System Level Laboratory

Measurement and Instrumentation Fundamentals

1 Introduction

You will learn about the basics of data acquisition functions supported in LabVIEW. You will learn how to configure the hardware of the data acquisition system using Measurement & Automation Explorer (MAX) in the lab. After getting familiar with the data acquisition VIs provided in LabVIEW, you will develop analog input applications using LabVIEW and MAX.

Figure 1 shows a simple analog voltage measurement program. It reads a voltage and adds it to a chart. The gray box around the program is a **While** Loop. The program elements inside the While Loop will execute repeatedly as long as the input to the condition terminal is false. That is, as long as the variable **Stop** is FALSE. **Stop** is the button on the front panel as shown in Figure 2. When the user presses the button, **Stop** becomes TRUE, and the While Loop stops executing.

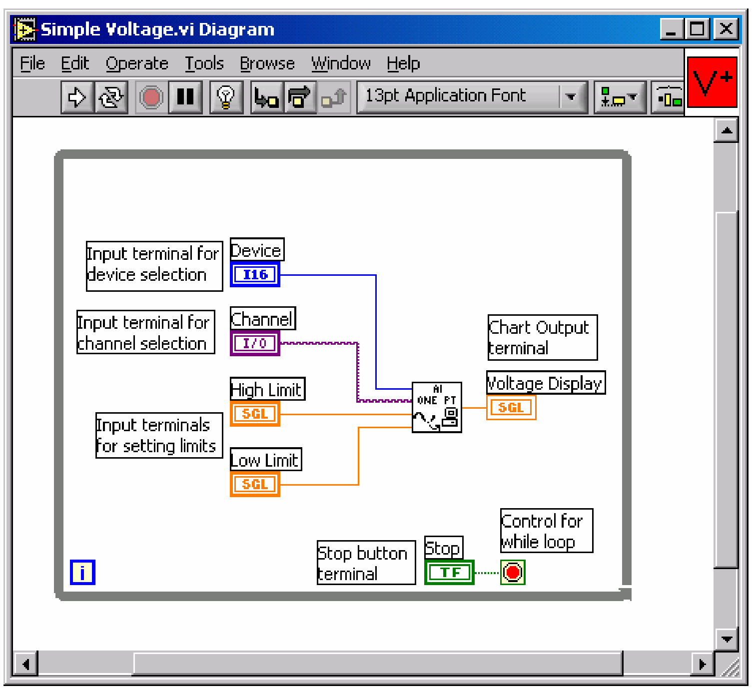


Figure 1. LabVIEW Program to Read a Voltage from a Single Channel

In the center of the While Loop, the **AI ONE PT** block refers to a Sub VI named "**AI Sample Channel.vi**". It reads a voltage value from the channel specified by **Channel** and the data acquisition device specified by **Device**. The output of **AI ONE PT** is a voltage value. Each time the While Loop runs, **AI ONE PT** outputs one voltage value to the terminal labeled **Voltage Display,** which is the connection point for the chart in the front panel shown in Figure 2. The update of the chart is such that every time a new value comes in, it is plotted along with all the previous numbers.

The **AI ONE PT** block in Figure 1 performs the data acquisition procedure. National Instruments has completed a major portion of the programming by providing software driver for the DAQ system. This means in order to take voltage measurements with the DAQ device, all you need to do is to include the **AI ONE PT** block in the program.

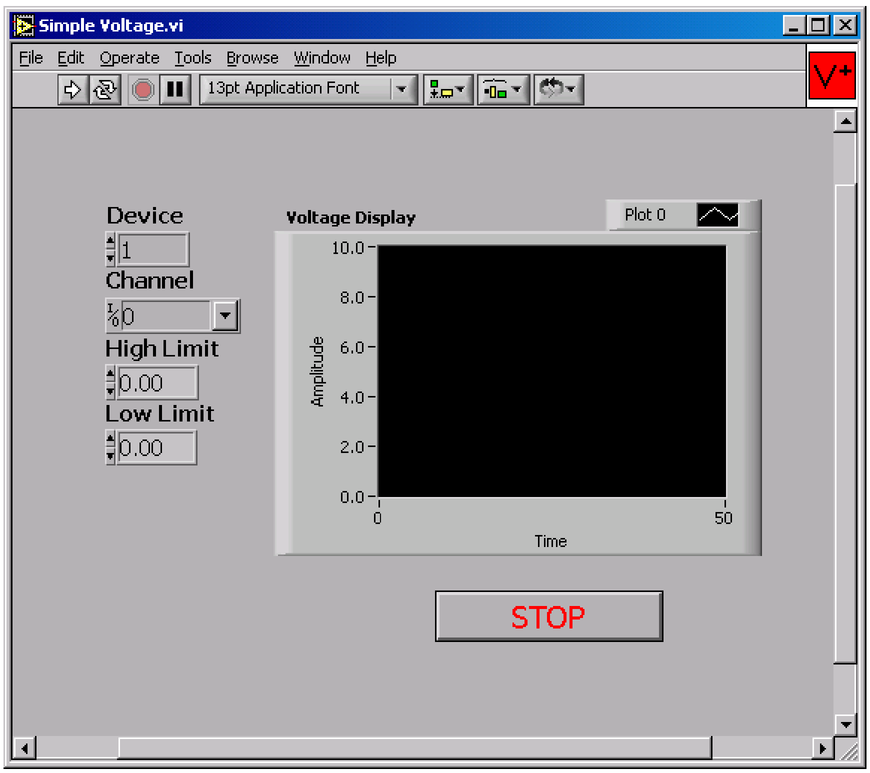
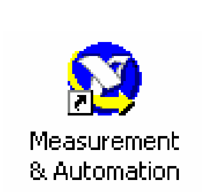


Figure 2. Front Panel of a Program that Reads and Displays a Voltage Waveform from Device 1 and Channel 0.

Measurement & Automation Explorer



Measurement & Automation Explorer, or MAX, is a software interface that gives you access to all National Instruments DAQ, GPIB, IMAQ, IVI, VISA, VXI, and Motion devices connected to your system. The shortcut to MAX is placed on the desktop during installation of NI-DAQ. MAX is used primarily to configure and test National Instruments hardware, but it offers other functionality, such as checking to see if you have the latest version of NI-DAQ installed. There are four configuration categories in MAX: Data Neighborhood, Devices and Interfaces, Scales, and Software Figure 3 show the function of MAX.

I. Data Neighborhood

Data Neighborhood contains the virtual channels. The Data Neighborhood shows currently configured virtual channels and provide utilities for testing and reconfiguring these virtual channels. Data Neighborhood also provides access to the DAQ Channel Wizard, which allows user to create new virtual channels.

(1) DAQ Channel Wizard

The DAQ Channel Wizard is a software interface that lets you create new virtual channels. A virtual channel is a shortcut to a configured channel in the system. You can set up the configuration information for the channel and give the channel a descriptive name. Later, you can use the descriptive name to access that channel and its configuration in LabVIEW. You can give the channel a description, decide what type of transducer the channel will use, set the range (determines gain), choose the grounding mode, assign custom scaling for the virtual channel, and give the channel a descriptive name to replace the channel number all at the same time.

For example, channel 0 on the BNC-2120 is hardwired to a temperature sensor, so you could create a virtual channel for channel 0 and call it Temperature Sensor. You can create virtual channels for analog input, analog output, and digital I/O. In this case, referring to a channel by a name (Temperature Sensor) instead of a number (0) helps you remember what the channel does.

II. Devices and Interfaces

Devices and Interfaces display the installed and detected National Instruments hardware. It includes utilities for configuring and testing these devices. The two utilities that are specific to DAQ devices are **Properties** and **Test Panels**.

(1) Properties

Properties are a utility for configuring DAQ devices. When you launch the Properties utility, a dialog box appears with the following tabs that you can use to configure the DAQ devices.

• The **System** tab allows you to change the device number, and testing the DAQ device. The first button is the Test Resources button. After you installed the DAQ device, right-click **Devices and Interfaces**, select **Properties** and right-click **Test Resources**. This button performs a basic test of the system resources assigned to the device. The system resources tested are the base I/O address, the interrupt request (IRQ), and the direct memory access (DMA).

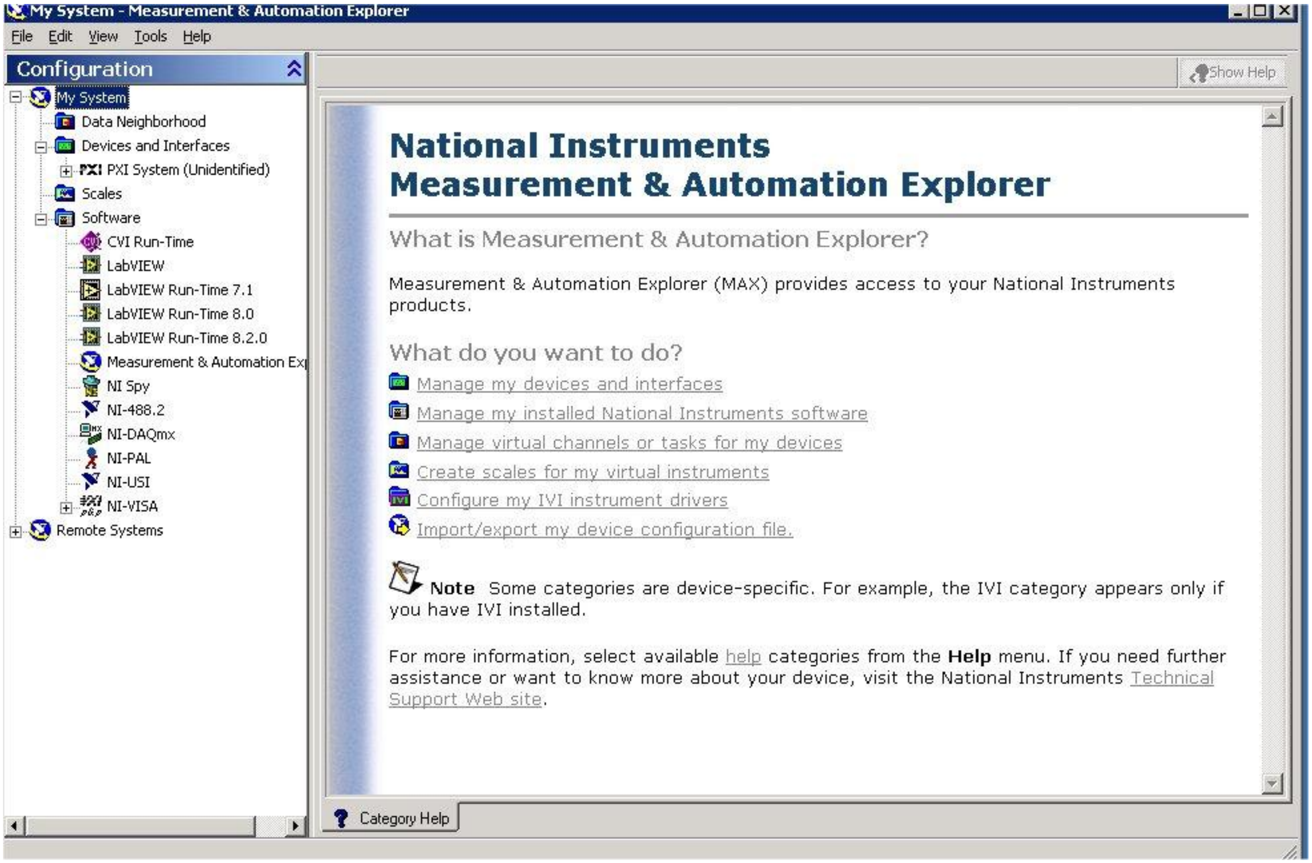


Figure 3 Measurement & Automation Explorer

– **Base I/O Address** — A DAQ device communicates with a computer primarily through its registers. NI-DAQ writes to configuration registers on the device to configure the device, and reads data registers on the device to obtain the device status or a signal measurement. The base I/O address setting determines where in the computer I/O space the device registers reside is.

– **Interrupt Request (IRQ)** — Another way the DAQ device communicates with the computer is through processor interrupts, which give the processor the ability to respond quickly to its peripherals. In the case of a DAQ device, it is not efficient for the processor to continually check if data is ready to be read from the device. A DAQ device can use an interrupt that signals the processor that it has data waiting to be read. Each interrupt request has a number assigned to it.

– **Direct Memory Access (DMA)** — The third way the DAQ device communicates with the computer is through direct memory access (DMA). DMA is a data transfer method in which data is transferred directly from the peripheral to computer memory, bypassing the processor. DMA is usually required to achieve maximum data transfer speed, making it useful for high-speed DAQ devices. DAQ devices that use the PCI bus have their own onboard DMA channels, and the PCI bus handles the sharing of that DMA.

• **AI** – Analog Input. The **AI** tab allows you to configure the default Polarity/Range for the ADC and the default mode for grounding the DAQ device. The default is applied only if the settings are not changed in LabVIEW.

• **AO –** Analog Output. The **AO** tab configures the default polarity of the analog output signal, and allows you to specify if you are using an external voltage reference for the DAC.

• **Accessory**. The **Accessory** tab specifies any accessories you are using with the DAQ device such as the TBX-68 (terminal block with built-in cold-junction compensation). If NI-DAQ does not need to know about the accessory, it will not be on the list. In that case, choose **None**.

• **OPC**. The **OPC** tab allows you to set the AI recalibration period if you are using the NI-DAQ OPC server. The use of the NI-DAQ OPC Server is beyond the scope of this lab.

(2) Test Panels

After the device passes the basic resource test and you configure the **System**, **AI**, **AO**, **Accessory**, and **OPC** tabs, return to the **System** tab and click the **Test Panels** button. The Test Panel is a utility for testing the analog input, analog output, digital I/O, and counter functionality of the DAQ device. The Test Panel is useful for troubleshooting because it allows you to test the functionality of the device directly from NI-DAQ. If the device does not work in the Test Panel, it will not work in LabVIEW. If you ever have unexplainable trouble with data acquisition in a LabVIEW program, use the **Test Resources** button and the **Test Panels** button to make sure the device is working properly.

III. Scales

Scales shows all the currently configured custom scales and provides utilities for testing and reconfiguring those custom scales. Scales also provides access to the DAQ Custom Scales Wizard, which allows you to create new custom scales.

(1) DAQ Custom Scales Wizard

The DAQ Custom Scales Wizard is a utility that creates custom scales you can use to determine scaling information for existing virtual channels. Each custom scale can have its own name and description to help you identify it.

A custom scale can be one of three types: linear, polynomial, or table.

• **Linear** — A scale that uses the formula $y = mx + b$.

• **Polynomial** — A scale that uses the formula $y = a0 + (a1 * x) + (a2 * x2) + \ldots + (an* xn)$.

• **Table** — A scale in which you enter the raw value and the corresponding scaled value in a table format.

IV. Software

Software shows all the currently installed National Instruments software. The icon for each software package is also a shortcut that you can use to launch the software. The **Software** category also includes a **Software Update** Agent. The purpose of the Software Update Agent is to check if the National Instruments software is the latest version. If the software isn't the latest version, the Software Update Agent opens the Web page on ni.com to download the latest version of the software.

(1) Software Architecture for Windows

The main component of NI-DAQ, the nidaq32.dll, makes function calls directly to a DAQ device. The function that the nidaq32.dll performs depends on where you access it from. Both MAX and LabVIEW can talk to NI-DAQ. MAX is used primarily for configuring and testing the DAQ device. It also tells what devices are present in the system by communicating with the Windows Device Manager and the Windows Registry.

2. Simulate the acquisition, processing and display the sensor data

Figure 4 shows how we measure the pressure, condition it and display it in a graph or chart in LabVIEW. Assume the resistance of the pressure sensor changes linearly with respect to the pressure: $R_s = 120p + 200$. The pressure varies from 0 to 5 psi. The sensor is used in a divider circuit to convert the resistance change to voltage change. The voltage will then be input to the computer and LabVIEW, in which a meter is implemented to display the pressure as changing from 0~5psi. Now construct a

VI to simulate the pressure changes in LabVIEW. In the lab, you will use the variance resistor and MAX to simulate the pressure sensor.

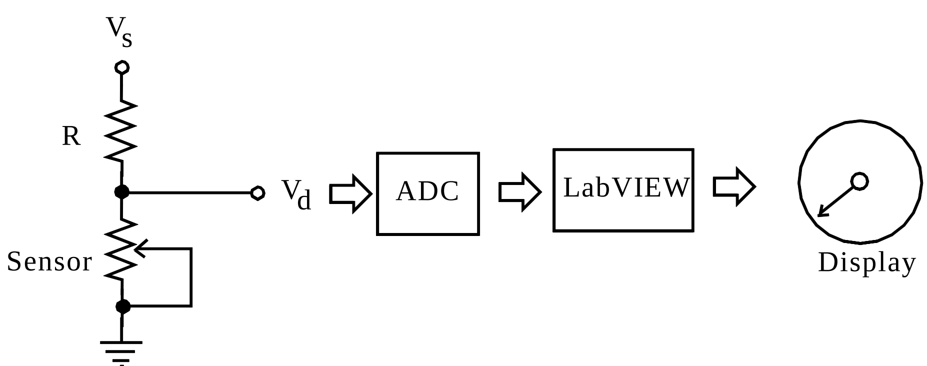


Figure 4 Simulate Pressure Sensor Acquisition and Display

Exercise (Turn it in as a GROUP):

Research through NI's website (www.ni.com) and youtube to find two videos explaining and/or demonstrating the usage of MAX.

Reminder: Bring your breadboard to the lab!