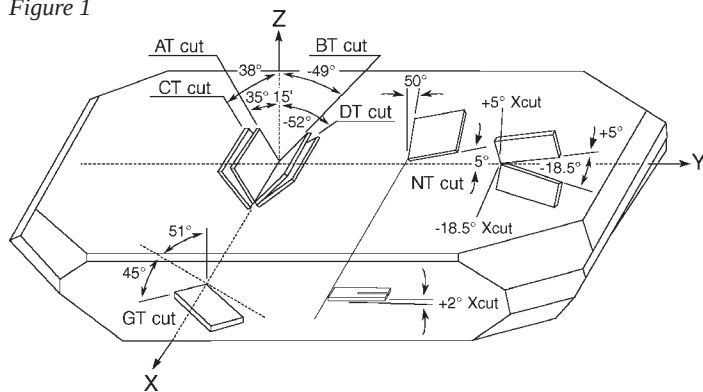


QUARTZ CRYSTAL THEORY OF OPERATION

Quartz crystal units serve as the controlling element of oscillator circuits by conversion of mechanical vibrations to electrical current at a specific frequency. This is accomplished by means of the "Piezoelectric" effect. Piezoelectricity is electricity created by pressure. In a piezoelectric material, the application of mechanical pressure along an axis will result in the creation of an electrical charge along an axis at right angles to the first. In some materials, the obverse piezoelectric effect is found, which means that the imposition of an electric field on the ends of an axis will result in a mechanical deflection along an axis at right angles to the first. Quartz is uniquely suited, in terms of mechanical, electrical and chemical properties, for the manufacture of frequency control devices. Quartz crystal units which oscillate within certain frequency and temperature ranges have been developed over the years. *Figure 1* shows the location of specific elements within a quartz stone.

Figure 1

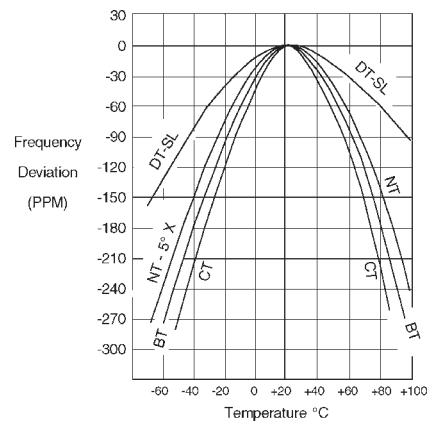


The elements as shown above vibrate in various modes, the most important of which are the extensional, flexural and shear. The mode of vibration determines the maximum frequency, stability vs. temperature, and resistance of a given element. The various modes of vibration are shown in *Figure 2*, while a comparison of the various frequency stabilities vs temperature are shown in *Figure 3*.

Figure 2

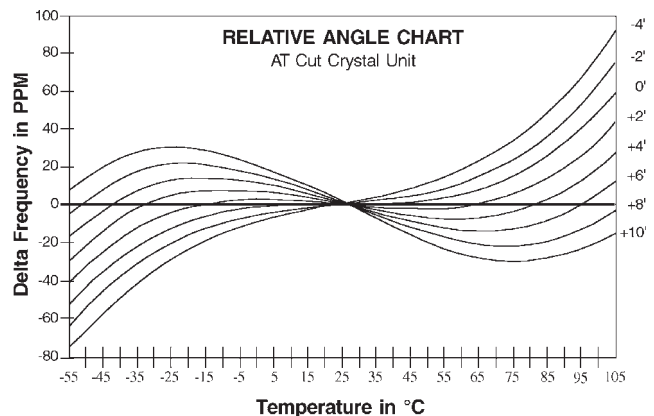
Thickness	Extensional
Fundamental	
3rd Overtone	
5th Overtone	
Face Shear	Length-Width Flexure

Figure 3



Of the various elements, the "AT" cut has become the most popular as it is available at relatively high frequencies, exhibits excellent frequency vs temperature stability and is widely available at reasonable cost. The frequency vs. temperature capabilities of the "AT" cut crystal unit are illustrated in *Figure 4*.

Figure 4



Fundamental vs. Overtone

This is of concern primarily when specifying the "AT" cut crystal unit. These units increase in frequency as the thickness of the resonator plate is diminished. At some point, typically around 30MHz, the plate becomes too thin for efficient processing. As the "AT" will resonate at odd integer multiples of the fundamental frequency, it is necessary to specify the desired order of overtone when ordering higher frequency crystals.

Drive Level

Drive level is the amount of power dissipated by the crystal. Drive level is usually specified in terms of micro or milliwatts, with a typical value being 100 microwatts.