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United Electronic Industries

The High-Performance Alternative

PowerDNA STP-AI-U Universal Analog Input Screw Terminal Panel — User Manual

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Table of Contents

List of Figures

Chapter 1 Connecting the STP to your Layer

1.1 Installing a Cable for a DNA-AI-225

This chapter defines the recommended procedure for connecting the STP-AI-U panel to your PowerDNA Layer board. Refer to Figure 2-1 for connector location and proceed as follows:

STEP 1: Select a cable for connecting the STP-AI-U panel to your PowerDNA Layer. If you have a DNA-AI-225 Layer, use a DNA-CBL-62 2.5-ft, 62-conductor round cable with 62-pin male connectors on both ends.

STEP 2: Plug one end into the DNA-AI-225 Layer DB-62 connector on the front of the PowerDNA Cube.

STEP 3: Plug the other end of the cable into the connector on the STP-AI-U panel marked J225. DO NOT CONNECT ANY OTHER CABLES TO THE STP BOARD.

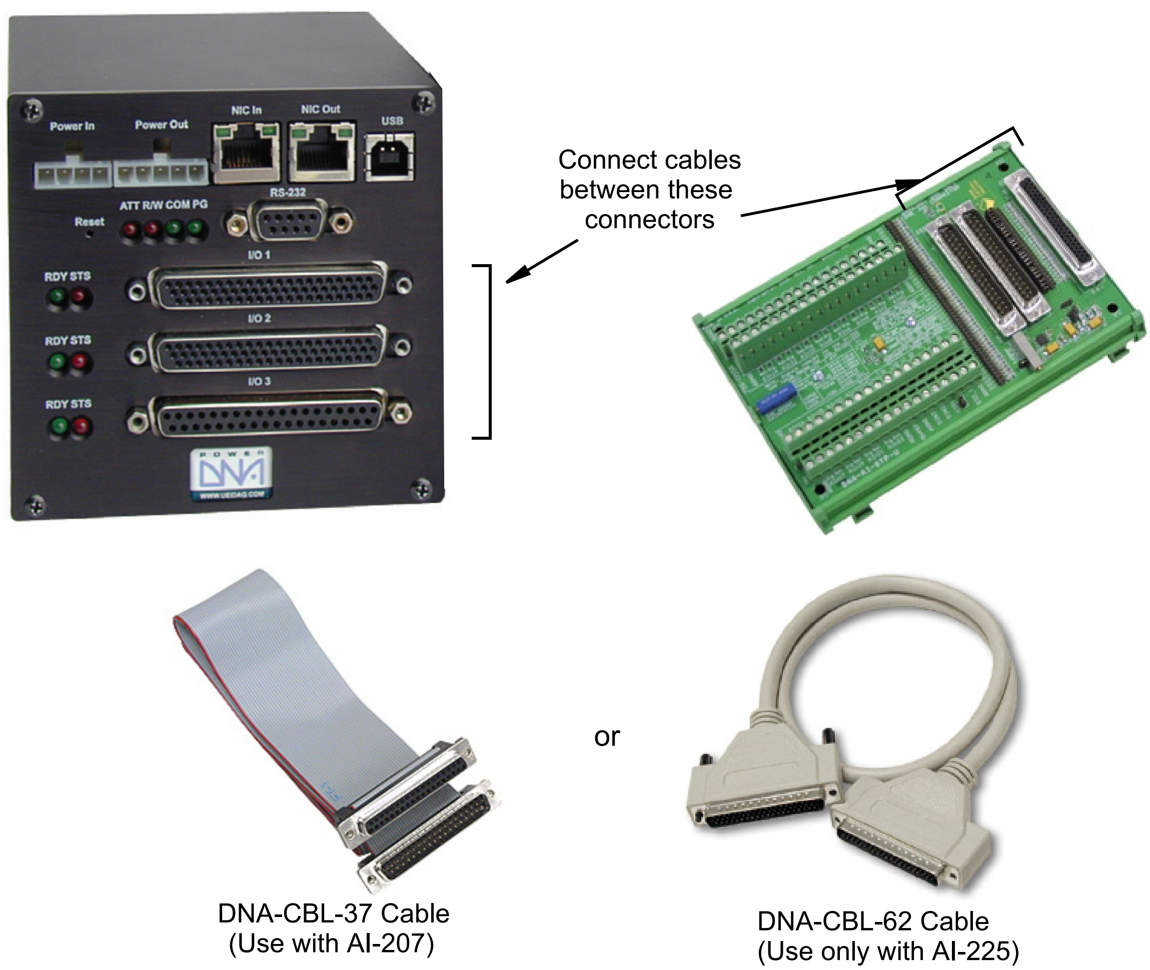


Figure 1-1 Connecting Your Layer to STP-AI-U Panel

1.2 Installing a Cable for a DNA-AI-207

Refer to **Figure 1-2** for connector location and proceed as follows:

STEP 1: Select a cable for connecting the STP-AI-U panel to your PowerDNA Layer. If you have a DNA-AI-207 Layer, use a DNA-CBL-37 3-ft., 37-conductor flat ribbon cable with 37-pin connectors (one male and one female).

STEP 2: Plug one end into the DNA-AI-207 Layer DB-37 connector on the front of the PowerDNA Cube.

STEP 3: Plug the other end of the cable into the connector on the STP-AI-U panel marked J207. DO NOT CONNECT ANY OTHER CABLES TO THE STP BOARD.

1.3 Connecting Power to Connectors

Connecting power to the connector used for your Layer requires you to install one or more jumpers, as follows:

STEP 1: Refer to **Figure 1-2** for location of jumpers.

STEP 2: If you are using a DNA-AI-225 Layer, install a jumper in JPOW1 between Terminals 2 and 3. Install a second jumper in JPOW2 between Terminals 2 and 3. Do not install any jumper in JPOW3.

STEP 3: If you are using a DNA-AI-207 Layer, install a jumper in JPOW1 between Terminals 2 and 3. Install a second jumper in JPOW2 between Terminals 1 and 2. Install a jumper in JPOW3 between terminals 1 and 2 (ON).

Figure 1-2 shows the locations of various jumpers on the STP-AI-U panel board. (Refer to Table 2-2 on page 12 for a summary of all jumper settings.)

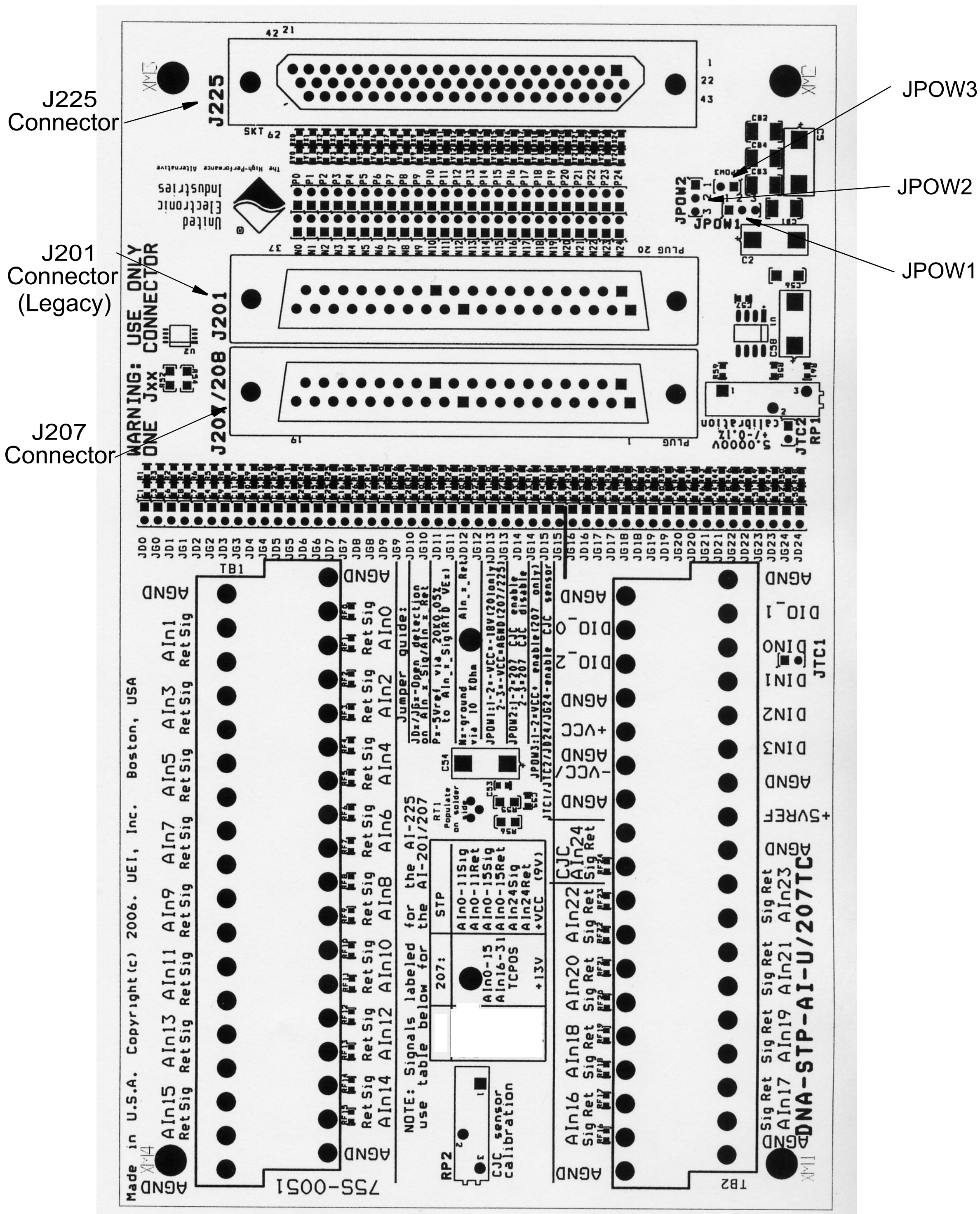


Figure 1-2   Location of Jumpers/Connectors on STP-AI-U Panel

Chapter 2 Connecting Analog Inputs to the STP

2.1 Overview

This chapter describes the procedures necessary to do the following:

- Connect analog inputs of various types to the STP-AI-U panel.
- Insert jumpers on the board to configure the inputs and options for the types of input signals you are working with. (Refer to Table 2-2 on page 12.)
- Define the linearization needed with an RTD input to convert analog voltage input to temperature.

2.2 Connecting Thermo-couples

To connect thermocouple inputs, do the following:

STEP 1: Connect each thermocouple signal line to the corresponding AINx Sig terminal on TB1 or TB2. Connect each thermocouple return line to the corresponding AINx Ret terminal on TB1 or TB2. Refer to **Figure 2-2** for location of TB1, TB2, and screw terminals.

STEP 2: To enable open thermocouple detection and low pass filter to ground, insert a jumper on JDx, where x is the channel number for that thermocouple. This action connects the signal line of the x channel to the open thermocouple detector circuit and a filter to ground. The location of JDx jumper terminals is noted in **Figure 2-2**.

NOTE: For every thermocouple return line, you should also enable a return to ground through a filter (jumper JGx), through a 10k resistor (Jumper Nx), or both. It is sufficient, however, to insert just the Nx jumper because of the wide difference in resistor values. Inserting both Nx and JGx jumpers is not necessary, but inserting both will not cause an error. The location of all jumper terminals is shown in **Figure 2-2**. (Refer to Table 2-2 on page 12 for a summary of all jumper settings.)

2.3 Enabling the CJC Feature

To enable cold junction compensation (CJC) for use with thermocouples, do the following:

STEP 1: Install jumpers on JTC1 and JTC2, as indicated in **Figure 2-2**.

This connects the CJC sensor to AIn 24 Sig and Ret lines.

STEP 2: Install jumpers on JD24, N24, and JG24, as indicated in **Figure 2-2**.

The JD24 jumper connects the Open TC detection/low pass filter feature to the AIn24 Sig line. The JG24 jumper connects a 10 megohm resistor and low pass filter to ground on the AIn24 Ret line. The N24 jumper connects a 10 kohm resistor to ground to the AIn24 Return line.

Figure 2-1 is a block diagram of the STP-AI-U panel. Refer to this figure to see the function of each jumper. (Refer to Table 2-2 on page 12 for a summary of all jumper settings.)

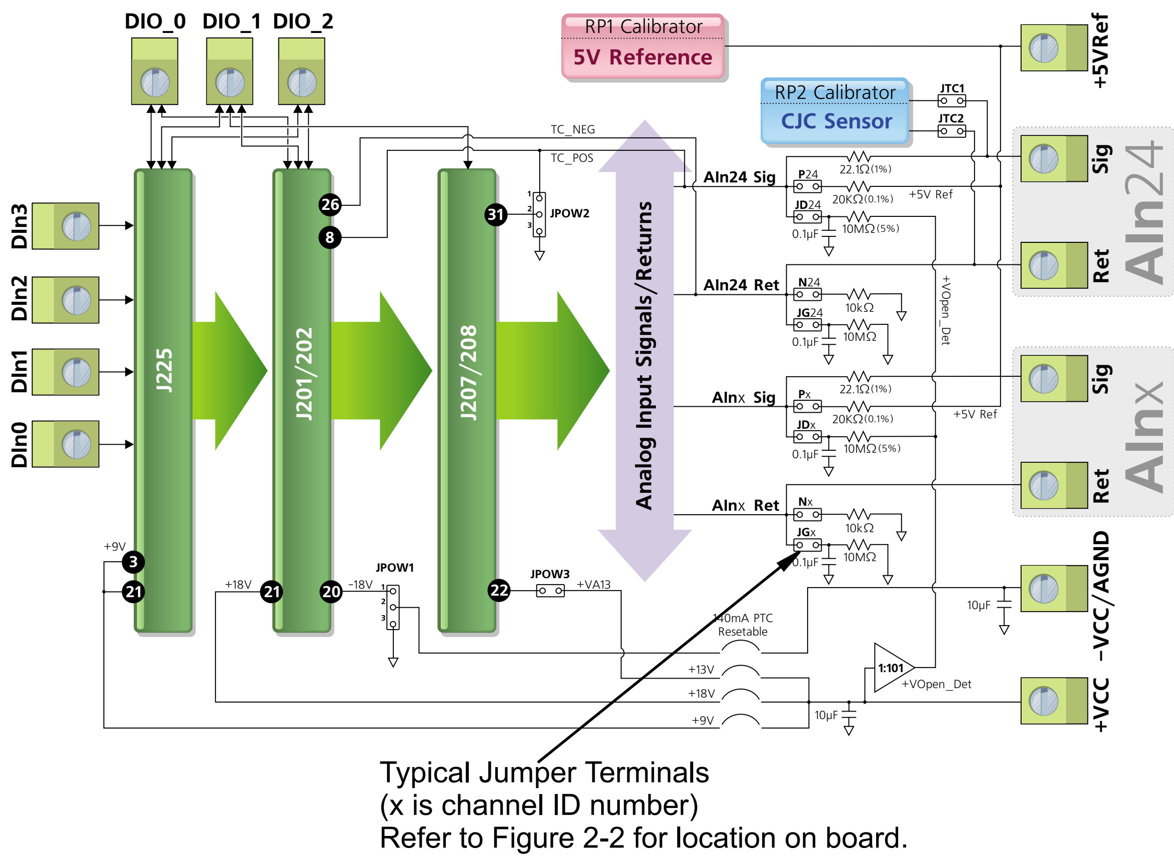


Figure 2-1 Block Diagram of DNA-STP-AI-U Panel

Figure 2-2 shows the locations of jumpers and terminals on the STP board.

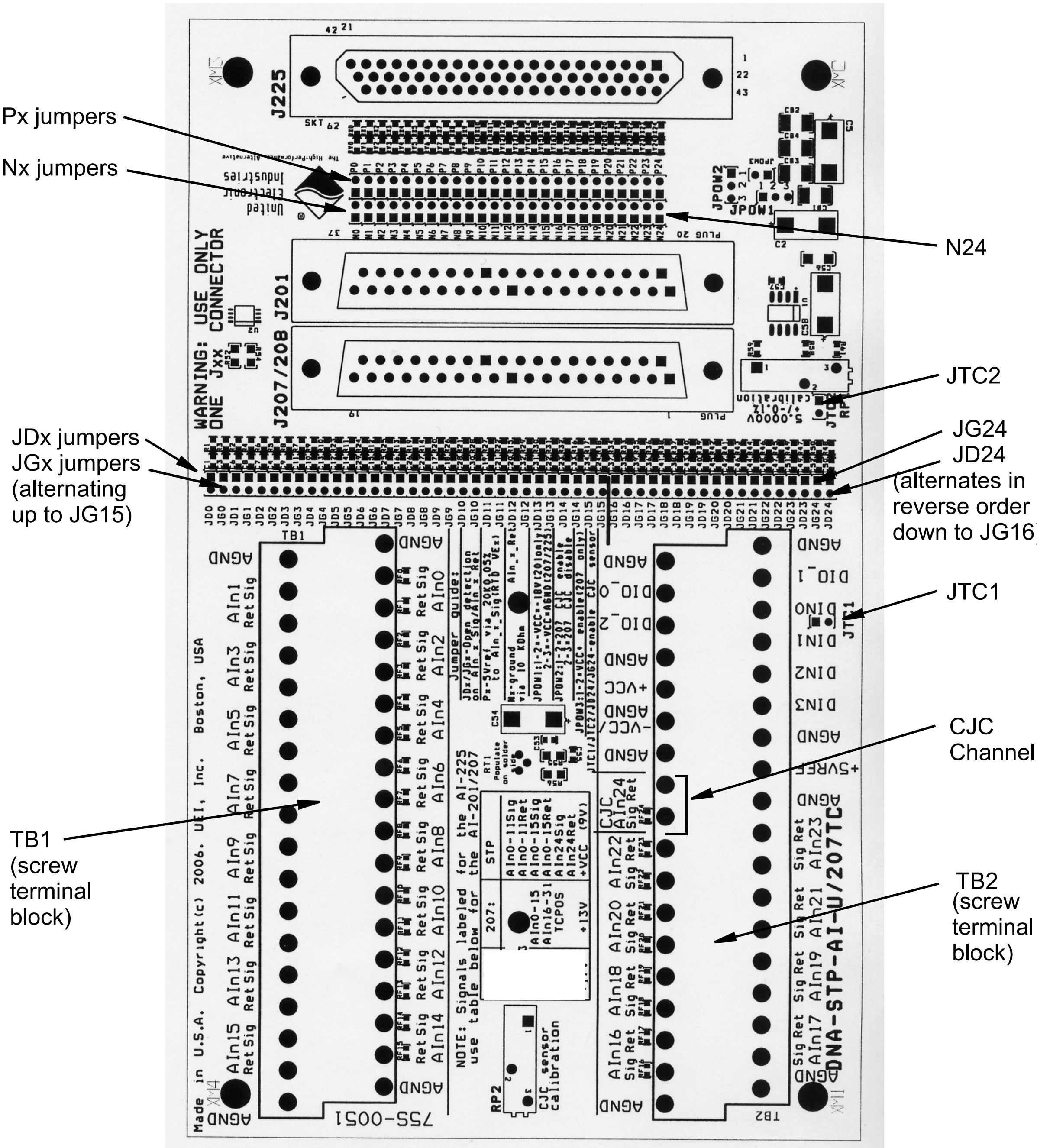


Figure 2-2 Location of Jumpers and Terminals on STP Panel

2.4 Connecting Voltage Inputs

To connect voltage (or millivolt) inputs to the STP, do the following:

STEP 1: Connect each voltage input signal line to a terminal onTB1 or TB2 marked AInx Sig, where x is the channel number.

STEP 2: Connect each voltage input return line to a terminal onTB1 or TB2 marked AInx Ret, where x is the channel number.

2.4.1 Enabling Filters

To enable return to ground through a 10 megohm resistor/low pass filter circuit, insert jumpers in JGx for each selected channel, where x is the channel number. The location of JGx jumper terminals is noted in **Figure 2-2**.

2.4.2 Enabling Return to Ground Through Resistor

To enable a ground return through a 10 kohm resistor on each voltage input, insert a jumper on Nx, where x is the channel number. This action connects the return line of the x channel input to ground through a 10kOhm resistor. The location of Nx jumper terminals is noted in **Figure 2-2**.

2.5 Connecting RTDs (+5V Excitation)

To connect +5VRef excitation to RTD inputs, do the following:

STEP 1: For every RTD input to which you want to connect internal +5V excitation, insert a jumper in Px, where x is the channel number of the signal line of the RTD input. The location of Px jumper terminals is noted in **Figure 2-2**.

NOTE: If you use an external voltage or current excitation source, do not insert any jumpers in Px, where x is the channel number. Instead, connect your external source directly to the AInx Sig terminals on TB1 or TB2.

STEP 2: Connect the screw terminal ”RET” to an “AGND” terminal.

2.6 Converting an RTD Voltage Signal to Temperature – 2-Wire

The following calculations may be used as a tool for converting the voltage signal measured across an RTD to temperature in Celsius.

The basic measuring circuit for a 2-wire RTD temperature detector is shown in **Figure 2-3**.

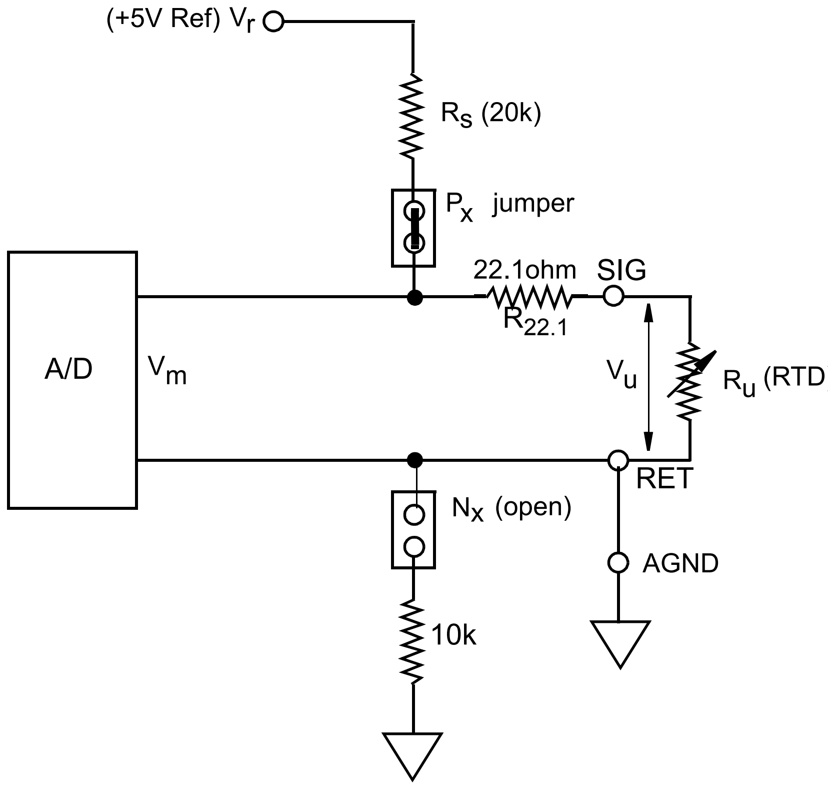


Figure 2-3 Two-wire RTD Circuit

Note that RET is connected directly to AGND.

Referring to **Figure 2-3**, the calculation (at 0°C) is as follows:

Temperature = 0 °C

R_u = unknown resistance (RTD)

V_r = 5VDC reference voltage

V_m= input voltage to A/D converter

$$R_u = \frac{(R_{22.1} + R_s) \cdot V_m - R_{22.1} V_r}{V_r - V_m}$$

Using the values listed above, the the value of R_u is:

$$R_u = \frac{(20022.1 \times 0.0303399) - 22.1(5)}{5 - 0.0303399} = 100\text{ohms}$$

Using a standard DIN 100 ohm Pt RTD with an alpha of 0.00385 ohms/°C yields the values shown in **Table 2-1**.

Temperature °C	R_u Ohms	V_m mV	$V_{22.1}$ mV	V_u mV	CURRENT mA
-200	18.52	10.134	5.5739	4.6204	.24950
-100	60.25	20.503	5.5025	14.990	.24879
0	100.0	30.339	5.4914	24.848	.24848
100	138.50	39.831	5.4808	34.348	.24800
200	175.86	49.005	5.4709	43.5341	.24755
300	212.05	57.861	5.4611	52.3997	.24711
400	247.09	65.902	5.4494	60.9275	.24658
500	280.98	74.639	5.4427	69.1997	.24628

Table 2-1 V_{in} vs. RTD Resistance at Various Temperatures

2.7 Converting an RTD Voltage Signal to Temperature – 4-Wire

The calculations in this section may be used as a tool for converting the voltage signal measured across an RTD to temperature in Celsius.

The basic measuring circuit for a 4-wire RTD temperature detector is shown in **Figure 2-4**.

NOTE:
Ch_x is used only to supply and read the excitation voltage for the RTD.

NOTE:
Ch_y is used to measure voltage across the RTD itself..

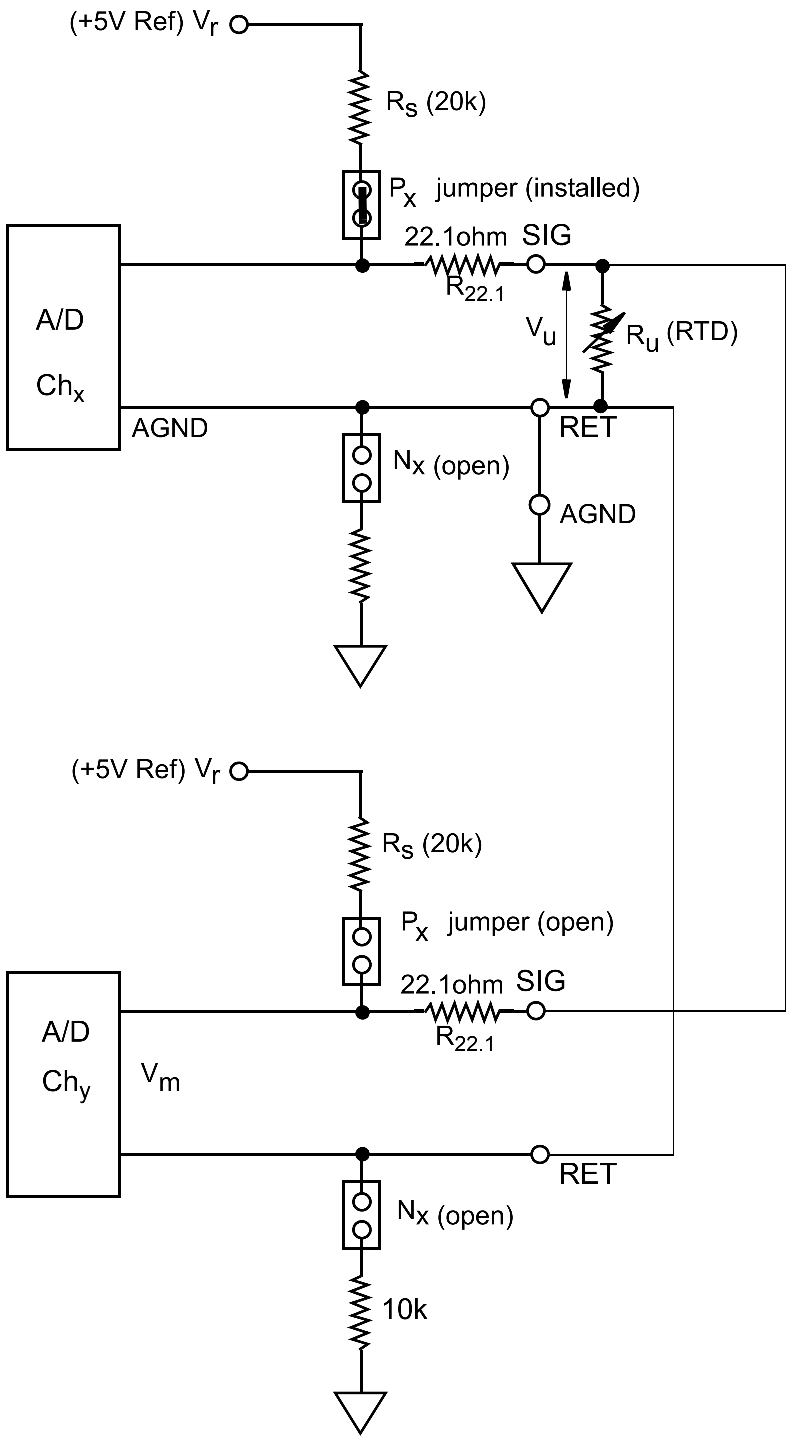


Figure 2-4 Four-wire RTD Circuit

As shown in the diagram, Channel x supplies and reads the excitation voltage for the 4-wire RTD circuit. Channel y reads the voltage across the RTD itself. Also note that RET is connected to AGND.

The calculation for determining the RTD resistance for Channel y is:

$$Ru = \frac{(R_s + R_{22.1}) \cdot V_m}{V_r - V_m}$$

The table below lists the calculation results at various temperatures.

Temperature °C	R_u Ohms	V_m mV
-200	18.52	4.62376
-100	60.31	15.04219
0	100.00	24.96663
100	138.50	34.57883
200	175.86	43.90573
300	212.05	52.94103
400	247.09	61.68922
500	280.98	70.15030

2.8 Jumper Settings Table

Table 2-2 summarizes the jumper settings required for selection of options for each layer type and function.

Layer Type	Sensor Type	Function	Jumper ID	Terminals Connected
DNA-AI-207	Thermocouples	Power	JPOW1	2-3
			JPOW2	1-2
			JPOW3	1-2
		Enable CJC	JTC1	ON
			JTC2	ON
			JD24	ON
			N24	ON
			JG24	ON
		Open TC Detect.	JDX	ON
			JGx	--
			Nx	ON
	Voltage	10k Return to GND	Nx	ON
		1 MΩ + Filter to GND	JGx	--
	RTD	+5V Internal Excit.	Px	ON
		User-supplied Extern Excitation	Px	Open
DNA-AI-225	Thermocouples	Power	JPOW1	2-3
			JPOW2	2-3
			JPOW3	Open
		Enable CJC	JTC1	ON
			JTC2	ON
			JD24	ON
			N24	ON
			JG24	ON
		Open TC Detect.	JDX	ON
			JGx	--
			Nx	ON
	Voltage	10k Return to GND	Nx	ON
		1 MΩ + Filter to GND	JGx	--
	RTD	+5V Int Exc.	Px	ON
		User-supplied External Excitation	Px	Open

Table 2-2 Jumper Settings Table

Appendix A

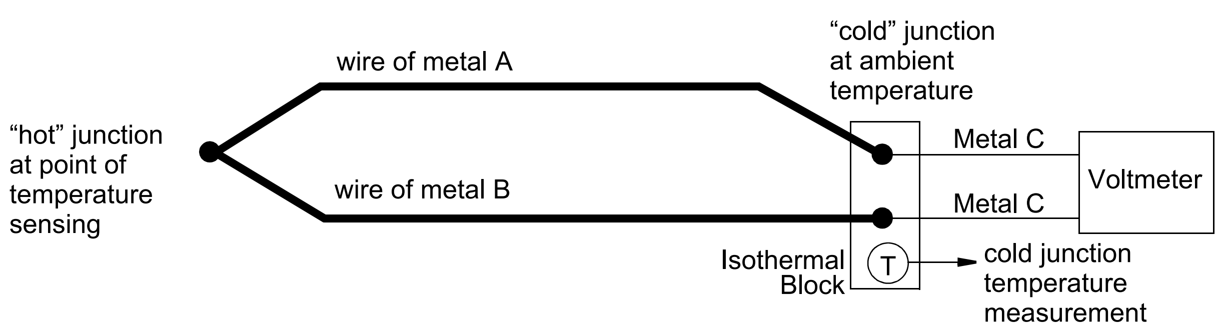
Thermocouple Measurement Using an AI-225/AI-207

A thermocouple is a sensor used to measure temperature in a wide range of applications. Its ability to sense temperature is based on the so-called “Seebeck Effect”, discovered by Thomas Seebeck in 1821. The Seebeck Effect, also known as the thermoelectric effect, states that any electrical conductor will produce a voltage when subjected to a thermal gradient. The magnitude and polarity of the voltage produced varies with the type of metal used for the conductor and the magnitude and polarity of the thermal gradient.

A thermocouple is constructed by connecting two conductors, composed of dissimilar metals, at both ends to form two junctions. Since the second conductor senses the same thermal gradient as the first, it also produces a voltage. This voltage, however, is different from that of the first conductor because it is made from a different metal. The small difference between the two voltages, which is typically in the millivolt range, is used for measurement of the thermal gradient.

Since the voltage is generated by a thermal difference between the junctions, one junction is called the “hot junction” and the other is called the “cold junction” or “reference junction.” An increase in the temperature difference between hot and cold junctions increases the voltage generated in a non-linear relation. The degree of linearity is a property of the two metals used to make the thermocouple.

Breaking the circuit to insert a voltmeter as shown in the diagram below illustrates how a thermocouple is typically used to measure temperature in an application.



Cold Junction Compensation Theory

Typically, a voltage is produced by a thermocouple at any given temperature. For example, the K-type thermocouple at 300°C will produce 12.2mV. To measure this voltage accurately, you must compensate for using any contact made to a thermocouple -- a technique called cold junction compensation (CJC). In case you are wondering why connecting a voltmeter to a thermocouple does not make several additional thermocouple junctions (leads connecting to the thermocouple, leads to the meter, inside the meter etc), the law of intermediate metals states that a third metal, inserted between the two dissimilar metals of a thermocouple junction will have no effect provided that the two junctions are at the same temperature. It is important to keep this in mind when we construct thermocouple junctions. Based on this law, it is quite acceptable to make a thermocouple junction by soldering the two metals together as the solder will not affect the reading. In practice, however, thermocouple junctions are made by welding the two metals together (usually by capacitive discharge) because this ensures that the performance is not limited by the melting point of solder.

Cold Junction Compensation Using a PowerDNA Screw Terminal Panel (STP)

Ambient temperature measurement is done by Cold Junction compensation (CJC). A PowerDNA Screw Terminal Panel has an isothermal metal block which is at ambient temperature. The voltage generated by the ambient temperature is measured using a dedicated CJC channel available in UEI Analog Input Layers. Software then determines the voltage created at the “cold” junction and subtracts this error voltage before linearizing the thermocouple input.

Table A-1 describes the CJC channel number for various Analog Input Layers using a DNA-STP-AI-U or a DNA-AI-207TC Screw Terminal Panel. Note, however, that the STP-AI-207TC is not used with the AI-225 Layer.

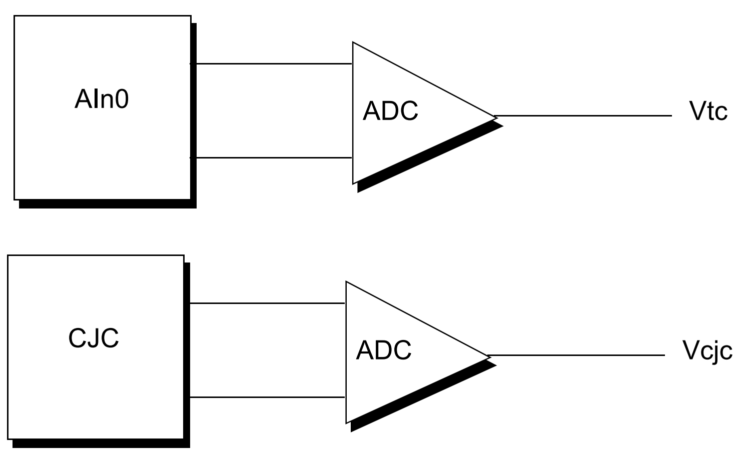
Table A-1.

Layer	CJC channel Number	Comments
AI-207	Channel 33	Single-Ended
AI-225	Channel 24	Single-Ended

Hardware Setup of Analog Input AI-225 and AI-207 Layers

Analog Input AI-225 and AI-207 Layers have a ***dedicated CJC channel*** which measures voltage corresponding to the ambient temperature. The example below shows the hardware set to measure temperatures accurately using a thermocouple.

The thermocouple input is connected to the one of the Analog Input channels and the CJC input is configured in software as per Table 1.



Vresult = Vtc + Vcjc

Linearization

Within the "usable" temperature range of any thermocouple, there is a proportional relationship between thermocouple voltage and temperature. This relationship, however, is by no means a linear relationship. In fact, most thermocouples are extremely non-linear over their operating ranges. To obtain temperature data from a thermocouple, it is necessary to convert the non-linear thermocouple voltage to temperature units. This process is called "linearization."

Several methods are commonly used to linearize thermocouples. At the low-cost end of the solution spectrum, one can restrict the thermocouple operating range such that the thermocouple is nearly linear to within the measurement resolution. At the opposite end of the spectrum, special thermocouple interface components (integrated circuits or modules) are available to perform both linearization and reference junction compensation in the analog domain. In general, neither of these methods is well-suited for cost-effective, multipoint data acquisition systems.

In addition to linearizing thermocouples in the analog domain, it is possible to perform such linearizations in the digital domain. This is accomplished by means of either piece-wise linear approximations (using look-up tables) or arithmetic approximations, or in some cases, a hybrid of these two methods.

Software Implementation

To do accurate temperature measurements, one has to read the channel where the thermocouple is connected, as well as a CJC channel. Feed these values to a NIST-derived polynomial formula to get an accurate thermocouple junction temperature.

Code Snippet for the AI-225:

To read the CJC channel, you must specify Channel 24 in single-ended mode in the channel list. The snippet of the code is shown below:

```
for (i = 0; i < CHANNELS; i++)  {
cl[i] = i |DQ_LNCL_GAIN(DQ_AI225_GAIN_1) } DQ_LNCL_DIFF;
}

   cl[CHANNELS] = 24 | DQ_LNCL_GAIN(DQ_AI225_GAIN_1);
```

Code Snippet for the AI-207:

To read the CJC channel, you must specify Channel 33 in single-ended mode in the channel list. The snippet of the code is shown below:

```
for (i = 0; i < CHANNELS; i++)  {
cl[i] = i |DQ_LNCL_GAIN(DQ_AI207_GAIN_1) } DQ_LNCL_DIFF;
}

   cl[CHANNELS] = 33 | DQ_LNCL_GAIN(DQ_AI207_GAIN_1);
```

Open TC Detection:

A DNA-STP-AI-U Screw Terminal Panel has the hardware implementation to detect an open TC. An Open TC will show high positive temperatures beyond the limits of the thermocouple range.

References:

- DNA-AI-225 User Manual
- DNA-AI-207 User Manual
- DNA-STP-AI-U User Manual

Index