**School:** New York City College of Technology

**Section/ Course:** EET 3120/ Sensors and Instruments

**Experiment #3:** Introduction to NI-Elvis II WorkStation

**Date/ Semester:** Mar. 19, 2015/ Spring 2015

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# *INTRODUCTION*

Objective:-

- o Continue graphical programming using LabVIEW;
- o The introduction to the NI-ELVIS II workstation;
- o Use the sub.Vis "temperature" (created in Experiment 2) and "DMM.vi" from the NI ELVISmx to measure and graph the output from a temperature sensor LM335.

# EQUIPMENT USED

Required software includes:

- o LabVIEW 2010
- o NI ELVIS II software

Required Soft front panels (SFPs):

- o Digital multimeter (DMM)
- o Digital voltmeter (DMM[V])
- o Digital ammeter (DMM[A])
- o Digital ohmmeter (DMM[$\Omega$])
- o Digital capacitance meter (DMM[C])

Required components include:

- o 1.0k $\Omega$ resistor
- o 2.2k$\Omega$ resistor
- o 1.0M$\Omega$ resistor
- o 5.6k$\Omega$ resistor
- o LM 335 temperature sensor

# PROCEDURE

➕ __Exercise 1.1: Measuring Component Values:-__

1. The NI ELVIS II workstation was connected to the computer via USB. Both the computer and the NI ELVIS II were turned on.

2. We searched our computer for the NI ELVISmx Instruction Launcher. A strip of NI ELVIS instruments appeared on the monitor.

3. Two banana leads were connected to the DMM inputs (VA) and (COM) located on the left side of the workstation. The other ends were used to measure the resistors.

4. From the strip of NI ELVIS instruments the DDM was selected.

5. On the DMM screen ohms "Ω" was selected, and the RUN arrow was clicked. This started measurement acquisitions of resistors R1 (1kΩ), R2 (2.2kΩ), and R3 (1MΩ).

➕ __Exercise 1.2: Building a Voltage Divider Circuit on the NI ELVIS II Protoboard:-__

1. Using resistor R1 and R2 the voltage divider circuit in figure 1was made.

### Figure 1
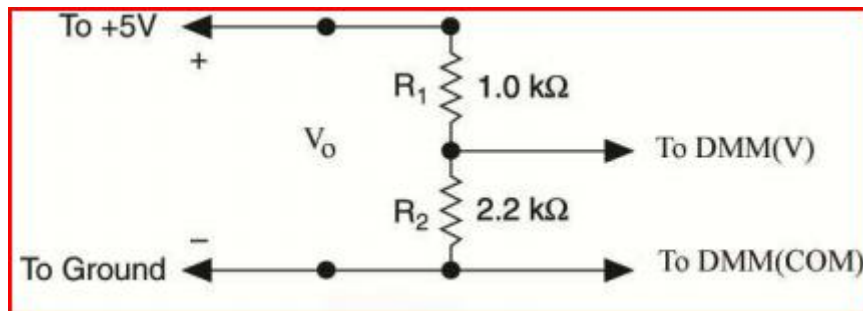


Vivian Vladutescu, "*EET 3120 Sensors and Instruments Laboratory Manual*", Sensors and Instrumentation 2015, page 42.

2. Connect the free terminal of R1 to the [+5V] pin socket. This will be our input.

3. Connect the free terminal of R2 to the {GROUND] pin socket.

4. Connect the banana lead to the DMM voltage input (VΩ) and (COM) located on the left-hand side of the NI ELVIS workstation. Use the other ends of the banana lead measure the input voltage "Vo" and the voltage across R2; as indicated in figure 1.

5. Check to ensure that all connections are correct before applying power to the circuit. The LEDs that indicate 15V, -15V, and +5 should were all lit and green in colour.

6. On the DMM the DC voltage was chosen, and the RUN button was clicked to begin measurement.

7. The input voltage "Vo" and the voltage across R2 were measured and recorded. Using the previously measured values of R1, R2 and Vo, we calculated the voltage across R2.

8. We then compared the voltage measured to our calculated value.

### ✦ Exercise 1.3: Using the DMM to Measure Current:-

1. We used the measure values of V2 and R2, and calculated the current flowing in the circuit in figure 1.

2. To perform a direct current measurement we move the banana leads from (VΩ) terminal to the (A) terminal on the left-hand side of the protoboard. Then placed the DMM in series with the resistor R2.

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

### ✦ Exercise 1.4: Observing the voltage development of an RC circuit:-

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.

4. From figure1; if we replaced R1 with the 1MΩ and R2 with the 1μF we can implement a simple RC circuit. Move your DMM leads to input sockets [VΩ▶ ⊢. ] and [COM]. The other ends go across the capacitor.

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 Vo. When you power off the circuit, the voltage across the capacitor falls exponentially to 0 V.

✚ 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, VC, to the first analog input socket, AI 0[+], and ground the AI 0[-] socket.

2. Close NI ELVIS II SPF's and Instrument Launcher and start LabVIEW. Open the LabVIEW program, RC Transient.vi shown in figure 2.
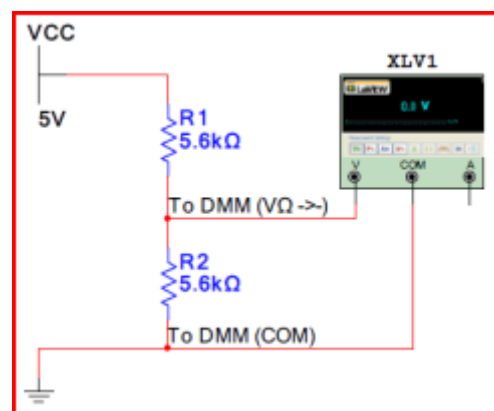
## Figure 2
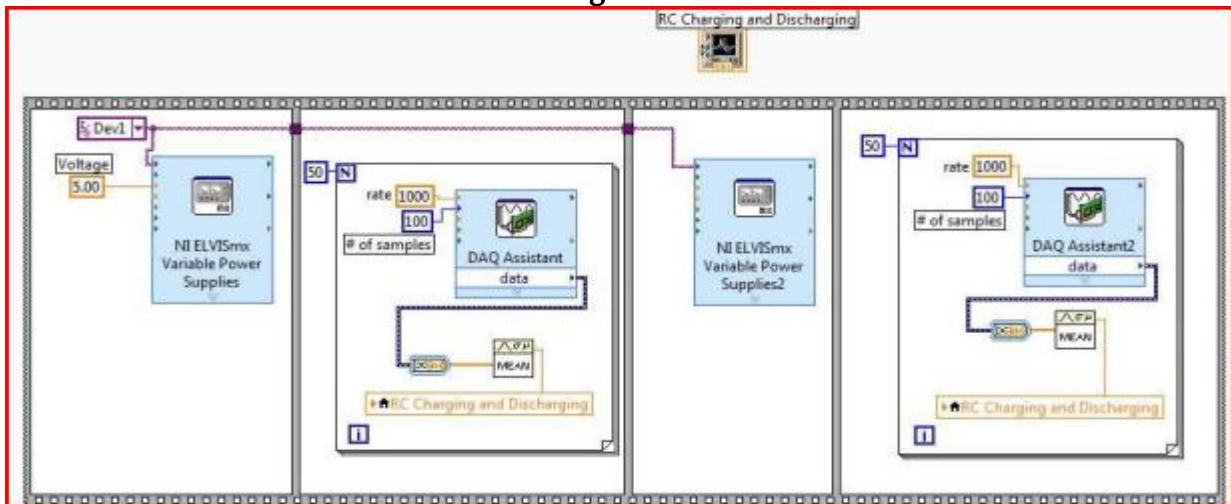


Vivian Vladutescu, "*EET 3120 Sensors and Instruments Laboratory Manual*", Sensors and Instrumentation 2015, page 46, Block Diagram of RC Transient.vi.

This program records one complete cycle of the charging and discharging of a RC circuit.

🔥 **Exercise 2.1: Implement a voltage divider with the NI ELVIS II platform:-**

1.  First 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 take measurements.

3.  On the prototyping board build a voltage divider based on the circuit shown in Figure3.

**Figure 3**



Vivian Vladutescu, "*EET 3120 Sensors and Instruments Laboratory Manual*", Sensors and Instrumentation 2015, page 49, Example of Voltage Divider Circuit.

4.  Connect the input voltage, Vcc, to the [+5 V] pin socket.

5.  Connect the common to the [GROUND] pin socket.

6. Connect the external leads to the DMM voltage inputs [VΩ ] and [COM] on the left-hand side of the NI ELVIS workstation and the other ends across the R2 resistor.

7. Check the circuit and power up the NI ELVIS II prototyping board (switch on the front of workstation, near the prototyping board). Verify that everything has been connected (the three power indicator LEDs, +15 V, –15 V, and +5 V, should now be lit and green in color).

8. Start the DMM SFP and press the Run button. Notice the measured voltage.

9. Stop the measurements by pressing the Stop button. Power down the prototyping board. Change the R2 resistor and repeat the measurement.

### Build a thermometer using the DMM SFP:

1. Wire the circuit shown in figure 3, with one change. Exchange R2 (5.6kΩ) with LM335 (you will require internet access to ascertain the function of each of the three pins.

2. Start the DMM SFP and press the Run button. Notice the measured voltage. Multiply by 100 manually. The resulting value is temperature in the Kelvin scale. Use Equations (8) and (9) to obtain the temperature in the Celsius and Fahrenheit scales.

3. Put your hand on the temperature sensor and notice the modification of the temperature.

### Build a thermometer using the DMM express VI in LabVIEW:-

1. Start the LabVIEW software

2. Open the Temperature Monitoring.vi. Modify the Diagram by following these steps:

   a. Navigate to Measurement I/O»NI ELVISmx and select the NI. ELVISmx Digital Multimeter express VI. Place it inside of the While Loop. The SFP will open.

b. Delete the Voltage Read subVI and the connection wire between this subVI and the temperature subVI.

c. Stop the DMM by pressing the Stop button.

d. Press the OK button and wait until the compilation of the VI is done.

e. Connect the Measurement output of the digital multimeter with the voltage input of the Temperature subVI (Figure4).

3. Create the Scale select control. Right click on the Scale select input of the Temperature subVI and select the Create Control option.

4. Activate the Panel window of the VI.

5. Run the VI and see the measured temperature. Put your hand on the temperature sensor and notice the variation.

6. Select another temperature scale from the Scale select control and see the values.

7. Press the STOP button. Save the VI as Real Temperature Monitoring.

Figure 4
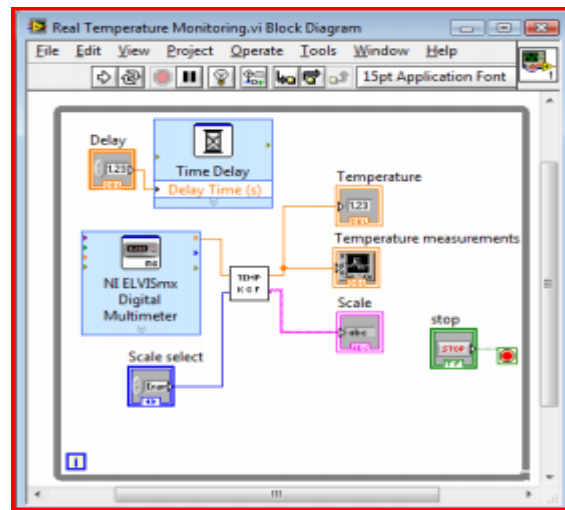


Vivian Vladutescu, "*EET 3120 Sensors and Instruments Laboratory Manual*", Sensors and Instrumentation 2015, page 51, Block Diagram of the Real Temperature monitoring.VI.

# THERORETICAL BACKGROUND

The voltage divider is a circuit that allows users to divide the input voltage into two parts. According to Kirchhoff's second law, the output voltage, V2 across R2, in figure 1 is calculated as follows:

$V2 = \frac{R2}{R1+R2} \times Vo$; Where Vo is the input voltage, R1 and R2 are resistor 1kΩ and 2.2kΩ respectively, and V2 is the voltage across resistor R2. One should notice that if R1 and R2 are the same value; the voltage across R2 will be half of the voltage supply.

We know from circuit analysis one that a capacitor when placed in a circuit supplied by a constant voltage source acts as an open circuit. Given enough time the voltage across that capacitor will become close in magnitude to the supply voltage.

Table 1 below verifies the statement above. It shows the time in seconds, voltage supply of the battery, voltage across the capacitor, and the current flowing through the circuit; in columns 1, 2, 3 and 4 respectively.

### Table 1

| Time (seconds) | Battery voltage | Capacitor voltage | Current |
|---|---|---|---|
| 0 | 15 V | 0 V | 1500 uA |
| 0.5 | 15 V | 5.902 V | 909.8 uA |
| 1 | 15 V | 9.482 V | 551.8 uA |
| 2 | 15 V | 12.970 V | 203.0 uA |
| 3 | 15 V | 14.253 V | 74.68 uA |
| 4 | 15 V | 14.725 V | 27.47 uA |
| 5 | 15 V | 14.899 V | 10.11 uA |
| 6 | 15 V | 14.963 V | 3.718 uA |
| 10 | 15 V | 14.999 V | 0.068 uA |

Table 1 Shows the Voltage Characteristics of a Capacitor in a DC Circuit, http://www.allaboutcircuits.com/vol_1/chpt_16/2.html, Mar.20, 2015

If we should replace resistor R2 in the voltage divider circuit in figure 1 and the voltage divider formula with LM 335. The theory and operation would be the same. Only in this case resistor R2 (LM335) will vary with changes in temperature; thus, varying the voltage drop

across R1 and itself. With the proper transfer function we can convert the voltage across LM335, into either degrees (˚C, ˚F, or K). The following transfer function below will convert voltage into temperature (˚C, ˚F, or K):

$$t[Kelvin] = V2 \times 100; \qquad \text{equ 1}$$
$$t[Celcius] = (V2 \times 100) - 273.15; \qquad \text{equ 2}$$
$$t[Fahrenheit] = \big((V2 \times 100) \times 1.8\big) - 459.67; \qquad \text{equ 3}$$

# RESULTS

## Exercise 1.1: Measuring Component Values:-

Resistors:
- R1== 0.9844kΩ          (nominal 1kΩ
- R2==2.1553kΩ           (nominal 2.2kΩ)
- R3==0.969MΩ            (nominal 1MΩ)

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

Table 2 ➔

|  | Supply Voltage, Vo | Voltage across R2, V2 |
|---|---|---|
| Theoretical Values | 5V | 3.4375V |
| Measured Values | 4.9336V | 3.3853V |
| Calculated using Maesured Values | 4.9336V | 3.3868V |

Table shows the theoretical value of the voltage across resistor R2 using ideal/nominal conditions of instruments and components. The voltage across resistor R2 was found using the actual values of the input voltage and resistance.

$$\boldsymbol{Error} = \frac{|Meas.Val-Calc.Val|}{Calc.Val} \times 100\% \; ➔ \; \frac{|3.3853V-3.3868V|}{3.3865V} * 100\% = \boldsymbol{0.044}\%.$$

The level of error between the measured value, and calculated value using the measurements of components is 0.044% which is very low.

### Figure 5
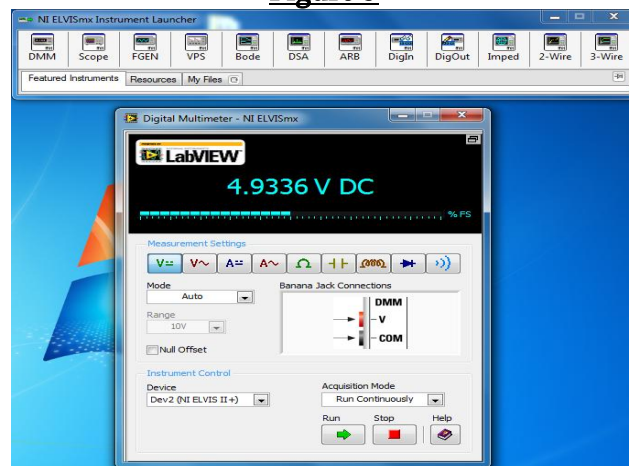


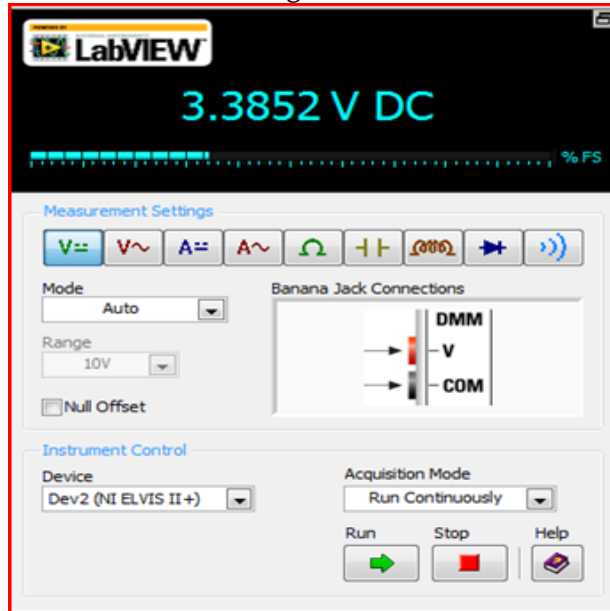Figure 5 is the value of the supply voltage (Vo)

Figure 6



Figure 6 shows the voltage measure across the resistor R2 (2.2kΩ) in the voltage divider circuit in figure 1.

### ✚ Exercise 1.3: Using the DMM to Measure Current:-

Calculated Current: 1.5706mA

Measure Current: 1.60mA

$$Error = \frac{|Meas.Val - Calc.Val|}{Calc.Val} \times 100\% \rightarrow \frac{|1.5706mA - 1.60mA|}{1.60mA} * 100\% = \mathbf{1.8375\%;}$$
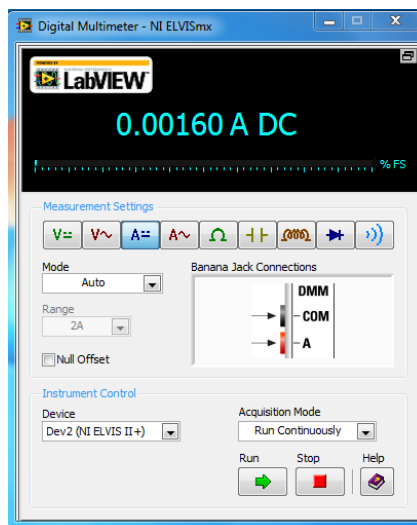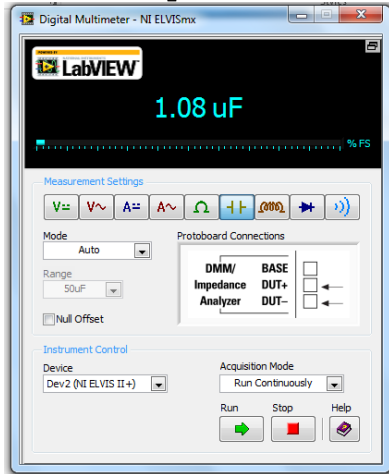
Figure 7



Figure 7 shows the current flowing through voltage divider circuit in figure 1.

## ⊕ Exercise 1.4: Observing the voltage development of an RC circuit:-

**Measured Capacitance**: We can see in figure 8 that the measured capacitance was1.08µF.
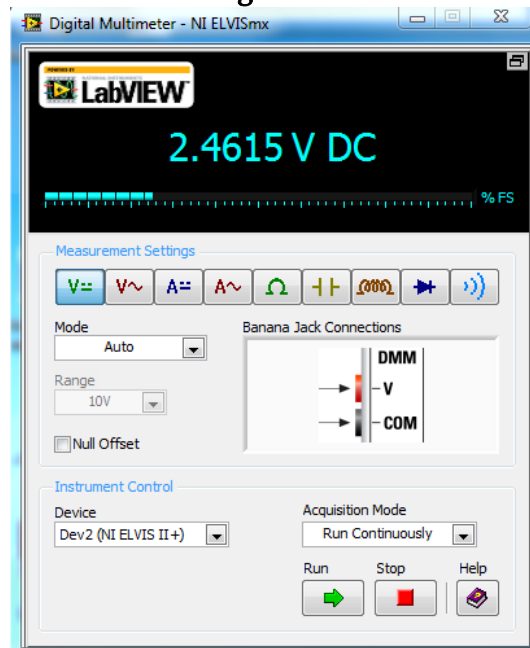


←Figure 8

## ⊕ Exercise 2.1: Implement a voltage divider with the NI ELVIS II platform:-

When two resistors with the same resistance are placed in series with each other the voltage across each will be exactly one half (1/2) of the supply voltage (Vo).

Figure 11 below shows the result of such a circuit (Figure 3).

### Figure 11

+ **Build a thermometer using the DMM SFP:-**
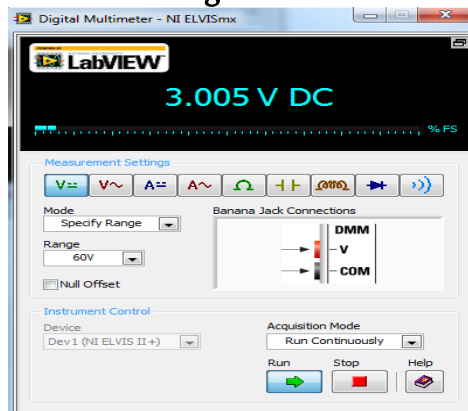


**Figure 12**

Figure 12 show the voltage at room temperature measured by the temperature sensor LM 335.

 We will use the equ 1, 2, and 3 to convert this voltage into the respective units of temperature then compare them to the temperature measure using LabVIEW.

- o  $t[Kelvin] = V2 \times 100$➔$3.005V \times 100 = \mathbf{300.5K};$
- o  $t[Celcius] = (V2 \times 100) - 273.15$➔$(3.005V \times 100) - 273.15 = \mathbf{27.25°C};$
- o  $t[Fahrenheit] = ((V2 \times 100) \times 1.8) - 459.673$➔$((3.005V \times 100) \times 1.8) - 459.673 = \mathbf{81.227°F}.$

+ **Build a thermometer using the DMM express VI in LabVIEW:-**
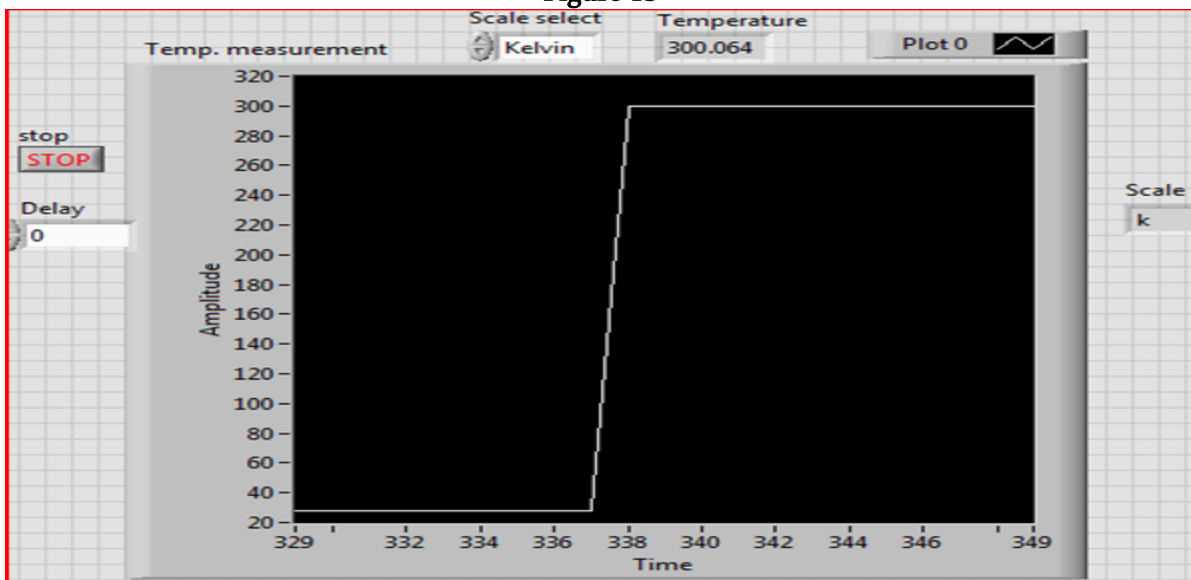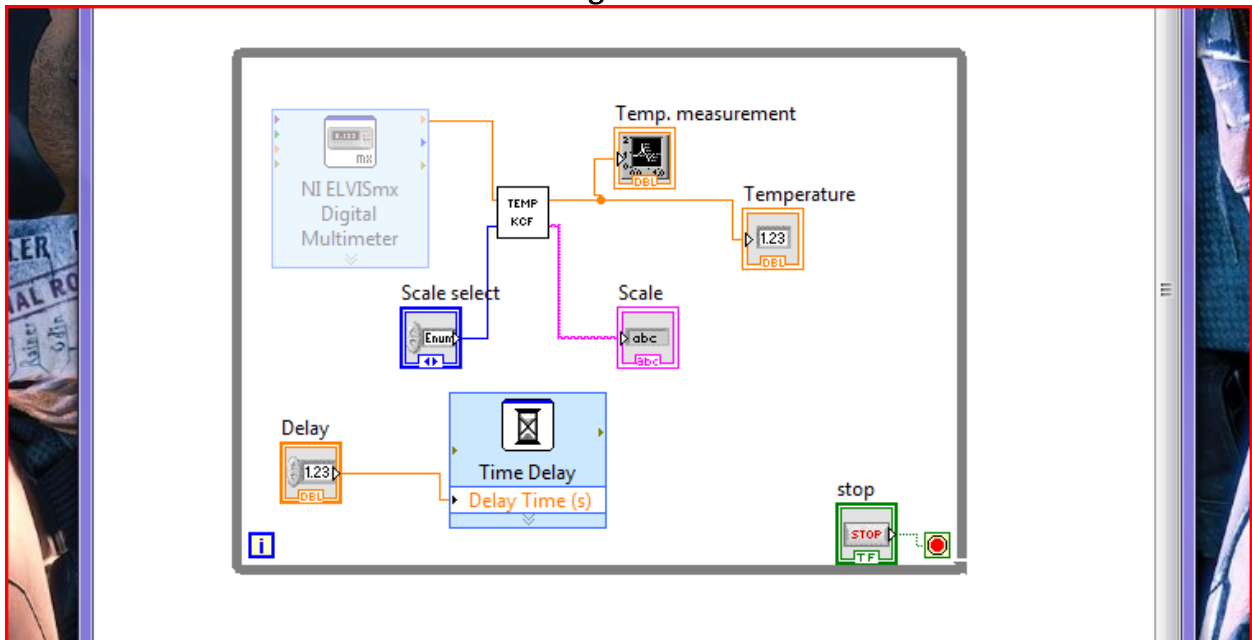


**Figure 13**

Figure 13 show the room temperature in Kelvin's. In Kelvin's the temperature is 300.064K. The LabVIEW program took the voltage measured by the DMM and converted it to Kelvin's.

The block diagram of the program that converted the measured voltage across LM335 to temperature is shown below in figure 14.

**Figure 14**



TEMP KCF is a sub VI we made during experiment 2. You can see that the TEMP KCF takes the voltage measurements from the NI ELVISmx Digital Miltimeter; converts it to the temperature chosen by the operator and outputs the result both graphical and numerically.
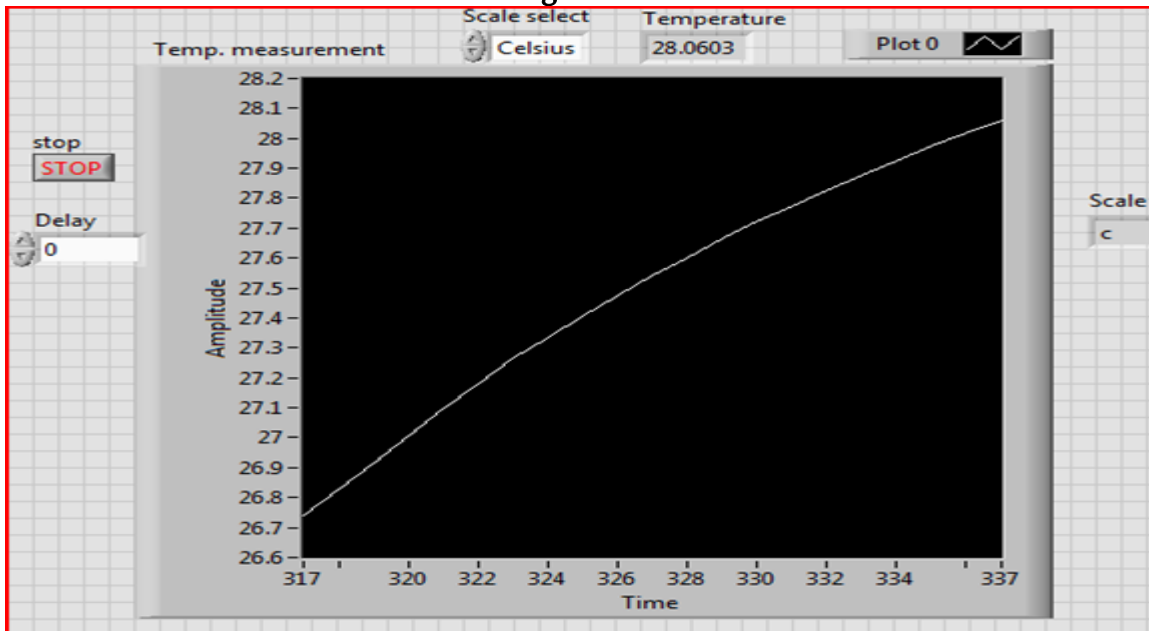
**Figure 15**



Figure 15 show the room temperature in Celsius "°C". In Celsius the temperature is 28.0603°C. The LabVIEW program took the voltage measured by the DMM and converted it to degrees Celsius.
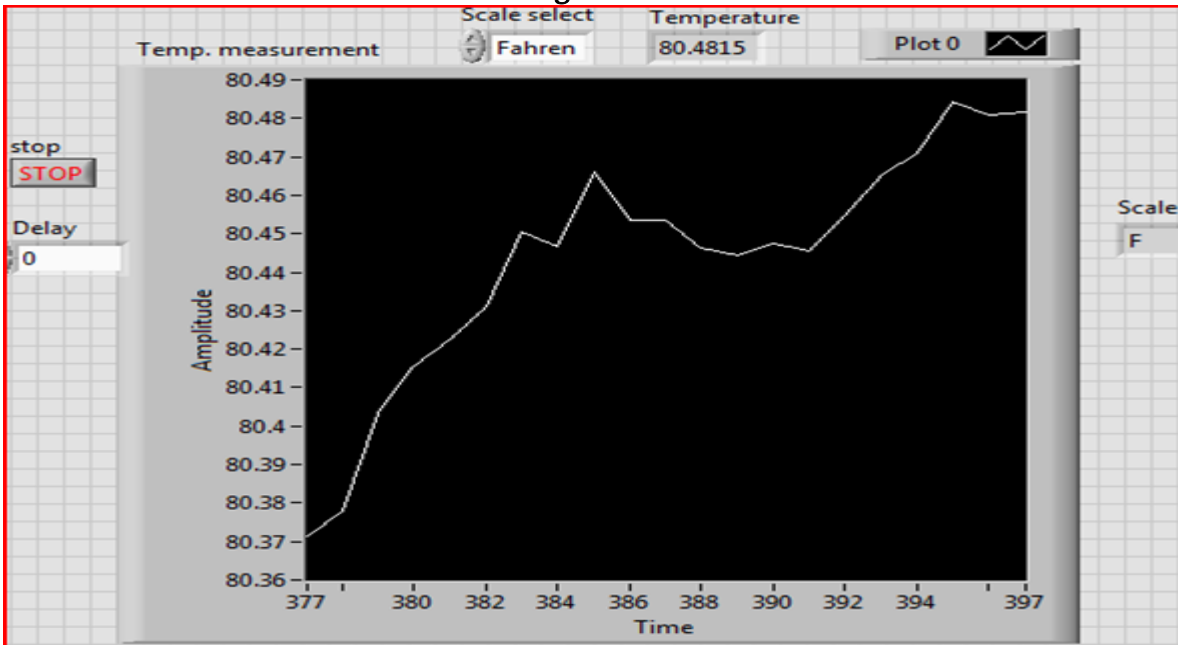
**Figure 16**



Figure 15 show the room temperature in Fahrenheit "°F". In Fahrenheit the temperature is 80.4815°F. The LabVIEW program took the voltage measured by the DMM and converted it to degrees Fahrenheit.

## CONCLUSION

This experiment gave us the opportunity to use the NI ELVIS II workstation along with LabVIEW, and NI ELVISmx launcher. During this experiment we were able to complete our KCF TEMP subVI. Unfortunately we were not able to get the RC Transient program to work in time.

## REFERENCES

EET 3120 Sensors and Instrument Laboratory Manual, Developed and Edited by Professor Viviana Vladutescu, Spring 2015.