

Space Charged or Low Voltage Am and Short Wave Radio

jim@wa6otp.com

(Winter 2016)

So before I tell you about the radios let me tell you about me and what I know and what I found out. First I found out I did not know as much as I thought I did. I am not a radio engineer; I have been into radio for over 60 years and am still learning. All self taught so there are many holes in what I know.

I am not going to show you the convoluted math, I do not know how to do it, I do not know what all of the words mean.

I will show you how I got my two radios to work, and work well.

It is easy when you know how. So it goes with all of life.

I wanted to make a tube radio for AM Broadcast and one for short wave.

I wanted to use 12 volts only.

I have a solar panel and 12 volts to the radio bench and it makes more power than I ever use.

I wanted the radio to be EMP safe, if that is possible.

I wanted to have it be useable in an off grid situation. I know I have TRX rigs. But...

So I looked on the internet, found many radio designs, some for low voltage some not. Most were for 6 volt tubes. I wanted 12 volt tubes for least amount of current draw.

I can build regen's, TRF's and combinations or variances of each. Regenerative Receivers work very well but take some constant knob turning.

I wanted a Super Heterodyne Receiver for easy control.

Looking through my spare parts I found lots of parts but when I started to do a preliminary layout one thing or another made it more and more difficult. IF cans

for one, one is not enough and I did not have two alike or I liked that could be modified. So to get started I made my own from scratch.

This was the beginning of what showed my ignorance and gave me some concerns.

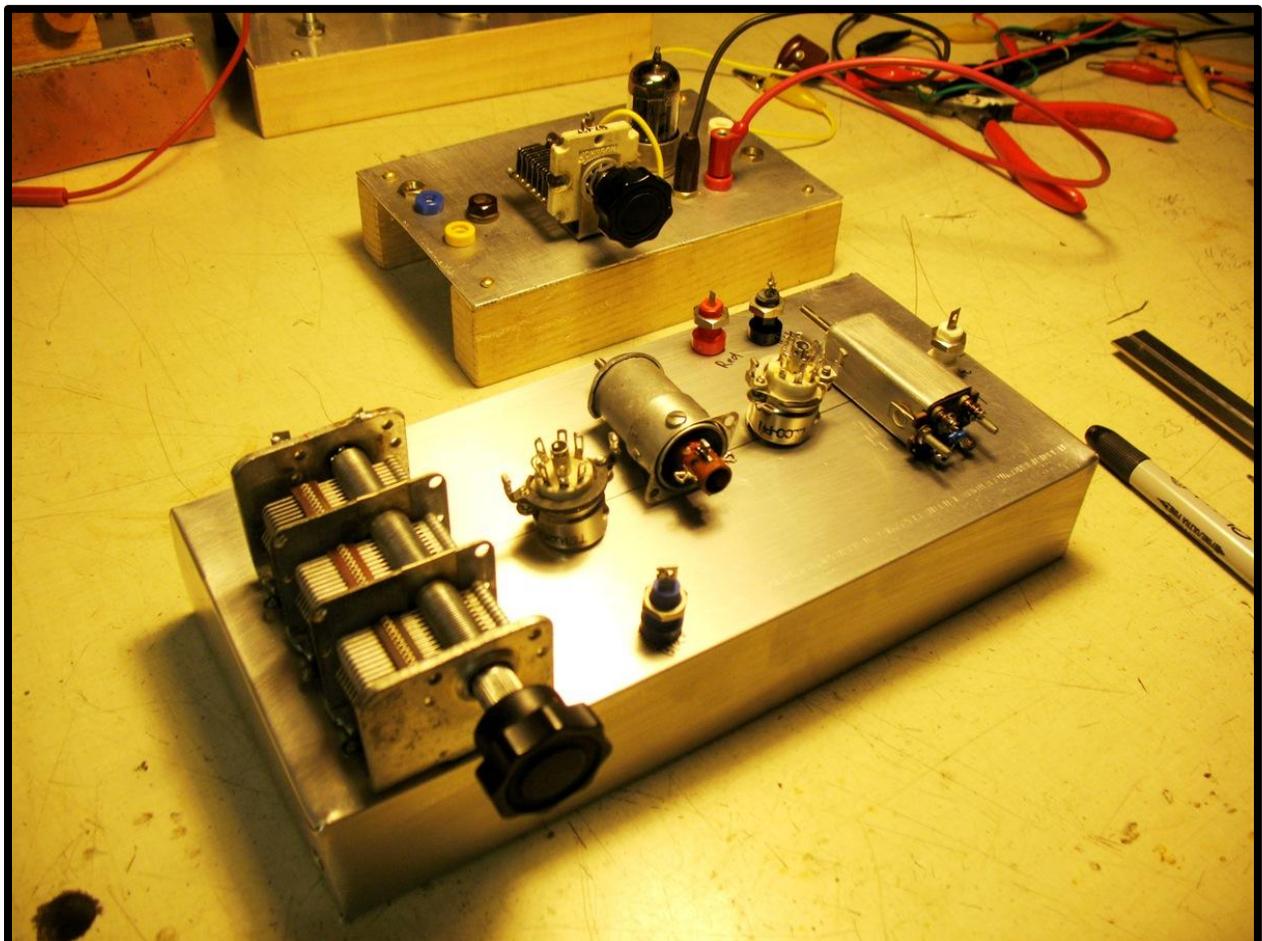
How much insertion loss is acceptable ?

How broad is a real IF can?

How to get a real measurement of the can? Hook to sig gen and scope that will do it, right? Well kind of, how do I hook it up? What happens if I reverse the leads? Some circuits have an IF with one coil and some with two coils in the can. Testing parts out of the circuit and in the circuit, they act differently.

I go on line to buy 1700 KC IF cans cannot find two the same, or they want \$40 for them. So I build single coil 1700 KC IF coil on slug tuned form and they seem OK.

Not sure if they are too sharp or insertion loss is too high. I set them aside. I think I will build this in stages and test each stage. I build test boards, ten of them.



LO in the back and Front End with parts placed

I build the LO first with a 12AU7A using just one triode. Works great. Stable. Then I start the Front end with the homemade 1700KC IF cans.



Above is Pictured A Test Front End with 1700KC IF

These numbers are for 1700KC IF, the finished radio used 435KC IF.

I build my first front end mixer with a 12AU6A, and an IF with 12BA6. Found a Double gang 7-413pF. I want to tune from 510Kc to 1550 Kc. Well with 200uF I need a cap that goes from 54pF to 460pF and it should tune from 520-1561 close enough for front end, I think. Now how to make the cap 7-413pf be 52-469pF? I parallel the cap with a fixed cap of 47pF, That will give me 54-460pF. I wrap a coil on a PVC pipe, 1.82 in diameter and 1.625 long, I thread it 48PTI and wrap 78 turns on it, 200pF. I test it and it is good.

LO was made for 1700 kc IF.

Coil form was PVC 1.060 diameter and .375 winding space for 38 turns of 31 gauge. Gave me 50 uH. I added trim cap of 70 pf in parallel with the LO section of the tuning cap, and then series it with 130 trim



I built the audio amp. I used a pair of 12K5's. I tried several transformers from the junk box and some work so-so. I broke down and bought a transformer, Atlas Sound HT-47 for \$12.78 from "LowVoltageProducts.com". This amp works very well, with plenty of volume. I hooked it up to a crystal set and the sound was so nice, no distortion.

All this I accomplished in the first week. Now my frustration starts and my mistakes begin. The front end works with a TRX amp, the tube amp works with a Xtal set, but they do not work together. Maybe not enough drive? Wrong. Maybe impedance is wrong? Wrong. I test, I change resistors. I change tubes. I change caps. Nothing gives me what I want. I build many variations with different tubes and designs. Some work badly and some not at all.

Things got quite confusing and I lost track of time and of exactly what I did each and every day for the next month. Really a month, I am old and retired and its winter and it is raining. I will make this work! It should work. So I know that two days were spent trying to understand what happened to the front end, it went into a hole and I could barely get anything out of it. Then I noticed I had moved my antenna switch and had no antenna for two days. I moved the switch and the radio came alive. I was mad to say the least.

I built about 40 individual test rigs. I made the chassis myself. I scrounged all the connectors and made patch cords and built and tested and built and tested. Some worked but not like they should. And I could not match up the IF with the Amp.

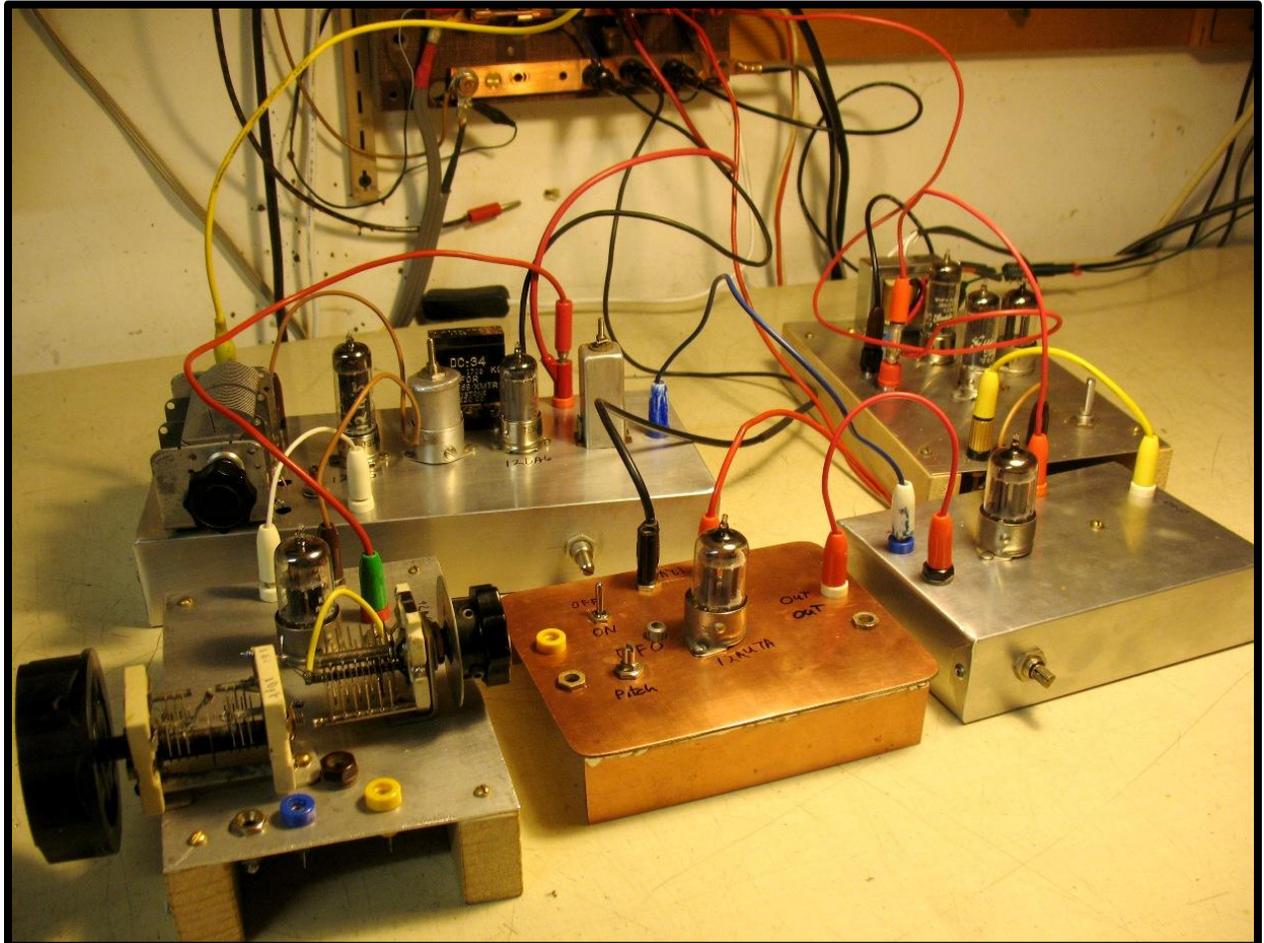
I spent several days on a detector test rig 12AV6, and it was dead from day one. I built the AVC circuit, then I pulled it out. I needed to just make it detect and pass on the signal. Many 15 hour days later I notice a cap that goes from the grid back to the diode through a resistor, and to the IF output, I see I have none. I put in a cap and the tube comes to life. I must have built 4 or 5 different tube detectors. Now this detector works.

I put the front end and IF strip into the detector and the detector into the amp and no luck. Blurry old eyed vision, I failed to see that I have two caps in series, one on the output of the detector and one on the input on the amp. I remove one.

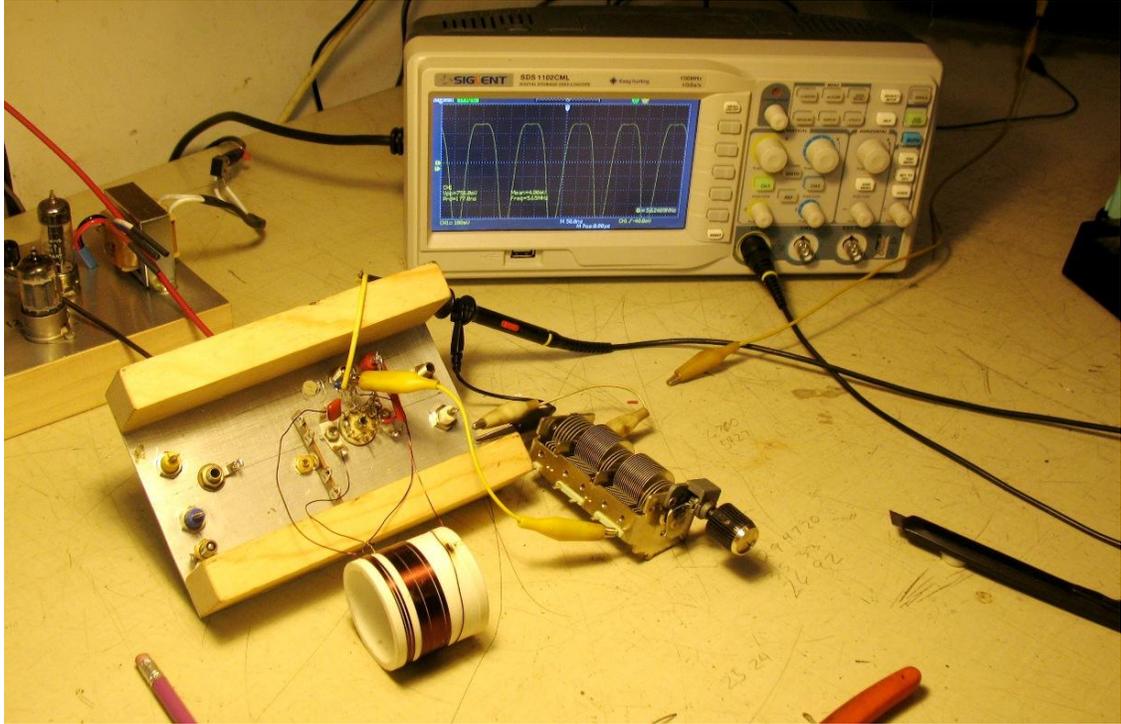
The radio works. I am amazed. It is loud. It tunes 40 stations. It sounds great.

I call my sister. My wife will not give me the correct response, after being usurped by a radio. My sis says "that's great"; she has no idea what I did, or what I have been through. I don't care I need someone to say it.

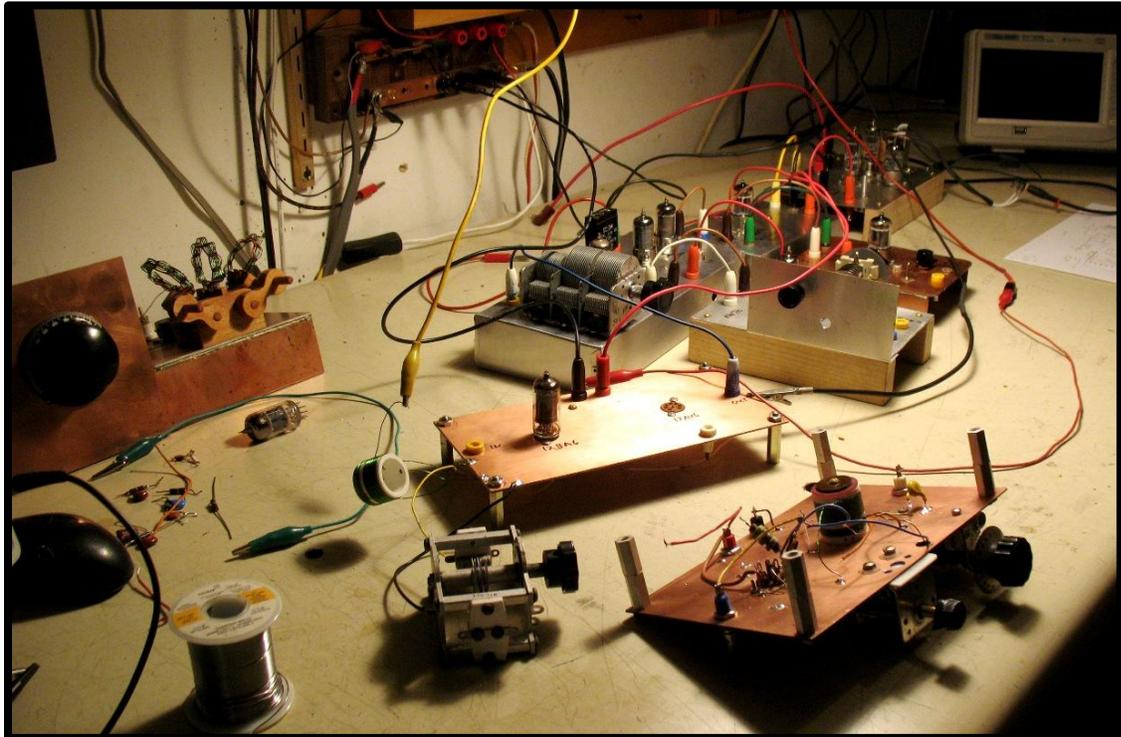
Testing Photos



This was the SW test version with the Front End in the back left and the audio amp back right, the LO is left front and the BFO in the middle and detector front right. It worked but not as good as I thought it should.



More testing tried an RF amp up front with some success. Still not happy.



More testing of different LO

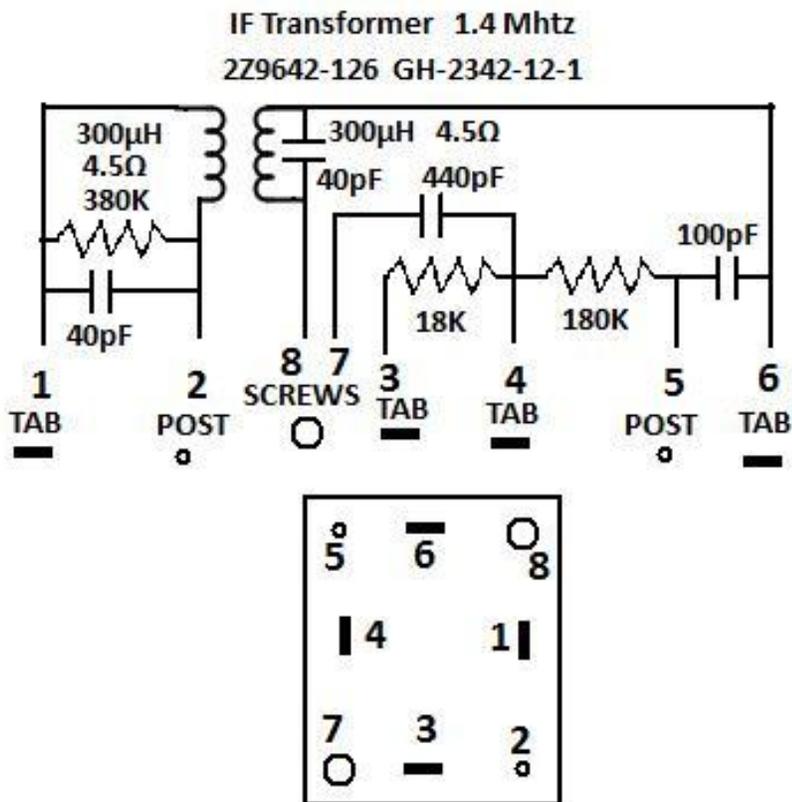
OK enough of that.

This is the version I ended up with, one for Broadcast and one for Short Wave.

I decide to change back to broadcast band and try new IF transformers.

I bought tubes, I bought IF cans, I bought output transformer. The IF cans I bought were 1.4 MHz. They had too much stuff on the inside so I stripped them and made them 435 KC.

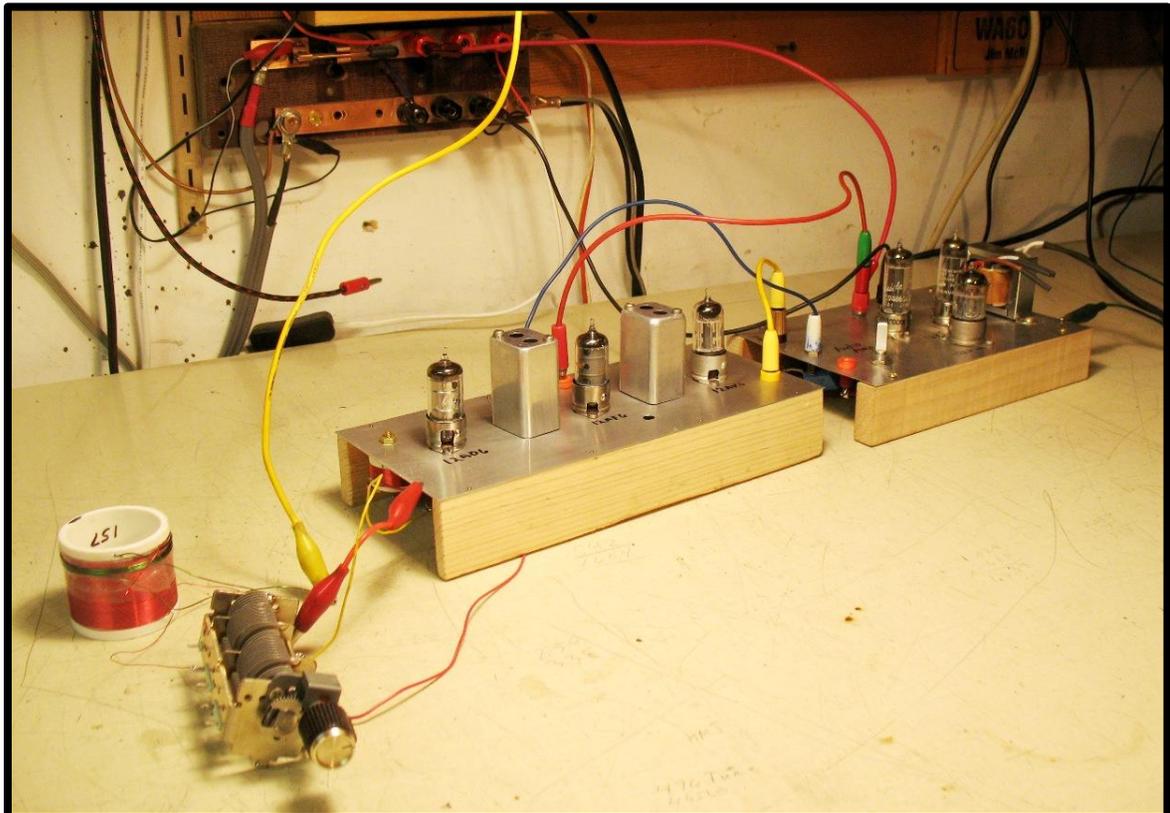
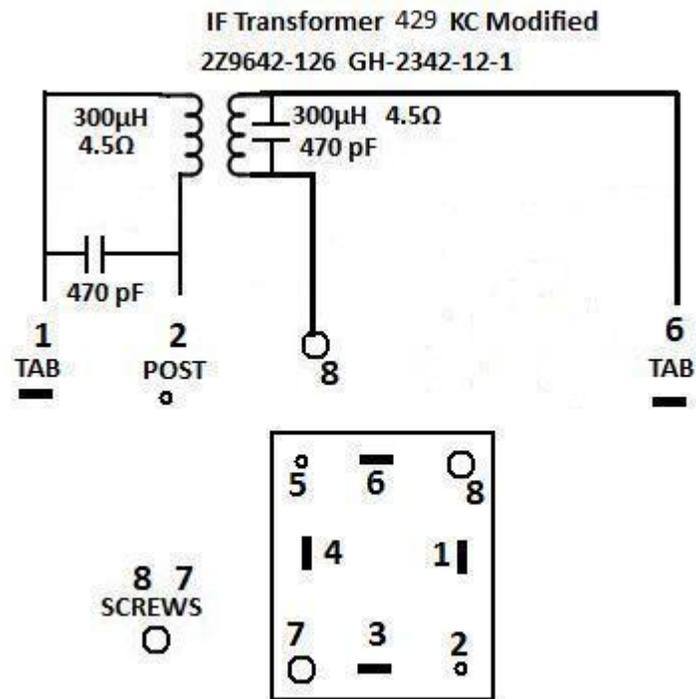
IF cans as I got them. \$5.00 each from Surplus Sales of Nebraska – Item GH2342-12-1





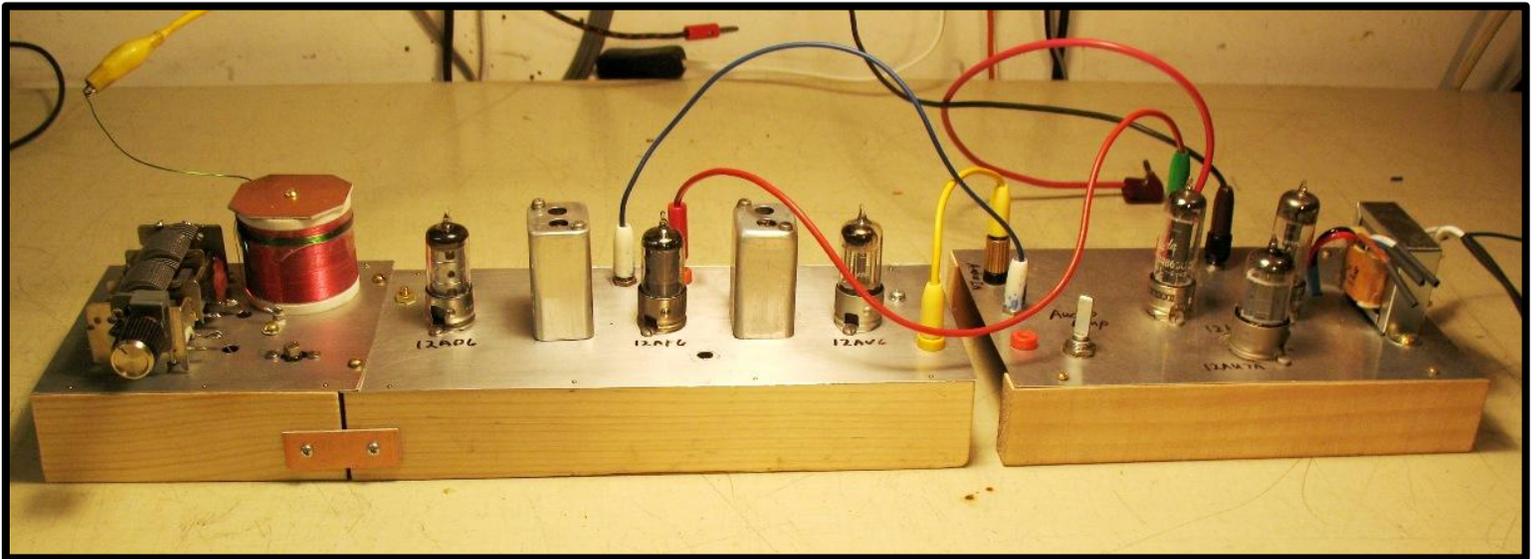
1"x 1.25" x 1.9"

After I changed them:

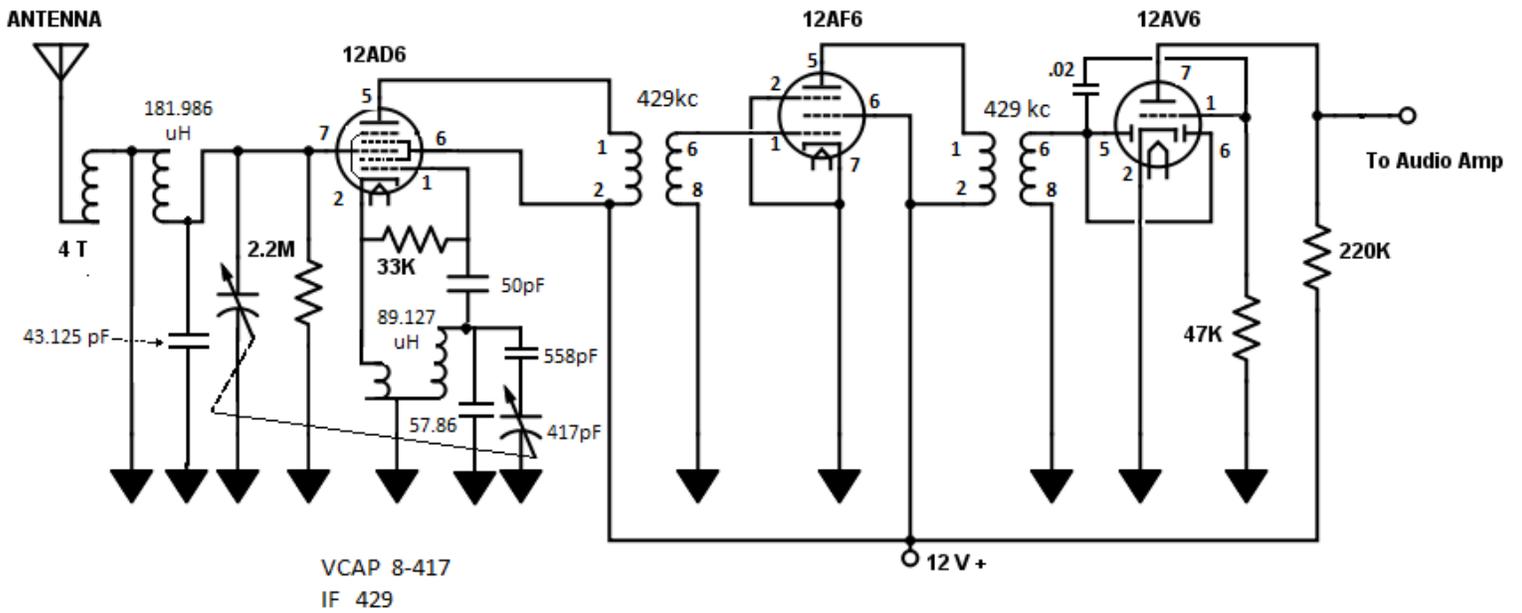


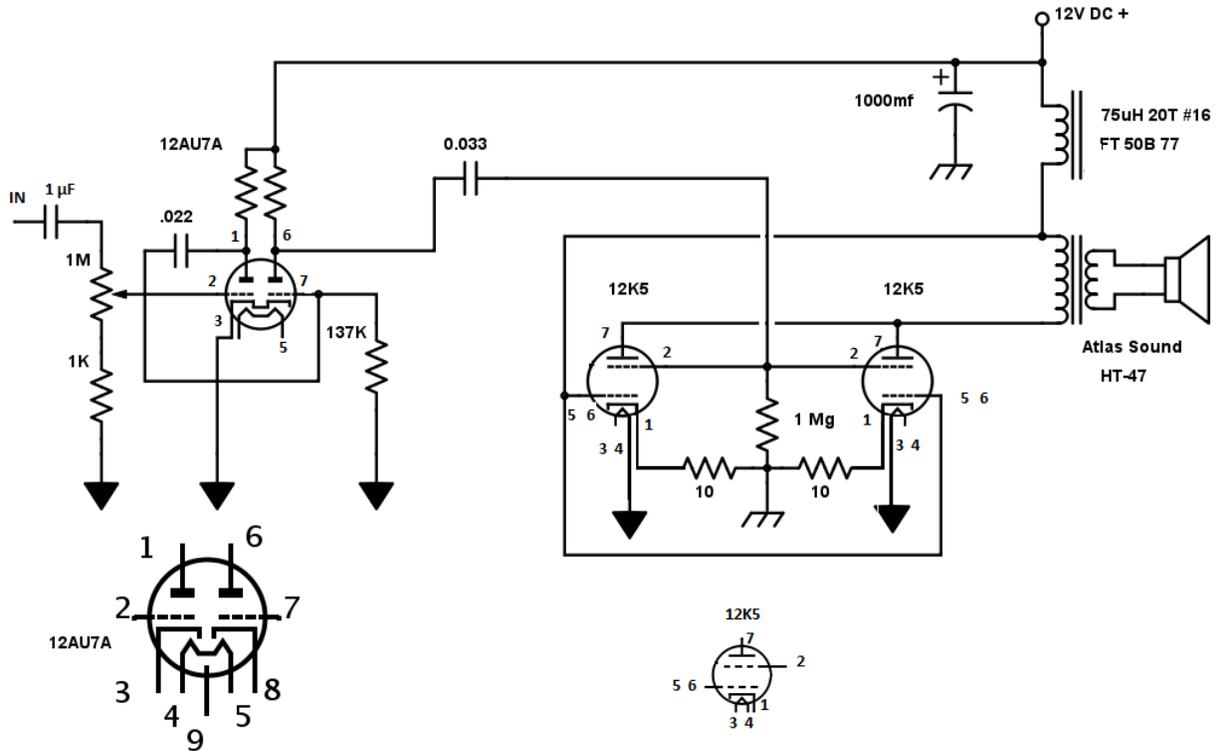
Testing Front End coil.

Finished Test Radio



12 Volt Broadcast AM Radio





This radio works good.

Things of note:

Use a tracking calculator to make the two capacitors track properly. It makes the trial and error method obsolete. It also is right the first time.

Most of the parts found in a High Voltage Radio are not needed in low voltage radio. Dropping resistors and most caps to ground just limit the radio and add to distortion.

The math on paper and the real world are different. Wire length and position of parts come into play.

You need to be able to adjust the coils and the caps in circuit to get things right. Open cap and adjust coil to high frequency wanted.

Close cap and adjust trim cap to low frequency wanted.

Do it several times to get the best balance.

Coil Data for BC.

Front End Secondary Coil (final coil)

Form .750 diameter X 1.2 long winding space 181.986 uH, I put too much on and peeled it off till it hit the range I needed.

Primary is 8 turns over the secondary.

Local Oscillator

Form .375 diameter X 1.0 long winding space, 89.127 uH same as above
I tried electron coupled but would not keep running so I went to link coupled.

Capacitor

BC used Capacitor from junk stereo 8pF to 417pF

Front end section needs to be 51pF – 460pF
Parallel 43pf will give 51pF – 460pF

LO section needs to tune from 979 – 2079 KC
89.127 uH
C2 is 57.86
C3 is 558

To change BC Radio to Short Wave change the front end coil and cap,
change the LO coil and cap.

Add BFO at 1.5 KC low of IF, for CW and SSB.

I will document short wave soon.

Things of note:

Most of the parts found in a High Voltage Radio are not needed in low voltage radio. Dropping resistors and most caps to ground just limit the radio and add to distortion.

The math on paper and the real world are different. You need to be able to adjust the coils and the caps in circuit to get things right.

Open cap and adjust coil to high frequency wanted.
Close cap and adjust trim cap to low frequency wanted.

Do it several times to get the best balance.

Coil Data for BC.

Front End Secondary Coil

Form 1.860 Diameter X 1.580 long winding space 76 turns 200 uH

Primary is 4 turns over the secondary.

Local Oscillator Electron Coupled

Form 1.060 diameter X .375 long winding space, 40 turns 54 uH

Tap 8 turns from ground

Capacitor

BC used Capacitor from stereo

7pF to 413pF

Front end section needs to be 51pF – 460pF

Parallel 43pf will give 51pF – 460pF

LO section needs to tune from 945 – 1985 KC

$54 \text{ uH} + 113 \text{ pF} = 2037$

$54 \text{ uH} + 530 \text{ pF} = 941$

We need to add 113pF in parallel with the cap

That gives us the readings above

To change BC Radio to Short Wave change the front end coil and cap, change the LO coil and cap. Add BFO at 1.5 KC low of IF, for CW and SSB.

I will document short wave soon.