DEPARTMENT OF MECHANICAL ENGINEERING AND MATERIALS SCIENCE
RICE UNIVERSITY

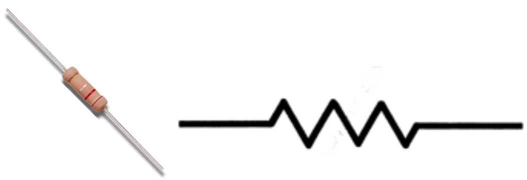
MECH 343: MODELING DYNAMIC SYSTEMS

Introduction to Hardware Laboratory Review

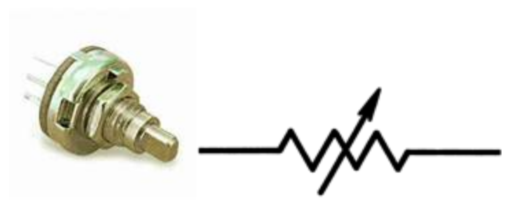
RESISTORS

Basics

Resistors (as their name implies) resist the flow of current caused by a voltage through a complete circuit. They are devices that are used in almost every digital and analog circuit. Resistors can be classified in two different ways: fixed or variable (as displayed below).



Fixed Resistor



Variable Resistor

Fixed resistors are available in carbon, thin film, and wire-wound varieties. The greater the physical size of the resistor, the greater the amount of electrical power it can handle without overheating and burning out. Variable resistors (or rheostats) are two-terminal resistors with a sliding contact that forms an adjustable voltage divider. These can also be used as potentiometers if three terminals are used instead of two.

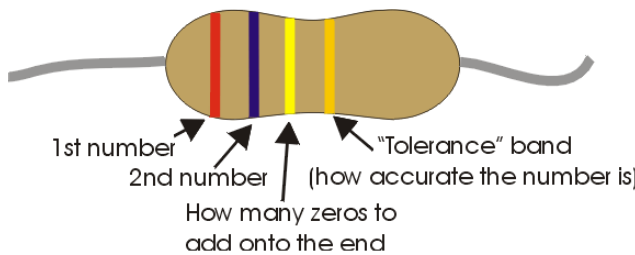
Reading Resistors

The values of resistors in Ohms (Ω) are given by a code of colored stripes. The color bands are the only way to tell one resistance from another without having to physically test the resistor. Most resistors have four bands of various colors.

1st Band	First digit of Ohmic value
2nd Band	Second digit of value
3rd Band	Multiplier (power of 10) by which the first two digits are to be multiplied by; Same number of zeros that follow the first two digits
4th Band	Tolerance of the resistor (percentage)

The colors are to be read from the edge they are the nearest to (which is always opposite of the tolerance band). The tolerance of a resistor is the precision of the resistor (or maximum difference between its actual value and expected value) and it is given as a ± percentage.

Tolerance values are identified by the colors brown, red, gold, silver, or the absence of a tolerance band.



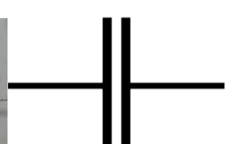
Color	Significant Figures	Multiplier	Tolerance
Black	0	10^0	-
Brown	1	10^1	±1%
Red	2	10^2	±2%
Orange	3	10^3	-
Yellow	4	10^4	-
Green	5	10^5	-
Blue	6	10^6	-
Violet	7	10^7	-
Gray	8	10^8	-
White	9	-	-
Gold	-	-	±5%
Silver	-	-	±10%
No Color	-	-	±20%

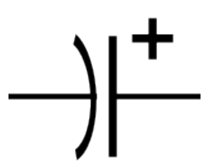
Note: Ideal Resistor Values are between 1K Ω and 100K Ω.

CAPACITORS

Basics

Capacitors is a two-terminal electrical component used to store energy in an electric field. Capacitors can range in value from pF (10^{-12} F) to µF (10^{-6} F). Below are symbolic representations of different capacitors:



Non Polarized Polarized Variable

Non-polarized capacitors are usually small disc capacitors that can be put into a circuit without regard to which terminal goes to + or -. Polarized capacitors have both + and – terminals and must be connected with + to + and – to -. Polarized capacitors are typically electrolytic capacitors, which resemble small cans with two terminals. The polarities of these capacitors will be marked on the sides of the "can" with either +/- or P/N labels. Variable capacitors (as their name suggests) are capacitors whose capacitance can be varied. They have a series of parallel metal plates, one set of which can be rotated away form the other. An example of a variable capacitor is the trimmer capacitor, in which loosening or tightening a pressure screw changes the capacitance.

Reading Capacitors

Reading capacitor values is slightly similar to reading those of a resistor. Large capacitors will usually have their capacitance value fully printed on them. Smaller disk type capacitors, however, often have 3 numbers and a letter to represent their capacitance value and tolerance percentage.

1st Number	First significant digit
2nd Number	Second significant digit of value
3rd Number	Multiplier (power of 10) by which the first two digits are to be multiplied by;
Letter Symbol	Tolerance of the resistor

Below are two tables that (i) match the third digit to its corresponding multiplier value and (ii) match the letter symbols with their corresponding tolerance

Third Digit	Multiplier
0	1
1	10
2	100
3	1,000
4	10,000
5	100,000
6	-
7	-
8	.01
9	.1

Letter Symbol	Tolerance %
B	± 0.10%
C	±0.25%
D	±0.5%
E	±0.5%
F	±1%
G	±2%
H	±3%
J	±5%
K	±10%
M	±20%
N	±0.05%
P	+100%, -0%
Z	+80%, -20%

MULTIMETERS

Basics

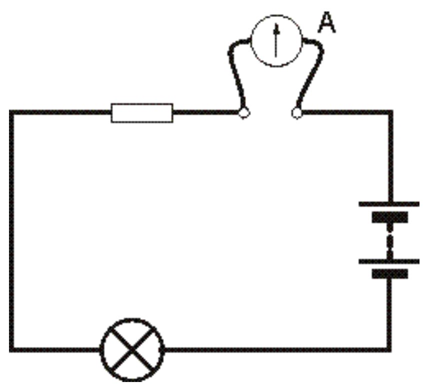
A multimeter is an electronic measuring instrument that is capable of measuring voltage, current and resistance using analog or digital circuits. Analog multimeters typically use a galvanometer needle display but often have precision and reading accuracy limitations. Digital multimeters (DMM or DVOM) display the quantity measured as a number (eliminating parallax errors). In these multimeters the signal under test is converted to a voltage and an amplifier with electronically controlled gain preconditions the signal.

Measuring Voltage

To run a test to measure voltage, you connect the red lead to the positive side of the battery or circuit that you are testing and the black lead to the negative (ground) side and set the dial to the voltage range you are expecting.

Measuring Current

When using a multimeter to measure current, you must break into the circuit so that the current passes through the meter as shown below.



How to measure a current using a multimeter

First insert the leads to the circuit in which the current is being measured and then set the multimeter switch to the correct current range you are expecting. When selecting the range, it is important to make sure that the maximum range is above the expected reading anticipated because selecting too high of a range may overload the meter.

Measuring Resistance

Although it is possible to read a resistor's resistance value by analyzing its color band, it may be necessary for you to use a multimeter to confirm the resistance. To test your resistor, make sure clip your rest leads onto the resistor leads and dial your multimeter to the resistance range you believe the resistor fits in (which should be simple since you can just analyze the color bands). If your multimeter reads 1 or 0, you have most likely guessed an incorrect resistance range and should move the dial to the next range up or down (respectively). If you happened to be on the lowest range of resistance on the multimeter and your read is still 0, your resistor has zero resistance.

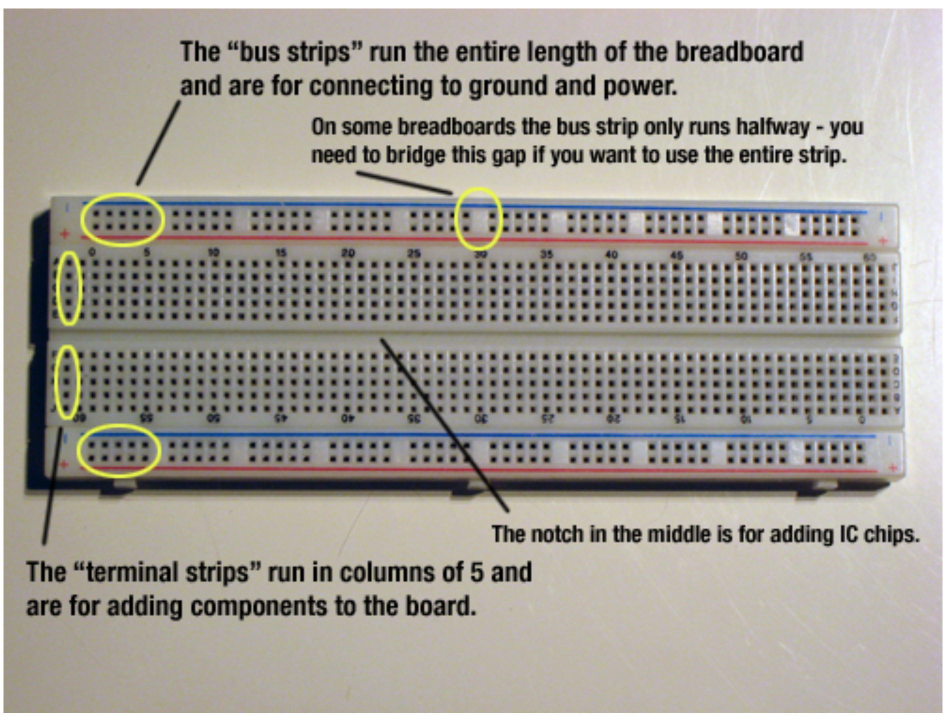
Please Note!

A common error when operating a multimeter is to set the meter to measure resistance or current and then connect it directly to a voltage source. Unfused (and even some fused) meters are ruin by such mistakes. It is important to always have the multimeter on the highest setting and disconnect it from the circuit before switching from one measurement to another.

BREADBOARDS

Basics

A breadboard is a construction base for prototyping of electronics specifically temporary circuit construction. It is formally considered to be a "solderless" breadboard because it does not require soldering to assemble and is reusable. The electrical connection between components is provided by an internal arrangement of electrical pathways. A breadboard can be divided into three parts: power buss strips, terminal strips, and dividing notch (a channel that separates the two groups of holes and is designed to accommodate a dual inline package style chip) as shown below.



Solderless Breadboard

Power Buss Strips

Buss strips run the length of the breadboard are electrically connected. These strips have red and blue lines on the sides of them and are typically used for power and ground connections. They are used to distribute a voltage or ground throughout the breadboard and are divided into two rows or holes (each row further divided into two groups of 25 holes). The 25 holes share an internal electrical connection. Any wire inserted into any of the 25 holes will share the same electrical connection.

Terminal Strips

The terminal strips consist of horizontal holes (5 columns) on each side of the breadboard. Anything plugged into any of the five holes in a single terminal strip will be electrically connected. It is important to note that one set of 5-column terminal strips on one side of the breadboard does not electrically connect to the terminal strips on the other side.

CIRCUITS

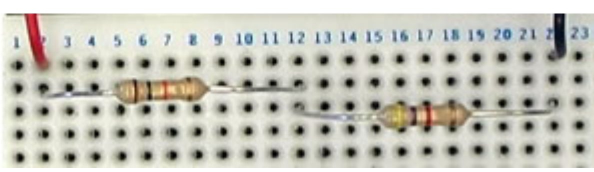
Basics

In this class you will be working with circuits, which are electrical networks that contain a closed loop giving a return path for the current. Finding voltages across and currents through components in an electrical circuit (much of what has been described above) is considered to be circuit analysis. For our labs you will need to familiarize yourself with RC, RLC, and by association LC circuits.

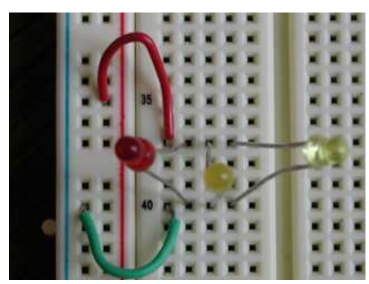
Resistor-capacitor (RC) circuits consist of resistors and capaciotrs driven by either a voltage or current source. Resistor-inductor-capacitor (RLC) circuits consist of resistors, inductors, and capacitors. And as the name suggests LC circuits consist of solely inductors and capacitors. The circuits provide a good base for analyzing fundamental behaviors of analog electronics. Further explanation on how components of these curcuits can be connect is explained below.

Connecting in Series

When components of a circuit are connected in series, the same current flows through all of the components because everything is in a single path. To connect components of a circuit in series on a breadboard make sure that only one leg of a component is in a terminal strip common to only one other component to ensure the current can only take a single path. An example is displayed below:



2 Resistors connected in series



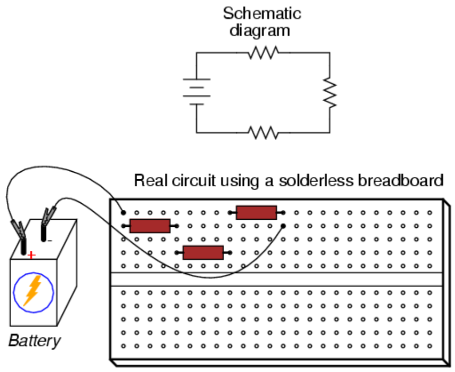
3 LEDs connected in parallel

Connecting in Parallel

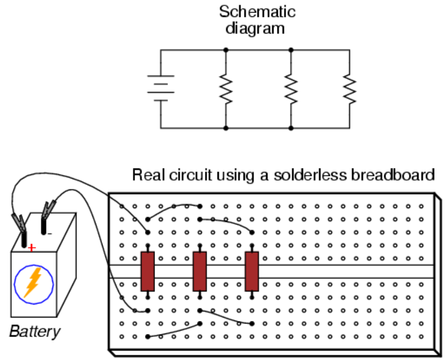
When components of a circuit are connected in parallel, they will have the same potential difference across them. This means that every component we want to be in parallel should have one leg in a specific terminal strip and the other leg in the another specific terminal strip. An example is shown above.

Schematics

Circuit diagrams or electronic schematics are often used to provide a simplified conventional graphical representation of an electrical circuit. These diagrams are identifiable by their simplified standard symbols used for the components of the circuit. Below are two examples of a schematic diagram matched with its corresponding circuit on a breadboard:



3-Resistor Series Circuit



3-Resistor Parallel Circuit

NI MYDAQ

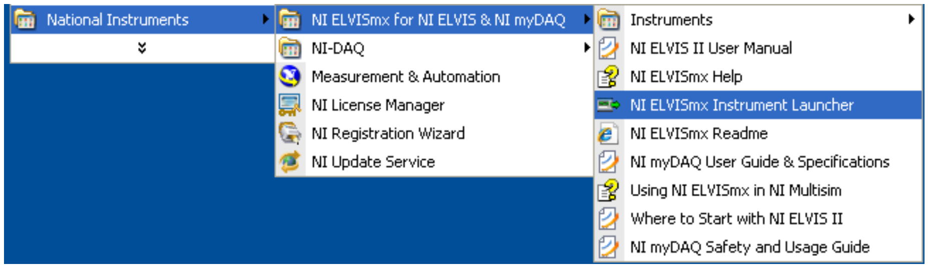
Basics

The NI myDAQ is a portable data acquisition (DAQ) device that uses LabVIEW software instruments, allowing studens to analyze and process acquired signals and control simple processes. The myDAQ provides analog input (AI), analog output (AO), digital input and output (DIO), audio input and output, DC power supplies, and most importantly (for this lab) digital multimeter (DMM) functions in a compact USB device.

NI my DAQ

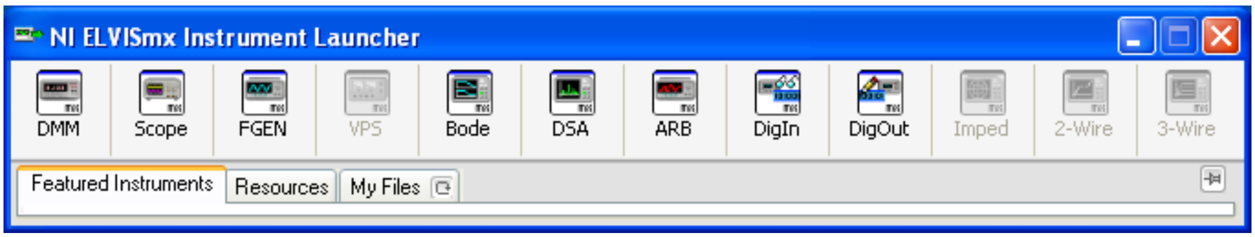
Connecting myDAQ to the Computer

1. Connect the myDAQ to your computer using the USB cable that came with the device
2. A blue LED light should appear near the USB connection on the myDAQ when the connection is established, indicating the myDAQ has power.
3. Next you should start the NI ELVISmx Instrument Launcher by going to the Windows Start menu and selecting Programs →National Instruments →NI ELVISmx for NI ELVIS & NI myDAQ → NI ELVISmx Instrument Launcher.



Pathway to NI ELVIS Instrument Launcher

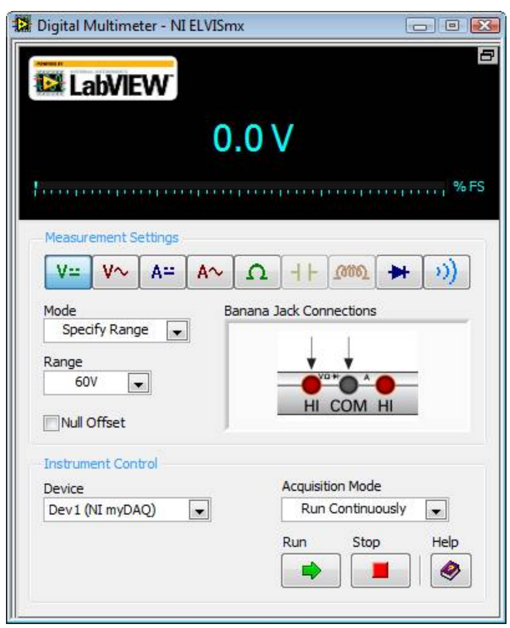
4. The panel below should appear on your screen:



NI ELVISmx Instrument Launcher Panel

The illuminated buttons show the currently available intruments in NI myDAQ.

In this lab you will be using the NI myDAQ digital multimeter (DMM) to measure voltage, current, and resistance. Launch the DMM by clicking the DMM button from the Instrument Launcher Panel. A soft front panel for the DMM should appear:



Panel for Digital Multimeter

Measuring Voltage with myDAQ

Measuring AC or DC voltage with the NI myDAQ DMM is available only through the banana jacks and can be done as follows:

1. For AC and DC voltage measurements, connect the VΩ (red) and COM (black) connectors on the bottom side of NI myDAQ to red banana jack and black banana jack, respectively.
2. The DMM is set in measuring DC Voltage mode when launched. Select the V-- or V~ button on the front panel of the DMM, depending on the signal to be measured, and the measurement type changes to show the value of the signal. Auto scaling should work best for most applications. If you want to specify the range, please start from the largest range and decrease the range according the measure result in order to protect the device from overdriven damage.
3. Using the probes to contact the corresponding signal leads. Remember that voltage is measured in PARALLEL to the device in question
4. Until now you have finished all the necessary setting and connections for voltage measurement. Then press the Run or Stop button from the soft front panel. Selecting the Run button provides continuous measurements of voltage. Selecting the Stop button stops the measurement and displays the instantaneous value of the voltage just before stopping the measurement.
5. Measuring DC voltage gives you the actual DC voltage, while measuring AC voltage gives you the RMS value of the AC voltage you are measuring.

Measuring Current with myDAQ

Measuring AC or DC current with the NI myDAQ DMM is available only through the banana jacks and can be done as follows:

1. For AC and DC current measurements, connect the A (red) and COM (black) connectors on the bottom side of NI myDAQ to red banana jack and black banana jack, respectively.
2. The DMM is set in measuring DC Voltage mode when launched. Select the A-- or A~ button on the front panel of the DMM, depending on the signal to be measured, and the measurement type changes to show the value of the signal. Auto scaling should work best for most applications. If you want to specify the range, please start from the largest range and decrease the range according the measure result in order to protect the device from overdriven damage.
3. Using the probes to contact the corresponding signal leads. Remember that current is measured in SERIES with the device in question.
4. Until now you have finished all the necessary setting and connections for current measurement. Then press the Run or Stop button from the soft front panel. Selecting the Run button provides continuous measurements of current. Selecting the Stop button stops the measurement and displays the instantaneous value of the current just before stopping the measurement.
5. Measuring DC current gives you the actual DC current, while measuring AC current gives you the RMS value of the AC current you are measuring.

Measuring Resistance with myDAQ

Measuring the resistance with the NI myDAQ DMM is available only through the banana jacks and can be done as follows:

1. For the resistance measurements, VΩ (red) and COM (black) connectors on the bottom side of NI myDAQ to red banana jack and black banana jack, respectively.
2. The DMM is set in measuring DC Voltage mode when launched. Select the Ω button on the front panel of the DMM to measure the resistance. Auto scaling should work best for most applications. If you want to specify the range, please start from the largest range and decrease the range according the measure result in order to protect the device from overdriven damage.
3. Using the probes to contact the resistor leads. Remember that the resistance is measured in Parallel with the device in question. The resistor in measurement should be disconnected from the circuit it is placed in, and otherwise the reading will not be correct.
4. Until now you have finished all the necessary setting and connections for resistance measurement. Then press the Run or Stop button from the soft front panel. Selecting the Run button provides continuous measurements of current. Selecting the Stop button stops the measurement and displays the instantaneous value of the resistance just before stopping the measurement

Setting Up the Power Supply

There are three power supplies available for use on NI myDAQ. +15 V and –15 V can be used to power analog components such as operational amplifiers and linear regulators. +5 V can be used to power digital components such as logic devices.

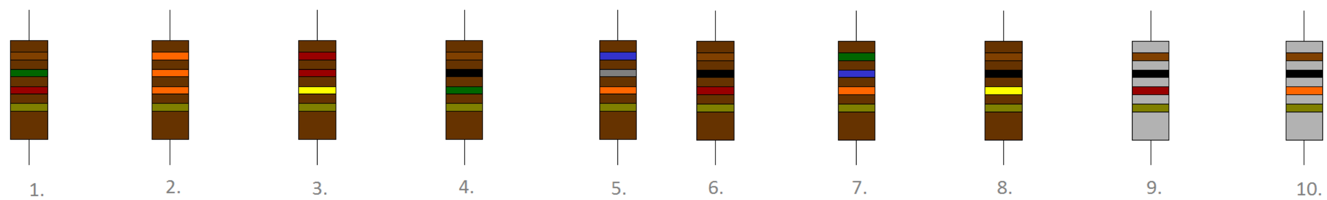
1. Connect the wire from +15, -15 or +5 screw terminal on NI myDAQ to the +15V, -15, or +5 (respectively) power rail in your breadboard, and then connect the wire from AGND (Analog Ground) screw terminal on NI myDAQ to the ground rail in your breadboard.
2. Connect NI myDAQ to your computer through the USB cable to power it up. When the blue LED lights, the power supply should be running.

EXPERIMENTAL SYSTEM AND EQUIPMENT

- Experimental System: RC circuits
- Circuit elements
- FLUKE digital multimeter-meter (DMM)
- The NI myDAQ

PRE-LAB ASSIGNMENT

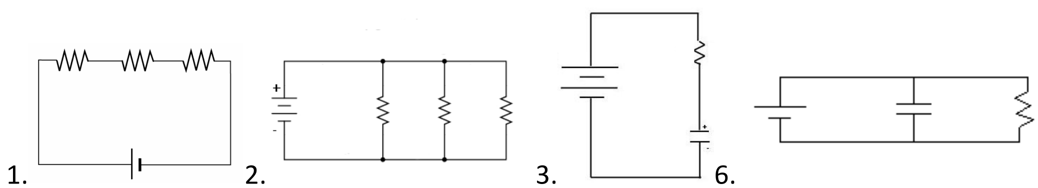
1. Identify the resistance values of the following resistors:

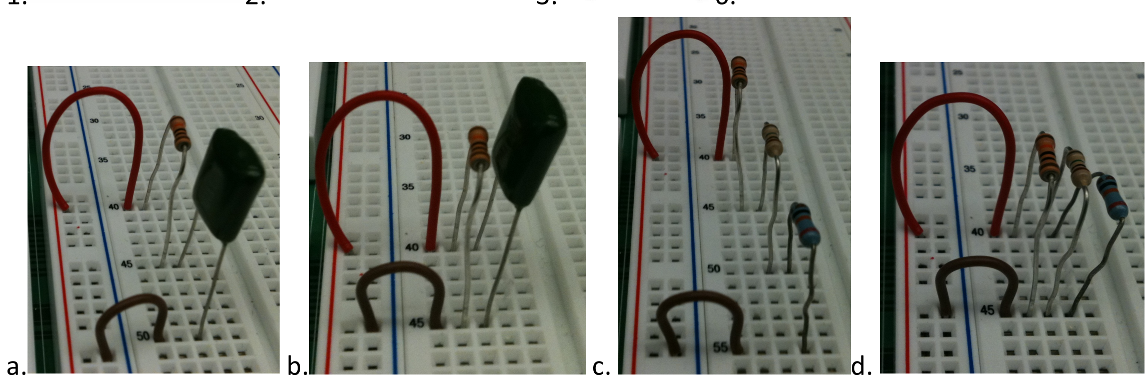


2. Identify the capacitance values of capacitors with the following labels:

a. 101	d. 226J
b. 104M	e. 225K
c. 472J	f. 154

3. Match the follow schematic diagrams and breadboard circuit pictures





LAB PROCEDURE

Part 1:

a) Start off with LED in series/parallel and ask about what they observed and if they can recount the electrical fundamentals behind it

b)

c) And then have them create an RC circuit and with a given amount of power ask what the i) voltage across blah ii) resistance of blah and iii) current running across blah
d) Then have them measure it using a FLUKE multimeter
e) Then have them use LabVIEW to do the same thing
f) And then compare the values…

RESULTS TO REPORT

- Results important to the procedure of this exercise such as calculations and observed data

REFERENCES

1. mil.ufl.edu/3111/docs/myDAQ/Intro_myDAQ.pdf
2. http://www.ianjuby.org/readres.html
3. http://www.4crawler.com/Diesel/CheapTricks/Tachometer/Capacitor.html
4. www.wisc-online/objects/ViewObjects.aspx?ID=eng701