Digital Multimeter

1. Introduction

The student will learn to use the digital multimeter to take resistance, voltage and current measurments. Resistor values and corresponding tolerances will be determined by nominal component markings, instrument readings and Ohm's law measurments.

2. Background

2.1. Multimeter Accuracy

The accuracy of of a measurment is often expressed as a tolerance. A tolerance can be expressed as a percent or in original units. For example, a ± 2% tolerance
on 50 Volts could also be expressed as ± 1 Volt.

The accuracy of a Digital MultiMeter (DMM) is listed on the bottom of the meter. It is given as a reading percent + number of least significant digits, such as ± (1% + 1 Digit). To use this accuracy description, do the following:

(1) Multiply the reading displayed on the meter by the percent accuracy.

(2) Round the result to the same number of significant digits as the reading orginally had.

(3) Take the result of Step 2 and add the Digit value in the least significant column.

A meter that reads 0.505 and has a tolerance of ± (3% + 2 Digits) actually has a tolerance of:

(1) 0.505 * 0.03 = 0.01515

(2) → 0.015 (after rounding)

(3) ± (0.015 + .002) = ± 0.017 (3.4% of 0.505)

Therefore, the actual value is between .488 and .522.

Whatever the meter displays is a place of accuracy, even if the number displayed is zero (e.g. a reading of 2.600 still has 4 places of accuracy, and a Digit value will be added in the thousandths column). It is always good lab practice to use the most accurate meter scale when making a measurement. Measuring a 10 Volt signal on the 20 Volt scale will be more accurate than measuring it on the 200 Volt scale.

2.2. Division Tolerances

To determine the tolerance of a calculation created by the division of two numbers with their own tolerances perform the following operation:

$$R \pm R' = \frac{V}{I} \pm \left(\frac{V'}{V} + \frac{I'}{I} \right) \left(\frac{V}{I} \right)$$

3. Experimental Procedure

3.1. Individual Resistor Measurements

3.1.1. Nominal Resistance

Select three 5% resistor with nominal values of 2200 ohms, 4700 ohms, and 6800 Ohms. Calculate* the resistor's tolerance (5%) and minimum and maximum resistance, and **record in Table 1**.

*__Include Calculations__ to determine the resistor’s tolerance, minimum resistance and maximum resistance for the 2200 Ω resistor **in the lab report**.

3.1.2. Ohmmeter Measurements

Measure each of these 3 resistors using the DMM as an ohmmeter. Calculate* the meter's tolerance for each measurement by following the example described in the background. Calculate the minimum and maximum circuit resistance for these ohmmeter measurements. **Record these results in Table 2**.

*__Include Calculations__ to determine the measurement’s tolerance, minimum and maximum actual resistance for the 2200 Ω resistor **in the lab report**.

3.1.3. Resistance using Ohm’s Law

Set up the DMM as a voltmeter (**not** Figure 1). Turn on the power supply and adjust the output to 10 Volts (DC). Measure the output with the DMM and record this voltage in Table 3. Calculate* the meter's tolerance for this voltage and record it in Table 3.

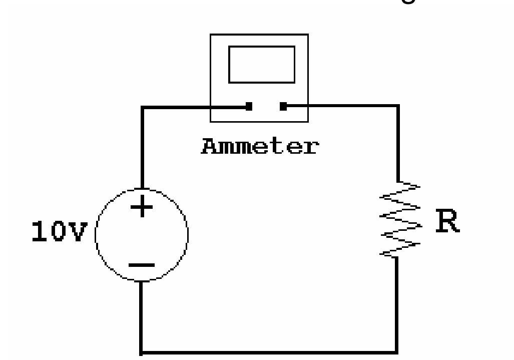

Figure 1: Current Measurement

Connect the circuit in Figure 1 for each resistor and use the DMM as an ammeter (AM) to record current. Calculate* the meter's tolerance for this current measurement. From these voltage and current measurements and their tolerances, calculate the circuit's resistance as v / i and tolerance using the method described in the Section 2. Determine the minimum and maximum circuit resistance for these meter readings. **Record these measurements in Table 3**.

> ***Include Calculations** to determine the voltmeter's tolerance, ammeter's tolerance, resistor's tolerance, minimum resistance and maximum resistance for the 2200 Ω resistor **in the lab report**.

3.2. Series Resistance Circuit

Connect the circuit in Figure 2.

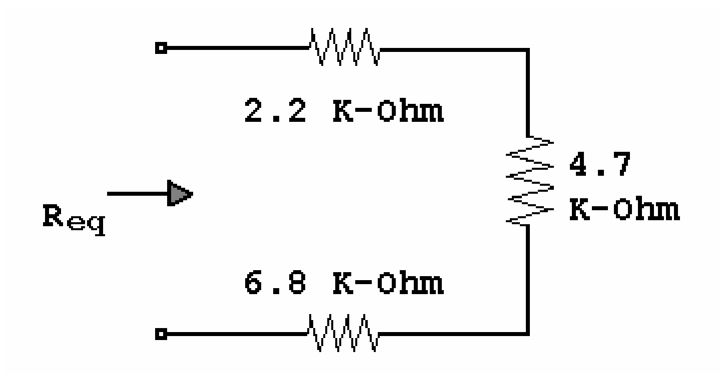

Figure 2: Series Resistors

From the color code on the resistors, calculate the circuit's nominal equivalent resistance, R_{eq}. Also calculate its tolerance at (5%), minimum and maximum circuit resistance and record in Table 4.

Measure the circuit's equivalent resistance using the DMM as an ohmmeter. Record this resistance measurement in Table 4. Calculate the meter's tolerance for this measurement and record in Table 4. Calculate the minimum and maximum circuit resistance for this ohmmeter measurement and record in Table 4.

Using the DMM as a voltmeter, adjust the DC power supply to approximately 10 Volts, measure the output and record this voltage in Table 5. Calculate the meter's tolerance for this voltage and record in Table 5.

Connect the circuit in Figure 1, BUT substitute the series circuit in Figure 2 for R. Use the DMM as the ammeter. Record the current in Table 5. Calculate the meter's tolerance for this current measurement and record in Table 5. From these voltage and current measurements and their tolerances, calculate the circuit's resistance, the tolerance on this calculated resistance, and the minimum and maximum circuit resistance for these meter readings and record in Table 5.

3.3. Parallel Resistance Circuit

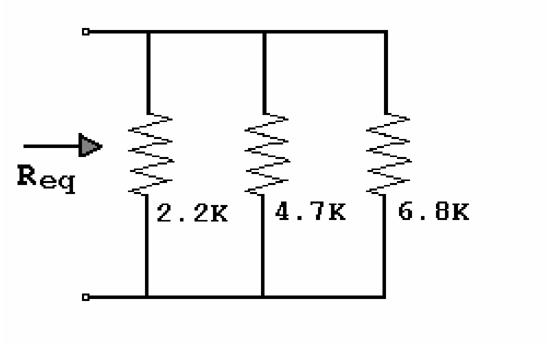

Figure 3: Parallel Resistors

Calculate the nominal equivalent resistance, tolerance (5%), minimum and maximum circuit resistance for the circuit shown in Figure 3, and record in Table 6.

Measure the circuit's equivalent resistance using the DMM as an ohmmeter. Calculate the meter's tolerance for this measurement. Calculate the minimum and maximum circuit resistance for this ohmmeter’s measurements. Record these measurements Table 6.

Using the DMM as a voltmeter, adjust the DC power supply to approximately 10 Volts, measure and record this voltage in Table 7. Calculate the meter's tolerance for this voltage and record in Table 7.

Connect the circuit in Figure 1, BUT substitute the parallel circuit in Figure 3 for R and use the DMM as the ammeter to measure the current. Calculate the meter's tolerance for this current measurement. From these voltage and current measurements and their tolerances, calculate the circuit's resistance, the tolerance on this calculated resistance, and the minimum and maximum circuit resistance for these meter readings. Record these measurements in Table 7.

4. Questions

This concludes lab 1. Please make sure to return all components to their appropriate bins and answer the following questions in your lab write-up:

1. Which measurement technique is most accurate?

2. Which measurement technique is most convienent?

3. Provide two scenarios, one for which it would be better to use each technique.

Data Entry and Lab Instructor Signature Page

Attach this page to your report.

Table 1: Nominal Resistance

Nominal	±	Minimum	Maximum
2200 Ohms	110 Ohms	2090 Ohms	
4700 Ohms			
6800 Ohms			

Table 2: Measured Resistance

Resistor	Measured Resistance	±	Minimum	Maximum
2200 Ω				
4700 Ω				
6800 Ω				

Table 3: Resistance by Ohm's Law

Voltage (V)		Current (mA)		Resistance (Ω)			
Meter	±	Meter	±	v / i	±	Min.	Max.

Table 4: Series Resistance

Nominal - R_{eq}	±	Minimum	Maximum
Measured - R_{eq}	**±**	**Minimum**	**Maximum**

Table 5: Series Resistance by Ohm's Law

Voltage (V)		Current (mA)		Resistance (Ω)			
Meter	±	Meter	±	v / i	±	Min.	Max.

Table 6: Parallel Resistance

Nominal - R_{eq}	±	Minimum	Maximum
Measured – R_{eq}	**±**	**Minimum**	**Maximum**

Table 7: Parallel Resistance by Ohm's Law

Voltage (V)		Current (mA)		Resistance (Ω)			
Meter	±	Meter	±	v / i	±	Min.	Max.