Allen-Bradley

CompactBlock LDX I/O Thermocouple Modules

1790D-T4T0, 1790D-4T0, 1790P-T4T0

User Manual

Rockwell Automation

Important User Information

Because of the variety of uses for the products described in this publication, those responsible for the application and use of these products must satisfy themselves that all necessary steps have been taken to assure that each application and use meets all performance and safety requirements, including any applicable laws, regulations, codes and standards. In no event will Rockwell Automation be responsible or liable for indirect or consequential damage resulting from the use or application of these products.

Any illustrations, charts, sample programs, and layout examples shown in this publication are intended solely for purposes of example. Since there are many variables and requirements associated with any particular installation, Rockwell Automation does not assume responsibility or liability (to include intellectual property liability) for actual use based upon the examples shown in this publication.

Allen-Bradley publication SGI-1.1, *Safety Guidelines for the Application, Installation and Maintenance of Solid-State Control* (available from your local Allen-Bradley office), describes some important differences between solid-state equipment and electromechanical devices that should be taken into consideration when applying products such as those described in this publication.

Throughout this publication, notes may be used to make you aware of safety considerations. The following annotations and their accompanying statements help you to identify a potential hazard, avoid a potential hazard, and recognize the consequences of a potential hazard:

WARNING	Identifies information about practices or circumstances that can cause an explosion in a hazardous environment, which may lead to personal injury or death, property damage, or economic loss.
ATTENTION	Identifies information about practices or circumstances that can lead to personal injury or death, property damage, or economic loss.
IMPORTANT	Identifies information that is critical for successful application and understanding of the product.

Rockwell Automation Support

Before you contact Rockwell Automation for technical assistance, we suggest you please review the troubleshooting information contained in this publication first.

If the problem persists, call your local Rockwell Automation representative or contact Rockwell Automation in one of the following ways:

Phone	United States/Canada	1.440.646.5800
	Outside United States/Canada	You can access the phone number for your country via the Internet: 1. Go to http://www.ab.com 2. Click on *Product Support* (http://support.automation.rockwell.com) 3. Under *Support Centers*, click on *Contact Information*
Internet	⇒	1. Go to http://www.ab.com 2. Click on *Product Support* (http://support.automation.rockwell.com)

If you need to contact Rockwell Automation for assistance, please have the following information available when you call:

- a clear statement of the problem, including a description of what the system is actually doing. Note the LED state; also note input and output image words for the module.
- a list of remedies you have already tried
- processor type and firmware number (See the label on the processor)
- hardware types in the system, including all I/O modules
- fault code if the processor is faulted

Your Questions or Comments on this Manual

If you find a problem with this manual, please notify us of it on the enclosed How Are We Doing form.

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Overview

This chapter describes the 1790D-4TO/T4TO (1790P-T4TO) Thermocouple/mV Input module and explains how the module reads thermocouple or millivolt analog input data. Included is:

- the module's hardware and diagnostic features
- an overview of system and module operation
- compatibility

General Description

The thermocouple/mV input module supports thermocouple and millivolt signal measurement applications that require up to four channels. It digitally converts and stores thermocouple and/or millivolt analog data from any combination of up to four thermocouple or millivolt analog sensors. Each input channel is individually configurable via software for a specific input device, and filter frequency, and provides open-circuit, over-range and under-range detection and indication. When configured for thermocouple inputs, the module can convert the thermocouple readings into digital temperature readings in °C or °F. When configured for mV inputs, the module assumes that the direct mV input signal is linear prior to input to the module.

The data can be configured on board each module as:

engineering units x 1

The module uses a digital filter that provides high frequency noise rejection for the input signals. The filter is programmable, allowing you to select from seven different filter frequencies for each channel:

- 10 Hz
- 25 Hz
- 50 Hz
- 60 Hz
- 100 Hz
- 250 Hz
- 500 Hz

The module uses five input words for data and status bits. Module configuration is stored in the module memory. The 1790D modules' configuration is done via RSNetWorx for DeviceNet™ programming software. See Chapter 3, Module Data, Status, and Channel Configuration for DeviceNet , for details on module configuration. The 1790P module configuration is explained in Appendix E.

Thermocouple/mV Inputs and Ranges

The table below defines thermocouple types and their associated full-scale temperature ranges. The second table lists the millivolt analog input signal ranges that each channel will support.

Table 1.1 Thermocouple Analog Input Signal Types

Thermocouple Type	Temperature Range	Scaling (Counts)	Resolution*	Accuracy** (0 to 55°C)
B	+300 to +1800°C	+3000 to +18000	0.1°C	±4.2°C
E	-270 to +1000°C	-2700 to +10000	0.1°C	±2.5°C
J	-210 to +1200°C	-2100 to +12000	0.1°C	±2.8°C
K	-270 to +1370°C	-2700 to +13700	0.1°C	±3.3°C
R	-50 to +1768°C	-500 to +17680	0.1°C	±3.6°C
S	-50 to +1768°C	-500 to +17680	0.1°C	±3.6°C
T	-270 to 400°C	-2700 to 4000	0.1 °C	±1.3°C
N	-270 to 1300°C	-2700 to 13000	0.1°C	±3.1°C

* Filter set for 10 Hz

** Module only

Table 1.2 mV Analog Input Signal Types

Millivolt Input	Range	Scaling (Counts)	Resolution*	Accuracy** (0 to 55°C)
10μV	-76.5 to +76.5 mV	-7650 to +7650	10μV	306μV

* Filter set for 10 Hz

** Module only

Hardware Features

The thermocouple/mV module contains either a fixed terminal block or a removable D-sub connector, which provides connections for four inputs for any combination of thermocouple and mV input devices. Channels are wired as differential inputs. The illustration below shows the hardware features of the module.

Figure 1.1 1790D-4T0/T4T0 DeviceNet Module

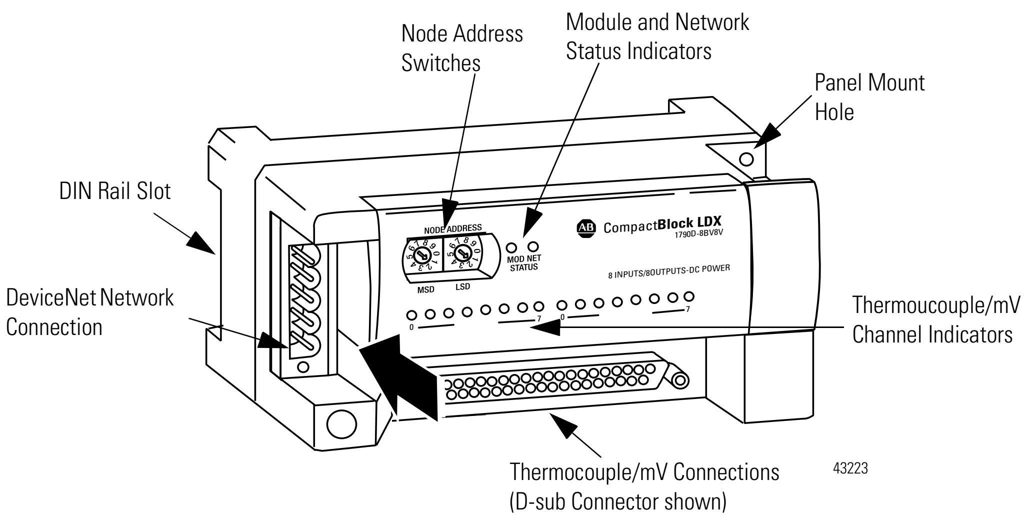
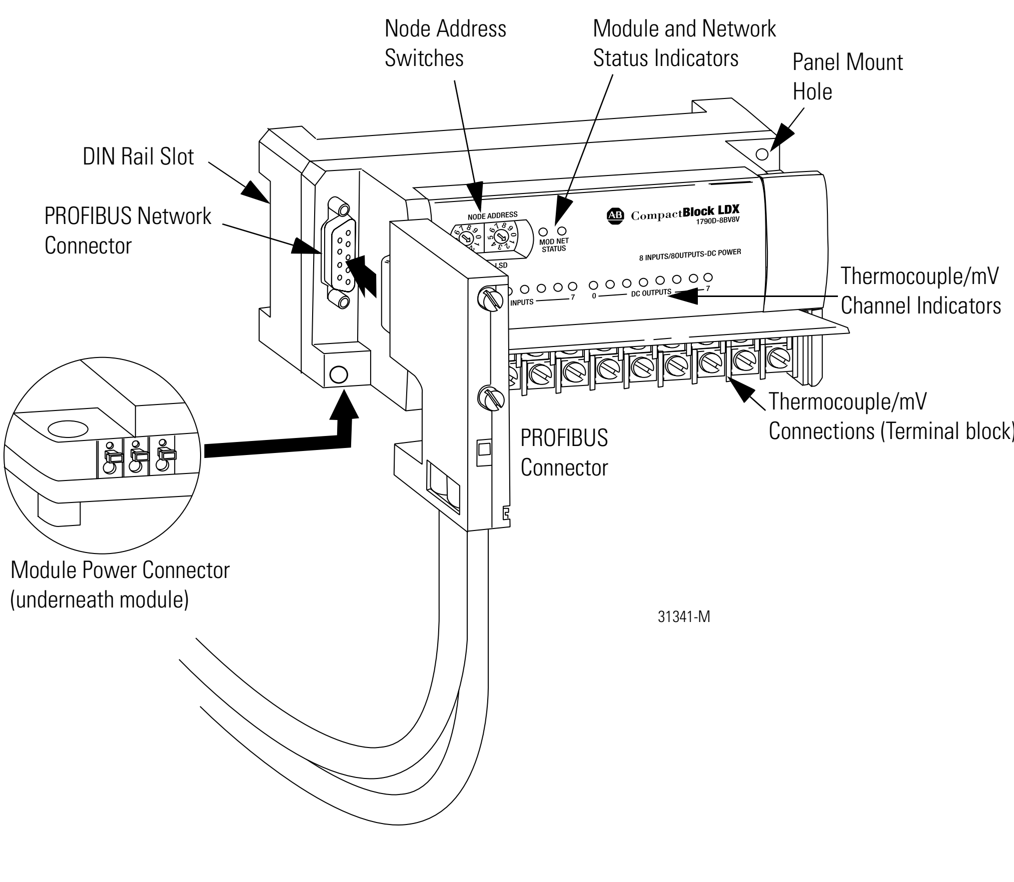


Figure 1.2 1790P-T4T0 PROFIBUS DP Module



Internal to the module, Cold Junction Compensation (CJC) sensors are attached to the terminal block to enable accurate readings from each channel. These sensors compensate for offset voltages introduced into the input signal as a result of the cold-junction where the thermocouple wires are connected to the module.

General Diagnostic Features

Module, network, and channel LEDs help you identify the source of problems that may occur during power-up or during normal channel operation. The LEDs indicate both status and power. See Chapter 4, *Diagnostics and Troubleshooting* , for details on power-up and channel diagnostics.

System Overview

The modules communicate to the controller or network scanner via the DeviceNet™ or PROFIBUS network. The 1790D modules also receive 24V dc power through DeviceNet. An external 24V dc auxiliary source is required to power the 1790P module and all thermocouple/mV channels.

System Operation

At power-up, the module performs a check of its internal circuits, memory, and basic functions. If no faults are found during power-up diagnostics, the module status LED is turned on (green).

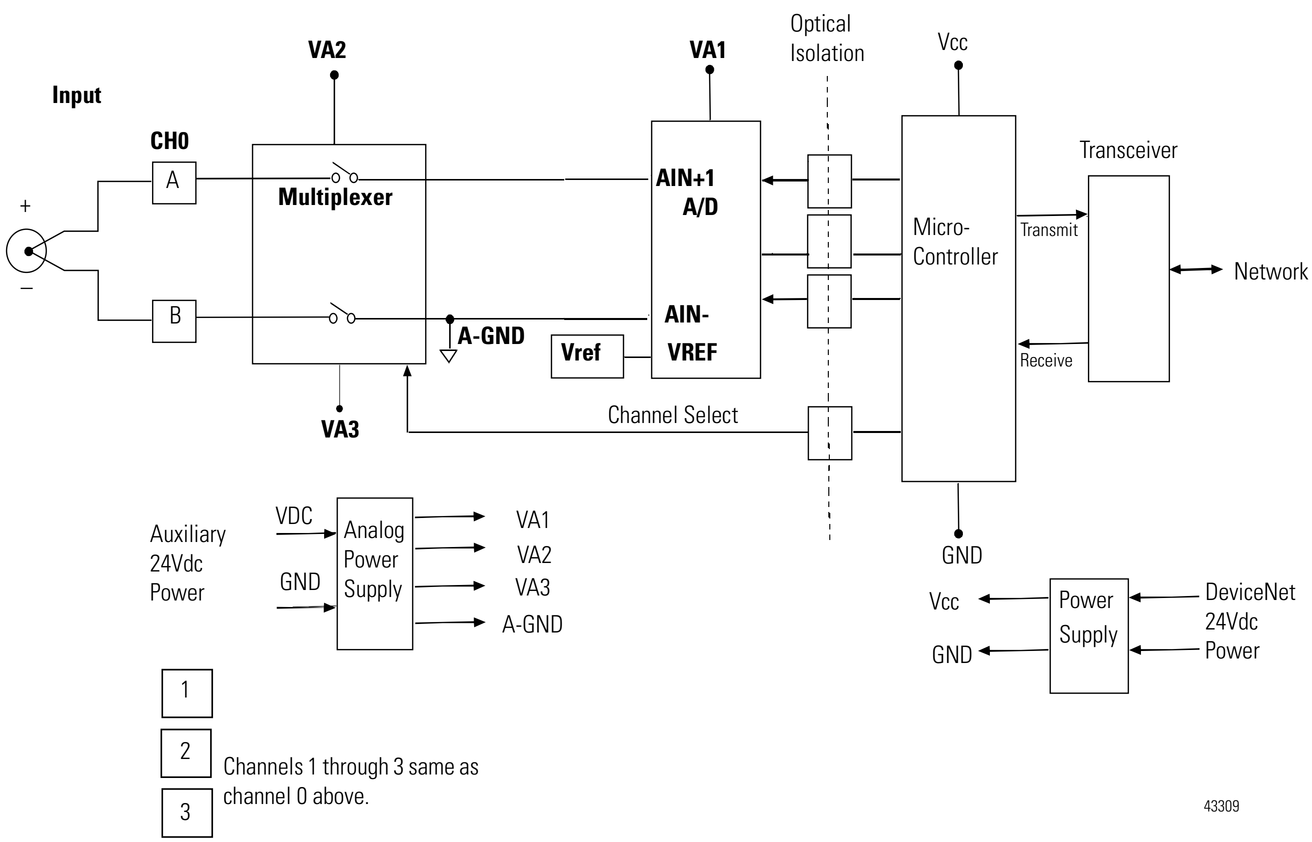
Once a channel is properly configured and enabled, the module continuously converts the thermocouple or mV input to a value within the range selected for that channel.

Each time the module reads an input channel, it tests the data for a fault (over- or under-range or open-circuit condition). If it detects a fault, the module sets a unique bit in the channel status word. See Input Data File on page 3-2. The module sends two's compliment binary converted thermocouple/mV data out over the network. See Appendix B for a description of two's compliment binary numbers.

Module Operation - DeviceNet Example

When the module recieves a differential input from an analog device, the module's circuitry multiplexes the input into an A/D converter. The converter reads the signal and converts it as required for the type of input. The module also continuously samples the CJC sensors and compensates for temperature changes at the terminal block cold junction, between the thermocouple wire and the input channel. See the block diagram below.

Figure 1.3 Block Diagram



Each channel can receive input signals from a thermocouple or millivolt analog input device, depending upon how you configured the channel.

When configured for thermocouple input types, the module converts the analog input voltages into cold-junction compensated and linearized digital temperature readings. The module uses the National Institute of Standards and Technology (NIST) ITS-90 standard for linearization for all thermocouple types (J, K, T, E, R, S, B, N).

When configured for millivolt inputs, the module converts the analog values directly into digital counts.

From the readings taken by the converter, the module sends thermocouple or mV data through the microcontroller to the DeviceNet network.

The PROFIBUS block diagram is similar.

Chapter Summary

In this chapter, you learned about the 1790D-4T0/T4T0 (1790P-T4T0) thermocouple/mV module. See Chapter 2 to learn how to install and wire the module.

Installation and Wiring

Before You Begin

This chapter tells you how to:

- determine the power requirements for the modules
- avoid electrostatic damage
- install the module
- wire the module's terminal block

Power Requirements

1790D-4T0/T4T0

The module receives system power from the DeviceNet network. An auxiliary field supply provides power for the thermocouple/mV channels.

Table 2.1 1790D-4T0/T4T0 Power Specifications

Power	Specification
DeviceNet	Supply voltage - 24V dc nominal Voltage range - 11-28.8V dc Power dissipation - 1.2W maximum @ 28.8V dc
Field	Supply voltage - 24V dc nominal Voltage range - 21.6-26.4V dc (±10%) Power dissipation - 1.5W maximum @ 26.4V dc

1790P-T4T0

The module requires external supplies for both system power and for the thermocouple/mV channels.

Table 2.2 1790P-T4T0 Power Specifications

Power	Specification
PROFIBUS	Supply voltage - 24V dc nominal Voltage range - 19.2-28.8V dc Power dissipation - 2W maximum @ 28.8V dc
Field	Supply voltage - 24V dc nominal Voltage range - 21.6-26.4V dc (±10%) Power dissipation - 1.5W maximum @ 26.4V dc

General Considerations

The modules are suitable for use in a commercial or light industrial environment when installed in accordance with these instructions. Specifically, this equipment is intended for use in clean, dry environments (Pollution degree 2[1]) and to circuits not exceeding Over Voltage Category II[2] (IEC 60664-1)[3].

Hazardous Location Considerations

This equipment is suitable for use in Class I, Division 2, Groups A, B, C, D or non-hazardous locations only. The following WARNING statement applies to use in hazardous locations.

WARNING

EXPLOSION HAZARD

- Substitution of components may impair suitability for Class I, Division 2.
- Do not replace components or disconnect equipment unless power has been switched off or the area is known to be non-hazardous.
- Do not connect or disconnect components unless power has been switched off or the area is known to be non-hazardous.
- This product must be installed in an enclosure.
- All wiring must comply with N.E.C. article 501-4(b).

(1) Pollution Degree 2 is an environment where, normally, only non-conductive pollution occurs except that occasionally a temporary conductivity caused by condensation shall be expected.

(2) Over Voltage Category II is the load level section of the electrical distribution system. At this level transient voltages are controlled and do not exceed the impulse voltage capability of the product's insulation.

(3) Pollution Degree 2 and Over Voltage Category II are International Electrotechnical Commission (IEC) designations.

The following information applies when operating this equipment in hazardous locations:	Informations sur l'utilisation de cet équipement en environnements dangereux :
Products marked "CL I, DIV 2, GP A, B, C, D" are suitable for use in Class I Division 2 Groups A, B, C, D, Hazardous Locations and nonhazardous locations only. Each product is supplied with markings on the rating nameplate indicating the hazardous location temperature code. When combining products within a system, the most adverse temperature code (lowest "T" number) may be used to help determine the overall temperature code of the system. Combinations of equipment in your system are subject to investigation by the local Authority Having Jurisdiction at the time of installation.	Les produits marqués "CL I, DIV 2, GP A, B, C, D" ne conviennent qu'à une utilisation en environnements de Classe I Division 2 Groupes A, B, C, D dangereux et non dangereux. Chaque produit est livré avec des marquages sur sa plaque d'identification qui indiquent le code de température pour les environnements dangereux. Lorsque plusieurs produits sont combinés dans un système, le code de température le plus défavorable (code de température le plus faible) peut être utilisé pour déterminer le code de température global du système. Les combinaisons d'équipements dans le système sont sujettes à inspection par les autorités locales qualifiées au moment de l'installation.

WARNING	**EXPLOSION HAZARD** • Do not disconnect equipment unless power has been removed or the area is known to be nonhazardous. • Do not disconnect connections to this equipment unless power has been removed or the area is known to be nonhazardous. Secure any external connections that mate to this equipment by using screws, sliding latches, threaded connectors, or other means provided with this product. • Substitution of components may impair suitability for Class I, Division 2. • If this product contains batteries, they must only be changed in an area known to be nonhazardous.	**AVERTISSEMENT**	**RISQUE D'EXPLOSION** • Couper le courant ou s'assurer que l'environnement est classé non dangereux avant de débrancher l'équipement. • Couper le courant ou s'assurer que l'environnement est classé non dangereux avant de débrancher les connecteurs. Fixer tous les connecteurs externes reliés à cet équipement à l'aide de vis, loquets coulissants, connecteurs filetés ou autres moyens fournis avec ce produit. • La substitution de composants peut rendre cet équipement inadapté à une utilisation en environnement de Classe I, Division 2. • S'assurer que l'environnement est classé non dangereux avant de changer les piles.

ATTENTION

Environment and Enclosure

This equipment is intended for use in a Pollution Degree 2 industrial environment, in overvoltage Category II applications (as defined in IEC publication 60664-1), at altitudes up to 2000 meters without derating.

This equipment is considered Group 1, Class A industrial equipment according to IEC/CISPR Publication 11. Without appropriate precautions, there may be potential difficulties ensuring electromagnetic compatibility in other environments due to conducted as well as radiated disturbance.

This equipment is supplied as "open type" equipment. It must be mounted within an enclosure that is suitably designed for those specific environmental conditions that will be present and appropriately designed to prevent personal injury resulting from accessibility to live parts. The interior of the enclosure must be accessible only by the use of a tool. Subsequent sections of this publication may contain additional information regarding specific enclosure type ratings that are required to comply with certain product safety certifications.

See NEMA Standards publication 250 and IEC publication 60529, as applicable, for explanations of the degrees of protection provided by different types of enclosure. Also, see the appropriate sections in this publication, as well as the Allen-Bradley publication 1770-4.1 ("Industrial Automation Wiring and Grounding Guidelines"), for additional installation requirements pertaining to this equipment.

ATTENTION

Preventing Electrostatic Discharge

This equipment is sensitive to electrostatic discharge, which can cause internal damage and affect normal operation. Follow these guidelines when you handle this equipment:

- Touch a grounded object to discharge potential static.
- Wear an approved grounding wriststrap.
- Do not touch connectors or pins on component boards.
- Do not touch circuit components inside the equipment.
- If available, use a static-safe workstation.
- When not in use, store the equipment in appropriate static-safe packaging.

WARNING

If you insert or remove the module while power is on, an electrical arc can occur. This could cause an explosion in hazardous location installations.

Be sure that power is removed or the area is nonhazardous before proceeding.

Selecting a Location

Reducing Noise

Most applications require installation in an industrial enclosure to reduce the effects of electrical interference. Thermocouple inputs are highly susceptible to electrical noise. Electrical noise coupled to the thermocouple inputs will reduce the performance (accuracy) of the module.

Group your modules in the enclosure to minimize adverse effects from radiated electrical noise and heat. Consider the following conditions when selecting a location for the module. Position the module:

- away from sources of electrical noise such as hard-contact switches, relays, and AC motor drives
- away from modules which generate significant radiated heat.

In addition, route shielded, twisted-pair wiring away from any high voltage I/O wiring.

Protecting the Circuit Board from Contamination

The printed circuit boards of analog modules must be protected from dirt, oil, moisture, and other airborne contaminants. To protect these boards, the system must be installed in an enclosure suitable for the environment. The interior of the enclosure should be kept clean and the enclosure door should be kept closed whenever possible.

Installing CompactBlock LDX I/O

Follow these steps to install the block:

1. Set the node address on the base block.
2. Mount the base block.
3. Wire the terminal blocks.
4. Connect the network cable.

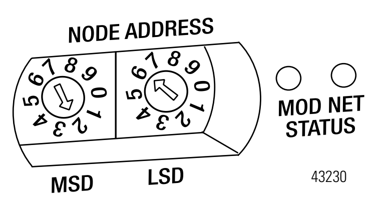
These steps are explained in detail in the following procedures for both the 1790D-4T0/T4T0 DeviceNet and 1790P-T4T0 PROFIBUS DP modules.

Set the Node Address on the DeviceNet 1790D-4T0/T4T0 Base Block

Each base block comes with its internal program set for node address 63. To reset the node address, adjust the switches on the front of the block. The two switches are most significant digit (MSD) and least significant digit (LSD). The switches can be set between 00 and 63.

The rotary switches are read at block power up only. Switch settings between 64 and 99 cause the block to use the last valid node address stored internally.

Example: Node Address is set at 26



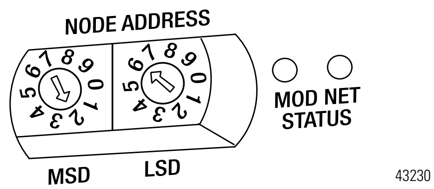
The node address may also be set through RSNetWorx for DeviceNet or a similar configuration tool. When software configuration is used for the node address, the switches must be set between 64 and 99.

Set the Station Address on the 1790P-T4T0 PROFIBUS DP Base Block

To set the station address, adjust the switches on the front of the base block. The two switches are most significant digit (MSD) and least significant digit (LSD). The switches can be set between 00 and 99.

The rotary switches are read at base block power up only.

Example: Node Address is set at 26



Mounting

Mount the Base Block

You can mount the base block to a panel or DIN rail. We recommend that you ground the panel or DIN rail before mounting the block.

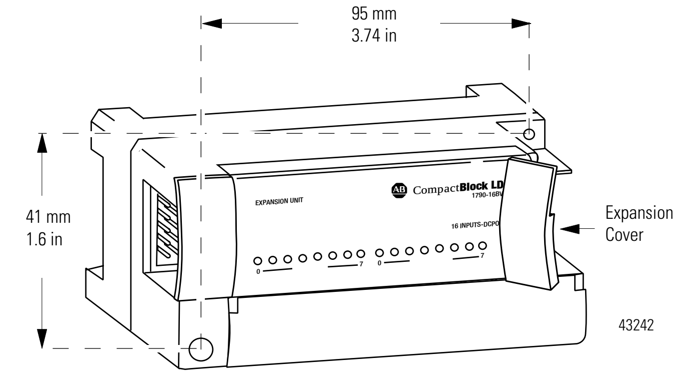
IMPORTANT The RTD and thermocouple base modules do not support any expansion blocks.

WARNING When used in a Class I, Division 2, hazardous location, this equipment must be mounted in a suitable enclosure with proper wiring method that complies with the governing electrical codes.

Panel Mounting

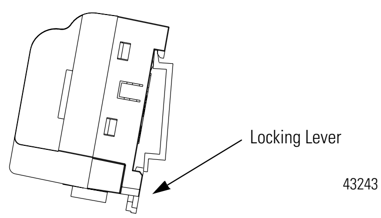
1. Place the block against the panel where you want to mount it.
2. Gently pull and position the expansion cover to the left.
3. Place a center punch, nail or similar device through the mounting holes in the block and make two marks on the panel (lower left and upper right corners of the module).
4. Remove the block and drill two holes in the panel to accommodate each of the mounting screws.

5. Replace the block on the panel and place a screw through each of the two mounting holes. Tighten the screws until the block is firmly in place.



DIN Rail Mounting

1. Hook the top slot of the block over the DIN Rail.
2. Pull down on the locking lever while pressing the block against the rail.



3. Push up on the locking lever to secure the block to the rail when the block is flush against the rail.

Connect the DeviceNet Cable to the 1790D-4T0/T4T0 Base Block

Follow these procedures when connecting the DeviceNet cable to the base block.

The required DeviceNet connector **is not supplied** with the block - you must purchase it separately. There are three types of connectors that you can order directly from Rockwell Automation or your local distributor:

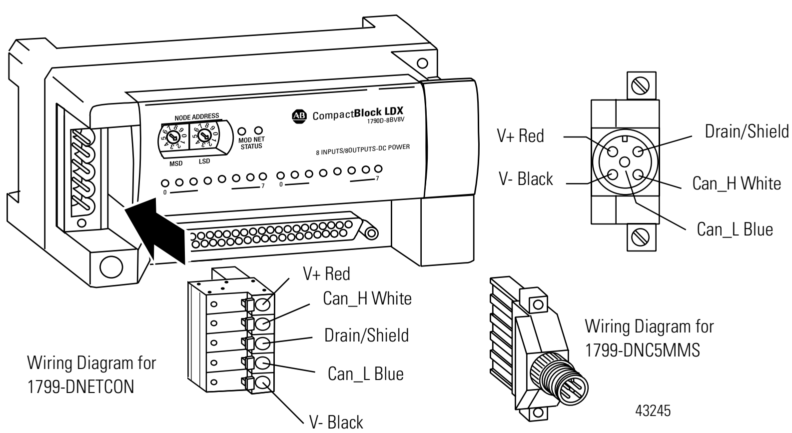
- 1799-DNETCON - 5-position open style connector
- 1799-DNETSCON - 5-position open style connector with locking screws
- 1799-DNC5MMS - 5-position open style to 5-pin micro male connector with locking screws

WARNING

If you connect or disconnect the DeviceNet cable with power applied to this module or any device on the network, an electrical arc can occur. This could cause an explosion in hazardous location installations.

Be sure that power is removed or the area is nonhazardous before proceeding.

Connect the DeviceNet wiring (drop line) to one of the DeviceNet connectors as shown below. A color-coded wiring diagram is also printed next to the connector on the left side of the module



Connect the PROFIBUS DP Terminal Connector to the 1790P-T4T0 Base Block

Follow these procedures to connect the PROFIBUS DP terminal connector to the base block.

WARNING

If you connect or disconnect the PROFIBUS cable with power applied to this module or any device on the network, an electrical arc can occur. This could cause an explosion in hazardous location installations.

Be sure that power is removed or the area is nonhazardous before proceeding.

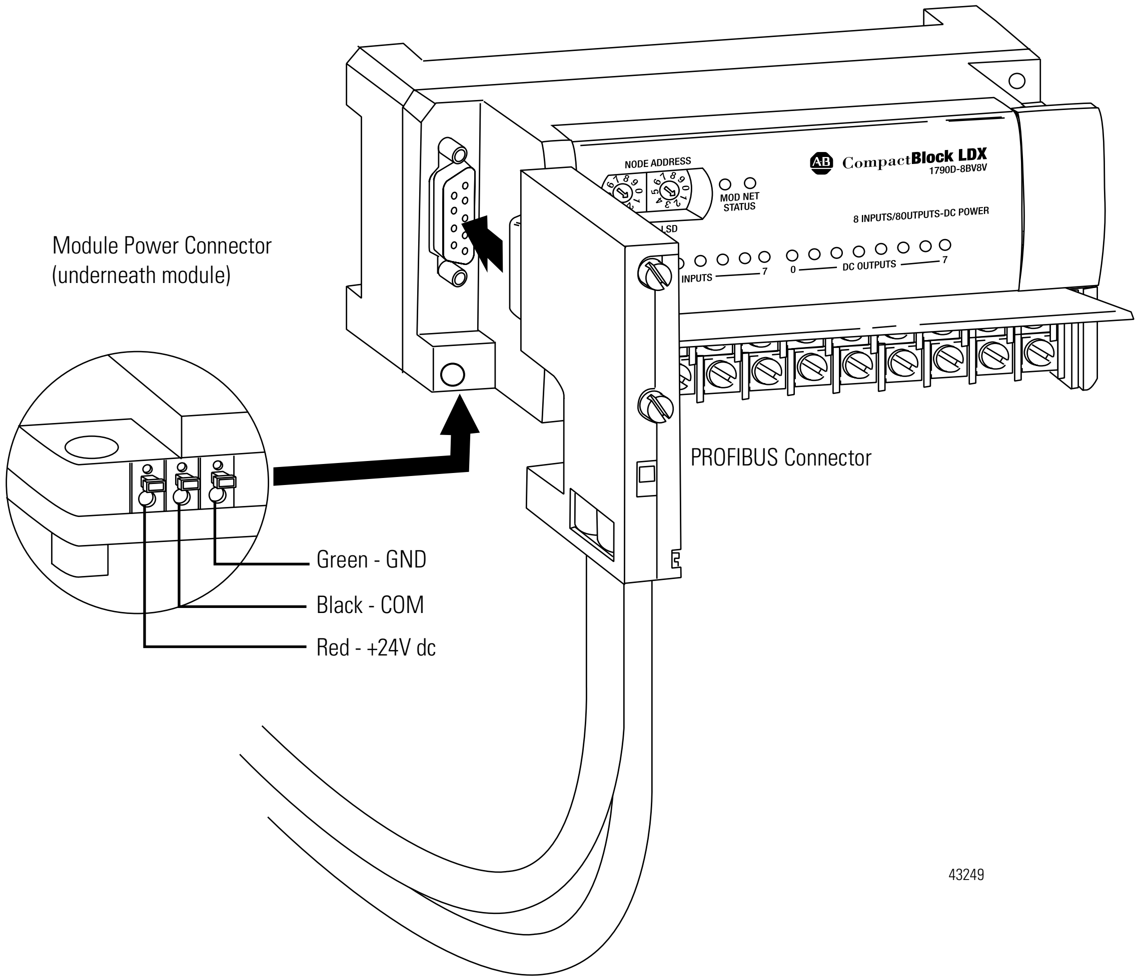
The required PROFIBUS female 9-pin D-sub connector **is not supplied** with the base block - you must purchase it separately.

Before you connect female 9-pin D-sub connector to the base block, make sure it is wired correctly as shown in the following table.

Table 2.3 Wiring Descriptions for 9-Pin D-Sub Connector

Pin Number	Name	Description
1	shield	Shield, Protective Ground
2	M24V	Minus 24V Output Voltage
3	RxD/TxD-P	Receive/Transmit-Data-P
4	CNTR-P	Control-p
5	DGND	Data Ground
6	VP	Voltage-Plus
7	P24V	Plus 24V Output Voltage
8	RxD/TxD-N	Receive/Transmit-Data-N
9	CNTR-N	Control-N

Once you have properly wired the connector, attach it to the base block as shown below. Use the locking screws on the connector to fasten it to the base block.



Connect Power to the 1790P-T4T0 Block

To apply power to the block, refer to the above illustration.

Field Wiring Connections

System Wiring Guidelines

Consider the following when wiring your system:

General

- Route field wiring away from any other wiring and as far as possible from sources of electrical noise, such as motors, transformers, contactors, and ac devices. As a general rule, allow at least 15.2 cm
(6 in.) of separation for every 120V of power.
- Routing field wiring in a grounded conduit can reduce electrical noise.
- If field wiring must cross ac or power cables, ensure that they cross at right angles.
- If multiple power supplies are used with analog millivolt inputs, the power supply commons must be connected.

Terminal Block

- Do not use the module's NC terminals as connection points.
- For millivolt sensors, use Belden 8761 shielded, twisted-pair wire (or equivalent) to ensure proper operation and high immunity to electrical noise.
- For a thermocouple, use the shielded, twisted-pair thermocouple extension lead wires specified by the thermocouple manufacturer. Using the incorrect type of thermocouple extension wire or not following the correct polarity will cause invalid readings.
- To ensures optimum accuracy, limit overall cable impedance by keeping a cable as short as possible. Locate the module as close to input devices as the application permits.

Grounding

ATTENTION The possibility exists that a grounded or exposed thermocouple can become shorted to a potential greater than that of the thermocouple itself. Due to possible shock hazard, take care when wiring grounded or exposed thermocouples. See Appendix D, Using Thermocouple Junctions.

- This product is intended to be mounted to a well-grounded mounting surface such as a metal panel. Additional grounding connections from the module's mounting tabs or DIN rail (if used) are not required unless the mounting surface cannot be grounded.
- Keep cable shield connections to ground as short as possible.
- Ground the shield drain wire at one end only. The typical location is as follows.
  - For grounded thermocouples or millivolt sensors, this is at the sensor end.
  - For insulated/ungrounded thermocouples, this is at the module end. Contact your sensor manufacturer for additional details.
- If it is necessary to connect the shield drain wire at the module end, connect it to earth ground using a panel or DIN rail mounting screw.
- Refer to *Industrial Automation Wiring and Grounding Guidelines*, Allen-Bradley publication 1770-4.1, for additional information.

Noise Prevention

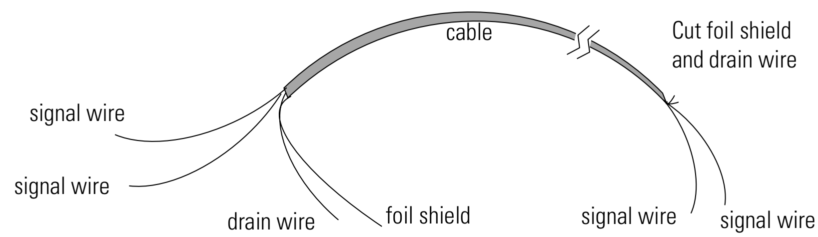
- To limit the pickup of electrical noise, keep thermocouple and millivolt signal wires as far as possible from power and load lines.
- If noise persists for a device, try grounding the opposite end of the cable shield. (You can only ground one end at a time.)

Wiring the Module

ATTENTION

To prevent shock hazard, care should be taken when wiring the module to analog signal sources. Before wiring any module, disconnect power from the system power supply and from any other source to the module.

After the module is properly installed, follow the wiring procedure below, using the proper thermocouple extension cable, or Belden 8761 for non-thermocouple applications.



To wire your module follow these steps.

1. At each end of the cable, strip some casing to expose the individual wires.
2. Trim the signal wires to 2-inch (5 cm) lengths. Strip about 3/16 inch (5 mm) of insulation away to expose the end of the wire.

ATTENTION

Be careful when stripping wires. Wire fragments that fall into a module could cause damage at power up.

3. At one end of the cable, twist the drain wire and foil shield together, bend them away from the cable, and apply shrink wrap. Then earth ground at the preferred location based on the type of sensor you are using. See Grounding on page 2-13.

4. At the other end of the cable, cut the drain wire and foil shield back to the cable and apply shrink wrap.
5. Connect the signal wires to the terminal block. Connect the other end of the cable to the analog input device.
6. Repeat steps 1 through 5 for each channel on the module.

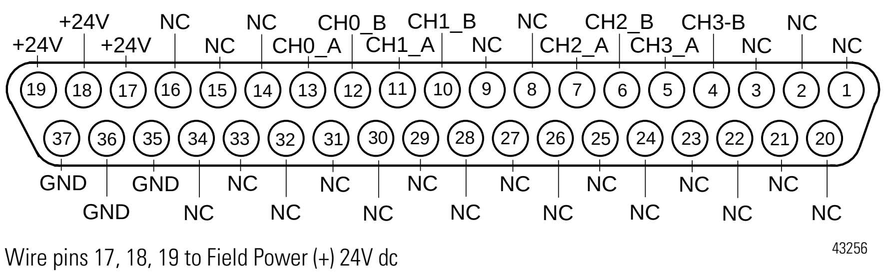
TIP

See Appendix D *Using Thermocouple Junctions* for additional information on wiring grounded, ungrounded, and exposed thermocouple types.

Wiring the Terminal Blocks

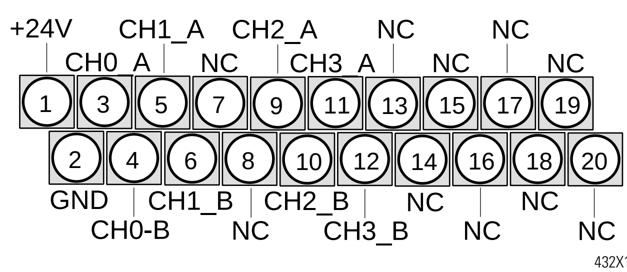
The following figures show how to wire the terminal blocks.

Figure 2.1 1790D-4R0-RTD Input Module D-Shell Wiring



Wire pins 17, 18, 19 to Field Power (+) 24V dc
Wire pins 35, 36, 37 to Field Power (-) GND

Figure 2.2 1790D-T4R0 and 179P-T4R0 RTD Input Module D-Shell Wiring



Wire pin 1 to Field Power (+) 24V dc
Wire pin 2 to Field Power (-) GND

IMPORTANT When using an ungrounded thermocouple, the shield must be connected to ground at the module end.

Cold Junction Compensation

To obtain accurate readings from each of the channels, the cold junction temperature (temperature at the module's terminal junction between the thermocouple wire and the input channel) must be compensated for. Cold junction compensating thermistors have been integrated in the module.

Chapter Summary

In this chapter, you learned how to install and wire your modules. See Chapter 3 to learn about module data, status, and channel configuration with DeviceNet.

Module Data, Status, and Channel Configuration for DeviceNet

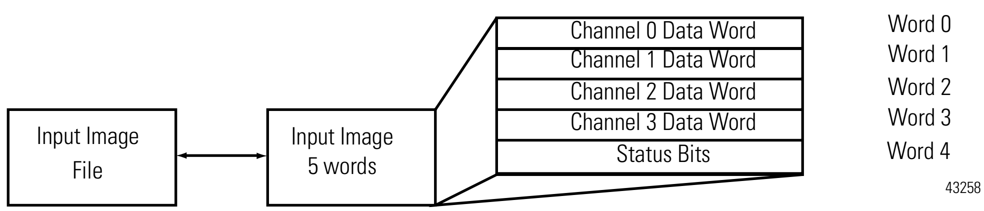
After installation of the thermocouple/mV input module, you must configure it for operation, usually using the programming software compatible with the controller (for example, RSLogix 500™ or RSLogix 5000™) or scanner (RSNetWorx for DeviceNet). Once configuration is complete and reflected in ladder logic, you will need to get the module up and running and then verify its operation. This chapter includes information on the following:

- module memory map
- accessing input image file data
- configuring channels
- running the module

Module Memory Map

The module uses five input words for data and status bits (input image).

Figure 3.1 Memory Map



Input Image

The input image file represents data words and status words. Input words 0 through 3 hold the input data that represents the value of the analog inputs for channels 0 through 3. These data words are valid only when the channel is enabled and there are no errors. Input word 4 holds status bits.

Accessing Input Image File Data

Five words of the processor input image table are reserved for the module's image data. You can access the information in the input image file using the programming software configuration screen.

Input Data File

The input data table lets you access thermocouple/mV input module read data for use in the control program, via word and bit access. The data table structure is shown in the tables below.

Table 3.1 Input Data Table

Word/ Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Thermocouple Input Data Channel 0															
1	Thermocouple Input Data Channel 1															
2	Thermocouple Input Data Channel 2															
3	Thermocouple Input Data Channel 3															
4	Not Used				S11	S10	S9	S8	Not Used				S3	S2	S1	S0

Table 3.2 Input Data Table

Word	Decimal Bit	Description
Read Word 0	Bits 00-15	Channel 0 input data
Read Word 1	Bits 00-15	Channel 1 input data
Read Word 2	Bits 00-15	Channel 2 input data
Read Word 3	Bits 00-15	Channel 3 input data
Read Word 4	Bits 00-03	Underrange for individual channels - Bit 00 corresponds to input channel 0, bit 01 corresponds to input channel 1 and so on.
		When set (1), the input signal is below the input channel's minimum range.
	Bits 04-07	Not used: Set to 0
	Bits 08-11	Overrange for individual channels - Bit 08 corresponds to input channel 0, bit 09 corresponds to input channel 1 and so on.
		When set (1), the input signal is above the input channel's maximum range, or open thermocouple is detected.
	Bit 12-15	Not used: Set to 0.

Input Data Values

Data words 0 through 3 correspond to channels 0 through 3 and contain the converted analog input data from the input device.

Under-Range Flag Bits (S0 to S3)

Under-range bits for channels 0 through 3 are contained in word 4, bits 0-3. When set (1), the under-range flag bit indicates a thermocouple temperature that is less than the minimum allowed temperature. The module automatically resets (0) the bit when the data value is again within the normal operating range.

Over-Range Flag Bits (S8 to S11)

Over-range bits for channels 0 through 3 are contained in word 4, bits 8-11. When set (1), the over-range flag bit indicates a thermocouple temperature that is greater than the maximum allowed temperature, a resistance input that is greater than the maximum allowed resistance for the module or an open channel is detected. The module automatically resets (0) the bit when the data value is again within the normal operating range.

Data Format

Thermocouple/mV data is presented in engineering units x1. The engineering units data format represents real temperature or voltage data provided by the module. Thermocouple data is reported in either °C or °F.

Table 3.3 RTD Data Format

Thermocouple Input Type	Range	Data Format	
		Engineering Units x1	
		0.1°C	0.1°F
B	-300 to +1800°C	-3000 to +18000	-5720 to +32720
E	-270 to +1000°C	-2700 to +10000	-4540 to +18320
J	-210 to +1200°C	-2100 to +12000	-3460 to +21920
K	-270 to +1370°C	-2700 to +13700	-4540 to +24980
R	-50 to +1768°C	-500 to +17680	-580 to +32140
S	-50 to +1768°C	-500 to +17680	-580 to +32140
T	-270 to +400°C	-2700 to +4000	-4540 to +7520
N	-270 to +1300°C	-2700 to +13000	-4540 to +23720

Table 3.4 Resistance Data Format

Resistance Input	Range	Data Format
		Engineering Units x1
10uV	-76.5 to +76.5mV	-7650 to 7650

The module scales input data to the actual temperature values for the selected thermocouple type per NIST ITS-90 standard. It expresses temperatures in 0.1 degree units, either °C or °F, depending on which temperature scale is selected. For mV inputs, the module expresses voltage in 10uV units.

Negative temperatures are returned in 16-bit two's complement binary format. See Appendix B for a detailed explanation of two's complement binary numbers.

Filter Frequency

The module supports filter selections corresponding to filter frequencies of 10 Hz, 25Hz, 50 Hz, 60 Hz, 100 Hz, 250 Hz, and 500 Hz. Your filter frequency selection is determined by the desired range for the input type, and the required effective resolution, which indicates the number of bits in the input data that do not vary due to noise. Also consider the required module update time when choosing a filter frequency. For example, the 10 Hz filter provides the greatest attenuation of 50 and 60 Hz noise and the greatest resolution, but also provides the slowest response speed.

The choice that you make for filter frequency will affect:

- noise rejection characteristics for module input
- channel step response
- channel cutoff frequency
- effective resolution
- module update time

Effects of Filter Frequency on Noise Rejection

The filter frequency that you choose for the module determines the amount of noise rejection for the inputs. A smaller filter frequency (e.g. 10Hz) provides the best noise rejection and increases effective resolution, but also increases channel update time. A larger filter frequency (e.g. 500 Hz) provides lower noise rejection, but also decreases the channel update time and effective resolution.

When selecting a filter frequency, be sure to consider channel cutoff frequency and channel step response to obtain acceptable noise rejection. Choose a filter frequency so that your fastest-changing signal is below that of the filter's cutoff frequency.

Common mode noise rejection for the module is better than 110 dB at 50 Hz (50 Hz filter) and 60 Hz (60 Hz filter). The module performs well in the presence of common mode noise. Improper earth ground can be a source of common mode noise.

IMPORTANT Transducer power supply noise, transducer circuit noise, and process variable irregularities can also be sources of common mode noise.

Channel Step Response

Another module characteristic determined by filter frequency is channel step response, as shown in the following table. The step response is the time required for the analog input signal to reach 100 percent of its expected final value, given a full-scale step change in the input signal. Thus, if an input signal changes faster than the channel step response, a portion of that signal will be attenuated by the channel filter. The channel step response is calculated by a settling time of 3 x (1 / filter frequency).

Table 3.5 Filter Frequency vs. Channel Step Response

Filter Frequency	Step Response
10 Hz	300 ms
25 Hz	120 ms
50 Hz	60 ms
60 Hz	50 ms
100 Hz	30 ms
250 Hz	12 ms
500 Hz	6 ms

Channel Cutoff Frequency

The channel cutoff frequency (-3 dB) is the point on the input channel frequency response curve where frequency components of the input signal are passed with 3 dB of attenuation. The following table shows cutoff frequencies for the supported filters.

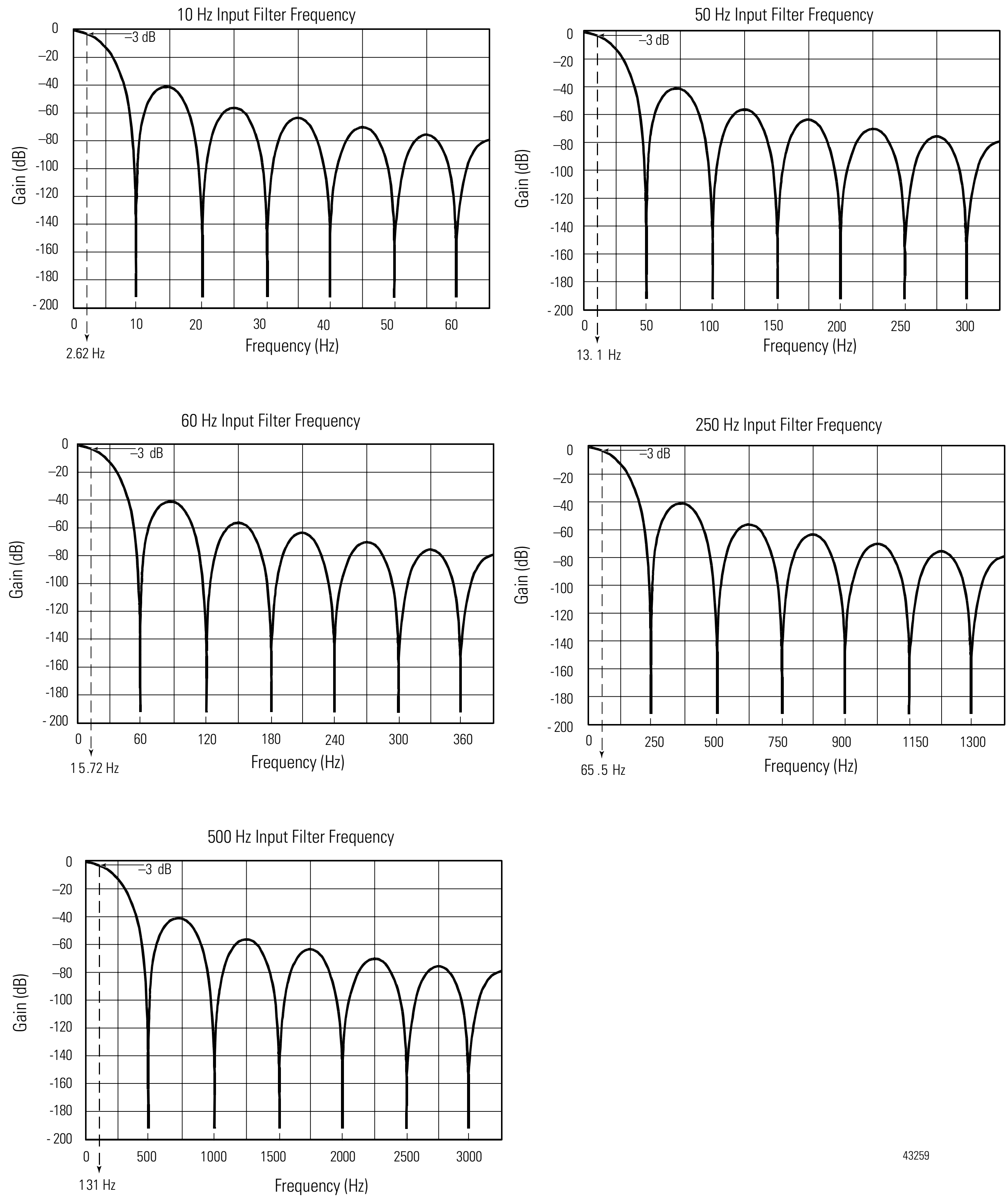
Table 3.6 Filter Frequency vs. Channel Cutoff Frequency

Filter Frequency	Channel Cutoff Frequency
10 Hz	2.62 Hz
25 Hz	6.55 Hz
50 Hz	13.1 Hz
60 Hz	15.7 Hz
100 Hz	26.2 Hz
250 Hz	65.5 Hz
500 Hz	131 Hz

All frequency components at or below the cutoff frequency are passed by the digital filter with less than 3 dB of attenuation. All frequency components above the cutoff frequency are increasingly attenuated, as shown in the following graphs for several of the input filter frequencies.

IMPORTANT Channel cutoff frequency should not be confused with channel update time. The cutoff frequency simply determines how the digital filter attenuates frequency components of the input signal.

Figure 3.2 Frequency Response Graphs



Effective Resolution

The effective resolution for an input channel depends upon the filter frequency selected for that channel. The table below identifies the number of significant bits used to represent the data for the mV input range for each available filter frequency. The number of significant bits is defined as the number of bits that will have little or no jitter due to noise, and is used in defining the effective resolution.

Table 3.7 Effective Resolution vs. Input FIlter Selection for mV Inputs

Filter Frequency	Effective Resolution
10 Hz	sign +13 bits: 10µV
25 Hz	sign +13 bits: 10µV
50 Hz	sign +13 bits: 10µV
60 Hz	sign +13 bits: 10µV
100 Hz	sign +13 bits: 10µV
250 Hz	sign +12 bits: 20µV
500 Hz	sign +11 bits: 40µV

The following graphs provide the effective resolution for each thermocouple type for each available filter frequency. These graphs do not include the affects of unfiltered input noise. Choose the frequency that most closely matches your system requirements.

Figure 3.3 Type B Thermocouple

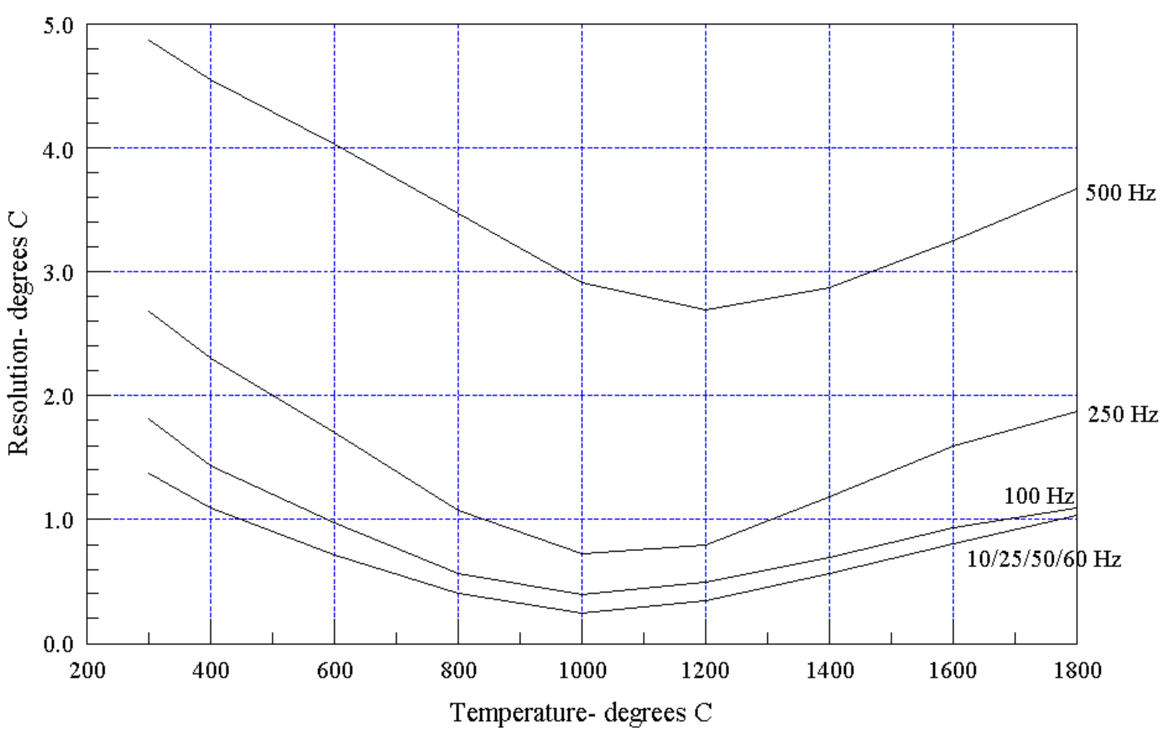


Figure 3.4 Type E Thermocouple

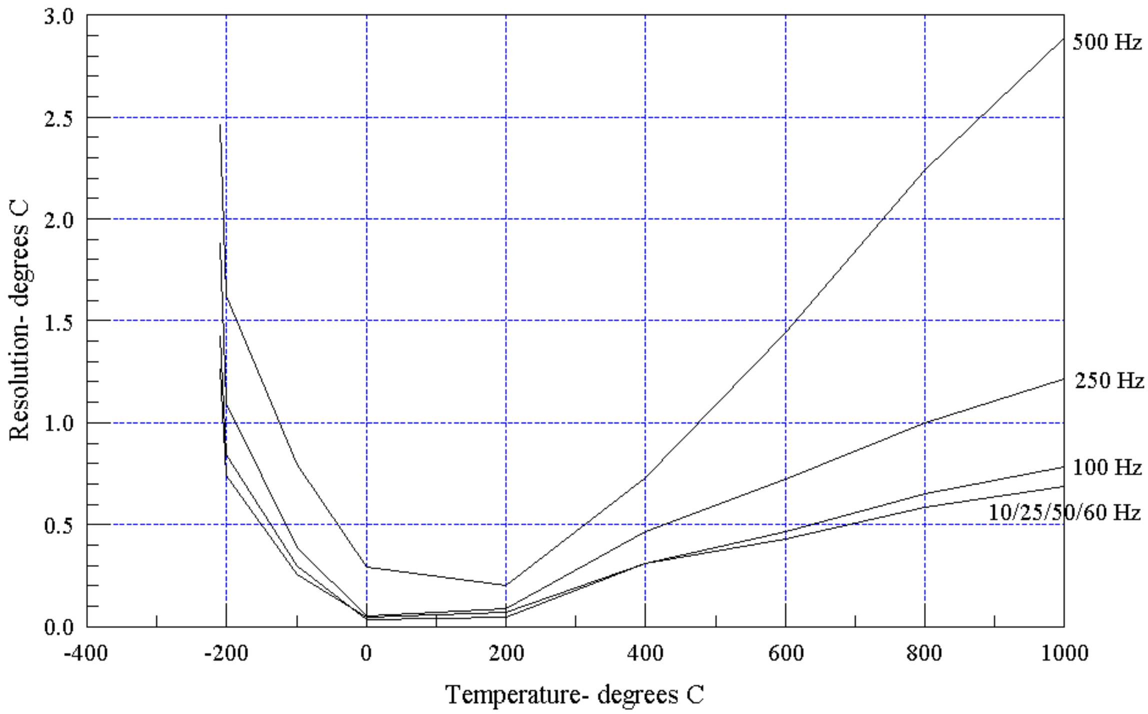


Figure 3.5 Type J Thermocouple

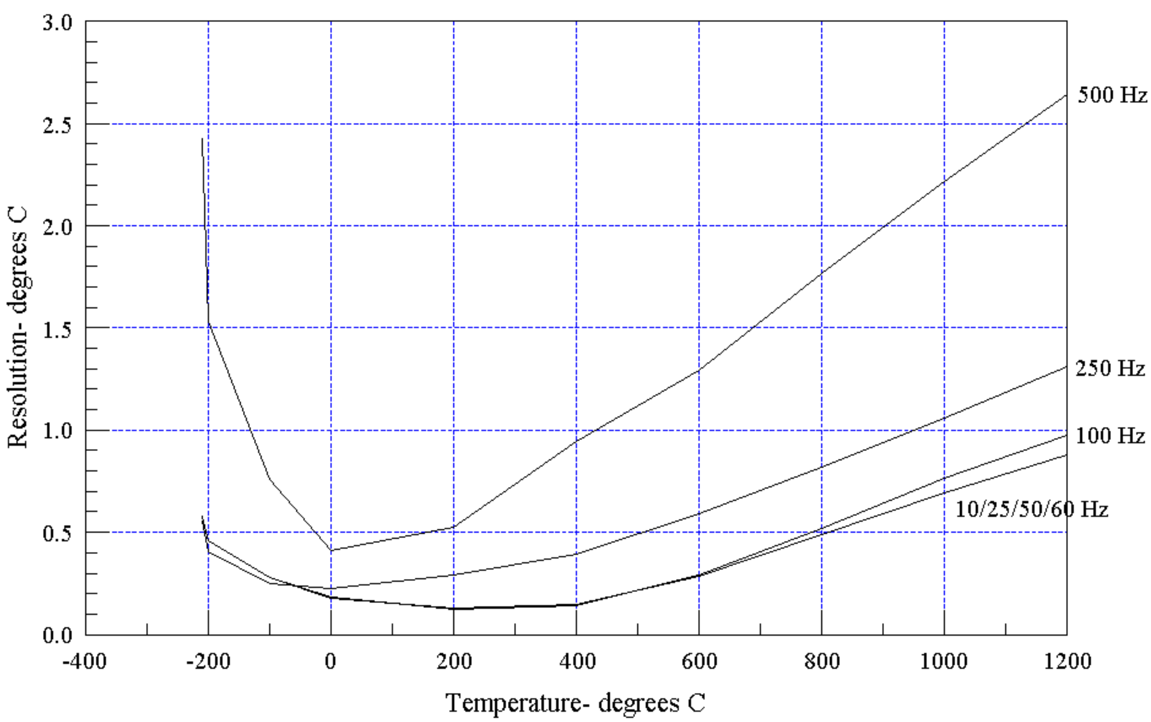


Figure 3.6 Type K Thermocouple

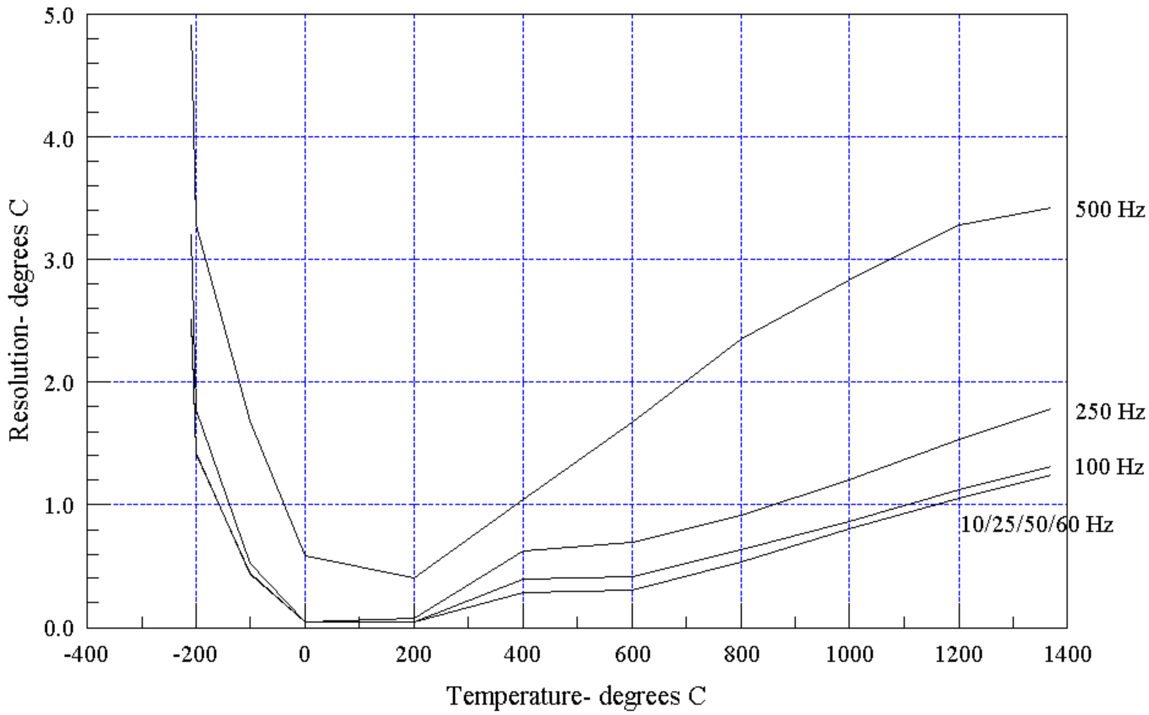


Figure 3.7 Type R Thermocouple

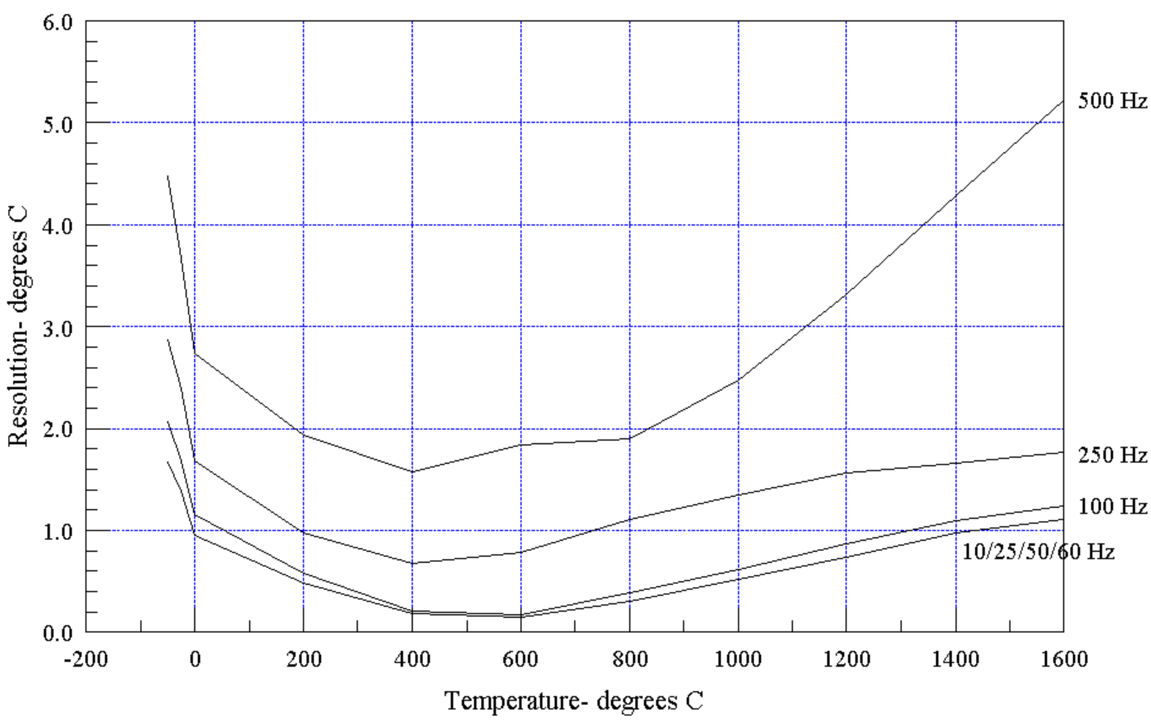


Figure 3.8 Type S Thermocouple

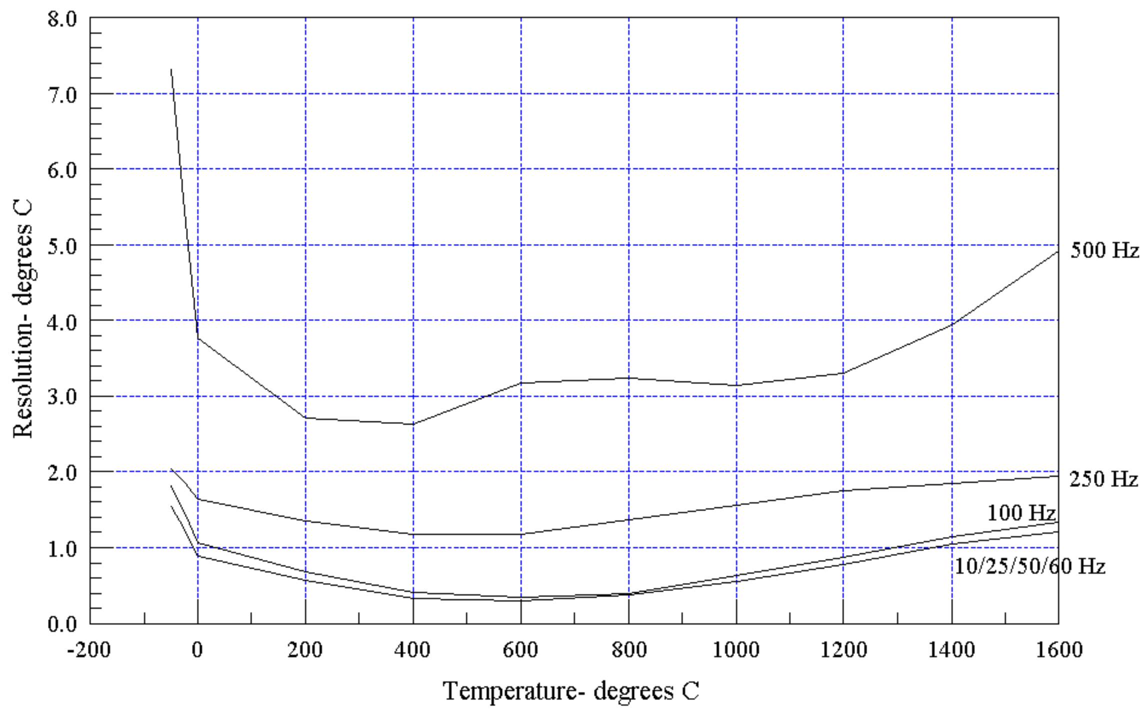


Figure 3.9 Type T Thermocouple

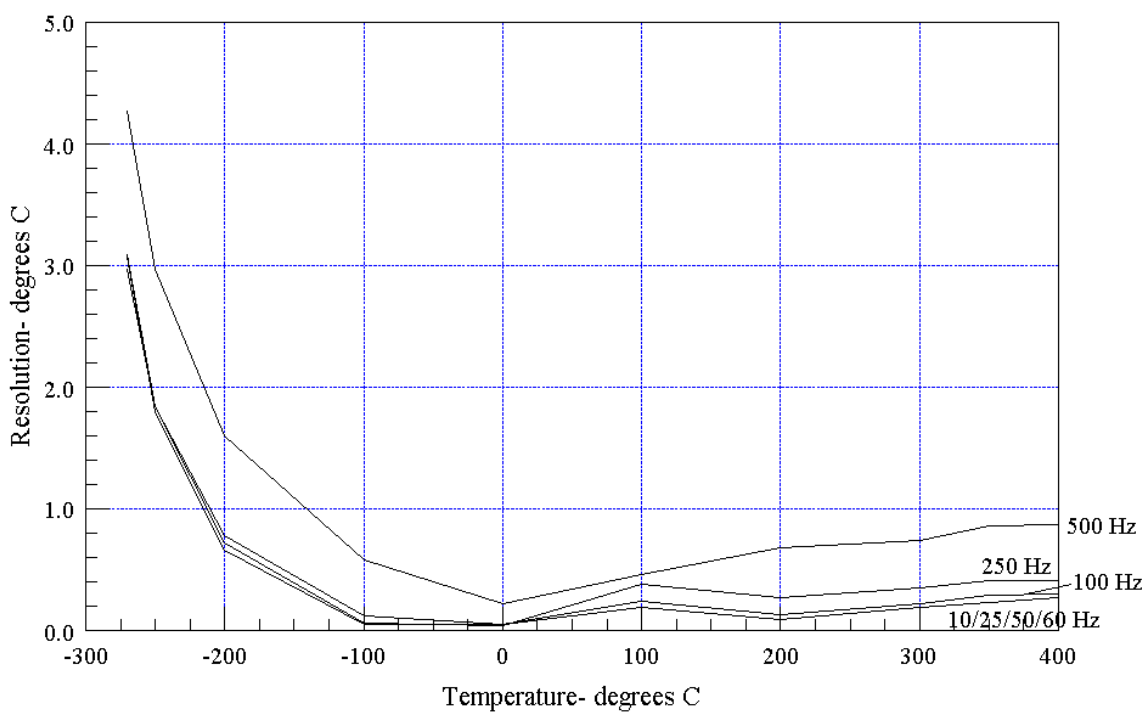
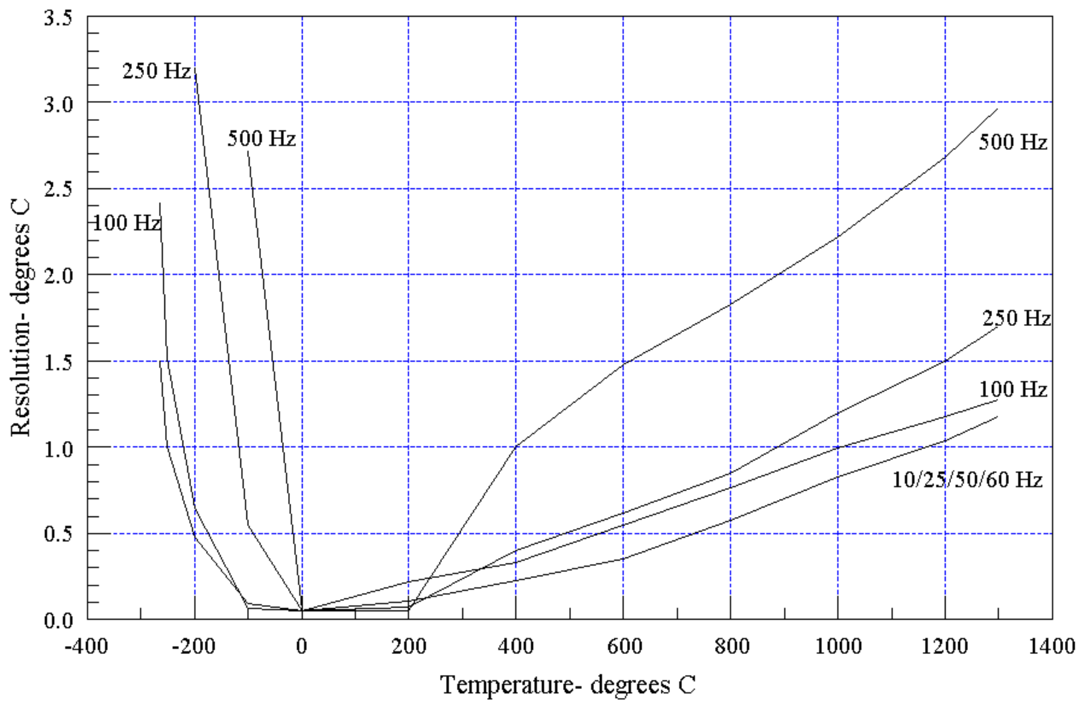


Figure 3.10 Type N Thermocouple



Cold Junction Compensation

When using thermocouples, cold junction compensation (CJC) is required at the termination of the thermocouple wire. A cold junction can be accomplished different ways:

- Use the built-in CJC
- Enter an estimated temperature
- Use an external CJC

Entering an estimated temperature may be the least accurate way for CJC compensation. Using external CJC is the most expensive way. Using the compensation built into the module provides the easiest way for CJC.

Built-in module cold junction linearization may be enabled or disabled. If enabled, the proper cold junction compensation value will be applied to the thermocouples. If disabled, the built-in cold junction temperature data is not applied to the inputs. In this case, a cold junction value can be added using the Cold Junction Offset parameter.

Determining Module Update Time

The module update time is defined as the time required for the module to sample and convert the input signals. Module update time is dependent on the number of input channels and the input filter selection.

The fastest update time occurs with the 500Hz filter enabled. The following table shows update times for all filter frequencies.

Table 3.8 Module Update Time

Filter Frequency	Module Update Time
10 Hz	3.0 seconds
25 Hz	1.3 seconds
50 Hz	668 milliseconds
60 Hz	580 milliseconds
100 Hz	383 milliseconds
250 Hz	204 milliseconds
500 Hz	144 milliseconds

Calculating Accuracy

Overall accuracy is determined from the combination of the module and the thermocouple. The total error is the sum of the following:

- module accuracy and error due to temperature
- thermocouple error
- error due to thermocouple lead wire
- CJC error

Module and Temperature Error

The combined module error and error due to ambient temperature is shown in the table below.

Table 3.9 Module and Temperature Error

Thermocouple Type	Error (10Hz Filter) 0 to 55°C
B	±4.2°C
E	±2.5°C
J	±2.8°C
K	±3.3°C
R	±3.6°C
S	±3.6°C
T	±1.3°C
N	±3.1°C

Thermocouple Error

The table below summarizes thermocouple error (for more Thermocouple Type information see Appendix C).

Table 3.10 Thermocouple Error

Thermocouple Type	Useable Range °C	Standard Tolerance Error *	Special Tolerance Error *
B	870 to 1700	±0.5%	±0.25%
E	0 to 900 -200 to 0	±1.7°C or ±0.5% ±1.7°C or ±1%	±1°C or ±0.4% ±1°C or ±0.5%
J	0 to 750	±2.2°C or ±0.75%	±1.1°C or ±0.4%
K	0 to 1250 -200 to 0	±2.2°C or ±0.75% ±2.2°C or ±2%	±1.1°C or ±0.4% NA
R	0 to 1450	±1.5°C or ±0.25%	±0.6°C or ±0.1%
S	0 to 1450	±1.5°C or ±0.25%	±0.6°C or ±0.1%
T	0 to 350 -200 to 0	±1°C or ±0.75% ±1°C or ±1.5%	±0.5°C or ±0.4% NA
N	0 to 1250	±2.2°C or ±0.75%	±1.1°C or ±0.4%

* Whichever error factor is greater.

Thermocouple Lead Wire Error

An error is introduced by the resistance of the thermocouple lead wire. The lead wire resistance in combination with the module input impedance acts as a voltage divider of the source thermoelectric voltage. Use the following table to estimate this error.

Table 3.11 Thermocouple Lead Wire Error

Thermocouple Wire Resistance (ohms per double foot - resistance out and back per foot)	Error Impact
0.1 ohm	insignificant
1 ohm	insignificant
10 ohm	0.0004%
100 ohm	0.004%
1000 ohm	0.04%
10,000 ohm	0.4%

CJC Error

If the internal CJC compensation is turned off, an error factor is introduced for either the external CJC or the estimated cold junction value.

Total Error

As an example, a B Type thermocouple operating at 100°C with 1000 ohms of lead wire, internal CJC and 10Hz filter enabled, in an ambient temperature of 30 to 50°C, is accurate to within:

Table 3.12 Example Error Calculation

Error Factor	From	Error
Module & Temperature	Table 3.9	4.2°C
Thermocouple	Table 3.10	.005 x 1000°C = 5.0°C
Lead Wire	Table 3.11	.0004 x 1000°C = 0.4°C
TOTAL ERROR		±9.6°C

Configuring DeviceNet Thermocouple/mV Module (1790D-4T0/T4T0)

Configuring 1790D-4T0/T4T0 thermocouple/mV modules is as easy as pointing and clicking. RSNetWorx™ lets you simply identify the network and configure the I/O modules with easy-to-use Electronic Data Sheets (EDS) files - just point to the field and click on your selection.

To obtain the EDS files you need to configure the modules, go to the following Website: **http:/www.ab.com/networks/eds**.

EDS files for blocks with matching catalog numbers (for D-Shell and terminal block versions) are the same. Thus, on the website or in RSNetWorx for DeviceNet, there may be only one catalog number listed for both versions.

When using 3rd party configuration software, simply load the EDS files into the software and follow the vendor's instructions.

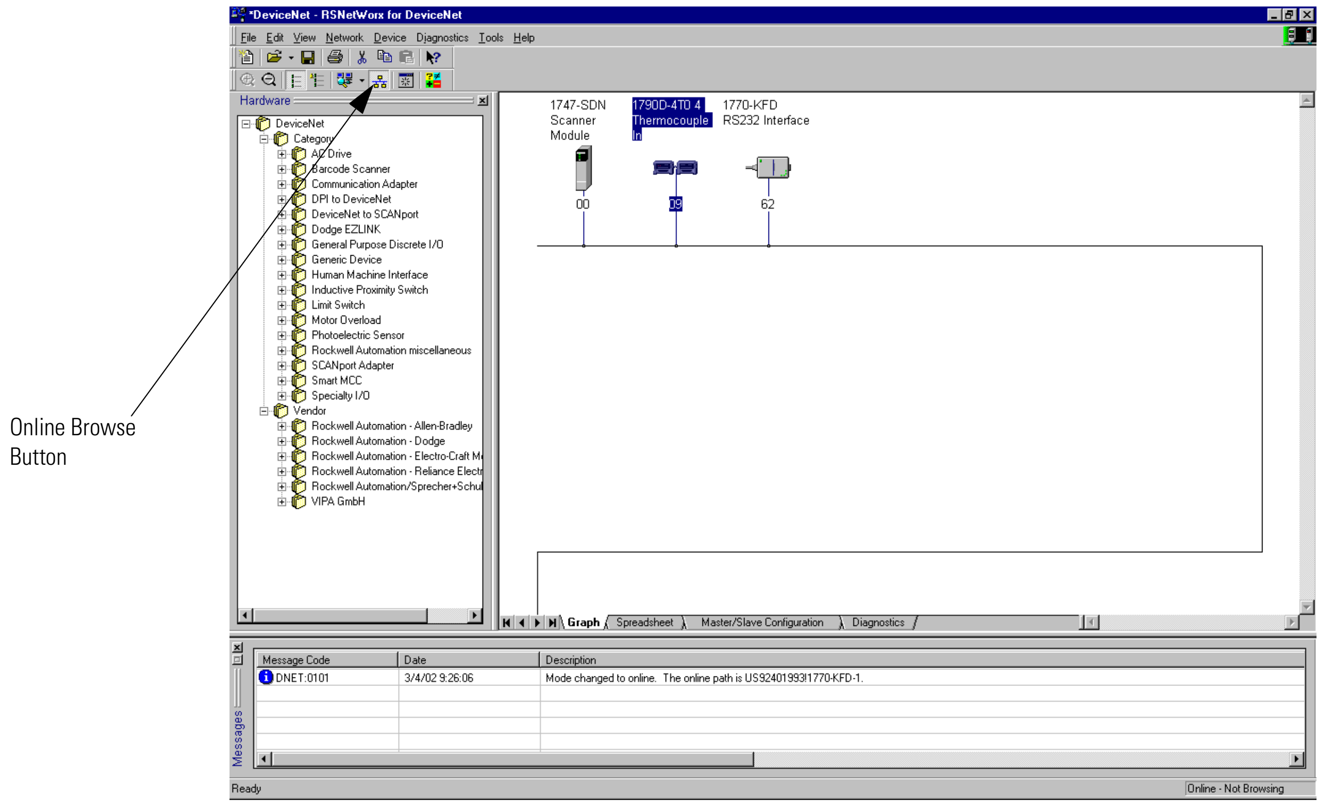
The following example takes you through configuring your thermocouple/mV module with RSNetWorx for DeviceNet, version 3.00 or later.

Refer to Appendix C to configure the 1790P-T4T0 PROFIBUS module.

Configure DeviceNet Thermocouple/mV Modules Using RSNetWorx

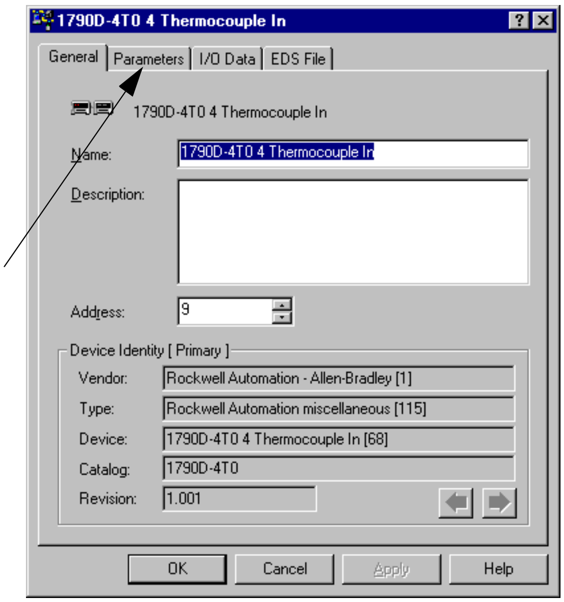
Following the steps below to configure 1790D-4T0/T4T0 thermocouple/ mV modules.

1. Open RSNetWorx for DeviceNet.
2. Using the selections on the left of the window below, construct you system. (If your network is up, just click on the Online Browse button.)



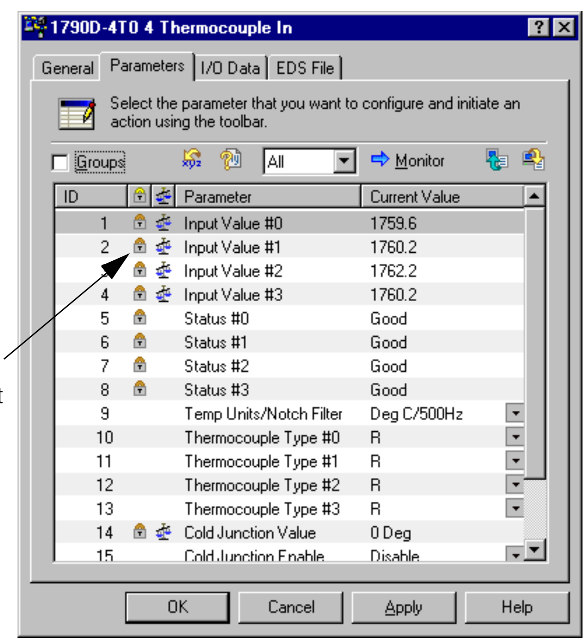
3. After setting up your system, double-click on the module you want to configure. (If you are online, upload the configuration and existing parameters from the module display.) A window similar to the following appears.

Click the device **Parameters** tab to display the screen in which you can set parameters.



Thermocouple/mV modules will have parameters similar to the following.

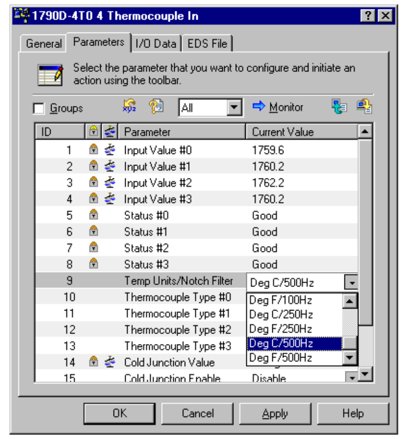
If you see a lock next to an entry, this indicates that you cannot change that parameter.



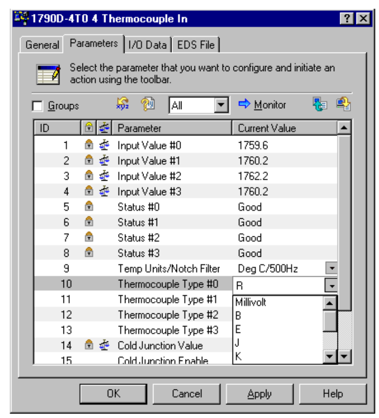
On this screen, you see all the parameters for the module. These include Autobaud, temperature units/filter frequency, cold junction compensation enable/manual offset, module status and input thermocouple/mV type.

Module configuration parameters include Temperature Units/Notch Filter frequency, Thermocouple/mV Input type, Cold Junction Compensation Enable/Manual Offset Value and Autobaud.

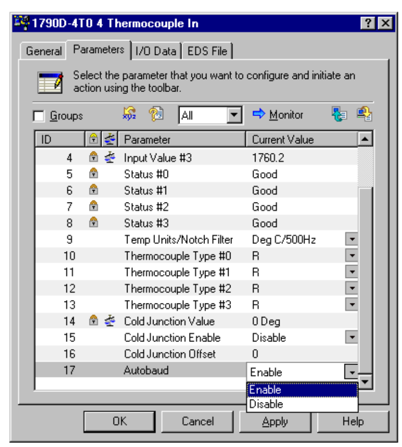
Select the desired temperature units (in degrees C or F) and notch filter frequency. ALL four channels will be configured identically.

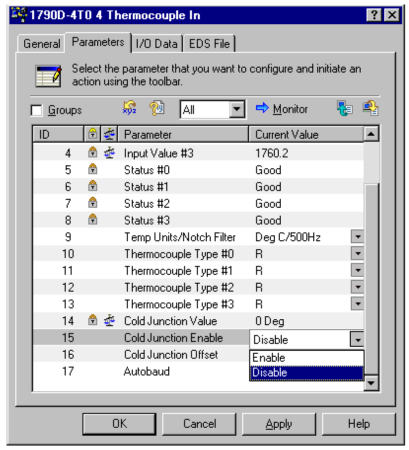


Select the thermocouple/ mV input type for each channel from the dropdown list.



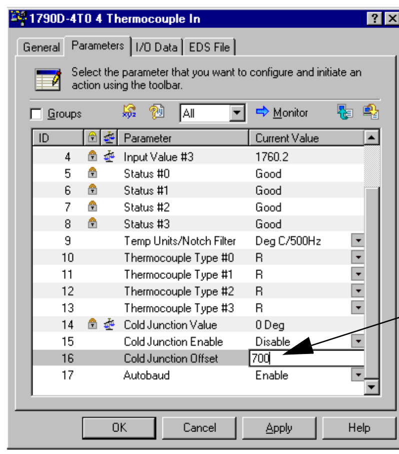
Select to have Autobaud either Enabled or Disabled.



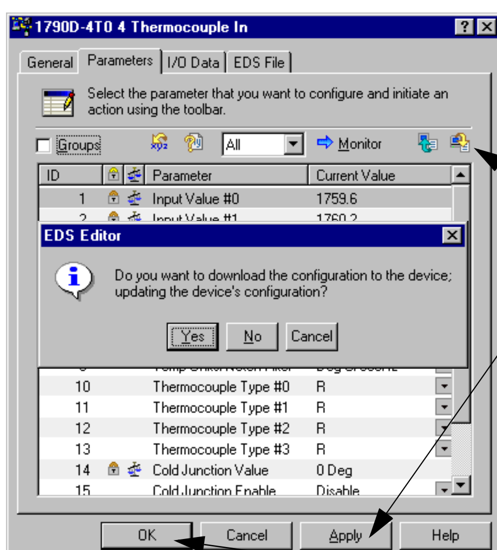


Select to Enable or Disable built-in cold junction compensation.

If built-in CJC is disabled, you can enter a constant cold junction offset value. The value is always entered in °C. The range is 0 to 70°C (000 to 700).



70°C is entered as 700 (158°F as 700 also).



Once module configuration is complete, click either the **Download** or **Apply** button and click **Yes** for the popup question.

Then click **OK** to close the module properties window.

Thermocouple/mV module parameters may be monitored real time. The most convenient way to monitor module parameters is to:

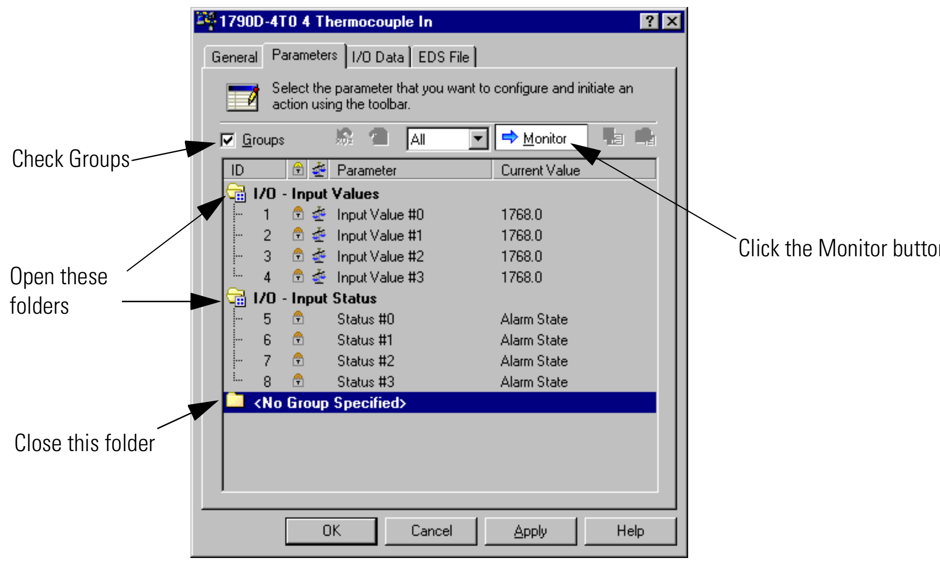
a. Click the Groups checkbox.

b. Close the No Group Specified folder

c. Open the I/O Input Values and I/O Input Status folders.

d. Click the Monitor button.

The module parameters are sequentially updated.



Chapter Summary

In this chapter, you learned how to setup and configure your module. See Chapter 4 to learn how to troubleshoot using the module indicators.

Diagnostics and Troubleshooting

This chapter describes module troubleshooting, containing information on:

- safety considerations when troubleshooting
- module vs. channel operation
- the module's diagnostic features
- critical vs. non-critical errors
- module condition data
- contacting Rockwell Automation for assistance

Safety Considerations

Safety considerations are an important element of proper troubleshooting procedures. Actively thinking about the safety of yourself and others, as well as the condition of your equipment, is of primary importance.

The following sections describe several safety concerns you should be aware of when troubleshooting your control system.

ATTENTION

Never reach into a machine to actuate a switch because unexpected motion can occur and cause injury.

Remove all electrical power at the main power disconnect switches before checking electrical connections or inputs/outputs causing machine motion.

Indicator Lights

When the green MOD and NET LED on the thermocouple module are illuminated, it indicates that power is applied to the module, that it has passed its internal tests and that the module is communicating on the network.

Activating Devices When Troubleshooting

When troubleshooting, never reach into the machine to actuate a device. Unexpected machine motion could occur.

Stand Clear of the Equipment

When troubleshooting any system problem, have all personnel remain clear of the equipment. The problem could be intermittent, and sudden unexpected machine motion could occur. Have someone ready to operate an emergency stop switch in case it becomes necessary to shut off power.

Program Alteration

There are several possible causes of alteration to the user program, including extreme environmental conditions, Electromagnetic Interference (EMI), improper grounding, improper wiring connections, and unauthorized tampering. If you suspect a program has been altered, check it against a previously saved master program.

Safety Circuits

Circuits installed on the machine for safety reasons, like over-travel limit switches, stop push buttons, and interlocks, should always be hard-wired to the master control relay. These devices must be wired in series so that when any one device opens, the master control relay is de-energized, thereby removing power to the machine. Never alter these circuits to defeat their function. Serious injury or machine damage could result.

Module Operation vs. Channel Operation

The module performs diagnostic operations at both the module level and the channel level. Module-level operations include functions such as power-up, configuration, and communication with a controller.

Channel-level operations describe channel related functions, such as data conversion and over- or under-range detection.

Internal diagnostics are performed at both levels of operation. When detected, module error conditions are indicated by the module status LED. Channel over-range or under-range conditions are reported in the module's input data table.

Power-up Diagnostics

Power-up diagnostics includes module status and network status.

Module Status

At module power-up, a series of internal diagnostic tests are performed. These diagnostic tests must be successfully completed. The following table shows module status LED indictor operation.

Table 4.1

1790D-4T0/T4T0, 1790P-4T0		
LED Indicator:	**Status:**	**Description:**
Module Status	Solid Red	Unrecoverable fault
	Flashing Red	Recoverable fault
	Solid Green	Normal operation - OK
	Flashing Green	Standby
	Off	No power

Network Status

The network status LED indicator shows the condition of the network connection. The following tables show network status LED indicator operation.

Table 4.2 1790D-4T0/T4T0 LED Descriptions

LED Indicator	Status	Description:
Network Status	Solid Red	Unrecoverable communication fault
	Flashing Red	Recoverable communication fault
	Solid Green	Communication path complete - OK
	Flashing Green	Communication path incomplete
	Off	Device not online or not powered

Table 4.3 1790P-4T0 LED Descriptions

LED Indicator	Status	Description
Network Status	Solid Green	Communication path complete - OK
	Flashing Green	Communication path incomplete
	Off	No power or baud rate search

Channel Diagnostics

When an input channel is enabled, the module performs a diagnostic check to see that the channel has been properly configured. In addition, the channel is tested on every scan for configuration errors, over-range and under-range, and open-circuit conditions.

Over- or Under-Range Detection

Whenever the data received at the channel word is out of the defined operating range, an over-range or under-range error is indicated in input data word 4.

Possible causes for an out-of-range condition include:

- The temperature is too hot or too cold for the type of thermocouple being used.
- The wrong thermocouple is being used for the input type selected, or for the configuration that you have programmed.
- The input device is faulty.
- The signal input from the input device is beyond the scaling range.

Open-Circuit Detection

On each scan, the module performs an open-circuit test on all channels. Whenever an open-circuit condition occurs, the overrange bit for that channel is set in input data word 4.

Possible causes of an open circuit include:

- the input device is broken
- a wire is loose or cut
- the input device is not installed on the configured channel
- a thermocouple is installed incorrectly

Module Error Definition Table

Thermocouple/mV module errors are expressed on a channel basis in input read word 4. The structure of the status data is shown in the following table.

Table 4.4 Word Bit Position

Word	Bit Description															
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
4	Not Used				S11	S10	S9	S8	Not Used				S3	S2	S1	S0

Table 4.5 Bit Descriptions

Word	Decimal Bit	Description
Read Word 4	Bits 00-03	Underrange for individual channels. Bit 00 corresponds to input channel 0, bit 01 corresponds to input channel 1 and so on. When set (1), the input signal if below the input channel's minimum range
	Bits 04-07	Not used: Set to 0
	Bit 08-11	Overrange for individual channels. Bit 08 corresponds to input channel 0, bit 09 corresponds to input channel 1 and so on. When set (1), the input signal if above the input channel's maximum range, or open thermocouple is detected
	Bit 12-15	Not used: Set to 0

Channel LED Indicator Operation

Individual channel LED indicator operation is shown in the following table.

Table 4.6 Individual Channel LEDs Indicator

I/O Channel LED Status Indicator	
Status:	**Description**
Flashing Green/Red	Power up
Off	Off line
Red	On line and no field power
Red	DeviceNet connection and no field power
Flashing Red	Field power and open wire
Green	Field power and valid input
Flashing Red	Input over range, open input
Flashing Red	Input under range
Flashing Red	Recoverable fault

Specifications

Environmental Specifications

Environmental Specifications	
Operating Temperature	0 to 55°C (32 to 131°F) IEC 60068-2-1 (Test Ad, Operating Cold), IEC 60068-2-2 (Test Bd, Operating Dry Heat), IEC 60068-2-14 (Test Nb, Operating Thermal Shock)
Storage Temperature	-40 to 85°C (-40 to 185°F) IEC 60068-2-1 (Test Ab, Un-packaged Non-operating Cold), IEC 60068-2-2 (Test Bb, Un-packaged Non-operating Dry Heat), IEC 60068-2-14 (Test Na, Un-packaged Non-operating Thermal Shock)
Relative Humidity	5-90% non-condensing IEC 60068-2-30 (Test Db, Un-packaged Non-operating)
Operating Altitude	2000m
Vibration	I2g @ 10-500Hz EC60068-2-6 (Test Fc, Operating)
Shock: Operating Non-operating	I0g 30g IEC60068-2-27 Test Ea, (Unpackaged Shock, ES#002)
Emissions	Group 1, Class A CISPR 11
ESD Immunity	8kV air discharges IEC 61000-4-2
Radiated RF Immunity	10V/m with 1kHz sine-wave 80%AM from 80MHz to 1000MHz 10V/m with 200Hz 50% Pulse 100%AM @ 900Mhz IEC 61000-4-3
EFT/B Immunity	±1kV @ 5kHz on power ports +2kV @ 5kHz on signal ports ±2kV @ 5kHz on communications ports IEC 61000-4-4
Surge Transient Immunity	±1kV line-line(DM) and ±2kV line-earth(CM) on power ports ±1kV line-line(DM) and ±2kV line-earth(CM) on signal ports ±2kV line-earth(CM) on shielded ports IEC 61000-4-5
Conducted RF Immunity	10Vrms with 1kHz sine-wave 80%AM from 150kHzto 80MHz IEC 61000-4-6
Enclosure Type Rating	None (open style)
Mounting	DIN rail or screw
Dimensions	52 x 104 x 42mm (2.03 x 4.07 x 1.64in)
Weight	0.3lb (0.1kg)

DeviceNet Specifications

Specification	Value
Network protocol	I/O Slave messaging: - Poll command - Bit Strobe command - Cyclic command - COS command
Network length	500 meters maximum @ 125Kbps 100 meters maximum @ 500Kbps
Indicators	1 red/green module status 1 red/green network status
Number of nodes	64 maximum - rotary switch type node address setting
Communication rate	125Kbps, 250Kbps, 500Kbps - auto baud rate selection
Isolation	Type test 1250Vac rms for 60 seconds between field power and DeviceNet (I/O to logic)
Wiring	Refer to publication DN-6.7.2

PROFIBUS DP Specifications

PROFIBUS DP Specifications	
Network Protocol	PROFIBUS-DP (EN50170) Communication of the slave with a Class 1 master Communication of the slave with a Class 2 master
Redundancy	Not supported
Repeater Control Signal	RS485 signal
Implementation Type	DPC31
Freeze Mode	Supported
Sync Mode	Supported
Auto Baud Rate	Supported
Fail Safe Mode	Supported
Station Type	Slave
FMS Support	Not supported
Indicators	1 red/green module status 1 red/green network status
Number of nodes	100 maximum - rotary switch type node address setting (0-99)
Network Length/ Communication rate	9.6Kbps @ 1000m (3280ft) 19.2Kbps @ 1000m (3280ft) 45.45Kbps @ 1000m (3280 ft) 93.75Kbps @ 1000m (3280ft) 187.5Kbps @ 1000m (3280ft) 500Kbps @ 400m (1312ft) 1.5mbps @ 200m (656ft) 3mbps @ 100m (328ft) 6mbps @ 100m (328ft) 12mbps @ 100m (328ft)
Isolation	Type test 1250Vac rms for 60 seconds between field power and PROFIBUS (I/O to logic)

General Specifications

General Specifications		
Wiring Category	2[1]	
Product Certifications (when product is marked)	c-UL-us	UL Listed for Class I, Division 2 Group A,B,C,D Hazardous Locations, certified for U.S. and Canada
	UR	UL Recognized Component Industrial Control Equipment
	CE[2]	European Union 89/336/EEC EMC Directive, compliant with: EN 61000-6-4; Industrial Emissions EN 50082-2; Industrial Immunity EN61326; Meas./Control/Lab., Industrial Requirements EN 61000-6-2; Industrial Immunity
	C-Tick[2]	Australian Radiocommunications Act, compliant with: AS/NZS 2064; Industrial Emissions
	ODVA	ODVA conformance tested to ODVA DeviceNet specifications
DeviceNet Power	Supply voltage - 24V dc nominal Voltage range - 11-28.8V dc Power dissipation - 1.2W maximum @ 28.8V dc	
PROFIBUS Power	Supply voltage - 24V dc nominal Voltage range - 19.2-28.8V dc Power dissipation - 2W maximum @ 28.8V dc	
Field Power	Supply Voltage - 24Vdc nominal Voltage Range - 21.6-26.4V dc (±10%) Power Dissipation - 1.5W maximum @ 26.4V dc	
Isolation	I/O to logic: photocoupler isolation Isolation voltage: Type Test 1250V ac rms for 60 seconds DeviceNet to logic: non-isolated Field power: non-isolated	
Indicators	4 red/green I/O status	
Wiring		
1790D-4R0	37-pin D-Shell connector	
1790D-T4R0	Terminal block connector screw torque: 7 inch pounds maximum	

1 Refer to publication 1770-4.1, *Programmable Controller Wiring and Grounding Guidelines.*

2 See the Product Certification link at www.ab.com for Declarations of Conformity, Certificates and other certification details.

IMPORTANT These modules do not support any expansion modules.

Thermocouple/mV Specifications

Thermocouple/mV Specifications			
Inputs per module	4 channel, Thermocouple/mV Input		
Input Range	±76.50 mV		
Sensors Supported	Sensor Type	Degree	Counts
	Voltage 10μV	-76.5 to +76.5	-7650 to +7650
	B	300 to 1800°C	3000 to 18000
	E	-270 to +1000°C	-2700 to +10000
	J	-210 to +1200°C	-2100 to +12000
	K	-270 to +1370°C	-2700 to +13700
	R	-50 to +1768°C	-500 to +17680
	S	-50 to +1768°C	-500 to +17680
	T	-270 to +400°C	-2700 to +4000
	N	-270 to 1300°C	-2700 to 13000
Resolution	16 bits, 0.1°C/bit or 0.1°F/bit (Thermocouple Sensors) 20bit Sigma-Delta modulation converter		
Data Format	16 bit Integer (2's compliment)		
Module Scan Time	140ms/channel @ Notch Filter = 60Hz		
Overall accuracy	0.2% Full scale @ 0°C-55°C		
Settable Notch Filter	10Hz (default), 25Hz, 50Hz, 60Hz, 100Hz, 250Hz, 500Hz		
Open Wire Detection	Out of range, open wiring		
Cold Junction Compensation Range	0 to 70°C		
Input Impedance	5M ohm		

Two's Complement Binary Numbers

The processor memory stores 16-bit binary numbers. Two's complement binary is used when performing mathematical calculations internal to the processor. Analog input values from the Thermocouple/mV module are returned to the processor in 16-bit two's complement binary format. For positive numbers, the binary notation and two's complement binary notation are identical.

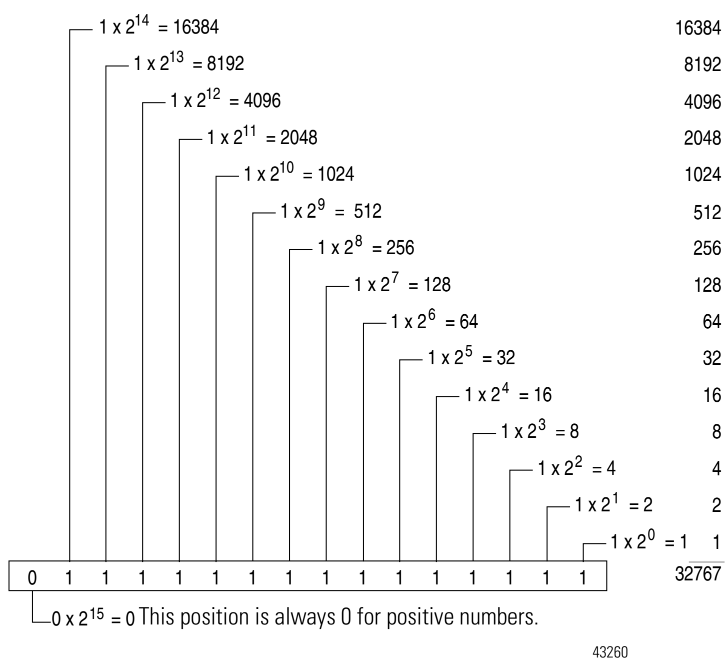
As indicated in the figure on the next page, each position in the number has a decimal value, beginning at the right with 2^0 and ending at the left with 2^{15}. Each position can be 0 or 1 in the processor memory. A 0 indicates a value of 0; a 1 indicates the decimal value of the position. The equivalent decimal value of the binary number is the sum of the position values.

Positive Decimal Values

The far left position is always 0 for positive values. As indicated in the figure below, this limits the maximum positive decimal value to 32767 (all positions are 1 except the far left position). For example:

0000 1001 0000 1110 = $2^{11}+2^{8}+2^{3}+2^{2}+2^{1}$ = 2048+256+8+4+2 = 2318

0010 0011 0010 1000 = $2^{13}+2^{9}+2^{8}+2^{5}+2^{3}$ = 8192+512+256+32+8 = 9000

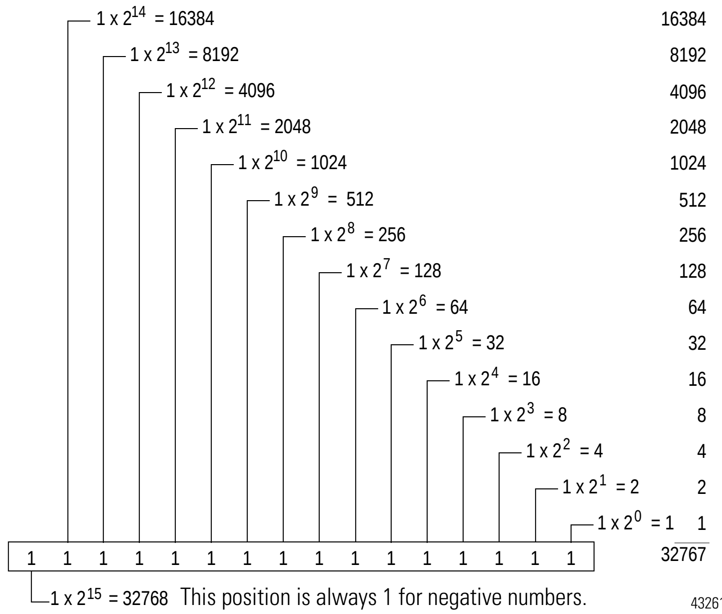


Negative Decimal Values

In two's complement notation, the far left position is always 1 for negative values. The equivalent decimal value of the binary number is obtained by subtracting the value of the far left position, 32768, from the sum of the values of the other positions. In the figure below (all positions are 1), the value is 32767 - 32768 = -1. For example:

$$1111\ 1000\ 0010\ 0011 = (2^{14}+2^{13}+2^{12}+2^{11}+2^{5}+2^{1}+2^{0}) - 2^{15} =$$

$$(16384+8192+4096+2048+32+2+1) - 32768 = 30755 - 32768 = -2013$$



Thermocouple Descriptions

The information in this appendix was extracted from the NIST Monograph 175 issued in January 1990, which supersedes the IPTS-68 Monograph 125 issued in March 1974. NIST Monograph 175 is provided by the United States Department of Commerce, National Institute of Standards and Technology.

International Temperature Scale of 1990

The ITS-90 [1,3] is realized, maintained, and disseminated by NIST to provide a standard scale of temperature for use in science and industry in the United States. This scale was adopted by the International Committee of Weights and Measures (CIPM) at its meeting in September 1989, and it became the official international temperature scale on January 1, 1990. The ITS-90 supersedes the IPTS-68(75) [2] and the 1976 Provisional 0.5 K to 30 K Temperature Scale (EPT-76) [4].

The adoption of the ITS-90 removed several deficiencies and limitations associated with IPTS-68. Temperatures on the ITS-90 are in closer agreement with thermodynamic values than were those of the IPTS-68 and EPT-76. Additionally, improvements have been made in the non-uniqueness and reproducibility of the temperature scale, especially in the temperature range from t68 = 630.74°C to 1064.43°C, where the type S thermocouple was the standard interpolating device on the IPTS-68.

For additional technical information regarding ITS-90, refer to the NIST Monograph 175.

Type B Thermocouples

This section discusses Platinum-30 percent Rhodium Alloy Versus Platinum-6 percent Rhodium Alloy thermocouples, commonly called type B thermocouples. This type is sometimes referred to by the nominal chemical composition of its thermoelements: platinum - 30 percent rhodium versus platinum - 6 percent rhodium or “30-6”. The positive (BP) thermoelement typically contains 29.60 ± 0.2 percent rhodium and the negative (BN) thermoelement usually contains 6.12 ± 0.02 percent rhodium. The effect of differences in rhodium content are described later in this section. An industrial consensus standard [21] (ASTM E1159-87) specifies that rhodium having a purity of 99.98 percent shall be alloyed with platinum of 99.99 percent purity to produce the thermoelements. This consensus standard [21] describes the purity of commercial type B materials that are used in many industrial thermometry applications that meet the calibration tolerances described later in this section. Both thermoelements will typically have significant impurities of elements such as palladium, iridium, iron, and silicon [38].

Studies by Ehringer [39], Walker et al. [25,26], and Glawe and Szaniszlo [24] have demonstrated that thermocouples, in which both legs are platinum-rhodium alloys, are suitable for reliable temperature measurements at high temperatures. Such thermocouples have been shown to offer the following distinct advantages over types R and S thermocouples at high temperatures: (1) improved stability, (2) increased mechanical strength, and (3) higher operating temperatures.

The research by Burns and Gallagher [38] indicated that the 30-6 thermocouple can be used intermittently (for several hours) up to 1790°C and continuously (for several hundred hours) at temperatures up to about 1700°C with only small changes in calibration. The maximum temperature limit for the thermocouple is governed, primarily, by the melting point of the Pt-6 percent rhodium thermoelement which is estimated to be about 1820°C by Acken [40]. The thermocouple is most reliable when used in a clean oxidizing atmosphere (air) but also has been used successfully in neutral atmospheres or vacuum by Walker et al [25,26], Hendricks and McElroy [41], and Glawe and Szaniszlo [24]. The stability of the thermocouple at high temperatures has been shown by Walker et al. [25,26] to depend, primarily, on the quality of the materials used for protecting and insulating the thermocouple. High purity alumina with low iron-content appears to be the most suitable material for the purpose.

Type B thermocouples should not be used in reducing atmospheres, nor those containing deleterious vapors or other contaminants that are reactive with the platinum group metals [42], unless suitably protected with nonmetallic protecting tubes. They should never be used in metallic protecting tubes at high temperatures.

The Seebeck coefficient of type B thermocouples decreases with decreasing temperature below about 1600°C and becomes almost negligible at room temperature. Consequently, in most applications the reference junction temperature of the thermocouple does not need to be controlled or even known, as long as it between 0°C and 50°C. For example, the voltage developed by the thermocouple, with the reference junction at 0°C, undergoes a reversal in sign at about 42°C, and between 0°C and 50°C varies from a minimum of -2.6μV near 21°C to a maximum of 2.3μV at 50°C. Therefore, in use, if the reference junction of the thermocouple is within the range 0°C to 50°C, then a 0°C reference junction temperature can be assumed and the error introduced will not exceed 3μV. At temperatures above 1100°C, an additional measurement error of 3μV (about 0.3°C) would be insignificant in most instances.

ASTM Standard E230-87 in the 1992 Annual Book of ASTM Standards [7] specifies that the initial calibration tolerances for type B commercial thermocouples be ±0.5 percent between 870°C and 1700°C. Type B thermocouples can also be supplied to meet special tolerances of ±0.25 percent. Tolerances are not specified for type B thermocouples below 870°C.

The suggested upper temperature limit of 1700°C given in the ASTM standard [7] for protected type B thermocouples applies to AWG 24 (0.51 mm) wire. This temperature limit applies to thermocouples used in conventional closed-end protecting tubes and it is intended only as a rough guide to the user. It does not apply to thermocouples having compacted mineral oxide insulation.

Type E Thermocouples

This section describes Nickel-Chromium Alloy Versus Copper-Nickel Alloy thermocouples, known as type E thermocouples. This type, and the other base-metal types, do not have specific chemical compositions given in standards; rather, any materials whose emf-temperature relationship agrees with that of the specified reference table within certain tolerances can be considered to be a type E thermocouple. The positive thermoelement, EP, is the same material as KP. The negative thermoelement, EN, is the same material as TN.

The low-temperature research [8] by members of the NBS Cryogenics Division showed that type E thermocouples are very useful down to liquid hydrogen temperatures (n.b.p. about 20.3K) where their Seebeck coefficient is about 8mV/°C. They may even be used down to liquid helium temperatures (4.2°K) although their Seebeck coefficient becomes quite low, only about 2mV/°C at 4K. Both thermoelements of type E thermocouples have a relatively low thermal conductivity, good resistance to corrosion in moist atmospheres, and reasonably good homogeneity. For these three reasons and their relatively high Seebeck coefficients, type E thermocouples have been recommended [8] as the most useful of the letter-designated thermocouple types for low-temperature measurements.

For measurements below 20K, the non-letter-designated thermocouple, KP versus gold-0.07, is recommended. The properties of this thermocouple have been described by Sparks and Powell [12].

Type E thermocouples also have the largest Seebeck coefficient above 0°C for any of the letter-designated thermocouples. For that reason they are being used more often whenever environmental conditions permit.

Type E thermocouples are recommended by the ASTM [5] for use in the temperature range from -200°C to 900°C in oxidizing or inert atmospheres. If used for extended times in air above 500°C, heavy gauge wires are recommended because the oxidation rate is rapid at elevated temperatures. About 50 years ago, Dahl [11] studied the thermoelectric stability of EP and EN type alloys when heated in air at elevated temperatures. His work should be consulted for details. More recent stability data on these alloys in air were reported by Burley et al. [13].

Type E thermocouples should not be used at high temperatures in sulfurous, reducing, or alternately reducing and oxidizing atmospheres unless suitably protected with protecting tubes. They also should not be used in vacuum (at high temperatures) for extended times because the chromium in the positive thermoelement, a nickel-chromium alloy, vaporizes out of solution and alters the calibration. In addition, their use in atmospheres that promote "green-rot" corrosion of the positive thermoelement should be avoided. Such corrosion results from the preferential oxidation of chromium in atmospheres with low, but not negligible, oxygen content and can lead to a large decrease in the thermoelectric voltage of the thermocouple with time. The effect is most serious at temperatures between 800°C and 1050°C.

The negative thermoelement, a copper-nickel alloy, is subject to composition changes under thermal neutron irradiation since the copper is converted to nickel and zinc.

Neither thermoelement of type E thermocouples is very sensitive to minor changes in composition or impurity level because both are already heavily alloyed. Similarly, they are also not extremely sensitive to minor differences in heat treatment (provided that the treatment does not violate any of the restrictions mentioned above). For most general applications, they may be used with the heat treatment given by the wire manufacturers. However, when the highest accuracy is sought, additional preparatory heat treatments may be desirable in order to enhance their performance. Details on this and other phases of the use and behavior of type KP thermoelements (EP is the same as KP) are given in publications by Pots and McElroy [14], by Burley and Ackland [15], by Burley [16], by Wang and Starr [17,18], by Bentley [19], and by Kollie et al. [20].

ASTM Standard E230-87 in the 1992 Annual Book of ASTM Standards [7] specifies that the initial calibration tolerances for type E commercial thermocouples be ±1.7°C or ±0.5 percent (whichever is greater) between 0°C and 900°C, and ±1.7°C or ±1 percent (whichever is greater) between -200°C and 0°C. Type E thermocouples can also be supplied to meet special tolerances which are equal to ±1°C or ±0.4 percent (whichever is greater) between 0°C and 900°C, and ±1°C or ±0.5 percent (whichever is greater) between -200°C and 0°C. Type E thermocouple materials are normally supplied to meet the tolerances specified for temperatures above 0°C. The same materials, however, may not satisfy the tolerances specified for the -200°C to 0°C range. If materials are required to meet the tolerances below 0°C, this should be specified when they are purchased.

The suggested upper temperature limit, 870°C, given in the ASTM standard [7] for protected type E thermocouples applies to AWG 8 (3.25 mm) wire. It decreases to 650°C for AWG 14 (1.63 mm), 540°C for AWG 20 (0.81 mm), 430°C for AWG 24 or 28 (0.51 mm or 0.33 mm), and 370°C for AWG 30 (0.25 mm). These temperature limits apply to thermocouples used in conventional closed-end protecting tubes and they are intended only as a rough guide to the user. They do not apply to thermocouples having compacted mineral oxide insulation.

Type J Thermocouples

This section discusses Iron Versus Copper-Nickel Alloy (SAMA) thermocouples, called type J thermocouples. A type J thermocouple is one of the most common types of industrial thermocouples, because of its relatively high Seebeck coefficient and low cost. It has been reported that more than 200 tons of type J materials are supplied annually to industry in this country. However, this type is least suitable for accurate thermometry because there are significant nonlinear deviations in the thermoelectric output of thermocouples obtained from different manufacturers. These irregular deviations lead to difficulties in obtaining accurate calibrations based on a limited number of calibration points. The positive thermoelement is commercially pure (99.5 percent Fe) iron, usually containing significant impurity levels of carbon, chromium, copper, manganese, nickel, phosphorus, silicon, and sulfur. Thermocouple wire represents such a small fraction of the total production of commercial iron wire that the producers do not control the chemical composition to maintain constant thermoelectric properties. Instead, instrument companies and thermocouple fabricators select material most suitable for the thermocouple usage. The total and specific types of impurities that occur in commercial iron change with time, location of primary ores, and methods of smelting. Many unusual lots have been selected in the past, for example spools of industrial iron wire and even scrapped rails from an elevated train line. At present, iron wire that most closely fits these tables has about 0.25 percent manganese and 0.12 percent copper, plus other minor impurities.

The negative thermoelement for type J thermocouples is a copper-nickel alloy known ambiguously as constantan. The word constantan has commonly referred to copper-nickel alloys containing anywhere from 45 to 60 percent copper, plus minor impurities of carbon, cobalt, iron, and manganese. Constantan for type J thermocouples usually contains about 55 percent copper, 45 percent nickel, and a small but thermoelectrically significant amount of cobalt, iron, and manganese, about 0.1 percent or more. It should be emphasized that type JN thermoelements are NOT generally interchangeable with type TN (or EN) thermoelements, although they are all referred to as “constantan”. In order to provide some differentiation in nomenclature, type JN is often referred to as SAMA constantan.

Type J thermocouples are recommended by the ASTM [5] for use in the temperature range from 0°C to 760°C in vacuum, oxidizing, reducing, or inert atmospheres. If used for extended times in air above 500°C, heavy gauge wires are recommended because the oxidation rate is rapid at elevated temperatures. Oxidation normally causes a gradual decrease in the thermoelectric voltage of the thermocouple with time. Because iron rusts in moist atmospheres and may become brittle, type J thermocouples are not recommended for use below 0°C. In addition, they should not be used unprotected in sulfurous atmospheres above 500°C.

The positive thermoelement, iron, is relatively insensitive to composition changes under thermal neutron irradiation, but does exhibit a slight increase in manganese content. The negative thermoelement, a copper-nickel alloy, is subject to substantial composition changes under thermal neutron irradiation since copper is converted to nickel and zinc.

Iron undergoes a magnetic transformation near 769°C and an alpha-gamma crystal transformation near 910°C [6]. Both of these transformations, especially the latter, seriously affect the thermoelectric properties of iron, and therefore of type J thermocouples. This behavior and the rapid oxidation rate of iron are the main reasons why iron versus constantan thermocouples are not recommended as a standardized type above 760°C. If type J thermocouples are taken to high temperatures, especially above 900°C, they will lose the accuracy of their calibration when they are recycled to lower temperatures. If type J thermocouples are used in air at temperatures above 760°C, only the largest wire, AWG 8 (3.3 mm) should be used and they should be held at the measured temperature for 10 to 20 minutes before readings are taken. The thermoelectric voltage of the type J thermocouples may change by as much as 40μV (or 0.6°C equivalent) per minute when first brought up to temperatures near 900°C.

ASTM Standard E230-87 in the 1992 Annual Book of ASTM Standards [7] specifies that the initial calibration tolerances for type J commercial thermocouples be ±2.2°C or ±0.75 percent (whichever is greater) between 0°C and 750°C. Type J thermocouples can also be supplied to meet special tolerances, which are equal to approximately one-half the standard tolerances given above. Tolerances are not specified for type J thermocouples below 0°C or above 750°C.

The suggested upper temperature limit of 760°C given in the above ASTM standard [7] for protected type J thermocouples applies to AWG 8 (3.25 mm) wire. For smaller diameter wires the suggested upper temperature limit decreases to 590°C for AWG 14 (1.63 mm), 480°C for AWG 20 (0.81 mm), 370°C for AWG 24 or 28 (0.51 mm or 0.33 mm), and 320°C for AWG 30 (0.25 mm). These temperature limits apply to thermocouples used in conventional closed-end protecting tubes and they are intended only as a rough guide to the user. They do not apply to sheathed thermocouples having compacted mineral oxide insulation.

Type K Thermocouples

This section describes Nickel-Chromium Alloy Versus Nickel-Aluminum Alloy thermocouples, called type K thermocouples. This type is more resistant to oxidation at elevated temperatures than types E, J, or T thermocouples and, consequently, it finds wide application at temperatures above 500°C. The positive thermoelement, KP, which is the same as EP, is an alloy that typically contains about 89 to 90 percent nickel, 9 to about 9.5 percent chromium, both silicon and iron in amounts up to about 0.5 percent, plus smaller amounts of other constituents such as carbon, manganese, cobalt, and niobium. The negative thermoelement, KN, is typically composed of about 95 to 96 percent nickel, 1 to 1.5 percent silicon, 1 to 2.3 percent aluminum, 1.6 to 3.2 percent manganese, up to about 0.5 percent cobalt and smaller amounts of other constituents such as iron, copper, and lead. Also, type KN thermoelements with modified compositions are available for use in special applications. These include alloys in which the manganese and aluminum contents are reduced or eliminated, while the silicon and cobalt contents are increased.

The low temperature research [8] by members of the NBS Cryogenics Division showed that the type K thermocouple may be used down to liquid helium temperatures (about 4K) but that its Seebeck coefficient becomes quite small below 20K. Its Seebeck coefficient at 20K is only about 4μV/K, being roughly one-half that of the type E thermocouple which is the most suitable of the letter-designated thermocouples types for measurements down to 20K. Type KP and type KN thermoelements do have a relatively low thermal conductivity and good resistance to corrosion in moist atmospheres at low temperatures. The thermoelectric homogeneity of type KN thermoelements, however, was found [8] to be not quite as good as that of type EN thermoelements.

Type K thermocouples are recommended by the ASTM [5] for use at temperatures within the range -250°C to 1260°C in oxidizing or inert atmospheres. Both the KP and the KN thermoelements are subject to deterioration by oxidation when used in air above about 750°C, but even so, type K thermocouples may be used at temperatures up to about 1350°C for short periods with only small changes in calibration. When oxidation occurs it normally leads to a gradual increase in the thermoelectric voltage with time. The magnitude of the change in the thermoelectric voltage and the physical life of the thermocouple will depend upon such factors as the temperature, the time at temperature, the diameter of the thermoelements and the conditions of use.

The ASTM Manual [5] indicates that type K thermocouples should not be used at high temperatures in sulfurous, reducing, or alternately oxidizing and reducing atmospheres unless suitably protected with protecting tubes. They also should not be used in vacuum (at high temperatures) for extended times because the chromium in the positive thermoelement, a nickel-chromium alloy, vaporizes out of solution and alters the calibration. In addition, avoid their use in atmospheres that promote “green-rot” corrosion [9] of the positive thermoelement. Such corrosion results from the preferential oxidation of chromium in atmospheres with low, but not negligible, oxygen content and can lead to a large decrease in the thermoelectric voltage of the thermocouple with time. The effect is most serious at temperatures between 800°C and 1050°C.

Both thermoelements of type K thermocouples are reasonably stable, thermoelectrically, under neutron irradiation since the resulting changes in their chemical compositions due to transmutation are small. The KN thermoelements are somewhat less stable than the KP thermoelements in that they experience a small increase in the iron content accompanied by a slight decrease in the manganese and cobalt contents.

ASTM Standard E230-87 in the 1992 Annual Book of ASTM Standards [7] specifies that the initial calibration tolerances for type K commercial thermocouples be ±2.2°C or ±0.75 percent (whichever is greater) between 0°C and 1250°C, and ±2.2°C or ±2 percent (whichever is greater) between -200°C and 0°C. In the 0°C to 1250°C range, type K thermocouples can be supplied to meet special tolerances that are equal to approximately one-half the standard tolerances given above. Type K thermocouple materials are normally supplied to meet the tolerances specified for temperatures above 0°C. However, the same materials may not satisfy the tolerances specified for the -200°C to 0°C range. If materials are required to meet the tolerances below 0°C, this should be specified when they are purchased.

The suggested upper temperature limit of 1260°C given in the ASTM standard [7] for protected type K thermocouples applies to AWG 8 (3.25 mm) wire. It decreases to 1090°C for AWG 14 (1.63 mm), 980°C for AWG 20 (0.81 mm), 870 for AWG 24 or 28 (0.51 mm or 0.33 mm), and 760°C for AWG 30 (0.25 mm). These temperature limits apply to thermocouples used in conventional closed-end protecting tubes and they are intended only as a rough guide to the user. They do not apply to thermocouples having compacted mineral oxide insulation.

Type N Thermocouples

This section describes Nickel-Chromium-Silicon Alloy Versus Nickel-Silicon-Magnesium Alloy thermocouples, commonly referred to as type N thermocouples. This type is the newest of the letter-designated thermocouples. It offers higher thermoelectric stability in air above 1000°C and better air-oxidation resistance than types E, J, and K thermocouples. The positive thermoelement, NP, is an alloy that typically contains about 84 percent nickel, 14 to 14.4 percent chromium, 1.3 to 1.6 percent silicon, plus small amounts (usually not exceeding about 0.1 percent) of other elements such as magnesium, iron, carbon, and cobalt. The negative thermoelement, NN, is an alloy that typically contains about 95 percent nickel, 4.2 to 4.6 percent silicon, 0.5 to 1.5 percent magnesium, plus minor impurities of iron, cobalt, manganese and carbon totaling about 0.1 to 0.3 percent. The type NP and NN alloys were known originally [16] as nicrosil and nisil, respectively.

The research reported in NBS Monograph 161 showed that the type N thermocouple may be used down to liquid helium temperatures (about 4K) but that its Seebeck coefficient becomes very small below 20K. Its Seebeck coefficient at 20K is about 2.5μV/K, roughly one-third that of type E thermocouples which are the most suitable of the letter-designated thermocouples types for measurements down to 20K. Nevertheless, types NP and NN thermoelements do have a relatively low thermal conductivity and good resistance to corrosion in moist atmospheres at low temperatures.

Type N thermocouples are best suited for use in oxidizing or inert atmospheres. Their suggested upper temperature limit, when used in conventional closed-end protecting tubes, is set at 1260°C by the ASTM [7] for 3.25 mm diameter thermoelements. Their maximum upper temperature limit is defined by the melting temperature of the thermoelements, which are nominally 1410°C for type NP and 1340°C for type NN [5]. The thermoelectric stability and physical life of type N thermocouples when used in air at elevated temperatures will depend upon factors such as the temperature, the time at temperature, the diameter of the thermoelements, and the conditions of use. Their thermoelectric stability and oxidation resistance in air have been investigated and compared with those of type K thermocouples by Burley [16], by Burley and others [13,44-47], by Wang and Starr [17,43,48,49], by McLaren and Murdock [33], by Bentley [19], and by Hess [50].

Type N thermocouples, in general, are subject to the same environmental restrictions as types E and K. They are not recommended for use at high temperatures in sulfurous, reducing, or alternately oxidizing and reducing atmospheres unless suitably protected with protecting tubes. They also should not be used in vacuum (at high temperatures) for extended times because the chromium and silicon in the positive thermoelement, a nickel-chromium-silicon alloy, vaporize out of solution and alter the calibration. In addition, their use in atmospheres with low, but not negligible, oxygen content is not recommended, since it can lead to changes in calibration due to the preferential oxidation of chromium in the positive thermoelement. Nevertheless, Wang and Starr [49] studied the performances of type N thermocouples in reducing atmospheres, as well as in stagnant air, at temperatures in the 870°C to 1180°C range and found them to be markedly more stable thermoelectrically than type K thermocouples under similar conditions.

The performance of type N thermocouples fabricated in metal-sheathed, compacted ceramic insulated form also has been the subject of considerable study. Anderson and others [51], Bentley and Morgan [52], and Wang and Bediones [53] have evaluated the high-temperature, thermoelectric stability of thermocouples insulated with magnesium oxide and sheathed in Inconel and in stainless steel. Their studies showed that the thermoelectric instabilities of such assemblies increase rapidly with temperature above 1000°C. It was found also that the smaller the diameter of the sheath the greater the instability. Additionally, thermocouples sheathed in Inconel showed substantially less instability above 1000°C than those sheathed in stainless steel. Bentley and Morgan [52] stressed the importance of using Inconel sheathing with a very low manganese content to achieve the most stable performance. The use of special Ni-Cr based alloys for sheathing to improve the chemical and physical compatibility with the thermoelements also has been investigated by Burley [54-56] and by Bentley [57-60].

Neither thermoelement of a type N thermocouple is extremely sensitive to minor differences in heat treatment (provided that the treatment does not violate any of the restrictions mentioned above). For most general applications, they may be used with the heat treatment routinely given by the wire manufacturer. Bentley [61,62], however, has reported reversible changes in the Seebeck coefficient of type NP and NN thermoelements when heated at temperatures between 200°C and 1000°C. These impose limitations on the accuracy obtainable with type N thermocouples. The magnitude of such changes was found to depend on the source of the thermoelements. Consequently, when the highest accuracy and stability are sought, selective testing of materials, as well as special preparatory heat treatments beyond those given by the manufacturer, will usually be necessary. Bentley's articles [61,62] should be consulted for guidelines and details.

ASTM Standard E230-87 in the 1992 Annual Book of ASTM Standards [7] specifies that the initial calibration tolerances for type N commercial thermocouples be ±2.2°C or ±0.75 percent (whichever is greater) between 0°C and 1250°C. Type N thermocouples can also be supplied to meet special tolerances that are equal to approximately one-half the standard tolerances given above. Tolerances are not specified for type N thermocouples below 0°C.

The suggested upper temperature limit of 1260°C given in the ASTM standard [7] for protected type N thermocouples applies to AWG 8 (3.25 mm) wire. It decreases to 1090°C for AWG 14 (1.63 mm), 980°C for AWG 20 (0.81 mm), 870°C for AWG 24 or 28 (0.51 mm or 0.33 mm), and 760°C for AWG 30 (0.25 mm). These temperature limits apply to thermocouples used in conventional closed-end protecting tubes and they are intended only as a rough guide to the user. They do not apply to thermocouples having compacted mineral oxide insulation.

Type R Thermocouples

This section describes Platinum-13 percent Rhodium Alloy Versus Platinum thermocouples, called type R thermocouples. This type is often referred to by the nominal chemical composition of its positive (RP) thermoelement: platinum-13 percent rhodium. The negative (RN) thermoelement is commercially-available platinum that has a nominal purity of 99.99 percent [21]. An industrial consensus standard (ASTM E1159-87) specifies that rhodium having a nominal purity of 99.98 percent shall be alloyed with platinum of 99.99 percent purity to produce the positive thermoelement, which typically contains 13.00 ± 0.05 percent rhodium by weight. This consensus standard [21] describes the purity of commercial type R materials that are used in many industrial thermometry applications and that meet the calibration tolerances described later in this section. It does not cover, however, the higher-purity, reference-grade materials that traditionally were used to construct thermocouples used as transfer standards and reference thermometers in various laboratory applications and to develop reference functions and tables [22,23]. The higher purity alloy material typically contains less than 500 atomic ppm of impurities and the platinum less than 100 atomic ppm of impurities [22]. Differences between such high purity commercial material and the platinum thermoelectric reference standard, Pt-67, are described in [22] and [23].

A reference function for the type R thermocouple, based on the ITS-90 and the SI volt, was determined recently from new data obtained in a collaborative effort by NIST and NPL. The results of this international collaboration were reported by Burns et al [23]. The function was used to compute the reference table given in this monograph.

Type R thermocouples have about a 12 percent larger Seebeck coefficient than do Type S thermocouples over much of the range. Type R thermocouples were not standard interpolating instruments on the IPTS-68 for the 630.74°C to gold freezing-point range. Other than these two points, and remarks regarding history and composition, all of the precautions and restrictions on usage given in the section on type S thermocouples also apply to type R thermocouples. Glawe and Szaniszlo [24], and Walker et al [25,26] have determined the effects that prolonged exposure at elevated temperatures (>1200°C) in vacuum, air, and argon atmospheres have on the thermoelectric voltages of type R thermocouples.

ASTM Standard E230-87 in the 1992 Annual Book of ASTM Standards [7] specifies that the initial calibration tolerances for type R commercial thermocouples be ±1.5°C or ±0.25 percent (whichever is greater) between 0°C and 1450°C. Type R thermocouples can be supplied to meet special tolerances of ±0.6°C or ±0.1 percent (whichever is greater).

The suggested upper temperature limit, 1480°C, given in the ASTM standard [7] for protected type R thermocouples applies to AWG 24 (0.51 mm) wire. This temperature limit applies to thermocouples used in conventional closed-end protecting tubes and it is intended only as a rough guide to the user. It does not apply to thermocouples having compacted mineral oxide insulation.

Type S Thermocouples

This section describes Platinum-10 percent Rhodium Alloy Versus Platinum thermocouples, commonly known as type S thermocouples. This type is often referred to by the nominal chemical composition of its positive (SP) thermoelement: platinum-10 percent rhodium. The negative (SN) thermoelement is commercially available platinum that has a nominal purity of 99.99 percent [21]. An industrial consensus standard (ASTM E1159-87) specifies that rhodium having a nominal purity of 99.98 percent shall be alloyed with platinum of 99.99 percent purity to produce the positive thermoelement, which typically contains 10.00 ± 0.05 percent rhodium by weight. The consensus standard [21] describes the purity of commercial type S materials that are used in many industrial thermometry applications and that meet the calibration tolerances described later in this section. It does not cover, however, the higher-purity, reference-grade materials that traditionally were used to construct thermocouples used as standard instruments of the IPTS-68, as transfer standards and reference thermometers in various laboratory applications, and to develop reference functions and tables [27,28]. The higher purity alloy material typically contains less than 500 atomic ppm of impurities and the platinum less than 100 atomic ppm of impurities [27]. Difference between such high purity commercial material and the platinum thermoelectric reference standard, Pt-67, are described in [27] and [28].

A reference function for the type S thermocouple, based on the ITS-90 and the SI volt, was determined recently from new data obtained in an international collaborative effort involving eight national laboratories. The results of this international collaboration were reported by Burns et al. [28]. The new function was used to compute the reference table given in this monograph.

Research [27] demonstrated that type S thermocouples can be used from -50°C to the platinum melting-point temperature. They may be used intermittently at temperatures up to the platinum melting point and continuously up to about 1300°C with only small changes in their calibrations. The ultimate useful life of the thermocouples when used at such elevated temperatures is governed primarily by physical problems of impurity diffusion and grain growth, which lead to mechanical failure. The thermocouple is most reliable when used in a clean oxidizing atmosphere (air) but may be used also in inert gaseous atmospheres or in a vacuum for short periods of time. However, type B thermocouples are generally more suitable for such applications above 1200°C. Type S thermocouples should not be used in reducing atmospheres, nor in those containing metallic vapor (such as lead or zinc), nonmetallic vapors (such as arsenic, phosphorus, or sulfur) or easily reduced oxides, unless they are suitably protected with nonmetallic protecting tubes. Also, they should never be inserted directly into a metallic protection tube for use at high temperatures. The stability of type S thermocouples at high temperatures (>1200°C) depends primarily upon the quality of the materials used for protection and insulation, and has been studied by Walker et al. [25,26] and by Bentley [29]. High purity alumina, with low iron content, appears to be the most suitable material for insulating, protecting, and mechanically supporting the thermocouple wires.

Both thermoelements of type S thermocouples are sensitive to impurity contamination. In fact, type R thermocouples were developed essentially because of iron contamination effects in some British platinum-10 percent rhodium wires. The effects of various impurities on the thermoelectric voltages of platinum based thermocouple materials have been described by Rhys and Taimsalu [35], by Cochrane [36] and by Aliotta [37]. Impurity contamination usually causes negative changes [25,26,29] in the thermoelectric voltage of the thermocouple with time, the extent of which will depend upon the type and amount of chemical contaminant. Such changes were shown to be due mainly to the platinum thermoelement [25,26,29]. Volatilization of the rhodium from the positive thermoelement for the vapor transport of rhodium from the positive thermoelement to the pure platinum negative thermoelement also will cause negative drifts in the thermoelectric voltage. Bentley [29] demonstrated that the vapor transport of rhodium can be virtually eliminated at 1700°C by using a single length of twin-bore tubing to insulate the thermoelements and that contamination of the thermocouple by impurities transferred from the alumina insulator can be reduced by heat treating the insulator prior to its use.

McLaren and Murdock [30-33] and Bentley and Jones [34] thoroughly studied the performance of type S thermocouples in the range 0°C to 1100°C. They described how thermally reversible effects, such as quenched-in point defects, mechanical stresses, and preferential oxidation of rhodium in the type SP thermoelement, cause chemical and physical inhomogeneities in the thermocouple and thereby limit its accuracy in this range. They emphasized the important of annealing techniques.

The positive thermoelement is unstable in a thermal neutron flux because the rhodium converts to palladium. The negative thermoelement is relatively stable to neutron transmutation. Fast neutron bombardment, however, will cause physical damage, which will change the thermoelectric voltage unless it is annealed out.

At the gold freezing-point temperature, 1064.18°C, the thermoelectric voltage of type S thermocouples increases by about 340uV (about 3 percent) per weight percent increase in rhodium content; the Seebeck coefficient increases by about 4 percent per weight percent increase at the same temperature.

ASTM Standard E230-87 in the 1992 Annual Book of ASTM Standards [7] specifies that the initial calibration tolerances for type S commercial thermocouples be ±1.5°C or ±0.25 percent (whichever is greater) between 0°C and 1450°C. Type S thermocouples can be supplied to meet special tolerances of ±0.6°C or ±0.1 percent (whichever is greater).

The suggested upper temperature limit, 1480°C, given in the ASTM standard [7] for protected type S thermocouples applies to AWG 24 (0.51 mm) wire. This temperature limit applies to thermocouples used in conventional closed-end protecting tubes and it is intended only as a rough guide to the user. It does not apply to thermocouples having compacted mineral oxide insulation.

Type T Thermocouples

This section describes Copper Versus Copper-Nickel Alloy thermocouples, called type T thermocouples. This type is one of the oldest and most popular thermocouples for determining temperatures within the range from about 370°C down to the triple point of neon (-248.5939°C). Its positive thermoelement, TP, is typically copper of high electrical conductivity and low oxygen content that conforms to ASTM Specification B3 for soft or annealed bare copper wire. Such material is about 99.95 percent pure copper with an oxygen content varying from 0.02 to 0.07 percent (depending upon sulfur content) and with other impurities totaling about 0.01 percent. Above about -200°C, the thermoelectric properties of type TP thermoelements, which satisfy the above conditions, are exceptionally uniform and exhibit little variation between lots. Below about -200°C the thermoelectric properties are affected more strongly by the presence of dilute transition metal solutes, particularly iron.

The negative thermoelement, TN or EN, is a copper-nickel alloy known ambiguously as constantan. The word constantan refers to a family of copper-nickel alloys containing anywhere from 45 to 60 percent copper. These alloys also typically contain small percentages of cobalt, manganese and iron, as well as trace impurities of other elements such as carbon, magnesium, silicon, etc. The constantan for type T thermocouples usually contains about 55 percent copper, 45 percent nickel, and small but thermoelectrically significant amounts, about 0.1 percent or larger, of cobalt, iron, or manganese. It should be emphasized that type TN (or EN) thermoelements are NOT generally interchangeable with type JN thermoelements although they are all referred to as “constantan”. In order to provide some differentiation in nomenclature, type TN (or EN) is often referred to as Adams’ (or RP1080) constantan and type JN is usually referred to as SAMA constantan.

The thermoelectric relations for type TN and type EN thermoelements are the same, that is the voltage versus temperature equations and tables for platinum versus type TN thermoelements apply to both types of thermoelements over the temperature range recommended for each thermocouple type. However, if should not be assumed that type TN and type EN thermoelements may be used interchangeably or that they have the same commercial initial calibration tolerances.

The low temperature research [8] by members of the NBS Cryogenics Division showed that the type T thermocouple may be used down to liquid helium temperatures (about 4K) but that its Seebeck coefficient becomes quite small below 20K. Its Seebeck coefficient at 20K is only about 5.6µV/K, being roughly two-thirds that of the type E thermocouple.

The thermoelectric homogeneity of most type TP and type TN (or EN) thermoelements is reasonably good. There is considerable variability, however, in the thermoelectric properties of type TP thermoelements below about 70K caused by variations in the amounts and types of impurities present in these nearly pure materials. The high thermal conductivity of the type TP thermoelements can also be troublesome in precise applications. For these reasons, type T thermocouples are generally unsuitable for use below about 20K. Type E thermocouples are recommended as the most suitable of the letter-designated thermocouple types for general low-temperature use, since they offer the best overall combination of desirable properties.

Type T thermocouples are recommended by the ASTM [5] for use in the temperature range from -200°C to 370°C in vacuum or in oxidizing, reducing or inert atmospheres. The suggested upper temperature limit for continuous service of protected type T thermocouples is set at 370°C for AWG 14 (1.63 mm) thermoelements since type TP thermoelements oxidize rapidly above this temperature. However, the thermoelectric properties of type TP thermoelements are apparently not grossly affected by oxidation since negligible changes in the thermoelectric voltage were observed at NBS [10] for AWG 12, 18, and 22 type TP thermoelements during 30 hours of heating in air at 500°C. At this temperature the type TN thermoelements have good resistance to oxidation and exhibit only small voltage changes heated in air for long periods of time, as shown by the studies of Dahl [11]. Higher operating temperatures, up to at least 800°C, are possible in inert atmospheres where the deterioration of the type TP thermoelement is no longer a problem. The use of type T thermocouples in hydrogen atmospheres at temperatures above about 370°C is not recommended since type TP thermoelements may become brittle.

Type T thermocouples are not well suited for use in nuclear environments since both thermoelements are subject to significant changes in composition under thermal neutron irradiation. The copper in the thermoelements is converted to nickel and zinc.

Because of the high thermal conductivity of type TP thermoelements, special care should be exercised when using the thermocouples to ensure that the measuring and reference junctions assume the desired temperatures.

ASTM Standard E230-87 in the 1992 Annual Book of ASTM Standards [7] specifies that the initial calibration tolerances for type T commercial thermocouples be ±1°C or ±0.75 percent (whichever is greater) between 0°C and 350°C, and ±1°C or ±1.5 percent (whichever is greater) between -200°C and 0°C. Type T thermocouples can also be supplied to meet special tolerances which are equal to approximately one-half the standard tolerances given above.

Type T thermocouple materials are normally supplied to meet the tolerances specified for temperatures above 0°C. However, the same materials may not satisfy the tolerances specified for the -200°C to 0°C range. If materials are required to meet the tolerances below 0°C, this should be specified when they are purchased.

The suggested upper temperature limit of 370°C given in the ASTM standard [7] for protected type T thermocouples applies to AWG 14 (1.63 mm) wire. It decreases to 260°C for AWG 20 (0.81 mm), 200°C for AWG 24 or 28 (0.51 mm or 0.33 mm), and 150°C for AWG 30 (0.25 mm). These temperature limits apply to thermocouples used in conventional closed-end protecting tubes and they are intended only as a rough guide to the user. They do not apply to thermocouples having compacted mineral oxide insulation.

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Using Thermocouple Junctions

This appendix describes the types of thermocouple junctions available, and explains the trade-offs in using them with the thermocouple/mV analog input module.

ATTENTION

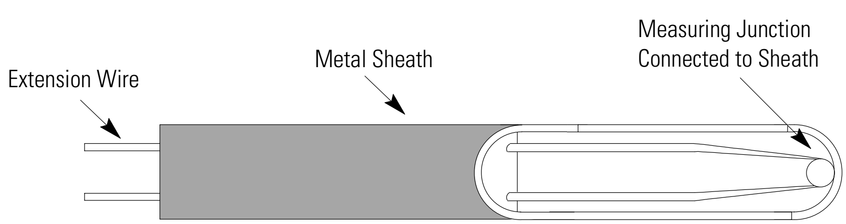
Take care when choosing a thermocouple junction, and connecting it from the environment to the module. If you do not take adequate precautions for a given thermocouple type, the electrical isolation of the module might be compromised.

Available thermocouple junctions are:

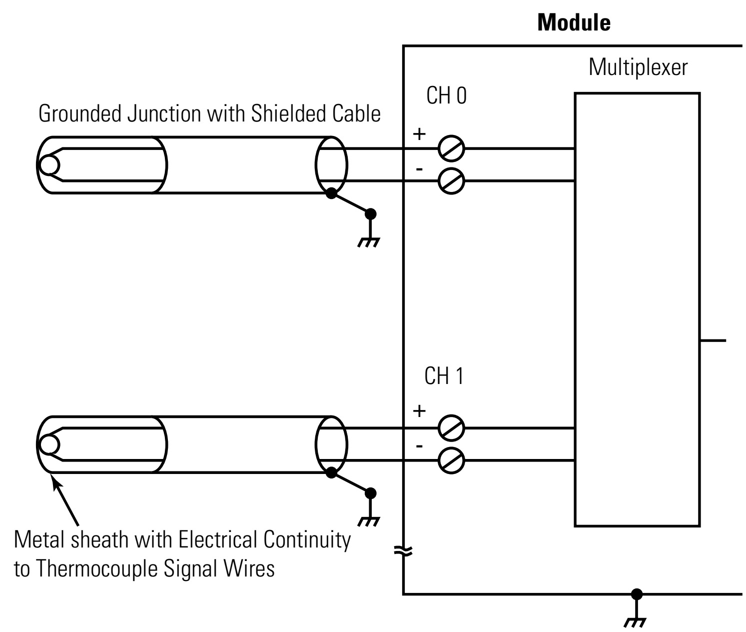
- grounded
- ungrounded (isolated)
- exposed

Using a Grounded Junction Thermocouple

With a grounded junction thermocouple, the measuring junction is physically connected to the protective sheath, forming a completely sealed integral junction. If the sheath is metal (or electrically conductive), there is electrical continuity between the junction and sheath. The junction is protected from corrosive or erosive conditions. The response time approaches that of the exposed junction type described in Using an Exposed Junction Thermocouple on page D-3.



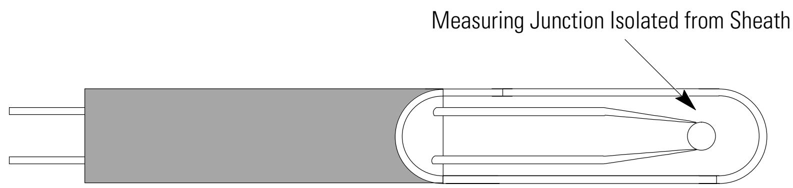
The shield input terminals for a grounded junction thermocouple are connected together and then connected to chassis ground. Use of this thermocouple with an electrically conductive sheath removes the thermocouple signal to chassis ground isolation of the module. In addition, if multiple grounded junction thermocouples are used, the module channel-to-channel isolation is removed, since there is no isolation between signal and sheath (sheaths are tied together). It should be noted that the isolation is removed even if the sheaths are connected to chassis ground at a location other than the module, since the module is connected to chassis ground.



Rockwell Automation recommends that a grounded junction thermocouple have a protective sheath made of electrically insulated material (for example, ceramic). An alternative is to float the metal sheath with respect to any path to chassis ground or to another thermocouple metal sheath. Thus, the metal sheath must be insulated from electrically conductive process material, and have all connections to chassis ground broken. Note that a floated sheath can result in a less noise-immune thermocouple signal.

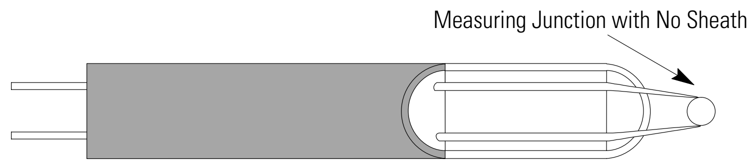
Using an Ungrounded (Isolated) Junction Thermocouple

An ungrounded (isolated) junction thermocouple uses a measuring junction that is electrically isolated from the protective metal sheath. This junction type is often used in situations when noise will affect readings, as well as situations using frequent or rapid temperature cycling. For this type of thermocouple junction, the response time is longer than for the grounded junction.

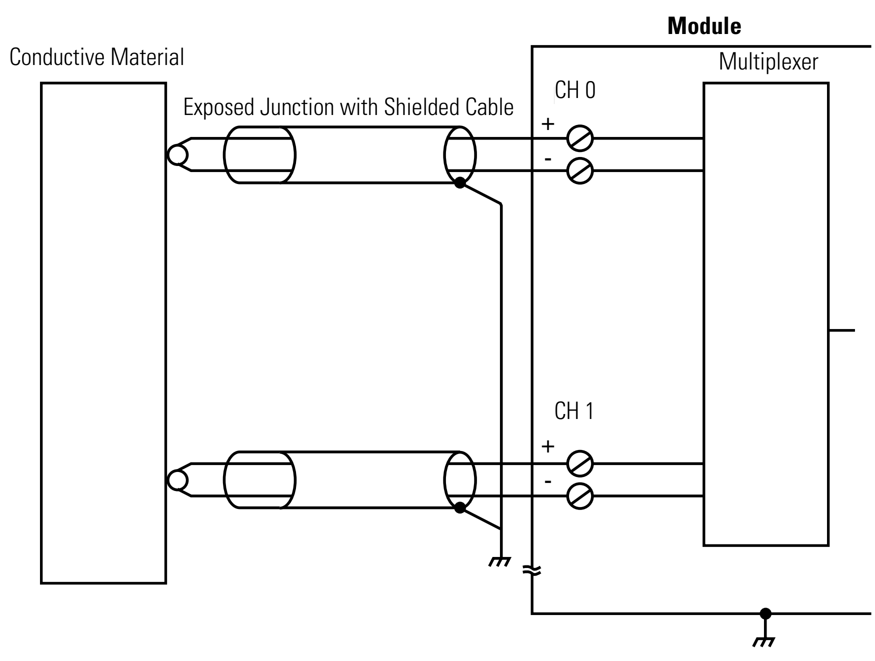


Using an Exposed Junction Thermocouple

An exposed junction thermocouple uses a measuring junction that does not have a protective metal sheath. A thermocouple with this junction type provides the fastest response time but leaves thermocouple wires unprotected against corrosive or mechanical damage.



As shown in the next illustration, using an exposed junction thermocouple can result in removal of channel-to-channel isolation. Isolation is removed if multiple exposed thermocouples are in direct contact with electrically conductive process material.



To prevent violation of channel-to-channel isolation:

- For multiple exposed junction thermocouples, do not allow the measuring junctions to make direct contact with electrically conductive process material.
- Preferably use a single exposed junction thermocouple with multiple ungrounded junction thermocouples.
- Consider using all ungrounded junction thermocouples instead of the exposed junction type.

Module Configuration for PROFIBUS

After installation of the thermocouple/mV module, you must configure it for operation, usually by using the programming software compatible with the controller or scanner. This appendix includes PROFIBUS configuration information.

Chapter 3 contains detailed information on module parameters and performance. While configuring your thermocouple/mV module for operation on PROFIBUS, refer to Chapter 3 for the following information:

- module memory map
- input data file
- data format
- filter frequencies
- channel step response
- channel cutoff frequency
- effective resolution
- module update time

Configure PROFIBUS Thermocouple/mV Modules (1790P-T4R0)

Configuration of the 1790P-T4T0 thermocouple/mV modules is accomplished through PROFIBUS configuration software with easy-to-use-GSD files. To obtain the GSD files you need to configure the module, access the following website.

http://www.ab.com/networks/gsd.

The example in this chapter shows you how to configure the thermocouple/mV module with the SST PROFIBUS Configuration tool.

Configure Thermocouple/mV Modules Using the SST PROFIBUS Configuration Tool

The configuration example outlined in this section is written for an experienced PROFIBUS user. Refer to your scanner and network documentation for more complete details.

Open your SST PROFIBUS Configuration tool.

IMPORTANT	If online, make sure the processor is in Program mode.

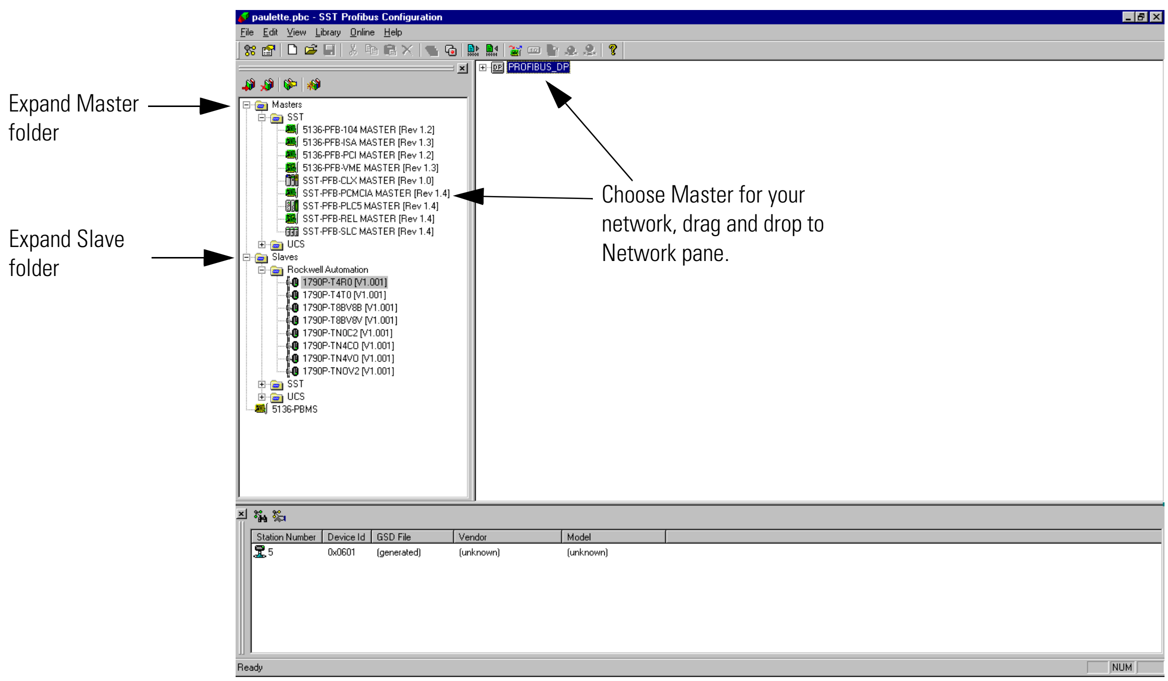
If it's not already installed, add the thermocouple/mV module GSD file from the dropdown menu. Access:

1. **Library>Add GSD**.
2. Click **File>New**.

   If the PROFIBUS devices pane is closed, choose:
3. **View>Library** to open the pane.

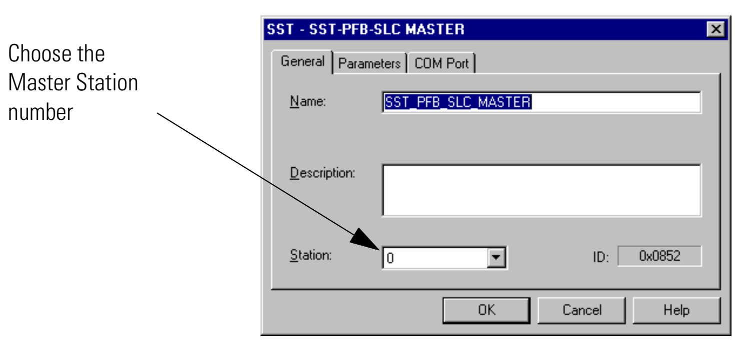
   If the on-line Browse pane is closed, choose:
4. **View>On-line** to open the pane.

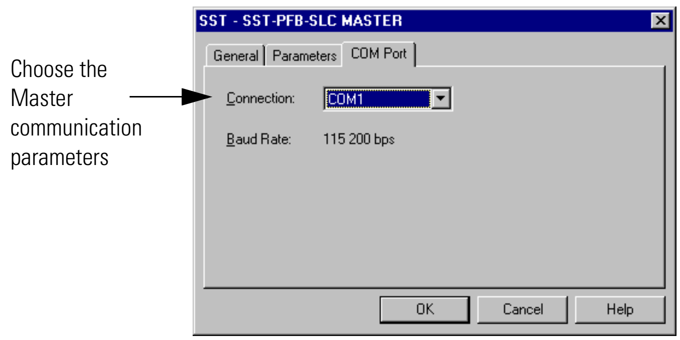
   You should now be ready to set up your system.
5. Expand the Master and Slaves folders in the PROFIBUS Device pane.



6. Choose the Master device for your network, drag and drop the device to the Network pane.

   From the following window:



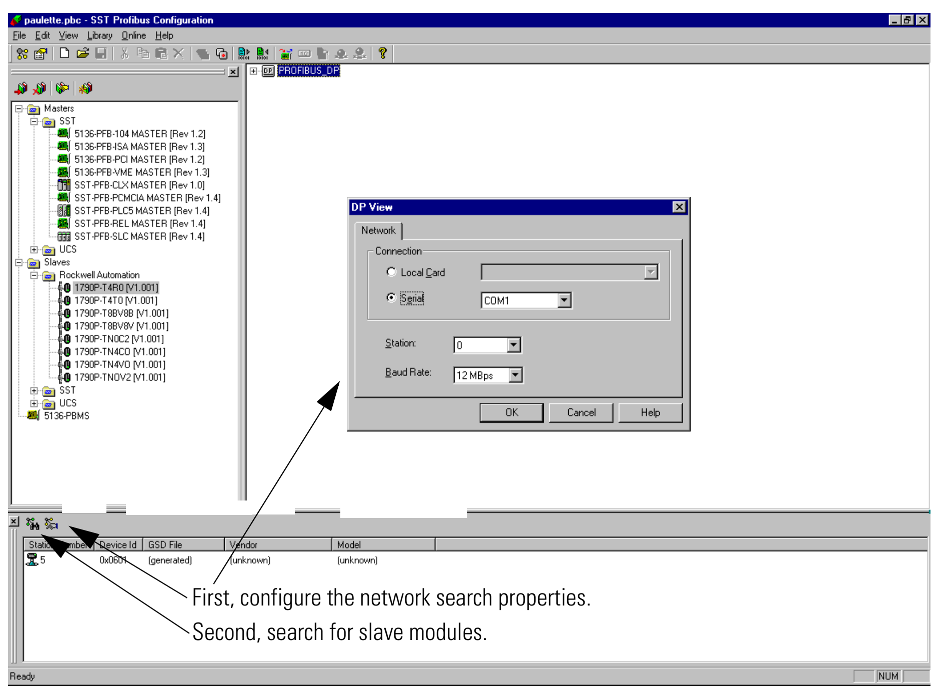


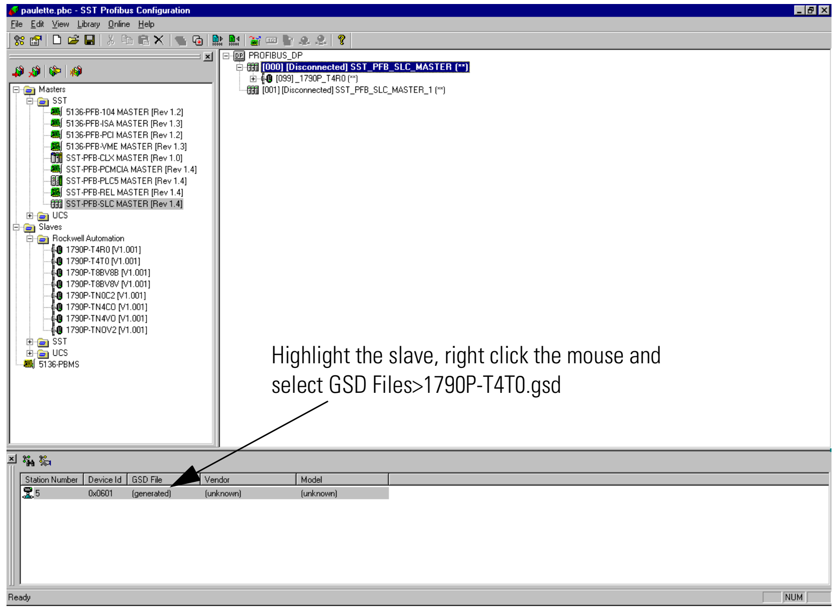
You can add modules to the network by:

1. Selecting slaves from the PROFIBUS Device pane
2. Dragging and dropping them to the network pane

   Or, if online, by performing a search for slaves

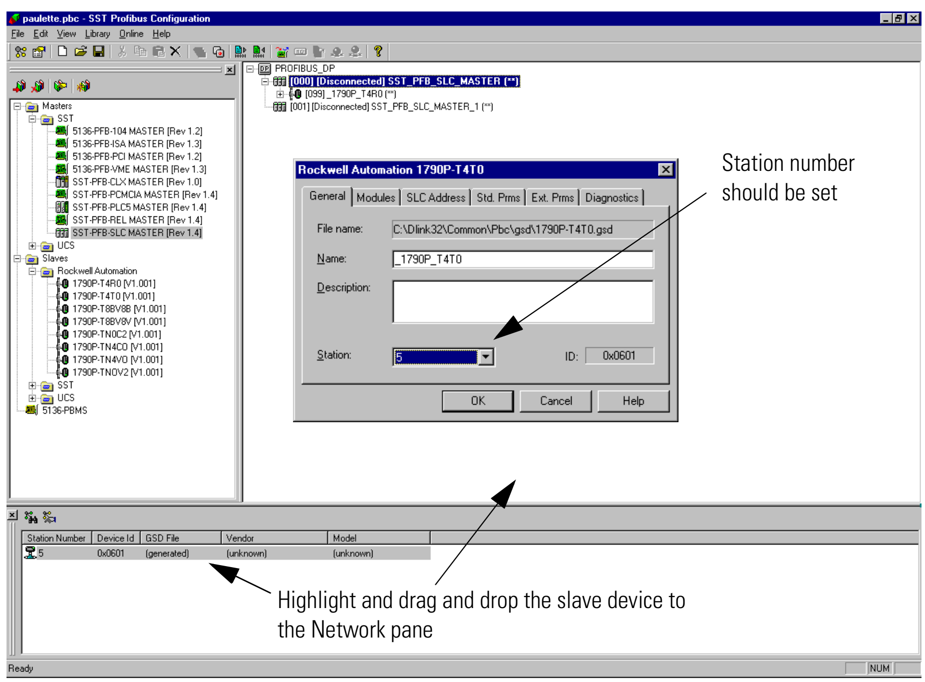
   See the following screens for an outline of this procedure.





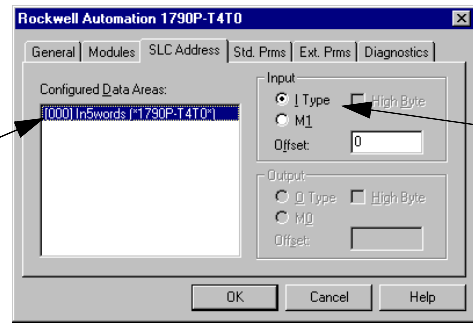
7. Highlight the slave from the Online Browse pane and drag and drop it to the Network pane.

The slave station number should be set. (If you dragged and dropped from the PROFIBUS Device pane, you must set the station number.)



8. Click the SLC address tab for data size information and to set the I/O data type. For this example, we choose I Type (Input Image in the processor).

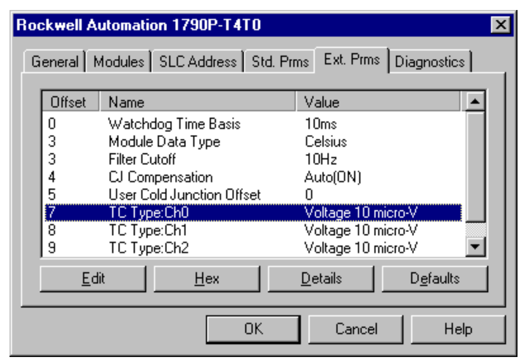
The 1790P-T4T0 module produces 5 words of data.



The produced 5 words will appear in the processor input data table.

9. Click the **Ext. Prms** tab.

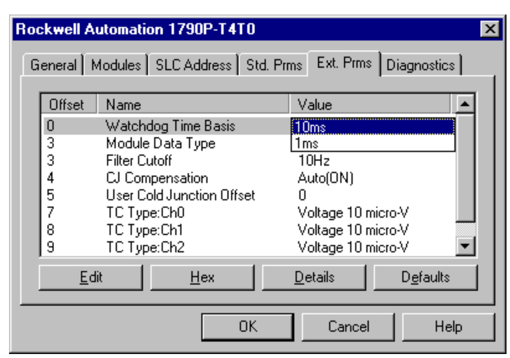
This is where the parameters that can be set for the slave thermocouple/mV module are configured.



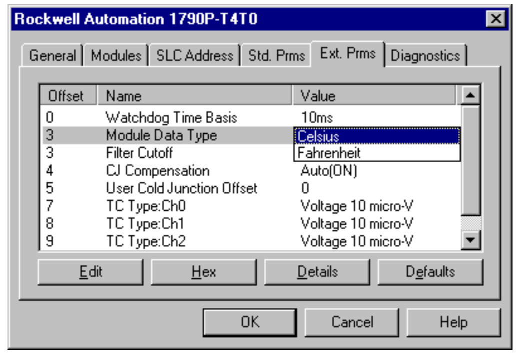
On this screen, you see all the parameters for the module. These include watchdog time, temperature units, filter frequency, cold junction compensation enable, manual offset and input thermocouple/ mV type.

Module configuration parameters include watchdog time base, temperature units, filter frequency, cold junction compensation enable, manual offset and input thermocouple/mV type.

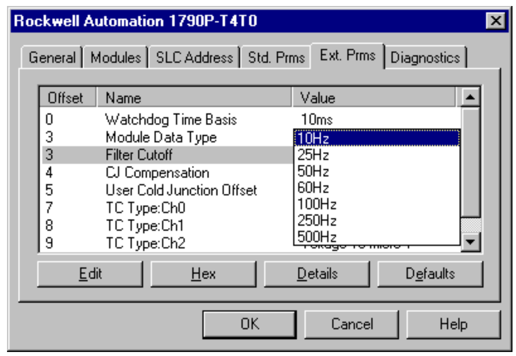
Select the watchdog time base (10 ms or 1 ms).



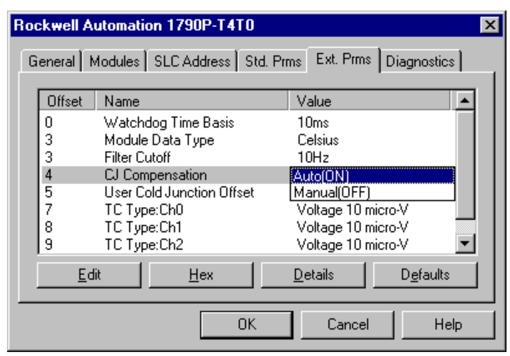
Select the temperature units (°C or °F). All four channels will be configured identically.



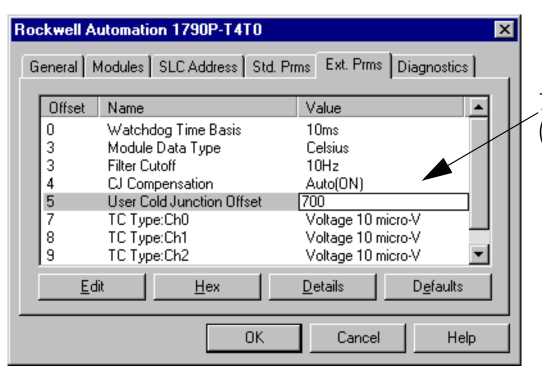
Select the filter cutoff frequency desired. All four channels will be configured identically.



Select to enable (auto) or disable (manual) built-in cold junction compensation.

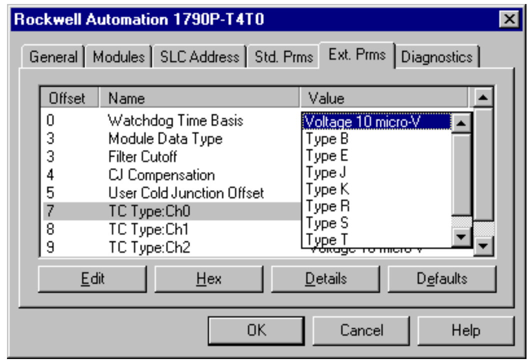


If built-in CJC is disabled, you can enter a constant cold junction offset value. The value is always entered in °C. The range is 0 to 70°C (000 to 700).



70°C is entered as 7000 (158°F as 700 also).

Select the thermocouple/mV input type for each channel from the dropdown list.



10. When configuration is complete, click the **OK** button to close the module properties screen.

Save the Configuration

To close the configuration:

1. Choose **File>Save As**.
2. Specify a file name and location to save your configuration.
3. Click **Save**.

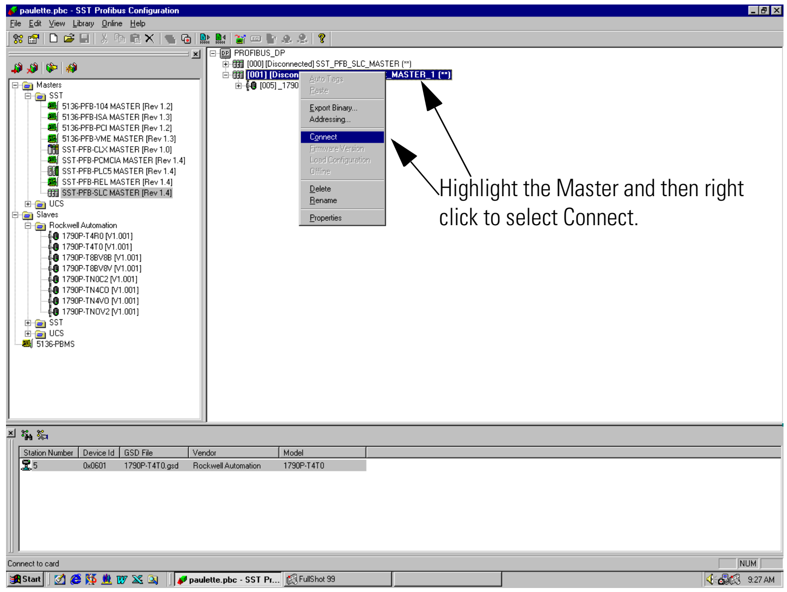
   This saves your project as a .pbc (PROFIBUS configuration file).

Download the Configuration

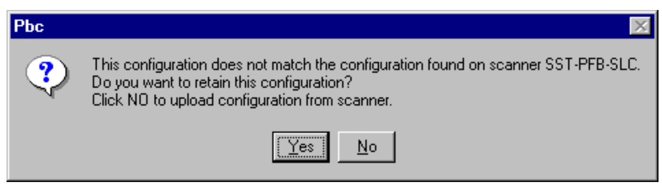
To download the configuration:

1. Verify that the processor is in Program Mode.
2. Make sure the serial communication cable is connected between the PC comm port and the scanner serial port.
3. Highlight Master in the Network pane.

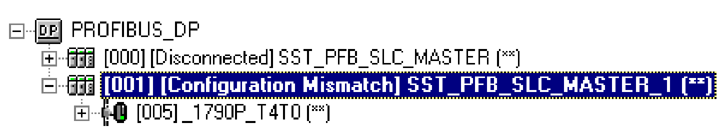
4. Right click to select Connect from the menu. (Or, choose **Edit>Connect**).



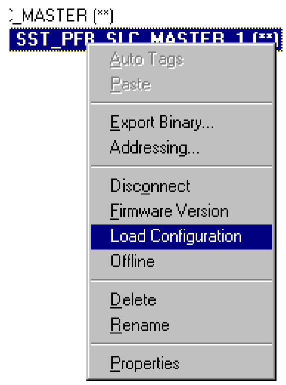
You may be prompted with a message indicating a configuration mismatch between what is in the scanner and your current PROFIBUS project. In this case, select **Yes** to retain your configuration.



Any configuration mismatches display for the Master status.



5. Load the configuration to the Master through one of the following methods.
   - Right click on the Master and select Load Configuration from the menu.



Or,

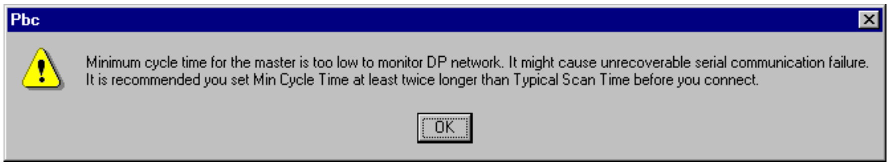
   - Select the **Load configuration** icon in the toolbar.

     If the scanner is online, the following message displays:

     Card is online. Do you want to load configuration.

   - Select **Yes** to load your new configuration.

You may receive this message:



This is only a warning that if your Min Cycle Time is not twice as long as the Scan Time then you may lose serial communications. This message can usually be ignored unless you require online monitoring.

The Master status now changes to the Configured Program Mode.

Your scanner is now configured and ready.

6. Turn the processor to Run mode.

The Net LED on the thermocouple/mV module should turn solid green as should the Comm LED on the scanner. The connection should report OK.

The master should now display:

Summary

This appendix illustrated how to configure your PROFIBUS thermocouple/mV module with the SST PROFIBUS Configuration tool.

For more information, consult your PROFIBUS network documentation, PROFIBUS scanner documentation and network configuration tool documentation.

The following terms and abbreviations are used throughout this manual. For definitions of terms not listed here refer to *Allen-Bradley's Industrial Automation Glossary*, Publication AG-7.1.

A/D Converter– Refers to the analog to digital converter inherent to the module. The converter produces a digital value whose magnitude is proportional to the magnitude of an analog input signal.

attenuation – The reduction in the magnitude of a signal as it passes through a system.

channel – Refers to input interfaces available on the module's terminal block. Each channel is configured for connection to a thermocouple or millivolt input device, and has its own data and diagnostic status words.

channel update time – The time required for the module to sample and convert the input signals of one enabled input channel and update the channel data word.

common mode rejection – For analog inputs, the maximum level to which a common mode input voltage appears in the numerical value read by the processor, expressed in dB.

common mode rejection ratio (CMMR) – The ratio of a device's differential voltage gain to common mode voltage gain. Expressed in dB, CMRR is a comparative measure of a device's ability to reject interference caused by a voltage common to its input terminals relative to ground. $\text{CMRR}=20\ \text{Log}_{10\ (V1/V2)}$

common mode voltage – The voltage difference between the negative terminal and analog common during normal differential operation.

common mode voltage range – The largest voltage difference allowed between either the positive or negative terminal and analog common during normal differential operation.

cut-off frequency – The frequency at which the input signal is attenuated 3 dB by a digital filter. Frequency components of the input signal that are below the cut-off frequency are passed with under 3 dB of attenuation for low-pass filters.

data word – A 16-bit integer that represents the value of the input channel. The channel data word is valid only when the channel is enabled and there are no channel errors. When the channel is disabled the channel data word is cleared (0).

dB – (decibel) A logarithmic measure of the ratio of two signal levels.

digital filter – A low-pass filter incorporated into the A/D converter. The digital filter provides very steep roll-off above it's cut-off frequency, which provides high frequency noise rejection.

effective resolution – The number of bits in a channel configuration word that do not vary due to noise.

filter – A device that passes a signal or range of signals and eliminates all others.

filter frequency – The user-selectable frequency for a digital filter.

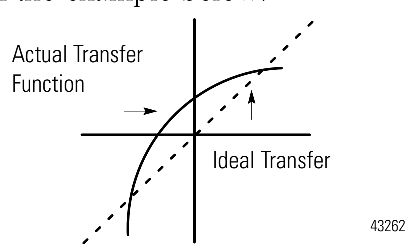
full-scale – The magnitude of input over which normal operation is permitted.

full-scale range – The difference between the maximum and minimum specified analog input values for a device.

input data scaling – Data scaling that depends on the data format selected for a channel configuration word. Scaling is selected to fit the temperature or voltage resolution for your application.

input image – The input from the module to the controller. The input image contains the module data words and status bits.

linearity error – Any deviation of the converted input or actual output from a straight line of values representing the ideal analog input. An analog input is composed of a series of input values corresponding to digital codes. For an ideal analog input, the values lie in a straight line spaced by inputs corresponding to 1 LSB. Linearity is expressed in percent full-scale input. See the variation from the straight line due to linearity error (exaggerated) in the example below.



LSB – Least significant bit. The LSB represents the smallest value within a string of bits. For analog modules, 16-bit, two's complement binary codes are used in the I/O image. For analog inputs, the LSB is defined as the rightmost bit of the 16-bit field (bit 0). The weight of the LSB value is defined as the full-scale range divided by the resolution.

module scan time – same as *module update time*

module update time – The time required for the module to sample and convert the input signals of all enabled input channels and make the resulting data values available to the processor.

multiplexer – An switching system that allows several signals to share a common A/D converter.

normal mode rejection – (differential mode rejection) A logarithmic measure, in dB, of a device's ability to reject noise signals between or among circuit signal conductors. The measurement does not apply to noise signals between the equipment grounding conductor or signal reference structure and the signal conductors.

number of significant bits – The power of two that represents the total number of completely different digital codes to which an analog signal can be converted or from which it can be generated.

overall accuracy – The worst-case deviation of the digital representation of the input signal from the ideal over the full input range is the overall accuracy. Overall accuracy is expressed in percent of full scale.

repeatability – The closeness of agreement among repeated measurements of the same variable under the same conditions.

resolution – The smallest detectable change in a measurement, typically expressed in engineering units (e.g. 1°C) or as a number of bits. For example a 12-bit system has 4096 possible output states. It can therefore measure 1 part in 4096.

sampling time – The time required by the A/D converter to sample an input channel.

step response time – The time required for the channel data word signal to reach a specified percentage of its expected final value, given a full-scale step change in the input signal.

thermocouple – A temperature sensing device consisting of a pair of dissimilar conductors welded or fused together at one end to form a measuring junction. The free ends are available for connection to the reference (cold) junction. A temperature difference between the junctions must exist for the device to function.

update time – see "module update time"

W

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Location/Phone

Would you like us to contact you regarding your comments?

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___Yes, please call me

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Return this form to: Allen-Bradley Marketing Communications, 1 Allen-Bradley Dr., Mayfield Hts., OH 44124-9705

Phone: 440-646-3176 Fax: 440-646-3525 Email: RADocumentComments@ra.rockwell.com

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