

**ASSP**

# Dual Serial Input PLL Frequency Synthesizer

## MB15F03

### ■ DESCRIPTION

The Fujitsu MB15F03 is a serial input Phase Locked Loop (PLL) frequency synthesizer with a 2.0GHz and a 500MHz prescalers. A 64/65 or a 128/129 for the 2.0GHz prescaler, and a 16/17 or a 32/33 for 500MHz prescaler can be selected that enables pulse swallow operation.

The latest BiCMOS process technology is used, resultantly a supply current is limited as low as 9.0mA typ. at a supply voltage of 3.0V.

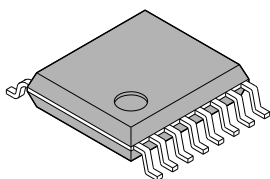
Furthermore, a super charger circuit is included to provide a fast tuning as well as low noise performance. As a result of this, MB15F03 is ideally suitable for digital mobile communications, such as PHS(Personal Handy Phone System), PCN (Personal Communication Network) and PCS(Personal Communication Service).

### ■ FEATURES

- High frequency operation      RF synthesizer    : 2.0GHz max.  
   IF synthesizer    : 500MHz max.
- Low power supply voltage:  $V_{CC} = 2.7$  to 3.6V
- Very Low power supply current :  $I_{CC} = 9.0$  mA typ. ( $V_{CC} = 3V$ )
- Power saving function :  $I_{PS1} = I_{PS2} = 10$   $\mu$ A max.
- Serial input 14-bit programmable reference divider: R = 5 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°C
- Plastic 16-pin SSOP package (FPT-16P-M05) and 16-pin BCC package (LCC-16P-M03)

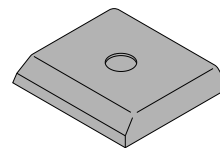
### ■ PACKAGES

16-pin, Plastic SSOP



(FPT-16P-M05)

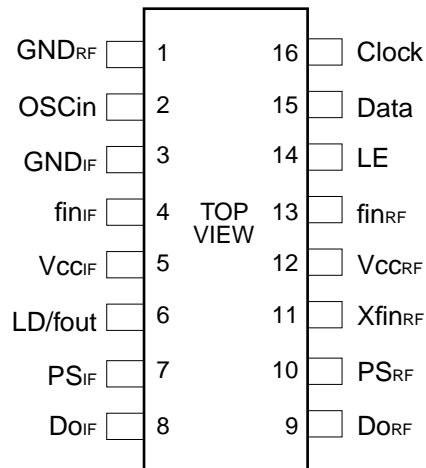
16-pin, Plastic BCC



(LCC-16P-M03)

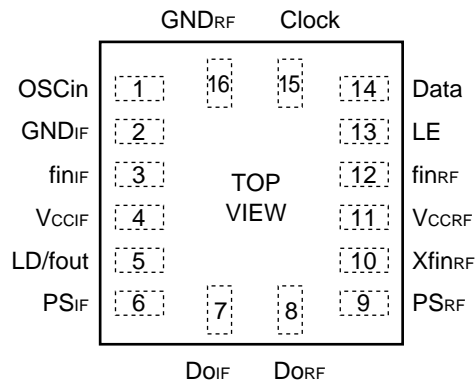
## ■ PIN ASSIGNMENTS

SSOP-16 pin



(FPT-16P-M05)

BCC-16 pin



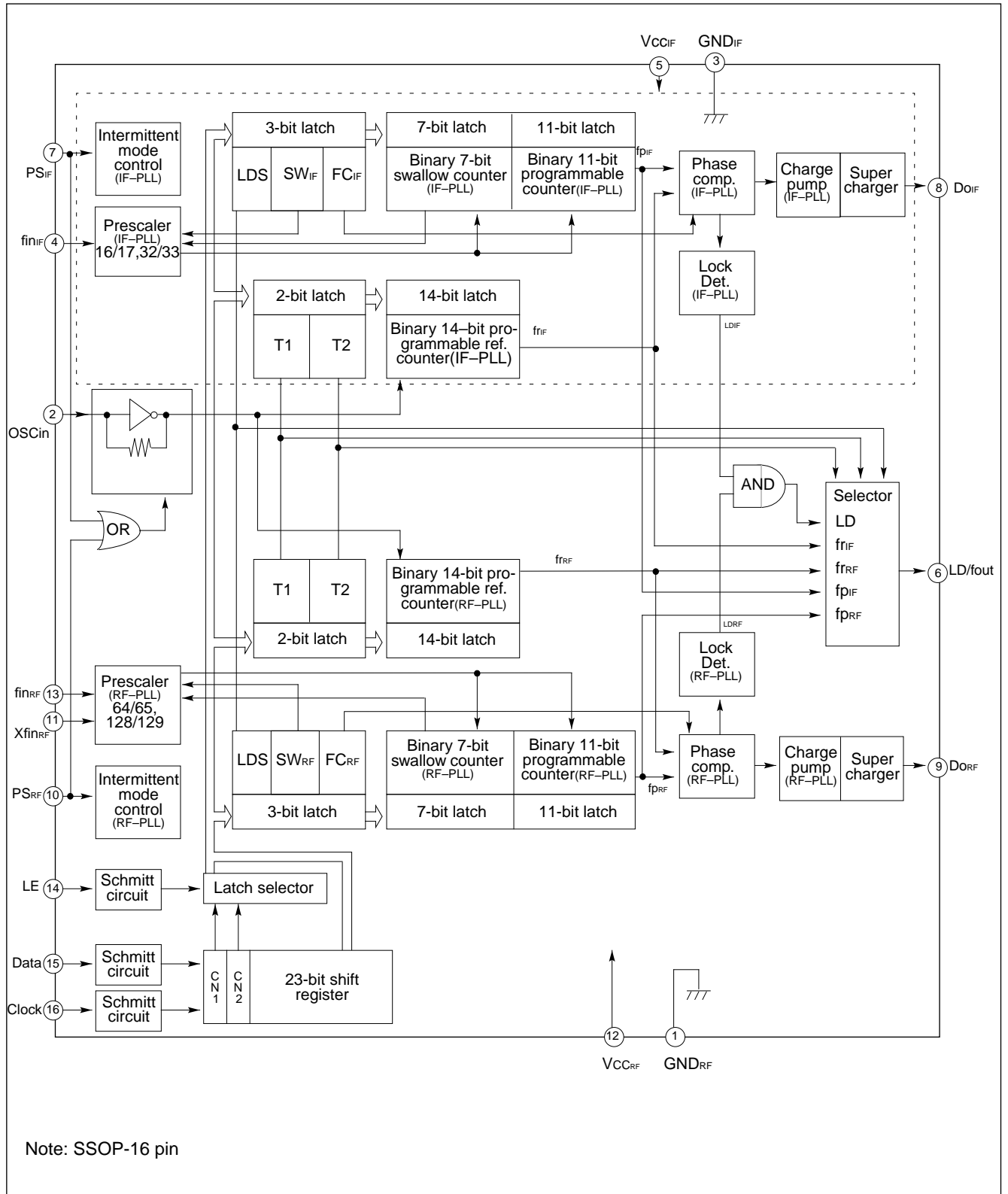
(LCC-16P-M03)

## ■ PIN DESCRIPTIONS

Pin No.		Pin name	I/O	Descriptions
SSOP	BBC			
1	16	GND <sub>RF</sub>	–	Ground for RF-PLL section.
2	1	OSC <sub>in</sub>	I	The programmable reference divider input. TCXO should be connected with a coupling capacitor.
3	2	GND <sub>IF</sub>	–	Ground for the IF-PLL section.
4	3	fin <sub>IF</sub>	I	Prescaler input pin for the IF-PLL. The connection with VCO should be AC coupling.
5	4	VCC <sub>IF</sub>	–	Power supply voltage input pin for the IF-PLL section. When power is OFF, latched data of IF-PLL is cancelled.
6	5	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	6	PS <sub>IF</sub>	I	Power saving mode control for the IF-PLL section. This pin must be set at "L" Power-ON. (Open is prohibited.) PS <sub>IF</sub> = "H" ; Normal mode PS <sub>IF</sub> = "L" ; Power saving mode
8	7	DO <sub>IF</sub>	O	Charge pump output for the IF-PLL section. Phase characteristics of the phase detector can be reversed by FC-bit.
9	8	DO <sub>RF</sub>	O	Charge pump output for the RF-PLL section. Phase characteristics of the phase detector can be reversed by FC-bit.
10	9	PS <sub>RF</sub>	I	Power saving mode control for the RF-PLL section. This pin must be set at "L" Power-ON. (Open is prohibited.) PS <sub>RF</sub> = "H" ; Normal mode PS <sub>RF</sub> = "L" ; Power saving mode
11	10	Xfin <sub>RF</sub>	I	Prescaler complimentary input for the RF-PLL section. This pin should be grounded via a capacitor.
12	11	VCC <sub>RF</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	12	fin <sub>RF</sub>	I	Prescaler input pin for the RF-PLL. The connection with VCO should be AC coupling.
14	13	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	14	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	15	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.

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## ■ BLOCK DIAGRAM



Note: SSOP-16 pin

## ■ ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Rating	Unit	Remark
Power supply voltage	$V_{CC}$	-0.5 to +4.0	V	
Input voltage	$V_i$	-0.5 to $V_{CC} + 0.5$	V	
Output voltage	$V_o$	-0.5 to $V_{CC} + 0.5$	V	
Storage temperature	$T_{STG}$	-55 to +125	°C	

WARNING: Semiconductor devices can be permanently damaged by application of stress (voltage, current, temperature, etc.) in excess of absolute maximum ratings. Do not exceed these ratings.

## ■ 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	

WARNING: Recommended operating conditions are normal operating ranges for the semiconductor device. All the device's electrical characteristics are warranted when operated within these ranges.

Always use semiconductor devices within the recommended operating conditions. Operation outside these ranges may adversely affect reliability and could result in device failure.

No warranty is made with respect to uses, operating conditions, or combinations not represented on the data sheet. Users considering application outside the listed conditions are advised to contact their FUJITSU representative beforehand.

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## ■ ELECTRICAL CHARACTERISTICS

Parameter	Symbol	Condition	Value			Unit		
			Min.	Typ.	Max.			
Power supply current*1	I <sub>CCIF</sub>	f <sub>inIF</sub> = 500MHz, f <sub>osc</sub> = 12MHz	–	3.0	–	mA		
	I <sub>CCRF</sub>	f <sub>inRF</sub> = 2000MHz, f <sub>osc</sub> = 12MHz	–	6.0	–			
Power saving current	I <sub>PSIF</sub>	V <sub>CCIF</sub> current at PS <sub>IF</sub> = "L"	–	–	10	μA		
	I <sub>PSRF</sub>	V <sub>CCRF</sub> current at PS <sub>IF/RF</sub> = "L"	–	–	10			
Operating frequency	f <sub>inIF</sub>	f <sub>inIF</sub>	IF-PLL	50	–	500	MHz	
	f <sub>inRF</sub>	f <sub>inRF</sub>	RF-PLL	100	–	2000		
	OSCin	f <sub>osc</sub>	min. 500mVp-p	3	–	40		
Input sensitivity	f <sub>inIF</sub>	V <sub>f<sub>inIF</sub></sub>	IF-PLL, 50Ω termination	–10	–	+2	dBm	
	f <sub>inRF</sub>	V <sub>f<sub>inRF</sub></sub>	RF-PLL, 50Ω termination	–10	–	+2	dBm	
	OSCin	V <sub>osc</sub>		500	–	V <sub>cc</sub>	mVp-p	
Input voltage	Data, Clock, LE	V <sub>IH</sub>	Schmitt trigger input	V <sub>cc</sub> x0.7+0.4	–		V	
		V <sub>IL</sub>	Schmitt trigger input	–	–	V <sub>cc</sub> x0.3–0.4		
	PS <sub>IF</sub> , PS <sub>RF</sub>	V <sub>IH</sub>		V <sub>cc</sub> x0.7	–		V	
		V <sub>IL</sub>		–	–	V <sub>cc</sub> x0.3		
Input current	Data, Clock, LE, PS <sub>IF</sub> , PS <sub>RF</sub>	I <sub>IH</sub>		–1.0	–	+1.0	μA	
		I <sub>IL</sub>		–1.0	–	+1.0		
	OSCin	I <sub>IH</sub>		0	–	+100	μA	
		I <sub>IL</sub>		–100	–	0		
Output voltage	LD/fout	V <sub>OH</sub>		V <sub>cc</sub> –0.4	–		V	
		V <sub>OL</sub>		–	–	0.4		
	DO <sub>IF</sub> , DO <sub>RF</sub>	V <sub>DOH</sub>		V <sub>cc</sub> –0.4	–		V	
		V <sub>DOL</sub>		–	–	0.4		
High impedance cutoff current	DO <sub>IF</sub> , DO <sub>RF</sub>	I <sub>OFF</sub>		–	–	1.1	μA	
Output current	LD/fout	I <sub>OH</sub>	V <sub>cc</sub> = 3.0V	–	–	–1.0	mA	
		I <sub>OL</sub>	V <sub>cc</sub> = 3.0V	1.0	–	–		
	DO <sub>IF</sub> , DO <sub>RF</sub>	I <sub>DOH</sub>	V <sub>cc</sub> = 3.0V, V <sub>DOH</sub> = 2.0V		–	–6.0 <sup>*2</sup>	–	mA
		I <sub>DOL</sub>	V <sub>cc</sub> = 3.0V, V <sub>DOL</sub> = 1.0V		–	–10.0 <sup>*2</sup>	–	

\*1: Conditions ; V<sub>CCIF/RF</sub> = 3V, T<sub>a</sub> = 25°C, in locking state.

\*2: Conditions ; T<sub>a</sub> = 25°C

## 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<sub>vco</sub>: 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 ≤ A ≤ 127)
- f<sub>osc</sub>: Reference oscillation frequency
- R: Preset divide ratio of binary 14-bit programmable reference counter (5 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.

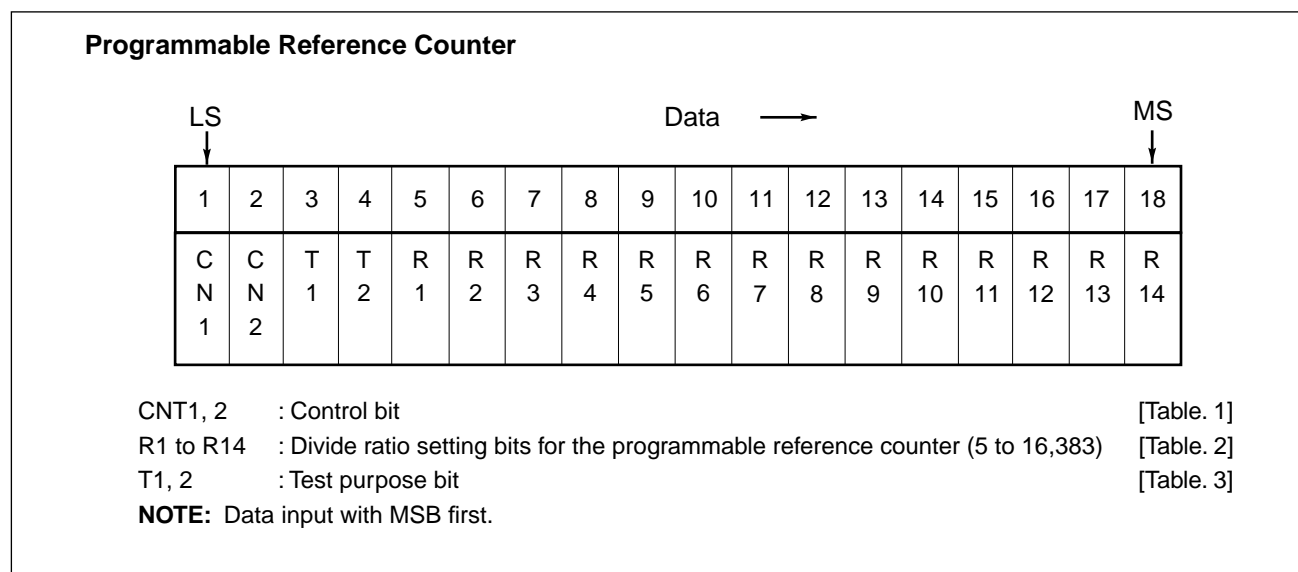
Serial data of binary data is entered through Data pin.

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.

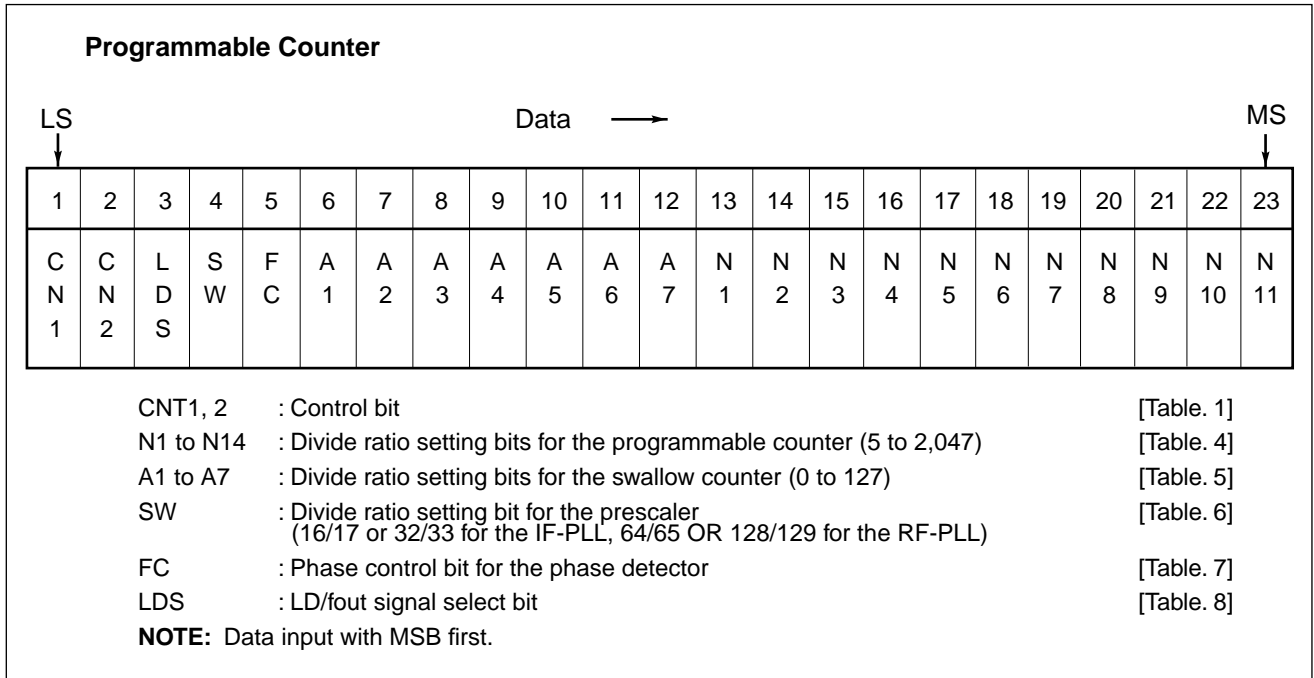
**Table1. Control Bit**

Control bit		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



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**Table2. Binary 14-bit Programmable Reference Counter Data Setting**

Divide ratio (R)	R 14	R 13	R 12	R 11	R 10	R 9	R 8	R 7	R 6	R 5	R 4	R 3	R 2	R 1
5	0	0	0	0	0	0	0	0	0	0	0	1	0	1
6	0	0	0	0	0	0	0	0	0	0	0	1	1	0
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
16383	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Note: • Divide ratio less than 5 is prohibited.

**Table.3 Test Purpose Bit Setting**

T 1	T 2	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 (A)	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

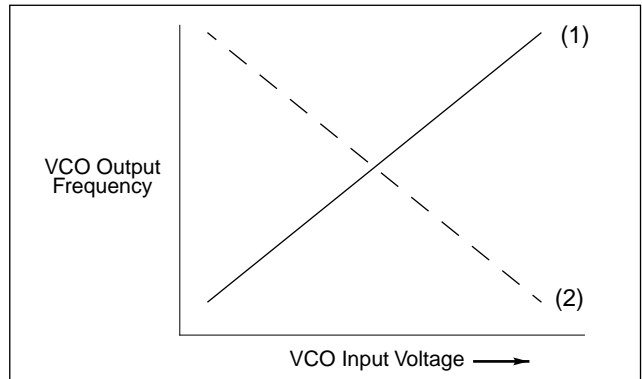
**Table. 6 Prescaler Data Setting**

		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	(1)	(2)

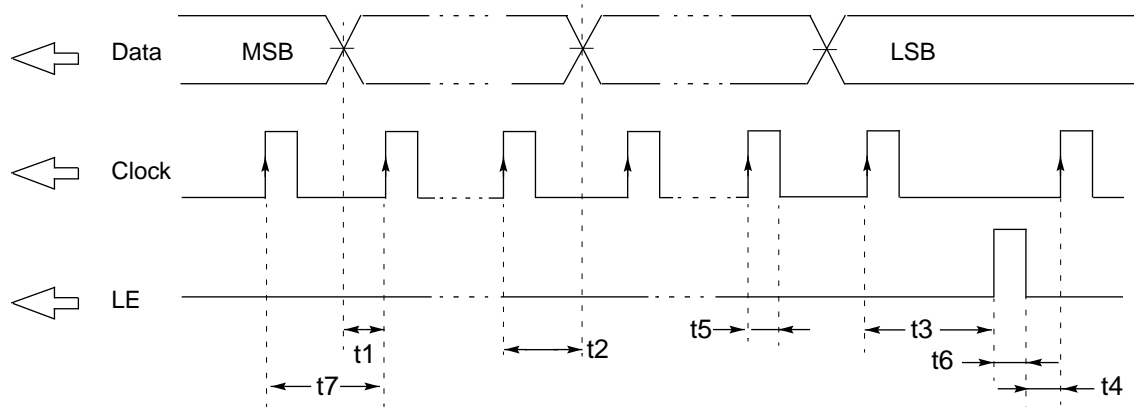
- Note:
- Z = High-impedance
  - Depending upon the VCO and LPF polarity, FC bit should be set.



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

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

## Serial Data Input Timing

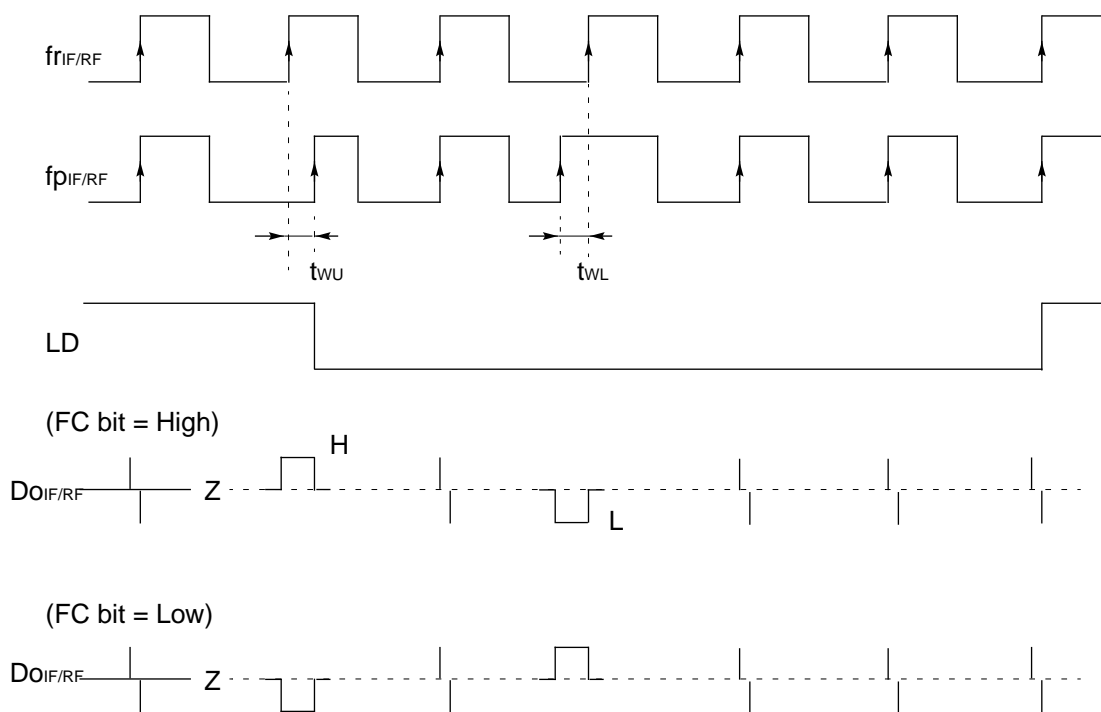


On rising edge of the clock, one bit of the data is transferred into the shift

Parameter	Min	Typ	Max	Unit
t1	20	–	–	ns
t2	20	–	–	ns
t3	30	–	–	ns
t4	20	–	–	ns

Parameter	Min	Typ	Max	Unit
t5	30	–	–	ns
t6	100	–	–	ns
t7	100	–	–	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  $D_{oIF/RF}$  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  $OSC_{in}$  input frequency as follows.
    - $t_{wU} \geq 8/f_{osc}$ : i.e.  $t_{wU} \geq 625ns$  when  $f_{osc} = 12.8$  MHz
    - $t_{wL} \leq 16/f_{osc}$ : i.e.  $t_{wL} \leq 1250ns$  when  $f_{osc} = 12.8$  MHz

## ■ POWER SAVING MODE (INTERMITTENT MODE CONTROL CIRCUIT)

Setting a PS<sub>IF(RF)</sub> pin to Low, IF-PLL (RF-PLL) enters into power saving mode resultant current consumption can be limited to 10μA (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 (fr) and comparison frequency (fp) 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.*

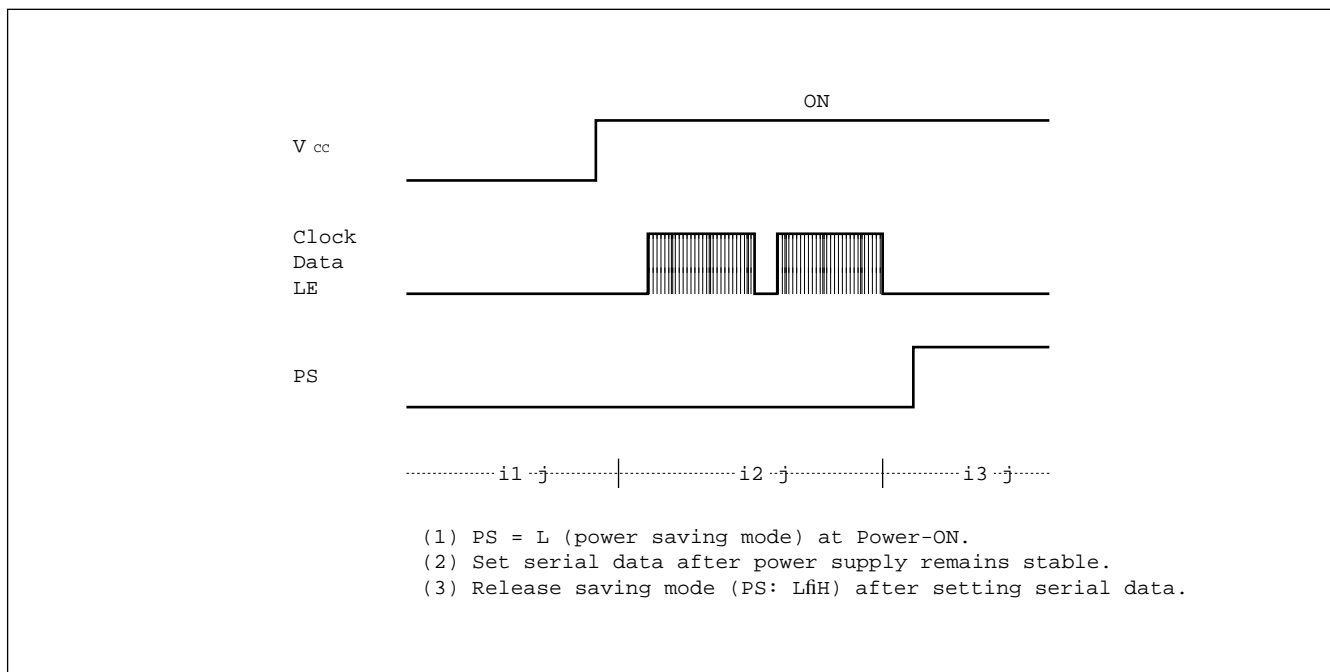
Allow 1 μs after frequency stabilization on power-up for exiting the power saving mode (PS: L to H)  
Serial data can be entered during the power saving mode.

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 10μA 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.

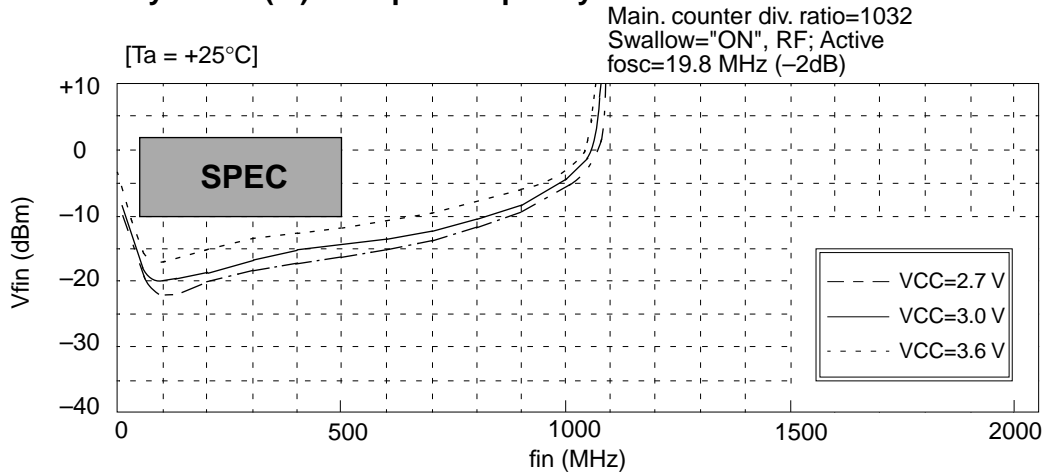
A VCO control voltage is naturally kept at the locking voltage which defined by a LPF's time constant. As a result of this, VCO's frequency is kept at the locking frequency.

PS <sub>IF</sub>	PS <sub>RF</sub>	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

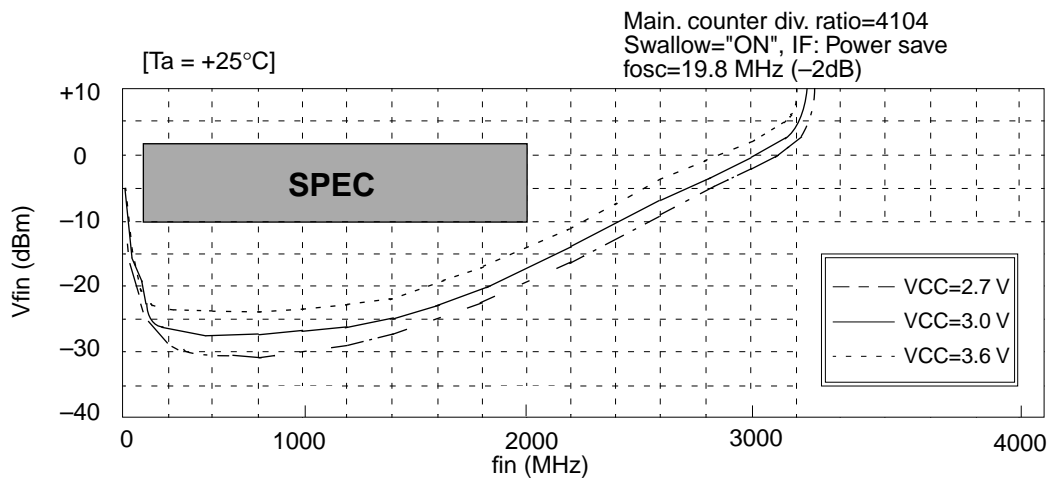


## ■ TYPICAL CHARACTERISTICS

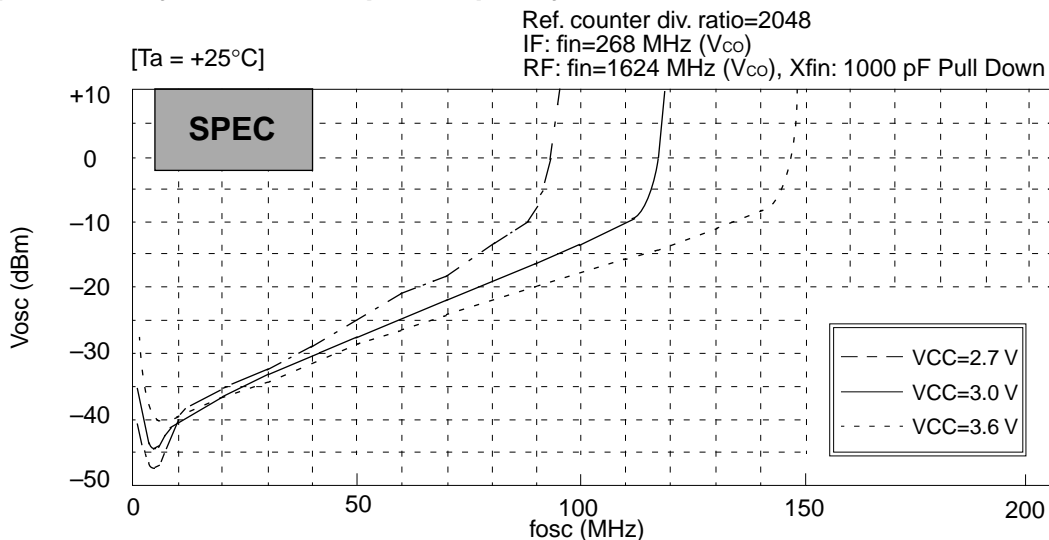
### Input sensitivity of FIN (IF) vs. Input Frequency



### Input sensitivity of FIN (RF) vs. Input Frequency



### Input sensitivity of OSC vs. Input Frequency

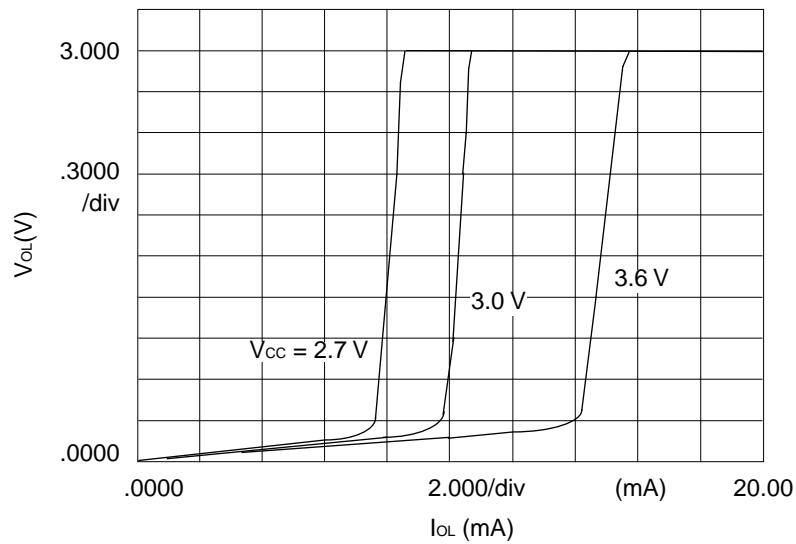
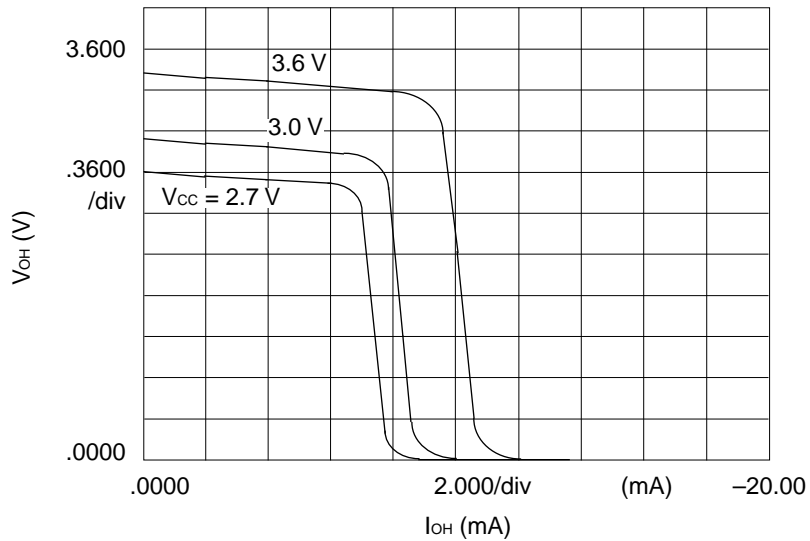


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## Do output Current

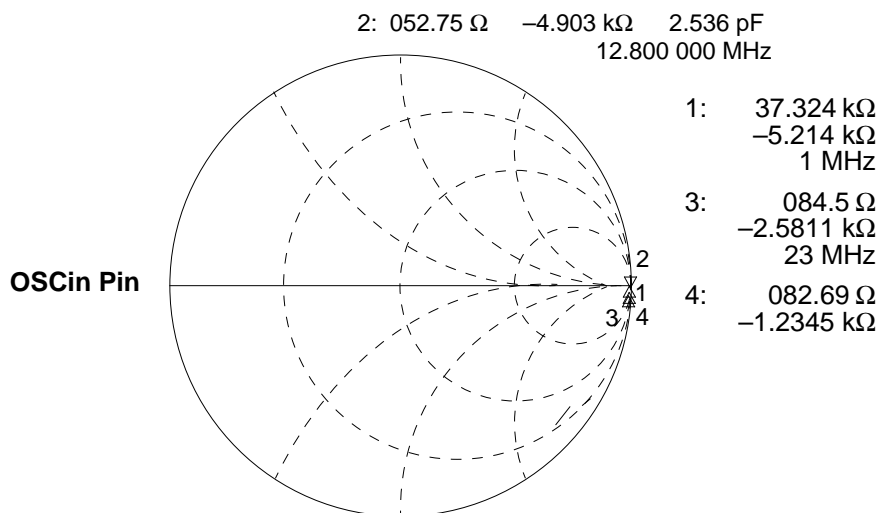
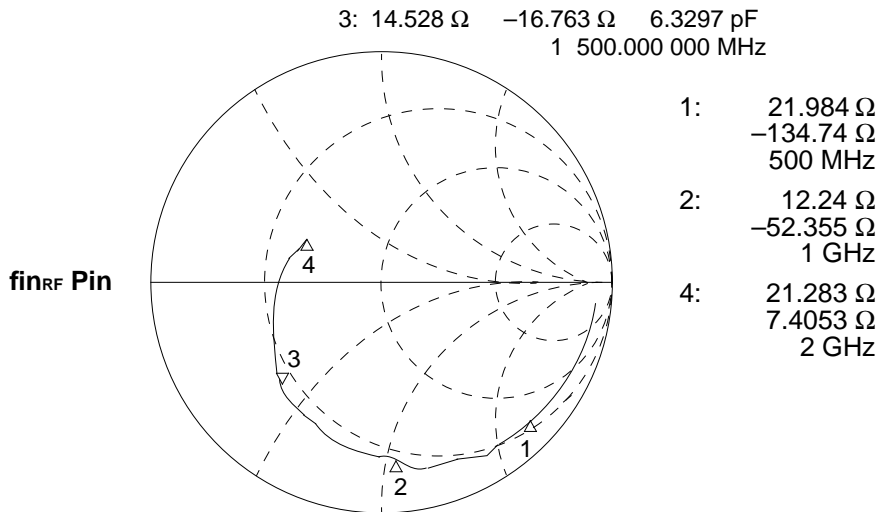
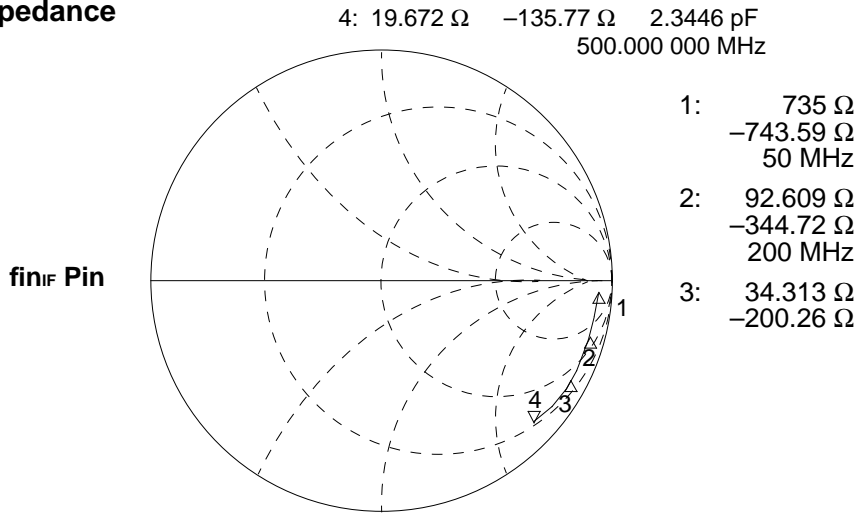
Conditions:  $T_a = +25^\circ\text{C}$   
 $V_{CC} = 2.7, 3.0, 3.6\text{ V}$



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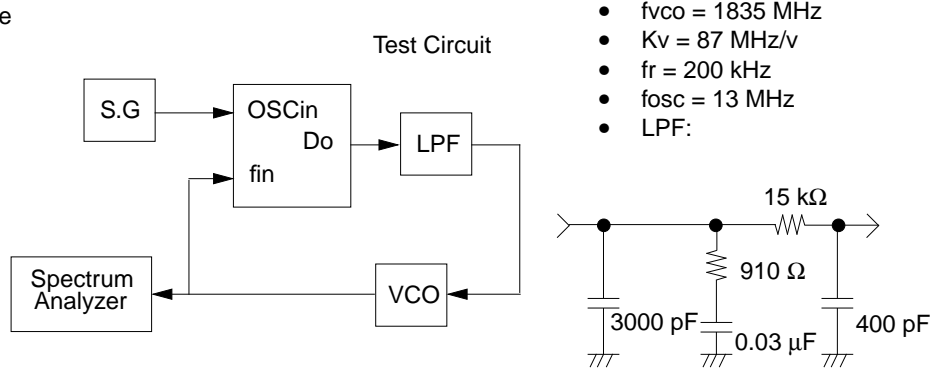
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## Input Impedance

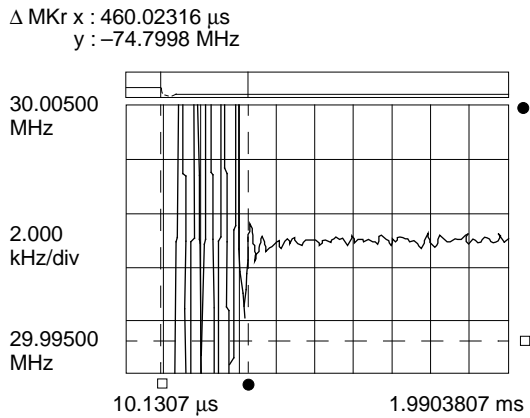


## REFERENCE INFORMATION

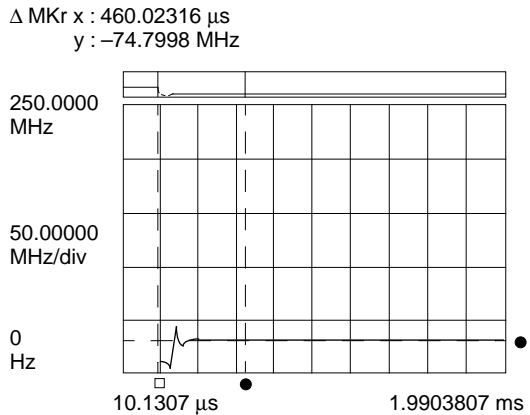
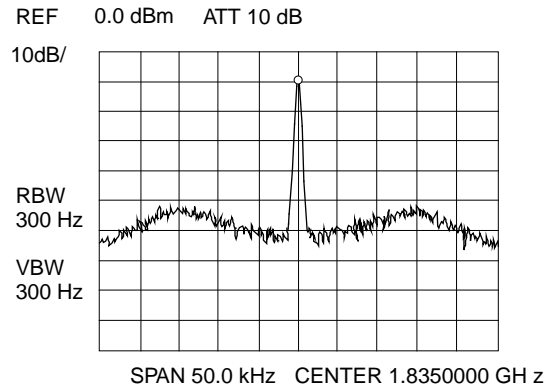
Typical plots measured with the test circuit are shown below. Each plot shows lock up time, phase noise and reference leakage.



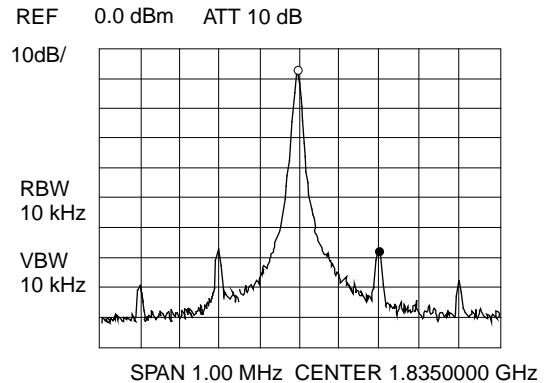
**PLL Lock Up Time = 460  $\mu\text{s}$**   
(1797.6 MHz  $\rightarrow$  1872.4 MHz, within  $\pm 1 \text{ kHz}$ )



**PLL Phase Noise**  
@ within loop band = 70.1 dBc/Hz

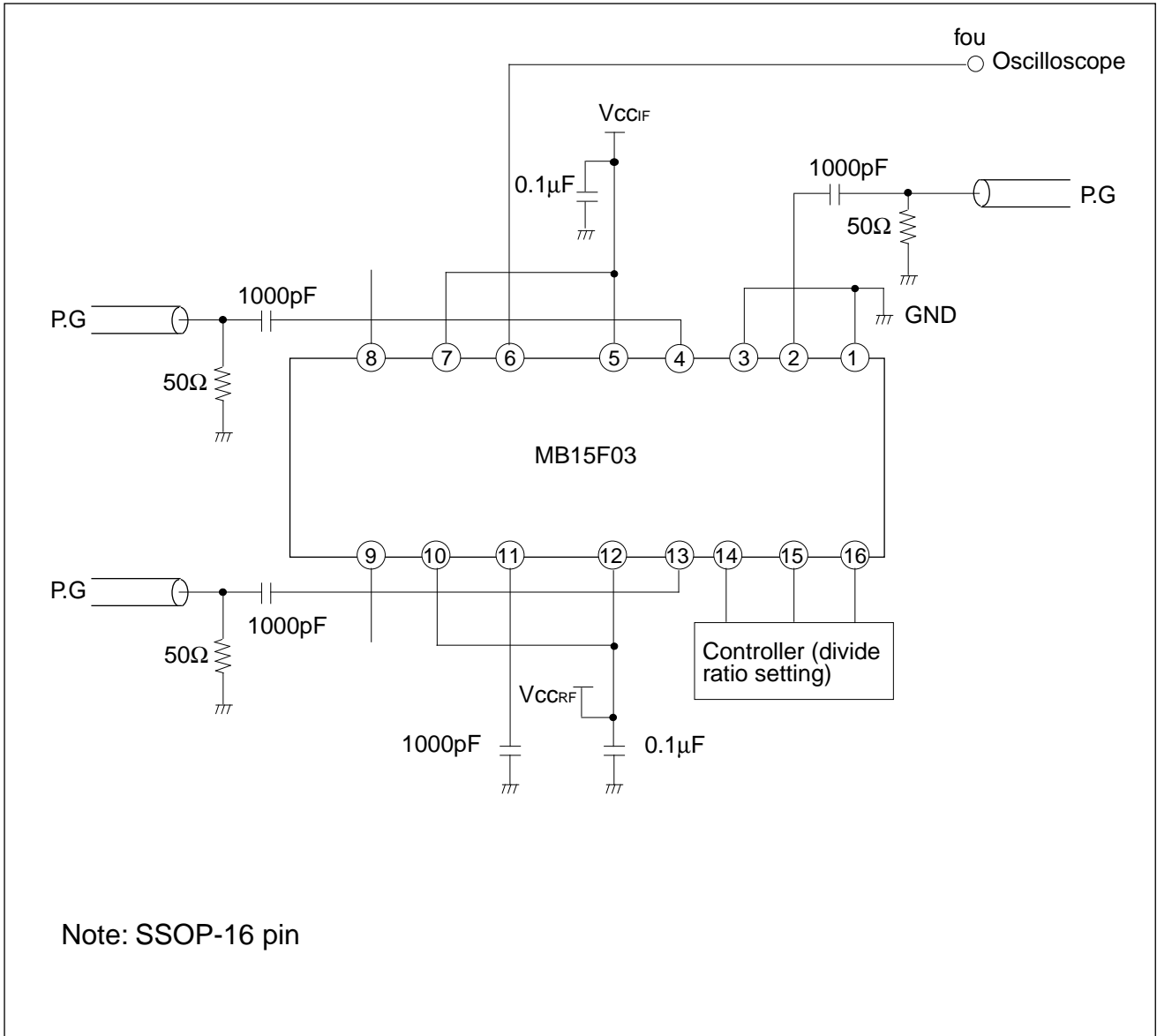


**PLL Reference Leakage**  
@ 200 kHz offset = 59 dBc



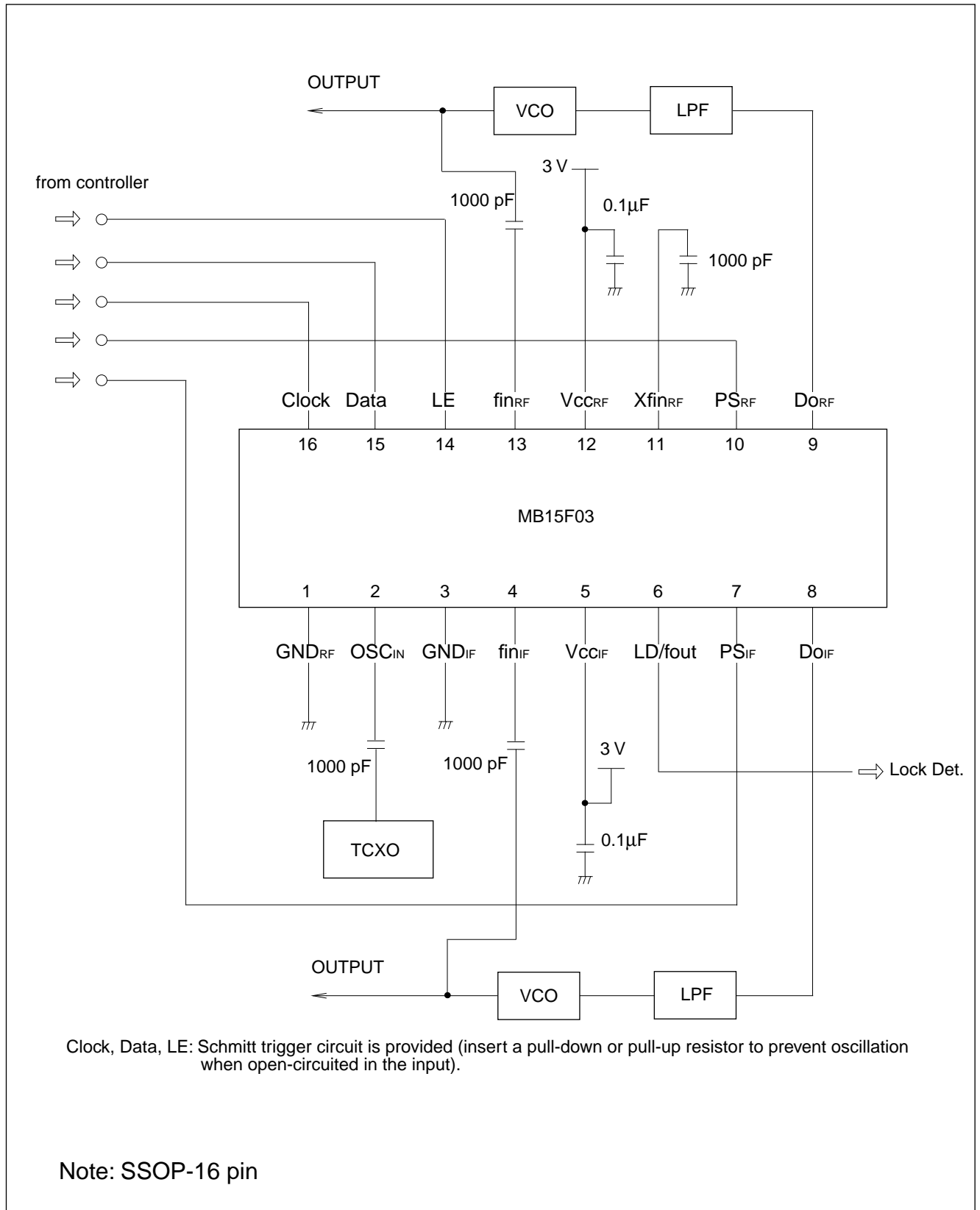


## ■ TEST CIRCUIT (Prescaler Input/programmable Reference Divider Input Sensitivity Test)



# MB15F03

## APPLICATION EXAMPLE



## ■ ORDERING INFORMATION

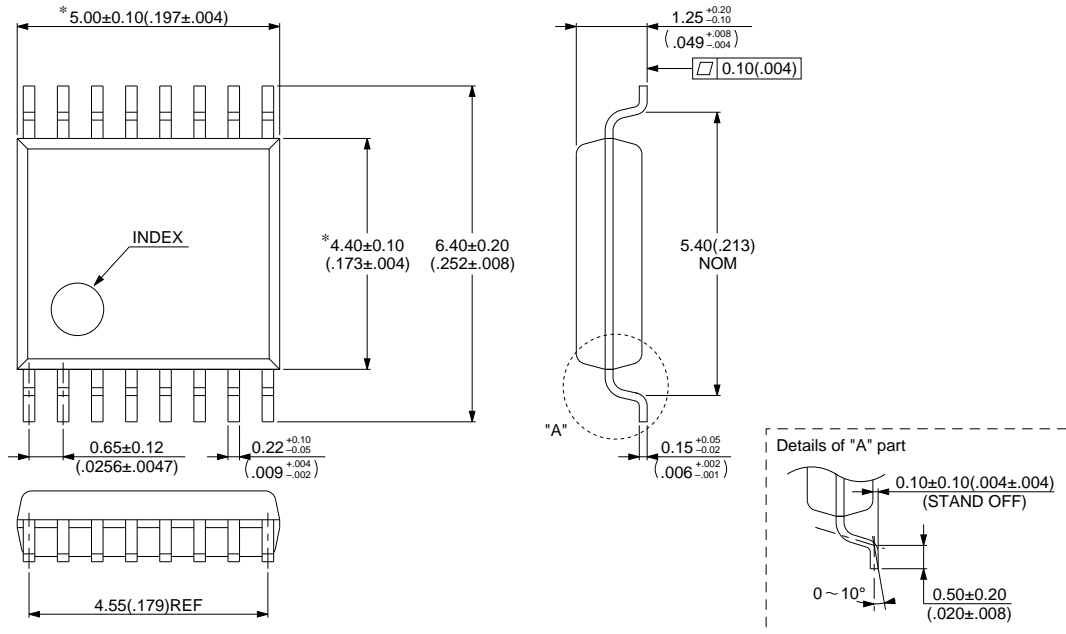
Part number	Package	Remarks
MB15F03 PFV	16 pin, Plastic SSOP (FPT-16P-M05)	
MB15F03 PV	16 pin, Plastic BCC (LCC-16P-M03)	

# MB15F03

## ■ PACKAGE DIMENSIONS

16 pins, Plastic SSOP  
(FPT-16P-M05)

\* : These dimensions do not include resin protrusion.

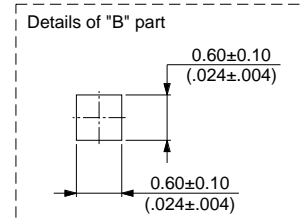
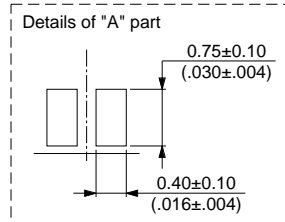
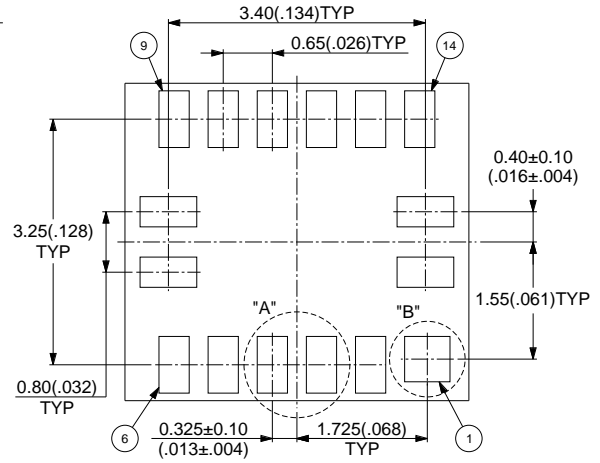
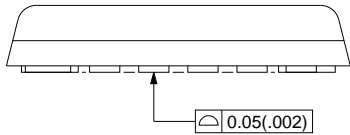
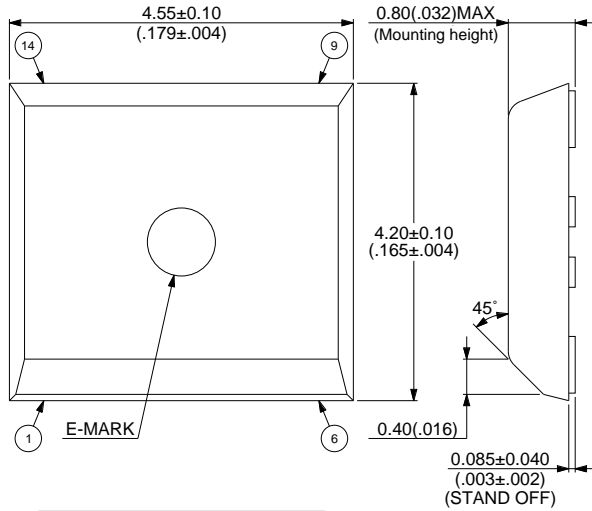


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Dimensions in mm (inches).

(Continued)

16-pin, Plastic BCC  
(LCC-16P-M03)



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Dimensions in mm (inches).

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