

UEI Application Notes:

AI-225 Thermocouple Measurement • Using DASyLab

App Note #023



**United
Electronic
Industries**

AI-225 Thermocouple Measurement • Using DASyLab

Introduction

Purpose: This paper outlines how to use an AI-225 layer, STP-AI-U terminal, and a K-type thermocouple, for measuring temperature.

Equipment

Our setup consisted of:

- (1) Omega K-type thermocouple wire (yellow with red stripe)
- (1) DNA-CM5 PowerDNA Cube, equipped with
 - (1) DNA-AI-225 Analog Input layer, connected to
 - (1) DNA-STP-AI-U terminal panel via
 - (1) Shielded, rounded, DNA-CBL-62 cable
- (1) Host PC connected to the DNA-CM5 (via Ethernet cable)

The DNA-AI-225 layer with the DNA-STP-AI-U terminal is ideal for thermocouple measurement. For a good thermocouple, accurate temperature changes can be measured to within 0.1°C!

The DNA-AI-225 layer provides an input range of ± 1.25 in $0.059\mu\text{V}$ increments (24-bit resolution), differential input, sample rates of 5 to 1,000 per second, and a dedicated CJC channel.

CJC, or cold-junction compensation, adjusts the offset caused by connecting different metal types (e.g. the thermocouple wires, and the terminal's connector block). In detail, a thermocouple is essentially two different types of metal wire connected at one end; the two thermocouple wires are screwed into the terminal block (yet another metal), forming another thermocouple at the junction. To remove the offset of this extra junction, the layer uses the STP-AI-U terminal's on-board IC (wired through the dedicated CJC channel) to determine and remove the extra offset. This method is "built-in" CJC compensation. For non-STP-AI-U connections, "constant" CJC compensation is used instead.

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Test Setup:

This section presumes that the PowerDNA Cube is already configured and tested to connect to a Host PC via Ethernet.

PowerDNA Cube Host PC Connectivity

Connect the Ethernet line to your PC. Connect the DNA-CBL-62 cable to the DNA-STP-AI-U terminal, and to the DNA-AI-225 layer.

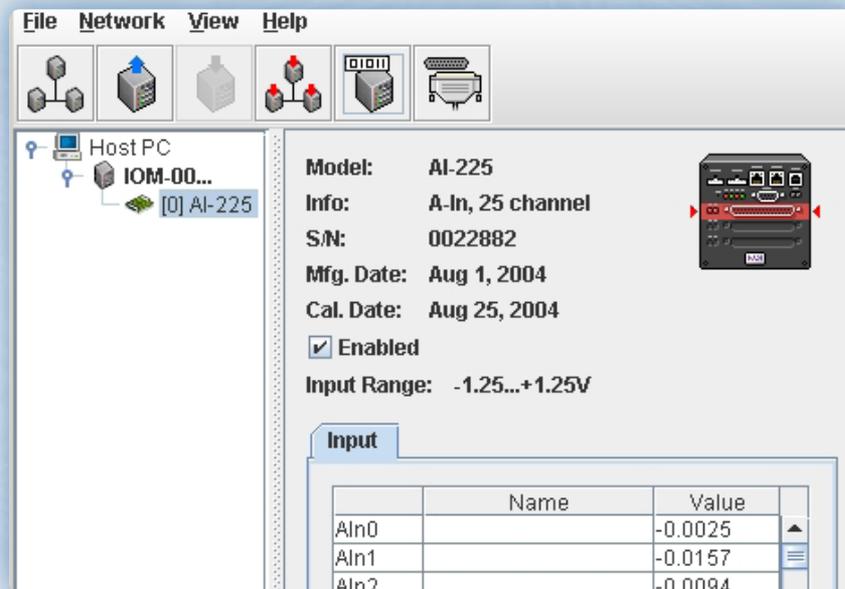
Supply power to the PowerDNA cube (we used a DNA-PSU-24 brick). Run the PowerDNA Explorer application from:

Start Menu » Programs » UEI » PowerDNA » PowerDNA Explorer

Scan the network, and connect to your cube. Select the AI-225 layer. From the menu, go to: Network » Read Input Data:

Values should display in the Input tab, indicating that the layer is functional. We incremented our precision voltage source between 0.0000V and 1.2500V, to double-check the input line for errors.

We knew that the layer was working correctly when PowerDNA Explorer reflected the values on the voltage source.



The screenshot shows the PowerDNA Explorer software interface. The top menu bar includes File, Network, View, and Help. Below the menu bar are several icons representing different hardware components. The main window is divided into two panes. The left pane shows a tree view with 'Host PC' at the top, followed by 'IOM-00...' and '[0] AI-225'. The right pane displays the configuration for the AI-225 layer. It includes fields for Model (AI-225), Info (A-In, 25 channel), S/N (0022882), Mfg. Date (Aug 1, 2004), Cal. Date (Aug 25, 2004), and a checked 'Enabled' checkbox. The Input Range is set to -1.25...+1.25V. Below this information is an 'Input' tab with a table showing the following data:

	Name	Value	
	AIn0	-0.0025	▲
	AIn1	-0.0157	☰
	AIn2	-0.0094	

Figure: Floating values read when testing reading on the AI-225.

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Terminal Setup for the DNA-STP-AI-U

The datasheet for the DNA-STP-AI-U, available online, contains block-level diagrams of the board and tables for configuration options.

Thermocouple jumpers to set are:

- ✓ JTC1/JTC2: Enable built-in CJC compensation sensor
- ✓ JPOW1: Sets to AGND the -VCC/AGND screw terminal
- ✓ JD1 to JD23, and JG1 to JG23:
Enable “Open TC” detection and signal filtering.
- ✓ JD24, JG24: Enable “Open TC” detection and filtering for CJC.
- ✓ N1 to N24 (required): signal return to ground.

Open thermocouple detection (or “Open TC” detection) is enabled by setting JD1 to JD24. When the thermocouple wires are not correctly screwed into the board, or the board is damaged, or the thermocouple wires are unwound, decoupled, or otherwise broken – the input channel will receive a full voltage. For our K-type thermocouple, using an input range of -10V to 10V, an open thermocouple is equivalent to approximately -4,144,602°C!

Setting JD1 to JD24 and JG1 to JG24 enables the low-pass filter for a better noise floor, including on the CJC channel (channel 24).

The jumpers are now set.

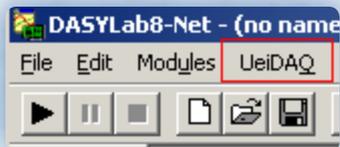
Screw the thermocouple leads into the terminal panel.

You are now ready to take measurements with the AI-225 and the DNA-STP-AI-U.

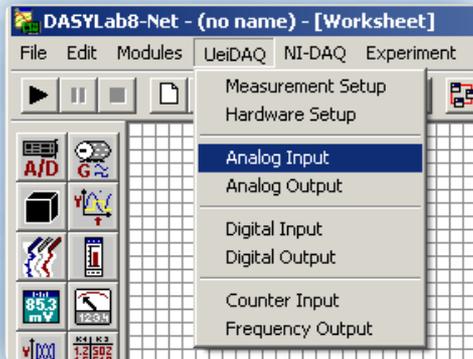
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Measuring with DASyLab

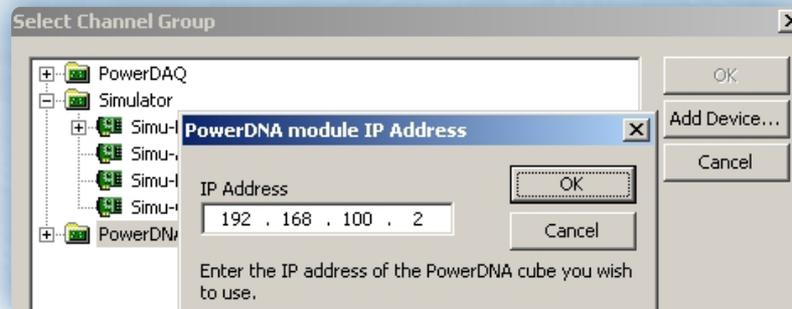
DASyLab Setup: You should have the PowerDNA and Framework drivers (both included in the PowerDNA Software Suite) installed; a menu “UeiDAQ” should be visible in the DASyLab menubar:



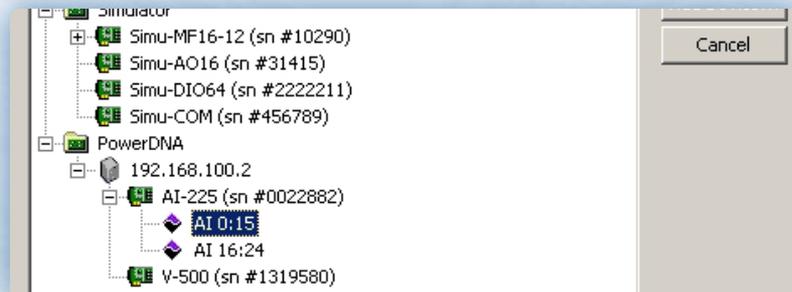
Select the “Analog Input” module from UeiDAQ menu:



Click in an open space on the worksheet to drop the AI module.
Select PowerDNA > Add Device... and add your Cube's IP.



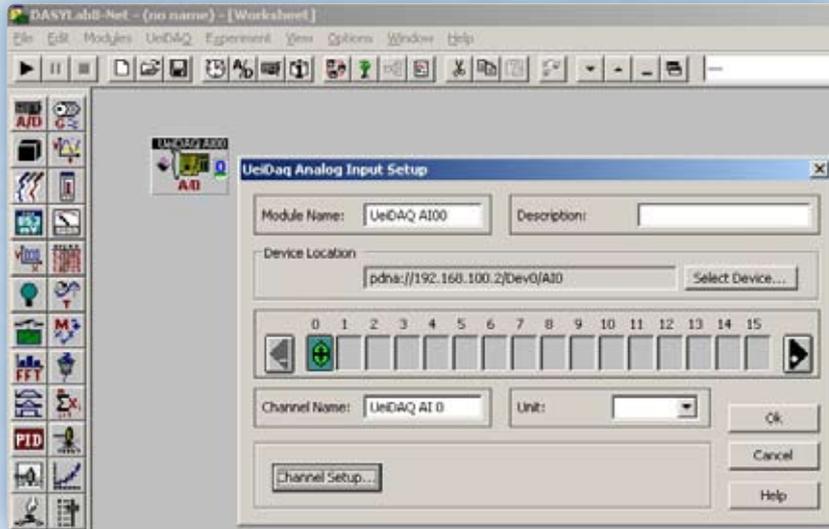
Browse the Cube devices to select the AI channels you want to use:



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An Analog Input block is created.

Double click on this block to open the property page:

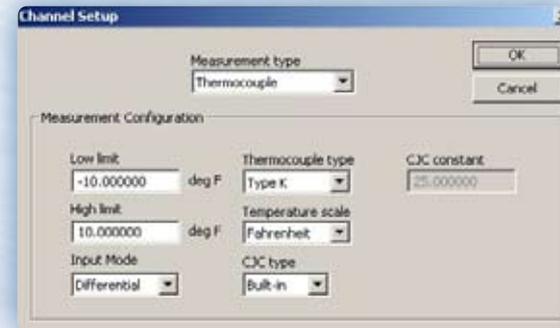


Press the Channel Setup button to adjust the Analog Input parameters (changes are applied to the currently selected channel!)

Under Channel Setup, change the Measurement type to Thermocouple.

Set up the measurement configuration:

- Select your Thermocouple type from the drop-down list.
- Select the Temperature scale for output
- For the AI-225 with STP-AI-U, select CJC type: Built-in otherwise, select the Constant and fill in the CJC constant
- Set the Input Mode to Differential



Note: Changing the “low limit” and “High limit” parameters will adjust the gain of the analog input amplifier

Click OK to commit the changes to the Channel Setup.

Click OK again to accept the Analog Input setup.

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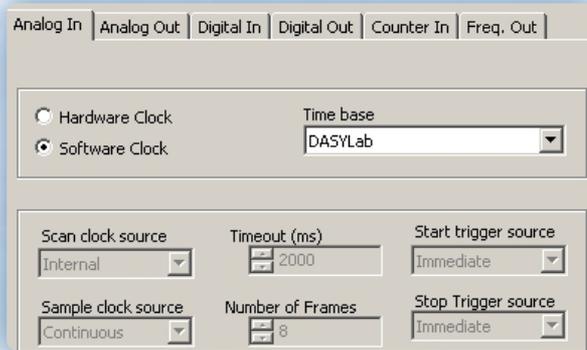
Next, adjust the timing type from the menu:

UeiDaq»Hardware Setup

a selection page will allow tuning data acquisition settings:

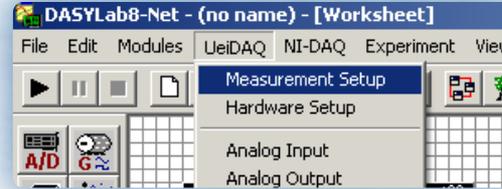


Set the clock to Software Clock, let DASyLab determine the time base.

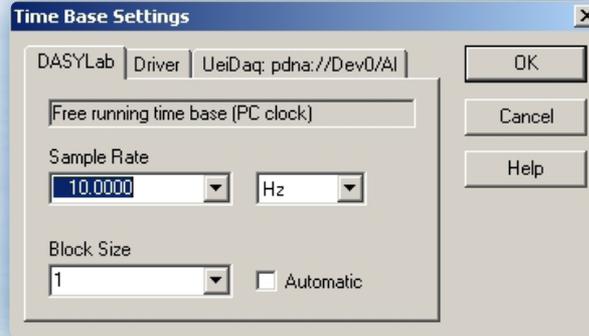


To adjust the time base (sampling rate), from the menu:

UeiDAQ»Measurement Setup



Select the "DASyLab" tab, and adjust your sample rate. The setting for our measurement is 10 Hz; as there is less hardware noise at lower sampling rates, and thermocouples do not require a high sampling rate.



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We displayed data in a Y/t chart – to add this type of chart, select:

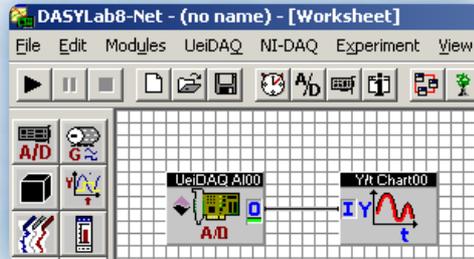
Module»Display»Y/t Chart

In the menu bar:



When the Y/t Chart block is created, simply connect the output of the Analog Input Block to the input of the Y/t chart in order to display data that will be acquired in this chart:

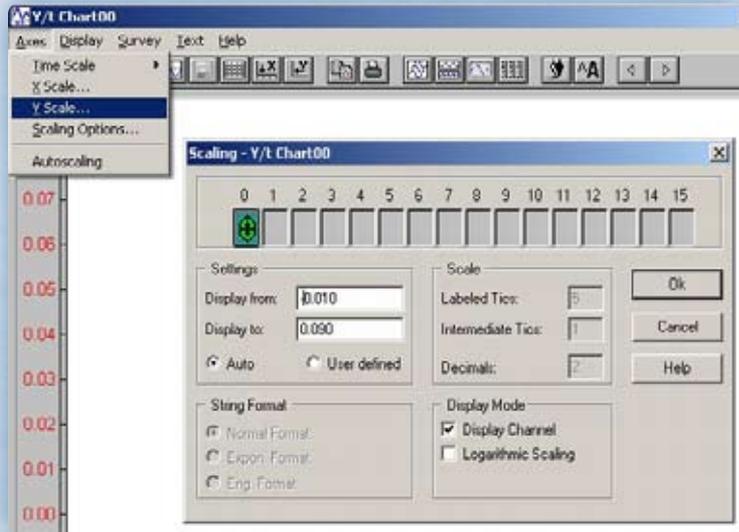
In the lower-left corner of the screen, a small child window labeled Y/tChart00 will be minimized.



Select the Y/t Chart window and restore it (or maximize it) so that it is visible and usable.

From the Y/t Chart's menu, select:

Axes » Y Scale...



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The default graph will display -5° to 5° . Adjust the axes of the chart to display a range from 0° to 100° . Click OK to commit the changes.

Alternatively, a Chart Recorder graph works equally well:

Modules » Display » Chart Recorder

Bring the main DASyLab window into focus. Creating a Digital Meter will help debug channels when they do not display on the graph.

From the menu:

Modules » Display » Digital Meter.

Connect the Input channel's output into the Digital Meter's input.

The experiment is now ready to be run.

Running the experiment under DASyLab

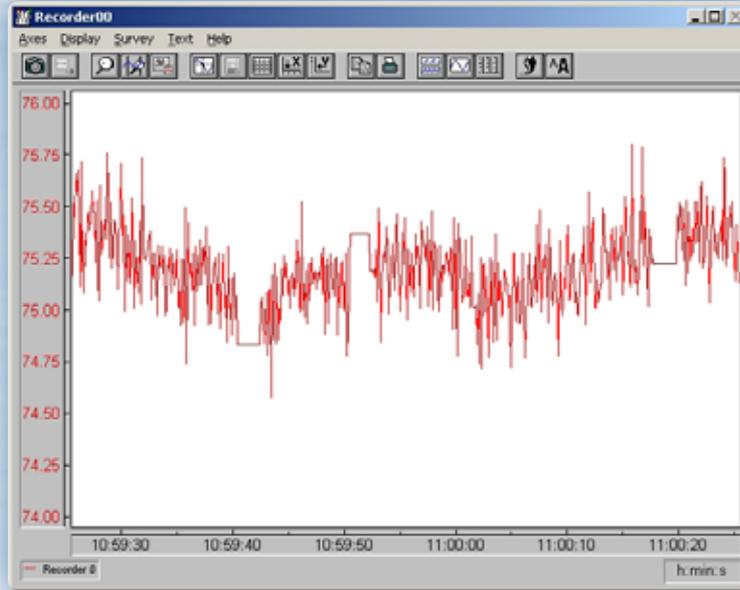
Run the program by pressing the Start Button. This is the very first button in the toolbar. This action begins the experiment.

The Y/t chart or recorder set up earlier should display the information as soon as the button is pressed.

Here are the results for the following setup:

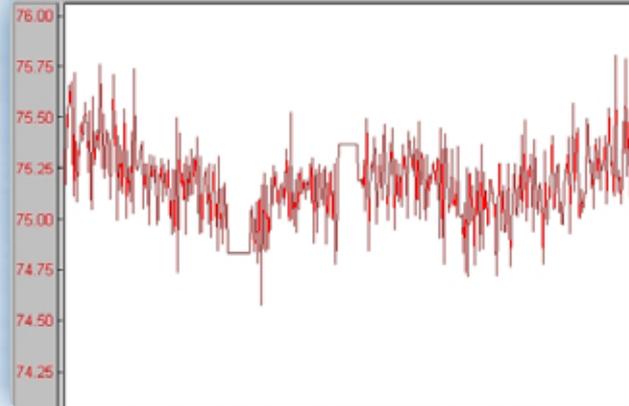
- (1) Omega K-type thermocouple wire (yellow with red stripe)
- (1) DNA-CM5 PowerDNA Cube, equipped with
 - (1) DNA-AI-225 Analog Input layer, connected to
 - a DNA-STP-AI-U terminal panel via
 - a shielded, rounded, DNA-CBL-62 cable
 - (1) Host PC connected to the DNA-CM5 (via Ethernet cable) running DASyLab with parameters:
 - 10 Hz Sample Rate in Software Mode
 - Channel 0 Setup: Differential, K-type TC, °F, Built-in CJC

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Note the quantity of noise on the output line.

Even in differential mode, the noise picked up by a long piece of wire (that behaves like an antenna) is not easily overcome.



Adding a 1uF to 10uF ceramic capacitor in parallel with the thermocouple reduces the bandwidth of the noise, in addition to the JDx/JGx jumpers.

Thicker wire (20-22 gauge from 28gauge) helps resist noise.

Running the experiment at lower frequency also helps reject noise at the AI-225.

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Sending the results to a text file (or Excel)

Modules » Files » Write Data

File Format: ASCII

Write Protection: Enabled

Multi-File... » Write As Multi File: Enabled » OK

File Name... » Desktop\thermo.txt

(it will be autosplit)

This completes the DASyLab how-to.

Next: Obtaining measurements using C#

Measurement and Results with .NET

The PowerDNA and Framework drivers (both included in the PowerDNA Software Suite) must be installed before continuing.

Note that all examples work with MsVS.NET including 2005 Express. For a free copy of VB.NET 2005, visit Microsoft's MSDN site:

<http://msdn.microsoft.com/vstudio/express/vb/download/>

Quick results using VB.NET

Measuring thermocouples is a low-speed analog input operation that can be done by modifying any analog input example written for MsVS.NET. This section on how to do this for Visual Basic .NET.

Open the Visual Basic.NET examples folder:

Start » Programs » UEI » Framework » Examples »
Visual Basic.NET Examples

Thermocouple readings are normally read very slowly, so single point-by-point acquisition suffices – use the SingleAI example.

Open the SingleAI example: double-click the vb_examples.sln file.

Right-click the SingleAI project, and select Set as Startup Project; this sets this project as the compile-able project.

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You may copy and comment out the lines for Channel configuration before changing it:

```
// mySs.CreateAIChannel("pdna://192.168.0.61/Dev2/Ai0:3",  
-10.0, 10.0, UeiDaq.AIChannelInputMode.Differential)
```

Change the Channel configuration line to work with thermocouples:
(where 192.168.100.2 is the cube's IP address)

```
mySs.CreateTCChannel("pdna://192.168.100.2/Dev0/Ai2", -  
10.0, 10.0, AIChannelInputMode.Differential, Tempera-  
tureScale.Fahrenheit, ColdJunctionCompensationType.  
BuiltIn, 70, "", AIChannelInputMode.Differential)
```

That's it! Now an explanation of why we use this mode, and how it works:

Open the UEIDAQ .NET Documentation from:

Start » Programs » UEI » Framework » Documentation »
UeiDaq Framework Documentation

and select help on UeiDaq::CUeiTCChannel from the Class List.

Notice from the documentation that the TC Channel configuration is essentially an enhanced AI Channel configuration that performs linearization and voltage-to-degrees translation for you. The function parameters are:

```
("resource string", min voltage, max voltage, Thermocouple-  
Type, TemperatureScale, ColdJunctionCompensationType,  
cjcConstant, cjcResource, AIChannelInputMode)
```

As discussed in the manual, the resource string is, for example:

```
pdna://192.168.100.2/dev0/Ai2
```

or, in abstract terms:

```
<driver>://<IP address>/<layer number>/<analog input,  
channel 2>
```

If you are using a non-standard board/setup, bypass channel validation by using a plus in front of the channel, as follows:

```
pdna://192.168.100.2/dev0/Ai+24
```

The minimum and maximum voltage automatically sets the gain.

Thermocouple type can be Type B, E, J, K, N, R, S, or T

CJC Compensation Type can be built-in (for the STP-AI-U w/ AI-225) or otherwise constant (in which case, cjcConstant must be defined as the ambient temperature of the room – e.g. 70°F). Otherwise, a cjcResource can be defined.

AIChannelInputMode can be set to differential (AI-225 only works in this mode) or single-ended (for SE-only boards with; connecting one lead to ground – not recommended due to noise).

That's it! Compile, and run.

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For a Glossary of terms used in this document as well as our other Application Notes and stories, Please refer to our online glossary at:

<http://www.ueidaq.com/data-acquisition-glossary/>

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