Data Acquisition and Signal Conditioning Course Manual

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For further support information, refer to the *Additional Information and Resources* appendix. To comment on National Instruments documentation, refer to the National Instruments Web site at ni.com/info and enter the info code feedback.

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3

Triggering

This lesson describes the theory and concepts of analog and digital triggering.

Topics

A. Triggering

B. Types of Triggers

C. Actions Caused by Triggering

A. Triggering

A trigger is a signal that causes an action, such as starting the acquisition of data. Use a trigger if you need to set a measurement to start at a certain time. For example, imagine that you want to test the response of a circuit board to a pulse input. You can use that pulse input as a trigger to communicate to the measurement device to start acquiring samples. If you do not use this trigger, you have to start acquiring data before you apply the test pulse.

When you configure a trigger, you must make two main decisions—what action you want the trigger to cause and how to produce the trigger.

If you want the trigger to begin the measurement, use a start trigger. If you want to acquire data before the trigger occurs, use a reference trigger, also known as a stop trigger, that captures samples before and after a trigger point, which becomes the reference position in the samples.

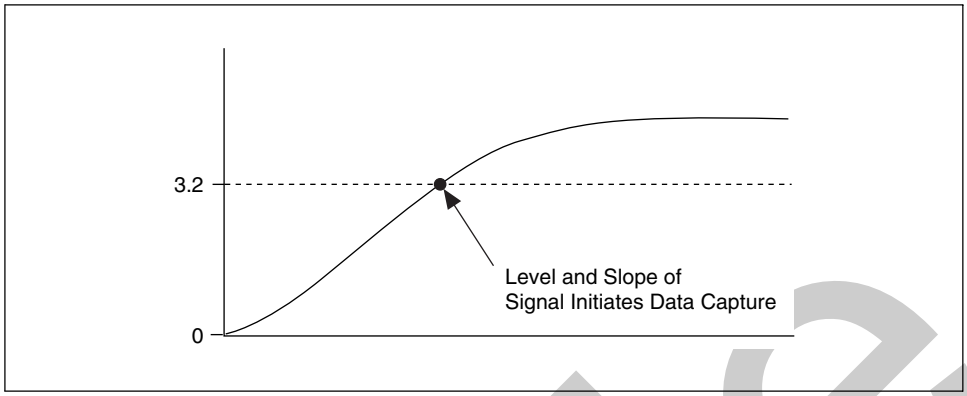
In addition to specifying the action you want a trigger to cause, you need to determine the source of the trigger. If you need to trigger off an analog signal, use an analog edge trigger or an analog window trigger. If the trigger signal is digital, you can use a digital edge trigger with a PFI pin as the source.

B. Types of Triggers

There are different types of triggers based on analog and digital signals. Few are analog edge trigger, analog window trigger and digital edge trigger.

Analog Edge Triggering

An analog edge trigger occurs when an analog signal meets a condition you specify, such as the signal level or the rising or falling edge of the slope. When the measurement device identifies the trigger condition, it performs the action you associated with the trigger, such as starting the measurement or marking which sample was acquired when the trigger occurred. For example, consider an application that monitors a temperature system. If you want to begin data acquisition only after the temperature rises to 50 °C, configure an analog trigger to occur when the temperature signal has a rising slope and voltage level corresponding to 50 °C. The following illustration shows triggering on a rising slope at a level of 3.2 V.

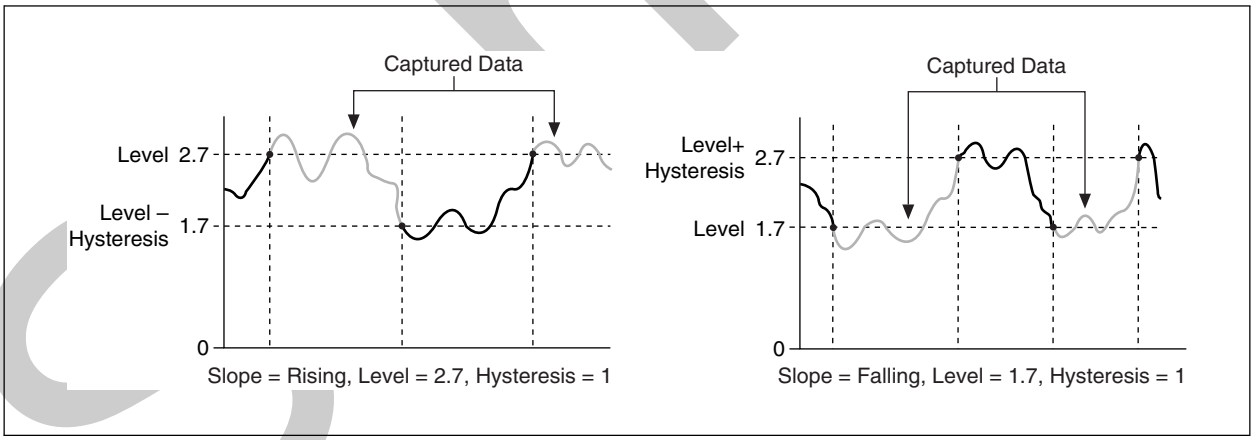


Hysteresis

Hysteresis adds a window above or below the trigger level and often reduces false triggering due to noise or jitter in the signal. When using hysteresis with a rising slope, the trigger asserts when the signal starts below **level** (or **threshold level**) and then crosses above **level**. The trigger deasserts when the signal crosses below **level** minus **hysteresis**.

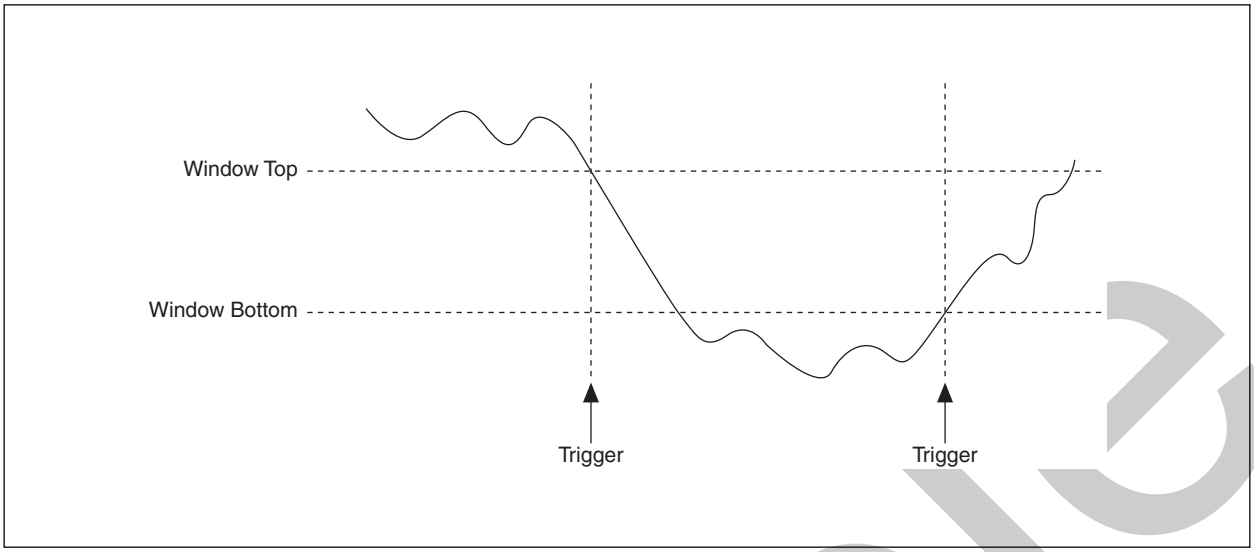
When using hysteresis with a falling slope, the trigger asserts when the signal starts above **level** (or **threshold level**) and then crosses below **level**. The trigger deasserts when the signal crosses above **level** plus **hysteresis**.

The following illustration demonstrates the data captured when using hysteresis with a rising and falling edge slope at a level of 2.7 V.

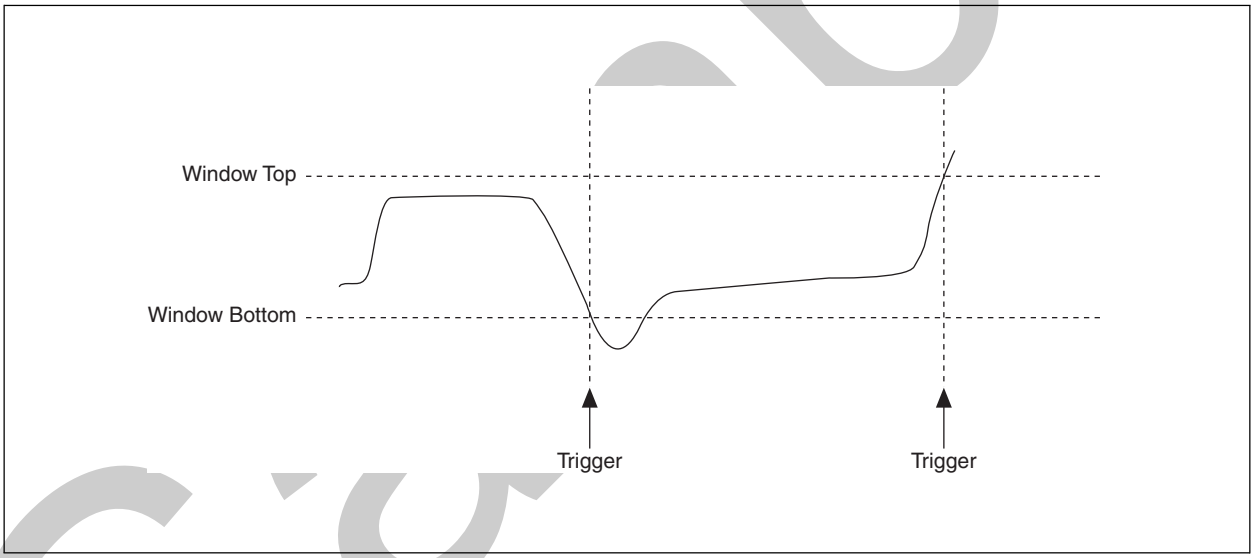


Analog Window Triggering

An analog window trigger occurs when an analog signal passes into (enters) or passes out of (leaves) a window as defined by the two voltage levels: Window Top and Window Bottom. Specify the voltage levels by setting the window top value and the window bottom value. In the following illustration, the trigger acquires data when the signal enters the window.

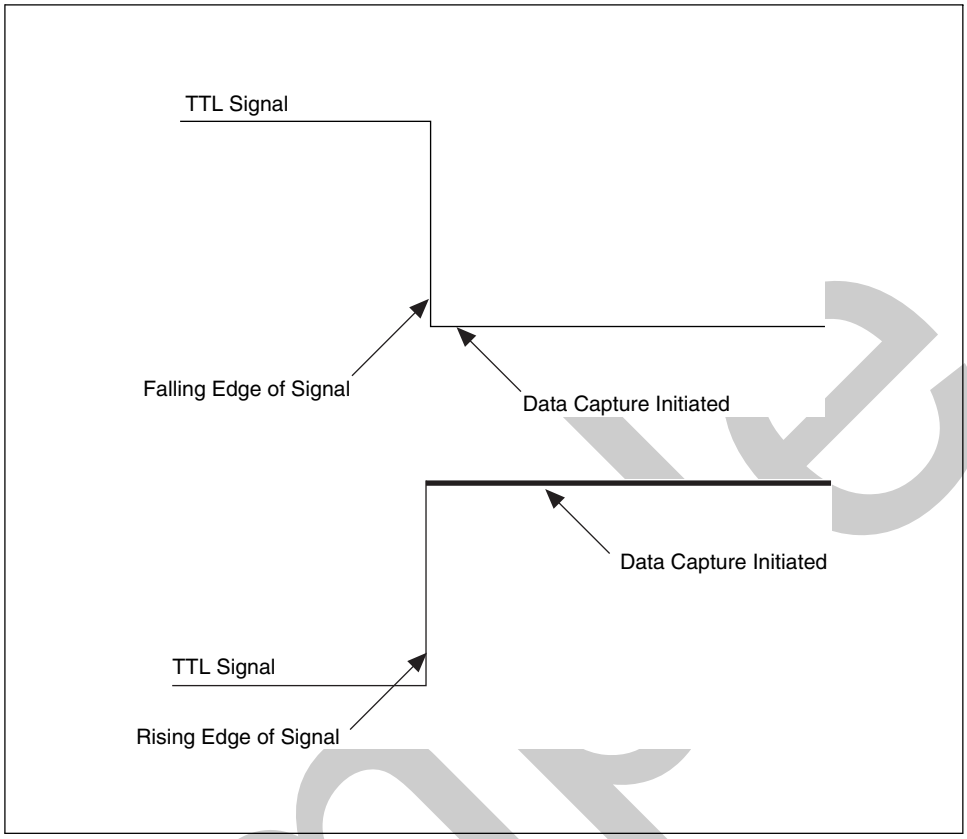


In the following illustration, the trigger acquires data when the signal leaves the window.



Digital Edge Triggering

A digital edge trigger is usually a TTL signal that has two discrete levels: a high level and a low level. A digital signal creates a falling edge when it moves from a high level to a low level. The signal creates a rising edge when it moves from a low level to a high level. You can produce start or reference triggers based on the falling or rising edge of a digital signal as shown in the following illustration. You usually connect digital trigger signals to PFI pins in a National Instruments measurement device.



C. Actions Caused by Triggering

There are four actions that a trigger can cause. Triggers are named after the actions they cause:

- Advance Trigger—Causes a switch device to execute the next entry in its instruction (scan) list.
- Pause Trigger—Pauses an acquisition. Deasserting pause trigger resumes an acquisition.
- Reference Trigger—Establishes the reference point in a set of input samples. Data acquired up to the reference point is pretrigger data. Data acquired after this reference point is posttrigger data.

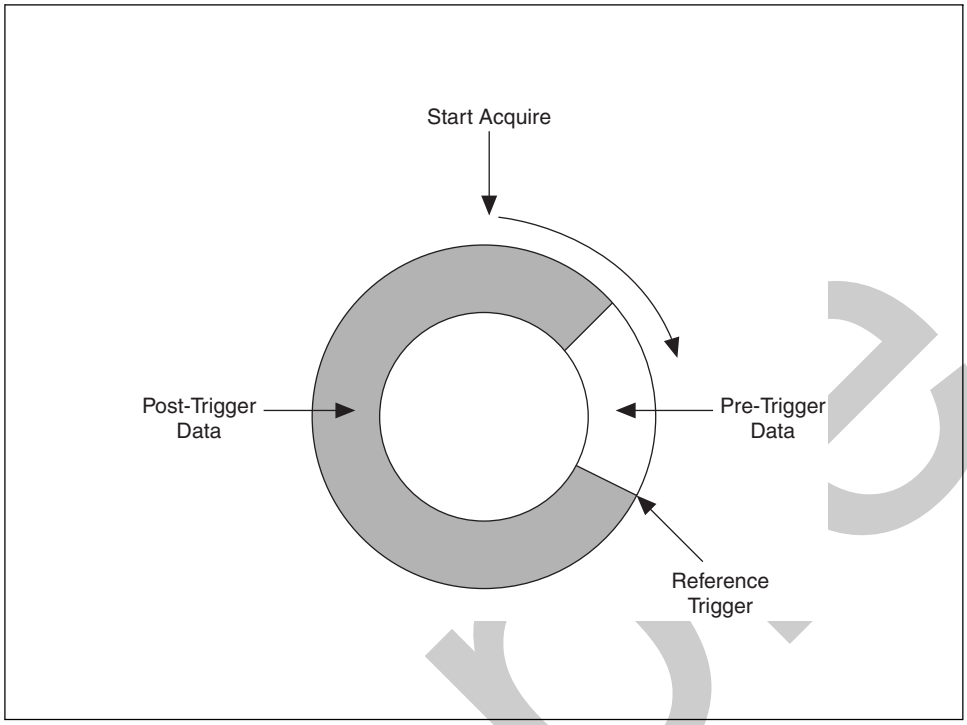


Figure 3-1. Reference Trigger

- Start Trigger—Begins an acquisition or generation.

This course describes only start, reference, and pause triggers.

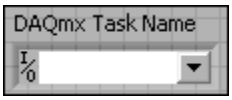
Note For analog triggering, M Series uses APFI0 and APFI1; E Series uses PFI0. Not all E Series and M Series devices support analog triggering. Refer to the device documentation or NI Measurement and Automation catalog to determine if your device supports analog triggering.

Exercise 3-1 Triggering using the DAQ Assistant in LabVIEW

Objective: To use the DAQ Assistant in LabVIEW to explore and configure different types of analog and digital triggers.

1. Connect the sine wave from the function generator to analog in 1 and the square wave from the function generator to analog in 2.
2. Launch LabVIEW and open a blank VI.

Front Panel

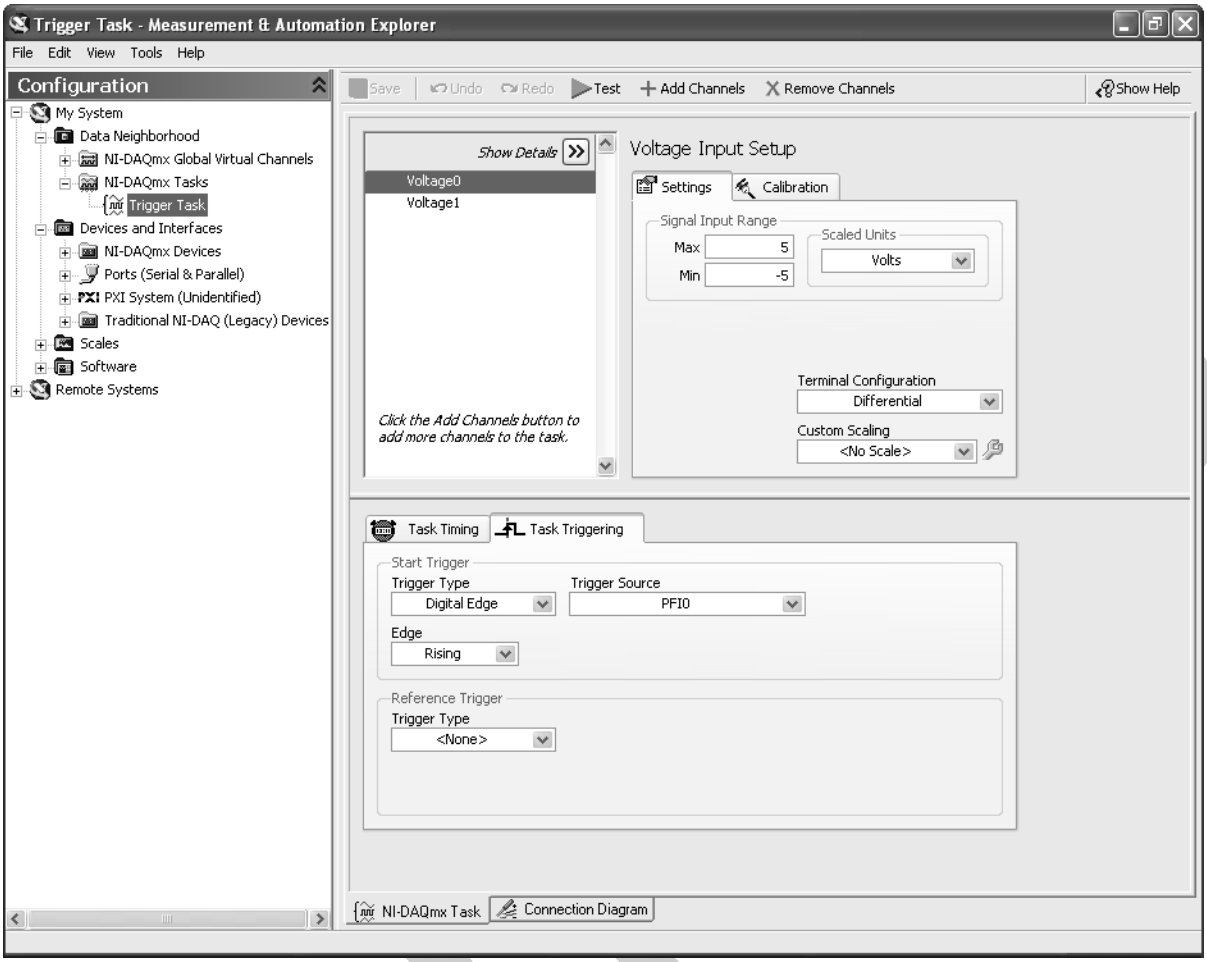


3. Place a **DAQmx Task Name** control on the front panel. Right-click the control and select **New NI-DAQmx Task»MAX** from the shortcut menu.
4. Use the DAQ Assistant to create a new task with the following settings:
   - **Measurement Type**: `Analog Input`
   - **Sensor Type**: `Voltage`
   - **Channels**: Select and highlight local channels `ai0` and `ai1` under the appropriate DAQ device by holding down the <Shift> key.
   - **Name**: `Trigger Task`
5. Click the **Finish** button.

Start Triggers

The following steps demonstrate digital edge and analog edge start triggers.

1. In the DAQ Assistant, click the **Task Triggering** tab. In the **Start Trigger** section, select **Digital Edge** from the **Trigger Type** pull-down menu.
2. Select **PFIO** from the **Source** pull-down menu and select **Rising** from the **Edge** pull-down menu. The digital trigger button on the DAQ Signal Accessory corresponds to the PFIO/TRIG1 signal line.



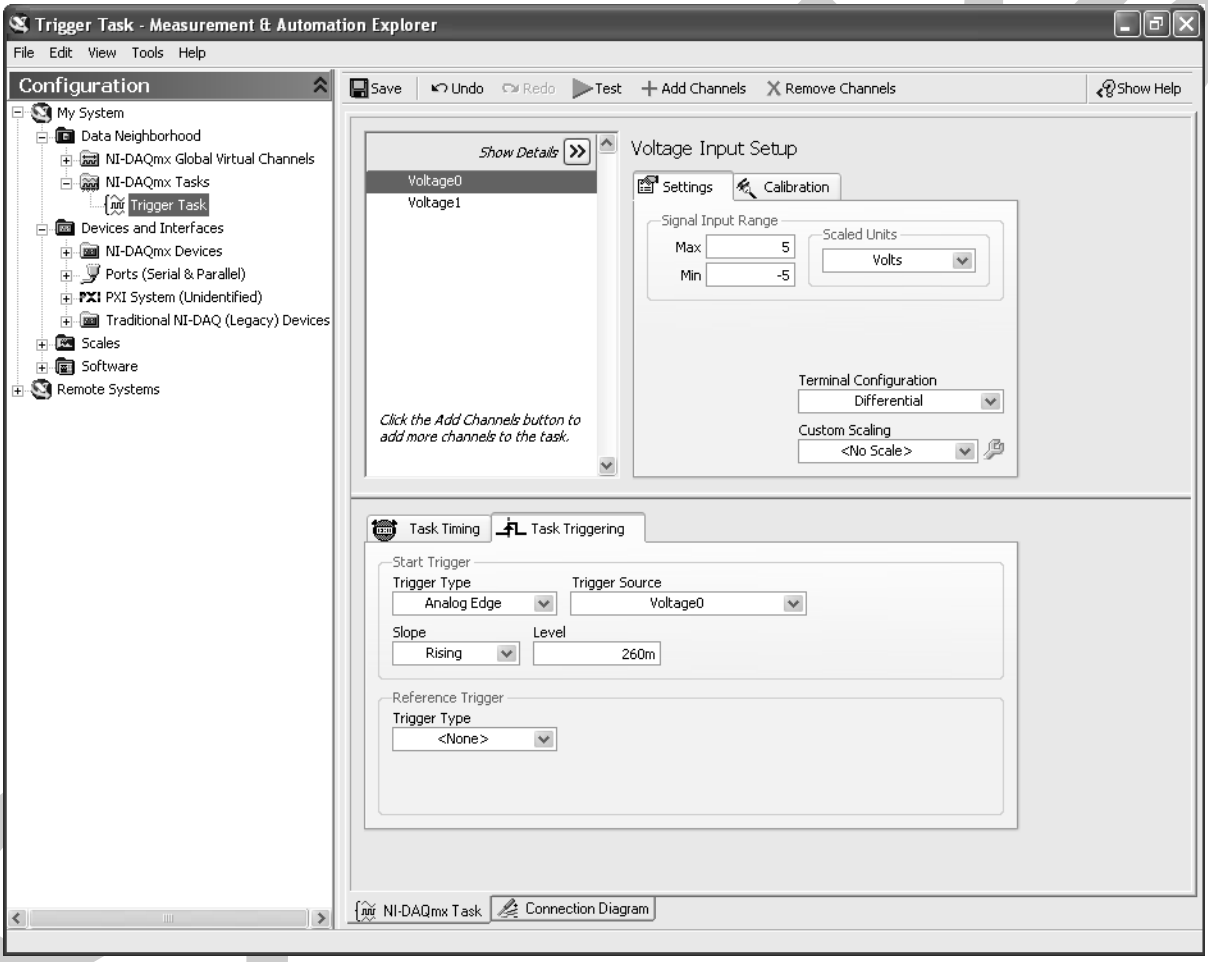
3. Click the **Test** button.
4. The Analog Input test panel is empty because the task is waiting on the rising edge of the PFIO line before acquiring any data. Press the digital trigger button on the DAQ Signal Accessory to enable the trigger.
5. Change the Y-axis scale to a minimum of 0.2 and a maximum of 0.3. Notice the approximate value of the channel Voltage0 and record it below. The recorded voltage is the raw voltage of the temperature sensor. Click the **Close** button to exit the Analog Input test panel.

   _____

6. Select channel Voltage0 from the channel list.
7. Change the input limits of Voltage0 to 0 and 1.
8. Because you chose analog input channels 0 and 1 for the task, the channels are listed in increasing order. The first channel in the scan order can trigger the remaining channels. Setting the ai0 channel as the first channel in the scan order indicates to NI-DAQmx that you want to trigger **Trigger Task** off of the temperature sensor channel of the DAQ Signal Accessory.

Note Steps 9 to 13 require an AI triggering DAQ device. If your computer does not have an AI triggering DAQ device, skip to the *Reference Triggers* section.

9. In the DAQ Assistant, click the **Task Triggering** tab. In the **Start Trigger** section, select **Analog Edge** from the **Trigger Type** pull-down menu.
10. Select **Voltage0** from the **Source** pull-down menu and select **Rising** from the **Slope** pull-down menu. Set **Level** slightly higher than the ambient temperature reading you noted in step 5.



11. Click the **Test** button.
12. Place your index finger over the temperature sensor to increase the temperature. When the temperature reaches the value of **Level**, data acquisition begins.

Note If triggering is not working, try changing the input limits of Voltage0 to a narrower input voltage range to decrease the code width and improve resolution of the triggering signal.

13. After acquiring data, click the **Stop** button and click the **Close** button to exit the test panel.

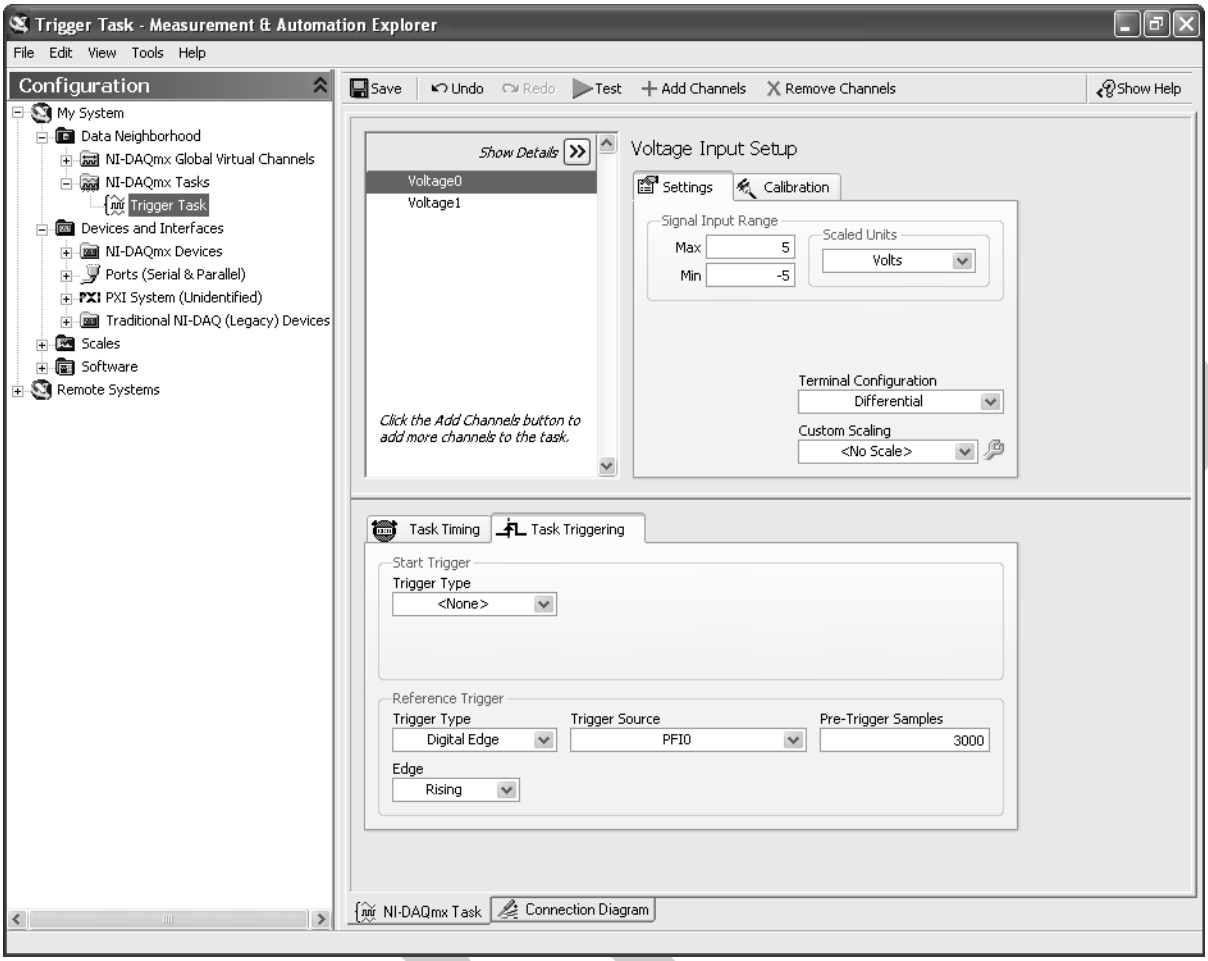
Reference Triggers

The following steps demonstrate the use of reference triggers.

1. Wire output A of the quadrature encoder to analog in 1 on the DAQ Signal Accessory.

2. Click the **Remove Channels** button and remove analog input channel Voltage0 from the task.
3. Click the **Task Timing** tab. Configure the following settings:
   - **Acquisition Mode**: `N Samples`
   - **Samples to Read**: `5000`
   - **Rate (Hz)**: `1000`
   - **Advanced Clock Settings - Clock Type**: `Internal`
4. Click the **Task Triggering** tab. In the **Start Trigger** section, select **none** from the **Trigger Type** pull-down menu.
5. In the **Reference** section, select **Digital Edge** from the **Trigger Type** pull-down menu and select **PFIO** from the **Source** pull-down menu.

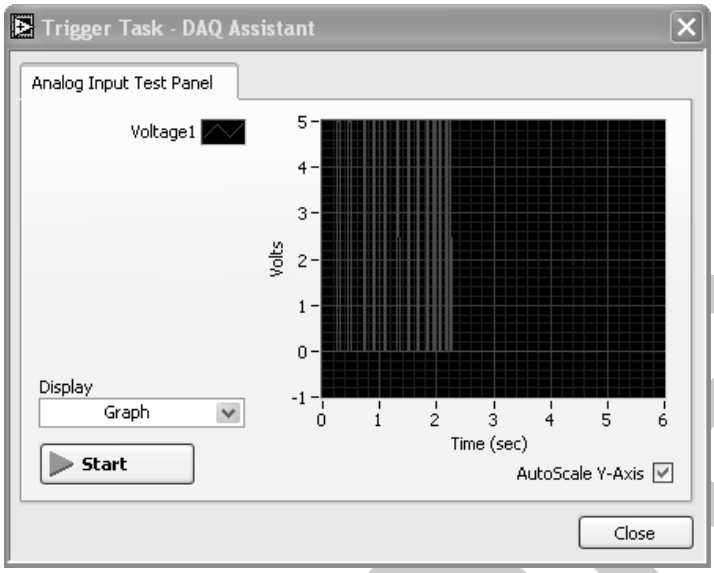
   Pretrigger Samples is the minimum number of pretrigger samples to acquire before recognizing a reference trigger. The minimum number of pretrigger samples allowed by NI-DAQmx is 2. The number of posttrigger samples is equal to the **Samples to Read** (specified in the **Task Timing** tab) minus the number of **Pretrigger Samples**.



Set **Pretrigger Samples** to `3000`. Since the total number of samples to acquire is 5,000 and the sampling rate is 1,000 Hz, the first three seconds will acquire the pretrigger samples.

6. Click the **Test** button.
7. Rotate the quadrature encoder for approximately three seconds and then press the digital trigger button on the DAQ Signal Accessory. The number of pulse spikes displayed on the test panel corresponds to the number of clicks the quadrature encoder rotated.

   In the following example, the quadrature encoder is rotated for a few number of clicks before the digital trigger button was pressed. Each click corresponds to a 5 V spike in the graph.



8. Click the **Close** button to exit the test panel.
9. Click the **OK** button to exit the DAQ Assistant.

NI-DAQmx Code Generation

The following steps demonstrate the use of the code generation feature of NI-DAQmx to automatically generate LabVIEW code based on settings for timing or triggering in a task or channel you configured in the DAQ Assistant.

1. Right-click the **DAQmx Task Name** control on the front panel and select **Generate Code»Configuration and Example** from the short cut menu. This option generates LabVIEW code to configure the task, based on the settings you selected in the DAQ Assistant and also generates code for an example measurement. In this case, the example measurement is an analog input since that is the type of measurement you selected for the task.

   View the block diagram, the code automatically appears. A waveform graph appears on the front panel because you configured the task to return N samples.
2. Run the VI. Rotate the quadrature encoder for approximately three seconds, then press the digital trigger button on the DAQ Signal Accessory.
3. Close the VI and exit LabVIEW. Do not save the VI.

End of Exercise 3-1

Summary

- Triggers can cause start, reference, pause, or advance actions.
- You can trigger off a digital edge.
- You can trigger off an analog edge or window.
- Many DAQ devices support analog triggering.
- Analog triggering is not a computationally intensive operation.
- Use the DAQ Assistant to test and configure triggering for NI-DAQmx tasks and channels. You also can use the DAQ Assistant to generate code in LabVIEW.