HAMTRONICS® T302 VHF FM EXCITER: INSTALLATION, OPERATION, & MAINTENANCE

GENERAL INFORMATION.

The T302 is a single-channel vhf fm exciter designed to provide 2 to 3½ Watts continuous duty output into a 50 ohm antenna system in the 144 MHz ham band or 148-174 MHz commercial band. Another model covers the 216-226MHz band or the 220-230MHz band. Operating power is +13.6 Vdc ±10% at 450-600 mA. There are several models, which have minor variations in parts and microcontroller programming, to provide coverage as shown in table 1.

A temperature controlled xtal oscillator (TCXO) provides a temperature stability of ±2ppm over a temperature range of -30°C to +60°C.

The Exciters are designed for narrow-band fm with ±5 kHz deviation or less. The audio input will accept a standard low-impedance dynamic microphone or any low-impedance audio source capable of providing 40mV p-p minimum into a 1K load.

INSTALLATION.

Mounting.

The four mounting holes provided near the corners of the board can be used with standoffs to mount the board in any cabinet arrangement. There is no need for a shielded cabinet except if the exciter is used in a repeater or in duplex service; however, do shield the exciter from any power amplifier.

Electrical Connections.

Power and input audio or data signals should be connected to the solder pads on the **BOTTOM** of the board with #22 solid hookup wire. Be very careful not to route the wiring under the board. Also avoid routing wiring along the rf amplifier circuits to avoid rf pickup in the wiring. Keep all wiring at the left and bottom sides of the board.

Power.

The T302 Exciter operates on +13.6 Vdc at about 450-600 mA. A well regulated power supply should be used. Positive and negative power leads should be connected to the exciter at E1 and E3. Be sure to observe polarity, since damage to the transistors will occur if polarity is reversed.

When you key the exciter, it takes about 500 milliseconds for the synthesizer to come on. This delay normally is not a problem. However, if you have an application which requires the rf output to be available instantly, you can apply power to the synthesizer all the time and only key the power to the amplifier stages.

Repeaters are one application where you might notice the delay; however, if you use a normal tail time setting on the repeater, the carrier will stay on all the time during a qso and only go off when everyone is finished using the repeater.

Normally, E1 and E4 are jumpered together by a trace on the bottom of the pc board. If you want to use E4 independently, use a tool to make a cut through that trace. Then, connect E4 to constant +13.6Vdc and connect E1 to the keying switch, e.g., the keyed B+ output of a repeater controller. Make sure that the keying circuit you use is capable of supplying up to 600 mA needed for E1. Current drain to power the synthesizer circuits separately at E4 is only about 30 mA.

Antenna Connections.

The antenna connection should be made to the pc board with an RCA plug of the low-loss type made for rf. We sell good RCA plugs with cable clamp. See A5 plug on website.

If you want to extend the antenna connection to a panel connector, we recommend using a short length of RG-174/u coax with the plug and keep the pigtails very short.

We do **not** recommend trying to use direct coax soldered to board or another type of connector. The method designed into the board results in lowest loss. When soldering the cable, keep the stripped pigtails as short as possible.

Audio Connections.

The T302 Exciter is designed for use with a low impedance dynamic mic (500-1000 ohms) or any low impedance audio source capable of supplying 40 mV p-p across 1000Ω. The microphone should be connected with shielded cable to avoid noise pickup. Higher level audio inputs, such as from a repeater controller, may not need to be shielded. Mic connections are made to E2 and E3 on the pc board. *Be sure to dress the audio cable away from any RF circuits.*

Subaudible Tone Connections.

If you want to transmit a CTCSS (subaudible) tone, you can connect the output of the tone encoder directly to CTCSS INPUT pad E5. This is a direct input to the modulator and bypasses all the audio processing.

Because this input is dc coupled, it is necessary to check the CTCSS Encoder unit to be sure the its output is ac coupled (has a blocking capacitor). Otherwise, the dc center voltage of the modulator will be upset. Note that the CTCSS Encoders we manufacture already have such a blocking capacitor; so nothing special is required. However, if you use some other encoder which does not have a blocking capacitor built in, it is necessary to add a 0.1µF capacitor in series with the input to E5 on the 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. Good CTCSS decoders can easily detect tones with less than 100Hz deviation.

ADJUSTMENTS.

Frequency Deviation Adjustments.

Set deviation limit pot R35 for the proper maximum deviation (normally ±5kHz) and then set af gain pot R26 for gain just sufficient to drive the audio up to full deviation on peaks. Since the deviation limit pot is after the limiter, it sets the absolute maximum deviation assuming the input signal is driven into limiting.

To adjust the audio controls, start by setting the af gain pot to maximum. Apply power to the exciter and talk into the microphone or apply audio of normal expected level to the exciter.

If the unit is setup with tones from a service monitor, use a tone frequency of 1000 Hz. Observe the deviation scope on a service monitor, and adjust the deviation limit pot for a peak deviation of 5 kHz. Then, adjust the af gain pot so that the exciter 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, background noise is increased and some distortion from excessive clipping may result.

Frequency Adjustment.

All crystals age a little over a long period of time; so it is customary to tweak any transmitter back onto the precise channel frequency once every year or two.

The adjustment should be done using an

Table 1. Quick Specification Reference

Model T302-1	138.000 - 148.235 MHz
Model T302-2	144.000 - 154.235 MHz
Model T302-3	154.200 - 164.435 MHz
Model T302-4	164.400 - 174.635 MHz
Model T302-5	216.000 - 226.235 MHz
Model T302-6	220.000 - 230.235 MHz
Operating Voltage:	+13.6Vdc ±10%
Operating Current:	450 mA @ 2W out
	550 mA @ 3W out
	650 mA @ 4W out
Operating Current, Synth only:	30 mA
Audio Input:	40 mV p-p min. into 1KΩ
Size:	5 in. W x 3 in. D

accurate service monitor or frequency counter. Of course, make sure the test equipment is exactly on frequency first by checking it against WWV or another frequency standard. No modulation should be applied to the transmitter during the adjustment period.

The channel frequency is trimmed precisely on frequency with a small variable capacitor, which is accessible through a hole in the top of the TCXO shield can. The proper tool is a plastic wand with a small metal ceramic 0.4 x 0.9 mm bit in the end.

Multichannel Operation.

The T302 may be programmed with more than one channel. If you ordered this option, you can change to the first alternate channel by grounding E6 or the second alternate channel by grounding E7. Grounding both terminals selects the third alternate. Ground terminals E8 and E9 are provided if you want to use jumpers, or you can use an external switch of some sort.

NOTE: *If the frequency is changed more than about 500 kHz, a complete alignment of the Exciter should be performed, as described in later text. Optimum operation only occurs if the synthesizer is adjusted to match the frequency setting and all the tuned amplifier circuits are peaked for the desired frequency.*

ALIGNMENT.

General Procedure.

A complete alignment is needed whenever the frequency is changed by more than about 500 kHz. Alignment ensures that the frequency synthesizer is optimized at the center of the vco range and that all *RF* amplifier stages are tuned to resonance.

Equipment needed for alignment is a dc voltmeter, a good vhf 50 ohm RF dummy load, an RF wattmeter accurate at vhf, 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 exciter should be adjusted with the proper hex tuning tool to avoid cracking the powdered iron slugs. Variable capacitors should be adjusted with a plastic tool having a small metal or ceramic bit. Our A1 Tuning Tool is ideal for this.

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

1. Do not operate without a 50 ohm load. The output transistor could be damaged from overheating.

2. Class C amplifiers can become spurious if under driven. Therefore, do not attempt to reduce power output by detuning the drive. Better ways to reduce output substantially are to reduce the B+ to as low as 10Vdc by adjusting the power supply or to remove the output transistor and replace it with a dc blocking capacitor if you really want low output.

3. RF power transistors Q5 and Q6 run quite warm at full drive, but not so hot that you can't touch them without being burned.

a. Connect 50 ohm dummy load to phono jack J1 through some form of vhf wattmeter suitable to measure up to 5W.

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-resistance connection through this path to the ground on the board.

☹ ***CAUTION: Be sure to observe polarity to avoid damage to transistors!***

A 1000 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 transistors. Better yet, if using a lab supply for testing, set the current limiter on the power supply to limit at 700 mA.

Note: *Meter 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. Typical test point indications are for the 144 MHz band unit and may differ for other bands.*

c. Connect voltmeter to TP1 (top lead of R6). Adjust vco coil L1 for +2Vdc. (Although the vco will operate over a wide range of tuning voltages from about 1V to 5V, operation is optimum if the vco is adjusted to 2V.)

d. Connect voltmeter to TP2. Adjust buffer coils L3 and L4 alternately for a peak.

e. Alternately, adjust driver coil L5, PA input coil L8, and PA output capacitor C44 for maximum output. Note that coil tuning may be very broad. There may be small interactions between tuning controls, so repeat until no more interactions are noticed.

f. At full drive, the total current drawn by the exciter should be 400-600 mA, and the RF output should be about 2 to 3.5W. Maximum output obtainable varies with many factors, so don't worry if it is a little lower or higher than expected.

Note that full output may not be possible when operating on a power supply less than 13.6 Vdc. Power output falls rapidly as operating voltage is reduced. For example, on a sample 144MHz unit, output level of 3.3W at 13.6Vdc was reduced to 2W output at 10Vdc.

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. And sometimes, you may wish to deliberately restrain the output level to be conservative. Reducing the power supply voltage is a good way to do it. Just don't operate below 10Vdc because the voltage regulators would fall out of regulation with too low an input. And do not reduce voltage by putting resistance in series with the supply; you want a well regulated/filtered power source.

After tuning the exciter 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.

g. Perform the carrier frequency and audio level adjustments given on page 2 to complete the alignment of the exciter.

THEORY OF OPERATION.

The T302 is a frequency synthesized vhf fm exciter. The carrier frequency is generated by voltage controlled oscillator Q1. The output is buffered by Q2 to minimize effects of loading and voltage variations of following stages from modulating the carrier frequency. The resultant signal is amplified in successive stages to provide 2 to 3.5 Watts output into a 50Ω load.

The frequency of the vco stage is controlled by phase locked loop synthesizer U2. A sample of the vco output is applied through the buffer stage and R1 to a prescaler in U2. The prescaler and other dividers in the synthesizer divide the sample down to 5kHz.

A reference frequency of 10.240 MHz is generated by a TCXO (temperature compensated crystal oscillator). The reference is divided down to 5 kHz.

The two 5kHz signals are compared to determine what error exists between them. The result is a slowly varying dc tuning voltage used to phase lock the vco precisely onto the desired channel frequency.

The tuning voltage is applied to carrier tune varactor diode D1, which varies its capacitance to tune the tank circuit formed by L1/C20/C21. C16 limits the tuning range of D1. The tuning voltage is applied to D1 through a third order low pass loop filter, which removes the 5kHz reference frequency from the tuning voltage to avoid whine.

Modulation is applied to the loop filter at R19. Audio or data signals are amplified by U5a, limited by D4/D5, and applied to R19 through low pass filter U5b. The first op amp, U5a, provides pre-emphasis so that higher audio frequencies deviate wider than lower frequencies. The second op amp, U5b, provides a 12dB/octave rolloff for any audio or data modulation products over 3000 Hz to prevent splatter interference to other nearby channels. A direct modulation input is provided through E5 and R37 for use with a subaudible tone (CTCSS) encoder.

A lock detector in the synthesizer ic provides an indication of when the synthesizer is properly locked on frequency. In order for it to lock, the vco must be tuned to allow it to generate the proper frequency within the range of voltages the phase detector in the synthesizer can generate, roughly 1Vdc to

5Vdc. If the vco does not generate the proper frequency to allow the synthesizer to lock, the lock detector output turns off U5c, which provides operating bias to the pre-driver amplifier, thus preventing the exciter from putting out signals which are off frequency. This feature ensures that the signal will reach the antenna only after the carrier locks on frequency.

Serial data to indicate the desired channel frequency and other operational characteristics of the synthesizer are applied to synthesizer U2 by microcontroller U1. Everything the synthesizer needs to know about the frequency, division schemes, reference frequency, and oscillator options is generated by the micro. When the microcontroller boots at power up, it sends several bytes of serial data to the synthesizer, using the data, clock, and latch enable lines running between the two ic's.

RF amplifier stages are powered directly by the +13.6Vdc. However, all the lower level stages are powered through voltage regulators for stability and to eliminate noise. U4 is an 8Vdc regulator to power the vco, buffer, and phase detector in the synthesizer. Additional filtering for the vco and buffer stages is provided by capacitance amplifier Q3, which uses the characteristics of an emitter follower to provide a very stiff supply, eliminating any noise on the power supply line.

Resistive voltage dividers provide lower voltages which are regulated because they are based on the regulated 8Vdc from U4. U5d provides a stiff +5Vdc supply for the frequency synthesizer and microcontroller.

TROUBLESHOOTING.

General.

Checking dc voltages and signal tracing with an RF voltmeter probe and oscilloscope will work well in troubleshooting the T302. 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 exciter draws about 30 mA of current when just the synthesizer and audio circuits are operating. When the exciter is generating an RF output, it draws a total of about 450-600 mA.

RF Amplifier Circuits.

You can use an RF probe with a dc voltmeter or scope to check the relative RF levels at the input and output of each stage. The output level should always be higher than the input level of a given stage. Also, check the dc operating and bias voltages for each stage. The pre-driver stage gets its bias only when the lock detector in the synthesizer is locked; so if that bias is missing, check the synthesizer and vco to see why it isn't locked.

Synthesizer Circuits.

Following is a checklist of things to look for if the synthesizer is suspected of not performing properly.

a. Check the output frequency of the vco buffer with a frequency counter.

b. Check the lock detector at either pad of R25 with a dc voltmeter. (7Vdc locked, 0Vdc unlocked).

c. Check tuning voltage at TP1. It should be about +2Vdc. Actual range over which the unit will operate is about +1Vdc to just under +5Vdc. However, for optimum results, the vco should be tuned to allow operation at about +2Vdc center voltage.

d. Check the operating voltage and bias on the vco and buffer.

e. Check the 10.240 MHz TCXO signal at pin 1 of the synthesizer ic. Be very careful not to short adjacent pins of the ic. A scope should show several volts p-p at 10.240 MHz.

f. The data, clock, and latch enable lines between the microcontroller and synthesizer ic's should show very brief and fast activity, sending data to the synthesizer ic shortly after the power is first applied or a dip switch setting is changed. Because this happens very fast, it can be difficult to see on a scope. Use 1µSec/div, 5Vdc/div, and NORMAL trigger.

Audio.

You can check the following levels with a scope.

a. The audio input must be 40mV p-p or greater at input E2 for full 5kHz deviation.

b. Gain control R26 sets the gain of amplifier U5a. Provided enough gain and audio input, the limiter output will provide about 1V p-p at the input of deviation pot R35.

c. The output of active filter U5b is a maximum of about 2V p-p if the limiter is driven into limiting. This assumes a test signal at about 1000 Hz. This ac signal should be riding on a dc center voltage of about +4.4Vdc. That is what should be applied to the modulator diode through R42.

d. You can also check for the presence of the proper dc voltages on the op amps, which use bias voltages of +4Vdc and +2.2Vdc. Refer to the power supply circuits on the schematic diagram.

Microphonics, Hum, and Noise.

The vco and loop filter are very sensitive to hum and noise pickup from magnetic and electrical sources. Some designs use a shielded compartment for vco's. We assume the whole board will be installed in a shielded enclosure; so we elected to keep the size small by not using a separate shield on the vco. However, this means that you must use care to keep wiring away from the vco circuit at the right side of the board. Having the board in a metal enclosure will shield these sensitive circuits from florescent lights and other strong sources of noise.

Because the frequency of a synthesizer basically results from a free running L-C oscillator, the tank circuit, especially L1, is very sensitive to microphonics from mechanical noise coupled to the coil. You should minimize any sources of vibration which might be coupled to the exciter, such as motors.

Excessive noise on the dc power supply which operates the exciter can cause noise to modulate the signal. Various regulators and filters in the exciter are designed to minimize sensitivity to wiring noise. However, in extreme cases, such as in mobile installations with alternator whine, you may need to add extra filtering in the power line to prevent the noise from reaching the exciter.

To varying degrees, whine from the 5kHz reference frequency can be heard on the signal under various circumstances. If the tuning voltage required to tune the vco on frequency is very high or low, near one extreme, the whine may be heard. This can also happen even when the tuning voltage is properly near the 2Vdc center if there is dc leakage loading on the loop filter. Any current loading, no matter how small, on the loop filter causes the phase detector to pump harder to maintain the tuning voltage. The result is whine on the signal. Such loading can be caused by connecting a voltmeter to TP1 for testing, and it can also be caused by moisture on the loop filter components.

Typical Dc Voltages.

The following dc levels in tables 3-5 were measured with a sensitive dc voltmeter 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 the exciter operating and fully tuned to provide normal output. Note that meter probe must have a 10 megΩ 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.

Use caution when measuring voltages on the surface mount ic. The pins are close together, and it is easy to short pins together and damage the ic. We recommend connecting the probe to a nearby component connected to the pin under question. Also, some pins are not used in this design, and you can generally not be concerned with making measurements on them.

Typical Audio Voltages.

Table 6 gives rough measurements of audio voltages which may be measured with an oscilloscope when an audio source with a tone about 1000 Hz is connected and modulating to full 5 kHz deviation. Measurements given were taken with an oscilloscope with audio 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.

REPAIRS.

If you need to unsolder and replace any components, be careful not to damage the plated through holes on the pc board. Do not drill out any holes. If you need to remove solder, use a solder sucker or solder wick. A toothpick or dental probe can be used with care to open up a hole.

If you need to replace a surface mount ic, first be very sure it is damaged. Then, carefully cut each lead off the case with fine nose cutters. Once the case is removed, individual leads can be unsoldered and the board can be cleaned up. Carefully position the new ic, and tack solder the two opposite corner leads before any other leads are soldered. This allows you to melt the solder and reposition the ic if necessary. Once you are sure, the remaining leads can be soldered. If you get a solder short between leads, use a solder sucker or solder wick to remove the excess solder.

If it becomes necessary to replace output transistor Q6, you must unsolder the three leads first from under the board. Then, carefully melt the solder securing the can to the top of the board. This requires a very hot iron or a hot air tool, and care must be taken to avoid damaging the board. Once the transistor is removed, a vacuum solder sucker can be used to clean the excess solder off the ground plane. Install the new output transistor flat against the board, and solder the leads on the bottom of the board. Then, solder the bottom of the metal can to the pcb ground plane with a continuous bead of solder flowing around the can. (Soldering the can to the ground plane is necessary to provide a low impedance emitter ground and heatsinking; the transistor is designed to be installed this way).

Table 3. Typical Test Point Voltages

TP1	Normally set at 2V
TP2	Roughly 0.3V
Note: These can vary considerably without necessarily indicating a problem.	

Table 4. Typical Xstr DC Voltages

STAGE	E	B	C
Q1 vco	1.5	2.2	7.2
Q2 buffer	0	0.75	5
Q3 dc filter	7.2	7.8	8
Q4 pre-driver	0.3	0.3	13.6
Q5 driver	0	0.2	13.6
Q6 pwr ampl	0	0	13.6
Limiter R33		0.43	
Limiter R34/diodes		1	
Limiter R35		0.43	

Figure 5. Typical IC DC Voltages

U1-1	4	U1-2	4
U2-1	2.7	U2-10	2.7
U2-2	5v locked	U2-11	2.7
	(pulses unlocked)	U2-12	5
U2-3	5 *	U2-13	3.3 *
U2-4	5 *	U2-14	5
U2-5	5	U2-15	*
U2-6	0-5 (2V tuned)	U2-16	*
U2-7	0	U2-17	5
U2-8	4.8	U2-18	0
U2-9	5 *	U2-19	0
	* = pin not used	U2-20	2.7
U5-1	4	U5-8	7
U5-2	4.5	U5-9	4
U5-3	4	U5-10	4.7
U5-4	8	U5-11	0
U5-5	2.2	U5-12	5
U5-6	2.4	U5-13	5
U5-7	4.5	U5-14	5

Table 6. Typical Audio Voltages

Test Point	mV p-p
E2 AF input	40(min)
U5-1	1000
D5 cathode	1000
U5-7	2000

PARTS LIST FOR T302 EXCITER.

☞Note: Values which vary with freq. band are shown in a table at the end of the parts list. Parts on bottom of board are 0805 or 0603 surface mount parts.

Following are notes specific to certain parts.

* Remove tuning slugs from coils L9-L11 in the output of the PA stage.

** Microcontroller must be factory programmed for frequency.

💣 Caution: Ic's are static sensitive. Use appropriate handling precautions to avoid damage.

Ref Desig	Value (marking)
C1	0.1µf
C2	100pf
C3	0.1µf
C4	100µf electrolytic
C5	100µf electrolytic
C6-C9	not assigned
C10	0.15µf mylar
C11	.01µf
C12	.001µf
C13	0.1µf
C14	100µf electrolytic
C15	0.1µf
C19	4.7µf electrolytic
C22	2pf
C26	not assigned
C27	0.1µf
C28-C29	100µf electrolytic
C30	not assigned
C43	220pf
C47	1µf electrolytic
C49	.033µf
C50	100µf electrolytic
C51	4.7µf electrolytic
C52	1µf electrolytic
C53-C54	.0033µf
C55-C56	220pf
C58	100µf electrolytic
D1	BB132 varactor diode
D2-D3	not assigned
D4-D5	1N4148
J1	RCA Jack
L2	0.33µH RF choke (red-sil-orn-orn)
L3-L5	2½ t., slug tuned (red)
L8	2½ t., slug tuned (red)
L9-L11 *	2½ t., NO SLUG (red)
Q1-Q2	MMBT5179
Q3	MMBT3904
Q4	MMBT5179
Q5	PN5179
Q6	MRF-237
R1	180Ω
R2	27Ω
R3-R4	not assigned
R5	10K
R6	47K
R7	1 meg
R8	2.2K
R9	10K
R10	6.8K
R11	3.9K
R12	180Ω
R13	47Ω
R14	47K
R15	470Ω
R16	not assigned
R17	6.8K
R18	2.2K
R19	100Ω
R20	15K
R21	2.2K
R23	not used
R25	470Ω
R26	1K trim pot. (102)
R27	47K
R28	1K
R29	150K
R30	3.9K
R31	4.7K
R32	2.2K
R33	1K
R34	10K
R35	1K trim pot. (102)
R36	47K
R37	10K
R38-R39	15K
R40-R41	47K
R42	6.8K
R43	27Ω
R44	not assigned
R45-R46	27Ω
U1 💣 **	MC9RS08KA1 µP
U2 💣	LMX-1501AMX synthesizer
U3 💣	10.240MHz TCXO (option)
U4	78L08ACP regulator

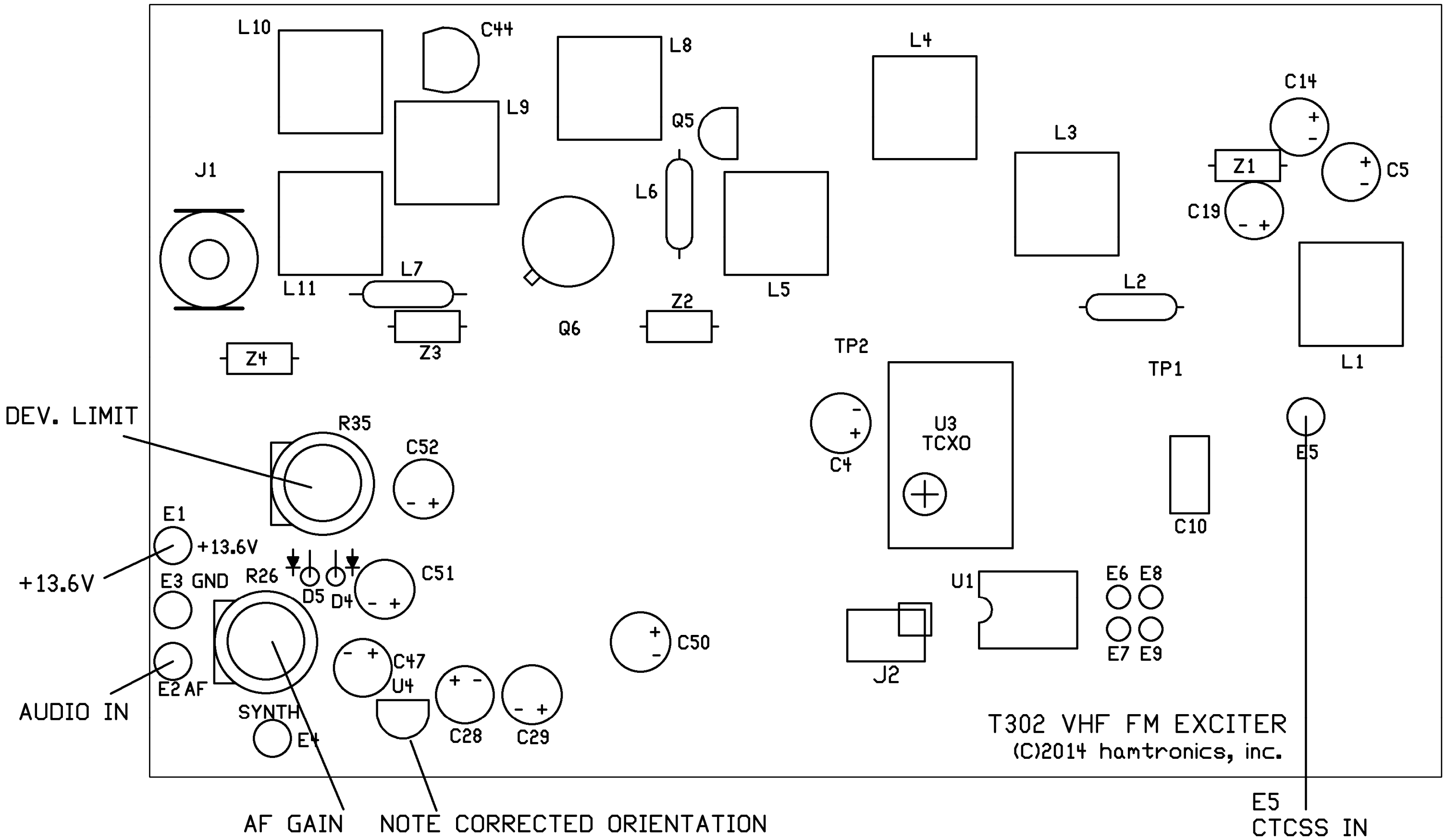
NOTE: Silk screen shows U4 incorrectly. It should be oriented with flat side away from edge of board instead of toward edge. See top view on next page..

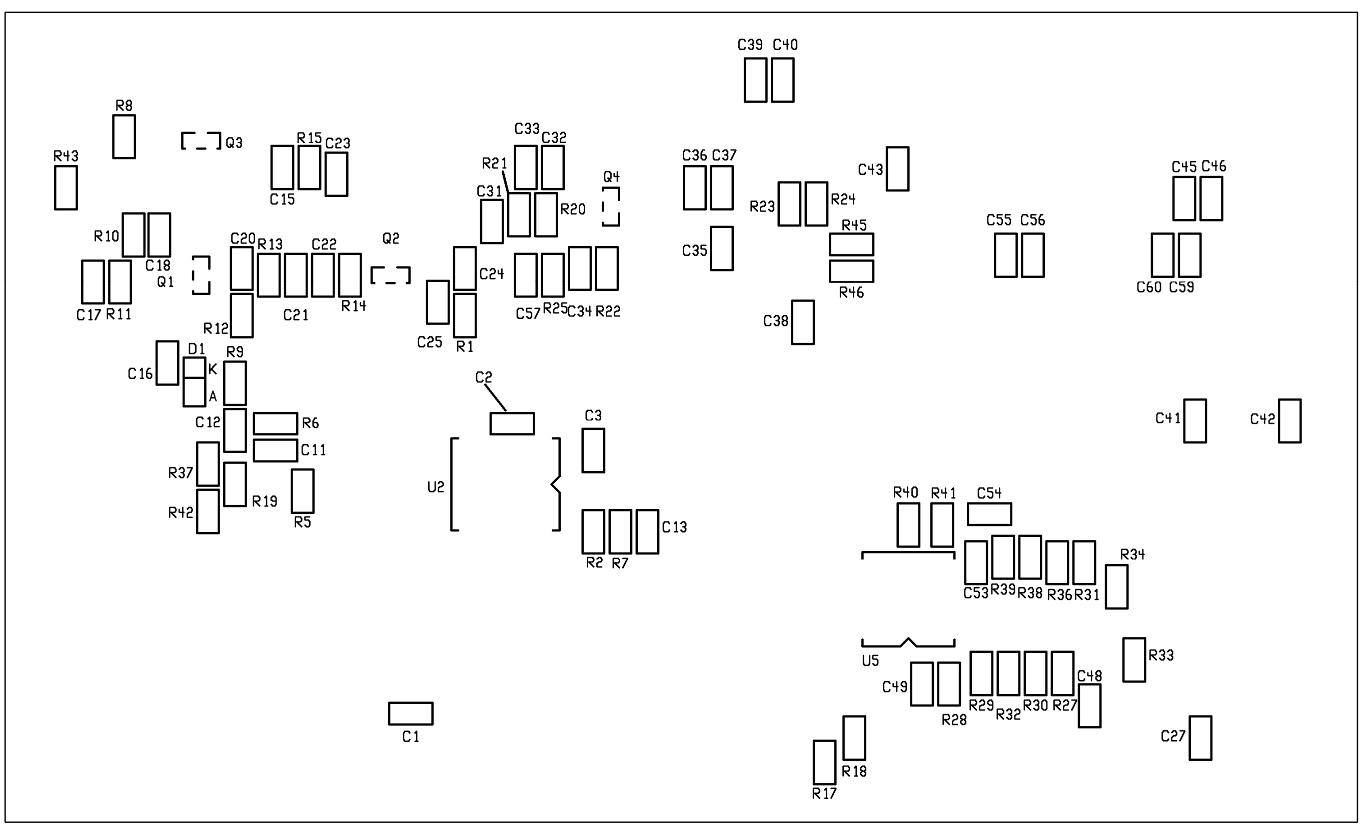
U5	LM324D (smt) op amp
Z1-Z4	Ferrite bead

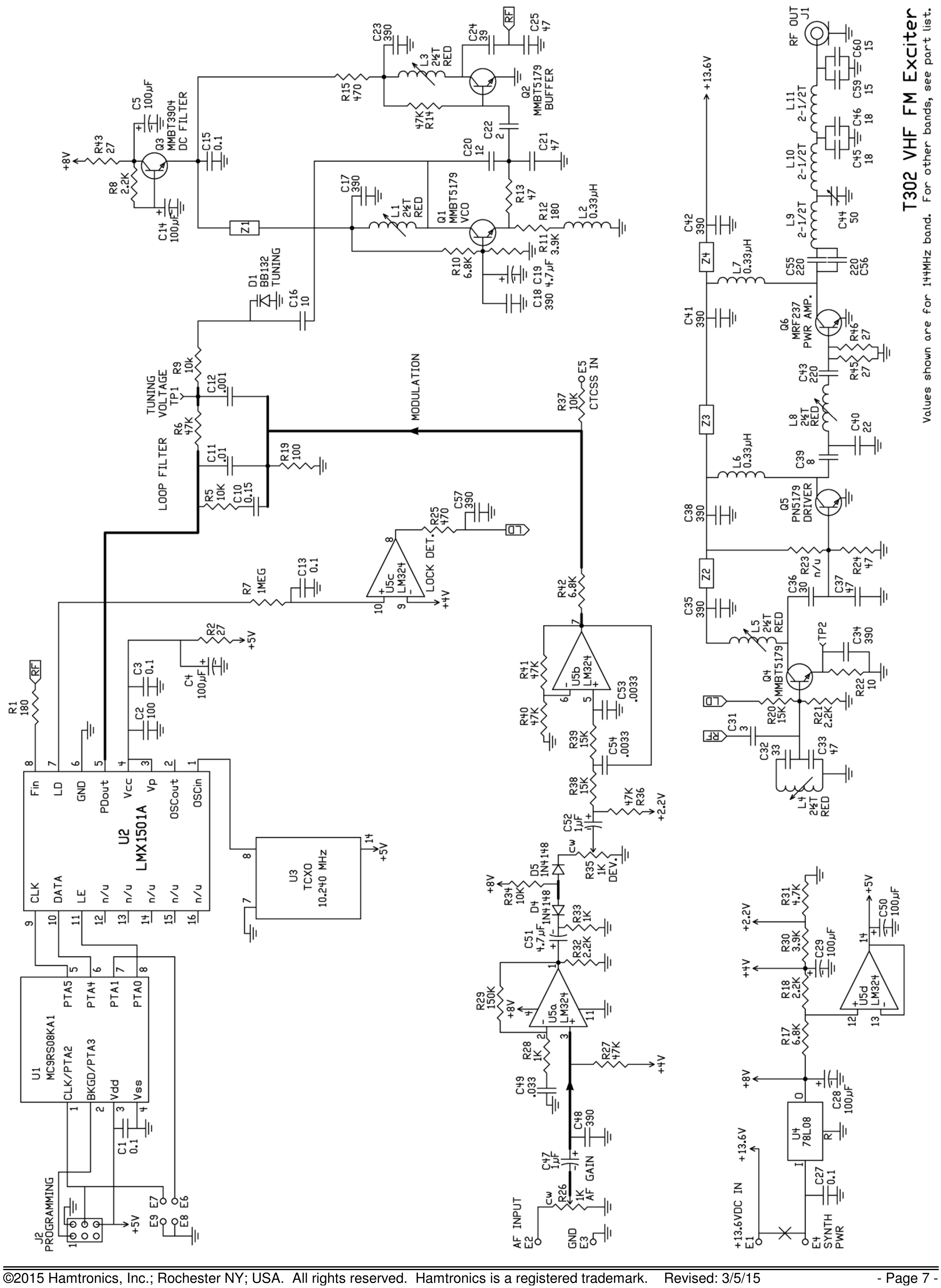
VALUES WHICH VARY WITH FREQUENCY BAND:

T302-2 is 144.000 - 154.235 MHz
T302-3 is 154.200 - 164.435 MHz
T302-4 is 164.400 - 174.635 MHz
T302-5 is 216.000 - 226.235 MHz
T302-6 is 220.000 - 230.235 MHz

Ref Desig	-2	-3	-4	-5/-6
C16	10	8	7	7
C20	12	10	8	10
C21	47	43	30	47
C24	39	33	30?	10?
C25	47	39	33	18
C31	3	?	?	?
C32	33	27	27	12
C33	47	39	33	18
C36	30	22	18	7
C37	47	39	27	n/u
C39	8	8	8	2
C40	22	18	15	6
C44	50pf var. (brn)	50pf var. (brn)	50pf var. (brn)	30pf var. (grn)
C45, C46	18	15	12	4
C59, C60	15	12	10	8
L1	2½T (red)	2½T (red)	2½T (red)	1½T (brn)
L6, L7	0.33µH	0.33µH	0.33µH	0.22µH
R22	10Ω	10Ω	10Ω	47Ω
R24	47Ω	47Ω	47Ω	100Ω
Bypass capacitors C17, C18, C23, C34, C35, C38, C41, C42, C48, C57 are 390pf for T302-2, -3, and -4 and 220pf for -5 and -6				


L10
C44
L8
L4
C14
L9
Q5
L3
C5
J1
Z1
L6
C19
L11
L7
L5
L2
Q6
Z2
Z3
Z4
L1
TP2
TP1
DEV. LIMIT
R35
C52
U3
TCXO
C4
E5
E1
+13.6V
C10
+13.6V
E3 GND
R26
D5
D4
C51
U1
E6 E8
E7 E9
C47
C50
J2
AUDIO IN
E2 AF
U4
C28
C29
SYNTH
E4
T302 VHF FM EXCITER
(C)2014 hamtronics, inc.
AF GAIN
NOTE CORRECTED ORIENTATION
E5
CTCSS IN


C39 C40
R8
Q3
R15
C23
C33
C32
R43
C15
R21
Q4
C36 C37
C43
C45 C46
C31
R20
R24
R23
R10
R45
C35
C55 C56
C20
R13
C22
Q2
C18
Q1
C24
R46
C60 C59
C17 R11
C21
R14
C57
R25
C34
R22
C38
R12
C25
R1
D1
C16
R9
K
A
C2
C3
C41
C42
C12
R6
C11
R37
U2
R19
R42
R5
R40
R41
C54
C13
R2
R7
R34
C53
R39
R38
R36
R31
R33
U5
C48
C49
R29
R30
R27
R28
R32
C1
C27
R18
R17


T302 VHF FM Exciter
Values shown are for 144MHz band. For other bands, see part list.