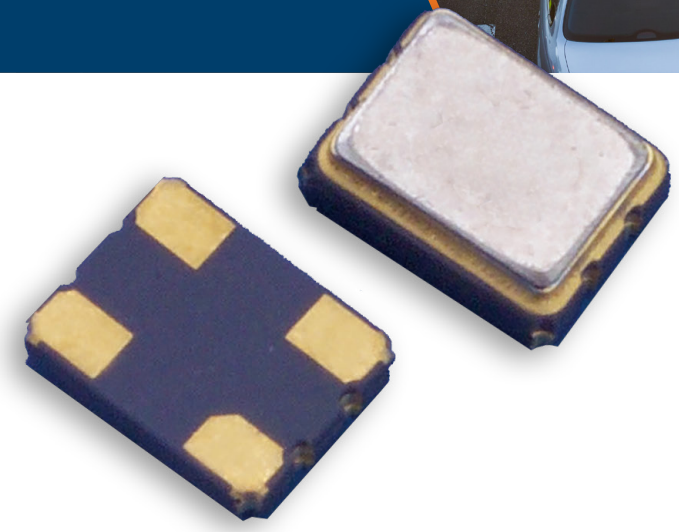
CTS Your Partner in Smart Solutions®

Crystals and Oscillators for Automotive Applications

AEC-Q200 Certified
Frequency Control Products



Application Note

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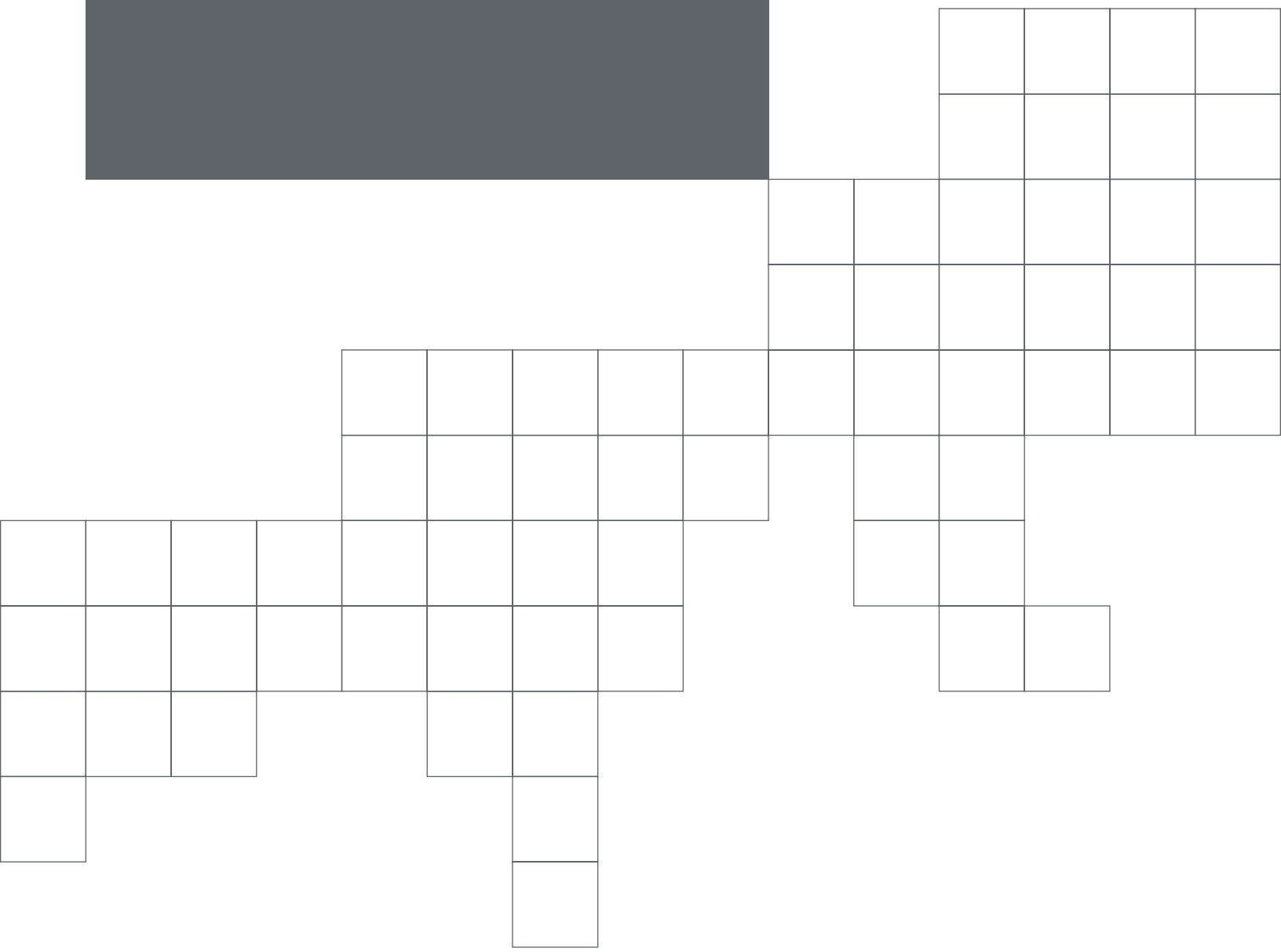


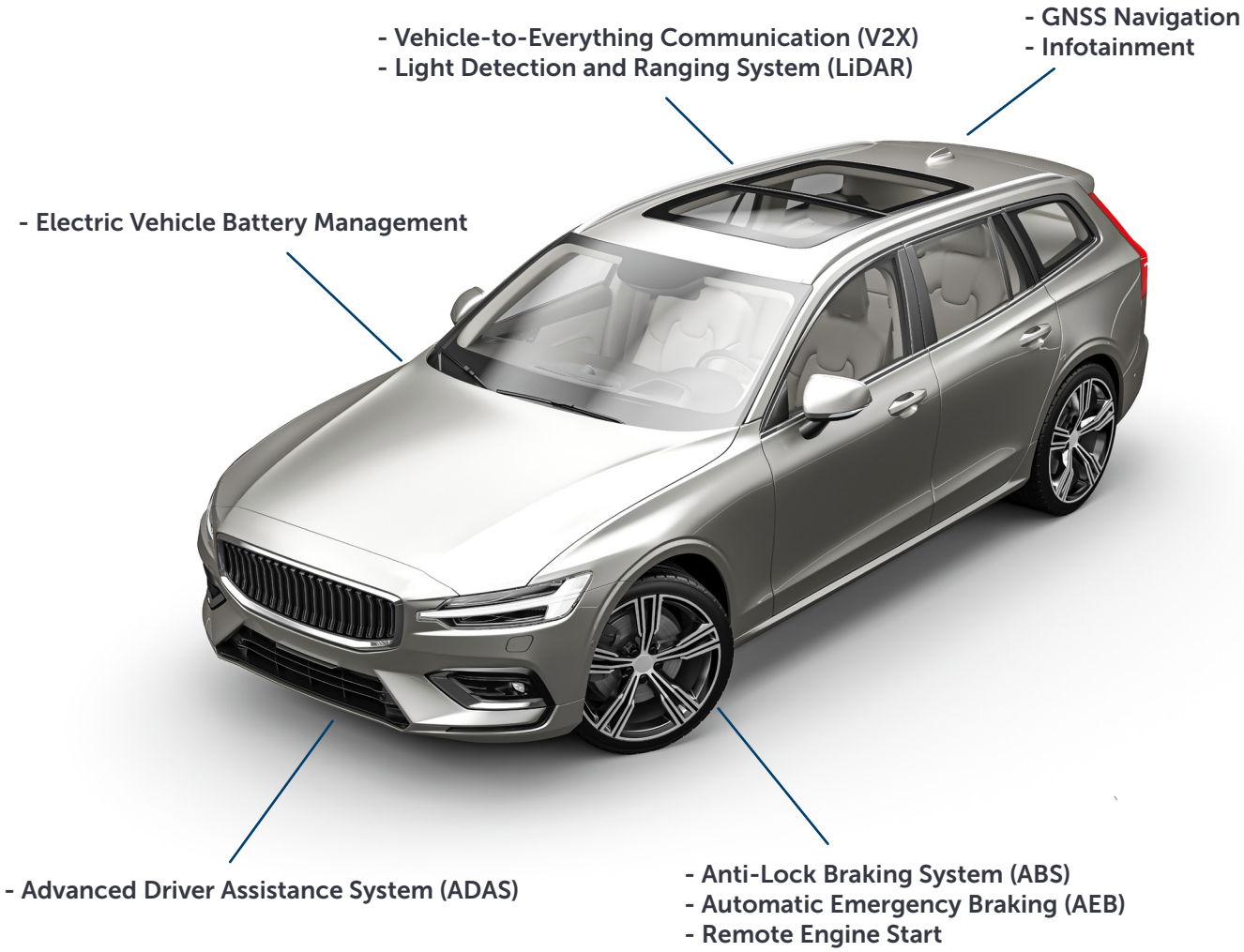
Introduction

Today's automobile and transportation sector is seeing rapid technological developments with new applications for passenger safety, comfortability and even enjoyment being added constantly.

Current vehicles are equipped with GNSS systems, infotainment, EV battery management, Advanced Drive Assistance Systems (ADAS), anti-lock braking, Automatic Emergency Braking (ABS and AEB), LiDAR and many similar features.

These electronic system advancements require stable and reliable frequency control devices to operate properly. Frequency control devices such as quartz crystals and oscillators provide an internal timing reference for the electronic systems by creating a stable electrical signal at a specified frequency. This helps the systems maintain accurate signal timing for proper performance. In an automotive setting, eletronic systems face certain performance challenges which in turn calls for automotive grade crystals and oscillators.

Automotive electronic systems using frequency control devices



What are automotive grade crystals and oscillators?

Automotive grade crystals and oscillators are high-stability frequency control devices that are designed to operate under the high temperatures and mechanical stress that occur in an in-vehicle operational environment.

Automotive grade crystals and oscillators are therefore subjected to stringent test criteria to ensure quality, safety and reliability. A device that fulfills these requirements will earn an AEC-Q200 qualification.

What is an AEC-Q200 qualification?

AEC-Q200 is a global standard that defines stress resistance criteria for passive electronic components intended for use in automotive applications. The standard is governed by the Automotive Electronics Council (AEC) that was established in the 1990s by the major US automobile manufacturers - Chrysler, Ford and GM.

The standard provides a benchmark for the quality and reliability of passive components, ensuring that they meet the rigorous demands of automotive applications. Components must pass a series of stringent tests outlined in the AEC-Q200 standard to be deemed "AEC-Q200 qualified." These tests assess factors like temperature, humidity, and mechanical stress.

The AEC established common part-quality system standards (AEC-Qxxx), and the most referenced documents are:

- AEC-Q100: Failure Mechanism Based Stress Test Qualification for Integrated Circuits
- AEC-Q101: Failure Mechanism Based Stress Test Qualification for Discrete Semiconductors
- AEC-Q200: Stress Test Qualification for Passive Components

The council revised AEC-Q200 to 'Revision E' in March 2023 that states qualification tests and in combination with JEDEC, MIL-STD and UL94 test procedures.

The following table lists the required tests for a quartz crystal. It can also be found on the AEC website. (Table 11. Table 11A allows for deviation from the stress qualifications test list. The supplier must however provide reasonable justification as to why the suggested tests do not apply.)

Test Number	Tests	References	Additional Requirements
1	Pre and Post Stress Electrical Test	User Specification	Test is performed at room temperature except as specified in the applicable stress reference and the additional requirements in this table.
3	High Temperature Exposure (Storage)	MIL-STD-202 Method 108	Tested at maximum specified operating temperature or maximum specified storage temperature (whichever is higher). Minimum test temperature shall be 85°C • 1000 hours • Unpowered • Measured at 24+4 hours after test conclusion
4	Temperature Cycling	JES-D22-A104	• Unpowered • 1000 cycles • Lower temperature of the chamber: -55°C • Upper temperature of the chamber: Maximum specified operating temperature and shall not exceed 85°C • Dwell time (soak time): - 15 minutes minimum - 30 minutes minimum if components weigh above 28g • Transition time: 1 minute maximum • Measurement at least 24 hours after test conclusion
7	Biased Humidity	MIL-STD-202 Method 103	• 1000 hours • 85°C/85%RH • Rated VDD applied with 1MΩ and inverter in parallel, 2x crystal C_L capacitors between each crystal leg and GND • Measurement at 24+4 hours after test conclusion
8	High Temperature Operational Life	MIL-STD-202 Method 108	• Note: 1000 hours • Temperature of the chamber: Maximum specified operating temperature up to 150°C • Rated VDD applied with 1MΩ and inverter in parallel, 2x crystal C_L capacitors between each crystal leg and GND • Measurement at 24+4 hours after test conclusion
9	External Visual	MIL-STD-883 Method 2009	• Inspect device construction, marking and workmanship • Pre and post electrical test not required
10	Physical Dimension	JES-D22-B100	• Verify physical dimensions to the applicable component specification • Pre and post electrical test not required

<table>
<tr><th>Test Number</th><th>Tests</th><th>References</th><th>Additional Requirements</th></tr>
<tr><td>11</td><td>Terminal Strength (THT)</td><td>MIL-STD-202 Method 211</td><td>
• Test THT component lead integrity only
• Test condition A (pull test):
<table>
<tr><th>Nominal Cross-Sectional Area (mm^2)</th><th>Force (N)</th></tr>
<tr><td>≤ 0.05</td><td>1</td></tr>
<tr><td>0.06 to 0.10</td><td>2.5</td></tr>
<tr><td>0.11 to 0.20</td><td>5</td></tr>
<tr><td>0.21 to 0.50</td><td>10</td></tr>
<tr><td>0.51 to 1.20</td><td>20</td></tr>
<tr><td>> 1.20</td><td>40</td></tr>
</table>
• Test condition C (wire-lead bend test):
<table>
<tr><th>Section Modulus (Zx) (mm^3)</th><th>Force (N)</th></tr>
<tr><td>≤ $1.5x10^{-3}$</td><td>0.5</td></tr>
<tr><td>$1.6x10^{-3}$ to $4.2x10^{-3}$</td><td>1.25</td></tr>
<tr><td>$4.3x10^{-3}$ to $1.2x10^{-2}$</td><td>2.5</td></tr>
<tr><td>$1.3x10^{-2}$ to $0.5x10^{-1}$</td><td>5</td></tr>
<tr><td>$0.6x10^{-1}$ to $1.9x10^{-1}$</td><td>10</td></tr>
<tr><td>> $1.9x10^{-1}$</td><td>20</td></tr>
</table>
• For round terminations: $Z_x = (\pi d^3)/32$ where d is the lead diameter
• For strip terminations: $Z_x = (ba^2)/6$ where a is the thickness of the rectangular strip perpendicular to the bending axis, b is the other dimension of the rectangular strip
• Notes: The values and formulars are per IEC 60068-2-21. 6th Edition
</td></tr>
<tr><td>12</td><td>Resistance to Solvents</td><td>MIL-STD-202 Method 215</td><td>
• In addition to the Method 215 solvents, add an aqueous wash chemical and follow chemical manufacturer's recommended parameters (i.e., solution temperature and immersion time)
• Applicable to ink-marked components and not laser-marked components
</td></tr>
<tr><td>13</td><td>Mechanical Shock</td><td>MIL-STD-202 Method 213</td><td>
• Figure 1 of Method 213
• THT: Condition C
• SMD: Condition C
• Tested per the supplier's recommended mounting method
</td></tr>
</table>

Test Number	Tests	References	Additional Requirements
14	Vibration	MIL-STD-202 Method 213	• 5g's for 20 minutes • 12 cycles for each of 3 orientations • Tested per the supplier's recommended mounting method • Verification of transfer load: During setup, verify that with the selected PCB design (size, thickness, and secure points), or an alternative mount, that the transferred load onto the components corresponds to the requested load. This verification can be achieved using a laser vibrometer or other adequate measuring device • Test from 10 Hz to 2000 Hz
15	Resistance to Soldering Heat	MIL-STD-202 Method 210	• THT: Conditions B or C • SMD: Condition K, time above 217°C, 60s to 150s • Non-soldered type mounting/attach are not applicable
17	ESD	AEC-Q200-002	
18	Solderability	J-STD-002	• Through-hole technology (THT): - Method A1, coating durability category 2 • SMD: - Method B1, coating durability category 2 - Method D, coating durability category 2 • Notes: In particular circumstances when SnPb reverse compatibility is requested by the user, Method A shall be used for THT and Method B shall be used for SMD • Magnification 50x • Pre and post electrical test not required • Non-soldered type mounting/attach are not applicable
19	Electrical Characterization	User Specification	• Parametrically test per lot and sample size requirements • Summary to show minimum, maximum, mean and standard deviation at room, minimum and maximum operating temperatures • Pre and post electrical test not required
20	Flammability	UL-94 or IEC 60695-11-5	• Applicable to components with exposed cured resins or plastic materials • If exposed resins or plastic materials are V-1, V-0 or 5VA. testing is not required • If exposed resins or plastic materials are not V-1, V-0 or 5VA, components or applicable parts of the component (e.g., sleeve or encapsulant), material shall be tested to the Needle Flame test per IEC 60695-11-5. Data from previously qualified materials can be supplied in place of conducting test • Pre and post electrical test not required

Test Number	Tests	References	Additional Requirements
21	Board Flex	AEC-Q200-005	
22	Terminal Strength (SMD)	AEC-Q200-006	
	Notes: For any deviation from the above stresses, refer to section 2.4.8. Back to Table C: Qualification Sample Size Back to Table D: Applicable Stress Conditions		

Automotive Grade Clock Oscillators

Features:

- AEC-Q200 Certified
- PPAP Compliant
- Operating Temperature: -40°C to 125°C
- HCMOS Output
- Complimentary Outputs (LVPECL and LVDS)
- Small Package Footprints

Applications:

- Automotive Electronics
- Infotainment and Audio/Video Systems
- Mobile Multimedia Systems
- Medical Electronics
- Commercial Military/Aerospace
- Industrial IoT
- M2M Communication
- Industrial Controls and Automation
- Test and Measurement

Automotive Grade Crystals

Features:

- AEC-Q200 Certified
- PPAP Compliant
- Small Package Footprints
- Extended Operating Temperature to 125°C
- Temperature Stability Reaching ±15ppm

Applications:

- RKE (Remote Keyless Entry)
- Infotainment and Audio/Video Systems
- Mobile Multimedia Systems
- Wireless Communication
- Bluetooth, ZigBee, Wi-Fi
- TPMS (Tire Pressure Monitoring System)
- Medical Electronics
- Commercial Military/Aerospace
- Industrial IoT
- M2M Communication
- Industrial Controls and Automation
- Test and Measurements

CTS Automotive Grade Clock Oscillators (AEC-Q200 Certified)

Model	Features	Package	Size	Output	Frequency	Phase Jitter	Frequency Stability	Supply Voltage	Temp Range
CA20C	Low Jitter Output Enable Fund & 3rd OT	SMD, 4-Pad Leadless Castellated Ceramic	2.0 x 1.6 mm	HCMOS	1.25 - 100 MHz	Typical: 0.5 PS Max Max: < 1.0 PS Max	±25ppm ±30ppm ±50ppm ±100ppm ±150ppm	1.8V 2.5V 3.3V	-40°C to 85°C -40°C to 105°C -40°C to 125°C -55°C to 105°C
CA25C	Low Jitter Output Enable Fund & 3rd OT	SMD, 4-Pad Leadless Castellated Ceramic	2.5 x 2.0 mm	HCMOS	1.25 - 156.25 MHz	Typical: 0.5 PS Max Max: < 1.0 PS Max	±25ppm ±30ppm ±50ppm ±100ppm ±150ppm	1.8V 2.5V 3.3V	-40°C to 85°C -40°C to 105°C -40°C to 125°C -55°C to 105°C
CA25P CA25L	Low Jitter Output Enable Fund & 3rd OT	SMD, 6-Pad Leadless Castellated Ceramic	2.5 x 2.0 mm	LVPECL LVDS	13.5 - 160 MHz	Max: 0.5 PS Max	±25ppm ±30ppm ±50ppm ±100ppm ±150ppm	1.8V 2.5V 3.3V	-40°C to 85°C -40°C to 105°C -40°C to 125°C
CA32C	Low Jitter Output Enable Fund & 3rd OT	SMD, 4-Pad Leadless Castellated Ceramic	3.2 x 2.5 mm	HCMOS	1.25 - 156.25 MHz	Typical: 0.5 PS Max Max: < 1.0 PS Max	±25ppm ±30ppm ±50ppm ±100ppm ±150ppm	1.8V 2.5V 3.3V	-40°C to 85°C -40°C to 105°C -40°C to 125°C -55°C to 105°C
CA32P CA32L	Low Jitter Output Enable Fund & 3rd OT	SMD, 6-Pad Leadless Castellated Ceramic	3.2 x 2.5 mm	LVPECL LVDS	13.5 - 160 MHz	Max: 0.5 PS Max	±25ppm ±30ppm ±50ppm ±100ppm ±150ppm	1.8V 2.5V 3.3V	-40°C to 85°C -40°C to 105°C -40°C to 125°C
CA50C	Low Jitter Output Enable Fund & 3rd OT	SMD, 4-Pad Leadless Castellated Ceramic	5.0 x 3.2 mm	HCMOS	1.25 - 156.25 MHz	Typical: 0.5 PS Max Max: < 1.0 PS Max	±25ppm ±30ppm ±50ppm ±100ppm ±150ppm	1.8V 2.5V 3.3V 5.0V	-40°C to 85°C -40°C to 105°C -40°C to 125°C -55°C to 105°C
CA50P CA50L	Low Jitter Output Enable Fund & 3rd OT	SMD, 6-Pad Leadless Castellated Ceramic	5.0 x 3.2 mm	LVPECL LVDS	13.5 - 160 MHz	Max: 0.5 PS Max	±25ppm ±30ppm ±50ppm ±100ppm ±150ppm	1.8V 2.5V 3.3V	-40°C to 85°C -40°C to 105°C -40°C to 125°C
CA70C	Low Jitter Output Enable Fund & 3rd OT	SMD, 4-Pad Leadless Castellated Ceramic	7.0 x 5.0 mm	HCMOS	1.25 - 156.25 MHz	Typical: 0.5 PS Max Max: < 1.0 PS Max	±25ppm ±30ppm ±50ppm ±100ppm ±150ppm	1.8V 2.5V 3.3V	-40°C to 85°C -40°C to 105°C -40°C to 125°C -55°C to 105°C
CA70P CA70L	Low Jitter Output Enable Fund & 3rd OT	SMD, 6-Pad Leadless Castellated Ceramic	7.0 x 5.0 mm	LVPECL LVDS	13.5 - 160 MHz	Max: 0.5 PS Max	±25ppm ±30ppm ±50ppm ±100ppm ±150ppm	1.8V 2.5V 3.3V	-40°C to 85°C -40°C to 105°C -40°C to 125°C

CTS Automotive Grade Crystals (AEC-Q200 Certified)

Model	Package	Size	Frequency	Frequency Tolerance at 25°C	Frequency Stability	Temp Range
HTA	SMD Metal Can	11.10 x 4.83 x 4.30 mm	3.2 - 65 MHz	±10ppm ±15ppm ±20ppm ±25ppm ±30ppm	±15ppm ±20ppm ±25ppm ±30ppm ±50ppm ±100ppm ±150ppm	-40°C to 85°C -40°C to 105°C -40°C to 125°C -55°C to 125°C
SA164	SMD, 4-Pad Seam Seal	1.6 x 1.2 x 0.40 mm	24 - 60 MHz	±10ppm ±15ppm ±20ppm ±30ppm ±50ppm	±15ppm ±20ppm ±30ppm ±50ppm ±100ppm ±150ppm	-40°C to 85°C -40°C to 105°C -40°C to 125°C -40°C to 150°C -55°C to 105°C -55°C to 125°C
SA204	SMD, 4-Pad Seam Seal	2.0 x 1.6 x 0.5 mm	16 - 96 MHz	±10ppm ±15ppm ±20ppm ±30ppm ±50ppm	±15ppm ±20ppm ±30ppm ±50ppm ±100ppm ±150ppm	-40°C to 85°C -40°C to 105°C -40°C to 125°C -40°C to 150°C -55°C to 105°C -55°C to 125°C
SA254	SMD, 4-Pad Seam Seal	2.5 x 2.0 x 0.65 mm	12 - 80 MHz	±10ppm ±15ppm ±20ppm ±30ppm ±50ppm	±15ppm ±20ppm ±30ppm ±50ppm ±100ppm ±150ppm	-40°C to 85°C -40°C to 105°C -40°C to 125°C -40°C to 150°C -55°C to 105°C -55°C to 125°C
SA324	SMD, 4-Pad Seam Seal	3.2 x 2.5 x 0.8 mm	8 - 160 MHz	±10ppm ±15ppm ±20ppm ±30ppm ±50ppm	±15ppm ±20ppm ±30ppm ±50ppm ±100ppm ±150ppm	-40°C to 85°C -40°C to 105°C -40°C to 125°C -40°C to 150°C -55°C to 105°C -55°C to 125°C
SA532	SMD, 2-Pad Seam Seal	5.0 x 3.2 x 1.1 mm	7.6 - 160 MHz	±10ppm ±15ppm ±20ppm ±30ppm ±50ppm	±15ppm ±20ppm ±30ppm ±50ppm ±100ppm ±150ppm	-40°C to 85°C -40°C to 105°C -40°C to 125°C -40°C to 150°C -55°C to 105°C -55°C to 125°C
SA534	SMD, 4-Pad Seam Seal	5.0 x 3.2 x 0.85 mm	7.6 - 160 MHz	±10ppm ±15ppm ±20ppm ±30ppm ±50ppm	±15ppm ±20ppm ±30ppm ±50ppm ±100ppm ±150ppm	-40°C to 85°C -40°C to 105°C -40°C to 125°C -40°C to 150°C -55°C to 105°C -55°C to 125°C
TFA16	SMD- 2-Pad Hermetic Ceramic	1.6 x 1.0 x 0.5 mm	0.032768 MHz	±10ppm ±20ppm	-0.034ppm/°C² Temp Coefficient	-40°C to 85°C -40°C to 105°C
TFA20	SMD- 2-Pad Hermetic Ceramic	2.0 x 1.2 x 0.6 mm	0.032768 MHz	±10ppm ±20ppm	-0.034ppm/°C² Temp Coefficient	-40°C to 85°C -40°C to 105°C
TFA32	SMD- 2-Pad Hermetic Ceramic	3.2 x 1.5 x 0.9 mm	0.032768 MHz	±10ppm ±20ppm	-0.034ppm/°C² Temp Coefficient	-40°C to 85°C -40°C to 105°C

Conclusion

AEC-Q200 crystals and oscillators are the premium choice compared to their standard commercial counterparts since they are designed, tested and qualified for more extreme environmental conditions. Due to their high quality and reliability, they are the preferred frequency control products for not just automotive applications, but other markets as well, such as medical, industrial agricultural, military and aerospace. Based on performance specifications and cost constraints, either standard commercial rated crystals and oscillators or AEC-Q200 qualified products can be chosen. Production Part Approval Process (PPAP) is available for the listed products, and they are all RoHS and REACH compliant.

About CTS

CTS is a leading designer and manufacturer of products that Sense, Connect, and Move. The company manufactures sensors, actuators, and electronic components in North America, Europe, and Asia. CTS provides solutions to OEMs in the aerospace, communications, defense, industrial, information technology, medical, and transportation markets.

Our extensive frequency control solutions include:

• Crystal resonators and clock oscillators that are qualified to AEC-Q200, produced on TS 16949 certified production lines, with PPAP compliance.

• Timing solutions supporting next generation chipsets for 5G and IoT.

• Options for customization to support oscillators and timing solutions.

• Designs that can function in extreme environments.

CTS has many products that are available through distribution partners, are competitively priced, have a variety of performance and package options, and that can be customized. Contact CTS to discuss the right timing solution for your application needs.

Contact Us

CTS Corporation

4925 Indiana Avenue

Lisle, IL 60532, USA

Website: www.ctscorp.com

Product Inquiries: www.ctscorp.com/contact-us