**EECE208 Intro to Electrical Engineering Lab** **Dr. Charles Kim**

## 4. DC Circuit II

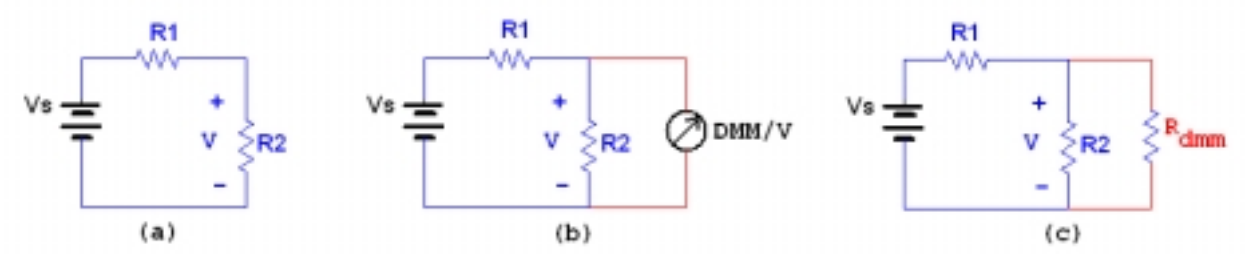
**Objectives:** This experiment emphasizes the measurement of DC voltage and current with DMM while dealing with the internal resistance effect to the measured value compared with the ideal (calculated) value. Along with the measurement precision, voltage divider and current divider are revisited in the experiment.

**Meter Resistance:** As we discussed in the class, a meter has internal resistance, series resistance for voltmeter and parallel resistance in Ammeter case. This internal resistance, whether added in parallel with a circuit or inserted in to the circuit, has some load effect to the circuit.

As illustrated below, the voltage V across R2 in the circuit(a) is, by voltage divider,

$$V_{calc} = V_s \frac{R_2}{R_1 + R_2} \quad (1).$$

When a DMM is used to measure the voltage across R2 as in (b), since there is internal resistance in the DMM when used as a voltmeter, the original circuit now has the DMM resistance $R_{dmm}$ as shown in (c).




Therefore, the voltage across R2 now is determined by the equivalent resistance of the parallel resistors of R2 and $R_{dmm}$. Hence, the voltage across R2 now becomes

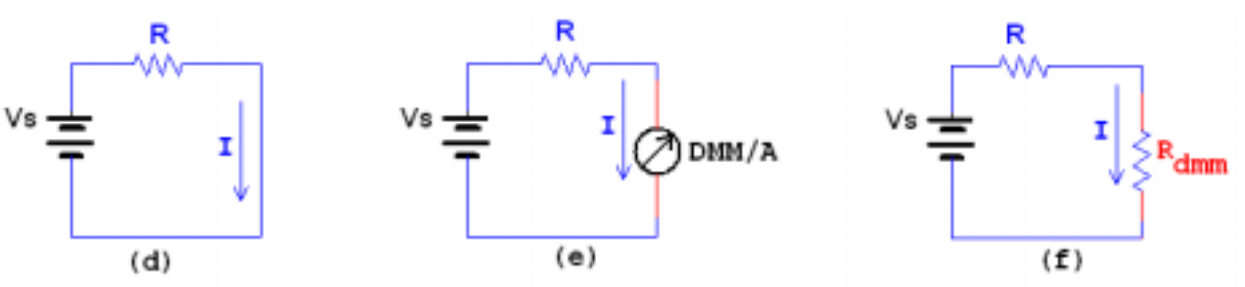
$$V_{meas} = V_s \frac{R_2 // R_{dmm}}{R_1 + (R_2 // R_{dmm})} = V_s \frac{\frac{R_2 \cdot R_{dmm}}{R_2 + R_{dmm}}}{R_1 + \frac{R_2 \cdot R_{dmm}}{R_2 + R_{dmm}}} = V_s \frac{R_2 R_{dmm}}{R_1 R_2 + R_1 R_{dmm} + R_2 R_{dmm}} \quad (2).$$

From equations (1) and (2), we can get the equation for $R_{dmm}$ for voltmeter use of DMM:

$$R_{dmm} = \frac{\frac{R_1 R_2}{R_1 + R_2} \cdot V_{meas}}{V_{calc} - V_{meas}} \quad (3)$$

Now let's consider current in a circuit. As illustrated below, the current through R in the circuit (d) is $I_{calc} = \frac{V_s}{R}$ (4).

When a DMM is used to measure the current in (e), since there is internal resistance in the DMM when used as a voltmeter, the original circuit now has the additional DMM resistance $R_{dmm}$ as shown in (f).




Therefore, the current through R now is determined by the some of two resistances: R and $R_{dmm}$. Hence, the current through R now becomes

$$I_{meas} = \frac{V_s}{R + R_{dmm}} \quad (5).$$

From equations (4) and (5), we can get the equation for $R_{dmm}$ for Ammeter use of DMM:

$$R_{dmm} = \frac{I_{calc} - I_{meas}}{\frac{I_{meas}}{R}} \quad (6)$$

**PRE-LAB -4:** **Name:** _____ **ID#:** _____

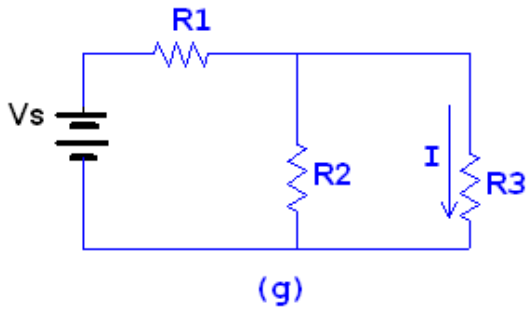
1. From equations (1) and (2), derive and prove equation (3).

2. From equations (4) and (5), derive and prove equation (6).

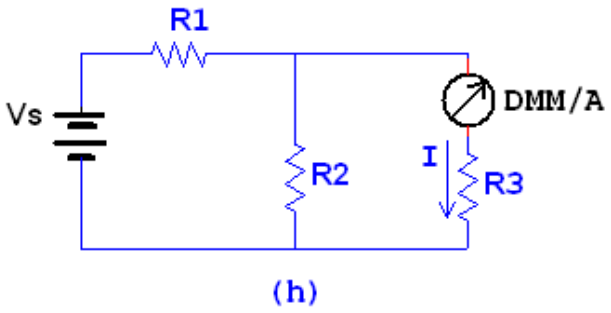
3. Consider a circuit shown below at (a) for current measurement.

   (i) Calculate the current through R3, $I_{calc}$.

   (ii) Now a DMM is used as an Ammeter measure the current as in (h). Derive an equation for the DMM internal resistance, $R_{dmm}$, in terms of $I_{meas}$, $I_{calc}$, and resistors.




(g)




(h)

**LAB PROCEDURE**

**Equipment:**

1. Breadboard.
2. Resistors
3. DMM for voltage and current measurements.
4. Power supply

**Procedures:**

A. Voltage Measurement

1. Obtain **two 1 KΩ resistors** as R1 and R2.
2. Using the DMM as Ohm-meter, measure precisely the resistance values of R1 and R2. Be sure to keep track which one corresponds to which one.

R1: _____ Ω

R2: _____ Ω

3. Using R1 and R2, form the circuit as in Fig.1 on your breadboard. Using Power Supply, apply +10V as the source voltage, $V_s$.

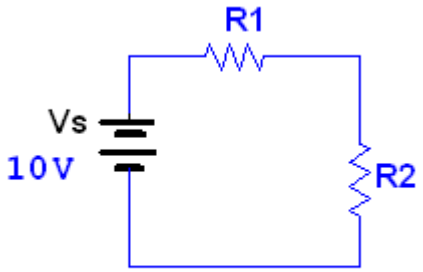



Fig. 1

4. Now, using DMM as voltmeter, measure the voltage $V_s$. This measured voltage may not be same as the one displayed on the Power Supply panel. Anyway, this is the correct value of $V_s$.

$V_s$: _____ V

5. Using the DMM as voltmeter, now measure the voltages across R1 and R2, respectively. Then, fill out the following table.

| Resistors | Calculated Voltage | Measured Voltage |
|---|---|---|
| R1 =( )Ω | V | V |
| R2= ( )Ω | V | V |

6. Using the Table above and the equation for the DMM internal resistance, find the DMM's internal resistance when used as voltmeter.

7. Comment on the accuracy of measurements made considering the internal resistance of DMM.

B. Current Measurement

1. Obtain one **5KΩ resistor** (as R1) and two **100 Ω resistors** (as R2 and R3).
2. Using the DMM as Ohm-meter, measure precisely the resistance values of R1, R2, and R3. Be sure to keep track which one corresponds to which one.

R1: _____ Ω
R2: _____ Ω
R3: _____ Ω

3. Using the resistors, form the circuit as in Fig.2 on your breadboard. Using Power Supply, apply +15V as the source voltage, $V_s$.

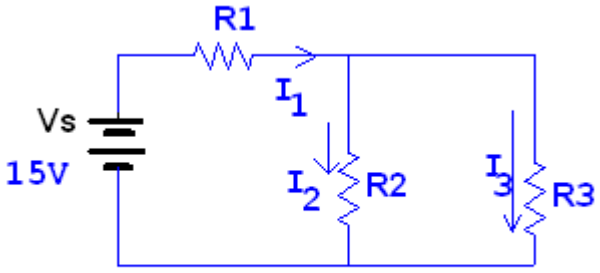


Fig. 2

4. Now, using DMM as voltmeter, measure the voltage $V_s$. This measured voltage may not be same as the one displayed on the Power Supply panel. Anyway, this is the correct value of $V_s$.

$V_s$: _____ V

5. Using the DMM as Ammeter, now measure the current through R1, R2, and R3 respectively. Then, fill out the following table.

| Resistors | Calculated Current | Measured Current |
|---|---|---|
| R1 =( )Ω | A | A |
| R2= ( )Ω | A | A |
| R3= ( )Ω | A | A |

6. Using the findings as shown in the Table above, find the DMM's internal resistance when used as Ammeter.

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7. Comment on the accuracy of measurements made considering the internal resistance of DMM.

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END