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

Technical Data and Instructions

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1.0 Introduction

The Cheap ‘N Easy II 80M 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 W2EWL 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 modifications are added to improve performance and functionality, including:

- Separate mixer stage using a dual triode
- PTT T/R switching at microphone connector
- Built-in antenna relay
- Relay switching for linear amplifier and receiver muting
- Metering of PA plate and grid current
- Frequency spotting switch
- Stable Colpitts VFO

The Cheap ‘N Easy II 80M was built from a US Army Signal Corps transmitter and is finished in natural aluminum. As in the W2EWL rig, a B&W Model 350 Type 2Q4 audio phase shift network is used. The unit covers the top end of the 75 meter phone band and puts out about 50 watts PEP. Power comes from a Heath HP-23 series power supply using the furnished interconnect 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 perforated 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. Note that some versions of the HP-23 supplies may not have an ON-OFF switch, so some means must be provided to control power. In all cases the Heath supply must be operated in the LV 250 DC mode, which may require some rewiring on units that don’t have the three-way power switch. Some supplies may also have a variable bias pot. The fixed bias of -130 is used for the Cheap ‘N Easy II 80M.

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, and linear relay. The muting line is grounded in receive and opened in transmit. The receiver is placed in the standby mode for T/R switching. The linear relay line is grounded in transmit and opened on receive.

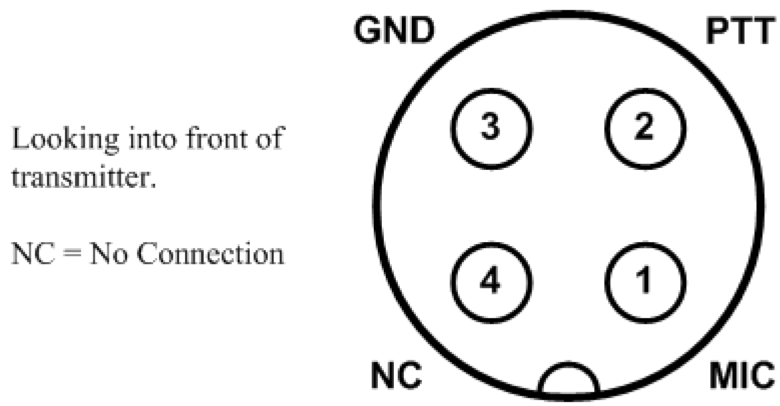

Figure 1 – Front Panel Microphone Connector

Figure 2 – Rear Panel Connections

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, MIC GAIN full CCW, 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 mode of the Heath power supply. Then place the TUNE/OP switch to TUNE and quickly adjust the CARRIER BALANCE controls for minimum output. These controls will not be exactly at the twelve o’clock position when balance is achieved, but this is not of concern.

The meter reads 200 ma full scale in the PLATE position and 1.0 ma full scale in the GRID position.

When minimum carrier has been achieved the plate current should be 40 ma (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 80 ma 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 110 ma (midpoint on the meter) at maximum power output. At this point the output will be about 50 watts and still in the linear region. You can actually drive it to over 50 watts, but the PA will be saturated at this point and will not be linear. Note that the PA LOAD may not have a lot of effect. The value of the 470 pf parallel capacitor in this circuit was chosen for maximum power and linearity into a 50 ohm dummy load, with PA LOAD set at about the middle of its range. If a good match cannot be obtained the parallel cap can be changed.

The mixer and driver plate capacitors (C4 and C5) were peaked for operation on 3.895 MHz. If changing frequency by more than about 5KHz they should readjusted for maximum output. These capacitors can be accessed through the top cover.

When the PA is tuned, set the TUNE/OP switch to OP, the meter switch to GRID and key the microphone. Then advance the MIC GAIN while talking into the microphone until grid current just starts to show on the meter. With typical high output microphones very little MIC GAIN will be required. Operating with the MIC GAIN set just below grid current is the best spot to minimize splatter.

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 and receiver audio 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 CW to increase transmitter frequency.

The VFO is quite stable and entirely satisfactory for SSB use. Figure 3 shows the results of a two hour drift test from a 74°F room temperature start. After a 45 minute warm up drift was less than 50 Hz per hour.

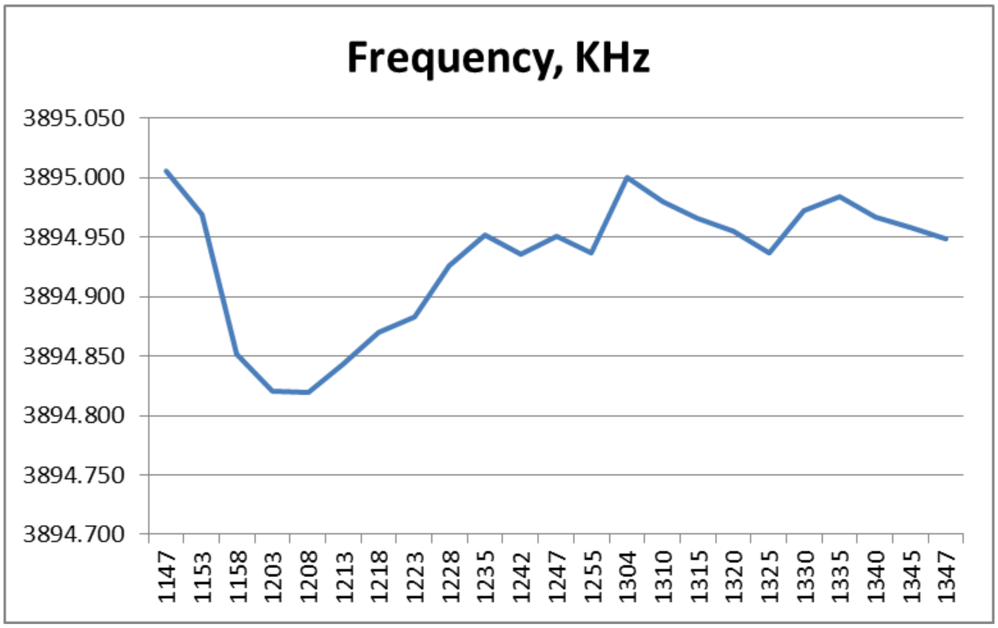

Figure 3 – VFO Drift Test

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 by adjustment of R2. 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. The capacitors are connected in series with the plate side of the transformers to keep the primary windings at ground potential. This puts less strain on the insulation between the windings and the core. These small transformers were designed for low voltage solid state circuits, so keeping the windings at ground potential means they only see audio voltages. In the W2EWL version this was not possible due to the quad section electrolytic capacitor that was used. Here the capacitor can had to be grounded, putting the transformer windings at B+ potential.

Sideband select switch S1 is located on the left side of the chassis and is intended primarily 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 9.0 MHz. 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 464 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 100 pF cap to form a series resonant tank circuit peaked at 9 MHz that feeds the grid of IF amplifier V4. The output of V4 is peaked in a 9 MHz tank circuit (L4). A shield across V4's socket isolates the input and output circuits. This stage has more than ample gain, and a 6.8k resistor across L4 provides a constant load and improves linearity.

A link on L4 applies the SSB signal 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 75 meter output in the tank circuit consisting of L5, C4 and a parallel 120 pF cap. This signal is further amplified in driver V6, resonated by L6, C5 and a parallel 100 pF cap, and applied to the grids of the PA tubes.

The W2EWL radio used a combined high level mixer/driver (12BY7, 6V6 or 12A6). 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.

A 12A6 was used for V6 because it has both a 12.6 volt filament and a metal shell grounded at pin 1 to provide shielding. And it is a genuine WWII tube that was used for the audio output stage in all of the Command receivers of the era. At 3.9 MHz it does a fine job.

A 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 80M 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 toroid coils and variable caps for the mixer and driver plate circuits. Vertical shields are mounted inside the original VFO coil enclosure 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 C6 feedback into the low end of the driver tank coil. The 7.5k resistor in the grid circuit provides a constant load to the driver tube and improves linearity. PA tank coil L7 was wound on a ceramic coil from the VFO of a 3-4 MHz Command transmitter. First the coil form was completely stripped of all windings. Then silver plated #18 gauge wire from the loading coil in the same Command set was used to fill up the entire length of the coil form. Before winding, 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 51 pf N750 cap across the VFO tank circuit provides temperature compensation, and in combination with the tap on L8, sets the VFO range to about 5.0 to 5.4 MHz.

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 R9 is a compromise of minimum to maximum line voltages versus reliable firing voltage and maximum V10 plate dissipation. In the end R9 was adjusted so that V10 felt comfortably warm to the touch at the typical 120 volts present on the power lines at KG7TR. It was observed that if no load is connected to the output of the radio, the high RF voltage in the PA tank coil will cause local hot spots to develop on the plate of V10 because of its proximity. However, with a normal 50 ohm load connected no interaction occurred. If this should become a problem a small brass shield has been provided. This can be slipped over V10 and the grounding lug secured to the nearby mounting screw of L7.

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. Power for K1 and K2 is provided by half-wave rectification and filtering of the 12.6 VAC filament voltage.

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 68k resistor. This limits the maximum plate current to less than 40 ma 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. In the TUNE position of S4 the PTT line is grounded, allowing the transmitter to be tuned and loaded to full output.

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 an 820 ohm resistor. The meter reads 200 ma full scale across the 1.0 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 GRID position of the METER switch the meter is connected directly across the 120 ohm resistor in series with the PA grid bias. The meter reads 1.0 ma full scale in the GRID position.

The filament chain is straightforward. A green LED with series resistor is connected to the filament supply to indicate power on. All tubes have 12.6 volt filaments.

5.0 Service and Alignment

To remove the top cover remove 20 #3-56 screws and pull it rearward. Don't forget to remove the screw in the center of the perforated section. This screw reinforces the shield section in front of the PA tubes. 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. Note that short #3-56 screws are used 12 places around the bottom section of the top cover. The longer screws are used for all other locations.

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. C4 and C5 were originally peaked for maximum output with the VFO set for 3.895 MHz. If changing frequency by more than about 5 KHz, C4 and C5 should be peaked at the new frequency. They are accessible through the top cover.

Neutralizing cap C6 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. Installing the top cover will have some effect on this adjustment, so it should be temporally installed as required until adjustment is complete.

If C1 must be adjusted, a VTVM with an RF probe or an oscilloscope with a 10X probe 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 phase 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 pass band. 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 pass band. 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 80M 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 4 and 5 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. In the old days sideband and carrier suppression were 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 80M. In retrospect 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 6 and 7 show the chassis top view and bottom views respectively, and Figure 8 shows the inside of the VFO compartment. 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. 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
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May, 2013

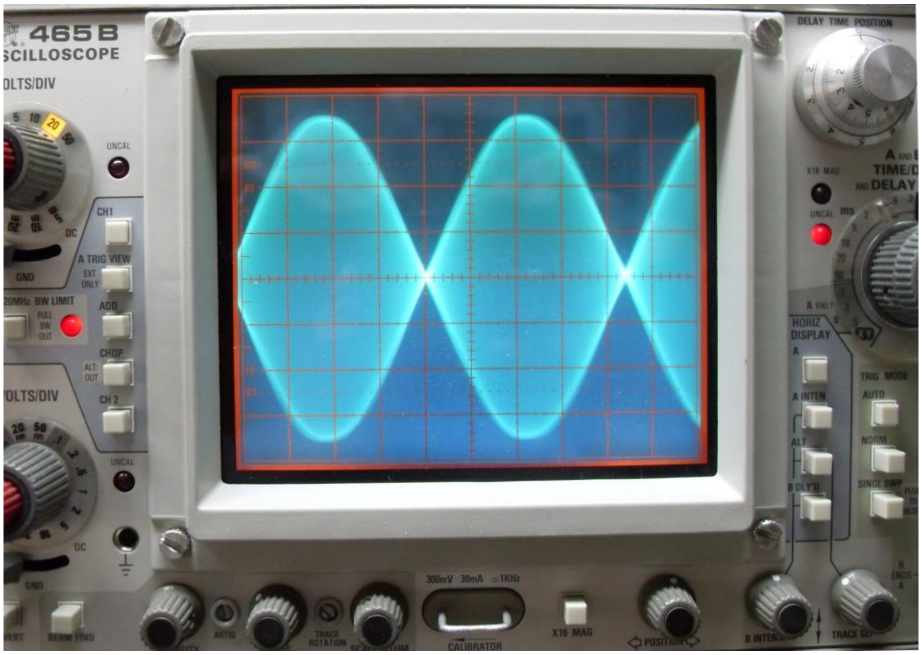

Figure 4 – Two Tone Pattern on Scope
Signal is about 140 volts p-p into 50 ohms, which is 50 watts PEP

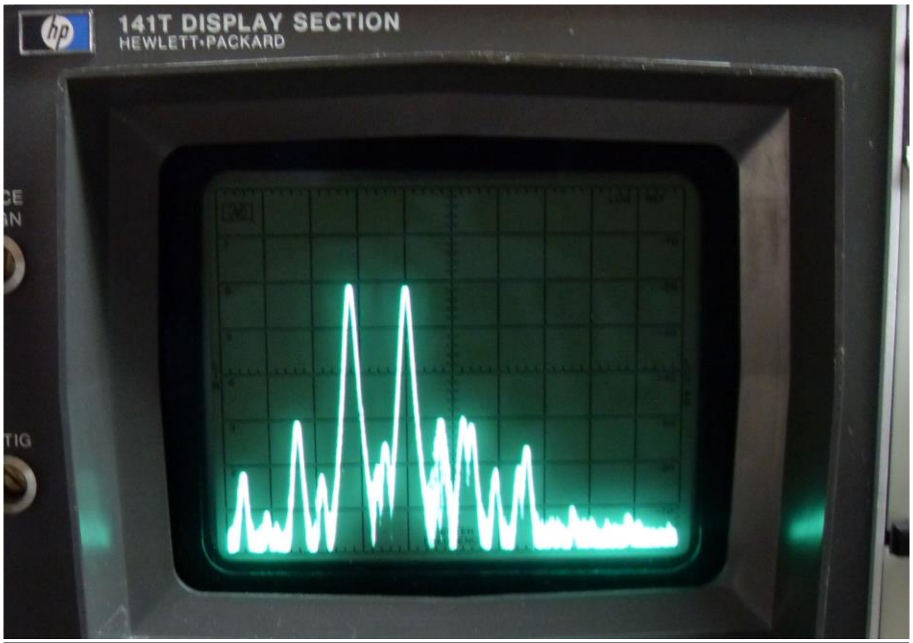

Figure 5 – Two Tone Pattern on Specan
Carrier is at center and horizontal divisions are 1 KHz, output is 50 watts PEP

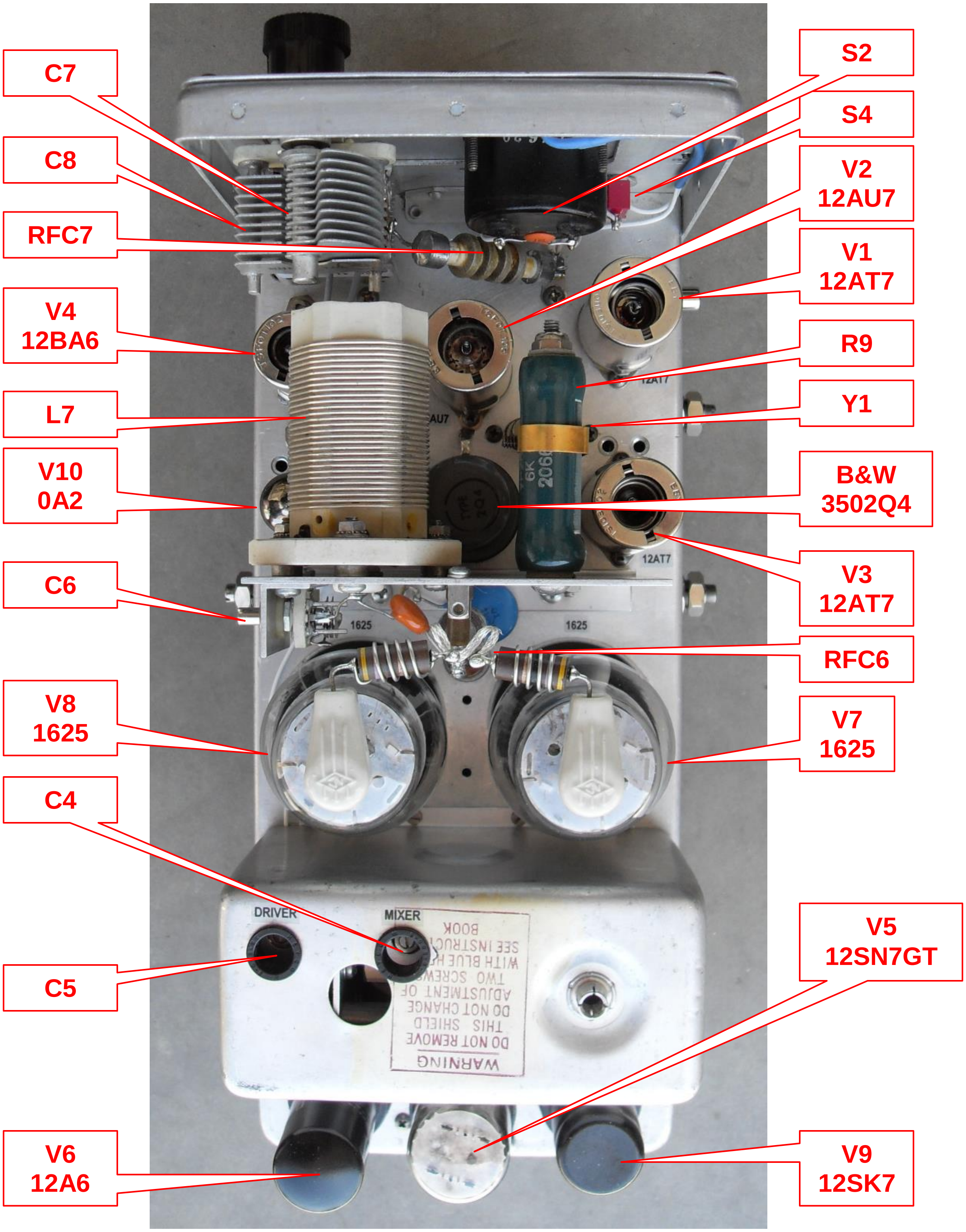

Figure 6 – Chassis Top View

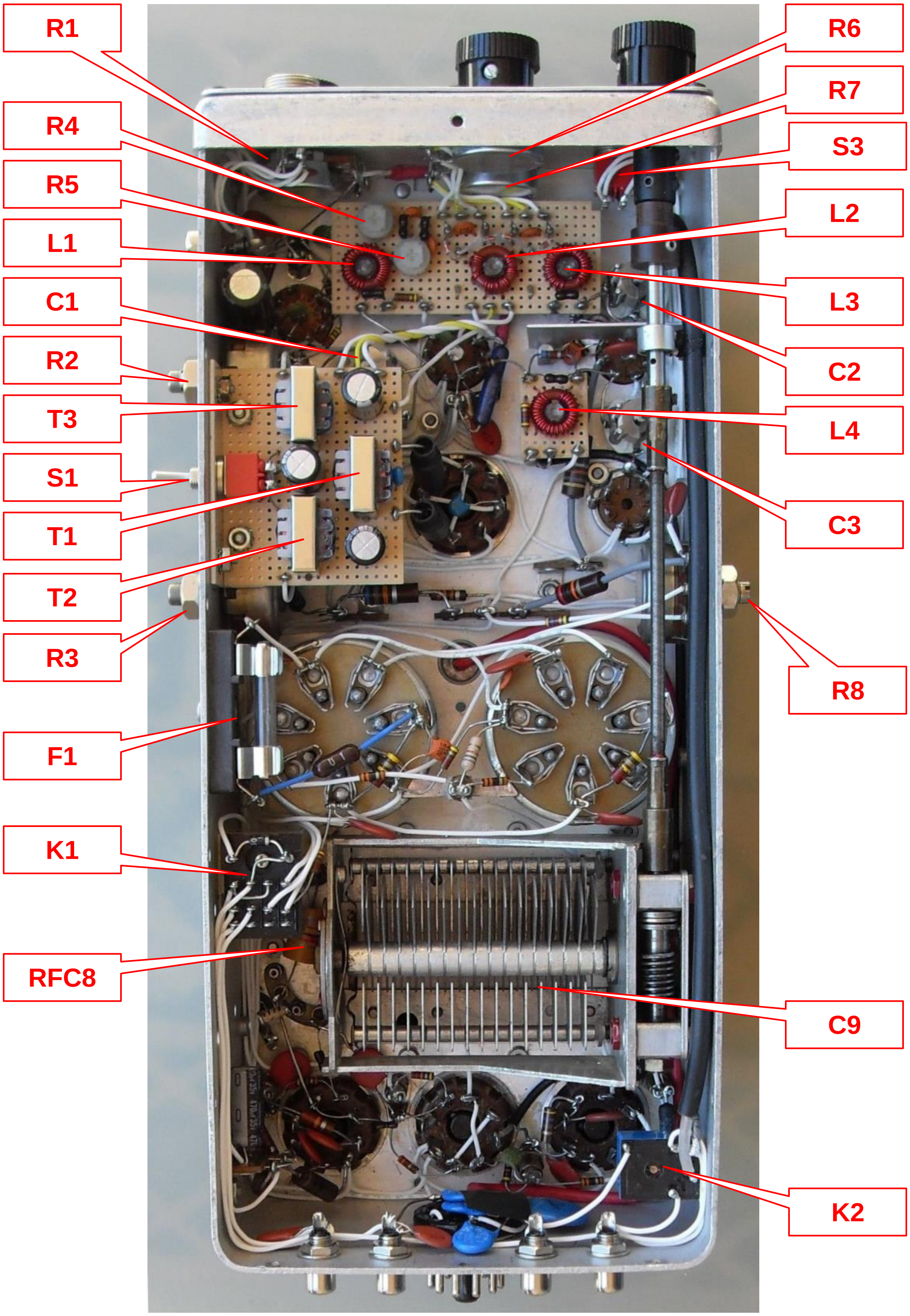

Figure 7 – Chassis Bottom View

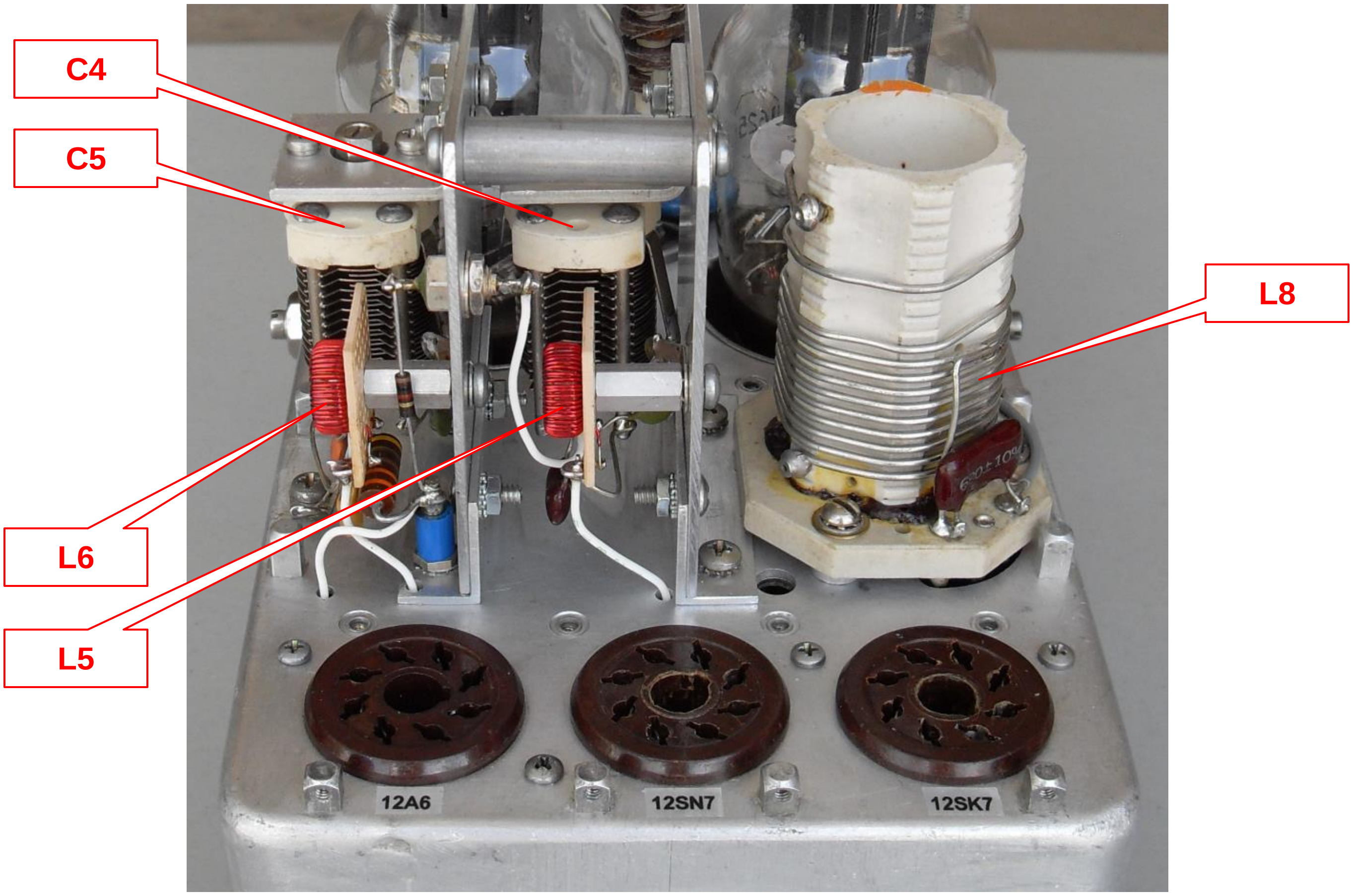

Figure 8 – VFO, Driver and Mixer Tank Circuits

Appendix A

Parts List

C1-C3	20 or 25 pF miniature air variable	
C4, C5	75 pF APC type air variable	
C6	10 pF miniature air variable	
C7	140 pF air variable	
C8	410 pF air variable, single gang, BC band type	
C9	Command Xmtr VFO variable, rear unit, 150 pF	
D1-D4	1N914 or 1N4148, matched with ohmmeter for forward resistance	
D5-D7	100 PRV GP silicon, 1N4002 or similar. Most any type 1 amp rectifier suitable.	
D8	Green LED	
F1	Fast acting fuse, .5 amp, 3AG size	
J1	Microphone jack, four pin	
J2-J4, J6, J7	RCA phono jack, chassis mount	
J5	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 4 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 of winding	
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	42 turns #26 on T50-2 toroid form	
L7	~17 uh, 29 turns #18 tinned copper on Command Xmtr VFO Coil, #6029 (3-4 MHz), remove all windings first and rewind with new wire	
L8	Command Xmtr VFO Coil, #6031 (5.3-7.0 MHz), high side tapped 8 turns from ground end, remove all other windings	
M1	0-100 µa meter, 1.5 inch diameter	
PC1, PC2	4 turns #18 space wound on 47 ohm, 2 watt carbon resistor	
R1	Panel mount, audio taper, composition	Mouser 31VJ601-F
R2, R3, R8	Panel mount, screwdriver adjust, linear taper, composition	
R4, R5	Miniature PCB mount, composition	

R6, R7	Panel mount, linear taper, composition	Mouser 31VA205-F
RFC1, RFC2	Pi-wound choke	Mouser 542-70F252AF-RC
RFC3-RFC5, RFC8	Molded epoxy miniature choke	
RFC6, RFC7	Pi-wound choke, 200 ma minimum	
S1-S4	Miniature toggle	
T1-T3	Miniature audio transformer, 20k CT to 1k ohm CT Use full primary and half of secondary	Mouser 42TM006-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 minimum 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.