# FLEX I/O Thermocouple/Millivolt Input Module

Catalog Number 1794-IT8

Allen-Bradley
by ROCKWELL AUTOMATION

**User Manual**

Original Instructions

# Important User Information

Read this document and the documents listed in the additional resources section about installation, configuration, and operation of this equipment before you install, configure, operate, or maintain this product. Users are required to familiarize themselves with installation and wiring instructions in addition to requirements of all applicable codes, laws, and standards.

Activities including installation, adjustments, putting into service, use, assembly, disassembly, and maintenance are required to be carried out by suitably trained personnel in accordance with applicable code of practice.

If this equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

In no event will Rockwell Automation, Inc. 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, Rockwell Automation, Inc. cannot assume responsibility or liability for actual use based on the examples and diagrams.

No patent liability is assumed by Rockwell Automation, Inc. with respect to use of information, circuits, equipment, or software described in this manual.

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

**WARNING:** Identifies information about practices or circumstances that can cause an explosion in a hazardous environment, which may lead to personal injury or death, property damage, or economic loss.

**ATTENTION:** Identifies information about practices or circumstances that can lead to personal injury or death, property damage, or economic loss. Attentions help you identify a hazard, avoid a hazard, and recognize the consequence.

**IMPORTANT** Identifies information that is critical for successful application and understanding of the product.

These labels may also be on or inside the equipment to provide specific precautions.

**SHOCK HAZARD:** Labels may be on or inside the equipment, for example, a drive or motor, to alert people that dangerous voltage may be present.

**BURN HAZARD:** Labels may be on or inside the equipment, for example, a drive or motor, to alert people that surfaces may reach dangerous temperatures.

**ARC FLASH HAZARD:** Labels may be on or inside the equipment, for example, a motor control center, to alert people to potential Arc Flash. Arc Flash will cause severe injury or death. Wear proper Personal Protective Equipment (PPE). Follow ALL Regulatory requirements for safe work practices and for Personal Protective Equipment (PPE).

The following icon may appear in the text of this document.

Identifies information that is useful and can help to make a process easier to do or easier to understand.

# Table of Contents

## Appendix A

**Resolution Curves, Worst Case Accuracy, Error Due to Open Circuit Current, and Worst Case Repeatability**

## About This Publication

This manual describes how to program, configure, and calibrate your FLEX™ I/O thermocouple/millivolt (mV) module.

## Who Should Use This Manual

This manual is intended for qualified personnel. You should be familiar with an Allen-Bradley® programmable logic controller features and its terminology we use. If not, see the user manual for your processor before attempting to use these modules.

In addition, if you are using this module in a DeviceNet® system, you must be familiar with DeviceNetManager™ Software and Microsoft Windows®. If not, see your software documentation or online help before attempting to use these modules.

## Download Firmware, AOP, EDS, and Other Files

Download firmware, associated files (such as AOP, EDS, and DTM), and access product release notes from the Product Compatibility and Download Center at rok.auto/pcdc.

## Summary of Changes

This publication contains the following new or updated information. This list includes substantive updates only and is not intended to reflect all changes.

| Topic | Page |
|---|---|
| Updated template | throughout |
| Updated Additional Resources | 5 |
| Added topic Module Overview | 7 |
| Updated definition for read word 10, bit 07 (07) in Table 4 | 16 |
| Updated definition for read word 11, bit 07 (07) in Table 8 | 22 |
| Updated temperature range for thermocouple types E, J, K, L, and T | 13, 13, 17, and 23 |
| Updated manual calibration procedure | 26 and 29...34 |
| Removed module specification details from Appendix A | 39 |
| Removed section How To Install Your Module | – |
| Removed Appendix B - Thermocouple Restrictions (Extracted from NBS Monograph 125 [IPTS-68]) | – |

## Additional Resources

These documents contain additional information concerning related products from Rockwell Automation. You can view or download publications at rok.auto/literature.

| Resource | Description |
|---|---|
| FLEX I/O and FLEX I/O-XT Selection Guide, publication 1794-SG002 | Provides guidance on how to select the FLEX I/O and FLEX I/O-XT™ modules and its accessories. |
| FLEX I/O Thermocouple/mV Input Module and RTD Input Module Installation Instructions, publication 1794-IN021 | Describes how to install and wire a FLEX I/O Thermocouple/mV input module or an RTD input module. |
| FLEX I/O DeviceNet Adapter Modules Installation Instructions, publication 1794-IN099 | Describes how to install and wire a FLEX I/O DeviceNet adapter. |
| 1794 FLEX I/O Analog, TC and RTD Modules Specifications Technical Data, publication 1794-TD016 | Describes technical, environmental, and certification specifications for FLEX I/O analog, TC, and RTD modules. |
| FLEX I/O EtherNet/IP Adapters Installation Instructions, publication 1794-IN082 | Describes how to install and wire the FLEX I/O EtherNet/IP™ adapters. |
| System Security Design Guidelines Reference Manual, publication SECURE-RM001 | Provides guidance on how to conduct security assessments, implement Rockwell Automation products in a secure system, harden the control system, manage user access, and dispose of equipment. |
| Industrial Components Preventive Maintenance, Enclosures, and Contact Ratings Specifications, publication IC-TD002 | Provides a quick reference tool for Allen-Bradley industrial automation controls and assemblies. |
| Safety Guidelines for the Application, Installation, and Maintenance of Solid-state Control, publication SGI-1.1 | Designed to harmonize with NEMA Standards Publication No. ICS 1.1-1987 and provides general guidelines for the application, installation, and maintenance of solid-state control in the form of individual devices or packaged assemblies incorporating solid-state components. |
| Industrial Automation Wiring and Grounding Guidelines, publication 1770-4.1 | Provides general guidelines for installing a Rockwell Automation industrial system. |
| Product Certifications website, rok.auto/certifications | Provides declarations of conformity, certificates, and other certification details. |

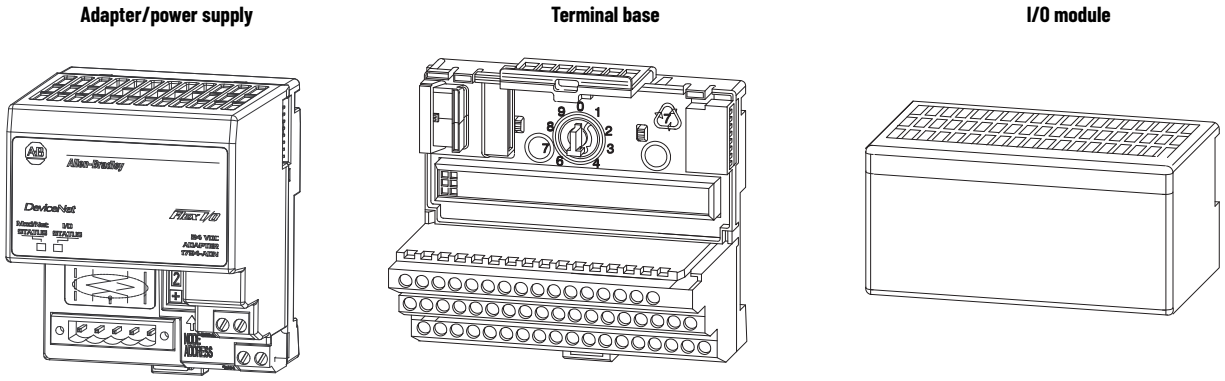
# Notes:

# Overview of FLEX I/O System and Thermocouple/mV Module

## FLEX I/O System

FLEX I/O is a distributed I/O system that connects to several networks including EtherNet/IP, ControlNet®, and DeviceNet. FLEX I/O is a flexible, low-cost, modular I/O for distributed applications and offers all the functions of larger, rack-based I/O without the space requirements. See Figure 1 to know the components of FLEX I/O system.

**Figure 1 - FLEX I/O System Components**




- **Adapter/power supply** – It powers the internal logic for up to eight FLEX I/O modules.
- **Terminal base** – It contains a terminal strip to terminate wiring for thermocouple/mV inputs.
- **I/O module** – It contains the bus interface and circuitry needed to perform specific functions related to your application.

## Module Overview

The FLEX I/O thermocouple/mV input module is a temperature/mV measuring module that accepts inputs from various thermocouples and from the mV source in the range of ±76.5 mV. The FLEX I/O thermocouple/mV input module is effective if you need:

- A cost effective module
- Applications that do not require high accuracy or high speed
- Support for grounded or ungrounded thermocouples

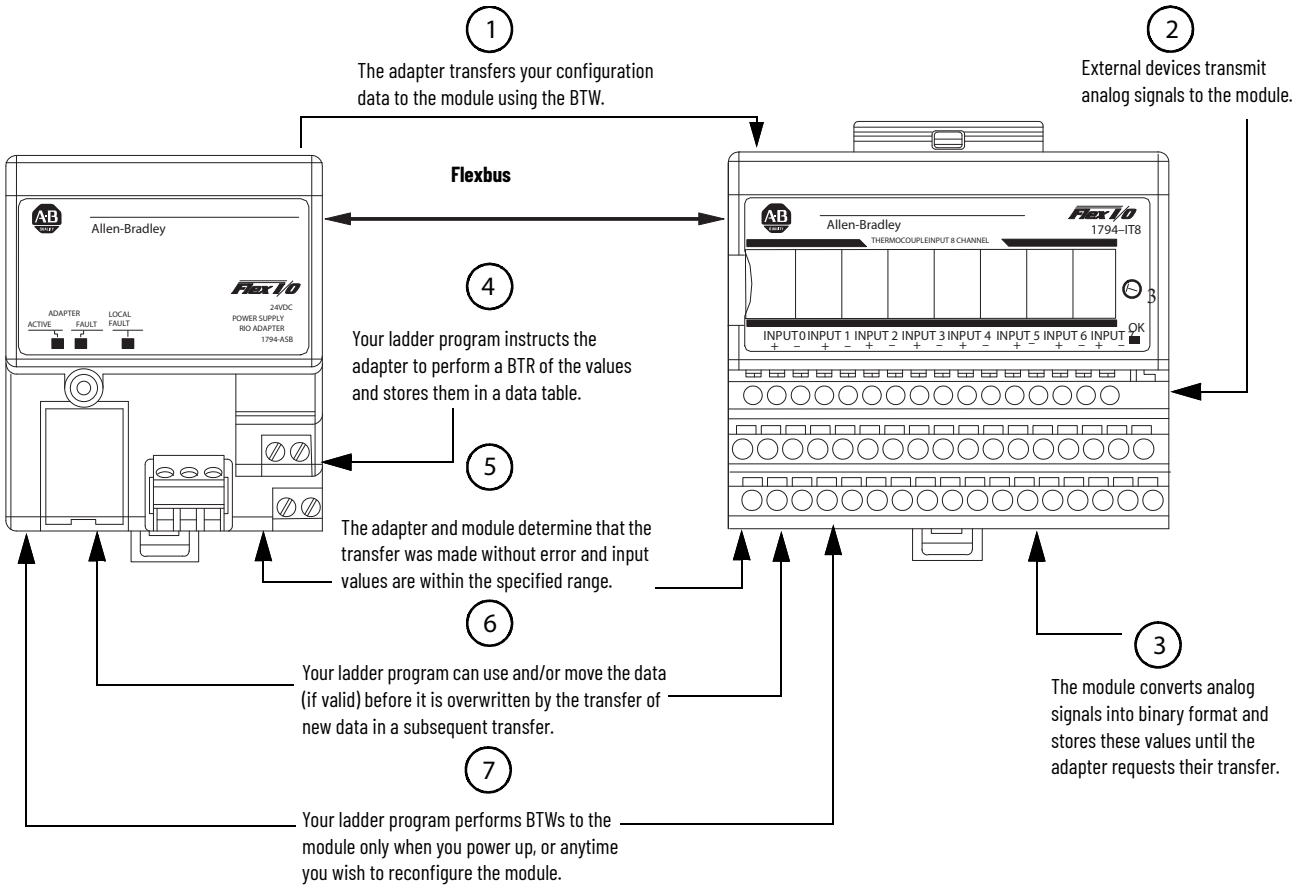
Use cold junction compensators in thermocouple mode. Two cold junction compensators are shipped with the FLEX I/O thermocouple/mV input module. You can order additional compensators using the catalog number 1794-CJC2. This module is suitable to work with grounded thermocouples, if certain guidelines are followed.

## How Modules Communicate with Programmable Controllers

The FLEX I/O thermocouple/mV input modules are block transfer modules that interface analog signals with any Allen-Bradley programmable controller that has block transfer capability. Block transfer programming moves input or output data words between the module memory and a designated area in the processor data table. Block transfer programming also moves configuration words from the processor data table to module memory.

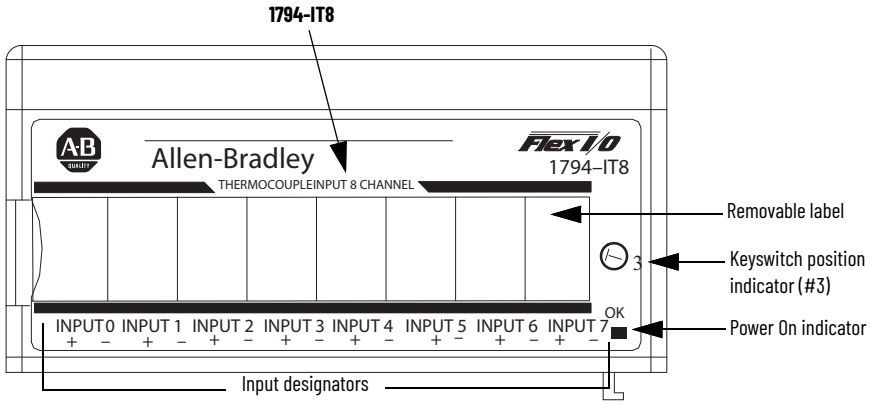
The FLEX I/O adapter/power supply transfers data to the module (Block Transfer Write [BTW]) and from the module (Block Transfer Read [BTR]) using BTW and BTR instructions in your ladder diagram program. These instructions let the adapter obtain input or output values and status from the module, and let you establish the modules mode of operation. Figure 2 shows the typical communication process.

**Figure 2 - Typical Communication Between an Adapter and an I/O Module**




## Features of Your Module

The module label identifies the keyswitch position, wiring, and module type. A removable label provides space for writing individual designations per your application.




The thermocouple/mV input module comes with two cold junction compensators. These are designed to mount in designated positions on the temperature terminal base unit (1794-TB3T). See FLEX I/O Thermocouple/mV Input Module and RTD Input Module Installation Instructions, publication 1794-IN021 on how to install the cold junction compensator assemblies.

## Power Requirements

The current draw through the terminal base determines the wiring of the terminal base unit. Verify that the current draw does not exceed 10 A.

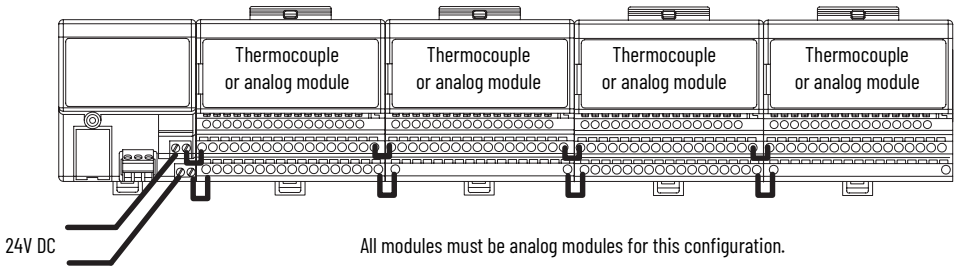
**ATTENTION:** Total current draw through the terminal base unit is limited to 10 A. Separate power connections may be necessary.

Methods of wiring the terminal base units are shown in Figure 3.

**ATTENTION:** Do not daisy-chain power or ground from the thermocouple terminal base unit to any AC or DC discrete module terminal base unit.

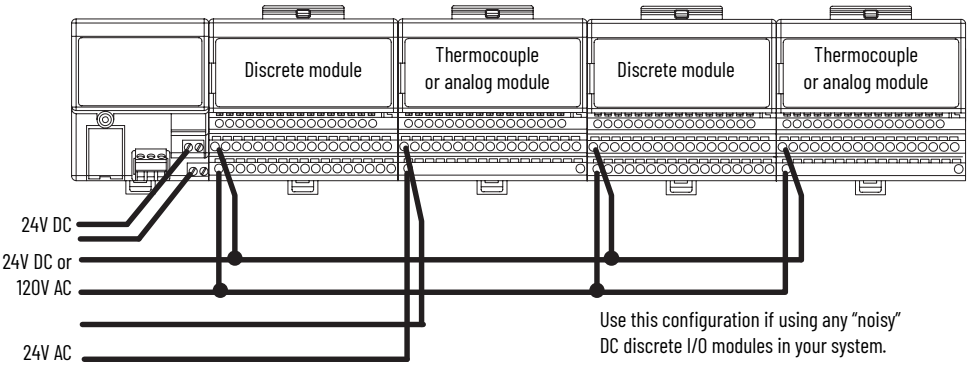
**Figure 3 - Terminal Base Wiring - 1794-TB2 and 1794-TB3**

**Daisy-chaining**



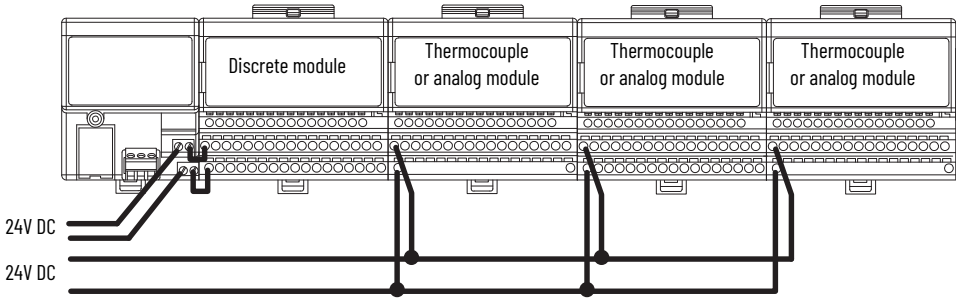

**Wiring when the total current draw is less than 10 A**

**Individual**




**Wiring when the total current draw is greater than 10 A**

**Combination**




**The total current draw through any base unit must not be greater than 10 A.**

# Notes:

# Program Your Module

## Block Transfer Programming

Your thermocouple/mV module communicates with the processor through bidirectional block transfers. This is the sequential operation of both read and write block transfer instructions.

A configuration BTW is initiated when the thermocouple/mV module is first powered up, and subsequently only when the programmer wants to enable or disable features of the module. The configuration BTW sets the bits which enables the programmable features of the module, such as scaling, alarms, ranges, and so on. The BTRs are performed to retrieve the information from the module.

The BTR programming moves status and data from the module to the processors data table. The processor user program initiates the request to transfer data from the module to the processor. The transferred words contain module status, channel status, and input data from the module.

**ATTENTION:** If the thermocouple/mV module is not powered up before the remote I/O adapter, the adapter cannot recognize the module. Verify that the thermocouple/mV module is installed and powered before or simultaneously with the remote I/O adapter. If the adapter does not establish communication with the module, cycle power to the adapter.

The following sample programs are minimum programs. All rungs and conditioning must be included in your application program. You can disable BTRs, or add interlocks to prevent writes if necessary. Do not eliminate any storage bits or interlocks included in the sample programs. If interlocks are removed, the program may not work properly.

Your program should monitor status bits and block transfer read activity.

## FLEX I/O Analog Module Sample Programs

The following sample programs show you how to use your analog module efficiently when operating with a programmable controller.

These programs show you how to:

- Configure the module
- Read the data from the module

These example programs illustrate the minimum programming required for the communication to take place.

### PLC-3 Programming

Block transfer instructions with the PLC-3® processor use one binary file in a data table section for the module location and other related data. This is the block transfer control file. The block transfer data file stores data that you want to transfer to your module (when programming a BTW) or from your module (when programming a BTR). The address of the block transfer data files are stored in the block transfer control file.

**The same block transfer control file is used for both the read and write instructions for your module.** A different block transfer control file is required for every module.

A sample program segment with block transfer instructions is shown in Figure 4, and described as follows:

**Figure 4 - PLC-3 Family Sample Program Structure**

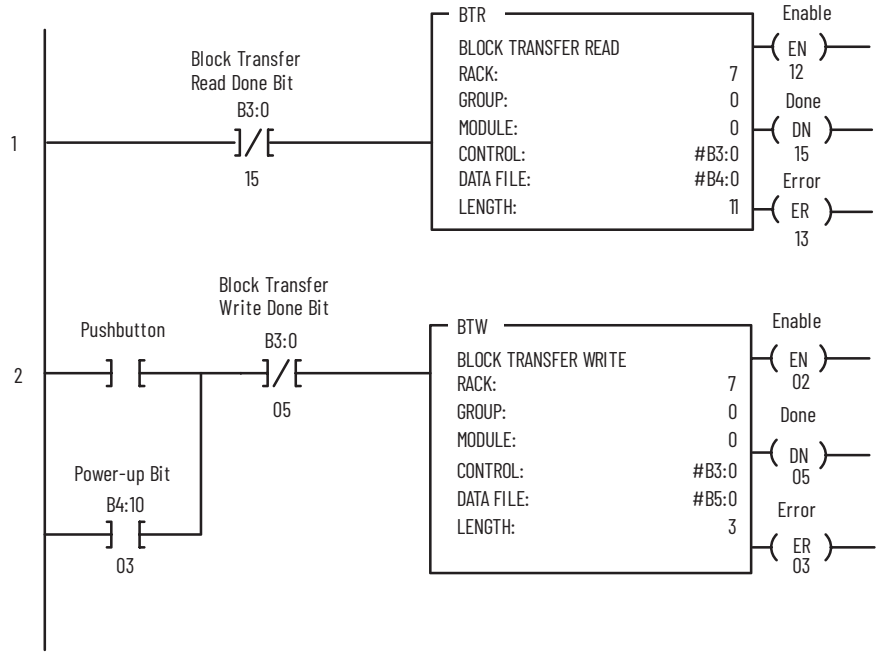
### Program Action

At power-up in RUN mode or when the processor is switched from PROG to RUN, the user program enables a block transfer read. Then it initiates a block transfer write to configure the module.

Thereafter, the program continuously performs read block transfers.

You must create the data file for the block transfers before you enter the block transfer instructions.

The Pushbutton allows you to manually request a block transfer write.




## PLC-5 Programming

The PLC-5® program is similar to the PLC-3 program with the following exceptions:

- Block transfer enable bits are used instead of done bits as the conditions on each rung.
- Separate block transfer control files are used for the block transfer instructions.

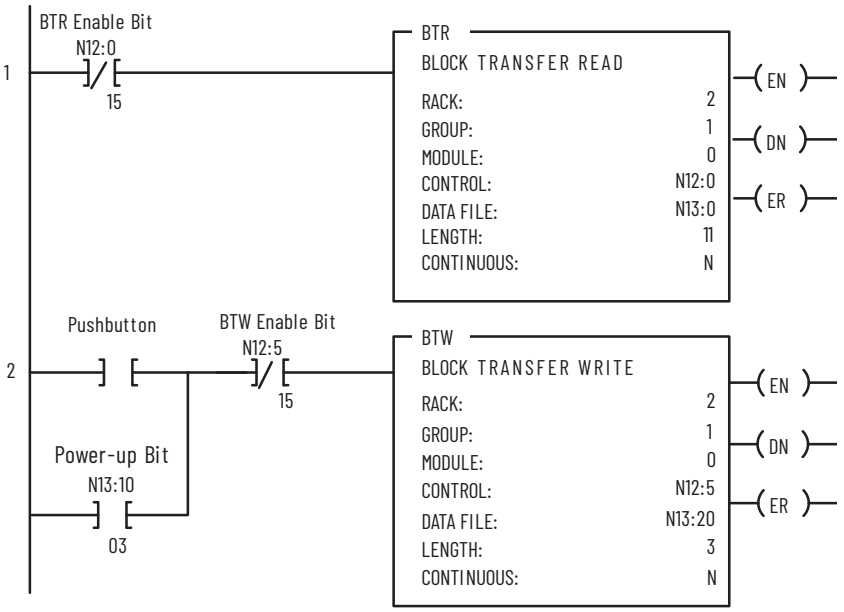
**Figure 5 - PLC-5 Family Sample Program Structure**

### Program Action

At power-up in RUN mode, or when the processor is switched from PROG to RUN, the user program enables a block transfer read. Then it initiates a block transfer write to configure the module.

Thereafter, the program continuously performs read block transfers.

The Pushbutton allows you to manually request a block transfer write.




## PLC-2 Programming

The FLEX I/O analog modules are not recommended for use with PLC-2® family programmable controllers due to the number of digits needed for high resolution.

# Write Configuration to Your Module and Read Status from Your Module with a Remote I/O Adapter

## Configure Your Module

Because of the wide variety of possible configurations, you must configure your module to conform to the specific application that you have chosen. The module is configured using a group of data table words that are transferred to the module using a block transfer write instruction.

The thermocouple module has the following software configurable features:

- Input/Output range selection, including full range and bipolar
- Selectable first notch filter
- Data reported in °C, °F, unipolar, or bipolar count

The PLC-5 family programmable controllers that use 6200 software (version 5.2 or later) programming tools can take advantage of the IOCONFIG utility to configure these modules. The IOCONFIG uses menu-based screens for configuration without having to set individual bits in particular locations. See your 6200 software documentation for more information.

## Range Selection

Individual input channels are configurable to operate with the following sensor types.

**Range Selection**

| Sensor Type | | Range |
|---|---|---|
| Voltage | Millivolt | –76.50…+76.50 mV |
| Thermocouple | Type B | 300…1800 °C (572…3272 °F) |
| | Type C | 0…2315 °C (32…4199 °F) |
| | Type E | –270…+1000 °C (-454…+1832 °F) |
| | Type J | –210…+1200 °C (-346…+2192 °F) |
| | Type K | –270…+1372 °C (-454…+2501 °F) |
| | Type L | –200…+800 °C (-328…+1472 °F) |
| | Type N | –270…+1300 °C (-454…+2372 °F) |
| | Type R | –50…+1768 °C (-58…+3214 °F) |
| | Type S | –50…+1768 °C (-58…+3214 °F) |
| | Type T | –270…+400 °C (-454…+752 °F) |

You can select individual channel ranges using write words 1 and 2 of the block transfer write instruction.

## Input Scaling

Scaling lets you report each channel in actual engineering units. Scaled values are in integer format.

**Input Scaling**

| Input Type | Range | Scaling | Maximum Resolution |
|---|---|---|---|
| Millivolt | –76.50…+76.50 mV | –7650…+7650 | 10 µV |
| Type B | 300…1800 °C (572…3272 °F) | 3000…18000 (5720…32720) | 0.1 °C (0.1 °F) |
| Type C | 0…2315 °C (32…4199 °F) | 0…23150 (320…41990) | 0.1 °C (0.1 °F) |
| Type E | –270…+1000 °C (-454…+1832 °F) | –2700…+1000 (-4540…+18320) | 0.1 °C (0.1 °F) |
| Type J | –210…+1200 °C (-346…+2192 °F) | –2100…+12000 (-3460…+21920) | 0.1 °C (0.1 °F) |

**Input Scaling (Continued)**

| Input Type | Range | Scaling | Maximum Resolution |
|---|---|---|---|
| Type K | –270...+1372 °C (-454...+2501 °F) | –2700...+13720 (-4540...+25010) | 0.1 °C (0.1 °F) |
| Type L | –200...+800 °C (-328...+1472 °F) | –2000...+8000 (-3280...+14720) | 0.1 °C (0.1 °F) |
| Type N | –270...+1300 °C (-454...+2372 °F) | –2700...+13000 (-4540...+23720) | 0.1 °C (0.1 °F) |
| Type R | –50...+1768 °C (-58...+3214 °F) | –500...+17680 (-580...+32140) | 0.1 °C (0.1 °F) |
| Type S | –50...+1768 °C (-58...+3214 °F) | –500...+17680 (-580...+32140) | 0.1 °C (0.1 °F) |
| Type T | –270...+400 °C (-454...+752 °F) | –2700...+4000 (-4540...+7520) | 0.1 °C (0.1 °F) |

In thermocouple mode, the scaled number has an implied decimal point 1 digit from the right. For example, if reading is 18000, temperature is 1800.0°. In millivolt mode, the implied decimal point is to the left of the last 2 digits. For example, if reading is 2250, actual reading is 22.50 mV.

You can select input scaling using the designated words of the write block transfer instruction. See Table 5 for Word/Bit descriptions of write word 0, bits 00, and 01.

## Hardware First Notch Filter

A hardware filter in the analog to digital converter lets you select a frequency for the first notch of the filter. Selection of the filter influences the analog to digital output data rate and changes the module throughput. Module throughput is a function of the number of inputs used and the first notch filter. Both of these influence the time from a thermocouple input to arrival at the backplane.

**Table 1 - Throughput in Normal Mode**

| A/D Filter First Notch Frequency (Effective Resolution) | 10 Hz (16-bits) | 25 Hz (16-bits) | 50 Hz (16-bits) | 60 Hz (16-bits) | 100 Hz (16-bits) | 250 Hz (13-bits) | 500 Hz (11-bits) | 1000 Hz (9-bits) |
|---|---|---|---|---|---|---|---|---|
| Number of Channels Scanned | System Throughput | | | | | | | |
| 1 | 325 ms | 145 ms | 85 ms | 75 ms | 55 ms | 37 ms | 31 ms | 28 ms |
| 2 | 650 ms | 290 ms | 170 ms | 150 ms | 110 ms | 74 ms | 62 ms | 56 ms |
| 3 | 975 ms | 435 ms | 255 ms | 225 ms | 165 ms | 111 ms | 93 ms | 84 ms |
| 4 | 1.3 s | 580 ms | 340 ms | 300 ms | 220 ms | 148 ms | 124 ms | 112 ms |
| 5 | 1.625 s | 725 ms | 425 ms | 375 ms | 275 ms | 185 ms | 155 ms | 140 ms |
| 6 | 1.95 s | 870 ms | 510 ms | 450 ms | 330 ms | 222 ms | 186 ms | 168 ms |
| 7 | 2.275 s | 1.015 s | 595 ms | 525 ms | 385 ms | 259 ms | 217 ms | 196 ms |
| 8 | 2.60 s(1) | 1.16 s | 680 ms | 600 ms | 440 ms | 296 ms | 248 ms | 224 ms |

(1) Default setting

## Reading Data From Your Module

Read programming moves status and data from the thermocouple input module to the processors data table. The processors user program initiates the request to transfer the data from the thermocouple/mV input module to the processor.

## Mapping Data for the Analog Modules

The following read and write words and bit/word descriptions describe the information written to and read from the thermocouple/mV input module. The module uses up to 11 words of input image and up to 3 words of output image. Each word is composed of 16 bits.

**1794-IT8 - Thermocouple/mV Input Module Image Table Mapping**

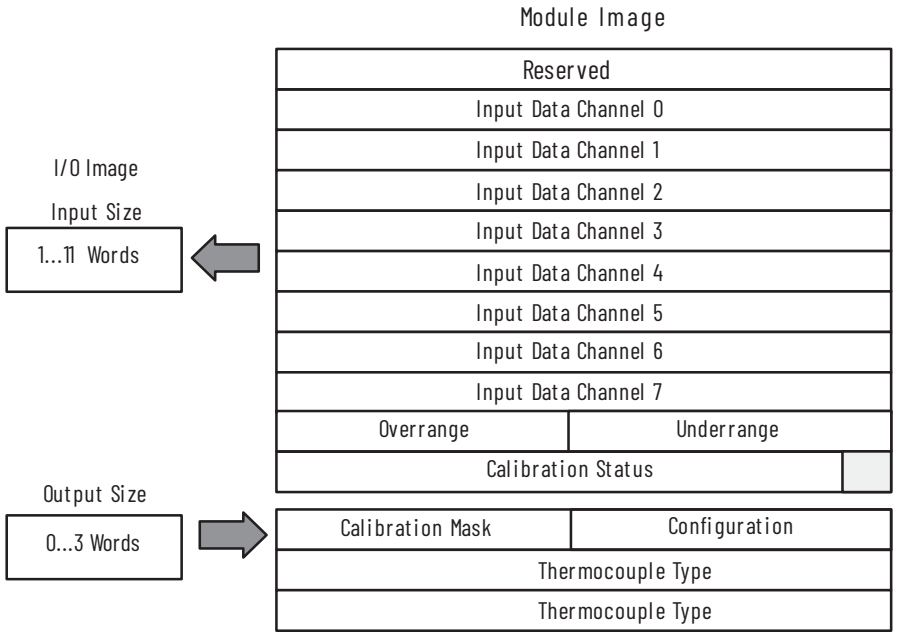



**Table 2 - Thermocouple/mV Input Module - 1794-IT8 Read**

| **Word/Dec. Bit** | **15** | **14** | **13** | **12** | **11** | **10** | **09** | **08** | **07** | **06** | **05** | **04** | **03** | **02** | **01** | **00** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Word/Octal Bit** | **17** | **16** | **15** | **14** | **13** | **12** | **11** | **10** | **07** | **06** | **05** | **04** | **03** | **02** | **01** | **00** |
| Read Word 0 | Reserved | | | | | | | | | | | | | | | |
| Read Word 1 | Channel 0 Input Data | | | | | | | | | | | | | | | |
| Read Word 2 | Channel 1 Input Data | | | | | | | | | | | | | | | |
| Read Word 3 | Channel 2 Input Data | | | | | | | | | | | | | | | |
| Read Word 4 | Channel 3 Input Data | | | | | | | | | | | | | | | |
| Read Word 5 | Channel 4 Input Data | | | | | | | | | | | | | | | |
| Read Word 6 | Channel 5 Input Data | | | | | | | | | | | | | | | |
| Read Word 7 | Channel 6 Input Data | | | | | | | | | | | | | | | |
| Read Word 8 | Channel 7 Input Data | | | | | | | | | | | | | | | |
| Read Word 9 | Overrange Bits | | | | | | | | Underrange Bits | | | | | | | |
| Read Word 10 | 0 | 0 | 0 | 0 | 0 | CB | CD | CR | 0 | Diagnostic Status | | | PU | BS | CJC Over | CJC Under |
| Where: | PU = Power-up<br>CB = Calibration bad<br>CD = Calibration done<br>CR = Calibration range<br>BS = Bad structure | | | | | | | | | | | | | | | |

**Table 3 - Thermocouple/mV Input Module - 1794-IT8 Write**

| **Word/Dec. Bit** | **15** | **14** | **13** | **12** | **11** | **10** | **09** | **08** | **07** | **06** | **05** | **04** | **03** | **02** | **01** | **00** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Word/Octal Bit** | **17** | **16** | **15** | **14** | **13** | **12** | **11** | **10** | **07** | **06** | **05** | **04** | **03** | **02** | **01** | **00** |
| Write Word 0 | 8-bit Calibration Mask | | | | | | | | CK | CH<br>CL | Filter Cutoff | | | FDF | Data Type | |
| Write Word 1 | Thermocouple 3 Type | | | | Thermocouple 2 Type | | | | Thermocouple 1 Type | | | | Thermocouple 0 Type | | | |
| Write Word 2 | Thermocouple 7 Type | | | | Thermocouple 6 Type | | | | Thermocouple 5 Type | | | | Thermocouple 4 Type | | | |
| Where: | CK = Calibration clock<br>CH = Calibration high<br>CL = Calibration low<br>FDF = Fixed digit filter bit | | | | | | | | | | | | | | | |

**Table 4 - Read Word/Bit Descriptions for 1794-IT8 Thermocouple/mV Input Module**

| Read Word | Decimal Bit (Octal Bit) | Definition |
|---|---|---|
| Read Word 0 | 00…15 (00…17) | Reserved |
| Read Word 1 | 00…15 (00…17) | Channel 0 Input data |
| Read Word 2 | 00…15 (00…17) | Channel 1 Input data |
| Read Word 3 | 00…15 (00…17) | Channel 2 Input data |
| Read Word 4 | 00…15 (00…17) | Channel 3 Input data |
| Read Word 5 | 00…15 (00…17) | Channel 4 Input data |
| Read Word 6 | 00…15 (00…17) | Channel 5 Input data |
| Read Word 7 | 00…15 (00…17) | Channel 6 Input data |
| Read Word 8 | 00…15 (00…17) | Channel 7 Input data |
| Read Word 9 | 00…07 (00…07) | **Underrange bits** – These bits are set if the input signal is below the input channels minimum range. |
| | 08…15 (10…17) | **Overrange bits** – These bits are set if the input signal is above the input channels maximum range or an open detector is detected. |
| Read Word 10 | 00 (00) | Cold Junction sensor underrange bit – This bit is set if the cold junction temperature is below 0 °C (32 °F). |
| | 01 (01) | Cold Junction sensor overrange bit – This bit is set if the cold junction temperature is above 70 °C (158 °F). |
| | 02 (02) | **Bad Structure** – This bit is set if an invalid thermocouple type is selected. |
| | 03 (03) | **Powerup bit** – This bit is set (1) until configuration data is received by the module. |
| | 04…06 (04…06) | **Critical Error bits** – If these bits are anything other than all zeros, return the module to the factory for repair. |
| | 07 (07) | Unused – Set to 1 |
| | 08 (10) | **Calibration Range bit** – Set to 1 if a reference signal is out of range during calibration. |
| | 09 (11) | **Calibration Done bit** – Set to 1 after an initiated calibration cycle is complete. |
| | 10 (12) | **Calibration Bad bit** – Set to 1 if the channel has not had a valid calibration. |
| | 11…15 (13…17) | Unused – Set to 0 |

**Table 5 - Write Word/Bit Descriptions for 1794-IT8 Thermocouple/mV Input Module**

| Write Word | Decimal Bit (Octal Bit) | Definition | | | | |
|---|---|---|---|---|---|---|
| Write Word 0 | 00-01 (00-01) | **Module Data Type** | | | | |
| | | **Bit** | **01** | **00** | **Definition** | |
| | | – | 0 | 0 | °C (default) | |
| | | | 0 | 1 | °F | |
| | | | 1 | 0 | Bipolar counts are scaled from –32,768…+32,767 | |
| | | | 1 | 1 | Unipolar counts are scaled from 0…65,535 | |
| | 02 (02) | **Fixed Digital Filter** – When this bit is set (1), a software digital filter is enabled. This filter settles to 100% of a Full Scale step input in 60 times the selected first notch filter time shown in Table 1. (**Default – Filter is disabled.**) | | | | |
| | 03…05 (03…05) | **A/D Filter First Notch Frequency** | | | | |
| | | **Bit** | **05** | **04** | **03** | **Definition** |
| | | – | 0 | 0 | 0 | 10 Hz (default) |
| | | | 0 | 0 | 1 | 25 Hz |
| | | | 0 | 1 | 0 | 50 Hz |
| | | | 0 | 1 | 1 | 60 Hz |
| | | | 1 | 0 | 0 | 100 Hz |
| | | | 1 | 0 | 1 | 250 Hz |
| | | | 1 | 1 | 0 | 500 Hz |
| | | | 1 | 1 | 1 | 1000 Hz |
| | 06 (06) | Calibration High/Low bit – This bit is set during gain calibration and reset during offset calibration. | | | | |
| | 07 (07) | Calibration clock – This bit must be set to 1 to prepare for a calibration cycle, then reset to 0 to initiate calibration. | | | | |
| | 08…15 (10…17) | Calibration mask – The channel or channels to be calibrated have the correct mask bit set. The bit 8 corresponds to the channel 0, bit 9 corresponds to the channel 1, and so on. | | | | |

**Table 5 - Write Word/Bit Descriptions for 1794-IT8 Thermocouple/mV Input Module (Continued)**

| Write Word | Decimal Bit (Octal Bit) | Definition | | | | | |
|---|---|---|---|---|---|---|---|
| Write Word 1 | 00…03 (00…03) | Channel 0 Thermocouple Type | | | | | |
| | | **Bit** | **03** | **02** | **01** | **00** | **Thermocouple Type – Range** |
| | | – | 0 | 0 | 0 | 0 | Millivolts (default) |
| | | | 0 | 0 | 0 | 1 | Type B, range 300…1800 °C (572…3272 °F) |
| | | | 0 | 0 | 1 | 0 | Type E, range –270…+1000 °C (–454…+1832 °F) |
| | | | 0 | 0 | 1 | 1 | Type J, range –210…+1200 °C (–346…+2192 °F) |
| | | | 0 | 1 | 0 | 0 | Type K, range –270…+1372 °C (–454…+2502 °F) |
| | | | 0 | 1 | 0 | 1 | Type R, range –50…+1768 °C (–58…+3214 °F) |
| | | | 0 | 1 | 1 | 0 | Type S, range –50…+1768 °C (–58…+3214 °F) |
| | | | 0 | 1 | 1 | 1 | Type T, range –270…+400 °C (–454…+752 °F) |
| | | | 1 | 0 | 0 | 0 | Type C, range 0…2315 °C (32…4199 °F) |
| | | | 1 | 0 | 0 | 1 | Type N, range –270…+1300 °C (–450…+2372 °F) |
| | | | 1 | 0 | 1 | 0 | Type L, range -200…+800 °C (-328…+1472 °F) |
| | | | 1 | 0 | 1 | 1 | Reserved |
| | | | 1 | 1 | 0 | 0 | The module reports cold junction temperature for channels 00…03. |
| | | | 1 | 1 | 0 | 1 | The module reports cold junction temperature for channels 04…07. |
| | | | 1 | 1 | 1 | 0 | Reserved |
| | | | 1 | 1 | 1 | 1 | No sensor is connected (do not scan). |
| | 04…07 (04…07) | Channel 1 Thermocouple Type (see bits 00…03) | | | | | |
| | 08…11 (10…13) | Channel 2 Thermocouple Type (see bits 00…03) | | | | | |
| | 12…15 (14…17) | Channel 3 Thermocouple Type (see bits 00…03) | | | | | |
| Write Word 2 | 00…03 (00…03) | Channel 4 Thermocouple Type (see write word 1, bits 00…03) | | | | | |
| | 04…07 (04…07) | Channel 5 Thermocouple Type (see write word 1, bits 00…03) | | | | | |
| | 08…11 (10…13) | Channel 6 Thermocouple Type (see write word 1, bits 00…03) | | | | | |
| | 12…15 (14…17) | Channel 7 Thermocouple Type (see write word 1, bits 00…03) | | | | | |

# Notes:

# Communication and I/O Image Table Mapping with the DeviceNet Adapter

## About DeviceNetManager

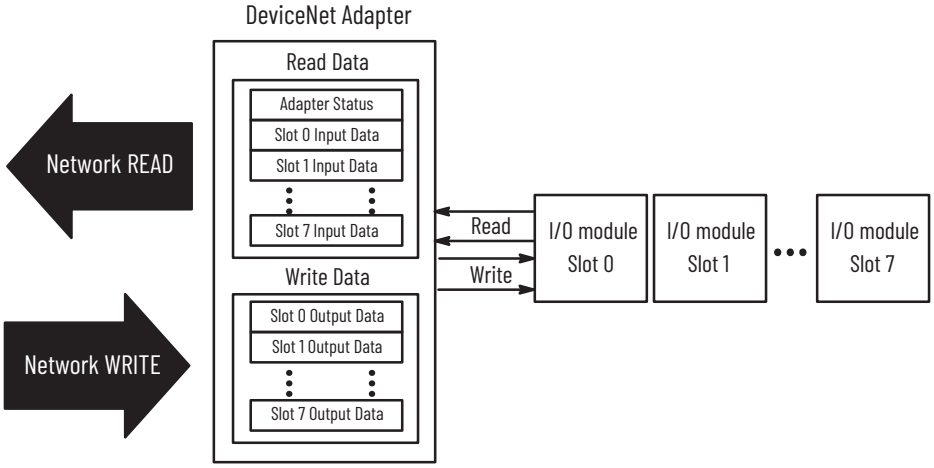
The DeviceNetManager software is a software tool used to configure your FLEX I/O DeviceNet adapter and its related modules. This software tool can be connected to the adapter via the DeviceNet network.

You must know and understand how the DeviceNetManager works in order to add a device to the network.

## Polled I/O Structure

The output data is received by the adapter in the order of the installed I/O modules. The Output data for Slot 0 is received first, followed by the Output data for Slot 1...7.

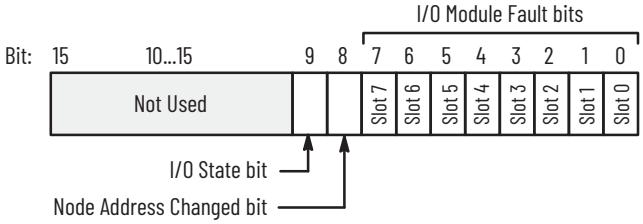
The first word of input data sent by the adapter is the Adapter Status Word. This is followed by the input data from each slot, in the order of the installed I/O modules. The input data from Slot 0 is first after the status word, followed by input data from Slot 2, and so on, up to Slot 7.




### Adapter Input Status Word

The input status word consists of:

- I/O Module Fault bits – 1 status bit for each slot
- Node Address Changed bit – 1 bit
- I/O State bit– 1 bit



The adapter input status word bit descriptions are shown in the following table.

| Bit Description | Bit | Explanation |
|---|---|---|
| I/O Module Faults | 0 | This bit is set (1) when an error is detected in slot position 0. |
| | 1 | This bit is set (1) when an error is detected in slot position 1. |
| | 2 | This bit is set (1) when an error is detected in slot position 2. |
| | 3 | This bit is set (1) when an error is detected in slot position 3. |
| | 4 | This bit is set (1) when an error is detected in slot position 4. |
| | 5 | This bit is set (1) when an error is detected in slot position 5. |
| | 6 | This bit is set (1) when an error is detected in slot position 6. |
| | 7 | This bit is set (1) when an error is detected in slot position 7. |
| Node Address Changed | 8 | This bit is set (1) when the node address switch setting has been changed since power-up. |
| I/O State | 9 | Bit = 0 – Idle<br>Bit = 1 – Run |
| — | 10…15 | Not used – Sent as zeros |

Possible causes for an I/O Module Fault are:

- Transmission errors on the FLEX I/O backplane
- A failed module
- A module removed from its terminal base
- Incorrect module insertion in a slot position
- The slot is empty.

The Node Address Changed bit is set when the node address switch setting is changed after power-up. The new node address does not take effect until the adapter is powered down and then powered back up.

## System Throughput

System throughput from the analog input to backplane is a function of:

- The configured A/D filter first notch frequency
- The number of channels that are actually configured for connection to a specific sensor

The A/D converter which converts channel 0…7 analog data to a digital word provides a programmable first notch filter. You can set the position of the first notch of this filter during module configuration. The selection influences the A/D output data rate, thus affecting system throughput.

The number of channels included in each input scan also affects system throughput.

## Mapping Data into the Image Table

The FLEX I/O thermocouple module data table mapping is shown in Figure 6.

**Figure 6 - 1794-IT8 - Thermocouple/mV Input Module Image Table Mapping**

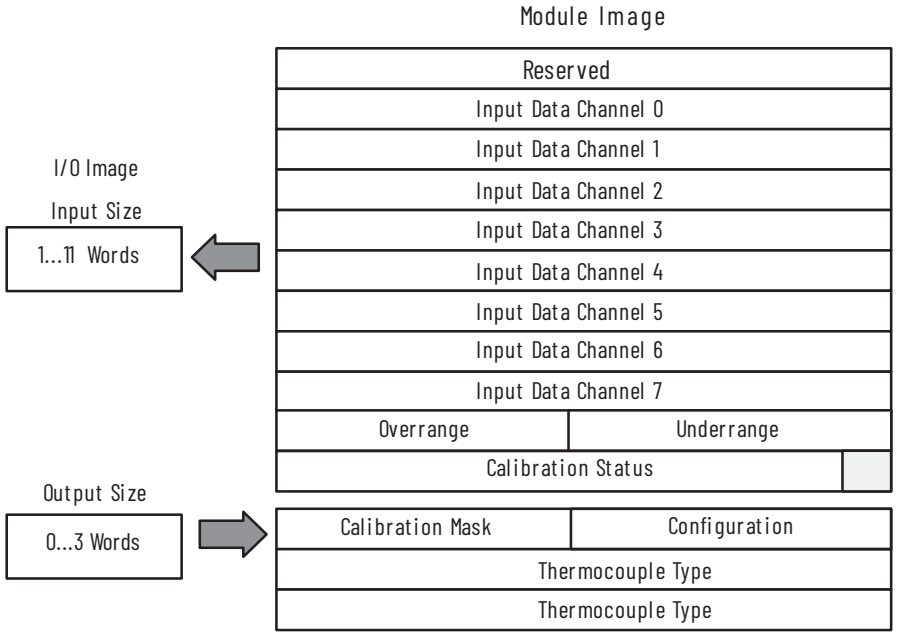



**Table 6 - Thermocouple/mV Input Module - 1794-IT8 Read**

| **Word/Dec. Bit** | **15** | **14** | **13** | **12** | **11** | **10** | **09** | **08** | **07** | **06** | **05** | **04** | **03** | **02** | **01** | **00** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Word/Octal Bit** | **17** | **16** | **15** | **14** | **13** | **12** | **11** | **10** | **07** | **06** | **05** | **04** | **03** | **02** | **01** | **00** |
| Read Word 1 | Reserved | | | | | | | | | | | | | | | |
| Read Word 2 | Channel 0 Input Data | | | | | | | | | | | | | | | |
| Read Word 3 | Channel 1 Input Data | | | | | | | | | | | | | | | |
| Read Word 4 | Channel 2 Input Data | | | | | | | | | | | | | | | |
| Read Word 5 | Channel 3 Input Data | | | | | | | | | | | | | | | |
| Read Word 6 | Channel 4 Input Data | | | | | | | | | | | | | | | |
| Read Word 7 | Channel 5 Input Data | | | | | | | | | | | | | | | |
| Read Word 8 | Channel 6 Input Data | | | | | | | | | | | | | | | |
| Read Word 9 | Channel 7 Input Data | | | | | | | | | | | | | | | |
| Read Word 10 | Overrange Bits | | | | | | | | Underrange Bits | | | | | | | |
| Read Word 11 | 0 | 0 | 0 | 0 | 0 | CB | CD | CR | 0 | Diagnostic Status | | | PU | BS | CJC Over | CJC Under |
| Where: | PU = Power-up<br>CB = Calibration bad<br>CD = Calibration done<br>CR = Calibration range<br>BS = Bad structure | | | | | | | | | | | | | | | |

**Table 7 - Thermocouple/mV Input Module - 1794-IT8 Write**

| **Word/Dec. Bit** | **15** | **14** | **13** | **12** | **11** | **10** | **09** | **08** | **07** | **06** | **05** | **04** | **03** | **02** | **01** | **00** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Word/Octal Bit** | **17** | **16** | **15** | **14** | **13** | **12** | **11** | **10** | **07** | **06** | **05** | **04** | **03** | **02** | **01** | **00** |
| Write Word 0 | 8-bit Calibration Mask | | | | | | | | CK | CH<br>CL | Filter Cutoff | | | FDF | Data Type | |
| Write Word 1 | Thermocouple 3 Type | | | | Thermocouple 2 Type | | | | Thermocouple 1 Type | | | | Thermocouple 0 Type | | | |
| Write Word 2 | Thermocouple 7 Type | | | | Thermocouple 6 Type | | | | Thermocouple 5 Type | | | | Thermocouple 4 Type | | | |
| Where: | CK = Calibration clock<br>CH = Calibration high<br>CL = Calibration low<br>FDF = Fixed digit filter bit | | | | | | | | | | | | | | | |

**Table 8 - Read Word/Bit Descriptions for 1794-IT8 Thermocouple/mV Input Module**

| Read Word | Decimal Bit (Octal Bit) | Definition |
|---|---|---|
| Read Word 1 | 00...15 (00...17) | Reserved |
| Read Word 2 | 00...15 (00...17) | Channel 0 Input data |
| Read Word 3 | 00...15 (00...17) | Channel 1 Input data |
| Read Word 4 | 00...15 (00...17) | Channel 2 Input data |
| Read Word 5 | 00...15 (00...17) | Channel 3 Input data |
| Read Word 6 | 00...15 (00...17) | Channel 4 Input data |
| Read Word 7 | 00...15 (00...17) | Channel 5 Input data |
| Read Word 8 | 00...15 (00...17) | Channel 6 Input data |
| Read Word 9 | 00...15 (00...17) | Channel 7 Input data |
| Read Word 10 | 00...07 (00...07) | **Underrange bits** – These bits are set if the input signal is below the input channels minimum range. |
| | 08...15 (10...17) | **Overrange bits** – These bits are set if the input signal is above the input channels maximum range or an open detector is detected. |
| Read Word 11 | 00 (00) | Cold junction sensor underrange bit – This bit is set if the cold junction temperature is below 0 °C (32 °F). |
| | 01 (01) | Cold junction sensor overrange bit – This bit is set if the cold junction temperature is above 70 °C (158 °F). |
| | 02 (02) | **Bad Structure** – This bit is set if an invalid thermocouple type is selected. |
| | 03 (03) | **Power-up bit** – This bit is set (1) until configuration data is received by the module. |
| | 04...06 (04...06) | **Critical Error bits** – If these bits are anything other than all zeros, return the module to the factory for repair. |
| | 07 (07) | Unused – Set to 1 |
| | 08 (10) | **Calibration Range bit** – Set to 1 if a reference signal is out of range during calibration. |
| | 09 (11) | **Calibration Done bit** – Set to 1 after an initiated calibration cycle is complete. |
| | 10 (12) | **Calibration Bad bit** – Set to 1 if the channel has not had a valid calibration. |
| | 11...15 (13...17) | Unused – Set to 0 |

**Table 9 - Write Word/Bit Descriptions for 1794-IT8 Thermocouple/mV Input Module**

| Write Word | Decimal Bit (Octal Bit) | Definition | | | | |
|---|---|---|---|---|---|---|
| Write Word 1 | 00...01 (00...01) | **Module Data Type** | | | | |
| | | **Bit** | **01** | **00** | **Definition** | |
| | | – | 0 | 0 | °C (default) | |
| | | | 0 | 1 | °F | |
| | | | 1 | 0 | Bipolar counts are scaled between –32,768 and +32,767 | |
| | | | 1 | 1 | Unipolar counts are scaled from 0...65,535 | |
| | 02 (02) | **Fixed Digital Filter** – When this bit is set (1), a software digital filter is enabled. This filter settles to 100% of a Full Scale step input in 60 times the selected first notch filter time shown on Table 1. **(Default – Filter is disabled.)** | | | | |
| | 03...05 (03...05) | **A/D Filter First Notch Frequency** | | | | |
| | | **Bit** | **05** | **04** | **03** | **Definition** |
| | | – | 0 | 0 | 0 | 10 Hz (default) |
| | | | 0 | 0 | 1 | 25 Hz |
| | | | 0 | 1 | 0 | 50 Hz |
| | | | 0 | 1 | 1 | 60 Hz |
| | | | 1 | 0 | 0 | 100 Hz |
| | | | 1 | 0 | 1 | 250 Hz |
| | | | 1 | 1 | 0 | 500 Hz |
| | | | 1 | 1 | 1 | 1000 Hz |
| | 06 (06) | Calibration High/Low bit – This bit is set during gain calibration and reset during offset calibration. | | | | |
| | 07 (07) | Calibration clock – This bit must be set to 1 to prepare for a calibration cycle, then reset to 0 to initiate calibration. | | | | |
| | 08...15 (10...17) | Calibration mask – The channel or channels to be calibrated have the correct mask bit set. The bit 8 corresponds to the channel 0, bit 9 corresponds to the channel 1, and so on. | | | | |

**Table 9 - Write Word/Bit Descriptions for 1794-IT8 Thermocouple/mV Input Module (Continued)**

| Write Word | Decimal Bit (Octal Bit) | Definition | | | | | |
|---|---|---|---|---|---|---|---|
| Write Word 2 | 00…03 (00…03) | Channel 0 Thermocouple Type | | | | | |
| | | **Bit** | **03** | **02** | **01** | **00** | **Thermocouple Type – Range** |
| | | – | 0 | 0 | 0 | 0 | Millivolts (default) |
| | | | 0 | 0 | 0 | 1 | Type B range 300…1800 °C (572…3272 °F) |
| | | | 0 | 0 | 1 | 0 | Type E range –270…+1000 °C (–454…+1832 °F) |
| | | | 0 | 0 | 1 | 1 | Type J range –210…+1200 °C (–346…+2192 °F) |
| | | | 0 | 1 | 0 | 0 | Type K range –270…+1372 °C (–454…+2502 °F) |
| | | | 0 | 1 | 0 | 1 | Type R range –50…+1768 °C (–58…+3214 °F) |
| | | | 0 | 1 | 1 | 0 | Type S range –50…+1768 °C (–58…+3214 °F) |
| | | | 0 | 1 | 1 | 1 | Type T range –270…+400 °C (–454…+752 °F) |
| | | | 1 | 0 | 0 | 0 | Type C range 0…2315 °C (32…4199 °F) |
| | | | 1 | 0 | 0 | 1 | Type N range –270…+1300 °C (–450…+2372 °F) |
| | | | 1 | 0 | 1 | 0 | Type L range -200…+800 °C (-328…+1472 °F) |
| | | | 1 | 0 | 1 | 1 | Reserved |
| | | | 1 | 1 | 0 | 0 | The module reports cold junction temperature for channels 00…03. |
| | | | 1 | 1 | 0 | 1 | The module reports cold junction temperature for channels 04…07. |
| | | | 1 | 1 | 1 | 0 | Reserved |
| | | | 1 | 1 | 1 | 1 | No sensor is connected (do not scan). |
| | 04…07 (04…07) | Channel 1 Thermocouple Type (see bits 00…03) | | | | | |
| | 08…11 (10…13) | Channel 2 Thermocouple Type (see bits 00…03) | | | | | |
| | 12…15 (14…17) | Channel 3 Thermocouple Type (see bits 00…03) | | | | | |
| Write Word 3 | 00…03 (00…03) | Channel 4 Thermocouple Type (see write word 1, bits 00…03) | | | | | |
| | 04…07 (04…07) | Channel 5 Thermocouple Type (see write word 1, bits 00…03) | | | | | |
| | 08…11 (10…13) | Channel 6 Thermocouple Type (see write word 1, bits 00…03) | | | | | |
| | 12…15 (14…17) | Channel 7 Thermocouple Type (see write word 1, bits 00…03) | | | | | |

## Defaults

Each I/O module has default values associated with it. At default, each module will generate inputs/status and expect outputs/configuration.

**Table 10 - Module Defaults**

| Module Defaults for: | | Factory Defaults | | Real Time Size | |
|---|---|---|---|---|---|
| **Catalog Number** | **Description** | **Input Default** | **Output Default** | **Input Default** | **Output Default** |
| 1794-IT8 | 8 Thermocouple Input | 11 | 4 | 10 | 0 |

Factory defaults are the values assigned by the adapter when you first power up the system, and no previous stored settings have been applied.

For analog modules, the defaults reflect the actual number of input words/output words. For example, the 8 thermocouple input analog module has 11 input words and 4 output words.

You can change the I/O data size for a module by reducing the number of words mapped into the adapter module, as shown in Table 10, Real Time Size column.

Real time sizes are the settings that provide optimal real time data to the adapter module.

The analog modules have 15 words assigned to them. This is divided into input words/output words. You can reduce the I/O data size to fewer words to increase data transfer over the backplane. For example, the 8 thermocouple input module has 11 words input or 4 words output with factory default. You can reduce the write words to 0, thus eliminating the configuration setting and unused words. And you can reduce the read words to 10 by eliminating the calibration status words.

# Notes:

# Calibrate Your Module

Your module is already calibrated when it is shipped. If a calibration check is required, proceed as follows.

Perform module calibration periodically, based on your application.

Module calibration may also be required to remove module errors due to aging of the components.

In addition, calibration may be required to eliminate long lead wire resistance due to open circuit detection current. See Error Due to Open Circuit Current Through Loop Resistance on page 44.

Use one of the following methods to calibrate your module:

- Manually Calibrate your Module
- 6200 I/O CONFIGURATION software (version 5.2 or later). See your 6200 software publications for calibration procedure.
- Use DeviceNetManager Software to Calibrate Your Module – See your DeviceNetManager software documentation for the DeviceNet adapter module, 1794-ADN. Some portion of this calibration is included here for use by personnel proficient with DeviceNet adapter configuration software.

| | |
|---|---|
| **IMPORTANT** | You can use a 1794-TB2 or 1794-TB3 terminal base unit if you are using the thermocouple/mV module in the millivolt mode only. You must use a 1794-TB3T terminal base unit for all thermocouple uses. |

## Tools and Equipment

To calibrate your thermocouple/mV input module you need the following tools and equipment:

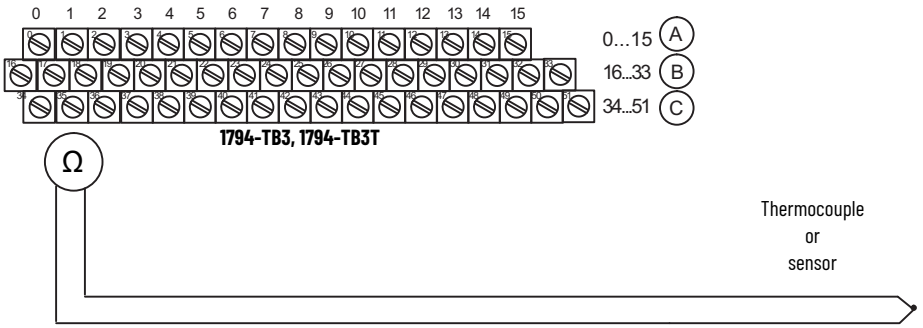
| Tool or Equipment | Description | | |
|---|---|---|---|
| Precision Voltage Source or Thermocouple Simulator and Calibration source | Range 0...100 mV<br>Resolution 0.001 mv (1 µV) | Analogic 3100, Data Precision 8200, or equivalent | |
| | | Thermocouple Simulator/ Calibrator Model 1120 | Ectron Corporation<br>8159 Engineer Road<br>San Diego, CA 92111-1980 |
| Industrial Terminal and Interconnect Cable | Programming terminal for Allen-Bradley family processors | | |

## Remove the Lead Wire or Thermocouple Extension Wire Resistance

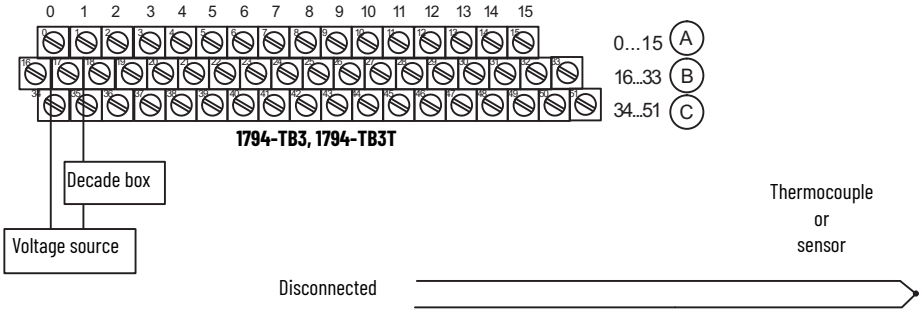
The thermocouple/mV module has an open circuit detection current. This is accomplished by a 1 µA current source in the module. This current flowing through the lead wire or thermocouple extension wire generates an error or offset voltage in the reading. Use Table 15 to determine if the magnitude of the error is acceptable.

To calibrate this error, proceed as follows:

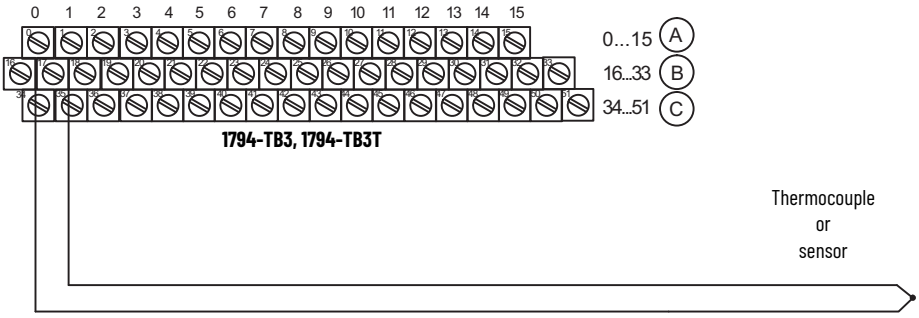
1. Measure the total loop resistance:
   a. Disconnect the lead wires at the terminal base unit.
   b. Measure the total loop resistance of both lead/extension wires and the thermocouple.
   c. If you use a sensor other than a thermocouple, disconnect the lead wires at the sensor and tie together for this measurement. Reconnect after measurement.
   d. After measurement, remove the ohmmeter.




2. Calibrate the error:
   a. Set the decade box to the value determined in Step 1 and connect in series with a precision voltage source.
   b. Connect to the input terminals of the particular channel that you are calibrating.
   c. Perform an Offset Calibration on page 29 and Gain Calibration on page 29.




3. Restore wire connections:
   a. Remove the decade box and voltage source.
   b. Reconnect the lead wires to the input terminals for the channel you calibrated.
   c. Repeat this procedure for the remaining channels.




# Manually Calibrate your Module

## Calibrate Your Module for a DeviceNet Network

You must calibrate the module in a FLEX I/O system. The module must communicate with the processor and a programming terminal. You can calibrate input channels in any order or all at once.

Before calibrating your module, you must enter ladder logic into the processor memory, so that you can initiate BTWs to the module and read inputs from the module.

| **IMPORTANT** | To let the internal temperature of the module stabilize, energize the module for at least 40 minutes before you start calibration. |
|---|---|

Module calibration consists of:

- Applying a reference voltage to the desired inputs

- Sending a message to the module indicating which inputs to read and what calibration step is being performed (offset). The module stores this input data.
- Applying a second reference signal to the module, and sending a second message indicating which inputs to read and what calibration step is being performed (gain).

The module computes new calibration values for the inputs. Once the calibration is complete, the module reports back the status information about the procedure. The following flowchart shows the procedure for calibration.

**IMPORTANT** Perform the offset calibration procedure first, then the gain calibration procedure.

**Flowchart for Calibration Procedure - DeviceNet Network**

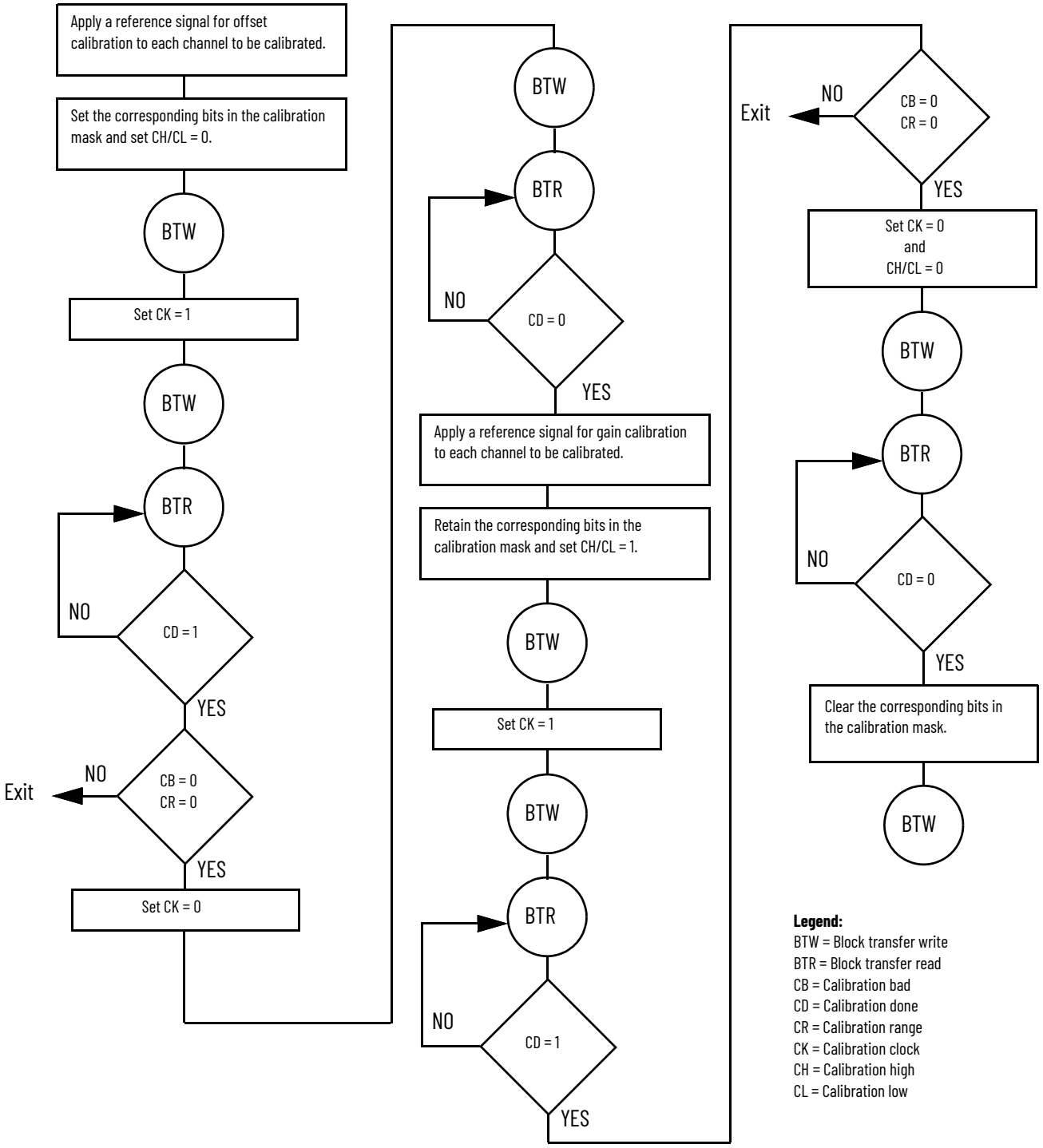
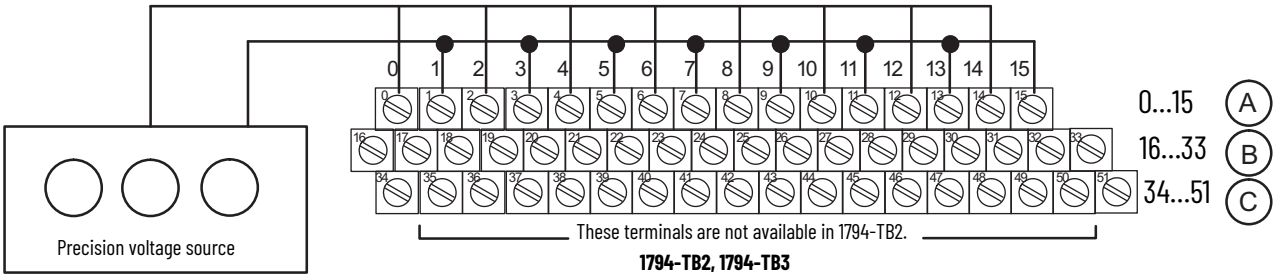
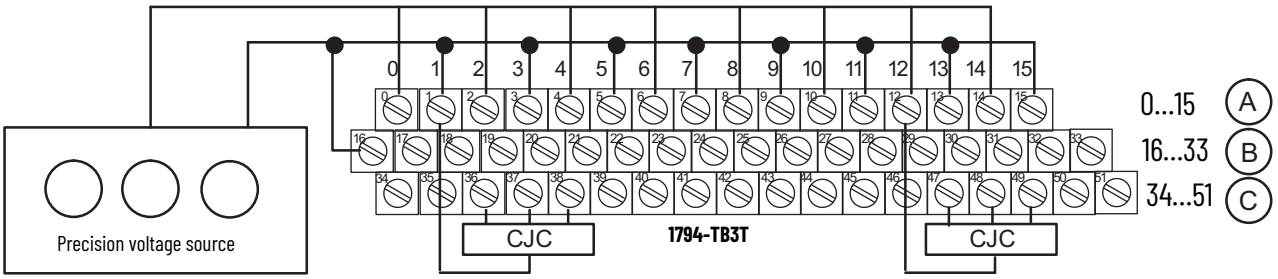


**Figure 7 - Wiring Diagram**

**Using a Precision Voltage Source**




**Note:** Use 1794-TB2 and 1794-TB3 terminal base units for millivolt inputs only.




**Note:** A CJC is not required if you are using the thermocouple for resistance only.

**Table 11 - Wiring Connections for the Thermocouple Module**

| Thermocouple Channel | 1794-TB2, 1794-TB3 Terminal Base Units | | | 1794-TB3T Terminal Base Unit(1) | | |
|---|---|---|---|---|---|---|
| | High Signal Terminal (+) | Low Signal Terminal (-) | Shield Return | High Signal Terminal (+) | Low Signal Terminal (-) | Shield Return(2) |
| 0 | 0 | 1 | 17 | 0 | 1 | 39 |
| 1 | 2 | 3 | 19 | 2 | 3 | 40 |
| 2 | 4 | 5 | 21 | 4 | 5 | 41 |
| 3 | 6 | 7 | 23 | 6 | 7 | 42 |
| 4 | 8 | 9 | 25 | 8 | 9 | 43 |
| 5 | 10 | 11 | 27 | 10 | 11 | 44 |
| 6 | 12 | 13 | 29 | 12 | 13 | 45 |
| 7 | 14 | 15 | 31 | 14 | 15 | 46 |
| 24V DC Common | Terminals 16...33 | | | Terminals 16, 17, 19, 21, 23, 25, 27, 29, 31, and 33 | | |
| +24V DC Power | **For 1794-TB2**: Terminals 34 and 51<br>**For 1794-TB3**: Terminals 34...51 | | | Terminals 34, 35, 50, and 51 | | |

(1) Terminals 36, 37, 38 and 47, 48, 49 are cold junction compensator connections.
(2) Terminals 39...46 are chassis ground.

**Table 12 - Read/Write Words for Calibration**

| Dec. Bit | 15 | 14 | 13 | 12 | 11 | 10 | 09 | 08 | 07 | 06 | 05 | 04 | 03 | 02 | 01 | 00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Octal Bit** | **17** | **16** | **15** | **14** | **13** | **12** | **11** | **10** | **07** | **06** | **05** | **04** | **03** | **02** | **01** | **00** |
| Read Word 10 | 0 | 0 | 0 | 0 | 0 | CB | CD | CR | 0 | Diagnostic Status | | | PU | BS | CJC Over | CJC Under |
| Write Word 0 | 8-bit Calibration Mask | | | | | | | | CK | CH<br>CL | Filter Cutoff | | | FDF | Data Type | |
| Where: | PU = Power-up<br>CB = Calibration bad<br>CD = Calibration done<br>CR = Calibration range<br>BS = Bad structure | | | | | | | | CK = Calibration clock<br>CH = Calibration high<br>CL = Calibration low<br>FDF = Fixed digit filter bit | | | | | | | |

*Offset Calibration*

Inputs can be calibrated one at a time or all at once. To calibrate the offsets for all inputs at once, proceed as follows:

1. Apply power to the module for 40 minutes minimum before you start calibration.
2. Connect 0.000V across each input channel. Connect all high signal terminals together and attach to the positive lead of the precision voltage source. Connect all low signal terminals together and attach to the negative lead of the precision voltage source.
3. After the connections stabilize, use a BTW to set the bits in the calibration mask that corresponds to the channels you want to calibrate to 1 (Bits 08...15 in write word 0).
4. Send another BTW to set the CK bit (07 in write word 0) to 1.
5. Monitor the CD bit (09 in read word 10). If the calibration is successful, the CD bit is set to 1. Verify that the CB bit (10 in read word 10) and the CR bit (08 in read word 10) are not set (should be 0).
6. Send another BTW to set the CK bit (07 in write word 0) to 0.
7. Monitor the CD bit (09 in read word 10). The CD bit is reset to 0.
8. If the calibration is successful, proceed to Gain Calibration.

*Gain Calibration*

After completing the offset calibration, proceed with the gain calibration:

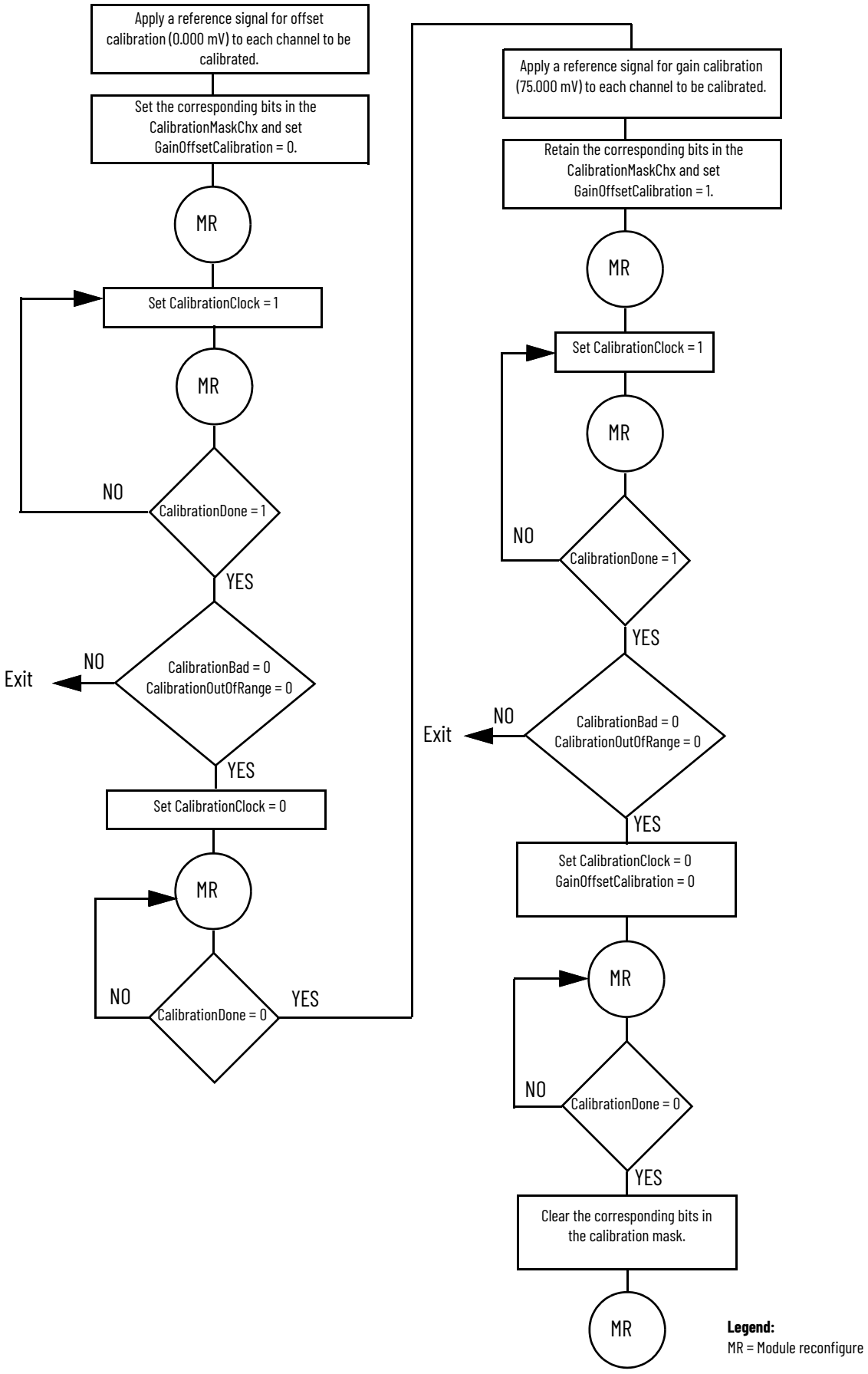
1. Apply power to the module for 40 minutes minimum before you start calibration.
2. Connect 75.000 mV across each input channel. Connect all high signal terminals together and attach to the positive lead of the precision voltage source. Connect all low signal terminals together and attach to the negative lead of the precision voltage source.
3. After the connections stabilize, send a BTW to the module to set the bit in the calibration mask that corresponds to the channel to be calibrated to 1, and the CH/CL bit (06 in write word 0) to 1 (Set bits 08...15 in write word 0 if calibrating all inputs at one time).
4. Send another BTW to set the CK bit (07 in write word 0) to 1.
5. Monitor the CD bit (09 in read word 10). If the calibration is successful, the CD bit is set to 1. Verify that the CB bit (10 in read word 10) and the CR bit (08 in read word 10) are not set (should be 0).
6. Send another BTW to set the CK bit (07 in write word 0) to 0.
7. Send another BTW to set the CH/CL bit (06 in write word 0) to 0.
8. Monitor the CD bit (09 in read word 10). The CD bit is reset to 0.
9. If individually calibrating the channels, do the Step 1...Step 7 again for offset calibration on any additional channels you want to calibrate.
10. Send a BTW to the module to clear all calibration mask bits to 0.

## Calibrate Your Module for a ControlNet or an EtherNet/IP Network

Use this procedure to calibrate your module when you use a ControlNet or an EtherNet/IP network.

During calibration the module stores the calibration data for two set points referred to as offset and gain. The offset calibration is taken with input 0.000 mV and the gain calibration is done with 75.000 mV.

**Figure 8 - Flowchart for Calibration Procedure - ControlNet or EtherNet/IP Network**

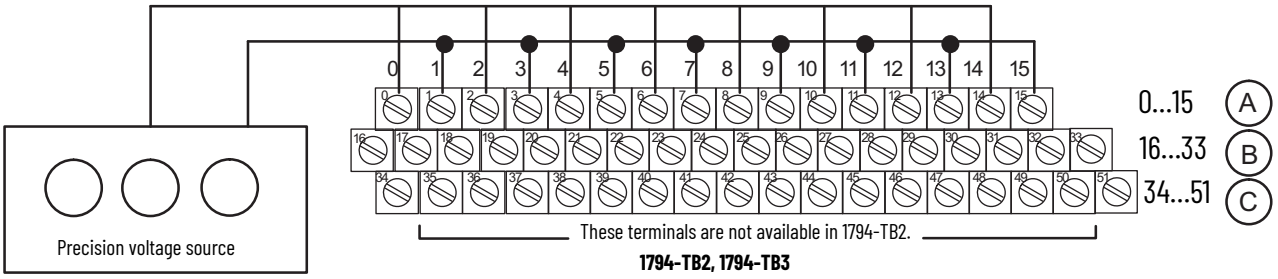


## *Calibration Setup*

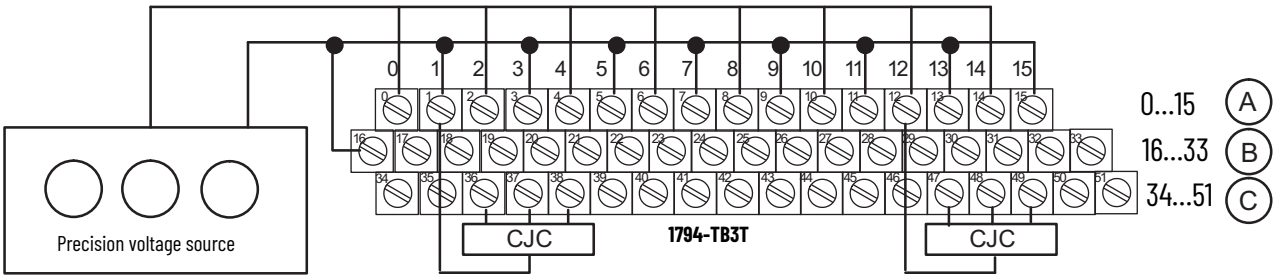
The field power to the module must be given separately, and should not be daisy-chained from the adapter. This is to prevent digital noise from interfering with calibration.

**Figure 9 - Wiring Diagram**

**Using a Precision Voltage Source**




**Note:** Use 1794-TB2 and 1794-TB3 terminal base units for millivolt inputs only.




**Note:** A CJC is not required if you are using the thermocouple for resistance only.

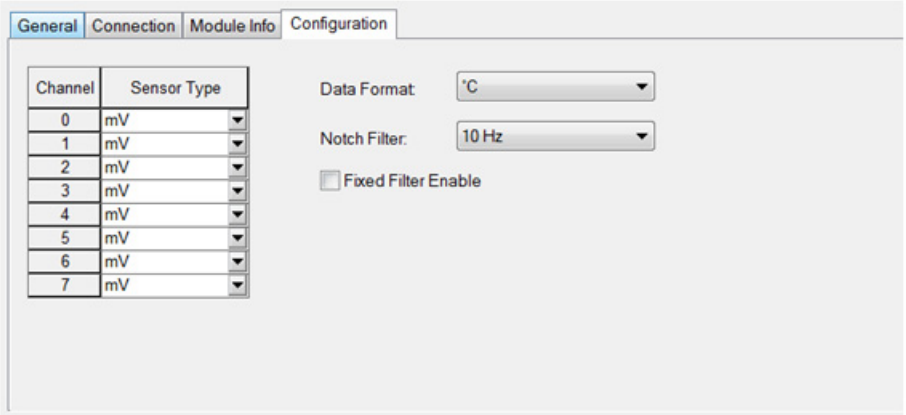
**Table 13 - Wiring Connections for the Thermocouple Module**

| Thermocouple Channel | 1794-TB2, 1794-TB3 Terminal Base Units | | | 1794-TB3T Terminal Base Unit(1) | | |
|---|---|---|---|---|---|---|
| | High Signal Terminal (+) | Low Signal Terminal (–) | Shield Return | High Signal Terminal (+) | Low Signal Terminal (–) | Shield Return(2) |
| 0 | 0 | 1 | 17 | 0 | 1 | 39 |
| 1 | 2 | 3 | 19 | 2 | 3 | 40 |
| 2 | 4 | 5 | 21 | 4 | 5 | 41 |
| 3 | 6 | 7 | 23 | 6 | 7 | 42 |
| 4 | 8 | 9 | 25 | 8 | 9 | 43 |
| 5 | 10 | 11 | 27 | 10 | 11 | 44 |
| 6 | 12 | 13 | 29 | 12 | 13 | 45 |
| 7 | 14 | 15 | 31 | 14 | 15 | 46 |
| 24V DC Common | Terminals 16...33 | | | Terminals 16, 17, 19, 21, 23, 25, 27, 29, 31, and 33 | | |
| +24V DC Power | **For 1794-TB2**: Terminals 34 and 51<br>**For 1794-TB3**: Terminals 34...51 | | | Terminals 34, 35, 50, and 51 | | |

(1) Terminals 36, 37, 38 and 47, 48, 49 are cold junction compensator connections.
(2) Terminals 39...46 are chassis ground.

### *Setting up Studio 5000 Logix Designer Application for Calibration*

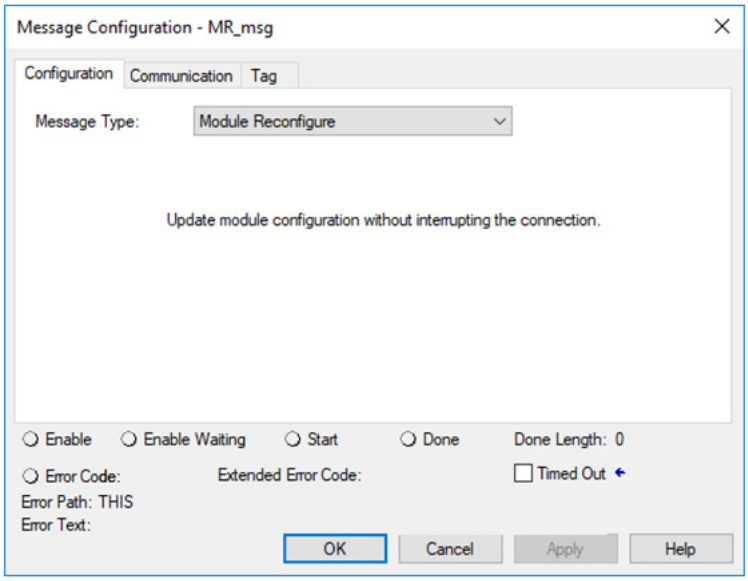
Open the Studio 5000 Logix Designer® application and set all the channels to mV in Configuration tab.



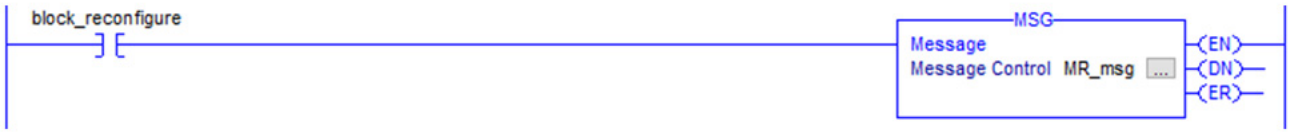

### *Module Reconfigure*

To add a rung with Module Reconfigure element in the ladder logic, proceed as follows:

1. Double-click on the Module Reconfigure option available in the Studio 5000 Logix Designer application. The below screen appears.

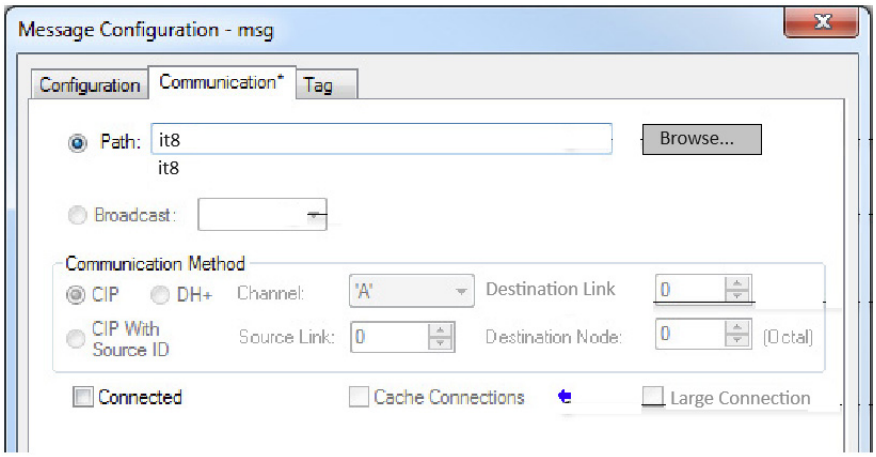



2. Use the MSG command and give it a tag name. The below example has a tag name as MR_msg.




3. Right-click on the tag name given in the Message Control field and declare it as a New MR_msg.
4. Select the button next to MR_msg. The Message Configuration - MR_msg dialog appears.
5. From the Message Type dropdown list, select Module Reconfigure.
6. Select Communication tab.

7. In Communication tab, select Browse and choose the 1794-IT8 module to be calibrated.




8. Use an ONS command or check the MSG.DN to make sure that the rung with Module Reconfigure is not continuously executed.
9. Press Ctrl+T to toggle the block_reconfigure on the rung in ladder logic.

| | |
|---|---|
| **IMPORTANT** | Whenever a module reconfiguration (MR) is mentioned in the procedure, toggle this rung. |

*Calibration Procedure*

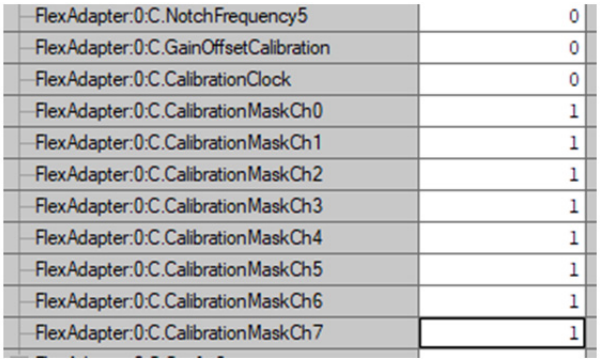
Once all the setup is done, power On the module. Keep the module powered On for 40 minutes. Once the 40 minute warm-up is completed, immediately perform the calibration. Make sure that there is no considerable time gap between the end of the warm-up and the start of the calibration.

Follow the procedure as shown in the calibration flowchart (See Figure 8). The reference signal for offset calibration is 0.000 mV and the reference signal for gain calibration is 75.000 mV. Set these values from the millivolt simulator.

| | |
|---|---|
| **IMPORTANT** | Perform the offset calibration procedure first, then perform the gain calibration procedure. |

*Offset Calibration*

1. Apply power to the module for 40 minutes before you start calibration.
2. Connect 0.000V across each input channel. Connect all high signal terminals together and attach to the positive lead of the precision voltage source. Connect all low signal terminals together and attach to the negative lead of the precision voltage source.
3. After the connections stabilize, set the bits in the calibration mask that correspond to the channels that you want to calibrate to 1. By setting the calibration mask bits you are fixing the channels to be calibrated. If CalibrationMaskChN is 1, this channel (Channel N) is calibrated. If CalibrationMaskChN is 0, this channel (Channel N) is not calibrated.




4. Set the GainOffsetCalibration bit to 0 and send a ModuleReconfigure.

5. Set the CalibrationClock bit to 1 and send another ModuleReconfigure.
6. Monitor the CalibrationDone bit. If the calibration is successful, the CalibrationDone bit is set to 1. Verify that the CalibrationBad bit and the CalibrationOutOfRange bit are not set (should be 0).

| | |
|---|---|
| FlexAdapter:0:I.CalibrationOutOfRange | 0 |
| FlexAdapter:0:I.CalibrationDone | 1 |
| FlexAdapter:0:I.CalibrationBad | 0 |

7. Set the CalibrationClock bit to 0 and send another ModuleReconfigure.
8. Monitor the CalibrationDone bit. The CalibrationDone bit is reset to 0.

| | |
|---|---|
| FlexAdapter:0:I.CalibrationOutOfRange | 0 |
| FlexAdapter:0:I.CalibrationDone | 0 |
| FlexAdapter:0:I.CalibrationBad | 0 |

9. If the calibration is successful, proceed to the Gain Calibration.

*Gain Calibration*

1. Make sure that the module is powered on for 40 minutes minimum before you start calibration.
2. Connect 75.000 mV across each input channel. Connect all high signal terminals together and attach to the positive lead of the precision voltage source. Connect all low signal terminals together and attach to the negative lead of the precision voltage source.
3. After the connections stabilize, set the bits in the calibration mask that correspond to the channels that you want to calibrate to 1.
4. Set the GainOffsetCalibration bit to 1 and send a ModuleReconfigure.

| | |
|---|---|
| FlexAdapter:0:C.GainOffsetCalibration | 1 |
| FlexAdapter:0:C.CalibrationClock | 1 |
| FlexAdapter:0:C.CalibrationMaskCh0 | 1 |
| FlexAdapter:0:C.CalibrationMaskCh1 | 1 |
| FlexAdapter:0:C.CalibrationMaskCh2 | 1 |
| FlexAdapter:0:C.CalibrationMaskCh3 | 1 |
| FlexAdapter:0:C.CalibrationMaskCh4 | 1 |
| FlexAdapter:0:C.CalibrationMaskCh5 | 1 |
| FlexAdapter:0:C.CalibrationMaskCh6 | 1 |
| FlexAdapter:0:C.CalibrationMaskCh7 | 1 |

5. Set the CalibrationClock bit to 1. Send another ModuleReconfigure.
6. Monitor the CalibrationDone bit. If the calibration is successful, the CalibrationDone bit is set to 1. Verify that the CalibrationBad bit and the CalibrationOutOfRange bit are not set (should be 0).

| | |
|---|---|
| FlexAdapter:0:I.CalibrationOutOfRange | 0 |
| FlexAdapter:0:I.CalibrationDone | 1 |
| FlexAdapter:0:I.CalibrationBad | 0 |

7. Set the CalibrationClock bit to 0 and send another ModuleReconfigure.
8. Set the GainOffsetCalibration bit to 0 and send another ModuleReconfigure.
9. Monitor the CalibrationDone bit. The CalibrationDone bit is reset to 0.

| | |
|---|---|
| FlexAdapter:0:I.CalibrationOutOfRange | 0 |
| FlexAdapter:0:I.CalibrationDone | 0 |
| FlexAdapter:0:I.CalibrationBad | 0 |

10. If individually calibrating the channels, perform the Step 1...Step 8 again for offset calibration on any additional channels that you want to calibrate.
11. Set all CalibrationMaskChN bits to 0. Send a ModuleReconfigure.

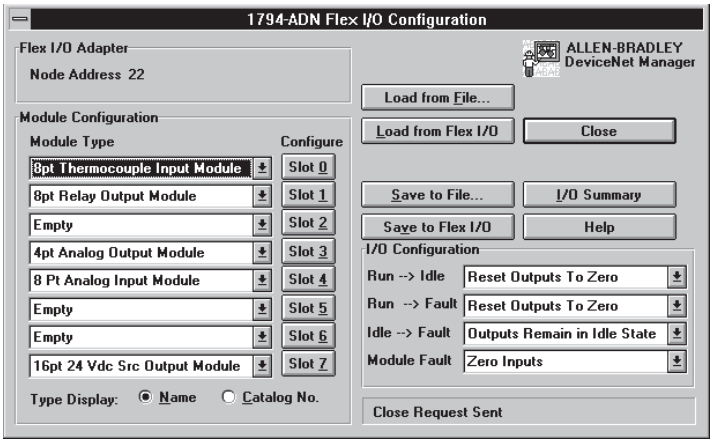
# Use DeviceNetManager Software to Calibrate Your Module

The following procedure assumes that you are using DeviceNetManager software (1787-MGR) and have the thermocouple/mV module installed in a working system.

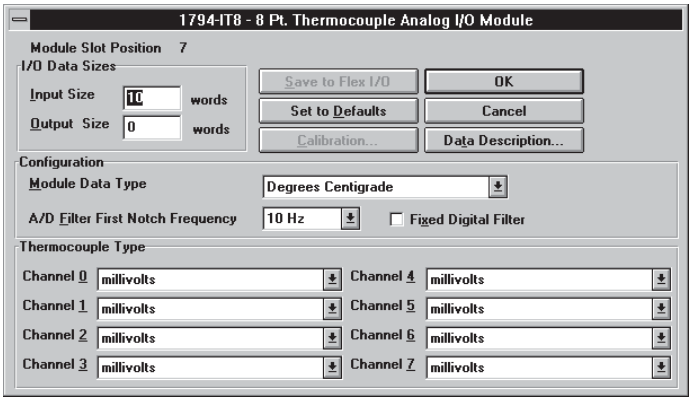
## Offset Calibration

You can calibrate the inputs one at a time or all at once. To calibrate the offsets for all inputs at once, proceed as follows:

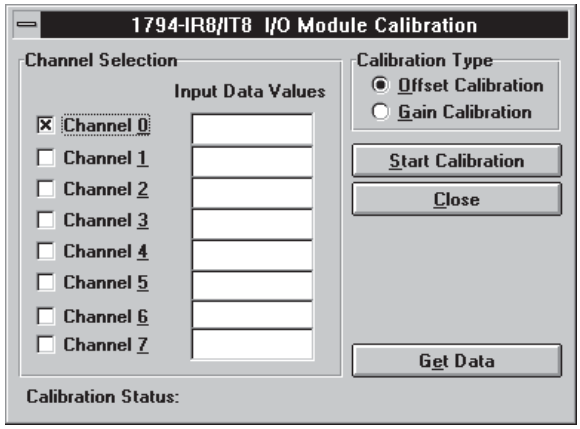
1. Connect 0.000 mV across each input channel. Connect all high signal terminals together and attach to the positive lead from the precision voltage source. Connect all low signal terminals together and attach to the negative lead.
2. Apply power to the module for 40 minutes before calibrating.
3. Select the Slot, which contains your thermocouple module in Module Configuration. For example, in the following screen, the thermocouple input module is in Slot 0. You must select Slot 0.



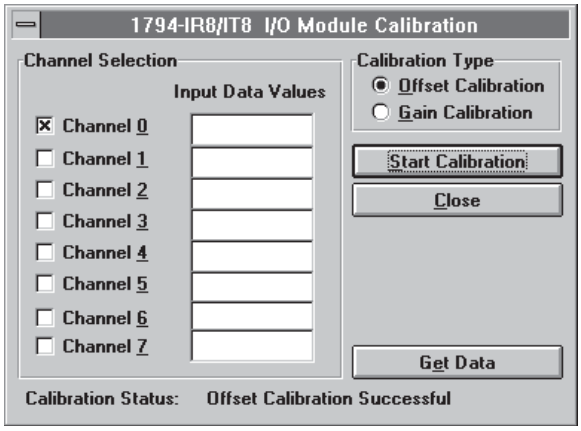

The following dialog appears:




4. Select Calibration... to get to the calibration screen.



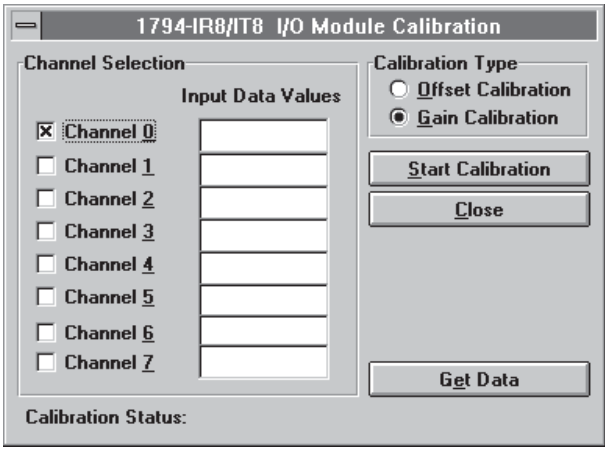
5. Under Channel Selection, select the checkboxes for channels that you want to calibrate.
6. Under Channel Type, select the Offset Calibration option. Then select Start Calibration.
7. When calibration is complete, you see a notification indicating Offset Calibration Successful in the Calibration Status area.



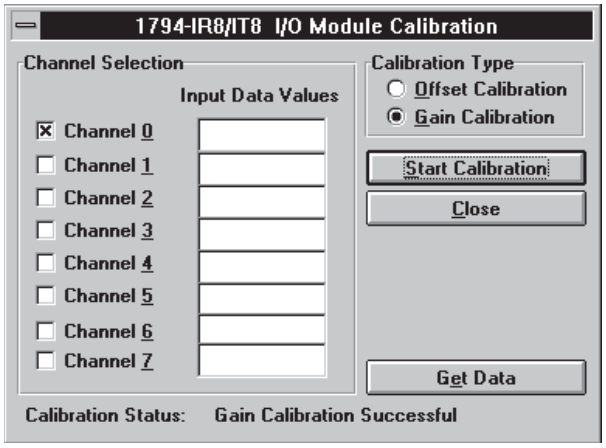

## Gain Calibration

Make sure that you have calibrated the offset for this channel before calibrating the gain.

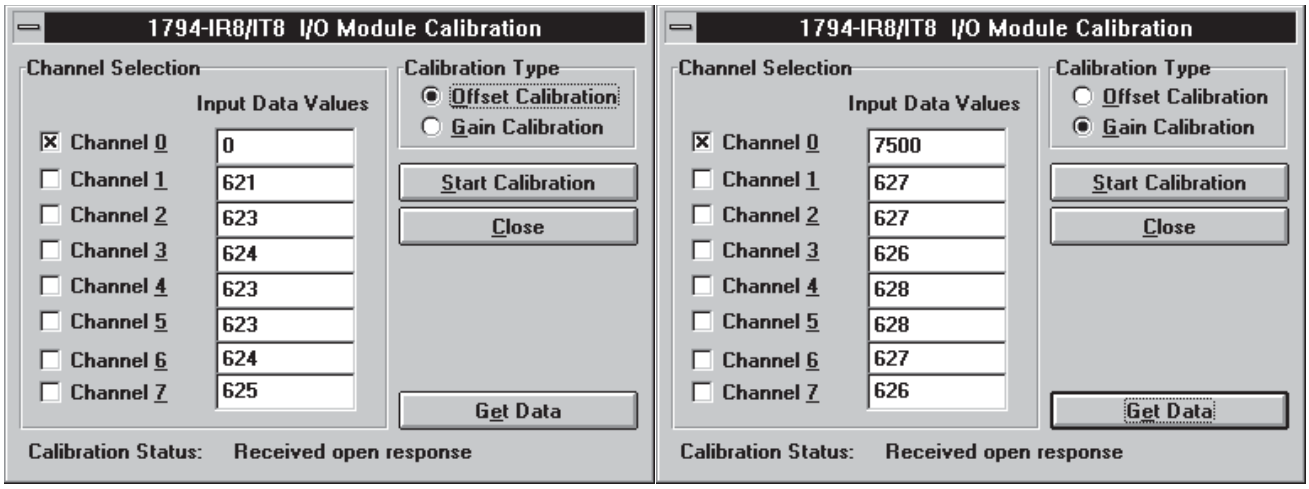
1. Connect 75.000 mV across each input channel. Connect all high signal terminals together and attach to the positive lead from the precision voltage source. Connect all low signal terminals together and attach to the negative lead.
2. Under Channel Selection, select the checkboxes for channels that you want to calibrate.



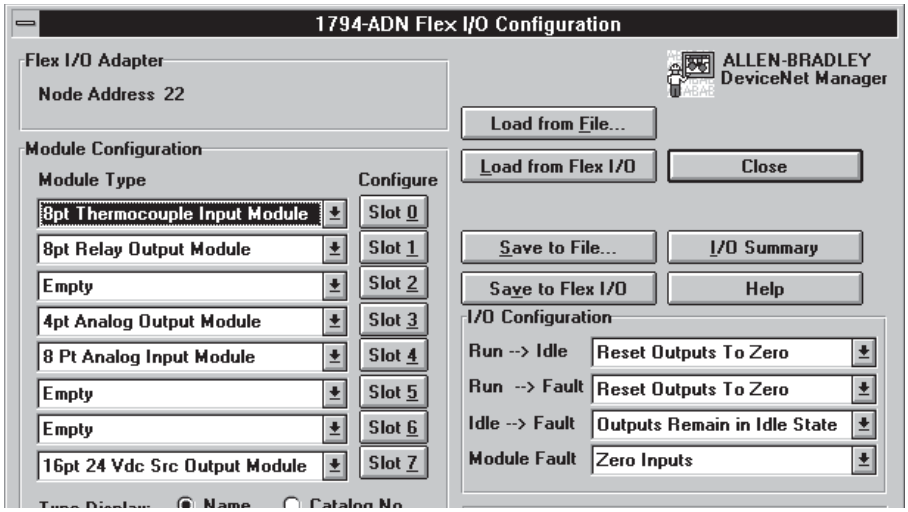

3. Under Channel Type, select the Gain Calibration option. Then select Start Calibration.
4. When calibration is complete, you see a notification indicating Gain Calibration Successful in the Calibration Status area.



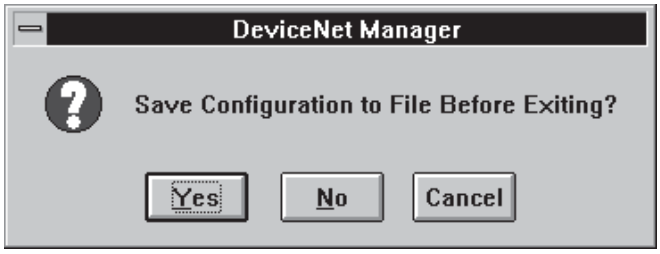
The Get Data option populates the screen with the actual values appearing at the inputs. There is an implied decimal point to the left of the last two digits. For example, the channel 0 data value reads 7500. The actual reading is 75.00 mV.




After both Offset and Gain Calibrations are successful, select Close. You return to the Module Configuration screen. Select Save to Flex I/O or Save to File... to save the configuration.




If you attempt to close without saving your configuration information by selecting the Close option, you are prompted to save the changes. Select Yes to continue.



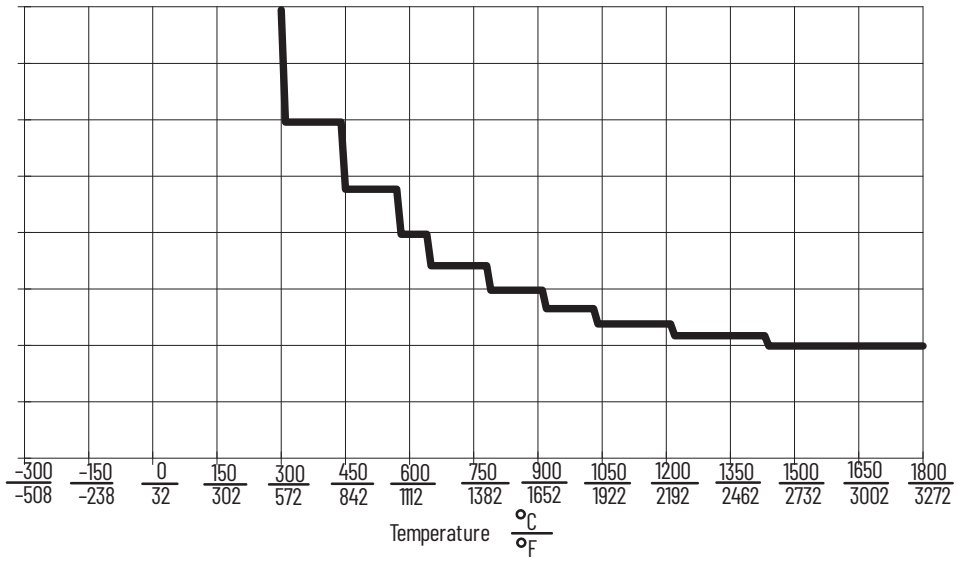
# Notes:

# Resolution Curves, Worst Case Accuracy, Error Due to Open Circuit Current, and Worst Case Repeatability

## Resolution Curves for Thermocouples

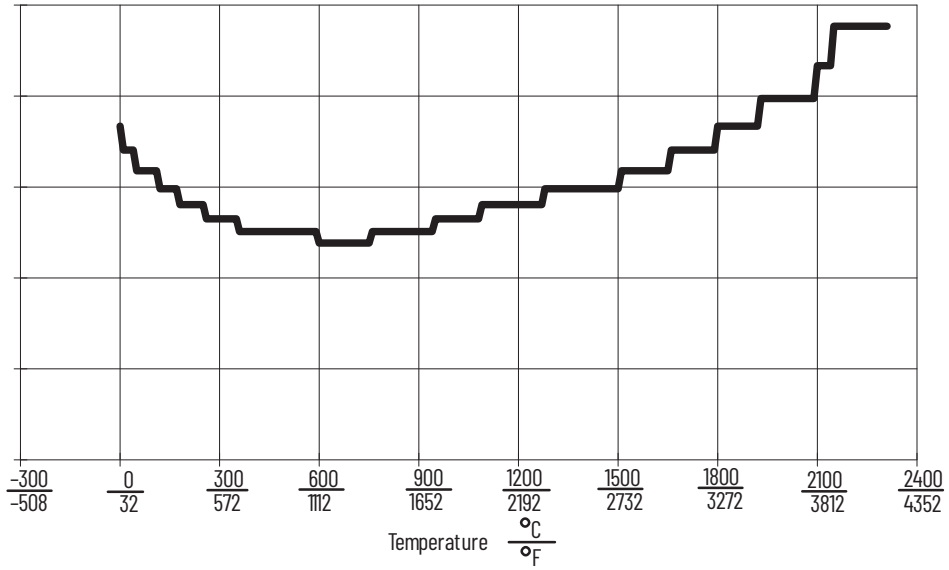
### Type B Thermocouple

| Resolution °C / °F | | | |
|---|---|---|---|
| 1000 Hz | 500 Hz | 250 Hz | 10...100 Hz |
| 102.4 / 184.3 | 25.60 / 46.08 | 6.40 / 11.52 | 0.80 / 1.44 |
| 89.60 / 161.3 | 22.40 / 40.32 | 5.60 / 10.08 | 0.70 / 1.26 |
| 76.80 / 138.2 | 19.20 / 34.56 | 4.80 / 8.64 | 0.60 / 1.08 |
| 64.00 / 115.2 | 16.00 / 28.80 | 4.00 / 7.20 | 0.50 / 0.90 |
| 51.20 / 92.16 | 12.80 / 23.04 | 3.20 / 5.76 | 0.40 / 0.72 |
| 38.40 / 69.12 | 9.60 / 17.28 | 2.40 / 4.32 | 0.30 / 0.54 |
| 25.60 / 46.08 | 6.40 / 11.52 | 1.60 / 2.88 | 0.20 / 0.36 |
| 12.80 / 23.04 | 3.20 / 5.76 | 0.80 / 1.44 | 0.10 / 0.18 |
| | | | 0 |



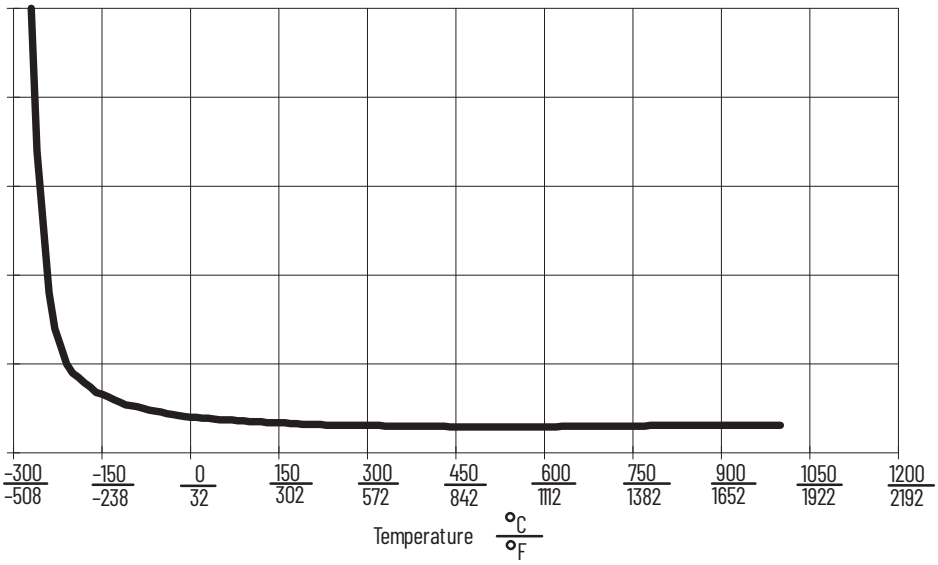
## Type C Thermocouple

| Resolution °C / °F | | | |
|---|---|---|---|
| 1000 Hz | 500 Hz | 250 Hz | 10...100 Hz |
| 32.00 / 57.60 | 8.00 / 14.4 | 2.00 / 3.60 | 0.25 / 0.45 |
| 25.60 / 46.08 | 6.40 / 11.52 | 1.60 / 2.88 | 0.20 / 0.36 |
| 19.20 / 34.56 | 4.80 / 8.64 | 1.20 / 2.16 | 0.15 / 0.27 |
| 12.80 / 23.04 | 3.20 / 5.76 | 0.80 / 1.44 | 0.10 / 0.18 |
| 6.400 / 11.52 | 1.60 / 2.88 | 0.40 / 0.72 | 0.05 / 0.09 |
| | | | 0 |




## Type E Thermocouple

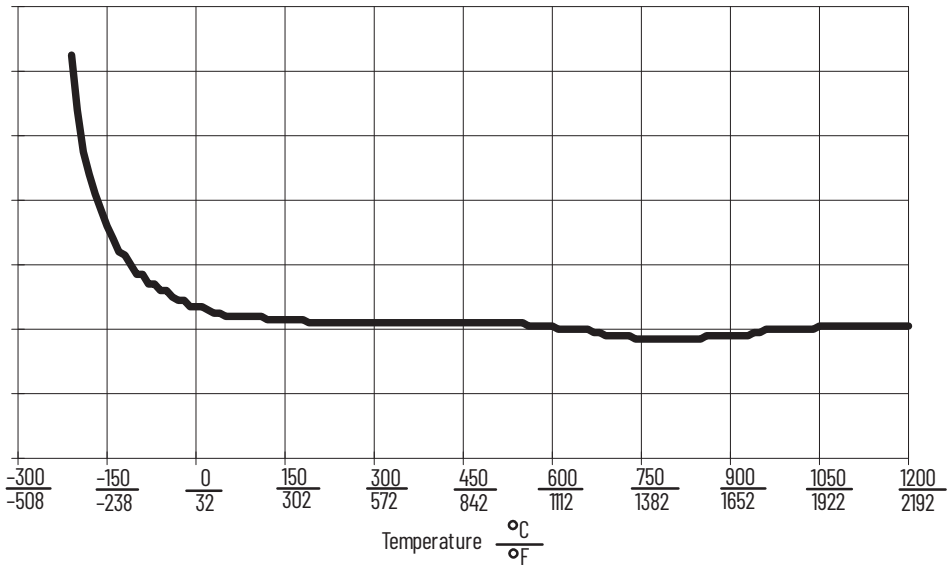
| Resolution °C / °F | | | |
|---|---|---|---|
| 1000 Hz | 500 Hz | 250 Hz | 10...100 Hz |
| 64.00 / 115.2 | 16.00 / 28.80 | 4.00 / 7.20 | 0.50 / 0.90 |
| 51.20 / 92.16 | 12.80 / 23.04 | 3.20 / 5.76 | 0.40 / 0.72 |
| 38.40 / 69.12 | 9.60 / 17.28 | 2.40 / 4.32 | 0.30 / 0.54 |
| 25.60 / 46.08 | 12.80 / 11.52 | 1.60 / 2.88 | 0.20 / 0.36 |
| 12.80 / 23.04 | 6.40 / 5.76 | 0.80 / 1.44 | 0.10 / 0.18 |
| | | | 0 |



## Type J Thermocouple

Resolution °C / °F

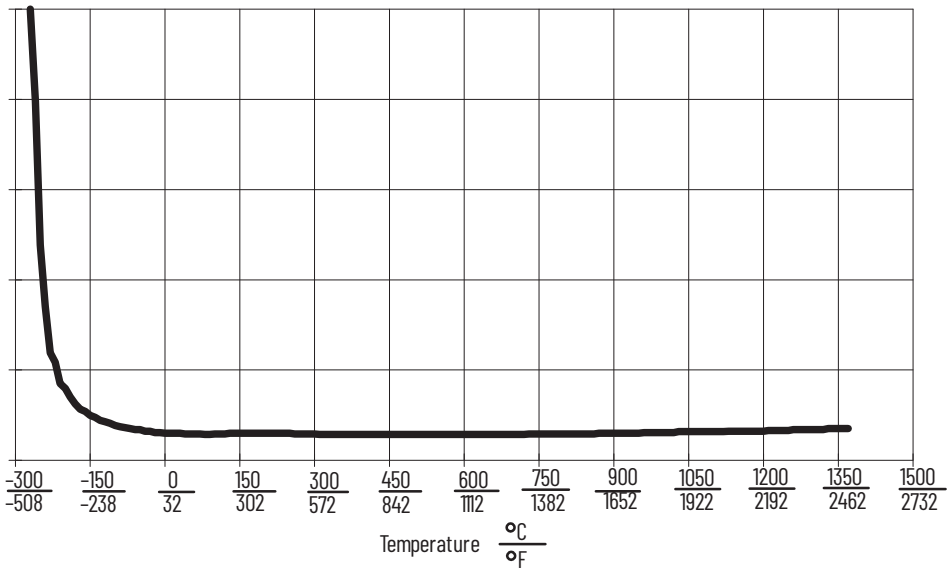
| 1000 Hz | 500 Hz | 250 Hz | 10...100 Hz |
|---|---|---|---|
| 17.92 / 32.25 | 4.480 / 8.064 | 1.120 / 2.016 | 0.140 / 0.252 |
| 15.36 / 27.65 | 3.840 / 6.912 | 0.960 / 1.728 | 0.120 / 0.216 |
| 12.80 / 23.04 | 3.200 / 5.760 | 0.800 / 1.440 | 0.100 / 0.180 |
| 10.24 / 18.43 | 2.560 / 4.608 | 0.640 / 1.152 | 0.080 / 0.144 |
| 7.680 / 13.82 | 1.920 / 3.456 | 0.480 / 0.864 | 0.060 / 0.108 |
| 5.120 / 9.216 | 1.280 / 2.304 | 0.320 / 0.576 | 0.040 / 0.072 |
| 2.560 / 4.608 | 0.640 / 1.152 | 0.160 / 0.288 | 0.020 / 0.036 |
| | | | 0 |



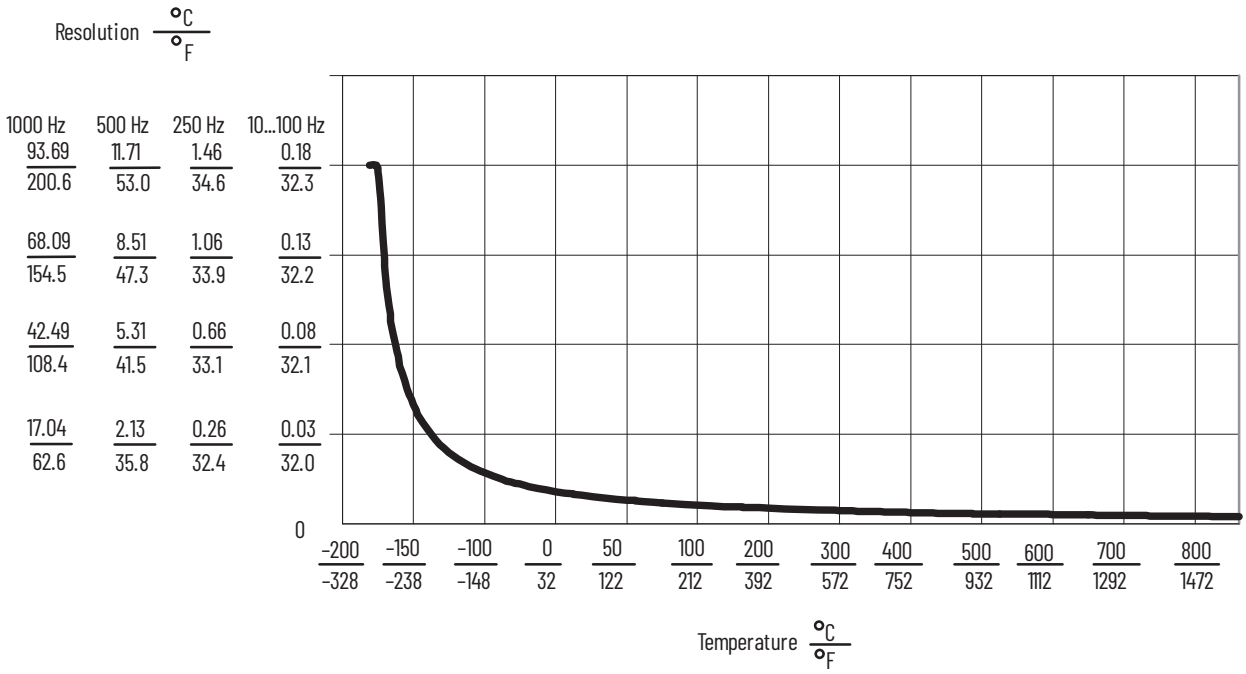

## Type K Thermocouple

Resolution °C / °F

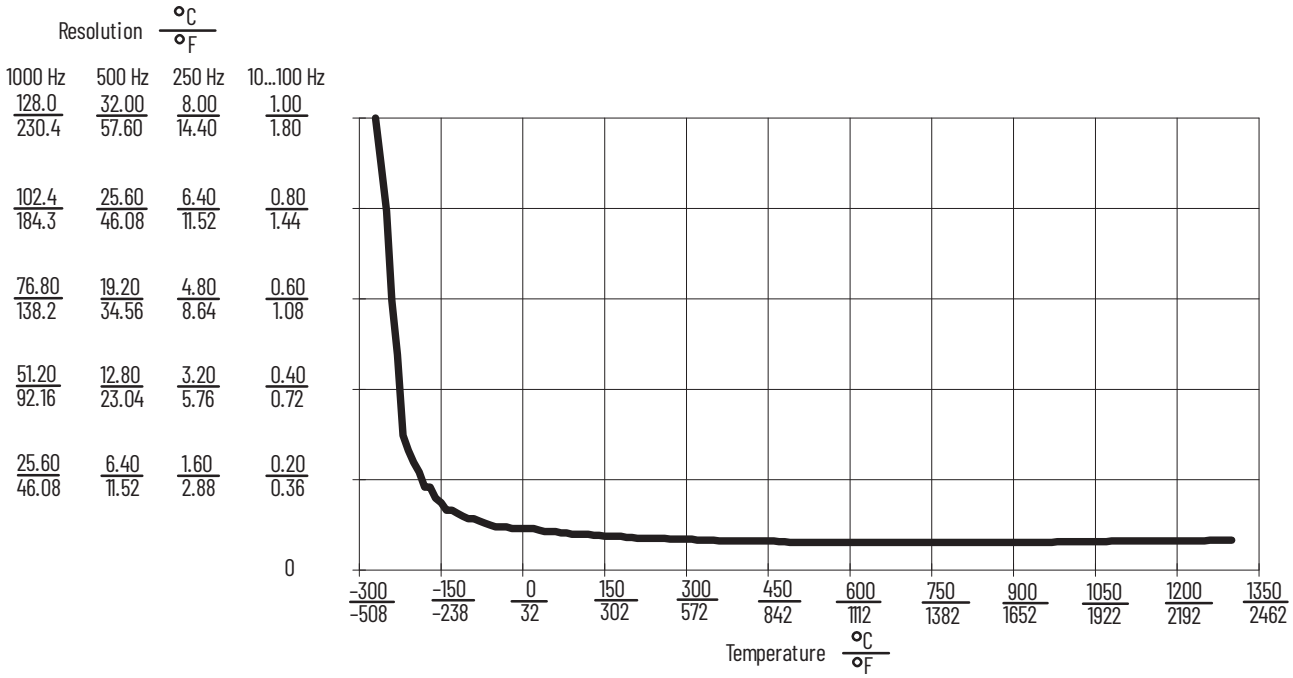
| 1000 Hz | 500 Hz | 250 Hz | 10...100 Hz |
|---|---|---|---|
| 128.0 / 230.4 | 32.00 / 57.60 | 8.000 / 14.40 | 1.000 / 1.800 |
| 102.4 / 184.3 | 25.60 / 46.08 | 6.400 / 11.52 | 0.800 / 1.440 |
| 76.80 / 138.2 | 19.20 / 34.56 | 4.800 / 8.640 | 0.600 / 1.080 |
| 51.20 / 92.16 | 12.80 / 23.04 | 3.200 / 5.760 | 0.400 / 0.720 |
| 25.60 / 46.08 | 6.400 / 11.52 | 1.600 / 2.880 | 0.200 / 0.360 |
| | | | 0 |



## Type L Thermocouple



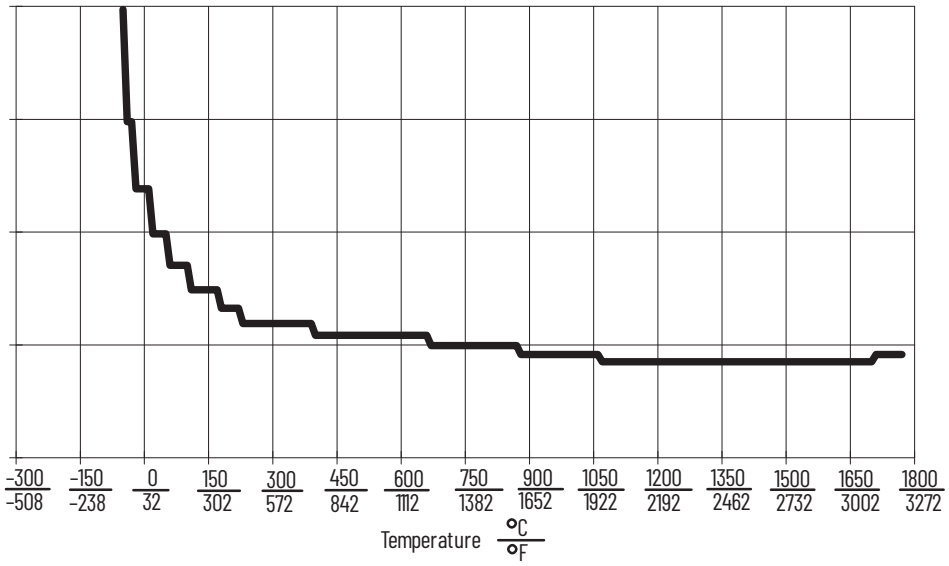

## Type N Thermocouple



## Type R Thermocouple

Resolution °C / °F

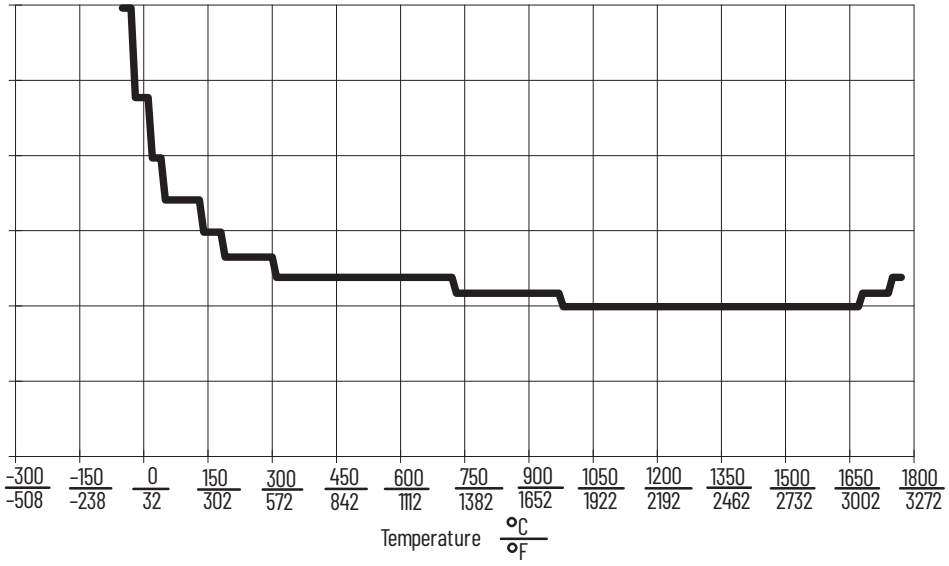
| 1000 Hz | 500 Hz | 250 Hz | 10...100 Hz |
|---|---|---|---|
| 102.4 / 184.3 | 25.60 / 46.08 | 6.40 / 11.52 | 0.80 / 1.44 |
| 76.80 / 138.2 | 19.20 / 34.56 | 4.80 / 8.64 | 0.60 / 1.08 |
| 51.20 / 92.16 | 12.80 / 23.04 | 3.20 / 5.76 | 0.40 / 0.72 |
| 25.60 / 46.08 | 6.40 / 11.52 | 1.60 / 2.88 | 0.20 / 0.36 |
| | | | 0 |



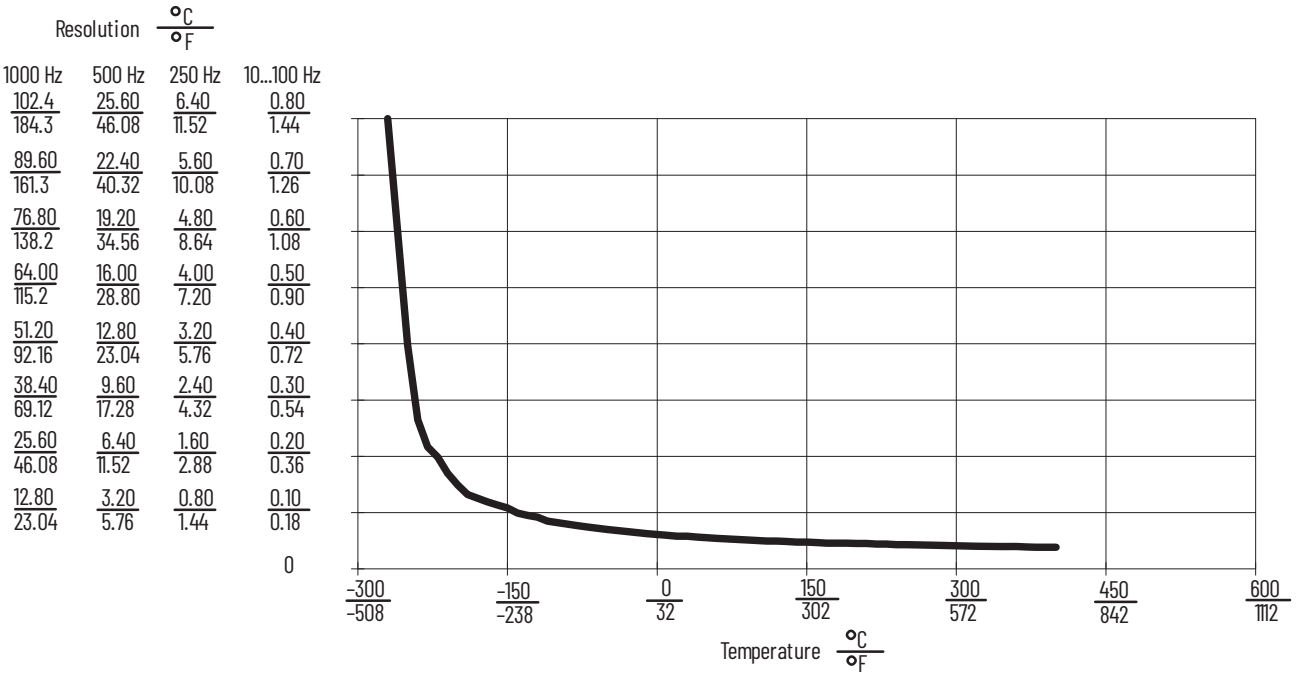

## Type S Thermocouple

Resolution °C / °F

| 1000Hz | 500Hz | 250Hz | 10-100Hz |
|---|---|---|---|
| 76.80 / 138.2 | 19.20 / 34.56 | 4.80 / 8.64 | 0.60 / 1.08 |
| 64.00 / 115.2 | 16.00 / 28.80 | 4.00 / 7.20 | 0.50 / 0.90 |
| 51.20 / 92.16 | 12.80 / 23.04 | 3.20 / 5.76 | 0.40 / 0.72 |
| 38.40 / 69.12 | 9.60 / 17.28 | 2.40 / 4.32 | 0.30 / 0.54 |
| 25.60 / 46.08 | 6.40 / 11.52 | 1.60 / 2.88 | 0.20 / 0.36 |
| 12.80 / 23.04 | 3.20 / 5.76 | 0.80 / 1.44 | 0.10 / 0.18 |
| | | | 0 |



## Type T Thermocouple




## Worst Case Accuracy for the Thermocouple/mV Module

**Table 14 - Worst Case Accuracy for the Thermocouple/mV Module**

| Input Type | Accuracy @ 25 °C | Accuracy @ 77 °F | Temperature Drift | |
|---|---|---|---|---|
| | | | 0...60 °C | 32...140 °F |
| B | ±3.70 °C | ±6.66 °F | ±0.710 °C/°C | ±0.710 °F/°F |
| E | ±0.51 °C | ±0.92 °F | ±0.104 °C/°C | ±0.104 °F/°F |
| J | ±0.68 °C | ±1.22 °F | ±0.130 °C/°C | ±0.130 °F/°F |
| K | ±1.00 °C | ±1.80 °F | ±0.186 °C/°C | ±0.186 °F/°F |
| R | ±3.16 °C | ±5.69 °F | ±0.601 °C/°C | ±0.601 °F/°F |
| S | ±3.70 °C | ±6.67 °F | ±0.651 °C/°C | ±0.651 °F/°F |
| T | ±0.67 °C | ±1.21 °F | ±0.174 °C/°C | ±0.174 °F/°F |
| N | ±1.07 °C | ±1.93 °F | ±0.223 °C/°C | ±0.223 °F/°F |
| C | ±3.40 °C | ±6.12 °F | ±0.434 °C/°C | ±0.434 °F/°F |
| L | ±0.58 °C | ±1.35 °F | ±0.119 °C/°C | ±0.119 °F/°F |
| mV | ±39 µV | ±39 µV | ±7.812 µV/°C | ±14.06 µV/°F |

## Error Due to Open Circuit Current Through Loop Resistance

**Table 15 - Error Due to Open Circuit Current Through Loop Resistance**

| Input Type | Error per Ω of Loop Resistance | |
|---|---|---|
| | (°C) | (°F) |
| B | 0.091 | 0.164 |
| E | 0.013 | 0.023 |
| J | 0.016 | 0.029 |
| K | 0.024 | 0.043 |
| R | 0.076 | 0.137 |
| S | 0.083 | 0.149 |
| T | 0.022 | 0.040 |
| N | 0.028 | 0.050 |

**Table 15 - Error Due to Open Circuit Current Through Loop Resistance (Continued)**

| Input Type | Error per Ω of Loop Resistance | |
|---|---|---|
| | (°C) | (°F) |
| C | 0.055 | 0.099 |
| L | 0.015 | 0.028 |
| mV | 0.417 mV (2.4 Ω = 1 LSB of error) | |

# Worst Case Repeatability for the Thermocouple/mV Input Module

**Table 16 - Worst Case Repeatability for the Thermocouple/mV Input Module**

| Input Type | Repeatability with Filter | | Repeatability without Filter | |
|---|---|---|---|---|
| | (°C) | (°F) | (°C/°C) | (°F/°F) |
| B | ±1.00 | ±1.80 | ±2.00 | ±3.60 |
| E | ±0.16 | ±0.29 | ±0.32 | ±0.58 |
| J | ±0.20 | ±0.36 | ±0.40 | ±0.72 |
| K | ±0.28 | ±0.50 | ±0.56 | ±1.00 |
| R | ±1.10 | ±1.98 | ±2.20 | ±3.96 |
| S | ±1.00 | ±1.80 | ±2.00 | ±3.60 |
| T | ±0.27 | ±0.54 | ±0.54 | ±1.08 |
| N | ±0.34 | ±0.61 | ±0.68 | ±1.22 |
| C | ±0.13 | ±0.23 | ±0.26 | ±0.46 |
| L | ±0.19 | ±0.30 | ±0.37 | ±0.62 |
| mV | ±12 µV | ±12 µV | ±24 µV/°C | ±24 µV/°F |

**Note**: The filter is enabled by setting bit 02 in write word 0.

## Notes:

# Notes:

## Rockwell Automation Support

Use these resources to access support information.

| | | |
|---|---|---|
| **Technical Support Center** | Find help with how-to videos, FAQs, chat, user forums, Knowledgebase, and product notification updates. | rok.auto/support |
| **Local Technical Support Phone Numbers** | Locate the telephone number for your country. | rok.auto/phonesupport |
| **Technical Documentation Center** | Quickly access and download technical specifications, installation instructions, and user manuals. | rok.auto/techdocs |
| **Literature Library** | Find installation instructions, manuals, brochures, and technical data publications. | rok.auto/literature |
| **Product Compatibility and Download Center (PCDC)** | Download firmware, associated files (such as AOP, EDS, and DTM), and access product release notes. | rok.auto/pcdc |

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## Waste Electrical and Electronic Equipment (WEEE)

At the end of life, this equipment should be collected separately from any unsorted municipal waste.

Rockwell Automation maintains current product environmental compliance information on its website at rok.auto/pec.



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