DESIGN OF AN ANALOG FIBER OPTIC TRANSMISSION SYSTEM

OBJECTIVE
To design and build a complete analog fiber optic transmission system, using light emitting diodes and photodiodes.

INTRODUCTION
A fiber optic transmission system consists of a transmitter, the fiber optic guide, and a receiver. The transmitter in this experiment is a light emitting diode (LED), the fiber is a large diameter (about 1 mm) plastic light guide, and the receiver is a photodiode, which acts an input to an amplifier. The amplifier drives a loudspeaker.

TRANSMITTER
Connect the circuit in Fig. 1, and drive the LED from the signal generator at a frequency of a few Hz. The LED is an electrical diode, which emits light when it is biased to conduct current in the forward direction. Since it is fabricated from a gallium arsenide compound instead of the familiar silicon, its forward voltage is much larger than the usual 0.7 V. What is the maximum forward current rating, and the maximum reverse voltage rating of the diode? Choose the resistor, R, to limit the current through the LED. *What is the purpose of the other diode?*

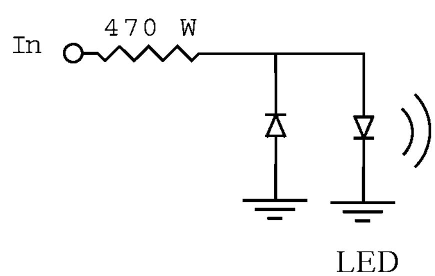

Figure 1

RECEIVER
The receiver is also an electrical diode, but one which generates a current when light falls on it. The simplest way of using it, and sometimes the most sensitive, is called the "photovoltaic" mode. Ideally, in this mode the diode is open circuited, but it may also have a large resistor across it, such as a scope probe. Increase the frequency of the signal generator to about 1 kHz, and use the circuit in Fig. 2 to observe the wave form of the light from the LED. In this circuit the op-amp can provide both a high input impedance and a large voltage gain. Adjust the dc offset and the amplitude controls on the signal generator to get as large a sine wave signal from the LED as possible. Be sure to keep the photodiode far enough away from the LED so that the signal does not exceed a few tenths of a volt - otherwise the photodiode will start to distort the signal because of its forward turn-on characteristics.

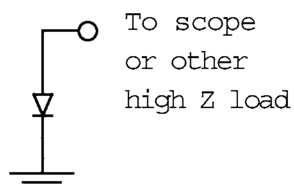

Figure 2

A more linear way to use a photodiode is to sense the current that it generates. This can be done by connecting it to a very low impedance, such as a small resistor, or a virtual ground (Fig. 3). Alternatively, it may be reverse biased and connected to a large resistor (Fig. 4). Either way, it generates a signal which is proportional to the photocurrent generated by the light falling on the diode.

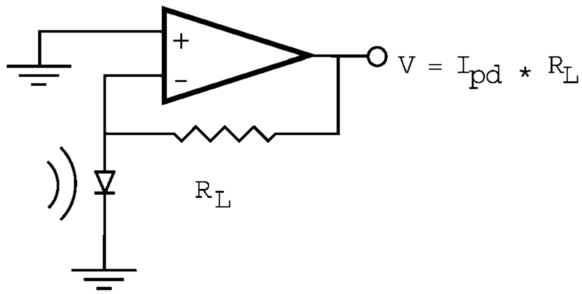

Figure 3. Current mode into a low impedance

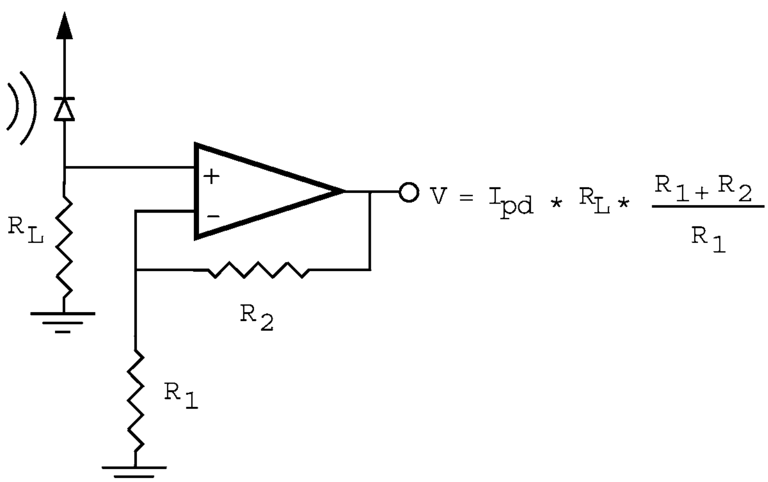

Figure 4. Current mode into a load resistor

IMPORTANT: This current has a polarity. It tends to drive the anode of the photodiode positive with respect to its cathode, so that all of the input signals in Figs. 2, 3, and 4 are positive. Because the inputs to the amplifiers have a dc component, the outputs will also have a dc component. This is not necessarily bad, but keep it in mind.

The total photocurrent expected, after transmission losses through the fiber guide, is less than 1 µA. Design an amplifier based on either Fig. 2 or Fig. 3 which will generate a signal large enough to drive a loudspeaker. **Careful:** The op-amp cannot supply enough current to drive the speaker directly, since speaker impedances are typically about 4 W. Either design a power driver stage, or put a resistor in series with the speaker (Fig. 5) that the amplifier can drive. This will also reduce the sound level (which is OK). **Careful again:** Make sure the dc noted above doesn't saturate the amplifier.

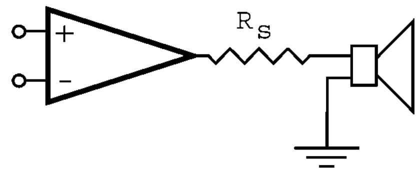

Figure 5

TRANSMISSION LINE

Mount the LED and the photodiode so that they both lie close to the plane of the circuit. Mount the length of fiber optic guide so that one end faces the LED and the other end faces the photodiode. Use short pieces of wire to fix all the components in place. You may wish to use additional mounting fixtures to help center the fiber on the LED and the photodiode. You may have to make small adjustments in order to get the best coupling of light into the fiber, and out of the fiber and into the photodiode.

SYSTEM OPERATION

Connect everything except the loudspeaker, and view the waveform on the scope. Note that the photodiode will detect not only the optical signal from the fiber, but also the optical signal from the room lights. The background current from the room lights can change the dc conditions in the photodiode. As previously noted, if your gain is too high it can drive the amplifier into saturation. In addition, if the room lights are modulated, the background light can cause unwanted ac signal. *What happens to the signal as you shield the photodiode from the room lights?* Connect the loudspeaker and run through the range of frequencies. *What happens to the signal as you misalign either of the ends of the fiber guide?*

OPTICAL DIODE APPLICATIONS

OBJECTIVE

To study the applications of diodes as light emitters and detectors.

PROCEDURE

1) Connect the circuit in Fig. 1, using a light emitting diode (LED). This diode has the property that when it is forward biased it emits light which is proportional to the current flowing through it. Because it is made of a gallium aluminum arsenide compound instead of silicon the turn on voltage is much larger than the usual 0.7 volts. Apply voltages of between 1 and 10 volts to the input of the circuit, and observe the light coming out of the diode and the voltage at point A. *What is the approximate turn on voltage of the diode?* Apply sine wave and square wave forms to the input at frequencies between 1 and 10 Hz. *Can you see the difference between a sine wave drive and a square wave drive?* Use the dc offset control to bias the drive voltage so that the diode is never turned off. Adjust this control and the amplitude control to get as bright an output from the diode as possible.

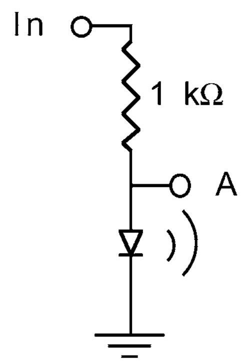

Figure 3

2) The circuit in Fig. 2 uses a silicon photodiode to detect the light from the LED. This diode has the property that it generates a current which is proportional to the incident light falling on it. The simplest, and sometimes the most sensitive way of using a photodiode is to measure the voltage developed across it by the incident light. Connect the photodiode directly to the scope probe, and point it at the LED. Be sure to keep the photodiode far enough away from the LED so that the signal does not exceed a few tenths of a volt - otherwise the forward turn-on characteristics of the photodiode may distort the signal. *Sketch the output across the photodiode. How does the signal you observe with the photodiode compare with the original signal driving the LED?* Increase the frequency of the signal generator to about 1 kHz. Does the signal you observe still have the same characteristics as observed at the lower frequency? *At what frequency does the LED seem to stop blinking, even though the wave form on the scope shows that it still is?*

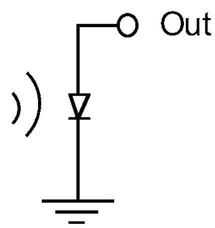

Figure 2

The background light from the room is also detected by the photodiode. This may change its operating point, and therefore the gain of the circuit in Fig. 2. In addition, since the room lights may be modulated, the background light can cause an unwanted ac signal. *What happens to the signal as you shield the photodiode from the room lights?*