

# ASSP

## Dual Serial Input PLL Frequency Synthesizer

### MB15B03

#### ■ DESCRIPTION

The Fujitsu MB15B03 is a serial input Phase Locked Loop (PLL) frequency synthesizer with a 1.1GHz and a 300MHz prescalers. A 64/65 or a 128/129 for the 1.1GHz prescaler, and a 16/17 or a 32/33 for 300MHz prescaler can be selected that enables pulse swallow operation.

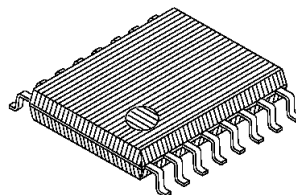
Furthermore, a super charger circuit is included to provide a fast tuning as well as low noise performance. As a result of this, MB15B03 is ideally suitable for digital mobile communications, such as GSM.

#### ■ FEATURES

- High frequency operation RF synthesizer : 1.1GHz max.  
IF synthesizer : 300MHz max.
- Low power supply voltage:  $V_{CC} = 2.7$  to  $3.6V$
- Very low power supply current :  $I_{CC} = 10$  mA typ. ( $V_{CC} = 3V$ )
- Power saving function :  $I_{PS1} = I_{PS2} = 100$   $\mu A$  typ. ( $V_{CC} = 3V$ )
- Serial input 14-bit programmable reference counter:  $R = 6$  to  $16,383$
- Serial input 18-bit programmable divider consisting of:
  - Binary 7-bit swallow counter:  $0$  to  $127$
  - Binary 11-bit programmable counter:  $5$  to  $2,047$
- On-chip high performance charge pump circuit and phase comparator, achieving high-speed lock-up and low phase noise
- Wide operating temperature:  $T_a = -40$  to  $85^{\circ}C$
- Plastic 16-pin SSOP package (FPT-16P-M05)

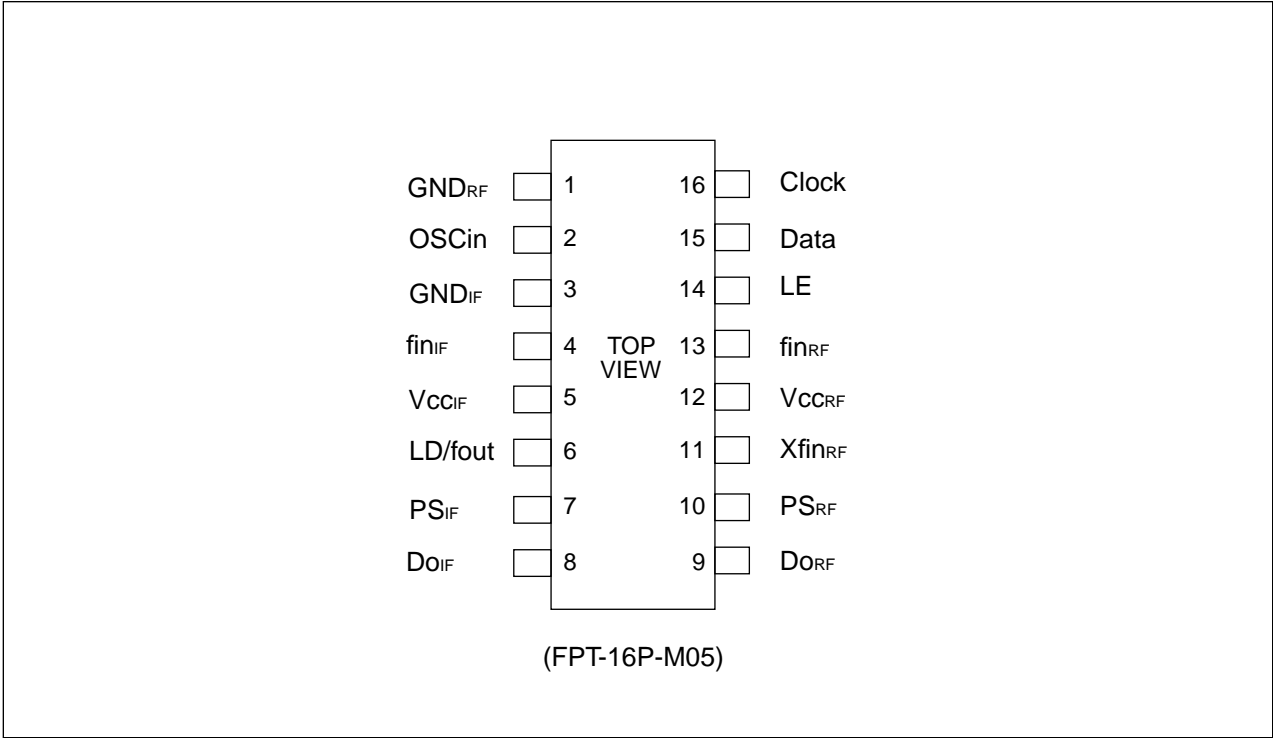
#### ■ PACKAGE

16-pin, Plastic SSOP



(FPT-16P-M05)

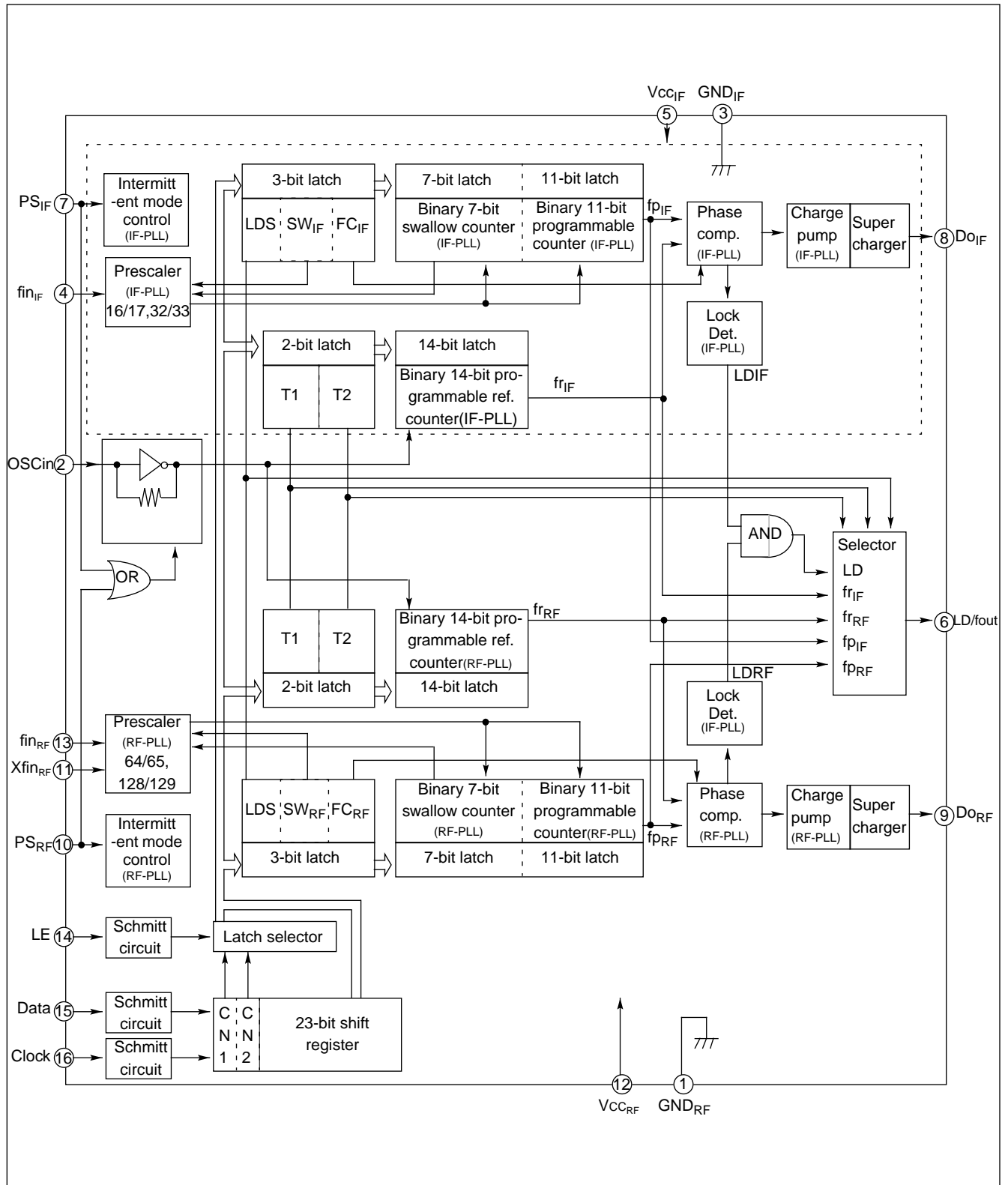
PIN ASSIGNMENT



## ■ PIN DESCRIPTIONS

Pin No.	Pin name	I/O	Descriptions
1	V <sub>CC</sub>	–	Ground for RF-PLL section.
2	OSC <sub>in</sub>	I	The programmable reference divider input. TCXO should be connected with a coupling capacitor.
3	GND <sub>IF</sub>	–	Ground for the IF section.
4	fin <sub>IF</sub>	I	Prescaler input pin for the IF-PLL. The connection with VCO should be AC coupling.
5	V <sub>CCIF</sub>	–	Power supply voltage input pin for the IF-PLL section. When power is OFF, latched data of the IF-PLL is cancelled.
6	LD/fout	O	Lock detect signal output (LD) / phase comparator monitoring output (fout) The output signal is selected by a LDS bit in a serial data. LDS bit = "H" ; outputs fout signal LDS bit = "L" ; outputs LD signal
7	PS <sub>IF</sub>	I	Power saving mode control for the IF-PLL section. This pin must be set at "L" at Power-ON. (Open is prohibited.) PS <sub>IF</sub> = "H" ; Normal mode PS <sub>IF</sub> = "L" ; Power saving mode
8	Do <sub>IF</sub>	O	Charge pump output for the IF-PLL section. Phase characteristics of the phase comparator can be reversed by the FC-bit.
9	Do <sub>RF</sub>	O	Charge pump output for the RF-PLL section. Phase characteristics of the phase comparator can be reversed by the FC-bit.
10	PS <sub>RF</sub>	I	Power saving mode control for the RF-PLL section. This pin must be set at "L" at Power-ON. (Open is prohibited.) PS <sub>RF</sub> = "H" ; Normal mode PS <sub>RF</sub> = "L" ; Power saving mode
11	Xfin <sub>RF</sub>	I	Prescaler complimentary input for the RF-PLL section. This pin should be grounded via a capacitor.
12	V <sub>CCRF</sub>	–	Power supply voltage input pin for the RF-PLL section, the shift register and the oscillator input buffer. When power is OFF, latched data of RF-PLL is cancelled.
13	fin <sub>RF</sub>	I	Prescaler input pin for the RF-PLL. The connection with VCO should be AC coupling.
14	LE	I	Load enable signal input (with the schmitt trigger circuit.) When LE is "H", data in the shift register is transferred to the corresponding latch according to the control bit in a serial data.
15	Data	I	Serial data input (with the schmitt trigger circuit.) A data is transferred to the corresponding latch (IF-ref counter, IF-Prog. counter, RF-ref. counter, RF-prog. counter) according to the control bit in a serial data.
16	Clock	I	Clock input for the 23-bit shift register (with the schmitt trigger circuit.) One bit data is shifted into the shift register on a rising edge of the clock.

## ■ BLOCK DIAGRAM



## ■ ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Rating	Unit	Remark
Power supply voltage	$V_{CC}$	−0.5 to +5.0	V	
Output voltage	$V_{OUT}$	−0.5 to $V_{CC} + 0.5$	V	
Output current	$I_{OUT}$	±10	mA	
Storage temperature	$T_{STG}$	−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.

## ■ RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Value			Unit	Note
		Min	Typ	Max		
Power supply voltage	$V_{CC}$	2.7	3.0	3.6	V	$V_{CCIF} = V_{CCRF}$
Input voltage	$V_i$	GND	–	$V_{CC}$	V	
Operating temperature	$T_a$	−40	–	+85	°C	

### Handling Precautions

- This device should be transported and stored in anti-static containers.
- This is a static-sensitive device; take proper anti-ESD precautions. Ensure that personnel and equipment are properly grounded. Cover workbenches with grounded conductive mats.
- Always turn the power supply off before inserting or removing the device from its socket.
- Protect leads with a conductive sheet when handling or transporting PC boards with devices.

## ■ ELECTRICAL CHARACTERISTICS

Parameter		Symbol	Condition	Value			Unit
				Min	Typ	Max	
Power supply current *1		$I_{CCIF}$	$f_{inIF} = 300\text{MHz}$ , $f_{osc} = 12\text{MHz}$	—	3.5	4.6	mA
		$I_{CCRf}$	$f_{inRF} = 1100\text{MHz}$ , $f_{osc} = 12\text{MHz}$	—	6.5	8.5	
Power saving current *2		$I_{PSIF}$	$V_{CCIF}$ current at $PS_{IF} = "L"$	—	100	—	$\mu\text{A}$
		$I_{PSRF}$	$V_{CCRF}$ current at $PS_{IF/RF} = "L"$	—	100	—	
Operating frequency	$f_{inIF}$	$f_{inIF}$	IF-PLL	50	—	300	MHz
	$f_{inRF}$	$f_{inRF}$	RF-PLL	100	—	1100	
	OSCin	$f_{OSC}$	min. 500mVp-p	—	12.8	23	
Input sensitivity	$f_{inIF}$	$V_{finIF}$	IF-PLL, 50 $\Omega$ termination (Refer to the test circuit.)	−10	—	+2	dBm
	$f_{inRF}$	$V_{finRF}$	RF-PLL, 50 $\Omega$ termination (Refer to the test circuit.)	−10	—	+2	dBm
	OSCin	$V_{OSC}$		500	—	—	mVp-p
Input voltage	Data, Clock, LE, PS	$V_{IH}$		$V_{CC} \times 0.7 + 0.4$	—	—	V
		$V_{IL}$		—	—	$V_{CC} \times 0.3 - 0.4$	
Input current	Data, Clock, LE, PS	$I_{IH}$		—	—	+1.0	$\mu\text{A}$
		$I_{IL}$		−1.0	—	—	
	OSCin	OSCin		−100	—	+100	
Output voltage	LD	$V_{OH}$	$V_{CC} = 3.0\text{V}$ , $I_{OH} = -1.0\text{mA}$	2.2	—	—	V
		$V_{OL}$	$V_{CC} = 3.0\text{V}$ , $I_{OL} = 1.0\text{mA}$	—	—	0.4	
High impedance cutoff current	Do	$I_{OFF}$		—	—	0.3	$\mu\text{A}$
Output current	LD	$I_{OH}$	$V_{CC} = 3.0\text{V}$	−1.0	—	—	mA
		$I_{OL}$	$V_{CC} = 3.0\text{V}$	—	—	1.0	
	Do	$I_{DOH}$	$V_{CC} = 3.0\text{V}$ , $V_{DOH} = 2.0\text{V}$ , $T_a = 25^\circ\text{C}$	−12	—	−3.5	mA
		$I_{DOL}$	$V_{CC} = 3.0\text{V}$ , $V_{DOL} = 1.0\text{V}$ , $T_a = 25^\circ\text{C}$	6	—	18	

\*1: Conditions ;  $V_{CCIF/RF} = 3\text{V}$ ,  $T_a = 25^\circ\text{C}$ , in locking state.

\*2: Conditions ;  $V_{CCIF/RF} = 3\text{V}$ ,  $T_a = 25^\circ\text{C}$ , in power saving state.

## ■ FUNCTIONAL DESCRIPTIONS

The divide ratio can be calculated using the following equation:

$$f_{VCO} = \{(P \times N) + A\} \times f_{osc} \div R \quad (A < N)$$

$f_{VCO}$ : Output frequency of external voltage controlled oscillator (VCO)

P: Preset divide ratio of dual modulus prescaler (16 or 32 for IF-PLL, 64 or 128 for RF-PLL)

N: Preset divide ratio of binary 11-bit programmable counter (5 to 2,047)

A: Preset divide ratio of binary 7-bit swallow counter ( $0 \leq A \leq 127$ )

$f_{osc}$ : Reference oscillation frequency

R: Preset divide ratio of binary 14-bit programmable reference counter (6 to 16,383)

## Serial Data Input

Serial data is entered using three pins, Data pin, Clock pin, and LE pin. Programmable dividers of IF/RF-PLL sections, programmable reference dividers of IF/RF PLL sections are controlled individually.

Serial data of binary data is entered through Data pin.

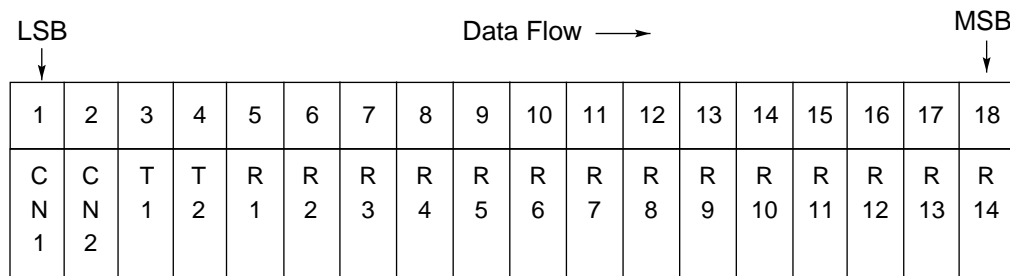
On rising edge of clock, one bit of serial data is transferred into the shift register. When load enable signal is high, the data stored in the shift register is transferred to one of latch of them depending upon the control bit data setting.

### Table.1 Control Bit

Control bits		Destination of serial data
CN1	CN2	
L	L	The programmable reference counter for the IF-PLL.
H	L	The programmable reference counter for the RF-PLL.
L	H	The programmable counter and the swallow counter for the IF-PLL
H	H	The programmable counter and the swallow counter for the RF-PLL

## Shift Register Configuration

## Programmable Reference Counter

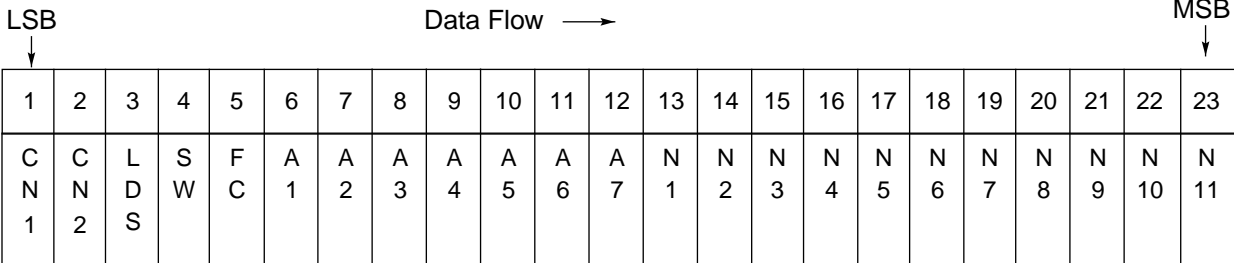


CNT1, 2 : Control bit (Table. 1)

R1 to R14 : Divide ratio setting bits for the programmable reference counter (6 to 16,383) (Table. 2)

T1, 2 : Test purpose bit (Table. 3)

## Programmable Counter



CN1, 2	: Control bit	(Table. 1)
N1 to N11	: Divide ratio setting bits for the programmable counter (5 to 2,047)	(Table. 4)
A1 to A7	: Divide ratio setting bits for the swallow counter (0 to 127)	(Table. 5)
SW	: Divide ratio setting bit for the prescaler (16/17 or 32/33 for the IF-PLL, 64/65 or 128/129 for the RF-PLL)	(Table. 6)
FC	: Phase control bit for the phase detector	(Table. 7)
LDS	: LD/fout signal select bit	(Table. 8)

### Table.2 Binary 14-bit Programmable Reference Counter Data Setting

[illegible]

Note: • Divide ratio less than 6 is prohibited.

### Table.3 Test Purpose Bit Setting

T <sub>1</sub>	T <sub>2</sub>	LD/fout pin state
L	L	Outputs fr <sub>IF</sub>
H	L	Outputs fr <sub>RF</sub>
L	H	Outputs fp <sub>IF</sub>
H	H	Outputs fp <sub>RF</sub>



**Table.4 Binary 11-bit Programmable Counter Data Setting**

Divide Ratio (N)	N 11	N 10	N 9	N 8	N 7	N 6	N 5	N 4	N 3	N 2	N 1
5	0	0	0	0	0	0	0	0	1	0	1
6	0	0	0	0	0	0	0	0	1	1	0
•	•	•	•	•	•	•	•	•	•	•	•
2047	1	1	1	1	1	1	1	1	1	1	1

Note: • Divide ratio less than 5 is prohibited.

**Table.5 Binary 7-bit Swallow Counter Data Setting**

Divide Ratio (N)	A 7	A 6	A 5	A 4	A 3	A 2	A 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

Note: • Divide ratio (A) range = 0 to 127

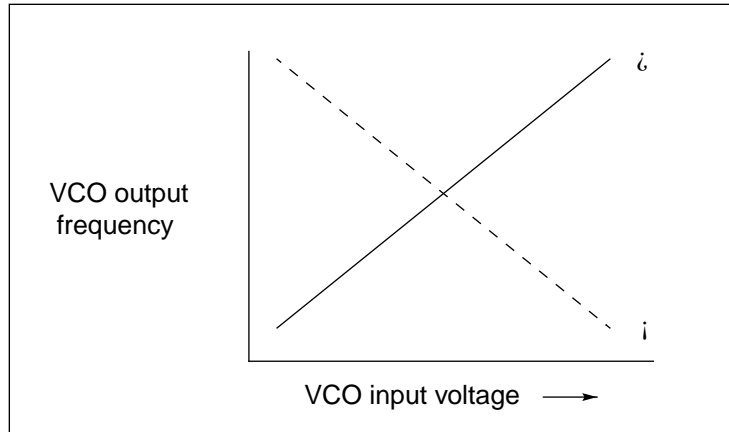
**Table.6 Prescaler Data Setting**

		SW = "H"	SW = "L"
Prescaler divide ratio	IF-PLL	16/17	32/33
	RF-PLL	64/65	128/129

**Table.7 Phase Comparator Phase Switching Data Setting**

	FC = H	FC = L
$f_r > f_p$	H	L
$f_r = f_p$	Z	Z
$f_r < f_p$	L	H
VCO Polarity	$\dot{i}$	$\dot{i}$

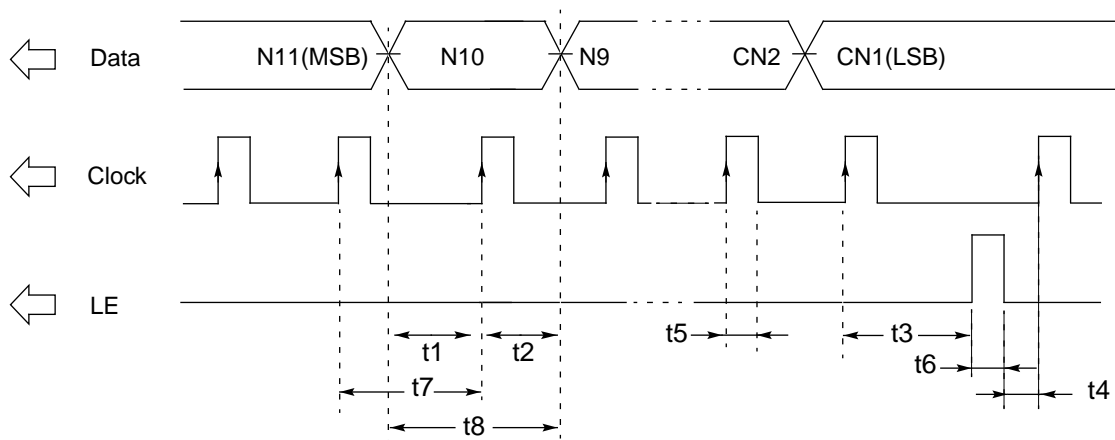
Note: •Z = High-impedance  
 •Depending upon the VCO and LPF polarity, FC bit should be set.



**Table.8 LD/fout Output Select Data Setting**

LDS	LD/fout output signal
H	fout ( $f_{rIF/RF}$ , $f_{pIF/RF}$ ) signals
Z	LD signal

## Serial Data Input Timing

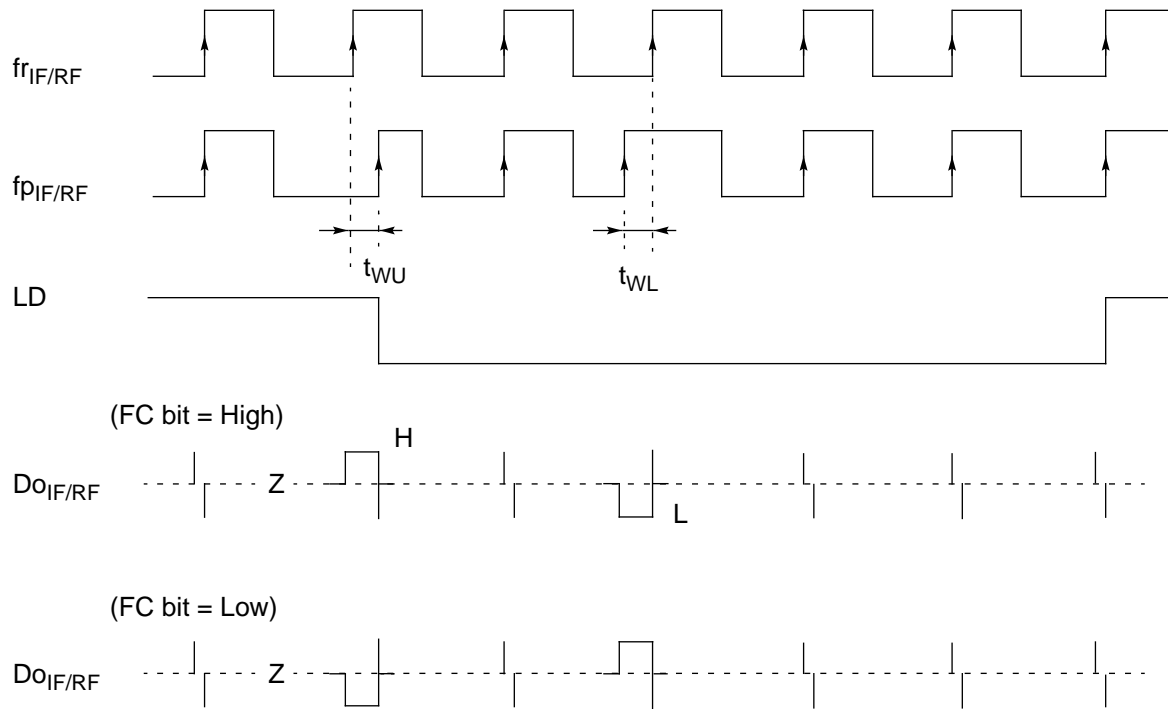


On rising edge of the clock, one bit of the data is transferred into the shift register.

Parameter	Min.	Typ.	Max.	Unit
t1	30	—	—	ns
t2	30	—	—	ns
t3	30	—	—	ns
t4	30	—	—	ns

Parameter	Min.	Typ.	Max.	Unit
t5	100	—	—	ns
t6	100	—	—	ns
t7	200	—	—	ns
t8	200	—	—	ns

## ■ PHASE DETECTOR OUTPUT WAVEFORM



LD Output Logic Table

IF-PLL section	RF-PLL section	LD output
Locking state / Power saving state	Locking state / Power saving state	H
Locking state / Power saving state	Unlocking state	L
Unlocking state	Locking state / Power saving state	L
Unlocking state	Unlocking state	L

- Note:
- Phase error detection range =  $-2\pi$  to  $+2\pi$
  - Pulses on  $Do\_IF/RF$  signals are output to prevent dead zone.
  - LD output becomes low when phase error is  $t_{WU}$  or more.
  - LD output becomes high when phase error is  $t_{WL}$  or less and continues to be so for three cycles or more.
  - $t_{WU}$  and  $t_{WL}$  depend on OSCin input frequency as follows.
    - $t_{WU} \geq 8/f_{osc}$ : i.e.  $t_{WU} \geq 625\text{ns}$  when  $f_{osc} = 12.8\text{ MHz}$
    - $t_{WL} \leq 16/f_{osc}$ : i.e.  $t_{WL} \leq 1250\text{ns}$  when  $f_{osc} = 12.8\text{ MHz}$

## Power Saving Mode (Intermittent mode control circuit)

Setting a  $PS_{IF(RF)}$  pin to Low, IF-PLL(RF-PLL) enters into power saving mode resultatly current consumption can be limited to 100 $\mu$ A (typ.). Setting PS pin to High, power saving mode is released so that the device works normally. In addition, the intermittent operation control circuit is included which helps smooth start up from stand by mode. In general, the power consumption can be saved by the intermittent operation that powering down or waking up the synthesizer. Such case, if the PLL is powered up uncontrolled, the resulting phase comparator output signal is unpredictable due to an undefined phase relation between reference frequency ( $f_r$ ) and comparison frequency ( $f_p$ ) and may in the worst case take longer time for lock up of the loop.

To prevent this, the intermittent operation control circuit enforces a limited error signal output of the phase detector during power up, thus keeping the loop locked.

*PS pin must be set "L" at Power-ON.*

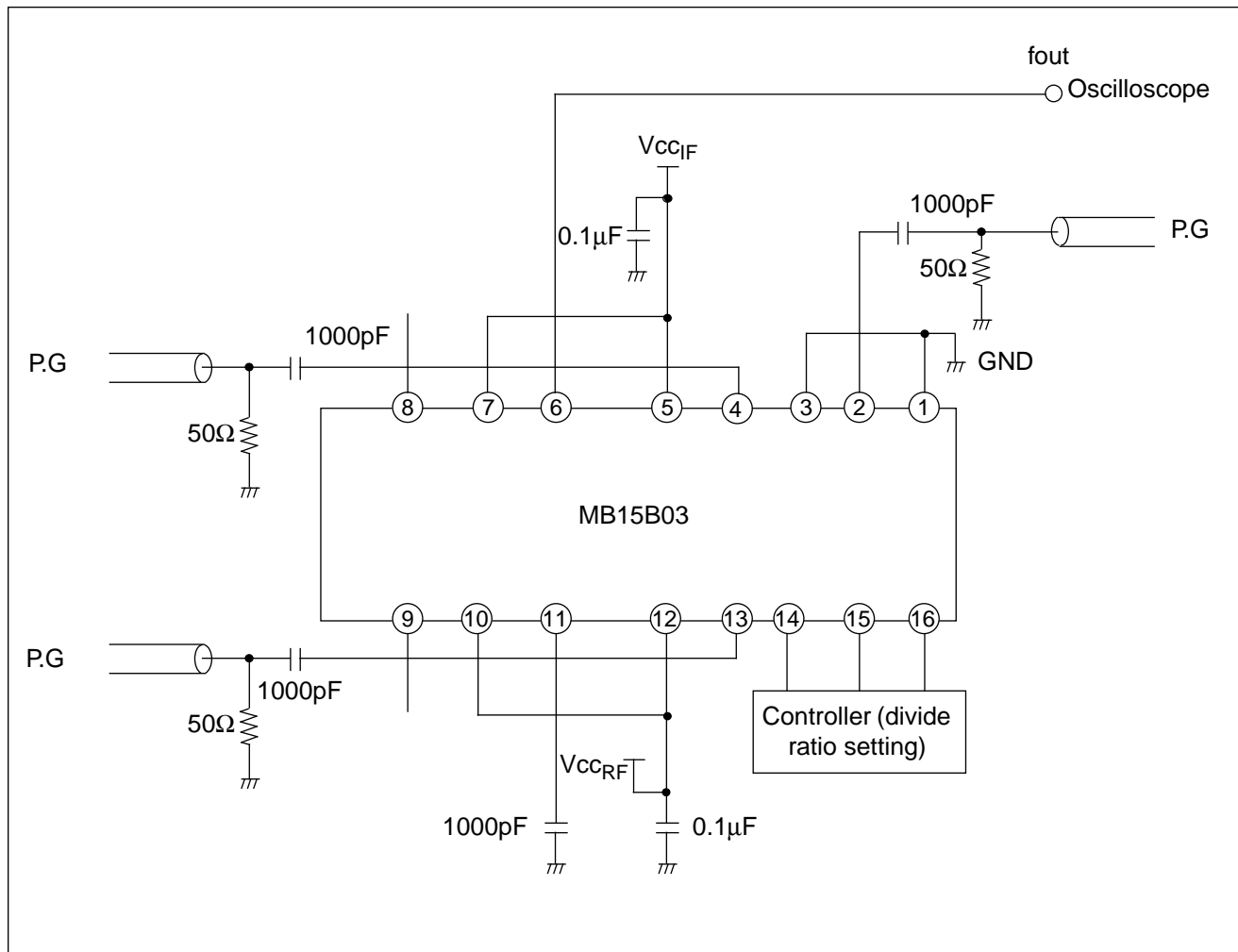
During the power saving mode, the corresponding section except for indispensable circuit for the power saving function stops working, then current consumption is reduced to 100 $\mu$ A per one PLL section.

At that time, the Do and LD become the same state as when a loop is locking. That is, the Do becomes high impedance.

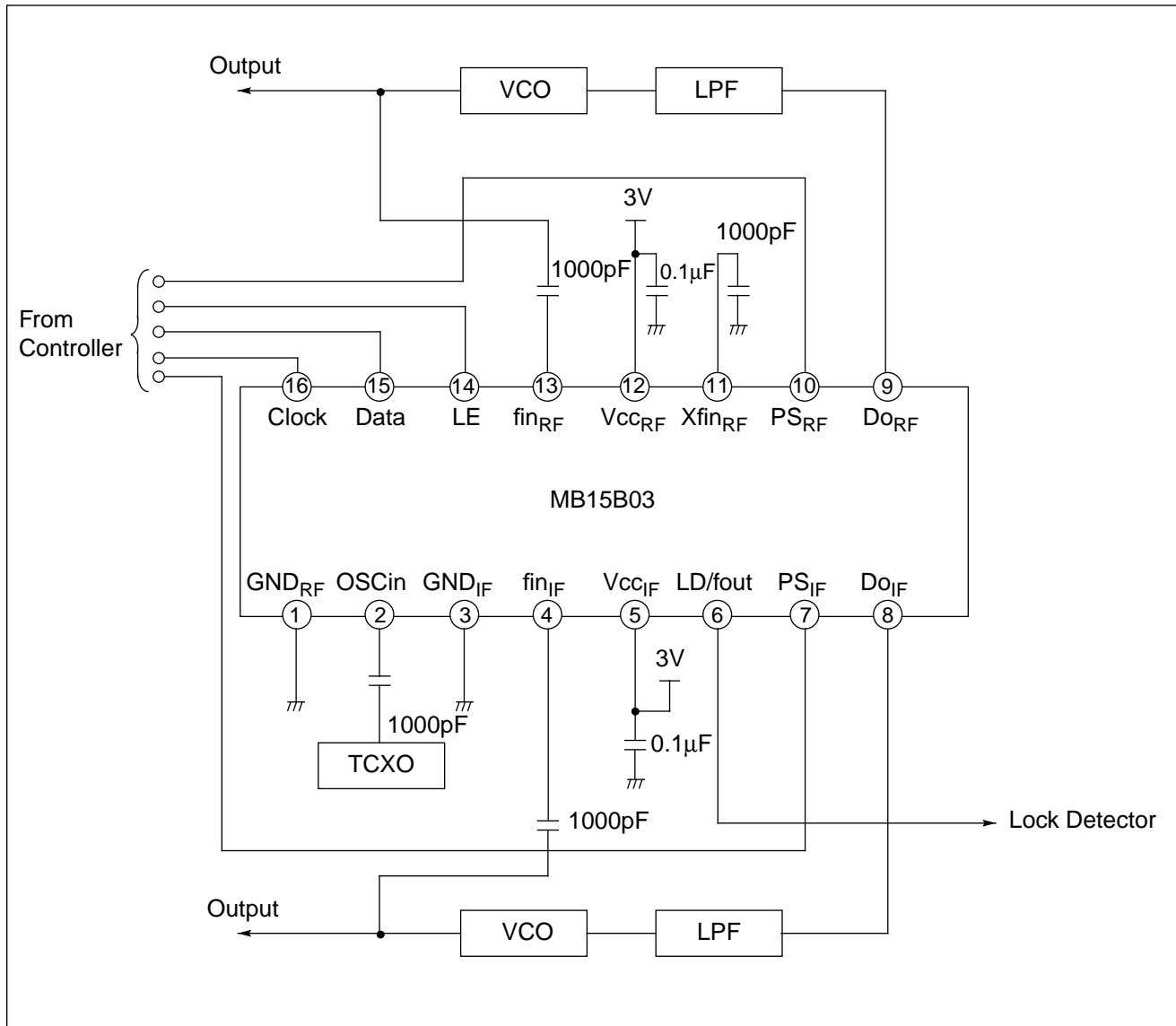
A VCO control voltage is naturally kept at the locking voltage which defined by a LPF's time constant. As a result of this, VCO's frequency is kept at the locking frequency.

$PS_{IF}$	$PS_{RF}$	IF-PLL counters	RF-PLL counters	OSC input buffer
L	L	OFF	OFF	OFF
H	L	ON	OFF	ON
L	H	OFF	ON	ON
H	H	ON	ON	ON

## ■ TEST CIRCUIT (Prescaler Input/Programmable Reference Divider Input Sensitivity Test)



## ■ APPLICATION EXAMPLE

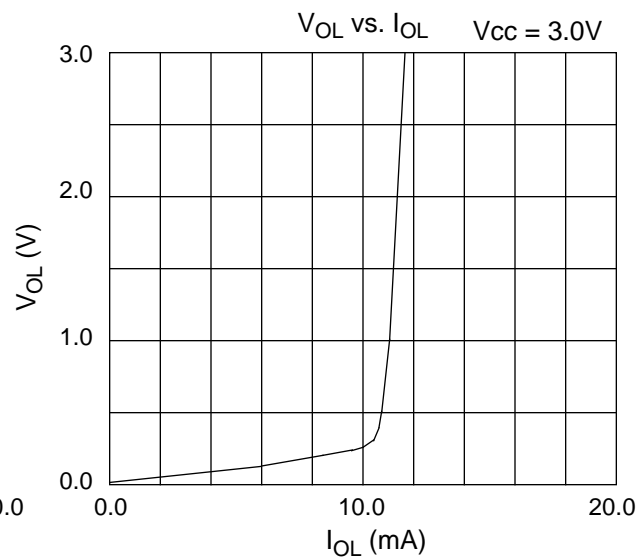
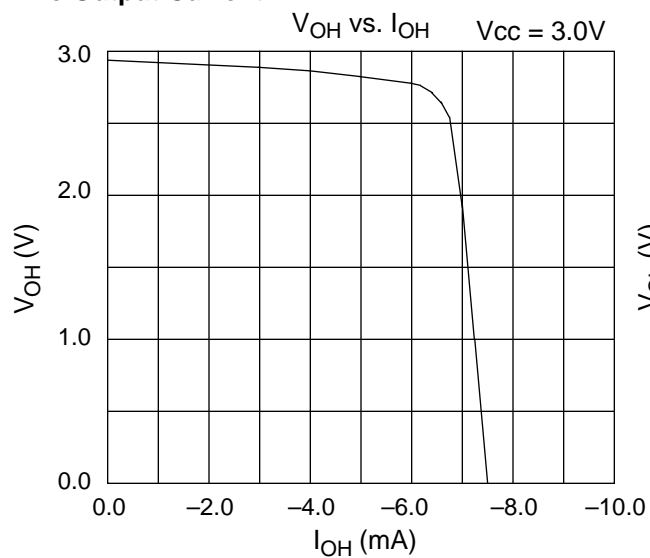


Note: Clock, Data, LE : Involves a schmitt circuit.

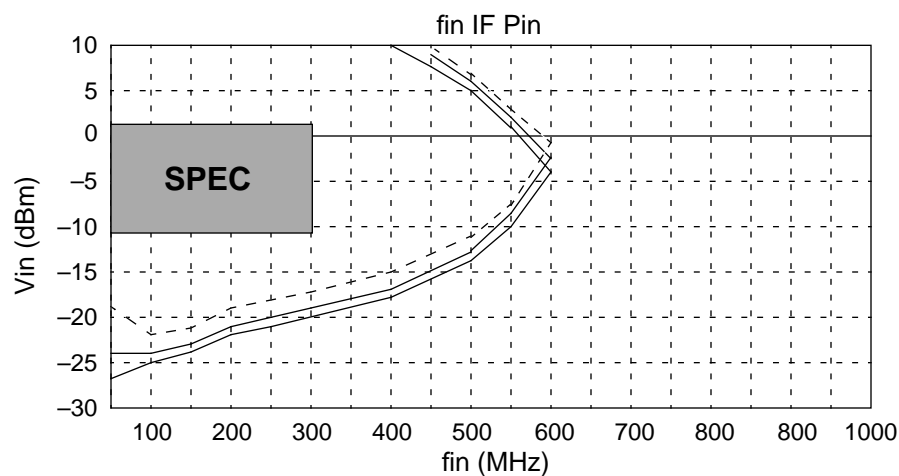
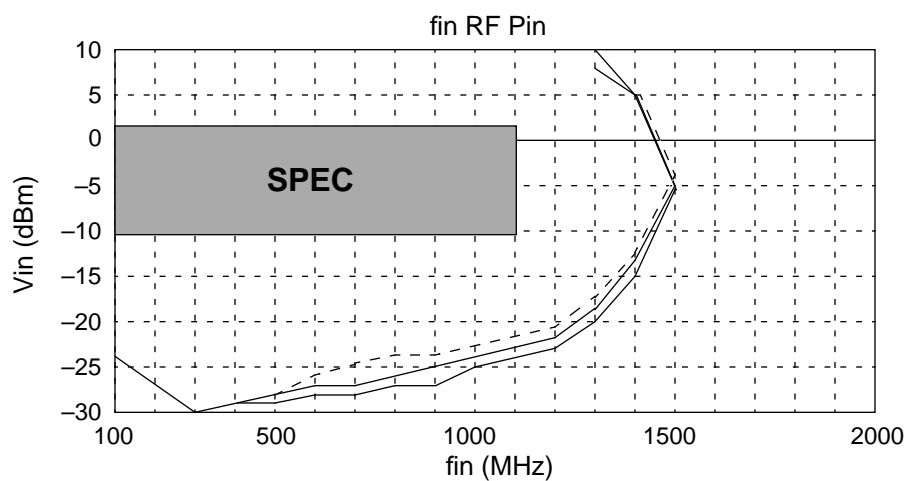
(When inputs are open, pull up/down resistor is necessary to prevent self-oscillation.)

## ■ TYPICAL CHARACTERISTICS

Do Output Current



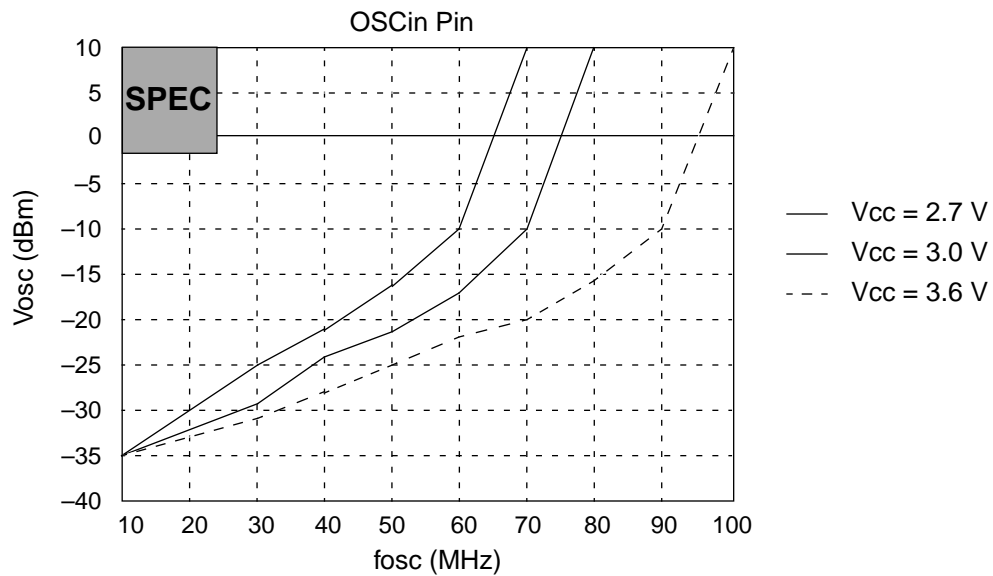
fin Input Sensitivity



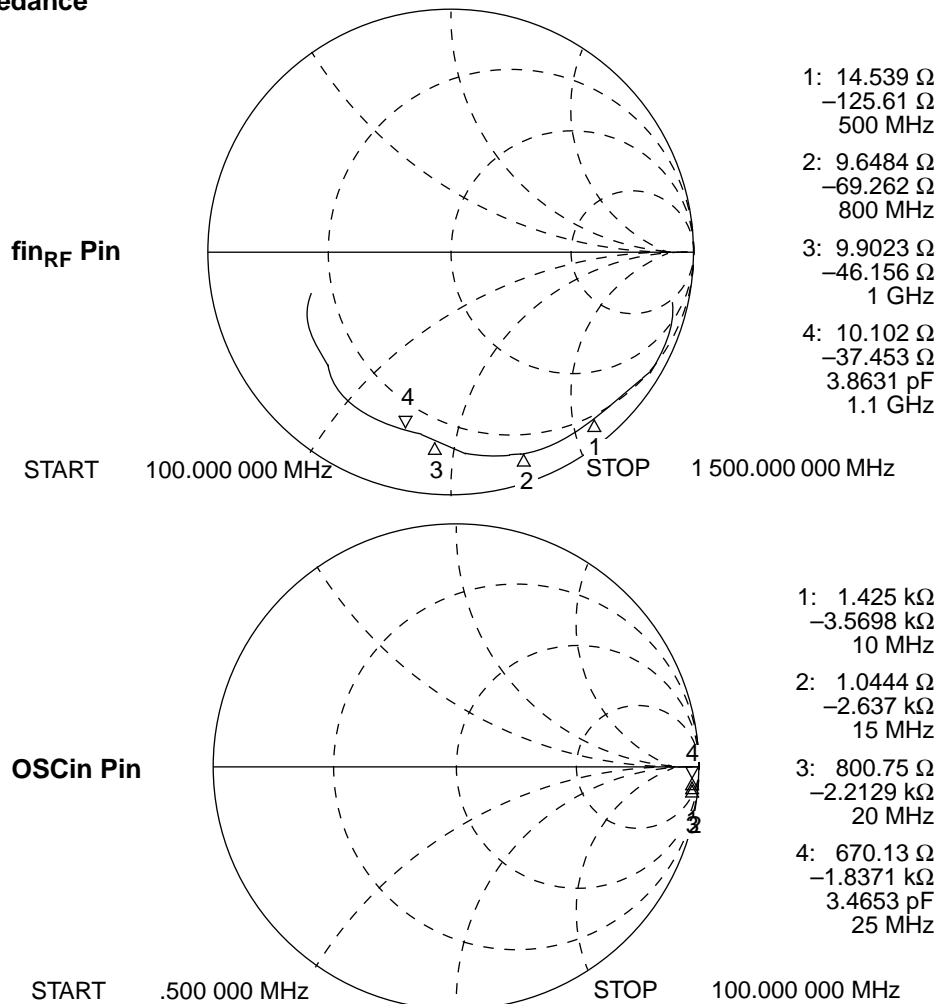
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## OSCin Input Sensitivity



## Input Impedance

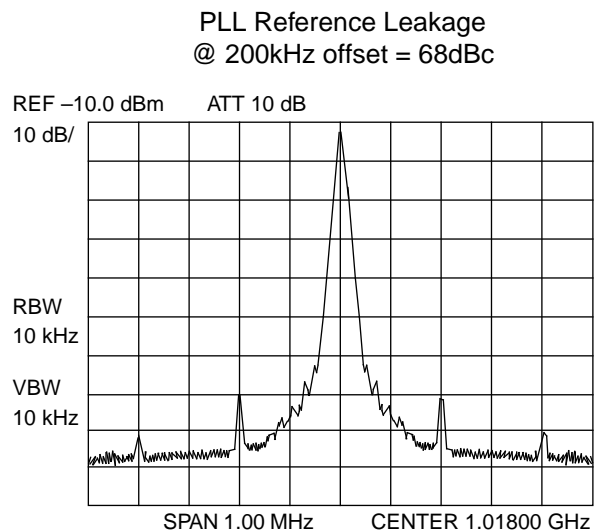
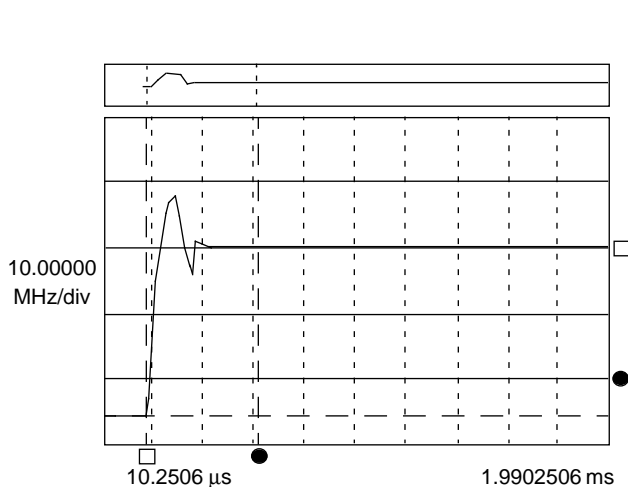
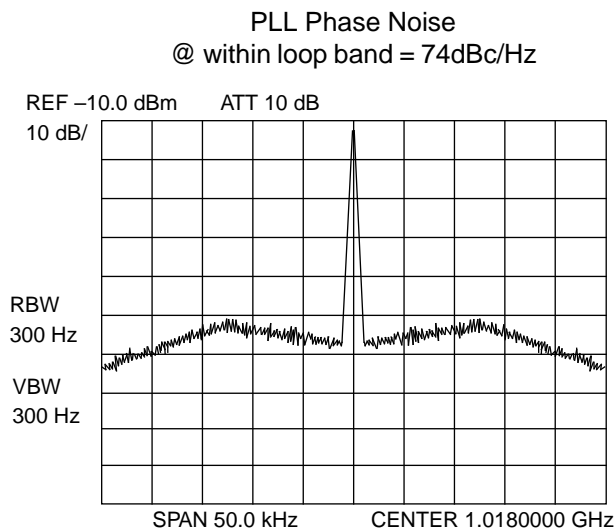
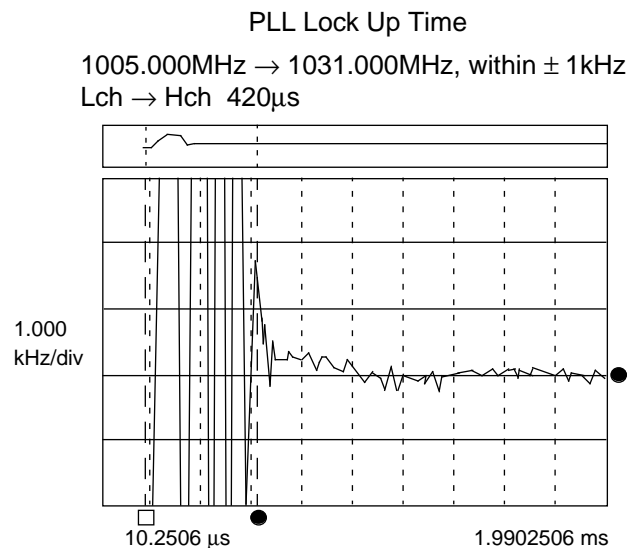
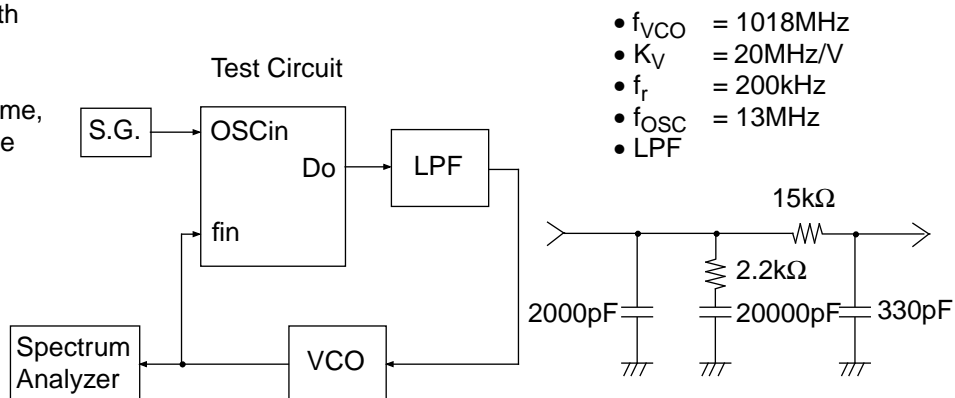




## REFERENCE INFORMATION

Typical plots measured with the test circuit are shown below.

Each plots show lock up time, phase noise, and reference leakage.

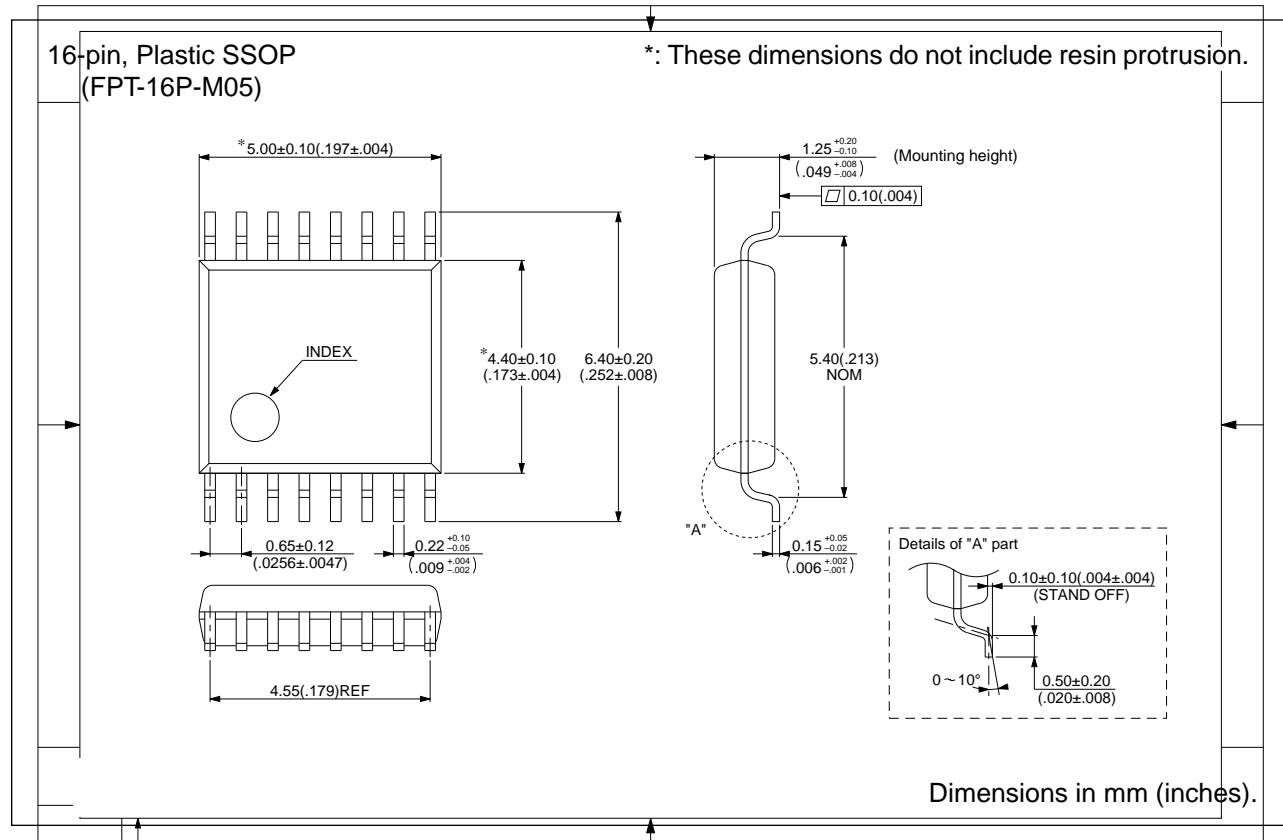


# MB15B03

## ■ ORDERING INFORMATION

Part number	Package	Remarks
MB15B03PFV	16-pin, Plastic SSOP (FPT-16P-M05)	

## ■ PACKAGE DIMENSION



## FUJITSU LIMITED

*For further information please contact:*

### **Japan**

FUJITSU LIMITED  
Corporate Global Business Support Division  
Electronic Devices  
KAWASAKI PLANT, 1015 Kamikodanaka,  
Nakahara-ku, Kawasaki-shi,  
Kanagawa 211, Japan  
Tel: (044) 754-3753  
Fax: (044) 754-3329

### **North and South America**

FUJITSU MICROELECTRONICS, INC.  
Semiconductor Division  
3545 North First Street  
San Jose, CA 95134-1804, U.S.A.  
Tel: (408) 922-9000  
Fax: (408) 432-9044/9045

### **Europe**

FUJITSU MIKROELEKTRONIK GmbH  
Am Siebenstein 6-10  
63303 Dreieich-Buchschlag,  
Germany  
Tel: (06103) 690-0  
Fax: (06103) 690-122

### **Asia Pacific**

FUJITSU MICROELECTRONICS ASIA PTE. LIMITED  
No. 51 Bras Basah Road,  
Plaza By The Park,  
#06-04 to #06-07  
Singapore 189554  
Tel: 336-1600  
Fax: 336-1609

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