Modifying the ICOM 7100 and 751A for LF Operation

by W8JI 1/14/2022

We have a very low-power restricted antenna amateur allocation at 470kHz or 630 meters.

After modifying my IC7100 for LF by standard published diode mods and changing four .0068uF in the PA section to .1uF (in parallel), measurements proved the output transformer iron was inadequate for 500kHz operation. Although approximately 15-20W was obtained at 475 kHz, it required 150 watts dc final input power. This left ~130 watts of heat in the final transistors, mostly in just one PA transistor! The other disadvantage was the lack of a receiver input.

IC7100 Changes

Initial measurements were made before capacitor changes at test points shown:

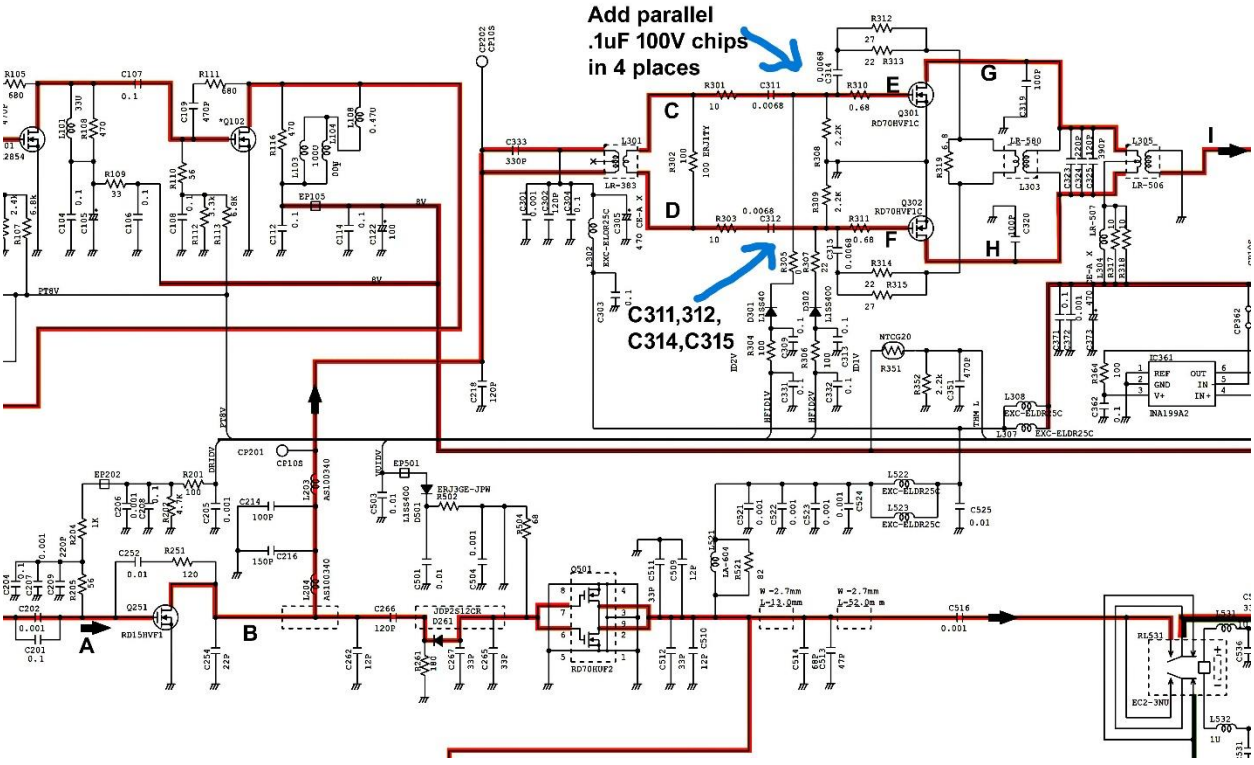

Figure 1 IC7100

Note: Oscilloscope voltages are not calibrated, and are for ***waveshape only***.

In all cases point A was a good sinewave. This indicates preceding stages are all clean:

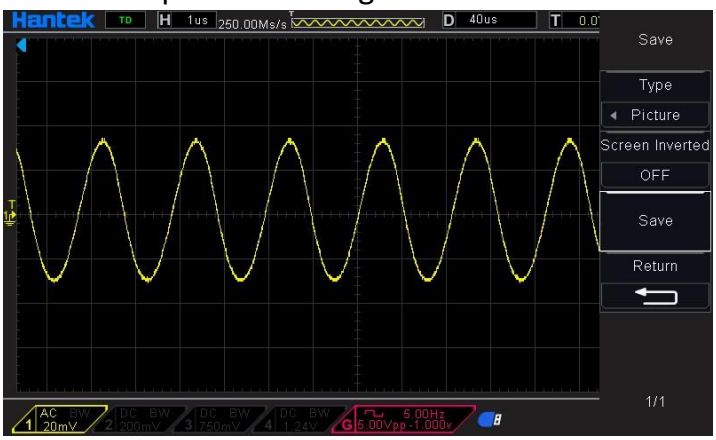

Figure 2 Point A

The drain of Q205 was a clipped sinewave, as expected for class AB single-ended operation without a high-Q tank. This waveform held true at points C and D, indicating normal driver stage performance:

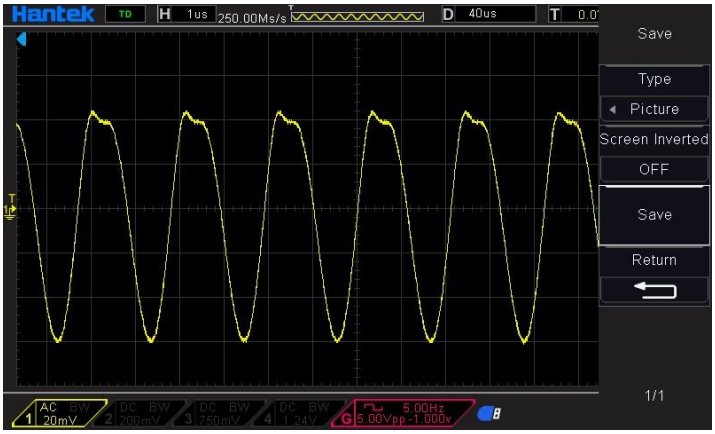

Figure 3 points B, C, and D similar

Major distortion with harmonic level enhancements occurred at the gates and drains of Q301 and Q302. E and F showed a radical waveform change with high harmonic levels

typical of this at E and F:

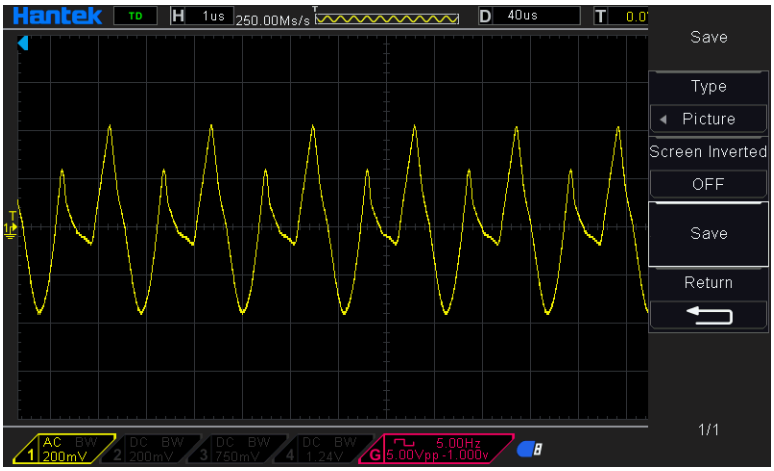

Figure 4 E and F typical unmodified

At the PA drains G and H:

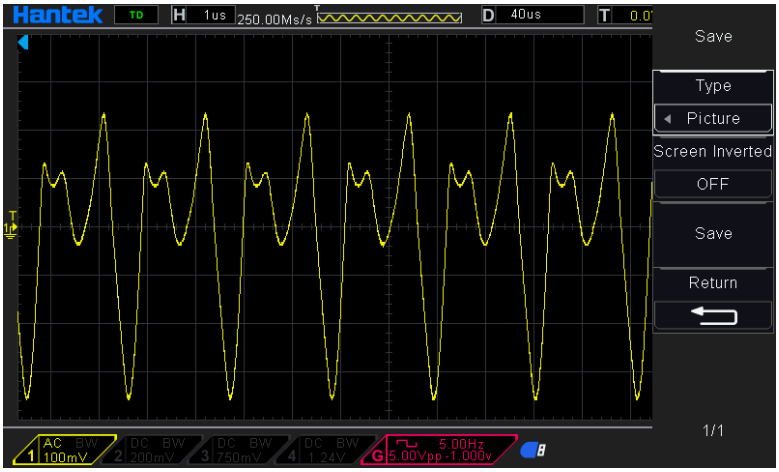

Figure 5 Drains Stock 7100

Changing C311,312, 314, and 315 by adding a 100V .1uF chip across the tops of existing .0068uF capacitors resulted in no measurable change in the PA at 160 meters and higher but cleaned up the waveform and reduced harmonics substantially. Unfortunately, the lack of proper iron makes the waveforms at Q301 and Q302 drains very much different.

Lack of efficiency and uneven PA transistor dissipation, along with the lack of a receive antenna input, caused me to investigate an old IC751A in my barn. The 7100 works, but not that well.

IC751A

IC-751A's served as my main radios in the 1990's. They were simple to repair, modify, and performed quite well for the day. Internet searches for LF mods revealed nothing. My IC-751A's are outdated, and not even used as test bench radios. While I retained full HF performance, I may eventually optimize the PA section.

Being an HF-only radio, I assumed the IC751A would be better at 470kHz performance. This proved correct. Circuit complexity dragged the modification discovery time out to several hours.

The 751A, being from late discrete component and early IC and processor days, is rather complex. The modification is not difficult, it only takes a handful of cheap components. The difficult part was learning the circuity.

Clipping one resistor at the front panel bottom allows general HF band transmission. This "CAP/MARS" mod is everywhere. My radios were already modified in this regard.

The IC-751A has filter band data supplied on an 8-pin DIP male connector plug to J3. The brown lead at the end, next to orange and yellow, is the LF filter selection. While I initially experimented with those leads, they can be left alone.

The factory low pass filter is asymmetrical, has a good bit of loss (about 10dB), and thus needs to be rebuilt. The 22uH inductors are perfect, only the capacitors need to be removed and replaced. The filter can be corrected with small chip capacitors under the board. I chose temperature-stable chips over mica or disc ceramic because they have very low loss and fit the location.

Moving one filter output wire, clipping a diode, replacing a choke, and updating the filter are all that are required. The result is an easy 30-watt output radio on 472kHz, and it has an external RX antenna port. While the output needs an outboard filter, it is far cleaner than the IC7100. To this writing date, I made no attempt to further improve PA efficiency. My radio has an abundance of drive, it simply lacks efficiency.

Modification Steps

Remove the case and the metal shield held by one screw to expose the RF board. Pull the plugs and screws, flip the board for access to both sides. Watch out for the ferrite ring over the transformer at the front edge. It is a loose fit and falls off. If you lose it the transformer will not tune! This is a topside view of LF mods.

Cut the diode(s) and remove all capacitors related to the LF filter:

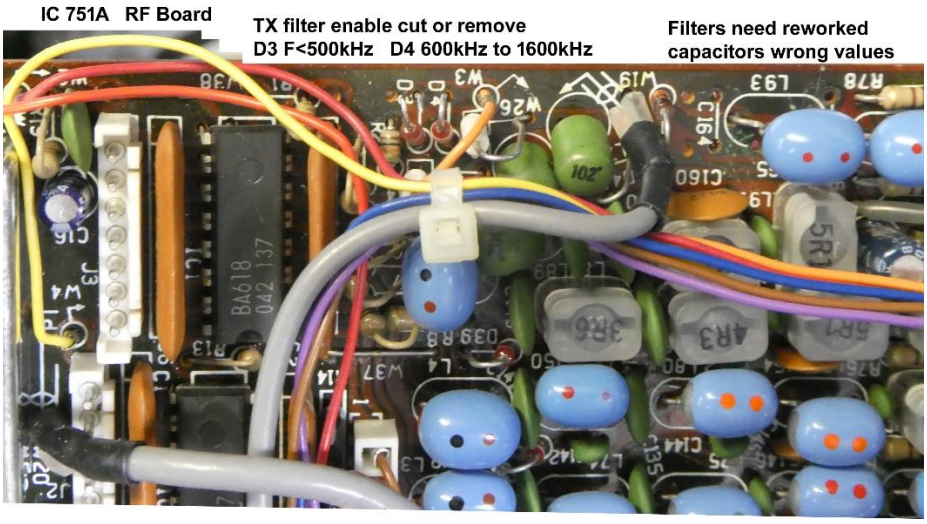

Figure 6 filter mods IC751A LF

Clean the board off, scrape the solder mask where necessary, and install temperature-stable 50-100Vdc chip capacitors:

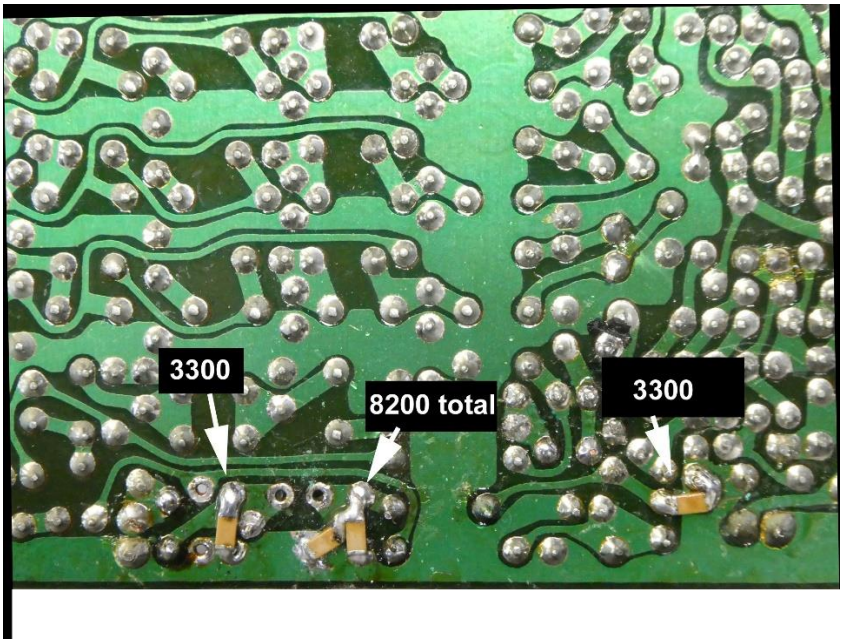

Figure 7 LF filter mod IC751A

L102 needs updated to 68uH or greater, being mindful of DC resistance and impedance across all of HF:

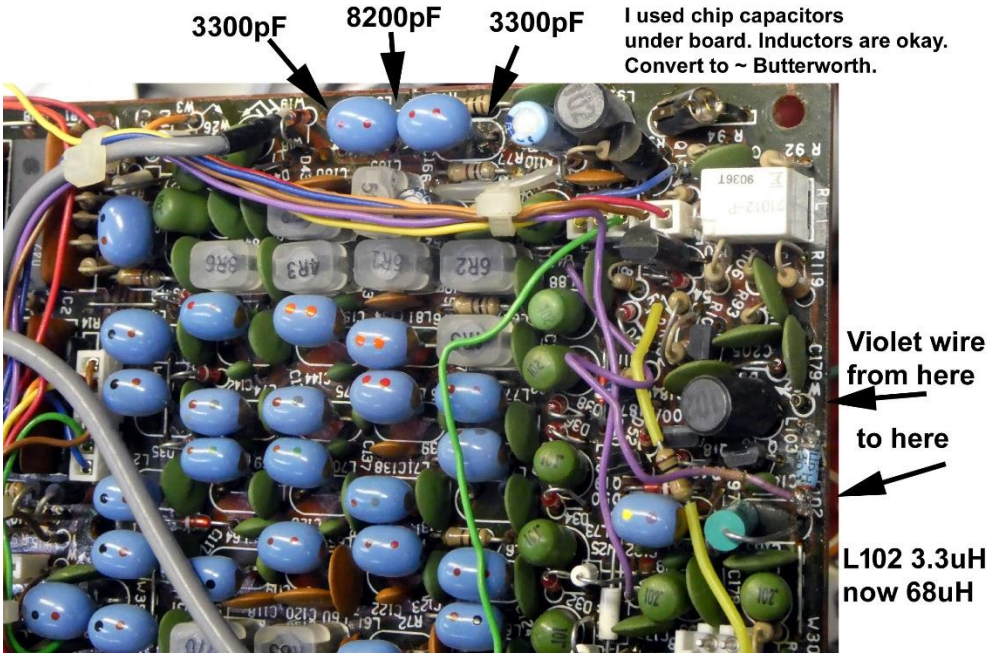

Figure 8 IC751A LF mods

I jumped out the attenuator in the BCB filter in case eventually I wanted to clip diode D4 and transmit in band 2:

Convert to 5-pole using existing inductors
3300pF end 1 (XR7 chips below board)
8200pF mid-section
3300pF end 2 Also clip D3 and L102 becomes 68uH high-Q

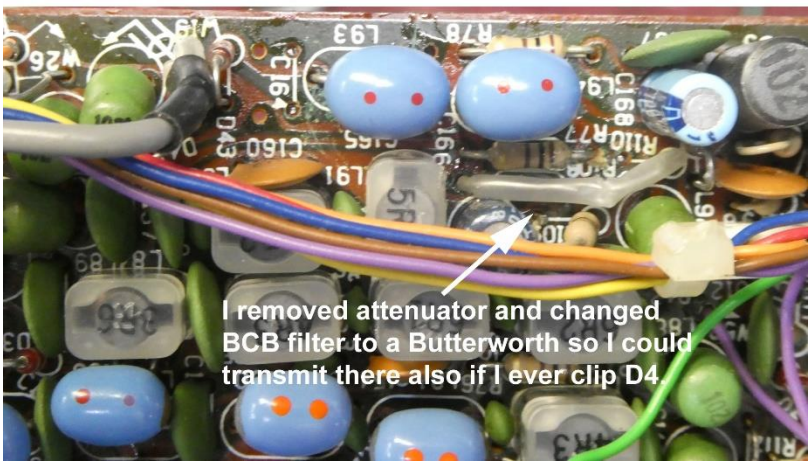

Figure 9 IC751A BCB filter

Transmitting Low-Pass Filter ~500kHz

My low-pass filter is a 5-pole “near-Butterworth” design. My design calls for two 3300pF and one ~9,000 pF capacitor in the center I use to “trim” the filter. The inductors are 23.5uH.

Fair-rite 5961002701 cores offer maximum temperature stability, minimal turns count, and very low loss. About 20-inches of #16AWG wire comprising 13-turns calculates as 23.66uH. In practice by spreading or compressing turns, I was able to get right at that value.

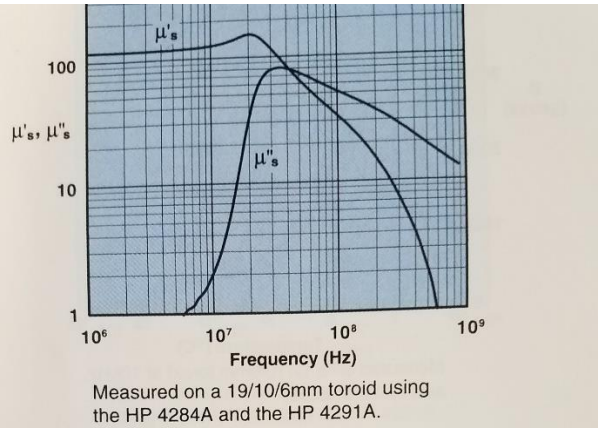

Figure 10 loss resistance vs. inductance curve 61 material

Fair-rite Corp’s data shows Q=1 at 13MHz. I measured Q in the 300 range at 475 kHz, making these very good inductors.

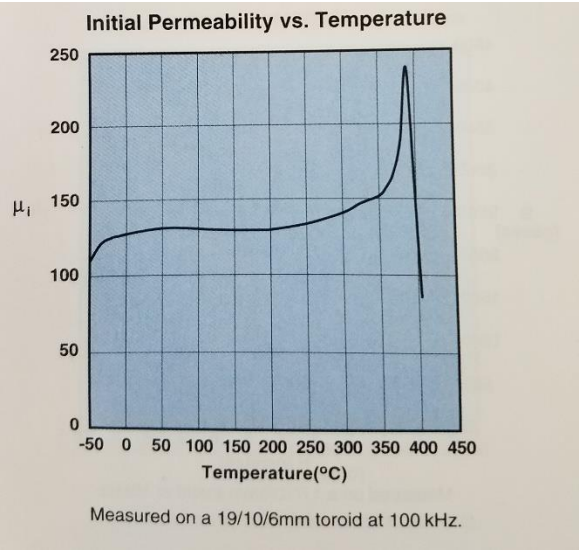

Figure 11 61 material ui vs temperature

The flat ui vs. temperature indicates the cores should be fairly stable over wide temperature ranges, only changing a few percent at room temperature.

I trimmed the center capacitor value for lowest loss and flattest SWR across the 472-479 range while maintaining an acceptable roll-off. These are my measured results:

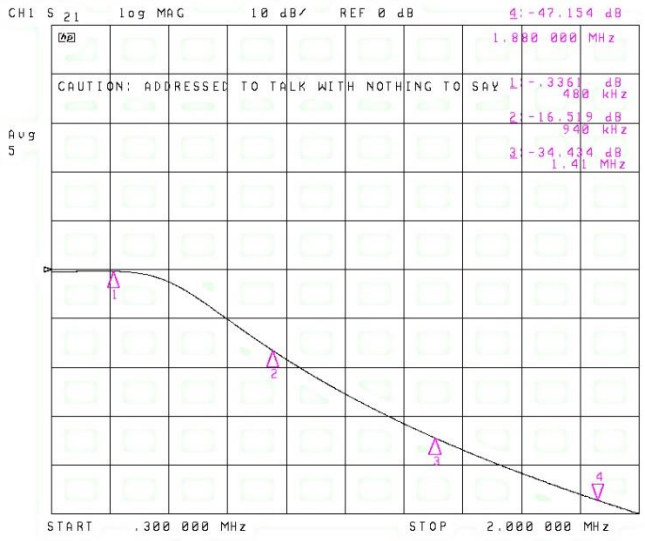

Figure 12 measured attenuation 550kHz low pass

By adding a single series-resonant notch with residual capacitance nulled out, I could obtain 2nd (or 3rd) harmonic attenuation better than 40 dB:

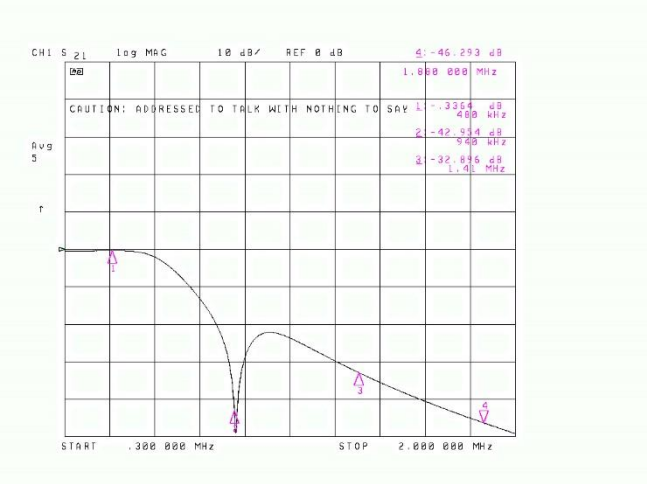

Figure 13 additional notch

My final filter was built in a scrap TVI filter case (ignore the writing). This case has been many things over the years, including being a switched matching network for a G5RV to be a “T” antenna for 160M.