On Manual

1.1 Introduction

? What is a Thevenin circuit?

PDF pg 29 (book page 21)

? What is the Drude model?

"predicts simple linear relationship $I = V/R$, where R arises from collisions of electrons with impurities and crystal vibrations (phonons)"

"If the two terminal device is a diode then the relationship between current and voltage is no longer linear but approximately exponential"

$$I = A\left(e^{\frac{V}{B}} - 1\right),\ \text{ where } A \text{ and } B \text{ are constants, } \ \text{Shockley Formula}$$

I-V curve current versus resistance dependence plot

Obtaining an I-V Curve

1. Connect the element to an external power source such as a variable voltage power supply
2. Measure the current *through* the device
3. Measure the voltage *across* the device
4. Vary the voltage from the power supply to change the current through the device and voltage across it
5. Measure new values
6. Repeat and plot points

Linear devices have I-V curves that are straight lines. When the "'response' or current through the device is proportional to the 'input' or voltage across the device over a proad range," the device obeys Ohm's Law.

Eq (1) - Ohm's Law

$$V = R \cdot I,\ \ I = GV = \left(\frac{1}{R}\right)V,\ \ G = \text{conductance}$$

Devices that obey Ohm's law are called **resistive** devices.

Non-resistive elements have non-linear responses "or" non-linear I-V curves. Diodes have a response that isn't even symmetric about zero voltage, as the "response depends on the polarity of the applied voltage."

Power

For DC (time-independent) circuits,

Eq (2) - Power in DC Circuits

$$P = V \cdot I = \frac{\text{energy}}{\text{unit time}}$$
$$= \frac{\text{potential energy change}}{\text{unit charge}} \times \frac{\text{charge passing through element}}{\text{second}}$$

If no power source is contained in the element, Eq (2) also gives the "rate at which energy is dissipated (usually converted into heat)."

"If the element is a power source, this power is the rate at which energy is produced by the source and delivered."

For resistive elements,

Eq (3) - Power dissipated in a resistive element

$$P = VI = I^2R = \frac{V^2}{R}$$

Does not apply to non-linear elements. Those require Eq (2).

1.2 Procedure

1.2.1 I-V (current-voltage) curves of passive elements

passive element a two-contact (or two-terminal) device that contains no source of power or energy

Part 1 goals:

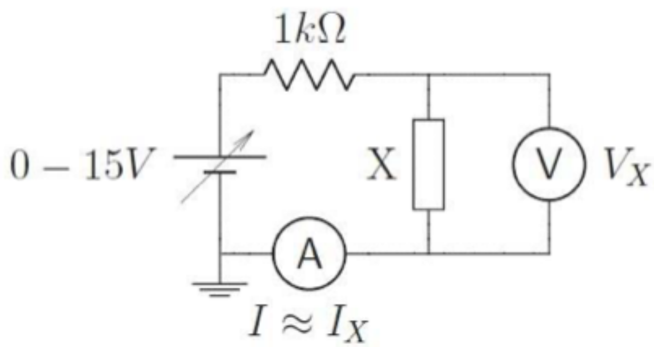
- measure and plot the
  - I-V curve
  - Power dissipation vs. Applied voltage

  for various passive circuit elements.
- Decide which of the circuit elements are resistive and which are not.
- Determine resistence for resistive elements

Connect the device being tested to a variable voltage power supply

Step 1

Set up circuit according to Figure 2 of the lab manual



"Recommendation: Use the nicer bench-style digital multimeter (DMM) that's available at your workstate as the voltmeter (the 'V' element in the schematic) and the handheld DMM as the ammeter."

⭐ Use the **HEATH** 2718 tri-power supply, but do not go about 15 V

Step 2

Discuss and answer question from manual:

"To avoid mishaps we use 1 kΩ limiting resistor in series with the power supply What is the maximum current that can flow in this circuit when the power supply is at its limit?"

Need to look up the rules for resistors in series. It's in the book.

Step 3

Record diagram of circuit in lab notebook. Diagram should include what devices are represented by symbols. Should be more detailed than above figure.

Step 4

Ask Dr. Lee to check wiring before turning on the power supply.

Step 5

[Data](Sheets) (Sheets)

[Data](Excel) (Excel)

From [Obtaining an I-V Curve]:

1. Measure the current *through* the device
2. Measure the voltage *across* the device

3. Vary the voltage from the power supply to change the current through the device and voltage across it
4. Measure new values
5. Repeat and plot points

"You can reverse the polarity of the applied voltage by reversing the orientation of the voltage supply element (shown by the battery symbol in Fig. 2)"

Step 6

Change to next device and repeat step 5

Device 1: $10\ \text{k}\Omega, \frac{1}{4}$ watt (maximum power dissipation), 5% (resistance tolerance) resistor

Device 2: $1\ \text{k}\Omega, \frac{1}{4}$ watt (maximum power dissipation), 5% (resistance tolerance) resistor

Device 3: $47\ \Omega, \frac{1}{4}$ watt (maximum power dissipation), 5% (resistance tolerance) resistor

Device 4: 5 Volt (nominal) Zener diode

Device 5: red LED

Device 6: light bulb (**Note**: replace the $1\ \text{k}\Omega$ resistor with $100\ \Omega$ resistor for this measurement)

Device #	1	2	3	4	5	6
Lab	1a	1b	1c	1d	1e	1f

"Make sure the power dissipated in the two terminal device does not exceed the allowed one."

1.2.2 I-V (current-voltage) curves of active circuit elements

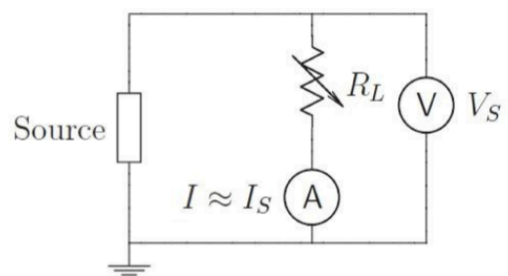


Figure 3. The setup for measuring the *load curve* of a power source or other active element. The objects labeled A and V are an ammeter and voltmeter, respectively. The resistor with an arrow through it is a variable resistance, sometimes called a *potentiometer*.

"If your values of R_L are too large, I will vary only a tiny amount; if R_L is too small, the total power V^2/R could exceed the power limitations of the resistor."

Step 1

Set up circuit according to Figure 3

Step 2

Measure the I-V curves and power output of

Device 1g: a 1.5 volt alkaline cell, using a $1\ k\Omega$ potentiometer for R_L

Device 1h: a voltage divider, using $\mathrm{R}_1 = \mathrm{R}_2 = 1\ \text{k}\Omega$ and $\mathrm{V} = 10$, $10\ \text{k}\Omega$ R_L. "The two circles labeled + and - in Figure 4 serve as the terminals of the source shown in the measurement setup in Figure 3.

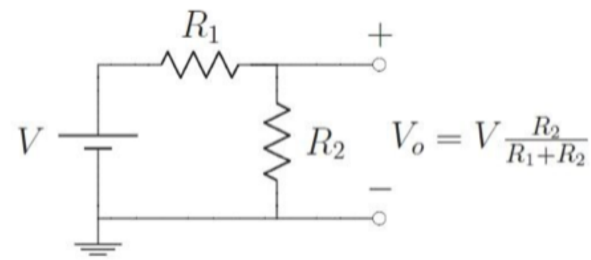


Figure 4: Schematic diagram of a voltage divider, for use in Lab 1h.

From the text: "A voltage divider has an input voltage, V_{in}, and an output voltage, V_{out}. We can determine the relationship..."

$$V_{\text{out}} = V_{\text{in}} \cdot \frac{R_2}{R_1 + R_2}$$

So, in 1h, $V_{\text{in}} = 10\ V,\ \ R_1, R_2 = 1\ k\Omega$

$$\therefore V_{\text{out}} = 10 \cdot \frac{1}{2} = 5\ V$$

"For a given input voltage, the larger the resistors in the divider are, the smaller the power dissipated is."

$$P = \frac{V_{\text{in}}^2}{R_1 + R_2} = \frac{100}{2000}$$

Weird results for last part. Redid for accuracy.