

# HAMTRONICS® TA451 UHF FM TRANSMITTER INSTALLATION, OPERATION, & MAINTENANCE

## GENERAL INFORMATION.

The TA451 is a single-channel uhf fm transmitter designed to provide 2 to 2½ Watts output (continuous duty) 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 600-650 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. The crystal is inserted into sockets on the board. The oven is installed on the board over the crystal, observing polarity by matching the 3-lead pattern to the holes in the board (see component location diagram). Then, the pins of the oven are soldered to the board.

## POWER.

The TA451 Transmitter operates on +13.6Vdc at about 600-650 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.

## 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 600-650 mA required by the transmitter may easily be switched by 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.

## AUDIO CONNECTIONS.

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 pads E2 and E3 on the pc board. *Be sure to dress the audio cable away from the piston trimmer capacitor; since close proximity could affect channel frequency.*

## AUDIO DEVIATION ADJUSTMENTS.

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 transmit-

ter. If the unit is setup with tones from a service monitor, use a tone frequency of 1000 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.

*Note that when the exciter is used in repeater service, instructions in the manuals for the COR and Autopatch modules should be used to set the exciter audio controls, since each repeater system requires a specific audio adjustment method.*

## FREQUENCY ADJUSTMENT.

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

*Note that the tuning range of piston capacitor C13 was deliberately limited to provide optimum frequency stability. With some crystals, the frequency may not be adjustable high enough. If this is the case, clip the jumper to disconnect C59 from the circuit, which raises the frequency range of the variable capacitor.*

## SUBAUDIBLE TONES.

If you want to transmit a CTCSS (subaudible) tone, you can connect the output of the tone encoder to the modulator, bypassing the speech processing circuits. The best way to do it is by connecting to the junction of C10 and C11, and the easiest way to make the connection is at the right hand leg of C11. A 47K resistor should be connected in series with the subaudible tone audio to avoid loading down the regular voice audio. Tone encoders normally have an output pot to adjust the deviation of the subaudible tone separate from the

voice level. (Our TD-3 and TD-5 Tone Decoder/Encoder modules already have a resistor on board; so it does not require an extra resistor, but you may need to change the value of the resistor to make it 47K for this exciter.)

The level of the subaudible tone should be set no higher than about 300 Hz deviation for best results. Otherwise, a buzz may be heard on the audio at the receiver. Since the deviation from a phase modulator is proportional to the modulating frequency, the low frequency of the tone makes it difficult to get large deviation levels without distortion. Since most decoders only need about 50 Hz deviation to detect, this should not be a problem.

## 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 degrees 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.

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 am-

plitude, 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 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 required 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 sensitive dc voltmeter, a good 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.

All variable capacitors should be set to the center of their range (turn them 90 degrees) if they have not previously been aligned.

*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 2½ Watts output (650 mA total current drain) for continuous duty operation. Reduce the drive by detuning C51 slightly if necessary.

3. Always follow alignment procedure exactly. Do not repeak multiplier coils for maximum output. Each multiplier stage has its own best moni-

toring test point.

4. Rf power transistors Q11 and Q12 run quite warm at full drive, but not so hot that you can't touch the transistors without being burned. The transistors should be cold with crystal removed from socket.

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 700 mA.

c. Connect voltmeter 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 2.5Vdc.

d. Connect voltmeter to TP2 (top lead of R32) in doubler stage Q8. Peak L3 and L4 alternately for maximum indication. Typical reading is about +1.0 to 2.5 Vdc.

e. Connect voltmeter to TP3 (top lead of R34) in second doubler stage Q9. Peak L5 and L6 alternately for maximum indication. Typical reading is about +0.7 to 1.5 Vdc.

f. Alternately peak C43, C48, C51, and C52, in that order, for maximum current on the ammeter. (This assumes the unit has not been tuned before and that no useable rf output indication is available. If the unit has been tuned before, peak these controls for maximum rf output instead.)

g. At this point, you should have a small indication on the relative power meter. Alternately peak C56 and C57 for maximum indication on the power meter. Then, repeak C43, C48, C51, and C52 for maximum output. Note that there are interactions between C51 and C52 and between C56 and C57; so it may be necessary to try several combinations of each to find the optimum settings.

h. At full drive, the total current drawn by the transmitter should be 600-650 mA, and the rf output should be about 2¼ to 2¾ Watts (a little less at frequencies above 450 MHz or after the unit has been on some time and heated up considerably).

Do not operate at a level above 650 mA on a continuous basis, but up to 700 mA is OK on a 25% duty cycle. The drive level may be adjusted by detuning C51 slightly from its peak.

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 40 mA at idle, with the crystal pulled out, and about 600-650 mA at full output.

## 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.

### TYPICAL DC VOLTAGES:

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	3 [2]	2 [2.8]	8.2
Q5	3 [2.8]	3.5 [3.5]	5.8
Q6	1.8 [1.5]	2.1 [2]	13.6
Q7	2.0 [0]	0	13.6
Q8	2.0 [0]	0	13.6
Q9	1.0 [0]	-0.3 [0]	13.6
Q10	0	0.25 [.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 voltmeter 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 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.

### TYPICAL AUDIO VOLTAGES (mV RMS):

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

## PARTS LIST, TA451 UHF FM TRANSMITTER

Note: ❶ indicates surface mount part under board.

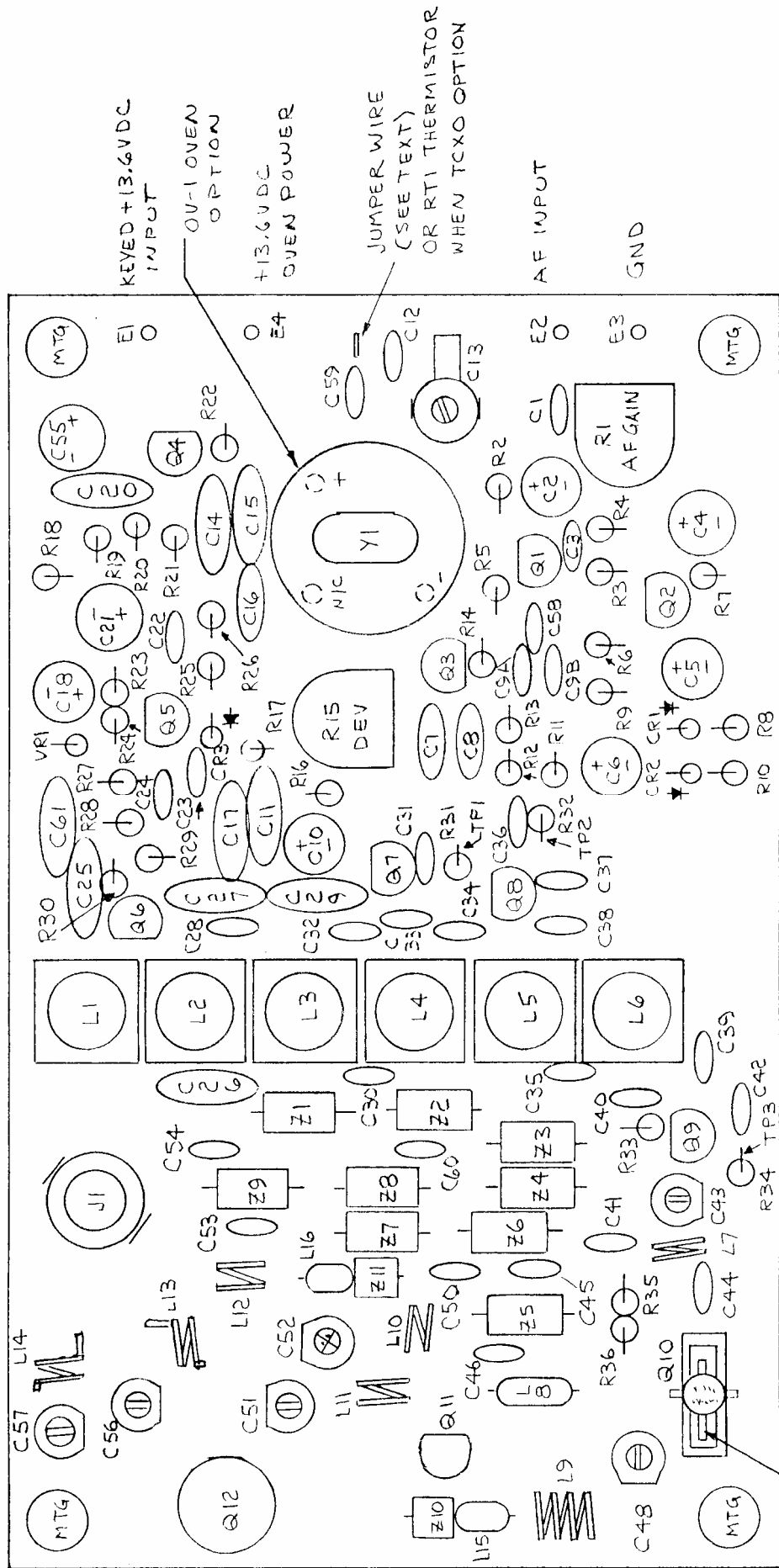
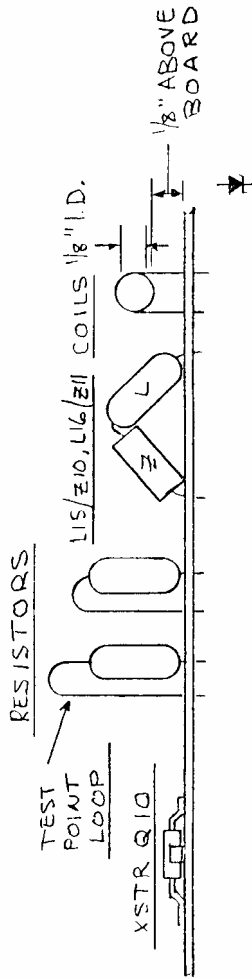
❷ Due to parts shortage, it is necessary to use two 6.8k resistors in series; join them at the top and tack solder leads together.

❸ Note: 0.5pf disc cap is no longer available. Carefully tack solder surface mount capacitor on bottom of board. Hold it carefully with tweezers to avoid dropping it.

Ref #	Value (marking)
C1	30pf
C2	1 uf electrolytic
C3	220 pF(221)
C4	10 uF electrolytic
C5	1 uf electrolytic
C6	1 uf electrolytic
C7-C8	.0047 uf (472)
C9A	.0022 uf (2.2nK or 2n2K)
C9B	not used
C10	1 uf electrolytic
C11	.01 uf disc (103)
C12	39 pf
C13	10 pf piston var cap
C14-C15	150 pf (151)
C16	47 pf
C17	150pf (151)
C18	4.7 uF electrolytic
C19	not used
C20	.01 uf disc (103)
C21	10 uF electrolytic
C22	.001 uf (102, 1nM, or 1nK)
C23	220 pf (221)
C24-C25	.001 uf (102, 1nM, or 1nK)
C26	.0022 uf (2.2nK or 2n2K)
C27	110 pf (111)
C28	2 pf
C29	110 pf (111)
C30	.001 uf (102, 1nM, or 1nK)
C31	100 pf
C32	30 pf
C33❸	0.5 pf chip cap
C34	30 pf
C35-C36	100 pf
C37	4 pf
C38❸	0.5 pf chip cap
C39	7 pf
C40	18 pf
C41	30 pf
C42	100 pf
C43	4.5 pf var. (white ceramic with brown cap.)
C44	2 pf
C45	100 pf

C46	30 pf
C47	not used
C48	4.5 pf var. (white ceramic with brown cap.)
C49	not used
C50	30 pf
C51	4.5 pf var. (white ceramic with brown cap.)
C52	7 pf var. (blue plastic)
C53-C54	30 pf
C55	10 uF electrolytic
C56-C57	7 pf var. (blue plastic)
C58	30 pf
C59	not used
C60	.001 uf (102, 1nM, or 1nK)
C61	.01 uf disc (103)
CR1-CR3	1N4148
J1	RCA Jack
L1-L2	6-1/2 turns (blue)
L3-L6	2-1/2 turns (red)
L7	Air wound (see text)
L8	0.33 uH rf choke (red-sil-orn-orn)
L9-L14	Air wound (see text)
L15, L16	0.33 uH rf choke (red-sil-orn-orn)
Q1-Q3	2N3904
Q4-Q8	2N5770
Q9	PN5179
Q10	MRF-2369 (21937)
Q11	Motorola MPS3866
Q12	APT MS1649 (or Philips BFQ-43S)
R1	1K pot (102)
R2	100k
R3	150k
R4	180 ohms
R5	47k
R6	8.2k
R7	1k
R8	4.7k
R9	47k
R10	4.7k
R11-R13❶	10k
R14	330k
R15	1k pot (102)
R16-R17❶	10k
R18	180 ohms
R19	100 ohms
R20❶	10k
R21	4.7k
R22	680 ohms
R23❷	15k (see note)
R24❶	10k
R25	470 ohms
R26-R27	2.2k
R28	27k
R29	4.7k
R30-R32	270 ohms
R33	1k
R34	100 ohms
R35	22k

R36	1k
RT1	Thermistor (tcxo option only; otherwise jumper)
VR1	1N5239B Zener Diode 9.1V
Y1	Channel crystal (see text)
Z1-Z11	Ferrite Beads



TA451 REV.10/89 UHF EXCITER

