# UNIVERSITY OF NORTH CAROLINA AT CHARLOTTE
# Department of Electrical and Computer Engineering

## EXPERIMENT 3 – DC VOLTAGE AND CURRENT SOURCES

### OBJECTIVES

In this experiment the V-I characteristics of a constant voltage source and a constant current source will be investigated.

### MATERIALS/EQUIPMENT NEEDED

Resistors: 200Ω, 510Ω, 1kΩ, 1.1kΩ, 1.8kΩ, 2kΩ
Rheostat (Load Resistor), 3kΩ or larger
Agilent U8031A DC Power Supply
Agilent 34461A Digital Multimeter

### INTRODUCTION

DC supplies, which operate from an AC source, must convert AC to DC. How well they do this is expressed in terms of "ripple factor" which, as will be seen later, defines the quality of the power supply where the smaller the ripple factor, the better the device. Regulation and ripple factor, where appropriate, will be determined for each device.

**Constant voltage source:** is a device that will maintain a constant voltage across its output terminals, regardless of the magnitude of the current it supplies (within limits, of course). Stated another way, it is a voltage source that has zero, or nearly zero, internal resistance. Obviously, a non-constant voltage source is one that has an appreciable internal resistance and will not maintain a constant terminal voltage as the load (current) varies. An example of a non-constant voltage source would be a car battery or a flashlight battery. There are regulated voltage supplies on the market today that have less than 0.05 percent variation (expressed as percent regulation) in their terminal voltage from a no-load to rated load condition.

$$Percent\_regulation = \frac{V_{No\_Load} - V_{Full\_Load}}{V_{Full\_Load}} \times 100\%$$

**Constant current source:** A constant current source is a device that will maintain a constant current output regardless of the magnitude of the voltage across its output terminals (within limits, of course). Stated another way, it is a current source that has infinite, or nearly infinite, internal resistance. A non-constant current source then could be defined as a current source that has a finite internal resistance. Regulated current sources are available on the market today with less than 0.1 percent variation (again expressed as percent regulation) in current from no-load to rated conditions.

Generally, the higher the rated current or rated voltage of a power source and the better the percent regulation it has, the more expensive it is. As it was mentioned before, DC supplies which operate from AC sources must convert AC to DC. How well they do this is expressed in terms of "ripple factor". Ripple factor is defined as follows:

$$Ripple\_factor = \frac{V_{AC(rms)} \text{ at its terminals}}{V_{DC} \text{ at its terminals}} \times 100\%$$

$$\text{or } Ripple\_factor = \frac{I_{AC(rms)} \text{ from its terminals}}{I_{DC} \text{ from its terminals}} \times 100\%$$

where the AC and DC terminal voltages or currents are measured under rated conditions. Generally, the smaller the ripple factor (a purer DC), the more expensive the power supply.

## PRELAB

1. The specification for a very large DC power supply is 2.18 megavolts at 0.18 amperes with a ripple factor of 0.1% and a regulation of 0.05%. Assuming any ripple is due solely to a 400 Hertz sinusoid, calculate:
   a. The maximum RMS value of the ripple voltage, $V_{AC}$
   b. The No-Load voltage of the power supply
2. To measure the no-load voltage of a DC voltage supply, the load resistor should be (circle one):
   a. Infinite (open-circuit)
   b. Zero (short-circuit)
   c. Equal to the internal resistance of the power supply.
3. To measure the no-load current of a DC current supply, the load resistor should be (circle one):
   a. Zero (short-circuit)
   b. Infinite (open-circuit)
   c. Equal to the internal resistance of the power supply.
4. To measure the output characteristics of a DC voltage supply that DOES NOT have a current-limit adjustment, the load resistance should be varied (circle one):
   a. from zero to infinite value.
   b. from infinite to zero value.
   c. from infinite to a value that gives rated conditions.
5. For the following voltages and currents, determine the resistance and wattage of the load resistor

**Table 3-1: Resistance and wattage of the load resistor (prelab, part 5)**

| Voltage ($V_{DC}$) | Current ($mA_{DC}$) | Load Resistance (Ω) | Load Wattage (W) |
|---|---|---|---|
| **20** | **80** | | |
| **20** | **100** | | |
| **50** | **100** | | |
| **100** | **100** | | |

## PROCEDURE

**CAUTION:** While performing the following laboratory procedures, make sure that the power rating of the load resistor is not exceeded. Please refer to Table 3-1 in the Prelab.

1. Show your pre-lab work to the instructor at the beginning of the lab session.
2. Determine the V-I characteristics of a regulated DC voltage supply
   a. Set the output voltage set at 20 V (no-load) and the short-circuit current limit to 80 mA.
   b. Build the circuit as seen in Figure 3-1
   c. Record the voltage and current measurements in Table 3-2 as you vary the load resistor. Remember to take more data points whenever the variable being plotted varies rapidly. Also measure $V_{AC}$ at the terminals of the power supply at a load current, which is 70 percent of the current limit.

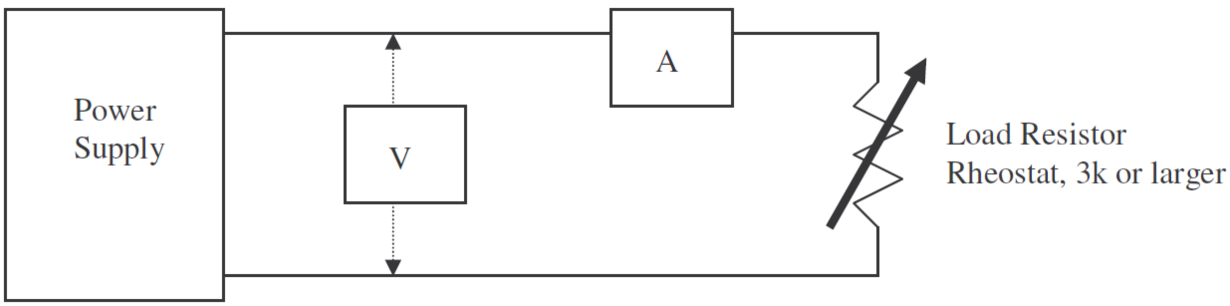


**Figure 3-1 Circuit diagram for LED display**

**CAUTION:** In the following two parts, DO NOT MAKE OR BREAK ANY CONNECTION UNLESS THE OUTPUT OF THE CURRENT SUPPLY IS OFF!!

3. Determine the I-V characteristics of a regulated DC Current supply
   a. Set the output current set at 100 mA (no-load) and its open-circuit voltage limit set at 20 V.
   b. Record the voltage and current measurements in Table 3-3 as you vary the load resistor. Again remember to take more data points when the variable being plotted varies rapidly. Also measure $I_{AC}$ from the terminals of the power supply at a load voltage, which is 70 percent of the voltage limit.
4. Using a 9V battery as the power source, measure the terminal voltage of the battery with the terminals open, and with load resistors of 2 kΩ, 1.8 kΩ, 1.1 kΩ, 510 Ω, and 200 Ω. Start with a fresh battery and place the load resistors across the terminals no longer than necessary to make an accurate voltage measurement. Record the data in Table 3-4.

## DATA/OBSERVATIONS

**Table 3-2: Voltage-Current characteristic for a DC voltage source set at 20V (open circuit) and 80mA (short circuit)**

| Voltage | Current |
|---|---|
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| | |
| | |
| | |
| **$V_{AC\ (rms)}$ at 70% of short circuit current** | **70% of short circuit current** |
| | |

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**Table 3-3: Current-Voltage characteristic for a DC current source set at 100 mA (short circuit) and 20V (open circuit)**

| Current | Voltage |
|---|---|
| | |
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| | |
| | |
| | |
| **$I_{AC\ (rms)}$ at 70% of open circuit voltage** | **70% of open circuit voltage** |
| | |

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**Table 3-4: Voltage-Current characteristic for a 9V battery**

| $V_T$ | $R_L$ | $I = V_T / R_L$ | $R_S = (V_{Open} - V_T) / I$ |
|---|---|---|---|
| | **Open** | | |
| | **2 kΩ** | | |
| | **1.8 kΩ** | | |
| | **1.1 kΩ** | | |
| | **1 kΩ** | | |
| | **510 Ω** | | |
| | **200 Ω** | | |

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## POST-LAB

1. Plot the V-I characteristic of the regulated DC Voltage supply.
2. Determine the ripple factor and percent regulation for the regulated DC Voltage supply.
3. Plot the I-V characteristics of the regulated DC Current supply.
4. Determine the ripple factor and percent regulation for the regulated DC Current supply.
5. From the data in Tables 3-2 is it possible to estimate an effective sourcing resistance for the DC voltage source? Explain.
6. From the data in Tables 3-3 is it possible to estimate an effective internal resistance for the DC current source? Explain.
7. From the data in Tables 3-4, estimate the internal resistance of the source. What is the percent voltage regulation for a load resistance of 1 kΩ?

Be sure to include all items from the post-lab exercise above in your written lab report.