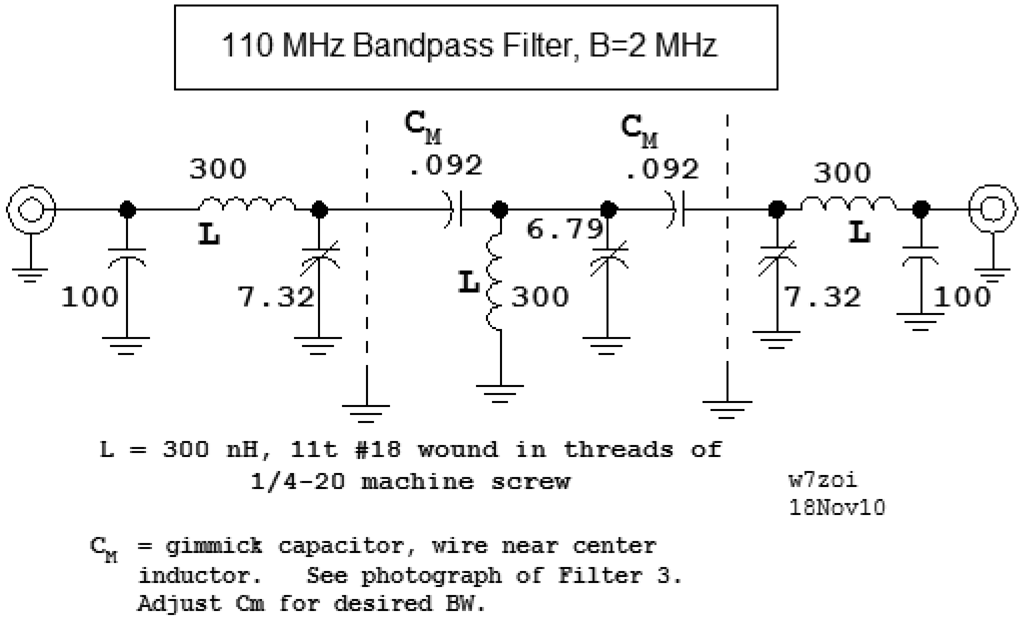
Capacitance of a wire above a foil:

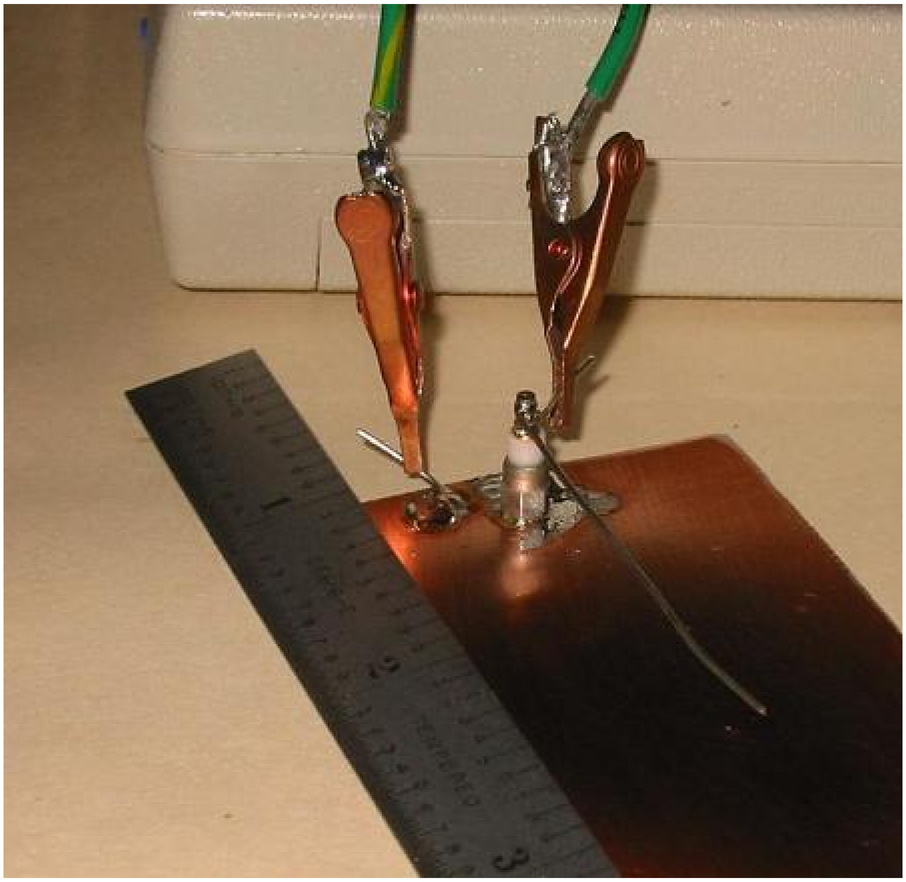
18July11 w7zoi

The VHF bandpass filter designed for the first IF filter at 110 MHz uses some unusual components. Especially unique are the 0.092 pF coupling capacitors shown in the schematic. That circuit is repeated below.

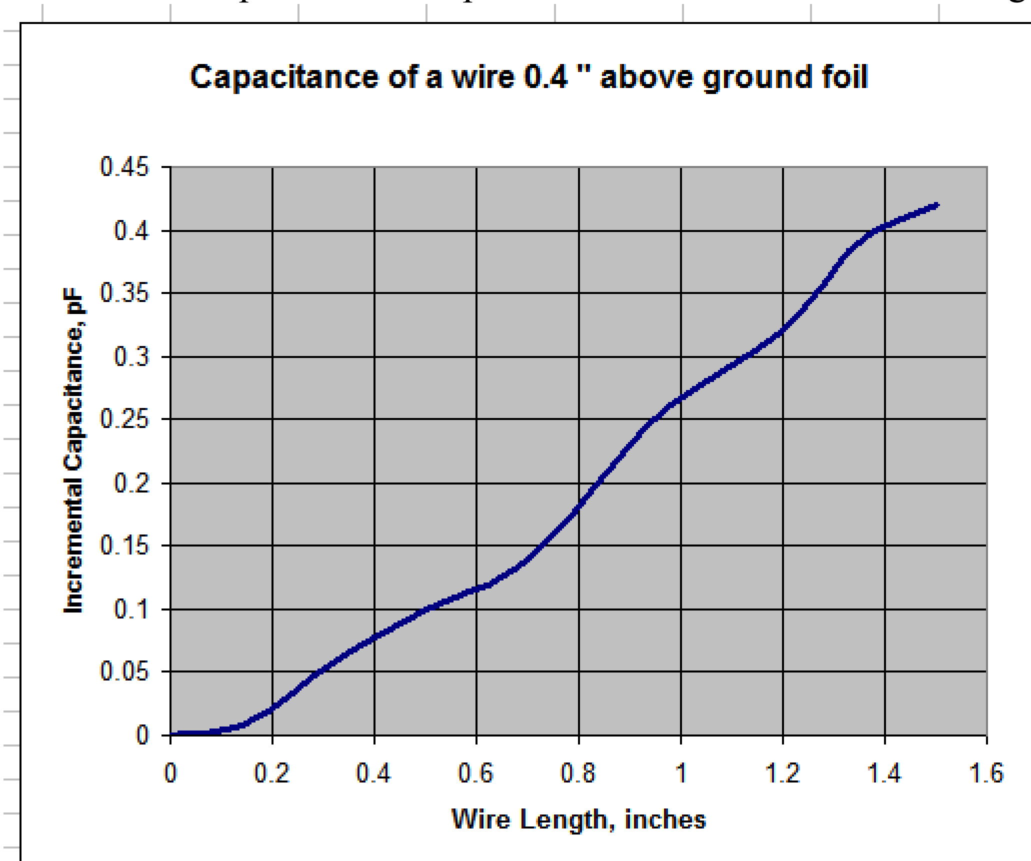


An often voiced question from beginning filter builders is, "Where do I purchase a capacitor with .092 pF?" The answer is that you don't. Even the stray C of a common resistor is more than that. It is necessary to fabricate your own capacitors, or to realize the same effect. What is important is to couple energy between the first and second resonator, and also to couple between the second and third resonators. This can be through any means that works. An especially easy way to realize the coupling is with a wire capacitor. A wire is attached to the "hot" end of the first resonator (the left 7.32 pF variable cap). That wire is then routed through a hole in the shield that isolates the tuned circuit from the second resonator. The piece of wire is then routed ***close to*** the coil of the second resonator. But the critical questions become **how long** the wire should be and **how close** it should be to the second resonator. The cap from resonator 2 to #3 is obviously treated with the same care.

We did an experiment with an AADE L/C meter and a capacitor fabricated with wire. We soldered a Teflon insulated terminal to a scrap of PC board and then attached a wire to the terminal to generate a capacitor. The wire length started at 1.5 inches, but was then reduced in small increments. See the photo below.



The "zero" function was not used during this measurement, so there was about 3.9 pF of stray capacitance. That was subtracted from the data during analysis with a spread sheet. The Incremental Capacitance was plotted as a function of the wire length, which is shown below.

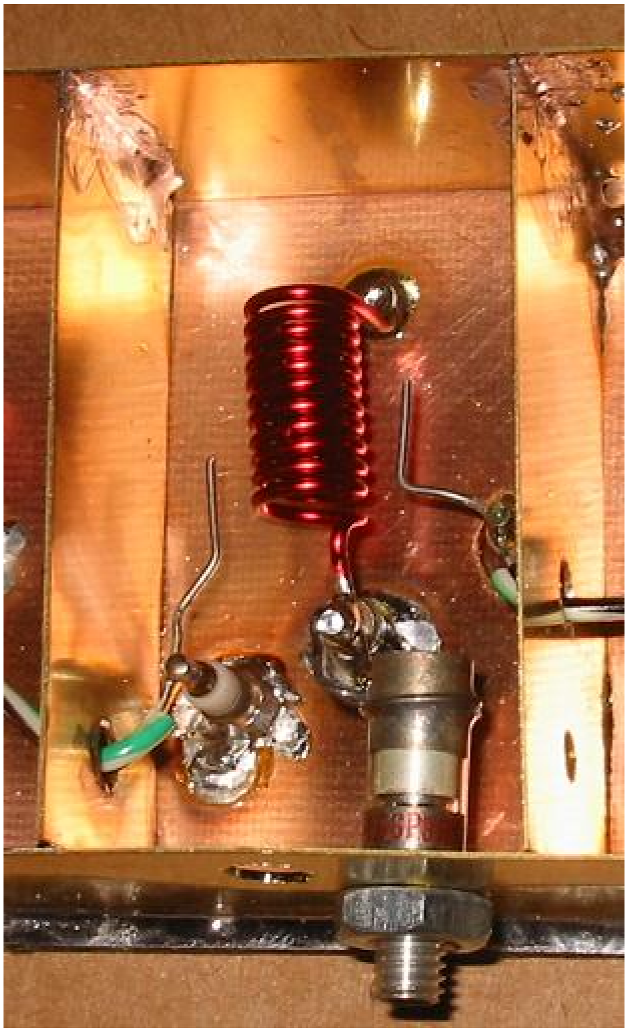


Of particular interest is the average slope of this curve, which is 0.28 pF per inch. This means that a wire of an inch will have C of 0.28 pF. The wire in the experiment was 0.4 inch from the ground foil. Pushing it closer would cause C to increase. The small valued 0.092 pF capacitor needed in our filter could be approximated with a wire that is about half an inch. The half inch is not the total wire length, but the amount of overlap with the coil.

Experimentally, the best way to set up a filter of this sort is to start with very small wires as the coupling capacitors. One end of the filter is driven with a 50 Ohm signal generator while the other end is terminated with a 50 Ohm detector. The detector could be a 50 Ohm power meter or spectrum analyzer, or even a 50 Ohm terminate scope of suitable bandwidth. Using the curve above, a good start might be wires that overlap the coil by perhaps 0.3 inch with a spacing of 0.4 inch. The variable capacitors are all adjusted at 110 MHz for the highest output. The filter insertion loss and bandwidth are measured. If they do not fit the desired response, the length and/or position of the coupling wires is changed and the process is repeated. If you ever reach a stage when a multiplicity of peaks is seen, that suggests that there is too much coupling.

There should be plenty of adjustment range available in this filter. Without changing any coils or coupling capacitors, I was able to move my filter from about 90 MHz up to about 130 MHz center frequency. There were three peaks by the time I got to 130 MHz, indicating over coupling. It is worthwhile to try moving the filter from 110 to something slightly different just to be sure that none of the variable capacitors are tuned to maximum or minimum value.

There is another problem that can come up with severe over coupling. If the resonator to resonator coupling is severely high, one of the peaks may be a long ways away from the desired filter center. So, when evaluating the experimental filter, be sure to use a very wide sweep. A swept instrument is not needed. However, a variable frequency generator is desired. See the paper that we presented in QST for December 1991 having to do with double tuned circuits. For this particular filter, we would recommend an evaluation sweep from 50 to 200 MHz.

 This photo is a close-up view of the second resonator.   Note the position of the wire coupling capacitors with respect to the body of the coil.   This appears to be a surprisingly good fit to the experimental data.   While the overall wire length exceeds 0.5 inch, the part that overlaps the most sensitive "hot" end of the coil is only about half an inch.

Click on BACK to return to the filter discussion.