HAMTRONICS® T51 VHF FM EXCITER MODULE INSTRUCTIONS

FUNCTIONAL DESCRIPTION.

The T51 is a single channel fm exciter designed to provide 2 Watts output on the 28, 50, 144, or 220 MHz ham bands or adjacent commercial bands. Refer to catalog for complete specifications.

A WORD ABOUT CONSTRUCTION.

If you are unfamiliar with this type of kit, it is important to note that instructions are more on the order of a good magazine article than a complete step-by-step assembly manual. This saves you time and boredom; but it requires that you read over explanatory material several times and follow the schematic and parts location diagrams to be sure you understand the techniques involved in completing the kit.

CONSTRUCTION.

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 on copper side of board to avoid wicking solder up into top side of pins.

b. Install three potentiometers.

c. Install transistors as shown. RF power transistors should be flat against board, and plastic transistors should be as low as possible (about 1/8 inch or less).

d. Install phono jack J1. If center contact pops out, push it back in place. Be sure to solder all 4 lugs.

e. Install 4 variable capacitors, orienting as shown so rotors are connected to ground.

f. Install electrolytic capacitors, observing polarity and seating as low as possible.

g. Install ceramic disc and tubular capacitors. Refer to parts list for frequency-sensitive parts. It may be necessary to form some capacitor leads to fit holes in board. Keep leads as short as possible.

Note: Disc capacitors with values of 100 pF and over are marked in pF with two significant figures and a multiplier similar to resistors. Any letter should be disregarded, as it is not a part of the value. Eg., 101 = 100 pF, 102 = 1000 pF (.001 uF), 103 = 10,000 pF (.01 uF), 221 = 220 pF, etc.

h. 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.

i. Use pieces of bus wire or resistor/capacitor clippings to install two jumpers on board.

j. Wind air wound coils L8-L12 as indicated on parts list, and solder in place with bottom of coils 1/16 inch above board. In lower frequency units, where insulated magnet wire is used, wire is solder-strip type. Be sure to use proper size wire as specified. Use a 1/8 inch diameter rod, such as a drill bit, as a forming tool on which to wind coils. After winding coils and spacing turns as specified, bend remaining pigtail leads at right angles to reach holes in board. (The board is set up to accomodate the largest coils required for the lowest band for which it was designed; so for higher bands, coil windings are shorter than the space between holes.) Bend leads over against copper side of board and trim short. Then, solder with hot iron to melt insulation. If you prefer, you may scrape insulation from ends of leads before mounting coil on board.

k. Install ferrite beads Z1-Z9 by stringing on bus wire as shown.

l. Z10 and Z11 are made by threading ferrite beads with 2-1/2 turns of #26 magnet wire like a toroid. Insert wire through hole in bead, bend around once and insert through bead hole a second time. Then, bend around again and insert through hole a third time. Draw wire tight. Insert leads in board, bend over against copper land areas, trim leads, and solder with hot iron to melt insulation.

m. Install slug tuned coils as shown. Install coil shields. Make sure they are fully seated, and solder both lugs. (Do not bend lugs over.) Install slugs in coils, and center them in the coils. CAUTION: Be sure to use a proper snug fitting tuning tool. Improper or worn tools can break slugs.

n. Solder short lengths of bus wire or lead clippings in the two holes along the location for the metal shield strip. Leave about 1/8 inch of lead above the board. Position metal shield strip as shown. Tack solder it to the two wire leads and the side of L2 shield. Use solder sparingly for best appearance.

o. Slide heatsinks on power transistors Q10 and Q11 and position open segment as shown. Since they are connected to collectors, it is important to avoid shorting to adjacent parts. If heatsinks become loose from repeated handling, remove, tighten, and reinstall them.

p. Check over all components and solder connections before proceeding.

CRYSTALS.

The T51 uses 32 pF parallel resonant, .0015% tolerance, HC-25/u fundamental crystals in the 9.0-13.5 MHz range (usually around 12 MHz for the popular bands). The crystal frequency is determined by dividing the channel frequency by 3 for 10 meters, by 4 for 6 meters, by 12 for 2 meters, or by 18 for 220 MHz. Plug the appropriate crystal into the socket pins provided on the board. If an A14-T Multichannel Adapter is used, refer to instructions packed with that module.

POWER.

Operating power required is +13.6 Vdc at 500 mA. A well regulated power supply should be used. Positive and negative power leads should be connected to the Exciter board at E1 and E3.

ALIGNMENT.

Equipment needed for alignment is a vtvm, a 50 ohm 5 Watt rf dummy load, a relative output meter, and a regulated 13.6 Vdc power supply with a 0-500 mA meter internally or externally connected in the supply line.

The slug tuned coils in the Exciter should always be adjusted with the proper plastic tuning tool. A loosely fitting or rounded tool may crack the slugs. The variable capacitors should be adjusted with a small, metal blade screwdriver, or preferably an insulated tuning tool with a small metal blade. All adjustments should be set to the center of their ranges before power is applied except

R34, which should be set to full clockwise. Note that the variable capacitors have a small arrow stamped in the metal rotor plate. Mid-range occurs with the arrow pointing to one side or the other. Maximum capacitance occurs with the arrow pointing to the round end.

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 (350-450 mA total current drain). Reduce setting of power control R34 slightly if necessary to limit drive level.
3. If unit oscillates or otherwise draws excessive current for some reason and reducing drive will not reduce current, immediately turn off power source and correct problem. Evidence of oscillation would be full output without drive (crystal removed) or output changing abruptly when tuning gradually.
4. Always follow alignment procedure exactly. Do not repeak all controls for maximum output; each tuning stage has its own best monitoring test point.
5. RF power transistors Q10 and Q11 run hot at full drive, but not so hot that you can't touch the heatsinks quickly without being burned. The transistors should be cold with crystal removed from socket. Never run the unit without heatsinks in place.

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

b. Turn off power supply. Connect it to B+ pad E1 and ground pad E3 on the Exciter board. OBSERVE POLARITY. A 500 mA meter or suitable equivalent should be connected in the B+ line to monitor current drawn by the Exciter. This is important to indicate potential trouble before it can overheat power transistors.

c. Turn on power supply, and adjust for + 13.6 Vdc output. Use vtvm to check regulated voltage. You should measure +8 to +10 Vdc at the left lead of R18.

NOTE: Vtvm indications used as references are typical but may vary widely due to many factors not related to performance, such as type of meter and circuit tolerances.

d. Connect vtvm to TP1 in second multiplier stage. Peak L1 and L2 alternately for maximum indication. Typical reading is about +1 to +3 Vdc.

e. Connect vtvm to TP2. Alternately adjust L3 and L4 for maximum. Typical reading is about +0.8 to 2.0 Vdc.

f. At this point, you should have a small indication on relative output meter. Alternately peak L5, L6, L7, C47, C49, and C50 for maximum output. If relative output meter is not sensitive enough to aid in peaking L5-L7, a vtvm and rf probe connected to base of Q10 can be used for rough tuning or a nearby receiver can be used if tuned to same channel. Use output meter for final peaking of all these adjustments, except do not repeak L1-L4 unless doing so at appropriate test points.

g. At full drive, the total current drawn by the Exciter module should be 350 to 450 mA. Under no circumstances should the current be allowed to exceed 500 mA. Adjust POWER control R34 to limit drive to 2 Watts or less (not more than 450-500 mA). If desired, control can be set for any lower level. Although unit is rated at 2 Watts continuous in free air, it is wise to use no higher level than necessary to drive your PA. This is especially true if unit is to be housed in a tight enclosure and operated continuously as in repeater service. Limiting power level can provide an extra margin of reliability in such demanding applications.

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

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

MICROPHONE AND AUDIO ADJUSTMENTS.

The T50 Exciter is designed to use with a low impedance dynamic microphone (500-1000 ohms). The microphone should be connected with shielded cable to avoid pickup. Mic. connections are made to E2 and E3 on the pc board.

To adjust deviation, start by setting pots R1 to maximum and R15 to midrange. Apply B+, and speak into microphone normally. Observe deviation meter on receiver or listen to audio with receiver squelch set tight. Set peak deviation control R15 for sufficient modulation, but no so high as to cause over deviation as indicated by distortion, carrier deviation meter swing on peaks, squelch pumping, etc.

The setting of mic. gain control R1 is a refinement not found on many exciters. It allows for gain adjustment to match your particular microphone or other audio input device. It should be set to provide sufficient audio for full modulation on voice peaks but low enough to remove background noise when not speaking and low enough to prevent excessive clipping effects (distortion)which normally result from overdriving the limiter.

REPEATER AUDIO INPUT.

In repeater service or other cases where high level audio is available, the audio can be connected after the microphone amplifier by connecting at E4 and E5 (resistor leads) as shown in diagrams. Adc blocking capacitor must be provided externally in the audio line (like C6). Nominal input level is 700 mVrms. The microphone amplifier can still be used for local microphone if microphone has muting switch.

OUT OF BAND OPERATION.

If the unit is to be used on a frequency outside the normal ham band for which the unit was designed, capacitor values in tuned circuits can be changed where necessary. If a tuning slug tends to be out of the coil as a tuning peak is approached, less capacitance is required; and more capacitance is required if the slug tends to be fully engaged in the coil winding.

HIGH STABILITY OPTION.

The standard exciter is designed for stable frequency operation in a room temperature environment, and it also provides fairly good frequency stability over wider temperature ranges. To hold commercial grade tolerance of 5 ppm over a -10°C to $+60^{\circ}$ C range, use the best grade commercial crystals, such as International HA-5 type, and change C14-C17 to dipped mica capacitors.

MOUNTING.

The four mounting holes provided in the corners of the board can be used in conjunction with screws and spacers to mount the board in any cabinet or panel arrangement. See catalog for pc board mounting kits. There is no need for a shielded cabinet except in repeater or duplex service.

KEYING.

The easiest way to key the Exciter when you wish to transmit is to run the B+ for the Exciter through the microphone push-to-talk switch. Although a relay can be used, it normally is not necessary, since the 350-450 mA required by the Exciter may be switched easily by the microphone switch. If the LPA 2-15 Power Amplifier is used with the Exciter, T/R switching for the antenna is accomplished electronically at the PA. If an LPA 2-45 or other higher power amplifier is used, an external coax relay with auxillary contacts should be used to switch antenna and B+ signals.

If the T50 Exciter is to be used on CW instead of FM, the B+ to the Exciter can be broken at Z3/R34. B+ should be applied to the low level stages through Z3 continuously, and cw keyed B+ should be applied to the driver and PA stages through E1 to key the carrier on and off.

The usual troubleshooting techniques of checking dc voltages and signal tracing with an rf voltmeter probe will work well in troubleshooting the Exciter. A dc voltage chart, an rf 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 measurment conditions, the indications may be helpful when used in a logical troubleshooting procedure. The Exciter should draw about 20-40 mA at idle (with crystal pulled) and about 350-450 mA at full 2W output.

Be careful when operating or troubleshooting to avoid driving the unit to levels over 2 Watts for extended periods or operating the unit at dc current drain levels over 500 mA. Also be careful to avoid continuous operation if an oscillation drives the unit to full output with the crystal pulled out. Keep an eye on an ammeter in the B+ line while tuning. Don't ever allow the unit to draw over 500 mA. Although it may be possible to obtain more than 2 Watts output, doing so may overheat the driver or PA transistors. Allowing these transistors to overheat may cause a thermal runaway condition, something which will not occur in normal operation. An unchecked thermal runaway can destroy a transistor. The symptom is a sudden drop in output power.

The most common troubles in all kits, based on our experience, are interchanged components (so you don't notice while building), cold solder joints, and solder splashes. Another common trouble is blown transistors due to reverse polarity or power line transients. It is a good practice to use a fuse and a reverse diode at the input of any homebrew gear. This practice can save much work and expense after an inadvertent mistake later on. Any relay coils on the B+ line should also have a reverse diode connected right across the coil to absorb the reverse transients which relays produce. Remember if you encounter problems during initial testing that it is easy to install parts in the wrong place. Don't take anything for granted. Double check everything in the event of trouble.

If all else fails, factory service is available at modest cost. Consult us first to obtain cost information before shipping unit back to the factory. Because we cannot do much that you can't, and because much of what we can do is checking everything described above, troubleshooting is time consuming no matter who does it. You can save the expense of factory service by your own diligent effort and that of friends. We are always available by phone to give technical advice - but please don't expect miracles.

TYPICAL DC VOLTAGES.

The following dc levels were measured with an 11 megohm fet vm on a sample Exciter 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 Exciter fully tuned to provide 2W output.

STAGE	E	B	C
Q1	0.85	1.5	4.5
Q2	0.04	0.6	1.5
CR1, CR2	A 1.8	C 1.4	-
Q3	4.2	4.8	9.1
Q4	4.3 (2.9)	2.8 (3.6)	8.3
Q5	3.1 (2.6)	3.4	6.2
Q6	1.4 (1.0)	1.7 (1.8)	13.6
Q7	2.2 (0)	0	13.6
Q8	1.3 (0)	0	13.6
Q9	0	-0.7 (0)	13.6
Q10	0	0	13.6
Q11	0	0	13.6

( ) = crystal pulled, no rf.

TYPICAL RF VOLTAGES.

The following measurments are rough checks of typical rf voltages (rms) at various points. These levels may be helpful to you. Although most hams do not have accurate rf voltmeters; a simple device, such as our model TE-3 RF Probe, may be used with a vtvm for signal tracing to find the point at which the signal may be blocked. These measurements were made with a Boonton model 92C RF Voltmeter without retuning. Regardless of what instrument is used, high impedances at some points result in sufficient loading so that the rf level is reduced when the probe is connected, or at least, probe loading results in inaccurate voltage measurements. Nevertheless, indications may be helpful in troubleshooting. (Voltages over 3 Vrms are beyond the range of the 92C.)

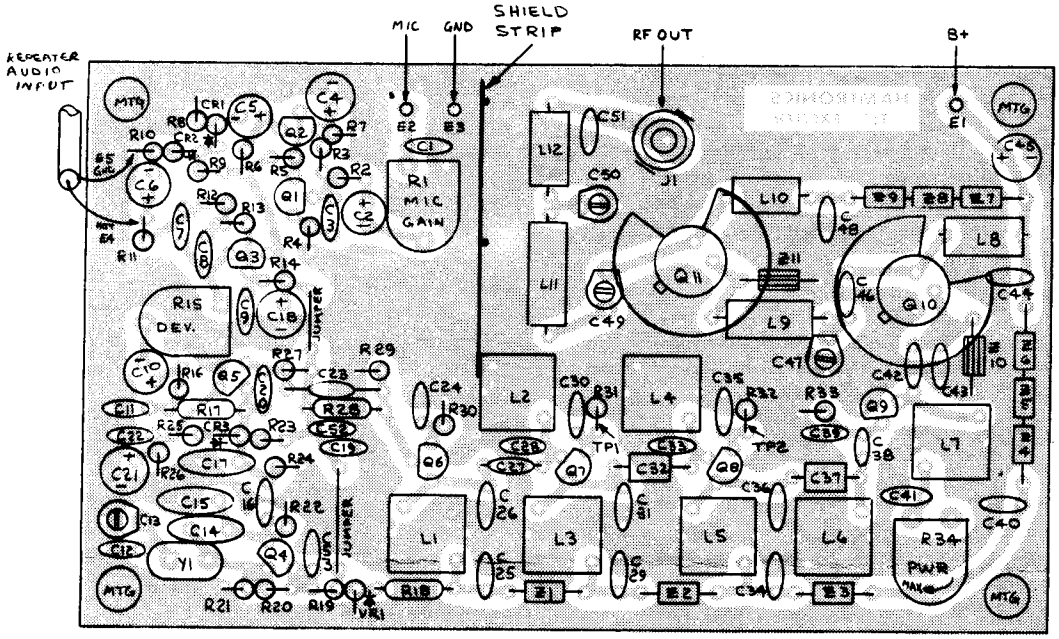
STAGE	E	B	C
Q4	2	4	0
Q5	0	1	1
Q6	0	1	over 3
Q7	0	3	over 3
Q8	0	2	2.5
Q9	0	2	3
Q10	0	1.5	over 3
Q11	0	3	over 3

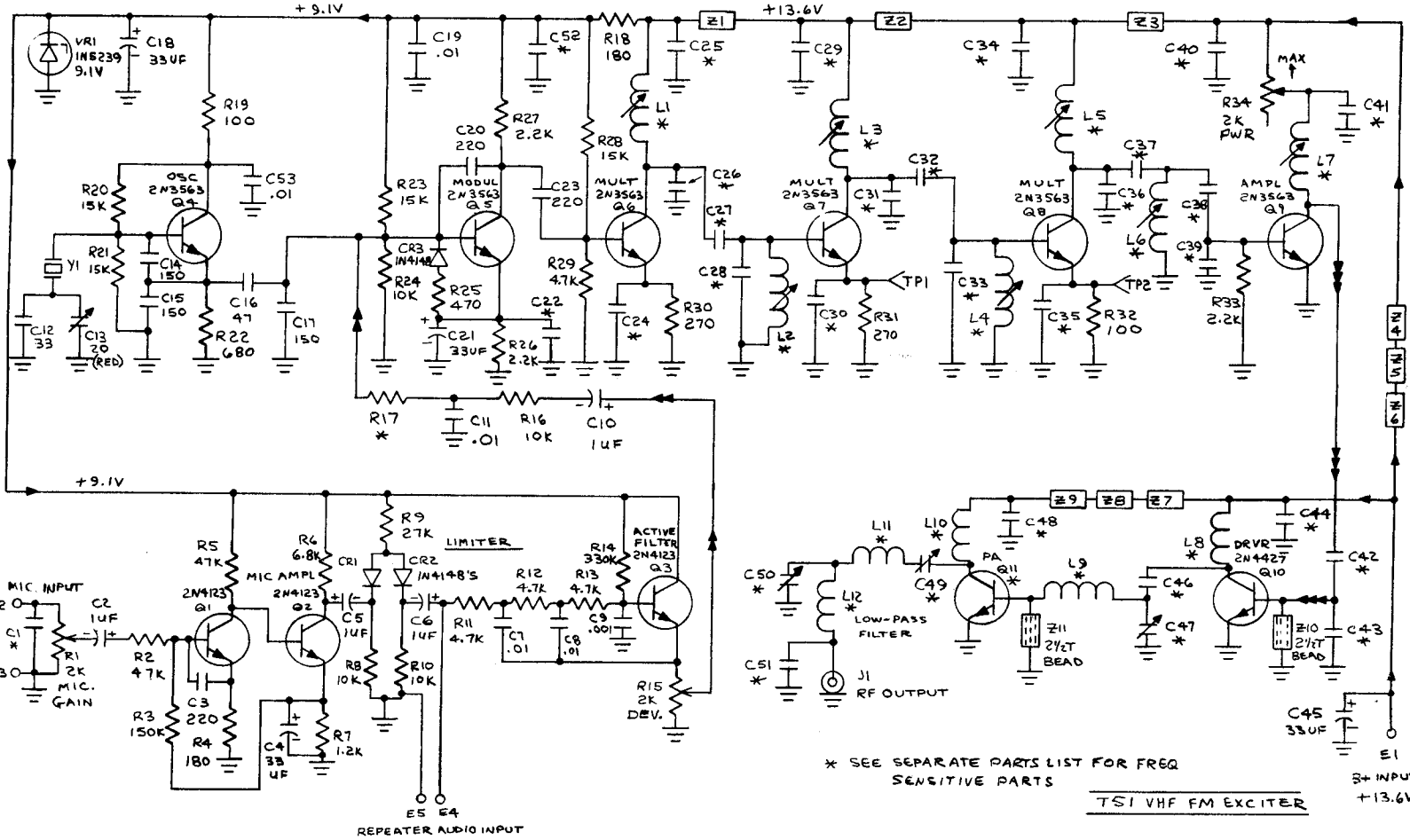
TYPICAL AUDIO VOLTAGES.

Following are rough measurements of audio voltages (rms)which may be measured with a sensitive vtvm or an oscilloscope when a low impedance dynamic microphone is connected. Measurments given were taken with Tektronix T922 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 none-the-less, indications may be useful for troubleshooting.

STAGE	E	B	C
Q1	0.5	1	10
Q2	0	10	700
Q3	500	500	-
Q4	-	30	-

Mic Input	1
Repeater Input	700


MIC
GND
SHIELD STRIP
RF OUT
B+
REPEATER AUDIO INPUT
R1 MIC GAIN
R15 DEV.
R34 PWR
L1
L2
L3
L4
L5
L6
L7
L8
L9
L10
L11
L12
Q1
Q2
Q3
Q4
Q5
Q6
Q7
Q8
Q9
Q10
Q11
Y1
J1
TP1
TP2
JUMPER


+9.1V
+13.6V
VR1 IN5239 9.1V
C18 33UF
R19 100
OSC 2N3563 Q4
MODUL 2N3563 Q5
MULT 2N3563 Q6
MULT 2N3563 Q7
MULT 2N3563 Q8
AMPL 2N3563 Q9
R34 2K PWR
MAX
L1
L3
L5
L7
TP1
TP2
R17
C11 .01
R16 10K
C10 1UF
MIC INPUT
MIC AMPL 2N4123 Q1
2N4123 Q2
LIMITER
CR1
CR2 IN4148'S
ACTIVE FILTER 2N4123 Q3
R1 2K MIC. GAIN
R15 2K DEV.
LOW-PASS FILTER
PA Q11
DRVR 2N4427 Q10
RF OUTPUT
E5 E4
REPEATER AUDIO INPUT
E1
B+ INPUT +13.6V
* SEE SEPARATE PARTS LIST FOR FREQ SENSITIVE PARTS
TSI VHF FM EXCITER

FREQUENCY SENSITIVE PARTS
T51-144 VHF FM EXCITER

Ref Desig	Value (Marking)
C1	220 pF (221)
C22	220 pF (221)
C24	.01 uF (103)
C25	.01 uF (103)
C26	62 pF
C27	1 pF
C28	62 pF
C29	.001 uF (102)
C30	.001 uF (102)
C31	20 pF
C32	0.5 pF disc
C33	18 pF
C34	220 pF (221)
C35	220 pF (221)
C36	8.2 pF or 8 pF
C37	0.5 pF disc
C38	10 pF
C39	62 pF
C40	220 pF (221)

Ref Desig	Value (Marking)
C41	220 pF (221)
C42	12 pF
C43	62 pF
C44	220 pF (221)
C46	5 pF
C47	20 pF variable (red)
C48	220 pF (221)
C49	20 pF variable (red)
C50	20 pF variable (red)
C51	20 pF
C52	220 pF (221)
Q11	SD-1115-7 or SD-1134-1
R17	10K
L1, L2	10-1/2 turns widespaced (blk)
L3, L4	7-1/2 turns widespaced (vio)
L5, L6	4-1/2 turns widespaced (yel)
L7	3-1/2 turns widespaced (orn)
L8, L9, L10	5 turns #22 magnet wire close spaced
L11	12 turns #22 magnet wire close spaced
L12	8 turns #22 magnet wire close spaced

NOTE: Add the following steps to alignment procedure for simplest procedure.

1. Set power control R34 to mid-range instead of full output before starting.

2. After step e, connect vtvm with normal resistor in probe (not VOM) to base of Q9. Adjust L5 and L6 alternately for maximum negative indication. Do not readjust L5-L6 as stated in step f.

3. Modify step g to this extent: For optimum efficiency, set R34 to desired level and repeak variable capacitors in driver and PA stage alternately until proper output level is reached at minimum gain control setting. At two meters, two watts output normally is obtained at less than 375 mA total current drain; so it is recommended that this level not be exceeded. If your power meter is not calibrated well, you can set power control R34 to 375 mA exciter current.

NOTE: Please correct error on schematic diagram. Polarity of C10 is incorrect. It should be as shown on parts location diagram.

Note the following two styles of 2N3563 transistors may be used interchangeably. The style with leads already molded in a triangular pattern matches the triangular layout of the boards; so disregard the shape of the case.