HAMTRONICS® R144 VHF FM RECEIVER, REV. 4/94: INSTALLATION AND MAINTENANCE

FUNCTIONAL DESCRIPTION.

The R144 is a premium commercial grade single-channel vhf fm receiver. It features a helical resonator front end with low-noise dual gate fet's, an 8-pole crystal filter plus a ceramic filter for superior i-f selectivity, and hysteresis squelch circuit to lock onto fading signals. The R144 kit is available for the 143-150 MHz band, and wired units are available for this band and also the 150-174 MHz commercial band.

CRYSTALS.

The channel crystal plugs into sockets on the board. We can order crystals for any frequency desired. If you order your own, be sure to supply the following specs.

The receiver uses 32 pF parallel resonant crystals in HC-25/u holders. Crystals operate in the fundamental mode. The crystal frequency for the 143-174 MHz band models is (F-10.7)/9. Frequency tolerance is .001%. 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 receivers with the temperature-compensated crystal oscillator (TCXO) option, since the crystal must be matched exactly to the compensation circuit in the receiver. If you use an OV-1 crystal oven, specify a crystal with a 60°C breakpoint.

INSTALLATION.

Power Connections.

The receiver operates on +13.6 Vdc at about 150 mA peak with full audio. Current drain with no audio is only about 35-40 mA. A crystal oven adds about 450 mA peak current drain when cold and only about 25 mA when warm. A well regulated power supply should be used.

Be sure that the power source does not carry high voltage or reverse polarity transients on the line, since semiconductors in the receiver can be damaged. The positive power supply lead should be connected to the receiver at terminal E3, and the negative power lead should be connected to the ground plane of the board through the mounting hardware or the shield of the coaxial cable. Be sure to observe polarity!

Speaker.

An 8-ohm loudspeaker should be connected to E2 with ground return to the ground plane through the mounting hardware. Use of lower impedance speaker or shorting of speaker terminal can result in ic damage. The receiver can also drive higher impedances, like 1K to 10K input impedances of COR boards, etc. There is no need to load down the output to 8 ohms.

Note that the audio output ic is designed to be heatsunk to the pc board through the many ground pins on the ic. When running moderately low audio levels as most applications require, it is no problem to use an ic socket; so we have provided one for your convenience. If you will be running high audio levels, check to see if the ic is getting hot. If so, you should remove the ic socket, and solder the LM-380 ic directly to the board for better heatsinking.

Antenna Connections.

The antenna connection should be made to the receiver with a phono plug. If you want to extend the antenna connection to a panel connector, we recommend using a short length of RG-174/u coax and a good phono plug with cable clamp *(see catalog).* 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 practical. When soldering the cable, keep the stripped ends as short as possible.

Mounting.

Some form of support should be provided under the pc board, generally mounting the board with spacers to a chassis. 3/8-inch holes should be provided in a front panel for the bushings of the *SQUELCH* and *VOLUME* controls. After sliding bushings through panel, washers and nuts can be installed on the outside of the panel. Be sure to provide support for the board; do not rely on the controls to support the board.

For repeater applications, the receiver should be mounted in an rf tight box, such as our model A16.

The receiver board relies on the mounting hardware to provide the dc and speaker ground connections to the ground plane on the board.

OPTIONS.

Squelch Circuit.

The squelch circuit has about 3 to 6 dB of hysteresis built in, so that once the squelch opens, the signal must drop 3 to 6 dB below the opening threshold before squelching again. This allows for some fading on mobile stations and prevents squelch pumping on heavy modulation. It also prevents cycling due to slight desense in repeater installations. Of course, this requires setting the threshold a little higher than if there was no hysteresis so that it will close with no signal. If you prefer the older type squelch, you can simply remove Q5 from the circuit; however, this is not recommended for repeater installations. If you want more or less hysteresis, you can decrease or increase the value of R25.

Repeater Use.

E4 provides a "carrier operated switch" output which may be connected to a COR module to turn a transmitter on and off. The output level is about 7V unsquelched and 0V squelched. There is a resistor in series with the output to limit current. Refer to COR module instructions for details.

If your repeater controller uses discriminator audio, rather than the speaker output, filtered discriminator audio is available at E5. The level is about 2V p-p. If you need audio which is squelched, take it from the input (right hand terminal on the *VOLUME* control.

Audio Muting.

If the receiver is used as a part of a transceiver, audio muting can be accomplished without switching the power or speaker lines. If the transmitter is keyed by applying B+ to the exciter, simply connect the keyed B+ through a 100K resistor to the junction of R25 and R27 on the receiver board. The dc level will be sufficient to trigger the squelch circuit in U2, regardless of the rf signal level coming into the receiver.

Of course, some means of discon-

necting the receiver from the antenna must be provided, and we recommend our *TRR Coax Relay Module* if the power level is under 25 Watts. Otherwise, a larger coax relay will be required.

Discriminator Meter.

If you wish to use a discriminator meter and you are handy in designing with op-amps, you can run a sample of the dc voltage at *DISCRIMINATOR* output terminal E5 to one input of an op-amp and tie the other input to a voltage divider pot set to provide a reference voltage of about +3.5Vdc.

S-Meter.

There is no s-meter function, as such, available in i-f amplifier ic's made for professional receivers; however, a signal strength indication is available at test point TP2. This voltage is a function of the noise level detected in the squelch circuit. It is about +3Vdc with no signal and 0Vdc with full quieting. You can tap off this point with a high-impedance circuit, such as an op-amp, to drive a meter or a computerized repeater controller.

Subaudible Tone Decoder.

To use our TD-3 Subaudible Tone Decoder or a similar module, connect its audio input to *DISCRIMINATOR* terminal E5. If you want to use it to mute the audio (instead of inhibiting a repeater transmitter as is normally done), connect the mute output of the TD-3 to the right-hand lug of the volume control.

ALIGNMENT.

Equipment needed for alignment is an fet voltmeter, an rf signal generator, a regulated 13.6Vdc power supply with a 0-200 mA meter internally or externally connected in the supply line.

The slug tuned coils in the receiver should be adjusted with the proper aluminum .062" square tuning tool to avoid cracking the powdered iron slugs. Variable capacitors should be adjusted with a plastic tool with a small metal bit on the end. Tools are available for adjusting the rf coils (model A28) and variable capacitor (model A2).

The *squelch* pot should be set fully counterclockwise. The *volume* pot should be set just a little clockwise.

a. Install channel crystal in socket.

b. Connect speaker and +13.6 Vdc. You should hear white noise.

c. Connect dc voltmeter to TP3 (top lead of R18). Adjust first L4, then L3 and L4 alternately for maximum response. (Approx. +1.2 to 2.2 Vdc typical.)

d. Connect stable signal generator to TP4 (right-hand lead of rf choke L9), using coax clip lead. Connect coax shield to pcb ground. Set generator to exactly 10.7000 MHz. Use a frequency counter or synthesized signal generator. Set level just high enough for full quieting. (At 1 uV, you should notice some quieting, but you need something near full quieting for the test.

e. Connect dc voltmeter to TP1 (top lead of R16). Adjust discriminator transformer L8 for +3.5Vdc. Note that the voltage changes very rapidly with tuning. Full swing of about 1 to 8V occurs within a few kHz, and a little drift (+/-1kHz) may be noticed due to the high sensitivity of the test signal. It is not necessary to maintain exactly 3.5V.

Note: There are two methods of adjusting the mixer and front end. One is to use an fet voltmeter with test point TP2, which is the top lead of CR3. The voltage at this point is proportional to the amount of noise detected in the squelch circuit; so it gives an indication of the quieting of the receiver. *A signal peak, therefore, is indicated by minimum noise voltage, not maximum.*

The other method is to use a regular professional SINAD meter.

In either case, a weak to moderate signal is required to observe any change in noise. If the signal is too strong, there will be no change in the reading as tuning progresses; so keep the signal generator turned down as receiver sensitivity increases during tuning.

If you use TP2 with a voltmeter, the signal can be modulated or unmodulated. If you use a SINAD meter, the standard method is a 1000 Hz tone with 3 kHz deviation.

f. Check that signal generator is still on 10.7000 MHz. With weak signal applied to Q2 gate-1 as before, adjust L2 for minimum noise or distortion. This step is critical to get lowest distortion in the crystal filter.

g. Remove signal generator so the receiver hears just noise. Readjust L8 slightly so that the voltage at TP1 is +3.5V with just noise coming through the i-f.

h. Connect signal generator to J1. Adjust to exact channel frequency, and turn output level up fairly high. Adjust frequency trimmer capacitor C16 to net the crystal to channel frequency, indicated by +3.5Vdc at test point TP1. If you can't find the signal at all, tune your signal generator up and down the band slightly. (Also check that oscillator is peaked as per step c.) If your crystal has the wrong load correlation or is slightly out of tolerance, you may be able to compensate by changing the value of C15 so C16 can net the crystal on frequency. *The piston capacitor tuning range is restricted to provide best frequency stability; so sometimes it may be necessary to change the fixed capacitor.* The proper adjustment results in +3.5Vdc, the same as preset for the exact 10.700 MHz i-f frequency earlier.

Maximum capacitance (lowest frequency) occurs with the piston screwed in all the way, and minimum capacitance (highest frequency) is with the piston all the way up. Be careful not to completely remove the piston. If the piston screw becomes a little tight (squeaky), you can apply a small amount of silicone oil to the threads.

i. Connect fet dc voltmeter to TP2 (top lead of CR3). Set signal generator for relatively weak signal, one which shows some change in the dc voltage indication at TP2. Alternately peak L5, L6, and L1 until no further improvement can be made.

j. Helical resonator T2 supplied in the kit has been factory aligned to 145 (223) MHz. Readjustment of the three screws may be necessary even if you are operating close to the preset frequency. Alternately adjust the three screws for best sensitivity.

Be careful not to adjust any screw more than just a few turns or you may unscrew the metal tuning slug from the end of its lead screw inside the resonator. If that should happen, you may be able to carefully disassemble the affected section and repair it.

k. Repeak L6 and L1 after the helical resonator is tuned to work out any interactions.

When properly tuned, sensitivity should be about 0.15 to 2.0 µV for12 dB SINAD.

TROUBLESHOOTING.

The usual troubleshooting techniques of checking dc voltages and signal tracing work well in troubleshooting the receiver. 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 most common troubles in all kits are interchanged components, cold solder joints, and solder splashes. Another common trouble is blown transistors and ic's due to reverse polarity or power line transients. 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 the receiver is completely dead, try a 10.700 MHz signal applied to TP4 (right-hand lead of rf choke L9) with a coax cable clip lead. You should be able to hear the quieting effect of a 10 uV carrier at 10.700 MHz. You can also connect the 10.700 MHz clip lead through a blocking capacitor to various sections of the crystal filter to see if there is a large loss of signal across one of the filter sections. Also, check the 10.245 MHz oscillator with a scope or by listening with an hf receiver or service monitor.

TABLE 1. TYPICAL DC VOLTAGES.

Xstr	E	(S)B	(G1)C	(D)G2 .
Q1	0	0	8	4
Q2	0.5	0	8	4
Q3	2.7	2.4	8	-
Q4	2.2	0	8	-
Q5 Squelched	0	0	0.7	-
Q5 Unsq	0	0.7	0	

U1	1	6	8	14
	7	0	7	13.6

U2	1	2	3	4	5	6	7	8
	7.9	7.2	7.2	8	1.1	1.1	1.1	8

U2	9	10	11	12	13	14	
	4.4	3.5	1 To 8	2.5		2.5	.3 To .7

U2	.	15	16	17	18	
	0(Sq), 7.2(Unsq)		0	0	2.3	

A signal generator on the channel frequency can be injected at various points in the front end. If the mixer is more sensitive than the rf amplifier, the rf stage is suspect. Check the dc voltages looking for a damaged fet.

If audio is present at the VOLUME control but not at the speaker, the audio ic may have been damaged by reverse polarity or a transient on the B+ line. If no audio is present on the volume control, the squelch circuit may not be operating properly. Check the dc voltages, and look for noise in the 10 kHz region, which should be applied to noise detector CR2/CR3 with no input signal. (Between pins 12 and 13 of U2 is an op-amp active filter tuned to 10 kHz.)

Typical Dc Voltages.

The dc levels in Table 1 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 no signal applied but oscillator running properly and with squelch open unless otherwise specified.

Typical Audio Levels.

Following are rough measurements of audio circuits, using an oscilloscope. Measurements were taken under two conditions. The first is with no input signal, just white noise so conditions can be reproduced easily. The second is with an input signal having a 1000 Hz tone modulated ±3kHz.

TABLE 2. TYPICAL AUDIO LEVELS (V p-p)

Measured At	On Noise	On Tone
U2 pin 10 (discrim.):	4	2
E5 (discriminator out):	3	1.5
U2 pin 13 (noise ampl):	4	0.4
Top of volume control:	0.8	0.2
Across 8Ω spkr term:	12	10

PARTS LIST FOR R144

Note: Capacitor values and helical resonator vary with frequency segments. Above 150 MHz, values may vary.

Ref #	Value (marking)
C1	18 pf
C2	62 pf
C3	.001 uf chip capacitor
C4	not assigned
C5	.001 uf (1nK or 1nM)
C6	4 pf
C7-C8	.001 uf chip capacitor
C9	.01 uf disc (103)
C10	.001 uf (1nK or 1nM)
C11	2 pf
C12	2 pf
C13	2 pf
C14	3 pf
C15	39 pf
C16	Piston trimmer, 2-11.2 pf
C17-C18	150 pf (151)
C19	.001 uf (102 or 1nK)
C20	68 pf
C21	1 pf
C22	7 pf (TXCO option only - see text)
C23	68 pf
C24	.01 uf disc (103)
C25-C26	.001 uf (1nK or 1nM)
C27	22 pf
C28	0.5 pf
C29	22 pf
C30	.01 uf disc (103)
C31	.001 uf (102, 1nM, or 1nK)
C32	0.5 pf
C33	47 uf electrolytic
C34	470 uf electrolytic
C35	10 uf electrolytic
C36	0.15 uf (red)
C37	0.1 uf monolithic (104)
C38	0.15 uf (red)
C39	.01 uf disc (103)
C40-C41	.001 uf (102, 1nM, or 1nK)
C42	.01 uf disc (103)
C43	0.47 uf electrolytic
C44	62 pf
C45	220 pf (221)
C46-C48	0.1 uf monolithic (104)
C49	120 pf
C50	0.47 uf electrolytic
C51	20 pf
C52	20 pf
C53	.047 uf chip capacitor
CR1	not used
CR2-CR3	1N4148 (may not be marked)
E1	Not assigned
E2-E5	Socket pins
FL1-FL4	Matched xtal filter set
FL5	Ceramic filter (blue)
J1	RCA jack
JMP-1	Jumper - see dwg
L1	2-1/2 turns (red)
L2	7A-691F IF transformer
L3-L4	6-1/2 turns (blue)
L5-L6	2-1/2 turns (red)
L7	0.22 uH rf choke (red-sil-red-red)
L8	455kHz IF transformer p/n 831-5 or YMC-15002 or T1003
L9	0.22 uH rf choke (red-sil-red-red)
OV-1	Crystal oven (option)
Q1-Q2	N.E.C. 3SK122 or Philips BF-988 dual-gate mos fet (static handling pre-cautions required)
Q3-Q5	2N3904 or 2N4124
R1-R2	100K
R3-R4	not assigned
R5-R6	100K
R7	180 ohms
R8-R11	not assigned
R12-R13	15K
R14	680 ohms
R15	not used
R16	330K
R17	1.2K
R18	470
R19	27K
R20	100K pot
R21	27K
R22	100K pot
R23	6.8K
R24	510K
R25	100K
R26	3.3K
R27	100K
R28	330K
R29	680 ohms
R30	3Ω (orn-blk-gold-gold) **-or-** 3.3Ω (orn-orn-gold-gold)
R31	47K
R32	15K
RT1	Thermistor (TXCO option only - see text)
T1	Not assigned
T2	Helical Res #1008 *[#1080]*
U1	LM-380N Speaker Amplifier
U2	MC-3359P IF Amplifier
U3	78L08 +8Vdc Regulator
Y1	Channel xtal (see text)
Y2	10.245 MHz, 62 pf IF xtal
Z1-Z6	Ferrite beads