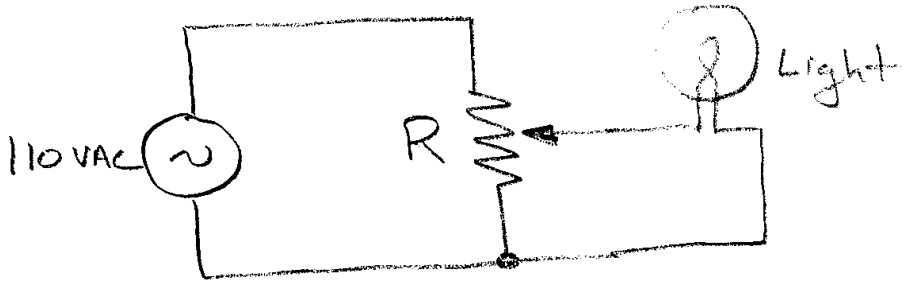
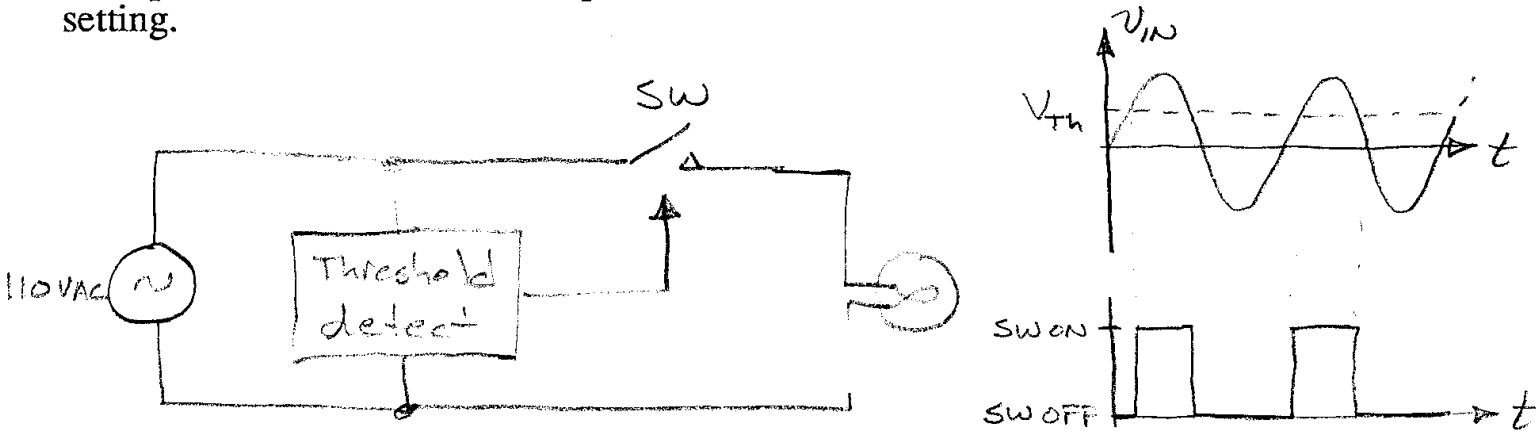
P1.1

One method would be to use a variable resistor as shown below. As the wiper on the resistor moves from the top to the bottom, the light varies from full brightness to completely off. This circuit is just a variable impedance divider.



A second method would be to use a variable threshold and only allow current to flow in the light when the input voltage is above the threshold. For this method to work we need a circuit to generate the threshold, which must depend on the setting of some control, and we need an electronically controllable switch. A simplified diagram is shown below along with the input waveform and an example of when the switch would be on for a given threshold setting.



The first method is simpler, but a significant amount of power is wasted in the variable resistor. The second method is close to what is used in solid-state dimmer switches; they typically use solid-state switches known as Triacs (see Chapter Two) which are turned on for some portion of each cycle of the sine wave.

P1.2

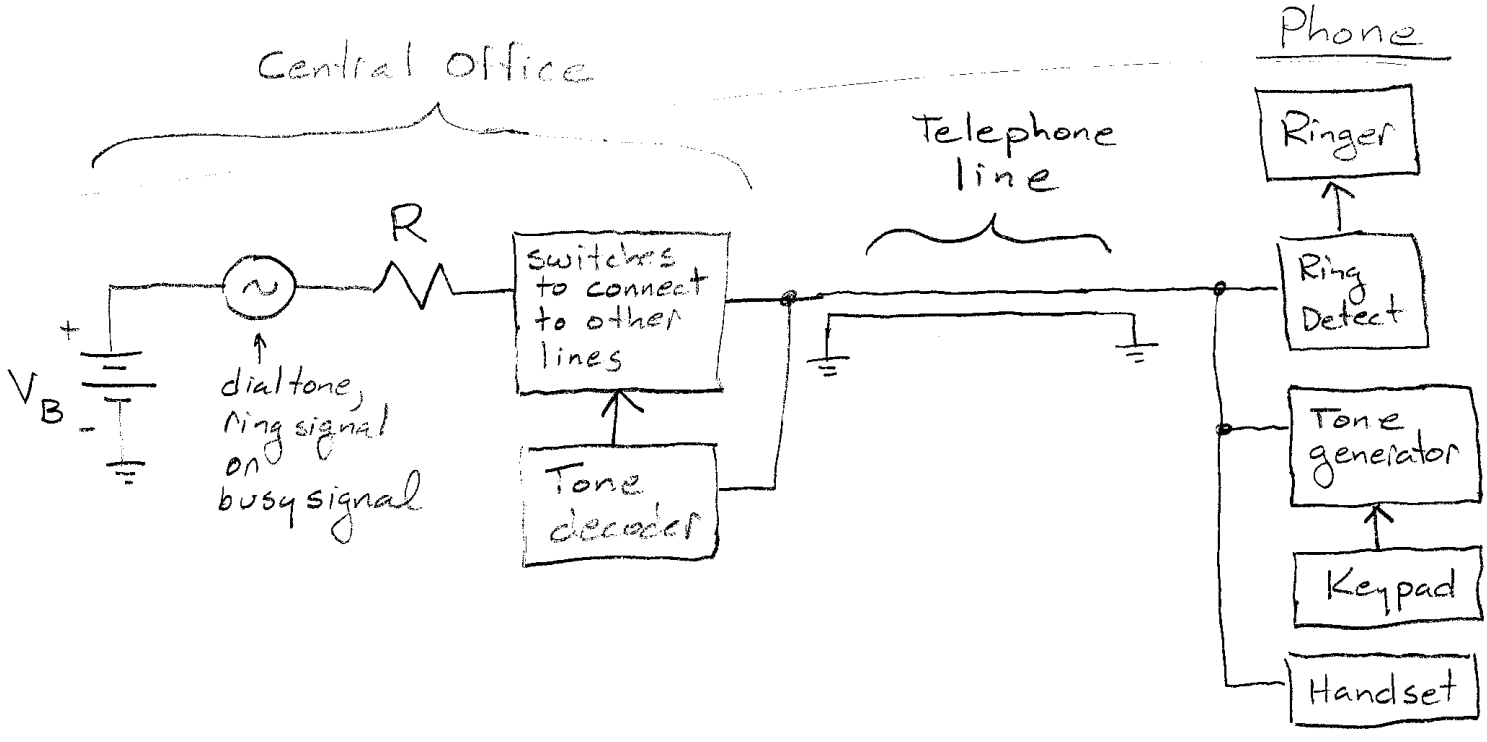
The switch is only capable of turning the power to the light on or off. Therefore, the light must detect some pattern of on-off-on switching in order to know what state to be in. For example, you could set it up so that if the light has been off for at least a few seconds and is then turned on once, it comes on steadily. If, on the other hand, it has been turned off for some time and is then turned on, off, and immediately back on again, it will come on in the motion detector mode. Alternatively, you could require that the light be turned on for some period of time, say 3 seconds, then off and back on again in order to trigger the motion detector mode. The first scheme is easier to use since it does not require the user to count for three seconds.

P1.3

One possible block diagram is shown below. The DC voltage, V_B, is used to power the phone. The central office (CO) can detect whether the phone is "on hook" or "off hook" by measuring the current flow in the line (one way to do this would be to monitor the voltage on the right-hand end of the series resistor). If the phone in on hook and the CO wants to ring the phone, an AC signal is added to the DC supply. This AC signal must be detected at the phone and used to trigger the ringer. When the phone is picked up to answer the call (i.e., it goes "off hook") the current consumed increases, the CO detects this increase, stops the ring signal and establishes the connection between this phone and the caller's phone. If no incoming call is present and the phone is taken off hook, the CO generates a dial tone and adds it to the DC supply. The phone then sends a sequence of tones to the CO to indicate the number it wants to be connected with. The CO must then decode these tones, ring the other line (or supply a busy signal if the phone is in use) and establish the connection if the other phone is picked up.

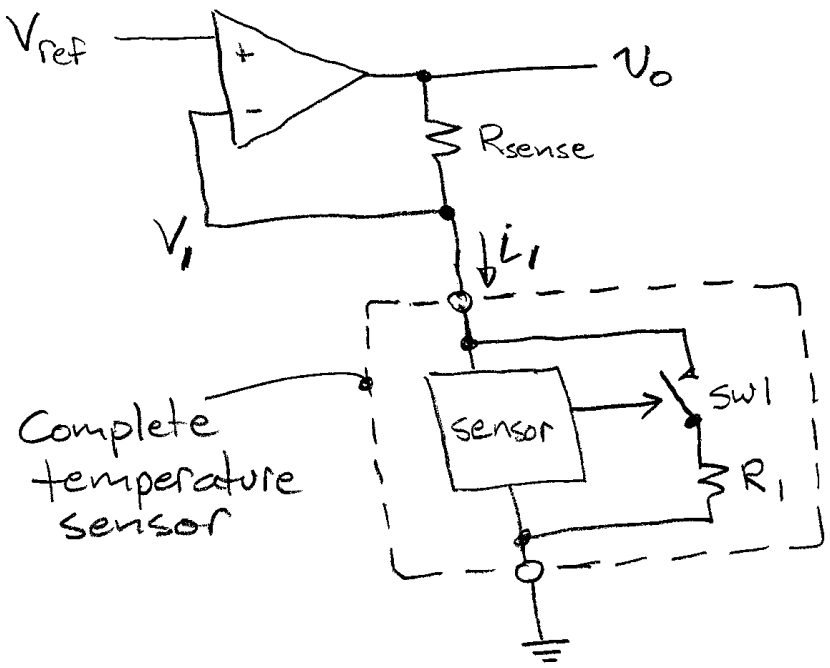
In order to implement the protocol described above, the CO must be able to generate ring signals, dial tones, and busy signals. In addition, the CO must be able to detect the current drawn from the line, decode the tones for dialing, and connect different phones together. The telephone must be able to sense the ring signal, send tones for dialing and must guarantee that the off-hook and on-hook DC current consumption is within specified limits.

In the United states, the DC supply voltage is 48 ± 6 V when the phone is on hook and between 43 and 79 V when the phone is off hook. The ring signal is a 75 Vrms 20 Hz sine wave that is repeatedly pulsed on for 2 seconds and off for 4 seconds. The dial tone is actually two tones, one at 350 Hz and one at 440 Hz and the tones used for dialing are a mixture of one low frequency (697, 770, 852, or 941 Hz) and one high frequency (1,209, 1,336, or 1,477 Hz). Each low frequency corresponds to a given row on the keypad and each high frequency corresponds to a given column. Using two frequencies minimizes the chances of a misdial due to background noise. The maximum current a single phone is supposed to draw when on hook is 1 μA. The current can vary considerably when off hook, but is typically 10-30 mA.



P1.4

One method would be to use the pulse output to modulate the current used by the sensor. The external circuit would then supply the sensor with a constant voltage and would simultaneously monitor the current. One way of accomplishing this is shown below.



The op amp keeps the the voltage supplied to the sensor constant:

$$V_1 = V_{ref}$$

The sensor output pulse controls SW1. When SW1 is closed, i_1 increases by V_1/R_1. When SW1 is open, i_1 is less.

Since i_1 flows through R_{sense} and V_1 is constant, V_o has steps with magnitude:

$$\Delta V_o = \Delta i_1 \cdot R_{sense} = \frac{V_1}{R_1} R_{sense}$$