PH 411/511 Electronics **Laboratory 1**

Resistance, Diodes and Voltage Dividers

Concept

The purpose of this lab is to introduce basic equipment and circuit-building techniques and to investigate ohmic and non-ohmic behavior, power dissipation, diode, and voltage dividers.

Helpful hints and warnings

Small resistors are guaranteed to dissipate at least 1/4 Watt without suffering damage from the heat. So, for use in a circuit, ensure that the power dissipated in each resistor in your circuit does not exceed this value unless instructed to do so. The fundamental definition of power dissipated within any object is $P = IV$, where P is the power in Watts, I is the current in Amperes and V is the potential difference across the object in Volts. If the object is ohmic, then $V = IR$ can be used in the expression for power to yield $P = I^2 R = V^2 / R$.

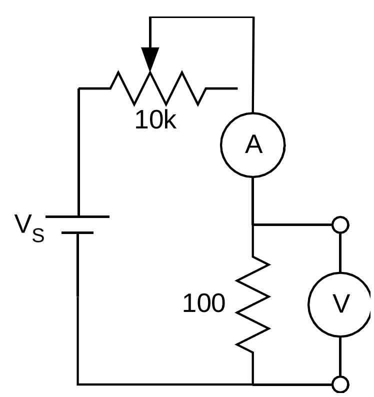
The input resistance of a DMM (digital multimeter) acting as a voltmeter, R_{input}, is not infinite. Thus, a DMM will act as another resistor in series with your circuit, thereby reducing the measured potential by virtue of an inadvertent voltage divider. Usually, $R_{input} \geq 10 MW$. Likewise, a DMM acting as an ammeter does not have the ideal zero resistance and will introduce an additional potential drop to the circuit.

Experimental Instructions

PART I

1. I-V curves and Ohmic behavior [please always use V_S= 5 V power setting]

The goal of this first experiment is to measure the $I(V)$ curves of some simple components and distingish between Ohmic and non-Ohmic behavior.

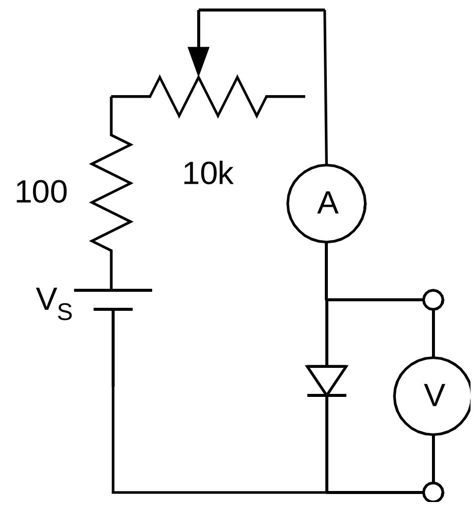


a. To investigate the Ohmic behavior, use your voltage source and a 10kΩ potentiometer as shown, on right.
Use two DMMs; you can use one DMM to measure the potential *V* across the resistor and another DMM to simultaneously measure the current *I* through the resistor, as shown at right.

(i) Adjust the potentiometer through its full range of values and plot *I* versus *V*.

(ii) Is the behavior Ohmic to within the estimated error, that is, is *I* linear with *V* with a slope of $1/R$? Please fit your data to a linear line to show explicitly.

b. Measure the *I*(*V*) curve of a simple diode (*e.g.* diode rectifier IN4007 in your kits). Modify your circuit to include the 100 W resistor as a current-limiting resistor and the diode as the test component, as shown at right.

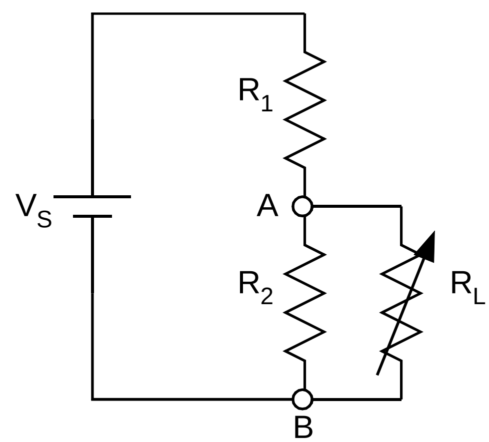


c. Measure the *I*(*V*) curve of a light-emitting diode (LED). You will find that the forward bias voltage required to make the LED conductive and bright is greater than that observed for the simple diode.

Is there a connection between the forward drop and the color of your diode?
Please measure and graph two different colors of LEDs to check.

2. Potential or voltage divider

Build a potential divider using the approximate values $R_1 = 100W$ and $R_2 = 100W$. Measure the output potential of the divider (*i.e.* across the load resistor) as you vary the value of the load resistance over the full range of the potentiometer.



- Over what range of load resistance would you declare this divider to be a reasonable "constant potential voltage source?"
- How does the result compare with the Problem Set #1 prediction?

PART I WRITE-UP tips: does not require a full write-up. Well-captioned(!) graphs with section headings are all that is required.

(1) I vs V curves for: (a) the resistor, (b) the diode, (c) LEDs (hopefully two colors)
(2) V_{AB} vs. R_L curves for the two voltage dividers (you'll want to compare to the theory here)
(3) Brief (2-3 sentence) conclusions for each graph. Did you demonstrate predicted resistor, diodes, and voltage divider behavior? Justify why for each case (e.g. linear trend, exponential trend).

PART II- Voltage divider equivalent circuits

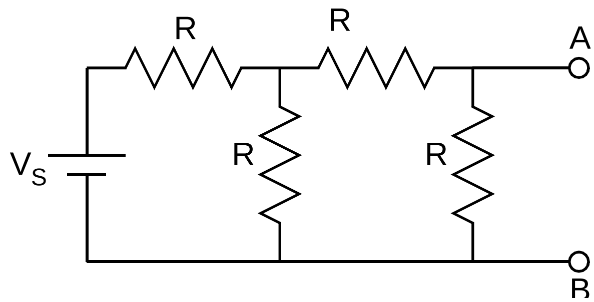
3. Equivalent total resistance and voltage dividers

Let' now gain more experience with voltage dividers. The equivalent open-circuit source potential V_{OC} and the equivalent total resistance R_{Tot} (also called the Thevenin resistance in some texts) are a way of characterizing a complicated circuit in terms of a simple circuit with one battery and one source resistor. When connected across a varying load R_L, the current I through the load and the potential V_{AB} across the load obeys the equation:

$$I(V_{AB}) = \frac{1}{R_{\text{Tot}}}(V_{OC} - V_{AB})$$

a. Build the circuit shown in the diagram below (with $R = 100$ W and $V_S = 5\ V$).

b. Determine the the open-circuit voltage V_{OC} by measuring the output potential V_{AB} with a high input resistance DMM. Use the above equation to explain why $V_{AB} = V_{OC}$.



c. Determine the equivalent source resistance R_{Tot} (sometimes also called the Thevenin resistance) by short-circuiting the output and measuring the current I_{sc} through this short-circuit. Sketch (by hand is fine) the $I(V_{AB})$ using you the two points obtained in a and b and the above equation.

Please include brief ~1-paragraph conclusion to section C.

Why is measuring the open-circuit voltage and short-circuit current important? Give some practical examples when an electrician might do these measurements.