Measuring an I-V curve

Motivation:

In this lab, we will learn how to measure an I-V curve of a circuit and what you can learn from this.

Related Lecture Content:

- Fundamentals: Units, current, voltage, power, linearity, active and passive, resistor, voltmeter and ammeter.

Before you start:

Read the General Lab Rules and Safety document on MyCourses.

The Breadboard

The breadboard shown in Figure 1 will be the construction base for your circuits in the lab. Each group of pins (holes) of the breadboard are connected inside the board by a metal strip to form a single node. In the central section (the big rectangle) there are two types of nodes, column nodes (blue) and row nodes (red); usually referred to as buses and terminals respectively. For a single column, the pins in each half are connected vertically (till the middle of the board marked by the 3M logo). The row nodes consist of five horizontally connected pins and are usually used to hold most of the circuit components such as resistors. For the breadboards available in the lab, there are also source nodes (yellow) at both sides of the board for connecting external equipment such as DC power supply and multimeters. For each source node, indicated by a black line, the pins are vertically and horizontally connected.

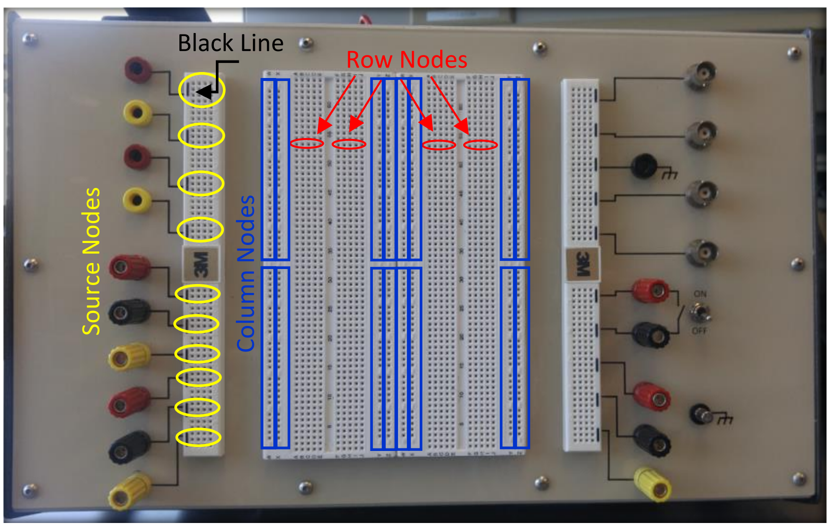
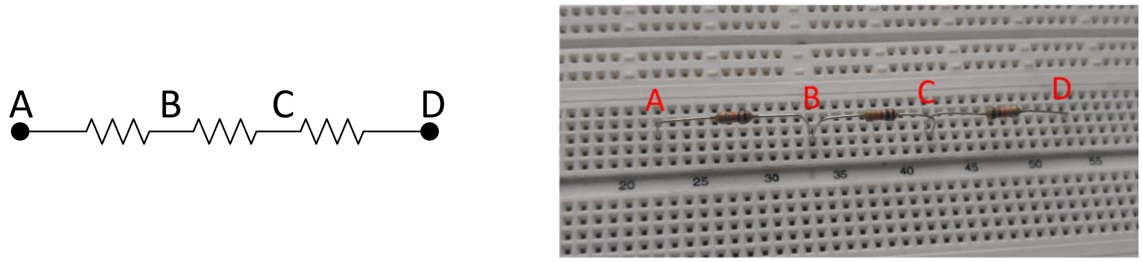


Figure 1: The Breadboard Layout

Translating a Schematic Diagram to a breadboard Layout

- Series Connection:
  Figure 2 shows a schematic diagram of three resistors connected in series and its construction on the breadboard.



(a) *(b)*

Figure 2: Connection of Three Resistors in Series (a) schematic diagram (b) breadboard construction

- Parallel Connection:
  Figure 3 shows a schematic diagram of two resistors connected in parallel and its construction on the breadboard.

(a) *(b)*

Figure 3: Connection of Two Resistors in Parallel (a) schematic diagram (b) breadboard construction

The DC Power Supply

The DC power supply used during this course has 2 channels, each of which has three terminals: +, –, and ground. The power is supplied through the + and – terminals only, while the ground terminal is connected to earth through the power cord and the wiring system in the laboratory.

When the channels are set to independent, their values can be set independently to the values desired. At the serial position, only the Master channel's values can be set, while the Slave channel follows the same set values.

Figure 4: Power Supply

The Multimeter

The multimeter is used in this lab as a voltmeter or an ammeter; each lab station is equipped with two multimeters: a Fluke 45 and an SDM3045X.

The Voltmeter

A voltmeter is an instrument used for measuring the electrical potential difference between two points in an electric circuit. The voltmeter should be placed in parallel with the circuit elements you need to measure the voltage drop across. Voltmeters can be analog or digital.

To use the Fluke 45 multimeter in measuring the voltage, press the V ⎓ button. You can set the range of the meter manually by the HI and LO buttons, or automatically by pressing the AUTO button.

To use the SDM3045X multimeter in measuring the voltage, press the DCV button. You can control the range from the $\frac{\text{Range}}{\text{Auto}}$ softkey menu on the screen.

Figure 5: Fluke 45 Multimeter and Schematic; terminals A and B are for voltage measurements

Figure 6: SDM3045X Multimeter; terminals A and B are for voltage measurements

The Ammeter

An ammeter is an instrument used to measure the current in a circuit. The current should pass through the ammeter to be measured; therefore, connect the ammeter in series with the circuit branch or component that you need to measure the current flowing through. The ammeter can be either analog or digital.

To use the Fluke 45 multimeter to measure the current, press the A ⎓ button and based on the range of current you can connect point A to the 10 A or to the 100 mA terminal of the multimeter. You can further control the range of the meter manually by the HI and LO buttons, or automatically by pressing the AUTO button.

To use the SDM3045X multimeter in measuring the current, press the Shift button then the DCV button (to access the DCI function). You can control the range from the $\frac{\text{Range}}{\text{Auto}}$ softkey menu on the screen.

Figure 7: Fluke 45 Multimeter and Schematic; terminals A and B are for current measurements

Figure 8: SDM3045X Multimeter; terminals A and B are for current measurements

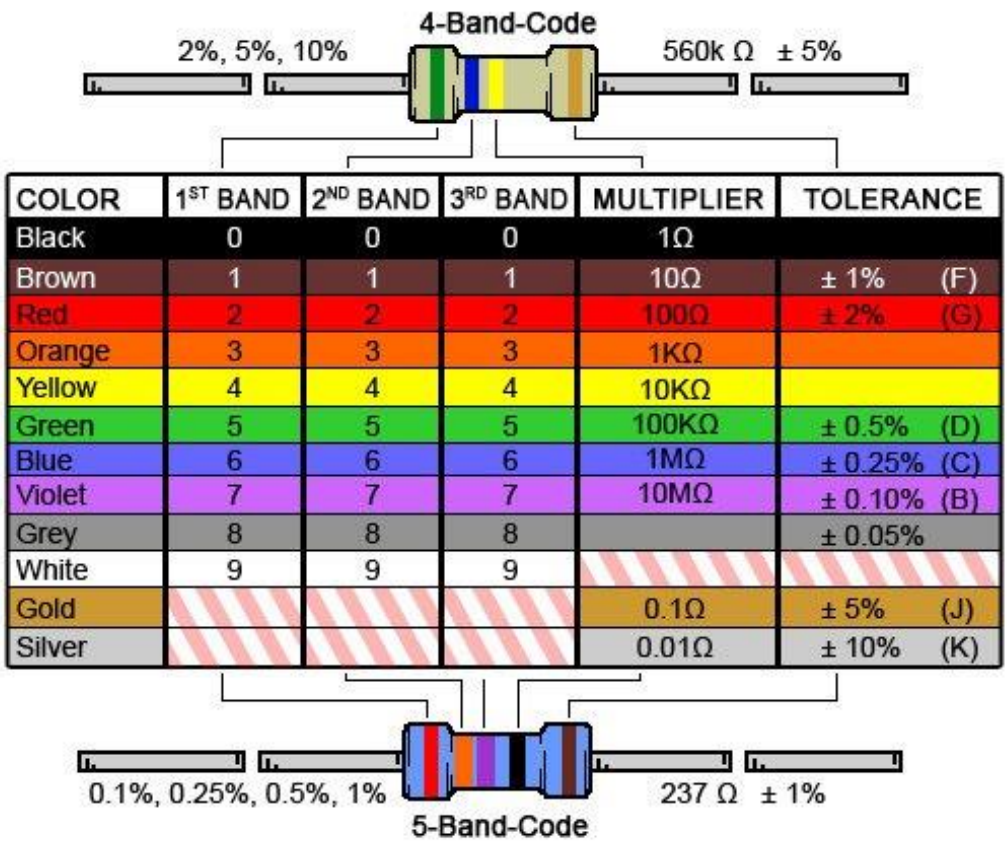
Experiment:

Please fill out the experimental report while going through the lab and submit it to the TA by the end of the lab for grading.

Part 1

The first circuit component that will be investigated is a resistor. Resistors are two terminal devices and are manufactured over a range of more than nine orders of magnitude. A pattern of 4 or 5 colored stripes is imprinted on the resistor to indicate its value. The color code for the pattern can be found below or at:

http://www.digikey.ca/en/resources/conversion-calculators/conversion-calculator-resistor-color-code-4-band



COLOR	1ST BAND	2ND BAND	3RD BAND	MULTIPLIER	TOLERANCE
Black	0	0	0	1Ω	
Brown	1	1	1	10Ω	± 1% (F)
Red	2	2	2	100Ω	± 2% (G)
Orange	3	3	3	1KΩ	
Yellow	4	4	4	10KΩ	
Green	5	5	5	100KΩ	± 0.5% (D)
Blue	6	6	6	1MΩ	± 0.25% (C)
Violet	7	7	7	10MΩ	± 0.10% (B)
Grey	8	8	8		± 0.05%
White	9	9	9		
Gold				0.1Ω	± 5% (J)
Silver				0.01Ω	± 10% (K)

Figure 9: Resistor Color Code from Digikey

1.1 Using the power supply, the voltmeter and the ammeter, set up a circuit as shown in Figure 10, with a 330 kΩ resistor. Measure and plot the current flowing through the resistor at different voltages, including negative voltages. Think carefully about your measurements with negative bias (V_P < 0 V). Take as many measurements as you find appropriate.

1.2 Based on the slope of your plot, what is the measured resistance of your resistor?

1.3 Based on your plot, is the resistor an active or passive element?

1.4 Based on your plot, is the resistor a linear element?

1.5 With the power supply at 10 V, what is the power absorbed/delivered by the resistor?

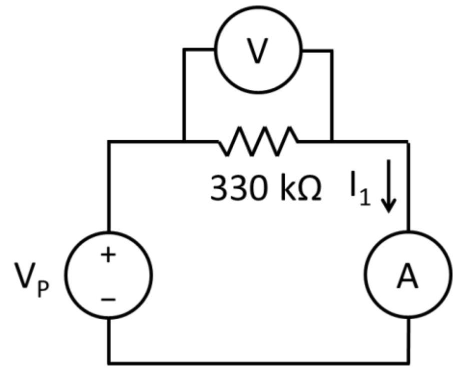


Figure 10: Resistor Circuit

Part 2:

Another important circuit element is the diode. Diodes are made of semiconductors such as silicon, or germanium. The electrical properties of a diode largely depend on the elements used in their design. Diodes are two terminal devices but unlike resistors, the terminals are not equivalent; there is an anode terminal and a cathode terminal.

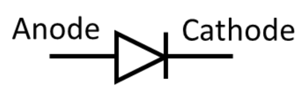


Figure 11: Diode Schematic

Set up the circuit of the photodiode shown in Figure 12, the solar cell can be modeled as a photodiode. The red and black wires of the solar cell are the anode and cathode, respectively, so be careful with how you connect the device to the circuit.

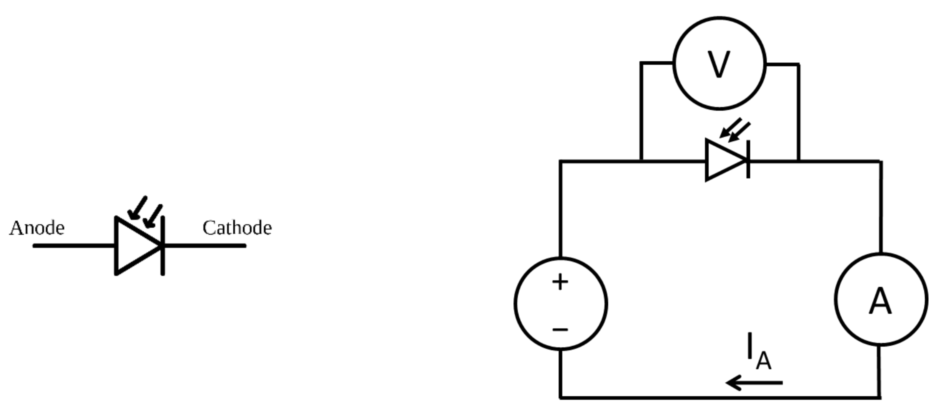


Figure 12: Photodiode and Photodiode Circuit Schematic

2.1 Measure the I-V curve of the photodiode using the power supply, the voltmeter and the ammeter. Think carefully about how you are going to measure and plot negative current.

2.2 Based on your plot, is the photodiode an active or passive element?

2.3 Based on your plot, is the photodiode a linear element?

2.4 What is the power absorbed/delivered by the photodiode at 0.5 V?