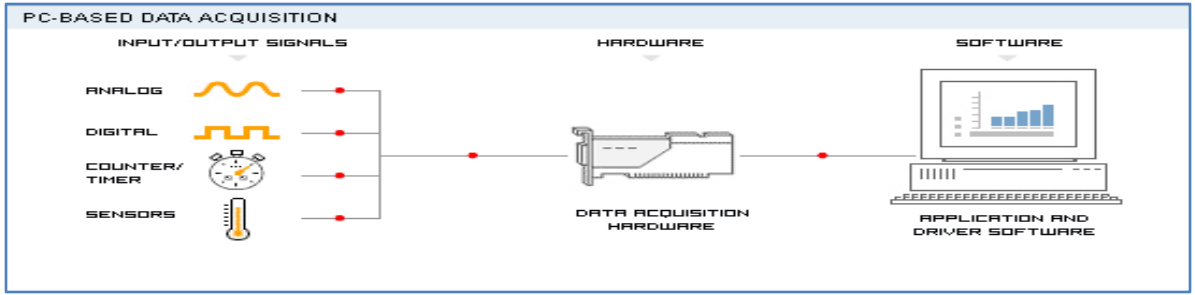
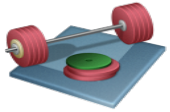
NATIONAL INSTRUMENTS LabVIEW

http://home.hit.no/~hansha/?page=labview

Introduction to DAQ with LabVIEW

USB-6008





with Self-paced Step-by-Step Exercises

Hans-Petter Halvorsen, M.Sc.

Contents

- LabVIEW
- What is DAQ?
- Using USB-6008 in LabVIEW
- Analog In
- Analog Out
- Datalogging

USB-6008
I/O Module

LabVIEW Installation

Note! You get the Serial Number from your Teacher, but the software can be used for 30 days before you need to enter a valid Serial Number.

Download the software here:

http://home.hit.no/~hansha/?page=labview

These are the main modules we use in the different courses at Telemark University College:

- **LabVIEW** (LabVIEW Professional Development System 32-Bit: English)
- **NI-DAQmx** (Hardware Driver for NI USB-6008, NI TC-01, etc.)
- **LabVIEW Control Design and Simulation Module**
- **LabVIEW MathScript RT Module**

Note! These packages are separate downloads!

All LabVIEW Software can be downloaded here: www.ni.com/download

Additional LabVIEW Resources

Here you will find lots of Videos, Tutorials and Exercises

- LabVIEW Training for Students (National Instruments):

http://ni.com/students/learnlabview

- LabVIEW Course:
http://home.hit.no/~hansha/?training=labview

Learning by Doing!

It is recommended that you watch some of the videos before you read furter

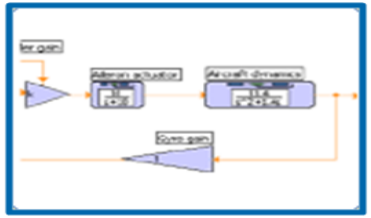
High-Level Design Tools

Configuration

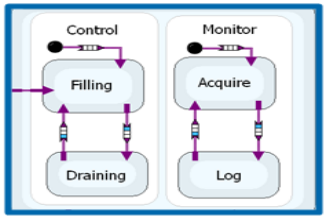
Textual Math

```
1 c = 0.285 + 0.013i;
2 [X Y] = meshgrid(x, y);
3 z = X + i*Y;
4 for k=1:30
5     z = z.^2 + c;
6 end
```

Simulation



Statechart



LabVIEW

Graphical Programming

Desktop Platform

Linux®

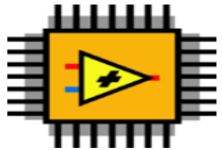
Macintosh

Windows

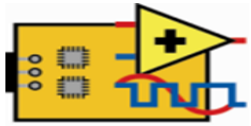
Embedded Platform

Real-Time

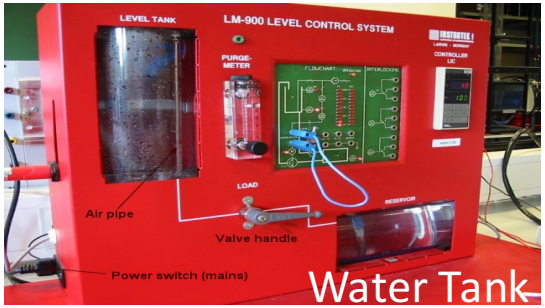
FPGA



MPU



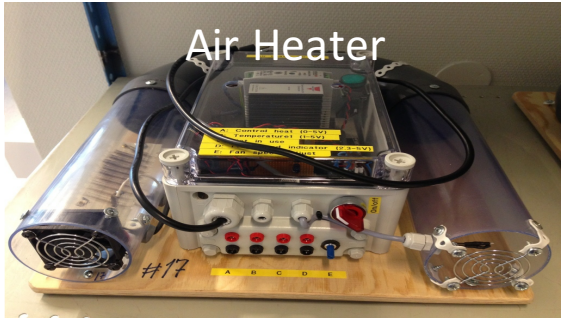
Hardware



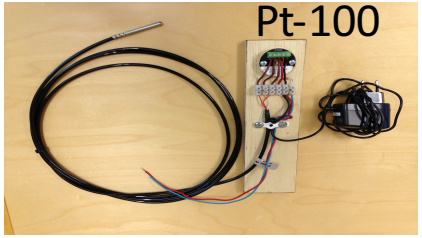
Water Tank

USB-6008


Wi-Fi DAQ

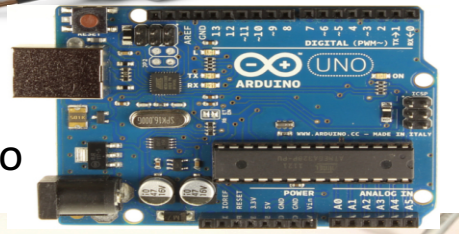


Air Heater


Pt-100


TC-01

ZigBee



Arduino

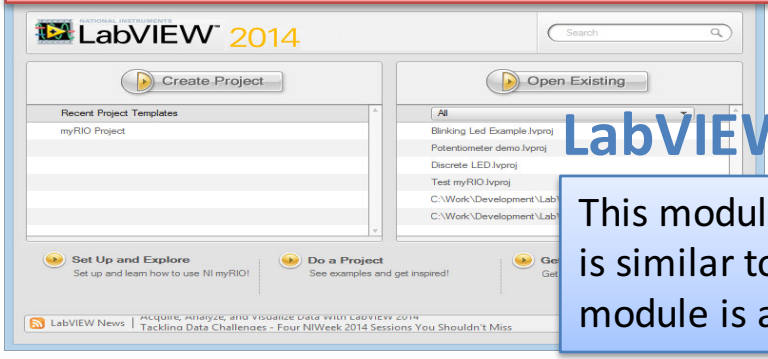

cRIO


NOx Sensor

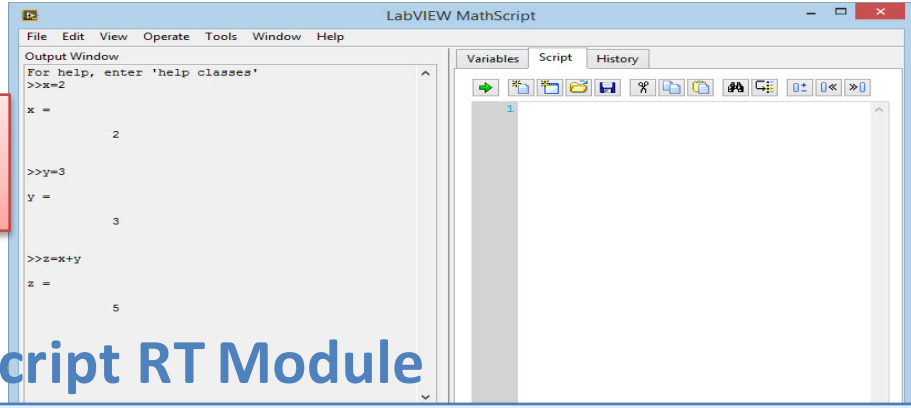
Vision System

LabVIEW

This is the core LabVIEW installation that installs the LabVIEW Programming Environment.



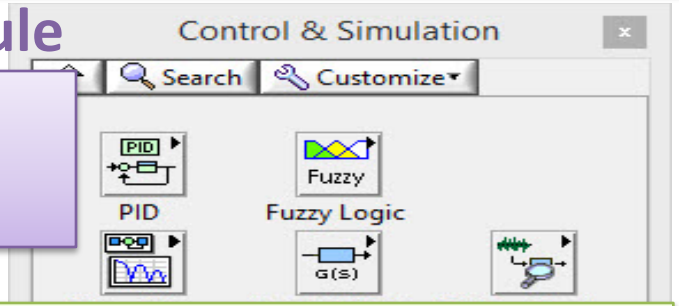
LabVIEW MathScript RT Module



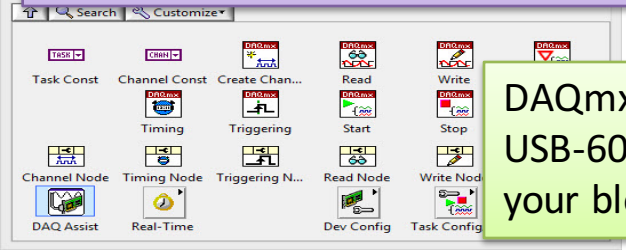
This module is a text-based tool that is very similar to MATLAB. The syntax is similar to MATLAB, you can create and run so-called m files, etc. The module is available from the Tools menu inside LabVIEW.

LabVIEW Control Design and Simulation Module

This module is used for creating Control and Simulation applications with LabVIEW. Here you will find PID controllers, etc. The module is available as a palette on your block diagram.



NI-DAQmx



DAQmx is the Hardware Driver needed in order to use hardware devices like NI USB-6008, NI TC-01, etc. inside LabVIEW. The module is available as a palette on your block diagram.

NATIONAL INSTRUMENTS

LabVIEW™ Quick Reference Guide

Keyboard Shortcuts

File

Ctrl-N	Create new VI
Ctrl-S	Save VI
Ctrl-P	Print

Edit

Ctrl-V	Paste object
Ctrl-U	Clean up diagram
Ctrl-Space	Activate quick drop
Ctrl-B	Remove broken wires
Ctrl-C	Copy an object
Ctrl-X	Cut object
Ctrl-Z	Undo last action
Ctrl-Shift-Z	Redo last action

Operate

Ctrl-R	Run VI
Ctrl-.	Abort VI

Window

Ctrl-E	Display block diagram/ front panel
Right-Click	Display controls/ functions palette
Shift-Right-Click	Display tools palette
Ctrl-T	Tile block diagram and front panel windows

Help

Ctrl-H	Display context help

Editing Tools

Tool	Icon	Description
Show Context Help		Display the context help window
Text Settings		Change the font setting for the VI, including size, style, and color
15pt Application Font		
Align Objects		Align selected objects
Distribute Objects		Space objects evenly
Resize Objects		Resize multiple front panel objects to the same size
Reorder		Reorder the layers of the objects
Clean Up Diagram		Rearrange wires and objects on the block diagram
Enter		Appears when a new value is available to replace an old value

Debugging Tools

Tool	Icon	Description
Run		Execute the VI
List Errors		List errors that prevent the VI from running
Run Continuously		Execute the VI continuously until abort or pause is pressed
Abort Execution		Stop VI execution immediately
Execution Highlighting		Animate data movement on the block diagram wires
Pause		Temporarily stop execution to debug a portion of the VI
Step Into		Single-step into a subVI or structure to debug it
Step Over		Execute a subVI or structure and pause at the next one
Step Out		Execute a subVI or structure and resume single-stepping

Tools Palette

Tool	Icon	Description
Automatic Tool Selection		Automatically choose the appropriate tool
Operating Tool		Change the value of a control or select the text within a control
Positioning Tool		Position, resize, and select objects
Labeling Tool		Edit text and create free labels
Wiring Tool		Wire objects together on a block diagram
Scrolling Tool		Scroll the window without using the scroll bars
Breakpoint Tool (Used for debugging)		Set breakpoints on VIs, functions, wires, loops, sequences, and cases
Probe Tool (Used for debugging)		Create probes on wires and display intermediate values on a wire in a running VI
Get Color Tool		Copy colors for pasting with the Color Tool
Coloring Tool		Set the foreground and background colors

http://www.ni.com/pdf/manuals/376039a.pdf

NATIONAL INSTRUMENTS LabVIEW

DAQ

Hans-Petter Halvorsen, M.Sc.

DAQ Hardware Examples

NI TC-01 Thermocouple Temperature Measurements

NI USB-6008 I/O Module

We will use this device

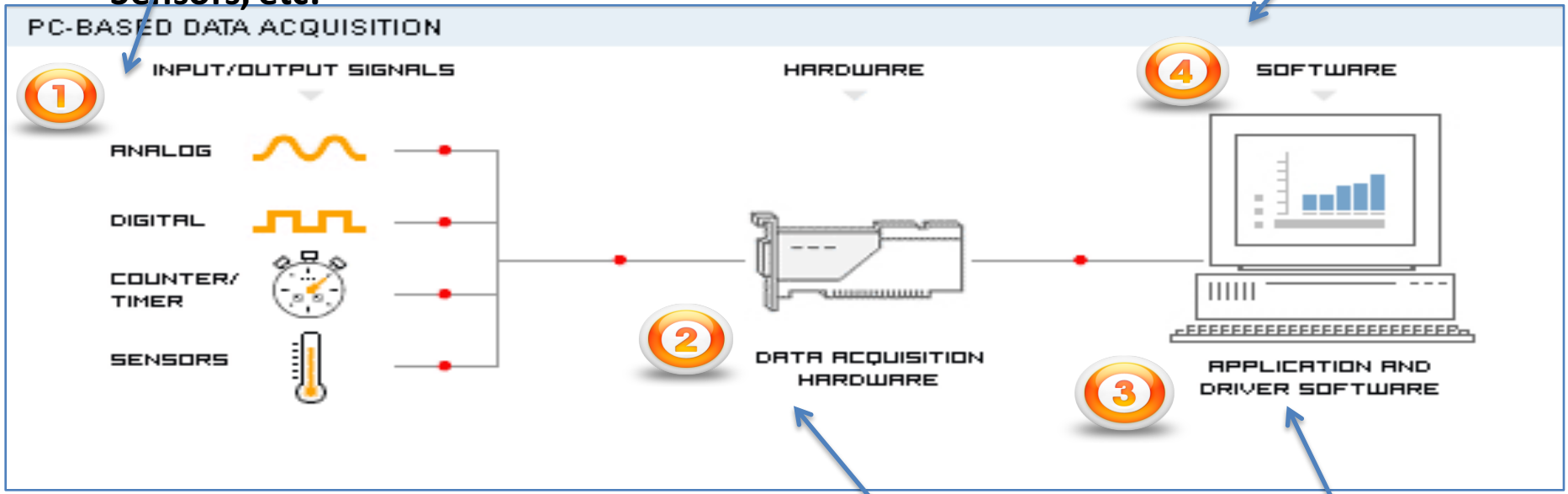
Analog/Digital Inputs/Outputs

Note! The **DAQmx** Driver is needed in order to use them inside LabVIEW!!

DAQ – Data Acquisition

Your App created with LabVIEW

Sensors, etc.



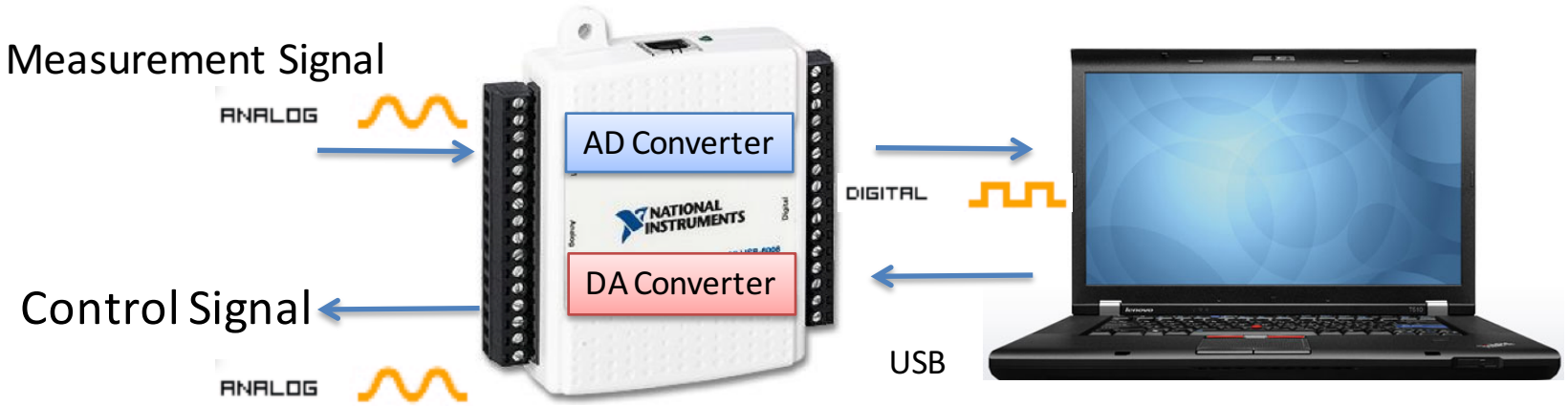
A DAQ System consists of 4 parts:

1. Physical input/output signals, sensors
2. DAQ device/hardware
3. Driver software
4. Your software application (Application software)

NI TC-01 Thermocouple Device
or
NI USB 6008 DAQ Device

NI DAQmx Driver

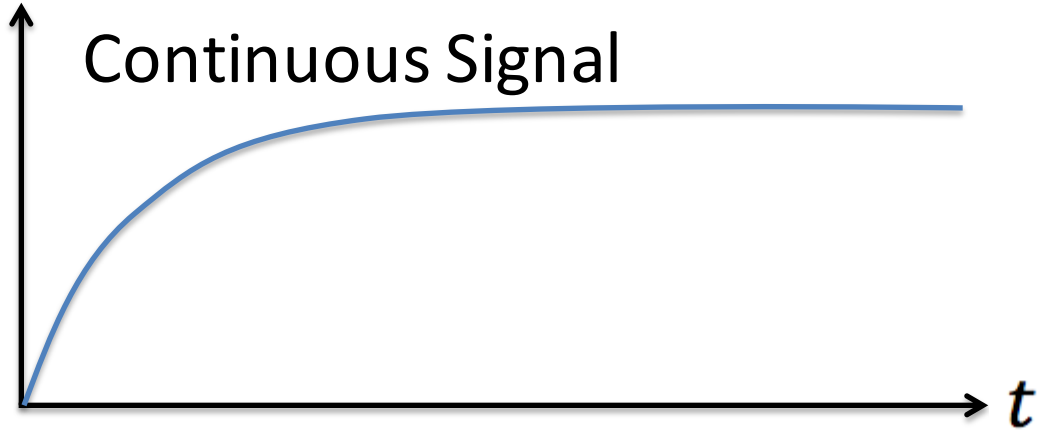
AD & DA Converters

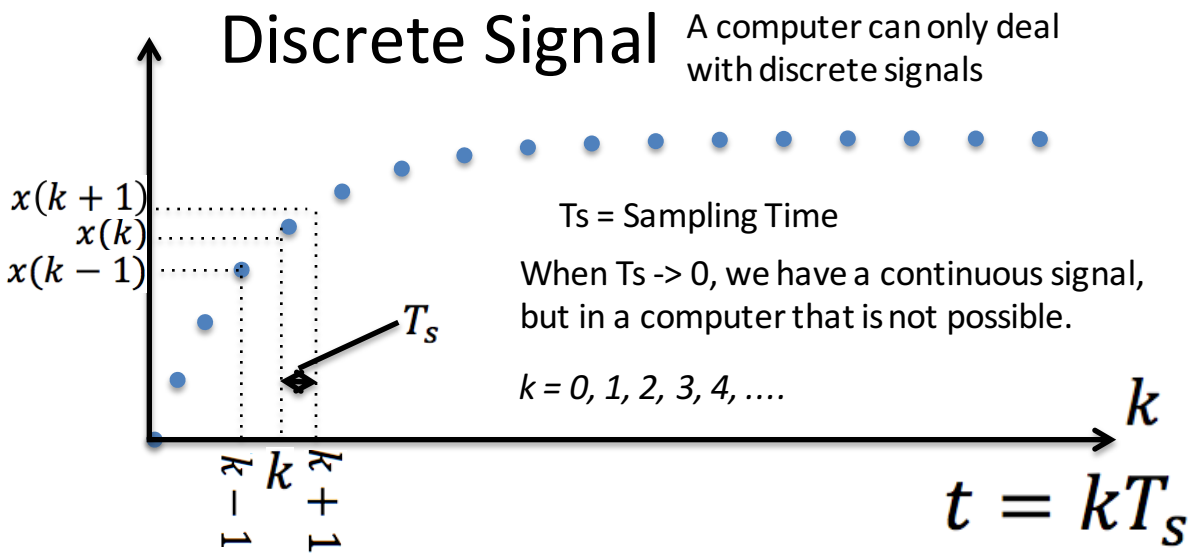


AD – Analog to Digital
DA – Digital to Analog

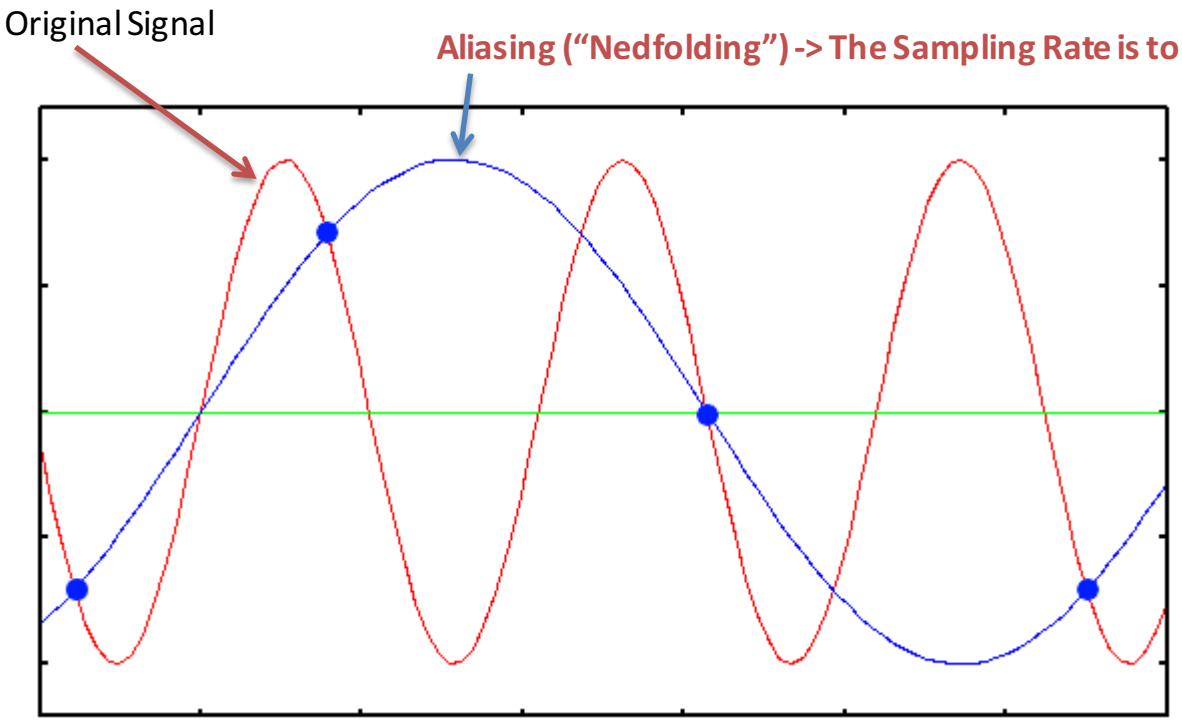
All Analog Signals needs to be converted to Digital Signals before the Computer can use them (AD Converter).

Continuous vs. Discrete Signals





Sampling and Aliasing



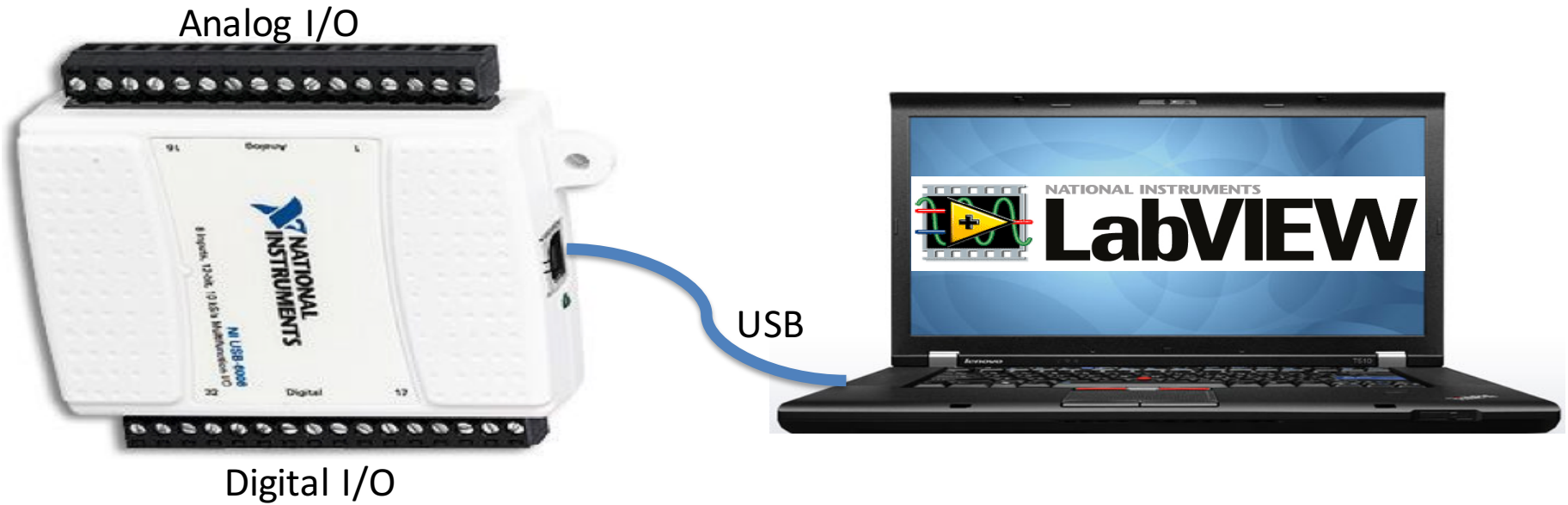
Using USB-6008 in LabVIEW

Hans-Petter Halvorsen, M.Sc.

Høgskolen i Telemark

USB-6008

How-To use USB-6008 with LabVIEW



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NI USB-6008 I/O Module

USB Connection

Note! **DAQmx** Driver is needed!!

Specifications:

-10-10V

- **8 analog inputs**, AI (12-bit, 10 kS/s, -10-10V)
- **2 analog outputs**, AO (12-bit, 150 S/s, 0-5V)
- **12 digital I/O** (DI/DO)
- 32-bit counter

0-5V

4 different types of Signals:

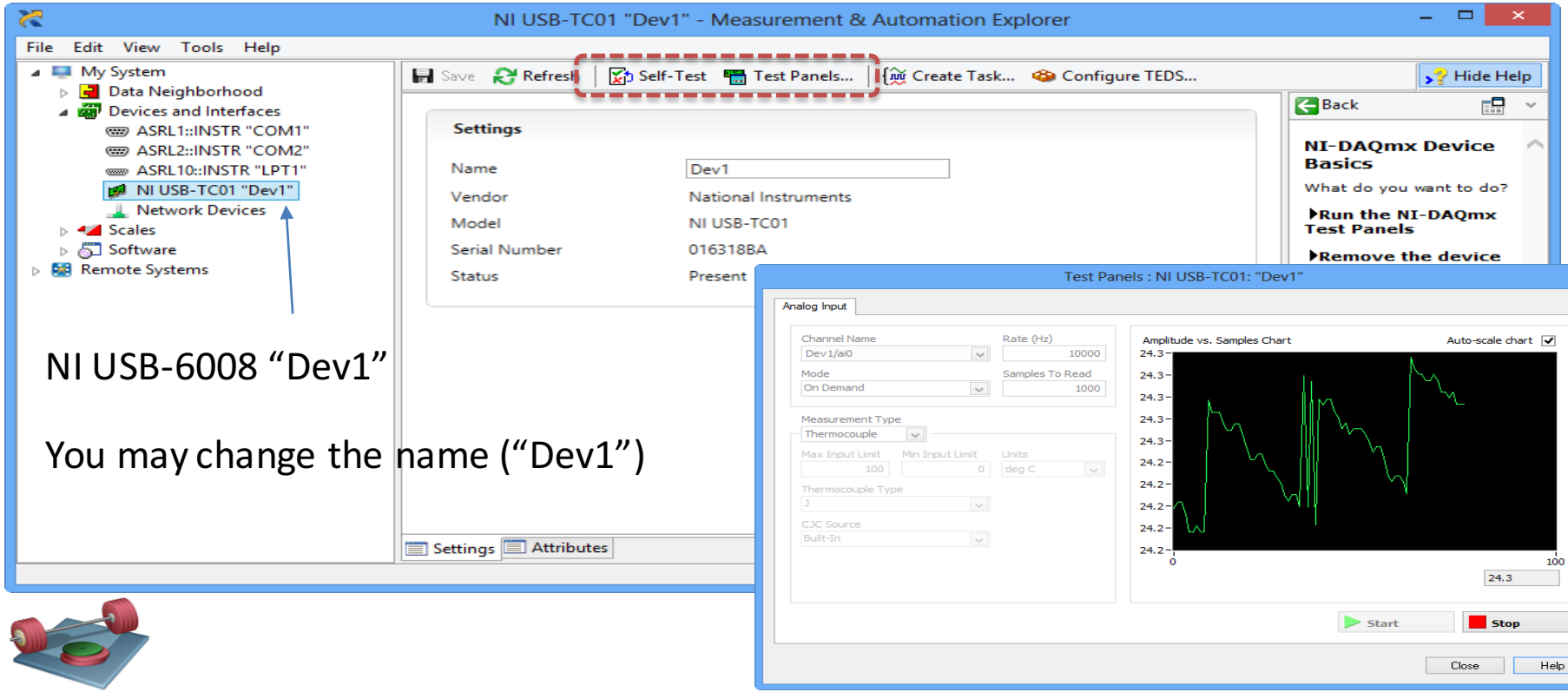
AO – Analog Output

AI – Analog Input

DO – Digital Output

DI – Digital Input

MAX – Measurement & Automation Explorer



NI USB-6008 “Dev1”

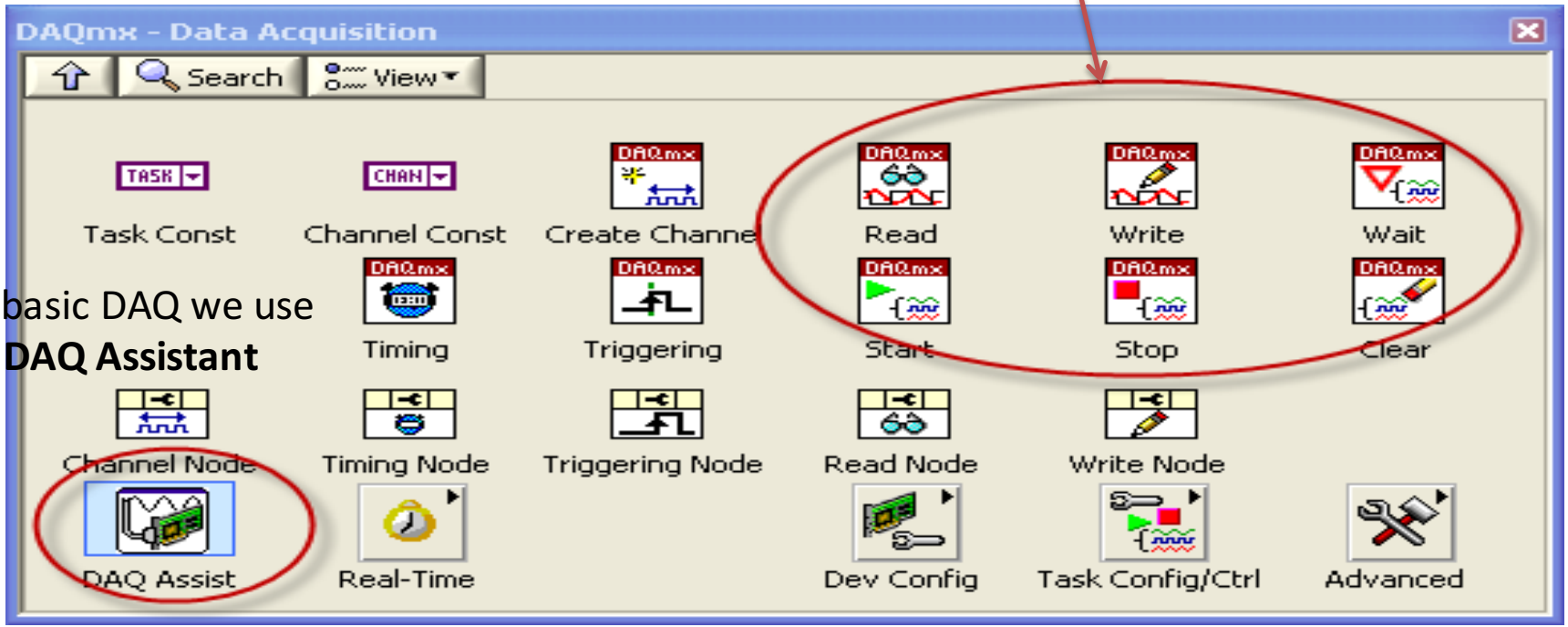
You may change the name (“Dev1”)

Students: Make sure that your device can be located in MAX. Run a “Self-Test” and use the “Test Panels” to make sure the device works properly.

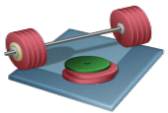
Data Acquisition Palette in LabVIEW

Functions Palette: “Measurement I/O” -> “NI DAQmx”

For more “advanced” DAQ we use these functions



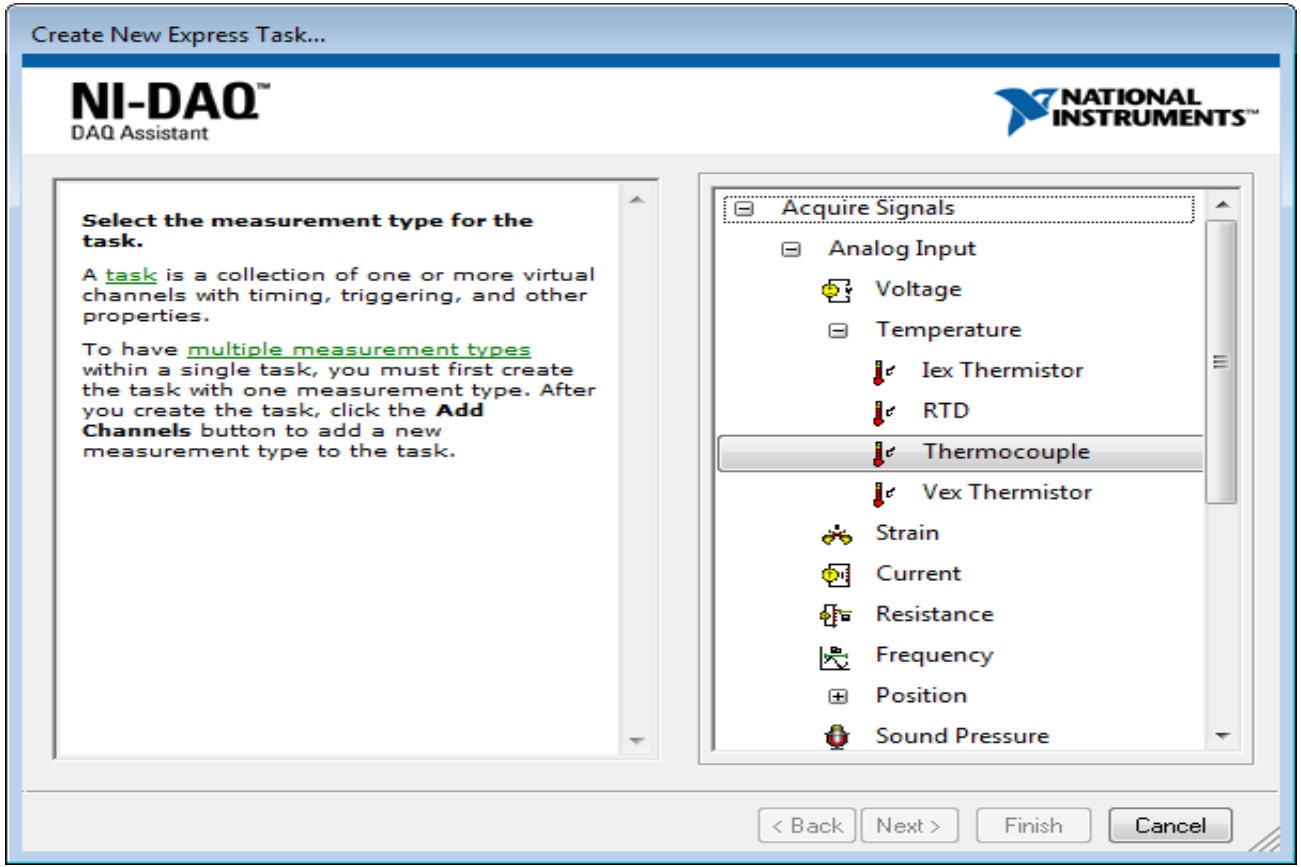
For basic DAQ we use the **DAQ Assistant**



Students: Make sure that you have this palette installed. If not, install the latest **DAQmx** driver!

LabVIEW DAQ Assistant

When you place the DAQ Assistant on the Block Diagram, a Wizard automatically pops up where you configure what you want to do, i.e., if you want to Read or Write Data, Analog or Digital signals, which channel you want to use, etc.



NATIONAL INSTRUMENTS LabVIEW

Analog In

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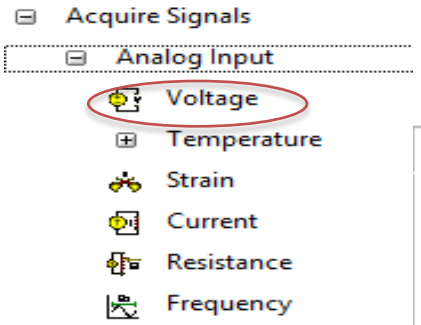
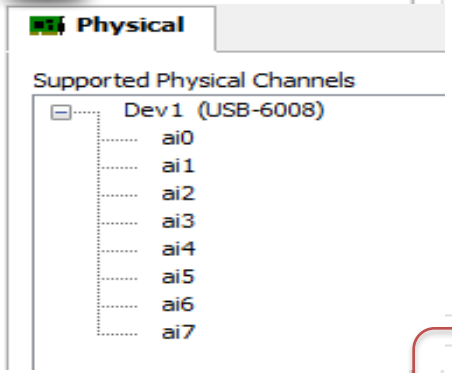
AI Settings in DAQ Assistant

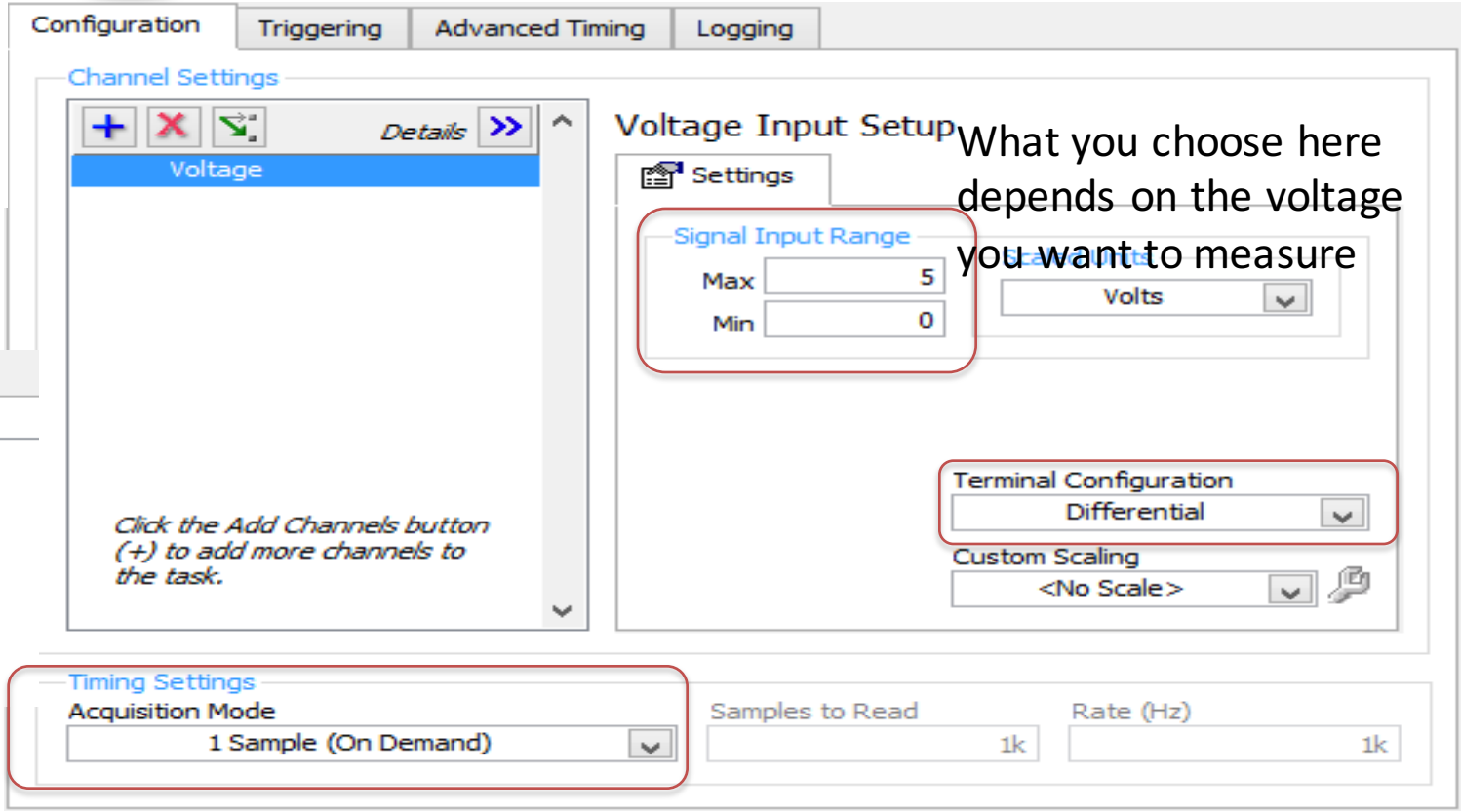
1 Type of Signals



2 Channel

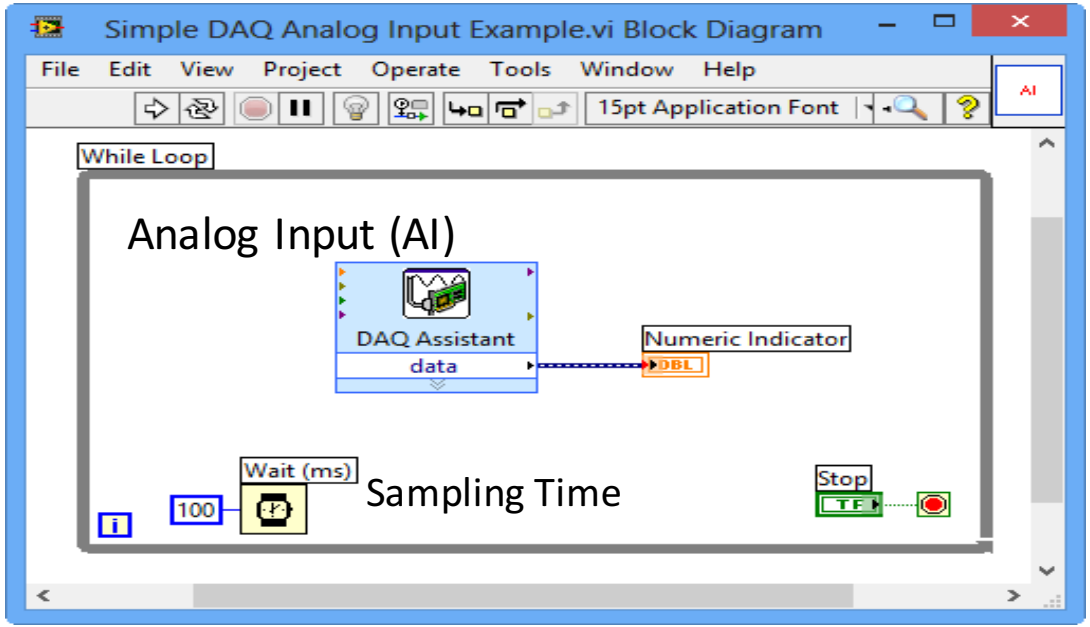


3 Properties

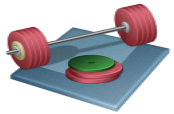


What you choose here depends on the voltage you want to measure

Read Analog Signals with USB-6008



Multimeter



Students: Use the USB-6008 DAQ device in order to read the voltage from different batteries. Use a Multimeter to check if you read the correct values.
Measure 5-10 different batteries. Use LabVIEW to find the average.

NATIONAL INSTRUMENTS LabVIEW

Analog Out

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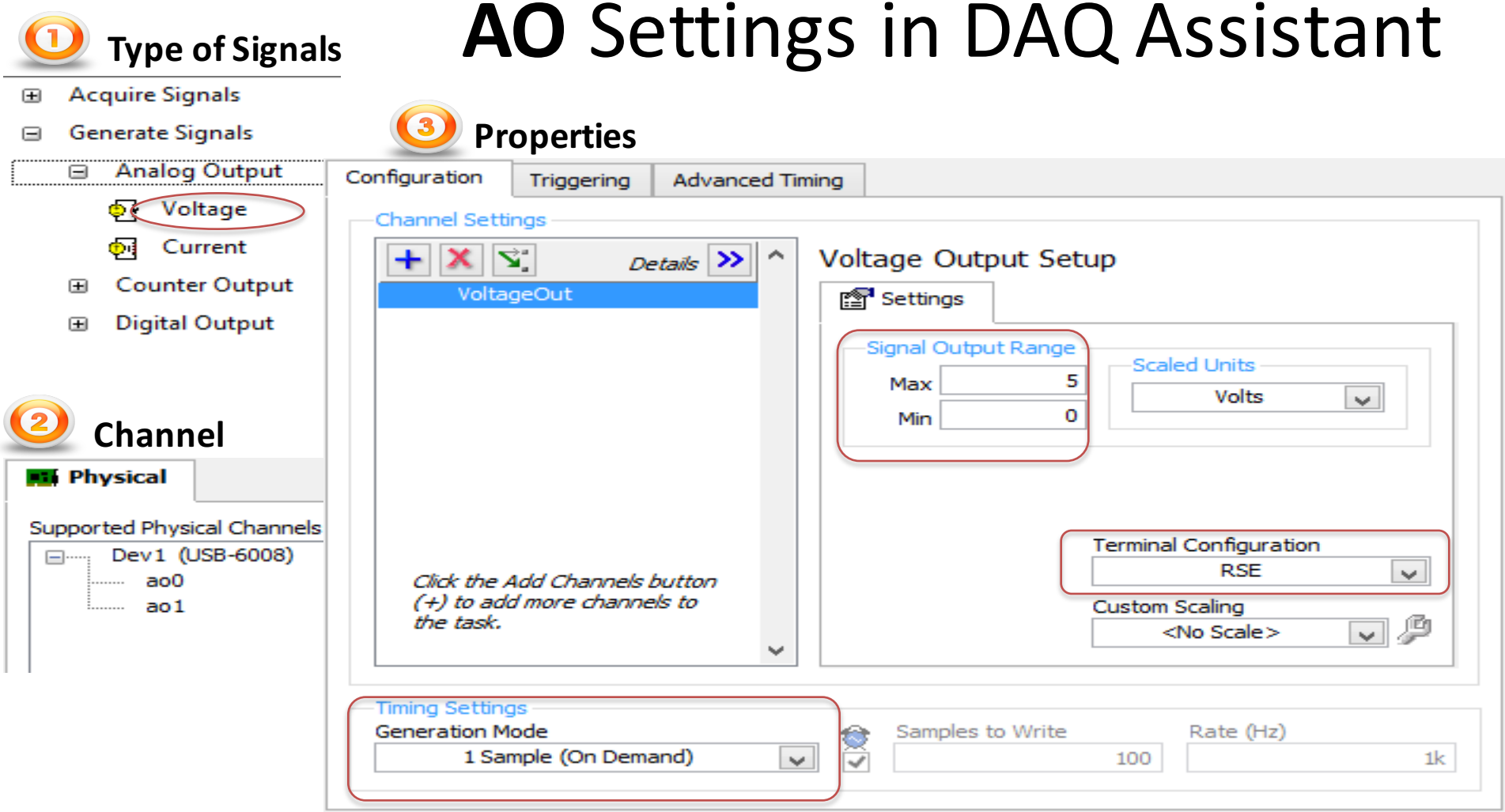
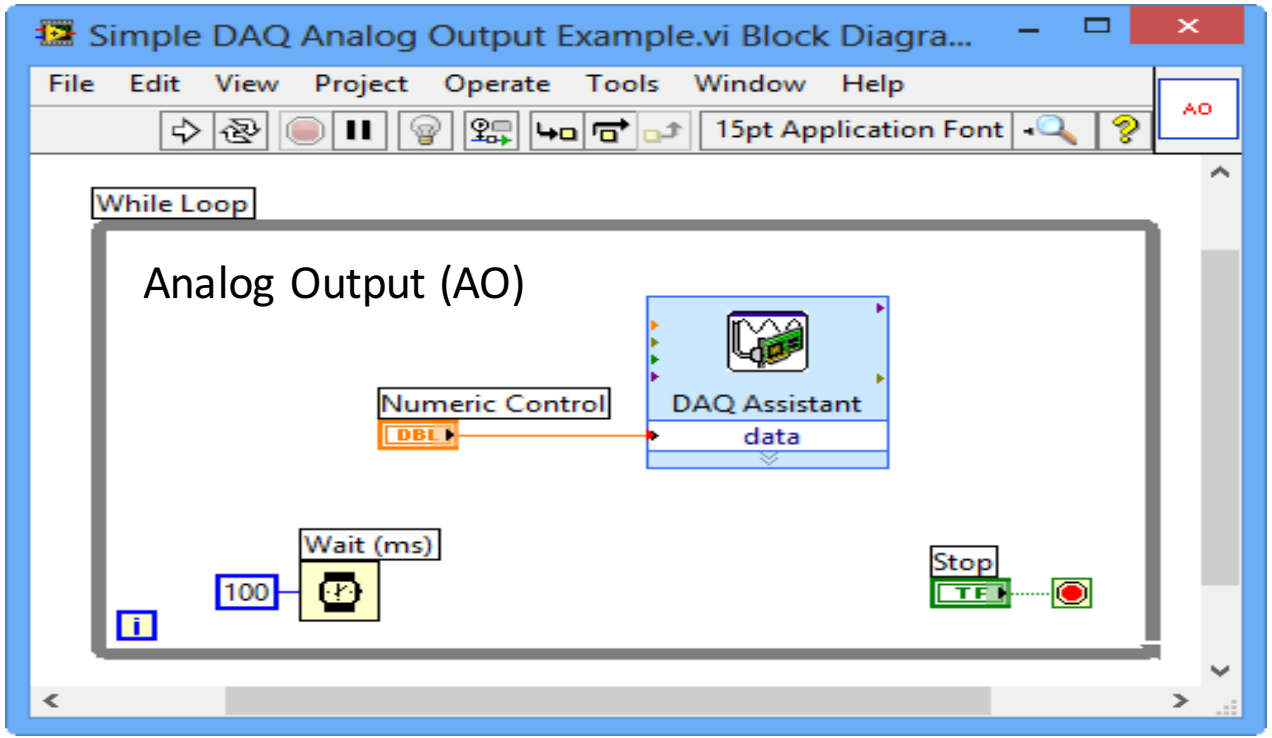
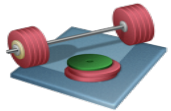
AO Settings in DAQ Assistant



Write Analog Signals using USB-6008



Multimeter



Students: Create this VI. Set different values on the Front Panel. Use a Multimeter to see if the DAQ device sends out the correct voltage signal.

NATIONAL INSTRUMENTS LabVIEW

Analog In + Analog Out

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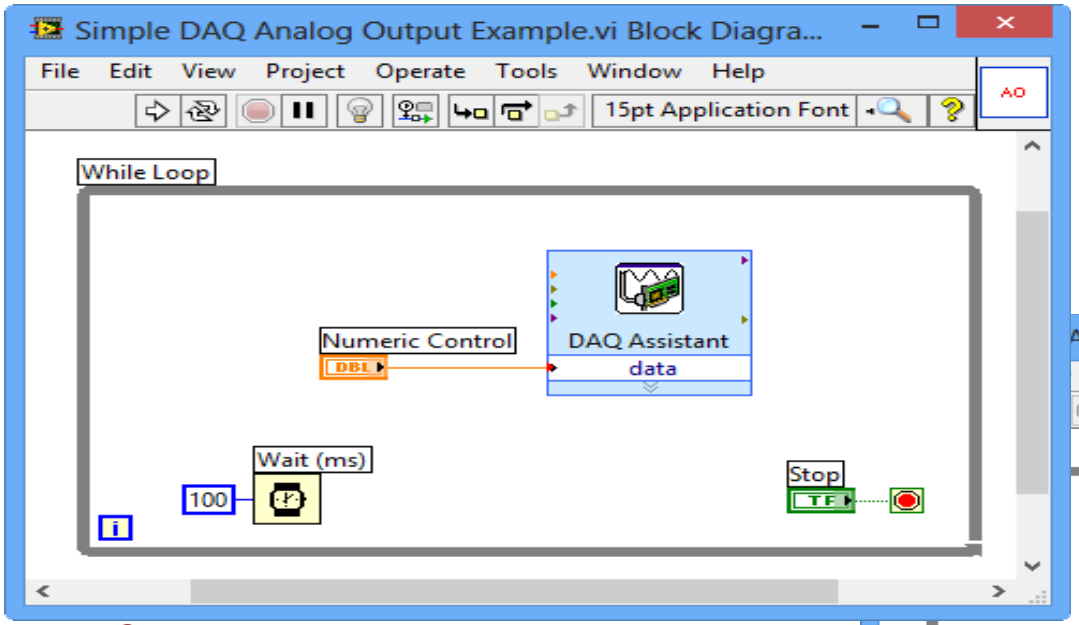
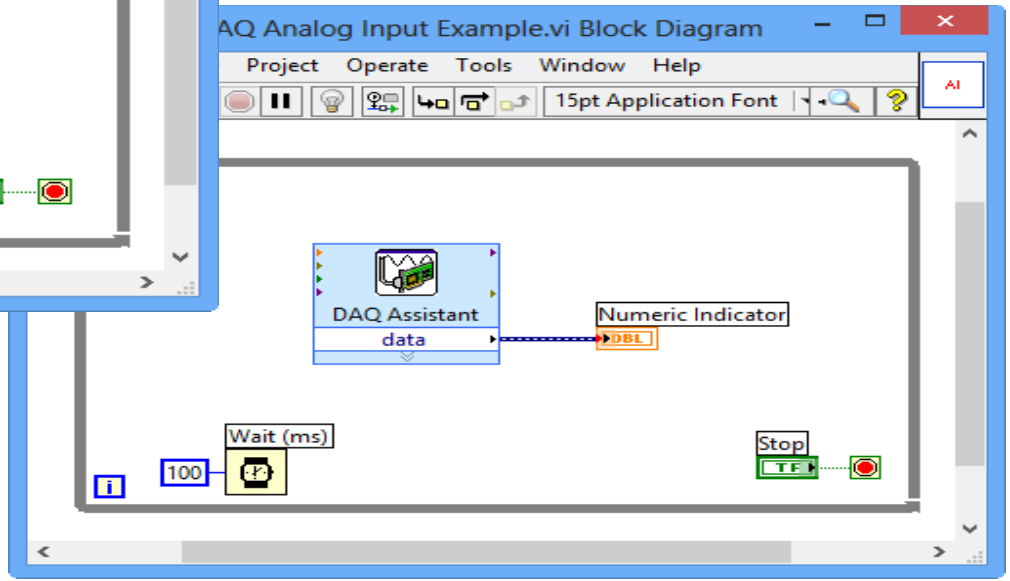
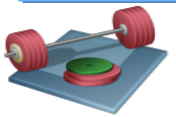
Write/Read Data using USB-6008

Analog Output (AO)



Analog Input (AI)

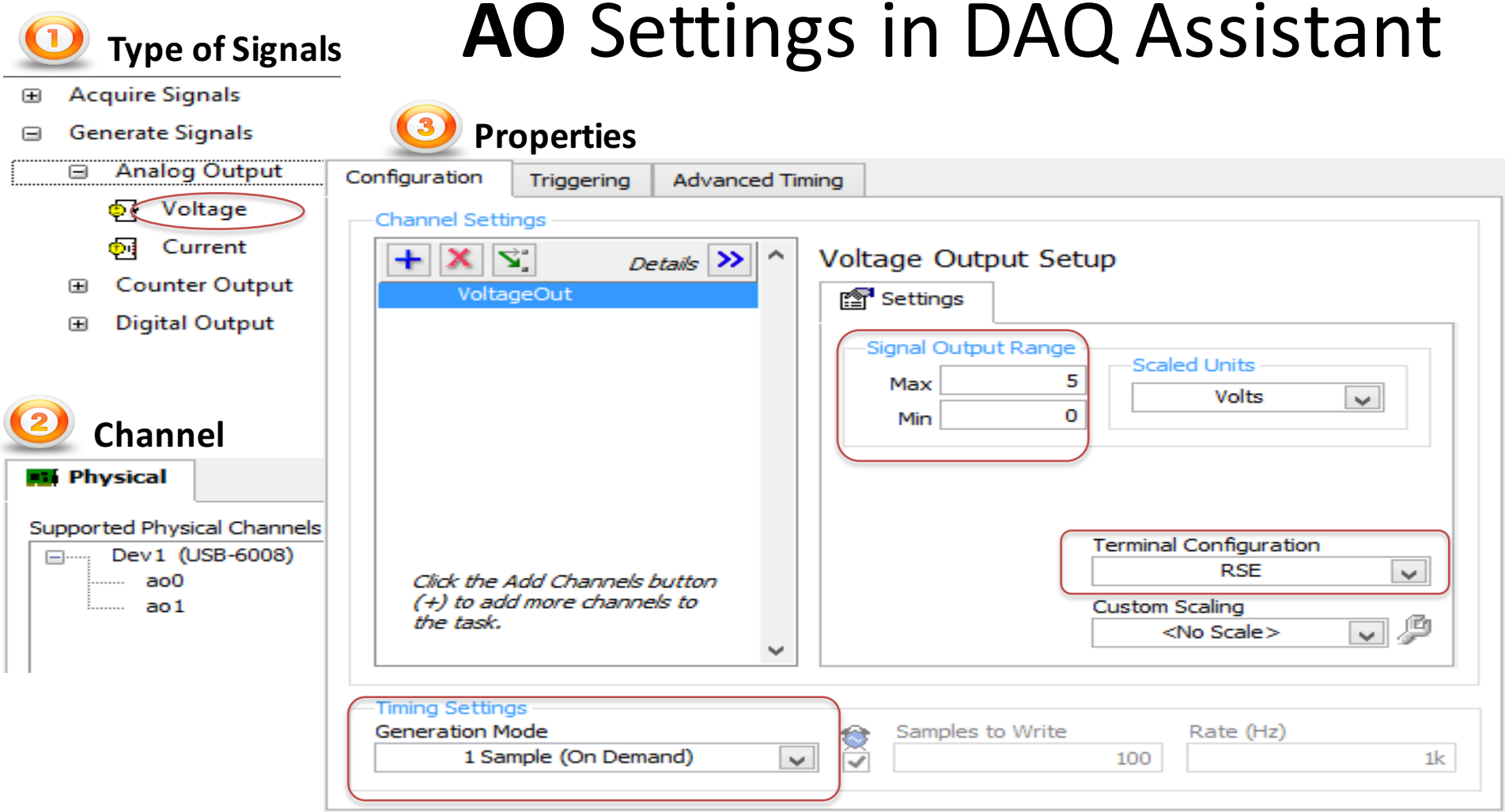




Students: Create these 2 VIs and run them simultaneously

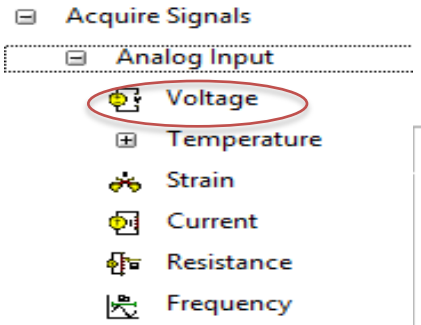
Connect the cables from Analog Output to the cables for Analog Input (so-called “Loopback Test”)

AO Settings in DAQ Assistant

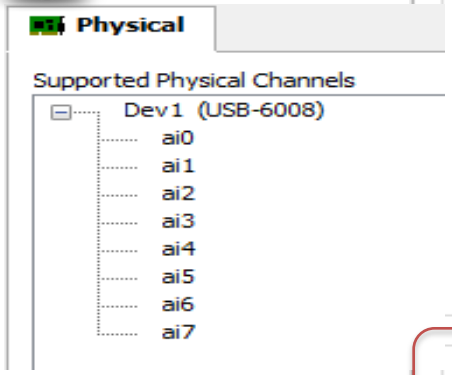


AI Settings in DAQ Assistant

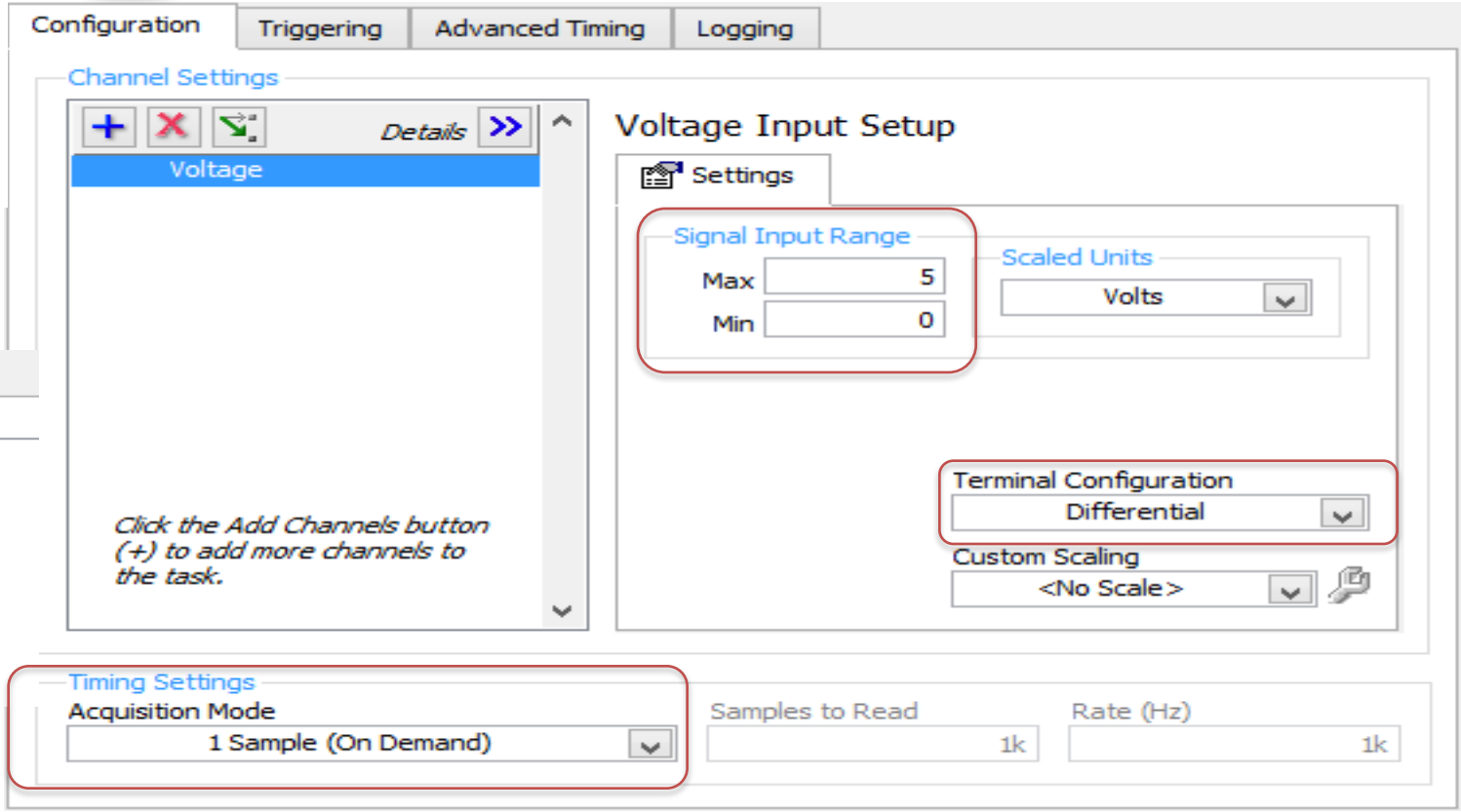
1 Type of Signals



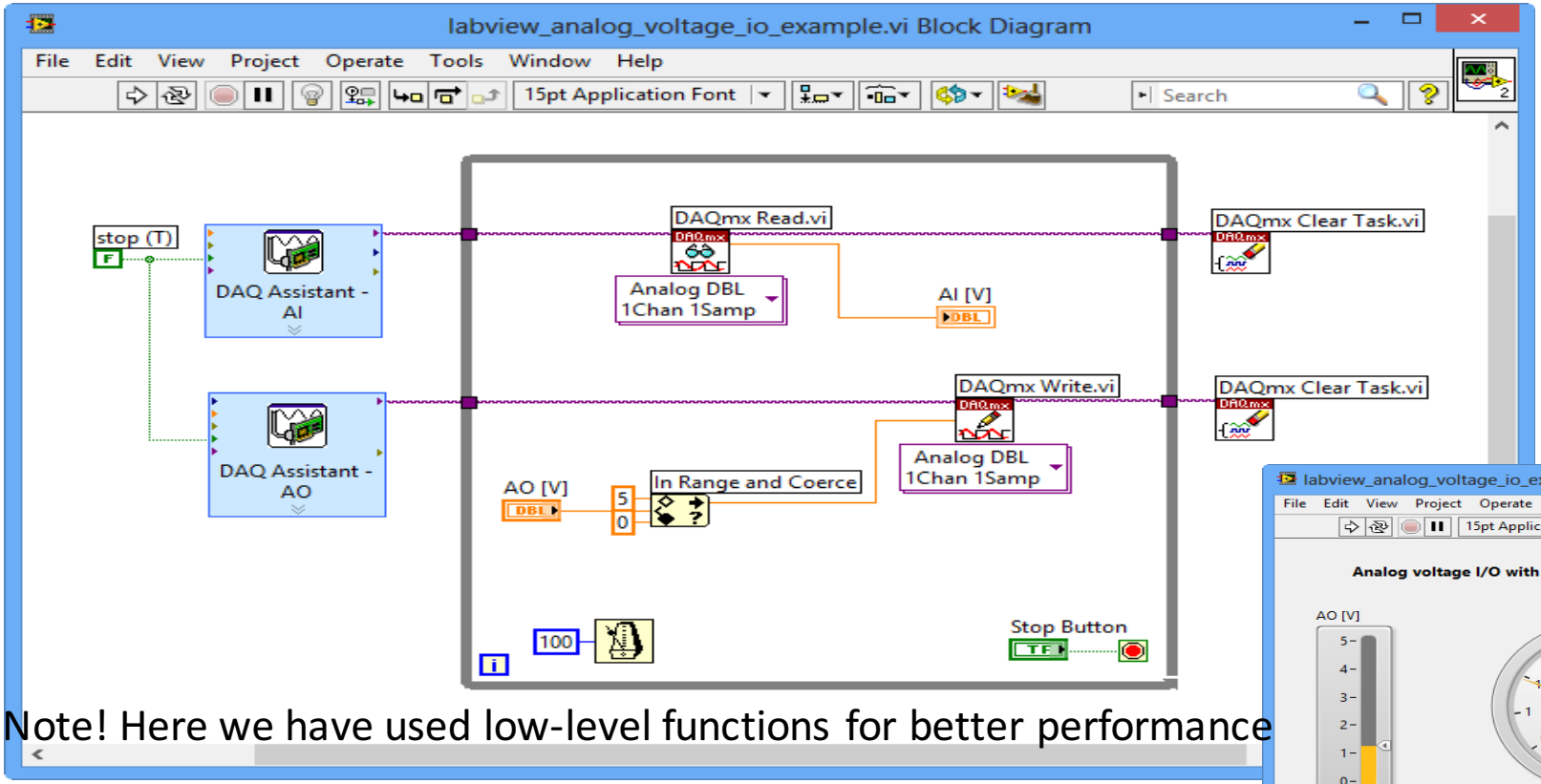
2 Channel



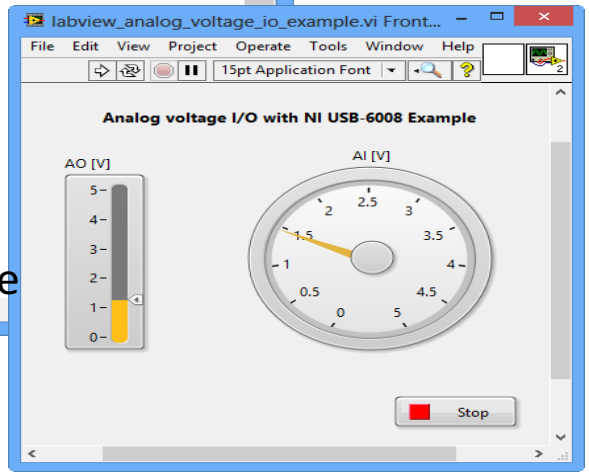
3 Properties

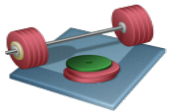


Analog In + Analog Out in same VI



Note! Here we have used low-level functions for better performance





Students: Create this Example

NATIONAL INSTRUMENTS LabVIEW

Datalogging

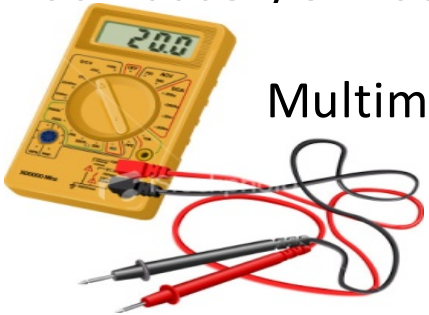
(You may skip this part)

Hans-Petter Halvorsen, M.Sc.

Datalogging

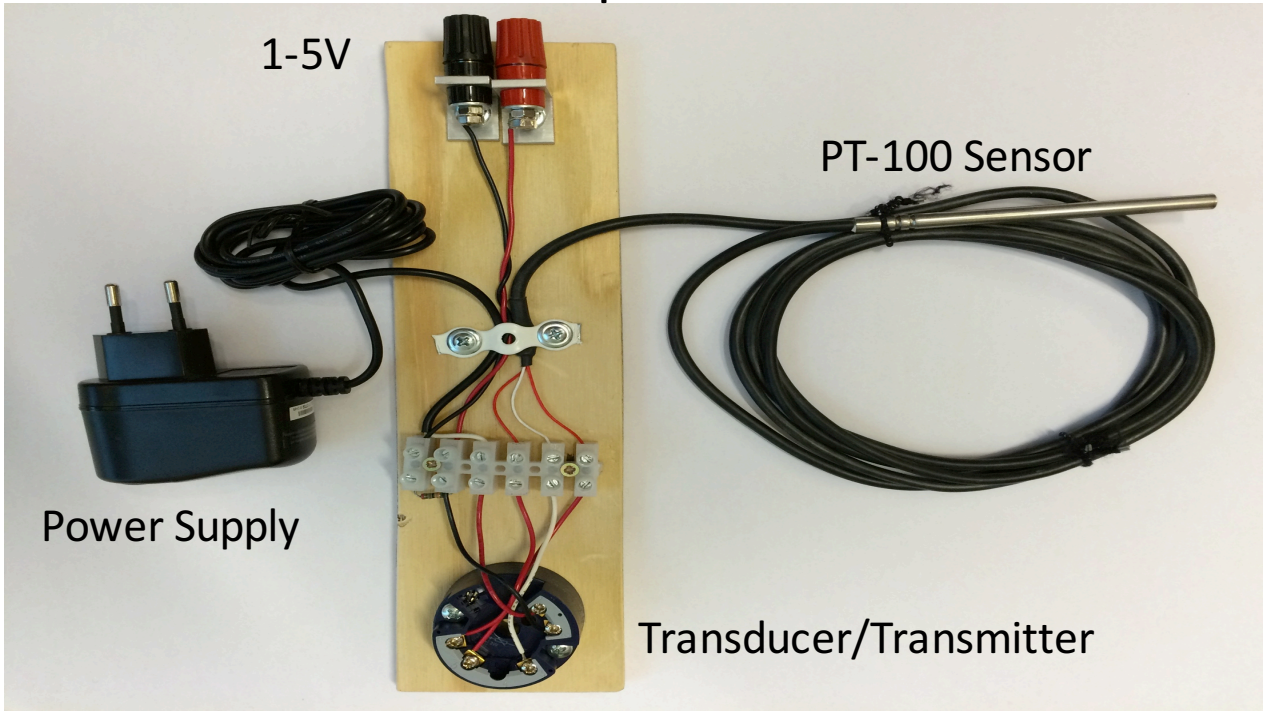
Here we will connect a PT-100 Temperature Sensor to the USB-6008 device in order to log temperature data. We will plot data and save data to a File.

USB-6008 I/O Module



Multimeter

PT-100 Temperature Sensor

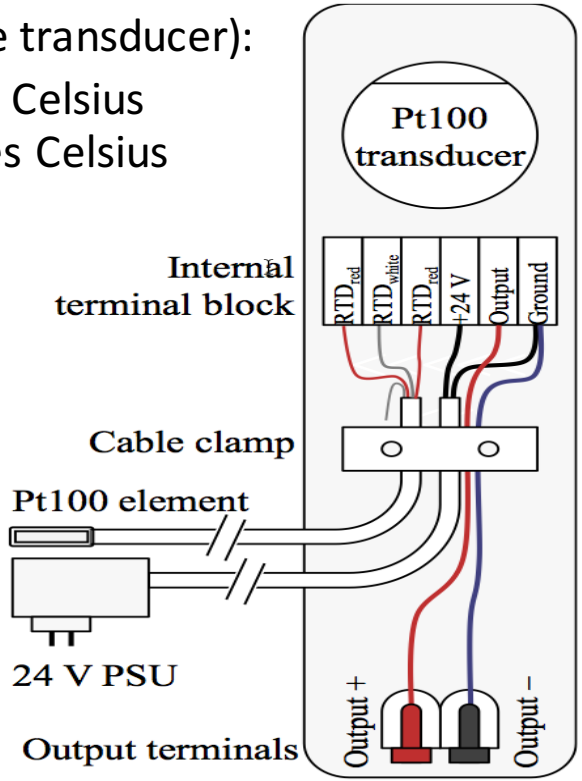


PT-100 Temperature Sensor

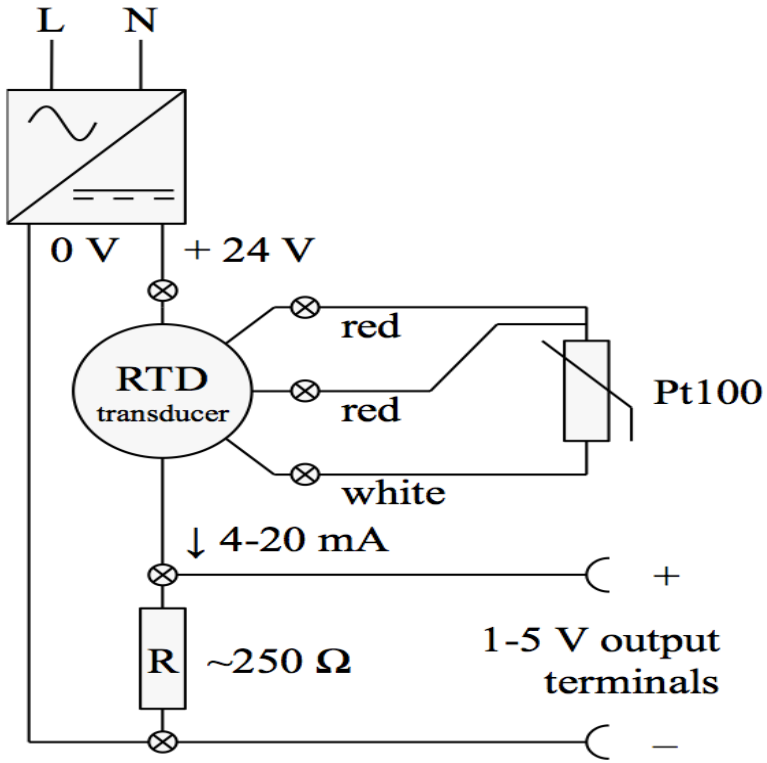
2 different types (see transducer):

1-5V -> 0-50 degrees Celsius

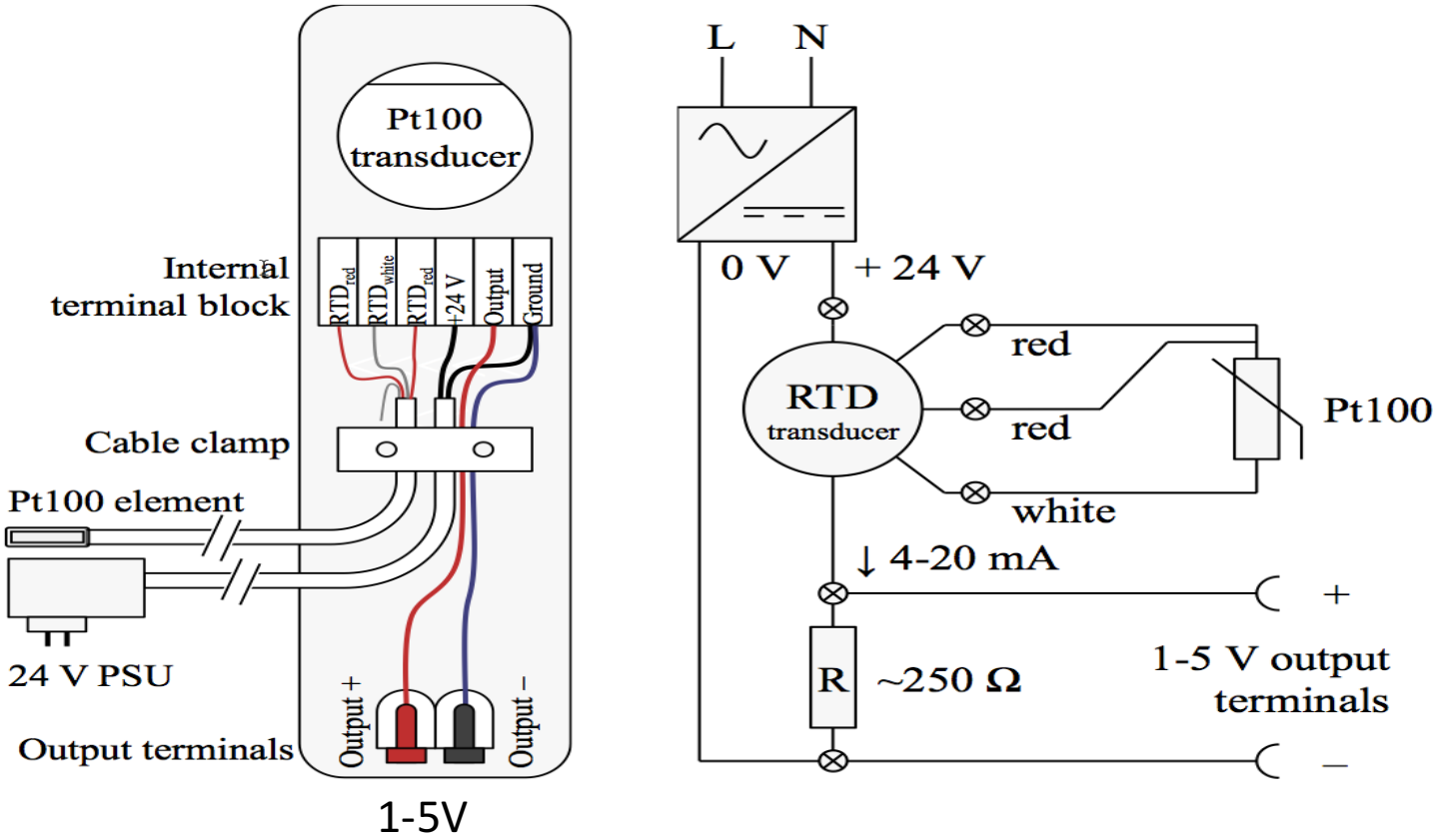
1-5V -> 0-100 degrees Celsius



1-5V

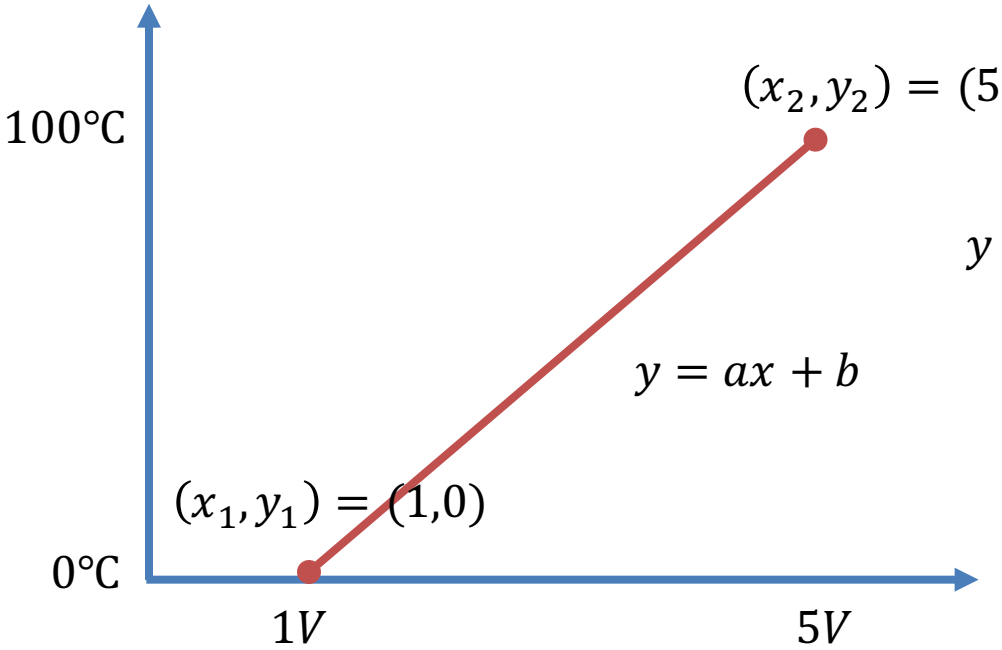


PT-100 Temperature Sensor



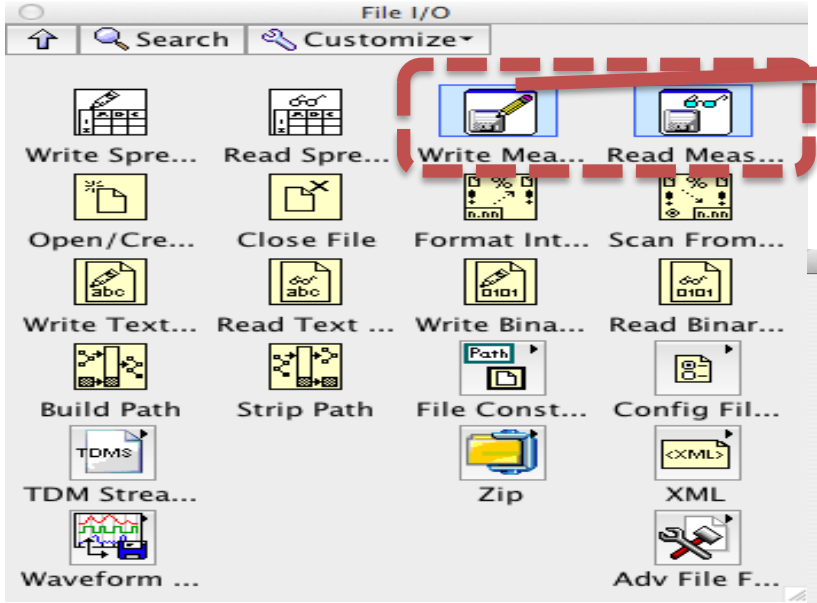
PT-100 Temperature Sensor

Converting from Voltage to Degrees Celsius

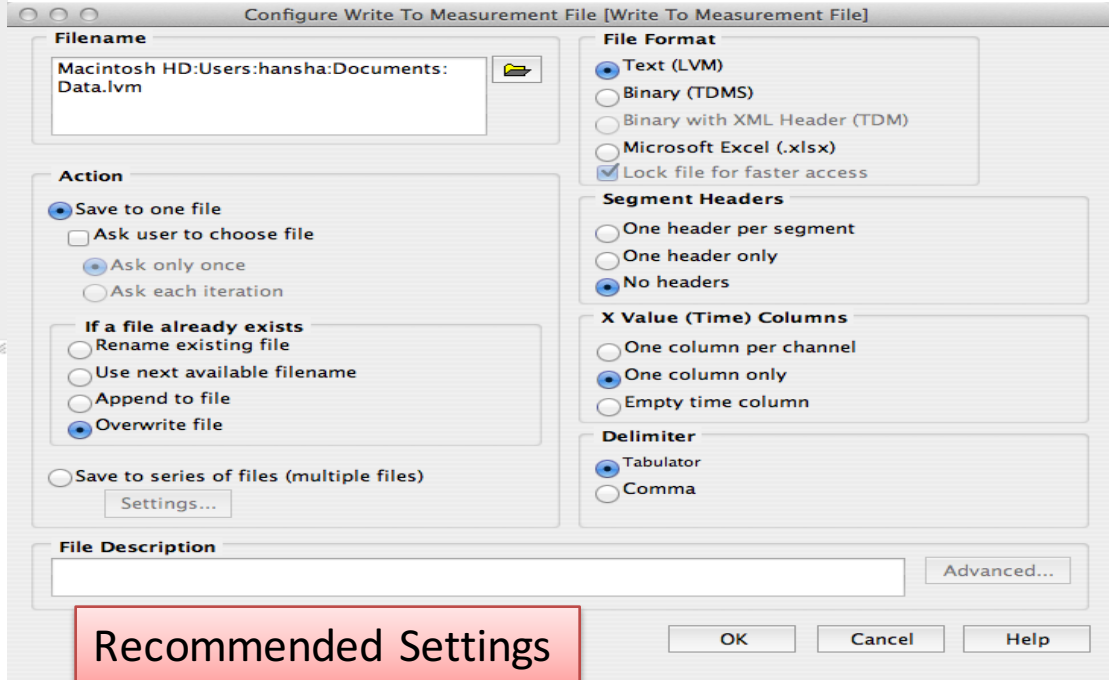


$$y - y_1 = \frac{y_2 - y_1}{x_2 - x_1}(x - x_1)$$

Save Data to File (Datalogging)

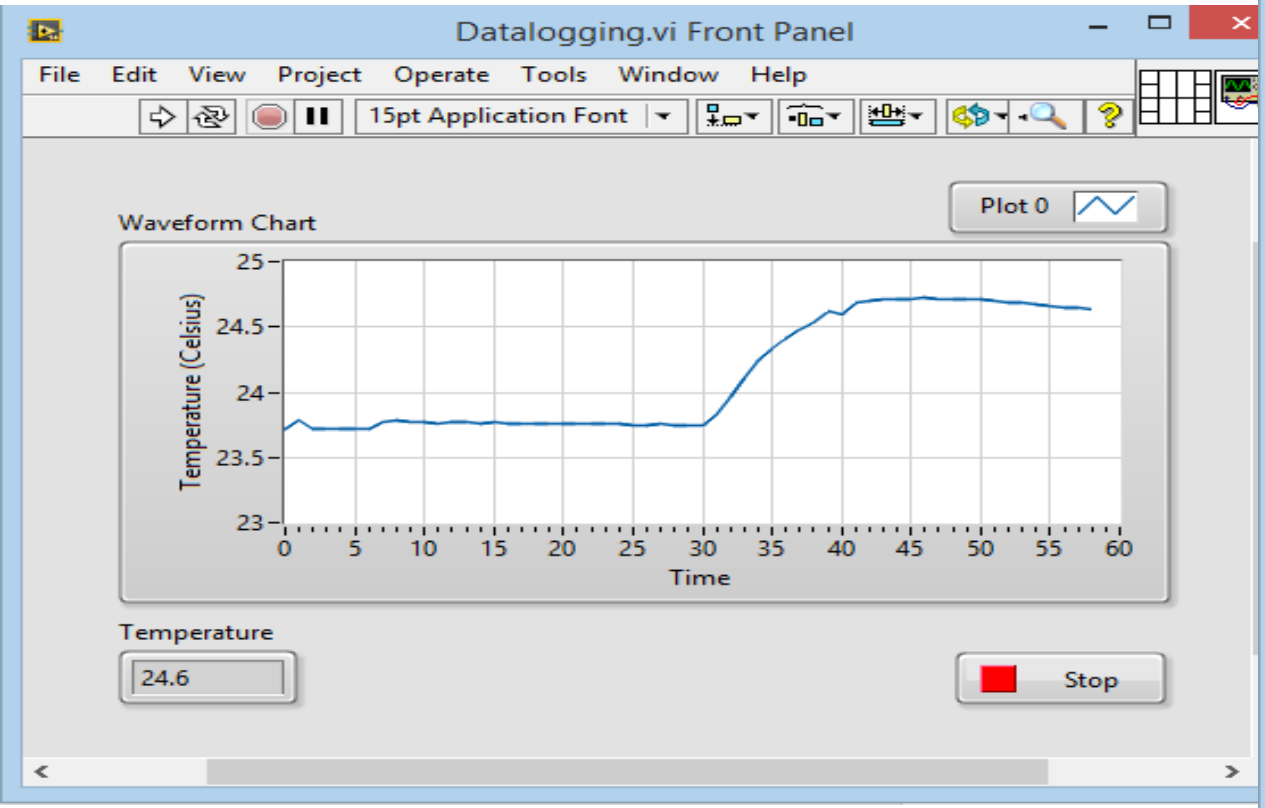


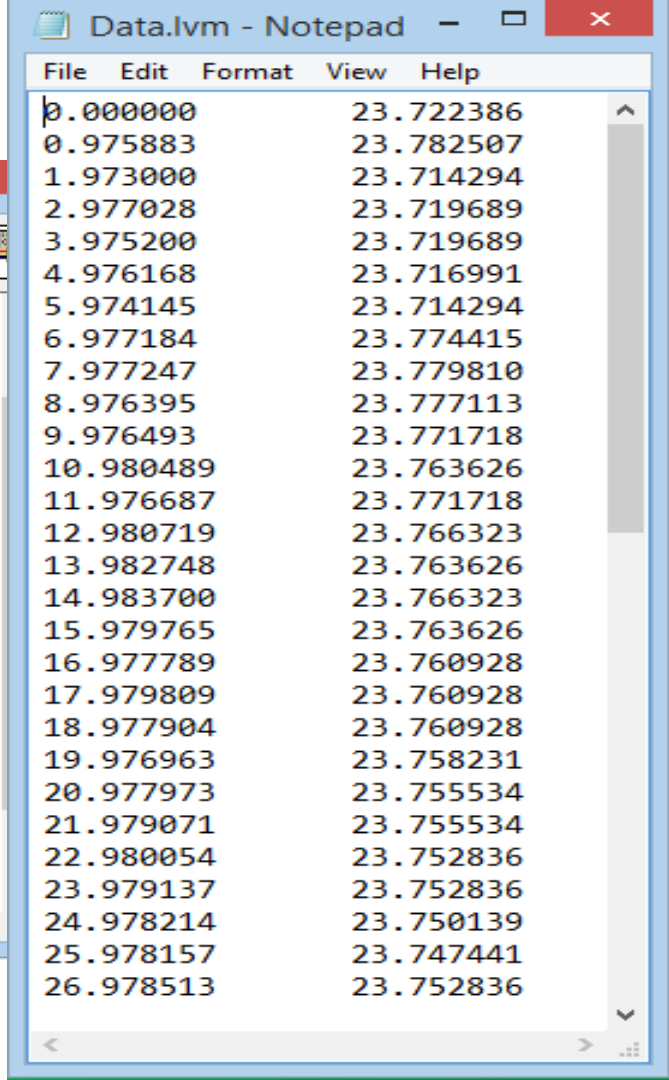
Right-click-Properties



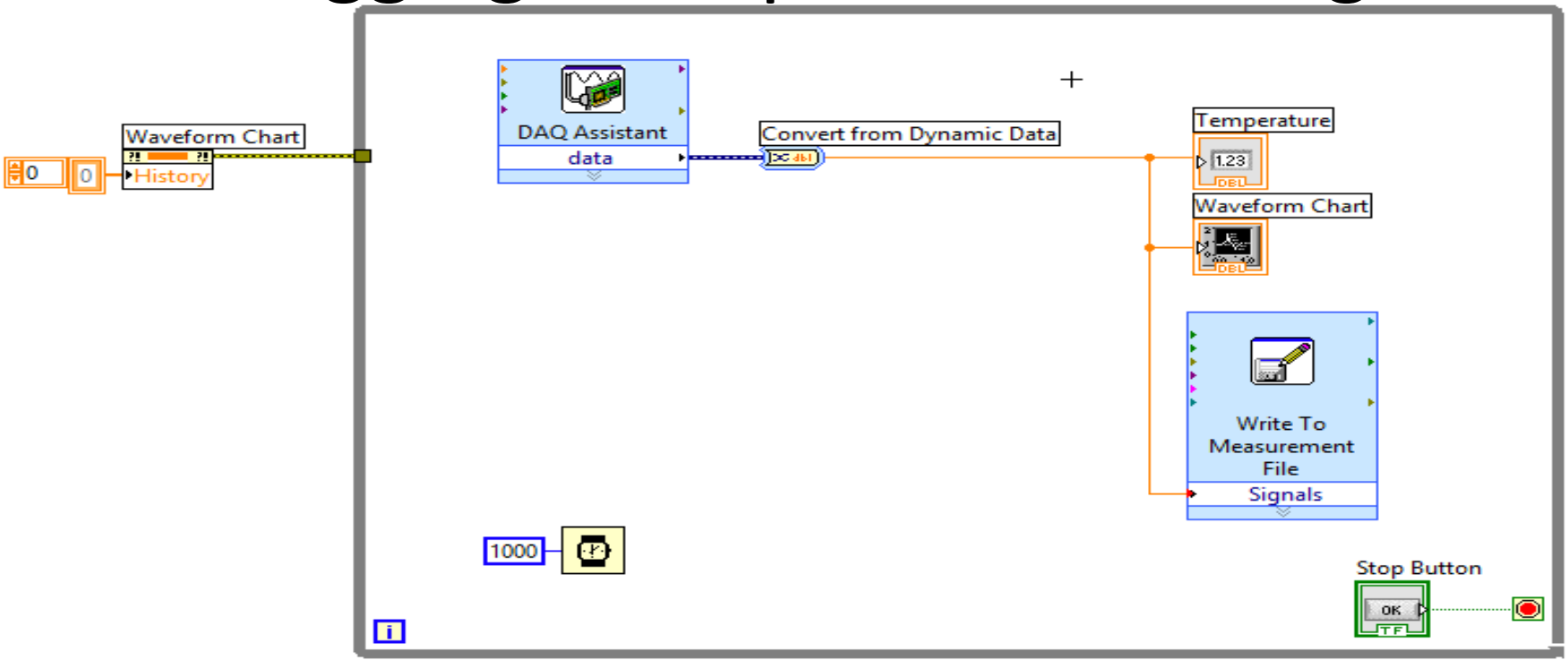
Recommended Settings

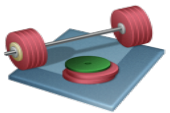
Datalogging Example





Datalogging Example – Block Diagram





Students: **(1)** Log Temperature Data, both Celsius and Fahrenheit (use SubVI) to a "Measurement File". **(2)** Use a Multimeter in order to check the values in the circuit. **(3)** Then Plot the Data in the File in Excel. **(4)** You should also create a new VI in LabVIEW where you plot the data from the File in a Graph

NATIONAL INSTRUMENTS LabVIEW

Measurement Filter

(You may skip this part)

Hans-Petter Halvorsen, M.Sc.

Lowpass Filter/Measurement Filter

The measured signals contains noise, so we should remove the noise using a Filter

The differential equation for a Measurement filter may be given as:

$$T_f \dot{y}_{mf}(t) = y_m(t) - y_{mf}(t)$$

Since we shall implement the Measurement Filter in a computer, we need to make a dicrete version of the filter. We use the Euler Backward discretization method:

$$\dot{x} \approx \frac{x(t_k) - x(t_{k-1})}{T_s}$$

Where Ts is the Sampling Time

Then we get:

$$y_{mf}(t_k) = \frac{T_f}{T_f + T_s} y_{mf}(t_{k-1}) + \frac{T_s}{T_f + T_s} y_m(t_k)$$

Or:

$$y_{mf}(t_k) = (1 - a) y_{mf}(t_{k-1}) + a y_m(t_k)$$

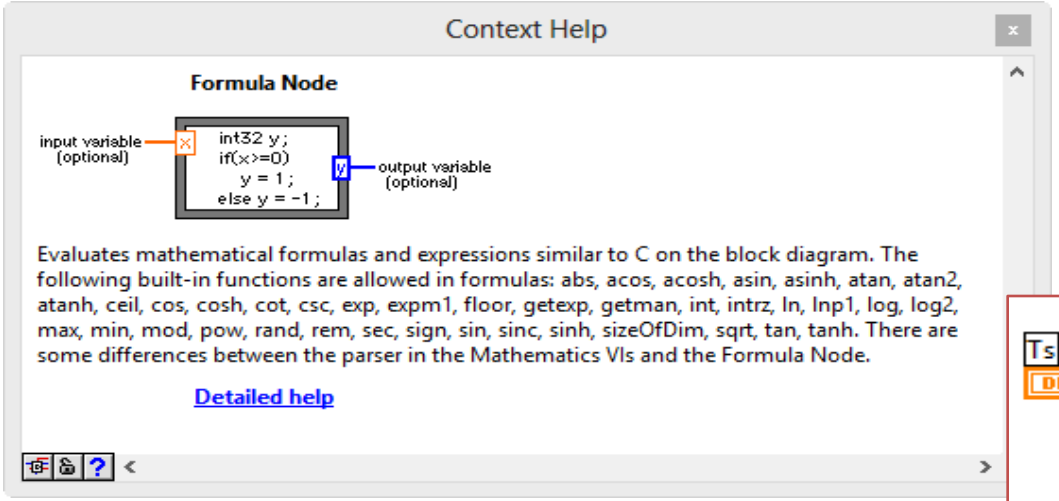
where

$$a = \frac{T_s}{T_f + T_s}$$

This discrete Measurement Filter can be easily implemented in a computer using e.g., LabVIEW, C#, etc.

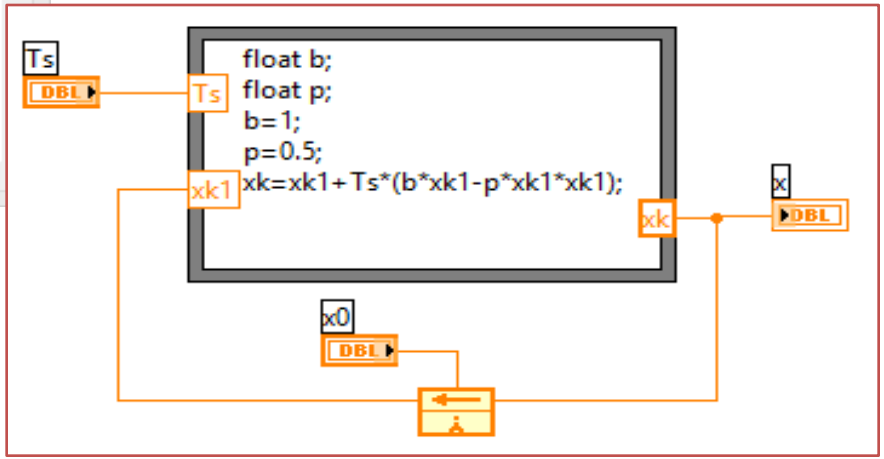
$$T_s \leq \frac{T_f}{5}$$

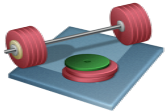
LabVIEW Formula Node



Formula Node: Create and use C code within LabVIEW

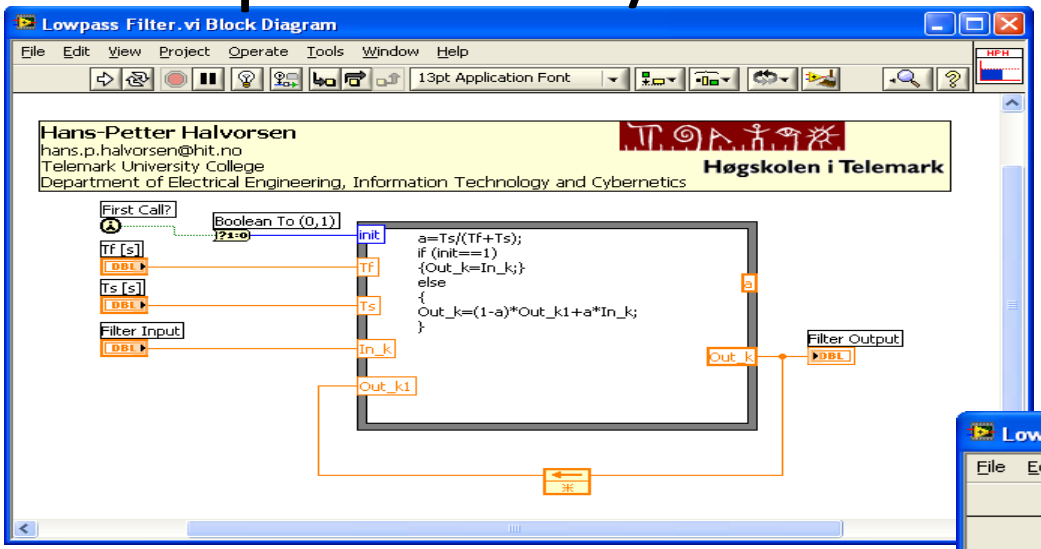
Example:

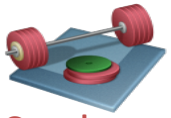




Students: Use the LabVIEW Formula Node.
in order to implement the Measurement Filter.

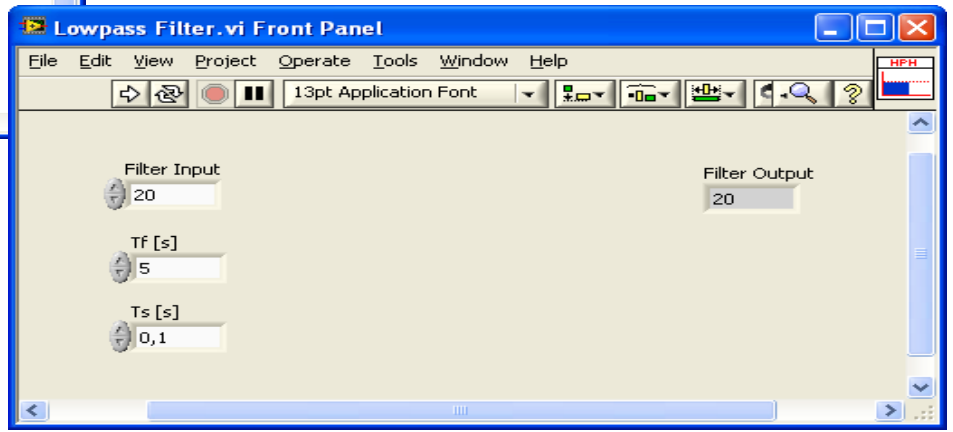
Lowpass Filter/Measurement Filter - Example





Students: Implement this Example using a LabVIEW Formula Node.

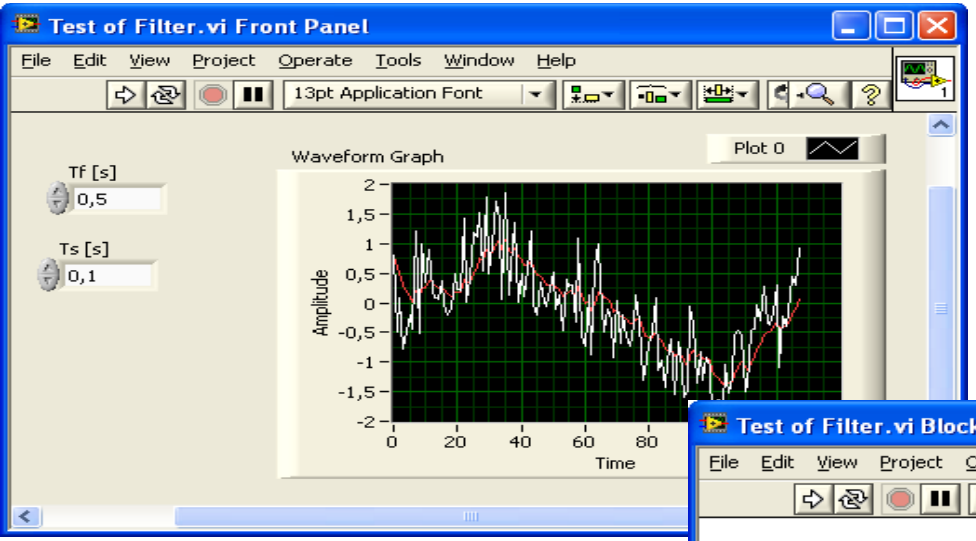
When finished, try to log data from your sensor with and without the Measurement Filter. Compare the results.



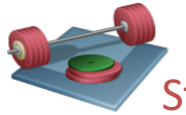
$$a = \frac{T_s}{T_f + T_s}$$

$$y_{mf}(t_k) = (1-a)y_{mf}(t_{k-1}) + a y_m(t_k)$$

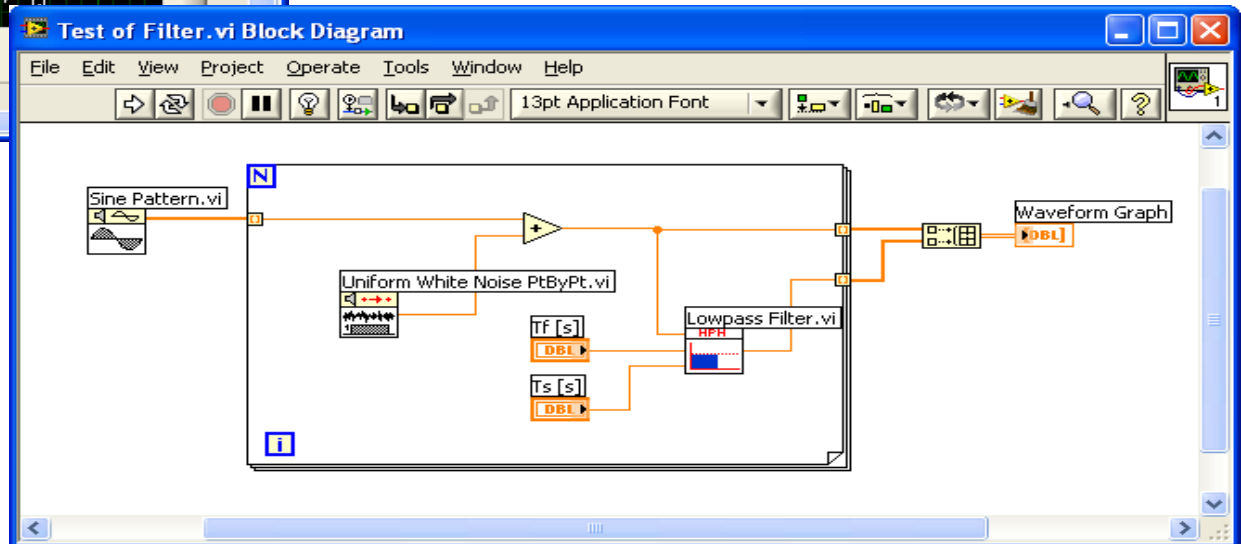
Testing the Filter



In this example we add noise to a Sine function. We then use the Measurement Filter to see if we can remove the noise afterwards.



Students: Try this Example.



As you can see this gives good results.
The filter removes the noise from the signal.

Additional LabVIEW Resources

Here you will find lots of Videos, Tutorials and Exercises

- LabVIEW Training for Students (National Instruments):

http://ni.com/students/learnlabview

- LabVIEW Course:
http://home.hit.no/~hansha/?training=labview

Learning by Doing!

It is recommended that you watch some of the videos before you read furter

NATIONAL INSTRUMENTS LabVIEW

Do you need more Practice? - Select a Challenge

Hans-Petter Halvorsen, M.Sc.

Temperature Logging

1. Create Logging App:

- Log the temperature in your house e.g., during the night using e.g, a TC-01 Thermocouple device.
- Plot the temperature in a Chart
- Log the temperature to a File

2. Create Analysis App:

- Read the temperature data from the file into LabVIEW
- Find Max temperature and Min temperature using built-in functions in LabVIEW
- Find also the Average/Mean temperature and the Standard deviation using built-in functions in LabVIEW

3. Do Analysis in Excel:

- Import the data into Excel and create a Plot
- Find Max, Min, Mean/AVG, SD using Excel
- Compare the results

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