HAMTRONICS® TB901 FM EXCITER INSTALLATION, OPERATION, & MAINTENANCE

GENERAL INFORMATION.

The TB901 is a single-channel low power fm transmitter (exciter) designed to provide 300-600 milliWatts continuous duty output into a 50 ohm antenna system in the 902-928 MHz ham band (900-960 MHz for export).

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 approximately 300 mA.

When the TB901 Exciter is used with the LPA901 Power Amplifier, the exciter is modified by removing the output stage to limit output power to less than 100mW in order to prevent damage to the PA.

CRYSTALS.

The TB901 uses 32 pF parallel resonant crystals in HC-25-u holders. Crystals operate in the fundamental mode at a frequency of F/72, which results in a crystal frequency of 12.527 to 12.888 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 degrees C range for which the unit was designed.

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 TB901 Exciter operates on +13.6Vdc at about 300 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 300 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 TB901 Exciter is driving it with rf power; so the pa should not require a separate keyline circuit.

AUDIO CONNECTIONS.

The TB901 Exciter 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 transmitter. 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.

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, change the value of C12 to a value about 10 pf lower.

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-5 Tone Decoder/Encoder module already has 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 TB901 is a fairly straight forward fm exciter, with a phase modulated 12-13 MHz signal multiplied by 72 to reach the 902-928 MHz output range. Crystal oscillator Q4 operates as a Colpitts oscillator at the fundamental frequency of approximately 12.5 MHz. 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 about 38 MHz. Q7 triples again to a range of about 114 MHz. This, in turn, is doubled in Q8 to a range of about 228 MHz and doubled again in Q9 to about 456 MHz. Q10 then doubles again to the output frequency in the 902-928 MHz band.

The signal is further amplified by driver Q11 and pa Q12 to provide the 100-250 milliWatt output signal to the 50 ohm antenna. Spurious signal rejection is provided by double tuned circuits between multiplier stages and a low pass filter in the output of the pa stage.

The audio processor circuits consist of microphone amplifier Q1-Q2, peak limiter CR1-CR2, and active filter Q3. The audio input, at a level of about 30 mV p-p, is amplified and applied to the limiter circuit. R1 provides adjustment of the audio gain. Processed audio, limited in peak amplitude, contains a small amount of harmonic distortion from the clipping process.

Active filter Q3 is a low pass filter which greatly reduces the effects of any distortion from the limiter to prevent splatter of sidebands outside the bandwidth allowed for one channel. Deviation potentiometer R15 allows for adjustment of the peak audio level applied to the modulator stage. C11/R17 is an rf filter to keep the carrier signal at 12 MHz from getting back into the active filter stage. R16-C11 acts as an additional low pass filter. Together with the active filter stage, it 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 sensitive relative output meter (or spectrum analyzer), and a regulated 13.6Vdc power supply with a 0-500 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 (A28 Tool in our catalog) 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. They should be aligned with the proper insulated tuning tool (A2 Tool in our catalog).

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 500 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.

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, C52, and C56, and C57, in that order, for maximum output at the antenna connector.

g. At full drive, the total current drawn by the transmitter should be about 300 mA, and the rf output should be about 300-600 milliWatts.

Note that full output may not be possible with less than 13.6 Vdc power supply. 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 these frequencies, even for short runs. A 2-foot test lead of small coax can drop as much as 1/2 power.

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 TB901. 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 300 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 normal 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.

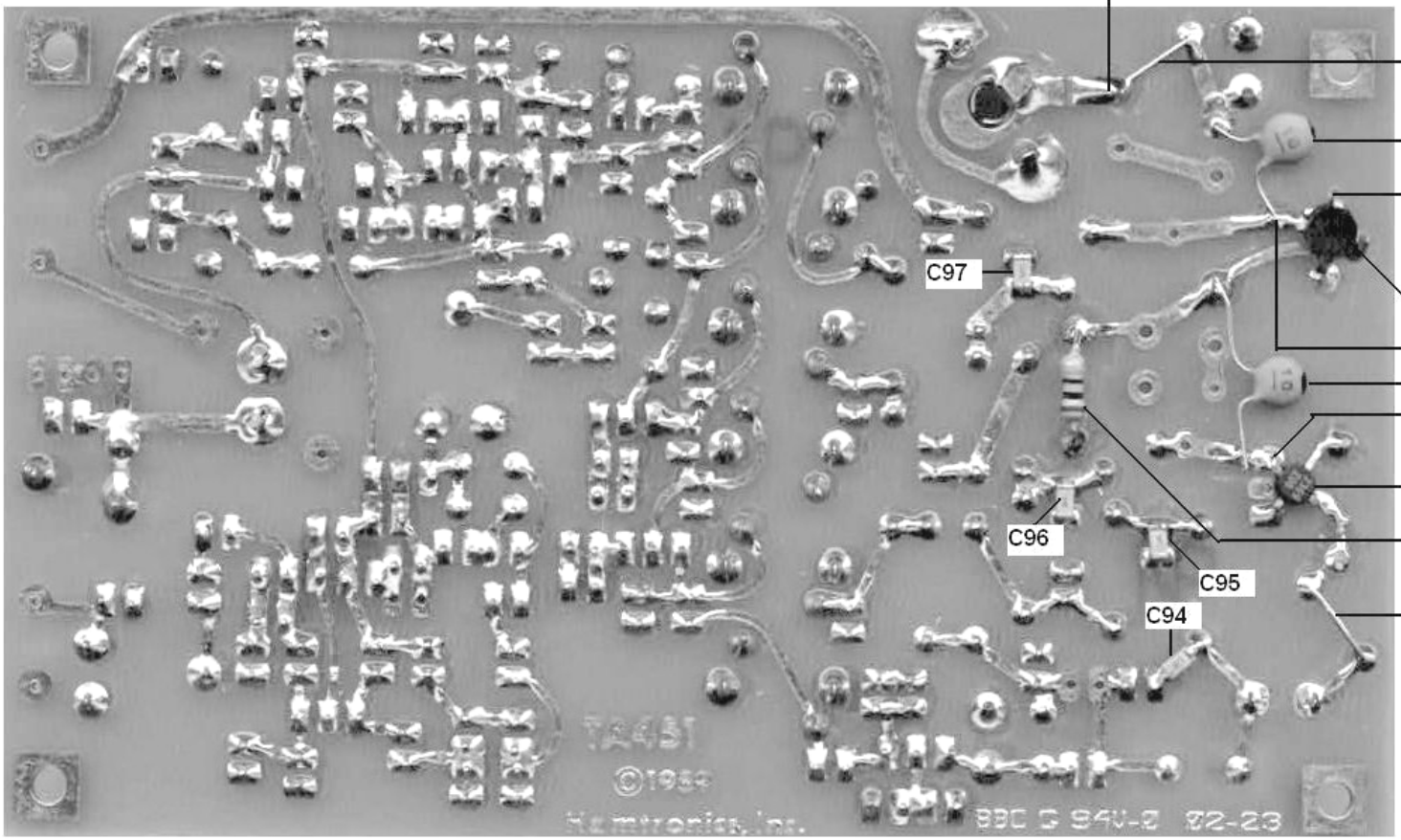
Following are rough measurements of audio voltages (in mV rms) which may be measured with a sensitive voltmeter or an oscilloscope when a low impedance dynamic microphone or other audio source is connected and modulating to full 5 kHz deviation. Measurements given were taken with a scope with mic gain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

TYPICAL AUDIO VOLTAGES (mV RMS):			
Mic Input 30mV			
STAGE	E	B	C
Q1	0.5	1	10
Q2	0	10	700
Q3	500	500	-
Q5	-	30	-

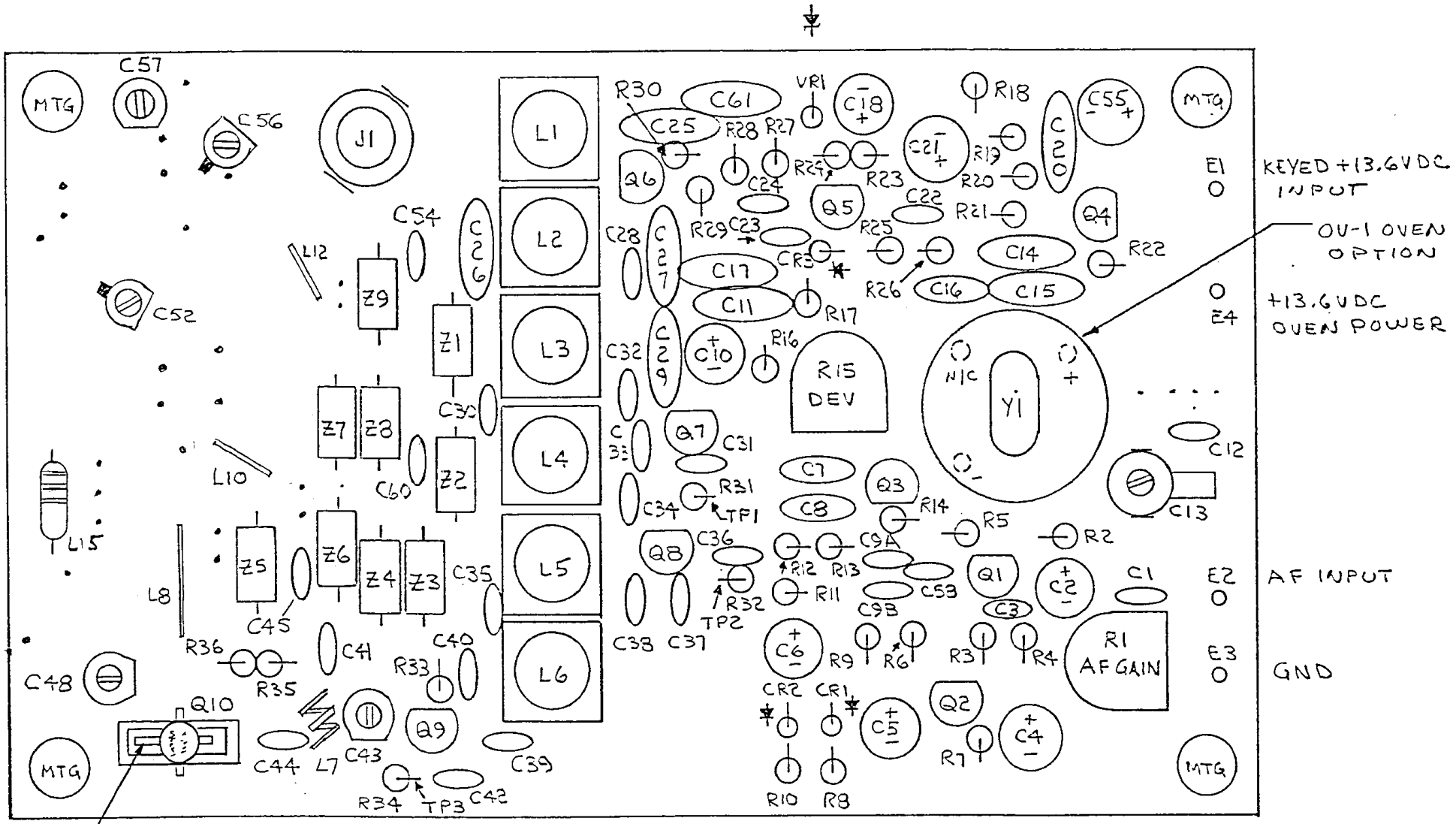
PARTS LIST, TB901 FM EXCITER.

Ref #	Value (marking)
C1	30pf
C2	2.2 uf electrolytic
C3	220 pF(221)
C4	10 uF electrolytic
C5	2.2 uf electrolytic
C6	2.2 uf electrolytic
C7-C8	.0047 uf (472)
C9A	.0022 uf (2.2nK or 2n2K)
C9B	not used
C10	2.2 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	120 pf
C32	30 pf
C33	0.5 pf
C34	30 pf
C35-C36	120 pf
C37	4 pf
C38	0.5 pf
C39	8 pf
C40	15 pf
C41-C42	30 pf
C43	4.5 pf var. (white)
C44	2 pf
C45	120 pf
C46-C47	not used
C48	4.5 pf var. (white)
C49-C51	not used
C52	4.5 pf var. (white)
C53	not used
C54	30 pf
C55	10 uF electrolytic
C56-C57	4.5 pf var. (white)
C58	30 pf
C59	not used
C60	.001 uf (102, 1nM, or 1nK)
C61	.01 uf disc (103)
C94-C97	68 pf smt chip cap.
C98-C99	10 pf disc cap.
CR1-CR3	1N4148
J1	RCA Jack
L1-L2	6-1/2 turns (blue)
L3-L6	2-1/2 turns (red)
L7	Air wound 3T.
L8	jumper
L9	not used
L10	loop
L11	not used
L12	loop
L13-L14	not used
L15	0.33 uH rf choke (red-sil-orn-orn)
Q1-Q6	2N3904
Q7-Q8	2N5770
Q9	PN5179
Q10-Q11	2SC2369
Q12	MRF-559
R1	1K pot (102)
R2	100k
R3	150k
R4	180 ohms
R5	47k
R6	8.2k
R7	1.2k
R8	4.7k
R9	47k
R10	4.7k
R11-R13	10k
R14	330k
R15	1k pot (102)
R16	10k
R17	10k
R18	180 ohms
R19	100 ohms
R20	10k
R21	4.7k
R22	680 ohms
R23	15k
R24	10k
R25	470 ohms
R26-R27	2.2k
R28	27k
R29	4.7k
R30-R32	270 ohms
R33	1.2k
R34	100 ohms
R35	10 ohms (under board)
R36	1.2k
VR1	1N5239B 9.1V Zener
Y1	Channel crystal (see text)
Z1-Z9	Ferrite Bead

 Revised: 11/4/03



TB901 Exciter, Rear of Board Showing Added Parts



Long Lead is Collector

TB-901 Exciter, PCB View