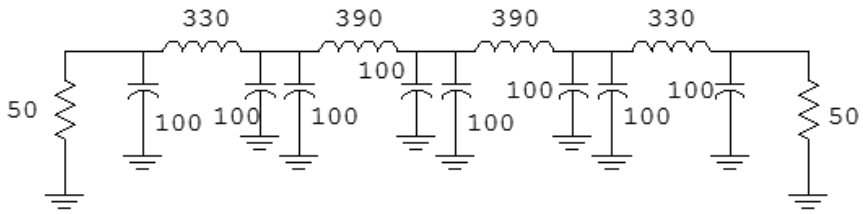
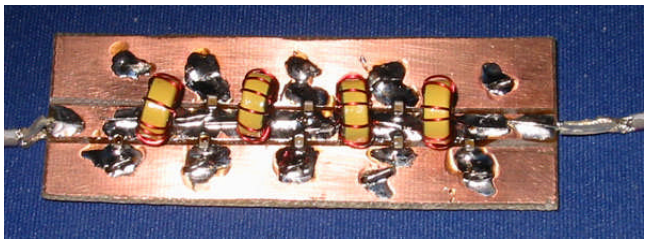
Experiments with a Simple Low Pass Filter

24 Feb 2009 w7zoi

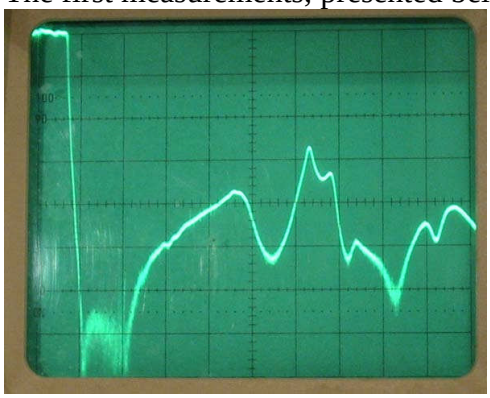
A project presently being built required a 35 MHz low pass filter with a sharp cutoff and reasonable stop band attenuation. Simulations suggested that a 9th order filter would suffice. A design was done using stock, off-the-shelf 330 and 390 nH inductor values and capacitors of either 100 or 200 pF. After the inductors were ordered I realized that I did not have any 200 pF capacitors in my SMT stock. *No matter – I could double up with the 100 pF capacitors.* The circuit is presented below.



The first filter was built while waiting for my order to arrive from Mouser. This is shown below where T30-6 toroid forms were used for the inductors of 9 or 10 turns.


The first filter built.

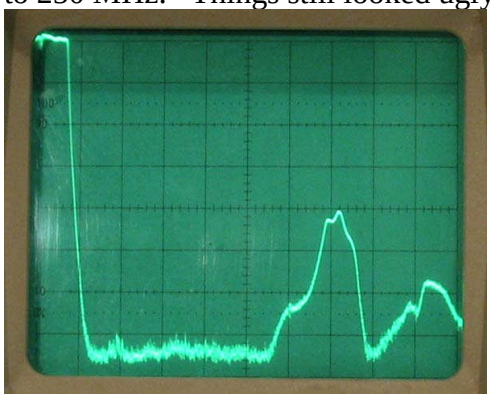
The first measurements, presented below, were horrid.


Poor coax, no shields.

The loss in the passband was low and the skirt drop-off was stellar. But the VHF stopband was severely compromised.

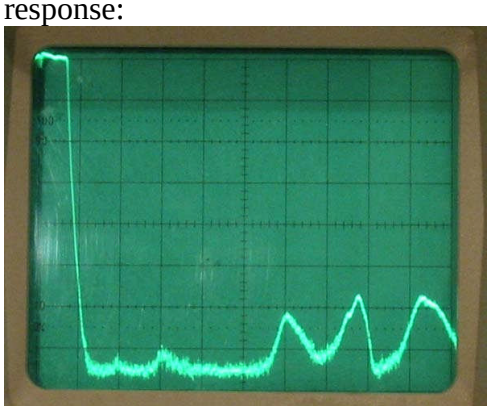
I noted during the measurements with a 500 MHz spectrum analyzer with built in tracking generator that the performance depended upon the cables. (All measurements used 10 dB/div and 50 MHz/div.) SMB coax connectors were added to the board and

some high quality double shielded cables were use to greatly improve the performance up to 250 MHz. Things still looked ugly at UHF. The observed plot is shown below:



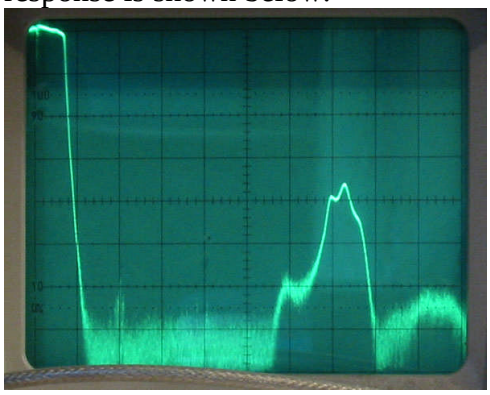
Good coax, no shields.

Next, three shields were added between the four inductors, producing the following response:



Good coax **with shields** added.

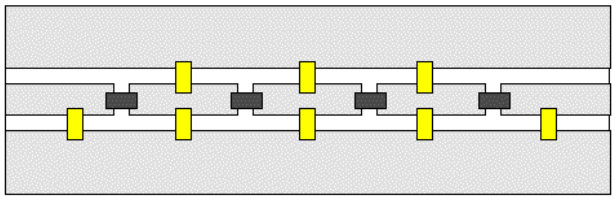
The experiments were set aside while awaiting parts. I assumed that the chip inductors would fix everything. The parts arrived and the chip inductors were immediately dropped onto the board. By now the shields had been removed. The disappointing response is shown below.



Chip inductors and capacitors.

What could be going on? The severe problem around 350 MHz does not seem reasonable. Or does it?

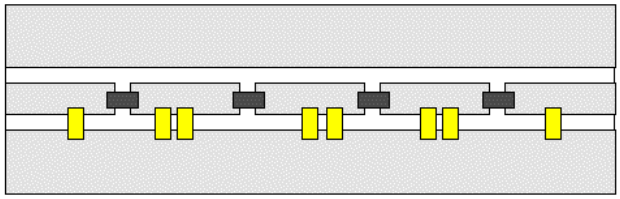
The following layout was used in this circuit where the chip inductors are black while the 100 pF chip capacitors are yellow.



Compromised layout.

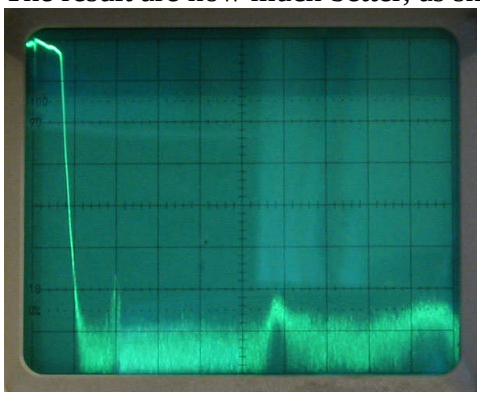
I had used parallel 100 pF capacitors to approximate the three inside 200 pF caps required. But parallel capacitors can be a problem in RF circuits. This was discussed on page 2.29 of EMRFD. The capacitors in the above photo are not really in parallel. When viewed from the perspective of a lower capacitor, the similar cap immediately above it looks like a capacitor in series with significant inductance. That L is the result of both the length of the upper capacitor and the length of PC board required to reach the capacitor. The upper capacitor has a similar jaded viewpoint of a lower cap.

The upper capacitors were removed and replaced by parallel capacitors that are very close to their identical twins, resulting in the following layout.

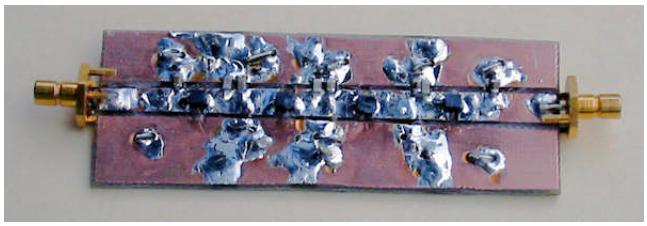


Improved layout.

The result are now much better, as shown below. A filter photo is also shown.



Response with improved layout. The loss in the SMT inductors is evident.



The final filter.