FUJITSU

DATA SHEET

ASSP for DTS
Bi-CMOS
1.1 GHz PLL Frequency Synthesizer
MB15A01

■ DESCRIPTION

The MB15A01 is a serial-input PLL (phase locked loop) frequency synthesizer LSI supporting a pulse swallow system.

The LSI consists of: a 1.1 GHz band, dual-modulus prescaler allowing either of 64/65 and 128/129 frequency divisions to be selected, a control signal generator circuit, a 19-bit shift register, a 15-bit latch, a reference divider (binary 14-bit reference counter), a 1-bit switch counter, a phase comparator with phase conversion functions, a charge pump, a crystal oscillator, an 18-bit latch, and programmable dividers (binary 7-bit swallow counter and binary 11-bit programmable counter).

The LSI is housed in a 16-pin or 20-pin SSOP package, contributing to space saving of the system incorporating it.

In addition, the MB15A01 operates at a low supply voltage of 3.0 V (typical), achieving low current consumption (typically I_{CC} = 6.5 mA)
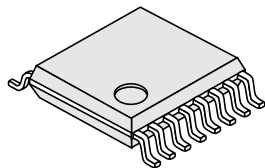
■ FEATURES

- Operation at high speed: fin = 1.1 GHz (Vin = −10 dBm)
- Pulse swallow function: Internal dual-modulus prescaler allowing either of 64/65 and 128/129 frequency divisions to be selected
- Low current consumption: I_{CC} = 6.5 mA (typical)
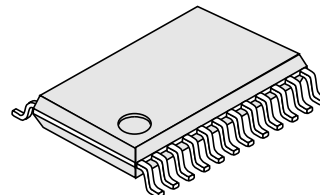
(Continued)

■ PACKAGES

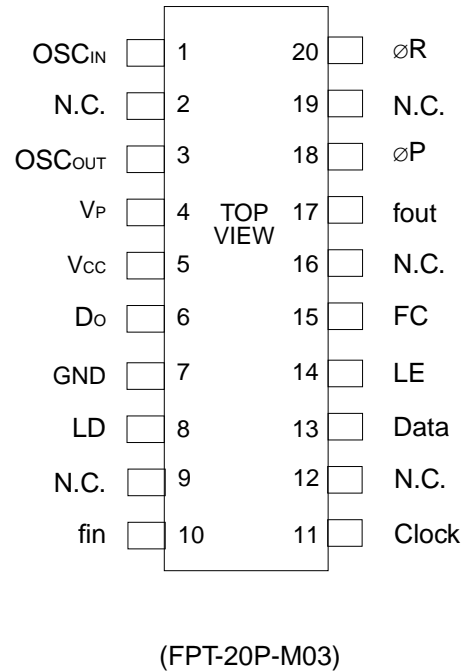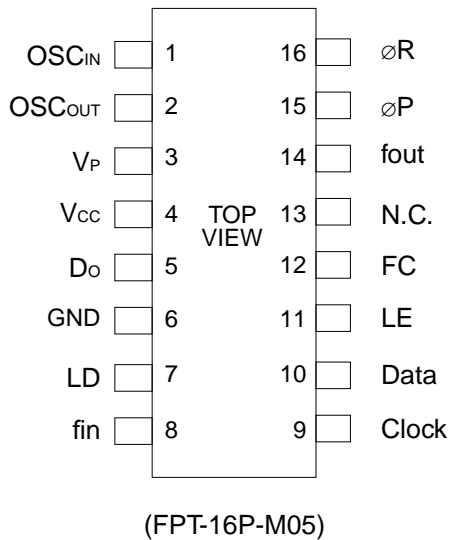16-pin Plastic SSOP

20-pin Plastic SSOP

(FPT-16P-M05)

(FPT-20P-M03)

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(Continued)

- Serial-input 18-bit programmable divider
  Divide ratio of binary 7-bit swallow counter (0 to 127)
  Binary 11-bit programmable counter (16 to 2,047)
- Serial-input 15-bit reference divider
  Divide ratio of binary 14-bit programmable reference counter (6 to 16,383)
  1-bit switch counter (for setting the prescaler divide ratio)
- Serial data configuration compatible with conventional models such as MB1511
- Two different phase comparator outputs
  Internal charge pump output (bipolar type)
  Output for external charge pump
- Wide range of operating temperature: Ta = –40 to +85°C

■ PIN ASSIGNMENTS

OSC_{IN}	1	16	$\varnothing R$
OSC_{OUT}	2	15	$\varnothing P$
V_P	3	14	fout
V_{CC}	4 TOP VIEW	13	N.C.
D_O	5	12	FC
GND	6	11	LE
LD	7	10	Data
fin	8	9	Clock

(FPT-16P-M05)

OSC_{IN}	1	20	$\varnothing R$
N.C.	2	19	N.C.
OSC_{OUT}	3	18	$\varnothing P$
V_P	4 TOP VIEW	17	fout
V_{CC}	5	16	N.C.
D_O	6	15	FC
GND	7	14	LE
LD	8	13	Data
N.C.	9	12	N.C.
fin	10	11	Clock

(FPT-20P-M03)

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MB15A01

■ PIN DESCRIPTION

Pin No.		Pin name	I/O	Function
SSOP-16	SSOP-20			
1	1	OSC$_{IN}$	I	Crystal oscillator connection pin serving as a reference divider input pin (Oscillator circuit input pin)
2	3	OSC$_{OUT}$	O	Crystal oscillator connection pin (Oscillator circuit output pin)
3	4	V$_P$	—	Power supply pin for charge pump output Connect this pin to V$_{CC}$ when the internal charge pump is not used.
4	5	V$_{CC}$	—	Power supply pin
5	6	D$_O$	O	Internal charge pump output pin
6	7	GND	—	GND pin
7	8	LD	O	Lock detector output pin When locked: LD = "H", When unlocked: LD = "L"
8	10	fin	I	Prescaler input pin The pin must be AC-coupled for input.
9	11	Clock	I	Clock input pin for 19-bit and 16-bit shift registers The shift resistors reads data at the rise of the clock pulse.
10	13	Data	I	Binary-coded serial data input pin The last bit in the data is a control bit. Control bit = "H": Sends data to the 15-bit latch. "L": Sends data to the 18-bit latch.
11	14	LE	I	Load enable signal input pin (with pull-up resistor) When LE = "H", the pin sends the contents of the shift register to the latch according to the control bit.
12	15	FC	I	Phase comparator phase switching pin (with pull-up resistor) When FC = "L", the pin inverts characteristics of the phase comparator. It also switches the fout pin (test pin) output between fr and fp.
13	2, 9, 12, 16, 19	N.C.	—	No connection.
14	17	fout	O	Phase comparator input monitor pin The pin outputs the reference divider output (fr) or programmable divider output (fp) signal depending on the FC pin input level. It is an N channel open-drain output.
15	18	øP	O	Phase comparator output pin for external charge pump This pin is an N channel open-drain output.
16	20	øR	O	Phase comparator output pin for external charge pump This pin is a CMOS output.

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MB15A01

■ BLOCK DIAGRAM

MB15A01

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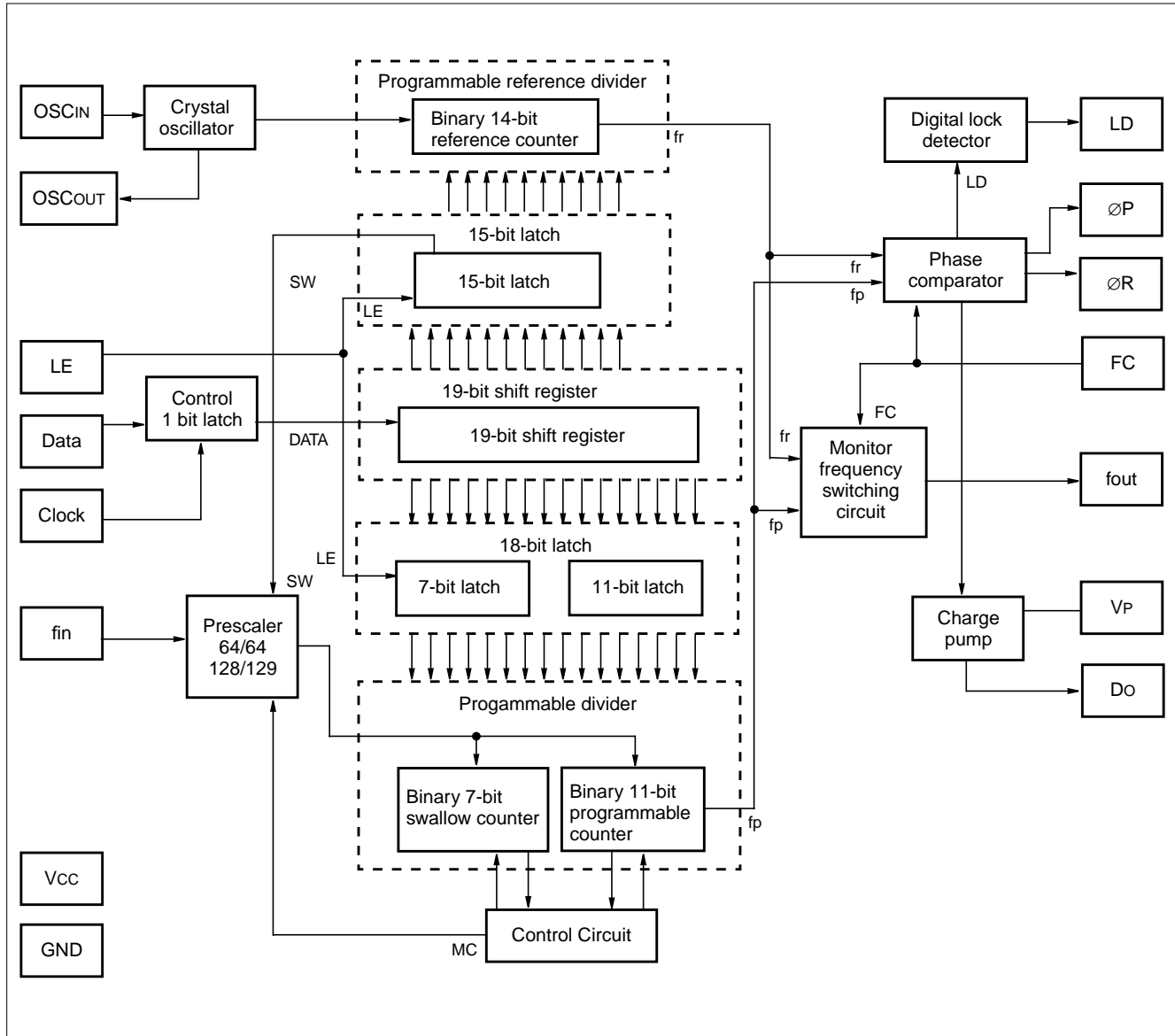
■ ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Rating		Unit	Remarks
		Min.	Max.		
Power supply voltage	V_{CC}	−0.5	+5.0	V	
	V_P	V_{CC}	+8.0	V	
Output voltage	V_O	−0.5	V_{CC} + 0.5	V	
Open-drain voltage	V_{OOP}	−0.5	+6.0	V	øP pin
Output current	I_O	−10	+10	mA	
Storage temperature	Tstg	−55	+125	°C	

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

■ RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Value			Unit
		Min.	Typ.	Max.	
Power supply voltage	V_{CC}	2.7	3.0	3.5	V
	V_P	V_{CC}	—	6.0	V
Input voltage	V_I	GND	—	V_{CC}	V
Operating temperature	Ta	−40	—	+85	°C

Precautions: Although the MB15A01 contains an antistatic element to prevent electrostatic breakdown and the circuitry has been improved in electrostatic protection, observe the following precautions when handling the device:
• When storing or carrying the device, put it in a conductive case.
• This is static-sensitive device; take proper anti-ESD Paricutin. Ensure that personnel and equipment are properly grounded. Cover workbenches with grounded conductive mats.
• Before fitting the device into or removing it from the socket, turn the power supply off.
• Protect leads with conductive sheet when handling or transporting PC boards with devices.

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Downloaded from Arrow.com.

■ ELECTRICAL CHARACTERISTICS

(V_{CC} = 2.7 V to 3.5 V, Ta = −40°C to +85°C)

Parameter		Symbol	Condition	Value			Unit
				Min.	Typ.	Max.	
Power supply current		I_{CC}	V_{CC} = 3 V, assuming fin = 1.1 GHz and OSC_{IN} = 12 MHz, in locking	—	6.5	—	mA
Operating frequency	fin	fin	Must be AC-coupled. The minimum operating frequency assumes coupling at 1000 pF.	10	—	1100	MHz
	OSC_{IN}	f_{OSC}	—	—	12	23	MHz
Input sensitivity	fin	V_{fin}	50 Ω system (Refer to the test circuit example)	−10	—	6	dBm
	OSC_{IN}	V_{OSC}	—	0.5	—	—	V_{P-P}
"H" level input voltage	Clock Data LE	V_{IH}	—	$V_{CC} \times 0.7$	—	—	V
"L" level input voltage		V_{IL}	—	—	—	$V_{CC} \times 0.3$	V
"H" level input current	Clock Data	I_{IH}	—	—	—	1.0	μA
"L" level input current		I_{IL}	—	—	—	−1.0	μA
Input current	OSC_{IN}	I_{OSC}	—	—	±50	—	μA
	LE, FC	I_{LE}	—	—	−60	—	μA
"H" level output voltage	øR, LD	V_{OH}	V_{CC} = 3 V, I_{OH} = −1.0 mA	2.1	—	—	V
"L" level output voltage	øP/R, LD	V_{OL}	V_{CC} = 3 V, I_{OL} = 1.0 mA	—	—	0.4	V
High-impedance cutoff current	D_O øP	I_{OFF}	V_P = V_{CC} to 6.0 V V_{OOP} = GND to 6.0 V	—	—	1.1	μA
Output current	øR, LD	I_{OH}	V_{CC} = 3 V	−1.0	—	—	mA
	øP/R, LD	I_{OL}	V_{CC} = 3 V	—	—	1.0	mA

■ FUNCTIONAL DESCRIPTIONS

1. Pulse Swallow Function

For the pulse swallow function, use the following equations to select their respective setting values:

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

f_{VCO}	:	Output frequency of externally connected VCO
P	:	Prescaler divide ratio (64 or 128)
N	:	Divide ratio of 11-bit programmable counter (16 to 2047)
A	:	Divide ratio of 7-bit swallow counter (0 to 127, A < N)
f_{osc}	:	Reference oscillation frequency
R	:	Divide ratio of 14-bit programmable reference counter (6 to 16383)

2. Serial Data Input Method

Serial data is processed using three input pins (Data, Clock, and LE pins) to control the 15-bit reference divider and the 18-bit programmable divider separately.
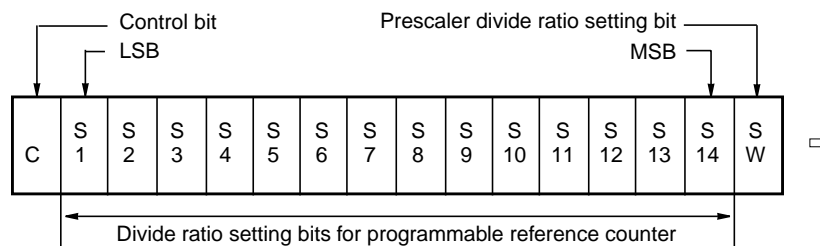
Input binary-coded serial data to the Data pin.

Serial data is input to the internal shift register in sequence at the rise of each clock pulse. When the load enable signal input pin has a high level (or open), the input data is transferred to the latch depending on the control bit.

Control bit = "H": Transfer to the 15-bit latch
Control bit = "L": Transfer to the 18-bit latch

(1) Divide Ratio of Reference Divider

The reference divider consists of a 16-bit shift register, a 15-bit latch, and a 14-bit reference counter. Serial data is made up of the following 16 bits:

Control bit
LSB
Prescaler divide ratio setting bit
MSB

C	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	SW

Divide ratio setting bits for programmable reference counter

• 14-bit programmable reference divide ratio

Divide ratio R	S14	S13	S12	S11	S10	S9	S8	S7	S6	S5	S4	S3	S2	S1
6	0	0	0	0	0	0	0	0	0	0	0	1	1	0
7	0	0	0	0	0	0	0	0	0	0	0	1	1	1
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•

Note: The divide ratio must not be less than 6.   (Set value: 6 to 16383)

SW: Prescaler division bit
       SW = "H": 64/65 division
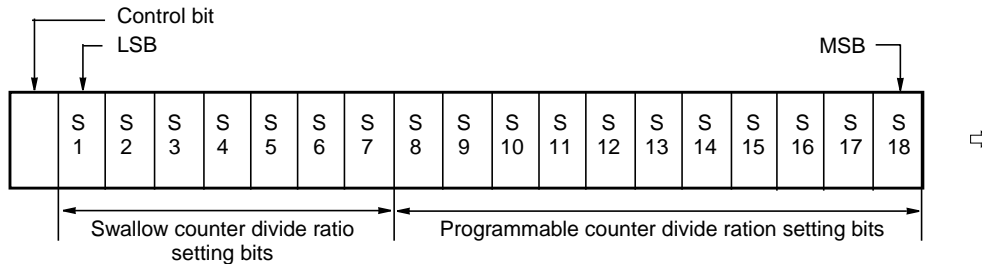   SW = "L": 128/129 division
S1 to S14: Divide ratio setting bits (Divide ratio of 6 to 16383)
C: Control bit (Set it to "H".)

Note: Start data input with MSB first.

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(2) Divide Ratio of Programmable Divider

The programmable divider consists of a 19-bit shift register, an 18-bit latch, 7-bit swallow counter, and an 11-bit programmable counter. Serial data is made up of the following 19 bits:

Control bit
LSB
MSB

| | S1 | S2 | S3 | S4 | S5 | S6 | S7 | S8 | S9 | S10 | S11 | S12 | S13 | S14 | S15 | S16 | S17 | S18 |

Swallow counter divide ratio setting bits

Programmable counter divide ration setting bits

• 7-bit swallow counter divide ratio

Divide ratio A	S7	S6	S5	S4	S3	S2	S1
0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	1
•	•	•	•	•	•	•	•

(Set value: 0 to 127)

• 11-bit programmable counter divide ratio

Divide ratio N	S18	S17	S16	S15	S14	S13	S12	S11	S10	S9	S8
16	0	0	0	0	0	1	0	0	0	0	0
17	0	0	0	0	0	1	0	0	0	0	1
•	•	•	•	•	•	•	•	•	•	•	•

Note: The divide ratio must not be less than 16. (Set value: 16 to 2047)
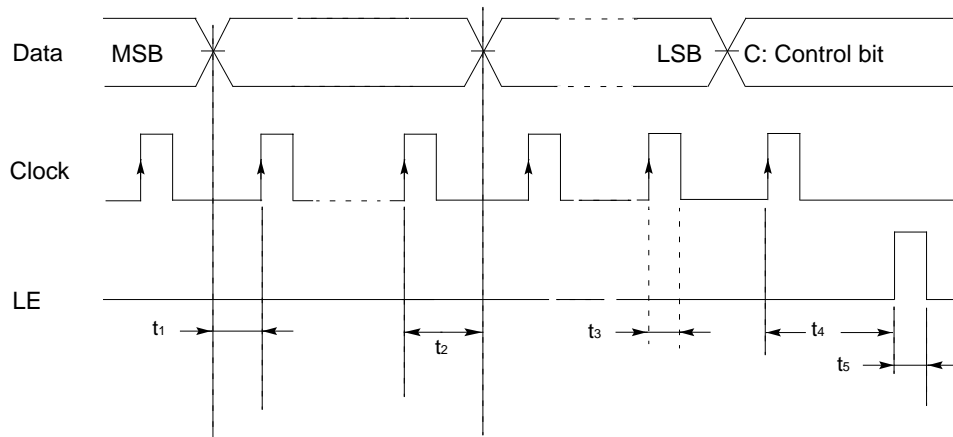
S1 to S7: Swallow counter divide ratio setting bits (Divide ration of 0 to 127)
S8 to S18: Programmable counter divide ration setting bits (Divide ration of 16 to 2047)
C: Control bit (Set it to "L")

Note: Start data input with MSB first.

(3) Serial Data Input Timing

Data   MSB   LSB   C: Control bit

Clock

LE

t1   t2   t3   t4   t5

t1, t4>100 ns, t2>1000 nw, t3>300 ns, t5>800 ns

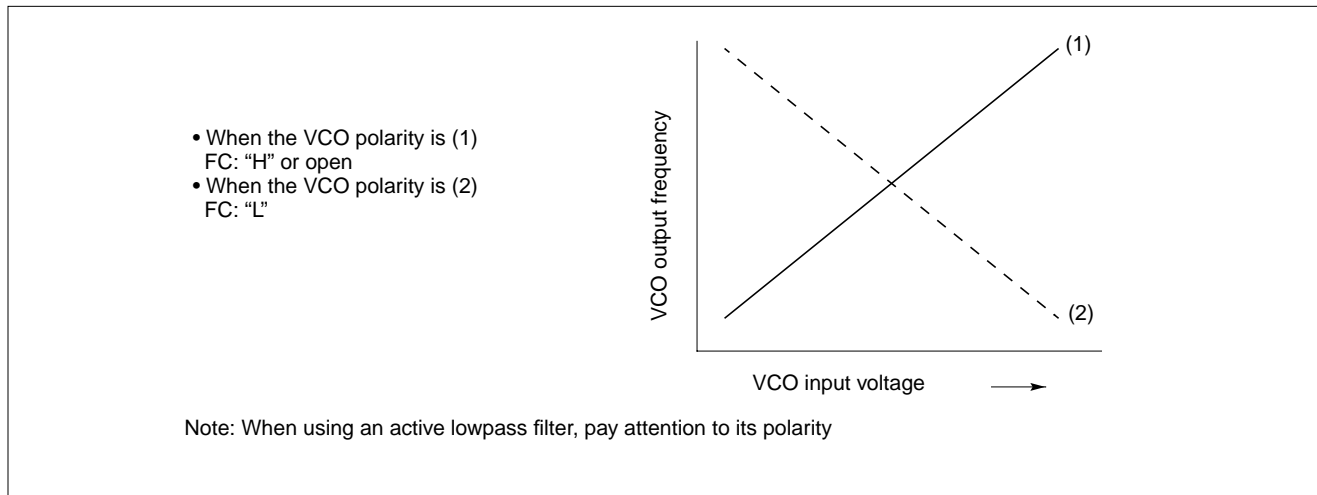Note: Serial data is fetched at the rise of each clock pulse.

3. Relation between FC Pin Inputs and Phase Characteristics

The FC pin is the phase switching pin for the phase comparator. Controlling the FC pin inverts the characteristics of the internal charge pump output (D_O) and phase comparator outputs (ϕR, ϕP). In addition, the phase comparator input monitor pin (fout) is also controlled via the FC pin. The following table lists relation between FC pin inputs and D_O, ϕR, ϕP, and fout:
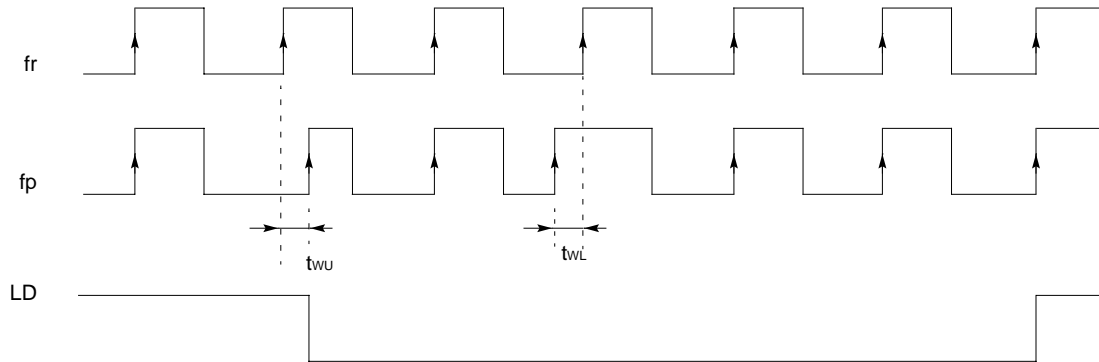
	FC: "H" (or open)				FC: "L"			
	D_O	ϕR	ϕP	fout	D_O	ϕR	ϕP	fout
fr > fp	H	L	L		L	H	Z	
fr < fp	L	H	Z	fr	H	L	L	fp
fr = fp	Z	L	Z		Z	L	Z	

Z: High impedance

When designing a synthesizer, control the FC pin depending on the VCO polarity.

• When the VCO polarity is (1)
  FC: "H" or open
• When the VCO polarity is (2)
  FC: "L"

VCO output frequency

(1)

(2)

VCO input voltage ⟶

Note: When using an active lowpass filter, pay attention to its polarity
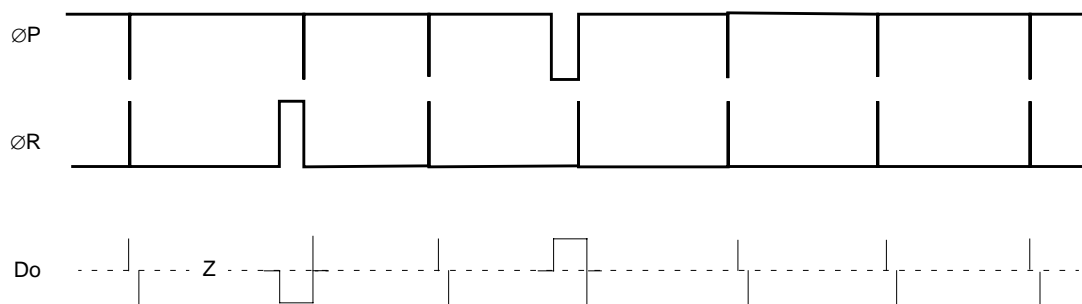
9

■ PHASE COMPARATOR OUTPUT WAVEFORMS
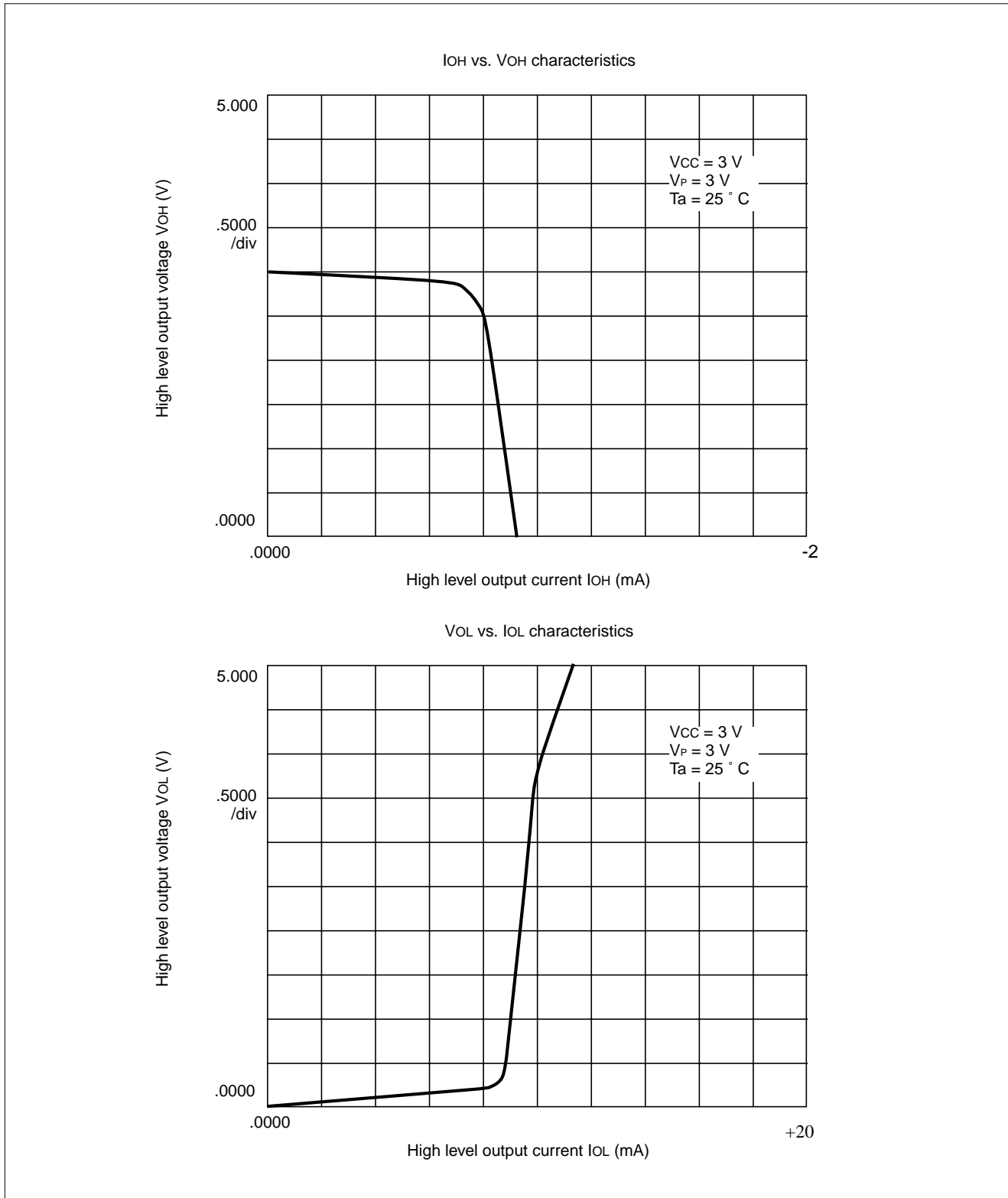

When the FC bit = "H"
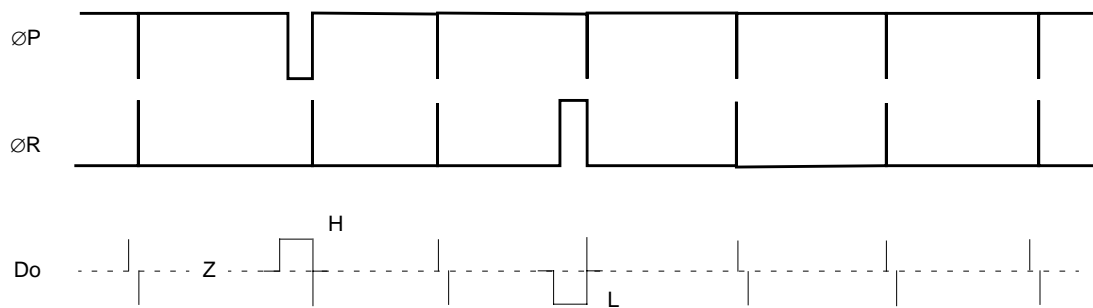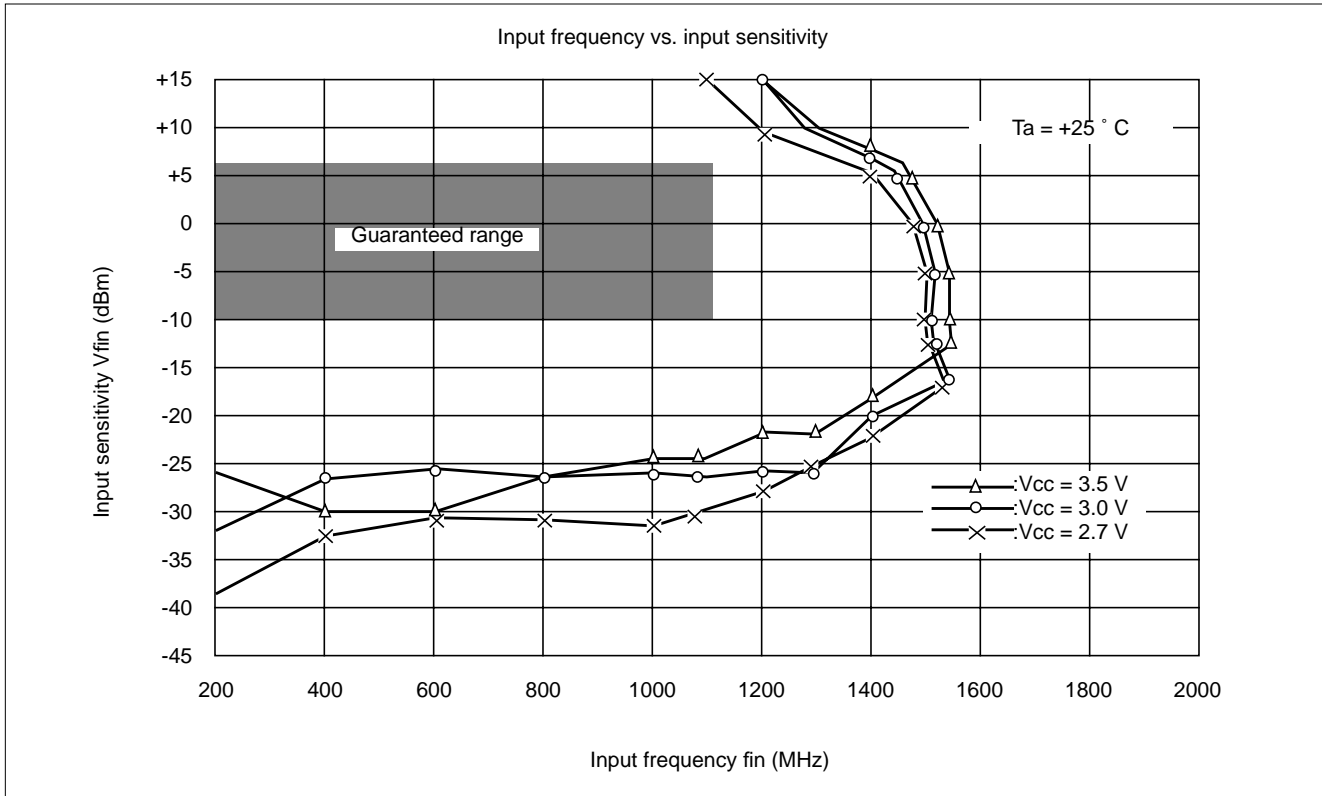
When the FC bit = "L"

Notes:
- A phase difference is detected between -2π and $+2\pi$, with gain = $Vp/4\pi$
- The LD output goes low when it becomes phase between phase difference t_{WU} or more. The LD output goes high when it remains equal to or smaller than t_{WL}, for three cycles or more.
- t_{WU} and t_{WL} are determined by the OSCIN input frequency as follows:
  $t_{WU} \geq 8/fosc$ (s)
  When focs = 12.8 MHz: $t_{WU} \geq 625$ ns
  $t_{WL} \leq 16/fosc$ (s)
  When fosc = 12.8 MHz: $t_{WL} \leq 1250$ ns
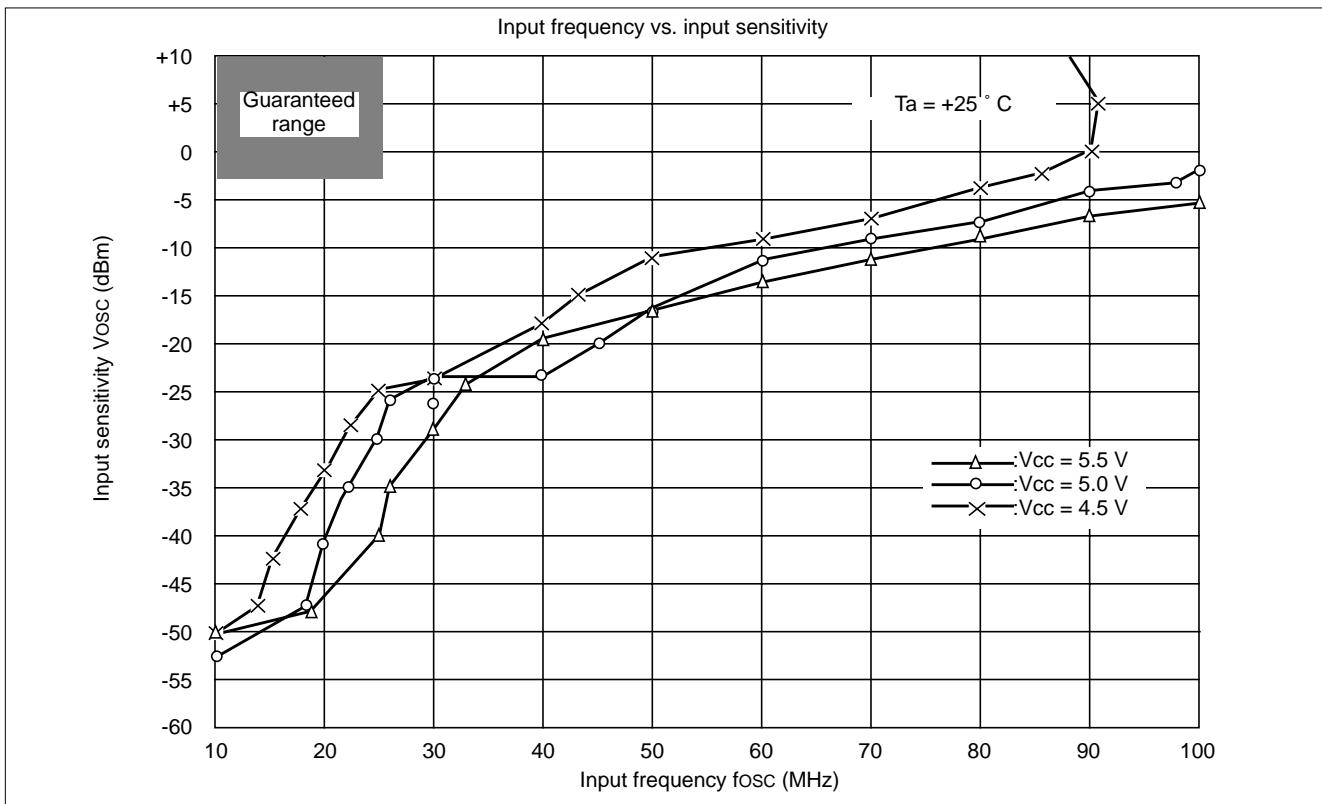
10

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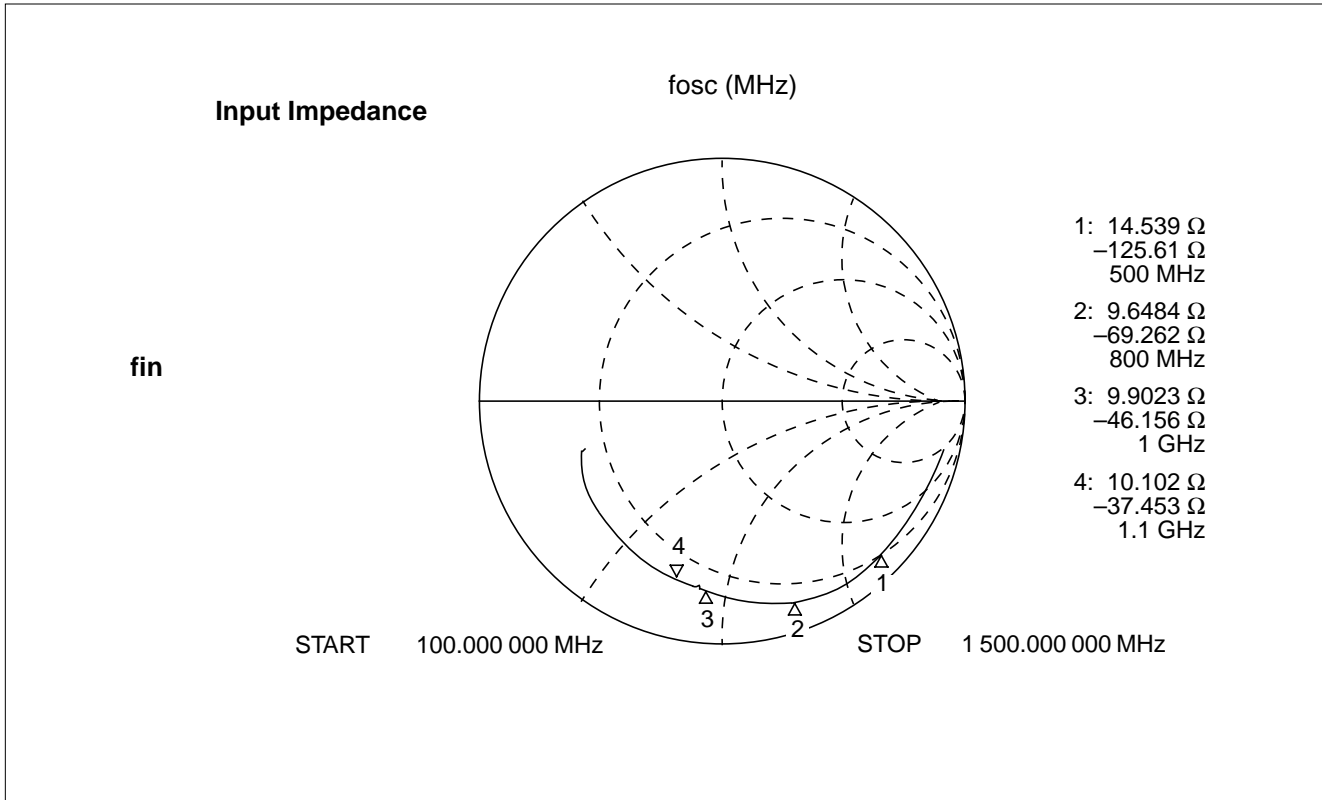## ■ TYPICAL CHARACTERISTIC CURVES

1. D$_O$ Output Current Characteristics

IOH vs. VOH characteristics

High level output voltage VOH (V)

5.000

.5000
/div

.0000

.0000   -2

VCC = 3 V
VP = 3 V
Ta = 25 ˚C

High level output current IOH (mA)

VOL vs. IOL characteristics

High level output voltage VOL (V)

5.000

.5000
/div

.0000

.0000   +20

VCC = 3 V
VP = 3 V
Ta = 25 ˚C

High level output current IOL (mA)

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2. fin Input Sensitivity Characteristics

Input frequency vs. input sensitivity

Input sensitivity Vfin (dBm)

Guaranteed range

Ta = +25 °C

:Vcc = 3.5 V
:Vcc = 3.0 V
:Vcc = 2.7 V

Input frequency fin (MHz)

3. OSC$_{IN}$ Input Sensitivity Characteristics

Input frequency vs. input sensitivity

Input sensitivity VOSC (dBm)

Guaranteed range

Ta = +25 °C

:Vcc = 5.5 V
:Vcc = 5.0 V
:Vcc = 4.5 V

Input frequency fOSC (MHz)

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4. fin Input Impedance Characteristics

Input Impedance

fosc (MHz)

fin

1: 14.539 Ω
   −125.61 Ω
   500 MHz

2: 9.6484 Ω
   −69.262 Ω
   800 MHz

3: 9.9023 Ω
   −46.156 Ω
   1 GHz

4: 10.102 Ω
   −37.453 Ω
   1.1 GHz

START   100.000 000 MHz   STOP   1 500.000 000 MHz

5. OSC_IN Input Impedance Characteristics

OSC_IN

1: 1.425 kΩ
   −3.5698 kΩ
   10 MHz

2: 1.0444 Ω
   −2.637 kΩ
   15 MHz

3: 800.75 Ω
   −2.2129 kΩ
   20 MHz

4: 670.13 Ω
   −1.8371 kΩ
   3.4653 pF
   25 MHz

START   .500 000 MHz   STOP   100.000 000 MHz

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■ TEST CIRCUIT EXAMPLE (fin/OSC_{IN} Input Sensitivity Measurement)

Controller (divide ratio settings)

fout output monitor selection using the FC pin

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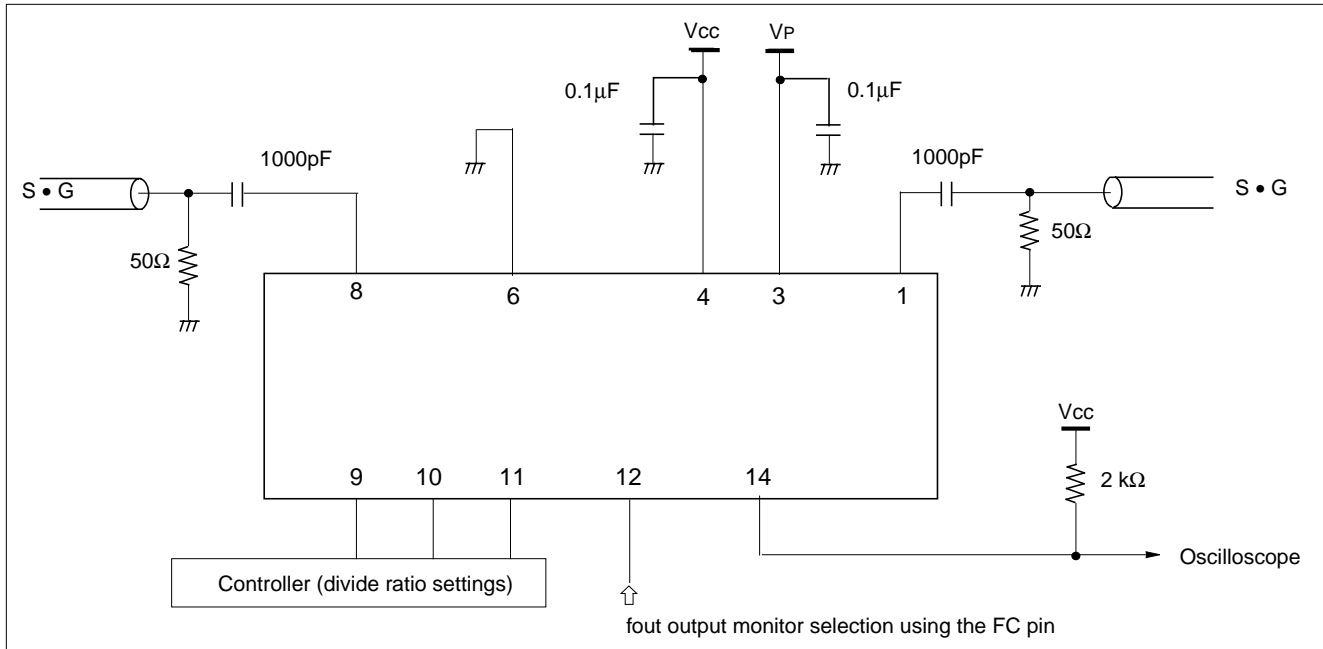
MB15A01

■ APPLICATION EXAMPLE (16-pin Package)

VPX   :6V max.
VP   :Connect the pin to Vcc when the internal charge pump is not used.
LE, FC   :With pull-up resistor
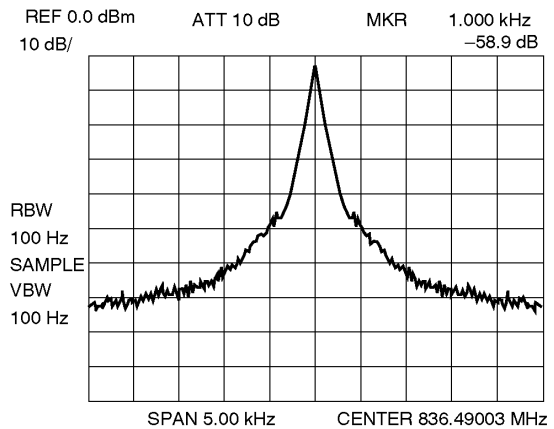ØP, fout :N channel open-drain output
ØR   :CMOS output

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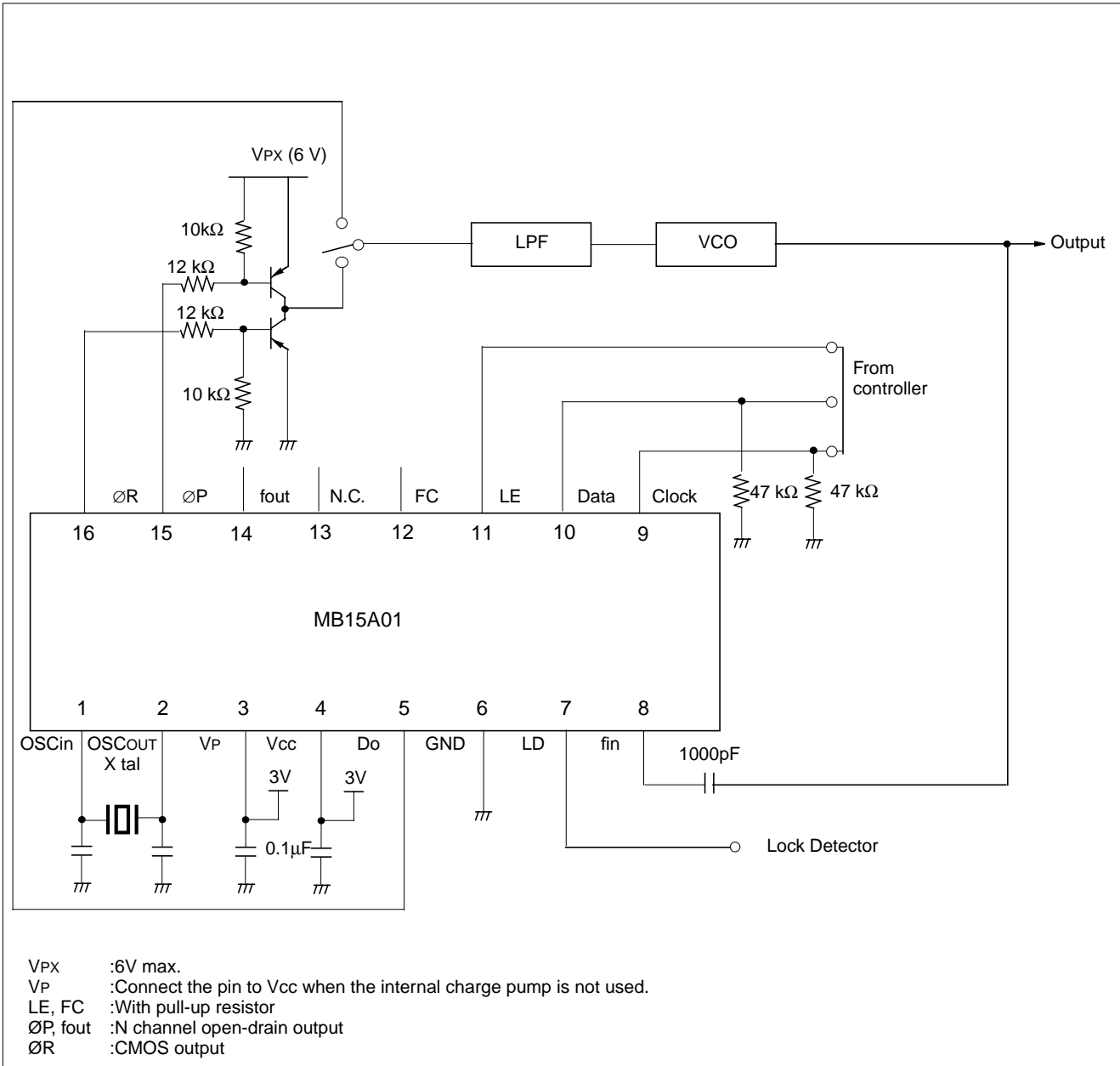
■ REFERENCE INFORMATION

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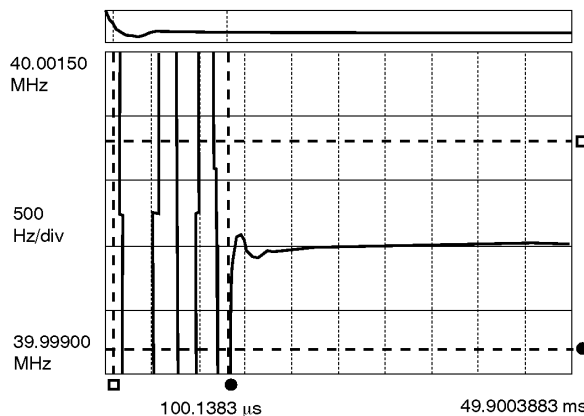phase noise, and reference
leakage.

Test Circuit

- f_{VCO} = 836.49 MHz
- K_V = 12 MHz/V
- f_r = 30 kHz
- f_{OSC} = 15.36 MHz
- LPF

S.G. → OSCin Do → LPF

fin

Spectrum Analyzer ← VCO

1.3 kΩ   2.2 kΩ
3.6 kΩ
47 nF   470 nF   47 nF
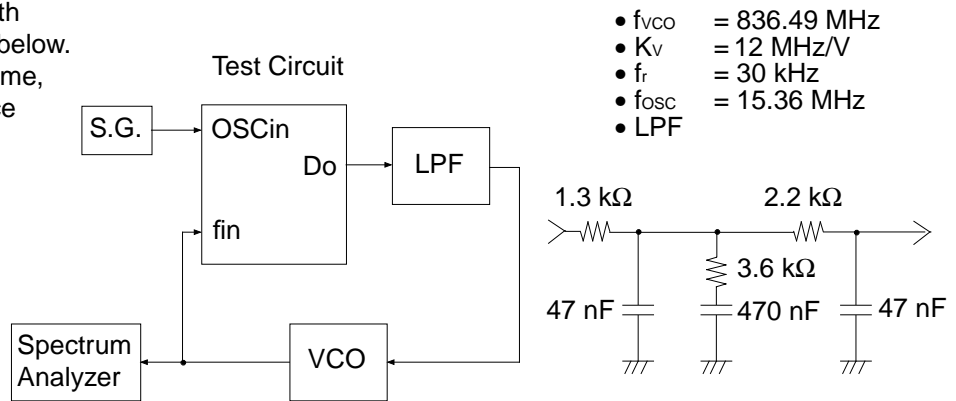
PLL Lock Up Time = 12 ms
(824.010 MHz → 848.97 MHz, within ±800 Hz)

40.00150 MHz

500 Hz/div

39.99900 MHz

100.1646 μs   49.9001646 ms
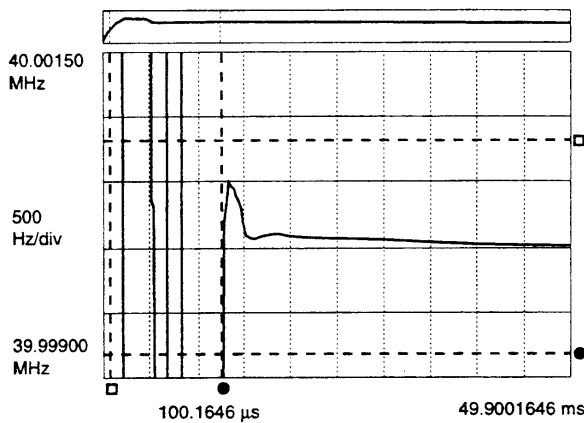
PLL Phase Noise
@ within loop band = 78.9 dBc/Hz

REF 0.0 dBm   ATT 10 dB   MKR   1.000 kHz
10 dB/   −58.9 dB

RBW 100 Hz
SAMPLE
VBW 100 Hz

SPAN 5.00 kHz   CENTER 836.49003 MHz

PLL Lock Up Time = 12.4 ms
(848.97 MHz → 824.019 MHz, within ±800 Hz)

40.00150 MHz

500 Hz/div

39.99900 MHz

100.1383 μs   49.9003883 ms

PLL Reference Leakage
@ 30kHz offset = 80.8 dBc

REF 0.0 dB m   ATT 10 dB   MKR   30.0 kHz
10 dB/   −80.8 dB

RBW 1 kHz
SAMPLE
VBW 1 kHz

SPAN 150 KHz   CENTER 836.490 MHz

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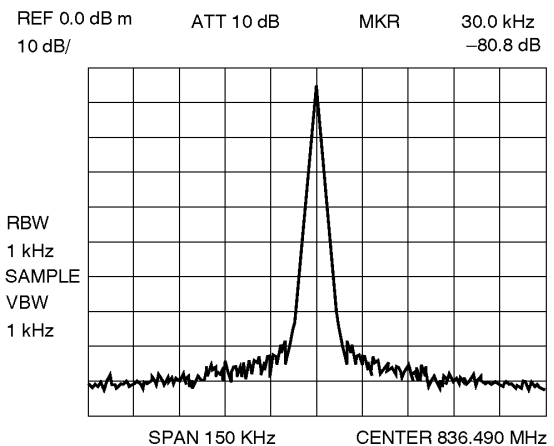
■ ORDERING INFORMATION

Part number	Package	Remarks
MB15A01PFV1	16-pin, Plastic SSOP (FPT-16P-M05)	
MB15A01PFV2	20-pin, Plastic SSOP (FPT-20P-M03)	

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■ **PACKAGE DIMENSIONS**

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

*: These dimensions do not include resin protrusion.

(Mounting height)

* 5.00±0.10(.197±.004)

1.25 $^{+0.20}_{-0.10}$
(.049 $^{+.008}_{-.004}$)

0.10(.004)

INDEX

* 4.40±0.10
(.173±.004)

6.40±0.20
(.252±.008)

5.40(.213)
NOM

0.65±0.12
(.0256±.0047)

0.22 $^{+0.10}_{-0.05}$
(.009 $^{+.004}_{-.002}$)

"A"

0.15 $^{+0.05}_{-0.02}$
(.006 $^{+.002}_{-.001}$)

Details of "A" part

0.10±0.10(.004±.004)
(STAND OFF)

0～10°

0.50±0.20
(.020±.008)

4.55(.179)REF
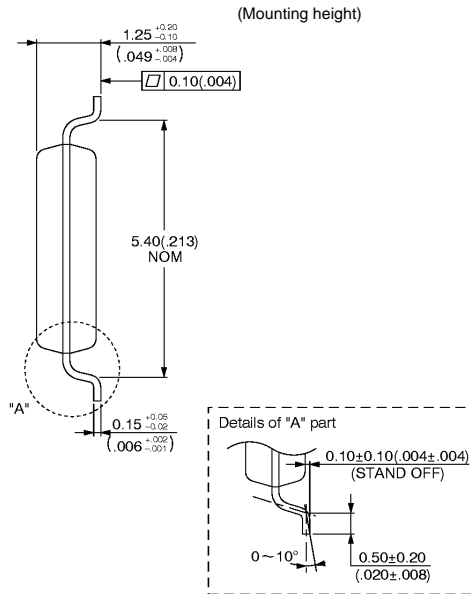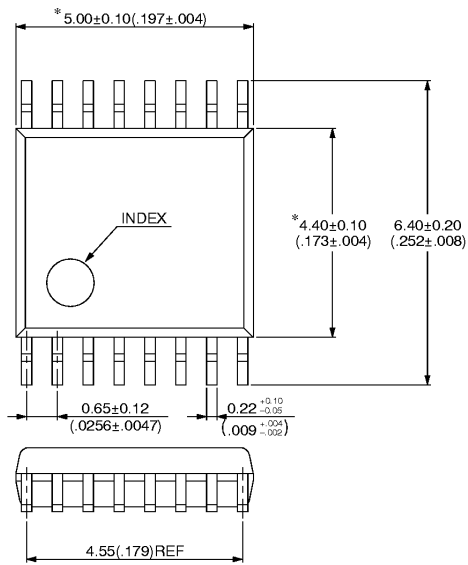
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Dimensions in mm (inches)

(Continued)

FUJITSU

(Continued)

20-pin, Plastic SSOP
(FPT-20P-M03)

*: These dimensions do not include resin protrusion.

*6.50±0.10(.256±.004)

1.25$^{+0.20}_{-0.10}$ (Mounting
(.049$^{+.008}_{-.004}$)

0.10(.004)

INDEX

*4.40±0.10   6.40±0.20
(.173±.004) (.252±.008)

5.40(.213)
NOM

0.65±0.12
(.0256±.0047)

0.22$^{+0.10}_{-0.05}$
(.009$^{+.004}_{-.002}$)

"A"

0.15$^{+0.05}_{-0.02}$
(.006$^{+.002}_{-.001}$)

Details of "A" part

0.10±0.10(.004±.004)
(STAND OFF)

0～10°

0.50±0.20
(.020±.008)

5.85(.230)REF
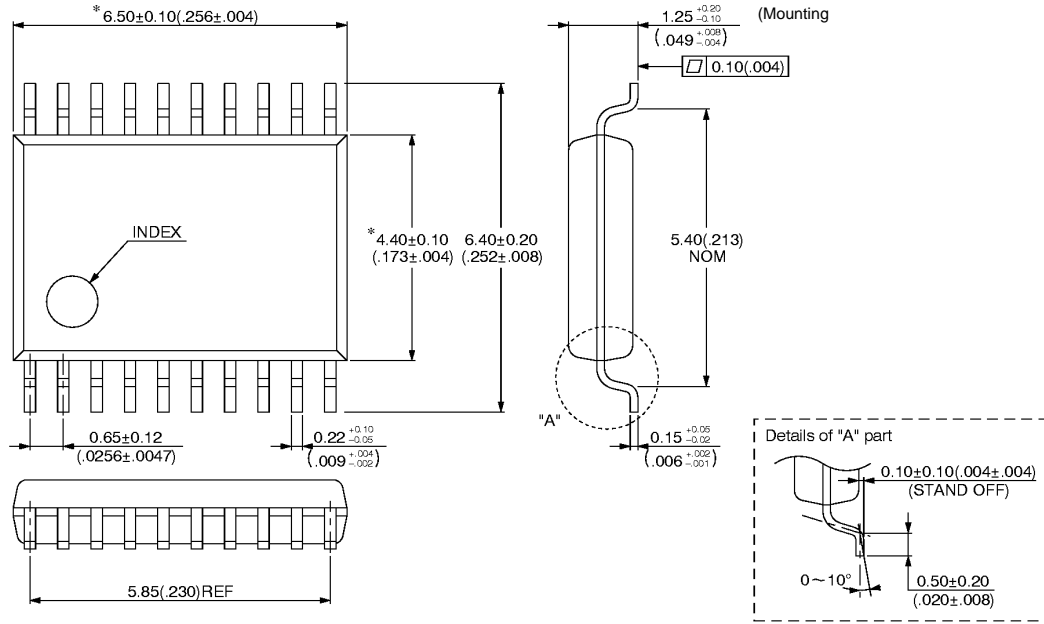
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Dimensions in mm (inches)

Worldwide Headquarters

Japan

Tel: +81 44 754 3753
Fax: +81 44 754 3332

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

Fujitsu Limited

1015 Kamiodanaka
Nakaharaku
Kawasaki 211
Japan

USA

Tel: +1 408 922 9000
Fax: +1 408 922 9179

Tel: +1 800 866 8608
Fax: +1 408 922 9179

http://www.fujitsumicro.com/

Fujitsu Microelectronics Inc
3545 North First Street
San José CA 95134-1804
USA

Customer Response Center
Mon-Fri: 7am-5pm (PST)

Asia

Tel: +65 281 0770
Fax: +65 281 0220

http://www.fsl.com.sg/

**Fujitsu Microelectronics
Asia PTE Limited**

#05-08, 151 Lorong Chuan
New Tech Park
Singapore 556741

Europe

Tel: +49 6103 6900
Fax: +49 6103 6901

http://www.fujitsu.ede.com/

**Fujitsu Mikroelektronik
GmbH**

Am Siebenstein 6-10
D-63303 Dreieich-Buchschlag
Germany

FJ No. DS04-21324-3E