Basic Crystal Filter Styles

Narrow Band Filters

Both discrete resonators and monolithic dual resonators have electrode pairs on opposite faces of a quartz wafer. These electrodes, in addition to exciting the natural mechanical resonances of the wafer, unavoidably produce a static capacitance (C_0). A narrow band filter is one where the network can be designed so the (C_0) is part of the network, supplemented in most cases by additional external capacitance. As the bandwidth increases the allowable amount of supplemental capacitance decreases and eventually becomes negative. For a filter to be narrow band, the allowable supplemental capacitance must be greater than or equal to zero. Maximum inductorless bandwidth is the bandwidth at which the supplemental capacitance is equal to zero and is the maximum bandwidth at which a narrow band design can be realized. The capacitance ratio C_0/C_1 of the resonator equivalent circuit determines this maximum bandwidth. For filters using fundamental mode AT-cut resonators, under ideal conditions this maximum bandwidth is approximately 0.32% of the center frequency. At bandwidths exceeding this limit, the network design must be changed to incorporate inductors that appear in shunt with the crystal resonators. I

Intermediate Band Filters

Intermediate band filters use inductors to remove excess capacitance presented by the resonator (C_0) and unavoidable supplemental stray capacitance. There are two types of intermediate band filters. The first type is sometimes called a narrow band filter with spreading coils (inductors). The inductors are treated as negative capacitances that absorb some of the (C_0) and stray shunt capacitance, leaving the reduced amount necessary for a narrow band design. In this type of filter the parasitic coil losses may cause severe rounding of the upper passband (or in some cases, rounding of the lower passband).
The second type of intermediate band filter is designed with no capacitance in parallel with the motional elements of the crystal resonator. The passband of this is largely unaffected by parasitic coil loss until the bandwidths become close to wide band. Filters of this type use redundant crystals. An 8-resonator design may only give 7 poles of performance. This disadvantage is offset by the flexibility of the design technique that allows the realization of elliptical function and single-sided responses. Most intermediate band designs use discrete resonators but they may incorporate monolithic dual resonators. Bandwidths are between 0.3% and 1.0% for fundamental resonators. Spurious responses will sometimes be present in the filter bandpass, will often be present in the transition region, and will usually be strongly excited in the filter stopband.

Wide Band Filters

These filters use inductors to contribute poles to the filter response at the same time as accommodating the resonator (C_0). For this reason, the filter response is very sensitive to inductance and Q values and requires precise temperature compensation of inductors if performance is to be maintained. Bandwidths are between 1% and 10% of center frequency. Discrete resonators are generally used. When AT-cut crystals are used, spurious responses will often be present in the filter passband and transition region. The inductors, since they add poles, may suppress spurious response in the filter stopband.