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# TC-01 Thermocouple in LabVIEW

Hans-Petter Halvorsen



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# Introduction



Hans-Petter Halvorsen

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# NI DAQ Hardware Examples

TC-01 Thermocouple



myDAQ



NI-DAQmx  
Hardware Driver

USB-6001



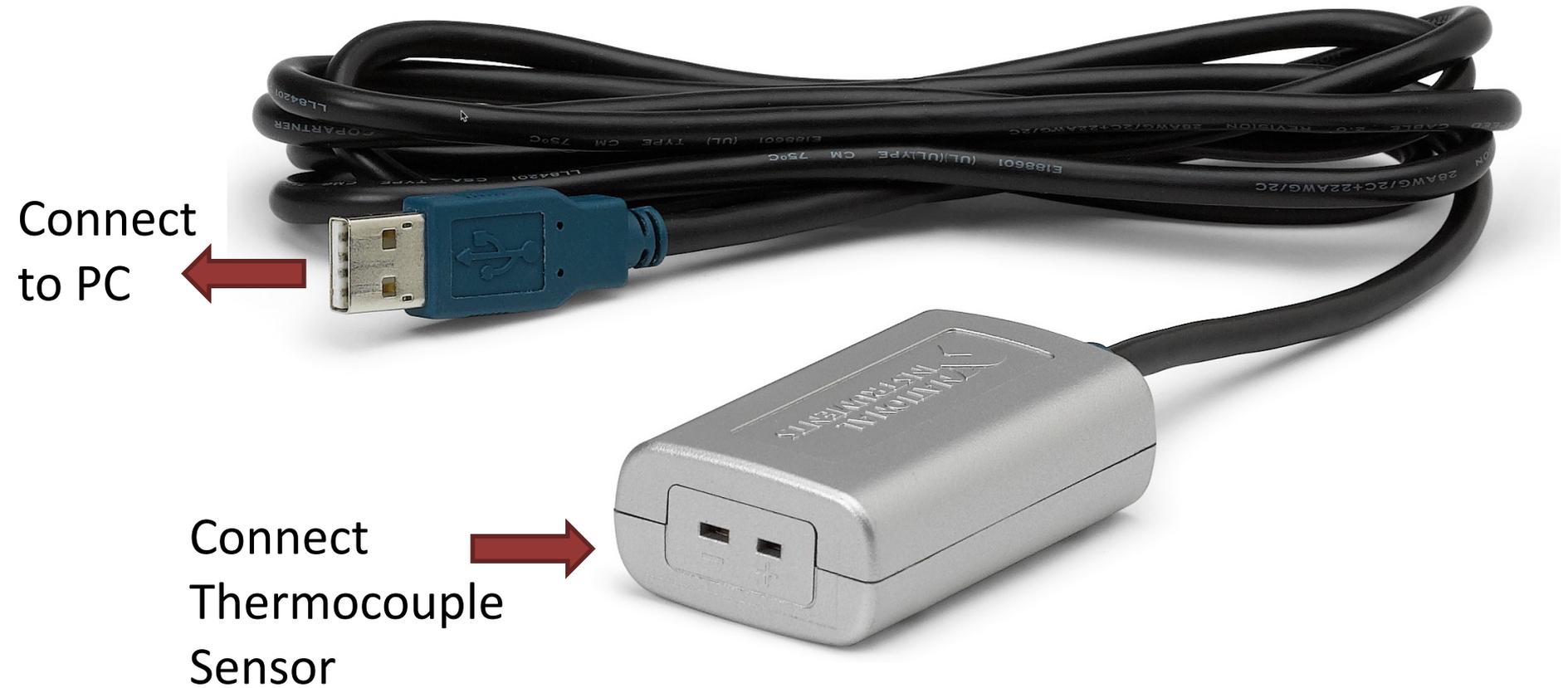
USB-6008



cDAQ



# NI USB TC-01 Thermocouple



# NI USB TC-01 Thermocouple



J-Type Exposed-Junction Thermocouple



J-Type Grounded Probe Thermocouple

# TC-01 Datasheet

Number of channels	1
ADC resolution	20 bits
Input range	$\pm 73.125$ mV
Common-mode range, Channel-to-USB ground	$\pm 30$ V
Common-mode rejection ratio (0 to 60 Hz), Common-to-USB ground	>145 dB
Noise rejection (50/60 Hz)	>80 dB
Temperature measurement ranges	Works over temperature ranges defined by NIST (J, K, R, S, T, N, E, and B thermocouple types; the E type has a maximum limit of 900 °C.)
Conversion time	250 ms
Sample rate	4 S/s, maximum, software-timed
Input bandwidth (-3 dB)	1 Hz
Differential input impedance	20 M $\Omega$ between isolated 3.3 V and ground
Input noise	2 $\mu$ V <sub>pp</sub>
Open thermocouple bias voltage	3.3 V
Cold-junction compensation sensor accuracy, 0 °C to 65 °C	1.25 °C maximum, 0.6 °C typical
Cold-junction compensation sensor resolution	0.0625 °C typical
Overvoltage protection	30 V max between TC+ and TC-

# DAQ System

A DAQ System consists of 4 parts:

- Physical input/output signals, **sensors** – In this case the Thermocouple Sensor/probe
- **DAQ device/hardware** – In this case the TC-01 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



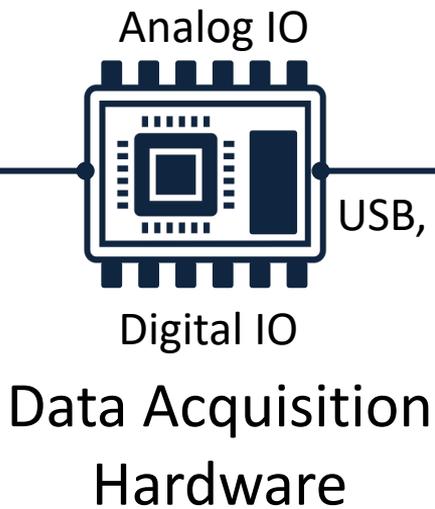
Digital Signals



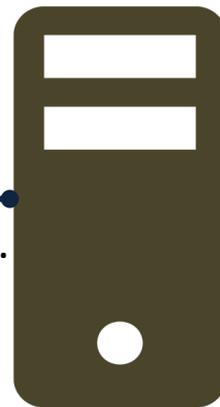
Sensors



(Analog/Digital Interface)



USB, etc.



PC

Software



Application

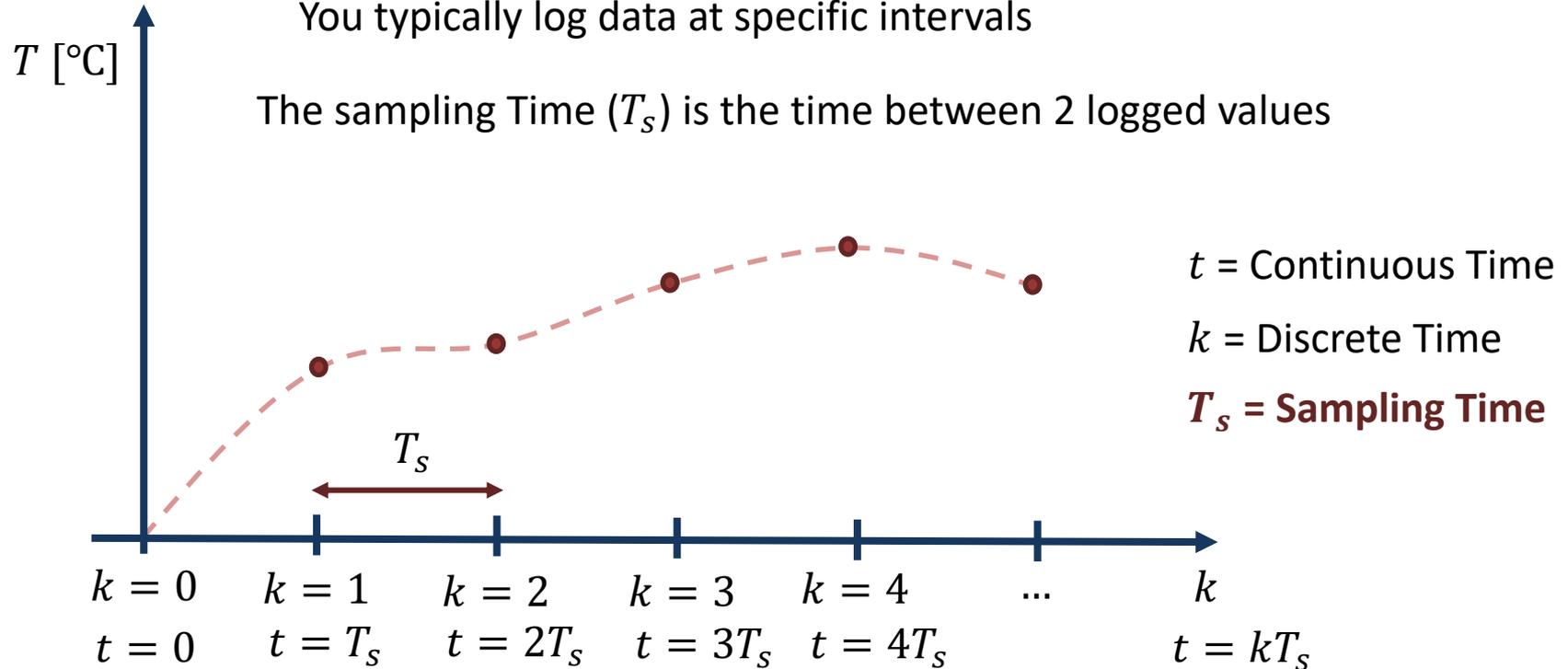
Hardware Driver

# Digital Signals

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



# DAQmx



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NI is now part of Emerson's new Test & Measurement business group.

LEARN MORE



## NI-DAQ™mx

NI-DAQ™mx provides support for customers using NI data acquisition and signal conditioning devices.

[± Read More](#)

**Note:** Install programming environments such as NI LabVIEW or Microsoft Visual Studio® before installing this product.

### DOWNLOADS

Supported OS	Windows ▾	<a href="#">View Readme</a>
Version	2023 Q4 ▾	
Included Editions	Full	
Application Bitness	32-bit and 64-bit	
Language	English, French, German, Japanese, Korean, Simplified Chinese	

### NI-DAQmx 2023 Q4

Release Date  
Oct/11/2023

Included Versions  
2023 Q4

- > Supported OS
- > Language
- > Checksum

DOWNLOAD

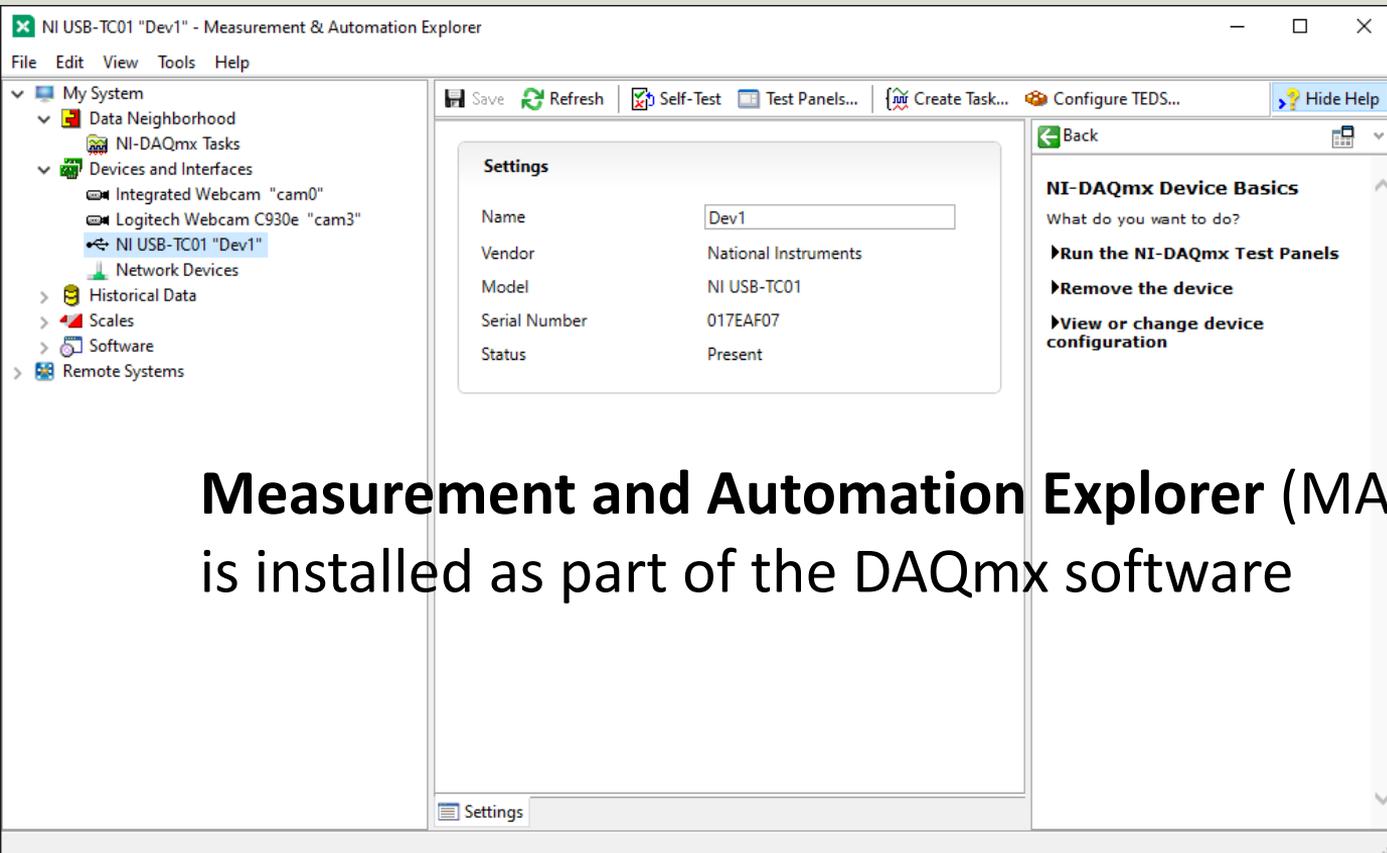
INSTALL OFFLINE

File Size  
5.68 MB

To use DAQ hardware in **LabVIEW** we need to use the **DAQmx** driver. It can be downloaded for free.

<https://www.ni.com/en/support/downloads/drivers/download.ni-daq-mx.html>

# MAX

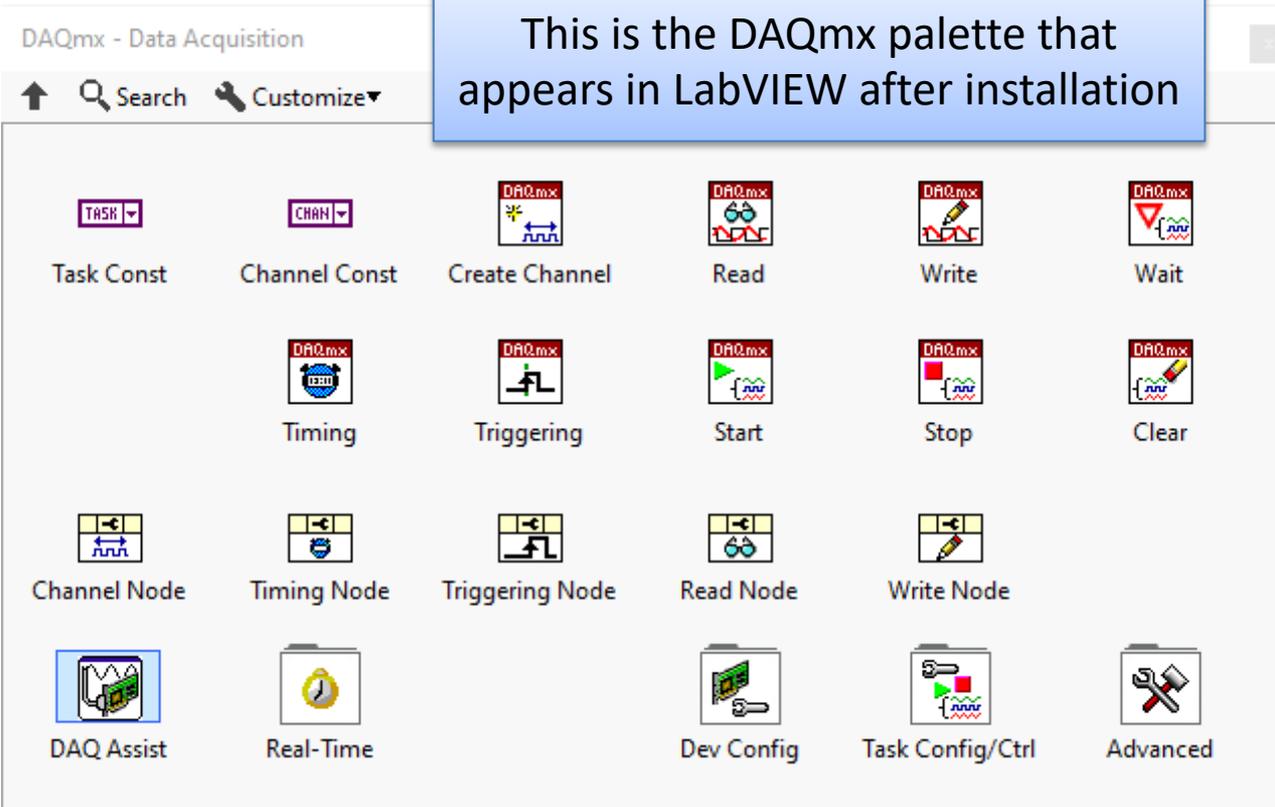


You can use MAX to test and configure your DAQ device

**Measurement and Automation Explorer (MAX)**  
is installed as part of the DAQmx software

# DAQmx in LabVIEW

This is the DAQmx palette that appears in LabVIEW after installation



To use DAQ hardware in **LabVIEW** we need to use the **DAQmx** driver. It can be downloaded for free.

<https://www.ni.com/en-no/support/downloads/drivers/download.ni-daq-mx.html>

# Getting Started with TC-01

NI USB-TC01 "Dev1" - NI Device Monitor



## Device Detected

NI USB-TC01  
Dev1

---

 **Test this device**  
using Test Panels Go

---

 **Begin an application with this device**  
using NI LabVIEW (32-bit) Go

---

 **Configure and test this device**  
using NI Measurement & Automation Explorer Go

---

 **View online device documentation** Go

---

 **Do nothing** Dismiss

NI USB-TC01 "Dev1" - Measurement & Automation Explorer

File Edit View Tools Help

- My System
  - Data Neighborhood
  - Devices and Interfaces
    - Integrated Webcam "cam0"
    - Logitech Webcam C930e "cam3"
    - NI USB-TC01 "Dev1"
    - Network Devices
  - Historical Data
  - Scales
  - Software
  - Remote Systems

Save Refresh Self-Test Hardware Configuration Utility Test Panels... Create Task... Configure TEDS... Hide Help

### Settings

Try the new Hardware Configuration Utility to configure your device.

Name	Dev1
Vendor	National Instruments
Model	NI USB-TC01
Serial Number	017EAF07
Status	Present

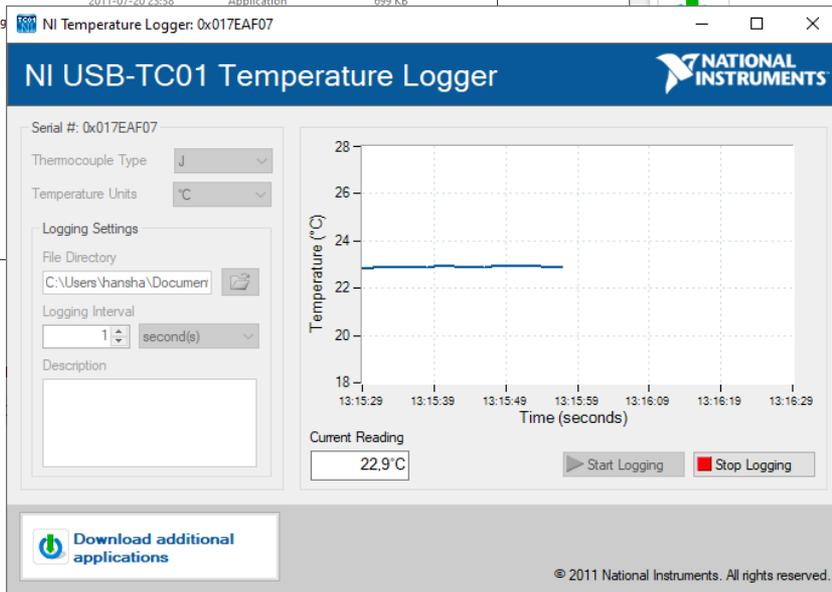
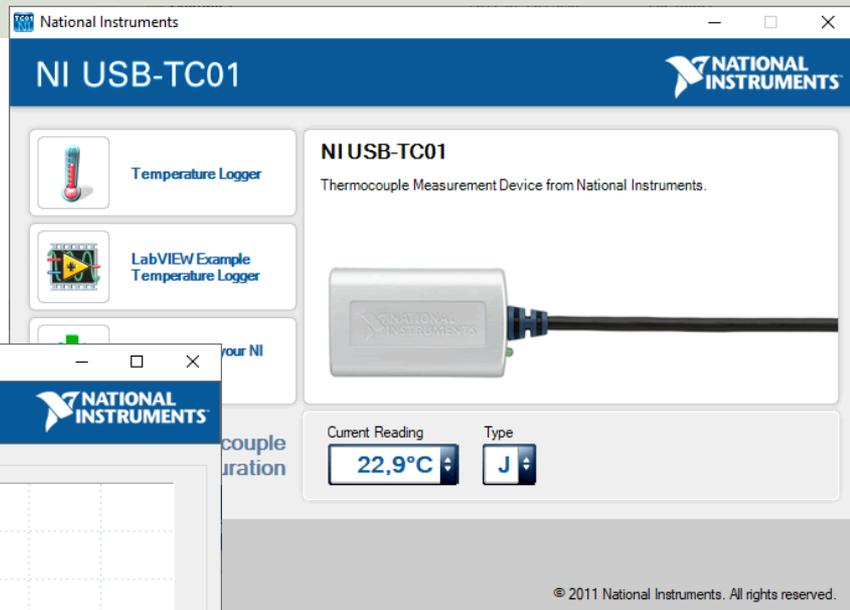
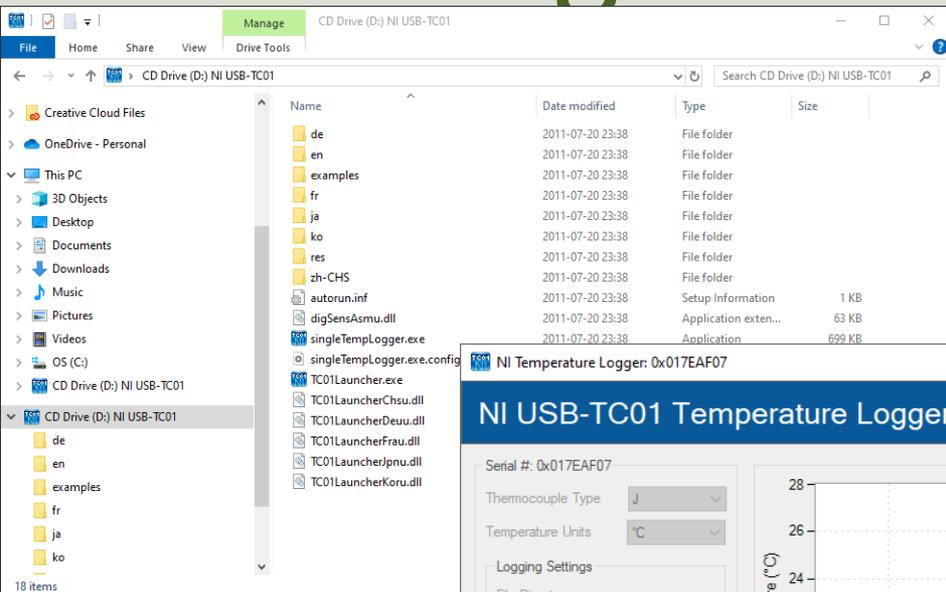
Settings

### NI-DAQmx Device Basics

What do you want to do?

- Run the NI-DAQmx Test Panels
- Remove the device
- View or change device configuration

# Getting Started with TC-01



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# Practical LabVIEW Examples



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# DAQ Assistant

TC-01 Thermocouple



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# DAQ Assistant

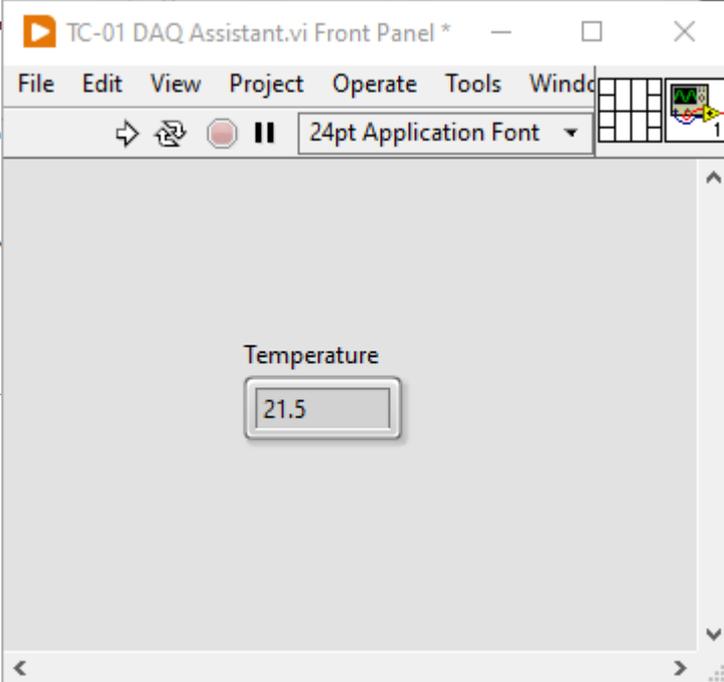
DAQmx - Data Acquisition

↑ Search Customize

- TASK
- CHAN
- Create Char
- Timing
- Triggering
- Channel Node
- Timing Node
- Triggering Node
- DAQ Assist
- Real-Time

TC-01 DAQ Assistant.vi Front Panel \*  
File Edit View Project Operate Tools Window  
24pt Application Font

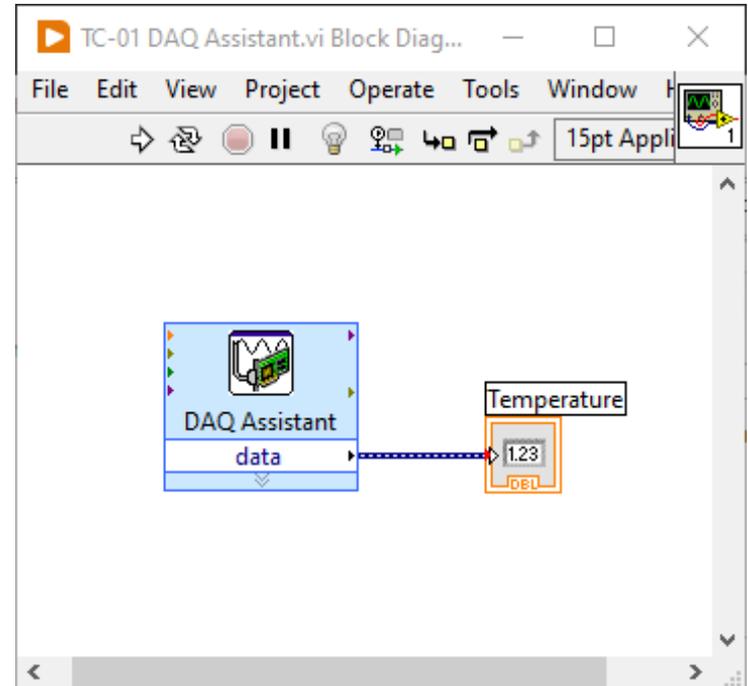
Temperature  
21.5



TC-01 DAQ Assistant.vi Block Diag...  
File Edit View Project Operate Tools Window  
15pt Appli

DAQ Assistant  
data

Temperature  
123



```
graph LR; DAQ[DAQ Assistant] -- data --> Temp[Temperature];
```

# DAQ Assistant

Create New ... ? X

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

- Voltage
  - Temperature
    - Iex Thermistor
    - RTD
    - Thermocouple**
    - Vex Thermistor
  - Strain

Create New ... ? X

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, the channel is added to 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

Physical

Supported Physical Channels

- Dev1 (USB-TC01)
  - ai0**

<Ctrl> or <Shift> click to select multiple channels.

< Back Next > Finish Cancel

The TC-01 device has only one Analog Input called ai0

DAQ Assistant

Undo Redo Run Add Channels Remove Channels Hide Help

Express Task Connection Diagram

Channel	Value
Temperature	0

Table Display Type

Configuration Triggering Advanced Timing Logging

Channel Settings

- Temperature

Thermocouple Setup

Settings

Signal Input Range

Max 100 Min 0 Scaled Units deg C

Thermocouple Type J

CJC Source Constant CJC Value 25

Timing Settings

Acquisition Mode 1 Sample (On Demand) Samples to Read 100 Rate (Hz) 1k

Value is the temperature of the cold junction of the thermocouple when CJC Source is set to Constant. The temperature value uses the same units as Input Range.

OK Cancel

Select CJC Source = "Built-in"

# Convert from Dynamic Data

Search Palettes

Return Customize

Convert from

Functions Controls

Convert from Dynamic Data

Configure Convert from Dynamic Data [Convert from Dynamic Data]

**Conversion**

Resulting data type

- 1D array of scalars - most recent value
- 1D array of scalars - single channel
- 2D array of scalars - columns are channels
- 2D array of scalars - rows are channels
- Single scalar**
- Single waveform

**Scalar Data Type**

Floating point numbers (double)

Boolean (TRUE and FALSE)

Channel

0

**Input Signal**

Channel 0 Channel 1

Amplitude

Time

Sample-Data

**Result Preview**

Single value (double)

2

Sample Data

OK Cancel Help

TC-01 DAQ Assistant2.vi Block Diagram

File Edit View Project Operate Tools Window Help

15pt Application Font

DAQ Assistant data

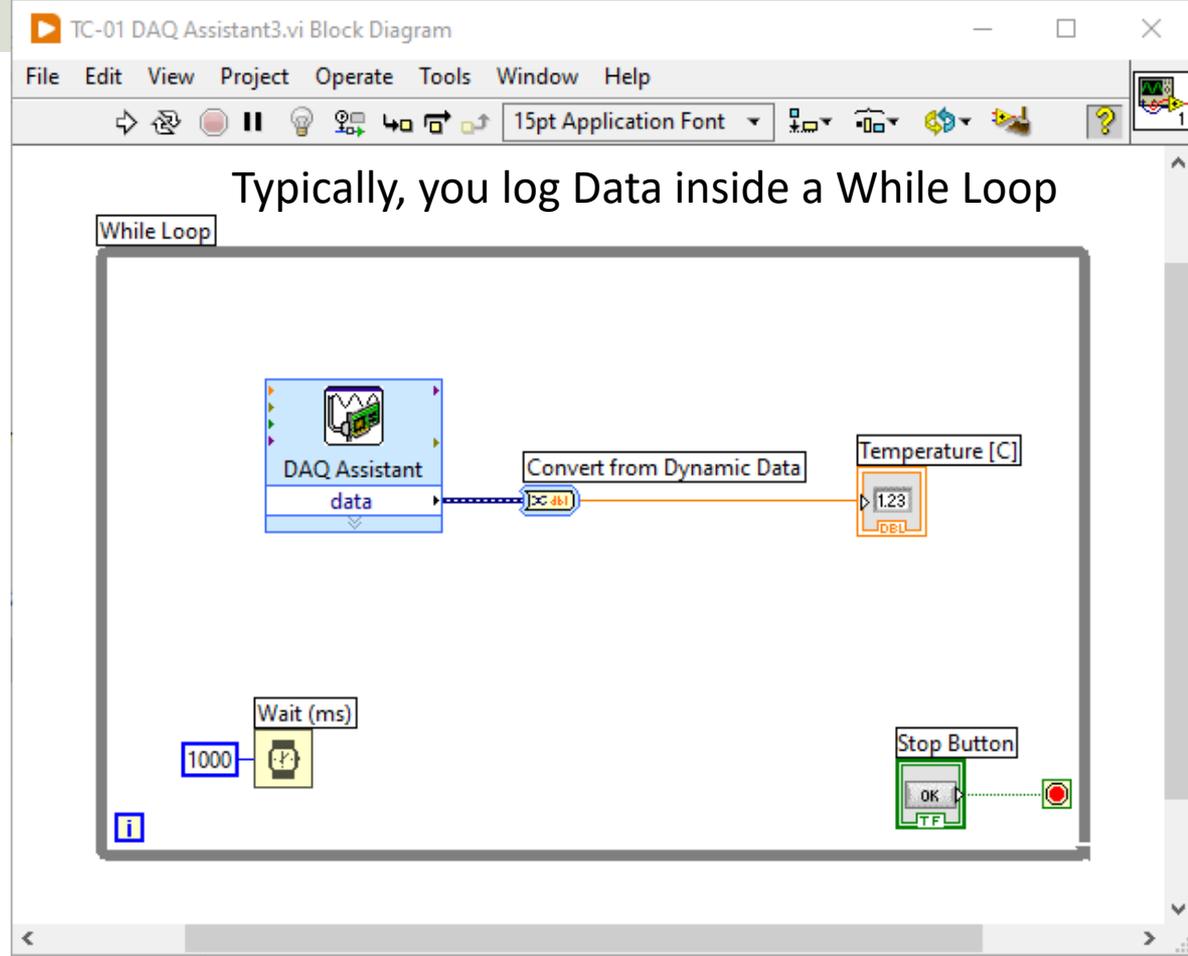
Convert from Dynamic Data

Temperature

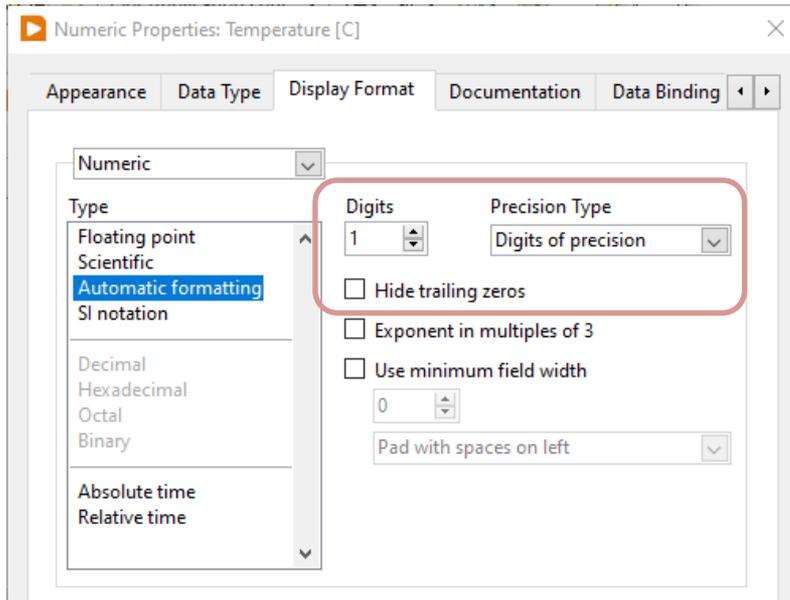
1.23

DEL

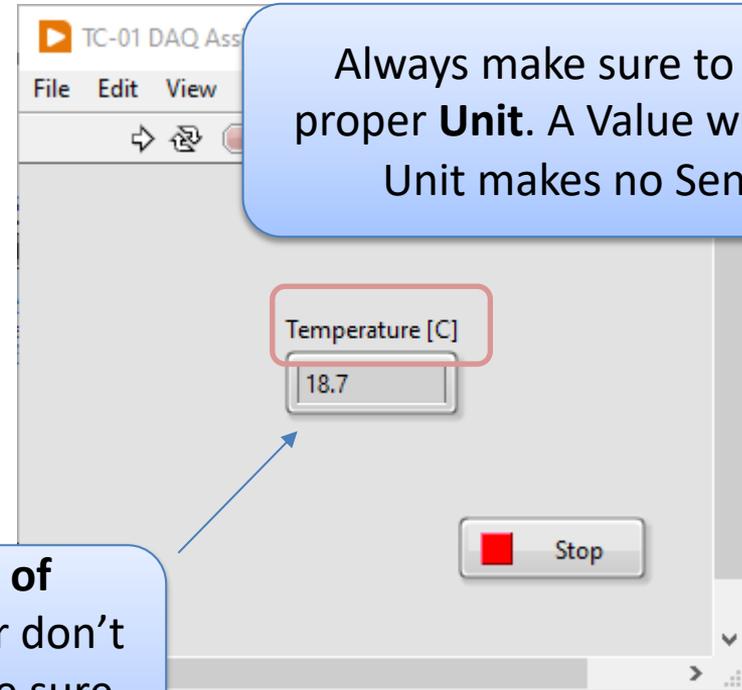
# While Loop



# Number of Decimals and Units



Make sure to select a proper **Number of Decimals**. Typically, a Temperature Sensor don't have an Accuracy with 10 Decimals. Make sure to read the Datasheet for the selected Sensor



Always make sure to add a proper **Unit**. A Value without a Unit makes no Sense!

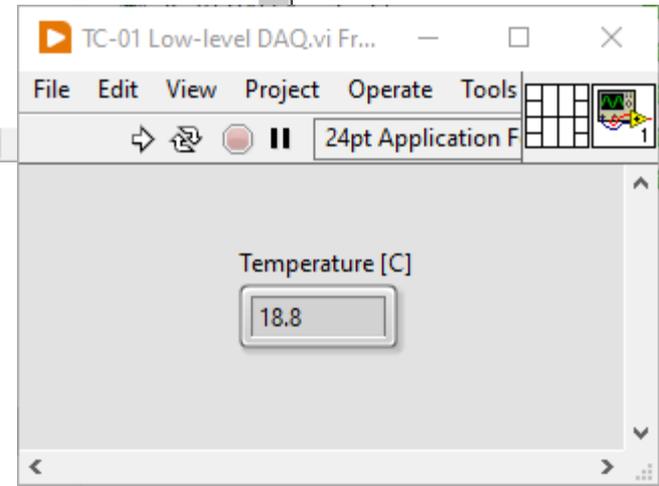
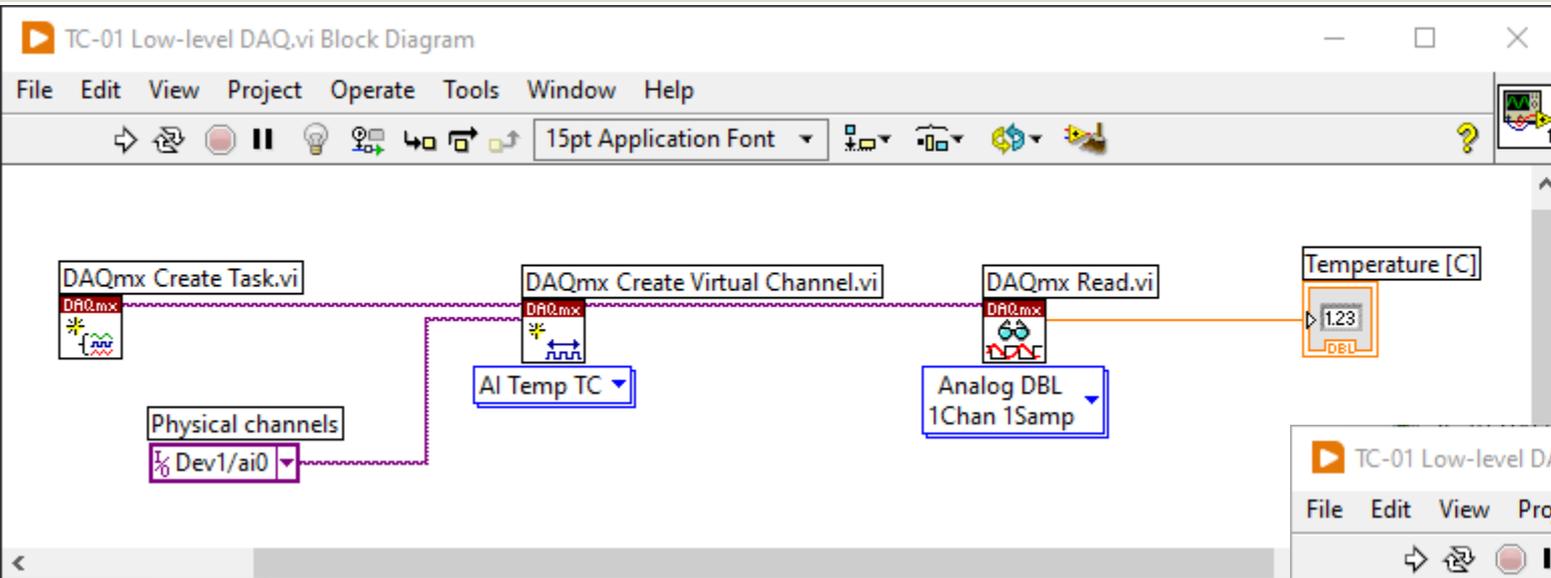
# Using “Low-level” DAQmx VIs

TC-01 Thermocouple

Hans-Petter Halvorsen



# Using “Low-level” DAQmx VIs



# Configure Additional Settings

Context Help

### DAQmx Create Channel (AI-Temperature-Thermocouple).vi

cjc channel  
cjc source  
minimum value  
maximum value  
task in  
**physical channels**  
name to assign  
units  
error in  
thermocouple type  
cjc value

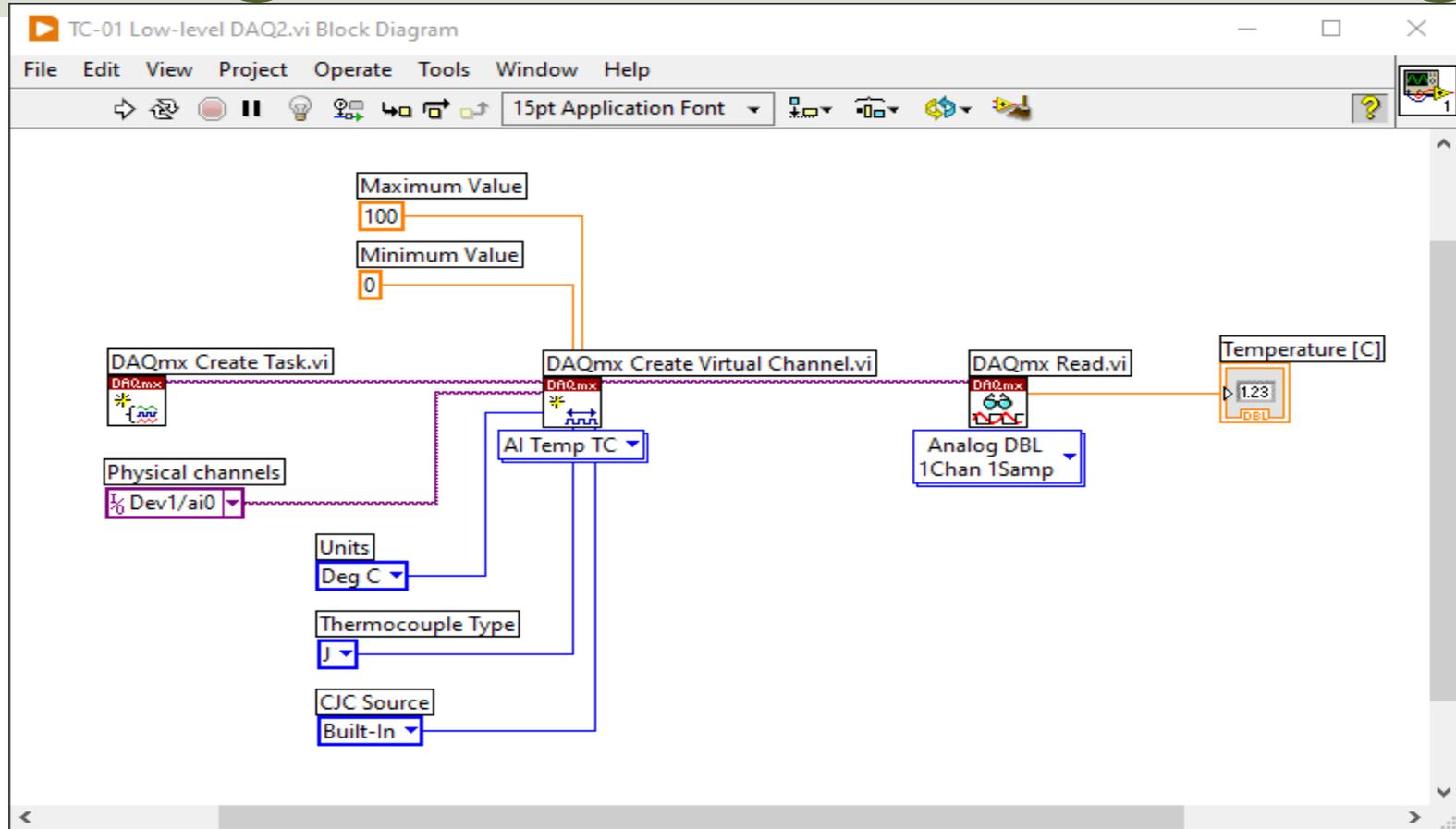
task out  
error out

Creates channel(s) that use a thermocouple to measure temperature.

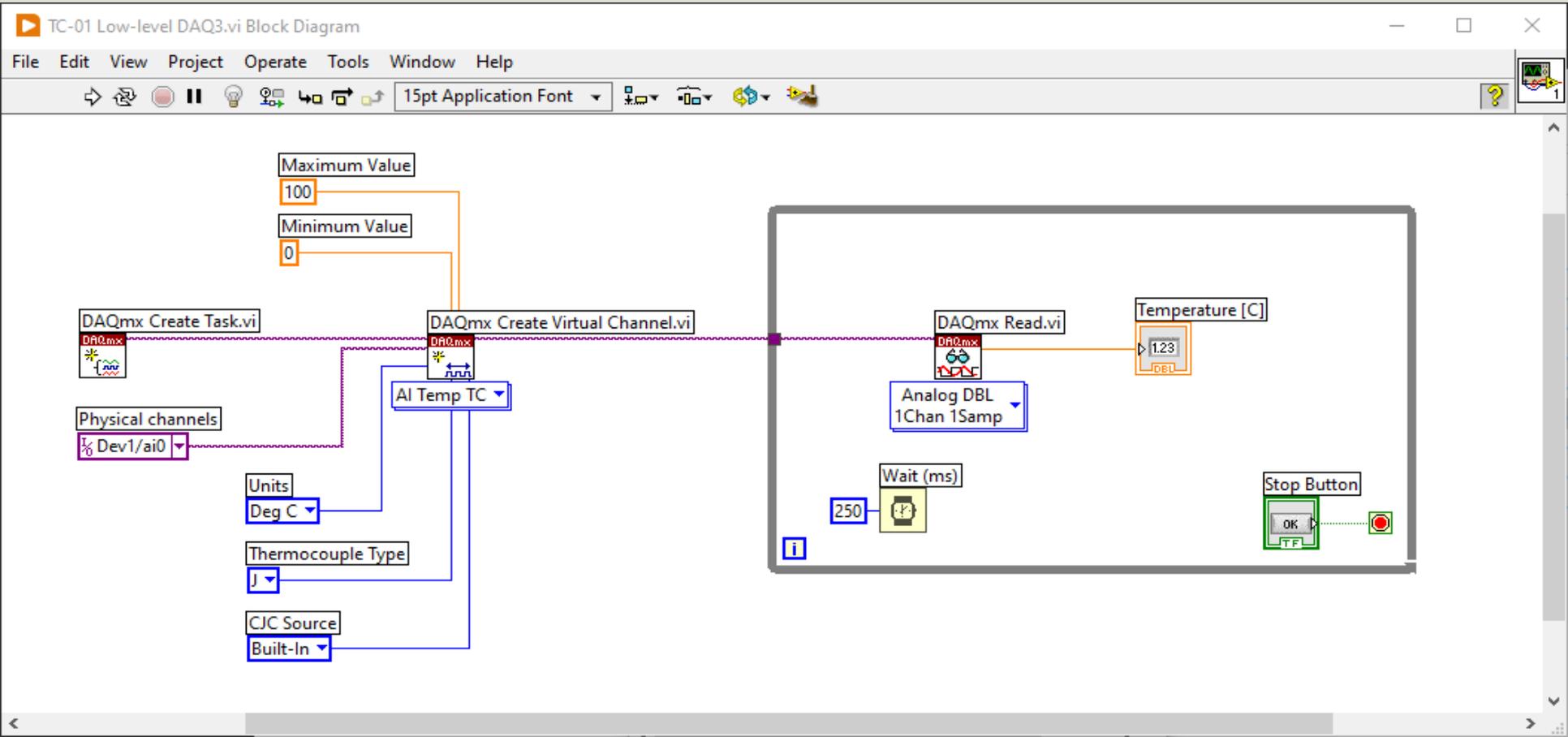
[Detailed help](#)

In the previous example we just used the default setting.  
If you need to change some of the default setting, just right-click on the select input and create a constant

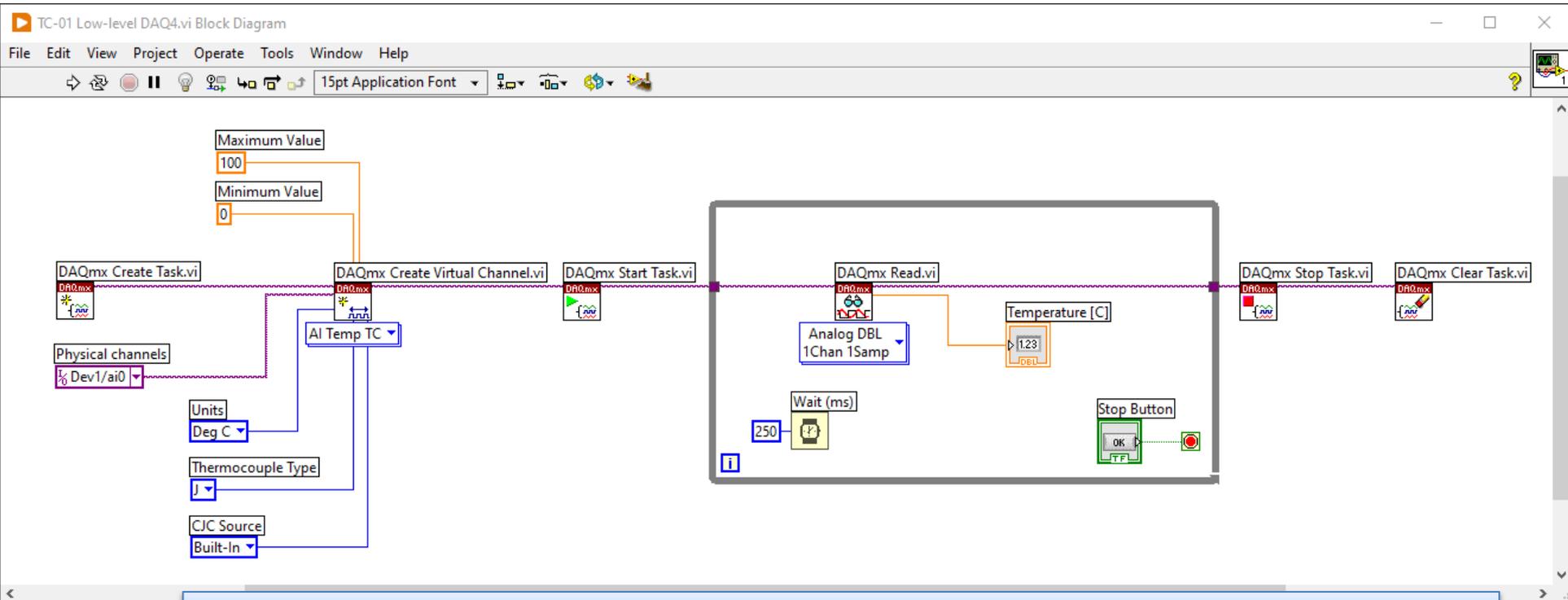
# Configure Additional Settings



# While Loop



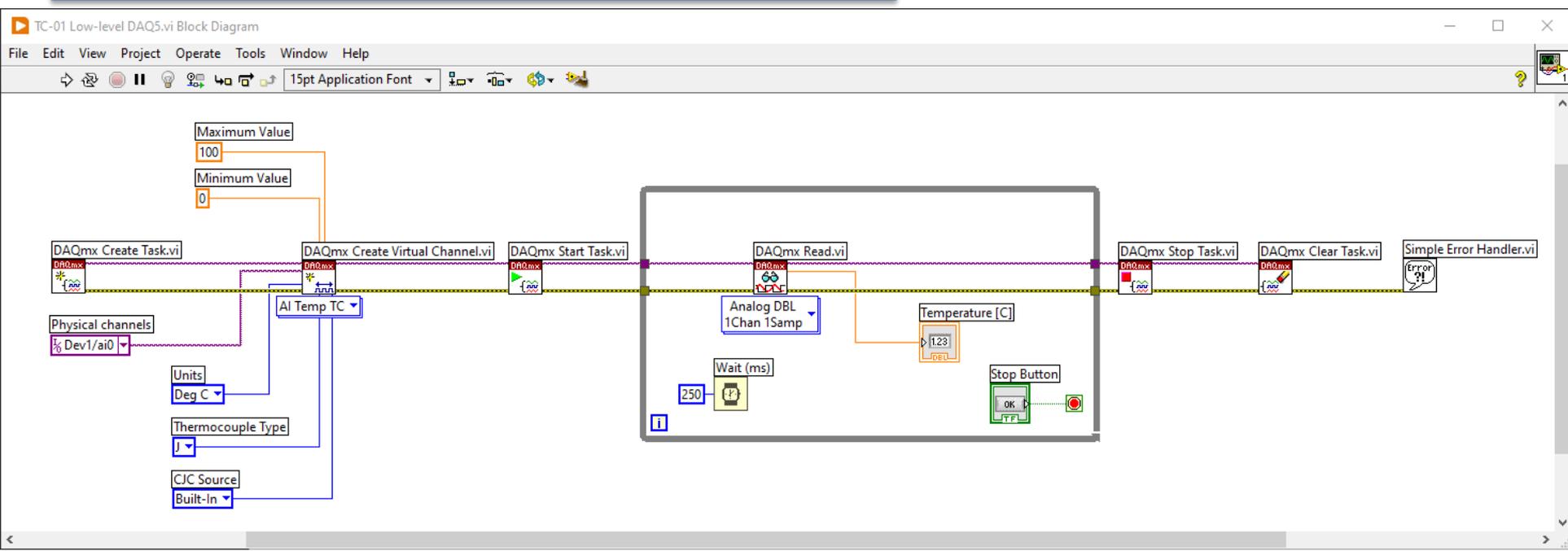
# While Loop with Start/Stop Task



Increase **speed** by using “Start Task” and “Stop Task” VIs outside the While Loop

# Final Application with Error Handling

All Applications should have proper Error Handling



Further Improvements: Use the **State Machine** programming principle in your Application

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