HAMTRONICS® TA51 VHF FM TRANSMITTER INSTALLATION, OPERATION, AND MAINTENANCE INSTRUCTIONS

GENERAL INFORMATION.

The TA51 is a single-channel vhf fm transmitter designed to provide 2 Watts continuous duty output into a 50 ohm antenna system in the 28, 50, 144, or 220 MHz ham bands, the 72 MHz ISM band, or the 148-175 MHz commercial 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 400-500 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 TA51 uses 32 pF parallel resonant crystals in HC-25/u holders. Crystals operate in the fundamental mode at a frequency of F/12 for the 144 MHz ham band or the adjacent commercial band, F/18 for the 220 MHz ham band, F/6 for the 72 MHz band, F/4 for the 50 MHz ham band, or F/3 for the 28 MHz ham band, which normally results in a crystal frequency in the 9-13 MHz area. 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 TA51 Transmitter operates on +13.6Vdc at about 400-500 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 via E4 from a supply line 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 TA51 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 R20 to maximum and R3 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 R20 for a peak deviation of 5 kHz. Then, adjust mic gain control R3 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.

Note that when the transmitter is used in repeater service, deviation control R20 should be set fully clockwise and only mic gain control R3 should be used to set the repeat level. The receiver audio level is already limited by the filters in the receiver.

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 near 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 400-500 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 TA51 transmitter is driving it with rf power; so the pa should not require a separate keyline circuit.

THEORY OF OPERATION.

The TA51 is a fairly straight forward fm transmitter, with a phase modulated 12 MHz signal multiplied up to reach the desired output range. Crystal oscillator Q1 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 Q2, which phase modulates the carrier with audio from the speech processor circuits.

For the 144 MHz ham band or the high commercial band, Q3 operates as a tripler to multiply the carrier frequency to a range of about 36 MHz. Q4 doubles this to a range of about 72 MHz. This, in turn, is doubled again in Q5 to range of about 144 MHz and doubled again in Q9 to the final output frequency. Q6 acts as a predriver amplifier, with potentiometer R38 varying the voltage to the collector to adjust the drive level to the output stages. The signal is further amplified by driver Q7 and pa Q8 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 two low pass filters in the output of the pa stage.

For the other bands, the various stages multiply the oscillator signal to the following approximate frequencies.

Band	Q1 Osc	Q3	Q4	Q5
28	9.5 MHz	x3 to 28	-	-
50	13 MHz	x2 to 26	x2 to 52	-
72	12 MHz	x3 to 36	x2 to 72	-
144	12 MHz	x3 to 36	x2 to 72	x2 to 144
220	13 MHz	x3 to 36	x3 to 110	x2 to 220

The audio processor circuits consist of microphone amplifier U1-A and U1-B, peak limiter CR1-CR2, amplifier

HAMTRONICS® TA51 VHF 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 IC socket with notch at end indicated for pins 1 and 14. Then plug in IC U1, being careful not to bend over any of the pins.

d. Install transistors Q1-Q8 as low as possible for short leads.

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

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

g. Install electrolytic capacitors, observing polarity.

h. Install ceramic capacitors. It may be necessary to form capacitor leads to fit holes in board. Keep leads as short as possible. Note that values over 100 pf are marked with two significant figures and a multiplier, much as resistors are marked but with numbers. The parts list gives the markings on such parts.

i. 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. For resistors used as test points (TP1-TP4), form as shown in the detail drawing at the top of the component location diagram to leave a small test point loop for connection of a meter probe. Be careful not to mix resistors which look similar, i.e., 150K and 510K.

j. Install rf chokes, spacing them slightly above the ground plane as shown in the detail.

k. Ferrite beads L15-L20 are supplied with wire leads already attached. Install them as shown.

l. 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.)

m. Remove the slugs from coils L10, L12, L13, and L14, and save them for spares. The coils of the driver and pa stages are not tuned with slugs because of the higher power levels. The slugs have a square slot. Refer to the note about tuning tools in the Alignment instructions on page 2 of the "Installation, Operation, and Maintenance" Manual.

n. Install transformer L1, soldering all leads and lugs.

o. Slide heatsinks on power transistors Q7 and Q8, and position to avoid shorting to adjacent parts. Since the cases of the transistors are at collector potential, be sure that the heatsink doesn't touch any adjacent parts.

p. Check over all components and solder connections before proceeding to alignment procedures.

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U1-D, and active filter U1-C. The audio input, at a level of about 30 mV p-p, is amplified and applied to the limiter circuit. R3 provides adjustment of the audio gain of the first op-amp. Processed audio, limited in peak amplitude, contains a small amount of harmonic distortion from the clipping process. Active filter U1-C 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 R20 allows for adjustment of the peak audio level applied to modulator Q2. C11/R23 is an rf filter to keep the 12 MHz carrier signal from getting back into the active filter stage. R21/C10/R22/C11 acts as an additional low pass filter. Together with the active filter stage, it provides a 12 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 R45 is regulated by zener diode VR1 and filtered by C60 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) and transformer L1 (model A1, $1.00) 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 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 R38 should be set fully clockwise.

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 (500 mA total current drain) for continuous duty operation. Do not exceed 2.5 Watts output (600 mA total current drain) for even momentary operation. Reduce setting of power control potentiometer R38 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 Q7 and Q8 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 t 13.6 Vdc, and connect it to B+ terminal E1 and groun terminal E3 on the pc board. It is permissible to use th braid of the coax cable or the mounting hardware to th chassis as a ground if the power supply has a goo low-impedance connection through this path to the groun on the board. **BE SURE TO OBSERVE POLARITY!** A 1000 m meter or suitable equivalent should be connected in the B line to monitor current drawn by the transmitter. This i important to indicate potential trouble before it ca overheat transistors. Better yet, if using a lab suppl for testing, set the current limiter on the power suppl to limit at 600 mA.

Note: Meter indications used as references are typica but may vary widely due to many factors not related t performance, such as type of meter and circuit tolerances Typical test point indications are for the 144 MHz or hig band unit and may differ for other bands. Fewe multiplier stages are used for units in the ranges belo 140 MHz. Consult parts list page for such models fo steps to be omitted during tune up, if any.

c. Connect vtvm to TP1 (top lead of R33). Peak L1 carefully for maximum indication. Note that reading will var only a small amount due to dc bias on the stage. Try t find exact peak, but L1 can be fine-tuned slightly later for best sounding audio. Typical reading is about +1.8 V.

d. Connect vtvm to TP2 (top lead of R35). Peak L2 an L3 alternately for maximum indication. Typical reading i about +1 to 1.5 Vdc.

e. Connect vtvm to TP3 (top lead of R37). Peak L4 and L alternately for maximum indication. Typical reading i about +0.3 to 0.8 Vdc.

f. Connect vtvm to TP4 (top lead of R40). Peak L6 and L alternately for maximum indication. Typical reading i about +0.07 to 0.11 Vdc.

g. At this point, you should have a small indication on the relative power meter. Alternately peak L8, C51, C53, and C56 for maximum indication on the power meter. Note that there are interactions between these adjustments, especially between tune capacitor C53 and loading capacitor C56; so it may be necessary to try several combinations to find the optimum settings.

h. At full drive, the total current drawn by the transmitter should be 400-500 mA, and the rf output should be about 2 Watts. Do not operate at a level above 500 mA on a continuous basis, but up to 550 mA is ok on a 25% duty cycle. Although it may be possible to drive some units up to 3 Watts or greater, to prevent overheating, do not exceed 2-1/2 Watts output or 600 mA current drain for even momentary operation. The drive level is adjusted with power control R38. If desired, it may be set to a lower level. Note that the driver and output stage variable capacitor settings depend on drive level. For each power level setting, there is an ideal combination of settings for the driver stage tuning capacitor and the output stage tune and load capacitors. For optimum efficiency, these capacitors should be repeaked anytime the power control setting is changed significantly. Adjusting these capacitors for best efficiency also optimizes the transmitter for best spurious reduction; so you get a double bonus for careful tuning.

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.

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.

i. Perform the carrier frequency and audio level adjustments given on page 1 to complete the alignment of the transmitter. Note that a small readjustment of L1 may enhance the level and quality of the modulation; so you may wish to try readjusting L1 about 1/4 turn in either direction before final adjustment of audio levels with R3 and R20.

TROUBLESHOOTING.

The usual troubleshooting techniques of checking dc voltages and signal tracing with an rf voltmeter probe will work well in troubleshooting the TA51. 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 30-50 mA at idle, with the crystal pulled out, and about 400-500 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 500 mA for extended periods. Keep an eye on an ammeter in the B+ line while tuning. Do not exceed 2-1/2 Watts output (550 mA total current drain) for even momentary operation. Reduce setting of power control potentiometer R38 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.

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	4.7	4.0	8.5
Q2	2.3	3.0	9.1
Q3	1.7	2.3	13.6
Q4	1.2	-0.35	13.6
Q5	0.5	-1.4	13.6
Q6	0.09	-0.5	variable
Q7	0	-0.14	13.6
Q8	0	(can't measure)	13.6

U1	1,2,3	4,5	6	7	8
	0.55	4.6	0.55	0	0.55
	9	10	11, 12, 13		14
	4.8	4.6	0.55		9.1

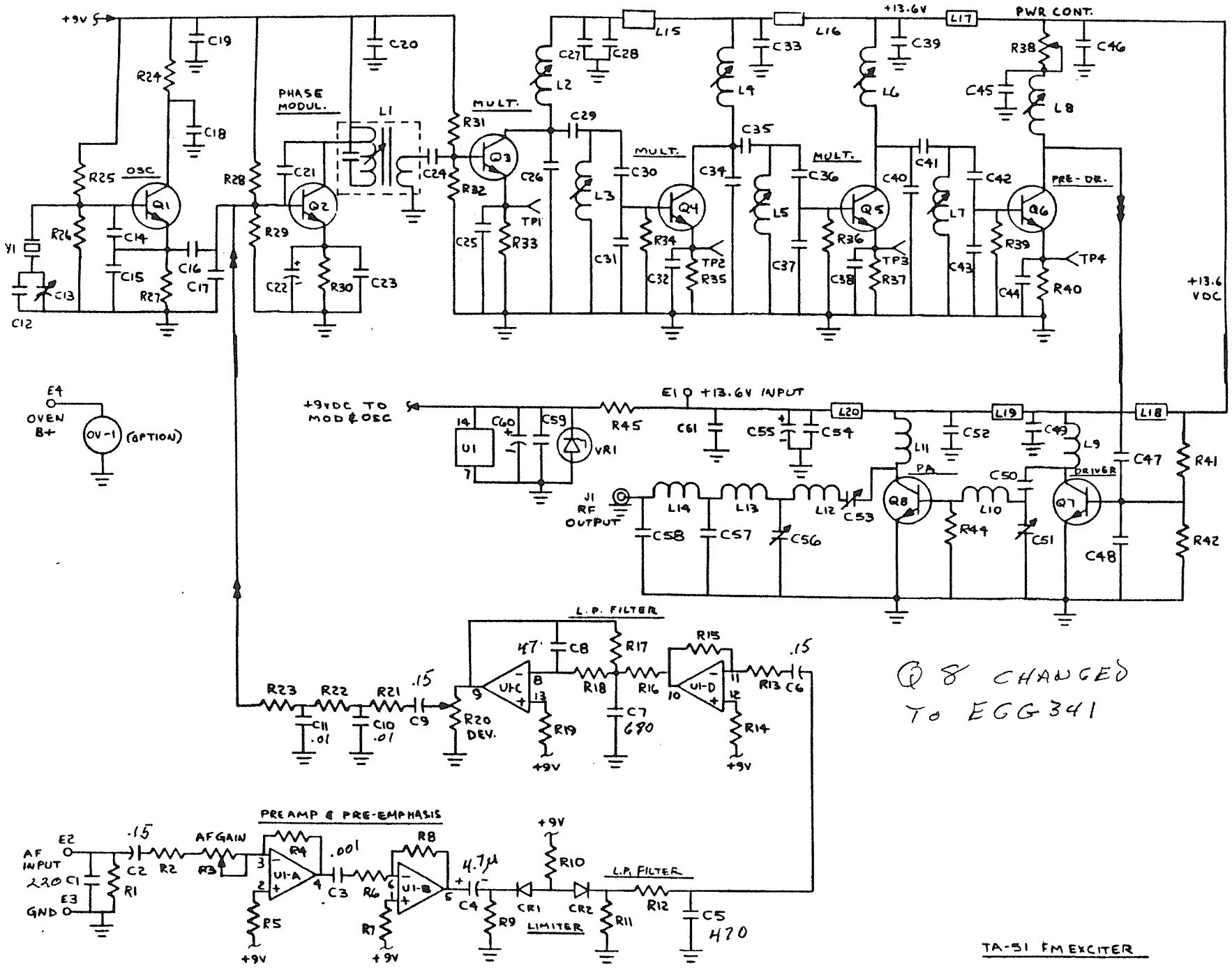
TYPICAL AUDIO VOLTAGES.

Following are rough measurements of audio voltages (in mV p-p) 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. Note: if rf affects oscilloscope pattern, unplug crystal.

Test Point	mV p-p
E2 AF input	10
U1-4	50
U1-5	400
CR2 cathode at R12 top	400
U1-10	700
U1-9	1000
Top of R23	220

PARTS LIST, TA51-144 FM EXCITER FOR 140-150 MHz.
(Capacitor values for 150-174 MHz may be slightly lower)

Ref Desig	Value (marking)
C1	220 pf (marked 221)
C2	.15 uf monolithic ceramic (red)
C3	.001 uf (102)
C4	4.7 uf electrolytic
C5	470 pf (471)
C6	.15 uf monolithic ceramic (red)
C7	680 pf (681)
C8	47 pf
C9	.15 uf monolithic ceramic (red)
C10-C11	.01 uf (103)
C12	39 pf
C13	10 pf white variable cap
C14-C15	150 pf (151)
C16	47 pf
C17	150 pf (151)
C18-C20	.01 uf (103)
C21	220 pf (221)
C22	47 uf electrolytic
C23	.01 uf (103)
C24	.001 uf (102)
C25	.01 uf (103)
C26	110 pf (111)
C27	220 pf (221)
C28	.01 uf (103)
C29	1 pf
C30	Jumper with short length of #22 bus wire trimmed from some component
C31	110 pf (111)
C32-C33	680 pf (681)
C34	27 pf
C35	0.5 pf
C36	39 pf
C37	62 pf
C38-C39	220 pf (221)
C40	18 pf
C41	0.5 pf
C42	27 pf
C43	39 pf
C44-C45	220 pf (221)
C46	.001 uf (102)
C47	18 pf
C48	39 pf
C49	220 pf (221)
C50	20 pf
C51	20 pf red variable cap
C52	220 pf (221)
C53	30 pf green variable cap
C54	220 pf (221)
C55	47 uf electrolytic
C56	30 pf green variable cap
C57	62 pf
C58	47 pf
C59	220 pf (221)
C60	47 uf electrolytic
C61	220 pf (221)
CR1-CR2	1N4148 (may be unmarked)
J1	RCA Jack
L1	12 MHz Transformer KAC-6184
L2-L5	6-1/2 turns (blue)
L6-L8	2-1/2 turns (red)
L9	0.33 uH choke (red-sil-orn-orn)
L10	2-1/2 turns (red), no slug
L11	0.33 uH choke (red-sil-orn-orn)
L12-L14	2-1/2 turns (red), no slug
L15-L20	Ferrite bead, pre-strung on wire
Q1-Q6	2N5770/8524
Q7	2N4427
Q8	SD1115-7
R1	2.2K
R2	47K
R3	1 meg pot (105)
R4	1 meg
R5	2 meg
R6	47K
R7	2 meg
R8	1 meg
R9	1.2K
R10	10K
R11	1.2K
R12	100K
R13	150K
R14	1 meg
R15	510K
R16	330K
R17	510K
R18	150K
R19	680K
R20	5 K pot (502)
R21-R23	15K
R24	100 ohms
R25-R26	15K
R27	680 ohms
R28	68K
R29	47K
R30	1.2K
R31	15K
R32	4.7K
R33	270 ohms
R34	not used
R35	270 ohms
R36	3.3K
R37	47 ohms
R38	2K pot (23d or 202)
R39	1.2K
R40	10 ohms
R41	2.2K
R42	27 ohms
R43	not used
R44	27 ohms
R45	180 ohms
U1	3301 (can sub 3401 or 3900)
VR1	1N5239B



Q8 CHANGED TO EGG341

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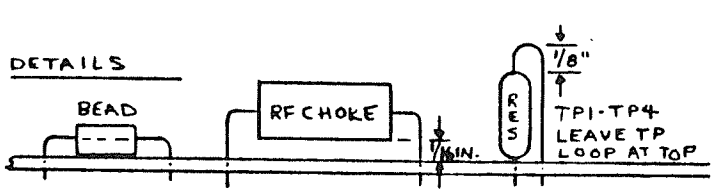

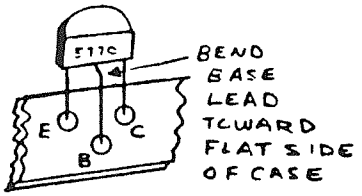

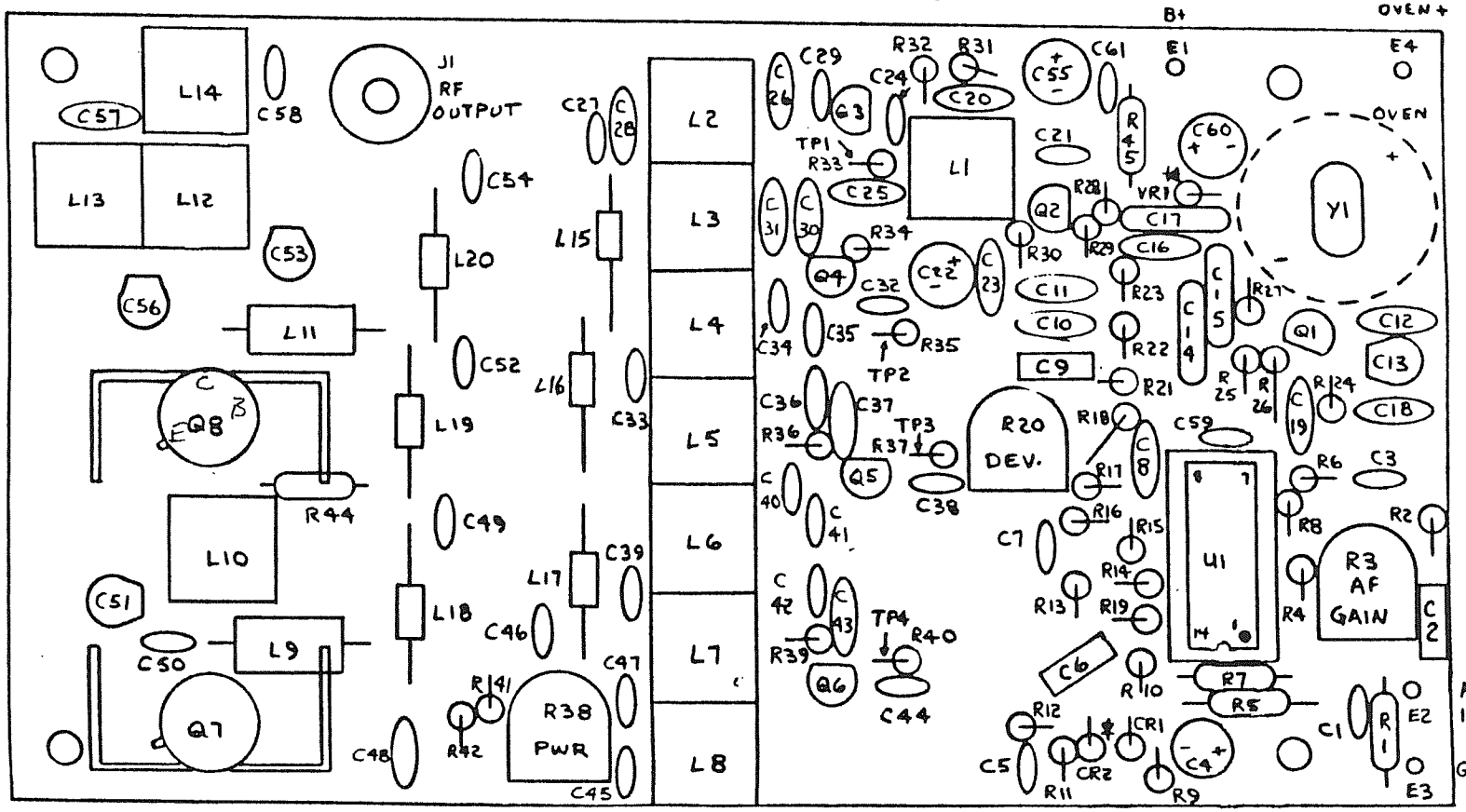

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