

Glossary

ABSOLUTE MAXIMUM RATING

Maximum rated voltage value assuring the normal operation of a crystal oscillator. Exceeding this value may result in a decrease in the reliability of a crystal oscillator.

AGING

The systematic change in frequency with time due to internal changes in the crystal and/or oscillator. Aging is often expressed as a maximum value in parts per million per year (ppm/yr). The rate of aging is typically greatest during the first 30 to 60 days, after which time the aging rate decreases. The following factors affect crystal aging: adsorption and desorption of contamination on the surfaces of the quartz, stress relief of the mounting and bonding structures, material outgassing, and seal integrity.

CALIBRATION ACCURACY (SEE FREQUENCY TOLERANCE)

CAPACITIVE RATIO

In applications (i.e. VCXO) where variations in the crystal parallel resonant frequency are desired, the capacitive ratio (r) may be specified. The capacitive ratio equation is shown below. This ratio is an indicator of the change in a parallel load resonant frequency as a direct result of a given change in crystal load capacitance. Because the value of this ratio has physical limitations when it is realized in a quartz crystal design, please consult Cardinal Components engineering department for product specifications.

$$r = \frac{C_0}{C_1}$$

CENTER FREQUENCY

The specified reference frequency of the crystal, typically specified in megahertz (MHz) or kilohertz (kHz).

CRYSTAL EQUIVALENT CIRCUIT

A crystal device consists of a quartz resonator with metal plating. This plating, located on both sides of the crystal and is connected to insulated leads on the crystal package. The device exhibits a piezoelectric response between the two crystal electrodes.

DRIVE LEVEL

A function of the driving or excitation current flowing through the crystal. 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 oscillation. Excessive drive level can cause poor aging characteristics and crystal damage.

DUTY CYCLE

The measure of output waveform uniformity. This term, also referred to as symmetry, is a measurement of the time that the output waveform is in a logic high state, compared to the logic low state, expressed as a percentage (%). This parameter is measured at a specific voltage threshold or at a percentage of the output waveform amplitude.

EQUIVALENT SERIES RESISTANCE (ESR)

The resistive element, measured in ohms, of a crystal device. The motional inductance (L_1) and motional capacitance (C_1) are of equal ohmic value but are exactly opposite in phase. The net result is that they cancel one another and only a resistance remains in the series leg of the above equivalent circuit. The ESR measurement is made only at the series resonant frequency (F_s), not at some predetermined parallel resonant frequency (F_L). Crystal resistance measured at some parallel load resonant frequency is often called the "effective" resistance.

FANOUT

Number of IC gates which can be connected to the output of a crystal oscillator.



Glossary

FREQUENCY STABILITY

The amount of frequency deviation from the ambient temperature frequency over the operating temperature range. This deviation is associated with a set of operating conditions, including operating temperature range, load capacitance, and drive level. This parameter is specified with a maximum and minimum frequency deviation, expressed in percent (%) or parts per million (ppm). The frequency stability is determined by the type of quartz cut and the angle of the quartz cut. Some of the secondary factors include mode of operation, drive level, load capacitance, and mechanical design.

Frequency stability includes frequency drifts over the operating temperature, input voltage changes, output load variations and the effects of long-term aging. The most standard stabilities are specified as ± 100 ppm, and ± 50 ppm. Cardinal Components oscillators can also be specified with ± 25 ppm and ± 10 ppm stabilities.

FREQUENCY TOLERANCE

The amount of frequency deviation from a specified center frequency at ambient temperature of 25°C. This parameter is specified with a maximum and minimum frequency deviation, expressed in percent (%) or parts per million (ppm). This deviation is associated with a set of operating conditions including load capacitance and drive level.

INPUT CURRENT

The amount of current consumption by an oscillator from the power supply, typically specified in milliamps (mA).

LOGIC COMPATIBILITY

In the past, CMOS, TTL, and ECL oscillators were only capable of driving output loads of the same logic family. With the introduction of HCMOS logic, dual compatible oscillators are manufactured that can drive two logic families. Most Cardinal Components oscillators are capable of driving both HCMOS and TTL loads. The dual compatible oscillator's output waveform voltages are derived from HCMOS logic. The logic output exceeds the minimum voltage level requirements of TTL, and with the higher output current capability of HCMOS, these dual compatible oscillators can drive both logic families. Be aware that oscillators not specifically designed for both families cannot be used to drive other logic families, i.e., TTL cannot drive HCMOS or ECL logic. Cardinal Components also offers oscillators that drive TTL and ECL logic exclusively.

NOMINAL FREQUENCY

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

MODE OF OPERATION

The Mode of Operation of a quartz device is one of the factors that will determine the frequency of oscillation. For "AT" cut quartz crystals, overtone modes are at odd frequency harmonics. For example, a crystal may operate at its fundamental frequency of 10 MHz, or at odd harmonics of approximately 30 MHz (Third Overtone), 50 MHz (Fifth Overtone) and 70 MHz (Seventh Overtone).

MOTIONAL CAPACITANCE (C₁) AND MOTIONAL INDUCTANCE (L₁)

The motional capacitance and inductance are designated by C_1 and L_1 . For a "Series" resonant crystal, the value of C_1 resonates with the value of L_1 at a frequency (F_s).

$$F_s = \frac{1}{2\pi \sqrt{L_1 C_1}}$$

Typically, L_1 is not mentioned when working with most crystals. Due to this absolute equation, it is only necessary to specify one motional component or the other. The industry standard is to specify a proper value of C_1 only. The actual value of C_1 has physical limitations when it is realized in a quartz crystal design. These constraints include the mode of operation, the quartz cut, the mechanical design, and the nominal frequency of the crystal.

OPERATING TEMPERATURE RANGE

The maximum and minimum temperatures that the crystal device can be exposed to during oscillation. Over this temperature range, all of the specified device operating parameters are guaranteed.

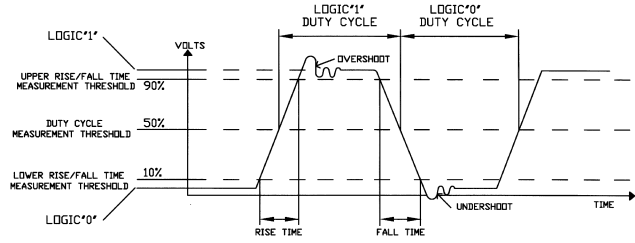


Glossary

OUTPUT VOLTAGE LEVELS

In digital logic, voltage levels are referred to in terms of logic "0" and logic "1". These levels vary depending on the type of output logic required for the application.

TTL	$V_{OL} = \text{Logic "0"} = 0.4V \text{ Max}$
	$V_{OH} = \text{Logic "1"} = 2.4V \text{ Max}$
HCMOS	$V_{OL} = \text{Logic "0"} = 0.5V \text{ Max}$
	$V_{OH} = \text{Logic "1"} = 4.5V \text{ Max}$
ECL	$V_{OL} = \text{Logic "0"} = -1.95V \text{ Min} / -1.60V \text{ Max}$
	$V_{OH} = \text{Logic "1"} = -1.00V \text{ Min} / -0.75V \text{ Max}$



OVERSHOOT/UNDERSHOOT

This effect is commonly called ringing. The output voltage can exceed the steady state plateau of either the logic "0" state or the logic "1" state for a period of time. This ringing will decrease in amplitude until the steady state plateau is reached. The ringing is caused by an unmatched impedance load presented to the oscillator output. It becomes more pronounced as the rise/fall times decrease and the output frequency increases. Proper output loading and good R.F./Microwave transmission line techniques must be used to prevent ringing on the waveform.

PULLABILITY

Pullability refers to the change in the parallel load resonant frequency as a function of change in crystal load capacitance. The equation below is used to calculate the frequency difference, expressed in ppm, between two parallel load resonant frequencies [F_{CL1} and F_{CL2}] as a direct result of a given change in crystal load capacitance [C_{L1} and C_{L2}]. Because there are several methods to express crystal pullability, please consult Cardinal Components engineering department for product specifications.

$$\frac{\Delta F}{F} = \frac{F_{CL1} - F_{CL2}}{F_{CL1}}$$

QUARTZ CRYSTAL

Synthetic quartz is composed of silicon and oxygen (silicon dioxide) 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. Conversely, when an electrical potential is applied to the surfaces of a crystal, mechanical deformation or vibration is generated. These vibrations occur at a frequency determined by the crystal design and oscillator circuit. Under proper conditions, quartz is used to stabilize the frequency of an oscillator circuit.

QUARTZ CRYSTAL OSCILLATOR

A timing device that consists of a crystal and an oscillator circuit, providing an output waveform at a specified reference frequency.

RISE AND FALL TIMES

Rise time is the amount of time, measured in nanoseconds that it takes to go from the logic "0" state to the logic "1" state. The fall time is the transition time from logic "1" state to logic "0" state. The time is measured at the 10% and the 90% points of the voltage transition.

SERIES VS. PARALLEL LOAD RESONANCE

A crystal can be used in an oscillator circuit to operate in either of two resonant modes: Series Resonance or Parallel Load Resonance (also known as antiresonance). The crystals used in these two types of modes are physically the same crystal, but calibrated to slightly different frequencies.

When a crystal is placed into an oscillator circuit, they oscillate together at a tuned frequency. This frequency is dependent upon the crystal design and the amount of Load Capacitance, if any, the oscillator circuit presents to the crystal. Specified in picofarads (pF), Load Capacitance is comprised of a combination of the circuit's discrete load capacitance, stray board ca-



Glossary

capacitance, and capacitance from semiconductor Miller effects. When an oscillator circuit presents some amount of load capacitance to a crystal, the crystal is termed "Parallel Load Resonant," and a value of Load Capacitance must be specified. If the circuit does not exhibit any capacitive loading, the crystal is termed "Series Resonant", and no value of Load Capacitance is specified. The "Parallel Load Resonant" operating frequency of a quartz crystal is based on the equation below:

$$F_L = F_s \left(\frac{C_1}{2(C_0 + C_L)} + 1 \right)$$

Where: F_s = Series Resonant Frequency (MHz)
 F_L = Parallel Load Resonant Frequency (MHz)
 C_L = Crystal Load Capacitance (pF)
 C_0 = Crystal Shunt Capacitance (pF)
 C_1 = Crystal Motional Capacitance (pF)

SHUNT CAPACITANCE (C0)

The static capacitance between the crystal terminals. Measured in picofarads (pF), shunt capacitance is present whether the device is oscillating or not (unrelated to the piezoelectric effect of the quartz). Shunt capacitance is derived from the dielectric of the quartz, the area of the crystal electrodes, and the capacitance presented by the crystal holder.

START-UP TIME

The specified time from oscillator power-up to the time the oscillator reaches steady state oscillation.

STORAGE TEMPERATURE RANGE

The minimum and maximum temperatures that the device can be stored or exposed to when in a nonoscillation state. After exposing or storing the device at the minimum or maximum temperatures for a length of time, all of the operating specifications are guaranteed over the specified Operating Temperature Range.

SUPPLY VOLTAGE

The DC input voltage necessary for oscillator operation, specified in volts.

SYMMETRY

Symmetry is defined as the ratio of amount of time the voltage is in the logic "1" state compared to the time in the logic "0" state. The measurements are taken at the 50% points of the voltage transition between the two logic states.

The time period of one cycle of the waveform is calculated first as below.

$$\frac{1}{\text{Frequency in Hz}} = \text{Time period in seconds}$$

Next, the time period of the logic "1" state is measured from the 50% point of the waveform's positive voltage transition to the 50% point of the waveform's negative voltage transition, then compared to the total waveform period. The calculation for symmetry is shown below:

$$\frac{\text{Logic "1" time in seconds}}{\text{Period of one cycle}} \times 100 = \% \text{ Symmetry}$$

For the % symmetry of the logic "0" state, subtract the logic "1" symmetry from 100%. For example, 40/60% means that the waveform is in its logic "1" state 40% and in the logic "0" state 60% of the total waveform time period.

TRI-STATE

An oscillator with the tri-state feature allows the output to be placed into a high impedance state with no output oscillation present. This feature is activated by the application of a logic control voltage to pin 1 of the oscillator.

TYPE/ANGLE OF QUARTZ CUT

The type and angle of a quartz cut affects the crystal device operating parameters, the most significant being frequency stability over temperature. The frequency stability is dependent upon the plane or the angle of the crystal element in relation to the crystalline axes of the crystal. The plane or angle is referred to as the crystal "cut". A common type of thickness shear crystal fabricated from Y bar quartz is the "AT" cut. The frequency stability and operating temperature range required by the customer determine the angle of cut utilized.

