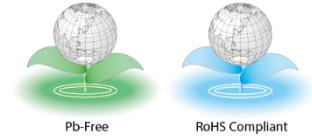


Features

- Any frequency between 1 MHz and 110 MHz accurate to 6 decimal places
- Operating temperature from -40°C to +85°C. Refer to MO2018 for -40°C to +85°C option and MO2020 for -55°C to +125°C option
- Excellent total frequency stability as low as ±20 ppm
- Low power consumption of +3.5 mA typical at f = 20 MHz
- Fast startup time of 5 ms
- LVC MOS/HCMOS compatible output
- 5-pin SOT23-5: 2.9mm x 2.8mm
- Pb-free, RoHS and REACH compliant
- For AEC-Q100 one-output clock generators, refer to MO2024 and MO2025

Applications

- Industrial, medical, automotive, avionics and other high temperature applications
- Industrial sensors, PLC, motor servo, outdoor networking equipment, medical video cam, asset tracking systems, etc.



Electrical Specifications

Table 1. Electrical Characteristics

All Min and Max limits are specified over temperature and rated operating voltage with 15 pF output load unless otherwise stated. Typical values are at +25°C and nominal supply voltage.

Parameters	Symbol	Min.	Typ.	Max.	Unit	Condition
Frequency Range						
Output Frequency Range	f	1	–	110	MHz	
Frequency Stability and Aging						
Frequency Stability	F_stab	-20	–	+20	ppm	Inclusive of Initial tolerance at +25°C, 1st year aging at +25°C, and variations over operating temperature, rated power supply voltage and load (15 pF ± 10%).
		-25	–	+25	ppm	
		-50	–	+50	ppm	
Operating Temperature Range						
Operating Temperature Range (ambient)	T_use	-20	–	+70	°C	Extended Commercial
		-40	–	+85	°C	Industrial
Supply Voltage and Current Consumption						
Supply Voltage	Vdd	+1.62	+1.8	+1.98	V	
		+2.25	+2.5	+2.75	V	
		+2.52	+2.8	+3.08	V	
		+2.7	+3.0	+3.3	V	
		+2.97	+3.3	+3.63	V	
		+2.25	–	+3.63	V	
Current Consumption	Idd	–	+3.8	+4.5	mA	No load condition, f = 20 MHz, Vdd = +2.8V, +3.0V or +3.3V
		–	+3.7	+4.2	mA	No load condition, f = 20 MHz, Vdd = +2.5V
		–	+3.5	+4.1	mA	No load condition, f = 20 MHz, Vdd = +1.8V
OE Disable Current	I_od	–	–	+4.3	mA	Vdd = +2.5V to +3.3V, OE = Low, Output in high Z state.
		–	–	+4.1	mA	Vdd = +1.8V, OE = Low, Output in high Z state.
Standby Current	I_std	–	+2.6	+4.3	µA	Vdd = +2.8V to +3.3V, \overline{ST} = Low, Output is weakly pulled down
		–	+1.4	+2.5	µA	Vdd = +2.5V, \overline{ST} = Low, Output is weakly pulled down
		–	+0.6	+1.3	µA	Vdd = +1.8V, \overline{ST} = Low, Output is weakly pulled down
LVC MOS Output Characteristics						
Duty Cycle	DC	45	–	55	%	All Vdds
Rise/Fall Time	Tr, Tf	–	1.0	2.0	ns	Vdd = +2.5V, +2.8V, +3.0V or +3.3V, 20% - 80%
		–	1.3	2.5	ns	Vdd = +1.8V, 20% - 80%
		–	–	2.0	ns	Vdd = +2.25V - +3.63V, 20% - 80%
Output High Voltage	VOH	90%	–	–	Vdd	IOH = -4.0 mA (Vdd = +3.0V or +3.3V) IOH = -3.0 mA (Vdd = +2.8V or +2.5V) IOH = -2.0 mA (Vdd = +1.8V)
Output Low Voltage	VOL	–	–	10%	Vdd	IOL = +4.0 mA (Vdd = +3.0V or +3.3V) IOL = +3.0 mA (Vdd = +2.8V or +2.5V) IOL = +2.0 mA (Vdd = +1.8V)

Table 1. Electrical Characteristics

Parameters	Symbol	Min.	Typ.	Max.	Unit	Condition
Input Characteristics						
Input High Voltage	V _{IH}	70%	–	–	V _{dd}	Pin 3, OE or \overline{ST}
Input Low Voltage	V _{IL}	–	–	30%	V _{dd}	Pin 3, OE or \overline{ST}
Input Pull-up Impedance	Z _{in}	50	87	150	k Ω	Pin 3, OE logic high or logic low, or \overline{ST} logic high
		2.0	–	–	M Ω	Pin 3, \overline{ST} logic low
Startup and Resume Timing						
Startup Time	T _{start}	–	–	5.0	ms	Measured from the time V _{dd} reaches its rated minimum value
Enable/Disable Time	T _{oe}	–	–	130	ns	f = 110 MHz. For other frequencies, T _{oe} = 100 ns + 3 * clock periods
Resume Time	T _{resume}	–	–	5.0	ms	Measured from the time \overline{ST} pin crosses 50% threshold
Jitter						
RMS Period Jitter	T _{jitt}	–	1.8	3.0	ps	f = 75 MHz, V _{dd} = +2.5V, +2.8V, +3.0V or +3.3V
		–	1.8	3.0	ps	f = 75 MHz, V _{dd} = +1.8V
Peak-to-peak Period Jitter	T _{pk}	–	12	20	ps	f = 75 MHz, V _{dd} = +2.5V, +2.8V, +3.0V or +3.3V
		–	14	25	ps	f = 75 MHz, V _{dd} = +1.8V
RMS Phase Jitter (random)	T _{phj}	–	0.5	0.9	ps	f = 75 MHz, Integration bandwidth = 900 kHz to 7.5 MHz
		–	1.3	2.0	ps	f = 75 MHz, Integration bandwidth = 12 kHz to 20 MHz

Table 2. Pin Description

Pin	Symbol	Power	Functionality
1	GND	Power	Electrical ground
2	NC	No Connect	No connect
3	OE/ \overline{ST} /NC	Output Enable	H ^[1] : specified frequency output L: output is high impedance. Only output driver is disabled.
		Standby	H or Open ^[1] : specified frequency output L: output is low (weak pull down). Device goes to sleep mode. Supply current reduces to I _{std} .
		No Connect	Any voltage between 0 and V _{dd} or Open ^[1] : Specified frequency output. Pin 3 has no function.
4	VDD	Power	Power supply voltage ^[2]
5	OUT	Output	Oscillator output

Notes:

- In OE or ST mode, a pull-up resistor of 10 k Ω or less is recommended if pin 3 is not externally driven. If pin 3 needs to be left floating, use the NC option.
- A capacitor of value 0.1 μ F or higher between V_{dd} and GND is required.

Top View

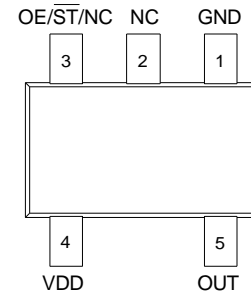


Figure 1. Pin Assignments

Table 3. Absolute Maximum Limits

Attempted operation outside the absolute maximum ratings may cause permanent damage to the part. Actual performance of the IC is only guaranteed within the operational specifications, not at absolute maximum ratings.

Parameter	Min.	Max.	Unit
Storage Temperature	-65	+150	°C
Vdd	-0.5	+4.0	V
Electrostatic Discharge	–	+2000	V
Soldering Temperature (follow standard Pb free soldering guidelines)	–	+260	°C
Junction Temperature ^[3]	–	+150	°C

Note:

- 3. Exceeding this temperature for extended period of time may damage the device.

Table 4. Thermal Consideration^[4]

Package	θ_{JA} , 4 Layer Board (°C/W)	θ_{JC} , Bottom (°C/W)
SOT23-5	421	175

Note:

- 4. Refer to JESD51 for θ_{JA} and θ_{JC} definitions, and reference layout used to determine the θ_{JA} and θ_{JC} values in the abovetable.

Table 5. Maximum Operating Junction Temperature^[5]

Max Operating Temperature (ambient)	Maximum Operating Junction Temperature
+70°C	+80°C
+85°C	+95°C

Note:

- 5. Datasheet specifications are not guaranteed if junction temperature exceeds the maximum operating junction temperature.

Table 6. Environmental Compliance

Parameter	Condition/Test Method
Mechanical Shock	MIL-STD-883F, Method2002
Mechanical Vibration	MIL-STD-883F, Method2007
Temperature Cycle	JESD22, Method A104
Solderability	MIL-STD-883F, Method2003
Moisture Sensitivity Level	MSL1 @ 260°C

Test Circuit and Waveform^[6]

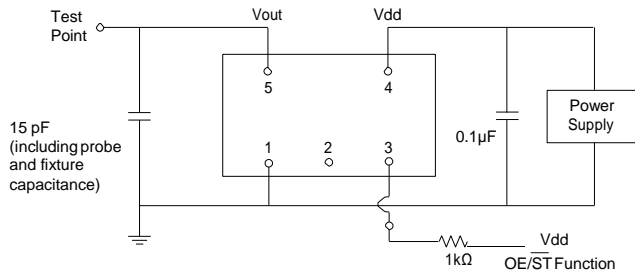


Figure 2. Test Circuit

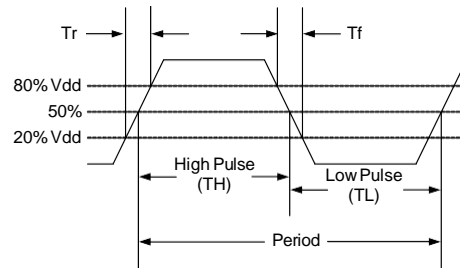
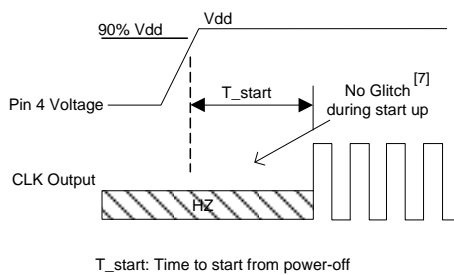


Figure 3. Output Waveform

Note:

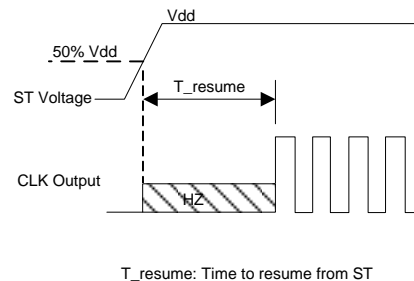
6. Duty Cycle is computed as $Duty\ Cycle = TH/Period$.

Timing Diagrams



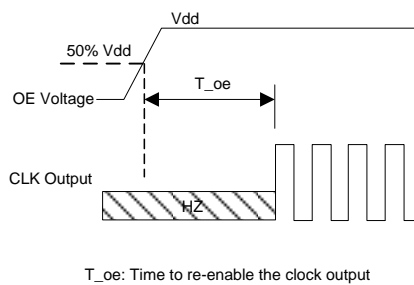
T_start: Time to start from power-off

Figure 4. Startup Timing (OE/ST Mode)



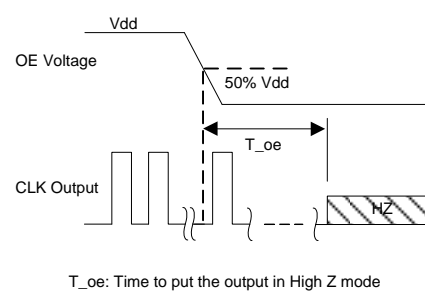
T_resume: Time to resume from ST

Figure 5. Standby Resume Timing (ST Mode Only)



T_oe: Time to re-enable the clock output

Figure 6. OE Enable Timing (OE Mode Only)



T_oe: Time to put the output in High Z mode

Figure 7. OE Disable Timing (OE Mode Only)

Note:

7. MO2001 has “no runt” pulses and “no glitch” output during startup or resume.

Performance Plots^[8]

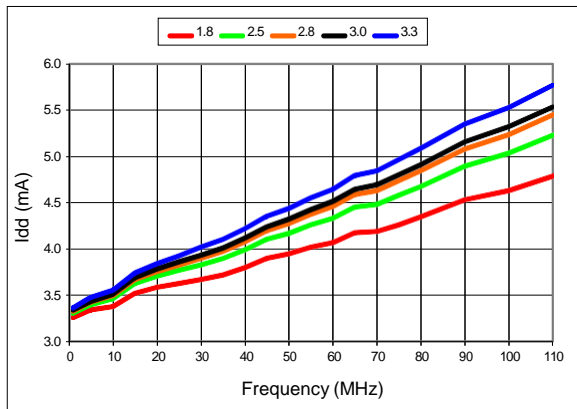


Figure 8. Idd vs Frequency

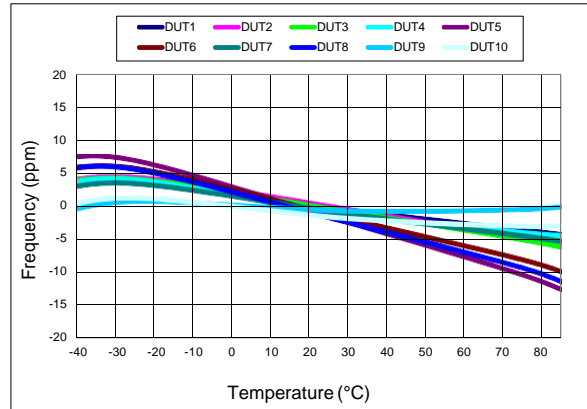


Figure 9. Frequency vs Temperature

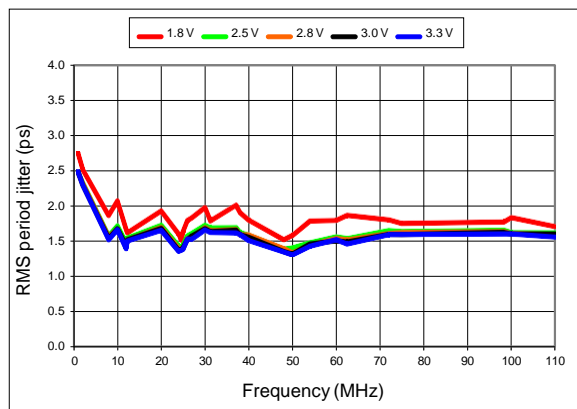


Figure 10. RMS Period Jitter vs Frequency

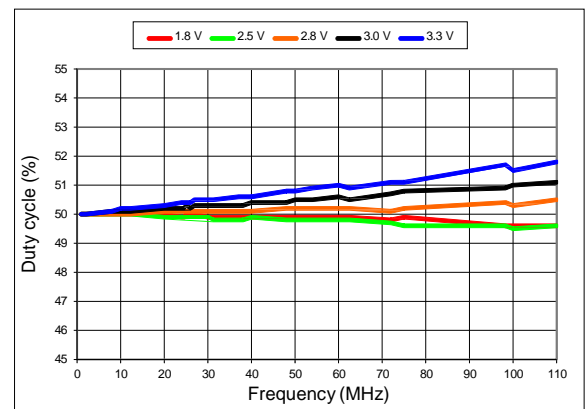


Figure 11. Duty Cycle vs Frequency

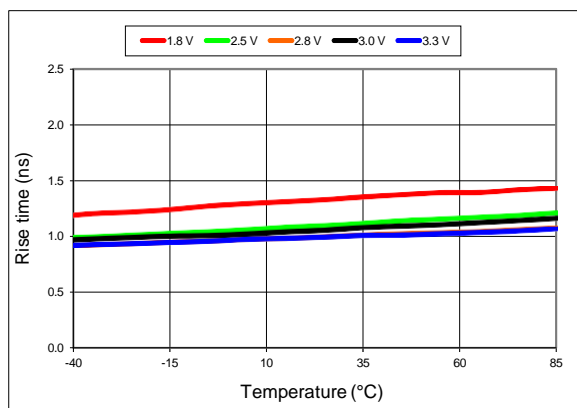


Figure 12. 20%-80% Rise Time vs Temperature

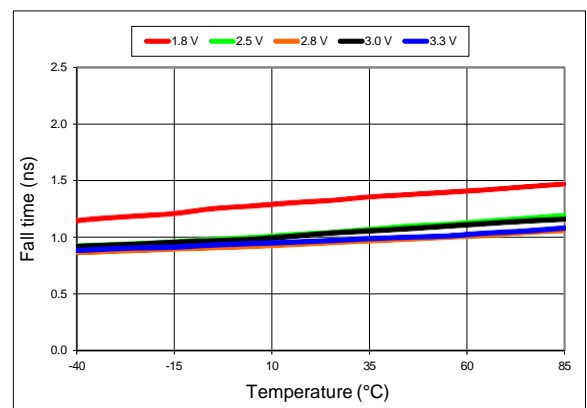


Figure 13. 20%-80% Fall Time vs Temperature

Performance Plots^[8]

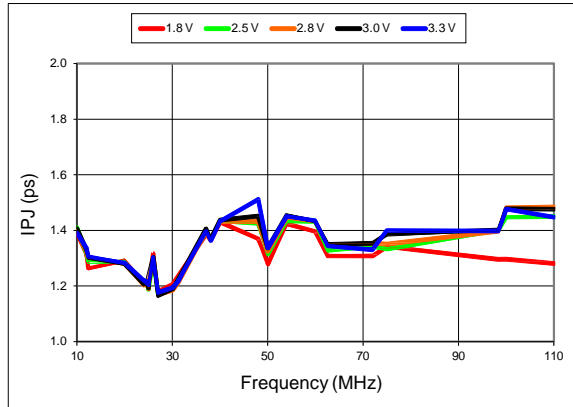


Figure 14. RMS Integrated Phase Jitter Random (12 kHz to 20 MHz) vs Frequency^[9]

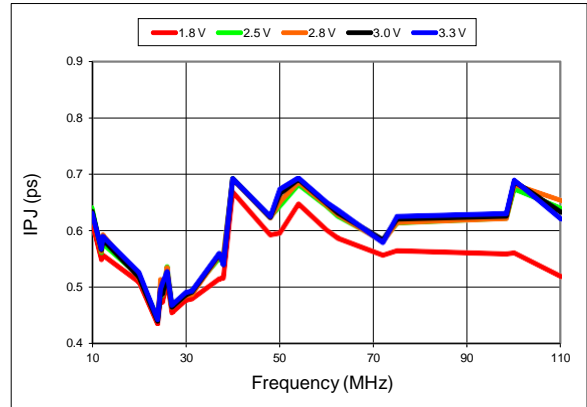


Figure 15. RMS Integrated Phase Jitter Random (900 kHz to 20 MHz) vs Frequency^[9]

Notes:

- 8. All plots are measured with 15 pF load at room temperature, unless otherwise stated.
- 9. Phase noise plots are measured with Agilent E5052B signal source analyzer. Integration range is up to 5 MHz for carrier frequencies up to 40 MHz.

Programmable Drive Strength

The MO2001 includes a programmable drive strength feature to provide a simple, flexible tool to optimize the clock rise/fall time for specific applications. Benefits from the programmable drive strength feature are:

- Improves system radiated electromagnetic interference (EMI) by slowing down the clock rise/fall time.
- Improves the downstream clock receiver's (RX) jitter by decreasing (speeding up) the clock rise/fall time.
- Ability to drive large capacitive loads while maintaining full swing with sharp edge rates.

For more detailed information about rise/fall time control and drive strength selection, contact KDS.

EMI Reduction by Slowing Rise/Fall Time

Figure 16 shows the harmonic power reduction as the rise/fall times are increased (slowed down). The rise/fall times are expressed as a ratio of the clock period. For the ratio of 0.05, the signal is very close to a square wave. For the ratio of 0.45, the rise/fall times are very close to near-triangular waveform. These results, for example, show that the 11th clock harmonic can be reduced by 35 dB if the rise/fall edge is increased from 5% of the period to 45% of the period.

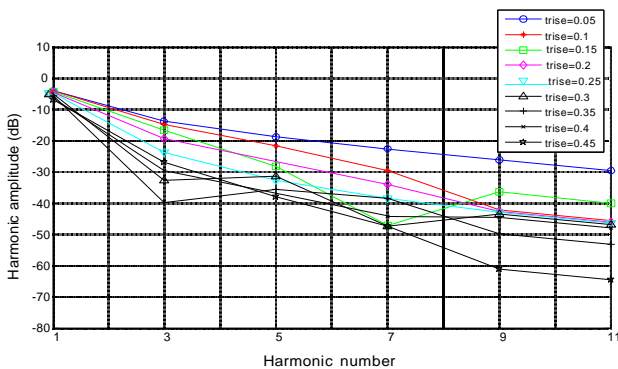


Figure 16. Harmonic EMI reduction as a Function of Slower Rise/Fall Time

Jitter Reduction with Faster Rise/Fall Time

Power supply noise can be a source of jitter for the downstream chipset. One way to reduce this jitter is to speed up the rise/fall time of the input clock. Some chipsets may also require faster rise/fall time in order to reduce their sensitivity to this type of jitter. Refer to the [Rise/Fall Time Tables \(Table 7 to Table 11\)](#) to determine the proper drive strength.

High Output Load Capability

The rise/fall time of the input clock varies as a function of the actual capacitive load the clock drives. At any given drive strength, the rise/fall time becomes slower as the output load increases. As an example, for a +3.3V MO2001 device with default drive strength setting, the typical rise/fall time is 1 ns for 15 pF output load. The typical rise/fall time slows down to 2.6 ns when the output load increases to 45 pF. One can choose to speed up the rise/fall time to 1.83 ns by then increasing the drive strength setting on the MO2001.

The MO2001 can support up to 60 pF in maximum capacitive loads with drive strength settings. Refer to the [Rise/Fall Time Tables \(Table 7 to 11\)](#) to determine the proper drive strength for the desired combination of output load vs. rise/fall time.

MO2001 Drive Strength Selection

Tables 7 through 11 define the rise/fall time for a given capacitive load and supply voltage.

1. Select the table that matches the MO2001 nominal supply voltage (+1.8V, +2.5V, +2.8V, +3.0V, +3.3V).
2. Select the capacitive load column that matches the application requirement (5 pF to 60 pF)
3. Under the capacitive load column, select the desired rise/fall times.
4. The left-most column represents the part number code for the corresponding drive strength.
5. Add the drive strength code to the part number for ordering purposes.

Calculating Maximum Frequency

Based on the rise and fall time data given in Tables 7 through 11, the maximum frequency the oscillator can operate with guaranteed full swing of the output voltage over temperature can be calculated as the following:

$$\text{Max Frequency} = \frac{1}{5 \times T_{rf_20/80}}$$

where Trf_20/80 is the typical value for 20%-80% rise/fall time.

Example 1

Calculate f_{MAX} for the following condition:

- Vdd = +1.8V (Table 7)
- Capacitive Load: 30 pF
- Desired Tr/f time = 3 ns (rise/fall time part number code = E)

Part number for the above example:

MO2001IE5-CEH-18E0-0066666660



Drive strength code is here.

Rise/Fall Time (20% to 80%) vs C_{LOAD} Tables

Table 7. V_{dd} = +1.8V Rise/Fall Times for Specific C_{LOAD}

Rise/Fall Time Typ (ns)					
Drive Strength \ C _{LOAD}	5 pF	15 pF	30 pF	45 pF	60 pF
L	6.16	11.61	22.00	31.27	39.91
A	3.19	6.35	11.00	16.01	21.52
R	2.11	4.31	7.65	10.77	14.47
B	1.65	3.23	5.79	8.18	11.08
T	0.93	1.91	3.32	4.66	6.48
E	0.78	1.66	2.94	4.09	5.74
U	0.70	1.48	2.64	3.68	5.09
F or "0": default	0.65	1.30	2.40	3.35	4.56

Table 8. V_{dd} = +2.5V Rise/Fall Times for Specific C_{LOAD}

Rise/Fall Time Typ (ns)					
Drive Strength \ C _{LOAD}	5 pF	15 pF	30 pF	45 pF	60 pF
L	4.13	8.25	12.82	21.45	27.79
A	2.11	4.27	7.64	11.20	14.49
R	1.45	2.81	5.16	7.65	9.88
B	1.09	2.20	3.88	5.86	7.57
T	0.62	1.28	2.27	3.51	4.45
E or "0": default	0.54	1.00	2.01	3.10	4.01
U	0.43	0.96	1.81	2.79	3.65
F	0.34	0.88	1.64	2.54	3.32

Table 9. V_{dd} = +2.8V Rise/Fall Times for Specific C_{LOAD}

Rise/Fall Time Typ (ns)					
Drive Strength \ C _{LOAD}	5 pF	15 pF	30 pF	45 pF	60 pF
L	3.77	7.54	12.28	19.57	25.27
A	1.94	3.90	7.03	10.24	13.34
R	1.29	2.57	4.72	7.01	9.06
B	0.97	2.00	3.54	5.43	6.93
T	0.55	1.12	2.08	3.22	4.08
E or "0": default	0.44	1.00	1.83	2.82	3.67
U	0.34	0.88	1.64	2.52	3.30
F	0.29	0.81	1.48	2.29	2.99

Table 10. V_{dd} = +3.0V Rise/Fall Times for Specific C_{LOAD}

Rise/Fall Time Typ (ns)					
Drive Strength \ C _{LOAD}	5 pF	15 pF	30 pF	45 pF	60 pF
L	3.60	7.21	11.97	18.74	24.30
A	1.84	3.71	6.72	9.86	12.68
R	1.22	2.46	4.54	6.76	8.62
B	0.89	1.92	3.39	5.20	6.64
T or "0": default	0.51	1.00	1.97	3.07	3.90
E	0.38	0.92	1.72	2.71	3.51
U	0.30	0.83	1.55	2.40	3.13
F	0.27	0.76	1.39	2.16	2.85

Table 11. V_{dd} = +3.3V Rise/Fall Times for Specific C_{LOAD}

Rise/Fall Time Typ (ns)					
Drive Strength \ C _{LOAD}	5 pF	15 pF	30 pF	45 pF	60 pF
L	3.39	6.88	11.63	17.56	23.59
A	1.74	3.50	6.38	8.98	12.19
R	1.16	2.33	4.29	6.04	8.34
B	0.81	1.82	3.22	4.52	6.33
T or "0": default	0.46	1.00	1.86	2.60	3.84
E	0.33	0.87	1.64	2.30	3.35
U	0.28	0.79	1.46	2.05	2.93
F	0.25	0.72	1.31	1.83	2.61

Pin 3 Configuration Options (OE, \overline{ST} , or NC)

Pin 3 of the MO2001 can be factory-programmed to support three modes: Output Enable (OE), standby (\overline{ST}) or No Connect (NC).

Output Enable (OE) Mode

In the OE mode, applying logic Low to the OE pin only disables the output driver and puts it in Hi-Z mode. The core of the device continues to operate normally. Power consumption is reduced due to the inactivity of the output. When the OE pin is pulled High, the output is typically enabled in $<1\mu\text{s}$.

Standby (\overline{ST}) Mode

In the ST mode, a device enters into the standby mode when Pin 3 pulled Low. All internal circuits of the device are turned off. The current is reduced to a standby current, typically in the range of a few μA . When \overline{ST} is pulled High, the device goes through the “resume” process, which can take up to 5 ms.

No Connect (NC) Mode

In the NC mode, the device always operates in its normal mode and outputs the specified frequency regardless of the logic level on pin 3.

Table 12 below summarizes the key relevant parameters in the operation of the device in OE, \overline{ST} , or NC mode.

Table 12. OE vs. \overline{ST} vs. NC

	OE	\overline{ST}	NC
Active current 20 MHz (max, +1.8V)	+4.1 mA	+4.1 mA	+4.1 mA
OE disable current (max. +1.8V)	+4.1 mA	N/A	N/A
Standby current (typical +1.8V)	N/A	+0.6 μA	N/A
OE enable time at 110 MHz (max)	130 ns	N/A	N/A
Resume time from standby (max, all frequency)	N/A	5.0 ms	N/A
Output driver in OE disable/standby mode	High Z	weak pull-down	N/A

Output on Startup and Resume

The MO2001 comes with gated output. Its clock output is accurate to the rated frequency stability within the first pulse from initial device startup or resume from the standby mode.

In addition, the MO2001 supports “no runt” pulses, and “no glitch” output during startup or resume as shown in the waveform captures in Figure 17 and Figure 18.



Figure 17. Startup Waveform vs. Vdd

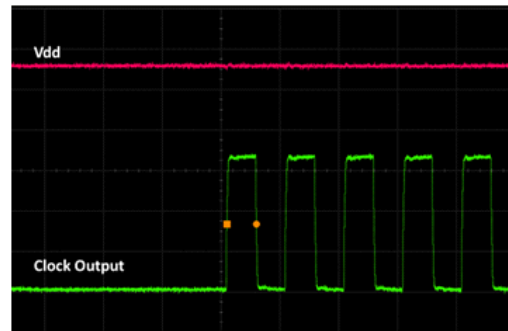
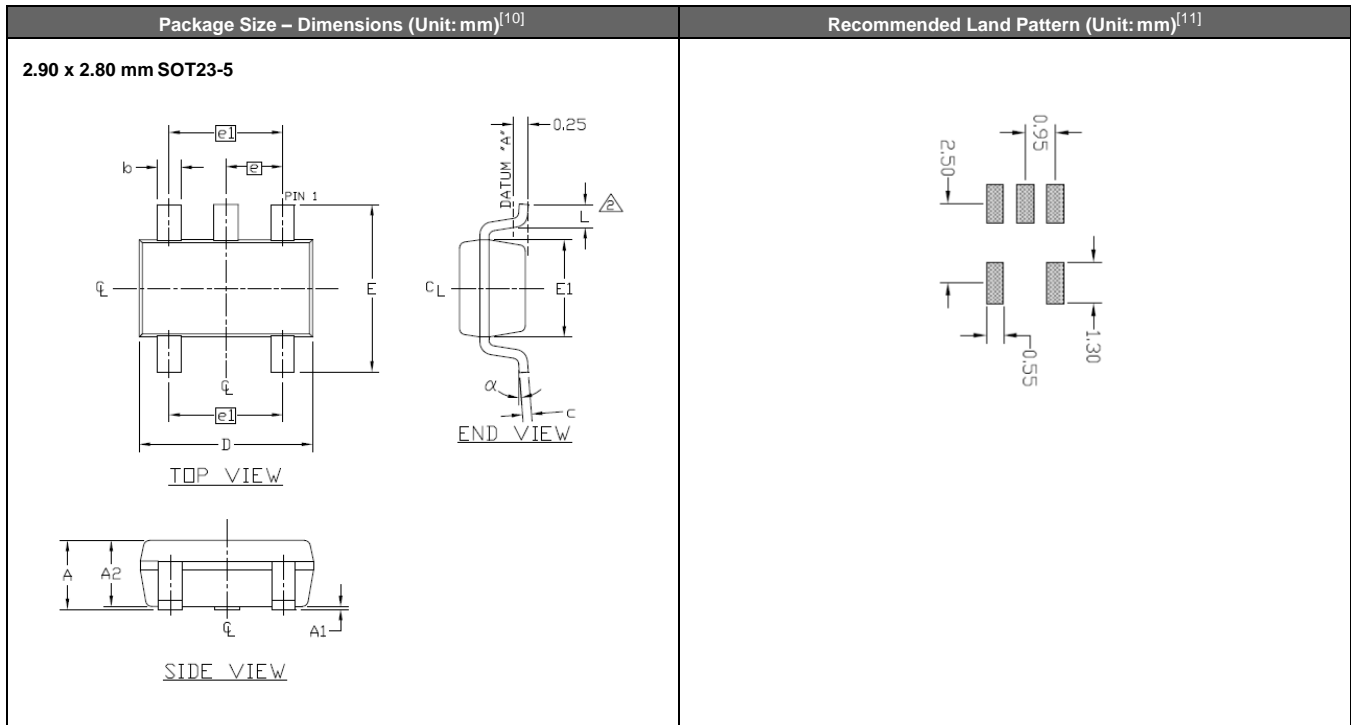


Figure 18. Startup Waveform vs. Vdd (Zoomed-in View of Figure 17)

Dimensions and Patterns



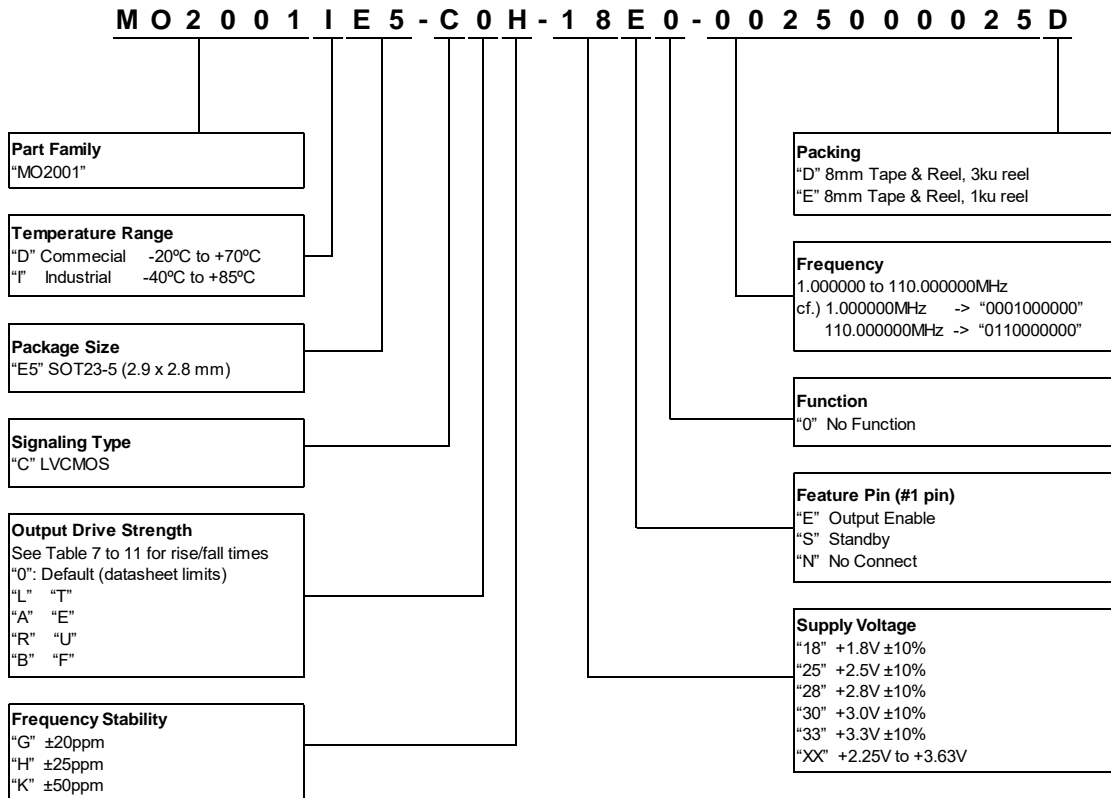
Notes:

- 10. Top marking: Y denotes manufacturing origin and XXXX denotes manufacturing lot number. The value of “Y” will depend on the assembly location of the device.
- 11. A capacitor value of 0.1 μ F between Vdd and GND is required

Table 13. Dimension Table

Symbol	Min.	Nom.	Max.
A	0.90	1.27	1.45
A1	0.00	0.07	0.15
A2	0.90	1.20	1.30
b	0.30	0.35	0.50
c	0.14	0.15	0.20
D	2.75	2.90	3.05
E	2.60	2.80	3.00
E1	1.45	1.60	1.75
L	0.30	0.38	0.55
L1	0.25 REF		
e	0.95 BSC.		
e1	1.90 BSC.		
α	0°	–	8°

Ordering Information



Revision History

Table 14. Datasheet Version and Change Log

Version	Release Date	Change Summary
0.95	03/13/2015	Initial Release
1.0	05/13/2015	<ul style="list-style-type: none"> Revised the Electrical Characteristics, Timing Diagrams and Performance Plots Revised SOT23 package diagram
1.01	09/29/2015	<ul style="list-style-type: none"> Revised the dimension table
1.02	04/18/2018	<ul style="list-style-type: none"> Changed Clock Generator to SOT23 Oscillator