

## BRIEF CIRCUIT DESCRIPTION

Signals from the antenna are amplified about 100 times by amplifier Q1 and fed to the regenerative stage, Q2, by transformer T1. Q2 is both an oscillator and an amplifier. As the current through Q2 is increased by RV1, the REGEN control, the gain and oscillation is increased. A point is reached, just before full oscillation, where Q2 has extremely high gain, 10,000 or more. This is what makes the DESERT RATT such a sensitive short wave receiver, in spite of its simplicity.

The frequency of the station is tuned in by the MAIN TUNE and FINE TUNE controls, RV2 and RV3, which sets the voltage on varicaps D2 and D3. This in turn determines the frequency the receiver will be tuned to.

The signal from the Q2 regen stage is fed to Q3 via C3. The radio waves from the station tuned in are converted to audio sound by detector diodes D4-D5. If these detector diodes were placed on Q2 directly, it would "load down" Q2, keeping the regen stage from being as sensitive as it is. Q3 "isolates" the diodes from loading down Q2.

The audio signal is developed across C14 and RV4. RV4 is the volume (AUDIO GAIN) control. It determines how much of the signal across C14 is sent to the audio amplifiers. Q4 doubles the audio signal, then applied to the power audio amplifier U1, which amplifies the signal about 200 times. This is sufficient audio voltage to drive the speaker to a comfortable listening level.

## DETAILED CIRCUIT DESCRIPTION

**Input amplifier Q1.** The signal at the antenna terminals is very weak, in the order of 1 to 20 $\mu$ V (1-20 millionths of a volt). The signal is first applied to high pass filter C1-C2-L1 to attenuate signals *below* about 2MHz to prevent interference from local AM broadcast stations. Q1 is a simple common emitter amplifier with a gain of 100 (10dB).

Only 3v is applied to the collector via T1 for lower power dissipation over 9v. The output signal is developed across the primary (points 1-2) of T1, which is induced into the secondary (points 3-6). Q1 also isolates the regen stage from the antenna. This keeps Q2 from accidentally becoming a transmitter.

**Regen stage, Q2** acts as both an amplifier and oscillator to form the high gain regenerative stage. It is a common base amplifier. The base is grounded to RF signals by C6. The input signal is applied to the emitter via C5 and T1, windings 5-6. The collector output signal is developed across the entire secondary of T1, windings 3-6. Note that only 3v is applied to this stage as well (at point 6 of T1). This low voltage, and the high resistance of REGEN control RV1, is what makes this circuit such a good regenerative stage with smooth regen action and good audio fidelity. This common base regen stage was designed by Charles Kitchen, N1TEV.

The gain of the stage is determined by the amount of current flowing from emitter to collector, as set by the resistance of RV1. The lower the resistance, the more current and gain of Q2. A portion of the output signal on the collector is applied to the emitter via C5 and T1, forming the oscillator feedback path. As gain is increased by RV1, a point will be reached when the feedback signal through C5 will cause Q2 to become an oscillator and will "squeal," masking the station signal. By backing off of the gain to just before this point of oscillation, Q2 will be an amplifier of extremely high gain. Gains of 10,000 to 100,000 are possible! This can produce a voltage at the collector of Q2 of around 10mV (.01 volts) from an input signal at the antenna of only around one millionths of a volt.

**Tuning circuit.** Q2 is also a tuned RF amplifier. The frequency of operation is determined by the inductance (L) and capacitance (C) of the parallel L-C circuit on Q2's collector. This is not obvious from the schematic. The inductance is provided by the secondary of T1, windings 3-6, which is at AC ground through C4. The parallel capacitance is the combination of C8 or C9 with tuning diodes, D2-D3.

The original DESERT RATT used a variable capacitor across T1 to tune in the stations, but these are becoming obsolete and very difficult to find. The receiver was converted to electronic tuning, using *varicaps*. A varicap is a diode whose capacitance is a function of the reverse voltage applied, forming a *variable capacitor*. The reverse bias is provided by the MAINTUNE and FINE

TUNE pots, RV2-RV3. This varies the voltage on D2-D3 from 0-9v for a capacitance change from about 8pF to 90pF (due to D2-D3 in parallel). 1N4004 are rectifier diodes, but exhibit fairly consistent volts vs. capacitance characteristics for use as varicaps in the DESERT RATT. R5 sets the current through the varicaps.

At the point of highest gain, Q2 collector has a very high impedance. The trick is to couple this highly amplified RF signal to the detector diodes without loading down Q2. The detector diodes, D4-D5, have a low impedance. The high gain of Q2 would be seriously lowered if the detector diodes were connected to Q2 directly.

**Emitter follower (EF) Q3** provides no voltage gain. An EF has high input impedance (hi-Z) and low output impedance (lo-Z). It acts as an active impedance transformer, converting the hi-Z input from Q2 to a low-Z output for driving the detector diodes. The base is biased above the 0.7v cut-off by applying a 2v bias. The RF is applied to the base via C10, a dc blocking capacitor. The output impedance is determined by R7.

**Detector diodes D4-D5** convert the modulation on the RF signal into an audio signal. The two diode scheme is a "voltage doubler" circuit, recovering twice the audio voltage over a single diode detector. The audio is developed across C14. The time constant of C14 and RV4 removes most of the RF signal, leaving only the lower frequency component of the audio for better fidelity and lowering the "hiss" found in most regenerative receivers. The audio signal across C14 is parallel to variable resistor RV4. The position of the wiper determines the amount of the audio voltage across C14 applied to Q4.

**Phase splitter Q4.** This stage converts the *single ended* input signal on the base to a *differential signal*, that is, two signals of opposite phase. Q4 provides no voltage gain in itself. For example, if the signal on the base goes *positive* 20mV, the emitter signal will also go *positive* by 20mV and the collector signal will go *negative* by 20mV for a 40mV *difference*. This, in effect, doubles (+6dB) the signal applied to U1. The two signals are about the same magnitude due to R9 and R10 being the same value.

The phase splitter was added to take

advantage of the differential inputs and "common mode rejection" characteristics of U1.

**Output amplifier U1** is a half-watt IC audio amplifier that accepts differential inputs and provides a single output suitable for driving an 8 speaker or head phones.

Signals that are common to the two inputs, that is, *in phase*, will not be amplified. This is called *common mode rejection*. Common mode signals at the input of U1 are from noise, such as AC hum from nearby lighting, RF floating around the circuit, and RF being transmitted by the Q2 regen stage. These common-mode sources are rejected by U1. Only signals that are differential will be amplified. This leaves primarily the *out of phase* audio signal coming from the Q4 phase splitter. This improves the fidelity and selectivity of the DESERT RATT by reducing the amount of noise and hiss entering the output amplifier.

The time constant of R9-C16 and R10-C17 also helps pass only signals in the normal hearing audio range to U1.

U1 has programmable gain. C18 between pins 1 and 8 bypasses an internal resistor to yield higher gain. R12-C12 is a filter to dampen out "cross over distortion" due to the internal push-pull output stage of U1. R11 and the large value (100 $\mu$ F) of C19 form a low pass filter to the 9v Vcc to U1. This prevents the "motor boating" sound common to this type of amplifier if Vcc is not properly filtered. C21 blocks the +4.5v DC on U1 pin 5 from the speaker, and passes only the AC audio component. The large value of C21 is to allow the lower audio frequencies (base components) to pass for higher fidelity.

**Voltage regulation** is by LED1-D1. There is about a 1.3-1.8v drop across LED1 and 0.7v across D1 for about 3v total. This voltage remains constant regardless of the actual voltage from the 9v battery to regulate the voltage to the regen stage for good stability. Otherwise, the gain and tuning would "drift" as the battery voltage dropped from use. The 1.3-1.8v from LED1 is also used as a regulated base bias to Q3 and Q4. The LED also serves as a power ON indicator. Longer battery life and more stable operation of the receiver results from the low voltage regulators.