

HAMTRONICS® R304 UHF FM RECEIVER: INSTALLATION, OPERATION, & MAINTENANCE

GENERAL INFORMATION.

There are some jobs a transceiver grade receiver just can't do, at least not well. That's where reliable Hamtronics® commercial quality receivers come in!

The R304 is the latest in a series of popular receivers for demanding applications which require exceptional sensitivity and selectivity. It is especially suited for repeaters, audio and data links, packet radio, and remote control. The R304 was designed to provide an alternative to our acclaimed R451 Receivers, offering instant setup without lengthy waits to obtain channel crystals. It is a single-channel uhf fm receiver for reception in the 440 MHz ham band or the adjacent commercial bands.

The R304 is our 4th generation uhf fm receiver, and it packs in features you've told us are important to you during our 35 years of designing receivers. It's up to the difficult jobs you've told us you have.

The R304 retains all of the popular features Hamtronics® receivers have been noted for. It uses triple-tuned circuits in the front end and excellent crystal and ceramic filters in the i-f with steep skirts for close channel spacing or repeater operation. The i-f selectivity, for instance, is down over 100dB at ±12 kHz away from the carrier, which is 40-50 dB better than most transceivers. Low noise fet's in the front end provide good overload resistance and 0.2µV sensitivity.

The R304 is designed for narrow-band fm with ±5 kHz deviation. The audio output will drive any load as low as 8Ω with up to 1 Watt continuous output or 2 Watts intermittent output. The receiver may be used with either voice or fsk data up to 9600 baud using an external data interface unit. An accessory TD-5 CTCSS Decoder unit is available for subaudible tone control.

The R304 features a new positive-acting, wide-range squelch circuit and additional output terminals for low-level squelched audio and discriminator audio as well as COS.

There are several models, which have minor variations in parts and microcontroller programming, to provide coverage as shown in table 1. Channel frequency is controlled by a

synthesizer with DIP switch channel setting.

The frequency reference for the R304 Receiver is a temperature compensated crystal oscillator (tcxo). This provides a temperature stability of ±2ppm over a temperature range of -30°C to +60°C.

INSTALLATION.

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 VOL-UME 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, since that could cause a break in the pcb solder connections.

The receiver board relies on the mounting hardware to provide the dc and speaker ground connections to the ground plane on the board; so metal standoffs and screws should be used for mounting.

Electrical Connections.

Power and input audio or data signals should be connected to the solder pads on the pc board with #22 solid hookup wire, which can be extended to a connector or feedthrough capacitors used on the cabinet in which it is installed. Be very careful not to route the wiring near the components on the left hand side of the board, which contains sensitive loop filter and vco circuits which could pick up noise from the wiring.

Power Connections.

The receiver operates on +13.6 Vdc at about 200 mA peak with full audio. Current drain with no audio is only about 60 mA. 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 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, such as the 1K to 20K input impedances of repeater controller boards. 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-380N-8 ic directly to the board for better heatsinking.

Antenna Connections.

The antenna connection should be made to the receiver with an RCA plug of the low-loss type made for rf. We have them available if you need one.

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 RCA 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

Table 1. Quick Specification Reference

Model R304-0	400.000 – 409.995 MHz
Model R304-1	410.000 – 419.995 MHz
Model R304-2	420.000 – 429.995 MHz
Model R304-3	430.000 – 439.995 MHz
Model R304-4	440.000 – 449.995 MHz
Model R304-5	450.000 – 459.995 MHz
Model R304-6	460.000 – 469.995 MHz
Sensitivity (12dB SINAD):	0.2µV
Squelch Sensitivity:	0.15µV
Adjacent Channel Selectivity:	±12 kHz at -100dB!
Image Rejection:	60dB
Modulation Acceptance:	±7.5 kHz
Audio Output:	up to 2 Watts (8 ohms).
Operating Power:	+13.6Vdc at 60-200 mA, depending on audio level.
Size:	4 in. W x 3-7/16 in. D (plus pot. shafts)

soldering the cable, keep the stripped ends as short as possible.

☛ *We recommend you always use antennas with a matching network which provides a dc ground on the driven element. This reduces chances of static buildup damaging the input stage of the receiver as well as providing safety for the building and other equipment.*

OPTIONS.

Repeater Use.

E5 provides a COS (carrier operated switch) output which may be connected to a COR module to turn a transmitter on and off. The output level is about 8V unscelched and 0V scelched. There is a resistor in series with the output to limit current. Therefore, the voltage that appears at the COR board will depend on the load resistance at the input of that board. For best results, be sure that the input resistance of the COR board is at least 47K. If the input resistance is too low, no damage to the receiver will occur; but the squelch circuit hysteresis will be affected.

If your repeater controller uses discriminator audio, rather than the speaker output, filtered discriminator audio is available at E4. The level is about 2V p-p. *Note that discriminator audio is not de-emphasized or squelched.* If you need audio which is squelched, take it from Repeater Audio terminal E1.

If your controller uses low level audio and has a high input impedance (20K or higher), squelched audio can be obtained from E1 independent of the VOLUME control.

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 E4 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 +3.3Vdc.

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 TP-3. This voltage is a function of the noise level detected in the squelch circuit. It also varies with SQUELCH control setting. With the SQUELCH set to where the squelch just closes, the dc voltage at

TP-3 is about -0.5V with no signal and +0.75 with full quieting signal. You can tap off this test 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-5 Subaudible Tone Decoder or a similar module, connect its audio input to *DISCRIMINATOR* terminal E4. 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-5 to E1 on the receiver.

ADJUSTMENTS.

Frequency Netting.

All crystals age a little over a long period of time; so it is customary to tweak any receiver back onto the precise channel frequency once a year during routine maintenance. This adjustment is called "netting", which is a term going back to days when all stations on a network would initially adjust their VFOs to all be on the same exact frequency before operating as a net.

Because modern solid state equipment doesn't require much routine maintenance, many receivers don't get their oscillators tweaked as a matter of routine any more, but they should.

The adjustment should be done using an 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.

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 bit in the end. (See A2 Alignment Tool in our catalog.)

To perform this adjustment, it is first necessary to verify that the discriminator is properly adjusted. Do this by connecting a dc voltmeter to TP4. Connect a signal generator set for 10.700 MHz to TP5 (left side of coil L9), and set the level for a relatively strong signal so there is very little white noise. Adjust discriminator coil T2 for 3.3Vdc. Then, reconnect the signal generator to antenna connector J1, and set it for the precise channel frequency. You can also use a strong signal on the air if you are sure it is right on frequency. Adjust the TCXO

trimmer capacitor for 3.3Vdc (to match the voltage obtained with the 10.700 MHz signal).

Setting Channel Frequency.

The channel frequency is determined by frequency synthesizer circuits, which use a dip switch in conjunction with programming in a microcontroller to set the channel. The microcontroller reads the dip switch information and does mathematics, applying serial data to the synthesizer ic whenever power is applied. Following is a discussion of how to set the dip switch to the desired channel frequency.

☛ **NOTE:** *If the frequency is changed more than about 1 MHz, a complete alignment of the receiver should be performed, as described in later text. Optimum operation only occurs if the synthesizer is adjusted to match the frequency switch setting and all the tuned amplifier circuits are peaked for the desired frequency.*

To determine what channel frequency to use, the microcontroller adds the frequency information from the dip switch to a "base" frequency stored in eeprom used for microcontroller programming. Each model of the R304 Receiver has a particular base frequency. For example, the R304-4 has a base frequency of 440.000 MHz, as shown in Table 1.

Dip switch settings are binary, which means each switch section has a different weighting, twice as great as the next lower section. Sections have weights such as 5 kHz, 10 kHz, etc., all the way up to 2.56 MHz. (See Table 2 or the schematic diagram for switch values.) For very large increments, there is even a jumper which can be added to the board between E6 and E7 for a 5.12 MHz increment, although this is rarely used.

The system sounds cumbersome, but it really is fairly simple, and you don't need to do this frequently. A piece of paper or a small calculator is handy to aid in determining which sections of the switch to turn on. When done, you might want to record the switch settings in table 3 for future reference.

Begin by subtracting the base frequency, e.g., 440.000, from the desired frequency to determine the total value of all the switch sections required to be turned on.

For starters, if the difference is less than 5.120 MHz, you don't need to jumper E6 to E7. If there is a jumper

installed on the board, you can merely clip it out. (Note: this jumper is always used for the upper end of the amateur repeater band, from 445.120 to 450.000.)

If the difference is greater than 2.560 MHz, turn on switch #1, and subtract 2.560 from the difference frequency to determine the remainder. Otherwise, skip switch #1.

Do the same for each of the other sections, from highest to lowest weighting, in sequence. Each time you consider the remainder, turn on the switch section with the highest weighting which will fit within the remainder without exceeding it. Each time it is found necessary to turn on a switch section, subtract the value of that section from the remainder to get the new remainder.

As an example, let us consider how to set the Exciter for output on 449.150 MHz. The following discussion is broken down into steps so you can visualize the process easier.

a. 449.150 - 440.000 base freq. = 9.150 MHz remainder. Install jumper from E6 to E7 to do the upper part of the band, because the remainder is greater than 5.12.

b. 9.150 - 5.120 = 4.030 MHz remainder. Turn on switch #1, which represents the largest increment to fit remainder.

c. 4.030 - 2.560 value of switch #1 = 1.470 MHz. Turn on #2, which is 1.280 MHz, the largest increment to fit the remainder.

d. 1.470 - 1.280 = 0.190 MHz remainder. Turn on #5, which is 0.160 MHz, the largest increment to fit the remainder.

e. 0.190 - 0.160 = 0.030 MHz remainder. Turn on switch #8 and switch #9, which have values of .020 and .010, respectively, which adds up to the remainder of .030 MHz. Note that when the remainder gets down into the double digit range, it is very easy to visualize turning on multiple switch sections to satisfy the entire re-

mainder, such as we just did.

When we finished, we had installed the jumper and turned on switch sections 1, 2, 5, 8, and 9.

Note: Dip switch information is read by the synthesizer only when power is first applied. If switch settings are changed, turn the power off and on again.

Shortcut ---

If you have access to the internet, our website has a long table of numbers which gives the equivalent settings for every possible frequency. We couldn't print it here because it takes 13 printed pages of space. Go to <http://www.hamtronics.com/dipswitch.htm>. Look up the frequency, and it will give you all the switch settings and tell you if you need to connect the jumper. The address is case sensitive, and you must enter the address manually because there is no link on our web site to click on for this.

Tricks ---

Although most users will set up the Exciter on a single frequency and perhaps never change it, there may be applications where you want to change between two or more nearby frequencies. In such cases, it is helpful to note the switch settings for one of the frequencies and simply which of the lower value switch sections to change to raise or lower the frequency for the other channel. It is not necessary to recalculate the whole range of settings.

Another trick if you want to switch between two or three frequencies used regularly is to use a toggle switch or rotary switch and a series of 1N4148 diodes to provide +5V to the microcontroller inputs in place of the dip switch. The diodes isolate the lines from each other. This unit is not intended to be used in place of a transceiver with its fancy frequency programming, but for simple applications, several frequencies can be switched this way. The microcontroller automatically sends data to the synthesizer whenever the frequency information at its input is changed; so changing the rotary switch will clue the micro to do the change.

ALIGNMENT.

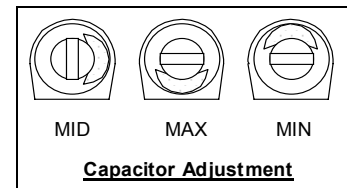
A complete alignment is needed whenever the frequency is changed by more than about 1 MHz. Alignment ensures that the frequency synthesizer is optimized at the center of the vco range and that all stages are

tuned to resonance.

Equipment needed for alignment is a sensitive dc voltmeter, a stable and accurate signal generator for the channel frequency, and a regulated 13.6Vdc power supply with a 0-200 mA meter internally or externally connected in the supply line.

The slug tuned coil should be adjusted with the proper .062" square tuning tool to avoid cracking the powdered iron slugs. Variable capacitors should be adjusted with a plastic tool having a small metal bit. (See A28 and A2 tools in catalog.)

All variable capacitors should be preset to the center of their range unless the unit has been previously aligned. (Do not preset the TCXO, which is already set to frequency at the factory.)



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.

a. Set the SQUELCH pot fully counterclockwise and the VOLUME pot just a little clockwise.

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

c. Set dip switches for desired frequency.

d. Connect voltmeter to TP1 (top lead of R5). Adjust vco coil L1 for +4Vdc. (Although the vco will operate over a wide range of tuning voltages from about 1V to 7V, operation is optimum if the vco is adjusted to 4V.)

e. Connect voltmeter to TP2 (top lead of R23). Adjust doubler variable capacitor C25 for a dip on the meter (minimum voltage). The reading normally will be about +5Vdc, and you will get a slight dip in the reading as you tune through resonance.

f. Adjust buffer variable capacitor

Device	Frequency Weight
Jumper E6-E7	5.120 MHz
Switch #1	2.560 MHz
Switch #2	1.280 MHz
Switch #3	640 kHz
Switch #4	320 kHz
Switch #5	160 kHz
Switch #6	80 kHz
Switch #7	40 kHz
Switch #8	20 kHz
Switch #9	10 kHz
Switch #10	5 kHz

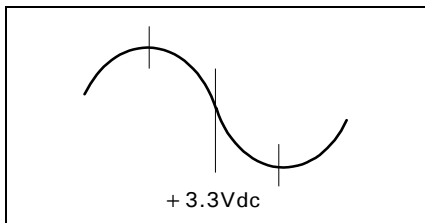
Frequency: _____	MHz								
Switch Sections Turned On: (circle)									
1	2	3	4	5	6	7	8	9	10
<input type="checkbox"/> Jumper									

C32 for a peak on the meter. This will be just a slight peaking (increase) of the voltage.

g. Connect stable signal generator to TP-5 (the left side of coil 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 so the frequency is accurate. Set level just high enough for full quieting. At 20 μ V, you should notice some quieting, but you need something near full quieting for the test (about 200 μ V).

h. Connect dc voltmeter to TP-4 (top lead of R30 on right side of board). Adjust discriminator transformer T2 for +3.3Vdc. Note that the transformer is fairly close from the factory and usually only requires less than $\frac{1}{4}$ turn in either direction.

☛ *Be careful not to turn the slug tight against either the top or bottom because the winding of the transformer can be broken. The tuning response is an S-curve; so if you turn the slug several turns, you may think you are going in the proper direction even though you are tuning further away from center frequency.*



i. Connect signal generator to J1 using a coax cable with RCA plug. Adjust signal generator to exact channel frequency, and turn output level up fairly high (about 1000 μ V). If necessary, adjust trimmer in TCXO to net the crystal to channel frequency, indicated by +3.3Vdc at test point TP-4. The frequency normally will be very close; so you may not need to adjust it at all except to compensate for aging.

Note: There are two methods of adjusting the mixer and front end. One is to use a voltmeter with test point TP-3, which is the top lead of R26. 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. With SQUELCH control fully ccw, the dc voltage at TP-3 varies from -0.5 Vdc with no signal (full noise) to +0.8 Vdc with full quieting signal.

The other method is to use a regular professional SINAD meter and a tone modulated signal.

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 TP-3 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.

j. Connect dc voltmeter to TP-3. Set signal generator for relatively weak signal, one which shows some change in the dc voltage indication at TP3. Alternately peak RF amplifier and mixer variable capacitors C27, C62, C39, C38, and C30 until no further improvement can be made.

When properly tuned, sensitivity should be about 0.15 to 0.2 μ V for 12 dB SINAD.

☛ Mixer output transformer T1 normally should not be adjusted. It is usually set exactly where it should be right from the factory. The purpose of the adjustment is to provide proper loading for the crystal filter, and if misadjusted, ripple in the filter response will result in a little distortion of the detected audio. If it becomes necessary to adjust T1, tune the signal generator accurately on frequency with about 4.5kHz fm deviation using a 1000 Hz tone. In order of preference, use either a SINAD meter, an oscilloscope, or just your ears, and fine tune T1 for minimum distortion of the detected audio.

THEORY OF OPERATION.

The R304 is a frequency synthesized uhf fm Receiver. Refer to the schematic diagram for the following discussion.

Low noise dual-gate mos fet's are used for the RF amplifier and mixer stages. The output of mixer Q7 passes through an 8-pole crystal filter to get exceptional adjacent channel selectivity.

U4 provides IF amplification, a 2nd mixer to convert to 455 kHz, a discriminator, noise amplifier, and squelch. Ceramic filter FL5 provides additional selectivity at 455 kHz. The noise amplifier is an op amp active filter peaked at 10 kHz. It detects noise at frequencies normally far above the voice band. Its output at pin 11 is

rectified and combined with a dc voltage from the SQUELCH control to turn a squelch transistor on and off inside the ic, which grounds the audio path when only noise is present. Inverter Q9 provides a dc output for use as a COS signal to repeater controllers.

The injection for the first mixer is generated by voltage controlled oscillator (vco) Q1. The injection frequency is 10.700 MHz below the receive channel frequency, and the vco operates at one half the injection frequency. The output of the vco is doubled by Q2 and buffered by Q3 to minimize effects of loading and voltage variations of following stages from modulating the carrier frequency. The buffer output is applied through a double tuned circuit (L5 and L10) to gate 2 of mixer Q7.

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/C33 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 temperature compensated crystal oscillator (tcxo). 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.

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 8Vdc. If the vco does not generate the proper frequency to allow the synthesizer to lock, the lock detector output will be much lower than the normal 4.5 to 5Vdc at TP1.

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 band, division schemes, reference frequency, and oscillator options is generated by the controller. Information about the base frequency of the band the Receiver is to operate on and the channel within that band is calculated in the controller based on information programmed in the eeprom on the controller and on channel settings done on dip switch S1 and jumper E6-E7. Whenever the microcontroller boots at power up, the microcontroller sends several bytes of serial data to the synthesizer, using the data, clock, and /enable lines running between the two ic's.

+13.6Vdc power for the Receiver is applied at E1. Audio output amplifier U5 is powered directly by the +13.6Vdc. All the other stages are powered through voltage regulators for stability and to eliminate noise. U6 is an 8Vdc regulator to power IF amplifier U4, RF amplifier Q6, mixer Q7, and the vco, buffer, and phase detector in the synthesizer. Additional filtering for the vco and buffer stages is provided by capacitance amplifier Q4, which uses the characteristics of an emitter follower to provide a very stiff supply, eliminating any possible noise on the power supply line. Q8 provides a stiff +5Vdc supply for the frequency synthesizer and microcontroller, which are both low current consumption CMOS devices.

TROUBLESHOOTING.

General.

The usual troubleshooting techniques of checking dc voltages and signal tracing with an RF voltmeter probe and oscilloscope will work well in troubleshooting the R304. DC voltage charts 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.

Current Drain.

Power line current drain normally is about 60 mA with volume turned down or squelched and up to 200 mA with full audio output.

If the current drain is approximately 100 mA with no audio output, check to see if voltage regulator U6 is hot. If so, and the voltage on the 8V line is low, there is a short circuit on the +8Vdc line somewhere and U6 is limiting the short circuit current to 100mA to protect the receiver from damage. If you clear the short circuit, the voltage should rise again. U6 should not be damaged by short circuits on its output line; however, it may be damaged by reverse voltage or high transient voltages.

Audio Output Stage.

Note that audio output ic U5 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-380N-8 ic directly to the board for better heatsinking.

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. This is fairly common with lightning damage.

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 present at U1-pin 11 with no input signal. (Between pins 10 and 11 of U1 is an op-amp active filter tuned to 10 kHz.)

RF Signal Tracing.

If the receiver is completely dead, try a 10.700 MHz signal applied to TP-5 (the left side of coil L9), using coax clip lead. Connect coax shield to pcb ground. Set level just high enough for full quieting. At 20 μ V, you should notice some quieting, but you need something near full quieting for the test, which requires about 200 μ V.

You can also connect the 10.700 MHz clip lead through a .01 μ f 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.

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, which can occur due to transients or reverse polarity on the dc power line. Also, it is possible to have the input gate (gate 1) of the RF amplifier fet damaged by high static charges or high levels of RF on the antenna line, with no apparent change in dc voltages, since the input gate is normally at dc ground.

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 tuning voltage at TP1. It should be about +4Vdc. Actual range over which the unit will operate is about +1Vdc to just under +8Vdc. However, for optimum results, the vco should be tuned to allow operation at about +4Vdc center voltage.

c. Check the operating voltage and bias on the vco, doubler, and buffer.

d. Check the 10.240 MHz TCXO signal at pin 1 of the synthesizer ic (actually best to check at pad next to pin 1; avoid trying to probe surface mount ic leads which are close together). A scope should show strong signal (several volts p-p) at 10.240 MHz.

e. Check the oscillator at pin 1 of microcontroller ic U1 with a scope. There should be a strong ac signal (several volts p-p) at the oscillator frequency.

f. The data, clock, and /enable lines between the microcontroller and synthesizer ic's should show very brief and very 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 100 μ Sec/div, 5Vdc/div, and normal trigger on rising pulse.

g. Check the microcontroller to see that its /reset line is held low momentarily when the power is first applied. C1 works in conjunction with an internal resistor and diode in the ic to make C1 charge relatively slowly when the power is applied. It should take about a second to charge up.

h. Check the switch and E6-E7 jumper settings to be sure you have the correct frequency information going to the microcontroller.

i. If you have a scope or spectrum analyzer, you can check the output pin of the divide by 64 prescaler at pin 13 of U2. There should be a strong signal (several volts p-p) at about 3.3 MHz. If this signal is absent, there may not be sufficient level of sample signal from the buffer at U2 pin 11. *Be careful not to short adjacent pins of the ic.*

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 fluorescent 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 Receiver, such as motors. In addition, it helps greatly to prevent the molded coil from vibrating with respect to the shield can. Both the coil and can are soldered to the board at the bottom, but the top of the coil can move relative to the can and therefore cause slight changes in inductance which show up as frequency modulation. Securing the top of the plastic coil form to the shield can with some type of cement or clear nail polish greatly reduces the microphonic effects. This practice is recommended in any installation where vibration is a problem.

Excessive noise on the dc power

supply which operates the Receiver can cause noise to modulate the synthesizer output. Various regulators and filters in the Receiver 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 Receiver.

Other usual practices for mobile installations are recommended, such as connecting the + power and ground return lines directly to the battery instead of using cigarette lighter sockets or dash board wiring.

To varying degrees, whine from the 5kHz reference frequency may 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 4Vdc center if there is dc 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.

Phase noise is a type of white noise which phase locked loop synthesizers produce. Many efforts are made during the design of the equipment to reduce it as much as possible. The phase noise in this unit should be almost as good as a crystal oscillator radio. If you notice excessive white noise even though the signal is strong, it may be caused by a noisy vco transistor, Q1. Try swapping with Q2 or Q3, which are the same type and see if that helps. When using a replacement transistor for repairs, be sure to use one of good quality.

If you suspect noise is being introduced in the synthesizer, as opposed to the signal path from the antenna to the detector, you can listen to the injection signal at 10.700 MHz below the channel frequency on a receiver or service monitor and hear what just the injection signal sounds like. Put a pickup lead on top of the Receiver board so you have a strong sample to hear so you are sure the noise is not due to weak signal pickup at the test receiver.

Typical Dc Voltages.

Tables 4-6 give dc levels 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 charts should be used with a logical troubleshooting plan. All voltages are positive with respect to ground except as indicated.

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 trying to connect meter 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 Levels.

Table 7 gives rough measurements of audio levels.. Measurements were taken using an oscilloscope, with no input signal, just white noise so conditions can be reproduced easily.

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 surface mount ic U2, 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 you replace the output transistor for any reason, be sure to space the metal can about the thickness of an index card above the pc board ground plane to avoid grounding the case, which is connected to the collector. Do not use any dielectric material under the transistor other than air. Also, be sure to put the heatsink on the transistor. Stator leads of piston

trimmer cap C6 can also short to the ground plane and require such spacing away from the board.

Table 4. Typical Test Point Voltages

TP1	Tuning V.	Normally set at +4Vdc
TP2	Buffer	approx. +5Vdc
TP3	Sig. Level	With SQUELCH control fully ccw, varies from -0.5 Vdc with no to +0.85 Vdc full quieting.
TP4	Freq.	Varies with frequency of input signal. Voltage at this point normally is adjusted for +3.3Vdc with a signal exactly on frequency. Can vary a little without being a problem.

Table 5. Typical Xstr DC Voltages

Xstr	Stage	E(S)	B(G1)	C(D)	G2
Q1	vco	1.0	1.5	7	-
Q2	doubler	0	0.65	5.2	-
Q3	buffer	0	0.65	4.6	-
Q4	dc filter	7.0	7.6	7.8	-
Q6	RF ampl	0	0	8	4
Q7	Mixer	0.5	0	8	2.6
Q8	5V regulator	5	5.6	8	-
Q9	sq. open	0	0	8	-
	sq. closed	0	0.65	0.1	-

Table 6. Typical IC DC Voltages

U1-1	4	U1-2	4
U2-1	2.1	U2-10	2.5
U2-2	5V locked (2.5V unlocked)	U2-11	2.5
U2-3	8 *	U2-12	5
U2-4	8 *	U2-13	3 *
U2-5	8	U2-14	5
U2-6	0-8 (4V tuned)	U2-15	*
U2-7	0	U2-16	*
U2-8	4.8	U2-17	5
U2-9	5 *	U2-18	0
	* = pin not used	U2-19	0
		U2-20	2.3
U4-1:	8	U4-10:	0.75
U4-2:	7.5	U4-11:	1.4
U4-3:	7.6	U4-12:	0.55 (with sq. just closed)
U4-4:	8	U4-13:	0V (sq. open), 7.6V (sq. closed)
U4-5:	7.6	U4-14:	0
U4-6:	7.6	U4-15:	0
U4-7:	7.6	U4-16:	1.8
U4-8:	8		
U4-9:	3.3 (Varies w/ freq.)		
U5-1:	0	U5-5:	0
U5-2:	0	U5-6:	6
U5-3:	0	U5-7:	13.6
U5-4:	0	U5-8:	7

Table 7. Typical Audio Voltages

Audio Test Point	Normal Level
U4-9 (Discriminator)	3V p-p audio
E4 (Disc Output)	2V p-p audio
TP-6	1V p-p audio
E1 (Repeater Output)	1V p-p audio
U4-11, top of R27 (noise ampl output)	2.5V p-p noise
Top of Vol Cont R32	300mV p-p audio
U5-2 (af ampl input)	0 to 100mV p-p (depends on volume control)
U5-6 or E2 (speaker ampl output)	0 to 8V p-p audio

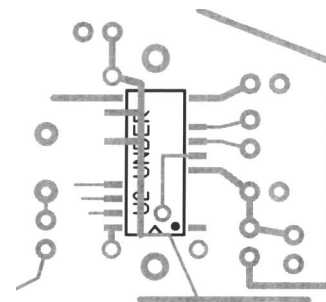


Figure 1. Placement of U2 Under PC Board (dot is pin 1).

PARTS LIST FOR R304 UHF FM RECEIVER.

Following are notes specific to certain parts.

① Microcontroller must be factory programmed for proper band.

② Resistors used as test point. These must be installed on the board oriented properly and with the top loop an extra 1/6" high to allow for connections to the loop later. (See detail in component location diagram.)

③ This part must be installed with a small space (about the thickness of an index card) under the part to prevent the bottom of the part from shorting to the ground plane.

④ This part is surface mounted on rear of board.

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

Ref Desig	Value (marking)
C1	1 µf electrolytic
C2 ④	0.1µf
C3	n/a
C4 ④	0.1µf
C5	10µf electrolytic
C6	100µf electrolytic
C7	n/a
C8 ④	100pf
C9 ④	0.1µf
C10	0.15µf mylar (red)
C11 ④	.01µf
C12-C13 ④	.001uf
C14	100µf electrolytic
C15 ④	0.1µf
C16 ④	6pf
C17,C18 ④	390pf
C19	100µf electrolytic
C20 ④	10pf
C21 ④	47pf
C22 ④	4pf
C23 ④	100pf
C24 ④	.001uf
C25	4.5pf var. (white ceramic with brown cap.)
C26 ④	2pf
C27	4.5pf var. (white ceramic with brown cap.)
C28 ④	6pf
C29 ④	100pf

C30	4.5pf var. (white ceramic with brown cap.)
C31 ④	100pf
C32	4.5pf var. (white ceramic with brown cap.)
C33 ④	2pf
C34	n/a
C35 ④	0.5pf
C36	n/a
C37 ④	100pf
C38-C39	4.5pf var. (white ceramic with brown cap.)
C40 ④	.001uf
C41 ④	5pf
C42 ④	6pf
C43 ④	5pf
C44	0.47µf electrolytic
C45	0.15µf mylar (red)
C46-C47 ④	.001uf
C48	0.15µf mylar (red)
C49-C50 ④	.01µf
C51	470µf electrolytic
C52	10µf electrolytic
C53	1µf electrolytic
C54	100µf electrolytic
C55	100µf electrolytic
C56 ④	220pf (221)
C57 ④	68pf
C58-C60 ④	0.1µf
C61 ④	.001uf
C62	4.5pf var. (white ceramic with brown cap.)
D1	BB809 varactor diode
D2-D3	1N4148 switching diode
FL1-FL4 ③	10.7MHz crystal filter (matched set of 4)
FL5	455kHz ceramic filter
J1	RCA Jack
L1	1½ turn slug-tuned coil (brn)
L2	0.22µH RF choke (red-sil-red-red)
L3-L4	2¾ turn air wound coil
L5	4¾ turn air wound coil
L6	1¾ turn air wound coil
L7	2¾ turn air wound coil
L8	5¾ turn air wound coil
L9	2¾ turn air wound coil
L10	5¾ turn air wound coil
Q1	2N5770
Q2-Q3	PN5179
Q4	2N3904
Q5	n/a
Q6-Q7	3SK122 MOS FET
Q8	2N3904
Q9	2N5770

R1	47Ω
R2 ④	100K
R3 ④	2meg
R4 ④	47K
R5 ②	22K
R6	100K
R7	330K
R8 ④	2.2K
R9 ④	10K
R10	6.8K
R11	3.9K
R12	180Ω
R13 ④	47Ω
R14 ④	15K
R15 ④	470Ω
R16	180Ω
R17-R18 ④	100K
R19	15K
R20 ④	2.2K
R21 ④	15K
R22 ④	2.2K
R23 ②	470Ω
R24 ④	27Ω
R25	180Ω
R26 ④	47K
R27 ④	330K
R28 ④	4.7K
R29 ④	680Ω
R30 ②	1.2K
R31 ④	22K
R32	100K panel mount pot.
R33 ④	2.2K
R34 ④	4.7K
R35 ④	47K
R36	330K
R37	3.9M
R38 ④	47K
R39	100K panel mount pot.
R40 ④	47K
R41 ④	100K
R42 ④	47K
S1	10 pos. DIP switch
T1	10.7MHz IF xfmr (7A-691F)
T2	455kHz IF transformer p/n 831-5 or YMC-15002 or T1003
U1 ①	MC68HC705J1A µP
U2 ①	MC145190F synthesizer
U3 ①	10.240MHz TCXO
U4	MC3361BP if ampl-det
U5	LM380N-8 audio output
U6	78L08 regulator
Y1 ③	10.245 MHz crystal
Z1-Z4	Ferrite bead, prestrung

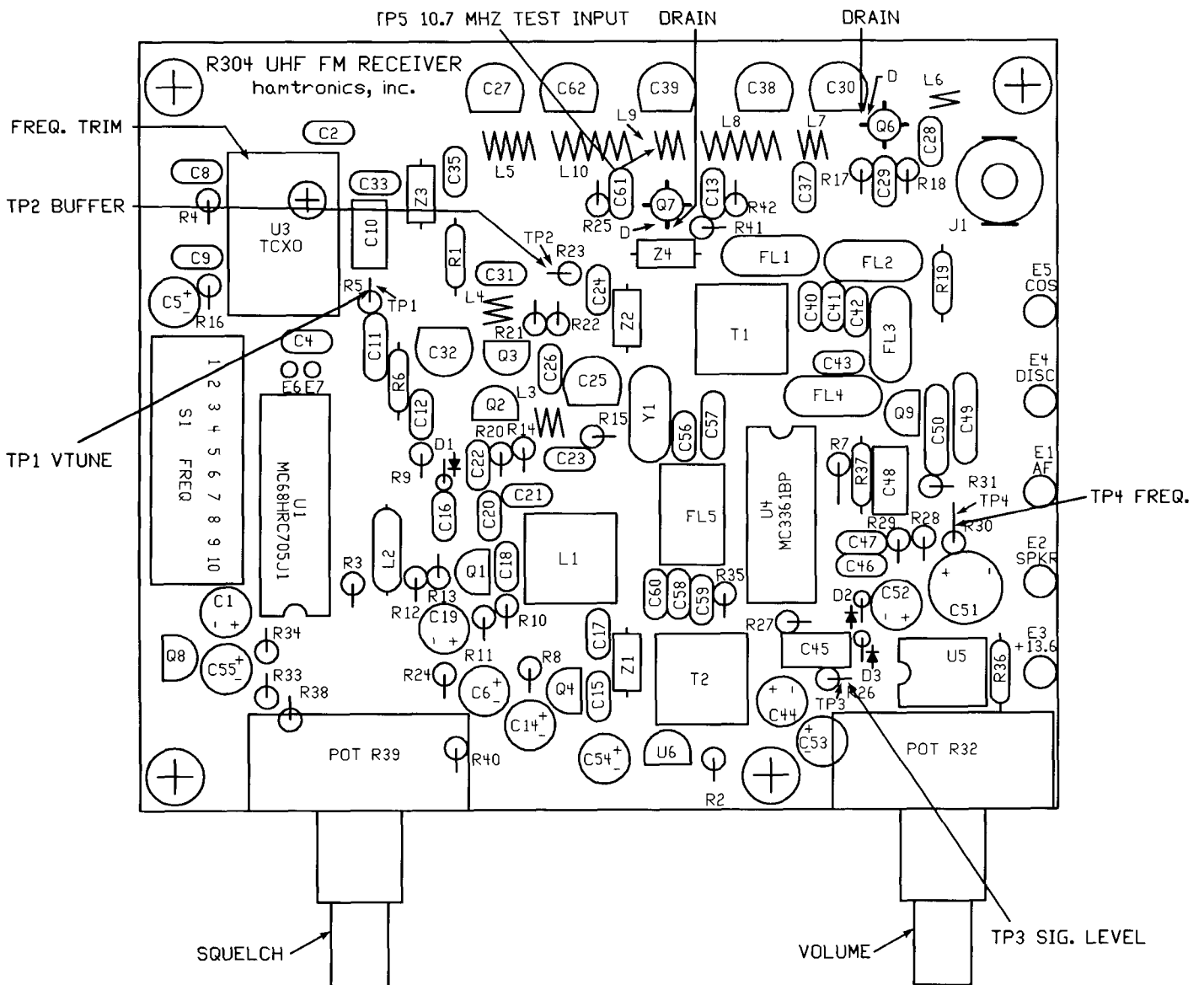
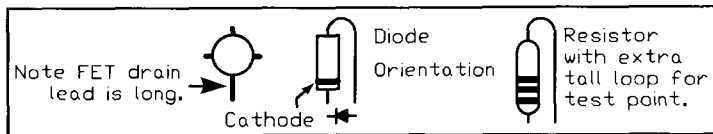


Figure 2. R304 UHF FM Receiver, Component Locations

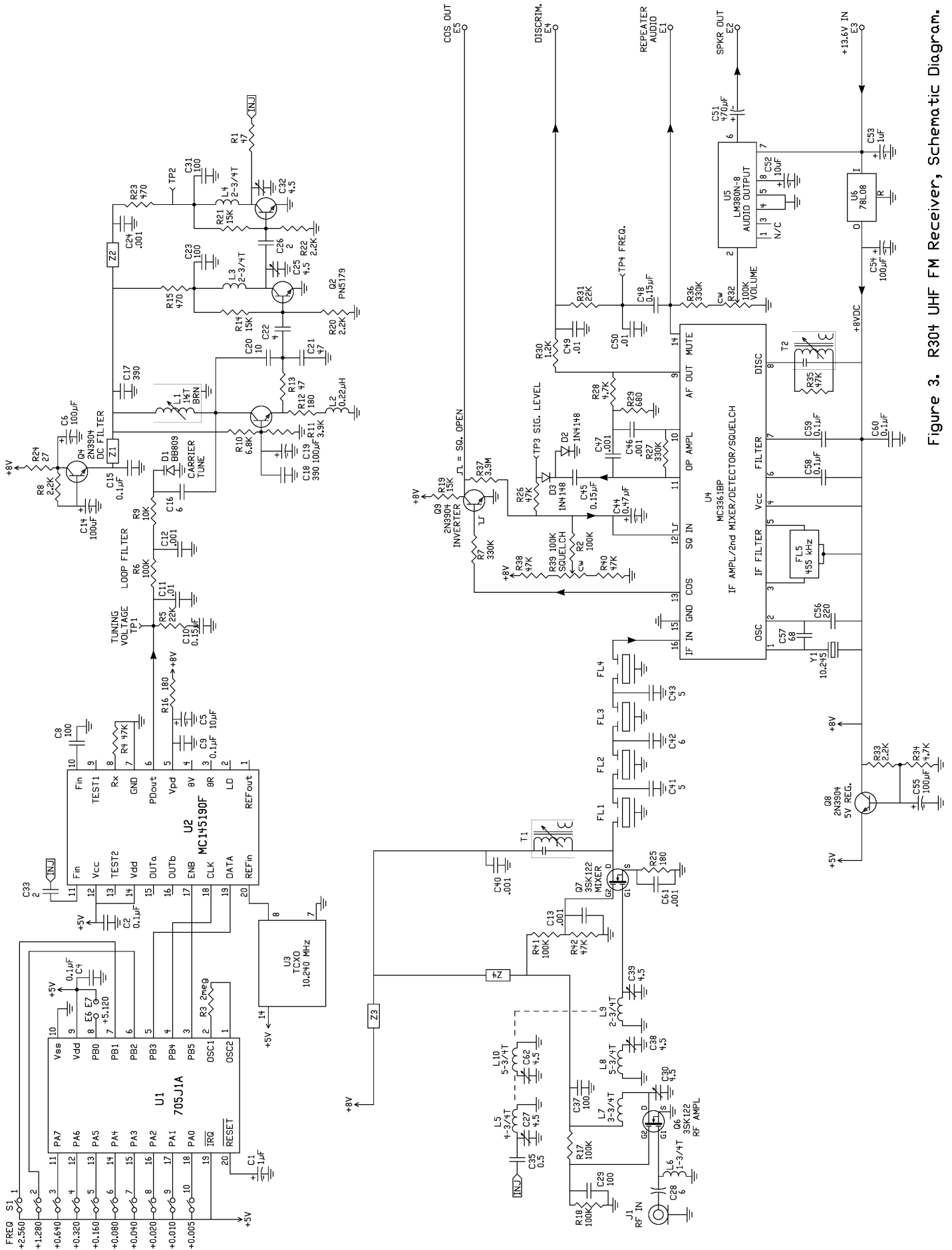


Figure 3. R304 UHF FM Receiver, Schematic Diagram.