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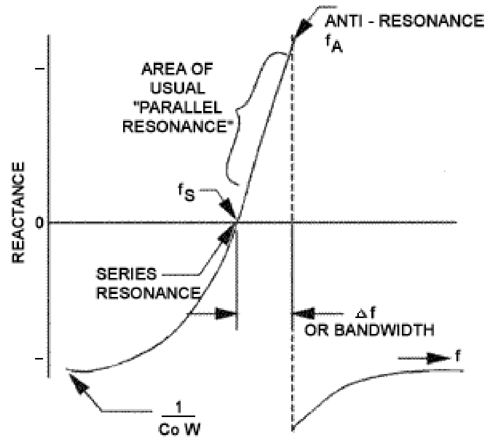
OSCILENT CORPORATION

Definitions

Q-Factor

Quality Factor (Q):

A measurement used to determine the units relative quality, or efficiency of operation. In a crystal resonator it is the reactance of the motional inductance or capacitance divided the motional resistance (See useful equations below) The maximum attainable short tern stability of a crystal depends on the "Q" value. In Figure 7, the separation between the series and parallel frequencies is called the bandwidth. As the bandwidth gets smaller, the value of "Q" rises, and the reactance slope gets steeper. Changes in the reactance of external circuit components have less effect (less "pullability") on high "Q" crystals, hence, there is more short term stability. **For more information, we suggest consulting the Oscilent Engineering Staff**.



Motional Capacitance (C1):

Illustrates the electronic equivalence of the mechanical elasticity of the unit. See below under Useful Equations for calculation method

Motional Resistance:

Also called Equivalent Series Resistance. The equivalent series resistance is the resistive element (R1) of the quartz crystal equivalent circuit. (see Equivalent Circuit below) This resistance represents the equivalent impedance of the crystal at natural resonant frequency (series resonance) ESR is measured by a Crystal Impedance (CI) meter.

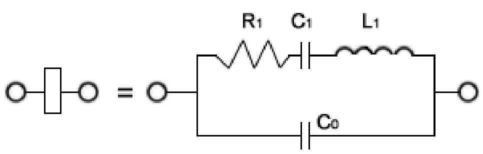
ESR values are generally stated as maximum values expressed in ohms. The ESR values vary with frequency, mode of operation, holder type, crystal plate size, electrode size, and mounting structure.

It is worth noting that the ESR value at a given frequency for an AT- strip crystal design is generally higher than that of the standard (round blank) design. This becomes more significant at lower frequencies. When transitioning from a series resonant through-hole HC-49/U type crystal to a smaller surface mount type utilizing an AT-strip crystal, some consideration may be given to the difference in the ESR values produced by different cuts.

The ESR becomes critical when resistance values reach a point were the oscillator circuit cannot adequately drive the crystal. Sluggish start-up or unwanted modes of operation may result.

Equivalent Circuit:

The equivalent circuit (shown in Figure A) depicts electrical activity of a quartz crystal unit operating at its natural resonant frequency. The shunt capacitance (Co), represents the capacitance of the crystal electrodes plus the capacitance of the holder and leads. R1, C1, and L1 compose the "motional arm" of the crystal, and are referred to as the motional parameters. The motional inductance (L1) represents the vibrating mass of the crystal unit. The motional capacitance (C1) represents the elasticity of the quartz, and the resistance (R1), represents bulk losses occurring within the quartz.



Useful Equations:

Equations	Definitions
f_S = (Series) frequency = $\frac{1}{2\pi\sqrt{L_1C_1}}$	C_0 = Static Capacitance in farads
C_L = Load capacitance = $\frac{C_1}{2\times\Delta f} - C_0$	C_1 = Motional capacitance in farads
Co = Shunt capacitance = $\frac{C_1}{2\times\Delta f} - C_L$	C_L = Load capacitance in farads

C_1 = Motional capacitance = $2(C_0 + C_L)\Delta f$	f = Nominal frequency in Hz
L_1 = Motional inductance = $\frac{1}{4\pi^2 f_s^2 C_1}$	f_L = Anti-resonant frequency in Hz
R_1 = Series resistance = $\frac{2\pi \times f_s \times L_1}{Q}$	f_S = Series resonant frequency in Hz
Q = Quality factor = $\frac{2\pi \times f_s \times L_1}{R_1}$	L = Inductance into Henrys
$f_L - f_s = \Delta f = \frac{C_1}{2(C_0 + C_L)}$	P_L = Pullability (ppm/pF)
P_L = Pullability = $\frac{C_1 \times 10^6}{2(C_0 + C_L)^2}$	Q = Quality factor
. .	R_1 = Series resistance in ohms

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