

ASSP

# Dual Serial Input PLL Frequency Synthesizer

## MB15F78UL

### ■ DESCRIPTION

The Fujitsu MB15F78UL is a serial input Phase Locked Loop (PLL) frequency synthesizer with a 2600 MHz and a 1200 MHz prescalers. A 32/33 or a 64/65 for the 2600 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 4.5 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 date. The data format is the same as the previous one MB15F08SL, MB15F78SP. Fast locking is achieved for adopting the new circuit.

The new package (BCC20) decreases a mount area of MB15F78UL more than 30% comparing with the former BCC16 (for dual PLL) .

MB15F78UL is ideally suited for wireless mobile communications, such as GSM and PCS.

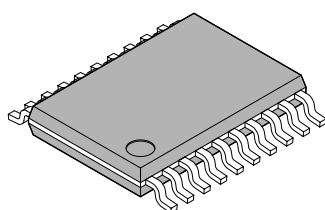
### ■ FEATURES

- High frequency operation : RX synthesizer : 2600 MHz Max.  
: TX synthesizer : 1200 MHz Max.
- Low power supply voltage :  $V_{CC} = 2.4$  to  $3.6$  V
- Ultra low power supply current :  $I_{CC} = 4.5$  mA Typ.  
( $V_{CC} = V_p = 2.7$  V,  $T_a = +25$  °C,  $SW_{TX} = SW_{RX} = 0$ , in TX/RX locking state)

*(Continued)*

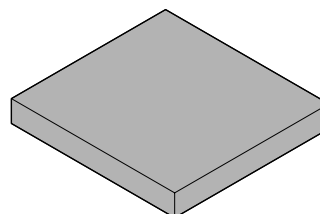
### ■ PACKAGES

20-pin plastic TSSOP



(FPT-20P-M06)

20-pad plastic BCC



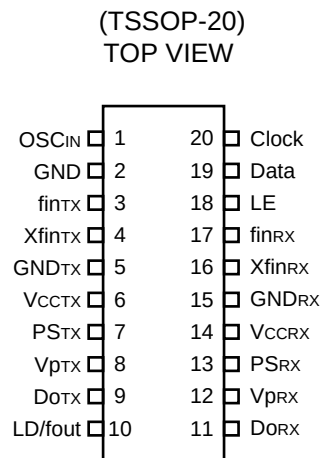
(LCC-20P-M05)

# MB15F78UL

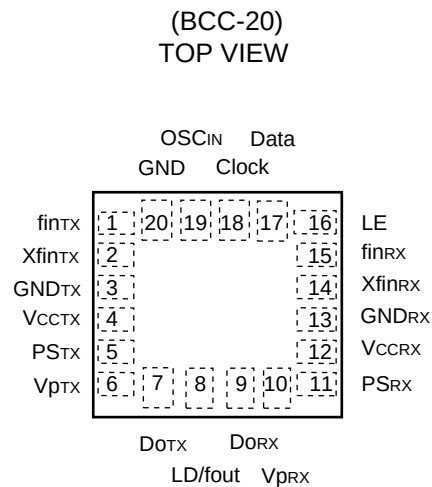
(Continued)

- Direct power saving function : Power supply current in power saving mode  
Typ. 0.1  $\mu$ A ( $V_{CC} = V_p = 2.7$  V,  $T_a = +25^\circ\text{C}$ )  
Max. 10  $\mu$ A ( $V_{CC} = V_p = 2.7$  V)
- Software selectable charge pump current : 1.5 mA/6.0 mA Typ.
- Dual modulus prescaler : 2600 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
- On-chip phase comparator for fast lock and low noise
- Built-in digital locking detector circuit to detect PLL locking and unlocking
- Operating temperature :  $T_a = -40$  to  $+85^\circ\text{C}$
- Serial data format compatible with MB15F08SL

## PIN ASSIGNMENTS



(FPT-20P-M06)

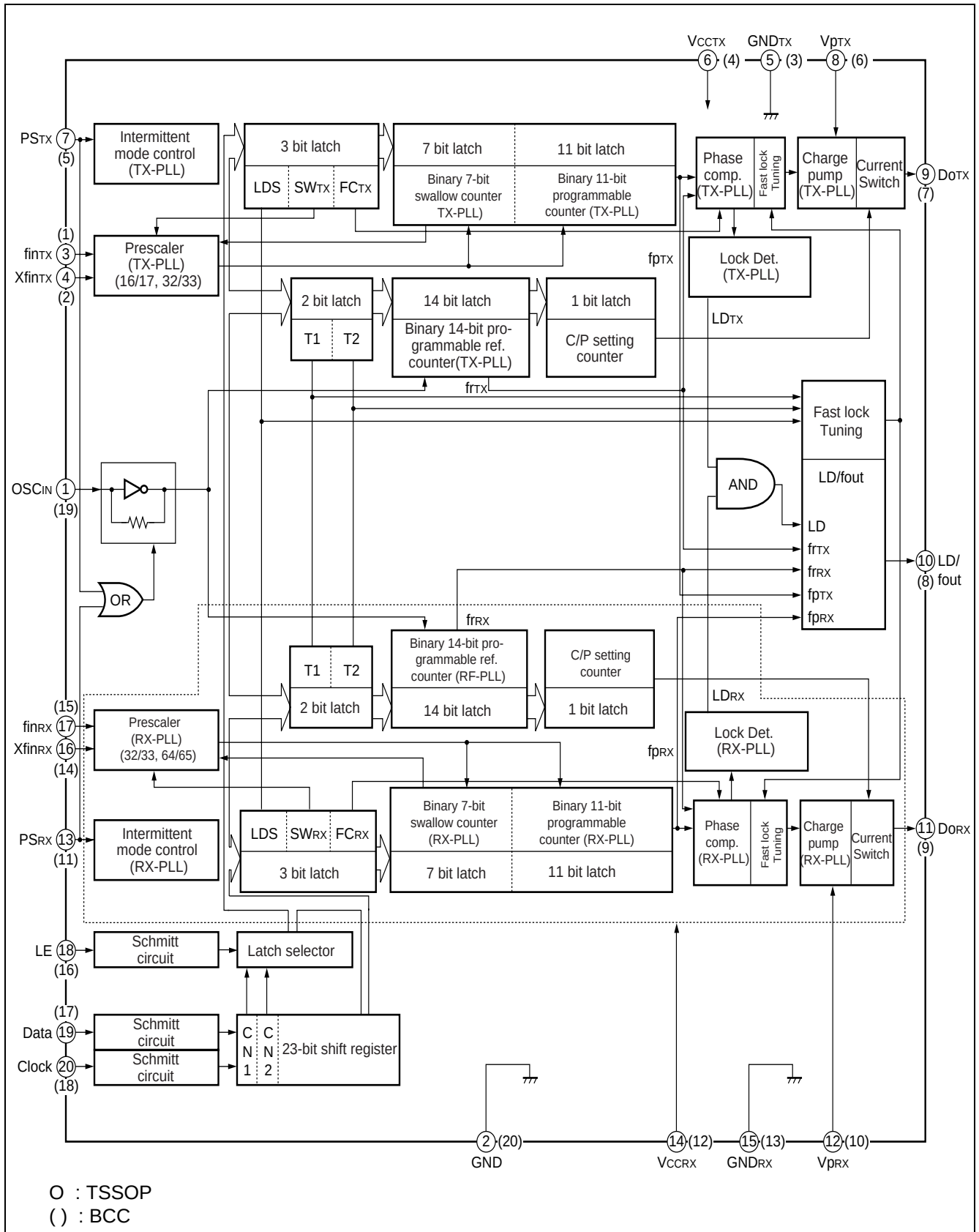


(LCC-20P-M05)

## ■ PIN DESCRIPTION

| Pin no. |     | Pin name           | I/O | Descriptions                                                                                                                                                                                                                    |
|---------|-----|--------------------|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TSSOP   | BCC |                    |     |                                                                                                                                                                                                                                 |
| 1       | 19  | OSC <sub>IN</sub>  | I   | The programmable reference divider input pin. TCXO should be connected with an AC coupling capacitor.                                                                                                                           |
| 2       | 20  | GND                | —   | Ground pin for OSC input buffer and the shift register circuit.                                                                                                                                                                 |
| 3       | 1   | fin <sub>TX</sub>  | I   | Prescaler input pin for the TX-PLL.<br>Connection to an external VCO should be via AC coupling.                                                                                                                                 |
| 4       | 2   | Xfin <sub>TX</sub> | I   | Prescaler complimentary input pin for the TX-PLL section.<br>This pin should be grounded via a capacitor.                                                                                                                       |
| 5       | 3   | GND <sub>TX</sub>  | —   | Ground pin for the TX-PLL section.                                                                                                                                                                                              |
| 6       | 4   | V <sub>CCTX</sub>  | —   | 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 <sub>TX</sub>   | I   | Power saving mode control pin for the TX-PLL section. This pin must be set at “L” when the power supply is started up. (Open is prohibited.)<br>PS <sub>TX</sub> = “H” ; Normal mode/PS <sub>TX</sub> = “L” ; Power saving mode |
| 8       | 6   | Vp <sub>TX</sub>   | —   | Power supply voltage input pin for the TX-PLL charge pump.                                                                                                                                                                      |
| 9       | 7   | D <sub>OTX</sub>   | O   | Charge pump output pin 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.<br>LDS bit = “H” ; outputs fout signal/LDS bit = “L” ; outputs LD signal                |
| 11      | 9   | D <sub>ORX</sub>   | O   | Charge pump output pin for the RX-PLL section.                                                                                                                                                                                  |
| 12      | 10  | Vp <sub>RX</sub>   | —   | Power supply voltage input pin for the RX-PLL charge pump.                                                                                                                                                                      |
| 13      | 11  | PS <sub>RX</sub>   | I   | Power saving mode control pin for the RX-PLL section. This pin must be set at “L” when the power supply is started up. (Open is prohibited.)<br>PS <sub>RX</sub> = “H” ; Normal mode/PS <sub>RX</sub> = “L” ; Power saving mode |
| 14      | 12  | V <sub>CCRX</sub>  | —   | Power supply voltage input pin for the RX-PLL section (except for the charge pump circuit)                                                                                                                                      |
| 15      | 13  | GND <sub>RX</sub>  | —   | Ground pin for the RX-PLL section                                                                                                                                                                                               |
| 16      | 14  | Xfin <sub>RX</sub> | I   | Prescaler complimentary input pin for the RX-PLL section.<br>This pin should be grounded via a capacitor.                                                                                                                       |
| 17      | 15  | fin <sub>RX</sub>  | I   | Prescaler input pin for the RX-PLL.<br>Connection to an external VCO should be via AC coupling.                                                                                                                                 |
| 18      | 16  | LE                 | I   | Load enable signal input pin (with the schmitt trigger circuit)<br>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 pin (with the schmitt trigger circuit)<br>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 pin for the 23-bit shift register (with a schmitt trigger circuit)<br>One bit of data is shifted into the shift register on a rising edge of the clock.                                                             |

## ■ BLOCK DIAGRAM



## ■ ABSOLUTE MAXIMUM RATINGS

| Parameter            |                                     | Symbol           | Rating          |                       | Unit |
|----------------------|-------------------------------------|------------------|-----------------|-----------------------|------|
|                      |                                     |                  | Min.            | Max.                  |      |
| Power supply voltage |                                     | V <sub>CC</sub>  | −0.5            | 4.0                   | V    |
|                      |                                     | V <sub>p</sub>   | V <sub>CC</sub> | 4.0                   | V    |
| Input voltage        |                                     | V <sub>I</sub>   | −0.5            | V <sub>CC</sub> + 0.5 | V    |
| Output voltage       | LD/fout                             | V <sub>O</sub>   | GND             | V <sub>CC</sub>       | V    |
|                      | D <sub>OTX</sub> , D <sub>ORX</sub> | V <sub>DD</sub>  | GND             | V <sub>p</sub>        | V    |
| Storage temperature  |                                     | T <sub>stg</sub> | −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 | Remarks                               |
|-----------------------|-----------------|-----------------|------|-----------------|------|---------------------------------------|
|                       |                 | Min.            | Typ. | Max.            |      |                                       |
| Power supply voltage  | V <sub>CC</sub> | 2.4             | 2.7  | 3.6             | V    | V <sub>CCRX</sub> = V <sub>CCTX</sub> |
|                       | V <sub>p</sub>  | V <sub>CC</sub> | 2.7  | 3.6             | V    |                                       |
| Input voltage         | V <sub>I</sub>  | GND             | —    | V <sub>CC</sub> | V    |                                       |
| Operating temperature | T <sub>a</sub>  | −40             | —    | +85             | °C   |                                       |

Note : • V<sub>CCRX</sub>, V<sub>pRX</sub>, V<sub>CCTX</sub> and V<sub>pTX</sub> must supply equal voltage.

Even if either RX-PLL or TX-PLL is not used, power must be supplied to V<sub>CCRX</sub>, V<sub>pRX</sub>, V<sub>CCTX</sub> and V<sub>pTX</sub> to keep them equal.

It is recommended that the non-use PLL is controlled by power saving function.

- Although this device contains an anti-static element to prevent electrostatic breakdown and the circuitry has been improved in electrostatic protection, observe the following precautions when handling the device.
  - When storing and transporting the device, put it in a conductive case.
  - Before handling the device, confirm the (jigs and) tools to be used have been uncharged (grounded) as well as yourself. Use a conductive sheet on working bench.
  - Before fitting the device into or removing it from the socket, turn the power supply off.
  - When handling (such as transporting) the device mounted board, protect the leads with a conductive sheet.

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.

# MB15F78UL

## ■ ELECTRICAL CHARACTERISTICS

(V<sub>CC</sub> = 2.4 V to 3.6 V, Ta = -40 °C to +85 °C)

| Parameter                     |                                   | Symbol                          | Condition                                                                                      | Value                     |        |                           | Unit             |
|-------------------------------|-----------------------------------|---------------------------------|------------------------------------------------------------------------------------------------|---------------------------|--------|---------------------------|------------------|
|                               |                                   |                                 |                                                                                                | Min.                      | Typ.   | Max.                      |                  |
| Power supply current          |                                   | I <sub>CCTX</sub> *1            | fin <sub>TX</sub> = 910 MHz<br>V <sub>CCTX</sub> = V <sub>pTX</sub> = 2.7 V                    | 1.1                       | 1.7    | 2.4                       | mA               |
|                               |                                   | I <sub>CCR<sub>X</sub></sub> *1 | fin <sub>RX</sub> = 2500 MHz<br>V <sub>CCR<sub>X</sub></sub> = V <sub>pRX</sub> = 2.7 V        | 1.8                       | 2.8    | 3.9                       | mA               |
| Power saving current          |                                   | I <sub>PSTX</sub>               | PS <sub>TX</sub> = PS <sub>RX</sub> = "L"                                                      | —                         | 0.1 *2 | 10                        | μA               |
|                               |                                   | I <sub>PSRX</sub>               | PS <sub>TX</sub> = PS <sub>RX</sub> = "L"                                                      | —                         | 0.1 *2 | 10                        | μA               |
| Operating frequency           | fin <sub>TX</sub> *3              | fin <sub>TX</sub>               | TX PLL                                                                                         | 100                       | —      | 1200                      | MHz              |
|                               | fin <sub>RX</sub> *3              | fin <sub>RX</sub>               | RX PLL                                                                                         | 400                       | —      | 2600                      | MHz              |
|                               | OSC <sub>IN</sub>                 | f <sub>OSC</sub>                | —                                                                                              | 3                         | —      | 40                        | MHz              |
| Input sensitivity             | fin <sub>TX</sub>                 | Pfin <sub>TX</sub>              | TX PLL, 50 Ω system                                                                            | -15                       | —      | +2                        | dBm              |
|                               | fin <sub>RX</sub>                 | Pfin <sub>RX</sub>              | RX PLL, 50 Ω system                                                                            | -15                       | —      | +2                        | dBm              |
|                               | OSC <sub>IN</sub>                 | V <sub>OSC</sub>                | —                                                                                              | 0.5                       | —      | V <sub>CC</sub>           | V <sub>P-P</sub> |
| "H" level input voltage       | Data, LE, Clock                   | V <sub>IH</sub>                 | Schmitt trigger input                                                                          | 0.7 V <sub>CC</sub> + 0.4 | —      | —                         | V                |
| "L" level input voltage       |                                   | V <sub>IL</sub>                 | Schmitt trigger input                                                                          | —                         | —      | 0.3 V <sub>CC</sub> - 0.4 | V                |
| "H" level input voltage       | PS <sub>TX</sub>                  | V <sub>IH</sub>                 | —                                                                                              | 0.7 V <sub>CC</sub>       | —      | —                         | V                |
| "L" level input voltage       | PS <sub>RX</sub>                  | V <sub>IL</sub>                 | —                                                                                              | —                         | —      | 0.3 V <sub>CC</sub>       | V                |
| "H" level input current       | Data LE Clock                     | I <sub>IH</sub> *4              | —                                                                                              | -1.0                      | —      | +1.0                      | μA               |
| "L" level input current       | PS <sub>TX</sub> PS <sub>RX</sub> | I <sub>IL</sub> *4              | —                                                                                              | -1.0                      | —      | +1.0                      | μA               |
| "H" level input current       | OSC <sub>IN</sub>                 | I <sub>IH</sub>                 | —                                                                                              | 0                         | —      | +100                      | μA               |
| "L" level input current       |                                   | I <sub>IL</sub> *4              | —                                                                                              | -100                      | —      | 0                         | μA               |
| "H" level output voltage      | LD/fout                           | V <sub>OH</sub>                 | V <sub>CC</sub> = V <sub>p</sub> = 2.7 V,<br>I <sub>OH</sub> = -1 mA                           | V <sub>CC</sub> - 0.4     | —      | —                         | V                |
| "L" level output voltage      |                                   | V <sub>OL</sub>                 | V <sub>CC</sub> = V <sub>p</sub> = 2.7 V, I <sub>OL</sub> = 1 mA                               | —                         | —      | 0.4                       | V                |
| "H" level output voltage      | Do <sub>TX</sub> Do <sub>RX</sub> | V <sub>DOH</sub>                | V <sub>CC</sub> = V <sub>p</sub> = 2.7 V,<br>I <sub>DOH</sub> = -0.5 mA                        | V <sub>p</sub> - 0.4      | —      | —                         | V                |
| "L" level output voltage      |                                   | V <sub>DOL</sub>                | V <sub>CC</sub> = V <sub>p</sub> = 2.7 V,<br>I <sub>DOL</sub> = 0.5 mA                         | —                         | —      | 0.4                       | V                |
| High impedance cutoff current | Do <sub>TX</sub> Do <sub>RX</sub> | I <sub>OFF</sub>                | V <sub>CC</sub> = V <sub>p</sub> = 2.7 V<br>V <sub>OFF</sub> = 0.5 V to V <sub>p</sub> - 0.5 V | —                         | —      | 2.5                       | nA               |
| "H" level output current      | LD/fout                           | I <sub>OH</sub> *4              | V <sub>CC</sub> = V <sub>p</sub> = 2.7 V                                                       | —                         | —      | -1.0                      | mA               |
| "L" level output current      |                                   | I <sub>OL</sub>                 | V <sub>CC</sub> = V <sub>p</sub> = 2.7 V                                                       | 1.0                       | —      | —                         | mA               |

(Continued)

(Continued)

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

| Parameter                |                                    | Symbol               | Condition                                                                                        |              | Value |      |      | Unit |
|--------------------------|------------------------------------|----------------------|--------------------------------------------------------------------------------------------------|--------------|-------|------|------|------|
|                          |                                    |                      |                                                                                                  |              | Min.  | Typ. | Max. |      |
| “H” level output current | D <sub>OTX</sub> *8                | I <sub>DOH</sub> *4  | V <sub>CC</sub> =V <sub>p</sub> =2.7 V,<br>V <sub>DOH</sub> = V <sub>p</sub> / 2,<br>Ta = +25 °C | CS bit = “H” | −8.2  | −6.0 | −4.1 | mA   |
|                          | D <sub>ORX</sub>                   |                      |                                                                                                  | CS bit = “L” | −2.2  | −1.5 | −0.8 | mA   |
| “L” level output current | D <sub>OTX</sub> *8                | I <sub>DOL</sub>     | V <sub>CC</sub> =V <sub>p</sub> =2.7 V,<br>V <sub>DOL</sub> = V <sub>p</sub> / 2,<br>Ta = +25 °C | CS bit = “H” | 4.1   | 6.0  | 8.2  | mA   |
|                          | D <sub>ORX</sub>                   |                      |                                                                                                  | CS bit = “L” | 0.8   | 1.5  | 2.2  | mA   |
| Charge pump current rate | I <sub>DOL</sub> /I <sub>DOH</sub> | I <sub>DOMT</sub> *5 | V <sub>DO</sub> = V <sub>p</sub> / 2                                                             |              | —     | 3    | —    | %    |
|                          | vs V <sub>DO</sub>                 | I <sub>DOVD</sub> *6 | 0.5 V ≤ V <sub>DO</sub> ≤ V <sub>p</sub> − 0.5 V                                                 |              | —     | 10   | —    | %    |
|                          | vs Ta                              | I <sub>DOTA</sub> *7 | −40 °C ≤ Ta ≤ +85 °C,<br>V <sub>DO</sub> = V <sub>p</sub> / 2                                    |              | —     | 5    | —    | %    |

\*1 : Conditions ;  $f_{osc} = 12.8 \text{ MHz}$ ,  $T_a = +25 \text{ }^{\circ}\text{C}$ ,  $SW = “L”$  in locking state.

\*2 :  $V_{CCTX} = V_{pTX} = V_{CCRX} = V_{pRX} = 2.7 \text{ V}$ ,  $f_{osc} = 12.8 \text{ MHz}$ ,  $T_a = +25 \text{ }^{\circ}\text{C}$ , in power saving mode.

$PS_{TX} = PS_{RX} = GND$

$V_{IH} = V_{CC}$ ,  $V_{IL} = GND$  (at CLK, Data, LE)

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

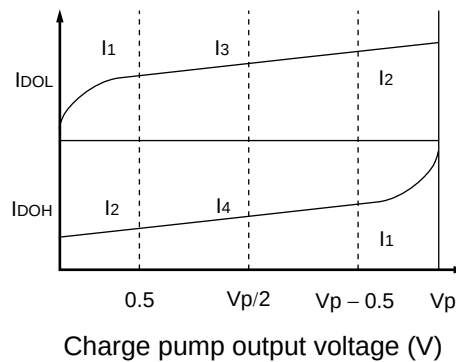
\*4 : The symbol “−” (minus) means the direction of current flow.

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

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

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

\*8 : When Charge pump current is measured, set  $LDS = “L”$ ,  $T1 = “L”$  and  $T2 = “H”$ .



## ■ 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<sub>IN</sub> input frequency)

R : Preset divide ratio of binary 14-bit programmable reference counter (3 to 16,383)

### 2. Serial Data Input

The 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.

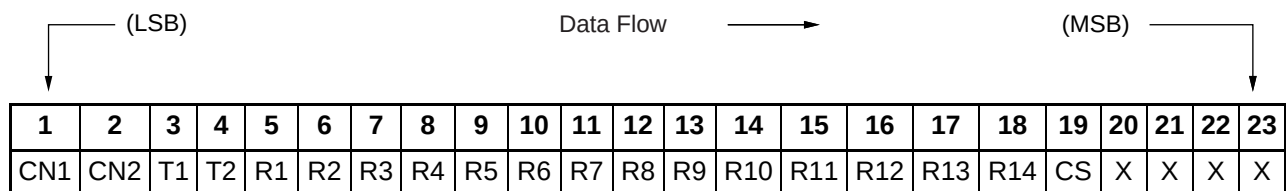
The serial data of binary data is entered through Data pin.

On rising edge of Clock, one bit of the 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 latches 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

- Programmable Reference Counter



CS : Charge pump current select bit

R1 to R14 : Divide ratio setting bits for the programmable reference counter (3 to 16,383)

T1, 2 : LD/fout output setting bit

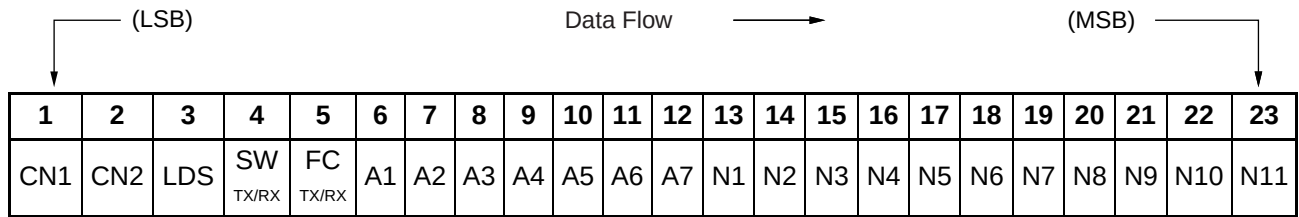
CN1, 2 : Control bit

X : Dummy bits (Set "0" or "1")

Note : Data input with MSB first.



## • Programmable Counter



A1 to A7 : Divide ratio setting bits for the swallow counter (0 to 127)

N1 to N11 : Divide ratio setting bits for the programmable counter (3 to 2,047)

LDS : LD/fout signal select bit

SW<sub>TX/RX</sub> : Divide ratio setting bit for the prescaler (TX : SW<sub>TX</sub>, RX : SW<sub>RX</sub>)

FC<sub>TX/RX</sub> : Phase control bit for the phase detector (TX : FC<sub>TX</sub>, RX : FC<sub>RX</sub>)

CN1, 2 : Control bit

Note : Data input with MSB first.

## (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  |

# MB15F78UL

- 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 Selectable Bit Setting

| LD/fout pin state |                  | LDS | T1 | T2 |
|-------------------|------------------|-----|----|----|
| LD output         |                  | 0   | 0  | 0  |
|                   |                  | 0   | 1  | 0  |
|                   |                  | 0   | 1  | 1  |
| fout output       | fr <sub>TX</sub> | 1   | 0  | 0  |
|                   | fr <sub>RX</sub> | 1   | 1  | 0  |
|                   | fp <sub>TX</sub> | 1   | 0  | 1  |
|                   | fp <sub>RX</sub> | 1   | 1  | 1  |

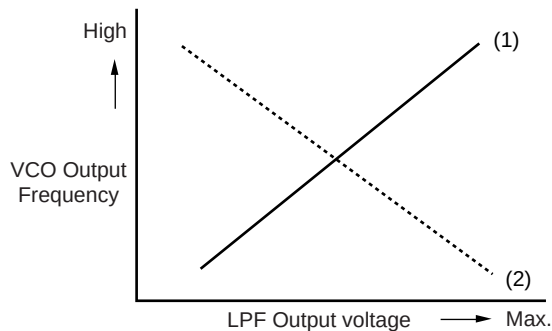
- Phase Comparator Phase Switching Data Setting

| Phase comparator input | FC = "H"                           | FC = "L"                           |
|------------------------|------------------------------------|------------------------------------|
|                        | Do <sub>TX</sub> /Do <sub>RX</sub> | Do <sub>TX</sub> /Do <sub>RX</sub> |
| 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.

- (1) VCO polarity FC = "H"  
 (2) VCO polarity FC = "L"



Note : Give attention to the polarity for using active type LPF.

### 3. Power Saving Mode (Intermittent Mode Control Circuit)

| Status            | PS <sub>TX</sub> /PS <sub>RX</sub> 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.

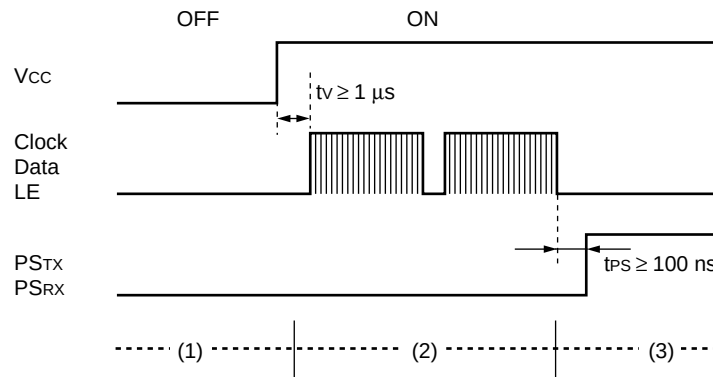
For the dual PLL, the lock detector, LD, is as shown in the LD Output Logic table.

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<sub>TX</sub> = PS<sub>RX</sub> = Low, for at least 1  $\mu$ s.
  - PS pins must be set at "L" at Power-ON

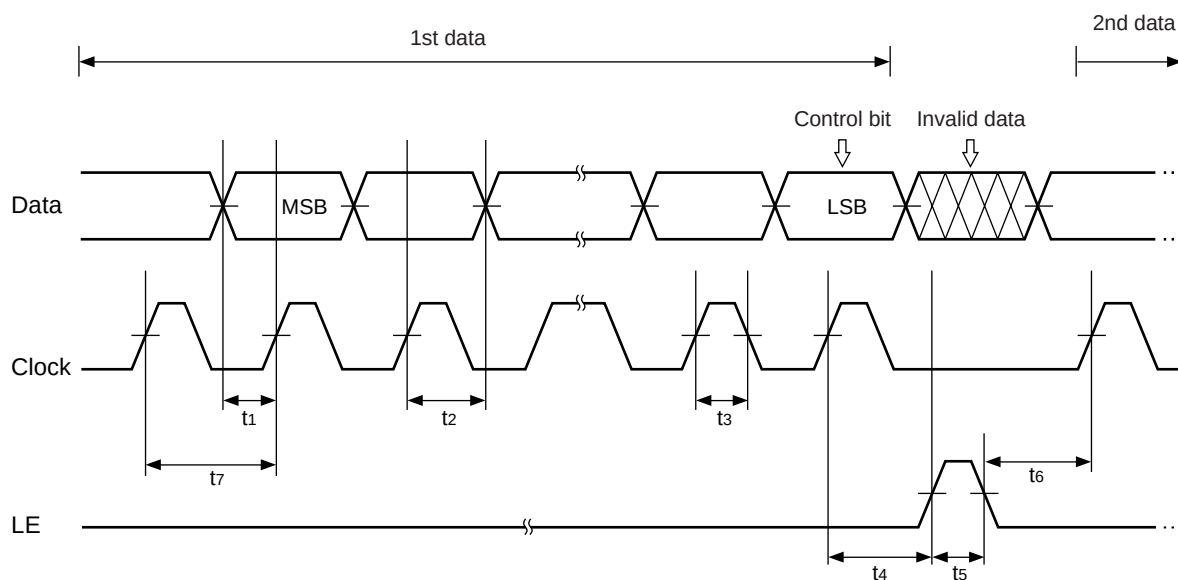


- (1) PS<sub>TX</sub> = PS<sub>RX</sub> = "L" (power saving mode) at Power-ON
- (2) Set serial data at least 1  $\mu$ s after the power supply becomes stable ( $V_{CC} \geq 2.2 V$ ).
- (3) Release power saving mode (PS<sub>TX</sub>, PS<sub>RX</sub> : "L"  $\rightarrow$  "H") at least 100 ns after setting serial data.

## 4. Serial data input timing

Divide ratio 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.

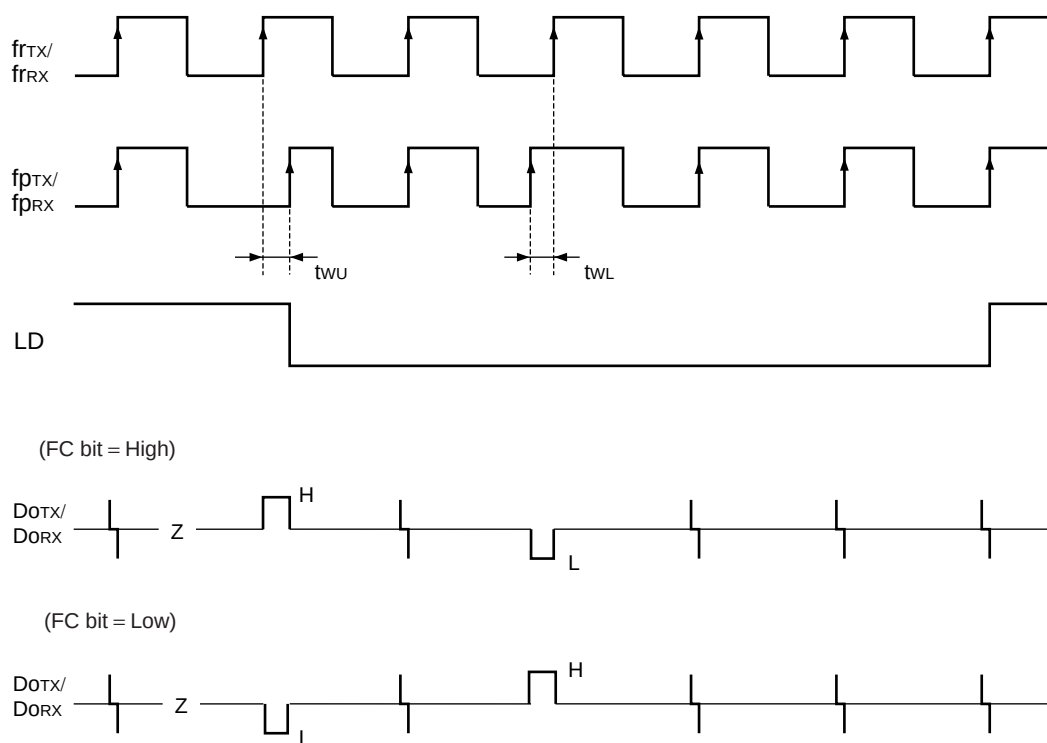


| Parameter | Min. | Typ. | Max. | Unit |
|-----------|------|------|------|------|
| $t_1$     | 20   | —    | —    | ns   |
| $t_2$     | 20   | —    | —    | ns   |
| $t_3$     | 30   | —    | —    | ns   |
| $t_4$     | 30   | —    | —    | ns   |

| Parameter | Min. | Typ. | Max. | Unit |
|-----------|------|------|------|------|
| $t_5$     | 100  | —    | —    | ns   |
| $t_6$     | 20   | —    | —    | ns   |
| $t_7$     | 100  | —    | —    | ns   |

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

## ■ PHASE COMPARATOR OUTPUT WAVEFORM



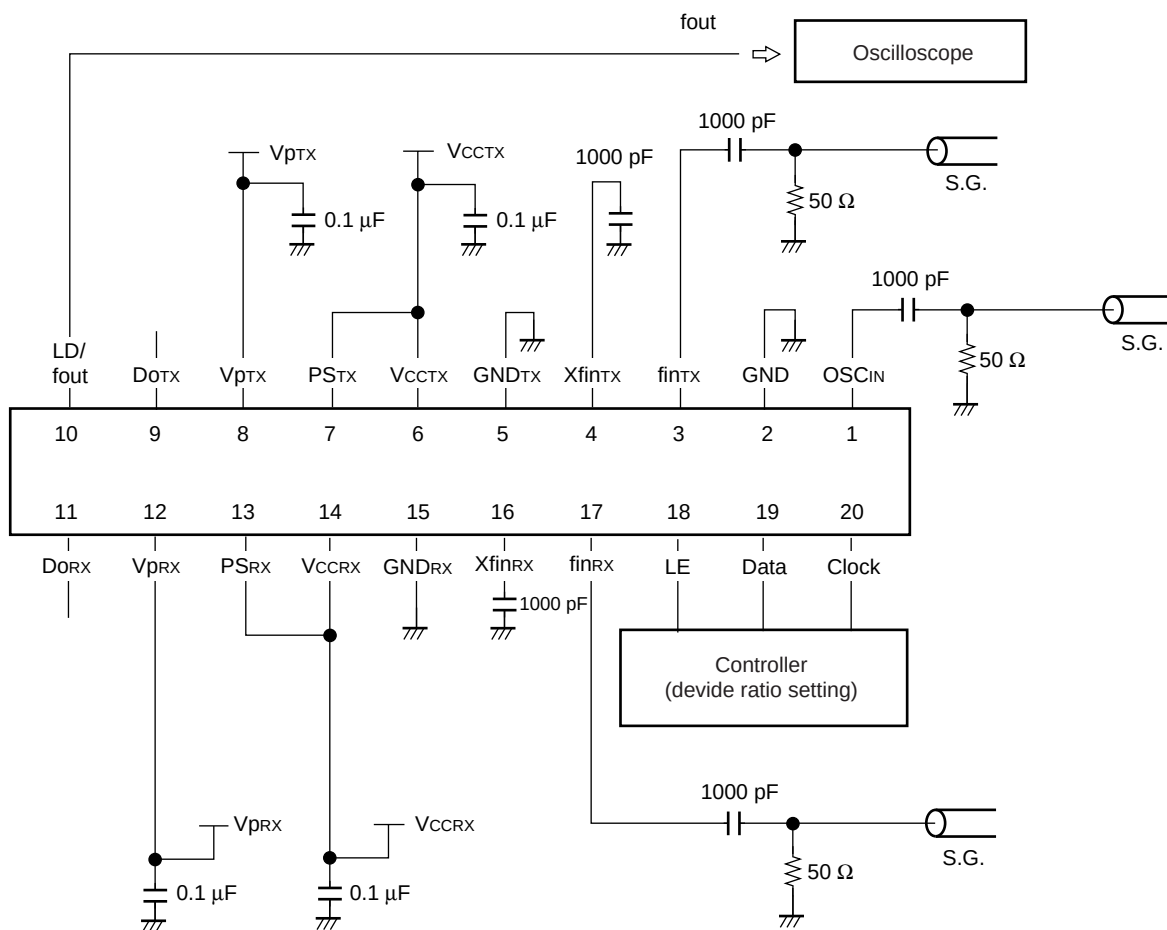
LD Output Logic Table

| 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 =  $-2\pi$  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<sub>IN</sub> input frequency as follows.
    - $t_{WU} \geq 2/f_{osc}$  : e.g.  $t_{WU} \geq 156.3$  ns when  $f_{osc} = 12.8$  MHz
    - $t_{WU} \leq 4/f_{osc}$  : e.g.  $t_{WL} \leq 312.5$  ns when  $f_{osc} = 12.8$  MHz

# MB15F78UL

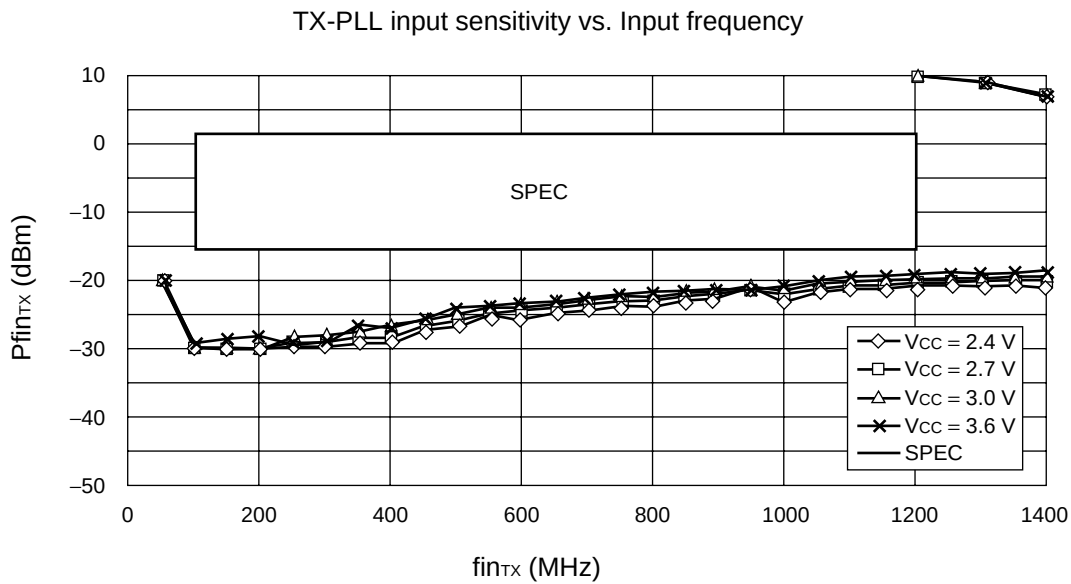
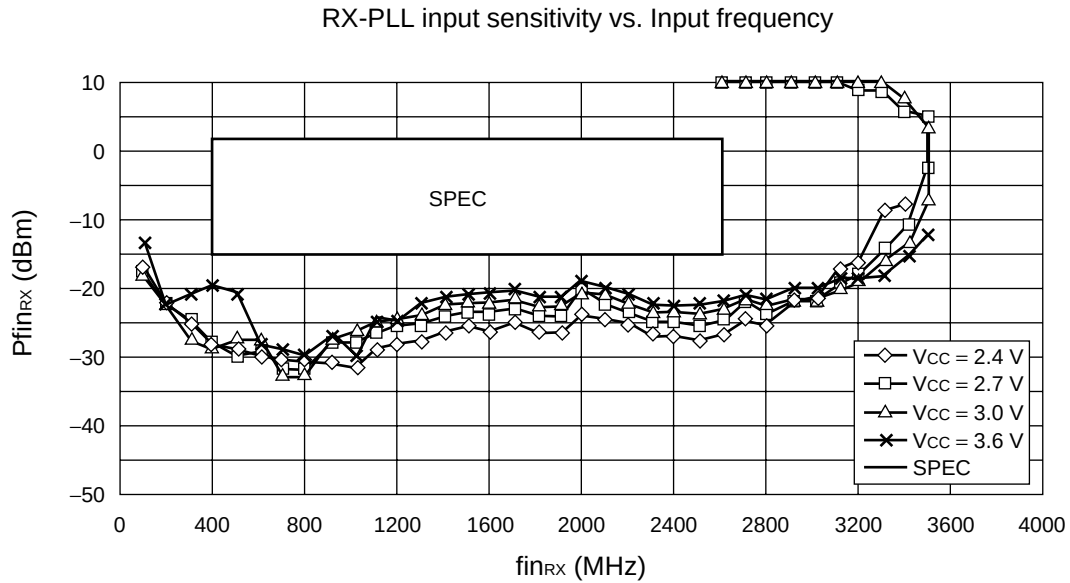
## ■ TEST CIRCUIT (for Measuring Input Sensitivity $f_{in}/OSC_{IN}$ )



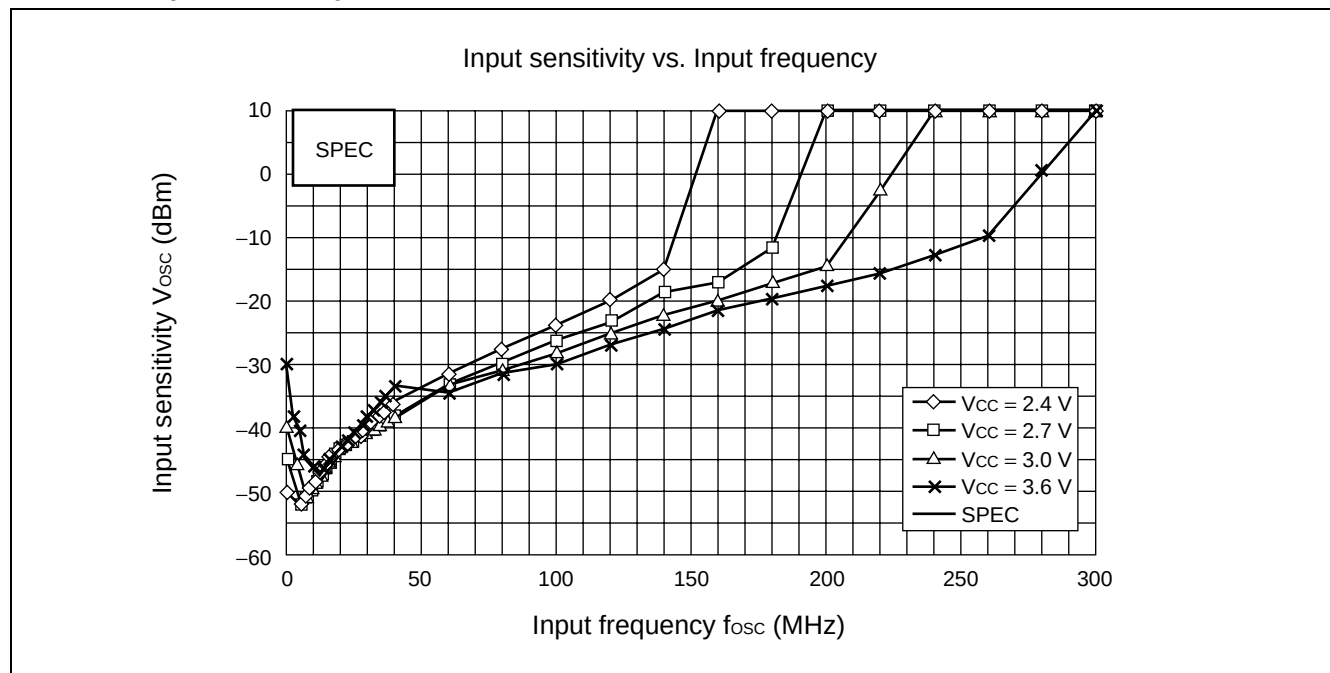
Note : The terminal number shows that of TSSOP-20

## ■ TYPICAL CHARACTERISTICS

### 1. fin input sensitivity



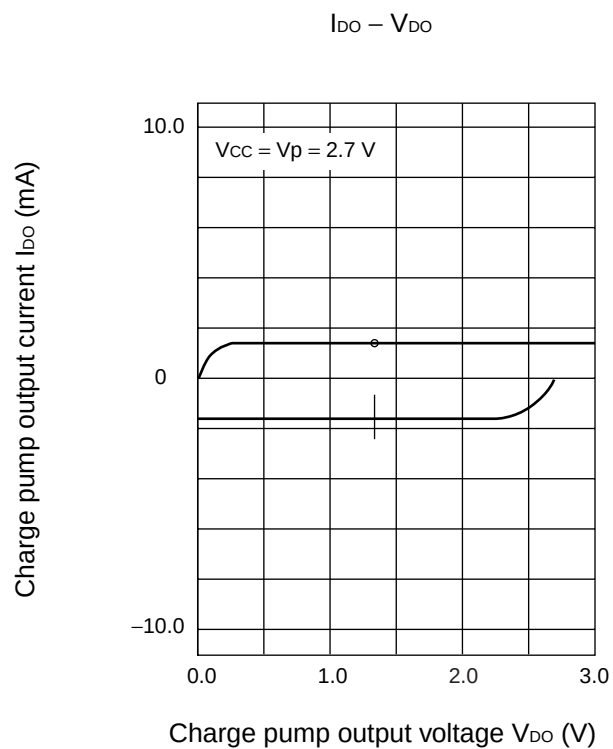
## 2. OSC<sub>IN</sub> input sensitivity



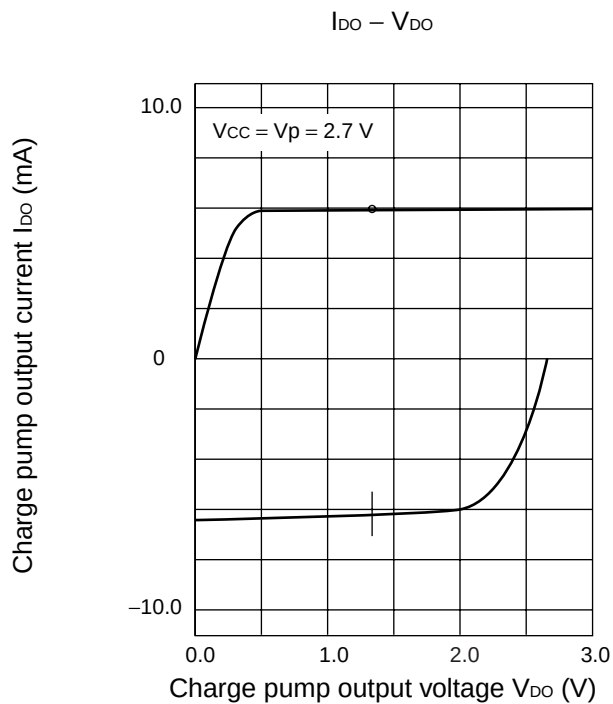


## 3. Do output current (RX PLL)

- 1.5 mA mode

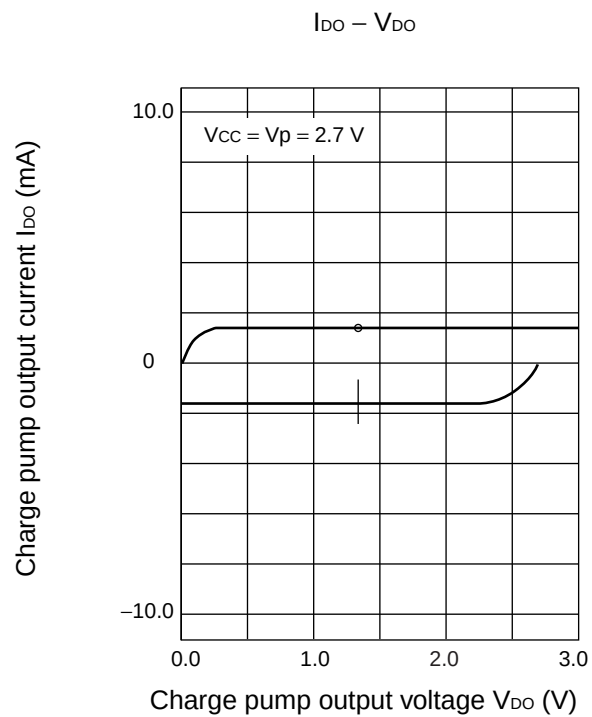


- 6.0 mA mode

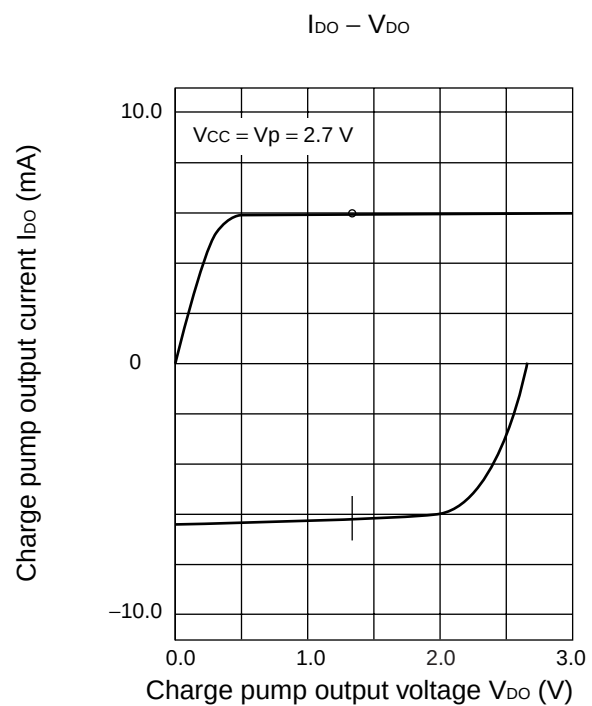


## 4. Do output current (TX PLL)

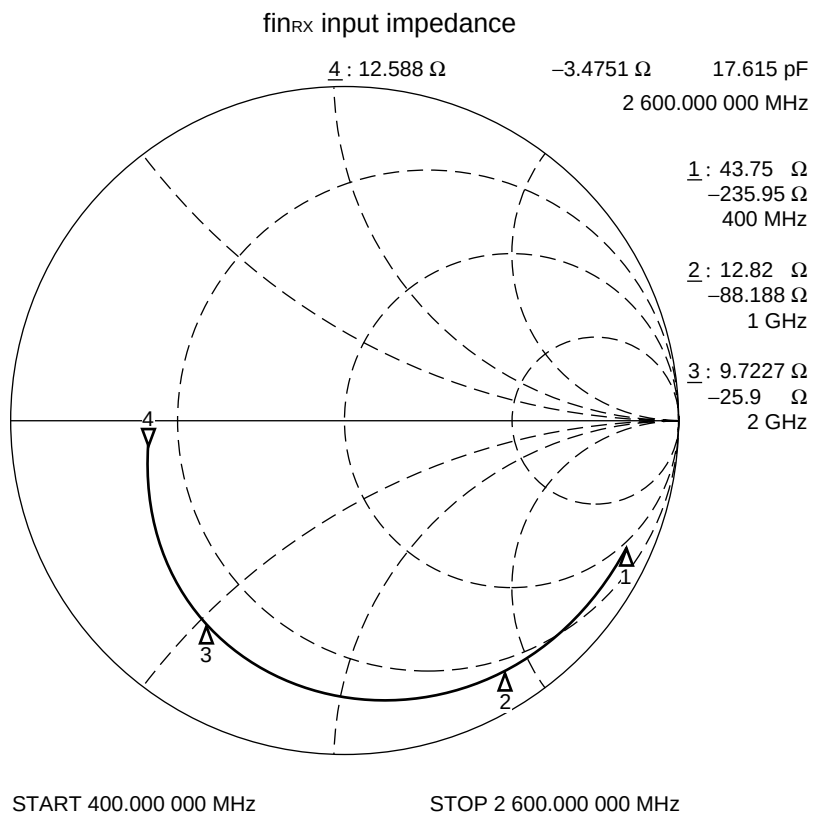
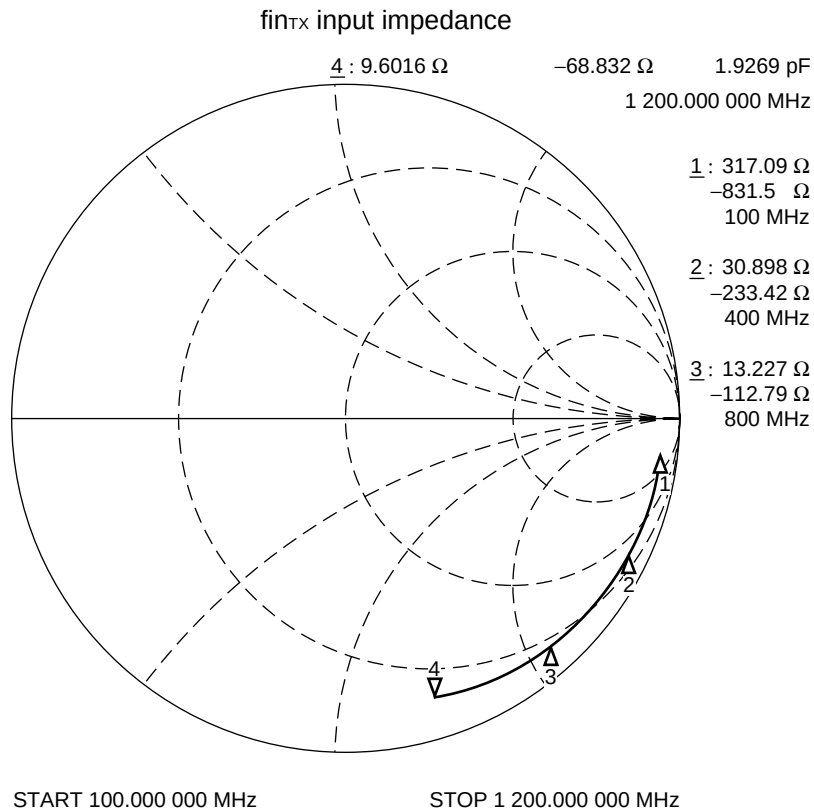
- 1.5 mA mode



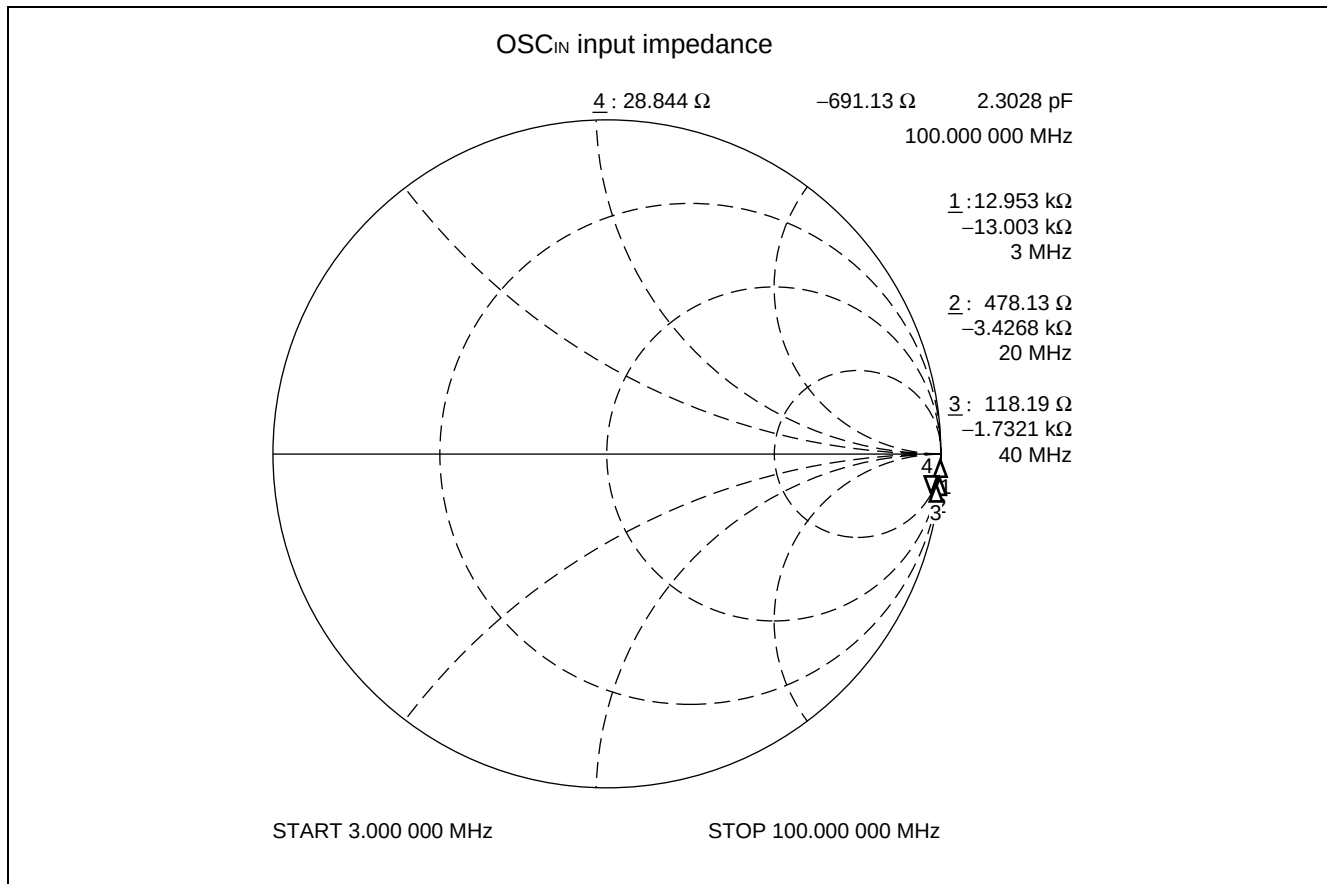
- 6.0 mA mode



## 5. fin input impedance

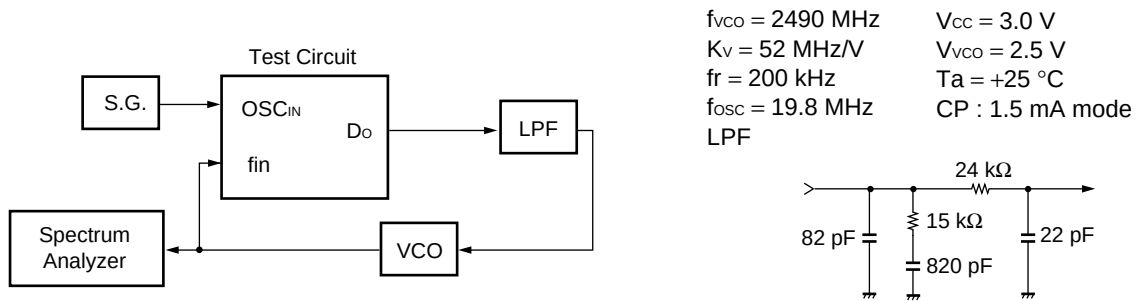


## 6. OSC<sub>IN</sub> input impedance

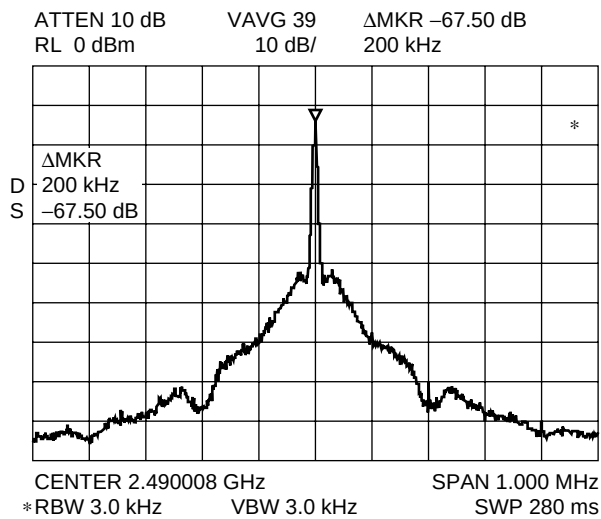


## REFERENCE INFORMATION

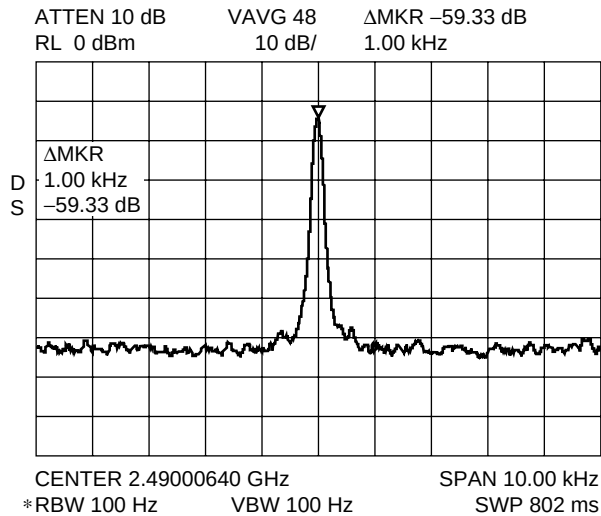
(for Look-up time, Phase noise and Reference leakage)



### • PLL Reference Leakage



### • PLL Phase Noise



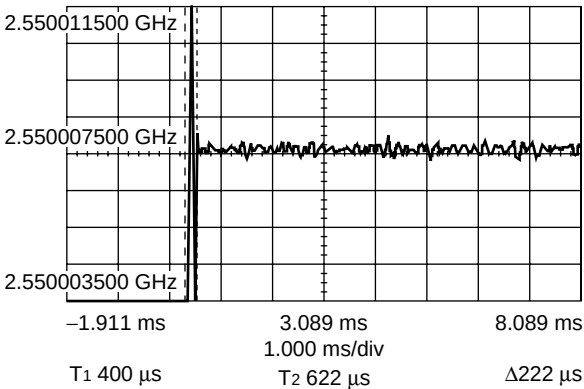
(Continued)

# MB15F78UL

(Continued)

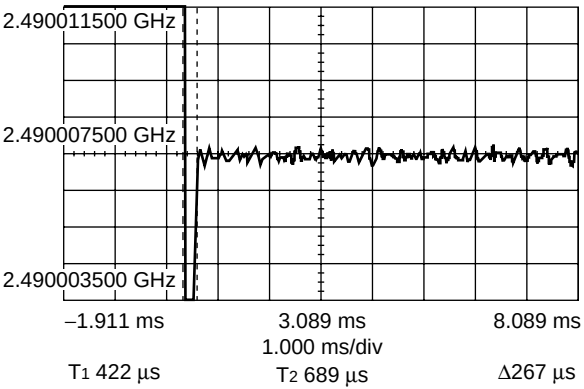
• PLL Lock-up time

2.49 GHz→2.55 GHz within  $\pm 1$  kHz  
Lch→Hch 222  $\mu$ s

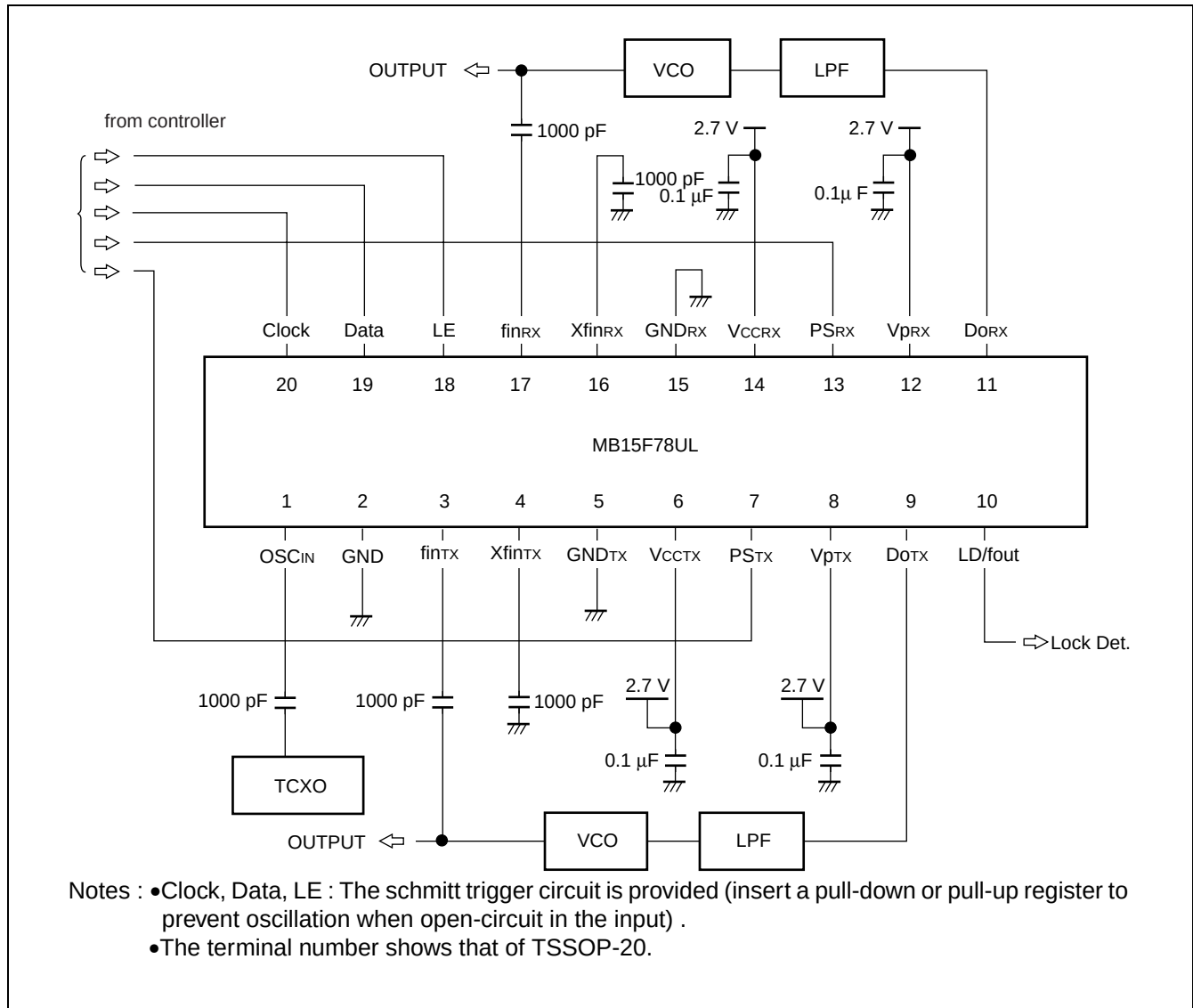


• PLL Lock-up time

2.55 GHz→2.49 GHz within  $\pm 1$  kHz  
Hch→Lch 267  $\mu$ s



## APPLICATION EXAMPLE



# MB15F78UL

## ■ USAGE PRECAUTIONS

- (1)  $V_{CCRX}$ ,  $V_{PRX}$ ,  $V_{CCTX}$  and  $V_{PTX}$  must be equal voltage.  
Even if either RX-PLL or TX-PLL is not used, power must be supplied to  $V_{CCRX}$ ,  $V_{PRX}$ ,  $V_{CCTX}$  and  $V_{PTX}$  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 |
|--------------|----------------------------------------|---------|
| MB15F78ULPFT | 20-pin, plastic TSSOP<br>(FPT-20P-M06) |         |
| MB15F78ULPVA | 20-pad, plastic BCC<br>(LCC-20P-M05)   |         |

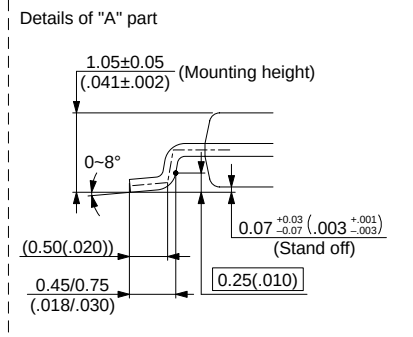
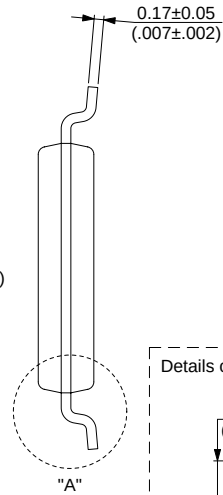
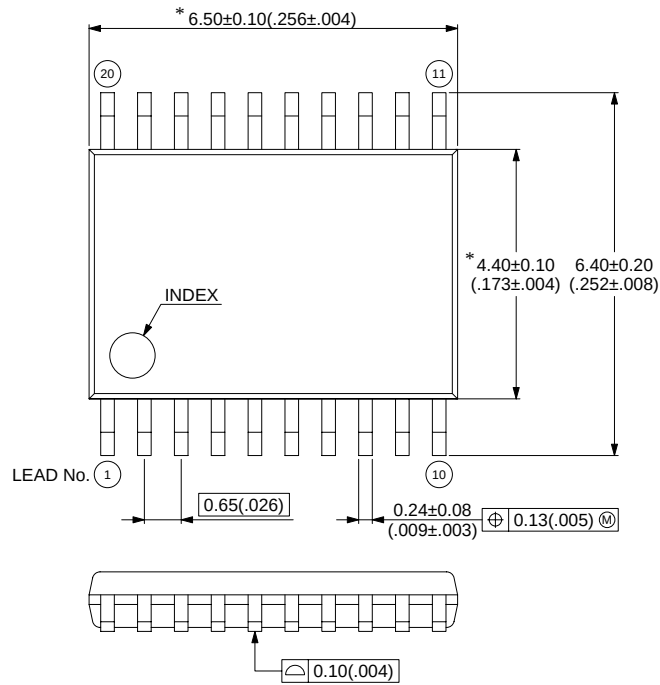


## ■ PACKAGE DIMENSIONS

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.



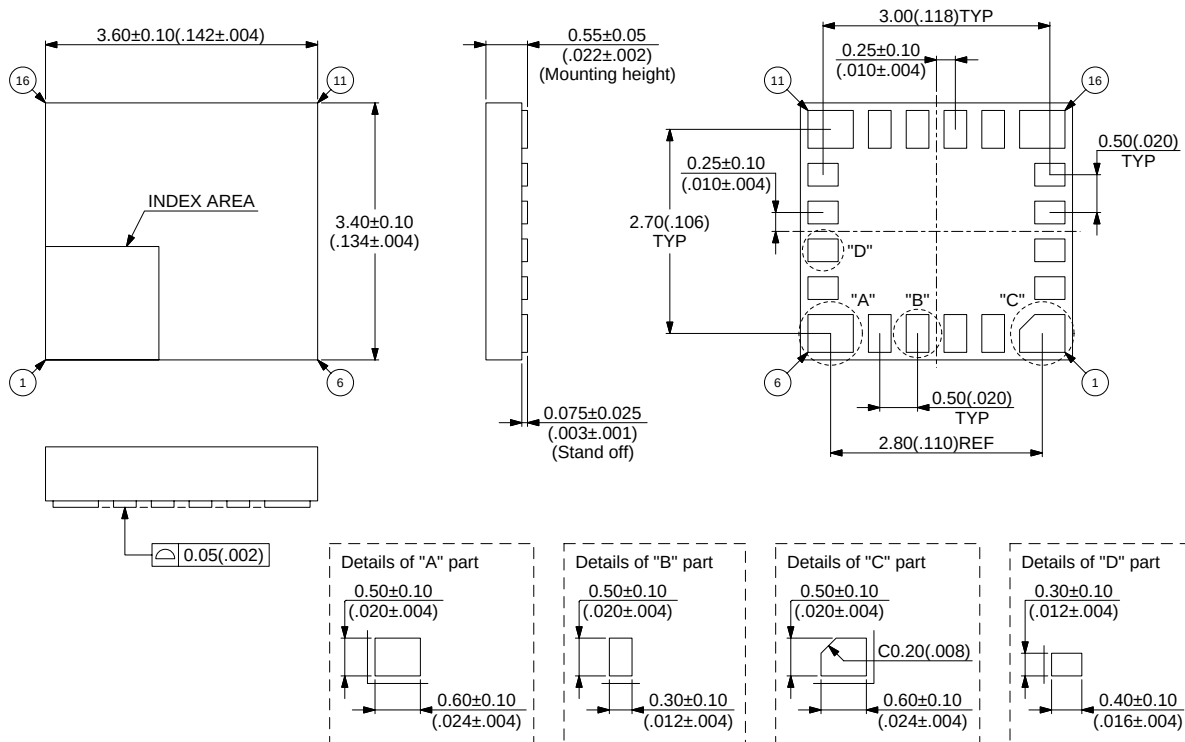
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Dimensions in mm (inches)

(Continued)

# MB15F78UL

(Continued)

20-pad plastic BCC  
(LCC-20P-M05)

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Dimensions in mm (inches)

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