

MEASUREMENTS AND INSTRUMENTATION

LAB #2: Introduction to Electronic Instrumentation (continued)

Equipment: DC Power Supply ([Protek 3015B](#))
Digital Multimeter ([FLUKE 187](#))
Function Generator ([Tektronix CFG250](#))
Oscilloscope ([Tektronix TDS 2014](#))
Electronic Prototyping Breadboard
Resistors (1M Ω , 10k Ω , 1k Ω , 220 Ω), 20k Ω Potentiometer, LED
Jumper wire kit
Silicon Photodiode

Objectives:

The purpose of this lab is to help you to become more proficient in using the equipment that you were introduced to in the previous lab. The instructions for this lab will not be as detailed as in lab 1 and as a consequence, you will be expected to do more on your own. Have fun.

Procedure:

In your lab notebook you should make a habit of writing down everything you do. Do not just answer the questions. Your homework for this lab will be to answer the questions (labeled “Q” and “HWQ”) posed below. Please use separate sheets of paper for the homework. The questions labeled as “HWQ” are to be answered on your homework only, not during the lab.

1 Voltage Divider / Potentiometer

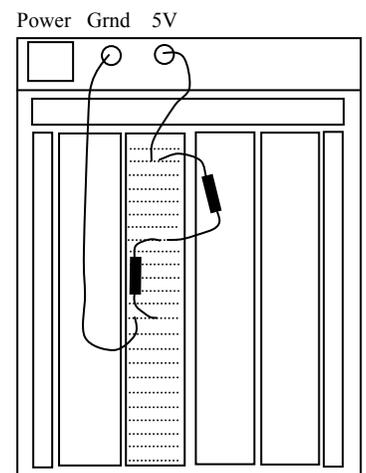
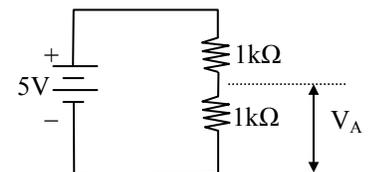
1.1. The electronic prototyping board makes it easy to wire up simple circuits. It has built-in power supplies of +5V and +/-15V. If yours does not have a built-in supply, then you will need to use the Protek DC supply as your voltage source. On the breadboard, some of the rows and columns are connected to save you some wiring. Use the ohmmeter to determine which ones are connected.

Wire-up a voltage divider with the two 1k Ω (brown) resistors as shown at right.

Your circuit should look something like that at the lower right.

Q: What is the voltage V_A ?

HWQ: How much current is flowing through the circuit?



Now make a voltage divider with the two $1\text{M}\Omega$ resistors (blue). Measure the voltage with both the digital multimeter and the o-scope. Again measure V_A .

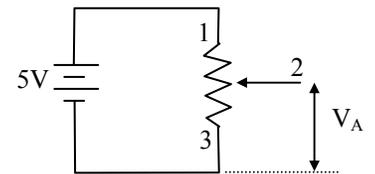
Q: What is the voltage with the DMM?

Q: What is the voltage with the o-scope?

HWQ: Why are they different?

1.2. The potentiometer (“pot”) is a variable resistor. The voltage is measured between the “wiper” (terminal 2 Black Wire) and the either of the other terminals. See the side of the pot for a diagram of the terminals. Measure the resistance (say between terminals 1 Red Wire and 2 White Wire) as you turn the knob. Verify that its max resistance is $20\text{ k}\Omega$.

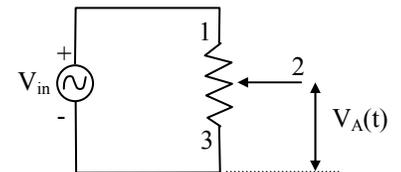
1.3. Wire-up the pot as shown, and use the DMM to measure V_A as you turn the pot. This type of circuit is similar to what is used for volume control on many electronic devices.



Q: Estimate your voltage resolution, i.e. the smallest voltage increment that you can reliably discern.

HWQ: If you needed higher resolution (e.g. for finer control over the volume), what characteristics of the potentiometer would be required?

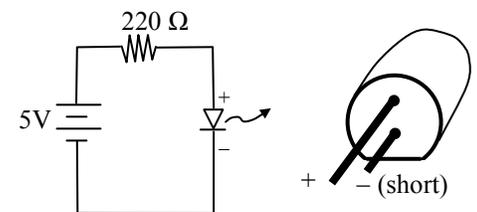
1.4. Connect the function generator to your potentiometer. Using your o-scope, look at the input (V_{in}) and the attenuated output (V_A) at the same time. You should trigger on the channel with V_{in} and set the trigger to ‘auto’ (if the sine waves scroll on the screen then switch the trigger to ‘normal’ and adjust the trigger level).



Q: What happens as you turn the pot? Make a sample sketch of the input and attenuated signals.

2 LED

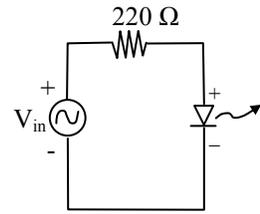
In this section you will use a light emitting diode (LED). An LED is a silicon semiconductor device that converts electrical energy into light.



2.1. Wire-up the LED to a 5V source as shown. The 220Ω resistor is used to limit the current through the LED. If the current is too high, the LED will burn out.

Q: How much current is flowing through the LED? (Hint: Measure the voltage drop across the resistor.)

2.2. Now disconnect the 5V supply from the LED. Connect the “Main” (variable voltage) output of the function generator to the o-scope, choose a square wave signal, and adjust the amplitude and offset to give a square wave pulse that varies between 0 and 5V. Note that you must pull-out the knob to change the offset. (Be careful, because if you accidentally give the LED a large negative voltage, you will smoke it.) Now use this output to drive the LED, while continuing to monitor the driving signal with the scope.



Play around with the frequency and amplitude of the driving signal to see its effect on the LED output.

Q: At what frequency can you no longer discern individual pulses (i.e. when it looks continuous)?

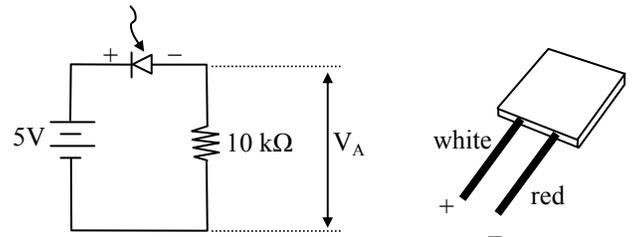
Q: At what amplitude (voltage) is the light from the LED no longer visible?

3 Photodiode

A photodiode is device that converts incident light into an electric charge or voltage. When the photodiode is connected to a load resistor, it acts as a current source when light is incident, and the measurement of the voltage drop across the load resistor will be proportional to the power of the radiated light.

3.1. Leave your LED circuit in place and on another part of the breadboard wire-up the photodiode as shown below. **(The white lead should be connected to 5V and the red lead to the resistor. If you reverse these connections the photodiode will be very unhappy.)** The photodiode has been mounted to a solid board to reduce its risk of damage and longer leads have been soldered to it.

3.2. Measure the output of the photodiode (i.e. the voltage V_A) on your o-scope. See how the signal responds as you vary the amount of light incident on the photodiode. To start with put the input coupling of the o-scope on **DC**, the trigger on **Auto** and then vary the trigger level until you get a signal. Be sure the trigger source is the channel the photodiode is connected to.



The room lights are powered by 60 Hz AC. Can you see them with the photodiode? If you don't see a good signal put the input coupling on AC and reduce the volts/division.

Q: For the room lights, do you measure 60 Hz? If not, what frequency do you see?

HWQ: Why is the frequency different from 60 Hz?

3.3. Put the photodiode on top of the LED and cover it with a paper sheet. Drive the LED with the function generator and look at both the input square wave and the photodiode output (V_A) on the scope.

Q: Is the photodiode reproducing the waveform of the LED? Sketch what you see. Record the peak-to-peak voltage.

HWQ: Use the attached sensitivity curve (provided by the manufacturer) to determine the radiated power incident on the photodiode (in Watts). For a green LED, the wavelength is about 500 nm.

Q: Drive the LED with a frequency of about 20 Hz and reduce the amplitude (voltage) of the input signal until the photodiode does not give a measurable output. (On the function generator the offset changes as you vary the amplitude. Be sure to monitor the signal on the scope so you keep a zero offset.) What can detect a lower light level, the photodiode or your eye?

Q: At how high of a frequency can you drive the photodiode before it is not able to respond as a square wave? Sketch what you see as the frequency is increased beyond this limit.

NC 2/03.

Revised by Ravi 1/07

Photodiode Responsivity Curve

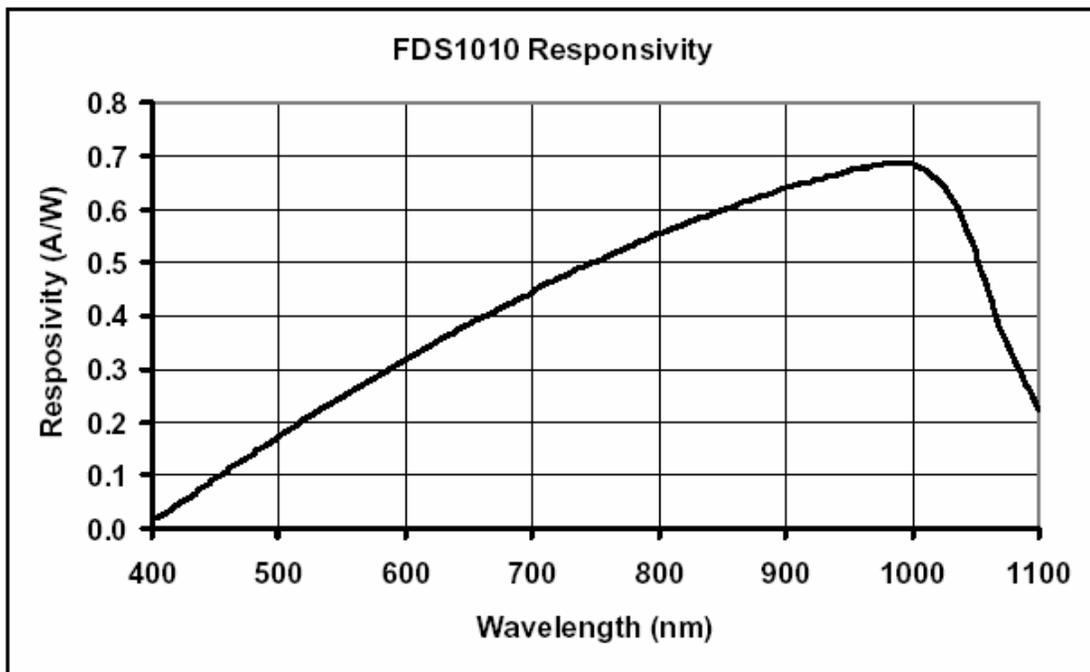


Figure 1: Typical Responsivity curve using Thorlabs calibration services.