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Score: ____________________ / 100

Laboratory # 1 Resistive Networks

EE188L Electrical Engineering I
NAU + CQUPT (Fall 2020)

Objectives

1. Learn to determine a resistor's value and tolerance from its color code and by measuring its value with the DMM.
2. Learn how to use a Protoboard to construct a circuit.
3. Identify current flow through components in various resistive circuits
4. Identify series and parallel connections of resistors
5. Calculate and measure equivalent resistance of series and parallel resistors
6. Determine circuits with maximum and minimum resistance, along with properties of voltages and currents in them.

Grading:

Activity #1 _____________ / 20 Activity #3 ___________ / 60

Activity #2 _____________ / 20

Important Concepts:

1. A test bench is used to power and measure electrical circuits. Each test bench in the laboratory contains a DC power supply, digital multimeter (DMM), oscilloscope, Protoboard, function generator, and computer.
2. The color code on a resistor specifies its intended (or nominal) value at room temperature and its tolerance (or how far off the true value might be).
3. The equivalent resistance is found by combining resistors together in series or parallel.
4. Resistors all in series produce maximum resistance and resistors all in parallel produce minimum resistance

Special Resources:

1. The PowerPoint file "Lab 2 Photos.ppt" is available in Bb Learn.

Activity #1: Resistance Color Codes and Measurement

The Digital Multimeter, or DMM, is used to make voltage, current or resistance measurements. This activity will use the DMM to measure resistance.

1. Get 4 resistors, 2 of one color code (or value) and 2 of a second color code (or value), in the range of 1 KΩ to 5 KΩ from the supply cabinet.

2. Note the color code and nominal value of all 4 resistors using the resistor color code and record each value in **Table 1**. Measure each resistor's value with the DMM and record in the next column of the same table. See "Lab 2 Photos.ppt" for how to measure resistance.

3. Calculate the % Error for each resistor using this formula:

% Error = 100% * (Measured Value - Nominal Value) / Nominal Value

Table 1. Resistor Values

	Color Code	Nominal Value	Measured Value	% Error
R1	Red Black Black Brown Brown	2k	1.990kΩ	0.5%
R2	Orange Blue Black Brown Brown	3.9k	3.916 kΩ	0.41%
R3	Red Black Black Brown Brown	2k	2.009 kΩ	0.45%
R4	Orange Blue Black Brown Brown	3.9k	3.957 kΩ	1.46%

4. Resistors are normally sold as 1%, 5%, or 10% as indicated by the last color band, meaning the actual value should have an X% error or less than that specified. From your small sample, how many of your resistors are not within tolerance, barely within tolerance, or well within tolerance?

My resistors are mostly within tolerance.

Activity #2: Introduction to the Protoboard

The Protoboard is a handy device for wiring circuits. Some may have built-in power supplies and all have holes for plugging in devices like resistors, capacitors, and integrated circuits and to make interconnections with wires.

1. In our lab, the Protoboard does NOT have built-in dc power supplies. So connect the +5 and -5Volts dc power from the lab power supplies to the protoboard. Record the exact **nominal** values of the power supplies in Table 2.

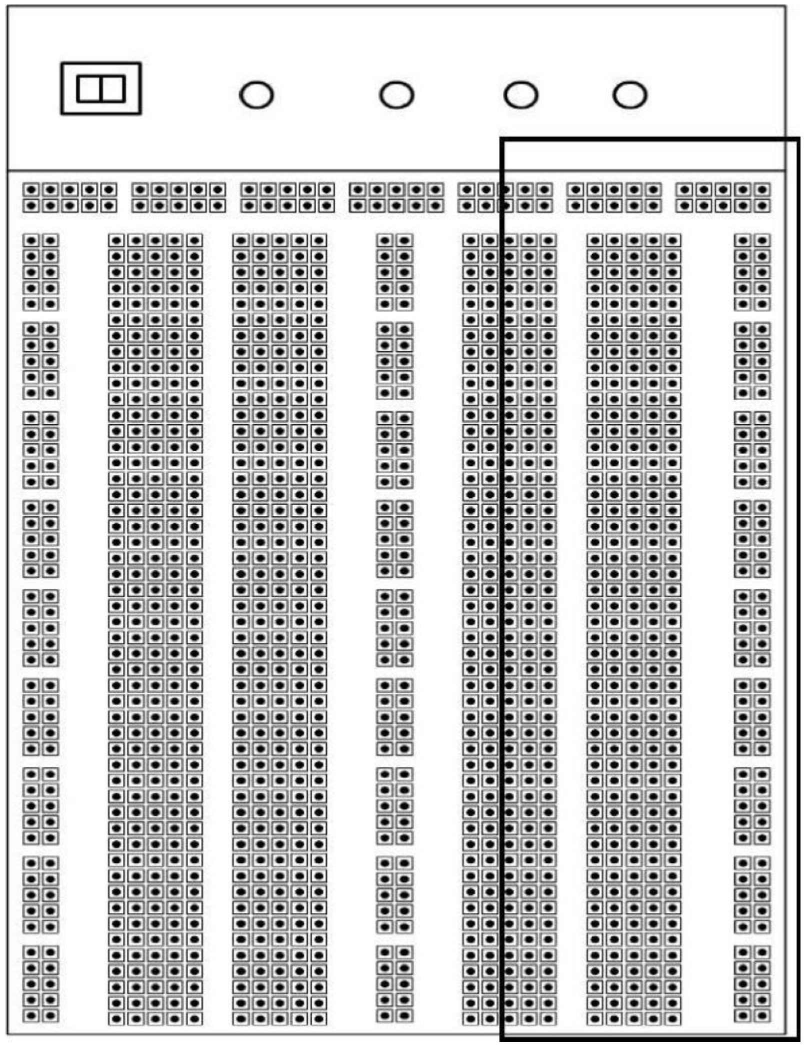
2. Calculate and record the % Error for each voltage source as

% Error = 100% * (Measured Value - Nominal Value) / Nominal Value

Table 2. Protoboard DC Power Supplies

Nominal Voltage	**Measured Voltage**	**% Error**
+5V	5.0091V	0.18%
-5V	-5.900V	0.18%

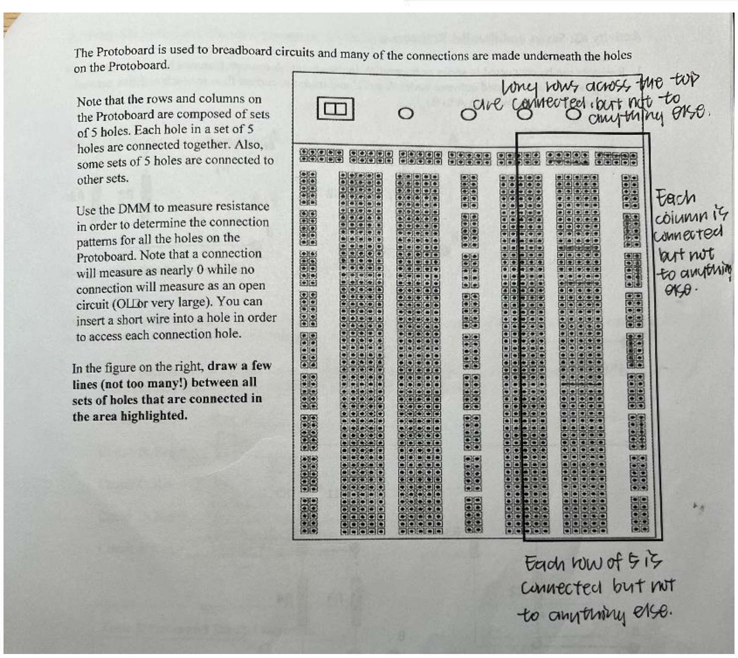
The Protoboard is used to breadboard circuits and many of the connections are made underneath the holes on the Protoboard.



Note that the rows and columns on the Protoboard are composed of sets of 5 holes. Each hole in a set of 5 holes are connected together. Also, some sets of 5 holes are connected to other sets.

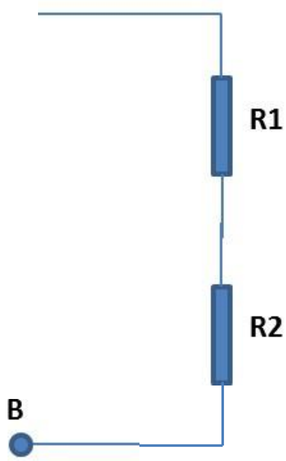
Use the DMM to measure resistance in order to determine the connection patterns for all the holes on the Protoboard. Note that a connection will measure as nearly 0 while no connection will measure as an open circuit (OL□or very large). You can insert a short wire into a hole in order to access each connection hole.

In the figure on the right, **draw a few lines (not too many!) between all sets of holes that are connected in the area highlighted.**

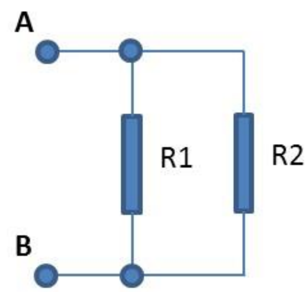


Activity #3: Series and Parallel Resistors

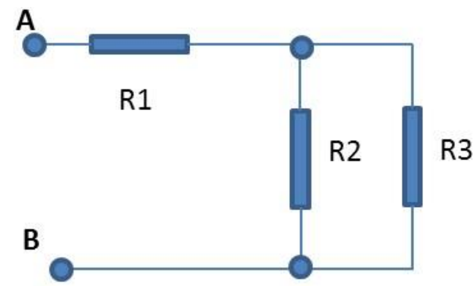
1. Resistors can be connected in series or in parallel. In the circuits A through E shown below, assume that a voltage source is connected between nodes A and B and trace the current flow for each resistive network. (Trace all possible paths from A to B)



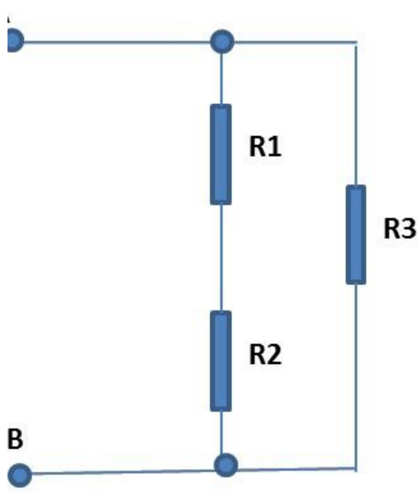
circuit A



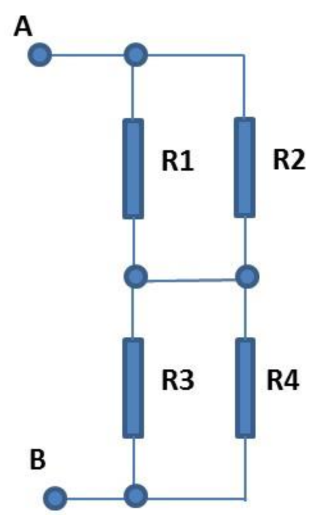
circuit B



circuit C



circuit D



circuit E

Activity #3: Series and Parallel Resistors: Calculations and Measurements

Resistors connected in series have an equivalent resistance given by:

$$Req=R1+R2+\cdots+Rn$$

Resistors in parallel have an equivalent resistance given by:

$$Req=\left(\frac{1}{R1}+\frac{1}{R2}+\cdots+\frac{1}{RN}\right)^{-1}$$

For two resistors this can be written as: $Req = \dfrac{R1*R2}{R1+R2}$

(Note: do not make the mistake that this formula will hold for three or more resistors. Req does not equal the product of the three or more resistors over their sum.)

1. Show the formula you would use and calculate the equivalent resistance between points **A** and **B** for each circuit. Fill in the values in **Table 3 with values from activity 1**.

Circuit A: Req = __________R_1+R_2____________________________________

Circuit B: Req = __________$R_1R_2/(R_1+R_2)$________________________________

Circuit C: Req = ______$R_1+R_2R_3/(R_2+R_3)$_______________________________

Circuit D: Req = ______$R_3(R_1+R_2)/(R_1+R_2+R_3)$____________________________

Circuit E: Req = _______ $(R_1+R_3)(R_2+R_4)/(R_1+R_2+R_3+R_4)$__________________

Table 3: Series and Parallel Resistors

	Req	
	Calculated	Measured
Circuit A	5.9kΩ	5.934 kΩ
Circuit B	1.322 kΩ	1.320 kΩ
Circuit C	3.322 kΩ	3.310 kΩ
Circuit D	1.494 kΩ	1.490 kΩ

Circuit E	2.644kΩ	2.647kΩ

2. Now build circuits **A–D** and measure the equivalent resistance between points **A** and **B** for each circuit using the DMM. Fill in the values in **Table 3**. Do the measured values agree with your calculation? They should agree closely, so go back and determine where you made either a calculation error or measurement error and make the correction.

   The measured values are very close to the calculated values.

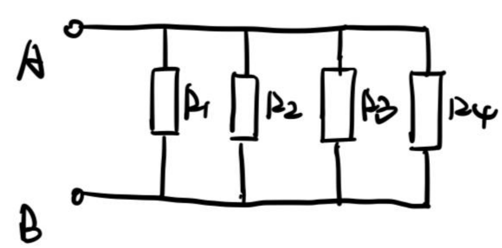
3. Build circuits **E** and measure the equivalent resistance between points **A** and **B** using the DMM. Fill in the value in **Table 3**.

   ____

4. What is the **maximum** equivalent resistance that you can get with your **four resistors**?

   ________11.8kΩ________ The **minimum?** ________667Ω__________

5. Draw the circuits below. Be sure to label R1, R2, R3 and R4.

Maximum Req	**Minimum Req**
	

6. a) First, build the **maximum resistance** circuit. **Before connecting the 5v supply**, measure the equivalent resistance. Req (max) = ______11.742 kΩ_________

Connect your circuit to the +5v supply; one end of the circuit should be connected to the +5v terminal and the other end to the reference connector. Measure the voltage across each resistor and enter the values into **Table 4** along with the measured values of each resistor from **Table 1**.

b) Next, build the **minimum resistance** circuit and **<u>disconnect the 5v supply</u>**.

Measure the equivalent resistance. Req (min) = ______662Ω________________ Connect your circuit to the +5v power supply; one end of the circuit should be connected to the +5v terminal and the other end to the reference connector.

Measure the voltage across each resistor and enter the values into **Table 4** below.

Table 4: Resistor Voltage Measurements				
Resistance			Voltage	
Value			Maximum Resistance Circuit	Minimum Resistance Circuit
R1	2 kΩ	VR1	0.848V	5.009V
R2	3.9	VR2	1.652V	5.005V
R3	2 kΩ	VR1	0.834V	5.008V
R4	3.9	VR2	1.670V	5.004V

7. For the **maximum equivalent resistance** circuit,

a) What did you notice about the voltage across each resistor in each pair?

<u>The voltage at both ends of a resistor with the same resistance value is equal.</u>

b) Which resistor had the highest voltage and which had the lowest voltage?

<u>Higher resistance resistors have higher voltages and low resistance resistors have lower voltages.</u>

c) The current supplied by the 5-volt source can be calculated using Ohm's Law, Isource = 5/Req. Calculate Isource. Be sure to include units.

Isource = _5/(R_1+R_2+R_3+R_4)=0.424mA_________________

8. For the **minimum equivalent resistance** circuit,

a) What did you notice about the voltage across each of the resistors, even though they all did not have the same resistance value? They have the same voltage.
b) If Current = Voltage/Resistance by Ohm's Law, which resistor(s) had the highest current and which had the lowest current? R1 R3 had the highest current. R2R4 had the lowest current
c) Using Ohm's Law, calculate the 4 currents through the resistors, add them together and compare them with Isource=5 volts/Req. $I_1=I_3=5V/R_1=5V/2k\Omega=2.5mA$ $I_2=I_4=5V/R_2=5V/3.9k\Omega=1.282mA$ $I=I_1+I_2+I_3+I_4=7.564mA > I_{source}$

9. Which circuit drew the highest current from the source and why?

The minimum equivalent resistance circuit because the four resistors are in parallel. The equivalent resistance value is the smallest and according to ohm`s law the current flowing is the highest

10. Which circuit drew the lowest current from the source and why?

The maximum equivalent resistance circuit. Because the four resistors are connected in series, the equivalent resistance value is the largest, according to the ohm`s law. The current flowing is the lowest.

IMPORTANT: Get the instructor's signature below. No signature, no marks!!

Instructor signature ______________________ **Date** ____________________

8. For the **minimum equivalent resistance** circuit,

a) What did you notice about the voltage across each of the resistors, even though they all did not have the same resistance value? They have the same voltage.
b) If Current = Voltage/Resistance by Ohm's Law, which resistor(s) had the highest current and which had the lowest current? R1. R3 had the highest current. R2 R4 had the lowest current.
c) Using Ohm's Law, calculate the 4 currents through the resistors, add them together and compare them with Isource=5 volts/Req. $I_1 = \frac{5V}{R_1} = \frac{5V}{2k\Omega} = 2.5mA = I_3.$ $I = I_1 + I_2 + I_3 + I_4 = 7.564mA.$ $I_2 = I_4 = \frac{5V}{R_2} = \frac{5V}{3.9k\Omega} = 1.282mA.$ $I > I_{source}.$

9. Which circuit drew the highest current from the source and why?

The minimum equivalent resistance circuit. Because the four resistors are in parallel. the equivalent resistance value is the smallest. and according to Ohm's law, the current flowing is the highest.

10. Which circuit drew the lowest current from the source and why?

The maximum equivalent resistance circuit. Because the four resistors are connected in series, the equivalent resistance value is the largest, according to the Ohm's law, the current flowing is the lowest.

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Instructor signature Li Xianshe 1022114880 9/25 **Date** ____________________