# Lab 1 – NI ELVIS II Workspace Environment
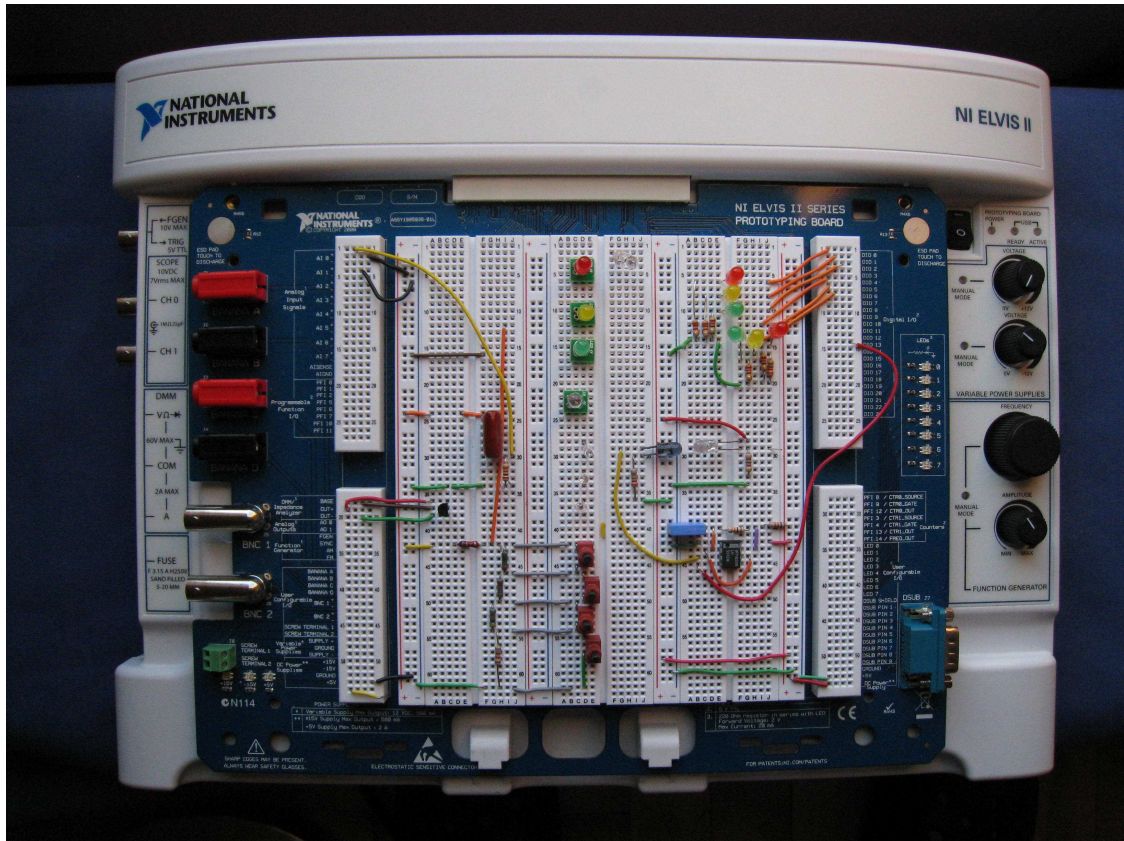


*Figure 1.0. NI ELVIS II Workstation*

The NI ELVIS II environment consists of the following components:

Hardware workspace for building circuits and interfacing experiments
NI ELVIS II software (created in NI LabVIEW software), which includes the following:
- Soft Front Panel (SFP) instruments
- LabVIEW APIs
- Multisim APIs

With the APIs, you can achieve custom control of and access to NI ELVIS II workstation features using LabVIEW programs and simulation programs written within Multisim.

**Goal:** This lab introduces NI ELVIS II by showing how you can use the workstation to measure electronic component properties. Then you can build circuits on the protoboard and later analyze them with the NI ELVIS II suite of SFP instruments. This lab also shows how you can use Multisim to design and simulate a circuit before building the circuit on the NI ELVIS II workstation and controlling it with a LabVIEW program.

**Required Soft Front Panels (SFPs)**
Digital Ohmmeter DMM[Ω],
Digital Capacitance Meter DMM[C]
Digital Voltmeter DMM[V]

**Required Components**
1.0 kΩ resistor, $R_1$, (brown, black, red)
2.2 kΩ resistor, $R_2$, (red, red, red)
1.0 MΩ resistor, $R_3$, (brown, black, green)
1 μF capacitor, C
Project resistors – 7.5 kΩ, 1 kΩ, 2 kΩ, 4 kΩ, and 8 kΩ nominal values

## Exercise 1.1: Measuring Component Values

1. Connect the NI ELVIS II workstation to your computer using the supplied USB cable. The box USB end goes to the NI ELVIS II workstation and the rectangular USB end goes to the computer. Turn on your computer and power up NI ELVIS II (switch on the back of workstation). The USB ACTIVE (orange) LED turns ON. In a moment, the ACTIVATE LED turns OFF and the USB READY (orange) LED turns ON.

2. On your computer screen, click on the NI-ELVISmx Instrument Launcher Icon or shortcut. A strip of NI ELVIS II instruments appears on the screen. You are now ready to make measurements.



*Figure 1.1. Instrument Launcher Icon Strip*

3. Connect two banana-type leads to the digital multimeter (DMM) inputs (VA ►┤) and (COM) on the left side of the workstation. Connect the other ends to one of the resistors.

4. Click on the DMM icon within the Launcher strip to select the digital multimeter.



*Figure 1.2. Digital Multimeter, Ohmmeter configuration*

You can use the DMM SFP for a variety of operations such as voltage, current, resistance, and capacitance measurements. Use the notation DMM[X] to signify the X operation.
The proper lead connections for this measurement are shown on the DMM front panel.

5. Click on the Ohm button [Ω] to use the digital ohmmeter function, DMM[Ω]. Click on the green arrow [Run] box to start the measurement acquisition. Measure the three resistors $R_1$, $R_2$, and $R_3$.

Fill in the following data:

| | | |
|---|---|---|
| $R_1$ | _____ | (1.0 kΩ nominal) |
| $R_2$ | _____ | (2.2 kΩ nominal) |
| $R_3$ | _____ | (1.0 MΩ nominal) |

To stop the acquisition, click on the red square [Stop] box.

NOTE: *If you click on the Mode box, you can change the {Auto} ranging to {Specify Range} and select the most appropriate range by clicking on the Range box.*

**End of Exercise 1.1**


## Exercise 1.2: Building a Voltage Divider Circuit on the NI ELVIS II Protoboard

1.  Using the two resistors, $R_1$ and $R_2$, assemble the following circuit on the NI ELVIS II protoboard.
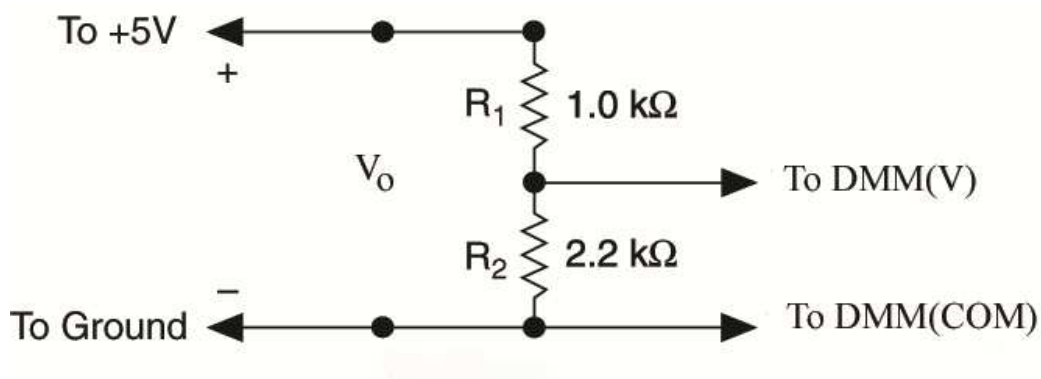


*Figure 1.3. Voltage Divider Circuit*

2.  Connect the input voltage, $V_O$, to the [+5 V] pin socket.
3.  Connect the common to the [GROUND] pin socket.
4.  Connect the external leads to the DMM voltage inputs (VΩ▶⊢) and (COM) on the side of the NI ELVIS workstation and the other ends across the input voltage, $V_O$, to make the first measurement.
5.  Check the circuit and then apply power to the protoboard by pushing the prototyping board power switch to the upper position [⊣]. The three power indicator LEDs, +15 V, -15 V, and +5 V, should now be lit and green in color.
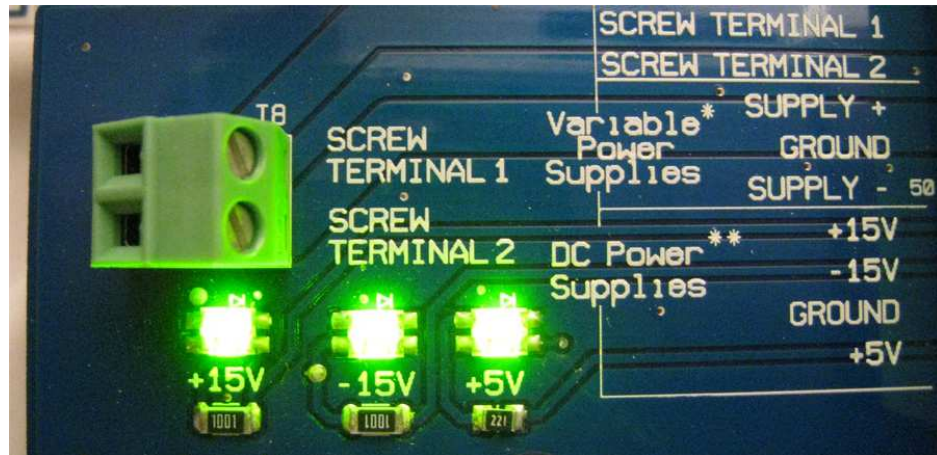
*Figure 1.4 Power LED Indicators on NI ELVIS II protoboard.*

*If any of these LEDS are yellow while the others are green, the resettable fuse for that power line has flipped off. To reset the fuse, turn off the power to the protoboard. Check your circuit for a short. Turn the power back on to the protoboard. The LED flipped should now be green.*

6.  Measure the input voltage, $V_o$, using the DMM[V] function. Press [Run] to acquire the voltage data.

$V_0$ (measured) _____

According to circuit theory, the output voltage, $V_2$ across $R_2$, is as follows:

$$V_2 = R_2/(R_1+R_2) * V_o.$$

7.  Using the previous measured values for $R_1$, $R_2$ and $V_o$, calculate $V_2$.

Next, use the DMM[V] to measure the actual voltage $V_2$.

$V_2$ (calculated) _____         $V_2$ (measured) _____

8.  How well does the measured value match your calculated value?

**End of Exercise 1.2**

## Exercise 1.3: Using the DMM to Measure Current

According to Ohm's law, the current (***I***) flowing in the above circuit is equal to $V_2/R_2$.

1.  Using the measured values of $V_2$ and $R_2$, calculate this current.

2. Perform a direct current measurement by moving the external lead connected to (VΩ►╂) to the current input socket (A). Connect the other ends to the circuit as shown below.
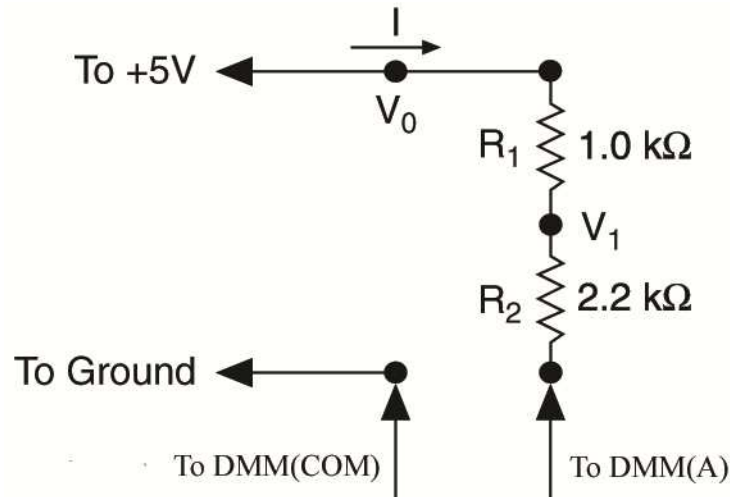


*Figure 1.5. Circuit Modification to measure Current*

3. Select the function DMM[A] and measure the current.

        *I* (calculated) _____
        *I* (measured) _____

4. How well does the measured value match your calculated value?

**End of Exercise 1.3**

## Exercise 1.4: Observing the Voltage Development of an RC Transient Circuit

Using the DMM[C] function, measure the 1 μF capacitor.

1. Connect the capacitor leads to the Impedance Analyzer inputs, [DUT+] and [DUT-], found on the left lower wiring block of a NI ELVIS II protoboard.

2. For capacitance and inductance measurements, the protoboard must be energized to make a measurement. Switch the protoboard power ON.

3. Click on the capacitor button [ ╡╞ ] to measure the capacitor C with the DMM[C] function. Press the Run button to acquire the capacitance value.

                C       _____       (μf)

4. Turn off the protoboard power and build the RC transient circuit as shown in the following figure. It uses the voltage divider circuit where $R_1$ is now replaced with $R_3$

(1 MΩ resistor) and $R_2$ is replaced with the 1 μF capacitor C. Move your DMM leads to input sockets [VΩ►⊢] and [COM]. The other ends go across the capacitor.
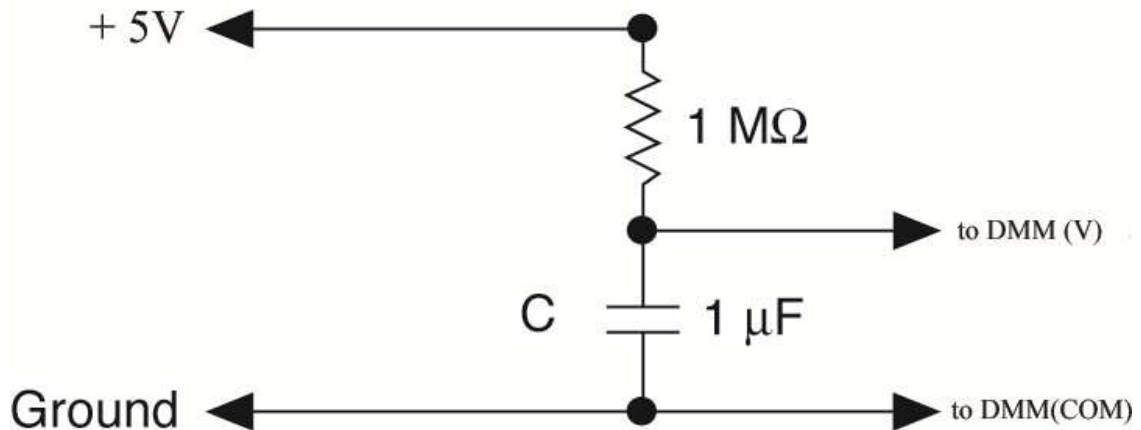


*Figure 1.6. RC Transient Circuit*

5. Select DMM[V] and click on RUN.

6. When you power up the protoboard, the voltage across the capacitor rises exponentially. Set the DMM voltage range to {Specify Range} [10 V]. Turn on the protoboard power and watch the voltage change on the digital display and on the %FS linear scale.

7. It takes about a few seconds to reach the steady-state value of $V_o$. When you power off the circuit, the voltage across the capacitor falls exponentially to 0 V. Try it!

*This demonstrates one of the special features of the NI ELVIS II digital multimeter − it can still be used even if the power to the protoboard is turned off.*

**End of Exercise 1.4**

## Exercise 1.5: Visualizing the RC Transient Circuit Voltage

1. Change the voltage source of the circuit from the +5 V supply to the variable power supply [SUPPLY+]. Connect the output voltage, $V_C$, to the first analog input socket, AI 0[+], and ground the AI 0[-] socket, as shown in the following figure.
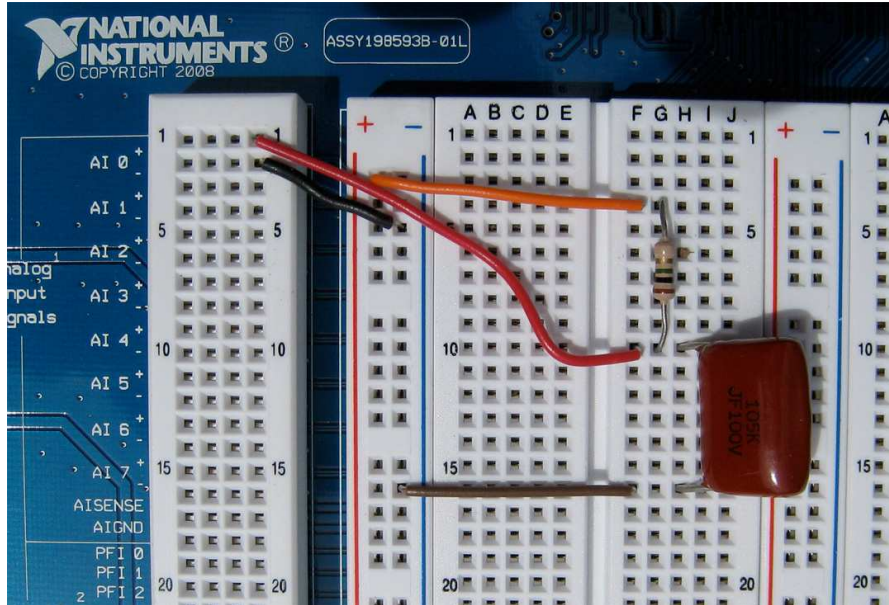
*Figure 1.7. RC Transient circuit on NI ELVIS II protoboard*

Close NI ELVIS II SPF's and Instrument Launcher and start LabVIEW.

Open the LabVIEW program, RC Transient.vi.

This program uses LabVIEW APIs to turn the variable power supply to a set voltage of +5 V for 5 s and then to reset the VPS voltage to 0 V for 5 s while the voltage across the capacitor is measured and displayed in real time on a LabVIEW chart.
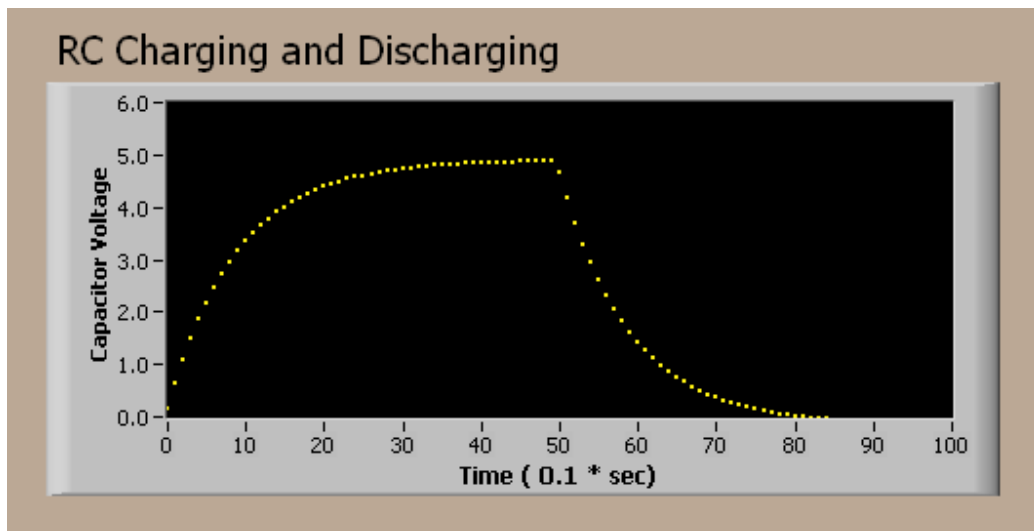


*Figure 1.8 Charging and Discharging Waveform of the RC Transient circuit*

This type of square wave excitation dramatically shows the charging and discharging characteristics of a simple RC circuit.

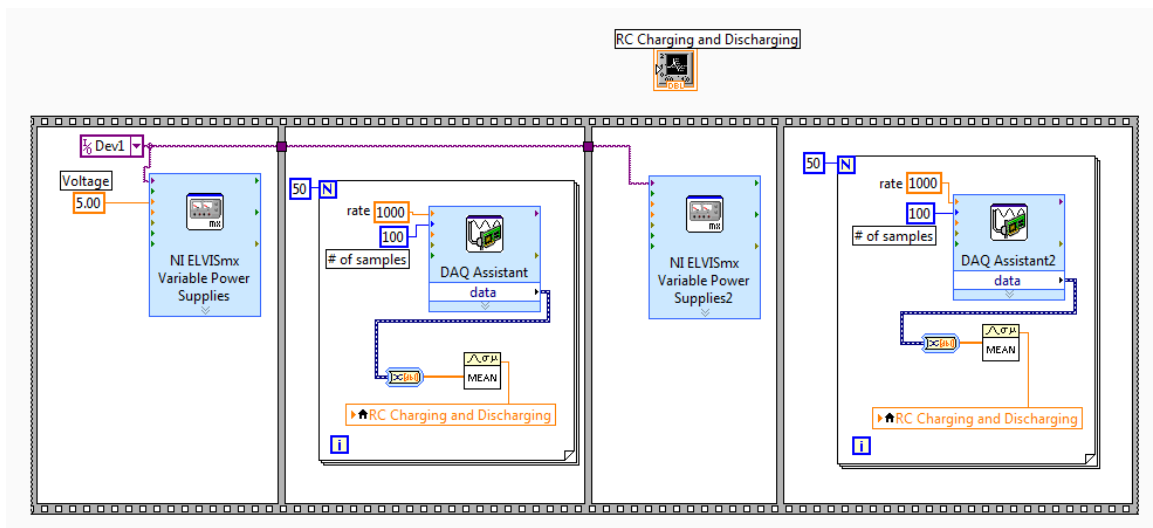2. Take a look at the LabVIEW diagram window to see how this program works.



*Figure 1.9. LabVIEW Block Diagram for the program RC Transient.vi*

In the first frame of the four-frame sequence, the NI-ELVISmx Variable Power Supplies VI (virtual instrument) outputs +5.00 V to the RC circuit on the NI ELVIS II protoboard. The next frame measures 50 sequential voltage readings across the capacitor at 1/10-second intervals. In the for loop, the DAQ Assistant takes 100 readings at a rate of 1000 S/s and passes these values to a cluster array (thick blue/white line). From the cluster, the data array (thick orange line) is passed on to the Mean VI. It returns the average value of the 100 readings. The average is then passed to the chart via a local variable terminal <<RC Charging and Discharging>>. The next frame sets the VPS+ voltage equal to 0 V. The last frame measures another 50 averaged samples for the discharge cycle. This program records one complete cycle of the charging and discharging of a RC circuit. To repeat the cycle, continuously place the above program inside a while loop.

*NOTE: This LabVIEW program is configured to connect to "Dev1" for your NI ELVIS workstation. If your device is configured to another device name, you need to rename your NI ELVIS workstation to "Dev1," in Measurement and Automation Explorer (MAX) or modify the LabVIEW programs to your current device name.*

## NI ELVIS II Challenge: Design a Burglar Alarm Using Multisim Simulation

Design a burglar alarm for a house requiring three entry sensors and one window sensor. If the alarm system is activated, sound the alarm as soon as one of the sensors detects an open door or window. Signal to the front panel displays which door or window is open and sound an alarm.

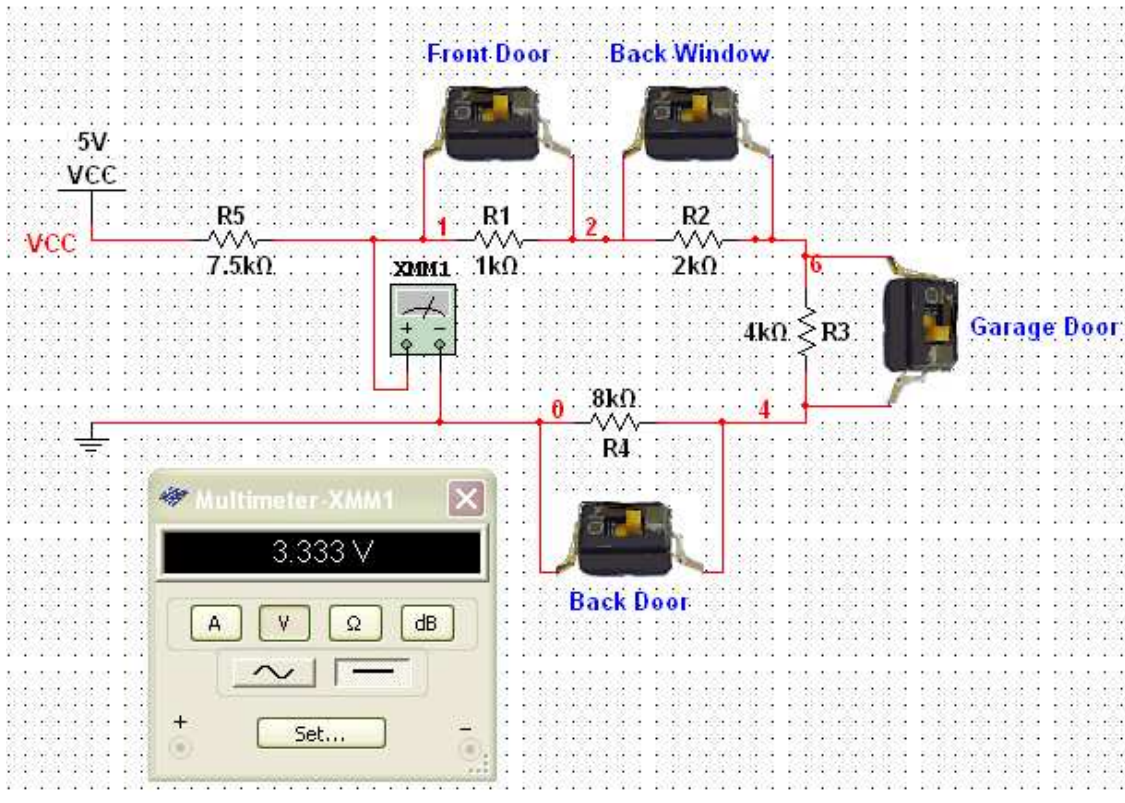Launch Multisim and open the file "Alarm Design Version 0.ms11".



*Figure 1.11.  Multisim Smart Sensor Design*

*The ON position of these switches (left side) signals when the door is closed. Click the switch to close or open a door or window.*

Your design consists of a power supply (+5 V), a digital multimeter, five resistors, and four switches. The four resistors, 1 kΩ, 2 kΩ, 4 kΩ, and 8 kΩ, are placed at the door or window locations with the resistor value as the "address" of that location. The circuit is a simple loop with the switches placed across the address resistors to simulate the opening and closing of a window or door. Finally, the resistor, R5, limits the current when all the switches are closed. The current limiting resistor value is taken as half of the value of all the address resistor values added in series (7.5 kΩ).

To view the circuit operation, click on Run and open (1) and close (0) each switch, one at a time, using the mouse cursor.

Fill in the following table:

| R1 | R2 | R3 | R4 | Voltage |
|----|----|----|----|---------|
| 0  | 0  | 0  | 0  | 0.00    |
| 1  | 0  | 0  | 0  |         |
| 0  | 1  | 0  | 0  |         |
| 0  | 0  | 1  | 0  |         |
| 0  | 0  | 0  | 1  |         |
| 1  | 1  | 1  | 1  | 3.33    |

*Table 1.12. Sensor Truth Table and Multimeter Voltage Readings*

Each switch when opened generates a unique voltage, which, when read by the voltmeter, reveals which window or door is open.

Now that the design is complete, you can transfer the design into the real world as a test circuit built on an NI ELVIS II protoboard.

Select five resistors as close to the design values as you have available. Launch NI ELVIS DMM($\Omega$) and measure the value for each of your chosen resistors.

Fill in the following table:

| | | |
|----|-------------------|-----------|
| R1 | _____ | (k$\Omega$) |
| R2 | _____ | (k$\Omega$) |
| R3 | _____ | (k$\Omega$) |
| R4 | _____ | (k$\Omega$) |
| R5 | _____ | (k$\Omega$) |

*Table 1.13. Table of Real Resistor values*

Now go back to Multisim and replace the nominal resistor values with the measured (real-world) resistor values by double-clicking on each resistor in turn and entering the measured value. This becomes your new Alarm Design Version 1.
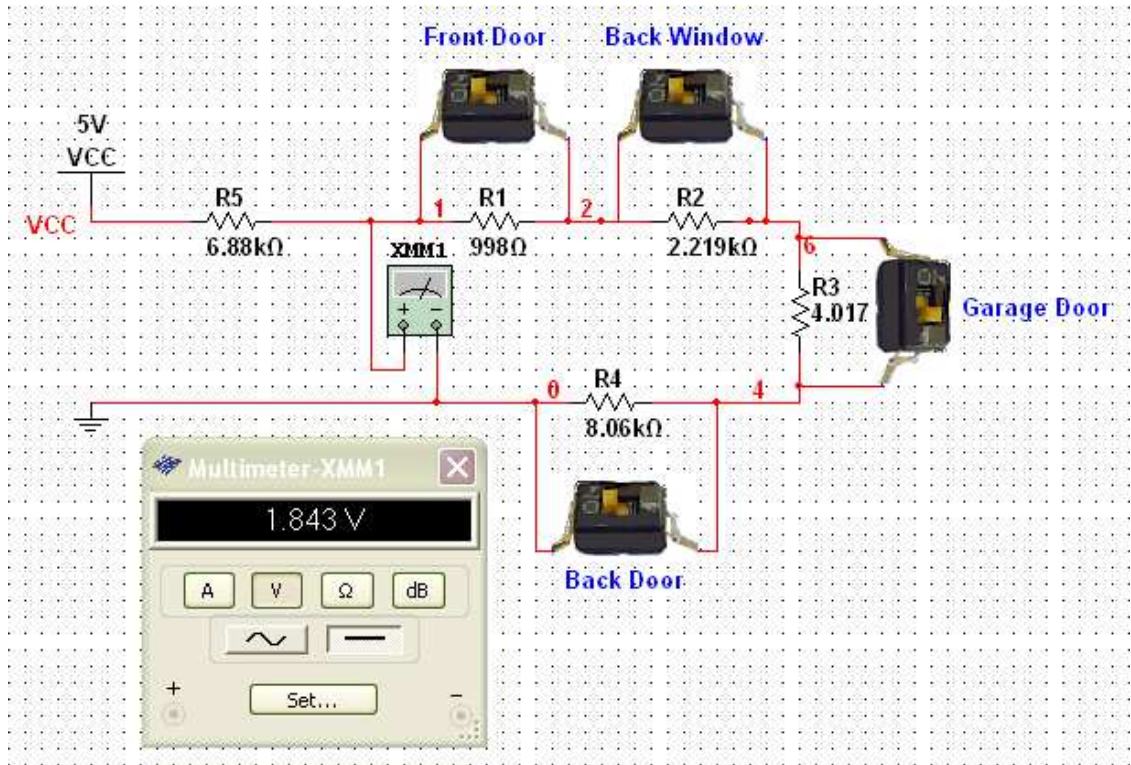
*Figure 1.14. Real World Sensor Design*

You can now repeat your measurements of the predicted voltage readings when a window or a door is opened or closed.

Use these resistors and five jumpers or push button switches to construct a circuit similar to the one shown on a NI ELVIS II protoboard in the following figure.
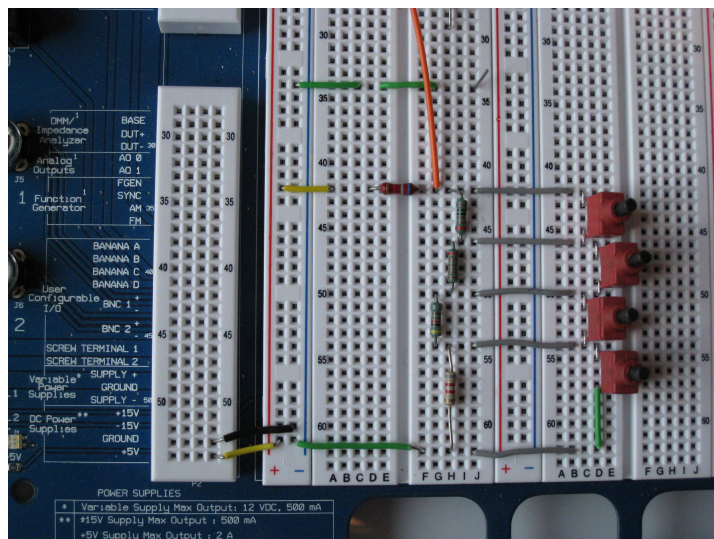


*Figure 1.15. Real World Sensor Circuit on NI ELVIS II protoboard*

Use the DMM[V] to verify its operation is similar to your real-world Multisim design, version 1.

## LabVIEW Demonstration

LabVIEW is a powerful programming language that you can use for many tasks including the measurement and control of circuits built on an NI ELVIS II protoboard. With one modification to the above circuit, you can route the alarm voltage levels to a LabVIEW program.

Connect the voltage + pin (orange wire) to [AI 0+] socket pin and the GROUND to [AI 0-] socket pin. You can leave the DMM[V] connected if you wish to monitor the sensor voltage. The digital multimeter uses a different data acquisition card than NI ELVIS II analog inputs use.

*Imagine running the NI ELVIS suite of SFPs at the same time as a LabVIEW program is running.*

Launch LabVIEW and open the program House.vi for a unique view of the burglar alarm system.

*NOTE: This LabVIEW program is configured to connect to "Dev1" for your NI ELVIS workstation. If your device is configured to another device name, you need to rename your NI ELVIS workstation to "Dev1," in Measurement and Automation Explorer (MAX) or modify the LabVIEW programs to your current device name.*
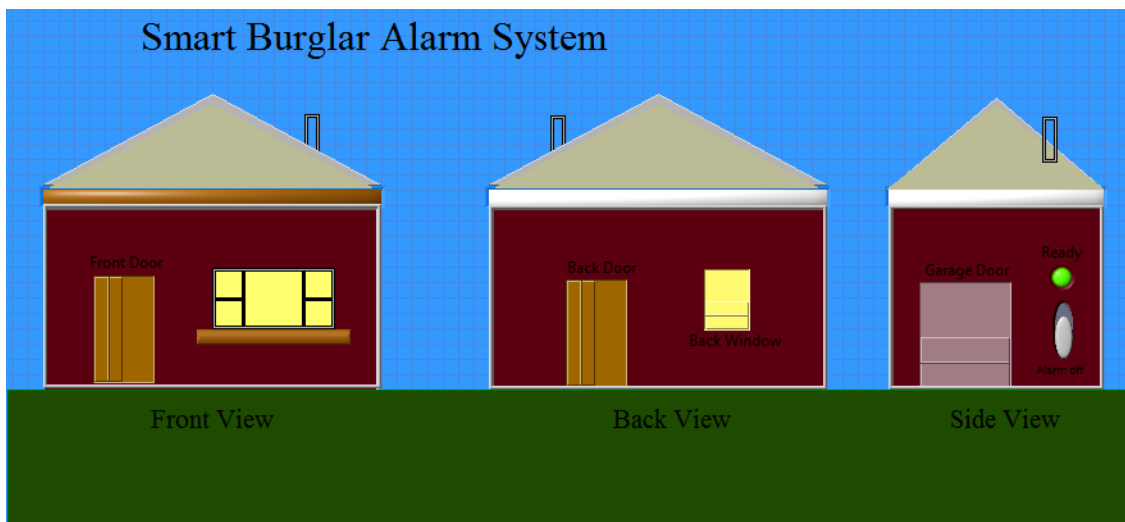


*Figure 1.16. LabVIEW Front Panel House.vi*

To operate the program, click on *Run*. If NI ELVIS II is connected and turned ON and power is applied to the protoboard, actions on the protoboard are signaled on the LabVIEW front panel. Each switch is mapped to a particular window or door. When open, an entry port appears black. Any open door or window sets off a red alarm along the eves trough. To end the program, click on the Alarm Off front panel slide switch.
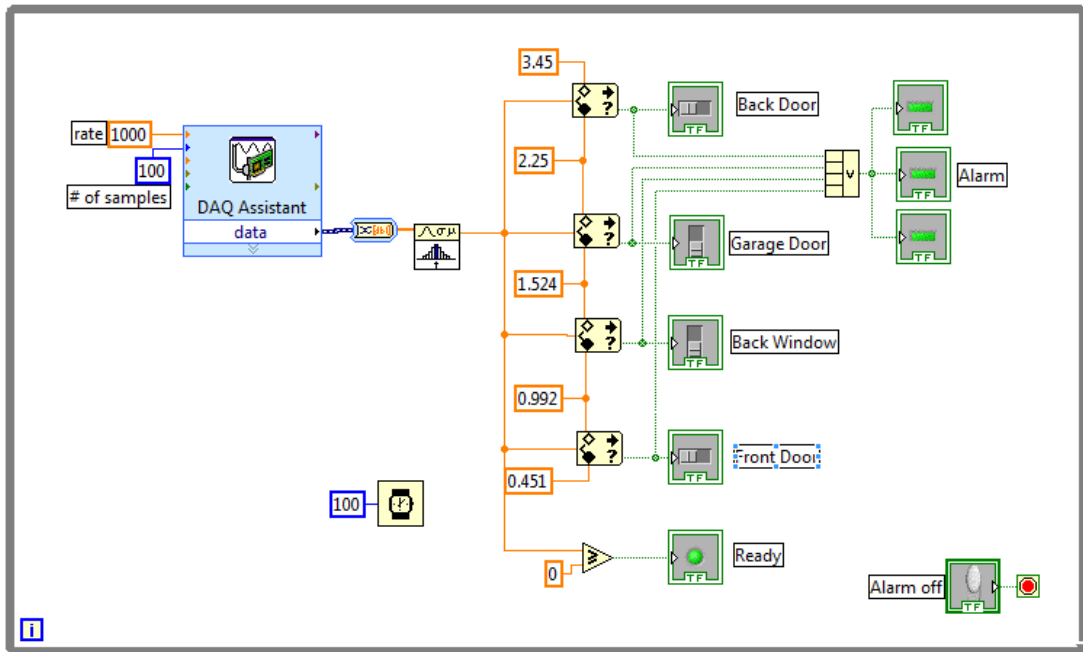
*Figure 1.17. The LabVIEW Block Diagram for the Program House.vi*

The DAQ Assistant is programmed to read 100 consecutive voltage values at a rate of 1000 S/s. From the data cluster (blue/white line), select the array of voltages. The Mean.vi calculates the average value of this set of readings and sends it to the voltage trigger ladder. Whenever the voltage level falls between two limiting values (orange boxes), the corresponding condition is signaled on the front panel. The limiting values are picked as halfway between two neighboring trigger levels. The four-input OR function sets off the alarm if any door or window is opened.

This design only detects the first occurrence of an open window or door. If you add a few more rungs to the limiting ladder, you can detect multiple openings and closings.