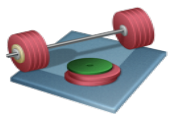
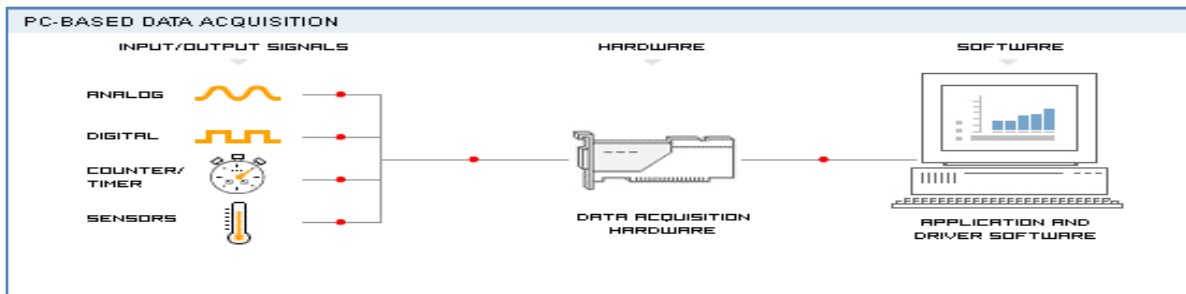




<http://home.hit.no/~hansha/?page=labview>

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 further

High-Level Design Tools

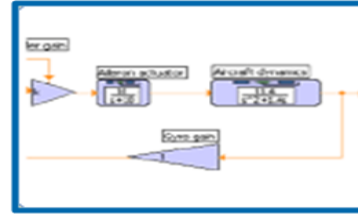
Configuration



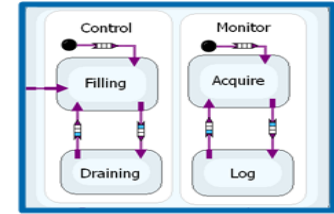
Textual Math

```
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

Linux®



Macintosh



Windows

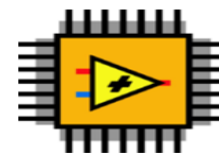


Desktop Platform

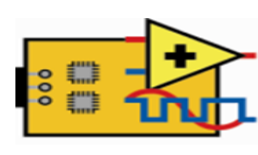
Real-Time



FPGA

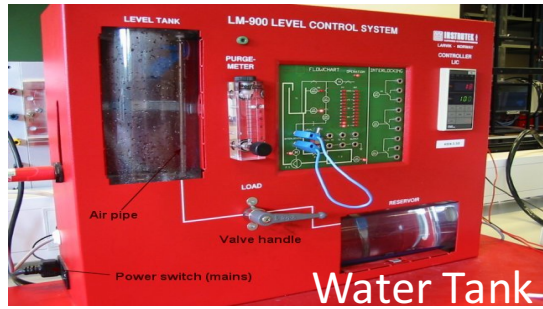


MPU



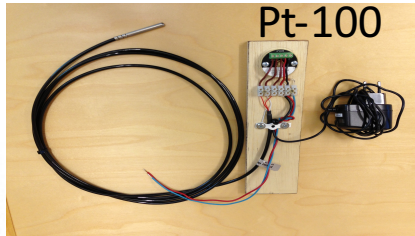
Embedded Platform

Hardware



USB-6008

Wi-Fi DAQ



Pt-100

Pt-100



ZigBee

ZigBee



TC-01

TC-01

TC-01

TC-01

TC-01

TC-01

TC-01

TC-01

TC-01

TC-01

TC-01

TC-01

TC-01

TC-01

TC-01

TC-01

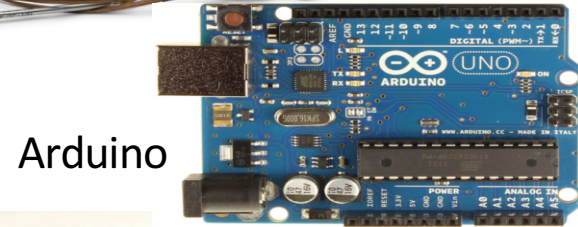


cRIO

cRIO

NOx Sensor

NOx Sensor



Arduino

Arduino

Arduino

Arduino

Arduino

Arduino

Arduino

Arduino

Arduino

Arduino



Vision System

Vision System

Vision System

Vision System

Vision System

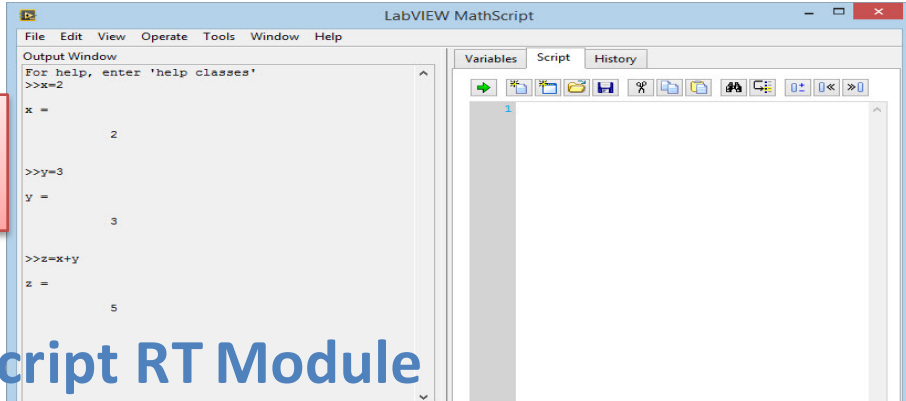
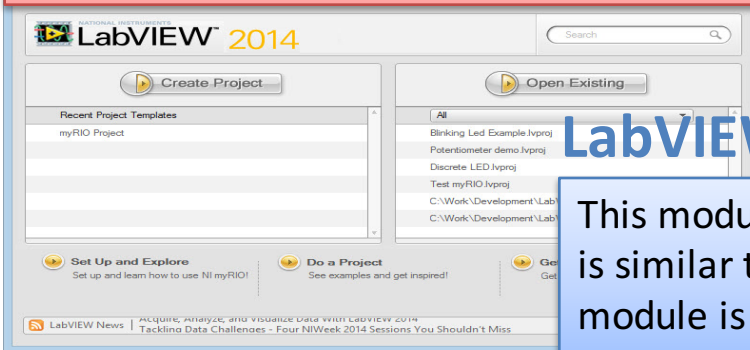
Vision System

Vision System

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.

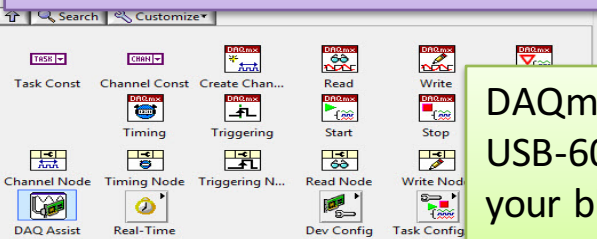
LabVIEW Control Design and Simulation Module

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.





LabVIEW™ Quick Reference Guide

Keyboard Shortcuts

File			
Ctrl-N	Create new VI	Ctrl-Z	Undo last action
Ctrl-S	Save VI	Ctrl-Shift-Z	Redo last action
Ctrl-P	Print		
Operate			
Ctrl-V	Paste object	Ctrl-R	Run VI
Ctrl-U	Clean up diagram	Ctrl-.	Abort VI
Ctrl-Space	Activate quick drop		
Ctrl-B	Remove broken wires		
Ctrl-C	Copy an object		
Ctrl-X	Cut object		
Window			
Ctrl-E	Display block diagram/ front panel		
Help			
		Right-Click	Display controls/ functions palette
		Shift-Right-Click	Display tools palette
		Ctrl-T	Tile block diagram and front panel windows
		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



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



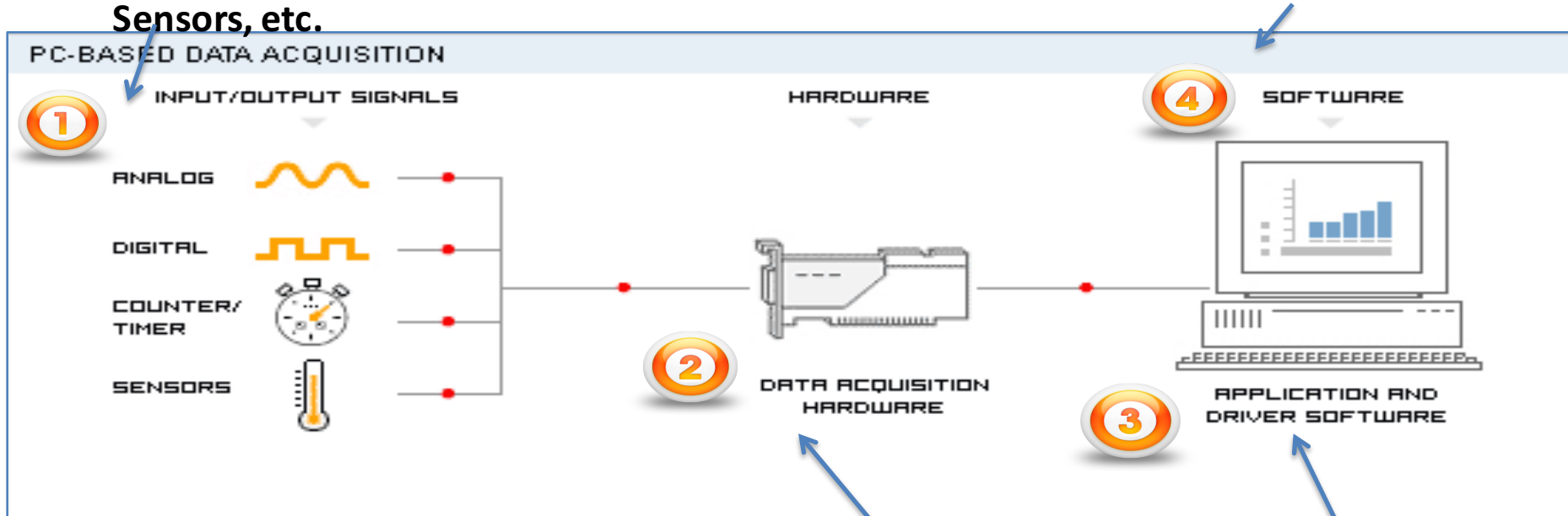
Analog/Digital Inputs/Outputs



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

DAQ – Data Acquisition

Your App created with LabVIEW



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)

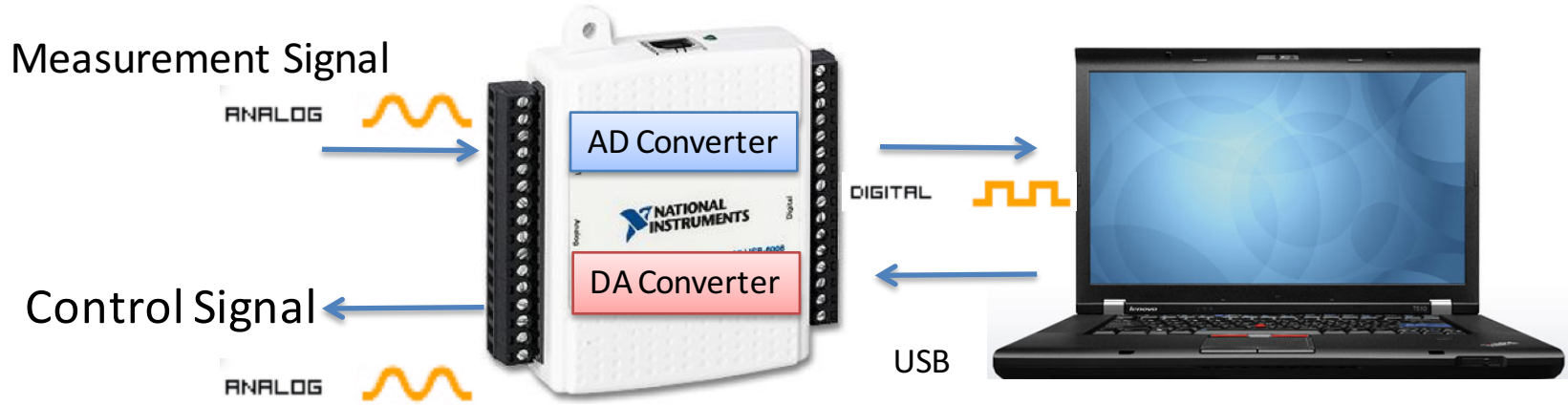
NI TC-01 Thermocouple Device

NI DAQmx Driver

or

NI USB 6008 DAQ Device

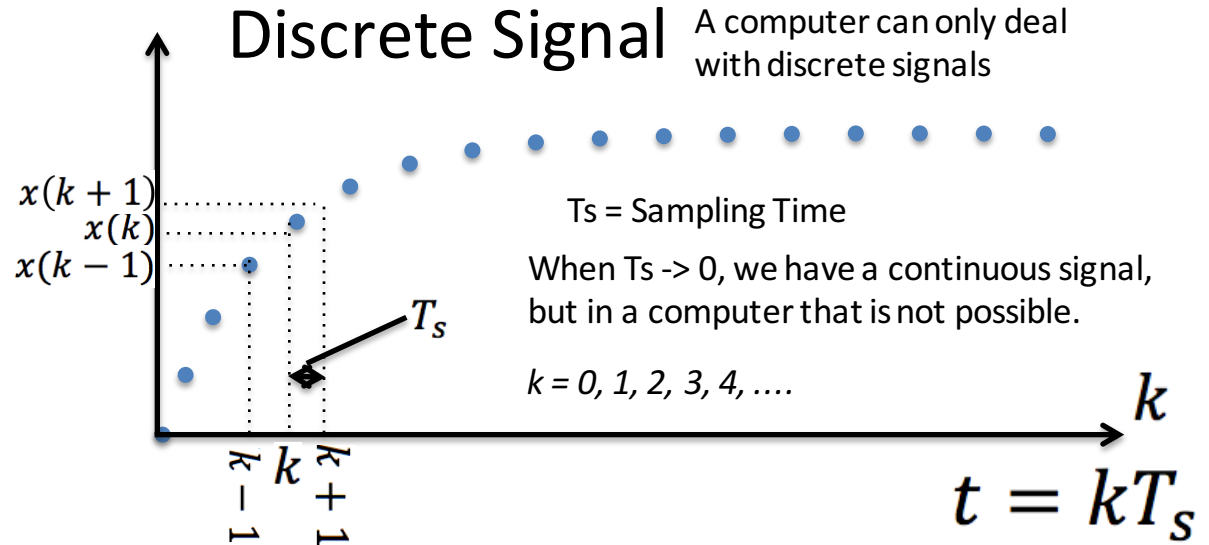
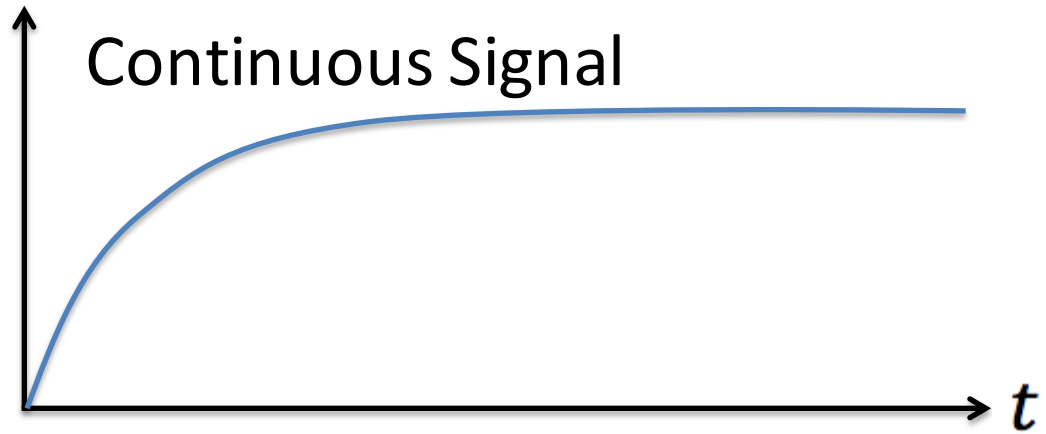
AD & DA Converters



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).

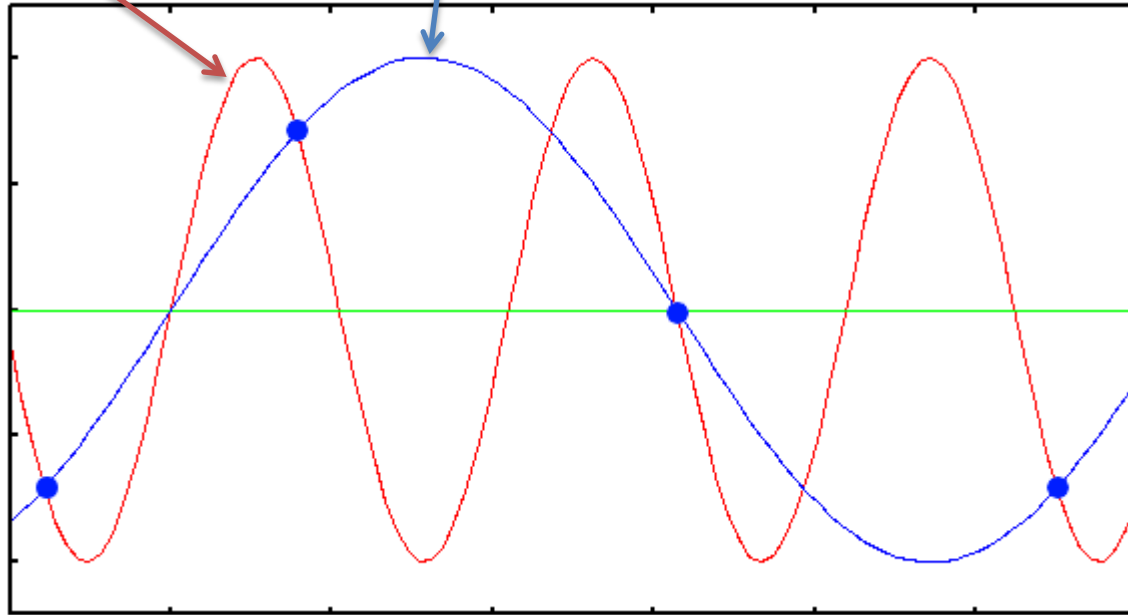
Continuous
vs.
Discrete
Signals



Sampling and Aliasing

Original Signal

Aliasing ("Nedfolding") -> The Sampling Rate is too low!



T_s

Sampling Time

$$f_s = \frac{1}{T_s}$$

Sampling Frequency



Using USB-6008 in LabVIEW

Hans-Petter Halvorsen, M.Sc.

USB-6008

How-To use USB-6008 with LabVIEW

Analog I/O



Digital I/O

USB



NI USB-6008 I/O Module

USB Connection



Specifications:

- 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) 0-5V
- 32-bit counter

4 different types of Signals:

AO – Analog Output

AI – Analog Input

DO – Digital Output

DI – Digital Input

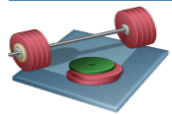
Note! **DAQmx** Driver is needed!!

MAX – Measurement & Automation Explorer

The screenshot displays the NI Measurement & Automation Explorer (MAX) interface. The main window title is "NI USB-TC01 'Dev1' - Measurement & Automation Explorer". The left pane shows a tree view of the system hierarchy, with "NI USB-TC01 'Dev1'" selected under "Network Devices". The main pane shows the "Settings" for the selected device, including Name (Dev1), Vendor (National Instruments), Model (NI USB-TC01), Serial Number (016318BA), and Status (Present). The "Test Panels" button is highlighted with a red dashed box. A smaller window titled "Test Panels : NI USB-TC01: 'Dev1'" is open, showing the "Analog Input" configuration. The "Channel Name" is "Dev1/ai0", "Rate (Hz)" is 10000, "Mode" is "On Demand", and "Samples To Read" is 1000. The "Measurement Type" is "Thermocouple", "Max Input Limit" is 100, "Min Input Limit" is 0, and "Units" is "deg C". The "Thermocouple Type" is "J" and "CJC Source" is "Built-In". A graph titled "Amplitude vs. Samples Chart" shows a fluctuating signal with a value of 24.3. The graph has a y-axis from 24.2 to 24.3 and an x-axis from 0 to 100. The "Start" and "Stop" buttons are visible at the bottom of the graph window.

NI USB-6008 "Dev1"

You may change the name ("Dev1")

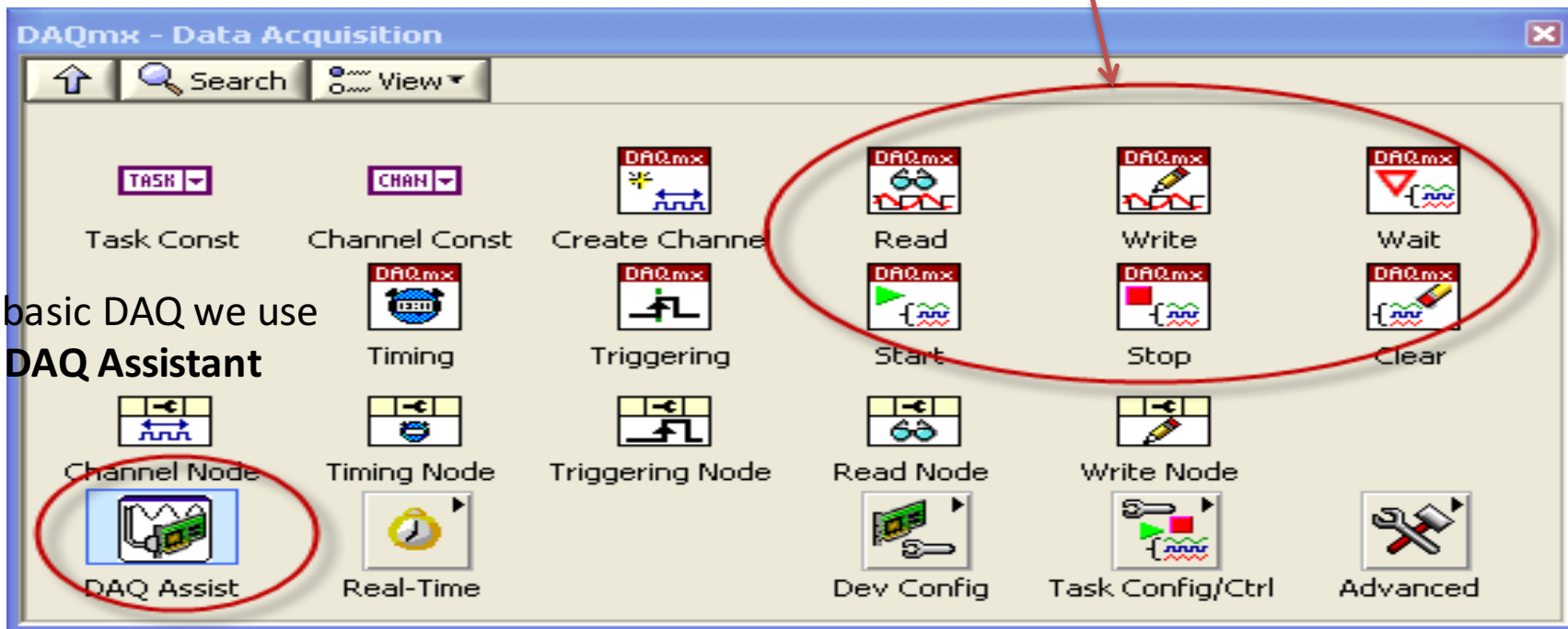


Students: Make sure that your device can be located in MAX. Run a "Self-Test" and use the "Test Panels" to make sure the device works properly.

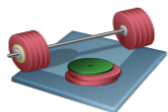
Data Acquisition Palette in LabVIEW

Functions Palette: "Measurement I/O" -> "NI DAQmx"

For more "advanced" DAQ we use these functions



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

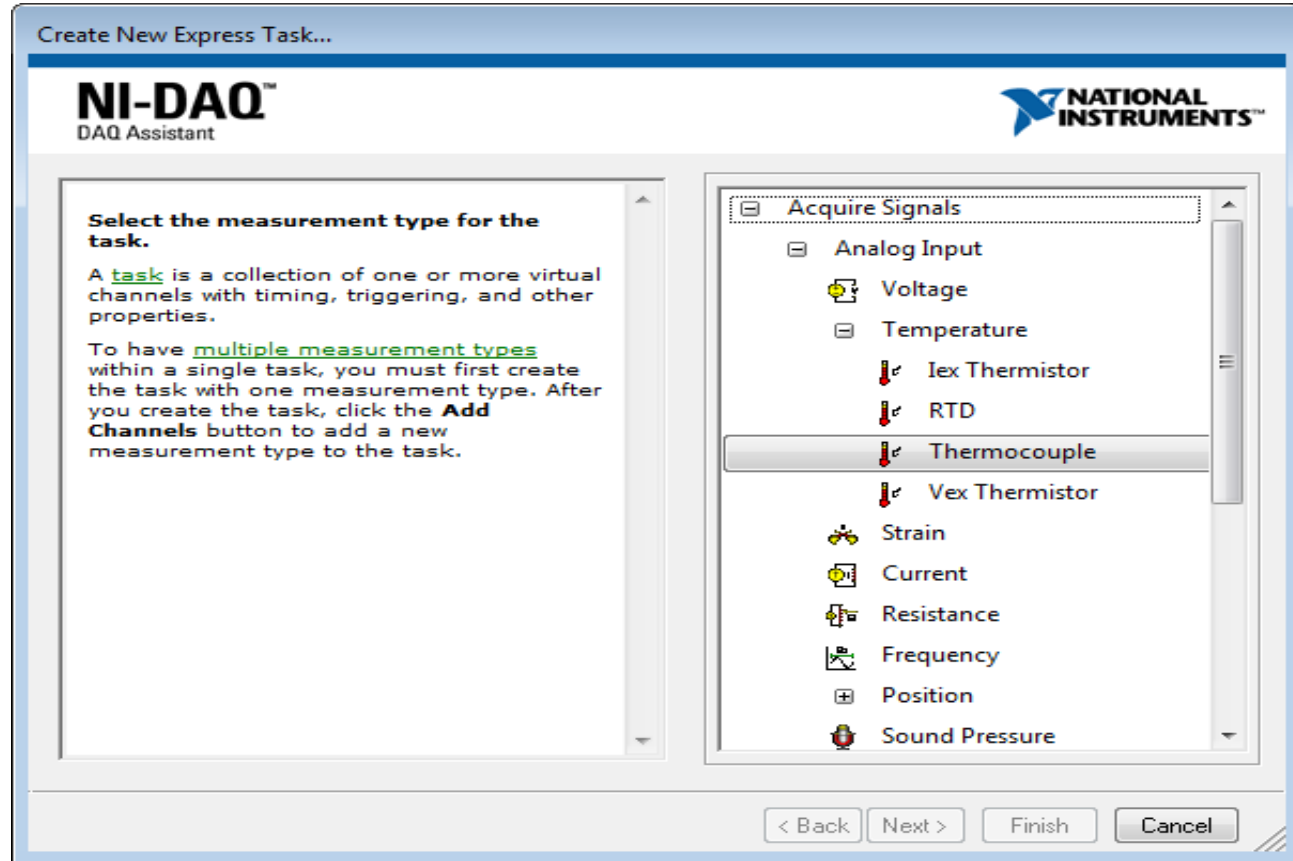


Students: Make sure that you have this palette installed. If not, install the latest DAQmx driver!

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

Hans-Petter Halvorsen, M.Sc.

1 Type of Signals

Acquire Signals

Analog Input

- Voltage
- Temperature
- Strain
- Current
- Resistance
- Frequency

2 Channel

Physical

Supported Physical Channels

- Dev1 (USB-6008)
 - ai0
 - ai1
 - ai2
 - ai3
 - ai4
 - ai5
 - ai6
 - ai7

3 Properties

AI Settings in DAQ Assistant

Configuration | Triggering | Advanced Timing | Logging

Channel Settings

Voltage

Click the Add Channels button (+) to add more channels to the task.

Voltage Input Setup

Settings

Signal Input Range

Max 5
Min 0

Units: Volts

Terminal Configuration: Differential

Custom Scaling: <No Scale>

Timing Settings

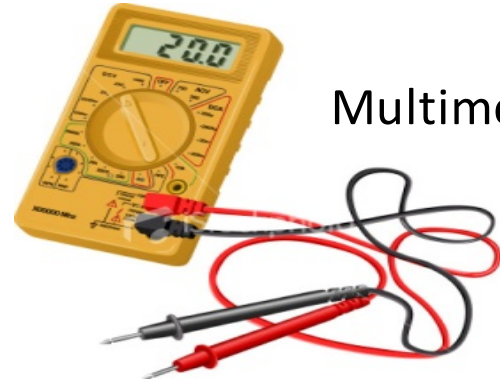
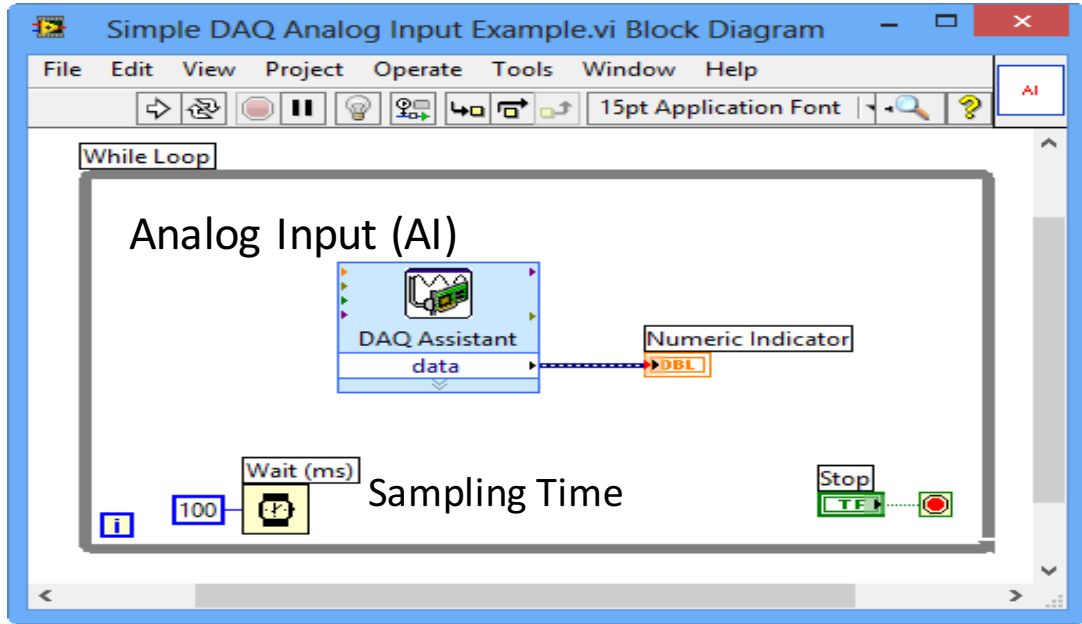
Acquisition Mode: 1 Sample (On Demand)

Samples to Read: 1k

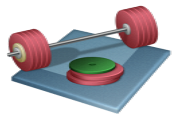
Rate (Hz): 1k

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

Hans-Petter Halvorsen, M.Sc.

AO Settings in DAQ Assistant

1 Type of Signals

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

2 Channel

Physical

Supported Physical Channels

- Dev1 (USB-6008)
 - ao0
 - ao1

3 Properties

Configuration | Triggering | Advanced Timing

Channel Settings

VoltageOut

Click the Add Channels button (+) to add more channels to the task.

Voltage Output Setup

Settings

Signal Output Range

Max: 5
Min: 0

Scaled Units

Volts

Terminal Configuration

RSE

Custom Scaling

<No Scale>

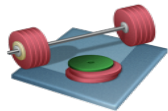
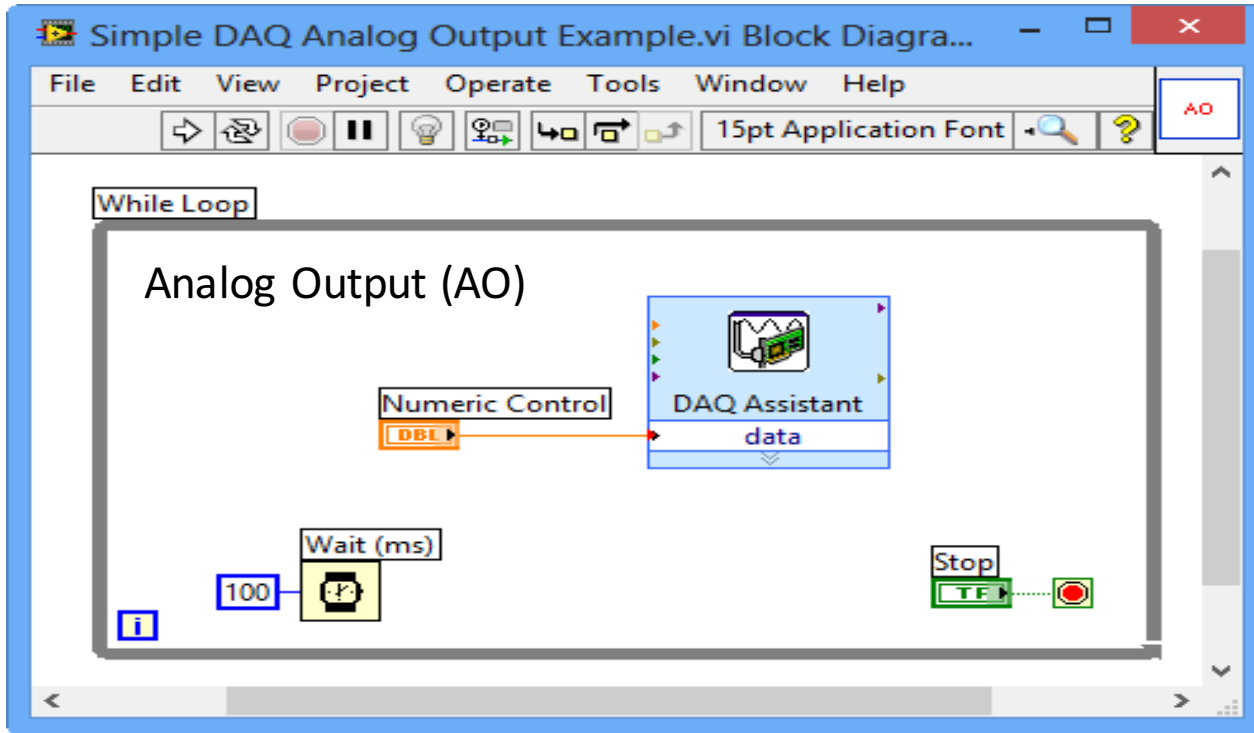
Timing Settings

Generation Mode: 1 Sample (On Demand)

Samples to Write: 100

Rate (Hz): 1k

Write Analog Signals using USB-6008



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

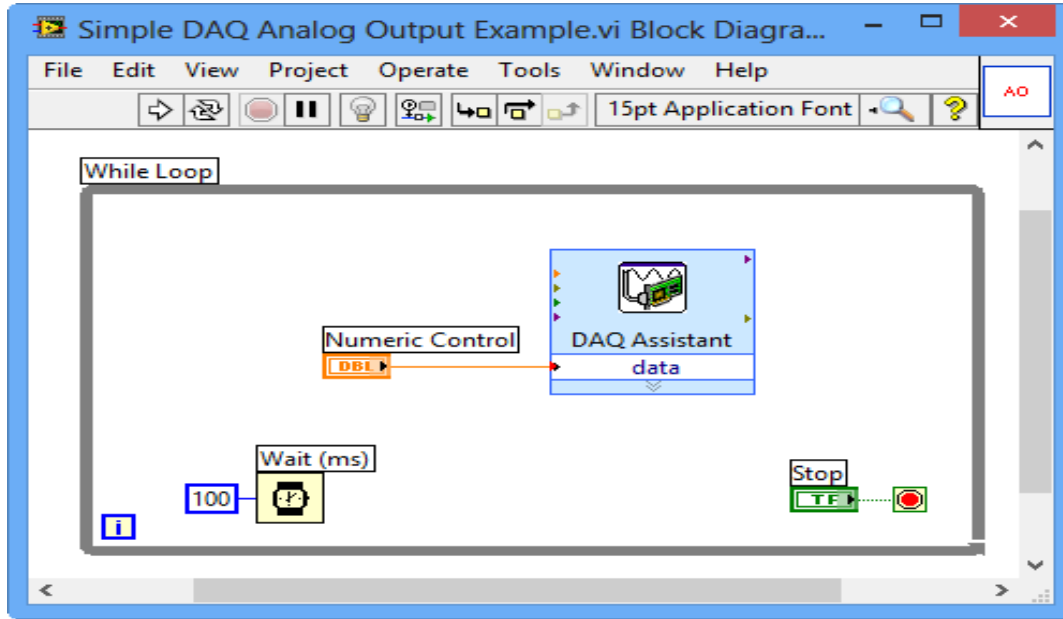


Analog In + Analog Out

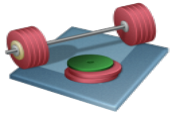
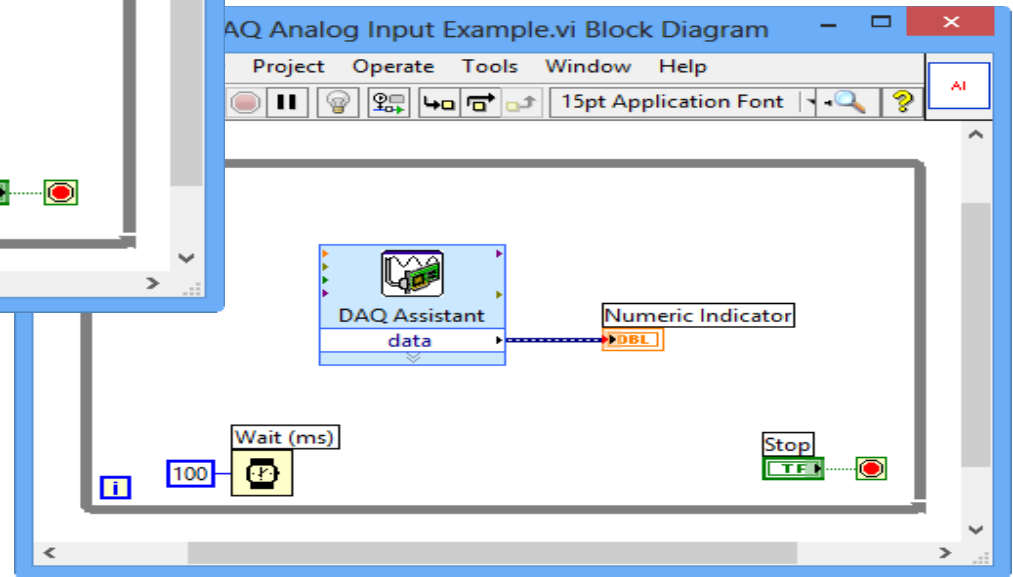
Hans-Petter Halvorsen, M.Sc.

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

1 Type of Signals

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

2 Channel

Physical

Supported Physical Channels

- Dev1 (USB-6008)
 - ao0
 - ao1

3 Properties

Configuration | Triggering | Advanced Timing

Channel Settings

VoltageOut

Click the Add Channels button (+) to add more channels to the task.

Voltage Output Setup

Settings

Signal Output Range

Max
Min

Scaled Units

Terminal Configuration

Custom Scaling

Timing Settings

Generation Mode

Samples to Write Rate (Hz)

1 Type of Signals

Acquire Signals

Analog Input

- Voltage
- Temperature
- Strain
- Current
- Resistance
- Frequency

2 Channel

Physical

Supported Physical Channels

- Dev1 (USB-6008)
 - ai0
 - ai1
 - ai2
 - ai3
 - ai4
 - ai5
 - ai6
 - ai7

3 Properties

AI Settings in DAQ Assistant

Configuration | Triggering | Advanced Timing | Logging

Channel Settings

- + X Add Channels
- Voltage
- Details >>

Click the Add Channels button (+) to add more channels to the task.

Voltage Input Setup

Settings

Signal Input Range

Max: 5
Min: 0

Scaled Units: Volts

Terminal Configuration: Differential

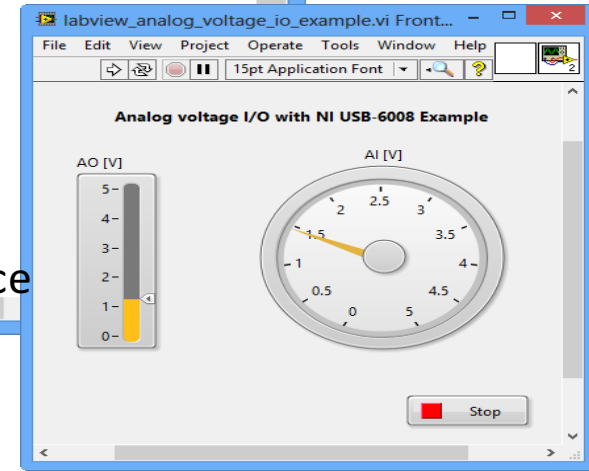
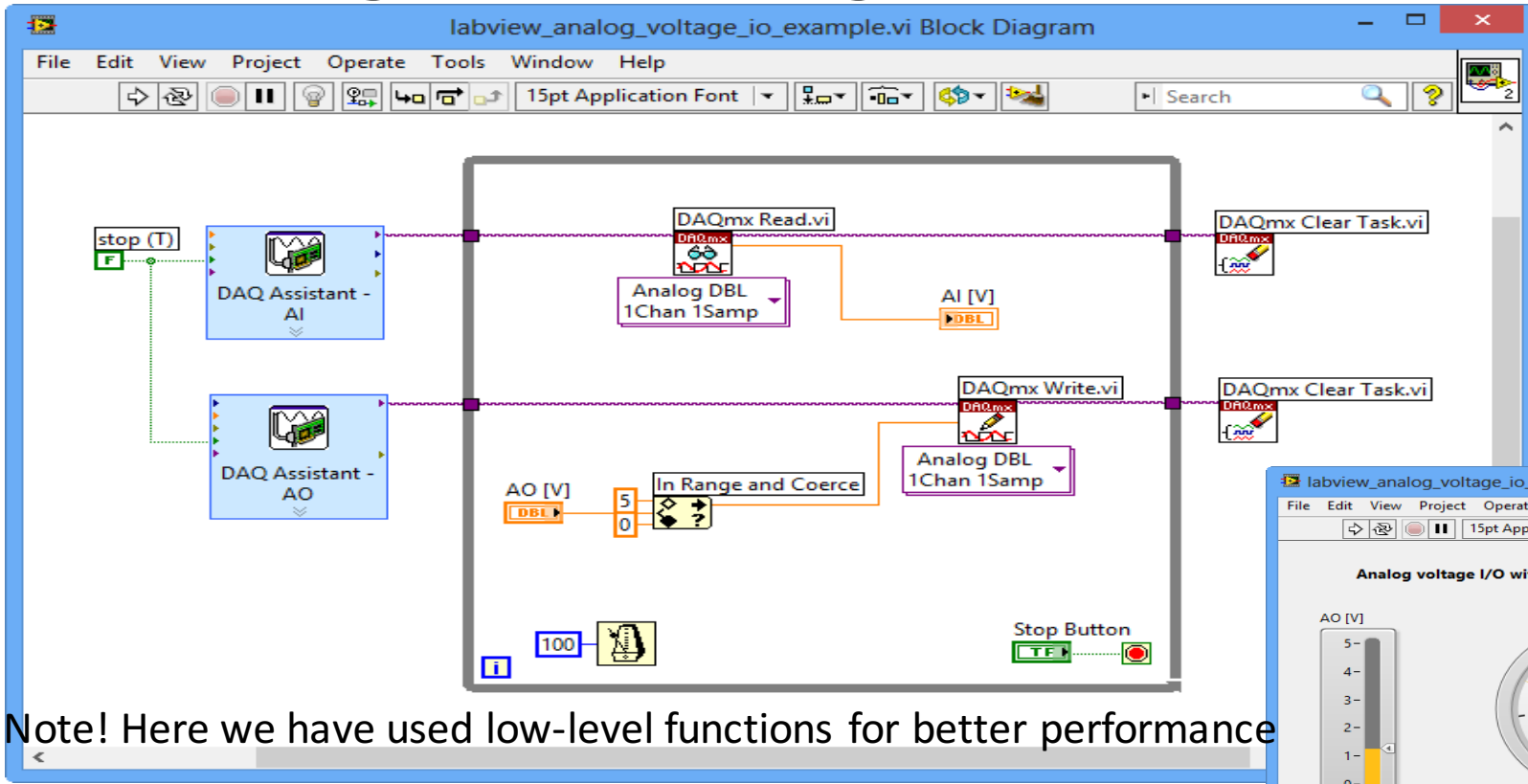
Custom Scaling: <No Scale>

Timing Settings

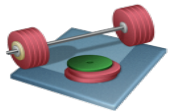
Acquisition Mode: 1 Sample (On Demand)

Samples to Read: 1k | Rate (Hz): 1k

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.

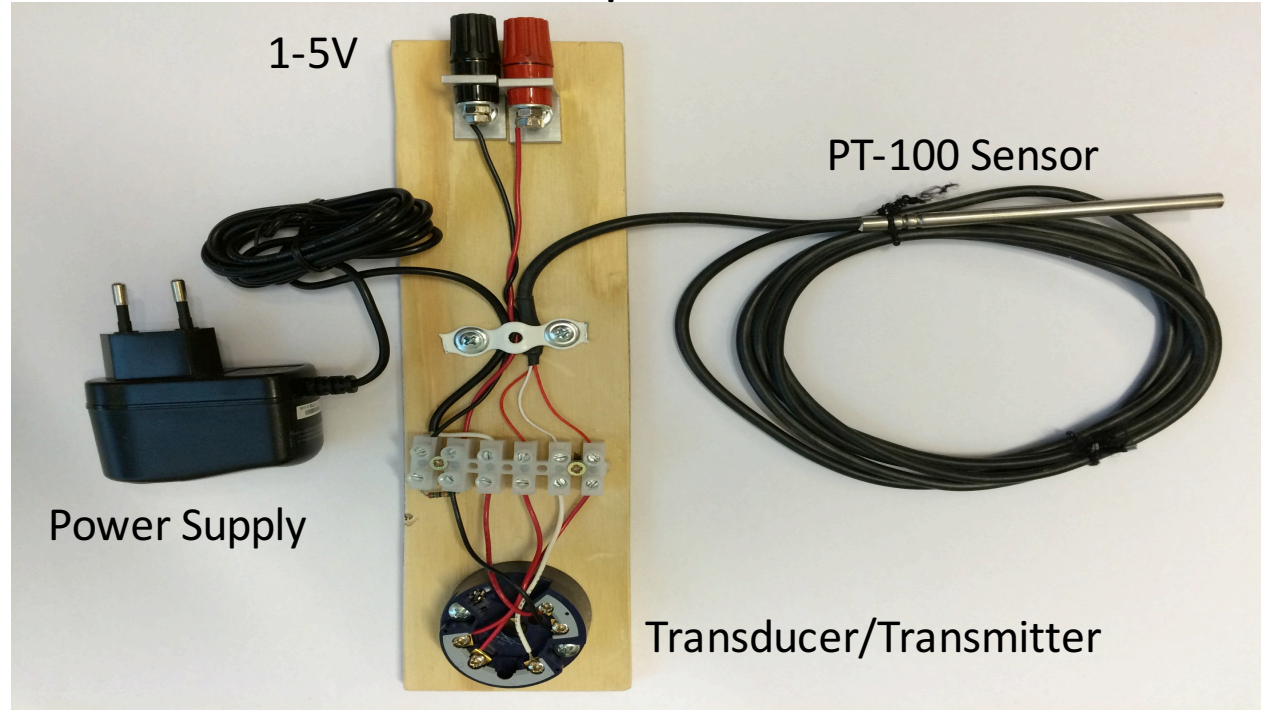
PT-100 Temperature Sensor



USB-6008 I/O Module



Multimeter



1-5V

PT-100 Sensor

Power Supply

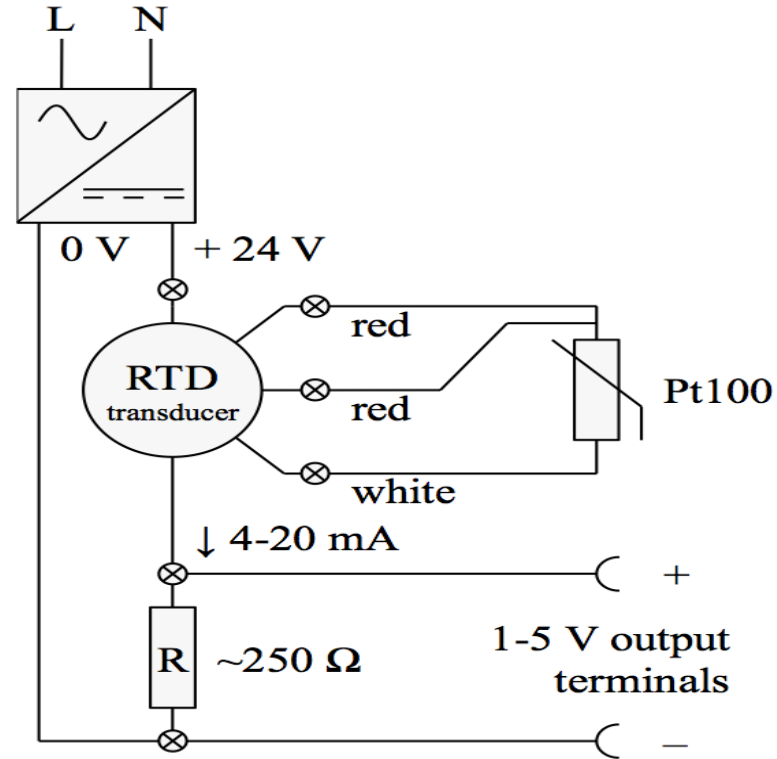
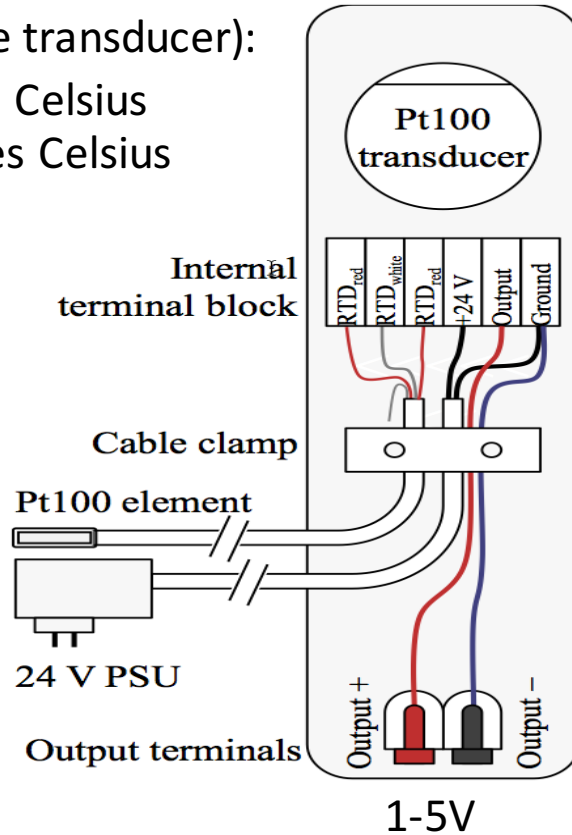
Transducer/Transmitter

PT-100 Temperature Sensor

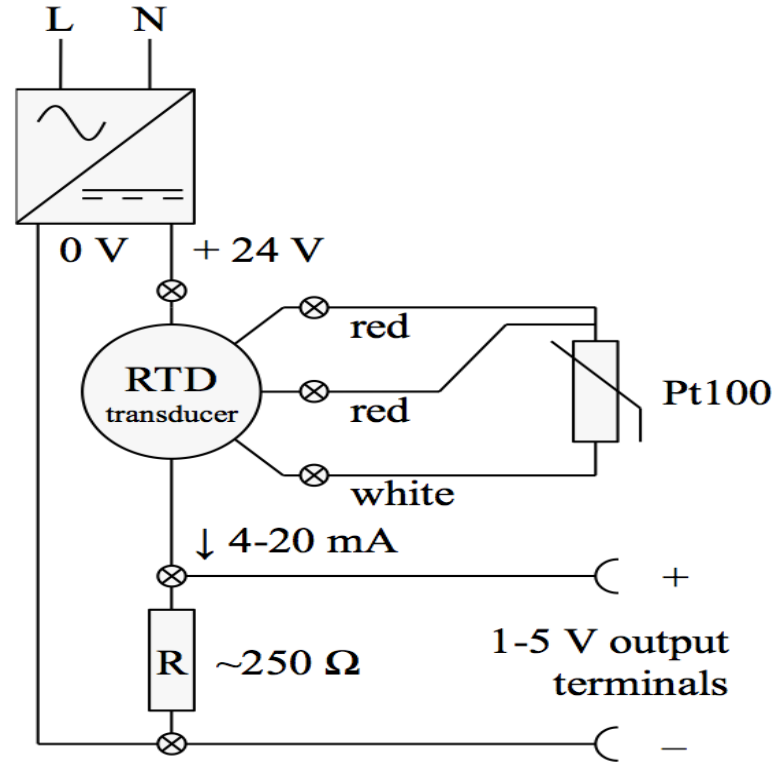
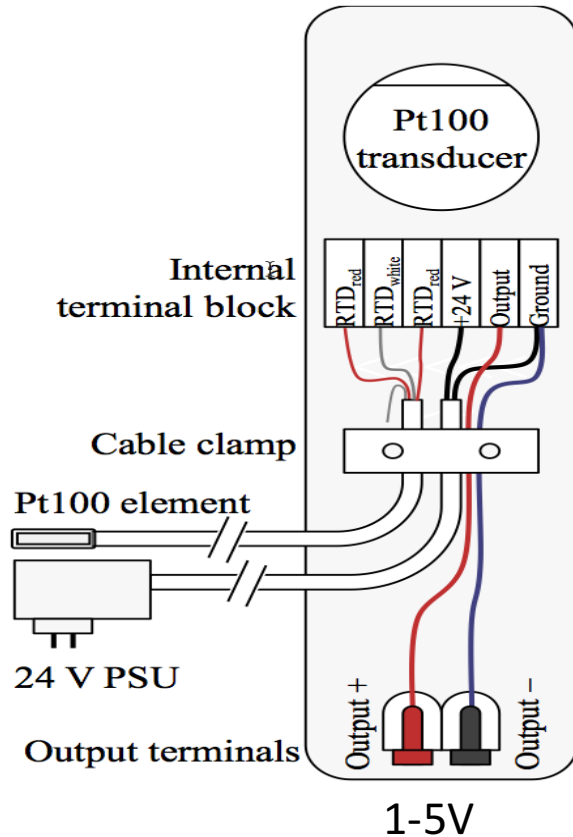
2 different types (see transducer):

1-5V -> 0-50 degrees Celsius

1-5V -> 0-100 degrees Celsius

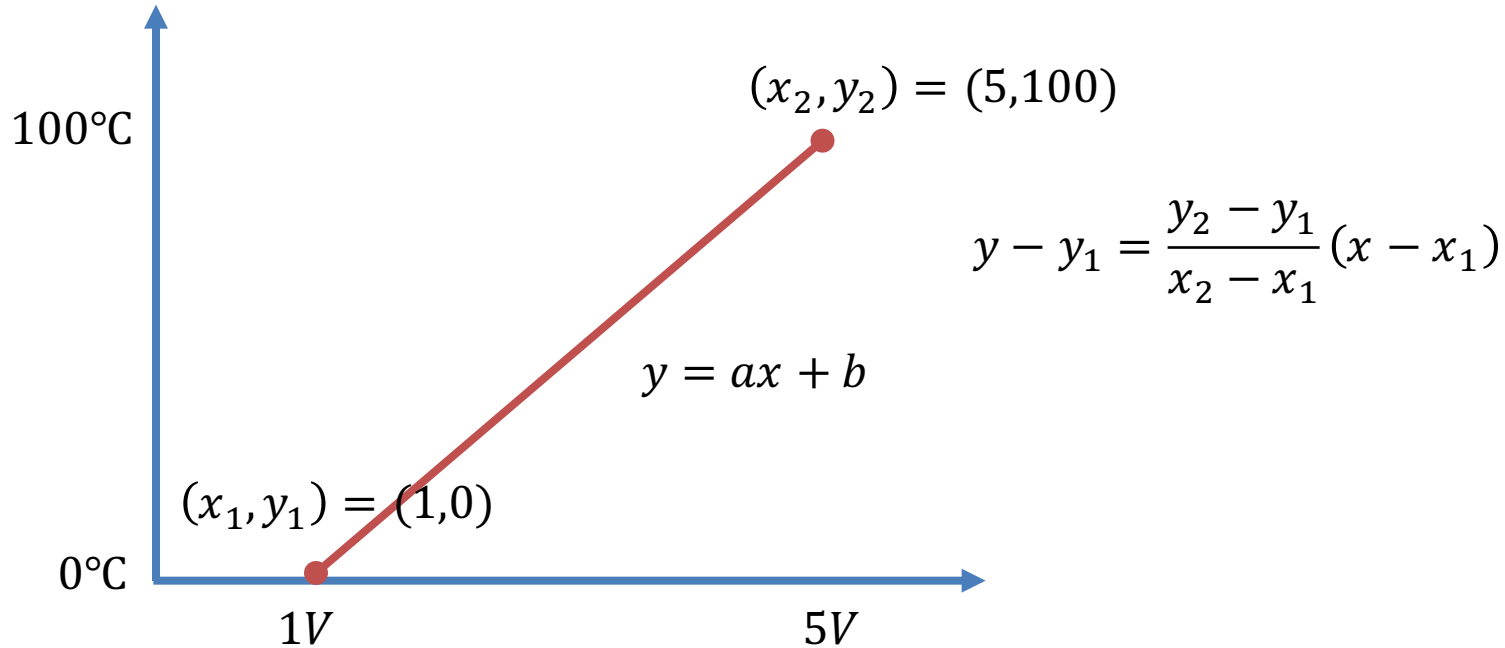


PT-100 Temperature Sensor

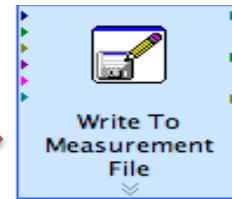
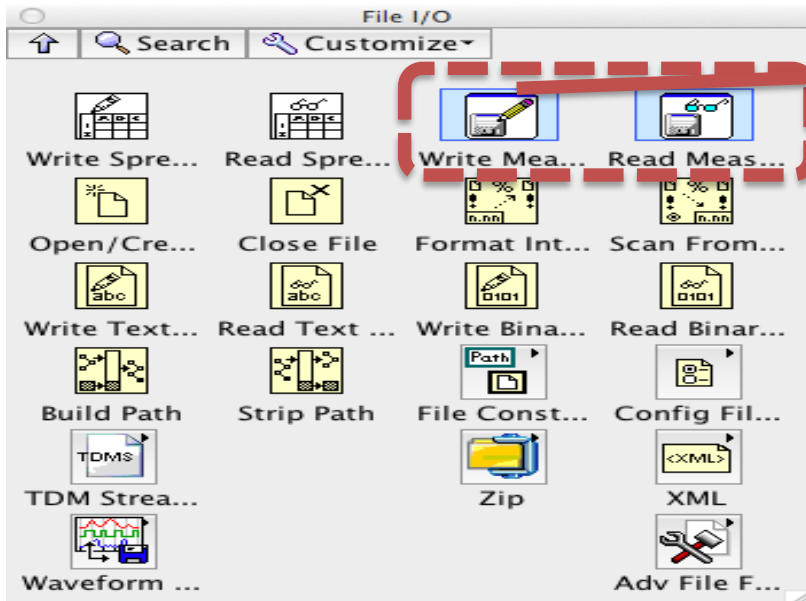


PT-100 Temperature Sensor

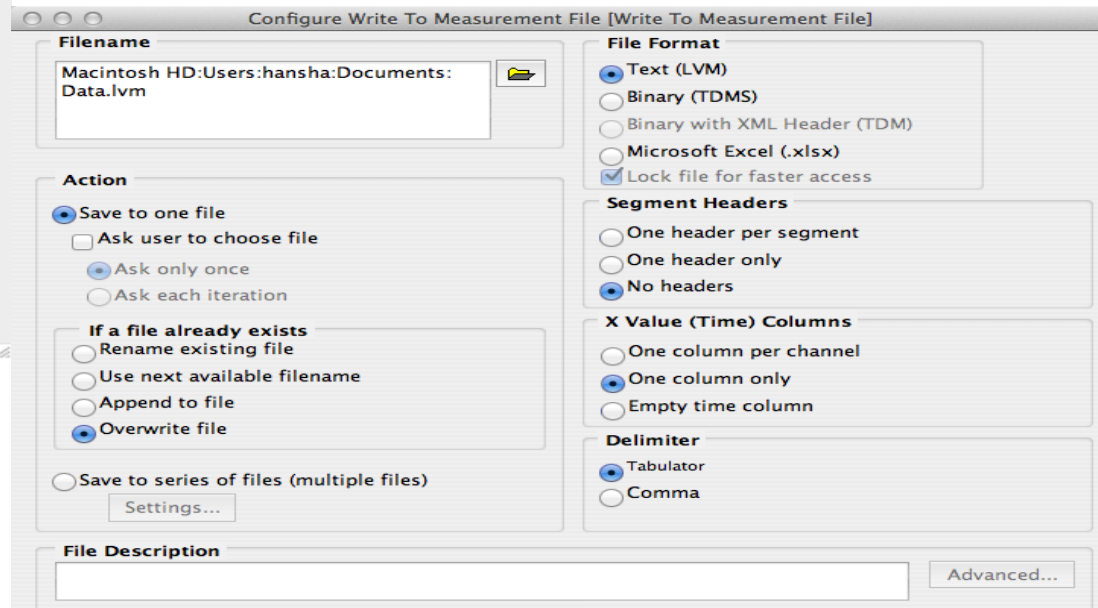
Converting from Voltage to Degrees Celsius



Save Data to File (Data logging)



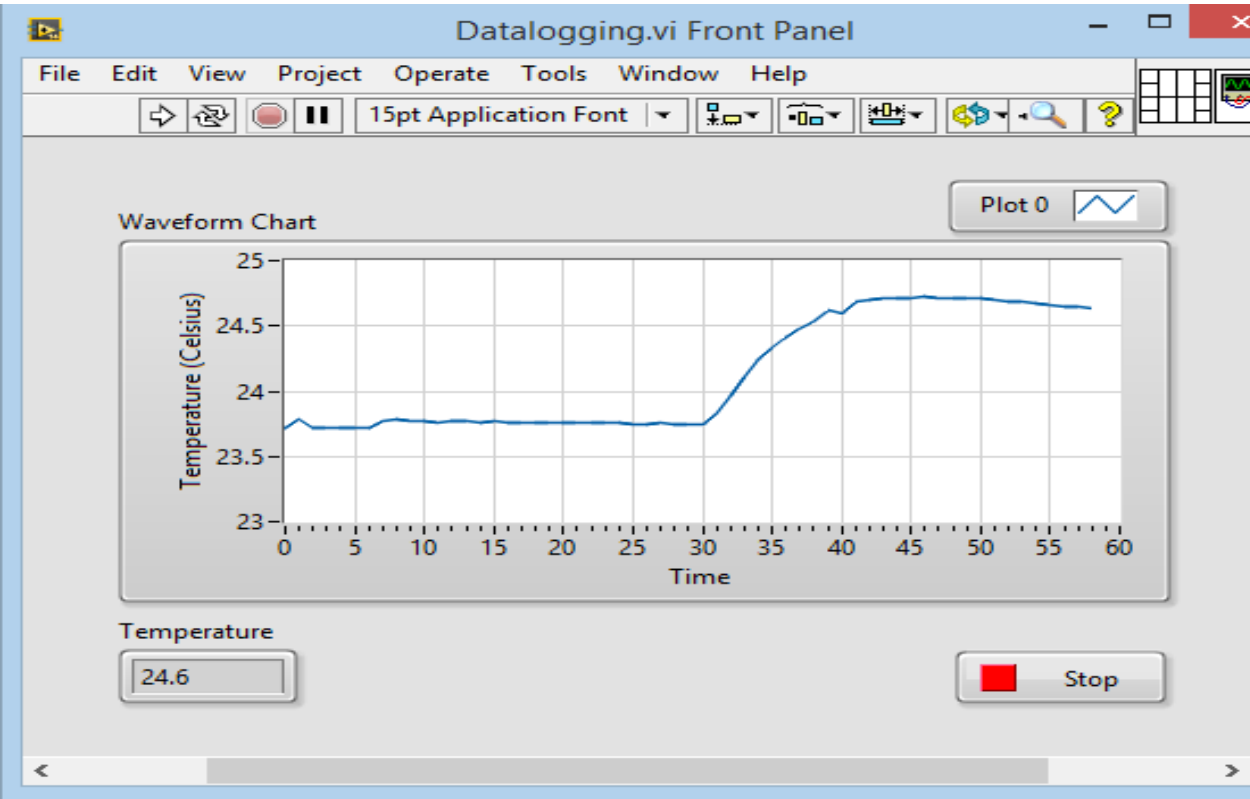
Right-click-Properties



Recommended Settings

OK Cancel Help

Datalogging Example

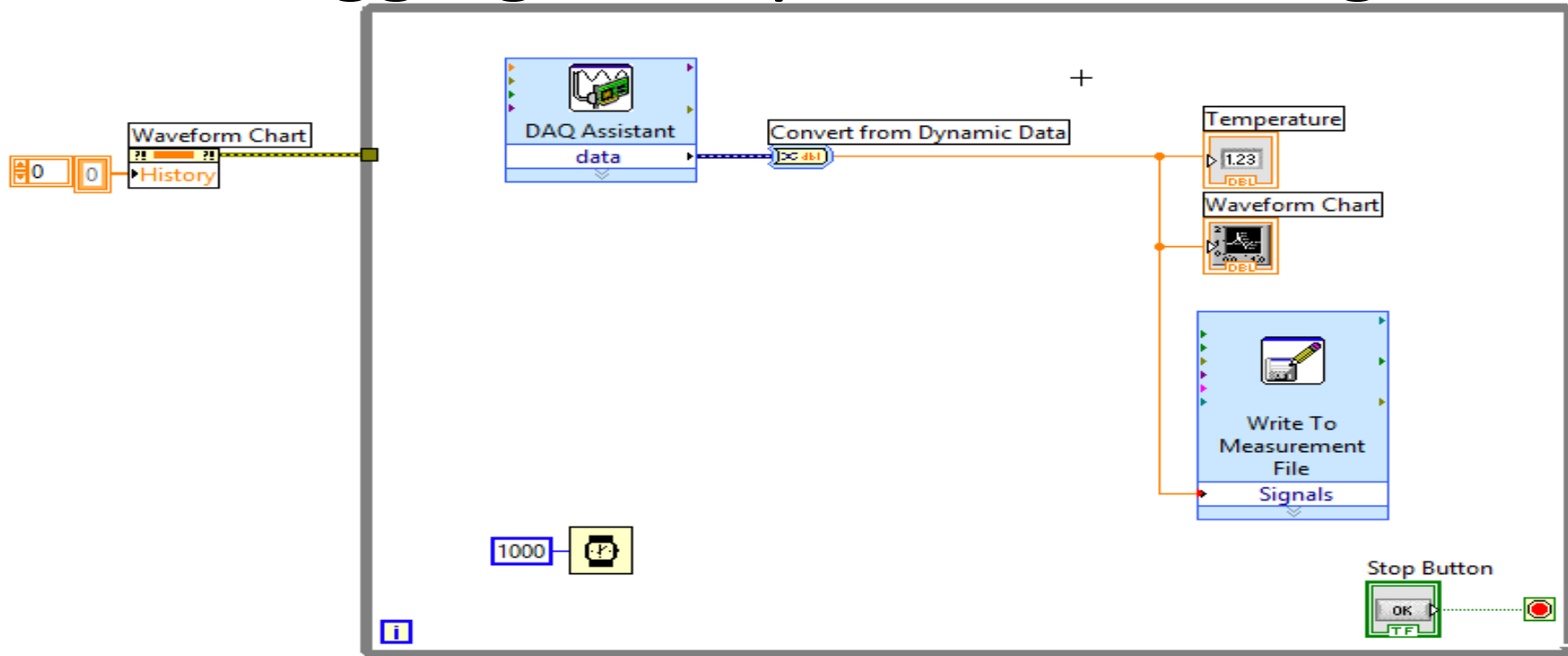


Data.lvm - Notepad

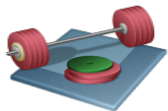
File Edit Format View Help

0.000000	23.722386
0.975883	23.782507
1.973000	23.714294
2.977028	23.719689
3.975200	23.719689
4.976168	23.716991
5.974145	23.714294
6.977184	23.774415
7.977247	23.779810
8.976395	23.777113
9.976493	23.771718
10.980489	23.763626
11.976687	23.771718
12.980719	23.766323
13.982748	23.763626
14.983700	23.766323
15.979765	23.763626
16.977789	23.760928
17.979809	23.760928
18.977904	23.760928
19.976963	23.758231
20.977973	23.755534
21.979071	23.755534
22.980054	23.752836
23.979137	23.752836
24.978214	23.750139
25.978157	23.747441
26.978513	23.752836

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 discrete version of the filter. We use the Euler Backward discretization method:

$$\dot{x} \approx \frac{x(t_k) - x(t_{k-1})}{T_s} \quad \text{Where } T_s \text{ is the Sampling Time}$$

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

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

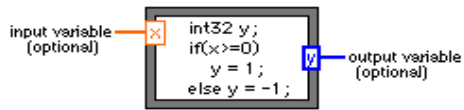
This discrete Measurement Filter can be easily implemented in a computer using e.g., LabVIEW, C#, etc.

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

LabVIEW Formula Node

Context Help

Formula Node

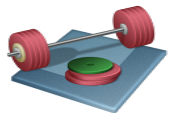
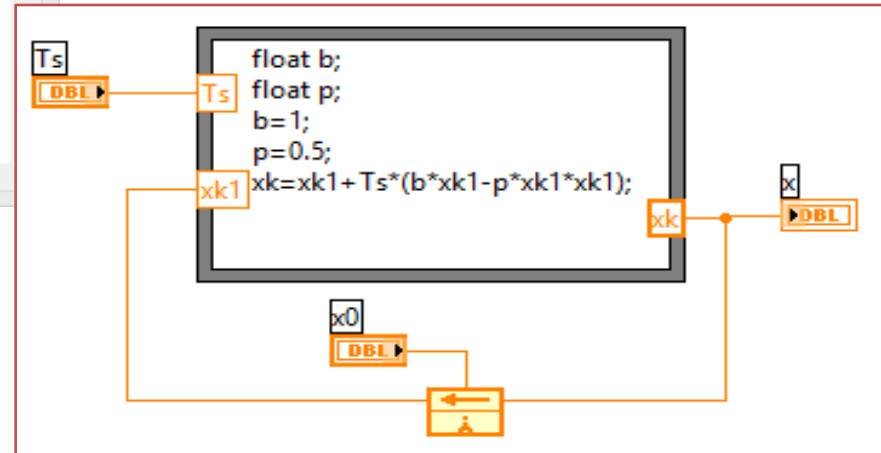


Evaluates mathematical formulas and expressions similar to C on the block diagram. The following built-in functions are allowed in formulas: abs, acos, acosh, asin, asinh, atan, atan2, atanh, ceil, cos, cosh, cot, csc, exp, expm1, floor, getexp, getman, int, intrz, ln, ln2, log, log2, max, min, mod, pow, rand, rem, sec, sign, sin, sinc, sinh, sizeofDim, sqrt, tan, tanh. There are some differences between the parser in the Mathematics VIs and the Formula Node.

[Detailed help](#)

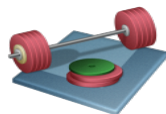
Formula Node: Create and use C code within LabVIEW

Example:



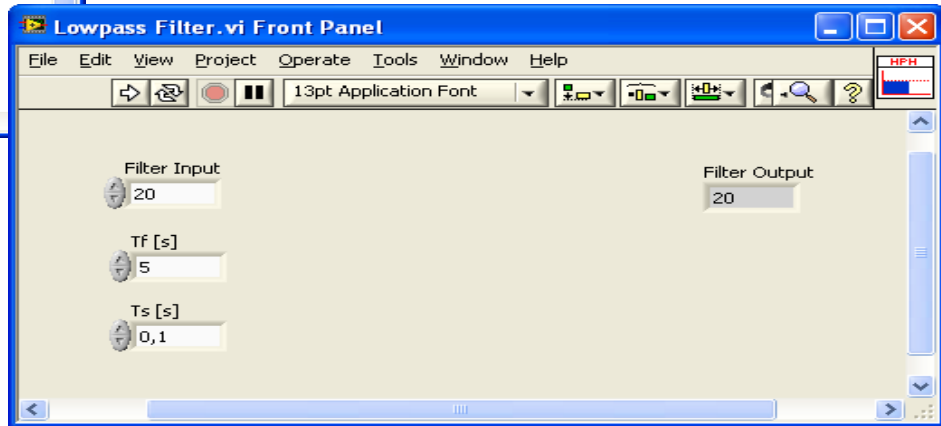
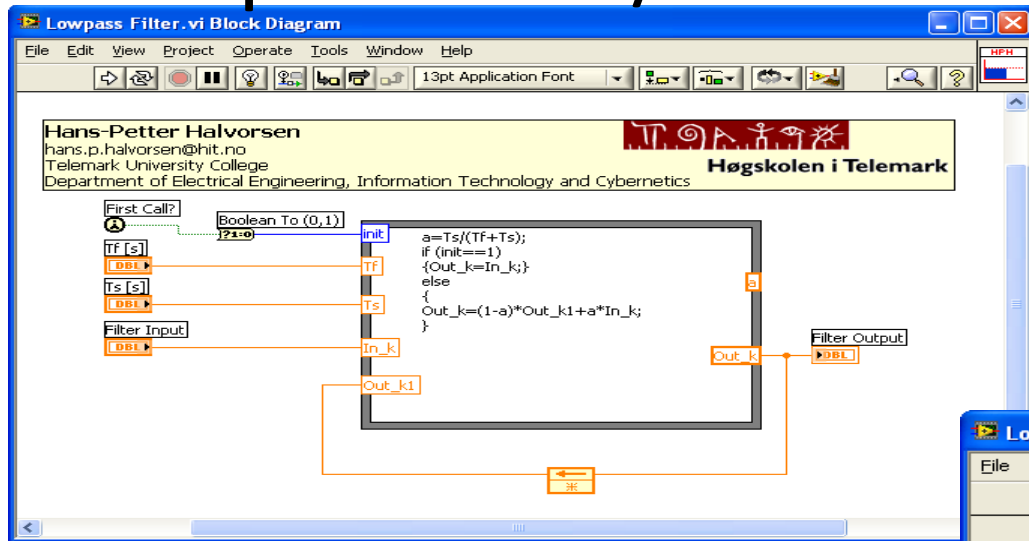
Students: Use the LabVIEW Formula Node in order to implement the Measurement Filter.

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.

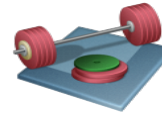


$$a = \frac{T_s}{T_f + T_s}$$

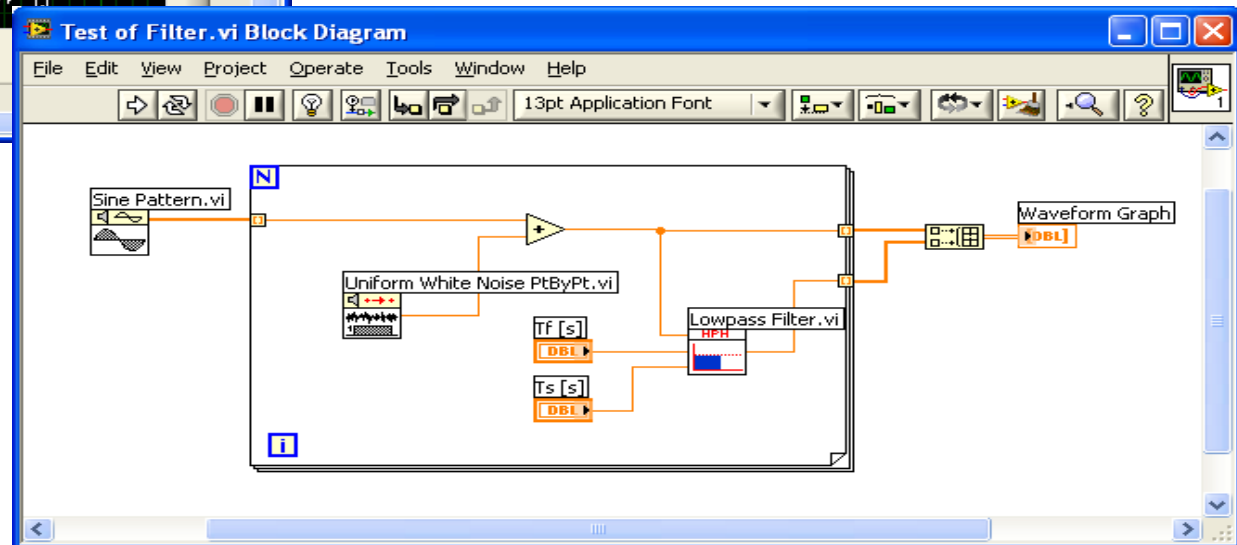
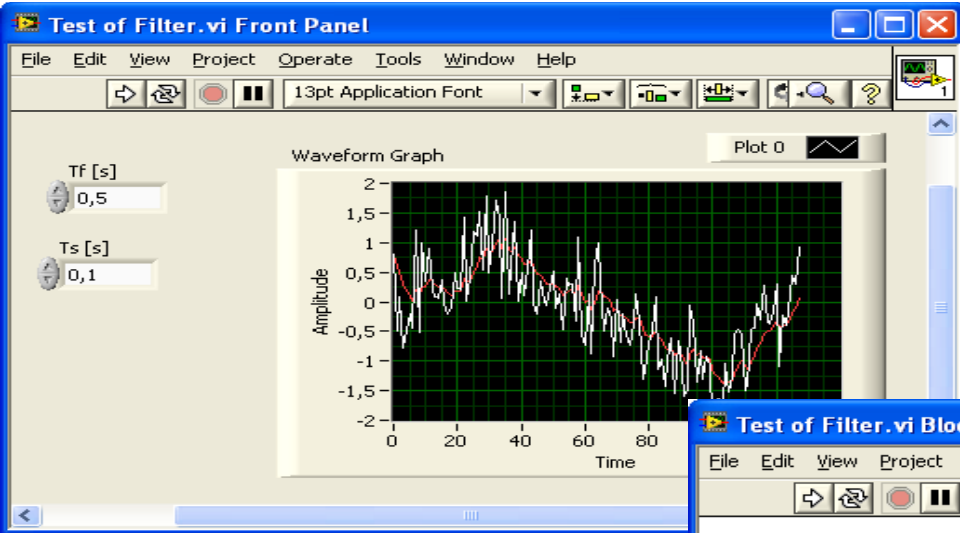
$$y_{mf}(t_k) = (1 - a)y_{mf}(t_{k-1}) + ay_m(t_k)$$

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 further



NATIONAL INSTRUMENTS

LabVIEW



Do you need more Practice? - Select a Challenge

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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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