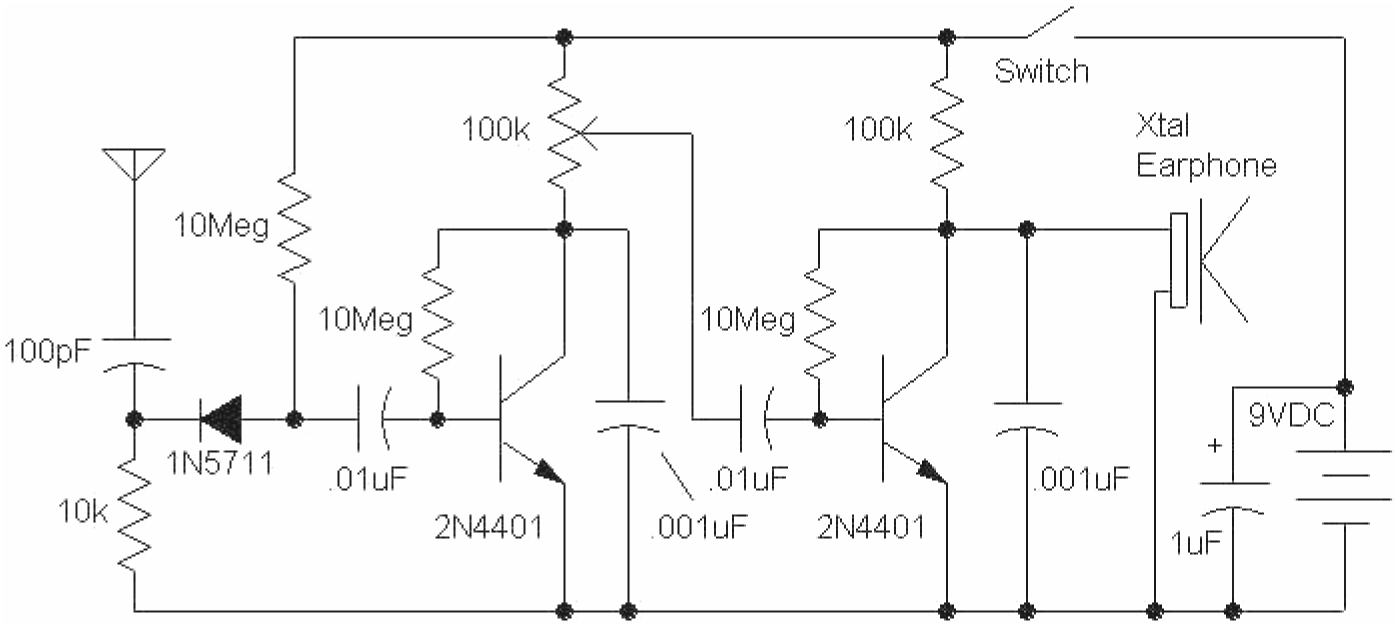
The Amazing All-Band Receiver

The Amazing All-Band Receiver is basically a diode detector followed by a high-gain audio amplifier. The detector uses a biased Schottky diode for excellent sensitivity and bandwidth; the detector will detect signals from below the AM broadcast band up to the microwave bands. The number of interesting signals is surprising; it is fun to drive around listening to the numerous strange sounds.

By trying different antennas and locations, this receiver has picked up AM radio stations, FM stations, TV video (buzz), car lock transmitters, cell phones, and even the microwave oven (a whoosh-whoosh sound as the microwave spreader rotated). It isn't clear how FM stations are demodulated; perhaps the antenna Q is sufficient for slope detection. (See reader Karen's excellent theory.) Even the familiar buzz from a narrow-band FM pager transmitter has been heard - somehow. There are some mysterious signals out there, too! What is that occasional descending whistle over by the highway? Some vehicles emit a curious buzz, too. If you hear a mysterious click-click now and then, its your cell phone!

Other signals that should be easy to receive include in-flight aircraft transmissions (this passive receiver will not interfere with communication/navigation systems), CB radio transmissions, amateur transmitters, "bugs", wireless networks and devices, radars, radio control transmitters, certain security/alarm systems, and even unexpected oscillations in your next circuit.

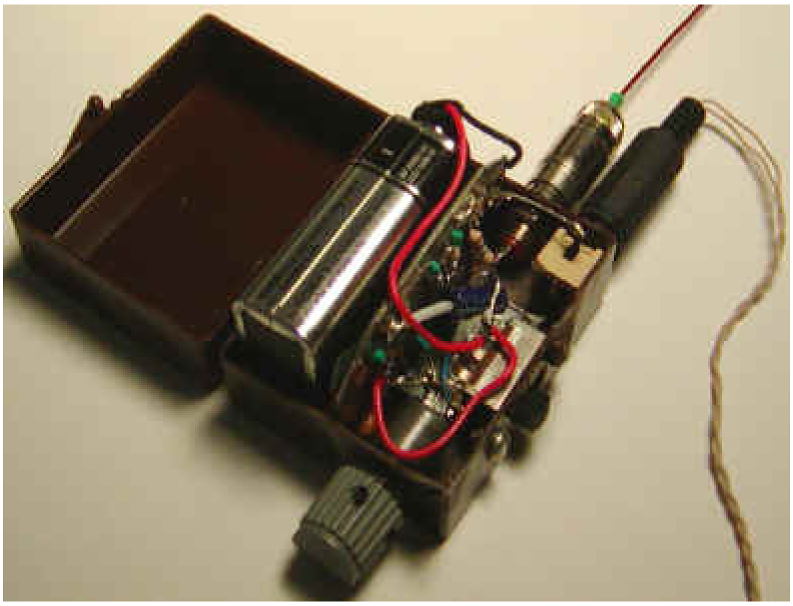
A short, perhaps 6", antenna is a great general-purpose length for general listening but trimming the length for the a desired band will give surprising sensitivity. For the antenna connection, use an RCA or similar connector with the ground connected to the battery negative. Loop antennas (loose end connected back to ground) work especially well for single frequencies and a tuning capacitor may be added across the loop. This detector circuit will also work well as a crystal radio, even at higher short-wave frequencies with the addition of a simple tuned circuit. Add a 10 to 100uH choke in series with the antenna near the receiver to keep out the higher frequency signals when listening to AM stations and connect the diode to a fairly high impedance tap on the tuned circuit since the diode impedance is high in this circuit. The 100pF capacitor and 10k resistor are not needed as long as the tuned circuit provides a DC path to ground for the diode. (See Crystal Radio Circuits for tuned circuit ideas.)

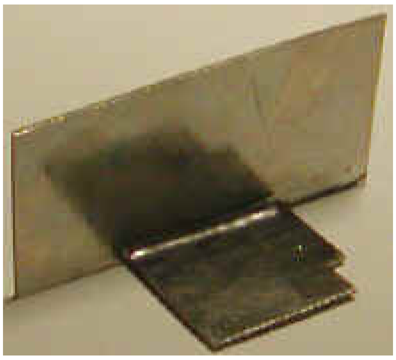


The above schematic shows a 100k volume control but the signals usually aren't loud so this component may be replaced with an ordinary 100k resistor. The .01uF capacitor would connect directly from the collector of the first transistor to the base of the second. This amplifier is non-inverting so a feedback squeal will be heard if the earphone wires are too near the antenna. Reduce the 100pF in the antenna if feedback squeal is a problem. The circuit draws only about 125uA so battery life is excellent. The circuit is designed for a sensitive crystal earphone and cannot drive most other types of earphones. One notable exception is older sensitive dynamic headphones which are rare treasures. To drive a lower impedance earphone, say a 60 ohm type, lower the last transistor's collector and base resistors from 100k and 10Meg to 1k and 100k but remember that the battery current will be much higher. An 8 ohm earphone will require a different output stage for satisfactory performance.

An inexpensive plastic box makes a great housing. The unit below employs a couple of pieces of tinned circuit board to hold the circuitry and to act as a battery holder. The tab on the circuit board assembly is soldered to the unused bottom row of pins on the power switch to hold it in place. A few drops of epoxy on the bottom side could serve the same purpose. Don't forget some fancy artwork for the front of the box!

(I have lots of these brown boxes and 1N5711s. Just ask.)



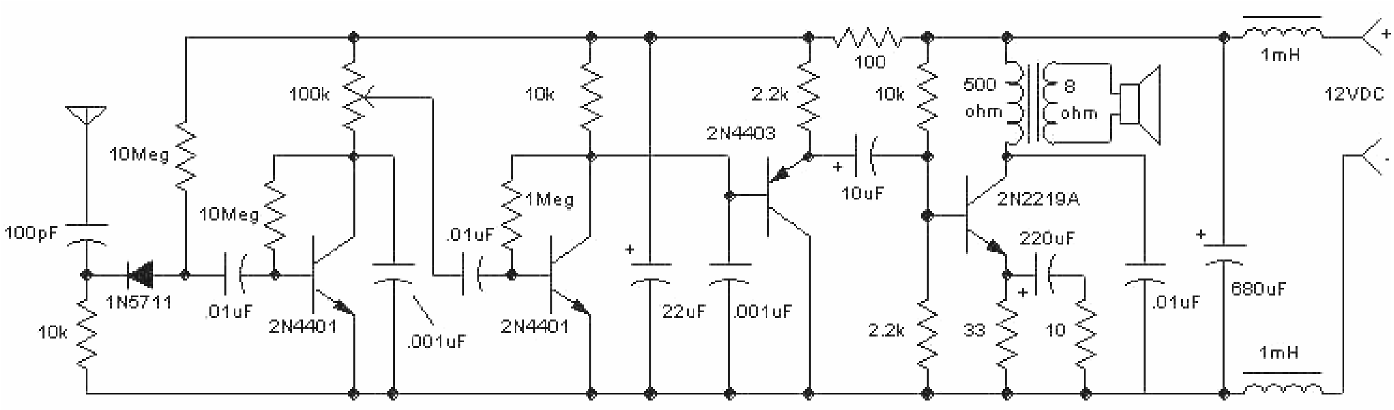


Any high-impedance high-gain audio amplifier circuit will work with the basic diode detector so feel free to experiment! Remember to leave the 10Meg bias resistor for the diode and couple the amplifier through a .01uF capacitor.

Here is a version of the all-band receiver for the car that I hesitate to publish! The following circuit can be tricky due to the very high gain combined with the high speaker currents which is a sure recipe for stability problems. Be warned that making it work right may be a challenge! It makes a great workbench companion, watching for undesired oscillations in your latest creation!

Automobile Warning: This thing will pick up police radar but only when a few yards away - not soon enough to serve as a conventional radar detector. Some states have laws against radar detectors and you may have a problem convincing the nice officer that your gadget is a harmless toy. Few people have hobbies like ours and nefarious motivations are usually suspected. A copy of this article might help but don't count on it!

A loud speaker version of the all-band receiver is shown below:



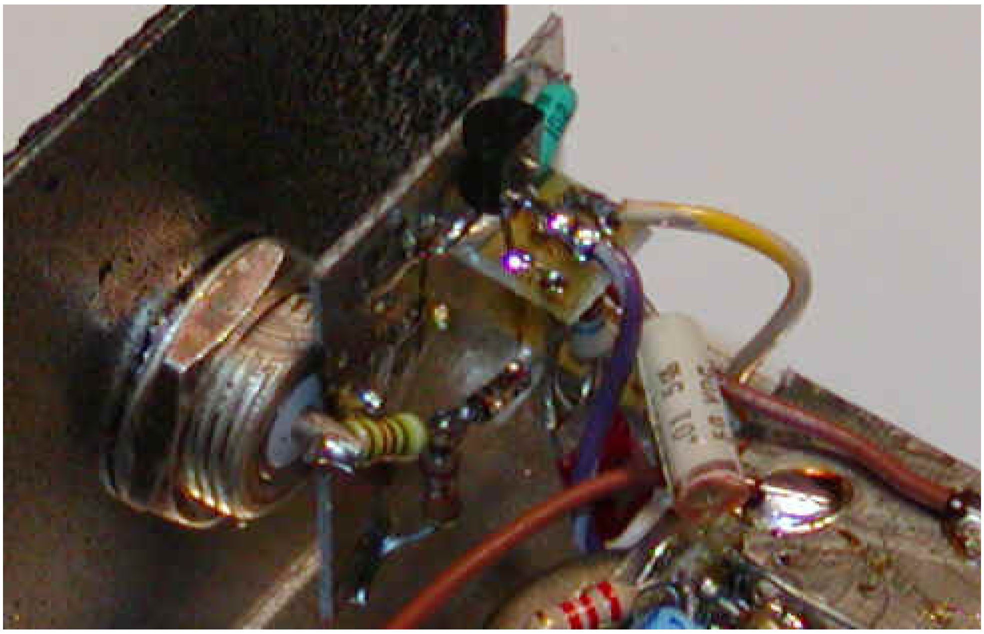
The circuit is similar to the two-transistor version but the second stage uses lower resistor values for driving a PNP emitter-follower. The emitter-follower provides enough current to drive a transformer-coupled class-A power amplifier that can deliver several hundred milliwatts to the speaker. A transformer-coupled class-A amplifier was chosen for a couple of reasons. First, the transformer provides an efficient match to the speaker and lowers the audio current flowing in the circuit ground. A similar circuit operating an 8 ohm speaker directly from the 12 volt supply would be much less efficient and would produce higher ground currents for a given volume. Second, the class-A amplifier is simple, performs well and, since the circuit operates from the car's battery, a little inefficiency is fine. Class-A audio output stages should not be overlooked by the experimenter! The gain of the output amplifier is reduced by a 10 ohm resistor in series with the 220uF emitter capacitor because the overall circuit gain is so high. If you experience stability problems, increase the value of this 10 ohm resistor; don't worry, there is plenty of gain left! The 2N2219A does dissipate about 1/2 watt so some heatsinking is required. Power transistors will work well, including TO-220 types which would not need a heatsink.

Placing the volume control in the DC path of the first transistor causes some noise when adjustments are made so it may be better to replace the pot with a fixed 100k resistor and to AC-couple the potentiometer to the collector.

The unit is constructed in a metal housing with a BNC connector for the antenna:

The audio transformer is the metal can in the picture above but any 500 ohm to 8 ohm miniature type will work. The output transistor has a black heatsink attached and is mounted to a miniature terminal strip. The red blob is one of the power chokes before it is secured to the capacitor with some hot-melt glue. Notice that the circuit is separated into three sections to reduce feedback. The output stage is directly connected to the incoming power leads, and the rest of the circuit has a filter consisting of a 100 ohm resistor and 22uF capacitor to reduce the possibility of feedback via the power supply.

The diode detector and first transistor are mounted directly on the BNC:



Before circuits are installed:

This gadget has enough gain to hear the internally-generated component noise with no antenna attached in a noisy car! After the unit was placed in a spot in the car relatively free from ignition noise, all sorts of strange sounds were detected. A shorter antenna is favored due to the abundance of FM and TV stations - try 2 or 3 inches. There are some common sounds: The penetrating buzz that sounds like 60Hz line noise is from TV stations, the really loud hiss means you are passing near a digital cell phone tower, the gaggle of music and voices are FM stations, other buzzes and tones are probably from digital networks, nearby cell phones, and other wireless devices but who knows!

A high fidelity AM radio was realized on the workbench simply by connecting the BNC through a 10uH choke to a tuned circuit consisting of a 120uH choke in parallel with a large variable capacitor. The antenna was about 3 feet long. This project makes a great universal detector for a variety of bench experiments. And, by building it, you will learn a lot about unwanted positive feedback, too! :)

Here is an email from a reader regarding FM detection:

Charles,

Thanks for an excellent circuits archive. I'm writing because I may be able to throw some light on the reason why Paul Beaumont's all band receiver can demodulate FM, despite having an AM-only detector. I believe it is due to multipath reception. Consider this:

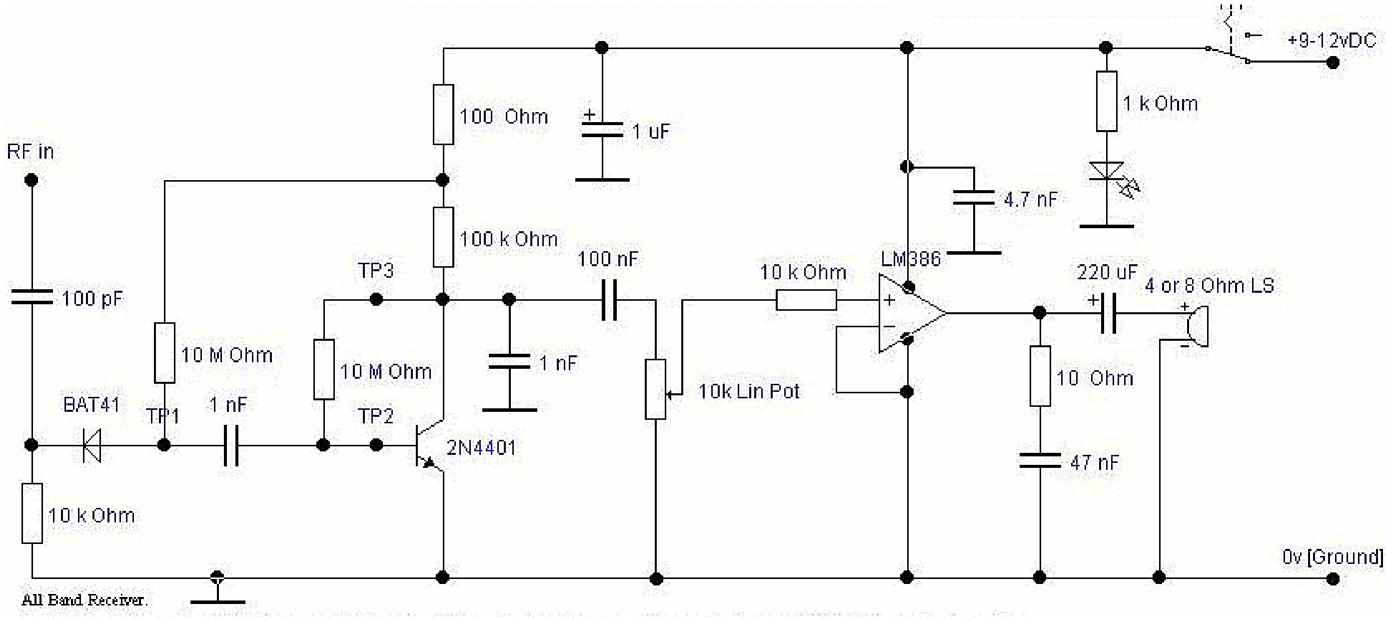
Your antenna receives an FM signal via the direct path, and also via an indirect path (perhaps a reflection off a tall building). The extra distance for the indirect path might be 300 meters. This corresponds to a delay of 1us for the indirect path. If the FM signal is at 100MHz, then the 1 us delay is exactly 100 cycles of the carrier. The two signals arrive in-phase and the signals produce a strong signal in the antenna. If, however, the FM carrier moves to 100.5 MHz, then the 1 us delay corresponds to 100.5 cycles of the carrier.

The signals arrive anti-phase and they cancel (to some extent at least). Now this is not so extreme as it seems. FM signals vary in carrier frequency by 0.15 MHz (+/-75 kHz). So if *any* multipath occurs, there is likely to be some AM resulting. Under the ideal conditions described, there would be considerable AM (perhaps 60% modulation depth). Hope this provides a plausible explanation!

Regards,

Karen

Here is a modification that uses an audio amplifier IC sent in by a reader (Paul Beaumont MIScT G7VAK):



- Supply voltage is 9 or 12 volts DC from a regulated supply. A battery is not used as consumption can rise to around 75mA in strong signal conditions.
- Amplifier is LM386 with an adequate gain of 20. Input from 10k pot and series 10k resistor to pin 3. Pin 2 and 4 to 0v line.
- To raise gain to 50 connect a 1.2k resistor and 10uF capacitor between pin 1 and pin 8 [- to pin 8].
- Output is via pin 5 and a 220uF capacitor, [+ towards pin5] 25v wkg or better. LS is a 4 or 8 Ohm miniature loudspeaker.
- Supply to LM386 is via pin 6 which is strapped to + rail but with a 4n7 decoupling capacitor near to the chip.
- Various lengths of antennae can be used and for experimentation a parallel tuned circuit can be connected between the RF input and the 0v [Ground] rail.
- If a BAT41 is not available a BAT85 can be used. 1N5711 and 1N6263 are also suitable.

Test Point Voltages [no signal, Fluke 83]
TP1 circa 100mV
TP2 circa 540mV
TP3 circa 2.95V

Paul Beaumont MIScT G7VAK

Thanks for the IC version, Paul!