FUJITSU SEMICONDUCTOR
DATA SHEET

DS04-29116-2E

Spread Spectrum Clock Generator

MB88151

■ DESCRIPTION

MB88151 is a clock generator for EMI (Electro Magnetic Interference) reduction. The peak of unnecessary radiation noise (EMI) can be attenuated by making the oscillation frequency slightly modulate periodically with the internal modulator. It corresponds to both of the center spread which modulates frequency in modulation off as Middle Centered and down spread which modulates so as not to exceed frequency in modulation off.

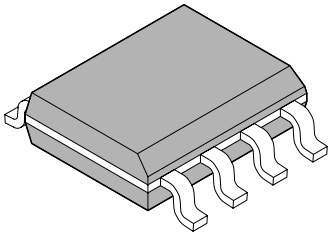
■ FEATURES

- Input frequency : 16.6 MHz to 33.4 MHz
- Multiplication rate : 1/2, 1, 2, 4
- Output frequency : 8.3 MHz to 16.7 MHz, 16.6 MHz to 33.4 MHz, 33.3 MHz to 66.7 MHz, 66.6 MHz to 133.4 MHz
- Modulation rate : ±0.5%, ±1.5% (Center spread), −1.0%, −3.0% (Down spread)
- Equipped with oscillation circuit : Range of oscillation 16.6 MHz to 33.4 MHz
- Modulation clock output Duty : 40% to 60%

(Continued)

■ PACKAGE

8-pin plastic SOP



(FPT-8P-M02)

FUJITSU

(Continued)

- Modulation clock
  Cycle-Cycle Jitter
  MB88151-100, 200 : Less than 100 ps
  MB88151-400 : Less than 150 ps
  MB88151-500 : Less than 200 ps
- Low current consumption by CMOS process : 5 mA (24 MHz : Typ-sample, no load)
- Power supply voltage : 3.3 V ± 0.3 V
- Operating temperature : − 40 °C to + 85 °C
- Package : SOP 8-pin

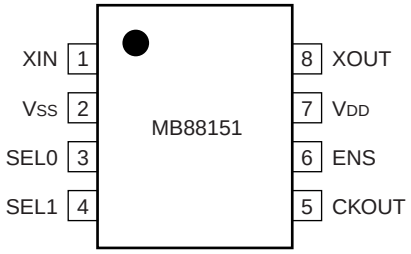
■ PRODUCT LINEUP

MB88151 has four kinds of multiplication type.

Product	Input frequency range	Multiplier ratio	Output frequency range
MB88151-100	16.6 MHz to 33.4 MHz	Multiplied by 1	16.6 MHz to 33.4 MHz
MB88151-200		Multiplied by 2	33.3 MHz to 66.7 MHz
MB88151-400		Multiplied by 4	66.6 MHz to 133.4 MHz
MB88151-500		Multiplied by 1/2	8.3 MHz to 16.7 MHz

■ PIN ASSIGNMENT

TOP VIEW

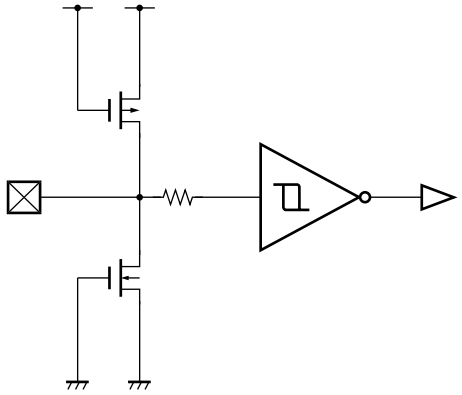
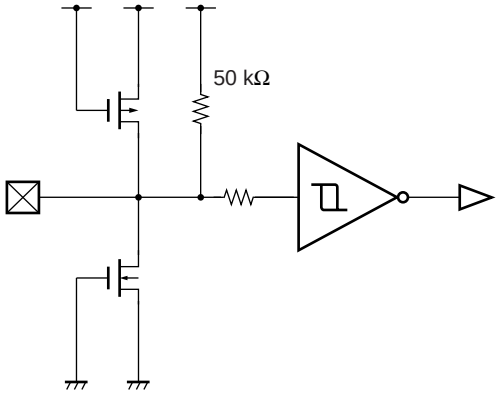
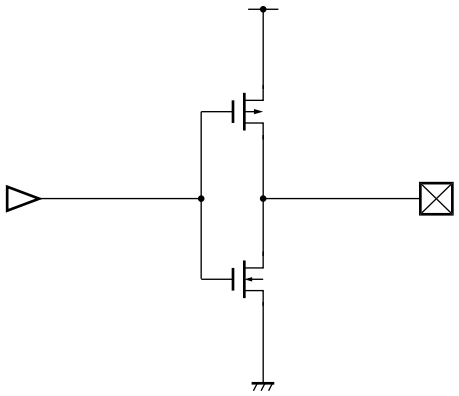


FPT-8P-M02

■ PIN DESCRIPTION

Pin name	I/O	Pin no.	Description
XIN	I	1	Resonator connection pin/clock input pin
V_{SS}	—	2	GND pin
SEL0	I	3	Modulation rate setting pin
SEL1	I	4	Modulation rate setting pin
CKOUT	O	5	Modulated clock output pin
ENS	I	6	Modulation enable setting pin (with pull-up resistance)
V_{DD}	—	7	Power supply voltage pin
XOUT	O	8	Resonator connection pin

■ I/O CIRCUIT TYPE

Pin	Circuit type	Remarks
SEL0 SEL1		• CMOS hysteresis input
ENS		• CMOS hysteresis input with pull-up resistor 50 kΩ (Typ)
CKOUT		• CMOS output • I_{OL} = 4 mA

Note : For XIN and XOUT pins, see “■OSCILLATION CIRCUIT”.

■ HANDLING DEVICES

Preventing Latchup

A latchup can occur if, on this device, (a) a voltage higher than V_{DD} or a voltage lower than V_{SS} is applied to an input or output pin or (b) a voltage higher than the rating is applied between V_{DD} and V_{SS}. The latchup, if it occurs, significantly increases the power supply current and may cause thermal destruction of an element. When you use this device, be very careful not to exceed the maximum rating.

Handling unused pins

Do not leave an unused input pin open, since it may cause a malfunction. Handle by, using a pull-up or pull-down resistor.

Unused output pin should be opened.

The attention when the external clock is used

Input the clock to XIN pin, and XOUT pin should be opened when you use the external clock.
Please pay attention so that an overshoot and an undershoot do not occur to an input clock of XIN pin.

Power supply pins

Please design connecting the power supply pin of this device by as low impedance as possible from the current supply source.

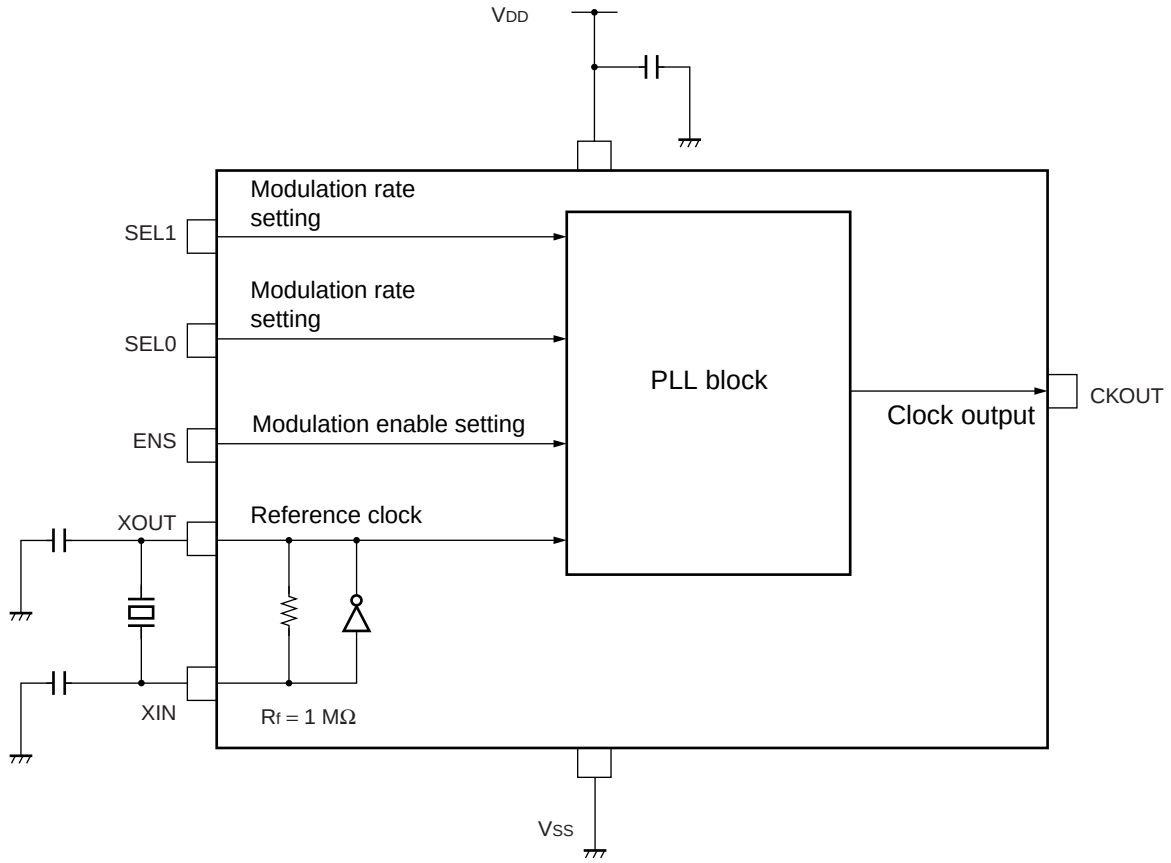
We recommend connecting electrolytic capacitor (about 10 μF) and the ceramic capacitor (about 0.01 μF) in parallel between V_{SS} and V_{DD} near the device, as a bypass capacitor.

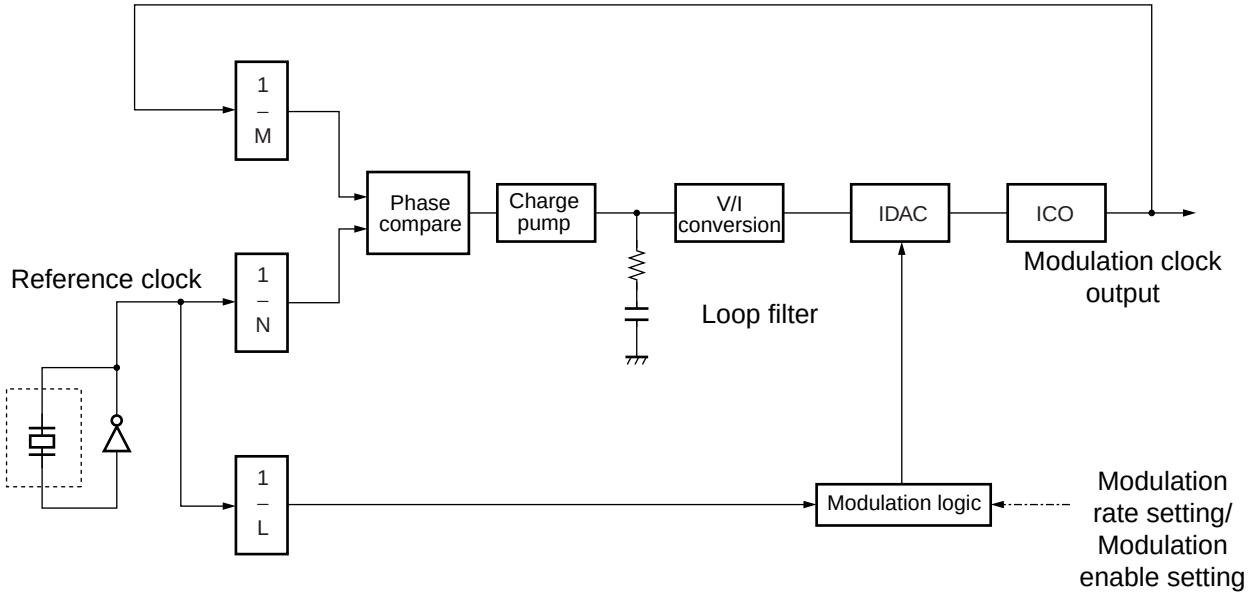
Oscillation circuit

Noise near the XIN and XOUT pins may cause the device to malfunction. Design printed circuit boards so that electric wiring of XIN or XOUT pin and the resonator do not intersect other wiring.

Design the printed circuit board that surrounds the XIN and XOUT pins with ground.

■ BLOCK DIAGRAM





MB88151 PLL block

A glitchless IDAC (current output D/A converter) provides precise modulation, thereby dramatically reducing EMI.

■ PIN SETTING

When changing the pin setting, the stabilization wait time for the modulation clock is required. The stabilization wait time for the modulation clock take the maximum value of "■ ELECTRICAL CHARACTERISTICS • AC characteristics Lock-Up time".

ENS modulation enable setting

ENS	Modulation
L	No modulation
H	Modulation

Note : Spectrum does not spread when "L" is set to ENS. The clock with low jitter can be obtained. Because of ENS has Pull-up resistance, spectrum spread when "H" is set to it or open the terminal.

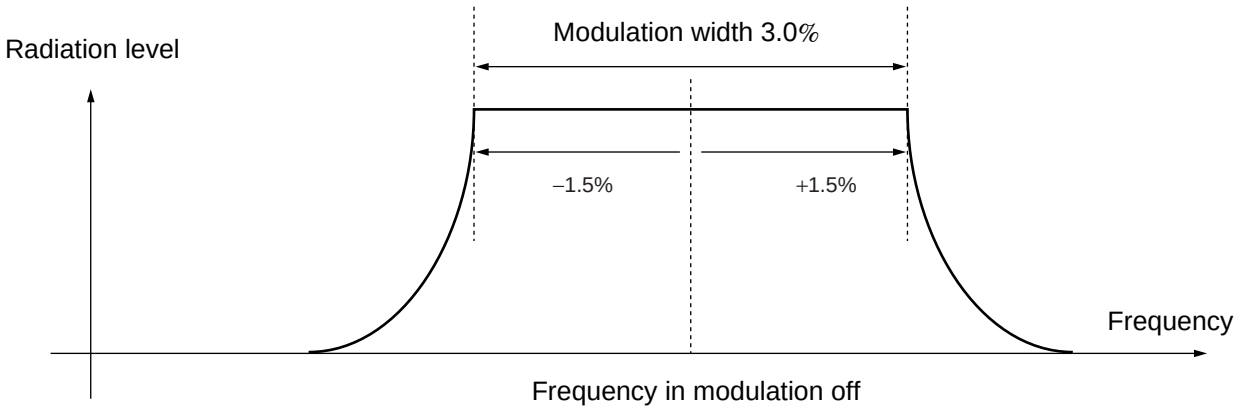
SEL0, SEL1 Modulation rate setting

SEL1	SEL0	Modulation rate	Modulation type
L	L	± 1.5%	Center spread
L	H	± 0.5%	Center spread
H	L	– 1.0%	Down spread
H	H	– 3.0%	Down spread

Note : The modulation rate can be changed at the level of the terminal.

• Center spread

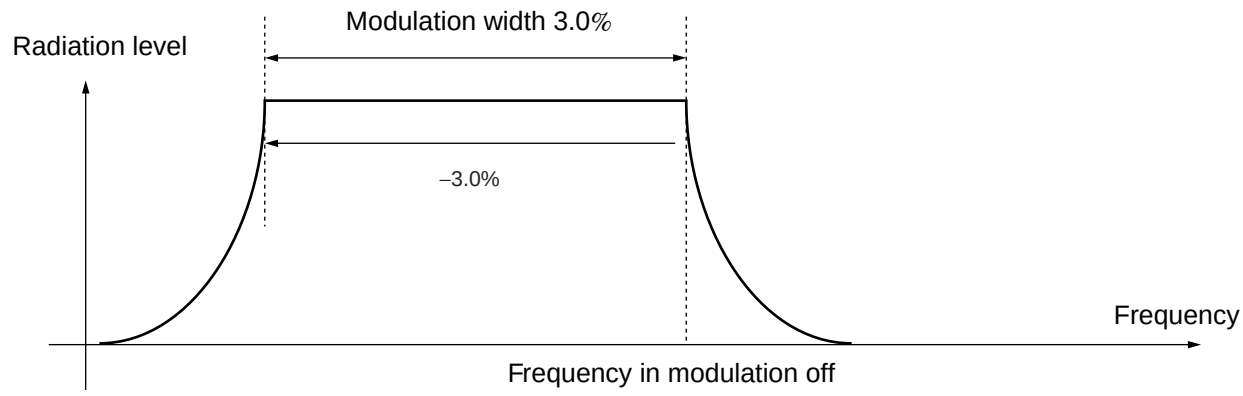
Spectrum is spread (modulated) by centering on the frequency in modulation off.



Center spread example of ± 1.5% modulation rate

• Down spread

Spectrum is spread (modulated) below the frequency in modulation off.



Down spread example of – 3.0% modulation rate

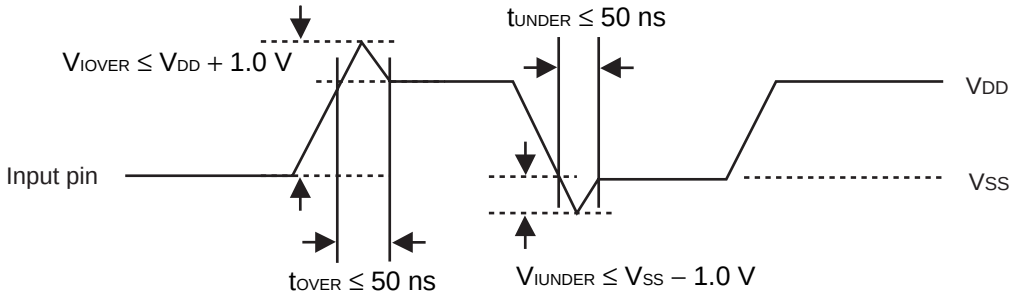
■ ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Rating		Unit
		Min	Max	
Power supply voltage*	V_{DD}	– 0.5	+ 4.0	V
Input voltage*	V_I	V_{SS} – 0.5	V_{DD} + 0.5	V
Output voltage*	V_O	V_{SS} – 0.5	V_{DD} + 0.5	V
Storage temperature	T_{ST}	– 55	+ 125	°C
Operation junction temperature	T_J	– 40	+ 125	°C
Output current	I_O	– 14	+ 14	mA
Overshoot	V_{IOVER}	—	V_{DD} + 1.0 ($t_{OVER} \leq$ 50 ns)	V
Undershoot	V_{IUNDER}	V_{SS}–1.0 ($t_{UNDER} \leq$ 50 ns)	—	V

* : The parameter is based on V_{SS} = 0.0 V.

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.

Overshoot/Undershoot



■ RECOMMENDED OPERATING CONDITIONS

(V_{SS} = 0.0 V)

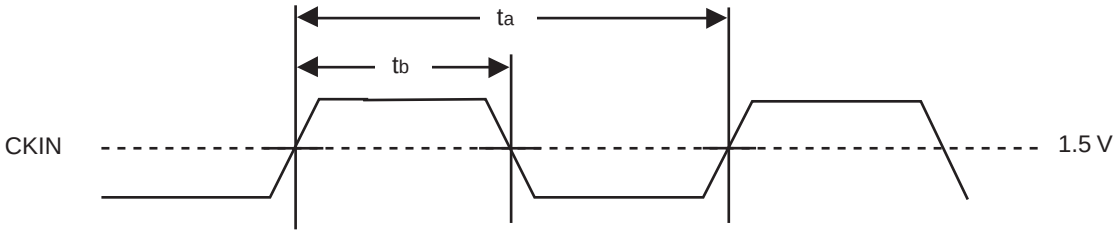
Parameter	Symbol	Pin	Conditions	Value			Unit
				Min	Typ	Max	
Power supply voltage	V_{DD}	V_{DD}	—	3.0	3.3	3.6	V
"H" level input voltage	V_{IH}	XIN, SEL0, SEL1, ENS	—	$V_{DD} \times 0.80$	—	$V_{DD} + 0.3$	V
"L" level input voltage	V_{IL}		—	V_{SS}	—	$V_{DD} \times 0.20$	V
Input clock duty cycle	t_{DCI}	XIN	16.6 MHz to 33.4 MHz	40	50	60	%
Operating temperature	Ta	—	—	– 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.

Input clock duty cycle ($t_{DCI} = t_b/t_a$)



■ ELECTRICAL CHARACTERISTICS

• DC Characteristics

(Ta = – 40 °C to + 85 °C, V_{DD} = 3.3 V ± 0.3 V, V_{SS} = 0.0 V)

Parameter	Symbol	Pin	Conditions	Value			Unit
				Min	Typ	Max	
Power supply current	I_{CC}	V_{DD}	No load capacitance at output 24 MHz MB88151-100	—	5.0	7.0	mA
Output voltage	V_{OH}	CKOUT	"H" level output, I_{OH} = – 4 mA	V_{DD} – 0.5	—	V_{DD}	V
	V_{OL}		"L" level output, I_{OL} = 4 mA	V_{SS}	—	0.4	V
Output impedance	Z_O	CKOUT	8.3 MHz to 133.4 MHz	—	45	—	Ω
Input capacitance	C_{IN}	XIN, SEL0, SEL1, ENS	Ta = + 25 °C, V_{DD} = V_I = 0.0 V, f = 1 MHz	—	—	16	pF
Load capacitance	C_L	CKOUT	8.3 MHz to 66.7 MHz	—	—	15	pF
			66.7 MHz to 100 MHz	—	—	10	
			100 MHz to 133.4 MHz	—	—	7	
Input pull-up resistance	R_{PU}	ENS	V_{IL} = 0.0 V	25	50	200	kΩ

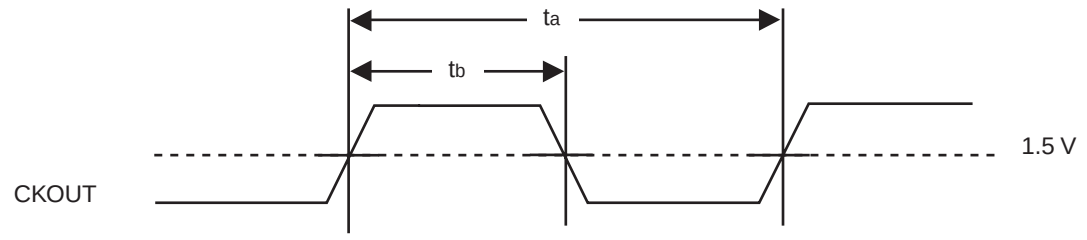
• AC Characteristics

(Ta = – 40 °C to + 85 °C, V_{DD} = 3.3 V ± 0.3 V, V_{SS} = 0.0 V)

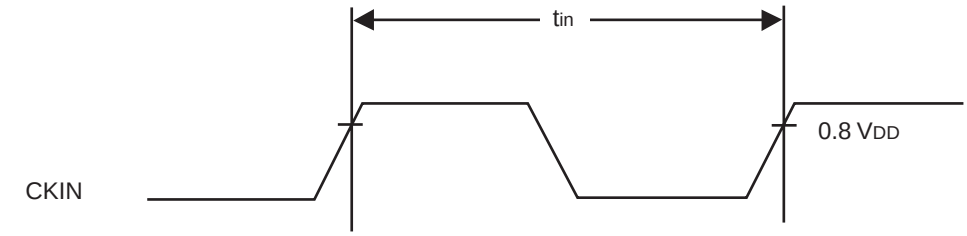
Parameter	Symbol	Pin	Conditions	Value			Unit
				Min	Typ	Max	
Oscillation frequency	f_x	XIN, XOUT	Fundamental oscillation	16.6	—	33.4	MHz
Input frequency	f_{in}	XIN	External clock input	16.6	—	33.4	MHz
Output frequency	f_{OUT}	CKOUT	MB88151-100 (Multiply by 1)	16.6	—	33.4	MHz
			MB88151-200 (Multiply by 2)	33.3	—	66.7	
			MB88151-400 (Multiply by 4)	66.6	—	133.4	
			MB88151-500 (2-frequency division)	8.3	—	16.7	
Output slew rate	SR	CKOUT	0.4 V to 2.4 V Load capacitance 15 pF	0.4	—	4.0	V/ns
Output clock duty cycle	t_{DCC}	CKOUT	1.5 V	40	—	60	%
Modulation frequency	f_{MOD}	CKOUT	—	—	12.5	—	kHz
Lock-Up time	t_{LK}	CKOUT	—	—	2	5	ms
Cycle-cycle jitter	t_{JC}	CKOUT	MB88151-100, 200 No load capacitance, Ta = + 25 °C, V_{DD} = 3.3 V, Standard deviation σ	—	—	100	ps
			MB88151-400 No load capacitance, Ta = + 25 °C, V_{DD} = 3.3 V, Standard deviation σ	—	—	150	
			MB88151-500 No load capacitance, Ta = + 25 °C, V_{DD} = 3.3 V, Standard deviation σ	—	—	200	

Note : The modulation clock stabilization wait time is required after the power is turned on, the IC recovers from power saving, or after FREQ (frequency range) or ENS (modulation ON/OFF) setting is changed. For the modulation clock stabilization wait time, assign the maximum value for lock-up time.

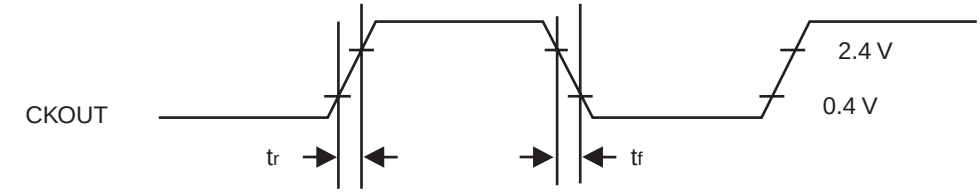
■ OUTPUT CLOCK DUTY CYCLE ($t_{DCC} = t_b/t_a$)



■ INPUT FREQUENCY ($f_{in} = 1/t_{in}$)

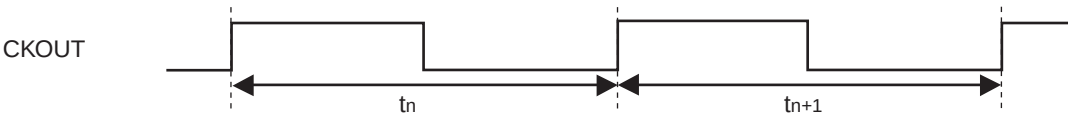


■ OUTPUT SLEW RATE (SR)



Note : SR = (2.4 – 0.4) /t_r, SR = (2.4 – 0.4) /t_f

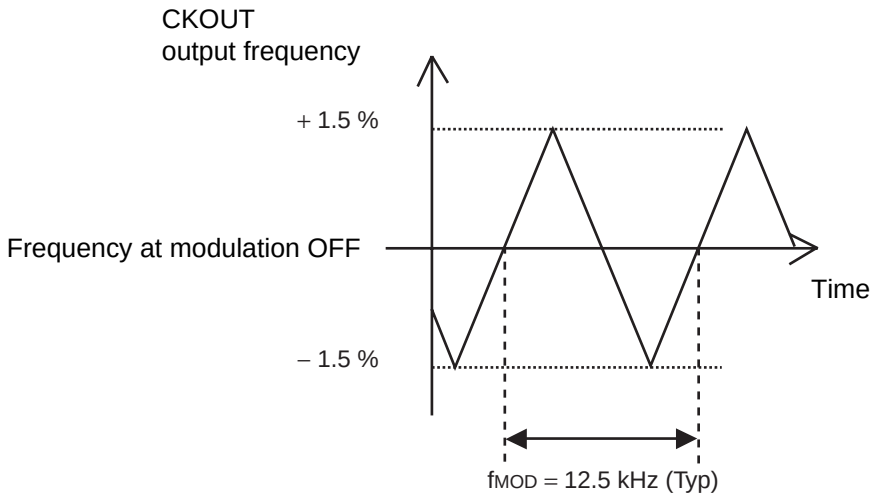
■ CYCLE-CYCLE JITTER ($t_{JC} = | t_n - t_{n+1} |$)



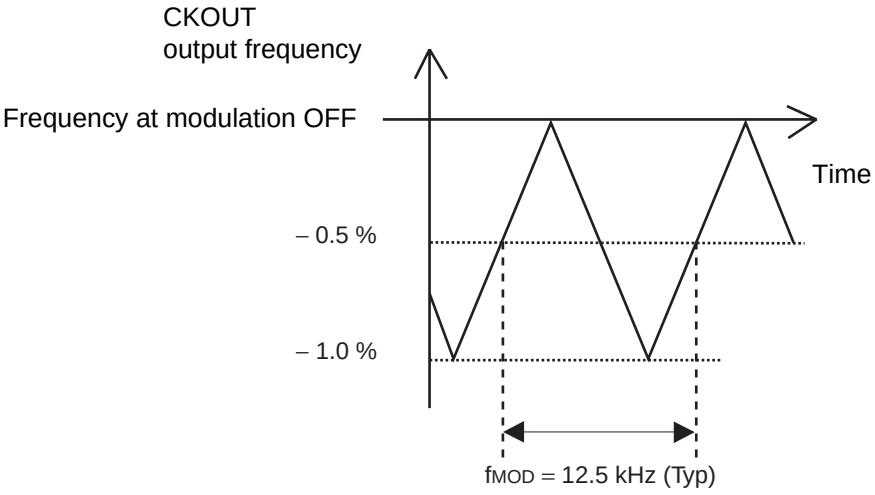
Note : Cycle-cycle jitter is defined the difference between a certain cycle and immediately after (or, immediately before) .

■ MODULATION WAVEFORM

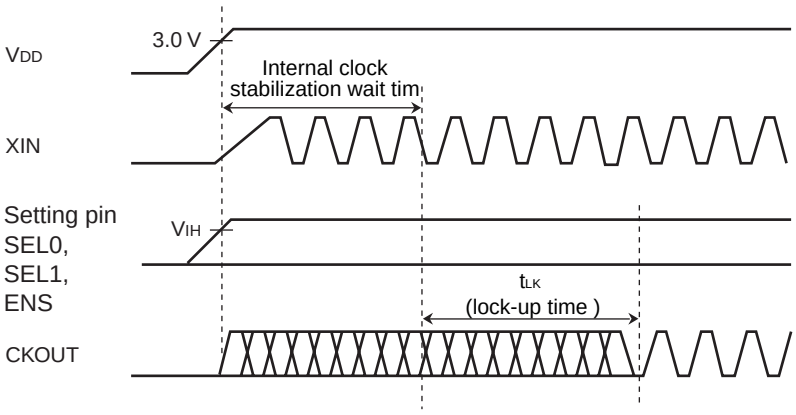
• ±1.5% modulation rate, Example of center spread



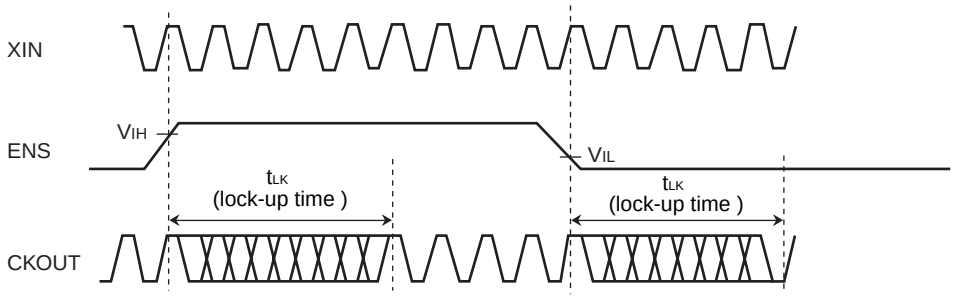
• –1.0% modulation rate, Example of down spread



■ LOCK-UP TIME



If the setting pin is fixed at the “H” or “L” level, the maximum time after the power is turned on until the set clock signal is output from CKOUT pin is (the stabilization wait time of input clock to XIN pin) + (the lock-up time “t_{LK}”). For the input clock stabilization time, check the characteristics of the resonator or oscillator used.



For modulation enable control using the ENS pin during normal operation, the set clock signal is output from CKOUT pin at most the lock-up time (t_{LK}) after the level at the ENS pin is determined.

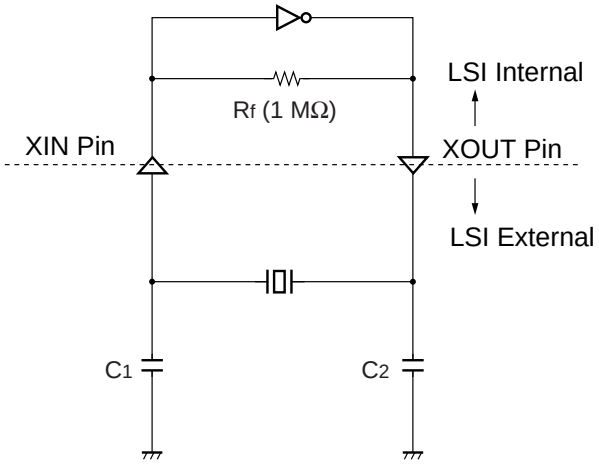
Note : When the pin setting is changed, the CKOUT pin output clock stabilization time is required. Until the output clock signal becomes stable, the output frequency, output clock duty cycle, modulation period, and cycle-cycle jitter cannot be guaranteed. It is therefore advisable to perform processing such as cancelling a reset of the device at the succeeding stage after the lock-up time.

■ OSCILLATION CIRCUIT

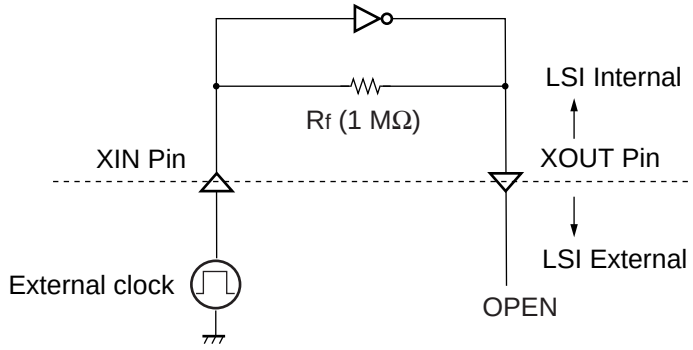
The figure below shows the connection example about general resonator. The oscillation circuit has the built-in resistance (1 MΩ) . The value of capacity (C_1 and C_2) is required adjusting to the most suitable value of individual resonator.
The most suitable value is different by individual resonator. Please refer to the resonator manufacturer which you use for the most suitable value.

Input the clock to XIN pin, and do not connect anything with XOUT pin if you use the external clock (you do not use the resonator).

- When using the resonator

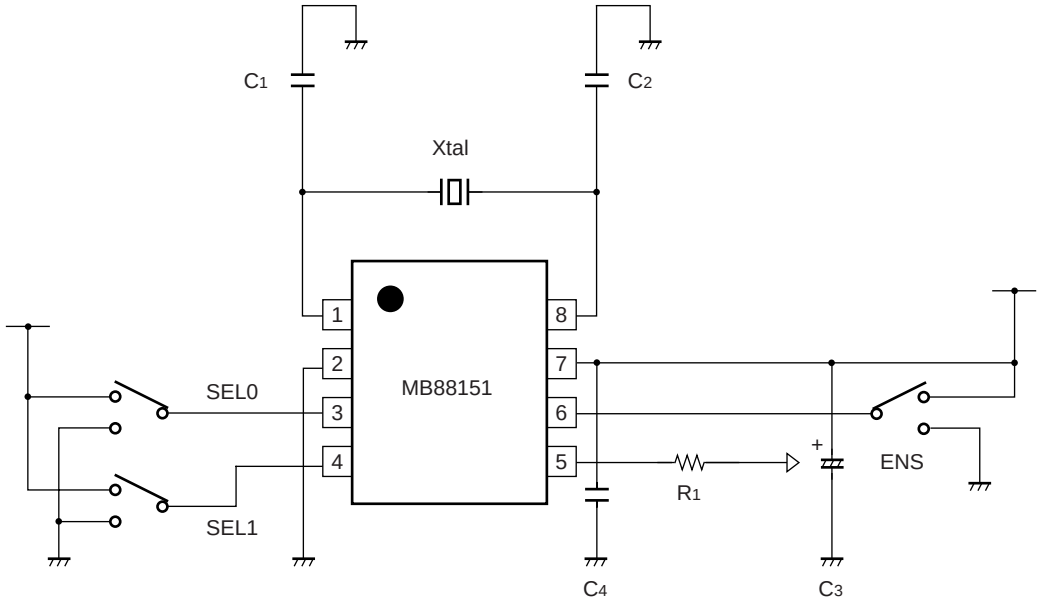


- When using an external clock



Note : Note that a jitter characteristic of an input clock may cause an affect a cycle-cycle jitter characteristic.

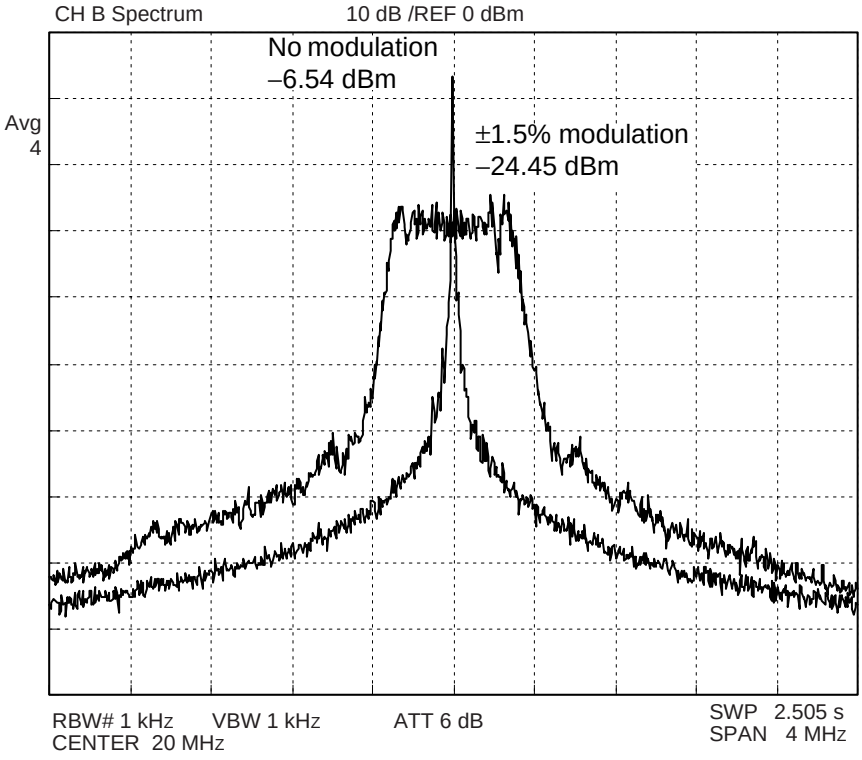
■ INTERCONNECTION CIRCUIT EXAMPLE



C_1, C_2	: Oscillation stabilization capacitance (see "■OSCILLATION CIRCUIT".)
C_3	: Capacitor of 10 μF or higher
C_4	: Capacitor about 0.01 μF (connect a capacitor of good high frequency property (ex. laminated ceramic capacitor) to close to this device)
R_1	: Impedance matching resistor for board pattern

■ SPECTRUM EXAMPLE CHARACTERISTICS

The condition of the examples of the characteristic is shown as follows : Input frequency = 20 MHz (Output frequency = 20 MHz : Using MB88151-100 (Multiply by 1)), Power - supply voltage = 3.3 V, None load capacity, Modulation rate = ± 1.5% (center spread).
Spectrum analyzer HP4396B is connected with CKOUT. The result of the measurement with RBW = 1 kHz (ATT use for − 6dB).



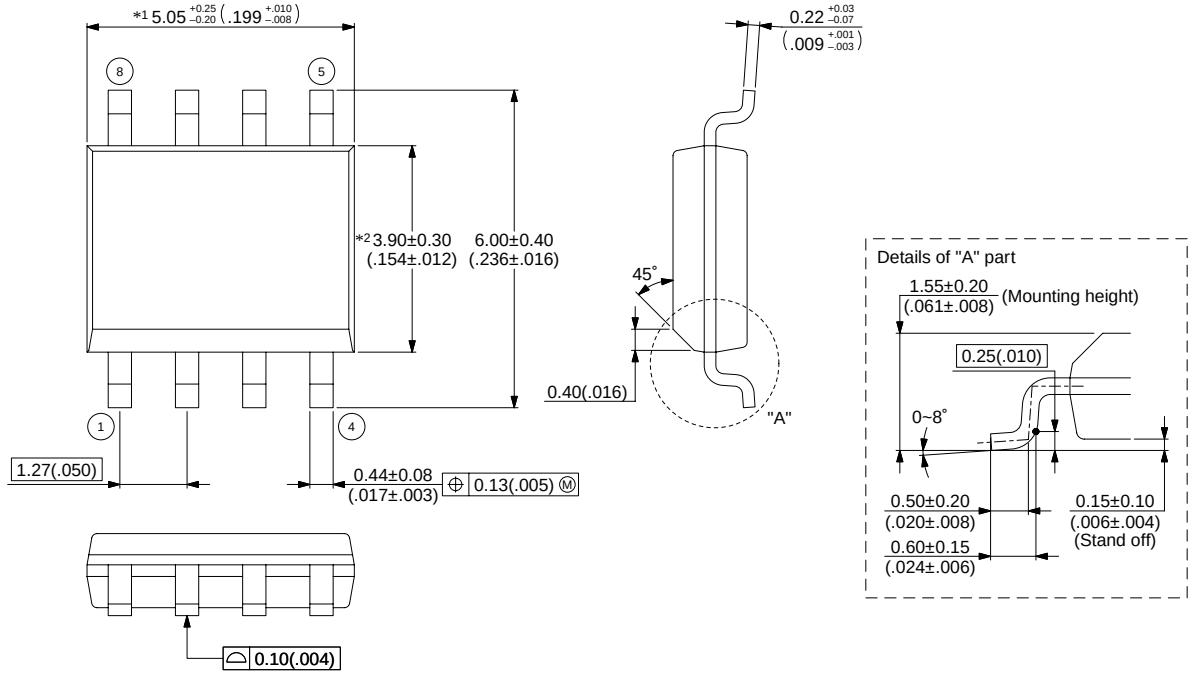
■ ORDERING INFORMATION

Part number	Input frequency range	Multiplier ratio	Output frequency range	Package	Remarks
MB88151PNF-G-100-JNE1 MB88151PNF-G-200-JNE1 MB88151PNF-G-400-JNE1 MB88151PNF-G-500-JNE1	16.6 MHz to 33.4 MHz	Multiplied by 1 Multiplied by 2 Multiplied by 4 Multiplied by 1/2	16.6 MHz to 33.4 MHz 33.3 MHz to 66.7 MHz 66.6 MHz to 133.4 MHz 8.3 MHz to 16.7 MHz	8-pin plastic SOP (FPT-8P-M02)	
MB88151PNF-G-100-JN-EFE1 MB88151PNF-G-200-JN-EFE1 MB88151PNF-G-400-JN-EFE1 MB88151PNF-G-500-JN-EFE1		Multiplied by 1 Multiplied by 2 Multiplied by 4 Multiplied by 1/2	16.6 MHz to 33.4 MHz 33.3 MHz to 66.7 MHz 66.6 MHz to 133.4 MHz 8.3 MHz to 16.7 MHz	8-pin plastic SOP (FPT-8P-M02)	Emboss taping (EF type)
MB88151PNF-G-100-JN-ERE1 MB88151PNF-G-200-JN-ERE1 MB88151PNF-G-400-JN-ERE1 MB88151PNF-G-500-JN-ERE1		Multiplied by 1 Multiplied by 2 Multiplied by 4 Multiplied by 1/2	16.6 MHz to 33.4 MHz 33.3 MHz to 66.7 MHz 66.6 MHz to 133.4 MHz 8.3 MHz to 16.7 MHz	8-pin plastic SOP (FPT-8P-M02)	Emboss taping (ER type)

■ PACKAGE DIMENSION

8-pin plastic SOP
(FPT-8P-M02)

Note 1) *1 : These dimensions include resin protrusion.
Note 2) *2 : These dimensions do not include resin protrusion.
Note 3) Pins width and pins thickness include plating thickness.
Note 4) Pins width do not include tie bar cutting remainder.



Dimensions in mm (inches)
Note: The values in parentheses are reference values.

FUJITSU LIMITED

The contents of this document are subject to change without notice. Customers are advised to consult with FUJITSU sales representatives before ordering.

The information, such as descriptions of function and application circuit examples, in this document are presented solely for the purpose of reference to show examples of operations and uses of Fujitsu semiconductor device; Fujitsu does not warrant proper operation of the device with respect to use based on such information. When you develop equipment incorporating the device based on such information, you must assume any responsibility arising out of such use of the information. Fujitsu assumes no liability for any damages whatsoever arising out of the use of the information.

Any information in this document, including descriptions of function and schematic diagrams, shall not be construed as license of the use or exercise of any intellectual property right, such as patent right or copyright, or any other right of Fujitsu or any third party or does Fujitsu warrant non-infringement of any third-party's intellectual property right or other right by using such information. Fujitsu assumes no liability for any infringement of the intellectual property rights or other rights of third parties which would result from the use of information contained herein.

The products described in this document are designed, developed and manufactured as contemplated for general use, including without limitation, ordinary industrial use, general office use, personal use, and household use, but are not designed, developed and manufactured as contemplated (1) for use accompanying fatal risks or dangers that, unless extremely high safety is secured, could have a serious effect to the public, and could lead directly to death, personal injury, severe physical damage or other loss (i.e., nuclear reaction control in nuclear facility, aircraft flight control, air traffic control, mass transport control, medical life support system, missile launch control in weapon system), or (2) for use requiring extremely high reliability (i.e., submersible repeater and artificial satellite).

Please note that Fujitsu will not be liable against you and/or any third party for any claims or damages arising in connection with above-mentioned uses of the products.

Any semiconductor devices have an inherent chance of failure. You must protect against injury, damage or loss from such failures by incorporating safety design measures into your facility and equipment such as redundancy, fire protection, and prevention of over-current levels and other abnormal operating conditions.

If any products described in this document represent goods or technologies subject to certain restrictions on export under the Foreign Exchange and Foreign Trade Law of Japan, the prior authorization by Japanese government will be required for export of those products from Japan.

F0502