A Simple Regen Radio for Beginners
Notes

QST September 2000, pp, 61-64
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Some readers have been asking for a more detailed circuit explanation for my beginner's regen radio project in the Sept 2000 issue of *QST*. This should answer most reader inquires.

A Detailed Circuit Description for "A Simple Regen Radio For Beginners" Project in the September 2000 Issue of *QST*.

Although this circuit uses very few components, its design and operation are NOT simple. This project evolved through several (less effective) earlier versions and is the result of many years of experimentation and testing.

Coil L1 and capacitor C1 tune the input signal from the whip antenna. Regenerative RF amplifier Q1 operates as a grounded base Hartley oscillator. Its positive feedback provides a signal amplification of around 100,000. Selectivity is also increased as regeneration introduces negative resistance into the Q1 regenerative loop which reduces the positive resistance in L1 (and also the losses in C1). Since the Q of L1 is equal to XL/R, selectivity increases as regeneration is applied. The combination of the very low operating power of this stage, only 30 microWatts, with the use of a simple whip antenna makes this receiver extremely portable and prevents it from interfering with other receivers in the area.

Q1 is a very high gain bipolar transistor. While it offers extremely high sensitivity, smooth regeneration control would not be possible without taking special precautions in the design. First, diodes D2-D4 are a simple voltage regulator that keeps the voltage powering Q1 very low, so that Q1 transistor operates at the bottom of its curve. I avoiding using a Zener here as I needed only 1.4V and I also needed to keep power consumption as low as possible (and silicon diodes are cheap and easy to find). Second, Resistors R1 and R2 provide a very large amount of negative bias which also helps to soften Q1's normally abrupt transition into oscillation. Finally, Potentiometer R2 controls regeneration and as R2 is adjusted to a lower resistance, Q1's gain increases (less bias) but at the same time R2's reduced resistance decreases regeneration by more heavily shunting the bottom portion of L1. These two opposing conditions help to linearize the otherwise highly exponential increase in regeneration as R2 is adjusted to a lower resistance. The resulting very smooth regeneration control is something not normally found with bipolar transistor regenerative circuits.

Several important features of this design permit this circuit to have very good selectivity and also help preserve the high gain of the regenerative RF stage. First, a simple whip antenna is used. This does not load down the collector of Q1 and it also does not add any significant capacitance across C1 (which would otherwise reduce the tuning range of the receiver). Diode D1 and capacitor C4 are a "floating" detector that provides very high sensitivity with very little loading on Q1. Note that the relatively low back resistance of the 1N34 diode provides the necessary DC return path for the detector. The combination of a very high gain regenerative RF stage with a very sensitive signal diode provides a sensitivity equal to that of many superheterodyne receivers while only consuming about 16microamps of power supply current (with R2 at mid position which is typically the threshold of oscillation).

Volume control R5 sets the level of detected audio driving IC1, an LM386 audio amplifier. Capacitor C7 operates the LM386 at a gain of 200. In order to prevent any significant loading of Q1, both the bottom of the volume control, R5, and Pin 3 of the LM386 "float" above ground so that both inputs of the IC are AC coupled. This is very important. The LM386's output is internally biased at mid-supply. However, if the 100k Ohm volume control was DC coupled to the LM386 (bottom of R5 and pin 3 of the LM386 both grounded), the high input bias currents of a marginal LM386 device could cause a very large output offset to occur.....several volts of offset could easily occur as the LM386 has 50k input resistors referenced to ground and the LM386 has a typical input bias current of 250nA...250nA times 50,000 Ohms times a gain of 200 equals 2.5V (0.000250mA times 50k times 200). By floating the bottom of the volume control and pin 3 of the LM386, both inputs are now at the same DC potential regardless of the magnitude of input bias current (and both inputs "see" 50k to ground).

Capacitor C5 provides low pass filtering that keeps RF out of the audio amplifier. Without it too much RF passes through the LM386 and into the headphones or speaker wiring then feeds back into the antenna circuit and causes motor boating on strong signals. C5 also improves the audio quality and slightly increases audio selectivity. Resistor R4 isolates the low pass filter from the detector circuit when the volume control is at the top of its range. Otherwise, the circuit would detune when the volume control was turned all the way up.

Capacitors C10, C12 and C13 decouple the power supply line and isolate the RF and audio stages. Due to the long time constant formed by R7 and C12, the detector will take approx. 7 seconds to start operating after the power switch is turned-on but operationally this is no big deal.

Diode D5 protects the receiver if the battery is connected backwards. The coil, L1, is wound onto a standard 35mm plastic film can or 1 inch diameter pill bottle. I did not use a torroid here partly because it might saturate (and therefore detune) the receiver at critical regeneration but mostly because beginners want something that's easy to find and won't scare them off. Note that the selectivity is more than adequate (for a beginner's radio) using a film can coil form and therefore it is doubtful that a torriod would add any significant improvement here anyway (but it still might be interesting to try though).

Capacitor C1 can be any air variable capacitor with 100pF to 365pF maximum capacitance. Frequency coverage will vary with the capacitor used but all should cover the 40 meter Ham band plus several international broadcast bands. Note that using a capacitor with a large tuning range (such as a 10 to 365pF) will make it more difficult to tune-in a station than using a smaller capacitor (such as a 10-150pF). Therefore, the optional fine tuning control is recommended when using large tuning capacitors.

By increasing C1's capacitance (or increasing the turns on L1), this radio will operate all the way down to the AM broadcast band (and probably long wave as well). But it is important to limit the total tuning range, so that it is still easy to tune-in a station. That is why I am specifying the max. capacitance of the air variable to 365pF. Operationally though, a 100pF or 150pF value is best. You can always just switch-in extra capacitance to move down to a lower band.

A fine tuning control may be added to the receiver using diode D6 which functions as a poor man's varactor. As the voltage from fine tuning control R7 is increased, the diode is reverse biased and its capacitance decreases. This fine tuning control is cheap and easy to add but its added capacitance will somewhat reduce the maximum frequency range of the receiver. You can compensate for this by removing turns from L1 (but keep the same ratio of turns for the tap if you reduce the total turns by 25 percent reduce the tap turns by 25 percent etc.).

Note that an audio taper control is specified for R8. This should be connected so that turning up the control causes an increase in voltage driving D6. The use of an audio (logarithmic) control helps to linearize the otherwise exponential decrease in capacitance as the voltage across D6 is increased. Note that capacitor C15 should be kept very small: 10pF MAX. Large values will give a greater capacitance (fine tuning) change but D6 will then start to load down Q1 and decrease gain and selectivity.

With a whip antenna and weak stations (during the day etc.) this receiver is easily detuned by hand capacitance changes. There are several simple cures for this. A one or two foot length of wire can be clipped to the metal front panel or an external antenna (any random length of insulated wire) can simply be wrapped around the whip antenna. Be careful not to overcouple the external antenna as this will also cause loading on Q1.

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