Holder: A case housing a thin piece of quartz crystal or crystal strip with vacuum-evaporated metal electrode and terminals for connections.

Frequency: The number of cycles of output waveform occurring per second. The unit of frequency is cycles per second, or Hertz, abbreviated Hz.

Fundamental mode: The main mode of the crystal.

Overtone mode: Odd numbers assigned for frequencies in terms of specified oscillation mode. Standard third overtone mode, followed by fifth, seventh, ninth, etc. It is not practical to go beyond ninth overtone. The frequencies are not exactly three, five, seven, or nine times the fundamental frequency.

Frequency tolerance: The allowable deviation from the nominal frequency at room temperature. Frequency tolerance is expressed in percentage, typical ±0.005% or in parts per millions (ppm), ±50ppm.

Equivalent Series Resistance: The value of impedance the crystal exhibits in the operating resonant circuit.

Drive level: The amount of power dissipation experienced by the crystal in the circuit. Drive level is expressed in milliwatts or microwatts. Excessive drive level will result in possible long-term frequency drift or crystal fracture.

Aging: The relative frequency change over a certain period of time. This rate of change of frequency is normally exponential in character. Typically, aging is computed within first 30 days and is calculated over a long term (one year or ten years). The highest aging rate occurs within the first week of operation and decreases slowly after that.

Frequency stability: The maximum allowable frequency deviation compared to the measured frequency at 25º C over the specified temperature range, i.e., 0 to + 70ºC.

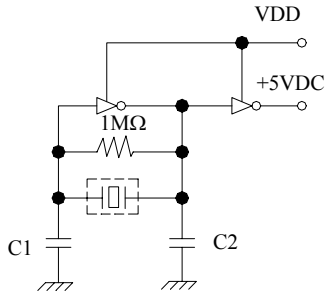
Shunt capacitance: Shunt capacitance (C_O) is the capacitance between the crystal terminals. It varies with package, usually it is smaller in SMD (4pF typical) and is 6pF in leaded crystals.

Spurious: Unwanted resonances usually above the operating mode, specified in dB max. or number of times of ESR. Frequency range must be specified. For example, spurious response shall be minimum 6dB or 2.5 x R in the frequency window of F_0 ± 200kHz.

Mode of *vibration:* The mode of vibration of quartz crystal varies with crystal cuts such as Thickness-shear for AT cuts and BT cuts, or Flexure mode for tuning fork crystals (+5ºX) cut, or Face-shear mode for CT, DT cuts. The most popular cut is the AT cut, which offers a symmetrical frequency shift over a wide temperature change.

Operating temperature range: Temperature range in which crystal units operate within specified conditions.

Load capacitance: Load capacitance (C_L) is the total amount of capacitance that the oscillator exhibits to the two crystal terminals. Load capacitance is needed to be specified when the crystal is used in a parallel mode. Load capacitance is calculated as follows:



C_1,C_2:See Specifications
IC: 4069 (Hex inverter)
(MOTOROLA)

$$C_L = \frac{(C_1 \times C_2)}{(C_1 + C_2)} + Cstray$$

Cstray may vary from 2pF to 6pF.

Figure 1 Load capacitance in circuit

Pullability: Frequency change as a function of load capacitance CL in a parallel resonant crystal. Pullability is a function of shunt capacitance Co motional capacitance C_1, and size of crystal.

Insulation resistance: Resistance between crystal's leads, or between lead and case (metal case). It is tested with a DC voltage at 100V ± 15V and insulation resistance is in the range of 500 Mohms.

Series resonance: Series resonance occurs when its impedance is at minimum at resonance. Its equivalent circuit at series resonance is a resistor.

Quality Factor: is a quality function of motional inductance, resonant frequency, and ESR. It is typical in the range of ten's to hundred's of thousands.

CRYSTAL EQUIVALENT CIRCUIT

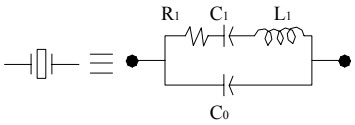


Figure 2

The equivalent circuit of a quartz crystal is shown to explain the basic elements governing the crystal characteristics and performance. It consists of a motional capacitance C_1, inductance L_1, series resistance R_1, and a shunted capacitance C_0. The first three parameters are known as the "motional parameters" of the quartz crystal element. See Fig. 2.