May 2022 r2

Tube Transmitter, NRR, and Two VFO's

My tube transmitter project has predictably morphed into a more complicated project, as expected.

Recap: A radio chum, Roger, VA1RST was showing me his selection of vintage tube gear and told me about the Novice Rig Roundup activity. This is a week long event aimed at vintage crystal control tube rigs and homebrew tube gear. Sounded like a good excuse to work my transmitter along with the companion Heath SB310 used as a receiver with the transmitter.

Since I didn't consider this NRR event when I built the transmitter , there were a few design and feature shortcomings. The original rig works on 80,40,30 and 20M with fundamental crystal control. It put out an honest 45 watts and worked very well. Interestingly, I found little activity with vintage radio gear on 20M CW. It all seems to concentrate on 40M mostly, some 80M and ….15M ! With sunspot activity increasing the solar flux index, 15M has darned good openings. It makes sense for NRR as 80,40 and 15M had specific novice class CW segments. Thus any classic novice activity would be on those bands. The NRR event concentrates point awards on these three bands, utilizing crystal control rigs. There are lesser points for any rigs with a VFO.

I had been planning a VFO, and after the 2022 NRR week, I decided I needed to be on 15M as well.

<u>First, the VFO #1 project</u> (there is a VFO #2)

I had this working before the 2022 NRR and it worked fine on 80 and 40M. Theoretically it's 40M harmonics would be suitable for 15M as well. Studying my treasured 1954 Radio Amateur's Handbook lent some excellent ideas for VFO's. After looking through my tube and parts stash, I decided on a 5763 oscillator with an OA2 to stabilize its plate and screen voltage.

Here is the circuit I settled on after a lot of trial and error:

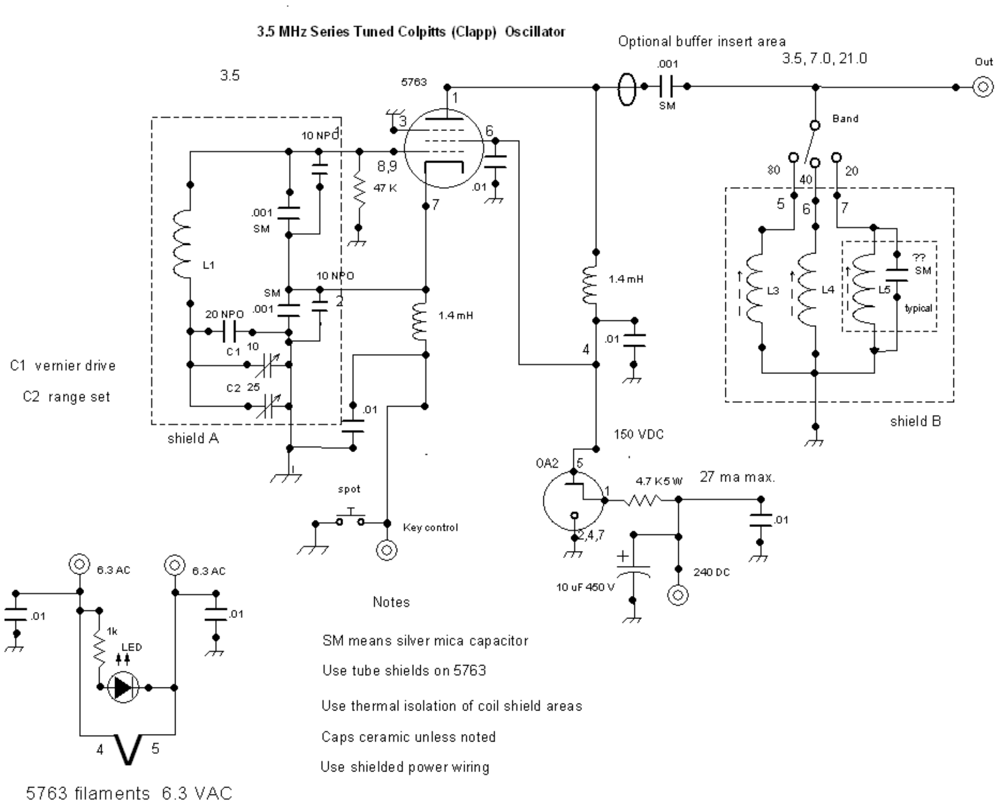

Figure 1 Final VFO schematic

To keep the thermal drift down, I made compartments in my VFO box to separately house the tube , the main oscillator coil and capacitors and the output tanks.

The dividers are double sided PC material.

Figure 2 The usual breadboard proofing

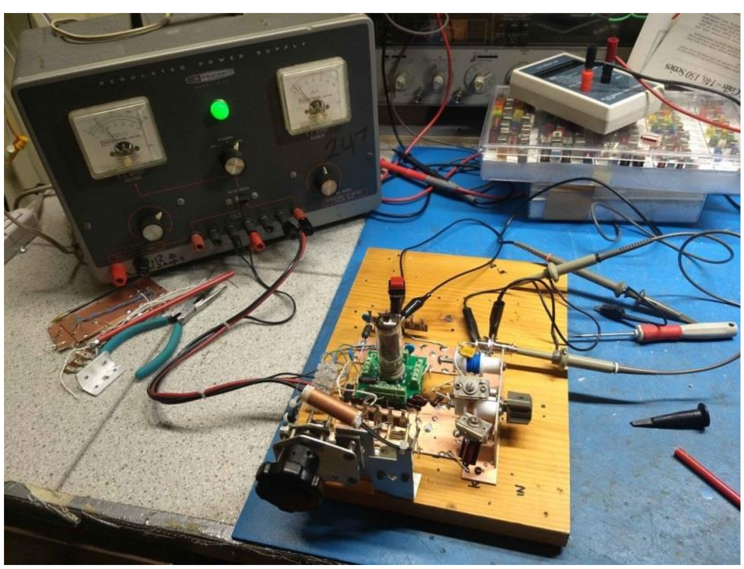

Figure 3 Internal dividers and oscillator coil/cap compartment

Figure 4 Testing output range with a receiver

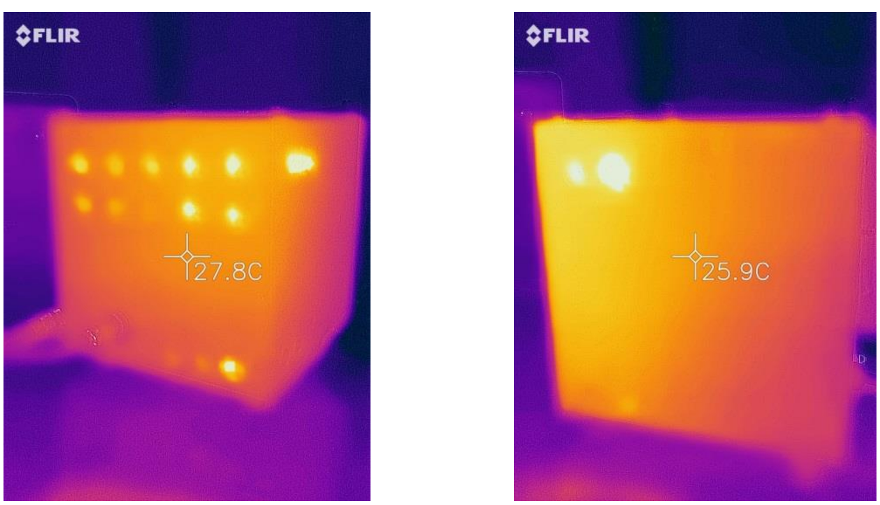

Figure 5 Thermal scans of back and side

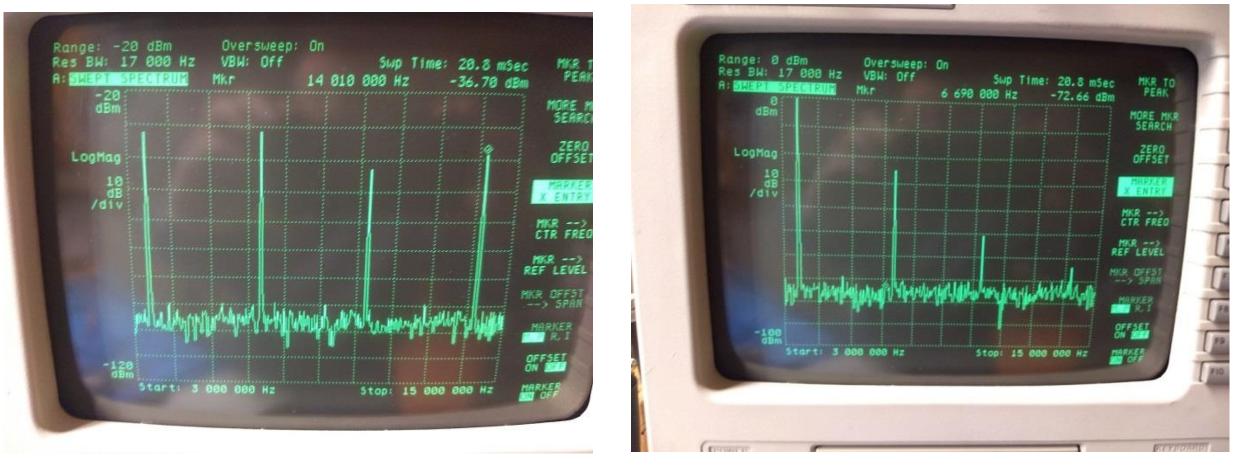

Figure 6 Left, output with no tank. Right, output with 80M tank engaged

Figure 7 Tx and VFO in operation

Performance: the VFO works very well on 80 and 40M, and the harmonic capability for 20M was OK, (since removed, see next section on the 15M change). The unit has plenty of drive to drive for the oscillator and subsequent 6CL6 driver tube. The addition of a few NPO capacitors, some additional cooling holes, and the use of a VR OA2 tube to supply plate voltage to the 5763 oscillator all contribute to stability. I cannot hear any chirp when I listen to the signal off the air. Mostly I zero in on the right frequency by using the spot function and listening on the receiver.

Next, the 15M addition:

My built in 4 band switch had 20M in the highest frequency position. It seemed reasonable to me to drop the 20M position in favour of 15M. This turned out to be a non trivial procedure.

I had lots of little issues trying to get this rig to put out some signal on 15m. I have one 15 M crystal. I did get it all working but can only get 15 watts out of the tx. This turns out to be plenty to make contacts when used with my Steppir 2 element yagi and RBN tests lit up beacons out to the West coast and all over Europe.

The problem with more power seemed to be focused on not quite enough drive signal on the 6146. I had added an external grid current meter to monitor drive current. The 6146 puts out 45 watts with a 1.5 mA drive, but the best I could get from the oscillator and driver tubes (both 6CL6's now) was around .8 mA. I tweaked up the oscillator and driver tanks, and modified taps on my PI-L output tank but 15 watts seems to be it.

The only hope for more drive resides with an external VFO.

While inside the tube transmitter chassis I also added a screen drive control for the 6CL6 driver, which turned out to be of marginal utility. I usually run the drive at the maximum level which seems like the right amount to force the 6146 into class C bias.

I also added a missing output safety choke across the load capacitor. I did not have a suitably sized one during the construction. These things are getting a little scarce. I could have made one but it would be physically a little large for the available space in the tank compartment.

Back to the VFO(s)

Next, I built up a dedicated tube VFO with a 6AU6 oscillator , an OA2 regulator and a 5763 buffer amplifier, with the hope being I could get a little more 15M fundamental drive.

Figure 8 The external crystal oscillator and buffer

While it worked fine as a crystal controlled oscillator, it didn't help produce any more drive than what was available in the tube transmitter.

I next checked out both 40M 3rd order harmonics from the tube VFO and the above separate oscillator. In both cases the harmonic levels were not high enough to drive the transmitter. Even with the use of 15M tanks after the oscillator and buffer stages.

I added a switch selectable 15M tank in the transmitter oscillator compartment and while that helped a little, the harmonic energy was still not large enough. The 15M tank did help increase the drive with the fundamental 21.060 MHz crystal I have, but it all added up to a 15 watt output.

I decided to let this 15M issue sit for a while as I really only wanted to make some NRR contacts on this band and could do that with the one crystal I have available.

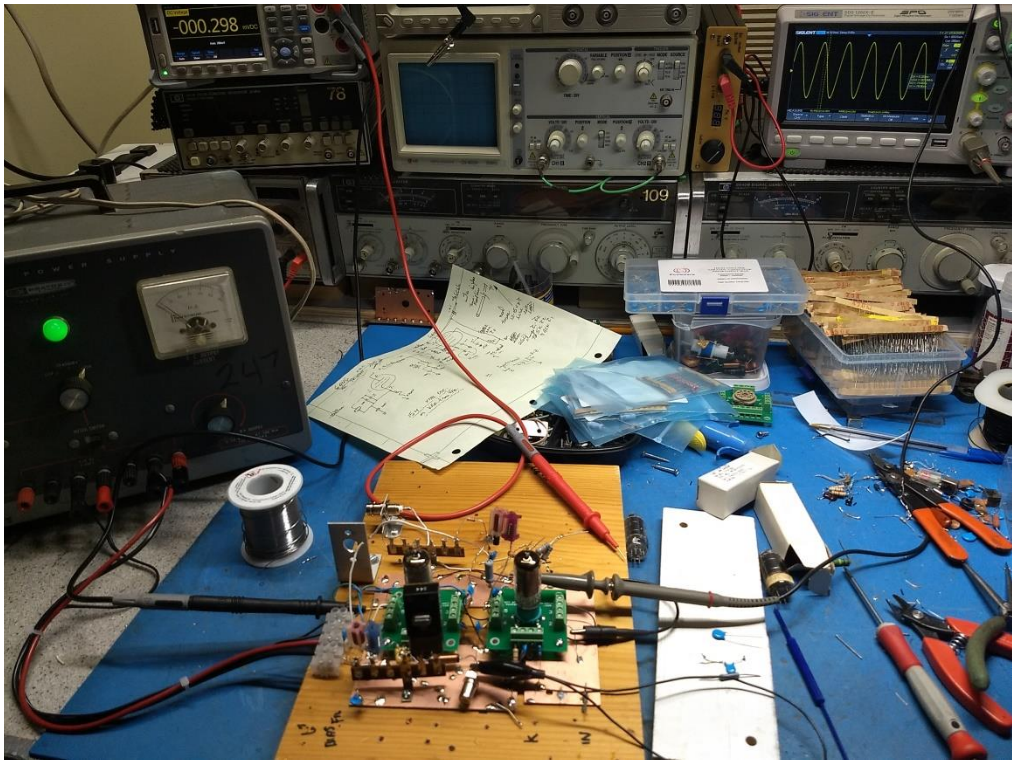

Figure 9 Experimenting with the crystal oscillator circuit for 15M

VFO #2…a solid state version.

A Johnson Viking II is joining my operations in June. Needing a VFO for this unit, and having the tube one available already, I decided to build a solid state VFO.

There is quite a lot of material around on VFO's with a junction JFET (J310 or MPF102) that came from collections of articles produced by Doug DeMaw and Wes Hayward. To drive tube circuits they typically include a buffer stage and an RF driver transistor setup as a linear amplifier. 2N3866's are typically used but I had some 2N5189's on hand from some previous broadband preamp projects and used those.

I settled on a VFO with 3 switch selectable outputs on 160, 80 40 Meters. A popular output idea is to use a 1:4 transmission line transformer on the output to increase the drive level. This feature was included on several articles but none showed enough detail to actually hook this up properly. Interesting. After some experimenting, I hit on the correct wiring method. I will mark it on the schematic when I get it finished.

Getting this thing to be stable and not swing when keyed was a challenge. In the end, the primary oscillator is left running all the time with the output lightly coupled to the buffer stage. I wound up with a nice waveform on 80 and 40 and a slightly distorted waveform on 160. The 160 waveform cleaned up nicely with a simple Chebyshev 3rd order filter, switch selectable from the panel. The 80M output was much higher than the 40 and 160 M output, so I added a switch selectable attenuator from the front panel as well.

There is a compromise on the output transformer core material. I tried type 61 and 43 material and settled on the 43 as producing the best results. On a side note, I am going to try using a 1:4 UNUN on the output of the tube VFO to see how it works to boost drive voltage level, if that turns out to be necessary.

<u>Some features I added:</u>

Power is supplied by either an external 12 Volt supply, or 6.3 VAC rectifier-doubler circuit in the unit. 6.3 VAC is available from both tube transmitters I intend to use this with as a tube filament supply.

Since the main oscillator runs all the time, you can detect this in the receiver on the transmit frequency all the time. To solve that problem, the main oscillator has a 10 KHz offset feature controlled by key line. Per DeMaw and Hayward descriptions in “Solid State Design for the Radio Amateur”.

My unit keys power to the buffer and amplifier stage.

An air variable and reduction drive controls the frequency.

A low priced frequency display module is used to read out the frequency. These things are low priced and do work, but the update rate is very slow. I actually prefer the direct readout pointer display I made for the tube VFO.

I have tested this with the tube transmitter project, and it works fine. While there may be some chirp in the CW note, I can’t notice it my receiver. I keep an FRG7 handy to the bench for testing just this sort of thing during construction.

Construction is a combination of an Eagle CAD/ milled single sided board and some dead bug construction tacked to the main oscillator shields made from PC board.

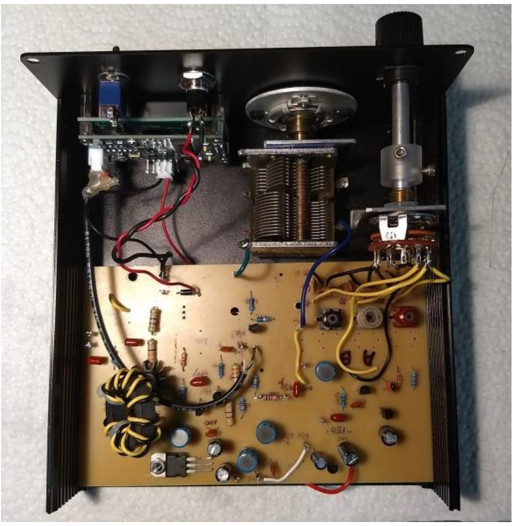

Figure 11 Case layout and main board, not final version of main board.

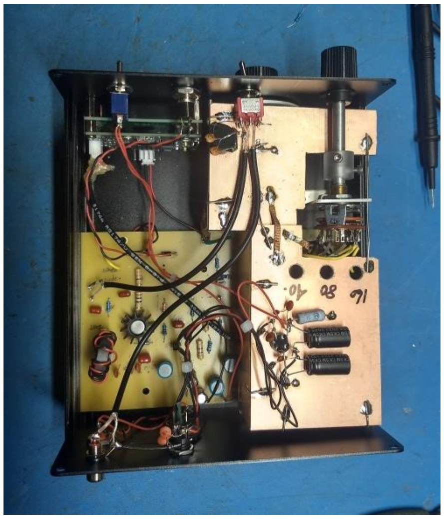

Figure 10 Oscillator shield , power supply and 160 filter

Figure 12 Operating with the tube transmitter

The display was a bit too bright for my cell phone picture, apologies.

My take away on the solid state VFO: this was more complicated and harder to build than the tube version. It does use less power, 100 mA at 12 VDC. It runs cooler and is stable. If you are driving tube equipment with a VFO, it may be easier to build one with a tube oscillator.. My tube VFO project is also stable after a 30 min warmup.