DAQ and I/O Modules in LabVIEW
Contents

• Introduction to DAQ and I/O Modules
• Getting Started with USB-600x
• Practical LabVIEW Examples
  – Analog Out
  – Analog In
  – Digital I/O
    • Digital Out
    • Digital in
Introduction to DAQ and I/O Modules
NI DAQ Hardware Examples

TC-01 Thermocouple

myDAQ

NI-DAQmx Hardware Driver

USB-6001

USB-6008

cDAQ
A DAQ System consists of 4 parts:

- **Physical input/output signals, sensors** – e.g., a Temperature Sensor or similar
- **DAQ device/hardware** – In this case the USB-600x device
- **Driver** software – In this case the DAQmx software
- Your software **Application** (Application Software) - in this case your LabVIEW application
DAQ System

Input/Output Signals

Analog Signals

Digital Signals

Sensors (Analog/Digital Interface)

Data Acquisition Hardware

Analog IO

Digital IO

USB, etc.

Software

Application

Hardware Driver

PC
A computer can only deal with discrete signals. You typically log data at specific intervals. The sampling time ($T_s$) is the time between 2 logged values.

$t = \text{Continuous Time}$

$k = \text{Discrete Time}$

$T_s = \text{Sampling Time}$
To use DAQ hardware in LabVIEW we need to use the DAQmx driver. It can be downloaded for free.
You can use MAX to test and configure your DAQ device.

**Measurement and Automation Explorer (MAX)**

is installed as part of the DAQmx software.
To use DAQ hardware in **LabVIEW** we need to use the **DAQmx** driver. It can be downloaded for free.

Getting Started with USB-600x
USB-600x DAQ series

Entry-Level, Plug-and-Play USB Data Acquisition

You depend on accurate measurements to make key decisions and discoveries, and NI’s plug-and-play USB multifunction I/O devices deliver quality measurements at an entry-level price.

USB-6008 has been replaced with newer versions like USB-6000, **USB-6001**, USB-6002 and USB-6003 which have similar functionality as USB-6008 and they all work in the same manner, and they all use the NI-DAQmx driver.

Compare NI’s Entry-Level, Stand-Alone Data Acquisition Devices

<table>
<thead>
<tr>
<th></th>
<th>USB-6003</th>
<th>USB-6002</th>
<th>USB-6001</th>
<th>USB-6000</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>I/O Type</strong></td>
<td>AI</td>
<td>AI</td>
<td>AI</td>
<td>AI</td>
</tr>
<tr>
<td><strong>No. of Channels</strong></td>
<td>4/8</td>
<td>4/8</td>
<td>4/8</td>
<td>4/8</td>
</tr>
<tr>
<td><strong>Sample Rate (kS/s and Timed)</strong></td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>4/8</td>
</tr>
<tr>
<td><strong>Resolution</strong></td>
<td>16 bits</td>
<td>16 bits</td>
<td>14 bits</td>
<td>12 bits</td>
</tr>
<tr>
<td><strong>Programming Language Support</strong></td>
<td>ANSI C, Python, Visual C# .NET, Visual Basic .NET, and LabVIEW</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
DAQ and I/O Modules in LabVIEW

Practical LabVIEW Examples

Hans-Petter Halvorsen
When using a DAQ or I/O Module device we have 4 options:

• **Analog Out** (Write) - AO
• **Analog In** (Read) - AI
• **Digital Out** (Write) - DO
• **Digital In** (Read) - DI

We will show some basic examples in each of these categories
DAQ and I/O Modules in LabVIEW

Analog Out
Analog Out (Write)

- Note! The USB-600x can only output a voltage signal between 0 and 5V
- The USB-600x has 2 Analog Out Channels:
  - AO0
  - AO1
Hardware Setup and Testing

Multimeter

USB-6008

To PC
Analog Out Example
Analog Out Example

Select the measurement type for the task.

- Acquire Signals
- Generate Signals
- Analog Output
  - Voltage
  - Current
  - Counter Output

Select the physical channel(s) to add to the task.

Physical

Supported Physical Channels

If you have previously configured global virtual channels, click the Virtual tab to add or copy global virtual channels to the task. When you copy the global virtual channel to the task, it becomes a local virtual channel. When you add a global virtual channel to the task, the task uses the actual global virtual channel, and any changes to that global virtual channel are reflected in the task.

If you have TDS configured, click the TDS tab to add TDS channels to the task.

For hardware that supports multiple channels in a task, you can select multiple channels to...
Using “Low-level” DAQmx VIs
DAQ and I/O Modules in LabVIEW

Analog In
USB-600x has

- **8 AI Referenced Single Ended (RSE) Analog Inputs Channels**
- or **4 AI Differential Analog Inputs Channels**

The Voltage Range is $-10V - 20V$

$0V - 5V$ is default
Differential vs RSE

AI Differential Analog - 4 channels

AI Referenced Single Ended (RSE) - 8 channels

The Analog Channels have common ground
Hardware Setup and Testing
Analog In - DAQ Assistant

Here, a 1.5V Battery is connected to Analog Input Channel 0 (AI0)
Convert from Dynamic Data
Reading Multiple Channels
Using “Low-level” DAQmx VIs

All Applications should have proper Error Handling
Reading Multiple Channels
Reading Multiple Channels – Alt B

Can be put into a SubVI

Further Improvements: Use the **State Machine** programming principle in your Application
Analog In - TMP36 Example

Note! The wires are connected as “RSE”
Note! The wires are connected as "RSE"
Convert form Voltage (V) to degrees Celsius

From the Datasheet we have:

\[(x_1, y_1) = (0.75V, 25^\circ C)\]
\[(x_2, y_2) = (1V, 50^\circ C)\]

There is a linear relationship between Voltage and degrees Celsius:

\[y = ax + b\]

We can find a and b using the following known formula:

\[y - y_1 = \frac{y_2 - y_1}{x_2 - x_1} (x - x_1)\]

This gives:

\[y - 25 = \frac{50 - 25}{1 - 0.75} (x - 0.75)\]

Then we get the following formula:

\[y = 100x - 50\]
TMP36 LabVIEW Example
TMP36 with Lowpass Filter
Lowpass Filter

- \( y \) - Input Signal with Noise
- \( yf \) - Output Signal/Filtered Signal where the Noise has been removed or Reduced
- \( Tf \) - Filter Time constant
- \( Ts \) - Sampling Time

**Formula:**

\[
float a = \frac{Ts}{(Tf+Ts)};
\]

\[
yf = (1-a) * yf_{prev} + a * y;
\]
A Low-pass Filter has the following Transfer Function:

\[ H(s) = \frac{y_f(s)}{y(s)} = \frac{1}{T_f s + 1} \]

We can find the Differential Equation for this filter using Inverse Laplace

We get:

\[ y_f(s)[T_f s + 1] = y(s) \]

\[ T_f y_f(s)s + y_f = y(s) \]

Finally, we get the following Differential Equation:

\[ T_f \dot{y}_f + y_f = y \]
Discrete Lowpass Filter

Discrete Lowpass Filter:

\[ y_f(k) = (1 - a)y_f(k - 1) + ay(k) \]

Where:

\[ \frac{T_s}{T_f + T_s} \equiv a \]

\( y(k) \) is the current Signal from the DAQ device (that contains noise)
\( y_f(k) \) is the Filtered Signal
\( y_f(k - 1) \) is previous filtered signal
\( T_f \) is the Filter Time Constant
\( T_s \) is the Sampling Time
DAQ and I/O Modules in LabVIEW

Digital I/O

Table of Contents

Hans-Petter Halvorsen
Digital I/O

- 12 Digital Channels
  - Port 0 Digital I/O Channels 0 to 7
  - Port 1 Digital I/O Channels 0 to 3

- You can individually configure each signal as an input or output.
Digital I/O

Dev1/port0/line0
Dev1/port0/line1
Dev1/port0/line2
Dev1/port0/line3
Dev1/port0/line4
Dev1/port0/line5
Dev1/port0/line6
Dev1/port0/line7

Dev1/port1/line0
Dev1/port1/line1
Dev1/port1/line2
Dev1/port1/line3
**Digital I/O**

<table>
<thead>
<tr>
<th>32</th>
<th>31</th>
<th>30</th>
<th>29</th>
<th>28</th>
<th>27</th>
<th>26</th>
<th>25</th>
<th>24</th>
<th>23</th>
<th>22</th>
<th>21</th>
<th>20</th>
<th>19</th>
<th>18</th>
<th>17</th>
</tr>
</thead>
<tbody>
<tr>
<td>GND</td>
<td>+5V</td>
<td>+2.5V</td>
<td>PFI0</td>
<td>P1.3</td>
<td>P1.2</td>
<td>P1.1</td>
<td>P1.0</td>
<td>P0.7</td>
<td>P0.6</td>
<td>P0.5</td>
<td>P0.4</td>
<td>P0.3</td>
<td>P0.2</td>
<td>P0.1</td>
<td>P0.0</td>
</tr>
</tbody>
</table>

**Dev1/Port0/line0:7**

P0.<0..7> Port 0 Digital I/O Channels 0 to 7 — You can individually configure each signal as an input or output.

**Dev1/Port1/line0:3**

P1.<0..3> Port 1 Digital I/O Channels 0 to 3 — You can individually configure each signal as an input or output.
DAQ and I/O Modules in LabVIEW

Digital Out
Digital Out

• 12 Digital Channels
  – Port 0 Digital I/O Channels 0 to 7
  – Port 1 Digital I/O Channels 0 to 3

• You can individually configure each signal as an input or output.
Hardware Setup and Testing

We test with a Multimeter

False → 0v
True → 5v
Digital Out LabVIEW Example

False → 0v
True → 5v
Select the measurement type for the task.

A task is a collection of one or more virtual channels with timing, triggering, and other properties. To have multiple measurement types within a single task, you must first create the task with one measurement type. After you create the task, click the Add Channels button to add a new measurement type to the task.

- Acquire Signals
- Generate Signals
  - Analog Output
  - Counter Output
  - Digital Output
  - Line Output
- Port Output

Select the physical channel(s) to add to the task.

If you have previously configured global virtual channels of the same measurement type as the task, click the Virtual tab to add or copy global virtual channels to the task. When you copy the global virtual channel to the task, it becomes a local virtual channel. When you add a global virtual channel to the task, the task uses the actual global virtual channel, and any changes to that global virtual channel are reflected in the task.

If you have TEDS configured, click the TEDS tab to add TEDS channels to the task.

For hardware that supports multiple channels in a task, you can select multiple channels to...
LED Example
LED Wiring Example

\[ R = 270\Omega \]
LED Example

False → 0v → LED OFF
True → 5v → LED ON
DAQ and I/O Modules in LabVIEW

Digital In

Table of Contents

Hans-Petter Halvorsen
• 12 Digital Channels
  – Port 0 Digital I/O Channels 0 to 7
  – Port 1 Digital I/O Channels 0 to 3

• You can individually configure each signal as an input or output.
Hardware Setup and Testing

Digital Out (P0.0)

Digital In (P0.1)
Digital In
Digital Out and In Example

Digital P0.0 is wired directly to P0.1 in this example.
Push Button Example
Push Button Wiring Example

Using external 10 kΩ Pull-up Resistor

\[ R = 10k\Omega \]
Push Button Wiring Example

Using **built-in/internal** 4.7 kΩ **Pull-up Resistor**
Pull-up Resistor

True/High

Switch Open

Resistor

DI

GND

+5V

False/Low

Switch Closed

Resistor

DI

GND

+5V

We Push the Button
When using a DAQ or I/O Module device we have 4 options:

- **Analog Out** (Write) - AO
- **Analog In** (Read) - AI
- **Digital Out** (Write) - DO
- **Digital In** (Read) - DI

We will show some basic Step by Step examples in each of these categories
Hans-Petter Halvorsen

University of South-Eastern Norway

www.usn.no

E-mail: hans.p.halvorsen@usn.no
Web: https://www.halvorsen.blog