High Temperature Frequency Control Solutions

White Paper

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Contents

HIGH TEMPERATURE FREQUENCY CONTROL SOLUTIONS

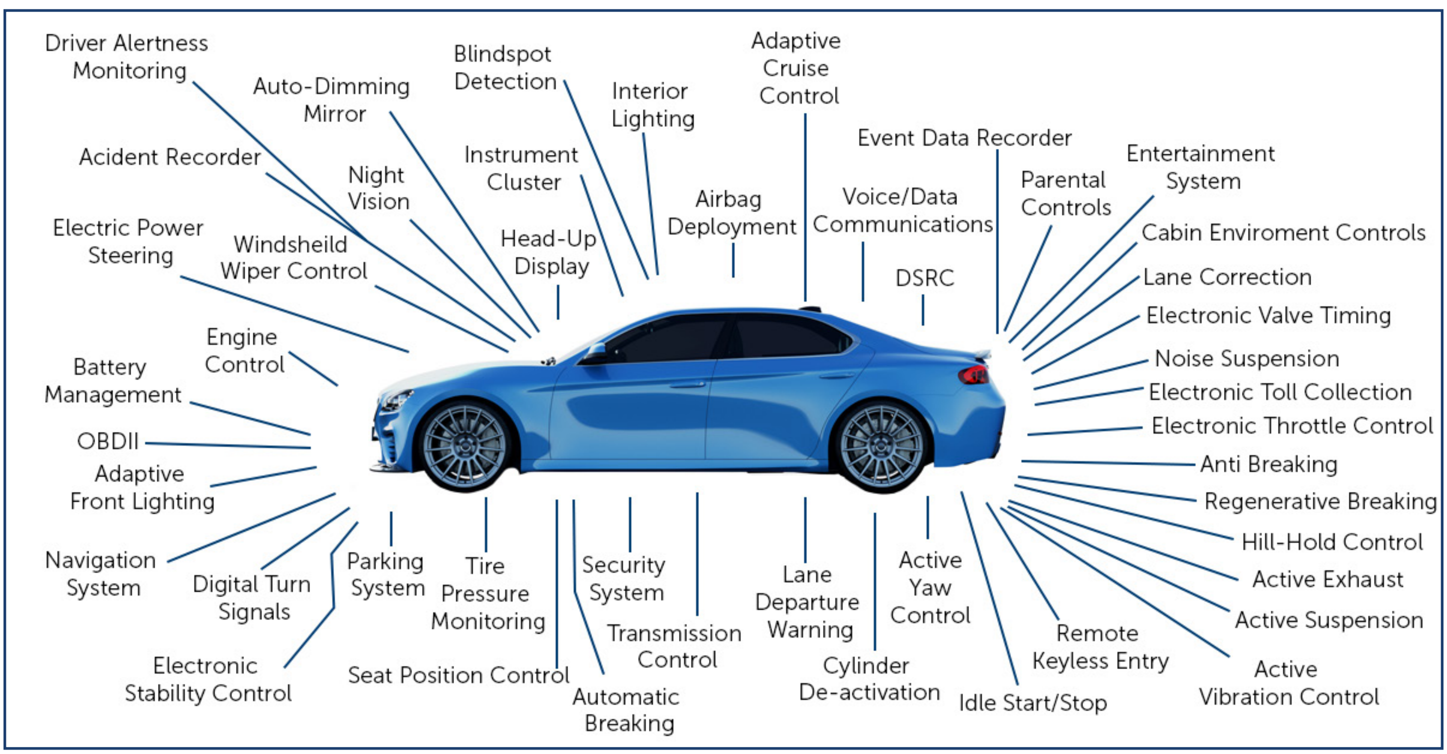
The demand for frequency references with higher operating temperature range capability is rapidly growing across all marketplaces. The range -40°C to +105°C is replacing -40°C to +85°C as the defacto industrial temperature range, partly due to system designers downsizing application boards and eliminating cooling fans from their systems. The expansion of electronic controls in automobiles is further pushing maximum operating temperatures to +125°C and beyond. There is also a growing acceptance of using commercial-type components for military, aerospace, and rugged industrial applications, driving the need for devices that can survive in their respective operating environments.

Harsher operating environments bring new demands and challenges to improve performance for frequency reference devices functioning in today's applications. These include integrated circuits [IC] used in oscillators operating at higher temperatures with concerns for thermal resistance such as junction temperature, quartz resonators and oscillators maintaining lower stability numbers over wider temperature ranges, Coefficient of Thermal Expansion [CTE] mismatches creating stresses in the resonator mounting structure that can accelerate aging and cause frequency perturbations [jumps] in oscillators.

CTS has an extensive portfolio of frequency references and timing solutions developed to operate at higher temperatures that specifically address the needs for automotive grade components, military and aerospace applications, as well as a variety of industrial environments.

AUTOMOTIVE GRADE COMPONENTS

In today's automobiles there can be up to 100 electronic control units [ECUs] used to perform various functions. The "connected car" is advancing communication protocols used within the vehicle and is increasing the need for multiple frequency references to support the timing requirements for technologies used.



Operating environments that electronic components will be subjected to are varied whether under the hood, within the drivetrain, or in cabin applications. Each environment requires a different operating temperature range. The automotive industry has developed test standards that control component/system compliance to provide excellent durability, quality, and consistency in the supply chain.

Beyond the automobile, automotive grade components are being widely accepted for use in medical, industrial, and military/aerospace [mil/aero] applications. These components meet the industry standards for high-quality devices, give excellent performance, are cost-effective, and are readily available - all essential characteristics to meet application requirements for these demanding industries.

Optimized for non-safety applications with wide temperature ranges, to +150°C, CTS has an array of standard crystal and oscillator products compliant to AEC-Q200 standards and manufactured on certified TS 16949 production lines. Additionally, CTS has developed timing solutions that support Advanced Driving Assistance Systems [ADAS] using radar/LIDAR technologies.

AEC-Q200

In the 1990's representatives from Chrysler, Ford, and General Motors came together and formed a consortium called the Automotive Electronics Council [AEC]. The AEC established common part-quality system standards, AEC-Qxxx, and the most commonly 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 AEC component technical committee's role is to establish and maintain global standards for reliable, high-quality electronic components. Components meeting these standards are suitable for use in the harsh automotive environment, with the intent of no additional component-level qualification testing necessary by the end user.

The reliability standard most applied to the frequency and timing products used in automotive applications is AEC-Q200. This standard details the stress tests applicable to passive electrical components to ensure reliable use in the automotive industry. AEC-Q200 also defines 5 component grades that categorize automotive application temperature environments that a product must function in, shown in the table below. The testing standards defined in the AEC-Qxxx documents use a combination of MIL-STD and JEDEC test procedures. A typical test procedure for quartz crystal products is shown in Table 11 in the Appendix.

Grade	Minimum Temperature	Maximum Temperature	Passive Component Type [maximum capability unless otherwise specified and qualified]	Typical/Example Application
0	-50°C	+150°C	Flat Chip ceramic resistors, X8R ceramic capacitors	All Automotive
1	-40°C	+125°C	Capacitor Networks, resistors, Inductors, Transformers, Thermistors, Resonators, Crystals and Varistors, all other ceramic and Tantalum Capacitors	Most Underhood
2	-40°C	+105°C	Aluminum Electrolytic Capacitors	Passenger Compartment Hot Spots
3	-40°C	+85°C	Film Capacitors, Ferrites, R/R-C Networks and Trimmer Capacitors	Most passenger Compartment
4	0°C	+70°C		Non-Automotive

Table 1. Component Grades

TS 16949

Factories supplying products or components with compliance to AEC-Qxxx standards are also required to be certified ISO/TS 16949, commonly denoted as TS 16949. This technical specification addresses the development of a Quality Management System [QMS] for the supply and delivery chain of the automotive industry. Originally based on ISO9001, the current specification released in 2016 as IATF16949: 2016 by the International Automotive Task Force superseded the ISO Tech Committee and replaced ISO/TS 16949:2009. TS 16949 was implemented as a supplement to and in conjunction with ISO 9001:2015.

PPAP Levels

Within the confines of automotive grade products and components is the Production Part Approval Process [PPAP]. Established by the Automotive Industry Action Group [AIAG], PPAP creates a set of reference manuals, procedures, reporting formats, and technical nomenclature that verifies a manufacturer's ability to produce and consistently provide an automotive grade device that fully complies with customer requirements. The PPAP documentation package must comply with one of the five submission levels known as Part Submission Warrant [PSW]; reference Table 2. Level 3 submission is typical for standard automotive grade crystals and oscillators.

Table 2 – PPAP Submission Levels	
Level 1	Part Submission Warrant (PSW) only.
Level 2	PSW with product samples and limited supporting data.
Level 3	**PSW with product samples and complete supporting data.**
Level 4	PSW and other requirements as defined by the customer
Level 5	PSW with product samples and complete supporting data available for review at the manufacturing location.

Table 2. PPAP Submission Levels

There are 18 elements addressed within the PPAP submission document package. A specific PSW level will define which elements must be present in the PPAP data package. The following list highlights some of the key elements; however, the latest PPAP revision should always be consulted to ensure compliance with current requirements.

Table 3 –Elements of PPAP	
Element 1	Design Documentation
Element 2	Engineering Change Documentation
Element 3	Customer Engineering Approval
Element 4	Design Failure Mode and Effects Analysis
Element 5	Process Flow Diagram
Element 6	Process Failure Mode and Effects Analysis
Element 7	Control Plan
Element 8	Measurement System Analysis Studies
Element 9	Dimensional Results
Element 10	Records of Material / Performance Tests
Element 11	Initial Process Studies
Element 12	Qualified Laboratory Documentation
Element 13	Appearance Approval Report
Element 14	Sample Production Parts
Element 15	Master Sample
Element 16	Checking Aids
Element 17	Customer Specific Requirements
Element 18	Part Submission Warrant

Table 3. Elements of PPAP

REFER TO P. 14 – 16 FOR CTS PRODUCT DETAILS

MILITARY AND AEROSPACE COMPONENTS

Electronic component suppliers to military and aerospace programs are very familiar with designing products that function over the standard -55°C to +125°C temperature range. Add to the operating environment high shock or vibration conditions, and the challenge to create robust devices that survive considerably magnifies. Highly developed MIL standards clearly define the requirements for approved use in military systems, covering commercial-off-the-shelf [COTS] and high-reliability components.

Frequency references and timing solutions are used in various mil/aero systems. CTS product portfolio provides automotive-grade crystal resonators and oscillators that are gaining popular use as COTS devices. Customized designs are also available to address high reliability and rugged packaging needs; low power, low G-sensitivity and enhanced phase noise performance requirements. CTS provides qualification testing, options for production electrical test screening [Group testing], and alternate solder attach pad finishes to address gold embrittlement issues.

COTS

Commercial-Off-The-Shelf [COTS] devices are not new to the aerospace, defense, and space industries. The movement to use these components has escalated in recent years to avoid using expensive custom made, highly specialized military parts.

COTS offers a more standardized set of components, since these designs meet industry standard package foot prints, automated process equipment, and excellent performance parameters. Product availability is essential to providing shorter lead-times and lower costs. Engineers using COTS components must assess the risk for using commercial parts and mitigate that risk in their given design and overall system.

As previously noted many mil/aero companies are evaluating and using automotive grade [AEC-Qxxx] devices in applications utilizing COTS components. The extra standards that govern AEC-Qxxx provide a higher grade product at lower costs with improvements in reliability testing, traceability, stability of supply; compared to “true” commercial devices or costly specialized military-grade components.

The CTS portfolio of quartz crystals and oscillators recommended for COTS applications benefits from improved manufacturing technologies. Full cleanroom facilities on highly automated production lines reduces product variability and promotes more industry standardization.

Hi-Reliability

As previously discussed, COTS frequency devices are finding use in many military and aerospace electronics applications. However, some applications will see a poor performance when COTS type components are used. In these designs, an engineer should consider using a device that offers a higher level of reliability that have attributes allowing for more customization in areas of electrical design, part construction, manufacturing processes and additional product testing, typically beyond the scope of a commercially produced device.

Applications that require a high precision frequency reference can have the electrical design manipulated to minimize phase noise, and phase jitter affects, which are essential in today's modern circuit applications. In oscillator designs, phase noise/jitter is mostly dependent on the quartz resonator design, quality of process crystal modeling, and assembly within the oscillator. Understanding the application environment, taking into account operating temperature range, shock and vibration concerns, and direct exposure to the elements; the frequency engineer can enhance the oscillator design by accounting for interfering modes or coupled modes on the quartz blank that can cause activity dips [perturbations] at specific temperature points over the range greatly affecting noise performance.

Oscillator start-up performance at cold temperatures will also be evaluated, to make sure it is reliable, especially for start-up at -55°C. The design engineer will further assess whether using an alternate crystal package and/or mounting structure is needed to reduce the effects of shock, vibration, and G-Sensitivity on the oscillator's overall noise performance.

A well-controlled process and a sound design is key to producing a quality precision frequency reference. Utilizing a cleanroom environment with strict contamination controls to manufacture the quartz resonator and oscillator is crucial to eliminating activity dips and improved oscillator aging performance. Electrical testing of finished oscillators to MIL-PRF-38534 and MIL-PRF-55310 for Class B/H and Class S/K standards is common and critical to ensure performance meets customer requirements. Finally, a sound Quality Management System [QMS] is essential to mitigate potential manufacturing process issues, provide complete traceability for components and materials used, and provide surveillance audits to ensure production personnel and quality inspectors are fully trained to controlled procedures.

Thermal Resistance

When a designer evaluates their system's overall reliability, it sometimes requires the knowledge of the thermal resistance of electrical components. The printed circuit board must be able to handle heat generated by the power consumption of integrated circuits. Understanding component power dissipation and high heat areas are necessary to prevent overheating the PC board and premature component failure. This can be especially important to component function as system PC boards are downsized, required to operate with extended operating temperature maximums, and in reduced air flow or “fan less” conditions.

An electrical component's thermal resistance is defined as the temperature difference occurring between the semiconductor element within the device package and the package surface or ambient atmosphere when the device consumes 1 watt [W] of power.

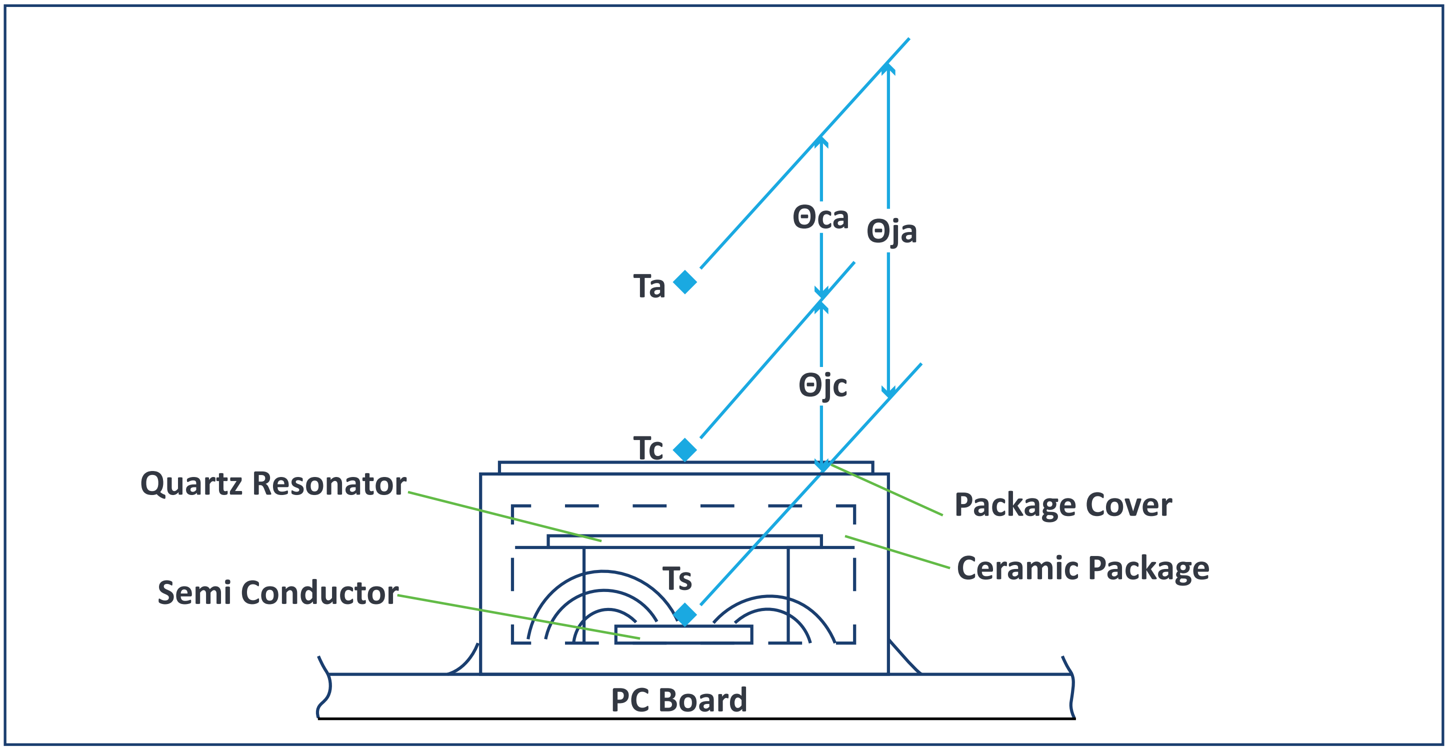
Thermal resistance measures the device package's heat dissipation capability from the active surface of the IC die [or junction] to a specific reference point, i.e. board, package, ambient, etc. The two thermal relationships most often documented for components with ICs are the junction-to-air thermal resistance [Θja] and the junction-to-case thermal resistance [Θjc].

CTS customers who commonly request thermal resistance information use our quartz resonator-based oscillators in mil/aero applications. CTS provides Θjc, Θja, and Tjmax recommendations upon request. Typical maximum junction temperature is +125°C. Refer to Table 3 for example model details. Consult CTS for characterization of other devices.

Thermal Relationships and Associated Formulas

The package detail shown in Figure 1 illustrates the common thermal relationships. The following associated formulas are defined as:

Common Thermal Resistance Parameters
[Typical Oscillator Package]



Junction-To-Case

The symbol Θjc, defines the thermal resistance from the semiconductor junction to the oscillator's case. A low Θjc value describes increased heat conduction, and a high value describes decreased heat conduction.

The formula shown below is used to calculate junction to case thermal resistance, specified in degrees Celsius per watt [°C/W].

Θjc = [Tj – Tc]/Pd

Tj = Junction temperature of the semiconductor device in degrees Celsius [°C]
Tc = External case or package temperature of the oscillator in degrees Celsius [°C]
Pd = Power dissipation of the oscillator in watts [W]

Junction-To-Ambient

Represented by the symbol Θja, it defines the thermal resistance from the semiconductor junction to the ambient air. It measures the capacity of a device to dissipate heat from the die surface to the ambient air.

The formula shown below is used to calculate junction to ambient thermal resistance, specified in degrees Celsius per watt [°C/W].

Θja = Θjc + Θca = [Tj – Ta]/Pd

Tj = Junction temperature of the semiconductor device in degrees Celsius [°C]
Ta = Ambient temperature outside the oscillator in degrees Celsius [°C]
Pd = Power dissipation of the oscillator [in watts [W]

Case-To-Ambient

Represented by the symbol Θca, it defines the thermal resistance between package surface and ambient air. Final formulas are used to calculate junction temperature and power dissipation of an oscillator.

Tj = [Θja *Pd] + Ta or Tj = [Θjc *Pd] + Tc

Pd = [Tj – Ta]/ Θja or Pd = [Tj – Tc]/ Θjc

Using the thermal resistance parameters to estimate the junction temperature [Tj] of the semiconductor, it is essential not to exceed the published maximum junction temperature [Tjmax], to ensure long-term reliability for the electric component.

Model CB3LV	[7.0mmx5.0mm Ceramic Package]	Model CA70	[7.0mmx5.0mm Ceramic Package]
Junction to Ambient [Θja]	181.4°C/W	Junction to Ambient [Θja]	185.2°C/W
Junction to Case [Θjc]	40.4°C/W	Junction to Case [Θjc]	74.1°C/W
Maximum Junction Temperature [Tjmax]	150°C	Maximum Junction Temperature [Tjmax]	150°C
Recommended Maximum Junction [Tjmax]	125°C	Recommended Maximum Junction [Tjmax]	125°C

Table 3. Model Details

REFER TO P. 14 – 22 FOR CTS PRODUCT DETAILS

INDUSTRIAL GRADE COMPONENTS

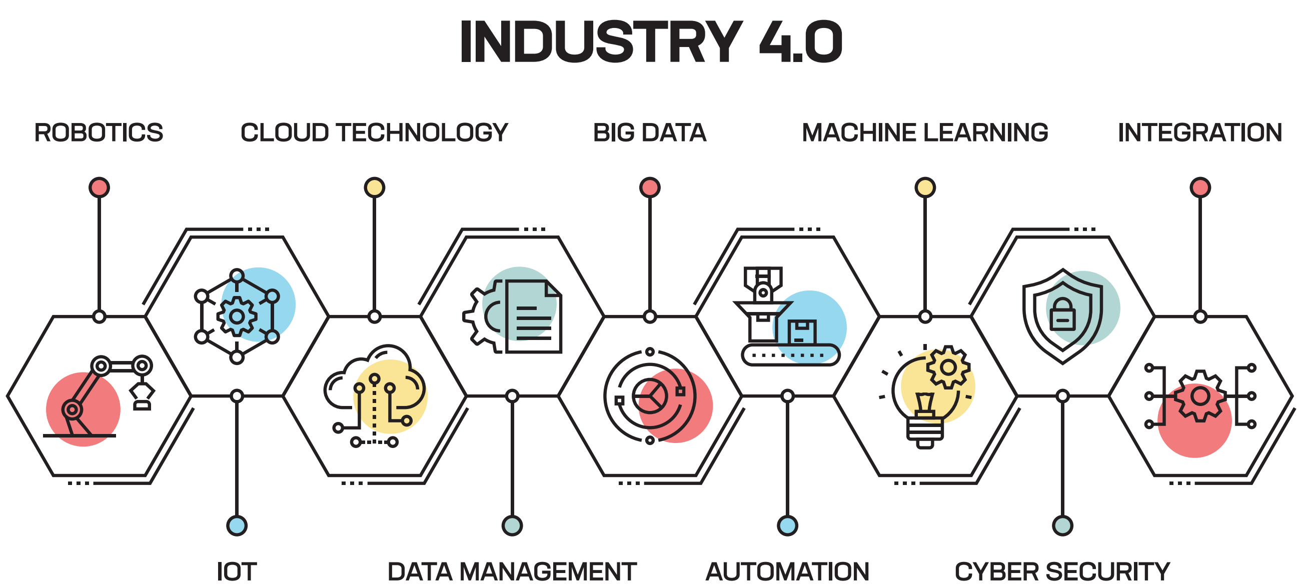
As previously mentioned, the operating temperature range -40°C to +105°C is becoming the standard for industrial-grade components. The exponential expansion of connectivity, communicating with "all things", via the Industrial Internet of Things [IIoT], is the driving factor for a wider temperature range. Connections to remote equipment and machinery, many times operating in harsh confines, has challenged component manufacturers to develop devices that will survive in these environments to extend beyond the traditional parameters of the past.

Through multiple communication protocols, connectivity is being made, pushing new performance-levels for the frequency reference [crystal resonator or oscillator] needed in these architectures. Extended temperature ranges, extreme temperature operation, shock and vibration requirements; CTS has a frequency solution to support many industrial applications.

IIoT

The Fourth Industrial Revolution, dubbed Industry 4.0, describes the continuation of automating conventional manufacturing and industrial practices, incorporating fast-developing Smart technologies. Industry 4.0 is driving the need to exchange and analyze vast sums of collected data that improve process control, increase throughput, and enable self-monitoring that can diagnose issues without operator intervention.

Industrial IoT [IIoT] applications are using more wireless technologies to connect large scale machine-to-machine communication [M2M], creating demands for reliable frequency timing components that can function in the operating environments of the Smart Factory. These environments offer challenges, including higher temperature ranges, shock and vibration elements, and low power constraints to support battery operation yet require processing large amounts of information with minimal time synchronization error, data loss, and very short and stable latency issues.



CTS has developed a portfolio of crystal resonators and clock oscillators for next generation IIoT MCUs, SoCs or FPGAs supporting 5G communication requirements for faster data speeds, low noise performance, and low power consumption. To meet the above standards CTS's IoT Enhanced crystals [4xxW Series] are designed and processed with the lowest series resistance values, while coupled with small load capacitance options, securing a safe gain margin GM for reliable oscillator start-up. Industrial grade clock oscillators [CHT Series] offer smaller stability options, improved noise performance, and maximum operating temperature to +125°C.

REFER TO P. 23 – 26 FOR CTS PRODUCT DETAILS

Extreme Environments

Many electrical systems are required to function and survive in extreme operating environments beyond the standard MIL-STD operating temperature range of -55°C to +125°C. Over the years, industrial applications have developed sensors, gauges, and data acquisition systems that can operate at +200°C and above in areas of deep well drilling, geothermal logging, and process monitoring, to name a few. In addition to high temperatures, many of these electronic devices need to survive under high shock and vibration conditions.

Even though the market for high-temperature electronics is small, predominately dominated by the petroleum industry, there are opportunities for new applications to expand in the transportation, automotive, military, and aerospace markets. The benefits for high-temperature components come from eliminating the need for heat sinks, supplemental cooling, creating lighter weight and smaller size systems.

In many of the high-temperature applications discussed, there will be requirements for a robust frequency reference. Building from rugged design techniques developed for military programs, CTS has oscillators and timing solutions that provide outstanding performance operating in severe conditions.

REFER TO P. 27 - 28 FOR CTS PRODUCT DETAILS

CONCLUSION

Harsh operating environments, which include expanded temperature ranges, bring demands and challenges for frequency reference and timing solution designs that impact performance and survivability. The increased use of AEC-Q200 compliant automotive components in multiple industries, military and aerospace standards for COTS, and high-reliability devices operating in extreme industrial environments; continue to push manufacturers to upgrade the reliability, standardization, and stability of the supply chain.

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 compliant with AEC-Q200, produced on TS 16949 certified production lines, with PPAP compliance.
- Timing solutions supporting next generation chipsets for 5G and IoT.
- COTS frequency devices for military and aerospace applications.
- Options for customization to support high-reliability oscillators and timing solutions.
- Designs that can function in extreme environment that include high shock and vibration elements.

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.

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TABLE 11 - TABLE OF METHODS REFERENCED QUARTZ CRYSTALS			
Stress	**NO.**	**Reference**	**Additional Requirements**
Pre- and Post-Stress Electrical Test	1	User spec.	Test is performed except as specified in the applicable stress reference and the additional requirements in Table 11.
High Temperature Exposure (Storage)	3	MIL-STD-202 Method 108	1000 hrs. at rated operating temperature (e.g. 85°C part can be stored for 1000 hrs at 85°C. Same applies for 125°C). Unpowered. Measurement at 24±4 hours after test conclusion.
Temperature Cycling	4	JESD22 Method JA-104	1000 cycles (-40°C to 125°C) Note: If 85°C part the 1000 cycles will be at that temperature rating. Measurement at 24±4 hours after test conclusion. 30min maximum dwell time at each temperature extreme. 1 min. maximum transition time.
Biased Humidity	7	MIL-STD-202 Method 103	1000 hours 85°C/85%RH. Rated V_{DD} applied with 1 MΩ and inverter in parallel, 2X crystal C_L capacitors between each crystal leg and GND. Measurement at 24±4 hours after test conclusion.
Operational Life	8	MIL-STD-202 Method 108	Note: 1000 hrs @ 125°C. If 85C part will be tested at that temperature. Rated V_{DD} applied with 1 MΩ and inverter in parallel, 2X crystal C_L capacitors between each crystal leg and GND. Measurement at 24±4 hours after test conclusion.
External Visual	9	MIL-STD-883 Method 2009	Inspect device construction, marking and workmanship. Electrical Test not required.
Physical Dimension	10	JESD22 Method JB-100	Verify physical dimensions to the applicable device detail specification. Note: User(s) and Suppliers spec. Electrical Test not required.
Terminal Strength (Leaded)	11	MIL-STD-202 Method 211	Test leaded device lead integrity only. Conditions: A (227 g), C (227 g).
Resistance to Solvents	12	MIL-STD-202 Method 215	Note: Also aqueous wash chemical - OKEM clean or equivalent. Do not use banned solvents.
Mechanical Shock	13	MIL-STD-202 Method 213	Figure 1 of Method 213. Condition C

TABLE 11 - TABLE OF METHODS REFERENCED QUARTZ CRYSTALS			
Stress	**NO.**	**Reference**	**Additional Requirements**
Vibration	14	MIL-STD-202 Method 204	5g's for 20 minutes 12 cycles each of 3 orientations. Note: Use 8"X5" PCB .031" thick with 7 secure points on one 8" side and 2 secure points on corners of opposite sides. Parts mounted within 2" from any secure point. Test from 10-2000 Hz.
Resistance to Soldering Heat	15	MIL-STD-202 Method 210	Condition B No pre-heat of samples. Note: Single Wave solder - Procedure 1 with solder within 1.5 mm of device body for Leaded. Procedure 1 except 230°C and immerse only to level to cover terminals for SMD.
Solderability	18	J-STD-002	For both Leaded & SMD. Electrical Test not required. Magnification 50 X. Conditions: Leaded: Method A @ 235°C, category 3. SMD: a) Method B, 4 hrs @ 155°C dry heat @ 235°C b) Method B @ 215°C category 3. c) Method D category 3 @ 260°C.
Electrical Characterization	19	User Spec.	Parametrically test per lot and sample size requirements, summary to show Min, Max, Mean and Standard deviation at room as well as Min and Max operating temperatures.
Flammability	20	UL-94	V-0 or V-1 Acceptable
Board Flex	21	AEC Q200-005	60 sec minimum holding time.
Terminal Strength (SMD)	22	AEC Q200-006	

NOTE: Pre-stress electrical tests also serve as electrical characterization.
Interval measurements for 1000 hour tests required at 250 and 500 hrs.

High Temperature Products

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AUTOMOTIVE, AEROSPACE, AND MILITARY PRODUCTS

Operating environments that automotive-grade components are subjected to vary whether under the hood, within the drivetrain, or in-cabin applications. Beyond the automobile, automotive-grade components are widely accepted for use in medical, industrial, and mil/aero COTS type applications. Optimized for non-safety applications with wide temperature ranges, to +150°C, CTS has an array of standard crystal and oscillator products compliant to AEC-Q200 standards and manufactured on certified TS 16949 production lines.

AEC-Q200 Crystal and COTS Crystal Product Tables

Automotive, Aerospace, Military and Industrial Grade Crystals [AEC-Q200 Compliant]		Package Size [mm]	Frequency Range [MHz]	Tolerance @ +25°C [ppm]	Temp. Stability [ppm]	Temp. Range [°C]	ESR Maximum [Ohm]
SA164	AT Cut Fundamental & 3rd Overtone	1.6x1.2 4-Pad	24-60	±10 ±15 ±20 ±30 ±50	±15 ±20 ±30 ±50 ±100 ±150	-40 to +85 -40 to +105 -40 to +125 -40 to +150 -55 to +105 -55 to +125	150 - 100 Fund
SA204		2.0x1.6 4-Pad	16-96				200 - 60 Fund
SA254		2.5x2.0 4-Pad	12-80				180 - 60 Fund
SA324		3.2x2.5 4-Pad	8-160				500 - 50 Fund 100 3rd OT
SA532		5.0x3.2 2-Pad	7.6-160				100 - 40 Fund 80 3rd OT
SA534		5.0x3.2 4-Pad					
TFA16	Tuning Fork Crystal Design	1.6x1.0 2-Pad	32.768	±10 ±20	-0.034ppm/°C^2 Temperature Coefficient	-40 to +85 -40 to +105	90k
TFA20		2.0x1.2 2-Pad				40 to +85 -40 to +105 -40°C to 125°C	90k
TFA32		3.2x1.5 2-Pad					70k
HTA	AT Cut Fundamental & 3rd Overtone	12.3x4.83 HC-49/US-SM	3.2 - 64	±10 ±15 ±20 ±25 ±30	±15 ±20 ±25 ±30 ±50 ±100 ±150	-40 to +85 -40 to +105 -40 to +125 -55 to +125	150 - 30 Fund 80 - 60 3rd OT

Crystal Product Features

CTS Key Crystal Parameters	Advantages
TS16949 Certified, AEC-Q200 and PPAP Compliant	Compliance to automotive industry requirements
	Multiple package sizes w/ industry standard pinout for drop-in replacement
Operating Temperature Ranges, to -55°C/+125°C	Supporting high temperature applications
Common Crystal Frequencies Available	Standard Disty stock for off-the-shelf availability
Low ESR Values	Provides more design margin to ensure robust system performance
High Q, Small Size, AT-Cut Quartz Resonators [except TFA products]	
Calibration Tolerance Options, ±25ppm, ±30ppm, ±50ppm, ±100ppm, ±150ppm	Application design flexibility
Temperature Stability Options, ±25ppm, ±30ppm, ±50ppm, ±100ppm, ±150ppm	
Standard Load Capacitance Values Available	
Customized Performance Parameters [contact factory for availability]	

AEC-Q200 and COTS Clock Oscillator Product Tables

Automotive, Aerospace, Military and Industrial Grade Clocks [AEC-Q200 Compliant]		Package Size [mm]	Frequency Range [MHz]	Tolerance @ +25°C [ppm]	Temp. Stability [ppm]	Temp. Range [°C]	Phase Jitter [ps Max]
HCMOS LVPECL LVDS	CA20C	2.0x1.6 4-Pad	1.25 - 100	1.8 2.5 3.3	±25, ±30, ±50, ±100, ±150 ±25, ±30, ±50, ±100, ±150 ±50, ±100, ±150 ±100, ±150	-40 to +85 -40 to +105 -40 to +125 -40 to +150 -55 to +105	<1 0.5 (LVPECL/ LVDS)
	CA25C CA25P CA25L	2.5x2.0 4-Pad or 6-Pad	1.25 - 160				
	CA32C CA32P CA32L	3.2x2.5 4-Pad or 6-Pad					
	CA50C CA50P CA50L	5.0x3.2 4-Pad or 6-Pad					
	CA70C CA70P CA70L	7.0x5.0 4-Pad or 6-Pad					

Clock Oscillator Product Features

CTS Clock Parameters	Advantages
TS16949 Certified, AEC-Q200 and PPAP Compliant	Multiple package sizes w/ industry standard pinout for drop-in replacement
	Compliance to automotive industry requirements
Operating Temperature Ranges, -40°C/+105°C & -40°C/+125°C	Supporting standard automotive applications
Common Clock Frequencies Available	Standard Disty stock for off-the-shelf availability
HCMOS, LVPECL or LVDS outputs	Waveform parameters providing high speed switching
RMS Jitter [12kHz - 20MHz]; 500fs Typical HCMOS, 500fs maximum LVPECL and LVDS	Provides more design margin to ensure robust system performance
Custom Frequencies Available	Application design flexibility
Frequency Stability Options, ±25ppm, ±30ppm, ±50ppm, ±100ppm, ±150ppm	
Output Enable [OE] Standard	

Industry Applications

Automotive	Industrial	Medical
Automotive Electronics	Industrial IoT [IIoT]	Ultrasound Equipment
Mobile Multimedia	M2M Communication	Physical Therapy Devices
Infotainment Systems	Industrial Controls	Respiration Monitors
Automotive Ethernet	Wireless Communication	Diagnostic Imaging
Audio/Video Systems	Test and Measurement	Lab Measurement Equipment

Military Applications

Commercial Military/ Aerospace *		
Wireless Communication	Portable Manpack Radio	Mobile and Airborne Communication
Edge Computing	Microwave Communication	Mobile Test Equipment
In-Flight Entertainment	Mil Radio	Radar Detection
Cabin Management Systems	GPS Holdover	Satellite Based Broadband
COTS Crystals & Clock Oscillators	Drone	Air Traffic Control
Surveillance Radio	Airborne Datalink	Military Radar
Data Links and Mobile Communication Systems	Secure Networking	PLL Reference for Datalinks

*** No Group testing or other military screenings are performed on AEC-Q200 products.**

MILITARY OSCILLATORS AND HI-RELIABILITY PRODUCTS

Frequency references and timing solutions are used in a variety of military and aerospace systems. Standard and customized designs are available from CTS that address high reliability and rugged packaging needs; low power, low G-sensitivity, and enhanced phase noise performance requirements. CTS provides qualification testing, options for production electrical test screening [Group testing], and alternate solder attach pad finishes to address gold embrittlement issues.

Military Oscillator Product Tables

Low Power OCXOs		Package Size [mm]	Frequency Range [MHz]	Supply Voltage [V]	Input Power [W]	Shock/Vibe
144	HCMOS	21.8x15x7.5	8 - 120	3.3, 5.0	0.15	500g, 1 msec/ 30G to 2000 Hz
148	HCMOS	15.9x15.1x10	8 - 100	3.3, 5.0	0.15	500g, 1 msec/ 30G to 2000 Hz
VFOV404	HCMOS Sinewave	21.85x15.1x10	5 - 250	3.3, 5.0	0.15	30g, 11 msec/ 10G to 2000 Hz
VFOV405	HCMOS	15.9x15.1x10	5 - 100	3.3, 5.0	0.15	30g, 11 msec/ 10G to 2000 Hz
VFOV406	HCMOS Sinewave	21.85x15.1x11.9	5 - 250	3.3, 5.0	0.15	30g, 11 msec/ 10G to 2000 Hz
VFOV504	HCMOS Sinewave	21.85x15.1x10	30 - 120	3.3, 5.0	0.15	30g, 11 msec/ 10G to 2000 Hz

Military TCXO Product Tables

Low Noise HFTCXOs		Package Size [mm]	Frequency Range	Stability -40°C/+85°C [ppm]	Pull Range [±ppm]
VFTX100	LVPECL	25x22x6	to 1 GHz	0.8	5
VFTX120 VFTX130	CMOS Sinewave	25x22x6	to 200 MHz	0.8	5
VFTX210	Sinewave	20x20x6	to 1 GHz	0.8	5
VFTX1412C	LVCMOS	14x12x5	to 165 MHz	0.4	5
VFTX1412P	LVPECL	14x12x5	to 165 MHz	0.4	5
577	HCMOS	7x5x1.35	to 122.88 MHZ	2.4	-

Clock Oscillator and TCXO Product Features

CTS OCXO Oscillator Features	CTS TCXO Features
Sinewave, Clipped Sinewave, HCMOS Outputs	Sinewave, Clipped Sinewave, HCMOS, LVPECL Outputs
Low G-sensitivity <0.3ppb/g	Stratum 3 stability <0.28ppm
High Stability <±1ppb	Phase Noise -170dBc/Hz at 100kHz
Low Phase Noise -174dBc/Hz	Output frequency Up to 1 GHz
Low Power <150mW	Ultra Low Jitter and Phase Noise <-170dBc/Hz @100kHz
Fast warm-up	Utilizes CTS Proprietary ASIC Technology [VFJA1412x]

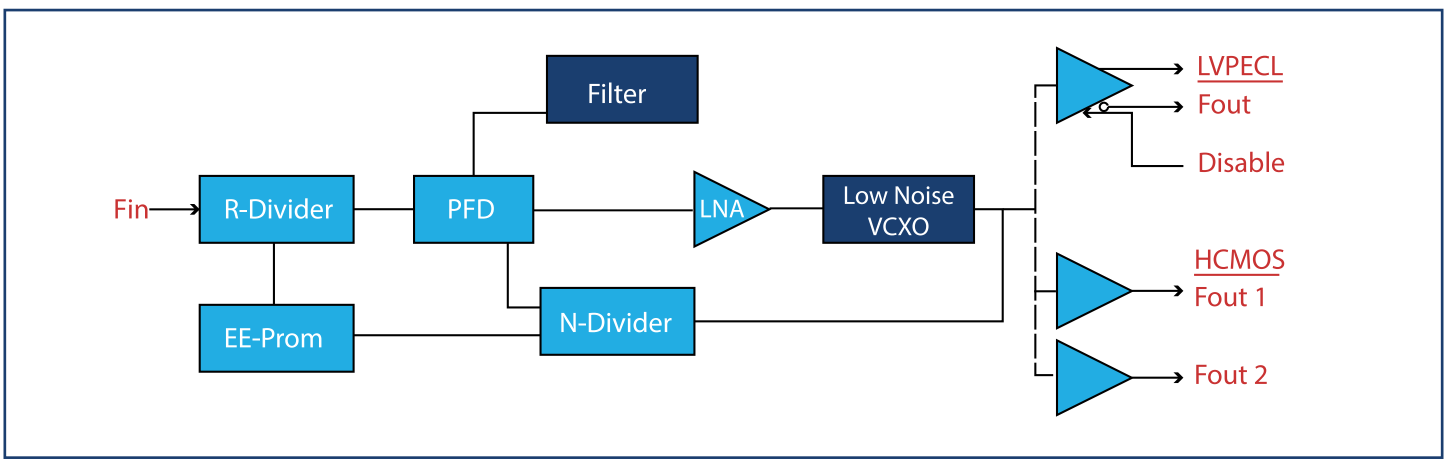
Synthesizer Modules

Synthesizer Modules Models	
VFJA1490P	9mmx14mm
VFJA1491P	9mmx14mm
VFJA1491C	9mmx14mm
VFJA9591C	9.5mmx9.1mm

Synthesizer Features

Synthesizer Features
Jitter Attenuators/Frequency Translators VCXO o/p Stage
PECL, CMOS, SINE Outputs
Any Frequency In to Any Frequency Out [<1000MHz]
Low Jitter @ <0.25ps Typical
Optional Ruggedized Structure for Mobile Applications

Integrated ASIC Synthesizer Solution



Industry Applications

Commercial Military/ Aerospace		
Wireless Communication	Portable Manpack Radio	Mobile and Airborne Communication
Edge Computing	Microwave Communication	Mobile Test Equipment
In-Flight Entertainment	Mil Radio	Radar Detection
Cabin Management Systems	GPS Holdover	Satellite Based Broadband
COTS Crystals & Clock Oscillators	Drone	Air Traffic Control
Surveillance Radio	Airborne Datalink	Military Radar
Data Links and Mobile Communication Systems	Secure Networking	PLL Reference for Datalinks

High Reliability Product Tables

High Reliability Oscillators		Package Size [mm]	Frequency Range [MHz]	Supply Voltage [V]	Temperature Range [°C]	Phase Jitter [ps Max]
HCMOS Clocks	680	7.0x5.0 4-Pad	1 - 100	1.8, 2.5 2.8, 3.3	-55 to +200	<1
	VFH2121	7.0x5.0 4-Pad	0.5 - 125	3.3, 5.0	-55 to +85 -55 to +125	<6
	VFH2321	7.0x5.0 4-Pad	0.85 - 165	1.8	-55 to +85 -55 to +125	<1
	T5321/T5421	7.0x5.0 4-Pad	1 - 100	3.3	-55 to +85 -55 to +125	<1
	T5621/T5721	7.0x5.0 4-Pad	0.16 - 100	5.0	-55 to +85 -55 to +125 -55 to +200	<1
HCMOS/TTLL VCXOs	VFH5070	7.0x5.0 6-Pad	1.0 - 80	3.3, 5.0	-55 to +85 -55 to +125	0.2 Typ
	VFHV750	7.0x5.0 6-Pad	1.0 - 80	3.3, 5.0	0 to +175 -40 to +175 -55 to +85 -55 to +125	0.2 Typ
	M6306	20.32x12.62 Thru-Hole M-1 Pkg.	1.0 - 35	5.0	-55 to +125	<15

Product Information

CTS Oscillator Features	Product Benefits	Environmental and Mechanical Conditions
HCMOS Outputs	Mechanically robust and weigh less than 0.2 grams	Shock –1000Gs, 0.35ms, ½ sine wave, 3 shocks in each plane
Stabilities – ±20ppm - ±75ppm	SMD packages are hermetic sealed ensuring integrity of the device	Vibration – 10-2000 Hz of 0.06" d.a. or 20Gs, whichever is less
Temperature Range – -55°C to +125°C or +200°C	Each oscillator is burned in at +125°C for 168 hours, temperature cycled and centrifuged then fully tested in accordance to Military Reliability Standards	Humidity – Resistant to 85% R.H. at +85°C
Phase Noise – Low as -170dBc/Hz	5 year minimum lifetime support [10 - 15 years on critical military and aerospace programs]	Leak – Per MIL-STD-883, Method 1014, Condition A and Condition C
Phase Jitter to 22fs	Specialized hybrid staff working inside an ISO Standard 14644-1:2015 Grade 7 Clean Room	Case – Hermetically sealed ceramic LCC
Shock – MIL-STD 883, Method 2002, Test Condition B	ISO 9001:2015 Certified Quality Management System	Pads – 40 micro-inch of gold over nickel
Vibration – MIL-STD 883, Method 2007, Test Condition A	R&D on-site to support any design integration inquiries	Solder dipped termination finish [optional]
Humidity – Resistant to +85°C @ Relative Humidity 85%	Marking – Laser engraved RoHS 6/6	Resistant to Solvents – Per MIL-STD-202, Method 215

Screening Information

Screening Guidelines
Product Level B Class 2 Oscillators [MIL-PRF-55310]
Internal Visual Inspection
Stabilization Bake – MIL-STD-883 Method 1008, Condition B
Temperature Cycling - MIL-STD-883 Method 1010, Condition B
Constant Acceleration – MIL-STD-883 Method 2001, Condition A
Fine Leak – MIL-STD-883 Method 1014, Condition A
Gross Leak – MIL-STD-883 Method 1014, Condition C
Burn-In – MIL-STD-883 Method 105, Condition B [+125°C for 160 hours with bias]
Electrical Test @ +25°C
Current – Frequency at max VDD
Rise Time – Frequency at min VDD
Fall Time – "Zero" logic level
Duty Cycle – "One" logic level
Tristate Option
Frequency at +25°C and frequency verification at temperature extremes
Serialized test data on each unit available upon request

First Article Inspection [FAI] Upon Request

CTS Reliability Test Procedures and Conditions for Quartz Crystal Oscillators

Group A Test

Electrical Characteristics at +25°C
Frequency at normal supply voltage and endpoints • Input current • Symmetry (Duty Cycle) • Zero/One levels • Rise/Fall times • Frequency (verify frequency at the temperature extremes)
Physical Dimensions • Length/Width • Height • Package finish (Corrosion, discoloration, etc.) • Marking placement/legibility

Group B Test

1000 hrs at or above +125°C, normal voltage, proper load (sample size by MIL-PRF-55310 Table 6, max. aging within 15 years requirment without catastrophic failures)

Group C Test. All units have passed Group A testing

A. Subgroup 1: 8 pcs.			
Standard	Condition	Description	End Point Measurement
MIL-STD-883	Method 2002 COND. B	Mechanical Shock 1500 g's, 0.5ms 5 drops, 6 axis	Frequency Output Waveform
MIL-STD-883	Method 2007 COND. B	Vibration, var. freq. 20 g's 0.06" disp., 20-20, 000-20 Hz	
MIL-STD-883	Method 2003	Solderability	Visual 95% Coverage
B. Subgroup 2: 4 pcs (one-half of Subgroup 1)			
Standard	Condition	Description	End Point Measurement
MIL-STD-883	Method 1011 COND. B	Thermal Shock Liq. To liq. 15 cycles	Frequency Output Waveform
MIL-STD-202	Method 105 COND. B	Altitude, 3.44 inch Hg. 12hrs	Frequency Output Waveform
MIL-STD-883	Method 1004	Moisture resist. with supply voltage applied ±25°C to ±65°C 90 to 100% RH, 10 cycles	Frequency Output Waveform

MIL-STD-202	Method 210 COND. A		Frequency Output Waveform
C. Subgroup 3: 4 pcs. (one-half of Subgroup 1)			
Standard	Condition	Description	End Point Measurement
	Storage Temp. No. Oper	24 hrs. @ -55°C 24 hrs. @ -125°C	Frequency Output Waveform
MIL-STD-883	Method 1009 COND. A	Salt Atmosphere 24 hrs. @ +35°C 0.5-3.0% Solution	Frequency Output Waveform Visual
MIL-STD-883	Method 1014 COND. A	Fine Leak	Qs <5 $X10^{-8}$
MIL-STD-883	Method 1014 COND. C	Gross Leak	Visual in +125°C Detector Fluid

Product Applications

Applications
Secured Network
Secured Satcomm Terminal
Missile Launcher
Naval Vessel Circuits Base Stations
Air Force Plane Circuits
Military Land Vehicle Circuits
Airborne or Stationary Radar Systems

INDUSTRIAL GRADE COMPONENTS

The operating temperature range -40°C to +105°C is becoming the standard for industrial-grade components. The exponential expansion of connectivity, communicating with"all things,"via the Industrial Internet of Things [IIoT], is the driving factor for a wider temperature range. Connections to remote equipment and machinery, many times operating in harsh confines, has challenged component manufacturers to develop devices that will survive in these environments to extend beyond the traditional parameters of the past. Extended temperature ranges, extreme temperature operation, shock and vibration requirements; CTS has a frequency solution to support many industrial applications.

IoT Enhanced Crystals

Model/ Data Sheet	Package Size [mm]	Frequency [MHz]	Tolerance @ +25°C	Temperature Stability	Temperature Range	ESR Maximum [Ohm]	Co Parameters [pF]
412W	1.2 x 1.0	32 – 80 Fundamental	±7ppm - ±30ppm	±10ppm - ±100ppm	-40°C to +85°C -40°C to +105°C -40°C to +125°C	100 – 60	1.0 Typ. <3.0 Max.
416W	1.6 x 1.2	24 – 52 Fundamental	±10ppm - ±30ppm	±10ppm - ±100ppm	-40°C to +85°C -40°C to +105°C -40°C to +125°C	150 – 80	1.0 Typ. <3.0 Max.
402W	2.0 x 1.6	16 – 52 Fundamental	±10ppm - ±30ppm	±10ppm - ±100ppm	-40°C to +85°C -40°C to +105°C -40°C to +125°C	150 – 50	1.0 Typ. <3.0 Max.
425W	2.5 x 2.0	16 – 52 Fundamental	±10ppm - ±30ppm	±10ppm - ±100ppm	-40°C to +85°C -40°C to +105°C -40°C to +125°C	100 – 40	1.0 Typ. <3.0 Max.
403W	3.2 x 2.5	10 – 54 Fundamental	±10ppm - ±30ppm	±10ppm - ±100ppm	-40°C to +85°C -40°C to +105°C -40°C to +125°C	150 – 35	1.0 Typ. <3.0 Max.

Low ESR Tuning Fork Product Table

Model/ Data Sheet	Package Size [mm]	Frequency [MHz]	Tolerance @ +25°C	Temperature Stability	Temperature Range	ESR Maximum [Ohm]	Co Parameters [pF]
TFE16	1.6 x 1.0	32.768kHz Tuning Fork	±20ppm	-0.034ppm/°C² Temp Coefficient	-40°C to +85°C	60k	1.5 Typ.
TFE20	2.0 x 1.2	32.768kHz Tuning Fork	±20ppm	-0.034ppm/°C² Temp Coefficient	-40°C to +85°C	50k	1.8 Typ.
TFE32	3.2 x 1.5	32.768kHz Tuning Fork	±20ppm	-0.034ppm/°C² Temp Coefficient	-40°C to +85°C	50k	1.0 Typ.

RTC TCXO

Model/ Data Sheet	Package Size [mm]	Frequency	Input Voltage [V]	Temperature Stability	Temperature Range	ESR Maximum [µA]	Output Load [pF]
TT32	3.2 x 2.5	32.768kHz HCMOS	+1.8V - +3.3V	±5.0ppm	-40°C to +85°C	2.0	15

AEC-Q200 Crystal and COTS Crystal Product Tables

Automotive, Aerospace, Military and Industrial Grade Crystals [AEC-Q200 Compliant]		Package Size [mm]	Frequency Range [MHz]	Tolerance @ +25°C [ppm]	Temp. Stability [ppm]	Temp. Range [°C]	ESR Maximum [Ohm]
SA164	AT Cut Fundamental & 3rd Overtone	1.6x1.2 4-Pad	24-60	±10 ±15 ±20 ±30 ±50	±15 ±20 ±30 ±50 ±100 ±150	-40 to +85 -40 to +105 -40 to +125 -40 to +150 -55 to +105 -55 to +125	150 - 100 Fund
SA204		2.0x1.6 4-Pad	16-96				200 - 60 Fund
SA254		2.5x2.0 4-Pad	12-80				180 - 60 Fund
SA324		3.2x2.5 4-Pad	8-160w				500 - 50 Fund 100 3rd OT
SA532		5.0x3.2 2-Pad	7.6-160				100 - 40 Fund 80 3rd OT
SA534		5.0x3.2 4-Pad					
TFA16	Tuning Fork Crystal Design	1.6x1.0 2-Pad	32.768	±10 ±20	-0.034ppm/°C² Temperature Coefficient	-40 to +85 -40 to +105	90k
TFA20		2.0x1.2 2-Pad				40 to +85 -40 to +105 -40°C to 125°C	90k
TFA32		3.2x1.5 2-Pad					70k

HTA	AT Cut Fundamental & 3rd Overtone	12.3x4.83 HC-49/US-SM	3.2 - 64	±10 ±15 ±20 ±25 ±30	±15 ±20 ±25 ±30 ±50 ±100 ±150	-40 to +85 -40 to +105 -40 to +125 -55 to +125	150 - 30 Fund 80 - 60 3rd OT

Industrial Grade Clock Oscillator Product Table

Industrial Grade Clock Oscillators		Package Size [mm]	Frequency Range [MHz]	Tolerance @ +25°C [ppm]	Temp. Stability [ppm]	Temp. Range [°C]	Phase Jitter [ps Max]
HCMOS	CHT25	2.5x2.0 4-Pad	1.25 - 156.25	1.8 2.5 3.3	±100, ±150	-55 to +105 -55 to +125	<1
	CHT32	3.2x2.5 4-Pad					
	CHT50	5.0x3.2 4-Pad					
	CHT70	7.0x5.0 4-Pad					

IoT Enhanced Crystals Product Features

CTS Product Parameters	Advantages
Low Plating Capacitance, <3.0pF [C_0]	Multiple package sizes w/ industry standard pinout
Low ESR Ranges	Power savings for low energy applications Reduction in oscillator gain margin Improves oscillator start-up over wide temperature ranges Enhances system signal to noise ratios
Small Load Capacitance Options	
Fundamental Crystal Designs	
Common Wireless Frequencies Available	Standard Disty stock for off-the-shelf availability
Operating Temperature Ranges, -40°C/+105°C & -40°C/+125°C	Supporting extended temperature industrial applications
Frequency Tolerance Options, ±7ppm to ±30ppm	Application design flexibility
Frequency Stability Options, ±10ppm to ±150ppm	
Custom Frequencies Available	

Low ESR Tuning Fork Product Features

CTS Product Parameters	Advantages
Low Plating Capacitance [C_0], 1.0pF Typical	Industry standard package sizes
Low ESR Values [R_1] <50k Ohms	Power savings for low energy applications Reduction in oscillator gain margin Improves oscillator start-up over wide temperature ranges
Small Load Capacitance Options [C_L]	
Temperature Range to -40°C to +85°C	

RTC TCXO Product Features

CTS Product Parameters	Advantages
Low Current Consumption, <2µA	Small package size Power savings for low energy applications
Tight Frequency Stability, ±5.0ppm	
Temperature Range to -40°C to +85°C	

Industrial Grade Clock Oscillator Product Features

CTS Product Parameters	Advantages
Operating Temperature Ranges, -55°C/+105°C & -55°C/+125°C	Multiple package sizes w/ industry standard pinout for drop-in replacement
Common Clock Frequencies Available	Supporting high temperature applications
HCMOS Output	Standard Disty stock for off-the-shelf availability
RMS Jitter [12kHz - 20MHz], 500fs Typical	Waveform parameters providing high speed switching
Custom Frequencies Available	Provides more design margin to ensure robust system performance
Voltage Options, +1.8V, +2.5V & +3.3V	Application design flexibility
Frequency Stability Options, ±25ppm, ±30ppm, ±50ppm, ±100ppm, ±150ppm	
Output Enable [OE] Standard	

Industry Applications Table

Internet of Things [IoT] / Industrial IoT [IIoT] / Smart Applications / Medical		
Wireless Communication	Bluetooth, Bluetooth Low Energy	Industrial Monitoring & Control
Low Power MCUs, SoCs, RF ICs	LoRa, LPWAN, 6LowPan, WLAN	Home/Building Automation
M2M Communication	Near Field Communication	In-Flight Entertainment
WiFi, ZigBee, ZigBeeRF4CE	Low Drive Chipsets	Test and Measurement
Z-Wave, Sigfox, SimpleLink	ISM Band Applications	Physical Therapy Devices

Industry Application Table

Industrial Clock Oscillator	Medical Clock Oscillator	Commercial Military/Aerospace Clock Oscillator *
Industrial IoT [IIoT]	Ultrasound Equipment	Wireless Communication
M2M Communication	Physical Therapy Devices	Edge Computing
Industrial Controls	Respiration Monitors	In-Flight Entertainment

Wireless Communication	Diagnostic Imaging	Cabin Management Systems
Test and Measurement	Lab Measurement Equipment	COTS Clock Oscillators

*** No Group testing or other military screenings are performed on CHT Series products**

EXTREME ENVIRONMENT PRODUCTS

Many electrical systems are required to function and survive in extreme operating environments that go beyond the standard MIL-STD operating temperature range of -55°C to +125°C. Deep well drilling, geothermal logging, and process monitoring are some of applications that require components to operate at +200°C, in environments that may have high shock and vibration conditions. Building from ruggedized design techniques developed for military programs, CTS has oscillators and timing solutions that provide outstanding performance operating in severe conditions.

Extreme Environment Clock Oscillators Product Table

Clock Oscillators		Package Size [mm]	Frequency Range [MHz]	Supply Voltage [V]	Temperature Range [°C]	Phase Jitter [ps Max]
HCMOS	680	7.0x5.0 4-Pad	1 - 100	1.8, 2.5 2.8, 3.3	-55 to +200	<1
	T1250/T3250	7.0x5.0 4-Pad	1 - 100	3.3, 5.0	-55 to +85 -55 to +125	
	T561/T5721	7.0x5.0 4-Pad	0.16 - 100	1.8	-55 to +85 -55 to +125	
	T7250/T9250	7.0x5.0 4-Pad	1 - 100	5.0	-55 to +85 -55 to +125 -55 to +200	

Extreme Environment VCXO's Product Table

VCXOs		Package Size [mm]	Frequency Range [MHz]	Supply Voltage [V]	Temperature Range [°C]	Phase Jitter [ps Max]
HCMOS/ TTL	VFH5070	7.0x5.0 6-Pad	1.0 - 80	3.3, 5.0	-55 to +85 -55 to +125	0.2 Typ
	VFHV750	7.0x5.0 6-Pad	1.0 - 80	3.3, 5.0	0 to +175 -40 to +175 -55 to +85 -55 to +125	0.2 Typ

Shock and Vibration Clock Oscillator Product Table

Clock Oscillators	Package Size [mm]	Frequency Range [MHz]	Supply Voltage [V]	Temperature Range [°C]	Phase Jitter [ps Max]

HCMOS	680	7.0x5.0 4-Pad	1 - 100	1.8, 2.5 2.8, 3.3	-55 to +200	<1

Shock and Vibration VCXO Product Table

VCXO's		Package Size [mm]	Frequency Range [MHz]	Supply Voltage [V]	Temperature Range [°C]	Phase Jitter [ps Max]
HCMOS	M6306	20.32x12.62 Thru-Hole M-1 Pkg.	1 - 35	5.0	-55 to +125	<15

Shock and Vibration OCXO's Product Table

High Reliability OCXO's		Package Size [mm]	Frequency Range [MHz]	Supply Voltage [V]	Temperature Range [°C]	Power Consumption [W Max]
HCMOS	148	15x15 Thru-Hole 5-pin	1 - 80	3.3,5.0	-40 to +85	0.25

Product Information

Product Features	Manufacturing Process	Applications
Clock Oscillator Devices – Developed w/ Special Components & Epoxies for High Temperature Ranges	Stabilization Bake – MIL-STD 883, Method 1008, Condition B	Down-Hole Drilling
Crystals – Designed Specifically to Withstand High Operating Temperature Ranges	Temperature Cycling – MIL-STD 883, Method 1010, Condition B	Oven Controllers
Temperature Range – -55°C to +200°C Available	Burn-In – MIL-STD 883, Method 1015, Condition B +125°C for 168 hours w/ bias	Industrial Process Control
Stabilities – ±25ppm [±0.01ppm OCXO] to ±75ppm	Fine Leak – MIL-STD 883, Method 1014, Condition A1	Military Communications and Military Vehicles
Output Types – CMOS, HCMOS, LVPECL, LVDS	Gross Leak – MIL-STD 883, Method 1014, Condition C	Vibrating Test Equipment
3 and 4 Point Crystal Mounting	Centrifuge – MIL-STD-883, Method 2001, Condition A	Paint Mixers and Weigh Scales

WEBSITE REFERENCE LINKS

Automotive Electronics Council [AEC]: http://www.aecouncil.com/
International Automotive Task Force[IATF]: https://www.iatfglobaloversight.org/
Automotive Industry Action Group [AIAG]: https://www.aiag.org/

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