Allen-Bradley

Thermocouple/mV Isolated Input Module

(Cat. No. 1746-INT4 Series B)

User Manual

Important User Information

Solid state equipment has operational characteristics differing from those of electromechanical equipment. “Safety Guidelines for the Application, Installation and Maintenance of Solid State Controls” (Publication SGI-1.1) describes some important differences between solid state equipment and hard–wired electromechanical devices. Because of this difference, and also because of the wide variety of uses for solid state equipment, all persons responsible for applying this equipment must satisfy themselves that each intended application of this equipment is acceptable.

In no event will the Allen-Bradley Company be responsible or liable for indirect or consequential damages resulting from the use or application of this equipment.

The examples and diagrams in this manual are included solely for illustrative purposes. Because of the many variables and requirements associated with any particular installation, the Allen-Bradley Company cannot assume responsibility or liability for actual use based on the examples and diagrams.

No patent liability is assumed by Allen-Bradley Company with respect to use of information, circuits, equipment, or software described in this manual.

Throughout this manual we use notes to make you aware of safety considerations.

ATTENTION: Identifies information about practices or circumstances that can lead to personal injury or death, property damage, or economic loss.

Attentions help you:

- identify a hazard
- avoid the hazard
- recognize the consequences

Important: Identifies information that is especially important for successful application and understanding of the product.

Summary of Changes

This publication contains new and revised information not included in the previous version.

New Information

The Thermocouple/mV Isolated Input module, cat. no. 1746-INT4 is now a series B module. The series B module is identical to the series A module with the exception that the series B module is CE certified and has CSA hazardous location approval (refer to Appendix A for complete ratings).

Compliance with European Union Directives

This series B module complies with the directives outlined in Chapter 1 of this document.

CSA Hazardous Location Approval

This series B module complies with CSA classifications as outlined under Specifications in Appendix A.

Revised Information

This publication also contains information formally included in a document update, publication 1746-6.16–DU1.

Change Bars

The areas in this manual which are different from previous editions are marked with change bars (as shown to the right of this paragraph) to indicate the addition of new or revised information.

Preface

Read this preface to familiarize yourself with the manual.
This preface covers the following topics:

- who should use this manual
- purpose and contents of this manual
- format conventions used in this manual
- terms and abbreviations
- Allen-Bradley support

Who Should Use this Manual

Use this manual if you are responsible for the design, installation, programming, or maintenance of an automation control system that uses Allen-Bradley small logic controllers.

You should have a basic understanding of SLC 500™ products. You should understand electronic process control and be able to interpret the ladder logic instructions required to control your application. If you do not, contact your local Allen-Bradley representative for training before using this product.

Purpose and Contents of this Manual

This manual is a learning and reference guide for the 1746-INT4 Thermocouple/mV Isolated Input Module. It contains the information you need to program, install, wire, and troubleshoot the module.

Contents of this Manual

Chapter	Title	Content
1	Overview	Describes module hardware features, and operation.
2	Quick Start	Serves as a *Quick Start Guide* for this module.
3	Installation and Wiring	Provides installation information and wiring guidelines.
4	Preliminary Operating Considerations	Describes the module ID code, I/O image words used by the module, input channel characteristics, and response to slot disabling.
5	Accessing Files to Configure I/O	Describes how to use the software to create a new file and configure I/O for system hardware.
6	Channel Configuration, Data, and Status	Describes configuration and status words used by the module. Explains how the module uses configuration data and generates status during operation.
7	Ladder Programming Examples	Gives ladder logic examples for configuring and operating the module that include verifying changes in configuration, using the PID instruction, monitoring status bits, and enabling autocalibration.
8	Module Diagnostics and Troubleshooting	Explains how to interpret LEDs and correct problems that may occur while using the module.
9	Application Programming Examples	Describes how to write ladder logic to achieve desired results for two example applications.
Appendices	**Title**	**Content**
A	Module Specifications	Provides physical, electrical, environmental, and functional specifications for the module.
B	Channel Configuration Worksheets	Provides a worksheet to help you configure each channel for operation.
C	Thermocouple Descriptions	Gives you information about thermocouples and the environments in which they perform best.
D	Channel Calibration	Gives you the procedure to calibrate input channels.
E	List of Terms and Abbreviations	Gives you the terms and abbreviations used in this manual.
F	CSA Hazardous Information	Gives you the definition of the CSA hazardous classification.

Format Conventions Used in this Manual

The following conventions are used throughout this manual:

- Bulleted lists such as this one provide information, not procedural steps.
- Numbered lists provide sequential steps or hierarchical information.
- Text in `this font` indicates words or phrases you should type.
- Key names appear in bold, capital letters within brackets (for example, **[ENTER]**).

Related Documentation

The following documents contain information that may be helpful to you as you use Allen-Bradley SLC products. To obtain a copy of any of those listed, contact your local Allen-Bradley office or distributor.

For	Read this Document	Document Number
An overview of the SLC 500 family of products	SLC 500 System Overview	1747-2.30
A description on how to install and use your *Modular* SLC 500 programmable controller	Installation & Operation Manual for Modular Hardware Style Programmable Controllers	1747-6.2
A description on how to install and use your *Fixed* SLC 500 programmable controller	Installation & Operation Manual for Fixed Hardware Style Programmable Controllers	1747-NI001
A procedural manual for technical personnel who use APS to develop control applications	Allen-Bradley Advanced Programming Software (APS) User Manual	9399-APSUM
A reference manual that contains status file data, instruction set, and troubleshooting information about APS	Allen-Bradley Advanced Programming Software (APS) Reference Manual	1747-6.15
An introduction to APS for first–time users, containing basic concepts but focusing on simple tasks and exercises, and allowing the reader to begin programming in the shortest time possible	Getting Started Guide for APS	9399-APSQS
A training and quick reference guide to APS	SLC 500 Software Programmer's Quick Reference Guide—available on PASSPORT at a list price of $50.00	ABT-1747–TSG001
A procedural and reference manual for technical personnel who use an HHT to develop control applications	Allen-Bradley Hand–Held Terminal User Manual	1747-NP002
An introduction to HHT for first–time users, containing basic concepts but focusing on simple tasks and exercises, and allowing the reader to begin programming in the shortest time possible	Getting Started Guide for HHT	1747-NM009
A resource manual and user's guide containing information about the analog modules used in your SLC 500 system.	SLC 500 Analog I/O Modules User Manual	1746-NM003
An article on wire sizes and types for grounding electrical equipment	National Electrical Code	Published by the National Fire Protection Association of Boston, MA.
A complete listing of current Allen–Bradley documentation, including ordering instructions. Also indicates whether the documents are available on CD-ROM or in multi–languages.	Allen-Bradley Publication Index	SD499
A glossary of industrial automation terms and abbreviations	Allen-Bradley Industrial Automation Glossary	AG-7.1

Allen-Bradley Support Services

Allen-Bradley offers support services worldwide, with over 75 Sales/Support offices, 512 authorized Distributors and 260 authorized Systems Integrators located throughout the United States alone, plus Allen-Bradley representatives in every major country in the world.

Local Product Support

Contact your local Allen-Bradley representative for:

- sales and order support
- product technical training
- warranty support
- support service agreements

Technical Product Assistance

If you need to contact Allen-Bradley for technical assistance, please review the information in the *Module Diagnostics and Troubleshooting* chapter first. Then call your local Allen-Bradley representative.

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Chapter 1

Module Overview

This chapter describes the thermocouple/millivolt isolated input module and explains how the SLC controller reads thermocouple or millivolt analog input data from the module. Included is information about:

- compliance with European Union Directives
- general description and hardware features
- an overview of system and module operation
- block diagram of channel input circuits

Compliance with European Union Directives

If this product has the CE mark, it is approved for installation within the European Union and EEA regions. It has been designed and tested to meet the following directives.

EMC Directive

This product is tested to meet Council Directive 89/336/EEC Electromagnetic Compatibility (EMC) and the following standards, in whole or in part, documented in a technical construction file:

- EN 50081-2EMC – Generic Emission Standard, Part 2 – Industrial Environment
- EN 50082-2EMC – Generic Immunity Standard, Part 2 – Industrial Environment

This product is intended for use in an industrial environment.

Low Voltage Directive

This product is tested to meet Council Directive 73/23/EEC Low Voltage, by applying the safety requirements of EN 61131–2 Programmable Controllers, Part 2 – Equipment Requirements and Tests.

For specific information required by EN 61131-2, see the appropriate sections in this publication, as well as the following Allen-Bradley publications:

- Industrial Automation Wiring and Grounding Guidelines (for noise immunity), publication 1770-4.1
- Automation Systems Catalog, publication B111

This equipment is classified as open equipment and must be mounted in an enclosure during operation to provide safety protection.

General Description

The module stores digitally converted thermocouple and/or millivolt (mV) analog data in its image table for retrieval by all fixed and modular SLC 500 processors. The module supports connections from any combination of up to four thermocouple and/or mV analog sensors.

Input Ranges

The following tables define thermocouple types and associated temperature ranges and the millivolt analog input signal ranges that each of the module's input channel will support. To determine the practical temperature range of your thermocouple, refer to the specifications in appendix A.

Thermocouple Temperature Ranges

Type	°C Temperature Range	°F Temperature Range
C	0°C to 2317°C	32°F to 4201°F
D	0°C to 2317°C	32°F to 4201°F
J	–210°C to 760°C	–346°F to 1400°F
K	–270°C to 1370°C	–454°F to 2498°F
T	–270°C to 400°C	–454°F to 752°F
B	300°C to 1820°C	572°F to 3308°F
E	–270°C to 1000°C	–454°F to 1832°F
R	0°C to 1768°C	32°F to 3214°F
S	0°C to 1768°C	32°F to 3214°F
N	0°C to 1300°C	32°F to 2372°F
CJC Sensor	0°C to 85°C	32°F to 185°F

Millivolt Input Ranges

–50 to +50 mV
–100 to +100 mV

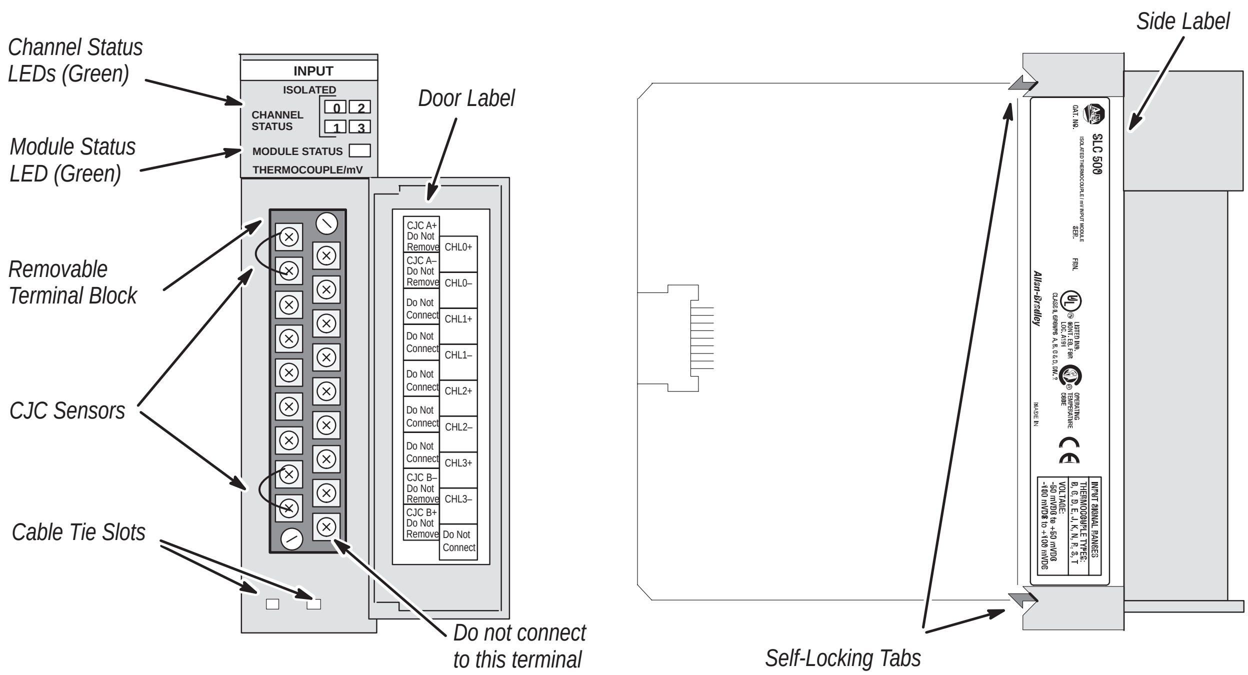
Each input channel is individually configurable for a specific input device, and provides open-circuit, over-range, and under-range detection and indication.

Hardware Features

The module fits into any single slot for I/O modules in either an SLC 500 modular system or an SLC 500 fixed system expansion chassis (1746-A2). It is a Class 1① module (uses 8 input words and 8 output words).

① Requires use of Block Transfer in a remote configuration.

The module contains a removable terminal block providing connections for four thermocouple and/or analog input devices. There are two cold-junction compensation (CJC) sensors that compensate for the cold-junction at ambient temperature rather than at freezing (0ºC). There are no output channels on the module. You configure the module with software rather than with jumpers or switches.



Hardware Features

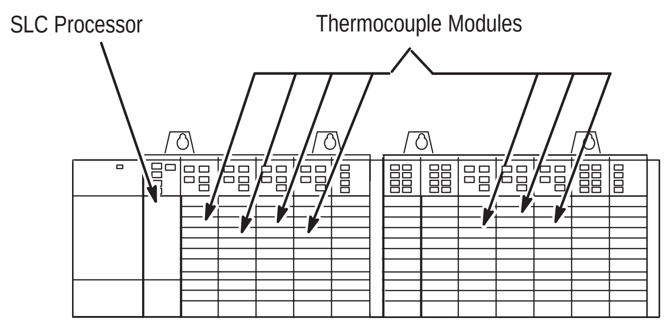
Hardware	Function
Channel Status LED Indicators	Display operating and fault status of channels 0, 1, 2, and 3
Module Status LED	Displays operating and fault status of the module
Side Label (Nameplate)	Provides module information
Removable Terminal Block	Provides electrical connection to input devices.
Door Label	Permits easy terminal identification
Cable Tie Slots	Secure input wiring at the module
Self-Locking Tabs	Secure module in chassis slot

Diagnostic LEDs

The module contains diagnostic LEDs that help you identify the source of problems that may occur during power-up or during normal operation. Power-up and channel diagnostics are explained in chapter 8, *Module Diagnostics and Troubleshooting*.

System Overview

The module communicates with the SLC 500 processor and receives +5Vdc and +24Vdc power from the system power supply through the parallel back-plane interface. No external power supply is required. You may install as many thermocouple modules in the system as the power supply can support.

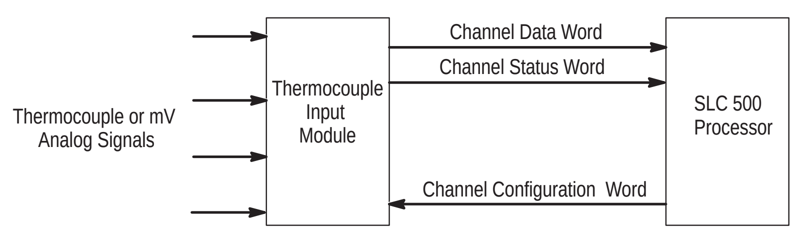


Each module channel can receive input signals from a thermocouple or a mV analog input device. You configure each channel to accept either one. When configured for thermocouple input types, the module converts analog input voltages into cold-junction compensated and linearized, digital temperature readings. The module uses the National Bureau of Standards (NBS) Monograph 125 and 161 based on IPTS-68 for thermocouple linearization.

When configured for millivolt analog inputs, the module converts analog values directly into digital counts. The module assumes that the mV input signal is linear.

System Operation

At power-up, the module checks its internal circuits, memory, and basic functions. During this time the module status LED remains off. If the module finds no faults, it turns on its module status LED.



After completing power-up checks, the module waits for valid channel configuration data from your SLC ladder logic program (channel status LEDs are off). After channel configuration data is transferred and channel enable bits are set for one or more channels, the module turns on its channel status LEDs. Then it continuously converts the thermocouple or millivolt input to a value within the range you selected for the channel.

Each time the module reads an input channel, the module tests that data for a fault, i.e. open-circuit, over-range, or under-range condition. If it detects such a condition, the module sets a unique bit in the channel status word and causes the channel status LED to blink.

The SLC processor reads the converted thermocouple or millivolt data from the module at the end of the program scan, or when commanded by the ladder program. After the processor and module determine that the data transfer was made without error, the data can be used in your ladder program.

Module Operation

The module's input circuitry consists of four differential analog inputs, each with its own analog-to-digital (A/D) convertor. The A/D convertors read the analog input signals and convert them to digital counts. The input circuitry also continuously samples the CJC sensors and compensates for temperature changes at the cold junction (terminal block). The figure on the following page shows a block diagram for the analog input circuitry.

Module Addressing

The module requires eight words each in the SLC processor's input and output image tables. Addresses for the module in slot e are as follows:

- I:e.0-3 thermocouple/mV data for channels 0-3, respectively
- I:e.4-7 status data for channels 0-3, respectively
- O:e.0-3 configuration data for channels 0-3, respectively
- O:e.4-7 reserved for future use. Do not use.

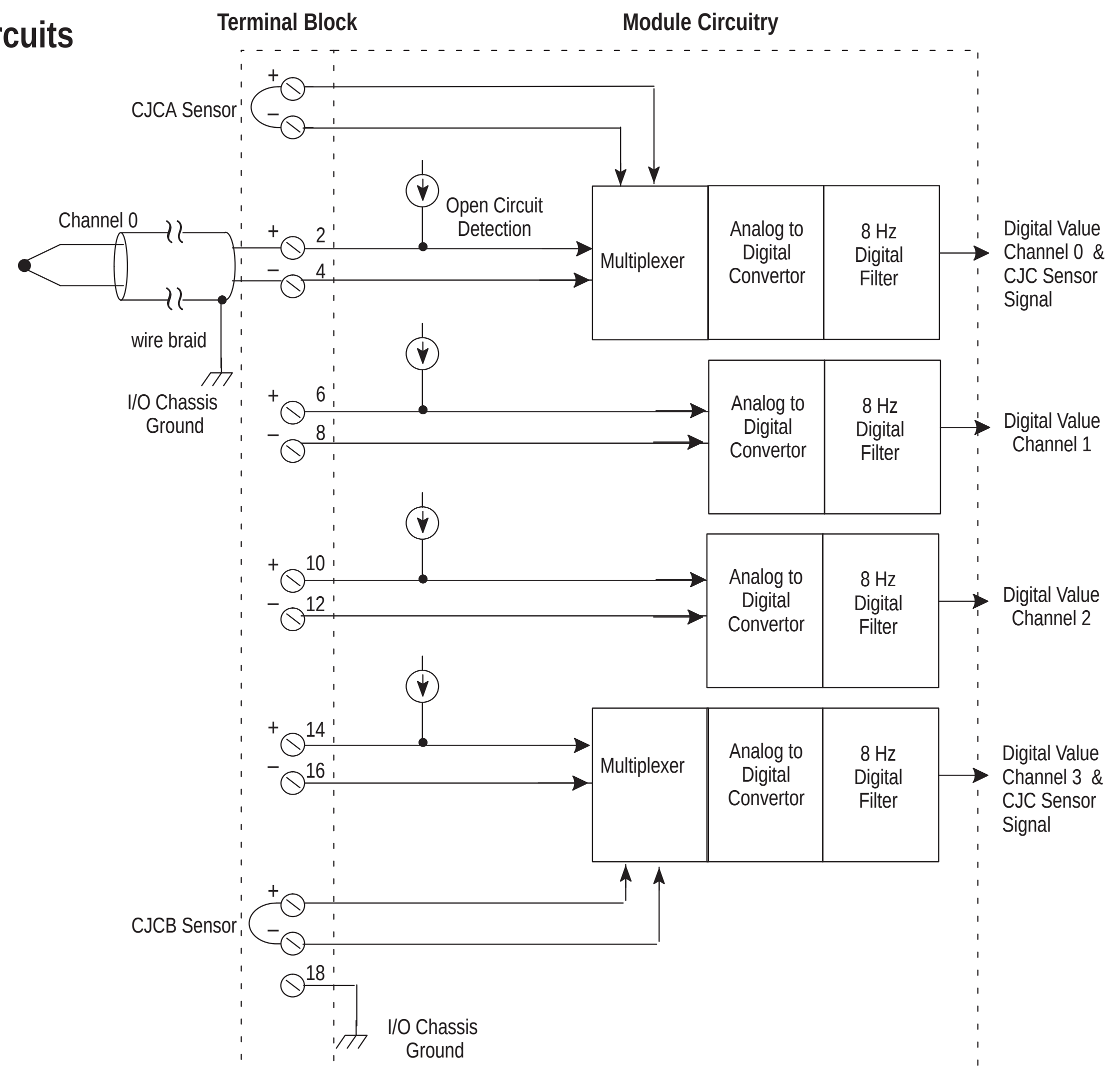
Compatibility with Thermocouple and Millivolt Devices and Cables

The module is compatible with the following NBS MN-125 and -161 standard types of thermocouples: B, C, D, E, J, K, N, R, S, and T and extension wire. Refer to appendices A and C for details. The module is also compatible with a variety of mV devices with an output of ±50 or ±100 mV.

To minimize interference from radiated electrical noise, we recommend twisted-pair and highly shielded cables such as the following:

For This Type of Device	We Recommend This Cable (or equivalent)
Thermocouple Type J	EIL Corp. J20-5-502
Thermocouple Type K	EIL Corp. K20-5-510
Thermocouple Type T	EIL Corp. T20-5-502
other Thermocouple types	consult with EIL Corp or other manufacturers
mV devices	Alpha Suprashield™ XTRA-GUARD 1 5121 (1pr), 5122 (2pr), 5131 (3pr), 5141 (4pr)

Block Diagram of Isolated Channel Input Circuits



Chapter 2

Quick Start

Use this chapter as an abbreviated procedure for getting the module into operation or as an overview if you need the additional steps described in subsequent chapters. This chapter assumes that you understand:

- SLC 500 products
- electronic process control
- ladder logic instructions

Because this chapter is a start-up guide, it *does not* contain detailed explanations. It does, however, refer to other chapters or to other SLC publications for more information.

If you are unsure of terms used or concepts presented in this chapter, *always read the referenced chapters* before trying to apply the information.

This chapter will:

- tell you what equipment you need
- explain how to install and wire the module
- show you how to set up one channel for thermocouple input
- examine the state of the LEDs at normal startup
- examine the channel status word

Required Tools and Equipment

Have the following tools and equipment ready:

- medium blade screwdriver
- medium cross-head screwdriver
- thermocouple or millivolt sensor
- thermocouple extension wire (if needed)
- the module
- I/O chassis
- SLC processor and power supply
- programming equipment
  (Programming examples in this manual demonstrate the use of Allen-Bradley's Advanced Programming Software for personal computers.)

Procedures

1.	Unpack the Module	Reference

Important:: Follow these precautions to prevent damaging the module from electrostatic discharge:

- Before handling the module, rid yourself of electric charge by touching a grounded object
- Avoid touching connector terminations and circuit components.
- When not in use, keep the module in its electrostatic shielded bag.

Unpack the module making sure that the contents include: –

- module (Catalog Number 1746-INT4)
- removable terminal block (factory–installed on module) with CJC sensors attached
- this user manual (publication number 1746-6.16)

If the contents are incomplete, call your local Allen-Bradley representative for assistance.

2.	Review Power Requirements	Reference

Chapter 3
(Installation and Wiring)

Appendix A
(Specifications)

Review the power requirements of the modules drawing power from the chassis power supply.

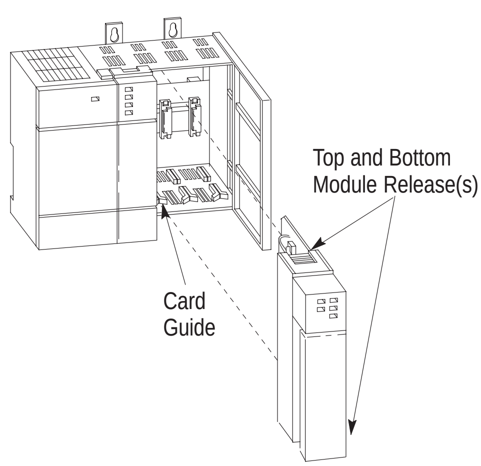
- The fixed, 2-slot chassis supports 2 1746-INT4 modules. If combining an INT4 module with a different type of module, refer to Considerations for a Fixed Controller in chapter 3.
- For a modular system, compute the total load on the system power supply using the procedure described in the SLC Installation & Operation Manual for Modular Controllers (publication 1747-6.2) or the SLC 500 Family System Overview (publication 1747-2.30).

3.	Install the Module	Reference

Chapter 3
(Installation and Wiring)

ATTENTION: Never install, remove, or wire modules with power applied to the chassis or devices wired to the module.

Make sure system power is off; then insert the the module into the I/O chassis.
In this example procedure, the module is inserted into slot 1.

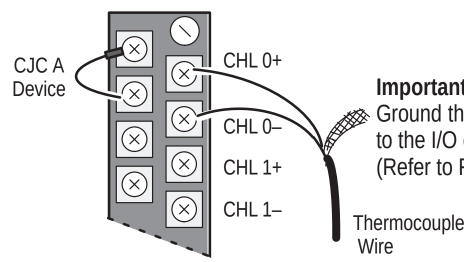


4.	Connect a Thermocouple	Reference

Connect thermocouple wires to channel 0 on the module's terminal block. Make sure both cold junction compensation (CJC) devices are securely attached.

Chapter 3
(Installation and Wiring)

Terminal Block



Important:
Ground the thermocouple's cable shield to the I/O chassis with 3/8" braid wire. (Refer to Figure 3.2.)

5.	Configure the Software to Accept the Module	Reference

Chapter 4
(Preliminary Operating Considerations)

Enter the module's ID and assigned slot (slot 1 in this example) into the system I/O configuration.

If using APS software, select **`Other`** at the bottom of the list of modules and enter the module ID code (3515) at the prompt on the I/O configuration display. No manual entry of special I/O configuration **`(SPIO CONFIG)`** information is required, as the module ID code automatically assigns the number of input and output words required by the module. Additional information on using Advanced Programming Software [APS] to configure your system can be found in The Getting Started Guide for APS [publication 9399-APSQS].

Example of Software Prompt:

```
Press ENTER to select I/O Module
Enter Module ID Code> 3515

offline        SLC 5/03                          File EXAMPLE
```

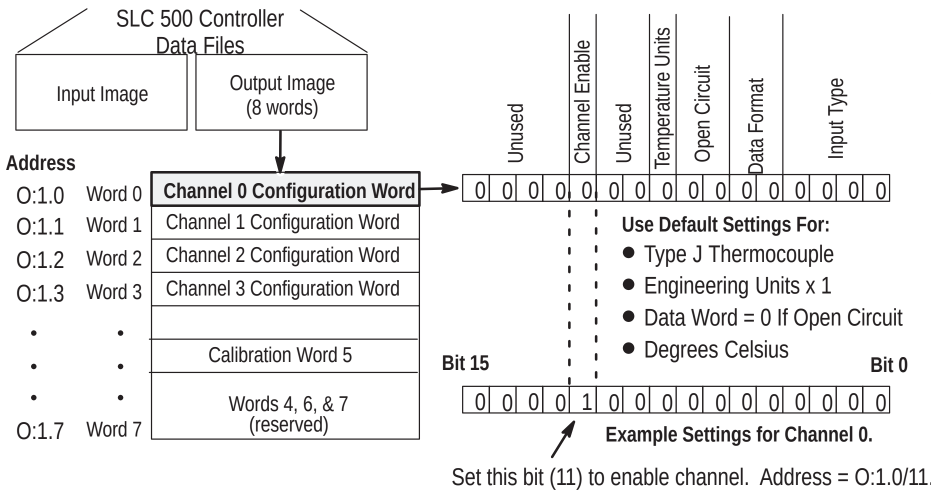
SELECT MODULE
F2

6.	**Set Up Channel 0**	**Reference**

Determine the operating parameters for channel 0. This example shows the channel 0 configuration word defined with all defaults (0) except for the channel enable (bit 11=1). Module assumed in slot 1. (For details on channel configuration, refer to the configuration worksheet on page 2-6)

Chapter 4
(Preliminary Operating Considerations)

Chapter 5
(Channel Configuration, Data, and Status)



7.	**Program the Transfer of the Configuration Word**	**Reference**

Program the transfer of the configuration word (from step 6) to the module.

1. Using the memory map function, create integer file N10. Integer file N10 should contain one element for each channel used. (For this example we used N10:0.)
2. Enter configuration parameters for channel 0 (from step 6) into N10:0.
   In this example all the bits of N10:0 are zero except for the channel enable bit (N10:0/11).
3. Program a ladder logic instruction to copy the contents of N10:0 to output word O:1.0.

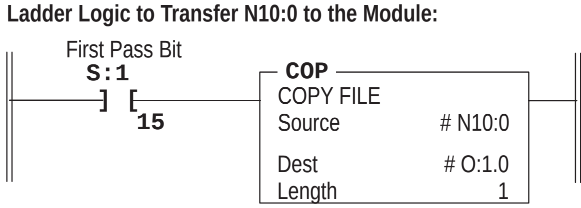
Chapter 6
(Ladder Programming Examples)

Chapter 8
(Application Examples)

Data Table Display of Integer File N10:0

```
address    15      data       0     address    15      data       0
N10:0       0000 1000 0000 0000
```

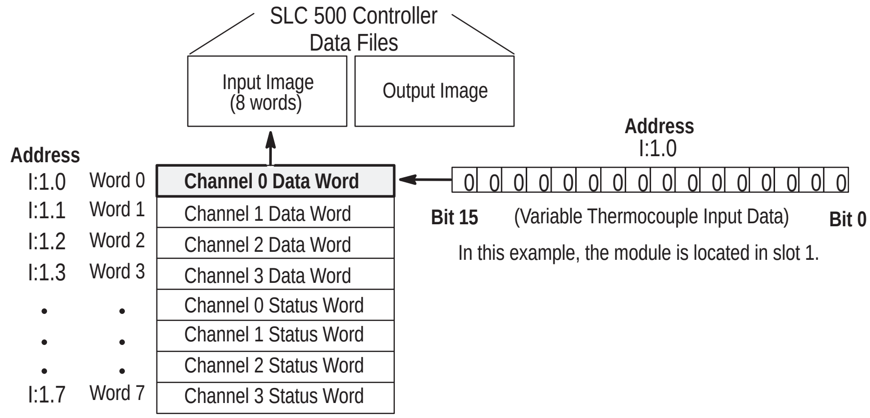
Ladder Logic to Transfer N10:0 to the Module:



On power up, the first pass bit (S:1/15) is set for one scan, enabling the COPY instruction to transfer the configuration word to the processor's output image table. From there it is transferred to the module in the processor's I/O scan.

8.	Write Ladder Logic to Process Input Data	Reference

Write ladder logic to process the thermocouple input data for your application.
(For information on programming, refer to the APS User Manual, publication 9399-APSUM.)



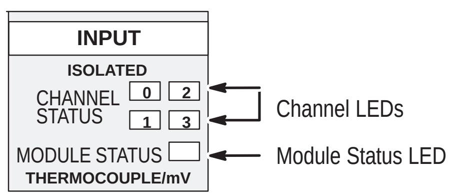
Chapter 5
(Channel Configuration, Data, and Status)

Chapter 6
(Ladder Programming Examples)

Chapter 8
(Application Examples)

9.	Apply Power and Download Your Program	Reference

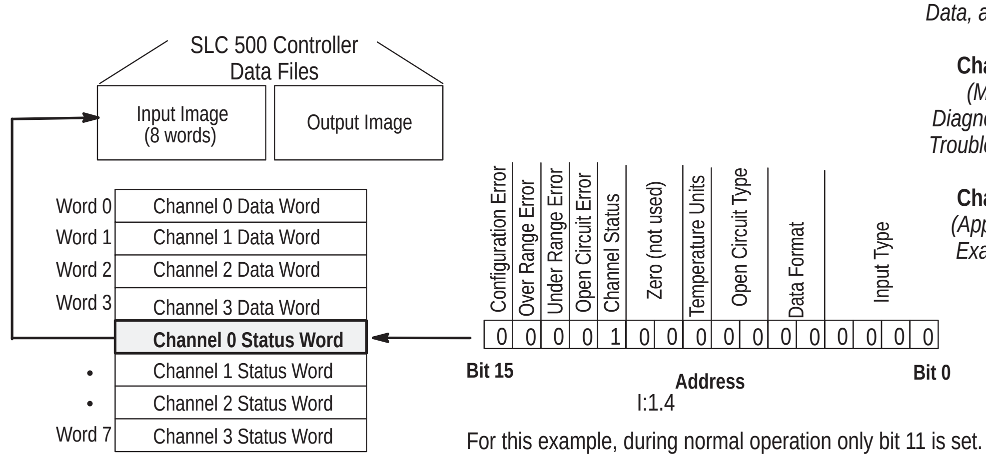
Apply power. Download your program to the SLC and put the controller into Run mode. In this example during a normal start up, the module status LED and channel status 0 LED turn on.



Chapter 7
(Module Diagnostics and Troubleshooting)

10.	Troubleshooting	Reference

Monitor the status of input channel 0 to determine its configuration setting and operational status. This is useful for troubleshooting when the blinking channel LED indicates that an error has been flagged. If the Module Status LED is off, or if the Channel 0 LED is off or blinking, refer to chapter 7.



For this example, during normal operation only bit 11 is set.

Chapter 5
(Channel Configuration, Data, and Status)

Chapter 7
(Module Diagnostics and Troubleshooting)

Chapter 8
(Application Examples)

Channel Configuration Worksheet

Select your bit configurations. Write them at the bottom of the worksheet. Use one worksheet for each channel.

Channel Configuration Word (O:e.0 through O:e.3) – Bit Descriptions

Bit(s)	Define	To Select	Set these bits in the Channel Configuration Word													Description
			15-12	11	10	9	8	7	6	5	4	3	2	1	0	
0–3	Input Type	TC Type J										0	0	0	0	**Project ____________________** **Slot Number _____** **Channel Number _____** **Configure the channel for the input type connected to it.** Valid inputs are thermocouples and analog input signals of ±50mV and ±100mV. You can configure the channel to read the cold-junction (CJC) temperature. When reading the CJC temperature, the channel ignores the physical input signal.
		TC Type K										0	0	0	1	
		TC Type T										0	0	1	0	
		TC Type E										0	0	1	1	
		TC Type R										0	1	0	0	
		TC Type S										0	1	0	1	
		TC Type B										0	1	1	0	
		TC Type N										0	1	1	1	
		±50mV										1	0	0	0	
		±100mV										1	0	0	1	
		TC Type C										1	0	1	0	
		TC Type D										1	0	1	1	
		Invalid										1	1	0	0	
		Invalid										1	1	0	1	
		Invalid										1	1	1	0	
		CJC Temp.										1	1	1	1	
4, 5	Data Format	Engr. Units x1								0	0					**Select the channel data format from:** **Engineering units (EU) x1 or x10** For EU x1, values are in 0.1 degrees or 0.01mV. For EU x10, values are in whole °C or °F or 0.1mV. **Scaled-for-PID (value is the same for any input type)** Proportional input signal range is scaled to 0-16,383 counts. **Proportional counts (value is same for any input type)** Proportional input signal range is scaled to ±32,767 counts. For more information, refer to next page.
		Engr. Units x10								0	1					
		Scaled-for-PID								1	0					
		Counts								1	1					
6, 7	Open Circuit Mode	Zero						0	0							**Select module response to a detected open circuit from:** **Zero** to force the channel data word to zero. U**pscale** to force the channel data word to full scale. D**ownscale** to force channel data word to low scale. **Important:** A bit selection or 1 1 is invalid. For an open CJC thermistor, mV channels are not affected. **Important:** The module requires 500 msec or one module update to flag the error while it ramps the channel input.
		Upscale						0	1							
		Downscale						1	0							
		Invalid						1	1							
8	Units °F, °C	Degrees C					0									**Select °C/°F for thermal inputs.** Ignored for mV inputs. **Important:** For EU x1 and °F (0.1°F), an over-range error will occur above 3276.7°F (cannot exceed 32767 counts).
		Degrees F					1									
9, 10	Unused	Unused			0	0										**These bits must be zero for a valid configuration.**
11	Chnl Enable	Channel Off		0												**Disable unused channels for faster response.** When set, the module configures the channel and reads the channel input before setting bit 11 in the status word. If you change the configuration word, the status word must reflect the change before new data is valid. If you clear the configuration word, the module clears channel and status words. For a new configuration word, channel data and status words remain cleared until the module sets this bit (11) in the status word.
		Channel On		1												
12-15	Unused	Unused	0000													**These bits must be zero for a valid configuration.**
Enter Your Bit Selections >>			0000													**For the Channel Configuration Word**

Chapter 3

Installation and Wiring

This chapter tells you how to:

- avoid electrostatic damage
- determine the module's chassis power requirement
- install the module
- wire signal cables to the the module's terminal block
- install the ferrite collar

Electrostatic Damage

Electrostatic discharge can damage semiconductor devices inside this module if you touch backplane connector pins. Guard against electrostatic damage by observing the following precautions:

ATTENTION: Electrostatic discharge can degrade performance or cause permanent damage. Handle the module as stated below.

- Touch a grounded object to rid yourself of charge before handling the module.
- Wear an approved wrist strap when handling the module.
- Handle the module from the front, away from the backplane connector. Do not touch backplane connector pins.
- Keep the module in its static-shield bag when not in use.

Power Requirements

The module receives its power through the SLC500 chassis backplane from the fixed or modular +5 V dc/+24 V dc chassis power supply. The maximum current drawn by the module is shown in the table below.

5V dc Amps	24Vdc Amps
0.11	0.085

When using the module in a *modular system*, add the values shown above to the requirements of all other modules in the SLC chassis to prevent overloading the chassis power supply.

When using the module in a *fixed controller*, be sure not to exceed the power supply rating for the pair of modules in the 2-slot I/O chassis.

Considerations for a Modular System

Place your module in any slot of an SLC500 modular, or modular expansion chassis, except for the left-most slot (slot 0) reserved for the SLC processor or adapter modules.

Considerations for a Fixed Controller

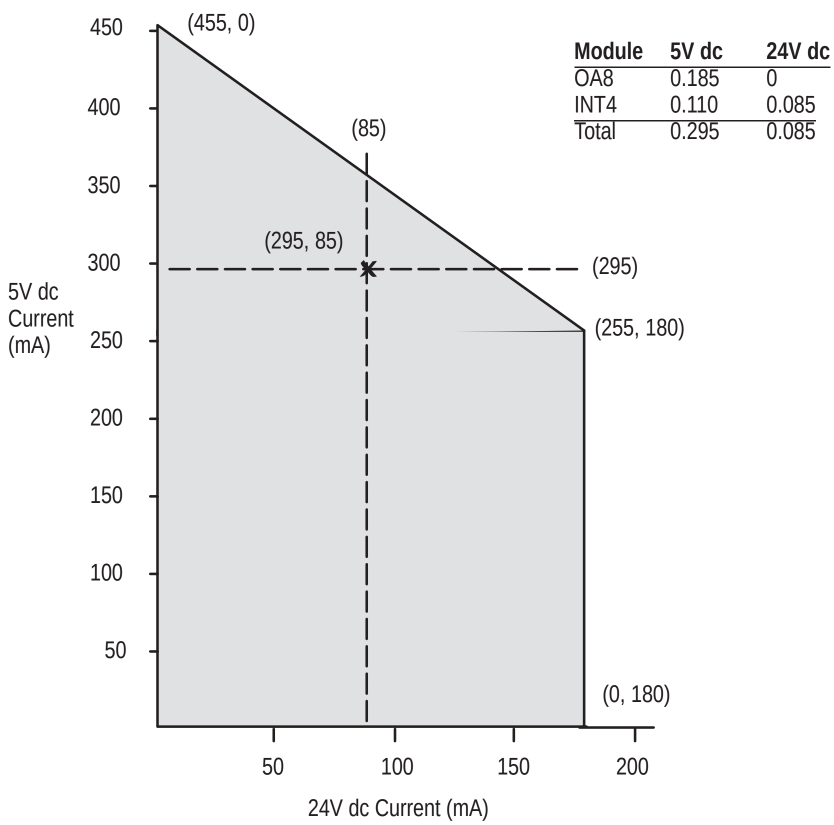
The power supply in the 2-slot SLC 500 fixed I/O chassis (1746-A2) can support only specific combinations of modules. Refer to the table at the left or to the Chart Method below to determine whether the power supply can support the pair of modules.

Fixed Controller Compatibility Table

Module	INT4	5V dc AMPS	24V dc AMPS
IA4	yes	0.035	–
IA8	yes	0.050	–
IA16	yes	0.085	–
IM4	yes	0.035	–
IM8	yes	0.050	–
IM16	yes	0.085	–
OA8	yes	0.185	–
OA16	yes	0.370	–
IB8	yes	0.050	–
IB16	yes	0.085	–
IV8	yes	0.050	–
IV16	yes	0.085	–
IG16	yes	0.140	–
OV8	yes	0.135	–
OV16	yes	0.270	–
OB8	yes	0.135	–
OG16	yes	0.180	–
OW4	yes	0.045	0.045
OW8	yes	0.085	0.090
OW16		0.170	0.180
IO4	yes	0.030	0.025
I08	yes	0.060	0.045
IO12	yes	0.090	0.070
NI4	yes	0.025	0.085
NIO4I		0.055	0.145
NIO4V		0.055	0.115
DCM		0.360	–
HS	yes	0.300	–
OB16	yes	0.280	–
IN16	yes	0.085	–
INT4	yes	0.110	0.085
BAS	yes	0.150	0.040
OB32		0.452	–
OV32		0.452	–
IV32	yes	0.106	–
IB32	yes	0.106	–
OX8	yes	0.085	0.090
NO4I		0.055	0.195
NO4V		0.055	0.145
ITB16	yes	0.085	–
ITV16	yes	0.085	–
KE	yes	0.150	0.040
KEn		0.150	0.145
OBP16	yes	0.250	–
NT4	yes	0.060	0.040
FIO4I		0.055	0.150
FIO4V		0.055	0.120

Chart Method
Use the chart to determine a valid pair of modules as follows:

1. For both modules, add the current rating at 5V dc and again at 24V dc.
2. On the chart, draw a horizontal line for the total 5V dc current rating.
3. On the chart, draw a vertical line for the total 24V dc current rating.
4. Observe the intersection. If within the chart boundary, the pair is OK.



Important: Some analog I/O modules such as the FIO4I, FIO4V, NO4I, and NO4V may require an additional 24V dc power supply. For those modules, as needed, refer to the user manual.

Module Installation and Removal

When installing the module in a chassis, it is not necessary to remove the terminal block from the module. However, if the terminal block is removed, use the write-on label located on the side of the terminal block to identify the module location and type.

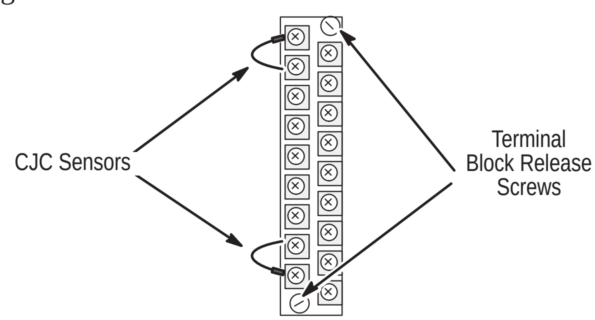
SLOT ____ RACK ____
● MODULE ______________

Terminal Block Removal

ATTENTION: Never install, remove, or wire modules with power applied to the chassis or devices wired to the module.

To remove the terminal block:

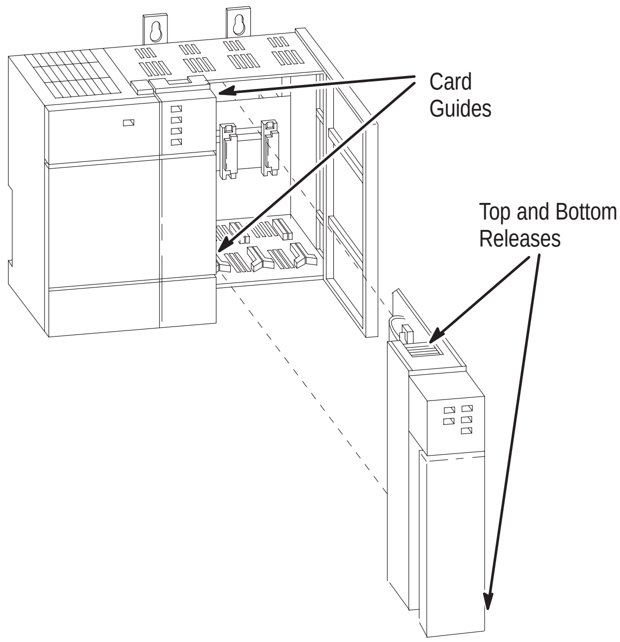
1. Loosen the two terminal block release screws. To avoid cracking the terminal block, alternate between screws as you remove them.
2. Grasp the terminal block at the top and bottom and pull outward and down. When removing or installing the terminal block be careful not to damage the CJC sensors.



Module Installation Procedure

1. Align the circuit board of the thermocouple module with the card guides located at the top and bottom of the chassis (Figure 3.1).
2. Slide the module into the chassis until both top and bottom retaining clips are secured. Apply firm even pressure on the module to attach it to its backplane connector. Never force the module into the slot.
3. Cover unused slots with the Card Slot Filler, Catalog Number 1746-N2.
4. To remove, press the releases at the top and bottom of the module, and slide the module out of the chassis slot.

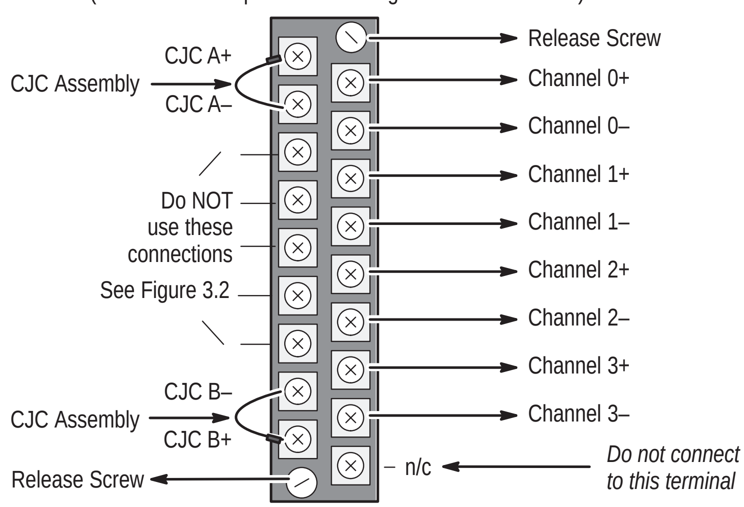
Figure 3.1
Installing the Module into the I/O Chassis



Wiring the Module

The module contains a green, 18-position, removable terminal block.

(Terminal Block Spare Part Catalog Number 1746-RT32)

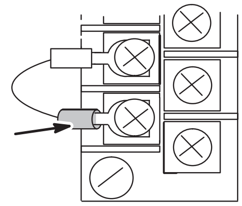


ATTENTION: Disconnect power to the SLC before attempting to install, remove, or wire the terminal block.

Cold Junction Compensation (CJC)

ATTENTION: Do not remove or loosen the cold junction compensating thermistors located on the terminal block. *Both thermistors are critical to ensure accurate thermocouple input readings at each channel.* The module will not operate in the thermocouple mode if a thermistor is removed.

In case of accidental removal of one or both thermistors, replace them by connecting them across the CJC terminals located at the top and/or bottom left side of the terminal block. Always connect the red lug to the (+) terminal (to CJC A+ or CJC B+).



Wiring Considerations

Thermocouple inputs are highly susceptible to electrical noise due to the small signal amplitudes (microvolt/°C). Most applications require that the processor and I/O chassis be installed in an industrial enclosure to reduce the effects of electrical interference. Consider the following conditions when selecting a slot location for the module. Position the module away from other modules that:

- connect to sources of electrical noise such as relays, and AC motor drives
- generate significant heat, such as 32-point I/O modules

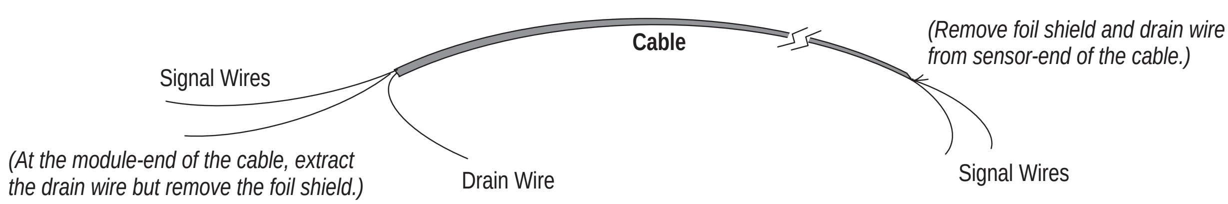
Follow these guidelines to wire your input signal cables:

- To limit the pickup of electrical noise, keep thermocouple and millivolt signal wires as far from power and load lines as possible .
- For high immunity to electrical noise, use Alpha 5121 (shielded, twisted pair) or equivalent wire for millivolt sensors; or use shielded, twisted pair thermocouple extension lead wire specified by the thermocouple manufacturer. Using the incorrect type of thermocouple extension wire or not following the correct polarity may cause invalid readings.
- Ground the shield drain wire at only one end of the cable. The preferred location is at the I/O chassis ground (Figure 3.2).

  (Refer to IEEE Std. 518, Section 6.4.2.7 or contact your sensor manufacturer for additional details.)
- keep all unshielded wires as short as possible
- Tighten screw terminals with care. Excessive tightening can strip a screw.
- The open-circuit detector generates approximately 20 nano-amperes into the thermocouple cable. A total lead resistance of 25 ohms (12.5 one-way) will produce 0.5 μV of error.
- Follow system grounding and wiring guidelines found in your SLC 500 Installation and Operation Manual.

Preparing and Wiring the Cables

To prepare and connect cable leads and drain wires, follow these steps.



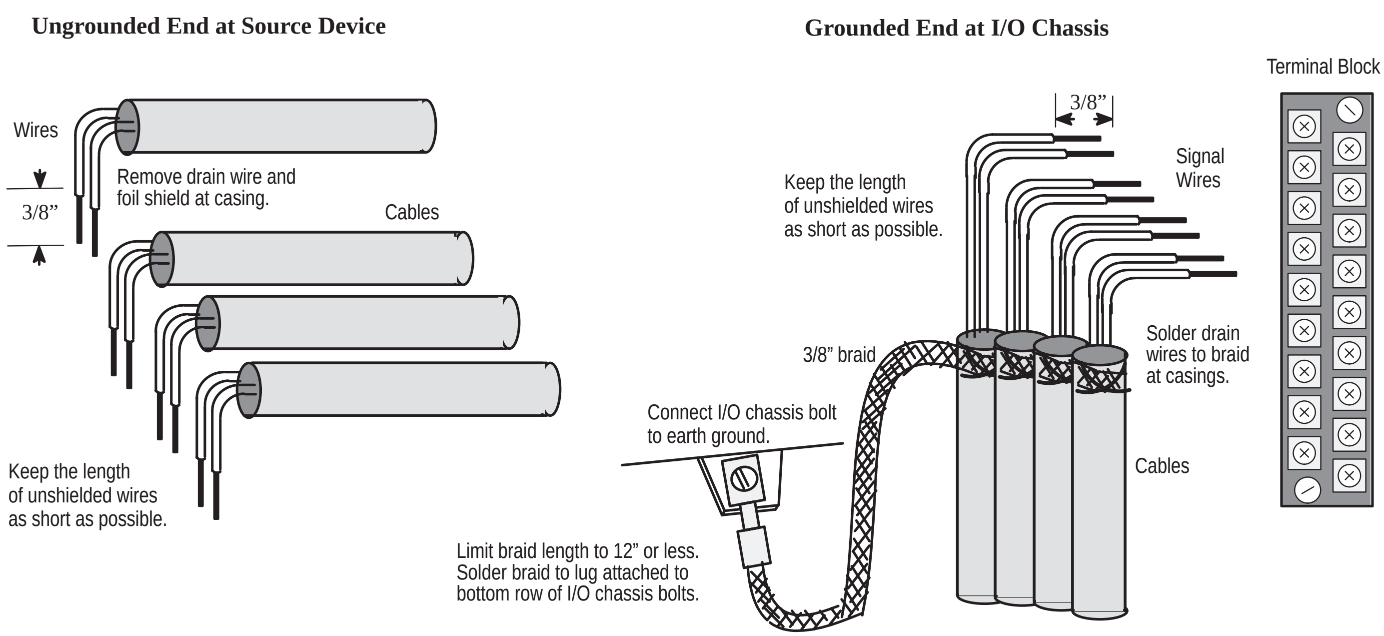
1. At each end of the cable, strip some casing to expose individual wires.
2. Trim signal wires to 5-inch lengths beyond the cable casing. Strip about 3/16 inch (4.76 mm) of insulation to expose the ends of the wires.
3. At the module-end of the cables (Figure 3.2):
   – extract the drain wire and signal wires
   – remove the foil shield
   – bundle the input cables with a cable strap
4. Connect drain wires together and solder them to a 3/8” wire braid, 12” long. Keep drain wires as short as possible.
5. Connect the 3/8” wire braid to the nearest chassis mounting bolt.

6. Connect the signal wires of each channel to the terminal block .
Important: Only after verifying that your connections are correct for each channel, trim the lengths to keep them short. Avoid cutting leads *too* short.

7. At the source–end of cables from mV devices (Figure 3.2):
– remove the drain wire and foil shield
– apply shrink wrap as an option
– connect to mV devices keeping the leads short

Important: If noise persists, try grounding the opposite end of the cable, instead. (Ground one end only.)

Figure 3.2
Cable Preparation and Connections to Minimize Electrical Noise Interference

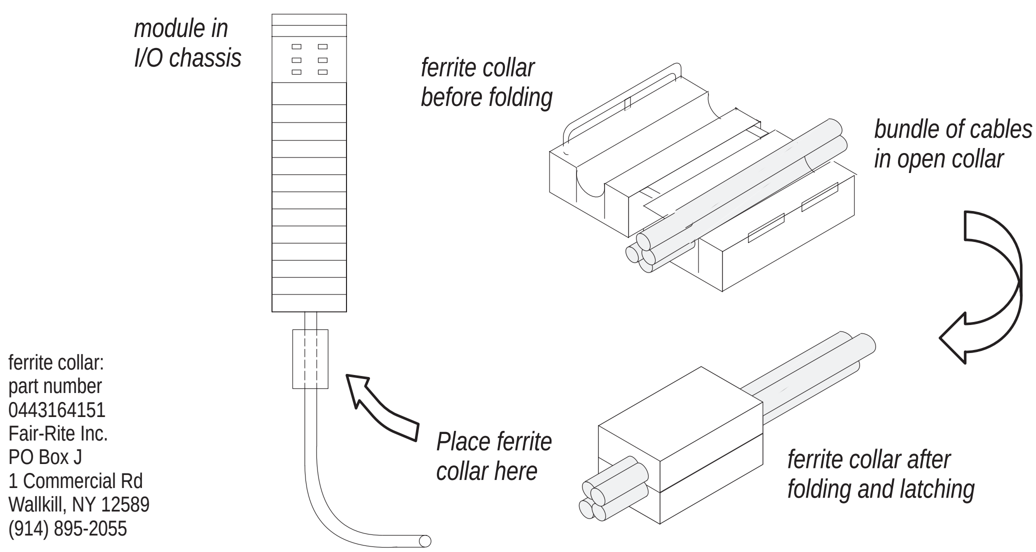


Installing the Ferrite Collar

For immunity to electrical noise with this CE-marked module, insert a ferrite collar (Fair-Rite Inc. part number 0443164151) around the input cables immediately beneath the module in the I/O chassis.

Do this as follows:

1. Bundle the cables at the module end.
2. Fold the collar so that it encircles the cables.
3. Press the plastic housing until the collar snaps together.
4. Check that the collar is fully latched.
5. If the collar slides on the cables, use a cable tie to secure it.



Notes:

Chapter 4

Preliminary Operating Considerations

This chapter explains how the module and the SLC processor communicate through the processor's I/O image tables. It also describes the module's input filter characteristics. Topics discussed include:

- module ID code
- module addressing
- input channel characteristics
- response to slot disabling

Module ID Code

The module ID code is a unique number assigned to each type of 1746 I/O module. The ID defines for the processor the type of I/O module and the number of words used in the processor's I/O image table.

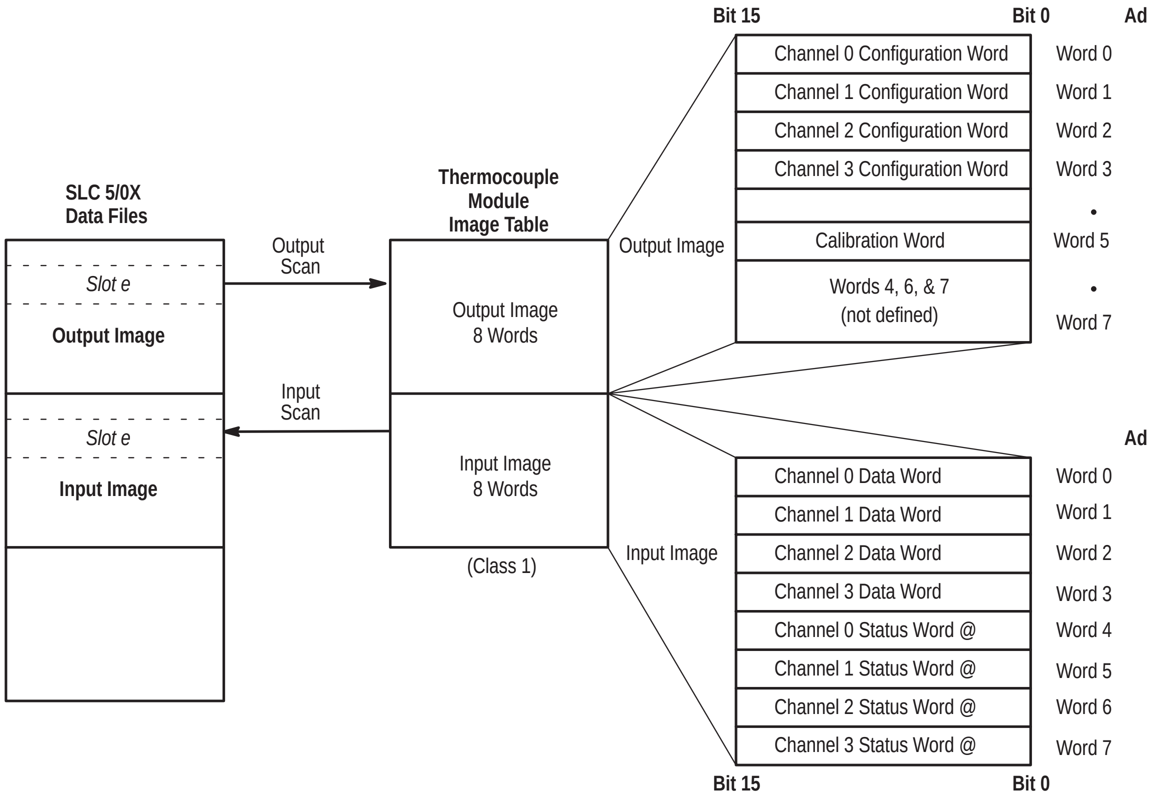
With APS software, use the system I/O configuration display to manually enter the module ID when assigning the slot number during configuration. Do this by selecting **`(other)`** from the list of modules on the system I/O configuration display and enter **3515**, the ID code for the 1746-INT4 module.

No special I/O configuration **`(SPIO CONFIG)`** is required. The module ID automatically assigns the correct number of input and output words.

If you are using a different programming software package, refer to the documentation that came with your software.

Module Addressing

The following memory map shows you how the SLC processor's output and input image tables are defined for the module.

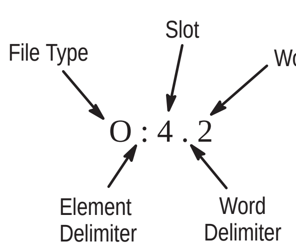


@ returns calibration status during calibration

Output Image – Configuration Words

Eight words of the SLC processor's output image table are reserved for the module. Output image words 0-3 are used to configure the module's input channels 0-3. Each output image word configures a single channel, and can be referred to as a configuration word. Word 5 is used for calibration. Each word has a unique address based on the slot number assigned to the module. (The remaining three words are not used.)

Example Address – If you want to configure channel 2 on the module located in slot 4 in the SLC chassis, your address would be O:4.2.



Chapter 6, *Channel Configuration, Data, and Status*, gives you detailed bit information about the data content of the configuration word.

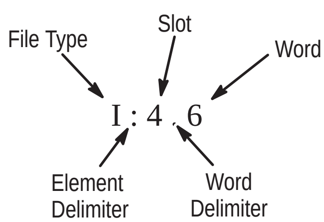
Input Image – Data Words and Status Words

Eight words of the SLC processor's input image table are reserved for the module. Input image words 0-3 (data words) hold the the temperature values of thermocouple analog inputs for channels 0-3. The data is valid only when the channel is enabled, no errors are detected, and not during calibration.

Input words 4-7 (status words) contain the status of channels 0-3. Status bits for a particular channel reflect the configuration settings that you entered into the configuration (output image) word for that channel. To receive valid status, the channel must be enabled and the module must have stored a valid configuration word for that channel. During calibration, these words return calibration status.

Each input image word has a unique address based on the slot number assigned to the module.

Example Address – To obtain the status of channel 2 (input word 6) of the module located in slot 4 in the SLC chassis, use address I:4.6.



Chapter 6, *Channel Configuration, Data, and Status*, gives you detailed bit information about the content of the data word and the status word.

Input Channel Characteristics

Each channel has an 8 Hz digital filter for input noise rejection, a multiplexer for processing cold-junction-compensation (CJC) values, and an analog-to- digital (A/D) converter to provide digital values for SLC processing.

Channel Cut-off Frequency, Update Time, and Step Response

The channel cut-off frequency is defined as the point on the frequency response curve where frequency components of the input signal are passed with 3 dB of attenuation by the input filter. All frequency components above cut-off frequency are increasingly attenuated, as show in the graph (next page). Cut-off frequency is also defined as the Normal Mode Rejection (NMR) in dB of attenuation at 50 Hz (European) or at 60 Hz (American).

We define module update time as the time required for the module to sample and convert channel input signals, multiplex them with the CJC reference value, and make the resulting values available to the SLC processor. It is typically 200 ms for multiplexing and 200 ms for sampling and converting.

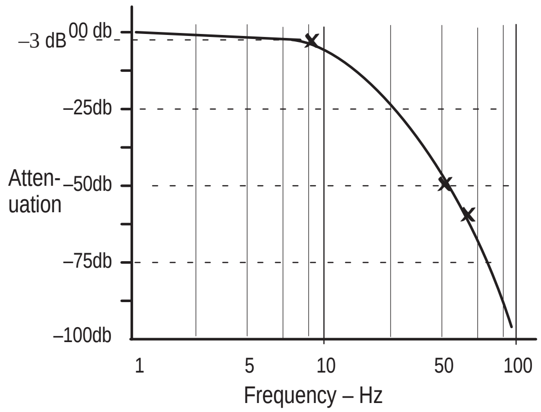
When sampling occurs *after* the signal reaches 99.9% of final value, the update time defines the minimum time (400 ms) for processing an input signal.

When sampling occurs just *before* the signal reaches 99.9% of final value,
we define step response (worst-case) as the sum of the times required for the analog input signal to change from 0 to 99.9% of its expected final value (see graph). It includes the times required for:

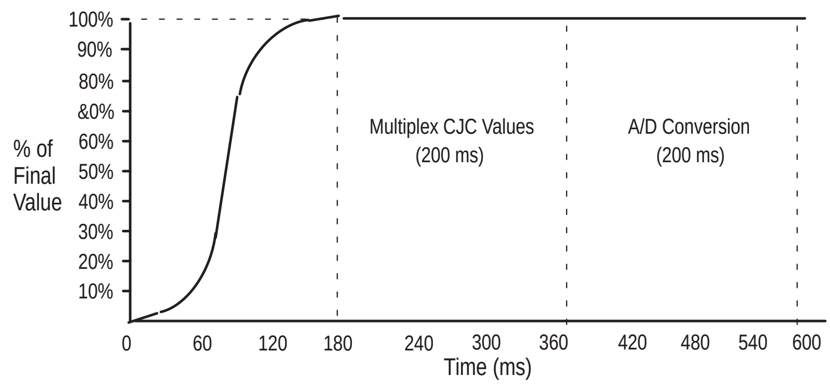
- input filter 180 ms
- CJC multiplexer 200 ms
- A/D converter 200 ms

This defines the maximum time required for processing an input signal.

Frequency Response of the 8 Hz Filter Converter



Step Response (worst case) for Filter, Multiplexer, and A/D



The following table summarizes the input channel characteristics:

Corner Frequency	50/60 Hz NMR	Filter Time	Update Time	Step Response (worst)
8 Hz	50-60 dB	180 ms	400 ms	600 ms

Effective Resolution of a Channel and Input Device

The effective resolution of an input channel depends upon the type of input device connected to it.

For thermocouples, we define resolution as the smallest increment of temperature that can be sampled after A/D conversion. It varies with temperature and with the type of thermocouple. We present a resolution graph for each type of thermocouple in Appendix A, Module Specifications.

Millivolt devices are generally considered linear, and the effective resolution is that of the channel itself.

Type of Device	Resolution
thermocouple	0.05°C-0.75°C @ 300°C depending on the thermocouple
millivolt sensor	3.4μV/bit

Response to Slot Disabling

By writing to the status file in your modular SLC processor you can disable any chassis slot. Refer to your SLC programming manual for the slot disable/enable procedure.

ATTENTION: Always understand the implications of disabling the module before using the slot disable feature.

Input Response

When the slot for this module is disabled, the module continues to update its inputs. However, the SLC processor does not read from a module whose slot is disabled. Therefore, inputs appearing in the processor image table remain in their last state, and the module's updated inputs are not read. When the processor re-enables the module slot, the current state of module inputs are read by the controller during the subsequent scan.

Output Response

When the slot for this module is disabled, configuration words in the SLC processor's output image table are held in their last state and not transferred to the module. When the slot is re-enabled, output image table words are transferred to the module during the subsequent scan.

Notes:

Chapter 5

Accessing Files to Configure I/O

This chapter shows how to apply Advanced Programming Software (APS) to:

- Create a new file
- Configure I/O
- Return to an existing file

For additional information on applying APS, refer to the User Manual for Advanced Programming Software, publication 9399-APSUM.

If you are using a different programming software package, refer to the documentation that came with your software.

Create a New File

We assume that you have already loaded APS into your computer.

1. Boot your software and access this Main Menu screen.

2. To create a new program file offline, press **OFFLINE PRG/DOC [F3]**.

You see the following PROGRAM DIRECTORY FOR PROCESSORS screen.

3. Press these two keys in succession:

CHANGE FILE [F4] followed by **CREATE FILE [F6]**.

You see the following processor selection screen:

4. Type the name of the file you want to create and press **[ENTER].**

The screen inserts the file name in the lower pop-up window.

5. Identify the type of processor you are using in the upper pop-up window. Use the cursor keys to highlight the processor and press **[ENTER].**

The screen displays processor ID information in the lower pop-up window.

6. What you do next depends on the processor you select.

If you select an:	And:	Then:
SLC 5/03 (or later) processor and press **[ENTER]**	the screen displays another pop-up window	Go to step 7
SLC 5/01 or 5/02 processor	n/a	Go to the section Configure I/O (on next page)

7. Identify the processor's operating system. Read it on the label found on the side of the processor. Then, in the upper pop-up window, cursor to the correct operating system and press **[ENTER].**

Now you are ready to configure the I/O of your SLC system.
You do this by telling the software what hardware your system is using.

Configure I/O

To configure your I/O, start with the processor selection screen (shown in step 3 on previous page).

1. Press **CONFIGR I/O [F5].**

   You see the following I/O configuration screen:

2. What you do next depends on what you want to do.

If you want to:	and your SLC System:	Then press:	and:
use the APS Read Config feature for SLC 5/03 (and later) processors	is installed and wired	**READ CONFIG [F1]**	**1.** Follow prompts to configure for SLC system hardware. **2.** Then return to step 10.
manually configure the software	• is a fixed hardware system • uses an SLC 5/01 or 5/02, or • is NOT installed or wired	**MODIFY RACKS [F4]**	Go to step 3 next.

3. To configure the first I/O rack, press **RACK 1 [F1]**.
   Observe this pop-up window:

4. Cursor to the description of the I/O rack you are using and press **[ENTER].**

   The screen displays the rack description for rack 1 (top of screen), and removes the pop-up window.

5. If using more I/O racks, repeat steps 3 and 4 for rack 2 followed by rack 3.

Important: At this point, the software does the following automatically:

- allocates slot numbers consecutively for the *configured set* of I/O racks. For example, slots 1-7 if you configured racks 1 and 2 at 4 slots each.
- places an asterisk (*) next to each slot number configured in steps 3-5.

6. To designate the I/O module for the subject slot in the I/O rack, cursor to the subject slot number and press **`MODIFY SLOT [F5]`**.

The screen lists the types of I/O modules.

7. With `[PAGE]` and `[↓] [↑]` keys, cursor to the module type for the subject slot and press `SELECT MODULE [F2].`

The screen displays the module type in the row for the subject slot.

8. To assign I/O modules to remaining I/O slots, repeat steps 6 and 7.

9. If the subject I/O module is not listed (step 6), cursor to the bottom of the list and select `OTHER.` Then type the module ID code and press **`[ENTER].`**

the ID code for 1746-INT4 is 3515

The screen inserts the module ID code in the row for the subject slot.

10. After configuring your I/O, to exit press:

`EXIT [F8]`
`SAVE & EXIT [F8]`
You get the prompt: NEW ARCHIVE FILE CREATED

`SAVE TO FILE [F9]`
You get the prompt: NEW CONFIGURATION SAVED TO FILE

`[ESC]`
`RETURN TO MAIN MENU [F3]`

Return to an Existing File

If you already created the program file for your application and want to add or edit ladder logic, return to it from the main menu screen as follows:

1. To return to a program file offline, press **OFFLINE PRG/DOC [F3]**.

You see the PROGRAM DIRECTORY FOR PROCESSORS screen.

2. Get the list of existing program files by pressing **CHANGE FILE [F4].**

You see a pop-up window with the list of existing program files.

3. Cursor to the file you want to open and press **OFFLINE PRG/DOC [F1]**.

The screen displays the name of the subject file in the header and removes the pop-up window.

4. To open the file so you can write or edit your ladder logic, press **MONITOR FILE [F8]**.

The screen displays the ladder logic of the subject program file.

5. To edit the logic, use function keys and follow the prompts as needed.

6. When finished programming, press **EXIT [F3]**.

7. If you want to save your work, press **SAVE [F2]**.
Then, follow the prompts and use function keys as needed to save the file.

Notes:

Channel Configuration, Data, and Status

This chapter examines channel configuration and status words, and explains how you use them. It gives you information about how to:

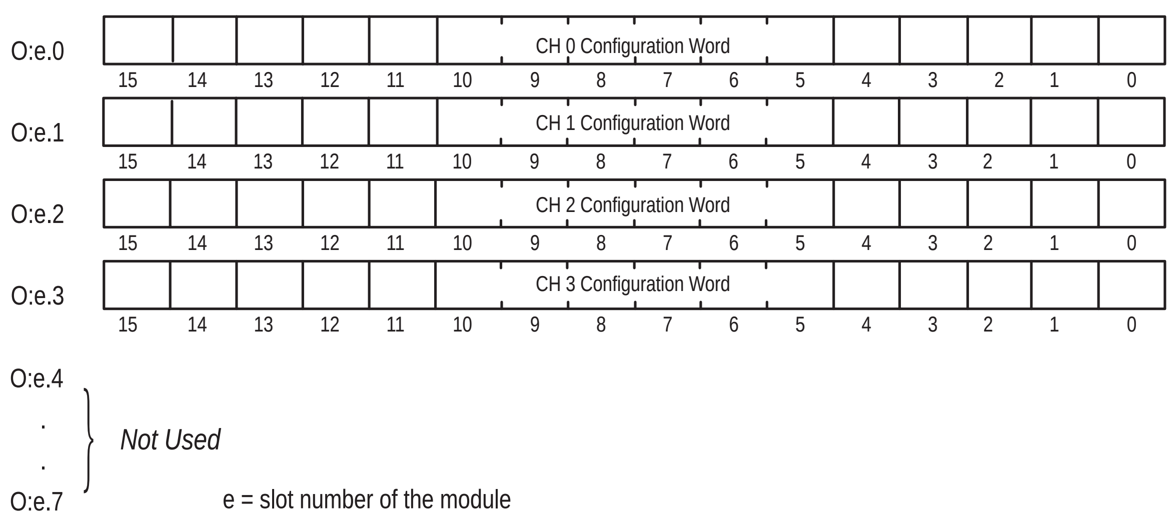
- configure a channel
- check a channel's status

Channel Configuration

Channel configuration words appear in the SLC controller's output image table as shown below. Words 0-3 correspond to module channels 0-3. Words 4-7 are not used.

After module installation, you must configure each channel to establish the way the channel operates (e.g., thermocouple type, temperature units, etc.). You configure the channel by setting bits in the configuration word using your programmer. We present bit descriptions next. (For information on addressing. using your software, and programming, refer to chapters 4, 5 and 7, respectively.)

SLC Output Image (Configuration) Words



The configuration word default settings are all zero. Next, we describe how you set configuration bits of a channel configuration word to set up the following channel parameters:

- type of thermocouple or mV input
- data format such as engineering units, counts, or scaled for PID
- how the channel should respond to a detected open input circuit
- temperature units in ^{o}C or ^{o}F
- whether the channel is enabled or disabled

Channel Configuration Word (O:e.0 through O:e.3) – Bit Descriptions

Bit(s)	Define	To Select	Set these bits in the Channel Configuration Word													Description
			15-12	11	10	9	8	7	6	5	4	3	2	1	0	
0–3	Input Type	TC Type J										0	0	0	0	**Configure the channel for the input type connected to it.** Valid inputs are thermocouples and analog input signals of ±50mV and ±100mV. You can configure the channel to read the cold-junction (CJC) temperature. When reading the CJC temperature, the channel ignores the physical input signal.
		TC Type K										0	0	0	1	
		TC Type T										0	0	1	0	
		TC Type E										0	0	1	1	
		TC Type R										0	1	0	0	
		TC Type S										0	1	0	1	
		TC Type B										0	1	1	0	
		TC Type N										0	1	1	1	
		± 50mV										1	0	0	0	
		± 100mV										1	0	0	1	
		TC Type C										1	0	1	0	
		TC Type D										1	0	1	1	
		Invalid										1	1	0	0	
		Invalid										1	1	0	1	
		Invalid										1	1	1	0	
		CJC Temp.										1	1	1	1	
4, 5	Data Format	Engr. Units x1								0	0					**Select the channel data format from:** **Engineering units (EU) x1 or x10** For EU x1, values are in 0.1 degrees or 0.01mV. For EU x10, values are in whole ºC or ºF or 0.1mV. **Scaled-for-PID (value is the same for any input type)** Proportional input signal range is scaled to 0-16,383 counts. **Proportional counts (value is same for any input type)** Proportional input signal range is scaled to ±32,767 counts. For more information, refer to next page.
		Engr. Units x10								0	1					
		Scaled-for-PID								1	0					
		Counts								1	1					
6, 7	Open Circuit Mode	Zero						0	0							**Select module response to a detected open circuit from:** **Zero** to force the channel data word to zero. U**pscale** to force the channel data word to full scale. D**ownscale** to force channel data word to low scale. **Important:** A bit selection or 1 1 is invalid. For an open CJC thermistor, mV channels are not affected. **Important:** The module requires 500 msec or one module update to flag the error while it ramps the channel input.
		Upscale						0	1							
		Downscale						1	0							
		Invalid						1	1							
8	Units ºF, ºC	Degrees C					0									**Select °C/°F for thermal inputs.** Ignored for mV inputs. **Important:** For EU x1 and °F (0.1°F), an over-range error will occur above 3276.7°F (cannot exceed 32767 counts).
		Degrees F					1									
9, 10	Unused	Unused			0	0										**These bits must be zero for a valid configuration.**
11	Chnl Enable	Channel Off		0												**Disable unused channels for faster response.** When set, the module configures the channel and reads the channel input before setting bit 11 in the status word. If you change the configuration word, the status word must reflect the change before new data is valid. If you clear the configuration word, the module clears channel and status words. For a new configuration word, channel data and status words remain cleared until the module sets this bit (11) in the status word.
		Channel On		1												
12-15	Unused	Unused	0000													**These bits must be zero for a valid configuration.**
Enter Your Bit Selections >>			0000													**Selected Configuration Word**

Selecting the Correct Data Format

Using Scaled-for-PID and Proportional Counts

To provide the highest display resolution, select Scaled-for-PID or Proportional Counts. To use either one, you may have to convert channel data to/from Engineering Units, manually or logically.

The following examples show you how to do this. You must obtain the minimum (S_{LOW}) and maximum (S_{HIGH}) values of the temperature or millivolt range for the channel's input type, and use them in your computations. We present these values in the section Using Channel Data Words (page 6-5) in the table Format for Channel Data Word.

Scaling Examples: Converting Between Units

Convert from Scaled-for-PID to Equivalent Engineering Units in ºC

Equation: Engr Units Equivalent = S_{LOW} + [(S_{HIGH} – S_{LOW}) x (Scaled-for-PID value displayed / 16384)]

Assume type J input type, scaled-for-PID, channel data = 3421.

From Channel Data Word Format table, S_{LOW} = –210°C and S_{HIGH} = 760°C.

Solution: Engr Units Equivalent = –210°C + [(760°C – (–210°C)) x (3421 / 16384)] = –7.46°C.

Convert from Engineering Units in ºC to Equivalent Scaled-for-PID Count

Equation: Scaled-for-PID Equivalent = 16384 x [(Engineering Units desired – S_{LOW}) / (S_{HIGH} – S_{LOW})]

Assume type J input type, scaled-for-PID, desired channel temp. = 344°C.

From Channel Data Word Format table, S_{LOW} = –210°C and S_{HIGH} = 760°C.

Solution: Scaled-for-PID Equivalent = 16384 x [(344°C – (–210°C)) / (760°C – (–210°C))] = 9357.

Convert from Proportional Counts to Equivalent Engineering Units in ºF

Equation: Engr Units Equivalent = S_{LOW} + { (S_{HIGH} – S_{LOW}) x [(Proportional Counts value displayed + 32768) / 65536] }

Assume type E input type, proportional counts, channel data = 21567 counts.

From Channel Data Word Format table, S_{LOW} = –454°F and S_{HIGH} = 1832°F.

Solution: Engr Units Equivalent = –454°F + { [1832°F – (–454°F)] x [(21567 + 32768) / 65536] } = 1441.3°F

Convert from Engineering Units in ºF to Equivalent Proportional Counts

Equation: Proportional Counts Equivalent = { 65536 x [(Engineering Units desired – S_{LOW}) / (S_{HIGH} – S_{LOW})] } – 32768

Assume type E input type, proportional counts, desired channel temp. = 1000°F.

From Channel Data Word Format table, S_{LOW} = –454°F and S_{HIGH} = 1832°F.

Solution: Proportional Counts Equivalent = { 65536 x [(1000°F– (–454°F)) / (1832°F– (–454°F))] } – 32768 = 8916 counts.

Channel Configuration Procedure

Use this procedure once for each channel to set configuration bits that determine channel operation. Use the table of bit descriptions and the blank configuration worksheet in Appendix B. Copy it as needed to write down configuration selections of all your channels.

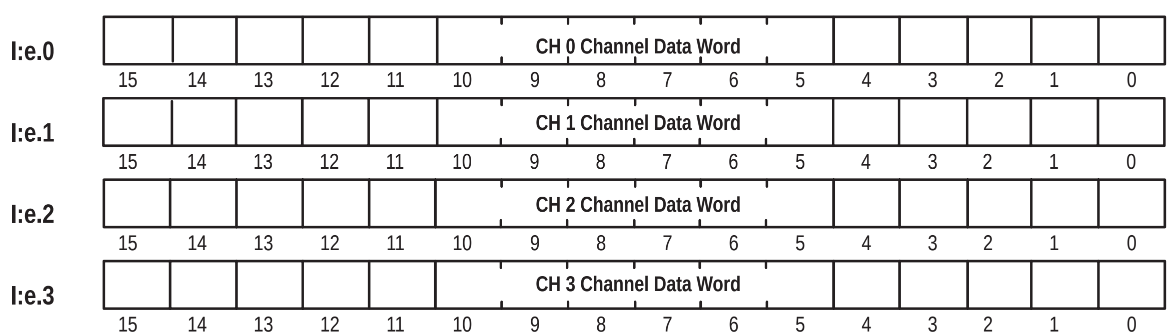
1. Determine the input device type (thermocouple or mV) for a channel and enter its respective 4-digit binary code in bit field 0-3.
2. Select the data format for the data word. Your selection determines how the analog input from the A/D converter will be expressed in the data word. Enter your 2-digit binary code in bit field 4-5.
3. Determine the desired change to the channel data word when the module detects an open input circuit. Enter the 2-digit binary code in bit field 6-7.
4. If the channel is configured for thermocouple inputs, determine if you want channel data in degrees Fahrenheit or Celsius, and set bit 8 accordingly.

   Important: If the channel is configured for a mV analog sensor, zero bit 8.
5. Enable the channel by setting bit 11. (Default disables the channel.)
6. Ensure that bits 9, 10, and 12-15 are zero.
7. Repeat steps 1-6 for each channel used.
8. After entering your ladder logic to transfer data to the module, switch the SLC controller to run mode to download channel configurations.

Using Channel Data Words

Thermocouple or millivolt input data reside in I:e.0-I:e.3 of the SLC controller's input image file (where e is the slot number assigned to the module). The values depend on the input type and data format that you select. When an input channel is disabled, its data word is reset (0).

SLC Controller's Input Image File (Data Word)



Format of a Channel Data Word

Input Type	Data Format					
	Engineering Units x 10		Engineering Units x 1		Scaled-for-PID	Proportional Counts
	° Celsius	° Fahrenheit	° Celsius	° Fahrenheit		
C	0 to 2317	32 to 4201	0 to 23170	320 to 32767	0 to 16383	–32768 to +32767
D	0 to 2317	32 to 4201	0 to 23170	320 to 32767	0 to 16383	–32768 to +32767
J	–210 to 760	–346 to 1400	–2100 to 7600	–3460 to 14000	0 to 16383	–32768 to 32767
K	–270 to 1370	–454 to 2498	–2700 to 13700	–4540 to 24980	0 to 16383	–32768 to 32767
T	–270 to 400	–454 to 752	–2700 to 4000	–4540 to 7520	0 to 16383	–32768 to 32767
E	–270 to 1000	–454 to 1832	–2700 to 10000	–4540 to 18320	0 to 16383	–32768 to 32767
R	0 to 1768	32 to 3214	0 to 17680	320 to 32140	0 to 16383	–32768 to 32767
S	0 to 1768	32 to 3214	0 to 17680	320 to 32140	0 to 16383	–32768 to 32767
B	300 to 1820	572 to 3308	3000 to 18200	5720 to 32767①	0 to 16383	–32768 to 32767
N	0 to 1300	32 to 2372	0 to 13000	320 to 23720	0 to 16383	–32768 to 32767
±50 mV	–50 to 50②	–50 to 50②	–500 to 500②	–500 to 500②	0 to 16383	–32768 to 32767
±100 mV	–1000 to 1000②	–1000 to 1000②	–10000 to 10000②	–10000 to 10000②	0 to 16383	–32768 to 32767
CJC Sensor	0 to 85	32 to 185	0 to 850	32 to 1850	0 to 16383	–32768 to 32767

① Type B, C, and D thermocouples cannot be represented in engineering units x 1 (°F) above 3276.7°F. Software treats it as an over-range error.
② When millivolts are selected, the temperature setting is ignored. Analog input data is the same for either °C or °F selection.

Resolution of a Channel Data Word

Input Type	Data Format							
	Engineering Units x 10		Engineering Units x 1		Scaled-for-PID		Proportional Counts	
	° Celsius	° Fahrenheit	° Celsius	° Fahrenheit	° Celsius	° Fahrenheit	° Celsius	° Fahrenheit
C	1°C/step	1°F/step	0.1°C/step	0.1°F/step	0.1414°C/step	0.2564°C/step	0.0353°C/step	0.0641°C/step
D	1°C/step	1°F/step	0.1°C/step	0.1°F/step	0.1414°C/step	0.2564°C/step	0.0353°C/step	0.0641°C/step
J	1°C/step	1°F/step	0.1°C/step	0.1°F/step	0.0592°C/step	0.1066°F/step	0.0148°C/step	0.0266°F/step
K	1°C/step	1°F/step	0.1°C/step	0.1°F/step	0.1001°C/step	0.1802°F/step	0.0250°C/step	0.0450°F/step
T	1°C/step	1°F/step	0.1°C/step	0.1°F/step	0.0409°C/step	0.0736°F/step	0.0102 °C/step	0.0184°F/step
E	1°C/step	1°F/step	0.1°C/step	0.1°F/step	0.0775°C/step	0.1395°F/step	0.0194°C/step	0.0349°F/step
R	1°C/step	1°F/step	0.1°C/step	0.1°F/step	0.1079°C/step	0.1942°F/step	0.0270°C/step	0.0486°F/step
S	1°C/step	1°F/step	0.1°C/step	0.1°F/step	0.1079°C/step	0.1942°F/step	0.0270°C/step	0.0486°F/step
B	1°C/step	1°F/step	0.1°C/step	0.1°F/step	0.0928°C/step	0.1670°F/step	0.0232°C/step	0.0417°F/step
N	1°C/step	1°F/step	0.1°C/step	0.1°F/step	0.0793°C/step	0.1428°F/step	0.0198°C/step	0.0357°F/step
±50 mV①	0.1mV/step	0.1mV/step	0.01mV/step	0.01mV/step	6.104 µV/step	6.104 µV/step	3.40 µV/step	3.40 µV/step
±100 mV①	0.1mV/step	0.1mV/step	0.01mV/step	0.01mV/step	13.6 µV/step	13.6 µV/step	3.40 µV/step	3.40 µV/step
CJC Sensor	1°C/step	1°F/step	0.1°C/step	0.1°F/step	0.0052°C/step	0.0093°F/step	0.0013°C/step	0.0023°F/step

① When millivolts are selected, the temperature setting is ignored. Analog input data is the same for either °C or °F selection.

Using Channel Status Words

Channel status words are stored in the SLC controller's input image file at addresses I:e.4-I:e.7 (where e is the slot number assigned to the module). Status words 4-7 correspond to and reflect the configuration of channels 0-3 (O:e.0-O:e.3).

Whenever a channel is disabled (O:e.x/11 = 0), its corresponding status word is zero. This condition tells you that input data contained in the channel data word is invalid and should be ignored.

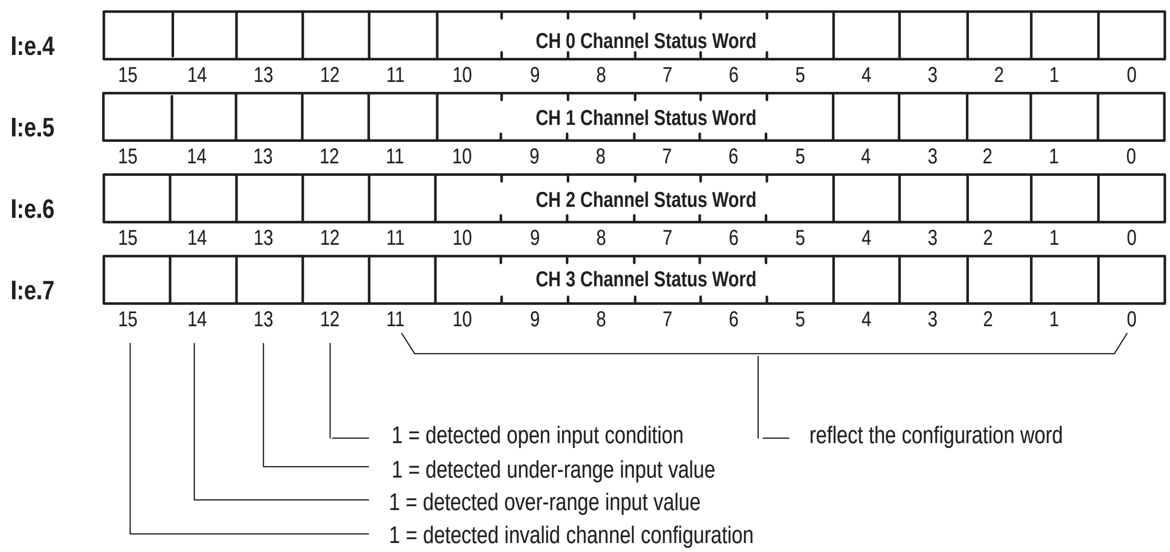
Important: The status word from a disabled channel is always zero.

The status word of an enabled channel indicates the following status:

- bits 0-10 reflect the channel configuration
- bit 11 indicates whether the channel is enabled or disabled (configuration)
- bits 12-15 indicate detected faults should they occur

We present status words as they appear in the input image table at I:e.4-I:e.7.

Module Input Image (Status Words)



Channel Status Word, Channels 0-3 (I:e.4 through I:e.7) – Bit Definitions

Bit(s)	Reflect/ Indicate	Configured for	With this bit code																Reflects Configuration Bits 0–11, and Indicates Detected Faults in Bits 12-15
			15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0–3	Input Type	TC Type J													0	0	0	0	Reflects the type of channel input.
		TC Type K													0	0	0	1	
		TC Type T													0	0	1	0	
		TC Type E													0	0	1	1	
		TC Type R													0	1	0	0	
		TC Type S													0	1	0	1	
		TC Type B													0	1	1	0	
		TC Type N													0	1	1	1	
		± 50mV													1	0	0	0	
		± 100mV													1	0	0	1	
		TC Type C													1	0	1	0	
		TC Type D													1	0	1	1	
		Invalid													1	1	0	0	The module faults when it detects an invalid configuration.
		Invalid													1	1	0	1	
		Invalid													1	1	1	0	
		CJC Temp.													1	1	1	1	
4, 5	Data Format	Engr. Units x1											0	0					Reflects the type of data format.
		Engr. Units x10											0	1					
		Scaled-for-PID											1	0					
		Counts											1	1					
6, 7	Open Input Mode	Zero									0	0							Reflects module response to a detected open input circuit (for all input types including CJC thermistor). The module faults when it detects an invalid configuration.
		Upscale									0	1							
		Downscale									1	0							
		Invalid									1	1							
8	Units ºF, ºC	Degrees C								0									Reflects temperature units.
		Degrees F								1									
9, 10	Unused	Unused						0	0										Faults when it detects a non–zero value.
11	Chnl Enable	Channel Off					0												Reflects enabled/disabled channel status. Status word of a disabled channel is zero. Channel data and status words remain cleared until the module sets this bit. in response to a new configuration word.
		Channel On					1												
12	Open Input	Diagnostics				0													Condition not detected.
						1													Detected open input.
13	Under Range	Diagnostics			0														Condition not detected.
					1														Detected under-range input.
14	Over Range	Diagnostics		0															Condition not detected.
				1															Detected over-range input.
15	Invalid Config	Diagnostics	0																Condition not detected.
			1																Detected invalid configuration.

Detected Faults Indicated by Bits 12-15

When the module detects any of the conditions described for bits 12-15, it:

- sets the corresponding bit
- blinks the status LED on the front panel for the channel having the fault

The module is designed to detect the following fault conditions:

Open-circuit Detection (Bit 12)

The module tests all enabled channels for an open-circuit condition each time it scans its inputs. Possible causes of an open circuit include:

- broken thermocouple or CJC thermistor
- thermocouple or CJC thermistor wire cut or disconnected

Out-Of-Range Detection (Bit 13 for under range, bit 14 for over range)

The module tests all enabled channels for an out-of-range condition each time it scans its inputs. Possible causes of an out-of-range condition include:

- the temperature is too hot or too cold for the thermocouple being used
- a type B, C, or D thermocouple may be registering a °F value in EU x1 beyond the range allowed by the SLC processor (beyond 32,767) for the data word
- a CJC thermistor may be damaged or the temperature within the cabinet containing the module may be outside the CJC thermistor range limits

Invalid Channel Configuration (Bit 15)

The module sets this fault bit when it detects the following invalid configurations:

- configuration bits 0-3: invalid input type = 1 1 0 0 , or 1 1 0 1, or 1 1 1 0
- configuration bits 6, 7: invalid code for open circuit mode = 1 1
- configuration bits 9-10, and 12-15: invalid non-zero bit setting

Chapter 7

Ladder Programming Examples

Earlier chapters explained how configuration words define channel operation. This chapter shows examples of ladder logic that you write to:

- load configurations into the output image file to be scanned to the module
- change the configuration of a channel
- verify that the change in configuration occurred
- process a channel input value with a PID instruction
- monitor channel status

We start with some basic concepts of the SLC processor.

Processor Basics

For the examples in this chapter, we have assigned the module to slot 3 and have addressed ladder logic files in the SLC processor as follows:

- configurations are stored in words 0-3 of integer file #N10
- configurations are scanned to the module from output image words O:3.0-O:3.3
- channel data words and channel status words are scanned from the module into input image words I:3.0-I:3.3 and I:3.4-I:3.7, respectively

During the program scan, the SLC processor follows the ladder logic instructions that you create to perform such functions as:

- copy or move configurations from integer file #N10 to the output image file to be scanned to the module during the next I/O scan
- verify a change in configuration by comparing the channel status word with the channel configuration word for equality
- examine channel status bits to see if the module flagged a fault condition
- autocalibrate a channel by cycling the channel enable bit on and off

During the I/O scan, the SLC processor scans configuration words from its output image file to the module, and scans data and status words from the module to its input image file. The SLC processor scans its I/O following each program scan.

We repeat the configuration word because it is used often in the examples.

Configuration Word

15 14 13 12	11	10 9	8	7 6	5 4	3 2 1 0
Not Used	**Channel Enable**	**Not Used**	**Temp Units**	**Response to Open Circuit**	**Data Format**	**Type of Input**
	0 = Disable 1 = Enable		0 = ºC 1 = ºF	0 0 = zero 0 1 = FS 1 0 = LS	0 0 = EU x1 0 1 = EU x10 1 0 = Scaled PID 1 1 = Prop Counts	0 0 0 0 = Type J 0 0 0 1 = Type K 0 0 1 0 = Type T 0 0 1 1 = Type E 0 1 0 0 = Type R 0 1 0 1 = Type S 0 1 1 0 = Type B 0 1 1 1 = Type N 1 0 0 0 = ± 50 mV 1 0 0 1 = ± 100 mV 1 0 1 0 = Type C 1 0 1 1 = Type D

Example Configuration Word with These Parameters:
channel enabled, ºC, zero for open circuit, EU x10, Type K thermocouple

0 0 0 0	1	0 0	1	0 0	0 1	0 0 0 1

Load Channel Configurations for Transfer to the Module

This example shows you how to set configuration bits and transfer configuration data of all four channels to the module with a single File Copy instruction.

Procedure

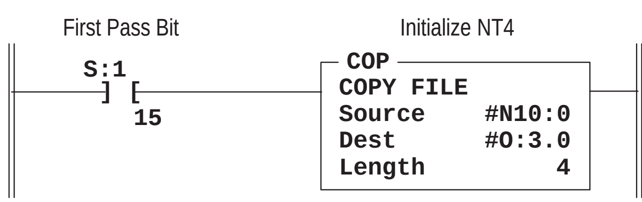
1. Using the memory map function, create integer file N10 with four elements (N10:0 through N10:3).

2. Using the APS software data monitor function, enter configuration parameters for all four thermocouple channels into integer file **#N10**.

```
  address        15      data       0       address        15      data       0
N10:0              0000 1001 0001 0001
N10:1              0000 1001 0001 0001
N10:2              0000 1001 0001 0001
N10:3              0000 1001 0001 0001


Press a key or enter value
N10:3/0 = 1
offline          no forces          binary data    decimal addr       File EXMPL
CHANGE                              SPECIFY        NEXT      PREV
RADIX                               ADDRESS        FILE      FILE
  F1                                  F5            F7        F8
```

3. Program a rung of ladder logic to copy the integer file #N10 into output image file O:3.0-O:3.3.



On power up, bit S:1/15 is set for the first program scan. It enables the Copy instruction to load configurations into the output image file for transfer to the module in the next I/O scan.

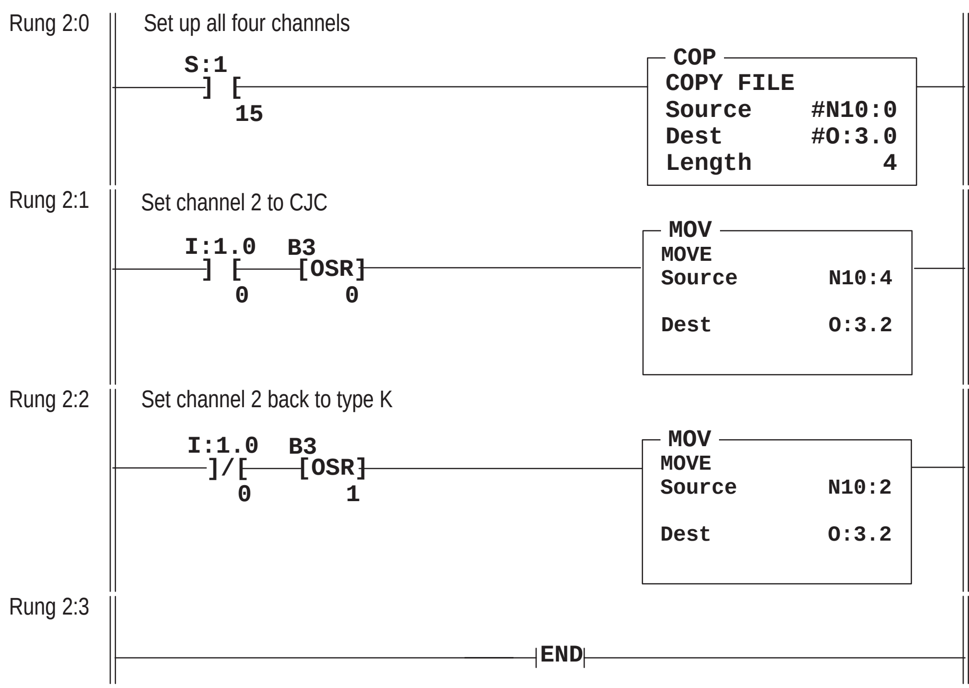
Change a Channel Configuration

The following example explains how to change the channel configuration word when the channel is currently enabled.

Example: Change the channel configuration word to read the temperature is inside the control cabinet as read by the CJC thermistor. Then restore the original channel configuration.

We use #N10:4 to store the new configuration word.
Consider input I:1.0/0 as a pushbutton switch for changing configurations.
The one-shot instruction OSR enables the Copy instruction once no matter how long the operator presses the pushbutton switch.

Program



Data Table

address	15 data 0	address	15 data 0
N10:0	0000 1001 0001 0001	N10:3	0000 1001 0001 0001
N10:1	0000 1001 0001 0001	N10:4	0000 1001 0001 1111
N10:2	0000 1001 0001 0001		

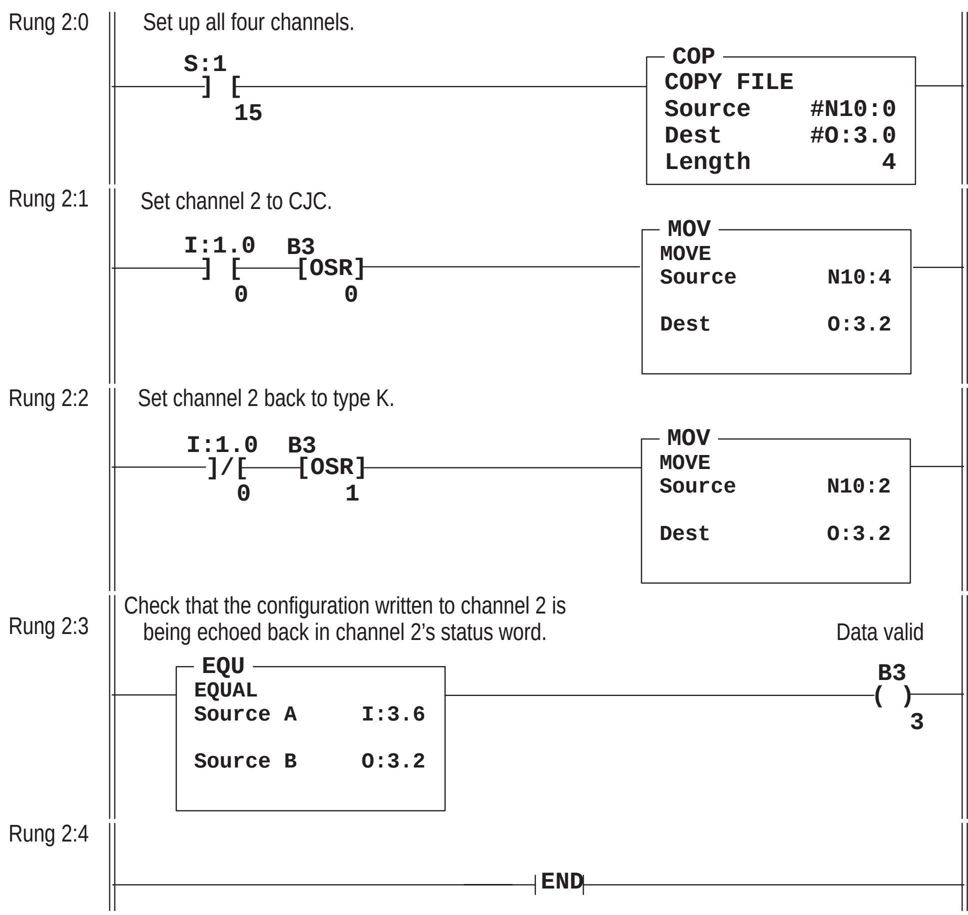
Important: While the module changes the channel configuration, it does not monitor inputs to any channel. For the delay in reading inputs, refer to *Channel Update Time* in chapter 4.

Verify Changes to a Channel Configuration

When changing a channel configuration, there is always a delay until the ladder logic reads the new data word based on the new configuration. Therefore, it is important to verify that a the module successfully stored the new channel configuration word. The following example explains how to verify a change to a channel configuration.

Example: Change the channel configuration word and verify the change by comparing the resulting status word with the configuration word for equality. We do this by adding rung 2:3 to the rungs in the previous example.

Program



Data Table

address	15 data 0	address	15 data 0
N10:0	0000 1001 0001 0001	N10:3	0000 1001 0001 0001
N10:1	0000 1001 0001 0001	N10:4	0000 1001 0001 1111
N10:2	0000 1001 0001 0001		

Process a Channel Input with the PID Instruction

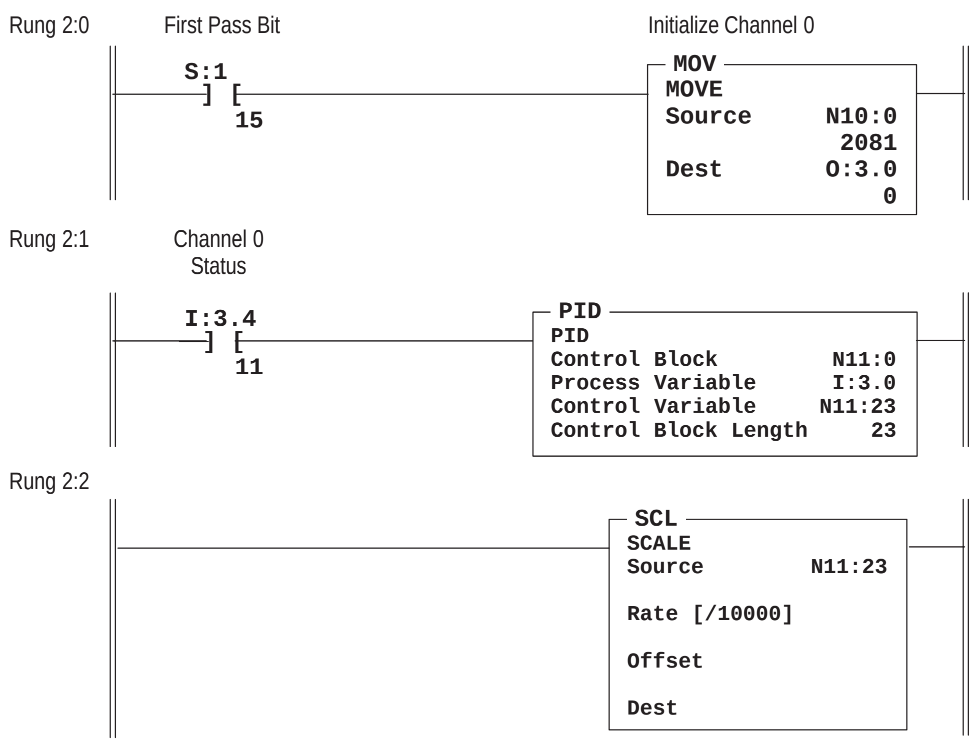
The module was designed to input a channel directly to a PID instruction of an SLC 5/02™ or later processor without the need of an intermediate scale operation.

Example: Use channel data as the process variable for the PID instruction.

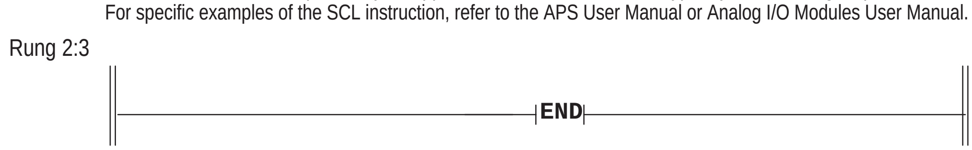
1. Select *scaled-for-PID* as the data type in the channel configuration word.
2. Specify channel data word as the process variable for the PID instruction.

In this example, the value 2081 is the numeric equivalent of configuration word N10:0 for channel 0. It is configured for a type K thermocouple, scaled-for-PID, zero the signal for an open input, °C, and channel enabled.

Program



Rate and Offset values depend on your application. The Destination will typically be an analog output channel. For specific examples of the SCL instruction, refer to the APS User Manual or Analog I/O Modules User Manual.



Data Table

address	15 data 0	address	15 data 0
N10:0	0000 1000 0010 0001		

(numerical equivalent = 2081)

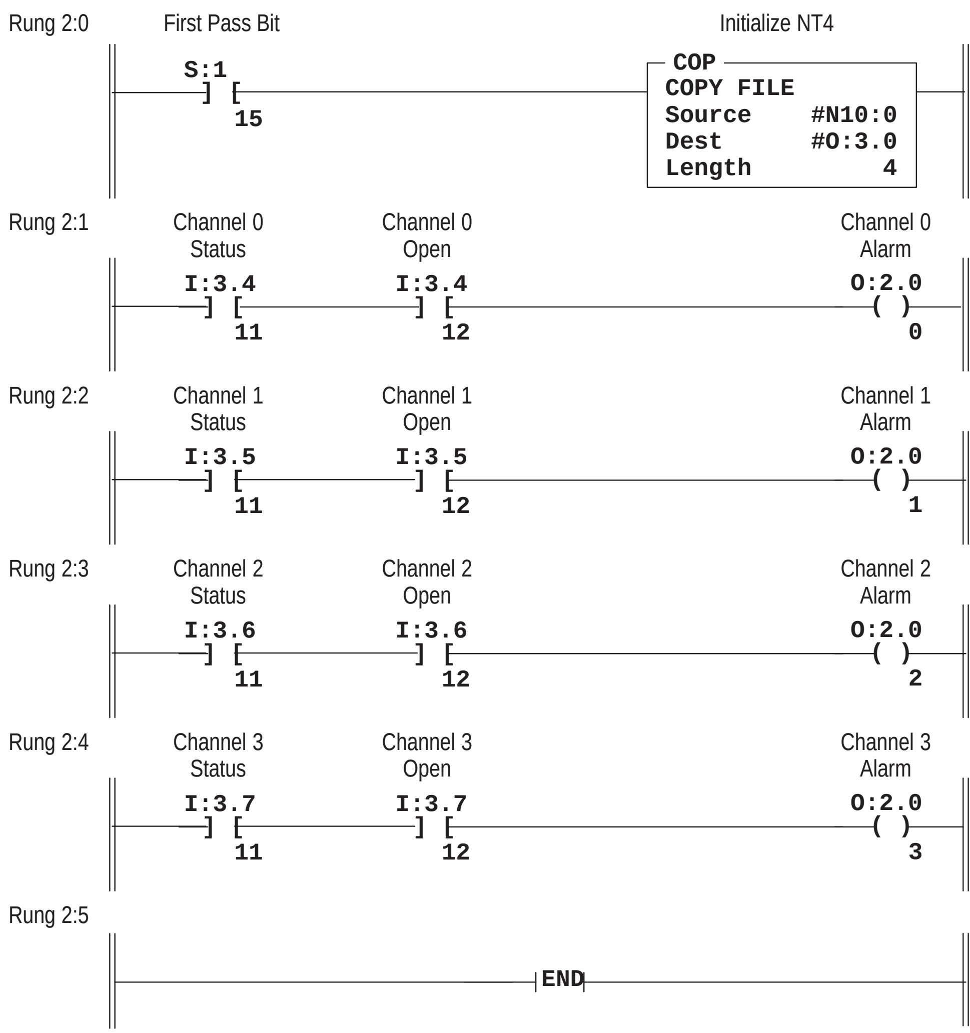
Monitor Channel Status Bits

This example shows how you could monitor the open-circuit error bit of each channel and set an alarm bit if the module detects an open input. An open-circuit error can occur if a thermocouple or CJC thermistor wire breaks or becomes disconnected from the terminal block.

In this example, we monitor the channel enable bit (bit 11) and the open-input bit (bit 12) in channel status words I:3.4-I:3.7, and use output image bits O:2.0/0-3 as alarm bits.

Important: If a CJC thermistor is not installed or is damaged, all four alarms are set, and all four channel LEDs blink.

Program



Data Table

address	15 data 0	address	15 data 0
N10:0	0000 1001 0001 0001	N10:3	0000 1001 0001 0001
N10:1	0000 1001 0001 0001		
N10:2	0000 1001 0001 0001		

Chapter 8

Module Diagnostics and Troubleshooting

This chapter describes troubleshooting with channel-status and module-status LEDs. It explains the types of conditions that might cause the module to flag an error, and suggests what corrective action you could take. Topics include:

- module and channel diagnostics
- LED indicators
- troubleshooting flowchart
- replacement parts
- contacting Allen-Bradley

Module and Channel Diagnostics

The module operates at two levels:

- module level
- channel level

Module level operation includes functions such as power-up, configuration, and communication with the SLC processor. ON indicates the module is OK. OFF indicates a fault.

Channel level operation includes functions such as data conversion and open-circuit detection. ON indicates the channel is OK. Blinking indicates a fault.

The module performs internal diagnostics at both levels, and immediately indicates detected error conditions with either of its status LEDs. When a status LED is continuously ON, the status is OK.

Module Diagnostics at Power-up

At module power-up, the module performs a series of internal diagnostic tests. If the module detects a failure, its module status LED remains off.

Channel Diagnostics

When a channel is enabled, the module checks for a valid configuration. Then on each scan of its inputs, the module checks for out-of-range and open-circuit fault conditions of its inputs including the CJC thermistor.

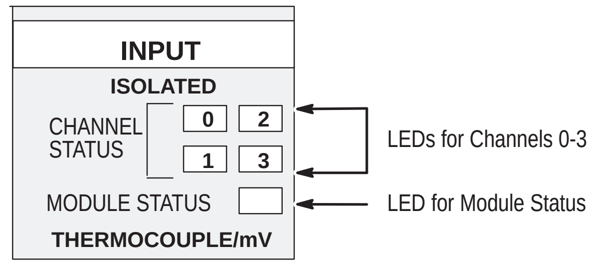
When the module detects a failure of any channel diagnostic test, it causes the channel status LED to blink and sets the corresponding channel fault bit. (bits 12-15 of the channel status word). Channel fault bits and LEDs are self-clearing when fault conditions are corrected.

Important: If you clear the channel enable bit, channel status bits are reset.

LED Indicators

The module has five LEDs:

- four channel-status LEDs, numbered to correspond with each channel
- one module-status LED



LED Troubleshooting Tables

Module-status LED

If Module Status LED is:	Then:	Take This Corrective Action:
On	The module is OK.	No action required.
Off	The module is turned off, or it detected a module fault.	Cycle power. If the condition persists, call your local distributor or Allen-Bradley customer service for assistance.

Module-status and Channel-status LEDs

If Module Status LED is:	And Channel Status LED is:	Then:	Take This Corrective Action:
On	**On**	The channel is enabled.	No action required.
	Blinking	The module detected: open-circuit condition under-range condition over-range condition channel configuration error	Examine error bits in the status word if bit 12 = 1, the input has an open circuit if bit 13 = 1, the input value is under range if bit 14 = 1, the input value is over range if bit 15 = 1, the configuration is invalid
	Off	The module is in power up, or the channel is disabled.	No action required.

Channel-status LEDs (Green)

The channel-status LED operates with status bits in the channel status word to indicate the following faults detected by the module:

- invalid channel configuration
- an open-circuit input
- out-of-range errors

When the module detects any of the following fault conditions, it causes the channel-status LED to blink and sets the corresponding fault bit in the channel status word. Channel fault bits (bits 12-15) and channel-status LEDs are self-clearing when fault conditions are corrected.

Open-circuit Detection (Bit 12)

The module tests all enabled channels for an open-circuit condition each time it scans its inputs. Possible causes of an open circuit include:

- broken thermocouple or CJC thermistor
- thermocouple or CJC thermistor wire cut or disconnected

Out-Of-Range Detection (Bit 13 for under range, bit 14 for over range)

The module tests all enabled channels for an out-of-range condition each time it scans its inputs. Possible causes of an out-of-range condition include:

- the temperature is too hot or too cold for the thermocouple being used
- a type B thermocouple may be registering a °F value in EU x1 beyond the range allowed by the SLC processor (beyond 32,767) for the data word
- a CJC thermistor may be damaged or the temperature within the cabinet containing the module may be outside the CJC thermistor range limits

Invalid Channel Configuration (Bit 15)

The module sets this fault bit when it detects any of the following invalid configurations:

- configuration bits 0-3: invalid input type = 1 1 0 0 , or 1 1 0 1, or 1 1 1 0
- configuration bits 6, 7: invalid code for open circuit mode = 1 1
- configuration bits 9-10, and 12-15: invalid non-zero bit setting

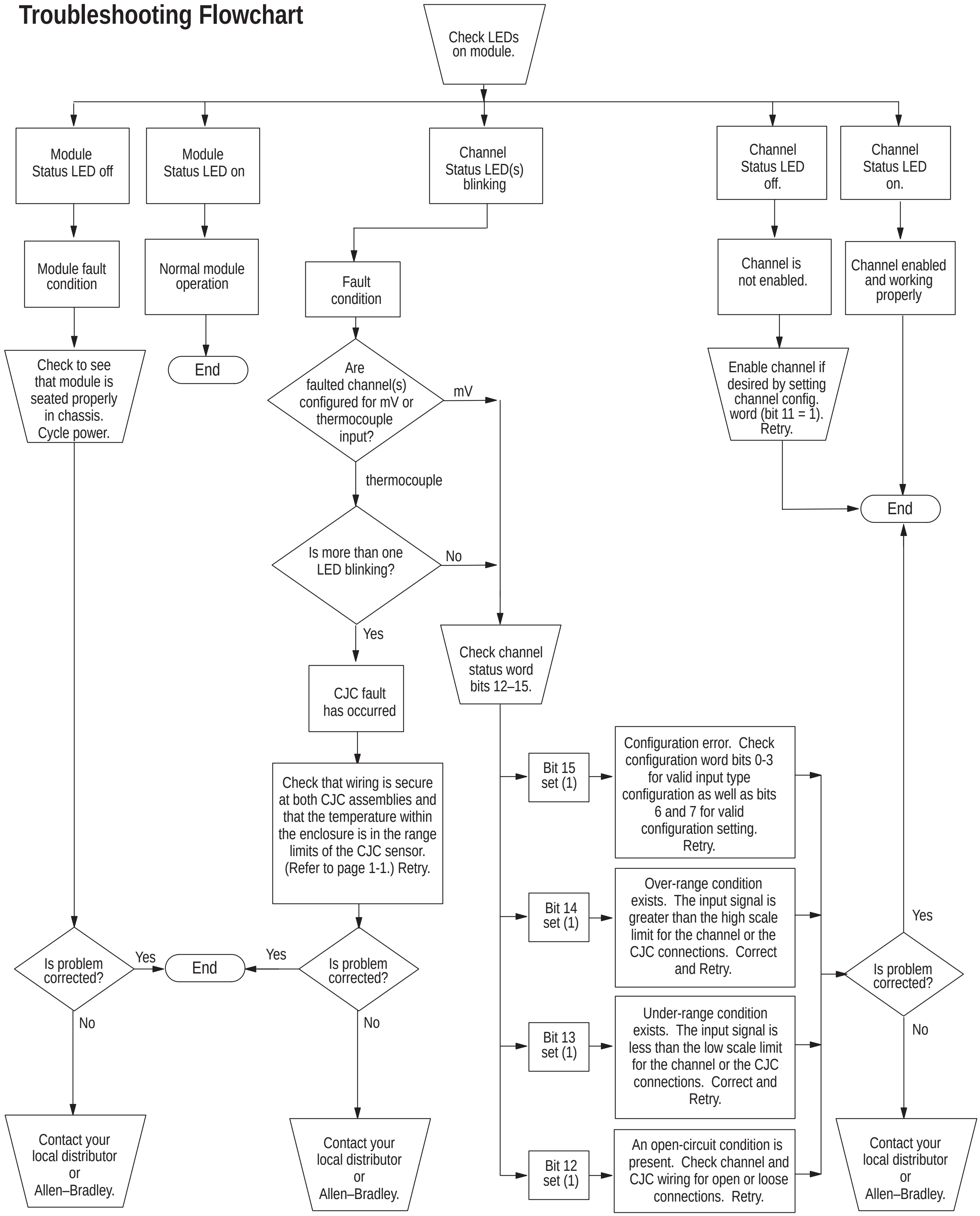
Module Status LED (Green)

The module-status LED indicates when the module detects a *non-recoverable fault* at power up or during operation. For this type of fault, the module:

- no longer communicates with the SLC processor
- disables all channels
- clears all data and status words

A module failure is non-recoverable and requires the assistance of your local distributor or Allen-Bradley Support Services (see Preface).

Troubleshooting Flowchart



Replacement Parts

The module has the following replaceable parts:

Part	Part Number
Replacement Terminal Block	1746-RT32
Replacement Terminal Cover	1746-R13 Series B
1746-INT4 User Manual	1746-6.16

Contacting Allen-Bradley

If you need to contact Allen-Bradley 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 doing, LED status, and bit status of I/O image words (channel configuration and status) for the module
- fault code if the SLC processor is faulted
- processor type and firmware (FRN) number from label on processor
- a list of things you have already tried to remedy the problem
- hardware types in the system including I/O modules and chassis

Notes:

Chapter 9

Application Programming Examples

This chapter provides two application examples to help you use the module:

- basic example
- supplementary example

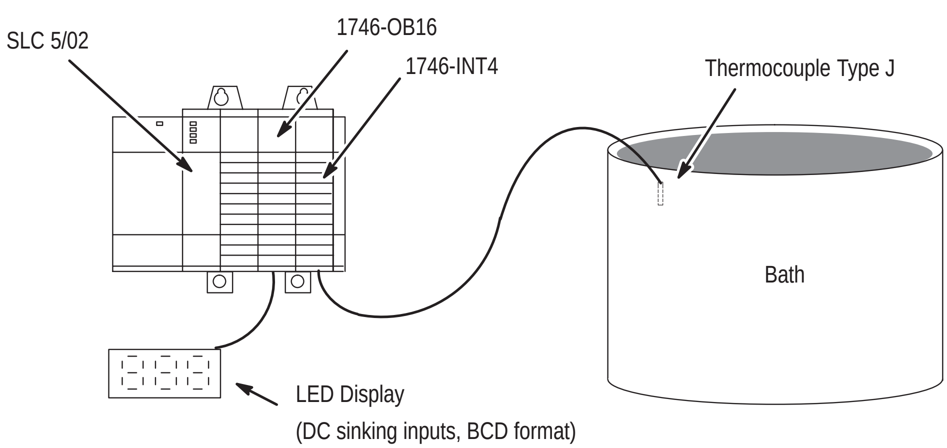
The basic example lets you display a temperature.

The supplementary example lets you manually select the display of temperature in °C or °F.

Basic Example (to display a temperature)

Application Setup

This example lets you display the temperature of a bath °F on an LED display device. The display device requires BCD data, so the program must convert the temperature reading to BCD.



Channel Configuration

Configure the thermocouple channel with the following setup:

- type J thermocouple (bits 3-0)
- °F displayed in whole degrees with EU = x10 (bits 8, 5, 4)
- zero the data word in the event of an open circuit (bits 7, 6)

Configuration Word

15 14 13 12	11	10 9	8	7 6	5 4	3 2 1 0
Not Used	**Channel Enable**	**Not Used**	**Temp Units**	**Response to Open Circuit**	**Data Format**	**Type of Input**
	0 = Disable 1 = Enable		0 = °C 1 = °F	0 0 = zero 0 1 = FS 1 0 = LS	0 0 = EU x1 0 1 = EU x10 1 0 = Scaled PID 1 1 = Prop Counts	0 0 0 0 = Type J 0 0 0 1 = Type K 0 0 1 0 = Type T 0 0 1 1 = Type E 0 1 0 0 = Type R 0 1 0 1 = Type S 0 1 1 0 = Type B 0 1 1 1 = Type N 1 0 0 0 = 0-100 mV 1 0 0 1 = ±100 1 0 1 0 = Type C 1 0 1 1 = Type D

Example Configuration Word with These Parameters:
channel enabled, °F, zero for open circuit, EU x10, Type J thermocouple

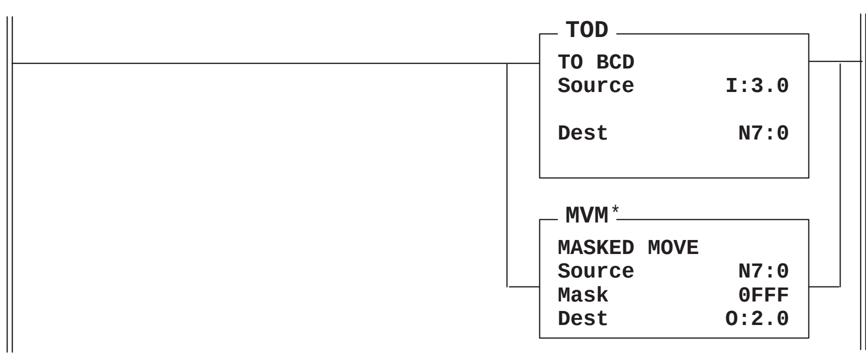
0 0 0 0	1	0 0	1	0 0	0 1	0 0 0 0

Program

Rung 2.0

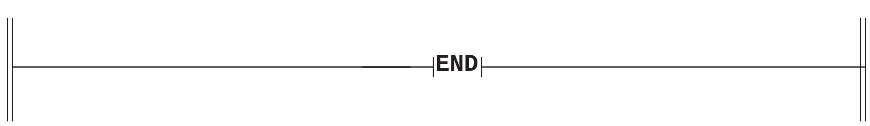
Rung 2.1

Convert the channel 0 data word (degrees F) to BCD and write this to the LED display.



* Note: The use of the masked move instruction with the 0FFF mask lets you use outputs 12, 13, 14, and 15 for other output devices in your system. The 7-segment display uses outputs 0-11.

Rung 2.2



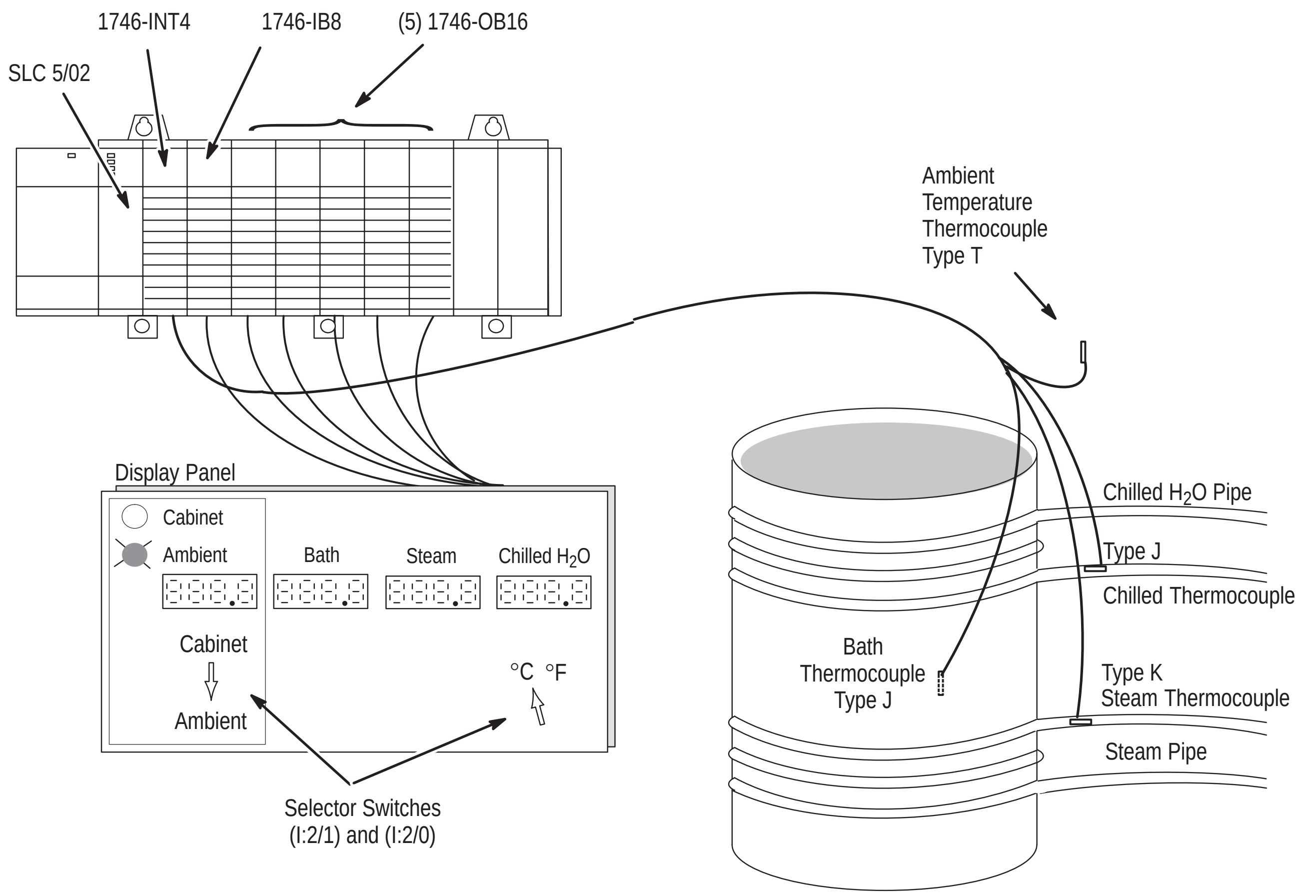
Data Table

address	15 data 0	address	15 data 0
N10:0	0000 1001 0001 0000		

Supplementary Example (select display in ºC or ºF)

Application Setup

This example shows how to display the temperature of several different thermocouples at display panel. A selector switch (I:2/0) lets the operator choose between displaying temperatures in °C or °F. A second selector switch (I:2/1) lets the operator switch a display between the ambient temperature near the bath and the temperature inside the control cabinet containing the SLC controller. Each display is a 4-digit, 7-segment LED display with the last digit representing tenths of a degree. The displays have DC-sinking inputs and use a BCD data format.



Channel Configuration

All channels are configured for:

- display temperature to tenths of a degree
- zero data word in the event of an open circuit

Configuration setup for **ambient thermocouple**:
- channel 0
- type T thermocouple

Configuration setup for **bath thermocouple**:
- channel 1
- type J thermocouple

Configuration setup for **steam thermocouple**:
- channel 2
- type K thermocouple

Configuration setup for **chilled H_2O thermocouple**:
- channel 3
- type J thermocouple

Configuration setup for **cabinet temperature**:
- channel 0
- CJC temperature

Configuration Word

15 14 13 12	Not Used	
11	Channel Enable	0 = Disable 1 = Enable
10 9	Not Used	
8	Temp Units	0 = °C 1 = °F
7 6	Response to Open Circuit	0 0 = zero 0 1 = FS 1 0 = LS
5 4	Data Format	0 0 = EU x1 0 1 = EU x10 1 0 = Scaled PID 1 1 = Prop Counts
3 2 1 0	Type of Input	0 0 0 0 = Type J 0 0 0 1 = Type K 0 0 1 0 = Type T 0 0 1 1 = Type E 0 1 0 0 = Type R 0 1 0 1 = Type S 0 1 1 0 = Type B 0 1 1 1 = Type N 1 0 0 0 = 0-100 mV 1 0 0 1 = ±100 1 0 1 0 = Type C 1 0 1 1 = Type D 1 1 1 1 = CJC temp

Configuration Words for this Example

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
0	0	0	0	1	0	0	x	0	0	0	0	0	0	1	0	**Channel 0**	(Ambient)
0	0	0	0	1	0	0	x	0	0	0	0	0	0	0	0	**Channel 1**	(Bath)
0	0	0	0	1	0	0	x	0	0	0	0	0	0	0	1	**Channel 2**	(Steam)
0	0	0	0	1	0	0	x	0	0	0	0	0	0	0	0	**Channel 3**	(Chilled H2O)
0	0	0	0	1	0	0	x	0	0	0	0	1	1	1	1	**Channel 3**	(Cabinet)

Program Setup

1. Set up two configuration words for each channel in file N10, one for °C and the other for °F. Include two configuration words for the CJC temperature in the cabinet containing the SLC controller.

Channel	Configuration Word Addresses	
	°F	°C
0	N10:0	N10:4
1	N10:1	N10:5
2	N10:2	N10:6
3	N10:3	N10:7
CJC	N10:8	N10:9

2. Write ladder logic to send channel configurations to the module when the operator changes the ºC/ºF or the ambient/cabinet selector switch. The OSR instruction (one-shot rising) makes these configuration changes edge-triggered, i.e. the module is reconfigured once each time the operator changes a switch position.

3. Write ladder logic to monitor the channel 0 status word to determine whether ambient or cabinet temperature is being displayed, and energize the appropriate pilot light.

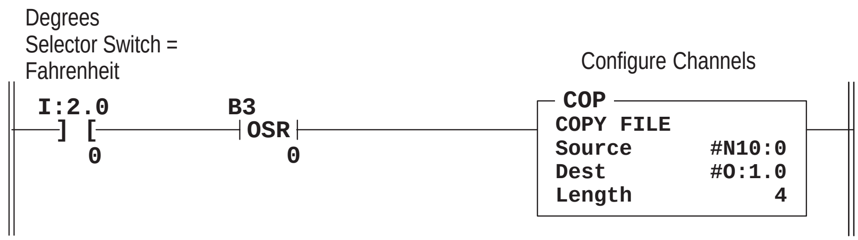
4. Write ladder logic to convert thermocouple data words to BCD and send them to the LED displays.

Program

The first six rungs change channel configurations based on the position of the two selector switches.

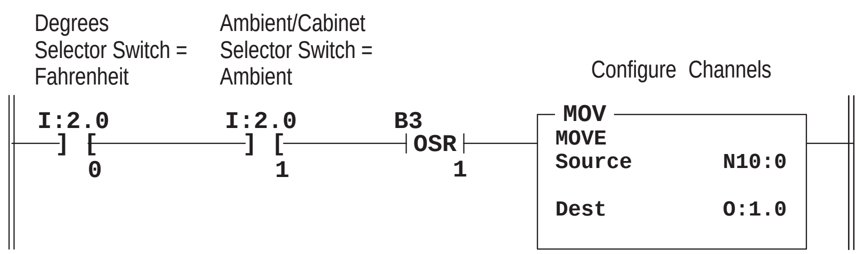
Rung 2.0

If the degrees selector switch is switched to Fahrenheit, configure all four channels to read in degrees Fahrenheit. The default for channel 0 is to read the ambient temperature thermocouple.



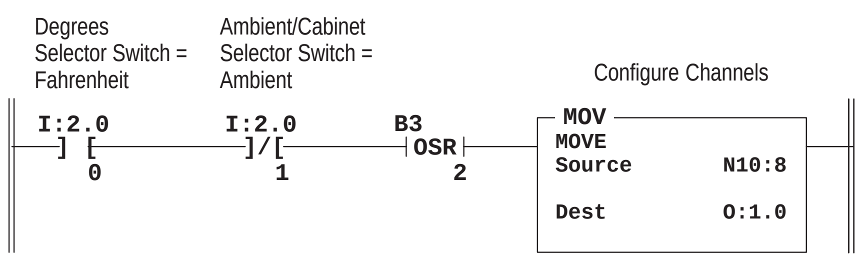
Rung 2.1

If the ambient/cabinet selector switch is switched to ambient, and the degrees selector switch is switched to Fahrenheit, configure channel 0 to read the ambient temperature thermocouple in degrees Fahrenheit.



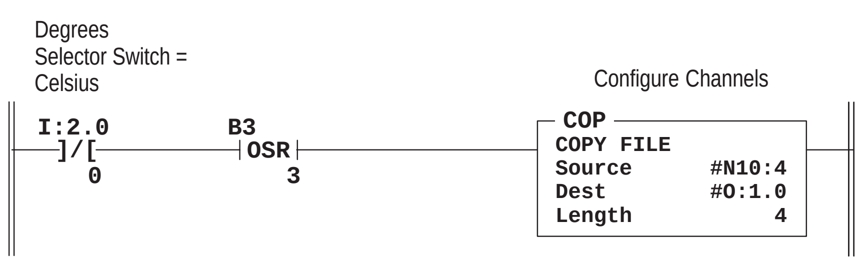
Rung 2.2

If the ambient/cabinet selector switch is switched to cabinet, and the degrees selector switch is switched to Farenheit, configure channel 0 to read the CJC sensor in degrees Fahrenheit.



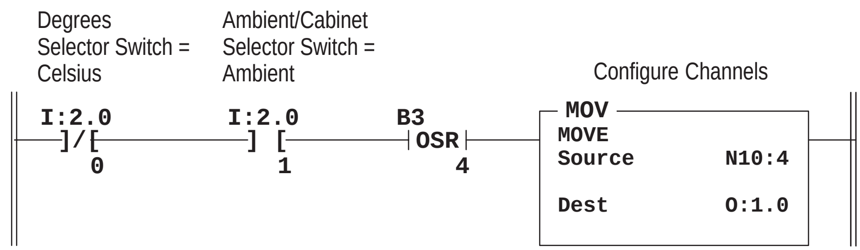
Rung 2.3

If the degrees selector switch is switched to Celsius, configure all four channels to read in degrees Celsius. The default for channel 0 is to read the ambient temperature thermocouple.



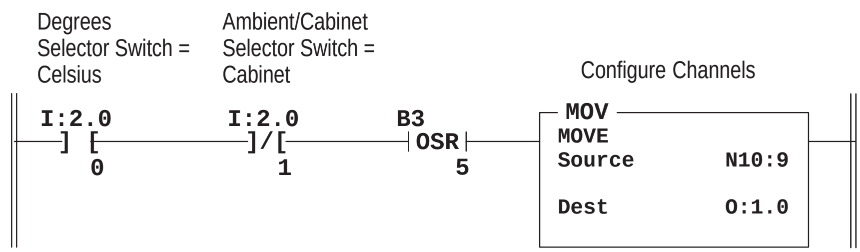
Rung 2.4

If the ambient/cabinet selector switch is switched to ambient, and the degrees selector switch is switched to Celsius, configure channel 0 to read the ambient temperature thermocouple in degrees Celsius.



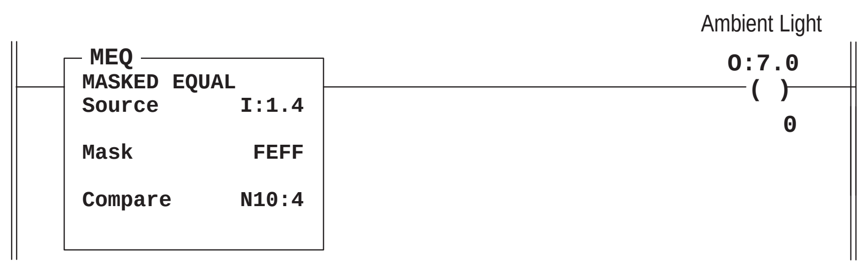
Rung 2.5

If the ambient/cabinet selector switch is switched to cabinet, and the degrees selector switch is switched to Celsius, configure channel 0 to read the CJC sensor in degrees Celsius.



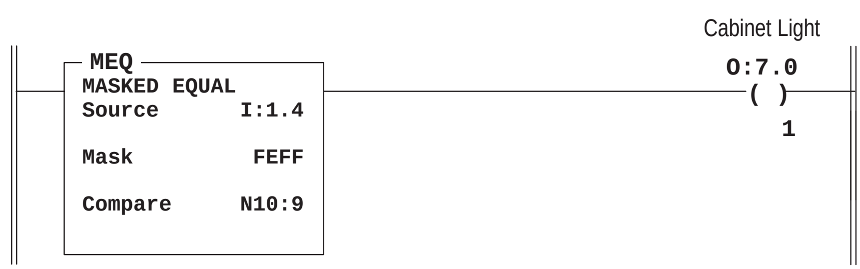
Rung 2.6

If channel 0 is configured to read the ambient thermocouple, energize the ambient pilot light on the panel.



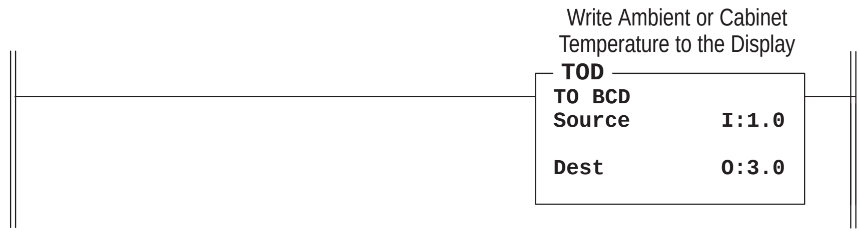
Rung 2.7

If channel 0 is configured to read the CJC sensor, energize the cabinet pilot light on the panel.

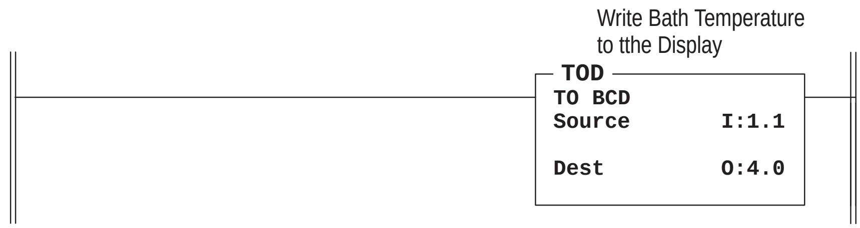


Rung 2.8

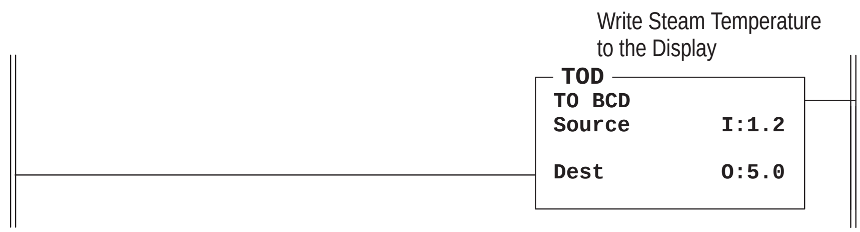
Convert data words to BCD format and send them to the LED displays.



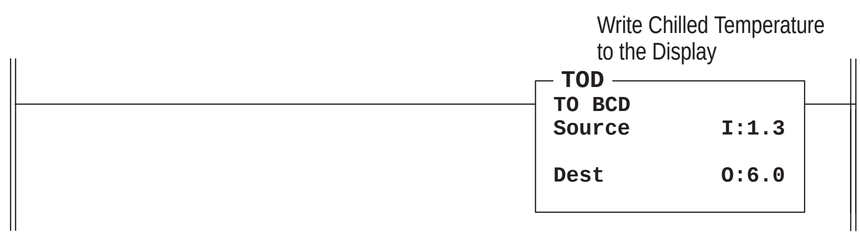
Rung 2.9



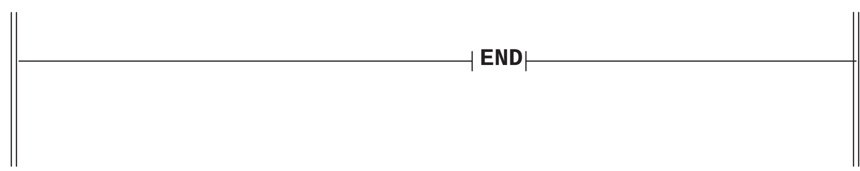
Rung 2.10



Rung 2.11



Rung 2.12



Data Table

address	15 data 0	address	15 data 0
N10:0	0000 1101 0000 0010	N10:5	0000 1100 0000 0000
N10:1	0000 1101 0000 0000	N10:6	0000 1100 0000 0001
N10:2	0000 1101 0000 0001	N10:7	0000 1100 0000 0000
N10:3	0000 1101 0000 0000	N10:8	0000 1101 0000 1111
N10:4	0000 1100 0000 0010	N10:9	0000 1100 0000 1111

Appendix A

Module Specifications

This appendix lists the specifications for the 1746-INT4 Thermocouple/mV Isolated Input Module.

Electrical Specifications

Backplane Current Consumption	110 mA at 5 VDC 85 mA at 24 VDC
Backplane Power Consumption	0.6W maximum (0.55W @ 5 VDC, 2W @ 24 VDC)
Number of Channels	4 (backplane and channel-to-channel isolated)
I/O Chassis Location	Any I/O module slot except slot 0
A/D Conversion Method	Sigma-Delta Modulation
Input Filtering	Analog filter with low pass digital filter
Normal Mode Rejection (between [+] input and [–] input)	Greater than 50 dB at 50 Hz Greater than 60 dB at 60 Hz
Common Mode Rejection (between inputs and chassis ground)	Greater than 120 dB at 50/60 Hz (with 1K ohm imbalance)
Channel Bandwidth (–3db)	8 Hz
Calibration	once yearly, if required
Isolation	1000 V transient or 150 VAC continuous channel-to-channel or channel-to-backplane

Physical Specifications

LED Indicators	5, green status indicators, one for each of 4 channels and one for module status
Module ID Code	3515
Recommended Cable: for thermocouple inputs . . . for mV inputs . . .	 Shielded twisted pair thermocouple extension wire① Alpha 5121 or equivalent
Maximum Wire Size	Two 14 AWG wires per terminal
Maximum Cable Impedance	150 ohms maximum loop impedance, for <1LSB error
Terminal Strip	Removable, Allen-Bradley spare part Catalog Number 1746-RT32

① Refer to the thermocouple manufacturer for the correct extension wire.

Environmental Specifications

Operating Temperature	0°C to 60°C (32°F to 140°F)
Storage Temperature	–40°C to +85°C (–40°F to +185°F)
Relative Humidity	5% to 95% (without condensation)
Agency Certification (when product is marked)	• CSA certified • CSA Class I, Division 2, Groups A, B, C, D certified Hazardous Locations • UL listed • CE marked for all applicable directives

Input Specifications

Type of Input (Selectable)	Thermocouple Type C 0°C to 2317°C (32°F to 4201°F) Thermocouple Type D 0°C to 2317°C (32°F to 4201°F) Thermocouple Type J –210°C to 760°C (–346°F to 1400°F) Thermocouple Type K –270°C to 1370°C (–454°F to 2498°F) Thermocouple Type T –270°C to 400°C (–454°F to 752°F) Thermocouple Type E –270°C to 1000°C (–454°F to 1832°F) Thermocouple Type R 0°C to 1768°C (32°F to 3214°F) Thermocouple Type S 0°C to 1768°C (32°F to 3214°F) Thermocouple Type B 300°C to 1820°C (572°F to 3308°F) Thermocouple Type N (14 AWG) 0°C to 1300°C (32°F to 2372°F) Millivolt (–50 mV dc to +50 mV dc) Millivolt (–100 mV dc to +100 mV dc)
Thermocouple Linearization	IPTS–68 standard, NBS MN–125, NBS MN–161
Cold Junction Compensation	Accuracy ±1.5°C, 0°C to 70°C (32°F to 158°F)
Input Impedance	Greater than 10MΩ
Temperature Scale (Selectable)	°C or °F and 0.1°C or 0.1°F
DC Millivolt Scale (Selectable)	0.1 mV or 0.01 mV
Open Circuit Detection Leakage Current	20 nA typical
Open Circuit Detection (Selectable)	Upscale, Downscale, or zero
Time to Detect Open Circuit	5 seconds, typical
Input Step Response	0 to 99.9% in 600 ms (worst case)
Input Resolution	See Input Resolution Graphs on following pages. They show the smallest measurable value based on combined hardware and software tolerances.
Display Resolution	See Channel Data Word Resolution table on page 6–5.
Overall Module Accuracy @ 25°C (77°F)	See Module Accuracy Table, page A–3
Overall Module Accuracy (0°C to 60°C, 32°F to 140°F)	See Module Accuracy Table, page A–3
Overall Module Drift	See Module Accuracy Table, page A–3
Module Update Time	Less than 500 ms
Channel Turn–Off Time	Up to one module update time

Overall Accuracy

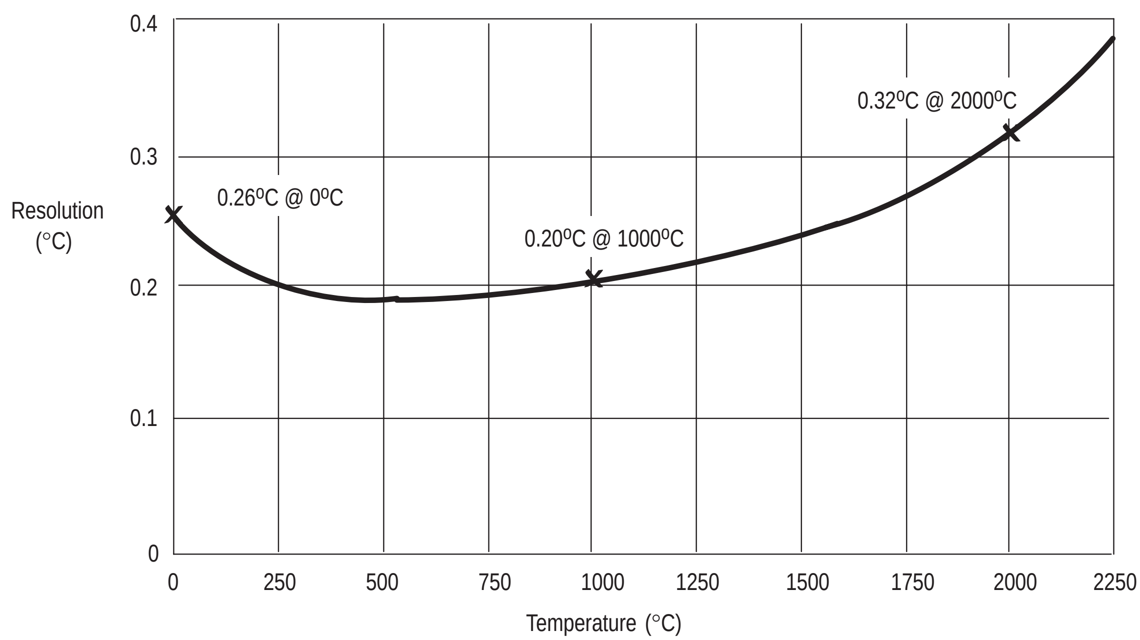
We define overall accuracy to include variances in cold-junction compensation, calibration, non-linearity, and resolution.

Input Type	Maximum Error① @ 25°C	Maximum Error① @ 77°F	Temperature Drift① (0°C–60°C)
J	±1.60°C	±2.88°F	±0.042°C/°C, °F/°F
K	±3.80°C	±6.84°F	±0.096°C/°C, °F/°F
T	±2.05°C	±3.69°F	±0.025°C/°C, °F/°F
E	±2.40°C	±4.32°F	±0.058°C/°C, °F/°F
S	±2.38°C	±4.29°F	±0.131°C/°C, °F/°F
R	±2.23°C	±4.02°F	±0.130°C/°C, °F/°F
B	±3.83°C	±6.90°F	±0.109°C/°C, °F/°F
N	±1.79°C	±3.23°F	±0.080°C/°C, °F/°F
C	±2.28°C	±4.11°F	±0.270°C/°C, °F/°F
D	±2.52°C	±4.54°F	±0.280°C/°C, °F/°F
±50 mV	±50 μV	±50 μV	±0.5 μV/°C ±50 ppm/°C
±100 mV	±50 μV	±50 μV	±0.5 μV/°C ±50 ppm/°C

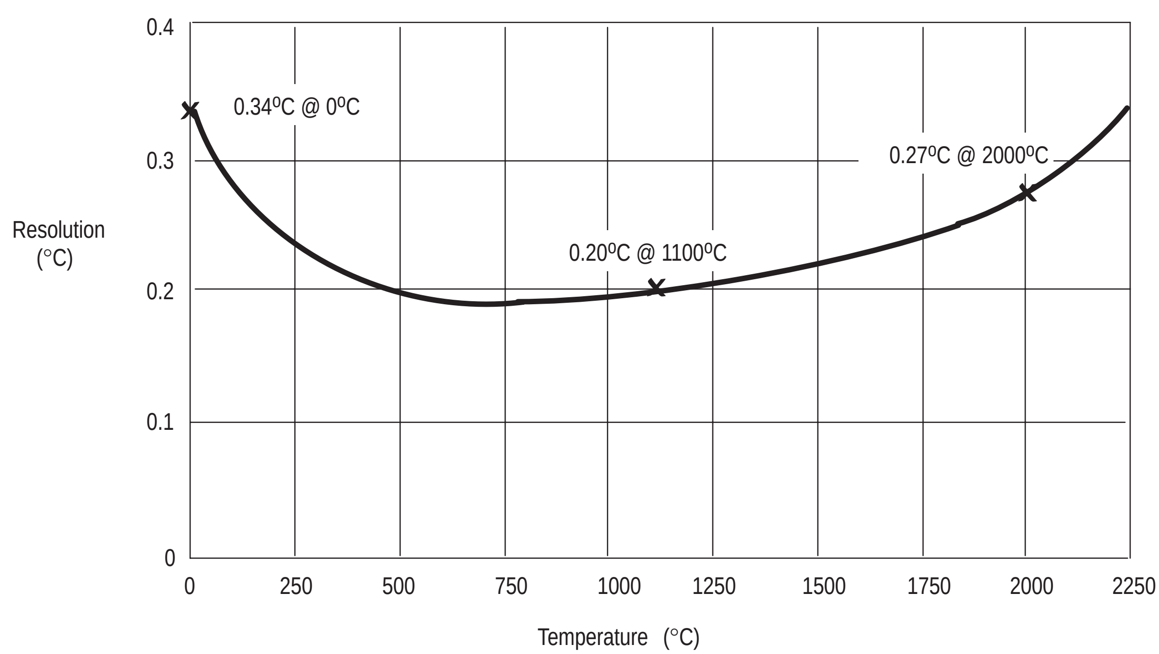
① Assumes the module terminal block temperature is stable.

Thermocouple Resolution

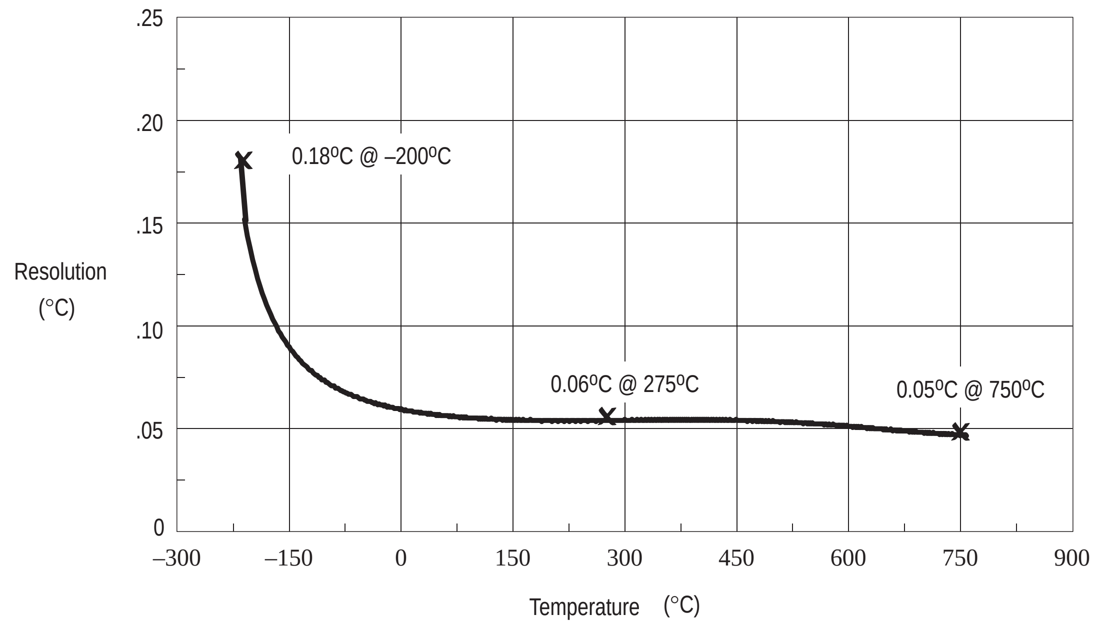
Type C Thermocouple



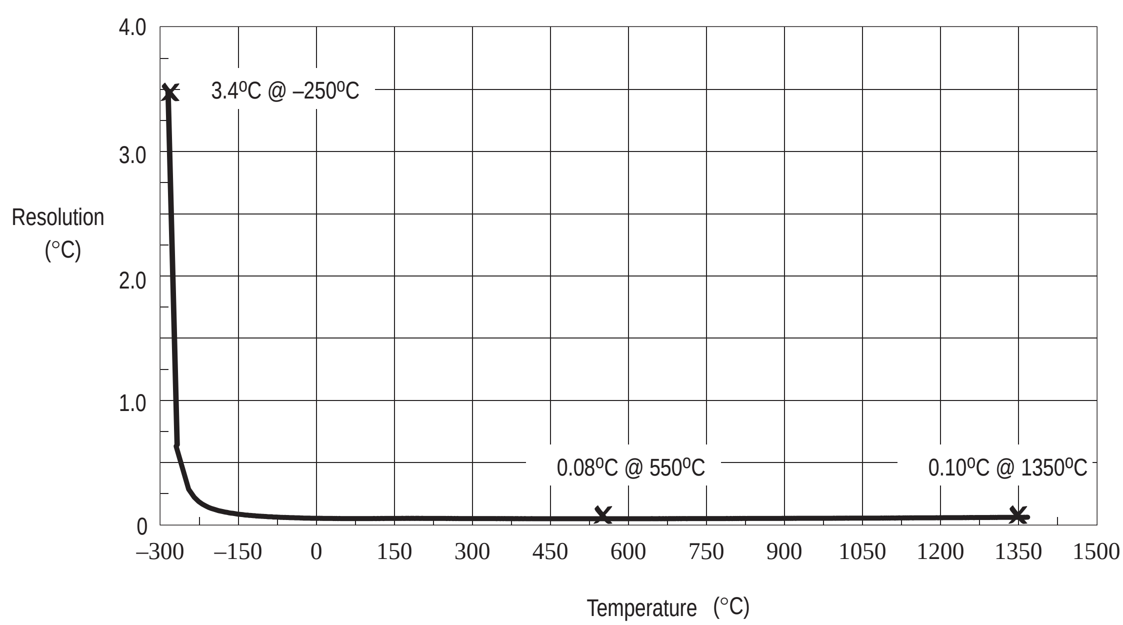
Type D Thermocouple



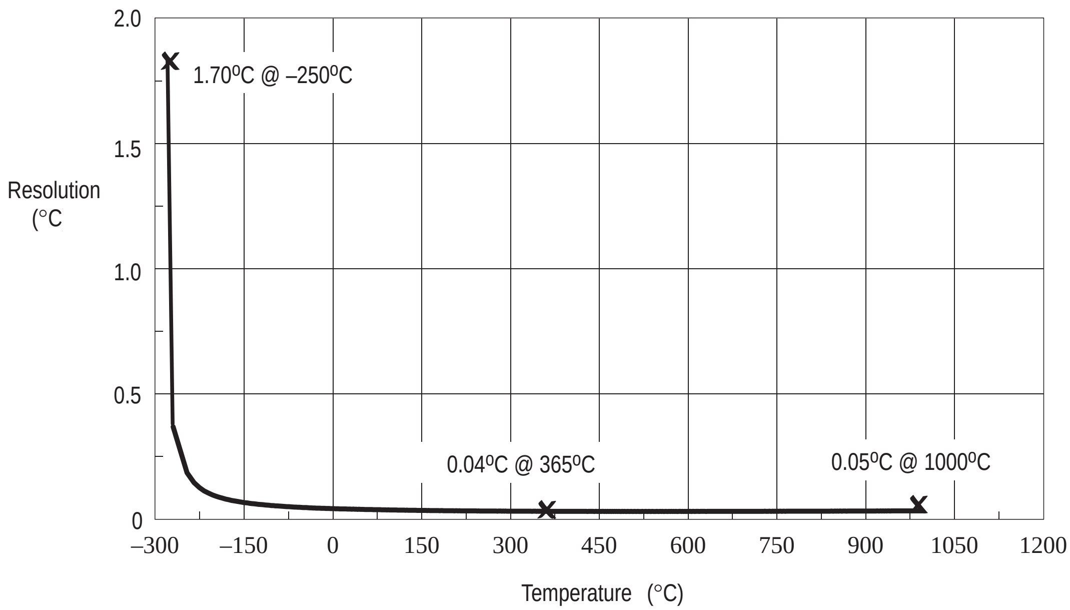
Type J Thermocouple



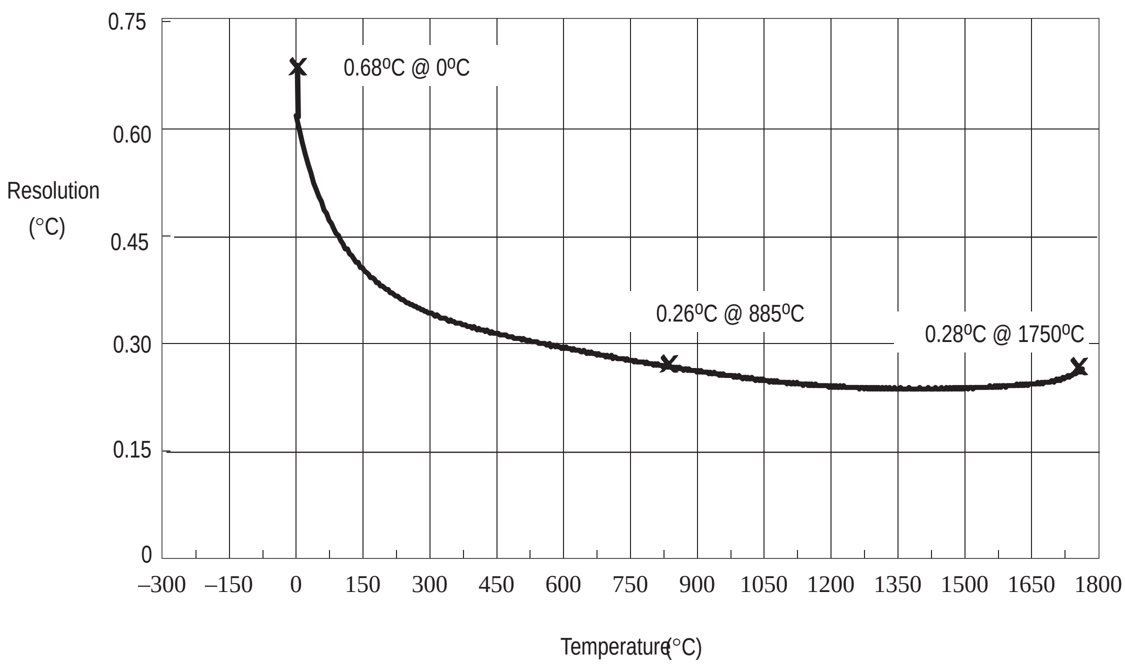
Type K Thermocouple



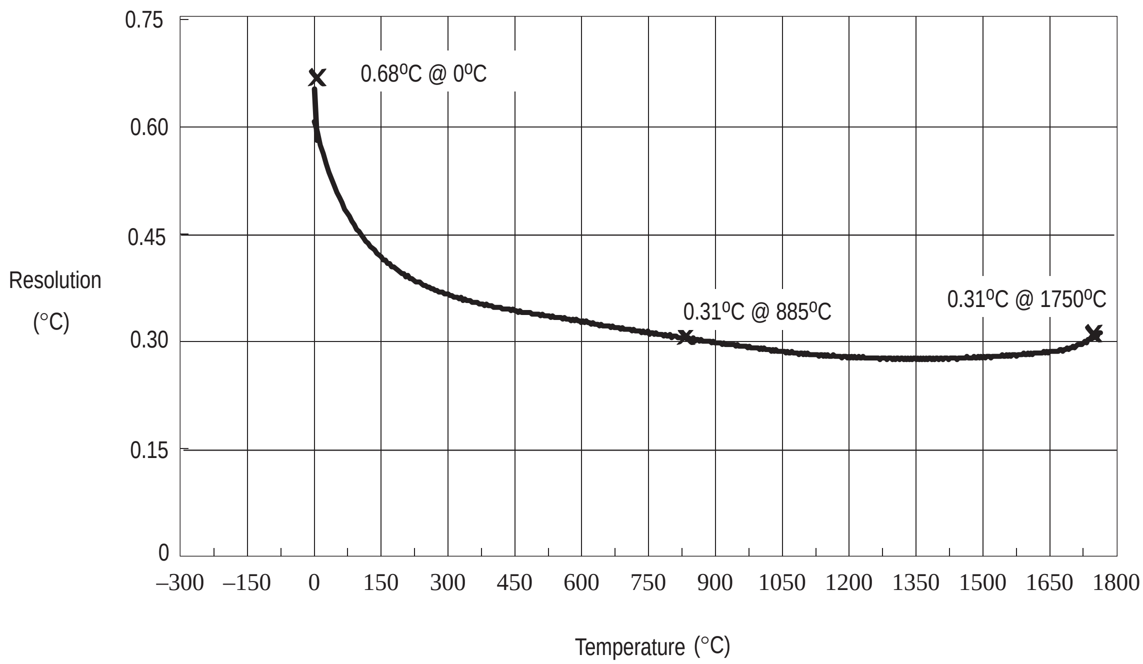
Type E Thermocouple



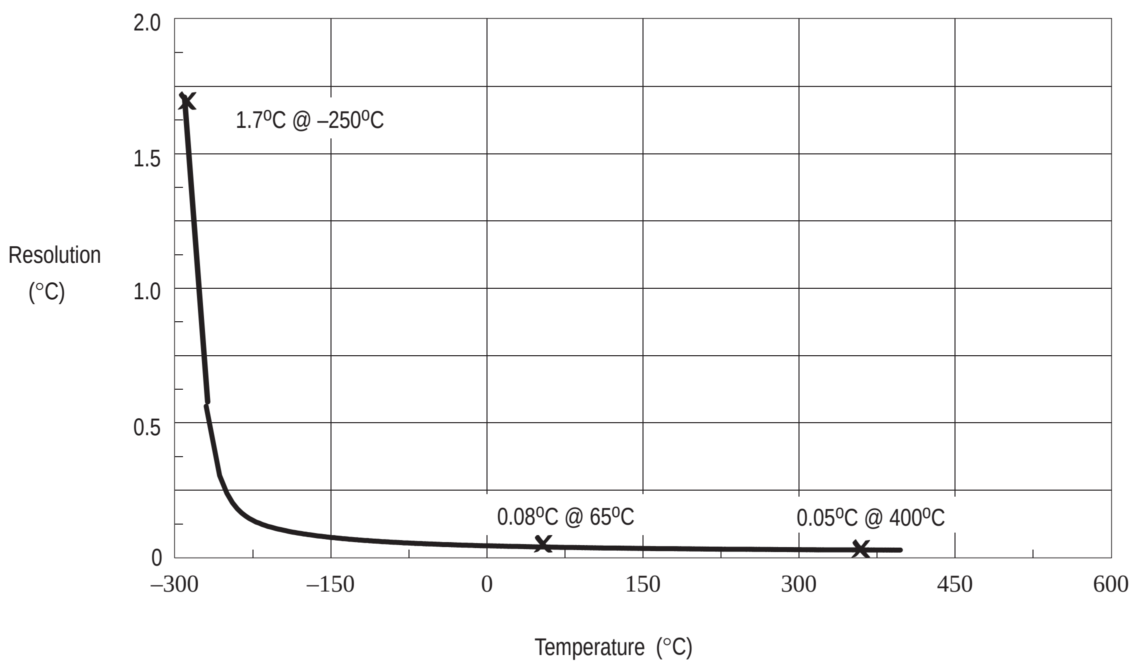
Type R Thermocouple



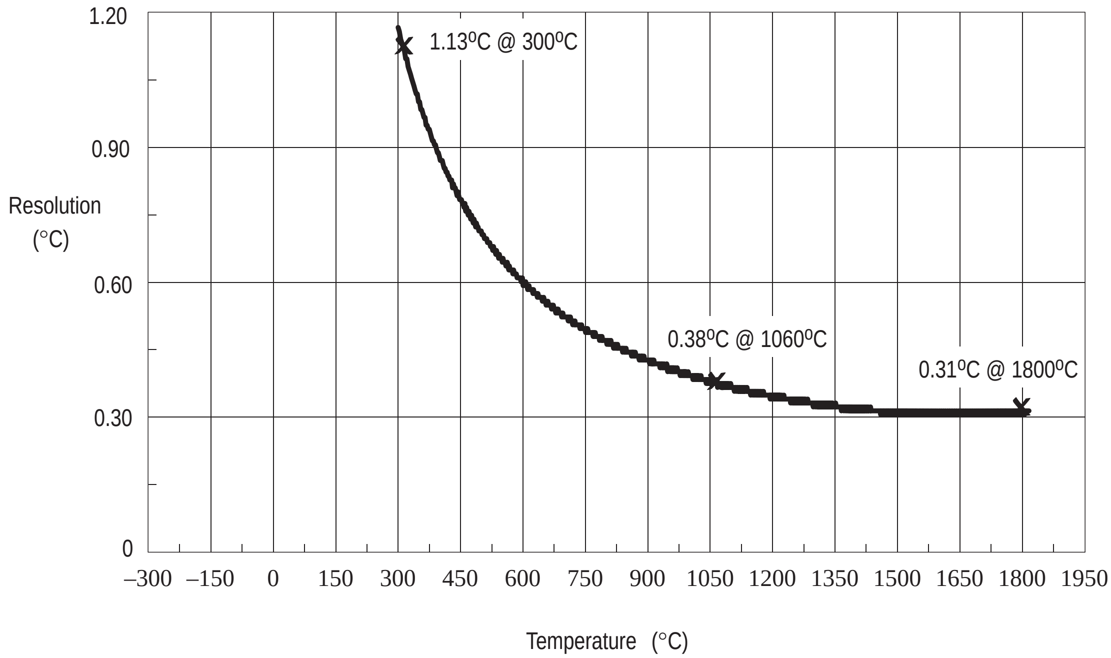
Type S Thermocouple



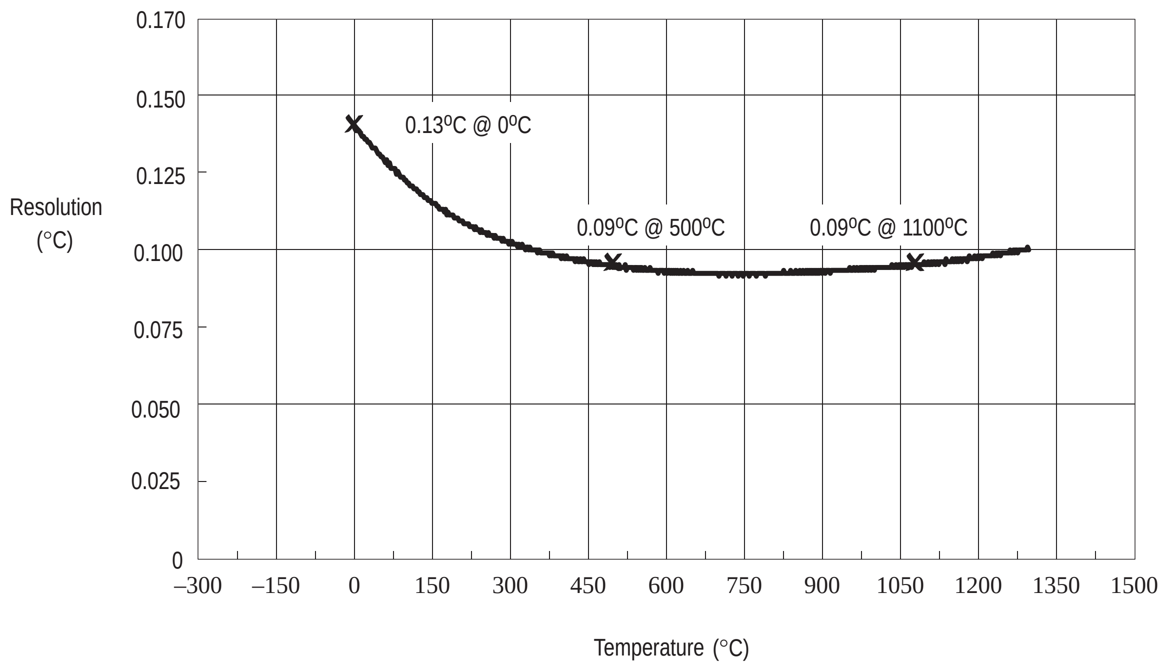
Type T Thermocouple



Type B Thermocouple



Type N Thermocouple



Channel Configuration Worksheets

Select your bit configurations. Write them down at the bottom of the worksheet. Use one worksheet for each channel.

Bit(s)	Define	To Select	Set these bits in the Channel Configuration Word 15-12	11	10	9	8	7	6	5	4	3	2	1	0	Description
0–3	Input Type	TC Type J										0	0	0	0	**Project ________________________** **Slot Number _____** **Channel Number _____**
		TC Type K										0	0	0	1	
		TC Type T										0	0	1	0	
		TC Type E										0	0	1	1	
		TC Type R										0	1	0	0	
		TC Type S										0	1	0	1	
		TC Type B										0	1	1	0	
		TC Type N										0	1	1	1	**Configure the channel for the input type connected to it.** Valid inputs are thermocouples and analog input signals of ±50mV and ±100mV. You can configure the channel to read the cold-junction (CJC) temperature. When reading the CJC temperature, the channel ignores the physical input signal.
		±50mV										1	0	0	0	
		±100mV										1	0	0	1	
		TC Type C										1	0	1	0	
		TC Type D										1	0	1	1	
		Invalid										1	1	0	0	
		Invalid										1	1	0	1	
		Invalid										1	1	1	0	
		CJC Temp.										1	1	1	1	
4, 5	Data Format	Engr. Units x1								0	0					**Select the channel data format from:** **Engineering units (EU) x1 or x10** For EU x1, values are in 0.1 degrees or 0.01mV. For EU x10, values are in whole °C or °F or 0.1mV. **Scaled-for-PID (value is the same for any input type)** Proportional input signal range is scaled to 0-16,383 counts. **Proportional counts (value is same for any input type)** Proportional input signal range is scaled to ±32,767 counts. For more information, refer to chapter 6..
		Engr. Units x10								0	1					
		Scaled-for-PID								1	0					
		Counts								1	1					
6, 7	Open Circuit Mode	Zero						0	0							**Select module response to a detected open circuit from:** **Zero** to force the channel data word to zero. U**pscale** to force the channel data word to full scale. D**ownscale** to force channel data word to low scale. **Important:** A bit selection or 1 1 is invalid. For an open CJC thermistor, mV channels are not affected. **Important:** The module requires 500 msec or one module update to flag the error while it ramps the channel input.
		Upscale						0	1							
		Downscale						1	0							
		Invalid						1	1							
8	Units °F, °C	Degrees C					0									**Select °C/°F for thermal inputs.** Ignored for mV inputs. **Important:** For EU x1 and °F (0.1°F), an over-range error will occur above 3276.7°F (cannot exceed 32767 counts).
		Degrees F					1									
9, 10	Unused	Unused			0	0										**These bits must be zero for a valid configuration.**
11	Chnl Enable	Channel Off		0												**Disable unused channels for faster response.** When set, the module configures the channel and reads the channel input before setting bit 11 in the status word. If you change the configuration word, the status word must reflect the change before new data is valid. If you clear the configuration word, the module clears channel and status words. For a new configuration word, channel data and status words remain cleared until the module sets this bit (11) in the status word.
		Channel On		1												
12-15	Unused	Unused	0000													**These bits must be zero for a valid configuration.**
Enter Your Bit Selections >>			0000													**For the Channel Configuration Word**

Select your bit configurations. Write them down at the bottom of the worksheet. Use one worksheet for each channel.

Channel Configuration Word (O:e.0 through O:e.3) – Bit Descriptions

Bit(s)	Define	To Select	Set these bits in the Channel Configuration Word													Description
			15-12	11	10	9	8	7	6	5	4	3	2	1	0	
0–3	Input Type	TC Type J										0	0	0	0	**Project ____________________**
		TC Type K										0	0	0	1	**Slot Number _____**
		TC Type T										0	0	1	0	**Channel Number _____**
		TC Type E										0	0	1	1	
		TC Type R										0	1	0	0	
		TC Type S										0	1	0	1	
		TC Type B										0	1	1	0	
		TC Type N										0	1	1	1	**Configure the channel for the input type connected to it.** Valid inputs are thermocouples and analog input signals of ±50mV and ±100mV. You can configure the channel to read the cold-junction (CJC) temperature. When reading the CJC temperature, the channel ignores the physical input signal.
		± 50mV										1	0	0	0	
		± 100mV										1	0	0	1	
		TC Type C										1	0	1	0	
		TC Type D										1	0	1	1	
		Invalid										1	1	0	0	
		Invalid										1	1	0	1	
		Invalid										1	1	1	0	
		CJC Temp.										1	1	1	1	
4, 5	Data Format	Engr. Units x1								0	0					**Select the channel data format from:** **Engineering units (EU) x1 or x10** For EU x1, values are in 0.1 degrees or 0.01mV. For EU x10, values are in whole °C or °F or 0.1mV. **Scaled-for-PID (value is the same for any input type)** Proportional input signal range is scaled to 0-16,383 counts. **Proportional counts (value is same for any input type)** Proportional input signal range is scaled to ±32,767 counts. For more information, refer to chapter 6..
		Engr. Units x10								0	1					
		Scaled-for-PID								1	0					
		Counts								1	1					
6, 7	Open Circuit Mode	Zero						0	0							**Select module response to a detected open circuit from:** **Zero** to force the channel data word to zero. U**pscale** to force the channel data word to full scale. D**ownscale** to force channel data word to low scale. **Important:** A bit selection or 1 1 is invalid. For an open CJC thermistor, mV channels are not affected. **Important:** The module requires 500 msec or one module update to flag the error while it ramps the channel input.
		Upscale						0	1							
		Downscale						1	0							
		Invalid						1	1							
8	Units °F, °C	Degrees C					0									**Select °C/°F for thermal inputs.** Ignored for mV inputs. **Important:** For EU x1 and °F (0.1°F), an over-range error will occur above 3276.7°F (cannot exceed 32767 counts).
		Degrees F					1									
9, 10	Unused	Unused			0	0										**These bits must be zero for a valid configuration.**
11	Chnl Enable	Channel Off		0												**Disable unused channels for faster response.** When set, the module configures the channel and reads the channel input before setting bit 11 in the status word. If you change the configuration word, the status word must reflect the change before new data is valid. If you clear the configuration word, the module clears channel and status words. For a new configuration word, channel data and status words remain cleared until the module sets this bit (11) in the status word.
		Channel On		1												
12-15	Unused	Unused	0000													**These bits must be zero for a valid configuration.**
Enter Your Bit Selections >>			0000													**For the Channel Configuration Word**

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Select your bit configurations. Write them down at the bottom of the worksheet. Use one worksheet for each channel.

Channel Configuration Word (O:e.0 through O:e.3) – Bit Descriptions

Bit(s)	Define	To Select	Set these bits in the Channel Configuration Word 15-12	11	10	9	8	7	6	5	4	3	2	1	0	Description
0–3	Input Type	TC Type J										0	0	0	0	**Project ____________________** **Slot Number _____** **Channel Number _____** **Configure the channel for the input type connected to it.** Valid inputs are thermocouples and analog input signals of ±50mV and ±100mV. You can configure the channel to read the cold-junction (CJC) temperature. When reading the CJC temperature, the channel ignores the physical input signal.
		TC Type K										0	0	0	1	
		TC Type T										0	0	1	0	
		TC Type E										0	0	1	1	
		TC Type R										0	1	0	0	
		TC Type S										0	1	0	1	
		TC Type B										0	1	1	0	
		TC Type N										0	1	1	1	
		±50mV										1	0	0	0	
		±100mV										1	0	0	1	
		TC Type C										1	0	1	0	
		TC Type D										1	0	1	1	
		Invalid										1	1	0	0	
		Invalid										1	1	0	1	
		Invalid										1	1	1	0	
		CJC Temp.										1	1	1	1	
4, 5	Data Format	Engr. Units x1								0	0					**Select the channel data format from:** **Engineering units (EU) x1 or x10** For EU x1, values are in 0.1 degrees or 0.01mV. For EU x10, values are in whole °C or °F or 0.1mV. **Scaled-for-PID (value is the same for any input type)** Proportional input signal range is scaled to 0-16,383 counts. **Proportional counts (value is same for any input type)** Proportional input signal range is scaled to ±32,767 counts. For more information, refer to chapter 6..
		Engr. Units x10								0	1					
		Scaled-for-PID								1	0					
		Counts								1	1					
6, 7	Open Circuit Mode	Zero						0	0							**Select module response to a detected open circuit from:** **Zero** to force the channel data word to zero. U**pscale** to force the channel data word to full scale. D**ownscale** to force channel data word to low scale. **Important:** A bit selection or 1 1 is invalid. For an open CJC thermistor, mV channels are not affected. **Important:** The module requires 500 msec or one module update to flag the error while it ramps the channel input.
		Upscale						0	1							
		Downscale						1	0							
		Invalid						1	1							
8	Units °F, °C	Degrees C					0									**Select °C/°F for thermal inputs.** Ignored for mV inputs. **Important:** For EU x1 and °F (0.1°F), an over-range error will occur above 3276.7°F (cannot exceed 32767 counts).
		Degrees F					1									
9, 10	Unused	Unused			0	0										**These bits must be zero for a valid configuration.**
11	Chnl Enable	Channel Off		0												**Disable unused channels for faster response.** When set, the module configures the channel and reads the channel input before setting bit 11 in the status word. If you change the configuration word, the status word must reflect the change before new data is valid. If you clear the configuration word, the module clears channel and status words. For a new configuration word, channel data and status words remain cleared until the module sets this bit (11) in the status word.
		Channel On		1												
12-15	Unused	Unused	0000													**These bits must be zero for a valid configuration.**
Enter Your Bit Selections >>			0000													**For the Channel Configuration Word**

Select your bit configurations. Write them down at the bottom of the worksheet. Use one worksheet for each channel.

Channel Configuration Word (O:e.0 through O:e.3) – Bit Descriptions

Bit(s)	Define	To Select	Set these bits in the Channel Configuration Word													Description
			15-12	11	10	9	8	7	6	5	4	3	2	1	0	
0–3	Input Type	TC Type J										0	0	0	0	**Project ________________________**
		TC Type K										0	0	0	1	**Slot Number _____**
		TC Type T										0	0	1	0	**Channel Number _____**
		TC Type E										0	0	1	1	
		TC Type R										0	1	0	0	
		TC Type S										0	1	0	1	
		TC Type B										0	1	1	0	**Configure the channel for the input type connected to it.** Valid inputs are thermocouples and analog input signals of ±50mV and ±100mV. You can configure the channel to read the cold-junction (CJC) temperature. When reading the CJC temperature, the channel ignores the physical input signal.
		TC Type N										0	1	1	1	
		± 50mV										1	0	0	0	
		± 100mV										1	0	0	1	
		TC Type C										1	0	1	0	
		TC Type D										1	0	1	1	
		Invalid										1	1	0	0	
		Invalid										1	1	0	1	
		Invalid										1	1	1	0	
		CJC Temp.										1	1	1	1	
4, 5	Data Format	Engr. Units x1								0	0					**Select the channel data format from:** **Engineering units (EU) x1 or x10** For EU x1, values are in 0.1 degrees or 0.01mV. For EU x10, values are in whole °C or °F or 0.1mV. **Scaled-for-PID (value is the same for any input type)** Proportional input signal range is scaled to 0-16,383 counts. **Proportional counts (value is same for any input type)** Proportional input signal range is scaled to ±32,767 counts. For more information, refer to chapter 6..
		Engr. Units x10								0	1					
		Scaled-for-PID								1	0					
		Counts								1	1					
6, 7	Open Circuit Mode	Zero						0	0							**Select module response to a detected open circuit from:** **Zero** to force the channel data word to zero. U**pscale** to force the channel data word to full scale. D**ownscale** to force channel data word to low scale. **Important:** A bit selection or 1 1 is invalid. For an open CJC thermistor, mV channels are not affected. **Important:** The module requires 500 msec or one module update to flag the error while it ramps the channel input.
		Upscale						0	1							
		Downscale						1	0							
		Invalid						1	1							
8	Units °F, °C	Degrees C					0									**Select °C/°F for thermal inputs.** Ignored for mV inputs. **Important:** For EU x1 and °F (0.1°F), an over-range error will occur above 3276.7°F (cannot exceed 32767 counts).
		Degrees F					1									
9, 10	Unused	Unused			0	0										**These bits must be zero for a valid configuration.**
11	Chnl Enable	Channel Off		0												**Disable unused channels for faster response.** When set, the module configures the channel and reads the channel input before setting bit 11 in the status word. If you change the configuration word, the status word must reflect the change before new data is valid. If you clear the configuration word, the module clears channel and status words. For a new configuration word, channel data and status words remain cleared until the module sets this bit (11) in the status word.
		Channel On		1												
12-15	Unused	Unused	0000													**These bits must be zero for a valid configuration.**
Enter Your Bit Selections >>			0000													**For the Channel Configuration Word**

Appendix C

Thermocouple Descriptions

The descriptions of thermocouples J, K, T, E, R, and S were extracted from NBS Monograph 125 (IPTS–68) issued March 1974. We also describe types C and D.

J Type Thermocouple

(Iron vs. Copper–Nickel <Constantan[1]>)

The J thermocouple “is the least suitable for accurate thermometry because there are significant nonlinear deviations in the thermoelectric output from different manufacturers. ... The total and specific types of impurities that occur in commercial iron change with time, location of primary ores, and methods of smelting.”

“Type J thermocouples are recommended by the ASTM [1970] for use in the temperature range from 0 to 760C in vacuum, oxidizing, reducing or inert atmospheres. If used for extended times above 500C, heavy gauge wires are recommended because the oxidation rate is rapid at elevated temperatures.”

“They should not be used in sulfurous atmospheres above 500C. Because of potential rusting and embrittlement, they are not recommended for subzero temperatures. They should not be cycled above 760C even for a short time if accurate reading below 760C are desired at a later time.”

“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.”

“Commercial iron undergoes a magnetic transformation near 769C and <an alpha – gamma> crystal transformation near 910C. Both of these transformation, especially the latter, seriously affect the thermoelectric properties of iron, and therefore, the Type J thermocouples. ... If Type J thermocouples are taken to high temperatures, especially above 900C, they will lose accuracy of their calibration when they are recycled to lower temperatures.”

“ASTM Standard E230–72 in the Annual Book of ASTM Standards [1972] specifies that the standard limits of error for Type J commercial thermocouples be ±2.2C between 0 and 277C and ±3/4 percent between 277 and 760C. Limits of error are not specified for Type J thermocouples below 0C or above 760C. Type J thermocouples can also be supplied to meet special limits of error, which are equal to one half the limits given above. The recommended upper temperature limit for protected thermocouples, 760C, applies to AWG 8 (3.3mm) wire. For smaller wires the recommended upper temperature decreases to 593C for AWG 14 (1.6mm), and 371C for AWG 24 or 28 (0.5 or 0.3mm).”

[1] It should be noted that the Constantan element of Type J thermoelements is NOT interchangeable with the Constantan element of Types T or N due to the different ration of copper and nickel in each.

K Type Thermocouple

(NIckel–Chromium vs. Nickel–Aluminum)

“This type is more resistant to oxidation at elevated temperatures than the Types E, J or T thermocouples and consequently it finds wide application at temperatures above 500C.”

“Type K thermocouples may be used at “liquid hydrogen” temperatures. However, their Seebeck coefficient (about 4uV/K at 20K) is only about one–half of that of E thermocouples. Furthermore, the thermoelectric homogeneity of KN thermoelements is generally not quite as good as that of EN thermoelements. Both the KP and the KN thermoelements do have a relatively low thermal conductivity and good resistance to corrosion in moist atmospheres at low temperatures.”

“Type K thermocouples are recommended by the ASTM [1970] for continuous use at temperatures within the range –250 to 1260C in oxidizing or inert atmospheres. Both the KP and the KN thermoelements are subject to oxidation when used in air above about 850C, but even so, Type K thermocouples may be used at temperatures up to about 1350C for short periods with only small changes in calibration.”

“They should not be used in sulfurous, reducing, or alternately reducing and oxidizing atmospheres unless suitably protected with protecting tubes. They should not be used in vacuum (at high temperatures) for extended times because the Chromium in the positive thermoelement vaporizes out of solution and alters the calibration. They should also no be used in atmospheres that promote “green–rot” corrosion (those with low, but not negligible, oxygen content).”

“ASTM Standard E230–72 in the Annual Book of ASTM Standards [1972] specifies that the standard limits of error for Type K commercial thermocouples be ±2.2C between 0 and 277C and ±3/4 percent between 277 and 1260C/ Limits of error are not specified for the Type K thermocouples below 0C. Type K thermocouples can also be supplied to meet special limits of error, which are equal to one half the standard limits of error given above. The recommended upper temperature limit for protected Type K thermocouples, 1260C, applies for AWG 8 (3.3mm) wire. For smaller wires it decreases to 1093C for AWG 14 (1.6mm), 982C for AWG 20 (0.8mm), and 871C for AWG 24 or 28 (0.5 or 0.3mm).”

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T Type Thermocouple

(Copper vs. Copper–Nickel <Constantan[①]>)

“The homogeneity of most Type TP and TN (or EN) thermoelements is reasonably good. However, the Seebeck coefficient of Type T thermocouples is moderately small at subzero temperatures (about 5.6uV/K at 20K), being roughly two–thirds that of Type E thermocouples. This, together with the high thermal conductivity of Type TP thermoelements, is the major reason why Type T thermocouples are less suitable for use in the subzero range than Type E thermocouples.”

“Type T thermocouples are recommended by the ASTM [1970] for use in the temperature range –184 to 371C in vacuum or in oxidizing, reducing or inert atmospheres. The recommended upper temperature limit for continuous service of protected Type T thermocouples is set at 371C for AWG 14 (1.6mm) 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 Roeser and Dahl [1938] observed negligible changes in the thermoelectric voltage of Nos. 12, 18, and 22 AWG Type TP thermoelements after heating for 30 hours in air at 500C. At this temperature the Type TN thermoelements have good resistance to oxidation and exhibit only small changes in thermal emf with long exposure in air, as shown by the studies of Dahl [1941].” ... “Operation of Type T thermocouples in hydrogen atmospheres at temperatures above about 370C is not recommended since severe embrittlement of the Type TP thermoelements may occur.”

“Type T thermoelements 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 thermoelement is converted to nickel and zinc.”

“Because of the high thermal conductivity of Type TP thermoelements, special care should be exercised in the use of the thermocouples to insure that both the measuring and reference junctions assume the desired temperatures.”

ASTM Standard E230–72 in the Annual Book of ASTM Standards [1972] specifies that the standard limits of error for Type T commercial thermocouples be ±2 percent between –101 and –59C, ±0.8C between –59 and 93C and ±3/4 percent between 93 and 371C. Type T thermocouples can also be supplied to meet special limits of error, which are equal to one half the standard limits of error given above (plus a limit of error of ±1 percent is specified between –184 and –59C). The recommended upper temperature limit for protected Type T thermocouples, 371C, applies to AWG 14 (1.6mm) wire. For smaller wires it decreases to 260C for AWG 20 (0.8mm) and 240C for AWG 24 or 28 (0.5 or 0.3mm).”

① It should be noted that the Constantan element of Type J thermoelements is NOT interchangeable with the Constantan element of Types T or N due to the different ration of copper and nickel in each.

E Type Thermocouple

(Nickel–Chromium vs. Copper–Nickel <Constantan[1]>)

“Type E thermocouples are recommended by the ASTM Manual [1970] for use in the temperature range from –250 to 871C in oxidizing or inert atmospheres. The negative thermoelement is subject to deterioration above about 871C, but the thermocouple may be used up to 1000C for short periods.”

“The ASTM Manual [1970] indicates the following restrictions ... at high temperatures. They should not be used in sulfurous, reducing or alternately reducing and oxidizing atmospheres unless suitable protected with protecting tubes. They should not be used in vacuum (at high temperatures) for extended times, because the Chromium in the positive thermoelement vaporizes out of solution and alters the calibration. They should also not be used in atmospheres that promote “green–rot” corrosion (those with low, but not negligible, oxygen content).”

“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.”

“ASTM Standard E230–72 in the Annual Book of ASTM Standards [1972] specifies that the standard limits of error for the Type E commercial thermocouples be ±1.7C between 0 and 316C and ±1/2 percent between 316 and 871C. Limits of error are not specified for Type E thermocouples below 0C. Type E thermocouples can also be supplied to meet special limits of error, which are less than the standard limits of error given above: ±1.25C between 0 and 316C and ±3/8 percent between 316 and 871C, applies to AWG 8 (3.3mm) wire. For smaller wires the recommended upper temperature decreases to 649C for AWG 14 (1.6mm), 538C for AWG 20 (0.8mm) and 427C for AWG 24 or 28 (0.5 or 0.3mm).”

[1] It should be noted that the Constantan element of Type J thermoelements is NOT interchangeable with the Constantan element of Types T or N due to the different ration of copper and nickel in each.

S and R Type Thermocouples

S (Platinum–10% Rhodium vs. Platinum)
R (Platinum–13% Rhodium vs. Platinum)

"The ASTM manual STP 470 [1970] indicates the following restrictions on the use of S {and R} type thermocouples at high temperatures: They should not be used in reducing atmospheres, nor in those containing metallic vapor (such as lead or zinc), nonmetallic vapors (such as arsenic, phosphorous or sulfur) or easily reduced oxides, unless suitable protected with nonmetallic protecting tubes. They should never be inserted directly into a metallic primary tube."

"The positive thermoelement, platinum–10% rhodium {13% rhodium for R}, is unstable in a thermal neutron flux because the rhodium converts to palladium. The negative thermoelement, pure platinum, is relatively stable to neutron transmutation. However, fast neutron bombardment will cause physical damage, which will change the thermoelectric voltage unless it is annealed out."

"The thermoelectric voltages of platinum based thermocouples are sensitive to their heat treatments. In particular, quenching from high temperatures should be avoided."

"ASTM Standard E230–72 in the Annual Book of ASTM Standards [1972] specifies that the standard limits of error for Type S {and R} commercial thermocouples be ±1.4C between 0 and 538C and ±1/4 percent between 538 and 1482C. Limits of error are not specified for Type S {or R} thermocouples below 0C. The recommended upper temperature limit for continuous use of protected thermocouples, 1482C, applies to AWG 24 (0.5mm) wire."

C and D Type Thermocouples

C (Tungsten-5% Rhenium vs. Tungsten-26% Rhenium)
D (Tungsten-3% Rhenium vs. Tungsten-25% Rhenium)

Types C and D thermocouples are recommended for use in the temperature range from 0 to 2320°C in *non*-oxidizing inert atmospheres. They are *not* practical for use below 750°F. Beware of embrittlement.

Code	Color code	Max Useful Temp Range	EMF Over Useful Range	Std Limits of Error
C	jacket:: wht-red trace + = wht, – = red	TC grade: 32-4208°F (0-2320°C) Ext grade: 32-1600°F (0-870°C)	0-37.066 mV	4.5-450°C 1.0% to 2320°C
D	jacket:: wht-yel trace + = wht, – = red	TC grade: 32-4208°F (0-2320°C) Ext grade: 32-500°F (0-260°C)	0-39.506 mV	4.5-450°C 1.0% to 2320°C

Channel Calibration

This appendix shows you how to calibrate the module's input channels.

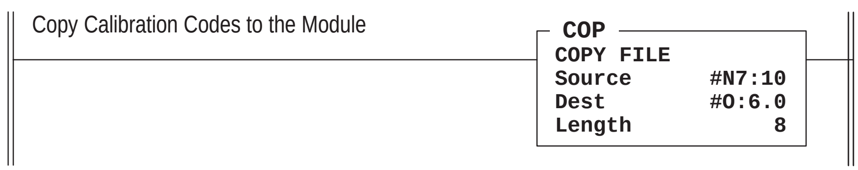
About the Procedure

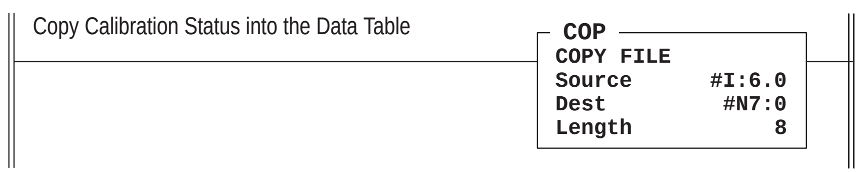
The purpose of the procedure is to store a pair of calibration values in EEPROM for each channel to set channel accuracy at 0.05% of full range regardless of channel circuit tolerances. The module is designed so you can calibrate its input channels individually or in groups. The thermocouple/mV operation of all channels is suspended during calibration.

With your programming terminal, you will enter calibration codes in word 5 of the configuration file and read status in words 4 and 5 of the status file. A rung of ladder logic copies calibration codes into the output image table for transfer to the module, and another rung copies calibration status from the module (input image table) into the data table. You perform calibration with the SLC processor in run mode. For more information on addressing calibration words, refer to chapter 4.

Calibration Logic

Before starting the procedure, enter the following calibration rungs into processor memory:

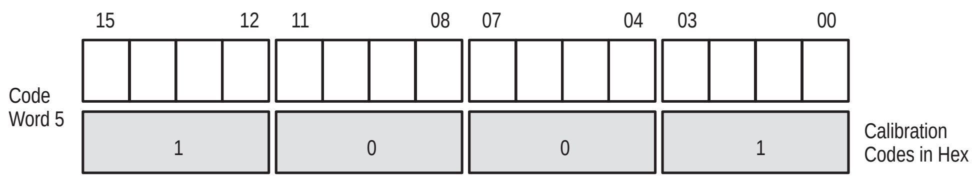




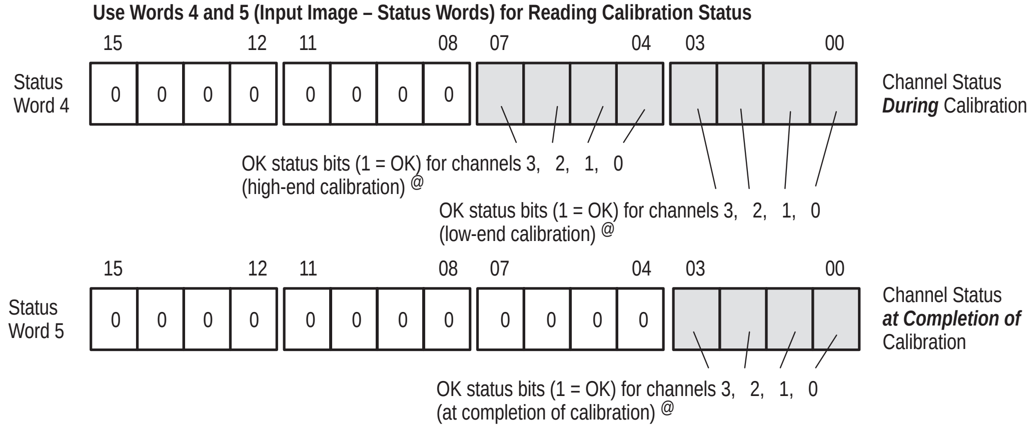
Calibration Codes and Status

Use the following format for entering calibration code words and reading calibration status bits. You will enter calibration values in Hex. You can read channel status OK bits at different steps in the calibration procedure, one bit for each channel you are calibrating.

Use Word 5 (Output Image – Configuration Word) for Entering Calibration Codes



Use Words 4 and 5 (Input Image – Status Words) for Reading Calibration Status



Channel status words 6 and 7 display “CAL4” during calibration

@ Reads F Hex if all four channels are OK.

Calibration Procedure

To perform this calibration procedure, you will need a precision dc voltmeter and precision power supply that can display and maintain a calibration voltage to 1/1000 of a millivolt: at 0.000 mV and 90.000 mV.

Prepare for calibration by removing the thermocouple leads from the input terminals of the channels that you want to calibrate. Switch the SLC processor to run mode so it can execute the calibration ladder logic. For convenience, we suggest that you calibrate all four channels at the same time.

1. With your programming terminal, enter calibration code **1001 Hex** into the data table address for configuration word 5.

2. Observe **status words 0-3, 6 and 7**.
The module returns the code “CAL4” Hex in status words 6 and 7.
It also clears channel data words 0-3.

3. Short circuit the pairs of input terminals for the channels you want to calibrate. Make the jumper as short as possible.

4. With your programming terminal, enter calibration code **1002 Hex** into the data table address for configuration word 5.

5. Observe **bits 0-3 in status word 4.**
If all the channels you are calibrating see zero voltage, the module returns status-OK bits set, one bit for each channel (F Hex for all four channels). Otherwise, the module returns channel status bits set to zero.

6. Apply 90.000 mV to the pairs of input terminals, all in parallel, for the channels you are calibrating. Make your leads as short as possible.

7. With your programming terminal, enter calibration code **1004 Hex** into the data table address for configuration word 5.

8. Observe **bits 4-7 in status word 4**.
If all the channels you are calibrating see 90.000 mV, the module returns status-OK bits set, one bit for each channel (F Hex for all four channels). Otherwise, the module returns channel status bits set to zero.

9. Remove the 90.000 mV calibration voltage.

10. With your programming terminal, enter calibration code **1008 Hex** into the data table address for configuration word 5.

11. Observe **bits 0-3 in status word 5.**
After the module burns the calibration values into its EEPROM, it returns status-OK bits set, one bit for each channel (F Hex for all four channels). If the module could not complete the calibration of one or more channels, it returns a zeroed status bit for that channel (non-F Hex returned)

12. To end the calibration procedure, enter calibration code **0000 Hex** into the data table address for configuration word 5 with your programming terminal. During thermocouple/mV operation, word 5 must be zero.

Notes:

Terms and Abbreviations

Terms and Abbreviations

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 – Refers to the analog-to-digital converter within the module. The converter produces a digital value whose magnitude is proportional to the instantaneous magnitude of an analog input signal.

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

channel – Refers to one of four, small-signal analog input interfaces to the module's terminal block. Each channel is configured for connection to a thermocouple or DC millivolt (mV) input device, and has its own configuration and status words.

chassis – A hardware assembly that houses devices such as I/O modules, adapter modules, processor modules, and power supplies.

CJC – (Cold Junction Compensation) The means by which the module compensates for the offset voltage error introduced by the temperature at the junction between the thermocouple lead wire and the input terminal block (the cold junction).

common mode rejection ratio – 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.
$CMRR=20\ Log_{10}\ (V1/V2)$

common mode voltage – A voltage signal induced in conductors with respect to ground (0 potential).

configuration word – Contains the channel configuration information needed by the module to configure and operate each channel. The module is designed for software rather than hardware configuration.

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

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

data word – A 16-bit integer that represents the value of the analog 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).

digital filter – A low-pass filter of the A/D converter. The digital filter provides high-frequency noise rejection.

effective resolution – The number of bits in the channel data word used to represent useful information.

full scale error – (gain error) The difference in slope between the actual and ideal analog/thermocouple transfer functions.

full scale range – (FSR) The difference between the maximum and minimum specified analog/thermocouple input values.

gain drift – The change in full scale transition voltage measured over the operating temperature range of the module.

input data scaling –Depends on the data format that you select for the channel data word. You can select from scaled-for-PID or Engineering Units for millivolt, thermocouple, or CJC inputs, which are automatically scaled. You may also select proportional counts, which you must compute to fit your application's temperature or voltage resolution.

local system – A control system with I/O chassis within several feet of the processor, and using1746-C7 or 1746-C9 ribbon cable for communication.

LSB – (Least Significant Bit) The bit that represents the smallest value within a string of bits. Refers to a data increment defined as the full scale range divided by the resolution.

multiplexer – An switching system that allows several input 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 electrical noise between differential inputs, but not between an input and ground or ground reference.

remote system – A control system where the chassis can be located several thousand feet from the processor chassis. Chassis communication is via the 1747-SN Scanner and 1747-ASB Remote I/O Adapter.

resolution – The smallest detectable change in a measurement, typically expressed in engineering units (e.g. 0.15C) or as a number of bits. For example, a 12-bit value has 4,096 possible counts. It can therefore be used to measure 1 part in 4096.

sampling time – The time for an A/D converter to sample an input channel.

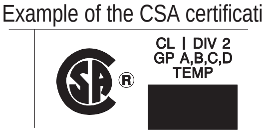
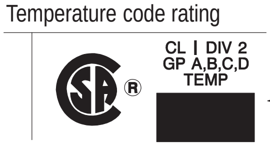
status word – Contains status information about the channel's current configuration and operational state. You can use this information in your ladder program to determine whether the channel data word is valid.

step response time – This is the time required for the module to process an input signal to reach *99.9%* of its expected final value, given a large step change in the input signal.

update time – The time for the module to sample and convert a channel input signal and make the resulting value available to the SLC™ processor.

Appendix **F**

CSA Hazardous Location Approval

CSA Hazardous Location Approval	Approbation d'utilisation dans des emplacements dangereux par la CSA
CSA® certifies products for general use as well as for use in hazardous locations. **Actual CSA certification is indicated by the product label** as shown below, and not by statements in any user documentation.	La CSA® certifie les produits d'utilisation générale aussi bien que ceux qui s'utilisent dans des emplacements dangereux. **La certification CSA en vigueur est indiquée par l'étiquette du produit** et non par des affirmations dans la documentation à l'usage des utilisateurs.
Example of the CSA certification product label 	Exemple d'étiquette de certification d'un produit par la CSA 
To comply with CSA certification for use in hazardous locations, the following information becomes a part of the product literature for CSA-certified Allen-Bradley industrial control products. • This equipment is suitable for use in Class I, Division 2, Groups A, B, C, D, or non-hazardous locations only. • The products having the appropriate CSA markings (that is, Class I Division 2, Groups A, B, C, D), are certified for use in other equipment where the suitability of combination (that is, application or use) is determined by the CSA or the local inspection office having jurisdiction.	Pour satisfaire à la certification de la CSA dans des endroits dangereux, les informations suivantes font partie intégrante de la documentation des produits industriels de contrôle Allen-Bradley certifiés par la CSA. • Cet équipement convient à l'utilisation dans des emplacements de Classe I, Division 2, Groupes A, B, C, D, ou ne convient qu'à l'utilisation dans des endroits non dangereux. • Les produits portant le marquage approprié de la CSA (c'est à dire, Classe I, Division 2, Groupes A, B, C, D) sont certifiés à l'utilisation pour d'autres équipements où la convenance de combinaison (application ou utilisation) est déterminée par la CSA ou le bureau local d'inspection qualifié.
Important: Due to the modular nature of a PLC® control system, the product with the highest temperature rating determines the overall temperature code rating of a PLC control system in a Class I, Division 2 location. The temperature code rating is marked on the product label as shown.	**Important:** Par suite de la nature modulaire du système de contrôle PLC®, le produit ayant le taux le plus élevé de température détermine le taux d'ensemble du code de température du système de contrôle d'un PLC dans un emplacement de Classe I, Division 2. Le taux du code de température est indiqué sur l'étiquette du produit.
Temperature code rating  Look for temperature code rating here	Taux du code de température  Le taux du code de température est indiqué ici
The following warnings apply to products having CSA certification for use in hazardous locations.	Les avertissements suivants s'appliquent aux produits ayant la certification CSA pour leur utilisation dans des emplacements dangereux.
ATTENTION: Explosion hazard — • Substitution of components may impair suitability for Class I, Division 2. • Do not replace components unless power has been switched off or the area is known to be non-hazardous. • Do not disconnect equipment unless power has been switched off or the area is known to be non-hazardous. • Do not disconnect connectors unless power has been switched off or the area is known to be non-hazardous. Secure any user-supplied connectors that mate to external circuits on an Allen-Bradley product using screws, sliding latches, threaded connectors, or other means such that any connection can withstand a 15 Newton (3.4 lb.) separating force applied for a minimum of one minute.	**AVERTISSEMENT:** Risque d'explosion — • La substitution de composants peut rendre ce matériel inacceptable pour lesemplacements de Classe I, Division 2. • Couper le courant ou s'assurer quel'emplacement est désigné non dangereux avant de remplacer lescomposants. • Avant de débrancher l'équipement, couper le courant ou s'assurer que l'emplacement est désigné non dangereux. • Avant de débrancher les connecteurs, couper le courant ou s'assurer que l'emplacement est reconnu non dangereux. Attacher tous connecteurs fournis par l'utilisateur et reliés aux circuits externes d'un appareil Allen-Bradley à l 'aide de vis, loquets coulissants, connecteurs filetés ou autres moyens permettant aux connexions de résister à une force de séparation de 15 newtons (3,4 lb. - 1,5 kg) appliquée pendant au moins une minute.
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Rockwell Automation

Allen-Bradley

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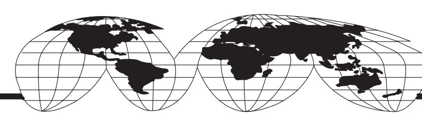

Worldwide representation.

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