Glossary of Crystal Terminology

Aging: Also referred to as long-term stability. A measure of the frequency stability of the crystal over an extended period of time and is usually expressed in terms of parts per million (ppm) per day or per year. Aging normally follows an exponential progression so that most aging takes place within the first few weeks of manufacture.

Allan Variance: Also known as short-term stability, this is the measure of oscillator stability in the time domain. Commonly referred to as the Allan variance, it measures the RMS change in successive frequency measurements for short gate times (milliseconds to seconds) and is important in timing applications. It typically improves as the gate time increases until it becomes a measure of the medium to long term drift of the oscillator. This drift is either the result of the temperature coefficient of the oscillator, and/or the aging.

Angle: It is the angle at which a resonator plate is cut from the quartz stone in relation to the original crystallographic axes. The angle of cut is critical to the performance of the crystal unit, particularly for frequency deviation over a temperature range.

AT cut: The commercial designation for a specifically oriented resonator plate, having desirable and repeatable operating characteristics. The plate is cut from a crystal of quartz such that the plate contains the X-axis and makes an angle of about 35 degrees with the optic or Z-axis. The "AT cut" is the most popular crystal unit manufactured today.

Bevel: A modification to one or both of the major faces of a resonator plate in which the face is altered to have a partially spherical configuration.

Blank: A round or rectangular quartz crystal that has been lapped to produce parallel major surfaces and has minor surfaces machined to the final dimensions required to build the desired resonator.

BT cut: The commercial designation for a specifically oriented resonator plate, having well known and repeatable characteristics.

Burst Noise: Burst or “popcorn” noise is believed to be connected to surface defects of the resonator (deep pits or scratches). Its source is confined to a very small area of the crystal.

C.I.: An abbreviation for "crystal impedance," also referred to as "resistance."

C0: An abbreviation for "Shunt Capacitance."

C1: An abbreviation for "Motional Capacitance."

Calibration Tolerance: The tolerance, in parts per million (ppm), to which the crystal manufacturer will set the resonator frequency during manufacture. This tolerance is always specified at a particular reference temperature (e.g. +/- 10PPM @+25C).

Can: The upper portion, or cover, of a crystal holder.

Capacitance: The property exhibited by two conductors separated by a dielectric where an electric charge becomes stored between the conductors. Capacitance is measured in "farads" and denoted by the letter "C."

Cold Weld: Cold welding is a solid-state welding process in which joining takes place without fusion at the interface of the two parts to be welded. Unlike in the fusion-welding processes, no liquid or molten phase is present in the joint. This is recommended for crystals facing diverse and extreme environments.

Contour: A modification to one or both of the major faces of a resonator plate in which the face is altered to have a completely spherical configuration.

Crystal cut: The orientation of the crystal element with respect to crystallographic axis of the crystal.

Drive Level: The Drive Level is the amount of power dissipation in the crystal, expressed in microwatts or milliwatts. Maximum power is the most power the device can dissipate while still maintaining operation with all electrical parameters guaranteed. Drive level should be maintained at the minimum levels necessary to initiate proper start-up and assure steady state oscillation. Excessive drive level can cause poor aging characteristics and crystal damage.

Etch: A method to improve the surface condition of a crystal and to increase the frequency of a blank.

FC cut: This cut has an improved temperature and frequency characteristic for ovenized applications (OCXO). The frequency vs. temperature curve is a sine with the inflection temperature at ~ +52"C. Please contact our factory regarding your specific requirements.

Frequency Stability: The amount of frequency deviation from the ambient temperature frequency over the operating temperature range. This deviation may be influenced by a set of operating conditions such as: Operating Temperature Range, Load Capacitance, and Drive Level. Frequency stability is specified with a maximum and minimum frequency deviation, expressed in percent (%) or parts per million (ppm). The cut of the crystal and angle of the cut will determine the frequency stability. Some secondary factors influencing frequency stability are the mode of operation, the drive level, the load capacitance, and mechanical design.

Fundamental: The lowest frequency at which a given crystal will oscillate.

G-Sensitivity or Vibration Sensitivity: Vibration sensitivity refers to the degradation of the close in noise performance of a crystal under the influence of external mechanical vibrations. Please inquire with our factory about your requirements.

Holder: The complete housing for a quartz resonator plate.

Impedance: The total opposition presented by a circuit or device to the flow of alternating current. Impedance is measured in "ohms" and denoted by the letter "Z."

Inflection Point: AT Cut crystals have a temperature vs. frequency characteristic that can be represented by a third order polynomial. This curve has a point where the slope is zero and the slope is positive on one side and negative on the other side. This point is defined as the inflection point.

IT cut: This crystal cut has an improved temperature and frequency characteristic for ovenized applications (OCXO). The frequency vs. temperature curve is a sine with the inflection temperature at ~ +78°C. Please contact our factory regarding your specific requirements.

L1: Abbreviation for "Motional Inductance."

Lapping: Moving a quartz crystal slab over a flat plate on which a liquid abrasive has been poured, to obtain a flat polished surface or to reduce the thickness a carefully controlled amount.

Load Capacitance: The value of capacitance used in conjunction with the crystal unit. Load capacitance is a parameter normally set by the customer, typically expressed in pF (picoFarads).

Long -Term Stability (Aging): Long-term stability is a measure of the frequency stability of the crystal over an extended period of time and is usually expressed in terms of parts per million (ppm) per day or per year. Aging normally follows an exponential progression so that most aging takes place within the first few weeks of manufacture.

Microphonic Noise: Vibration-induced noise in the otherwise frequency-independent noise floor range (up to 30kHz). It consists of discrete spurious peaks that are usually the result of the crystal resonator and support resonances. Microphonic noise can be significantly reduced by proper choice of resonator cut and geometry, bonding techniques and support configuration.

Modes of Vibration: Quartz crystals naturally vibrate in several simultaneous resonance modes referred to as the fundamental or overtone modes. Usually one of these modes is designed to be dominant at the desired operating frequency. The fundamental frequency of vibration is a function of the resonator physical dimensions and angle of cut while the overtone modes occur at odd numbered harmonics of the fundamental mode and include the 3^{rd}, 5^{th}, 7^{th}, 9^{th} and 11^{th} harmonics.

Motional Capacitance: Abbreviated as "Cm" or "C1", motional capacitance illustrates the electronic equivalence of the mechanical elasticity of the unit.

Motional Inductance: Abbreviated as "Lm" or "L1", motional inductance illustrates the electronic equivalence of the mechanical mass of the unit.

Nominal frequency: The specified "name plate frequency" of a crystal or oscillator.

Operating Temperature Range: A range of temperatures over which the crystal will meet the specified frequency stability.

Ovenized crystals: Any crystal designed to operate at a temperature above the anticipated ambient temperature (typically +50°C to +110°C) in order to eliminate changes in frequency due to the change in temperature.

Overtone: The odd numbered multiples of the fundamental frequency, including the 3^{rd}, 5^{th}, 7^{th}, 9^{th} and 11^{th} harmonics.

Parallel Resonant: One of the two modes a crystal will vibrate in. represented by 'f_a.'

Phase Noise: Phase noise is a term used to describe instability in the phase or frequency of a crystal unit in periods of time of a few seconds or less. It is measured as the ratio of power in the noise to that in the carrier at a specified offset frequency (Fourier frequency) in a specified bandwidth. The measurement bandwidth is usually normalized to 1Hz. By knowing the inherent phase noise of a crystal resonator, oscillator designers can predict the lowest oscillator phase noise attainable using that resonator.

Plate: A quartz blank or resonator.

Polish: The process used in the manufacture of some types of quartz crystals resulting in a very fine surface finish.

Pullability: The pullability of a crystal describes how the operating frequency may be changed by varying the load capacitance. The pullability specification helps you decide how much trimming will be required to compensate for circuit component variations. Since there are several methods in which to express crystal pullability, please consult our factory for product specifications.

Q: Quality Factor is the ratio of energy stored in a system divided by the energy dissipated in the system. The quality factor characterizes the acoustic loss in quartz crystal resonators.

Quartz Crystal: Synthetic quartz is composed of Silicon and Oxygen (Silicon Dioxide SiO_2) and is cultured in autoclaves under high pressure and temperature. Quartz exhibits piezoelectric properties that generate an electrical potential when pressure is applied on the surfaces of the crystal.

Resistance Weld: Procedure involving pressure sealing with electricity and back filling with nitrogen to force out oxygen and moisture. This process provides superior aging characteristics.

Resistance: The opposition to current flow in a circuit represented by the letter "R" and is measured in "ohms."

SC-Cut: A doubly rotated crystal cut plate (theta = 34 degrees and seven minutes and phi = 21 degrees and fifty six minutes) that is used in precision oscillators. It is placed in an oven and operated at the crystal's lower turning point, around 100° C.

Series Resonant: One of the two modes a crystal will vibrate in. represented by 'f_r.'

Short-term Stability: The measure of oscillator stability in the time-domain. Commonly referred to as the Allan variance, it measures the RMS change in successive frequency measurements for short gate times (milliseconds to seconds) and is important in timing applications. It typically improves as the gate time increases until it becomes a measure of the medium to long term drift of the oscillator. This drift is either the result of the temperature coefficient of the oscillator, and/or the aging.

Shunt Capacitance (C0): Shunt capacitance is the element in the resonator equivalent circuit representing the electrostatic (parallel-plate) capacitance of the electrodes plus the holder capacitance. Shunt capacitance is also referred to as static capacitance.

SMD: Abbreviation for "surface mounted device."

Spur: A substitution for the term "Spurious Frequency Response," a frequency occurring at some point higher than the desired mode but lower than the next overtone.

Spurious or Unwanted Modes: Variations at frequencies which are not fundamental or overtone modes are referred to as spurious or unwanted modes. These unwanted responses are influenced by many factors, including the dimension of the quartz wafer, the surface finish, the size and thickness of the electrode and the mounting technique.

Tape and Reel: Refers to the packaging method used to accommodate automated pick-and-place equipment.

Temperature Stability: The measure of the frequency change due to temperature changes. It is measured by placing the oscillator in a temperature chamber and allowing it to stabilize. After the frequency is measured, the temperature is changed and the sequence is repeated until the desired temperature range has been covered. The most common method of specification is from the room temperature value, as the oscillator is normally calibrated at room temperature.

X-Axis: Known as the "electrical axis," the X-axis is parallel to a line bisecting the angles between adjacent prism faces.

Y-Axis: Known as the "mechanical axis," the Y-Axis runs at right angles through the prism face as well as at right angles to the X-Axis.

Z-Axis: Known as the "optical axis" and is an axis of threefold symmetry. All physical properties repeat each 120 ° as the crystal is rotated around the Z-axis.