1. Preparatory Lab Work: Measuring Component Characteristics Using LabView

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

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):

\[ I = \frac{V}{R} \]  

(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 SC-2075 Accessory Board has 8 Differential Analog Input Channels (1 with Banana Plug terminals, 2 BNC terminals, and 5 Spring Terminals). This allows you to read in up to 8 different voltages into LabView for analysis. The PCI-6024E Data Acquisition Card is the Analog to Digital Converter. It has a maximum voltage rating \(\pm 10\) 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

Voltage measurement using Labview is a straightforward procedure. For current measurements, we can use an implicit method by noting that current $I$ in an ohmic resistor is proportional to the voltage applied across this resistor ($V_B - V_A$). This gives us a formula:

$$I = \frac{V_B - V_A}{R}$$

(2)

By measuring the voltages on two terminals of a resistor of known resistance one can calculate current. LabView can do this calculation for us, and gives us a complete picture of the current flowing in the resistor.

Equipment and Materials

- NI PCI-6024E Data Acquisition Card 68-pin NI Cable
- NI SC-2075 Signal Conditioning Accessory
- Wavetek 19 or GwInstek 8219A Function Generator
- Global Specialties 1310 DC power supply
- HP 34401A Multimeter
- 10kΩ, 1kΩ resistor
- 1N4005 silicon diode Connecting wires

Procedure

Part A. Basic Current Measurements (LabView)

1) Connect the SC-2075 to the computer using the 68-pin cable
2) Open LabView and place the DAQ Assistant (Express >> Input >> DAQ) on the block diagram
3) Configure the DAQ assistant to Acquire Signals >> Analog Input >> Voltage >> ai3 & ai4
4) Change the minimum and maximum input range to +10 and -10 Volts respectively for each channel
5) Set Acquisition Mode to 1 Sample (On Demand)
6) Split the signal from the DAQ Assistant (Express >> Sig Manip >> Split Signal) (expand the Split Signal Block by dragging the top upwards to see 2 signal paths)
7) Subtract the 2 signals and Divide the answer by a Numeric Constant and set to 1000 (Numeric >> Subtract, Divide, Numeric Constant) (This is how we obtain the current)
8) On the Front Panel, Place 3 Waveform Charts (Graph >> Waveform Chart) labeled Input Voltage, Device Voltage, Current
9) Place a Stop Button on the Front Panel (Boolean >> Stop Button)
10) In the Block Diagram, wire the waveform charts to each of the signals from the DAQ, and one to the answer of the division block

11) Place a **Wait until next Multiple ms** (Timing >> Wait until…) and wire a **Numerical Constant** of 10 to the multiple ms input

12) Create a **While loop** around the entire block diagram

13) Wire the stop button and the Error Out of the DAQ Assistant through an **Unbundle by Name** to an **OR** Gate, with the output to the Stop terminal of the While loop (This will allow you to stop the program manually, or if there is an error it will terminate automatically)

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Fig 2. LabView Block Diagram
**Part A. Basic Current Measurements (Breadboard)**

1) On the SC2075, connect the 10kΩ and 1kΩ resistors as in Fig. 1
2) Connect the DC power supply to Vin
3) Connect Analog Input CH3 and CH4 spring terminals as in Fig. 1
4) Set the DC power supply to 5V and take Voltage and Current measurements on LabView
5) (Either adjust axis on graphs to obtain values, or place a numerical indicator to see value)
6) Compare Current measurement from LabView with an HP Multimeter reading
**Part B. 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) Re-route the **Error Out** from the DAQ Assistant to the **Error In** on the Build XY Graph, and then to the **Unbundle by Name** block.

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*Fig. 4 (Above) LabView Block Diagram for Part B, (Below) LabView Front Panel for Part B*
Part B. Measuring Characteristic Curve (Breadboard)
1) Disconnect the DC power supply and connect the Function Generator in its place
2) Set the Function Generator to ±5V, 1Hz Triangle waveform (you can refer to the Input Voltage waveform Chart on LabView to set the function generator)
3) Run the LabView software and record characteristic curve for 10kΩ resistor
4) Replace the 10kΩ resistor with the 1N4005 diode and take measurements

(Optional) Part C. 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 Assistant, place a Collector (Express>>Signal Manip>>Collector) and set to 1000 samples
3) Connect the Collector to Statistics (Express>>Signal Manip>>Statistics) and set to RMS
4) Change the
5) Disconnect the XY graph, as it will not be needed

(Optional) Part C. Measuring Impedance – Breadboard
1) Disconnect the Diode from Part B and place a 10uF Capacitor in its place
2) Set the Function generator to 100Hz

Formatting the Front Panel graphs
1) Label the axes appropriately, and set the scale of the Y-axes to SI-notation
2) Set the time difference on the X-axis to 2 seconds
3) Show Major and Minor grid lines for the Y-axis to make accurate measurements, or add a numerical indicator to view the instantaneous numerical reading of the graph

Data
1) For Part A, compare the Current reading from LabView to a Current reading using the HP Multimeter
2) For Part B, calculate the slope of the characteristic curve and invert it to obtain the resistance of the 10kΩ resistor. Compare this value to the resistance measured on the HP Multimeter

References
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.