TQC2018B

High Temp, Single-Chip, One-Output Clock Generator

TOKYO QUARTZ CO.,LTD

Features

- Frequencies between 1 MHz and 110 MHz accurate to 6 decimal places
- Operating temperature from -40°C to 125°C. For -55°C option, refer to TQC2020 and TQC2021
- Supply voltage of 1.8V or 2.5V to 3.3V
- Excellent total frequency stability as low as ±20 ppm
- Low power consumption of 3.5 mA typical at 1.8V
- LVCMOS/LVTTL compatible output
- 5-pin SOT23-5 package: 2.9mm x 2.8mm
- RoHS and REACH compliant, Pb-free, Halogen-free and Antimony-free
- **For AEC-Q100 clock generators, refer to TQC2024 and TQC2025**

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.

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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	Refer to Table 14 for the exact list of supported frequencies list of supported frequencies
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	
		-30	–	+30	ppm	
		-50	–	+50	ppm	
Operating Temperature Range						
Operating Temperature Range (ambient)	T_use	-40	–	+105	°C	Extended Industrial
		-40	–	+125	°C	Automotive
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	4.7	mA	No load condition, f = 20 MHz, Vdd = 2.8V, 3.0V or 3.3V
		–	3.6	4.5	mA	No load condition, f = 20 MHz, Vdd = 2.5V
		–	3.5	4.5	mA	No load condition, f = 20 MHz, Vdd = 1.8V
OE Disable Current	I_od	–	–	4.5	mA	Vdd = 2.5V to 3.3V, OE = Low, Output in high Z state.
		–	–	4.3	mA	Vdd = 1.8V, OE = Low, Output in high Z state.
Standby Current	I_std	–	2.6	8.5	µA	Vdd = 2.8V to 3.3V, $\overline{ST}$ = Low, Output is weakly pulled down
		–	1.4	5.5	µA	Vdd = 2.5V, $\overline{ST}$ = Low, Output is weakly pulled down
		–	0.6	4.0	µA	Vdd = 1.8V, $\overline{ST}$ = Low, Output is weakly pulled down
LVCMOS 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%
		–	1.0	3	ns	Vdd = 2.25V - 3.63V, 20% - 80%
Output High Voltage	VOH	90%	–	–	Vdd	IOH = -4 mA (Vdd = 3.0V or 3.3V) IOH = -3 mA (Vdd = 2.8V or 2.5V) IOH = -2 mA (Vdd = 1.8V)
Output Low Voltage	VOL	–	–	10%	Vdd	IOL = 4 mA (Vdd = 3.0V or 3.3V) IOL = 3 mA (Vdd = 2.8V or 2.5V) IOL = 2 mA (Vdd = 1.8V)

Table 1. Electrical Characteristics (continued)

Parameters	Symbol	Min.	Typ.	Max.	Unit	Condition
Input Characteristics						
Input High Voltage	VIH	70%	–	–	Vdd	Pin 3, OE or $\overline{ST}$
Input Low Voltage	VIL	–	–	30%	Vdd	Pin 3, OE or $\overline{ST}$
Input Pull-up Impedence	Z_in	50	87	150	kΩ	Pin 3, OE logic high or logic low, or $\overline{ST}$ logic high
		2	–	–	MΩ	Pin 3, $\overline{ST}$ logic low
Startup and Resume Timing						
Startup Time	T_start	–	–	5	ms	Measured from the time Vdd 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	ms	Measured from the time $\overline{ST}$ pin crosses 50% threshold
Jitter						
RMS Period Jitter	T_jitt	–	1.6	2.5	ps	f = 75 MHz, Vdd = 2.5V, 2.8V, 3.0V or 3.3V
		–	1.9	3	ps	f = 75 MHz, Vdd = 1.8V
Peak-to-peak Period Jitter	T_pk	–	12	20	ps	f = 75 MHz, Vdd = 2.5V, 2.8V, 3.0V or 3.3V
		–	14	25	ps	f = 75 MHz, Vdd = 1.8V
RMS Phase Jitter (random)	T_phj	–	0.5	0.8	ps	f = 75 MHz, Integration bandwidth = 900 kHz to 7.5 MHz
		–	1.3	2	ps	f = 75 MHz, Integration bandwidth = 12 kHz to 20 MHz

Table 2. Pin Description

Pin	Symbol	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 Vdd or Open[1]: Specified frequency output. Pin 3 has no function.
4	VDD	Power	Power supply voltage[2]
5	OUT	Output	Oscillator output

Notes:

1. In OE or $\overline{ST}$ mode, a pull-up resistor of 10 kΩ or less is recommended if pin 3 is not externally driven. If pin 3 needs to be left floating, use the NC option.
2. A capacitor of value 0.1 μF or higher between Vdd and GND is required.

Top View

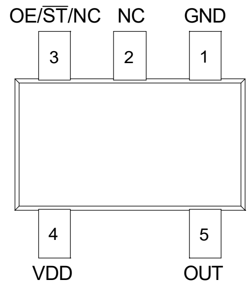


Figure 1. Pin Assignments

Table 3. Absolute Maximum Limits

Attempted operation outside the absolute maximum ratings of the part 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	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 above table.

Table 5. Maximum Operating Junction Temperature[5]

Max Operating Temperature (ambient)	Maximum Operating Junction Temperature
105°C	115°C
125°C	135°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, Method 2002**
Mechanical Vibration	**MIL-STD-883F, Method 2007**
Temperature Cycle	**JESD22, Method A104**
Solderability	**MIL-STD-883F, Method 2003**
Moisture Sensitivity Level	**MSL1 @ 260°C**

Test Circuit and Waveform[6]

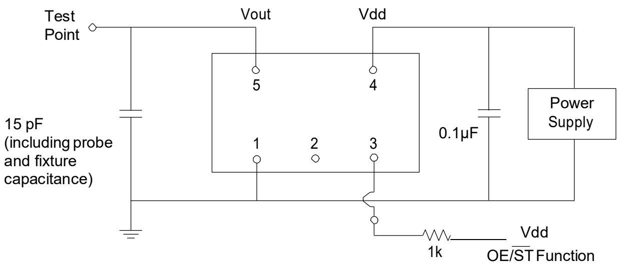


Figure 2. Test Circuit

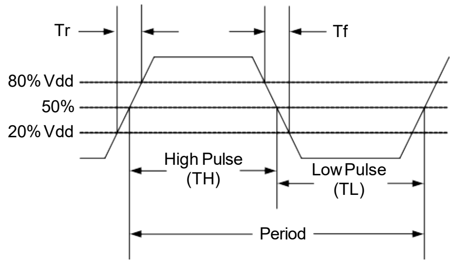
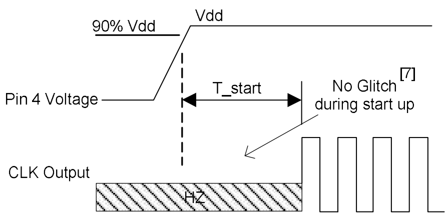


Figure 3. Output Waveform

Note:

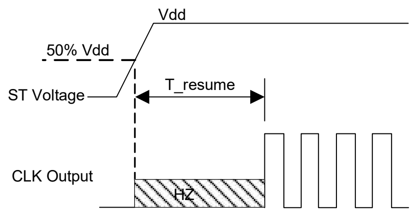
6. Duty Cycle is computed as Duty Cycle =TH/Period.

Timing Diagrams



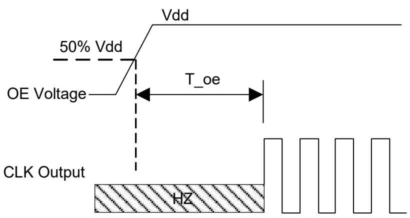
T_start: Time to start from power-off

Figure 4. Startup Timing (OE/ST Mode)



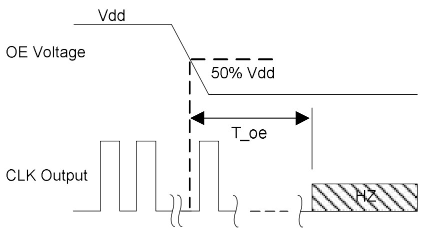
T_resume: Time to resume from ST

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. TQC2018 has "no runt" pulses and "no glitch" output during startup or resume.

Performance Plots[8]

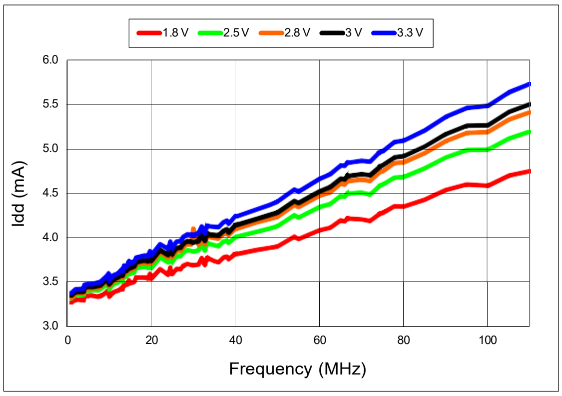


Figure 8. Idd vs Frequency

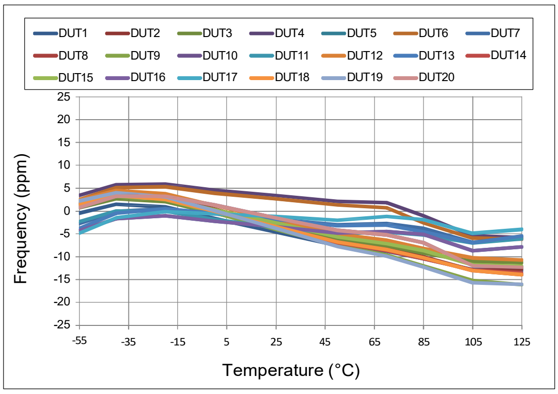


Figure 9. Frequency vs Temperature

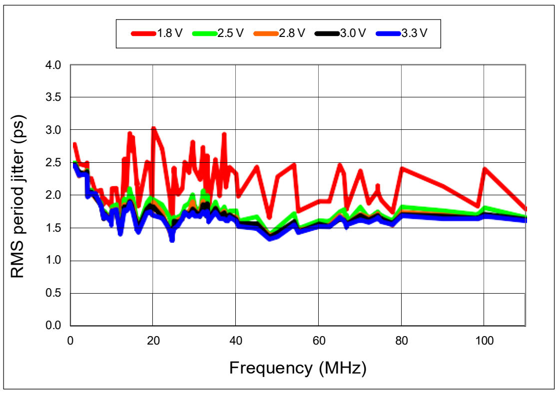


Figure 10. RMS Period Jitter vs Frequency

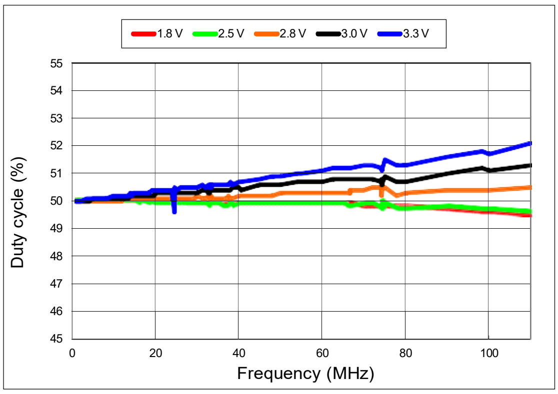


Figure 11. Duty Cycle vs Frequency

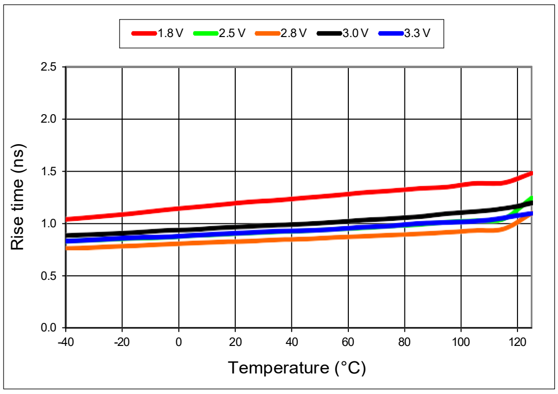


Figure 12. 20%-80% Rise Time vs Temperature

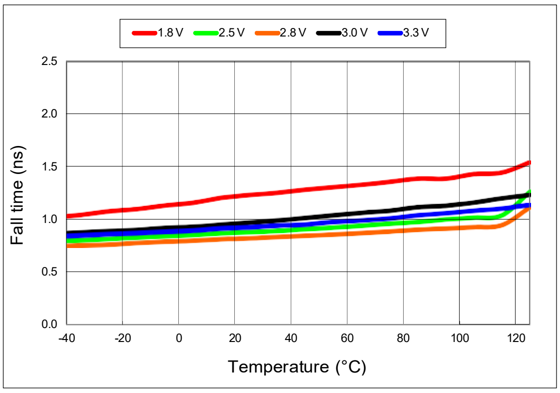


Figure 13. 20%-80% Fall Time vs Temperature

Performance Plots[8]

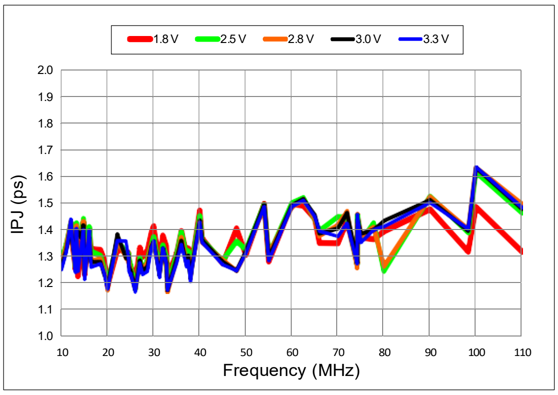


Figure 14. RMS Integrated Phase Jitter Random (12k to 20 MHz) vs Frequency[9]

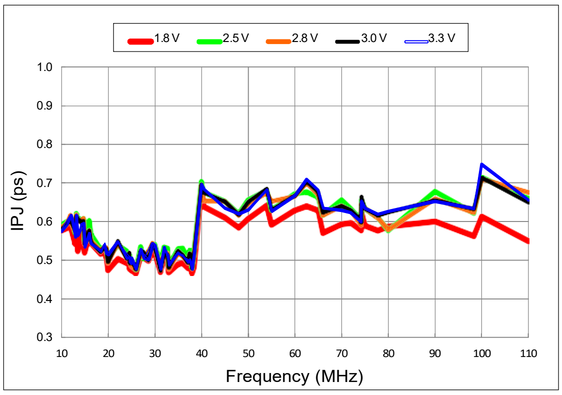


Figure 15. RMS Integrated Phase Jitter Random (900 kHz to 20 MHz) vs Frequency[9]

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 TQC2018 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, see the TQC Application Notes section:

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.

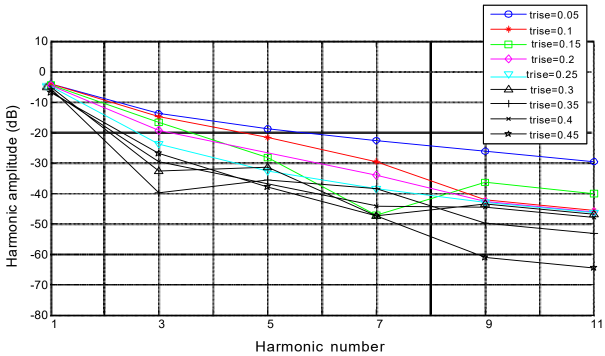


Figure 16. Harmonic EMI reduction as a Function of Slower Rise/Fall Time

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 senTQCivity 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 TQC2018 device with default drive strength setting, the typical rise/fall time is 1ns 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 TQC2018.

The TQC2018 can support up to 60 pF in maximum capacitive loads with drive strength settings. Refer to the Rise/Tall Time Tables (Table 7 to 11) to determine the proper drive strength for the desired combination of output load vs. rise/fall time

TQC2018 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 TQC2018 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:

$$\text{Max Frequency} = \frac{1}{5 \times Trf\_20/80}$$

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:

TQC2018BI**E**S2-18E-66.666660

Drive strength code is inserted here. Default setting is "-"

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

Table 7. Vdd = 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 "-": default	0.65	1.30	2.40	3.35	4.56

Table 8. Vdd = 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 "-": 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. Vdd = 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 "-": 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. Vdd = 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 "-": 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. Vdd = 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 "-": 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 TQC2018 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 <1µs.

Standby ($\overline{ST}$) Mode

In the $\overline{ST}$ 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)	4.5 mA	4.5 mA	4.5 mA
OE disable current (max. 1.8V)	4.3 mA	N/A	N/A
Standby current (typical 1.8V)	N/A	0.6 uA	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 ms	N/A
Output driver in OE disable/standby mode	High Z	weak pull-down	N/A

Output on Startup and Resume

The TQC2018 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 TQC2018 supports "no runt" pulses, and "no glitch" output during startup or resume as shown in the waveform captures in Figure 17 and Figure 18.

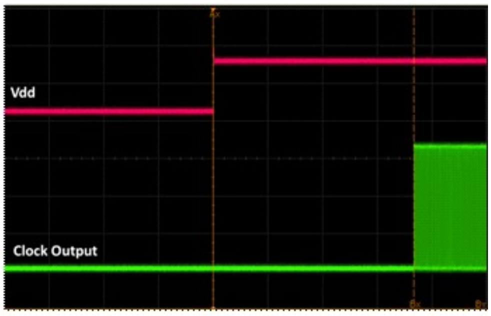


Figure 17. Startup Waveform vs. Vdd

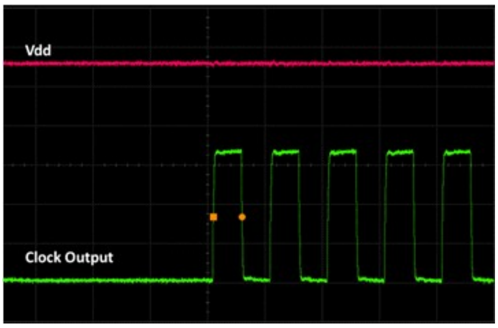
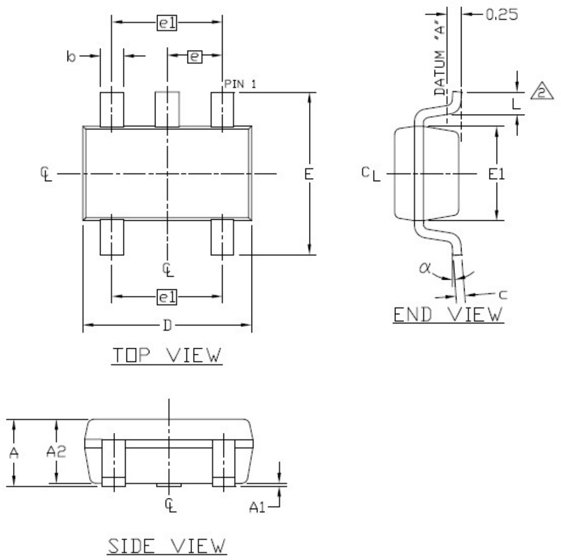
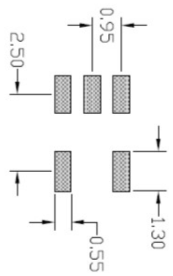


Figure 18. Startup Waveform vs. Vdd (Zoomed-in View of Figure 17)

Dimensions and Patterns

Package Size – Dimensions (Unit: mm)[10]	Recommended Land Pattern (Unit: mm)[11]
2.90 x 2.80 mm SOT23-5 	

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 µF 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

The Part No. Guide is for reference only. To customize and build an exact part number, use the TQC Part Number Generator.

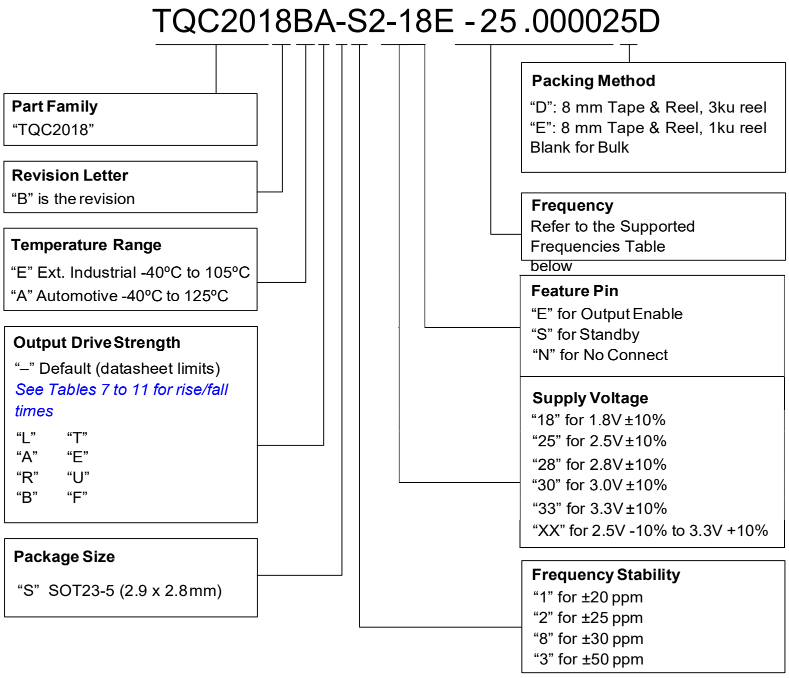


Table 14. List of Supported Frequencies[12, 13]

Frequency Range (-40 to +105°C or -40 to +125°C)	
Min.	**Max.**
1.000000 MHz	61.222999 MHz
61.674001 MHz	69.795999 MHz
70.485001 MHz	79.062999 MHz
79.162001 MHz	81.427999 MHz
82.232001 MHz	91.833999 MHz
92.155001 MHz	94.248999 MHz
94.430001 MHz	94.874999 MHz
94.994001 MHz	97.713999 MHz
98.679001 MHz	110.000000 MHz

Notes:

12. Any frequency within the min and max values in the above table are supported with 6 decimal places of accuracy.
13. Please contact TQC for frequencies that are not listed in the tables above.

Table 15. Additional Information

Document	Description	Download Link
Time Machine II	MEMS oscillator programmer	
Field Programmable Oscillators	Devices that can be programmable in the field by Time Machine II	
Manufacturing Notes	Tape & Reel dimension, reflow profile and other manufacturing related info	
Qualification Reports	RoHS report, reliability reports, composition reports	
Performance Reports	Additional performance data such as phase noise, current consumption and jitter for selected frequencies	
Termination Techniques	Termination design recommendations	
Layout Techniques	Layout recommendations	

Revision History

Table 16. Datasheet Version and Change Log

Version	Release Date	Change Summary
1.0	5/14/15	Final Production Release.
1.01	9/29/15	• Revised the dimension table

Silicon MEMS Outperforms Quartz

Best Reliability

Silicon is inherently more reliable than quartz. Figure 1 shows a comparison with quartz technology.

Why is EpiSeal™ MEMS Best in Class:

- EpiSeal MEMS resonators are hermetically vacuum-sealed during wafer processing, which eliminates foreign particles and improves long term aging and reliability
- MEMS resonator is paired with advanced analog IC

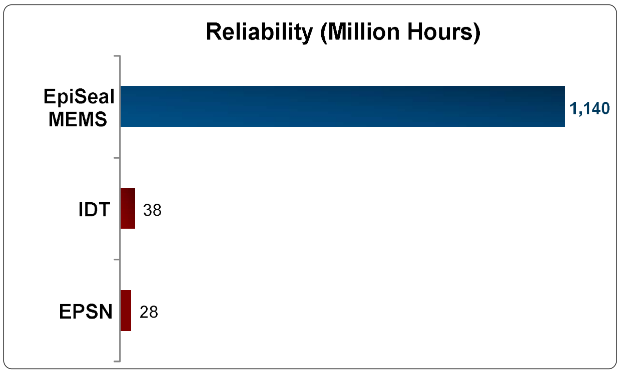


Figure 1. Reliability Comparison[1]

Best Aging

Unlike quartz, EpiSeal MEMS oscillators have excellent long-term aging performance which is why every new EpiSeal MEMS product specifies 10-year aging.

Why is EpiSeal MEMS Best in Class:

- EpiSeal MEMS resonators are hermetically vacuum-sealed during wafer processing, which eliminates foreign particles and improves long term aging and reliability
- Inherently better immunity of electrostatically driven MEMS resonator

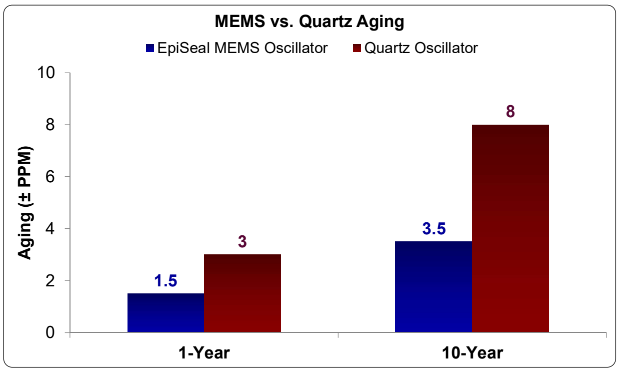


Figure 2. Aging Comparison[2]

Best Electro Magnetic Susceptibility (EMS)

EpiSeal MEMS oscillators in plastic packages are up to 54 times more immune to external electromagnetic fields than quartz oscillators as shown in Figure 3.

Why is EpiSeal MEMS Best in Class:

- Internal differential architecture for best common mode noise rejection
- Electrostatically driven MEMS resonator is more immune to EMS

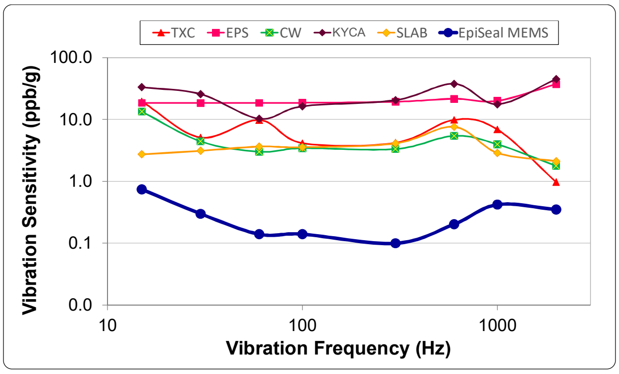


Figure 3. Electro Magnetic Susceptibility (EMS)[3]

Best Power Supply Noise Rejection

EpiSeal MEMS oscillators are more resilient against noise on the power supply. A comparison is shown in Figure 4.

Why is EpiSeal MEMS Best in Class:

- On-chip regulators and internal differential architecture for common mode noise rejection
- MEMS resonator is paired with advanced analog CMOS IC

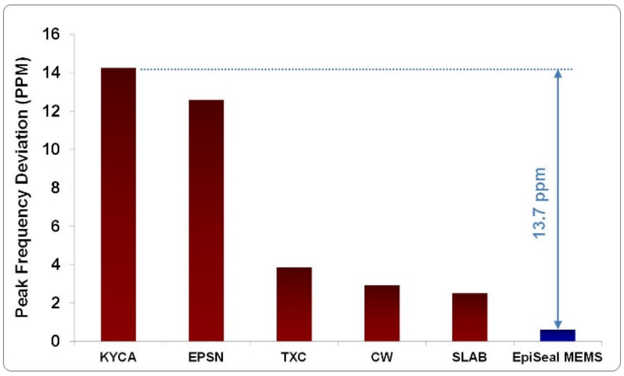


Figure 4. Power Supply Noise Rejection[4]

Best Vibration Robustness

High-vibration environments are all around us. All electronics, from handheld devices to enterprise servers and storage systems are subject to vibration. Figure 5 shows a comparison of vibration robustness.

Why is EpiSeal MEMS Best in Class:

- The moving mass of MEMS resonators is up to 3000 times smaller than quartz
- Center-anchored MEMS resonator is the most robust design

Best Shock Robustness

EpiSeal MEMS oscillators can withstand at least 50,000g shock. They maintain their electrical performance in operation during shock events. A comparison with quartz devices is shown in Figure 6.

Why is EpiSeal MEMS Best in Class:

- The moving mass of MEMS resonators is up to 3000 times smaller than quartz
- Center-anchored MEMS resonator is the most robust design

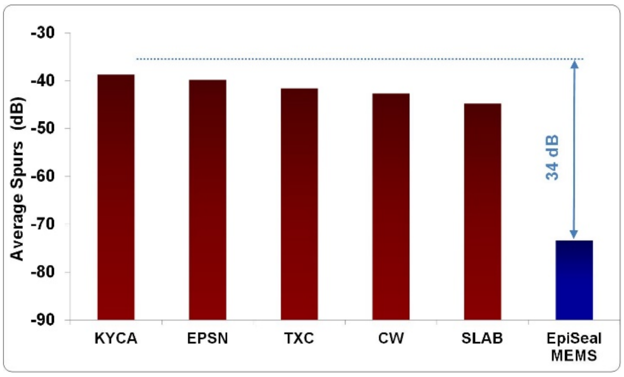


Figure 5. Vibration Robustness[5]

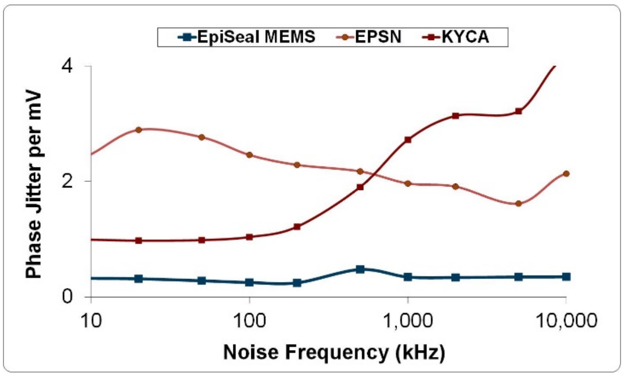


Figure 6. Shock Robustness[6]

Figure labels:

TXC = TXC
Epson = EPSN
Connor Winfield = CW
Kyocera = KYCA
SiLabs = SLAB
TQC = EpiSeal MEMS

Notes:

1. Data source: Reliability documents of named companies.
2. Data source: TQC and quartz oscillator devices datasheets.
3. Test conditions for Electro Magnetic Susceptibility (EMS):
   - According to IEC EN61000-4.3 (Electromagnetic compatibility standard)
   - Field strength: 3V/m
   - Radiated signal modulation: AM 1 kHz at 80% depth
   - Carrier frequency scan: 80 MHz – 1 GHz in 1% steps
   - Antenna polarization: Vertical
   - DUT position: Center aligned to antenna

   Devices used in this test:

Label	Manufacturer	Part Number	Technology
EpiSeal MEMS	TQC	TQC9120AC-1D2-33E156.250000	MEMS + PLL
EPSN	Epson	EG-2102CA156.2500M-PHPAL3	Quartz, SAW
TXC	TXC	BB-156.250MBE-T	Quartz, 3rd Overtone
CW	Conner Winfield	P123-156.25M	Quartz, 3rd Overtone
KYCA	AVX Kyocera	KC7050T156.250P30E00	Quartz, SAW
SLAB	SiLab	590AB-BDG	Quartz, 3rd Overtone + PLL

4. 50 mV pk-pk Sinusoidal voltage.

   Devices used in this test:

Label	Manufacturer	Part Number	Technology
EpiSeal MEMS	TQC	TQC8208AI-33-33E-25.000000	MEMS + PLL
NDK	NDK	NZ2523SB-25.6M	Quartz
KYCA	AVX Kyocera	KC2016B25M0C1GE00	Quartz
EPSN	Epson	SG-310SCF-25M0-MB3	Quartz

5. **Devices used in this test:**
   same as EMS test stated in Note 3.
6. Test conditions for shock test:
   - MIL-STD-883F Method 2002
   - Condition A: half sine wave shock pulse, 500-g, 1ms
   - Continuous frequency measurement in 100 μs gate time for 10 seconds

   Devices used in this test:
   same as EMS test stated in Note 3.
7. Additional data, including setup and detailed results, is available upon request to qualified customer.