HAMTRONICS® RWWV RECEIVER: INSTALLATION, OPERATION, & MAINTENANCE

GENERAL INFORMATION.

The RWWV is a compact, dedicated receiver module for reception of the 10.000 MHz WWV time and frequency standard broadcasts from the U. S. National Institute of Standards and Technology in Fort Collins, CO and WWVH in Kauai, HI.

The RWWV is a very sensitive and selective AM superhet receiver, crystal controlled on 10.000 MHz. Don't let the size fool you – it receives WWV as well as any $1000 receiver!

The RWWV operates either on a 9V battery (not supplied) or a 9-14Vdc power supply. If you buy it with the cabinet, a 12Vdc Power Adapter is supplied for connection to 115Vac wall power.

The RWWV has a 50Ω input you can connect it to any type of hf antenna. It is so sensitive, you can even get good reception with just a small length of wire or an indoor whip antenna.

The RWWV has a speaker amplifier and even a squelch circuit to mute the audio if the signal fades into the noise. The 10 MHz signal can be heard for a large part of the day throughout the country; so you can get time and frequency calibration almost any time.

You will have fun learning about other interesting things on WWV at certain times besides just the time. Features such as accurate tone frequencies, geophysical alerts (solar activity reports), marine storm warnings, and global positioning system (GPS) and Omega navigation system status reports. Later in this instruction manual, we tell you about all these broadcasts.

SPECIFICATIONS for RWWV Receiver:
Mode: AM reception on 10.000 MHz, crystal controlled
Sensitivity: 0.2µV for 10 dB s/n
Selectivity: ±3 kHz at -3dB, -50 dB @±10 kHz
Image Rejection: 43 dB
AGC: both i-f and rf agc
Operating Power: 9-14Vdc, 80 mA at min.vol.
Size: 2-5/16 x 3 inches
Shipping Weight: 1 lb.

ALIGNMENT.

Alignment is relatively simple, but it does require an accurate and stable signal generator. The receiver is very selective. If you have a good outdoor antenna and conditions for reception are good, you may be able to tune with the WWV signal on the air. However, hf signals vary in strength due to fading; so it is difficult, at best, to tune without a signal generator. Some have used inexpensive clock oscillators from Radio Shack, but they may not be exactly on frequency.

First, connect up power and speaker. (See INSTALLATION Section for details.) Make sure squelch is disabled (E4 and E5 disconnected or switch open).

Connect a signal generator, set for exactly 10.000 MHz, to the antenna terminals.

Connect a dc voltmeter to TP1, which is the top lead of R5. This is the agc (automatic gain control) line for the rf amplifier stage. The voltage at this point varies from about 3.5V with no signal to close to 0V with a strong signal. Therefore, you will be tuning for the lowest dc voltage, not the highest.

During alignment, you want to adjust the 10MHz input signal to a level which provides an indication within the agc range for tuning, i.e., a weak signal. As tuning progresses, you may need to turn the signal generator attenuator down to stay within range.

☹ *Be sure not to damage a transformer by turning its core tight against one end or the other. It is only necessary to adjust them a few turns.*

Before tuning, if the unit has never been tuned before, preset the slugs in rf transformers T1-T3 by turning each one about 5/8 turn (slightly more than ½ turn) counterclockwise. This will get them close to final tuning for 10 MHz.

Then, start tuning by adjusting detector transformer T7 for lowest agc voltage.

Alternately adjust 455 kHz i-f transformers T4-T6. There will be a small interaction between these three; so repeat tuning of each a few times until no further improvement is possible.

Finally, adjust rf amplifier transformers T2 and T3 and antenna transformer T1 for lowest agc voltage. There may be a small interaction between T2 and T3; so repeat until no further improvement is possible.

After all transformers have been adjusted initially, a small improvement made be made by fine tuning all the adjustments slightly.

The receiver is very selective, as is required to eliminate interference from adjacent signals on hf bands. Therefore, it is necessary to make sure the signal generator is right on frequency. Although you can retune slightly with an antenna connected so you can use the WWV signal for tuning, selective fading usually causes the WWV signal to vary up and down in level too much to use for accurate alignment.

If your signal generator drifts or is not calibrated accurately enough, try coupling the signal generator to the input while an antenna is connected so you can zero beat the signal generator against WWV for the final calibration. After the generator is adjusted to zero beat, turn up the attenuator to drown out the WWV signal so only the higher level signal from the generator is reflected in the agc test point voltage. Then, you can touch up all your adjustments, especially T4-T7, which set the exact frequency of the detector.

If you intend to use the squelch feature to quiet the receiver when no usable signal is present, you can check the squelch by connecting a jumper between E4 and E5 or turning on the squelch switch if one has been installed. As you vary the signal generator level, the squelch should open and close at a fairly low level. However, because of the ambient noise on the hf bands, you don't want it to be extremely sensitive as the squelch on vhf fm receivers. If you wish, the value of R8 can be changed to reset the squelch threshold; but reserve judgment until you have had a chance to operate the receiver for awhile and see what squelch action would be best for your application. *(Note that most people don’t bother using squelch because they are not listening for long periods.)*

INSTALLATION.

Mounting.

The pc board has four mounting holes, in the corners. 4-40 screws and threaded standoffs or similar hardware may be used to mount the unit in a chassis or project box.

Power Connections.

The unit is designed to operate either on 9Vdc from a battery or battery eliminator or on 12-13.6Vdc from a regulated power supply. Power connections should be made through a power switch (if desired) to E3 (+) and E2 (-) on the pc board. Light weight hookup wire can be used because the unit draws very little current.

If you want to use a 9V transistor radio battery, a small battery connector with attached leads is available at Radio Shack and other electronic stores, as are small loudspeakers and project boxes or plastic cases you can use.

☹ *Be sure to observe polarity! Damage will result if polarity is reversed. Also, be sure that there are no devices connected to the same power supply which might cause transients which could damage semiconductors. Any relays operating from the same power source must have transient suppression diodes across their coils.*

Note that the value of R7 which should be installed on the pc board depends on what the input voltage will be. Check the parts list to be sure you have the correct value for the power source you intend to use.

Antenna Connections.

Many types of antennas can be used with the receiver, and it doesn't hurt to experiment. For portable operation, you may want to try a small collapsible whip antenna or a piece of wire tied up to a support. For base station use, you can get better results with a longwire antenna or some other form of hf antenna strung up outside. Sometimes, using an antenna tuner can provide better sensitivity.

If you use an outside antenna, the connection to the receiver should be through an appropriate type of coaxial cable. The connections to the receiver should be made by stripping the ends of the coax about 3/8 inch and soldering to E7 and E8 on the board as shown in the component location diagram.

If you have the board mounted in a chassis, it is a good idea to mount a coax jack on the chassis, such as an SO-239 "UHF" connector. In such a case, miniature coax, such as RG-174/u is handy for the connection between the board and the chassis connector. Then, larger diameter cable can be used between the chassis connector and the antenna.

Audio Connections.

The receiver can be used with any loudspeaker with an impedance of 8Ω or greater and will provide 1 to 2 watts of audio. The speaker should be connected between E1 and ground (E2 or chassis connection).

The receiver is equipped with a squelch circuit for the benefit of those wishing to use it. You may not want to bother with it if you use the receiver just to listen for time or frequency calibration occasionally.

The squelch circuit has a fixed resistor (R8) to set the threshold. If you want to use the squelch feature, there must be a connection made between E4 and E5 on the board. A simple jumper wire will suffice if you want to use the squelch feature all the time.

A toggle switch connected between E4 and E5 allows the squelch to be turned on and off. This provides a more convenient way to enable and disable the squelch than having to reset a pot every time you want to open the squelch manually. However, if you prefer the old method of having a squelch pot on your front panel, you can use a 100K pot in series with about a 27K fixed resistor in place of R8.

OPERATION.

Basic Operation.

Operation is simple. Once power, antenna, and speaker are connected, merely turn on power and adjust Volume control R4 for a convenient level. After that, you only need to turn on power when you want to listen. If you have installed a squelch switch or a jumper in its place, the receiver will automatically mute when the signal level is too weak to hear well. *(Note that most people don’t bother using squelch because they are not listening for long periods.)*

As mentioned in the Installation Section, you may wish to experiment to find the type of antenna which gives the best compromise between performance and ease of use. Because the receiver is so sensitive, a simple collapsible whip antenna or a piece of wire can give surprisingly good results. However, a permanently installed long wire or other hf antenna will provide the most consistent results.

WWV Signal Features.

Figure 1 shows the broadcast schedule for WWV in Fort Collins, CO. A similar schedule is available for WWVH in Hawaii. This diagram is extracted from a National Institute of Standards and Technology publication. If you want to order a copy, it is available for a modest charge from the Government Printing Office, Washington DC 20402. Write and ask for a current list of available publications.

The two features of most interest are precise frequency of the carrier signal, to calibrate radio and test equipment, and precise time information given each minute as a voice transmission. But there are many other interesting parts of their transmissions.

There are various tones which can be used to check audio equipment or musical instruments and they can be captured to detect the start of each hour or each minute.

At certain intervals, voice announcements are made for the benefit of other government agencies. See figure 1. The predominant ones are as follows.

Marine storm warnings are prepared by the National Weather Service and broadcast for areas of the Atlantic and Pacific Oceans which are of interest to the U.S. Government.

Global Positioning System status announcements are prepared by the Coast Guard to give current status information about the GPS satellites.

Omega Navigation System reports are prepared by the Coast Guard to give the status of the 8 Omega transmitting stations in the 10-14kHz frequency range. These serve as navigation aids.

Geophysical alerts are prepared by the Space Environment Services Center of NOAA. They are broadcast on the 18th minute of the hour and give information of interest to hams as well as various scientific organizations regarding solar activity, geomagnetic fields, solar flares, and other geophysical statistics. This propagation information can help you decide when the DX will be good.

How to do Frequency Calibrations.

It is easy to calibrate a signal generator using the RWWV Receiver. Simply couple the signal generator with a cw signal loosely to the antenna input while an antenna is connected and adjust the signal generator level to get a beat note on the receiver. Then, adjust the frequency of the signal generator for zero beat. The signal generator can then be used to calibrate other equipment, such as a frequency counter.

THEORY OF OPERATION.

Refer to the schematic diagram.

The antenna input at 10.000 MHz is amplified by dual-gate mosfet Q1 to establish a low noise figure. Selectivity for image rejection and out-of-band interference is provided by antenna transformer T1 and double-tuned transformers T2-T3.

Crystal oscillator Q2 provides a stable mixer injection signal of 10.455 MHz. This signal is injected through C23 to mixer U1-A.

The 455 kHz output of the mixer passes through a triple-tuned transformer circuit T4-T6 to provide sharp adjacent-channel selectivity. The 455 kHz i-f signal is amplified further in U1-B and coupled through T7 to detector U1-C.

The detected audio is amplified by U2 to provide up to 2W of audio to drive a loudspeaker through dc blocking capacitor C18.

Detector U1-C develops two agc (automatic gain control) signals used to provide constant audio output and prevent overload. One is used internally to gain control the i-f amplifier stages. The other, from pin 13, is a delayed agc used to bias gate 2 of rf amplifier Q1. The latter agc signal, available at test point TP1 (the top lead of R5), is used as a tuning indicator for alignment. It also is applied to U1-D to operate a squelch circuit, which quiets the receiver audio when no strong signal is present. The value of R8 sets the threshold at which squelch transistor Q4 turns on.

TROUBLESHOOTING.

Finding a problem usually is a matter of common sense, and knowing what happened just before a problem developed can be a strong clue.

One of the best ways to narrow down the area of the problem is by signal tracing, applying signals from a signal generator to various points in the circuit.

Following are some measurements we made on a sample unit to see how strong a signal is required to cause a 1V reduction in the agc voltage at TP1, e.g., to drop the agc voltage from 4V to 3V. A cw signal is used, with no modulation.

(Note that, in some cases, when we touched an ic pin with the test lead, the agc voltage went up about a volt to 5V with no signal applied, just because we disturbed the normal impedance at that point in the circuit. This is of no concern, just look for a 1V drop from that reference point.)

Injecting a 10.000 signal at the antenna input E7/E8, it takes about 0.2µV to cause a 1V drop in agc.

Injecting the same signal to the mixer at U1 pin 2, it took 0.7µV. To inject this signal, use a coax test lead from the signal generator with a .01µf disc cap soldered to the end of the center conductor, using very short leads. Then, touch the other lead of the disc cap to ic pin 2.

Doing the same thing with a coax test lead terminated through a .01µf disc cap, applying 455 kHz to U1 pin 4, the input of the i-f amplifier, it took 18µV for a 1V reduction in agc.

Doing the same thing with 455 kHz applied to the detector input at pin 8 of U1, it took 800µV for a 1V reduction in agc.

We also noted that it generally took about 0.5µV of carrier at the antenna input to give 10dB of noise quieting and about 1µV to give 20dB quieting. These measurements were made at the speaker with an oscilloscope.

DC Voltages.

Following are dc voltages measured on a sample unit with 9Vdc operating power applied. Voltages on speaker amplifier ic U2 will be proportionately higher if the receiver is operated on 12V or 13.6V instead of 9V.

Measurements were taken with no input signal and with oscillator Q2 running properly. Voltages on Q2 will vary if the crystal is damaged or otherwise not oscillating.

It is notable that ic U1 has a 5.8V zener diode internally connected to B+ pin 10. This works in conjunction with R7 to regulate the voltage of the power bus feeding all the other stages connected to that bus, including rf amplifier Q1.

Cabinet Wiring.

When the receiver is supplied in a cabinet, the normal VOLUME control on the pc board is replaced with a 100K panel mounted control. Wiring from the pc board to the panel mounted pot includes a 150K dropping resistor in series with the audio to the pot to reduce the maximum level applied to the internal speaker.

Cabinet circuitry also includes an LED and a POWER switch. A 680Ω resistor is connected in series with the anode of the LED to limit the current.

Typical DC Transistor Voltages				
Stage	E/S	B/G1	C/D	G2
Q1 (RF Ampl)	0	0	5.8	4
Q2 (Osc.)	3.5	2.2	5.1	-
Q3 squelched	0	0	0.68	-
unquelched	0	1.1	0.04	-
Q4 squelched	0	0.68	0.02	-
unsquelched	0	0.04	0	-

Typical DC IC Voltages					
U1-1	U1-2	U1-3	U1-4	U1-5	U1-6
0.9	1.4	5.5	0.6	0	5.6
U1-7	U1-8	U1-9	U1-10	U1-11	U1-12
1.4	1.4	0.9	5.8	0.75	0.7
U1-13	U1-14	U1-15	U1-16	U2-1	U2-2
4	0.85	0	5.8	0	0
U2-3	U2-4	U2-5	U2-6	U2-7	U2-8
0	0	0	5.5	9	5

AGC Action

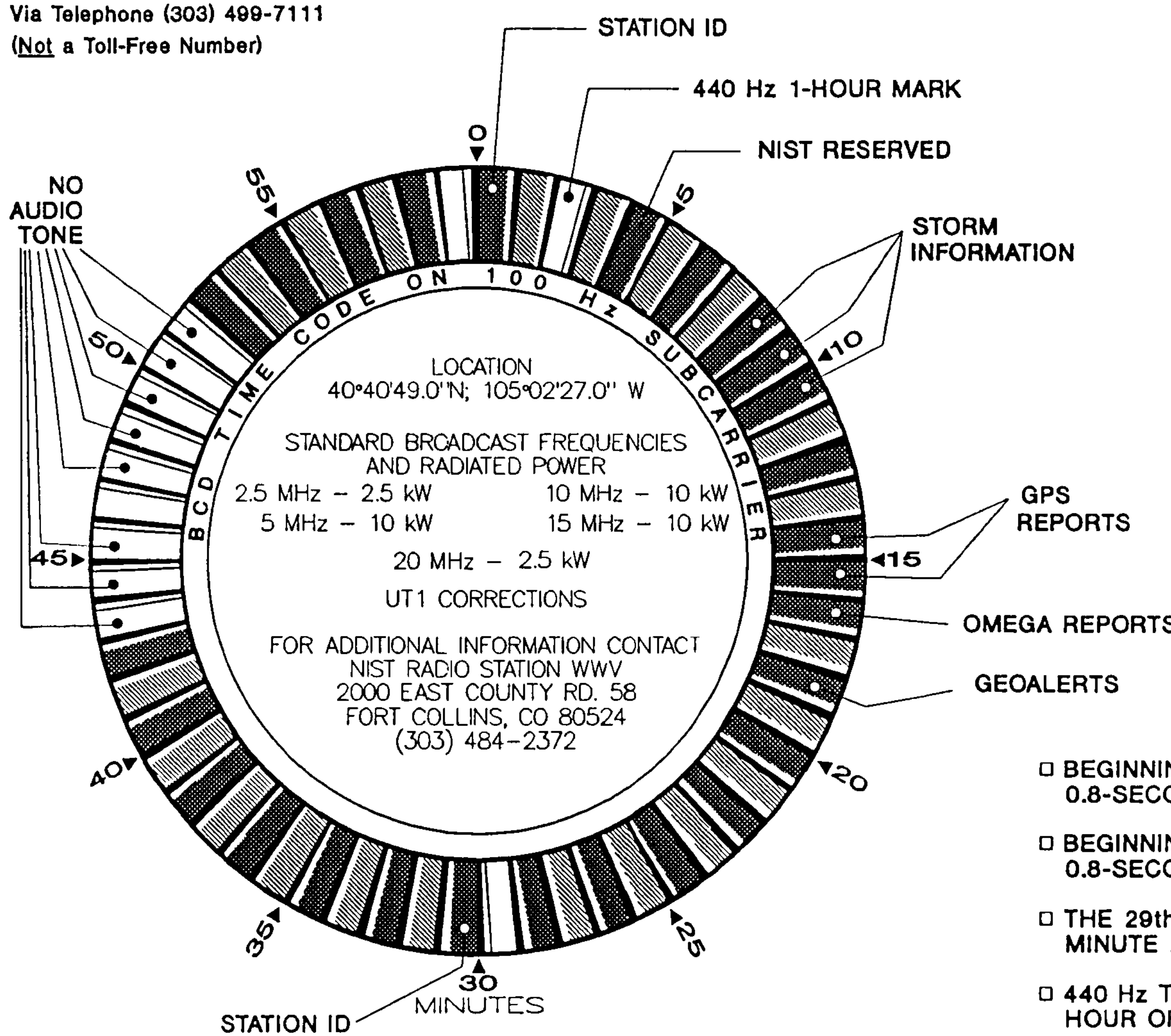
We checked the agc action AT TP1 vs. signal level at the antenna input and found the following correlation.
With no signal, the level was 4Vdc.
0.2µV gave a drop to 3V.
1µV dropped agc to 2.5V.
8µV dropped agc to 1V.
30µV dropped agc to 0.5V.
300µV dropped agc to 0.25V.
3mV dropped agc to 0.23V.

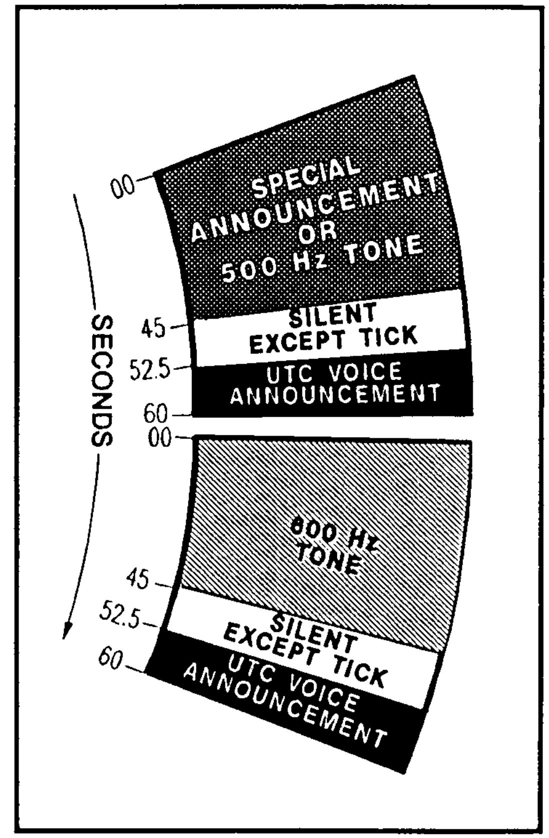
WWV

Broadcast Format

Via Telephone (303) 499-7111

(<u>Not</u> a Toll-Free Number)



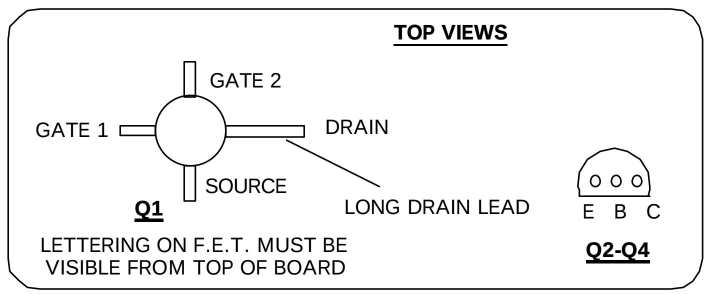


- BEGINNING OF EACH HOUR IS IDENTIFIED BY 0.8-SECOND-LONG, 1500-Hz TONE.
- BEGINNING OF EACH MINUTE IS IDENTIFIED BY 0.8-SECOND-LONG, 1000-Hz TONE.
- THE 29th AND 59th SECOND PULSES OF EACH MINUTE ARE OMITTED.
- 440 Hz TONE IS OMITTED DURING FIRST HOUR OF EACH DAY.

Figure 1. The hourly broadcast schedules of WWV.

PARTS LIST.

Ref Design	Description (marking)
C1	.01 µf (103)
C2	6 pf
C3-C6	.01 µf (103)
C7-C8	1 pf
C9	.01 µf (103)
C10-C11	0.1 µf monolithic (104)
C12	47 µf electrolytic
C13-C14	.01 µf (103)
C15	.0022 µf (2.2nK or 2n2K)
C16	47 µf electrolytic
C17	4.7 µf electrolytic
C18	47 µf electrolytic
C19	0.15 µf mylar (red)
C20	68 pf
C21	220 pf (221)
C22	.01 µf (103)
C23	20 pf
C24	0.1 µf monolithic (104)
Q1	N.E.C. 3SK122 dual-gate mosfet static sensitive
Q2-Q4	2N3563 or 2N5770
R1	180Ω
R2	100Ω
R3	27K
R4	20K or 22K Pot. (223)
R5	15K
R6	3.3Ω (orn-orn-gold)
R7	100Ω (for 9V operation) 180Ω (for 12V or 13.6V)
R8	100K
R9-R10	15K
R11	100Ω
R12-R13	15K
R14	680Ω
T1-T3	10 MHz IF Xfmr (7A-691F)
T4-T7	455 kHz IF Xfmr (T1003 or RLC-352)
U1	Harris CA-3088E AM IF Ampl/Detector IC
U2	N.S.C. LM-380N-8 Audio Amplifier
Y1	10.455 MHz HC-50/u Crystal
Z1	Ferrite Bead, prestrung



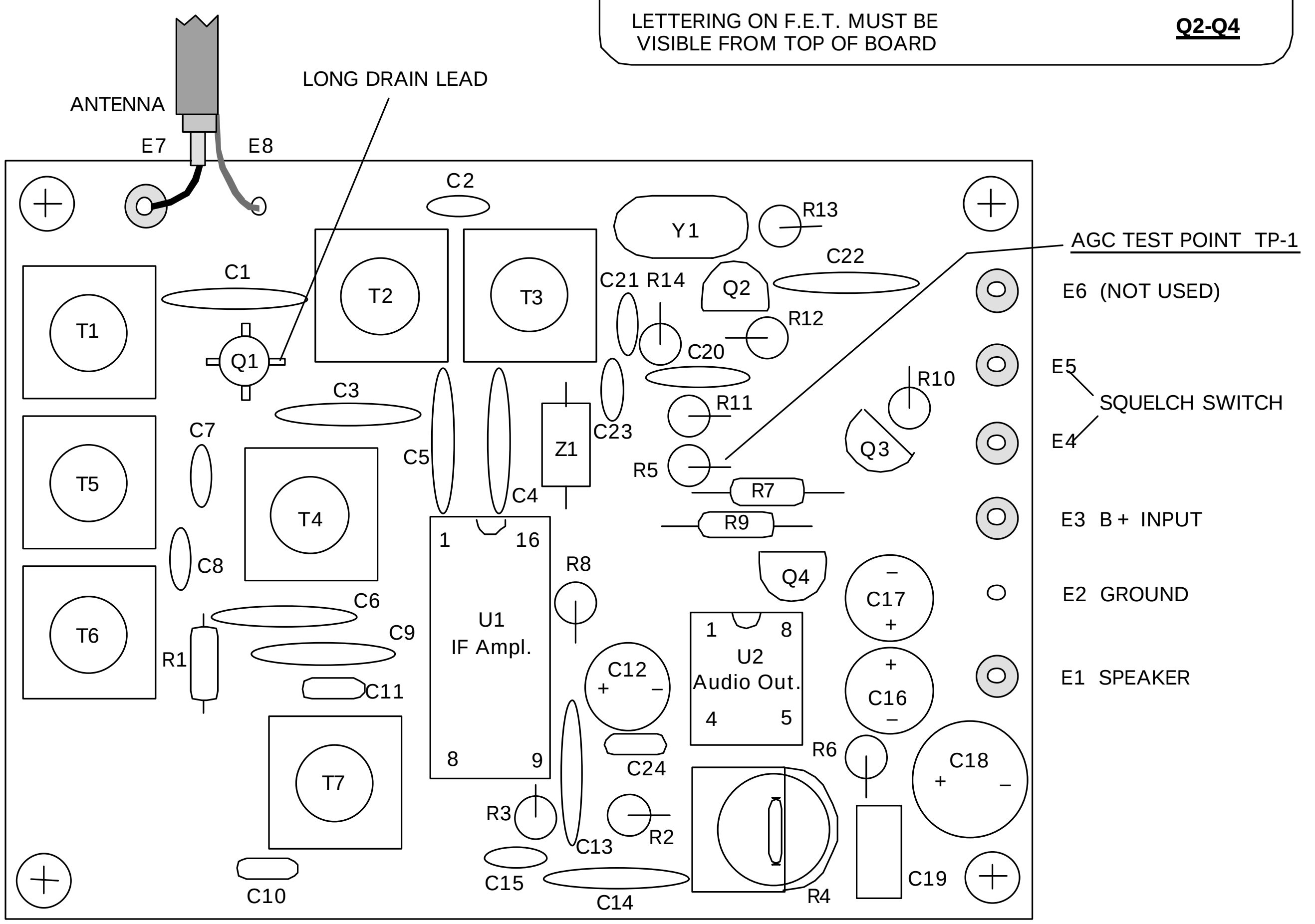


Figure 2. RWWV Receiver, Component Location Diagram

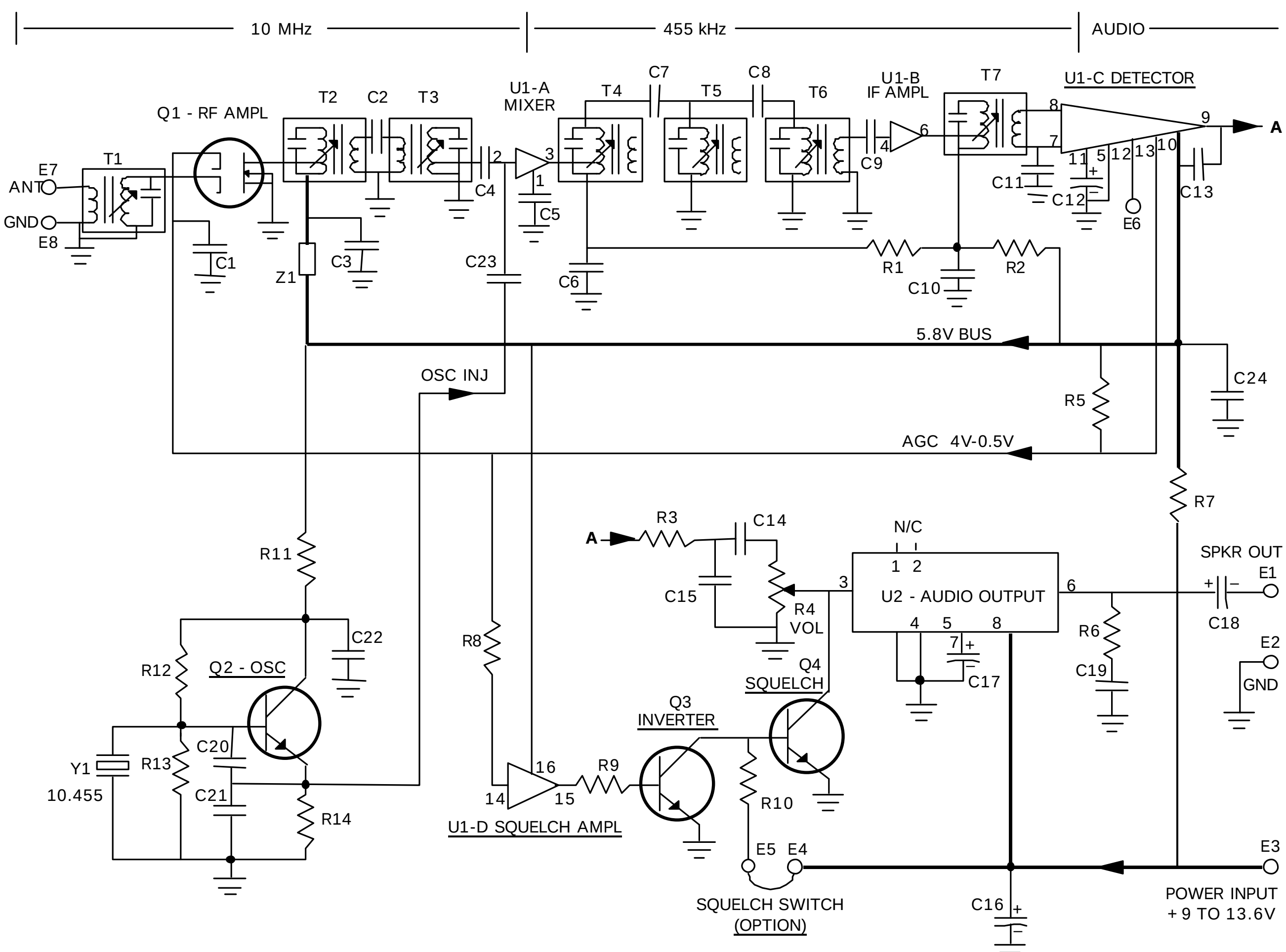


Figure 3. RWWV Receiver, Schematic Diagram

