.4	0.3	0.008
OP291/296 C, B, A	188	1.4	0.3	0.008
OP292/297 C, B, A	188	1.4	0.3	0.008
OP293/298 C, B, A	188	1.4	0.3	0.008
"P" Dip LED	750	2.3	1.7	0.008
OPB706 (LED)	700	5.2	3.6	0.008
OP123/124, OP223/224(1)	240	4.6	1.1	0.008
OP123/124, OP223/224(2)	400	4.5	1.8	0.008
"P" Dip (LED)(3)	450	3.8	1.7	0.008
"P" Dip (LED)(4)	500	3.4	1.7	0.008

(1) OP123/124 mounted on 0.062" double-sided PC board.
(2) OP123/124 mounted in OPB125/253 housing.
(3) "P" Dip soldered in 0.062" double-sided PC board.
(4) "P" Dip mounted in standard Dip socket.

The first four (OP123 through OP136) GaAs LED's are all hermetic packages. The maximum allowable junction temperature is 125°C. See the example below for one use of Table 2.

(1) OP123/124 has $R_{THJA} = 980°CW^{-1}$

With $\Delta T_j = (125°C - 25°C) = 100°C$.

The maximum power that can be dissipated is:

$$P_{D(max)} = \frac{\Delta T_j}{R_{THJA}} = \frac{100°C}{980°CW^{-1}} = 102 \text{ mW}$$

The next three of the units listed are plastic packages. The maximum allowable junction temperature is 85°C.

OP140 has $R_{THJA} = 740°CW^{-1}$

With $\Delta T_j = (85°C - 25°C) = 60°C$

The maximum power that can be dissipated is:

$$P_{D(max)} = \frac{\Delta T_j}{R_{THJA}} = \frac{60°C}{740°CW^{-1}} = 81 \text{ mW}$$

The derating factor above 25°C can be readily calculated from this information.

(2) OP123/124

$$\text{Derating Factor} = \frac{\Delta P_D}{\Delta T_j} = \frac{102 \text{ mW}}{100°C} = 1.02 \text{ mW°C}^{-1}$$

OP140

$$\text{Derating Factor} = \frac{81 \text{ mW}}{60°C} = 1.35 \text{ mW°C}^{-1}$$

Most manufacturers will give more conservative deratings than these numbers. This is normally due to the devices being used in a quasi heat sink. For example, the OP123/124 is normally mounted in a double sided PC board. The OP140 is normally soldered into a PC board. This would improve the R_{THJA} numbers. This becomes readily apparent by referring to the R_{THJA} number of $980°CW^{-1}$ for the OP123/124 in free air and the R_{THJX} number of $240°CW^{-1}$ when the units are mounted in a double sided PC board as shown in Table 2 or the $400°CW^{-1}$ when they are mounted in the OPB125 or OPB253 housing. There is also a variation in R_{THJA} brought about by a variation in the integrity of the thermal bond between the GaAs LED and the mount surface. This is not easy to measure and is not adaptable to 100% production testing.

Temperature Response to a Thermal Power Step

A forward current step is introduced into a GaAs LED causing heat to be generated in the unit and causing the junction temperature to rise. The rise in junction temperature follows the formula shown below:

$$(3) \quad \theta_j(t) = \theta_A + P_D \times R_{THJA}\left(1 - e^{-\frac{t}{\tau_{TH}}}\right)$$

Where t is time in seconds
P_D is dissipated power
τ_{TH} is thermal time constant
R_{THJA} is junction to ambient air thermal resistance
θ_A is ambient temperature.

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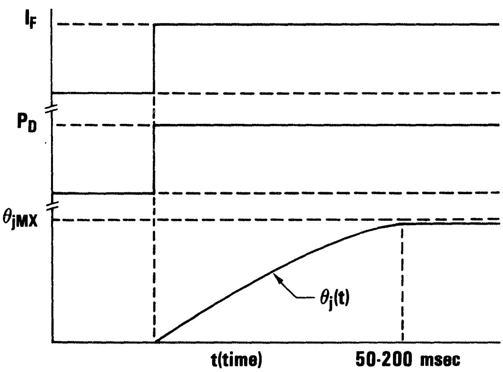
The junction temperature will approach its maximum value after $t = 5\ \tau_{TH}$ or 5 thermal time constants which approximates 50 to 200 milliseconds. Figure 2 shows the forward current step, the resulting power generated within the chip itself, and the rise in junction temperature versus time.

Figure 2—I_F, P_D, and Junction Temperature Versus Time



Practically, P_O will decrease slightly as soon as the junction temperature of the chip starts to rise and will stabilize 50 to 200 milliseconds after the power is applied. This is discussed in more detail in the section on power droop.

At temperature equilibrium, the maximum junction temperature (θ_{jMX}) is:

(4) $\theta_{jMX} = \theta_A + P_D^* \times R_{THJA}$

Where $P_D^* = V_F \times I_F$
V_F = Forward Voltage @ θ_{jMX}
θ_A = Ambient Temperature.
*For purpose of calculation, P_D = P @ 25°C. The resulting error will have minor impact on the answer. Since V_F decreases with increasing temperature, the resulting answers will be conservative.

Example: Using an OP133 which has a measured output of 5.3 mW @ θ_A = 25°C, calculated the output in a system where I_F = 40 mA and θ_A = 50°C. The I_F versus P_O without heating is relatively linear above 5 mA.

$$P_O\ (40\ \text{mA @ } 25°\text{C}) = P_O\ (100\ \text{mA}) \times 40/100 = 5.3\ \text{mW} \times 0.4 = 2.12\ \text{mW}$$

The power generated within the LED causing the junction temperature to rise is:

$$P_D = V_F \times I_F = 1.5\ \text{volts} \times 0.04\text{A} = 0.06\ \text{watts}$$

The final junction temperature is:

$$\theta_j = \theta_A + P_D R_{THJA} = 50°\text{C} + (0.06 \times 490) = 79.4°\text{C}$$

The output power of the OP133 is:

(5) $P_O(\theta_j) = P_O(25°C) \times e^{-K(\theta_j - 25°C)}$

$$P_O(79.4°\text{C}) = 2.12 \times e^{-0.008(79.4 - 25)} = 1.38\ \text{mW}$$

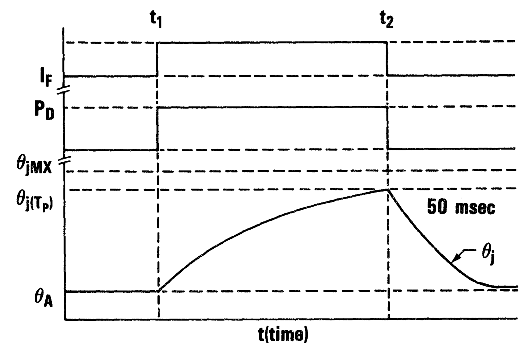
This constitutes a 35% decrease in output power from the 25°C level. The value of K was taken from Table 2.

Temperature Response to a Thermal Power Pulse

A forward current pulse is introduced into a GaAs LED. This pulse is shorter than the 50 to 200 milliseconds required for the junction temperature to approach its highest value.

Figure 3 shows the relationship of the current pulse to the power pulse to the junction temperature versus time.

Figure 3—Current Pulse, Power Pulse, and $\theta_{j(T_P)}$ Versus Time



When I_F begins to flow, the power generated within the LED causes $\theta_{j(t)}$ to follow the relationship:

(6) $$\theta_{j(t)} = \theta_A + P_D R_{THJA} \left(1 - e^{-\frac{t}{\tau_{TH}}}\right) \qquad t_1 \leq t \leq t_2$$

When I_F stops @ time t_2, the P_D will stop and the junction temperature θ_j will start to decrease. This will follow the relationship:

(7) $$\theta_{j(t)} = \theta_A + \left[P_D R_{THJA} \left(1 - e^{-\frac{T_P}{\tau_{TH}}}\right)\right]\left(e^{-\frac{t}{\tau_{TH}}}\right) \qquad t > t_2$$

Example: A single 1A pulse 100 μsec wide is applied to an OP136. What will the junction temperature be at the end of the 100 μsec pulse?

$$\theta_{jMX}(100\ \mu sec) = \theta_A + P_D R_{THJA}\left(1 - e^{-\frac{t}{\tau_{TH}}}\right)$$

$$\theta_{jMX}(100\ \mu sec) = 25°C + (2V \times 1A) \times 470\left(1 - e^{-\frac{10^{-4}}{2 \times 10^{-2}}}\right)$$

$$= 25°C + 4.6°C = 29.6°C$$

Same as above except t = 1 msec

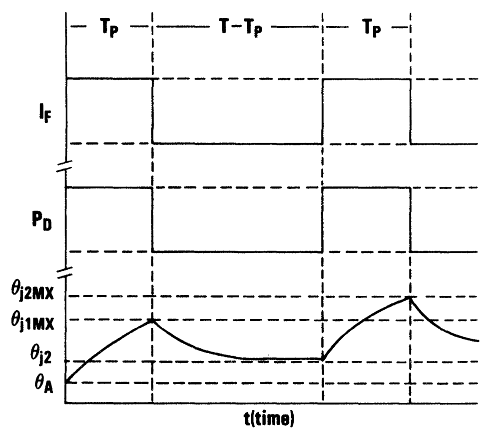
$$\theta_{jMX}(1\ msec) = 25°C + 2 \times 470\left(1 - e^{-\frac{10^{-3}}{2 \times 10^{-2}}}\right)$$

$$= 25°C + 45.5°C = 70.5°C$$

Temperature Response to Recurrent Thermal Pulses

A forward current pulse is introduced into a GaAs LED. At some later time, the pulse is repeated. Figure 4 shows the relationship of I_F to P_D to θ_j.

Figure 4—I_F, P_D, and θ_j Versus Time



The junction temperature θ_j rises during the first power pulse from θ_A to θ_{j1MX}.

Refer to Equation (3).

$$\theta_{j1MX} = \theta_A + P_D R_{THJA}\left(1 - e^{-\frac{T_P}{\tau_{TH}}}\right)$$

The junction temperature θ_j decreases during the off time of the power pulse from θ_{j1MX} to θ_{j2}.

Refer to Equation (7).

$$\theta_{j2} = \theta_A + \left[P_D R_{THJA}\left(1 - e^{-\frac{T_P}{\tau_{TH}}}\right)\right]\left(e^{-\frac{(T - T_P)}{\tau_{TH}}}\right)$$

During the second pulse, the junction temperature will rise from θ_{j2} to θ_{j2MX}.

Refer to Equation (3), (6).

$$\theta_{j2MX} = \theta_{j2} + P_D R_{THJA}\left(1 - e^{-\frac{T_P}{\tau_{TH}}}\right)$$

After the second pulse is removed, the junction temperature will decrease to a new minimum temperature θ_{j3}.

Refer to Equation (7).

$$\theta_{j3} = \left[\theta_{j2} + P_D R_{THJA}\left(1 - e^{-\frac{T_P}{\tau_{TH}}}\right)\right]\left(e^{-\frac{(T - T_P)}{\tau_{TH}}}\right)$$

This swinging movement of θ_j goes on and on with $\theta_{jMX(n)}$ and $\theta_{j(n)}$ gradually rising to a stabilized value. At the end of the n^{th} pulse, the junction temperature is $\theta_{jn}MX$.

$$(8)\quad \theta_{jnMX} = \theta_A + \left[P_D R_{THJA}\left(1 - e^{-\frac{T_P}{\tau_{TH}}}\right)\right] \times \left[\sum_{i=0}^{i=n-1}\left(e^{-\frac{(T - T_P)}{\tau_{TH}}}\right)\right]$$

When the temperature stabilization point is finally reached, the θ_{jMX} becomes:

$$(9)\quad \theta_{jMX} = \theta_A + P_D R_{THJA}\left(\frac{1 - e^{-\frac{T_P}{\tau_{TH}}}}{1 - e^{-\frac{T_P}{\tau_{TH}\left(\frac{n}{1-n}\right)}}}\right)$$

Where $n = \frac{T_P}{T}$ or duty cycle

For small values of (n), the equation simplifies to:

$$(10)\quad \theta_{jMX} = \theta_A + P_D R_{THJA} K_{eff}$$

Where $K_{eff} = \dfrac{1 - e^{-\frac{T_P}{\tau_{TH}}}}{1 - e^{-\frac{T_P}{n\tau_{TH}}}}$ = effective duty cycle

The minimum junction temperature becomes:

$$(11)\quad \theta_{jMIN} = \theta_A + P_D R_{THJA} K_{eff}\left(e^{-\frac{T_P}{n\tau_{TH}}}\right)$$

The delta temperature or the difference between θ_{jMX} and θ_{jMIN} becomes:

$$(12)\quad \Delta\theta_j = \theta_{jMX} - \theta_{jMIN}$$

$$\Delta\theta_j = P_D R_{THJA} K_{eff}\left(1 - e^{-\frac{T_P}{n\tau_{TH}}}\right)$$

$$= P_D R_{THJA}\left(1 - e^{-\frac{T_P}{\tau_{TH}}}\right)$$

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Example: An OP136 is operated at $I_F = 1A$, $n = 1\%$, $T_P = 100$ μsec. What is θ_{jMX}? θ_{jMIN}? $\Delta\theta_j$?

$$\text{OP136 } R_{THJA} = 470°CW^{-1}$$

$$P_D = 1A \times 2V = 2W$$

$$K_{eff} = \frac{1 - e^{-\frac{10^{-4}}{2 \times 10^{-2}}}}{1 - e^{-\frac{10^{-4}}{2 \times 10^{-4}}}} = 1.26 \times 10^{-2}$$

Refer to Equation (10).

$$\theta_{jMX} = 25°C + (2 \times 470 \times 1.26 \times 10^{-2}) = 36.7°C$$

Refer to Equation (11).

$$\theta_{jMIN} = 25°C + (2 \times 470 \times 1.26 \times 10^{-2}) \left(e^{-\frac{10^{-4}}{2 \times 10^{-4}}}\right)$$
$$= 32.1°C$$

Refer to Equation (12).

$$\Delta\theta_j = 36.7° - 32.1 = 4.6°C$$

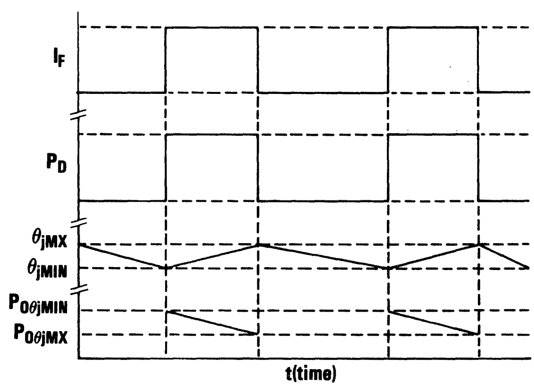
Verifying, refer to Equation (12).

$$\Delta\theta_j = 2 \times 470 \left(1 - e^{-\frac{10^{-4}}{2 \times 10^{-2}}}\right)$$
$$= 4.6°C$$

Power Droop

The junction temperature of an LED will oscillate between θ_{jMX} and θ_{jMIN} under recurrent pulses after the pulses have been on for a period of time. The radiant power output (P_0) will decrease during the "ON" time as the junction temperature rises from θ_{jMIN} to θ_{jMX}. This is shown in Figure 5 and is called power droop.

Figure 5– I_F, P_D, and θ_j, and P_0 Versus Time



This decrease in power out or power droop during the "ON" cycle is dependent on θ_{jMX} and θ_{jMIN}. Most systems desire this droop to be kept below 5-10% in order to limit the influence on system operation. The major factors that control this are the forward current (I_F), forward voltage drop (V_F), pulse duration (T_P), duty cycle (n), and thermal resistance (R_{THJA}).

$$P_0(\theta_{jMIN}) = P_0(25°C) \times e^{-K(\theta_{jMIN} - 25°C)}$$

$$P_0(\theta_{jMX}) = P_0(25°C) \times e^{-K(\theta_{jMX} - 25°C)}$$

By definition, the power droop is:

$$P_{Droop} = \frac{P_0(\theta_{jMIN}) - P_0(\theta_{jMX})}{P_0(\theta_{jMIN})}$$

$$(13) \quad P_{Droop} = 1 - e^{-K(\theta_{jMX} - \theta_{jMIN})}$$

Example: An OP136 is being operated at $I_F = 1A$ and $n = 1\%$. What is the maximum pulse width for a droop of 5%?

$$P_{Droop} = 1 - e^{-K(\theta_{jMX} - \theta_{jMIN})}$$

$$0.05 = 1 - e^{-0.008(\theta_{jMX} - \theta_{jMIN})}$$

$$\theta_{jMX} - \theta_{jMIN} = 6.41°C$$

Refer to Equation (12) for $\Delta\theta_j$.

$$\Delta\theta_j = P_D R_{THJA} \left(1 - e^{-\frac{T_P}{\tau_{TH}}}\right)$$

$$6.41 = 2 \times 470 \left(1 - e^{-\frac{T_P}{2 \times 10^{-2}}}\right)$$

$$T_P = 138 \ \mu sec$$

Example: What is the power droop if T_P is changed to 100 μsec?

$$\Delta\theta_j = P_D R_{THJA} \left(1 - e^{-\frac{T_P}{\tau_{TH}}}\right)$$
$$= 2 \times 470 \left(1 - e^{-\frac{10^{-4}}{2 \times 10^{-2}}}\right)$$
$$= 4.6°C$$

$$P_{Droop} = 1 - e^{-0.008(4.6°C)}$$
$$= 3.6\%$$

Example: What is the power droop on the OP133 under the same conditions as the OP136?

$$I_F = 1A, \ n = 1\%, \ T_P = 100 \ \mu sec$$

$$\Delta\theta_j = P_D R_{THJA} \left(1 - e^{-\frac{T_P}{\tau_{TH}}}\right)$$
$$= (1A \times 2.5 \ V) \times 490 \left(1 - e^{-\frac{10^{-4}}{1.5 \times 10^{-2}}}\right)$$
$$= 8.07$$

$$P_{Droop} = 1 - e^{-0.008(8.07)}$$

$$P_{Droop} = 0.0625 = 6.25\%$$

TRW

Example: What is the maximum power that can be dissipated in the OPB950 when T_P is 20 μsec, duty cycle is 1%, and droop is restricted to 5% maximum?

$$P_{Droop} = 1 - e^{-K(\theta_{jMX} - \theta_{jMIN})}$$

$$0.05 = 1 - e^{-0.008(\theta_{jMX} - \theta_{jMIN})}$$

$$(\theta_{jMX} - \theta_{jMIN}) = 6.41°C$$

$$\Delta\theta_j = P_D R_{THJA}\left(1 - e^{-\frac{T_P}{\tau_{TH}}}\right)$$

$$6.41 = P_D \times 250\left(1 - e^{-\frac{20 \times 10^{-6}}{3.24 \times 10^{-3}}}\right)$$

$$P_D = 4.23$$

With a V_F of approximately 2.5 volts, the maximum I_F under the above conditions would be 1.7 amps.

Conclusion

The data presented will allow calculations that effect various power levels, pulse widths, and duty cycles on TRW GaAs LEDs. All standard products are covered. The pertinent thermal formulae are included as a separate section for easy reference. These formulae coupled with the information given in Table 2 will allow designers to optimize their design utilizing TRW LEDs in the pulse mode.

Daniel Cognard

William Nunley
Applications Specialist

8. Thermal Formulae

1. Maximum Power Dissipation

$$P_{D(MAX)} = \frac{T_j}{R_{THJA}}$$

2. Derating Factor

$$\frac{\Delta P_D}{\Delta T_j}$$

3. Effective Duty Cycle
(Square current pulses)

$$K_{eff} = \frac{1 - e^{-\frac{T_P}{\tau_{TH}}}}{1 - e^{-\frac{T_P}{n\tau_{TH}}}}$$

4. Maximum Junction Temperature
(Repetitive Pulses)

$$\theta_{jMX} = \theta_A + P_D R_{THJA} K_{eff}$$

5. Minimum Junction Temperature
(Repetitive Pulses)

$$\theta_{jMIN} = \theta_A + P_D R_{THJA} K_{eff}\left(e^{-\frac{T_P}{n\tau_{TH}}}\right)$$

6. Junction Temperature Swing

$$\Delta\theta_j = P_D R_{THJA}\left(1 - e^{-\frac{T_P}{\tau_{TH}}}\right)$$

7. Power Droop

$$P_{Droop} = 1 - e^{-0.008(\Delta\theta_j)}$$

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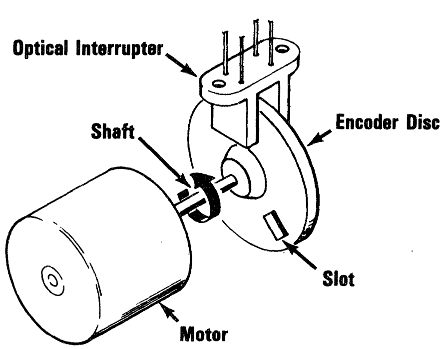
Motion sensing with optical interrupters—selecting the proper sensor for optimum system design.

This application bulletin will discuss many of the variables associated with single channel encoding. This will include design considerations for using both non-apertured and apertured transistors or Photologic™ output devices. Refer to application bulletins 112 and 116 for additional information.

General Discussion

The most common application of optoelectronics is the sensing of motion with an optical interrupter. The normal single channel optical interrupter module consists of an emitter or energy source and a receiver or energy sensor separated by a slot or air gap. The interruption of this beam causes an on/off signal from the sensor. When the energy path is blocked, the sensor will be "off" allowing only leakage current to flow. When the energy path is open, the sensor will be "on," causing significantly higher currents to flow. This is often accomplished by placing a rotating plate (or encoder disc) in the slot between the LED and energy sensor as shown in Figure 1.

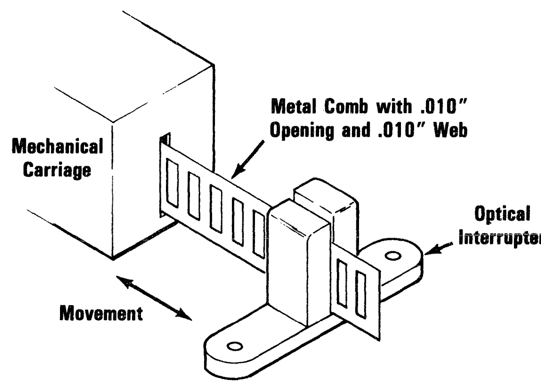
Figure 1 – Tachometer or Motor Speed Monitor



There is usually an opening or slot in the encoder disc that allows the photosensor to be exposed to energy from the LED once each revolution. The energy through the slot will cause the sensor to turn "on" when the slot is present and turn "off" after the slot goes by. This energy pulse will relate the mechanical motion of the encoder disc to the electrical signal by giving one pulse per revolution. By counting these pulses for a given time interval, the speed of rotation may be determined. This gives rise to the "Tachometer" or motor speed monitor.

This encoder disc may be replaced with a fence or comb that passes through the same slot. The same logic presented for the encoder disc will hold true. One electrical pulse is formed for each opening in the fence or comb that passes the LED/sensor pair. Thus the linear motion of the fence or comb can be related to an electrical series of pulses. Figure 2 shows this mechanical system pictorially.

Figure 2 – Linear Encoder Relating Distance Versus Pulses

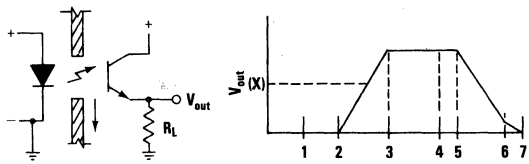


Analysis of the use of an optical interrupter module for a specific application requires several considerations to be analyzed. Most design engineers consider cost, functionality, and reliability as goals in their design. Most important, however, is total application performance. The part must be designed so that minimum support is required in a production type environment. This production environment begins with the fabrication of the basic design and continues through the design performance in subsequent sub-assemblies until the final product is complete. The design is considered successful if, once implementation is complete, the system runs so smoothly, the designer receives no negative feedback. This requires "luck" or a systematic approach to understanding and consideration of all major variables. This application bulletin will use a tachometer design as the mechanism to apply the philosophy of "the successful designer approach."

Non-apertured Encoding

Most tachometer applications require a digital signal which can be easily processed to determine the speed at which a mechanical motion is taking place. There are several variables that need to be discussed that control this digital signal. Figure 3 pictorially represents the general wave shape that will appear across the load resistor as the slot goes by the sensor.

Figure 3 – Pictorial Representation of Signal Pulse



POINTS		DESCRIPTION
Turn on delay time	1	Sensor starts to be uncovered
Gain + turn on time	2	Sensor starts to turn "on"
Slot Width	3	Sensor reaches maximum turn "on" or saturation
Turn off delay time	4	Sensor starts to be covered
Turn off time	5	Sensor starts to turn "off"
	6	Sensor is completely covered
	7	Sensor output of signal current decreases to leakage

As the slot starts to open up the energy path between the sensor and the LED, the sensor will start to turn "on." If the system has adequate gain, the sensor will saturate prior to the trailing edge of the slot reaching the leading edge of the sensor. The signal level will diminish as the slot goes by reducing the energy level to the sensor.

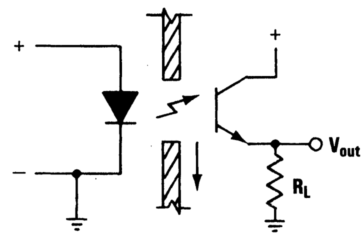
This time interval from 1 through 7 will remain fairly consistent for a given setup. As different units from various production runs are substituted, the main variations that will be viewed are:

a. Variations in slope between 2 and 3
b. Variations in slope between 5 and 7

As the system gain increases, the turn on time will decrease and the flat portion between 3 and 5 will get wider. In other words, 3 will move to the left and 5 will move to the right. The turn on delay will decrease slightly, moving 2 to the left. The point labeled 7 will move to the right showing the sensor turn off time has increased. This will cause the voltage reading at point 6 to increase. As the system gain decreases, the inverse will happen. Points 3, 4, and 5 will become one point and start to decrease. Points 1 and 6 never move. If the circuit is desired to turn on or off at level "X," the "X" will move as these slopes change.

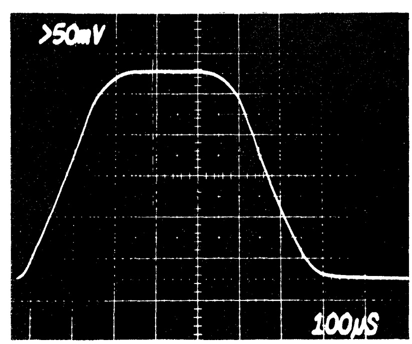
The OPB860T55 is a commercially available optical interrupter from TRW Optoelectronics Division. It has no built-in aperture. It will be used as an example for the discussion of the choice of a specified load resistor. Figure 4 shows a typical circuit where V_{out} will drive the input of a TTL gate such as the SN7414 Schmitt trigger.

Figure 4 – Optical Beam Interrupter

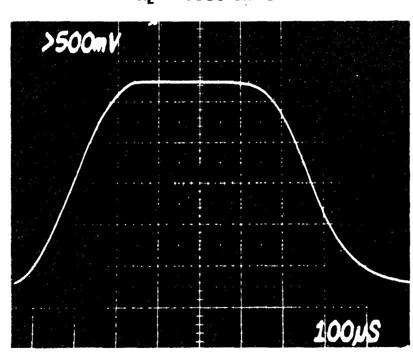


The choice of this load resistor is usually the first parameter the design engineer must consider. The end result is a TTL compatible analog voltage generated across this load resistor. The minimum allowed on-state current and the maximum allowed off-state current of the OPB860T55 become the first two restrictions on the choice of this load resistor. In order to be able to generate a reliable digital output, the system must guarantee the analog voltage will swing above and below the positive and negative going thresholds, respectively, of the TTL gate. Figure 5 shows the output of the OPB860T55 with the resistive load of 1000 ohms, and 10,000 ohms.

Figure 5 – OPB860T55 Output Versus R_L



R_L = 1000 ohms



R_L = 10,000 ohms

L

A study of these photographs will quickly show a positive and a negative aspect. As you increase the value of the load resistor, the analog voltage swing across it quickly increases. The standard product guarantees 500 microamperes of output with a 20-milliampere input. This corresponds to 500 millivolts across 1000 ohms and 5 volts across 10,000 ohms. The maximum turn on voltage required to trip the SN7414 is 2.0 volts. It also becomes apparent that as you increase the value of the load resistance, the rise and fall time is adversely affected. The rise time (10% to 90%) is 160 microseconds with the 1000-ohm load increasing to 180 microseconds with the 10,000-ohm load. The fall time (90% to 10%) is 170 microseconds with the 1000-ohm load increasing to 200 microseconds with the 10,000-ohm load. The frequency response is significantly decreased with increased load resistance. Keep in mind that the measured rise times and fall times are a combination of the electrical rise and fall time of the sensor as well as the mechanical rise and fall time of the system. The sensor gradually is exposed to the light as it is uncovered and the light is gradually removed as it is covered. This increase in load resistance may lead to a secondary problem.

As the magnitude of the load resistor is increased, greater care must be taken in the mechanical design to prevent off-state problems. This means guarding against spurious light signals that may create noise or unwanted signal levels adequate to give a signal pulse when none is there.

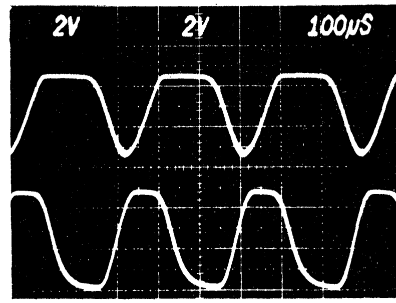
Two other options become potential problem solvers. Increasing the LED drive current will increase the output current. Care must be taken as increasing the drive current will also decrease reliability. The supplier may be asked to select units that will give a higher output. This will increase the cost in inverse proportion to the amount of units meeting the new requirements that lie within the production distribution.

Apertured Encoding

The OPB860 series are available with sensor apertures of .010″ and .050″. The OPB860T51 which has a .010″ × .040″ sensor aperture will be discussed. It offers a good alternative to the OPB860T55 when resolution becomes more critical. Figure 6 shows the comparison of the wave shapes across the 1000-ohm R_L of the OPB860T55 and OPB860T51.

The waveforms shown in Figure 6 are made with an apertured disc that had .025″ openings and .038″ opaque areas for its total periphery. This causes the OPB860T55 (top trace) not to go completely to ground potential which is the cross hatched "x" line on the scope faceplate. This is due to the "light bleed" around the .038″ opaque area causing the sensor to continue conduction. This would not be present in single pulses per revolution. Minimization of the "light bleeding" can be obtained by making the encoder disc (50% opaque-50% open) 25% larger than the width of the sensor aperture. The turn on and turn off times are about 60 microseconds for the OPB860T51 and 80 microseconds for the OPB860T55. This is due to the mechanical turn on and turn off

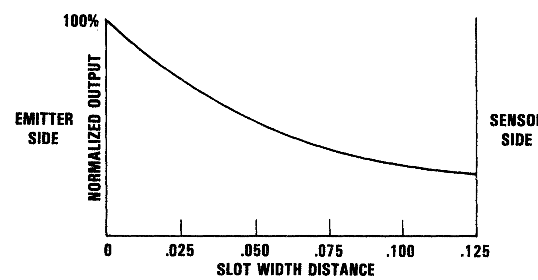
Figure 6 – OPB860T55 (upper) Versus OPB860T51 (lower)



times being limited to .010″ in the OPB860T51 while going as long as .060″ on the OPB860T55.

In addition, it is important to keep the encoder disc as close to the sensor as possible to further decrease "light bleeding." Note that the output level of the sensor in an individual unit will decrease as the encoder wheel moves laterally from the LED or emitter side toward the sensor side of the unit. This is shown in Figure 7.

Figure 7 – Normalized Sensor Output Versus Lateral Slot Opening



This is brought about because the energy from the LED is not collimated and does not have a point source radiation pattern. In addition to the encoder position relative to the sensor, the effect can be minimized by minimizing wobble of the encoder wheel within the interrupter slot. In more complex applications where much greater resolution is needed, i.e., the width of the LED and sensor apertures are decreased to the point that energy from the LED cannot be detected by the sensor, the use of a multi-slotted aperture called a reticle with a pattern identical to the encoder disk is used. (See Application Bulletin 116 for more information.) The effect is a shuttering of light. It allows more energy to be sensed by the sensor while maintaining high resolution.

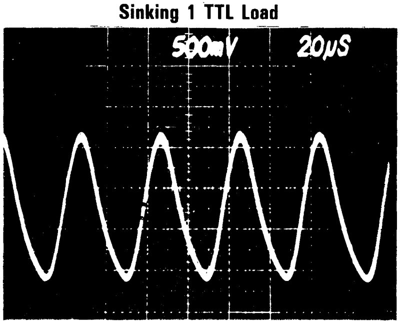
Another solution to the higher resolution requirements is to use Photologic™. This improves timing accuracy when it is not convenient to have amplification circuitry in close physical proximity to the optical interrupter module. This amplification guards against noise causing spurious signals which could upset system performance.

Apertured Function Encoding

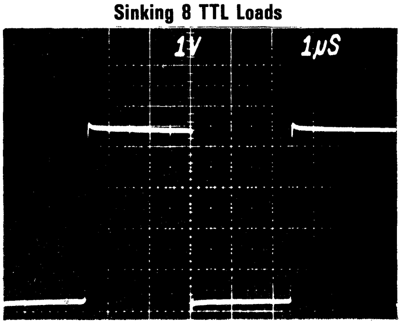
The solution to the problems presented before is a sensor function. The OPB960T51 is similar in appearance to the OPB860T51. It requires three leads for the sensor rather than two leads. The sensor function is a Photologic™ chip consisting of a photo sensitive element and a Schmitt trigger buffer integrated on a common chip. The housing contains a .010″ aperture in front of the Photologic™ sensor to allow for high resolution encoding. The frequency response of the OPB960T51 is improved over the OPB860T51 to 250 kHz with typical rise and fall times of 70 nanoseconds. The output is capable of driving 8 TTL loads over the temperature range of −40 °C to +70 °C. Figure 8 clearly shows the suitability of the OPB960T51 when compared to the OPB860T51.

Figure 8

OPB860T51 @ 25 kHz
Sinking 1 TTL Load



OPB960T51 @ 200 kHz
Sinking 8 TTL Loads



As long as the required frequency response is slow enough and the output is adequate, the OPB860T51 is the best choice from a system cost. This is further supported if unused logic gates exist for the designer to process the opto signal into a digital output. As the applications become more sophisticated and importance is shifted to improved performance and simplification of complex processing circuits, the OPB960T51 becomes the best choice for the designer. A major advantage to the designer is the guaranteed performance from −40 °C to +70 °C. The result is a much more reliable design in terms of degradation and system performance.

Conclusion

The OPB860T55 (non-apertured optical interrupter) will perform quite reliably in low speed, low resolution encoding. The OPB860 family offers an improvement in resolution. The narrow aperture offers superior resolution in linear encoders. The OPB960T51 and the new OPB10000 family (see 1985 Data Book) is the choice where higher output levels, speed, and precise resolution are required.

Refer to Application Bulletins 112 and 116 for additional information.

THOMAS W. SWARD
Product Manager

WILLIAM NUNLEY
Applications Specialist

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Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958

Optoelectronics Division
TRW Electronic Components Group

Application Bulletin 110
January 1985

Optically isolated triac drivers – the solution to home appliance control designs.

The OPI 3009, OPI 3010, and OPI 3011 series of optically coupled isolators use a GaAs infrared emitting diode input with a photosensitive silicon bilateral switch output that functions like a triac. These parts may be used as the interface between the electronic controls of a home appliance and the power triac used to control the load. An added advantage is obtained from this approach since the user of the appliance is isolated from the 115 VAC line by the optically coupled isolator. This appliance bulletin will discuss several variations of input and output circuitry necessary to perform this type of control.

GENERAL DISCUSSION

The OPI 3009 series requires a minimum of 10 to 30 mA of LED current (depending on the device specified) to latch the output into the "ON" condition. The control pulse to the LED must have adequate drive capability to supply this current. When the control or signal pulse is applied and the output is latched into the "ON" condition, the bilateral switch will sink up to 100 mA AC. This current would normally be used as control or gating current for a power triac or as drive current for any load requiring less than 100 mA. When the control or signal pulse current through the LED is removed and the bilateral switch output is in the "OFF" condition, the output current will drop below 100 nA at rated V_{DRM} at room temperature. Thus, the AC load is controlled by a signal pulse from the control electronics through the optically coupled isolator, and users giving inputs to the control electronics will be isolated from the line voltage by the coupler.

PERFORMANCE CHARACTERISTICS

The control pulse from the electronic controller may be used to control any number of loads. In a dishwasher, it might control:

Water Solenoid . . . . "ON" or "OFF"
Drain Pump . . . . "ON" or "OFF"
Circulating Fan . . . . "ON" or "OFF"
Heating Element* . . . . "ON" or "OFF"

*The heating element could also be controlled as a percentage ON/OFF by varying the control pulse width within a time period for different levels of heat. If one minute time periods were selected, the input control could pulse the heating element "ON" a maximum of 7200 times within this minute for 60 cycle AC, or any percentage of that time.

INPUT REQUIREMENTS

An electronic controller for the dishwasher functions would need a minimum of four control elements. If the microprocessor used as the controller were MOS with a sink capability of 0.5 mA or less, amplification of the control pulse would be required to actuate the coupler. A hex buffer or inverter could provide this amplification and control the four functions leaving two buffers or inverters unused.

Table 1 shows the components required. The schematic is shown in Figure 1. For supply voltage of 12 or 15 Volts, use one of the circuits shown in Figure 2.

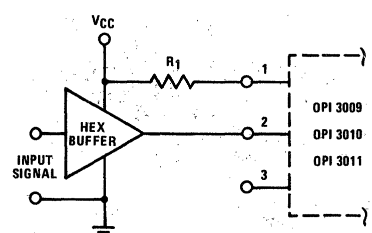
When the circuit has to operate below 25°C, the drive to the LED's must be increased. A 10% increase will allow operation to 0°C. The curve for this is shown on Product Bulletin No. 2076. The drive must also be increased to allow for operational life degradation. Increases of 30% on the OPI 3009, 15% on the OPI 3010, and 10% on the OPI 3011 should allow operation for 50,000 hours.

TABLE 1

V_{CC} Volts DC	R_1 (ohms) OPI 3009 30 mA	R_1 (ohms) OPI 3010 15 mA	R_1 (ohms) OPI 3011 10 mA	Hex Buffer
5	100	200	300	SN7416

FIGURE 1

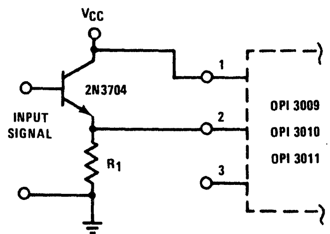
Typical Input Circuitry for Low Control Current Values
Signal Input Low – Isolator Output "ON"



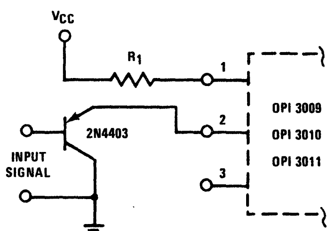
The optical coupler can be driven in this manner from any type of electronic controls which have output levels too low to drive the coupler directly. If the output current sink levels are adequate to drive the coupler directly, the designer can select the appropriate coupler.

The hex buffer may not be the most economical method for supplying the control current required by the optical coupler if the electronic controller is used to control only one or two functions. In this case, the circuits shown in Figure 2 may be more desirable. The first two have identical function performance to the circuit shown in Figure 1, while the third one is equivalent to replacing the buffer with an inverter. The gain of the transistors shown is adequate to drive any of the optical couplers with 0.5 mA of signal current. R_1 should be selected based on the supply voltage and the LED current required to operate the optical isolator. A base current limiting resistor may be used in circuit 3 if the drive levels exceed 0.5 mA.

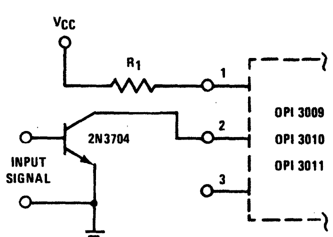
FIGURE 2
Input Circuitry for Small Number of Control Functions



CIRCUIT 1
(SIGNAL INPUT "LOW", ISOLATOR OUTPUT "ON")



CIRCUIT 2
(SIGNAL INPUT "LOW", ISOLATOR OUTPUT "ON")



CIRCUIT 3
(SIGNAL INPUT "LOW", ISOLATOR OUTPUT "OFF")

The input drivers shown in Figures 1 and 2 are adequate to cover the normal type of electronic controllers.

OUTPUT REQUIREMENTS

The output of the coupler will vary as a function of the input signal or control pulse and with the type of load. Figure 3 shows the principal voltage and current waveforms across the power triac or the bilateral switch when the load is resistive. The triac turns "ON" when the signal pulse is applied and the gate current exceeds the minimum triac gate current. If the gate or control signal is removed at time T_2, the device continues to conduct until the instantaneous current approaches zero. The device is now in the "OFF" state. Current will drop to the leakage value and the device supports the source voltage across its main terminals. Figure 4 shows a typical output circuit for a resistive load such as a heater element. The 180 ohm resistor is added to protect the photosensitive bilateral switch in the optical coupler from current surges.

FIGURE 3
Principal Voltage and Current Waveform with Resistive Load

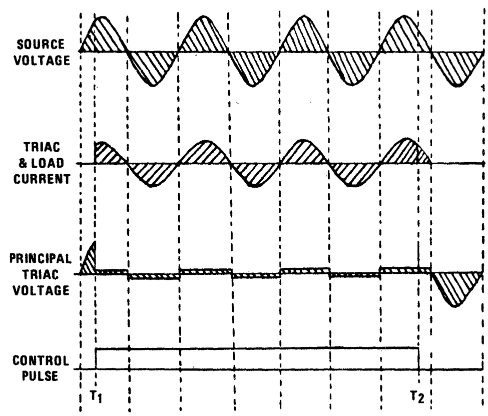
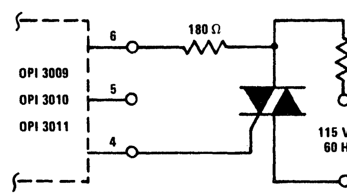


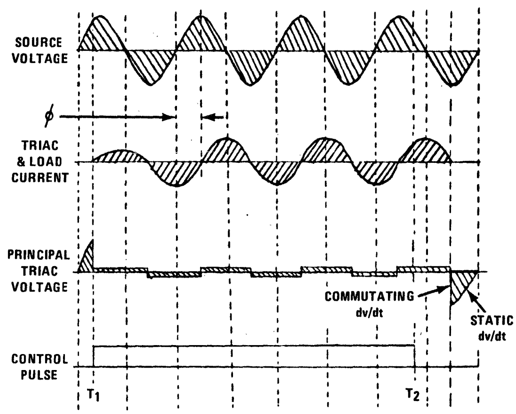
FIGURE 4
Output Driving Resistive Load



When the load is inductive (fan motor, water pump, solenoid), additional precautions must be taken. Figure 5 shows the power triac or the bilateral switch principal voltage and current waveforms with an inductive load. When the control pulse is turned "ON" the triac will turn "ON" after the minimum gate turn-on current is exceeded.

L

FIGURE 5
Principal Voltage and Current Waveform with an Inductive Load



In a circuit with an inductive load, the voltage leads the current by some phase angle ϕ as shown in Figure 5. When the gate or trigger current is removed at time T_2, the bilateral switch or the triac will continue to conduct until the current drops below the holding current level. The voltage drop across the inductive load will then be impressed across the main terminals of the device. The rate at which this voltage is impressed is primarily governed by the characteristics of the bilateral switch or triac and the characteristics of the inductive load. The rate of voltage change across the main terminals of the control device when the device cuts off is called "commutating" dv/dt. When the device is off and the sustaining line voltage is being blocked, the dv/dt drops to "static" dv/dt. The rate of change of either commutating or static dv/dt may be adequate to turn the devices on. The addition of a "snubber" network will reduce the rate of voltage rise seen by the control device by forming a parallel RC path. Figure 6 shows the output circuit with the snubber network (shown with darkened lines) placed across the main terminals of the power triac.

FIGURE 6
Application of "Snubber" Network for Inductive Loads

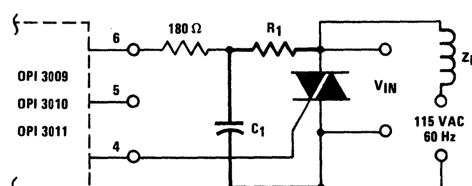


Table 2 shows the values of R_1 and C_1 for ranges of power triac gate current from 10 to 100 mA while maintaining the trigger voltage, V_{IN}, at ≈ 40 Volts.

TABLE 2
Value of R_1 and C_1 for Various Gate Current Ranges

I_{GT}(mA)	R_1 (Ω)	C_1 (μF)	V_{in} Trigger Voltage (V)
100	220	0.10	43
70	400	0.06	44
40	800	0.03	42
30	1200	0.02	44
15	2400	0.01	42
10	3600	0.006	45

1. The 180 ohm resistor is chosen to limit the surge current into the coupler. It is:

   $R = V_{peak}/I_{max} = 180/1.2A^* = 150\ \Omega$

   The 180 ohm resistor is the closest 10% standard value above 150 Ω to limit the C_1 discharge current to less than 1.2A.

2. The R_1C_1 time is obtained by:

   $dv/dt = V_{toff}/R_1C_1$ (Worst Case)

   Static dv/dt (T_j = 70°C) = 8.0 V/μs = 8×10^6 V/s (Worst Case)

   $$R_1C_1 = V_{toff}\ (dv/dt) = \frac{180}{8\times10^6} = 22.5 \times 10^{-6}$$

   If the gate is to be triggered at ≈ 40 Volts and requires 100 mA of I_{GT}, then:

   $(180 + R_1) = V_{IN}/I_{GT} = 40/.1 = 400\ \Omega$

   $R_1 = 220\ \Omega$

   $R_1C_1 = 22.5 \times 10^{-6}$ sec

   $C_1 = 22.5 \times 10^{-6} / 220 \approx 0.1\ \mu F$

   Solving more precisely for V_{IN}:

   V_{IN} = (100 mA x 180Ω) + (100 mA x 220Ω) + (V_{DROP} in coupler* or 3.0 V)

   $V_{IN} = 18 + 22 + 3 = 43$ Volts

   The triac will trigger at 43 Volts with 100 mA of gate current with R_1 = 220 Ω and C_1 = 0.1 μF and will sustain a worst case dv/dt of 8.0 V/μs.

*From Product Bulletin 2076

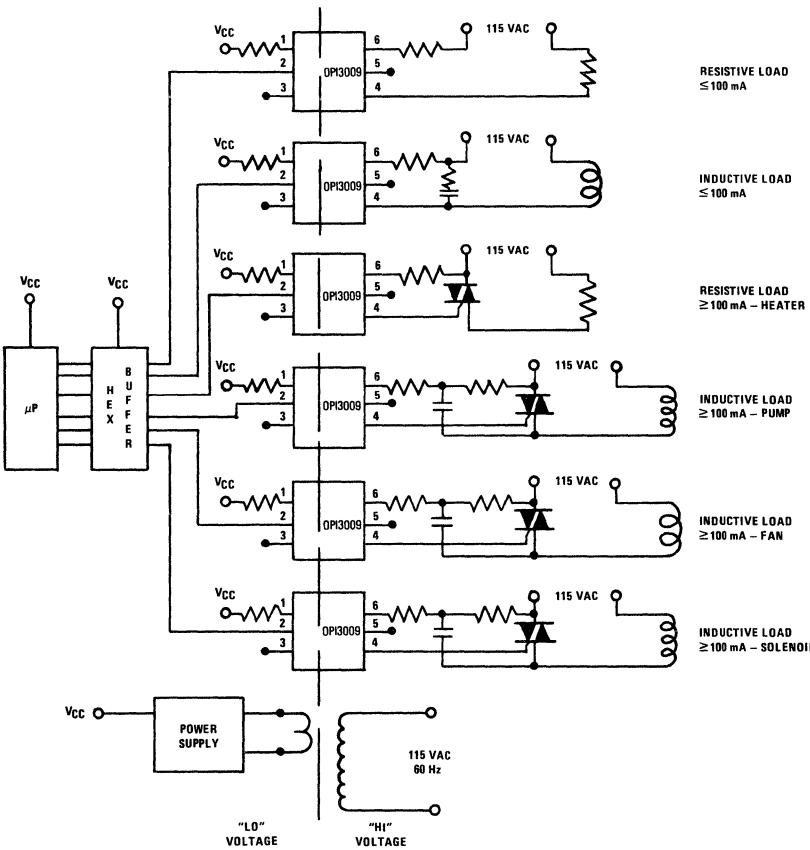
Figure 7 shows a typical layout of a system using a microprocessor driving a hex buffer, which in turn drives 6 opto couplers. The isolators are in turn driving:

1. A resistive load of ≤ 100 mA directly.
2. An inductive load of ≤ 100 mA directly.
3. A power triac with gate current ≥ 100 mA driving a heating element.
4. A power triac with gate current ≥ 100 mA driving a water pump.
5. A power triac with gate current ≥ 100 mA driving a fan motor.
6. A power triac with gate current ≥ 100 mA driving a solenoid.

The additional connection shows the transformer from the 115 VAC line which provides the DC power supply for the hex buffer, opto coupler inputs, and the microprocessor.

The dashed line shows the separation of high and low voltages.

FIGURE 7
Block Diagram Layout of System



CONCLUSION

The OPI3009 series offers a versatile combination of interfaces between electronic controls and the load in home appliances. The introduction of the OPI3020 family has expanded this series to allow interface in applications where 220 VAC replaces the 115 VAC line voltages. The introduction of the OPI3030 and OPI3040 family with zero voltage crossing further expanded the series by eliminating the need for a "snubber" circuit in applications where an inductive or capacitive load is driven.

GEORGE MAGOUN

BHARAT SHAH
Product Engineer

WILLIAM NUNLEY
Applications Specialist

Soldering to semiconductor leads – a supplement to manufacturer's specifications.

Normal lead soldering information furnished on semiconductor product data sheets is limited to the maximum temperature, the maximum time at this temperature and the minimum distance from the temperature to the case of the unit. This bulletin discusses some of the aspects of soldering using an iron, a pot, or a flow bath. This will involve discussions of both hermetic or metal packaged parts and plastic encapsulated parts.

GENERAL DISCUSSION

A variety of different methods are used to make a solder joint between a semiconductor product and the circuit to which it is wired. Care and expertise are required to minimize unit loss and maximize unit yield. A few technique improvements, and suggestions as to proper solder and flux selections are discussed. Familiarization with the points brought out in this bulletin will assist the user to minimize solder problems.

PERFORMANCE CHARACTERISTICS

A typical data sheet will have the following information in the absolute maximum ratings:

Lead Soldering Temperature . . . . 240°C
(1/16 inch from case for 3 seconds)

These conditions except for "time" are readily controlled in flow soldering and solder pot applications. It becomes difficult to control the maximum temperature in solder iron applications. The normal solder used is 60/40 lead tin which softens at 180°C and flows at 220°C. If the temperature of the iron or the time it is in contact with the solder lead interface is not controlled, the 240°C can be significantly exceeded. Several techniques or controls are helpful in preventing this overheating.

1. Limiting the maximum temperature of the iron by controlling the power to the iron. The slower the operator is, the cooler the iron should be.
2. Careful selection of proper solder, flux, iron, tip and surface preparation can minimize problems.
3. Verbal explanation, knowledgeable tutoring and assistance, and pictorial examples can also be helpful.
4. Proper design of the work station to minimize fatigue and encourage repeatable operator steps such that the solder operation is done in the same sequence by the same motions.
5. Once the technique is learned, it is very important to encourage speed. Normally, the higher the output, the higher the quality level once the basic technique has been mastered.
6. Design of the PC board land patterns with the unit and method of soldering of uppermost importance can be of significant help. The subsequent discussion on soldering of the pill package will illustrate this.

Table I lists the solder, flux, dwell times and distances recommended by TRW on their hermetic and plastic encapsulated components.

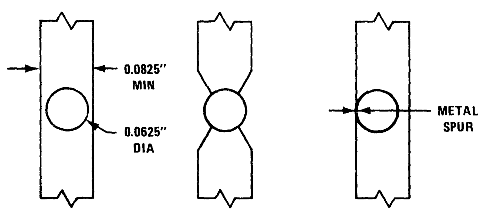
TABLE I – Soldering Components Listing

PACKAGE	TYPE OF SOLDER	TYPE OF FLUX	MAX DWELL TIME	DISTANCE FROM CASE	COMMENTS
Flow Soldering					
Hermetic	63/37 Tin Lead Bar	Active Rosin foaming flux (Kester 197 is suitable)	10 Sec	1/16"	Except for "pill" packages
Plastic	63/37 Tin Lead Bar		10 Sec	1/16"	
Solder Pot					
Hermetic	63/37 Tin Lead Bar	Kester 1544 is suitable	10 Sec	1/16"	Use water white rosin flux on pills (Alpha 100 is suitable)
Plastic	63/37 Tin Lead Bar		10 Sec	1/16"	
Solder Iron					
Hermetic	60/40 Tin Lead Wire Rosin Core, as small a diameter as possible		3 Sec	1/16"	If fluxing is required, use mildly activated rosin flux dispensed from hypodermic needle. Kester 1544 is suitable.
Plastic			3 Sec	1/16"	
All rosin flux residue can be removed with isopropyl alcohol and water rinses. (All recommended fluxes are rosin base.)					

The pill package (OP 600—OP 123 types) requires more care than any other package. The unit is designed for solder contact on either side of a PC board by any of the three techniques. It is not normally flow soldered since two passes must be made through the machine, and tooling can be complicated. Care must be taken in the PC board design to prevent subsequent problems. The mounting hole should be drilled to 0.0625" ±0.001". The following should be considered when designing the land area for the lens side of the device:

FIGURE I

PC Land Pattern Design



1. If space permits, allow a minimum of 0.010" on either side of mounting holes.
2. Design with cutaways when lands are narrow or consistent orientation of tabs is desired.
3. Hole off center with narrow lands will create fingers of land pattern due to "undercut" that may short the unit as the package is inserted into the hole.

The two desirable factors are: To have as much surface area of land pattern adjacent to the unit as possible to ensure support of both lens mounting tabs to prevent tilting, and to provide mechanical strength of land pattern when unit is being reworked or removed.

HAND SOLDERING

Once the packages are inserted into the PC board, the board should be turned so lens side is down and resting on a hard rubber or similar surface that will prevent damage to the glass lens but firmly support it. The operator will then press firmly down on the board with one hand. The iron is held in the other hand with the tip resting on the land pattern approximately 1/4" from the unit. The tip is slowly moved toward the unit; while watching the land pattern melt ahead of the tip. The speed of travel is as fast as the operator can handle the movement comfortably ensuring the land pattern melts. At the time the tip reaches the unit, solder is fed by the hand resting on the board without removing the downward pressure. The iron is wiped around the unit at the same rate of travel as was used on the land pattern. Once the 360° circle is complete, the solder wire is removed. The operator may make another 360° turn with the iron. Experience will show the best way. After all the plug sides are soldered, the board will be inverted and the lens tabs will be soldered to the two land patterns. The same technique is used except omit the 360° circle. The tabs are soldered in two operations.

SOLDER POT or DIP SOLDERING

A popular method of soldering pills in PC boards, when the design permits, is dip soldering or immersing the pill in the PC board in molten solder. The following conditions called out in Table II should be used.

TABLE II - Dip Soldering

Temperature of solder	230°C ±5°C
Insertion or retraction rate	0.25 inches/second
Dwell Time	3—5 seconds
Flux	"R" type (non-activated)
Flux Dilution	Methanol

CAUTION: After removing from the solder pot, the unit should be held still until the solder has hardened. Vertical insertion and removal with minimum lateral movement is required for minimum problems (inadequate coverage or shorts). There should be a minimum of 0.025" clearance between lands to prevent bridging.

All solder joints on all other packages in 0.062" PC boards should be soldered on the side away from the component. This guarantees the minimum distance of 1/16" from device to heat source. On open air solder joints, a pair of long nose pliers or some other heat sink gripping the lead between the joint and the unit can prevent problems. By following the information given above and exercising good judgement and common sense, the user will encounter very few problems related to solder joints on TRW components.

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WILLIAM NUNLEY
Applications Specialist

HOWARD BROWN

Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958

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TRW Electronic Components Group

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TWO CHANNEL OPTICAL INTERRUPTERS MAY BE USED FOR DETERMINING DIRECTION OF ROTATION, SPEED, AND THE RELATIVE LOCATION OF A ROTATING SHAFT

TRW has two types of dual channel optical interrupters available. The OPB 822 family has two side-by-side channels on 0.212" centers and the OPB 831S20 has two vertical channels on 0.200" centers. These standard parts may be used for determining direction of rotation, speed, and relative location of a rotating shaft. This bulletin will discuss some of the design aspects of two channel encoding along with circuit concepts and unit performance. See Application Bulletins 108 and 116.

GENERAL DISCUSSION

Rotational direction of a shaft can be readily determined by utilizing the two channels of an optical interrupter, an encoder disc with a number of openings around the circumference, and some simple electronics. The speed and relative shaft location information is available as a by-product and requires some additional electronics.

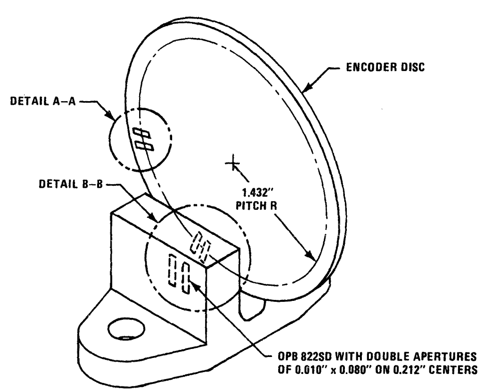
Figure 1 is a pictorial definition of terms used in this bulletin and should be referred to for clarification. A period is defined as 360 electrical degrees or the mechanical width of one opening plus one closure at the central point of the slot near the circumference of the encoder disc. When using a vertical, dual-channel unit, the outer row of periods are normally offset by 90 electrical degrees, or 1/4 period, from the inner row of periods. This will cause one channel to turn on approximately 90 electrical degrees ahead of the other as a function of rotation. In shaft encoding terminology, quadrature is the term defining determination of rotational direction by the phase relationship between the outputs of the two channels. System design normally uses 90° for this phase shift. Speed can be determined by accumulating the number of signal pulses for a fixed period of time, dividing by the number of periods per revolution thus obtaining the revolutions for this time period. Relative location is determined by dividing 360 by the number of periods around the circumference. A pulse is generated for each of these rotational segments. Counters may be used to relate a certain number of pulses to a desired action. This bulletin will describe the method of obtaining the three pieces of information (rotation direction, speed, and relative location) rather than what is done with the information.

PERFORMANCE CHARACTERISTICS

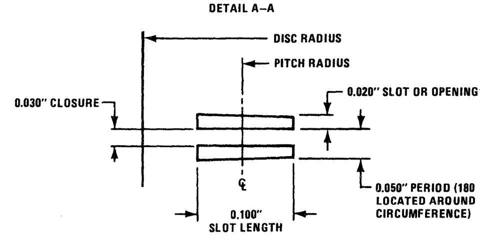
The OPB 822SD is used as the demonstration interrupter to describe method and operation. Apertures (0.010" x 0.080") are mounted in front of both sensors and LED's. The 0.010" dimension is perpendicular to the rotational vector of the encoder disc at the slot between the sensor and LED. A system is desired with 2° mechanical resolution of rotational movement, thus 360°/2 or 180 cycles or periods around the circumference. Each cycle or period corresponds to an opening and a closure in the encoder disc passing a sensor and LED combination.

FIGURE 1

Pictorial Definition of Terms

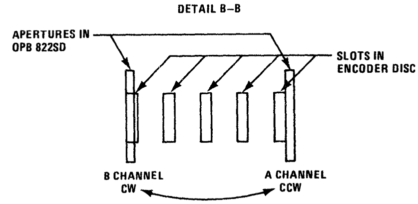


DETAIL A–A



* The sides of the slots lie on the extension of the two radii that are 1.432" long and 0.020" apart at the chord that defines the width of the center of the slot. The contained ∠ at that point is 0.8°.

DETAIL B–B



An off-multiple of periods between the center line of the sensor apertures (0.212") is required for the 90° phase shift. This off-multiple can be 1/4, 3/4, 1-1/4, 1-3/4, 2-1/4, 2-3/4 etc. periods. For example, a period of 0.050" will yield 4-1/4 cycles or periods in the 0.212" distance between these apertures.* The radius of the encoder disc is determined to be 1.432". (0.050" period x 180 periods per revolution x 1/2 π = radius). The opening in the disc should not be less than 0.010" as this would decrease the guaranteed output signal. A good rule for designing encoders is to keep the ratio of the opening to the closure at 2/3's. The disc can now be specified as:

Pitch radius — 1.432" (From center of wheel to ℄ of slots and apertures)

Slot length — 0.100" (0.020" tolerance above 0.080" aperture)

Disc radius — 1.562" (0.025" tolerance between disc and bottom of slot)

Openings — 0.020" on chord @ 1.432" radius (180 required)

Closure — 0.030" on chord @ 1.432" radius (180 required)

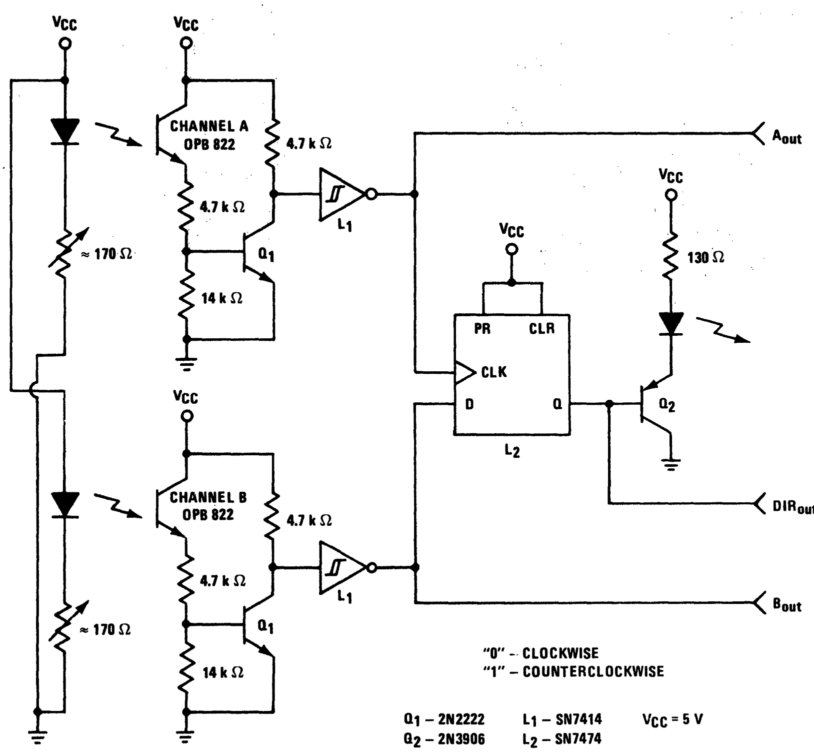
Disc material and thickness — Polycarbonate plastic, 0.060" thick

Crosstalk will not occur due to the narrow apertures (0.010") on both sensor and LED. This disc was then paired with the circuit shown in Figure 2.

* $\frac{0.212}{\text{off-multiple}}$ x mechanical resolution (pulses/revolution) x 1/2 π = pitch radius.

As shown in Figure 2, channel "B" provides the "D" input and channel "A" provides the "clock" input to the SN7414. (The SN7414 converts the relatively slow transitions from the mechanical motion to TTL compatible rise and fall times.) Since channel "A" clocks the latch at its positive transition, the state of channel "B" at "D" determines the state of the latch. If the "Q" output of the latch is high (1 state) then the "D" input was high when channel "A" turned "ON". Thus channel "B" turned "ON" prior to channel "A". This implies counterclockwise direction of

FIGURE 2 — Schematic for Determination of Rotation Direction, Relative Position and Speed



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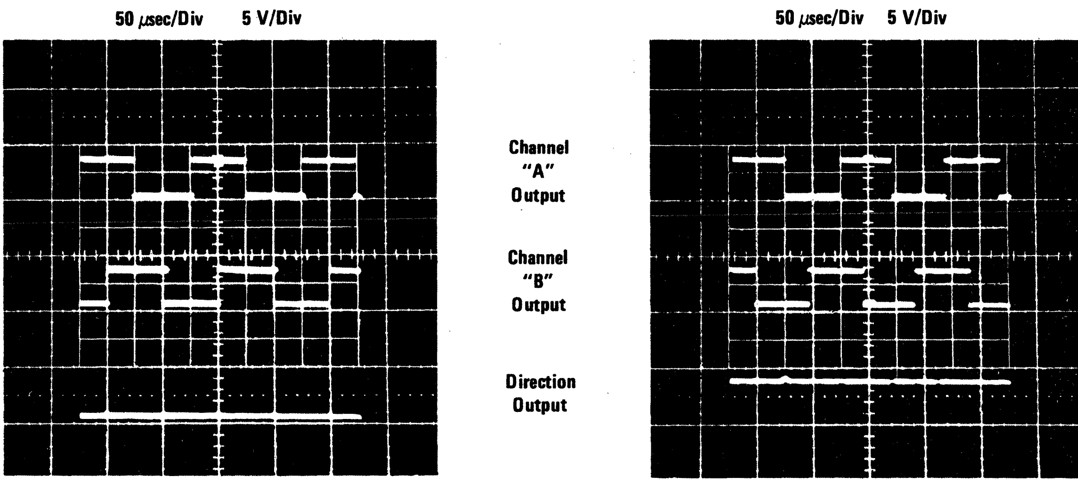
rotation. For clockwise rotation, channel "A" turns on prior to channel "B" and the "Q" output of the latch will be low (0 state). The pulses at A out or B out may be used for speed and/or relative location. Speed may be determined by counting the output pulses for a given time period and dividing the total count by 180 (pulses per revolution). Relative event location may be controlled within approximate 2° accuracy$\left(\frac{360^\circ}{180}\right)$ by specifying the number of pulses between related events. For example, 45 pulses would correspond to 1/4 rotation or 90 mechanical rotational degrees.

The photographs shown in Figure 3 demonstrate the "0" and "1" level for clockwise and counterclockwise rotation.

The left photograph shows a "0" level denoting clockwise rotation. The right photograph shows the opposite. Additional circuitry may be added using the time base pulses already present. If a third interrupter channel were added that could relate back to a fixed location of the shaft, then the relative location could be changed to true location. This might become the left margin control, right margin control and/or index for next line control. All of these functions could be performed quite easily. The same technique may be used in linear motion where the encoder disc is replaced by a comb with a series of openings and closures. The direction of movement, speed, and the relative location of the comb could be used as discussed before by molding the comb with the openings 0.020" wide by 0.100" high every 0.050" length along the comb.

FIGURE 3



Clockwise Direction | Counterclockwise Direction

Operating Frequency 10 kHz

CONCLUSION

In summary, this is a very versatile technique for relating electrical signals to linear or rotational motion, speed and either relative or true location of that motion.

RICHARD DAHLBERG

WILLIAM NUNLEY
Applications Specialist

Optoelectronics Division
TRW Electronic Components Group

Application Bulletin 113
January 1985

Reflective Assemblies – Design considerations for single-sided sensing applications.

General Discussion

A reflective assembly generally consists of a single emitter and sensor in the same housing. This provides a major mounting advantage because optical access to the surface to be sensed is required from only one side. However, this can lead to a wide variety of design variables involving mounting configurations, reflective surfaces, and sensing circuits.

Designers are often faced with conditions that prevent reflective assemblies from being used as specified by the manufacturer. Reflective surfaces may be different than specified, or the gap between the assembly and the reflective surface may be greater or less than specified and/or cannot be consistently maintained. The mounting requirements may make tight control impractical and/or the "contrast ratio"[1] may have to be improved.

TRW offers several reflective assemblies providing the designer with alternative solutions to these problems.

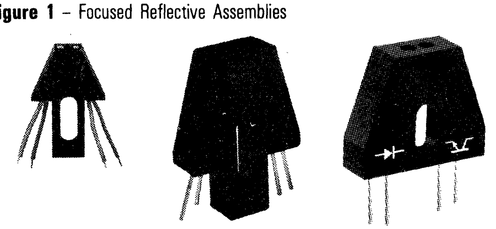
Performance Characteristics

TRW Optoelectronics Division makes two types of reflective assemblies; focused and unfocused.

A. Focused Reflective Assemblies

The focused version is made from discrete devices with convex lenses. Figure 1 shows three versions of this configuration. (Discrete devices are internal to the housing and are not shown.)

Figure 1 – Focused Reflective Assemblies



OPB125A, 253A   OPB703A   OPB708, 709

In this device type, the on-state collector current, $I_{C(ON)}$, peaks when a reflective surface is placed 0.100″ to 0.200″ (2.5 to 5.0 mm) in front of the assembly.

$I_{C(ON)}$ is the collector current created from the reflected infrared radiation emitted from the LED and detected by the sensor from a reflective surface. $I_{C(ON)}$ maximum is 75% of the distance to the intersection of the optical axes of the LED and photosensor. In other words, discretes focused to a reflective surface at a distance from the housing of .200″ would have an approximate peak $I_{C(ON)}$ at .150″. This is due to the emitted radiation following a diverging pattern rather than a straight line through its center line and the sensor viewing a converging pattern rather than a straight line through its center line. The angular mountings of the discretes are ideal for detecting the presence of a polished or specular surface.

(1) The ratio between the minimum and the maximum amount of reflected infrared radiation seen by the sensor.

B. Unfocused Reflective Assemblies

The unfocused version is made from discrete devices with plano or non-magnifying lenses. Figure 2 shows two versions of this configuration.

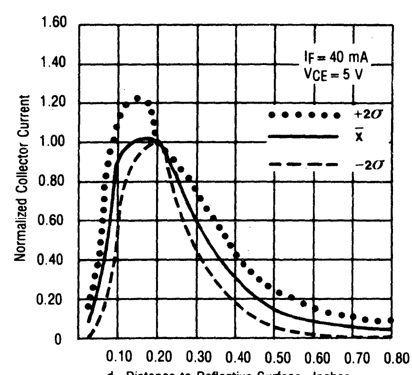
Figure 2

OPB706, 707   OPB711, 712

In this type of device the $I_{C(ON)}$ peaks when a reflective surface is placed 0.050″ to 0.080″ (1.25 to 2.0 mm) in front of the assembly. The units are designed for mounting in sockets or printed circuit boards. Plano lenses make unfocused assemblies ideal for detecting the presence of diffuse surfaces.

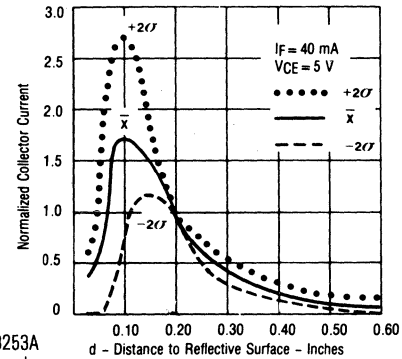
Figure 3 shows variation in output versus distance from a given reflective surface for both focused and unfocused devices.

Figure 3 – Normalized Collector Current vs. Distance to Reflective Surface

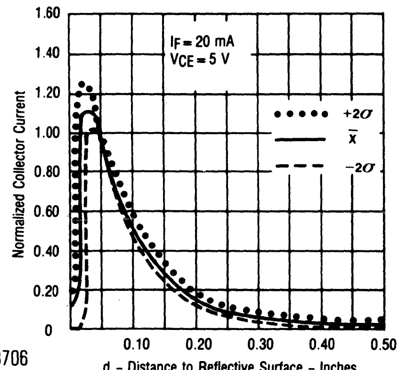


OPB703A
Focused

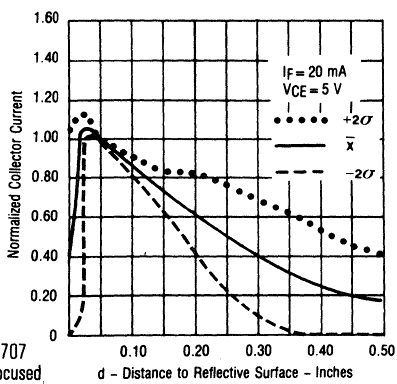
L



OPB253A
Focused



OPB706
Unfocused



OPB707
Unfocused

C. Variations in Signal Level

The signal level from the reflective assembly can vary for a variety of other reasons. An understanding of these variables is necessary for successful design:

1. Variations in Distance (or inconsistency in placement of reflective surfaces). Since the output from the sensor will decrease (see Figure 3) as the distance between the reflective surface and the assembly increases, the designer must either minimize the physical variation or compensate for it in the electrical design. Table 1 shows the magnitude of signal changes at various distances.

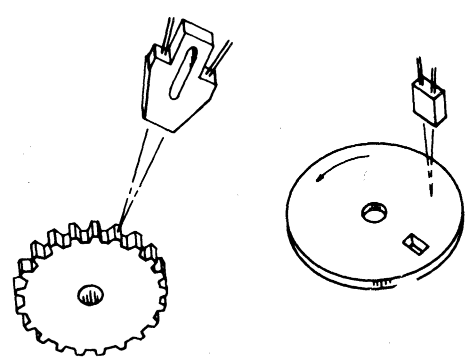
Table I – Typical Variation in Signal Level with Distance Changes (Data Sheet Conditions for $I_{C(ON)}$).

D (a) (b)	OPB125A	OPB703A	OPB706	OPB708	OPB711
.025	12 μA	35 μA	1270 μA	34 μA	855 μA
.050	89 μA	89 μA	1111 μA	175 μA	726 μA
.100	345 μA	233 μA	552 μA	537 μA	523 μA
.200	254 μA	277 μA	202 μA	359 μA	185 μA
.300	135 μA	159 μA	81 μA	100 μA	83 μA
.450	63 μA	59 μA	34 μA	23 μA	34 μA
.500	54 μA	44 μA	26 μA	17 μA	26 μA

Notes:
(a) D is distance from assembly face to reflective surface.
(b) Reflective surface is 90% diffuse reflectance Kodak neutral white test card.

This phenomenon can be used to an advantage in certain reflective applications. Figure 4 shows an OPB125A sensing gear teeth. Good contrast ratios are obtained since the distance to the reflective surface significantly varies. Figure 4 also shows an OPB706 used as a tachometer. The cutout in the encoder wheel allows one pulse per revolution. The OPB125A uses sensitivity vs. distance while the OPB706 uses sensitivity vs. reflective surface at a given distance.

Figure 4 – Applications vs. Contrast Ratios



OPB125A OPB706

2. Variation in Reflectivity of Surfaces–Many designers make the initial mistake of assuming that a photosensor will see infrared radiation the same way the human eye sees visible light. This frequently is not the case. In fact, a black surface and a white surface can have similar reflective properties when illuminated with infrared radiation. Tables 2 and 3 show the variation in signal level with different reflective surfaces.

Table 2 – Focused Reflective Assemblies
Typical $I_{C(ON)}$ (Signal) vs. Reflective Surfaces
(Standard Data Sheet Conditions used for distance, LED forward current and sensor supply voltage)

Focused Reflective Assemblies

Surface	OPB253A	OPB125A	OPB708	OPB703A	OPB709
	D[a]=.20"	D=.20"	D=.150"	D=.20"	D=.150"
1	689 μA	33390 μA	6160 μA	6260 μA	41180 μA
2	680 μA	33850 μA	5890 μA	6340 μA	39120 μA
3	1.59 μA	34.55 μA	6.39 μA	13.23 μA	22940 μA
4	115 μA	5420 μA	420 μA	750 μA	3720 μA
5	84.5 μA	4330 μA	320 μA	580 μA	2920 μA
6	51.18 μA	2250 μA	230 μA	400 μA	1810 μA
7	41.9 μA	1660 μA	410 μA	460 μA	3010 μA
8	123.0 μA	7920 μA	728 μA	1090 μA	5040 μA
9	90.0 μA	4850 μA	351 μA	6880 μA	2750 μA
10	118.0 μA	7330 μA	648 μA	1020 μA	4850 μA
11	100.0 μA	5760 μA	439 μA	7990 μA	3290 μA
12	116.0 μA	7010 μA	614 μA	9840 μA	462 μA
13	106.0 μA	6080 μA	471 μA	8450 μA	3600 μA
14	67.0 μA	3490 μA	430 μA	6050 μA	2690 μA
15	1.39 μA	36.07 μA	6.76 μA	13.50 μA	24.76 μA
16	0.24 μA	9.17 μA	1.55 μA	3.87 μA	1.08 μA

Notes:
(a) D is distance from assembly face to reflective surface.
1. Aluminum foil tape (shiny, efficient reflective surface).
2. Alzak (similar to 1).
3. Alzak painted with Flat Black Velvet (3M #101-C10 Black). Painted surface destroys shiny reflective surface and gives velvety matte finish.
4. Kodak 90% diffuse reflectance neutral white paper.
5. White bond paper.
6. No. 3 graphite pencil on white bond with entire viewing of sensor shaded by graphite mark.
7. Mylar magnetic tape.
8. Clear, smooth plastic tape finish.
9. Same as (8) except matte finish.
10. Same as (8) except blue color.
11. Same as (10) except matte finish.
12. Same as (8) except red color.
13. Same as (12) except matte finish.
14. Same as (8) except gray color.
15. 3M Tape No. 476 (a dull black surface).
16. No reflective surface.

Several interesting observations can be made.

I. The shiny metallic surfaces of (1) and (2) give the best reflectance.

II. The black velvet paint gives excellent contrast between (2) and (3).

III. The signal level drops when using diffuse reflectance, (4) neutral white paper, bond paper (5), or mylar magnetic tape (7).

IV. The graphite pencil mark gives relatively small change since it both improves the reflectivity (smeared shiny graphite) and disrupts the pore fibers of the paper.

V. Plastic surfaces do not reflect as well as polished surfaces. Examples: (8), (10), (12), (13)

VI. Plastic matte reflects almost as well as plastic smooth surfaces. Examples: (8) versus (9); (10) versus (11); (12) versus (13).

VII. Color makes very little difference. Examples: (8), (10), (12), and (14), or (9), (11), and (13).

VIII. The 3M tape #476 is an excellent non-reflecting surface (15).

IX. The best non-reflecting surface is no surface (16).

Table 3 – Unfocused Reflective Assemblies
Typical $I_{C(ON)}$ (Signal) vs. Reflective Surfaces
(Standard data sheet conditions used for distance, LED forward current and sensor supply voltage)

Unfocused Reflective Assemblies

Surface	OPB706	OPB707A	OPB711	OPB712
	D[a]=.05"	D=.05"	D=.08"	D=.08"
1	1950 μA	53990 μA	1430 μA	31630 μA
2	1000 μA	54250 μA	1220 μA	29930 μA
3	960 μA	52350 μA	1220 μA	29160 μA
4	21 μA	3400 μA	31 μA	1160 μA
5	860 μA	52330 μA	1050 μA	28700 μA
6	390 μA	41920 μA	520 μA	21900 μA
7	95 μA	17260 μA	130 μA	5670 μA
8	964 μA	52990 μA	1360 μA	31330 μA
9	913 μA	47570 μA	1230 μA	31400 μA
10	985 μA	52260 μA	1300 μA	31100 μA
11	961 μA	52270 μA	1280 μA	30800 μA
12	996 μA	52810 μA	1310 μA	31500 μA
13	972 μA	52520 μA	1380 μA	31200 μA
14	4740 μA	39340 μA	650 μA	24260 μA
15	24 μA	4250 μA	34 μA	1400 μA
16	.751 μA	.51 μA	4.32 μA	.2 μA

Notes:
(a) D is distance from assembly face to reflective surface.
1. Kodak 90% diffuse reflectance neutral white paper.
2. Aluminum foil tape (shiny reflective surface).
3. Alzak tape (similar to 2).
4. Alzak painted with Flat Black Velvet (3M #101-C10 Black) paint.
5. White bond paper.
6. No. 3 graphite pencil on white bond with entire viewing area of sensor shaded by graphite mark.
7. Mylar magnetic tape.
8. Clear, smooth plastic tape finish.
9. Same as (8) except matte finish.
10. Same as (8) except blue color.
11. Same as (10) except matte finish.
12. Same as (8) except red color.
13. Same as (12) except matte finish.
14. Same as (8) except gray color.
15. 3M Tape #476 (a dull black surface).
16. No reflective surface.

The same type of observation can be made about unfocused assemblies as were made on focused assemblies with one exception:

The Kodak 90% diffused reflectance neutral white paper offers the best reflective surface.

The information in Table 2 and Table 3 can be used to design the surface in your system.

3. Variations in Reflective Surface Size–Another problem may arise as a result of the size of the reflective area. An optimum sized reflective surface would be one which will yield no increase in $I_{C(ON)}$ when its size is increased. Then as the size of the reflective surface shrinks from the optimum size the signal level will decrease. As a result, these units are better used as surface detectors than as mark or line detectors.

4. Variations in $I_{C(ON)}$ from Assembly to Assembly–There is a wide $I_{C(ON)}$ variation from assembly to assembly. Table 4 shows this variation.

Table 4 – Minimum, Typical, and Maximum $I_{C(ON)}$(1)
(Data Sheet Conditions for $I_{C(ON)}$)

Sensor	$I_{C(ON)}$ Min.	$I_{C(ON)}$ Typ.	$I_{C(ON)}$ Max. (2)
OPB125A	2000 μA	8400 μA	14500 μA
OPB253A	25 μA	125 μA	168 μA
OPB703A	200 μA	500 μA	1100 μA
OPB708	10 μA	25 μA	1100 μA
OPB709	1000 μA	8000 μA	12000 μA
OPB706A	500 μA	1000 μA	2500 μA
OPB706B	350 μA	700 μA	1920 μA
OPB706C	200 μA	400 μA	1820 μA
OPB707A	25000 μA	50000 μA	59400 μA
OPB707B	17000 μA	34000 μA	43500 μA
OPB707C	10000 μA	20000 μA	39300 μA
OPB711	350 μA	700 μA	1950 μA
OPB712	20000 μA	40000 μA	60000 μA

Notes: (1) Measurements taken using an Eastman Kodak neutral white test card having 90% diffuse reflectance as a reflective surface placed at the optimum distance from the assembly head.

(2) The maximums are not a guaranteed specification as they are calculated from the two sigma points based on the distribution.

5. Variations in Signal Levels Due to Sporadic Problems–Spurious reflections due to illumination from outside sources may cause false triggering. Also foreign material can decrease the desired "on" signal, depending on what it is and where it is located. Consideration must be given to these sources.

D. Applications

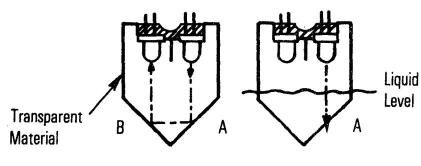
A variety of applications are well suited to reflective assemblies.

a) The variability in output versus distance can be used to detect variations in surface location.

b) The variability in reflectivity can be used to measure surface roughness.

c) Liquid level sensors are easily fabricated as shown by the illustration in Figure 5. The radiation normally would be reflected from surface "A" to surface "B". When liquid covers surfaces A and B, the change in the index of refraction causes the radiation to continue through surface "A", and not to be reflected back to the receiving sensor.

Figure 5 – Liquid Level Sensor

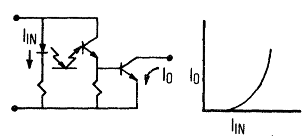


d) Reflective assemblies have wide applications in industrial controls and surveillance applications where a retro-reflective surface sends the light back to the sensor. This normally requires a custom assembly as the distances covered may span up to 50 feet.

e) Reflective assemblies have wide applications in office machines for detecting the presence or absence of paper as it moves through the machine. A variety of special techniques are used to improve the contrast ratio. Many of these designs use custom packages. Figure 6 shows some of these special techniques.

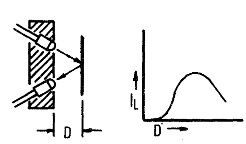
Figure 6 – Special Techniques for Improving Contrast Ratios

Non-Linear Transfer Function Improves Contrast Ratio



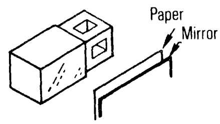
• Customer requirements for electrical performance and mechanical configuration are met exactly.

Optical Techniques Used to Reject Reflections from Close Objects

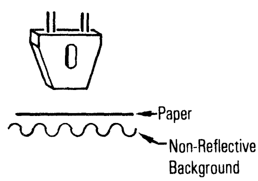


• Development costs vary depending on complexity.

Figure 6 – Special Techniques for Improving Contrast Ratios (continued)



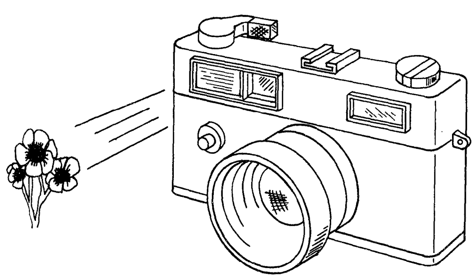
• Paper interruptive is less reflective than the mirror background



• Paper interruptive is more reflective than non-reflective background.

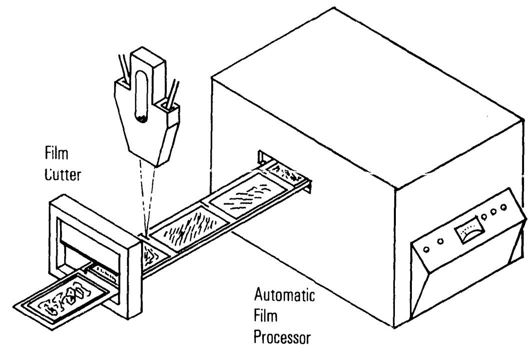
f) A sophisticated camera application is shown in Figure 7. The system can work as either a flash control or a shutter control. When used as a shutter control the photosensor receives outside light when the shutter is open. When the amount of outside light reaches a predetermined level (adequate for film exposure), the shutter is closed. The flash control is similar except the photosensor shuts off the flash when a predetermined amount of light is reflected from the subject to the sensor.

Figure 7 – Automatic Shutter or Flash Control



g) Reflective sensors can also be used in high speed print cutting. Figure 8 shows this application. The machine processor prints a thin black line on the white border between each print. The black line causes a small decrease in the amount of light reflected back into the photosensor which causes the print cutter mechanism to trigger.

Figure 8 – OPB125A – High Speed Print Cutting



Conclusion

The information presented should allow the designer to understand the basic variables that exist in reflective assemblies. An understanding of these variables will allow the designer to decide on the best reflective assembly for his application and how to choose other system piece parts for a successful design and implementation.

Tom Sward
Senior Design Engineer
Reflective Assemblies
Optoelectronics Division

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Optoelectronics Division
TRW Electronic Components Group

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January 1985

Gallium aluminum arsenide – a new generation of infrared LEDs superior to gallium arsenide.

The first light source for actuating an optoelectronic photosensor was the tungsten filament or incandescent lamp. It was eventually replaced by the GaAs infrared emitting diode which offered longer life, smaller size, less power to operate and less heat generated. The GaAs LED is still the workhorse of the industry and will continue to be used in steadily decreasing numbers for the next few years. It will eventually be replaced by GaAlAs as the industry standard for two major reasons: GaAlAs offers at least twice the power output at the same input current (I_F) level and significantly improved coupling efficiency.

GENERAL DESCRIPTION

Typically, a GaAs LED mounted on a TO-46 header with a flat window can will emit 5 milliwatts total radiant flux at an I_F = 100 mA. At the same I_F, a GaAlAs LED will typically emit 10 milliwatts total radiant flux. Similar increases are possible in other packages. This allows the designer some options which have not been available before.

In addition, silicon doped GaAs has a spectral emission centered at approximately 935 nanometers. GaAlAs has a spectral emission at approximately 875 nanometers which is very close to the peak response of silicon phototransistors. This improves coupling efficiency by approximately 30%.

FIGURE 1

Photodiode Collector Current Versus LED Forward Current With Both GaAlAs and GaAs

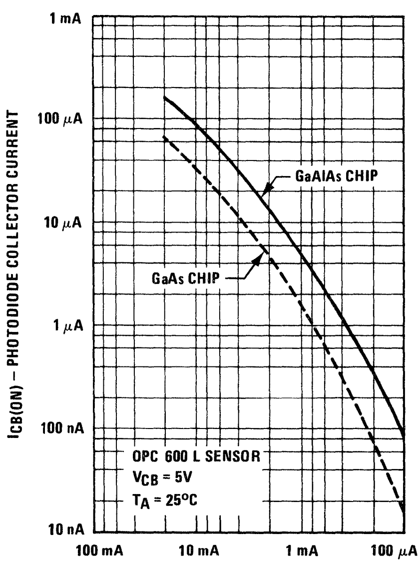
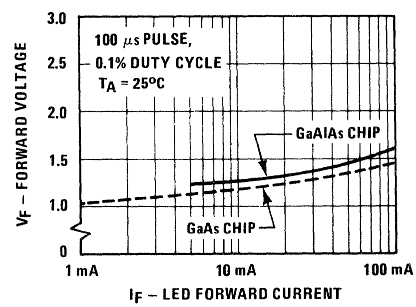


Figure 1 graphically illustrates the improvement in photodiode collector current as a result of both the higher radiant flux and the optimized spectral emission.

The only negatives to GaAlAs are a slightly higher forward voltage (V_F) (see Figure 2) and a slightly higher initial cost. With process improvements and higher volumes, this cost difference whould eventually disappear.

FIGURE 2

Forward Voltage Versus LED Forward Current

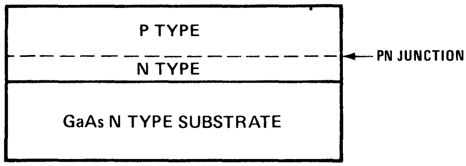


CHIP FABRICATION

All TRW GaAlAs LED's are made by means of a straightforward single step solution grown liquid phase epitaxial (LPE) preparation technique. Initially it is much the same process as making GaAs LED's. N type GaAs substrates approximately 16 mils thick are placed in a furnace and heated to around 920°C. A melted mixture of gallium, gallium arsenide and silicon (called the "melt") is then placed on top of the substrates. In the case of GaAlAs, aluminum (Al) is added to the melt. The furnace then starts cooling, and an epitaxial N type layer begins to grow on top of the substrates. As the cooling continues, the silicon in the melt which is amphoteric changes polarity or "flips" to P type material at approximately 900°C, forming the PN junction. The growth process continues until the epi layer reaches a thickness of 7–8 mils. (See Figure 3.)

FIGURE 3

Typical Epitaxial Layer Growth



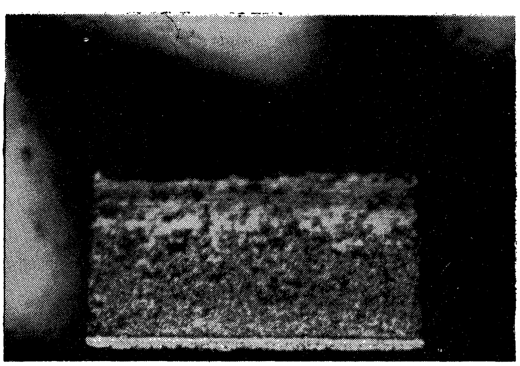
The nature of the Al in the melt is such that it is depleted or used up rapidly in the early stages of the epi growth. Concentration is virtually zero at the top of the P layer.

The substrate is then etched away with an etchant that readily dissolves GaAs. As the etchant contacts the N layer, the aluminum causes the etch rate to be slowed to 1/100th of the initial rate. This is convenient because it helps to ensure that the N layer is not materially etched.

After etching, appropriate ohmic contacts are added by evaporation techniques. A gold contact completely covers the P layer or backside, and a dot matrix contact is put on the N layer or topside. The chips are then sawed into their final size. A final etching is done to remove saw damage and to roughen the surface of the N layer which enhances light output. (See Figure 4.)

FIGURE 4

Typical Chip Cross Section



WHAT MAKES GaAlAs SUPERIOR?

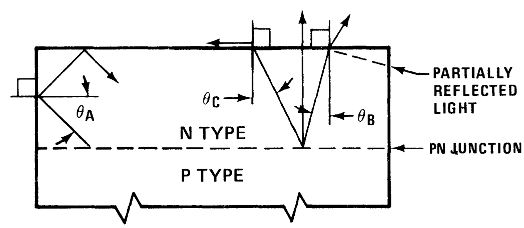
The wavelength of the emitted light of an LED is related to the energy in the photons of light it emits. Also the higher the band gap energy of the semiconductor material, the higher the photon energy. Al atoms increase the band gap energy in proportion to the concentration which allows adjustment of the photon wavelength. By controlling this concentration, the wavelength can be varied to approximate the peak spectral response of a silicon phototransistor or 875 nanometers.

GaAlAs also has an improved radiation window. In order for an LED to emit more light, absorption of photons traveling through the material must be as low as possible. In other words, there must be a high probability that the photons generated at the junction will reach a surface and escape. For this to happen effectively, the photon energy must be less than the band gap energy of the material. In previous discussions, it was mentioned that Al atoms increase the band gap energy. The heaviest concentration of Al atoms is at the N layer surface with rapidly decreasing concentration toward the PN junction. Photons generated at the junction then travel a path through steadily increasing band gap energy levels until they reach the surface. This property ensures a much reduced chance of re-absorption of photons than does a material in which the band gap energy is constant from junction to surface such as GaAs.

One final plus, GaAlAs has an index of refraction which is slightly lower than GaAs. This affects the critical angle which defines the angle at which there is total internal reflection. (See Figure 5.)

FIGURE 5

Definition of Critical Angle



The critical angle is determined by the formula:

$\text{SIN}\ \theta_C = \frac{n_1}{n_2}$ Where n_1 is the index of refraction of air, or 1, and n_2 is the index of refraction of the chip material.

With GaAs, $n_2 = 3.6$

$$\text{SIN}\ \theta_C = \frac{1}{3.6}$$

$$\theta_C = 16^\circ$$

With GaAlAs, $n_2 = 3.4$

$$\text{SIN}\ \theta_C = \frac{1}{3.4}$$

$$\theta_C = 17^\circ$$

At angles less than the critical angle, there is partial reflection. (See angle θ_B in Figure 5.) At angles greater than the critical angle, there is total internal reflection. (See angle θ_A in Figure 5.)

There are ways of improving surface emission. One, mentioned earlier, is the post-dicing etch cleanup which roughens the chip surface. This increases the likelihood of photons striking the surface at less than the critical angle. Another improvement is the addition of a clear epoxy, antireflective, domed lens placed over the chip which actually enlarges the critical angle to approximately 24°.

RELIABILITY

Since GaAlAs and GaAs junctions are formed in the same manner, the chips should have the same reliability. Life tests to date indicate that this is true. Data shows that both GaAlAs and GaAs have from 5 to 8% degradation after 1,000 hours of maximum rated operation.

DRAWBACKS

GaAlAs has inherently high V_F. The higher the band gap energy, the higher the V_F must be to impart adequate energy to the electrons. Typical V_F for TRW's GaAs LED's at 100 mA is 1.5V vs. 1.75V for GaAlAs. This difference increases slightly at higher current levels.

CONCLUSION

Many power-starved optical assembly packages will be helped immediately by using GaAlAs. Special optosensor assemblies such as card readers, paper tape readers, paper sensors and precision shaft encoders will become easier to design.

Electronic assemblies which operated with an LED/sensor pair will benefit immediately.

- With optocouplers, higher current transfer ratios will be available, and the LED and sensor will not need to be mounted as close to each other which will allow higher isolation voltages.
- With reflective assemblies, reflective objects will be able to be sensed at greater distances than before.
- With interrupter assemblies, precise alignment and gap width will not be as critical. Since there is more light available, aperturing can be reduced for higher resolution or photosensor gain can be reduced for better signal-to-noise ratio and improved gain-bandwidth product.
- In battery-operated applications, a GaAlAs LED can replace a GaAs LED and provide the same light output at ½ the current drive.
- Since the same light output can be produced at ½ the current drive, GaAlAs LED's will have much longer operating life.

GaAlAs, with its superior performance, will give the designer more options and design flexibilities than were previously available.

DEAN WOLFE

Optoelectronics Division
TRW Electronic Components Group

Application Bulletin 116
January 1985

Linear and rotary encoders are evolving to meet the demands of new system requirements, higher performance requirements, harsh environmental conditions and lower cost.

Table of Contents

Introduction

Linear and rotary encoders have come in a wide variety of design styles over the years, the most common being rotary switches, potentiometers, capacitive, magnetic, and optical types. The optical encoder has become the most popular of these encoding methods due to its long life, simplicity of construction, versatility, high accuracy and high resolution. This application bulletin will briefly define an optical encoder, and bring the designer up to date on encoder terminology, design techniques and limitations. Refer to Application Bulletins 108 and 112 for additional information.

General Discussion

An encoder is an electromechanical device used to monitor the motion or position of an operating mechanism, and to translate that information into a useful output. We define an optical encoder as an optoelectronic device which translates rotational or linear movement into some usable electronic waveform. Encoders generally consist of two parts; a "moving unit" which is attached to and moves with the device being monitored. The moving unit contains information to be sensed by the "stationary unit." The stationary unit consists of an LED and a photosensor (or a combination of LEDs and photosensors) mounted on opposite sides of a slot through which the moving unit passes, thereby modulating the light path(s).

The types of output information available are speed, velocity (speed with direction) and relative or absolute positioning. The output can be either analog or digital depending on the type of photosensor used. For a more thorough description of encoding techniques, refer to TRW Optoelectronics Division Application Bulletin 108.

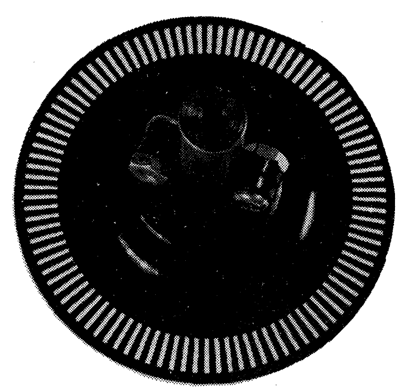
Encoder Components

a. The Moving Unit

The modulation of the light path(s) in the optical encoder is accomplished by the moving unit which is a "scale" (linear encoder) or a "disc" (rotational encoder). The scale or disc is attached to the operating mechanism and contains alternating areas of transparency and opacity to the light path. The size, shape, and frequency of these areas is the basis of the output information supplied by the encoder.

A number of materials are currently being used in the fabrication of scale and disc components. A few examples are given below and on page 2 with the advantages and disadvantages of each.

Molded Plastic



Advantages	Disadvantages
Low cost	Resolution of < 50 lines per inch
Durable	Relative mechanical and thermal instability

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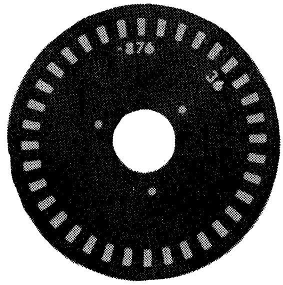
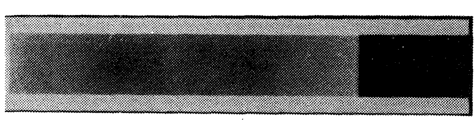
Etched Metal



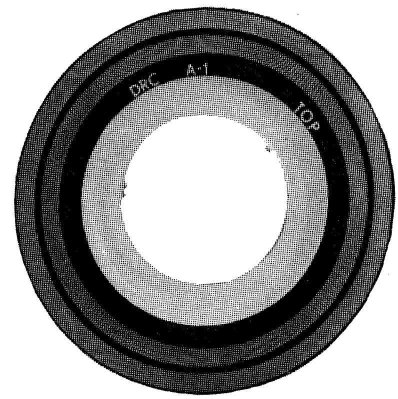
Advantages	Disadvantages
Reasonable cost	Resolution of < 150 lines per inch
Resistant to shock and vibration	
Good thermal stability	

Mylar Film



Advantages	Disadvantages
Reasonable cost	Mechanical, thermal, and humidity instability
Resolution of < 1000 lines per inch	Can be damaged in handling

Chrome on Glass



Advantages	Disadvantages
Resolution of > 2500 lines per inch	High cost
Excellent optical quality	Can be damaged in handling
Excellent mechanical, thermal and humidity stability	

b. The Stationary Unit

The stationary unit contains all the components necessary to generate the light source and sense its intensity as it is being modulated by the scale or disc. It sometimes contains the signal conditioning electronics required to amplify and/or digitize the output of the encoder. The light source consists of one or more incandescent lamps or light emitting diodes and may include lensing to improve the collimation of the light source. Most recent optical encoders use LEDs because of their lower cost, longer life, better shock resistance, and lower power consumption.

(1) Sensing Elements

Solar cells, photodiodes, phototransistors, and photosensitive integrated circuits are all used in optical encoders. TRW Optoelectronics Division Photologic™ series of photosensors was developed to enable the stationary unit to provide a digital output which can be directly interfaced with TTL, LSTTL, CMOS, and other standard logic families.

(2) Apertures and Reticles

One method of improving encoder resolution is the "sizing down" of the photosensitive area. This is done by placing a reticle with a certain aperture size in front of the photosensor. The reticle contains a pattern of transparent and opaque areas which are optically mated to the scale or disc being "read." The transparent areas are referred to as apertures, and one or more apertures may be placed in the reticle over the photosensor in high resolution designs. Some examples of reticles made of the same materials, and intended to be used with the scale and disc samples discussed earlier, are shown in figure 1. The same advantages and disadvantages apply. In the case of molded plastic, apertures are molded right into the housing.

Figure 1 – Examples of Reticles

Molded Plastic | **Etched Metal** | **Mylar Film** | **Chrome on Glass**

(3) Signal Conditioning Electronics
Resistors, capacitors, integrated circuits, input/output connectors, and additional components are often contained on a printed circuit board in the stationary unit. These components are used to amplify the photosensor output and interface the encoder to the system in which it is used.

(4) Housing
The components used in the construction of the stationary unit are usually held in position by mounting them into a metal or plastic housing. The housing is then mounted to the operating mechanism (motor, etc.) to optimize the interface between the moving and stationary units. In some cases, the moving and stationary units are packaged together and external linkages are provided for coupling the packaged encoder to the operating mechanism.

Operating Principals

a. Modulating the Light Source

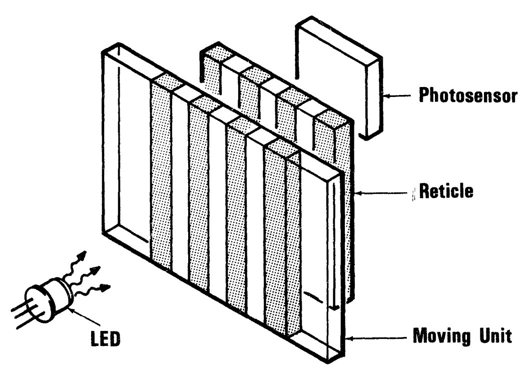
The movement of the scale or disc in the light path is the source of modulation of the light in an optical encoder. A simple example of modulation would be the interruption of the light beam in a burglar alarm. The momentary interruption or reduction of light is easily detected. As resolution requirements increase, apertures become smaller and detection becomes more difficult. An improvement over standard aperturing is the light shutter.

b. The Light Shutter

The reticles used in optical encoders may contain 20 or more alternating transparent/opaque areas in front of each sensor. If the moving unit and the reticle have identically matched patterns of 50% duty cycle (transparent and opaque areas are the same width) then the emitted light received by the sensor will be at a maximum when all the transparent areas of the reticle are exactly superimposed with those of the moving unit, as illustrated in figure 2.

When the moving unit moves one area width, the emitted light received by the sensor will be at a minimum, but not zero since in this type of light modulation there is some slight light leakage around the opaque areas in the moving unit. This sequence repeats for each cycle of movement, and is referred to as the "light-shutter" because of the similarity of operation to a camera shutter.

Figure 2 – Light Shutter



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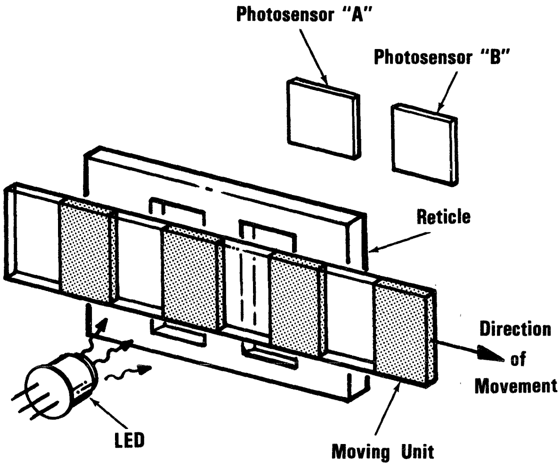
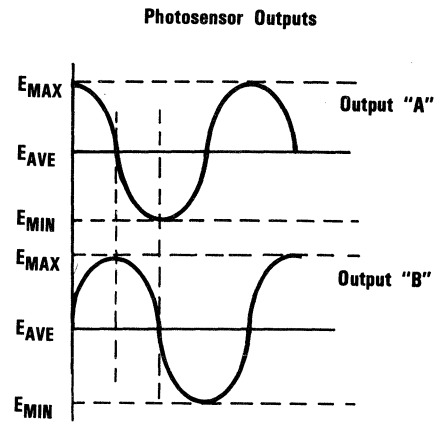
c. Quadrature

Determination of direction of movement of the moving unit is also possible by locating two photosensors in the encoder and mechanically shifting the aperture pattern in the reticle over one photosensor, ¼ cycle from the aperture pattern in the reticle over the other photosensor as shown below. This causes a "phase shift" in the output of one photosensor relative to the other and indicates direction of motion. This phase relationship is called "Quadrature," and is illustrated in figure 3.

Figure 3 – Quadrature





The output from photosensor "A" rises 90° ahead of the output from photosensor "B" indicating that the moving unit is moving to the right. If the moving unit were moving to the left, the output from "B" would be 90° ahead of "A." For more information on dual channel encoding refer to TRW Optoelectronics Division Application Bulletin 112.

Sensing Circuit Techniques

The use of the light shutter permits the design of an optical encoder capable of very high resolution. However, electrical and mechanical errors must be considered and compensated for in the design to allow full use of this capability.

a. Single-Ended Encoders

The use of a single photosensor to generate each output in an optical encoder is inherently limited. LEDs will degrade with time and temperature resulting in changes in the output signal shape and level. However, if performance requirements are not severe, the single ended approach offers the simplest design approach and lowest cost.

b. Convoluted Duty Cycle Encoders

The use of 50% duty cycle components in a single-ended encoder does not necessarily guarantee the optimum in performance. A reduction in the duty cycle of the reticle (making the opaque area wider than the transparent area) and an increase in LED drive current will improve the output performance of an encoder that is being digitized by a comparator. Operating a phototransistor at very high light conditions will tend to reduce its frequency response. The use of convoluted duty cycle usually requires the use of a photodiode type of photosensor. TRW Optoelectronics Photologic™ series of photosensors are ideally suited for this type of application.

c. Automatic Gain Control

An unmodulated photosensor channel can be incorporated exclusively to monitor the intensity of the emitted light from the LED. Feedback is then provided to a drive circuit powering the LED. This compensates for degradation from all causes and will enhance the long term performance of the encoder. The trade-off is in increased cost and circuit complexity.

d. Differential Circuitry

By generating quadrature in "complementary format" (i.e., 0°/180°, 90°/270°), the complementary phases may be differentially amplified or compared to generate the required quadrature output (generally 0° and 90°). This approach allows noise reduction and drift compensation. An additional advantage is the ability to operate high gain phototransistors in the nonsaturated mode, thereby improving frequency response. The negatives are increased cost and circuit complexity.

e. Zero Referencing

Many encoders provide speed, velocity, and relative position data, but a starting position must be known to derive true position. An extra photosensor is sometimes provided to look for a single point of transparency or opacity at a specific place on the scale or disc. The sensing of this point is used to zero the counting circuitry driven by the encoder during power-up, or any time an error in count is detected.

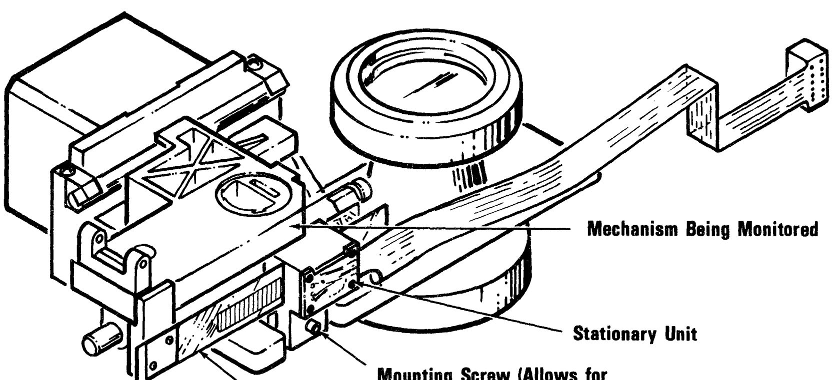
Mechanical Interfacing

The best possible performance from an optical encoder is dependent on the proper selection of materials, circuit design and the integrity with which the encoder is attached to the operating mechanism. The space between the scale or disc and the reticle must be as narrow as possible and consistently maintained throughout the travel of the moving unit. Variations will result in degraded performance.

a. Mounting The Moving Unit

A properly designed housing provides for flatness across the surface of the reticle at some absolute height from the mounting surface of the stationary unit. This allows the positioning of the moving unit to be performed as a separate operation. Disc mounting requires two steps: (1) affixing the disc to a hub using adhesive and/or a clamp ring; (2) mounting the hub/disc to the device being monitored using adhesives and/or set screws located 90° apart on the hub. Linear scales are mounted to a bracket on the operating mechanism at one or both ends. The entire scale must travel evenly and precisely through both end extremes. A typical encoder mounting application is illustrated in figure 4.

Figure 4 – Encoder Mounting



b. Mounting the Stationary Unit

The stationary unit should be designed to allow rotational or displacement adjustments. These adjustments compensate for mechanical tolerances in fabrication of the stationary and moving units that could prohibit the final fine tuning needed by the light shutter.

c. Maintaining the Gap

The distance between the scale or disc, and the reticle is referred to as the "gap." In photo-emulsion type light shutter components, the emulsion sides should be facing each other and a minimum space maintained to prevent abrasive damage. If the properties of the

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operating mechanism and the housing are known (thermal expansion, end play, eccentricity, etc.) the moving unit can be mounted using a spacer. Then the fixed unit is simply inserted, adjusted and locked in place. Another solution is a sliding bearing inserted between the shutter components to prevent wear damage.

d. Error Related to the Gap

A gap of zero width allows for complete modulation of the emitted light shutter. Any increase in gap width will result in reduced modulation where:

$$\% \text{ Modulation} = \frac{\text{Signal Output (ACVpp)}}{\text{Max. Achievable Undistorted Signal Output}} \times 100$$

The reduced modulation is caused by non-collimated light from the LED (i.e., leakage around the shutter components) and becomes substantial as the gap width approaches the aperture width in size.

Variations in the gap during the travel of the moving unit result in amplitude modulation. These variations affect the interface circuitry driven by the encoder during signal conditioning or digitizing and can cause clipping, positive pulse width modulation or variation in time between output pulses (in a pulse output encoder).

The quadrature relationship between the output channels will vary as the sum of the error on each individual channel.

e. Performance Limits

The optical encoder provides direction information only as long as the quadrature related signals occur in proper sequence. Any phase, duty cycle, or modulation error that interrupts or reverses this sequence defines the ultimate limit of an incremental encoder.

Conclusion

Optical sensing is currently the most versatile method of motion sensing in rotary and linear applications. LED and photosensitive integrated circuit technology, along with innovative sensing techniques are keeping pace with today's sensing requirements so that the advantages of long life, high resolution, reliable operation in harsh environments, and low cost are available in almost any motion sensing application.

J. W. Davidson, III

Lowell Johnson
Market Analyst

Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958

Optoelectronics Division
TRW Electronic Components Group

Application Bulletin 118
January 1985

Understanding infrared diode power ratings.

Introduction

Infrared emitting diode power measurement is dependent upon a number of variables which must be precisely defined in order for design engineers to utilize data sheet information. Manufacturers differ not only in the techniques used in measuring power, but also in their interpretations of the definitions of the parameters which are measured. This application bulletin is intended to clarify this misunderstanding, especially for GaAs and GaAlAs solution grown epitaxial devices.

General Discussion

Power is measured in units of energy per unit of time, and the conventional MKS unit is the Watt. Some factors which must be controlled to make accurate power measurements are discussed below.

The energy an LED emits is in the form of photons, and a photon's energy is inversely proportional to its wavelength. To measure the power emitted, the technique must take into account both the rate of photon emission and the average wavelength of the photons. Both the rate emission of the LED chip and the average wavelength of the emitted photons change as functions of chip temperature. See Figures 1 and 2 for examples of this change.

Figure 1. Output Power vs. Ambient Temperature for both GaAs and GaAlAs IR LEDs

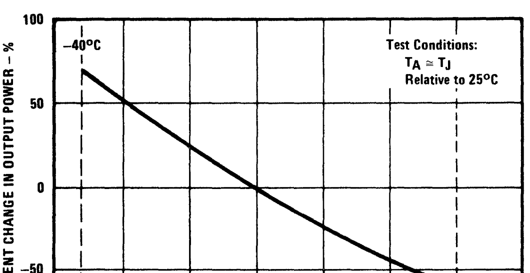
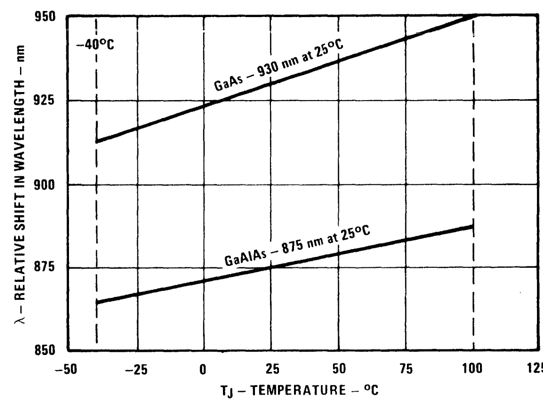


Figure 2. Peak Wavelength vs. Ambient Temperature for both GaAs and GaAlAs IR LEDs



Stress on the chip will cause any defects in the chip to expand along the planes of the crystalline structure in a process called dark line defect formation. This degrades the chip, and power output decreases as a function of time. Measurements made after the chip has been stressed mechanically, thermally, or electrically will be lower than initial readings. Figures 3, 4, and 5 illustrate the magnitude of this change due to applied DC current for variations of ambient temperature, current level, and different materials used as emitters.

Figure 3. Percent Change in GaAs IR LED Mounted in Metal TO-46 Package vs. Time at 25°C and 55°C

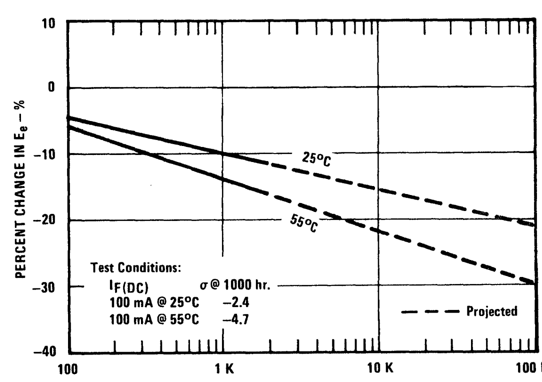


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Figure 4. Percent Change in GaAlAs IR LED Mounted in Plastic TO-46 Package vs. Time at Various Current Levels

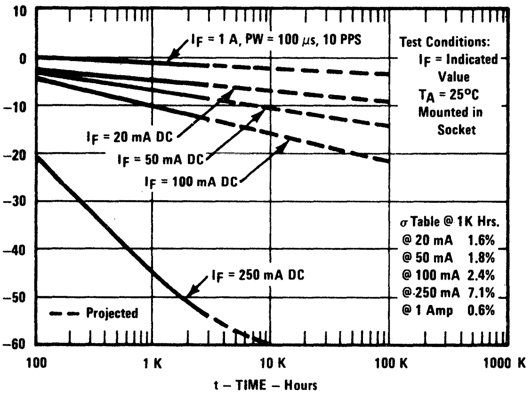
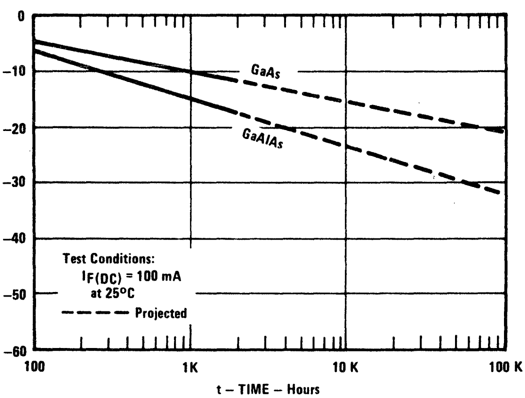


Figure 5. Percent Change in GaAs and GaAlAs IR LED Mounted in Metal TO-46 Package vs. Time under Same Conditions

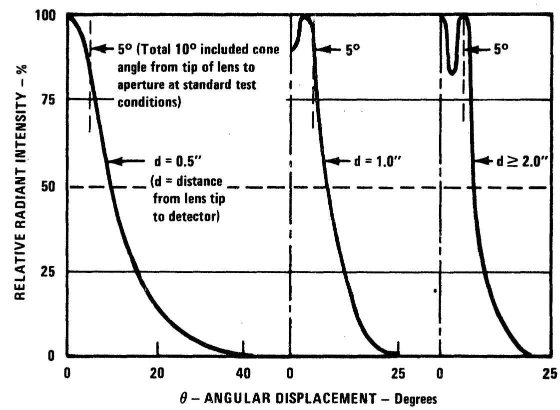


The response of most detectors is also wavelength and temperature dependent. The surface of the detector can reflect photons depending upon the wavelength, the angle of incidence, and the type of protective coating on the detector surface. The range of linearity in power detection can be exceeded by some emitting devices. Also, there are other minor characteristics of detectors which must be considered. Obviously, the accuracy of the detection system is critically important.

Any measurement of directed output is dependent upon complex optics which include chip centering in the reflective cup, reflector design, chip to lens centering, bubbles or contaminants in the packaging, and the fact that approximately half of the emitted photons exit the chip from the side walls rather than the top surface.

Many devices have radiation patterns which change as the distance from the device to the detector is varied, so this distance can be important in directed output measurement. See Figure 6:

Figure 6. OP295/OP296/OP297 Relative Radiant Intensity vs. Angular Displacement



It is essential that these variables be exactly specified in order for users to extract necessary information from data sheets. Separate application bulletins address the thermal behavior of LEDs (Bulletins 105 and 121) and the characteristics of GaAs and GaAlAs LEDs (Bulletin 114). Power measurement is integrally tied to the information contained in these bulletins, and even a basic understanding is difficult without understanding the information they contain.

Parameter Definitions and Measurement Techniques

There have traditionally been two methods of defining power measurement, but there have been different interpretations for each.

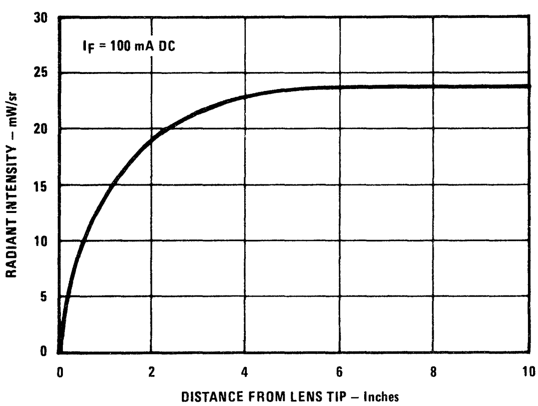
The first method is radiant power output (P_O or E_e), sometimes called total power. A strict interpretation of P_O is that the total amount of radiation exiting the package in any direction should be measured. TRW has interpreted radiant power output to be only that radiation which exits the package in a direction useful to most customers. The measurement includes only that radiation collected by a flat surface detector near the lens tip and orthogonal to the lens axis. Radiation emitted from the sides or back of the package and surface reflections from the detector are not collected. Therefore, TRW devices are conservatively rated (sometimes by a factor of 2 depending on the device type) when compared to devices which are measured differently by other manufacturers. For instance, P_O readings for the narrow (15° between half power points) radiation pattern OP295 are typically 60% higher when using a parabolic reflector than when using the standard TRW P_O test fixture.

P_O measurements are normally useful only for devices which have wide radiation patterns because the primary application is in providing a relatively even intensity over a large area. Radiation which exits the side or back of the package is not useful without external reflectors; and if external reflectors are added, there are intensity peaks in the radiation pattern which are detrimental in most applications.

The second major way to measure power is on-axis intensity. This is done by measuring the power incident upon a specified area. The most common method is to provide a fixture which has a fixed distance from the device to an aperture of precisely known area which is placed in front of a detector. This measured power can then be specified as average power per unit area (both $E_e(APT)$ and P_A are equivalent and the unit of measure is normally mW/cm^2) or as average power per unit cone angle (I_e; where the unit of measure is mW/sr).

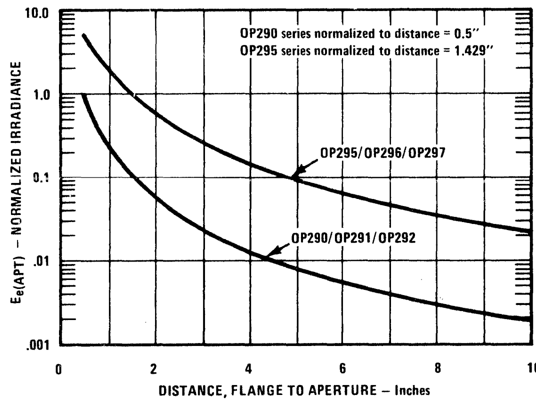
Most LEDs cannot be modeled as a point or discrete source except at distances which are very large compared to the package dimensions and/or optical dimensions. Thus, the foundation assumption in spherical calcaulations (using mW/sr) is invalid and attempts to use this model can lead to errors. Therefore, the calculated value of I_e is dependent upon distance for most applications, and a design engineer can be misled by the mathematical model into assuming that I_e is a constant regardless of distance. Note in Figure 7 how the mW/sr becomes consistent at approximately 6 inch separation.

Figure 7. Output Intensity in mW/sr vs. Distance from Lens Side of Mount Flange on T–1 3/4 Package



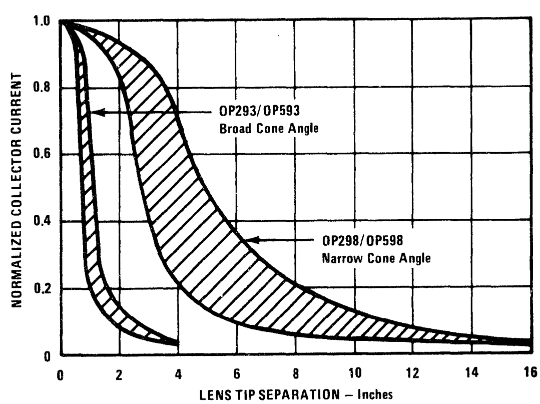
TRW has chosen to use $E_e(APT)$ or P_A rather than I_e for devices which don't have a virtual source that is distance independent. This is the preferred parameter because a simple performance graph can then show how $E_e(APT)$ varies with distance as shown in Figure 8.

Figure 8. Output Intensity in mW/cm^2 vs. Distance from Lens Tip on T–1 3/4 Package



$E_e(APT)$ measurements have historically been made only for narrow radiation pattern devices because their major application is to have a high on-axis intensity for good coupling efficiency with a small sensing area photodetector (see Figure 9).

Figure 9. Coupling Characteristics of Plastic TO-46 Phototransistor and GaAlAs IR LED vs. Separation Between Lens Tips



However, TRW is now using the measurement parameter with wide radiation pattern devices also. $E_e(APT)$ is a key design parameter when the distance and aperture are chosen to give maximum useful information. The distance is chosen so two criteria are met: first, all intensity peaks should fall within the aperture opening for devices with normal optics; and second, the distance should be at a maximum with the constraint that the intensity does not vary more than 10% from point to point within the aperture opening for normal devices. Aperture size is typically chosen so that it is slightly larger than the lens diameter of a detector which is mechanically matched to the dimensions of the LED. This provides the user with a mechanical alignment tolerance as well as the average power intensity within the aperture. Figures 10A, 10B, and 10C show information from the T–1 3/4 data sheet.

Figure 10A. Outline Drawing from OP293/298 GaAlAs Data Sheet

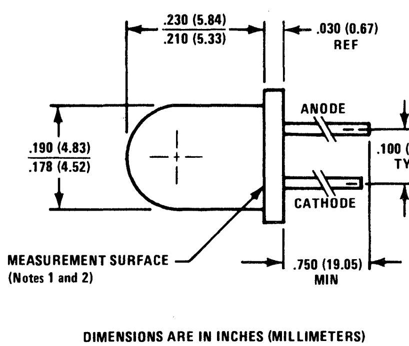


Figure 10B. Beam Pattern of OP293

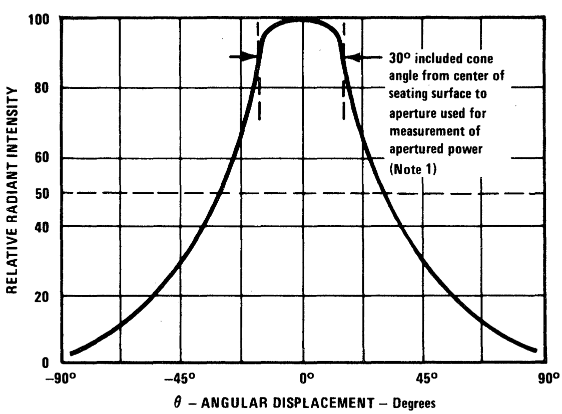
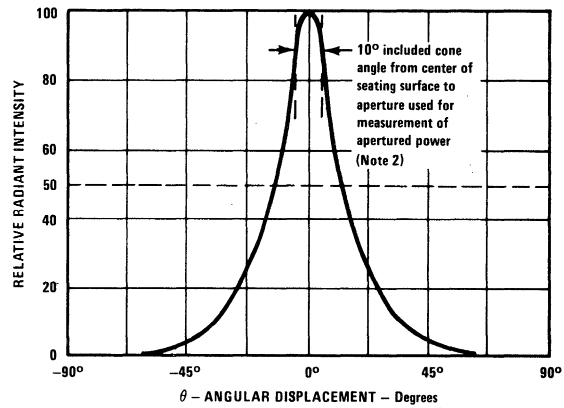


Figure 10C. Beam Pattern of OP298



Notes to Figures 10A, 10B, and 10C:

(1) $E_{e(APT)}$ is a measurement of the average apertured radiant energy incident upon a sensing area 0.250" (6.35 mm) in diameter perpendicular to and centered on the mechanical axis of the lens and 0.500" (1.27 mm) from the measurement surface. $E_{e(APT)}$ is not necessarily uniform within the measured area.

(2) $E_{e(APT)}$ is a measurement of the average apertured radiant energy incident upon a sensing area 0.250" (6.35 mm) in diameter perpendicular to and centered on the mechanical axis of the lens and 1.429" (36.30 mm) from the measurement surface. $E_{e(APT)}$ is not necessarily uniform within the measured area.

Conclusion

Power measurement of LEDs varies more than any other parameter between different manufacturers. Part of the difference is in interpretation of the definitions of the parameters measured and part is the technique used. Users should be able to predict how devices will work in their application by using data sheet information, and this bulletin should be useful to that end.

Kirk Bailey
Product Engineer,
Discrete LEDs and Sensors

Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958

Optoelectronics Division
TRW Electronic Components Group

Application Bulletin 119
January 1985

A comparison of plastic versus metal packaging for infrared sensors and emitters.

Introduction

Recent advances in optoelectronic packaging technology have resulted in the development of plastic infrared sensors and emitters which are in many ways superior to their metal counterparts. While the metal package is still the right choice for some applications, plastic devices offer decided advantages in cost, output power, reliability, power dissipation, and optical quality. This application bulletin will compare the two packages and show how the better performance of the plastic part is obtained.

Cost

The lower cost of the plastic package is a result of reduced labor costs (due mainly to automation of the assembly process) and reduced materials cost. Plastic device construction lends itself to automation, and the expensively tooled piece parts characteristic of metal devices are simply not required.

Mounting the chip and attaching the bond wire are two of the most labor intensive phases in the manual assembly of optoelectronic semiconductors. The problem is especially acute for LEDs as the chips are small and relatively delicate, and they must be mounted in a reflective well to utilize their lateral emission. Automation of these processes requires extremely precise mechanical placement, which is difficult with the individual headers used in metal devices. In contrast, the "strip" lead frame (Figure 1) used in making plastic devices can be stepped through automatic chip mount and wire bond machines so that precision locating of the mounting surface is readily performed.

Figure 1A. IR LED 20 Unit Lead Frame

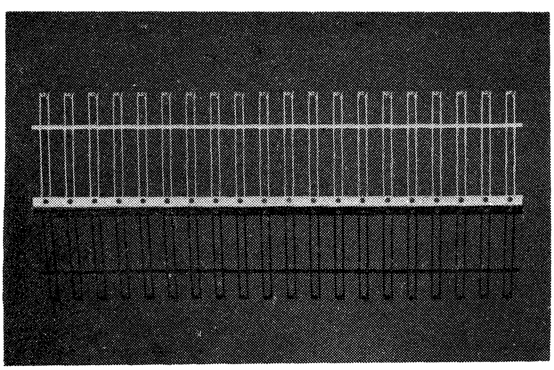


Figure 1B. Detail Enlargement of LED Chip Mounting Area

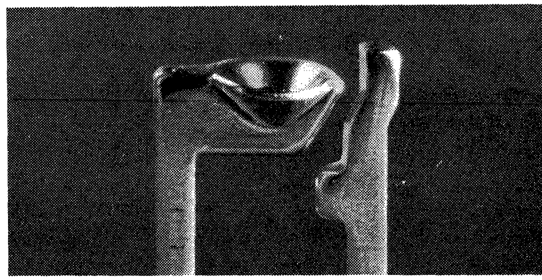


Figure 2A shows the detail of an IR LED that has been mounted, bonded and coated with the silicone gel that enhances the energy emitted. Figures 2B, 2C, and 2D show examples of the production machines used for hand mounting, semiautomatic mounting, and fully automated mounting of the IR LED chips on different headers or lead frames.

Figure 2A. Detail of Mounted and Bonded Chip

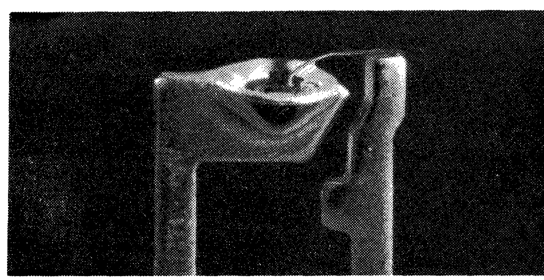


Figure 2B. Hand Mount Station ≈ 100 units/hour

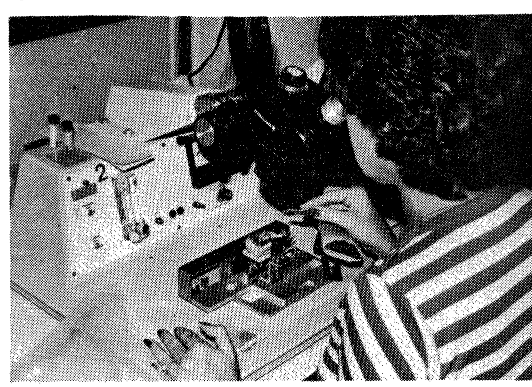


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Figure 2C. **Semi-automated Mount Station ≈ 500 units/hour**

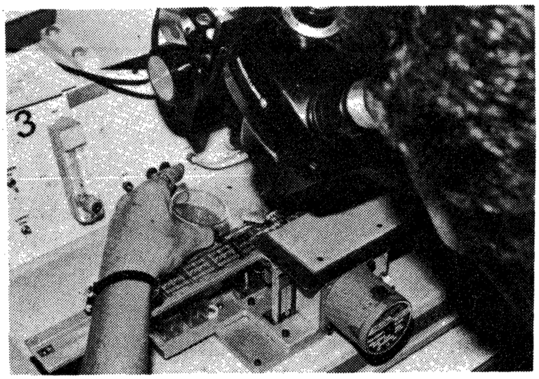
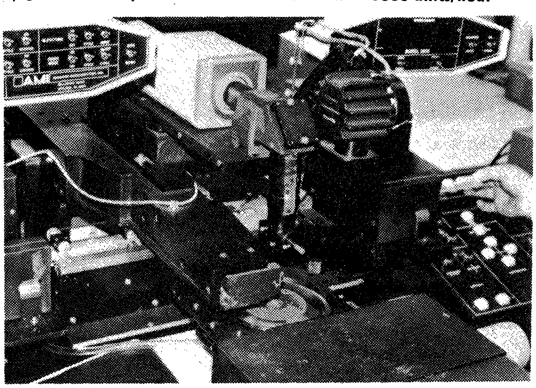


Figure 2D. **Fully Automated Mount Station ≈ 5000 units/hour**

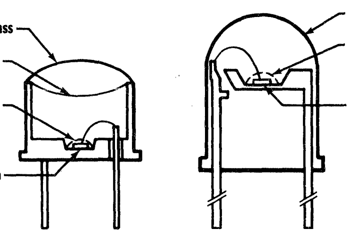


The initial cost of an automatic chip mount machine (Figure 2) or automatic bonder is high but the dramatic increase in throughput results in an overall cost reduction for the finished part. For example, manually dispensing conductive epoxy onto the lead frame and mounting the chip with tweezers produces typically 100 units per hour. Partial automation, by mechanically indexing the lead frame into position for a manual mount operation, increases this to about 500 units per hour. Fully automating the process results in 5000 to 6000 units per hour.

Output Power

A typical plastic LED has approximately 40% more output power than its metal equivalent (see Table I). There are two reasons for this. One is that metal LED headers allow some of the chip's output power to be radiated into the opaque wall of the package. Perfect reflectivity at these surfaces is not attainable and much of this radiation is absorbed before it can escape through the lens. The other problem with the metal package is that the lens has two surfaces. Some of the optical radiation which does reach the lens is reflected back into the package and absorbed. Figure 3 shows a comparison of the optical properties of the two package types.

Figure 3. Optical Interfaces in Metal and Plastic Packages for IR LED



The following table shows a comparison of total output power on the metal package and the mechanically equivalent plastic package.

Table 1. Output Power (P_O) in Metal and Plastic Packages @ I_F = 100 mA

Device Type		P_O
Metal TO-46	Low Range	8.0 mW
	Mid Range	10.0 mW
	High Range	12.0 mW
Plastic TO-46	Low Range	12.0 mW
	Mid Range	15.0 mW
	High Range	18.0 mW

Power Dissipation

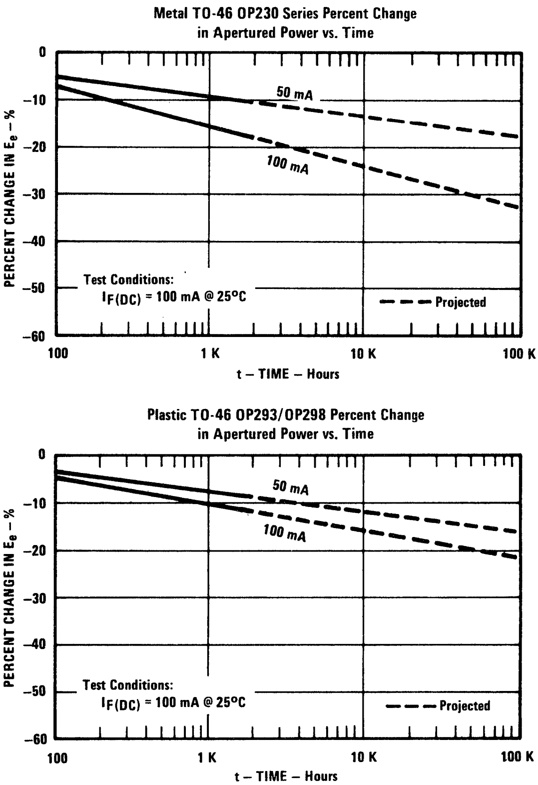
The power dissipation rating for a device is a function of its thermal impedance, which is the ability of the package to get rid of heat generated by the chip. This varies from a maximum with an infinite heat sink to a minimum with no heat sink. (Applications Bulletin 121 covers in detail the techniques used to measure these quantities.) In practice, TO-46 LEDs, TO-18 sensors, and their plastic equivalents are used in a socket or soldered in a PC board; this results in a thermal impedance somewhere between the two extremes. The primary heat flow path for a device under these conditions is via the leads, and some heat sinking is provided by the socket or PC board.

Since the leads of plastic devices have a larger cross-sectional area (.020" x .020" vs. .017" dia.) and are made from a more thermally conductive material (copper-silver vs. nickel-iron alloy), the thermal path of the plastic part is normally about 40% better than that of its metal equivalent. This results in significantly improved power dissipation ratings for the plastic part. Infinite heat sink ratings will show the metal part to be equal or superior since these ratings take advantage of the better thermal conductivity of the metal package body; however, since a heat sink is rarely used, the plastic part usually offers better thermal performance.

Reliability

In optoelectronic technology the two main reliability considerations are long term LED degradation and catastrophic failure of LEDs or sensors due to thermal and mechanical stress. In the case of long term LED degradation, the plastic device has a definite advantage due to its improved power dissipation characteristics and the lower junction temperatures which result. Figure 4 shows life test data for the metal OP231 and the plastic equivalent OP298 operated at 100 mA.

Figure 4. Operating Life Test Data on Metal and Plastic TO-46 Packages



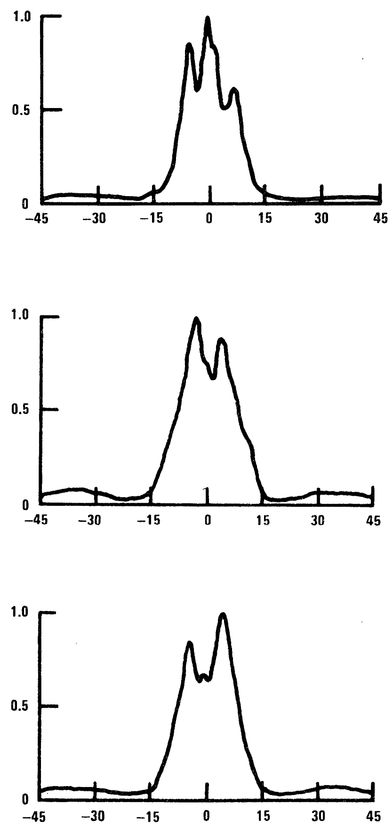
Catastrophic failure due to thermal or mechanical stress, which usually occurs early in the operating life of a device, results from forces on the chip or bond wire which can dismount or delaminate that chip, disconnect the wire bond, or break the bond wire. The design of the metal part gives it the advantage here as there are no such forces on the chip or bond wire. However, the machine fabrication of the plastic part is very repeatable and mechanically accurate so that there are fewer failures due to assembly variables. In the end, neither part has a clear cut advantage with respect to catastrophic failures. Historical data generated by the TRW Quality Assurance group supports this conclusion.

Optical Quality

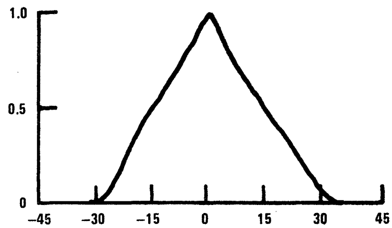
Lens performance is especially important for LEDs and in this respect the plastic part is distinctly superior. The automated chip placement is a contributing factor since inaccurate placement of the LED chip in its reflective well can cause power loss and a deviation between the optical and mechanical axes of the finished part. However, the most significant factor is the lens itself. In the plastic lens there is only one surface, which is controlled by the precisely machined and polished surface in which it is cast or molded. The glass lens used in metal packages is flame polished from a molded glass pellet, and the resulting lens exhibits variations in focal length and surface curvature so that the radiation pattern of the finished part is difficult to control. Figure 5 shows typical radiation patterns for OP131/OP231 metal parts and OP293 plastic parts. This illustrates the improved consistency of the plastic lens.

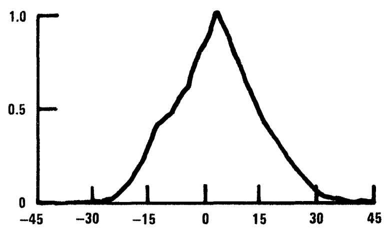
Figure 5. Radiation Patterns on Metal and Plastic TO-46 Packages

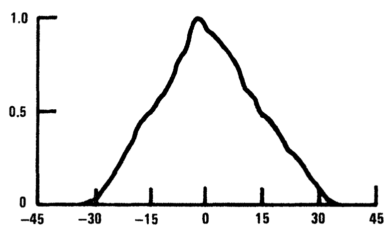
OP131/OP231 Metal TO-46



OP298 Plastic TO-46







Hermeticity

The metal packages of the TO-18 or TO-46 type can be leak tested utilizing the helium or radioactive systems and show a decided advantage in that they are hermetic. The seal or leak rate on the plastic parts is primarily a function of leak path. The moisture or harmful material must traverse along the lead/plastic interface from the outside world to the junction of the chip. Normally moisture is considered the culprit since increased leakage is the problem. The problem is much more severe on a phototransistor since it is operated with a reverse bias on the collector-base junction; increased leakage will result in a higher "off" level, with a decrease in gain in the "on" level. The small leakage due to non-hermeticity is not as big a problem on LEDs since they operate in the forward mode and increased leakage will appear as a very slight reduction in energy transmitted. Metal units offer an advantage in hermeticity. This primarily pertains to the receiver or sensor and is not a major factor in the LED.

Temperature Range

The normal temperature range for metal can type parts has been set from −55°C to +150°C. These limits are somewhat arbitrary but will satisfy what is required. They primarily come from limitations in a silicon transistor in that h_{FE} decreases with decreasing temperature and I_{CEO} increases with increasing temperature. The same temperature characteristics were utilized on metal can LEDs.

The primary stress mechanism with plastic parts is the result of "glass transition". This is the temperature at which plastic starts a recure cycle. The stresses that result are thermal expansion mismatches which can shear the chip from mount or shear the bond wire. In early plastics utilized in opto components, this "glass transition" occurred in the 100—110°C range. The maximum temperature was specified at 85°C, and sometimes to 100°C range. Improvement in plastics has now raised this to the 125-130°C range. Recent ratings reflect this in allowing a maximum package temperature of 100°C while allowing the chip to attain a 125°C temperature. The poor thermal conductivity of the plastic keeps it well below 125°C. In the future, this trend should continue, eventually allowing metal and plastic parts to carry the same ratings. At the present time, however, the advantage on temperature range remains with the metal can.

Solvents Affecting Plastic

The plastics used for TRW Optoelectronics' devices are epoxies. These are thermosetting materials which have excellent solvent resistances. They are considered to be not harmed by most acids, hydroxides, soaps and detergents. Exposures to alcohols, gasoline, and most industrial solvents are non-detrimental. However, acetone and xylene are two common solvents which should be avoided. Prolonged exposure to sodium and potassium hydroxides should likewise be avoided.

For purposes of cleaning or similar short term exposures, the plastic devices can be considered tolerant of any standard chemical that doesn't show obvious attack on a test sample. For long term exposures, such as immersed applications, contact the factory for more information.

Conclusion

A thorough analysis of the evidence shows that improved materials, processes, and automation give plastic housings a decided advantage over their metal counterparts for opto sensors and LEDs in most applications. Their use can reduce costs, provide improved reliability through longer life, and offer increased infrared power output. In summary, the plastic packages represent a significant technological advantage over their metal can predecessors.

Martin McCrorey
Characterization Laboratory Manager

TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958

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Optoelectronics Division
TRW Electronic Components Group

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Designing a "Wide-Gap Optical Switch" using an OP293/OP298 (plastic TO-46 equivalent) LED and OP593/OP598 (plastic TO-18 equivalent) phototransistor.

Introduction

The application described here is commonly referred to as "object presence" sensing. It is the use of a single pair of active components, (LED and sensor) to sense the interruption of an optical path by an "opaque" object. This type of beam interrupt switch is applied in industrial controls and computer peripherals to signal:

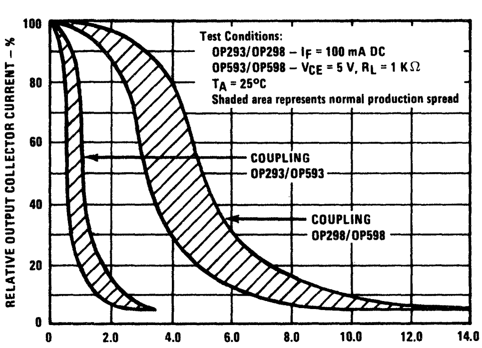
- seating of tape cartridge
- door position on disk drives
- obstructions of document paths
- conveyor feed rates

Compared to many encoder type switches this application is simpler from the standpoint of speed and resolution requirements. It can, however, have its own set of challenging design considerations depending on the length of the optical path and the constraints of performance, environment, and cost. This example is intended to illustrate the major design variables of a relatively long optical path switch and how the information of the component data sheet can be used to choose and apply the parts.

"The Gap"

Many off-the-shelf optical components are easily applied in short-gap switches because their inherent coupling characteristics produce a useable signal over a wide range of drive and mounting conditions. As the gap widens, the coupling of light between the emitter and sensor drops off rapidly and an appreciation of techniques for optimizing performance is critical. The coupling curve from the OP293/OP298 data sheet illustrates the relationship between signal strength and gap width.

Figure 1 – Coupling Characteristics of OP293/OP298 and OP593/OP598 vs. Lens Tip Separation



The more rapid decrease in coupling vs. distance of the OP293/OP593 pair is due to the differences in package lenses which produce a wider beam angle.

Other package types have similar coupling curves, most decreasing with distance more rapidly than this family of parts. The OP298/OP598 pair will be used for the example because of the superior coupling at longer distances.

All the performance optimizing techniques are tied to the clear definition of system constraints and minimizing both electrical and mechanical tolerances.

"Black Box"

The "system" level of the application should be as clearly defined as possible to enable definition of mechanical tolerances, ambient conditions, and output limits.

The "Black Box" is defined by a package outline, an electrical schematic and some environmental conditions.

Figures 2, 3 and 4 completely define the requirements of the system.

Figure 2 – Package Outline

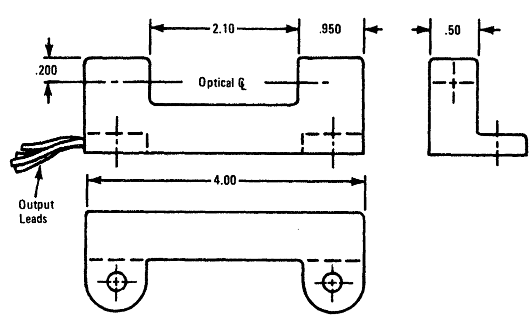


Figure 3 – Schematic/Drive

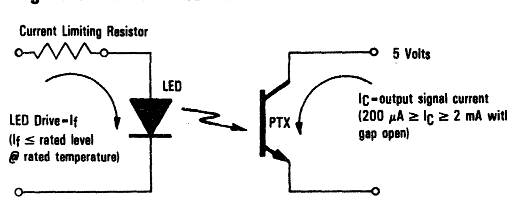


Figure 4 – Operating Conditions

Operating Temperature Range . . . . (0°C to 55°C)
Voltage Supply Tolerance . . . . (±10%)
Required Operating Life . . . . 50K Hours

Other ambient conditions: To simplify the example, assume a relatively clean environment and one in which ambient light conditions will not produce errors in the output signal. Both of these conditions can be addressed with filters over the devices and additional performance tolerances.

Basic Guidelines

To ensure that the system will work over the full range of operating conditions and will also be manufacturable, some trade-offs and tolerances must be introduced. As with every other circuit, the performance variations versus temperature, life, and supply voltage are considered. The optically coupled circuit has the additional tolerance associated with the beam alignment of the LED and sensor.

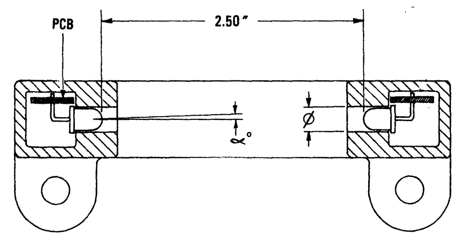
Oftentimes the single largest tolerance of the optical (infrared) switch design is associated with the degradation of LED power output over time. By nature, the efficiency of either GaAs or GaAlAs LEDs decreases with use and is directly proportional to both drive current and operating temperature. Since the "Black Box" definition fixed the temperature range, the degradation tolerance can be minimized only by minimizing the drive level. The other system components can be considered to have virtually no performance change with time in a clean environment.

The Coupled Pair

The basic tasks of the switch design are selection of a component pair which will meet the black box conditions and encasing the pair in a manner which will optimize long-term performance. The packaging scheme will define the exact lens-to-lens spacing, the beam alignment accuracy, and the components' heat sinking conditions that dictate power dissipation.

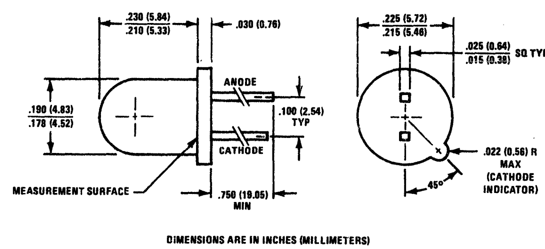
Figure 5 shows a section view of the switch with the components mounted on a printed circuit board and held in alignment by cylindrical plastic cavities. The lenses of the parts are recessed in the cavities. This increase in the lens-to-lens spacing will decrease the coupling slightly; but, the aperturing effect of the cylinders will limit the beam angle of the parts and help reduce reflections or the sensing of light from other sources which could give erroneous signals. Additional stray light protection could be provided if required by making changes in interfering surfaces or by aperturing.

Figure 5 – Mechanical Design



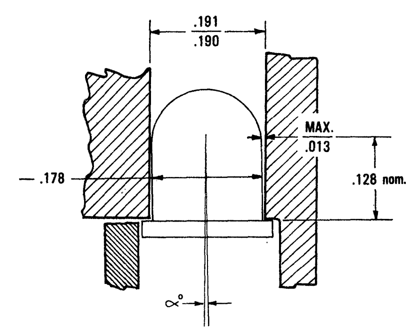
The mechanical alignment of the components will depend primarily on three tolerances, (1) the diameter of the LED and sensor package, (2) the diameter of the cylindrical cavities, and (3) the straightness or flatness of the housing which maintains the beam axis.

Figure 6 – Package Tolerance



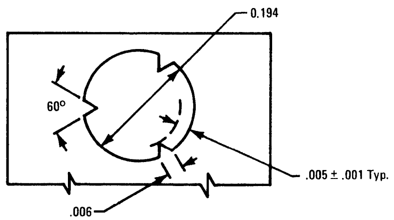
From the data sheet of the OP298 and OP598 (figure 6), the discrete package tolerance is ±.006 inches for both LED and sensor. Figure 7 shows the possible beam misalignment attributable to the worst case dimensions of the component and housing if the cavity is made to fit the largest possible package. It is assumed the cylindrical cavity can be molded to a tolerance of ±.0005 inches.

Figure 7 – Package Misalignment



In practice, an improvement can be made on the fit of the components by introducing details in the cavities which make use of the plastic's flexibility. Even with glass filled material, the addition of small ribs along the cavity walls will hold the smaller diameter components in better alignment and can compress to allow a press fit of the larger parts.

Figure 8 – Tightening Ribs



The tightening ribs shown in figure 8, reduce the diameter mismatch to (.184 – .178) = .006 max. reducing the optical axis displacement to:

$$\tan^{-1} \frac{.006}{.128} \approx 2.9°$$

The misalignment associated with curvature of the housing will depend on the method of construction; however, for a molded plastic housing of this size it would be fair to assume a flatness of .005 inch. Over the optical path of (2.50 inches) this warp should not contribute more than $\approx \tan^{-1} \frac{.005}{2.50} \approx .11°$ shift off axis. With this addition to the shift from the cavity tolerance, it can be assumed the LED or sensor could be misaligned as much as four degrees (3°).

Power Requirements

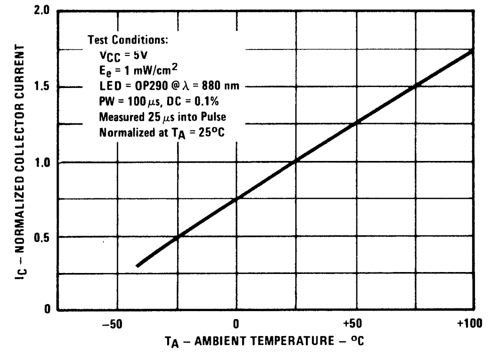
The ratings of the OP598 are given in terms of milliamps (mA) of collector current when irradiated by a tungsten source of 5 mW/cm² and supply voltage of 5 volts. The data sheet characteristics, together with the "black box" constraints, enable calculation of the power required from the LED.

The tolerances to be considered for the transistor's power requirements are associated with collector current changes with temperature and optical axis alignment.

The shift in spectral response of the transistor and spectral emission of the LED over temperature are relatively minor tolerances here but may need to be considered in designs with broader temperature ranges.

The data sheet curve for normalized collector current vs. temperature (figure 9), indicates an increase of one percent per degree Celsius, in a pulsed mode. The low current requirements of this design will not contribute enough heating to warrant adjustments to this curve. However, in a conservative design, this temperature characteristic should not be used as a factor that completely compensates for the opposite temperature effect of the LED. The temperature sensitivity is dependent on the transistor's electrical gain and can vary significantly. The curve can be used as a worst-case tolerance, (25%) at the low temperature of this design.

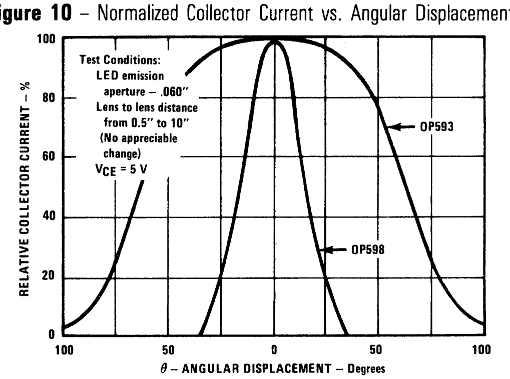
Figure 9 – Normalized Collector Current vs. Ambient Temperature



The worst-case optical axis misalignment has already been calculated to be four degrees (3°). Its effect can be estimated from the curve of normalized collector current vs. angular displacement, figure 10. The narrow beam of the OP598 makes the part more sensitive than the OP593 to misalignment (dropping ≈ 15%) but this does not outweigh the rated performance advantage of more than two to one.

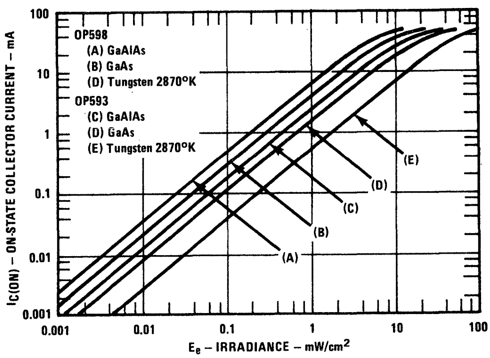
In contrast to many hermetic devices, the molded optics of the OP598 is very consistent. The beam pattern graph, therefore, accurately represents performance and requires no additional tolerancing.

Figure 10 – Normalized Collector Current vs. Angular Displacement



To find the basic radiant power requirement, the data sheet's tungsten test rating must be converted to one which reflects the transistor's sensitivity to the GaAlAs emission of the OP298. Figure 11 shows how the collector current varies with power intensity and the type of source used.

Figure 11 – OP593/OP598 I_C vs. Irradiance



Curves A, B and D represent the typical response of the OP598 to GaAlAs, GaAs and tungsten sources respectively.

Curves C, D and E show the OP593 collector current variation vs. power for each source.

The tungsten response curve of the OP598 (curve D), intersects the irradiance level of 5 mW/cm² at a current level of between seven and eight milliamps. This curve, therefore, reflects the minimum response of the highest range part (OP598A), or the middle of the rated response range for the OP598B. Direct calculation from the data of the curve, therefore, will insure performance estimates that are representative of a relatively wide distribution of the available components.

The parallel relationship of these curves can be translated into a convenient conversion ratio between each source. To determine the required power from each source for a given current level, the following conversions apply:

- tungsten to GaAs – divide by 1.50,
- tungsten to GaAlAs – divide by 2.55,
- GaAs to GaAlAs – divide by 1.70.

The power required to drive the transistor at the system's minimum limit of 200 μA can now be calculated.

Applying the initial tolerances to the minimum limit

- 25% for temperature effects,
- 15% for axis misalignment,
- 10% power supply and measurement accuracies,

establishes a new limit of (200 μA) (1.75) = 350 μA.

The curve of figure 11 for tungsten intersects 350 μA at a radiant power level of about 250 μW/cm².

Applying the conversion factor for GaAlAs, the power requirement is reduced to approximately 100 μW/cm², which corresponds closely to the top curve of figure 11.

LED Drive

The ratings for the OP298 LED, like that of the OP598, establish performance limits at one set of conditions. The calculated power requirement of the transistor, together with the data sheet information, will be used to determine the minimum drive current for the OP298.

Tolerances we can apply to the LED without knowing how it will be operated, include:

- coupling vs. gap width,
- I_f vs. supply tolerance,
- axis misalignment,
- effects of ambient temperature.

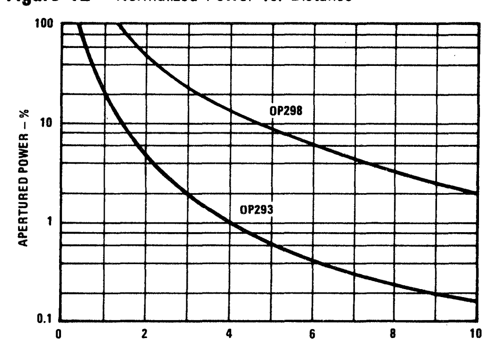
The effects of power degradation with life and device heating require some knowledge of the operating current level.

Figure 12, Normalized Power vs. Distance, provides a conversion factor from the data sheet test distance to the applications gap distance. Since the curves reflect the spacing from the sensor to the LED flange, add the package length of .22 inches to the optical path length of 2.50 inches for conversion.

At the distance of 2.72 inches, the OP298 retains about 30% of its rated power intensity. The similarity in size between the data sheet aperture (.25") and the applications sensor diameter should make this conversion very accurate.

It is obvious from this figure why the narrow beam OP298 was chosen over the wider beam OP293. With the gap separation of this system, the OP293 retains only 2.5% of its rated power.

Figure 12 – Normalized Power vs. Distance

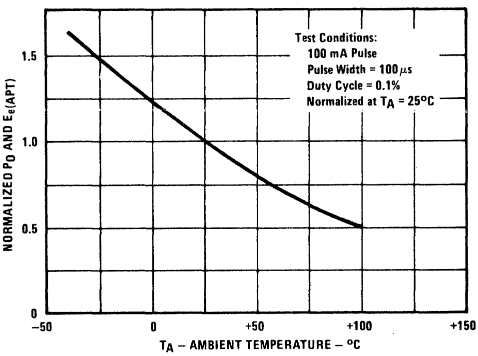


Assuming the LED current will be controlled by the five (5) volt supply and a limiting resistor, a notable tolerance results. Even with a quality resistor, the variation of the LED's forward voltage vs. current can produce a 15% drive current tolerance for a 10% voltage supply tolerance.

The axis misalignment from the mechanical design has been calculated to be 3° worst case. As with OP598, the effect on coupling will be in the range of 15%.

The system's ambient temperature range contributes a power tolerance of 25% at the upper limit of 55°C, as shown in figure 13.

Figure 13 – Normalized P_O and $E_{e(APT)}$ vs. Ambient Temperature



With these tolerance factors (15% axis misalignment; 15% power supply tolerance; and, 25% ambient temperature limit) and the power requirement of 100 μW/cm², the data sheet ratings can now be used.

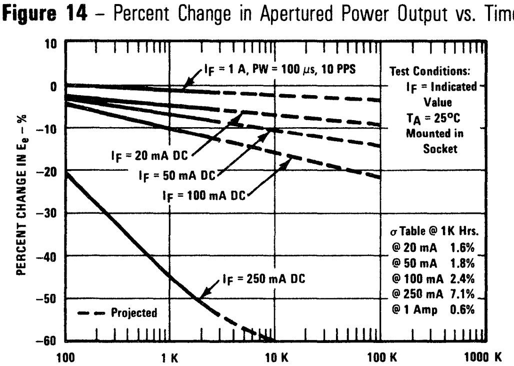
Taking the initial estimate of power required by the sensor (100 μW/cm²), we can apply these first tolerances.

$100\ \mu W/cm^2 \times (85\% \times 85\% \times 75\%)^{-1} = 100\ \mu W/cm^2 \times (1.85) = 185\ \mu W/cm^2$

This is the amount of power intensity which would be required at the data sheet's test distance of 1.425 inches. As was shown on figure 12, an IRLED at the designed gap would have only 30% of power measured at 1.425 inches. To convert for this 70% drop with distance, divide by 0.3. Thus
P min @ (2.75″) = 617 μW/cm²

Referring to figure 14, it is evident from the curves of "Apertured Power Output vs. Time" that regardless of drive level, some decrease in available power must be accommodated as the unit is operated. To minimize this degradation effect, it will be important to select the lowest useable drive.

Figure 14 – Percent Change in Apertured Power Output vs. Time



In another application with more demanding temperature requirements or less available heat sinking capacity, the upper limit of the LED drive may be dictated by the power dissipation rating. Note 1 of the data sheet shows, however, that the maximum continuous current can be applied up to 62.5°C with PC board heat sinking.

To get a rough idea of the design tolerance for degradation, follow the curve labeled 50 mA DC to the intersection at 50,000 hours (or approximately six years) of operation. The average unit will show a decrease in power of roughly 14% if operated at 25°C. The sigma (σ) table at the side of the curve indicates an additional 1.8% degradation for each standard deviation of distribution from this average. Each curve will run approximately parallel to the average curve through the 50,000 hour point.

Add three standard deviation percentages (3σ) to the 14% to estimate the degradation of the full distribution of components.
$14\% + (3) \times (1.8) = 19.4\%$

To again take a conservative approach, assume the average temperature is 40°C rather than the 25°C illustrated by the curves of figure 14.

Characteristic data has shown that less degradation will occur from conditions of low current/high temperature than from high current/low temperature. Therefore, use the later condition as a model for the former and build in some safety factor. It should be kept in mind, however, that making degradation calculations with a higher current model is a very conservative approach, especially when working from the minimum ratings of the device.

From the thermal parameters of the OP298 data sheet, find the "normal" heat sinked thermal resistance of
$R_{THJA} = 188°C/Watt$.

With an average ambient temperature of 40°C, it is necessary to reflect a temperature rise of
$40°C - 25°C = 15°C$.

To raise the junction temperature by 15°C it is necessary to have a power dissipation increase of
$15°C/188°C/watt \approx .080$ watts.

With an LED forward voltage of 1.6 volts, the increase in forward current associated with this power would be
80 mW/1.6 volts = 50 mA.

Therefore, use the 100 mA degradation curve to simulate the system if the average ambient temperature is 40°C and the drive current is 50 mA.

At the 50,000 hour point, the 100 mA curve shows an average degradation of 20% and each standard deviation produces an additional 2.4%.

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For the full distribution of components, therefore, the maximum degradation should be 20% + (3) (2.4%) = 27.2%.

An additional temperature related power tolerance needs to be included in the calculation which will enable the conversion from the pulsed power rating at 25°C to a direct continuous current rating at the upper operating limit of 55°C.

Refer to the curve of figure 13, "Normalized Apertured Power vs. Temperature," and the thermal resistance rating to make this conversion.

Choosing again an operating point of 50 mA and noting that the worst-case forward voltage is 2.0 volts, the maximum power dissipation would be
$P_d = (.050)\ (2.0) = .100$ watts.

Using the thermal resistance of 188°C/watt, the temperature rise of the junction would be
$T_{JA} = (.100)\ (188°C) = 18.8°C$.

It can be assumed that this junction temperature rise at an ambient temperature of 25°C and 100 mA DC would have essentially the same effect as an ambient rise of 18.8°C in the pulsed condition.

From the curve of figure 13, we can see the effect is to reduce the available power by approximately 18%.

Combination of all these tolerances allows calculation of a drive level which accommodates six years of continuous operation over the full temperature range. Adding these tolerances, 27.2 percent for degradation, and 18 percent for junction temperature rise indicates that at least 60 percent of the initial power will be available at "end of life."

The baseline power must first be calculated at the selected drive level of 50 mA using the minimum ratings of the data sheet.

IRLED is rated at 3.6 mW/cm^2 with a drive of 100 mA. Since the relationship between current and power is relatively linear in this range of operation, the power at 50 mA drive will be about one-half that at 100 mA, or 1.8 mW/cm^2.

Then applying the tolerances from heat and degradation
(1.8 mW/cm^2) × (60%) = 1080 μW/cm^2

This is the minimum power the LED will provide over its full life and under worst-case conditions.

We can compare this figure with the power we calculated as the minimum required by the sensor, 617 μW/cm^2. Even with all the conservative design assumptions, the 50 mA drive level provides more than the necessary power.

The designer can, at this point, choose to further reduce the drive of the LED to enhance the operating life or maintain the margin for the sake of broadening the distribution of useable components. This can oftentimes be a cost consideration since price is usually directly proportional to power rating.

Conclusions

It should be kept in mind that throughout these calculations, most worst-case conditions were applied simultaneously, resulting in a very conservative design. The example shows that under certain conditions these components can be easily applied in switches which span several inches without straining the limits of performance.

The narrow beam components OP598/OP298 in particular are applicable in a wide range of configurations.

T. E. Eichenberger
Section Manager – Assemblies Engineering

Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958

TRW

Application Bulletin 121
January 1985

The successful design engineer has a clear understanding of the thermal impedance of the optical semiconductor. This understanding allows reliable system design that encompasses the dissipation rating of the optical semiconductor.

Introduction

The maximum power dissipation rating for a semiconductor device is usually defined as the largest amount of power which can be dissipated by the device without exceeding safe operating conditions. This quantity of power is a function of:

1. Ambient temperature
2. The maximum junction temperature considered safe for the particular device
3. The increase in junction temperature above ambient temperature per unit of power dissipation for the device package in a given mounting configuration

Item 3 is called thermal impedance and is determined in the lab with techniques such as those described in this bulletin. Item 2 is determined from reliability experiments and is usually considered to be 150°C, although it may be lower due to temperature limits imposed by the package material. Item 1 results in lower power dissipation ratings at higher ambient temperatures as described by derating curves, also described in this bulletin.

Thermal Impedance Calculations

The formula for calculating thermal impedance is

$$R_{THJA} = \frac{T_J - T_A}{P_D}$$

where: R_{THJA} = thermal impedance, junction to ambient (also called θ_{JA}); units are $\frac{°C}{Watt}$

T_J = junction temperature of the device under test
T_A = ambient air temperature
P_D = device power dissipation

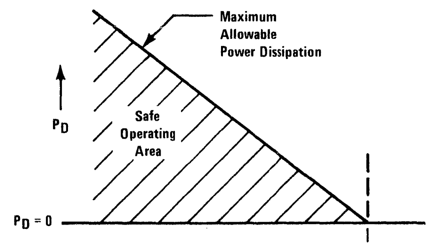
R_{THJA} refers to the thermal impedance of a device with no heat sink, suspended in still air on thermally non-conductive leads. This is the worst case (highest value) for thermal impedance.

To calculate the maximum allowable power dissipation, we substitute numbers for R_{THJA} (measured in the lab) and T_J (using the maximum value determined from reliability experiments) then rearrange terms to get

$$P_{D(MAX)} = \frac{T_{J(MAX)} - T_A}{R_{THJA}}$$

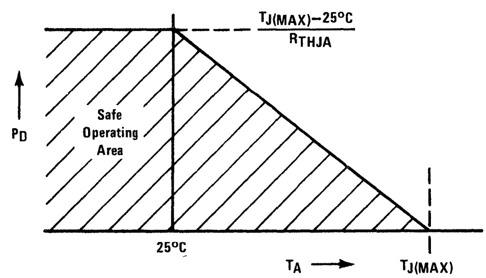
This results in a linear power dissipation rating curve which intercepts zero power dissipation at $T_A = T_{J(MAX)}$, and with a slope which is $-1/R_{THJA}$ as shown in Figure 1A:

Figure 1A. Initial Thermal Derating Curve



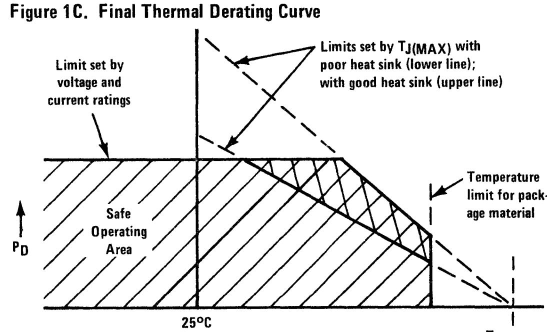
The usual (and conservative) method of rating power dissipation is to limit the curve to the safe value for normal room temperature, which is 25°C. The result is a curve shaped like Figure 1B:

Figure 1B. Thermal Operating Curve from 25°C



Since there are voltage, current, and ambient temperature limitations which are not related to chip temperature, the final power dissipation rating curve (often called a "derating" curve) for a given device might look like the curve shown in Figure 1C:

Figure 1C. Final Thermal Derating Curve



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Since thermal impedance is very nearly constant for different levels of power dissipation, we merely have to measure the junction temperature at a known quantity of power dissipation, then substitute into the right side of the formula:

$$R_{THJA} = \frac{T_J - T_A}{P_D}$$

to find the thermal impedance of the device.

It is important to define the ambient conditions since air movement, lead length, and contact with thermal conductors all affect the measured T_J. The best case (lowest value) of thermal impedance is obtained with an infinite heat sink, i.e. by keeping the entire outside of the device at ambient temperature. Since case temperature equals ambient temperature under these conditions, infinite heat sink thermal impedance is called R_{THJC}, defined as:

$$R_{THJC} = \frac{T_J - T_C}{P_D}$$

where T_C = case temperature. The worst case encountered in real applications involves a device with full-length leads, mounted in a socket with no air movement. Thermal impedance under these conditions is called R_{THJX} and is calculated using the same formula as R_{THJA}. R_{THJX} is used to calculate actual worst case derating curves.

Junction Temperature Measurement

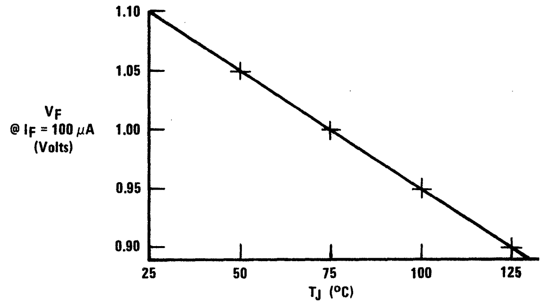
All these calculations depend on having a way to measure junction temperature in a chip while the device is dissipating power. This is done by using the chip as its own thermometer. Forward biased PN junctions have a voltage drop which decreases with temperature; by using a forward current small enough that no significant chip heating occurs, we can measure this voltage drop at known chip temperature simply by varying the ambient temperature of the package. Under these conditions, T_J approximately equals T_A, and we can control and measure T_A. See Table 1 for the junctions used for this measurement.

Table 1. Junctions Used for Measuring Temperature – T_J

Device Type	Junction Biased
LEDs, Diodes	Anode to Cathode
Transistors	Base-emitter or base-collector. If the device normally has no base lead as in phototransistors, special samples must be made with the base bonded out instead of the emitter.
ICs	Reverse bias the substrate (negative to V_{CC} lead, positive to ground).

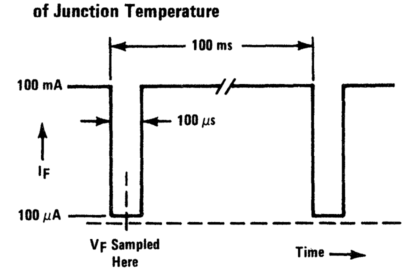
As a result of these measurements, we have a graphic representation of voltage drop versus junction temperature at a known low current. Figure 2A might be typical for an LED:

Figure 2A. Voltage Drop vs. Junction Temperature for IR LED



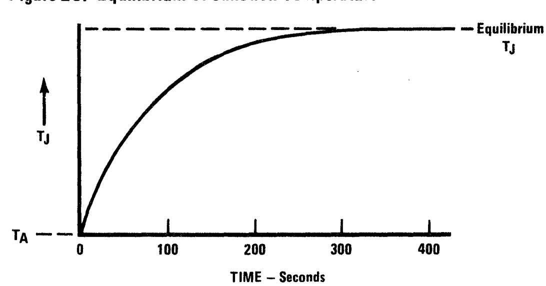
Now to find R_{THJA}, R_{THJX}, or R_{THJC} we place the device in the desired mounting configuration and apply a specific amount of power dissipation to the device, sufficient to provide significant chip heating. The junction temperature is monitored by interrupting the power and substituting the low forward bias current (our "thermometer"), 100 μA for the LED described in Figure 2A. The voltage drop must be measured before the junction has time to cool significantly. We use a 100 μs interruption which is consistent with the thermal time constant of the devices being measured; a sample and hold circuit maintains the reading so it can be recorded with a voltmeter. The applied waveform for the above LED would appear as shown in Figure 2B:

Figure 2B. Timing Cycle for Device Heating and Monitoring of Junction Temperature



Because of the sample and hold circuit, the voltmeter reading reflects the junction temperature of the chip as shown graphically in Figure 2A. For a typical plastic LED, the temperature rises after application of DC power for several minutes as shown in Figure 2C.

Figure 2C. Equilibrium of Junction Temperature



When the voltmeter reading has stopped changing, we (1) substitute the reading back into the graph to get the actual T_J; (2) multiply the large forward current, in this case 100 mA, by the voltage drop on the diode with 100 mA applied, to get the power dissipation; (3) measure the actual T_A; and (4) substitute into the R_{THJA} formula to get a value for thermal impedance.

Example

A typical OP290 infrared emitting diode is found to have V_F characteristics as shown at an I_F Ot 100 μA:

T_A (°C)	V_F (Volts)
25	1.080
50	1.030
75	0.980
100	0.930

It is then connected to a test circuit and immersed in agitated silicone dielectric fluid at a temperature of 25°C; this is a good approximation of an infinite heat sink for a low power device. An I_F of 100 mA is applied. Every 100 ms the I_F is reduced to 100 μA for a period of 100 μs, after which the I_F returns to 100 mA. Using a sample and hold circuit we observe that the V_F of the device during the low current intervals starts cut at 1.080 Volts but rapidly decreases, eventually stabilizing at 1.050 Volts. Interpolating between 1.080 Volts (25°C) and 1.030 Volts (50°C) we find that junction temperature is now 40°C.

The V_F is measured during the 100 mA I_F period and found to be 1.50 Volts. Thus, the power dissipation is 150 mW (99.9 percent of the time). Substituting into the formula,

$$R_{THJA}\text{ (infinite heat sink)} = R_{THJC} = \frac{40-25}{.150} = 100°\text{C/W}$$

When the same test is conducted with the device in still air, mounted in a PC board socket, the final values of V_F are 1.024 at 100 μA and 1.40 at 100 mA. Thus T_J = 53°C and

$$R_{THJX} = \frac{53-25}{.140} = 200°\text{C/W}$$

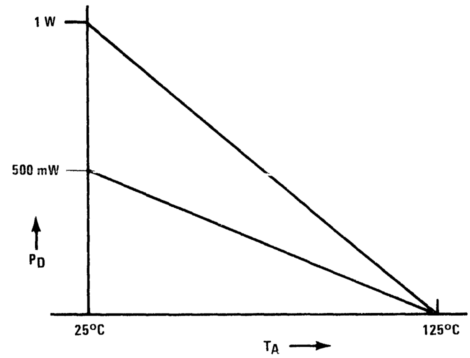
The power derating curves are:

$$P_D = \frac{T_{J(MAX)} - T_X}{R_{THJA}} = \frac{125 - T_A}{100} \text{ with infinite heat sink , and}$$

$$P_D = \frac{125 - T_A}{200} \text{ with no heat sink.}$$

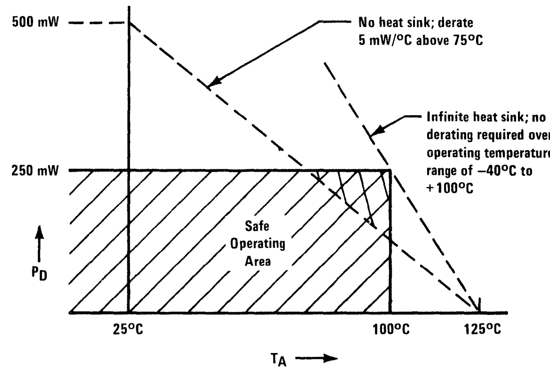
Graphing the derating curve gives two lines as shown in Figure 3A:

Figure 3A. Thermal Derating for "Infinite" and "No" Heat Sink



But the device is limited to 250 mW for reliability reasons, and the plastic package can withstand only 100°C due to the glass transistion temperature of the plastic. Thus, the final power derating curve is shown in Figure 3B:

Figure 3B. Final Thermal Derating



The entire shaded area can be used with an infinite heat sink; the cross-hatched area is forbidden for a device with no heat sink.

Conclusions

Power dissipation ratings for DC operating conditions are calculated with the techniques just described. For a device operated under steady state conditions, these procedures provide a method of establishing operating limits which are consistent with good device reliability. However, under pulsed conditions, the thermal time constants of the device must be considered. For information on the subject of junction heating under pulsed conditions, refer to TRW Application Bulleting 105, "Thermal Behavior of GaAs LEDs".

Martin McCrorey
Characterization Laboratory Manager

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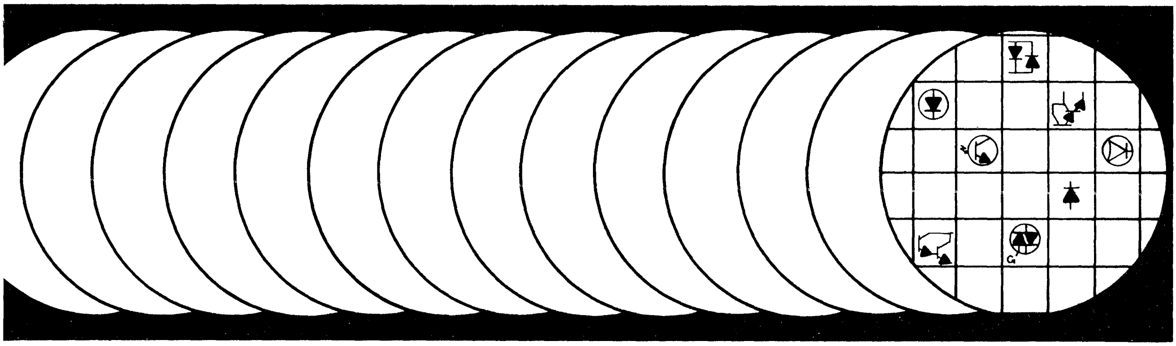
TRW reserves the right to make changes at any time in order to improve design and to supply the best product possible.

Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958



Glossary of Symbols and Terms

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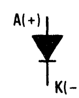
Glossary of Symbols and Terms

Term	Symbol	Description
Acceptance Angle	Θ	The maximum angle which a ray may traverse and still be detected by a photosensor, usually measured from the optical axis.
Acceptance Cone	—	A cone with an included angle such that any ray within the cone will be detected by the sensor and any ray outside will not.
Ambient Temperature	T_A	Temperature of air or liquid surrounding any electrical part or device.
Angstrom	Å	10^{-10} meter; a unit of length sometimes used to describe wavelength of optical radiation.
Anode	A	The positive terminal of a diode, i.e., the terminal which must have a positive voltage relative to the other terminal (cathode) before the device will conduct.
Aperture	—	A hole or window in an opaque material, used to control the transmission of light.
Aperture Angle	Θ	For radiation sources, the angle between the half power points. See Beam Angle.
Axis of Measurement	—	The direction from the source of radiant energy, relative to the optical axis, in which the measurement of radiometric and/or spectroradiometric characteristics is preferred.
Base	B	The control terminal of a transistor. In a phototransistor, control is provided by light or infrared energy which falls on the transistor and generates a current in the base.
Beam Angle	Θ	A measure of the angular displacement of emitted energy, usually measured as the included angle from one half power point to the other.
Beam Half Angle	—	A measure of the angular displacement of emitted energy, generally measured from the optical axis to the half power point. See Emission Angle.
Blackbody	—	Ideally, a body that would absorb all and reflect none of the radiant energy falling upon it; its reflectivity would be zero and its absorbency (and consequently its emissivity) would be 100%. In practice, a radiator of uniform temperature whose radiant emittance in all parts of the spectrum is the maximum obtainable from any temperature radiation at the same temperature, or a radiator whose spectral radiant emittance conforms with Planck's law of radiation.
Buffer Amp Linearity, Low Voltage	V_{LL}	Output voltage from the buffer of the ABC sensor with a specified input voltage applied to the buffer.
Cathode	K	The negative terminal of a diode, i.e., the terminal which must have a negative voltage relative to the other terminal (anode) before the device will conduct.
Collector	C	The positive current carrying terminal of an NPN transistor.
Collector-Base Breakdown Voltage	$V_{(BR)CBO}$	The reverse bias voltage at which the collector-base junction of a transistor will conduct a specified (non-destructive) current much higher than the normal leakage currents that occur at lower voltages. In an NPN transistor, it is measured with the collector positive, the base negative, and the emitter open.
Collector Current	I_C	The amount of current flowing into the collector terminal of a transistor.
Collector-Emitter Breakdown Voltage	$V_{(BR)CEO}$	The voltage at which a transistor, biased in the normal direction with no optical or electrical input to the base, will conduct a specified (non-destructive) current much higher than the normal leakage currents which occur at lower voltages.
Collector-Emitter Saturation Voltage	$V_{CE(SAT)}$	The collector-emitter voltage of a transistor which is turned "on" by an optical or electrical input to the base, measured under specified conditions of input level and output current load.
Color Temperature	—	The temperature of a blackbody having the same visible color as that of a given non-blackbody radiator.

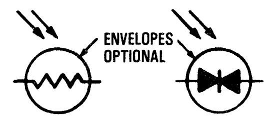
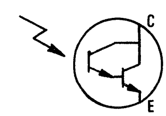
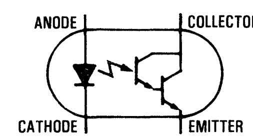
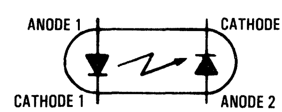
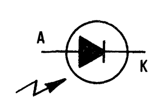
Term	Symbol	Description
Common Emitter	—	A circuit configuration in which the emitter terminal is common to both input and output current loops; also called grounded emitter.
Commutating dV/dt	—	A changing voltage. In a triac the ability to block this rapidly changing voltage.
Conversion Efficiency, Photovoltaic Diode	—	The ratio of maximum available power output resulting from photovoltaic operation to total incident radiant flux.
Critical Angle	θ_C	The maximum angle of incidence for which light will be transmitted from one medium to another. Light approaching at a greater angle of incidence will be reflected.
Current Transfer Ratio	CTR	In an optically coupled isolator, the ratio of output (transistor) current to input (LED) current under specified conditions.
Dark Condition	—	The condition attained when the electrical parameter under consideration approaches a value which cannot be altered by further irradiation shielding.
Dark Current	I_D	The current that flows through a photodetector when there is no optical input; usually used in reference to photodiodes.
DC Current Gain	H_{FE}	The ratio of collector current to base current in a transistor biased in the common emitter configuration.
DC or AC Input-to-Output Current; Isolation Voltage	I_{IO}	The current between all input terminals shorted together and all output terminals shorted together at a specified voltage.
DC or AC Input-to-Output Voltage; Isolation Voltage	V_{IO}	The voltage applied between all input terminals shorted together and all output terminals shorted together.
Delay Time	t_d	The time elapsed between a step increase in the input and a change in the output equal to 10% of its maximum change.
Detector Noise Current	I_n	The broadband output noise current.
Diode	—	A two terminal device (usually semiconductor) which freely conducts current in one direction and blocks it in the other. 
Duty Cycle	dc	In a signal composed of regularly recurring pulses, the product of the pulse width and the repetition frequency multiplied by 100 to give a percentage.
Duty Factor	—	In a signal composed of regularly recurring pulses, the product of the pulse width and the repetition frequency. Same as duty cycle except that it is expressed as a ratio rather than a percentage.
Emission Angle	—	For radiation sources, the angle with respect to the optical axis at which the radiant power is half the maximum.
Emitter	E	The negative current carrying terminal of an NPN transistor.
Emitter (Radiometric)	—	In radiometrics, a source of radiation.
Emitter-Collector Breakdown Voltage	$V_{(BR)ECO}$	The voltage at which a transistor, biased opposite its normal direction with no optical or electrical input to the base, will conduct a specified (non-destructive) current much higher than the normal leakage currents which occur at lower voltages.
Emitter Current	I_E	The value of current flowing in the emitter terminal of a transistor.
Fall Time	t_f	The time that elapses while a pulse waveform decreases from 90% to 10% of its maximum value.

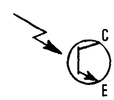
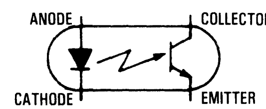
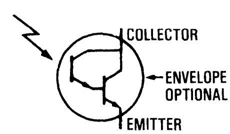
Glossary of Symbols and Terms

Term	Symbol	Description
Fiber Optics	—	Generally, the technology of using transparent glass or plastic fibers which carry light. Signals can be sent over large distances at high speed by coupling optoelectronic devices via fiber optics.
Flux Density, Luminous or Radiant Intensity	—	The quotient of (1) the respective luminous or radiant flux at a surface divided by (2) the area of the surface.
Forward Bias Voltage	V_F	An external voltage applied in the conducting direction of a PN junction. The positive terminal is connected to the P-type region, and the negative terminal to the N-type region.
Forward Current	I_F	The current which flows across a semiconductor junction when a forward-bias voltage is applied.
Forward Voltage	V_F	The voltage across a diode when it is forward biased at a specified current.
Frequency	f	The number of recurrences of a periodic phenomenon in a unit of time. Usually expressed in hertz (Hz), which is the number of recurrences per second.
Gallium Aluminum Arsenide	GaAlAs	A crystalline compound used to make IREDs. Note: the addition of aluminum to the GaAs roughly doubles the power output of the device at the same input current.
Gallium Arsenide	GaAs	A crystalline compound used to make IREDs.
Half-Density Beam Angle	Θ	The full-cone angle within which the radiant intensity is not less than half of the maximum intensity. See also Beam Angle.
Half Power Point	HP	For radiation sources, the point in the radiation pattern at which the radiant intensity is half the maximum.
High Level Output Voltage	V_{OH}	The voltage on the output terminal of a logic circuit with input level and output load applied that, according to the product specification, will establish a high level at the output.
High Level Supply Current	I_{CCH}	In a logic circuit, the supply current required to operate the circuit when input conditions are such that the output is in the high logic state.
Holding Current	I_H	In a triac, the minimum current through the main terminals which will maintain the device in the on-state in the absence of an input to the gate.
Illuminance (Illumination); Irradiance	E	The respective luminous or radiant flux density incidence on a surface; quotient of the flux divided by the area of illuminated or irradiated surface.
Infrared	IR	Optical radiation that is characterized by wavelength longer than normally perceived by the eye, but shorter than radio waves. TRW Optoelectronics Division emitters radiate in the infrared range.
Infrared Emitting Diode	IRED	A diode which emits infrared radiation when forward biased.
Input-to-Output Capacitance	C_{IO}	The capacitance between the output of the photosensitive element and the input of the photoemitter element, called coupling capacitance.
Input-to-Output Resistance	R_{IO}	The resistance between the input and output of an optoisolator when the input leads are shorted together and the output leads are shorted together.
Interrupter Assembly	—	Same as Transmissive Assembly.
Irradiance	E_e	The radiant flux density incident on a surface; the quotient of the flux divided by the area of the irradiated surface. Units: watts/square meter, milliwatts/square cm.
Isolation Leakage Current	I_{ISO}	The current produced in an optoisolator when the input leads are shorted together, the output leads are shorted together, and a specified voltage is applied between the input and output.

Term	Symbol	Description
Isolation Voltage	V_{ISO}	The input-to-output voltage withstanding capability of an optically coupled isolator.
Junction Temperature	T_J	The temperature at the PN junction within a semiconductor device.
Light	—	Optical radiation in the range of wavelengths which can be perceived by the human eye.
Light Current	I_L	Current flow through a photosensitive device when exposed to radiant energy.
Light-Emitting Diode (LED)	—	A device capable of emitting luminous energy resulting from the recombination of electrons and holes
Low Level Output Voltage	V_{OL}	The voltage on the output terminal of a logic circuit with input level and output loading applied such that, according to the product specification, a low level at the output will be established.
Low Level Supply Current	I_{CCL}	In a logic circuit, the supply current required to operate the circuit when the input conditions are such that the output is in the low logic state.
Lower Ramp Threshold Voltage	V_{RL}	The lower threshold voltage of the RC pin on the ABC sensor. The circuit discharges a capacitor connected to this pin until the voltage on the capacitor reaches the lower threshold voltage.
Luminous Energy	Q, (Q_V)	Energy traveling in the form of visible radiation.
Luminous Flux, Radiant Flux	—	The respective time rate of flow of luminous or radiant energy.
Maximum Power Dissipation	$P_{D(MAX)}$	Maximum power that a device can safely dissipate under specified conditions which include ambient temperature, heat sinking, and air circulation.
Micron	—	10^{-6} meter.
Nanometer	nm	10^{-9} meter; equal to 10 angstroms or 10^{-3} micron.
Noise Equivalent Bandwidth	B_n	The equivalent bandwidth of a flat (or white) noise spectrum with sharp cutoff and the same maximum value that contains the same noise power as the actual broadband output noise power of the device or current.
Noise Equivalent Power	NEP	The radiant flux at a specific wavelength incident on a detector which gives a signal-to-noise ratio of unity. Unit: watts.
Off-State Collector Current	I_{CEO}	The collector current in a transistor with no optical or electrical input to the base.
Off Time	t_{off}	Storage time plus fall time.
On-State Collector Current	$I_{C(ON)}$	The output (collector) current of a transistor when there is a specified optical or electrical input to the base.
On Time	t_{on}	Delay time plus rise time.
Operating Temperature	T_O	The temperature or range of temperatures over which a device is expected to operate within specified performance limits.
Optical Axis	—	A line about which the radiant energy pattern is centered; usually perpendicular to the active area.
Optical Radiation	—	Electromagnetic radiation in the range of wavelengths from 10 nanometers (extreme ultraviolet) to 1 millimeter (extreme infrared).
Optically Coupled Isolator	—	A device that is designed for transferring electrical signals by utilizing optical energy to provide coupling, with electrical isolation between input and output. Optically coupled isolators usually consist of an IRED coupled to one of a variety of sensor types, shielded from ambient light.

Glossary of Symbols and Terms

Term	Symbol	Description
Optically Coupled Triac Driver	—	An optically coupled isolator whose output is designed to control the gate of a power triac.
Optocoupler	—	See Optically Coupled Isolator.
Optoelectronic Device	—	A device which responds to, emits, or modifies electromagnetic radiation in the visible, infrared, and/or ultraviolet spectral regions, or a device that utilizes such radiation for its internal operation.
Optoisolator	—	See Optically Coupled Isolator.
Peak On-State Surge Current	$I_{TM(SURGE)}$	An on-state current of short duration and specified waveshape which represents the maximum current surge capacity of a triac.
Peak Wavelength	λp	The wavelength at which the power output of an emitter is maximum.
Photoconductive Diode	—	A photodiode that is intended to be used as a photoconductive transducer.
Photoconductive Transducer	—	A device that is intended to change its conductance as a function of incident light or radiation. 
Photocoupler	—	See Optically Coupled Isolator.
Photocurrent	—	The difference between light current and dark current in a photodetector.
Photodarlington	—	A photosensor consisting of two transistors on a single chip, configured such that the current from the first (photosensitive) transistor is amplified by the gain of the second transistor. Note: photodarlingtons have very high current output compared to phototransistors but speed and linearity are relatively poor. 
Photodarlington Coupler	—	An optocoupler in which the photosensitive element is a darlington-connected phototransistor. 
Photodiode, Avalanche	—	A photodiode that is intended to take advantage of avalanche multiplication of photocurrent.
Photodiode Coupler	—	An optocoupler in which the photosensitive element is a photodiode. 
Photodetector	—	A device that responds electrically when exposed to radiant energy.
Photodiode	—	A diode which is sensitive to incident radiation. Incident photons cause the diode to conduct (if reverse biased) or to generate a current. Note: photodiodes typically have much less output current than phototransistors but are faster and more linear. 

Term	Symbol	Description
Photoemissive Device	—	Synonym for a photoemitter.
Photoemitter	—	A device that emits electromagnetic radiation in the visible, infrared, and/or ultraviolet spectral regions.
Photologic™ Coupler	—	An optocoupler in which the photosensitive element is a digital output integrated circuit.
Photon	—	A quantum (the smallest possible unit) of radiant energy; a photon carries a quantity of energy equal to Planck's constant times the frequency.
Photosensitive Device	—	A device that is responsible to electro-magnetic radiation in the visible, infrared, and/or ultraviolet spectral regions.
Photosensor	—	A device which controls or generates an electric current when irradiated by light.
Phototransistor	—	A transistor which is sensitive to incident radiation. The incident photons result in a base current which is then amplified by the gain of the transistor. 
Phototransistor Coupler	—	An optocoupler in which the photosensitive element is a phototransistor.  Note: The base region may or may not be brought out as an electrical terminal.
Phototransistor, Darlington Connected	—	A phototransistor, the collector and emitter of which are connected to the collector and base, respectively, of a second transistor.  Note: The base regions may or may not be brought out as electrical terminals.
Phototriac Driver Coupler	—	An optocoupler in which the photosensitive element is either a zero current crossing triac driver or a zero voltage crossing driver.
Point Source	—	A radiation source with a maximum diameter less than $1/10$ the distance between source and detector.
Propagation Delay	t_{PLH}, t_{PHL}	In a logic circuit, the time delay between a specified change in input and a corresponding change in the output logic state. t_{PLH} is measured with the output changing from low to high and t_{PHL} with the output changing from high to low.
Radiance	N, L_e	The radiant intensity of the energy leaving or passing through a surface, divided by its area.
Radiant Efficiency	—	The ratio of the total radiant flux emitted to the total input power.
Radiant Flux	Φ_e	Rate of flow of radiant energy, expressed in watts.
Radiant Intensity	I_e	The radiant flux generated per unit solid angle in a given direction, expressed in milliwatts per steradian (mW/sr).
Radiation Pattern	—	The representation of the intensity of emission as a function of direction, in a given plane.
Radiometric	—	Of or pertaining to radiation in all wavelengths.

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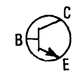
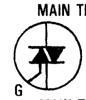
Glossary of Symbols and Terms

Term	Symbol	Description
Ramp Leakage Current	I_{RL}	In the ABC sensor, the current that flows through the RC pin (pins) when the device is operated under specified conditions.
Reflective Assembly	—	A device in which an IRED and a photosensor are mounted side by side, such that the photosensor is only irradiated when a reflective object passes in front of the device. Reflective assemblies are used to sense the presence of reflective objects.
Repetitive Peak Off-State Current	I_{DRM}	In a triac, the maximum instantaneous value of the off-state current that results from the application of repetitive peak off-state voltage.
Responsivity	R	A description of the optical sensitivity of a photosensor. It is the ratio of the output current or voltage to the input radiant flux, typically expressed as amps per watt or volts per watt.
Reverse Breakdown Voltage	$V_{(BR)R}$	The reverse bias voltage at which a diode will conduct a specified (non-destructive) current much higher than the normal leakage currents which occur at lower voltages.
Reverse Current	I_R	The current that flows when a reverse bias voltage is applied to a semiconductor junction.
Rise Time	t_r	The time that elapses while a pulse waveform increases from 10% to 90% of its maximum value.
RMS On-State Current	$I_{T(RMS)}$	In a triac, the principal current when the device is in the on-state.
Silicon	Si	An element, abundant in the earth's crust, which is used in highly purified form to make most of the semiconductors used in the modern electronics industry (including all TRW Optoelectronics Division photodetectors). Pure crystalline silicon is carefully "doped" with very small amounts of impurities to control its electrical characteristics.
Snell's Law	—	The law of refraction which predicts the behavior of electromagnetic radiation as it passes from one homogeneous isotropic media to another; expressed as $n1 \sin\Theta 1 = n2 \sin\Theta 2$ where n1 and n2 are refractive indices and $\Theta 1$, $\Theta 2$, refer to the angles between the rays and the normal to the interface.
Spectral Bandwidth	BW	The wavelength interval in which a photometric or radiometric spectral quantity is not less than half of its maximum value.
Spectral Response	—	A description of the electrical output characteristic versus wavelength of radiation incident upon a device, usually expressed by a curve.
Static dV/dt	dV/dt	The measure of the ability of a triac or SCR to block a rapidly rising voltage. Static dV/dt is usually measured with application of full rated voltage to the device in a very short but controlled time period. It is expressed in volts/microsecond.
Static Gate Trigger Current	I_{GT}	In a triac, the minimum gate current required to switch the device from the off-state to the on-state.
Steradian	sr	The solid angle subtending an area on the surface of a sphere equal to the square of the sphere's radius. There are 4π steradians in a sphere.
Storage Temperature	T_{STG}	The maximum temperature at which a device may be stored with no power applied.
Storage Time	t_s	The time elapsed between a step decrease in the input and a change in the output equal to 10% of its maximum change.
Supply Voltage	V_{CC}	The power supply voltage required to operate a circuit.
Total Power Output	P_O	The total power that is radiated by a device, expressed in watts or milliwatts.

Term	Symbol	Description
Transistor	—	A three terminal active semiconductor device which is capable of providing power amplification. 
Transmissive Assembly	—	A device in which an IRED and a photosensor are mounted facing each other on either side of a slot, such that an opaque object passing through the slot will interrupt the I_R radiation path and be detected by the photosensor.
Triac	—	A five layer semiconductor device which provides switching action for either polarity of applied voltage and can be controlled in either polarity by a single gate electrode. Triacs are usually used in power control applications. 
Trigger Leakage	I_{T1}, I_{T2}	The current that flows in the trigger terminal of the ABC sensor. I_{T1} is measured with the trigger pin at ground potential and I_{T2} with the trigger pin at V_{CC} potential.
Trigger Voltage	V_T	The minimum voltage which, when applied to the trigger pin of the ABC sensor, will force the RC pin to sink current. Once triggered by a rising edge of this minimum amplitude, the RC pin sinks current until the voltage on the capacitor reaches the lower ramp threshold voltage.
Upper Ramp Threshold Voltage	V_{RU}	The upper threshold voltage of the RC pin on the ABC sensor. The circuit charges a capacitor connected to this pin until the voltage on the capacitor reaches the upper threshold voltage.
Visible-Light-Emitting Diode	VLED	Synonym for light-emitting diode.
Wavelength	λ	The velocity of a wave divided by its frequency. The wavelength of infrared radiation is usually expressed in nanometers.

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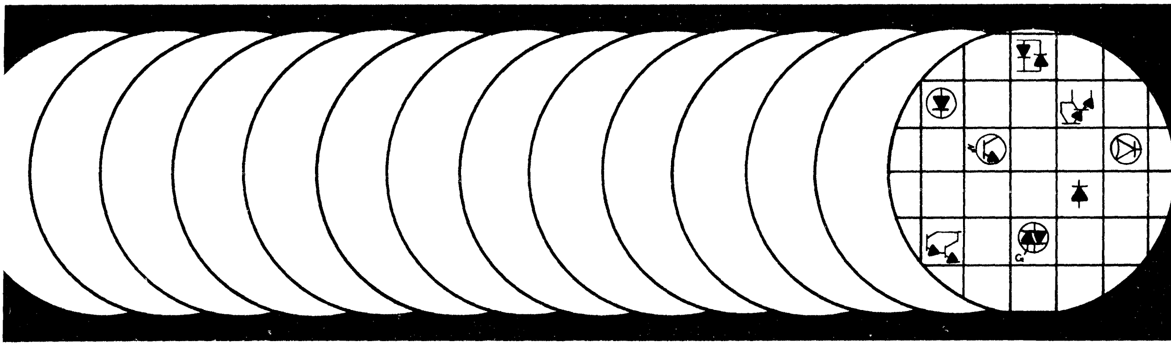

Optoelectronics Interchangeability Guide

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Use of This Interchangeability Guide

TRW product selections included in this guide meet and often exceed the performance specifications of products from other manufacturers. Use of this cross reference to substitute other products in place of TRW products is not recommended and is strictly at the user's own risk. In addition, TRW assumes no responsibility for use of this cross reference guide in actual circuit design or product replacement. TRW data sheets should always be consulted prior to product selection.

Code Definitions

A .... Direct Replacement
B .... Electrical Difference
C .... Mechanical Difference
D .... Call TRW*
E .... No Equivalent

*Devices that can be second sourced if volume and pricing warrant

Competitor Part No.	Description	TRW Part No.	Code	Page
1-53-32-2	Collimated LED	OP160SLC	B,C	10
10-53-0032-1	Collimated LED	OP160SLD	B,C	10
10-53-0032-3	Collimated LED	OP160SLB	B,C	10
10-53-0032-4	Collimated LED	OP160SLA	B,C	10
10-53-0032-5	Collimated LED	OP160SLA	B,C	10
1N6264	Hermetic LED	—	D	—
1N6265	Hermetic LED	—	D	—
1N6266	Hermetic LED	—	D	—
3N261	4-Pin TO-72 Transistor Coupler	3N245	B	166
3N262	4-Pin TO-72 Transistor Coupler	3N245	B	166
3N263	4-Pin TO-72 Transistor Coupler	3N245	B	166
4N22	Hi Rel TO-5 Hermetic Transistor	4N22A	C	170
4N23	Hi Rel TO-5 Transistor Coupler	4N23A	C	170
4N24	Hi Rel TO-5 Transistor Coupler	4N24A	C	170
4N25	6-Pin Transistor Coupler	4N25	A	172
4N25A	6-Pin Transistor Coupler	4N25	A	172
4N26	6-Pin Transistor Coupler	4N26	A	172
4N27	6-Pin Transistor Coupler	4N27	A	172
4N28	6-Pin Transistor Coupler	4N28	A	172
4N29	6-Pin Transistor Coupler	4N29	A	174
4N29A	6-Pin Transistor Coupler	4N29	C	174
4N30	6-Pin Transistor Coupler	4N30	A	174
4N31	6-Pin Transistor Coupler	4N31	A	174
4N32	6-Pin Transistor Coupler	4N32	A	174
4N32A	6-Pin Darlington Coupler	4N32	A	174
4N33	6-Pin Transistor Coupler	4N33	A	174
4N36	6-Pin Transistor Coupler	4N36	A	176
4N37	6-Pin Transistor Coupler	4N37	A	176
4N38	6-Pin High VBR Transistor Coupler	4N38	A	178
4N38A	6-Pin High VBR Transistor Coupler	4N38A	A	178
4N39	6-Pin SCR Driver Coupler	—	E	—
4N40	6-Pin SCR Driver Coupler	—	E	—
4N45	6-Pin Darlington IC Coupler	4N45	A	180
4N46	6-Pin Darlington IC Coupler	4N46	A	180
4N47	TO-5 Transistor Coupler	OPI103	B	106
4N48	TO-5 Transistor Coupler	OPI103	B	106
4N49	TO-5 Transistor Coupler	OPI103	B	106
4N55	Dual Transistor Coupler	—	D	—
6N134	Hi Rel Dual Logic Coupler	—	D	—
6N135	8-Pin Transistor Coupler	6N135	A	184
6N136	8-Pin Transistor Coupler	6N136	A	184
6N137	8-Pin High Speed Logic Coupler	6N137	A	188
6N138	8-Pin Darlington Coupler	6N138	A	192
6N139	8-Pin Darlington Coupler	6N139	A	192
6N140	8-Pin Dual Coupler	—	D	—

Competitor Part No.	Description	TRW Part No.	Code	Page
8SS	Hall Effect Magnetic Sensor	OH360	B,C	340
BP100	Plastic Photodiode	—	E	—
BP101/I	Plastic Transistor	—	E	—
BP101/II	Plastic Transistor	—	E	—
BP101/III	Plastic Transistor	—	E	—
BP101/IV	Plastic Transistor	—	E	—
BP102/I	Plastic Transistor	—	E	—
BP102/II	Plastic Transistor	—	E	—
BP102/III	Plastic Transistor	—	E	—
BP102/IV	Plastic Transistor	OP801	B,C	78
BP103-1	TO-18 Hermetic Transistor	—	E	—
BP103-2	TO-18 Hermetic Transistor	—	E	—
BP103-3	TO-18 Hermetic Transistor	—	E	—
BP103-4	TO-18 Hermetic Transistor	—	E	—
BP103B	Plastic Transistor	—	E	—
BP103B-1	T-1 ¾ Plastic Transistor	—	E	—
BP103B-2	T-1 ¾ Plastic Transistor	—	E	—
BP103B-3	T-1 ¾ Plastic Transistor	—	E	—
BP103B-4	T-1 ¾ Plastic Transistor	—	E	—
BP103/I	Plastic Transistor	—	E	—
BP103/II	Plastic Transistor	—	E	—
BP103/III	Plastic Transistor	—	E	—
BP103/IV	Plastic Transistor	OP801	B,C	78
BP104	Plastic PIN Photodiode	OP913W	B,C	96
BPW13A	TO-18 Hermetic Transistor	OP800W	B	80
BPW13B	TO-18 Hermetic Transistor	OP801W	B	80
BPW13C	TO-18 Hermetic Transistor	OP802W	B	80
BPW14A	TO-18 Hermetic Transistor	OP803	B	78
BPW14B	TO-18 Hermetic Transistor	OP804	B	78
BPW14C	TO-18 Hermetic Transistor	OP805	B	78
BPW16N	Plastic Transistor	—	E	—
BPW17N	Plastic Transistor	—	E	—
BPW20	TO-56 Hermetic Photodiode	OP913W	B,C	96
BPW21	TO-56 Hermetic Photodiode	OP913W	B,C	96
BPW21M	TO-56 Hermetic Photodiode	OP913W	B,C	96
BPW24	TO-18 Hermetic Photodiode	OP913	B,C	96
BPW28	TO-18 Hermetic Photodiode	—	E	—
BPW32	Plastic PIN Photodiode	OP913	B,C	96
BPW33	Plastic PIN Photodiode	OP913	B.C	96
BPW34	Plastic PIN Photodiode	OP913	B,C	96
BPW35	Plastic Photodiode	—	E	—
BPW36	TO-18 Hermetic Transistor	OP804	A	78
BPW37	TO-18 Hermetic Transistor	OP803	A	78
BPW38	TO-18 Hermetic Darlington	OP830	B	86
BPW39A	Plastic Lateral Transistor	OP550SLB	B,C	64

Competitor Part No.	Description	TRW Part No.	Code	Page
BPW39B	Plastic Lateral Transistor	OP550SLA	B,C	64
BPW40	T-1¾ Plastic Transistor	OP501SLC	B,C	52
BPW41	Plastic Photodiode	–	E	–
BPW42	T-1 Plastic Transistor	OP501SLC	B,C	52
BPW43	T-1¾ Plastic Photodiode	–	E	–
BPX38-1	TO-18 Hermetic Transistor	OP800W	B	80
BPX38-2	TO-18 Hermetic Transistor	OP801W	B	80
BPX38-3	TO-18 Hermetic Transistor	OP801W	B	80
BPX38-4	TO-18 Hermetic Transistor	–	D	–
BPX38/I	TO-18 Hermetic Transistor	OP800W	B	80
BPX38/II	TO-18 Hermetic Transistor	OP801W	B	80
BPX38/III	TO-18 Hermetic Transistor	OP802W	B	80
BPX38/IV	TO-18 Hermetic Transistor	–	E	–
BPX43-1	TO-18 Hermetic Transistor	OP802	B	78
BPX43-2	TO-18 Hermetic Transistor	OP803	B	78
BPX43-3	TO-18 Hermetic Transistor	OP804	B	78
BPX43-4	TO-18 Hermetic Transistor	OP805	B	78
BPX43/I	TO-18 Hermetic Transistor	OP802	B	78
BPX43/II	TO-18 Hermetic Transistor	OP803	B	78
BPX43/III	TO-18 Hermetic Transistor	OP804	B	78
BPX43/IV	TO-18 Hermetic Transistor	OP805	B	78
BPX48	Plastic PIN Photodiode	–	E	–
BPX60	TO-5 Hermetic Photodiode	OP913W	B	96
BPX62/I	Pill Hermetic Transistor	OP602	B	76
BPX62/II	Pill Hermetic Transistor	OP602	B	76
BPX62/III	Pill Hermetic Transistor	OP603	B	76
BPX62/IV	Pill Hermetic Transistor	OP604	B	76
BPX63	Plastic TO-18 Photodiode	–	E	–
BPX65	TO-18 Photodiode	–	E	–
BPX66	TO-18 Photodiode	–	E	–
BPX79	Plastic Photodiode	–	E	–
BPX80	10 Element Plastic Transistor	–	E	–
BPX81	Plastic Transistor	–	E	–
BPX81-1	Plastic Transistor	–	E	–
BPX81-2	Plastic Transistor	–	E	–
BPX81-3	Plastic Transistor	–	E	–
BPX81-4	Plastic Transistor	–	E	–
BPX81/I	Plastic Transistor	–	E	–
BPX81/II	Plastic Transistor	–	E	–
BPX81/III	Plastic Transistor	–	E	–
BPX81/IV	Plastic Transistor	–	E	–
BPX82	2 Element Plastic Transistor	–	E	–
BPX83	3 Element Plastic Transistor	–	E	–
BPX84	4 Element Plastic Transistor	–	E	–
BPX85	5 Element Plastic Transistor	–	E	–
BPX86	6 Element Plastic Transistor	–	E	–
BPX87	7 Element Plastic Transistor	–	E	–
BPX88	8 Element Plastic Transistor	–	E	–
BPX89	9 Element Plastic Transistor	–	E	–
BPX90	Plastic PIN Photodiode	–	E	–
BPX91	Plastic PIN Photodiode	–	E	–
BPX92	Plastic PIN Photodiode	–	E	–
BPX93	Plastic PIN Photodiode	–	E	–
BPX99	TO-52 Hermetic Darlington	OP830	B,C	86
BPY11/I	Plastic Photodiode	–	E	–
BPY11/II	Plastic Photodiode	–	E	–
BPY11/III	Plastic Photodiode	–	E	–
BPY11/IV	Plastic Photodiode	–	E	–
BPY11/P	Plastic Photodiode	–	E	–
BPY12	Plastic Photodiode	–	E	–
BPY47	Plastic Photodiode	–	E	–

Competitor Part No.	Description	TRW Part No.	Code	Page
BPY48	Plastic Photodiode	–	E	–
BPY61/I	Glass Transistor	–	E	–
BPY61-I	Glass Transistor	–	E	–
BPY61/II	Glass Transistor	–	E	–
BPY61-II	Glass Transistor	–	E	–
BPY61-III	Glass Transistor	–	E	–
BPY61/III	Glass Transistor	–	E	–
BPY61/IV	Glass Transistor	–	E	–
BPY61-IV	Glass Transistor	–	E	–
BPY62/I	TO-18 Hermetic Transistor	OP801	B	78
BPY62-I	TO-18 Hermetic Transistor	OP801	B	78
BPY62-II	TO-18 Hermetic Transistor	OP802	B	78
BPY62/II	TO-18 Hermetic Transistor	OP802	B	78
BPY62-III	TO-18 Hermetic Transistor	OP803	B	78
BPY62/III	TO-18 Hermetic Transistor	OP803	B	78
BPY64	Plastic Photodiode	–	E	–
C0900E	TO-5 PIN Photodiode	OP913	B,C	96
C3081	TO-5 PIN Photodiode	OP913	B,C	96
C3082	TO-5 PIN Photodiode	OP913	B,C	96
C03812	TO-5 PIN Photodiode	OP913	B,C	96
C30012	Laser Diode	–	E	–
C30013	Laser Diode	–	E	–
C30099	Laser Diode	–	E	–
C30116	InGaAs LED	–	E	–
C30116/F	InGaAs LED	–	E	–
C30122	TO-46 Hermetic LED	OP130	A	6
C30807	TO-18 PIN Photodiode	–	E	–
C30808	TO-5 PIN Photodiode	OP913	B,C	96
C30809	TO-18 PIN Photodiode	–	E	–
C30810	TO-5 PIN Photodiode	OP913	B,C	96
C30822	TO-18 PIN Photodiode	–	E	–
C30831	TO-18 PIN Photodiode	–	E	–
C30839	TO-5 PIN Photodiode	OP913	B,C	96
C86011E	Coaxial Hermetic LED	–	E	–
C86025A	Coaxial Hermetic LED	–	E	–
C86025E	T-1¾ Plastic LED	OP291C	C	32
CLA7	Axial Transistor Coupler	OPI1264A	B,C	116
CLA7AA	Axial Transistor Coupler	OPI1264A	B,C	116
CLA7D	Axial Darlington Coupler	OPI113	B,C	108
CLA7DA	Axial Darlington Coupler	–	D	–
CLA60	Axial Hermetic Coupler	OPI120	B,C	110
CLA60AA	Axial Hermetic Coupler	OPI120	B,C	110
CLA60AB	Axial Hermetic Coupler	OPI120	B,C	110
CLA65	Axial Hermetic Coupler	–	D	–
CLA65AA	Axial Hermetic Coupler	–	D	–
CLA90	Axial Hermetic Coupler	–	D	–
CLA90AA	Axial Hermetic Coupler	–	D	–
CLCR-590	Darlington Chip	–	D	–
CLCT-320	Transistor Chip	–	D	–
CLCT-320A	Transistor Chip	–	D	–
CLCT-367	Transistor Chip	–	D	–
CLCT-511	Transistor Chip	–	D	–
CLCT-511A	Transistor Chip	–	D	–
CLI-2	6-Pin Transistor Coupler	–	D	–
CLI-4	6-Pin Transistor Coupler	–	D	–
CLI-4	6-Pin Transistor Coupler	–	D	–
CLI-5	6-Pin Transistor Coupler	OPI2252	A	132
CLI-6	6-Pin Transistor Coupler	OPI2253	A	134
CLI-7	6-Pin Transistor Coupler	OPI2251	A	130
CLI-8	6-Pin Transistor Coupler	OPI2252	A	132
CLI-9	6-Pin Transistor Coupler	–	D	–

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Competitor Part No.	Description	TRW Part No.	Code	Page
CLI-10	6-Pin Darlington Coupler	—	D	—
CLI-11	6-Pin Darlington Coupler	OPI3253	A	156
CLI-12	6-Pin Darlington Coupler	OPI3251	A	152
CLI-13	6-Pin Darlington Coupler	OPI3252	A	154
CLI-14	6-Pin Darlington Coupler	OPI3251	A	152
CLI-25	6-Pin Transistor Coupler	—	D	—
CLI-26	6-Pin Transistor Coupler	—	D	—
CLI-27	6-Pin Darlington Coupler	—	E	—
CLI-28	6-Pin Darlington Coupler	—	E	—
CLI-55	Transistor Interrupter	—	E	—
CLI-55A	Transistor Interrupter	—	E	—
CLI-55B	Transistor Interrupter	—	E	—
CLI-55C	Transistor Interrupter	—	E	—
CLI-200	Transistor Interrupter	—	D	—
CLI-200D	Transistor Interrupter	—	E	—
CLI-200S	Transistor Interrupter	—	E	—
CLI-210	Transistor Interrupter	OPB804	B,C	240
CLI220	Transistor Interrupter	—	E	—
CLI-230	Transistor Interrupter	—	E	—
CLI-300	Transistor Interrupter	—	E	—
CLI-305	Transistor Interrupter	—	E	—
CLI-325	Transistor Interrupter	—	E	—
CLI-355	Transistor Interrupter	—	E	—
CLI-375	Transistor Interrupter	—	E	—
CLI-395	Transistor Interrupter	—	E	—
CLI-506	6-Pin Transistor Coupler	OPI2251	A	130
CLI-506B	6-Pin Transistor Coupler	OPI2251	B	130
CLR2049	Hermetic Darlington	—	D	—
CLR2050	Hermetic Darlington	OP830W	B,C	88
CLR2060	Hermetic Darlington	OP830W	B,C	88
CLR2170	Hermetic Darlington	—	D	—
CLR2180	Hermetic Darlington	OP830W	B	88
CLR3180	Pill Hermetic Transistor	—	E	—
CLR5101	Hermetic Darlington	—	E	—
CLT-2010	TO-18 Hermetic Transistor	OP800W	B,C	80
CLT-2020	Hermetic Transistor	OP801W	B,C	80
CLT-2030	Hermetic Transistor	OP801W	B,C	80
CLT2035	TO-18 Hermetic Transistor	OP802W	B	80
CLT-2130	TO-18 Hermetic Transistor	OP801	B	78
CLT2140	TO-18 Hermetic Transistor	OP801	B	78
CLT2150	TO-18 Hermetic Transistor	OP802	B	78
CLT2160	TO-18 Hermetic Transistor	OP803	A	78
CLT2164	TO-18 Hermetic Transistor	OP804	A	78
CLT2165	TO-18 Hermetic Transistor	OP805	A	78
CLT3020	Pill Hermetic Transistor	—	E	—
CLT3030	Pill Hermetic Transistor	—	E	—
CLT3160	Pill Hermetic Transistor	OP602	A	76
CLT3170	Pill Hermetic Transistor	OP604	A	76
CLT5160	Hermetic Transistor	—	E	—
CLT5170	Hermetic Transistor	—	E	—
CLT5260	Hermetic Transistor	—	E	—
CNY17-1	6-Pin Transistor Coupler	CNY17/1	A	102
CNY17-2	6-Pin Transistor Coupler	CNY17/2	A	102
CNY17-3	6-Pin Transistor Coupler	CNY17/3	A	102
CNY17-4	6-Pin Transistor Coupler	CNY17/4	A	102
CNY17A	6-Pin Transistor Coupler	CNY17/1	B	102
CNY17B	6-Pin Transistor Coupler	CNY17/2	B	102
CNY17C	6-Pin Transistor Coupler	CNY17/3	B	102
CNY17D	6-Pin Transistor Coupler	CNY17/4	B	102
CNY17/I	6-Pin Transistor Coupler	CNY17/1	A	102
CNY17/II	6-Pin Transistor Coupler	CNY17/2	A	102
CNY17/III	6-Pin Transistor Coupler	CNY17/3	A	102
CNY17/IV	6-Pin Transistor Coupler	CNY17/4	A	102
CNY18-1	4-Pin TO-72 Transistor Coupler	3N243	C	166

Competitor Part No.	Description	TRW Part No.	Code	Page
CNY18-2	4-Pin TO-72 Transistor Coupler	3N243	C	166
CNY18-3	4-Pin TO-72 Transistor Coupler	3N244	B,C	166
CNY18-4	4-Pin TO-72 Transistor Coupler	3N245	B,C	166
CNY18-5	4-Pin TO-72 Transistor Coupler	3N245	B,C	166
CNY18-6	4-Pin TO-72 Transistor Coupler	3N245	B,C	166
CNY18/I	4-Pin TO-72 Transistor Coupler	3N243	C	166
CNY18/II	4-Pin TO-72 Transistor Coupler	3N243	C	166
CNY18/III	4-Pin TO-72 Transistor Coupler	3N244	B,C	166
CNY18/IV	4-Pin TO-72 Transistor Coupler	3N245	B,C	166
CNY18/V	4-Pin TO-72 Transistor Coupler	3N245	B,C	166
CNY18/VI	4-Pin TO-72 Transistor Coupler	3N245	B,C	166
CNY21	4-Pin TO-116 Transistor Coupler	OPI1264A	C	116
CNY28	Transistor Interrupter	OPB816	C	246
CNY29	Darlington Interrupter	—	D	—
CNY31	Darlington Coupler	OPI7340	C	160
CNY32	Transistor Coupler	OPI7002	C	160
CNY33	6-Pin High Voltage Transistor Coupler	OPI6100	B	158
CNY34	6-Pin SCR Driver Coupler	—	E	—
CNY35	6-Pin AC Input Transistor Coupler	OPI2500	B	138
CNY36	Transistor Interrupter	CNY36	A	238
CNY37	Transistor Interrupter	OPB867T55	A	274
CNY47	Transistor Coupler	—	D	—
CNY47A	Transistor Coupler	—	D	—
CNY48	6-Pin Darlington Coupler	OPI3153	B	156
CNY51	Transistor Coupler	—	E	—
CNY64	4-Pin Transistor Coupler	OPI1264B	C	116
CNY65	4-Pin Transistor Coupler	OPI1264B	C	116
CNY66	4-Pin Transistor Coupler	OPI1264B	C	116
CNY70	Transistor Reflective	OPB706B	C	218
CNY71	6-Pin AC Input Transistor Coupler	OPI2500	A	138
CNY75A	6-Pin Transistor Coupler	CNY17/2	A	102
CNY75B	6-Pin Transistor Coupler	CNY17/3	A	102
CNY75C	6-Pin Transistor Coupler	CNY17/4	A	102
CQW13	T-1¾ Plastic LED	OP290A	B	32
CQW14	T-1¾ Plastic LED	OP290A	B	32
CQX14	TO-46 Hermetic LED	OP133	B	6
CQX15	TO-46 Hermetic LED	OP133W	B	6
CQX16	Hermetic LED	OP131	A	6
CQX17	TO-46 Hermetic LED	OP131W	A	6
CQX18A	Plastic Lateral LED	OP140SLB	B,C	8
CQX18B	Plastic Lateral LED	OP140SLA	B,C	8
CQX19	Plastic LED	OP293A	B,C	36
CQX20	Laser Diode	—	E	—
CQX46	T-1 Plastic LED	OP161SLA	B	14
CQX47	Plastic Lateral LED	OP240SLA	B,C	24
CQY17-4	TO-18 Hermetic LED	OP132W	A	6
CQY17-5	TO-18 Hermetic LED	OP133W	B	6
CQY17/IV	TO-18 Hermetic LED	OP132W	A	6
CQY17/V	TO-18 Hermetic LED	OP133W	B	6
CQY18/III	TO-18 Hermetic LED	OP131W	A	6
CQY18/IV	TO-18 Hermetic LED	OP132W	A	6
CQY18/V	TO-18 Hermetic LED	OP133W	B	6
CQY31	TO-18 Hermetic LED	OP131W	B	6
CQY32	TO-18 Hermetic LED	OP131	B,C	6
CQY33N/E	TO-18 Hermetic LED	OP131W	B	6
CQY33N/F	TO-18 Hermetic LED	OP132W	B	6
CQY34N/E	TO-18 Hermetic LED	OP132	B,C	6
CQY34N/F	TO-18 Hermetic LED	OP133	B	6
CQY35N/E	TO-18 Hermetic LED	OP132	B,C	6
CQY35N/F	TO-18 Hermetic LED	OP133	B	6
CQY36N	Plastic LED	—	E	—
CQY37N	Plastic LED	—	E	—
CQY57/I	Pill Hermetic LED	OP124	A	4
CQY57/II	Pill Hermetic LED	—	E	—

Competitor Part No.	Description	TRW Part No.	Code	Page
CQY57/III	Pill Hermetic LED	—	E	—
CQY57/IV	Pill Hermetic LED	—	E	—
CQY77-1	TO-18 Hermetic LED	OP131	B	6
CQY77-2	TO-18 Hermetic LED	OP132	B	6
CQY77-3	TO-18 Hermetic LED	OP133	B	6
CQY77/I	TO-18 Hermetic LED	OP131	B	6
CQY77/II	TO-18 Hermetic LED	OP132	B	6
CQY77/III	TO-18 Hermetic LED	OP133	B	6
CQY78-1	TO-18 Hermetic LED	OP131W	B	6
CQY78-2	TO-18 Hermetic LED	OP132W	B	6
CQY78-3	TO-18 Hermetic LED	OP133W	B	6
CQY78/I	TO-18 Hermetic LED	OP131W	B	6
CQY78/II	TO-18 Hermetic LED	OP132W	B	6
CQY78/III	TO-18 Hermetic LED	OP133W	B	6
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CQY98	T-1¾ Plastic LED	OP290A	B	32
CQY99	T-1¾ Plastic LED	OP290A	B	32
F5D1	TO-46 Hermetic LED	OP233	A	22
F5D2	TO-46 Hermetic LED	OP232	B	22
F5D3	TO-46 Hermetic LED	OP232	B	22
F5E1	TO-46 Hermetic LED	OP233W	A	22
F5E2	TO-46 Hermetic LED	OP232W	B	22
F5E3	TO-46 Hermetic LED	OP232W	B	22
F5F1	Plastic Lateral LED	OP140SLD	C	8
F5G1	Plastic Lateral LED	OP240SLA	C	24
FCD810	6-Pin Transistor Coupler	OPI2251	A	130
FCD810A	6-Pin Transistor Coupler	OPI2151	A	130
FCD810B	6-Pin Transistor Coupler	OPI2251	A	130
FCD810C	6-Pin Transistor Coupler	—	E	—
FCD810D	6-Pin Transistor Coupler	—	E	—
FCD820	6-Pin Transistor Coupler	OPI2252	A	132
FCD820A	6-Pin Transistor Coupler	OPI2152	A	132
FCD820B	6-Pin Transistor Coupler	OPI2252	A	132
FCD820C	6-Pin Transistor Coupler	—	E	—
FCD820D	6-Pin Transistor Coupler	—	E	—
FCD825	6-Pin Transistor Coupler	OPI2153	A	134
FCD825A	6-Pin Transistor Coupler	OPI2153	A	134
FCD825B	6-Pin Transistor Coupler	OPI2253	A	134
FCD825C	6-Pin Transistor Coupler	—	E	—
FCD825D	6-Pin Transistor Coupler	—	E	—
FCD830	6-Pin Transistor Coupler	OPI2152	B	132
FCD830A	6-Pin Transistor Coupler	OPI2252	B	132
FCD830B	6-Pin Transistor Coupler	OPI2252	B	132
FCD830C	6-Pin Transistor Coupler	—	E	—
FCD830D	6-Pin Transistor Coupler	—	E	—
FCD831	6-Pin Transistor Coupler	OPI2251	B	130
FCD831A	6-Pin Transistor Coupler	OPI2151	B	130
FCD831B	6-Pin Transistor Coupler	OPI2251	B	130
FCD831C	6-Pin Transistor Coupler	—	E	—
FCD831D	6-Pin Transistor Coupler	—	E	—
FCD836	6-Pin Transistor Coupler	OPI2151	B	130
FCD836C	6-Pin Transistor Coupler	—	E	—
FCD836D	6-Pin Transistor Coupler	—	E	—
FCD850	6-Pin Darlington Coupler	OPI3250	C	150
FCD850C	6-Pin Darlington Coupler	—	E	—
FCD850D	6-Pin Darlington Coupler	—	E	—
FCD855	6-Pin Darlington Coupler	OPI3252	C	154
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FCD860	6-Pin Darlington Coupler	OPI3251	C	152
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FPA105	Transistor Reflective	OPB706C	B,C	218
FPA106	Transistor Reflective	OPB706C	B	218
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FPE510	Hermetic LED	OP131W	B,C	6
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FPE530	TO-46 Hermetic LED	OP133W	A	6
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FPT110	Plastic Transistor	OP500W	B,C	50
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FPT120B	Plastic Transistor	—	D	—
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FPT130	Plastic Transistor	OP500W	B,C	50
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FPT130B	Plastic Transistor	—	E	—
FPT131	Plastic TO-18 Transistor	OP593A	B	72
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GE3011	6-Pin Triac Driver Coupler	OPI3011	B	142
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Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958

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H21A6	Transistor Interrupter	OPB872T55	C	274
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H21B3	Darlington Interrupter	—	D	—
H21B4	Darlington Interrupter	OPB872T55	B,C	274
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HOA1180-1	Transistor Reflective	—	E	—
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HOA1872-2	Transistor Interrupter	—	E	—
HOA1872-3	Darlington Interrupter	—	E	—
HOA1872-11	Transistor Interrupter	—	E	—
HOA1872-12	Transistor Interrupter	—	E	—
HOA1872-13	Darlington Interrupter	—	E	—
HOA1873-1	Transistor Interrupter	—	E	—
HOA1873-2	Transistor Interrupter	—	E	—
HOA1873-3	Darlington Interrupter	—	E	—
HOA1873-11	Transistor Interrupter	—	E	—
HOA1873-12	Transistor Interrupter	—	E	—
HOA1873-13	Darlington Interrupter	—	E	—
HOA1874-1	Transistor Interrupter	OPB816	B,C	246
HOA1874-2	Transistor Interrupter	OPB817	B,C	246
HOA1874-3	Darlington Interrupter	—	D	—
HOA1874-11	Transistor Interrupter	OPB816	B,C	246
HOA1874-12	Transistor Interrupter	OPB817	B,C	246
HOA1874-13	Darlington Interrupter	—	D	—
HOA1875-1	Transistor Interrupter	—	E	—
HOA1875-2	Transistor Interrupter	—	E	—
HOA1875-3	Darlington Interrupter	—	E	—
HOA1876-1	Transistor Interrupter	—	E	—
HOA1876-2	Transistor Interrupter	—	E	—
HOA1876-3	Darlington Interrupter	—	E	—
HOA1877-1	Transistor Interrupter	—	E	—

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HOA1877-3	Darlington Interrupter	—	E	—
HOA1878-11	Transistor Interrupter	OPB816	B	246
HOA1878-12	Transistor Interrupter	OPB817	B	246
HOA1878-13	Darlington Interrupter	—	E	—
HOA1879-11	Transistor Interrupter	—	D	—
HOA1879-12	Transistor Interrupter	—	D	—
HOA1879-15	Transistor Interrupter	—	D	—
HOA1881-11	Transistor Interrupter	OPB823A	B	256
HOA1881-12	Transistor Interrupter	—	D	—
HOA1881-13	Darlington Interrupter	—	E	—
HOA2001	Logic Interrupter	—	D	—
HOA2003	Logic Interrupter	—	D	—
HOA2498-1	Transistor Reflective	—	D	—
HOA2498-2	Transistor Reflective	—	D	—
HOA2498-3	Darlington Reflective	—	D	—
HOA2762-1	Transistor Interrupter	—	E	—
HOA2762-2	Transistor Interrupter	—	E	—
HOA2762-3	Darlington Interrupter	—	E	—
HOA2862-1	Transistor Interrupter	—	E	—
HOA2862-2	Transistor Interrupter	—	E	—
HOA2862-3	Darlington Interrupter	—	E	—
IL1	6-Pin Transistor Coupler	OPI2252	A	132
IL-1	6-Pin Transistor Coupler	OPI2252	A	132
IL-5	6-Pin Transistor Coupler	OPI2253	A	134
IL-12	6-Pin Transistor Coupler	OPI2151	A	130
IL12	6-Pin Transistor Coupler	OPI2151	A	130
IL15	6-Pin Transistor Coupler	OPI2251	A	130
IL-15	6-Pin Transistor Coupler	OPI2151	A	130
IL16	6-Pin Transistor Coupler	OPI2251	B	130
ILQ-74	16 Pin Quad Coupler	—	E	—
IL74	6-Pin Transistor Coupler	OPI2152	A	132
IL-74	6-Pin Transistor Coupler	OPI2152	A	132
IL-100	8-Pin High Speed Logic Coupler	6N137	A	188
IL-101	8-Pin High Speed Logic Coupler	OPI8137	B	188
IL-201	6-Pin Transistor Coupler	CNY17/2	B	102
IL-202	6-Pin Transistor Coupler	CNY17/3	B	102
IL-203	6-Pin Transistor Coupler	CNY17/4	B	102
IL-250	6-Pin AC Input Transistor Coupler	OPI2501	B	138
IL-501	6-Pin Transistor Coupler	OPI2253	A	134
IL-505	6-Pin Transistor Coupler	OPI2253	A	134
IL-512	6-Pin Transistor Coupler	OPI2251	A	130
IL-530	6-Pin Darlington Coupler	OPI3253	B	156
IL-555	6-Pin Darlington Coupler	OPI3252	B	154
ILA-30	6-Pin Darlington Coupler	OPI3251	B	152
ILA-55	6-Pin Darlington Coupler	OPI3252	B	154
ILCA2-30	6-Pin Darlington Coupler	OPI3250	B	150
ILCA2-55	6-Pin Darlington Coupler	OPI3252	B	154
ILCT-6	6-Pin Transistor Coupler	—	E	—
ILD-1	8-Pin Dual Coupler	—	D	—
ILD-74	8-Pin Dual Coupler	—	D	—
ILD-506	8-Pin Dual Transistor Coupler	—	E	—
ILQ-1	16 Pin Quad Coupler	—	E	—
IN5722	Pill Hermetic Transistor	OP601	A	76
IN5723	Pill Hermetic Transistor	OP602	A	76
IN5724	Pill Hermetic Transistor	OP603	A	76
IN5725	Pill Hermetic Transistor	OP604	A	76
IRL-60	Axial Plastic LED	—	E	—
JAN4N47	Hi Rel TO-5 Transistor Coupler	JAN4N24A	B	332
JAN4N48	Hi Rel TO-5 Transistor Coupler	—	E	—
JAN4N49	Hi Rel TO-5 Transistor Coupler	—	E	—
JANTX4N47	Hi Rel TO-5 Transistor Coupler	—	D	—
JANTX4N48	Hi Rel TO-5 Transistor Coupler	—	E	—
JANTX4N49	Hi Rel TO-5 Transistor Coupler	—	E	—

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JANTXV4N48	Hi Rel TO-5 Transistor Coupler	—	E	—
JANTXV4N49	Hi Rel TO-5 Transistor Coupler	—	E	—
K3010P	6-Pin Triac Driver Coupler	OPI3010	B	142
K3020P	6-Pin Triac Driver Coupler	OPI3020	B	144
K-5100	Coaxial Hermetic Transistor	—	E	—
K-5101	Coaxial Hermetic Transistor	—	E	—
K-5102	Coaxial Hermetic Transistor	—	E	—
K-5103	Coaxial Hermetic Transistor	—	E	—
K-5200	TO-18 Hermetic Transistor	OP802W	A	80
K-5201	TO-18 Hermetic Transistor	OP800W	A	80
K-5202	TO-18 Hermetic Transistor	OP801W	A	80
K-5203	TO-18 Hermetic Transistor	OP802W	A	80
K-5210	TO-18 Hermetic Transistor	OP801W	A	80
K-5211	TO-18 Hermetic Transistor	OP802W	A	80
K-5250	TO-18 Hermetic Transistor	OP803	A	78
K-5251	TO-18 Hermetic Transistor	OP802	A	78
K-5253	TO-18 Hermetic Transistor	OP801	A	78
K-5255	TO-18 Hermetic Transistor	OP802	A	78
K-5256	TO-18 Hermetic Transistor	OP804	A	78
K-5257	TO-18 Hermetic Transistor	OP805	A	78
K-5258	TO-18 Hermetic Transistor	OP805	A	78
K-5500	T-1 Plastic Transistor	OP500	A	46
K-5501	T-1 Plastic Transistor	OP500SLA	A	46
K-5502	T-1 Plastic Transistor	OP500SLB	A	46
K-5503	T-1 Plastic Transistor	OP500SLC	A	46
K-5504	T-1 Plastic Transistor	OP500SLD	A	46
K-5505	T-1 Plastic Transistor	OP500	A,C	46
K-5550	Plastic Lateral Transistor	OP550SLC	C	64
K-5551	Plastic Lateral Transistor	OP550SLA	C	64
K-5552	Plastic Lateral Transistor	OP550SLB	C	64
K-5553	Plastic Lateral Transistor	OP550SLC	C	64
K-5554	Plastic Lateral Transistor	OP550SLD	C	64
K-6100	Coaxial Hermetic LED	—	E	—
K-6101	Coaxial Hermetic LED	—	E	—
K-6102	Coaxial Hermetic LED	—	E	—
K-6103	Coaxial Hermetic LED	—	E	—
K-6200	TO-46 Hermetic LED	OP131W	A	6
K-6201	TO-46 Hermetic LED	OP131W	A	6
K-6202	TO-46 Hermetic LED	OP132W	A	6
K-6203	TO-46 Hermetic LED	OP133W	A	6
K-6204	TO-46 Hermetic LED	OP133W	A	6
K-6250	TO-46 Hermetic LED	OP132	A	6
K-6251	TO-46 Hermetic LED	OP130	A	6
K-6252	TO-46 Hermetic LED	OP131	A	6
K-6253	TO-46 Hermetic LED	OP133	A	6
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K-6302	TO-46 Hermetic LED	OP232W	A	22
K-6304	TO-46 Hermetic LED	OP232W	A	22
K-6350	TO-46 Hermetic LED	OP231	A	22
K-6351	TO-46 Hermetic LED	OP231	A	22
K-6352	TO-46 Hermetic LED	OP232	A	22
K-6354	TO-46 Hermetic LED	OP233	A	22
K-6500	T-1 Plastic LED	OP160SL	A	10
K-6501	T-1 Plastic LED	OP160SLA	A	10
K-6502	T-1 Plastic LED	OP160SLB	A	10
K-6503	T-1 Plastic LED	OP160SLC	A	10
K-6504	T-1 Plastic LED	OP160SLD	A	10
K-6505	T-1 Plastic LED	OP160SL	A	10
K-6550	Plastic Lateral LED	OP140SL	C	8
K-6551	Plastic Lateral LED	OP140SLA	C	8
K-6552	Plastic Lateral LED	OP140SLB	C	8
K-6553	Plastic Lateral LED	OP140SLC	C	8

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K-6554	Plastic Lateral LED	OP140SLD	C	8
K-6555	Plastic Lateral LED	OP140SL	C	8
K-7100	Coaxial Hermetic Photodiode	—	E	—
K-7200	TO-18 Photodiode	OP913W	B,C	96
K-7250	TO-18 Photodiode	OP913	B,C	96
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K-7400	Plastic Lateral Photodiode	—	E	—
K-7500	Quad Photodiode	—	E	—
K-8010	TO-18 Matched Pair	—	D	—
K-8020	Plastic T-1 Matched Pair	OPS661	A	306
K-8030	Plastic Lateral Matched PairLED	OPS692	A	308
K-8031	Plastic Lateral Matched PairLED	OPS692	B	308
K-8040	Plastic Lateral Matched PairLED	—	D	—
K-8050	Fiber Optic Pair	—	E	—
K-8100	Transistor Interrupter	OPB862T55	A	272
K-8101	Transistor Interrupter	OPB867T55	B	272
K-8102	Transistor Interrupter	OPB865T55	B	272
K-8103	Transistor Interrupter	OPB866T55	B	272
K-8105	Transistor Interrupter	OPB860T55	B	272
K-8106	Darlington Interrupter	—	E	—
K-8107	Darlington Interrupter	—	E	—
K-8108	Darlington Interrupter	—	E	—
K-8110	Transistor Interrupter	OPB860T51	B	272
K-8111	Transistor Interrupter	OPB865T51	B	272
K-8112	Transistor Interrupter	OPB813S7	A	244
K-8113	Transistor Interrupter	OPB813S5	A	244
K-8114	Transistor Interrupter	OPB813S3	A	244
K-8115	Transistor Interrupter	—	E	—
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K-8117	Transistor Interrupter	—	E	—
K-8118	Transistor Interrupter	—	E	—
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K-8121	Transistor Interrupter	OPB862N55	B	272
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K-8133	Transistor Interrupter	OPB875T55	C	272
K-8134	Transistor Interrupter	OPB876T55	C	272
K-8135	Transistor Interrupter	OPB877T55	C	272
K-8136	Transistor Interrupter	OPB875T51	C	272
K-8137	Transistor Interrupter	OPB813S7	C	244
K-8138	Transistor Interrupter	OPB813S5	C	244
K-8139	Transistor Interrupter	OPB813S3	C	244
K-8140	Transistor Interrupter	OPB870N51	B	272
K-8141	Transistor Interrupter	OPB872N55	B	272
K-8150	Transistor Interrupter	OPB820	A	250
K-8151	Transistor Interrupter	OPB820S7	A	250
K-8152	Transistor Interrupter	OPB820S7	A	250
K-8153	Transistor Interrupter	OPB820S5	A	250
K-8154	Transistor Interrupter	—	E	—
K-8155	Transistor Interrupter	—	E	—
K-8156	Darlington Interrupter	—	E	—
K-8160	Transistor Interrupter	OPB821	A	252
K-8161	Transistor Interrupter	OPB821S7	A	252
K-8162	Transistor Interrupter	OPB821S7	A	252
K-8163	Transistor Interrupter	OPB820S5	A	250
K-8164	Transistor Interrupter	—	E	—
K-8165	Transistor Interrupter	—	E	—
K-8166	Darlington Interrupter	—	E	—
K-8170	Transistor Interrupter	OPB823A	A	256
K-8171	Transistor Interrupter	OPB882T55	C	256
K-8172	Darlington Interrupter	—	E	—
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K-8181	Transistor Interrupter	OPB877T55	B	272
K-8190	Transistor Interrupter	—	E	—
K-8191	Transistor Interrupter	—	E	—
K-8240	Transistor Interrupter	—	E	—
K-8242	Transistor Interrupter	—	E	—
K-8243	Transistor Interrupter	—	E	—
K-8250	Transistor Interrupter	—	E	—
K-8251	Transistor Interrupter	—	E	—
K-8252	Transistor Interrupter	—	E	—
K-8255	Transistor Interrupter	—	E	—
K-8256	Transistor Interrupter	—	E	—
K-8700	Transistor Reflective	OPB708	B	222
K-8701	Transistor Reflective	—	E	—
K-8702	Transistor Reflective	—	E	—
K-8703	Transistor Reflective	—	E	—
K-8710	Transistor Reflective	OPB709	B	222
K-8711	Transistor Reflective	—	E	—
K-8712	Transistor Reflective	—	E	—
K-8713	Transistor Reflective	—	E	—
K-8720	Transistor Reflective	—	E	—
K-8730	Transistor Reflective	OPB730	A	226
K-8731	Transistor Reflective	OPB710	A	226
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K-8900	Axial Transistor Coupler	OPI110	A	108
K-8901	Axial Transistor Coupler	OPI1264A	A	116
K-8902	Axial Transistor Coupler	OPI1264B	A	116
K-8903	Axial Transistor Coupler	OPI1264C	A	116
K-8910	Axial Darlington Coupler	OPI113	A	108
K-8920	Axial Transistor Coupler	OPI120	A	110
K-8930	Axial Darlington Coupler	OPI123	A	110
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K-8941	TO-5 Transistor Coupler	OPI103	A	106
K-8945	TO-5 Darlington Coupler	OPI130	A	118
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K-9001	T-1 Plastic Darlington	OP530	A	60
K-9002	T-1 Plastic Darlington	OP530	A	60
K-9010	Lateral Plastic Darlington	OP560	B,C	70
K-9011	Lateral Plastic Darlington	OP560	B,C	70
K-9012	Lateral Plastic Darlington	OP560	B,C	70
K-9020	TO-18 Hermetic Darlington	OP830	A	86
K-9021	TO-18 Hermetic Darlington	OP830	B	86
K-9022	TO-18 Hermetic Darlington	OP830	B	86
K-9030	TO-18 Hermetic Darlington	OP830W	A	88
K-9042	Coaxial Hermetic Darlington	—	E	—
K-9043	Coaxial Hermetic Darlington	—	E	—
L12H4	Plastic Lateral Transistor	OP550	B,C	64
L14C1	TO-18 Hermetic Transistor	OP801W	B	80
L14C2	TO-18 Hermetic Transistor	OP800W	B	80
L14F1	TO-18 Hermetic Darlington	OP830	B	86
L14F2	TO-18 Hermetic Darlington	OP830	B	86
L14G1	TO-18 Hermetic Darlington	OP830	B	86
L14G2	TO-18 Hermetic Transistor	OP802	B	78
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L14H1	Plastic Lateral Transistor	OP550	B,C	64
L14H2	Plastic Lateral Transistor	OP550SLD	B,C	64
L14H3	Plastic Lateral Transistor	OP550SLD	B,C	64
L14H4	Plastic Lateral Transistor	OP550	B,C	64
L14N1	TO-18 Hermetic Transistor	OP802W	B	80
L14N2	Hermetic Transistor	—	D	—
L14P1	TO-18 Hermetic Transistor	OP805	B	78
L14P2	TO-18 Hermetic Transistor	OP805	B	78
L14Q1	Plastic Lateral Transistor	OP550SLA	B	64

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LD241/I	Plastic TO-18 LED	OP293C	B,C	36
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LD242-2	Plastic TO-18 LED	OP293B	B,C	36
LD242-3	Plastic TO-18 LED	OP293A	B,C	36
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LD261(1)	1 Element LED	–	E	–
LD261-4	Plastic Radial LED	–	E	–
LD261-5	Plastic Radial LED	–	E	–
LD261-6	Plastic Radial LED	–	E	–
LD261/I	Plastic LED	–	E	–
LD261/II	Plastic LED	–	E	–
LD261/III	Plastic LED	–	E	–
LD261/IV	Plastic LED	–	E	–
LD262	2 Element LED	–	E	–
LD262(2)	2 Element LED	–	E	–
LD263	3 Element LED	–	E	–
LD263(3)	3 Element LED	–	E	–
LD264	4 Element LED	–	E	–
LD264(4)	4 Element LED	–	E	–
LD265	5 Element LED	–	E	–
LD265(5)	5 Element LED	–	E	–
LD266	6 Element LED	–	E	–
LD266(6)	6 Element LED	–	E	–
LD267	7 Element LED	–	E	–
LD267(7)	7 Element LED	–	E	–
LD268	8 Element LED	–	E	–
LD268(8)	8 Element LED	–	E	–
LD269	9 Element LED	–	E	–
LD269(9)	9 Element LED	–	E	–
LD270	10 Element LED	–	E	–
LD270(10)	10 Element LED	–	E	–
LD271	T-1¾ Plastic LED	OP291B	A	32
LD271A	T-1¾ Plastic LED	OP291C	A	32
LD271H	T-1¾ Plastic LED	OP291A	A	32
LD271L	T-1¾ Plastic LED	OP291B	A	32
LD273	Plastic Dual LED	–	E	–
LED55B	TO-46 Hermetic LED	OP132	A	6
LED55BF	TO-46 Hermetic LED	OP132W	A	6
LED55C	TO-46 Hermetic LED	OP133	B	6
LED55CF	TO-46 Hermetic LED	OP133W	B	6
LED56	TO-46 Hermetic LED	OP131	A	6
LED56F	TO-46 Hermetic LED	OP131W	A	6
LPT100	Ceramic Lensed LED	–	E	–
LPT100A	Ceramic Lensed LED	–	E	–
LPT100B	Ceramic Lensed LED	–	E	–
LPT110	Ceramic Flat LED	–	E	–
LPT110A	Ceramic Flat LED	–	E	–
LPT110B	Ceramic Flat LED	–	E	–
LS600	Pill Hermetic Transistor	OP600	A	76
MCP3032	6-Pin Triac Driver Coupler	OPI3032	B	146
MCA7	Darlington Reflective	OPB711	A	230
MCA8	Transistor Interrupter	OPB870T55	B,C	274
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MCA81	Transistor Interrupter	OPB870T55	B,C	274
MCA230	6-Pin Darlington Coupler	OPI3150	A	150
MCA231	6-Pin Darlington Coupler	OPI3151	A	152
MCA255	6-Pin Darlington Coupler	OPI3152	A	154
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MCP3009	6-Pin Triac Driver Coupler	OPI3009	B	142
MCP3010	6-Pin Triac Driver Coupler	OPI3010	B	142
MCP3011	6-Pin Triac Driver Coupler	OPI3011	B	142
MCP3012	6-Pin Triac Driver Coupler	OPI3012	B	142
MCP3020	6-Pin Triac Driver Coupler	OPI3020	B	144
MCP3021	6-Pin Triac Driver Coupler	OPI3021	B	144
MCP3022	6-Pin Triac Driver Coupler	OPI3022	B	144
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MCP3040	6-Pin Triac Driver Coupler	OPI3040	B	148
MCP3041	6-Pin Triac Driver Coupler	OPI3041	B	148
MCP3042	6-Pin Triac Driver Coupler	OPI3042	B	148
MCP3043	6-Pin Triac Driver Coupler	OPI3043	B	148
MCS2	6-Pin SCR Driver Coupler	–	E	–
MCS21	6-Pin SCR Driver Coupler	–	E	–
MCS2400	6-Pin SCR Driver Coupler	–	E	–
MCS2401	6-Pin SCR Driver Coupler	–	E	–
MCT2	6-Pin Transistor Coupler	OPI2152	A	132
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MCT4	4-Pin TO-72 Transistor Coupler	3N243	A	166
MCT6	8-Pin Dual Transistor Coupler	–	E	–
MCT8	Transistor Interrupter	OPB872T55	B,C	274
MCT26	6-Pin Transistor Coupler	OPI2151	A	130
MCT66	8-Pin Dual Transistor Coupler	–	E	–
MCT81	Transistor Interrupter	OPB872T55	B,C	274
MCT210	6-Pin Transistor Coupler	OPI2100	A	126
MCT270	6-Pin Transistor Coupler	OPI2253	B	134
MCT271	6-Pin Transistor Coupler	OPI2253	A	134
MCT272	6-Pin Transistor Coupler	4N35	A	176
MCT273	6-Pin Transistor Coupler	OPI2100	B	126
MCT274	6-Pin Transistor Coupler	–	D	–
MCT275	6-Pin Transistor Coupler	–	D	–
MCT276	6-Pin Transistor Coupler	OPI2252	B	132
MCT277	6-Pin Transistor Coupler	4N36	B	176
MCT2200	6-Pin Transistor Coupler	OPI2152	A	132
MCT2201	6-Pin Transistor Coupler	4N35	A	176
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ME7124	Plastic LED	OP297A	B,C	32
ME7161	Plastic LED	–	D	–
MFOD100	Fiber Optic PIN Diode	–	D	–
MFOD102F	Fiber Optic PIN Diode	–	D	–
MFOD104F	Fiber Optic PIN Diode	–	D	–
MFOD200	TO-18 Fiber Optic Transistor	–	D	–
MFOD202F	Plastic Fiber Optic Transistor	–	D	–
MFOD300	Plastic Fiber Optic Transistor	–	D	–
MFOD302F	Plastic Fiber Optic Darlington	–	D	–
MFOD402F	Integrated Detector Preamp Fiber Optic	–	E	–
MFOD404F	Integrated Detector Preamp Fiber Optic	–	E	–
MFOD405F	Integrated Detector Preamp Fiber Optic	–	E	–
MFOE100	Fiber Optic LED	–	E	–
MFOE102F	Fiber Optic LED	–	E	–
MFOE103F	Fiber Optic LED	–	E	–
MFOE103FB	Fiber Optic LED	–	E	–
MFOE106F	Fiber Optic LED	–	E	–
MFOE107F	Fiber Optic LED	–	E	–
MFOE108F	Fiber Optic LED	–	E	–
MFOE200	Fiber Optic LED	–	E	–
MFOE1201	Fiber Optic LED	–	E	–

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MFOE1202	Fiber Optic LED	—	E	—
MID400	8-Pin AC Logic Coupler	—	D	—
MLED15	Micro-T LED	—	E	—
MLED71	Plastic Lateral LED	OP140SL	B,C	8
MLED90	Plastic Lateral LED	OP140SL	B,C	8
MLED92	Plastic Lateral LED	OP140SL	B,C	8
MLED93	Plastic Lateral LED	OP140SL	B,C	8
MLED94	Plastic Lateral LED	OP140SL	B,C	8
MLED95	Plastic Lateral LED	OP140SL	B,C	8
MLED910	Pill Hermetic LED	OP123	A	4
MLED930	TO-18 Hermetic LED	OP133	B	6
MOC119	6-Pin Transistor Coupler	OPI3250	A	150
MOC601A	6-Pin Transistor Coupler	OPI2251	A	130
MOC602A	6-Pin Transistor Coupler	OPI2252	A	132
MOC603A	6-Pin Transistor Coupler	OPI2253	A	134
MOC604A	6-Pin Transistor Coupler	4N35	A	176
MOC622A	6-Pin Transistor Coupler	4N29	A	174
MOC623A	6-Pin Darlington Coupler	OPI3250	A	150
MOC624A	6-Pin Darlington Coupler	OPI3253	A	156
MOC625A	6-Pin Darlington Coupler	OPI3253	B	156
MOC626A	6-Pin Transistor Coupler	4N29	A	174
MOC627A	6-Pin Darlington Coupler	OPI3250	A	150
MOC628A	6-Pin Darlington Coupler	OPI3253	A	156
MOC629A	6-Pin Darlington Coupler	OPI3253	B	156
MOC633A	6-Pin Triac Driver Coupler	OPI3020	B	144
MOC634A	6-Pin Triac Driver Coupler	OPI3021	B	144
MOC635A	6-Pin Triac Driver Coupler	OPI3022	B	144
MOC640A	6-Pin Triac Driver Coupler	OPI3040	B	148
MOC641A	6-Pin Triac Driver Coupler	OPI3041	B	148
MOC1000	6-Pin Transistor Coupler	4N26	A	172
MOC1001	6-Pin Transistor Coupler	4N25	A	172
MOC1002	6-Pin Transistor Coupler	4N27	A	172
MOC1003	6-Pin Transistor Coupler	4N28	A	172
MOC1005	6-Pin Transistor Coupler	OPI2253	A	134
MOC1006	6-Pin Transistor Coupler	OPI2253	A	134
MOC1200	6-Pin Transistor Coupler	4N29	A	174
MOC3002	6-Pin SCR Driver Coupler	—	E	—
MOC3003	6-Pin SCR Driver Coupler	—	E	—
MOC3007	6-Pin SCR Driver Coupler	—	E	—
MOC3009	6-Pin Triac Driver Coupler	OPI3009	A	142
MOC3010	6-Pin Triac Driver Coupler	OPI3010	A	142
MOC3011	6-Pin Triac Driver Coupler	OPI3011	A	142
MOC3012	6-Pin Triac Driver Coupler	OPI3012	A	142
MOC3020	6-Pin Triac Driver Coupler	OPI3020	A	144
MOC3021	6-Pin Triac Driver Coupler	OPI3021	A	144
MOC3022	6-Pin Triac Driver Coupler	OPI3022	A	144
MOC3023	6-Pin Triac Driver Coupler	OPI3023	A	144
MOC3030	6-Pin Triac Driver Coupler	OPI3030	A	146
MOC3031	6-Pin Triac Driver Coupler	OPI3031	A	146
MOC3032	6-Pin Triac Driver Coupler	OPI3032	A	146
MOC3040	6-Pin Triac Driver Coupler	OPI3040	A	148
MOC3041	6-Pin Triac Driver Coupler	OPI3041	A	148
MOC5003	6-Pin Schmitt Trigger Coupler	OPI8012	B	162
MOC5004	6-Pin Schmitt Trigger Coupler	OPI8012	B	162
MOC5005	6-Pin Schmitt Trigger Coupler	OPI8012	B	162
MOC5006	6-Pin Schmitt Trigger Coupler	OPI8012	B	162
MOC5007	6-Pin Schmitt Trigger Coupler	OPI8012	B	162
MOC5008	6-Pin Schmitt Trigger Coupler	OPI8012	B	162
MOC5009	6-Pin Schmitt Trigger Coupler	OPI8012	B	162
MOC5010	6-Pin Amplifier Coupler	—	E	—
MOC7811	Transistor Interrupter	OPB871T55	C	272
MOC7812	Transistor Interrupter	OPB872T55	C	272
MOC7813	Transistor Interrupter	OPB872T55	C	272
MOC7821	Transistor Interrupter	OPB871N55	C	272

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MOC8021	6-Pin Darlington Coupler	—	D	—
MOC8030	6-Pin Darlington Coupler	OPI3252	B	154
MOC8050	6-Pin Darlington Coupler	OPI3252	B	154
MOC8100	6-Pin Transistor Coupler	OPI2253	A	134
MOC8111	6-Pin Transistor Coupler	OPI2252	A	132
MOC8112	6-Pin Transistor Coupler	OPI2253	A	134
MOC8113	6-Pin Transistor Coupler	4N35	A	176
MOC8204	6-Pin High Voltage Transistor Coupler	OPI6000	B	158
MOC8205	6-Pin High Voltage Transistor Coupler	OPI6100	B	158
MOC8206	6-Pin High Voltage Transistor Coupler	OPI6100	B	158
MRD14B	TO-92 Plastic Darlington	OP560	B,C	70
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MRD160	Plastic Transistor	—	E	—
MRD300	TO-18 Hermetic Transistor	OP800	B	78
MRD-310	TO-18 Hermetic Transistor	OP800	B	78
MRD310	TO-18 Hermetic Darlington	OP830	B	86
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MRD370	TO-18 Hermetic Darlington	OP830	B	86
MRD500	TO-18 Photodiode	OP913	B,C	96
MRD510	TO-18 Photodiode	OP913W	B,C	96
MRD601	Pill Hermetic Transistor	OP601	A	76
MRD602	Pill Hermetic Transistor	OP602	A	76
MRD603	Pill Hermetic Transistor	OP603	A	76
MRD604	Pill Hermetic Transistor	OP604	A	76
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MRD701	Plastic Lateral Transistor	OP550SLA	B,C	64
MRD711	Plastic Darlington	OP560	B,C	70
MRD721	Plastic PIN Photodiode	—	E	—
MRD920	TO-92 SCR Sensor	—	E	—
MRD3010	TO-18 Triac Driver Sensor	—	D	—
MRD3011	TO-18 Triac Driver Sensor	—	D	—
MRD3050	TO-18 Hermetic Transistor	OP801	B	78
MRD3051	TO-18 Hermetic Transistor	OP802	B	78
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MT1	TO-18 Hermetic Transistor	OP802W	A	80
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SPX1873-2	Transistor Interrupter	—	E	—
S153P	TO-56 Hermetic Photodiode	OP913	B,C	96
S168P	TO-18 Hermetic PIN Diode	OP913	B,C	96
S171P	Custom Photodiode	—	E	—
S181P	Custom Photodiode	—	E	—
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S86018E	Edge Emitter LED	—	E	—
S86020E	Edge Emitter LED	—	E	—
S86021E	Edge Emitter LED	—	E	—
SCD11B1	6-Pin Darlington Coupler	OPI3253	A	156
SCD11B2	6-Pin Darlington Coupler	OPI3250	A	150
SCD11B3	6-Pin Darlington Coupler	OPI3250	A	150
SCD255	6-Pin Darlington Coupler	—	D	—
SD1410-1	Darlington Photosensor	—	E	—
SD1410-2	Darlington Photosensor	—	E	—
SD1410-3	Darlington Photosensor	—	E	—
SD1410-4	Darlington Photosensor	—	E	—

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SD1440-1	Hermetic Transistor	—	E	—
SD1440-2	Hermetic Transistor	—	E	—
SD1440-3	Hermetic Transistor	—	E	—
SD1440-4	Hermetic Transistor	—	E	—
SD2410-1	Pill Hermetic Darlington	OP302	B	44
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SD2440-1	Pill Hermetic Transistor	OP601	B	76
SD2440-2	Pill Hermetic Transistor	OP602	B	76
SD2440-3	Pill Hermetic Transistor	OP603	B	76
SD2440-4	Pill Hermetic Transistor	OP604	B	76
SD3410-1	TO-18 Hermetic Darlington	OP830W	B	88
SD3410-2	TO-18 Hermetic Darlington	OP830W	B	88
SD3410-3	TO-18 Hermetic Darlington	OP830W	B	88
SD3410-4	TO-18 Hermetic Darlington	—	D	—
SD3421-2	TO-18 Hermetic Photodiode	—	D	—
SD3443-1	TO-18 Hermetic Transistor	OP801W	B	80
SD3443-2	TO-18 Hermetic Transistor	OP802W	B	80
SD3443-3	TO-18 Hermetic Transistor	OP802W	B	80
SD5410-1	TO-18 Hermetic Darlington	OP830	B	86
SD5410-2	TO-18 Hermetic Darlington	OP830	B	86
SD5410-3	TO-18 Hermetic Darlington	OP830	B	86
SD5421-2	TO-18 Hermetic Photodiode	—	D	—
SD5422-2	TO-18 Hermetic Photodiode	—	D	—
SD5443-1	TO-18 Hermetic Transistor	OP802	A	78
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SD5443-3	TO-18 Hermetic Transistor	OP804	B	78
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SD5600	TO-18 Schmitt Trigger Sensor	OPL800	B	82
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SDC413-1	Darlington Chip	OPC300R	B,C	204
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SDC440-1	Transistor Chip	OPC600L	B,C	206
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SDP8403-1	T-1¾ Plastic Transistor	OP500	B,C	46
SDP8403-2	T-1¾ Plastic Transistor	OP500SLA	B,C	46
SDP8403-3	T-1¾ Plastic Transistor	OP500SLC	B,C	46
SDP8403-4	T-1¾ Plastic Transistor	OP500SLB	B,C	46
SDP8405-1	T-1 Plastic Transistor	OP500	B	46
SDP8405-2	T-1 Plastic Transistor	OP500	A	46
SDP8405-3	T-1 Plastic Transistor	OP500SLD	A	46
SDP8405-4	T-1 Plastic Transistor	OP500SLC	A	46
SDP8405-5	T-1 Plastic Transistor	OP500SLB	A	46
SDP8405-6	T-1 Plastic Transistor	OP500SLA	A	46
SDP8406-1	Plastic Lateral Transistor	OP550SLD	B,C	64
SDP8406-2	Plastic Lateral Transistor	OP550SLC	B,C	64
SDP8406-3	Plastic Lateral Transistor	OP550SLB	B,C	64
SDP8406-4	Plastic Lateral Transistor	OP550SLA	B,C	64
SDP8407-1	Plastic Transistor	OP508F	B,C	56
SDP8600-1	Plastic Lateral Schmitt Trig Sensor	OPL550	B,C	66
SDP8603-1	Schmitt Trigger Sensor	OPL550	B,C	66
SDP8607-1	Schmitt Trigger Sensor	OPL550	B,C	66
SE1450-1	Coaxial Hermetic LED	—	E	—
SE1450-2	Coaxial Hermetic LED	—	E	—
SE1450-3	Coaxial Hermetic LED	—	E	—
SE1450-4	Coaxial Hermetic LED	—	E	—
SE2450-1	Hermetic LED	—	E	—
SE2450-2	Hermetic LED	—	E	—
SE2460-2	Pill Hermetic LED	OP123	B	4
SE2460-1	Pill Hermetic LED	OP123	B	4
SE2460-3	Pill Hermetic LED	OP124	B	4
SE2450-3	Hermetic LED	—	E	—
SE3453-2	TO-46 Hermetic LED	OP131W	A	6
SE3453-3	TO-46 Hermetic LED	OP132W	A	6
SE3453-4	TO-46 Hermetic LED	OP133W	A	6
SE3453-1	TO-46 Hermetic LED	OP131W	A	6
SE3455-1	TO-46 Hermetic LED	OP131W	A	6
SE3455-2	TO-46 Hermetic LED	OP132W	A	6
SE3455-3	TO-46 Hermetic LED	OP133W	A	6
SE3455-4	TO-46 Hermetic LED	OP133W	B	6
SE3470-1	TO-46 Hermetic LED	OP231W	A	22
SE3470-2	TO-46 Hermetic LED	OP232W	A	22
SE3470-3	TO-46 Hermetic LED	OP233W	A	22
SE3470-4	TO-46 Hermetic LED	OP233W	A	22
SE5453-1	TO-46 Hermetic LED	OP130	A	6
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SE5453-4	TO-46 Hermetic LED	OP133	A	6
SE5455-1	TO-46 Hermetic LED	OP131	A	6
SE5455-2	TO-46 Hermetic LED	OP132	A	6
SE5455-3	TO-46 Hermetic LED	OP133	A	6
SE5455-4	TO-46 Hermetic LED	OP133	B	6
SE5455-5	TO-46 Hermetic LED	OP133	B	6
SE5470-1	TO-46 Hermetic LED	OP231	A	22
SE5470-2	TO-46 Hermetic LED	OP232	A	22
SE5470-3	TO-46 Hermetic LED	OP233	A	22
SE5470-4	TO-46 Hermetic LED	OP233	A	22
SEC450-1	Infrared LED Chip	OPC123	B,C	201
SEC456-1	Infrared LED Chip	OPC216	B,C	202
SEP8503-1	Plastic LED	OP160SL	B,C	10
SEP8502-1	Plastic LED	OP160SL	B,C	10
SEP8504-1	Plastic Lateral LED	OP140SL	B,C	8
SEP8505-1	T-1 Plastic LED	OP160SL	A	10
SEP8505-2	T-1 Plastic LED	OP160SL	B	10
SEP8505-3	T-1 Plastic LED	OP160SLD	B	10
SEP8505-4	T-1 Plastic LED	OP160SLC	B	10
SEP8505-5	T-1 Plastic LED	OP160SLB	B	10
SEP8505-6	T-1 Plastic LED	OP160SLA	A	10
SEP8506-1	Plastic Lateral LED	OP140SL	B,C	8
SEP8506-2	Plastic Lateral LED	OP140SLC	B,C	8
SEP8506-3	Plastic Lateral LED	OP140SLB	B,C	8
SEP8506-4	Plastic Lateral LED	OP140SLA	B,C	8
SEP8507-1	Plastic LED	OP168F	B,C	16
SEP8507-2	Plastic LED	OP168F	B,C	16
SEP8703-1	T-1¾ Plastic LED	OP292C	B,C	32
SEP8705-1	T-1 Plastic LED	OP260SLA	A	26
SFH100	Photodiode	—	E	—
SFH200	Photodiode	—	E	—

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SFH203	Plastic PIN Photodiode	—	E	—
SFH204	Four Quadrant Diode	—	E	—
SFH205	Plastic PIN Photodiode	—	E	—
SFH206	Plastic PIN Photodiode	—	E	—
SFH206K	Plastic PIN Photodiode	—	E	—
SFH305-1	Plastic Transistor	—	E	—
SFH305-2	Plastic Transistor	—	E	—
SFH305-3	Plastic Transistor	—	F	—
SFH305-4	Plastic Transistor	—	E	—
SFH309	Plastic Transistor	OP501SL	C	52
SFH400-1	TO-18 Hermetic LED	OP132	B	6
SFH400-2	TO-18 Hermetic LED	OP133	B	6
SFH400-3	TO-18 Hermetic LED	OP133	B	6
SFH401-1	TO-18 Hermetic LED	OP131W	B	6
SFH401-2	TO-18 Hermetic LED	OP132W	B	6
SFH401-3	TO-18 Hermetic LED	OP133W	B	6
SFH402-1	TO-18 Hermetic LED	OP131W	B	6
SFH402-2	TO-18 Hermetic LED	OP132W	B	6
SFH402-3	TO-18 Hermetic LED	OP133W	B	6
SFH404	TO-46 Header Only LED	—	D	—
SFH405-1	Plastic LED	OP169SL	B.C	18
SFH405-2	Plastic LED	OP169SLD	B.C	18
SFH405-3	Plastic LED	OP169SLC	B.C	18
SFH405-4	Plastic LED	OP169SLC	B.C	18
SFH407-1	TO-46 Header Only LED	—	D	—
SFH407-2	TO-46 Header Only LED	—	D	—
SFH407-3	TO-46 Header Only LED	—	D	—
SFH409	T-1 Plastic LED	OP161SL	A	14
SFH500	TO-18 Hermetic Transistor	OP802W	B	80
SFH600-0	6-Pin Transistor Coupler	CNY17/1	A	102
SFH600-1	6-Pin Transistor Coupler	CNY17/2	A	102
SFH600-2	6-Pin Transistor Coupler	CNY17/3	A	102
SFH600-3	6-Pin Transistor Coupler	CNY17/4	A	102
SFH601-1	6-Pin Transistor Coupler	CNY17/1	B	102
SFH601-2	6-Pin Transistor Coupler	CNY17/2	B	102
SFH601-3	6-Pin Transistor Coupler	CNY17/3	B	102
SFH601-4	6-Pin Transistor Coupler	CNY17/4	B	102
SFH900	Transistor Reflective	—	D	—
SG2XXX	Laser Series Products	—	E	—
SG1002	Coaxial Hermetic LED	—	E	—
SG1003	Coaxial Hermetic LED	—	E	—
SG1004	Coaxial Hermetic LED	—	E	—
SG1009	TO-46 Hermetic LED	OP131	B,C	6
SG1009A	TO-46 Hermetic LED	OP132	A	6
SG1009A/F	TO-46 Hermetic LED	OP132W	A	6
SG1009/F	TO-46 Hermetic LED	OP131W	A	6
SG1010	TO-46 Hermetic LED	OP131	A	6
SG1010A	TO-46 Hermetic LED	OP132	A	6
SG1010A/F	TO-46 Hermetic LED	OP131W	A	6
SG1010/F	TO-46 Hermetic LED	OP131W	A	6
SPX2E	6-Pin Transistor Coupler	OPI2253	B	134
SPX6	6-Pin Transistor Coupler	OPI2253	B	134
SPX26	6-Pin Transistor Coupler	OPI2251	B	130
SPX33	6-Pin Transistor Coupler	OPI2253	B	134
SPX35	6-Pin Transistor Coupler	CNY17/3	B	102
SPX53	6-Pin Transistor Coupler	OPI2253	B	134
SPX74A1	6-Pin Transistor Coupler	OPI2252	B	132
SPX103	6-Pin Transistor Coupler	CNY17/3	B	102
SPX1160-1	Transistor Reflective	—	D	—
SPX1160-2	Transistor Reflective	—	D	—
SPX1160-3	Darlington Reflective	—	D	—
SPX1180-1	Transistor Reflective	—	E	—
SPX1180-2	Transistor Reflective	—	E	—

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SPX1396-1	Transistor Reflective	OPB710	B	226
SPX1396-2	Transistor Reflective	OPB710	B	226
SPX1396-3	Transistor Reflective	OPB710	B	226
SPX1397-1	Transistor Reflective	OPB706A	B	218
SPX1397-2	Transistor Reflective	OPB706A	B	218
SPX1397-4	Transistor Reflective	OPB706A	B	218
SPX1397-31	Darlington Reflective	OPB707A	B	218
SPX1397-32	Darlington Reflective	OPB707A	B	218
SPX1397-34	Darlington Reflective	OPB707A	B	218
SPX1404-1	Transistor Reflective	OPB703A	B	216
SPX1404-2	Transistor Reflective	OPB703A	B	216
SPX1404-3	Darlington Reflective	OPB703A	B	216
SPX1405-1	Transistor Reflective	OPB703A	B	216
SPX1870-21	Transistor Interrupter	OPB821S12	B	252
SPX1870-23	Darlington Interrupter	—	D	—
SPX1870-31	Transistor Interrupter	OPB821S7	B,C	252
SPX1870-33	Darlington Interrupter	—	D	—
SPX1872-1	Transistor Interrupter	—	E	—
SPX1872-2	Transistor Interrupter	—	E	—
SPX1872-3	Transistor Interrupter	—	E	—
SPX1872-4	Transistor Interrupter	—	E	—
SPX1872-11	Transistor Interrupter	OPB870N55	B,C	272
SPX1872-12	Transistor Interrupter	OPB870N55	B,C	272
SPX1872-13	Transistor Interrupter	OPB872N55	B.C	272
SPX1872-14	Transistor Interrupter	OPB872N55	B	272
SPX1873-1	Transistor Interrupter	—	E	—
SPX1873-3	Transistor Interrupter	—	D	—
SPX1873-4	Transistor Interrupter	—	E	—
SPX1873-11	Transistor Interrupter	OPB870T55	B,C	272
SPX1873-12	Transistor Interrupter	OPB870T55	B,C	272
SPX1873-13	Darlington Interrupter	OPB872T55	B,C	272
SPX1873-14	Transistor Interrupter	—	E	—
SPX1874-1	Transistor Interrupter	—	E	—
SPX1874-2	Transistor Interrupter	—	E	—
SPX1874-3	Transistor Interrupter	—	E	—
SPX1874-4	Transistor Interrupter	—	E	—
SPX1874-11	Transistor Interrupter	OPB865T55	B,C	272
SPX1874-12	Transistor Interrupter	OPB865T55	B.C	272
SPX1874-13	Transistor Interrupter	OPB866T55	B,C	272
SPX1874-14	Transistor Interrupter	OPB872T55	D	272
SPX1875-1	Transistor Interrupter	—	D	—
SPX1875-2	Transistor Interrupter	—	D	—
SPX1875-3	Darlington Interrupter	—	D	—
SPX1877-1	Transistor Interrupter	OPB818	B,C	248
SPX1877-2	Transistor Interrupter	OPB818	B,C	248
SPX1877-3	Darlington Interrupter	—	D	—
SPX1878-11	Transistor Interrupter	OPB875T55	C	272
SPX1878-12	Transistor Interrupter	OPB875T55	C	272
SPX1878-13	Transistor Interrupter	OPB875T55	C	272
SPX1878-14	Transistor Interrupter	OPB877T55	C	272
SPX1879-11	Transistor Interrupter	OPB865T55	A	272
SPX1879-12	Transistor Interrupter	OPB866T55	A	272
SPX1879-14	Transistor Interrupter	OPB867T55	A	272
SPX1879-15	Transistor Interrupter	OPB865T51	A	272
SPX1881-11	Transistor Interrupter	OPB885T55	A	276
SPX1881-12	Transistor Interrupter	OPB885T55	A	276
SPX1881-13	Darlington Interrupter	—	D	—
SPX1881-14	Transistor Interrupter	OPB887T55	A	276
SPX2001	Schmitt Trigger Interrupter	—	D	—
SPX2498-1	Transistor Reflective	—	D	—
SPX2498-2	Transistor Reflective	—	D	—
SPX2498-3	Darlington Reflective	—	D	—
SPX2762-1	Transistor Interrupter	—	E	—

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SPX2762-3	Transistor Interrupter	—	E	—
SPX2762-4	Transistor Interrupter	—	E	—
SPX2862-1	Transistor Interrupter	—	E	—
SPX2862-2	Transistor Interrupter	—	E	—
SPX2862-3	Transistor Interrupter	—	E	—
SPX2862-4	Transistor Interrupter	—	E	—
SPX7110	6-Pin Transistor Coupler	OPI2251	B	130
SPX7130	6-Pin Transistor Coupler	CNY17/1	B	102
SPX7150	6-Pin Transistor Coupler	CNY17/2	B	102
SPX7270	6-Pin Transistor Coupler	OPI2251	B	130
SPX7271	6-Pin Transistor Coupler	CNY17/1	B	102
SPX7272	6-Pin Transistor Coupler	CNY17/2	B	102
SPX7273	6-Pin Transistor Coupler	CNY17/4	B	102
SPX7530	6-Pin Transistor Coupler	CNY17/1	B	102
SPX7550	6-Pin Transistor Coupler	CNY17/2	B	102
SPX7590	6-Pin Transistor Coupler	CNY17/3	B	102
SPX7901	6-Pin Logic Gate Coupler	—	E	—
SPX8000-1	Plastic Lateral Matched PairLED	OPS693	B	308
SPX8001-1	Plastic Matched Pair	—	D	—
SPX8002-1	Plastic Matched Pair	—	D	—
SPX8003-1	Plastic T-1 Matched Pair	OPS662	B	306
SPX8004-1	Plastic Matched Pair	—	D	—
ST-100	Photovoltaic Cell	—	E	—
ST-101	Photovoltaic Cell	—	E	—
ST-102	Photovoltaic Cell	—	E	—
ST-200	Photovoltaic Cell	—	E	—
ST-201	Photovoltaic Cell	—	E	—
ST-202	Photovoltaic Cell	—	E	—
ST-203	Photovoltaic Cell	—	E	—
ST-300	Photovoltaic Cell	—	E	—
ST-301	Photovoltaic Cell	—	E	—
ST-400	Photovoltaic Cell	—	E	—
ST-500	Photovoltaic Cell	—	E	—
ST/A 71	Array	—	E	—
ST/A 71-SS	Array	—	E	—
ST/A 72	Array	—	E	—
ST/A 73	Array	—	E	—
ST/A 73-SS	Array	—	E	—
ST/A 74-SS	Array	—	E	—
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STCT1	Transistor Interrupter	—	E	—
STCT2	Transistor Interrupter	—	E	—
STD-1540-1	Coaxial Hermetic Photodiode	—	E	—
STD-1540-2	Coaxial Hermetic Photodiode	—	E	—
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STD-1850-2	TO-18 Hermetic Photodiode	—	E	—
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STD-2050-1	TO-18 Hermetic Photodiode	—	E	—
STD-2050-2	TO-18 Hermetic Photodiode	—	E	—
STDD-210	Pill Hermetic Photodiode	OP900	A	94
STIN-135D1	Darlington Interrupter	—	E	—
STIN-135D2	Darlington Interrupter	—	E	—
STIN-135T1	Transistor Interrupter	OPB875T55	B,C	272
STIN-135T2	Transistor Interrupter	OPB875T55	B,C	272
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STLD-1500-2	Coaxial Hermetic LED	—	E	—

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STLD-1500-4	Coaxial Hermetic LED	—	E	—
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STLD-1600-2	Pill Hermetic LED	OP123	B,C	4
STLD-1600-3	Pill Hermetic LED	OP124	C	4
STLD-1700-1	Pill Hermetic LED	OP123	A	4
STLD-1700-2	Pill Hermetic LED	OP123	A	4
STLD-1700-3	Pill Hermetic LED	OP124	A	4
STLD-1700-4	Pill Hermetic LED	OP224	C	20
STLD-1800-1	TO-46 Hermetic LED	OP130W	A	6
STLD-1800-2	TO-46 Hermetic LED	OP131W	B	6
STLD-1800-3	TO-46 Hermetic LED	OP131W	A	6
STLD-1900-1	TO-46 Hermetic LED	OP130W	A	6
STLD-1900-2	TO-46 Hermetic LED	OP131W	B	6
STLD-1900-3	TO-46 Hermetic LED	OP132W	A	6
STLD-2000-1	TO-46 Hermetic LED	OP130	A	6
STLD-2000-2	TO-46 Hermetic LED	OP130	B	6
STLD-2000-3	TO-46 Hermetic LED	OP131	A	6
STLD-2100-1	TO-46 Hermetic LED	OP130	A	6
STLD-2100-2	TO-46 Hermetic LED	OP131	A	6
STLD-2100-3	TO-46 Hermetic LED	OP132	A	6
STLD-2100-4	TO-46 Hermetic LED	OP133	A	6
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STOC-1400	Axial Darlington Coupler	OPI123	C	110
STOC-1401	Axial Darlington Coupler	OPI123	C	110
STOC-1402	Axial Darlington Coupler	OPI123	B,C	110
STOC-1410	Axial Diode Coupler	—	E	—
STOC-1411	Axial Diode Coupler	—	E	—
STOC-1412	Axial Diode Coupler	—	E	—
STOC-1420	Axial Transistor Coupler	OPI120	B,C	110
STOC-1421	Axial Transistor Coupler	OPI120	C	110
STOC-1422	Axial Transistor Coupler	OPI120	B,C	110
STOC-1430	Axial Transistor Coupler	OPI1264A	B,C	116
STOC-1431	Axial Transistor Coupler	OPI1264A	C	116
STOC-1432	Axial Transistor Coupler	OPI1264B	C	116
STPD-1510-1	Coaxial Hermetic Darlington	—	E	—
STPD-1510-2	Coaxial Hermetic Darlington	—	E	—
STPD-1510-3	Coaxial Hermetic Darlington	—	E	—
STPD-1510-4	Coaxial Hermetic Darlington	—	E	—
STPD-1610-1	Pill Hermetic Darlington	OP302	A	44
STPD-1610-2	Pill Hermetic Darlington	OP303	B	44
STPD-1610-3	Pill Hermetic Darlington	OP304	B	44
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STPD-1810-2	TO-18 Hermetic Darlington	OP830W	B	88
STPD-1810-3	TO-18 Hermetic Darlington	OP830W	A	88
STPD-1810-4	TO-18 Hermetic Darlington	OP830W	B	88
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STPT-60	Pill Hermetic Transistor	OP600	A	76
STPT-61	Pill Hermetic Transistor	OP601	A	76
STPT-62	Pill Hermetic Transistor	OP602	A	76
STPT-63	Pill Hermetic Transistor	OP603	A	76
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STPT-100B	Plastic Transistor	OP593B	B,C	72
STPT-110	Plastic Transistor	OP593C	C	72
STPT-110A	Plastic Transistor	OP593C	B,C	72
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STPT-120A	Plastic Transistor	OP593A	B,C	72
STPT-120B	Plastic Transistor	OP593A	B,C	72

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STPT-130B	Plastic Transistor	OP593A	B,C	72
STPT-225P	Custom Transistor	—	E	—
STPT-240P	Custom Transistor	—	E	—
STPT-260P	Custom Transistor	—	E	—
STPT-260Q	TO-5 Hermetic Transistor	—	E	—
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STPT-1520-2	Coaxial Hermetic Transistor	—	E	—
STPT-1520-3	Coaxial Hermetic Transistor	—	E	—
STPT-1520-4	Coaxial Hermetic Transistor	—	E	—
STPT-1530-1	Coaxial Hermetic Transistor	—	E	—
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STPT-1630-1	Pill Hermetic Transistor	OP602	A	76
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STPT-1630-3	Pill Hermetic Transistor	OP604	B	76
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STPT-1820-1	TO-18 Hermetic Transistor	OP800W	A	80
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STPT-2020-1	TO-18 Hermetic Transistor	OP800	A	78
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STPT-2020-4	TO-18 Hermetic Transistor	OP805	A	78
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STPT-2030-2	TO-18 Hermetic Transistor	OP805	A	78
STPT-2030-3	TO-18 Hermetic Transistor	OP805	A	78
STRD-70	Darlington Reflective	OPB711	C	230
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STRT-850	Transistor Reflective	OPB706A	A	218
STRT-850A	Transistor Reflective	OPB706A	B	218
STRT-850A/F	Transistor Reflective	OPB706A	B	218
STRT-850B	Transistor Reflective	OPB706A	B	218
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STRT-920-3	Transistor Reflective	—	E	—
STRT-950	Transistor Reflective	—	D	—
STRT-1747	Transistor Reflective	—	E	—
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TIED59	Avalanche Photodiode	—	E	—
TIED69	Avalanche Photodiode	—	E	—
TIED87	Avalanche Photodiode	—	E	—
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TIES06	Stud Mount LED	—	E	—
TIES12	Stud Mount LED	—	E	—
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TIL24	Pill Hermetic LED	OP124	A	4
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TIL25	Pill Hermetic LED	OP124	A	4
TIL26	TO-18 Hermetic LED	OP132	B	6
TIL31	TO-18 Hermetic LED	OP132	B	6
TIL31B	TO-18 Hermetic LED	OP132	A	6
TIL31BHR2	Hi Rel TO-18 Hermetic LED	OP231TX	B,C	318
TIL32	T-1 Plastic LED	OP160SL	A	10
TIL33	TO-18 Hermetic LED	OP131	B	6
TIL33B	TO-18 Hermetic LED	OP131	A	6
TIL34	TO-18 Hermetic LED	OP131	B	6
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TIL46	LED Array	—	E	—
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TIL103	TO-5 Transistor Coupler	OPI103	A	106
TIL107	Hermetic Transistor Coupler	OPI1264B	C	116
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TIL109	Axial Transistor Coupler	OPI1264A	B	116
TIL111	6-Pin Transistor Coupler	OPI2152	A	132
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TIL113	6-Pin Darlington Coupler	OPI3151	A	152
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TIL115	6-Pin Transistor Coupler	OPI2250	A	128
TIL116	6-Pin Transistor Coupler	OPI2252	A	132
TIL117	6-Pin Transistor Coupler	OPI2253	A	134
TIL118	6-Pin Transistor Coupler	OPI2251	A	130
TIL119	6-Pin Darlington Coupler	OPI3150	A	150
TIL119A	6-Pin Darlington Coupler	OPI3150	C	150
TIL120	4-Pin TO-72 Transistor Coupler	3N244	A	166
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TIL124	6-Pin Transistor Coupler	OPI2251	A	130
TIL125	6-Pin Transistor Coupler	OPI2252	A	132
TIL126	6-Pin Transistor Coupler	OPI2253	A	134
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TIL144	Transistor Interrupter	OPB870T55	B,C	272
TIL145	Darlington Interrupter	OPB872T55	B,C	272
TIL146	Darlington Interrupter	OPB872T55	B,C	272
TIL147	Transistor Interrupter	OPB847	A	270
TIL147A	Transistor Interrupter	OPB847	C	270
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TIL149	Transistor Reflective	OPB708	C	222
TIL153	6-Pin Transistor Coupler	OPI2251	A	130
TIL154	6-Pin Transistor Coupler	OPI2252	A	132
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TIL156	6-Pin Darlington Coupler	OPI3251	A	152
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TIL159	Transistor Interrupter	OPB848	A	270
TIL160	Darlington Interrupter	—	D	—
TIL161	Darlington Interrupter	—	D	—
TIL167-1	Transistor Interrupter	OPB870T51	A	272
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TIL168-2	Darlington Interrupter	—	D	—
TIL169-1	Transistor Interrupter	OPB870N51	A	272
TIL169-2	Transistor Interrupter	OPB872N51	A	272
TIL170-1	Darlington Interrupter	—	D	—
TIL170-2	Darlington Interrupter	—	D	—
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TIL414	T-1¾ Plastic Transistor	OP598A	B,C	72
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TIL416	Plastic Lateral Darlington	OP560	B	70
TIL601	Pill Hermetic Transistor	OP601	A	76
TIL602	Pill Hermetic Transistor	OP602	A	76
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TIL604HR2	Hi Rel Pill Hermetic Transistor	OP602TX	B,C	322
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TIL906-1	T-1¾ Plastic LED	OP297C	B	32
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TL3103	Linear Hall Effect Sensor	—	D	—
TLN107	Plastic Lateral LED	OP140SLC	B,C	8
TP60	Photodiode	—	E	—
TP61	Photodiode	—	E	—
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V194P	Plastic TO-18 LED	OP293A	B,C	36
V213P	TO-18 Hermetic LED	OP131W	B	6
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V390P	T-1¾ Plastic LED	OP290A	B	32
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XC-55-25	TO-46 Hermetic LED	OP133	B	6
XC-55-FA	TO-46 Hermetic LED	OP130W	A	6
XC-55-FB	TO-46 Hermetic LED	OP131W	A	6
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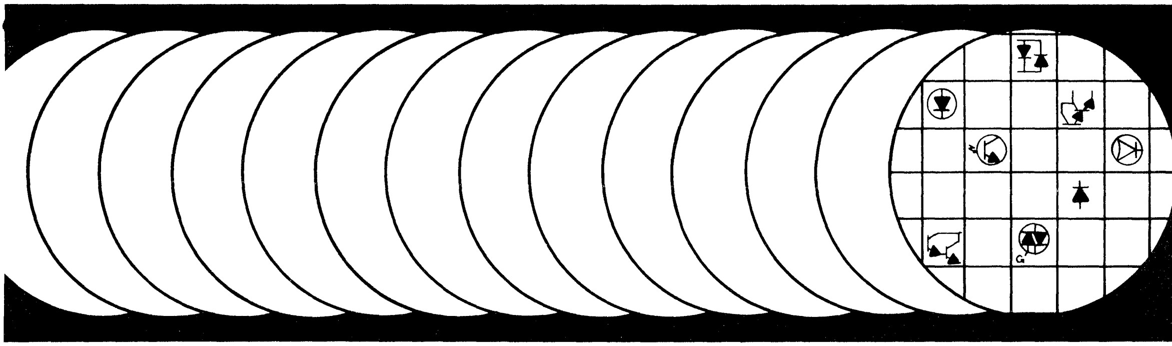
XC-88-FB	TO-46 Hermetic LED	OP232W	A	22
XC-88-FC	TO-46 Hermetic LED	OP233W	A	22
XC-88-FD	TO-46 Hermetic LED	OP233W	A	22
XC-88-PA	TO-46 Hermetic LED	OP231	A	22
XC-88-PB	TO-46 Hermetic LED	OP232	A	22
XC-88-PC	TO-46 Hermetic LED	OP233	A	22
XC-88-PD	TO-46 Hermetic LED	OP233	A	22
XC-99-30	TO-46 Hermetic LED	OP232	B	22
XC-99-50	TO-46 Hermetic LED	OP233	B	22
XC-880-A	T-1¾ Plastic LED	OP297C	A	32
XC-880-B	T-1¾ Plastic LED	OP297B	A	32
XC-880-C	T-1¾ Plastic LED	OP297A	A	32
XC-880-D	T-1¾ Plastic LED	OP297A	A	32
XC-881-A	T-1¾ Plastic LED	OP292C	A	32
XC-881-B	T-1¾ Plastic LED	OP292B	A	32
XC-881-C	T-1¾ Plastic LED	OP292A	A	32
XC-881-D	T-1¾ Plastic LED	OP292A	A	32
XC-940-A	T-1¾ Plastic LED	OP297C	B	32
XC-940-B	T-1¾ Plastic LED	OP297B	B	32
XC-940-C	T-1¾ Plastic LED	OP297A	B	32
XC-940-D	T-1¾ Plastic LED	OP297A	B	32
XC-941-A	T-1¾ Plastic LED	OP292C	B	32
XC-941-B	T-1¾ Plastic LED	OP292B	B	32
XC-941-C	T-1¾ Plastic LED	OP292A	B	32
XC-941-D	T-1¾ Plastic LED	OP292A	B	32
XC-1209-A	T-1 Plastic LED	OP160SL	A	10
XC-1209-B	T-1 Plastic LED	OP160SLC	A	10
XC-1209-C	T-1 Plastic LED	OP160SLB	A	10
XC-1209-D	T-1 Plastic LED	OP160SLA	A	10
XC-1288-A	T-1 Plastic LED	OP260SLC	A	26
XC-1288-B	T-1 Plastic LED	OP260SLB	A	26
XC-1288-C	T-1 Plastic LED	OP260SLA	A	26
XC-1288-D	T-1 Plastic LED	OP260SLA	A	26

Optoelectronics Division, TRW Electronic Components Group, 1207 Tappan Circle, Carrollton, TX 75006 (214) 323-2200, TWX-910-860-5958



Sales Office and Distributor Locations

0

Authorized Distributors

TRW Optoelectronics Authorized Distributors

Alabama

Arrow	(205) 837-6955
Hall-Mark	(205) 837-8700
Hamilton-Avnet	(205) 837-7210
Pioneer	(205) 837-9300

Arizona

Arrow	(602) 968-4800
Fisher/Brownell	(602) 967-1464
Hall-Mark	(602) 437-1200
Hamilton-Avnet	(602) 231-5100

California

Arrow	(818) 701-7500
	(619) 565-4800
	(415) 487-4600
	(408) 745-6600
	(714) 838-5422
Avnet	(714) 754-6111
	(818) 700-2600
Bell Industries	(213) 515-1800
	(714) 220-0681
	(408) 734-8570
	(818) 340-1940
Fisher/Brownell	(818) 289-0255
	(619) 560-8545
	(408) 988-6041
Hall-Mark	(818) 716-7300
	(916) 722-8600
	(213) 217-8400
	(619) 268-1201
	(408) 946-0900
	(714) 669-4700
Hamilton-Avnet	(714) 989-4602
	(916) 925-2216
	(619) 571-7510
	(408) 743-3355
Hamilton Electro Sales	(818) 700-6500
	(714) 641-4100
	(213) 558-2121
Pacesetter Electronics	(714) 779-5855
	(408) 734-5470
Prime Electro	(213) 379-3642

Colorado

Arrow	(303) 696-1111
Bell Industries	(303) 424-1985
Hall-Mark	(303) 790-1662
Hamilton-Avnet	(303) 740-1000

Connecticut

Arrow	(203) 265-7741
Hall-Mark	(203) 269-0100
Hamilton-Avnet	(203) 797-2800

Florida

Arrow	(813) 576-8995
	(305) 429-8200
	(305) 725-1480
Chip Supply Company	(305) 298-7100
Hall-Mark	(305) 971-9280
	(305) 855-4020
	(813) 530-4543
Hamilton-Avnet	(305) 971-2900
	(813) 576-3930
	(305) 628-3888
Pioneer	(305) 834-9090
	(305) 428-8877

Georgia

Arrow	(404) 449-8252
Hall-Mark	(404) 447-8000
Hamilton-Avnet	(404) 447-7507
Pioneer	(404) 448-1711

Illinois

Arrow	(312) 397-3440
Hall-Mark	(312) 860-3800
Hamilton-Avnet	(312) 860-7700
Newark Electronics*	(312) 784-5100
Pioneer	(312) 437-9680
R. M. Electronics	(312) 364-6122

Indiana

Arrow	(317) 243-9353
Hamilton-Avnet	(317) 844-9333
Pioneer	(317) 849-7300
R. M. Electronics	(317) 291-7110

Iowa

Arrow	(319) 395-7230
Hamilton-Avnet	(319) 362-4757

Kansas

Hall-Mark	(913) 888-4747
Hamilton-Avnet	(913) 888-8900

Maryland

Arrow	(301) 995-0003
Hall-Mark	(301) 988-9800
Hamilton-Avnet	(301) 995-3500
Pioneer	(301) 921-0660

Massachusetts

Arrow	(617) 933-8130
Gerber Electronics	(617) 769-6000
Greene-Shaw Company	(617) 969-8900
Hall-Mark	(617) 667-0902
Hamilton-Avnet	(617) 935-9700

Michigan

Arrow	(313) 971-8220
	(616) 243-0912
Hamilton-Avnet	(616) 243-8805
	(313) 522-4700
Pioneer	(313) 525-1800
R. M. Electronics	(616) 531-9300

Minnesota

Arrow	(612) 830-1800
Hall-Mark	(612) 854-3223
Hamilton-Avnet	(612) 932-0600
Pioneer	(612) 935-5444

*all U.S. locations

TRW

Missouri

Arrow....................(314) 567-6888
Hall-Mark..................(314) 291-5350
Hamilton-Avnet..............(314) 344-1200

New Hampshire

Arrow....................(603) 668-6968
Hamilton-Avnet..............(603) 624-9400

New Jersey

Arrow....................(609) 596-8000
(201) 575-5300
Hall-Mark..................(201) 575-4415
(609) 235-1900
Hamilton-Avnet..............(609) 424-0100
(201) 575-3390

New Mexico

Arrow....................(505) 243-4566
Bell Industries...............(505) 292-2700
Hamilton-Avnet..............(505) 765-1500
International Electronics........(505) 345-8127

New York

Aquas....................(716) 454-7800
Arrow Int'l Division...........(516) 293-6363
Arrow....................(516) 231-1000
(315) 652-1000
(716) 427-0300
Hall-Mark..................(516) 737-0600
Hamilton-Avnet..............(315) 437-2641
(516) 231-9800
(716) 475-9130

North Carolina

Arrow....................(919) 876-3132
(919) 725-8711
Hall-Mark..................(919) 872-0712
Hamilton-Avnet..............(919) 878-0819
Pioneer....................(704) 527-8188

Ohio

Arrow....................(513) 435-5563
(216) 248-3990
Hall-Mark..................(216) 349-4632
(614) 888-3313
Hamilton-Avnet..............(216) 831-3500
(513) 439-6700
(614) 882-7004
Pioneer....................(216) 587-3600
(513) 236-9900

Oklahoma

Arrow....................(918) 665-7700
Hall-Mark..................(918) 665-3200

Oregon

Arrow....................(503) 684-1690
Bell Industries...............(503) 241-4115
Hamilton-Avnet..............(503) 635-8157

Pennsylvania

Arrow....................(412) 856-7000
Hamilton-Avnet..............(412) 281-4150
Pioneer....................(215) 674-4000
(412) 782-2300

Texas

Arrow....................(214) 380-6464
(512) 835-4180
(713) 530-4700
Fisher/Brownell..............(214) 235-3177
Hall-Mark..................(512) 258-8848
(214) 553-4300
(713) 781-6100
Hamilton-Avnet..............(512) 837-8911
(713) 780-1771
(214) 659-4111
International Electronics........(214) 233-9323
(915) 598-3406
Pioneer....................(512) 835-4000
(214) 386-7300
(713) 988-5555

Utah

Arrow....................(801) 972-0404
Bell Industries...............(801) 972-6969
Hall-Mark..................(801) 268-3779
Hamilton-Avnet..............(801) 972-2800

Virginia

Arrow....................(804) 282-0413

Washington

Arrow....................(206) 643-4800
Bell Industries...............(206) 747-1515
Hamilton-Avnet..............(206) 643-3950

Wisconsin

Arrow....................(414) 764-6600
Hall-Mark..................(414) 797-7844
Hamilton-Avnet..............(414) 784-4510

Canada

Arrow....................(610) 421-3302
(416) 661-0220
(418) 687-4231
(613) 226-6903
Electrosonic................(416) 494-1555
Future Electronics............(514) 694-7710
(613) 820-8313
(416) 663-5563
(403) 259-6408
(604) 438-5545
(403) 486-0974
Hamilton-Avnet..............(403) 230-3586
(416) 677-7432
(613) 226-1700
(514) 331-6443
(604) 437-6667

0

Domestic Sales Office Locations

Alabama
TRW/ECG
2707 Artie Street
Suite 12
Huntsville, AL 35805
(205) 533-7600

Arizona
TRW/ECG
6728 E. Avalon Drive
Suite A
Scottsdale, AZ 85251
(602) 994-0441

Arkansas
TRW/ECG
1700 Dallas Parkway
Suite 200
Dallas, TX 75248
(214) 248-8000

California
TRW/ECG
6150 Canoga Ave.
Suite 109
Woodland Hills, CA 91367
(818) 703-1771

TRW/ECG
5959 Century Blvd.
Suite 900
Los Angeles, CA 90045
(213) 535-6178

TRW/ECG
2101 Fourth Street
Suite 255, Bldg. B
Santa Ana, CA 92705
(714) 550-1101

TRW/ECG
7867 Convoy Ct.
Suite 306
San Diego, CA 92111
(619) 279-3990

Straube Associates
2551 Casey Avenue
Mountain View, CA 94043
(415) 969-6060

Colorado
Straube Associates
7970 Sheridan Blvd.
Suite C
Westminster, CO 80003
(303) 426-0890

Connecticut
TRW/ECG
137 Rowayton Avenue
Rowayton, CT 06853
(203) 853-4466

Florida
TRW/ECG
1001 N.W. 62nd Street
Suite 306F
Ft. Lauderdale, FL 33309
(305) 772-3000

TRW/ECG
6220 S. Orange Blossom Trail
Suite 151
Orlando, FL 32809
(305) 857-3650

Georgia
TRW/ECG
3300 Holcomb Bridge Rd.
Suite 260
Norcross, GA 30092
(404) 447-6154

Idaho
Straube Associates
3509 S. Main Street
Salt Lake city, UT 84115
(801) 263-2640

Illinois-Central
C.H. Horn & Associates
Executive Plaza Bldg.
4403 First Avenue, SE
Cedar Rapids, IA 52403
(319) 393-8703

Illinois-Northern
TRW/ECG
5725 East River Road
Suite 485
Chicago, IL 60631
(312) 693-7730

Illinois-Southern
The John G. Macke Co.
11710 Administration Dr.
Suite 31
St. Louis, MO 63141
(314) 432-2830

Indiana
Robert O. Whitesell
3426 Taylor Street
Ft. Wayne, IN 46804
(219) 432-5591

Robert O. Whitesell
6691 E. Washington
Indiananpolis, IN 46219
(317) 359-9283

Robert O. Whitesell
1825 S. Plate St.
Suite A
Kokomo, IN 46901
(317) 457-9217

Iowa
C.H. Horn & Associates
Executive Plaza Bldg.
4403 First Avenue, SE
Cedar Rapids, IA 52403
(319) 393-8703

Kansas
MIDTEC Associates, Inc.
7702 Mize Road
DeSoto, KS 66108
(913) 441-6565

Kentucky
Robert O. Whitesell
110 Daventry Lane
Suite 210
Louisville, KY 40223
(502) 426-7696

Louisiana
TRW/ECG
17000 Dallas Parkway
Suite 200
Dallas, TX 75248
(214) 248-8000

Maine
TRW/ECG
Westborough Office Park
1900 West Park Drive
Westborough, MA 01581
(617) 870-0745

Maryland
TRW/ECG
1000 Grosvenor Century Plaza
Suite 328
Columbia, MD 21044
(301) 964-9110

Massachusetts
TRW/ECG
Westborough Office Park
1900 West Park Drive
Westborough, MA 01581
(617) 870-0745

Byrne Associates (D.E.C. only)
74 Main Street
Maynard, MA 01754
(617) 897-3131

Michigan
TRW/ECG
(Automotive Accounts Only)
24175 Research Dr.
Farmington Hills, MI 48024
(313) 478-7210

Robert O. Whitesell
688 Cascade W. Parkway SE
Grand Rapids, MI 49506
(616) 942-5420

Robert O. Whitesell
1822 Hilltop Road
St. Joseph, MI 49085
(616) 983-7337

Robert O. Whitesell
18444 W. 10 Mile Road
Southfield, MI 48075
(313) 559-5454

Robert O. Whitesell (Automotive)
8333 Office Park Drive
Suite A
Grand Blanc, MI 48439
(313) 695-0770

Minnesota
TRW/ECG
3050 Metro Drive
Metro Office Park, Suite 301
Minneapolis, MN 55420
(612) 854-6616

Mississippi
TRW/ECG
3300 Holcomb Bridge Rd.
Suite 260
Norcross, GA 30092
(404) 447-6154

Missouri-Eastern
The John G. Macke Co.
11710 Administration Dr.
Suite 31
St. Louis, MO 63141
(314) 432-2830

Missouri-Western
MIDTEC Associates, Inc.
7702 Mize Road
DeSoto, KS 66018
(913) 441-6565

Montana
Straube Associates
3509 S. Main Street
Salt Lake City, UT 84115
(801) 263-2640

Nebraska
MIDTEC Associates, Inc.
7702 Mize Road
DeSoto, KS 66018
(913) 441-6565

Nevada
TRW/ECG
6728 E. Avalon Drive
Suite A
Scottsdale, AZ 85251
(602) 994-0441

New Hampshire
TRW/ECG
Westborough Office Park
1900 West Park Drive
Westborough, MA 01581
(617) 870-0745

New Jersey-North
TRW/ECG
137 Rowayton Ave.
Rowayton, CT 06853
(203) 853-4466

New Jersey-South
TRW/ECG
2 Bala Cynwyd Plaza
Suite 909
Bala Cynwyd, PA 19004
(215) 667-3400
Tlx 510-662-4780

New Mexico
S.W. Sales
3125 Cuervo NE
Albuquerque, NM 87110
(505) 883-1388
Tlx 910-964-1394

New York-Upstate
TRW/ECG
425 Cross Key Office Park
Fairport, NY 14450
(716) 425-3775
Tlx 510-253-1594

New York-Metropolitan Area
TRW/ECG
137 Rowayton Avenue
Rowayton, CT 06853
(203) 853-4466
Tlx 710-468-3058

North Carolina
TRW/ECG
2302 W. Meadowview
Suite 110
Greensboro, NC 27407
(919) 852-4676
Tlx 510-922-7300

Ohio
Robert O. Whitesell
1172 W. Galbraith
Cincinnati, OH 45231
(513) 521-2290

Robert O. Whitesell
6000 W. Creek Road
Suite 21
Cleveland, OH 44131
(216) 447-9020

Robert O. Whitesell
6161 Busch Blvd.
Suite 108
Columbus, OH 43229
(614) 888-9396

Robert O. Whitesell
4133 S. Dixie Avenue
Dayton, OH 45439
(513) 298-9546

Oklahoma
TRW/ECG
17000 Dallas Parkway
Suite 200
Dallas, TX 75248
(214) 248-8000

Oregon
TRW/ECG
7100 SW Hampton
Suite 214
Tigard, OR 97223
(503) 620-5032

Pennsylvania
TRW/ECG
2 Bala Cynwyd Plaza
Suite 909
Bala Cynwyd, PA 19004
(215) 667-3400

Robert O. Whitesell
1360 Old Freeport Road
Suite 1B
Pittsburgh, PA 15238
(412) 963-6161

Rhode Island
TRW/ECG
Westborough Office Park
1900 West Park Drive
Westborough, MA 01581
(617) 870-0745

South Carolina
TRW/ECG
2302 W. Meadowview
Suite 110
Greensboro, NC 27407
(919) 852-4676

South Dakota
TRW/ECG
3050 Metro Drive
Metro Office Park, Suite 301
Minneapolis, MN 55420
(612) 854-6616

Tennessee
TRW/ECG
330 Holcomb Bridge Rd.
Suite 260
Norcross, GA 30092
(404) 447-6154

Texas
TRW/ECG
17000 Dallas Parkway
Suite 200
Dallas, TX 75248
(214) 248-8000

TRW/ECG
9000 Southwest Freeway
Suite 116
Houston, TX 77074
(713) 772-5541

S. W. Sales
2267 Trawood, Bldg. E 3
El Paso, TX 79935
(915) 594-8259

Utah
Straube Associates
3509 S. Main Street
Salt Lake City, UT 84115
(801) 263-2640

Vermont
TRW/ECG
Westborough Office Park
1900 West Park Drive
Westborough, MA 01581
(617) 870-0745

Virginia
TRW/ECG
8000 Franklin Farms Drive
Suite 217
Richmond VA 23229
(804) 288-8334

Washington
TRW/ECG
13555 Bellevue Redmond Road
Suite 208
Bellevue, WA 98005
(206) 641-9996

West Virginia
Robert O. Whitesell
4133 S. Dixie Avenue
Dayton, OH 45439
(513) 298-9546

Wisconsin
TRW/ECG
16535 W. Bluemound Road
Suite 208
Brookfield, WI 53005
(414) 784-7773

Wyoming-Eastern
Straube Associates
7970 Sheridan Blvd., Suite C
Westminster, CO 80003
(303) 426-8090

Wyoming-Western
Straube Associates
3509 S. Main Street
Salt Lake City, UT 84115
(801) 263-2640

Canada
Renmark Electronics Ltd.
180 Yorkland Boulevard
Suite 1
Toronto, Ontario M2J 1R5
(416) 494-5445

Renmark Electronics Ltd.
357 Dufferin Place
Carleton Place, ONT K7C 3K4
(613) 727-0320

Puerto Rico
Electronics Sales Assoc.
Calle 203 - GO 11
Country Club 3rd Ext.
Rio Piedras, PR 00924
(809) 762-6707, 762-6459

O

International Sales Office Locations

Argentina
YEL S.R.L.
Cangallo 1454
PISO 8. -OF. 41
1037 Buenos Aires, Argentina
46-2211
TLX 18605

Australia
Total Electronics
P.B. 250 Post Office, Burwood
9 Harker St.
Victoria, 3125 Australia 03-679306
61232884044
TLX 31261

Austria
Transistor Vertriebs GmbH
Auhofstrasse 41a
1130 Wien, Austria
222-829401
TLX 133738

Belgium
Sotronic S.A.
Rue Pere de Deken 14
1040 Bruxelles, Belgium
2-7361007
TLX 25141

Denmark
Dansk Komponent Import Aps
Jaegersborg Alle 16
DK-2920
Charlottenlund, Denmark
1-640-099
TLX 15474

Finland
Turion OY
P.O. Box 24
SF-00781 Helsinki
Finland
0-372-144
TLX 124388

France
REA S.A.
9, Rue Ernest Cognacq
92301 Levallois-Perret, France
1-7581111
TLX 620630

Germany
TRW GmbH
Konrad-Celtis-Strasse 81
8000 Muenchen 70 Germany
89-71030
TLX 5213456

Nuemueller
Eschenstrasse 2
8028 Taufkirchen
Germany
89-612080
TLX 522106

Getronic
Warnstedtstrasse 59
2000 Hamburg 54
Germany
40-5404046
TLX 215032

Hong Kong
Tektron Electronics Ltd.
1702 Bank Centre
635 Nathan Road
Kowloon, Hong Kong
3-856-199
TLX 38513

India
Accutrol Systems Pri. Ltd.
Express Towers, 11th Floor
Nariman Point
Bombay 400 021
India
2020118
TLX 953113731

Ireland
Neltronic Ltd.
John F. Kennedy Road
Naas Road
Dublin 12
Ireland
01 501845
TLX 24837

Israel
Talviton Electronics Ltd.
9 Biltmor Street
P.O. Box 21104
Tel-Aviv, Israel
3-44-4570
TLX 33400

Italy
Dott.Ing Giuseppe De Mico Spa
Viale Vittorio Veneto, 8
20060 - Cassina De Pecchi
Milano, Italy
2-952-0551
TLX 330869

Japan
Nihon Teksel Co., Ltd.
Kyoshin Building
Shibuya-Ku 13-14 Sakuragaoka-machi
Tokyo 150 Japan
3-461-5121
TLX 23723

Korea
Tess-Ko
CPO Box 10036
Seoul, Korea
027542454
TLX 78723231

The Netherlands
Koning En Hartman N.V.
P.O. Box 125
30 Energieweg 1
2600 AC Delft
The Netherlands
15-609906
TLX 38250

New Zealand
Professional Electronics
P.O. Box 31143 Milford
22A Milford Road
Auckland, New Zealand
9-493-029
TLX 21084

Norway
H.C.A. Melbye
Haavard Martinsens Vei 19
P.O. Box 8, Haugenstau
Oslo 9, Norway
472-106050
TLX 71860

Portugal
Ditram LDA
Av. Miguel Bombarda 133
1D
Lisboa 1 Portugal
19-545313
TLX 14182

Singapore
Seamax Engineering Private Ltd.
80 Genting Lane
09-04 Genting Blk. Ruby Ind. Complex
Republic of Singapore 1334
747-6155
TLX 51147

South Africa
Allied Electric (Pty.) Ltd.
P.O. Box 6387
Dunswart 1508
Transvaal, South Africa (R.S.A.)
52-8661
TLX 425559

Spain
Amitron, S.A.
Avenida Valladolid 47-A
2800 Madrid
Spain
1-247-9313
TLX 45550

Sweden
Martinsson & Co. Instrument AB
(Opto Products Only)
Box 960
S-126 09 Hagersten
Sweden
8-744-0300
TLX 13077

Nordisk Elektronik AB
(Power Products Only)
Box 27301
S-102 54
Stockholm, Sweden
46 8 635040
TLX 10547

Switzerland
Memotec AG (Opto Products Only)
Gaswerkstrasse 32
4901 Langenthal
Switzerland
63-281122
TLX 982550

Baerlocher A.G.
(Power Products Only)
Postfach 578
8037 Zyerich
Switzerland
142-9900
TLX 822762

Taiwan

Sea Union Engineering
P.O. Box 45-95 Taipei
3F, No. 162
Chang & East Rd., Section 2
Taipei, Taiwan R.O.C.
2-751-6856
TLX 24209

United Kingdon

MCP Electronics Ltd.
(Power Products Only)
26-32 Rosemont Road
Alperton, Wembley
Middlesex HAO 1RU England
01-902-5941
TLX 923457

Norbain Electro-Optics
(Opto Products Only)
Norbain House
Boulton Road, Reading, RG2 OLT
Berkshire England
734-864411
TLX 847203

Yugoslavia

Transistor Vertriebs GmbH
Auhofstrasse 41a
1130 Wien, Austria
222-829401
TLX 133738

Northern Europe

Steve Couchman
TRW Optoelectronics
15-17 High Street
Bedford MK40 1RU
England
(234) 21 77 11
TLX 825553

TRW GmbH
M.H. Trompstraat 8
3143 AP Maassluis
The Netherlands
(1899) 20921

Central Europe

Reiner Dollwetzel
TRW GmbH
Konrad-Celtis-Strasse 81
8000 Muenchen 70 Germany
89-71030
TLX 5213456

Nikolaus-Lenau-Platz 17
7032 Sindelfingen
Germany
7031-33-01-11

Wilmersiek 2A
4920 Lemgo
Germany
(5261) 12-99-2

Southern Europe

TRW Composants
Electronique S.A.
212 Avenue Paul Doumer
92500 Rueil-Malmaison
France
(1) 75-81-240

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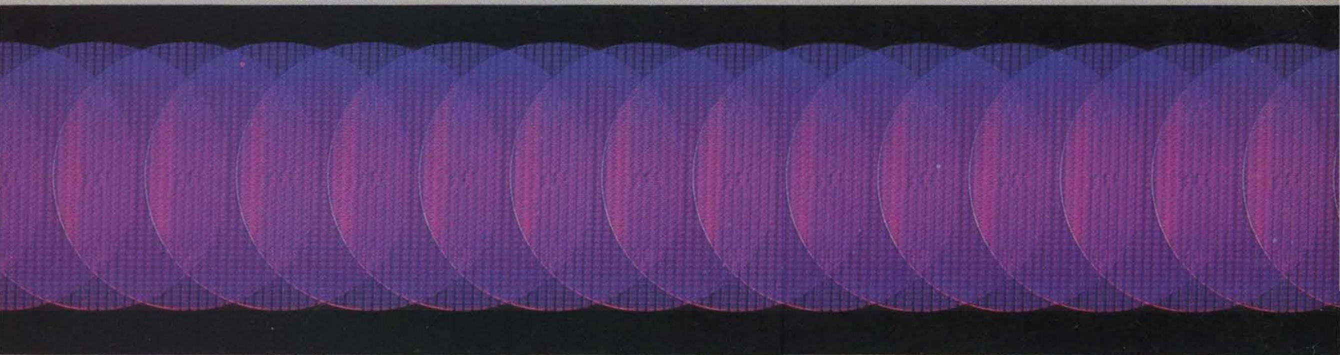

Optoelectronics Division
TRW Electronic
Components Group
1201 Tappan Circle
Carrollton, TX 75006