# HAMTRONICS® R123 VHF RUNWAY LIGHT CONTROLLER: INSTALLATION, OPERATION, & MAINTENANCE

## GENERAL INFORMATION.

### Functional Description.

The R123 Receiver is designed for small airports to facilitate pilot control of lighting. It builds on proven frequency synthesized receiver technology Hamtronics® vhf and uhf fm repeater receivers have been noted for. It is tunable over a range of 118-137 MHz in 25kHz increments. It uses triple-tuned circuits in the front end and crystal and ceramic filters in the i-f with steep skirts for excellent adjacent channel and out-of-band selectivity.

The R123 has a microcontroller which is responsible for watching the squelch to determine what is happening on the air. It responds to mic clicks as follows.

- Runway lights may be activated by keying the aircraft comm. radio microphone several times, typically three times in five seconds.
- If the airport is equipped with variable intensity lighting, the pilot can select intensities by keying the microphone 3, 5, or 7 times in a 5-second period.
- Lights remain on for a specific period of time, usually 15 minutes.
- A dip switch option permits change in intensity after initial turn-on. Front panel LED indicates when lights have been activated at any intensity.
- A second LED indicates when the squelch is open.

The R123 Receiver has an audio output; however, this is an fm receiver, not am, to provide excellent squelch carrier detection; therefore, even though you can listen to the channel, it will not detect am signals as an ordinary aircraft receiver will. You will be able to hear if there is a signal or any interference on the channel.

**Table 1. Quick Reference**

**Frequency range:** 118-137 MHz
**Channel spacing:** 25 kHz. Frequency set with dip switch; (repeaking coils required for freq change more than 2 MHz - use A1 tool)
**Squelch sensitivity:** adjustable 0.3 - 2 µV
**12dB sinad sensitivity:** 0.3 µV
**Adjacent channel selectivity:** 100 dB
**Image rejection:** 60-70dB
**Temp stability:** ±2ppm -30°C to +60°C
**Control outputs:** three separately controlled open-collector switching transistors able to sink up to 50 mA to ground on circuits up to 15Vdc. External solid state relays can be controlled for high current loads.
**Antenna connector:** RCA jack (50Ω)
**Power and control connections:** solder terminals on pc board
**Size:** 4 in wide, 3 in deep, 1.25 in high.
**Operating Power:** +13.6Vdc +-10% at approx. 50mA, depending on audio level

## INSTALLATION.

### Mounting.

Some form of support should be provided under the pc board, generally mounting the board with standoffs to a chassis.

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

### Electrical Connections.

The antenna connection is made with a coaxial connector. All other connections are made at solder terminals on the pc board. Table 2 identifies the terminals used for these connections. The view of the pc board at the rear of the manual identifies the solder terminals on the pcb module.

Power and control signals should be connected to the unit with #22 solid hookup wire. Be careful not to route the wiring close to the components on the left hand side or rear of the pc board, which contains sensitive rf circuits which could pick up noise or be detuned from the wiring.

**Be sure to solder wires only on the *bottom* of the board.** A short circuit can be created by soldering on the top.

### 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 practical. When soldering the cable, keep the stripped ends as short as possible.

### Power Connections.

The receiver operates on +13.6 Vdc ±10%. Current drain is about 50 mA. A well filtered power supply should be used. There is a voltage regulator on the board.

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 soldered to E6 ground terminal on the board. Be sure to observe polarity to avoid damage!

### Optional 12Vdc Power Adapter.

The A40 adapter is rated for 12Vdc at 200 mA load. It is a filtered dc power source but is not regulated. Since there is a voltage regulator on the receiver board, a regulated power supply is not necessary, as long as it is a well-filtered supply.

The adapter actually puts out close to 18Vdc with no load and drops to about 15-16Vdc with the load a receiver presents.

To install the adapter, clip the ends of the leads off and strip them about ¼ inch. The lead with the small grooves molded into it is positive, and the smoother lead is negative.

The stripped leads can be soldered to the + power input and ground terminals of the pc board. *Be sure to observe polarity to avoid damaging the receiver module. Because it is difficult to tell the ribbed lead from the smooth lead, double check before applying power to the radio to avoid damage.*

### Control Outputs.

The R123 has three output transistors used to turn on one or more relays. These are called Output A, Output B, and Output C, normally corresponding to 3, 5, and 7 clicks of the mic button. Each transistor can sink as much as 50mA at voltages up to +15Vdc. In other words, the transistors switch ground on and off and can be used to ground the (-) end of a relay input.

*CAUTION: Be careful not to exceed the voltage or current capabilities of the transistors. Also, be very careful about transients generated by inductive loads, such as relays.* All mechanical relay coils must have a diode connected across the coil to absorb transients from inductive kickback, which can reach several hundred volts when the coil is switched off. See application diagrams, which follow, for examples of how to connect the diode, which basically must conduct any energy of reverse polarity; so the diode is connected backwards from regular polarity of the power source. Therefore, the diode does not conduct unless there is a reverse voltage. ***NOTE THAT SOLID STATE RELAYS DO NOT HAVE A COIL; SO THEY DO NOT NEED A DIODE. SUCH RELAYS ARE PREFERRED BECAUSE THEY DO NOT PRESENT A DANGER TO THE RADIO.***

The relay should be mounted in an electrical cabinet for safety. If you use a solid state relay, it should be mounted on a metal surface for proper heatsinking. For instance, our A95 relay may be operated with a load up to 4Amp at room temperature with no heatsink. For operation at elevated temperatures or for load currents over 4 Amp (up to 10 Amp), the relay needs to be heat sunk to a large metal surface, and a good size electrical cabinet should provide ample surface for that.

To provide heatsinking for the relay, it must be mounted on a bare metal surface. If necessary, a large aluminum plate can be installed in the cabinet to provide bare metal for heatsinking. Before screwing the relay to the heatsink surface, spread a very thin layer of heatsink compound on the metal relay base to transfer the heat to the heatsink.

*CAUTION: Installer is responsible to ensure that proper heatsinking is provided. Warranty does not cover damage to relay which might result from improper installation.*

To allow pilot control of runway lights (PCL), the three output transistors are turned on by clicking the microphone button in the aircraft, as explained later under Operation. Three clicks in five seconds turns on Output A, five clicks turns on Output B, and seven clicks turns on Output C. The outputs can be used to control relays to turn on the ac power for the lights. Think about how you want the lights to operate before wiring the outputs. There are ways to provide different options, depending on the wiring. The three outputs can be used to control relays for three levels of lighting. (More information in Operation section.)

Figure 2 shows two ways to turn on large ac loads with the receiver. The preferred method is to use a modern solid state relay which can be controlled with a small dc current and switch large ac loads. Solid state relays can be obtained from Hamtronics as an accessory. Figure 2A shows how to wire a solid state relay, with the negative side of the control input switched by the output of receiver.

The older method of switching large loads is to use a small dc relay to turn on a large ac power contactor. This method is shown in figure 2B. Make sure that the smaller relay can be operated with less than 50mA of current, and be sure to place a reverse polarity diode across the coil to prevent inductive kickback from damaging the receiver. This diode can be almost any type, including 1N4148, 1N914, 1N4001.

**Table 2. Connections.**

| Function | Terminal |
|---|---|
| Ground | Mtg Screws & E6 |
| +13.6 Vdc Power | E3 |
| Speaker | E2 |
| Relay Out A (3 clicks) | E7 |
| Relay Out B (5 clicks) | E8 |
| Relay Out C (7 clicks) | E9 |

(E1, E4, & E5 normally not used)

# OPERATION.

## General.

The R123 has a microcontroller which is responsible for watching the squelch to determine what is happening on the air. Green LED D5, on the left, indicates when a signal is detected. Red LED D6, on the right, is used to indicate when any one, two, or three of the outputs are turned on by the receiver.

## Squelch Setting.

The squelch control, which is the small trim pot on the left side of the board, sets the threshold at which signals will be detected. Green LED D5, on the left, indicates when a signal is detected. The proper way to set the squelch threshold is to turn the pot ccw until the LED comes on and then turn it cw just past the point where the LED turns off again. Of course, do this when no one is transmitting. If you have a speaker connected, you can also listen to determine when the squelch is open.

**There may be installations where this default setting is too sensitive. If you get false triggering of the relay, try setting the squelch control a little more clockwise.** Since aircraft normally have line of sight communications with the airport, most times a receiver does not need maximum sensitivity.

## Option Switch.

Ten position dip switch S1 is used to program the microcontroller for two functions. Switch section 1 provides selection of a timer option. Sections 2-10 set the channel frequency.

Switch 1 selects an option to allow changes to be made by the pilot after initially turning on lights. If this switch is off, the receiver accepts only the first valid command until the timer expires, eg, 15 minutes. If this switch is on, the receiver will accept a new command while the timer is running, either another intensity or extending the current intensity.

Switch positions 2 through 10 are used to set the channel frequency. A detailed explanation appears later in the manual in alignment procedures.

## Pilot Control of Lighting.

If a pilot clicks his push-to-talk button three, five, or seven times within five seconds, runway lights can be activated with Outputs A, B, and C, respectively. Depending on wiring, this can turn on runway lights at up to 3 intensity levels.

The receiver is designed to meet FAA standards, which basically say the following:

The decoder must energize 1, 2, or 3 relays upon the receipt of a series (7 pulses maximum) of electrical pulses (microphone clicks) within a 5 second period, hold the relays energized for 15 minutes, and de-energize the relays after 15 minutes.

Further, a 5.0 second gate period must be started by the first pulse received. At the third pulse, the first relay must be energized. At the fifth pulse, the second relay must be energized. At the seventh pulse, the third relay must be energized.

If 2 or 3 relays are energized and a new series of pulses are received, at the third pulse, all relays except the first, must be de-energized and the timer reset for a full 15 minutes. At the fifth pulse, the second relay must be energized. At the seventh pulse, the third relay must be energized.

This option for allowing changes to be made after the initial setting is selected with dip switch #1, as previously explained.

When you install the system, carefully plan how you want the lights to respond to any possible condition. With the proper combination of programming and wiring the outputs to relays, you can make the lighting system operate smoothly and safely. Following are factors to be considered.

The three outputs can be used to control three different intensities of lights by turning

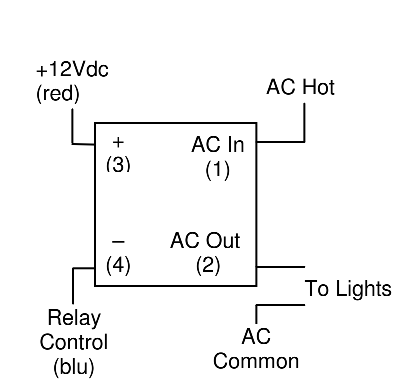



**Figure 2A. Solid State Relay Wiring.**

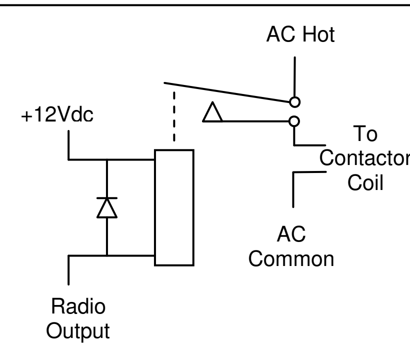



**Figure 2B. Small Relay Switching Power Contactor.**

on different electric circuits to the lights. More often, though, only a single intensity is used, especially with newer styles of lights, and any one of the three outputs can be used for the single relay to turn on those lights. Thus, by selecting which output you wire to the relay, you can require 3, 5, or 7 clicks to activate the lights.

The receiver has the option of allowing changes to the command after an initial command is executed. If the switch is on, subsequent commands will be carried out, otherwise, they will be ignored until the time delay is completed for turning off the lights. If you do not allow changes and someone, even unintentionally, sends a command, they cannot carry out another command for 15 minutes or whatever the time delay is set for.

Red LED (D6) on the front of the receiver will illuminate anytime a command is in effect, that is, whenever one of the outputs is activated. Note that multiple outputs can be turned on at once. Output A (and the red LED) always comes on when the first three clicks are received. Output B comes on if 5 or more clicks are received, and Output C comes on if 7 or more clicks are received within the 5 second window.

### If you have problems turning on lights.

A few users have commented that they have trouble turning on lights sometimes or that the lights turn off early. Here are a few things to consider.

The number of clicks is important. You must send exactly the correct number of clicks within 5 seconds. Requiring 5 or 7 clicks is a bit harder to send accurately than 3 clicks; so most airports use 3 clicks.

Dip switch position 1 may be turned on to permit changes to be made by the pilot after initially turning on lights. If this switch is off, the receiver accepts only the commands sent within the 5 second window beginning with the first click. After one or more outputs are turned on, no changes can be made for 15 minutes.

The receiver may also pick up signals a pilot is sending to a nearby airport if they use the same frequency you do. So always consider that a command might be coming from someone other than a pilot using your airport. It is good to use a unique channel frequency for your receiver. Most of our customers order receivers for 122.800 or 122.900MHz. So if you use one of these channels for your receiver, another nearby airport may also use that channel.

If you are picking up signals from pilots far away, it may be that your receiver is too sensitive. Because aircraft have line of sight to the airport, signals can be received over a great range. Your antenna may be too effective (if you use a big antenna), or you may need to adjust the squelch sensitivity in the receiver to prevent weaker signals from activating the receiver. Refer to the section on Squelch Setting above.

## FREQUENCY SETTING.

The channel frequency is determined by frequency synthesizer circuits, which use the DIP switch in conjunction with programming in the microcontroller to set the frequency. The microcontroller reads the dip switch information and does mathematics, applying data to the synthesizer ic. 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. It is anticipated that most customers will continue to use the alignment done at the factory for the frequency they specified. There is no reason to do anything unless you need to change frequencies. Be careful not to disturb the DIP switch if you don't need to change frequencies.*

To determine what channel frequency to use, the microcontroller adds the frequency information from the dip switch to the normal 120MHz "base" frequency (or alternate base frequency we use for receivers for frequencies very high or very low in the band, which are unusual).

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 25 kHz, 50 kHz, 100kHz, etc., all the way up to 12.775 MHz.

When done, you might want to record the switch settings in table 3 for future reference.

We make it easy by publishing a long table of possible settings on our website. Refer to the following link and be sure to type in the underscore characters…

http://www.hamtronics.com/dipswitch_R123_R317.htm

The table online has two sections to it. The first set of listings is for a 120MHz base frequency, which most receivers use. Because the dip switch has a range of less than the full band, we program the micro with a different base frequency for those few receivers sold for use at the very low or very high end of the aircraft band. Those settings are shown in the second section online.

Look up the frequency, and it will give you all the binary switch settings.

For example, here are settings for two common frequencies, using 120MHz base. Note that the X in the first position represents the option switch, not part of the frequency, as explained earlier.

122.800 MHz = `X0011 10000`
122.900 MHz = `X0011 10100`

## ALIGNMENT.

### General Information.

It is assumed that the Receiver was ordered for a particular frequency and aligned at the factory for that frequency. The following procedure is only necessary if you change frequencies by more than 1MHz. Most customers will never have to perform alignment.

Following are three alignment procedures. The first is alignment of the frequency synthesizer and receiver front end (rf amplifier and mixer). This must be done whenever the channel frequency is changed by more than 1 MHz. The R123 is a high performance receiver and is designed to be very selective. Therefore, retuning is necessary for optimum performance. The second procedure is alignment of the i-f stages, which normally is only necessary if some parts are replaced. The third procedure is trimming the TCXO (temperature compensated crystal oscillator) to exact frequency, which normally is never necessary.

### Equipment Needed.

Equipment needed for alignment is a sensitive dc voltmeter and a stable and accurate communications service monitor for the channel frequency.

The slug tuned coils in the receiver should be adjusted with the proper hex tuning tool to avoid cracking the powdered iron slugs. Variable capacitors and i-f transformers should be adjusted with a plastic tool having a small ceramic or metal bit. See our A1 Tuning Tool if you don't have one.

### Channel Frequency Alignment.

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.

a. Set dip switches for desired frequency.

b. Connect dc voltmeter to Osc Tune test point TP1 (pad on top of pcb). 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.)

c. Connect dc voltmeter to buffer TP2 (pad on top of pcb). Adjust buffer coil L2 for a peak.

d. Connect dc voltmeter to RF Tune test point TP4 (pad on top of pcb), or alternately, use a SINAD meter.

e. Connect service monitor signal generator output to J1 using a coax cable with RCA plug. Adjust signal generator to exact channel frequency, and set it for carrier output only.

f. During tuning, adjust service monitor signal output level as needed to get an indication within the range of the noise detector driving the test point for the voltmeter. Note that the test point level will be effective for tuning only with a relatively weak signal and will saturate with too strong a signal. Basically, you are reading the noise level in the squelch circuit.

g. Adjust L4, L5, L6, L7, and L8 for minimum voltage. Voltage goes down, not up, with increased signal level (trying to minimize noise).

### Alignment of I-F Stages.

a. Connect dc voltmeter to DISC pad E4 on top of pcb.

b. With no input signal (just noise), adjust i-f transformer T3 for +2Vdc on the meter.

*Be careful not to turn the slug tight against either the top or bottom because the winding of the transformer can be broken.*

### Oscillator Trimming.

If you suspect that the TCXO needs adjustment, which normally it does not, proceed as follows.

a. First, perform step b of the Channel Frequency Alignment procedure to be sure vco is set to frequency.

b. Set the service monitor for 10.700 MHz and connect rf output to TP3 on top of board.

c. Connect dc voltmeter to E4 as indicated for discriminator alignment above.

d. Use a 0.4 x 0.9mm ceramic tuning tool to adjust the small variable capacitor in the TCXO for +2V.

## THEORY OF OPERATION.

The R123 is a frequency synthesized vhf fm receiver, the design of which was chosen because of its vastly superior squelch action compared to an am receiver. However, since am audio is not detected, the receiver does not allow listening to aircraft transmissions, although you can listen to hear if there is any interference. It is optimized only for control, not for monitoring audio in the normal sense. Refer to the schematic diagram for the following discussion.

Low noise dual-gate mos fet's are used for RF amplifier Q4 and mixer Q5. The output of the first mixer is coupled through a 10.700 MHz crystal filter to the second mixer, which is in U3.

U3 provides IF amplification, a 2$^{nd}$ mixer to convert to 455 kHz, an fm detector, and squelch. Ceramic filter FL5 provides additional adjacent channel selectivity at 455 kHz.

The output of the fm detector at pin 9 of U3 is applied to an active filter stage, which is peaked at 10,000 Hz, looking for noise when there is no signal. The noise output is detected by D3/D4 and drives the squelch detector input at pin 12. A variable dc voltage from SQUELCH pot R25 is also applied to pin 12 through a summing circuit to allow squelch threshold adjustment.

The COS (carrier operated squelch) signal from pin 13 drives the IRQ interrupt input on microcontroller U1 to indicate when a signal is detected. It also turns switch Q7 on and off to illuminate green LED D5 to indicate when a signal is present to allow the Squelch pot to be properly set.

The injection frequency for the first mixer is generated by vco (voltage controlled oscillator) Q1. The injection frequency is 10.700 MHz above the receive channel frequency. The output of the vco is buffered by Q2 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 to gate 2 of mixer Q5.

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 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/C15/C16. C12 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.

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 ic needs to know about the band, division schemes, reference frequency, and oscillator options is generated by the microcontroller. 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 eprom on the controller and on channel settings done on dip switch S1. 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.

Microcontroller U1 also provides the intelligence to control runway lights. It senses squelch openings at interrupt pin 1, and its three outputs drive switching transistors Q8, Q9, and Q10. These transistors are capable of driving external relays and may be used in other ways as described in the Installation section. Care must be used to avoid reverse polarity, overvoltage, and transients, all which can damage the transistors.

+13.6Vdc power for the receiver is applied at E3. U6 is a 5V regulator to provide stability and C55 and C56 eliminate noise. 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 possible noise on the power supply line.

## 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 R123. 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.

### Current Drain.

Power line current drain normally is about 38 mA with volume turned down or squelched and up to 100 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 5V line is low, there is a short circuit on that bus 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 ground pins on the ic.

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

| Table 3. My Switch Settings | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Frequency:____________________ MHz** | | | | | | | | | |
| Switch Sections Turned On: (circle) | | | | | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

properly. Check the dc voltages, and look for noise in the 10 kHz region, which should be present at U4-pin 11 with no input signal. (Between pins 10 and 11 of U4 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-3 using coax test lead. Set level just high enough for full quieting. At 1 µV, you should notice some quieting, but you need something near full quieting for the test.

You can also connect the 10.700 MHz test 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.

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 +2.0Vdc. Actual range over which the unit will operate is about +0.5Vdc to about +4.5Vdc. However, for optimum results, the vco should be tuned to allow operation at about +2.0Vdc center voltage.

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

d. Check the TCXO at pin 1 of the synthesizer ic. A scope should show strong signal (1.5 Vp-p) at 10.240 MHz.

e. The data, clock, and latch enable lines between the microcontroller and synthesizer ic's should show very brief and very fast activity, sending data to the synthesizer ic. Because this happens very fast, it can be difficult to see on a scope. Use 1mSec/div, 5Vdc/div, and normal trigger.

### 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. 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 receiver, such as motors.

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.

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 2.0Vdc 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.

### 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 surface mount ics. The pins are close together, and it is easy to short pins together and damage the ic. Try to connect meter to a nearby component connected to the pin under question.

### 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.

**Table 4. Typical Test Point Voltages**

| | | |
|---|---|---|
| TP1 | Tuning V. | Normally set at 2V |
| TP2 | Buffer | approx. 0.3 – 0.6V |
| TP3 | Test Input | (No reading) |
| TP4 | Noise det. | With SQUELCH control fully ccw, varies from -0.3 Vdc with no to +0.9 Vdc full quieting. |
| E4 | DISC | Varies with frequency of input signal. Voltage at this point normally is adjusted for +2Vdc 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 | 0.9 | 1.6 | 3.8 | - |
| Q2 | buffer | 0 | 0.7 | 2.4 | - |
| Q3 | dc filter | 4.1 | 4.8 | 5 | - |
| Q4 | RF ampl | 0 | 0 | 4.6 | 2.3 |
| Q5 | Mixer | 0 | 0 | 4.9 | 0 |
| Q6 | sq. open | 0 | 0 | 5 | - |
| | sq. closed | 0 | 0.65 | 0.14 | - |

**Table 6. Typical IC DC Voltages**

| | | | |
|---|---|---|---|
| U2-1 | 2.4 | U4-1 | 5 |
| U2-2 | 2.4 | U4-2 | 4.4 |
| U2-3&4 | 5 | U4-3 | 4.8 |
| U2-5 | 0 – 5V | U4-4 | 5 |
| | (~2V tuned) | U4-5 | 3.8 |
| U2-7 | 5 | U4-6 | 3.8 |
| U2-8 | 1.6 | U4-7 | 3.8 |
| U2-9 | 0 | U4-8 | 5 |
| U2-10 | 0 | U4-9 | 2 (aligned) |
| U2-11 | 0 | U4-10 | 0.8 |
| | | U4-11 | 2 |
| U5-1 | 1.4 | U4-12 | 0.6 (with squelch just closed) |
| U5-3 | 0.01 | | |
| U5-5 | 6 | U4-13 | 0 (sq open) |
| U5-6 | 13.6 | | 7.5 (squelch closed) |
| U5-7 | 7 | U4-14 | 0 |
| U5-8 | 1.4 | U4-15 | 0 |
| | | U4-16 | 1.8 |

**Table 7. Typical Audio Voltages**

| Audio Test Point | Normal Level |
|---|---|
| U4-9 (Discriminator) | 3V p-p audio |
| E4 (Disc Output) | 2V p-p audio |
| E1 (Repeater Output) | 1V p-p audio |
| U4-11 (noise ampl) | 3V p-p noise |
| CW lug of VOL cont. | 400mV p-p audio |
| U5-3 (af ampl input) | 0 to 200mV p-p |
| U5-5 or E2 (speaker ampl output) | 0 to 7V p-p audio |

# PARTS LIST FOR R123 RECEIVER.

Note: Resistors and capacitors are 0805 or 0603 smt type unless noted otherwise.

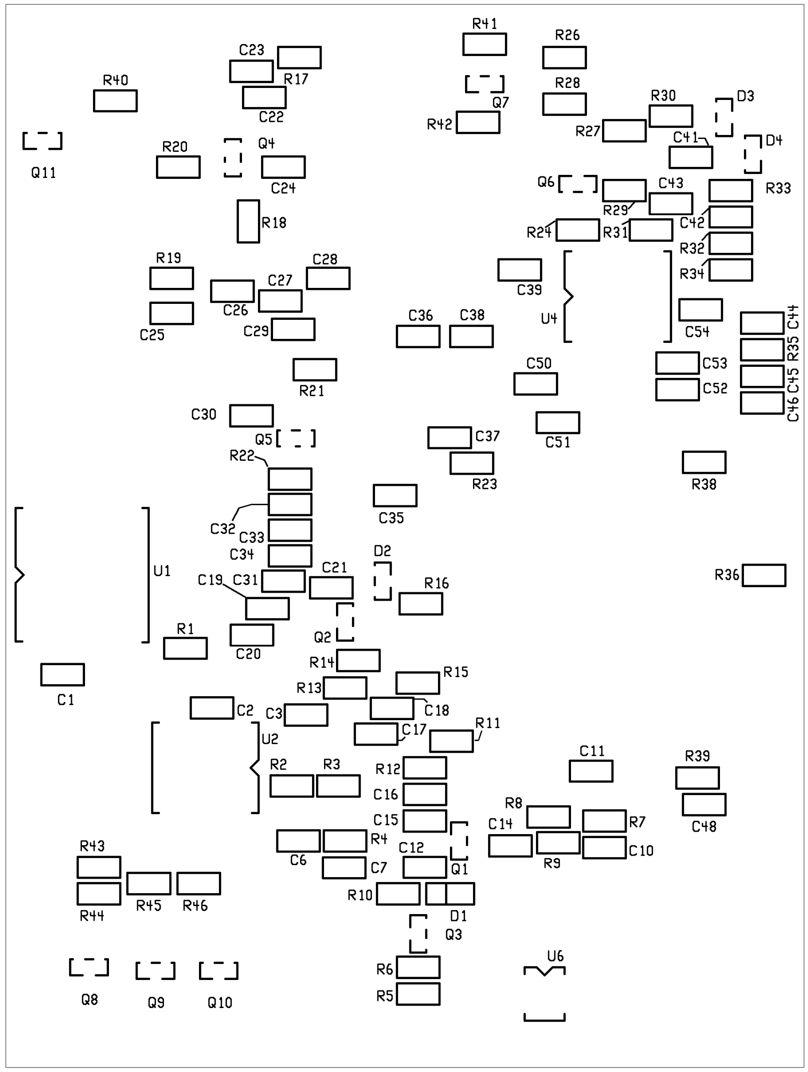
Values shown are for 120 – 130 MHz range. Factory changes some values for frequencies beyond this range.

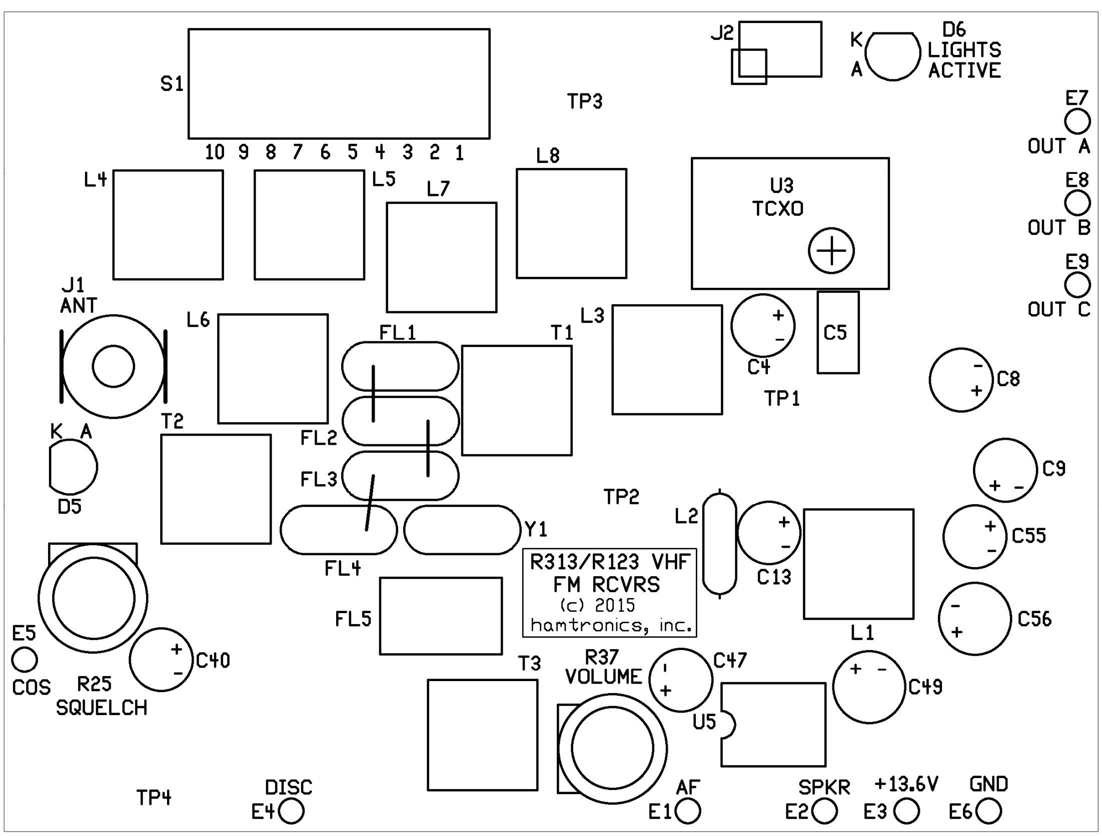
💣 Caution: IC's are static sensitive. Use appropriate handling precautions to avoid damage.

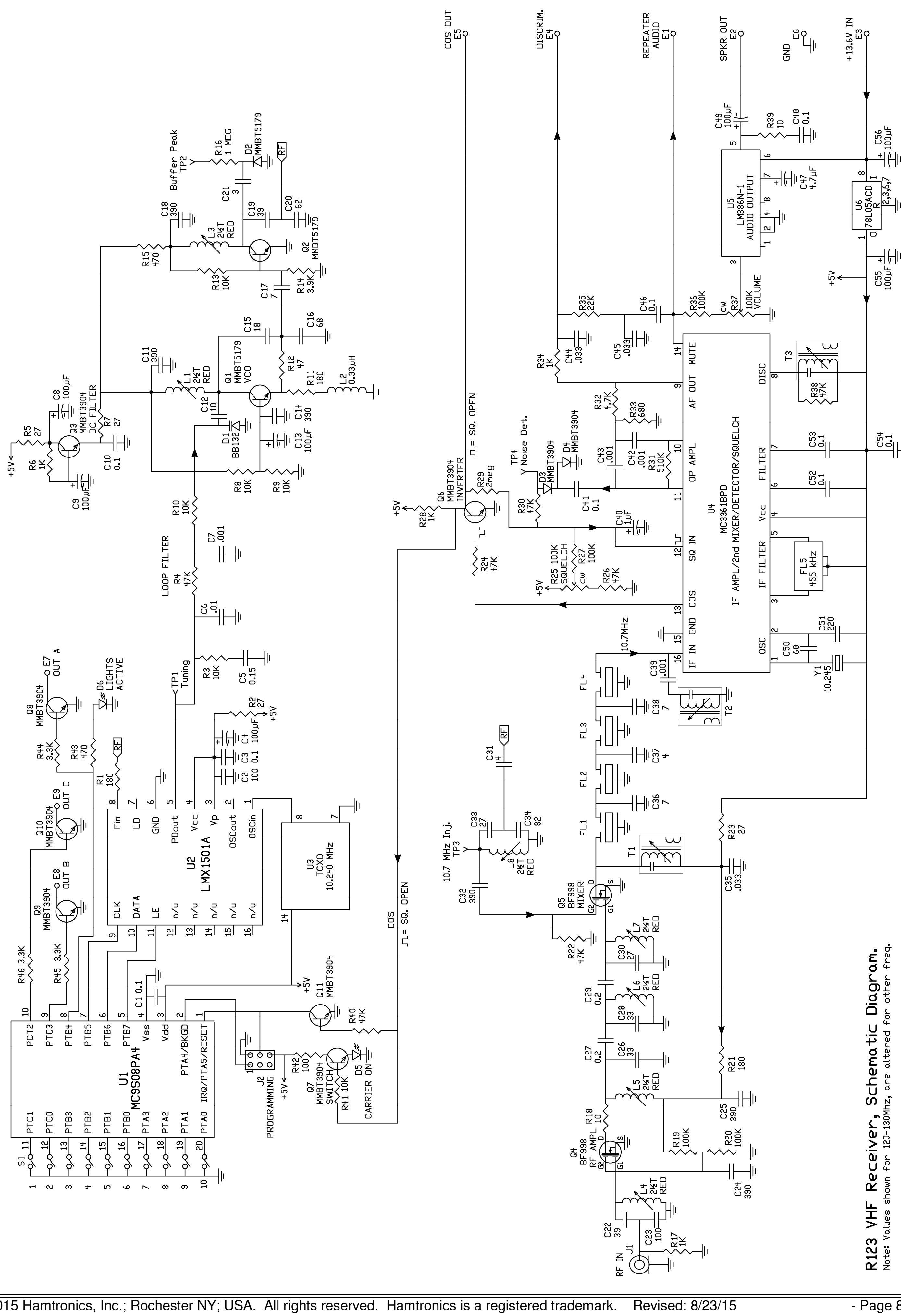
* Polarity for LED's: long lead is anode, same as electrolytic caps.

** Polarity for varicap diode D1: bar end is cathode, opposite end (anode) goes on pad next to grounding via.

| Ref Desig | Value (marking) |
|---|---|
| C1 | 0.1µf |
| C2 | 100pf |
| C3 | 0.1µf |
| C4 | 100µf electrolytic |
| C5 | 0.15µf mylar |
| C6 | .01µf |
| C7 | .001uf |
| C8-C9 | 100µf electrolytic |
| C10 | 0.1µf |
| C11 | 390pf |
| C12 | 10pf |
| C13 | 100µf electrolytic |
| C14 | 390pf |
| C15 | 18pf |
| C16 | 68pf |
| C17 | 7pf |
| C18 | 390pf |
| C19 | 39pf |
| C20 | 62pf |
| C21 | 3pf |
| C22 | 39pf |
| C23 | 100pf |
| C24-C25 | 390pf |
| C26 | 33pf |
| C27 | 0.2pf |
| C28 | 33pf |
| C29 | 0.2pf |
| C30 | 27pf |
| C31 | 4pf |
| C32 | 390pf |
| C33 | 27pf |
| C34 | 82pf |
| C35 | .033µf |
| C36 | 7pf |
| C37 | 4pf |
| C38 | 7pf |
| C39 | .001uf |
| C40 | 1µf electrolytic |
| C41 | 0.1µf |
| C42-C43 | .001µf |
| C44-C45 | .033µf |
| C46 | 0.1µf |
| C47 | 4.7µf electrolytic |
| C48 | 0.1µf |
| C49 | 100µf electrolytic |
| C50 | 68pf |
| C51 | 220pf |
| C52-C54 | 0.1µf |
| C55-C56 | 100µf electrolytic |
| D1 | BB132 varactor diode ** |
| D2 | MMBT5179 (used as diode) |
| D3-D4 | MMBT3904 (used as diode) |
| D5 | Green LED * |
| D6 | Red LED * |
| FL1-FL4 | 10.7MHz crystal filter (matched set of 4) |
| FL5 | LT455DW ceramic filter |
| J1 | RCA Jack |
| J2 | 6 pin header |
| L1 | 2½ t. slug tuned (red) |
| L2 | 0.33µH RF choke (red-sil-orn-orn) |
| L3-L8 | 2½ t. slug tuned (red) |
| Q1-Q2 | MMBT5179 |
| Q3 | MMBT3904 |
| Q4-Q5 | BF998 MOS FET |
| Q6-Q11 | MMBT3904 |
| R1 | 180Ω |
| R2 | 27Ω |
| R3 | 10K |
| R4 | 47K |
| R5 | 27Ω |
| R6 | 1K |
| R7 | 27Ω |
| R8-R10 | 10K |
| R11 | 180Ω |
| R12 | 47Ω |
| R13 | 10K |
| R14 | 3.9K |
| R15 | 470Ω |
| R16 | 1meg |
| R17 | 1K |
| R18 | 10Ω |
| R19-R20 | 100K |
| R21 | 180Ω |
| R22 | 47K |
| R23 | 27Ω |
| R24 | 47K |
| R25 | 100K trim pot |
| R26 | 47K |
| R27 | 100K |
| R28 | 1K |
| R29 | 2meg |
| R30 | 47K |
| R31 | 510K |
| R32 | 4.7K |
| R33 | 680Ω |
| R34 | 1K |
| R35 | 22K |
| R36 | 100K |
| R37 | 100K trim pot |
| R38 | 47K |
| R39 | 10Ω |
| R40 | 47K |
| R41 | 10K |
| R42 | 100Ω |
| R43 | 470Ω |
| R44-R46 | 3.3K |
| S1 | 10 pos. dip switch |
| T1-T2 | 10.7MHz IF xfmr (T1005) |
| T3 | 455kHz IF xfmr (T1003) |
| U1 💣 | MC9S08PA4VWJ µP |
| U2 💣 | LMX1501A PLL |
| U3 💣 | 10.240 MHz TCXO |
| U4 | MC3361BP-S16 IF ampl |
| U5 | LM386N-1 AF output |
| U6 | 78L05ACD regulator |
| Y1 | 10.245 MHz crystal |


R41
R26
C23
R17
R40
C22
Q7
R28
R30
D3
R42
R27
C41
D4
Q11
R20
Q4
C24
Q6
C43
R33
R29
C42
R18
R24
R31
R32
R19
C28
R34
C27
C39
C26
C25
C29
C36
C38
U4
C54
C44
R35
C45
C46
C53
C50
C52
R21
C30
Q5
C37
C51
R22
R23
R38
C35
C32
C33
C34
D2
U1
C21
R36
C19
C31
R16
Q2
R1
C20
R14
R15
C1
R13
C2
C18
C3
R11
C17
U2
C11
R39
R2
R3
R12
C16
C48
R8
C15
C14
R7
R4
C12
R9
C10
R43
C6
C7
Q1
R10
D1
R44
R45
R46
Q3
U6
R6
R5
Q8
Q9
Q10


J2
K
A
D6
LIGHTS
ACTIVE
S1
TP3
E7
OUT A
10 9 8 7 6 5 4 3 2 1
L8
L4
L5
L7
U3
TCXO
E8
OUT B
J1
ANT
E9
OUT C
L6
FL1
T1
L3
C5
C4
C8
TP1
K A
T2
FL2
C9
FL3
D5
TP2
L2
C55
Y1
C13
R313/R123 VHF
FM RCVRS
(c) 2015
hamtronics, inc.
FL4
C56
FL5
L1
E5
C40
R37
VOLUME
C47
T3
C49
COS
R25
SQUELCH
U5
TP4
DISC
E4
AF
E1
SPKR
E2
+13.6V
E3
GND
E6




R123 VHF Receiver, Schematic Diagram.

**Note:** Values shown for 120-130Mhz, are altered for other freq.