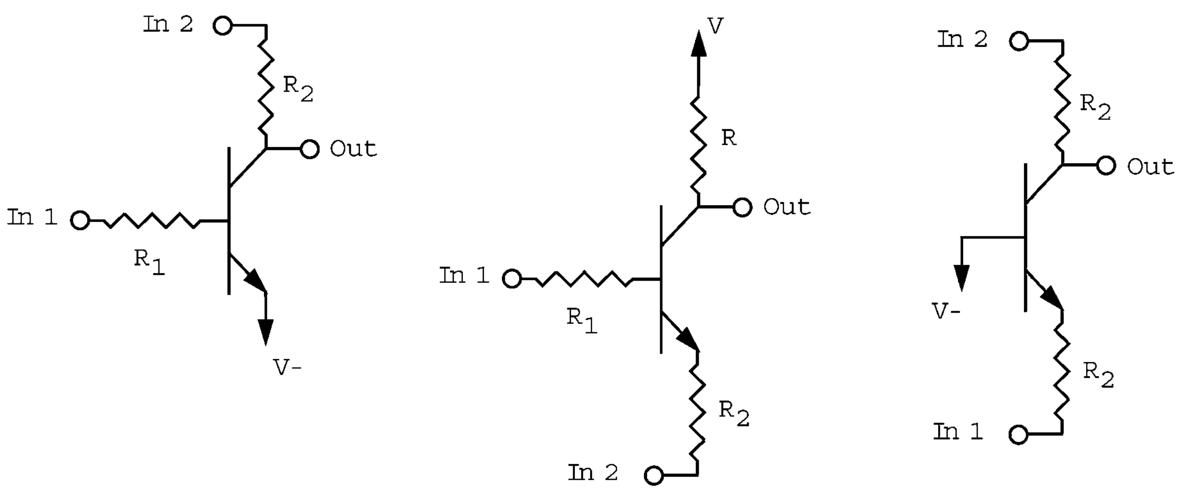
DESIGN OF AN AM RADIO FREQUENCY TRANSMITTER AND RECEIVER

OBJECTIVE
To design and construct an amplitude modulated radio frequency source, and to detect and demodulate the radio frequency signal and use it to drive a loudspeaker.

PROCEDURE
1) Transmitter.
For the transmitter you must find a way to modulate the amplitude of a radio frequency (rf) source at an audio frequency (af). The rf, at about 0.5 MHz, and the af, at about 1 kHz, may be obtained from separate function generators. Note that the some generators have a dc offset control which is usually activated by **pulling out** the dc offset knob. This control may be helpful in setting biases so that the output signal is not distorted.

There are many ways in which transistors (or diodes) can be used to modulate the amplitude of an rf signal. Three possibilities are shown in Fig. 1. In each case the output is at the collector of the transistor, and the af and rf signals go to the two inputs. Choose one of the three circuits, pick values for the resistors, and decide which input you wish for the audio and which for the rf. Then adjust the signal levels and the dc offset until you obtain a modulated rf output with a peak to peak amplitude of at least 5 volts and no clipping distortion. Build this circuit on the one side of your circuit board.



(a) (b) (c)

Figure 1. Transistor AM Modulators

Keep these somewhat conflicting points in mind while you are designing and debugging the circuit:

1) For large rf amplitude, the transistor should be turned on hard, approaching saturation, during half of the rf cycle, and should be turned completely off during the other half.

2) Avoid driving the transistor into hard saturation, because then it will take longer for it to turn off during the next half cycle.

3) Use a relatively small collector resistor, so that the RC time constant (where C is the stray capacitance at the collector) is small enough to give you a good rise time.

4) Avoid too large voltages and too small resistors, to minimize the power dissipated in the resistors and the transistor. For example, with a 1 kWresistor and 10 volts, the power dissipated is 0.1 watt, which is a reasonable limit for 1/4 watt resistors.

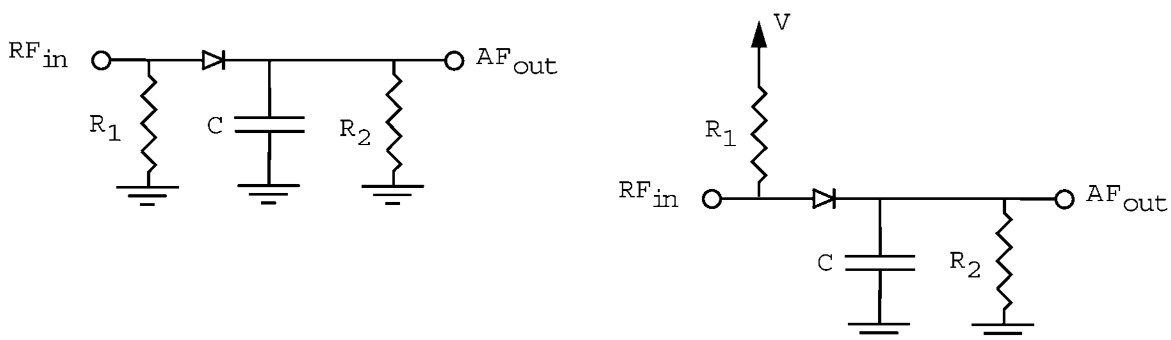
5) For a transmitting antenna you may wish to try a piece of wire about 12 inches long, looped so that it extends about 6 inches into the air. A longer wire will transmit better, but it will also load the transmitter more. If anyone else can pick up your signal, your wire is too long!

Which circuit did you choose? What are the values you chose for resistors and supply voltages? How large a modulated signal did you obtain?

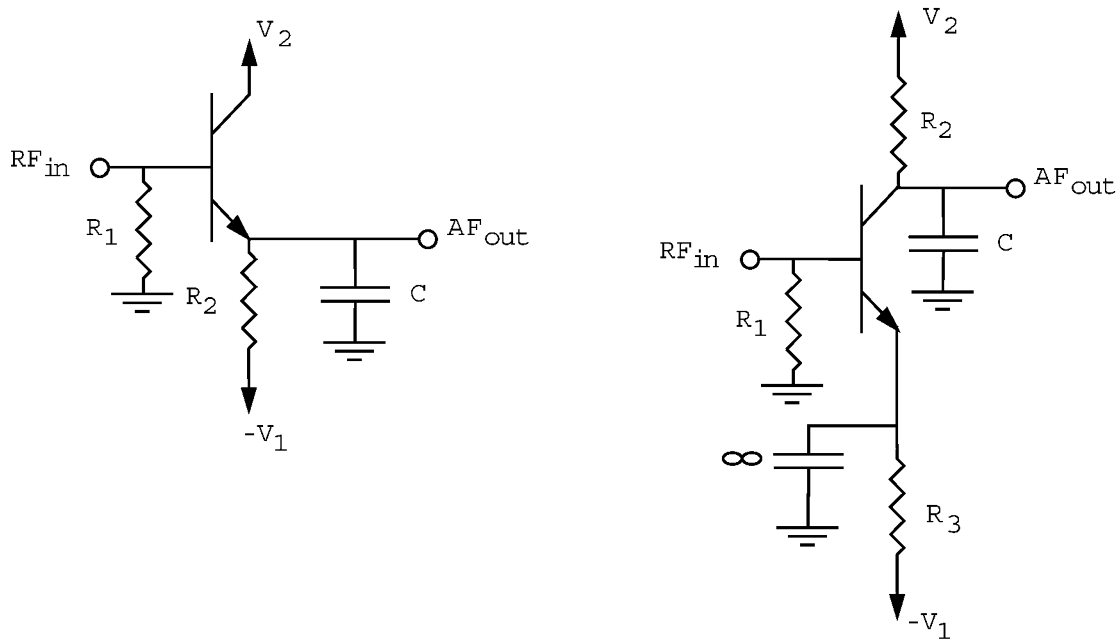
Receiver

The rf may be "picked up" by a similar, receiving antenna, facing the transmitting antenna. Design and construct a circuit to "demodulate" the rf, or to extract the audio frequency envelope that limits the amplitude of the rf signal. Choose one of the circuits shown in Fig. 2. Figs. 2a and 2b are simple diode peak rectifiers. The diode in 2b is forward biased, to prevent the first 0.7 volt of rf signal from being lost. Fig. 2c is similar, except that the diode is replaced by a transistor. This is a much better circuit than the one in Fig. 2b, because the current gain in the transistor produces b times as much output. In Fig. 2d the collector current is filtered to obtain the demodulated signal. Optimize your choice of resistors and bias conditions so that you obtain the largest possible signal with minimal distortion. Choose C large enough to attenuate the rf signal, but not so large that it attenuates the af signal. Note that because the currents in the receiver are small, you may wish to use large resistors to obtain a strong signal.

Which circuit did you choose? What are the values you chose for resistors, capacitors, and supply voltages? How large a demodulated signal did you obtain? How far apart can you place the transmitting and receiving antennas?



(a) (b)



(c) (d)

Figure 2 – AM Demodulator Circuits

Loudspeaker Driver

The demodulated signal you obtained above can be detected with your 'scope, but it probably does not have either a large enough voltage, or a low enough impedance, to drive your loudspeaker very well. Design a single transistor amplifier to take the signal from the demodulator and drive the loudspeaker. Pay attention to impedance levels. For example, there may be an adequate voltage signal which is badly attenuated when an eight ohm speaker is connected. This can be helped with an emitter follower or (especially) a source follower, which extracts the signal with little loading. Your demodulated signal may also be at an inconvenient dc level. In this case you can use a capacitor to block the dc component. **Caution:** At these frequencies the location of components can be as important as the values of the components themselves. For example, it is often a good idea to split the capacitor C in Figs. 2c and 2d into two capacitors, of value C/2 each, with one capacitor at the detecting transistor, and the other at the base of the emitter follower driving the loudspeaker.

Draw the circuit diagram you designed to drive the loudspeaker. Show the values of all components and supply voltages. *What signal level did you measure at the input to the driver? What signal level was applied to the loudspeaker?*

QUESTIONS

1) Receivers usually use tuned circuits. State two major advantages of using a tuned circuit in a receiver.

2) *Why is 0.5 MHz a better choice of rf than 1.0 MHz?*

PSPICE ASSIGNMENT

Use PSPICE to design a different modulator from the one you chose for the transmitter. Sketch your new design, indicating the values of the voltages and resistors. *How does the performance of this modulator compare to that of your original design?*