

# TQC8209

## High Frequency, Ultra Performance Oscillator

TOKYO QUARTZ CO.,LTD

### Features

- Any frequency between 80.000001 and 220 MHz accurate to 6 decimal places
- 100% pin-to-pin drop-in replacement to quartz-based oscillators
- Ultra-low phase jitter: 0.5 ps (12 kHz to 20 MHz)
- Frequency stability as low as  $\pm 10$  PPM
- Industrial or extended commercial temperature range
- LVC MOS/LVTTL compatible output
- Standard 4-pin packages: 2.5 x 2.0, 3.2 x 2.5, 5.0 x 3.2, 7.0 x 5.0 mm x mm
- Outstanding silicon reliability of 2 FIT or 500 million hour MTBF
- Pb-free, RoHS and REACH compliant
- Ultra-short lead time

### Applications

- SATA, SAS, Ethernet, 10-Gigabit Ethernet, SONET, PCI Express, video, Wireless
- Computing, storage, networking, telecom, industrial control



EXPRESS  
SAMPLES



GREEN  
SOLUTIONS



LIFETIME  
WARRANTY

### Electrical Characteristics

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Output Frequency Range	f	80.000001	–	220	MHz	
Frequency Stability	F <sub>stab</sub>	-10	–	+10	PPM	Inclusive of Initial tolerance at 25 °C, and variations over operating temperature, rated power supply voltage and load
		-20	–	+20	PPM	
		-25	–	+25	PPM	
		-50	–	+50	PPM	
Operating Temperature Range	T <sub>use</sub>	-20	–	+70	°C	Extended Commercial
		-40	–	+85	°C	Industrial
Supply Voltage	V <sub>dd</sub>	1.71	1.8	1.89	V	Supply voltages between 2.5V and 3.3V can be supported. Contact TQC for guaranteed performance specs for supply voltages not specified in this table.
		2.25	2.5	2.75	V	
		2.52	2.8	3.08	V	
		2.97	3.3	3.63	V	
Current Consumption	I <sub>dd</sub>	–	34	36	mA	No load condition, f = 100 MHz, V <sub>dd</sub> = 2.5V, 2.8V or 3.3V
		–	30	33	mA	No load condition, f = 100 MHz, V <sub>dd</sub> = 1.8V
OE Disable Current	I <sub>OD</sub>	–	–	31	mA	V <sub>dd</sub> = 2.5V, 2.8V or 3.3V, OE = GND, output is Weakly Pulled Down
		–	–	30	mA	V <sub>dd</sub> = 1.8 V. OE = GND, output is Weakly Pulled Down
Standby Current	I <sub>std</sub>	–	–	70	μA	V <sub>dd</sub> = 2.5V, 2.8V or 3.3V, $\overline{ST}$ = GND, output is Weakly Pulled Down
		–	–	10	μA	V <sub>dd</sub> = 1.8 V. $\overline{ST}$ = GND, output is Weakly Pulled Down
Duty Cycle	DC	45	–	55	%	f <= 165 MHz, all V <sub>dds</sub> .
		40	–	60	%	f > 165 MHz, all V <sub>dds</sub> .
Rise/Fall Time	T <sub>r</sub> , T <sub>f</sub>	–	1.2	2	ns	15 pF load, 10% - 90% V <sub>dd</sub>
Output Voltage High	VOH	90%	–	–	V <sub>dd</sub>	IOH = -6 mA, IOL = 6 mA, (V <sub>dd</sub> = 3.3V, 2.8V, 2.5V) IOH = -3 mA, IOL = 3 mA, (V <sub>dd</sub> = 1.8V)
Output Voltage Low	VOL	–	–	10%	V <sub>dd</sub>	
Input Voltage High	VIH	70%	–	–	V <sub>dd</sub>	Pin 1, OE or $\overline{ST}$
Input Voltage Low	VIL	–	–	30%	V <sub>dd</sub>	Pin 1, OE or $\overline{ST}$
Input Pull-up Impedance	Z <sub>in</sub>	–	100	250	kΩ	Pin 1, OE logic high or logic low, or $\overline{ST}$ logic high
		2	–	–	MΩ	Pin 1, $\overline{ST}$ logic low
Startup Time	T <sub>start</sub>	–	7	10	ms	Measured from the time V <sub>dd</sub> reaches TQCs rated minimum value
OE Enable/Disable Time	T <sub>oe</sub>	–	–	115	ns	f = 80 MHz, For other frequencies, T <sub>oe</sub> = 100 ns + 3 cycles
Resume Time	T <sub>resume</sub>	–	–	10	ms	In standby mode, measured from the time $\overline{ST}$ pin crosses 50% threshold. Refer to Figure 5.
RMS Period Jitter	T <sub>jitt</sub>	–	1.5	2	ps	f = 156.25 MHz, V <sub>dd</sub> = 2.5V, 2.8V or 3.3V
		–	2	3	ps	f = 156.25 MHz, V <sub>dd</sub> = 1.8V
RMS Phase Jitter (random)	T <sub>phj</sub>	–	0.5	1	ps	f = 156.25 MHz, Integration bandwidth = 12 kHz to 20 MHz
First year Aging	F <sub>aging</sub>	-1.5	–	+1.5	PPM	25°C
10-year Aging		-5	–	+5	PPM	25°C

#### Note:

- All electrical specifications in the above table are specified with 15 pF output load and for all V<sub>dd</sub>(s) unless otherwise stated.

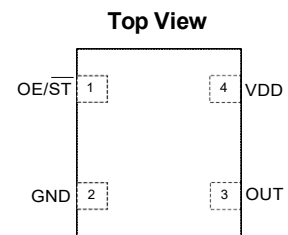
# TQC8209

## High Frequency, Ultra Performance Oscillator

TOKYO QUARTZ CO.,LTD

### Pin Configuration

Pin	Symbol	Functionality
1	OE/ $\overline{\text{ST}}$	Output Enable H or Open <sup>[2]</sup> : specified frequency output L: output is high impedance. Only output driver is disabled.
		Standby H or Open <sup>[2]</sup> : specified frequency output L: output is low (weak pull down). Device goes to sleep mode. Supply current reduces to I <sub>std</sub> .
2	GND	Power Electrical ground <sup>[3]</sup>
3	OUT	Output Oscillator output
4	VDD	Power Power supply voltage <sup>[3]</sup>



#### Notes:

2. A pull-up resistor of <math><10\text{ k}\Omega</math> between OE/  $\overline{\text{ST}}$  pin and Vdd is recommended in high noise environment.
3. A capacitor of value 0.1  $\mu\text{F}$  between Vdd and GND is recommended.

### Absolute Maximum

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	$^{\circ}\text{C}$
VDD	-0.5	4	V
Electrostatic Discharge	-	2000	V
Soldering Temperature (follow standard Pb free soldering guidelines)	-	260	$^{\circ}\text{C}$
Junction Temperature	-	150	$^{\circ}\text{C}$

### Thermal Consideration

Package	$\theta_{\text{JA}}$ , 4 Layer Board ( $^{\circ}\text{C}/\text{W}$ )	$\theta_{\text{JA}}$ , 2 Layer Board ( $^{\circ}\text{C}/\text{W}$ )	$\theta_{\text{JC}}$ , Bottom ( $^{\circ}\text{C}/\text{W}$ )
7050	191	263	30
5032	97	199	24
3225	109	212	27
2520	117	222	26

### 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 SenTQCivity Level	MSL1 @ 260 $^{\circ}\text{C}$

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## High Frequency, Ultra Performance Oscillator

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### Phase Noise Plot

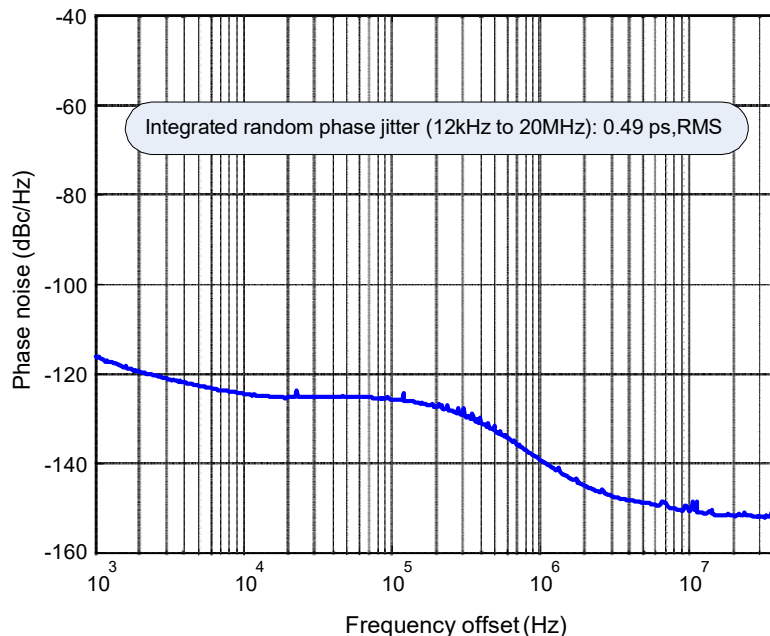


Figure 1. Phase Noise, 156.25 MHz, 3.3V, LVCMOS Output

### Test Circuit and Waveform

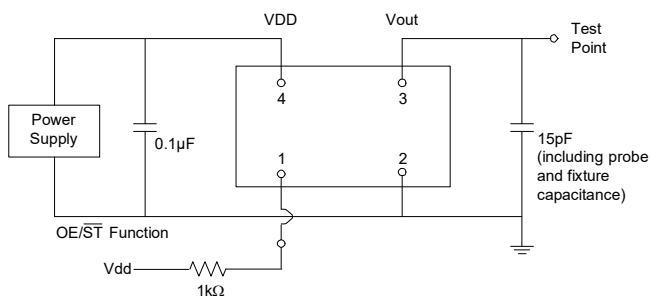


Figure 2. Test Circuit

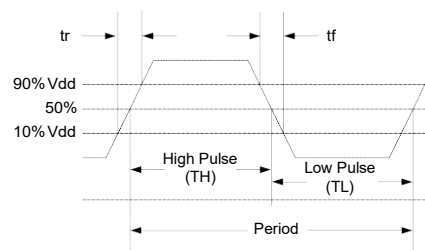


Figure 3. Waveform

#### Notes:

4. Duty Cycle is computed as  $Duty\ Cycle = TH/Period$ .
5. TQC8209 supports the configurable duty cycle feature. For custom duty at any given frequency, contact [TQC](#).

# TQC8209

## High Frequency, Ultra Performance Oscillator

### Timing Diagram

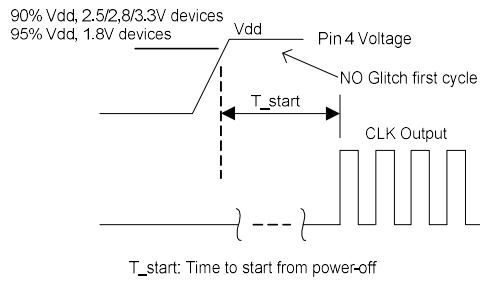


Figure 4. Startup Timing (OE/ST Mode)

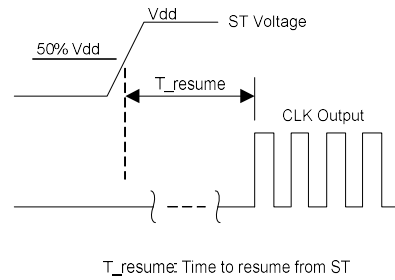


Figure 5. Standby Resume Timing (ST Mode Only)

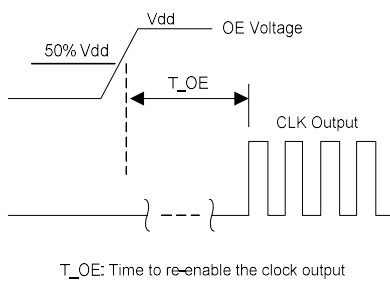


Figure 6. OE Enable Timing (OE Mode Only)

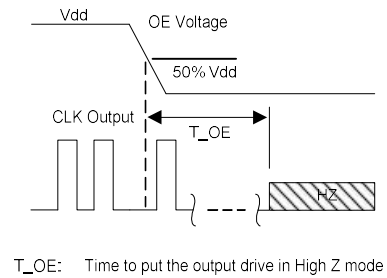


Figure 7. OE Disable Timing (OE Mode Only)

**Notes:**

- 6. TQC8209 supports NO RUNT pulses and No glitches during startup or resume.
- 7. TQC8209 supports gated output which is accurate within rated frequency stability from the first cycle.

# TQC8209

## High Frequency, Ultra Performance Oscillator

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### Performance Plots<sup>[8]</sup>

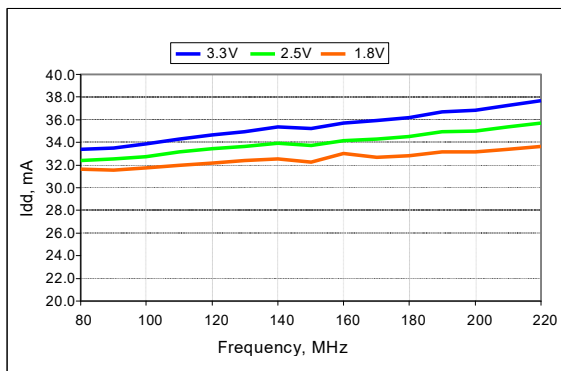


Figure 8. Idd vs Frequency

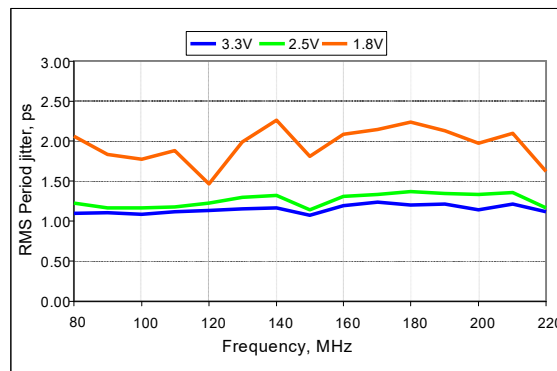


Figure 9. RMS Period Jitter vs Frequency

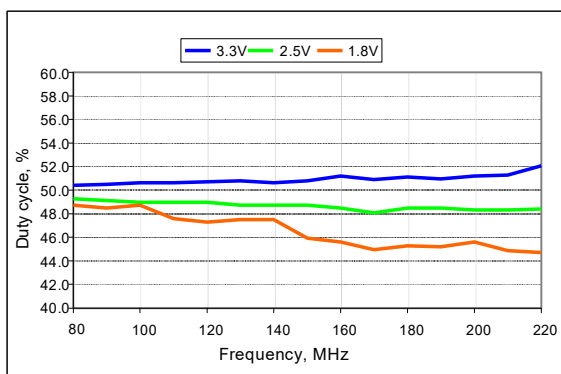


Figure 10. Duty Cycle vs Frequency

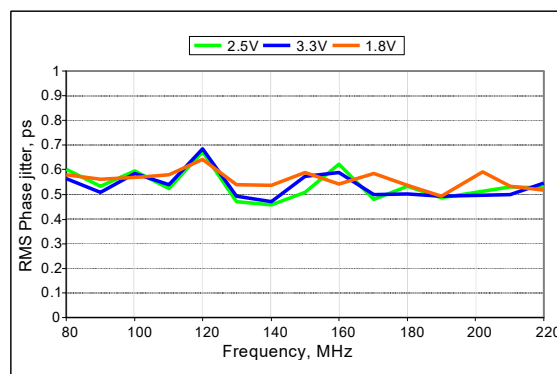


Figure 11. RMS Phase Jitter vs Frequency

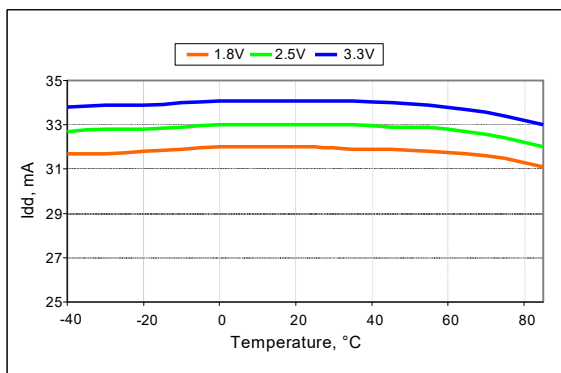


Figure 12. Idd vs Temperature, 100 MHz Output

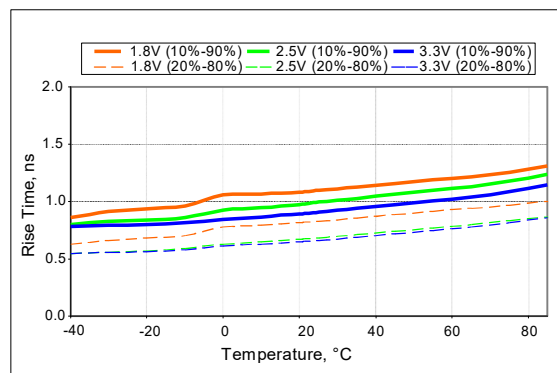


Figure 13. Rise Time vs Temperature, 100 MHz Output

**Note:**

8. All plots are measured with 15pF load at room temperature, unless otherwise stated.

# TQC8209

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### Programmable Drive Strength

The TQC8209 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 Applications Note section;

### EMI Reduction by Slowing Rise/Fall Time

Figure 14 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.

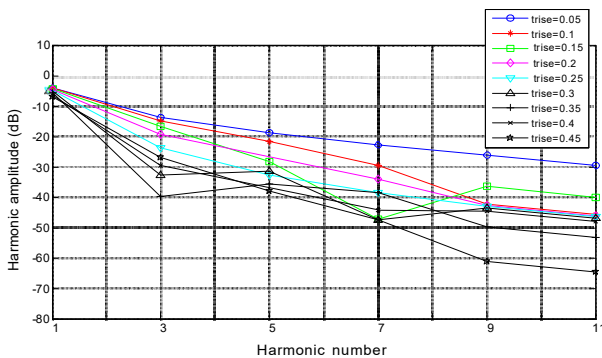


Figure 14. Harmonic EMI reduction as a Function of Slower Rise/Fall Time

### 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 increase rise/fall time (edge rate) of the input clock. Some chipsets would require faster rise/fall time in order to reduce their sensitivity to this type of jitter. The TQC8209 provides up to 3 additional high drive strength settings for very fast rise/fall time. Refer to the [Rise/Fall Time Tables](#) 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 TQC8209 device with default drive strength setting, the typical rise/fall time is 1.15ns for 15 pF output load. The typical rise/fall time slows down to 2.72ns when the output load increases to 45 pF. One can

choose to speed up the rise/fall time to 1.41ns by then increasing the drive strength setting on the TQC8209.

The TQC8209 can support up to 60 pF or higher in maximum capacitive loads with up to 3 additional drive strength settings. Refer to the [Rise/Fall Time Tables](#) to determine the proper drive strength for the desired combination of output load vs. rise/fall time

### TQC8209 Drive Strength Selection

Tables 1 through 5 define the rise/fall time for a given capacitive load and supply voltage.

1. Select the table that matches the TQC8209 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 1 through 4, the maximum frequency the oscillator can operate with guaranteed full swing of the output voltage over temperature as follows:

$$\text{Max Frequency} = \frac{1}{6 \times (\text{Trise})}$$

### Example 1

Calculate  $f_{\text{MAX}}$  for the following condition:

- Vdd = 1.8V (Table 1)
- Capacitive Load: 30 pF
- Desired Tr/f time = 3 ns (rise/fall time part number code = G)

Part number for the above example:

TQC8209AIGG2-18E-55.500000



Drive strength code is inserted here. Default setting is “-”

# TQC8209

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### Rise/Fall Time (10% to 90%) vs C<sub>LOAD</sub> Tables

Rise/Fall Time Typ (ns)					
Drive Strength \ C <sub>LOAD</sub>	5 pF	15 pF	30 pF	45 pF	60 pF
L	12.45	17.68	19.48	46.21	57.82
A	6.50	10.27	16.21	23.92	30.73
R	4.38	7.05	11.61	16.17	20.83
B	3.27	5.30	8.89	12.18	15.75
S	2.62	4.25	7.20	9.81	12.65
D	2.19	3.52	6.00	8.31	10.59
T	1.76	3.01	5.14	7.10	9.15
E	1.59	2.59	4.49	6.25	7.98
U	1.49	2.28	3.96	5.55	7.15
F	1.22	2.10	3.57	5.00	6.46
W	1.07	1.88	3.23	4.50	5.87
G	1.01	1.64	2.95	4.12	5.40
X	0.96	1.50	2.74	3.80	4.98
K	0.92	1.41	2.56	3.52	4.64
Y	0.88	1.34	2.39	3.25	4.32
Q	0.86	1.29	2.24	3.04	4.06
Z or "": Default	0.82	1.24	2.07	2.89	3.82
M	0.77	1.20	1.94	2.72	3.61
N	0.66	1.15	1.84	2.58	3.41
P	0.51	1.09	1.76	2.45	3.24

Table 1. V<sub>dd</sub> = 1.8V Rise/Fall Times for Specific C<sub>LOAD</sub>

Rise/Fall Time Typ (ns)					
Drive Strength \ C <sub>LOAD</sub>	5 pF	15 pF	30 pF	45 pF	60 pF
L	8.68	13.59	18.36	32.70	42.06
A	4.42	7.18	11.93	16.60	21.38
R	2.93	4.78	8.15	11.19	14.59
B	2.21	3.57	6.19	8.55	11.04
S	1.67	2.87	4.94	6.85	8.80
D	1.50	2.33	4.11	5.68	7.33
T	1.06	2.04	3.50	4.84	6.26
E	0.98	1.69	3.03	4.20	5.51
U	0.93	1.48	2.69	3.73	4.92
F	0.90	1.37	2.44	3.34	4.42
W	0.87	1.29	2.21	3.04	4.02
G or "": Default	0.67	1.20	2.00	2.79	3.69
X	0.44	1.10	1.86	2.56	3.43
K	0.38	0.99	1.76	2.37	3.18
Y	0.36	0.83	1.66	2.20	2.98
Q	0.34	0.71	1.58	2.07	2.80
Z	0.33	0.65	1.51	1.95	2.65
M	0.32	0.62	1.44	1.85	2.50
N	0.31	0.59	1.37	1.77	2.39
P	0.30	0.57	1.29	1.70	2.28

Table 2. V<sub>dd</sub> = 2.5V Rise/Fall Times for Specific C<sub>LOAD</sub>

Rise/Fall Time Typ (ns)					
Drive Strength \ C <sub>LOAD</sub>	5 pF	15 pF	30 pF	45 pF	60 pF
L	7.93	12.69	17.94	30.10	38.89
A	4.06	6.66	11.04	15.31	19.80
R	2.68	4.40	7.53	10.29	13.37
B	2.00	3.25	5.66	7.84	10.11
S	1.59	2.57	4.54	6.27	8.07
D	1.19	2.14	3.76	5.21	6.72
T	1.00	1.79	3.20	4.43	5.77
E	0.94	1.51	2.78	3.84	5.06
U	0.90	1.38	2.48	3.40	4.50
F	0.87	1.29	2.21	3.03	4.05
W	0.62	1.19	1.99	2.76	3.68
G or "": Default	0.41	1.08	1.84	2.52	3.36
X	0.37	0.96	1.72	2.33	3.15
K	0.35	0.78	1.63	2.15	2.92
Y	0.33	0.67	1.54	2.00	2.75
Q	0.32	0.63	1.46	1.89	2.57
Z	0.31	0.60	1.39	1.80	2.43
M	0.30	0.57	1.31	1.72	2.30
N	0.30	0.56	1.22	1.63	2.22
P	0.29	0.54	1.13	1.55	2.13

Table 3. V<sub>dd</sub> = 2.8V Rise/Fall Times for Specific C<sub>LOAD</sub>

Rise/Fall Time Typ (ns)					
Drive Strength \ C <sub>LOAD</sub>	5 pF	15 pF	30 pF	45 pF	60 pF
L	7.18	11.59	17.24	27.57	35.57
A	3.61	6.02	10.19	13.98	18.10
R	2.31	3.95	6.88	9.42	12.24
B	1.65	2.92	5.12	7.10	9.17
S	1.43	2.26	4.09	5.66	7.34
D	1.01	1.91	3.38	4.69	6.14
T	0.94	1.51	2.86	3.97	5.25
E	0.90	1.36	2.50	3.46	4.58
U	0.86	1.25	2.21	3.03	4.07
F or "": Default	0.48	1.15	1.95	2.72	3.65
W	0.38	1.04	1.77	2.47	3.31
G	0.36	0.87	1.66	2.23	3.03
X	0.34	0.70	1.56	2.04	2.80
K	0.33	0.63	1.48	1.89	2.61
Y	0.32	0.60	1.40	1.79	2.43
Q	0.32	0.58	1.31	1.69	2.28
Z	0.30	0.56	1.22	1.62	2.17
M	0.30	0.55	1.12	1.54	2.07
N	0.30	0.54	1.02	1.47	1.97
P	0.29	0.52	0.95	1.41	1.90

Table 4. V<sub>dd</sub> = 3.3V Rise/Fall Times for Specific C<sub>LOAD</sub>

# TQC8209

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### Instant Samples with Time Machine and Field Programmable Oscillators

TQCime supports a field programmable version of the TQC8209 low power oscillator for fast prototyping and real time customization of features. The [field programmable devices](#) (FP devices) are available for all five standard TQC8209 package sizes and can be configured to one's exact specification using the [Time Machine II](#), an USB powered MEMS oscillator programmer.

### Customizable Features of the TQC8209 FP Devices Include

- Any frequency between 1 – 110 MHz
- Three frequency stability options,  $\pm 20$  PPM,  $\pm 25$  PPM,  $\pm 50$  PPM
- Two operating temperatures,  $-20$  to  $70^{\circ}\text{C}$  or  $-40$  to  $85^{\circ}\text{C}$
- Five supply voltage options, 1.8V, 2.5V, 2.8V, 3.0V, and 3.3V
- Output drive strength

For more information regarding TQC's field programmable solutions, contact to TQC.

TQC8209 is typically factory-programmed per customer ordering codes for volume delivery.

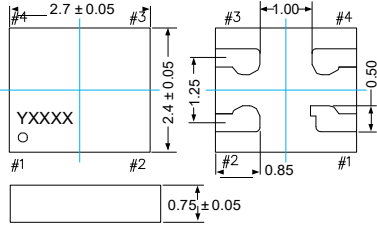
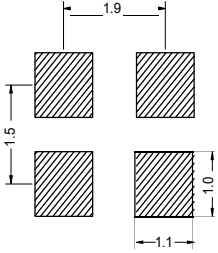
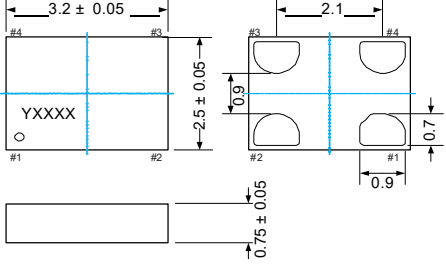
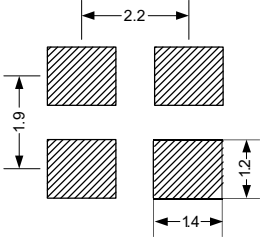
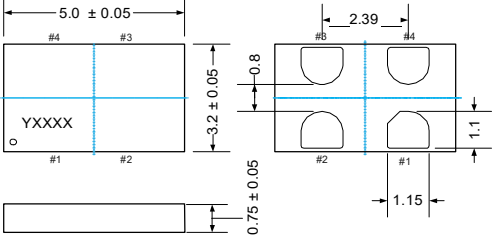
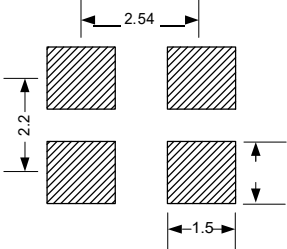
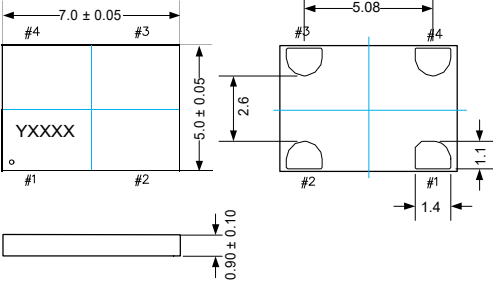
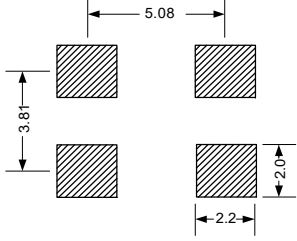


# TQC8209

## High Frequency, Ultra Performance Oscillator

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### Dimensions and Patterns

Package Size – Dimensions (Unit: mm) <sup>[9]</sup>	Recommended Land Pattern (Unit: mm) <sup>[10]</sup>
<p><b>2.7 x 2.4 x 0.75 mm (100% compatible with 2.5 x 2.0 mm footprint)</b></p> 	
<p><b>3.2 x 2.5 x 0.75 mm</b></p> 	
<p><b>5.0 x 3.2 x 0.75 mm</b></p> 	
<p><b>7.0 x 5.0 x 0.90 mm</b></p> 	

**Notes:**

- 9. 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.
- 10. A capacitor of value 0.1 μF between Vdd and GND is recommended.

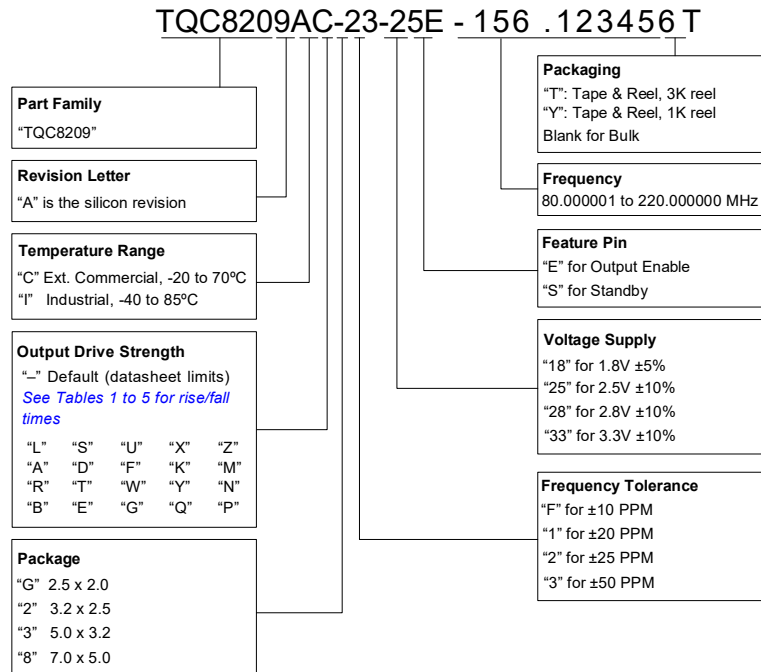
# TQC8209

## High Frequency, Ultra Performance Oscillator

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### Ordering Information

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



### Additional Information

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

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## High Frequency, Ultra Performance Oscillator

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### 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

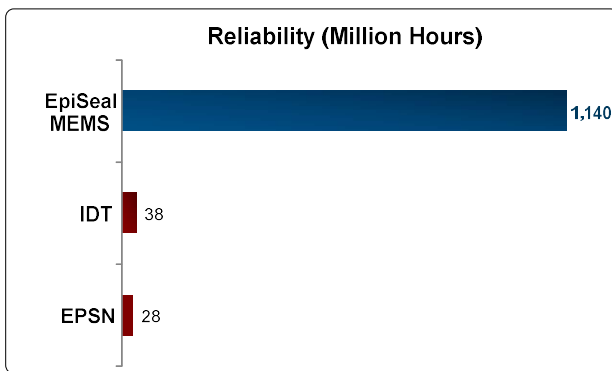


Figure 1. Reliability Comparison<sup>[1]</sup>

#### 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

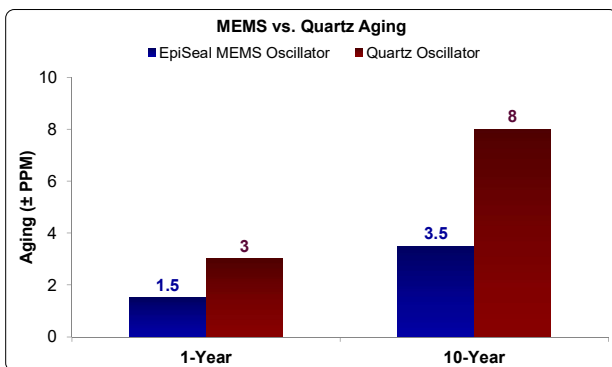


Figure 2. Aging Comparison<sup>[2]</sup>

#### 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

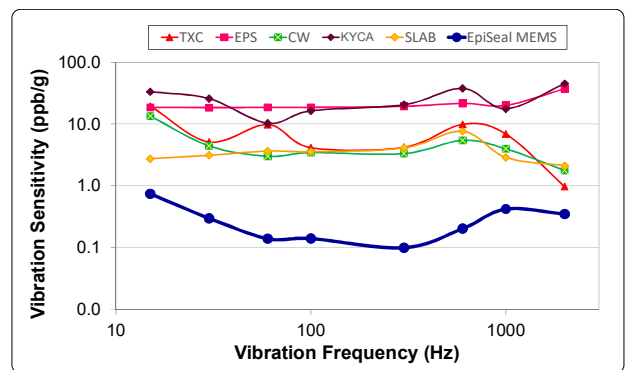


Figure 3. Electro Magnetic Susceptibility (EMS)<sup>[3]</sup>

#### 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

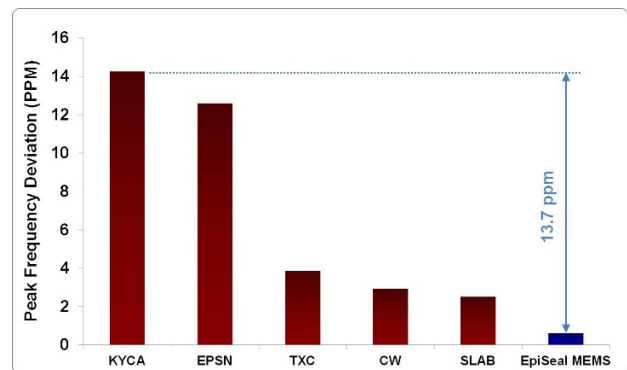


Figure 4. Power Supply Noise Rejection<sup>[4]</sup>

# TQC8209

## High Frequency, Ultra Performance Oscillator

### 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

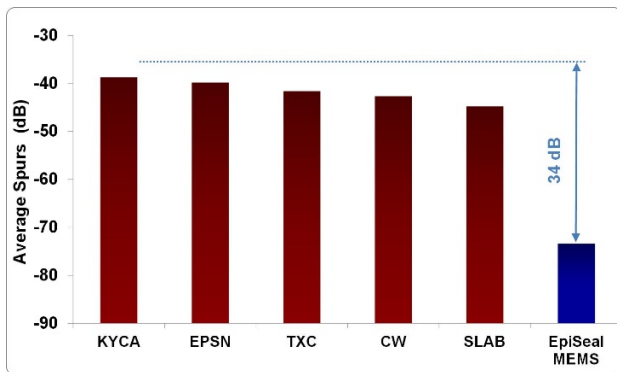


Figure 5. Vibration Robustness<sup>[5]</sup>

### 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

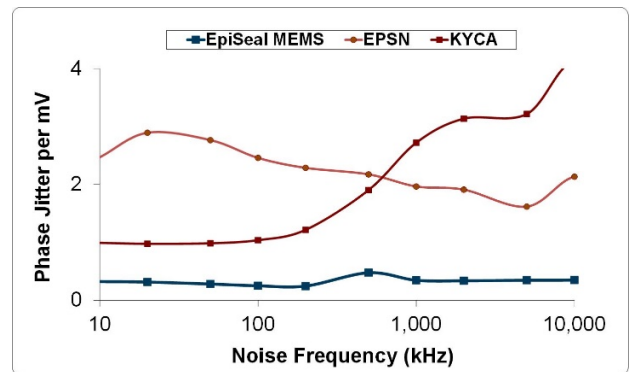


Figure 6. Shock Robustness<sup>[6]</sup>

#### Figure labels:

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

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## High Frequency, Ultra Performance Oscillator

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### 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, 3 <sup>rd</sup> Overtone
CW	Conner Winfield	P123-156.25M	Quartz, 3 <sup>rd</sup> Overtone
KYCA	AVX Kyocera	KC7050T156.250P30E00	Quartz, SAW
SLAB	SiLab	590AB-BDG	Quartz, 3 <sup>rd</sup> 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  $\mu$ s 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.