

MyDAQ Integrated Hardware Exercises



**Texas Tech University
Electrical & Computer Engineering**

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myDAQ Connections

Analog Input:

2 channels, 200kS/s, 16-bit

Analog Output:

2 channels, 200kS/s, 16-bit

3.5mm stereo audio jacks

Digital I/O: 8 LVTTL lines

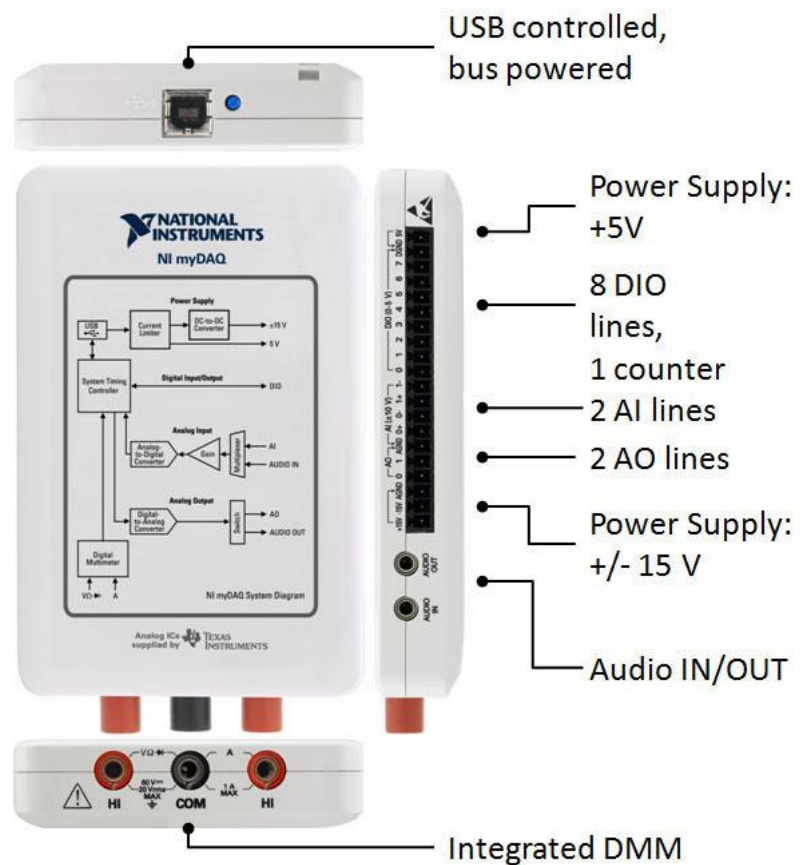
Counter: 1 counter/timer

Integrated DMM: V, A, Ohm

Power Supply: +5V, +/-15V

Screw term + mass term option

Bus Powered (USB) operation



*****CAUTION:** When working with the MyDAQ, do NOT connect it to a wall outlet or any voltage source of more than 60 V (DC) or 20 V (rms) with the Digital Multimeter probes or any other parts. Doing so can cause injury to you and your MyDAQ. ***

MyDAQ Integrated Hardware Exercise #1 – Voltage Divider (DC)

Objective

This exercise demonstrates a simple voltage divider circuit to the student using Labview, the NI myDAQ and a breadboard. The student will use the MyDAQ to provide a voltage source to a voltage division circuit and then check the output voltage using the Digital Multimeter. The student is encouraged to change the resistor values to verify the voltage output is consistent with the voltage division formula.

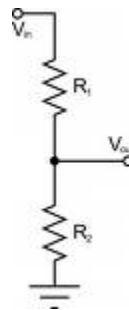
Materials Needed

Computer with NI ELVISmx installed, NI myDAQ, breadboard, four small wires with ends stripped, and two resistors.

Procedure

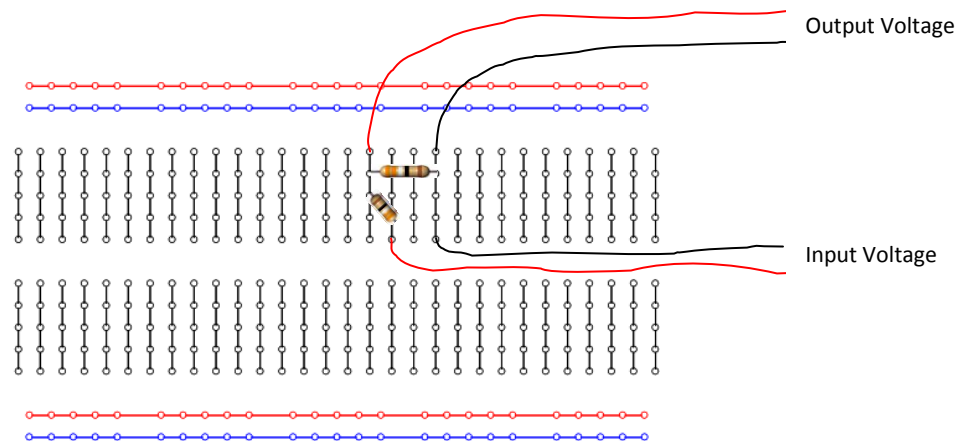
- I. **Setup.** The student should be familiar with the following simple voltage divider on paper:

Where the output voltage, $V_{out} = V_{in} \left(\frac{R_2}{R_1 + R_2} \right)$.



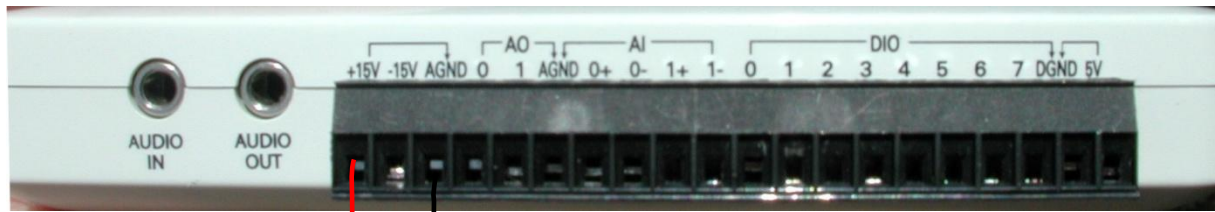
Now, take your breadboard and arrange the two resistors so that they match this schematic, leaving room to connect voltage input and output.

Next, connect four wires to the input and output terminals of your circuit. There should be two for the input voltage and two for the output voltage. Your arrangement might look something like this:



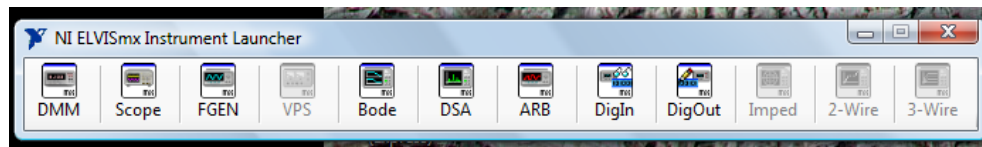
Now, connect the wires from the breadboard to the myDAQ. Connect the input voltage on the breadboard as it is shown above to the +15V DC source on the myDAQ. To connect wires to the myDAQ ports, simply insert the wire into the slot and use the NI screwdriver to tighten the hold on the wire.

Side view of myDAQ



To the *input*
voltage of circuit
on breadboard

- II. **Open myDAQ software.** Once the circuit is properly set up and connected to the myDAQ, plug in the myDAQ to the computer using the USB cord. You should see the NI ELVISmx Instrument Launcher automatically open when you plug in the myDAQ. (If the drivers and software have been properly installed.) Click on the DMM button to open the Digital Multimeter. Plug in the black and red probes to the bottom of the myDAQ. For this lab, use the left hand red plug for voltage measurements.



- III. **Measure Voltage.** On the Digital Multimeter window, make sure that the DC Voltage option is highlighted (this is the default setting) and that the range is set to 60 V and click "Run." Connect the two black and white probes to the wires attached to the output voltage on the breadboard circuit.

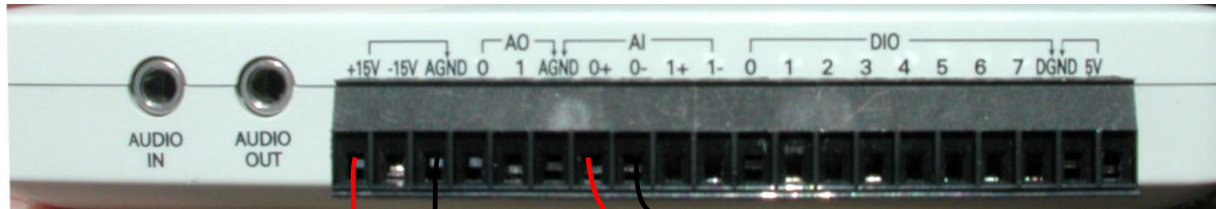


What is the voltage that the DMM measures? _____

- IV. **View Voltage in Oscilloscope.** Another easy way to measure voltage is with an oscilloscope. Click on the Scope button on the ELVISmx instrument launcher. Connect the wires on the output voltage of the circuit (the wires you just measured with the probes in Part III) to the **AI 0** ports of the myDAQ as shown below:

Analog Output Analog Input

Side view of myDAQ



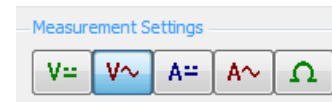
To the *input*
voltage of circuit
on breadboard

To the *output*
voltage of circuit on
breadboard

Now, click “Run” on the oscilloscope window, and then click “Autoscale.” You should see a straight line on the graph. (If the line is below the x-axis, simply switch the wire positions to make the voltage positive). The RMS value shown beneath the graph should match the value you measured with the DMM.

Does the value match? _____

- V. Calculate.** Use the values of your resistors (You can find these values by using the attached resistor chart or using the Ohm button on the DMM), calculate the theoretical output voltage of the circuit and compare this to what you measured with the DMM and the Oscilloscope. The value of the input voltage is the DC voltage that the myDAQ is outputting to the circuit, which is labeled as 15 Volts. This might not be exact, so measure this value yourself using the DMM. To do this, you can put the probes directly on the screws above the ports (+15V and AGND).



Value of your Resistor 1 _____
 Value of your Resistor 2 _____
 Value of input Voltage Amplitude _____

Calculated Value of Output Voltage Amplitude using voltage division equation

$$V_{out} = V_{in} \left(\frac{R_2}{R_1 + R_2} \right)$$

Does the calculated value match the value observed with the DMM and on the oscilloscope? _____

If it does not match exactly, what are some possible reasons? _____

MyDAQ Integrated Hardware Exercise #2 – Thévenin's Theorem

Objective

The purpose of this lab is to demonstrate Thevenin's Theorem. The student will build a simple circuit and then measure the Thevenin equivalent voltage and resistance, as well as calculate them, and compare the values.

Materials Needed

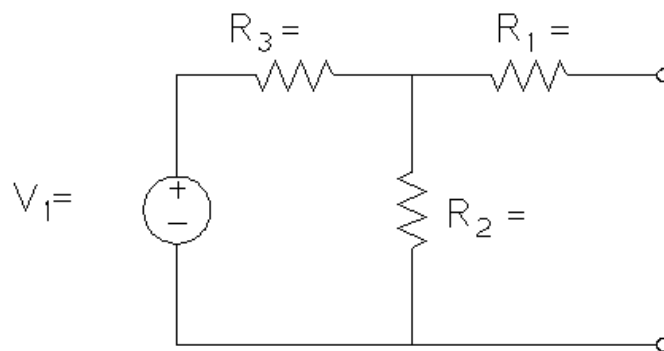
Computer with NI ELVISmx installed, NI myDAQ, breadboard, four small wires with ends stripped, and three resistors.

Procedure

I. Background

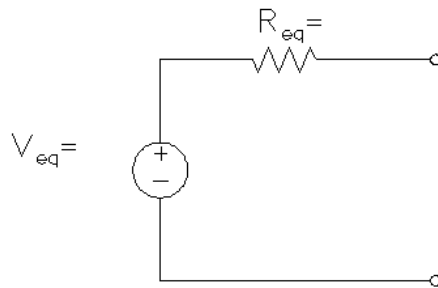
Thevenin's Theorem is a way of simplifying linear circuits. A circuit with multiple voltage sources and multiple components can be reduced to an equivalent circuit with one voltage source in series with a resistor.

- II. **Setup.** Set up the following circuit on your breadboard using resistors of your choice. Label Each resistor with your value:

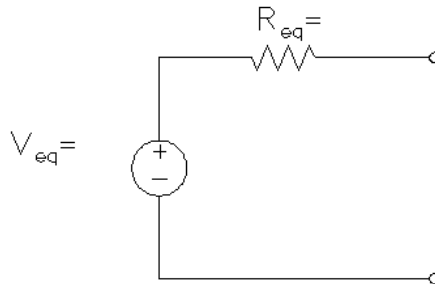


- III. **Analyze.** To calculate the Thevenin equivalent voltage, use the same voltage division formula that you used in Lab #1: $V_{out} = V_{in} \left(\frac{R_2}{R_2 + R_3} \right)$ In this case, R_1 is not considered, because we are treating the end as an open circuit, and therefore no current is flowing through R_1 .
To calculate the Thevenin equivalent resistance, treat the voltage source as a short circuit. In this case, R_2 and R_3 are in parallel, and collectively in series with R_1 , so that $R_{eq} = R_2 || R_3 + R_1 = \frac{R_2 R_3}{R_2 + R_3} + R_1 = R_{eq}$

- A. Calculate the equivalent voltage and resistance and fill in the values below:

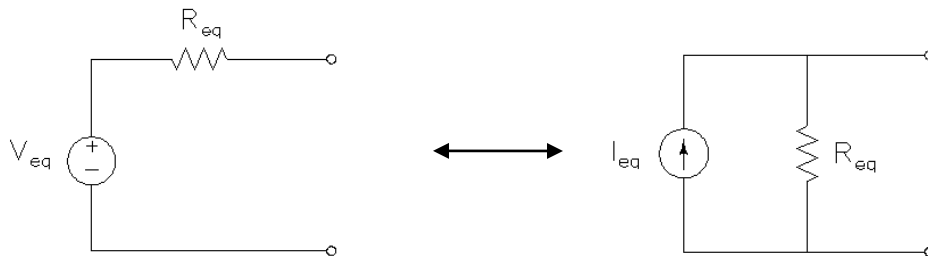


- B. Measure the equivalent (output) voltage using the DMM, and measure the equivalent resistance by shorting the input source. To do this, simply place a wire between the two nodes where the input voltage wires connect. Enter these values below:

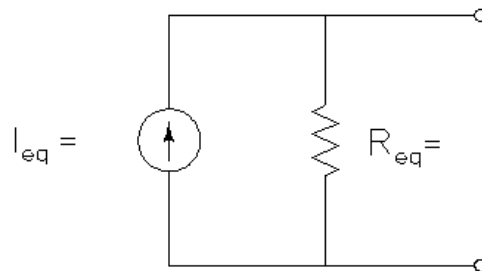


How do your two equivalent circuits (calculated and measured) differ? _____
What are some possible reasons for this? _____

IV. Norton Equivalent. The Thevenin equivalent circuit can also be converted to a Norton equivalent, with a current source instead of voltage. In this case: $I_{eq} = \frac{V_{eq}}{R_{eq}}$



Convert your equivalent circuit to a Norton equivalent, and fill in the values below:



Integrated Hardware Exercise #3 – Current Divider (DC)

Objective

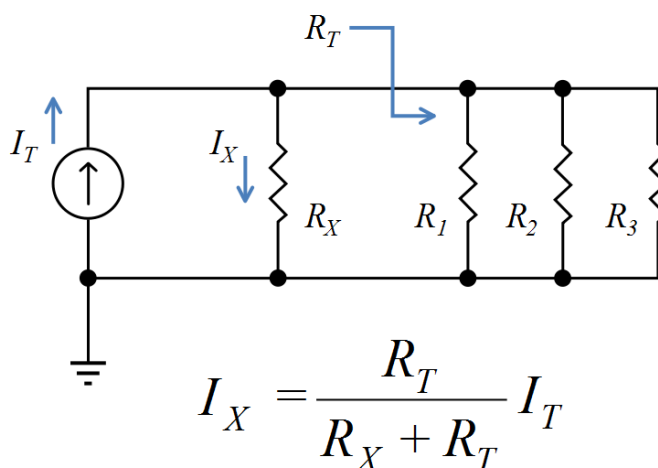
This exercise demonstrates a simple current divider circuit to the student using the NI ELVISmx Software, the NI myDAQ and a breadboard. The student will produce a signal using a Labview program, send the signal to a circuit on a breadboard through the myDAQ, and then analyze the signal with a Labview program. The student can change the parameters of the output signal such as amplitude and frequency, and watch in real time how the input signal changes after it travels through the circuit. Once the exercise is complete, the student is encouraged to change the circuit by adding resistors or other components as he or she desires, to see the effects of the components on the output signal.

Materials Needed

Computer with NI ELVISmx installed, NI myDAQ, breadboard, four small wires with ends stripped, and four resistors.

Procedure

- I. **Background.** The student should be familiar with the following simple current divider on paper:

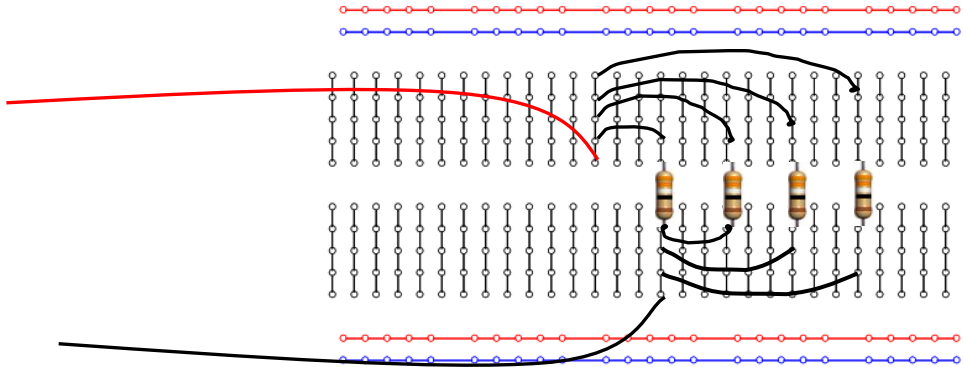


In this formula, R_T is the total resistance of R_1 , R_2 , and R_3 , which is all three resistors in parallel, given by the formula: $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

The current divider differs from the voltage divider in Lab #1 in that the relationship to the impedance is inverted. Basically, in the voltage divider, the impedance across the resistor where the resulting voltage was being measured was in the numerator. In the current divider, the impedance where the current is being considered is in the denominator.

- II. **Setup.** Now, take the breadboard and arrange the resistors so that they match this schematic, leaving room to connect voltage input and output.

Next, connect two wires to the input terminals of your circuit. Your arrangement might look something like this: (You can add as many resistors as you like, following this pattern)



Try to relate the schematic shown in Part 1 to this breadboard diagram. You can see the difference between the current source and the voltage source (as shown in the previous lab's schematic) in that the red wire is connected to the entire circuit and is the current source, while the ground (black) wire connects all the resistors to ground. So a current source takes what would have been the negative or ground wire for the input voltage and connects it to the entire circuit, rather than having it be a part of the input voltage provided by a voltage source.

Connect the input voltage wires to the +15 V source and AGND as you did in the Voltage Divider lab. To check the current on this circuit, you will need to create an open circuit and measure the current across that gap using the Digital Multimeter (DMM).

- III. **Calculate Current Division.** Using the above formula for current division, calculate the current across each resistor.

Current across R1 _____

Current across R2 _____

Current across R3 _____

Current across R4 _____

Now use the DMM to check these values physically. Do the calculated values match the observed values? _____

Would you expect these values across the different resistors (either calculated or measured) to be the same? Why or why not?

MyDAQ Integrated Hardware Exercise #4– RC Circuit (DC)

Objective

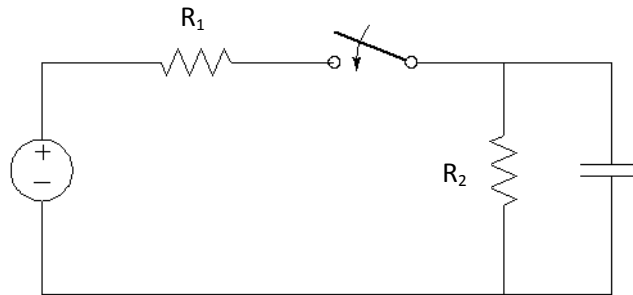
This exercise demonstrates an RC circuit. The student will use the DC current from the myDAQ with an RC circuit on a breadboard and the Elvismx software to discover the time constant of the circuit.

Materials Needed

Computer with Labview 8.6 installed, NI myDAQ, breadboard, a 100 μF capacitor, small wires with ends stripped, a switch, and two resistors, 10k Ω (R_1) and 3.3 k Ω (R_2).

Procedure

I. **Background.** A schematic of a simple RC circuit looks like this:

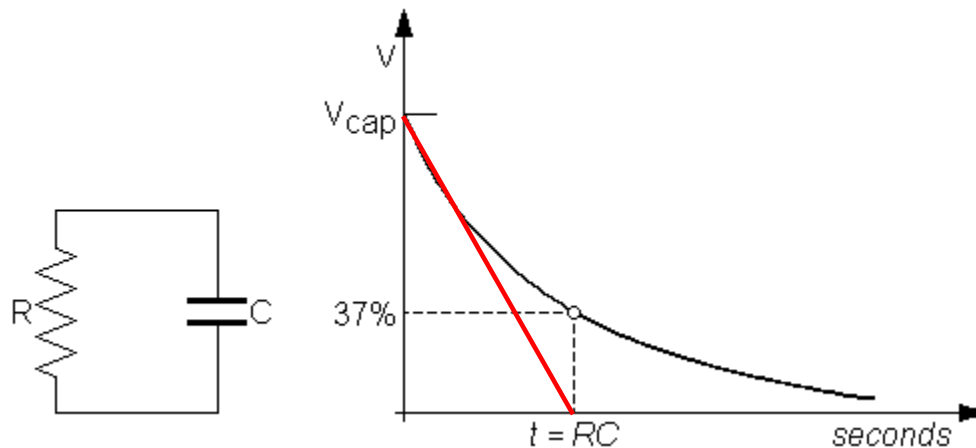


The two equations governing this graph are

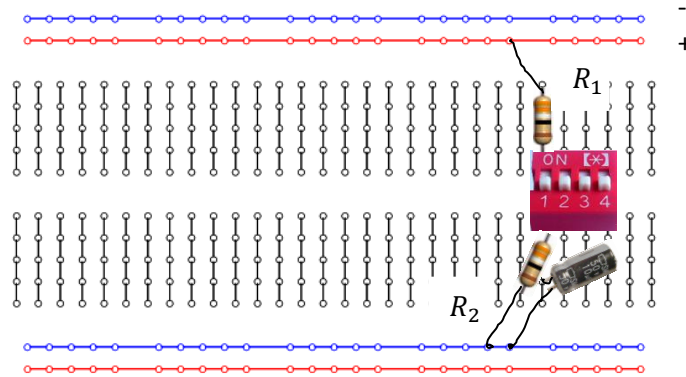
$$v(t) = V_0 - \frac{V_0}{\tau} t \quad v(t) = V_0 e^{-\frac{t}{\tau}}$$

where $\tau = R \cdot C = \text{time constant}$

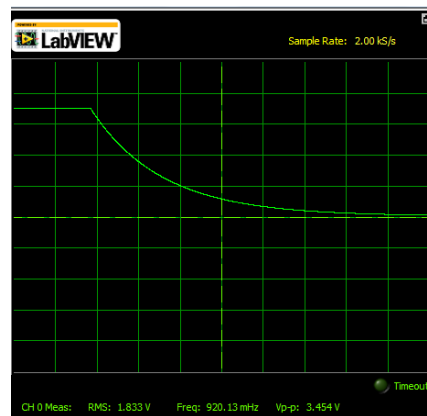
RC Discharge



- II. **Setup.** Arrange the circuit on the breadboard to match the schematic. Connect the ground wire on the breadboard to the analog ground on the myDAQ (AGND) and the power to the +15 Volts. Your arrangement might look something like this:



- III. **View Oscilloscope.** When your circuit is finished and properly connected to the myDAQ, open the oscilloscope program and run it. Now flip the switch on the dipswitch that is connected to the circuit and watch the capacitor charge on the oscilloscope. When it is charged, flip the switch off again to see it discharge, and click the stop button to freeze the graph. Your graph should look something like this:



- IV. **Estimate Time Constant.** Estimate the time constant of the circuit by drawing a straight line on the graph as shown in part I. Use the value of the *timebase* as the time value of each box on the graph. Write this value here _____.

- V. **Calculate Time Constant.** The actual calculated time constant from the equation in Part I is: _____.

How close was your estimation? _____

What is the purpose of the 10 kΩ resistor? (R1) _____

What happens if you try to run the circuit without this resistor? _____

MyDAQ Integrated Hardware Exercise #5– Phase Shift in an RC Circuit (AC)

Objective

This exercise demonstrates the phase shift that takes place between an input and output signals through an RC Circuit.

Materials Needed

Computer with Labview 8.6 installed, NI myDAQ, breadboard, a .1 μF capacitor, small wires with ends stripped, and one 10K Ω resistor.

Procedure

I. Background

A capacitor behaves differently than a resistor. A resistor allows current flow through it which is proportional to the voltage drop, as in $V = IR$. A capacitor, on the other hand, opposes changes in voltage, so that the current that flows through it is proportional not to the *voltage*, but to the *change in voltage*. This is called *reactance*.

$$i_{\text{capacitor}} = C \frac{dV}{dt}$$

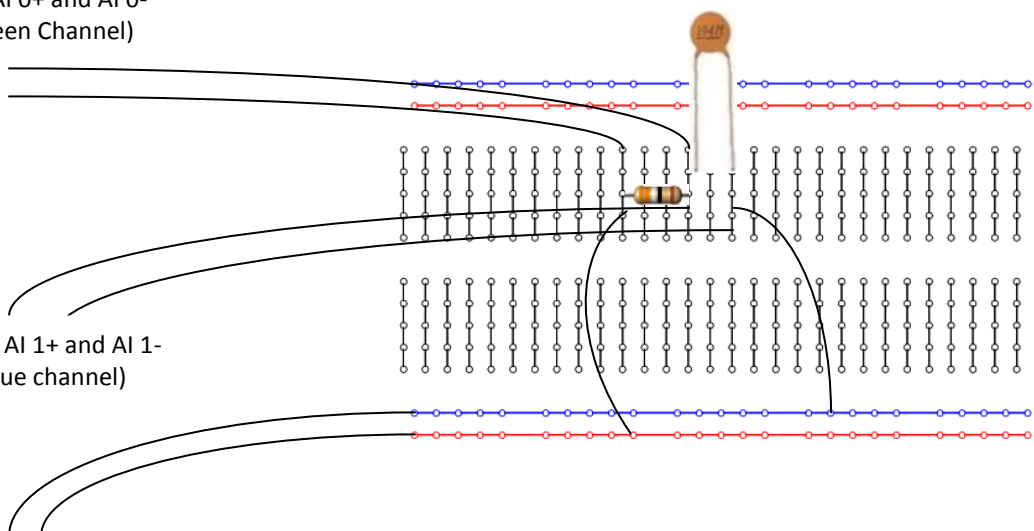
Practically, this reactance in the capacitor causes the voltage across the capacitor to *lag* (*fall behind*) the current in the capacitor. In other words, when a signal travels through a capacitor, it gets *out of phase* with the input signal.

- II. **Setup.** To see the difference in phase of the signal as it goes through the capacitor, set up a simple RC circuit on a breadboard. Your arrangement should look something like this:

To AI 0+ and AI 0-
(Green Channel)

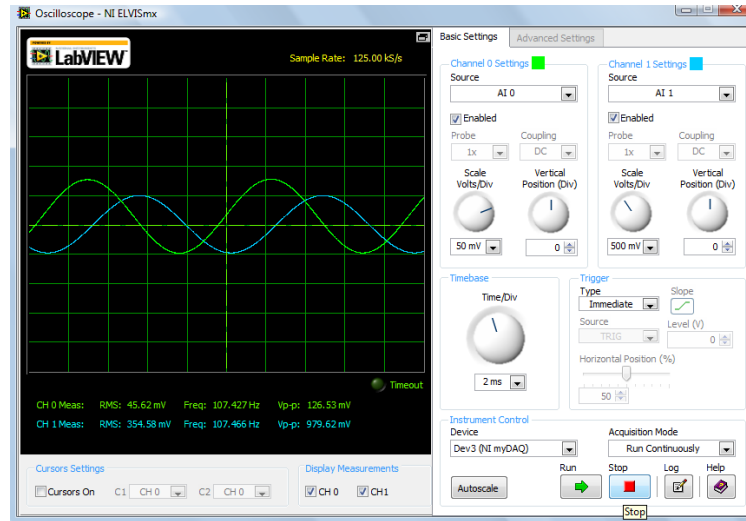
To AI 1+ and AI 1-
(Blue channel)

To AO 0 and AO AGND



- III. **Create Function.** Open the Function Generator and create a sinusoidal signal with a frequency of around 100 Hz and click “Run.”
- IV. **View Oscilloscope.** Open the Oscilloscope and click “Enabled” on the Channel 1 settings. Click “Run” and then “Autoscale.”

You should see a graph that looks like this:



- V. **Consider.** Does the voltage across the capacitor (The blue signal) look out of phase with the signal across the resistor (the green signal)? _____

If it is out of phase, does it look like it is leading or lagging the input signal? _____

Switch the wires that are measuring the capacitor voltage (wires connected to AI 1). Now, does the capacitor signal look like it is leading or lagging the input signal?

MyDAQ Integrated Hardware Exercise #6– Low Pass and High Pass Filter (AC)

Objective

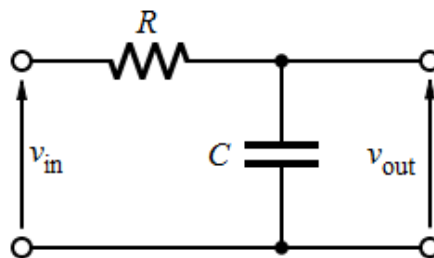
This exercise demonstrates a simple low pass and a high pass RC filter.

Materials Needed

Computer with Labview 8.6 installed, NI myDAQ, breadboard, a 100 μF capacitor, small wires with ends stripped, and one resistor.

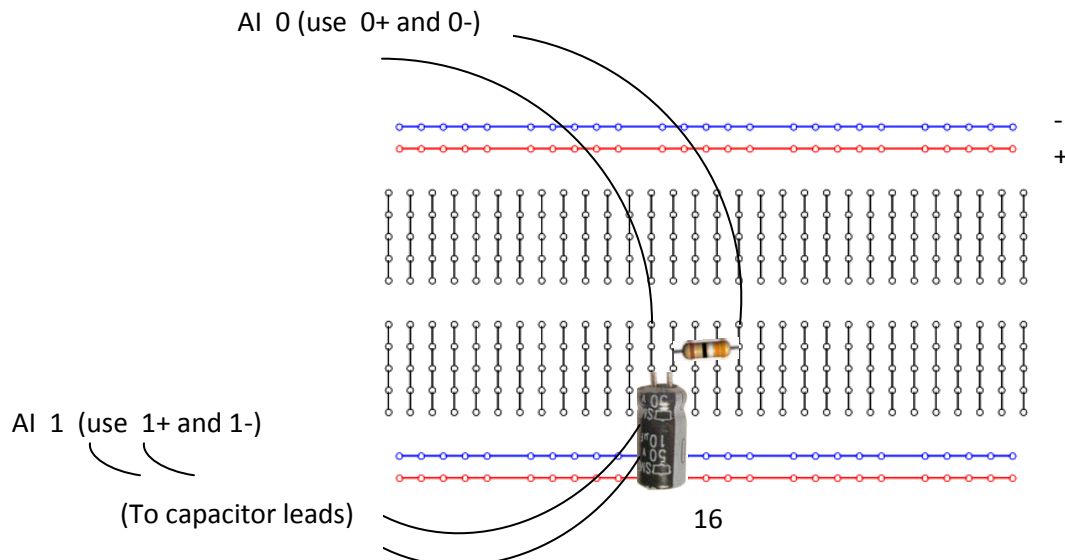
Procedure

- I. **Background.** A schematic of a simple RC low pass filter:

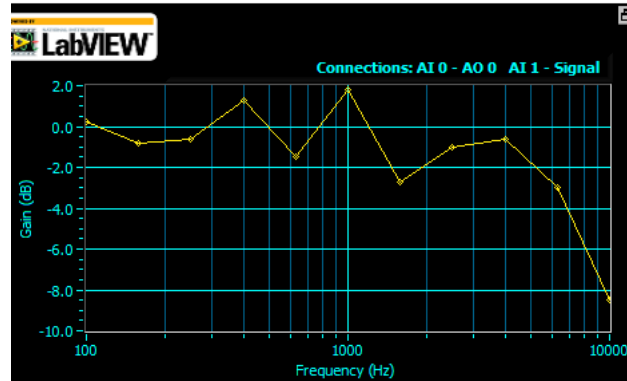


This circuit will filter out high frequencies and let lower ones pass, because at low frequencies, the capacitor has time to charge and discharge at the same rate as the input voltage changes, effectively blocking the low frequency signals so they go to the output. (A capacitor will not conduct DC current, which is similar to low frequency). At higher frequencies, the capacitor doesn't have enough time to match the input voltage and begins to act like a short, and the input signal never reaches the output. (A capacitor conducts AC current much better).

- II. **Setup.** Using the same resistor and capacitor as in Lab #3, set up the circuit on the breadboard to match the schematic, connecting the leads to AI 0 and AI 1. The arrangement should look something like this:



- III. **Open Bode Plots.** Use the Bode plot function to view the frequency response of the filter. Change the steps per decade and run it a few times to see the trend. The response plot should show a decrease in gain as frequency increases.



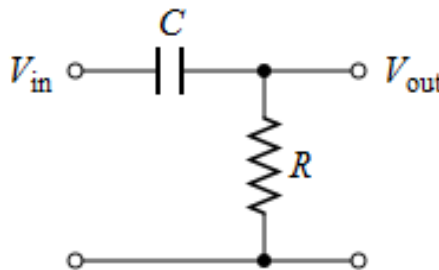
- IV. **Frequency response in real time.** Now change the input wires on the circuit (those connected to AI 1+ and 1-) to the AO 0 channel (use AO 0 and AGND). Close the Bode Plot function. Use the function generator to output a function to the filter, and use the oscilloscope to watch the filtered signal. As you change the output signal frequency, observe how the amplitude decreases and then virtually disappears as frequency increases.
- V. **Calculate cutoff Frequency.** Use the following formula to calculate the cutoff frequency for this filter. (If you are using the same resistor and capacitor as in the previous lab, you already have the time constant, τ).

$$f_c = \frac{1}{2\pi RC}$$

Cutoff Frequency _____

In your estimation, does the Bode plot begin to decrease at this frequency? If not, what factors may have caused this? _____

- VI. **Change to High Pass Filter.** Now consider the following schematic of a simple High Pass Filter:



Simply switch the locations of the capacitor and the resistor on the circuit to build a high pass filter. Change the output frequency again as for the low pass filter and observe its opposite nature. If you change the output signal wires again to the AI 1 channel, you can see the bode plot for the high pass filter with the Bode plot function.

Does the calculated cutoff frequency agree with each bode plot? _____

MyDAQ Integrated Hardware Exercise #7– Band Pass Filter

Objective

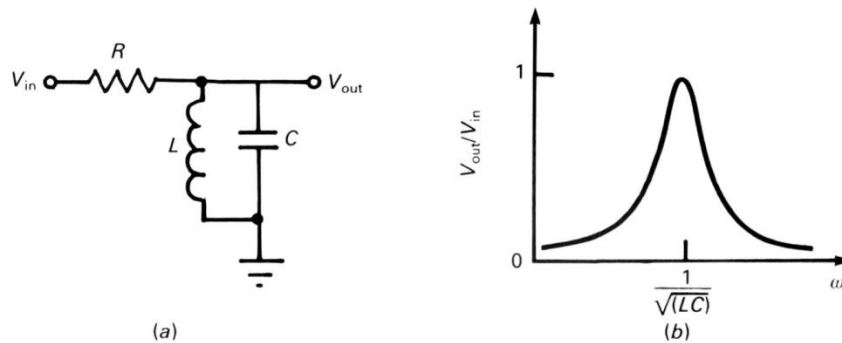
This exercise demonstrates a simple RLC band- pass filter.

Materials Needed

Computer with Labview 8.6 installed, NI myDAQ, breadboard, a 100 μF capacitor, 100 μH inductor, small wires with ends stripped, and one resistor.

Procedure

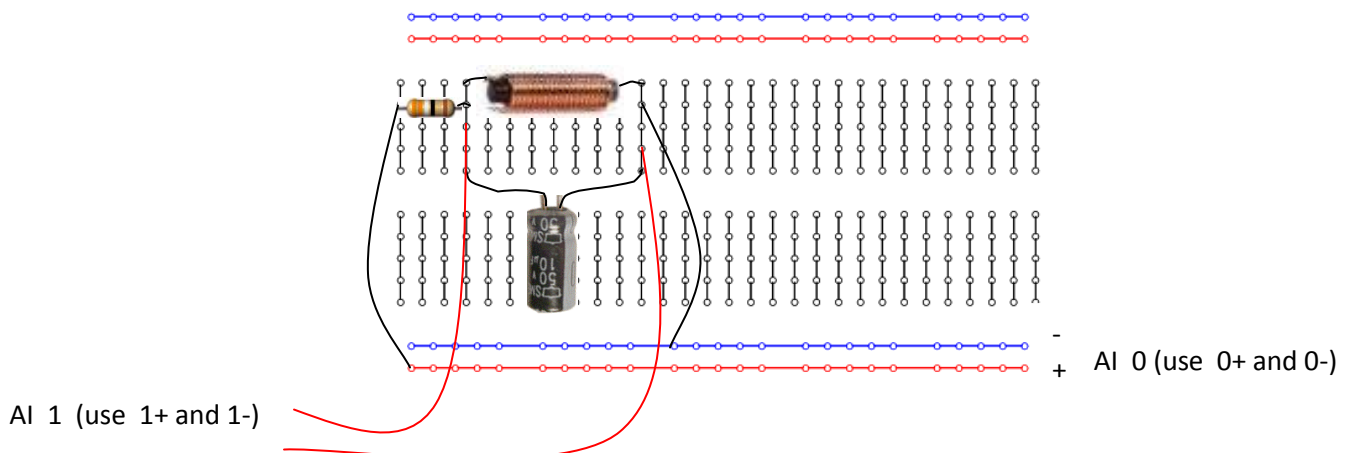
- I. **Background.** A schematic of a simple band pass filter:



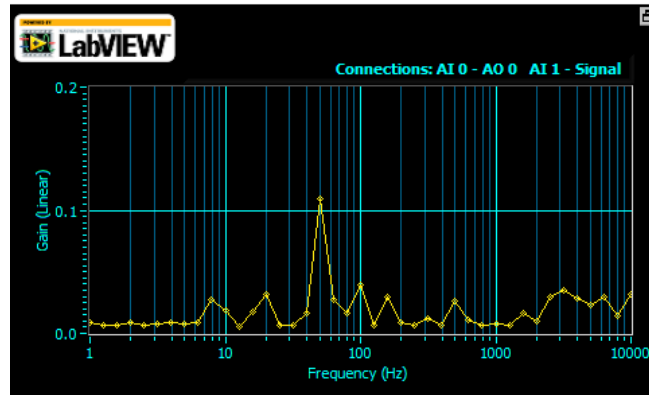
(a) A simple band pass filter; (b) its frequency response.

A band pass filter filters out low *and* high frequencies. This is useful in producing a specific frequency.

- II. **Setup.** Build a circuit on the breadboard to match the schematic. Your arrangement might look something like this:



- III. **Open Bode Plots.** Find the frequency response of the circuit by running the Bode plot function. Your graph should have a similar trend:



- IV. **Check Frequency Response.** Use the oscilloscope and the function generator to see the filter work while you change the input frequency. You will need to change the wires so that the function you are generating is sent out through AO 0 to the circuit (previously AI 0 in Part II) and the oscilloscope is connected to AI 0 (previously AI 1 in Part II). As you change the frequency, note how the amplitude increases at a certain point and then decreases.

Around what frequency does the signal have a maximum amplitude? _____
Does this agree or disagree with your Bode plot? _____
If it disagrees, what might be some reasons why? _____

MyDAQ Integrated Hardware Exercise #8 – Voltage Divider (AC)

Objective

This exercise demonstrates a simple voltage divider circuit to the student using Labview, the NI myDAQ, and a breadboard. The student will produce a signal using a Labview program, send the signal to a circuit on a breadboard through the myDAQ, and then analyze the signal with a Labview program. The student can change the parameters of the output signal such as amplitude and frequency, and watch in real time how the input signal changes after it travels through the circuit. Once the exercise is complete, the student is encouraged to change the circuit by adding resistors or other components as he or she desires, to see the effects of the components on the output signal.

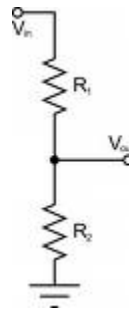
Materials Needed

Computer with Labview 8.6 installed, “Voltage Divider” Labview VI, NI myDAQ, breadboard, four small wires with ends stripped, and two resistors.

Procedure

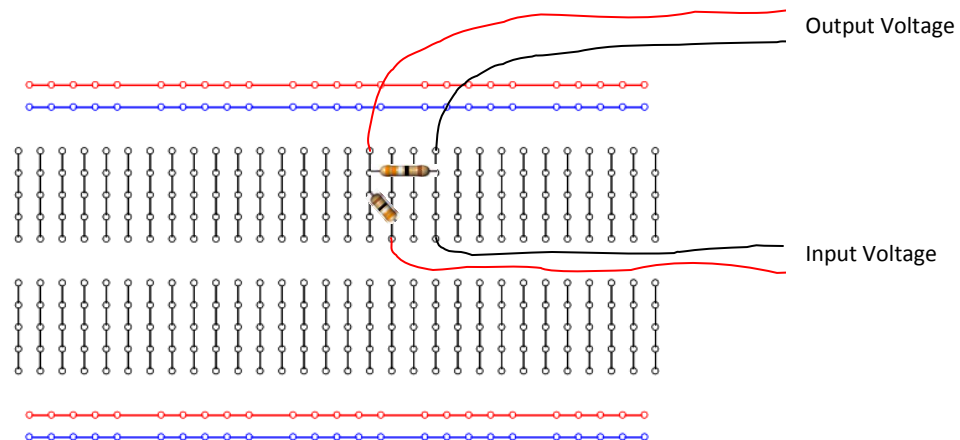
VI. **Setup.** The student should be familiar with the following simple voltage divider on paper:

Where the output voltage, $V_{out} = V_{in} \left(\frac{R_2}{R_1 + R_2} \right)$.

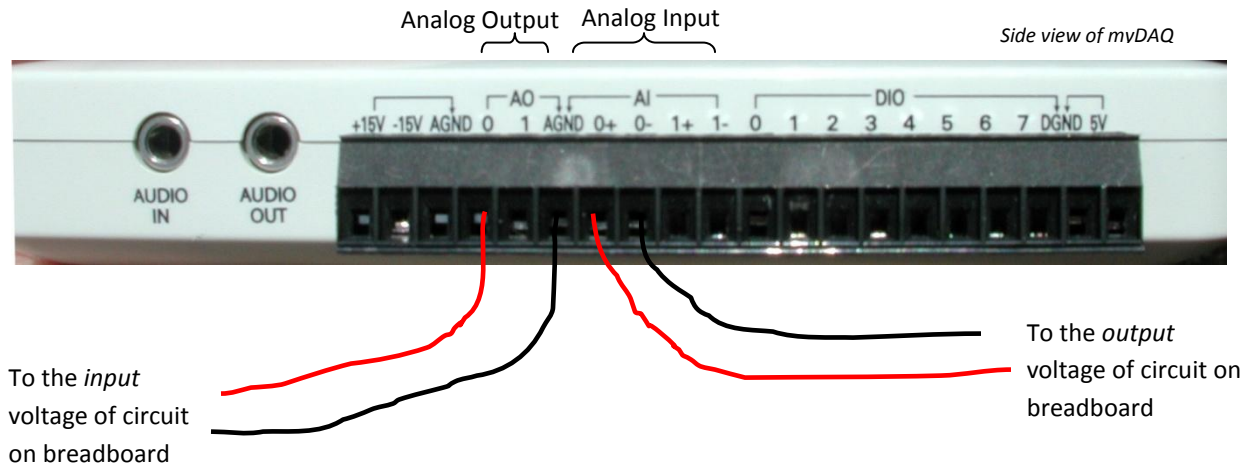


Now, take your breadboard and arrange the two resistors so that they match this schematic, leaving room to connect voltage input and output.

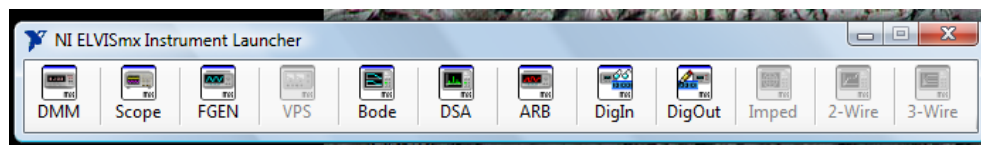
Next, connect four wires to the input and output terminals of your circuit. There should be two for the input voltage and two for the output voltage. Your arrangement might look something like this:



Now, connect the wires from the breadboard to the myDAQ. The input voltage on the breadboard as it is shown above is actually the *output* voltage on the myDAQ, and the output voltage on the breadboard is the *input* voltage on the myDAQ.



- VII. **Open myDAQ software.** Once the circuit is properly set up and connected to the myDAQ, plug in the myDAQ to the computer using the USB cord. You should see the NI ELVISmx Instrument Launcher automatically open when you plug in the myDAQ. (If the drivers and software have been properly installed.) Click on the DMM button, the Scope button, and the FGEN button to open the Digital Multimeter, Oscilloscope, and the Function Generator (the three leftmost buttons). To use the Multimeter, plug in the probes to the bottom of the myDAQ. For this lab, use the left hand red plug for voltage measurements.



- VIII. **Generate Function.** On the function generator window, check to see that “NI myDAQ” is listed under “Device” at the bottom. Then click “Run.”

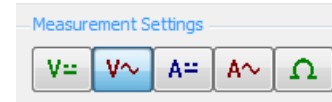


- IX. **View Oscilloscope.** In the oscilloscope window, click the “Run” button, and you should see the function that you generated, after it has gone through your voltage divider circuit.

- X. **Measurement.** Test out your voltage divider circuit by changing the amplitude on the output amplitude and watching the input graph to see how the circuit affects it. Try changing other parameters such as frequency and waveform type.

- XI. DMM.** You can also measure the value of your resistors using the multimeter, which can also be used to check voltage directly on the circuit. The value on the multimeter should match the RMS value given on the oscilloscope. Be sure to put the multimeter in the correct mode; since we are outputting an analog signal, click the analog voltage button.

Value of your Resistor 1 _____
Value of your Resistor 2 _____
Value of input Voltage Amplitude _____



Calculated Value of Output Voltage Amplitude using voltage division equation

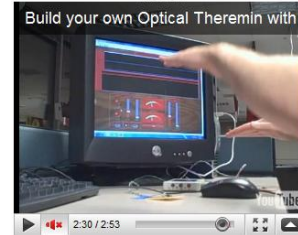
_____ $V_{out} = V_{in} \left(\frac{R_2}{R_1 + R_2} \right)$

Does the calculated value match the value seen in on the oscilloscope? _____

If it does not match exactly, what are some possible reasons? _____

More Stuff To Do With Your myDAQ from www.ni.com/mydaqzone

- 1. Optical Theremin - Autotune VI** - The myDAQ Optical Theremin is a musical instrument which is played in a similar method compared to a real theremin. It uses two photodiodes as optical sensors for input from the performer and generates a sine wave which is output via the headphone jack. The performer moves his or her hands over the sensors to control the intensity of light. One sensor is used to control the pitch and the other changes the gain. When the user moves his or her hands up and down over the sensor the pitch and gain raise and lower accordingly.



Materials

- 1x myDAQ
- 1x Speaker/Headphones
- 2x Photodiodes
- 2x 741 Op-Amps
- 4x 5.1Mohm resistors
- 2x Breadboards/perfboards/something to hold the circuit
- □ 10x pieces of wire

Estimated Cost: \$5 + myDAQ + Speaker/Headphones

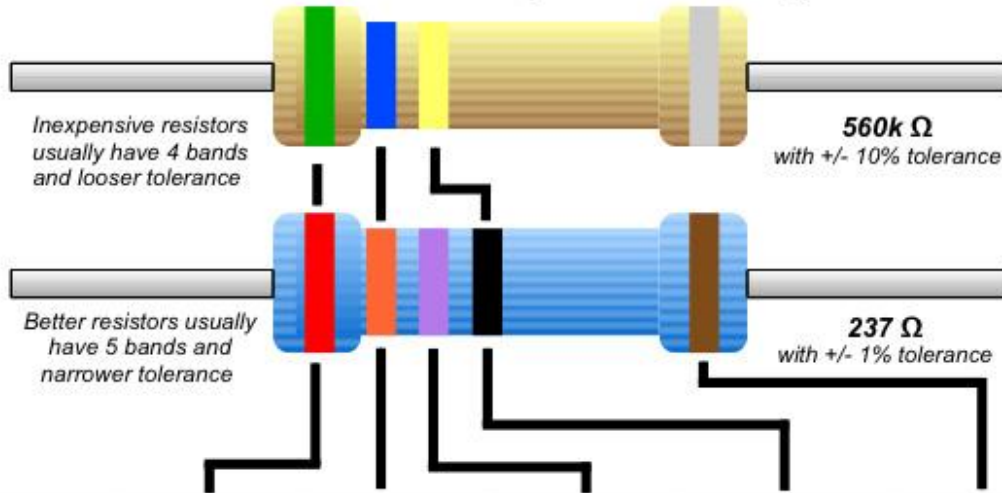
- 2. Piano Staircase with NI myDAQ and \$25**

<http://waterloolabs.blogspot.com/2010/07/mydaq-piano-staircase-video-live.html>



Resistor Identification

The end with more bands should point left when reading colors.



Color	1 st Band	2 nd Band	3 rd Band	Multiplier	Tolerance
Black	0	0	0	x 1 Ω	
Brown	1	1	1	x 10 Ω	+/- 1%
Red	2	2	2	x 100 Ω	+/- 2%
Orange	3	3	3	x 1K Ω	
Yellow	4	4	4	x 10K Ω	
Green	5	5	5	x 100K Ω	+/- .5%
Blue	6	6	6	x 1M Ω	+/- .25%
Violet	7	7	7	x 10M Ω	+/- .1%
Grey	8	8	8		+/- .05%
White	9	9	9		
Gold				x .1 Ω	+/- 5%
Silver				x .01 Ω	+/- 10%

Surface-Mount

Surface-Mount (SMD) resistors use a similar system. Resistance is indicated by a 3-digit code like 104, sometimes followed by a letter. Rare, precision resistors have 4 digits (3+multiplier).

104	1 st Digit	2 nd Digit	3 rd Digit (rare)	Multiplier	(10 with 4 zeros)
	1	0		4	= 100k Ω

- 0 Ω resistors (marked "0") are used instead of wire links to simplify robotic assembly.
- Resistors less than 100 Ω use a 0 multiplier to mean "x 1" so "100" = 10 Ω , "470" = 47 Ω

This is a low-res version of the PDF available on www.zachpoff.com

****Remember, you can check the resistance directly with the DMM on your myDAQ!!!!****