AM Detector Circuits

Diode based AM detector circuits have been used in countless AM radio sets over the past decades, a quick survey of the internet shows little relevant information about alternatives to such simple circuits. A collection of AM detector circuits are presented here which may be used for a variety of applications such as enhanced crystal sets, RF voltmeters and very sensitive VSWR meters.

The diode detector and what is wrong with it?

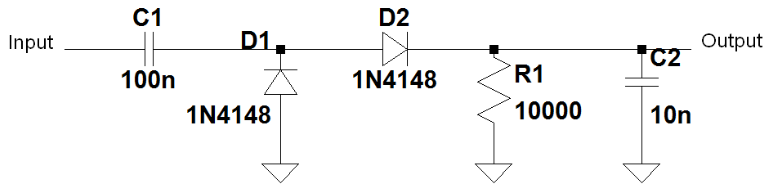

Figure 1. A simple diode detector.

Figure 1 shows a standard diode detector circuit. Commonly used in cheap AM radios this has got to be one of the most dreadful circuits in RF engineering. Typical distortion levels in detected audio are over 10% and its efficiency as a detector collapses as the input goes below a few 10's of millivolts (even with attempts at active biasing). The reason for such performance is the variable dynamic resistance of a semiconductor diode. The dynamic resistance is a function of the voltage across a diode at any one time. Applying an AC voltage across a diode, the diode could be swapped out with a resistor equal to its dynamic resistance at any one instant without any change in circuit behavior. When reverse biased the diode's dynamic resistance is extremely high. When forward biased the dynamic resistance reduces dramatically with increasing voltage. Obviously charging up the smoothing capacitor C1 through such a dynamically changing resistance is not going to do much for linearity and will result in low efficiency for small signal changes.

The Infinite Impedance detector

Figure 2 shows an infinite impedance detector from the bygone age of thermionic tubes (valves).

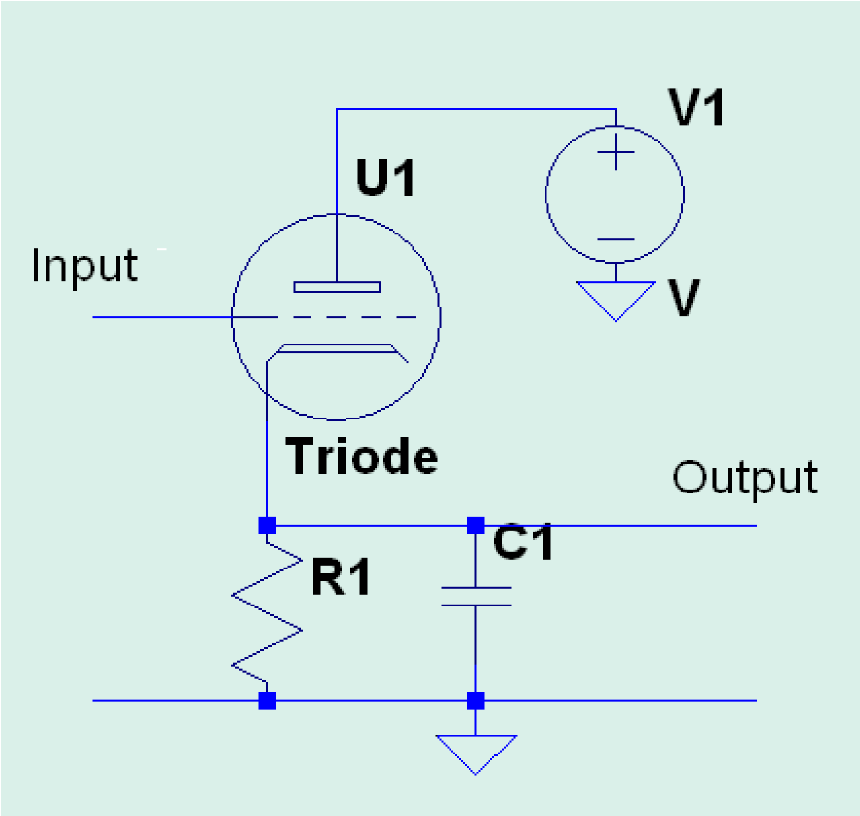

Figure 2. Thermionic infinite impedance AM detector.

It is basically a voltage follower circuit with a smoothing capacitor. The dynamic resistance across the tube (between the anode and cathode) decreases on voltage peaks at the input but is otherwise very high. The input impedance at the grid is always very high. A modern equivalent is shown in figure 3.

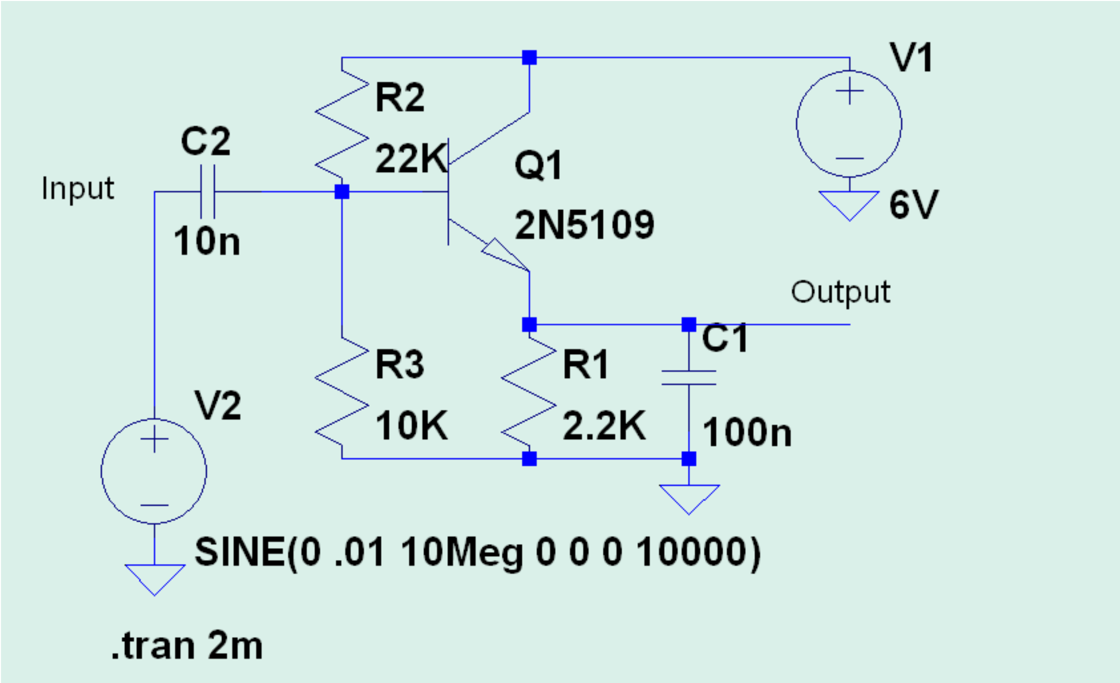

Figure 3. A BJT version of the thermionic infinite impedance detector.

It is a basic emitter follower with the addition of a smoothing capacitor. In this case the input impedance is actually very low at RF frequencies in contrast to the thermionic version; however it does represent an improvement over the basic diode detector.
A further improvement can be obtained by using a complementary feedback pair as in figure 4.

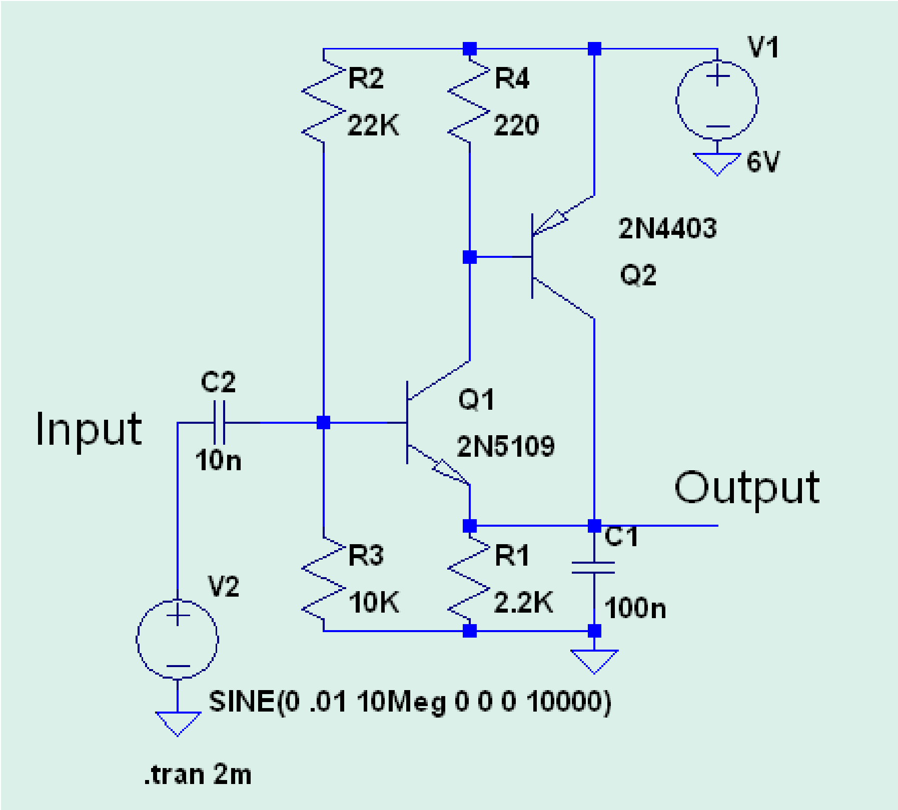

Figure 4. AM detector using a complementary feedback pair.

The input impedance can be considerably increased using a constant current source in place of the emitter resistor as shown in figure 5.
Normally for HF radio circuits up to about 30MHz you can use commonplace transistors such as the 2N2222. However for the circuits in figures 3, 4 and 5 proper RF transistors are mandatory for frequencies above about 1 MHz if you want good performance. For stability reasons the pnp transistor in figure 5 should have a lower Ft than the npn transistor.

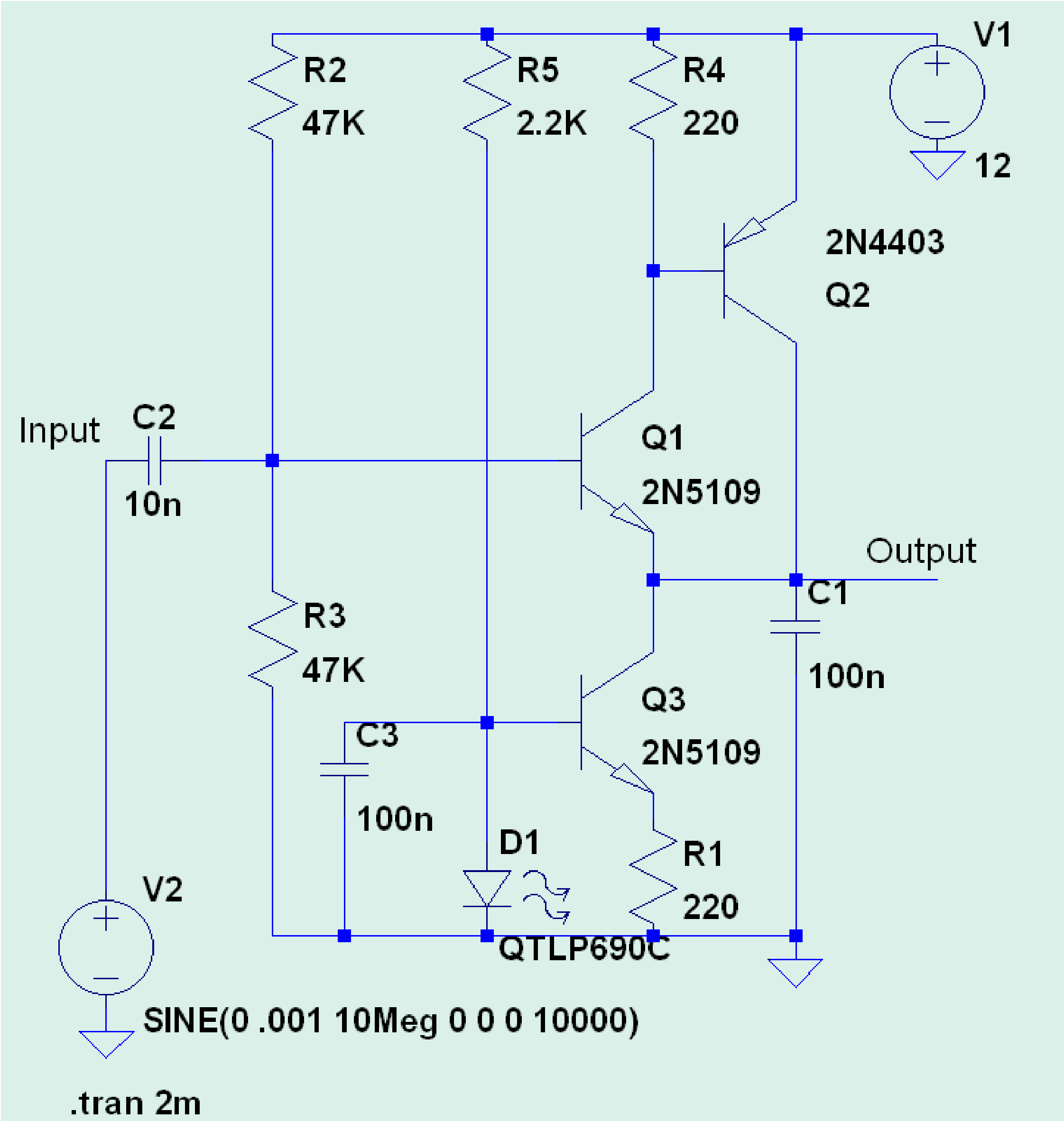

Figure 5. Emitter resistor replaced by a constant current source.

Pushing past the dynamic resistance problem

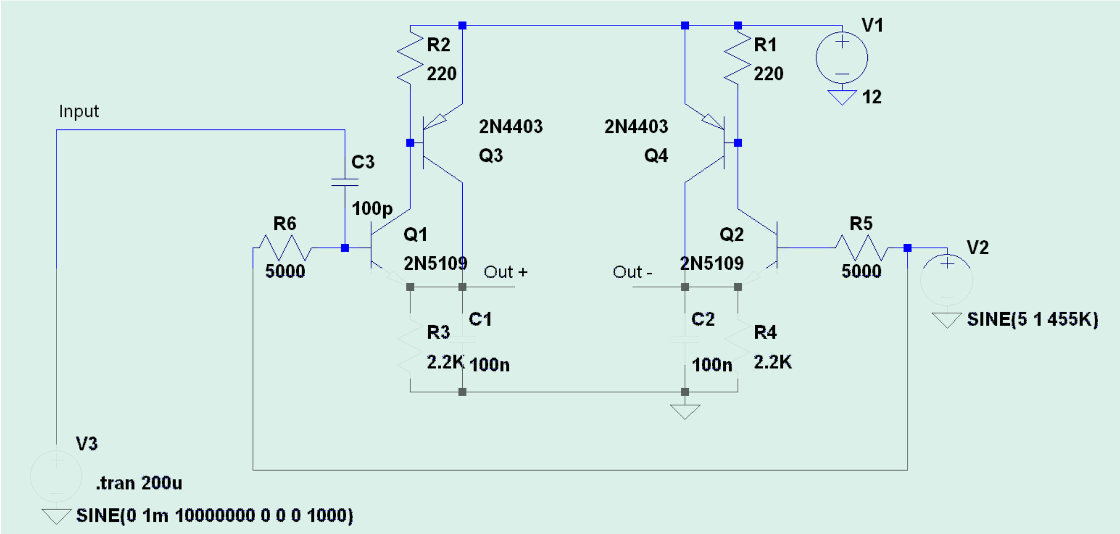

Figure 6. AM detector with differential outputs.

V2 supplies 5V bias with 1 volt pp at 455 KHz superimposed on it to reduce the dynamic resistance seen by small signals.

Even though the circuit in figure 5 is a good improvement it still cannot detect down to the microvolt range. And still the problem is with the dynamic resistance of the circuit. One method to deal with this is to add a large continuous RF signal to the input signal. This helps by reducing the dynamic impedance to lower levels than would otherwise be obtained with the small signal alone.

Figure 6 show such a circuit. The best frequency for the continuous signal is usually between 30Khz and 1MHz with 455KHz being a convenient choice.
This method can even be used with the basic diode detector to create an enhanced crystal set for example.

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Appendix

Miscellaneous circuits

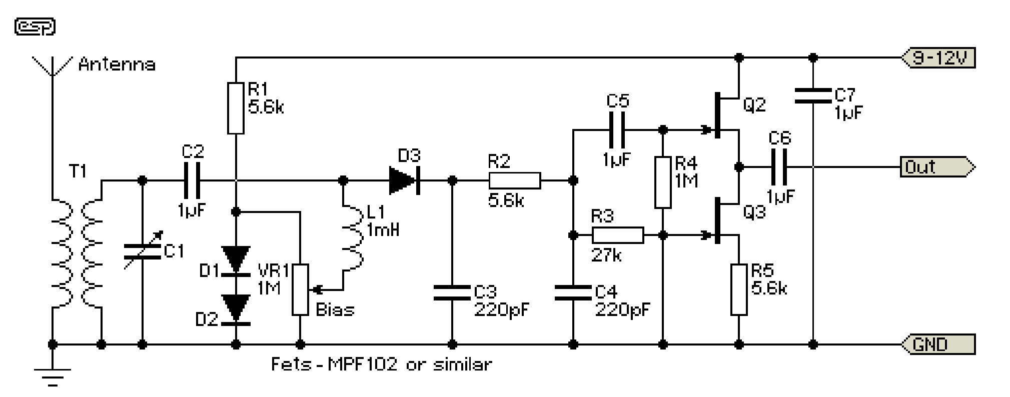

Figure 7. Improved Diode Detector with diode biasing

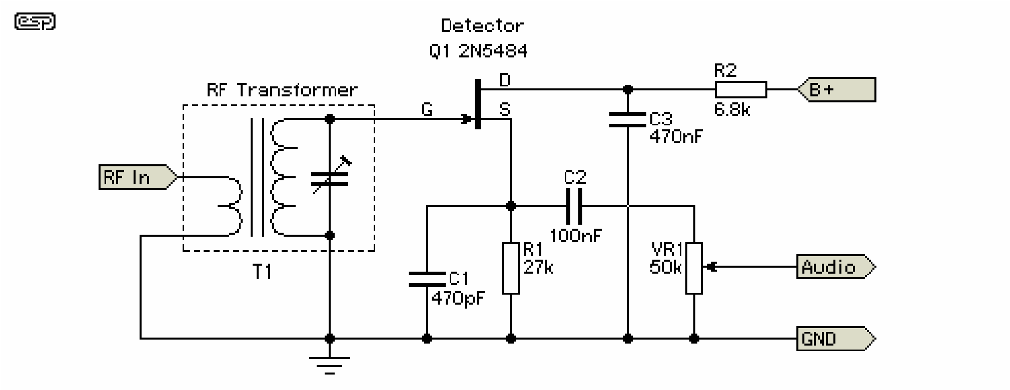

Figure 8. FET Based Infinite Impedance Detector

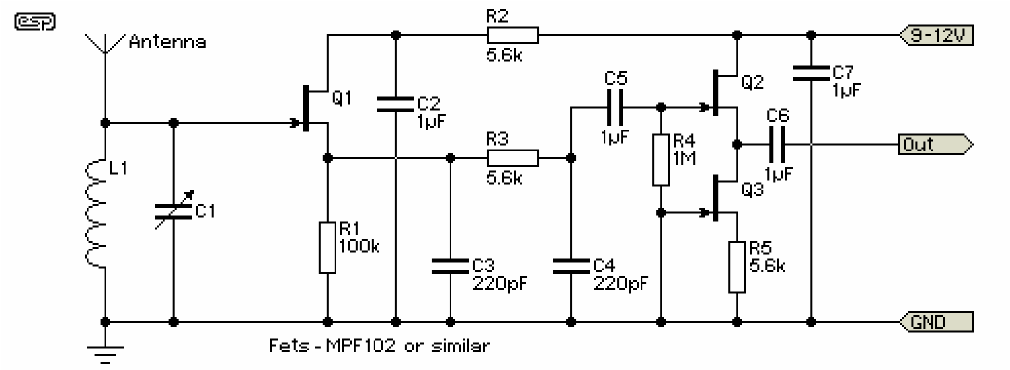

Figure 9. Improved Infinite Impedance Detector

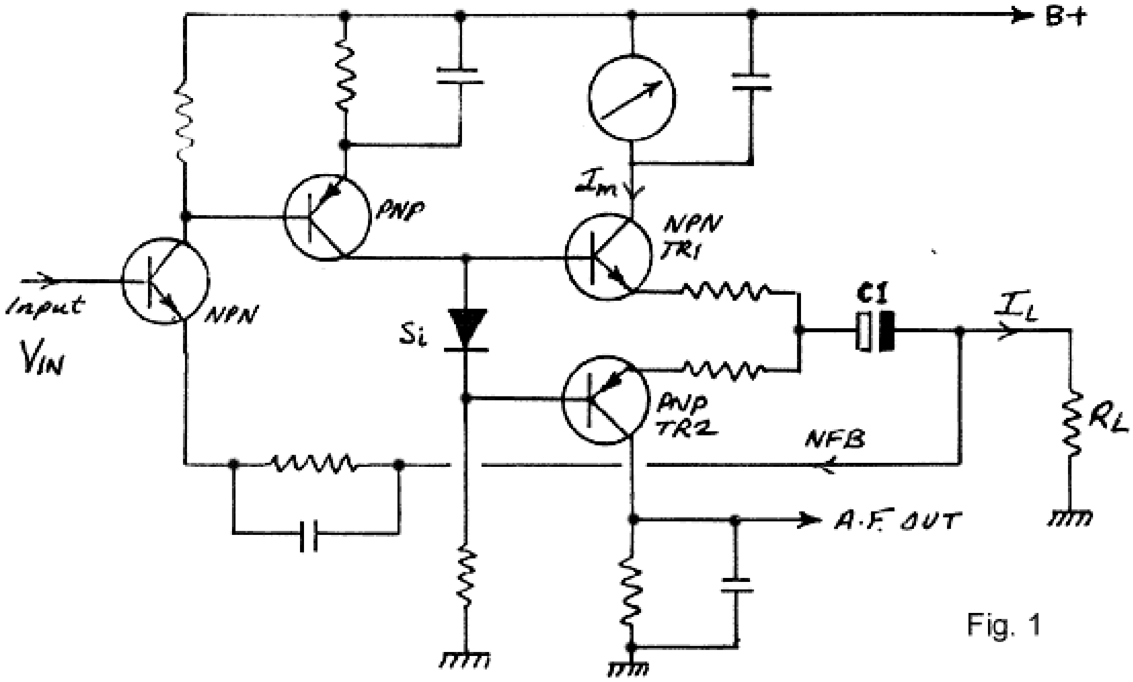

Figure 10. AM detector using a class B amplifier. As the RF input signal increases the power dissipated in the load RL increases. This increases the current drain of the amplifier which is monitored to produce the AF output.

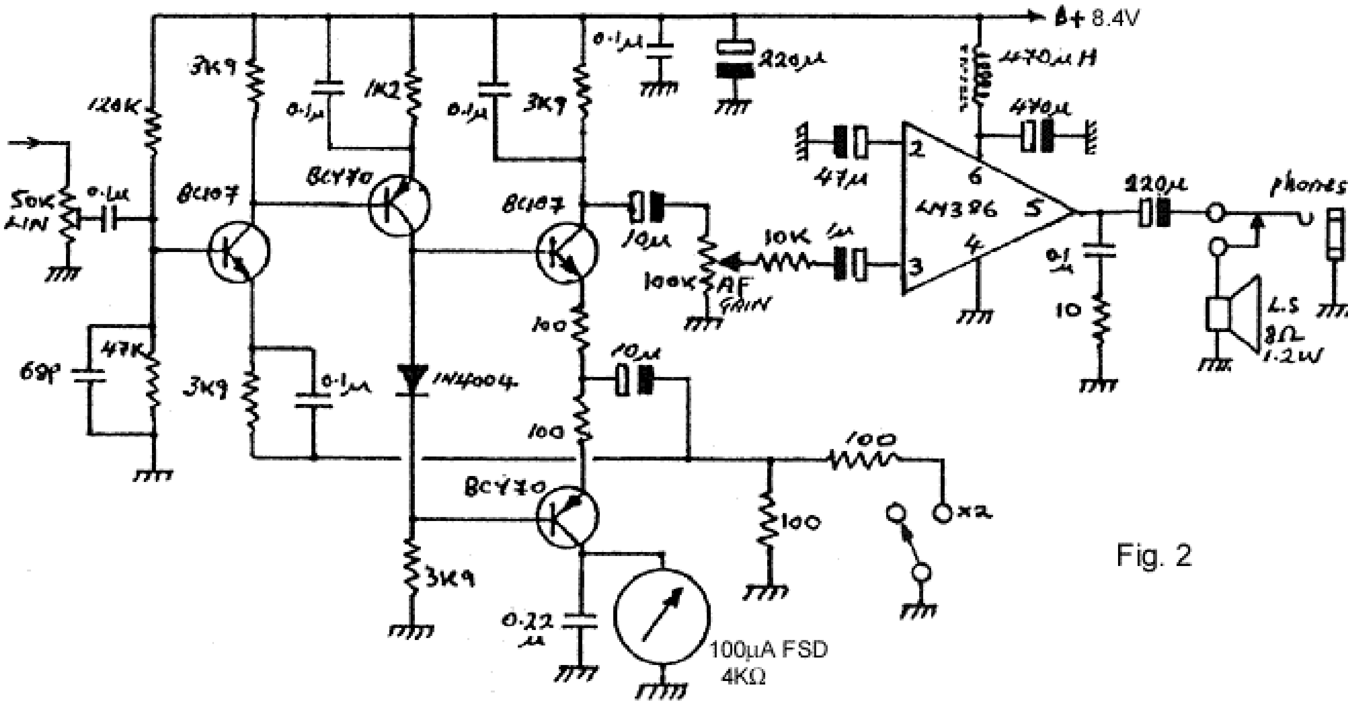

Figure 11. Working example of figure 10.

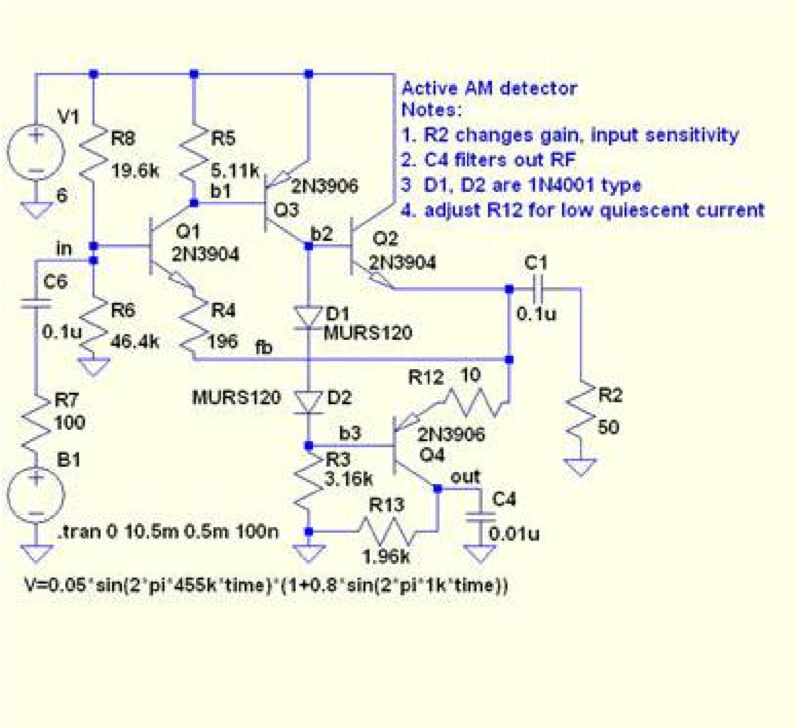

Figure 12. Another class B detector circuit.

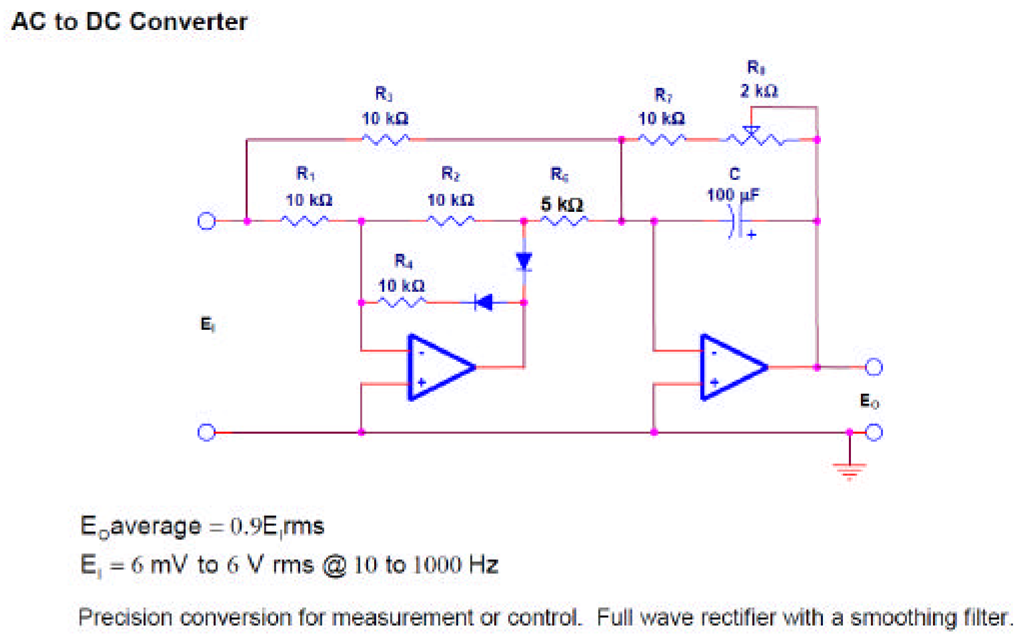

Figure 13. Op-Amp rectifier with smoothing filter. Very high frequency signal components are generated when the diodes switch requiring high speed op-amps.

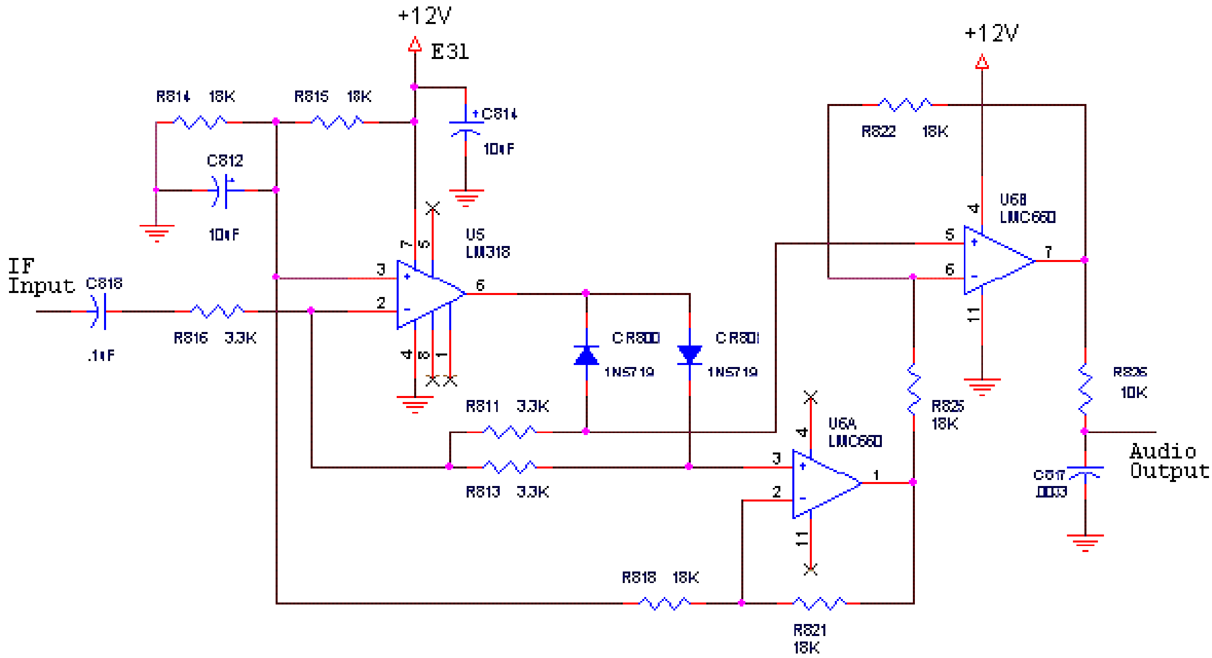

Figure 14. Precision Full-wave AM Detector for 50KHz IF.