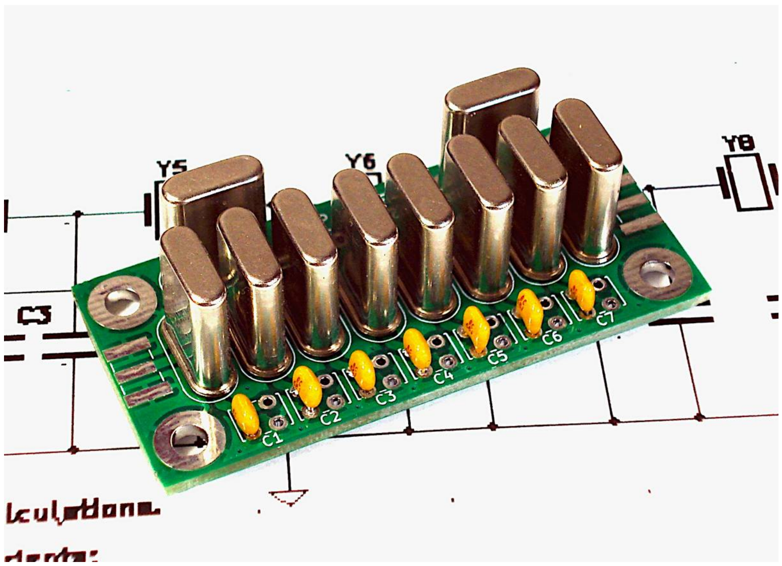
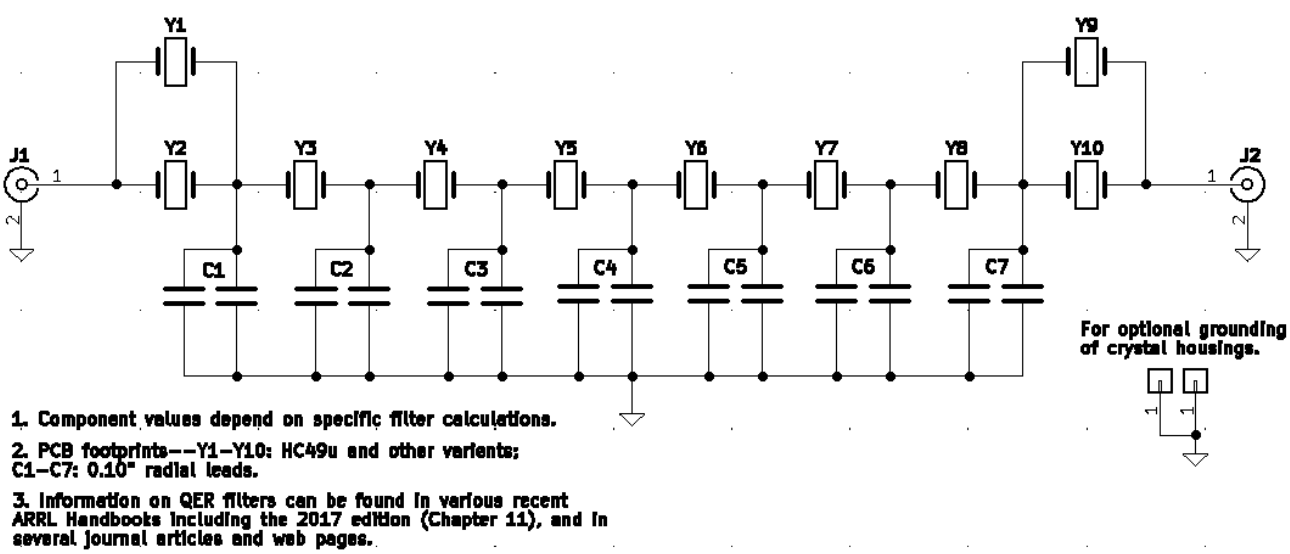
mostly DIY RF™

QER (Quasi-Equiripple) Crystal Filter Kit



Some would say a crystal-based IF filter is the very heart and soul of a good SSB rig. There's no doubt that a clean, ripple-free and narrow-skirted "xtal" filter is essential for excellent performance, especially in a receiver. They are, however, among the most difficult builds for a home-brewing amateur to pull off.

Among the easiest types, though, are quasi-equiripple designs that *do* require using "xtals" closely-matched in resonant frequency (within 50Hz, but the closer the better), but that *do not* require the careful measurement of "motional parameters" or ESR. More on QER crystal filters can be found in recent (since at least 2010) editions of the ARRL *Handbook*.

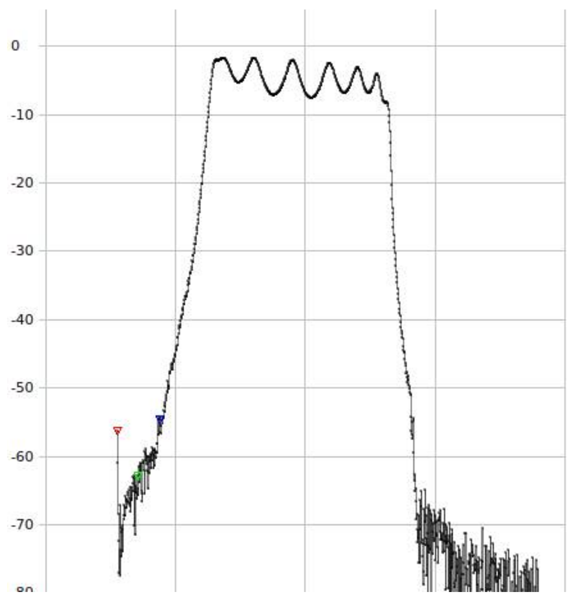


The schematic diagram shows what looks at first glance like a regular "ladder" filter, but a QER filter is distinguished by the parallel xtals at each end. It is this arrangement that minimizes pass-band ripple. Another characteristic of a QER filter is that the shunt capacitor values are all the same, their actual value will determine the bandwidth of the filter. The larger the value, the narrower the bandwidth.

Depending on the crystal frequency (and sometimes on the batch of a given frequency), the actual value will vary--usually between 33pF and 122pf for an SSB filter with a 2700Hz bandwidth (as measured at the upper and lower -3dB points). In order to facilitate capacitance adjustment, the QER PC board has pads for parallel capacitors so that values between standard values may be obtained. With crystal filters, there's no getting past the need for a "cut-and-try" approach.

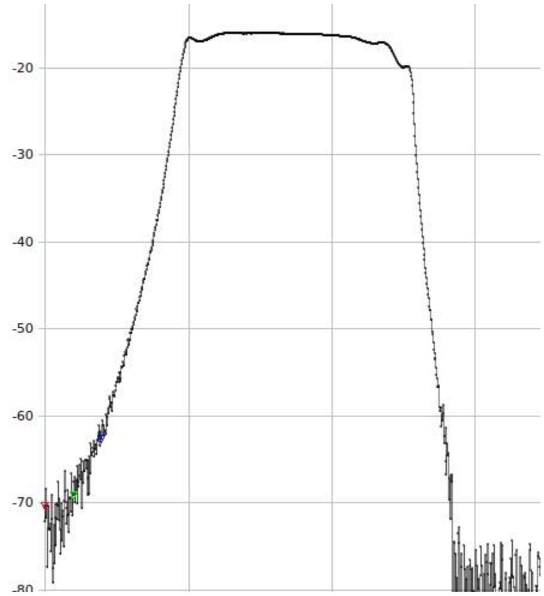
Whether or not you purchased your QER filter as a kit or fully assembled, you will receive information regarding its *provisional* "native" impedance. You will then need to integrate the filter into your circuitry such that a good *practical* impedance termination (i.e., "match") is provided for the filter's input and output. Methods for doing so are presented below. Without proper impedance matching, the passband could have significant ripple, and this could have a bad impact on how good a receiver's audio sounds as well as the nature of your transmitted signal.

Here is a nanoVNA plot of a 4.915MHz filter with no matching:



The ripple is pronounced, having a depth of about 6dB. This is enough to make voice hard to listen to--perhaps barely intelligible--and it may cause certain digital modes to fail entirely. This particular filter has a "native" (i.e., with no matching circuitry) impedance of 550Ω, and it's being plotted with a VNA input of 50Ω. If you insert this into rig circuitry also "expecting" 50Ω, this is the ripple you'll get in the rig's IF response.

The following plot is pretty-much what you want to see from an acceptable filter:



This plot has a fairly-flat top, with shallow notches on the extremes of the passband. It is not clear these are real or just an artifact of the nanoVNA plotting. In either case, they are shallow and on the margins of the response and therefore will not have any noticeable effect on practical performance. Note that this plot shows an insertion loss of about 15dB. This is a result of the impedance-matching method (series resistance) used to determine the native impedance. Properly matched to the impedance of IF circuitry (using transformers or L-networks), the actual insertion loss is typically between 2 and 4dB.

The plot also shows the characteristic steepness of the upper "skirt" of the passband compared to the lower skirt. It is widely understood that this makes crystal filters better suited for lower-sideband use than for upper-sideband. While this makes obvious sense, it should be noted that the lower skirt is probably still steep enough for practical applications. In cases where it is not, the filter is used for USB through *sideband inversion*.

You may have to provide your own impedance matching at one or both ends of the filter. These need be no more elaborate than simple LC networks (two components), and there are a number of online calculators available to design them. A particularly-good one has been provided by **W8DIZ** of ***Kits and Parts***: **http://toroids.info/**. If you have the means to "sweep" the filter's passband (such as with an inexpensive NanoVNA), you can observe the result of your matching efforts directly. Otherwise, you can just listen to the result and judge accordingly.

Based on tests with the batch of crystals included in this kit, the following shunt capacitors have been included: ____pF, ____pF, ____pF to render a filter with 2700Hz bandwidth. A relatively easy way of choosing which to use is to "tack-solder" the ____pF in place (after having installed the crystals) and observe the resulting bandwidth. Leave the capacitor leads long and cut them short only when you're ready for permanent installation. At the frequencies involved, the effect of longer lead length will be negligible. If after using the highest value provided you want a narrower bandwidth, solder a smaller-value capacitor in parallel with each one. A parallel set of pads is provided on the PCB for this purpose. The "native" impedance of the filter is approximately _______ ohms.

If you wish, you can solder a bare wire across the top of the crystals (use a low temp and be quick) and ground one end of it. You can find out more about doing so by Googling "grounding crystals in a filter."