1. Preparatory Lab Work: Measuring Component Characteristics Using LabView

Demonstrations:
1. Measuring voltage
2. Measuring current
3. Measuring resistance
4. Current-voltage characteristics
5. Temperature

Introduction
Operation of any electronic device is determined by three basic quantities: Voltage ($V$), Current ($I$) and Resistance ($R$). The relationship between them is given by (1):

$$I = \frac{V}{R}$$  \hspace{1cm} (1)

This equation presented as a graph is known as current-voltage characteristic (IV-characteristic). If resistance of an electronic component is independent of current and voltage, the graph is a straight line and the Eq. 1 is called Ohm’s Law. In this case, the component is an ohmic resistor. If resistance of an electronic component does depend on current, or voltage, its IV-characteristic is non-linear and this component has non-ohmic resistance. Regular resistors in electronic circuits are ohmic resistors, while diodes and transistors have non-ohmic resistances.

LabView as a Voltmeter
The BNC-2120 has 8 analog inputs (all are BNC terminals). This allows you to read in up to 8 different voltages into LabView for analysis. The BNC-2120 also has the option to switch A0 to be a temperature reference, and A1 to be used as a thermocouple input. There are also options for each analog input to be ground referenced, or floating. The PCI-6024E Data Acquisition Card is the Analog to Digital Converter. It has a maximum voltage rating ±10 V, and uses a 12 bit sampling bus. This gives us the accuracy of the voltage reading to 1:4096 of the full scale range. The maximum sampling rate is 200 kS/s, so at the Nyquist sampling rate, the maximum frequency that can be captured is 100 kHz. For any of the specified ranges, the minimum division of the measurement can be determined as follows:

<table>
<thead>
<tr>
<th>Maximum Voltage</th>
<th>Minimum Voltage</th>
<th>Minimum Division</th>
</tr>
</thead>
<tbody>
<tr>
<td>+10V</td>
<td>-10V</td>
<td>20/4096 = 4.88mV</td>
</tr>
<tr>
<td>+5V</td>
<td>-5V</td>
<td>10/4096 = 2.44mV</td>
</tr>
<tr>
<td>+500mV</td>
<td>-500mV</td>
<td>1/4096 = 244μV</td>
</tr>
<tr>
<td>+50mV</td>
<td>-50mV</td>
<td>0.1/4096 = 24.4μV</td>
</tr>
</tbody>
</table>
**LabView as an Ammeter**

Since the BNC 2120 can only directly measure voltages, an external “shunt resistor” must be utilized to measure currents. To do this, make sure the channel being used to measure current is set to Floating source (FS). When setting up the DAQ in Labview, just choose Analog Input > Current Measurement. When the DAQ Assistant pops up, make sure to choose Shunt resistor to external, and set it to whatever the shunt resistor being used is.

**Equipment and Materials**

- NI PCI-6024E Data Acquisition Card, 68-pin NI Cable
- NI BNC-2120 Accessory
- Wavetek 19 or GwInstek 8219A Function Generator
- Global Specialties 1310 DC power supply
- Corning Hotplate
- HP 34401A Multimeter
- Beaker with water
- Resistance decade box, test resistors
- 1N4005 silicon diode (or similar)
- K type thermocouple

**Procedure**

*Part A. Basic Current Measurements (LabView)*

1) Connect the BNC-2120 to the computer using the 68-pin cable and make sure NI Max is configured to BNC-2120 (with Temperature Reference Enabled)
2) Open LabView and place **DAQ Assistant** (Express>>Input>>DAQ) on the block diagram
3) Configure the DAQ assistant to Acquire Signals >> Analog Input >> Current >> ai2
4) Make sure that the Shunt Resistor setting is set to **external**, and set value to 100 (measure R to be more accurate)
5) Set Max/Min to ±50m Amps
6) Set Acquisition Mode to **1 Sample (On Demand)**
7) Press OK to close DAQ Assistant
8) Right click on the data output of **DAQ Assistant** and place a **Numeric Indicator**
9) Create a **While loop** around the entire block diagram
10) Place a **Wait ms** (Timing >> Wait ms) and wire a **Numerical Constant** of 100 to the millisecond input

11) On the Front Panel, place a **Stop Button** (Boolean >> Stop Button)

12) In the Block Diagram, wire the **Stop Button** to the **Loop Condition**

![Fig 2. DAQ Assistant Setup and Configuration](image)

![Fig 3. LabView Block Diagram for Current Measurements](image)

**Part A. Basic Current Measurements (BNC-2120)**

1) From the BNC-2120, connect the Shunt Resistor and the Decade box in series as in Fig.4

2) Connect the circuit to DC power supply

3) Connect BNC cable from ai2 across Shunt Resistor

4) Make sure that ai2 is in GS mode

5) Set the DC power supply to 5V and set Decade box Resistance to 1kΩ

6) Run LabView and take current measurement (you may need to adjust the display properties of the numerical indicator to get a more precise reading)
7) Compare Current measurement from LabView with an HP Multimeter reading, and theoretical calculation of current with Ohm’s Law (Use 5V as source, assume R values nominal)
8) Repeat for Load Resistance of 1kΩ, 2kΩ, 3kΩ, 4kΩ, 5kΩ

Part B. Measuring Resistance (LabView)
1) Open up DAQ Assistant and add a new channel (Analog Input >> Voltage >> ai3)
2) Set Max/Min to ±10V
3) Place a Split Signal and expand to have 2 outputs (Express >> Sig Manip >> Split Signal)
4) Place another Numeric Indicator connected to the second data output
5) Place a division block, and divide the voltage by the current (Numeric >> Divide)
6) Place a final Numeric Indicator on the output of the division block

Part B. Basic Resistance Measurements (BNC-2120)
1) Using the same setup as part A, connect ai3 across the Decade box as in Fig 6
2) Make sure that ai3 is in GS mode
3) Take Resistance measurements of Decade Box on LabView, and again compare to HP Multimeter reading of Decade box resistance, and theoretical settings of Decade Box
4) Repeat for Load Resistance of 1kΩ, 2kΩ, 3kΩ, 4kΩ, 5kΩ
Part C. Measuring **Characteristic Curve (LabView)**

1) On the Front Panel, place an **Express XY Graph** (Graph >> Ex XY Graph)
2) On the block diagram, right click on the Build XY Graph block, and choose **properties**. **Uncheck the box to clear all data on each call.**
3) Connect Current to Y input, and Voltage to X input

![LabView Block Diagram for Part C](image)

Part C. Measuring **Characteristic Curve (BNC-2120)**

1) Disconnect the DC power supply and connect the Function Generator in its place
2) Set the Function Generator to $5V_{pp}$, 1Hz Triangle waveform
3) Run the LabView software and record characteristic curve for the Decade Box
4) Record slope of graph either by hand, or by exporting data to excel and doing linear fit
5) Repeat for Load Resistance of $1k\Omega$, $2k\Omega$, $3k\Omega$, $4k\Omega$, $5k\Omega$, and once for the 1N4005 diode
Part D. Measuring Temperature (LabView)

1) In DAQ Assistant, add new channel ai1 (Analog Input>>Temperature>> Thermocouple)
2) Select Kelvins under Scaled units and set the Range from 100 to 400
3) Set Thermocouple Type to K, and CJC source to Channel>>Temp Ref
4) Expand the Split Signal to give a third channel, and create a Numeric Indicator on it for Temperature
5) Place a Waveform Chart in parallel with the Numeric Indicator
6) Set Timer Constant to 500
7) Format the Chart X-Axis to Absolute Time, and under Scales, set Min=0, Max=600
**Part D. Measuring Temperature (BNC-2120)**

1) Connect thermocouple to min-connector input on BNC-2120
2) Set switch on ai0 to Temp Ref
3) Set switch on ai1 to Thermocouple
4) Place thermocouple in cold water and record temperature of water heating up from room temperature until boiling
5) Place thermocouple in beaker of dry ice and confirm low temperature of dry ice

*(Optional) Part E. Measuring Impedance - LabView*

1) To get Labview to measure RMS, you need to collect the signal, and then have it calculate the RMS
2) Directly from the DAQ Asst, place a Collector (Express>>Signal Manip>>Collector) and set to 1000 samples
3) Connect the Collector to Statistics (Express>>Signal Analysis>>Statistics) and set to RMS
4) Change the numeric constant on the Wait until Next ms to 1
5) Disconnect the XY graph, as it will not be needed

*(Optional) Part E. Measuring Impedance – Breadboard*

1) Disconnect the Diode from Part B and place a 1uF Capacitor in its place
2) Set the Function generator to 100Hz, sine wave
3) Record RMS voltage and current, and calculated impedance
4) Repeat for 10uF, 47uF, 100uF, 10mH, 86mH, 440mH

**Data**

1) For Part A, compare the Current reading from LabView to a Current reading using the HP Multimeter, and to theoretical calculations.
2) For Part B, compare Resistance reading from LabView to readings from HP Multimeter, and to theoretical calculations.
3) For Part C, calculate the slope of the characteristic curve and invert it to obtain the resistance of the resistors. Compare this value to the resistances measured in Part B.
4) For Part D, verify the temperature of boiling water obtained.
5) For Part E, compare the measured values of impedance with theoretical values based on $Z_c = \frac{1}{2\pi fC}$ and $Z_L = 2\pi fL$
Questions

1. How you would modify virtual instrument to be used for measurements of power developed on a resistor.

2. How you would use virtual instrument to get information about conductance of the measured device.

3. How you would modify the program in order to increase sensitivity of measurements.

4. How you would modify the measurement setup in order to increase range of measurements, e.g. to measure greater voltages and greater currents.

References