

# MB1501/MB1501H/MB1501L

## SERIAL INPUT PLL FREQUENCY SYNTHESIZER

### SERIAL INPUT PLL FREQUENCY SYNTHESIZER WITH 1.1GHz PRESCALER

The Fujitsu MB1501/MB1501H/MB1501L, utilizing BI-CMOS technology, is a single chip serial input PLL frequency synthesizer with pulse-swallow function.

The MB1501 series contain a 1.1GHz two modulus prescaler that can select either 64/65 or 128/129 divide ratio; control signal generator; 16-bit shift register; 15-bit latch; programmable reference divider (binary 14-bit programmable reference counter); 1-bit switch counter; phase comparator with phase inverse function; charge pump; crystal oscillator; 19-bit shift register; 18-bit latch; programmable divider (binary 7-bit swallow counter and binary 11-bit programmable counter).

The MB1501 operates on a low supply voltage (3V typ) and consumes low power (45mW at 1.1GHz).

#### MB1501 Product Line

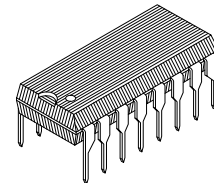
	V <sub>P</sub> Voltage	V <sub>OP</sub> Voltage	Lock up time	D <sub>O</sub> Output Width	High-level Output Current	Low-level Output Current
MB1501	8V max	8.5V max	Middle speed	Middle	Middle	Middle
MB1501H	10V max	10.0V max	High speed	Low	High	Low
MB1501L	8V max	8.5V max	Low speed	High	Low	High

- High operating frequency:  $f_{IN\ MAX}=1.1GHz$  ( $V_{IN\ MIN}=0.20V_{P-P}$ )
- On-chip prescaler
- Low power supply voltage: 2.7V to 5.5V (3.0V typ)
- Low power supply consumption: 45mW (3.0V, 1.1GHz operation)
- Serial input 18-bit programmable divider consisting of:
  - Binary 7-bit swallow counter (Divide ratio: 0 to 127)
  - Binary 11-bit programmable counter (Divide ratio: 16 to 2047)
- Serial input 15-bit programmable reference divider consisting of:
  - Binary 14-bit programmable reference counter (Divide ratio: 8 to 16383)
  - 1-bit switch counter (SW) Sets divide ratio of prescaler
- 2types of phase detector output
  - On-chip charge pump (Bipolar type)
  - Output for external charge pump
- Wide operating temperature:  $T_A=-40^{\circ}C$  to  $+85^{\circ}C$

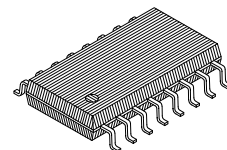
#### ABSOLUTE MAXIMUM RATINGS (see NOTE)

Rating	Symbol	Condition	Value	Unit
Power Supply Voltage	V <sub>CC</sub>		-0.5 to +7.0	V
	V <sub>PH</sub>	MB1501H	V <sub>CC</sub> to 12.0	V
	V <sub>P</sub> , V <sub>PL</sub>	MB1501/1501L	V <sub>CC</sub> to 10.0	V
Output Voltage	V <sub>OUT</sub>		-0.5 to V <sub>CC</sub> +0.5	V
Open-drain Output	V <sub>OOPH</sub>	MB1501H	-0.5 to 11.0	V
	V <sub>OOP</sub> , V <sub>OOPH</sub>	MB1501/1501L	-0.5 to 9.0	V
Output Current	I <sub>OUT</sub>		±10	mA
Storage Temperature	T <sub>STG</sub>		-55 to +125	°C

**NOTE:** Permanent device damage may occur if the above **Absolute Maximum Ratings** are exceeded. Functional operation should be restricted to the conditions as detailed in the operational sections of this data sheet. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

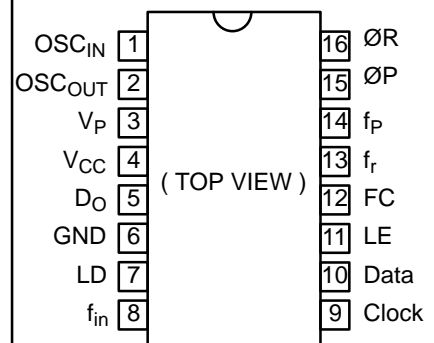


PLASTIC PACKAGE  
DIP-16P-M04



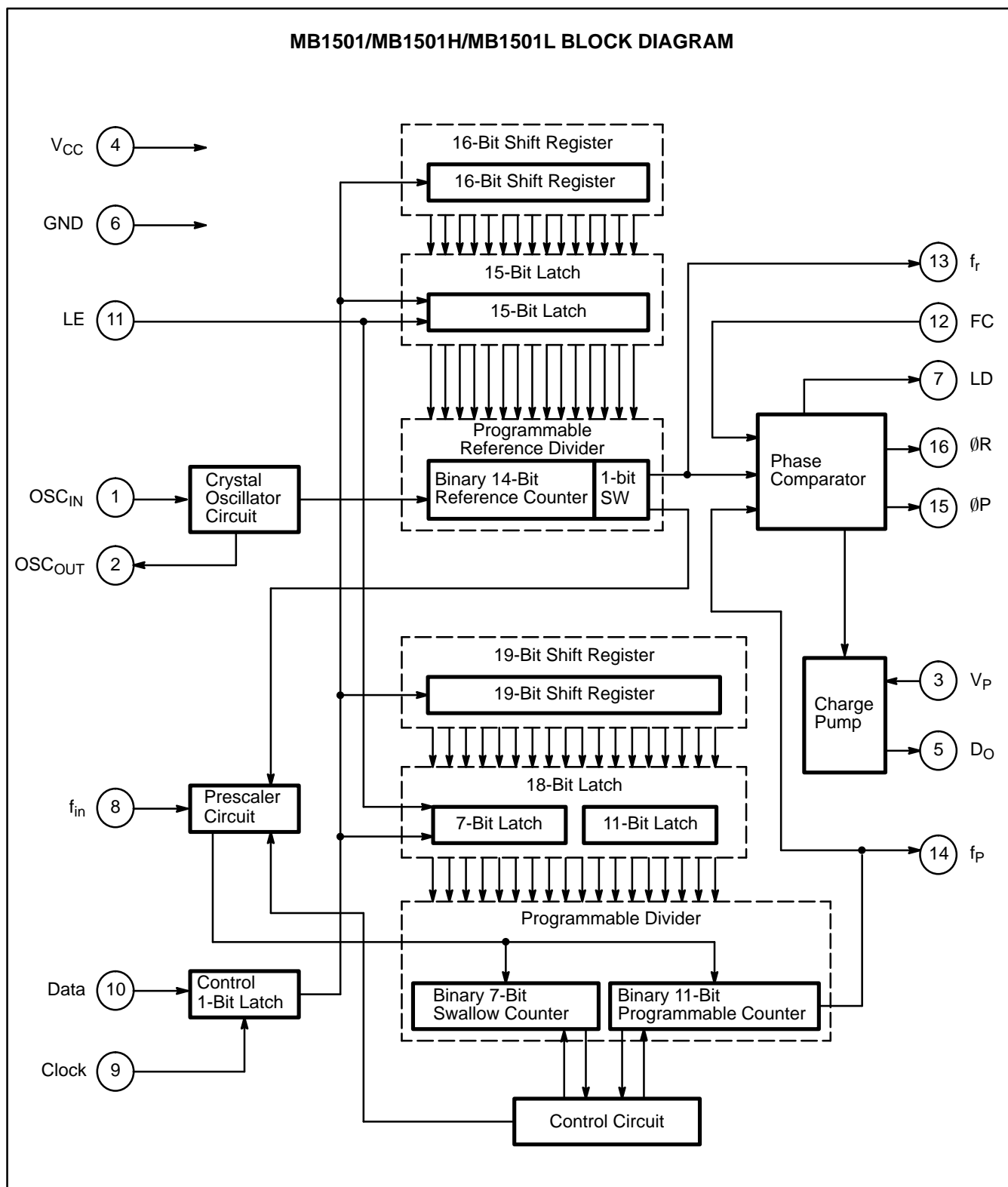
PLASTIC PACKAGE  
FPT-16P-M06

#### PIN ASSIGNMENT



This device contains circuitry to protect the inputs against damage due to high static voltages or electric fields. However, it is advised that normal precautions be taken to avoid application of any voltage higher than maximum rated voltages to this high impedance circuit.

**MB1501**  
**MB1501H**  
**MB1501L**



## PIN DESCRIPTIONS

Pin No.	Pin Name	I/O	Descriptions
1 2	OSC <sub>IN</sub> OSC <sub>OUT</sub>	I O	Oscillator input. Oscillator output. A crystal is placed between OSC <sub>IN</sub> and OSC <sub>OUT</sub> .
3	V <sub>P</sub>	—	Power supply input for charge pump.
4	V <sub>CC</sub>	—	Power supply voltage input.
5	D <sub>O</sub>	O	Charge pump output. Phase characteristic can be inversed depending upon FC input.
6	GND	—	Ground.
7	LD	O	Phase comparator output. This pin outputs high when the phase is locked. While the phase difference of f <sub>r</sub> and f <sub>p</sub> exists, the output level goes low.
8	f <sub>in</sub>	I	Prescaler input. The connection with an external VCO should be an AC connection.
9	Clock	I	Clock input for 19-bit shift register and 16-bit shift register. Each rising edge of the clock shifts one bit of data into the shift registers.
10	Data	I	Serial data of binary code input. The last bit of the data is a control bit. The last data bit specifies which latch is activated. When the last bit is high level and LE is high-level, data is transferred to 15-bit latch. When the last bit is low level and LE is high level, data is transferred to 18-bit latch.
11	LE	I	Load enable input (with internal pull up resistor). When LE is high level (or open), data stored in the shift register is transferred to latch depending on the control data.
12	FC	O	Phase selecting input of phase comparator (with internal pull up resistor). When FC is low level, charge pump and phase detector characteristics can be inversed.
13	f <sub>r</sub>	O	Monitor pin of phase comparator input. It is the same as programmable reference divider output.
14	f <sub>p</sub>	O	Monitor pin of phase comparator input. It is the same as programmable divider output.
15 16	ØP ØR	O O	Outputs for external charge pump. Phase characteristics can be inversed depending on FC input. ØP pin is an N-channel open-drain output.

# FUNCTIONAL DESCRIPTIONS

## SERIAL DATA INPUT

Serial data input is input using Data pin, Clock pin and LE pin, The 15-bit programmable reference divider and 18-bit programmable divider are controlled respectively.

On rising edge of the clock shifts one bit of the data into the internal shift registers.

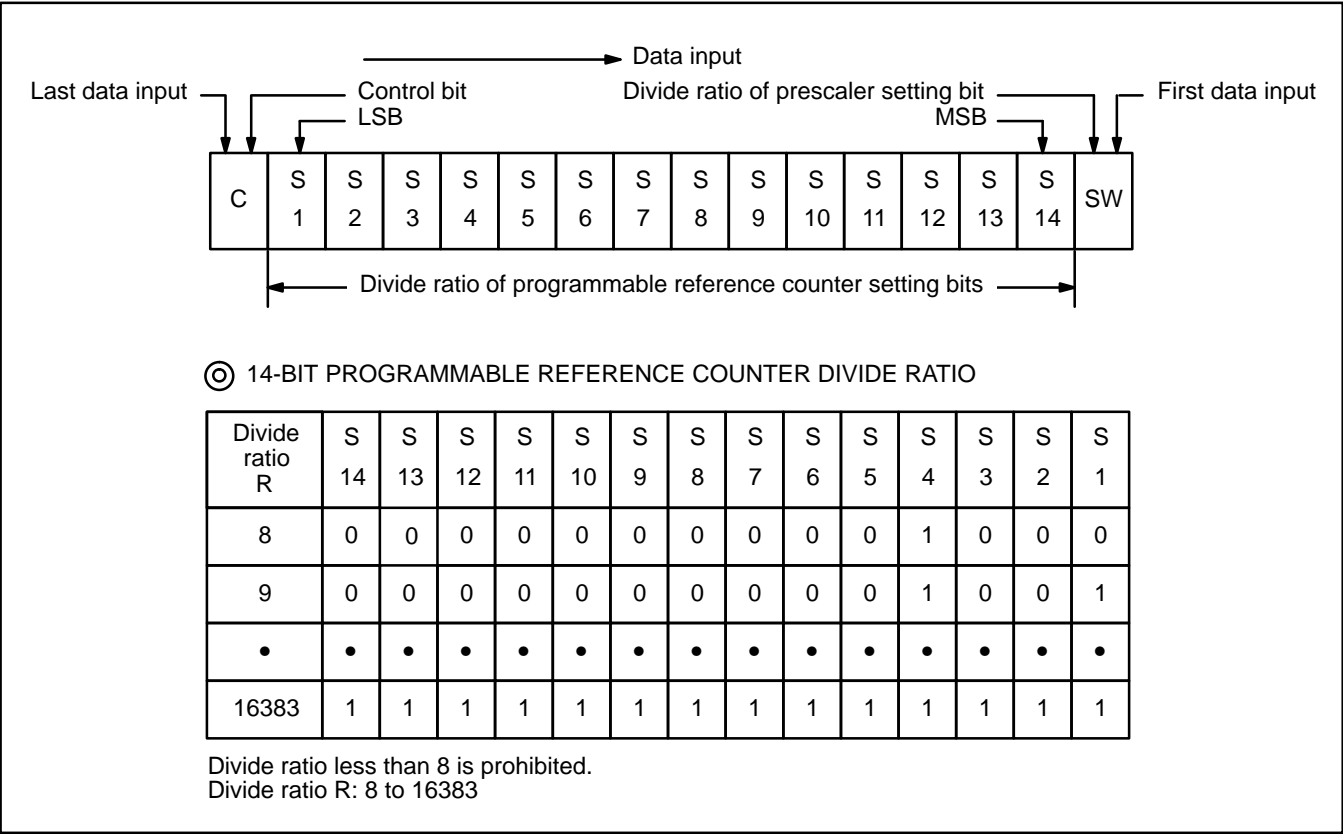
When load enable (LE) is high level (or open), data stored in shift registers is transferred to 15-bit latch or 18-bit latch depending upon the control bit level.

Control data "H" ; Data is transferred into 15-bit latch.

Control data "L" ; Data is transferred into 18-bit latch.

## PROGRAMMABLE REFERENCE DIVIDER

Programmable reference divider consists of 16-bit shift register, 15-bit latch and 14-bit reference counter. Serial 16-bit data format is shown below.



SW: Divide ratio of prescaler setting bit.

SW="H" : 64

SW="L" : 128

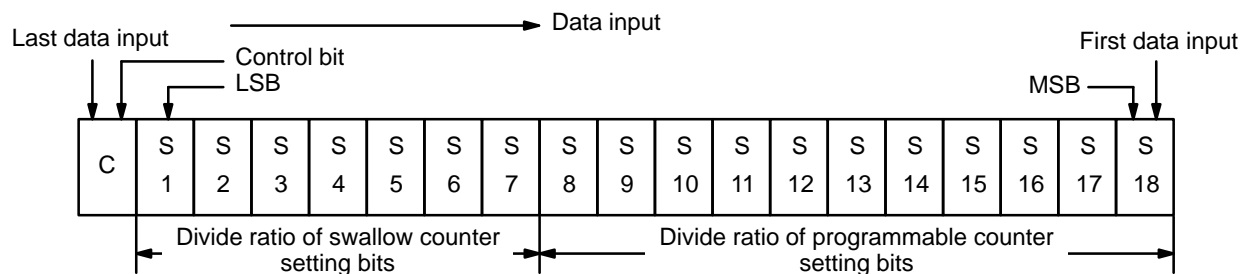
S1 to S14: Divide ratio of programmable reference counter setting bits (8 to 16383)

C: Control bit (Control bit is set to high.)

# FUNCTIONAL DESCRIPTIONS

## PROGRAMMABLE DIVIDER

Programmable divider consists of 19-bit shift register, 18-bit latch, 7-bit swallow counter and 11-bit programmable counter. Serial 19-bit data format is shown below.



Ⓒ 7-BIT SWALLOW COUNTER DIVIDE RATIO

Divide ratio A	S 7	S 6	S 5	S 4	S 3	S 2	S 1
0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	1
•	•	•	•	•	•	•	•
127	1	1	1	1	1	1	1

Divide ratio A : 0 to 127

Ⓒ 11-BIT PROGRAMMABLE COUNTER DIVIDE RATIO

Divide ratio N	S 18	S 17	S 16	S 15	S 14	S 13	S 12	S 11	S 10	S 9	S 8
16	0	0	0	0	0	0	1	0	0	0	0
17	0	0	0	0	0	0	1	0	0	0	1
•	•	•	•	•	•	•	•	•	•	•	•
2047	1	1	1	1	1	1	1	1	1	1	1

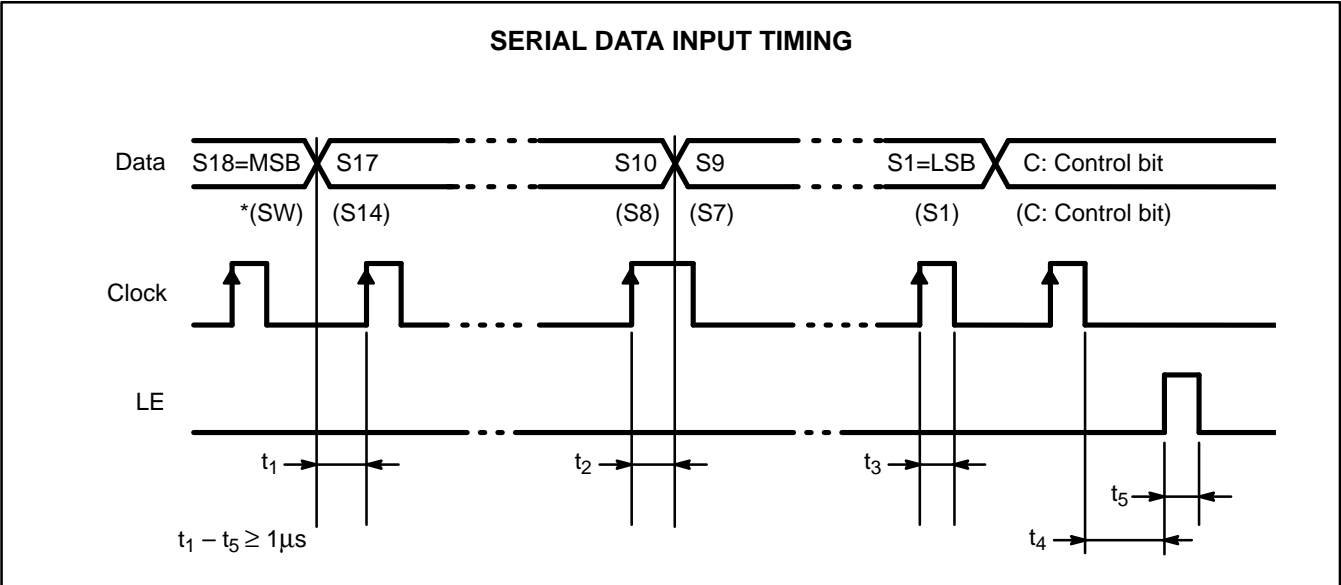
Divide ratio less than 16 is prohibited.  
Divide ratio N : 16 to 2047

S<sub>8</sub> to S<sub>18</sub> : Divide ratio of programmable counter setting bits (16 to 2047)

S<sub>1</sub> to S<sub>7</sub> : Divide ratio of swallow counter setting bits (0 to 127)

C: Control bit (Control bit is set to low.)

Data is input from MSB data.



On the rising edge of the clock shifts one bit of the data into the shift registers.  
Parenthesis data is used for setting the divide ratio of the programmable reference divider.

**PHASE CHARACTERISTICS**

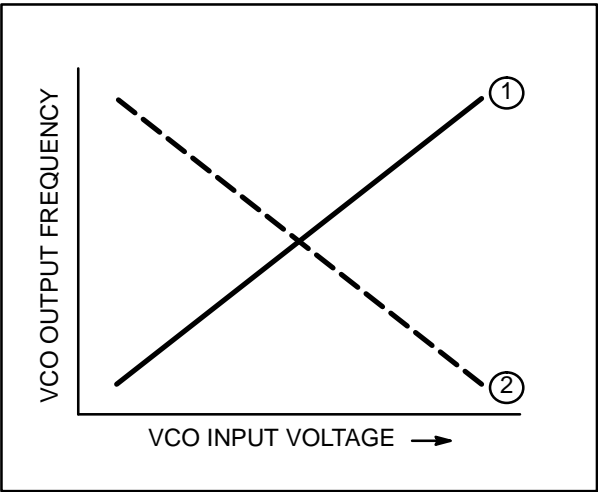
FC pin (pin 12) is provided to inverse the phase comparator characteristics. The characteristics of internal charge pump output (D<sub>O</sub>), phase detector outputs (ØR, ØP) can be inversed depending upon FC input data. Outputs are shown below.

	FC=H (or open)			FC=L		
	D <sub>O</sub>	ØR	ØP	D <sub>O</sub>	ØR	ØP
$f_r > f_p$	H	L	L	L	H	Z
$f_r < f_p$	L	H	Z	H	L	L
$f_r = f_p$	Z	L	Z	Z	L	Z

**Note:** Z=(High impedance)

Depending upon VCO characteristics, FC pin should be set accordingly:  
When VCO characteristics are like ①, FC should be set high or open circuit;  
When VCO characteristics are like ②, FC should be set Low.

**VCO CHARACTERISTICS**



## RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol		Value			Unit
			Min	Typ	Max	
Power Supply Voltage	$V_{CC}$		2.7	3.0	5.5	V
	$V_{PH}$	MB1501H	$V_{CC}$		10.0	V
	$V_P, V_{PL}$	MB1501 MB1501L	$V_{CC}$		8.5	
Open-drain Output	$V_{OOPH}$	MB1501H	$V_{CC}$		10.0	V
	$V_{OOP}, V_{OOPL}$	MB1501 MB1501L	$V_{CC}$		8.5	
Input Voltage	$V_{IN}$		GND		$V_{CC}$	V
Operating temperature	$T_A$		-40		+85	°C

## ELECTRICAL CHARACTERISTICS

( $V_{CC}=2.7$  to  $5.5V$ ,  $T_A=-40$  to  $+85^{\circ}C$ )

Parameter	Pin Name	Symbol	Condition		Value			Unit
					Min	Typ	Max	
Power Supply Current	V <sub>CC</sub>	I <sub>CC</sub>	*1		—	15	—	mA
Operating Frequency	f <sub>in</sub>	f <sub>IN</sub>	*2		10	—	1100	MHz
	OSC <sub>IN</sub>	f <sub>OSC</sub>			—	12	20	MHz
Input Sensitivity	f <sub>in</sub>	V <sub>fin1</sub>	V <sub>CC</sub> =2.7 to 4.0V		−10	—	6	dBm
		V <sub>fin2</sub>	V <sub>CC</sub> =4.0 to 5.5V		−4	—	6	dBm
	OSC <sub>IN</sub>	V <sub>IN</sub>			0.5	—	—	V <sub>P-P</sub>
High-level Input Voltage	Except f <sub>in</sub> and OSC <sub>IN</sub>	V <sub>IH</sub>			0.7xV <sub>CC</sub>	—	—	V
Low-level Input Voltage		V <sub>IL</sub>			—	—	0.3xV <sub>CC</sub>	V
High-level Input Current	Data, Clock	I <sub>IH</sub>			—	1.0	—	μA
Low-level Input Current		I <sub>IL</sub>			—	−1.0	—	μA
Input Current	OSC <sub>IN</sub>	I <sub>IN</sub>			—	±50	—	μA
	LE, FC	I <sub>LE</sub>			—	−60	—	μA
High-level Output Voltage	Except D <sub>O</sub> and OSC <sub>OUT</sub>	V <sub>OH</sub>	V <sub>CC</sub> =3.0V		2.4	—	—	V
Low-level Output Voltage		V <sub>OL</sub>			—	—	0.4	V
N-channel Open-drain Cutoff Current	ØP	I <sub>OFF</sub>	V <sub>CC</sub> ≤ V <sub>P</sub> ≤ 8V		—	—	1.1	μA
High-level Output Current	Except D <sub>O</sub> and OSC <sub>OUT</sub>	I <sub>OH</sub>			−1.0	—	—	mA
Low-level Output Current		I <sub>OL</sub>			1.0	—	—	mA
High-level Output Current	D <sub>O</sub>	I <sub>DOHH</sub>	MB1501H	V <sub>CC</sub> =3V V <sub>P</sub> =12V, T <sub>A</sub> =25°C	−2.2	−4.5	—	mA
		I <sub>DOH</sub>	MB1501	V <sub>CC</sub> =3V V <sub>P</sub> =6V, T <sub>A</sub> =25°C	−0.5	−2.0	—	mA
		I <sub>DOHL</sub>	MB1501L		−0.5	−1.1	−2.2	mA
Low-level Output Current		I <sub>DOLH</sub>	MB1501H	V <sub>CC</sub> =3V V <sub>P</sub> =12V, T <sub>A</sub> =25°C	2.2	6.0	—	mA
		I <sub>DOL</sub>	MB1501	V <sub>CC</sub> =3V V <sub>P</sub> =6V, T <sub>A</sub> =25°C	1.5	6.0	—	mA
		I <sub>DOLL</sub>	MB1501L		4.5	12.0	—	mA
Leakage Current	D <sub>O</sub> , ØP	D <sub>OZ</sub>	MB1501H	V <sub>CC</sub> =3V, V <sub>P</sub> =12V T <sub>A</sub> =25°C	—		1.0	μA
			MB1501 MB1501L	V <sub>CC</sub> =3V, V <sub>P</sub> =9V T <sub>A</sub> =25°C				

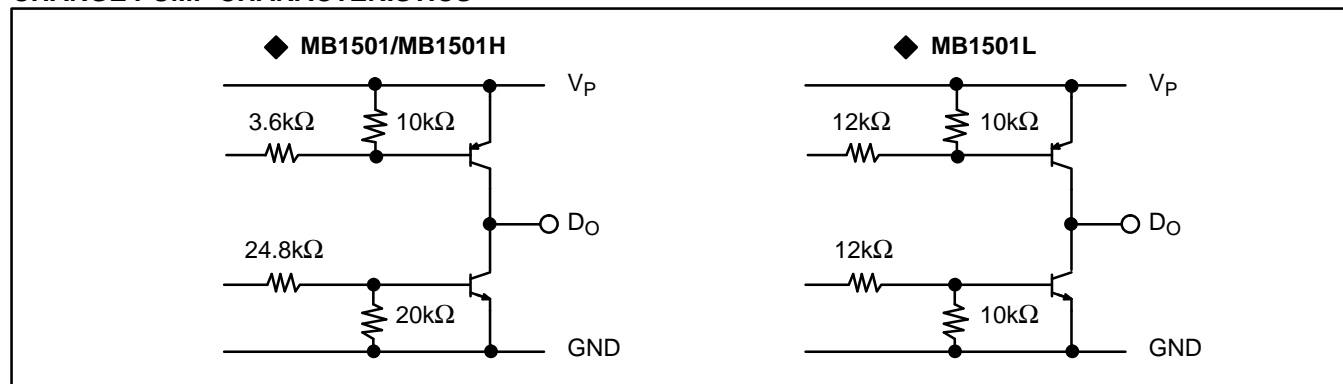
**Note:** \*1  $V_{CC}=3.0V$ ,  $f_{IN}=1.1GHz$ ,  $f_{OSC}=12MHz$  crystal.  
Inputs are grounded except  $f_{IN}$ , and outputs are open.

\*2 Input coupling capacitor 1000pF is connected.

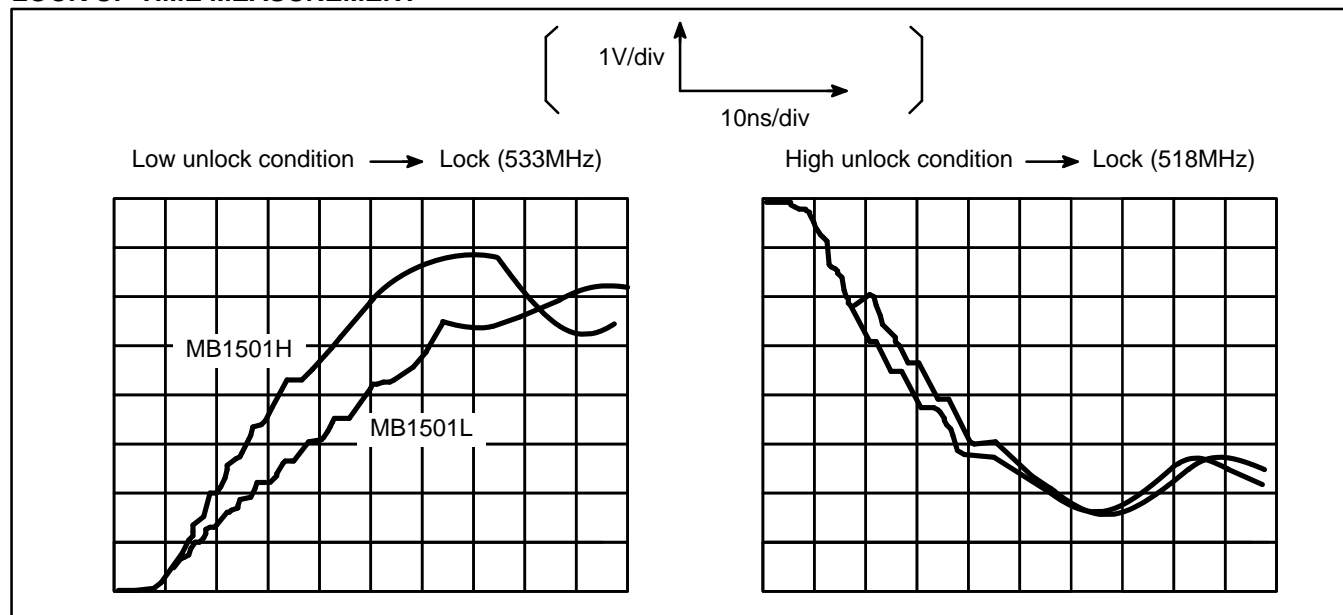


# TYPICAL CHARACTERISTICS CURVES

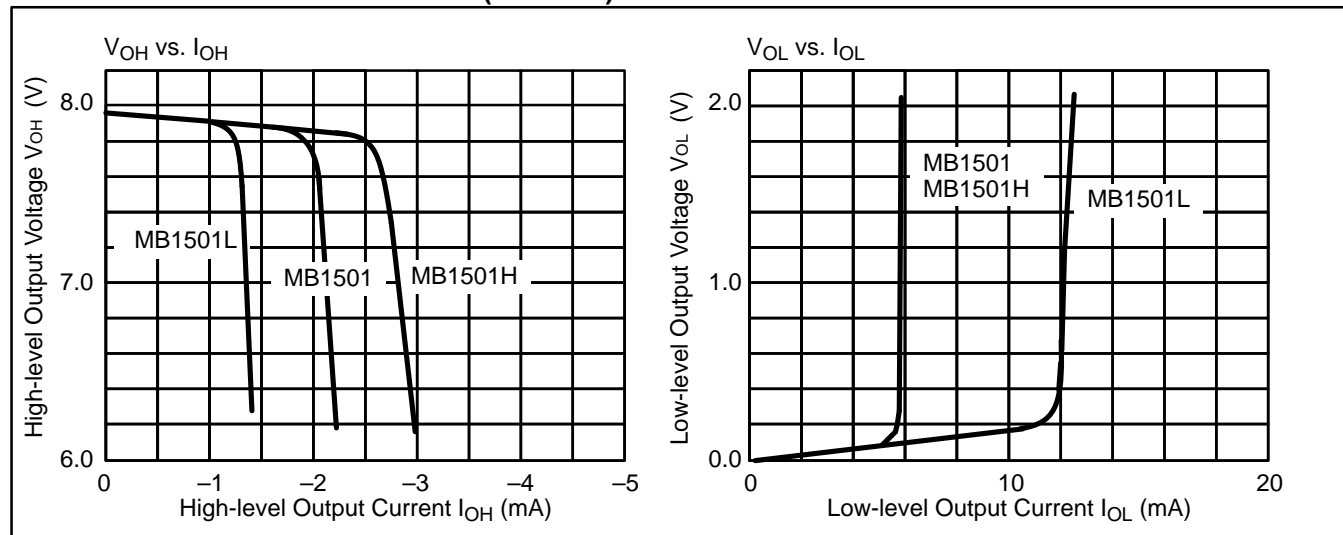
## CHARGE PUMP CHARACTERISTICS



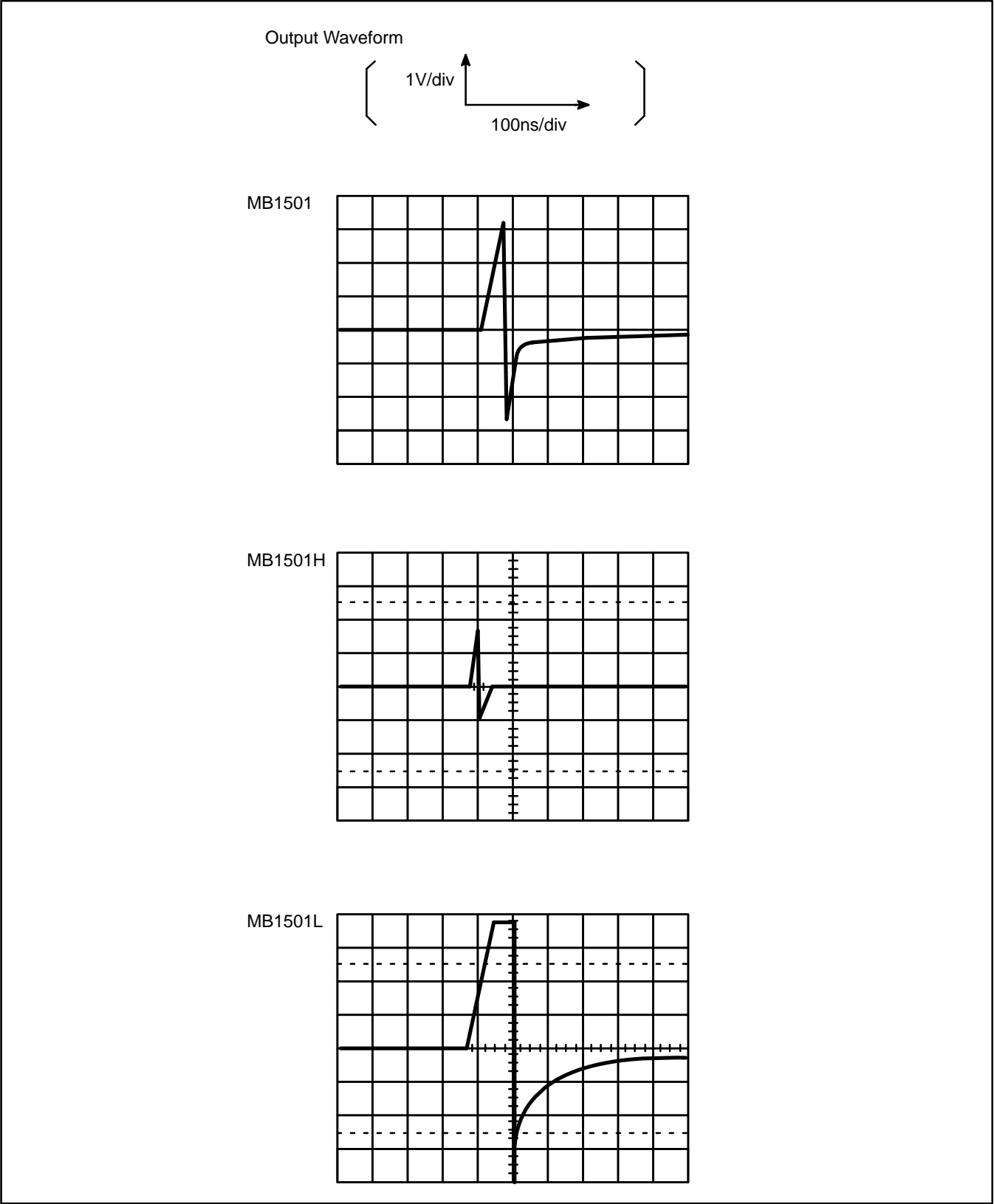
## LOCK UP TIME MEASUREMENT



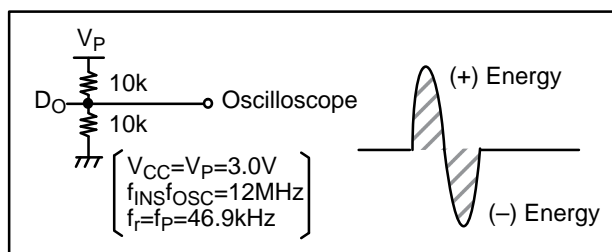
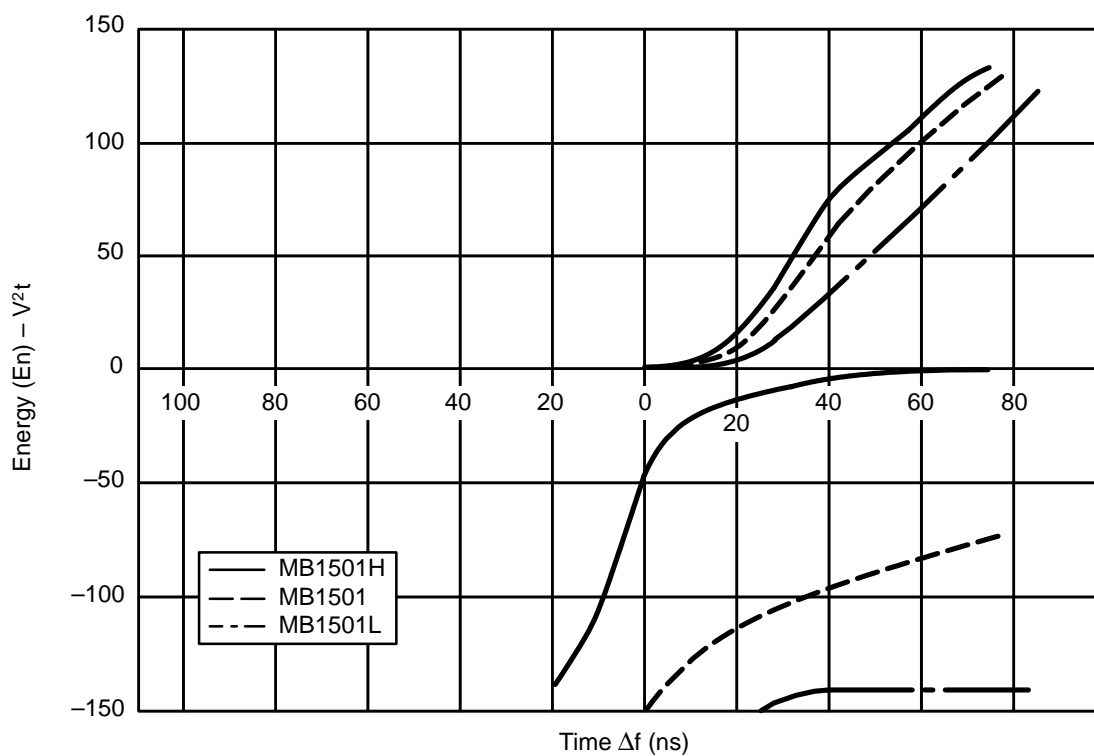
## DO PIN OUTPUT CURRENT CURVES (TYPICAL)



D<sub>O</sub> PIN OUTPUT WAVEFORM AT LOCK CONDITION

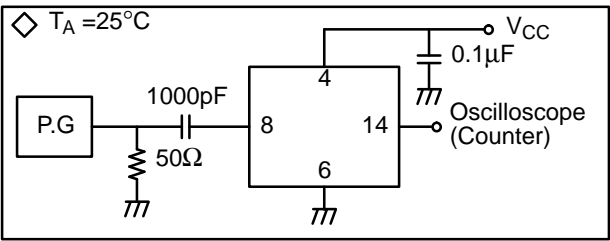
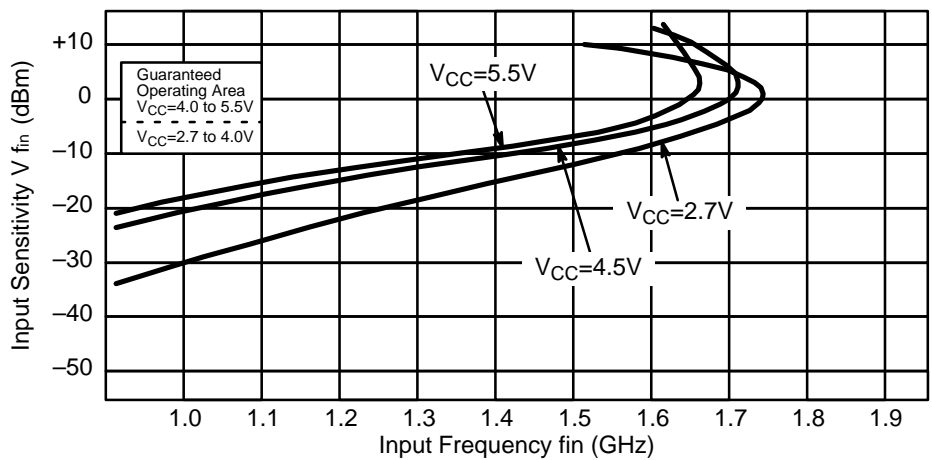


PHASE CHARACTERISTICS ( $\Delta f$  vs.  $D_O$  OUTPUT ENERGY)

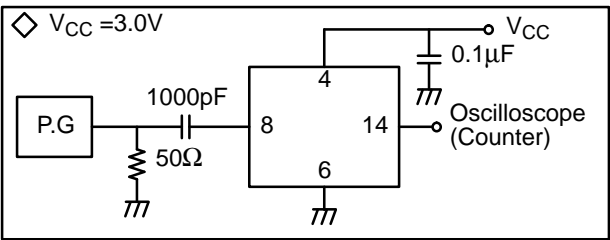
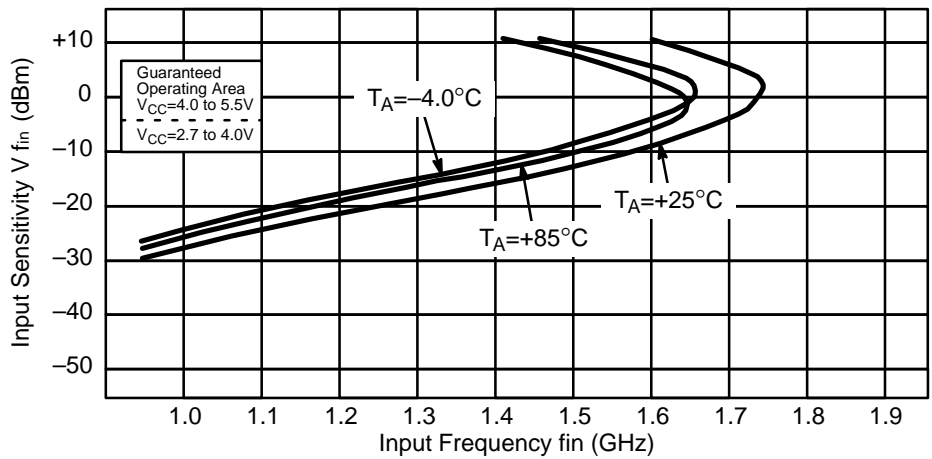


INPUT SENSITIVITY

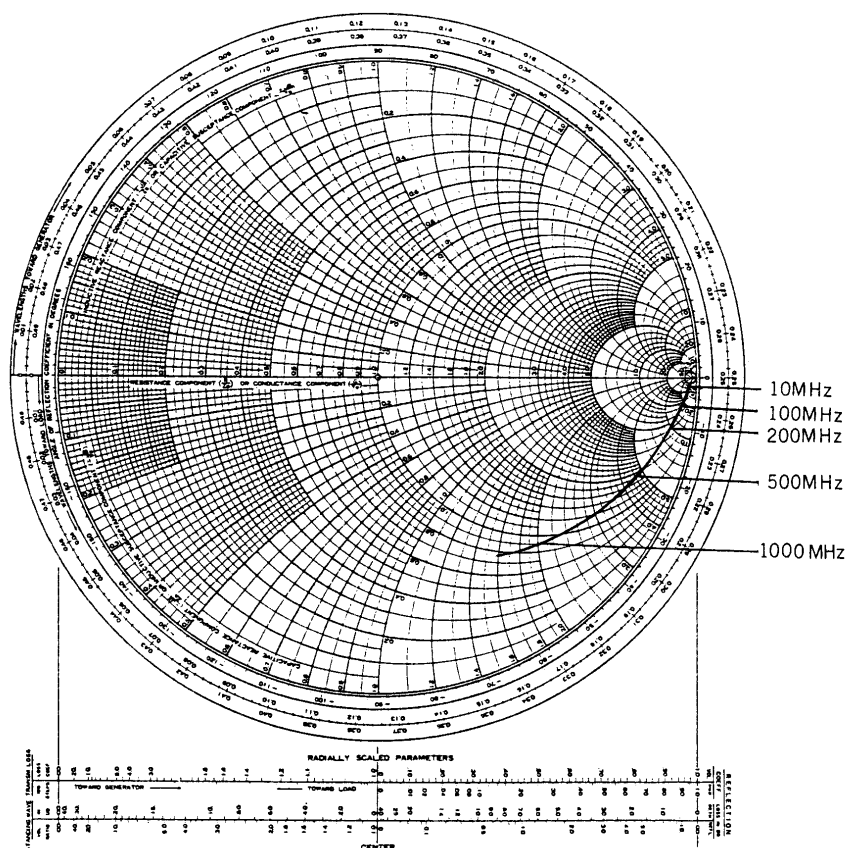
Input Sensitivity vs. Input Frequency (Supply Voltage Dependence)



Input Sensitivity vs. Input Frequency (Temperature Dependence)

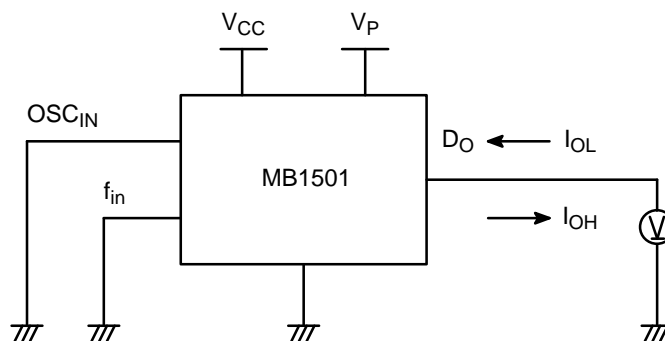


## INPUT IMPEDANCE

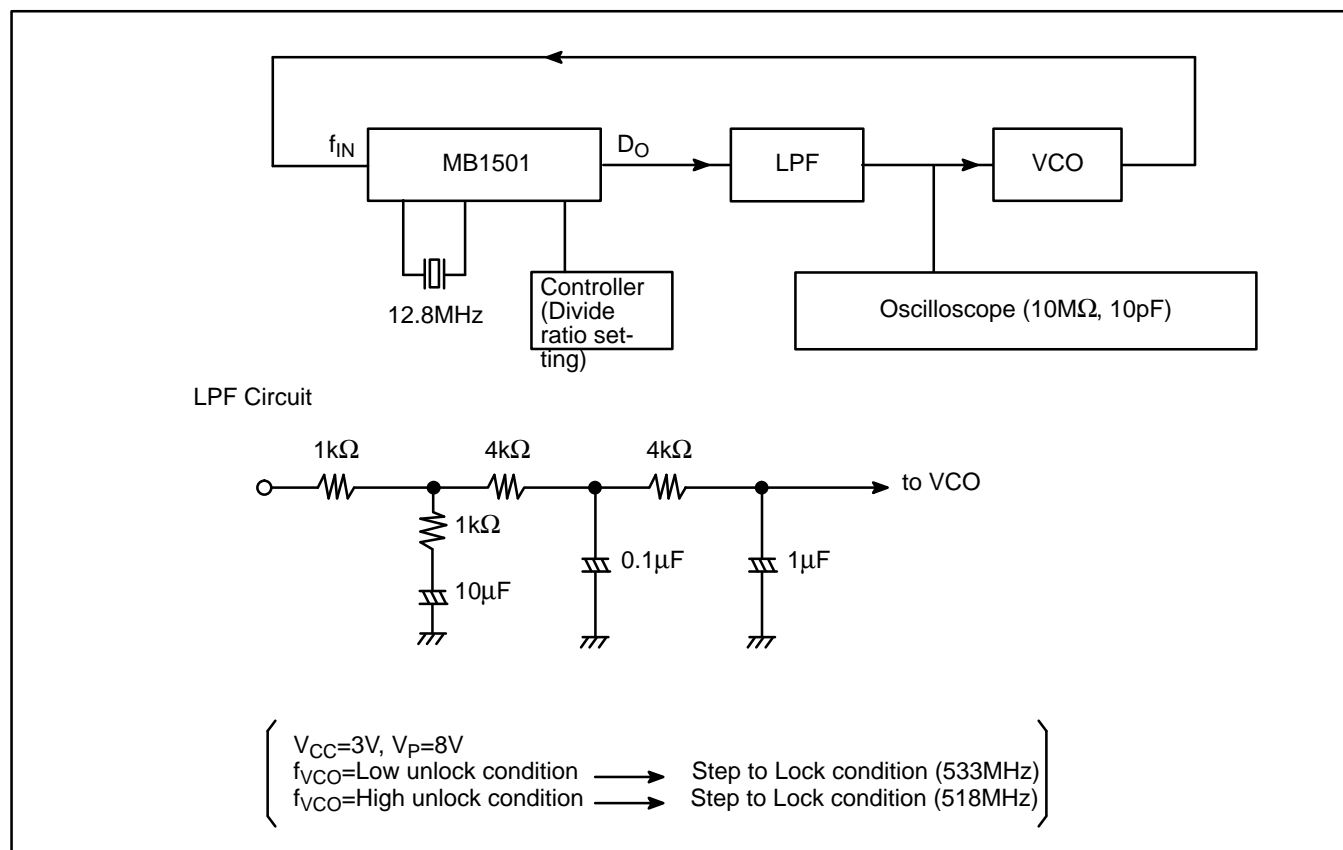


## TEST CIRCUIT

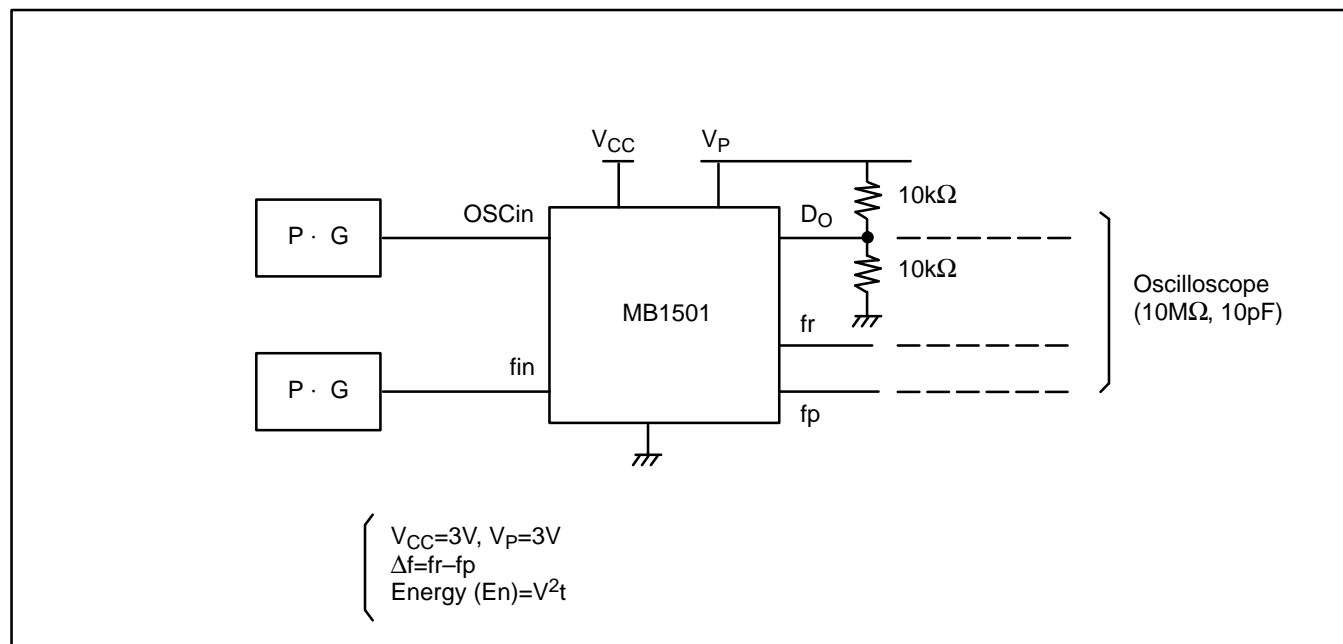
### D<sub>O</sub> Pin Output Current ( $I_{OH}$ , $I_{OL}$ ) Measurement



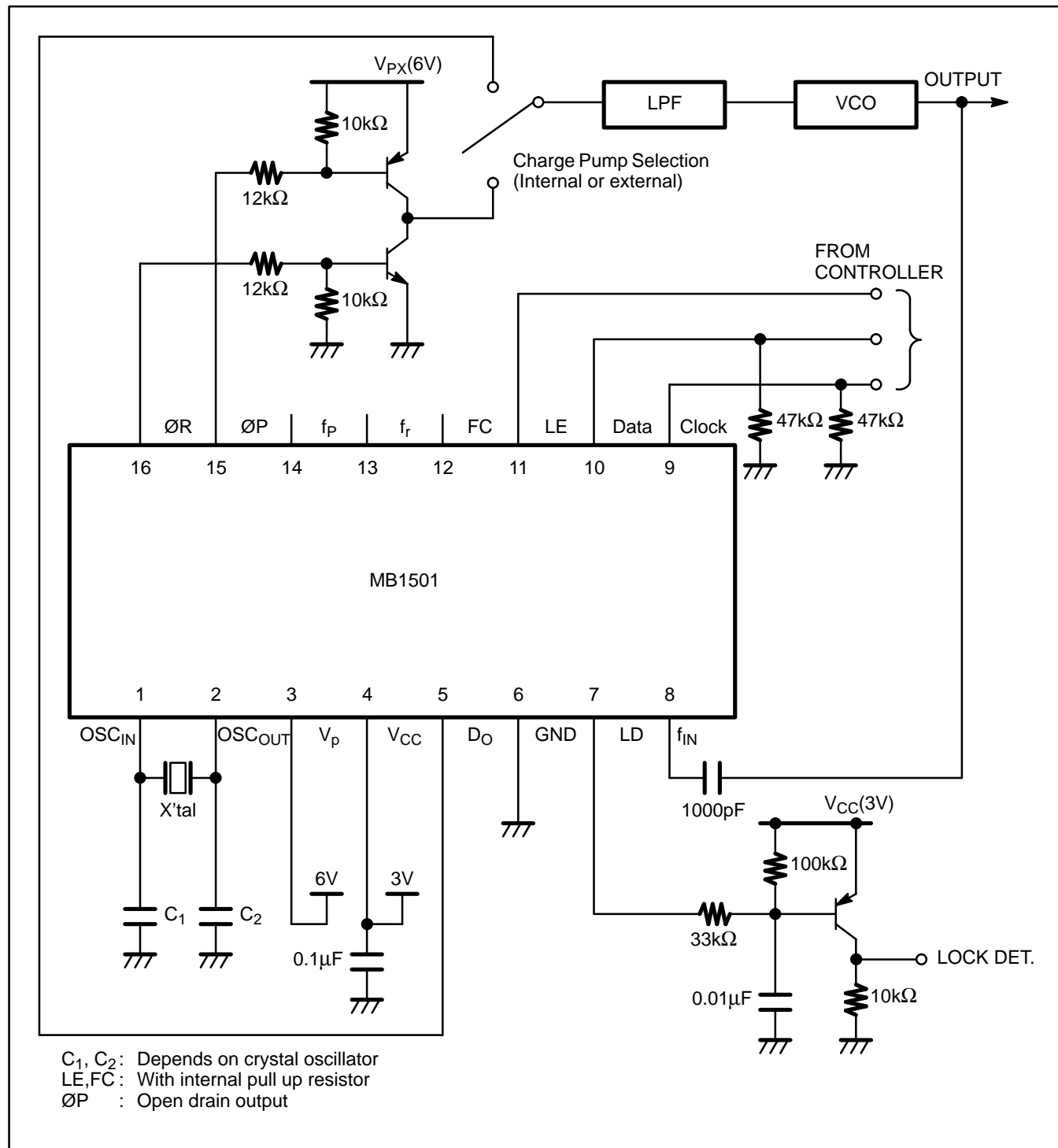
## Lock up Time Measurement



## Phase Characteristics Measurement



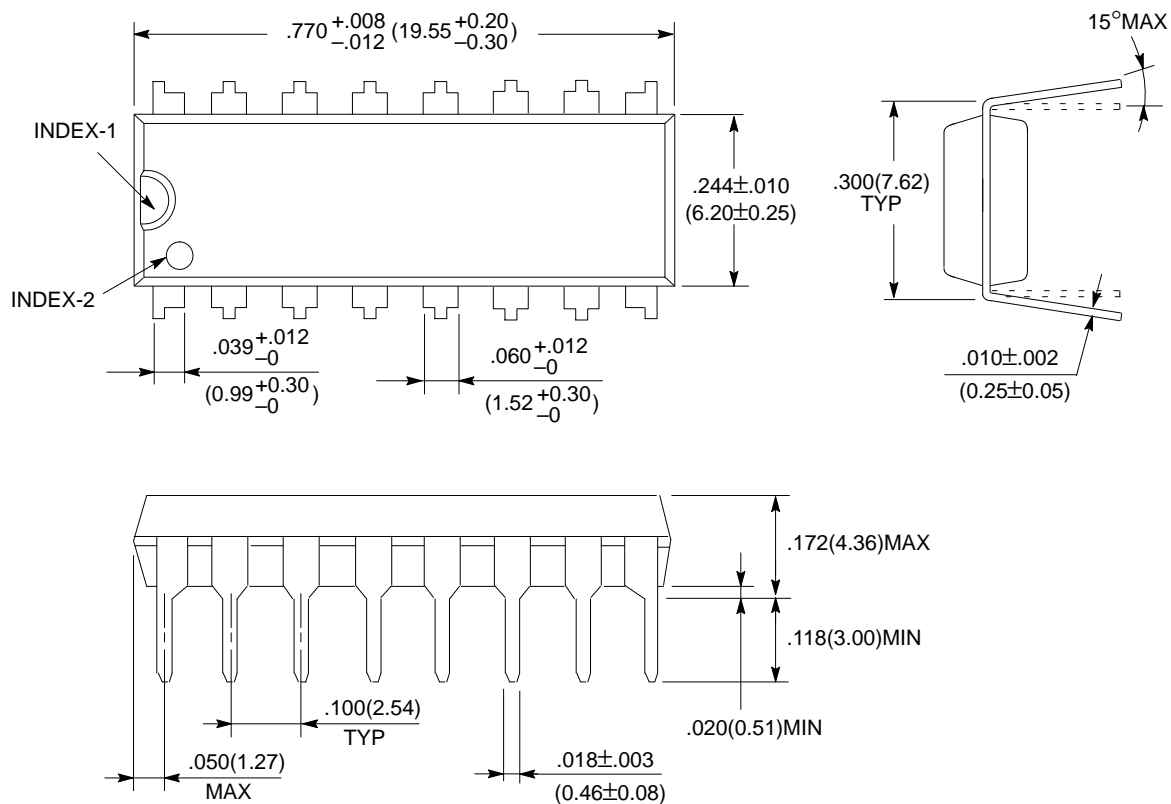
## TYPICAL APPLICATION EXAMPLE



MB1501  
MB1501H  
MB1501L

## PACKAGE DIMENSIONS

16-LEAD PLASTIC DUAL IN-LINE PACKAGE  
(Case No.: DIP-16P-M04)



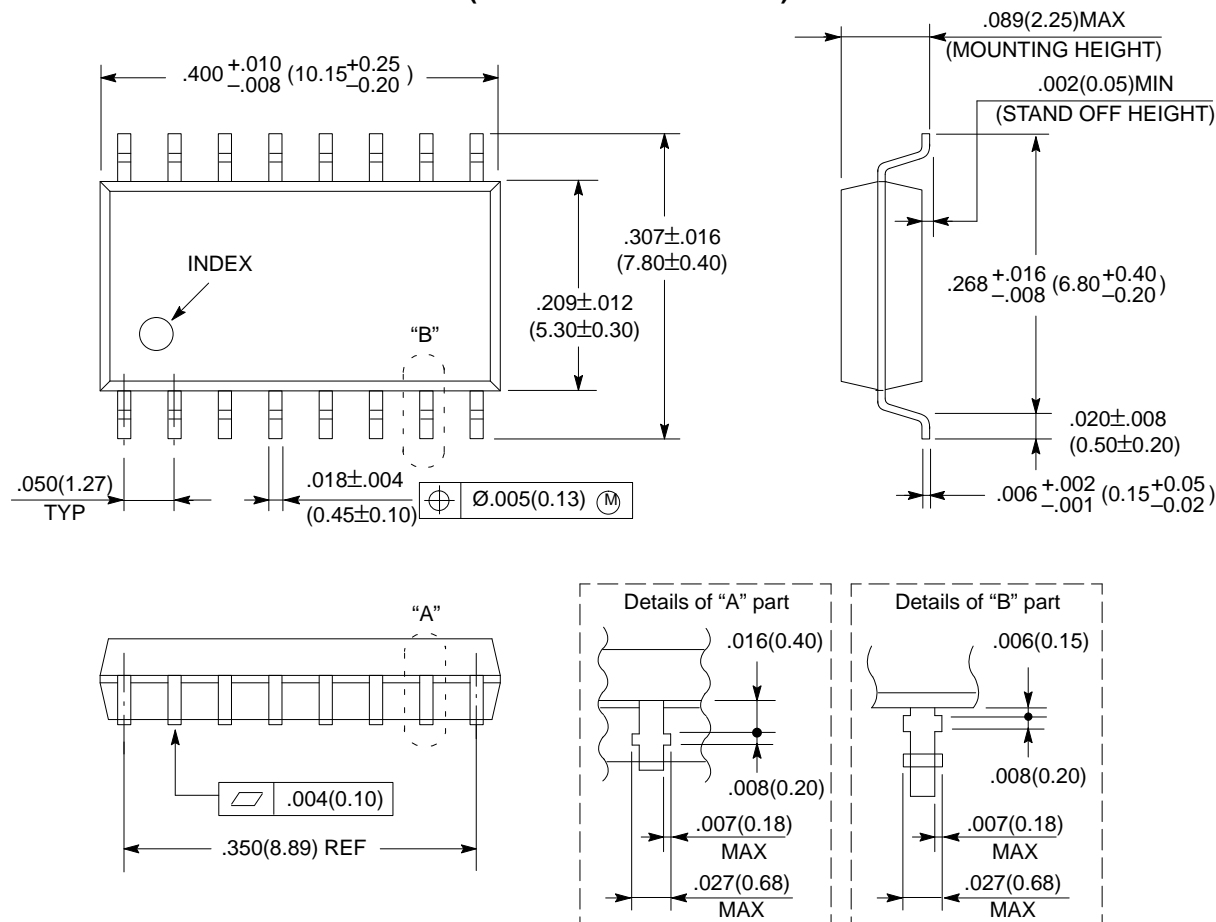
©1991 FUJITSU LIMITED D16033S-2C

Dimensions in  
inches (millimeters)



## PACKAGE DIMENSIONS

### 16-LEAD PLASTIC FLAT PACKAGE (Case No.: FPT-16P-M06)



©1991 FUJITSU LIMITED F16015S-2C

Dimensions in  
inches (millimeters)