Objective

The purposes of this laboratory session are to familiarize the students with a device model for a light emitting diode (LED) and verify Kirchhoff's laws. In this laboratory session the student will:

1. Construct a circuit containing an LED
2. Gather data over a range of voltages applied to the circuit in order to develop a quantitative model for the LED circuit.

Pre-Laboratory Work

Read this handout thoroughly.
If you have not already, watch the video ‘DC Power Supply and Breadboards’

Light Emitting Diode Information

An LED is a two terminal semiconductor device that ideally conducts electricity only in one direction. When a forward voltage is applied, above a threshold voltage, the device passes current, and emits light. When a reverse voltage or an insufficient forward voltage is applied the LED does not pass current. A diagram of an LED and its circuit symbol are shown below.

![LED Diagram](image1)

The LED has a current voltage relationship of

\[ I_D = I_S \left( \frac{V}{V_t} \right)^n - 1 \]

This equation is here only for informational purposes. Do not use in the laboratory analysis.

The relationship between current and voltage is not linear. However, we can model the behavior as a piece-wise function where \( I_D = 0 \) A for reverse voltages and for forward voltages below a certain threshold, and \( I_D \) increases linearly above that. A simple model of the circuit is shown in Fig. 2.

![LED Circuit Symbol](image2)

The circuit symbol of the diode and a corresponding circuit model are shown above. Determining the values for \( R_{model} \) and \( V_{model} \) can produce a reasonable approximation of the behavior of the diode.
In order to use the model, appropriate values for $R_{\text{model}}$ and $V_{\text{model}}$ need to be determined. The values for $R_{\text{model}}$ and $V_{\text{model}}$ can be determined by comparing the ideal curve to a linear approximation, as shown in Fig. 3.

![Graph showing the ideal diode current voltage relationship and the linear approximation terms for the model shown in Fig. 2.](image)

**Fig. 3.** Graph showing the ideal diode current voltage relationship and the linear approximation terms for the model shown in Fig. 2.

**Procedure**

Obtain a parts kit from the instructor. Measure and record the resistance of each of the resistors to be used. After this, construct the circuit shown below.

![Fig. 4. The schematic of the LED circuit from which students will gather data for this project. DO NOT use this figure as the schematic in the report. You must make your own.](image)

Starting at $V_{\text{DC}}=0$ V, measure and record $V_{\text{IN}}$ and the voltage across the diode. Increase the supplied voltage in increments of 0.25 V (the Analog Discovery will start with an output of $\pm500$ mV), recording the two voltages, until $\pm V_{\text{DC}}$ is 5 V (i.e. $V_{\text{IN}}$ will be 10 V). If you are using a single-sided voltage supply, use 0.5 V increments from 0 V to 10 V.

**Assignment**

Generate a document following the informal laboratory report format that includes the following sections:

1. **Report Header**
2. **Schematic**
   Include a schematic diagram of the model. Calculate the values for $R_{\text{model}}$ and $V_{\text{model}}$ for the diode used in this laboratory project and include them on the schematic diagram.
3. **Data**
   From the data gathered determine the current-voltage relationship for the LED. Graph the
measured and modeled current-voltage relationship on the same graph.  
Note: Data that are graphed are already in the document. Do not include a table of the graphed data.

4. **Discussion**  
Answer the following question: Why are two 470 Ω resistors used in parallel when a standard value 240 Ω resistor is available and could easily be obtained? (The 5 Ω difference is not a big deal.) Include the answer in the document.

Any unexpected (theoretically or otherwise) quantities must be explained.

All graphs and figures must be descriptively captioned (what the object shows or demonstrates).

**Check-off**  
In order to receive credit for performing this laboratory project it is necessary to have the instructor or student assistant review your data. The data must then be submitted for the laboratory project data assignment in Canvas for this project (only files in pdf are accepted).