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# HAMTRONICS® TA451 UHF FM TRANSMITTER INSTALLATION, OPERATION, AND MAINTENANCE INSTRUCTIONS

**GENERAL INFORMATION.**

The TA451 is a single-channel uhf fm transmitter designed to provide 2 Watts continuous duty output into a 50 ohm antenna system in the 400-470 MHz band. It is designed for narrow-band fm with 5 kHz deviation. Audio input is designed to accept a standard low-impedance dynamic microphone or any low-impedance audio source capable of providing 30mV p-p into a 2K load. Operating power is +13.6 Vdc +-10% at 500-600 mA.

The sequence of presentation of the following information assumes that you purchased a wired transmitter, ready to operate. If you purchased a kit, refer to page 2 for Alignment instructions prior to performing audio level or frequency adjustments.

**CRYSTALS.**

The TA451 uses 32 pF parallel resonant crystals in HC-25/u holders. Crystals operate in the fundamental mode at a frequency of F/36, which results in a crystal frequency of 12.5 to 13.056 MHz. We recommend that any new crystals be ordered directly from us to be sure that they will perform properly over the -30 to +60°C range for which the unit was designed. This is especially true for commercial transmitters with the TCXO option, since the crystal must be matched exactly to the compensation circuit in the transmitter. If you use an OV-1 crystal oven, specify a crystal with a 60°C breakpoint.

**POWER.**

The TA451 Transmitter operates on +13.6Vdc at about 500- 600 mA. A well regulated power supply should be used. Positive and negative power leads should be connected to the transmitter at E1 and E3. Be sure to observe polarity. If a crystal oven is used, +13.6Vdc should be connected to the oven separate from E1, since E1 is keyed on and off to transmit. Oven power should remain on constantly during any period when transmission is expected.

**MICROPHONE AND AUDIO DEVIATION ADJUSTMENTS.**

The TA451 Transmitter is designed for use with a low impedance dynamic microphone (500-1000 ohms) or any low impedance audio source capable of supplying 30 mV p-p across 2000 ohms. The microphone should be connected with shielded cable to avoid noise pickup. Mic connections are made to E2 and E3 on the pc board. The leads can be wrapped and soldered around the posts or the inside of the posts can be prefilled with solder and the lead soldered inside the post when the solder is remelted.

To adjust the audio controls, start by setting potentiometer R1 to maximum and R15 to midrange. Apply B+ to E1 to key the transmitter and talk into the microphone or apply audio of normal expected level to the transmitter. If the unit is setup with tones from a service monitor, use a tone frequency of 2500 Hz. Observe the deviation meter or the scope on a service monitor, and adjust R15 for a peak deviation of 5 kHz. Then, adjust mic gain control R1 so that the transmitter deviation just swings up to 5 kHz on modulation peaks. This will provide the optimum setting, with sufficient audio gain to achieve full modulation but with the limiter occasionally clipping voice peaks to prevent over-modulation. Avoid setting the audio gain higher than necessary. Although the deviation limiter will prevent over-modulation, microphone background noise is increased and some distortion from excessive clipping may result.

**FREQUENCY ADJUSTMENT.**

The crystal frequency is precisely set on the channel frequency with variable capacitor C13, using an accurate service monitor or frequency counter.

**MOUNTING.**

The four mounting holes provided in the corners of the board can be used in conjunction with screws and standoffs to mount the board in any cabinet or panel arrangement. See catalog for A26 PC Mounting Kits. There is no need for a shielded cabinet except if the transmitter is used in a repeater or in duplex service.

**KEYING.**

The easiest way to key the transmitter is to run the B+ for the unit (E1) through the push-to-talk switch in the microphone or a similar spst switch. Although a relay may be used, it is not necessary; since the 500-600 mA required by the transmitter may easily be switched be most microphone switches. If you are interfacing with some sort of control board, a PNP transistor, such as a TIP-30, can be used to switch the current to operate the transmitter. If a power amplifier is driven by the transmitter, the pa (assuming class-C operation) will draw current only when the TA451 transmitter is driving it with rf power; so the pa should not require a separate keyline circuit.

**THEORY OF OPERATION.**

The TA451 is a fairly straight forward fm transmitter, with a phase modulated 12-13 MHz signal multiplied by 36 to reach the 400-470 MHz output range. Crystal oscillator Q4 operates as a Colpitts oscillator at the fundamental frequency of approximately 12 MHz. When supplied with TCXO option, a thermistor compensates for cold temperatures by gradually reducing the amount of load capacitance in series with the crystal at temperatures below 10°C. The oscillator output is fed into reactance modulator Q5, which phase modulates the carrier with audio from the speech processor circuits.

Q6 operates as a tripler to multiply the carrier frequency to a range of 33 to 39 MHz. Q7 triples again to a range of 100 to 117.5 MHz. This, in turn, is doubled in Q8 to a range of 200 to 235 MHz and doubled again in Q9 to the final output range of 400 to 470 MHz. Q10 acts as a predriver amplifier, with potentiometer R37 varying the voltage to the collector to adjust the drive level to the output stages. The signal is further amplified by driver Q11 and pa Q12 to provide the 2 Watt output signal to the 50 ohm antenna. Spurious signal rejection is provided by double tuned circuits between multiplier stages and a low pass filter in the output of the pa stage.

The audio processor circuits consist of microphone amplifier Q1-Q2, peak limiter CR1-CR2, and active filter Q3. The audio input, at a level of about 30 mV p-p, is amplified and applied to the limiter circuit. R1 provides adjustment of the audio gain. Processed audio, limited in peak amplitude, contains a small amount of harmonic distortion from the clipping process. Active filter Q3 is a low pass filter which greatly reduces the effects of any distortion from the limiter to prevent splatter of sidebands outside the bandwidth allowed for one channel. Deviation potentiometer R15 allows for adjustment of the peak audio level applied to the modulator stage. C11/R17 is an rf filter to keep the carrier signal at 12 MHz from getting back into the active filter stage. R16/C11 acts as an additional low pass filter. Together with the active filter stage, it

 

Pin 7 Red PTT
Pin 17 BLK COS

# HAMTRONICS® TA451 UHF FM TRANSMITTER, ASSEMBLY INSTRUCTIONS

a. Install socket pins E1-E3 and the crystal sockets. Cut them from the metal carrier strip. Install from top of board, and rock them while pressing into holes. They will snap in place when fully seated. Solder lightly to avoid wicking solder up into top of pins. **Note:** If a crystal oven is used, sockets should not be installed for the crystal. Instead, one socket should be installed in position E4, the B+ connection point for the crystal oven.

b. Install three potentiometers.

c. Install transistors Q1-Q9 as low as possible for short leads.

d. Install Q10 from the bottom of the board with printing up and body inserted in the large hole in the board. Long (collector) lead should be tack soldered to the long land area, and shorter (base) lead should be soldered to short land area. Emitter lead(s) should be soldered to the ground plane. Some transistors have one emitter lead and some have two. In either case, the emitter leads are the ones at right angles to the base and collector leads.

e. Install the rf power transistors flat against the board, and solder the leads on the bottom of the board. Then, solder the bottom of Q12's metal can to the pcb ground plane with a continuous bead of solder flowing around the can. (This is necessary to provide a low impedance emitter ground; the transistor is designed to be installed this way.) Be careful not to use so much solder that it flows under the can and shorts the base and collector leads.

f. Install phono jack J1. Solder all four lugs under the board.

g. Install variable capacitors, orienting as shown so rotors are connected to ground. For those with one lead connected to ground plane, bend that lead at right angles and solder close to the body for good uhf ground. Note that there are two types of variable capacitors which are white. The 10 pf white plastic body capacitor is C13. The 4.5 pf white ceramic body capacitors with the brown spot on the rotor screw are the other type. The 4.5 pf ceramic capacitors should have the ground lead bent just under the "T" shape bar on the lead, not at the bottom of the capacitor, to prevent breaking the lead off. Since the 4.5 pf capacitors were made with a bend in the lead at the bottom of the capacitors, bending again at the same point can fracture the lead. The red capacitors can be bent right at the body. Note that C48 may fit tight in the holes in some pc boards. If so, rock the leads in as well as you can, and then fill the holes with solder. Since the holes are plated through, this should bond to the capacitor leads ok.

h. Install electrolytic capacitors, observing polarity.

i. Install ceramic capacitors. It may be necessary to form capacitor leads to fit holes in board. Keep leads as short as possible. For those capacitors with ground lead connected on top side ("X" marked on lead in diagram), bend the ground lead at right angles as shown and tack solder close to body. Note that all top side ground connections must be soldered very close to the body of the part for low-impedance ground.

j. Install resistors and diodes, observing polarity on diodes. Note that there are 2 kinds of diodes. On vertical parts, form top lead directly over for shortest leads. The circle on the location diagram indicates where the body of the part should be.

k. Wind air wound coils L7 and L9-L14 as indicated on schematic and location diagrams, using **#22 tinned bus wire** supplied.

L7 and L11 are 3/4 turn loops bent over a 1/8 inch forming tool, such as a drill bit. L7 Should be installed with its top loop **5/16 inch above the board.** L11 should be installed with its top loop **1/4 inch above the board.**

L9-L10 and L12-L14 are multiturn coils wound on an 1/8 inch diameter forming tool and then soldered with the **tops 1/4 inch above the board.** L10 and L12-L14 are spaced out to fill the distance between mounting holes, generally one to two wire diameters between turns. L9 turns should be spaced as close together as possible without shorting. It is easiest to space them and neaten them up after the leads are soldered in place.

l. Install rf choke L8 as shown.

m. Ferrite beads Z1-Z6, Z8, and Z9 are supplied with wire leads already attached. Install them as shown.

n. Z7 is a ferrite bead (supplied unstrung) which you wind with 2-1/2 turns of **#26 magnet wire** strung through like a toroid as shown in the location diagram. The magnet wire is solderable at high temperatures. Pull leads tight through board, bend over, trim to about 1/16 inch, and solder with a hot iron. After about ten seconds, the insulation will melt and solder will bond to the wire.

o. Install slug tuned coils as shown. Install coil shields. The 2-1/2 turn (red) coils come with shields already on the coils; however, in some cases, the shield must be removed and rotated 90° in order to fit holes in pc board. The 6-1/2 turn (blue) coils have shields supplied separately. Make sure the coils and shields are fully seated, and solder both shield lugs. (Do not bend lugs over, but you can bend the coil leads over a little to hold them in place while soldering.)

p. Set metal shield strip in place as shown along center of board. Tack solder left edge to shield can for L1 as shown, and then carefully align the right end of the shield. Tack solder in several places along bottom of shield strip to ground plane. Work from left to right, and align it neatly as soldering progresses.

q. Slide heatsinks on power transistors Q11 and Q12, and position to avoid shorting to adjacent parts. Since the case of Q11 is at collector potential, be sure that the heatsink doesn't touch any adjacent parts.

r. Check over all components and solder connections before proceeding. Note that there are extra holes in the board next to Q10 and Q11 which merely act as "vias" to carry the ground through the board and are not used to mount components; so they will be empty.

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provides an 18 dB/octave rolloff for any frequencies over 3000 Hz.

Dc power for the transmitter is applied at E1 when the unit is to transmit. +13.6 Vdc is applied to all stages, except the oscillator, modulator, and audio stages. A 9.1 Vdc regulator provides power for those stages for stability of the carrier frequency under varying input voltages and for noise and hum filtering. Power supplied through R18 is regulated by zener diode VR1 and filtered by C18 to isolate the sensitive stages from the outside world.

**ALIGNMENT.**

Equipment needed for alignment is a vtvm, a good uhf 50 ohm rf dummy load, a relative output meter, and a regulated 13.6Vdc power supply with a 0-1000 mA meter internally or externally connected in the supply line.

The slug tuned coils in the transmitter should be adjusted with the proper .062" square tuning tool to avoid cracking the powdered iron slugs. You may not have such a tool, since this type of slug is relatively new; so we have included an inexpensive brass tuning wrench with your unit. A fancier aluminum tool, with a straight 1/4" handle, more like you are accustomed to, is available as an accessory (model A28, $2.50). Tools for adjusting the variable capacitors and potentiometers (model A2, $2.50) are also available. The advantage of a metal tool is that it fits well and doesn't wear out like the plastic ones do. However, if you insert the tool deep enough that the end protrudes beyond the bottom of the slug, minor detuning can occur. This is easily prevented by putting a piece of tape or a small amount of solder on the brass tool 3/8" above the bottom to act as a shoulder to rest on the top of the slug.

All variable capacitors should be set to the center of their range (turn them 90°) if they have not previously been aligned. Power control R37 should be set fully clockwise.

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**NOTE:** Following are some ground rules to help avoid trouble. Always adhere to these guidelines.

1. Do not operate without a 50 ohm load.
2. Do not exceed 2 Watts output (650 mA total current drain) for continuous duty operation. Do not exceed 3 Watts output (800 mA total current drain) for even momentary operation. Reduce setting of power control potentiometer R37 slightly if necessary.
3. Always follow alignment procedure exactly. Do not repeak all controls for maximum output. Each multiplier stage has its own best monitoring test point.
4. Rf power transistors Q11 and Q12 run hot at full drive, but not so hot that you can't touch the heatsinks without being burned. The transistors should be cold with crystal removed from socket. Never run the unit without heatsinks in place.

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a. Connect 50 ohm dummy load to phono jack J1 through some form of relative output meter.

b. Check output voltage of power supply, adjust it to 13.6 Vdc, and connect it to B+ terminal E1 and ground terminal E3 on the pc board. It is permissible to use the braid of the coax cable or the mounting hardware to the chassis as a ground if the power supply has a good low-impedance connection through this path to the ground on the board. **BE SURE TO OBSERVE POLARITY!** A 1000 mA meter or suitable equivalent should be connected in the B+ line to monitor current drawn by the transmitter. This is important to indicate potential trouble before it can overheat transistors. Better yet, if using a lab supply for testing, set the current limiter on the power supply to limit at 800 mA.

c. Connect vtvm to TP1 (top lead of R31) in second tripler stage Q7. Peak L1 and L2 alternately for maximum indication. Typical reading is about +1.5 to 2.5 Vdc.

d. Connect vtvm to TP2 (top lead of R32) in doubler stage Q8. Peak L3 and L4 alternately for maximum indication. Typical reading is about +0.8 to 1.5 Vdc.

e. Connect vtvm to TP3 (top lead of R34) in second doubler stage Q9. Peak L5 and L6 alternately for maximum indication. Typical reading is about +1 to 2 Vdc.

f. At this point, you should have a small indication on the relative power meter. Alternately peak C43, C47, C48, C52, C56, and C57 for maximum indication on the power meter. Note that there are interactions between C47 and C48 and between C56 and C57; so it may be necessary to try several combinations of each to find the optimum settings. If relative output meter is not sensitive enough, you can use vtvm rf probe at base of Q12 for preliminary adjustments or a nearby receiver can be used as an indicator. Use output meter for final adjustment.

g. At full drive, the total current drawn by the transmitter should be 500-600 mA, and the rf output should be about 2 Watts. Do not operate at a level above 600 mA on a continuous basis, but up to 700 mA is ok on a 25% duty cycle. Do not exceed 800 mA for even momentary operation. The drive level is adjusted with power control R37. The drive level is adjusted with power control potentiometer R37. If desired, R37 can be set for any lower level.

Note that full output may not be possible with less than 13.6 Vdc B+. Power output falls rapidly as operating voltage is reduced. This does not necessarily mean that the unit cannot be used on lower B+ voltage, however, since it is hard to distinguish even a 2:1 reduction in power on the air.

Good low-loss coax must be used at uhf frequencies, even for short runs. A 2-foot test lead of small coax can drop as much as 1/2 Watt from a 2 Watt signal.

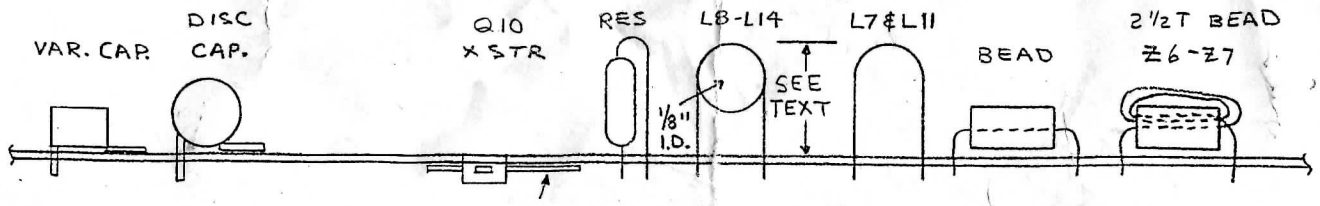
After tuning the transmitter into a known good 50 ohm dummy load, it should not be retuned when later connected to the antenna or power amplifier. Of course, the antenna or pa should present a good 50 ohm load to the exciter.

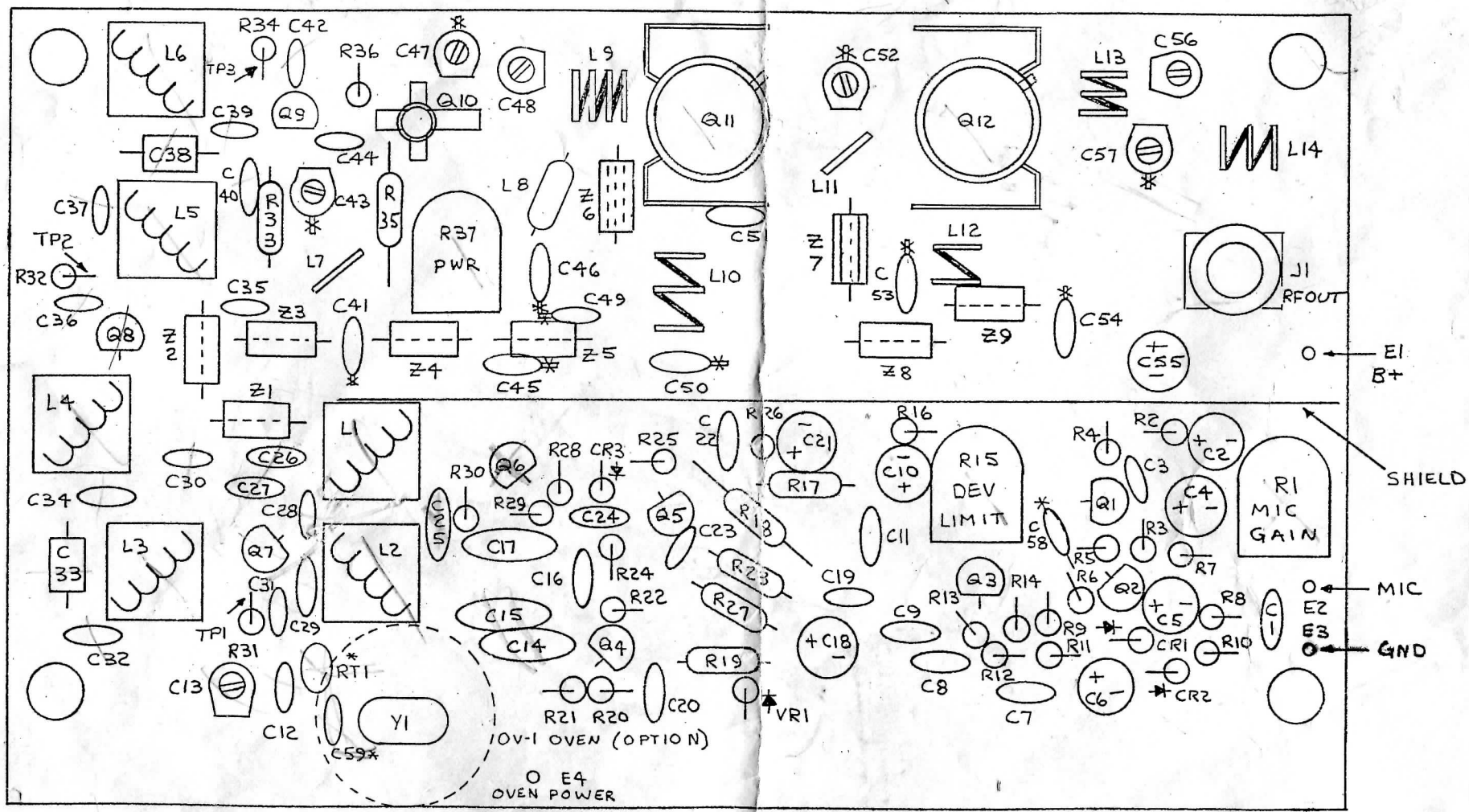
h. Perform the carrier frequency and audio level adjustments given on page 1 to complete the alignment of the transmitter.

**TROUBLESHOOTING.**

The usual troubleshooting techniques of checking dc voltages and signal tracing with an rf voltmeter probe will work well in troubleshooting the TA451. A dc voltage chart and a list of typical audio levels are given to act as a guide to troubleshooting. Although voltages may vary widely from set to set and under various operating and measurement conditions, the indications may be helpful when used in a logical troubleshooting procedure. The transmitter should draw about 20-40 mA at idle, with the crystal pulled out, and about 500-650 mA at full output.

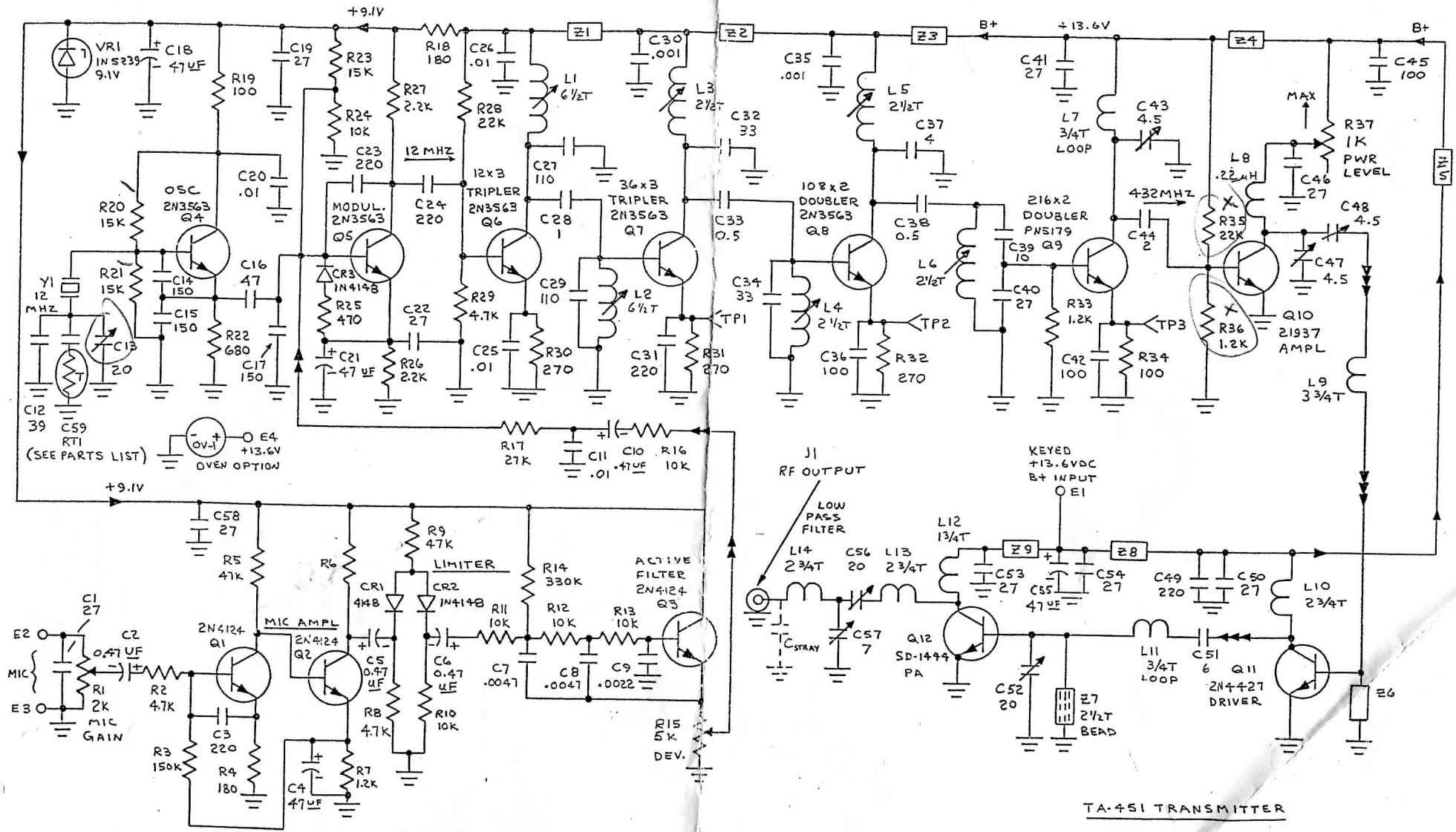
Be careful when operating or troubleshooting to avoid driving the unit to levels over 2 Watts or operating the unit at dc current drain levels over 650 mA for extended periods. Keep an eye on an ammeter in the B+ line while tuning. Do not exceed 3 Watts output (800 mA total current drain) for even momentary operation. Reduce setting of power control potentiometer R37 slightly if necessary. Allowing the driver or output transistor to overheat may cause a thermal runaway condition, something which will not occur in normal operation. An unchecked thermal runaway can destroy a transistor.




*RT1 & C59 FOR TCXO OPTION ONLY

TA-451 UHF XMTR




TA-451 TRANSMITTER

**PARTS LIST, TA451 UHF FM TRANSMITTER.**

| Ref Desig | Description (marking) |
|---|---|
| C1 | 27pf |
| C2 | 0.47 uf electrolytic |
| C3 | 220 pF(221) |
| C4 | 47 uf electrolytic |
| C5-C6 | 0.47 uf electrolytic |
| C7-C8 | .0047 uf (472) |
| C9 | .0022 uf green mylar (222) |
| C10 | 0.47 uf electrolytic |
| C11 | .01 uf (103) |
| C12 | 39 pf (33 pf with tcxo option only) |
| C13 | 20 pf var cap (pink plastic body) |
| C14-C15 | 150 pf (151) |
| C16 | 47 pf |
| C17 | 150pf (151) |
| C18 | 47 uf electrolytic |
| C19 | 27 pf |
| C20 | .01 uf (103) |
| C21 | 47 uf electrolytic |
| C22 | 27 pf |
| C23-C24 | 220 pf (221) |
| C25-C26 | .01 uf (103) |
| C27 | 110 pf (111) |
| C28 | 1 pf |
| C29 | 110 pf (111) |
| C30 | .001 uf (102) |
| C31 | 220 pf (221) |
| C32 | 33 pf |
| C33 | 0.5 pf |
| C34 | 33 pf |
| C35 | .001 uf |
| C36 | 100 pf (101) |
| C37 | 4 pf |
| C38 | 0.5 pf |
| C39 | 10 pf |
| C40-C41 | 27 pf |
| C42 | 100 pf (101) |
| C43 | 4.5 pf var cap (white with brown rotor screw) |
| C44 | 2 pf |
| C45 | 100 pf (101) |
| C46 | 27 pf |
| C47-C48 | 4.5 pf var cap (same as C43) |
| C49 | 220 pf (221) |
| C50 | 27 pf |
| C51 | 6 pf |
| C52 | 20 pf var cap (red) |
| C53-C54 | 27 pf |
| C55 | 47 uf electrolytic |
| C56 | 20 pf var cap (red) |
| C57 | 7 pf var cap (blue) |
| C58 | 27 pf |
| C59 | 7 pf (used only with tcxo option) |

| Ref Desig | Description (marking) |
|---|---|
| CR1-CR3 | 1N4148 |
| E1-E3 | Solder Terminals |
| J1 | RCA Jack |
| L1-L2 | 6-1/2 turns (blue) |
| L3-L6 | 2-1/2 turns (red) |
| L7 | Air wound coil - see text |
| L8 | 0.22 uH rf choke (red-sil-red-red) |
| L9-L14 | Air wound coils - see text |
| Q1-Q3 | 2N4124 |
| Q4-Q8 | PN3563 |
| Q9 | PN5179 |
| Q10 | N.E.C. 21937 |
| Q11 | 2N4427 |
| Q12 | Thompson SD-1444 |
| R1 | 2K pot (23d) |
| R2 | 4.7k |
| R3 | 150k |
| R4 | 180 ohms |
| R5 | 47k |
| R6 | 10k |
| R7 | 1.2k |
| R8 | 4.7k |
| R9 | 47k |
| R10-R13 | 10k |
| R14 | 330k |
| R15 | 5k pot (502) |
| R16 | 10k |
| R17 | 27k |
| R18 | 180 ohms |
| R19 | 100 ohms |
| R20-R21 | 15k |
| R22 | 680 ohms |
| R23 | 15k |
| R24 | 10k |
| R25 | 470 ohms |
| R26-R27 | 2.2k |
| R28 | 22k |
| R29 | 4.7k |
| R30-R32 | 270 ohms |
| R33 | 1.2k |
| R34 | 100 ohms |
| R35 | 22k |
| R36 | 1.2k |
| R37 | 1k pot (102) |
| RT1 | Thermistor (tcxo option only) |
| VR1 | 1N5239B Zener Diode 9.1V |
| Z1-Z6 | Ferrite Beads (prestrung) |
| Z7 | 2-1/2 turns magnet wire on ferrite bead (see text) |
| Z8-Z9 | Ferrite Beads (prestrung) |

**TYPICAL DC VOLTAGES.**

The following dc levels were measured with an 11 megohm fet vm on a sample unit with 13.6 Vdc B+ applied. All voltages may vary considerably without necessarily indicating trouble. The chart should be used with a logical troubleshooting plan. All voltages are positive with respect to ground except as indicated. Voltages are measured with crystal plugged in and oscillating and transmitter fully tuned to provide 2W output. Note that meter probe must have 1 megohm or similar resistor in probe to isolate from rf signals. Even then, the type of meter and probe has an effect on the readings taken on points where rf is present. Voltages in [brackets] are measurements taken with the crystal pulled, no rf.

| STAGE | E | B | C |
|---|---|---|---|
| Q1 | 0.04 | 0.7 | 1.4 |
| Q2 | 0.75 | 1.4 | 4.5 |
| CR1,CR2 | (A) 1.1 | (C) 0.6 | |
| Q3 | 4.2 | 5.0 | 9.1 |
| Q4 | 4.5 [3] | 3 [3.8] | 8.2 |
| Q5 | 3.1 [2.8] | 3.5 [3.5] | 5.8 [6] |
| Q6 | 1.8 [1.5] | 2.1 [2] | 13.6 |
| Q7 | 2 [0] | 0 | 13.6 |
| Q8 | 1 [0] | 0 | 13.6 |
| Q9 | 1.4 [0] | -0.3 [0] | 13.6 |
| Q10 | 0 | 0.25 [0.75] | 13.6 |
| Q11 | 0 | 0 | 13.6 |
| Q12 | 0 | 0 | 13.6 |

**TYPICAL AUDIO VOLTAGES.**

Following are rough measurements of audio voltages (in mV rms) which may be measured with a sensitive vtvm or an oscilloscope when a low impedance dynamic microphone or other audio source is connected and modulating to full 5 kHz deviation. Measurements given were taken with a Tek scope with mic gain and deviation controls fully cw and sufficient audio input applied for full deviation of the rf signal. Measurements are typical of what might be indicated during a sustained whistle or with an audio signal generator. Of course, readings may vary widely with setup; but levels given are useful as a general guide.

| STAGE | E | B | C |
|---|---|---|---|
| Mic Input | 1 | | |
| Q1 | 0.5 | 1 | 10 |
| Q2 | 0 | 10 | 700 |
| Q3 | 500 | 500 | - |
| Q5 | - | 30 | - |