The Cheap 'N Easy II
Homebrew SSB Transmitter
20 Meter Version

Technical Data and Instructions

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1.0 Introduction

The Cheap 'N Easy II is a KG7TR rendition of the "Cheap and Easy S.S.B." rig originally built in the mid 1950's by Tony Vitale (SK, W2EWL at the time) and copied by countless other hams. The construction article for the W2WEL rig appeared in the March, 1956 issue of *QST* as well as early editions of ARRL's *Single Sideband for the Radio Amateur*. Tony's approach was to modify a WWII Command transmitter into a phasing type SSB transmitter. The KG7TR re-spin of that popular homebrew rig is a 21st century tribute to Tony's work and stays mostly true to his original design. A few improvements are added to improve performance and functionality, including:

- Separate mixer stage using a dual triode
- Automatic Level Control (ALC)
- Provision for linear amplifier ALC input
- PTT T/R switching
- Built-in antenna relay
- Relay switching for linear amplifier and receiver muting
- Metering of plate current and ALC level
- Frequency spotting switch
- Stable Colpitts VFO

The Cheap 'N Easy II was built from a Navy Command transmitter and features an attractive black wrinkle finish for the chassis and top cover. As in the W2EWL rig, a B&W Model 350 Type 2Q4 audio phase shift network is used. The unit covers the complete 20 meter phone band and puts out 40 watts PEP. Power comes from a Heath HP-23B power supply using the furnished cable.

2.0 Installation and Hookup

CAUTION

+800 volts is present on the plate caps of the PA tubes and their parasitic suppressors anytime the power supply is turned on. These components are close to the top expanded metal cover. Do not allow any metal or conductive object to penetrate the cover into these components. When the top cover is removed exercise extreme caution in this area.

The transmitter is best located on a shelf due to the position of the VFO tuning control. There is no power switch on the transmitter, so the three way switch on the Heath power supply is used to control AC power. The Heath supply must be operated in the LV (250 DC) mode. The 11 pin interconnect cable is 34 inches in length, which is ample for locating the power supply in a convenient location.

The front panel microphone connector is a standard four pin configuration and is shown in Figure 1. The PTT line has about 18 VDC on it in standby and is grounded for transmit.

The station interconnects on the rear panel are shown in Figure 2 and are basically the same as a Collins S-Line transmitter. RCA jacks are provided for RF output, receiver antenna, receiver muting, linear relay, and linear ALC. The muting line is grounded in receive and opened in transmit. The receiver is placed in the standby mode for T/R switching.

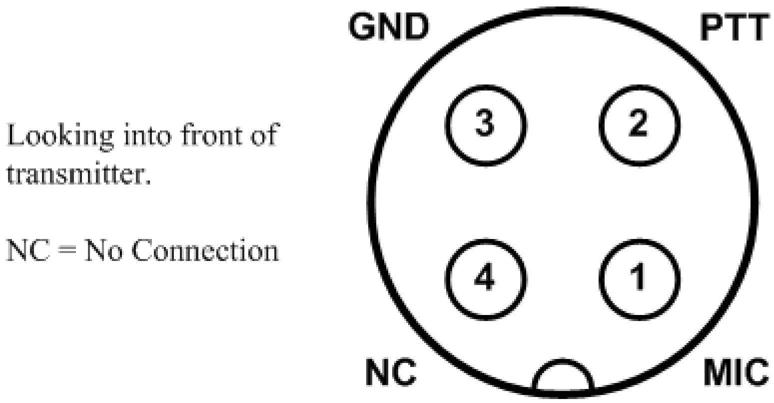

Figure 1 – Front Panel Microphone Connector

Figure 2 – Rear Panel Connections

The linear relay line is grounded in transmit and opened on receive. The linear ALC jack operates in the conventional manner, and applies negative going ALC voltage from the linear to reduce transmitter output. Linear ALC is diode OR'ed to the transmitter's internal ALC voltage such that if the linear starts clipping before the transmitter, the linear will control the output level.

3.0 Tune Up and Operation

Before applying power set the TUNE/OP switch to OP, the SPOT/OP switch to OP, the METER switch to PLATE, and make sure the microphone is not keyed. Turn on the power and let the unit warm up. Make sure you are using the LV (250 DC) position of the Heath power supply switch. Then place the TUNE/OP switch to TUNE and quickly adjust the CARRIER BALANCE controls for minimum output. These controls will not be at the twelve o’clock position when balance is achieved, but this is not of concern.

When minimum carrier has been achieved the plate current should be 40ma (two divisions on the meter). If it isn’t, adjust the PA BIAS pot on the right side of the chassis until it is. With a suitable RF load and power indicating device connected, unbalance one of the CARRIER BALANCE pots to get about 80ma of drive. Then adjust the PA TUNE and PA LOAD controls for maximum output power. This should occur approximately at plate current dip. Increase the drive with the balance pot and continue adjusting the tuning and loading until the plate current is about 100 to 110ma (midpoint on the meter) at maximum power output. At this point the output will be about 40 watts and still in the linear region. You can actually drive it to about 50 watts maximum, but the PA will be saturated at this point and will not be linear.

When the PA is tuned, set the TUNE/OP switch to OP, the meter switch to ALC and key the microphone. With the MIC GAIN full CCW, adjust the ALC ZERO pot on the right side of the chassis for a zero meter reading. Then advance the MIC GAIN while talking into the microphone until the meter peaks at no more than one third scale. With most microphones very little MIC GAIN will be required.

Note that the ALC circuit is inhibited (ALC voltage is grounded) when the TUNE/OP switch is in the TUNE position. This allows more accurate tuning and loading without interaction from the ALC. The TUNE position should not be used for actual operation; the OP position and microphone PTT should be used so that ALC can do its job.

Transmitter frequency can be spotted by setting the SPOT/OP switch to SPOT. Carrier balance can also be checked in SPOT before transmitting. The T/R and antenna relays do not operate in spot, so no RF will be transmitted. If trying to spot on top of a strong station coming into the receiver it may be necessary to unbalance the carrier a little to hear the Cheap “N Easy II.

If you have a microphone that is hot in receive you can actually spot using the “Chirping Canary” method that Collins describes for their S-Line radios. The MIC GAIN has to be advanced to the point that the microphone causes feedback with the receiver audio and the chirping is heard, but use the minimum setting that works so you don’t get a lot of spurious and confusing heterodynes.

Because there is no frequency dial and the tuning rate is very slow, it is easy to lose the transmitter signal if the VFO is tuned too far off from your receiver frequency. This is especially true if you don’t remember which way you turned the VFO knob. If this happens it is much easier to find the signal by tuning the receiver to the transmitter and then bringing them both back to the desired frequency. Keep in mind that you have to turn the FREQ knob CCW to increase transmitter frequency.

The VFO is quite stable and entirely satisfactory for SSB use after a 20 minute warm up. In tests from a room temperature start, after a 20 minute warm up the frequency drifted upward about 100 Hz over the next 60 minutes and then completely stabilized.

4.0 Circuit Description and Design Details

Refer to the schematic foldout at the back of this booklet for the following discussion. V1A and V1B amplify the microphone signal at J1 and apply its output across the MIC GAIN pot R1. J2 provides a convenient port for connection to an audio oscillator or two-tone generator for testing and alignment. The signal at the wiper of R1 is applied to the grid of V2A for further amplification and impedance step down for input to the B&W audio phase shift network. The two chokes and two capacitors at the output of T1 roll off the audio response above 3 KHz.

The audio from T1 is applied to the phase shift network in the ratio of 2:7, with R2 providing the fine adjustment. The case of the B&W network is grounded with a braided strap because of the high RF environment (i.e., the PA tank coil) in proximity to it. Output of the network is two signals 90 degrees apart in phase and roughly equal in amplitude. These signals are amplified by V3A and V3B and stepped down in impedance to drive the balanced modulator. R3 is used to balance the audio level for best sideband suppression.

All three audio transformers are decoupled from the DC plate voltage using 10uF electrolytic caps. This keeps DC out of the transformer coils which can saturate the small cores and cause distortion. Plus the DC current carrying capacity of these transformers is limited.

Sideband select switch S1 is located under the chassis and is intended only for alignment purposes. It works by reversing the phase of audio channel B. This causes the opposite sideband to be generated.

V2B is a crystal controlled oscillator that provides a carrier at 9.045 MHz. This frequency is the result of a crystal that was available in the junk box. It is sufficiently close to the 9.0 MHz usually used in these circuits to work without problems. The carrier is taken from a link on the plate tank coil (L1) of V2B and applied to a passive RC phase shift network. R4 and R5 are adjusted to provide two 9 MHz signals 90 degrees out of phase. These signals are combined with the two audio signals in the balanced modulator. Common silicon signal diodes are used instead of the 6AL5s in the W2EWL radio. R6 and R7 balance the carrier for minimum output. Adjustment of these pots at the null is quite sensitive, despite "bandspread" of the variable range by using 220 ohm resistors in series with them.

Output of the modulator is combined in a special bifilar wound tank coil (L2) broadly tuned by the two 470 pF caps. A link on L2 couples the SSB signal to the low side of L3. The high side is connected to C2 and a parallel 110 pF cap to form a series resonant tank circuit peaked at 9 MHz. ALC voltage is connected to the low side of the L2 link for application to the control grid of V4, a remote cutoff pentode. The ALC works just like the AGC in a receiver – the more negative the voltage the less gain through V4.

The output of V4 is peaked in a 9 MHz tank circuit and applied through a link on L4 to the grid in the left section of V5. The other section of V5 receives the nominal 5 MHz VFO signal. The two signals combine in the common cathode and plate circuit and produce the desired 20 meter output in the tank circuit consisting of L5 and the parallel 47 pF cap. This signal is further amplified in driver V6, resonated by L6 and the 27 pF and 12 pF caps in parallel, and applied to the grids of the PA tubes.

The W2EWL radio used a combined high level mixer/driver (12BY7 or 6V6). This arrangement appeared marginal for providing the 60 volts peak-to-peak drive needed at the grids of the 1625s for full output. So a separate mixer stage was added to the design. This had the added advantage of reducing spurious outputs since another stage of tuned RF amplification is added in the signal path.

Another problem encountered with using the narrow and deep Command set chassis is getting the various signals to the right places with minimum lead lengths. This is especially true of the driver output. From most aspects the best place for the VFO, mixer and driver tubes is at the rear of the chassis. But to get the driver output to the PA grids requires getting around the VFO variable cap. In addition, there is not a lot of room at the rear of the chassis for mixer and driver tank coils.

In the Cheap "N Easy II this dilemma was solved by doing away with the large range set variable cap used topside in the original VFO, and using the freed up space for fully shielded slug-tuned coils for the mixer and driver outputs. The range set variable is simply replaced with a fixed silver mica cap. Vertical shields are mounted inside the original VFO coil shield to separate the mixer and driver coils from each other and the VFO tank coil. The driver output is routed up into the rear end of the shield to the tank circuit and back down out the front end. This brings the signal up and over the VFO variable. Octal tubes were employed at the rear of the chassis so that the existing holes could be used without modification, plus this adds a further touch of WWII vintage hardware to the radio.

The PA stage is of standard design with a pi-network output. Neutralization is provided via C4 feedback into the low end of the driver tank coil. PA tank coil L7 was wound on a piece of PVC pipe using silver plated wire from one of the old Command set coils. The wire was dipped in liquid silver polish to remove tarnish, as were many other silver plated components scavenged from the WWII equipment.

The VFO is a Colpitts circuit using a common-as-dirt 12SK7. The coil is from the 5.3-7.0 MHz Command transmitter. V9 and V5 are adjacent, which allows VFO output to be taken from V9's cathode directly to V5's grid through a small silver mica coupling cap. The N1500 cap across the tank circuit provides temperature compensation.

Voltage regulation for the two oscillators is provided by V10. The socket connections are arranged so that removing the tube cuts voltage to the oscillators. Adjustment of R10 is a compromise of minimum to maximum line voltages versus reliable firing voltage and maximum V10 plate dissipation. In the end R10 was adjusted so that V10 felt comfortably warm to the touch at the typical 120 volts present on the power lines at KG7TR.

PA bias and T/R grid block bias are derived from a voltage divider across the -130 volt supply. The 33k resistor at the low end of this divider is grounded by relay K1 when in transmit. This puts V5 grids at ground and PA grids at about -27 volts, as set by R8. In receive the line is opened to increase the bias beyond tube cutoff. In addition to grid block bias, screen voltage on V4 and the PA tubes is removed by K1 in receive. Additional contacts on K1 switch antenna relay K2 as well as the receiver mute and linear T/R circuits.

In the SPOT position S3 grounds the bias line to the mixer and PA grids, and also routes screen voltage to V4 and the PA tubes through a 100k resistor. This limits the maximum plate current to about 40ma when the carrier is fully unbalanced. The T/R and antenna relays are not energized in the SPOT mode to prevent RF radiation and protect the receiver.

Power for K1 and K2 is provided by half-wave rectification and filtering of the 12.6 VAC filament voltage. RFC10 helps keep 60 Hz spikes out of other circuitry.

ALC voltage is derived by rectifying PA grid current pulses across the 10k resistor connected to R8. Diodes D6 and D7 comprise a voltage doubler. The resulting voltage is filtered by a fast attack, slow decay network and sent to the grid of V4. ALC from a linear is routed to V4 through D5. Whichever voltage is most negative will control V4's gain.

In the TUNE position of S4 the PTT line is grounded. The ALC line is also grounded in TUNE to prevent interaction of ALC during adjustment of PA tuning and loading.

When METER switch S2 is in the PLATE position the minus side of the meter is grounded and the plus side is connected to the PA cathodes through a precision resistor. The meter reads 200ma full scale across the 5 ohm cathode resistor in this position. Fuse F1 opens if a PA tube develops any shorts, including heater to cathode. If this happens the meter movement is protected because the fuse is upstream of the cathode resistor.

In the ALC position of the METER switch the minus side of the meter is connected to V4's cathode through a series resistor. The plus side is connected to the wiper of R9 in a voltage divider network. Voltage regulator U1 supplies 5 volts to the top of this divider to provide a solid reference voltage on the plus side of the meter. When negative going

ALC voltage is applied to the grid of V4 its cathode voltage drops, causing a positive deflection of the meter. Many S-meters in receivers work the same way. Diode D12 prevents the meter from pegging full scale in receive, when V4 is totally cutoff and its cathode voltage is zero.

The filament chain is straightforward. A green LED with series resistor is connected to the filament supply to indicate power on. Although the 6AG7 is a great tube for a driver, it does not have a 12 volt version that would allow direct connection to a Heath HP-23B supply. To get around this problem, a 6SN7 was used for V5 and its filament connected in series with V6. A resistor is connected across V5's filament to compensate for the extra 50ma of filament current drawn by V6.

5.0 Service and Alignment

To remove the top cover remove 19 #3-56 screws and pull it rearward. To remove the bottom cover remove 12 #3-56 screws and pull it up and rearward. Don't forget the screw at the front center location.

To remove the PA tubes, first remove the #6 Phillips screw between the parasitic suppressors that holds the bus bar to the ceramic insulator. After removing the screw pull both plate caps, suppressors and bus bar off together as a unit. Then it's a cinch to remove the tubes. Note the position of the fiber washer – it goes against the insulator, then the bus bar and finally the locking solder lug.

Most circuits should never need alignment unless parts have been replaced. If required, C2 and C3 are adjusted for maximum output with the carrier unbalanced or an audio signal applied. L5 and L6 are peaked for maximum output with the VFO set for about 14.275 MHz, or whatever the favorite operating frequency may be. If operation on several different frequencies is anticipated, L5 and L6 can be peaked at slightly different frequencies to make the output flatter across the 20 meter phone band.

Neutralizing cap C4 is carefully adjusted using a dummy load. It is moved a small amount in either direction until plate current dip and maximum power output occur simultaneously. It will not need adjustment unless the PA tubes are replaced, and then only a small adjustment should be required.

If C1 must be adjusted an RF probe with VTVM or an oscilloscope should be used to monitor the RF voltage at the input to the balanced modulator. It will be noticed that as C1 is rotated the oscillator will start up and quickly go to maximum output, and then drop off. The proper adjustment is to set the amplitude about ten percent lower than the peak on the side that keeps oscillating. This adjustment will affect the RF phasing.

For the SSB circuits there are four adjustments to tackle – RF phase on R4 and R5, and audio ratio and balance on R2 and R3 respectively. R4 and R5 will affect the carrier amplitudes as well, so balance pots R6 and R7 must be readjusted each time phase is touched.

There are plenty of articles in vintage SSB publications on how to adjust a phasing exciter, including the original W2EWL articles, so step by step details are not provided here. B&W recommends the circuits be adjusted using a low amplitude, low distortion 1,000 Hz audio signal and an oscilloscope. The B&W method is one approach, but it only guarantees good sideband suppression at 1 KHz.

What is apparent right away using an audio oscillator is that the opposite sideband suppression varies as the audio frequency is swept across the audio passband. This is a limitation of the B&W or any other type of phase shift network – there is no one single best setting for the complete audio passband. The tolerance specified for the B&W network is ±1.5 degrees over 300 to 3,000 Hz. In theory this provides a minimum sideband suppression of -37db over the range. The Cheap 'N Easy II ended up being adjusted using a spectrum analyzer and an Elecraft 2T-Gen two tone test generator (700 and 1,900 Hz). The four adjustments were tweaked until the best overall sideband suppression and balance for the two tones was achieved on both USB and LSB.

The audio filter used at the output of T1 helps reduce output above 3,000 Hz, but the cutoff is not as sharp as a mechanical or crystal filter, or a modern solid state audio filter using op-amps. The opposite sideband suppression decreases rapidly as the audio frequency increases beyond 3,000 Hz, so to avoid adjacent channel interference it helps to use a communications microphone with good cutoff above this frequency. All in all, performance in this area is about the same as the venerable Hallicrafters HT-37.

For reference, a scope trace and specan trace using the Elecraft two tone test generator are shown in Figures 3 and 4 respectively. These traces represent about the best you can get from a phasing rig like this. Opposite sidebands and carrier are down about 30 db from the two tone signals. Sideband and carrier suppression are usually expressed in terms of a single tone signal, which adds 6 db to these values. So 35 db or so of sideband and carrier suppression is pretty much what a B&W network and the balanced modulator can do in the Cheap 'N Easy II. In perspective, it couldn't have been any better in the original W2EWL version. Most tube PAs and linear amps produce third order IMD products greater than this anyway, so it's not a big deal.

Figures 5 and 6 show the chassis top view and bottom views respectively. Major components and adjustments are identified. Appendix A is a parts list for major components. The 11x17 fold out of the schematic is after Appendix A. At the end of this booklet you will find copies of the W2EWL articles (with apologies for some missing pages in the QST article) and the instruction sheet that came with the B&W Model 350 Type 2Q4 used in this rig. A .pdf copy of this booklet is also available from KG7TR.

By all means, enjoy the radio. It's a one-of-a-kind classic!

Mike Bohn
KG7TR
May, 2012

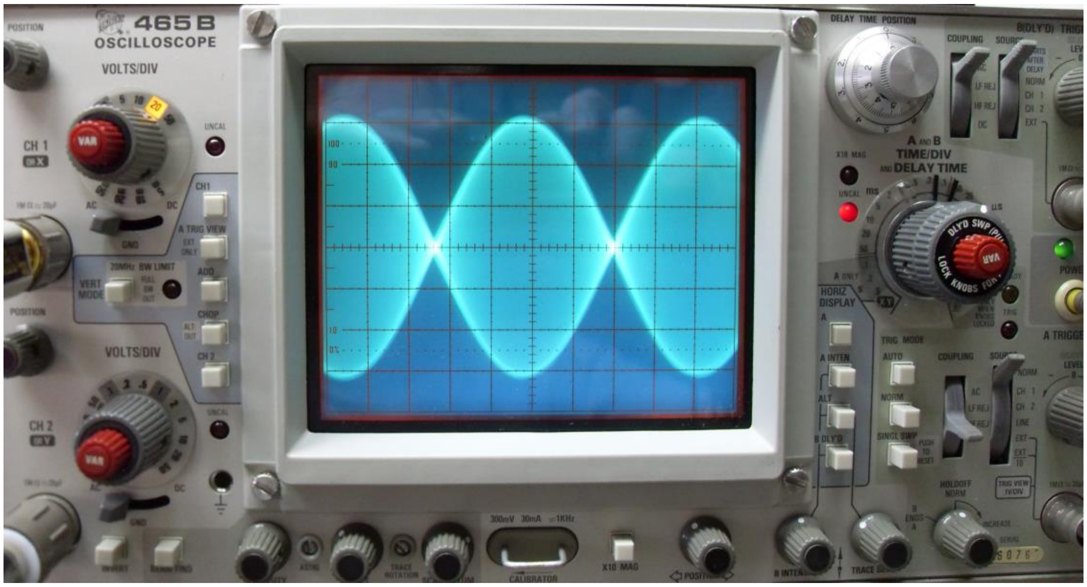

Figure 3 – Two Tone Pattern on Scope
Signal is about 125 volts p-p into 50 ohms, which is 40 watts PEP

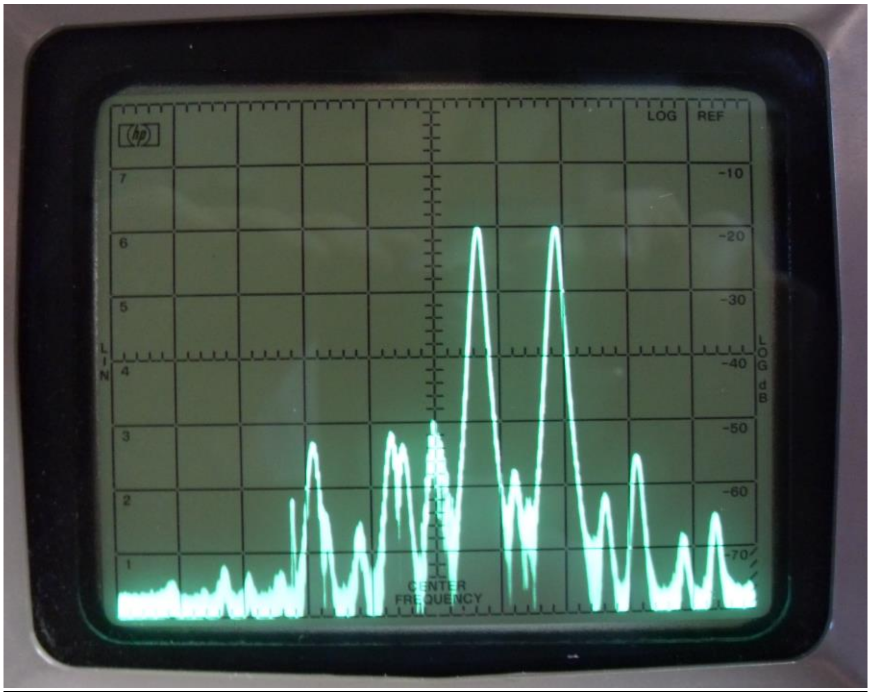

Figure 4 – Two Tone Pattern on Specan
Carrier is at center and horizontal divisions are 1 KHz, output is 40 watts PEP

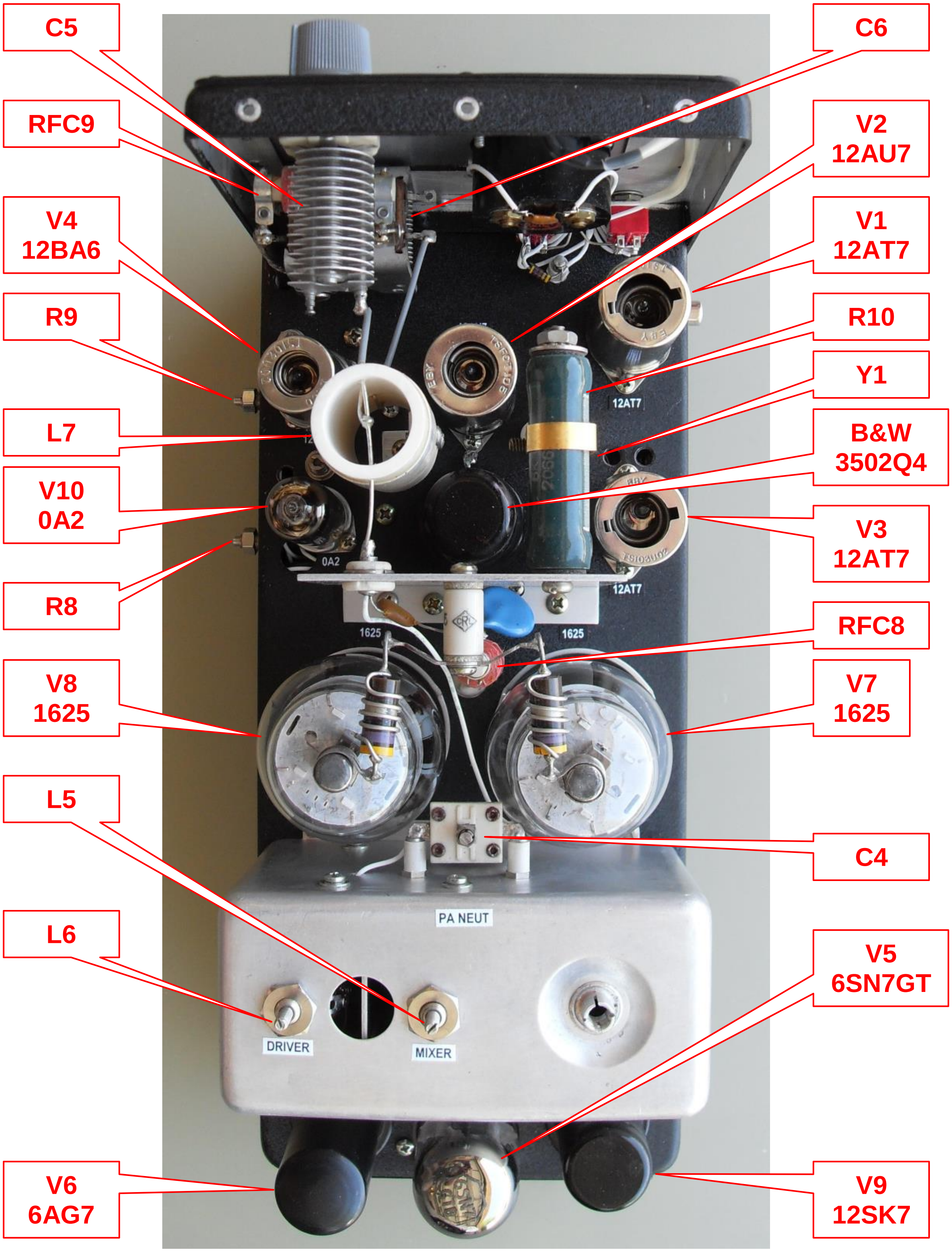

Figure 5 – Chassis Top View

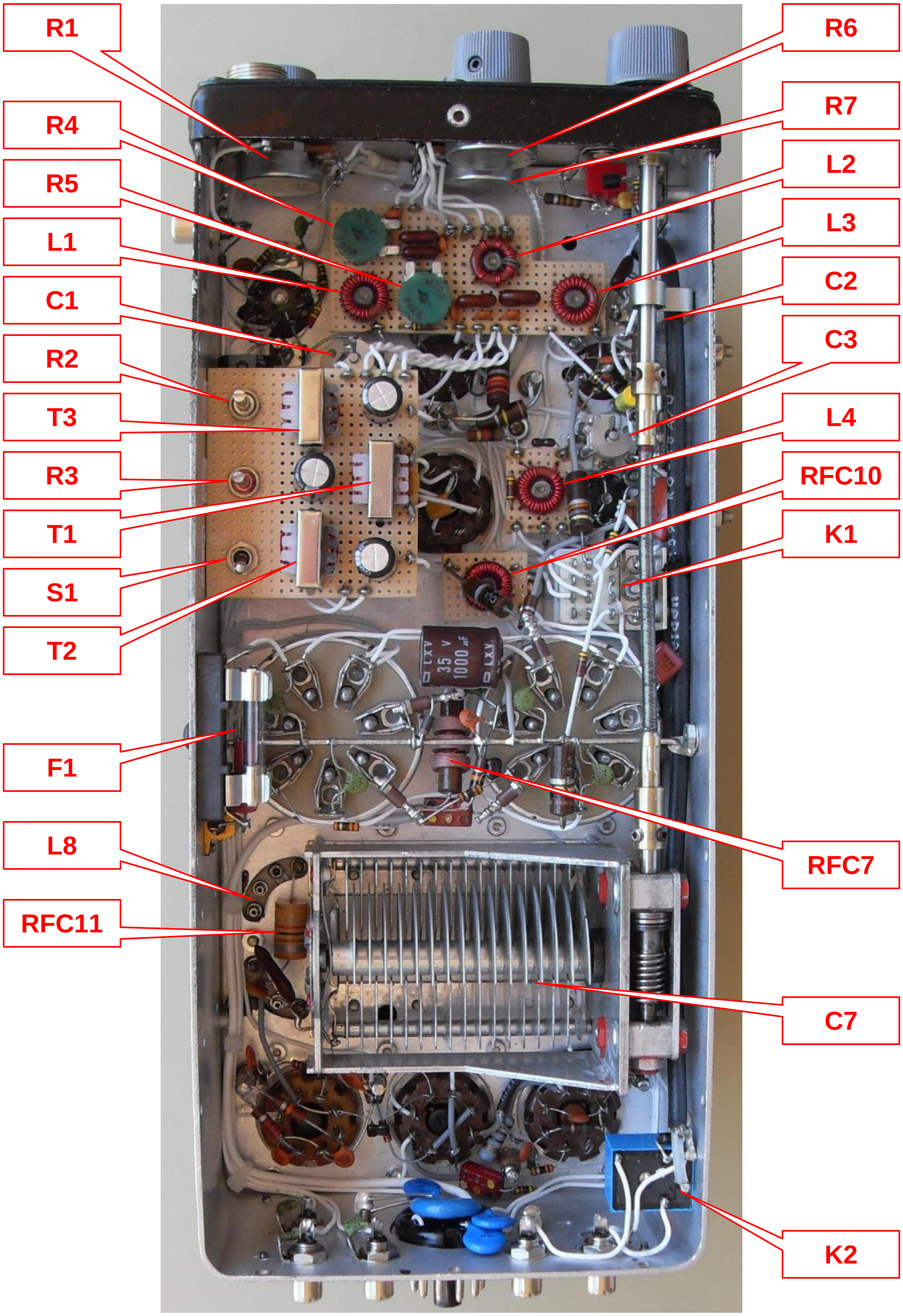

Figure 6 – Chassis Bottom View

Appendix A

Parts List

C1-C3	20 or 25 pF miniature air variable	
C4	10 pF miniature air variable, double spacing	
C5	50 pF air variable, double spacing	
C6	410 pF air variable, single gang, BC band type	
C7	Command Xmtr VFO variable, rear unit, 150 pF	
D1-D4	1N914 or 1N4148, matched with ohmmeter for forward resistance	
D5-D10, D12	100 PRV GP silicon, 1N4002 or similar. Most any type 1 amp rectifier suitable.	
D11	Green LED	
F1	Fast acting fuse, .5 amp, 3AG size	
J1	Microphone jack, four pin	
J2-J5, J7, J8	RCA phono jack, chassis mount	
J6	11 pin chassis mount plug to mate with power supply cable	
K1	4PDT, 12 VDC coil, 150 ohms minimum	
K2	SPDT, 12 VDC coil, 400 ohms minimum	
L1	22 turns #24 on T50-2 toroid form, link 3 turns #24 over cold end	
L2	6 turns #24 bifilar wound on T50-2 toroid form. Link 2 turns #24 or #26 magnet or hookup wire over center, see photo	
L3	22 turns #24 on T50-2 toroid form	
L4	22 turns #24 on T50-2 toroid form, link 5 turns #24 over cold end	
L5, L6	10 turns #20 on ½ inch slug tuned form. Turns are close wound on end farthest from mounting nut.	National XR-50 form
L7	3.5 uh, 13 turns #18 tinned copper on ¾ inch PVC pipe (~one inch dia) to occupy 1.0 inch length	
L8	Command Xmtr VFO Coil, #6031, 5.3-7.0 MHz, high side tapped 8 turns from ground end	
M1	0-1 ma meter, 1.5 inch diameter	
PC1, PC2	4 turns #18 space wound on 47 ohm, 2 watt carbon resistor	
R1	Panel mount, audio taper	Mouser 31VJ601-F
R2, R3	Miniature panel mount, composition	
R4, R5	Miniature PCB mount, composition	
R6, R7	Panel mount, linear taper, composition	Mouser 31VA205-F
RFC7	Pi-wound choke	
RFC8,	Pi-wound choke, 200 ma minimum	

RFC9		
RFC10	78 turns #26 jumble wound on FT50A-43 toroid form	
S1-S4	Miniature toggle, DPDT	
T1-T3	Miniature audio transformer, 25k CT to 600 ohm CT	Mouser 42TM017-RC
Y1	9.0 MHz crystal, exact frequency not critical	

General Notes for Transmitter Parts:

1. Fixed capacitors: Capacitors marked with an asterisk are silver mica, 500 volt rating. Capacitors with a plus sign are electrolytic. All other capacitors are disc ceramic, 500 volt rating except as noted. Capacitors used in low voltage circuits such as the balanced modulator may be 100 volt rating.
2. Fixed resistors: Unless otherwise noted, all resistors are 0.25 watt, 5 percent tolerance, carbon composition or carbon film. 0.5 and 1.0 watt are 5 percent tolerance, carbon composition or carbon film. 2 watts and greater are wire wound.
3. RF Chokes: Except for RFC7 through RFC10, all chokes are miniature epoxy coated type.
4. Military tube types 6201 and 5814 may be substituted for 12AT7 and 12AU7 respectively.