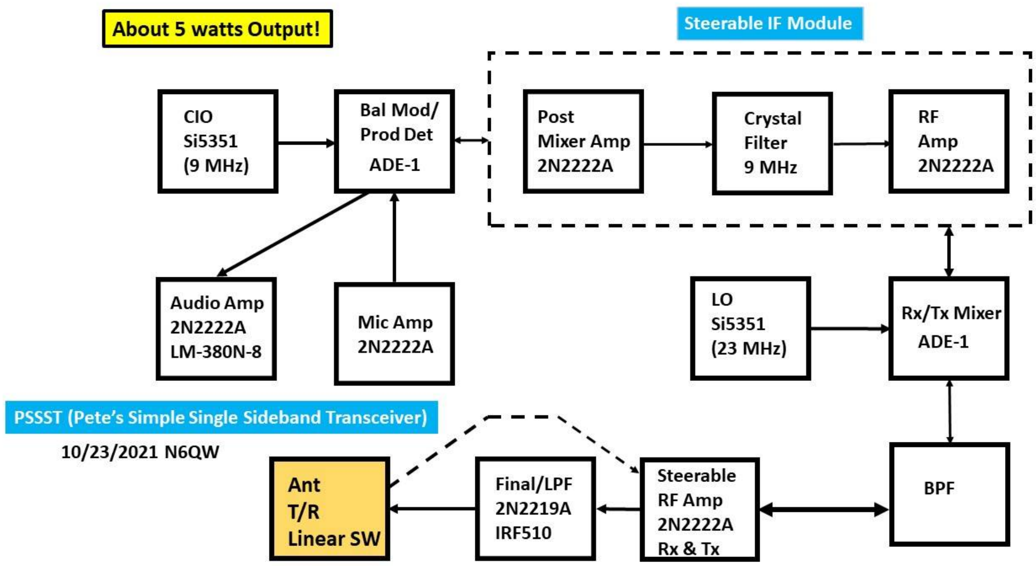
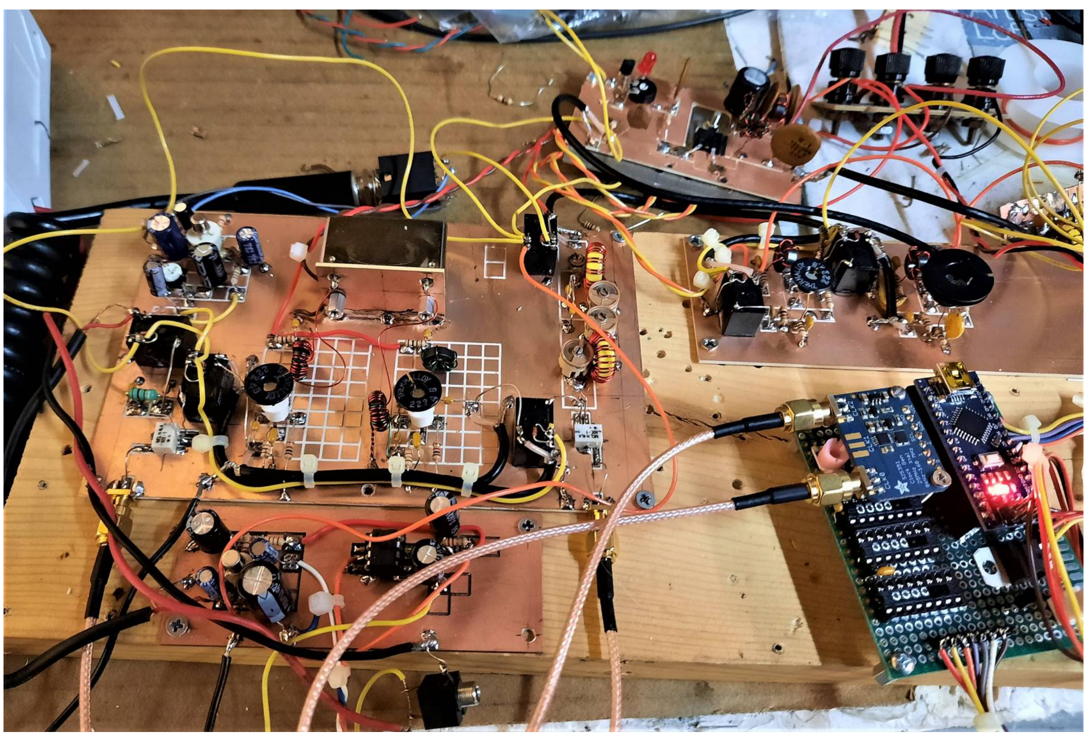
Meet the PSSST ~ An Amazing SSB Transceiver!

Pete Juliano, N6QW

from https://www.n6qw.com/PSSST_20.html





Our goal is to create a fully functioning "Minimalist" SSB transceiver using something different than the currently popular bilateral (Bitx) topology and in doing so use the minimum number of transistor devices. The ensuing webpages describe a fully functional and operational 20M SSB transceiver that uses a total of 7 transistors, Five of those transistors are 2N2222A, the

6th is a 2N2219A and the 7th is now a RD006HHF1. With some shopping all seven can be purchased for under $10 total. The output power is 4 Watts with the RD006HHF1. If you stick with the IRF510 the cost is under $5.

The innovation in this project is that two of the modules (the IF Module and the Rx RF Amp/Tx Pre- Driver) are relayed steered within the radio so that in one direction they are in the Receive path and in the 2nd position they are in the Transmit path. This saves a lot of circuitry and less opportunity for errors. We strived to use readily available and common parts so they can be easily obtained and at low cost.

The circuitry was simulated using LT Spice to insure proper biasing and that maximum gain can be acheived. One success factor we heartily believe in is the use of commercial crystal filters. This approach is to entice as many builders as possible wherein we see building a homebrew filter as major stumbling block. We suggest once the rig is working then you can go play science project with a homebrew filter.

I am happy to report my 1st contact (11/6) with VA7RW (Ray). That was barefoot and Ray was complimentary about the audio. I mention this as I spent a good deal of time simulating the audio response curve of the Microphone amp. BTW that same amp circuit was used as the audio pre-amp driving an LM380N-8 IC.

Here is a clincher on Receive there are four 2N2222A's and one LM-380N-8 active in the circuitry. On Transmit there are four 2N2222A's, one 2N2219A and the RD006HHF1 (or IRF510) active.

My goal has been met!

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The idea for a Minimalist SSB Transceiver came up when I tried unsuccessfully to build the three tube IMP SSB Transmitter from W4IMP (SK). What I saw in the early building stages were not so good results (ie the balanced modulator was crap) -- so I thought this is wasting a lot of time* therefore, why not do it in solid state but make it a transceiver. I started first with a requirements document. [*It may have to do with the LO drive level to the Shottky Diode Balanced Modulator. Someday a revisit to those boards; but not now.]

At this point I am introducing link pages that detail the project.

1. **The Digital LO/BFO & Code**
2. The Band Pass Filter
3. The Microphone Amplifier
4. The LM-380 Audio Amplifier
5. The IF Module & Relay Steering

I will endeavor to address why I have done certain things a certain way. The 1st is: Why 20M? The answer is Sunspot cycle 25. Things are perking up and the opportunity exist to work DX with QRP!

Part of my effort on this rig is to encourage those new to homebrewing to build the project. Key to that is the use of a commercial crystal filter. The next time you build a transceiver after the PSSST, then is when you can learn about Dishal, G3UUR, W7ZOI, AADE and WA5BDU. Right now I want you to have a successful and working rig. That means starting with a commercial filter!

Building a crystal filter for the very 1st time can be problematic. That said an excellent video on how to build a crystal ladder filter comes from Nick, m0ntv. It has an appropriate title **"Crystal Filters for the Fearful". You can see that here Fearful Filters!**

Building a Crystal Filter without prior experience could result in terrible performance and levels of frustration that would cause most to call it quits. It takes a lot more than plunking 4 crystals in a circuit and calling it victory!

Successfully building a high quality filter is possible; but requires a deliberative and "follow the process" effort (and a lot of luck)! Regrettably my experience has shown too many hams start at page one and immediately want to jump to the last page. There is a lot in the middle that is missed and that results in Bad Filters!

BUT unless you are extremely disciplined (and lucky) the first one will suck BIG Time!

To move this forward, I have been in contact with Antony, G4CFY who along with his XYL operates Spectrum Comms who manufacture commercial Crystal Filters with frequencies of 9 and 10.7 MHz as standard products. So this is a source for you. [The 1st link is to the main site and the 2nd is to the page with the Filters. QED]

The Arduino Code will be provided for either filter frequency. Optionally the Spectrum Comms Filter matching can be either 50 or 800 Ohms -- I will also provide matching transformer data for either impedance. The 10.7 MHz Filter is a particularily excellent choice if 17M operation is contemplated. It will also work FB on 20M. Do Not Build your filter for this project as there is a high probability it will suck!

For my build I used a 9 MHz GQRP Club filter (no longer around) but its match is 500 Ohms in out. This is the easy 19 to 6 match. 19^2 =361 and the 6^2 =36 thus the 361/36 = 10:1

which is a match to 50 Ohms. A 50 Ohm match is a 1:1 and 800 ohms is a 16 to 1 easily done with 16 Turns and 4 Turns. 16^2 = 256 and 4^2 = 16. Thusly 256/16 = 16:1 and match from 50 Ohms to 800 Ohms. The cores are FT-37-43 and the wire is #26 enamel.

When Halloween rolled around my four kids would always ask about making their costumes and I would answer: First you start with a Poncho. Well all of my projects start with a block diagram.

This project initially started as a simple solid state transmitter to replace the W4IMP 3 tube transmitter. But after a bit of noodling on the matter, I then saw the possibilities of expanding it to a simple transceiver using Solid State Devices.

The first thing that should catch your eye from the inital Block Diagram is the use of the 2N2222A transistor at 5 locations. Added to the mix is a 2N2219A and one IRF510. So why the 2N2222A instead of the 2N3904, when the latter actually has a higher device dissipation (625 mw versus 500 mw). A really good question but this is where studying the data sheets pays off. Firstly, the 2N2222A comes in the metal TO-18 case style which means it can be fitted with a heat sink. Do Not use the TO-92 version of the 2N2222! The circuits run hot and you need the heat sinks!

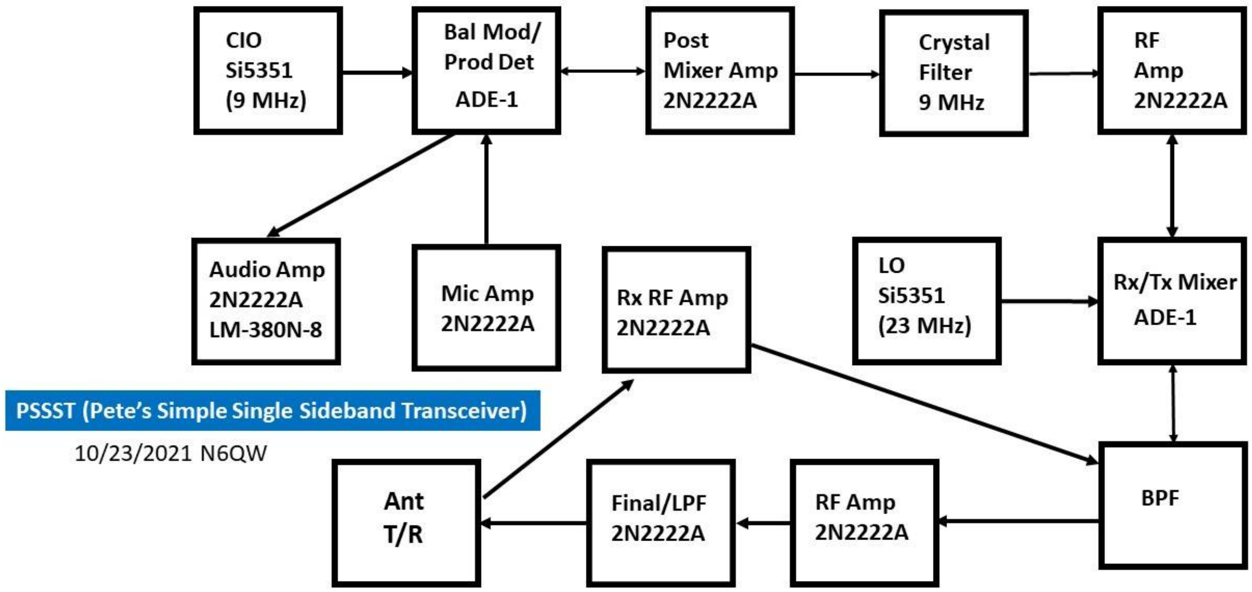
Another factor is continuous current draw -- the 2N3904 is 200 ma whereas the 2N2222A is 500 ma. Oh, another reason -- the 2N2222A is related to the 2N2219A (same die) only a different case style BUT their power dissipations are different! See 2N2222A/2N2219A

Many of my designs use the 2N2219A as the Driver transistor for a IRF510. Recently a project of mine was built by the VWS (Vienna Wireless Society in Vienna VA) and contacts were made on 40M using just the 2N2219A.

Let me not kid you --the design will try to squeeze every bit of juice out of the circuits and having a heatsink and higher current draw is important. The Ft cutoff frequency for either device (2N3904 or 2N2222A) is well above where it will be used.

So how does this work? Not shown is a TR relay where the NC closed connection goes to the Receiver RF Amp stage and from there to a relay connecting it to the Band Pass Filter. On Transmit the TR relay shifts over from the NC (receive) contact to NO (transmit) connecting to linear amp stages. The Band Pass Filter connects to the ADE-1 but is switched to either of the two (Rx and Tx) RF stages. But it is at the Band Pass Filter where some "Magic" occurs.

The magic is in the form of a steerable IF Module comprised of two 2N2222A amplifier stages with a filter in the middle. The key here, as opposed to the bilateral stages so commonly seen in popular topology, is a ***single pass system*** that sends the signals in one direction. What changes during the transition from receive to transmit is what is connected to the input and output ports of the IF Module -- ie signal steering.



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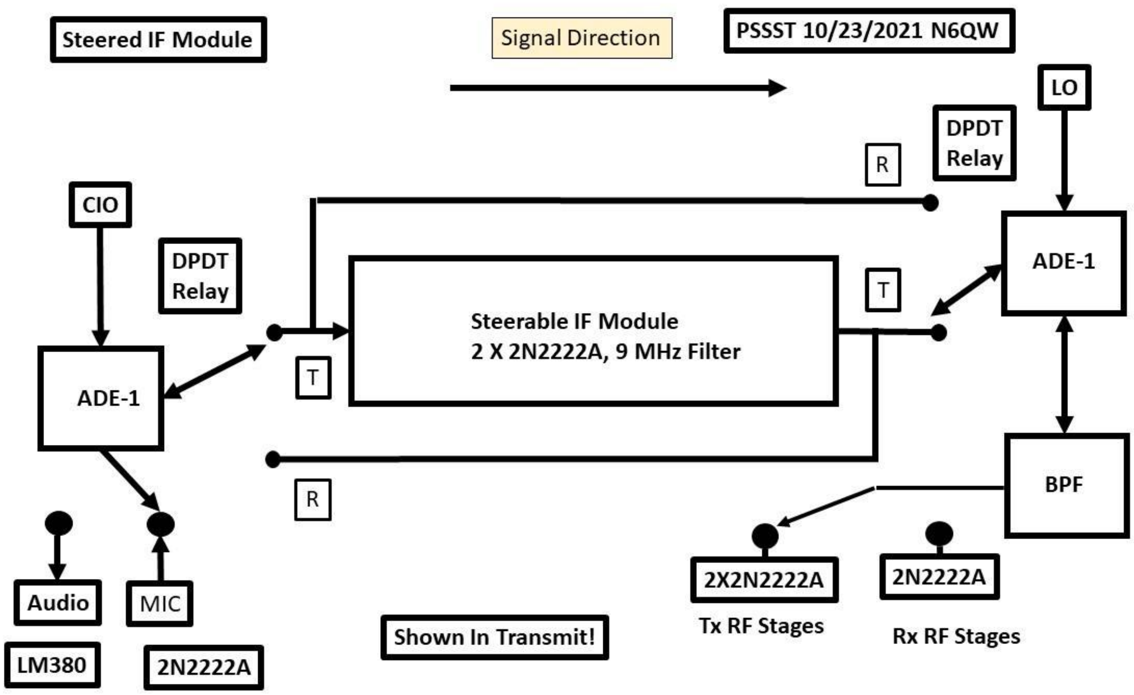


So, lets follow the signals! On transmit the output of the microphone amp is fed to an ADE-1 (Acting as both a Balanced Modulator and Product Detector.) where the DSB signal is sent through the IF Module where USB is passed (because of the BFO Frequency chosen) on to the 2nd ADE-1 which is the Transmit Mixer stage and mixed with the LO which is operating above the incoming outgoing / signal frequency. Thus a subtractive mix and sideband inversion and on to the Band Pass Filter. The additive mix is way above the Band Pass Filter range and is not passed.

A word here about BFO frequencies. Because of the subtractive mixing to get to the signal frequency and assuming USB -- the higher BFO frequency (above the Filter Center Frequency) is used.

On Receive the signal from the antenna (through the TR) goes to a moderate gain Receiver RF Amplifier on to the Band Pass Filter into the Rx/Tx Mixer stage. Here the signal is steered to the input port of the IF Module and the output is fed to the ADE-1 now working as a Product Detector and on to 2N2222A / LM-380 Audio Amplifier Module. My testing has shown with the minimum of devices it was necessary to step up the system gain via the audio stages.

Noteworthy is that the BFO and LO frequencies are generated via an Arduino Nano / Si5351. An added bonus -- the BFO/LO signals are connected to the same ADE-1's in either Receive or Transmit.

We haven't turned on the soldering iron (one of the last things we do); but we have spent a lot of time with LT Spice. I have identified four separate circuit configurations for the 2N2222A transistors. The first is the Microphone Amplifier stage where I looked carefully at the low end frequency response -- so the audio doesn't sound "tinny" or pinched.

Next was the IF amp module with the two 2N2222A amps. Of consideration is that the Crystal Filter I used has a Zin/out of 500 Ohms. So the IF Module stage considered that aspect. The simulations show about a 42 dB gain but we must also consider the filter loss of perhaps 6-10 dB -- so the net IF Module gain is > 30 dB.

The third 2N2222A design was the Receiver RF amp stage with a gain of around 10 dB. It is an untuned stage for several reasons. Stability and Simplicity are the two operative words. This design is good to 30 MHz and doubles as the same design for the Transmit Pre-Driver stage.

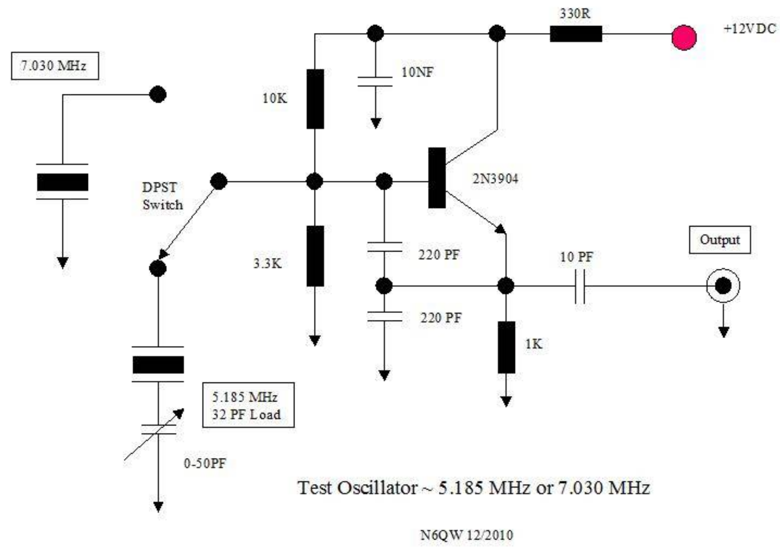
The fourth design is for the Final RF Amp Stage. Let me not kid you -- this stage is being run balls out and needs a heat sink! My goal is 13 Volts PTP which is around 400 mw. [13^2*2.5 = 422.5 mw). It would take about 90 ma across 50 Ohms to produce 400 mw. Now if we assume 50% efficiency in the device that would mean 180 ma to produce 400 mw. Thus you can see my choice for the 2N2222A.

While four designs are mentioned there are 5 applications as the Microphone Amplifier is replicated and used as the Audio Pre-Driver

This is a starting point for our SSB Transceiver design and undoubtedly will require revisions. The simulations look good ~ but real hardware performance is the test that counts.

The PSSST Project Build

Before I present the fabricate/build details, I want to stress the nesessity of having some test equipment to determine if something is working or not. Two such devices can be built for pennies and work very well. The 1st is a test oscillator to determine if in the last go around you smoked some transistors. It is also good to test devices (thinking they are good when they may be duds) before installing them in a circuit .



This Test Oscillator was built for another project (over 12 years ago) and I ended up sending it to an Extra Class Ham that couldn't get his to work --yes, he had piss poor soldering skills! So today I gathered up some floor sweepings and built another one only this time with a 14.060 MHz crystal. So now you get the drift (no crystals don't drift) -- not only will it test transistors; but also can be a weak signal source for testing and peaking the Receiver. I love "twofer's".

It took about 15 minutes to build including milling out a copper board. See the following link for the current build of the Test Oscillator.

The second piece of home built piece of test equipment is an RF Probe that is attached to your DVM. This is a crude level O Scope substitute. But what it will do is give you indication that RF is present and to determine relative magnitudes of RF. The readings may not be super accurate but it is the relative readings -- like tweaking and tuning a BPF results in more output. That can be very useful. See this link for a sketch of the RF Probe.

[Yes, that same Extra Class got this along with the Test Oscillator as he could not understand how to wire it up. I hope he never takes off the cover of his IC7300! I was too late in realizing that I should have not sent him those two items -- he will never learn by someone just handing him the gear. Help is one thing -- *enabling ignorance is another*!]

Another "tester" is a general coverage receiver with a BFO. With such a receiver you can see if an oscillator is oscillating and also where is it oscillating -- it doesn't have to give you a readout to 5 decimal places (like those that tout the Nano VNA); but you would know if it is close to 7.2 MHz and that it is oscillating. Another result of the test -- how does it sound? Does it sound clean? It is a like a go no go tetser.

The Build/Fabricate Noodling Process

Often you will hear me speak about noodling which is time spent with the Soldering Iron in the "OFF" position and you use your brain to think about the project. I keep a notebook and pencil handy to jot down notes as I go through the process.

My "noodling process" resulted initially in the concept and design of two boards with the island squares to house the circuits. The main board is 4 X 6 inches and the secondary board is 2 X 6 inches. The secondary board will house the Rx RF Amp and the Tx Amplifiers stages and the Tx LPF. All other circuit elements except for the LM-380 audio amp and the Digital LO/BFO are on the Main Board. The plan is to have the second board be mounted vertically and directly behind the Main Board. See this link for the layout of the two boards I fabricated for the main transceiver.

The Main Board shown in the link identifies the circuit block elements; but importantly the circuits are built in the form of islands. This is done so individual circuit changes/improvements can be done on a specific island. The squares were made "large' just in case I need to make changes.

My initial approach for the audio stage was the LM-386 Packaged Modules after several ham friends (N2CQR, G4WIF) had purchased similar boards on eBay -- essentially 10 Boards for $10. They have had great success with those boards. The one I bought has the volume control mounted on the board and the whole assembly mounts on the front panel via the pot. It also uses a different amp IC. I was excited as I saw some possibilities for space conservation.

But initial testing has proven the module I bought as unsuitable. As I said it is not the same one as used by my friends; but just does not have enough audio gain. Think of a Limp ... Good enough for high quality earphones; but not good enough for the $2 CVS specials. So my initial approach of two boards changed and I fabricated a third board.

A look at my milled crcuit boards may- cause a small panic -- don't panic! So sit down ... Search on Rex Harper W1REX [qrpme.com] and he has a website that sells the island squares, in sheets, so you can just break off what you need and super glue those to a piece of copper PC Board. So you can make the same boards like mine, without having to use a CNC Mill.

Build and Test As You Go!

My thought process led me to a logic sequence of "Build and Test" as you go. The worst thing you can do with any project is to solder everything in place and power it up only to find out it does not work! It also may result in a small smoke cloud on your workbench.

If you build small pieces and "test as you go" then you have that well in hand so that before you install the last piece you know up to that point --everything works.

[When I worked for a living I attended a manufacturing executives conference and as luck would have it sat next to the guy who ran the Toyota US Assembly Plant. We chatted a bit about how we ran our manufacturing lines (I was building military aircraft [F-15, F/A-18]; but our processes were similar, however, his had a few bonus ideas.). He mentioned that every 100th car on the line went through an automated special inspection process. I quickly asked isn't that expensive? He immediately said NO! Here is why. At that time he was shipping 2200 cars a day from that plant. He then said to me which would you rather do -- fix a problem on 100 cars or 2200 cars. That is when that concept snuck into my hobby -- test as you go.]

Because there will be so much information to share, I am creating many sub-pages so that page loading will not cause for the OM's a beard to grow or for the YL's another Brazilian Waxing session before the first page fully loads.

1	**The Digital LO/BFO & Code**
2	The Band Pass Filter
3	The Microphone Amplifier
4	The Pakaged LM-386 Audio Amp
5	The IF Module & Relay Steering
6	The Receiver RF Amplifier
7	The Audio Amplifier Stage
8	The Transmit Linear Amp Stage
9	The Wiring Integration
10	The Performance Results

My noodling process led me to sequencing the builds starting first with the Digital LO/BFO. When I am ready to start some testing it will be available as a part of the test process. (Shades of Heathkits!) My LO operates above the incoming / outgoing signal frequency by an amount of the BFO. So while the dial says 14.2 the LO is operating around 23.2 MHz. Now if I crank the dial so that the LCD reads 5 Megahertz --the LO is spitting out RF at 14 MHz and that now becomes useful for some testing.

The next Board is the new 3rd Board -- the Audio Amplifier. This will have to be moved up on the build sequence because of the poor results with the packaged Audio Amp model that I bought.

Think for a minute -- with the LM-380 Audio Amplifier and Digital LO/BFO we would sequence the follow on builds so that the Band Pass Filter and the ADE-1 Receiver Transmitter Mixer stage would be installed.

With just those two parts plus the Audio Amp and the Digital VFO (cranked down so that the LCD reads 5 Megahertz) I would have the makings of a Direct Conversion Receiver on 20 Meters. So that would be a test point and having the Digital VFO enables such testing. If that all works as a DCR then check those moudles off of the list. Our Test Oscillator at 14.060 MHz would be a local weak signal source -- is that a "fourfer" ?

At the other end of the board, by building the Microphone Amp and connecting the ADE-1 DBM used as the BM/PD, I now can test for a Double Sideband Signal coming out of the ADE-1. This is a key point -- with the actual building of the Band Pass Filter and the Microphone Amplifier I am able to test a good deal of the transceiver. This test as you go essentially is a check off list.

The real heart of the build is the IF Module and steering relays. The work to this point when completed now gives us about 75% of the whole transceiver and that is all on this mainboard plus the Audio Amp and Digital LO/BFO assemblies. Another nonus of this approach -- the testing of this subsytem -- if all works (ie receiveing a weak signal and having a SSB signal at the output of the BPF) Then the only issues when the full transceiver is complete is the Rx RF Amplifier and the Transmit RF sections.

The last two on our list (Items 6 and 7) are contained on the second board that houses the Receiver RF Amp stage and Transmitter RF Amplifier section.

Steps to a Successful Construction

Getting organized for the build / fabricate stage is as important as the circuit design. Too many homebrewer's start off a project woefully lacking even the basic tools and the right parts. A 10K resistor is not a good sub for a resistor specified as 47K.

When it comes to tools I recently have shifted over from my expensive DVM to a good quality VOM. (One costing about $30 versus the $9 Harbor Frieght one). If I smoke it, I will be mad but not as mad as smoking the $175 DVM. It works well. I also have a Siglent 100 MHz DSO and FeelTech Signal generator and an Audio Range DDS. One very useful tool is a homebrew SWR bridge and Power Meter. If you can wiggle the meter it is transmitting.

I also have not one; but two Nano VNA's and I don't trust either one of them. You never get the same answer using the same circuit measured with the two devices and you never get a consistent answer on the one I think is working. So I would bypass the use of a Nano VNA and I do!

Now, before the Nano VNA there were processes to measure Band Pass Filters. I did just that and you will see that in the link to the BPF. I centered the sig gen on 14.2 and terminated the BPF in 50 Ohms. I put my scope on that resistor and then peaked the trimmer for TFMS (tune for maximum smoke) at 14.2 MHz. Then I moved the sig gen up in frequency and down in frequency and noted where the signal dropped by 3 dB (half power) and then 6 dB (quarter power). A bit more time consuming -- but that I trust and so should you! My power measurements are consistent with the LT Spice simulations -- so no fuzz on this as there is with the Nano VNA's I have.

When it comes to the LPF the same setup as the BPF will clearly show the cutoff frequency and that too can be simulated in LT Spice and compared for consistency. Avoid the Nano VNA --they sometimes lie!

So before lighting off the iron have all of the parts in hand and have them segregated by the stages. I use plastic sandwich bags (see through) to collect the parts and then using my Sharpie Pen write on the bag the name of the modules for which the parts are intended, like Mic Amp, Audio Amp, BPF and so on.

Equally important is the "quality process" before applying power which checks critical factors.

- All parts are installed
- All parts installed at the right location
- All parts are installed with proper polarity (diodes, transistors)
- All joints are soldered properly
- The power is connected with the proper polarity
- Power is connected to all active devices
- Look for shorts, solder bridges or missing connections
- Use your VOM to check resistance values (no unseen shorts)
- Insure loads are fitted to power output stages.
- In the case of receivers -- is the antenna connected
- This may seem obvious -- using masking tape secure the DUI (not drinking but Device Under Investigation) so that it is securely fastened to the work bench. I have actually smoked some circuits because the board moved while being tested and wires got shorted!

The PSSST-20 Band Pass Filter

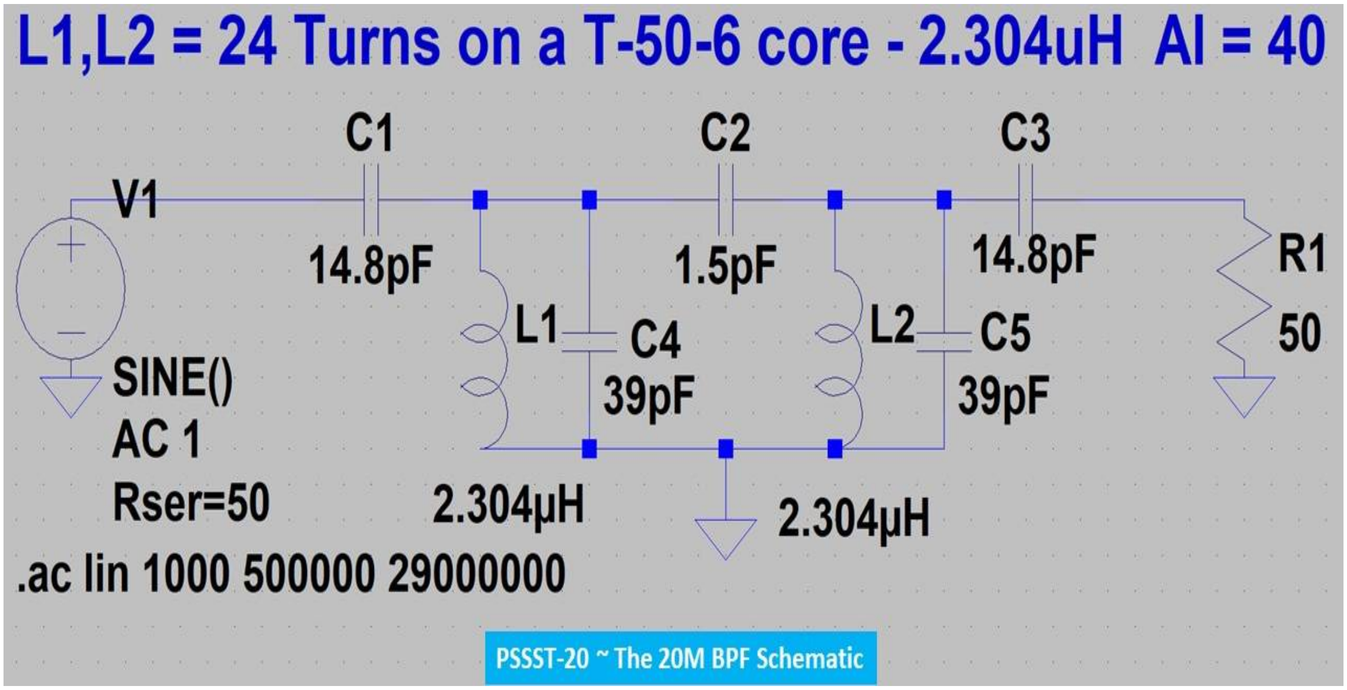
Within this transceiver there are several signal mixing processes with some being the ones we want and others are "out of band". Thus there is a need for filtering to pass only the signals we want while rejecting the undesirable signals.

Based on our topology we are able to use a single Band Pass Filter (BPF) on the Receive side so we only hear the signals in the band we are operating within. That same BPF works on the Transmit side to only pass the desired transmitted signal. A cousin to the BPF is the Low Pass Filter following the transmit stage so that no harmonics are passed.

The following filter has been used in many of my transciever projects and is adequate enough to satisfy the FCC. It is not a brick wall filter; but satisfactory for this application. The last photo shows a layout for the PC Board you can etch in your kitchen sink. The pad size is 3/4 inch by 3/4 inch.

Many would be itching to whip out their Nano VNA and take measurements. Go right ahead. But for me I won't! I have two Nano VNA's and trust neither of them! For one with the same Device Under Investigation you don't get the same answer with the two units. The one I think may be working does not give repeatable results. Test and get one set of values. Come back later and nothing changed and not the same result. Yes I did the calibration process and had everything terminated properly. I think the Nano VNA is overhyped and purely a cute toy. You should be suspicious of anything you do with your Nano VNA.

But old school is to use a signal generator and an Oscilloscope. That is what I did and have some photos of the readings. My DSO readings correlate to the LT Spice Simulation. Now there is two independent tests and that I Trust!



The Microphone Amplifier

In keeping with our minimalist approach, we are using but a single transistor for this task. The requirements for our circuit have many facets:

High Output

Wide Frequency Response

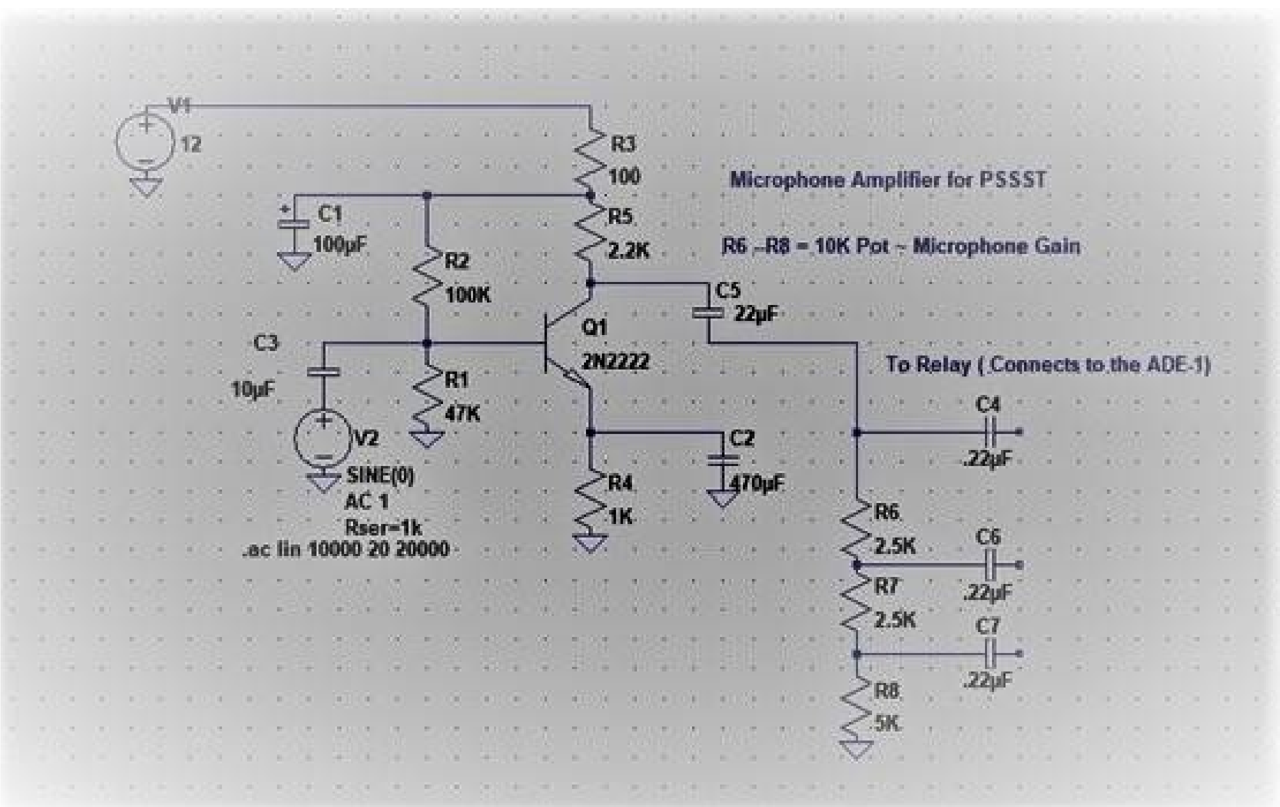
Low End CutOff Freq.

Presence

High Impedance Input

We have been working on an ideal Microphone Amp Circuit that addresses the five points in the table. With 2N2222A we may have found it!

The second circuit block to be addressed after the BPF is the Microphone Amplifier which will rest on the upper board upper Left Hand corner in the 5X5 matrix. The Pad size is 0.2 inches by 0.2 inches. As you will see in the plot good for 20 to 20kHz and should add "presence" to your signal with its flat response and certainly no complaints about the signal lacking lows. See the Photo below of the Mic Amp AND the relay wiring to switch between the Audio Amp and the Mic Amp from the ADE-1.



The Digital LO and BFO ~ Arduino + Si5351 and Color TFT

The PSSST started out with a 16X2 LCD and while we got creative we found having more real estate to display information was a huge bonus. The added icing to the cake ~ Color, lots of it. It also solved another issue. I noted with the LCD that the encoder would jump digits. That problems seems to be less with the Color TFT which perhaps says something in the code is the differential.

The Wire List Link shows the Pin wiring to the Arduino and the Color TFT. Guys and Gals I am bristling a bit when I get emails asking if some cheapo display will work with this circuit. Like in the TV Commercials of Old I am NOT the Shell Answer Man. If you have a display then check the Pin out of your display to the wire list and that is you job NOT mine. Secondly my code uses the ST7735 Libraries. If you pick a Color TFT with the ILI9341 Code Set, then it is up to you to find the libraries and the wire correlation. Time to step up and figure out this stuff on your own.

The capabilities of the Digital VFO includes selection of USB or LSB and various step tuning rates. Now embedded in the code is a selection of essentially two VFO's. I have set one so that start up is 14.2 MHz and the others is 14.074 Mhz. So at a flcik of a switch I check what is happening on FT-8 wihout having to tune down to that part of the band.

But there is more to this functionality. If we use a DPDT switch we could use one half to control two different frequencies in two bands --such as either 40M or 20M. The other half of the switch could power on relays so that you would have a comparable BPF and LPF switched in line depending upon what band is chosen. The USB/LSB selection now has import especialy if cruising down to 40M SSB. So just with some embedded code and one DPDT switch we have a two band SSB transceiver. We are still using just 7 transistors.

Bonus feature: TUNE Tone. Built is is a 10 second pulsed 988Hz tone that can be fed into the Microphone jack for tune up purposes. You won't find that in a BITX or QEX!

There is no pad layout as Vector prototype board was used and the whole assembly was wire wrapped (this is digital not RF).

NOTE on the Arduino Code. If you want the Sketch Info then send me an email to craponthebench@gmail.com By doing it this way I can gage how many homebrewers are working on the project. Or if you are so inclined --write your own code.

LM-380N-8 Audio Amplifier Stage

I started this project with a purchased module that had an integral volume control soldered to the board and had a threaded nut so that the assembly simply screwed on to the front panel. What I bought (regrettably too hurried before I clicked Buy It Now) had some TDA device that accepts a stereo input and provides a setero output.

It was like bringing a knife to a gunfight and was woefully underpowred and meant I likely would need a pre-amp stage ahead of it. So I just moved on and built a pre-amp stage and an output stage on a single board. It is now robust enough to amplify weak signals.

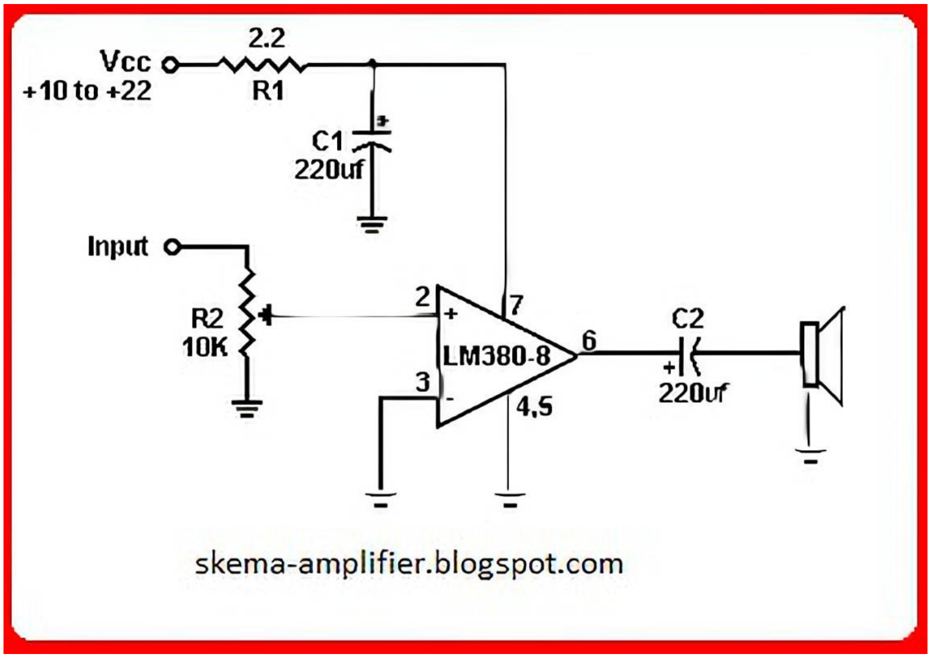
The Pre-Amp stage is the same design as the Microphone Amplifier (2N2222A) and the output stage is a LM-380N-8 which needs only three additional components; one 2.2 Ohm resistor and a two 220 Uf capacitors. That is it! The 10K volume control connects the Pre-Amp electronics with the LM380N-8 output stage.

Voltage is applied to Pin 7 via the 2.2 Ohm bypassed with the 220 Uf. The output is taken from Pin 6 via another 220 Uf. Pins 3, 4 and 5 are grounded and Pin 2 is the Input via the Center Wiper of the 10K pot. Pins 1 and 8 are NC. The Plus side of the 220 Uf output cap is connected to Pin 6 .

For those who don't read: THE SAME AMP IS USED FOR THE MIC AMP AS WELL AS THE AUDIO PRE-AMP ! The Plot Data for the 2N2222A is the same for either one.

I tested the Mic Amp in Transmit using audio tones at 200 Hz, 1000 Hz and 3000 Hz. The output is FLAT so your signal will have Presence!

You have heard how it sounds from some of the embedded you tube videos and this is a keeper module!



Steerable IF Module

If there was ever a case of identifying who is doing all of the lifting --this is the Module! The idea for this came from another project of mine called "The Paesano" which was a take off from a transceiver built by the EA QRP Club called the The Perigrino (Pilgrim). In the EA deisgn the filter was switched between transmit and recieve.

I extended that concept to switching the whole IF section not just the Filter. So the task was two fold with the first being coming up with suitable amplifier stage ahead of and following the Crystal Filter itself and the second piece was the steering of the module. The steering was the easy part as I have done that numerous times before.

So in looking at the two amp stages and because the IF module is essentially steered between two double balanced mixers, the 1st stage is in effect a Post Mixer Amplifier (PMA). The second stage is nothing more than a RF Amplifier at the IF frequency. So if you dare read EMRFD or follow QEX or Solid State Design For the Radio Amateur, you know there is much said about the PMA. It has to be a strong amp for good IMD performance but also provide a constant impedance so no distortion to the Filter. The added task is that you don't "overrun the Filter with too much signal.

In keeping with my Minimalist approach I ignored all of that mumbo jumbo; but just took a reasoned approach. Here is where I started. Firstly there are not a lot of amplifier stages in the rig. The second piece of that since it is steerable, there has to be sufficient gain for both transmitting and receiving. Thus read compromise and balance. Of equal importance is matching from the 50 Ohms of the DBM's to the IF Module and internally from the Amplifiers stages to the Crystal Filter itself. My GQRP Club Filter has a Zin/out of 500 Ohms.

For other filters such as Spectrum Comms.UK they are either configured for 50 Ohms or 800 Ohms. From the manufacturer the actual impedance is 200 Ohms and there is a 4:1 matching transformer, which depending on how it is wired can give you 4:1 Up or 4:1 Down. BTW that is another issue with homebrew filters ~ finding the impedance to match. A poor match results in a lot of pass band ripple. Those who use a Nano VNA --it may be lying to you.

Next we wanted to use the 2N22222A because we already knew that the PMA would run hot. Most of the Hayward designs have a 2N3866 or 2N5109 for the PMA --those are more than a 2N3904. As you will recall the 2N2222A in the TO-18 case style can be fitted with a heat sink. Now we also had to look at the gain across the whole module which says the net gain = PMA (Gain), Filter (Loss) and RF Amp (Gain).

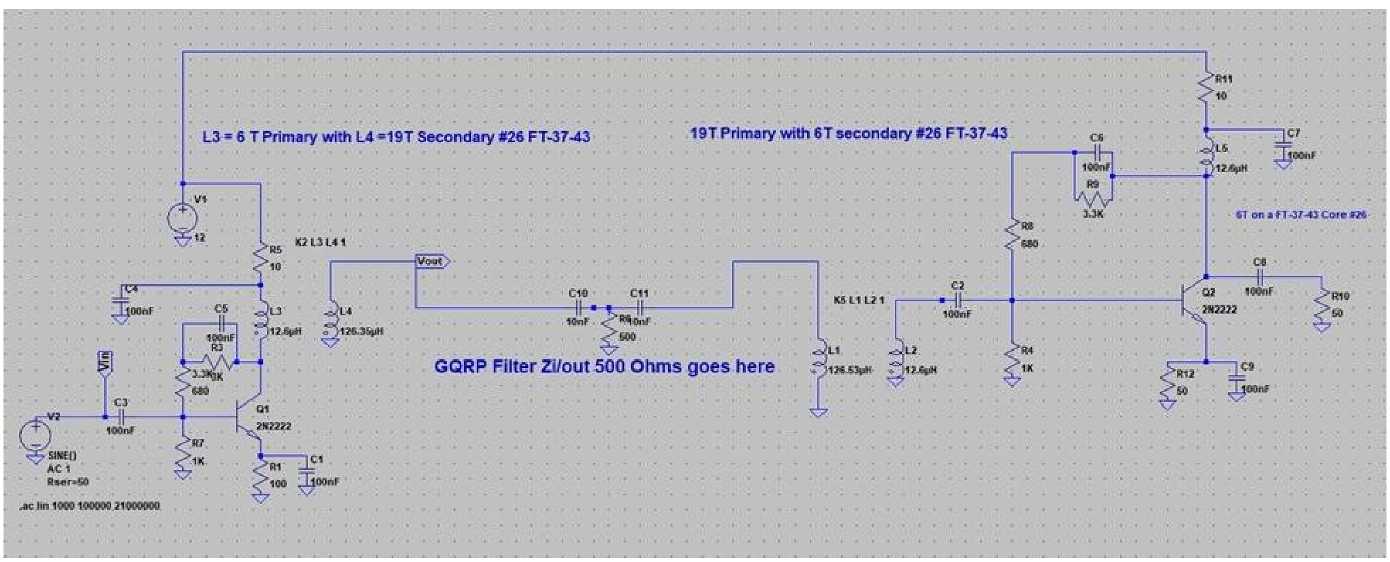
This is where LT Spice comes in the picture and a "PLUG" Gain Loss of the Filter of somewhere from 6 to 10 dB is not unrealistic. I did not use my two Nano VNA's (untrustworthy) to do any measurements and the plug number is in the typical range. A Loss of only 2dB in a filter is either spectacular or a faulty measurement. The Botton Line = likely across the Module we should see something greater than 30 dB and to have that consistent in both Receive and Transmit.

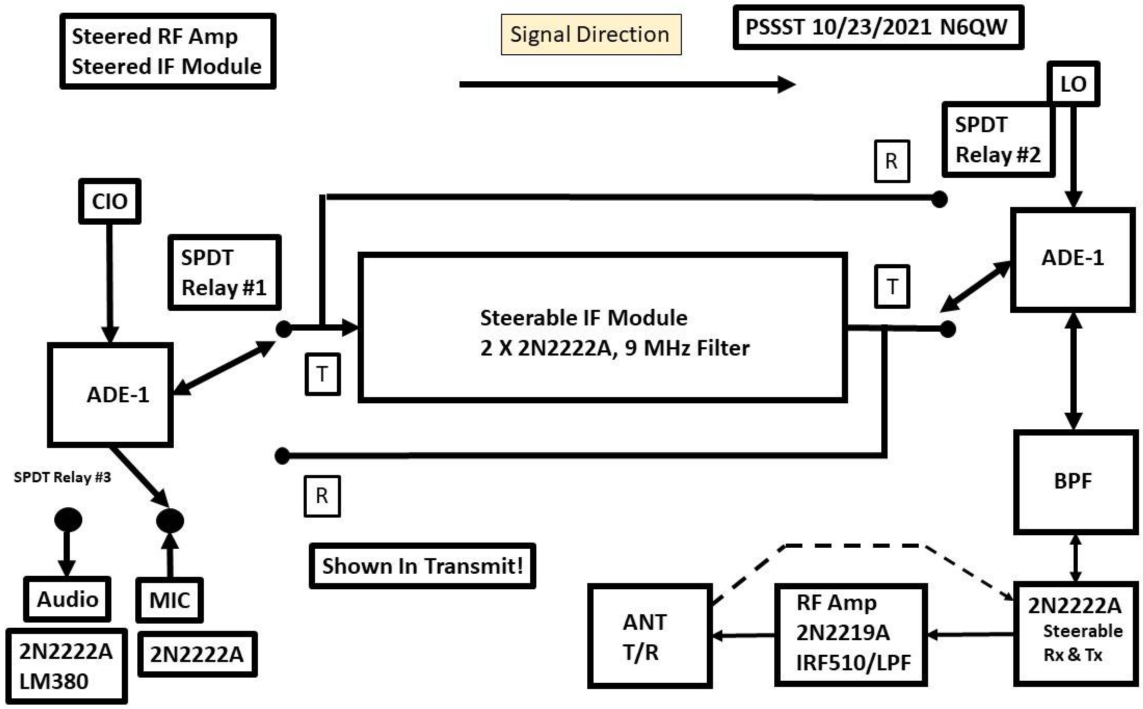
SPECIAL NOTE: In the simulation you will see C10 and C11 with a 500 Ohm resistor stuck in between them. This is to simulate the crystal filter. These are NOT installed in the actual circuit. Simply connect the Filter to the Output side of the coil on the PMA and the Input side of the RF Amplifier stage. Given past experience this is good for two or three emails from those who don't read the information and simply connect things.

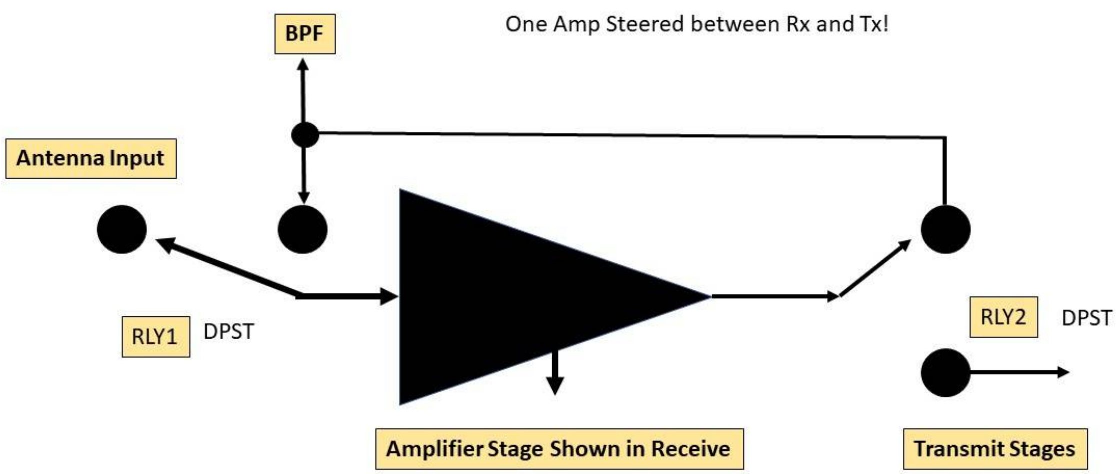
In the last photo link you will see the Main Board where in the upper left corner, the Microphone Amp and in the upper right corner the Band Pass Filter. Also note the steering relays and the ADE-1 Double Balanced Mixers. Interspersed between the Mic Amp/Audio Amp Relay and the ADE-1 is an Audio Low Pass Filter comprised of a 1 MHy Choke and two 100nF caps. One of the Mixing products in the Product Detector is NOT Audio!

There is one relay near the top of the Main Board next to the BPF. That relay on receive povides power to the Audio Amp. However on Transmit it powers the RF stages (Bias only to the IRF510/RD006HHF1) , the Microphone Amp, the Driver and power to the Linear Amplifier Switch. All other circuits are powered ON at all times.

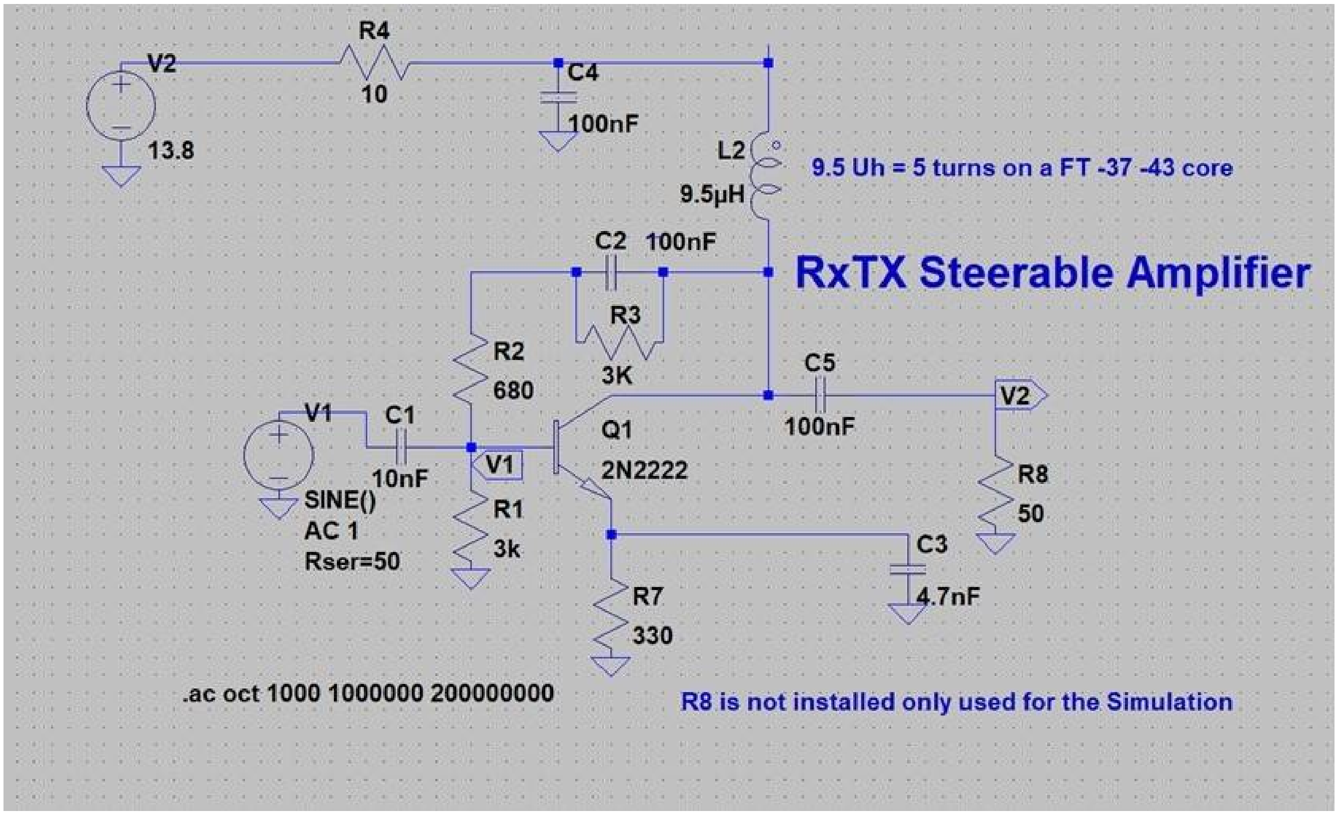
The wiring to the ADE-1's and the Three Relays is shown in the Main Link Wire Integration







In receive the signal from the amp passes on to the BPF. But when switched to transmit, the signal Out of the BPF is amplified and passed on to the Transmit stages



The Driver and Final Amplifier Stages

These are perhaps better known as the "Grief Stages" as often they cause the most grief when trying to build a transceiver. I can't tell you how many times when 20% of a project is spent on the earlier modules and getting them working, whereas the Driver and Final are only 20% of the hardware but consume 80% of the time to get them tamed. [We have a Pareto Principle at work here and we are not talking about rabbits.]

This often is the result of trying to get as much power output as possible with the minimum number of stages. High gain over driven amps are ripe for oscillation. That said by adopting some standard layouts for these stages you can get a leg up on making them behave properly.

The Drivers stage uses the very same pad layout as the steerable Rx/Tx stage used as in the RX RF Amp and the Tx Prediver so I won't repeat here. However there are some minor circuit changes to drive the pants off the 2N2219A. In our write up we clearly stated and showed that the two deivces are essentially the same. But with the T0-39 case style of the 2N2219A you can get a higher device dissipation over the TO-18 case on the 2N2222A. We will show that circuit diagram. No my instincts tells me I will get emails where is the layout for the Driver -- spoon feeding again! In the photo link you will see the Driver next to the Steerable amplifier .

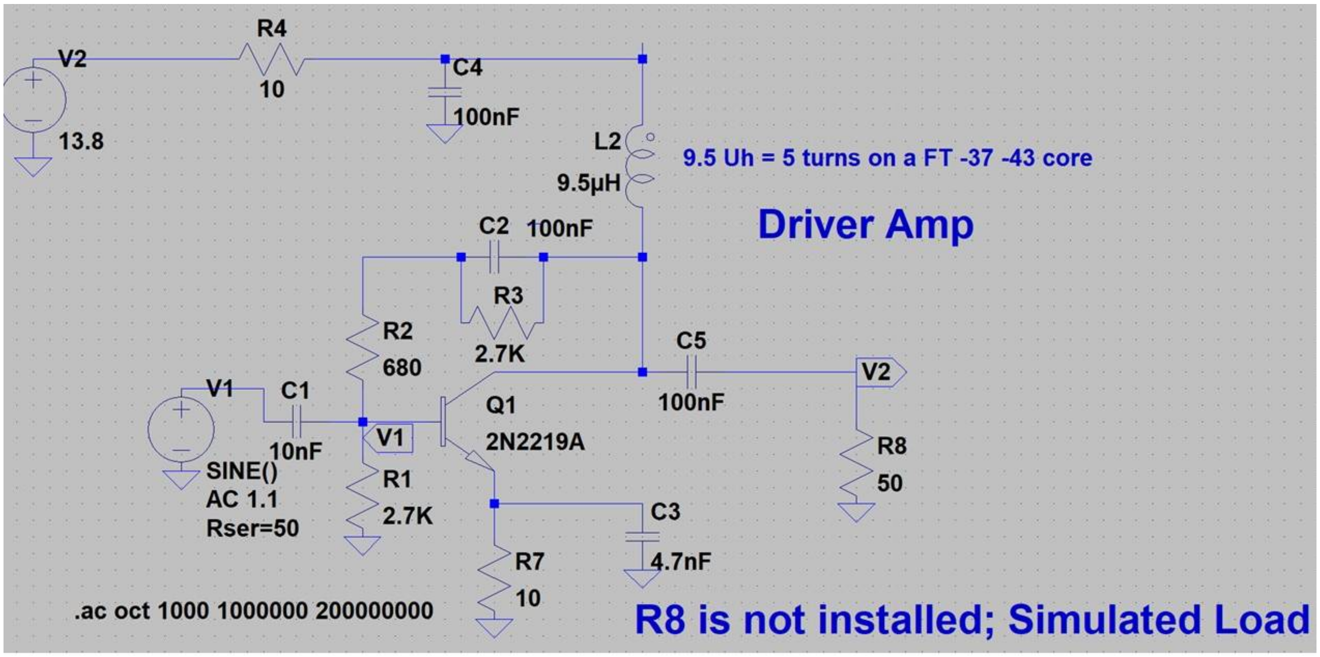
Early on I started with the IRF510 which worked OK; but upon rigorous measurement found we were only getting about 2.5 watts out. The 1st contact to Canada was made at that power level. I have since switched over to the Mitsubishi RD006HHF1 (about 5X the cost of the IRF510, $5 versus $1) but I now get about 4 watts out.

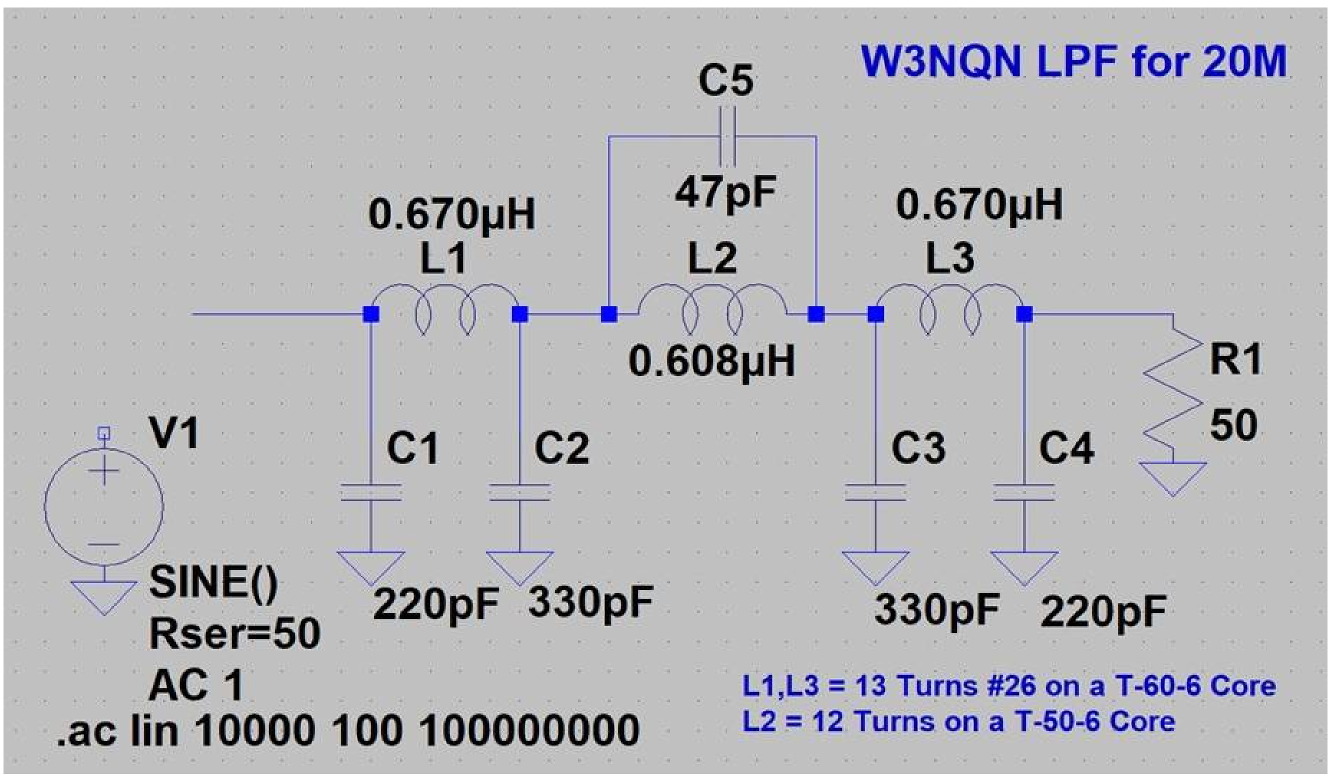
Important NOTE: There are those who delight in picking apart my designs and will jump on the schematic for the IRF510 regarding the note about use in the Sudden Transceiver. Yes I recycle designs and if something works, I use it over and over and this IRF510 Amp is no exception. BTW the Sudden was a published article in the GQRP SPRAT.

The pad layout I will show can accept either device BUT not the same pinout. The IRF510 from (facing up) left to right is G, D, S. The RD006HHF1 is G, S and D. The huge difference is that you need an insulator kit for the IRF510 whereas the RD006HHF1 -- screw it down to the chassis just use some heatsink compound.

I used the pad layout which is shown but added the parts to it to show what parts go where on the pads. I know this by heart (my design) but other won't. Now the pad for the IRF/RD is actually cut through the PC board as that is where you make an attachment to a heat sink either through an insulator with the IRF510 or directly with the RD006HHF1. So if using the MePads just leave an open space. If you are using a CNC after cutting the initial board, go back and "hog out" (machining term) the area for the RF device.

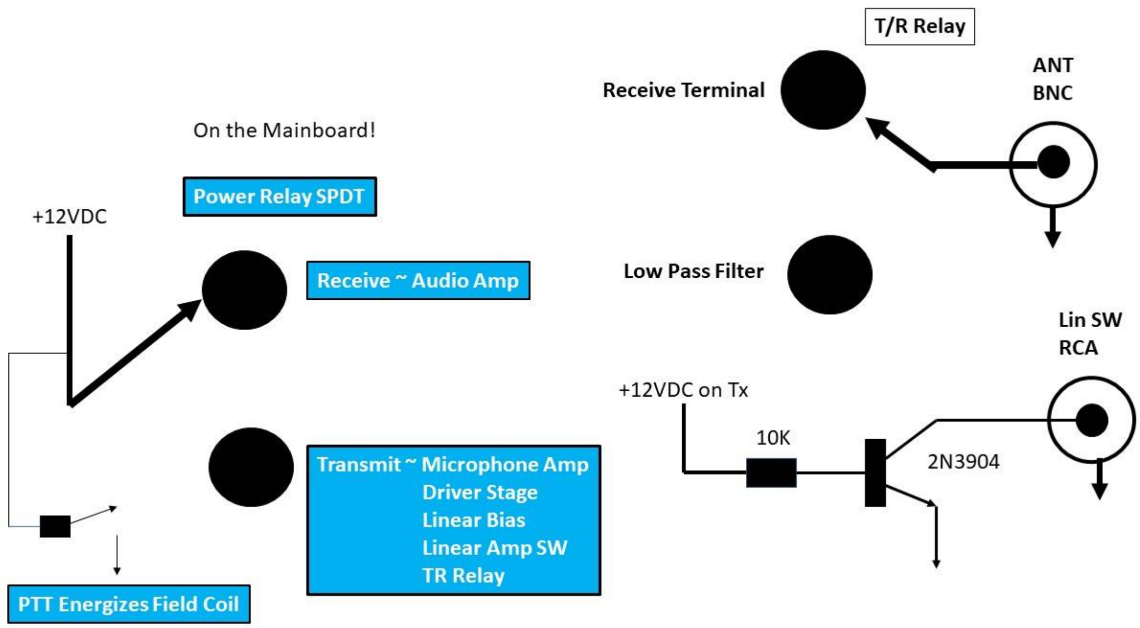
The RF Linear Amp Board has an interesting mod not shown on the schematic and needed if you use the RD006HHF1 and that is an LED. By lifting the ground Pin of the LM78L05 from ground and installing a LED between the Pin and actual ground--when you key the Bias the LED lights -- cool way to know the Amp is "ON". But more importantly it sets a threshold level so that the LM78L05 now puts out a regulated 6 VDC not 5 VDC. The RD006HHF1 can run with a higher Bias. But if you use the max Bias with the IRF510 --you will smoke. Don't say I did tell you that would happen. Information is also provided for the W3NQN LPF which addresses the 2nd Harmonic content.


V2
13.8
R4
10
C4
100nF
L2
9.5µH
9.5 Uh = 5 turns on a FT -37 -43 core
Driver Amp
C2 100nF
R3
2.7K
R2
680
C5
100nF
V2
V1
C1
10nF
V1
Q1
2N2219A
SINE()
AC 1.1
Rser=50
R1
2.7K
R8
50
C3
4.7nF
R7
10
.ac oct 1000 1000000 200000000
R8 is not installed; Simulated Load


W3NQN LPF for 20M
C5
47pF
0.670µH
L1
L2
0.608µH
0.670µH
L3
R1
50
V1
C1
C2
C3
C4
SINE()
Rser=50
AC 1
220pF
330pF
330pF
220pF
.ac lin 10000 100 100000000
L1,L3 = 13 Turns #26 on a T-60-6 Core
L2 = 12 Turns on a T-50-6 Core

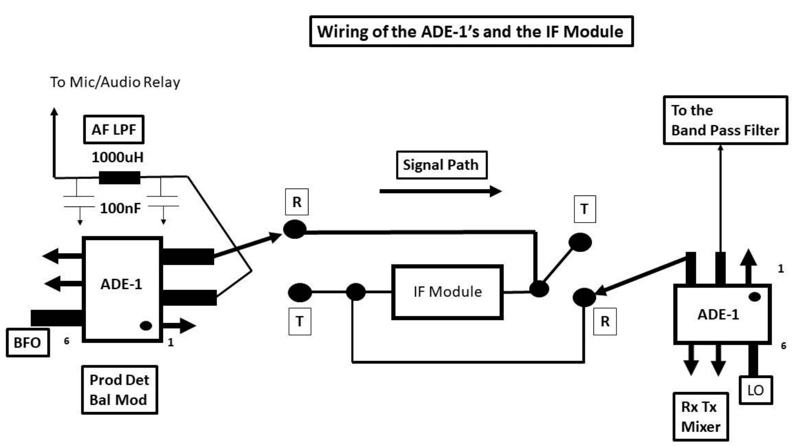
Power and Linear Switching Details

The Mane Board has a DPST relay that switches power to various circuits depending upon whether in Receive or Transmit. Just the Audio Amp stage is switched off during Transmit. Whereas several other Transmit functions are OFF during Receive.



Wiring Integration

This series of webpages is to document what I have in my head; but you possibly wouldn't kow. The first we will cover is the two Double Balanced Mixers (ADE-1's) and how the are connected so that the signals routed into and out from The IF Module arrive at the proper place. The two relays are 12 VDC SPDT and are communication grade.



PSSST Performance Results

I have built about 55 SSB Transceivers over the last 50 years with a few tube type but mostly all Solid State. Some were pretty complex like the multiband KWM-4 and the only one other one that was a low part count --like 10 Transistors was The Simple SSB on my n6qw.com website.

By and large this is the least complex, has the lowest number of Transistors and actually is one of the best performers! I am at the kicking myself stage for not taking this approach many years ago. Who said Simple is Best? Well they were right!

Thus having built so many transceivers I have a very good idea of what is working well versus what is barely working. So I can just lisetn to one of my transceivers and just know where it sits on scale. It goes without saying I do have an internal list of Check Off Items as Metrics.

In order to measure performance there must be some criteria and then a test against that criteria enables an evaluation of performance. By simulating the circuits in LT Spice, we had a fairly solid idea of how the circuit modules would perform before soldering anything.

We knew the gain and frequency response of the Mic Amp/Audio Pre-Amp as well as the performance of the Steerable RxTx Amplifier Module. The IF Module simulation gave us a feel as to how it would perform with a filter installed. The Band Pass and Low Pass Filters were our Go To Ciruits so their performance was well known and used in many rigs. The same applies to the IRF510/RD006HHF1. The Driver Stage with the 2N2219A has also been employed in many of my transceiver projects.

Thus the only unknowns as to the ciruits being used were the Steerable Modules and the Microphone/Audio Pre-Amp. If you read between the lines we were building in success by building upon known levels of performance. You can't imagine the thrill when you hear "It really sounds Good!"

Some changes were made after the 1st few contacts, For one we swapped in the RD006HHF1 for the IRF510. The other change was the emitter resistor of the Steerable RxTx Amplifier circuit. The emitter resistor was initially 51 Ohms. Smokin Hot is a good description and I also found on one very loud signal there was a slight hint of audio distortion. Too Much Gain! Successive simulations with 100, 180, 220 and now 390 Ohms has reduced the stage gain by about 2 dB.

Now the 2N2222A runs a lot cooler and signals are amplified and no hint of overdriving the gain. It is a good balance. There is something terribly noisy in my neighborhood. Pull the antenna connection and the receiver is like dead but reconnect and you detect the noise. Actually I saw this with several other transceivers in my shack including commercial units.

1	**Does it Work?**	**Yes, 8 Contacts in 3 Days.**
2	Signal Quality?	High Marks ~ Sounds Excellent
3	7 Transistors?	Requirement Met @ > 4 watts
4	Temperature?	Good Balance Heat/Performance
5	Standard Parts?	No Exotic Unobtanium Parts
6	Full Doumentation?	Website Documentation
7	Unique Design?	Steerable Circuit Modules
8	Spurs/Oscillation?	None Found
9	Robust Design?	Most Modules Worked 1st Time
10	Easily Replicated ?	Website Has Extensive Build Info
11	Cost of Entry?	About $150 with all new parts.
12	Curb Appeal?	Strong Functional Layout & Build.