

ASSP

Dual Serial Input
PLL Frequency Synthesizer

MB15F78SP

■ DESCRIPTION

The Fujitsu MB15F78SP is a serial input Phase Locked Loop (PLL) frequency synthesizer with a 2550 MHz prescaler and a 1200 MHz prescaler. A 32/33 or a 64/65 for the 2550 MHz prescaler, and a 16/17 or a 32/33 for the 1200 MHz prescaler can be selected for the prescaler that enables pulse swallow operation.

The BiCMOS process is used, as a result a supply current is typically 5.5 mA at 2.7 V. The supply voltage range is from 2.4 V to 3.6 V. A refined charge pump supplies well-balanced output current with 1.5 mA and 6 mA selectable by serial data.

The new package (BCC20) decreases an area of MB15F78SP more than 30 % comparing with the former BCC16 (for dual PLL).

MB15F78SP is ideally suited for wireless mobile communications, such as GSM.

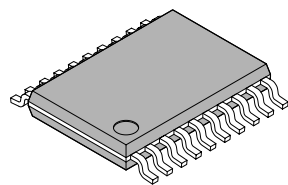
■ FEATURES

- High frequency operatio : RX synthesizer : 2550 MHz max
: TX synthesizer : 1200 MHz max
- Low power supply voltage : $V_{CC} = 2.4$ to 3.6 V
- Ultra Low power supply current : $I_{CC} = 5.5$ mA typ.
($V_{CC} = V_p = 2.7$ V, $T_a = +25^\circ\text{C}$, $SW_{TX} = SW_{RX} = 0$, in TX/RX locking state)
- Direct power saving function : Power supply current in power saving mode
Typ. $0.1 \mu\text{A}$ ($V_{CC} = V_p = 2.7$ V, $T_a = +25^\circ\text{C}$), Max. $10 \mu\text{A}$ ($V_{CC} = V_p = 2.7$ V)
- Software selectable charge pump current: 1.5 mA/6.0 mA typ.

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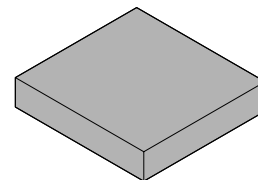
■ PACKAGES

20-pin plastic TSSOP



(FPT-20P-M06)

20-pad plastic BCC



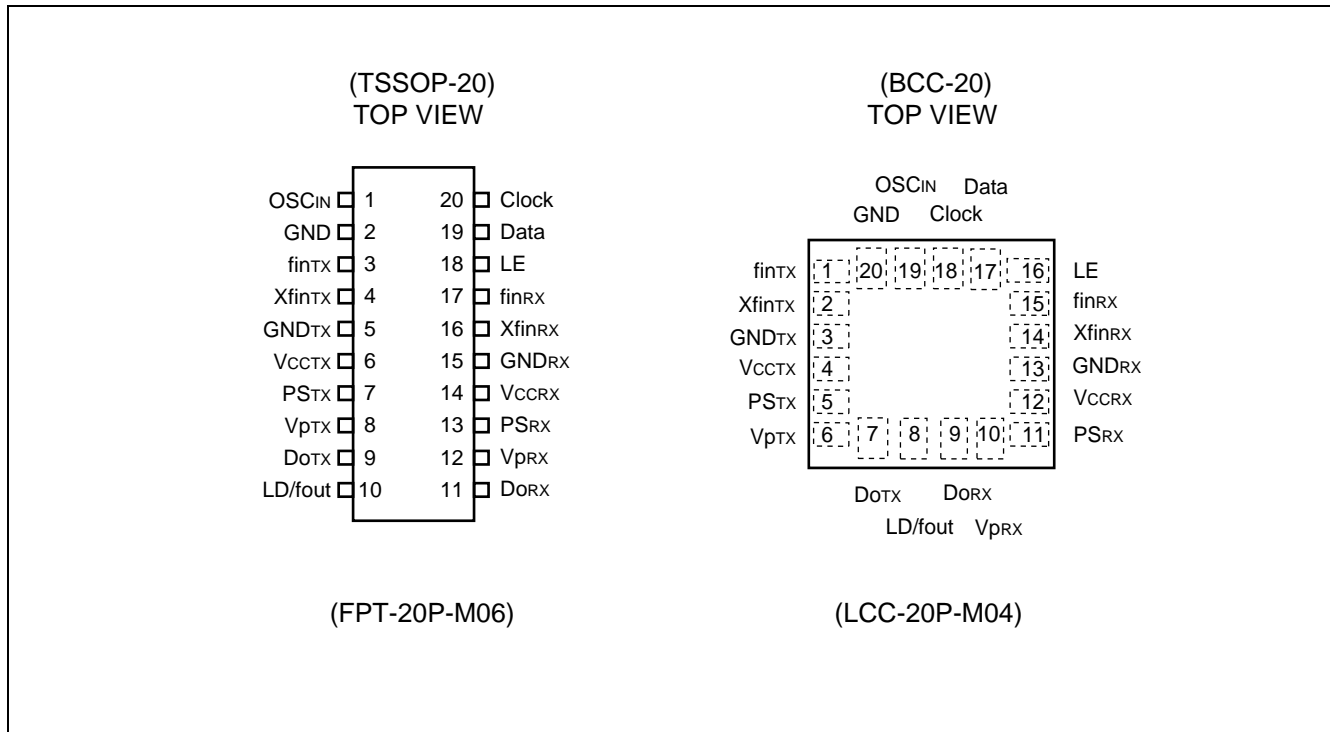
(LCC-20P-M04)

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- Dual modulus prescaler : 2550 MHz prescaler (32/33 or 64/65)/1200 MHz prescaler (16/17 or 32/33)
- 23-bit shift register
- Serial input binary 14-bit programmable reference divider : R = 3 to 16,383
- Serial input programmable divider consisting of:
 - Binary 7-bit swallow counter : 0 to 127
 - Binary 11-bit programmable counter: 3 to 2,047
- Built-in high-speed tuning, low-noise phase comparator, current-switching type constant current circuit
- On-chip phase control for phase comparator
- Built-in digital locking detector circuit to detect PLL locking and unlocking
- Operating temperature : Ta = -40 to +85°C
- Sireal data format compatible with MB15F08SL

■ PIN ASSIGNMENTS

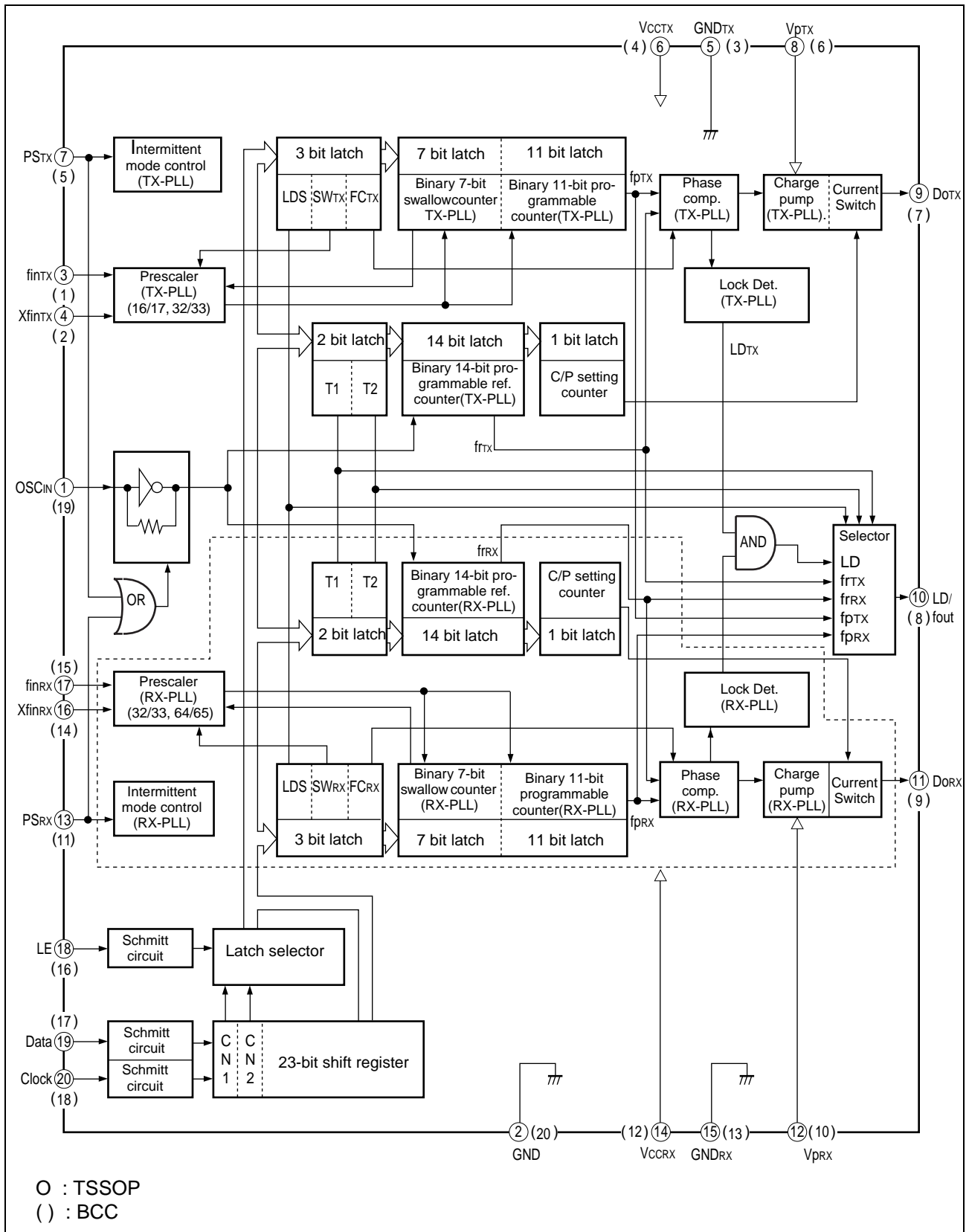


■ PIN DESCRIPTION

Pin no.		Pin name	I/O	Descriptions
TSSOP	BCC			
1	19	OSC _{IN}	I	The programmable reference divider input. TCX0 should be connected with a AC coupling capacitor.
2	20	GND	—	Ground for OSC input buffer and the shift register circuit.
3	1	fin _{TX}	I	Prescaler input pin for the TX-PLL. Connection to an external VCO should be via AC coupling.
4	2	Xfin _{TX}	I	Prescaler complimentary input pin for the TX-PLL section. This pin should be grounded via a capacitor.
5	3	GND _{TX}	—	Ground for the TX-PLL section.
6	4	V _{CC} _{TX}	—	Power supply voltage input pin for the TX-PLL section(except for the charge pump circuit), the oscillator input buffer and the shift register.
7	5	PS _{TX}	I	Power saving mode control for the TX-PLL section. This pin must be set at "L" Power-ON. (Open is prohibited.) PS _{TX} = "H" ; Normal mode / PS _{TX} = "L" ; Power saving mode
8	6	V _p _{TX}	—	Power supply voltage input pin for the TX-PLL charge pump.
9	7	D _{OT} _{TX}	O	Charge pump output for the TX-PLL section.
10	8	LD/fout	O	Lock detect signal output (LD)/phase comparator monitoring output (fout).The output signal is selected by LDS bit in the serial data. LDS bit = "H" ; outputs fout signal / LDS bit = "L" ; outputs LD signal
11	9	D _{OR} _{TX}	O	Charge pump output for the RX-PLL section.
12	10	V _p _{RX}	—	Power supply voltage input pin for the RX-PLL charge pump.
13	11	PS _{RX}	I	Power saving mode control for the RX-PLL section. This pin must be set at "L" Power-ON. (Open is prohibited.) PS _{RX} = "H" ; Normal mode / PS _{RX} = "L" ; Power saving mode
14	12	V _{CC} _{RX}	—	Power supply voltage input pin for the RX-PLL section(except for the charge pump circuit).
15	13	GND _{RX}	—	Ground for the RX-PLL section.
16	14	Xfin _{RX}	I	Prescaler complimentary input pin for the RX-PLL section. This pin should be grounded via a capacitor.
17	15	fin _{RX}	I	Prescaler input pin for the RX-PLL. Connection to an external VCO should be via AC coupling.
18	16	LE	I	Load enable signal input(with the schmitt trigger circuit). When LE is set "H", data in the shift register is transferred to the corresponding latch according to the control bit in a serial data.
19	17	Data	I	Serial data input(with the schmitt trigger circuit). A data is transferred to the corresponding latch(TX-ref. counter, TX-prog. counter, RX-ref.counter, RX-prog.counter) according to the control bit in a serial data.
20	18	Clock	I	Clock input for the 23-bit shift register (with a schmitt trigger circuit). One bit of data is shifted into the shift register on a rising edge of the clock.

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■ BLOCK DIAGRAM



■ ABSOLUTE MAXIMUM RATINGS

Parameter		Symbol	Rating		Unit
			Min.	Max.	
Power supply voltage		V _{CC}	-0.5	4.0	V
		V _p	V _{CC}	4.0	V
Input voltage		V _I	-0.5	V _{CC} + 0.5	V
Output voltage	LD/fout	V _O	GND	V _{CC}	V
	D _{OTX} , D _{ORX}	V _{DD}	GND	V _p	V
Storage temperature		T _{stg}	-55	+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
			Min.	Typ.	Max.	
Power supply voltage		V _{CC}	2.4	2.7	3.6	V
		V _p	V _{CC}	2.7	3.6	V
Input voltage		V _I	GND	—	V _{CC}	V
Operating temperature		T _a	-40	—	+85	°C

WARNING: The recommended operating conditions are required in order to ensure the normal operation of the semiconductor device. All of the device's electrical characteristics are warranted when the device is operated within these ranges.

Always use semiconductor devices within their recommended operating condition ranges. 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 representatives beforehand.

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■ ELECTRICAL CHARACTERISTICS

($V_{CC} = 2.4\text{ V to }3.6\text{ V}$, $T_a = -40\text{ }^\circ\text{C to }+85\text{ }^\circ\text{C}$)

Parameter	Symbol	Condition	Value			Unit	
			Min.	Typ.	Max.		
Power supply current	I_{CCTX}^{*1}	TX PLL	—	2.2	—	mA	
	I_{CCRX}^{*2}	RX PLL	—	3.3	—	mA	
Power saving current	I_{PSTX}	$PS_{TX} = PS_{RX} = \text{"L"}$	—	0.1^{*8}	10	μA	
	I_{PSRX}	$PS_{TX} = PS_{RX} = \text{"L"}$	—	0.1^{*8}	10	μA	
Operating frequency	f_{inTX}^{*3}	f_{inTX}	TX PLL	50	—	1200	MHz
	f_{inRX}^{*3}	f_{inRX}	RX PLL	400	—	2550^{*9}	MHz
	OSC _{IN}	f_{OSC}	—	3	—	40	MHz
Input sensitivity	f_{inTX}	P_{finTX}	TX PLL, 50 Ω system	-15	—	+2	dBm
	f_{inRX}	P_{finRX}	RX PLL, 50 Ω system	-15^{*9}	—	+2	dBm
	OSC _{IN}	V_{OSC}	—	0.5	—	V_{CC}	V_{P-P}
"H" level input voltage	Data, LE, Clock	V_{IH}	Schmitt trigger input	$0.7 V_{CC} + 0.4$	—	—	V
"L" level input voltage		V_{IL}	Schmitt trigger input	—	—	$0.3 V_{CC} - 0.4$	V
"H" level input voltage	PS_{TX}	V_{IH}	—	$0.7 V_{CC}$	—	—	V
"L" level input voltage	PS_{RX}	V_{IL}	—	—	—	$0.3 V_{CC}$	V
"H" level input current	Data LE Clock	I_{IH}^{*4}	—	-1.0	—	+1.0	μA
"L" level input current		I_{IL}^{*4}	—	-1.0	—	+1.0	μA
"H" level input current	OSC _{IN}	I_{IH}	—	0	—	+100	μA
"L" level input current		I_{IL}^{*4}	—	-100	—	0	μA
"H" level output voltage	LD/fout	V_{OH}	$V_{CC} = V_p = 2.7\text{ V}$, $I_{OH} = -1\text{ mA}$	$V_{CC} - 0.4$	—	—	V
"L" level output voltage		V_{OL}	$V_{CC} = V_p = 2.7\text{ V}$, $I_{OL} = 1\text{ mA}$	—	—	0.4	V
"H" level output voltage	DO _{TX} DO _{RX}	V_{DOH}	$V_{CC} = V_p = 2.7\text{ V}$, $I_{DOH} = -0.5\text{ mA}$	$V_p - 0.4$	—	—	V
"L" level output voltage		V_{DOL}	$V_{CC} = V_p = 2.7\text{ V}$, $I_{DOL} = 0.5\text{ mA}$	—	—	0.4	V
High impedance cutoff current	DO _{TX} DO _{RX}	I_{OFF}	$V_{CC} = V_p = 2.7\text{ V}$ $V_{OFF} = 0.5\text{ V to }V_p - 0.5\text{ V}$	—	—	2.5	nA
"H" level output current	LD/fout	I_{OH}^{*4}	$V_{CC} = V_p = 2.7\text{ V}$	—	—	-1.0	mA
"L" level output current		I_{OL}	$V_{CC} = V_p = 2.7\text{ V}$	1.0	—	—	mA

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($V_{CC} = 2.4 \text{ V to } 3.6 \text{ V}$, $T_a = -40 \text{ }^\circ\text{C to } +85 \text{ }^\circ\text{C}$)

Parameter		Symbol	Condition	Value			Unit	
				Min.	Typ.	Max.		
“H” level output current	D_{OTX}	I_{DOH}^{*4}	$V_{CC} = V_p = 2.7 \text{ V}$, $V_{DOH} = V_p/2$, $T_a = +25 \text{ }^\circ\text{C}$	CS bit = “H”	—	-6.0	—	mA
	D_{ORX}			CS bit = “L”	—	-1.5	—	mA
“L” level output current	D_{OTX}	I_{DOL}	$V_{CC} = V_p = 2.7 \text{ V}$, $V_{DOL} = V_p/2$, $T_a = +25 \text{ }^\circ\text{C}$	CS bit = “H”	—	6.0	—	mA
	D_{ORX}			CS bit = “L”	—	1.5	—	mA
Charge pump current rate	I_{DOL}/I_{DOH}	I_{DOMT}^{*5}	$V_{DO} = V_p / 2$	—	3	—	%	
	vs V_{DO}	I_{DOVD}^{*6}	$0.5 \text{ V} \leq V_{DO} \leq V_p - 0.5 \text{ V}$	—	10	—	%	
	vs T_a	I_{DOTA}^{*7}	$-40 \text{ }^\circ\text{C} \leq T_a \leq +85 \text{ }^\circ\text{C}$, $V_{DO} = V_p / 2$	—	10	—	%	

*1 : $f_{inTX} = 910 \text{ MHz}$, $f_{osc} = 12.8 \text{ MHz}$, $V_{CCTX} = V_{pTX} = 2.7 \text{ V}$, $SW_{TX} = 0$, $T_a = +25 \text{ }^\circ\text{C}$, in locking state.

*2 : $f_{inRX} = 2500 \text{ MHz}$, $f_{osc} = 12.8 \text{ MHz}$, $V_{CCRX} = V_{pRX} = 2.7 \text{ V}$, $SW_{RX} = 0$, $T_a = +25 \text{ }^\circ\text{C}$, in locking state.

*3 : AC coupling. 1000 pF capacitor is connected under the condition of minimum operating frequency.

*4 : The symbol “-” (minus) means direction of current flow.

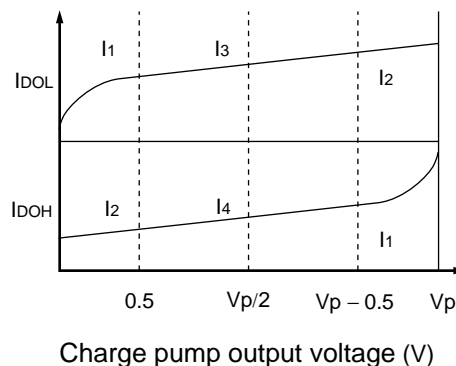
*5 : $V_{CC} = V_p = 2.7 \text{ V}$, $T_a = +25 \text{ }^\circ\text{C}$
 $(|I_3| - |I_4|) / [(|I_3| + |I_4|) / 2] \times 100 \text{ (\%)}$

*6 : $V_{CC} = V_p = 2.7 \text{ V}$, $T_a = +25 \text{ }^\circ\text{C}$ (Applied to each I_{DOL} , I_{DOH})
 $[(|I_2| - |I_1|) / 2] / [(|I_1| + |I_2|) / 2] \times 100 \text{ (\%)}$

*7 : $V_{CC} = V_p = 2.7 \text{ V}$, $T_a = +25 \text{ }^\circ\text{C}$ (Applied to each I_{DOL} , I_{DOH})
 $[|I_{DO(+85^\circ\text{C})}| - |I_{DO(-40^\circ\text{C})}|] / [(|I_{DO(+85^\circ\text{C})}| + |I_{DO(-40^\circ\text{C})}|) / 2] \times 100 \text{ (\%)}$

*8 : $f_{osc} = 12.8 \text{ MHz}$, $V_{CCRX} = V_{pRX} = V_{CCTX} = V_{pTX} = 2.7 \text{ V}$, $T_a = +25 \text{ }^\circ\text{C}$

*9 : 2500 MHz to 2550 MHz, $V_{CC} = 2.7 \text{ V to } 3.6 \text{ V}$, $P_{finmin} = -10 \text{ dBm}$



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■ FUNCTIONAL DESCRIPTION

1. Pulse swallow function

$$f_{vco} = [(P \times N) + A] \times f_{osc} \div R$$

- f_{vco} : Output frequency of external voltage controlled oscillator (VCO)
- P : Preset divide ratio of dual modulus prescaler (16 or 32 for TX-PLL, 32 or 64 for RX-PLL)
- N : Preset divide ratio of binary 11-bit programmable counter (3 to 2,047)
- A : Preset divide ratio of binary 7-bit swallow counter ($0 \leq A \leq 127$, $A < N$)
- f_{osc} : Reference oscillation frequency (OSC_{IN} input frequency)
- R : Preset divide ratio of binary 14-bit programmable reference counter (3 to 16,383)

2. Serial Data Input

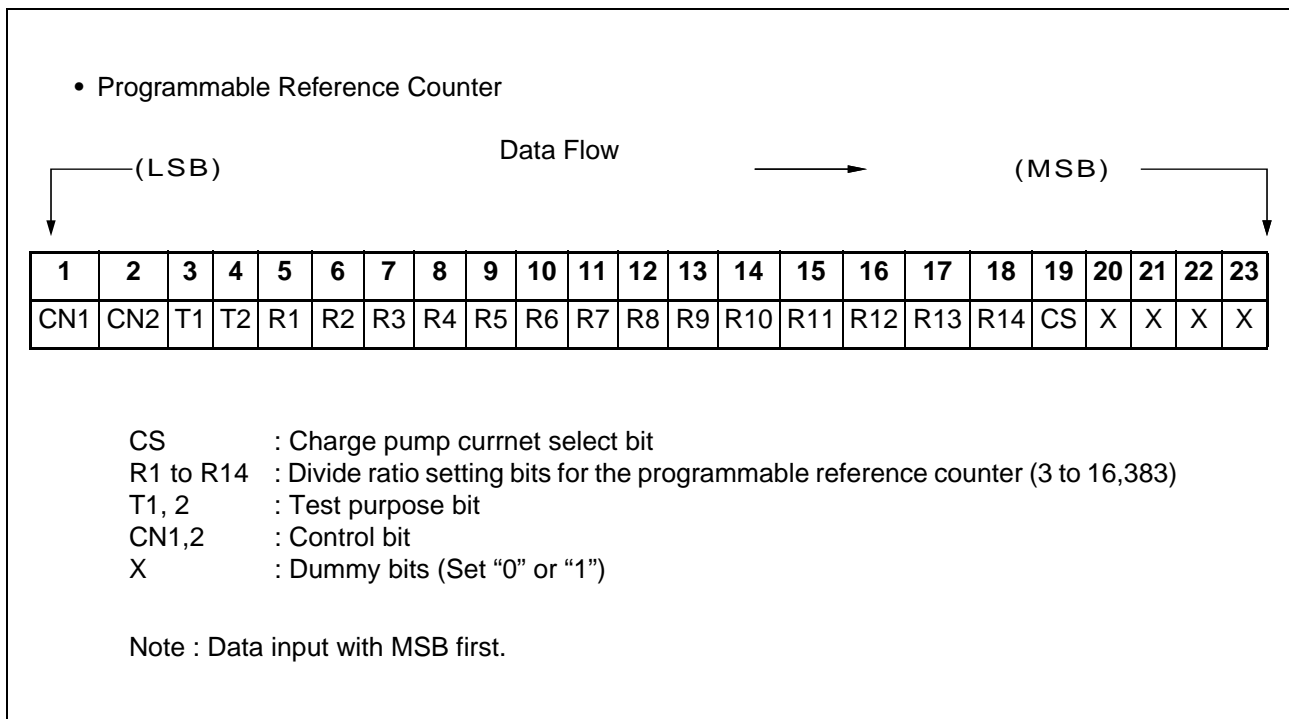
Serial data is entered using three pins, Data pin, Clock pin, and LE pin. Programmable dividers of TX/RX-PLL sections, programmable reference dividers of TX/RX-PLL sections are controlled individually.

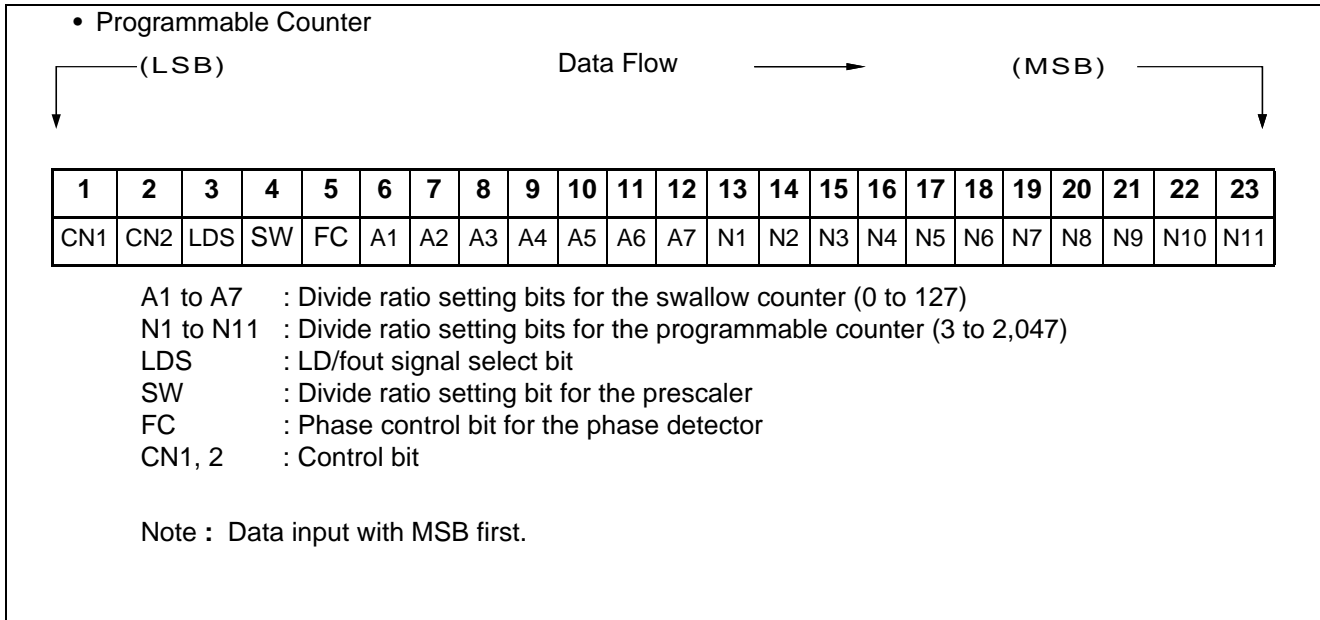
Serial data of binary data is entered through Data pin.

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

	The programmable reference counter for the TX-PLL	The programmable reference counter for the RX-PL	The programmable counter and the swallow counter for the TX-PLL	The programmable counter and the swallow counter for the RX-PLL
CN1	0	1	0	1
CN2	0	0	1	1

(1) Shift Register Configuration





(2) Data setting

• Binary 14-bit Programmable Reference Counter Data Setting

Divide ratio	R14	R13	R12	R11	R10	R9	R8	R7	R6	R5	R4	R3	R2	R1
3	0	0	0	0	0	0	0	0	0	0	0	0	1	1
4	0	0	0	0	0	0	0	0	0	0	0	1	0	0
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
16383	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Note : Divide ratio less than 3 is prohibited.

• Binary 11-bit Programmable Counter Data Setting

Divide ratio	N11	N10	N9	N8	N7	N6	N5	N4	N3	N2	N1
3	0	0	0	0	0	0	0	0	0	1	1
4	0	0	0	0	0	0	0	0	1	0	0
•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•
2047	1	1	1	1	1	1	1	1	1	1	1

Note : Divide ratio less than 3 is prohibited.

• Binary 7-bit Swallow Counter Data Setting

Divide ratio	A7	A6	A5	A4	A3	A2	A1
0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	1
•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•
127	1	1	1	1	1	1	1

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- Prescaler Data Setting

Divide ratio	SW = "H"	SW = "L"
Prescaler divide ratio TX-PLL	16/17	32/33
Prescaler divide ratio RX-PLL	32/33	64/65

- Charge Pump Current Setting

Current value	CS
±6.0 mA	1
±1.5 mA	0

- LD/fout Output Select Data Setting

LD/fout output signal	LDS
fout signal	1
LD signal	0

- Test Purpose Bit Setting

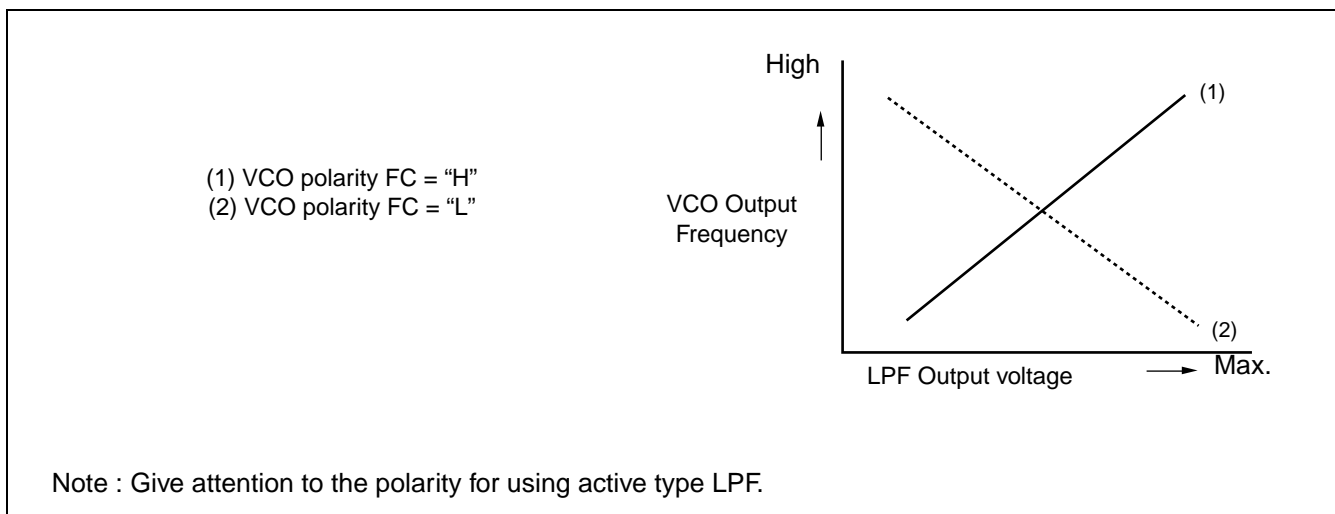
LD/fout pin state	T1	T2
Outputs fr _{TX} .	0	0
Outputs fr _{RX} .	1	0
Outputs fp _{TX} .	0	1
Outputs fp _{RX} .	1	1

- Phase Comparator Phase Switching Data Setting

Phase comparator input	FC = "H"	FC = "L"
	Do _{TX} /Do _{RX}	Do _{TX} /Do _{RX}
fr > fp	H	L
fr < fp	L	H
fr = fp	Z	Z

Z : High-impedance

Depending upon the VCO and LPF polarity, FC bit should be set.



3. Power Saving Mode (Intermittent Mode Control Circuit)

Status	PS _{TX} /PS _{RX} pins
Normal mode	H
Power saving mode	L

The intermittent mode control circuit reduces the PLL power consumption.

By setting the PS pins low, the device enters into the power saving mode, reducing the current consumption. See the Electrical Characteristics chart for the specific value.

The phase detector output, Do, becomes high impedance.

For the dual PLL, the lock detector, LD, is as shown in the LD Output Logic table.

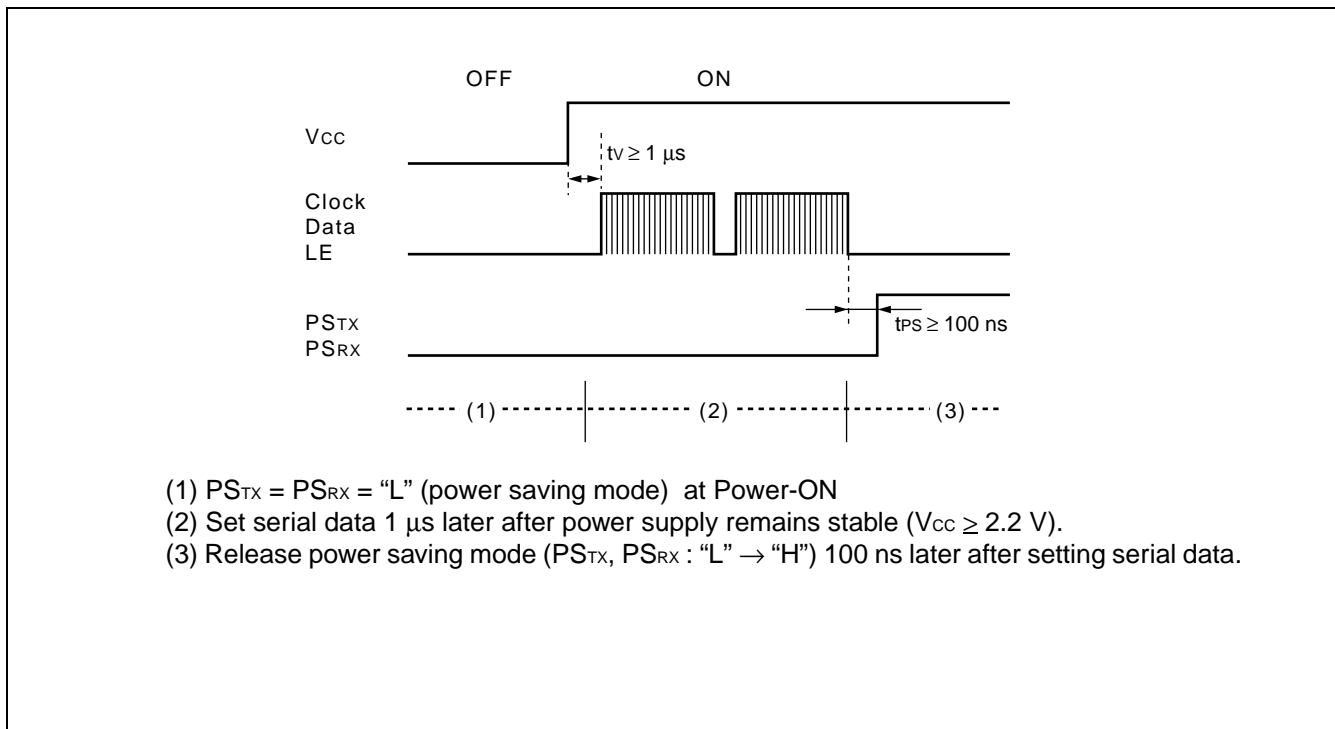
Setting the PS pins high, releases the power saving mode, and the device works normally.

The intermittent mode control circuit also ensures a smooth startup when the device returns to normal operation. When the PLL is returned to normal operation, the phase comparator output signal is unpredictable. This is because of the unknown relationship between the comparison frequency (f_p) and the reference frequency (f_r) which can cause a major change in the comparator output, resulting in a VCO frequency jump and an increase in lockup time.

To prevent a major VCO frequency jump, the intermittent mode control circuit limits the magnitude of the error signal from the phase detector when it returns to normal operation.

Notes: •When power (V_{CC}) is first applied, the device must be in standby mode, PS_{TX} = PS_{RX} = Low, for at least 1 μ s.

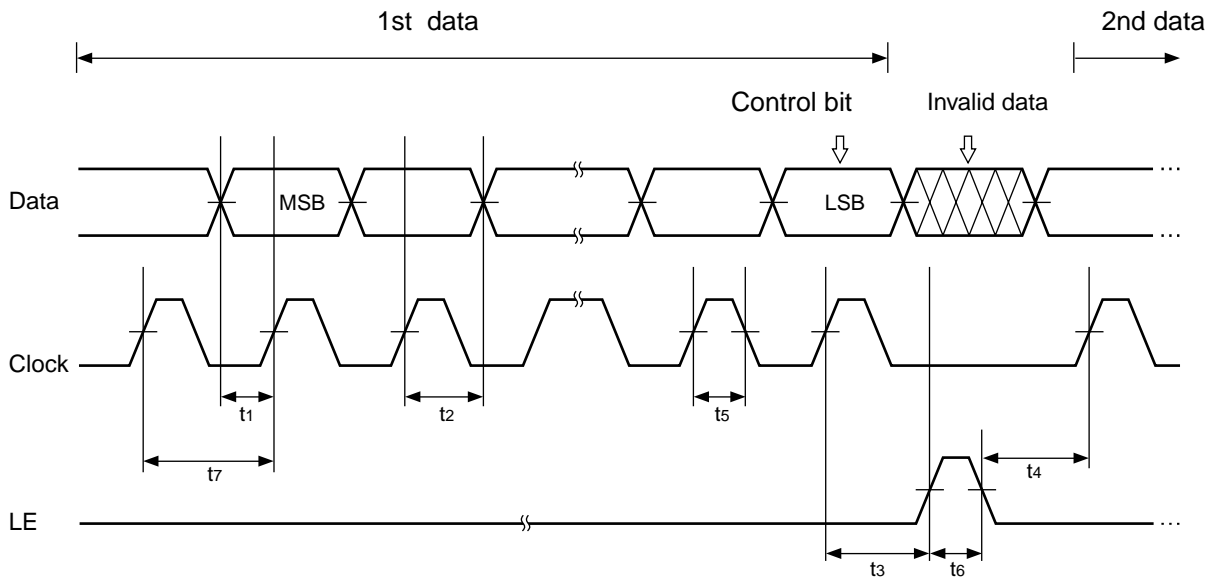
•PS pins must be set at “L” for Power-ON



4. Serial data input timing

Frequency multiplier setting is performed through a serial interface using the Data pin, Clock pin, and LE pin.

Setting data is read into the shift register at the rise of the clock signal, and transferred to a latch at the rise of the LE signal. The following diagram shows the data input timing.

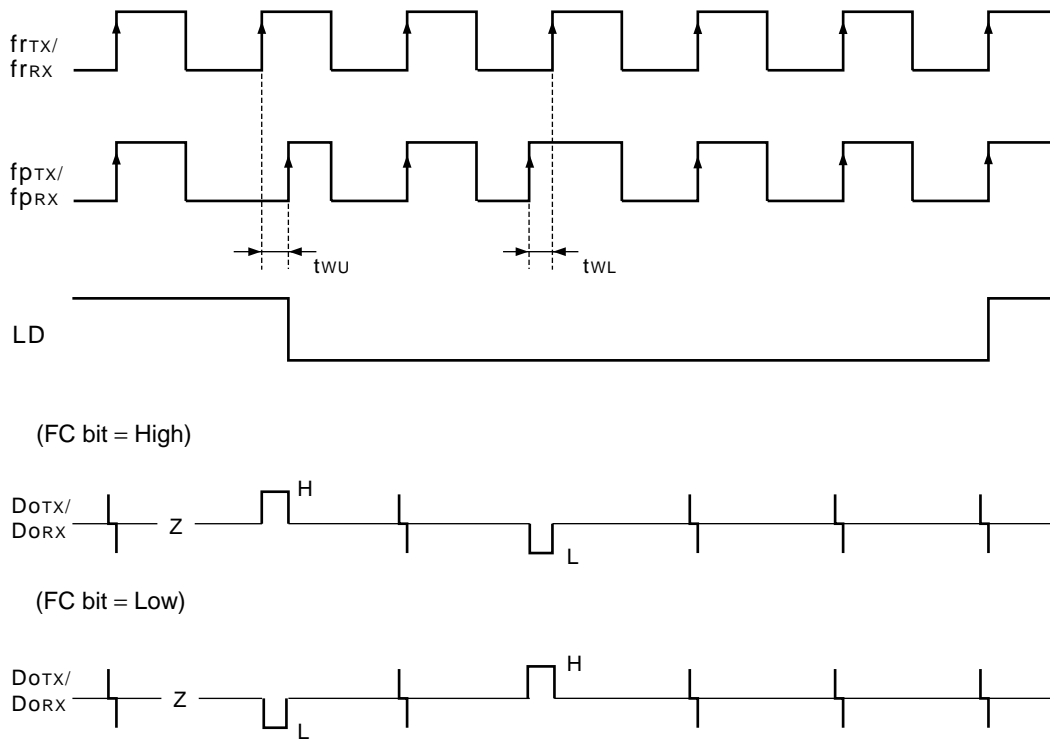


Parameter	Min.	Typ.	Max.	Unit
t ₁	20	—	—	ns
t ₂	20	—	—	ns
t ₃	30	—	—	ns
t ₄	20	—	—	ns

Parameter	Min.	Typ.	Max.	Unit
t ₅	30	—	—	ns
t ₆	100	—	—	ns
t ₇	100	—	—	ns

Note : LE should be “L” when the data is transferred into the shift register.

■ PHASE COMPARATOR OUTPUT WAVEFORM



LD Output Logic Table

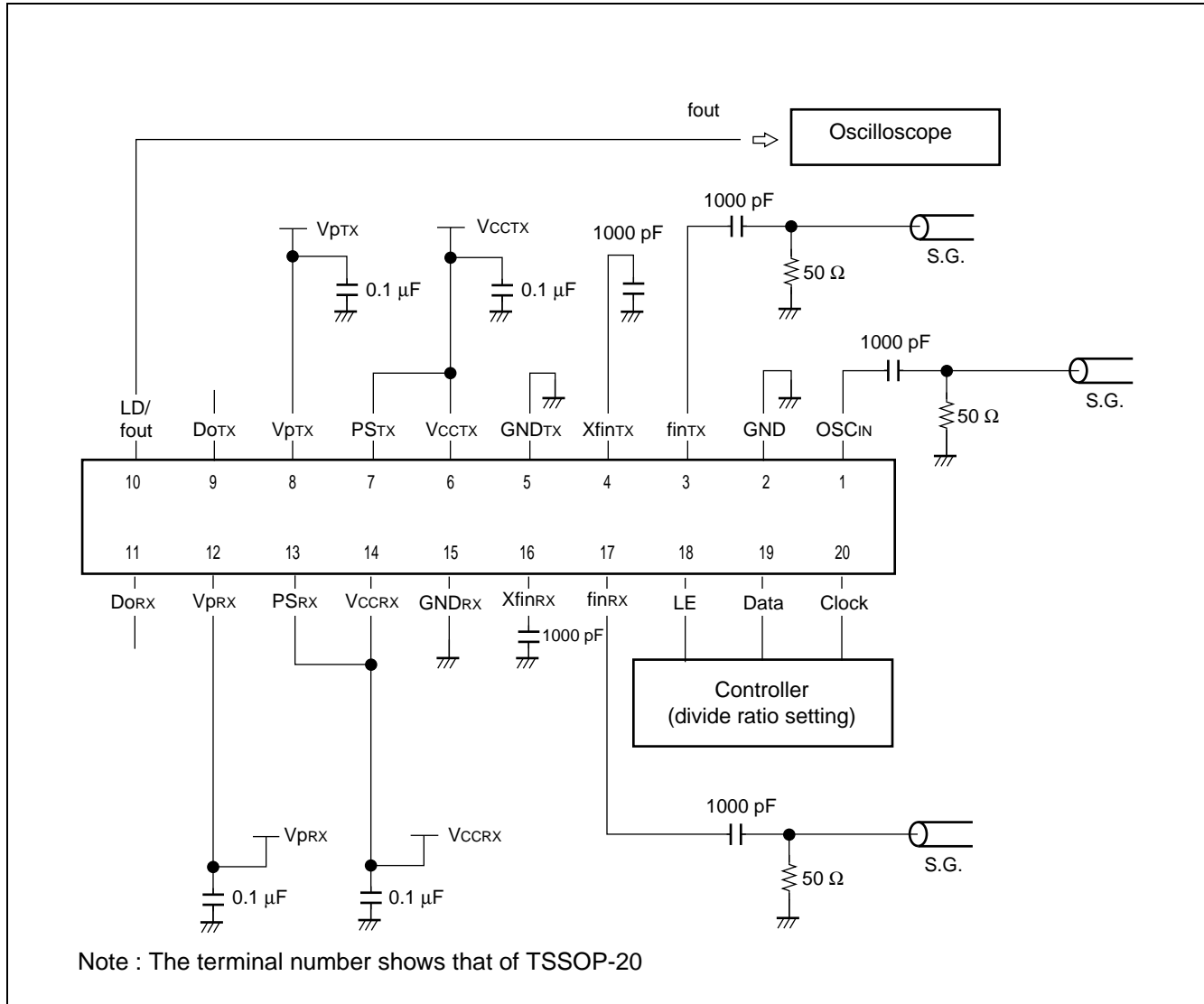
TX-PLL section	RX-PLL section	LD output
Locking state/Power saving state	Locking state/Power saving state	H
Locking state/Power saving state	Unlocking state	L
Unlocking state	Locking state/Power saving state	L
Unlocking state	Unlocking state	L

Notes: • Phase error detection range = -2π to $+2\pi$

- Pulses on DoTX/DoRX 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.
 $t_{wU} \geq 2/f_{osc}$: e.g. $t_{wU} \geq 156.3$ ns when $f_{osc} = 12.8$ MHz
 $t_{wL} \leq 4/f_{osc}$: e.g. $t_{wL} \leq 312.5$ ns when $f_{osc} = 12.8$ MHz

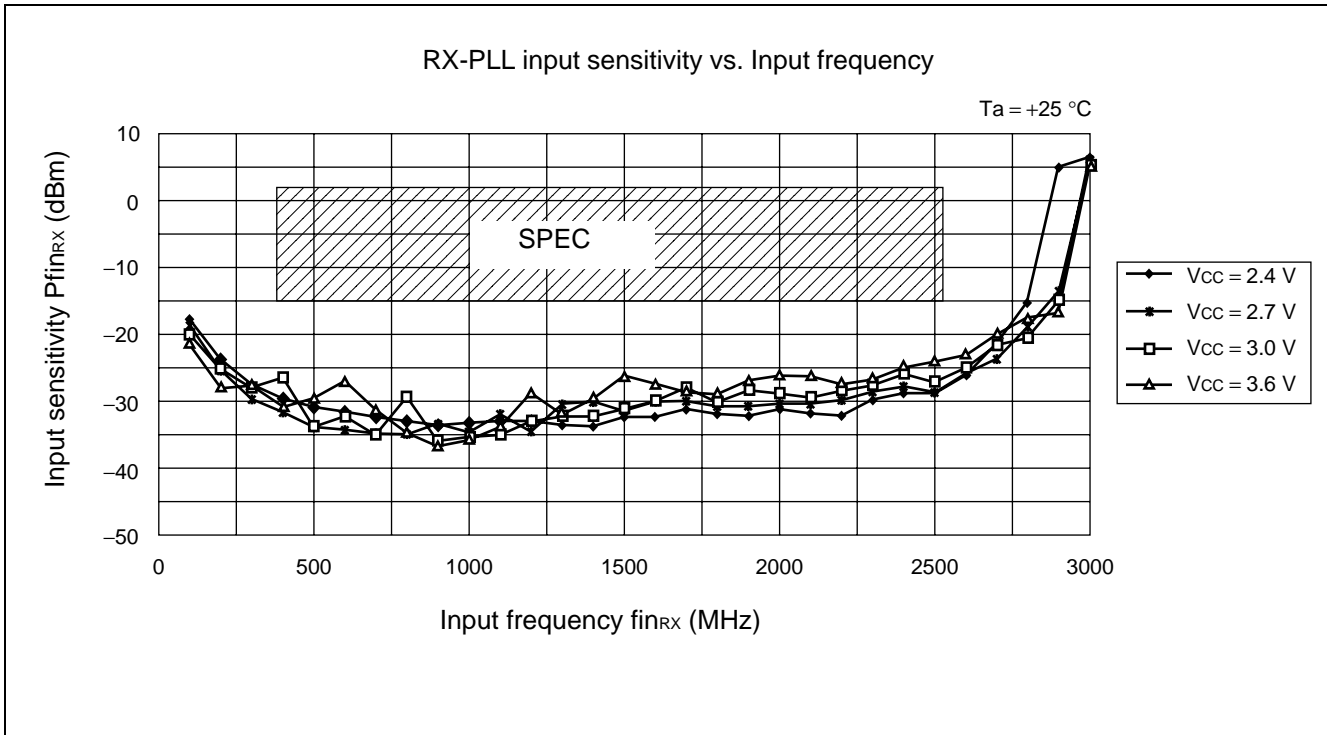
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■ TEST CIRCUIT (for Measuring Input Sensitivity f_{in}/OSC_{IN})

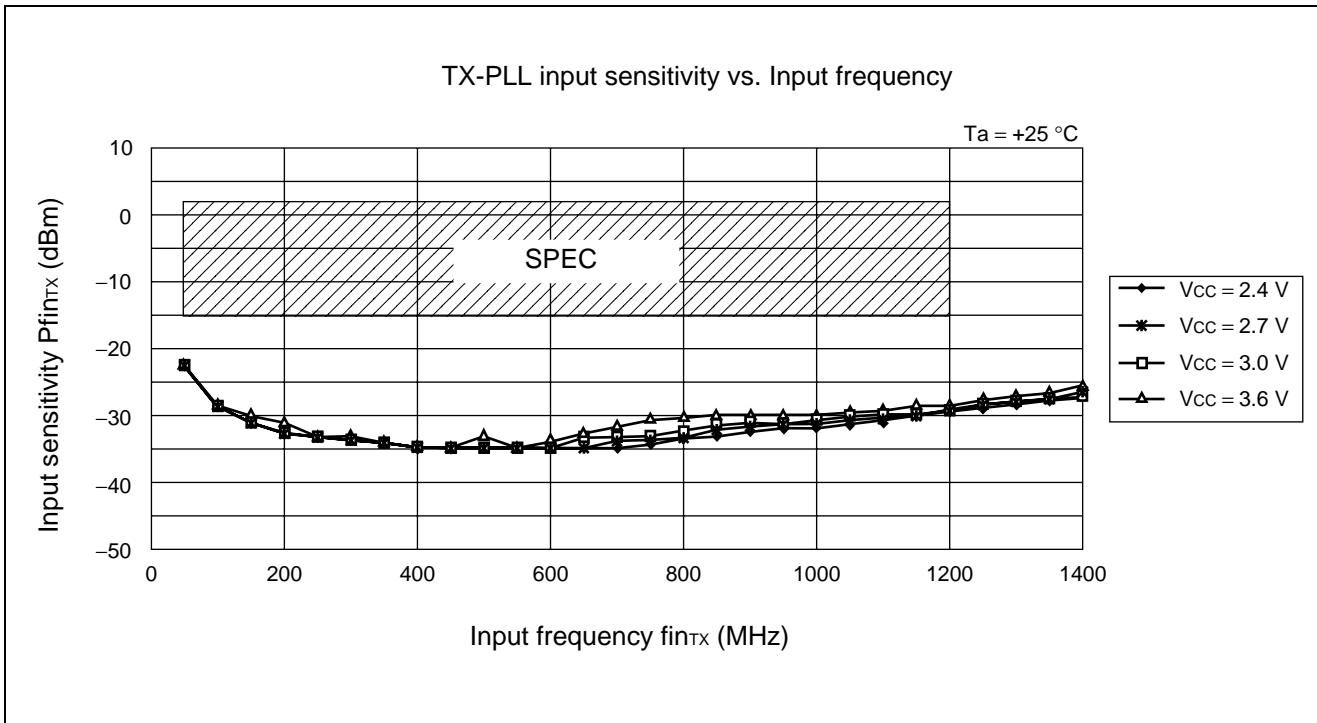


TYPICAL CHARACTERISTICS

1. f_{inRX} input sensitivity

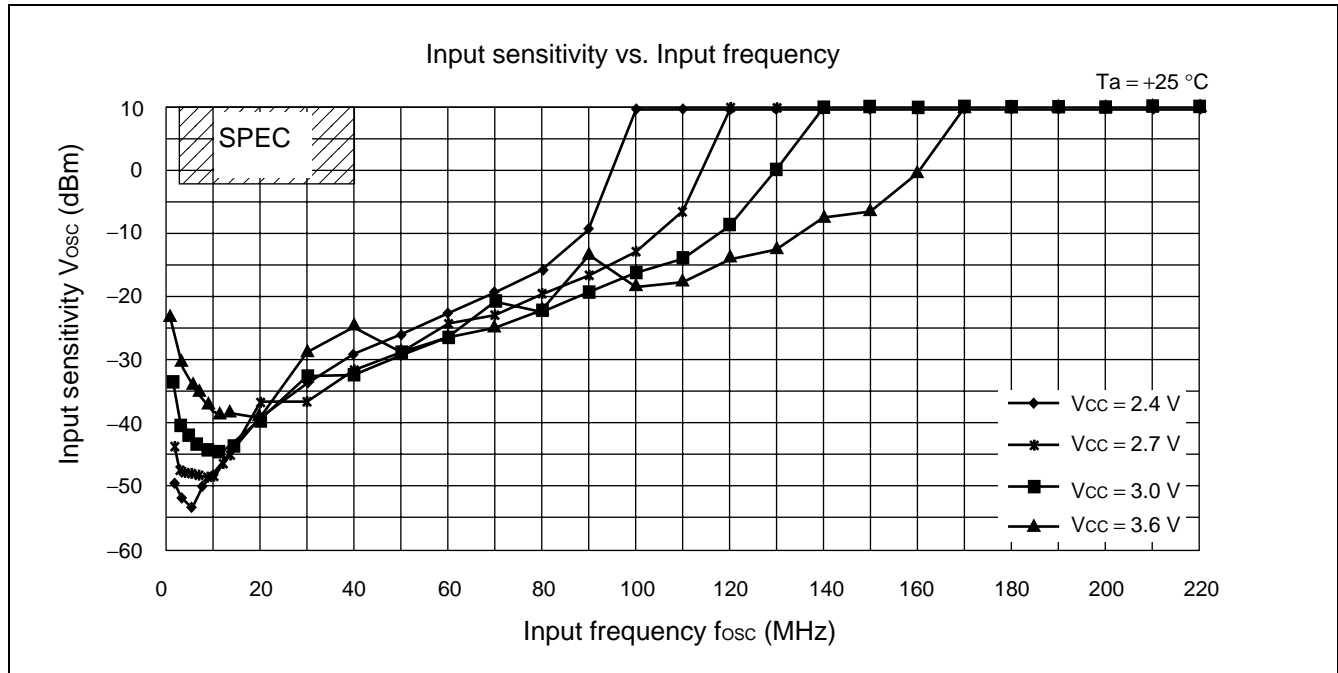


2. f_{inTX} input sensitivity



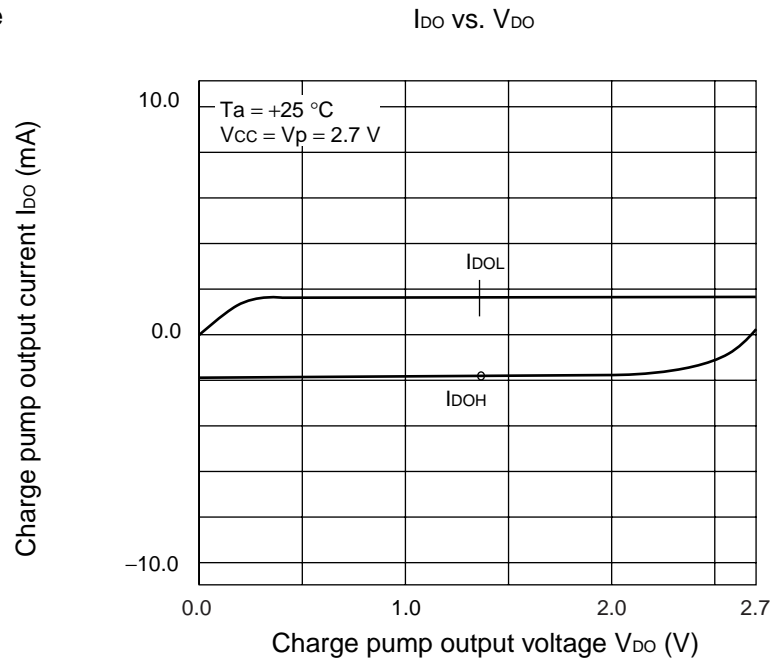
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3. OSC_{IN} input sensitivity

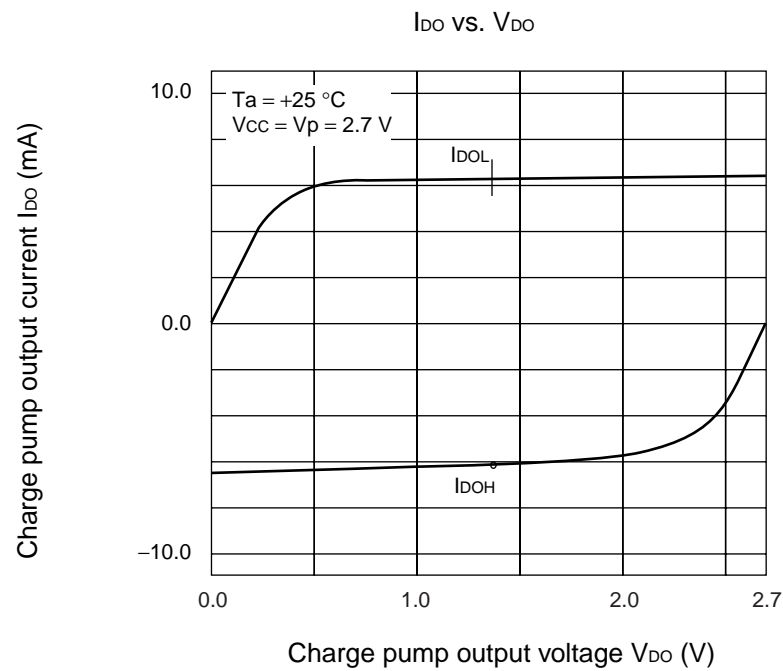


4. Do output current (RX PLL)

- 1.5 mA mode

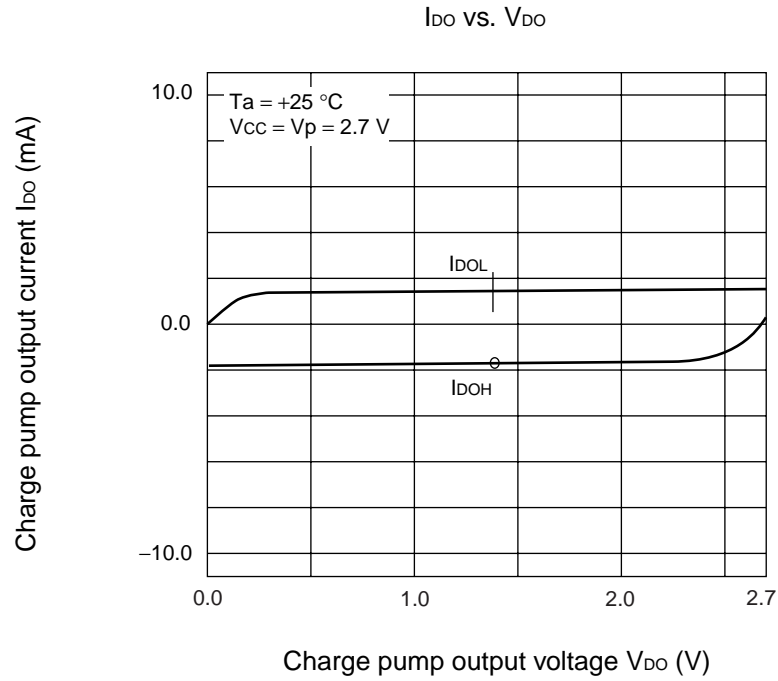


- 6.0 mA mode

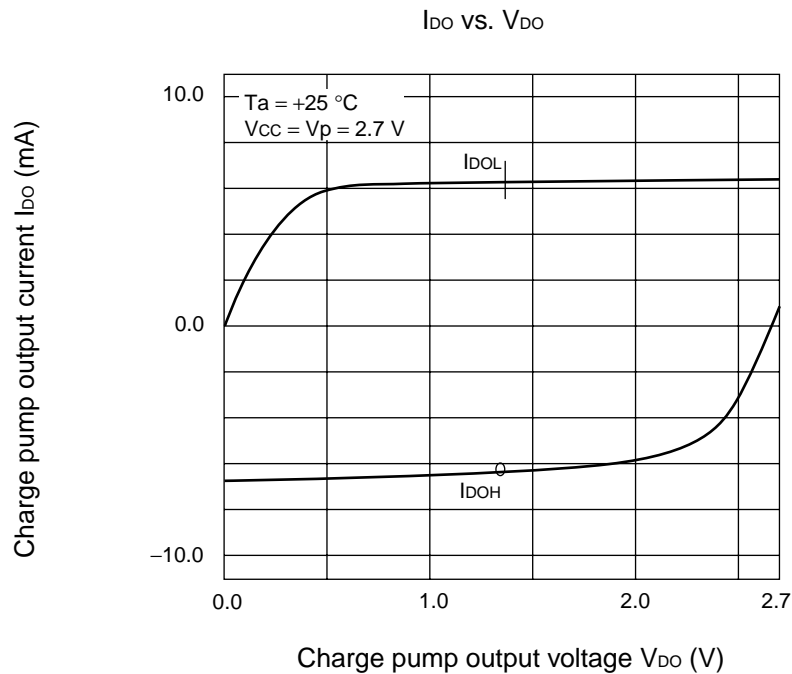


5. Do output current (TX PLL)

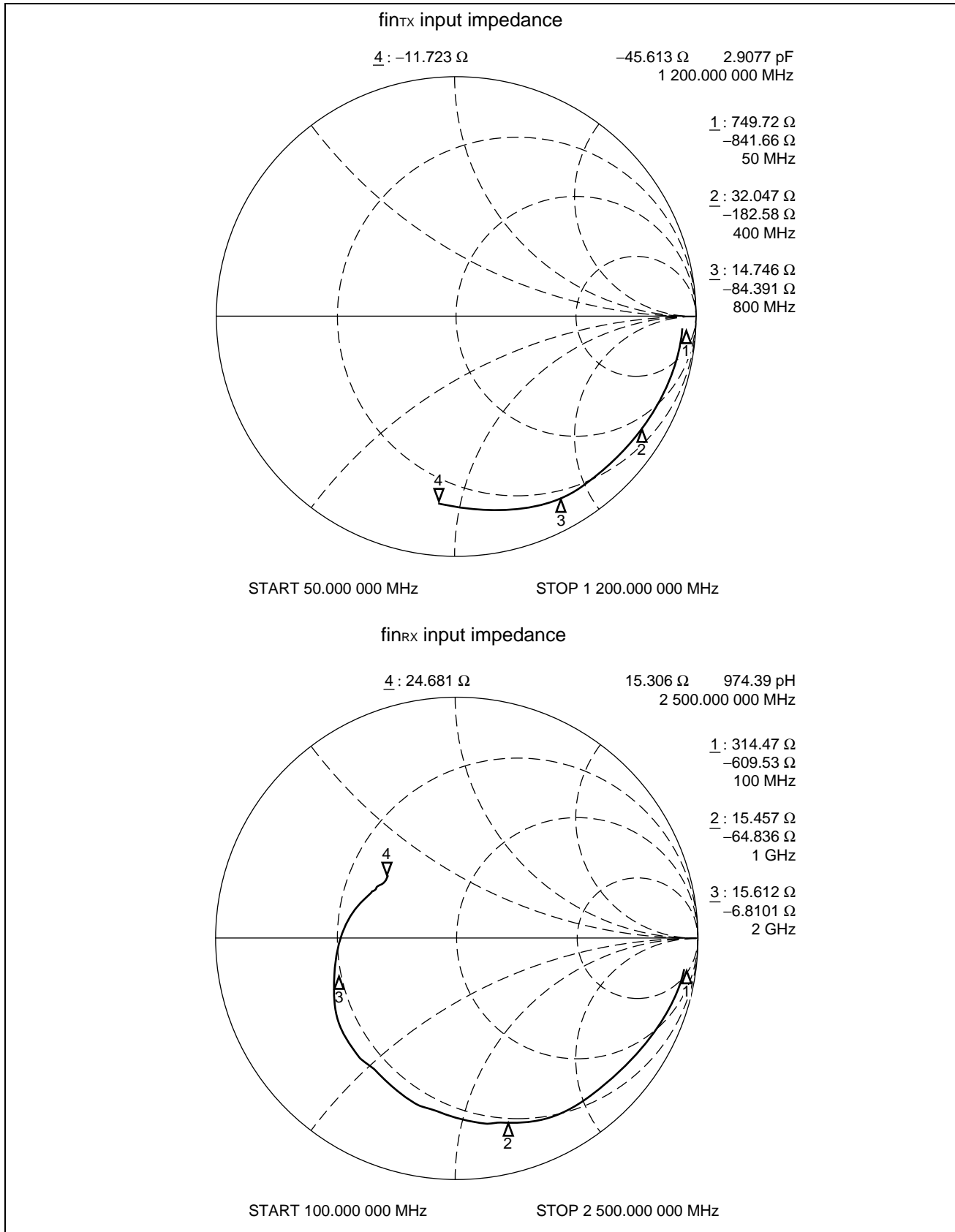
- 1.5 mA mode



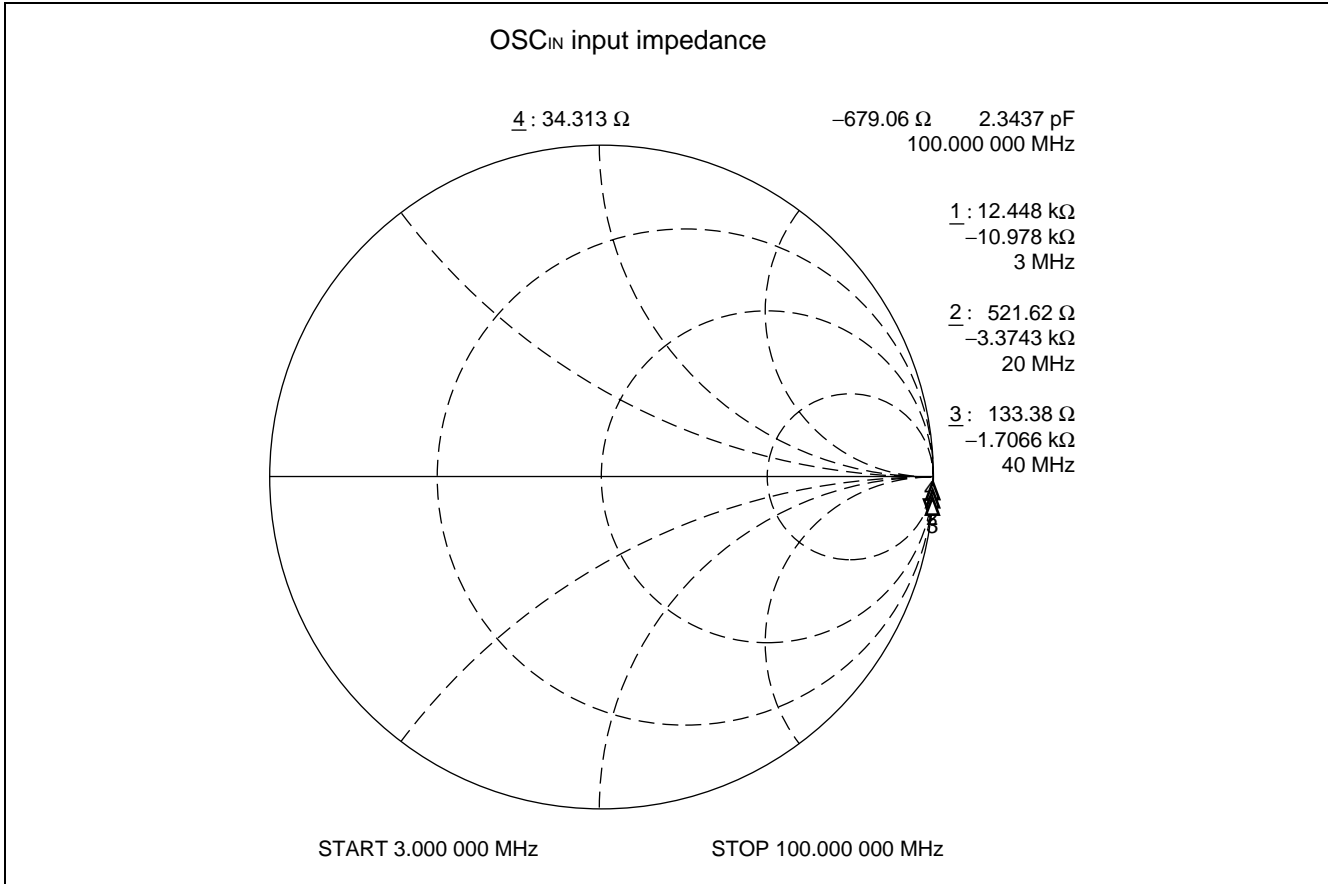
- 6.0 mA mode



6. fin input impedance

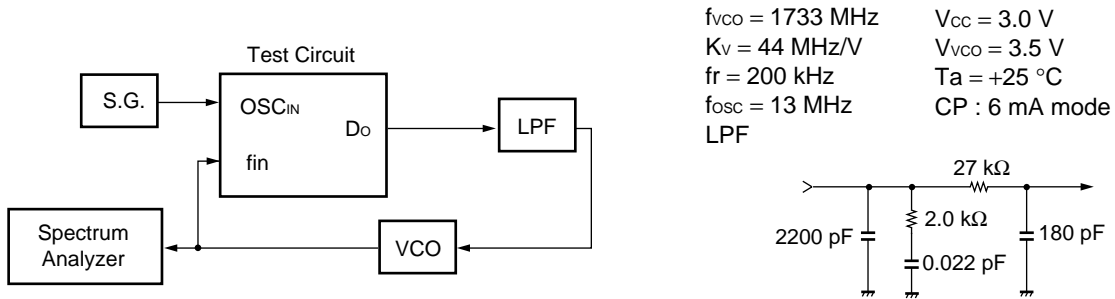


7. OSC_{IN} input impedance

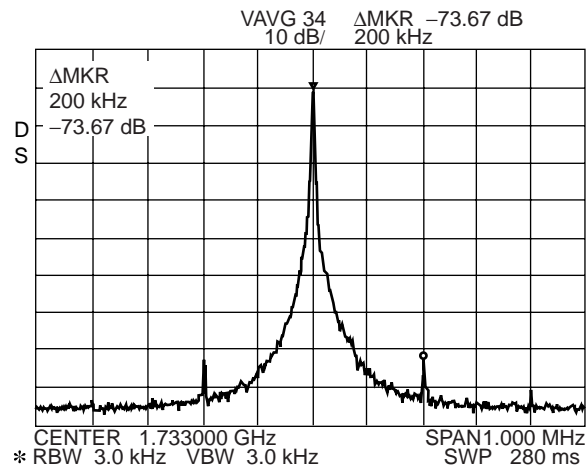


REFERENCE INFORMATION

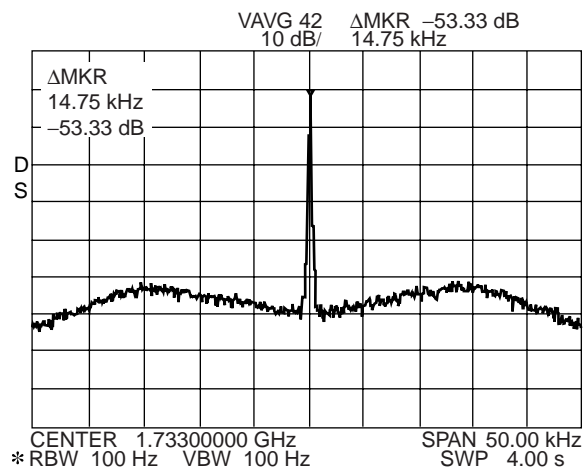
(for Look-up time, Phase noise and Reference leakage)



• PLL Reference Leakage



• PLL Phase Noise



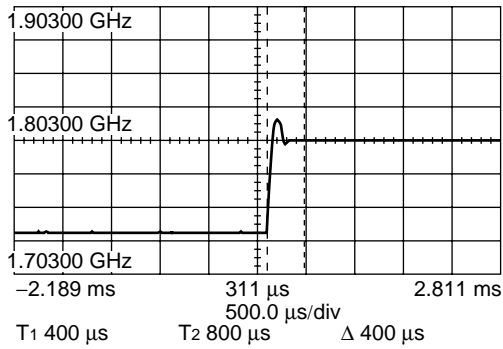
(Continued)

MB15F78SP

(Continued)

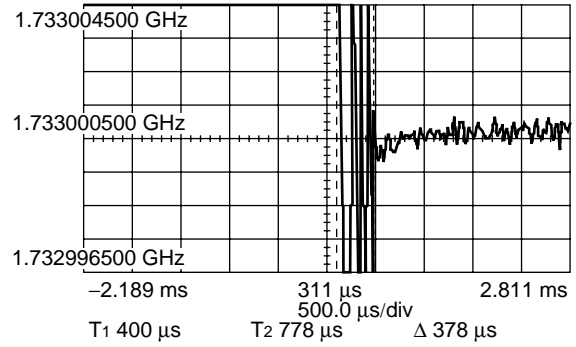
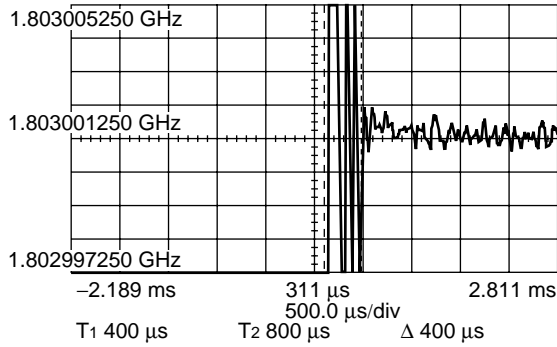
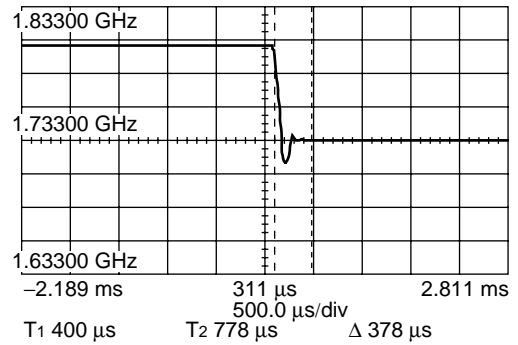
• PLL Lock-up time

1733 MHz → 1803 MHz within ± 1 kHz
Lch → Hch 400 μ s

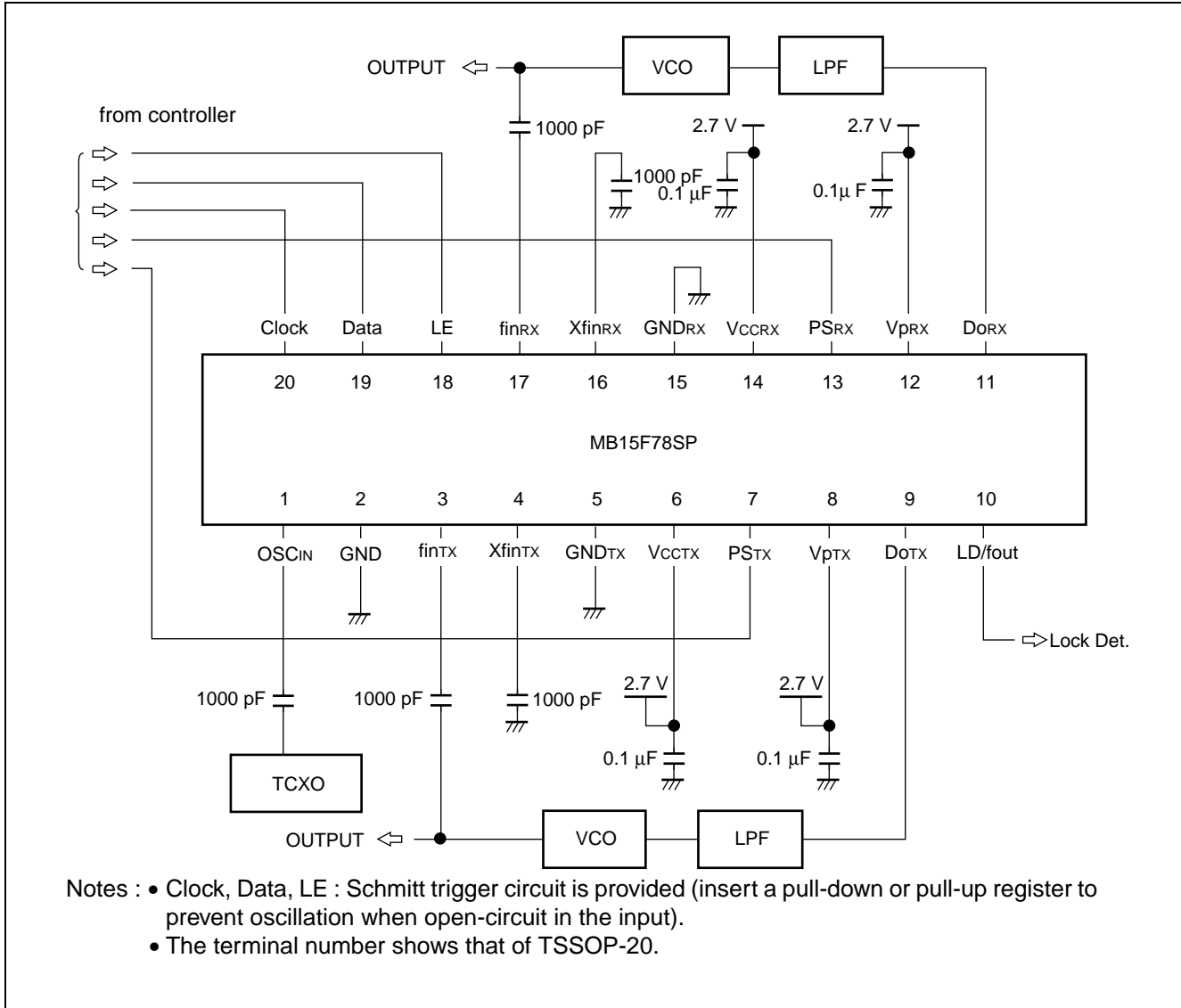


• PLL Lock-up time

1803 MHz → 1733 MHz within ± 1 kHz
Hch → Lch 378 μ s



APPLICATION EXAMPLE



MB15F78SP

■ USAGE PRECAUTIONS

- (1) $V_{CCR\text{X}}$, $V_{p\text{RX}}$, $V_{CCT\text{X}}$ and $V_{p\text{TX}}$ must equal equal voltage.
Even if either RX-PLL or TX-PLL is not used, power must be supplied to both $V_{CCR\text{X}}$, $V_{p\text{RX}}$, $V_{CCT\text{X}}$ and $V_{p\text{TX}}$ to keep them equal. It is recommended that the non-use PLL is controlled by power saving function.
- (2) To protect against damage by electrostatic discharge, note the following handling precautions:
 - Store and transport devices in conductive containers.
 - Use properly grounded workstations, tools, and equipment.
 - Turn off power before inserting or removing this device into or from a socket.
 - Protect leads with conductive sheet, when transporting a board mounted device.

■ ORDERING INFORMATION

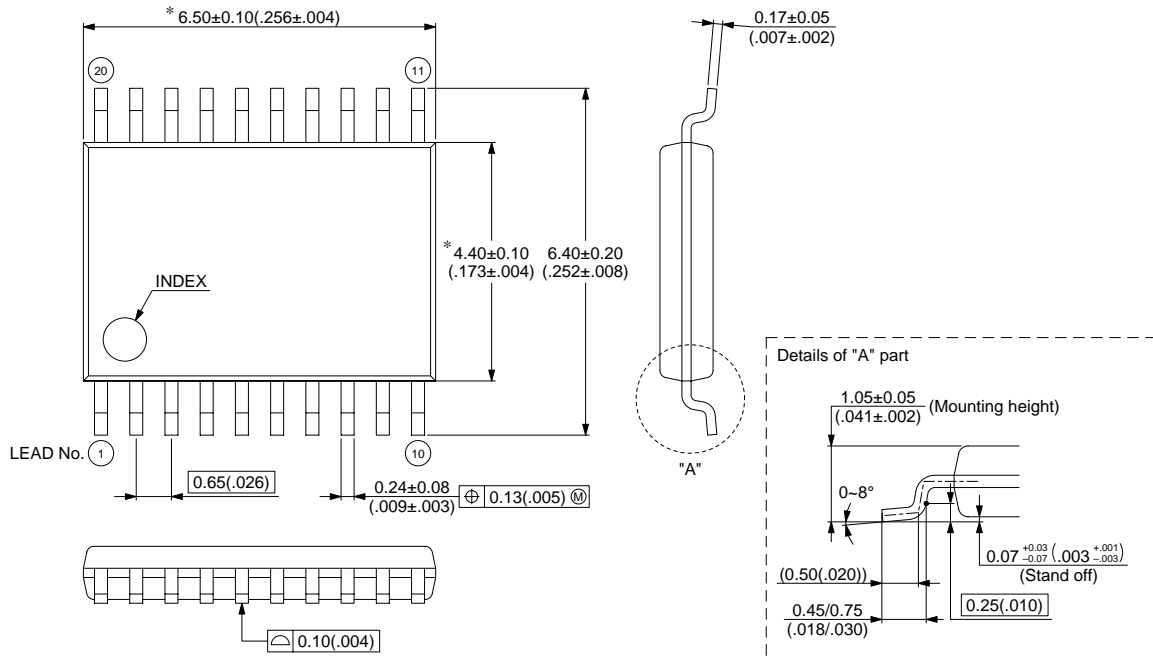
Part number	Package	Remarks
MB15F78SPPFT	20-pin, plastic TSSOP (FPT-20P-M06)	
MB15F78SPPV	20-pad, plastic BCC (LCC-20P-M04)	

■ PACKAGE DIMENSIONS

20-pin plastic TSSOP
(FPT-20P-M06)

Note 1) * : These dimensions do not include resin protrusion.

Note 2) Pins width and pins thickness include plating thickness.



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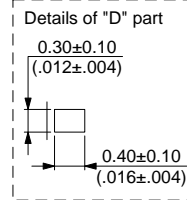
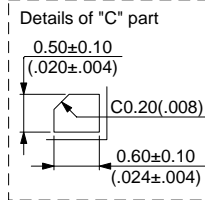
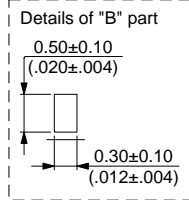
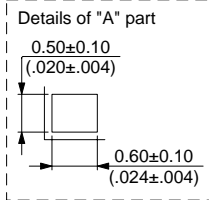
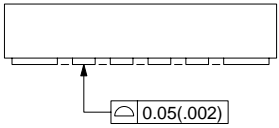
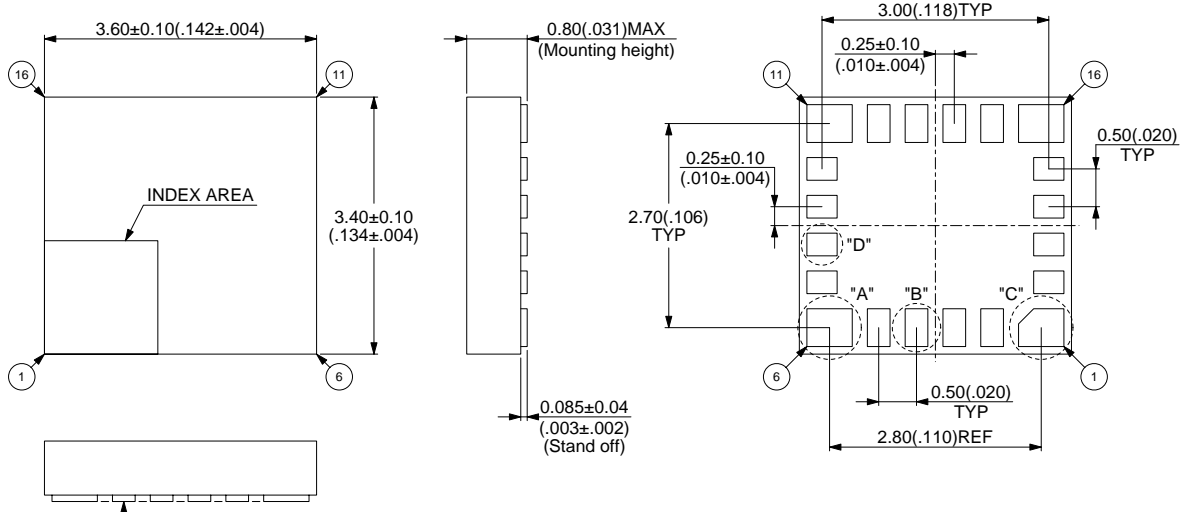
Dimensions in mm (inches)

(Continued)

MB15F78SP

(Continued)

20-pad plastic BCC (LCC-20P-M04)



Dimensions in mm (inches)

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FUJITSU LIMITED

For further information please contact:

Japan

FUJITSU LIMITED
Corporate Global Business Support Division
Electronic Devices
KAWASAKI PLANT, 4-1-1, Kamikodanaka,
Nakahara-ku, Kawasaki-shi,
Kanagawa 211-8588, Japan
Tel: +81-44-754-3763
Fax: +81-44-754-3329

<http://www.fujitsu.co.jp/>

North and South America

FUJITSU MICROELECTRONICS, INC.
3545 North First Street,
San Jose, CA 95134-1804, U.S.A.
Tel: +1-408-922-9000
Fax: +1-408-922-9179

Customer Response Center
Mon. - Fri.: 7 am - 5 pm (PST)
Tel: +1-800-866-8608
Fax: +1-408-922-9179

<http://www.fujitsumicro.com/>

Europe

FUJITSU MICROELECTRONICS EUROPE GmbH
Am Siebenstein 6-10,
D-63303 Dreieich-Buchsschlag,
Germany
Tel: +49-6103-690-0
Fax: +49-6103-690-122

<http://www.fujitsu-fme.com/>

Asia Pacific

FUJITSU MICROELECTRONICS ASIA PTE. LTD.
#05-08, 151 Lorong Chuan,
New Tech Park,
Singapore 556741
Tel: +65-281-0770
Fax: +65-281-0220

<http://www.fmap.com.sg/>

Korea

FUJITSU MICROELECTRONICS KOREA LTD.
1702 KOSMO TOWER, 1002 Daechi-Dong,
Kangnam-Gu, Seoul 135-280
Korea
Tel: +82-2-3484-7100
Fax: +82-2-3484-7111

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