

The OctalMania Radio Set

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Note: This is an update and expansion of the article that originally appeared in Electric Radio (ER) magazine in August, 2011. Schematics and parts list are provided on the kg7tr.com website. - MB

Introduction

The OctalMania Radio Set shown in Figure 1 is more or less a sequel to the Vintage SSB Special Radio Set that was described in the May through August 2010 issues of ER. During construction of those radios I amassed several boxes of parts from junked Command transmitters and receivers. I also learned a lot from experimenting with various kinds of tube circuits used in SSB equipment, gaining a pretty good idea of what works and what doesn't. And I still had a nagging desire to make a transmitter that used a pair of 6146's to produce the benchmark 100 watts of output.

The final catalyst that got this project off the ground was simple enough – a whole bag of Amphenol snap-ring octal sockets acquired at the annual Williams hamfest. These were the brown phenolic sockets used in Command sets and other war surplus radios. And there were lots more of these sockets in my stash of parts. Working with the WWII 1625s in the Vintage SSB radios was nostalgic and fun, so I started thinking why not a transmitter and receiver using octal tubes exclusively?

The most common octal tubes certainly date back to the 1940's or maybe earlier. Many of them were predecessors to popular seven and nine pin miniature tubes and have identical characteristics. Even though the designs are over seven decades old, from a technical standpoint I reasoned these tubes should still be able to produce high quality SSB transmission and reception up to at least 20 meters. Using the traditional 5 MHz VFO and 9 MHz IF would allow 80 and 20 meter operation with suitable band switching. This seemed like a good idea since there are a lot of vintage radio nets on these two bands. A bonus would be a complete radio set capable of transceive operation. With a couple of extra touches like digital frequency readouts and modern crystal filters I figured it should be possible to fashion a transmitter and receiver that would work well and be easy to use. With some rough ideas in mind I started buying a variety of octal tubes at hamfests to supplement my existing collection.

After nine months of endeavor the OctalMania Radio Set is on the air and working great. As with the Vintage SSB Special, anyone who would like more information on the OctalMania radios such as schematics, parts lists and high resolution photos is more than welcome to contact me via e-mail.

Mechanical Layout

There was no pressing need to make this equipment small and then end up working in tight spaces. A radio using octal tubes is not likely to be compact anyway, so for this project it was decided to use conventional rack and panel construction. The transmitter is stacked on top of the receiver to save space as shown in Figure 1. The transmitter and receiver top and bottom views are shown in Figures 2 and 3 respectively. A seven inch rack panel and 10 x 17 x 3 inch chassis are used for each radio. Sheet metal from some old BC-375 tuning units made good stock for the various shields and enclosures. The combination of octal sockets and large chassis allowed ample working space and resulted in big, impressively sized radios. There was enough room in the receiver for a power supply and speaker. With a built-in antenna relay, the only external equipment needed is a Heath HP-23B power supply for the transmitter. The stacked set weighs in at 38 pounds.

The stacked configuration also allows the shortest possible connection from the receiver VFO to the transmitter for transceive operation. By design, the VFOs in both units are in the exact same location.

When stacked, a four inch coax cable runs from an RCA jack on top of the receiver chassis next to the VFO buffer tube to another jack directly above on the transmitter's chassis bottom.

The front panels are secured to each other with 1.0" by .125" angle stock. The rears of the chassis are braced to each other using 1.0" by .125" bar stock. All bracing is secured with .25" bolts. This makes for a very sturdy arrangement that provides excellent cooling, displays the radios well, and is much less expensive than a relay rack or cabinet. The angle and bar stock are aluminum and were purchased at the local home improvement store.

The PA enclosure was made using ventilated covers from the old tuning units. Most of it is fastened together with .5" angle stock and pop rivets. The smaller enclosures on the transmitter and receiver shield the carrier oscillator and BFO tubes respectively. The 6SN7 and 12SN7 dual triodes used here provide a convenient means to switch sidebands, but the down side is they only come in a glass envelope. It was discovered that these tubes radiate a lot of RF that can leak into the receiver 9 MHz IF and turn on the AGC, so shielding was a must. The BFO circuitry in the underside of the receiver is also well shielded and bypassed to keep RF where it belongs. Of course all of the metal tubes used in the radios bring the metal envelope out on pin 1. Simply connecting this pin to the chassis provided excellent shielding.

The VFOs use the venerable Command transmitter components which offer excellent stability, smooth operation and a slow tuning rate for SSB. Using digital frequency displays eliminates the need for a mechanical dial and allows use of the zero-backlash variable capacitors found at the rear of Command transmitters. The VFO components are mounted upside down from the way they are in the original Command transmitters. This arrangement gets the tuning knob up higher on the front panel for a more useable location. The VFO compartments are structurally beefed up with shielding and bracing for mechanical stability.

The coil cans are from Command receivers. With the exception of the receiver BFO coil, all use the original air variables mounted to mica plates. All coils are wound on toroid forms. The transmitter was constructed first, and when I started out I intended to implement band switching via plug-in coils. In preparation, most of the coil assemblies on hand were modified to add an octal plug to their base (salvaged from old metal tubes) which would then plug into yet more octal sockets on the chassis. But due to the number of circuits that needed to be switched, rotary switches turned out to be an easier way to go. Because most of my supply of coil assemblies was already modified, the plug-in coil method was still used for all but three coils. It ended up providing an easy way to remove the assemblies for modification. All in all there are 35 octal sockets used in the whole radio set, so it is easy to see how I came up with the OctalMania moniker.

My sheet metal skills and tools are somewhat limited and tend to be in the caveman category. Most work was done with a saber saw fitted with metal cutting blades, a variable speed hand drill, an eight inch drill press, a sheet metal nibbling tool, and lots and lots of filing. One thing I did at the outset was to procure a 1.156" chassis punch on eBay. This was the exact size needed for the snap ring octal sockets and was worth every penny.

Circuit Descriptions

Block diagrams of the transmitter and receiver are shown in Figures 4 and 5 respectively. Schematics and parts lists are available at kg7tr.com.

Some of the components and circuits are common to both units and so will be described first. Reference designators for the tubes were assigned to more or less reflect signal progression through each radio. As such, where a different reference designator is used for the same tube in the transmitter or receiver, a "T" or "R" suffix is added for clarification in the discussion that follows.

At the heart of each radio is crystal filter FL1. These are INRAD (inrad.net) model 2309, an eight pole experimenter's filter with a center frequency of 9.000 MHz and a bandwidth of 2.1 kHz. This

bandwidth was chosen because it's the same as Collins S-Line equipment and is just right for crowded bands. INRAD also sells the matching carrier crystals used in the radios. For ideal transceive operation the transmitter and receiver filters should have exactly the same bandwidth and center frequency so that the IF frequency will be the same. If this is the case, when the receiver VFO is injected into the mixers the received and transmitted signal frequencies will be identical. I was concerned that this would be a problem since the model 2309 is billed as an experimenter's filter, meaning any two filters might not have identical bandpass characteristics. But the radios seem to work just fine with the filters I have. The receiver BFO crystals were set 20 dB down the filter slopes and the transmitter carrier crystals were then zero beat with them. Signal reports that I get while operating in transceive mode indicate I'm transmitting on frequency with good audio, so everything is evidently matched well enough for practical use.

The VFOs use a pentode (V10T and V6R) as an oscillator in a Colpitts circuit. The cathode of this tube is connected directly to the grid of the buffer (V11T and V7R), which is a cathode follower. Output is taken from the cathode and sent to the mixers (V6T and V2R). The output of the receiver VFO is also made available for connection to the transmitter. The VFOs were temperature compensated to the extent possible with available capacitors and patience. Although identical in every respect, the two VFOs do drift a little bit differently. During the final temperature test in the stacked configuration, from a room temperature start the receiver drifted downward about 450 Hz in the first 15 minutes. For the next 80 minutes it drifted upward about 30 Hz. The transmitter drifted downward about 190 Hz in the first 15 minutes, and then in the next 80 minutes drifted upward about the same amount to end up where it started. Since the transmitter is above the receiver it does pick up some heat from below. In either case the thermal stability is more than acceptable given that this is homebrew and these are very old tubes and components. Mechanical stability and backlash characteristics are excellent as well.

V4T and V8R are dual triodes with one section connected to the LSB crystal (9.0015 MHz) and the other to the USB crystal (8.9985 MHz). The desired frequency is generated by grounding the cathode circuit of the associated triode section. The plates are tied together and connected to a common tank circuit. A link on the tank coil provides 9 MHz carrier to the balanced modulator in the transmitter or to product detector V9 in the receiver. The radios are designed to operate LSB on 80 meters and USB on 20 meters. This is implemented by tying the cathode circuits of V4T and V8R to appropriate contacts on one of the band switch sections. No provision is made for opposite sideband selection.

The digital frequency displays are model DFD-1A from Almost All Digital Electronics (aade.com). This module is offered as a kit, and consists of a frequency counter with an LCD display and additional circuitry to add or subtract an offset frequency equal to the IF frequency. The unit can also provide a switch selectable display of the emission type, which for these radios was set to LSB and USB. In the as-supplied configuration the offset frequency is set by three onboard 15 turn trimpots in a coarse, medium and fine arrangement. Because the IF frequency in the OctalMania radios is different for LSB and USB, remote trimpots for medium and fine offset for each band and sideband (four total) were located under the chassis and connected to band switch sections to get the correct readouts. Counter input from the VFOs is via a small pickup wire mounted next to the tank coil.

Looking at the transmitter specifically, the two triode stages of V1 amplify the microphone signal and apply it across the MIC GAIN pot for normal operation. V3 is a RC phase shift oscillator whose output is switched across the MIC GAIN pot for tune up. The audio signal is picked off the wiper of the pot and applied to the grid of V2. The output of this stage is coupled to the primary of an audio output transformer from a Command receiver. The secondary is approximately 600 ohms impedance and drives the dual diode balanced modulator. The 9 MHz carrier is also applied to the modulator. The output of the modulator works into a wideband transformer consisting of a trifilar winding on a ferrite toroid. One of the trifilar windings is connected to FL1, which filters out the unwanted sideband and provides about 20 dB of extra carrier suppression. Overall carrier suppression is about 45 to 50 dB.

The output of FL1 is fed to V5 for amplification. Output from V5 is fed to V6 where it is mixed with the 5.0 to 5.5 MHz VFO signal to produce either 80 or 20 meter output, depending on which tank circuit is selected by the band switch. The VFO signal applied to V6 comes from either the transmitter or receiver VFO depending on the position of FREQUENCY CONTROL, a DPDT switch. The other pole of this switch removes B+ from V10 and V11 when in the RCVR position.

V7 amplifies the SSB signal from V6 to a level sufficient to drive V8 and V9 to 100 watts output on either band. The output of V7 is filtered by a band switch selected tank circuit in the same manner as the mixer. Both stages are peaked by the DRIVER TUNE variable capacitors which are mechanically connected together. V9 and V10 ended up being 6883Bs because I was able to get a pair of new tubes inexpensively and the Heath supply puts out 12.6 VAC so the heaters work directly off of it.

The PA tank coil is from a 3.0-4.0 MHz Command transmitter and is tapped for 20 meter operation. A two pole rotary switch section located in the PA cage jumpers the tank coil for 20 meters and adds loading capacitance for 80 meters. The switch is mechanically linked to the main band switch shaft under the chassis using servo arms, ball links and control rods from RC model airplane hardware. This allows a single band switch knob to do it all. Also in the PA cage is a relay that switches the antenna between the transmitter output and the receiver. To help prevent splattering, the gain of V5 is reduced by negative voltage generated by the ALC circuit whenever the PA grids draw current. Another audio output transformer from a Command receiver is used in this circuit to sample PA grid current across its secondary. The resultant audio frequency voltage appearing on the primary is rectified and filtered to produce the ALC voltage. A metering circuit measures grid and plate currents as well as ALC action on the voltage at V5's cathode.

Transmitter power comes from a common Heath supply as shown on the diagram. The 12.6 VAC filament voltage is rectified and filtered to 12 VDC and used for the T/R and antenna relay coils as well as the digital readout. V12 provides regulated B+ for the VFO and carrier oscillator.

Turning to the receiver block diagram, RF from the antenna is applied to band switched tuned circuits and then on to the grid of V1. The output of V1 is coupled through another band switched tuned circuit to the signal grid of mixer V2. The grid and plate circuits of V1 are peaked by the PRESELECTOR variable capacitors which are mechanically connected together just like the transmitter. The 5.0 to 5.5 MHz VFO signal is applied to the injection grid of V2 causing a 9 MHz IF signal to appear at its plate. This is applied to FL1 through a matching transformer. The filter output goes through another matching transformer to the grid of V3. The output of V3 is fed to the grids of V4 and V5.

IF output from V4 and BFO voltage from V8 are applied to the product detector, V9. Audio appearing at the plate of V9 is filtered to remove the RF components and then applied to the AF GAIN control. The signal picked off the pot is connected to the grid of V10 for amplification. V10 output is then coupled to the grid of V11. V11's plate is connected to the primary of the audio output transformer. The secondary is connected to the built-in speaker and the PHONES jack on the receiver front panel.

V5 is a separate AGC amplifier that picks off the IF signal ahead of the last IF stage to provide isolation from the BFO signal. The output of V5 is rectified and filtered for fast attack and slow decay characteristics. The resulting AGC voltage is applied to V1, V3 and V4. Although V4 is actually out of the AGC loop, the overall AGC action is pretty flat and very effective. Once the threshold is reached, the receiver output is constant within a few dB to over a volt of input signal. IF gain control and receiver muting are implemented by connecting the AGC return to a T/R switched negative bias voltage that varies with the IF GAIN setting, similar to a Collins S-Line receiver. The voltage at the cathode of V3 varies with AGC voltage and is used to drive the S-meter relative to a fixed reference voltage at the cathode of V11.

The receiver power supply uses silicon rectifiers throughout. Main power comes from a power transformer donated to me at a hamfest. I think it might have been from an old Hammarlund receiver.

The supply is a choke input circuit and produces 170 volts of B+. This is plenty for the tubes in a receiver and helps to keep things cool. As in the transmitter, V12 provides regulated voltage for the oscillators. The unused 5 VAC rectifier winding is used to power the secondary of a filament transformer. The primary is rectified and filtered to get -110 VDC bias. The low voltage AC is also rectified and filtered for the digital readout.

In Conclusion

This radio is a regular on the Vintage Sideband net that meets on Sundays on 14.293 MHz. Once again, if you have any questions or would like more information please feel free to contact me at bohn48@msn.com. Be sure to include "OctalMania" in your subject line so I can find your message in my inbox.



Figure 1: The OctalMania Radio Set

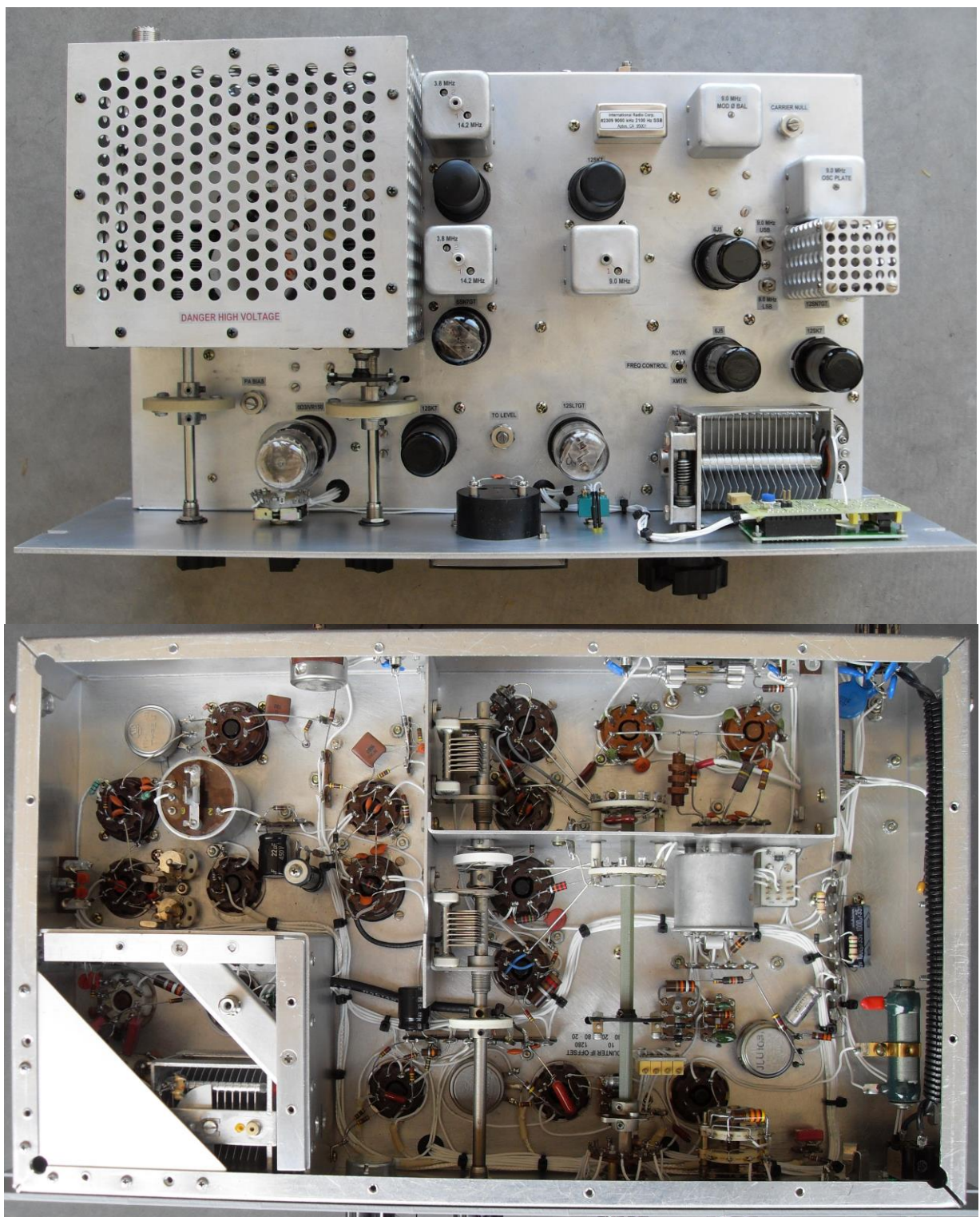


Figure 2: Transmitter Top and Bottom Views

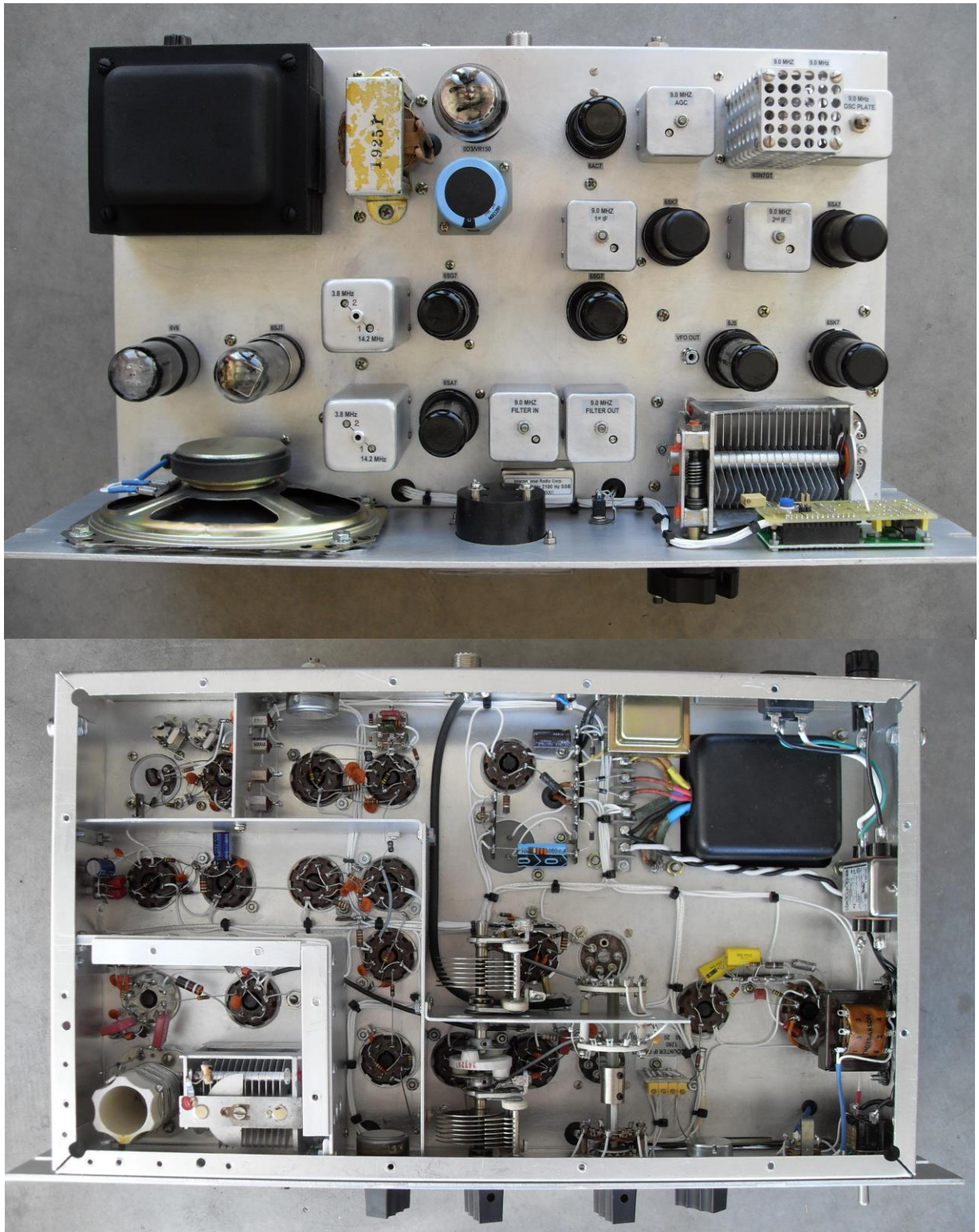


Figure 3: Receiver Top and Bottom Views

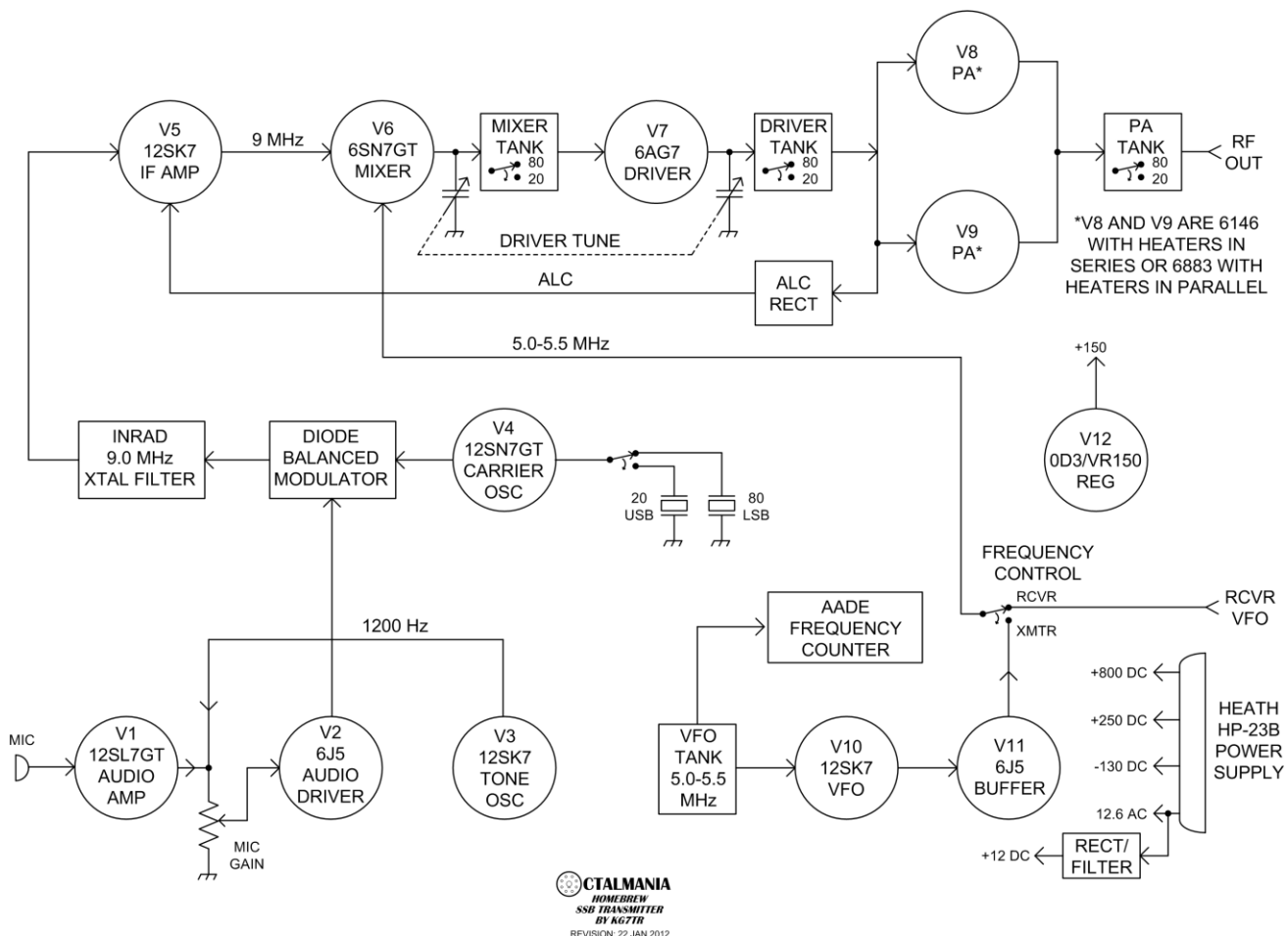


Figure 4: Transmitter Block Diagram

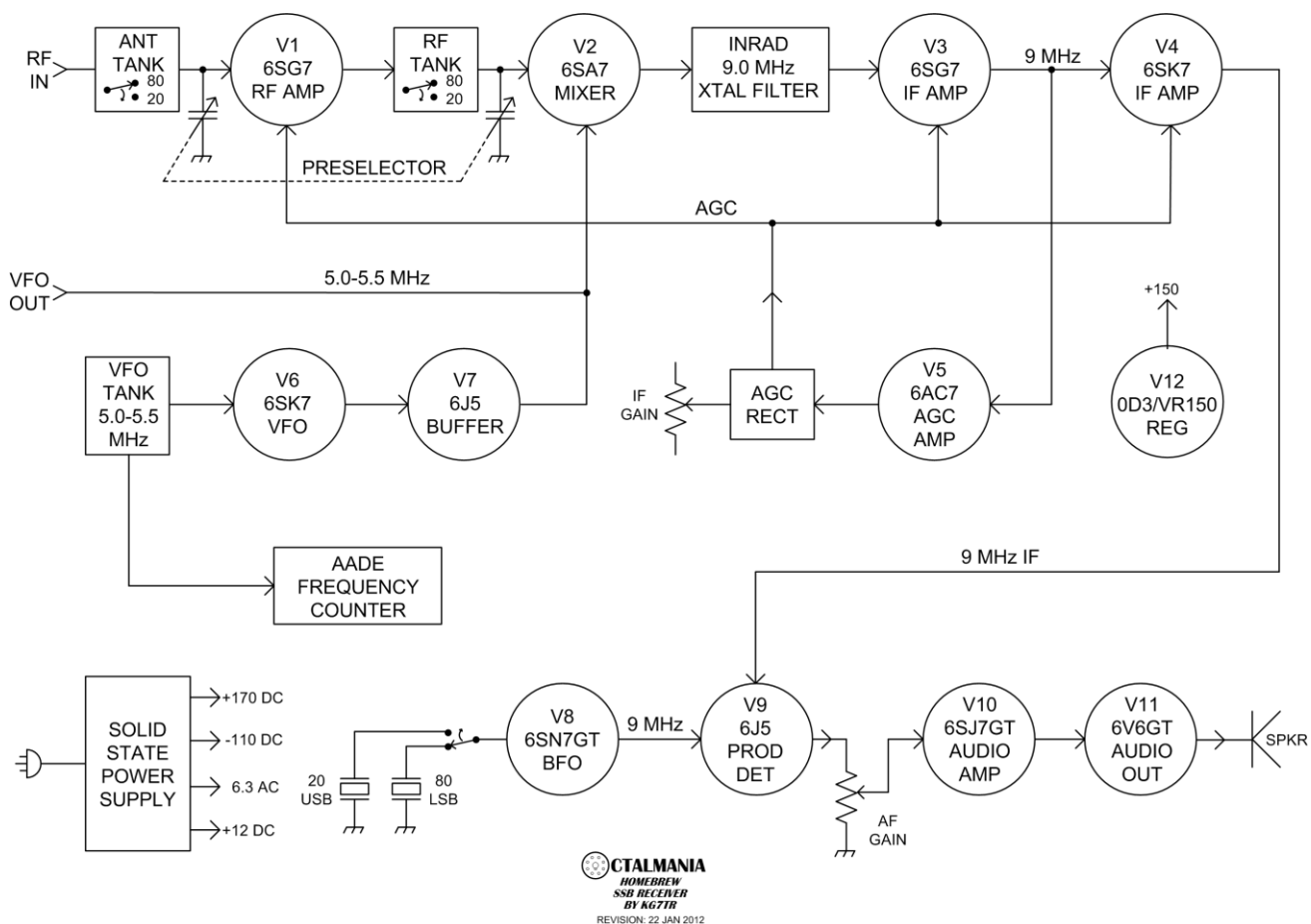


Figure 5: Receiver Block Diagram