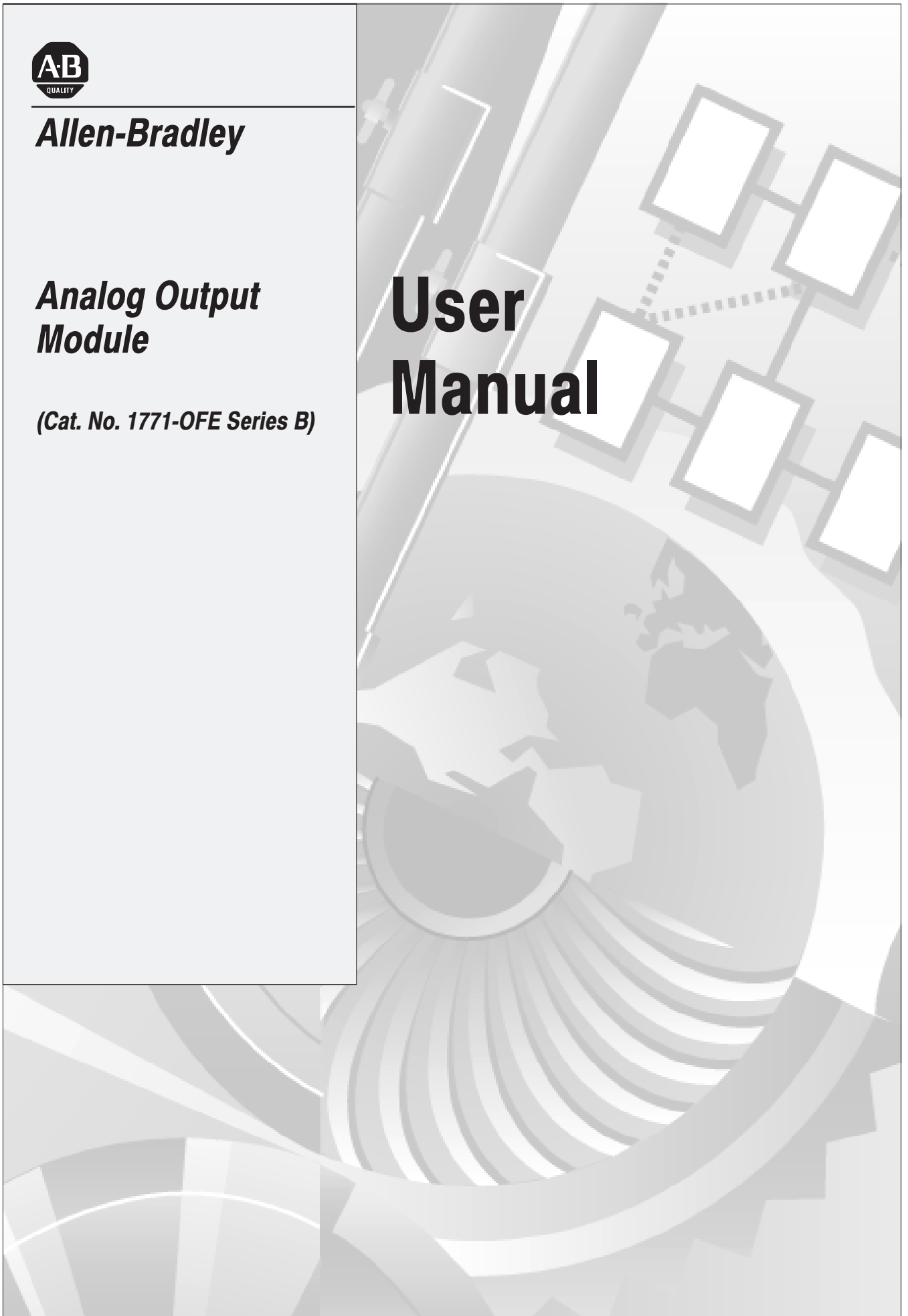**A·B** QUALITY

Allen-Bradley

Analog Output Module

(Cat. No. 1771-OFE 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.

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.

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 the publication contains updated information from the last release.

Updated Information

This publication covers the Series B version of the Analog Output module.In addition, this version of the manual contains information formally included in publication 1771-6.5.30–RN1, dated December 1995.

A revised circuit board layout has the configuration jumpers relocated from previous versions. Access holes are included in the side cover so that covers no longer have to be removed to adjust the jumpers or potentiometers.

The module also contains information on "Compliance to European Union Directives."

Change Bars

To help you find new and updated information in this release of the publication, we have included change bars as shown to the right of this paragraph.

Preface

Manual's Purpose

This manual shows you how to use the analog output module with an Allen-Bradley programmable controller. It describes methods for installing, programming, calibrating, and troubleshooting your module.

Audience

To make efficient use of your module, you must be able to program and operate an Allen-Bradley programmable controller. In particular, you must be able to program block transfer instructions.

In this manual we assume that you know how to do this. If you do not, refer to the appropriate programming and operations manual for the processor that you are using.

Vocabulary

In this manual we refer to the:

- Analog Output Module (cat. no. 1771-OFE) as the "output module"
- Programmable Controller as the "processor" or "controller."

Manual Organization

The 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 Analog Output Module	Description of the module, including general and hardware features. How modules communicate with programmable controllers
2	Module Installation	Power requirements, keying, module location and hardware configuration
3	Module Configuration	Software configurations, output range selection, data format and data scaling
4	Module Programming	Writing data to the module, and other programming considerations (default block length, block transfer boundary word, and watchdog timer)
5	Module Status and Input Data	Reading data from the module
6	Calibrating Your Output Module	Calibration procedures
7	Diagnostics and Troubleshooting	Troubleshooting Guide for problem diagnosis

Appendices	Title
A	Specifications
B	Block Transfer with Mini-PLC-2 and PLC-2/20 Processors
C	Data Table Formats

Related Products

You can install your output module in any system that uses Allen-Bradley programmable controllers that have block transfer capabilities and the 1771 I/O structure.

For more information on your programmable controllers, contact your nearest Allen-Bradley office.

Product Compatibility

The 1771-OFE module can be used with any 1771 I/O chassis. Communication between the discrete 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 transfer data and write block transfer data. I/O image table use is an important factor in module placement and addressing selection. Compatibility and data table use is listed in the following table.

Table P.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			Chassis Series	
					1/2-Slot	1-Slot	2-Slot		
1771-OFE	8	8	5	13	Y	Y	Y	A, B	

A = Compatible with 1771-A1, -A2, -A4
B = Compatible with 1771-A1B, -A2B, -A3B, -A3B1, -A4B
Y = Compatible without restriction.

- You can place your module in any I/O module slot of the I/O chassis.
- You can put two output modules in the same module group.
- Do not put the module in the same module group as a discrete high density module.
- 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).

Table of Contents

Overview of the Analog Output Module

What This Chapter Contains

Read this chapter to familiarize yourself with the analog output module.

About the Analog Output Module

The Analog Output Module (cat. no. 1771-OFE) is an intelligent block transfer module that converts binary or four-digit BCD values (supplied by your processor) to analog signals at its four module outputs. The module accomplishes the data transfer with block transfer programming.

Block transfer write (BTW) programming moves up to 13 words of data from the processor to the module for digital to analog (D/A) conversion in one program scan. This information is converted to analog signals and is sent to the appropriate output channels.

A block transfer read (BTR) moves five words of data from the module to the processor data table, if desired, for diagnostic purposes. The BTR is discussed in Chapter 7, "Diagnostics and Troubleshooting."

The module has a scaling feature that converts data sent to the module in engineering units to the proper analog signals.

You may connect up to four analog output devices--such as valve positioners, motor speed controllers, signal converters or recorders--to the analog output module's four channels. All analog output device inputs should conform to the voltage or current ratings of each module output channel.

Module Features

In the programmable controller system, the analog output module provides the following functions:

- four individually isolated differential outputs
- selectable scaling to engineering units
- selectable data format
- selectable voltage ranges (1771-OFE1 only)
- no external power required--power is drawn from the 1771 I/O chassis backplane.
- requires only one I/O slot

Output Ranges

There are three versions of the analog output module:

Catalog Number	Module Output	Output Range	
1771-OFE1	Voltage	1-5V dc 0-10V dc $\pm$10V dc	Selected by configuration jumpers
1771-OFE2	Current	4-20mA	Factory set
1771-OFE3	Current	0-50mA	Factory set

The voltage version (1771-OFE1) voltage output range is selected with configuration jumpers in the module:

Note: The 1771-OFE1 is shipped with the selection jumpers in the $\pm$10V position.

The current output versions (1771-OFE2 and -OFE3) are factory set.

How Analog Modules Communicate with Programmable Controllers

The processor transfers data to the module (block transfer write) and from the module (block transfer read) using BTW and BTR instructions in your ladder diagram program. These instructions let the processor send output values to the module, establish the module's mode of operation (see illustration below) and receive status information from the module.

Communication Between Processor and Module

Programmable Controller

Analog Output Module
Cat. No. 1771-OFE
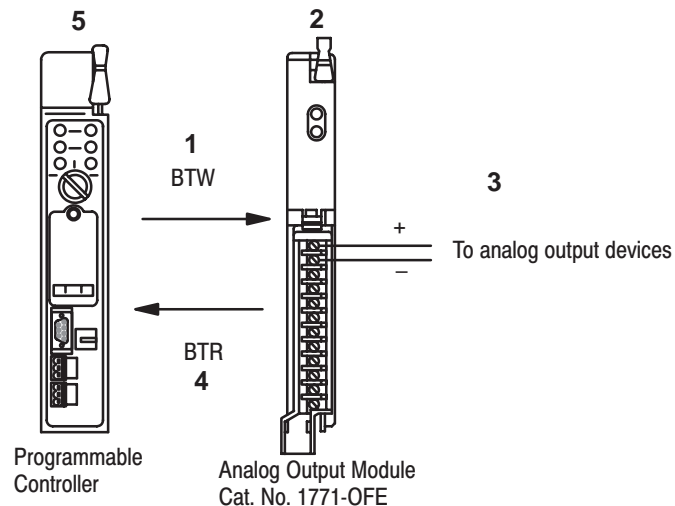
12876

1. The processor transfers your configuration and output data to the module via a block transfer write instruction.

2. The module converts the data into proportional voltage or current outputs.

3. These module outputs drive external analog devices.

4. When instructed by your ladder program, the processor performs a read block transfer of output values and module status.

5. The processor and module determine that the transfer was made without error.

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.

Accuracy

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

Chapter Summary

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

Module Installation

What This Chapter Contains

In this chapter, you will read about:

Read this installation chapter completely before you install your module. Double check all connections and option selections before you begin programming your module.

> ⚠️ **ATTENTION:** To avoid injury to personnel and damage to equipment, disconnect and lockout all ac power supplies before installing and wiring the output module.

Compliance to European Union Directives

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

EMC Directive

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

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

This product is intended for use in an industrial environment.

Low Voltage Directive

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

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

- Industrial Automation Wiring and Grounding Guidelines For Noise Immunity, publication 1770-4.1
- Guidelines for Handling Lithium Batteries, publication AG-5.4
- Automation Systems Catalog, publication B111

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

Calculating Power Requirements

The analog output module receives its power through the 1771 I/O chassis backplane from the chassis power supply. It does not require any other external power supply. When planning your system, you must consider the power usage of all modules in the I/O chassis to prevent overloading the I/O chassis backplane and/or power supply. Add this to the requirements of all other modules in the I/O chassis.

Analog Module	Power Requirement
1771-OFE1	1.5A @ 5V dc
1771-OFE2	
1771-OFE3	2.5A @ 5V dc

ATTENTION: Do not insert or remove modules from the I/O chassis while system power is ON. Failure to observe this rule could result in damage to module circuitry.

Determine Module Location in the I/O Chassis

You can place your module in any I/O module slot of the I/O chassis with the following guidelines:

- Do not put the module in the same module group as a discrete high-density module.
- Avoid placing output modules close to ac modules or high-voltage dc modules.
- Group output modules together within an I/O chassis whenever possible to minimize noise interference from other modules.
- You can put two output modules in the same module group.

Setting Module Configuration Jumpers

The module configuration jumpers consist of:

- the last state configuration jumper (all versions)
- the voltage range configuration jumpers (1771-OFE1 only).

Current Output Version

Current version modules (1771-OFE2 and -OFE3) have all configuration jumpers installed and require no additional configuration. The configuration jumper for the Last State mode output level is in the default position (MID). See "Last State Configuration Jumpers" below.

Voltage Output Version

If you are using the voltage output version, you need to set several configuration jumpers on the module's circuit board. You must set these jumpers before you can proceed with configuring the module. When you set these jumpers, you configure each channel for one of the three voltage ranges listed above. **The module is shipped with the plugs in the $\pm$10V position.**

Important: You do not have to remove the module cover to set the configuration jumpers

Last State Configuration Jumpers

The LAST STATE configuration jumpers determine the value of all the module's outputs whenever communication between the module and the processor is lost. This condition occurs when a processor or adapter faults, or the processor is placed in the PROG or TEST mode, or if the remote I/O cable breaks.

This is a significant safety feature. You can choose to have the module's outputs go to the maximum, minimum, or middle of their respective ranges or hold their last state if a module or system fault occurs or if the system processor changes from RUN to PROG mode.

You do this by placing the LAST STATE configuration jumpers on eight (four jumpers on sets of pins) of the stake pins marked MAX, MIN, MID on the module's circuit board (Figure 2.1). If you do not place configuration jumpers in one of these positions, the module defaults to the HOLD LAST VALUE setting.

Figure 2.1 shows jumper positions for the 1771-OFE, Series B, Analog Output Module LAST STATE Configuration Jumpers.

Important: Ignore the MAX, MIN, MID markings on the printed circuit board.

Important: On power-up, the module's output is disabled until the module receives the first block transfer write. The output then enables with the value that you send it in the block transfer write block.

Important: We ship 1771-OFE modules with the LAST STATE configuration jumpers in the MID position.

ATTENTION: Switch 1 of the I/O rack affects the function of the configuration settings as indicated in the table below.

Rack Switch 1 Setting	Configuration Jumper Setting			
	MIN	**MID**	**MAX**	**HOLD LAST STATE**
Last State	Last State	Last State	Last State	Last State
Reset	Min	Mid	Max	Last State

Figure 2.1
LAST STATE Configuration Jumper
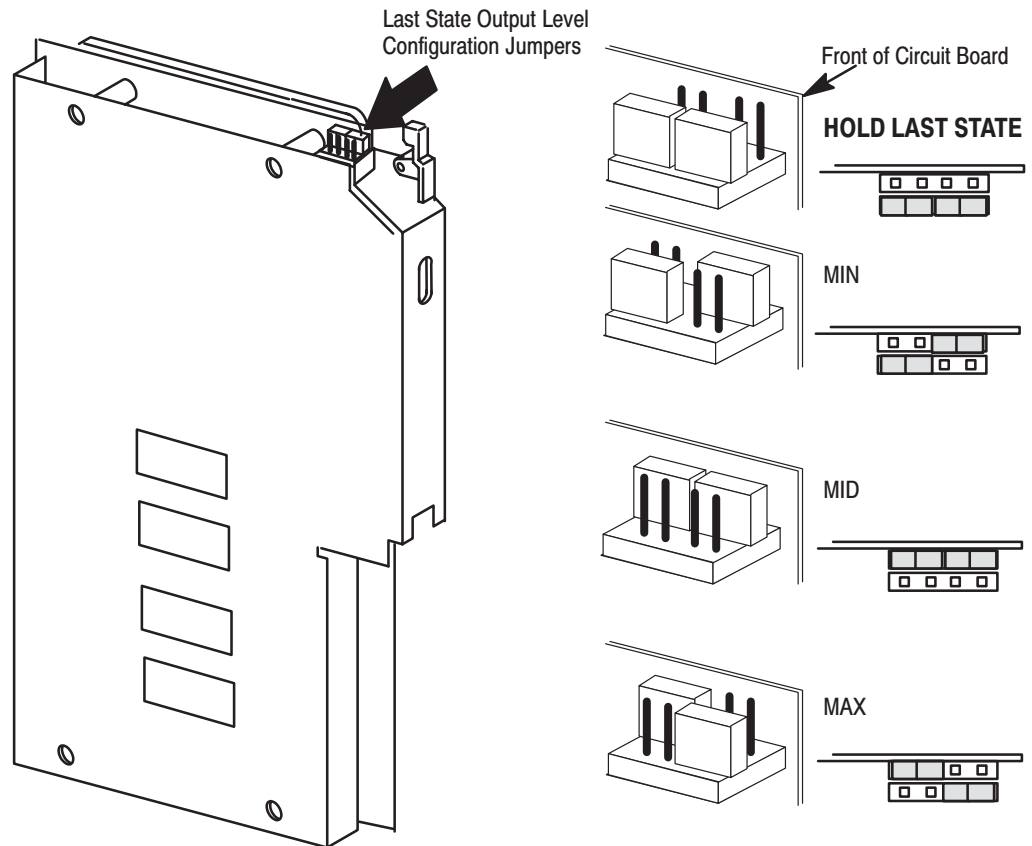
Table 2.A lists the output ranges and their minimum, maximum, and middle values.

Table 2.A
Output Last State Configuration Values

Output Range Selection	Minimum Value	Middle Value	Maximum Value
4-20mA	4mA	12mA	20mA
0-50mA	0mA	25mA	50mA
1-5V	1V	3V	5V
0-10V	0V	5V	10V
±10V	-10V	0V	+10V

These output conditions are active **only** if the following conditions exist:

- the module faults
- the processor is in the PROGRAM or TEST mode
- rack switch 1 is in the reset position

Rack switch 1 determines what output conditions occur during a rack fault.

Rack Switch 1 Setting	Configuration Jumper Setting			
	MIN	MID	MAX	HOLD LAST STATE
Last State	Last State	Last State	Last State	Last State
Reset	Min	Mid	Max	Last State

To set the last state configuration jumpers, proceed as follows.

> ⚠️ **ATTENTION:** Do not insert modules into or remove modules from the I/O chassis while system power is ON. Failure to observe this rule could result in damage to module circuitry and unexpected machine operation.

1. Locate the jumpers as shown in Figure 2.1.

2. Carefully pull up on the jumpers to remove from the pins.

3. Reposition as necessary to provide the value selected in Table 2.A.

Setting Voltage Range Configuration Jumpers (1771-OFE1 only)

If you ordered the voltage output version, you must set several configuration jumpers located inside the module on the circuit board. To do this, follow these steps:

2. Locate the configuration jumpers and set them according to your output voltage requirements (Figure 2.3).

Last State Output Level Configuration Jumpers

Access holes for Configuration Jumpers
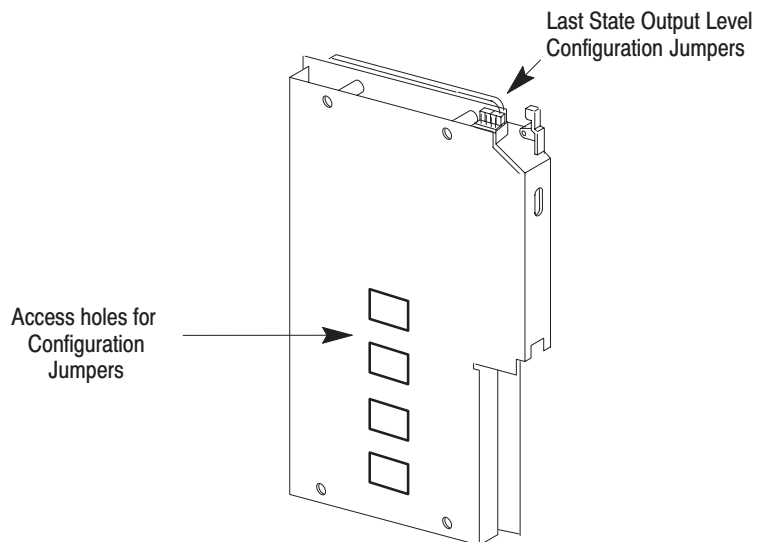
5. Position the jumpers as indicated in Figure 2.3.

Figure 2.3
Configuration Jumper Locations

LAST STATE

In

Out

(side view
of jumper)

Configuration Jumper Location	Desired Voltage Range			Output Channel
	0–10V	± 10V	1–5V	
P3, Jumper 5	In	Out	Out	
6	In	Out	Out	
7	Out	In	Out	1
8	Out	In	Out	
9	Out	Out	In	
10	Out	Out	In	
P5, Jumper 5	In	Out	Out	
6	In	Out	Out	
7	Out	In	Out	2
8	Out	In	Out	
9	Out	Out	In	
10	Out	Out	In	
P7, Jumper 5	In	Out	Out	
6	In	Out	Out	
7	Out	In	Out	3
8	Out	In	Out	
9	Out	Out	In	
10	Out	Out	In	
P9, Jumper 5	In	Out	Out	
6	In	Out	Out	
7	Out	In	Out	4
8	Out	In	Out	
9	Out	Out	In	
10	Out	Out	In	

Install the Keying Bands

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

- Insert or remove keys with your fingers.
- Make sure the key placement is correct

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

Position the keying bands in the backplane connectors to correspond to the key slots on the module.

Place the keying bands:
between 10 and 12
between **26** and **28**

Upper Connector
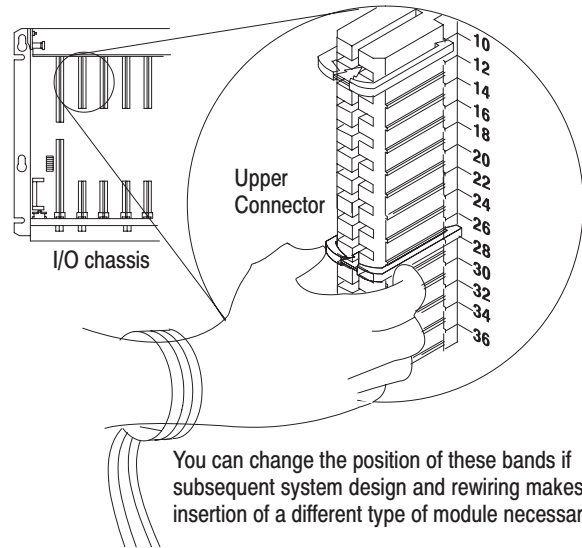
I/O chassis

You can change the position of these bands if subsequent system design and rewiring makes insertion of a different type of module necessary.

Install the Module and Field Wiring Arm

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

- Failure to remove power from the backplane or wiring arm could cause module damage, degradation of performance, or injury.
- Failure to remove power from the backplane could cause injury or equipment damage due to possible unexpected operation.

1

Attach the wiring arm (1771-WC) to the horizontal bar at the bottom of the I/O chassis.

The wiring arm pivots upward and connects with the module so you can install or remove the module without disconnecting the wires.
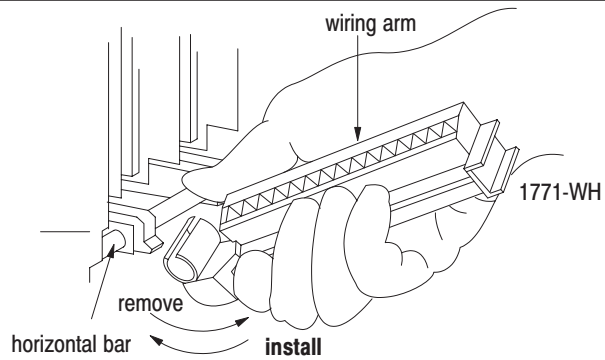
2

1771-A1B, -A2B, -A3B, -A3B1, -A4B I/O chassis
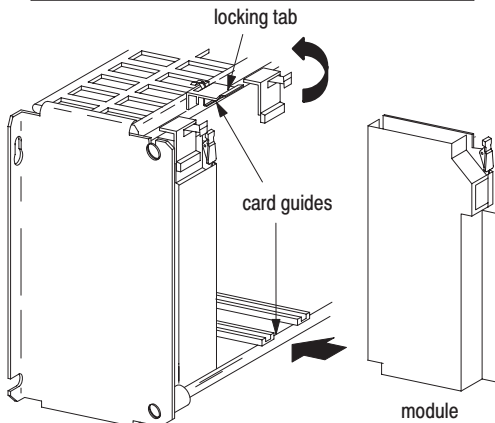
Snap the chassis latch over the top of the module to secure it.

1771-A1B, -A2B, -A3B1, -A4B Series B I/O chassis
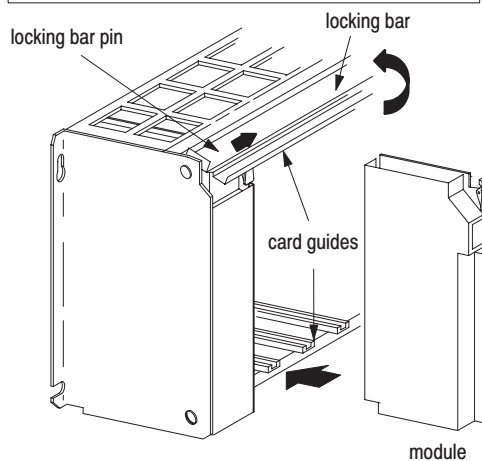
Swing the chassis locking bar down into place to secure the modules. Make sure the locking pins engage.

Connect the Wiring

The analog devices connect to the analog module through a field wiring arm (cat. no. 1771-WC). The field wiring arm pivots on the front of the I/O chassis to connect with the module. You can remove the module from the chassis without disconnecting user wiring because wiring connections are made on the field wiring arm. The connection diagram (Figure 2.5) shows connections to the field wiring arm.

> ⚠ **ATTENTION:** To avoid injury to personnel and damage to equipment, disconnect and lockout ac power from the processor and system power supplies before wiring the module.

Figure 2.5
Connection of Analog Devices to the Field Wiring Arm (cat. no. 1771-WC)

|	
A	Channel 1 output (+) lead
0	Channel 1 output (-) lead
1	Channel 2 output (+) lead
2	Channel 2 output (-) lead
3	Channel 3 output (+) lead
4	Channel 3 output (-) lead
5	Channel 4 output (+) lead
6	Channel 4 output (-) lead
7	Not used
B	Not used

User Analog Device

Functional Ground

Field Wiring Arm Cat. No 1771-WC
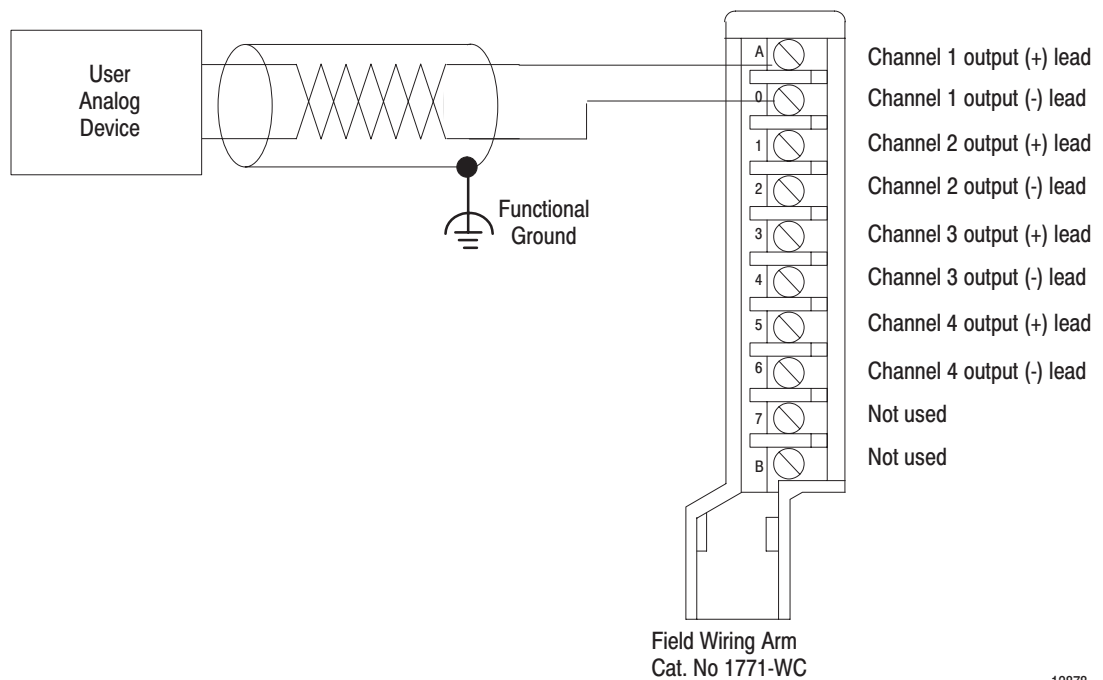
12878

The sensor cable must be shielded. The shield must:
- extend the length of the cable, but be connected only at the 1771 I/O chassis
- extend up to the point of termination

Important: The shield should extend to the termination point, exposing just enough cable to adequately terminate the inner conductors. Use heat shrink or another suitable insulation where the wire exits the cable jacket.

The module requires shielded cable for signal transmission to the analog devices. Use Belden 8761 shielded cable, which consists of a single insulated, twisted-pair of conductors, covered along their entire length by a foil shield and encased in plastic. The shield reduces the effect of induced noise at any point along the cable.

Ground the Chassis and Module

You must ground the shield at the chassis end only. We recommend connecting each output cable's shield to a properly grounded common bus. Refer to "Industrial Automation Wiring and Grounding Guidelines for Noise Immunity," publication 1770-4.1, for additional information.
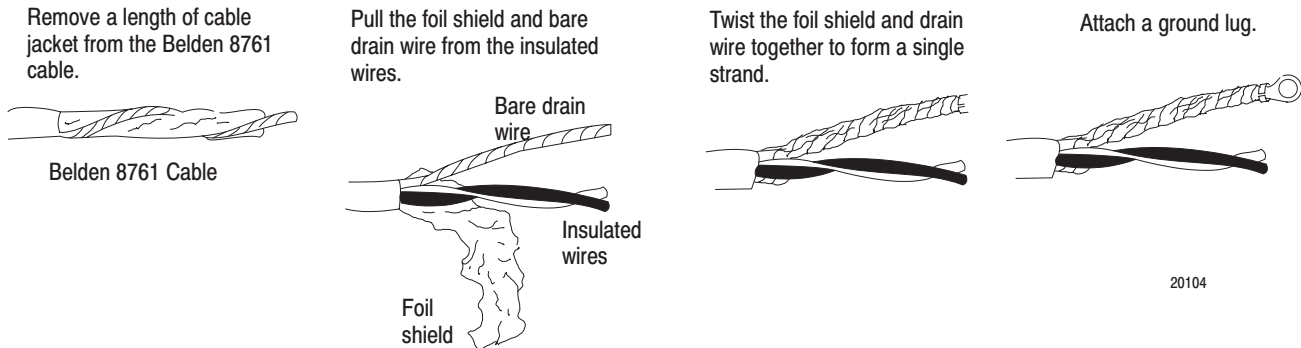
Figure 2.6
Cable Grounding

Remove a length of cable jacket from the Belden 8761 cable.

Belden 8761 Cable

Pull the foil shield and bare drain wire from the insulated wires.

Bare drain wire

Insulated wires

Foil shield

Twist the foil shield and drain wire together to form a single strand.

Attach a ground lug.

20104

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.

Ground Lug

Nut

Nut and Captive Washer

Grounding Stud

Star Washer

Ground Lug[1]

I/O Chassis Side Plate

Shield and Drain twisted together
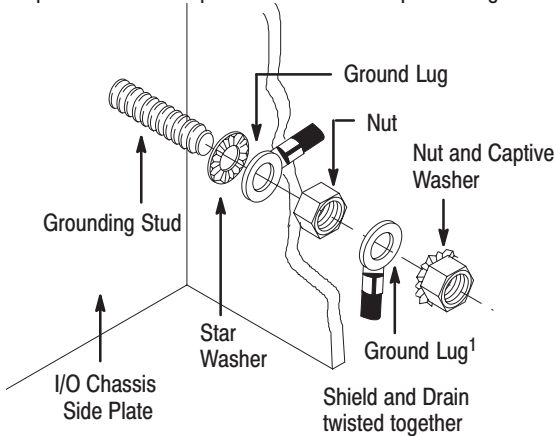
[1]Use the cup washer if crimp-on lugs are not used.

19480

Single-point Grounding

Extend shield to termination point.
Expose just enough cable to adequately terminate inner conductors.

Use heat shrink tubing or other suitable insulation where wire exits cable jacket.

Shield and Drain twisted together

#10 Thread-forming screw

External-tooth Washers
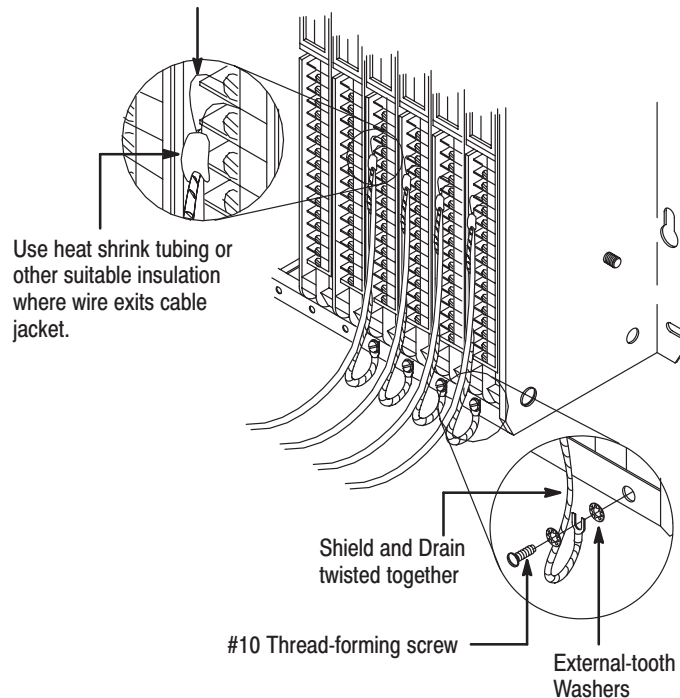
19923

Interpreting the Indicator Lights

The front panel of the module contains a green RUN and a red FLT (fault) indicator. At power-up, the red FLT indicator lights and remains ON during an initial module self-check. If a fault is found initially or occurs later, the red FLT indicator stays lit. If a fault is not found, the red indicator will turn off and the green RUN indicator will turn on and remain on.

Possible module fault causes and corrective actions are discussed in Chapter 7, "Diagnostics and Troubleshooting."

Figure 2.7
Diagnostic Indicators
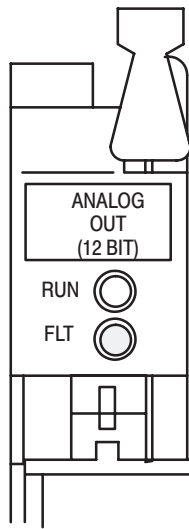
Chapter Summary

In this chapter, you learned how to set the module configuration jumpers, connect the field wiring to the field wiring arm, and install your module in the I/O chassis.

Configuring Your Output Module

What This Chapter Contains

In this chapter, you will read about:

Configuring Your Module

Because of the many analog devices available and the wide variety of possible applications, you must configure the module to conform to the analog device and specific application that you have chosen. You do this with a block transfer write instruction (BTW). The write block can be up to 13 words long and contains output data and information on data format and scaling.

Word Assignment for Block Transfer Write

Word/Dec. Bit	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Word/Octal Bit	17	16	15	14	13	12	11	10	07	06	05	04	03	02	01	00
1	Channel 1 Data Value															
2	Channel 2 Data Value															
3	Channel 3 Data Value															
4	Channel 4 Data Value															
5	Data Format	Reserved			Minimum/Maximum Scaling Value Polarity									Data Polarity		
6	Channel 1 Minimum Scaling Value															
7	Channel 1 Maximum Scaling Value															
8	Channel 2 Minimum Scaling Value															
9	Channel 2 Maximum Scaling Value															
10	Channel 3 Minimum Scaling Value															
11	Channel 3 Maximum Scaling Value															
12	Channel 4 Minimum Scaling Value															
13	Channel 4 Maximum Scaling Value															

Important: A block transfer write length of 0 will result in a default length of 13. A block transfer read length of 0 will result in a default length of 5.

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.

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.

The first four words in the BTW contain the actual data in binary or four-digit BCD format, which is converted by the module into voltage or current signals. When using the PLC-5, the 2's complement binary can be used provided the $\pm$10V range is not used.

Word	Decimal Bit (Octal Bit)	Description
1	00-15 (00-17)	Channel 1 Data Value
2	00-15 (00-17)	Channel 2 Data Value
3	00-15 (00-17)	Channel 3 Data Value
4	00-15 (00-17)	Channel 4 Data Value
5		Configuration Word - refer to Figure 3.1 below.
6	00-15 (00-17)	Channel 1 Minimum scaling value
7	00-15 (00-17)	Channel 1 Maximum scaling value
8	00-15 (00-17)	Channel 2 Minimum scaling value
9	00-15 (00-17)	Channel 2 Maximum scaling value
10	00-15 (00-17)	Channel 3 Minimum scaling value
11	00-15 (00-17)	Channel 3 Maximum scaling value
12	00-15 (00-17)	Channel 4 Minimum scaling value
13	00-15 (00-17)	Channel 4 Maximum scaling value

Word 5 in the BTW is the module configuration word. Information that you enter in this word tells the module what data format to expect and the polarity of the data and scaling values.

The remaining eight words (words 6 through 13) in the BTW are reserved for minimum and maximum scaling values. You enter these values if you wish to scale a particular channel.

Configuration Word

Word 5 of the block transfer write is the module configuration word (Figure 3.1). It contains information on:

- data polarity
- scaling polarity
- data format

Figure 3.1
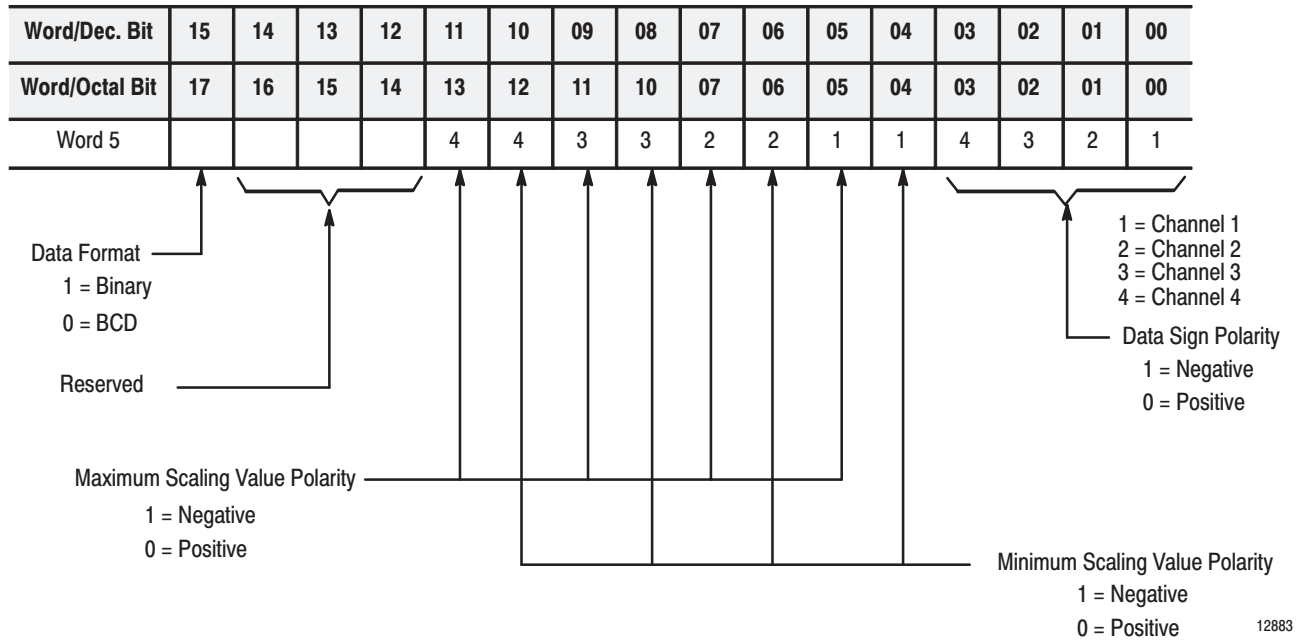**Configuration Block Transfer Write Word 5**

Word/Dec. Bit	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Word/Octal Bit	17	16	15	14	13	12	11	10	07	06	05	04	03	02	01	00
Word 5					4	4	3	3	2	2	1	1	4	3	2	1

Data Format
1 = Binary
0 = BCD

Reserved

Maximum Scaling Value Polarity
1 = Negative
0 = Positive

1 = Channel 1
2 = Channel 2
3 = Channel 3
4 = Channel 4

Data Sign Polarity
1 = Negative
0 = Positive

Minimum Scaling Value Polarity
1 = Negative
0 = Positive

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Table 3.A
Bit/Word Descriptions for Configuration Block Transfer Write Word 5

Word	Decimal Bit (Octal Bit)	Description
5	00-03	Data polarity bits. When set (1), indicate negative data. When reset (0), indicate positive data. Bit 00 corresponds to channel 1, bit 01 to channel 2, etc.
	04	When set (1), indicates negative minimum scaling value for Channel 1. When reset (0), indicates positive minimum scaling value for channel 1.
	05	When set (1), indicates negative maximum scaling value for Channel 1. When reset (0), indicates positive maximum scaling value for channel 1.
	06	When set (1), indicates negative minimum scaling value for Channel 2. When reset (0), indicates positive minimum scaling value for channel 2.
	07	When set (1), indicates negative maximum scaling value for Channel 2. When reset (0), indicates positive maximum scaling value for channel 2.
	08 (10)	When set (1), indicates negative minimum scaling value for Channel 3. When reset (0), indicates positive minimum scaling value for channel 3.

Word	Decimal Bit (Octal Bit)	Description
Word 5 continued	09 (11)	When set (1), indicates negative maximum scaling value for Channel 3. When reset (0), indicates positive maximum scaling value for channel 3.
	10 (12)	When set (1), indicates negative minimum scaling value for Channel 4. When reset (0), indicates positive minimum scaling value for channel 4.
	11 (13)	When set (1), indicates negative maximum scaling value for Channel 4. When reset (0), indicates positive maximum scaling value for channel 4.
	12-14 (14-16)	Reserved
	15 (17)	When set (1), tells the module to expect binary data. When reset (0), signifies four-digit BCD data.

Default Configuration

At power-up, the module's microprocessor assumes default conditions of:

- positive data words
- no scaling
- BCD data

The module's microprocessor receives these values if you do not enter data into the configuration word:

Data Format

The voltage or current value at one of the module's outputs is directly proportional to the value specified in that channel's data word. The output scale is divided into 4095 parts, which means that as the data word is incremented or decremented, the output signal is incremented or decremented 1/4095 of the full scale.

Table 3.B shows the incremented voltage or current assigned to each bit for the four different output scales. For example, if the data word for Channel 1 contains the value 0000 0111 1111 1111 (2047 decimal), the output for Channel 1 would be 2047/4095 or approximately 1/2 of the full scale.

Table 3.B
Output Ranges and Resolution

Nominal Range	Unscaled Code Range	Actual Output Range	Δ V/Bit or Δ I/Bit
1 to 5 volts	0 to 4095	1 to 5.00V +0.1%	0.976 mV/Bit
0 to 10 volts	0 to 4095	0 to 10.00V +0.1%	2.44 mV/Bit
-10 to +10 volts	-4095 to +4095	-10 to +10.00V +0.1%	4.88 mV/Bit
4 to 20 mA	0 to 4095	4 to 20.00 mA +0.1%	0.0039 mA/Bit
0 to 50 mA	0 to 4095	0 to 50.00 mA +0.1%	0.0122 mA/Bit

Some examples of how to determine the value of the data word needed to produce the desired output voltage or current follow:

Example 1

Output Range	4-20mA
Data Format	BCD (0-4095)
Desired Output	9.5mA
D I/Bit	0.0039mA/Bit (from Table 3.B)

Remember, 4mA corresponds to scale minimum

$$\frac{(9.5mA - 4mA)}{0.0039mA/Bit} \quad @ 1410 \text{ (decimal)} = 0001\ 0100\ 0001\ 0000 \text{ (BCD)}$$

You would enter 1410 (BCD) or 0001 0100 0001 0000 into the data word in order to get an output of 9.5 mA.

Example 2

Output Range	0-10V
Data Format	12-bit binary (0-FFF)
Desired Output	9.0V
D I/Bit	2.44mV/Bit (from Table 3.B)

$$\frac{9.0V}{2.44mV/Bit} \quad @ 3689 \text{ (decimal)} = 0000\ 1110\ 0110\ 1001 \text{ (binary)}$$

You would enter 0000 1110 0110 1001 into the data word to get an output of 9.0V.

These values are loaded into the module's memory, from the processor, with a block transfer write.

Important: If you are using BCD data format, you must download values to the module in the BCD format and set the corresponding data polarity bit (see Figure 3.1) if a negative output is desired.

Important: If the binary data format is selected, data can be downloaded in a binary or 2's complement binary data format. If binary is used, the appropriate data polarity bit must be set to express a negative value. The 2's complement format expresses a negative value via the bit pattern.

If the processor input information governs the module's outputs, remember that data written to the output module must fall within certain limits. Both BCD and binary data must fall within the range ±9999. You can use the negative ranges by setting the "negative data" bits in word 5 of the BTW.
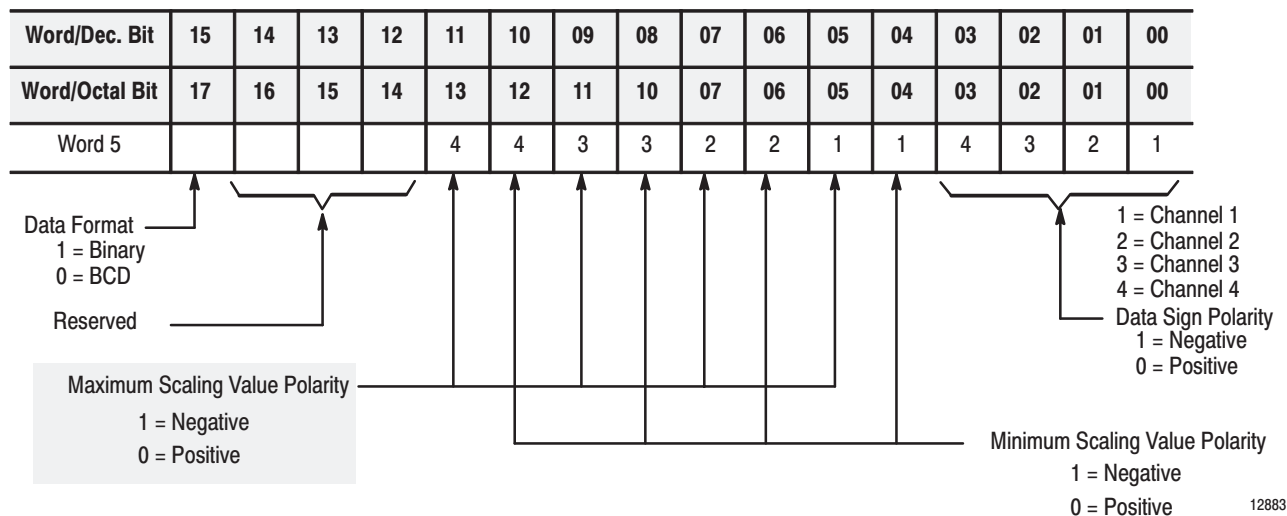
Scaling

Scaling is the conversion of unscaled data to engineering units--such as gallons/minute, degrees centigrade, and pounds/square inch. You can use the scaling feature to send the data for each channel to the module in an optional scaled value representing actual engineering units. This value is scaled by the module to a proportional binary value before it is used by the corresponding channel. The resolution of this data is one part in 4095.

The scaling feature is implemented by entering scaling values in the data format selected in words 6 through 13 of the BTW.

Scaling Value Polarity

Bits 04 to 11 (04 to 13 octal) of the configuration word (word 5) in the write block designate positive or negative scaling values (Figure 3.2). By setting the appropriate negative scaling bit in word 5, you can scale negative data or enable a negative scaling value. The sign bits are ignored if a corresponding channel is not scaled.

Figure 3.2
Location of Scaling Value Polarity Bits in the Block Transfer Write Configuration Word

Word/Dec. Bit	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Word/Octal Bit	17	16	15	14	13	12	11	10	07	06	05	04	03	02	01	00
Word 5					4	4	3	3	2	2	1	1	4	3	2	1

Data Format
1 = Binary
0 = BCD
Reserved

Maximum Scaling Value Polarity
1 = Negative
0 = Positive

Minimum Scaling Value Polarity
1 = Negative
0 = Positive

1 = Channel 1
2 = Channel 2
3 = Channel 3
4 = Channel 4
Data Sign Polarity
1 = Negative
0 = Positive

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Maximum and Minimum Scaling Values

Words 6-13 of the write block transfer contain maximum and minimum scaling values for each channel. Word 6 corresponds to Channel 1 scale minimum, word 7 to Channel 1 scale maximum, word 8 to Channel 2 scale minimum, and so on (Figure 3.3).

The maximum and minimum scaling values are the upper and lower limits for output data. The module's microprocessor reads these values and automatically scales output data from the write block transfer.

The largest value that you can enter for a maximum scaling value is 9999. The smallest value you can enter for a minimum scaling value is -9999 (the minus sign is implemented by setting the appropriate bit in the configuration word).

Important: The maximum scale value must be larger than the minimum scale value. If not, block transfers continue but data is not acknowledged by the module's microprocessor. Outputs remain in their last state before the fault.

Even if you scale fewer than four channels, a full 13-word block transfer is performed.

When scaling, all scaling information must be entered into the data table using the same format that the module sends to the data table.

If Module is configured for:	Then enter scaling values in:
BCD format	BCD
2's complement	Binary
Signed Magnitude Binary	

Important: PLC-2 users should always use BCD format because the PLC-2 processor performs math functions using BCD data. The PLC-3, PLC-5 and PLC-5/250 use integer math, you should use 2"s complement binary for any data that will be used with math instructions (including PID and CAR routines). BCD format is usually reserved for display purposes only.

Figure 3.3
Location of Maximum and Minimum Scaling Values in the Write File

Word	Description
1	Channel 1 Data Value
2	Channel 2 Data Value
3	Channel 3 Data Value
4	Channel 4 Data Value
5	Configuration Word
6	Channel 1 Minimum Scaling Value
7	Channel 1 Maximum Scaling Value
8	Channel 2 Minimum Scaling Value
9	Channel 2 Maximum Scaling Value
10	Channel 3 Minimum Scaling Value
11	Channel 3 Maximum Scaling Value
12	Channel 4 Minimum Scaling Value
13	Channel 4 Maximum Scaling Value

If you do not wish to scale a particular channel, set the scaling values as shown below.

If your range is:	Set Maximum Scaling Value to:	Set Minimum Scaling Value to:
4-20mA		
1-5V	4095	0000
0-10V		
+10 to -10V	4095	-4095[1]

[1] This also requires you to set the appropriate sign bit in the configuration word for the minimum scaling value.

For example, suppose you choose the 1 to 5 volt range and BCD data format for your module. You have a thermocouple input that reports a temperature between 100ºC and 900ºC back to your processor. You would like this input temperature scale to correspond to an output meter scale.

You would enter the following minimum and maximum scaling values into Words 6 and 7 of the write block:

Meter Scale Value	Scaled Value	Output Voltage	Unscaled Value (BCD)
Meterscale 100%	900ºC	5.0V	4095
	700ºC	4.0V	3072

Example:
  Word 6 = 0100
  Word 7 = 0900
	500ºC	3.0V	2048

Example:
  Meterscale 31%
  Meterscale 25%
	350ºC
	300ºC
		2.25V
		2.0V
			1280
			1024

Meterscale 0%	100ºC	1.0V	0

If the processor sends a data value to the module that corresponds to 350ºC, the value is scaled to the 100ºC to 900ºC range and the corresponding output voltage for that channel is 2.25 volts, which would position the scale accordingly at 31% of full scale.

Procedure for Configuring Your Module

Now that we have explained the purpose and function of each word in the block transfer write block, you should be ready to enter configuration data. Consult your programming manuals for the proper techniques required to set up block transfer instructions with your programmable controller. Refer to chapter 4 for example programs.

Important: A block transfer write length of 0 will result in a default length of 13. A block transfer read length of 0 will result in a default length of 5.

Chapter Summary

In this chapter, you learned how to configure your module using a block transfer write instruction.

Module Programming

What This Chapter Contains

In this chapter you will read about:

Block Transfer with the Analog Output Module

If you have used other intelligent I/O modules, you may be familiar with bidirectional block transfer programming. Bidirectional block transfer is the sequential performance of both read and write operations. Typically, in previous bidirectional block transfer modules, the enable bits of both read and write instructions could be set ON at the same time.

Although the module can perform both read and write operations, the module does not allow the enable bit of both read and write instructions to be set ON at the same time. Your program must toggle requests for the read and write instructions as shown in our sample programs.

> ⚠ **ATTENTION:** At no time should both the read and write instructions be enabled. Undesirable data could transfer resulting in unpredictable machine operation.

Block Transfer Programming Formats

In order for the processor to exchange data with the output module, you must include block transfer read and write instructions in your program. The types of programming formats available for block transfer are block format and multiple GET instructions. You can program most processors that use the 1771 I/O structure with block format instructions. **Exceptions are the Mini-PLC-2 (cat. no. 1772-LN3) and PLC-2/20 (cat. no. 1772-LP1, -LP2) processors; they use the multiple GET instructions.** Refer to Appendix B for information on block transfer with the Mini-PLC-2 and the PLC-2/20.

There are three types of block format instructions--one each for the PLC-2, PLC-3, and PLC-5 processors. Each is described in the paragraphs that follow.

Block Transfer Programming - PLC-2 Family Processors Only

Output data is transferred from the processor's data table to the module with a write block transfer. Diagnostic information is transferred from the module to the processor's data table with a read block transfer. In order for these transfers to take place, you must enter certain parameters into your block transfer instructions. A sample program segment with block transfer read and write is shown in Figure 4.1 and described in the following paragraphs.

An example program with block transfer instructions is shown in Figure 4.2. A data table map (Table 4.A) and a data table word assignment (Table 4.B) are also shown. Figure 4.3 shows how the binary representation of configuration options is represented in BCD (as it appears in our data table map).

Figure 4.1
PLC-2 Family Sample Program Structure

Program Action

At power-up, the program performs a write block transfer that configures the module. When the first write block transfer is complete, the program toggles between read and write block transfers. The program takes into account that the read and write request bits cannot be set simultaneously.

Upon completion of a successful read block transfer, data from the module is moved from the buffer file (block transfer read file) to a storage data file. This prevents the processor from using invalid data should block transfer communications fail.

Rungs 1 and 2
The first two rungs of the sample program segment toggle requests for the read and write instructions. Notice that the EXAMINE ON instructions in Rungs 1 and 2 are the done bits of the read and write instructions. By latching or unlatching a storage bit, the write done bit (XXX/X6) triggers the read block transfer instruction and the read done bit (XXX/X7) triggers the write block transfer instruction.

Rung 3
The write block transfer instruction in Rung 3 sends configuration, output, and scaling data to the module from the processor in one program scan.

Rung 4
The read block transfer instruction in Rung 4 sends module status information and a copy of the output data to the processor from the module in one program scan.
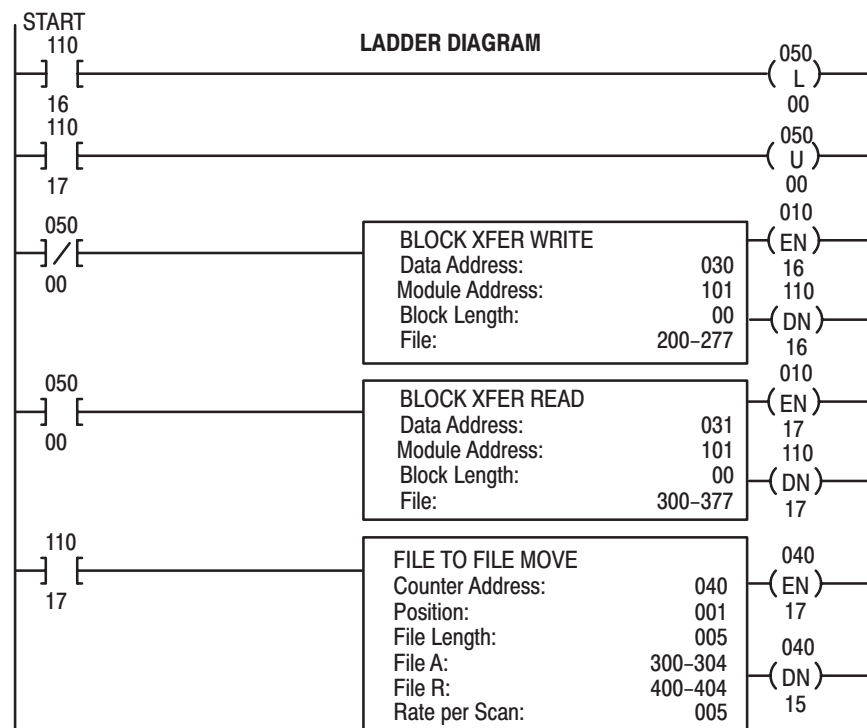
Rung 5

When a read block transfer has been successfully completed, its done bit (Bit XXX/X7) is set. When the done bit is set, it enables the file-to-file move instruction. The read block transfer data file (buffer) is then moved into a storage data file. This prevents the processor from transmitting invalid data should a block transfer communication fault occur.
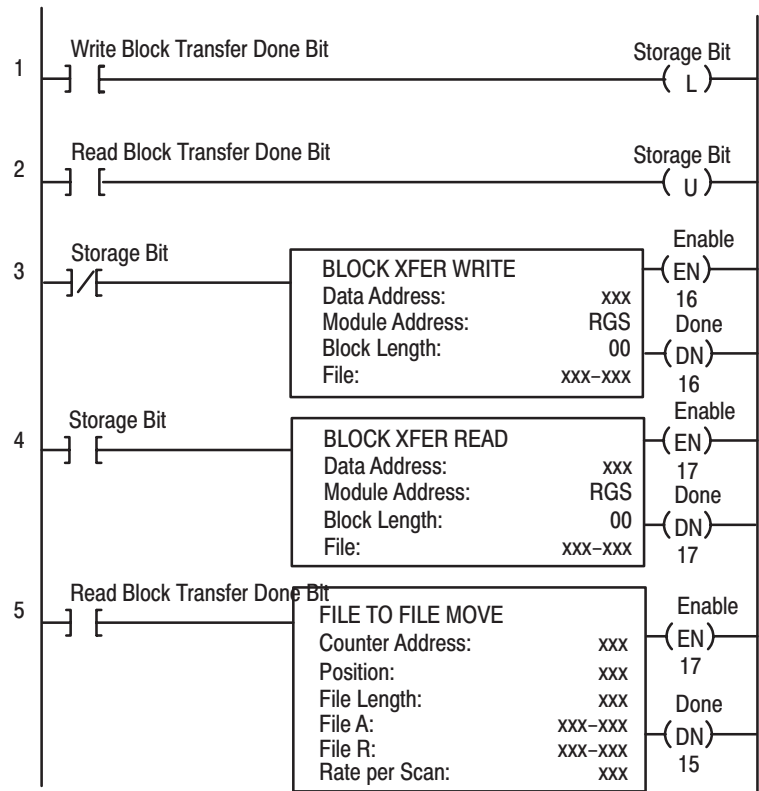
PLC-2 Family Example Program

Module Location	Rack 1, Module Group 0, Slot 1
T/C Addresses	030 for Block Transfer Write 031 for Block Transfer Read
BTW File (Configuration file)	0200-0214
BTR File (Buffer file)	0300-0304
Output Data File	0400-0404
Storage Bit	050/00
BTW Done Bit	110/16
BTR Done Bit	110-17
Module Configuration	**1771-OFE1 (Voltage Version)**
Voltage Range	1 to 5V
Data Format	BCD
Scaling Parameters	Channels 1 and 2 = No scaling Channel 3 = -20 to 275 Channel 4 = 100 to 500

Figure 4.2
PLC-2 Family Example Program

LADDER DIAGRAM

START
110
16 → (050 L 00)

110
17 → (050 U 00)

050
00 (/)

BLOCK XFER WRITE
Data Address: 030
Module Address: 101
Block Length: 00
File: 200–277
(010 EN 16) 110 (DN 16)

050
00

BLOCK XFER READ
Data Address: 031
Module Address: 101
Block Length: 00
File: 300–377
(010 EN 17) 110 (DN 17)

110
17

FILE TO FILE MOVE
Counter Address: 040
Position: 001
File Length: 005
File A: 300–304
File R: 400–404
Rate per Scan: 005
(040 EN 17) 040 (DN 15)

Table 4.A
Data Table Map

Allen-Bradley Programmable Controller
Data Table MAP (128-word)

PAGE_____ OF _____
ADDRESS_____ TO _____

PROJECT NAME OFE Data Table–Write Block

PROCESSOR   PLC-2 Family

DESIGNER _____

DATA TABLE SIZE _____

STARTING WORD ADDRESS
—— 00

BIT NUMBER

DESCRIPTION

Configuration Data

(BTW)

5 Words–No Scaling

13 words–With Scaling

STARTING WORD ADDRESS
—— 00

BIT NUMBER

DESCRIPTION

Buffer Area
BTR

STARTING WORD ADDRESS
—— 00

BIT NUMBER

DESCRIPTION

Input Data
File FFM

11157

Table 4.B
PLC-2 Family Data Table Word

ALLEN–BRADLEY
Programmable Controller
DATA TABLE WORD ASSIGNMENTS (64–WORD)

PAGE ___2___ OF ___2___
ADDRESS _____ TO _____

PROJECT NAME ___OFE PROGRAM___   PROCESSOR ___PLC-2 FAMILY & PLC-3___

DESIGNER _____   DATA TABLE SIZE _____

WORD ADDR	DESCRIPTION	WORD ADDR	DESCRIPTION
0	CH 1 DATA	0	
1	CH 2 DATA	1	
2	CH 3 DATA	2	
3	CH 4 DATA	3	
4	0100	4	
5	0	5	
6	4095	6	
7	0	7	
0	4095	0	
1	20	1	
2	275	2	
3	100	3	
4	500	4	
5		5	
6		6	
7		7	
0		0	
1		1	
2		2	
3		3	
4		4	
5		5	
6		6	
7		7	
0		0	
1		1	
2		2	
3		3	
4		4	
5		5	
6		6	
7		7	

Comments: Block length for block transfer write is 00. Unscaled channels have a minimum scaling value of 0 and a
maximum scaling value of 4095. If channels 1 and 2 were configured for + 10V operation, then the minimum scaling value would be -4095 and the maximum scaling value would be +4095. Since channel 3 has a negative minimum scaling value, you must set the polarity bit (bit 10) associated with channel 3's minimum scaling word in the configuration word (word 5 of the write block).

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Figure 4.3
Binary Configuration Word Represented in BCD

Channel 3 Minimum Scaling Factor Polarity
Set (1) = Negative
Reset (0) = Positive

Word/Dec. Bit	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00	
Word/Octal Bit	17	16	15	14	13	12	11	10	07	06	05	04	03	02	01	00	
Word 5	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	Binary
	0				1				0				0				BCD

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Block Transfer Programming - PLC-3 Family Processors Only

Block transfer operation with the PLC-3 processor uses 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 (during block transfer write) or from your module (block transfer read). The address of the block transfer data file is stored in the block transfer control file. A sample program segment is shown in Figure 4.4 and described in the following paragraphs.

The industrial terminal prompts you to create a control file when either block transfer instruction is entered. The same block transfer control file is used for both read and write instructions for your module.

PLC-3 Example Program

Module Location	Rack 1, Module Group 0, Slot 1
Block Transfer Control File	FB1:0
BTW File (Configuration file)	FB2:1
BTR File (Buffer file)	FB3:1
Output Data File	FB4:1
Storage Bit	B0/0
BTW Done Bit	B1:0/05
BTR Done Bit	B1:0/15
Module Configuration	**1771-OFE1 (Voltage Version)**
Voltage Range	1 to 5V
Data Format	BCD
Scaling Parameters	Channels 1 and 2 = No scaling Channel 3 = -20 to 275 Channel 4 = 100 to 500

Figure 4.4
PLC-3 Sample Program Structure

Program Action

Upon completion of a successful read block transfer, data from the module is moved from the buffer file (block transfer read file) to a storage data file. This prevents the module from using invalid data should block transfer communications fail.

At power-up, the program performs a write block transfer that configures the module. When the first write block transfer is complete, the program toggles between read and write block transfers. The program takes into account that the read and write request bits cannot be set simultaneously.

Rungs 1 and 2

The first two rungs of the sample program segment toggle requests for the read and write instructions. Notice that the EXAMINE ON instructions in Rungs 1 and 2 are the done bits of the read and write instructions. By latching or unlatching a storage bit, the write done bit (XXXXX:XXXX/05) triggers the BTR instruction and the read done bit (XXXXX:XXXX/15) triggers the BTW instruction.
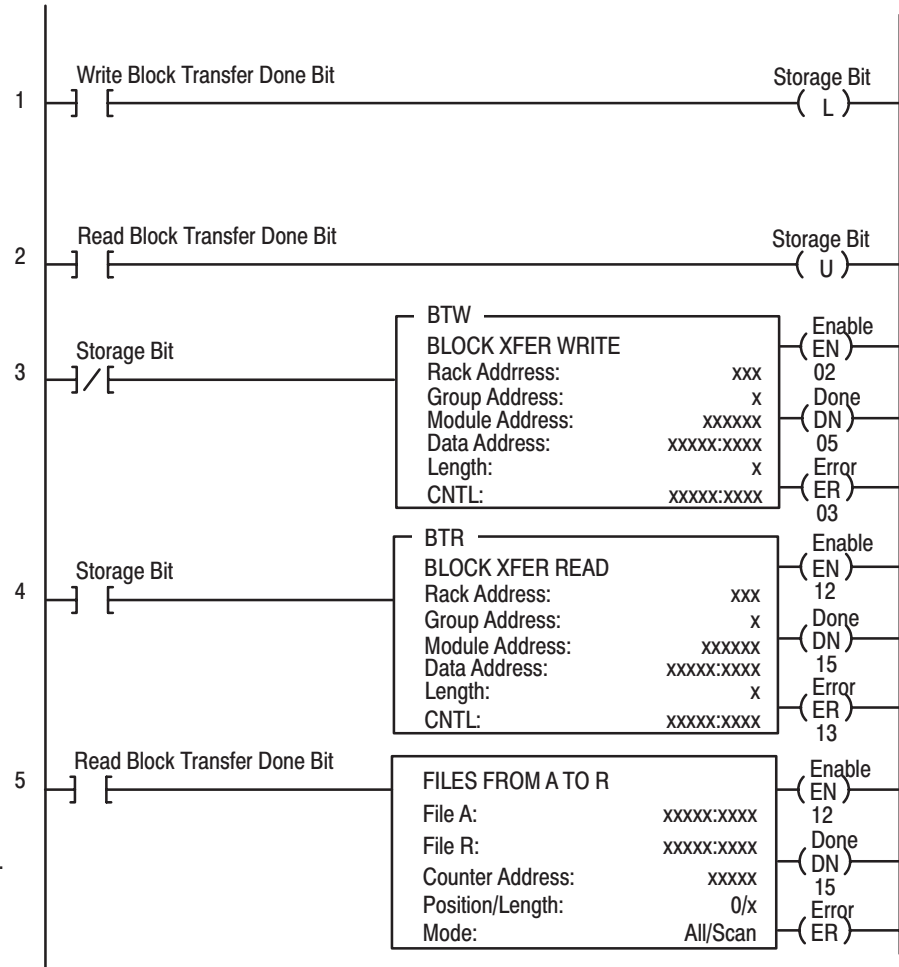
Rung 3

The write block transfer instruction in Rung 3 sends configuration, output, and scaling data to the module from the processor in one program scan.
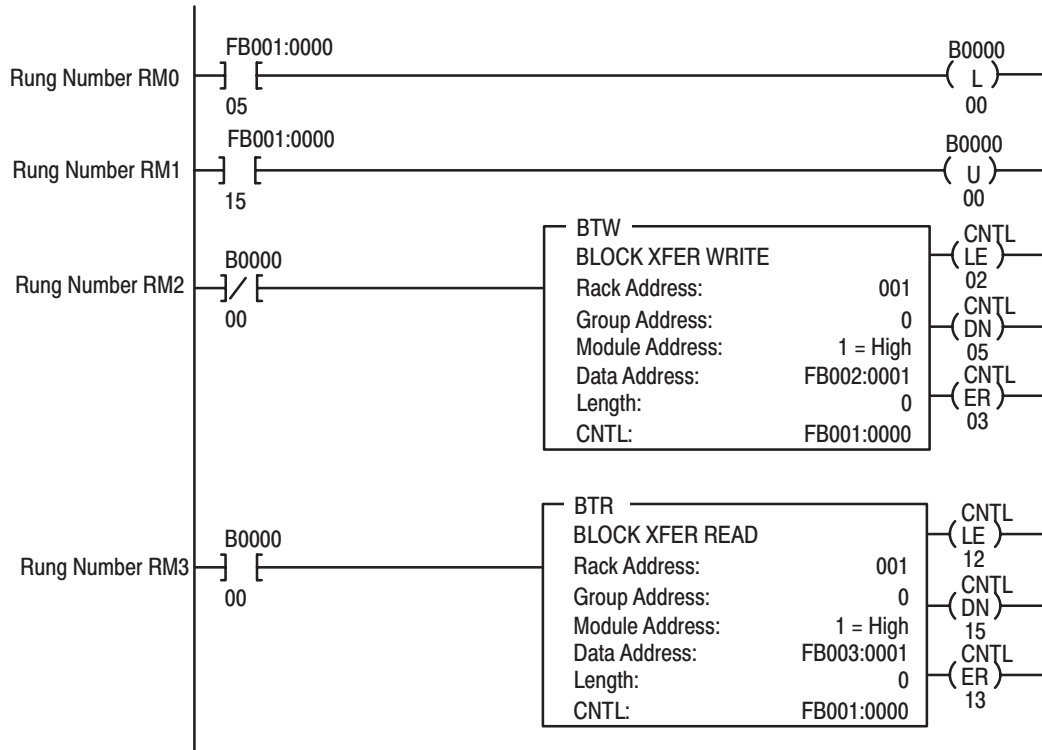
Rung 4

The read block transfer instruction in Rung 4 sends module status information and a copy of the output data to the processor from the module in one program scan.

Rung 5

When a read block transfer has been successfully completed, its done bit is set. When the done bit (XXXXX:XXXX/15) is set, it enables the file-to-file move instruction. The read block transfer data file (buffer) is then moved into a storage data file. This prevents the processor from transmitting invalid data should a block transfer communication fault occur.

Rung 1: Write Block Transfer Done Bit —] [— Storage Bit (L)

Rung 2: Read Block Transfer Done Bit —] [— Storage Bit (U)

Rung 3: Storage Bit —]/[—
```
BTW
BLOCK XFER WRITE
Rack Addrress:        xxx
Group Address:          x
Module Address:    xxxxxx
Data Address:   xxxxx:xxxx
Length:                 x
CNTL:           xxxxx:xxxx
```
Enable (EN) 02
Done (DN) 05
Error (ER) 03

Rung 4: Storage Bit —] [—
```
BTR
BLOCK XFER READ
Rack Address:         xxx
Group Address:          x
Module Address:    xxxxxx
Data Address:   xxxxx:xxxx
Length:                 x
CNTL:           xxxxx:xxxx
```
Enable (EN) 12
Done (DN) 15
Error (ER) 13

Rung 5: Read Block Transfer Done Bit —] [—
```
FILES FROM A TO R
File A:         xxxxx:xxxx
File R:         xxxxx:xxxx
Counter Address:     xxxxx
Position/Length:       0/x
Mode:              All/Scan
```
Enable (EN) 12
Done (DN) 15
Error (ER)

Figure 4.5
PLC-3 Example Program

Table 4.C
PLC-3 Data Table Word Assignments for Example 1

Start = FB002:0000

Word #	0	1	2	3	4	5	6	7
00000	0000	2048	1024	0150	0350	0100	0000	4095
00008	0000	4095	0020	0275	0100	0500		

Block Transfer Programming - PLC-5 Family Processors Only

The PLC-5's bidirectional program is very simple because the processor handles the enable bits and ensures valid data. Two examples are shown. The first is a write-only program you can use when module status is not required. The second is a read/write program.

Important: If the 1771-OFE module is configured in BCD data format and you are using a PLC-5 processor, extra programming will have to be added to the ladder program (i.e. a CPT or TOD instruction) to convert binary data to BCD data before it is transferred to the 1771-OFE module's block transfer write data file. Also, when checking your program's operation, remember to verify proper output voltage/current values based on the data values sent to the module.

Figure 4.6
PLC-5 Example Program 1

Program Action (Example 1)

Rung 1
The BTW is writing in an "as-fast-as-possible" mode. As soon as the instruction executes, it is reenabled for another transfer. Instruction execution could also be scheduled using a timer done bit or some other input condition.
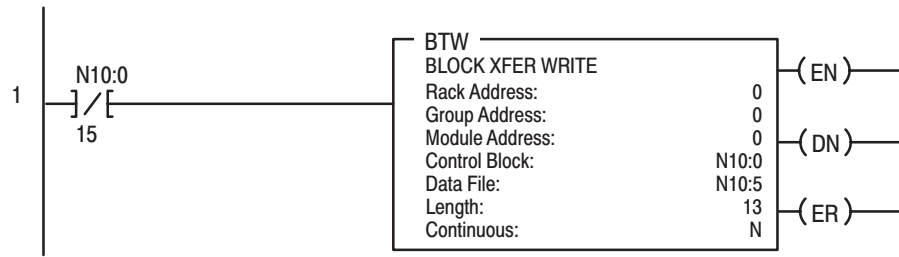
Module Location	Rack 0, Module Group 0, Slot 0
File Configuration	
Control Array	N10:0
Data File	N10:5
Configuration Word	N10:9
Enable Bit	N10:0/15

Figure 4.7
PLC-5 Example Program 2

Program Action (Example 2)

Rung 1
The enable bits of both instructions alternate execution between rungs. This rung is executed first. When the BTR is done, both enable bits are off until the next rung is scanned at which time the BTW is enabled.

Rung 2
The BTW is writing in an "as-fast-as-possible" mode. As soon as the instruction executes, it is reenabled for another transfer. Instruction execution could also be scheduled using a timer done bit or some other input condition.
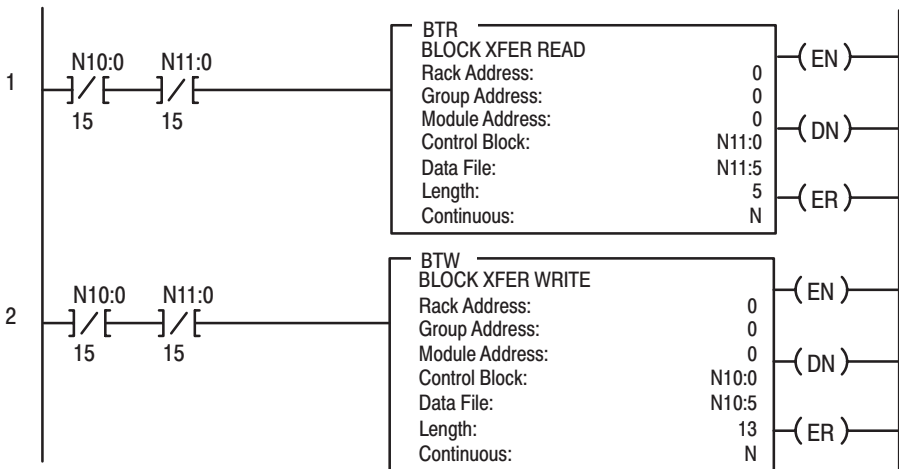
Module Location	Rack 0, Group 0, Slot 0
File Configuration	BTR
Control Array	N11:0
Data File	N11:5
Output Data Image	N11:5 through N11:8
Status Word	N11:9
Enable Bit	N11:0/15
File Configuration	BTW
Control Array	N10:0
Data File	N10:5
Configuration Word	N10:9
Enable Bit	N10:0/15

Other Programming Considerations

When writing your program, there are some additional programming techniques that you should consider. They are:

- block length and scaling considerations
- block transfer boundary word - PLC-2 family processors
- module update time
- buffering data - PLC-2 family processors only
- system expansion recommendations

Block Length and Scaling Considerations

There are three possible write block configurations that involve scaling:

- no channels scaled
- fewer than four channels scaled
- all four channels scaled

No Channels Scaled

If you do not wish to scale any of your data, you can enter a block length of five words in the write block transfer instruction. The bit that indicates BCD or 12-bit binary data format (Bit 17) in Word 5, the module configuration word, is the only bit in Word 5 that is examined by the module. The remaining bits (00-16) are ignored by the module because these bits indicate scaling value polarity and data polarity. The module does not acknowledge negative data unless scaling is used.

Fewer than Four Channels Scaled

To scale only one, two, or three of the four channels, enter a block length of 00 and enter the appropriate scaling values for the channels to be scaled. You must enter 0 or -4095 for the minimum scaling value and +4095 for the maximum scaling value for any unscaled channels, depending on the range selected.

All Four Channels Scaled

To scale all four channels, enter a block length of 00 and enter the appropriate scaling values for the four channels, as shown in the following table.

If You Want	And Channel Is Configured for:	Then Enter:
No Channels Scaled	+10V, 0-10V, 1-5V, 4-20 mA, 0-50mA	A Block Length of 5 No Scaling Information
Fewer than Four Channels Scaled	+10V	A Block Length of 00 Appropriate Scaling Values -4095 Minimum Scaling Value and +4095 Maximum Scaling Value for Unscaled Channel(s)
	0-10V, 1-5V, 4-20 mA, 0-50mA	A Block Length of 00 Appropriate Scaling Values 0 Minimum Scaling Value and 4095 Maximum Scaling Value for Unscaled Channels
All Four Channels Scaled	+10V, 0-10V, 1-5V, 4-20 mA, 0-50mA	A Block Length of 00 Appropriate Scaling Values

Block Transfer Boundary Word - PLC-2 Family Processors Only

The purpose of the boundary word is to tell the processor not to search for additional block transfer addresses.
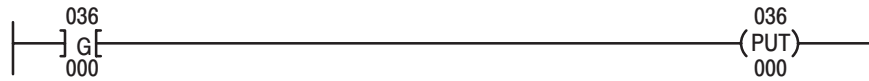
You set the boundary word by entering one word (16 bits) of zeros in the timer/counter accumulated value area of the data table, after the word containing the last block transfer module address.

For example, if the last block transfer data address in the accumulated value area of the data table is 035, the block transfer boundary word is addressed as 036. Figure 4.8 shows the data table structure and a sample GET/PUT instruction used to program a block transfer boundary word.

Figure 4.8
Data Table Structure and GET/PUT Instruction Example for Block
Transfer Boundary Word

	030	First Block Transfer Data Address
	031	
	032	
	033	
	034	
	035	Last Block Transfer Data Address
Timer/Counter Accumulated Values Area	036	Address of Block Transfer Boundary W
	037	Beginning Address for Timer/Counter
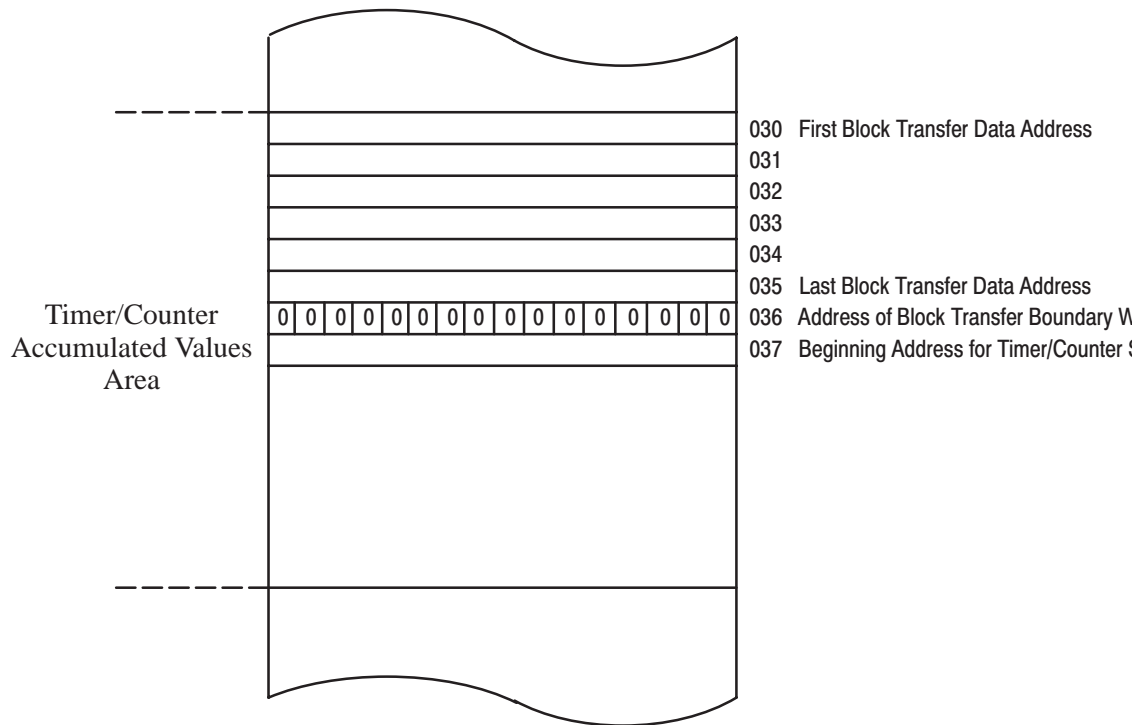
Block Transfer Boundary Word Instruction

```
      036                                          036
     ] G [                                        ( PUT )
      000                                          000
```

Module Update Time

Update time is defined as the amount of time it takes for the output module to receive a block transfer scan and update all output channels. Refer to Figure 4.9. The output module updates the four output channels in:

- 8 milliseconds when BCD data format and scaling are used
- 1.6 milliseconds when binary data format and no scaling are used

Block transfer from the processor is inhibited during this time span.

Figure 4.9
Module Output Update Time

Legend:

X = Block Transfer inhibited while update is being completed for 8 milliseconds with BCD and scaling, 1.6 milliseconds with binary and no scaling

Y = Block transfer enabled
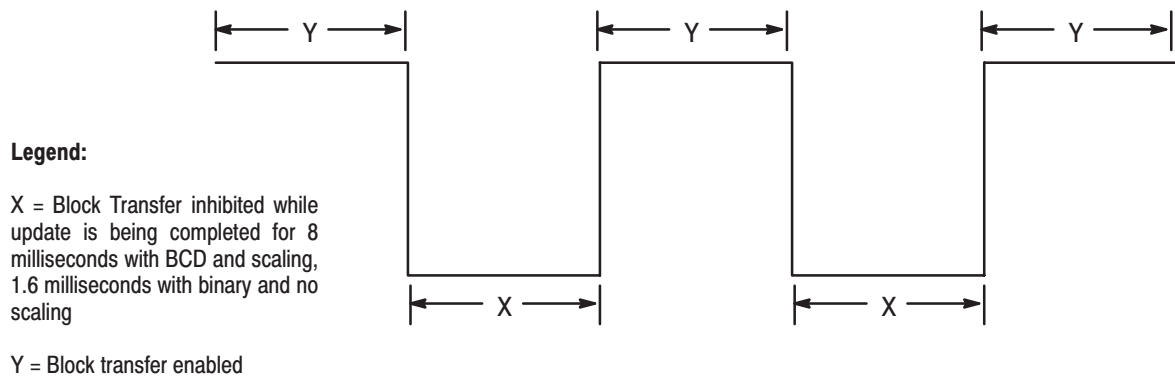
12896

System Expansion Recommendations - PLC-2 Processors Only

If you plan to add more block transfer modules to your system at some future date, we recommend that you reserve a few words in the first available time/counter value area of the data table for block transfer addresses. This eliminates the need to reconfigure your data table.

Chapter Summary

In this chapter you learned how to write data to the module, the data formats used for block transfer, special programming techniques, and were given sample program examples.

Module Status and Input Data

What This Chapter Contains

In this chapter, you will read about:

Reading Data from the Module

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

The transferred words contain module status, channel status and input data from the module. The maximum BTR data file length required is five words.

Figure 5.1
Word Assignment for Block Transfer Read

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 1	Channel 1 DAC Input Data															
2	Channel 2 DAC Input Data															
3	Channel 3 DAC Input Data															
4	Channel 4 DAC Input Data															
5	Not used	I/O Reset	Reserved											Data Valid		

Important: The user program that uses the read block transfer must make sure that Bits 06 and 07 (the write enable and read enable request bits) of the MCB are not set simultaneously.

Table 5.A
Bit/Word Description for Block Transfer Read

Word	Decimal Bits (Octal Bits)	Description
1	Bits 00-15 (00-17)	Channel 1 DAC input data.
2	Bits 00-15 (00-17)	Channel 2 DAC input data.
3	Bits 00-15 (00-17)	Channel 3 DAC input data.
4	Bits 00-15 (00-17)	Channel 4 DAC input data.
5	Bits 00-03	When set, indicate invalid channel data is sent to the module. These bits are not reset until a correct write block transfer is sent. Bit 00 corresponds to Channel 1, Bit 01 to Channel 2, and so on.
	Bits 04-13 (04-15)	Reserved
	Bit 14 (16)	Is the I/O RESET bit. When set, it indicates that the processor is in TEST or PROGRAM mode (i.e., block transfer data is not being written to the module).

The first four words of the block transfer read show the actual 12 bits of data sent to the module's digital to analog converters (DACs). The first four words in the block transfer read appear in 12-bit binary format regardless of the module's mode of operation (BCD or 12-bit binary).

The fifth word contains the status of each DAC word; that is, whether data is out of range or scaling is improperly programmed. The fifth word also indicates that I/O RESET has been established (when the processor is in the PROG/TEST or RUN mode).

Chapter Summary

In this chapter, you learned the meaning of the status data the module sends to the processor.

Calibrating Your Output Module

Chapter Objectives

In this chapter, you will read how to calibrate your output module.

Tools and Test Equipment

Table 6.A lists tools and test equipment required for module calibration.

Table 6.A
Test Equipment

Used On:	Equipment	Description
Voltage Versions	5-1/2 Digit Voltmeter	0.01% Accuracy Minimum.
	4 Load Resistors	1.0K or Greater, 0.25W, 1.0% (P/N 628217-01)
Current Versions	4 Load Resistors	250 ohm or Greater, 0.25W, 0.01% (P/N 940719-01)
Both Voltage and Current	Small Jeweler's Screwdriver or "Pot Tweeker" Alignment Tool	Newark Electronics 500 North Pulaski Road Chicago, IL 60624
	Backplane Extender Card	Cat. No. 1771-EX

Calibrating Your Module

The analog output module is shipped from the factory **already calibrated.** If it becomes necessary to recalibrate the analog output module, you must calibrate it in an I/O chassis. The module needs to communicate with the processor. Calibration consists of two tasks:

- preparing the module for calibration
- calibrating each channel

The calibration procedure for the voltage output version module is different from the calibration procedure for the current output version module. Refer to the appropriate section for your module.

> ⚠ **ATTENTION:** Do not attempt calibration without reading and thoroughly understanding all steps in this procedure. Also, do not attempt to calibrate this module in an operating system.

Voltage Output Version (1771-OFE1)

Preparation for Calibration –

1. Turn off the processor and I/O chassis power.

2. Remove the field wiring arm.

3. Remove the analog output module from the I/O chassis.

4. Remove the module covers.

5. Connect the backplane extender card (cat. no. 1771-EX) to the circuit board.

6. Insert the extender card/circuit board assembly in the I/O chassis.

7. Reinstall the field wiring arm.

Important: If you have a spare or unused field wiring arm, you may want to temporarily switch it with the module's present field wiring arm. You can use this spare arm for test purposes in order to avoid disconnecting your analog device wires.

Important: The accuracy of this calibration procedure is dependent upon the precision of your load resistors. Use resistors with a tolerance of 1.0%. You should be able to attain voltage readings to +1mV. For greater accuracy, use load resistors with tolerances less than 1.0%.

Use load resistors with values of 1K ohms. For greater accuracy, you can substitute the 1K ohm resistor with a resistor that more closely approximates your actual device load.

Calibration Procedure

1. Disconnect your analog device wires from the module's field wiring arm if you are not using a spare field wiring arm for calibration.

MAX

2. Attach a resistor with a value of 1K or greater (to approximate your actual load) across Channel 1 (the top two screws in Figure 6.1) of the field wiring arm.

3. Attach three more 1K resistors across the remaining three channels on the field wiring arm just as you did in Step 2 (Figure 6.1).

4. Place the LAST STATE configuration jumpers (Figure 6.2) in the MAX position (if they are not there already).

5. Select the +10V output range by placing the four channel configuration jumpers in the position shown in Figure 6.2.
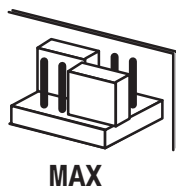
6. Connect the voltmeter leads across the top two screws on the field wiring arm (Channel 1). The top screw is positive, and the second (lower) screw is negative.

7. Turn on the processor, I/O chassis, and the industrial terminal.

Figure 6.1
Resistor Placement on Field Wiring Arm

Field Wiring Arm

1K or greater resistors

Channel 1
Channel 2
Channel 3
Channel 4

A
0
1
2
3
4
5
6
7
8

12898
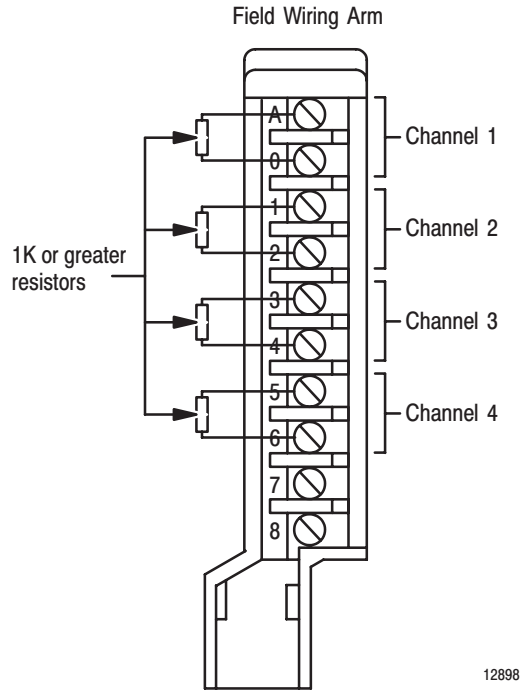
Figure 6.2
LAST STATE Configuration Jumpers

LAST STATE

Printed Circuit Board   Top View

Position plugs as required.

Front of Module

Hold last state   Min   Mid   Max   11918-I
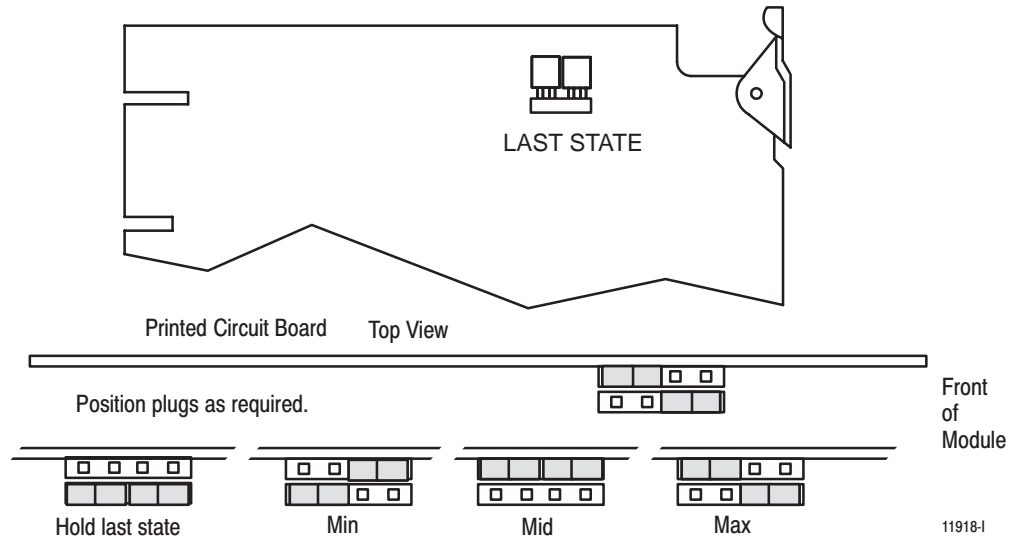
Figure 6.3
Location of Configuration Jumpers and Resistor Pots

Configuration Jumpers
(set for +10V scale)

Channel 0 — R67 R66

Channel 1 — R74 R73

Channel 2 — R81 R80

Channel 3 — R88 R87

Resistor Potentiometers
Adjustment Screws
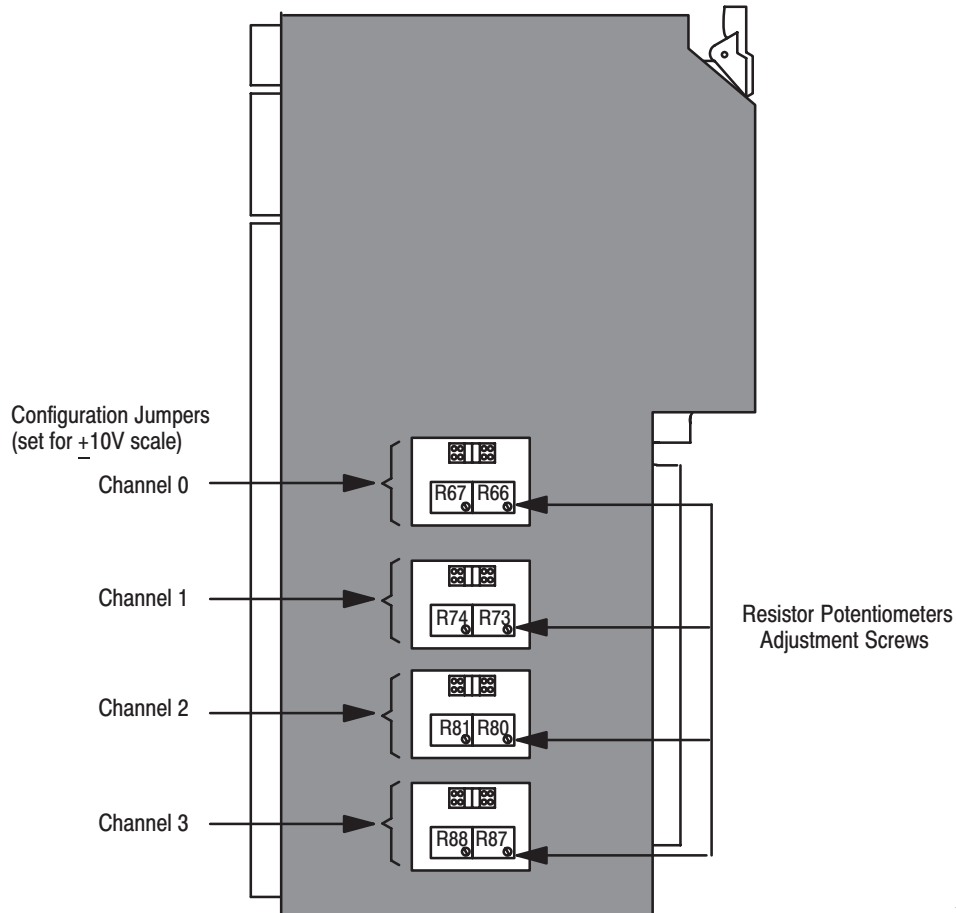
12993
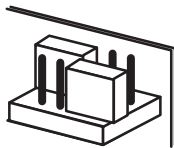
MAX
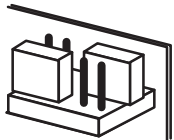
MIN
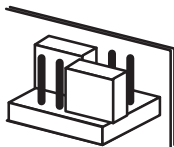
MAX

8. Place the processor in the TEST or PROG mode.

9. Output full scale (+10V) either with write block transfer data or by placing the LAST STATE configuration jumpers in the **MAX** position.

10. Adjust R66 until the reading is 10V +1mV.

11. Output -10V either with write block transfer data or by placing the LAST STATE configuration jumpers in the **MIN** position.

12. Adjust R67 until the reading is one-half the difference between -10V and the initial reading.

13. Output full scale (+10V) again, either with write block transfer data or by placing the LAST STATE configuration jumpers in the **MAX** position.

14. Adjust R66 again until the reading is 10V +1mV.

15. Reconnect the voltmeter to the appropriate screws on the field wiring arm. Repeat Steps 9 through 14 for Channels 2, 3, and 4, until you obtain the desired tolerance. Table 6.B lists the appropriate resistor pots for each channel.

Table 6.B
Resistor Pots

Channel	Resistor Pots
1	R66, R67
2	R73, R74
3	R80, R81
4	R87, R88

16. Turn off power to the module.

17. Return the LAST STATE configuration jumpers to the position they were in before you started calibration.

18. Return the channel configuration jumpers to their original positions.

19. Remove the extender card and return the circuit board to the module.

20. Replace the module covers.

21. Return the module to the I/O rack.

22. Replace your analog device wires (or the original field wiring arm if you used a spare for calibration purposes).

Your module should now be properly calibrated and ready for use.

Current Output Version (1771-OFE2)

Preparation for Calibration

1. Turn off the processor and I/O chassis power.

2. Remove the analog output module from the I/O chassis.

3. Remove the module covers.

4. Connect the backplane extender card (cat no. 1771-EX) to the circuit board.

5. Insert the extender card/circuit board assembly in the I/O chassis.

6. Reconnect the field wiring arm.

Channel Calibration

**1.** Disconnect your analog device wires from the module's field wiring arm.

Important: If you have a spare or unused field wiring arm, you may want to temporarily switch it with the module's present field wiring arm. You can use this spare arm for test purposes in order to avoid disconnecting your analog device wires.

Important: The accuracy of this calibration procedure is dependent upon the precision of your load resistors. We suggest using resistors with a tolerance of 0.01%. You should be able to attain voltage readings to $\pm2mV$. (If you use resistors of a value different from 250 ohms, you should be able to attain voltage readings of $\pm0.05\%$ of V out.) If you require greater accuracy, you need to use load resistors with tolerances less than 0.01%.

Use load resistors with values of 250 ohms. For greater accuracy, you can use a resistor that more closely approximates your actual device load.

2. Attach a resistor with a value of 250 ohms across Channel 1 (the top two screws) of the field wiring arm.

3. Attach three more 250 ohm resistors across the remaining three channels on the field wiring arm just as you did in step 2 (Figure 6.4).
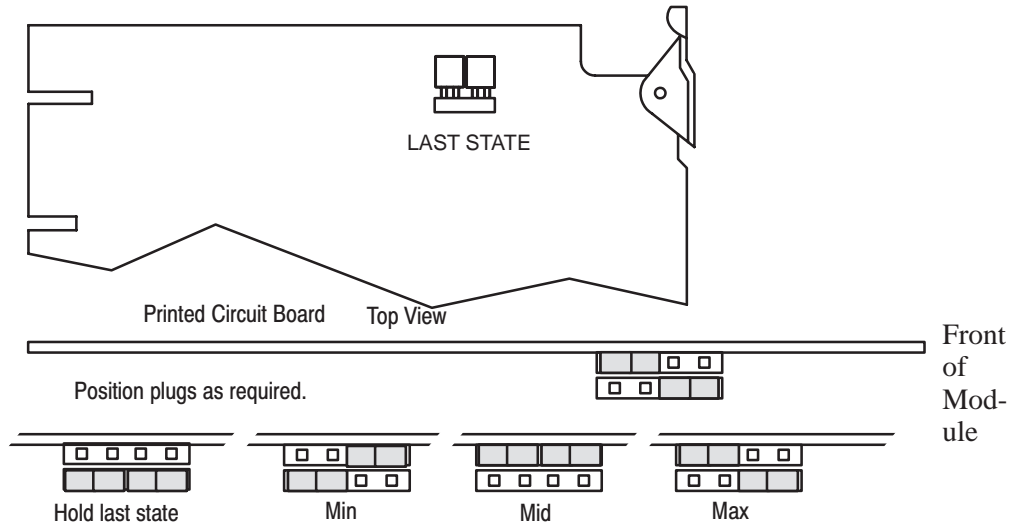
Figure 6.4
Resistor Placement on Field Wiring Arm
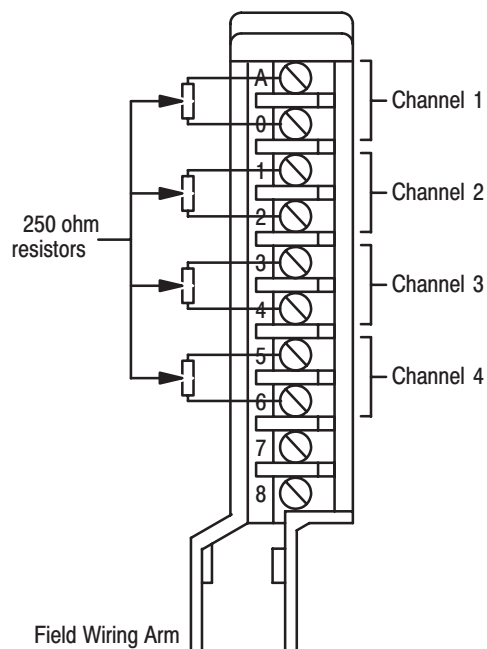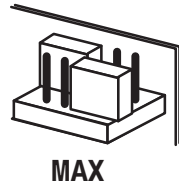
4. Place the LAST STATE configuration jumpers (Figure 6.5) in the MAX position (if they are not there already).

MAX

Figure 6.5
LAST STATE Configuration Jumpers in MAX Position

LAST STATE

Printed Circuit Board   Top View

Position plugs as required.

Hold last state   Min   Mid   Max

Front
of
Mod-
ule

11919-I

5. Connect the voltmeter leads across the top two screws on the field wiring arm (Channel 1). The top screw is positive, and the second (lower) screw is negative.

6. Turn on the processor, I/O chassis, and the industrial terminal.

7. Place the processor in the TEST or PROG mode.

8. Output full scale (+20mA) either with write block transfer data or by placing the LAST STATE configuration jumpers in the **MAX** position.

MAX

9. Adjust R66 until the reading is +5V (20mA) +2mV (Figure 6.6).

10. Output +4mA (1V - minimum scale) either with write block transfer data or by placing the LAST STATE configuration jumpers in the **MIN** position.

MIN

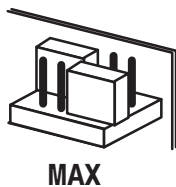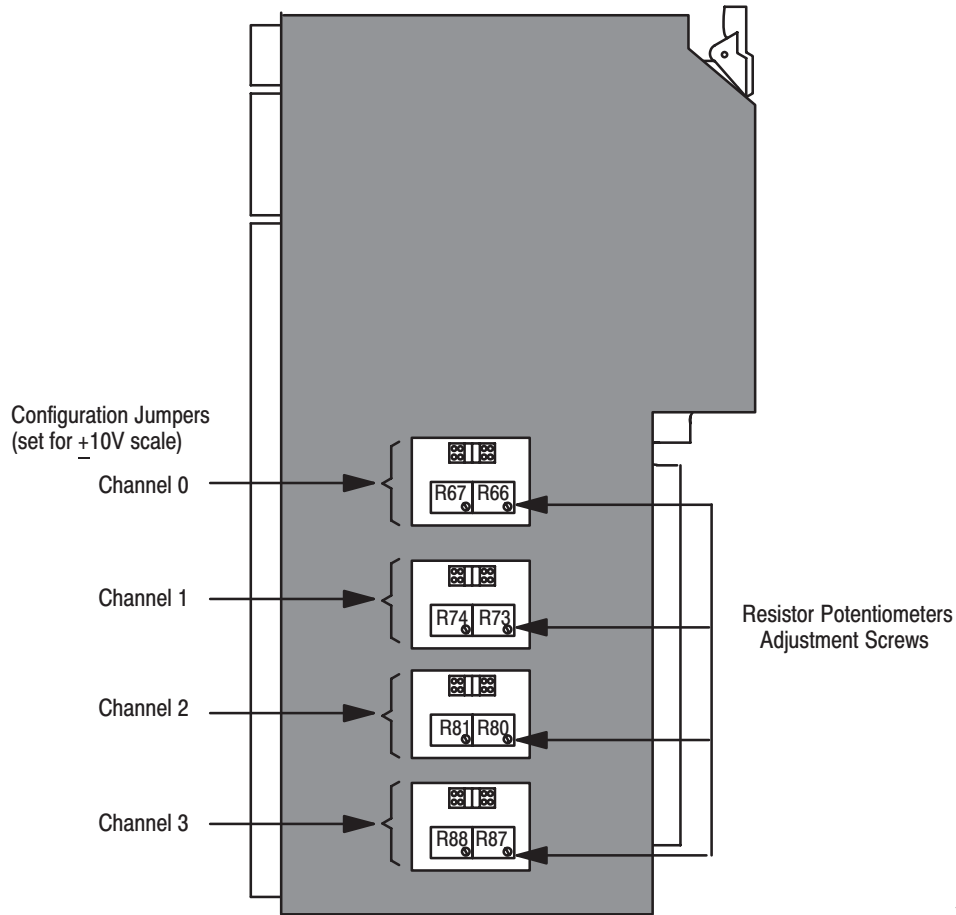**11.** Adjust R67 until the reading is 3/4 the difference between 1V and the initial minimum scale reading.
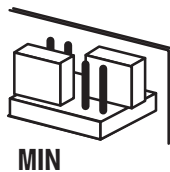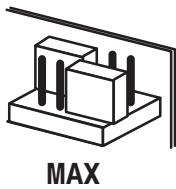
Figure 6.6
Location of Resistor Pots

Configuration Jumpers
(set for +10V scale)

Channel 0

R67 R66

Channel 1

R74 R73

Channel 2

R81 R80

Channel 3

R88 R87

Resistor Potentiometers
Adjustment Screws

12993

MAX

12. Output full scale (+20mA) again, either with write block transfer data or by placing the LAST STATE configuration jumpers in the MAX position.

13. Adjust R66 until the reading is 5V +2mV.

14. Reconnect the voltmeter to the appropriate screws on the field wiring arm. Repeat Steps 8 through 13 for Channels 2, 3, and 4 until the desired tolerance is obtained. Table 6.C lists the appropriate resistor pots.

Table 6.C
Resistor Pots

Channel	Resistor Pots
1	R66, R67
2	R73, R74
3	R80, R81
4	R87, R88

15. Remove the extender card and return the circuit board to the module.

16. Replace the LAST STATE configuration jumpers to their original position.

17. Replace the module covers.

18. Return the module to the I/O rack.

19. Replace your analog device wires (or the original field wiring arm if you used a spare for calibration procedures).

Your module should now be properly calibrated and ready for use.

Current Output Version (1771-OFE3)

Preparation for Calibration

1. Turn off power to the processor and I/O chassis.

2. Remove the analog output module from the I/O chassis.

3. Remove the module covers.

4. Connect the backplane extender card (cat. no. 1771-EX) to the circuit board and insert the extender card into the I/O chassis.

5. Reconnect the wiring arm to the circuit board.

Channel Calibration

**1.** Disconnect your analog device wiring from the module's wiring arm.

Important: If you have a spare or unused field wiring arm, you may want to temporarily switch it with the module's present wiring arm. Use the spare wiring arm for test and calibration purposes to eliminate disconnecting your device wiring.

Important: The accuracy of this calibration procedure depends on the precision of the load resistors used. Use resistors with a tolerance of 0.01%. You should be able to obtain voltage readings to $\pm$5mV. (If you use resistors of a value different from 250 ohms, you should be able to obtain voltage readings of $\pm$0.05% of V out). If you require greater accuracy, use load resistors with tolerances less than 0.01%.
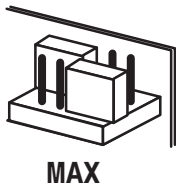
If greater accuracy is required, substitute resistors that more closely approximate your actual device load.

2. Attach 250 ohm resistor across Channel 1 (the top two screws) on the field wiring arm.

Figure 6.7
Resistor Placement on Field Wiring Arm

250 ohm resistors

Channel 1
Channel 2
Channel 3
Channel 4
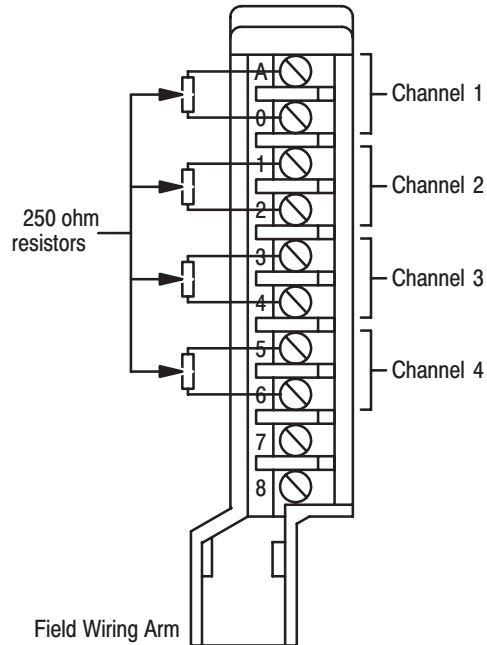
Field Wiring Arm   12991

3. Attach three more 250 ohm resistors across Channels 2, 3, and 4 (Figure 6.7).

4. Place the LAST STATE configuration jumpers in the MAX position (if they are not there already).

MAX

5. Connect a voltmeter across the top two screws on the field wiring arm (top screw is positive, and second screw is negative).

6. Turn processor, I/O chassis, and industrial terminal ON.

7. Place processor in the TEST or PROG mode.

8. Output full scale (+50mA) with write block transfer data.

9. Adjust R66 (Figure 6.6) until the reading is +12.5V (50mA) +5mV.

10. Repeat steps 8 and 9 for channels 2, 3 and 4. Adjust as necessary until the desired tolerance is obtained. Associated resistor potentiometers are shown in Table 6.D.

Table 6.D
Resistor Potentiometers

Channel	Resistor Potentiometer
1	R66
2	R73
3	R80
4	R87

11. Remove the extender card and circuit board from chassis.

12. Replace Last State configuration jumpers to their original position.

13. Replace the module covers and insert the module into the I/O chassis.

14. Replace field wiring on field wiring arm (or position original wiring arm on module if you used a spare field wiring arm for this calibration procedure).

Your module is now properly calibrated and ready for use.

Chapter Summary

In this chapter, you learned how to calibrate your module using simple test equipment.

Diagnostics and Troubleshooting

Chapter Objectives

In this chapter, you will read how to troubleshoot your output module using indicator lights and diagnostic bits.

Interpreting the Indicator Lights

The front panel of the module contains a green RUN and a red FLT (fault) indicator (Figure 7.1). At power-up, the red FLT indicator lights and remains ON during an initial module self-check . If a fault is found initially or occurs later, the red FLT indicator stays lit. If a fault is not found, the red indicator will turn off and the green RUN indicator will turn on and remain on. Possible module fault causes and corrective actions are shown in Table 7.A.

Figure 7.1
Diagnostic Indicators
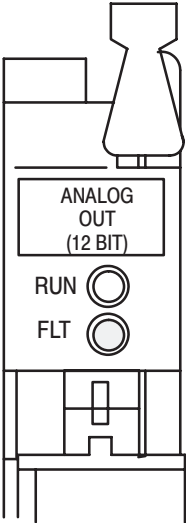
17948

Table 7.A
Troubleshooting Chart

Condition	Possible Cause	Recommended Action
Green RUN indicator does not come on.	No Power to Module Bad internal fuse	• Check I/O chassis for power. • Turn off power to I/O chassis. Remove and reinsert module into chassis. Return power to I/O chassis.
Red FAULT indicator is on continuously with the processor in program and run modes.	Unsuccessful Power-Up • EPROM Fault • Checksum Error	• Cycle power. • Replace faulty module if necessary.
Block transfers are not being performed.	• Block Transfer Instructions Programmed Incorrectly • Module has failed self-diagnostics.	• Check user program . • Cycle power. • Replace faulty module if necessary.

Read Block Transfer Status Words

The module allows a five-word read block transfer for rudimentary program or hardware debugging (Figure 7.2). If a read block transfer request is for more or less than five words, the module will not perform a read block transfer.

Figure 7.2
Word Assignment for Read Block Transfer

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 1	Channel 1 DAC Input Data															
2	Channel 2 DAC Input Data															
3	Channel 3 DAC Input Data															
4	Channel 4 DAC Input Data															
5	Not used	I/O Reset	Reserved											Data Valid		

Important: The user program that utilizes the read block transfer must make sure that bits 06 and 07 (the write enable and read enable request bits) of the MCB are not set simultaneously.

The first four words of the read block transfer show the actual 12 bits of data sent to the module's digital-to-analog converters (DACs). The first four words in the read block transfer appear in 12-bit binary format regardless of the module's mode of operation (BCD or 12-bit binary).

The fifth word contains the status of each DAC word; that is, whether data is out of range or scaling is improperly programmed. The fifth word also indicates that I/O RESET has been established (when the processor is in the PROG/TEST or RUN mode).

Word	Bits	Description
5	Bits 00-03	When set, indicate invalid channel data is sent to the module. These bits are not reset until a correct write block transfer is sent. Bit 03 corresponds to Channel 4, Bit 02 to Channel 3, and so on.
	Bit 16	Is the I/O RESET bit. When set, it indicates that the processor is in TEST or PROGRAM mode (i.e., block transfer data is not being written to the module).

Chapter Summary

In this chapter you learned how to use the indicator lights and word 5 in the BTR for troubleshooting your module.

Specifications

Outputs per Module	4 Individually Isolated
Module Location	Bulletin 1771 I/O Chassis – One Slot
Output Voltage Ranges (Nominal) – 1771-OFE1	+1 to +5V DC –10 to +10V DC 0 to +10V DC
Output Current (maximum)	10mA per Channel in Voltage Mode (1771–OFE1)
Output Current Ranges (Nominal)	+4 to +20mA (1771–OFE2) 0 to +50mA (1771–OFE3)
Digital Resolution	12-Bit Binary – 1 Part in 4095
Output Capacitance	0.01µF (Voltage Outputs) 0.022µF (Current Outputs)
Output Impedance	<0.25 ohms for Voltage Outputs Exclusive of Contact Wiring Resistance >1.5 megohms for Current Outputs
Max Loop Impedance in the Current Mode	1771-OFE2 – Up to 1200 ohms Load Resistance 1771-OFE3 – Up to 400 ohms Load Resistance
Output Overload Protection	All outputs are protected against short circuit load conditions not to exceed one minute.
Backplane Power	1771-OFE1　　　　1.50A 1771-OFE2　　　　1.50A 1771-OFE3　　　　2.50A
Power Dissipation	1771-OFE1　　　　7.9W 1771-OFE2　　　　7.9W 1771-OFE3　　　　13.1W
Thermal Dissipation	1771-OFE1　　　　26.9 BTU/hr 1771-OFE2　　　　26.9 BTU/hr 1771-OFE3　　　　44.5 BTU/hr
Isolation	1000V rms Between Output Channels Tested at 1500V (Transient) for 1s Between the Output Circuit and the Control Logic (System Side)
D/A Converter Specifications Settling Time	0.8 ms Maximum for a Resistive Load
Internal Scan Rate	8.0 ms for All Channels Using BCD Data and Scaling 1.6 ms for All Channels Using Binary Data and No Scaling
Accuracy (Including Linearity, Gain, and Offset at 25ºC)	+0.1% of Full Scale +1/2 LSD (BCD Mode) +1/2 LSB (BINARY Mode)
Temperature Coefficient	+50 ppm/ºC of Full Scale Range
Specifications continued on next page	

Environmental Conditions Operational Temperature: Storage Temperature: Humidity Rating:	0°C to +60°C (+32°F to +140°F) −40°C to +85°C (−40°F to +185°F) 5% to 95% (Non−Condensing)
Field Wiring Arm	Catalog No. 1771-WC
Field Wiring Arm Screw Torque	7-9 pound-inches (0.6−1.1Nm)
Agency Certification (when product or packaging is marked)	• CSA certified • CSA Class I, Division 2, Groups A, B, C, D certified Hazardous or non-hazardous locations • UL listed • UL Class I, Division 2, Groups A, B, C, D certified Hazardous or non-hazardous locations • CE marked for all applicable directives

Block Transfer with Mini-PLC-2 and PLC-2/20 Processors

Multiple GET Instructions

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 write 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 B.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) to which or from which the data is transferred. The file address is stored in Word 130, 100_8 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 that the module is in the lower slot and that this is a block transfer read operation (if this were a block transfer write operation, "07" would be replaced by "06").

Important: The OUTPUT ENERGIZE Address 012/07 in this example indicates that the module is in Slot 0. The address could be 012/17, which indicates that the module is in Slot 1 (012/06 or 012/16 for a write operation).

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 six 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 B.1
Multiple GET Instructions
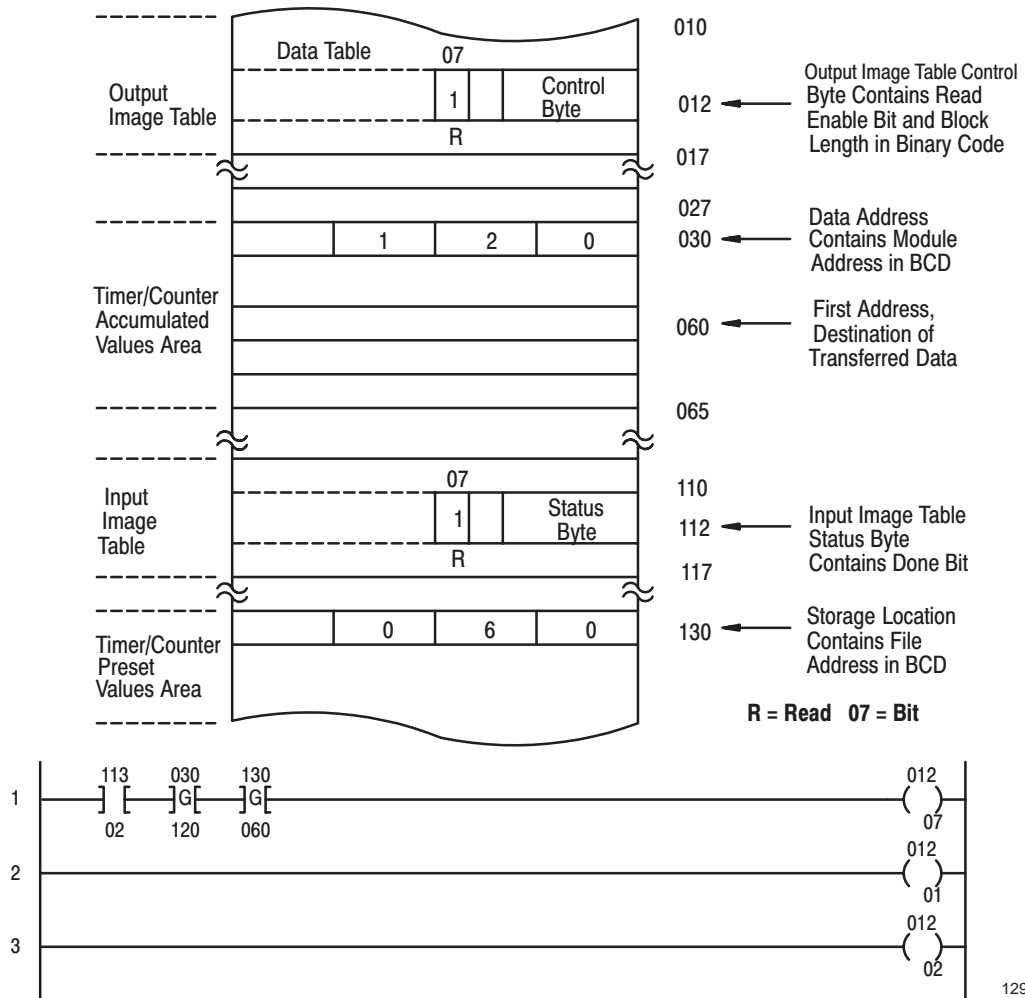
Setting the Block Length (Multiple GET Instructions Only)

The output module is capable of transferring up to 13 words in one program scan. The number of words transferred is determined by the block length entered in the output image table control byte.

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 B.2 shows if your output module is set up to transfer five words, you would set Bits 00 and 02 of the lower output image table control byte. The binary equivalent of five words, as stated in the look-up table, is 000101.

Figure B.2
Setting Block Length

Block Transfer Read Enable Bit

Read 5 Words from Module

For Block Transfer Active Operations Only

| 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |

Output Image Table

Data Table

| | 1 | | Control Byte | 010 |

010

012 — Output Image Table Control Byte Contains Read Enable Bit and Block Length in Binary Code

R

017

027

030 — Data Address Contains Module Address in BCD

| 1 | 2 | 0 |
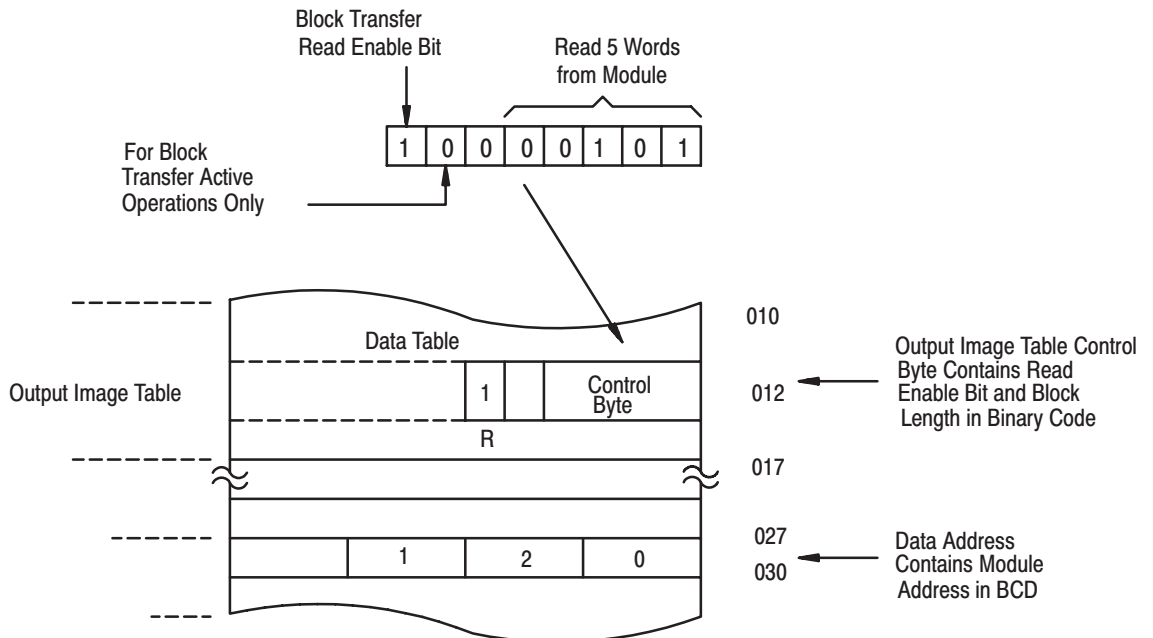
Number of Words to Transfer	Binary Bit Pattern Lower Output Image Table Byte					
	05	04	03	02	01	00
Default	0	0	0	0	0	0
1	0	0	0	0	0	1
2	0	0	0	0	1	0
3	0	0	0	0	1	1
4	0	0	0	1	0	0
5	0	0	0	1	0	1
6	0	0	0	1	1	0
↓	↓	↓	↓	↓	↓	↓
13	0	0	1	1	0	1

12995

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

$$0 \times 2^3 = 0$$
$$0 \times 2^2 = 0$$
$$0 \times 2^1 = 0 \quad \Big\} \ 1$$
$$1 \times 2^0 = 1$$

$$0 \times 2^3 = 0$$
$$0 \times 2^2 = 0$$
$$1 \times 2^1 = 2 \quad \Big\} \ 2$$
$$0 \times 2^0 = 0$$

$$0 \times 2^3 = 0$$
$$0 \times 2^2 = 0$$
$$1 \times 2^1 = 2 \quad \Big\} \ 3$$
$$1 \times 2^0 = 1$$

$$1 \times 2^3 = 8$$
$$0 \times 2^2 = 0$$
$$0 \times 2^1 = 0 \quad \Big\} \ 9_{10}$$
$$1 \times 2^0 = 1$$

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

   1   2   3   9
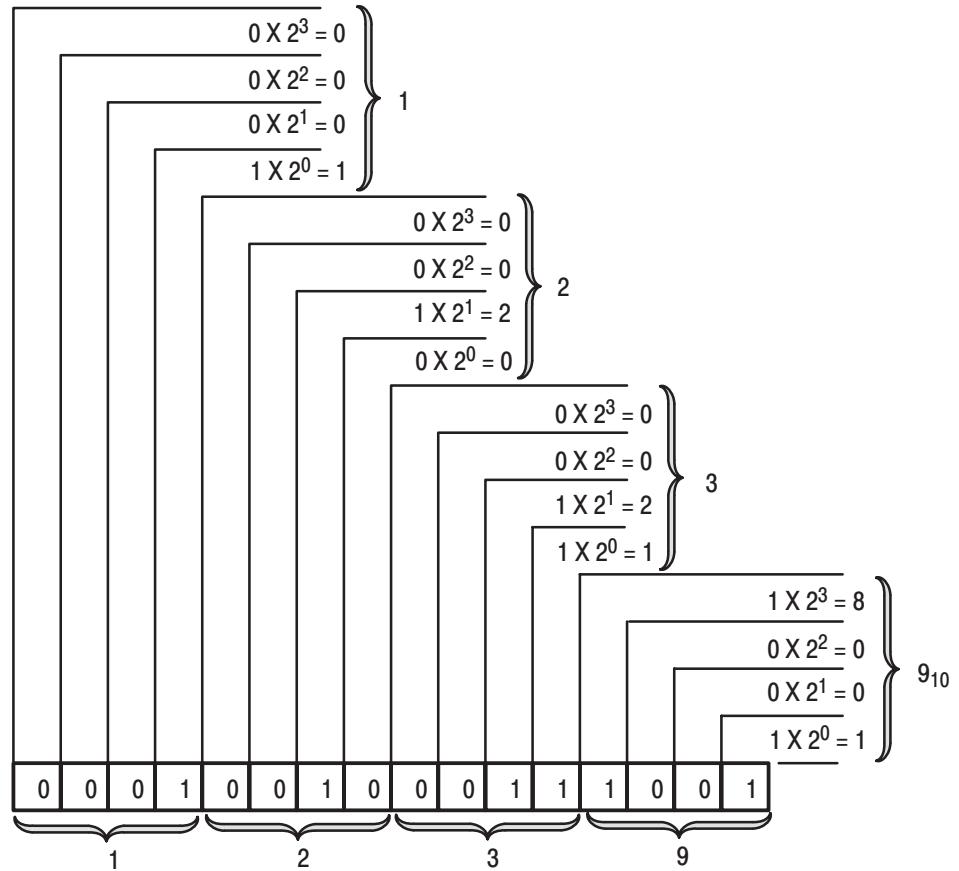
12955-I

Table C.A
BCD Representation

Place Value				Decimal Equivalent
2^3 (8)	2^2 (4)	2^1 (2)	2^0 (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 processsor. 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.

C–4

Table of Contents

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Cat. No. **1771–OFE/B**   Pub. No. **1771–6.5.30**   Pub. Date **November 1998**   Part No. **955124–45**

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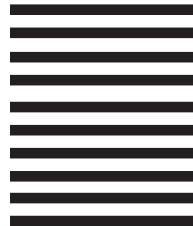
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