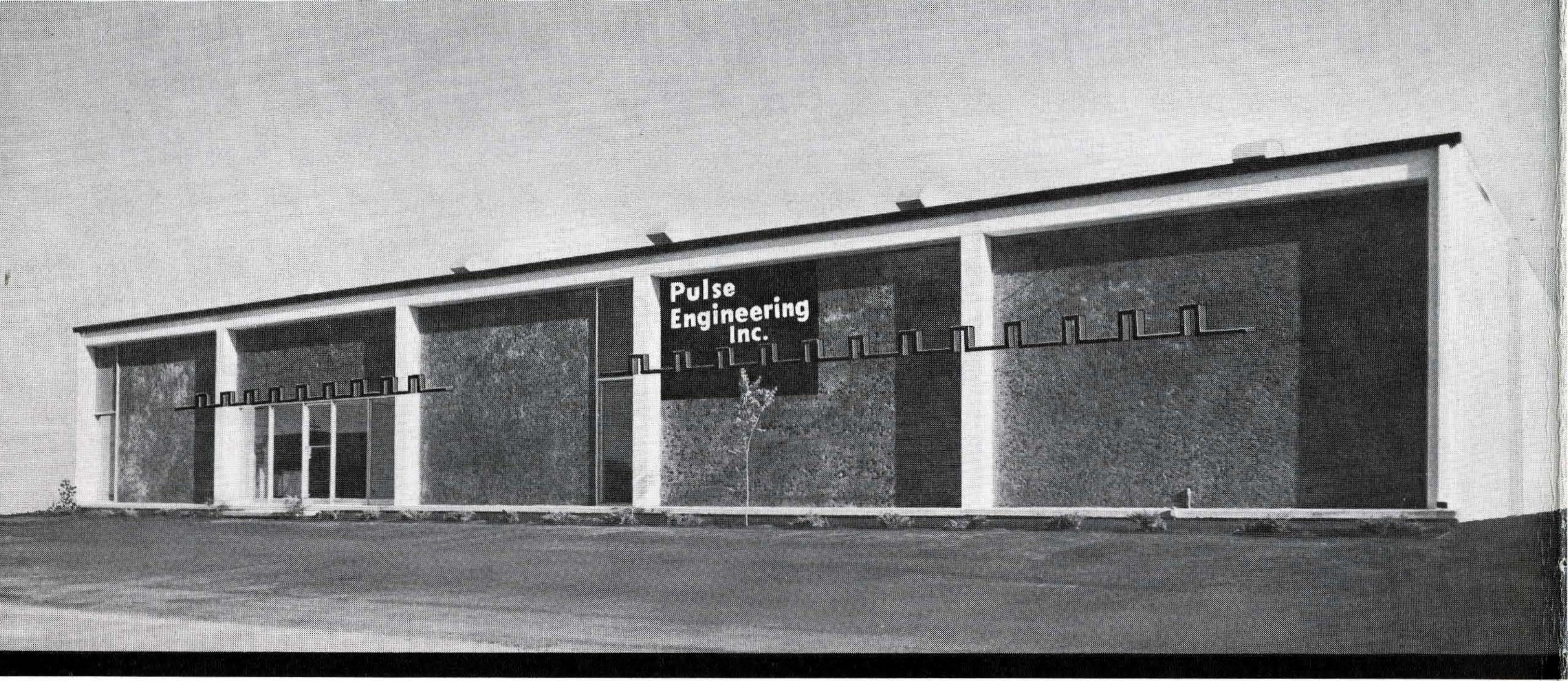
CATALOG 202 1959-1960

# CATALOG AND APPLICATION MANUAL OF PULSE TRANSFORMERS

**Pulse Engineering Inc.**

560 ROBERT AVENUE • SANTA CLARA, CALIFORNIA
PHONE: CHERRY 8-6040 TWX: SJ 578



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## TO OUR CUSTOMERS

The main purpose of this catalog is to save time and money for the circuit designer and purchasing agent by supplying the technical information necessary to correctly choose a suitable transformer. To assist designers new to the pulse field in the application of pulse components, this catalog contains a section on magnetics and broad band transformer theory.

The units cataloged here are those believed to have the broadest interest and application. As far as possible, specification parameters have been reduced to standard, easily measurable, characteristics. Outline drawings of individual parts and electrical test methods are included to assist both design and quality control personnel.

In addition to the units contained in the catalog, Pulse Engineering Sales Representatives have a reference file of approximately 1,000 designs listed simply by type, open-circuit inductance of primary winding, and turns ratio.

We sincerely hope you find this catalog a valuable addition to your reference library.

Very truly yours,
PULSE ENGINEERING, INC.

Hugh B Fleming
Hugh B. Fleming
*President*

Pulse
Engineering
Inc.

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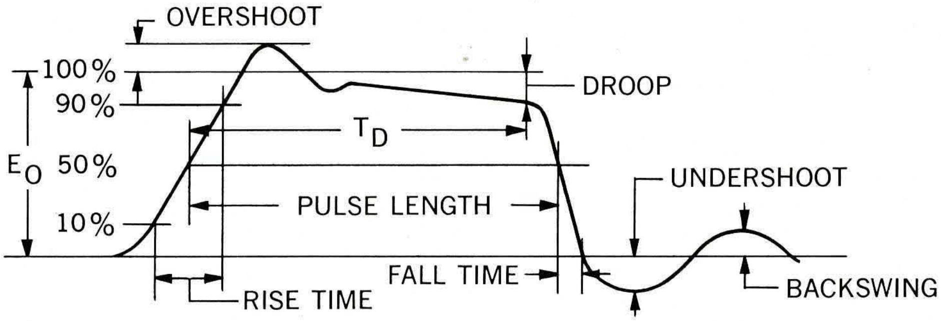


FIG. 1

## DEFINITION OF TERMS

### AMPLITUDE

The intersection of the leading edge of the pulse with a smooth curve approximating the top of the pulse, extended to meet the leading edge.

### RISE TIME

Time required for the pulse amplitude to increase from 10 percent to 90 percent amplitude.

### PULSE WIDTH

Time interval between the intersections of the 50 percent amplitude line with the leading and trailing edges of the pulse.

### OVERSHOOT

Amplitude of the first maximum excursion of the pulse beyond the 100 percent amplitude level expressed as a percentage of this 100 percent amplitude.

### BACKSWING

Amplitude of the first maximum excursion in the negative amplitude direction after the trailing edge of the pulse, expressed as a percentage of the 100 percent amplitude.

### DROOP

The decrease in mean pulse amplitude from the 100 percent level, at some specified time interval following the initial attainment of 100 percent amplitude. This decrease is expressed as a percentage of the 100 percent amplitude.

# HOW TO ORDER PULSE TRANSFORMERS

## Part Identification

The four digit catalog number referred to in this catalog as the "PE" or Pulse Engineering number together with the case designator, if applicable, completely identifies each transformer. Earlier catalogs used a type designator in front of the four digit number such as ES6-1239. In this catalog, the same unit would be referred to as PE-1239. Available case styles pertaining to the various models are indicated on each page with the transformer listing. If you desire a case other than the style "normally stocked," the case style designator should be added to the "PE" number to obtain the case configuration you want. For example: PE-1239-W.

## Immediate Delivery—2-5 Days

Starred (*) catalog items are normally carried in stock for immediate shipment. In addition, many local representative offices carry a stock of miniatures. These offices are indicated (*) on the back cover.

## Fast Delivery—5-15 Days

Fast delivery is available on all items shown in this catalog. Transformers listed in each sales engineer's design file are available on 10-20 day delivery.

## Speed your Prototype

If you cannot find a suitable standard catalog unit, the following procedure will often save you time and money. (1) Buy and test the most nearly applicable unit you can locate in this catalog or your Pulse Engineering representative's file of designs. (2) Send us an oscillogram showing its performance in your circuit and indicate needed improvements. Often a modified standard unit can be quickly and economically supplied.

## Prototype Delivery—15-45 Days

When your needs are completely unique, Pulse Engineering will design to your specific requirements. A circuit diagram plus information on the following will be needed:

1. **Input and output voltages**
2. **Input and output impedances**
3. **Pulse width**
4. **Repetition rate**
5. **Droop**
6. **Rise time**
7. **Overshoot**

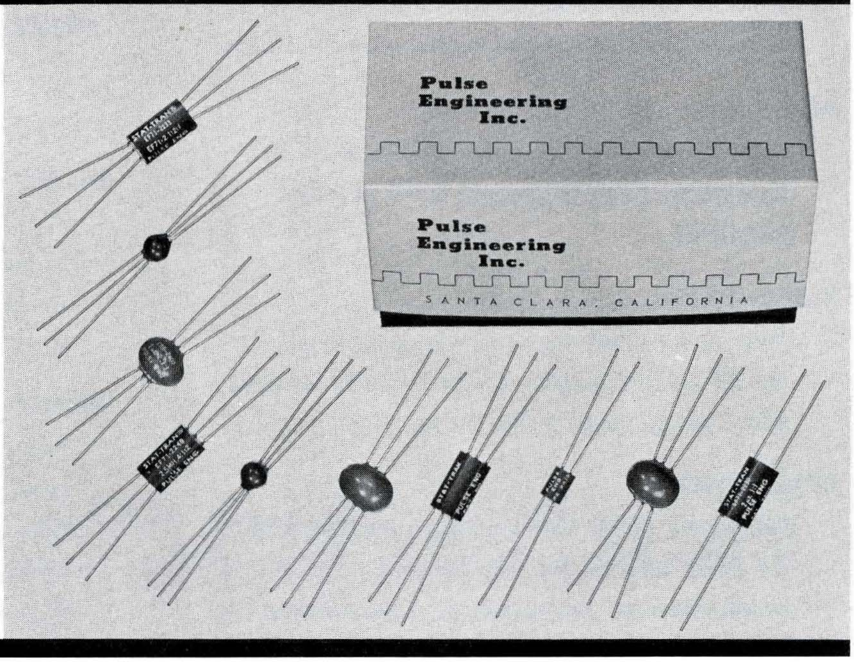
## Experimental Kit Available

To assist you in experimental circuit construction, Pulse Engineering offers a kit of 10 pulse transformers.

Any 10 miniature units found in this catalog can be purchased as a kit.

This is a convenient time-saving way to keep a representative selection on hand for various experimental uses.

Kit price (any 10 miniatures in normally stocked case styles), *$50.00*



# PULSE TRANSFORMER THEORY

Before considering pulse transformer theory and applications, it will be helpful to review some of the background thinking that precedes any successful transformer design.

Most important criterion of adequate broadband or pulse transformer design is effect of the transformer on amplitude and shape of the output signal. This effect can be related to, and predicted from, the values of the elements in the equivalent circuit for the transformer.

The next most important criterion is life, or time to failure. Transformer failure is most often caused by electrical breakdown, mechanical failure, or a combination of both. The short-time voltage breakdown strength of the transformer depends upon the breakdown strength of the insulation between turns, between windings, and from windings to core. Long-term breakdown strength depends upon the life of the insulation. The life of any insulation depends upon its operating temperature, which is determined by the losses in the wire and core, and by the efficiency with which heat generated in the windings and core is transferred to the surface of the transformer and dissipated to the surroundings. Mechanical failure may occur when the stresses resulting from rapid accelerations and decelerations are not considered in the mechanical design of the unit.

A third criterion of a design is size and weight. Minimum size and weight are obtained by operating wire at a current density consistent with the maximum allowable temperature rise of the unit, the insulation at its maximum allowable voltage stress, and the core at a flux density dictated by the maximum allowed for the design.

A fourth criterion is cost, which depends on types and amounts of materials used and ease of assembly.

## General Magnetics Theory

When an electric current flows in a conductor, a magnetic potential gradient is established. Magnetic potential, or magneto motive force (mmf), is nearly analogous to the electro motive force that causes current to flow in an electric circuit. Magneto motive forces have their source in electric currents which commonly link the magnetic circuit in the form of a coil. When current I flows in each of N linking turns of a coil, the effective mmf expressed in gilberts is: $F = 0.4 \pi NI$. The magnetic potential gradient is $H = \frac{F}{l}$ gilbert per centimeter. This quantity, more commonly known as magnetizing force, has been given the name, oersted.

Magnetizing force causes a magnetic force field to surround the conductor. This field of force can be conveniently considered as consisting of a number of closed loops or lines. The strength of the field depends upon the density of the lines. The CGS unit of magnetic flux density is the gauss. One gauss is equal to one line per square centimeter.

If the current carrying conductor is coiled around a magnetic material, flux lines tend to exist in this material rather than surrounding non-magnetic materials. Permeability ($\mu$) of the magnetic material is a measure of the preference of the flux for magnetic over non-magnetic materials. For example, suppose a coil carrying a certain current produces a flux density of 1 gauss in air at its center. If replacing the air core with a closed loop of magnetic material increased the flux density to 2,000 gauss, the permeability of the material is 2,000. The fundamental expression that relates these parameters is: $B = \mu H$.

## Permeabilities

Of greatest interest to the transformer designer are materials which have permeabilities greater than 1. These include the magnetic ceramics (ferrites) with permeabilities up to 5,000, silicon steels with permeabilities in the 10-20 thousand range, and the nickel irons in which permeabilities of 1 million have been realized. In working with these materials, one soon realizes that permeability is a function of the flux density at which they are operating. For example, a certain ferrite material may have a permeability of 800 at a low level (10 gauss) and 3,000 at 2,000 gauss. Temperature also affects the permeability of magnetic materials. Temperature coefficients vary from approximately 2000 PPM per degree C for silicon steels to 4500 PPM for some ferrites.

The effects of these non-linear permeability changes can be reduced by the inclusion of an air (or other non-magnetic material) gap in the magnetic circuit. The action of the gap can be understood if one thinks of the magnetic circuit in terms of a series electrical circuit analog. The gap is equivalent to a large fixed value resistor while the rest of the core may be represented by a small value variable resistor. If the values of the resistors are in the ratio of 10:1, a 300% change in the small resistor (core permeability) only causes a 30% change in the current flowing (flux density) in the analog. Inclusion of an air gap in a pulse transformer core has another beneficial effect which will be discussed in the next section.

## Saturation

Another important characteristic of magnetic materials is the phenomenon of saturation. In the example cited above, if the magnetizing force (current) is increased, a flux density will be reached where further increases in magnetizing force will produce no significant increase in flux. This flux density is termed "the saturation flux density," $B_{sat}$, for the material.

Materials used at their saturation levels undergo great reductions in permeability. Saturation levels vary greatly. Most of the magnetic ferrites saturate at 3,000 to 5,000 gauss, nickel irons at 6,000 to 8,000 gauss, and silicon steels at 12,000 to 14,000 gauss. Because of their low saturation levels and sensitivity to mechanical shock, high-permeability nickel-irons are generally used in special low level applications such as memory core matrix drivers, shift registers and memory read out transformers.

If the relation between B and H is plotted, the familiar B-H or hysteresis loop for the material results. The loop shown in solid lines in Figure 2 shows this relation for a toroidal (gapless) sample of a typical magnetic material used in pulse transformers. Notice that in the absence of magnetizing force ($H = 0$) there is a residual or remnant flux, $B_r$, left in the core.

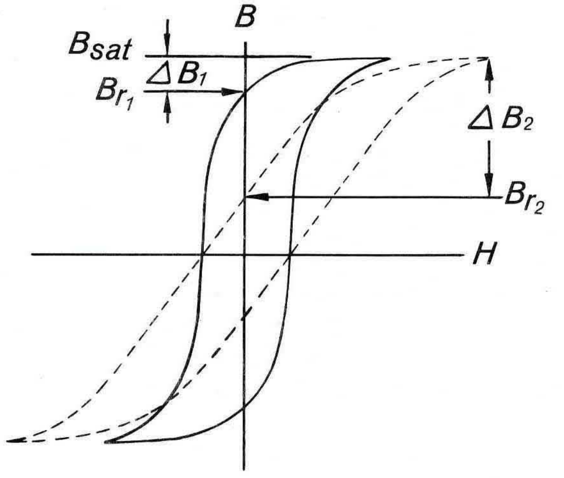


FIG. 2

The remnant flux in the core of a transformer that must pass unidirectional pulses presents a problem because it reduces the available flux change to $\triangle B_1$. For this reason, most pulse transformer cores are gapped slightly. The dotted B-H loop in Fig. 2 is for the same core with a gap in the magnetic circuit. Notice that the remnant flux has been reduced to $Br_2$ and available flux swing increased to $\triangle B_2$.

## The ET Constant

If a constant voltage, E, is applied at $t_1$ to a coil of N turns, flux, $\phi$, will build up in the core according to $E = -N\frac{d\phi}{dt} \times 10^{-8}$. For small changes in $\phi$ and t, this expression reduces to $E \triangle T = -N \triangle \phi \times 10^{-8}$. Recalling that total core flux $\phi$ is equal to flux density times the core area, i.e., $\phi = BA$, we can write $E \triangle t = -N \triangle BA \times 10^{-8}$ volt-seconds, which is the familiar pulse transformer equation. For any given transformer, N (turns), B (maximum operating flux swing), and A (core area) are fixed and their product can be considered a constant. Each transformer has an $E \triangle T$, or simply ET constant that is indicative of its flux capacity. This constant is a valuable aid to the circuit designer in choosing a transformer for a given application, for as long as the maximum operating voltage of a transformer is not exceeded, any combination of pulse length, T, and peak pulse voltage, E, the product of which is equal to or less than that of its ET constant, can be accommodated by that transformer. The ET constant in volt-microseconds is given for each transformer in this catalog. Its usefulness will be demonstrated by an example to be given in the applications section of this discussion.

## Loss Characteristics

Magnetic material loss characteristics are an important consideration in the choice of material for a pulse transformer core. Core loss manifests itself in the form of core heating. This heating, in addition to the winding copper losses, determines the temperature rise of the transformer, and thus is a determining factor in the life of the transformer.

Compared to the ferrites, silicon steel has relatively high eddy current losses. Losses in silicon steel cores can be lowered by reducing the thickness of the metal used. One mil is the thinnest silicon steel tape commercially available.

Pulse Permeability and pulse core losses can most conveniently be related to the *rate of change* of flux in the core*. One and two mil oriented-grain silicon steels can be operated at rates of change of flux up to 8 and 16 kilogauss per microsecond, respectively, without excessive eddy current loss. Under these conditions, effective pulse permeabilities of 5,000 are obtained in most "C" core configurations. For a given rate of change of flux, pulse loss in one mil steel tape is about 25% of that in 2 mil tape. Ferrites, on the other hand, because of their low losses, may be operated at higher rates of change of flux. Twenty kilogauss per microsecond is not uncommon.

To summarize: The specific requirements of any given application will always dictate the core material to be used. In general, 2 mil steel is used for pulse lengths greater than 1 per second, 1 mil steel for 0.1 $\mu$sec and longer, and ferrite below 0.25 $\mu$sec.

## Configurations

Core materials are used in several configurations for transformers. "E-I" cores, "U-I" cores, "C" cores, cup cores and toroidal cores are a few of the types available to the designer. Of these, "U-I" cores and "C" cores are the most useful in pulse transformer design, for they allow the use of rectangular winding forms.

When winding on rectangular coil forms, coil geometry and hence leakage inductance, distributed capacitance, and voltage gradients may be accurately controlled. This close control is easily maintained in a production setup. When winding toroidal cores in production, such control is difficult to maintain.

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* See **Pulse Transformer Design and Test Methods, Part III, Final Report, pp. 62 ff., P. R. Gillette, K. W. Henderson, K. Oshima, R. M. Rowe. Contract No. DA36-039-SC-42645, Stanford Research Institute, July, 1955.**

Transformers wound on cup cores have comparatively high leakage inductance and low distributed capacity and are difficult to insulate. For this reason their use is usually restricted to high impedance low voltage transformers. In the discussion concerning pulse transformer equivalent circuits, the importance of controlling leakage inductance and distributed capacity will be discussed.

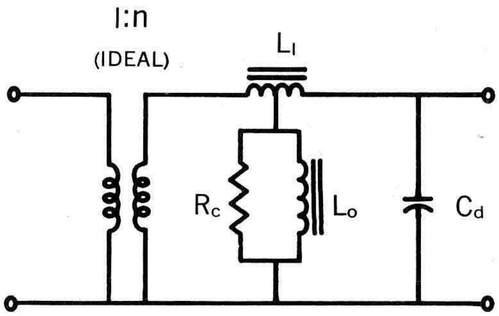
## Elementary Broad Band Theory

Pulse transformers differ from conventional types primarily in their capacity to pass a broad band of frequencies with minimum attenuation and phase distortion. They are usually more difficult to specify and design, since the impedances they work into are not always easily determined and since their required band width is disguised in the three major portions of pulse anatomy. These are: (1) the pulse front (rise time), (2) pulse top (droop), and (3) pulse tail (pulse fall time and backswing). The term pulse transformer, as we use it, refers to linear type pulse transformers and does not cover shift registers, core switches, and other non-linear magnetic elements sometimes classed with pulse transformers.

## Equivalent Circuits

Experience has shown that the behavior of a transformer under conditions of pulse or sine wave excitation can, in most cases, $(n \gg 1)$ be adequately described by the circuit of Figure 3.

**FIG. 3**



Since some of the elements are ineffective during certain portions of the pulse, the well known simplifications shown in Figures 4, 5 and 6 are possible.

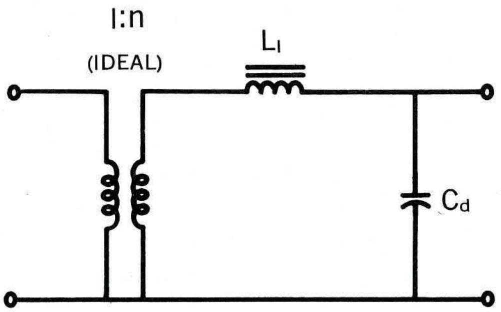
# PULSE RISE

Figure 4 is the approximate equivalent circuit for the high frequency response of the transformer indicating performance during the rise time of the pulse. In order for the load voltage to rise to E max, it must build up in a time interval limited by leakage inductance $L_l$ and the distributed capacity, $C_d$ (including load shunt capacity). At the time of pulse rise, the impedance of the transformer is very nearly equal to $\sqrt{\frac{L_l}{C_d}}$

This value is often referred to as the characteristic impedance of the transformer. In conjunction with the external circuit impedances involved, it determines the shape of the pulse leading edge. The rise time of the transformer is a function of $\sqrt{L_l C_d}$.

Reducing this quantity results in extended high frequency response and fast pulse rise time. Close control of these parameters is an important factor in assuring uniform leading edge performance in a production run of transformers.

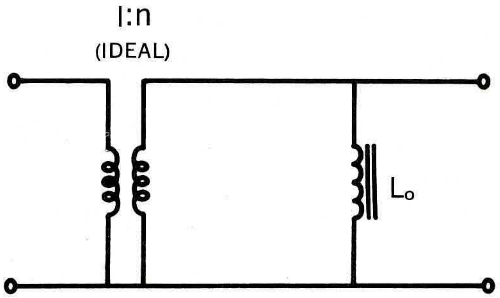
**FIG. 4**



# PULSE TOP (Low Frequency)

When the pulse voltage has reached E max, magnetizing and load currents are flowing in the primary winding. The rate of change of the magnetizing current is determined by $L_o$, the open circuit inductance of the transformer (refer to Figure 5). If the open circuit inductance is relatively high, the rate of increase in magnetizing current will be small; the pulse transformer will have good low frequency characteristics and pass pulse tops with very little droop. Since magnetizing current is related to inductance, voltage, and time by the expression $I_m \approx \frac{ET}{L_o}$ it is occasionally specified instead of open circuit inductance or pulse droop.

**FIG. 5**



When a transformer is matched, i.e., $R_{source} = N^2 R_{Load}$, the percent droop in T seconds is given approximately by % droop $= \frac{50\ R_L T}{L_o}$; where $R_L$ is the load impedance, and $L_o$ is the inductance of the load winding. This relation is represented in the nomograph of Figure 8.

# PULSE TAIL

The conditions existing in the transformer at the end of the pulse are approximately described by the circuit of Figure 6.

The magnetic energy in the core at pulse termination plus the charge on $C_D$ causes a current to flow into R. $C_d$ consists of both transformer distributed and load capacity; $R_L$ is a parallel combination of load resistance and equivalent core less resistance, $R_c$. This current may be oscillatory or damped, depending on the values of $L_o$, $C_d$, and $R_L$. The tail shape can be changed by varying $L_o$ and $C_d$, however, varying the values of these elements also changes pulse front and top characteristics.

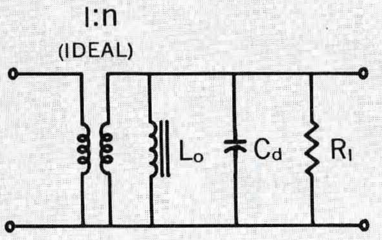


**FIG. 6**

# APPLICATION AIDS

The following two charts are included to aid the circuit designer in selecting a suitable transformer for his circuit.

### Blocking Oscillator Pulse Width Chart

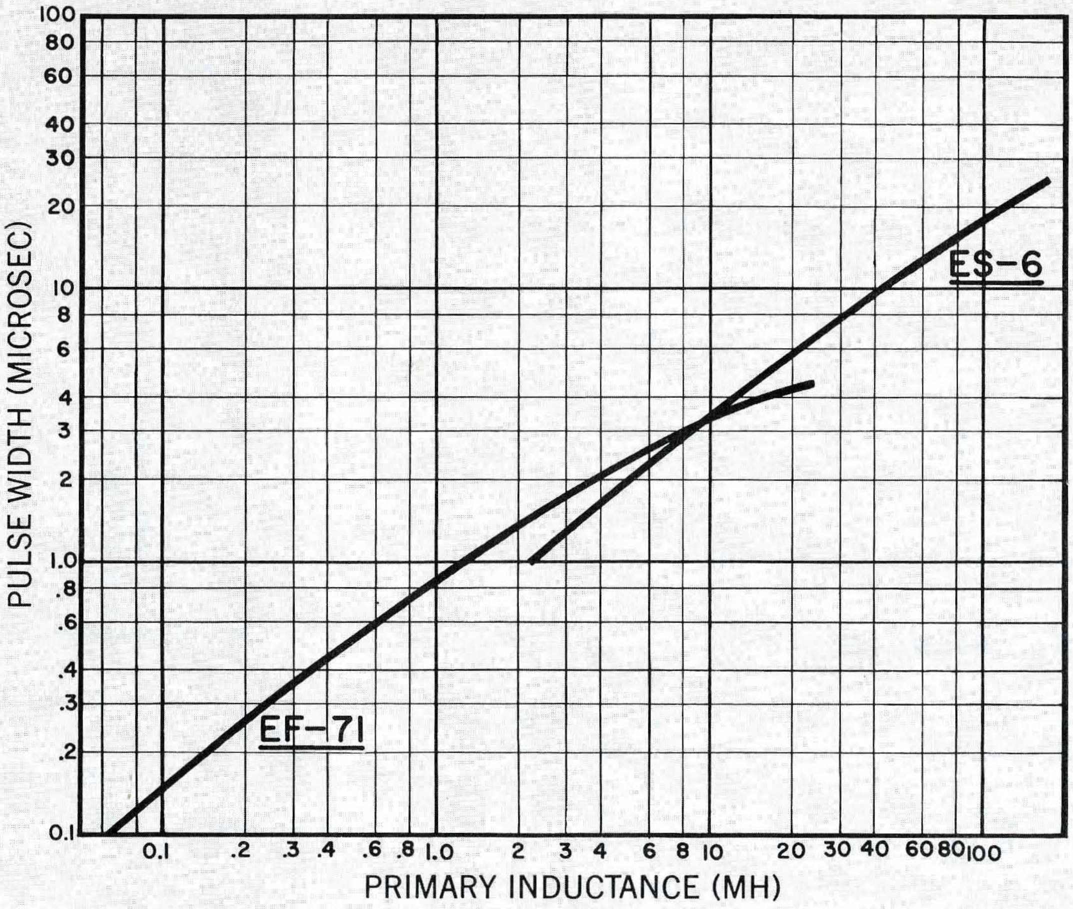
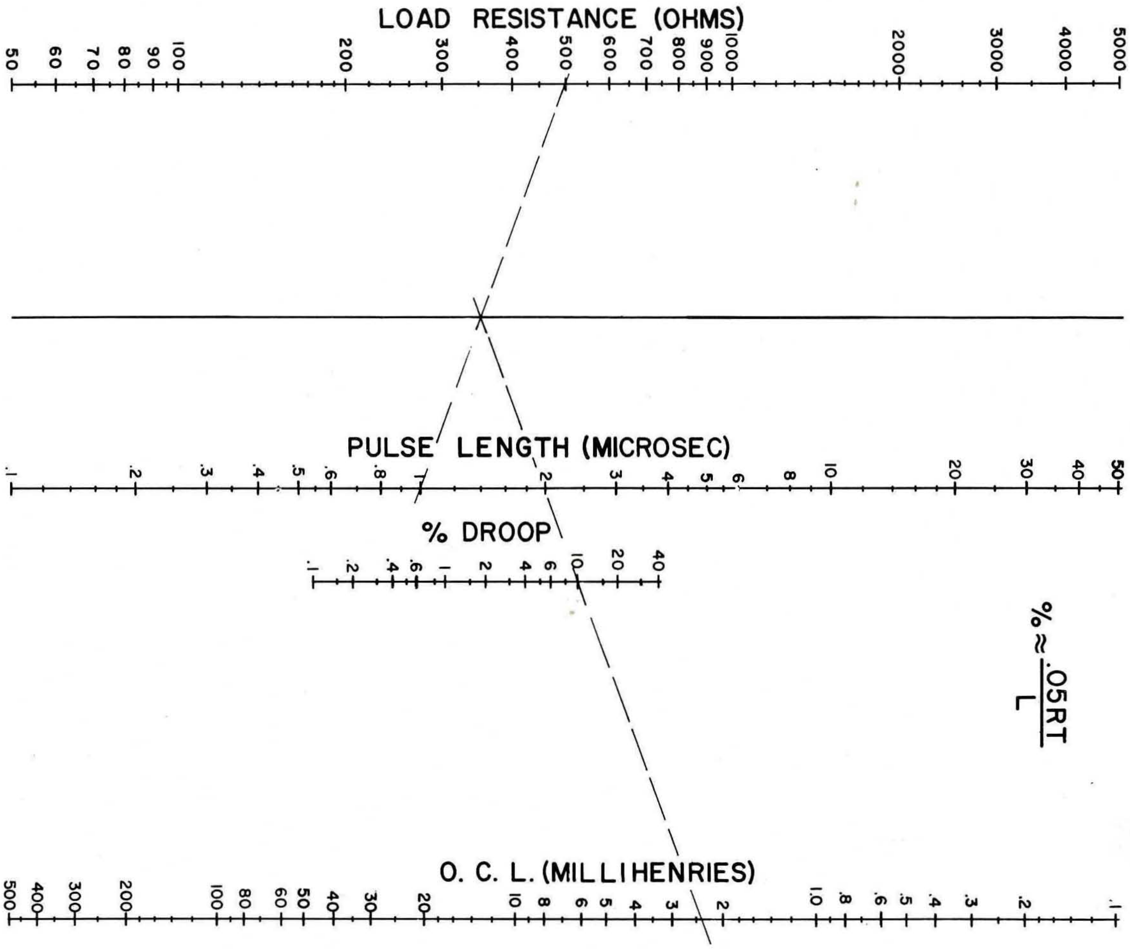


**FIG. 7**

The chart in Figure 7 shows the approximate relation between primary inductance and BO pulse width of 1:1 transformers in the standard circuit of Figure 9. For example, PE-2227 with an OCL of 0.5 mh can be expected to give a BO pulse width of approximately 0.5 $\mu$sec.

# Droop – Impedance – Pulse – Width – OCL – Nomograph



$$\% \approx \frac{.05RT}{L}$$

FIG. 8

The nomograph of Figure 8 can be used to determine the droop a transformer will have for any conditions of loading. For example, suppose a transformer is needed to couple 1 $\mu$sec pulses from a 500 ohm source to a 500 ohm load. The input level is to be 800 volt peak and the output level 800 volt peak on the 500 ohm load. The rise time is to be less than 0.1 $\mu$sec and the droop less than 10%. The pulse repetition rate is 10 kc. The first step in the solution of this problem is to determine the average power level at which the unit is going to be operated. Peak power is $\frac{800^2}{500} = 1280$ watts.

Average power is peak power x duty cycle = peak power x pulse length x repetition rate = $1280 \times 1 \times 10^{-6} \times 1 \times 10^4 =$ 12.8 watts. The required ET Constant is computed from the maximum pulse length and maximum pulse voltage the transformer must accommodate: ET = $800 \times 1 \times 10^{-6} = 800$ volt-microseconds. The primary inductance required to meet the 10% droop specification is approximately 2.5 mh (determined with the aid of Figure 7).

The average power level of 12.8 watts indicates that a type H-8 transformer would be satisfactory. However, the max peak operating voltage for reliable operation of this type of transformer is 600 volts, so a type H-10 must be chosen. Looking at the H-10 list, we see that PE-2264 will meet all the requirements, since its rise time is less than 0.1 $\mu$sec and its ET, primary OCL, max peak operating voltage, and max average power exceed those of the required transformer.

P-2264 is listed as a three winding transformer with a turns ratio of 1:2:1. It is easily converted to a 1:1 transformer, however, by connecting the primary and tertiary windings in series aiding (i.e., connect the primary finish to the tertiary start) and using the combined windings as the primary. This arrangement will decrease leakage inductance and increase distributed capacitance thereby reducing the transformer characteristic impedance somewhat. Rise time will be relatively unaffected.

When looking in this catalog for a particular transformer, the fact that impedances transform by the turns ratio squared should be kept in mind. For instance, suppose a 3:1 step down H-10 transformer with an 80 mh minimum primary inductance is needed. At first glance, no such transformer appears in the catalog. The problem has an easy solution, however. PE-2215 has the required turns ratio of 3:1. Since the inductance of the 1 winding is 10 mh, the inductance of the 3 winding is 9 x 10 = 90 mh. This is a comfortable margin over the 80 mh minimum requirement, and PE-2215 may be used in the application if its rise time and ET Constant are satisfactory.

# TESTING — INSPECTION AND TOLERANCES, CATALOG ITEMS

## MECHANICAL

Visual and mechanical inspection ensures the units conform to the outline prints on standard items shown in this catalog. Standard AQL level inspection quantities are based upon lot size and MIL STD-105A. Dimensions, appearance and markings are also checked.

## ELECTRICAL

Electrical inspection verifies that the magnetic component will perform as described in the catalog. We usually prefer specifying to minimums or maximums rather than providing transformers with special plus or minus tolerances. Values for leakage inductance and distributed capacitance stated herein are nominal. They are offered as a guide to the user. A maximum tolerance can be held on request.

## DESCRIPTION

The standard Pulse Engineering tests and tolerances for catalog items are shown below. Special tests and tolerances may be negotiated at the option of the user.

| TEST | EQUIPMENT |
|---|---|
| Insulation resistance is a maximum tolerance. | Freed Mod. 1620 Megohmmeter |
| DC resistance is a maximum tolerance. | ESI Imped. Bridge Model 250 DA<br>Resistance Bridge |
| Capacity-winding to winding is a maximum tolerance. | Tektronix L-C Meter or Impedance Bridge |
| Leakage inductance is a maximum tolerance. | Impedance Bridge or L-C Meter |
| Droop is a maximum tolerance. | Pulse Gen. and Oscilloscope |
| Pulse width formed in a blocking oscillator is a minimum tolerance. | Std. B.O. Test Jig |
| High potential testing is a go-no-go test. | High Potential Tester |
| Pulse rise time is a maximum tolerance. | Pulse Gen. and Oscilloscope |
| Open circuit inductance is a minimum tolerance. | Impedance Bridge or L-C Meter |
| Turns ratio is a nominal tolerance, usually ± 10%. | Sine Wave Oscillator and Vacuum Tube Voltmeter |

## OCL (Open Circuit Inductance) TEST

Open circuit inductance (primary winding) is measured on an ESI 250 DA Bridge, frequency—1 kc at the voltages indicated in the table. (The primary winding for catalog purposes is always considered to be the first winding, regardless of turns ratio.)

Below 300 microhenries, OCL is measured on a Tektronix L-C Meter Model 130. This measurement can also be made on the Boonton Q Meter, provided the coil Q is high enough. (It is generally impractical to make Q meter inductance measurements on steel core transformers.) Inconsistencies will result if the Q meter readings are not corrected for transformer distributed capacitance effects.

### 1 KC TEST VOLTAGES TO BE USED IN MEASURING OCL ON ESI BRIDGE

| | |
|---|---|
| 0.3 + mh to 1 mh | 0.04 volt |
| 1 + mh to 3 mh | 0.08 volt |
| 3 + mh to 10 mh | 0.2 volt |
| 10 + mh to 30 mh | 0.5 volt |
| 30 + mh to 100 mh | 1.0 volt |
| 100 + mh to 300 mh | 2.0 volt |
| 300 + mh up | 5.0 volt |

## WINDING TO WINDING CAPACITY TEST

(Approximately equal to $C_d$ for a 1:1 inverting transformer.) This test is made on a Tektronix L-C Meter, Model 30, with coil windings shorted start to finish.

3 uuf To 580

## LEAKAGE INDUCTANCE TEST

For values below 300$\mu$h, this test is made on a Tektronix L-C Meter with secondary shorted and reading $L_1$ on primary. Care must be taken to obtain a low resistance secondary short circuit with the shortest possible lead lengths. Length of primary leads to the instrument must be consistent with the magnitude of the quantity being measured.

[illegible] – 300

Above 300$\mu$h, this test is performed on an ESI Impedance Bridge.

## DROOP TEST

The decrease in mean pulse amplitude from the 100% level (as shown in definition of terms) to some specified interval of time following the initial attainment of 100% level is the droop (or sag) of the pulse top. This test is made with proper source and load impedances as shown in Figure 13 on page 10. Allowance must be made in the choice of source impedance for generator impedance. A chart for computing pulse droop for the designs in this catalog is on page 7.

## BLOCKING OSCILLATOR TEST

Transformers rated on this test are required to generate a pulse of specified width in the circuits of Figure 9 or 10 as measured at the 50% amplitude points on an accurate time base oscilloscope. Key problem to resolve is effect of circuit elements other than the transformer on pulse width. An exchange of standards is necessary to properly perform this test.

## MAGNETRON TRANSFORMER TESTING

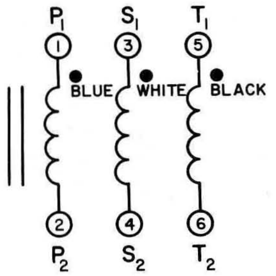
These transformers are tested in a hydrogen thyratron line-type modulator under conditions that closely simulate their actual operating conditions. Parameters measured include rise time, overshoot, and droop. A key test given this type of transformer is the induced voltage test. All transformers must be able to withstand 100% induced voltage overloads.

## MAGNETIZING CURRENT TEST

This test may be performed at the customer's request. The instruments required are a pulse generator, non inductive current viewing resistor, and calibrated oscilloscope.

# TRANSFORMER TERMINATIONS AND MARKINGS

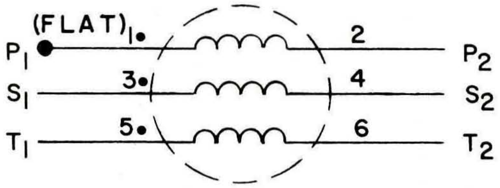
## ■ Standard Transformer Connections



Terminals may be identified by colored polarity dots in place of numbers. Dots show terminals with the same instantaneous polarity. (P1—blue, S1—white, T1—black.)

## CASE STYLE Y

**TOP VIEW (HIGH SIDE)**

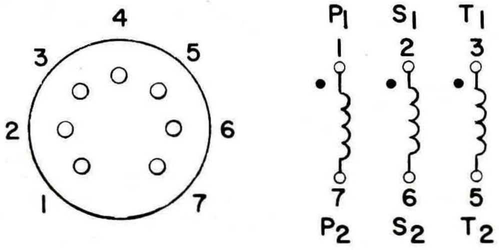


**LEAD NO'S. MARKED ON UNIT**

*MARKING:* PE NUMBER
PULSE ENGINEERING
Optional identification such as: 2MH, 1:1:1
Polarity dots or numbers

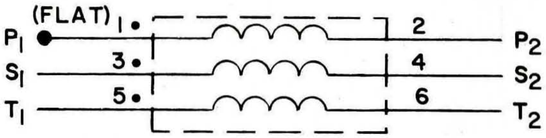
## CASE STYLE V

**BOTTOM VIEW**



*MARKING:* PE NUMBER
PULSE ENGINEERING
Optional coil diagram

## CASE STYLES Z, U & W



**LEAD NO'S. AND CONNECTION DIAG. MARKED ON UNIT**

*MARKING:* PE NUMBER
PULSE ENGINEERING
COIL DIAGRAM
Optional identification such as: 3MH, 1:2:3
Polarity dots or numbers

## MODELS H8, H10, ETC.

*MARKING:* PE NUMBER
PULSE ENGINEERING
Optional: Coil Diagram, Turns Ratio and Primary OCL
Terminal Marking

## General Considerations When Specifying Transformers for Blocking Oscillator Applications

It is impractical to impose both an OCL test and a BO test upon a transformer due to circuit and core vagaries. One test or the other should be used, but not both.

Circuit designers are urged to control pulse width in their application by the addition of an RC timing circuit. For very precise control, the inclusion of a delay line in the pulse forming circuitry is recommended.

Operating temperatures are another important consideration in BO design. Typical values of temperature coefficient of pulse width are +.0012/°C for steel and —.003/°C for ferrite.

### *DESIGN NOTE*

For designers who wish to use 3-winding transformers and load the 3rd winding, the following data will be helpful.

The loading resistance that can be tolerated on the 3rd winding of a 1:1:1 STAT-TRAN® for a 25% reduction in pulse width is approximately 500 ohms.

The loading resistance that can be tolerated on the 3rd winding of an ES6 of 1:1:1 turns ratio for a 25% reduction in pulse width is approximately 1600 ohms.

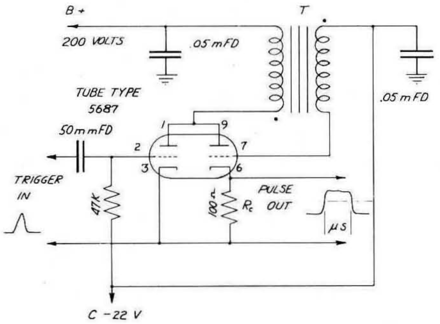


**FIG. 9**

## Vacuum Tube Blocking Oscillator Applications

Figure 9 shows a typical BO test circuit. (This circuit is not recommended for other than test application since it depends upon transformer OCL for generated pulse width.) Other parameters, principally the tube characteristics, also affect the pulse width. Properly calibrated with standards, the circuit of Figure 9 can be used as a definitive test for pulse width and pulse rise time provided:

1. *Grid and plate returns are at ground through low inductance capacitors and short leads.*
2. *The tube characteristics are within their specifications.*
3. *Supply voltages are as specified.*
4. *Trigger amplitude is no greater than that required to reach 0 grid volts.*
5. *Trigger pulse width is less than BO pulse width or is differentiated.*

Refer to the chart, Figure 7, page 6 for correlation between open circuit inductance and maximum pulse width for 1:1 turns ratio transformers in the blocking oscillator circuit of Figure 9.

## Transistor Blocking Oscillator Applications

A major difference in transistor BO circuits is that they require a low impedance transformer. Switching currents rather than voltages are the criteria.

A common turns ratio used in transistor BO's is 4:1, with the 4N winding in the collector and the 1N winding in the emitter.

| PULSE WIDTH (µSEC) | $T_1$ |
|---|---|
| .5-5 | 2N599 |
| 3-20 | 2N597 |

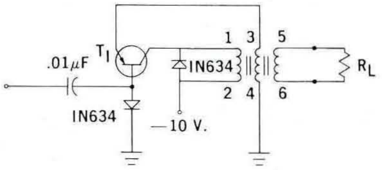


**FIG. 10**

The circuit of Figure 10 is useful as a transformer evaluation and test circuit. (Other circuits may be more suitable for application.)

## Coupling Applications

The MICROSTAT®, STAT-TRAN® and ES6 Series transformers can couple a very wide band of frequencies. See Figures 11 and 12 for some typical frequency response plots.

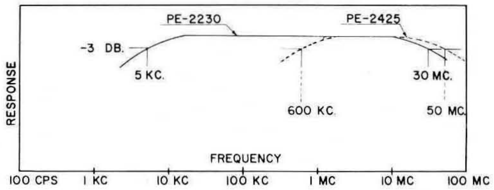


**FIG. 11**

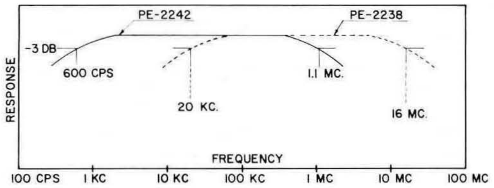


**FIG. 12**

In general, ferrite core units are preferred for pulse coupling applications because of their gapped construction and low core loss which provides for higher efficiency than other units of conventional construction.

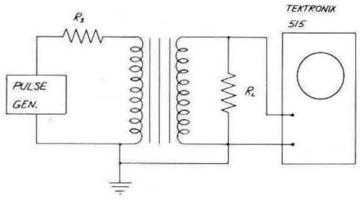


**FIG. 13**

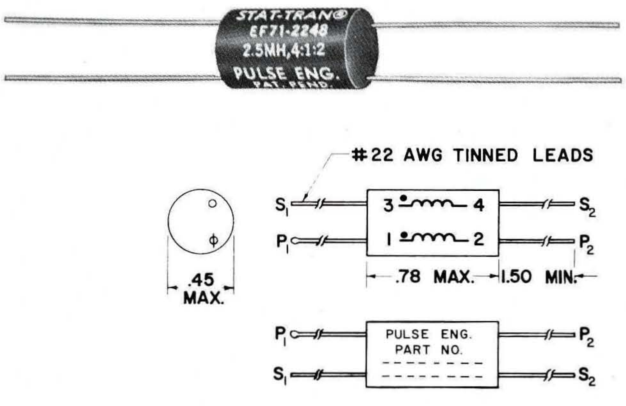
Pulse rise time and droop for a given design can be evaluated in a circuit like Figure 13. $R_s$ is the source impedance and should include consideration of the internal impedance of the generator. $R_l$ is the load resistor.

Figure 8, on page 7, shows how to determine droop for a particular transformer OCL in your application, if you know source and load impedances.

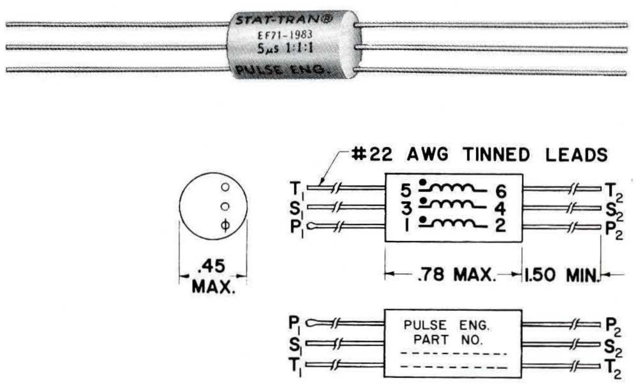
Pulse droop is indicative of low frequency response and is approximately proportional to pulse width. Therefore, holding $R_s$ and $R_l$ constant, a transformer passing a 2µs pulse with 15% droop can be used for a 4µs pulse at 30% droop. This is true until core saturation is approached, i.e., the ET Constant is exceeded.

# STAT-TRANS® (EF71)

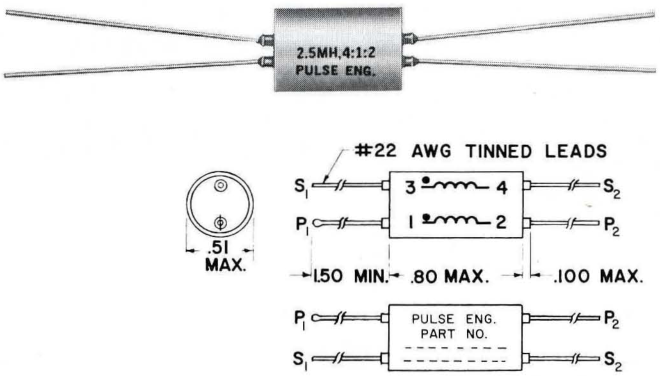
STAT-TRAN® miniature pulse transformers are specially designed, patented (Pat. No. 2,885,643) to provide minimum core loss and greater bandwidth. Better insulation resistance provides longer life and greater reliability than toroid and cup core types. Design features for this new-type transformer are noted in Figure 14.



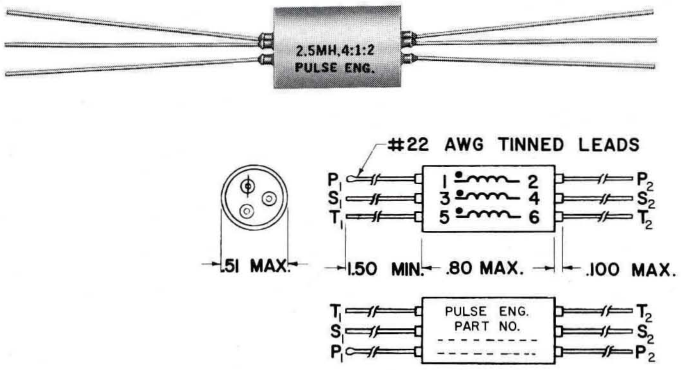
CASE "U" & "Z" 2 WDG.



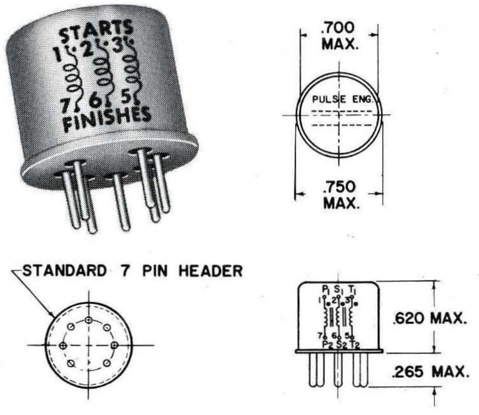
CASE "U" & "Z" 3 WDG.



CASE "W" 2 WDG.



CASE "W" 3 WDG.



CASE STYLE V

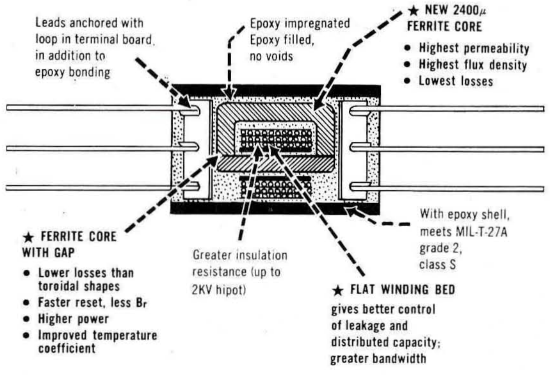


FIG. 14

## STAT-TRANS® Normally used for transistor blocking oscillator applications

| CATALOG NUMBER | PRIMARY O.C.L. (mh) | TURNS RATIO | ET** CONSTANT (volt-μsec) | TYPICAL APPLICATION | RISE TIME (μsec) | LEAKAGE INDUCTANCE (μh) | CAPACITY PRI/SEC (μμf) |
|---|---|---|---|---|---|---|---|
| 2710 | 0.008 | 1:5:7 | 10 | 0.1 to 0.2μs | 0.02 | 0.2 | 11 |
| 2572 | 0.05 | 6:1:3 | 24 | 0.1 to 0.2μs | 0.006 | 3.5 | 6 |
| *2445 | 0.05 | 4:1:2 | 30 | 0.07 to 0.1μs | 0.005 | 2.0 | 11 |
| *2444 | 0.10 | 4:1:2 | 38 | 0.1 to 0.2μs | 0.008 | 2.0 | 17 |
| 2468 | 0.15 | 5:5:1 | 30 | 0.1 to 0.5μs | 0.02 | 0.6 | 20 |
| *2443 | 0.20 | 4:1:2 | 50 | 0.1 to 0.5μs | 0.01 | 4.0 | 17 |
| *2671 | 0.20 | 4:1:4 | 50 | 0.1 to 0.5μs | 0.007 | 4.0 | 11 |
| *2694 | 0.20 | 4:1:8 | 50 | 0.1 to 0.5μs | 0.06 | 4.0 | 15 |
| 3187 | 0.35 | 1:2:6 | 210 | 0.1 to 1.0μs | 0.07 | 0.6 | 24 |
| *2442 | 0.40 | 4:1:2 | 70 | 0.2 to 4.0μs | 0.03 | 5.0 | 16 |
| *2672 | 0.40 | 4:1:4 | 70 | 0.2 to 4.0μs | 0.008 | 3.0 | 16 |
| 2695 | 0.40 | 4:1:1:4 | 70 | 0.2 to 4.0μs | 0.02 | 4.0 | 25 |
| 2658 | 1.4 | 5:1:5 | 140 | 1.0 to 15.0μs | 0.02 | 12.0 | 15 |
| 2708 | 2.5 | 6:1:2 | 140 | 1.0 to 12.0μs | 0.02 | 4.0 | 21 |
| 2730 | 2.5 | 2:1:1 | 100 | 1.0 to 12.0μs | 0.02 | 3.5 | 27 |
| *2248 | 2.8 | 4:1:2 | 100 | 1.0 to 12.0μs | 0.03 | 5.2 | 37 |
| *2673 | 3.0 | 4:1:4 | 100 | 1.0 to 12.0μs | 0.02 | 5.2 | 24 |
| *2249 | 5.0 | 4:1:2 | 150 | 1.0 to 20.0μs | 0.06 | 4.8 | 68 |
| 2570 | 30 | 7:1 | 300 | 1.0 to 50.0μs | 0.02 | 26 | 35 |

*Items normally carried in stock.

**Based on highest turn winding. Product of pulse width (μsec) and peak voltage (volts) on highest turn winding must not exceed this value if core saturation is to be avoided. See design example on page 7.

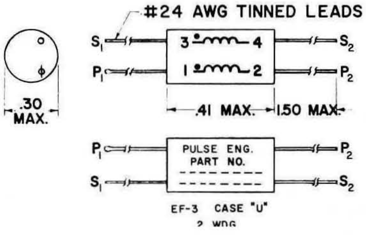
## STAT-TRANS® Normally used for coupling applications

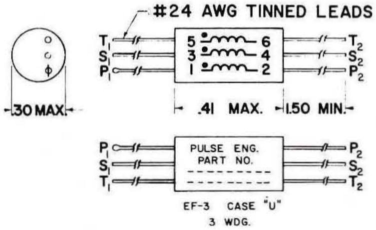
| CATALOG NUMBER | PRIMARY O.C.L. (mh) | TURNS RATIO | ET** CONSTANT (volt-μsec) | TYPICAL APPLICATION | RISE TIME (μsec) | LEAKAGE INDUCTANCE (μh) | CAPACITY PRI/SEC (μμf) |
|---|---|---|---|---|---|---|---|
| *2425 | 0.1 | 1:1 | 20 | Coupling | 0.004 | 0.5 | 13 |
| *2196 | 0.2 | 2:1 | 30 | Coupling | 0.004 | 1.5 | 12 |
| 2143 | 0.3 | 5:1:5 | 40 | Coupling | 0.005 | 3.0 | 7.0 |
| *2232 | 0.7 | 1:2:1 | 100 | Coupling | 0.02 | 1.0 | 34 |
| *1637 | 0.8 | 1:4:1 | 200 | Coupling | 0.07 | 3.0 | 17 |
| 2919 | 1.5 | 1 ct:9 | 320 | Coupling | 0.14 | 2.2 | 36 |
| 2228 | 1.7 | 1:1 | 70 | Coupling | 0.008 | 2.2 | 30 |
| *2233 | 2.5 | 1:2:1 | 190 | Coupling | 0.02 | 3.0 | 36 |
| 3016 | 2.5 | 8:1 | 90 | Coupling | 0.02 | 9.0 | 14 |
| *1628 | 2.5 | 1:4 | 400 | Coupling | 0.08 | 1.6 | 74 |
| *1627 | 2.5 | 1:3 | 300 | Coupling | 0.03 | 2.0 | 68 |
| *2230 | 5 | 1:1 | 150 | Coupling | 0.04 | 10 | 31 |
| *2244 | 6 | 1:2 | 290 | Coupling | 0.05 | 12 | 30 |
| 2070 | 9 | 6:1 | 200 | Coupling | 0.008 | 0.4 | 50 |
| *2214 | 20 | 4:1 | 250 | Coupling | 0.04 | 2.0 | 145 |
| 2243 | 20 | 1:1 | 250 | Coupling | 0.08 | 4.0 | 80 |

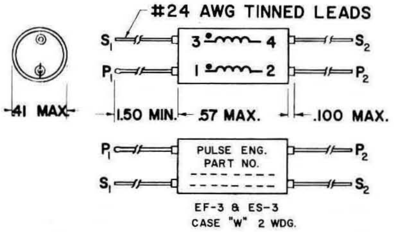
*Items normally carried in stock.

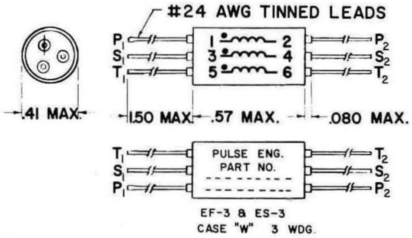
**Based on highest turn winding. Product of pulse width (μsec) and peak voltage (volts) on highest turn winding must not exceed this value if core saturation is to be avoided. See design example on page 7.

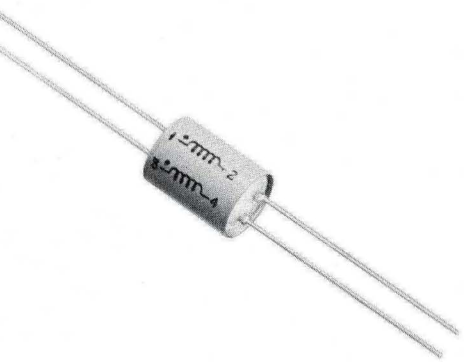
# MICRO-STATS® – EF3











MICRO-STATS® (U. S. Patent 2,885,643) possess the same advantages to the designer outlined under STAT-TRANS® plus small size.

MICRO-STATS® have small ferrite "C-I" cores and are useful in transistor-computer circuitry. Most design characteristics of STAT-TRANS® up to 3 mh primary inductance are available in this package.

The MICRO-STAT® is normally stocked in "U" case styles and is available in "W" case per MIL-T-27A, Grade 1, Class S.

| | |
|---|---|
| Average power rating (40° C Rise) . | 0.7 watts |
| Peak pulse voltage . . . . . . | 250 volts maximum |
| Hi pot . . . . . . . . . . | 500 v rms |
| Insulation resistance . . . . . | 10,000 megohms |

| CATALOG NUMBER | PRIMARY O.C.L. (mh) | TURNS RATIO | ET** CONSTANT (volt-$\mu$sec) | TYPICAL APPLICATION | RISE TIME ($\mu$sec) | LEAKAGE INDUCTANCE ($\mu$h) | CAPACITY PRI/SEC ($\mu\mu$f) |
|---|---|---|---|---|---|---|---|
| 2976 | 0.025 | 1:1:1 | 10 | Transistor B.O. | 0.002 | 0.3 | 11 |
| *2993 | 0.025 | 1:3 | 17 | Coupling | 0.003 | 0.2 | 10 |
| *3189 | 0.05 | 1:1 | 12 | Coupling | 0.002 | 0.4 | 10 |
| *3190 | 0.10 | 1:1 | 12 | Coupling | 0.002 | 0.3 | 10 |
| *3073 | 0.12 | 2:1 | 13 | Transistor B.O. | 0.003 | 0.6 | 10 |
| 3074 | 0.12 | 1:1:1 | 13 | Transistor B.O. | 0.003 | 0.5 | 20 |
| *2991 | 0.20 | 1:1 | 17 | Coupling | 0.003 | 0.6 | 11 |
| 3200 | 0.20 | 3:1:2 | 17 | Transistor B.O. | 0.003 | 1.3 | 8 |
| *3075 | 0.20 | 4:1:2 | 17 | Transistor B.O. | 0.004 | 2.2 | 7 |
| 3201 | 0.40 | 3:1:2 | 25 | Transistor B.O. | 0.004 | 2.0 | 10 |
| *3191 | 0.50 | 1:1 | 28 | Coupling | 0.004 | 1.1 | 12 |
| 3196 | 2.0 | 2:1 | 50 | Coupling | 0.007 | 3.0 | 12 |
| *2992 | 3.0 | 1:2 | 120 | Coupling | 0.007 | 0.9 | 12 |
| *2834 | 3.0 | 3:1 | 60 | Coupling | 0.01 | 8.2 | 11 |

*Items normally carried in stock.

**Based on highest turn winding. Product of pulse width ($\mu$sec) and peak voltage (volts) on highest turn winding must not exceed this value if core saturation is to be avoided. See design example on page 7.

# ES6 RIBBON CORE MINIATURES

The ES6 design is recommended for applications requiring blocking oscillator pulse widths of more than 1 μs, or when greater stability of OCL and BO pulse width with change in ambient temperature is desired.

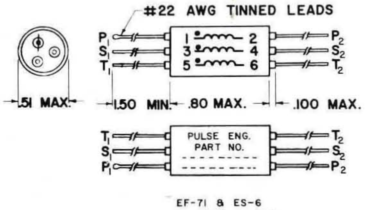
ES6 transformers have the same high insulation resistance features found in STAT-TRANS®.

They are available in much higher inductance values than other types, which broadens the scope of their application beyond pulse circuitry.

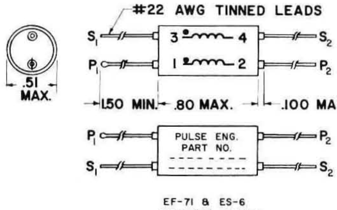
Although the majority of ES6's were originally designed as blocking oscillator transformers, many of these units save size and weight in transistor power amplifiers, and thyratron circuits. PE 2147, for example, has a usable frequency range of 180 cps to 500,000 cps as a 1:4 between 300Ω and 5400Ω.

ES6's are normally stocked in "Y" case styles to MIL-T-27A Grade 2, Class R and S. Most can be supplied in case W and V to MIL-T-27A, Grade 1, Class S.

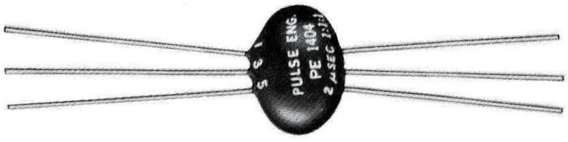
| | |
|---|---|
| Average power rating (40°C Rise) | 2 watts up to 10 mh pri O.C.L.<br>1 watt 10 to 40 mh pri O.C.L.<br>0.5 watt 40 to 150 mh pri O.C.L. |
| Peak pulse voltage . . . . . . . | 300 volts max. |
| Hi pot . . . . . . . . . . . . | 700 v rms |
| Insulation resistance . . . . . | 10,000 megohms |
| Approx. TC of BO pulse width . . . | +0.0012/°C |



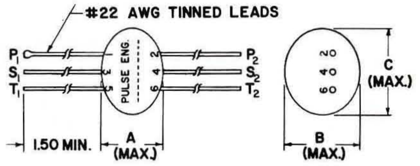
EF-71 & ES-6
CASE "W" 3 WDG.



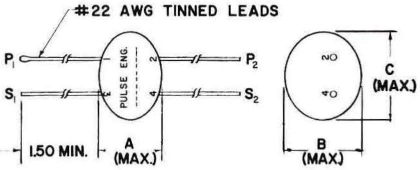
EF-71 & ES-6
CASE "W" 2 WDG.



ES-6 CASE "Y" 3 WDG.

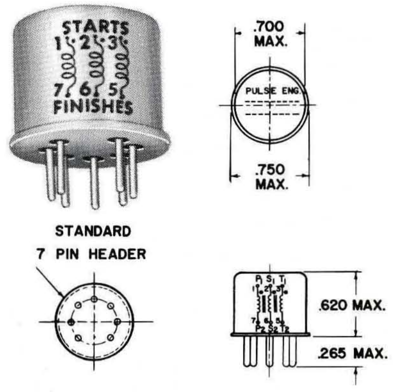


| CASE | MAX OCL | A | B | C |
|---|---|---|---|---|
| Y-1 | 1 MH | .594 | .594 | .594 |
| Y-2 | 10 MH | " | .656 | .656 |
| Y-3 | 150 MH | " | .750 | .750 |



ES-6 CASE "Y" 2 WDG.

| CATALOG NUMBER | PRIMARY O.C.L. (mh) | TURNS RATIO | ET** CONSTANT (volt-μsec) | TYPICAL APPLICATION | RISE TIME (μsec) | LEAKAGE INDUCTANCE (μh) | CAPACITY PRI/SEC (μμf) |
|---|---|---|---|---|---|---|---|
| *2237 | 1.0 | 1:2 | 250 | B.O. to 1μs, coupling | 0.025 | 2.0 | 115 |
| *1239 | 1.5 | 1:1 | 130 | B.O. to 1μs, coupling | 0.035 | 4.0 | 38 |
| *2240 | 2.0 | 1:2 | 250 | B.O. to 1μs, coupling | 0.025 | 4.0 | 40 |
| *2236 | 2.5 | 1:1:1 | 220 | B.O. to 1μs coupling | 0.025 | 4.0 | 40 |
| *2901 | 3.0 | 1:5 | 1100 | Coupling | 0.160 | 5.0 | 50 |
| *2238 | 5.0 | 1:1 | 200 | B.O. to 2μs | 0.035 | 16 | 42 |
| *2239 | 5.0 | 1:1:1 | 200 | B.O. to 2μs | 0.035 | 5.0 | 50 |
| *2407 | 8.5 | 2:1:1 | 200 | B.O. to 2μs | 0.015 | 13 | 42 |
| 3001 | 8.5 | 2:2:1 | 350 | B.O. to 3μs | 0.05 | 10 | 50 |
| *2241 | 10 | 1:2 | 530 | B.O. to 5μs | 0.18 | 28 | 45 |
| 2960 | 15 | 4:1:8 | 480 | Transistor B.O. | 0.20 | 11 | 68 |
| *3003 | 15 | 1:2:1 | 480 | Demodulation | 0.07 | 6.5 | 90 |
| *1381 | 18 | 1:1 | 530 | B.O. to 5μs | 0.09 | 22 | 55 |
| *2225 | 20 | 1:1:1 | 530 | B.O. to 5μs | 0.10 | 18 | 55 |
| *2982 | 20 | 4:1:2 | 260 | Transistor B.O. | 0.05 | 18 | 44 |
| *2479 | 60 | 1:1:1 | 950 | B.O. to 10μs | 0.40 | 80 | 62 |
| *2242 | 60 | 1:1 | 1300 | B.O. to 10μs | 0.30 | 120 | 58 |
| *2429 | 60 | 1:3 | 3800 | Coupling | 0.55 | 200 | 68 |
| *2147 | 60 | 1:4 ct | 4700 | Coupling | 0.25 | 180 | 132 |
| *2245 | 120 | 1:2 | 2500 | Coupling | 0.90 | 90 | 130 |
| *2477 | 140 | 1:1:1 | 2000 | B.O. to 20μs | 0.55 | 220 | 60 |
| *1791 | 140 | 1:1 | 2000 | B.O. to 20μs | 0.50 | 220 | 20 |
| 2946 | 160 | 1:6 | 1200 | Transistor coupling | 0.20 | 65 | 85 |

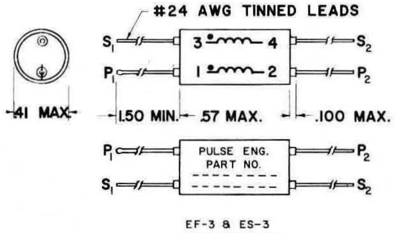


CASE STYLE V

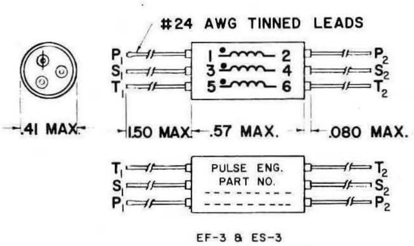
*Items normally carried in stock.

**Based on highest turn winding. Product of pulse width (μsec) and peak voltage (volts) on highest turn winding must not exceed this value if core saturation is to be avoided. See design example on page 7.

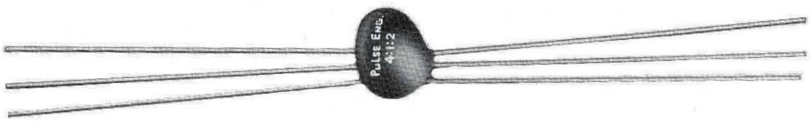
# ES3 TRANSFORMERS

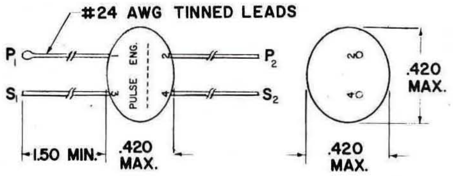


EF-3 & ES-3 CASE "W" 2 WDG.

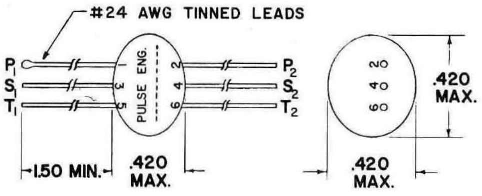


EF-3 & ES-3 CASE "W" 3 WDG.





ES-3 CASE "Y" 2 WDG.



ES-3 CASE "Y" 3 WDG.

ES3 is a micro-miniature pulse transformer with a gapless wound core of thin strip oriented grain silicon steel. These transformers are available in primary inductances up to 10 mh. They are useful in vacuum tube and transistor blocking oscillators where a lower temperature coefficient of permeability is desired than is available with ferrites. They are also useful as low impedance pulse coupling units.

They are normally stocked in the "Y" case style which will pass applicable MIL-T-27A, Grade 2, Class S tests. Also available in "W" case per MIL-T-27A, Grade 1, Class S.

| | |
|---|---|
| Average power rating (40°C Rise) . . . | 0.5 watts |
| Peak pulse voltage . . . . . . . . | 250 v maximum |
| Hi-pot . . . . . . . . . . . . . | 500 v rms |
| Insulation resistance . . . . . . . | 10,000 megohms |
| Approx. TC of BO pulse width . . . . | +0.0012/°C |

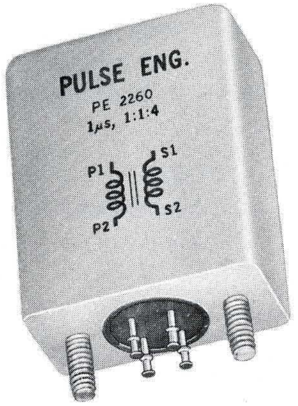
| CATALOG NUMBER | PRIMARY O.C.L. (mh) | TURNS RATIO | ET** CONSTANT (volt-$\mu$sec) | TYPICAL APPLICATION | RISE TIME ($\mu$sec) | LEAKAGE INDUCT-ANCE ($\mu$h) | CAPACITY PRI/SEC ($\mu\mu$f) |
|---|---|---|---|---|---|---|---|
| 2682 | 0.02 | 4:1:2 | 15 | Transistor B.O. | 0.004 | 2.0 | 8.0 |
| 2704 | 0.04 | 3:1:1 | 20 | Transistor B.O. | 0.004 | 2.0 | 12 |
| 2651 | 0.10 | 2:1:1 | 30 | Va. tube B.O. | 0.005 | 1.0 | 18 |
| *2779 | 0.10 | 3:1:1 | 35 | Transistor B.O. | 0.005 | 1.5 | 20 |
| *2701 | 0.10 | 4:1 | 35 | Transistor B.O. | 0.004 | 2.0 | 12 |
| *2652 | 0.20 | 2:1:1 | 40 | Va. tube B.O. | 0.005 | 1.5 | 18 |
| *3177 | 0.20 | 5:1:5 | 40 | Demodulation | 0.005 | 2.0 | 18 |
| *2513 | 0.40 | 4:1:2 | 45 | Transistor B.O. | 0.006 | 3.0 | 12 |
| 2650 | 0.40 | 2:1:1 | 45 | Transistor B.O. | 0.006 | 2.0 | 20 |
| 3176 | 0.40 | 3:2:1 | 45 | Transistor B.O. | 0.007 | 2.0 | 20 |
| *3040 | 0.60 | 1:1 | 60 | Va. tube B.O., coupling | 0.006 | 1.5 | 20 |
| *3041 | 0.60 | 1:1:1 | 60 | Va. tube B.O., coupling | 0.006 | 1.5 | 20 |
| *3194 | 1.0 | 1:1 | 75 | Va. tube B.O., coupling | 0.006 | 1.5 | 20 |
| 2742 | 2.5 | 2:1 | 100 | Coupling | 0.008 | 3.0 | 20 |
| *2741 | 2.5 | 4:1 | 100 | Transistor B.O. | 0.015 | 10 | 18 |
| *2816 | 2.5 | 4:1:4 | 140 | Transistor B.O. | 0.015 | 10 | 18 |
| *2848 | 2.5 | 4:1:2 | 140 | Transistor B.O. | 0.015 | 10 | 18 |
| 2743 | 5.0 | 4:1 | 250 | B.O. and coupling | 0.020 | 15 | 20 |
| 2744 | 10 | 4:1 | 330 | B.O. and coupling | 0.035 | 45 | 22 |

*Items normally carried in stock.

**Based on highest turn winding. Product of pulse width ($\mu$sec) and peak voltage (volts) on highest turn winding must not exceed this value if core saturation is to be avoided. See design example on page 7.

# PULSE MODULATION TRANSFORMERS FOR MAGNETRONS; TRAVELING WAVE TUBES; KLYSTRONS; HF TRIODES

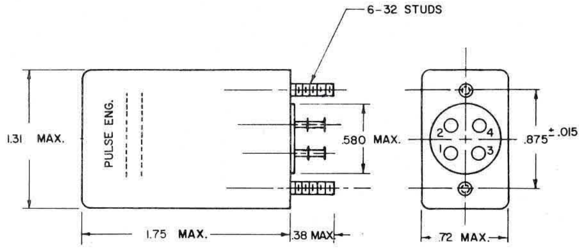
## ■ H8 SERIES available in hermetically sealed or form encapsulated case styles.



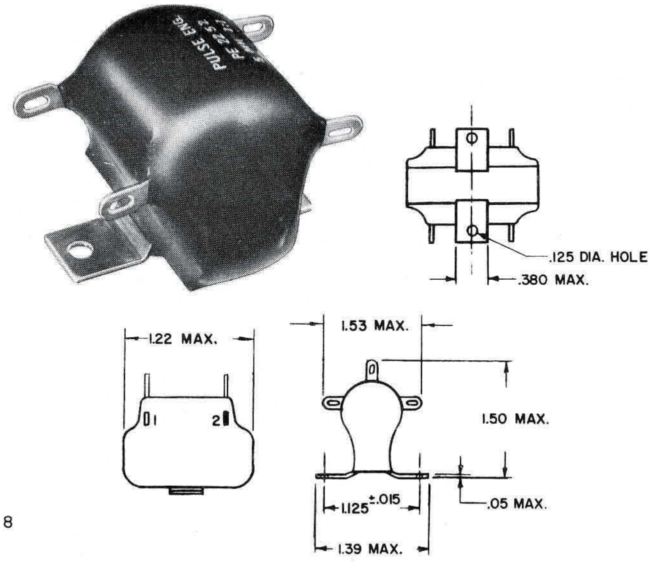
The H8 Series is useful for applications requiring higher average power than is available in the miniature type. Typical applications are pulse coupling, reversing, computer readout, and video coupling. These designs are useful as driver transformers in hard tube pulse modulators and as low power pulse modulation transformers.

| | |
|---|---|
| Average power rating (40°C Rise) . . . | 15 watts |
| Peak pulse voltage . . . . . . . . | 600 v |
| Hi-pot . . . . . . . . . . . . | 1.5 kv rms |

Normally stocked in hermetically sealed case style to MIL-T-27A, Grade 1, Class R. Also available form encapsulated to MIL-T-27A Grade 2, Class R. Class S and T available on special request.



H-8



E-8

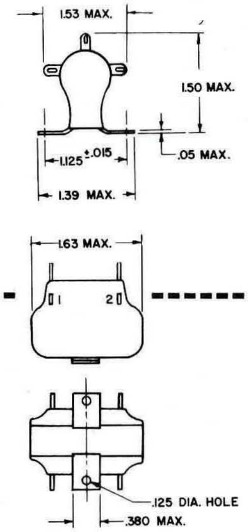
| CATALOG NUMBER | PRIMARY O.C.L. (mh) | TURNS RATIO | ET** CONSTANT (volt-μsec) | TYPICAL APPLICATION | RISE TIME (μsec) | LEAKAGE INDUCTANCE (μh) | CAPACITY PRI/SEC (μμf) |
|---|---|---|---|---|---|---|---|
| *2261 | 4.0 | 1:2 | 3800 | Mod. coupling | 0.06 | 6.0 | 90 |
| *2259 | 5.0 | 1:1 | 1100 | B.O. coupling | 0.06 | 25 | 110 |
| 2500 | 5.0 | 1:1:1 | 1900 | B.O. coupling | 0.10 | 50 | 180 |
| *1453 | 8.0 | 1:1.4 | 1500 | Coupling | 0.08 | 25 | 35 |
| 2810 | 10 | 1:2.5 | 2200 | B.O. coupling | 0.1 | 50 | 40 |
| *2263 | 15 | 1:1 | 3500 | B.O. coupling | 0.06 | 55 | 24 |
| 2260 | 20 | 1:1.4 | 2600 | Driver | 0.10 | 35 | 50 |
| *2514 | 60 | 2:1 | 7600 | Coupling | 0.12 | 115 | 125 |

*Items normally carried in stock.

**Based on highest turn winding. Product of pulse width (μsec) and peak voltage (volts) on highest turn winding must not exceed this value if core saturation is to be avoided. See design example on page 7.

# PULSE MODULATION TRANSFORMERS FOR MAGNETRONS; TRAVELING WAVE TUBES; KLYSTRONS; HF TRIODES

## ■ H-10 SERIES available in hermetically sealed or form encapsulated case styles.



E–10

The H10 Series of transformers are used in blocking oscillator and coupling applications where considerable peak power must be generated. A typical circuit utilizing the H10 transformer in a blocking oscillator with the 3E29 pentode is shown in Figure 15. This series of designs can produce BO pulse widths up to 20 microseconds.

This design is also very useful in coupling and modulation applications for pulse amplitudes up to 1,500 volts. Band widths closely approaching those obtainable in the ES6 designs can be obtained with this transformer.

| | |
|---|---|
| Average power rating (40°C Rise) . . . | 25 watts |
| Peak pulse voltage . . . . . . . . | 1.5 kv maximum |
| Hi-pot . . . . . . . . . . . . | 2.5 kv rms |

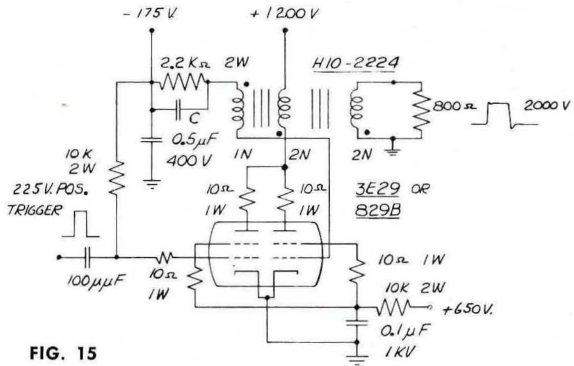
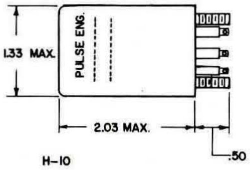
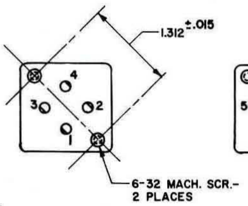


FIG. 15

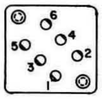
H10 designs are normally stocked in the hermetically sealed package to MIL-T-27A, Grade 1, Class R. Some units are stocked in the E10 form encapsulated package to MIL-T-27A, Grade 2, Class R. All designs are available in Class S and T temperature ratings on special order and in either style.



H-10



4-TERMINAL



6-TERMINAL

*NOTE: TERMINAL NO'S MARKED ON UNIT.*

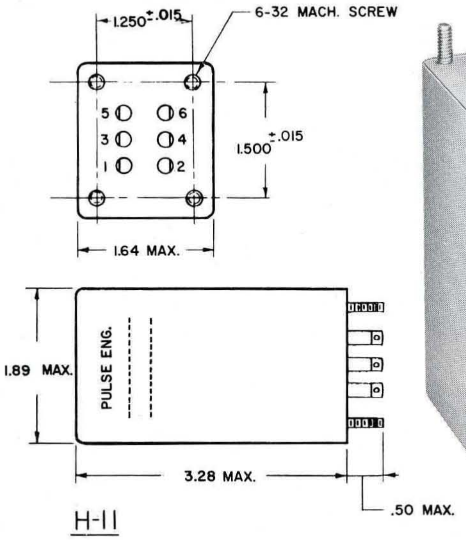
*Items normally carried in stock.

**Based on highest turn winding. Product of pulse width (μsec) and peak voltage (volts) on highest turn winding must not exceed this value if core saturation is to be avoided. See design example on page 7.

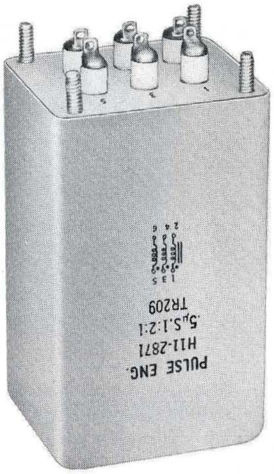
| CATALOG NUMBER | PRIMARY O.C.L. (mh) | TURNS RATIO | ET** CONSTANT (volt-μsec) | TYPICAL APPLICATION | RISE TIME (μsec) | LEAKAGE INDUCTANCE (μh) | CAPACITY PRI/SEC (μμf) |
|---|---|---|---|---|---|---|---|
| *2273 | 0.75 | 1:1:1 | 1000 | B.O. 0.3 to 1μs | 0.04 | 4.0 | 40 |
| *2253 | 3.0 | 1:2 | 5000 | Coupling | 0.05 | 6.0 | 50 |
| *2264 | 3.0 | 1:2:1 | 5000 | B.O. 0.5 to 5μs | 0.08 | 10 | 50 |
| *1685 | 3.0 | 1:2:2 | 5000 | B.O. 0.5 to 5μs | 0.08 | 8.0 | 50 |
| 2252 | 4.0 | 1:1 | 2500 | Coupling | 0.05 | 12 | 50 |
| *2656 | 4.0 | 1:2 | 5000 | Coupling | 0.06 | 8.0 | 60 |
| *2224 | 5.0 | 1:2:2 | 6000 | B.O. 1 to 7μs | 0.08 | 12 | 70 |
| 2269 | 7.5 | 1:2 | 7500 | Coupling | 0.10 | 20 | 60 |
| *2216 | 12 | 1:2 | 9000 | Coupling | 0.15 | 40 | 60 |
| *2215 | 12 | 1:3 | 13000 | Coupling | 0.15 | 12 | 100 |
| *2275 | 20 | 1:1:1 | 5000 | B.O. 0.5 to 5μs | 0.08 | 45 | 90 |
| 2268 | 30 | 1:1 | 7500 | Coupling | 0.10 | 90 | 40 |

# PULSE MODULATION TRANSFORMERS FOR MAGNETRONS; TRAVELING WAVE TUBES; KLYSTRONS; HF TRIODES

## ■ H-11 SERIES available in hermetically sealed or form encapsulated case styles.



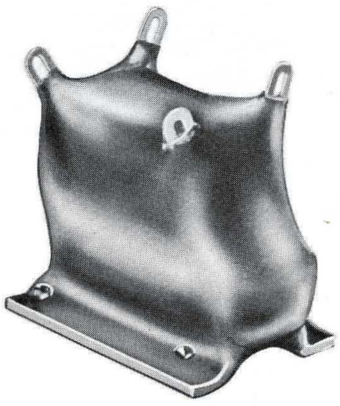
H-11

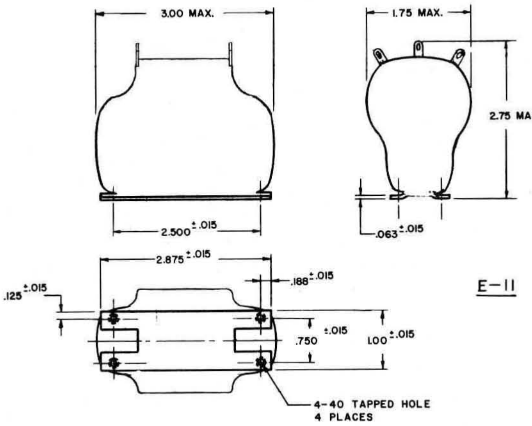


The H-11 Series is recommended for applications requiring long pulses at moderate power, or modulation applications requiring higher operating voltages and average power than is available in the H-10 Series. The blocking oscillator designs are useful in circuits like that of Figure 16 at operating voltages of 2-3 kv and pulse widths to 50 μsec.

| | |
|---|---|
| Average power rating (40°C Rise) | 40 watts |
| Peak pulse voltage | 3 kv maximum |
| Hi-pot | 5 kv rms |
| Insulation resistance | 10,000 megohms minimum |

Units normally stocked are similar to the hermetically sealed MIL-T-27A, Grade 1, Class R unit shown. They are available on special order to meet Class S and T temp. ratings in form encapsulated packages to meet requirements of MIL-T-27A, Grade 2, Class R, S or T.





E-11

| CATALOG NUMBER | PRIMARY O.C.L. (mh) | TURNS RATIO | ET** CONSTANT (volt-μsec) | TYPICAL APPLICATION | RISE TIME (μsec) | LEAKAGE INDUCTANCE (μh) | CAPACITY PRI/SEC (μμf) |
|---|---|---|---|---|---|---|---|
| *2204 | 1.0 | 1:1 | 1700 | Coupling | 0.10 | 2.0 | 240 |
| *2203 | 1.0 | 1:2 | 3500 | Coupling | 0.10 | 2.0 | 240 |
| *2871 | 1.2 | 1:2:1 | 7500 | B.O. 0.5 to 5μs | 0.05 | 3.0 | 150 |
| *2265 | 11 | 1:2:1 | 22500 | B.O. 1 to 25μs | 0.15 | 19 | 130 |
| *2871 | 1.2 | 1:2:1 | 7500 | B.O. 0.5 to 5μs | 0.05 | 3.0 | 150 |
| 2517 | 20 | 1:2 | 30000 | Coupling | 0.25 | 30 | 100 |
| *2266 | 20 | 1:2:1 | 30000 | B.O. 2 to 50μs | 0.25 | 30 | 130 |

*Items normally carried in stock.

**Based on highest turn winding. Product of pulse width (μsec) and peak voltage (volts) on highest turn winding must not exceed this value if core saturation is to be avoided. See design example on page 7.

# PULSE MODULATION TRANSFORMERS FOR MAGNETRONS; TRAVELING WAVE TUBES; KLYSTRONS; HF TRIODES

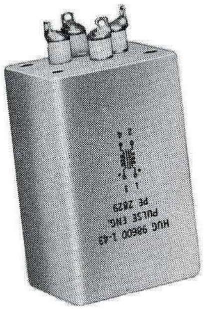
## ■ H-12 SERIES available in hermetically sealed or form encapsulated case styles.

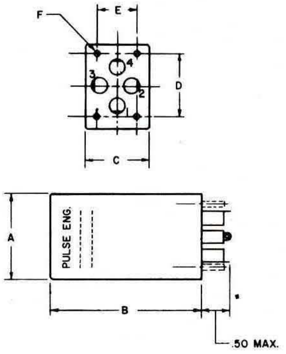
| | |
|---|---|
| Average power rating (40°C Rise) . . . | 30 watts |
| Peak pulse voltage . . . . . . . . | 2 kv maximum |
| Hi-pot . . . . . . . . . . . . . | 4 kv rms |
| Insulation resistance . . . . . . . | 10,000 megohms |

H-12 designs are modulation transformers for various types of high frequency oscillators. Most designs are for hard tube modulators with circuitry similar to that shown in Figure 16. Three of the designs listed are constructed especially to transmit pulse group codes. The fidelity of pulse group operation is dependent upon a wide variety of factors too lengthy to detail in this catalog. A partial listing is:

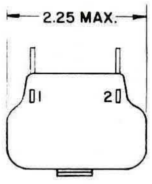
1. Operating point of modulator and oscillator.
2. Adequate drive.
3. Shunt capacity loading of oscillator.
4. Amount of additional resistance damping that can be tolerated.
5. Relation of pulse width to minimum leading edge spacing.

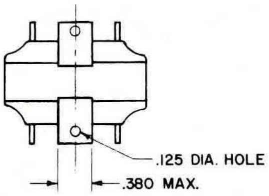
Units normally stocked are similar to the hermetically sealed MIL-T-27A, Grades 1 and 4, Class S unit shown. They are available on special order to meet Class S and T temperature ratings and in form encapsulated packages to meet requirements of MIL-T-27A, Grade 2, Class R, S or T.

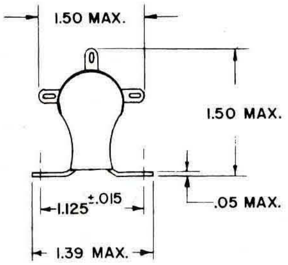




| | A(MAX) | B(MAX) | C(MAX) | D(±.015) | E(±.015) | F |
|---|---|---|---|---|---|---|
| H-12A | 1.41 | 2.28 | 1.07 | 1.000 | .625 | 6-32 x .281 $^{+.010}_{-.000}$ NC-2B INSERT |
| H-12B | 1.63 | 2.47 | 1.03 | 1.000 | .625 | 6-32 x .375 $^{+.000}_{-.010}$ NC-2B STUD |







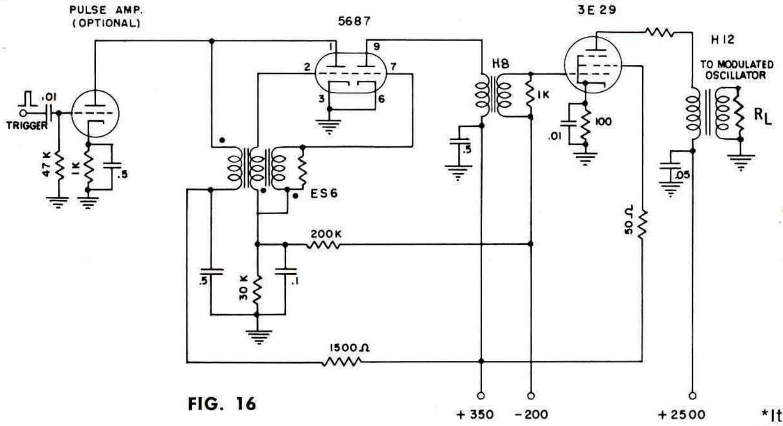


FIG. 16

*Items normally carried in stock.

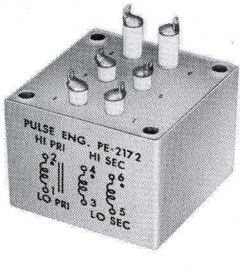
**Based on highest turn winding. Product of pulse width ($\mu$sec) and peak voltage (volts) on highest turn winding must not exceed this value if core saturation is to be avoided. See design example on page 7.

| CATALOG NUMBER | PRIMARY O.C.L. (mh) | TURNS RATIO | ET** CONSTANT (volt-$\mu$sec) | TYPICAL APPLICATION | RISE TIME ($\mu$sec) | LEAKAGE INDUCTANCE ($\mu$h) | CAPACITY PRI/SEC ($\mu\mu$f) | CASE DIMENSIONS HERMETICALLY SEALED UNIT ONLY |
|---|---|---|---|---|---|---|---|---|
| 2787 | 0.13 | 1:1.9 | 1900 | Mod. | 0.05 | 2.0 | 10 | H-12B |
| *2511 | 0.50 | 1:2.2 | 4800 | Note 1 | 0.10 | 15 | 50 | H-12A |
| 2251 | 2.5 | 1:2 | 2200 | Mod. | 0.05 | 35 | 35 | H-12B |
| *2181 | 4.0 | 1:1.4 | 1900 | Note 2 | 0.05 | 60 | 45 | H-12B |
| *2829 | 25 | 1:2.2 | 12400 | Note 3 | 0.20 | 35 | 120 | H-12A |
| 2277 | 50 | 1:1 | 22500 | Mod. | 0.15 | 300 | 22 | H-12A |

Note 1 — 0.5$\mu$s pulses spaced 1.5 $\mu$sec; 30 pulses/group max. Note 2 — 0.5$\mu$s pulses spaced 1.5 $\mu$sec; 20 pulses/group max.

Note 3 — 0.5$\mu$s pulses spaced 1.5 $\mu$sec; 6 pulses/group max.

# MAGNETRON TRANSFORMERS FOR USE WITH THYRATRON LINE MODULATORS



H-13

E-13

H-19

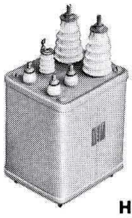
## Outline drawings available on request.

Listed below are a group of pulse modulation transformers primarily intended for magnetron tubes. A characteristic of this type transformer is the bifilar winding on the high voltage secondary, which provides filament current for the magnetron. The low impedance primary is designed to operate from a pulse forming network discharged by a thyratron or four layer diode. (See Fig. 17.)

Units operating at peak voltages below 7 kv are available either hermetically sealed or form encapsulated. Units operating above 7 kv are oil filled and have expansion bellows.

Pulse Forming Networks (PFNs) and charging chokes are available for each transformer on special order.

H-16



H-14

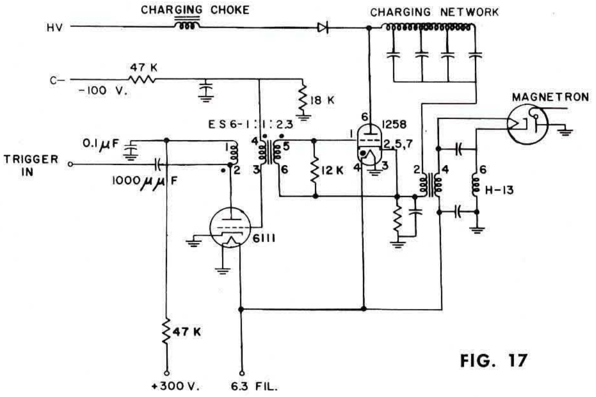


FIG. 17

### LOW POWER TYPES — 1-7 kw PEAK POWER (45 watt avg. for 40°C rise)

| CATALOG NUMBER | TURNS RATIO | IMPEDANCE | RISE TIME | PULSE WIDTH | PULSE VOLTAGE | FILAMENT CURRENT | CASE STYLE |
|---|---|---|---|---|---|---|---|
| *3077 | 1:8 | 25/1600 | .1 | .2 to 1.5μs | 2 KV | 1 A | E13 |
| *2043 | 1:5 | 50/1250 | .1 | .2 to 2μs | 5 KV | 1 A | E13 |
| *2172 | 1:8 | 50/3200 | .1 | .2 to 1μs | 5 KV | .5 A | H13 |
| *3132 | 1:4.5 | 50/1000 | .04 | .2 to 1μs | 3 KV | 1 A | E13 |
| 3178 | 1:4.5 | 50/1000 | .02 | .05 to .2μs | 2.5 KV | 5 A | E13 |

NOTE: Any of the above units can be modified to operate from a hard tube modulator plate such as 3E29, etc.

### MEDIUM POWER MAGNETRON TRANSFORMERS 150-250 kw PEAK POWER (85 watt avg. for 40°C rise)

| CATALOG NUMBER | TURNS RATIO | IMPEDANCE | RISE TIME | PULSE WIDTH | PULSE VOLTAGE | FILAMENT CURRENT | CASE STYLE |
|---|---|---|---|---|---|---|---|
| *1874 | 1:4 | 50/800 | .1 | .2 to 2μs | 16 KV | 2 A | H14 |
| *1896 | 1:4.5 | 50/1000 | .05 | .1 to .3μs | 16 KV | 2 A | H14 |
| 2205 | 1:4.5 | 50/1000 | .1 | .2 to 2μs | 16 KV | 2 A | H14 |

### HIGH POWER MAGNETRON TRANSFORMERS .5-1.5 megawatt PEAK POWER (400 watt avg. for 40°C rise)

| CATALOG NUMBER | TURNS RATIO | IMPEDANCE | RISE TIME | PULSE WIDTH | PULSE VOLTAGE | FILAMENT CURRENT | CASE STYLE |
|---|---|---|---|---|---|---|---|
| *2258 | 1:4.5 | 50/1000 | .1 | .3 to 5μs | 27 KV | 2.5 A** | H16 |
| *2653 | 1:7 | 25/1200 | .2 | .5 to 2.5μs | 30 KV | 16 A | H19 |
| *2823 | 1:4.7 | 50/1100 | .15 | .5 to 2.5μs | 28 KV | 14 A | Open Frame |
| 2866 | 1:6.4 | 50/2000 | .18 | .25 to 2.5μs | 64 KV | 2.5 A**<br>for T.W.T.'s | Open Frame |

*Items normally carried in stock.

**Filament transformer can be added if higher filament current is desired.

## SALES ENGINEERING REPRESENTATIVES

Pulse Engineering representatives are located throughout the United States and Canada to provide immediate technical information and quotations.

In some cases, representative offices carry a stock of Pulse Engineering transformers to give you immediate delivery at factory prices on quantities below 100 units. These offices are marked (★).

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Phone: ENdicott 5-0296

**BOSTON (Ashland), Massachusetts**
John J. Goode Associates
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Phone: TRinity 2-4485

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## ERRATA SHEET
## Catalog #202

October 2, 1959

### Page 8, Paragraph 2

Delete "Values for leakage........held on request." Substitute as below.

Catalog values of leakage inductance and winding to winding capacity are nominal as presented. If the user wishes an inspection or control on these values he should state the values required by his application. The Pulse Engineering recommendation is to rate the test values of leakage inductance and winding to winding capacity at the maximum that can be accepted rather than plus or minus a percentage of the center value.

### Page 8, Under "TEST"

Insulation Resistance is a minimum tolerance, (Not maximum as shown).

### Page 8, OCL (Open Circuit Inductance) TEST

Delete "Below 300 microhenries.... ....distributed capacitance effects." Substitute as below.

There is one exception to the above procedure: below 300 microhenries, the OCL of ferrite core units is measured on a TEKTRONIX L-C Meter, model 130.

### Page 8, 1 KC TEST VOLTAGES TO BE USED IN MEASURING OCL ON ESI BRIDGE

Delete table. Substitute as below.

| | |
|---|---|
| 0.1 + mh to 0.3 mh | 0.02 volt |
| 0.3 + mh to 1 mh | 0.04 volt |
| 1 + mh to 3 mh | 0.08 volt |
| 3 + mh to 10 mh | 0.2 volt |
| 10 + mh to 30 mh | 0.5 volt |
| 30 + mh to 100 mh | 1.0 volt |
| 100 + mh to 300 mh | 2.0 volt |
| 300 + mh up | 5.0 volt |

-- OVER --

## Page 12

| CATALOG NUMBER | PRIMARY O.C.L. (mh) | TURNS RATIO | ET** CONSTANT (volt-μsec) | TYPICAL APPLICATION | RISE TIME (μsec) |
|---|---|---|---|---|---|
| 2228 | 1.3 | 1:1 | 76 | TO 1.0μs | .02 |
| 2229 | 1.3 | 1:1:1 | 76 | TO 1.0μs | .02 |
| 2233 | 2.3 | 1:2:1 | 190 | TO 2.0μs | .02 |

## Page 13

| CATALOG NUMBER | PRIMARY O.C.L. (mh) | TURNS RATIO | ET** CONSTANT (volt-μsec) | TYPICAL APPLICATION | RISE TIME (μsec) |
|---|---|---|---|---|---|
| *2695 | 0.40 | 4:2CT:4 | 70 | 0.2-4.0 | .02 |
| 2248 | 2.5 | 4:1:2 | 100 | 1.0 TO 12.0μs | .03 |
| 2228 | 1.3 | 1:1 | 76 | COUPLING | .02 |

*AVAILABLE CASE STYLE "V" ONLY.

## Page 14

| CATALOG NUMBER | PRIMARY O.C.L. (mh) | TURNS RATIO | ET** CONSTANT (volt-μsec) | TYPICAL APPLICATION | RISE TIME (μsec) |
|---|---|---|---|---|---|
| 2992 | 1.0 | 1:2 | 120 | COUPLING | 0.007 |

## Page 15

| CATALOG NUMBER | PRIMARY O.C.L. (mh) | TURNS RATIO | ET** CONSTANT (volt-μsec) | TYPICAL APPLICATION | RISE TIME (μsec) |
|---|---|---|---|---|---|
| 2237 | 0.5 | 1:2 | 130 | B.O. TO 1μs COUPLING | 0.025 |
| 2236 | 1.5 | 1:1:1 | 220 | B.O. TO 1μs COUPLING | 0.025 |
| 2241 | 5.0 | 1:2 | 530 | B.O. TO 5μs | 0.18 |
| 1381 | 15.0 | 1:1 | 530 | B.O. TO 5μs | 0.1 |
| 2225 | 15.0 | 1:1:1 | 530 | B.O. TO 5μs | 0.1 |
| 2479 | 45.0 | 1:1:1 | 950 | B.O. TO 10μs | 0.4 |
| 2242 | 45.0 | 1:1 | 950 | B.O. TO 10μs | 0.4 |

## Page 16

| CATALOG NUMBER | PRIMARY O.C.L. (mh) | TURNS RATIO | ET** CONSTANT (volt-μsec) | TYPICAL APPLICATION | RISE TIME (μsec) |
|---|---|---|---|---|---|
| 2682 | 0.10 | 4:1:2 | 25 | TRANSISTOR B.O. | 0.004 |
| 2704 | 0.10 | 3:1:1 | 25 | TRANSISTOR B.O. | 0.004 |
| 2651 | 0.10 | 2:1:1 | 25 | VA. TUBE B.O. | 0.005 |
| 2779 | 0.20 | 3:1:1 | 40 | TRANSISTOR B.O. | 0.005 |
| 2701 | 0.10 | 4:1 | 25 | TRANSISTOR B.O. | 0.004 |

## Page 20

| CATALOG NUMBER | PRIMARY O.C.L. (mh) | TURNS RATIO | ET** CONSTANT (volt-μsec) | TYPICAL APPLICATION | RISE TIME (μsec) | CASE DIMENSIONS |
|---|---|---|---|---|---|---|
| 2829 | 5.0 | 1:2:2 | 12400 | NOTE 3 | 0.20 | H-12 A |
| 2277 | 5 0 | 1:1 | 22500 | MOD | 0.15 | H-12 B |