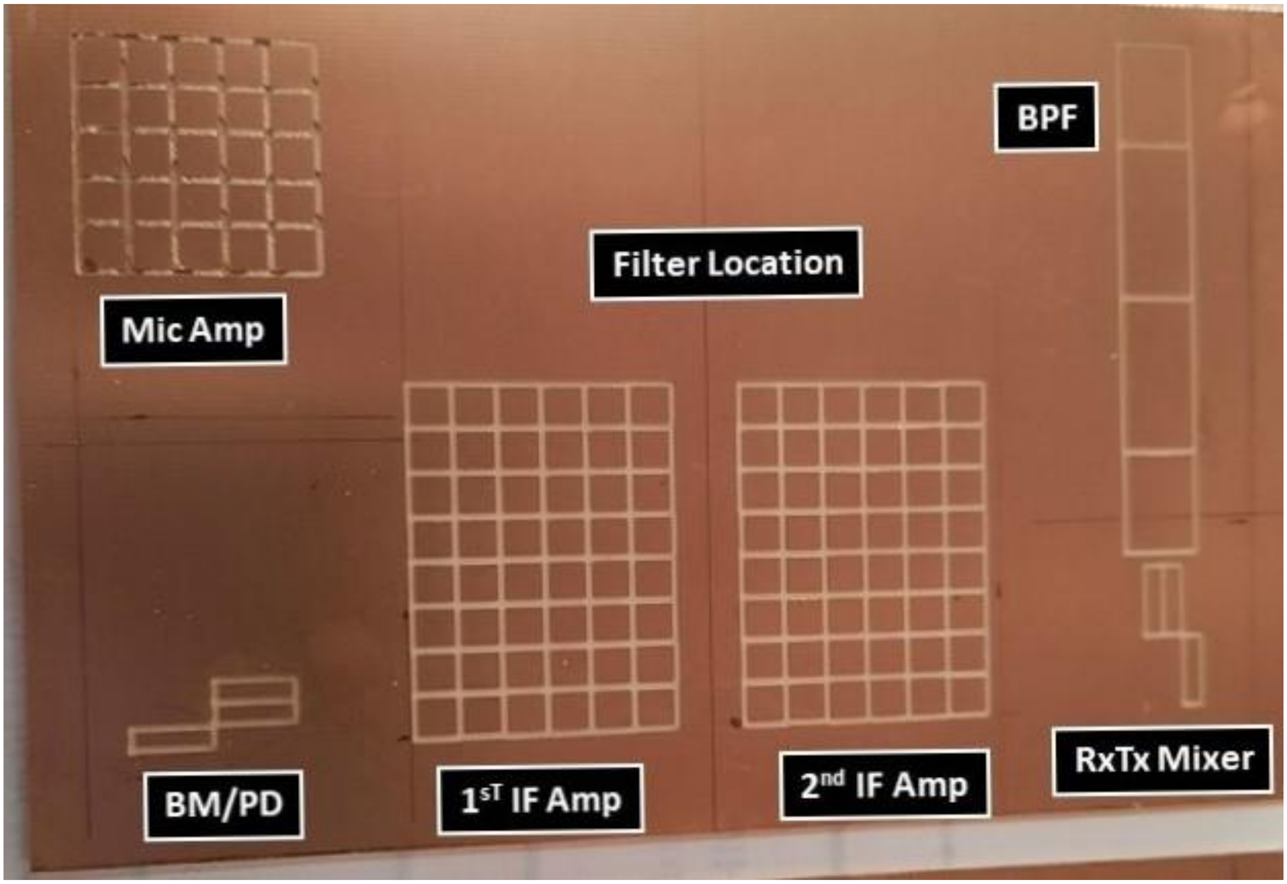
The Next Project… A 2022 Transceiver.

9/27/2022 Where to Start the CNC Design?

I had great success with the mainboard layout used in the P3ST project and so that might be a starting point for the 2022 design. Both are steerable module projects and thus the issues worked out for the earlier project provide a good foundation for the new project. So, in this case throwing out the baby with the bath water is not a good plan.



The P3ST Mainboard

Above is the mainboard from the prior project and actually this is not one single CNC Program as it is actually 6 programs that are essentially "CNC Modules" and this enables me to pick a location on a board to cut a module.

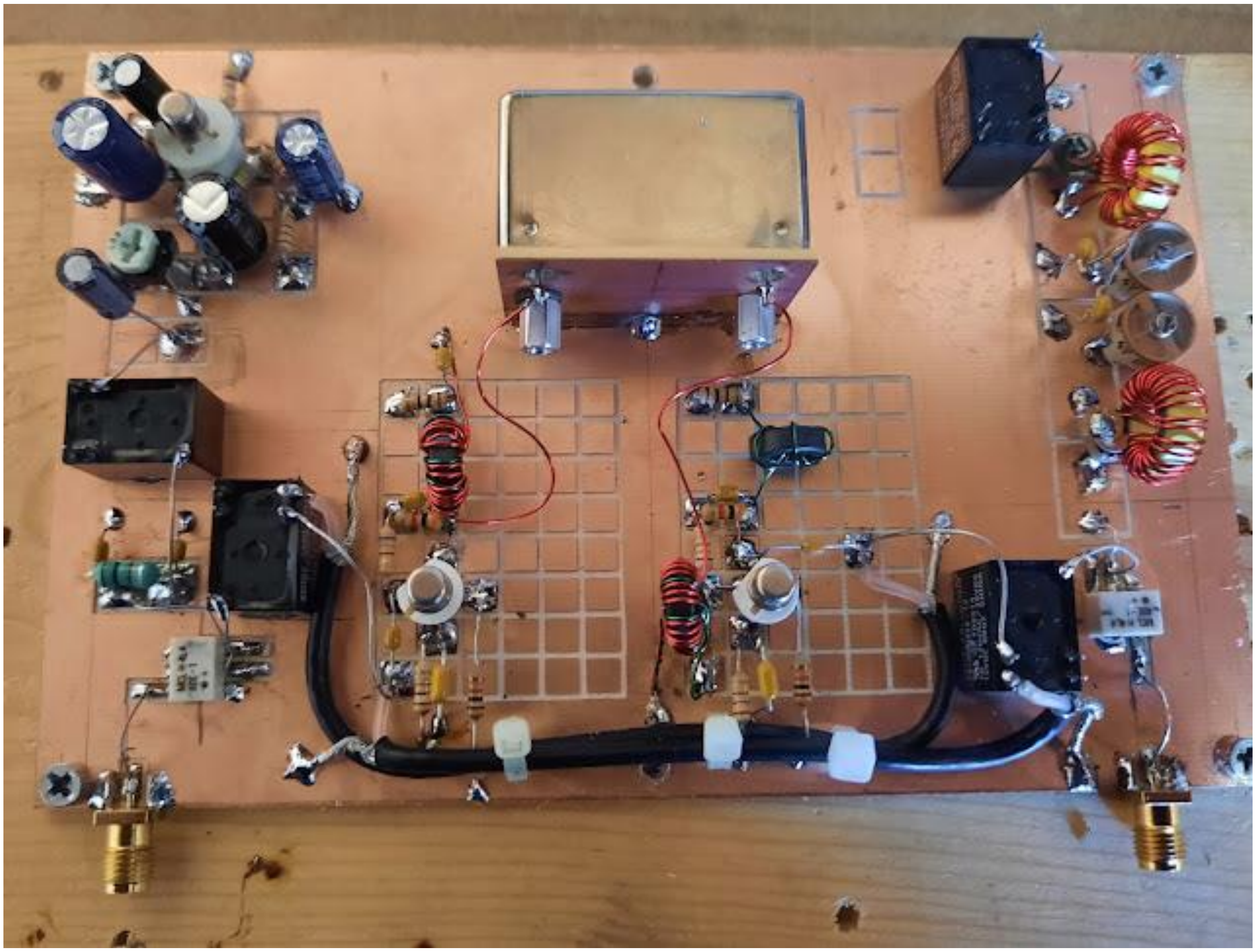
[One of the huge advantages of the island square CNC Modules as opposed to a component specific PC

Board is that I was able to take a board layout from another project and directly adapt that to the new project. This is the heart of "agile manufacturing" --something I picked up when I worked in aerospace.]

Two things have to happen with the 2022 project, and these are:

1. **The P3ST Board was 4 X 6 inches and now I have to go back to the Cookie Tin and determine the size of a board I can shoehorn into the tin. I think the 6-inch dimension is OK, but the 4 inch may be a wee too tight.**
2. **The 2nd task is look at the real estate of what is labeled "1st IF Amp" as this area is now both the Post Mixer Amp plus the 1st IF Amp. This might require adding a few more columns to the pads. Or it might be enough space as is. How we resolve that is to use a piece of graph paper and to add the circuit components to see if a layout can be made within the space confines. We also need a peek at the IF Filter Space to see if the G4CFY filter fits in the open area.**

Here is a photo of the as built P3ST Main Board and look at the open space of the 1st IF Amp ---likely most all will fit in the space allocation. The Crystal Filter may need to be offset to the left (in the photo) but that too looks like a go. Using the earlier work will be a huge time saver!



P3ST Main Board.

The Radio Gods must be beaming down on me as a quick measure of the external dimensions of the Cookie Tin are 4.5-inches X 8-inches. No Board cutting! I will have to accommodate the position of the SMA connectors, but you can purchase vertically mounted versions -- so not a showstopper!

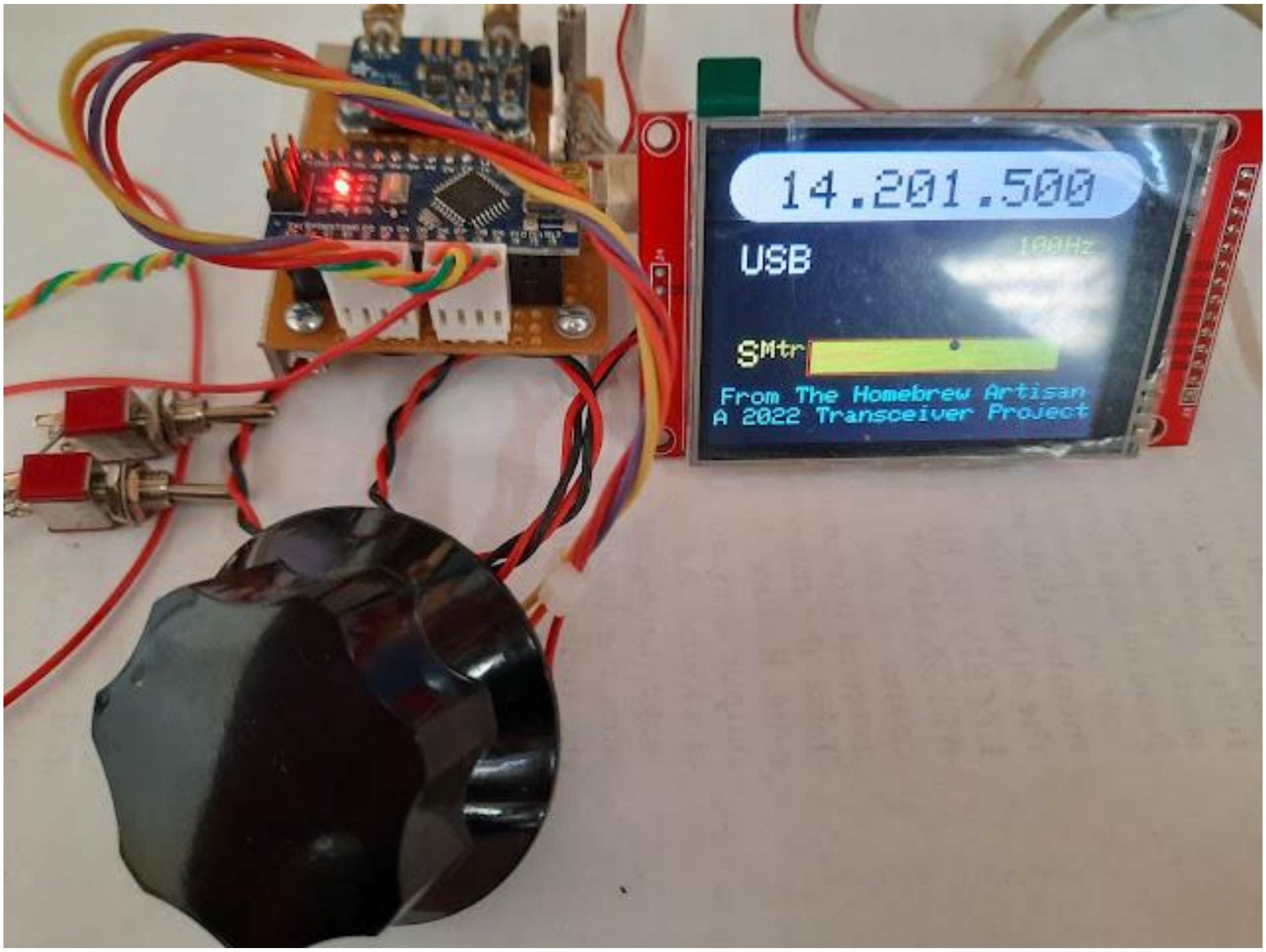
I love it when a plan comes together and sometimes you just need to be clever. Like with Mary Jo, when I stopped talking about the back seat of the 57 VW Beetle, she assumed I had lost interest in her. So after about a month of a cool but polite attitude toward her -- when I suggested the back seat -- she jumped at the opportunity. Clever is, Clever does!

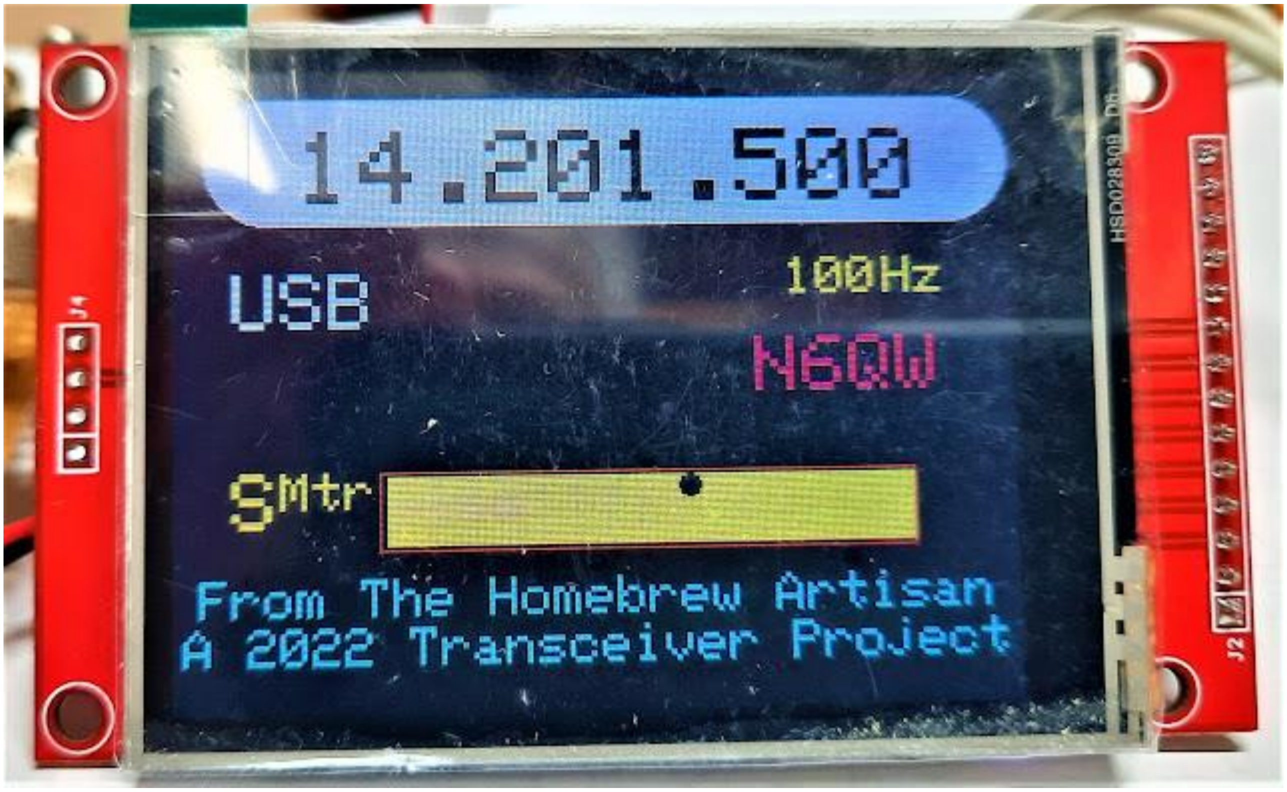
9/26/2022 The Boards for CNC Millings

I hope to start laying out the boards for CNC Milling, so you won't see much change in the postings for several days so keep checking back. Hard to show anything when you have nothing to show.

This is unlike Mary Jo in the back seat of the 57 VW Beetle -- a lot to see.

9/24/2022 The Digital LO/BFO Build!





This is the Digital LO/BFO that will be used in the 2022 Rig. Note the use of Perforated Board, the Sockets, Pin Headers, SMA Connectors on the Si5351 and a Real Knob for those of us who suffer from FFS. I used the 2.2 Inch display as that will fit in the front panel real estate. Already I think this is starting to look pretty cool.

(This is almost as good as getting Mary Jo into the back seat of the 57 VW Beetle -- well almost!)

73's
Pete N6QW

An Updated PDF version of the posts through 9/23 is located on a link at https://www.n6qw.com

9/23/2022 Tribal Digital LO/BFO Knowledge.

Yesterday I had a round of emails on a related subject and thought this might be a good subject for the current blog project.

So, what choices do you have for the actual fabrication?

Immediately when you mention a VFO and construction practices -- my mind regrettably drifts back to the dark days of

Analog VFO's and how the Mechanical Construction was a significant factor of whether or not your VFO drifted like Mary Jo after two drinks or remained on frequency. Surely, we always need to exercise appropriate and proper fabrication methodologies, but there is not so much concern about the mechanical aspect in digital builds as you are stuck with if pursuing the dark side Analog VFO's.

For the most part until you hit the Output Ports on the Si5351 breakout board, all signals are digital! This opens a huge hole on what you can do during the fabrication stages, circuit layout and the methodologies employed.

Some approaches I have used include the use of:

1. Sockets for the Arduino Nano and Si5351 which is huge if you are prone to smoking parts. Blow a Nano or Si5351 simply remove the item from the socket and replace with a

new device. The signals are mostly digital and for the output side you can use the SMA connectors usually supplied with the Si5351 boards. Soldering to the Si5351 pads is acceptable -- but again smoke a part and it is more than simply unscrewing a SMA connector. The sockets are easily used with perforated board, and this offers great flexibility. I have even used single sided copper vector board where the top side of the board is a terrific ground plane. Before inserting the sockets into the single side copper vector board take a 1/8-inch drill bit and ream out the holes a bit so there is no possibility of a socket pin to ground plane short.

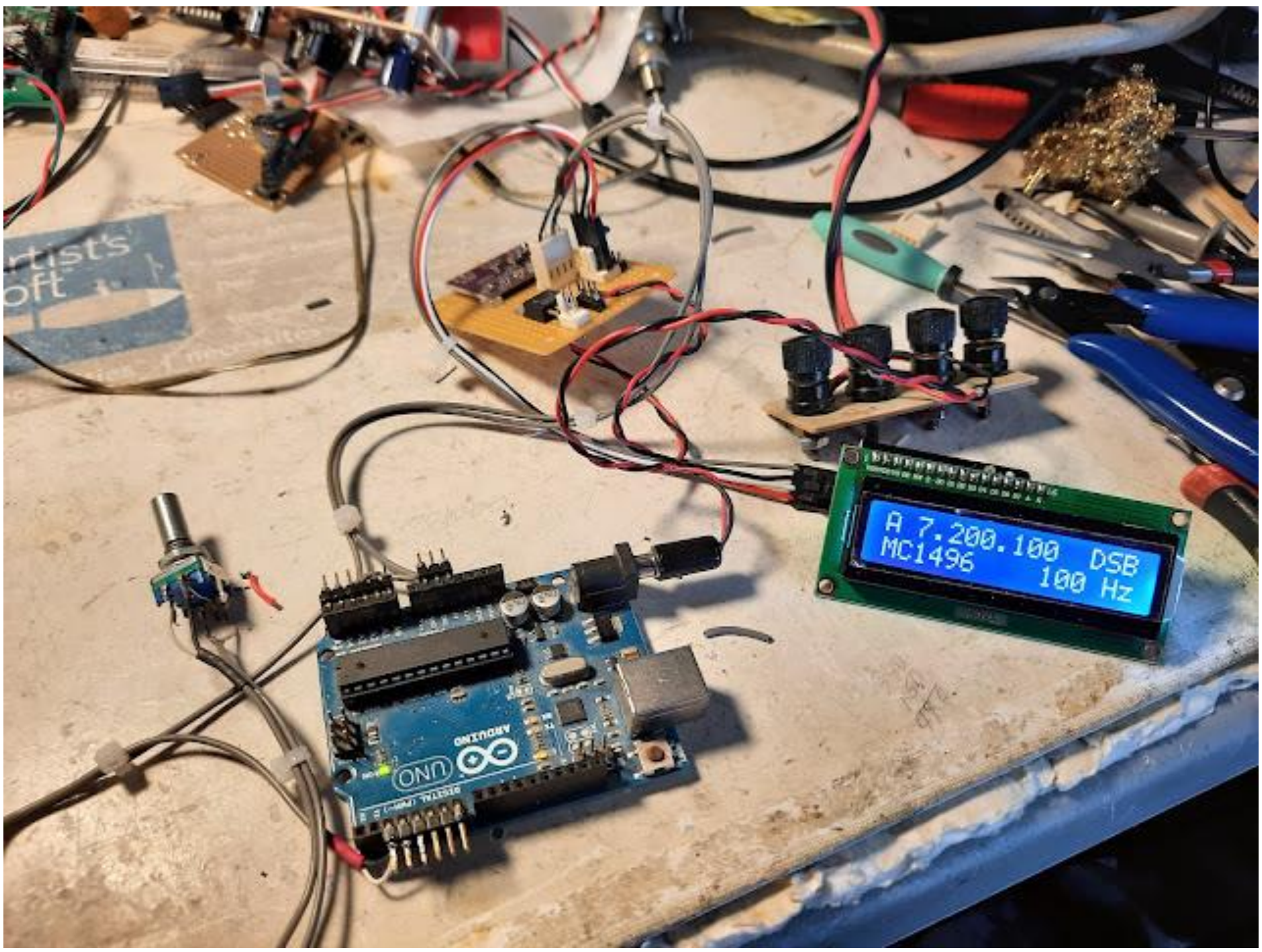
2. Wire wrapping a popular technique of the past, but also a curse if you are prone to smoking parts as you literally have to unwrap all of the connections and opportunities abound for making an error.
3. PC Boards. If you are adept at creating Gerber files, then having boards made in

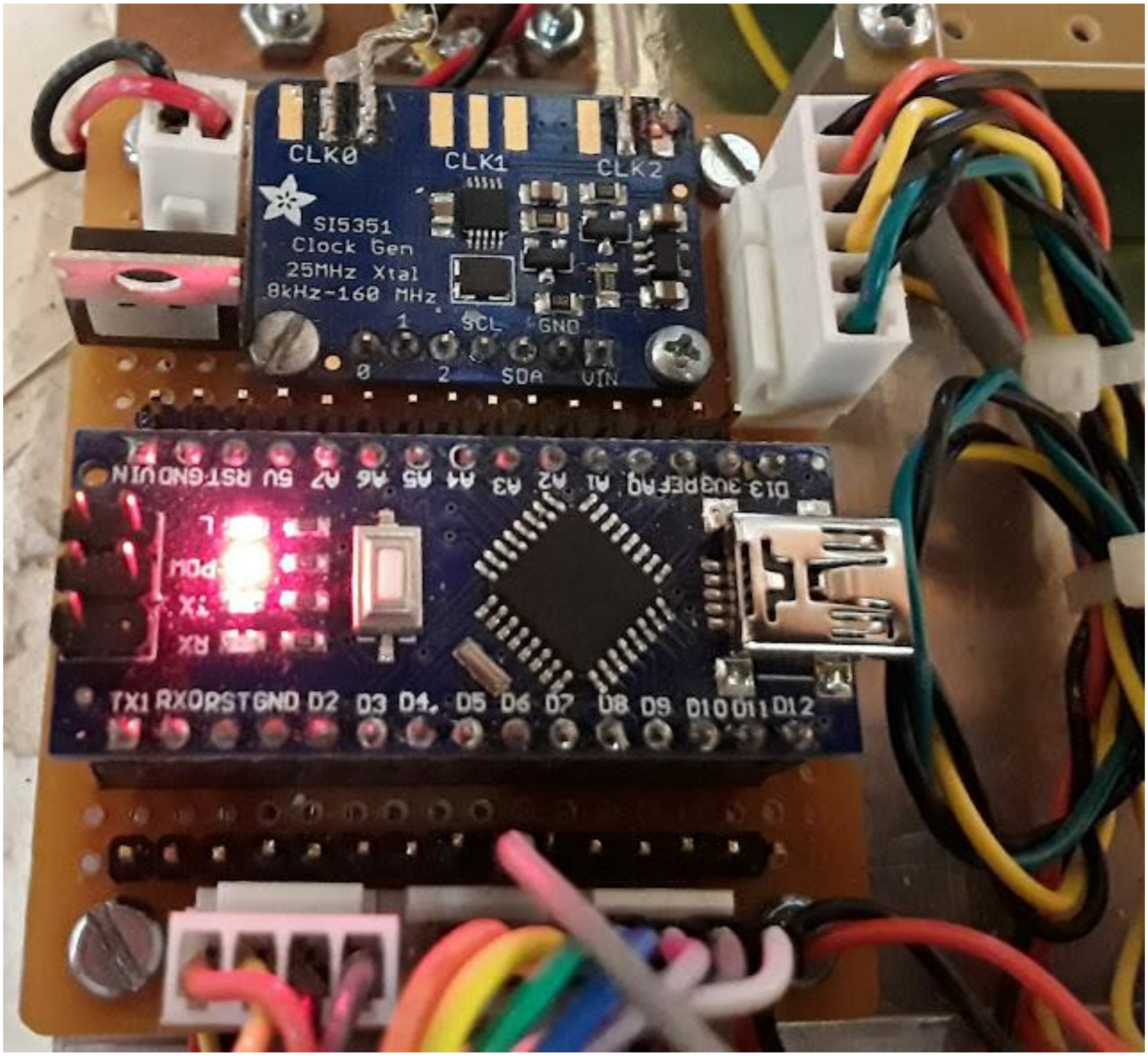
China is pretty painless. I do not like this method where you directly solder the device to the board as it is an issue if you are prone to smoking parts. Unsoldering some 30 pads that are the size of a pin head is incompatible with my FFS. (Fat Finger Syndrome)

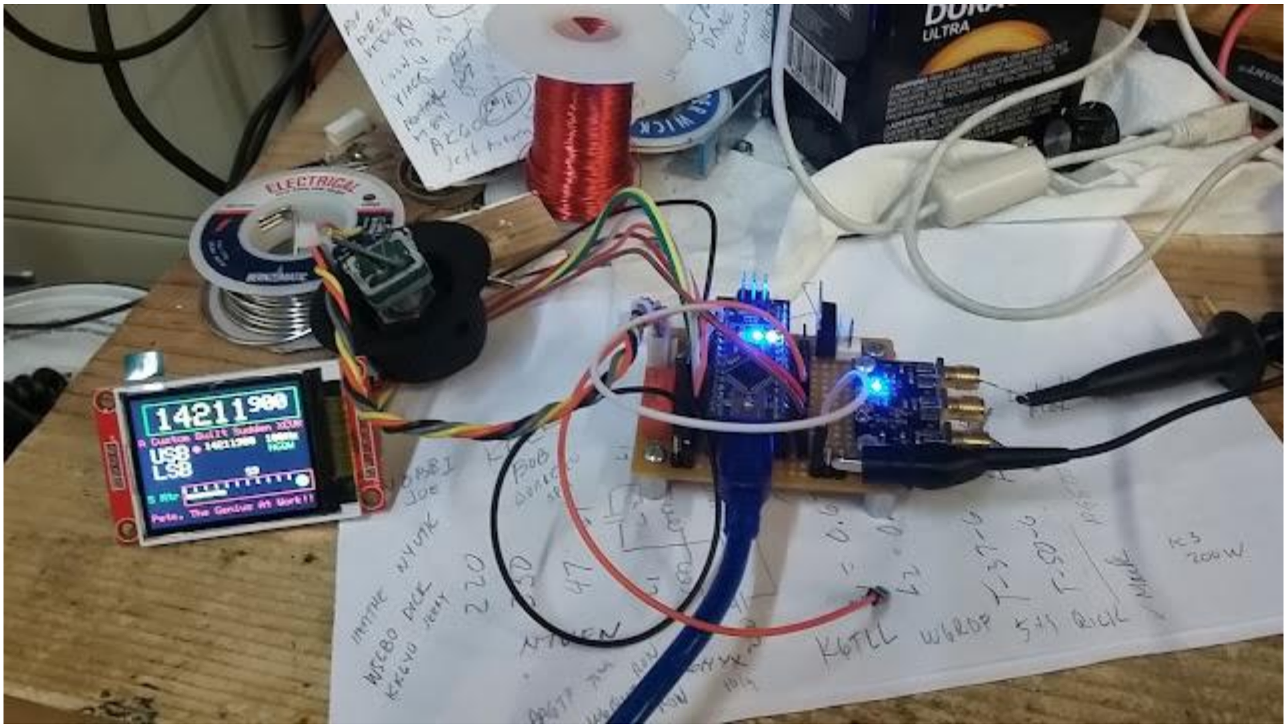
4. Manhattan construction is not a good alternative unless you use something like boards from W1REX. The 1/10-inch pin spacing is hard to do with pads that are 0.2-inch square. You will have a mess on your hands.
5. SMD parts again with the Manhattan approach is difficult with the pin spacing. The use of carrier boards does alleviate part of the problem. MPJA (Marlin P Jones Associates) has some great deals on Carrier Boards.

A short recap -- Digital is less critical on the fabrication as is required with the Analog build. There are many options for the actual build with sockets being the most flexible if you smoke a lot of parts. Perforated board allows moving of the pieces to achieve a compact layout.

9/22/2022 Some Typical Digital BFO/LO Builds.




CLK0
CLK1
CLK2
SI5351
Clock Gen
25MHz Xtal
8kHz-160 MHz
1
SCL
GND
0
2
SDA
VIN
VIN GND RST 5V A7 A6 A5 A4 A3 A2 A1 A0 REF 3V3 D13
L
POW
TX
RX
TX1 RX0 RST GND D2 D3 D4 D5 D6 D7 D8 D9 D10 D11 D12



9/20/2022 Part #2 Wire List

Below is the "wire list" for the Arduino Nano (or any Arduino). This is more or less another standard I have adopted. It sure makes for easy trouble shooting as I have memorized the pins and so when tracing a circuit, I know by rote which pin is which pin and where it connects. This happens to be the wire list for the P3ST but will work for the 2022 SSB Transceiver.

	Pin	Comments
	D2	I use a Bourns 24 PPR PEC Series Encoder 100K MTBF
	D3	
	GND	
	A3	Sets the step size from 10 Hz to 100kHz ~ Momentary PB
	D4	Two Frequencies Select with default startup of 14.2 MHz
	D5	Default FT-8 startup Frequency 14.074 MHz (Alt use a different band like 40M)
	A1	Normally USB on 20M.
	A2	A Ten Second Pulsed 988Hz Tone is initiated with this Pin ~ Momentary PB
	D6	A Square Wave output (Needs RC Filtering for a Sine Wave)
	3.3V	This is the wiring for the ST7735 128X160 Color TFT Display
	D13	Using other displays like the ILI9341 is a Different Pin Out and needs
	D11	the ILI9341 Library
	D9	
	D8	
	D10	
	GND	
	A4	This is the Wiring for the Si5351 PLL Clock Generator
	A5	Clock 0 is the Local Oscillator Output
	+5VDC	Clock 2 is the Beat Frequency Oscillator Output
	GND	

9/19/2022 Digital LO/BFO

The critical path item for the project is the Digital LO/BFO! This is the heart of the rig and if you are still fooling around with Analog VFO's this is the time to jump into the modern world.

The Digital LO/BFO Used in the Wireless Set ~ An example of the Possible!

One of the initial stumbling blocks was the software and that is no longer an issue. There are tons of sketches available, and I freely supply my "kluge work" to anyone who requests the information. You cannot beat the accuracy and stability of the modern electronics.

The device of choice is the Arduino Nano and the Si5351. Add in a Bourns Mechanical Encoder along with a nice Color TFT and you are there. Some bonus features are Selectable Sidebands and the generation of a Tune Tone.

Of benefit is I have adopted a standard process for building the Digital LO/BFO inclusive of a 9 VDC on board regulator, sockets for the Arduino and Si-5351 and finally pin header sockets for plugging in the Color TFT, the Encoder and the associated controls.

Thusly the next several posts will focus on the Digital LO/BFO. Time to step out of the past and into the future. You can do it!

9/18/2022 Project Recap

Later today I will be posting on my website https://www.n6qw.com a **pdf** docu ment of the postings from 9/18 through the initial post. This way you can have a paper document of the project so far.

The next phase of the project will involve the hardware build and I will follow a sequence used in the P3ST project. Essentially the first build will be the Digital LO/BFO as this then will become a critical piece of test equipment for testing as you build the rest of the project.

Following the BFO/LO build will be the Bottom Board fabrication using the template previously provided. I will spend some time minimizing the size of that bottom board by using cardboard cutouts of the circuit island blocks and moving those about a board drawn on a piece of graph paper. By doing this step I can get the board coordinates of where to cut the squares on the finalized PCB. Keep in mind this all has to fit inside the Mrs. Field cookie tin, so this is on the critical path for those of you who have done PERT or CPM.

In essence the bottom board drives the final size of the top board since this will be a stacked assembly. A caution here if you lack skills in doing this kind of detailed analysis your project will be doomed to failure. This is not where you send in a box top and suddenly you are an Extra Class ham, all with the blessing of the ARRL. No this is where you have to know stuff to do stuff!

If you follow what I do you can learn some tricks in homebrew fabricating a functional SSB Transceiver.

Next tackle the Audio Amp stage which is built as a small sub-assembly and can be tested as a standalone. Make it small as you will be stuffing it in some small corner of the box.

Once the bottom board is done, install the two ADE-1's, build the Band Pass Filter and the Microphone Amplifier. Using the Digital LO/BFO with these circuits you have now built a Direct Conversion Receiver and a

DSB Transmitter. The DCR along with the prior built Audio Amp will enable you to peak the BPF and the Microphone Amplifier lets you see a DSB signal coming out of the Balanced Modulator.

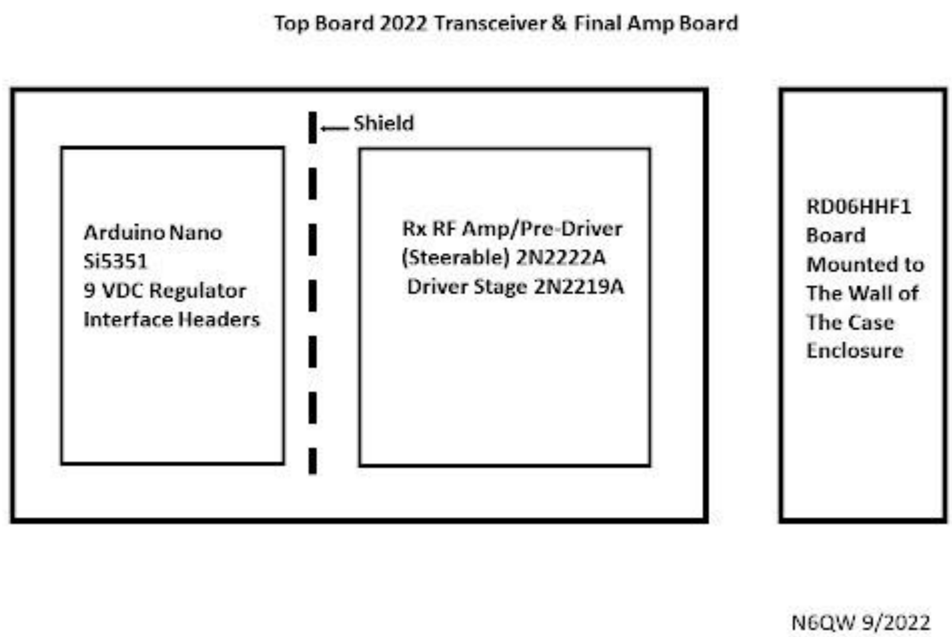
This is nothing more than what Heathkit did --test as you build. Once these parts are working you now can add the Post Mixer Amp, 1st IF, Crystal Filter and the 2nd IF.

Now if there is something awry -- you already know the parts that are working and so the trouble shooting effort becomes less onerous and the problem lies in the new circuitry just built.

I am providing this now at a high level but will detail more as each board is fabricated and tested. Yes, you are going to have to keep reading this blog to get the painful details.

9/17/2022 Top Board Layout

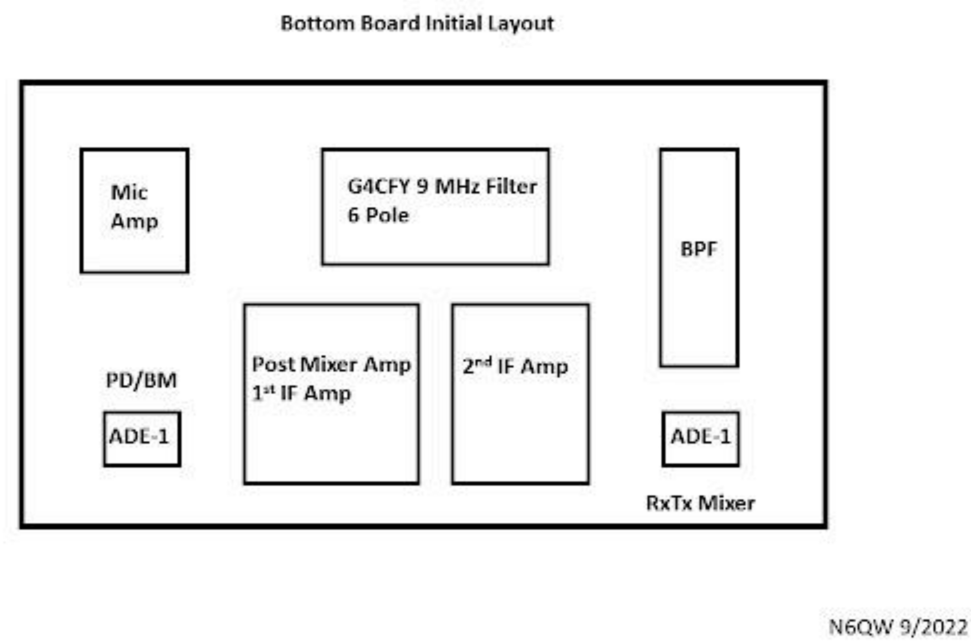
The selection of placing the Arduino on the Top Board has roots in the practical where this approach was chosen because of wire management. The front panel sits above the Top Board and there are many wires which interconnect the Arduino to the front panel and this approach makes for a small amount of cabling.



In total there are close to 15 wires in the interconnect with 7 for the Color TFT, 4 for the Encoder, 1 for the USB/LSB select, 1 for the TUNE Tone and 1 for the MOX and 1 for the Common Ground.

Our future posts will focus on PC Board Fabrication.

9/16/2022 Board Layouts



This is the 1st Cut at the Bottom Board Layout which follows a similar layout for the P3ST. Yes, I found something that works so why not reuse it!

I have selected this as the bottom board since the BPF once set will not need readjustment and the Microphone gain once set should not need constant tweaking. That said I can place a Mic Gain level control on the front panel to control not the amplifier gain but the gain level of the microphone itself.

The top board would have the Rx RF Amp/Pre-Driver, the Driver and the Final Amp. Also fitted to this board would be the Digital BFO/LO. Yes, a careful layout is needed along with some circuit shielding.

9/15/2022 Crystal Filter Matching

Clemenza Says: Ditch the Gun & Grab the Cannoli!

Today a short review of Crystal Filter matching. Given that those who might consider building this transceiver will either have a filter kicking around in a bin somewhere or considering (shudder) building one or perhaps a purchase of a new filter. Regardless my interface to the filter in/out is 50 Ohms thus you will have to match that impedance.

Typical filter frequencies include the following: 50 Ohms, 200 Ohms, 500 Ohms, 800 Ohms, and even 2.2K. The process I will outline will enable you to match the impedance of other filters.

A 50 Ohm to 50 Ohm match is a simple connection to the filter. For a 200-ohm Filter a 4:1 transformer will do the job with a caveat. The 4:1 is the simple bifilar wound transformer with one end to ground, the common connection to 50 Ohms and the other lead to the filter. Now the caveat is the number of turns should be sufficient so as not to load the 50 Ohm source.

For 500 Ohms the simple answer is a 19 Turn Coil Tapped at the 6th Turn where we have 19^2 = 361 and 6^2 = 36. Thusly 361/36 = 10 so 50 Ohms now looks into 500

Ohms. You can also use two separate windings.

If your filter is 800 ohms, the match to 50 Ohms is 16:1. This is easily done with a transformer that has 8 Turn Primary and a 32 Turn Secondary. The match is 32^2 = 1024 and 8^2 = 64 where 1024/64 = 16:1. Or a 32-turn winding tapped at the 8th turn.

A 2.2K filter such as those found in Heathkit radios is a 44:1 match, a bit more complex. If we use a 40 Turn winding tapped at 6 Turns, we get 40^2 = 1600 and 6^2 = 36. 1600/36 = 44.44: 1 which is close enough for government work.

Now some other caveats and that is the filter frequency itself. There seems to be a general consensus that filters in the range of 4 to 12 MHz are better choices for single conversion transceivers. Heathkit and early Yaseu filters are in the 3 MHz range (3.395 and 3.180 MHz) which could be issues with harmonics of the BFO slipping through the BPF where the second harmonic of the Heath filter is near 40 Meters. Bottom Line: the problem becomes one of unwanted frequencies slipping through Band Pass and Low Pass filters.

Hers is another example of such a mix. G4CFY offers two filter frequencies 9 MHz and 10.7 MHz. If you chose the 10.7 MHz and put that on 20M then the LO would be in 24 MHz range. A 24.9 MHz LO with a 10.7 MHz IF places a subtractive mix at 14.2 MHz. The LO is in the 12 Meter band! This might require extraordinary filtering to keep the rig clean.

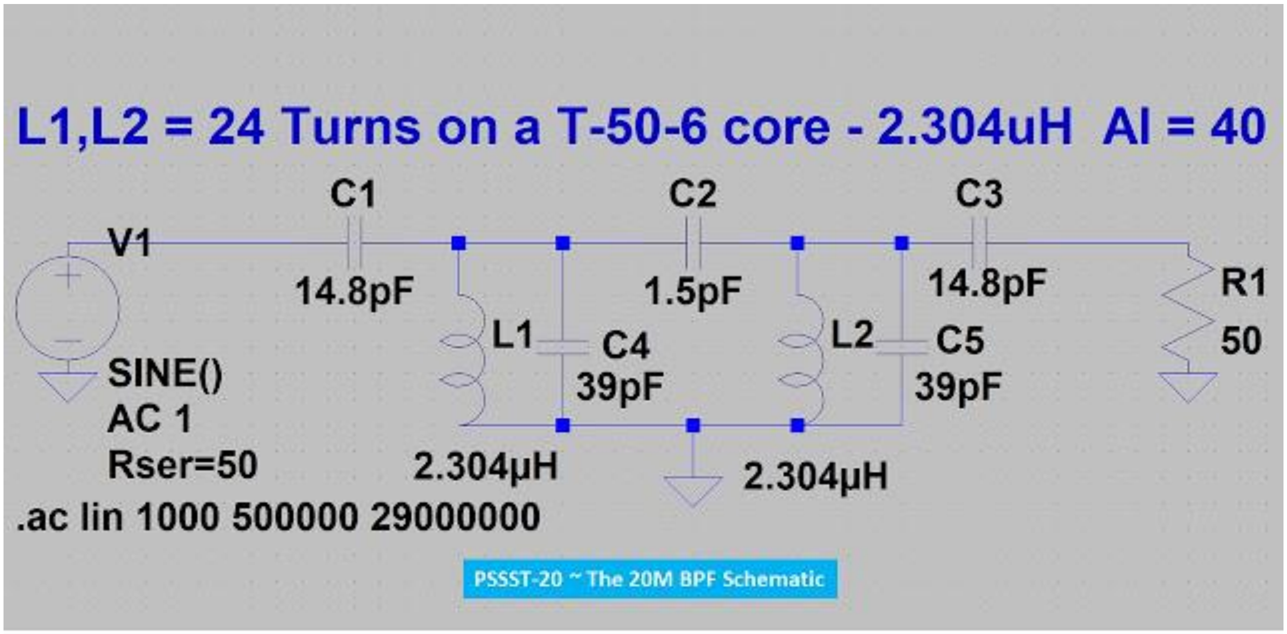
For those who have masochistic tendencies who will want to pursue fabricating a homebrew filter often the matching impedances are in the 200 to 400 Ohm range. INRAD sells a 4-pole 9 MHz filter, Model 350 that has no matching transformers but is 200 Ohms so the 4:1 match will work with that filter.

9/14/2022 Some of the Final Pieces

We have as yet to talk about three of the major pieces for the 2022 Rig. Those include the Band Pass Filter, the Low Pass Filter and the Digital LO/BFO.

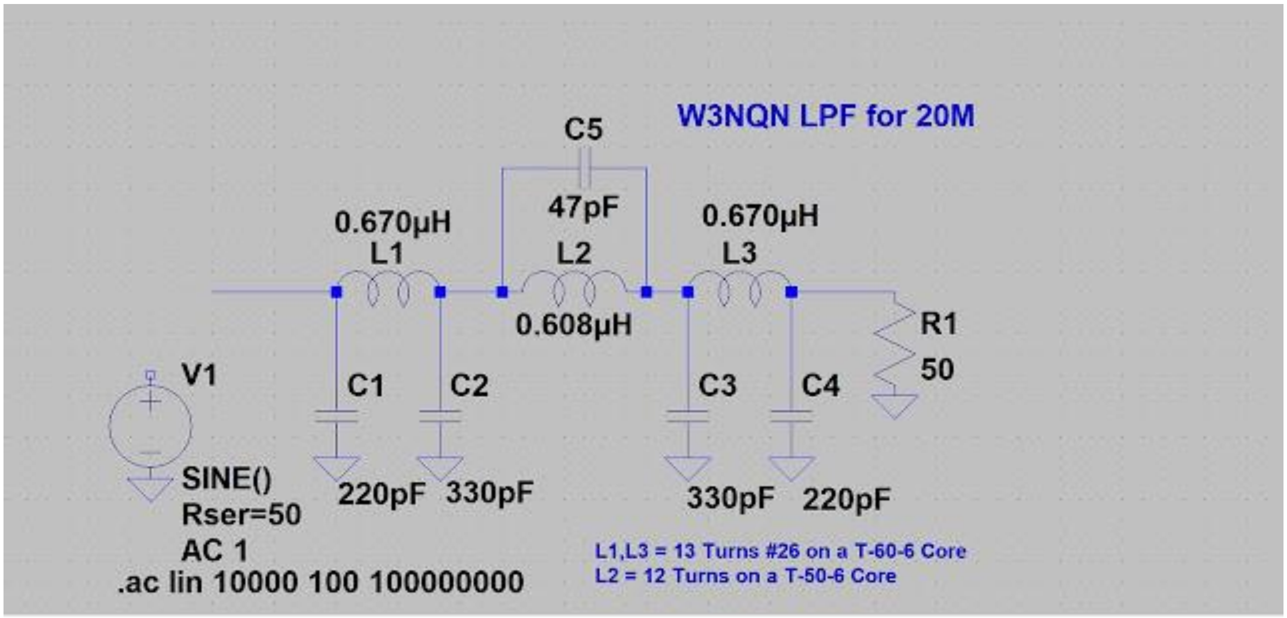
For those of you fortunate enough to own SSDRA, which I consider superior to EMRFD (yet the same author), W7ZOI has a manual exercise on how to hand design a Band Pass Filter. This is takes you down to the bowels of how a BPF is designed and lets you see something far superior to plugging numbers into blocks on a spread sheet. You are in essence close to the electrons!

With this level of understanding in SSDRA, thence LT Spice enables you to design networks by understanding the value of the section coupling capacitor which drives a flat or humped response on the filter curve. For those who are inextricably linked to the Nano VNA you can see the same effect. But the Nano VNA is an after the fact measuring tool not a design tool!



BTW in SSDRA, W7ZOI shows you how to arrive at small values of section coupling capacitors --something you won't find on your Nano VNA!

Now there is a seminal design paper by W3NQN dealing with Low Pass Filters which is critically important in addressing second harmonics of your signal. It was published in QST. Email me if you can't find a copy. The slick trick -- standard values of capacitors and the work is based on Elsie (LC).

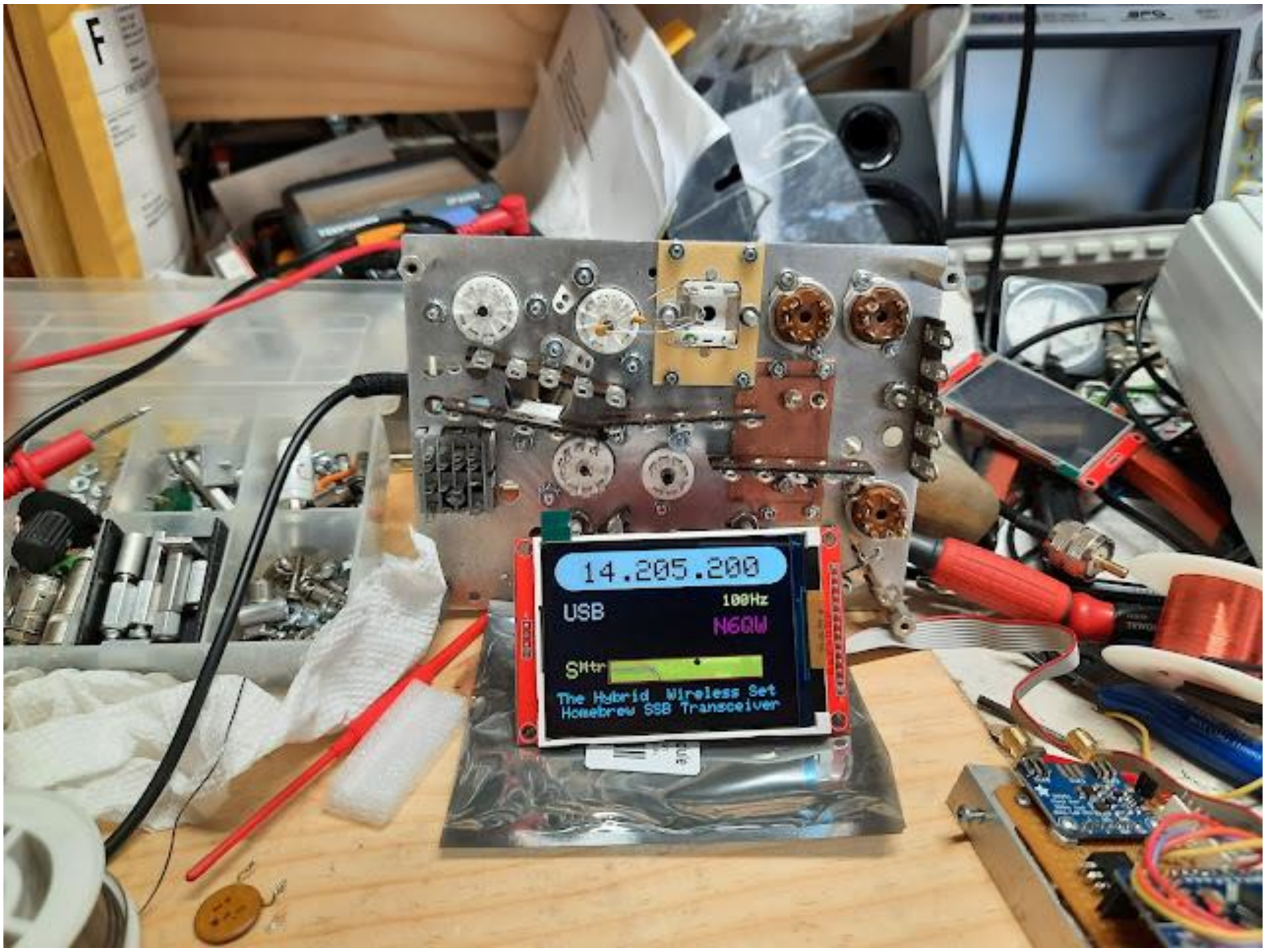


[SPECIAL NOTE: R1 (50 Ohms) on both schematics is for the simulation and not installed in the Final Hardware. You would not believe how many emails I get about why is R1 there!]

Finally, we have the Digital LO/BFO which now will need some consideration of the available panel real estate and the size of the display. I have a choice of Color TFT displays ranging in size from less than 1-inch square to a whopping 3.2 inches. We also have available a 1.8-inch display and a 2.4 -inch display. This will take a lot of work to finalize the panel layout and not unlike Mary Jo trying fit into a 29A foundation with her 44DD's.

The code for each is a bit different but exists so it is only a matter of choosing which display. Behind whichever display is an Arduino Nano and a Si5351 for which I have a standard compact layout.

The Less than 1-inch Square Display



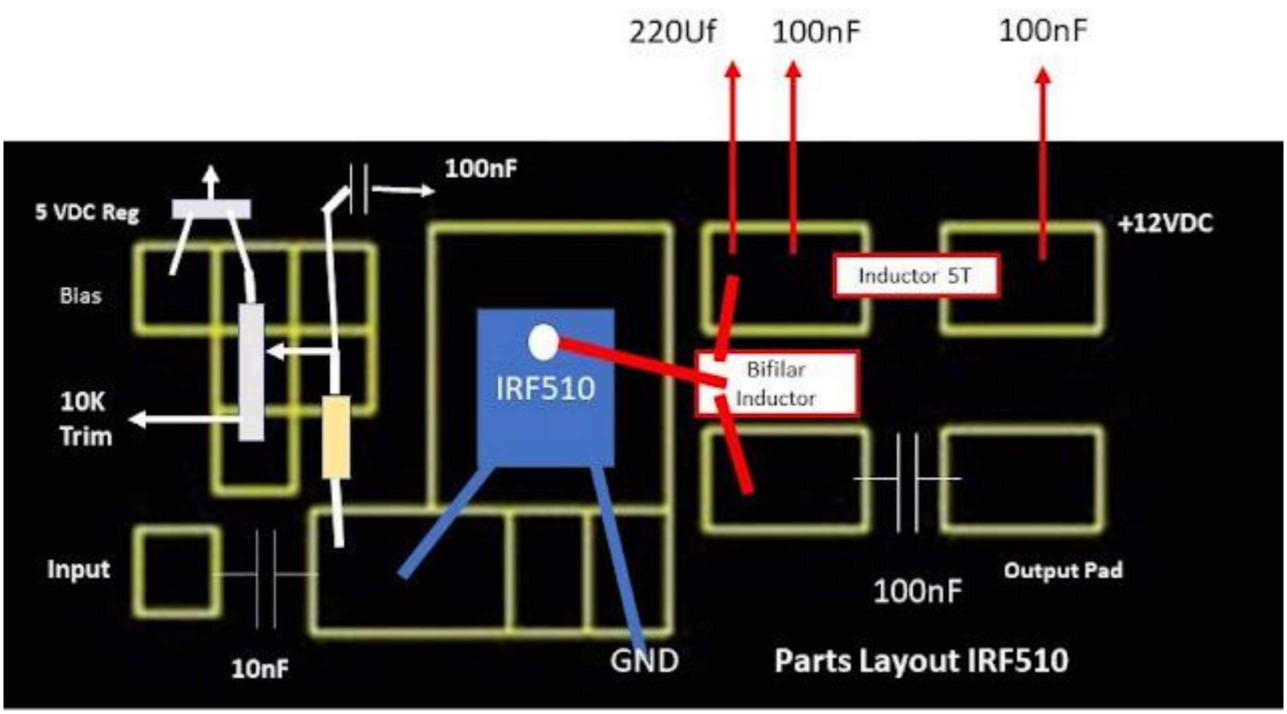
The 3.2 Inch Display

Now we need to circle back to see if we have forgotten anything before proceeding with the actual fabrication.

So far, we have done nothing but noodling and this is critical as we have identified the measure 40 times items where we only have to cut once.

9/13/2022 More Details on the 2022 project.

(Many of the new project circuits were used in the P3ST project and have worked well. Again, no hardware as such has been built for the 2022 project.)



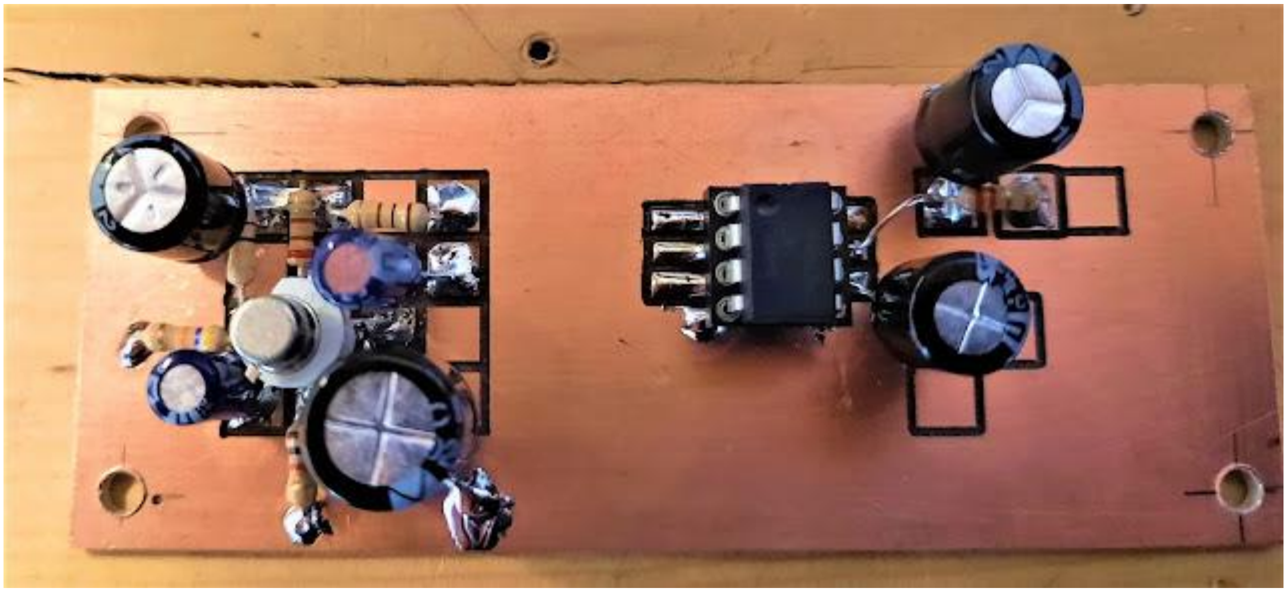
Standard Layout for the IRF510 or RD06HHF1

One key to a successful project is the concept of using well established processes and circuits. Over a period of experimentation, I developed a standard layout for the Final Amplifier stage that embodies keeping the inputs away from outputs, provides space to install parts and yet has a small footprint.

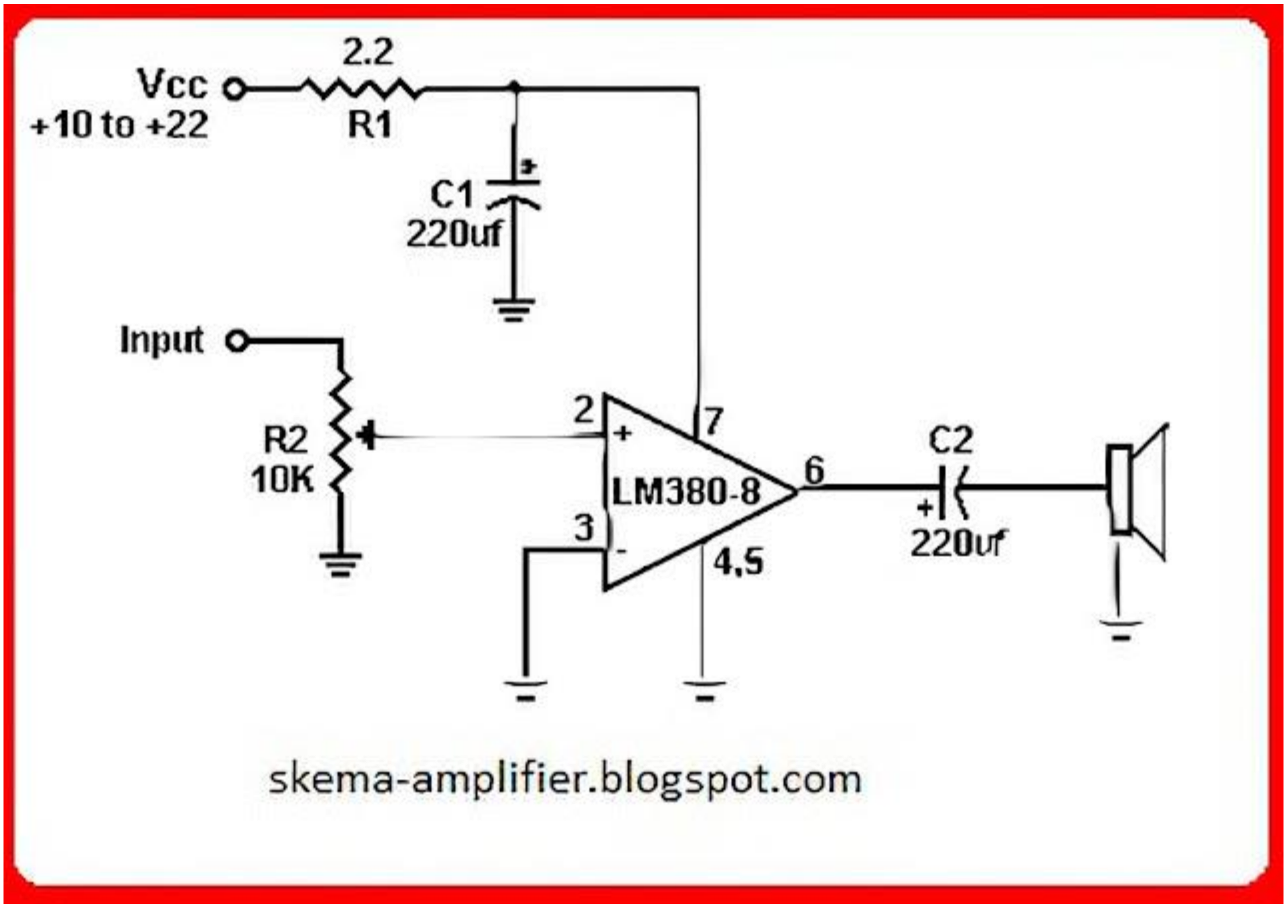
Parts Layout RD06HHF1 (An earlier version.)

The Audio Amplifier consists of a 2N22222A Pre-Amp Stage (the same circuit as the

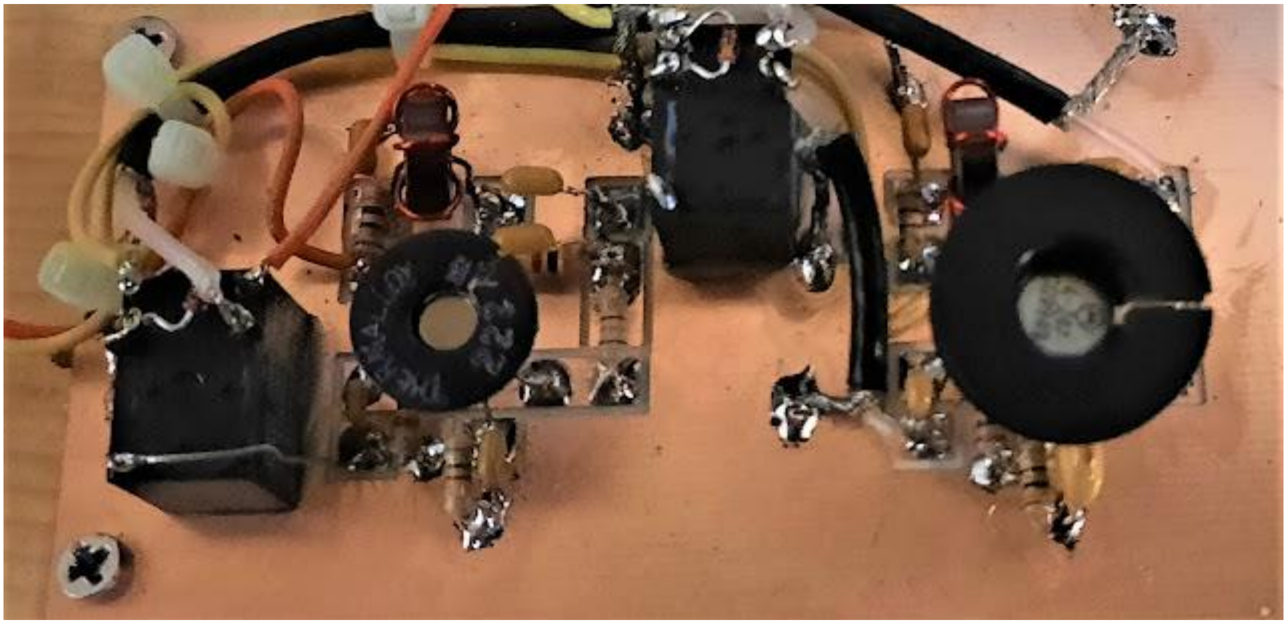
Microphone Amplifier) and an LM380N-8 for the final Audio stage. This is shown below.



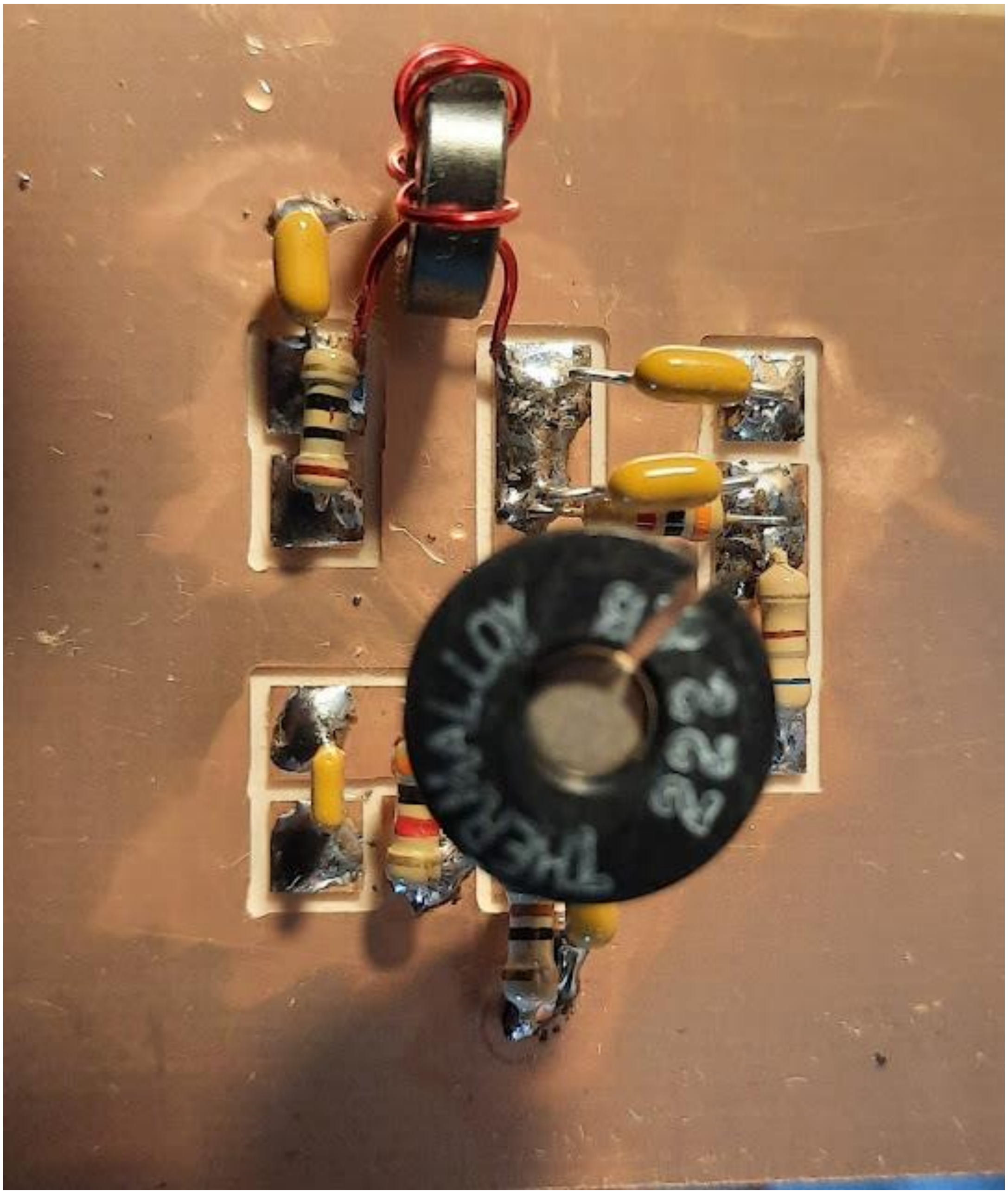
LM-380N-8 Schematic

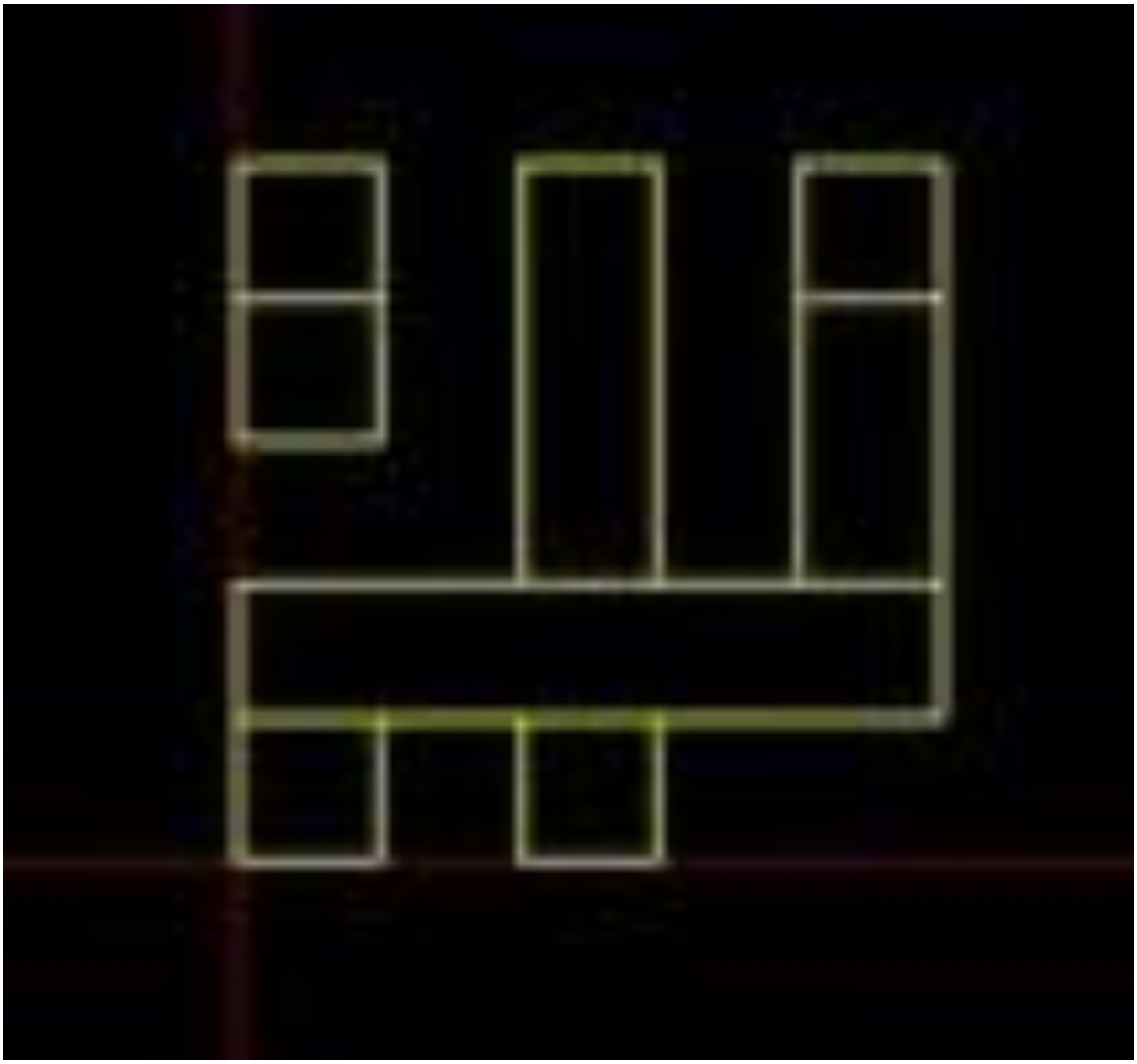


Below is a board that houses the RF Amplifier/Pre-Driver and the Driver Stage. This board enables a bit of compactness and shortened interconnections.



The Driver Stage and Layout


THERMALLOY



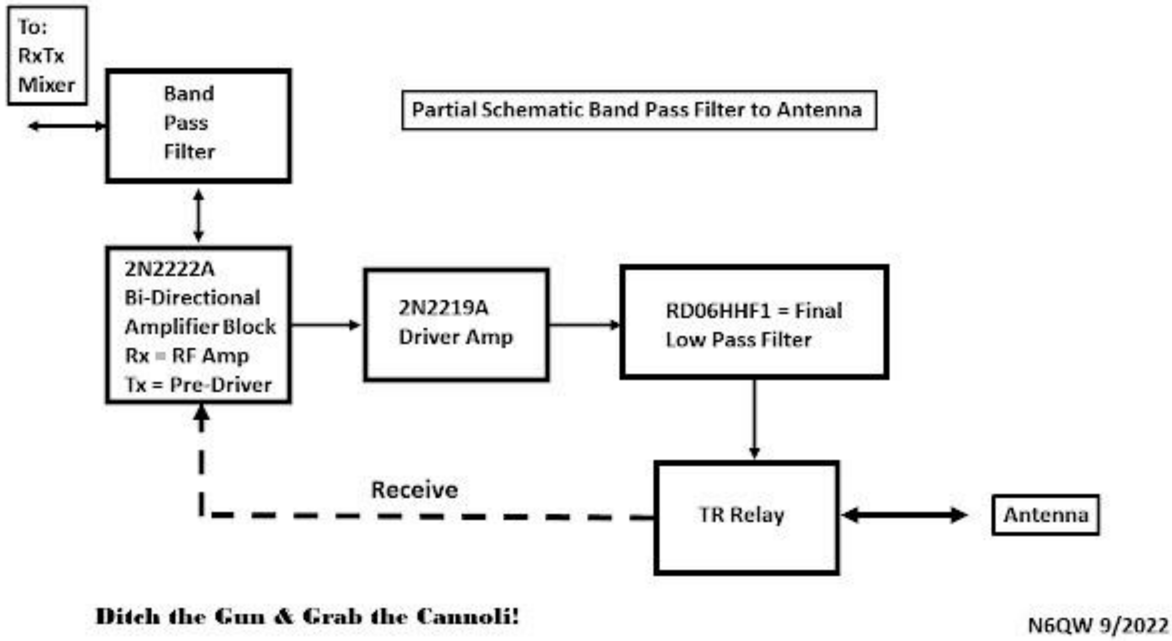
Ditch the Gun & Grab the Cannoli!

The import of the Cannoli statement is that the soldering iron has been in the OFF position, and we are literally fully designing the transceiver using a paper analytical approach.

We will be using the G4CFY filter which can be wired for either a Zin/out of 50 Ohms or 800 Ohms. The basic filter is 200 Ohms, and the matching transformers are 4:1. Thusly, how you connect the 4:1 result in the two values (50 or 800). That will be the subject of the next posting.

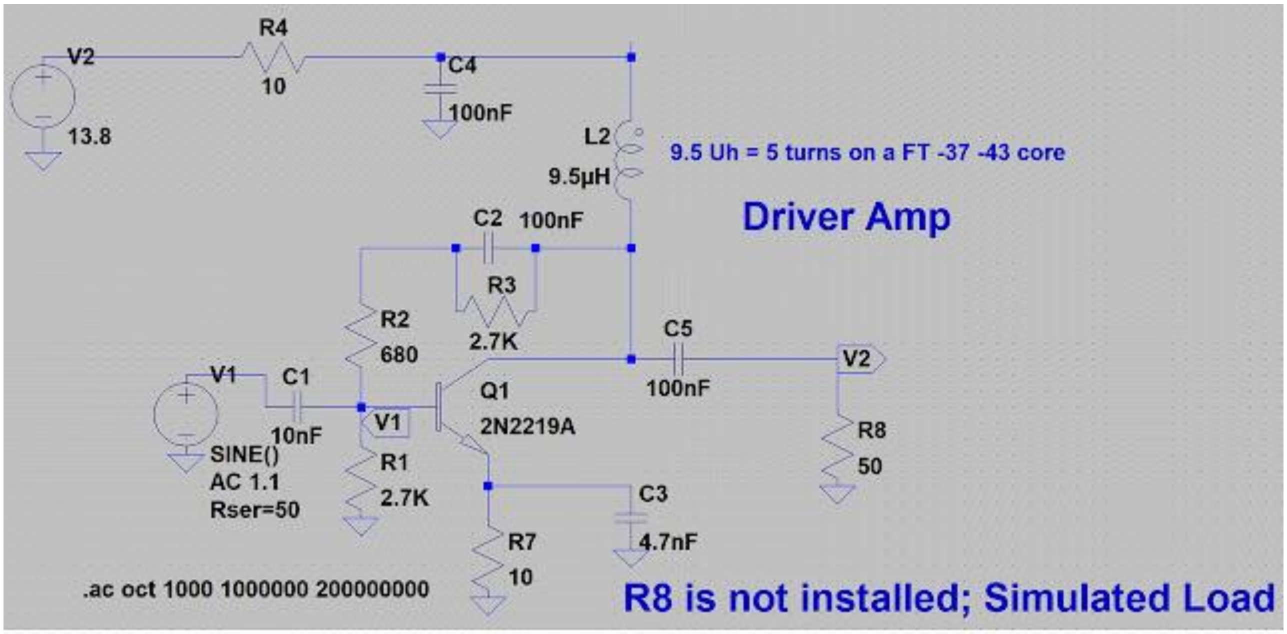
73's
Pete N6QW

9/12/2022 A Few More Circuits.



The Second Half of the Block Diagram

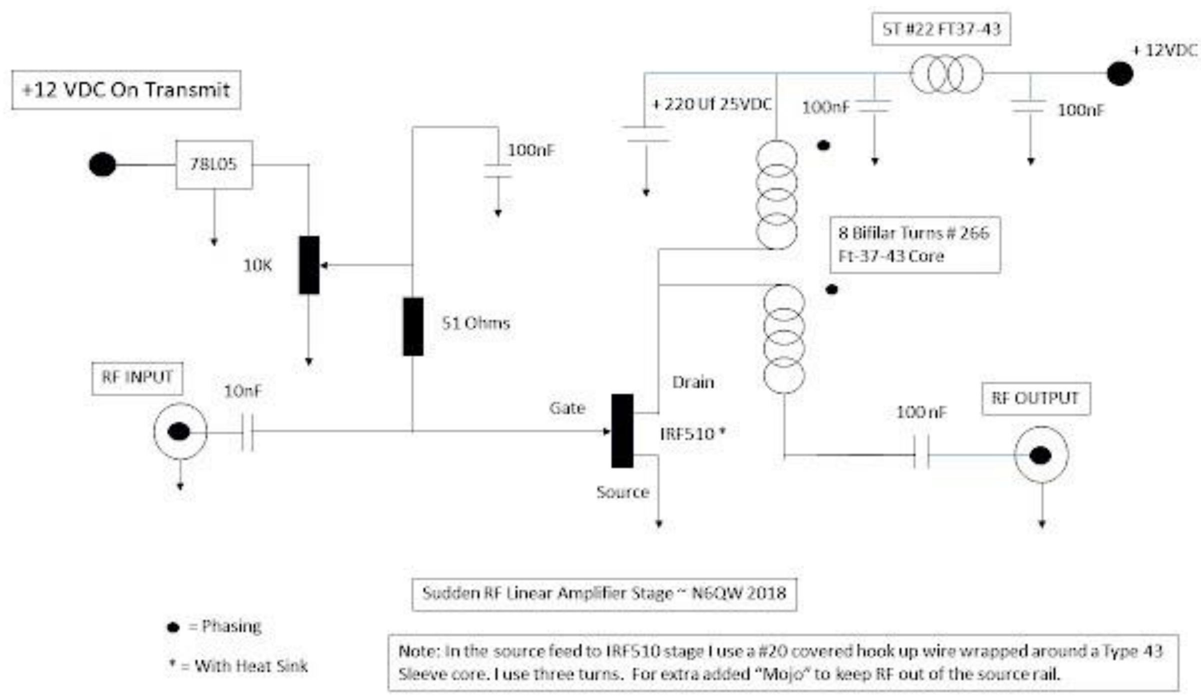
I subscribe to if it is not broken, then don't fix it. Two of my go to circuits are the RF Driver and the Final Amplifier. For the Driver I use the 2N2219A and there is very practical reason for this that being it works and is less expensive than the 2N3866 or the 2N5109. Another really big reason -- it is modeled in LT Spice! In case you didn't know the 2N2222A and the 2N2219A are identical in characteristics save for the larger die area of the 2N2219A which results in a higher device dissipation.



BTW Amidon has revised the Specs on the FT-37-43 so that the current Al value is 350 so that if you checked my work you would come up with the inductance at 8.75 micro Henery -- it will still work with 5 Turns. In the past I fully know my work is always checked. This design was made when the Al Value was different than the current 350.

I have a standard layout for the Final Amp stage, and it will accept either an IRF510 or

RD06HHF1. In the case of the IRF510 you will need a mica insulator when you attach the Tab to a heat sink as it is the Drain. The RD06HHF1 has the Tab as the Source so no insulator required. I also add a LED to the ground connection of the 78L05 as this raises the regulated voltage to something greater than 5 VDC. The quiescent current draw of the RD06HHF1 is greater than the IRF510 so you will need a larger sized heatsink.



Above is the schematic for an IRF510. For the RD06HHF1 lift the ground connection on the 78L05 and insert and LED between that pin and the ground plane. All other connections and components remain the same. The bonus is that the LED comes on when you transmit. How Cool is that?

Again, new photos to attract more viewers.

9/11/2022 More Thoughts About the Final Build.

Eventually what is built will have to be fitted inside of Mrs. Fields (The Cookie Tin). Rookie Mistake -- thinking about that after all is built! So, the time to do that is before the 1st board is fabricated.

I have great success using stacked boards and that seems like a good template. In addition, great thought must be given to servicing.

A short story about the replication of a Wes Hayward project and servicing issues. If you are fortunate enough to own the premiere W7ZOI publication SSDRA, you can see his competition grade CW receiver project. I built that receiver with the addition of putting every circuit module in an aluminum mini-box. There are no way external signals could get into that receiver other than through the antenna port. That worked well.

What didn't work well was when there was a problem every circuit was inaccessible. It was impossible to put a scope probe on various circuit elements -- a really bad idea. You had to disassemble the whole receiver just to find the problem. Lesson learned.

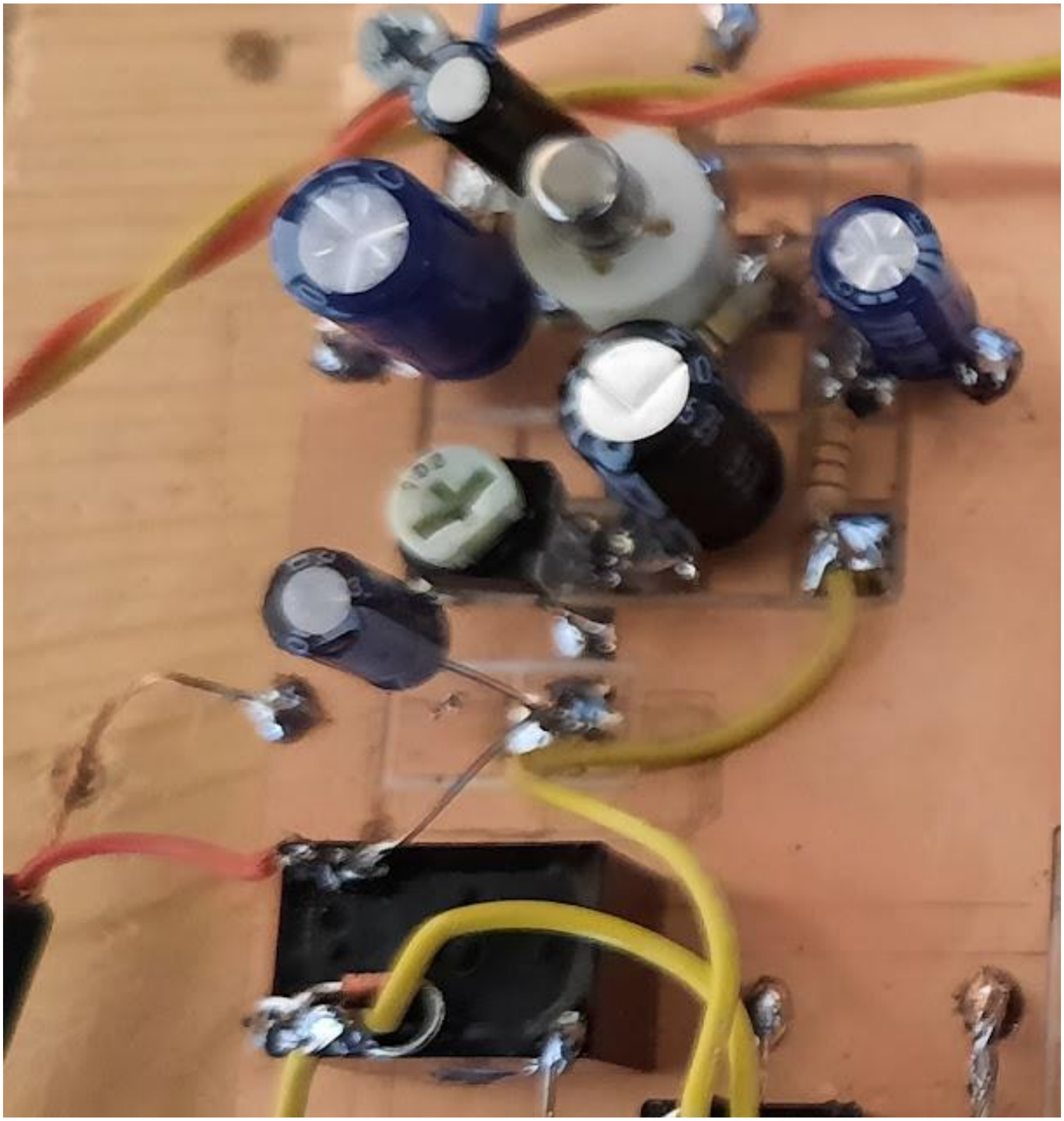
Additional considerations are heat, especially with the RD06HHF1 and another the I/O ports. My prior experience with this highlights a path where the front panel includes functionalities typically found on the back panel. Thusly front panel real estate is divided into the high rent and low rent districts. Ergonomics plays a vital role in the placement of various controls. I have fat fingers so teensy knobs are not in the scheme of things.

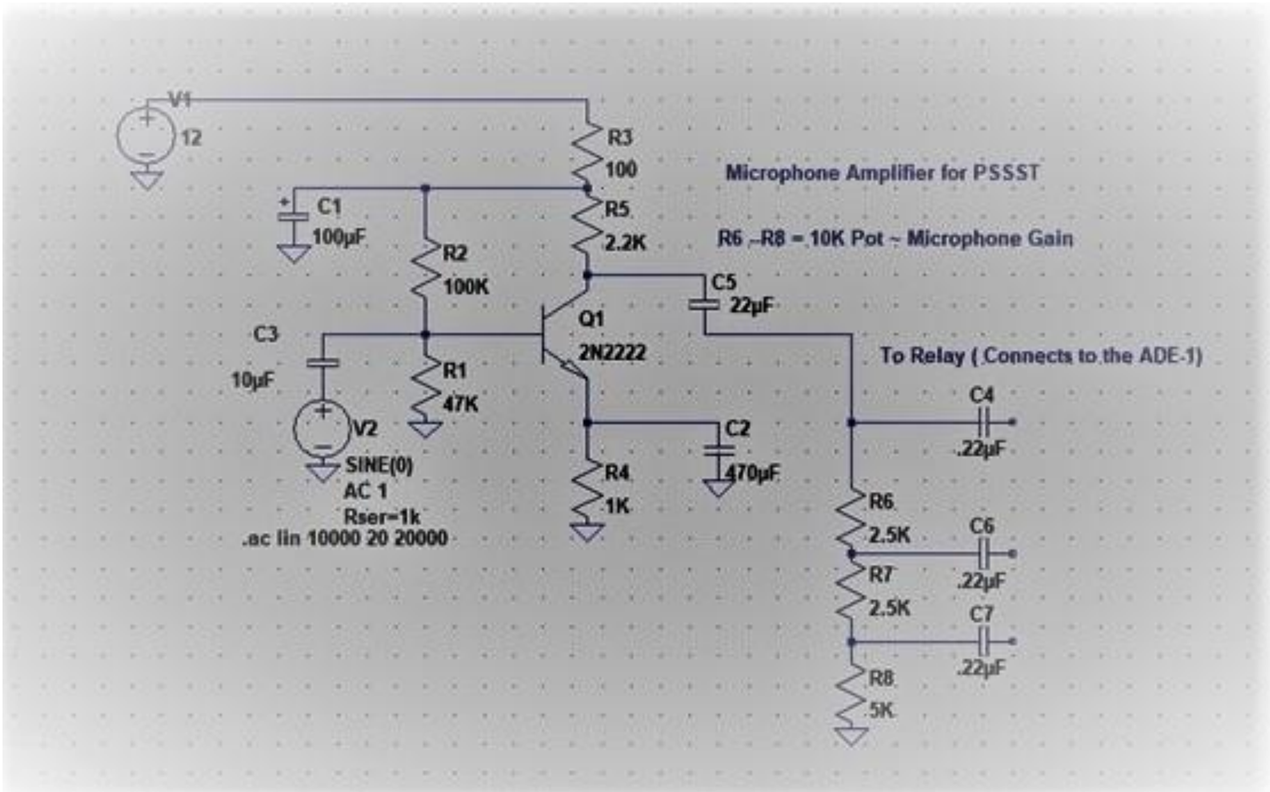
Yet another consideration is that the Cookie Tin is small so once set up how do you make it stay put on the operating location. Hint: Velcro!

Again, we have built none of the hardware, but all of the items mentioned so far are impactful to the actual hardware fabrication.

Just so there are changing pictures on the blog -- included today is the Microphone Amp as used in the P3ST.

R6-R8 in the actual hardware build is a 10K Pot. These resistors are used in the LT Spice simulation to show that the output is flat no matter where the wiper is positioned the output is a flat response! This very same circuit is used as the Audio Pre-Amplifier stage.



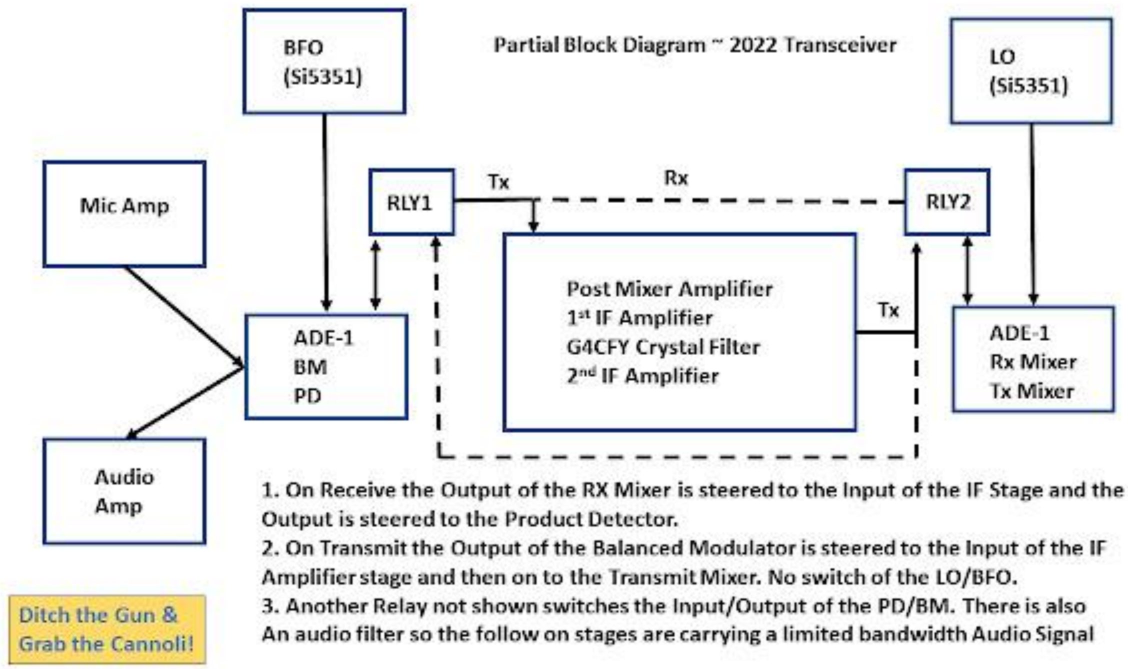


Having a new photo on the blog with each posting is sort of like blog reader flypaper -- it is an attracting device.

As Clemenza says: "Ditch the Gun and Grab the Cannoli!"

9/10/2022 A Paper Built Rig, So Far

Up to now no actual hardware has been built but most of the work has been analytical with great deference to LT Spice. But I do think it is time to start the work on the block diagram and to also specify some open blocks.



This is the Ah Ha moment as we are using a relay steerable module something I had great success with on the P3ST and the Peashooter.

Now while I have shown several relays this also may be an opportunity, at least for what is shown in the partial block diagram, for would be builders to use diode steering as the signal levels are low enough that you don't have to worry about smoking a diode.

A recommended diode is the 1N3070 as it has excellent RF Characteristics. I happen to have a 9 MHz G4CFY Crystal Filter and so that is the IF frequency. Search this blog for diode steering and you will see a posting on how to do it! Look for November 15, 2021, entitled "The Art of the Steer"

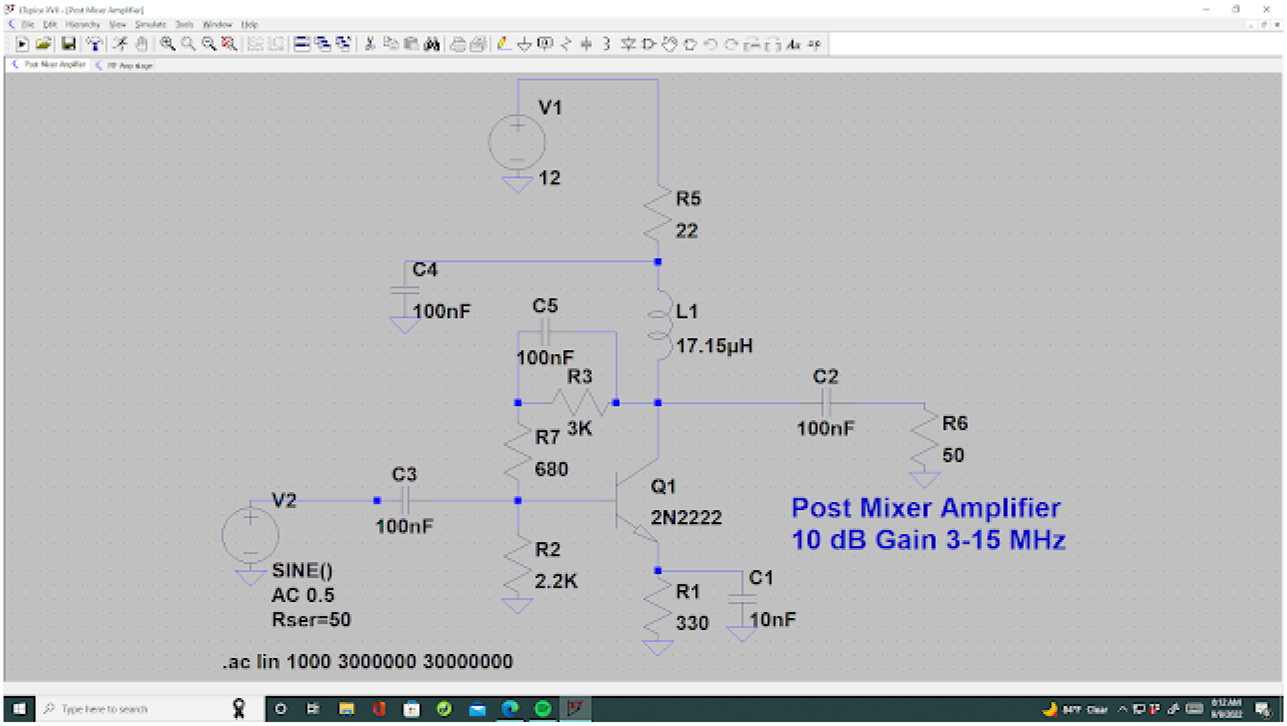
You will note we have a mix of either JFETs or Dual Gate MOSFETS at several locations. The venerable 2N2222A will find a home in three of the blocks and of course we have the 2N2219A Driver and for the final amp the Mitsubishi RD06HHF1. Rounding this out will be two ADE-1's and of course and the Arduino Nano and the Si5351 for the Digital LO/BFO. The Final Audio stage will be the LM-380N-8.

9/09/2022 The Post Mixer Amplifier

Using the ADE-1 there is a conversion loss of around 6 to 7 dB as defined by the manufacturer. The Post Mixer Amplifier is intended to null the effect of the conversion loss while providing a bit of a signal boost. So, if we looked at something in the range of 10dB that would offset the loss plus add about 3 dB of gain. In our original gain distribution, we had pegged the Post Mixer Amp at 20 dB. A later look gave me pause that perhaps is too much gain for that stage.

But our IF stages can pump out a few extra dB per stage and so that then would become a zero-sum game.

I have a preliminary Broad Band design with the thought here that there would be different IF frequencies based on a builder's choice and therefore this amp would become universal. The 10dB Gain figure is over the range 3 to 15 MHz, the typical range of Crystal Filters. Note L1 is 7 Turns of #26 on a FT-37-43 Core.


V1
12
R5
22
C4
100nF
C5
100nF
L1
17.15µH
R3
3K
C2
100nF
R6
50
R7
680
C3
100nF
V2
Q1
2N2222
Post Mixer Amplifier
10 dB Gain 3-15 MHz
SINE()
AC 0.5
Rser=50
R2
2.2K
R1
330
C1
10nF
.ac lin 1000 3000000 30000000

Clemenza Says: "Ditch the gun and grab the Cannoli"!

9/08/2022 A Broad Band Amplifier

Before we leave the 1st IF Amplifier/3dB stage, I should mention that a similar amp stage, 2nd IF, would be used following the Crystal Filter. Luckily such a stage would need to have a 50 Ohm output suitable for driving either the 50 Ohm Port of a DBM on the Product Detector or the 50 Ohm Port of the Transmit Mixer. Now you will have to match from your Crystal Filter to the input to the 2nd IF which is 50 Ohms.

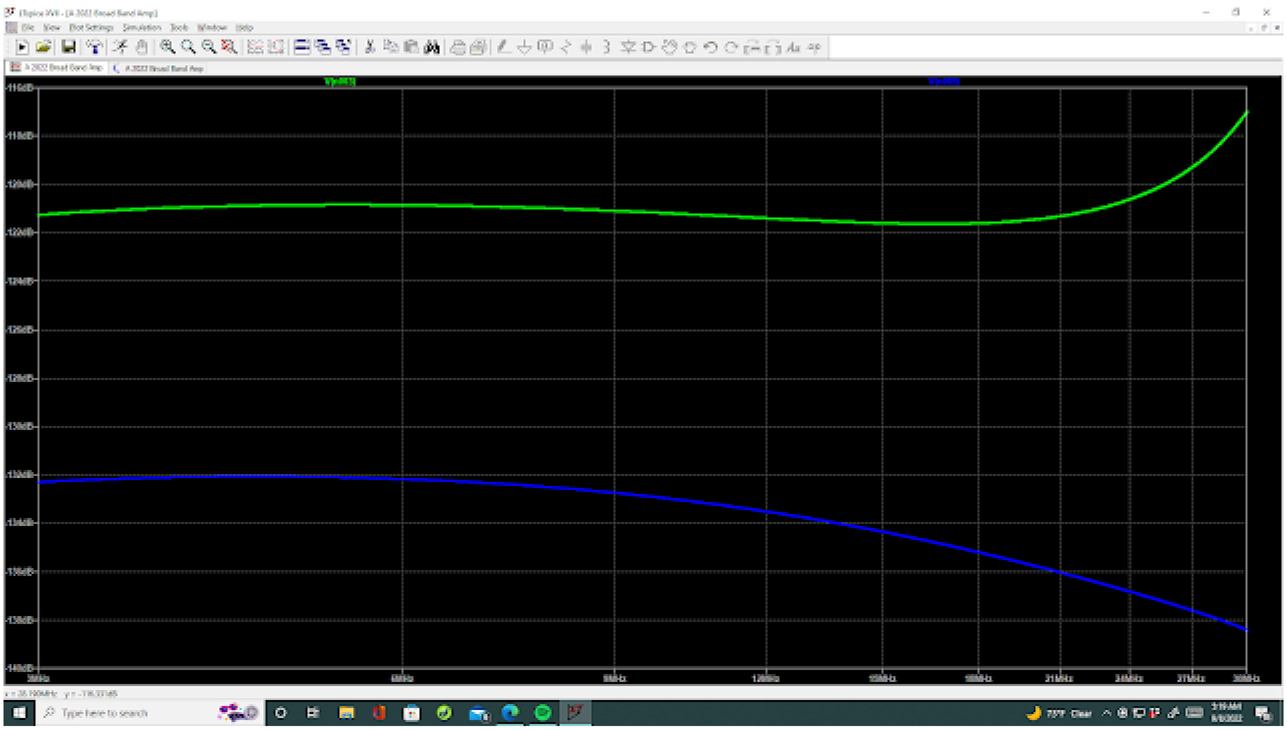
Using the process from the earlier post you can translate C1, C2 and L1 to your favorite filter frequency. I would avoid a homebrew filter especially if you have never built one before. The arcane methodology of the Dishal filters is best left to others if again you are new to constructing filters.

Do not believe that you simply slap 4 crystals in a circuit add the 5 coupling caps and you are there. You are not! You can purchase 9 MHz commercial especially high-quality filters from Spectrum Comms in the UK. (Owner G4CFY)

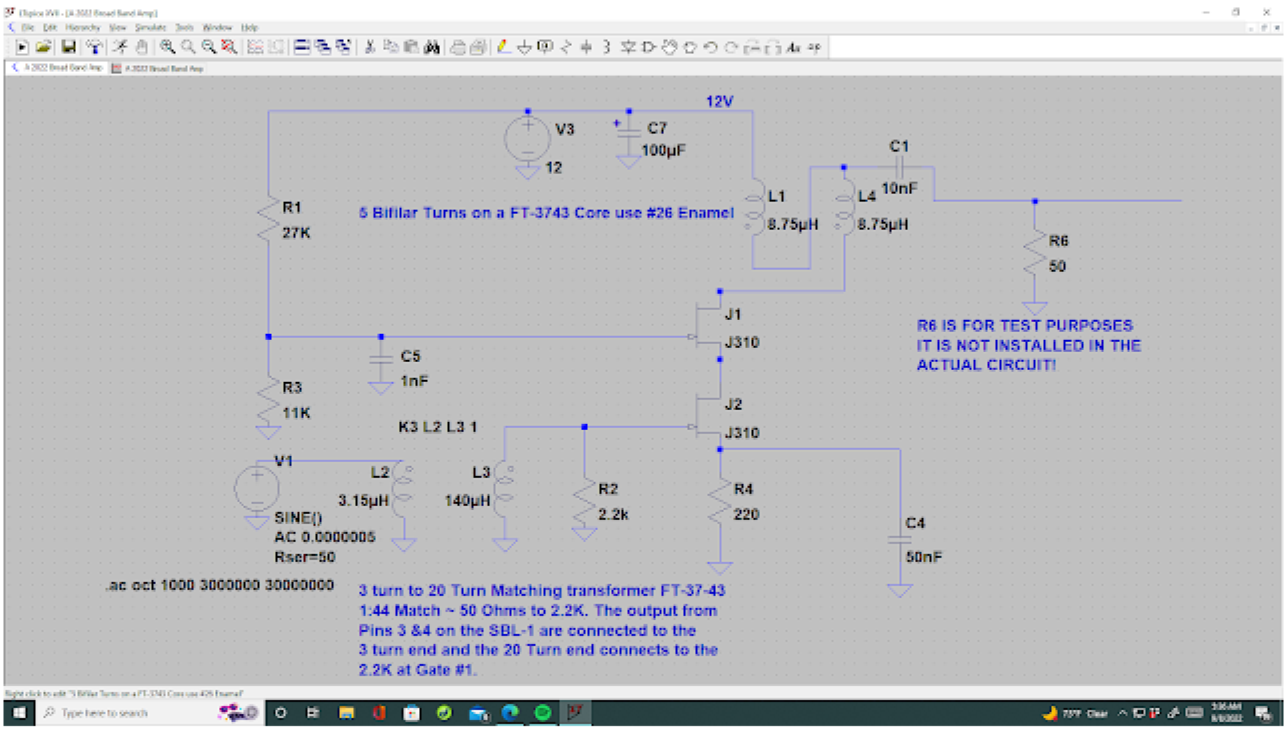
http://www.spectrumcomms.co.uk/

We will need a Broad Band Amplifier for the RF stage and I have noodled out something which will give you about 10 dB gain out to 10 Meters.

The goal of this stage is to provide a flat response across the HF bands. I purposefully set the input signal level to 0.5 Microvolts which is more in the range of signals picked off of your questionable antenna (a lead connected to a plastic rain gutter) or a chunk of wire laying on the shack floor.



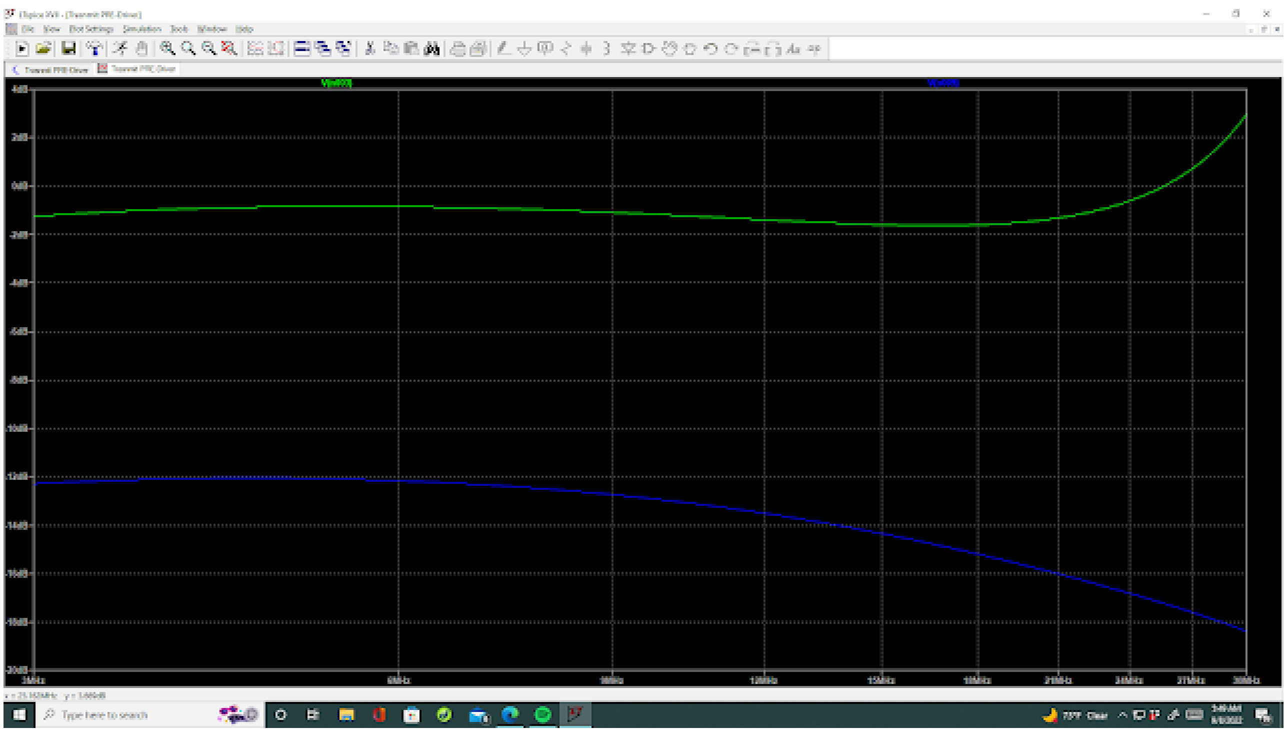
The blue line is the input signal level which I assume is being loaded by the input as the frequency increases. The Green line is the signal output across 50 Ohms. That is a flat response and the spread between the in/out is 10 dB over 30 MHz.



R6 is for test purposes (50 Ohm Load) and not installed in the final circuit. You wouldn't believe despite the notes on the drawings the volume of emails -- What does R6 do?

Up to this point we have the IF amplifier stages, the 3dB Pad and the receiver RF Amplifier. In many of my projects this stage was made to be steerable so that on Receive it was the RF Amplifier stage but on transmit it was the Transmit Pre-Driver stage and there is no reason why this could not be employed as well for that purpose.

Here is a plot with the input changed from 0.5 microvolt to 500 Millivolts and the 10 dB gain holds across the HF Bands.



Thus, we now have several of the blocks required for the transceiver. The RxTx Mixer will be an ADE-1 and the same for the Product Detector and Balanced Modulator.

Since I had such great success with the 2N2222A as the Microphone Amplifier and Audio Pre-Amp this will also be used for the project. Also, to be pressed into service is the LM-380N-8 Audio Chip.

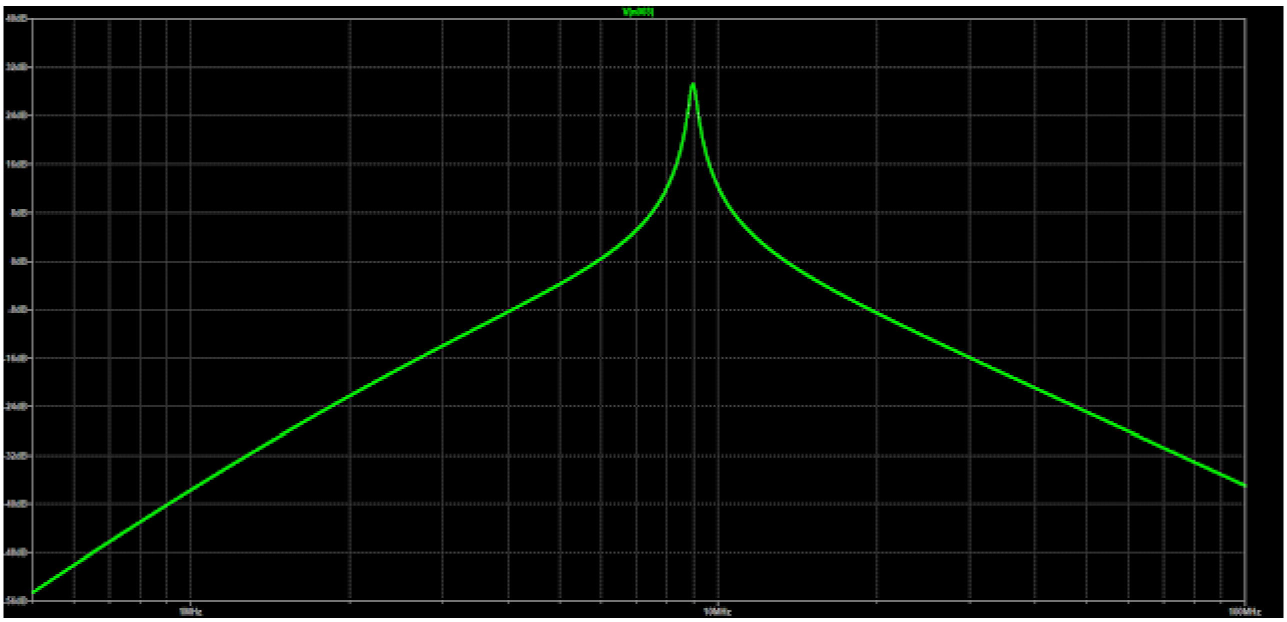
The RF Driver will be the 2N2219A and the Final the Mitsubishi RD06HHF1. Again, these are seasoned well behaved circuits used in many projects!

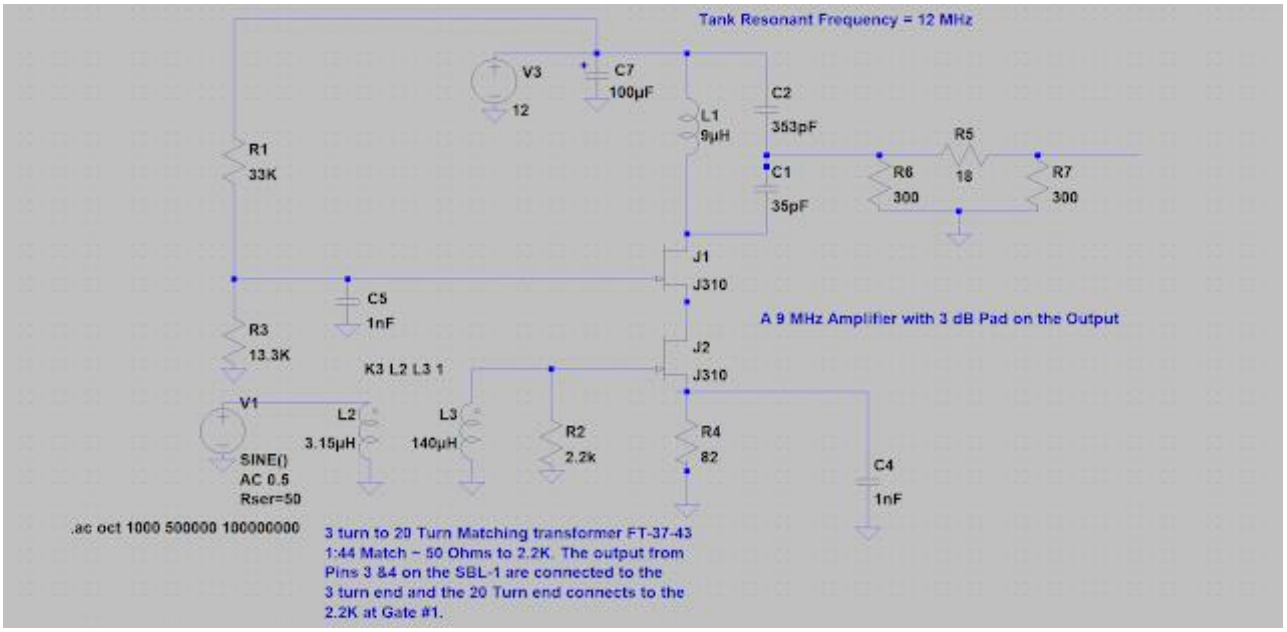
The unknown at this time is the Post Mixer Amplifier following the Mixer Stage and ahead of the 1st IF Amplifier Stage. That will be the next nut to crack, and it smells like a 2N2222A

Now essentially, we have the elements of a block diagram which will also be formally defined in the future. But our process was aided by the use of known blocks that did not need a detailed analysis as they are of known performance.

Are you following along, OK?

9/07/2022 A 9MHz Amplifier with 3dB Pad. Using Capacitive Matching.





The values for L1, C1 and C2 for 9 MHz have been developed using a seat of the pants approach. I will explain. The Pad has been modified to now provide 3dB of attenuation using close to value resistors. The purist would say 292 Ohms and 17.9 Ohms, but the values shown are close enough for government work!

The circuit constants were developed by looking at C7 and C2. These two caps are actually in series and therefore C7 (at 9MHz) looks like a short to ground for RF (roughly 0.18 Ohms) whereas the C2 you will find is

50 Ohms at 9 MHz so that matches the 50 Ohm termination of the Pad. Now taking advantage of the of the 10:1 feature such as you have a 10 Ohm resistor in parallel with a 1 Ohm -- the result is near 1 Ohm. The same for capacitors in series. So, if we make C1, 1/10 of C2 its value is 35 PF. It looks like 500 Ohms at 9 MHz.

Now C1 and C2 are in series across the Inductor and their series value is just south of 32 pF which must resonate with L1 at 9 MHz which drives the inductor value. Thus 32pF (31.8 pF) and 9 UHy resonates near 9 MHz.

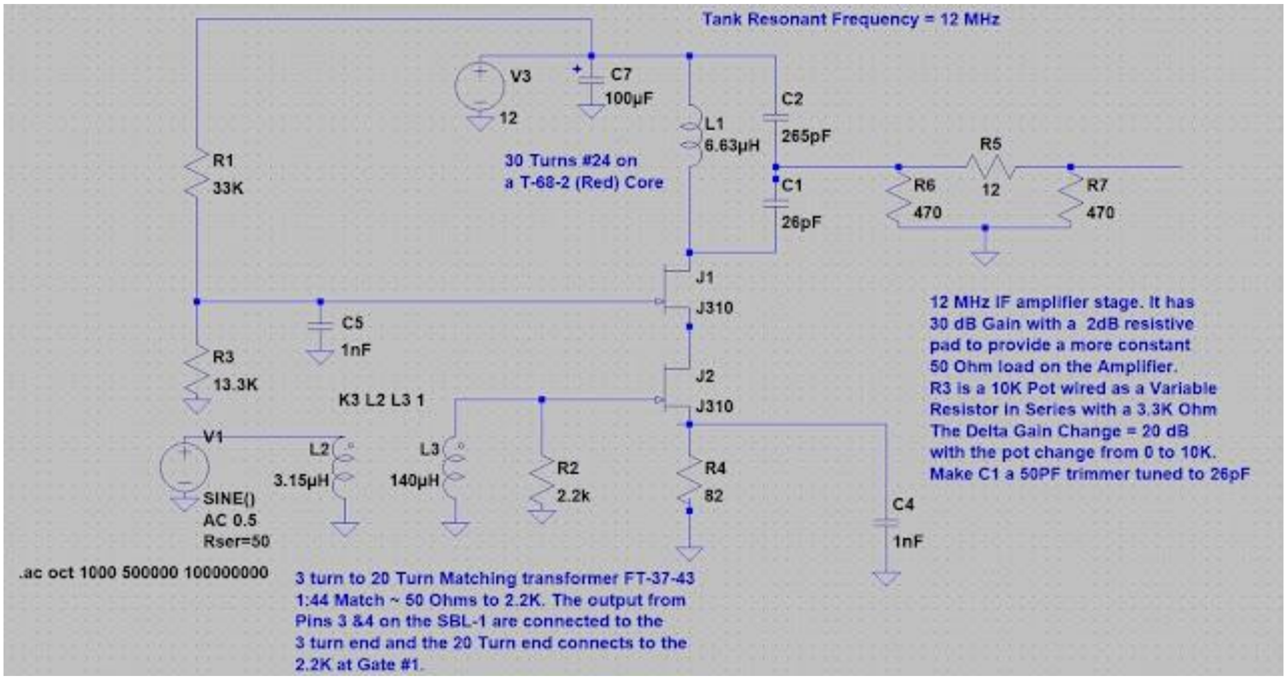
The next posting will show a broad band RF amp stage. BTW the BF991 DGM has been found on eBay with many suppliers in the UK not China.

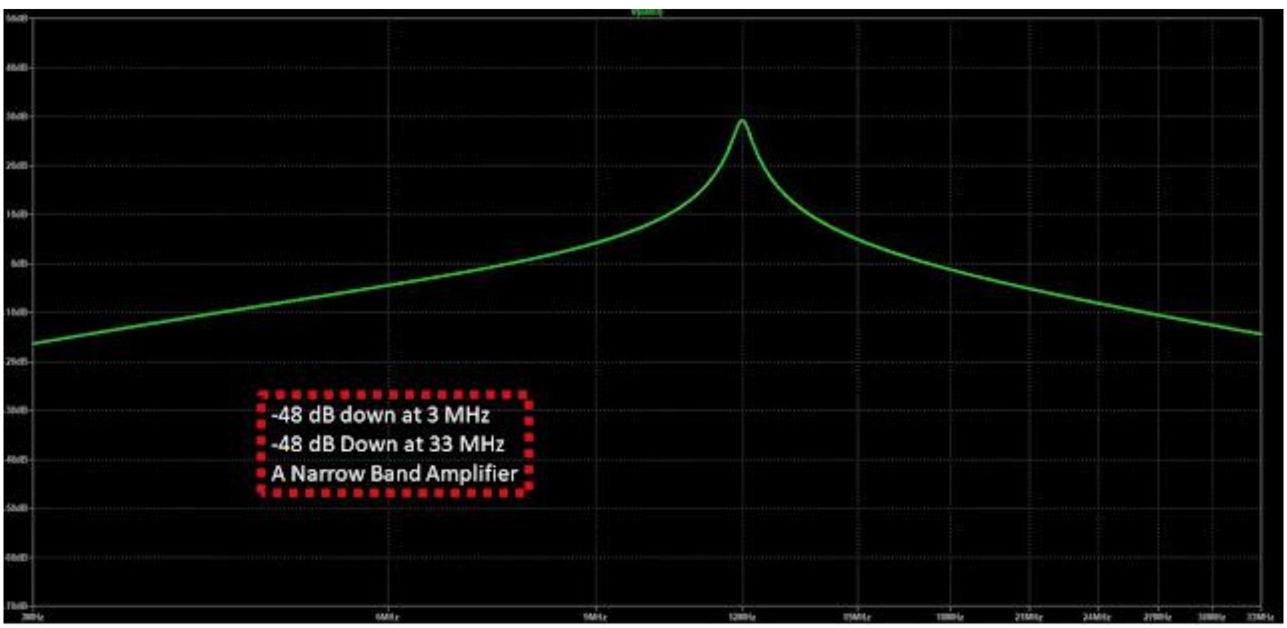
That said the BF998 was a favorite of W7ZOI, but you must limit the Drain supply voltage to about 10 VDC. The BF991 can take up to 20VDC which makes it ideal from portable or mobile operation as no voltage dropping needed. The BF998 are also available on eBay including one US Source.

9/06/2022 A look at some of the circuits!

I purposefully have not shared a block diagram as this is the Fan Dancer effect. You look and for the longest time all you see is Fans, but you have your suspicions and hope soon to catch a glimpse.

One circuit element identified in our Gain Block assignment, well actually two pieces are the 1st IF amp stage and the -3dB pad. So, what would such a circuit look like? This is where LT Spice comes home to roost -- you do know that was mentioned early on as a tool.





The first item to cover is that I pulled this from my files and is not what actually what will be used in the rig but serves as an example.

The IF is at 12 MHz, and it only uses a -2 dB Pad. But it is the approach that is decidedly of import. The input is matched to 50 Ohms and the Pad is 50 Ohms that is capacitively matched to the tank circuit. Thusly, when we define the IF frequency, we need to recalculate the tank values (C2, C1, L1) and to set the pad to -3dB.

Now a word about this amplifier and a look at the plot is the tell-tale answer. It is great for an IF amp with a somewhat narrow bandwidth but awful as a Broad Band RF Amplifier. So, if you simply used this as an RF amp --it would not do so good on 40M or 20M. We talk about this as a source of signal loss in the System. The block must be used for the purpose intended.

Following the -3B Pad would be the matching transformer to our Crystal Filter. The J310's seem to be drying up so that might be of a concern. Real Dual Gate MOSFET's are an alternative but they too are hard to find. The BF991 is a good candidate.

This piece of the circuit likely caused some head scratching, but you can take the values and do your own simulation. BTW do not forget to specify the coefficient of coupling for the input transformer otherwise you will get no output!

Clemenza says: "Ditch the gun and grab the cannoli"! Thank You Richard Castellano!

9/05/2022 What is 100 dB System Gain?

If we arbitrarily suggest a 100 dB System Gain across the Receiver, just what does that mean? A standard often used is S9 and that relates to a signal of 50 microvolts. The simple view is a signal picked off the air at 50 microvolts with a 100 dB System Gain would register 5 volts at the end of that system. You can do the math where 100 dB = 20 * (log (5/0.000050)). That is a healthy increase in signal level. [5 Volts (RMS) across 50 Ohms is 500 milliwatts --just for reference purposes.]

I took a notional look at a 100 dB Gain Distribution across a Receiver, and this is only one cut of what may be required to deliver 5 volts from a 50-microvolt signal.

Stage	Gain/Loss in dB	
RF Amplifier	10	
Mixer Stage	-7	
Post Mixer Amp	20	
1st IF Stage	25	
3dB Pad	-3	
Cryrstal Filter	-5	
2nd IF Stage	25	
Product Detector	-7	
Audio Pre-Amp	20	
Audio Amp	22	
Total System Gain dB	100	

Some observations from this notional look starting with the RF amp stage that only has 10 dB of Gain which is a compromise between signal and noise. Yes, the 1st stage is impactful on how much noise rides along.

Some would argue that this number should only be about 7 dB or maybe even less. The Atlas Series of Transceivers had no RF Stage to address noise at the front end!

Jumping to the end we have nearly half the overall resultant gain located in the audio amp stages. A simple 2N2222A can deliver a very clean 20 dB of signal boost and for a final stage I would not use the LM386 but the LM380N-8 which has plenty of headroom and easily can supply 22 dB of signal output power. This hefty amount of gain assuming we balanced the signal to exceed the noise does not add to the noise with the proper devices operated well within their range of operation.

Now something not often seen in my rigs is a 3 dB pad and a strong post mixer amplifier. This is an alternative to the TIA. Noteworthy is the 2N5109 or 2N3866 were often seen in W7ZOI's Post Mixer Amplifier stages. The 3DB Pad is to provide a constant load to the crystal filter. My Fat Finger Syndrome has struck once again in the misspelling of CRYSTAL Filter. Since the 3 dB Pad is typically 50 Ohms careful matching to the Crystal Filter input impedance is requisite!

The classic solenoid wound coil on a FT-37-43 core with 19 Turns tapped at the 6th Turn matches 50 Ohms to 500 Ohms. For the NB 19^2 = 361 and 6^2 = 36 so that 361/36 = 10 and 500 Ohms becomes 50 Ohms, or 50 Ohms becomes 500 Ohms.

Another note -- this topology would dictate a "single pass" in one direction through the Crystal Filter since a pure bilateral approach would be complex with the 3 dB Pad. But we know how to do that!

So now I need to look at a realistic overall Systems Gain and this post is to merely frame a process as to how to assign real world values to the block modules and to test the reasonability of the various stage gains.

Yet another reason to have the soldering iron off. Ditch the gun and grab the cannoli!

Radio Gear on the Kon Tiki Raft, Call Sign LI2B-- System Performance was critical!

Look at the above photo --this is where having great equipment is critical. I think one of the rigs was a National 173. I also seem to remember one of the crew, named Torstein Raaby operated a Paraset behind enemy lines in WW2 and was key in the sinking of a German battleship.

The Kon Tiki Call Sign was LI2B. Of Note, LI2B was in regular contact with W3YA the ham club at Penn State. The call W3YA belonged to Professor Gil Crossley. While a student at Penn State, I visited the W3YA shack and saw many photos of the Kon Tiki.

9/04/2022 Losses in the Receiver stages

So, what does a receiver actually do? Wow that is a fundamental question that can be somewhat answered by the following:

1. A Receiver is a combination of circuits that take weak signals traveling through

the ionosphere and reproduces them into useful information
2. The key to the received signal is that it is faithfully reproduced without loss of information
3. The receiver circuits do not compromise the original signal.

I am reminded of RCA and the clever advertising campaign of the small dog (Nipper) listening to a loudspeaker with the caption to the effect of listening to his master's voice. That picture captures the several points mentioned earlier.

Taking a huge leap, we often think of a Receiver as a device to take those very weak signals and to amplify them for useful purposes. But we often don't think about the losses in such a process. Thus, our overall gain block must account for not only the stage gain per block module but also the losses in various blocks.

Just what are those losses in a receiver? In fact, there are many and some are dictated by the topology. I will cover some of the major culprits but likely I have not uncovered all of them.

1. Passive mixers. It is so cool to use Double Balanced Mixers like the ADE-1 or SBL-1 or even the TUF-1. No DC voltage is required and typically just four connections: IF, RF, LO and Ground. But they all suffer from a Conversion Loss, which may be on the order of 6 to 7 dB.
2. Crytal Filters. These too can have loss and I typically peg that in the 5 to 7 dB range. Although a friend built a 10-pole filter, and his measurements indicate only a 2 dB loss. That may not be typical!
3. Impedance matching. If we fail to match the In's and Out's there will be losses. This also extends to matching across a range of frequencies. Broad Band is not a

YL Orchestra but indeed a flat response across a wide frequency range.

4. Band Pass Filters. If the design employs Band Pass filters and they are not carefully designed then there may be a peak in the middle of the band but a rapid drop off at the ends, A flat response across a band of frequencies is a design issue.
5. Internally generated noise. Yes, that gets down to things like packaged audio amplifiers and active mixers (NE602). These can be noisy and if there is noise then there is a signal loss!

So, circuit losses are not just a matter of 1 to 2 dB but if we employ DBM's for the Mixer and Product Detector that is 14 dB, coupled with the crystal filter loss is now pushing 20 dB just across those three elements. If you now add in losses from impedance mismatching and poorly designed Band Pass Filters, we are inching toward 30 dB of loss. That my friend is not insignificant.

So, if one were to pick a gain number like 100 dB across the whole receiver then you would have to start with 130 dB system gain to account for the losses.

This is where Haywards TIA amps can play a role with termination insensitivity amps. Hayward found especially around crystal filters if you had a varying impedance this led to signal distortion. Our signal not only must be amplified but also faithfully reproduced. But are there other ways to do this without using the TIA. Short Answer = Yes.

9/03/2022 ~ The Overall Gain of the Receiver Section.

First Rule: Turn off the Soldering Iron as having a hot iron with nothing to solder is simply a distraction!

Think of the famous line from the movie "The Godfather". Paulie Gatto was rubbed out and Clemenza says to his associate "Leave the Gun and Take the Cannoli". So, I say to you "Leave the Soldering Iron OFF and do the noodling"! BTW my mother's family name was Gatto.

You could slap dash together a bunch of circuits, hopefully no Bitx, no TIA or no EMRFD and what would you have? It might work but is it working well! Too early to declare victory!

It is best to start with an overall gain distribution for the entire Receiver section and then look at the stage gain (and losses) of the individual receiver blocks. Often a lot of gain is put in the 1st RF Amplifier stage and indeed you will boost the signal BUT you will also boost the noise so that spells compromise and moderation.

Then there are endearing terms such as "Dynamic Range" which factors in the ability of the receiver to amplify both weak and strong signals. If in the stages following the

RF Amp stage, you arrange the gain to boost the weak signals -- the very strong signal blast through the remainder of the circuitry. That is why Volume Controls and sophisticated AGC circuits were invented.

We also need to pay attention to the minimum discernable signal (MDS) that the receiver can hear. In the receivers of old we find that the published sensitivity factors often said that you simply didn't hear that weak DX stations.

Then there are issues with internally generated noise -- you know the poor LM386 that just seems bloody awful noisy. You spent a lot of time on the front end to end up sabotaging the project with a noisy audio stage.

For this posting we have not gone into the depths of the overall gain and only mentioned some of the factors involved in making the design decisions for the topology. In time we will flesh out the myriad of those factors. We also hope to establish an overall gain design goal. (Some say 100 dB while others say 200 dB -- but we hope to peg that number. You got to think hard and long about 200 dB and how do you prevent it from becoming an audio oscillator.)

It is not enough to just build a radio! But the real joy is to build a radio that hears well and works well on todays' modern bands. The emphasis on the hearing part applies to most hams as we do a lot more listening than we do transmitting. To wit that applies to the majority of hams as well who spend time working contests! The DX'ers of course do a lot of listening! For those of us who are homebrewer's, the listening part is a test of our design!

While we are "noodling" stage of the project, if you want to participate in this adventure then this is a good time to engage yourself with LT Spice. This project may actually cause a surge in the use of the Nano VNA if you feel comfortable in trusting that device. A good quality DSO and a solid Signal Generator are some basic tools also needed.

****

This project will start from the back end and usually an afterthought in most projects. I have a neat small metal box that originally held a food product. So now the challenge is how to build a SSB transceiver inside the confines of this box.

As typical I have requirements list of features and functionalities. It has to have a Digital VFO, Color TFT and that is a starter. It will mostly be transistors and the band of choice will be 20M. After all the Cycle 25 is supposed to be so spectacular.

But hidden in my noodling process for this rather small transceiver is DFMA (Designed for Manufacturing and Assembly). I have built rigs that once done were really hard to service. By starting with this premise will affect how it is designed, how it is built and how it is assembled.

Then the focus immediately turns to topology. It has to be something that is not the usual cookie cutter approach where you start with Bitx circuits then add TIA circuits and finally only stuff from EMRFD. This is time to think out of the box. Yes, No analog VFO!

Regrettably you will have to know stuff to replicate this rig. Yes, you will have to learn something other than the Menu listing from an ICOM IC-7300. Are you up to the challenge?

Pete, N6QW