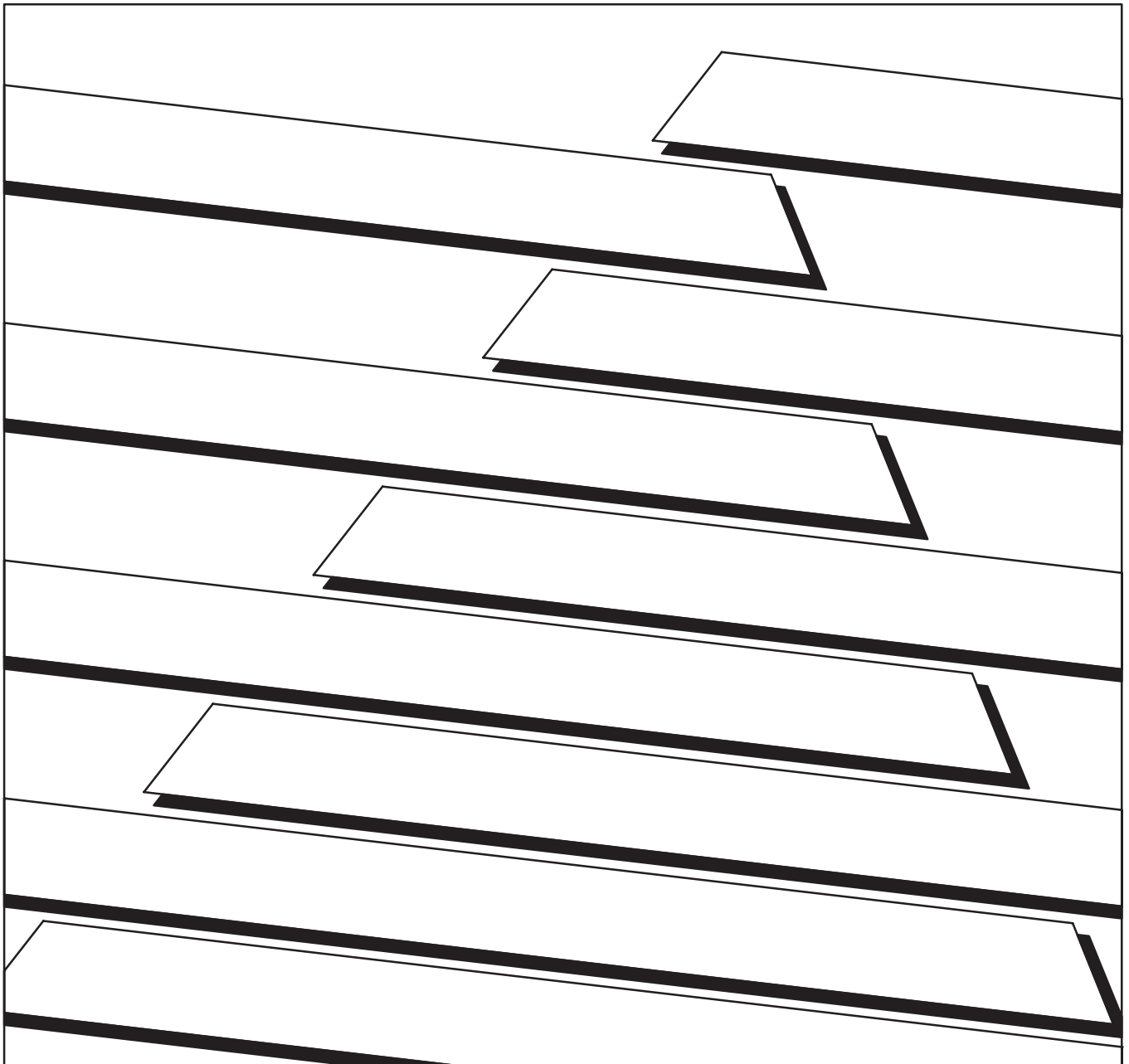




**ALLEN-BRADLEY**

# Isolated Analog Input Module Cat. No. 1771-IL Series B

User Manual



## Important User Information

Because of the variety of uses for the products described in this publication, those responsible for the application and use of this control equipment must satisfy themselves that all necessary steps have been taken to assure that each application and use meets all performance and safety requirements, including any applicable laws, regulations, codes and standards.

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

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

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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.



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

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Attention helps you:

- Identify a hazard.
- Avoid the hazard.
- Recognize the consequences.

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

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

## Summary of Changes

### Summary of Changes

This release of this publication contains new and revised information from the last release.

#### New Information

This manual covers the series B version of the 1771-IL isolated input module. The 1771-IL series B module has 16-bit resolution, improved sample time, and auto-calibration.

#### Revised Information

Many areas in this manual have been modified. Change bars (as shown to the right side of this paragraph) are used to indicate new or revised information. Every chapter in this manual has been revised. Please read carefully.

# Using This Manual

## Purpose of Manual

This manual shows you how to use your Isolated Analog 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 to make efficient use of your input module. In particular, you must know how to program block transfers.

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

## Vocabulary

In this manual, we refer to:

- the 1771-IL series B analog input module as the “input module,” or the “1771-IL/B”
- the Programmable Controller as the “controller”

## Manual Organization

This manual is divided into seven 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
1	Overview of the input module	Description of the module including general and hardware features
2	Installing the module	Module power requirements, keying, chassis location Wiring of the field wiring arm
3	Communicating with your module	Reading data from your module Sample programs
4	Configuring your module	Hardware and software configuration Input range selection Data format
5	Module status and input data	Reading data from the module
6	Calibrating your module	Information on calibrating your module
7	Troubleshooting	Troubleshooting guide for problem diagnosis

Appendix	Title	Topics Covered
A	Specifications	
B	Configuration Example	
C	Data Formats	Information on BCD, 2s complement binary, signed magnitude
D	Block transfer with Mini-PLC-2 and PLC-2/20 processors	How to use GET-GET instructions

## Related Products

You can install your input module in any system that uses Allen-Bradley 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

The 1771-IL series B module 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. I/O image table use is an important factor in module placement and addressing selection. The module's data table use is listed in Table P.A.

**Table P.A**  
**Compatibility and Use of Data Table**

Catalog Number	Use of Data Table				Compatibility			
	Input Image Bits	Output Image Bits	Read-Blocks Words	Write-Block Words	Addressing			Chassis Series
					1/2-Slot	1-Slot	2-slot	
1771-IL/B	8	8	15	37	Y	Y	Y	A, B

A = Compatible with 1771-A1, -A2, -A4  
B = Compatible with 1771-A1B, -A2B, -A3B, -A4B  
Y = Compatible without restriction.

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. You can put 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 using 1- or 2-slot addressing. Avoid placing output modules 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).

## Overview of the Input Module

### Chapter 1

Chapter Objectives .....	1-1
Module Descriptions .....	1-1
Features .....	1-1
How Analog Modules Communicate with Programmable Controllers ..	1-2
Accuracy .....	1-3
Chapter Summary .....	1-3

## Installing the Input Module

### Chapter 2

Chapter Objectives .....	2-1
Before You Install Your Input Module .....	2-1
Electrostatic Damage .....	2-1
Power Requirements .....	2-2
Module Location in the I/O Chassis .....	2-2
Module Keying .....	2-2
Wiring Your Input Module .....	2-3
Grounding .....	2-5
Setting the Voltage/Current Selection Jumpers .....	2-6
Module Installation .....	2-7
Indicator Lights .....	2-7
Chapter Summary .....	2-8

## Communicating With Your Module

### Chapter 3

Chapter Objectives .....	3-1
Block Transfer Programming .....	3-1
PLC-2 Programming .....	3-2
PLC-3 Programming .....	3-3
PLC-5 Programming .....	3-4
Module Scan Time .....	3-5
Chapter Summary .....	3-5

## Configuring Your Module

### Chapter 4

Chapter Objectives .....	4-1
Configuring Your Input Module .....	4-1
Input Range Selection .....	4-2
Block Transfer Write Format .....	4-3
Data Format .....	4-4
Digital Filtering .....	4-4
Real Time Sampling .....	4-5
Scaling .....	4-7
Default Configuration .....	4-10
Chapter Summary .....	4-13

<b>Module Status and Input Data</b>	<b>Chapter 5</b>	
	Chapter Objectives .....	5-1
	Reading Data From Your Module .....	5-1
	Chapter Summary .....	5-3
<b>Calibrating Your Module</b>	<b>Chapter 6</b>	
	Chapter Objective .....	6-1
	Tools and Equipment .....	6-1
	Calibrating your Input Module .....	6-1
	About Auto-calibration .....	6-1
	Performing Auto-calibration .....	6-2
	Chapter Summary .....	6-5
<b>Troubleshooting</b>	<b>Chapter 7</b>	
	Chapter Objective .....	7-1
	Diagnostics Reported by the Module .....	7-1
	Status Reported by the Module .....	7-2
<b>Specifications</b>	<b>Appendix A</b>	
	Specifications .....	A-1
<b>Configuration Example</b>	<b>Appendix B</b>	
	Sample Configuration of the Analog Input Module .....	B-1
<b>Data Formats</b>	<b>Appendix C</b>	
	4-Digit Binary Coded Decimal (BCD) .....	C-1
	Signed-magnitude Binary .....	C-2
	Two's Complement Binary .....	C-2
<b>Block Transfer (Mini-PLC-2 and PLC-2/20 Processors)</b>	<b>Appendix D</b>	
	Multiple GET Instructions—Mini-PLC-2 and PLC-2/20 Processors ...	D-1
	Setting the Block Length (Multiple GET Instructions only) .....	D-3



## Overview of the Input Module

### Chapter Objectives

This chapter gives you information on:

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

### Module Descriptions

The input module is an intelligent block transfer module that interfaces analog input signals with any Allen-Bradley programmable controllers that have block transfer capability. 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 that requires no 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.

### Features

This module senses up to eight analog signals at its inputs and converts them to a proportional four-digit BCD or 16-bit binary value while providing channel to channel and channel to ground isolation of  $\pm 1000V$ . You can select from five voltage or three current input ranges. Each input is software selectable on a per channel basis.

This module's features include:

- Eight software configurable differential inputs
- User program selectable input ranges on a per channel basis (see Table 1.A)
- Selectable real-time sampling
- Selectable scaling to engineering units
- Selectable digital filtering
- $\pm 1000V$  input isolation, channel-to-channel, channel-to-ground
- Selectable high and low input alarms

**Table 1.A**  
**Program Selectable Input Ranges**

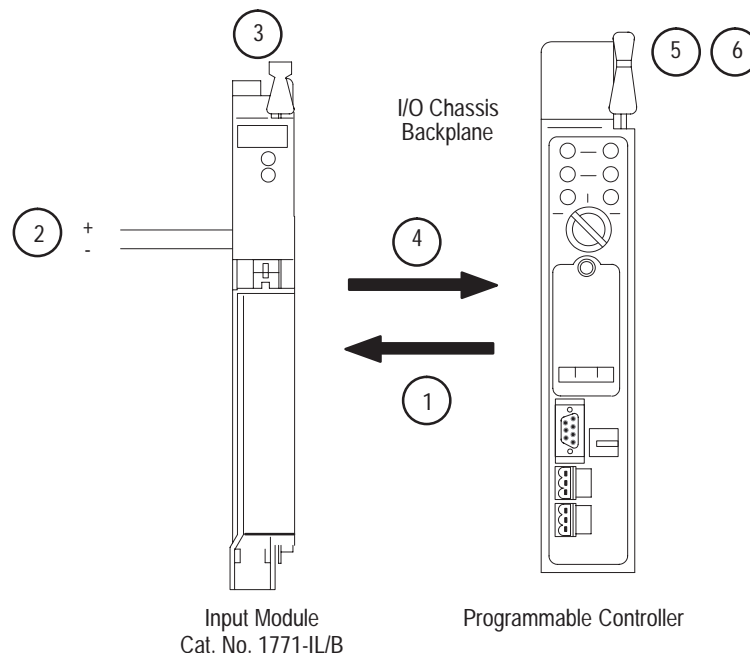
Voltage Ranges	Current Ranges
1 to 5V dc	4 to 20mA
0 to 5V dc	0 to 20mA
-5 to +5V dc	-20 to +20mA
-10 to +10V dc	
0 to 10V dc	

## How Analog Modules Communicate with Programmable Controllers

The processor 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 processor obtain input values and status from the module, and let you establish the module's mode of operation (Figure 1.1).

1. The processor transfers your configuration data, and alarm values to the module via a block transfer write instruction.
2. External devices generate analog signals that are transmitted to the module.

**Figure 1.1**  
**Communication Between Processor and Module**



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3. The module converts analog signals into binary or BCD format, and stores these values until the processor requests their transfer.
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 operator intervention or at power-up.

## **Accuracy**

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

## **Chapter Summary**

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

## Installing the 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
- configuring your module voltage/current selection jumpers
- 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 should:

You need to:	As described under:
Calculate the power requirements of all modules in each chassis.	Power Requirements, page 2-2.
Determine where to place the module in the I/O chassis.	Module Location in the I/O Chassis, page 2-2.
Select the input for each channel.	Setting the Voltage/Current Selection Jumpers, page 2-2.
Key the backplane connector in the I/O chassis.	Module Keying, page 2-4.
Make connections to the wiring arm.	Wiring Your Input Module, page 2-5, and Grounding, page 2-7

### Electrostatic Damage

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



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

- Wear an approved wrist strap grounding device, or 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.

## Power Requirements

Your module receives its power through the 1771 I/O power supply. The Isolated Analog input module requires 1.2A at 5V from the power supply.

Add this current 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 I/O module slot of the I/O chassis except for the extreme left slot. This slot is reserved for programmable controller processors or adapter modules.

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

- Group analog input 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.

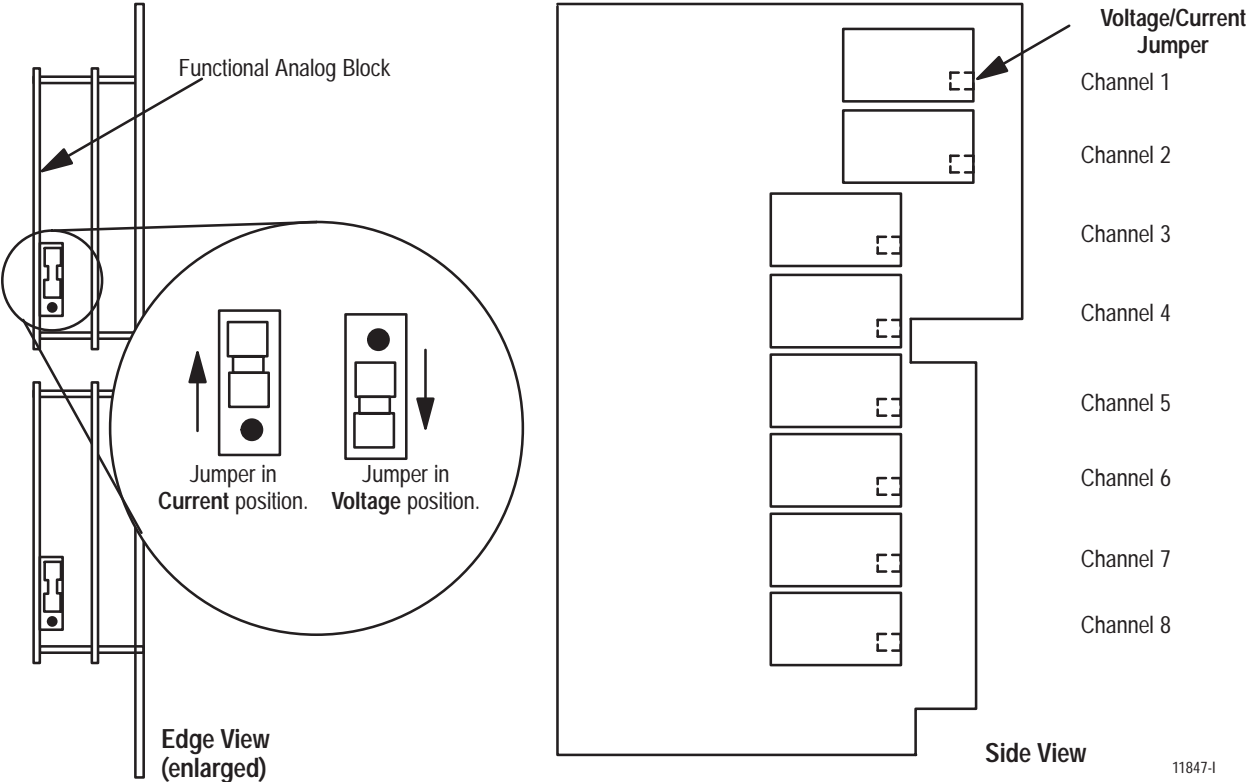
## Setting the Voltage/Current Selection Jumpers

The Isolated Analog Input Module (1771-IL/B) is shipped with each channel set for voltage mode. If a milliamp input is desired, you must set a jumper on the functional analog block (FAB) for that particular channel.

To set the selection jumpers for your desired inputs, proceed as follows:

1. Remove the module's left hand cover plate (the one without the labels).
2. Locate the selection plugs (Figure 2.1).
3. Position the jumpers as shown in Figure 2.1 for your particular module.
4. Reassemble the module after you have finished checking and/or setting the selection plugs.

Figure 2.1  
Configuration Jumper Settings for 1771-IL/B Inputs



## Installing the Analog Module

To install your module in an I/O chassis:

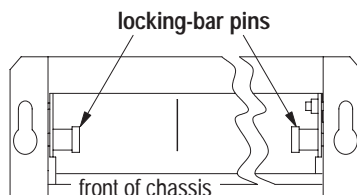
1. First, turn off power to the I/O chassis:



**ATTENTION:** Remove power from the 1771 I/O chassis backplane and disconnect the cable from the module 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 could cause module damage, degradation of performance, or injury.



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2. Lift the locking latch holding the module into the chassis. (On chassis equipped with a chassis locking bar, pull the locking-bar pins to release the locking bar and swing it up.)
3. Position the keying bands (Figure 2.2) in the backplane connectors to correspond to the key slots on the module. This prevents you from inserting the wrong module in this slot. This analog module uses:
  - between 10 and 12
  - between 32 and 34



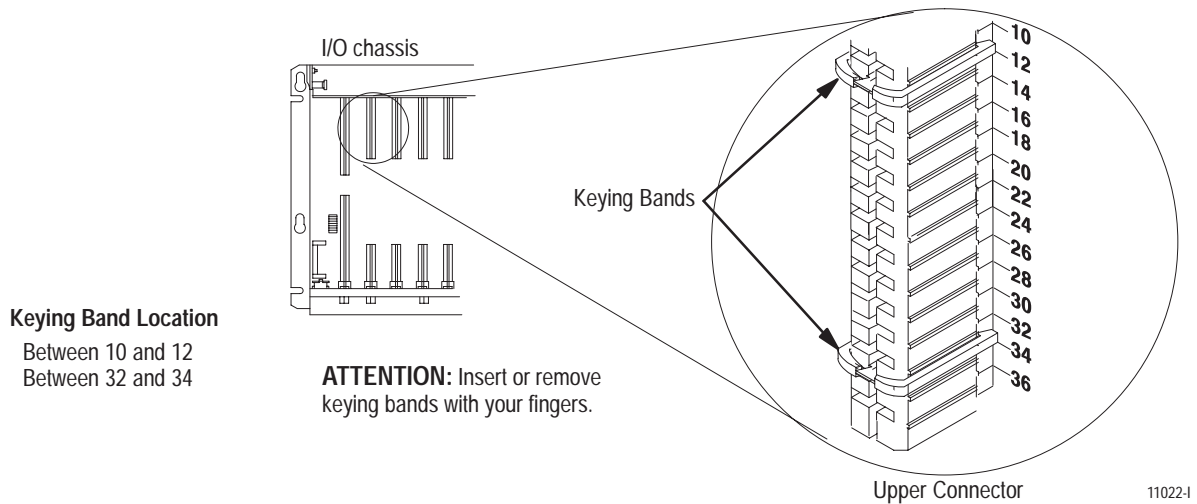
**ATTENTION:** Observe the following precautions when inserting or removing keys:

- insert or remove keys with your fingers
- make sure that key placement is correct

Incorrect keying or the use of a tool can result in damage to the backplane connector and possible system faults.

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 2.2  
Keying Positions



4. Place the module in the plastic tracks on the top and bottom of the slot that guides the module into position.
5. Do not force the module into its backplane connector. Apply firm even pressure on the module until it is firmly seated in the chassis.  
**Note:** The chassis locking bar will not close if all modules are not seated properly.
6. Snap the chassis locking bar (or locking latch on earlier chassis) over the top of the module to secure it. Make sure the locking pins on the locking bar are fully engaged.
7. Connect the wiring to the module as explained under “Connecting Wiring” below.

## Connecting Wiring to Your Input Module

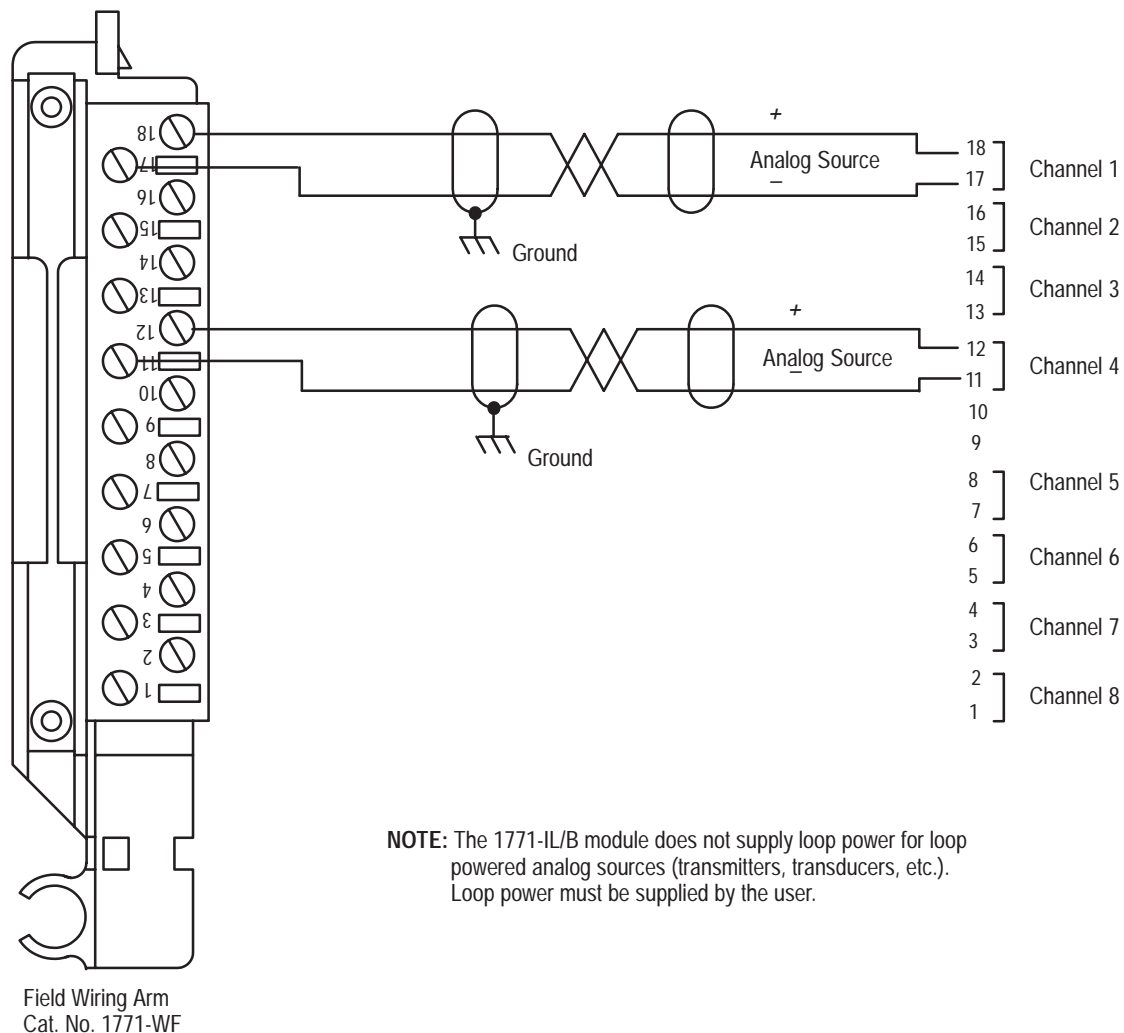
Connect your input devices to the cat. no. 1771-WF wiring arm shipped with the module. Attach the wiring arm to the pivot bar at the bottom of the I/O chassis. It pivots upward and connects with the module so you can install or remove the module without disconnecting the wires.

Connect inputs to the 1771-IL/B module as shown in Figure 2.3. This module is shipped from the factory configured for voltage inputs but can be configured for any combination of current and voltage inputs. If you want to change the configuration, refer to “Setting the Voltage/Current Selection Jumpers” as explained earlier in this chapter.

**Important:** The module configuration jumpers must be set for either voltage or current before inserting the module into the I/O chassis.



Figure 2.3  
Wiring Connections for the Isolated Analog Input Module (1771-IL/B)

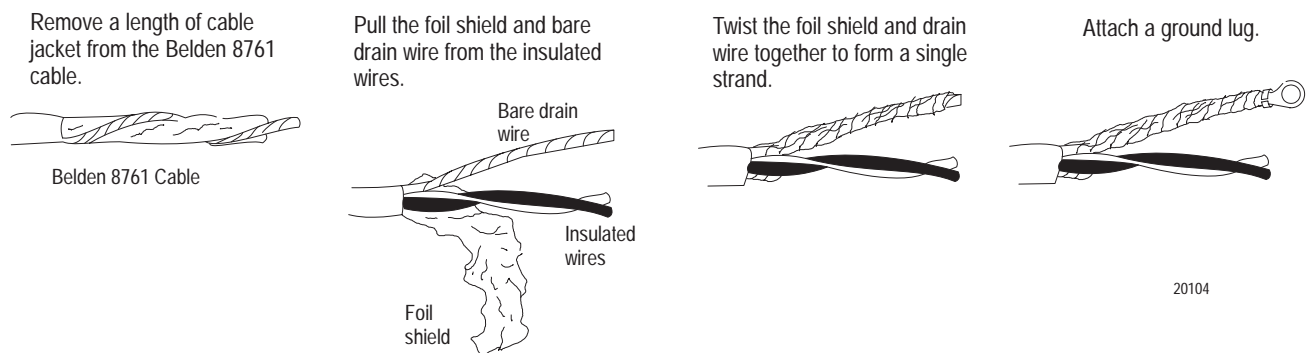


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# Grounding

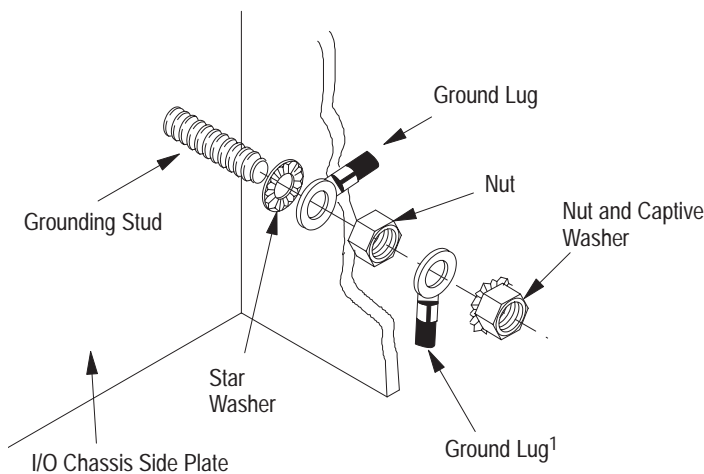
When using shielded cable wire, ground the foil shield and drain wire only at one end of the cable. We recommend that you wrap the foil shield and drain wire together and connect them to a chassis mounting bolt (Figure 2.4). At the opposite end of the cable, tape exposed shield and drain wire with electrical tape to insulate it from electrical contact.

Figure 2.4  
Cable Grounding



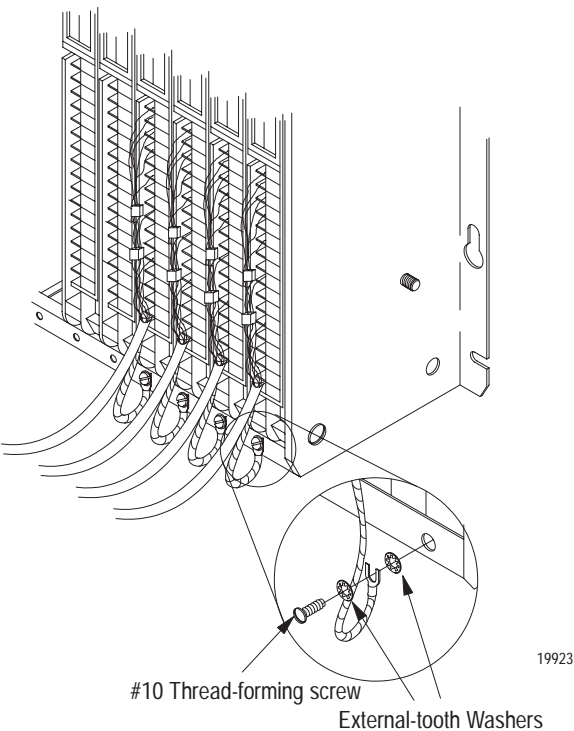
## Chassis Ground

When you connect grounding conductors to the I/O chassis grounding stud, place a star washer under the first lug, then place a nut with captive lock washer on top of each ground lug.



<sup>1</sup>Use the cup washer if crimp-on lugs are not used.

## Single-point Grounding

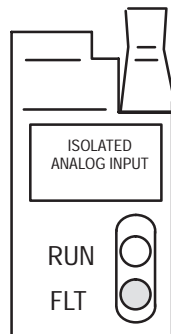


Refer to Wiring and Grounding Guidelines, publication 1770-4.1, for additional information.

## Indicator Lights

The front panel of the input module contains a green RUN and a red FLT (fault) indicator (Figure 2.5). At powerup, 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. Upon completion of a block transfer write (BTW), the green RUN indicator will be on and the red FLT indicator will be off. If a fault is found initially or occurs later, the red FLT indicator lights. Possible module fault causes and corrective actions are discussed in Chapter 7, Troubleshooting.

**Figure 2.5**  
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.

## Communicating With Your Module

### Chapter Objectives

In this chapter, we describe

- block transfer programming
- quick-start sample programs in the PLC-2, PLC-3 and PLC-5 processors
- module scan time issues

### Block Transfer Programming

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

A configuration **BTW** is initiated when the analog 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 enable the programmable features of the module, such as scaling, alarming, real time sampling, etc. Block Transfer reads are performed to retrieve information from the module.

Subsequent BTWs occur 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 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.

**The analog input module will work with a default configuration of zeroes entered in the configuration block.** This results in the default settings of: 1 to 5V dc or 4 to 20mA (depending on voltage/current selection jumper), BCD data format, no real time sampling (RTS), no digital filter, no scaling, and no alarms. Refer to Chapter 4 for more information. 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 the 1771-IL series B module to powerup and operate.

## PLC-2 Programming

The PLC-2 program example regulates when each block transfer will be initiated to eliminate problems caused by limited regulation of bidirectional block transfers. Both storage bits are needed, (as shown in the example), to accomplish this task in all PLC-2 systems, local or remote, with long or short program scans. Therefore, the program as shown is the minimum required. Note that PLC-2 processors that do not have the block transfer instruction must use the GET-GET block transfer format which is outlined in appendix D.

**Figure 3.1**  
PLC-2 Family Sample Program Structure

### Program Action

#### Rung 1

Block transfer read buffer: the file-to-file move instruction holds the block transfer read (BTR) data (file A) until the processor checks the data integrity. If the data was successfully transferred, the processor energizes the BTR done bit, initiating a data transfer to the buffer (file R) for use in the program. If the data is corrupted during the BTR operation, the BTR done bit is not energized and data is not transferred to the buffer file. In this case, the data in the BTR file will be overwritten by data from the next BTR.

#### Rungs 2 and 3

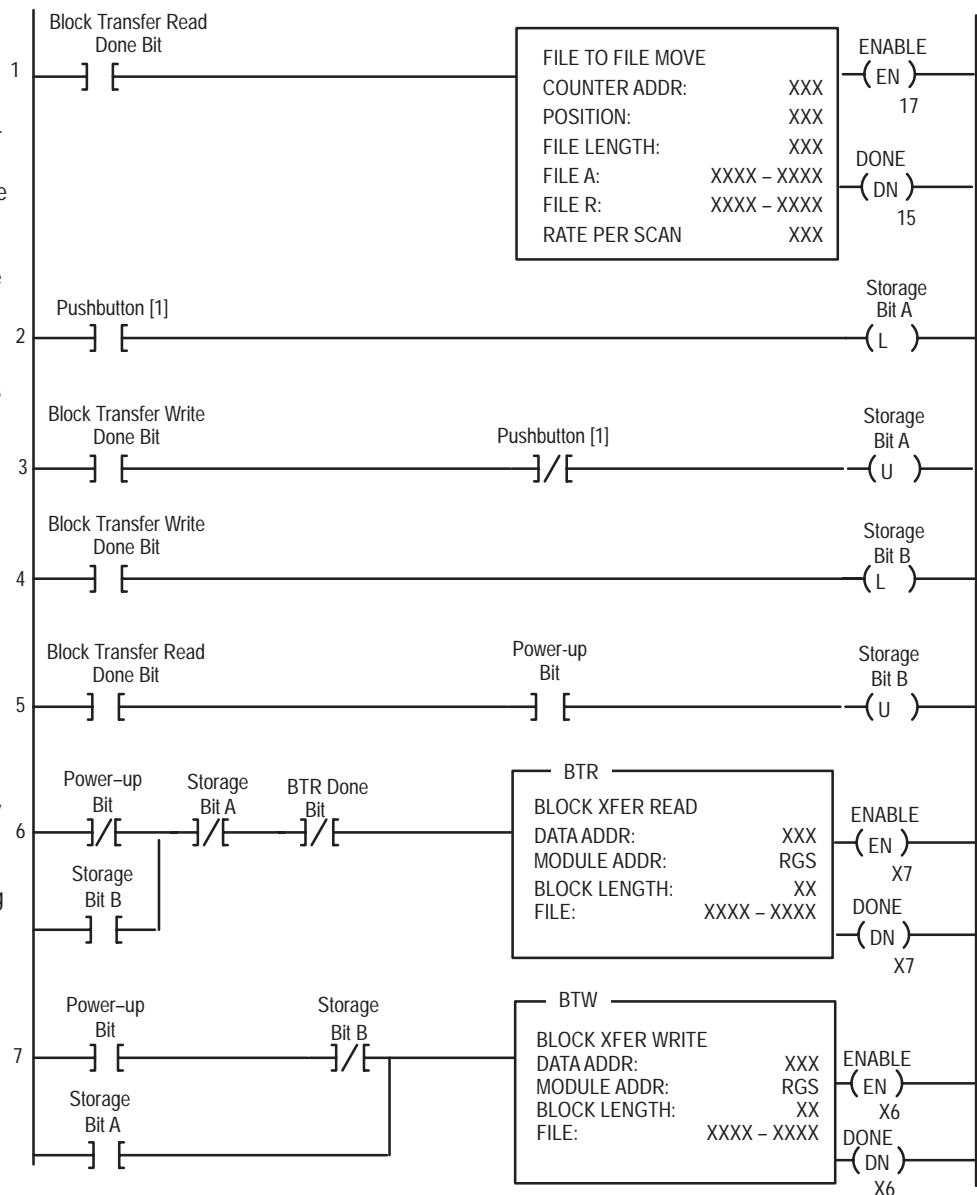
These rungs provide for a user-initiated block transfer write (BTW) after the module is initialized at power-up. Pressing the pushbutton locks out BTR operation and initiates a BTW that reconfigures the module. Block transfer writes will continue for as long as the pushbutton remains closed.

#### Rungs 4 and 5

These rungs provide a "read-write-read" sequence to the module at power-up. They also insure that only one block transfer (read or write) is enabled during a particular program scan.

#### Rungs 6 and 7

These rungs are the conditioning block transfer rungs. Include all the input conditioning shown in the example program.



[1] You can replace the pushbutton with a timer "done" bit to initiate the block transfer write on a timed basis. You can also use any storage bit in memory.

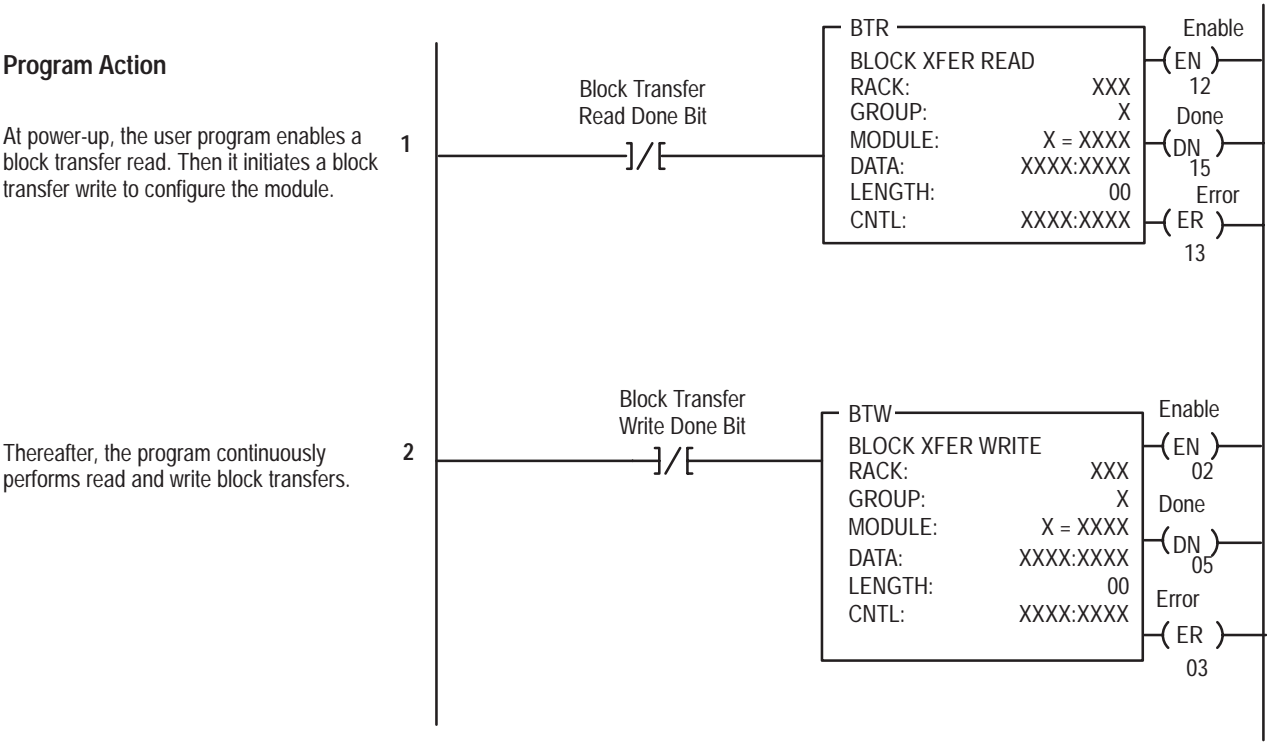
PLC-3 Programming

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 your module (when programming a block transfer write) or from your 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 3.2, and described below.

Figure 3.2  
PLC-3 Family Sample Program Structure



## PLC-5 Programming

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

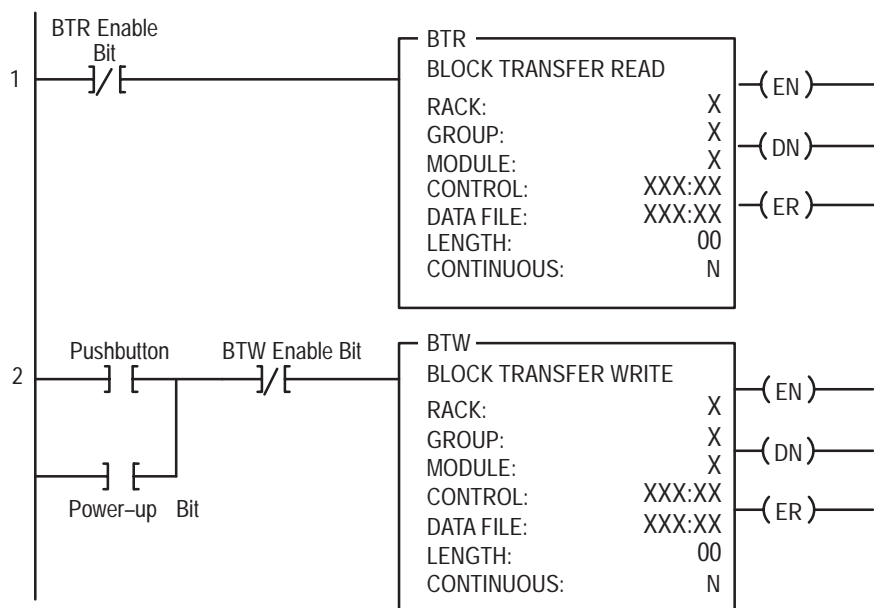
1. Block transfer enable bits are used instead of done bits as the conditions on each rung.
2. Separate block transfer control files are used for the block transfer instructions.

**Figure 3.3**  
**PLC-5 Family Sample Program Structure**

### Program Action

At power-up, the program enables a block transfer read (rung 1). Then it examines the power-up bit in the BTR file and initiates one block transfer write to configure the module (rung 2).

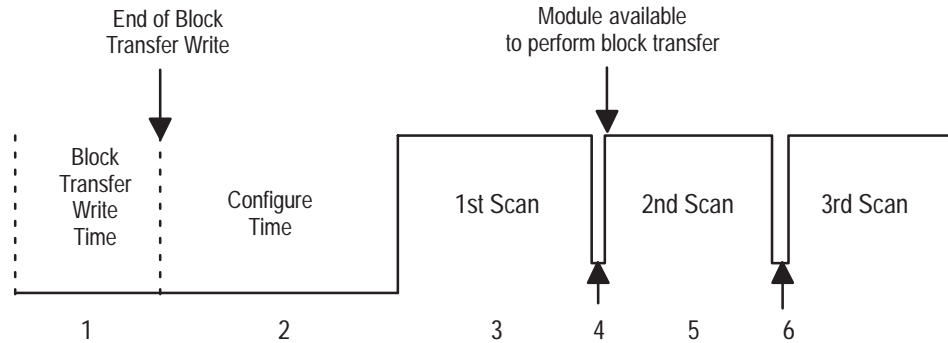
Thereafter, the program continuously reads data from the module (rung 1). A subsequent BTW operation is enabled by a pushbutton switch (rung 2). Changing the processor mode will not initiate a block transfer write.



## 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 Appendix A.

**Figure 3.4**  
**Block Transfer Time**



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**Internal Scan time** = 50ms  
**T** = 100ms, 200ms, 300ms, 3.1s.

The following description references the sequence numbers in Figure 3.4.

Following a block transfer write (1) the module inhibits communication until after it has loaded the new configuration data (2), scanned the inputs and/or outputs (3), and filled the data buffer (4). Configuration block transfers, therefore, should only be performed when the module is being configured or calibrated.

Any time after the buffer is filled (4), a block transfer read (BTR) request can be acknowledged.

When operated in the default mode, new data will be available for a BTR every 50 milliseconds. When operated in real time sample mode (RTS = T), BTRs will be ignored by the module for “T” milliseconds, at which time a single BTR will be allowed.

## Chapter Summary

In this chapter, you learned how to program your programmable controller. You were given sample programs for your PLC-2, PLC-3 and PLC-5 family processors.

You also read about module scan time.



## Configuring Your Module

### Chapter Objectives

In this chapter you will read how to:

- configure your module's hardware
- condition your inputs
- enter your configuration data.

### Configuring Your Input 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. **Before continuing, make sure you read “Setting Voltage/Current Selection Jumpers” in chapter 2.**

The software configurable features available with the Isolated Analog Input Module (1771-IL series B) are:

- input range selection
- data format
- digital filtering
- real time sampling
- scaling to engineering units
- high and low alarms

Configure your module for its intended operation by means of your programming terminal and block transfer write (BTW) instructions.

**Note:** Programmable controllers that use 6200 software programming tools can take advantage of the IOCONFIG utility to configure this module. IOCONFIG uses menu-based screens for configuration without having to set individual bits in particular locations. Refer to your 6200 software literature for details.

**Note:** Programmable controllers that use process configuration and operation software (cat. no. 6190-PCO) can take advantage of those development and runtime tools used for the application of programmable controllers in process control. The PCO worksheets and the menu-driven configuration screens and faceplates let you configure, test/debug and operate the I/O module. Refer to your 6190-PCO software literature for details.

During normal operation, the processor transfers from 1 to 37 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 for each channel.

**When a block transfer write length of 0 is programmed, the 1771-IL series B will respond with the Series A default length of 19.**

## Input Range Selection

Individual inputs are configurable to operate with any one of five voltage or three current ranges. You can select individual channel ranges using the designated words of the write block transfer instruction (Table 4.A). Two bits are allocated for each channel. For example, for channel 1, set bits 00 and 01 as follows:

**Table 4.A**  
**Bit Settings for Voltage or Current Inputs**

Bit 01	Bit 00	Voltage or current input
0	0	1 to 5 V DC, 4 to 20 mA <sup>1</sup>
0	1	0 to 5 V DC, 0 to 20 mA <sup>1</sup>
1	0	-5 to +5 V DC, -20 to +20 mA <sup>1</sup>
1	1	-10 to +10 V DC, 0 to 10 V DC <sup>2</sup>

<sup>1</sup> Current input mode selected by configuration plug.

<sup>2</sup> Configurable using bipolar scaling.

The 1771-IL/B has 16-bit resolution across the  $\pm 10$ V range. For compatibility purposes, the default scaling for all ranges is 12-bits (0-4095 or  $\pm 4095$ ). This allows the series B module to be directly interchangeable with the series A module. To use the full 16-bit capability, scaling values must be changed. Refer to "Scaling" later in this chapter.

Table 4.B shows the incremented voltage or current assigned to each bit for the seven different input ranges. For example, if the channel 1 input range is 0 to +5V and the actual incoming signal is at mid-range (+2.5V) the value in the module's data word, if using default scaling, would be 0000 1000 0000 0000 (binary) or 2048 (decimal). The input (default scaling) is 2048/4096, or 1/2 of full scale.

**Table 4.B**  
**Input Voltage and Current Ranges for the Analog Input Module**

Nominal Voltage or Current Range	Default Scaling BCD Output Range	Voltage or Current Per Bit	Data from A/D Converter	Voltage or Current Per Bit
+1 to +5V	0000 to +4095	0.98mV	3063 to 15316	0.33mV
0 to 5V	0000 to +4095	1.22 mV	32768 to 15316	0.33mV
-5 to +5V	-4095 to +4095	1.22mV	-15316 to 15316	0.33mV
-10 to +10V	-4095 to +4095	2.44mV	-30632 to 30632	0.33mV
0 to +20mA	0000 to +4095	0.0049mA	0 to 15316	0.0013mA
+4 to +20mA	0000 to +4095	0.0039mA	3063 to 15316	0.0013mA
-20 to +20mA	-4095 to +4095	0.0049mA	-15316 to 15316	0.0013mA

**Note:** Voltage and current input ranges are selectable on a per channel basis.

To get the same resolution available from the A/D converter, scale each channel as shown in Table 4.C.

**Table 4.C**  
**Scaling Endpoints**

Voltage/Current Range	Minimum Scaling Endpoint	Maximum Scaling Endpoint
+1 to 5V	3063	15316
4 to 20mA	3063	15316
0 to 5V	0	15316
0 to 20mA	0	15316
-5 to 5V	-15316	15316
-20 to 20mA	-15316	15316
-10 to 10V	-30632	30632
0 to 10V	-30632	30632

## Block Transfer Write Format

You select the format to enter values in the block transfer write table. Bit 08 (10 octal) of BTW word 2 sets the parameters for scaling, high and low alarms, and the digital filter constant.

Decimal Bit 08 Octal Bit 10	BTW Data Format	You must enter all values in:
0	BCD (default)	BCD
1	Two's Complement Binary	Two's Complement Binary

## Data Format

You must also indicate what format will be used to read data from your module. Typically, BCD is selected with PLC-2 processors, and 2's complement binary is selected with PLC-3 and PLC-5 processors. See Appendix C for details on data format.

**Table 4.D**  
**Selecting the Data Format**

Decimal Bit 10 (Octal Bit 12)	Decimal Bit 09 (Octal Bit 11)	Data Format
0	0	BCD
0	1	not used
1	0	two's complement binary
1	1	signed magnitude binary

## Digital Filtering

The analog input module has hardware-based high frequency filters on all channels to reduce the effect of electrical noise on the input signal. Software digital filtering is meant to reduce the effect of process noise on the input signal.

The digital filter equation is a classic first order lag equation (Figure 4.1). Using a step input change to illustrate the filter response (Figure 4.2), you can see that when the digital filter constant time elapses, 63.2% of the total response is reached. Each additional time constant achieves 63.2% of the remaining response.

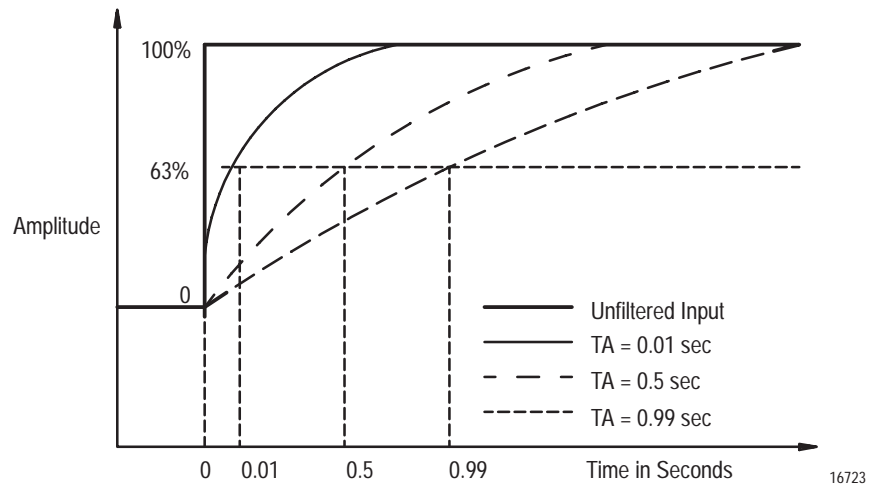
**Figure 4.1**  
**Digital Filter Equation**

$$Y_n = Y_{n-1} + \left[ \frac{\Delta t}{\Delta t + TA} \right] (X_n - Y_{n-1})$$

**Where:**

- $Y_n$  = present output, filtered peak voltage (PV)
- $Y_{n-1}$  = previous output, filtered PV
- $\Delta t$  = module channel update time (seconds)
- $TA$  = digital filter time constant (seconds)
- $X_n$  = present input, unfiltered PV

Figure 4.2  
Digital Filter Lag Equation Illustration



Digital filter time constant values of .00 BCD to .99 BCD (0.00 to 2.55 binary) (.00 = no filter) are set in bits 00 through 07 of word 3 of the block transfer write instruction. If an invalid digital filter value is entered (i.e., .1F BCD), the invalid filter value bit in the block transfer read status area will be set. If an invalid digital filter value is entered, the module will not perform digital filtering. If you choose to use the digital filtering feature, the filter time constant value chosen will apply to all input signals.

## Real Time Sampling

The real time sampling (RTS) mode of operation provides data gathered at precisely timed intervals for use by the processor.

Use RTS for time based functions (such as PID and totalization) in the PLC. RTS allows accurate time based calculations in local or remote I/O racks. In the RTS mode the module scans and updates its inputs at a user defined time interval (T) 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 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 next BTR.

Set appropriate bits in the BTW data file to enable the RTS mode. You can select RTS periods ranging from 50 ms to 3.1 seconds in increments of 100ms for the 1771-IL/B. Refer to Table 4.E below for actual bit settings. Note that the default mode of operation is implemented by placing all zeroes in bits 11 through 15 (13 through 17 octal).

**Table 4.E**  
**Examples of Bit Settings for the Real Time Sample Mode**

Decimal Bits	15	14	13	12	11	Sample Time Period
Octal Bits	17	16	15	14	13	
	0	0	0	0	0	No RTS, Default settings: 50ms
	0	0	0	0	1	100ms
	0	0	0	1	0	200ms
	0	0	0	1	1	300ms
	0	0	1	0	0	400ms
	0	0	1	0	1	500ms
	0	0	1	1	0	600ms
	0	0	1	1	1	700ms
	0	1	0	0	0	800ms
	0	1	0	0	1	900ms
	0	1	0	1	0	1.0s
	0	1	1	1	1	1.5s
	1	0	1	0	0	2.0s
	1	1	0	0	1	2.5s
	1	1	1	1	0	3.0s
	1	1	1	1	1	3.1s

## Scaling

Each channel has two scaling points, low and high. The signal value at these points is fixed. For example, the high scaling point of a  $\pm 10\text{V}$  output channel always corresponds to an input signal equal to  $+10.000\text{V}$ .

To implement the scaling feature, you insert the minimum and maximum scaled values in the appropriate configuration words.

The format of the scaling values is determined by the BTW format bit (bit 08, word 2). The range in BCD format is  $\pm 9999$ . The range in binary format is  $\pm 32767$ .

For example, assume that at  $0\text{mA}$ , the device connected to this input channel is producing  $0\text{ psi}$ , and at  $20\text{mA}$  it produces  $150\text{ psi}$ , and the 1771-IL/B range selected is  $4$  to  $20\text{mA}$ . Extrapolation indicates that at  $4\text{mA}$ , the device is producing  $30\text{ psi}$ . By setting the low scale value of the input to  $30$  and the high scale value to  $150$ , this input channel will report data in  $\text{psi}$ . For better resolution, you can multiply both of the scaling values by the same multiplier as long as both scale values are in the range of  $\pm 9999$  BCD or  $\pm 32767$  binary. By setting the low scale to  $3000$  and the high scale value to  $15000$ , you would report data in units of  $0.01\text{ psi}$  per count.

Maximum resolution can be obtained by setting the low scale value to  $-9999$  in BCD and the high scale value to  $+9999$  in BCD ( $-32767$  low and  $+32767$  high in binary).

**For example**, if in the  $1$  to  $5\text{V}$  mode, the scaling points are  $1$  and  $5\text{ volts}$ . If you set the scaling to  $\pm 32767$ , the maximum the module will display will be  $32767$ . If  $5.1\text{V}$  is applied, the display will be  $32767$  and the overrange bit for that channel will be set.

**Note:** To achieve the  $0$  to  $+10\text{V}$  range you must use bipolar scaling. Select the  $\pm 10\text{V}$  range and scale for  $\pm$  the actual intended range. If you need  $0$  to  $100\text{ gpm}$ , set scaling values at  $-100$  and  $+100$ . You will effectively be creating a  $0$  to  $10\text{V}$  range that is scaled from  $0$  to  $100$ .

## Implementing the Scaling Feature

You implement the scaling feature by:

1. Inserting minimum and maximum scaled values in the appropriate configuration words
2. If using BCD, and any of the minimum or maximum values are negative, set the appropriate sign bits in the minimum or maximum sign bit words.

## Scaling Ranges

The maximum range of the scaling values is  $\pm 9999$  BCD or  $\pm 32767$  binary. These values must be entered in the format selected in word 2, bit 08 (10).

If invalid values are entered into the scaling words, the corresponding input in the **BTR data will be zero** and the invalid scaling bit will be set.

Table 4.F  
Default Scaling Values

Input Range	Default Scaling Value
-10 to +10V	-4095 to +4095
-5 to +5V	
0 to 5V	0 to +4095
1 to 5V	

If scaling and alarms are not selected, the module still requires specific BTR and BTW file lengths for the number of channels used. Table 4.G shows the required BTR and BTW file lengths.

Table 4.G  
Block Transfer Read and Write File Lengths (with no scaling or alarms)

Channels Used	BTR File Length	BTW File Length
1	5	5
2	6	7
3	7	9
4	8	11
5	9	13
6	10	15
7	11	17
8	12	19

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



## Alarms

Each input channel has alarm functions that provide status indication through associated status bits in the block transfer read data returned by the module.

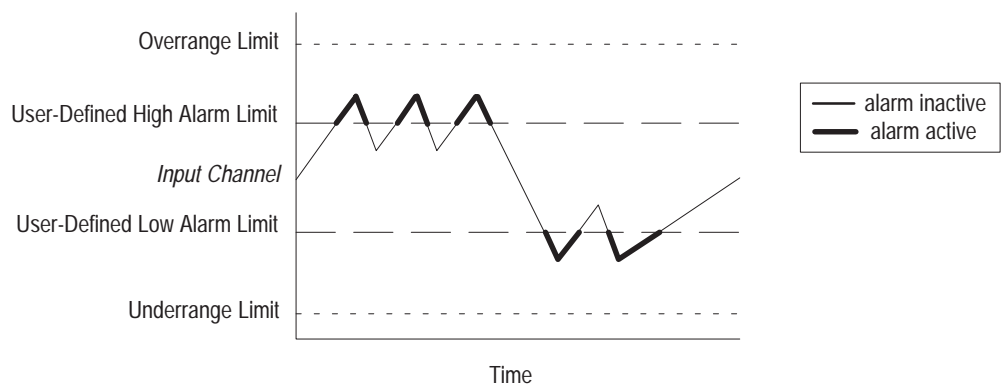
**Underrange alarm** - This bit is set if the input falls below the minimum range for that specific input type. This alarm is predefined and cannot be changed by the user. In current loop inputs, this bit also indicates an open loop.

**Overrange alarm** - This bit is set if the input rises above the maximum range for that specific input type. This alarm is predefined and cannot be changed by the user. For all voltage inputs, this bit indicates an open channel.

Range	Underrange Bit is set when the input signal is less than:	Overrange Bit is set when the input signal is greater than:
1 to 5V/4 to 20mA	1V dc or 4mA	5V dc or 20mA
0 to 5V/0 to 20mA	Zero	5V dc or 20mA
-5 to 5V/-20 to 20mA	-5V dc or -20mA	5V dc or 20mA
-10 to +10V	-10V dc	+10V dc

**User-defined alarms** let the user specify a range of “good” input values. If the input value goes outside of this range, the module will set the low or high alarm bit for that channel. The alarm values are written to the module in the same units as the scaling values. Valid alarm values are  $\pm 9999$  BCD or  $\pm 32767$  binary. If you select “no alarms” you must set both the low alarm value and the high alarm value to zero. If either the low or high alarm for a channel is not zero, alarms for that channel are enabled.

**Figure 4.3**  
**Alarm Example**



## Default Configuration

If a write block with all zeroes is written to the module, the default selections will be:

- 1 to 5V dc or 4 to 20mA (depends on voltage/current selection jumper)
- BCD data format
- no real time sampling (RTS)
- no digital filter
- no scaling
- no alarms

**Note:** Input data is set to 0 until an initial block transfer write is received by the module.

**Figure 4.4**  
**Word Assignments for the Isolated Analog Input Module**  
**(1771-IL series B)Block Transfer Write**

Decimal Bits	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Octal Bits	17	16	15	14	13	12	11	10	07	06	05	04	03	02	01	00
Word 1	Range Selection Bits for Channels 1 through 8															
	8		7		6		5		4		3		2		1	
2	Real Time Sampling					Data Format		BTW Format	Digital Filter							
3	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1
	Sign bits, maximum scaling values								Sign bits, minimum scaling values							
4	Channel 1 - minimum scaling															
5	Channel 1 - maximum scaling															
6	Channel 2 - minimum scaling															
7	Channel 2 - maximum scaling															
8	Channel 3 - minimum scaling															
9	Channel 3 - maximum scaling															
10	Channel 4 - minimum scaling															
11	Channel 4 - maximum scaling															
12	Channel 5 - minimum scaling															
13	Channel 5 - maximum scaling															
14	Channel 6 - minimum scaling															
15	Channel 6 - maximum scaling															
16	Channel 7 - minimum scaling															

Decimal Bits	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Octal Bits	17	16	15	14	13	12	11	10	07	06	05	04	03	02	01	00
17	Channel 7 - maximum scaling															
18	Channel 8 - minimum scaling															
19	Channel 8 - maximum scaling															
20	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1
	Sign bits, high alarm values								Sign bits, low alarm values							
21	Channel 1 - Low Alarm Value															
22	Channel 1 - High Alarm Value															
23	Channel 2 - Low Alarm Value															
24	Channel 2 - High Alarm Value															
25	Channel 3 - Low Alarm Value															
26	Channel 3 - High Alarm Value															
27	Channel 4 - Low Alarm Value															
28	Channel 4 - High Alarm Value															
39	Channel 5 - Low Alarm Value															
30	Channel 5 - High Alarm Value															
31	Channel 6 - Low Alarm Value															
32	Channel 6 - High Alarm Value															
33	Channel 7 - Low Alarm Value															
34	Channel 7 - High Alarm Value															
35	Channel 8 - Low Alarm Value															
36	Channel 8 - High Alarm Value															
37	8	7	6	5	4	3	2	1	Not Used				S	G	O	
	Inhibit bits for calibration												Calibration bits			

## Bit/Word Descriptions for the Isolated Analog Input Module Configuration Block

Note that decimal bits are shown. Octal bits are shown in parentheses.

Word	Decimal Bit (Octal Bit)	Description
Word 1	Bits 00-15 (00-17)	Input range selections, grouped 2 bits for each channel, allow selection of any of 7 input voltage or current ranges. See Table 4.A.
Word 2	Bits 00-07	Digital filter reduces effect of noise on the input. See "Digital Filtering."
	Bit 08 (10)	<b>BTW format bit.</b> This bit determines the format for scaling, digital filter constant, and high and low alarms. Bit 08 (10) = 0 - Values must be entered in BCD Bit 08 (10) = 1 - Values must be entered in Two's Complement Binary
	Bits 09-10 (11-12)	<b>Data format</b> is used to match format of processor. See Table 4.D.
	Bits 11-15 (13-17)	<b>Real time sampling</b> defaults to 50ms if zeroes are entered. See Table 4.E for other real time sample intervals.
Word 3	Bits 00-07	<b>Minimum sign bits</b> , when set, designate minimum scaling values that are negative in BCD. Default = 0 - positive.
	Bits 08-15 (10-17)	<b>Maximum sign bits</b> , when set, designate maximum scaling values that are negative in BCD. Default = 0 - positive.
Word 4	Bits 00-15 (00-17)	<b>Minimum scaling values</b> for channel 1. Enter in format selected in word 2, bit 08 (10). Valid entries are between +9999 and -9999 in BCD; -32767 and +32767 in binary. Default = 0 - no scaling.
Word 5	Bits 00-15 (00-17)	<b>Maximum scaling values</b> for channel 1. Enter in format selected in word 2, bit 08 (10). Valid entries are between +9999 and -9999; -32767 and +32767 in binary. Default = 0 - no scaling.
Words 6-19	Bits 00-15 (00-17)	Minimum and maximum scaling values for channels 2 through 8. Enter in format selected in word 2, bit 08 (10). Valid entries are between +9999 and -9999; -32767 and +32767 in binary. Default = 0 - no scaling.
Word 20	Bits 00-07	<b>Low alarm sign bits. These bits are only used when BCD format is chosen in word 2, bit 08 (10).</b> When a bit is set (1), the low alarm value for that channel is negative. Default is bit reset (0), positive.
	Bits 08-15 (10-17)	<b>High alarm sign bits. These bits are only used when BCD format is chosen in word 2, bit 08 (10).</b> When a bit is set (1), the high alarm value for that channel is negative. Default is bit reset (0), positive.
Word 21	Bits 00-15 (00-17)	<b>Low alarm value</b> for channel 1. This represents the value at which the low alarm bit for channel 1 (word 13 of the BTR) will be set.
Word 22	Bits 00-15 (00-17)	<b>High alarm value</b> for channel 1. This represents the value at which the high alarm bit for channel 1 (word 14 of the BTR) will be set.
Words 23 thru 36	Bits 00-15 (00-17)	Low and high alarm values for channels 2 thru 8.

Word	Decimal Bit (Octal Bit)	Description
Word 37	Bit 00	<b>Offset Calibration bit.</b> When this bit is set (1), offset calibration is to be performed. When set, no other calibration function bits can be set. Default is 0, no offset calibration.
	Bit 01	<b>Gain Calibration bit.</b> When this bit is set (1), gain calibration is to be performed. When set, no other calibration function bits can be set. Default is 0, no gain calibration.
	Bit 02	<b>Save calibration values.</b> When this bit is set (1), new calibration values will be saved in EEPROM. Default = 0, values not saved.
	Bits 03-07	Not used.
	Bits 08-15 (10-17)	<b>Inhibit Channel Calibration.</b> When this bit is set (1), that particular channel will not be calibrated. Default = 0, all channels to be calibrated.

## Chapter Summary

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

## Module Status and Input Data

### Chapter Objectives

In this chapter you will read about:

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

### Reading Data From Your Module

Block transfer read programming moves status and data from the input module to the processor's data table in one I/O scan (Figure 5.1). The processor's user program initiates the request to transfer data from the input module to the processor.

**Figure 5.1**  
Word Assignments for the Isolated Analog Input Module  
(1771-IL series B) Block Transfer Read

Decimal Bits	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00	
Octal Bits	17	16	15	14	13	12	11	10	07	06	05	04	03	02	01	00	
Word 1	Not used								A	HF	IA	IF	RTS	IS	OR	PU	Status word
2	Not used								8	7	6	5	4	3	2	1	Underrange bits - Channels 1-8
3	Not used								8	7	6	5	4	3	2	1	Overrange bits - Channels 1-8
4	Not used								8	7	6	5	4	3	2	1	Polarity bits - Channels 1-8
5	Channel 1 Input																Channel 1 Input
6	Channel 2 Input																Channel 2 Input
7	Channel 3 Input																Channel 3 Input
8	Channel 4 Input																Channel 4 Input
9	Channel 5 Input																Channel 5 Input
10	Channel 6 Input																Channel 6 Input
11	Channel 7 Input																Channel 7 Input
12	Channel 8 Input																Channel 8 Input
13	Not used								8	7	6	5	4	3	2	1	Low Alarm Bits
14	Not used								8	7	6	5	4	3	2	1	High Alarm Bits
15	8	7	6	5	4	3	2	1	CF	EF	Not used			S	G	O	Calibration Status Bits

The Isolated Analog Input Module (1771-IL series B) reports the status of all eight channels to the processor as outlined below.

**Table 5.A**  
**Bit/Word Descriptions for the Isolated Analog Input Modules (1771-IL)**  
**Read Block Transfer Data**

Word	Decimal Bit (Octal Bit)	Description
Word 1	Bit 00	<b>Power up bit (PU)</b> is set after initial power up. It will not reset until the module receives a valid write block transfer. <b>Note:</b> Input data is set to zero until the first BTW is received.
	Bit 01	<b>Out of range bit (OR)</b> is set if one or more channels are either over or under range.
	Bit 02	<b>Invalid scaling bit (IS)</b> is set if the firmware cannot use the scaling data in the BTW. Acceptable values are between -9999 and +9999 in BCD, and -32767 to +32767 in binary.
	Bit 03	<b>Real time sample (RTS)</b> time out bit is set if the module is using RTS and a block transfer read has not occurred within the programmed RTS period.
	Bit 04	<b>Invalid Filter bit (IF)</b> is set if the filter parameters are not correct. <b>The value must be between 00 and 99 (0.00 and 0.99 seconds) in BCD; or 0 and 255 (0 to 2.55) in binary.</b>
	Bit 05	<b>Invalid Alarm bit (IA)</b> is set if any alarm value is unusable, such as expecting BCD and value is in 2's complement binary.
	Bit 06	<b>Hardware Failure bit (HF)</b> is set if the analog module has an internal hardware failure (such as fuse blown or open, etc.).
	Bit 07	<b>Alarm violation status bit (A)</b> is set if one or more channels are in an alarm condition.
Word 2	Bits 08-15 (10-17)	Not used
	Bits 00-07	Individual <b>underrange bits</b> for each channel. Bit 00 for channel 1, bit 01 for channel 2, etc.
Word 3	Bits 08-15 (10-17)	Not used
	Bits 00-07	Individual <b>overrange bits</b> for each channel. Bit 00 for channel 1, bit 01 for channel 2, etc.
Word 4	Bits 08-15 (10-17)	Not used
	Bits 00-07	<b>Polarity (sign)</b> bits are set when the input is less than zero in both BCD and signed magnitude data formats. Bit 00 for channel 1, bit 01 for channel 2, etc.
Word 5 thru 12		<b>Input data values.</b> Word 5 for channel 1, word 6 for channel 2, etc.

Word	Decimal Bit (Octal Bit)	Description
Word 13	Bits 00-07 (00-07)	<b>Low Alarm bits</b> for channels 1 through 8 respectively. Each bit represents an alarm indicator for that channel. When the bit is set, the value of that channel is below the low alarm value.
	Bits 08-15 (10-17)	Not used
Word 14	Bits 00-07 (00-07)	<b>High Alarm bits</b> for channels 1 through 8 respectively. Each bit represents an alarm indicator for that channel. When the bit is set, the value of that channel is above the high alarm value.
	Bits 08-15 (10-17)	Not used
Word 15	Bit 00	<b>Offset Calibration Complete (O)</b> . When this bit is set, the offset calibration request was successfully completed.
	Bit 01	<b>Gain Calibration Complete (G)</b> . When this bit is set, the gain calibration request was successfully completed.
	Bit 02	<b>Save Complete (S)</b> . When this bit is set, the "save calibration values to EEPROM" was successfully completed.
	Bits 03-05	Not used
	Bit 06	<b>EEPROM Fault (EF)</b> . When this bit is set, the calibration values could not be saved to EEPROM.
	Bit 07	<b>Calibration Fault (CF)</b> . When this bit is set, the module could not perform offset or gain calibration. This bit is set when a save is requested.
	Bits 08-15 (10-17)	<b>Calibration Inhibited</b> . Each bit represents a channel that was not calibrated, either due to an error or a user request. If the channel was requested not to be calibrated, these bits confirm that request.

## Chapter Summary

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



## Module Calibration

### Chapter Objective

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

### Tools and Equipment

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

Tool or Equipment	Description	Model/Type	Available from:
Precision Voltage Source	0-10V, 1 $\mu$ V resolution; Accuracy of better than 2mV	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 analog 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 send data to the module (BTW), and the processor can read data from the module (BTR).

Calibration is accomplished using a method called “auto-calibration.”

### About Auto-calibration

Auto-calibration calibrates the input by generating offset and gain correction values and storing them in EEPROM in the module. 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 37 is performed to the module (any time after the module has been powered up), it interrogates word 37 for a request for auto-calibration.
- The request can be for the following: offset calibration, gain calibration, save operation (save to EEPROM). Note that only one bit may be set at one time. To completely calibrate the module, three BTWs must be sent: one for each offset, gain and save operations.

## Performing Auto-calibration

Calibration of the module consists of applying 0.00000V across each input channel for offset calibration, and +10.00000V across each input channel for gain correction.



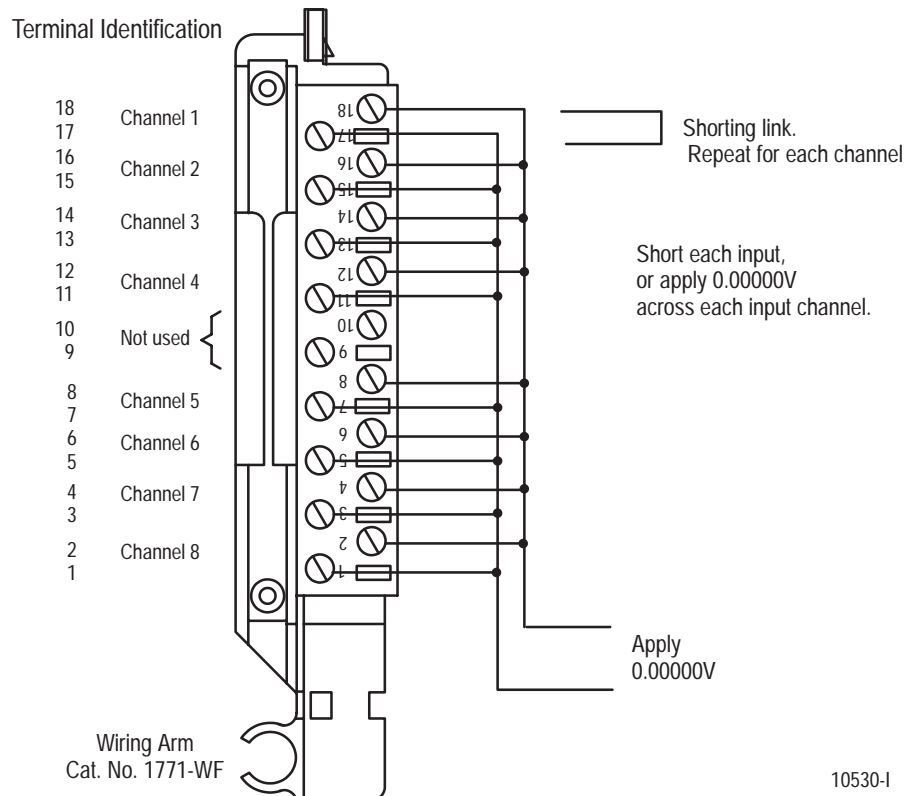
**ATTENTION:** Verify that each channel's configuration jumper is set to the voltage mode (refer to "Setting the Voltage/Current Selection Jumpers" in chapter 2.) Failure to do so can damage the module.

### Offset Calibration

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

1. Verify that each channel has its jumper set for **voltage mode**. (Refer to "Setting the Voltage/Current Selection Jumper" in chapter 2. Check the position of the jumper on each channel.
2. Apply power to the module.
3. Connect shorting links, or apply 0.00000V across each input channel on the 1771-WF field wiring arm as shown in Figure 6.1.

**Figure 6.1**  
**Shorting Inputs for Offset Calibration**



10530-I

4. After the connections stabilize, request the offset calibration by setting bit 00 in block transfer write word 37 and sending a block transfer write (BTW) to the module. Refer to Table 6.A.

When the BTW is sent, all channels are calibrated to 0.00000V.

Table 6.A  
Write Block Transfer Word 28

Decimal 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
Word 37	Inhibit Calibration								Requested Auto-Calibration							
	8	7	6	5	4	3	2	1	Set these bits to 0				Requested Save Values	Requested Gain Cal.	Requested Offset Cal.	

**NOTE:** Normally, all channels are calibrated simultaneously (decimal bits 08-15; octal bits 10-17 of word 37 are 0). To disable calibration on any channel, set the corresponding bit 08 through 15 decimal, or 10 through 17 octal, of word 37.

5. Queue block transfer reads (BTRs) to monitor for offset calibration complete and any channels which may have not calibrated successfully. Refer to Table 6.B.

Table 6.B  
Read Block Transfer Word 13

Decimal 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
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	

6. Reset bit 00 (0) (requested offset calibration).
7. Proceed to Gain Calibration below.

## Gain Calibration

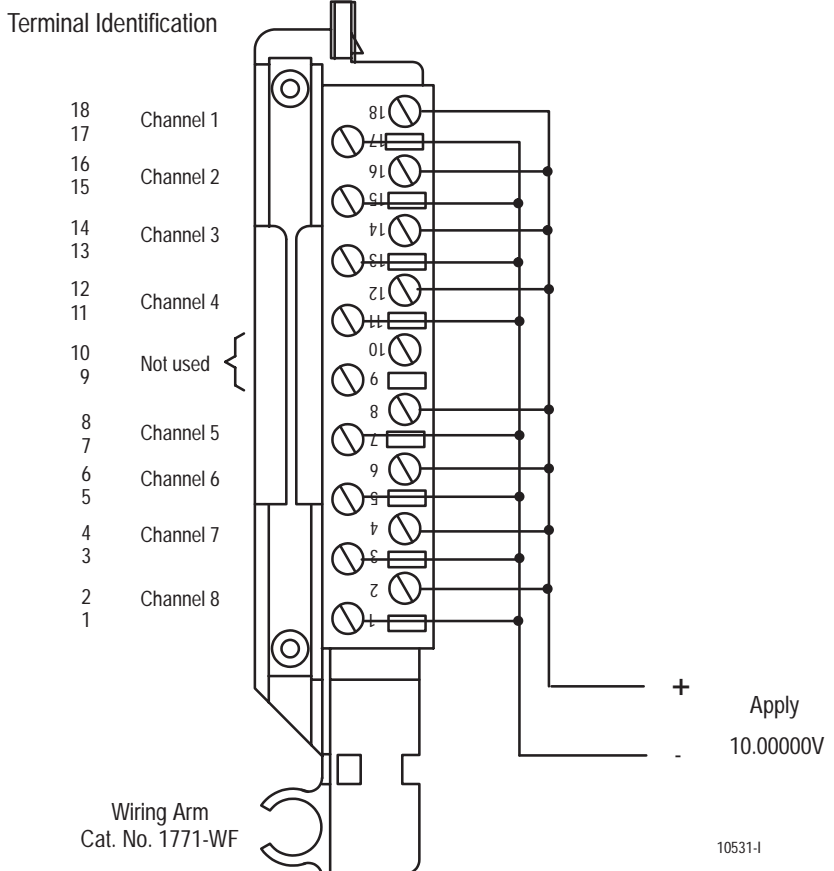
Calibrating gain requires that you apply +10.00000V across each input channel.

To calibrate the gain of an input, proceed as follows:

**NOTE:** Normally, all channels are calibrated simultaneously (decimal bits 08015, octal bits 10-17 of word 37 are 0). To disable calibration on any channel, set (1) the corresponding bit 08-15 decimal (10-17 octal) of word 37.

1. Apply +10.00000V across each input channel as shown in Figure 6.2.

**Figure 6.2**  
**Applying 10.00000V for Gain Calibration**



2. After the connections stabilize, request the gain calibration by setting bit 01 in BTW word 37 and sending a block transfer write (BTW) to the module. Refer to Table 6.A.

When the BTW is sent, all channels are calibrated to +10.00000V.

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

## Save Calibration Values

If any "uncalibrated channel" bits 08-15 (10-17 octal) of word 15 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 37 and sending the BTW to the module. Refer to Table 6.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.

## Chapter Summary

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

## Troubleshooting

### Chapter Objective

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

### Diagnostics Reported by the Module

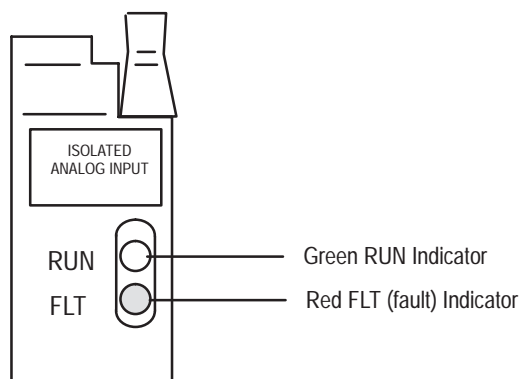
At powerup, the module momentarily turns on both indicators as a lamp test, then checks for

- 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 programmable controller processor. Monitor the green and red indicators and status bits in word 1 of the BTR file when troubleshooting your module.

**Figure 7.1**  
**Module Indicators**











10528-I

## Troubleshooting with the Indicators

Table 7.A shows indications, probable causes and recommended actions to correct common faults.

**Table 7.A**  
**Troubleshooting Chart for the Isolated Analog Input Module (1771-IL series B)**

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

<sup>1</sup> 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 7.B.

Table 7.B  
Status Reported in Word 1

Word	Decimal Bit (Octal Bit)	Description
Word 1	Bit 00	<b>Power up bit (PU)</b> is set after initial power up. It will not reset until the module receives a valid write block transfer. <b>Note:</b> Input data is set to zero until the first BTW is received.
	Bit 01	<b>Out of range bit (OR)</b> is set if one or more channels are either over or under range.
	Bit 02	<b>Invalid scaling bit (IS)</b> is set if the firmware cannot use the scaling data in the BTW. Acceptable values are between -9999 and +9999 in BCD, and -32767 to +32767 in binary.
	Bit 03	<b>Real time sample (RTS)</b> time out bit is set if the module is using RTS and a block transfer read has not occurred within the programmed RTS period.
	Bit 04	<b>Invalid Filter bit (IF)</b> is set if the filter parameters are not correct. <b>The value must be between 00 and 99 (0.00 and 0.99 seconds) in BCD; or 0 and 255 (0 to 2.55) in binary.</b>
	Bit 05	<b>Invalid Alarm bit (IA)</b> is set if any alarm value is unusable, such as expecting BCD and value is in 2's complement binary.
	Bit 06	<b>Hardware Failure bit (HF)</b> is set if the analog module has an internal hardware failure (such as blown fuse, etc.).
	Bit 07	<b>Alarm bit (A)</b> is set if there is an alarm indication on any channel.

### 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 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 7.C.

Table 7.C  
Status Reported in Words 2 and 3

Word	Decimal Bit (Octal Bit)	Description
Word 2	Bits 00-07	Individual <b>underrange bits</b> for each channel. Bit 00 for channel 1, bit 01 for channel 2, etc.. 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.
Word 3	Bits 00-07	Inputs <b>overrange</b> . Bit 00 is channel 1, bit 07 is channel 8. If input connections and voltages are correct, this status may indicate a hardware failure.



## Status Reported in Words 13 and 14

Design your program to monitor over/under alarm 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 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 alarm condition. Refer to Table 7.D.

**Table 7.D**  
**Status Reported in Words 13 and 14**

Word	Decimal Bit (Octal Bit)	Description
Word 13	Bits 00-07 (00-07)	<b>Low Alarm bits</b> for channels 1 through 8 respectively. Each bit represents an alarm indicator for that channel. When the bit is set, the value of that channel is below the low alarm value.
Word 14	Bits 00-07 (00-07)	<b>High Alarm bits</b> for channels 1 through 8 respectively. Each bit represents an alarm indicator for that channel. When the bit is set, the value of that channel is above the high alarm value.

## Status Reported in Word 15

Design your program to monitor status bits in word 15 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 7.E.

Table 7.E  
Status Reported in Word 15

Word	Decimal Bit (Octal Bit)	Description
Word 15	Bit 00	<b>Offset Calibration Complete (O).</b> When this bit is set, the offset calibration request was successfully completed.
	Bit 01	<b>Gain Calibration Complete (G).</b> When this bit is set, the gain calibration request was successfully completed.
	Bit 02	<b>Save Complete (S).</b> When this bit is set, the "save calibration values to EEPROM" was successfully completed.
	Bits 03-05	Not used
	Bit 06	<b>EEPROM Fault (EF).</b> When this bit is set, the calibration values could not be saved to EEPROM.
	Bit 07	<b>Calibration Fault (CF).</b> When this bit is set, the module could not perform offset or gain calibration. This bit is set when a save is requested.
	Bits 08-15 (10-17)	<b>Calibration Inhibited.</b> Each bit represents a channel that was not calibrated (bit 08 (10) - channel 1, bit 09 (11) - channel 2 and so on). This bit is set either due to an error or a user request. If the channel was requested not to be calibrated, these bits confirm that request.

## Chapter Summary

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

## Specifications

Inputs per module	8 fully isolated differential
Module Location	1771 I/O rack - 1 slot
Input voltage ranges (nominal)	+1 to +5V DC 0 to 5V DC -5 to +5V DC -10 to +10V DC
Input current ranges (nominal)	+4 to +20mA 0 to +20mA -20 to +20mA
Resolution	16-bit binary over full range
Accuracy	Voltage: Typical - 0.01% of full scale range @ 25°C Maximum - 0.05% of full scale range @ 25°C Current: Typical - 0.06% of full scale range @ 25°C Maximum - 0.1% of full scale range @ 25°C (Includes 0.05% when using internal current resistor)
Linearity	±1 LSB
Repeatability	±1 LSB
Isolation Voltage	±1000V peak, channel to channel, channel to ground for 1s
Input overvoltage protection	voltage mode: 140V ac (rms) continuous; current mode: 8V dc continuous
Unscaled BCD and binary output data to the processor	0000 to +4095 <sub>10</sub> for unipolar ranges (0 to 5V, +1 to +5V, 0 to +20mA, and +4 to +20mA) -4095 <sub>10</sub> to 4095 <sub>10</sub> for bipolar ranges ±5V, ±10V, ±20mA input ranges
Input impedance	>10 megohms for voltage ranges; 250 ohms for current ranges
Common mode rejection	>120 db @ 60Hz and 1K ohm source imbalance
Common mode impedance	>50 megohms shunted by <5 nF
Normal mode rejection	>120 db @ 60Hz
Current Requirements	1.0A @ +5V from I/O chassis backplane
Open Circuit Detection	Voltage mode: Open input produces upscale reading. Current mode: Open input produces zero reading.
Time to Detect Open Circuit	10 seconds maximum
Calibration	Auto-calibration (offset and gain) Zero offset and gain adjustment for each channel via programming terminal Verify every six months for maintaining absolute accuracy
Power Dissipation	6.5 Watts maximum
Thermal Dissipation	22.2 BTU/hr maximum
Engineering units sent to processor	±9999 BCD with selectable scaling ±32767 binary

Continued on next page

Specifications continued	
Calibration Interval	calibration should be checked at 6 month intervals to maintain specified accuracy
Internal scan rate	50 milliseconds for 8 channels
Environmental conditions operational temperature: storage temperature: relative humidity	0 to 60°C (32 to 140°F) -40 to 85°C (-40 to 185°F) Operating: 5 to 95% (without condensation) Non-operating: 5 to 80% (without condensation)
Conductors    Wiring Category	14 gauge stranded (max.) 3/64 inch insulation (max.) Category 2 <sup>1</sup>
Keying	between 10 and 12 between 32 and 34
Wiring Arm	Cat. No. 1771-WF
<sup>1</sup> Refer to publication 1770-4.1, "Programmable Controller Wiring and Grounding Guidelines."	

## Configuration Example

### Sample Configuration of the Analog Input Module

The following is a sample configuration for the 1771-IL series B isolated analog input module. Entering the data shown in Figure B.1 in the configuration words of the write block transfer data file will result in the following module setup.

Overall Module Functions Chosen	
Digital Filter Time Constant	0.5 seconds
Data Format	2's Complement Binary
Real Time Sampling Rate	1.5 seconds

Individual Channel Functions Chosen		
	Input Range	Scale Value Low/High (counts)
Channel 1	1-5V	1000/5000
Channel 2	1-5V	-5000/-1000
Channel 3	0-5V	0000/5000
Channel 4	0-5V	-5000/0000
Channel 5	±5V	-2500/2500
Channel 6	±5V	-5000/5000
Channel 7	±10V	-100/100
Channel 8	±10V	-9999/9999

The above configuration for the 1771-IL/B isolated analog input module would be set up using the following PLC-5 data table file (Figure B.1).

**Figure B.1**  
**Sample PLC-5 Data File (Hexadecimal Data) for an Isolated Analog Input**  
**Module (cat. no. 1771-IL series B)**

Address	0	1	2	3	4	5	6	7	8	9
N10:00	0000	0000	0000	000A	09C2	F246	09B9	F632	04E0	09BE
N10:10	0019	09BD	0000	0000	0000	0000	0000	0000	0000	0000
N10:20	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
N10:30	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
N10:40	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
N10:50	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
N10:60	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
N10:70	FA50	7C50	02FA	1000	5000	5000	1000	0000	5000	5000
N10:80	0000	2500	2500	5000	5000	0100	0100	9999	9999	0000
N10:90	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
N10:100	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
N10:110	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
N10:120	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
N10:130	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
N10:140	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000

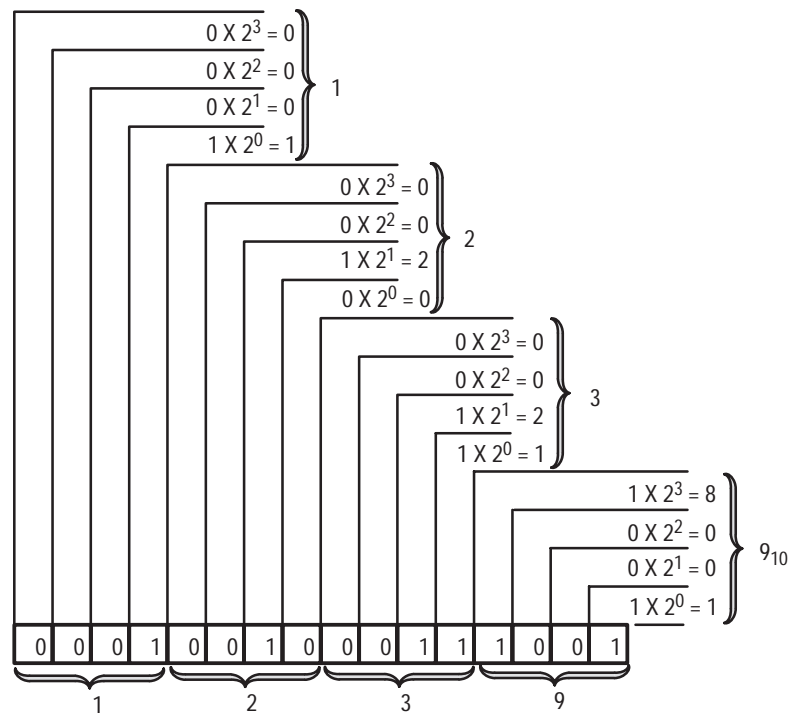
The block transfer read starts at N10:00.  
The block transfer write starts at N10:70.

## Data Table Formats

### 4-Digit Binary Coded Decimal (BCD)

The 4-digit BCD format uses an arrangement of 16 binary digits to represent a 4-digit decimal number from 0000 to 9999 (figure C.1). The BCD format is used when the input values are to be displayed for operator viewing. Each group of four binary digits is used to represent a number from 0 to 9. The place values for each group of digits are  $2^0$ ,  $2^1$ ,  $2^2$  and  $2^3$  (Table C.A). The decimal equivalent for a group of four binary digits is determined by multiplying the binary digit by its corresponding place value and adding these numbers.

Figure C.1  
4-Digit Binary Coded Decimal



12955-1

Table C.A  
BCD Representation

2 <sup>3</sup> (8)	Place Value			Decimal Equivalent
	2 <sup>2</sup> (4)	2 <sup>1</sup> (2)	2 <sup>0</sup> (1)	
0	0	0	0	0
0	0	0	1	1
0	0	1	0	2
0	0	1	1	3
0	1	0	0	4
0	1	0	1	5
0	1	1	0	6
0	1	1	1	7
1	0	0	0	8
1	0	0	1	9

## Signed-magnitude Binary

Signed-magnitude binary is a means of communicating numbers to your processor. It should be used with the PLC-2 family when performing computations in the processor. It cannot be used to manipulate binary 12-bit values or negative values.

**Example:** The following binary number is equal to decimal 22.

$$10110_2 = 22_{10}$$

The signed-magnitude method places an extra bit (sign bit) in the left-most position and lets this bit determine whether the number is positive or negative. The number is positive if the sign bit is 0 and negative if the sign bit is 1. Using the signed magnitude method:

$$0\ 10110 = +22$$

$$1\ 10110 = -22$$

## Two's Complement Binary

Two's complement binary is used with PLC-3 processors when performing mathematical calculations internal to the processor. To complement a number means to change it to a negative number. For example, the following binary number is equal to decimal 22.

$$10110_2 = 22_{10}$$



First, the two's complement method places an extra bit (sign bit) in the left-most position, and lets this bit determine whether the number is positive or negative. The number is positive if the sign bit is 0 and negative if the sign bit is 1. Using the complement method:

$$0\ 10110 = 22$$

To get the negative using the two's complement method, you must invert each bit from right to left after the first "1" is detected.

In the above example:

$$0\ 10110 = +22$$

Its two's complement would be:

$$1\ 01010 = -22$$

Note that in the above representation for +22, starting from the right, the first digit is a 0 so it is not inverted; the second digit is a 1 so it is not inverted. All digits after this one are inverted.

If a negative number is given in two's complement, its complement (a positive number) is found in the same way:

$$1\ 10010 = -14$$

$$0\ 01110 = +14$$

All bits from right to left are inverted after the first "1" is detected.

The two's complement of 0 is not found, since no first "1" is ever encountered in the number. The two's complement of 0 then is still 0.

## Block Transfer (Mini-PLC-2 and PLC-2/20 Processors)

### Multiple GET Instructions - Mini-PLC-2 and PLC-2/20 Processors

Programming multiple GET instructions is similar to block format instructions programmed for other PLC-2 family processors. The data table maps are identical, and the way information is addressed and stored in processor memory is the same. The only difference is in how you set up block transfer read instructions in your program.

For multiple GET instructions, individual rungs of ladder logic are used instead of a single rung with a block transfer instruction. A sample rung using multiple GET instructions is shown in Figure D.1 and described in the following paragraphs.

**Rung 1:** This rung is used to set four conditions.

- **Examine On Instruction (113/02)** - This is an optional instruction. When used, block transfers will only be initiated when a certain action takes place. If you do not use this instruction, block transfers will be initiated every I/O scan.
- **First GET Instruction (030/120)** - identifies the module's physical address (120) by rack, group and slot; and where in the accumulated area of the data table this data is to be stored (030).
- **Second GET Instruction (130/060)** - indicates the address of the first word of the file (060) that designates where the data will be transferred. The file address is stored in word 130, 100<sub>8</sub> above the data address.
- **Output Energize Instruction (012/07)** - enables the block transfer read operation. If all conditions of the rung are true, the block transfer read enable bit (07) is set in the output image data table control byte. The output image table control byte contains the read enable bit and the number of words to be transferred. The output energize instruction is defined as follows:
  - "0" indicates that it is an output instruction
  - "1" indicates the I/O rack address
  - "2" indicates the module group location within the rack
  - "07" indicates this is a block transfer read operation (if this were a block transfer write operation, "07" would be replaced by "06".)

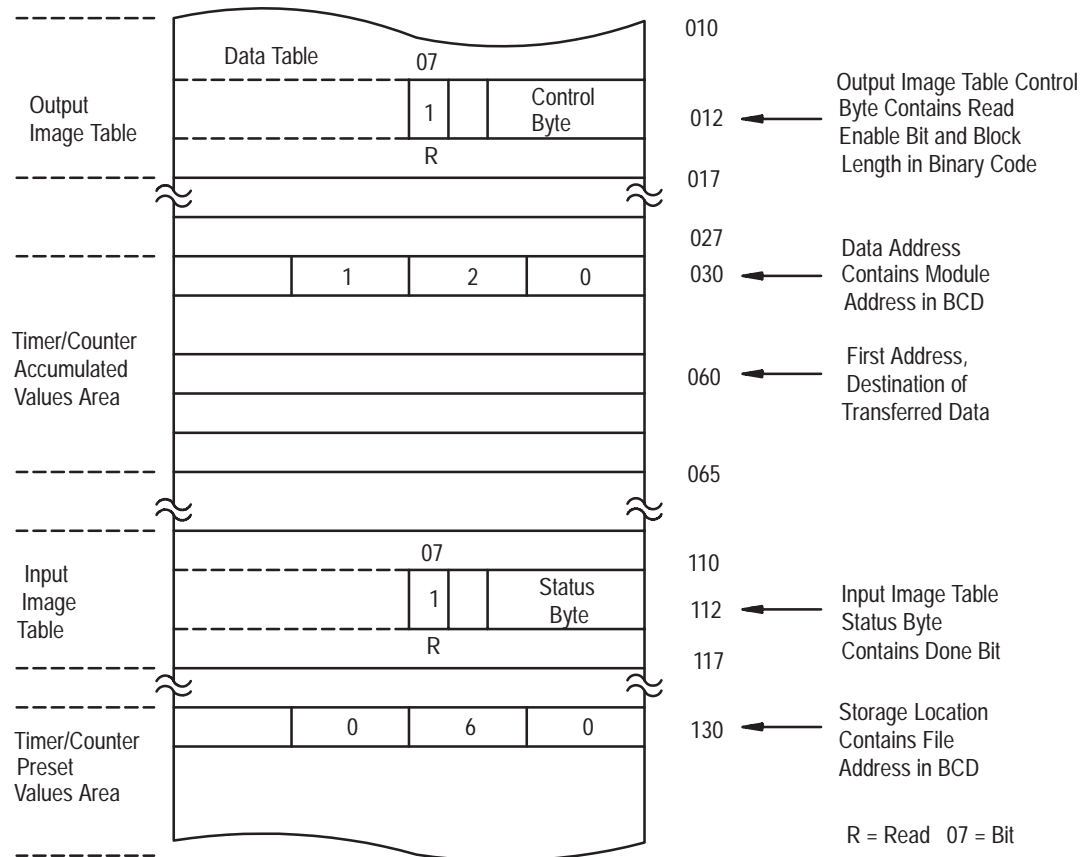
## Appendix D

### Block Transfer (Mini-PLC-2 and PLC-2/20 Processors)

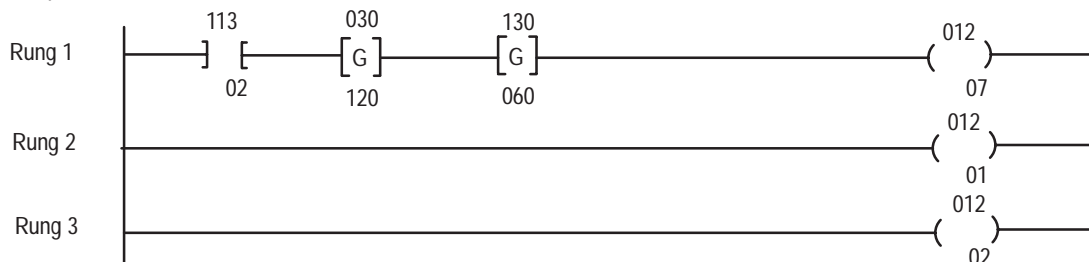
**Rungs 2 and 3:** These output energize instructions (012/01 and 012/02) define the number of words to be transferred. This is accomplished by setting a binary bit pattern in the module's output image table control byte. The binary bit pattern used (bits 01 and 02 energized) is equivalent to 6 words or channels, and is expressed as 110 in binary notation.

**Rung Summary:** Once the block transfer read operation is complete, the processor automatically sets bit 07 in the input image table status byte and stores the block length of the data transferred.

**Figure D.1**  
Multiple GET Instructions (Mini-PLC-2 and PLC-2/20 Processors Only)



#### Multiple GET Instructions



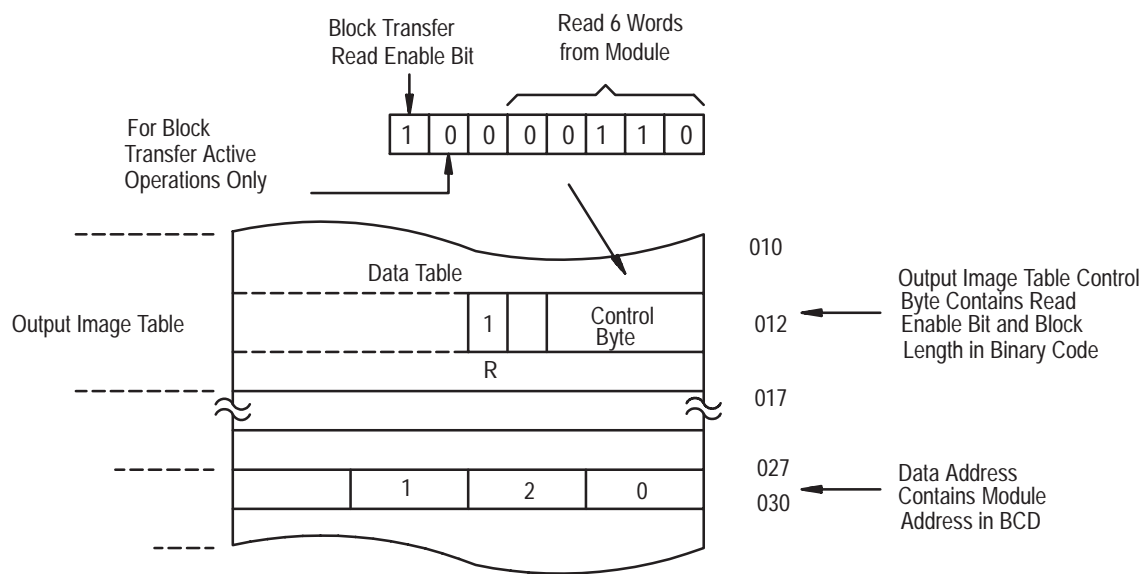
### Setting the Block Length (Multiple GET Instructions only)

The input module transfers a specific number of words in one block length. The number of words transferred is determined by the block length entered in the output image table control byte corresponding to the module’s address.

The bits in the output image table control byte (bits 00-05) must be programmed to specify a binary value equal to the number of words to be transferred.

For example, Figure D.2 shows if your input module is set up to transfer 6 words, you would set bits 01 and 02 of the lower image table control byte. The binary equivalent of 6 words is 000110. You would also set bit 07 when programming the module for block transfer read operations. Bit 06 is used when block transfer write operations are required.

**Figure D.2**  
**Setting Block Length (Multiple GET Instructions only)**



Number of Words to Transfer	Binary Bit Pattern Lower Output Image Table Byte					
	05	04	03	02	01	00
Default	0	0	0	0	0	0
1	0	0	0	0	0	1
2	0	0	0	0	1	0
3	0	0	0	0	1	1
4	0	0	0	1	0	0
5	0	0	0	1	0	1
6	0	0	0	1	1	0
:						
18	0	1	0	0	1	0
19	0	1	0	0	1	1

**A**

alarms, 4-9  
     overrange, 4-9  
     underrange, 4-9

**B**

BCD format, 1-3  
 bit settings, voltage or current input, 4-2  
 block transfer, 1-1, 2-2, 3-1  
     write, 4-5  
 block transfer read, 3-1, 3-2, 5-1  
     word assignments, 5-1  
 block transfer write, 3-2  
 BTR format, bit/word descriptions, 5-2

**C**

Calibration, tools, 6-1  
 communication, 1-2  
 configuration, default, 4-10  
 configuration block, 4-10  
     bit/word descriptions, 4-12  
 configuration BTW, 3-1  
 configuring your module, 4-1  
 connecting wiring, 2-5

**D**

data formats  
     2's complement binary, C-2  
     4-digit binary coded decimal, C-1  
     signed-magnitude binary, C-2  
 default configuration, 4-10  
 description of module, 1-1  
 Diagnostics  
     indicators, 7-1  
     reported by module, 7-1

**E**

electrostatic discharge, 2-1

**F**

features, 1-1  
 field wiring arm, 2-5  
 filtering, 4-4

**G**

grounding, 2-7

**I**

indicator lights, 2-8  
 input range, selection, 4-2  
 installation, of module, 2-4

**K**

keying bands, 2-4

**M**

module features, 1-1  
 module installation, 2-4  
 module location in the I/O chassis, 2-2

**N**

noise interference, 2-2

**P**

power requirements, 2-2  
 pre-installation considerations, 2-1  
 programming, with multiple GETs, D-1  
 programming example  
     PLC-2, 3-2  
     PLC-3, 3-3  
     PLC-5, 3-4

**R**

ranges, input voltage and current, 4-3  
 real time sampling, 4-5  
 RTS bit settings, 4-6

## S

- scaling
  - implementation, 4-7
  - ranges, 4-8
- scan time, 3-5
- specifications, A-1

## T

- Troubleshooting, table, 7-2

## U

- update time, 1-1

## W

- wiring connections, 2-6

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