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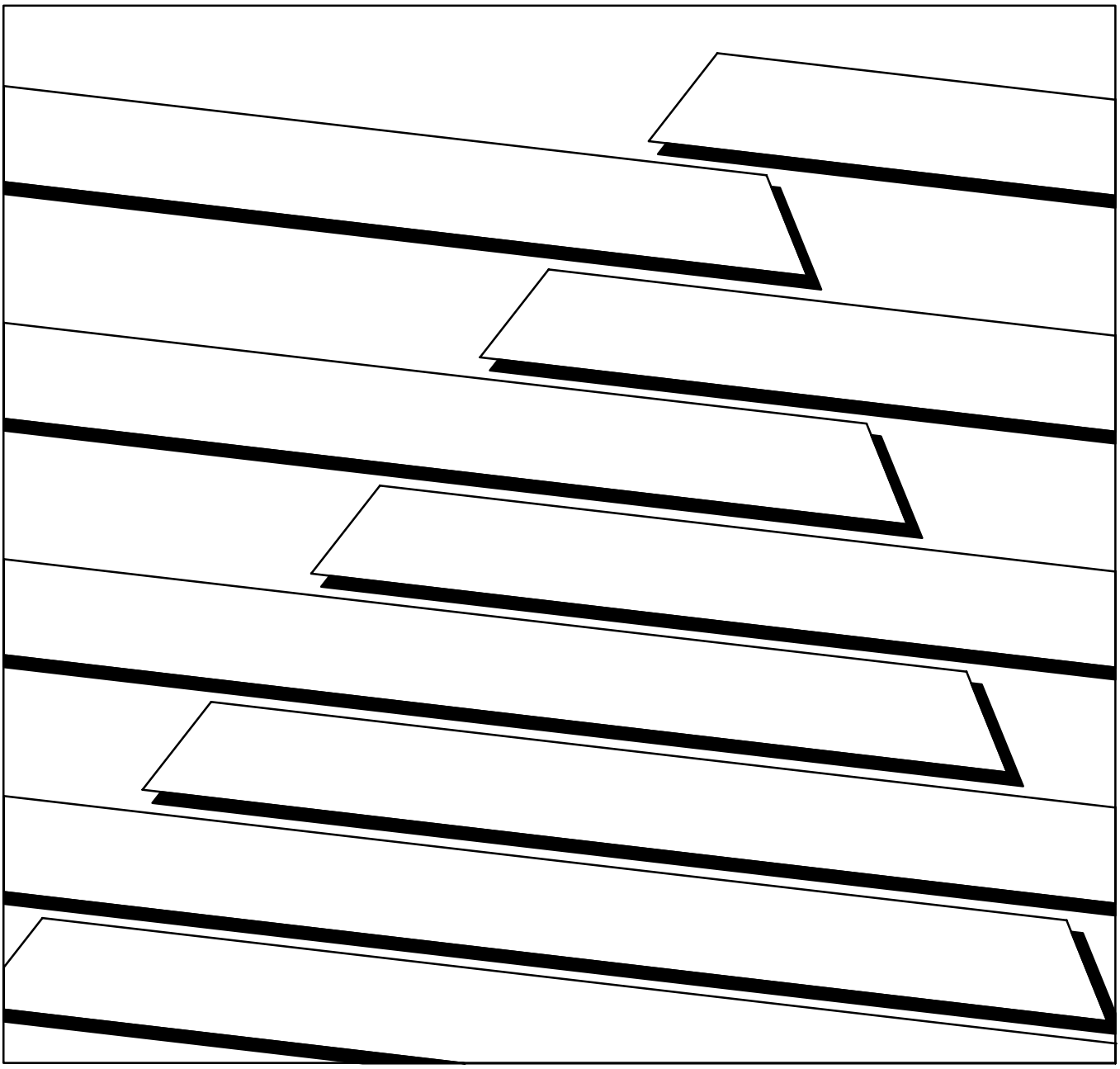
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Find the *Rockwell / Allen-Bradley 1771-IXHR* at our website: ***Click HERE***

ALLEN-BRADLEY

High Resolution Thermocouple/Millivolt Input Module Cat. No. 1771–IXHR

User Manual



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Important User Information

Because of the variety of uses for this product and because of the differences between solid state products and electromechanical products, those responsible for applying and using this product must satisfy themselves as to the acceptability of each application and use of this product. For more information, refer to publication SGI–1.1 (Safety Guidelines For The Application, Installation and Maintenance of Solid State Control).

The illustrations, charts, and layout examples shown in this manual are intended solely to illustrate the text of this manual. Because of the many variables and requirements associated with any particular installation, Allen–Bradley Company cannot assume responsibility or liability for actual use based upon the illustrative uses and applications.

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Throughout this manual we make notes to alert you to possible injury to people or damage to equipment under specific circumstances.



WARNING: Tells readers where people may be hurt if procedures are not followed properly.



CAUTION: Tells readers where machinery may be damaged or economic loss can occur if procedures are not followed properly.

Warnings and Cautions:

- Identify a possible trouble spot.
- Tell what causes the trouble.
- Give the result of improper action.
- Tell the reader how to avoid trouble.

Important: We recommend you frequently backup your application programs on appropriate storage medium to avoid possible data loss.

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Chapter 1

Using This Manual

Purpose of Manual

This manual shows you how to use your High Resolution Thermocouple/Millivolt input module with an Allen–Bradley programmable controller. It helps you install, program, calibrate, and troubleshoot your module.

Audience

You must be able to program and operate an Allen–Bradley programmable controller (PLC) to make efficient use of your input module. In particular, you must know how to program block transfer instructions.

We assume that you know how to do this in this manual. If you do not, refer to the appropriate PLC programming and operations manual before you attempt to program this module.

Vocabulary

In this manual, we refer to:

- The individual input module as the “input module” or the ”IXHR”
- The Programmable Controller, as the “controller.”

Manual Organization

This manual is divided into eight chapters. The following chart shows each chapter with its corresponding title and a brief overview of the topics covered in that chapter.

Chapter	Title	Topics Covered
2	Overview of the Input Module	Description of the module, including general and hardware features
3	Installing the Input Module	Module power requirements, keying, chassis location Wiring of field wiring arm
4	Module Programming	How to program your programmable controller for this module Sample programs
5	Module Configuration	Hardware and software configuration Module write block format
6	Module Status and Input Data	Reading data from your module Module read block format
7	Module Calibration	How to calibrate your module
8	Troubleshooting	Diagnostics reported by the module

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Chapter	Title	Topics Covered
Appendix A	Specifications	Your module's specifications
Appendix B	Programming Examples	
Appendix C	Thermocouple Characteristics	Extractions from NBS Monograph 125 (IPTS–68)

Warnings and Cautions

This manual contains warnings and cautions.



WARNING: A warning indicates where you may be injured if you use your equipment improperly.



CAUTION: Cautions indicate where equipment may be damaged from misuse.

You should read and understand cautions and warnings before performing the procedures they precede.

Related Products

You can install your input module in any system that uses Allen–Bradley PLC–3 and PLC–5 programmable controllers with block transfer capability and the 1771 I/O structure.

Contact your nearest Allen–Bradley office for more information about your programmable controllers.

Product Compatibility

These input modules can be used with any 1771 I/O chassis. Communication between the analog module and the processor is bidirectional. The processor block–transfers output data through the output image table to the module and block–transfers input data from the module through the input image table. The module also requires an area in the data table to store the read block and write block data. I/O image table use is an important factor in module placement and addressing selection. The module's data table use is listed in the following table.

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Table 1.A
Compatibility and Use of Data Table

Catalog Number	Use of Data Table				Compatibility			
	Input Image Bits	Output Image Bits	Read Block Words	Write Block Words	Addressing 1/2 –slot	Addressing 1–slot	Addressing 2–slot	Chassis Series
1771–IXHR	8	8	12/13	27/28	Yes	Yes	Yes	A and B

A = Compatible with 1771–A1, A2, A4 chassis.
B = Compatible with 1771–A1B, A2B, A3B, A4B chassis.
Yes = Compatible without restriction
No = Restricted to complementary module placement

You can place your input module in any I/O module slot of the I/O chassis. You can put:

- two input modules in the same module group
- an input and an output module in the same module group.

Do not put the module in the same module group as a discrete high density module unless you are using 1 or 1/2 slot addressing. Avoid placing this module close to AC modules or high voltage DC modules.

Related Publications

For a list of publications with information on Allen–Bradley programmable controller products, consult our publication index SD499.

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Chapter 2

Overview of the High Resolution Thermocouple/Millivolt Input Module

Chapter Objectives

This chapter gives you information on:

- features of the input module
- how an input module communicates with programmable controllers

Module Description

The High Resolution Thermocouple/Millivolt input module is an intelligent block transfer module that interfaces analog input signals with any Allen–Bradley programmable controllers that have block transfer capability.

Note: Use with PLC–2 family programmable controllers is not recommended. The 1771–IXHR module is only available with 2's complementary binary as its only data type. The PLC–2 family does not use 2's complementary binary.

Block transfer programming moves input data words from the module's memory to a designated area in the processor data table in a single scan. It also moves configuration words from the processor data table to module memory.

The input module is a single slot module which does not require an external power supply. After scanning the analog inputs, the input data is converted to a specified data type in a digital format to be transferred to the processor's data table on request. The block transfer mode is disabled until this input scan is complete. Consequently, the minimum interval between block transfer reads is the same as the total input update time for each analog input module (25ms).

Features of the Input Module

The 1771–IXHR module senses up to 8 differential analog inputs and converts them to values compatible with Allen–Bradley programmable controllers.

This module's features include:

- 8 input channels configurable for thermocouple input ranges or millivolt input ranges: Types B, E, J, K, T, R and S thermocouples and ±100 millivolts
- two types of inputs allowed: 4 of one input type and 4 of another
- cold junction compensation
- scaling to selected temperature range in °C or °F
- temperature resolution of 0.1°C or 0.1°F, millivolt resolution to 1 microvolt
- user selectable high and low temperature alarms
- all features selectable through programming

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- self–diagnostics and status reporting at power–up
- detection of open circuit if thermocouple fails
- automatic offset and gain calibration for each channel
- software calibration of all channels, eliminating potentiometers
- programmable filters for each group of 4 inputs
- X10 magnification (zoom) for millivolt mode

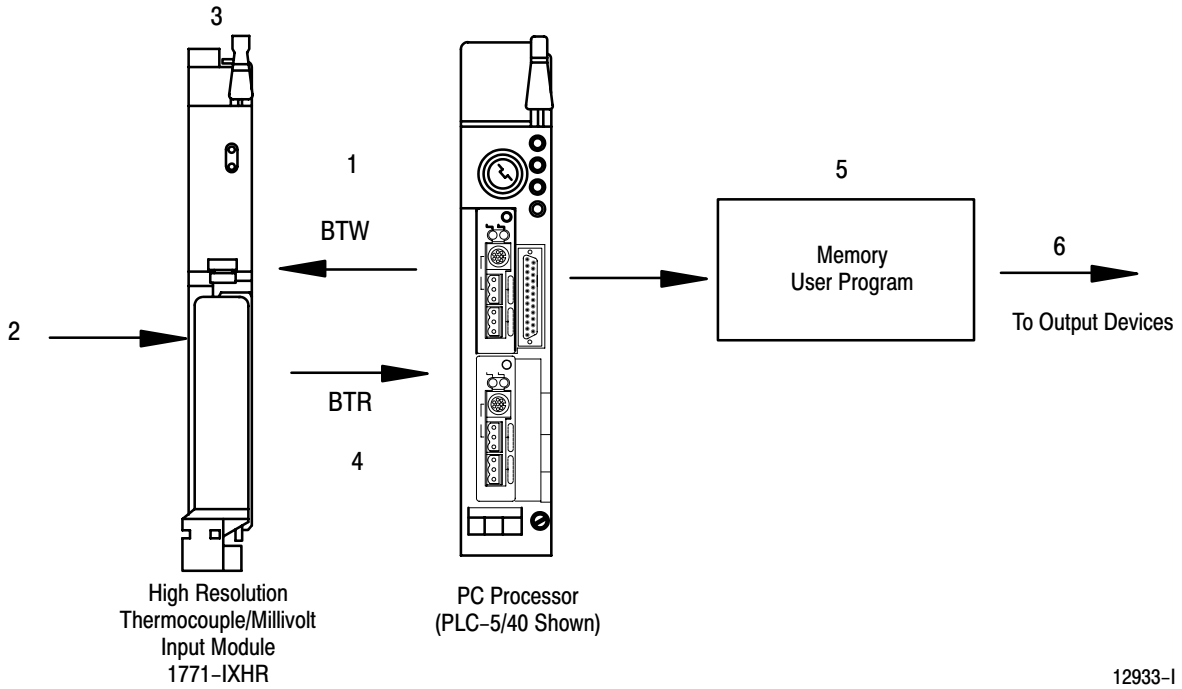
How Analog Modules Communicate with Programmable Controllers

The processor transfers data to and from the module using BTW (block transfer write) and BTR (block transfer read) instructions in your ladder diagram program. These instructions let the processor obtain input values and status from the module, and let you establish the module's mode of operation (Figure 2.1).

1. The processor transfers your configuration data and calibration values to the module using a block transfer write instruction.

2. External devices generate analog signals that are transmitted to the module.

Figure 2.1
Communication Between Processor and Module



3. The module converts analog signals into binary format, and stores these values until the processor requests their transfer.

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4. When instructed by your ladder program, the processor performs a read block transfer of the values and stores them in a data table.

5. The processor and module determine that the transfer was made without error, and that input values are within specified range.

6. Your ladder program can use and/or move the data (if valid) before it is written over by the transfer of new data in a subsequent transfer.

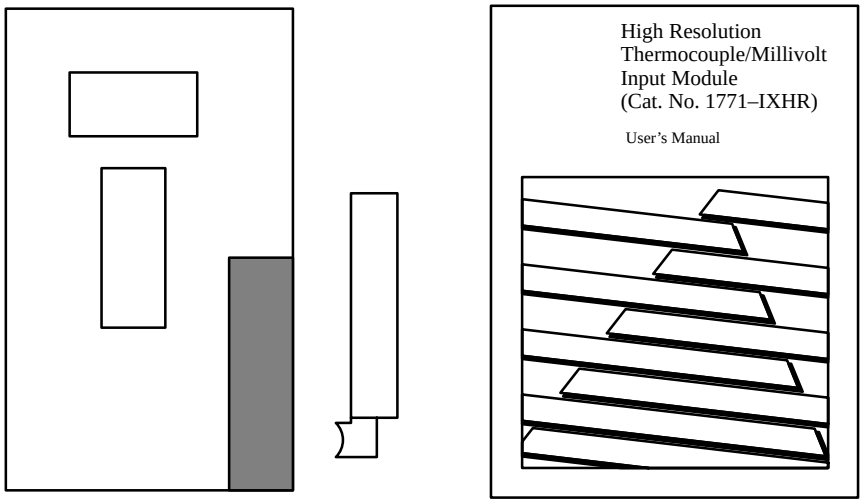
7. Your ladder program should allow write block transfers to the module only when enabled by the operator at power–up.

Accuracy

The accuracy of the input module is described in Appendix A.

Getting Started

Your input module package contains the following items. Please check that each part is included and correct before proceeding.



Input Module 1771–IXHR

Field Wiring Arm Cat. No. 1771–WI

User's Manual 1771–6.5.80

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Chapter Summary

In this chapter you read about the functional aspects of the input module and how the module communicates with programmable controllers.

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Chapter 3

Installing the High Resolution Thermocouple/Millivolt Input Module

Chapter Objectives

This chapter gives you information on:

- calculating the chassis power requirement
- choosing the module's location in the I/O chassis
- keying a chassis slot for your module
- wiring the input module's field wiring arm
- installing the input module

Before You Install Your Input Module

Before installing your input module in the I/O chassis you must:

Action required:	Refer to:
Calculate the power requirements of all modules in each chassis.	Power Requirements
Determine where to place the module in the I/O chassis.	Module Location in the I/O Chassis
Key the backplane connector in the I/O chassis.	Module Keying
Make connections to the wiring arm.	Connecting Wiring and Grounding

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 warning:



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

- Wear an approved wrist strap grounding device when handling the module.
- Touch a grounded object to rid yourself of electrostatic charge before 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, or during shipment.

Power Requirements

Your module receives its power through the 1771 I/O chassis backplane from the chassis power supply. The maximum current drawn by the thermocouple/millivolt input module from this supply is 750mA (3.75 Watts).

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Add this value to the requirements of all other modules in the I/O chassis to prevent overloading the chassis backplane and/or backplane power supply.

Module Location in the I/O Chassis

Place your module in any slot of the I/O chassis except for the extreme left slot. This slot is reserved for processors or adapter modules.

Group your modules to minimize adverse affects from radiated electrical noise and heat. We recommend the following.

- Group analog and low voltage DC modules away from AC modules or high voltage DC modules to minimize electrical noise interference.
- Do not place this module in the same I/O group with a discrete high–density I/O module when using 2–slot addressing. This module uses a byte in both the input and output image tables for block transfer.

After determining the module's location in the I/O chassis, connect the wiring arm to the pivot bar at the module's location.

Module Keying

Use the plastic keying bands, shipped with each I/O chassis, for keying the I/O slot to accept only this type of module.

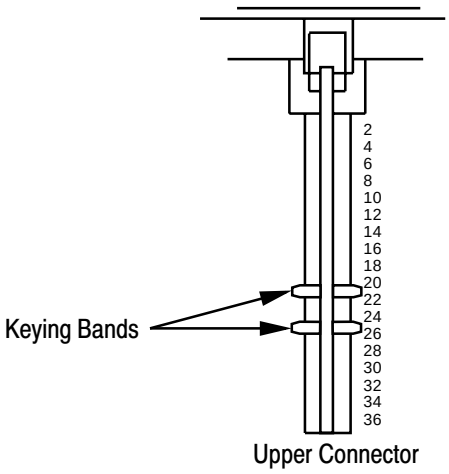
The input modules are slotted in two places on the rear edge of the circuit board. The position of the keying bands on the backplane connector must correspond to these slots to allow insertion of the module. You can key any connector in an I/O chassis to receive these modules except for the leftmost connector reserved for adapter or processor modules. Place keying bands between the following numbers labeled on the backplane connector (Figure 3.1):

- Between 20 and 22
- Between 24 and 26

You can change the position of these bands if subsequent system design and rewiring makes insertion of a different type of module necessary. Use needlenose pliers to insert or remove keying bands.

Figure 3.1
Keying Positions

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CAUTION: The High Resolution Thermocouple/Millivolt Input Module uses the same keying slots as the 1771–IXE Thermocouple/Millivolt Input Module. If you are replacing a 1771–IXE with a 1771–IXHR, the ladder program must be modified to accept the new block transfer format.

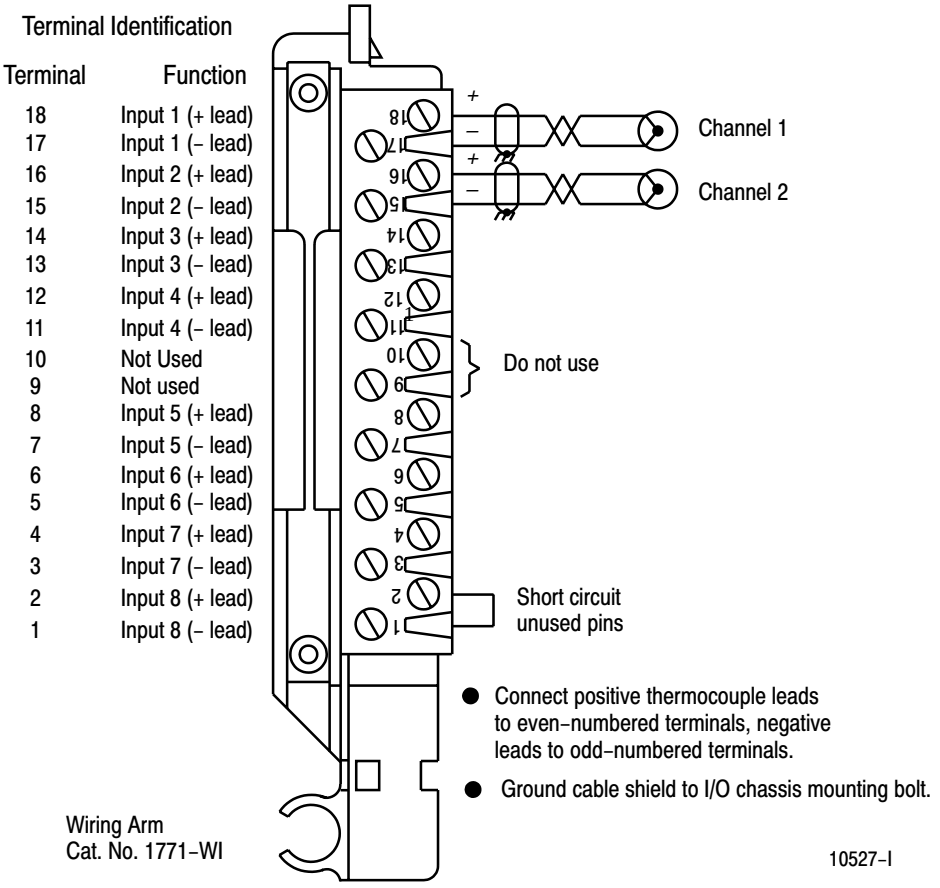
Connecting Wiring

Connect your I/O devices to the 1771–WI field wiring arm shipped with the module (see Figure 3.2). Attach the field wiring arm to the pivot bar at the bottom of the I/O chassis. The field wiring arm pivots upward and connects with the module so you can install or remove the module without disconnecting the wires.

Connect inputs in successive order starting with channel 1: positive leads to even–numbered terminals, negative leads to odd–numbered terminals of the wiring arm. Make connections to channel 1 at wiring arm terminals 18 (+) and 17(–). Follow the connection label on the side of the module for connecting the remaining inputs (Figure 3.2).

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Figure 3.2
Connection Diagram for the 1771–IXHR Inputs



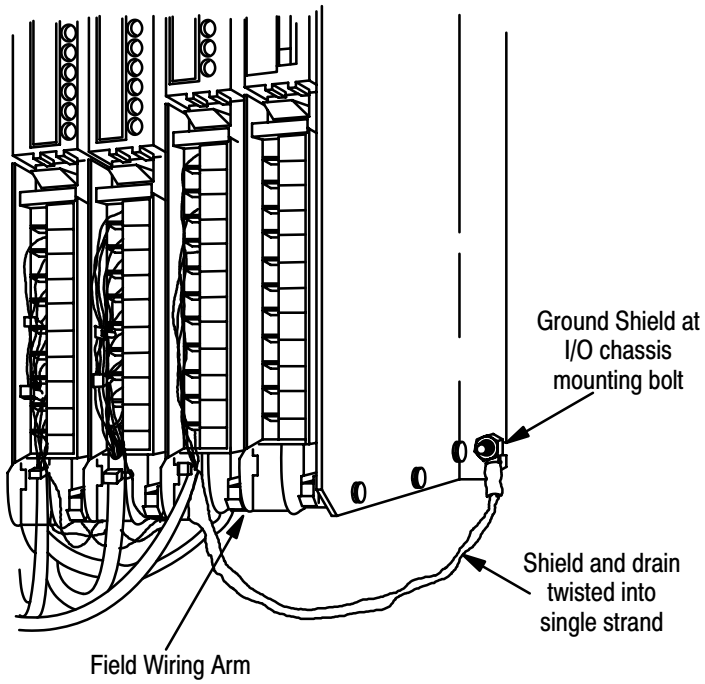
Do not connect an input to terminals 9 and 10. They are reserved for the cold junction temperature sensor inside the wiring arm. Short circuit unused input terminals by connecting a jumper wire between the positive and negative input terminals of each unused channel. Refer to appendix A to determine maximum cable length.

Grounding the Input Modules

When using shielded cable or shielded thermocouple extension wire, ground the foil shield and drain wire only at one end of the cable. We recommend that you wrap the foil shield and drain wire together and connect them to a chassis mounting bolt (Figure 3.3). At the opposite end of the cable, tape exposed shield and drain wire with electrical tape to insulate it from electrical contact.

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Figure 3.3
Cable Grounding



Refer to Wiring and Grounding Guidelines, publication 1770–4.1 for additional information.

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Installing the Input Module

When installing your module in an I/O chassis:

1. First, turn off power to the I/O chassis:

WARNING: Remove power from the 1771 I/O chassis backplane and wiring arm before removing or installing an I/O module.

Failure to remove power from the backplane could cause injury or equipment damage due to possible unexpected operation.

Failure to remove power from the backplane or wiring arm could cause module damage, degradation of performance, or injury.

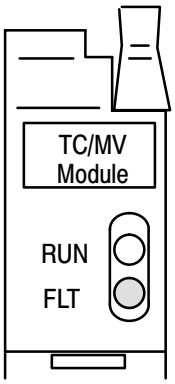
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2. Place the module in the plastic tracks on the top and bottom of the slot that guides the module into position.
3. Do not force the module into its backplane connector. Apply firm even pressure on the module to seat it properly.
4. Snap the chassis latch over the top of the module to secure it.
5. Connect the wiring arm to the module.

Interpreting the Indicator Lights

The front panel of the input module contains a green RUN and a red FLT (fault) indicator (Figure 3.4). At power–up, the green and red indicators are on. An initial module self–check occurs. If there is no fault, the red indicator turns off. The green indicator will blink until the processor completes a successful write block transfer to the module. If a fault is found initially or occurs later, the red FLT indicator lights. Possible module fault causes and corrective action are discussed in Chapter 8, Troubleshooting.

Figure 3.4
Diagnostic Indicators



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Chapter Summary

In this chapter you learned how to install your input module in an existing programmable controller system and how to wire to the field wiring arm.

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Chapter 4

Module Programming

Chapter Objectives

In this chapter, we describe

- Block Transfer programming
- Sample programs in the PLC–3 and PLC–5 processors
- Module scan time issues

Block Transfer Programming

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

The block transfer write (BTW) instruction is initiated when the analog module is first powered up, and subsequently only when the programmer wants to write a new configuration to the module. At all other times the module is basically in a repetitive block transfer read (BTR) mode.

The following example programs accomplish this handshaking routine. These 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 desired. Do not eliminate any storage bits or interlocks included in the sample programs. If interlocks are removed, the program may not work properly.

Your analog input module will work with a default configuration of all zeroes entered in the configuration block. Refer to chapter 5 to see the what this configuration looks like. Also, refer to Appendix B for example configuration blocks and instruction addresses to get started.

Your program should monitor status bits (such as overrange, underrange, alarms, etc.) and block transfer read activity.

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

PLC–2 Applications

Due to the number of digits required for high resolution readings, the 1771–IXHR module only reads input values in 2's complement binary. Since the PLC–2 family PLCs do not naturally read this data format, the IXHR module is not recommended for use with PLC–2 family programmable controllers.

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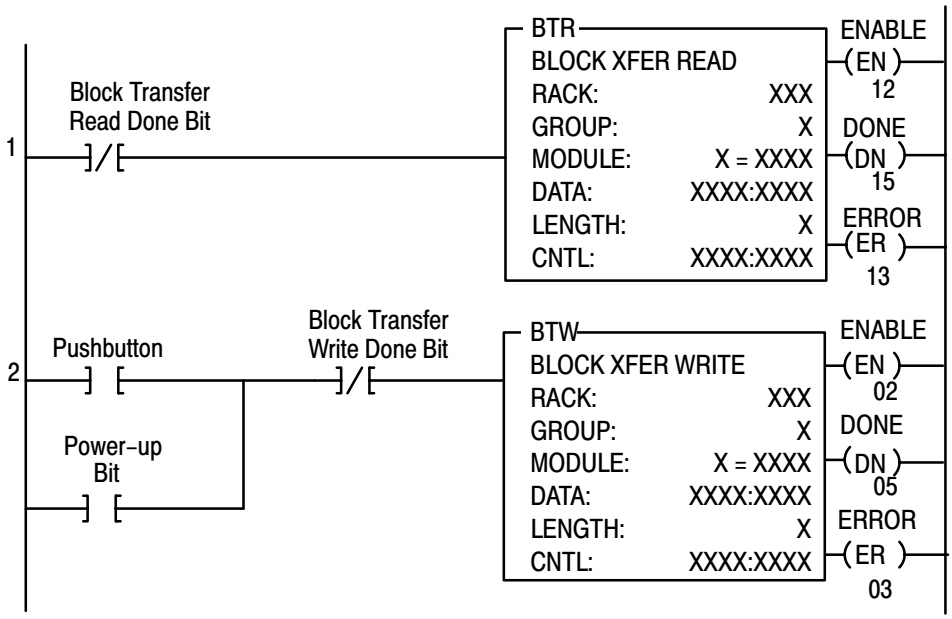
PLC–3 Program Example

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

The industrial terminal prompts you to create a control file when a block transfer instruction is being programmed. **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 4.1, and described below.

Figure 4.1
PLC–3 Family Sample Program Structure



Program Action

At power–up, the user program examines the BTR done bit in the block transfer read file, initiates a write block transfer to configure the module, and then does consecutive read block transfers continuously. The power–up bit can be examined and used anywhere in the program.

Rungs 1 and 2 – Rungs 1 and 2 are the block transfer read and write instructions. The BTR enable bit in rung 1, being false, initiates the first read block transfer. After the first read block transfer, the module performs a block transfer write and then does continuous block transfer reads until the pushbutton is used to request another block transfer write.

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After this single block transfer write is performed, the module returns to continuous block transfer reads automatically.

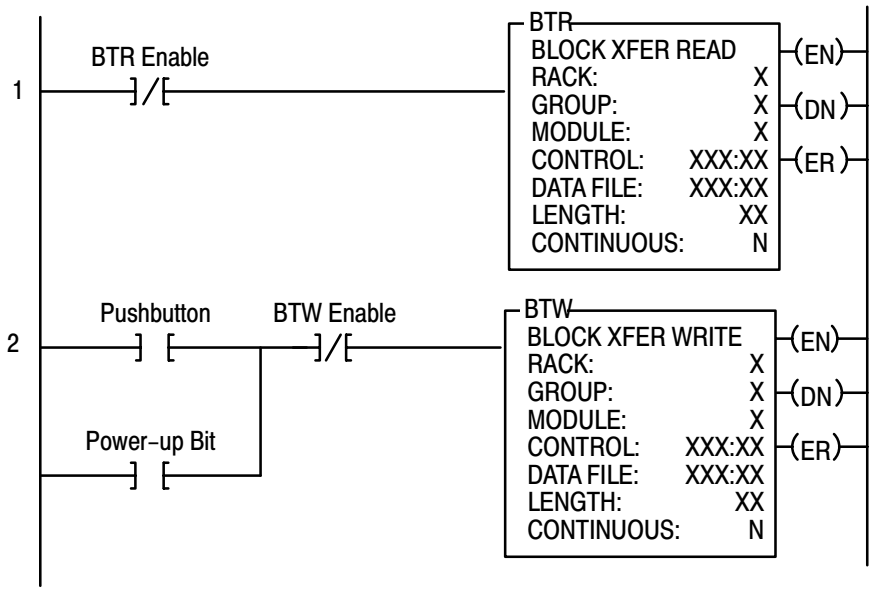
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PLC–5 Program Example

The PLC–5 program is very similar to the PLC–3 program with the following exceptions:

- You must use enable bits instead of done bits as the conditions on each rung.
- A separate control file must be selected for each of the BT instructions. Refer to Appendix B.

Figure 4.2
PLC–5 Family Sample Program Structure



Program Action

Rungs 1 and 2 – At power–up, the program enables a block transfer read and examines the power–up bit in the BTR file (rung 1). Then, it initiates one block transfer write to configure the module (rung 2). Thereafter, the program continuously reads data from the module (rung 1).

A subsequent BTW operation is enabled by a pushbutton switch (rung 2). Changing processor mode will not initiate a block transfer write unless the first pass bit is added to the BTW input conditions.

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Module Scan Time

Scan time is defined as the amount of time it takes for the input module to read the input channels and place new data into the data buffer. Scan time for your module is shown in Figure 4.3.

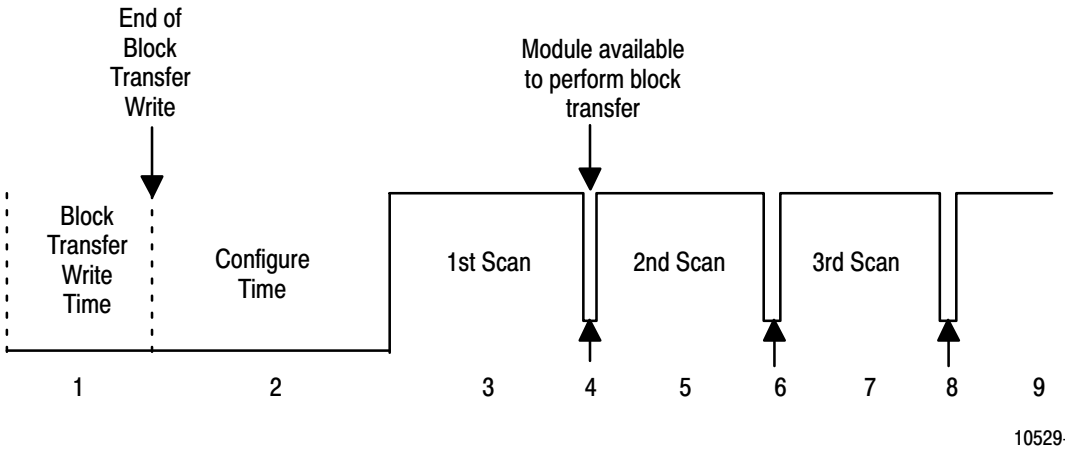
The following description references the sequence numbers in Figure 4.3.

Following a block transfer write “1” the module inhibits communication until after it has configured the data and loaded calibration constants “2”, scanned the inputs “3”, and filled the data buffer “4”. Write block transfers, therefore, should only be performed when the module is being configured or calibrated.

Any time after the second scan begins “5”, a block transfer read (BTR) request “6” can be acknowledged.

When operated in the default mode (RTS) = 00, a BTR will be released every 25 milliseconds. When operated in RTS = T, BTR will be waived until ”T”millseconds, at which time 1 BTR will be released.

Figure 4.3
Block Transfer Time



Internal Scan time = 25msec
T = 25ms, 50ms, 75ms ... 3.1sec.

Chapter Summary

In this chapter, you learned how to program your programmable controller. You were given sample programs for your PLC–3 and PLC–5 family processors.

You also read about module scan time.

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Chapter 5

Module Configuration

Chapter Objectives

In this chapter you will read how to configure your module's hardware, condition your inputs and enter your data.

Configuring the Module

Because of the many analog devices available and the wide variety of possible configurations, you must configure your module to conform to the analog device and specific application that you have chosen. Data is conditioned through a group of data table words that are transferred to the module using a block transfer write instruction.

You can configure the following features for the 1771–IXHR module:

- type of input
- one or two input types
- X10 magnification for millivolt data
- ^{o}C or ^{o}F
- real time sampling
- millivolt bias level (zoom mode only)
- input filtering
- alarming
- calibration

Configure your module for its intended operation by means of your programming terminal and write block transfers.

During normal operation, the processor transfers from 1 to 27 words to the module when you program a BTW instruction to the module's address. The BTW file contains configuration words, high and low channel alarm settings, and calibration values that you enter for each channel. **When a block transfer length of 0 is programmed, the 1771–IXHR will respond with a default value of 27.**

This module is permanently configured to accept and report data in 2's complementary binary format only. It is not recommended for use with PLC–2 family programmable controllers.

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Input Type

The thermocouple/millivolt input module accepts the following types of inputs:

Table 5.A
Types of Inputs

Input Type	Input Type	Temperature Range °C	Bits 05	04	03	02	01	00
Millivolt	Millivolt	–100 to +100	0	0	0	0	0	0
Thermocouple	B	320 to 1800	1	1	1	1	1	1
	E	–270 to 1000	0	0	1	0	0	1
	J	–210 to 1200	0	1	0	0	1	0
	K	–270 to 1380	0	1	1	0	1	1
	R	–50 to 1770	1	0	1	1	0	1
	S	–50 to 1770	1	1	0	1	1	0
	T	–270 to 400	1	0	0	1	0	0

The input type is selected by setting bits in the block transfer write (BTW) file. Two different inputs can be selected. You can have 4 inputs set for one type, and 4 inputs set for another type; or you can have all inputs the same. If you select different types of inputs, set bit 06 to 1. If you do not select 2 different input types, the module defaults to all inputs set to those selected by bits 00 –02.

Set this bit for 2 different input types (see table 5.D)

Set these bits for input type.

Word	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
1	Sample Time							T	Z	E	Input Type			Input Type		

Zoom Feature

The zoom feature (word 2) can be enabled when millivolt inputs are used. This feature allows you to view ±30mV (in 1µV increments) around a selected value ranging from –70 to +70mV.

Temperature Scale

The temperature scale reported by the module is selected by setting bit 08 in the configuration word. When bit 08 is set (1), the temperature is reported in degrees Fahrenheit. When reset (0), the temperature is reported in degrees Celsius. The temperature bit 08 is ignored when the millivolt input type is selected.

Real Time Sampling

The real time sampling (RTS) mode of operation provides data from a fixed time period for use by the processor. RTS is invaluable for time based functions (such as PID and totalization) in the PLC. It allows accurate time based calculations in local or remote I/O racks.

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In the RTS mode the module scans and updates its inputs at a user defined time interval (ΔT) instead of the default interval. The module ignores block transfer read (BTR) requests for data until the sample time period elapses. The BTR of **a particular data set** occurs only once at the end of the sample period and subsequent requests for transferred data are ignored by the module until a new data set is available. If a BTR does not occur before the end of the next RTS period, a time–out bit is set in the BTR status area. When set, this bit indicates that at least one data set was not transferred to the processor. (The actual number of data sets missed is unknown.) The time–out bit is reset at the completion of the BTR.

Set appropriate bits in the BTW data file to enable the RTS mode. You can select RTS periods ranging from 25 milliseconds (msec) to 3.1 seconds in increments of 25msec. Refer to Table 5.B below for a sampling of actual bit settings. Note that the default mode of operation is implemented by placing all zeroes in bits 09 through 15.

Table 5.B
Bit Settings for the Real Time Sample Mode

Decimal Bits	15	14	13	12	11	10	09	Sample Time Period
	0	0	0	0	0	0	0	Inhibited
	0	0	0	0	0	0	1	25 ms
	0	0	0	0	0	1	0	50 ms
	0	0	0	0	1	0	0	100 ms
	0	0	1	0	0	0	0	400 ms
	0	0	1	0	1	0	0	500 ms
	0	0	1	1	0	0	0	600 ms
	0	0	1	1	1	0	0	700 ms
	0	1	0	0	0	0	0	800 ms
	0	1	0	0	1	0	0	900 ms
	0	1	0	1	0	0	0	1.0 sec
	0	1	1	1	1	0	0	1.5 sec
	1	0	1	0	0	0	0	2.0 sec
	1	1	0	0	1	0	0	2.5 sec
	1	1	1	1	0	0	0	3.0 sec
	1	1	1	1	1	0	0	3.1 sec

Important: Use decimally addressed bit locations for PLC–5 processors.

Channel Alarms

Each channel has high and low alarm values associated with it. These bits and words are explained in the bit/word definitions in Table 5.D.

Calibration

You have the ability to calibrate this module using auto–calibration or by manually setting the individual channel words. Words 20 through 27 in the configuration word (Table 5.D) are the manual calibration words for channels 1

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through 8 respectively. Word 28 activates the auto–calibration feature. Calibration is explained in chapter 7.

Configuration Block for a Block Transfer Write

The complete configuration block for the block transfer write to the module is defined in Table 5.C below.

Table 5.C
Configuration Block for the High Resolution Thermocouple/Millivolt Input Module Block Transfer Write

Word	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
1	Sample Time							T	Z	E	Type			Type		
2	Zoom Value for Group 2 (Channels 5–8)							Zoom Value for Group 1 (Channels 1–4)								
3	Filter Value for Group 2 (Channels 5–8)							Filter Value for Group 1 (Channels 1–4)								
4	Channel 1 Low Alarm Value															
5	Channel 1 High Alarm Value															
6	Channel 2 Low Alarm Value															
7	Channel 2 High Alarm Value															
8	Channel 3 Low Alarm Value															
9	Channel 3 High Alarm Value															
10	Channel 4 Low Alarm Value															
11	Channel 4 High Alarm Value															
12	Channel 5 Low Alarm Value															
13	Channel 5 High Alarm Value															
14	Channel 6 Low Alarm Value															
15	Channel 6 High Alarm Value															
16	Channel 7 Low Alarm Value															
17	Channel 7 High Alarm Value															
18	Channel 8 Low Alarm Value															
19	Channel 8 High Alarm Value															
20	Calibration Values for Channel 1															
21	Calibration Values for Channel 2															
22	Calibration Values for Channel 3															
23	Calibration Values for Channel 4															
24	Calibration Values for Channel 5															
25	Calibration Values for Channel 6															
26	Calibration Values for Channel 7															
27	Calibration Values for Channel 8															
28	Auto–calibration Request Word															

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E = enable bit for input types (refer to bit/word description)
T = temperature scale bit (refer to bit/word description)
Z = zoom enable: 0 = normal 10μV; 1 = X10 (1μV)

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Bit/Word Descriptions

Bit/word descriptions of BTW file words 1 thru 3 (configuration), 4 thru 19 (channel alarm values), and 20 thru 27 (calibration values) are presented in Table 5.D. Enter data into the BTW instruction after entering the instruction into your ladder diagram program.

Table 5.D
Bit/Word Definitions for the High Resolution Thermocouple/Millivolt Input Module

<table>
<tr><th>Word</th><th>Bits</th><th>Description</th></tr>
<tr><td>Word 1</td><td>bits 00–02</td><td>Input type codes for inputs 1 thru 8 (or 1 thru 4 if bit 06 is set to 1). Tells the module what type of input device you connected to the module.
<table>
<tr><th>Type</th><th>02</th><th>01</th><th>00</th></tr>
<tr><td>Millivolt input</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>”B” thermocouple</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>”E” thermocouple</td><td>0</td><td>0</td><td>1</td></tr>
<tr><td>”J” thermocouple</td><td>0</td><td>1</td><td>0</td></tr>
<tr><td>”K” thermocouple</td><td>0</td><td>1</td><td>1</td></tr>
<tr><td>”R” thermocouple</td><td>1</td><td>0</td><td>1</td></tr>
<tr><td>”S” thermocouple</td><td>1</td><td>1</td><td>0</td></tr>
<tr><td>”T” thermocouple</td><td>1</td><td>0</td><td>0</td></tr>
</table></td></tr>
<tr><td></td><td>bits 03–05</td><td>Input type codes for inputs 5 thru 8 (bit 06 must be set to 1). Tells the module what type of input device you connected to inputs 5 thru 8.
<table>
<tr><th>Type</th><th>05</th><th>04</th><th>03</th></tr>
<tr><td>Millivolt input</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>”B” thermocouple</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>”E” thermocouple</td><td>0</td><td>0</td><td>1</td></tr>
<tr><td>”J” thermocouple</td><td>0</td><td>1</td><td>0</td></tr>
<tr><td>”K” thermocouple</td><td>0</td><td>1</td><td>1</td></tr>
<tr><td>”R” thermocouple</td><td>1</td><td>0</td><td>1</td></tr>
<tr><td>”S” thermocouple</td><td>1</td><td>1</td><td>0</td></tr>
<tr><td>”T” thermocouple</td><td>1</td><td>0</td><td>0</td></tr>
</table></td></tr>
<tr><td></td><td>bit 06</td><td>When set to 0 bits 00–02 define input type for all channels.
When set to 1 bits 00–02 defines input type for channels 1–4, and bit 03–05 defines input type for channels 5–8.</td></tr>
<tr><td></td><td>bit 07</td><td>Enables X10 magnification when millivolt inputs have been selected. Enabling this feature causes the BTR data to display ±30.000mV around the value selected by word 2. Use the digital filter (word 3) to stabilize the readings when using this mode.</td></tr>
<tr><td></td><td>bit 08</td><td>Temperature scale bit, when set, reports temperature in °F; when reset, in °C. The module ignores this bit for millivolt inputs.</td></tr>
</table>

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<table>
<tr><th>Word</th><th>Bits</th><th>Description</th></tr>
<tr><td>Word 1 (cont.)</td><td>bits 09–15</td><td>Real time sample interval bits determine the sample time for updating module inputs. You select sample time in 0.025 second intervals using binary code. (All values between 0.025 and 3.1 seconds in 0.025 second intervals are available.) We tabulated some values for you.
<table>
<tr><th>Sample Time</th><th>15</th><th>14</th><th>13</th><th>12</th><th>11</th><th>10</th><th>09</th></tr>
<tr><td>0.1</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>0</td><td>0</td></tr>
<tr><td>0.5</td><td>0</td><td>0</td><td>1</td><td>0</td><td>1</td><td>0</td><td>0</td></tr>
<tr><td>0.6</td><td>0</td><td>0</td><td>1</td><td>1</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0.7</td><td>0</td><td>0</td><td>1</td><td>1</td><td>1</td><td>0</td><td>0</td></tr>
<tr><td>0.8</td><td>0</td><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0.9</td><td>0</td><td>1</td><td>0</td><td>0</td><td>1</td><td>0</td><td>0</td></tr>
<tr><td>1.0</td><td>0</td><td>1</td><td>0</td><td>1</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>1.5</td><td>0</td><td>1</td><td>1</td><td>1</td><td>1</td><td>0</td><td>0</td></tr>
<tr><td>2.0</td><td>1</td><td>0</td><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>2.5</td><td>1</td><td>1</td><td>0</td><td>0</td><td>1</td><td>0</td><td>0</td></tr>
<tr><td>3.0</td><td>1</td><td>1</td><td>1</td><td>1</td><td>0</td><td>0</td><td>0</td></tr>
</table></td></tr>
<tr><td>Word 2</td><td>bits 00–07</td><td>Zoom center value for channels 1–4. These values are used when millivolt inputs have been selected and bit 07 of word 1 has been set to enable zoom (i.e. 1µV display resolution). Enter a value in 2's complement binary format ranging from –70mV to +70mV. The displayed range will then be ±30.000mV around the selected value, displayed in 1µV increments. Refer to Table 5.E</td></tr>
<tr><td></td><td>bits 08–15</td><td>Zoom center value for channels 5–8. These values are used when millivolt inputs have been selected. Enter a value in 2's complement binary format ranging from –70mV to +70mV. The displayed range will then be ±30.000mV around the selected value, displayed in 1µV increments. Refer to Table 5.E</td></tr>
<tr><td>Word 3</td><td>bits 00–07</td><td>Filter values for channels 1–4. The filter operates on the display data only. Alarms, underrange and overrange operate in real time. The filter constant is equal to: TC = 0.025(1 + filter value). Refer to Table 5.F.</td></tr>
<tr><td></td><td>bits 08–15</td><td>Filter values for channels 5–8. The filter operates on the display data only. Alarms, underrange and overrange operate in real time. The filter constant is equal to: TC = 0.025(1 + filter value). Refer to Table 5.F</td></tr>
<tr><td>Words 4 thru 19</td><td></td><td>Low and High channel alarm values that you enter via the terminal in 2's complementary binary. Store low and high channel alarms in pairs, low alarm values in even–numbered words, high alarm values in odd–numbered words. For example, store channel 1 low and high alarm values in words 4 and 5, respectively. Alarms are disabled by setting the low alarm equal to the high alarm. If the zoom feature is enabled, the alarm values should be the difference between the "actual alarm limit" and "zoom center value" in word 2. (Refer to the example PLC–5 program in chapter 5.)</td></tr>
</table>

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Word	Bits	Description
Words 20 thru 27		Calibration words are a composite of two independent bytes for each channel. Enter calibration data in signed magnitude binary only. The most significant bit in each byte is the sign bit; set for negative, reset for positive. Use the high byte (bits 08–15) for offset correction, the low byte (bits 00–07) for gain correction for each channel. Use word 20 for channel 1 thru word 27 for channel 8. Refer to Chapter 7 for calibration procedures.
Word 28		Auto–calibration request word – used to automatically calibrate selected channels and save the calibration constants in EEPROM. (Refer to Chapter 7.)

Table 5.E
Example Zoom Settings for Word 2

Zoom Settings	Bit Settings (15–08) or (07–00)
Zoom center = 70mV (maximum)	01000110 (decimal equivalent 70)
Zoom center = 0mV	00000000 (decimal equivalent 0)
Zoom center = –1mV	11111111 (decimal equivalent –1)
Zoom center = –70mV (minimum)	10111010 (decimal equivalent –70)
Only used in millivolt mode with Z = 1. Millivolt data will be in 1μV resolution with range of ±30.000mV. Zoom will be used to center the range of interest between ±70mV. Over and underrange bits will be asserted outside of the display range. For decimal equivalent values from 71 to 127 and –71 to –128 the zoom center will default to 0.	

Table 5.F
Example Filter Values for Word 3

Filter Value	Bit Setting (15–08) or (07–00)
No filter	0000000
Tau = 50ms	00000001
Tau = 75ms	00000010
Tau = 6.4 seconds	11111111
Filter values increase in increments of 25msec.	

Chapter Summary

In this chapter you learned how to configure your module's hardware, condition your inputs and enter your data.

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Chapter 6

Module Status and Input Data

Chapter Objectives

In this chapter you will read about:

- reading data from your module
- input module read block format

Reading Data from the Module

Block transfer read programming moves status and data from the input module to the processor's data table in one I/O scan (Table 6.A). The processor user program initiates the request to transfer data from the input module to the processor.

During normal operation the module transfers up to 12 words to the processor's data table file. The words contain module status and input data from each channel. **During normal operation, when a block transfer length of zero (0) is programmed, the 1771–IXHR will respond with a default length of 12.**

Table 6.A
BTR Word Assignments for the 1771–IXHR Input Module

Decimal Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	Not used								Status Codes							
2	Inputs overrange								Inputs underrange							
3	Inputs > high alarm								Inputs < low alarms							
4	Channel 1 input															
5	Channel 2 input															
6	Channel 3 input															
:	:															
11	Channel 8 input															
12	Cold Junction Temperature in °C or °F[1]															
13	Inhibits								Auto–calibration request							

[1] = Cold junction temperature is provided in 0.1°C or 0.1°F resolution. The filter time constant (Tau) for this value is fixed at 6.4 seconds.

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Bit/Word Descriptions

The complete bit/word description for the block transfer read from the module is defined in Table 6.B.

Table 6.B
Bit/Word Description for the 1771–IXHR Input Module

Word	Bit	Definition
Word 1	Bit 00	Power–up bit is set to indicate that the module is waiting for its first write block transfer
	Bit 01	Out of range bit is set if one or more channel inputs are above or below the range for which you configured the module
	Bit 02	Real time sample time–out bit is set when the module updates an input buffer with new data before the processor has read the previous data. Monitor this bit only if you select real time sampling.
	Bit 03	Not used
	Bit 04	Low cold junction temperature bit is set when the cold junction temperature is less than 0.0°C or 32.0°F.
	Bit 05	High cold junction temperature bit is set when the cold junction temperature exceeds 60.0°C or 140.0°F.
	Bit 06	Dynamic clamp bit. Prevents rapid changes in data due to data corruption over the opto–isolation barrier as a result of ESD, radiation bursts, etc. 0 = feature active 1 = feature inhibited
	Bit 07	EEPROM calibration values could not be read.
	Bits 08–15	Not used
Word 2	Bits 00–07	Underrange bit for each channel is set to indicate an input is out of range: bit 00 for channel 1 thru bit 07 for channel 8.
	Bits 08–15	Overrange bit for each channel is set to indicate an input is out of range: bit 08 for channel 1 thru bit 15 for channel 8. Also set for open channel detection.
Word 3	Bits 00–07	Low alarm bit for each channel is set to indicate the input is less than the low limit value you entered in the corresponding low alarm word (BTW word 4, 6, 8, 10, 12, 14, 16, or 18): bit 00 for channel 1 thru bit 07 for channel 8.
	Bits 08–15	High alarm bit for each channel is set to indicate the input has exceeded the high limit value you entered in the corresponding high alarm word (BTW word 5, 7, 9, 11, 13, 15, 17, or 19): bit 08 for channel 1 thru bit 15 for channel 8.
Words 4–11		Input for channel 1 through 8 respectively in 0.1°C or 0.1°F resolution for temperature and 10μV or 1μV resolution for millivolts.
Word 12		Cold junction temperature in 0.1°C or 0.1°F.

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Word	Bit	Definition
Word 13		Auto–calibration word.
	Bit 00	Offset calibration complete bit
	Bit 01	Gain calibration complete bit
	Bit 02	Save to EEPROM bit
	Bits 03–05	Not used
	Bit 06	EEPROM fault bit
	Bit 07	Calibration fault bit
	Bits 08–15	Uncalibrated channel bits

Chapter Summary

In this chapter you learned the meaning of the status information that the input module sends to the processor.

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Chapter 7

Module Calibration

Chapter Objective

In this chapter we tell you how to calibrate your module.

Tools and Equipment

To calibrate your module you will need the following tools and equipment:

Tool or Equipment	Description	Model/Type	Available from:
Precision Voltage Source	0–100mV, 1µV resolution	Analogic 3100, Data Precision 8200 or equivalent	
Industrial Terminal and Interconnect Cable	Programming terminal for A-B family processors	Cat. No. 1770–T3 or Cat. No. 1784–T45, –T47, –T50, etc.	Allen–Bradley Company Highland Heights, OH

Calibrating your Input Module

The high resolution thermocouple/millivolt input module is shipped already calibrated. If it becomes necessary to recalibrate the module, you must calibrate the module in an I/O chassis. The module must communicate with the processor and industrial terminal.

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

Calibration can be accomplished using either of two methods:

- auto–calibration
- manual calibration

The auto–calibration method is recommended since it is easier and less time consuming than manual calibration. Manual calibration can be used if you are more familiar with this type of calibration, or if you desire to compensate for thermocouple or lead error.

About Auto–calibration

Auto–calibration calibrates the input by generating offset and gain correction values and storing them in EEPROM. These values are read out of EEPROM and placed in RAM memory at initialization of the module.

The auto–calibration routine operates as follows:

- Whenever a block transfer write (BTW) of length 28 is performed to the module (any time after the module has been powered up), it interrogates word 28 for a request for auto–calibration.
- The request can be for the following: offset calibration, gain calibration, save operation (save to EEPROM).

When using auto–calibration, write transfer calibration words 20 through 27 must contain zeroes.

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Performing Auto–calibration

Calibration of the module consists of applying 0.000mV across each input channel for offset calibration, and +100.000mV across each input channel for gain correction.

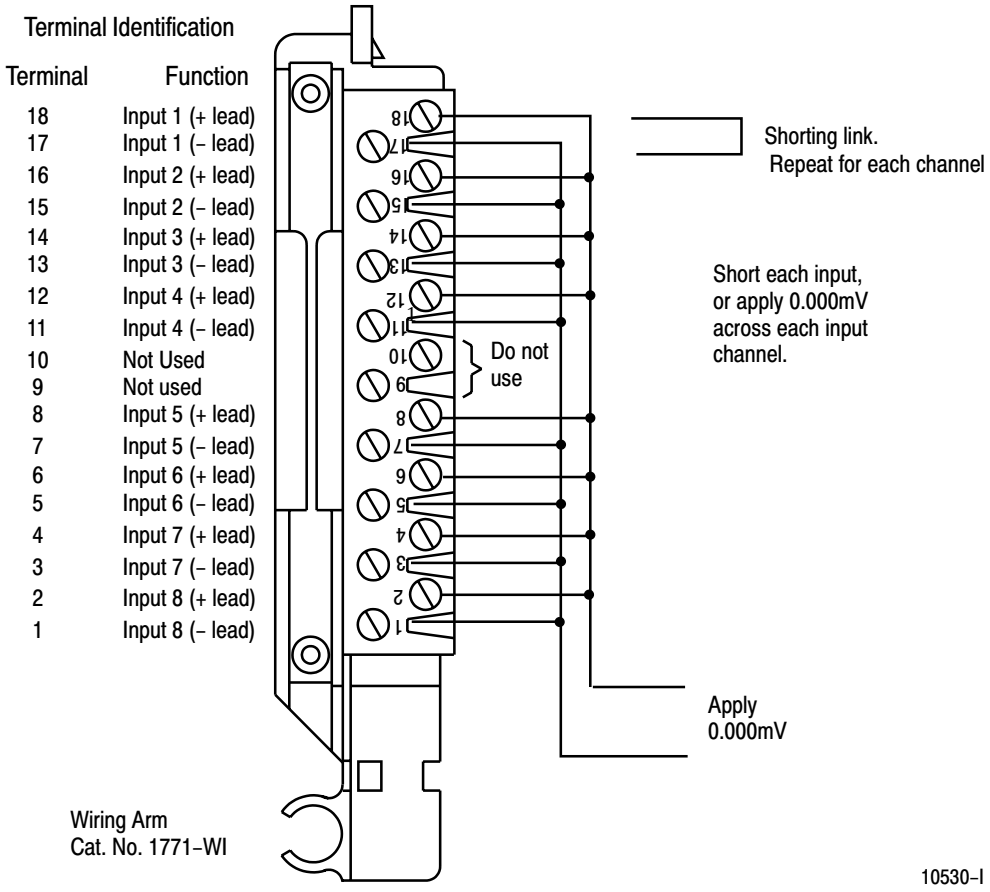
Offset Calibration

Normally all inputs are calibrated together. To calibrate the offset of an input, proceed as follows:

1. Apply power to the module.

2. Connect shorting links, or apply 0.000mV across each input channel on the 1771–WI field wiring arm as shown in Figure 7.1.

Figure 7.1
Shorting Inputs for Offset Calibration



3. After the connections stabilize (about 10 seconds), request the offset calibration by setting bit 00 in block transfer write word 28 and sending a block transfer write (BTW) to the module. Refer to Table 7.A.

   When the BTW is sent, all channels are calibrated to 0.000mV.

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Table 7.A
Write Block Transfer Word 28

Word/Bit	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Word 28	Inhibit Calibration on Channel								Requested Auto–Calibration							
	8	7	6	5	4	3	2	1	Set these bits to 0				Requested clamp inhibit	Requested Save Values	Requested Gain Cal.	Requested Offset Cal.

NOTE: Normally, all channels are calibrated simultaneously (bits 08–15 of word 28 are octal 0). To disable calibration on any channel, set the corresponding bit 08 through 15 of word 28. To disable the clamp inhibit function, set bit 06.

4. Queue block transfer reads (BTRs) to monitor for offset calibration complete and any channels which may have not calibrated successfully. Refer to Table 7.B.

Table 7.B
Read Block Transfer Word 13

Word/Bit	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Word 13	Uncalibrated Channels								Auto–Calibration Status							
	8	7	6	5	4	3	2	1	Cal. Fault	EEPROM Fault	Not used			Save to EEPROM Complete	Gain Cal. Complete	Offset Cal. Complete

5. Proceed to Gain Calibration below.

Gain Calibration

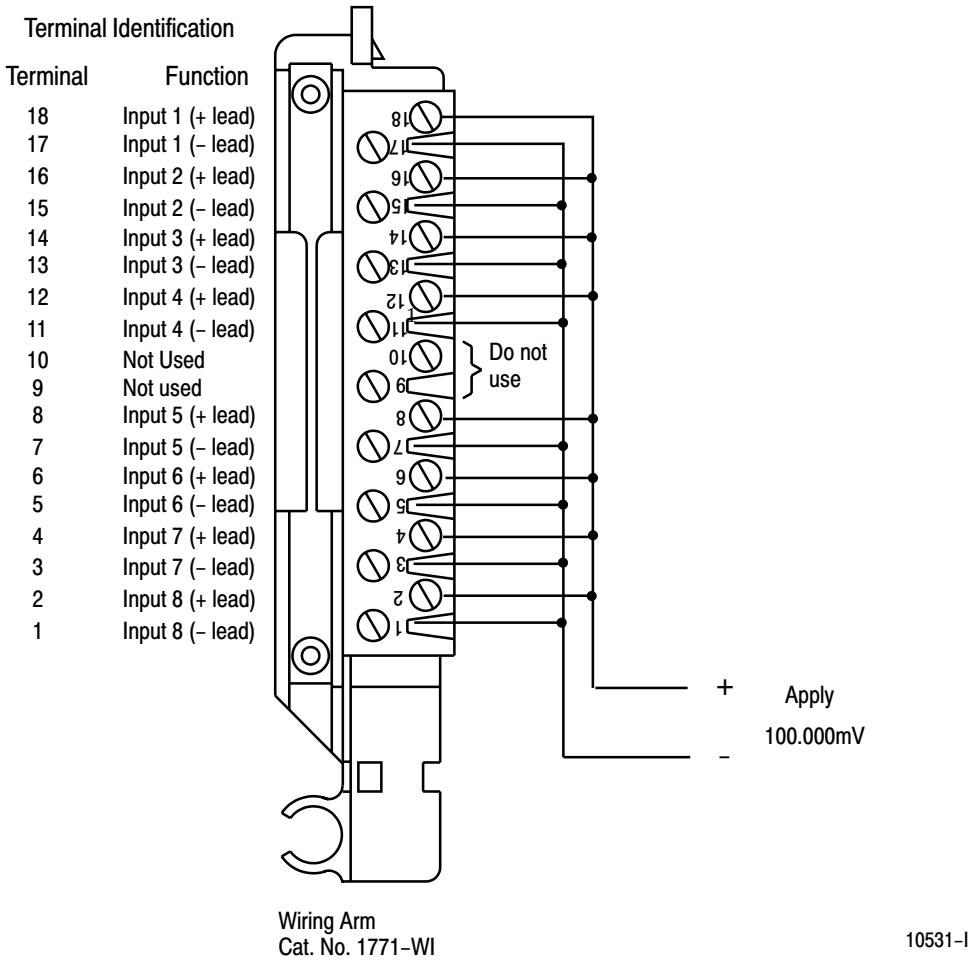
Calibrating gain requires that you apply +100.000mV across each input channel.

Normally all inputs are calibrated together. To calibrate the gain of an input, proceed as follows:

1. Apply +100.000mV across each input channel as shown in Figure 7.2.

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Figure 7.2
Applying 100.00mV for Gain Calibration



2. After the connections stabilize (about 10 seconds), request the gain calibration by setting bit 01 in BTW word 28 and sending a block transfer write (BTW) to the module. Refer to Table 7.A.

When the BTW is sent, all channels are calibrated to +100.00mV.

NOTE: Normally, all channels are calibrated simultaneously (bits 08–15 of word 28 are octal 0). To disable calibration on any channel, set the corresponding bit 08 through 15 of BTW word 28.

3. Queue BTRs to monitor for gain calibration complete and any channels which may not have calibrated successfully.

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Save Calibration Values

If any ”uncalibrated channel” bits (bits 08–15 of BTR word 13) are set, a save cannot occur. Auto–calibration should be performed again, starting with offset calibration. If the module has a faulty channel, the remaining functioning channels can be calibrated by inhibiting calibration on the faulty channel.

The module can be run with the new calibration values, but will lose them on power down. To save these values, proceed as follows:

1. Request a ”save to EEPROM” by setting bit 02 in BTW word 28 and sending the BTW to the module. Refer to Table 7.A.

2. Queue BTRs to monitor for ”save complete”, ”EEPROM fault” and ”calibration fault.” An EEPROM fault indicates a nonoperative EEPROM; a calibration fault indicates at least one channel was not properly offset or gain calibrated and a save did not occur.

Performing Manual Calibration

You calibrate each channel by applying a precision voltage to the input terminals, comparing correct with actual results, and entering correction into the corresponding calibration word for that channel. The correction takes affect after it is transferred to the module by the corresponding BTW instruction in your ladder diagram program. Always start with offset adjustment followed by gain adjustment.

Before calibrating the module, you must enter ladder logic into processor memory, so that you can initiate write block transfers to the module, and the processor can read inputs from the module. Write transfers will contain calibration values in words 20 through 27 for the channel you are calibrating.

Use a precision voltage source, such as Data Precision 8200 or equivalent, for your calibration input voltage.

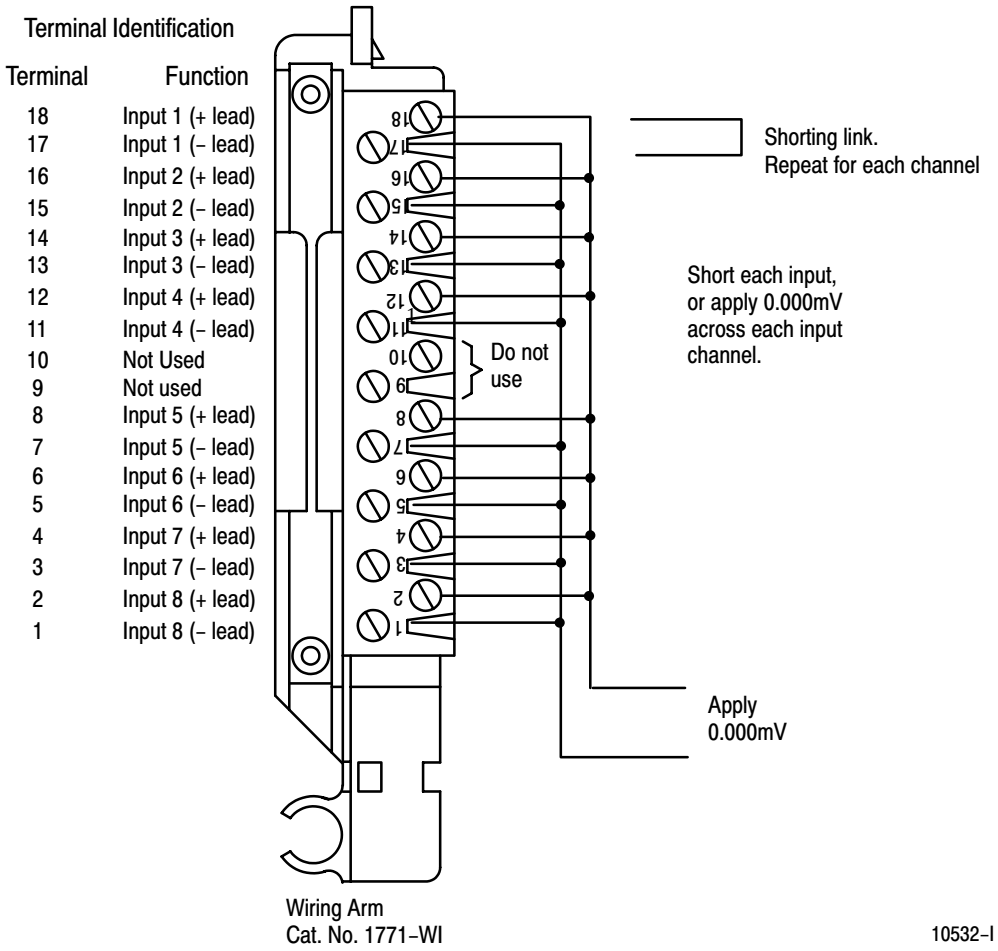
Setting Channel Offset Calibration

1. Select the millivolt range and zoom = 0.

2. Apply 0.000 millivolts to the channel input as shown in Figure 7.3.

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Figure 7.3
Shorting Inputs for Offset Calibration



3. Observe the input value read by the processor (word 4 of the BTR file for channel 1). It should be 0.

4. Multiply the difference between your observed value and 0.000 by 3.0933. Determine the magnitude and sign of the required correction. (With zoom = 1, divide the difference by 3.2328.)

You can adjust the correction up to ±127 binary counts (±410.56µV).

A negative correction means that the reading was too high and you want to **subtract** a corrective amount from that reading.

A positive correction means that the reading was too low and you want to **add** a corrective amount to that reading.

5. Enter the magnitude and sign of the correction in binary code into the upper (offset correction) byte of the calibration word for that channel. (BTW file, word 20, bits 15–08 for channel 1.)

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For example, if the observed value was 17, enter –53 [(0 – 17) x 3.0933 = –53] in signed magnitude binary into the upper byte of the calibration word for that channel. Enter 10110101 in bits 15–08 of word 20. The lower byte will remain zero at this time.

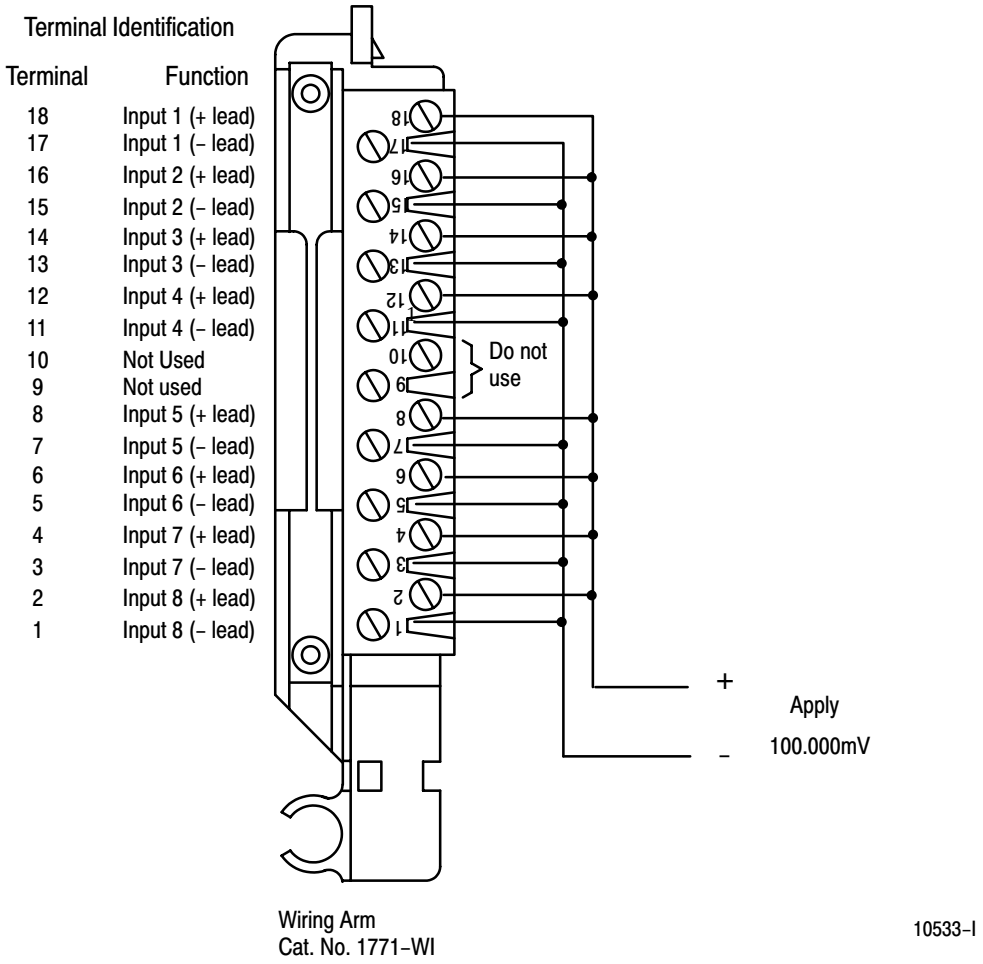
6. Repeat steps 3 through 5 for each of the remaining input channels.

7. Initiate a write block transfer to send the corrections to the module. The input value read by the processor should now be 0000 for all channels.

Setting Channel Gain Calibration

1. Now set the precision voltage source for +100.000 millivolts. Allow sufficient time (at least 10 seconds) for the input filter and voltage source to settle.

Figure 7.4
Applying 100.000mV for Gain Calibration



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2. Record the input value read by the processor in the BTR file (word 4 for channel 1). Determine the **percentage** difference from 10000 and the sign of the correction.

You can adjust the correction up to ±0.19379%.

A negative correction means that the reading was too high and you want to **subtract** a corrective amount from that reading.

A positive correction means that the reading was too low and you want to **add** a corrective amount to that reading.

For example, if the observed value was 10014, then 10000–10014 = –14, and –14 divided by 10000 = –0.14%.

3. Using the following table, select gain correction values that most nearly add up to the percentage that you determined in step 1. Select a value only once.

Bit	Value
Bit 07	Sign bit
Bit 06	= 0.0976562%
Bit 05	= 0.0488281%
Bit 04	= 0.024414%
Bit 03	= 0.012207%
Bit 02	= 0.00610351%
Bit 01	= 0.00305175%
Bit 00	= 0.00152587%

Enter the bit code representing the sum of the corrections into the lower byte (gain correction) of the calibration word for that channel.

For example, to attain the value of 0.140%, you would add:

Percentage	Bit Number
0.0976562	Bit 06
0.024414	Bit 04
0.012207	Bit 03
0.00610351	Bit 02
Total = 0.1403807%	

Enter 11011100 in the lower byte of the calibration word for that channel. This entry would set bits 07 (sign) and 06, 04, 03 and 02 which is –0.1403807, very close to the required –0.14. Remember to keep the upper byte the same as it was from step 5.

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4. Repeat the above steps 2 and 3 for channels 2 through 8.

5. Initiate a write block transfer to send the corrections to the module. The input value read by the processor should now be 10000 for all channels.

6. If the correction changes the result in the wrong direction, change the sign and reenter it.

Important: If the % correction required is larger than +0.19379, check your reference voltage. If the reference voltage is correct, perform auto–calibration.

Chapter Summary

In this chapter, you learned how to calibrate your input module.

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Chapter 8

Troubleshooting

Chapter Objective

We describe how to troubleshoot your module by observing LED indicators and by monitoring status bits reported to the processor.

Diagnostics Reported by the Module

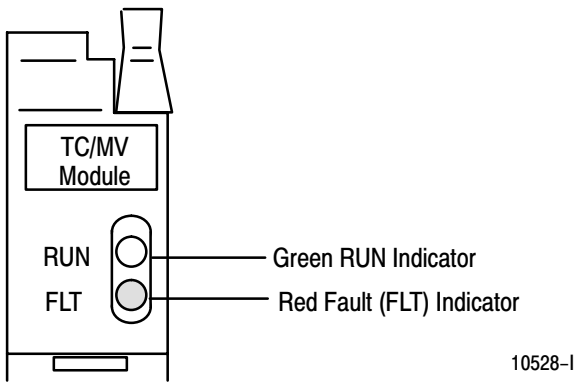
At power–up, the module momentarily turns on both indicators as a lamp test, then checks for

- correct RAM operation
- EPROM operation
- EEPROM operation
- a valid write block transfer with configuration data

Thereafter, the module lights the green RUN indicator when operating without fault, or lights the red FAULT indicator when it detects fault conditions. If the red FAULT indicator is on, block transfers will be inhibited.

The module also reports status and specific faults (if they occur) in every transfer of data to the PC processor. Monitor the green and red LED indicators and status bits in word 1 of the BTR file when troubleshooting your module.

Figure 8.1
LED Indicators



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Troubleshooting with the Indicators

Table 8.A shows LED indications and probable causes and recommended actions to correct common faults.

Table 8.A
Troubleshooting Chart for the 1771–IXHR Input Module

Indication	Probable Cause	Recommended Action
Both LEDs are OFF	No power to module Possible short on the module LED driver failure	Check power to I/O chassis. Cycle as necessary. Replace module.
Red FLT LED ON and Green RUN LED is ON	Microprocessor, oscillator or EPROM failure	Replace module.
Red FLT LED ON	If immediately after power–up, indicates RAM or EPROM failure.[1]	Replace module.
	If during operation, indicates possible microprocessor or backplane interface failure.[1]	Replace module.
Green RUN LED is flashing	Power–up diagnostics successfully completed.	Normal operation.
	If LED continues to flash, and write block transfers (BTW) cannot be accomplished, you have a possible interface failure.	Replace module.

[1] When red LED is on, the watchdog timer has timed out and backplane communications are terminated. Your user program should monitor communication.

Status Reported by the Module

Status Reported in Word 1

Design your program to monitor status bits in the lower byte of word 1, and to take appropriate action depending on your application requirements. You may also want to monitor these bits while troubleshooting with your industrial terminal. The module sets a bit (1) to indicate it has detected one or more of the following conditions as shown in Table 8.B.

Table 8.B
Status Reported in Word 1

Word	Bit	Explanation
1	00	Module is powered but has not received its first (configuration) block transfer. The green LED is flashing.
	01	One or more inputs are out of the range for which you configured the module.
	02	Module updated its inputs before the processor read them. The RTS interval timed out before the processor read the data.
	03	Not used

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Word	Bit	Explanation
Word 1 (cont)	04	The module's ambient temperature is below 0ºC. Temperature readings will be inaccurate.
	05	The module's ambient temperature is above 60ºC. Temperature readings will be inaccurate.
	06	Not used
	07	EEPROM calibration constants could not be read. The module will continue to operate but readings may be inaccurate.
	08–15	Not used

Status Reported in Words 2 and 3

Design your program to monitor over/under range bits, and to take appropriate action depending on your application requirements. You may also want to monitor these bits while troubleshooting with your industrial terminal.

Bits 00–07 and 08–15 each represent an input for channels 1–8, respectively. For example, bit 04 represents input channel 5. The module sets a bit (1) to indicate it has detected an out of range condition. Refer to Table 8.C.

Table 8.C
Status Reported in Words 2 and 3

Word	Bit	Condition
2	00–07	Inputs underrange. Bit 00 is channel 1, bit 07 is channel 8. If input connections and voltages are correct, this status may indicate failed channel communications with the microprocessor. If all channels are underrange, this indicates a possible dc/dc converter failure or a blown fuse.
	08–15	Inputs overrange. Bit 08 is channel 1, bit 15 is channel 8. If input connections and voltages are correct, this status may indicate a failed thermocouple functional analog block (TC FAB).
3	00–07	Corresponding channel input value is below the alarm value that you entered for that channel.
	08–15	Corresponding channel input value has exceeded the alarm value that you entered for that channel.

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Status Reported in Word 13

Design your program to monitor status bits in word 13 during auto–calibration, and to take appropriate action depending on your requirements. You may also want to monitor these bits while troubleshooting with your industrial terminal. The module sets a bit (1) to indicate it has detected one or more of the following conditions as shown in Table 8.D.

Table 8.D
Status Reported in Word 13

Word	Bit	Condition
13	6	The EEPROM could not be written.
	7	Channel(s) could not be calibrated as indicated by bits 08 through 15 respectively.
	08–15	Bit 08 (channel 1) through bit 15 (channel 8) could not be calibrated. Check field wiring arm connections and source for proper voltage.

Chapter Summary

In this chapter, you learned how to interpret the LED status indicators, status words and troubleshoot your input module.

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Appendix **A**

Specifications

Number of Inputs	8, all of the same type or 4 each of 2 different types
I/O Chassis Location	Any single I/O module slot
Type of Input (Selectable)	Type B, Pt–30% Rh/Pt–6% Rh (320 to 1800°C) Type E, chromel/constantan (–270 to 1000°C) Type J, iron/constantan (–210 to 1200°C) Type K, chromel/alumel (–270 to 1380°C) Type R, Pt/Pt–13% Rh (–50 to 1770°C) Type S, Pt/Pt–10% Rh (–50 to 1770°C) Type T, copper/constantan (–270 to 400°C) Millivolt (–100 to +100mV dc)
Thermocouple Linearization	IPTS–68 standard, NBS MN–125
Cold Junction Compensation	Range: 0 to 60°C Accuracy: ±0.5°C
Temperature Scale (Selectable)	°C or °F
Input Resolution	3.2328µV
Display Resolution	0.1°C, 0.1°F; or 1.0µV, 10µV
Input Isolation	1000V peak between inputs, between input and common, and between input and backplane connections
Common Mode Rejection	120dB at 60Hz, up to 1000V peak
Common Mode Impedance	Greater than 10 megohms
Normal Mode Rejection	60dB at 60Hz over ±100mV
Input Overvoltage Protection	120V rms, continuous
Open Input Detection	Open input produces an overrange in less than 10 seconds
Input Connections	18–terminal wiring arm (Cat. No. 1771–WI)
Data Format	2's complement binary
Calibration Methods	Auto – Auto–calibration for offset and gain Manual – Zero offset and gain adjustment for each channel via programming terminal Verify every six months for maintaining absolute accuracy
Processor Compatibility	PLC–3 or PLC–5 family processor using the 1771 I/O structure and block transfer. (Not recommended for use with PLC–2 family processors.)
Environmental Conditions Operating Temperature: Rate of Change: Storage Temperature: Relative Humidity:	 0 to 60°C (32 to 140°F) Ambient changes greater than 0.5°C per minute may temporarily degrade performance during periods of change –40 to 85°C (–40 to 185°F) 5 to 95% (without condensation)
Backplane Power Consumption	750mA @ 5V; 3.75 Watts maximum
Field Wiring Arm	Cat. No. 1771–WI
Keying	Between 20 and 22 Between 24 and 26

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High Resolution Thermocouple/Millivolt Input Module Accuracy

The accuracy of your thermocouple readings depends on:

- module accuracy
- lead resistance effect
- accuracy of the thermocouple

The accuracy of the module is shown in Table A.A and Table A.B at ambient temperature (25ºC) and over the temperature range (0–60ºC).

Use the calibration procedure in Chapter 7 to adjust your module to compensate for your specific environment.

Table A.A
Thermocouple Range Accuracy Based on Temperatures Above 0ºC

Thermocouple Type	Temperature Range ºC	Max Error @ Calibration Temperature (25ºC)[1]	Temperature Drift ºC/ºC (0–60ºC) or ºF/ºF (32–140ºF)
B	320 to 1800	±1.07ºC/±1.91ºF	±0.0746
E	–270 to 1000	±0.50ºC/±0.90ºF	±0.0400
J	–210 to 1200	±0.51ºC/±0.90ºF	±0.0423
K	–270 to 1380	±0.52ºC/±0.94ºF	±0.0640
T	–270 to 400	±0.52ºC/±0.92ºF	±0.0183
R	–50 to 1770	±1.14ºC/±2.00ºF	±0.0914
S	–50 to 1770	±1.12ºC/±2.01ºF	±0.0926

[1] Type E, J, K, T, R and S error is specified from 0ºC (32ºF) to the maximum range of the thermocouple. Type B is specified from 600ºC to maximum range. Error does not include thermocouple or lead error (see appendix F and page A–3).

Table A.B
Millivolt Range Accuracy

Millivolt Range	Max Error @ Calibration Temperature (25ºC)	Millivolt Drift
–100 to 100 (Normal mode)	±8.85µV	±3.856µV/ºC
–100 to 100 (Zoom mode)	±5.78µV	±3.856µV/ºC

Table A.C
Radiated Noise Susceptibility

Radiated Noise	Susceptibility Error
300–1000MHz Circular Wave, Field Strength = 10V/M	< ±1%

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Lead Resistance Compensation

Allowable Distances

The open thermocouple detection circuit injects a current of approximately 7.3 nanoamps into the thermocouple cable. A total lead resistance of 1370 ohms (685 ohms one–way) cable resistance will produce 10uV of error.

Source Impedance Compensation for Millivolt Inputs

Source resistance causes similar errors to occur with millivolt inputs. If source resistance is less than 100 ohms, no compensation is necessary to maintain stated accuracy. If source resistance is greater than 100 ohms, the error can be calculated as follows:

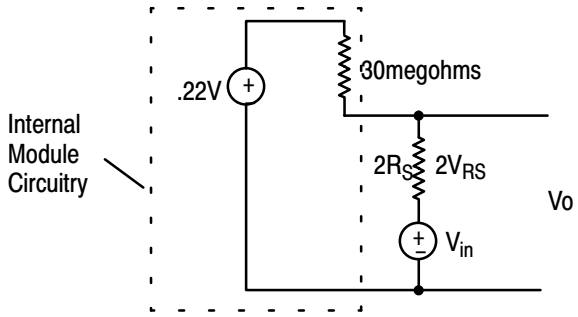
$$\text{Error (in offset calibration counts)} = - \frac{309329\ R_s\ (0.22 - Vin)}{R_s + 15M\ \text{ohms}}$$

Where R_s = source resistance (one–way cable resistance)
V_{in} = applied input voltage

When using thermocouples, Vin is the approximate thermocouple voltage of the temperature of interest.

$V_O = V_{IN} + 2V_{RS}$

Error = $2V_{RS}$



To maintain a display error of < 5uV at V_{in} = OV, R_S should be < 341 ohms. Refer to NBS NM–125 Thermocouple Reference Tables for determining actual thermocouple voltage versus temperature readings.

Filtering

Hardware
The analog input module has hardware–based high frequency filters on all channels to reduce the effect of electrical noise on the input signal. In addition, a 6–pole digital filter, which begins rolling off at 8.0Hz, is also incorporated.

Software
A first order programmable filter is also available. Filter time constants range from 0 (disabled) to 255 (6.4 seconds).

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Appendix **B**

Programming Examples

Sample Programs for the Input Module

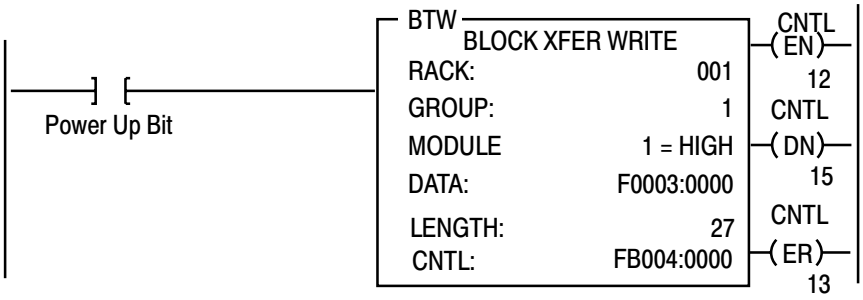
The following are sample programs for entering data in the configuration words of the write block transfer instruction when using the PLC–3 or PLC–5 family processors.

PLC–3 Family Processors

Following is a sample procedure for entering data in the configuration words of the write block transfer instruction when using a PLC–3 processor. For a complete sample program, refer to Figure 4.2.

To enter data in the configuration words, follow these steps:

Example:
Enter the following rung for a write block transfer:



F0003:0000 is the address of the write block transfer data file. You want to enter/examine word 1.

1. Press [SHIFT][MODE] to display your ladder diagram on the industrial terminal.

2. Press DD,03:0[ENTER] to display the block transfer write file.

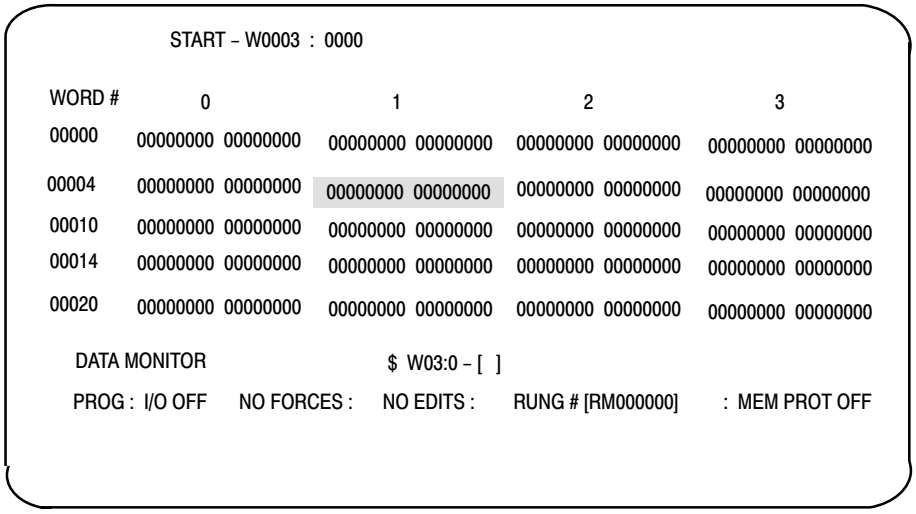
The industrial terminal screen should look like Figure B.2. Notice the highlighted block of zeroes. This highlighted block is the cursor. It should be in the same place as it appears in Figure B.2. If it is not, you can move it to the desired position with the cursor control keys. Once you have the highlighted cursor in the right place, you can go on to step 3.

3. Enter the data corresponding to your bit selection in words 0 through 4.

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4. When you have entered your data, press [ENTER]. If you make a mistake, make sure the cursor is over the word you desire to change. Enter the correct data and press [ENTER].

Figure B.2
Write Block Transfer for a PLC–3 Processor

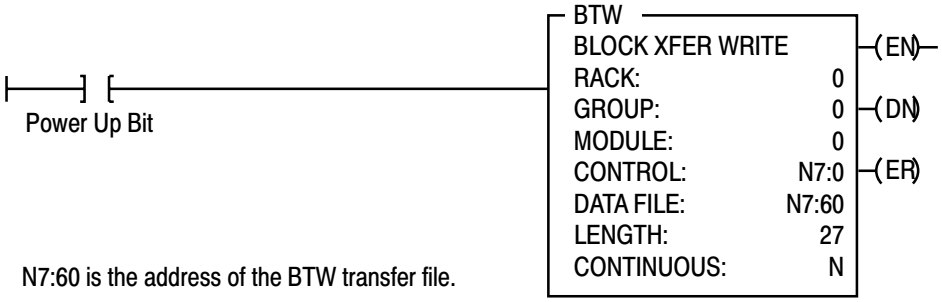


5. Press [CANCEL COMMAND]. This returns you to the ladder diagram.

PLC–5 Family Processors

The following is a sample procedure for entering data in the configuration words of the block transfer write instruction when using a PLC–5 processor. For a complete sample program, refer to figure 4.3.

1. Enter the following rung:



N7:60 is the address of the BTW transfer file.

2. Press [F8],[F5] and enter N7:60 to display the configuration block.

The industrial terminal screen should like Figure B.3.

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Figure B.3
Sample PLC–5 Data File (Hexadecimal Data)

Address	0	1	2	3	4	5	6	7	8	9
N7:60	50D8	0046	007F	8EB8	7148	8EB8	7148	8EB8	7148	8EB8
N7:70	7148	FE70	0352	FE70	0352	FE70	0352	FE70	0352	0000
N7:80	0000	0000	0000	0000	0000	0000	0000			

The above data file would configure the module as follow:

- ”K” thermocouples on inputs 5–8
- millivolt inputs on channels 1–4
- temperature scale of Celsius
- zoom enabled for channels 1–4
- real time sampling set to a 1 second scan rate
- zoom center set to +70mV (46H = 70D)
- filter time constant = 6.4 seconds for channels 1–4
- all channel alarms ON
- low alarm values for channels 1–4 set (–29.000mV + 70mV) = 41.000mV
- high alarm values for channels 1–4 set to (29.000mV + 70mV) = 99.000mV
- low alarm values for channels 5–8 set to –40.0ºC
- high alarm values for channels 5–8 set to +85.0ºC
- all user calibration values set to 0

Note: Put data file in decimal format to view addresses 61 through 78.

3. Enter the data corresponding to your bit selections and add alarm and calibration values, if so desired.

4. [ESC] returns you to the main menu.

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Appendix C

Thermocouple Restrictions (Extracted from NBS Monograph 125 (IPTS–68))

General

Following are some restrictions extracted from NBS Monograph 125 (IPTS–68) issued March 1974 on thermocouples B, E, J, K, R, S and T:

B (Platinum – 30% Rhodium vs Platinum – 6% Rhodium) Type Thermocouples

"The ASTM manual STP 470 [1970] indicates the following restrictions on the use of B type thermocouples at high temperatures: They should not be used in reducing atmospheres, nor in those containing metallic or nonmetallic vapors, unless suitably protected wiht nonmetallic protecting tubes. They should never be inserted directly into a metallic primary tube."

"At temperatures below 450C the Seebeck coefficient of Type B thermocouples becomes quite small and is almost negligible in the normal room temperature range. Consequently, in most applications the reference junction temperature of the thermocouple does not need to be controlled or even known, as long as it is between 0 and 50C."

Studies have shown that "a .1 percent change in the Rhodium content of the Pt–30% Rh thermoelement produces a corresponding change in the thermocouple voltage of about 15uV (i.e. 1.3C) at 1500C. In contrast a change of only .01% in the Rhodium content of Pt–6% Rh thermoelement also produces a voltage change of about 15uV (1.3C) at this temperature."

"The thermoelectric voltages of Type B thermocouples is sensitive to their history of annealing, heat treatment and quenching. Calibration of Type B wires above 1600C is undesirable in most circumstances."

"ASTM Standard E230–72 in the Annual Book of ASTM Standards [1972] specifies that the standard limits of error for Type B commercial thermocouples be + 1/2 percent between 871 and 1705C. Limits of error are not specified for Type B thermocouples below 871C. The recommended upper temperature limit for protected thermocouples, 1705C, applies to AWG 24 (0.5mm) wire."

E (Nickel–Chromium vs Copper–Nickel <Constantan*>) Type Thermocouple

"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.

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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 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 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. The recommended upper temperature limit for protected thermocouples, 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 (.8mm) and 427C for AWG 24 or 28 (0.5 or 0.3mm).

J (Iron vs Copper–Nickel <Constantan*>) Type Thermocouple

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 gage 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 readings 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."

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"Commercial iron undergoes a magnetic transformation near 769C and <an alpha – gamma> crystal transformation near 910C. Both of these transformations, 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 decrease to 593C for AWG 14 (1.6mm), and 371C for AWG 24 or 28 (0.5 or 0.3mm).

* 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 ratio of copper and nickel in each.

K (Nickel–Chromium vs Nickel–Aluminum) Type Thermocouple

"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 Type 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

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alters the calibration. They should also not 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).”

R (Platinum–13% Rhodium vs Platinum) and S (Platinum–10% Rhodium vs Platinum) Type Thermocouples

“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 suitably 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% 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.

T (Copper vs Copper–Nickel <Constantan*>) Type Thermocouple

“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

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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 from –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, +/–.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).

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