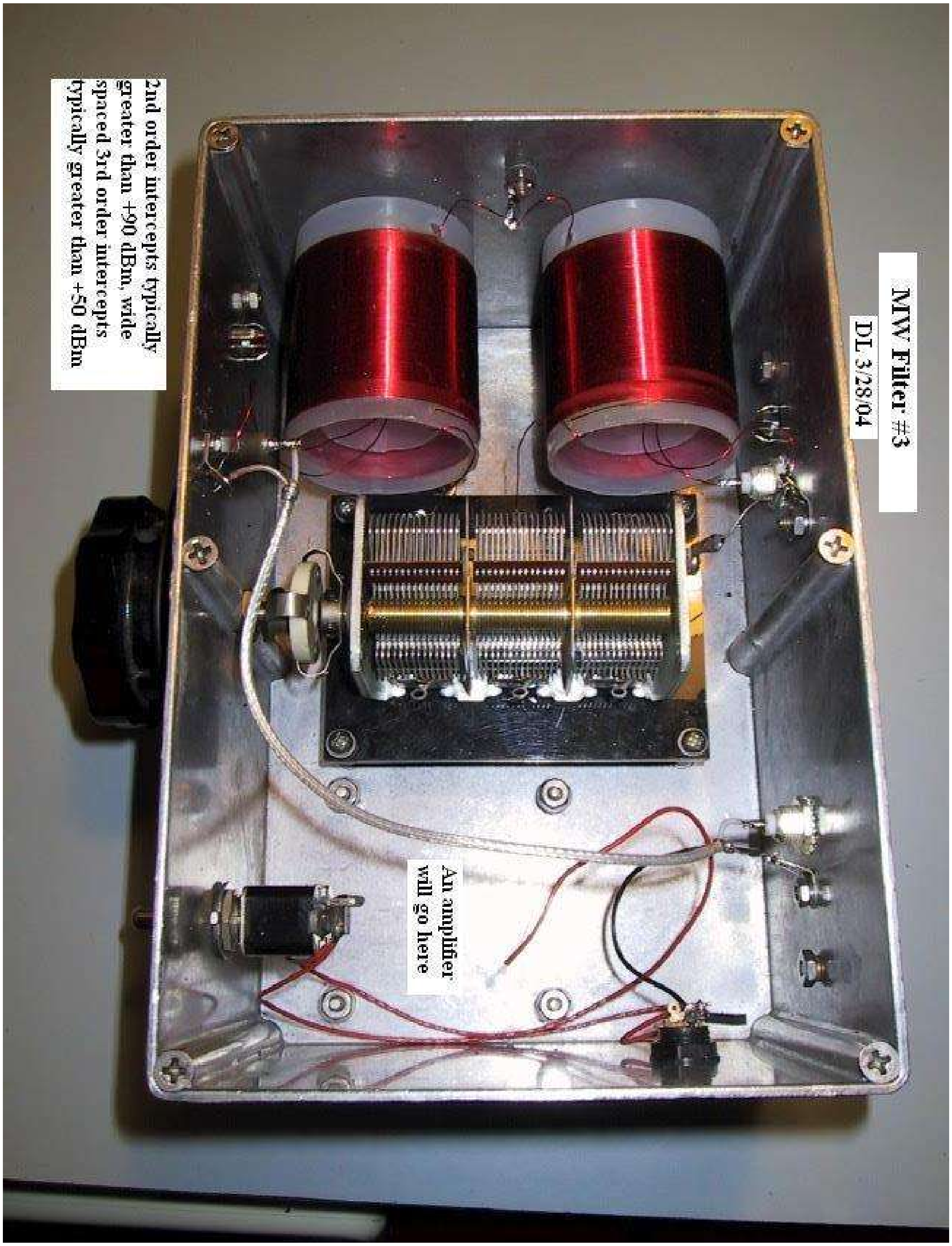
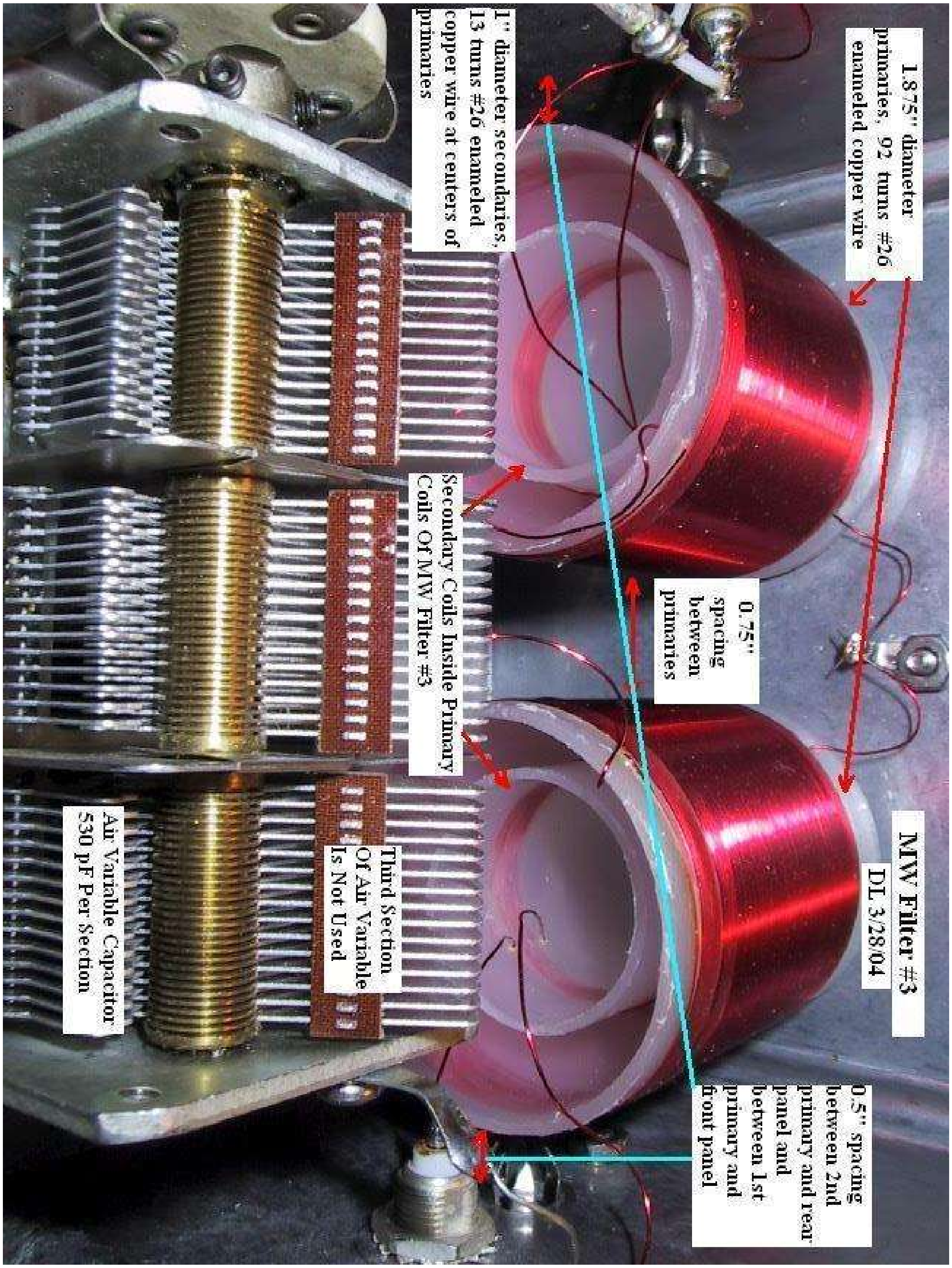
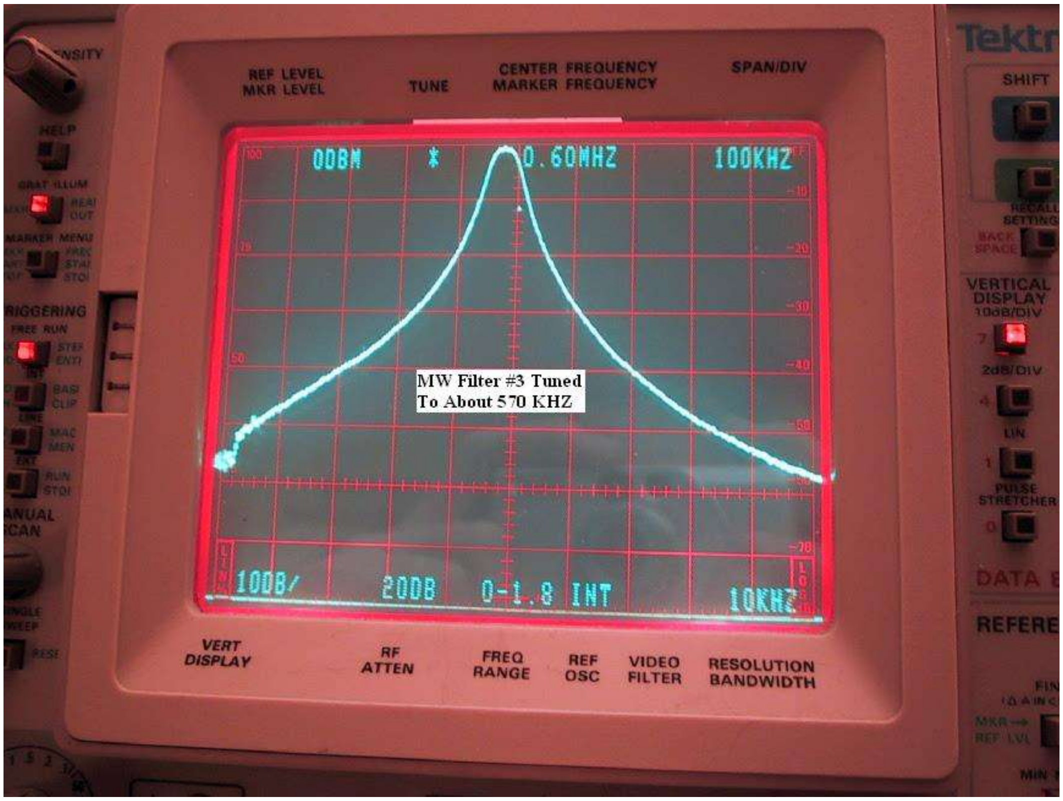
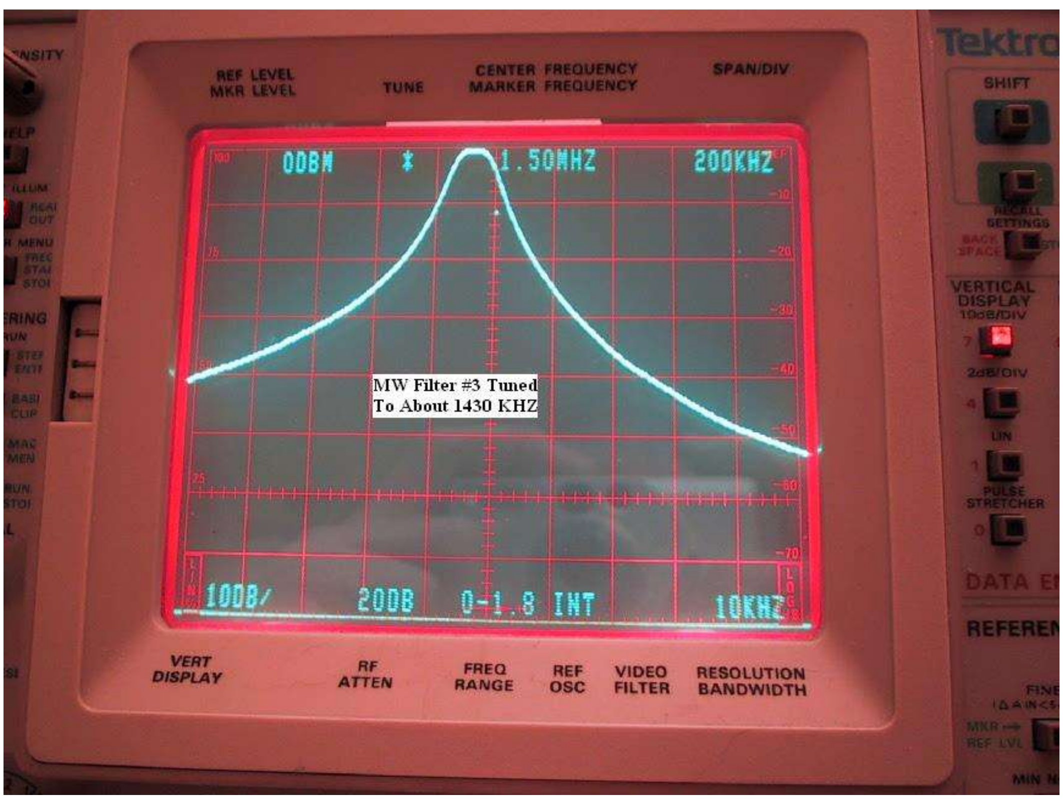
MW Filter #3 **Dallas Lankford, 12/4/05**




1.875" diameter primaries, 92 turns #26 enameled copper wire
MW Filter #3
DL 3/28/04
0.75" spacing between primaries
0.5" spacing between 2nd primary and rear panel and between 1st primary and front panel
1" diameter secondaries, 13 turns #26 enameled copper wire at centers of primaries
Secondary Coils Inside Primary Coils Of MW Filter #3
Third Section Of Air Variable Is Not Used
Air Variable Capacitor 530 pF Per Section

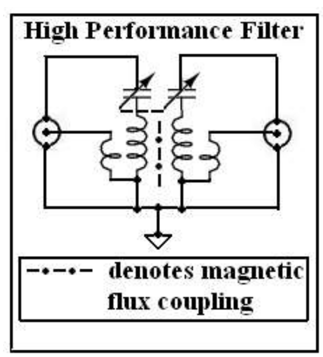

MW Filter #3 Tuned
To About 570 KHZ
0DBM
0.60MHZ
100KHZ
10DB/
20DB
0-1.8 INT
10KHZ


MW Filter #3 Tuned
To About 1430 KHZ
0DBM
1.50MHZ
200KHZ
10DB/
20DB
0-1.8 INT
10KHZ

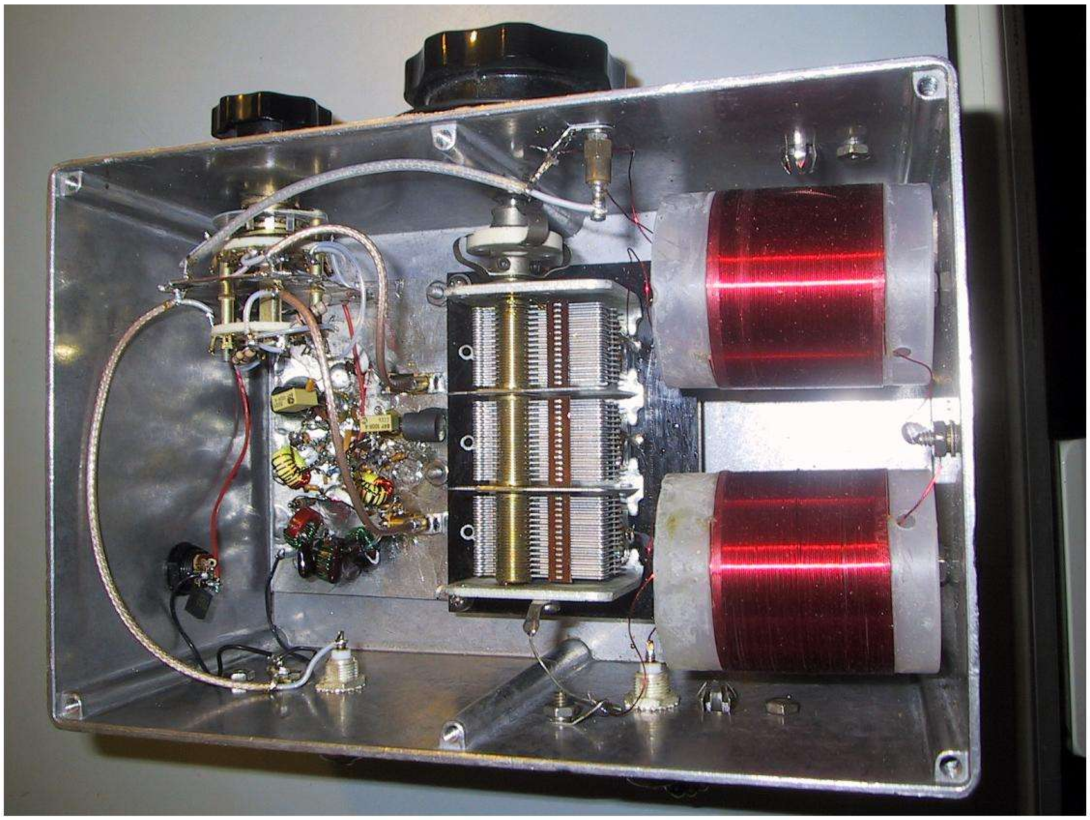
This note describes an ultra high performance tracked tuned filter for the MW band. I have designed and built similar filters for the SW bands up to about 35 MHz. Originally I developed these filters to entertain myself. But when I read recently of intermodulation distortion (IMD) problems experienced by various DXers, at beverage sites and elsewhere, it occurred to me that this filter might reduce or eliminate such IMD.

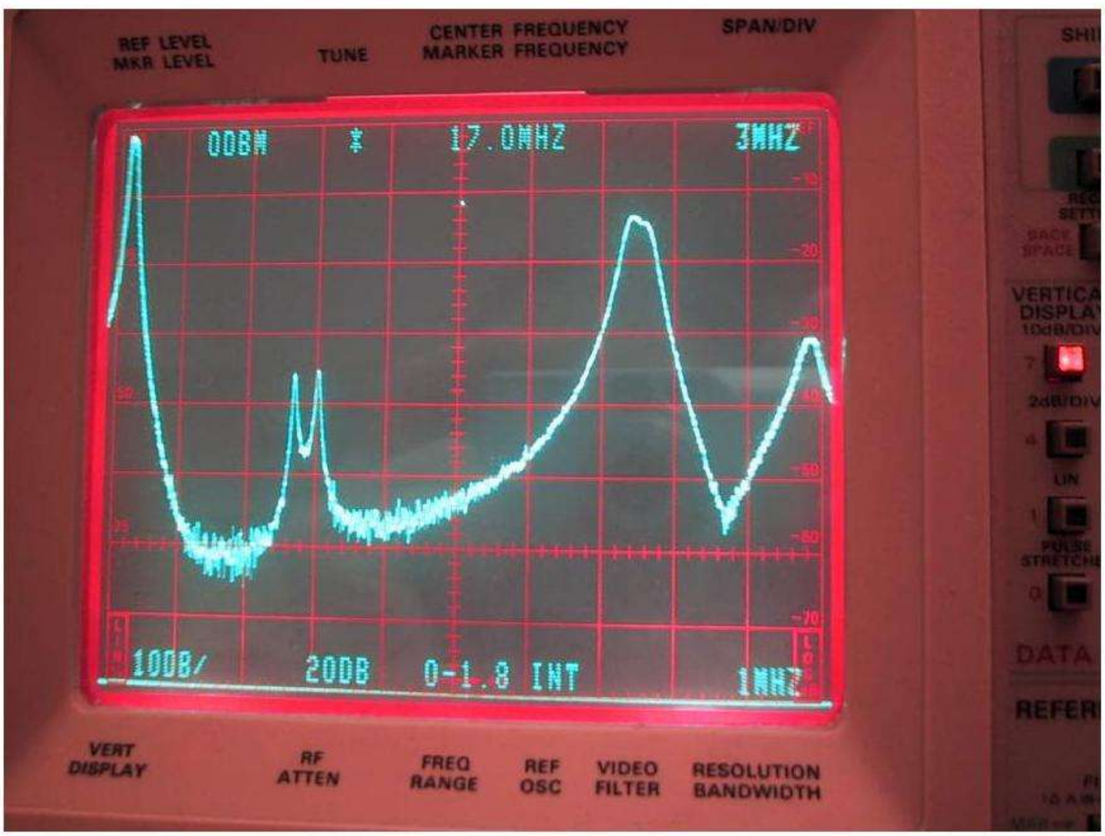
Second order IMD is inherently wide spaced, such as 600 + 700 = 1300 kHz (for example, very strong signals on 600 and 700 kHz might combine and be heard when you tune to 1300 kHz). A filter like the one described here can reduce or eliminate 2nd order IMD. Third order IMD may be close spaced, wide spaced, or anything in between. There is little you can do about close spaced 3rd order IMD other than buy or build a better receiver, or use a high performance phased antenna array. But a filter like the one described here can reduce or eliminate wider spaced 3rd order IMD. As mentioned above, the 2nd order input intercept (IIP2) of this filter is typically greater than +90 dBm, while the sufficiently wide spaced 3rd order input intercept (IIP3) is typically greater than +50 dBm (for example, with tones at 1100 and 1600 kHz and IMD3 at 600 kHz). Insertion loss of the filter is typically less than 4 dB.

The filter was built in a recycled metal box - www.mouser.com Mouser # 400-4589, mfg. Deltron, 8.7x5.7x4.2 inches - which had been used for a previous project. The air variable tuning capacitor is a triple section 13 - 500 pF - secure.tubesandmore.com Antique Electronic Supply # C-V500-X3 - left over from the previous project. Only two sections were used, the air variable need not be isolated from ground as shown in the photo above, and an insulated flexible coupler also need not be used. But, the indicated spacings between the large air core inductors (between the two inductors, between each inductor and the walls of the metal box, between each inductor and the air variable capacitor, etc.) and between the primaries and secondaries should be duplicated closely, if not exactly; otherwise the filter performance may be degraded. Coil form sizes, numbers of turns, geometries of the primaries and secondaries, and other spacings are given in the 2nd photo at the beginning of the article (above). Filter shape factor and insertion loss depends on duplicating those measurements very closely, if not exactly. The coil forms are pill bottles, standard sizes (I assume), with the larger 1.875" diameter by 2.75" long, and the smaller 1" diameter by 2.5" long. The finished coils were mounted to the side of the metal box with 6-32 machine screws, flat washers, split ring lock washers, and nuts. The #26 enameled wire of the windings was brought through tiny holes drilled in the pill bottles at appropriate places. The final 10 turns or so of the windings on each of the ends were affixed with bee's wax (pinch off a little wax, press it onto the windings, and heat with a hair dryer until it flows... you can see the bee's wax on the big coils in the 1st and 2nd photo above).



The filter is a double tuned parallel LC tuned circuit, with air core inductors, each with a secondary and primary. It uses magnetic flux coupling between the two parallel LC tuned circuits rather than capacitive coupling which is almost always used in such double tuned parallel LC tuned circuits. The magnetic flux coupling accounts for the superior shape and stopband attenuation of this filter. This also accounts for why the filter geometry is so critical in determining filter shape, insertion loss, and stopband attenuation; small changes in the inductor dimensions or positions relative to each other or relative to the metal box or capacitor may cause large changes in the magnetic flux coupling. The filter is symmetric; either end may be the input, in which case the other end is the output.





REF LEVEL
MKR LEVEL
TUNE
CENTER FREQUENCY
MARKER FREQUENCY
SPAN/DIV
0DBM
17.0MHZ
3MHZ
10DB/
20DB
0-1.8 INT
1MHZ
VERT DISPLAY
RF ATTEN
FREQ RANGE
REF OSC
VIDEO FILTER
RESOLUTION BANDWIDTH

This filter is called MW Filter #3 because it is the 3rd one I built. Why there were two others and the details of the first two need not concern us here. The photo below shows the completed MW Filter #3. The output of the filter is switched through one of 3 paths: (1) directly to the output, so that the net gain is about - 4 dB (the filter insertion loss), (2) through a 11 dB gain push-pull Norton amp, followed by a 3 MHz low pass filter, followed by a 5 dB attenuator, so that the net gain is about 2 dB, and (3) , through the 11 dB gain push-pull Norton amp and 3 MHz low pass filter but with no attenuation, so that the net gain is about 7 dB. The 3 MHz low pass filter is used because of the relatively low stopband attenuation at some higher frequencies as shown in the spectrum analyzer scan from 2 to 32 MHz in the photo above. The 3 MHz low pass filter was not used with the first (bypass) position in order to make the unenhanced filter available for potential further development. I have not observed any spurious responses without the 3 MHz low pass filter, but an ounce of prevention is worth a pound of cure. If you don't want to build your own push-pull Norton amplifier, you can buy one from Kiwa Electronics, Broadband Preamp *Version 2.0* (remove it from their metal box and put it in you MW Filter #3). A push-pull Norton amplifier is probably overkill; a single Norton amp, or any other reasonably good amplifier would probably suffice. The filter shape and stopband attenuation greatly enhance the 2nd order and wide spaced 3rd order performance of any amp or receiver. The 3 position switch of this version is not necessary; I have used it only to evaluate various configurations quickly. In my opinion, the appropriate configuration consists of the filter, a push-pull Norton amplifier, and a 5 element 3 MHz low pass filter.

As an example of how MW Filter #3 may be used to enhance the performance of a receiver, I recently used it (with position 2 = 2 dB gain) with a receiver having +15 dBm IP2 and 0 dBm IP3. MW Filter #3 increased the intercepts to about +78 dBm IP2 and about +42 dBm wide spaced IP3. The system sensitivity remained about the same.

I have built two other similar MW filters, both with (smaller) 1" diameter primaries, which will fit into smaller metal boxes, and one with (simpler) primary and secondary wound on the same 1" diameter coil form. These will be described in another article.