Building an AM radio

Objectives
By the end of this lab, the students should be able to:

- describe the function of the variable resistor, variable capacitor in the radio circuit
- describe how variable capacitors are connected in circuits
- describe how variable resistors are connected in circuits
- describe the “hidden workings” of a electronics prototyping board
- construct a AM radio (or any circuit) using a project board, components, jumper wires and a diagram

Introduction
Amplitude Modulated (AM) radio signals carry an audio signal (electrical information that can be converted to sound). The audio information is encoded on the radio wave by changing the amplitude of a high frequency radio wave. The base frequency of the electromagnetic radio wave (called the carrier wave) is much higher than the frequency of the audio information it carries (550kHz to 1600kHz versus 20Hz to 20kHz). The diagram at right shows how the encoding works. The amplitude of the carrier wave is not constant. The fast variation is the carrier wave. The relatively slow variations in the amplitude create an envelope that shows the frequencies in the audio signal. The diagram is somewhat distorted to show the principle. The amplitude of a typical radio signal varies much more slowly than the picture suggests. (How many periods of a 600kHz carrier would have to be shown in order to show half of a period of a 100 Hz sound?)

An extremely basic AM radio, consisting of a detector (a diode in the circuit at the right) and an antenna, is shown at right. The diode only allows current to flow in the direction indicated by its symbol. This circuit detects AM signals and converts them to audio signals.

The second circuit at the right is a (slightly) more sophisticated version. The design includes a tuning section. By setting the resonant frequency of the circuit to the frequency of the desired carrier wave, the user selects one carrier frequency for conversion.

The radio you will build (see the diagrams on the last page of the handout) includes an AM detector (a transistor in this case), a low pass filter (to remove the carrier wave from the audio signal) and an amplifier.

Web Resources
The web has some good resources on AM radios. Googling “crystal radio” yields quite a bit of info on how to build a radio. One such site is http://sci-toys.com/scitoy/scitoy/radio/radio.html. The web also has some good explanations of how the AM detector works. Google “AM detector” or “envelope detector”. One such resource is http://www.st-andrews.ac.uk/~www_pa/Scots_Guide/RadCom/part9/page2.html.

Figure 1: Amplitude modulated carrier signal
Figure 2: Simple AM detector circuit
Figure 3: AM detector circuit with tuner block

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Instructions

1. Some of the AM radio is already made. A battery holder, coil, variable capacitor, potentiometer (a.k.a. variable resistor), project board and earphone jack have been mounted to a small piece of plywood.
   - Identify which component is which.
   - Use a multimeter to figure out how the potentiometer works. (Hint: Use the ohm-meter setting on the multimeter).

2. Prototype board is used for making and testing temporary circuits. Prototype boards have internal connections. The internal connections allow you to build a circuit with relatively few wires needed and to avoid soldering. Obtain an un-mounted project board. Inspect it. Figure out the pattern of internal connections. You can do this by looking at the back of an un-mounted project board or by using an ohm-meter.
   - Which holes will be at the same potential (provided small currents are flowing)?
   - Which holes can be held at different potentials? In other words, which sets of holes are electrically isolated from each other?

3. Obtain a kit of components for your radio. Inspect them.
   - Identify the different kinds of components: resistors, capacitors, transistors, and integrated chip.
   - **Hooking up asymmetric components incorrectly will lead to unintended operation** (more often than not unintended operation means self-destruction). Identify all non-symmetric components. Note: Some “two-legged” components, including many capacitors, are asymmetric.

4. Use the diagrams on the next page to construct the circuit. You may note slight discrepancies between the parts in your kit and the parts provided. In particular, the resistance values called for might not match the contents of your kit. In general, you can use resistance values that are within a factor of two or so and still get the circuit to work. **Pay attention to the proper connection of asymmetric components** (including capacitors)! **Leave the battery out** until you have visually double-checked the circuit against the diagram.

5. Put in the battery and test the radio. In order to get a signal, you may need to …
   - tune the radio. (Which circuit element does this?)
   - turn up the volume on the earphone (Which circuit element does this?)
   - rotate the entire radio. (Why might the orientation matter? Which element needs to be aligned? What does it need to be aligned with? Why?)