Frequently Asked Questions

Question: ***Why are crystals specified with a frequency tolerance and stability, while oscillators are specified only with a stability requirement?***
Answer: The answer to this question is somewhat a "specmanship" issue. It is usually assumed that a crystal is used in some type of oscillator circuit. The user will know what the total stability of this oscillator, plus aging, needs to be over the desired operating temperature. For instance, if a requirement is for 100 ppm maximum total allowable frequency deviation, including aging, over the temperature range of 0° to 70°C, he could order a crystal that has 50 ppm tolerance at room temperature (25°C) and 50 ppm stability over the operating temperature. In these cases, the stability over temperature is referenced to what the frequency is at room temperature.

For Oscillators, the end user is usually only concerned with the total stability including over the operating temperature. In this case, he may request an oscillator that needs stability of 100 ppm, including aging, over the temperature of 0° to 70°C, like the MHO+13TAD. In the actual manufacturing process, the oscillator is built much the same as the crystal mentioned above. Variations for the effects of the oscillator circuitry are taken into account in the design of the product. The crystal used internal to the oscillator is built with an initial tolerance of 50 ppm at 25°C. The crystal is designed to operate at a specific stability (50 ppm) over the operating temperature. When mounted in the oscillator, the combined total stability is within the 100 ppm maximum specification.

Question: ***What is meant by the term "aging" as it pertains to crystals?***
Answer: Aging is the change in frequency of a crystal over time. Aging can be in the positive or negative direction. Aging affects contribute to the overall frequency drift of the oscillator that the crystal is used in. There are several causes for aging: stress relief in the crystal's mounting structure, internal contamination, moisture absorption, and changes in the quartz material. Some of these conditions can occur as a result of the crystal being exposed to shock and vibration levels, or operating temperatures above the recommended limits, or the loss of hermeticity due to weld or glass to metal seal deterioration. Particulate contamination, which attaches itself to the crystal wafer, will cause a negative shift in the crystal's frequency. Loss of crystal mass or elctrode material will usually exhibit a positive shift in the crystal's frequency. In order to reduce aging in a crystal, the unit needs to be manufactured in an ultra-clean environment, and sealed in a hermetic package. Crystals can be "pre-aged", to a certain degree, to minimize the effects of aging. Because aging characteristics tend to follow a logarithmic curve, most of the aging of a crystal will occur in the first year of its life. With proper processing, a crystal can be made to exhibit aging characteristics in the ±0.5 ppm to 177, 1 ppm per year range.

Question: ***What are the main differences between at AT-strip crystal and an AT-round blank or wafer crystal?***
Answer: The obvious difference between these two types of crystals is in their size. The AT round blank, or plano-plano type of crystal, has been around for 50 years and is used in many HC-49/U (MP-1) type crystals. The crystal used in an HC-49/U can have a diameter ranging from 0.200" to 0.350" depending on the frequency of the crystal. Because of the large surface area, the round blank can have a relatively large electrode. This is desirable for crystals that need to have wide pullability. Also, the larger electrode and blank size will usually exhibit low ESR values. The HC-49/U round blank crystals are also suitable for wide temperature range (-55°C to +125°5°C to +125°C) while achieving good stability.

Drive levels from 0.1 mW to 2 mW are possible with many round blank designs. The round blank's frequency is determined by its thickness and diameter; the higher the frequency the thinner the crystal blank. Because of this, fundamental frequencies up to about 33 MHZ are possible, but with yield loss due to breakage. These high frequency fundamentals are fragile and can easily be damaged by the end user if subjected to extreme shock and vibration environments. Virtually any frequency from about 1.8 MHz to 200 MHz can be made using the HC-49/U type crystal.

The AT-strip crystal has been around for about 17 years, and was developed in Japan. About 90% of AT-strip crystal manufacturing is done in the Far East. The AT-strip crystal utilizes a small rectangular piece of quartz that is a fraction of the size of the HC-49/U round blank design. Its length to width ratio, and its thickness determine the frequency of the AT-strip crystal. Because of the very small amount of surface area, only a small electrode can be attached to the crystal strip. The size of this crystal, and the electrode, also make the AT-strip crystal undesirable for applications that require a wide pullability (±200 ppm). The AT-strip crystal typically exhibits higher ESR values for a given frequency than the HC-49/U round blank types. Each frequency for AT-strip crystals is uniquely designed. This means that not all frequencies in the given range are designed and developed. AT-strip crystals are available at specific frequencies in the 3.579545 MHz to 200.00 MHz range. The major advantages of using the AT-strip crystal are related to its size. Surface Mount crystals as small as 2.5 X 3.2 X 0.8 mm are now available because of advances in AT-strip technology. Other advances in this technology are providing improved ESR, temperature stability, and higher fundamental frequencies. Because the AT-strip crystal has considerably less mass than the HC-49/U round blank type crystal, it is often better suited for high shock and vibration environments. Their small sizes also make them ideal for use in small package surface mount oscillators.