Allen-Bradley

MicroLogix™ 1200 and MicroLogix 1500 Programmable Controllers

Bulletins 1762 and 1764

Instruction Set Reference Manual

Rockwell Automation

Important User Information

Solid state equipment has operational characteristics differing from those of electromechanical equipment. *Safety Guidelines for the Application, Installation and Maintenance of Solid State Controls* (Publication SGI-1.1 available from your local Rockwell Automation sales office or online at http://www.ab.com/manuals/gi) describes some important differences between solid state equipment and hard-wired electromechanical devices. Because of this difference, and also because of the wide variety of uses for solid state equipment, all persons responsible for applying this equipment must satisfy themselves that each intended application of this equipment is acceptable.

In no event will Rockwell Automation, Inc. be responsible or liable for indirect or consequential damages resulting from the use or application of this equipment.

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

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

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

WARNING ⚠	Identifies information about practices or circumstances that can cause an explosion in a hazardous environment, which may lead to personal injury or death, property damage, or economic loss.
ATTENTION ⚠	Identifies information about practices or circumstances that can lead to personal injury or death, property damage, or economic loss. Attentions help you: • identify a hazard • avoid a hazard • recognize the consequence
IMPORTANT	Identifies information that is critical for successful application and understanding of the product.

SHOCK HAZARD	Labels may be located on or inside the drive to alert people that dangerous voltage may be present.

The information below summarizes the changes to this manual since the last printing as publication 1762-RM001E-EN-P, October 2003.

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

Firmware Revision History

Features are added to the controllers through firmware upgrades. See the latest release notes, 1762-RN001, to be sure that your controller's firmware is at the level you need. Firmware upgrades are not required, except to allow you access to the new features. *See "Firmware Upgrades" on page 5 for details.*

Firmware Upgrades

Enhanced features are added to the controllers through a firmware upgrade. *This firmware upgrade is not required, except to allow you access to the latest features.* To use the newest features, be sure your controller's firmware is at the following level:

Programmable Controller	Firmware Revision	Catalog Numbers
MicroLogix 1200	Series C, Revision H, FRN12	1762-L24AWA, -L24BWA, - L24BXB, -L40AWA, -L40BWA and -L40BXB controllers
MicroLogix 1500	Series C, Revision D, FRN9	1764-LSP, -LRP processors

To upgrade the firmware for a MicroLogix controller visit the MicroLogix web site at http://www.ab.com/micrologix.

To use all of the latest features, RSLogix 500 programming software must be version 6.10.10 or higher.

New Information

The table below lists pages of this manual where new information appears.

For This New Information	See Page
Added 1762-IQ32T digital input module	20
Added 1762-OX6I digital output module.	20
Added 1762-1762-OV32T, 1762-OB32T digital output module	21
Added 1762-OF4 analog output module.	24
Added 1769-IQ16F and 1769-IQ32 digital input modules.	31
Added 1769-OB8 and 1769-OB32 digital output modules.	34
Added reference to 1769-SM1 Compact I/O to DPI/SCANport Module.	44
For memory module information function file, added functionality types 4 and 5 for MM2 and MM2RTC.	77
Added notes about using the Channel Status screen in RSLogix 500 to reset communication diagnostic counters. For the new MicroLogix 1500 (1764-LRP only) FRN 8, the Clear function resets both channel 0 and channel 1. Previously, only channel 0 would be reset. The Channel Status screen is unique for each protocol. Therefore, examples of the RSLogix 500 screens were added below each Diagnostic Counter Block definition table.	87 to 97

For This New Information	See Page
Added DF1 Half-Duplex Master Diagnostic Counters Block (MicroLogix 1200, FRN 7 and higher MicroLogix 1500 1764-LSP, FRN 8 and higher MicroLogix 1500 1764-LRP, FRN 8 and higher [Channel 1 only]) of Comms Status file.	91
Added DF1 Radio Modem Diagnostic Counters Block (MicroLogix 1200, FRN 7 and higher MicroLogix 1500 1764-LSP, FRN 8 and higher MicroLogix 1500 1764-LRP, FRN 8 and higher [Channel 1 only] of Comms Status file.	92
Added Modbus RTU Master Diagnostic Counters Block (Presentation Layer) of Comms Status file.	95
Modified Active Node Table Block information to reflect addition of new communication options and added Active Node Table screenshot from RSLogix 500.	98
For the Pulse Train Output (PTO) Function, added a NOTE that the accelerate/decelerate intervals are no longer required to be the same. Independent values can now be defined for these intervals.	148
Updated RSLogix 500 screen shot of PTO Function File to show new ADI bit.	153
Updated to show new ADI bit.	154
Added section: PTO Accel/Decel Pulses Independent (ADI).	161
Revised section: PTO Accel / Decel Pulses or File:Elem, if ADI=1 (ADP).	162
Added Error Code -3 (Undefined Accel/Decel) to PTO list of error codes.	167
Added footnote regarding Masked Move Instruction (MVM) enhancement.	241
For PID instruction parameter, Control Variable Percent (CVP), changed “User Program Access” from “read/write” to “status read”, and modified text below CVP table to correct previously incorrect information.	324
Added .DATA[n] sub-element addressing format to section that describes Addressing String Files.	353
Added NOTE about using the ASCII Clear Buffers (ACL) instruction to clear DF1 communication buffers.	356
Added DF1 Half-Duplex Master and Modbus RTU Master to list of protocols that can be used for messaging.	386
Modified Message File Sub-Elements configuration information to reflect addition of Modbus Master.	392
Added Message File Target Location Information for Target Device = Modbus Device and the FRN level that supports this.	395
Added Modbus messaging information to the Message File Sub-Element 17 - Status Bits table.	396
Added information about how the MSG instruction Start (ST) Bit works with DF1 Radio Modem and Modbus RTU Master protocols.	399
In the Configuring a Local Message section, added message configuration information regarding communications modules (1769-SDN and 1769-SM1) and protocols (Modbus, Radio Modem).	408 to 417
In the Local Messaging Examples section, added information about configuring a Modbus RTU message type.	417
In 2nd paragraph, changed "CIP stands for ‘Control & Information Protocol’" to "CIP stands for ‘Common Industrial Protocol’"	426
In the Local Messaging Examples section, added Example 5 - Configuring a Modbus Message.	432
Added Modbus Error Codes to the list of MSG instruction error codes.	441
Added Expansion I/O Communication Module Error to the list of MSG instruction error codes.	442
Added section about S:4 Free Running Clock Comparison for SLC 500 and MicroLogix Controllers.	491
Added Notes to RTC status addresses that the status value does not update while viewing online with RSLogix 500. The value needs to be monitored in the RTC function file.	501
Added Error Codes 0042 (invalid recipe number) and 0044 (invlaid write to RTC function file).	512
Added DF1 Radio Modem to list of supported protocols.	517
Added section describing DH-485 Broadcast Messages.	519
Revised section on DF1 Half-Duplex Protocol to add DF1 Half-Duplex Master protocol information and information on Broadcast Messages.	523
Added new section: DF1 Radio Modem Protocol	535
Added Modbus Master information to section on Modbus RTU Protocol.	544 to 555
Added new Appendix: Knowledgebase Quick Starts, for configuring function file applications.	559
Added list of Function Files to List of Instructions on the inside back cover page of the manual.	

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Recipe (MicroLogix 1500 only) and Data Logging (MicroLogix 1500 1764-LRP Processor only)

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MicroLogix 1500 Memory Usage and Instruction Execution Time

Appendix B

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Appendix C

Fault Messages and Error Codes

Appendix D

Preface

Read this preface to familiarize yourself with the rest of the manual. It provides information concerning:

- who should use this manual
- the purpose of this manual
- related documentation
- conventions used in this manual
- Rockwell Automation support

Who Should Use this Manual

Use this manual if you are responsible for designing, installing, programming, or troubleshooting control systems that use MicroLogix 1200 or MicroLogix 1500 controllers.

You should have a basic understanding of electrical circuitry and familiarity with relay logic. If you do not, obtain the proper training before using this product.

Purpose of this Manual

This manual is a reference guide for MicroLogix 1200 and MicroLogix 1500 controllers. It describes the procedures you use to program and troubleshoot your controller. This manual:

- gives you an overview of the file types used by the controllers
- provides the instruction set for the controllers
- contains application examples to show the instruction set in use

Common Techniques Used in this Manual

The following conventions are used throughout this manual:

- Bulleted lists such as this one provide information, not procedural steps.
- Numbered lists provide sequential steps or hierarchical information.
- *Italic* type is used for emphasis.
- Change bars appear beside information that has been changed or added since the last revision of this manual. Change bars appear in the margin as shown to the right of this paragraph.

Related Documentation

The following documents contain additional information concerning Rockwell Automation products. To obtain a copy, contact your local Rockwell Automation office or distributor.

For	Read this Document	Document Number
Information on mounting and wiring the MicroLogix 1200 Programmable Controller, including a mounting template and door labels.	MicroLogix 1200 Programmable Controllers Installation Instructions	1762-IN006
Detailed information on planning, mounting, wiring, and troubleshooting your MicroLogix 1200 system.	MicroLogix 1200 Programmable Controllers User Manual	1762-UM001
Information on mounting and wiring the MicroLogix 1500 Base Units, including a mounting template for easy installation	MicroLogix 1500 Programmable Controllers Base Unit Installation Instructions	1764-IN001
Detailed information on planning, mounting, wiring, and troubleshooting your MicroLogix 1500 system.	MicroLogix 1500 Programmable Controllers User Manual	1764-UM001
A description on how to install and connect an AIC+. This manual also contains information on network wiring.	Advanced Interface Converter (AIC+) User Manual	1761-6.4
Information on how to install, configure, and commission a DNI	DeviceNet™ Interface User Manual	1761-6.5
Information on DF1 open protocol.	DF1 Protocol and Command Set Reference Manual	1770-6.5.16
In-depth information on grounding and wiring Allen-Bradley programmable controllers	Allen-Bradley Programmable Controller Grounding and Wiring Guidelines	1770-4.1
A description of important differences between solid-state programmable controller products and hard-wired electromechanical devices	Application Considerations for Solid-State Controls	SGI-1.1
An article on wire sizes and types for grounding electrical equipment	National Electrical Code - Published by the National Fire Protection Association of Boston, MA.	
A glossary of industrial automation terms and abbreviations	Allen-Bradley Industrial Automation Glossary	AG-7.1

Rockwell Automation Support

Before you contact Rockwell Automation for technical assistance, we suggest you please review the troubleshooting information contained in this publication first.

If the problem persists, call your local distributor or contact Rockwell Automation in one of the following ways:

Phone	United States/Canada	1.440.646.3434
	Outside United States/Canada	You can access the phone number for your country via the Internet: 1. Go to http://www.ab.com 2. Click on *Product Support* (http://support.automation.rockwell.com) 3. Under *Support Centers*, click on *Contact Information*
Internet	⇒	1. Go to http://www.ab.com 2. Click on *Product Support* (http://support.automation.rockwell.com)

I/O Configuration

This section discusses the various aspects of Input and Output features of the MicroLogix 1200 and MicroLogix 1500 controllers. Each controller comes with a certain amount of *embedded I/O*, which is physically located on the controller. The controller also allows for adding *expansion I/O*.

This section discusses the following I/O functions:

Embedded I/O

The MicroLogix 1200 and 1500 provide discrete I/O that is built into the controller as listed in the following table. These I/O points are referred to as Embedded I/O.

Controller Family		Inputs		Outputs	
		Quantity	Type	Quantity	Type
MicroLogix 1200 Controllers	1762-L24BWA	14	24V dc	10	relay
	1762-L24AWA	14	120V ac	10	relay
	1762-L24BXB	14	24V dc	10	5 relay 5 FET
	1762-L40BWA	24	24V dc	16	relay
	1762-L40AWA	24	120V ac	16	relay
	1762-L40BXB	24	24V dc	16	8 relay 8 FET

MicroLogix 1500 Base Units	1764-24BWA	12	24V dc	12	relay
	1764-24AWA	12	120V ac	12	relay
	1764-28BXB	16	24V dc	12	6 relay 6 FET

AC embedded inputs have fixed input filters. DC embedded inputs have configurable input filters for a number of special functions that can be used in your application. These are: high-speed counting, event interrupts, and latching inputs. The 1764-28BXB has two high-speed outputs for use as pulse train output (PTO) and/or pulse width modulation (PWM) outputs. The 1762-L24BXB and -L40BXB each have one high-speed output.

MicroLogix 1200 Expansion I/O

If the application requires more I/O than the controller provides, you can attach I/O modules. These additional modules are called *expansion I/O*.

Expansion I/O Modules

MicroLogix 1200 expansion I/O (Bulletin 1762) is used to provide discrete and analog inputs and outputs, and specialty modules. For the MicroLogix 1200, you can attach up to six additional I/O modules. The number of 1762 I/O modules that can be attached to the MicroLogix 1200 is dependent on the amount of power required by the I/O modules.

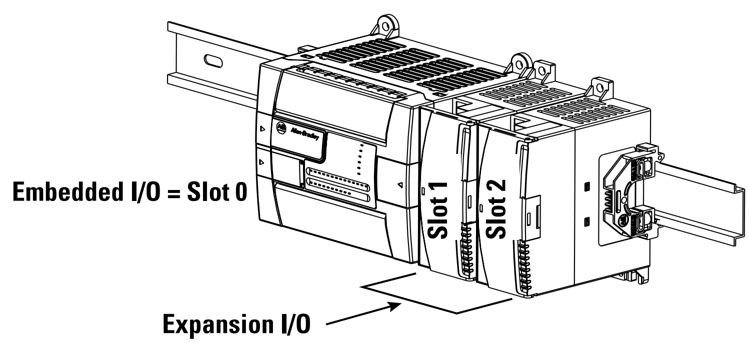
See the *MicroLogix 1200 User Manual*, publication 1762-UM001 for more information on valid configurations.

TIP Visit the MicroLogix web site (http://www.ab.com/micrologix.) for the MicroLogix 1200 Expansion I/O System Qualifier.

Addressing Expansion I/O Slots

The figure below shows the addressing for the MicroLogix 1200 and its I/O.

The expansion I/O is addressed as slots 1 through 6 (the controller's embedded I/O is addressed as slot 0). Modules are counted from left to right as shown below.



TIP In most cases, you can use the following address format: X:s/b (X = file type letter, s = slot number, b = bit number)

See I/O Addressing on page 46 for complete information on address formats.

MicroLogix 1200 Expansion I/O Memory Mapping

Discrete I/O Configuration

1762-IA8 and 1762-IQ8 Input Image

For each input module, the input data file contains the current state of the field input points. Bit positions 0 through 7 correspond to input terminals 0 through 7.

Word	Bit Position															
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	x	x	x	x	x	x	x	x	r	r	r	r	r	r	r	r

r = read only, x = not used, always at a 0 or OFF state

1762-IQ16 Input Image

For each input module, the input data file contains the current state of the field input points. Bit positions 0 through 15 correspond to input terminals 0 through 15.

Word	Bit Position															
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r

r = read only

1762-IQ32T Input Image

For each input module, the input data file contains the current state of the field input points. Bit positions 0…15 together with word 0/1 correspond to input terminals 0…31.

Word	Bit Position															
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r
1	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r

r = read only

1762-OX6I Output Image

For each output module, the output data file contains the controller-directed state of the discrete output points. Bit positions 0 through 5 correspond to output terminals 0 through 5.

Word	Bit Position															
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0	0	0	r/w	r/w	r/w	r/w	r/w	r/w

r/w = read and write, 0 = always at a 0 or OFF state

1762-OA8, 1762-OB8, and 1762-OW8 Output Image

For each output module, the output data file contains the controller-directed state of the discrete output points. Bit positions 0 through 7 correspond to output terminals 0 through 7.

Word	Bit Position															
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w

r/w = read and write, 0 = always at a 0 or OFF state

1762-OB16 and 1762-OW16 Output Image

For each output module, the output data file contains the controller-directed state of the discrete output points. Bit positions 0 through 15 correspond to output terminals 0 through 15.

Word	Bit Position															
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w

r/w = read and write

1762-OV32T, 1762-OB32T Output Image

For each output module, the output data file contains the controller-directed state of the discrete output points. Bit positions 0…15 together with word 0/1 correspond to output terminals 0…31.

Word	Bit Position															
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
1	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w

r/w = read and write

Analog I/O Configuration

The following table shows the data ranges for 0 to 10V dc and 4 to 20 mA.

Valid Input/Output Data Word Formats/Ranges

Normal Operating Range	Full Scale Range	Raw/Proportional Data	Scaled-for-PID
0 to 10V dc	10.5V dc	32760	16380
	0.0V dc	0	0
4 to 20 mA	21.0 mA	32760	16380
	20.0 mA	31200	15600
	4.0 mA	6240	3120
	0.0 mA	0	0

1762-IF2OF2 Input Data File

For each input module, slot x, words 0 and 1 contain the analog values of the inputs. The module can be configured to use either raw/proportional data or scaled-for-PID data. The input data file for each configuration is shown below.

Raw/Proportional Format

Word	Bit Position															
	15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	0	Channel 0 Data 0 to 32768												0	0	0
1	0	Channel 1 Data 0 to 32768												0	0	0
2	reserved															
3	reserved															
4	reserved														S1	S0
5	U0	O0	U1	O1	reserved											

Scaled-for-PID Format

Word	Bit Position															
	15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	0	0	Channel 0 Data 0 to 16,383												0	0
1	0	0	Channel 1 Data 0 to 16,383												0	0
2	reserved															
3	reserved															
4	reserved														S1	S0
5	U0	O0	U1	O1	reserved											

The bits are defined as follows:

- Sx = General status bits for channels 0 and 1. This bit is set when an error (over- or under-range) exists for that channel, or there is a general module hardware error.

- Ox = Over-range flag bits for channels 0 and 1. These bits can be used in the control program for error detection.
- Ux = Under-range flag bits for channels 0 and 1. These bits can be used in the control program for error detection.

1762-IF2OF2 Output Data File

For each module, slot x, words 0 and 1 contain the channel output data.

Raw/Proportional Format

Word	Bit Position															
	15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	0	Channel 0 Data 0 to 32,768												0	0	0
1	0	Channel 1 Data 0 to 32,768												0	0	0

Scaled-for-PID Format

Word	Bit Position															
	15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	0	0	Channel 0 Data 0 to 16,383												0	0
1	0	0	Channel 1 Data 0 to 16,383												0	0

1762-IF4 Input Data File

For each module, slot x, words 0 and 1 contain the analog values of the inputs. The module can be configured to use either raw/proportional data or scaled-for-PID data. The input data file for either configuration is shown below.

1762-IF4 Input Data File

Word	Bit Position															
	15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	SGN0	Channel 0 Data														
1	SGN1	Channel 1 Data														
2	SGN2	Channel 2 Data														
3	SGN3	Channel 3 Data														
4	reserved												S3	S2	S1	S0
5	U0	O0	U1	O1	U2	O2	U3	O3	reserved							
6	reserved															

The bits are defined as follows:

- Sx = General status bits for channels 0 through 3. This bit is set when an error (over- or under-range) exists for that channel, or there is a general module hardware error.
- Ox = Over-range flag bits for channels 0 through 3. These bits are set when the input signal is above the user-specified range. The module continues to convert data to the maximum full range value during an over-range condition. The bits reset when the over-range condition clears.
- UIx = Under-range flag bits for input channels 0 through 3. These bits are set when the input signal is below the user-specified range. The module continues to convert data to the maximum full range value during an under-range condition. The bits reset when the under-range condition clears.
- SGNx = The sign bit for channels 0 through 3.

1762-OF4 Input Data File

For each module, slot x, words 0 and 1 contain the analog output module status data for use in the control program.

1762-OF4 Input Data File

Word	Bit Position															
	15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Reserved												SO3	SO2	SO1	SO0
1	Reserved								UO0	OO0	UO1	OO1	UO2	OO2	UO3	OO3

The bits are defined as follows:

- SOx = General status bits for output channels 0 through 3. This bit is set when an error (over- or under-range) exists for that channel, or there is a general module hardware error.
- OOx = Over-range flag bits for output channels 0 through 3. These bits indicate an input signal above the user range and can be used in the control program for error detection. The module continues to convert analog data to the maximum full range value while this bit is set (1). The bit is reset (0) when the error clears.
- UOx = Under-range flag bits for output channels 0 through 3. These bits indicate an input signal below the user range. They can be used in the control program for error detection. The module continues to convert analog data to the minimum full range value while this bit is set (1). The bit is reset (0) when the error clears.

1762-OF4 Output Data File

For each module, slot x, words 0 through 3 contain the channel output data.

Raw/Proportional Format

Word	Bit Position															
	15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	0	Channel 0 Data 0 to 32,760												0	0	0
1	0	Channel 1 Data 0 to 32,760												0	0	0
2	0	Channel 2 Data 0 to 32,760												0	0	0
3	0	Channel 3 Data 0 to 32,760												0	0	0

Words 0 through 3 contain the analog output data for channels 0 through 3, respectively. The module ignores the “don’t care” bits (0 through 2), but checks the sign bit (15). If bit 15 equals 1, the module sets the output value to 0V or 0 mA.

Scaled-for-PID Format

Word	Bit Position															
	15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	0	0	Channel 0 Data 0 to 16,380												0	0
1	0	0	Channel 1 Data 0 to 16,380												0	0
2	0	0	Channel 2 Data 0 to 16,380												0	0
3	0	0	Channel 3 Data 0 to 16,380												0	0

Words 0 through 3 contain the analog output data for channels 0 through 3, respectively. The module ignores the “don’t care” bits (0 and 1), but checks the sign bit (15), and bit 14. If bit 15 equals 1, the module sets the output value to 0V or 0 mA. If bit 15 equals zero and bit 14 equals 1, the module sets the output value to 10.5V dc or 21 mA.

Specialty I/O Configuration

1762-IR4 RTD/resistance Module Input Data File

For each module, slot x, words 0 through 3 contain the analog values of the inputs. Words 4 and 5 provide sensor/channel status feedback. The input data file for each configuration is shown below.

Word /Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	Analog Input Data Channel 0															
1	Analog Input Data Channel 1															
2	Analog Input Data Channel 2															
3	Analog Input Data Channel 3															
4	Reserved				OC3	OC2	OC1	OC0	Reserved				S3	S2	S1	S0
5	U0	O0	U1	O1	U2	O2	U3	O3	Reserved							

The bits are defined as follows:

- Sx = General status bits for input channels 0 through 3. This bit is set (1) when an error (over- or under-range, open-circuit or input data not valid condition) exists for that channel, or there is a general module hardware error. An input data not valid condition is determined by the user program. See the *MicroLogix™ 1200 RTD/ Resistance Input Module User Manual*, publication number 1762-UM003, for details.
- OCx = Open-circuit indication for channels 0 through 3, using either RTD or resistance inputs. Short-circuit detection for RTD inputs only. Short-circuit detection for resistance inputs is not indicated because 0 is a valid number.
- Ox = Over-range flag bits for input channels 0 through 3, using either RTD or resistance inputs. These bits can be used in the control program for error detection.
- Ux = Under-range flag bits for channels 0 through 3, using RTD inputs only.
  These bits can be used in the control program for error detection. Under-range detection for direct resistance inputs is not indicated because 0 is a valid number.

1762-IT4 Thermocouple Module Input Data File

For each module, slot x, words 0 through 3 contain the analog values of the inputs. The input data file is shown below.

Word/ Bit	**15**	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	SGN	Analog Input Data Channel 0														
1	SGN	Analog Input Data Channel 1														
2	SGN	Analog Input Data Channel 2														
3	SGN	Analog Input Data Channel 3														
4	Reserved			OC4	OC3	OC2	OC1	OC0	Reserved			S4	S3	S2	S1	S0
5	U0	O0	U1	O1	U2	O2	U3	O3	U4	O4	Reserved					

The bits are defined as follows:

- Sx = General status bits for channels 0 through 3 (S0 through S3) and the CJC sensor (S4). This bit is set (1) when an error (over-range, under-range, open-circuit, or input data not valid) exists for that channel. An input data not valid condition is determined by the user program. Refer to the *MicroLogix™ 1200 I/O Thermocouple/mV Input Module User Manual*, publication number 1762-UM002 for additional details.
- OCx = Open-circuit indication for channels 0 through 3 (OC0 through OC3) and the CJC sensor (OC4).
- Ox = Over-range flag bits for channels 0 through 3 (O0 through O3) and the CJC sensor (O4). These bits can be used in the control program for error detection.
- Ux = Under-range flag bits for channels 0 through 3 (U0 through U3) and the CJC sensor (U4). These bits can be used in the control program for error detection.

MicroLogix 1500 Compact™ Expansion I/O

If the application requires more I/O than the embedded I/O that the controller provides, you can attach I/O modules. These additional modules are called *expansion I/O*.

Expansion I/O Modules

Compact I/O (Bulletin 1769) is used to provide discrete and analog inputs and outputs and, in the future, specialty modules. For the MicroLogix 1500, you can attach up to 16[1] additional I/O modules. The number of modules that can be attached is dependent on the amount of power required by the I/O modules.

See the *MicroLogix 1500 User Manual*, publication 1764-UM001, for more information on valid configurations.

TIP	Visit the MicroLogix web site (http://www.ab.com/micrologix) for the MicroLogix 1500 Expansion I/O System Qualifier.

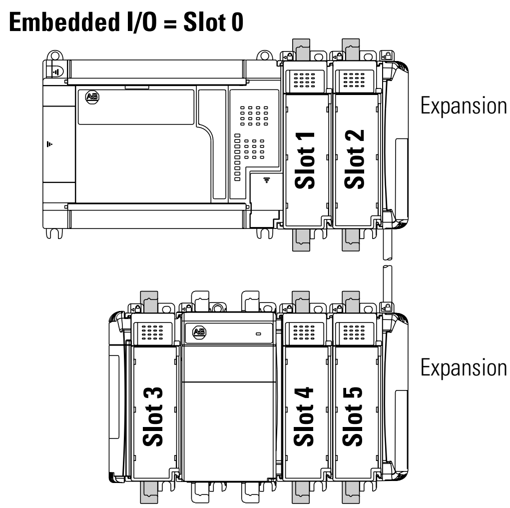
Addressing Expansion I/O

The figure below shows the addressing for the MicroLogix 1500 and its I/O.

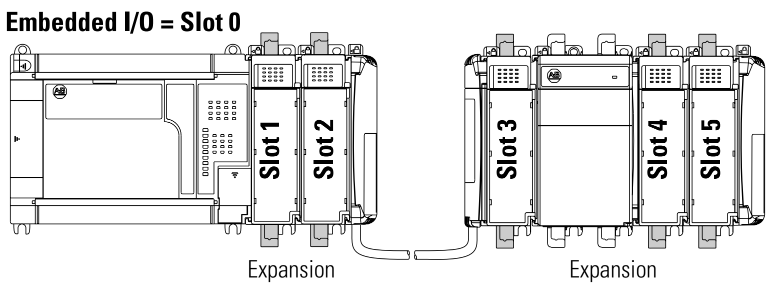
The expansion I/O is addressed as slots 1 through 16 (the controller's embedded I/O is addressed as slot 0). Power supplies and cables are not counted as slots, but must be added to the RSLogix 500 project in the I/O configuration. Modules are counted from left to right on each bank as shown in the illustrations below.

(1) Limit of 8 modules for Series A Base Unit.

Vertical Orientation



Horizontal Orientation



TIP

In most cases, you can use the following address format: X:s/b (X = file type letter, s = slot number, b = bit number)

See I/O Addressing on page 46 for complete information on address formats.

Expansion Power Supplies and Cables

To use a MicroLogix 1500 controller with a 1769 Expansion I/O Power Supply, verify that you have the following:

- MicroLogix 1500 Processor:
  Catalog Number 1764-LSP, FRN 3 and higher
  Catalog Number 1764-LRP, FRN 4 and higher
- Operating System Version: You can check the FRN by looking at word S:59 (Operating System FRN) in the Status File.

IMPORTANT

If your processor is at an older revision, you must upgrade the operating system to FRN 3 or higher to use an expansion cable and power supply. On the Internet, go to http://www.ab.com/micrologix to download the operating system upgrade. Select MicroLogix 1500 System; go to downloads.

ATTENTION

LIMIT OF ONE EXPANSION POWER SUPPLY AND CABLE

The expansion power supply cannot be connected directly to the controller. It must be connected using one of the expansion cables. Only one expansion power supply may be used in a MicroLogix 1500 system. Exceeding these limitations may damage the power supply and result in unexpected operation.

MicroLogix 1500 Compact™ Expansion I/O Memory Mapping

Discrete I/O Configuration

1769-IA8I Input Image

For each input module, the input data file contains the current state of the field input points. Bit positions 0 through 7 correspond to input terminals 0 through 7, bits 8 through 15 are not used.

Word	Bit Position															
	15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	x	x	x	x	x	x	x	x	r	r	r	r	r	r	r	r

r = read, x = not used, always at a 0 or OFF state

1769-IM12 Input Image

For each input module, the input data file contains the current state of the field input points. Bit positions 0 through 11 correspond to input terminals 0 through 11, bits 12 through 15 are not used.

Word	Bit Position															
	15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	x	x	x	x	r	r	r	r	r	r	r	r	r	r	r	r

r = read, x = not used, always at a 0 or OFF state

1769-IA16, 1769-IQ16, and 1769-IQ16F Input Image

For each input module, the input data file contains the current state of the field input points. Bit positions 0 through 15 correspond to input terminals 0 through 15.

Word	Bit Position															
	15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r

r = read

1769-IQ32 Input Data File

For each input module, slot x, word 0 in the input data file contains the current state of the field input points.

Word	Bit Position															
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r
1	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r

r = read

1769-IQ6XOW4 Input Image

For each module, the input data file contains the current state of the field input points. Bit positions 0 through 5 correspond to input terminals 0 through 5, bits 6 through 15 are not used.

Word	Input Bit Position															
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	x	x	x	x	x	x	x	x	x	x	r	r	r	r	r	r

r = read, x = not used, always at a 0 or OFF state

1769-IQ6XOW4 Output Image

For each module, the output data file contains the current state of the control program's directed state of the discrete output points. Bit positions 0 through 3 correspond to output terminals 0 through 3, bits 4 through 15 are not used.

Word	Output Bit Position															
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	x	x	x	x	x	x	x	x	x	x	x	x	r/w	r/w	r/w	r/w

r/w = read and write, x = not used, always at a 0 or OFF state

1769-OA8, 1769-OB8, 1769-OW8, and 1769-OW8I Output Image

For each module, the output data file contains the current state of the control program's directed state of the discrete output points. Bit positions 0 through 7 correspond to output terminals 0 through 7, bits 8 through 15 are not used.

Word	Output Bit Position															
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	x	x	x	x	x	x	x	x	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w

r/w = read and write, x = not used, always at a 0 or OFF state

1769-OA16, 1769-OB16, 1769-OB16P, 1769-OV16, and 1769-OW16 Output Image

For each module, the output data file contains the current state of the control program's directed state of the discrete output points. Bit positions 0 through 15 correspond to output terminals 0 through 15.

Word	Output Bit Position															
	15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w

r/w = read and write

1769-OB32 Output Data File

For each module, slot x, word 0 in the output data file contains the control program's directed state of the discrete output points.

Word	Output Bit Position															
	15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w
1	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w	r/w

r/w = write

Analog I/O Configuration

1769-IF4 Input Data File

For each input module, words 0 through 3 contain the analog values of the inputs.

Word	Bit Position															
	15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	SGN	Analog Input Data Channel 0														
1	SGN	Analog Input Data Channel 1														
2	SGN	Analog Input Data Channel 2														
3	SGN	Analog Input Data Channel 3														
4	not used												S3	S2	S1	S0
5	U0	O0	U1	O1	U2	O2	U3	O3	Set to 0							

The bits are defined as follows:

- SGN = Sign bit in two's complement format.
- Sx = General status bits for channels 0 through 3. This bit is set (1) when an error (over- or under-range) exists for that channel.
- Ux = Under-range flag bits for channels 0 through 3. These bits can be used in the control program for error detection.
- Ox = Over-range flag bits for channels 0 through 3. These bits can be used in the control program for error detection.

1769-OF2 Output Data File

For each module, words 0 and 1 in the output data file contain the channel 0 and channel 1 output data.

Word	Bit Position															
	15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	SGN	Channel 0 Data 0 to 32,768														
1	SGN	Channel 1 Data 0 to 32,768														

SGN = Sign bit in two's complement format.

1769-IF4XOF2 Input Data File

The input data file provides access to input data for use in the control program, over-range indication for the input and output channels, and output data feedback as described below.

Word	Bit Position															
	15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	SGN	Analog Input Data Channel 0								0	0	0	0	0	0	0
1	SGN	Analog Input Data Channel 1								0	0	0	0	0	0	0
2	SGN	Analog Input Data Channel 2								0	0	0	0	0	0	0
3	SGN	Analog Input Data Channel 3								0	0	0	0	0	0	0
4	Not Used(1)												I3	I2	I1	I0
5	Not Used	H0	Not Used	H1	Not Used(1)								E1	E0	O1	O0
6	SGN	Output Data Echo/Loopback for Output Channel 0								0	0	0	0	0	0	0
7	SGN	Output Data Echo/Loopback for Output Channel 1								0	0	0	0	0	0	0

(1) All unused bits are set to 0 by the module.

IMPORTANT Input words 6 and 7 contain the Output Data Echo/Loopback information for output channels 0 and 1 respectively. Bits 0 through 6 and Bit 15 of words 6 and 7 should always be set to zero in your control program. If they are not set to 0, the invalid data flag (Ex) will be set for that channel by the module. However the channel will continue to operate with the previously converted value.

The bits are defined as follows:

- **SGN** = Sign bit in two's complement format. Always positive (equal to zero) for the 1769-IF4XOF2 module.
- **Ix** = Over-range flag bits for input channels 0 through 3. These bits can be used in the control program for error detection. When set to 1, the bits signal that the input signal is outside the normal operating range. However, the module continues to convert analog data to the maximum full-range value. When the over-range condition is cleared, the bits automatically reset (0).
- **Ox** = Word 5, bits 0 and 1 provide over-range indication for output channels 0 and 1. These bits can be used in the control program for error detection. When set to 1, the bits signal that the output signal is outside the normal operating range. However, the module continues to convert analog data to the maximum full-range value. When the over-range condition is cleared, the bits automatically reset (0).

TIP Under-range indication is not provided because zero is a valid number.

- **Ex** = When set (1), this bit indicates that invalid data (e.g. the value sent by the controller is outside the standard output range or increment; e.g. 128, 256, etc.) has been set in the output data bits 0 through 6, or the sign bit (15).
- **Hx** = Hold Last State bits. When set (1), these bits indicate that the channel is in a Hold Last State condition.
- **Words 6 and 7** = These words reflect the analog output data echo of the analog value being converted by the digital/analog converter, not necessarily the electrical state of the output terminals. They do not reflect shorted or open outputs.

IMPORTANT It is only important to use the loopback function of input words 6 and 7 if the controller supports the Program Mode or Fault Mode functions, and if it is configured to use them.

1769-IF4XOF2 Output Data File

The output data file applies only to output data from the module as shown in the table below.

Word	Bit Position															
	15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	SGN	Analog Output Data Channel 0								0	0	0	0	0	0	0
1	SGN	Analog Output Data Channel 1								0	0	0	0	0	0	0

IMPORTANT Bits 0 through 6 and Bit 15 of output data words 0 and 1 should always be set to zero in your control program. If they are not set to 0, the invalid data flag (Ex) will be set for that channel. However the channel will continue to operate with the previously converted value. If a MVM (Move with Mask) instruction is used with a mask of 7F80 (hexidecimal) to move data to the output words, writing to bits 0 through 6 and bit 15 can be avoided.

Specialty I/O Configuration

1769-IR6 RTD/resistance Module Input Data File

The first six words (0 to 5) of the input data file contain the analog RTD or resistance values of the inputs. Words 6 and 7 provide sensor/channel status feedback for use in your control program as shown below.

Word	Bit Position															
	15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	RTD/resistance Input Data Channel 0															
1	RTD/resistance Input Data Channel 1															
2	RTD/resistance Input Data Channel 2															
3	RTD/resistance Input Data Channel 3															
4	RTD/resistance Input Data Channel 4															
5	RTD/resistance Input Data Channel 5															
6	Not Used		OC5	OC4	OC3	OC2	OC1	OC0	Not Used		S5	S4	S3	S2	S1	S0
7	U0	O0	U1	O1	U2	O2	U3	O3	U4	O4	U5	O5	Not Used			

Word 6 and 7 status bits are defined as follows:

- **Sx** = General status bit for channels 0 through 5. This bit is set (1) when an error (over- or under-range, open-circuit, or input data not valid) exists for that channel. An input data not valid condition is determined by the user program. This condition occurs when the first analog-to-digital conversion is still in progress at power-up or after a new configuration has been sent to the module. Refer to the *RTD/resistance Input Module User Manual*, publication number 1769-UM005, for details.
- **OCx** = Open-circuit detection bit for channels 0 through 5. These bits are set (1) when either an open or shorted input for RTD inputs or an open input for resistance inputs is detected.

TIP Short-circuit detection for resistance inputs is not indicated because 0 is a valid number.

- **Ux** = Under-range flag bits for channels 0 through 5, using RTD inputs only. These bits can be used in the control program for error detection. There is no under-range error for a direct resistance input, because 0 is a valid number.
- **Ox** = Over-range flag bits for channels 0 through 5, using either RTD or resistance inputs. These bits can be used in the control program for error detection.

1769-IT6 Thermocouple Module Input Data File

The input data file contains the analog values of the inputs.

Word	Bit Position															
	15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Analog Input Data Channel 0															
1	Analog Input Data Channel 1															
2	Analog Input Data Channel 2															
3	Analog Input Data Channel 3															
4	Analog Input Data Channel 4															
5	Analog Input Data Channel 5															
6	OC7	OC6	OC5	OC4	OC3	OC2	OC1	OC0	S7	S6	S5	S4	S3	S2	S1	S0
7	U0	O0	U1	O1	U2	O2	U3	O3	U4	O4	U5	O5	U6	O6	U7	O7

The bits are defined as follows:

- Sx = General status bit for channels 0 through 5 and CJC sensors (S6 and S7). This bit is set (1) when an error (over-range, under-range, open-circuit, or input data not valid) exists for that channel. An input data not valid condition is determined by the user program. This condition occurs when the first analog-to-digital conversion is still in progress, after a new configuration has been sent to the module.
- OCx = Open circuit detection bits indicate an open input circuit on channels 0 through 5 (OC0 through OC5) and on CJC sensors CJC0 (OC6) and CJC1 (OC7). The bit is set (1) when an open-circuit condition exists.
- Ux = Under-range flag bits for channels 0 through 5 and the CJC sensors (U6 and U7). For thermocouple inputs, the under-range bit is set when a temperature measurement is below the normal operating range for a given thermocouple type. For millivolt inputs, the under-range bit indicates a voltage that is below the normal operating range. These bits can be used in the control program for error detection.
- Ox = Over-range flag bits for channels 0 through 5 and the CRC sensors (O6 and O7). For thermocouple inputs, the over-range bit is set when a temperature measurement is above the normal operating range for a given thermocouple type. For millivolt inputs, the over-range bit indicates a voltage that is above the normal operating range. These bits can be used in the control program for error detection.

1769-HSC High-Speed Counter Module Output Array

The information in the following table is a quick reference of the array. Refer to the *Compact I/O High Speed Counter User Manual*, publication 1769-UM006, for detailed information.

The default value for the Output Array is all zeros.

Word	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Description	Bit Detail
0	Out15	Out14	Out13	Out12	Out11	Out10	Out09	Out08	Out07	Out06	Out05	Out04	Out03	Out02	Out01	Out00	OutputOnMask.0 -- OutputOnMask.15	
1	Out15	Out14	Out13	Out12	Out11	Out10	Out09	Out08	Out07	Out06	Out05	Out04	Out03	Out02	Out01	Out00	OutputOffMask.0 -- OutputOffMask.15	
2	R15	R14	R13	R12	R11	R10	R09	R08	R07	R06	R05	R04	R03	R02	R01	R00	RangeEn.0 -- RangeEn.15	
3																	Reserved	
4									RBF								ResetBlownFuse	
5							RPW	RREZ	Z Inh	Z Inv	D Inh	D Inv	RCU	RCO	SP	En	Ctr0ControlBits →	Ctr0En Ctr0SoftPreset Ctr0ResetCountOverflow Ctr0ResetCountUnderflow Ctr0DirectionInvert Ctr0DirectionInhibit Ctr0ZInvert Ctr0ZInhibit Ctr0ResetRisingEdgeZ Ctr0ResetCtrPresetWarning
6							RPW	RREZ	Z Inh	Z Inv	D Inh	D Inv	RCU	RCO	SP	En	Ctr1ControlBits	
7							RPW					D Inv	RCU	RCO	SP	En	Ctr2ControlBits	
8							RPW					D Inv	RCU	RCO	SP	En	Ctr3ControlBits	
9																	Reserved	
10, 11	Range12To15[0].HiLimOrDirWr																Range12To15[0].HiLimOrDirWr	
12, 13	Range12To15[0].LowLimit																Range12To15[0].LowLimit	
14	Out15	Out14	Out13	Out12	Out11	Out10	Out09	Out08	Out07	Out06	Out05	Out04	Out03	Out02	Out01	Out00	Range12To15[0].OutputControl.0 .... .15	
15								Inv			LDW	Type			ToThisCtr		Range12To15[0].Config Flags →	Range12To15[0].ToThisCounter_0 Range12To15[0].ToThisCounter_1 Range12To15[0].Type Range12To15[0].LoadDirectWrite Range12To15[0].Invert
16, 17	Range12To15[1].HiLimOrDirWr																Range12To15[1].HiLimOrDirWr	
18, 19	Range12To15[1].LowLimit																Range12To15[1].LowLimit	
20	Out15	Out14	Out13	Out12	Out11	Out10	Out09	Out08	Out07	Out06	Out05	Out04	Out03	Out02	Out01	Out00	Range12To15[1].OutputControl.0 .... .15	
21								Inv			LDW	Type			ToThisCtr		Range12To15[1].Config Flags →	Range12To15[1].ToThisCounter_0 Range12To15[1].ToThisCounter_1 Range12To15[1].Type Range12To15[1].LoadDirectWrite Range12To15[1].Invert
22, 23	Range12To15[2].HiLimOrDirWr																Range12To15[2].HiLimOrDirWr	
24, 25	Range12To15[2].LowLimit																Range12To15[2].LowLimit	
26	Out15	Out14	Out13	Out12	Out11	Out10	Out09	Out08	Out07	Out06	Out05	Out04	Out03	Out02	Out01	Out00	Range12To15[2].OutputControl.0 .... .15	
27								Inv			LDW	Type			ToThisCtr		Range12To15[2].Config Flags →	Range12To15[2].ToThisCounter_0 Range12To15[2].ToThisCounter_1 Range12To15[2].Type Range12To15[2].LoadDirectWrite Range12To15[2].Invert
28, 29	Range12To15[3].HiLimOrDirWr																Range12To15[3].HiLimOrDirWr	
30, 31	Range12To15[3].LowLimit																Range12To15[3].LowLimit	

32	Out15	Out14	Out13	Out12	Out11	Out10	Out09	Out08	Out07	Out06	Out05	Out04	Out03	Out02	Out01	Out00	Range12To15[3].OutputControl.0 ... .15		
33								Inv			LDW	Type			ToThisCtr		Range12To15[3].Config Flags	→	Range12To15[3].ToThisCounter_0 Range12To15[3].ToThisCounter_1 Range12To15[3].Type Range12To15[3].LoadDirectWrite Range12To15[3].Invert

1769-HSC High-Speed Counter Module Input Array

The information in the following table is a quick reference of the array. Refer to the *Compact I/O High Speed Counter User Manual*, publication 1769-UM006, for detailed information.

The default value for the Input Array is all zeros.

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Description	
0											Z1	B1	A1	Z0	B0	A0	InputStateA0 -- InputStateZ1	
1	Out15	Out14	Out13	Out12	Out11	Out10	Out09	Out08	Out07	Out06	Out05	Out04	Out03	Out02	Out01	Out00	Readback.0 -- Readback.15	
2	InvalidRangeLimit12…15				InvalidCtrAssignToRange12…15				GenErr	InvOut	MCfg		Out0Overcurrent -- Out3…				Status Flags →	InvalidRangeLimit12 ... 15
3	R15	R14	R13	R12	R11	R10	R09	R08	R07	R06	R05	R04	R03	R02	R01	R00	RangeActive.0 -- RangeActive.15	InvalidCtrAssignToRange12 ... 15
4 5	Ctr[0].CurrentCount																Ctr[0].CurrentCount	GenError
6 7	Ctr[0].StoredCount																Ctr[0].StoredCount	InvalidOutput ModConfig
8 9	Ctr[0].CurrentRate																Ctr[0].CurrentRate	Out0Overcurrent0 ... 3
10 11	Ctr[0].PulseInterval																Ctr[0].PulseInterval	
12										C0PW	RV		IDW	REZ	CUdf	COvf	Ctr[0].StatusFlags →	Ctr[0].Overflow
13																	Reserved	Ctr[0].Underflow
14 15	Ctr[1].CurrentCount																Ctr[1].CurrentCount	Ctr[0].RisingEdgeZ
16 17	Ctr[1].StoredCount																Ctr[1].StoredCount	Ctr[0].InvalidDirectWrite ----------------
18 19	Ctr[1].CurrentRate																Ctr[1].CurrentRate	Ctr[0].RateValid
20 21	Ctr[1].PulseInterval																Ctr[1].PulseInterval	Ctr[0].PresetWarning
22										C1PW	RV	IC	IDW	REZ	CUdf	COvf	Ctr[1].StatusFlags →	Ctr[1].Overflow
23																	Reserved	Ctr[1].Underflow
24 25	Ctr[2].CurrentCount																Ctr[2].CurrentCount	Ctr[1].RisingEdgeZ
26 27	Ctr[2].CurrentRate																Ctr[2].CurrentRate	Ctr[1].InvalidDirectWrite Ctr[1].InvalidCounter Ctr[1].RateValid Ctr[1].PresetWarning

Word									Tag		Bit Tags
28		C2PW	RV	IC	IDW		CUdf	COvf	Ctr[2].StatusFlags	→	Ctr[2].Overflow Ctr[2].Underflow ---------------- Ctr[2].InvalidDirectWrite Ctr[2].InvalidCounter Ctr[2].RateValid Ctr[2].PresetWarning
29									Reserved		
30 31	Ctr[3].CurrentCount								Ctr[3].CurrentCount		
32 33	Ctr[3].CurrentRate								Ctr[3].CurrentRate		
34		C3PW	RV	IC	IDW		CUdf	COvf	Ctr[3].StatusFlags	→	Ctr[3].Overflow Ctr[3].Underflow ---------------- Ctr[3].InvalidDirectWrite Ctr[3].InvalidCounter Ctr[3].RateValid Ctr[3].PresetWarning

1769-SDN DeviceNet Scanner Module Data Organization

The scanner uses the input and output data images to transfer data, status and command information between the scanner and the controller. The basic structure is shown below. Refer to the *Compact I/O DeviceNet Scanner Module User Manual*, publication 1769-UM009, for more detailed information.

Input Data Image

The input data image is transferred from the scanner module to the controller.

Word	Description	Data Type
0 to 63	Status Structure	64-word array
64 and 65	Module Status Register	2 words
66 to 245	Input Data Image	180-word array

Output Data Image

The output data image is transferred from the controller to the scanner module.

Word	Description	Data Type
0 and 1	Module Command Array	2-word array
2 to 181	Output Data Image	180-word array

The following table shows the bit descriptions for the Module Command Array.

Word	Bit	Operating Mode
0	0	1 = Run, 0 = Idle
	1	1 = Fault
	2	1 = Disable Network
	3	Reserved(1)
	4	1 = Reset
	5 to 15	Reserved(1)
1	0 to 15	Reserved(1)

(1) DO NOT manipulate Reserved Bits. Doing so may interfere with future compatibility.

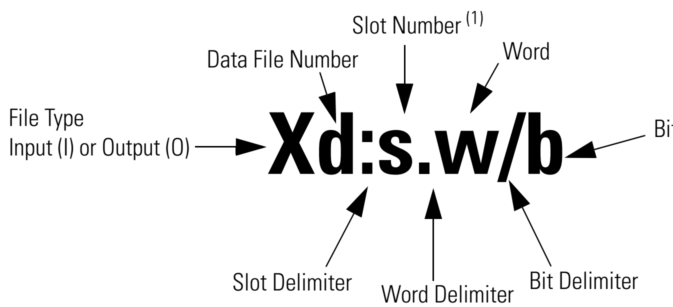
1769-SM1 Compact I/O to DPI/SCANport Module

The 1769-SM1 Compact I/O to DPI/SCANport module provides a Compact I/O connection for up to three DPI or SCANport-enabled drives or power products. It can be used with a MicroLogix 1500, 1764-LRP, Series C or higher. Refer to the *1769-SM1 Compact I/O DPI/SCANport Module User Manual*, publication 1769-UM010, for detailed information on using the module.

I/O Addressing

Addressing Details

The I/O addressing scheme and examples are shown below.



(1) I/O located on the controller (embedded I/O) is slot 0.
I/O added to the controller (expansion I/O) begins with slot 1.

Format	Explanation		
Od:s.w/b	**X**	File Type	Input (I) or Output (O)
	d	Data File Number *(optional)*	0 = output, 1 = input
Id:s.w/b	**:**	Slot delimiter *(optional, not required for Data Files 2 to 255)*	
	s	Slot number (decimal)	Embedded I/O: slot 0
			Expansion I/O: • slots 1 to 6 for MicroLogix 1200 (See page 19 for an illustration.) • slots 1 to 16(1) for MicroLogix 1500 (See page 28 for an illustration.)
	.	Word delimiter. Required only if a word number is necessary as noted below.	
	w	Word number	Required to read/write words, or if the discrete bit number is above 15. Range: 0 to 255
	/	Bit delimiter	
	b	Bit number	0 to 15

(1) Slots 1 to 8 for Series A Base Units.

Addressing Examples

Addressing Level	Example Address(1)	Slot	Word	Bit
Bit Addressing	O:0/4(2)	Output Slot 0 (Embedded I/O)	word 0	output bit 4
	O:2/7(2)	Output Slot 2 (Expansion I/O)	word 0	output bit 7
	I:1/4(2)	Input Slot 1 (Expansion I/O)	word 0	input bit 4
	I:0/15(2)	Input Slot 0 (Embedded I/O)	word 0	input bit 15
Word Addressing	O:1.0	Output Slot 1 (Expansion I/O)	word 0	
	I:7.3	Input Slot 7 (Expansion I/O)	word 3	
	I:3.1	Input Slot 3 (Expansion I/O)	word 1	

(1) The optional Data File Number is not shown in these examples.

(2) A word delimiter and number are not shown. Therefore, the address refers to word 0.

I/O Forcing

I/O forcing is the ability to override the actual status of the I/O at the user's discretion.

Input Forcing

When an input is forced, the value in the input data file is set to a user-defined state. For discrete inputs, you can force an input "on" or "off". When an input is forced, it no longer reflects the state of the physical input or the input LED. For embedded inputs, the controller reacts as if the force is applied to the physical input terminal.

TIP When an input is forced, it has no effect on the input device connected to the controller.

Output Forcing

When an output is forced, the controller overrides the status of the control program, and sets the output to the user-defined state. Discrete outputs can be forced "on" or "off". The value in the output file is unaffected by the force. It maintains the state determined by the logic in the control program. However, the state of the physical output and the output LED will be set to the forced state.

TIP If you force an output controlled by an executing PTO or PWM function, an instruction error is generated.

Input Filtering

The MicroLogix 1200 and 1500 controllers allow users to configure groups of DC inputs for high-speed or normal operation. Users can configure each input group's response time. A configurable filter determines how long the input signal must be "on" or "off" before the controller recognizes the signal. The higher the value, the longer it takes for the input state to be recognized by the controller. Higher values provide more filtering, and are used in electrically noisy environments. Lower values provide less filtering, and are used to detect fast or narrow pulses. You typically set the filters to a lower value when using high-speed counters, latching inputs, and input interrupts.

Input filtering is configured using RSLogix 500 programming software. To configure the filters using RSLogix 500:

1. Open the "Controller" folder.
2. Open the "I/O Configuration" folder.
3. Open slot 0 (controller).
4. Select the "embedded I/O configuration" tab.

The input groups are pre-arranged. Simply select the filter time you require for each input group. You can apply a unique input filter setting to each of the input groups:

Controller	MicroLogix 1200	MicroLogix 1500
Input Groups	• 0 and 1 • 2 and 3 • 4 and above	• 0 and 1 • 2 and 3 • 4 and 5 • 6 and 7 • 8 and above

The minimum and maximum response times associated with each input filter setting can be found in your controller's User Manual.

Latching Inputs

The MicroLogix 1200 and 1500 controllers provide the ability to individually configure inputs to be latching inputs (sometimes referred to as pulse catching inputs). A latching input is an input that captures a very fast pulse and holds it for a single controller scan. The pulse width that can be captured is dependent upon the input filtering selected for that input.

The following inputs can be configured as latching inputs:

Controller	MicroLogix 1200	MicroLogix 1500
DC Inputs	0 through 3	0 through 7

You enable this feature with RSLogix 500 programming software. With an open project:

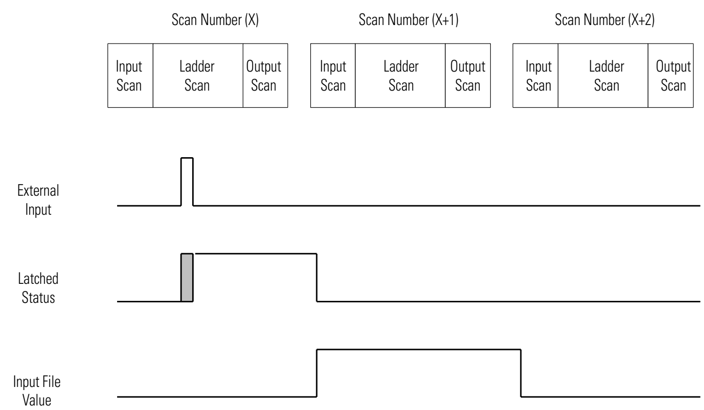
1. Open the "Controller" folder.
2. Open the "I/O Configuration" folder.
3. Open slot 0 (controller).
4. Select the "embedded I/O configuration" tab.

5. Select the mask bits for the inputs that you want to operate as latching inputs.

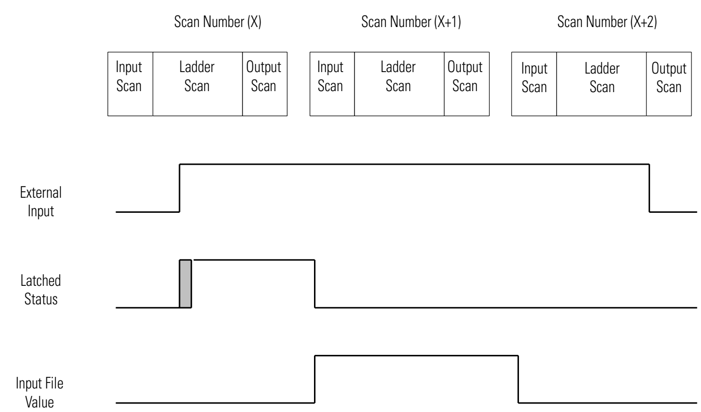
6. Select the state for the latching inputs. The controller can detect both "on" (rising edge) and "off" (falling edge) pulses, depending upon the configuration selected in the programming software.

The following information is provided for a controller looking for an "on" pulse. When an external signal is detected "on", the controller "latches" this event. In general, at the next input scan following this event, the input image point is turned "on" and remains "on" for the next controller scan. It is then set to "off" at the next input scan. The following figures help demonstrate this.

Rising Edge Behavior - Example 1



Rising Edge Behavior - Example 2



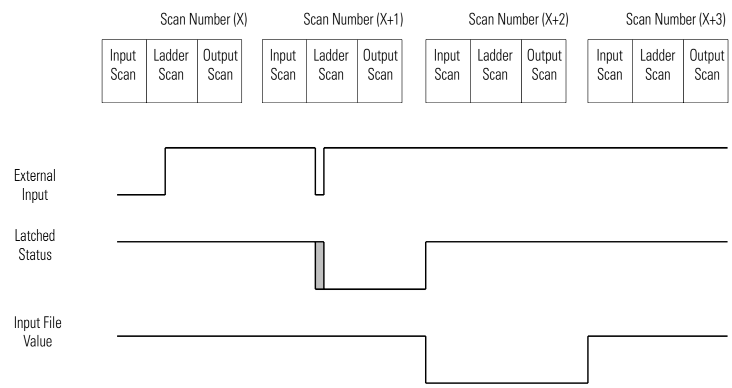
TIP The "gray" area of the Latched Status waveform is the input filter delay.

IMPORTANT The input file value does not represent the external input when the input is configured for latching behavior. When configured for rising edge behavior, the input file value is normally "off" ("on" for 1 scan when a rising edge pulse is detected).

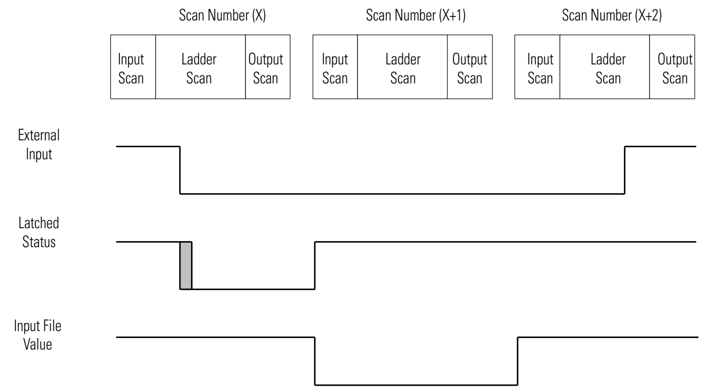
The previous examples demonstrate rising edge behavior. Falling edge behavior operates exactly the same way with these exceptions:

- The detection is on the "falling edge" of the external input.
- The input image is normally "on" (1), and changes to "off" (0) for one scan.

Falling Edge Behavior - Example 1



Falling Edge Behavior - Example 2



TIP The “gray” area of the Latched Status waveform is the input filter delay.

IMPORTANT The input file value does not represent the external input when the input is configured for latching behavior. When configured for falling edge behavior, the input file value is normally “on” (“off” for 1 scan when a falling edge pulse is detected).

Configuring Expansion I/O Using RSLogix 500

Expansion I/O must be configured for use with the controller. Configuring expansion I/O can be done either manually, or automatically. Using RSLogix 500:

1. Open the "Controller" folder.
2. Open the "I/O Configuration" folder.
3. For manual configuration, drag the Compact I/O module to the slot.

   For automatic configuration, you must have the controller connected online to the computer (either directly or over a network). Click the "Read I/O Config" button on the I/O configuration screen. RSLogix 500 will read the existing configuration of the controller's I/O.

Some I/O modules support or require configuration. To configure a specific module, double-click on the module, an I/O configuration screen will open that is specific to the module.

Controller Memory and File Types

This chapter describes controller memory and the types of files used by the MicroLogix 1200 and MicroLogix 1500 controllers. The chapter is organized as follows:

Controller Memory

File Structure

MicroLogix 1200 and 1500 user memory is comprised of Data Files, Function Files, and Program Files (and B-Ram files for the MicroLogix 1500 1764-LRP processor). Function Files are exclusive to the MicroLogix 1200 and 1500 controllers; they are not available in the MicroLogix 1000 or SLC controllers.

TIP The file types shown below for data files 3 through 7 are the default filetypes for those file numbers and cannot be changed. Data files 9 through 255 can be added to your program to operate as bit, timer, counter, control, integer, string, long word, message, or PID files.

Data Files		Function Files		Program Files		Specialty Files[1]	
0	Output File	HSC	High Speed Counter	0	System File 0	0	Data Log Queue 0
1	Input File	PTO[2]	Pulse Train Output	1	System File 1	1	Data Log Queue 1
2	Status File	PWM[2]	Pulse Width Modulation	2	Program File 2	2 to 255	Data Log Queues 2 to 255
3	Bit File	STI	Selectable Timed Interrupt	3 to 255	Program Files 3 to 255	0	Recipe File 0
4	Timer File	EII	Event Input Interrupt			1	Recipe File 1
5	Counter File	RTC	Real Time Clock			2 to 255	Recipe Files 2 to 255
6	Control File	TPI	Trim Pot Information				
7	Integer File	MMI	Memory Module Information				
8	Floating Point File	DAT[3]	Data Access Tool				
9 to 255	(B) Bit	BHI	Base Hardware Information				
	(T) Timer	CS	Communications Status				
	(C) Counter	IOS	I/O Status				
	(R) Control	DLS[1]	Data Log Status				
	(N) Integer						
	(F) Floating Point[4]						
	(ST) String[5]						
	(L) Long Word						
	(MG) Message						
	(PD) PID						
	(PLS) Programmable Limit Switch[4]						

(1) Specialty files for Data Logging are only used by the MicroLogix 1500 1764-LRP processor. Specialty files for Recipes are only used by MicroLogix 1500 Series C processors.

(2) The PTO and PWM files are only used in MicroLogix 1200 and 1500 BXB units.

(3) The DAT files are only used in MicroLogix 1500 controllers.

(4) The floating point and programmable limit switch files are available in MicroLogix 1200 and 1500 Series C controllers.

(5) The string file is available in MicroLogix 1200 controllers and MicroLogix 1500 1764-LSP Series B (and later) and 1764-LRP processors.

User Memory

User memory is the amount of storage available to a user for storing ladder logic, data table files, I/O configuration, etc., in the controller.

User data files consist of the system status file, I/O image files, and all other user-creatable data files (bit, timer, counter, control, integer, string, long word, MSG, and PID).

A word is defined as a unit of memory in the controller. The amount of memory available to the user for data files and program files is measured in user words. Memory consumption is allocated as follows:

- For *data files*, a word is the equivalent of 16 bits of memory. For example,
  - 1 integer data file element = 1 user word
  - 1 long word file element = 2 user words
  - 1 timer data file element = 3 user words

  TIP Each input and output data element consumes 3 user words due to the overhead associated with I/O forcing.

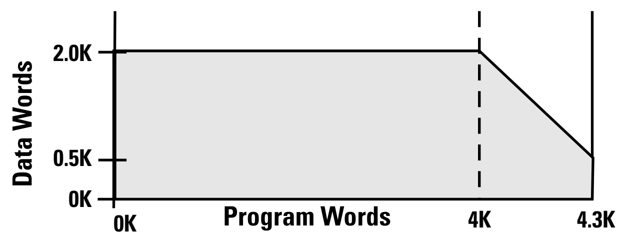
- For *program files*, a word is the equivalent of a ladder instruction with one operand. For example[1],
  - 1 XIC instruction, which has 1 operand, consumes 1 user word
  - 1 EQU instruction, which has 2 operands, consumes 2 user words
  - 1 ADD instruction, which has 3 operands, consumes 3 user words
- *Function files* do not consume user memory.

TIP Although the controller allows up to 256 elements in a file, it may not actually be possible to create a file with that many elements due to the user memory size in the controller.

(1) These are approximate values. For actual memory usage, see the tables in Appendix A and B of this manual.

MicroLogix 1200 User Memory

The MicroLogix 1200 controller supports 6K of memory. Memory can be used for program files and data files. The maximum data memory usage is 2K words as shown below.

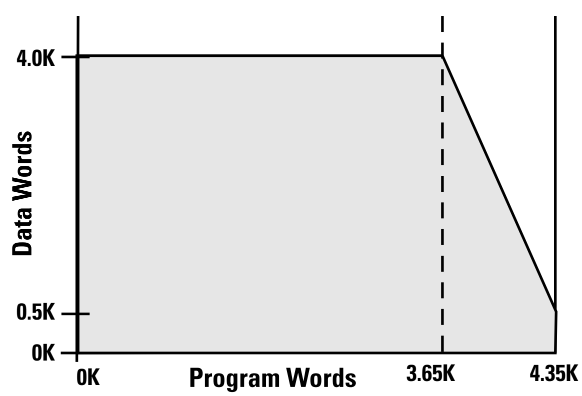


See “MicroLogix 1200 Memory Usage and Instruction Execution Time” on page 463 to find the memory usage for specific instructions.

MicroLogix 1500 User Memory

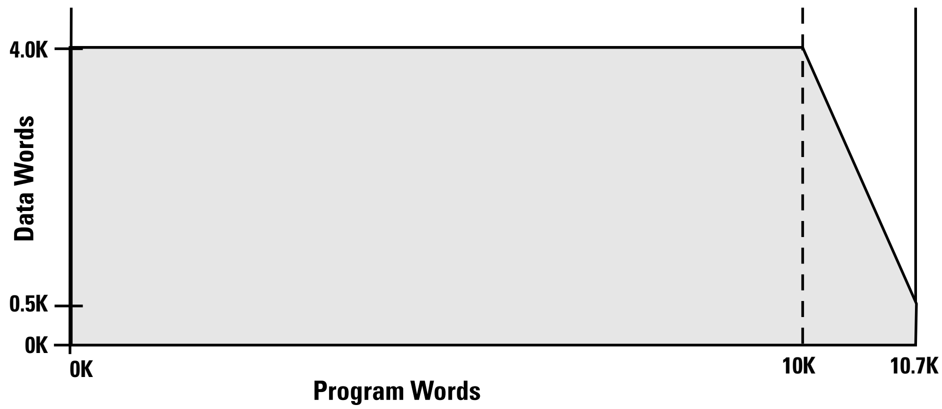
MicroLogix 1500, 1764-LSP Processor

The 1764-LSP processor supports over 7K of memory. Memory can be used for program files and data files. The maximum data memory usage is 4K words as shown below.



MicroLogix 1500, 1764-LRP Processor

The 1764-LRP processor supports 14K of memory. Memory can be used for program files and data files. The maximum data memory usage is 4K words as shown below.



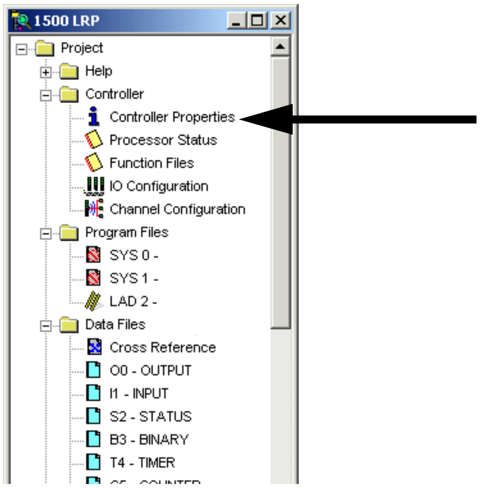
IMPORTANT For the MicroLogix 1500, the maximum file size of any single ladder file is 6.4K words. You can utilize the entire programming space by using multiple ladder files through the use of subroutines.

The 1764-LRP processor also supports 48K bytes of battery backed memory for Data Logging or Recipe operations. See Chapter 22 for Data Logging and Recipe information.

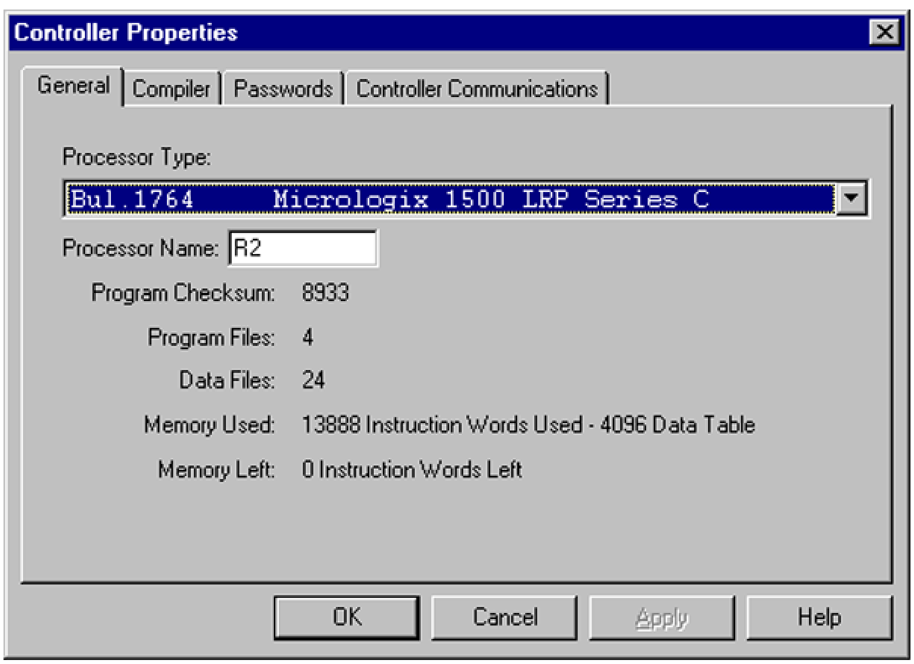
See “MicroLogix 1500 Memory Usage and Instruction Execution Time” on page 471 to find the memory usage for specific instructions.

Viewing Controller Memory Usage

1. Highlight and open *Controller Properties*.



2. The amount of *Memory Used* and *Memory Left* will appear in the *Controller Properties* window once the program has been verified.



Data Files

Data files store numeric information, including I/O, status, and other data associated with the instructions used in ladder subroutines. The data file types are:

File Name	File Identifier	File Number(1)	Words per Element	File Description
Output File	O	0	1	The Output File stores the values that are written to the physical outputs during the Output Scan.
Input File	I	1	1	The Input File stores the values that are read from the physical inputs during the Input Scan.
Status File	S	2	1	The contents of the Status File are determined by the functions which utilize the Status File. See "System Status File" on page 479 for a detailed description.
Bit File	B	**3**, 9 to 255	1	The Bit File is a general purpose file typically used for bit logic.
Timer File	T	**4**, 9 to 255	3	The Timer File is used for maintaining timing information for ladder logic timing instructions. See "Timer and Counter Instructions" on page 185 for instruction information.
Counter File	C	**5**, 9 to 255	3	The Counter File is used for maintaining counting information for ladder logic counting instructions. See "Timer and Counter Instructions" on page 185 for instruction information.
Control File	R	**6**, 9 to 255	3	The Control Data file is used for maintaining length and position information for various ladder logic instructions. See Control Data File on page 354 for more information.
Integer File	N	**7**, 9 to 255	1	The Integer File is a general purpose file consisting of 16-bit, signed integer data words.
Floating Point File	F	**8**, 9 to 255	1	The Floating Point File is a general purpose file consisting of 32-bit IEEE-754 floating point data elements. See Using the Floating Point (F) Data File on page 206 for more information.
String File	ST	9 to 255	42	The String File is a file that stores ASCII characters. See String (ST) Data File on page 353 for more information.
Long Word File	L	9 to 255	2	The Long Word File is a general purpose file consisting of 32-bit, signed integer data words.
Message File	MG	9 to 255	25	The Message File is associated with the MSG instruction. See "Communications Instructions" on page 385 for information on the MSG instruction.
Programmable Limit Switch File	PLS	9 to 255	6	The Programmable Limit Switch (PLS) File allows you to configure the High-Speed Counter to operate as a PLS or rotary cam switch. See Programmable Limit Switch (PLS) File on page 141 for information.
PID File	PD	9 to 255	23	The PID File is associated with the PID instruction. See "Process Control Instruction" on page 315 for more information.

(1) File Number in **BOLD** is the default. Additional data files of that type can be configured using the remaining numbers.

Protecting Data Files During Download

Data File Download Protection

Once a user program is in the controller, there may be a need to update the ladder logic and download it to the controller without destroying user-configured variables in one or more data files in the controller. This situation can occur when an application needs to be updated, but the data that is relevant to the installation needs to remain intact.

This capability is referred to as *Data File Download Protection*. The protection feature operates when:

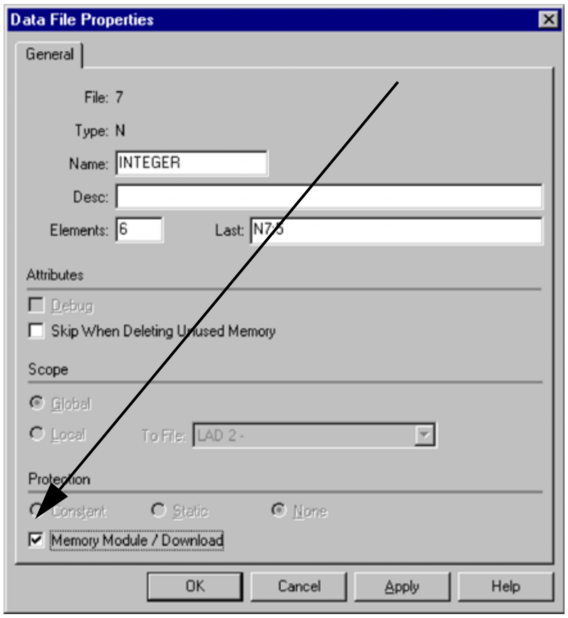
- A User Program is downloaded via programming software
- A User Program is downloaded from a Memory Module

Setting Download File Protection

Download File Protection can be applied to the following data file types:

- Output (O)
- Input (I)
- Binary (B)
- Timer (T)
- Counter (C)
- Control (R)
- Integer (N)
- Floating Point (F)
- String (ST)
- Long Word (L)
- Proportional Integral Derivative (PD)
- Message (MG)
- Programmable Limit Switch (PLS)

TIP The data in the Status File cannot be protected.



Access the Download Data File Protect feature using RSLogix 500 programming software. For each data file you want protected, check the Memory Module/Download item within the protection box in the Data File Properties screen as shown in this illustration. To access this screen, right mouse click on the desired data file.

User Program Transfer Requirements

Data File Download Protection only operates when the following conditions are met during a User Program or Memory Module download to the controller:

- The controller contains protected data files.
- The program being downloaded has the same number of protected data files as the program currently in the controller.
- All protected data file numbers, types, and sizes (number of elements) currently in the controller exactly match that of the program being downloaded to the controller.

If all of these conditions are met, the controller will not write over any data file in the controller that is configured as Download Protected when a program is downloaded from a memory module or programming software.

If any of these conditions are not met, the entire User Program is transferred to the controller. Additionally, if the program in the controller contains protected files, the Data Protection Lost indicator (S:36/10) is set to indicate that protected data has been lost. For example, a control program with protected files is transferred to the controller. The original program did not have protected files or the files did not match. The data protection lost indicator (S:36/10) is then set. The data protection lost indicator represents that the protected files within the controller have had values downloaded and the user application may need to be re-configured.

TIP The controller will not clear the Data Protection Lost indicator. It is up to the user to clear this bit.

Static File Protection

When a data file is Static File Protected, the values contained in it cannot be changed via communications, except during a program download to the controller.

Using Static File Protection with Data File Download Protection

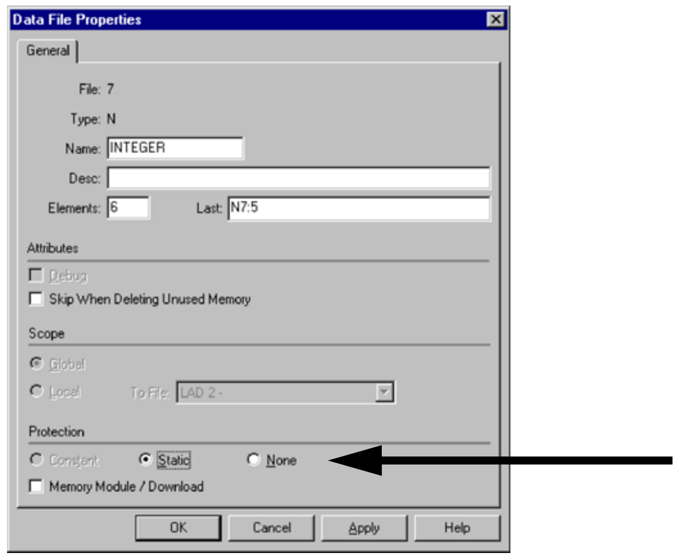
Static File Protection and Data File Download Protection can be used in combination with any MicroLogix 1200 Controller Series B and higher, and MicroLogix 1500 Processor Series B and higher.

Setting Static File Protection

Static File Protection can be applied to the following data file types:

- Output (O)
- Input (I)
- Status (S)
- Binary (B)
- Timer (T)
- Counter (C)
- Control (R)
- Integer (N)
- Floating Point (F)
- String (ST)
- Long Word (L)
- Proportional Integral Derivative (PD)
- Message (MG)
- Programmable Limit Switch (PLS)

Access the Static File Protect feature using RSLogix 500 programming software. For each data file you want protected, select the Static protection in the Data File Properties screen as shown in this illustration. To access this screen, right mouse click on the desired data file.

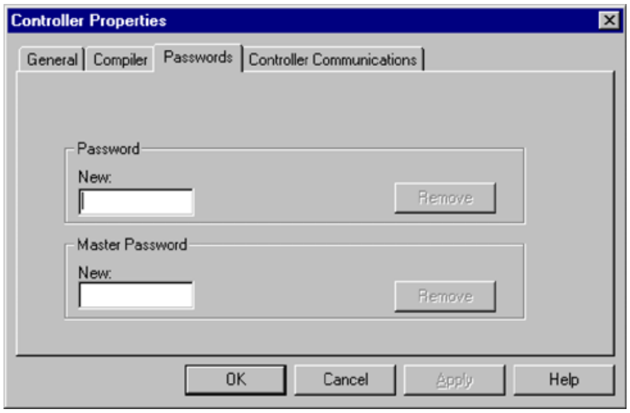


Password Protection

MicroLogix controllers have a built-in security system, based on numeric passwords. Controller passwords consist of up to 10 digits (0-9). Each controller program may contain two passwords, the Password and the Master Password.

Passwords restrict access to the controller. The Master Password takes precedence over the Password. The idea is that all controllers in a project would have different Passwords, but the same Master Password, allowing access to all controllers for supervisory or maintenance purposes.

You can establish, change, or delete a password by using the Controller Properties dialog box. It is not necessary to use passwords, but if used, a master password is ignored unless a password is also used.



TIP If a password is lost or forgotten, there is no way to bypass the password to recover the program. The only option is to clear the controller's memory.

If the Memory Module User Program has the "Load Always" functionality enabled, and the controller User Program has a password specified, the controller compares the passwords before transferring the User Program from the Memory Module to the controller. If the passwords do not match, the User Program is not transferred and the program mismatch bit is set (S:5/9).

Clearing the Controller Memory

If you are locked out because you do not have the password for the controller, you can clear the controller memory and download a new User Program.

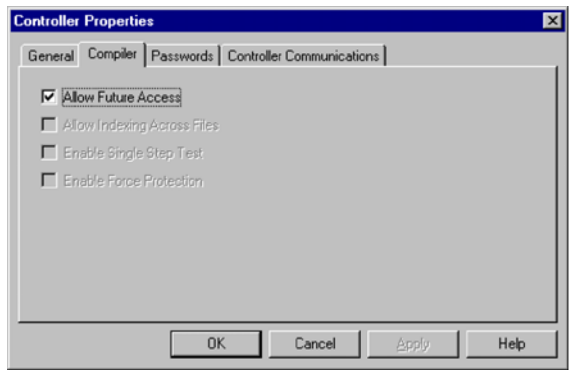
You can clear the memory when the programming software prompts you for a System or Master Password to go on-line with the controller. To do so:

1. Enter 65257636 (the telephone keypad equivalent of MLCLRMEM, MicroLogix Clear Memory).
2. When the Programming Software detects this number has been entered, it asks if you want to clear the memory in the controller.
3. If you reply "yes" to this prompt, the programming software instructs the controller to clear Program memory.

Allow Future Access Setting (OEM Lock)

The controller supports a feature which allows you to select if future access to the User Program should be allowed or disallowed after it has been transferred to the controller. This type of protection is particularly useful to an OEM (original equipment manufacturer) who develops an application and then distributes the application via a memory module or within a controller.

The Allow Future Access setting is found in the Controller Properties window as shown below.



When Allow Future Access is deselected, the controller requires that the User Program in the controller is the same as the one in the programming device. If the programming device does not have a matching copy of the User Program, access to the User Program in the controller is denied. To access the User Program, clear controller memory and reload the program.

TIP

Functions such as change mode, clear memory, restore program, and transfer memory module are allowed regardless of this selection.

Controller passwords are not associated with the Allow Future Access setting.

Function Files

This chapter describes controller function files. The chapter is organized as follows:

Overview

Function Files are one of the three primary file structures within the MicroLogix 1200 and MicroLogix 1500 controllers (Program Files and Data Files are the others). Function Files provide an efficient and logical interface to controller resources. Controller resources are resident (permanent) features such as the Real-Time Clock and High-Speed Counter. The features are available to the control program through either instructions that are dedicated to a specific function file, or via standard instructions such as MOV and ADD. The Function File types are:

Function Files

File Name	File Identifier	File Description
High-Speed Counter	**HSC**	This file type is associated with the High-Speed Counter function. See "Using the High-Speed Counter and Programmable Limit Switch" on page 109 for more information.
Pulse Train Output (MicroLogix 1200 and 1500 BXB units only.)	**PTO**	This file type is associated with the Pulse Train Output Instruction. See "Pulse Train Outputs (PTO) Function File" on page 153 for more information.
Pulse Width Modulation (MicroLogix 1200 and 1500 BXB units only.)	**PWM**	This file type is associated with the Pulse Width Modulation instruction. See "Pulse Width Modulation (PWM) Function File" on page 169 for more information.
Selectable Timed Interrupt	**STI**	This file type is associated with the Selectable Timed Interrupt function. See "Using the Selectable Timed Interrupt (STI) Function File" on page 301 for more information.
Event Input Interrupt	**EII**	This file type is associated with the Event Input Interrupt instruction. See "Using the Event Input Interrupt (EII) Function File" on page 308 for more information.
Real-Time Clock	**RTC**	This file type is associated with the Real-Time Clock (time of day) function. See "Real-Time Clock Function File" on page 71 for more information.
Trim Pot Information	**TPI**	This file type contains information about the Trim Pots. See "Trim Pot Information Function File" on page 76 for more information.
Memory Module Information	**MMI**	This file type contains information about the Memory Module. See "Memory Module Information Function File" on page 77 for more information.
Data Access Tool Information (MicroLogix 1500 only.)	**DAT**	This file type contains information about the Data Access Tool. See "DAT Function File (MicroLogix 1500 only)" on page 80 for more information.
Base Hardware Information	**BHI**	This file type contains information about the controller's hardware. See "Base Hardware Information Function File" on page 83 for the file structure.
Communications Status File	**CS**	This file type contains information about the Communications with the controller. See "Communications Status File" on page 84 for the file structure.
I/O Status File	**IOS**	This file type contains information about the controller I/O. See "Input/Output Status File" on page 99 for the file structure.

Real-Time Clock Function File

The real-time clock provides year, month, day of month, day of week, hour, minute, and second information to the Real-Time Clock (RTC) Function File in the controller.

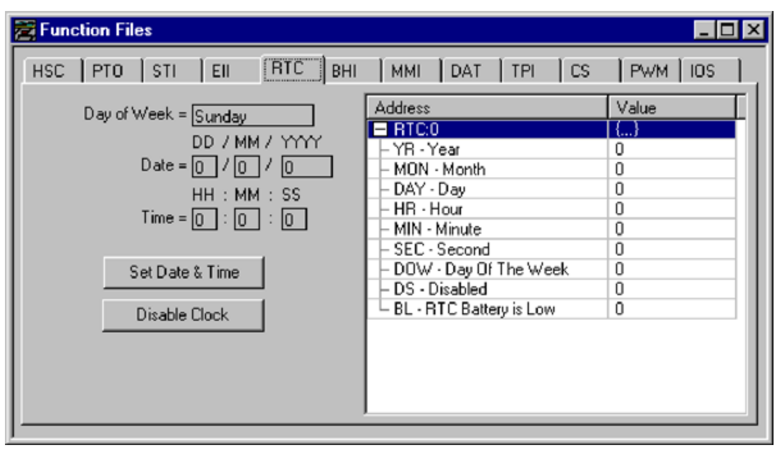
The Real-Time Clock parameters and their valid ranges are shown in the table below.

Real-Time Clock Function File

Feature	Address	Data Format	Range	Type	User Program Access
YR - RTC Year	RTC:0.YR	word	1998 to 2097	status	read-only
MON - RTC Month	RTC:0.MON	word	1 to 12	status	read-only
DAY - RTC Day of Month	RTC:0.DAY	word	1 to 31	status	read-only
HR - RTC Hours	RTC:0.HR	word	0 to 23 (military time)	status	read-only
MIN - RTC Minutes	RTC:0.MIN	word	0 to 59	status	read-only
SEC - RTC Seconds	RTC:0.SEC	word	0 to 59	status	read-only
DOW - RTC Day of Week	RTC:0.DOW	word	0 to 6 (Sunday to Saturday)	status	read-only
DS - Disabled	RTC:0/DS	binary	0 or 1	status	read-only
BL - RTC Battery Low	RTC:0/BL	binary	0 or 1	status	read-only

Writing Data to the Real-Time Clock

The programming screen is shown below:



When valid data is sent to the real-time clock from the programming device or another controller, the new values take effect immediately. In RSLogix 500, click on *Set Date & Time* in the RTC Function File screen to set the RTC time to the current time on your PC.

The real-time clock does not allow you to load or store invalid date or time data.

TIP Use the *Disable Clock* button in your programming device to disable the real-time clock before storing a module. This decreases the drain on the battery during storage.

Real-Time Clock Accuracy

The following table indicates the expected accuracy of the real-time clock for various temperatures.

Real-Time Clock Accuracy at Various Temperatures

Ambient Temperature	Accuracy[1]
0°C (+32°F)	+34 to -70 seconds/month
+25°C (+77°F)	+36 to -68 seconds/month
+40°C (+104°F)	+29 to -75 seconds/month
+55°C (+131°F)	-133 to -237 seconds/month

(1) These numbers are worst case values over a 31 day month.

RTC Battery Operation

The real-time clock has an internal battery that is not replaceable. The RTC Function File features a battery low indicator bit (RTC:0/BL), which represents the status of the RTC battery. When the battery is low, the indicator bit is set (1). This means that the battery will fail in less than 14 days, and the real-time clock module needs to be replaced. When the battery low indicator bit is clear (0), the battery level is acceptable, or a real-time clock is not attached.

ATTENTION Operating with a low battery indication for more than 14 days may result in invalid RTC data if power is removed from the controller.

RTC Battery Life Expectancy

Battery State	Temperature	Time Duration
Operating	0°C to +40°C (+32°F to +104°F)	5 years[1]
Storage	-40°C to +25°C (-40°F to +77°F)	5 years minimum
	+26°C to +60°C (+79°F to +140°F)	3 years minimum

(1) The operating life of the battery is based on 6 months of storage time before the real-time clock is used.

RTA - Real Time Clock Adjust Instruction

Instruction Type: output

Execution Time for the RTA Instruction

Controller	When Rung Is:	
	True	**False**
MicroLogix 1200	4.7 µs	3.7 µs
	556.2 µs (false-to-true transition)	
MicroLogix 1500	4.1 µs	2.6 µs
	426.8 µs (false-to-true transition)	

The RTA instruction is used to synchronize the controllers Real-Time Clock (RTC) with an external source. The RTA instruction will adjust the RTC to the nearest minute. The RTA instruction adjusts the RTC based on the value of the RTC Seconds as described below.

IMPORTANT The RTA instruction will only change the RTC when the RTA rung is evaluated true, after it was previously false (false-to-true transition). The RTA instruction will have no effect if the rung is always true or false.

RTA is set:

- If RTC Seconds are less than 30, then RTC Seconds is reset to 0.
- If RTC Seconds are greater than or equal to 30, then the RTC Minutes are incremented by 1 and RTC Seconds are reset to 0.

The following conditions cause the RTA instruction to have no effect on the RTC data:

- No RTC attached to the controller
- RTC is present, but disabled
- An external (via communications) message to the RTC is in progress when the RTA instruction is executed. (External communications to the RTC takes precedence over the RTA instruction.)

To re-activate the RTA instruction, the RTA rung must become false, and then true.

TIP There is only one internal storage bit allocated in the system for this instruction. Do not use more than one RTA instruction in your program.

TIP

You can also use a MSG instruction to write RTC data from one controller to another to synchronize time. To send (write) RTC data, use RTC:0 as the source and the destination. *This feature not available with the Series A controllers.*

Trim Pot Information Function File

The composition of the Trim Pot Information (TPI) Function File is described below.

Trim Pot Function File

Data	Address	Data Format	Range	Type	User Program Access
TPD Data 0	TPI:0.POT0	Word (16-bit integer)	0 - 250	Status	Read Only
TPD Data 1	TPI:0.POT1	Word (16-bit integer)	0 - 250	Status	Read Only
TP0 Error Code	TPI:0.ER	Word (bits 0 to 7)	0 - 3	Status	Read Only
TP1 Error Code		Word (bits 8 to 15)			

The data resident in TPI:0.POT0 represents the position of trim pot 0. The data resident in TPI:0.POT1 corresponds to the position of trim pot 1. The valid data range for both is from 0 (counterclockwise) to 250 (clockwise).

Error Conditions

If the controller detects a problem with either trim pot, the last values read remain in the data location, and an error code is put in the error code byte of the TPI file for whichever trim pot had the problem. Once the controller can access the trim pot hardware, the error code is cleared. The error codes are described in the table below.

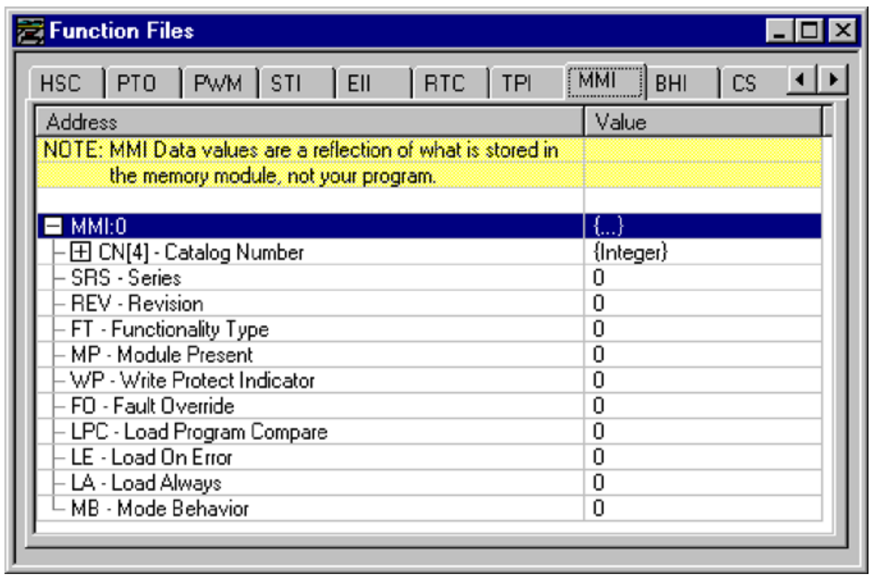
Trim Pot Error Codes

Error Code	Description
0	Trim pot data is valid.
1	Trim pot subsystem detected, but data is invalid.
2	Trim pot subsystem did not initialize.
3	Trim pot subsystem failure.

Memory Module Information Function File

The controller has a Memory Module Information (MMI) File which is updated with data from the attached memory module. At power-up or on detection of a memory module being inserted, the catalog number, series, revision, and type (memory module and/or real-time clock) are identified and written to the MMI file in the user program. If a memory module and/or real-time clock is not attached, zeros are written to the MMI file.

The memory module function file programming screen is shown below:



The parameters and their valid ranges are shown in the table below.

MMI Function File Parameters

Feature	Address	Data Format	Type	User Program Access
FT - Functionality Type	MMI:0.FT	word (INT)	status	read-only
MP - Module Present	MMI:0/MP	binary (bit)	status	read-only
WP - Write Protect	MMI:0/WP	binary (bit)	control	read-only
FO - Fault Override	MMI:0/FO	binary (bit)	control	read-only
LPC - Program Compare	MMI:0/LPC	binary (bit)	control	read-only
LE - Load On Error	MMI:0/LE	binary (bit)	control	read-only
LA - Load Always	MMI:0/LA	binary (bit)	control	read-only
MB - Mode Behavior	MMI:0/MB	binary (bit)	control	read-only

FT - Functionality Type

The LSB of this word identifies the type of module installed:

- 1 = Memory Module (MM1)
- 2 = Real-Time Clock Module (RTC)
- 3 = Memory and Real-Time Clock Module (MM1RTC)
- 4 = Memory Module (MM2)
- 5 = Memory and Real-Time Clock Module (MM2RTC)

MP - Module Present

The MP (Module Present) bit can be used in the user program to determine when a memory module is present on the controller. This bit is updated once per scan, provided the memory module is first recognized by the controller. To be recognized by the controller, the memory module must be installed prior to power-up or when the controller is in a non-executing mode. If a memory module is installed when the controller is in an executing mode, it is not recognized. If a recognized memory module is removed during an executing mode, this bit is cleared (0) at the end of the next ladder scan.

WP - Write Protect

When the WP (Write Protect) bit is set (1), the module is write-protected and the user program and data within the memory module cannot be overwritten

IMPORTANT	Once the WP bit is set (1), it cannot be cleared. Only set this bit if you want the contents of the memory module to become permanent.

FO - Fault Override

The FO (Fault Override) bit represents the status of the fault override setting of the program stored in the memory module. It enables you to determine the value of the FO bit without actually loading the program from the memory module.

IMPORTANT	The memory module fault override selection in the Memory Module Information (MMI) file does not determine the controller's operation. It merely displays the setting of the user program's Fault Override bit (S:1/8) in the memory module.

See "Fault Override At Power-Up" on page 484 for more information.

LPC - Load Program Compare

The LPC (Load Program Compare) bit shows the status of the load program compare selection in the memory module's user program status file. It enables you to determine the value without actually loading the user program from the memory module.

See "Memory Module Program Compare" on page 489 for more information.

LE - Load on Error

The LE (Load on Error) bit represents the status of the load on error setting in the program stored in the memory module. It enables you to determine the value of the selection without actually loading the user program from the memory module.

See "Load Memory Module On Error Or Default Program" on page 484 for more information.

LA - Load Always

The LA (Load Always) bit represents the status of the load always setting in the program stored in the memory module. It enables you to determine the value of the selection without actually loading the user program from the memory module.

See "Load Memory Module Always" on page 485 for more information.

MB - Mode Behavior

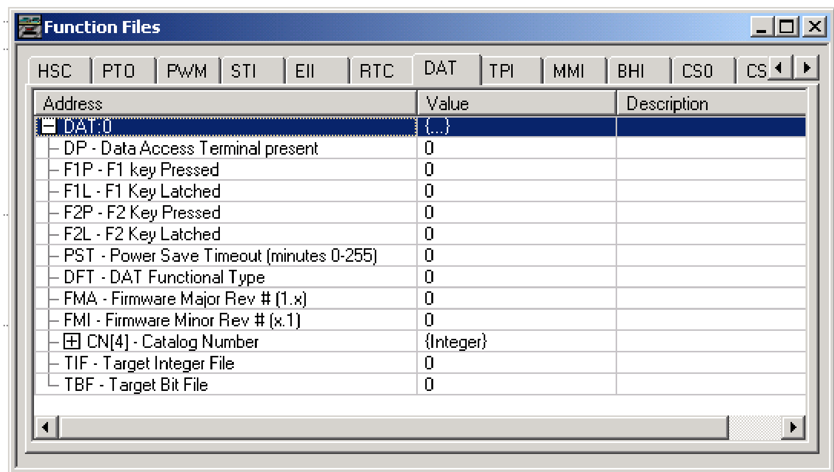
The MB (Mode Behavior) bit represents the status of the mode behavior setting in the program stored in the memory module. It enables you to determine the value of the selection without actually loading the user program from the memory module.

See "Power-Up Mode Behavior" on page 485 for more information.

DAT Function File (MicroLogix 1500 only)

TIP This section describes the DAT Function File. For instructions on operating the DAT, see the *MicroLogix 1500 User Manual*, publication 1764-UM001.

Data Access Tool (DAT) configuration is stored in the processor in a specialized configuration file called the DAT Function File. The DAT Function File, which is part of the user's control program, is shown below.



The DAT function file contains the Target Integer File, the Target Bit File, and the Power Save Timeout parameter. These three parameters are described in the table below.

Feature	Address	Data Format	Type	User Program Access
Target Integer File	DAT:0.TIF	Word (int)	Control	Read Only
Target Bit File	DAT:0.TBF	Word (int)	Control	Read Only
Power Save Timeout	DAT:0.PST	Word (int)	Control	Read Only

Target Integer File (TIF)

The value stored in the TIF location identifies the integer file with which the DAT will interface. The DAT can read or write to any valid integer file within the controller. Valid integer files are N3 through N255. When the DAT reads a valid integer file number, it can access the first 48 elements (0 to 47) of the specified file on its display screen. The next 48 bits (words 48 to 50) are used to define the read-only or read/write privileges for the 48 elements.

The only integer file that the DAT interfaces with is the file specified in the TIF location. The TIF location can only be changed by a program download.

IMPORTANT Use your programming software to ensure that the integer file you specify in the TIF location, as well as the appropriate number of elements, exist in the controller's user program.

The example table below shows a DAT configured to use integer file number 50 (DAT:0.TIF = 50).

Element Number	Data Address	Protection Bit	Element Number	Data Address	Protection Bit	Element Number	Data Address	Protection Bit
0	N50:0	N50:48/0	16	N50:16	N50:49/0	32	N50:32	N50:50/0
1	N50:1	N50:48/1	17	N50:17	N50:49/1	33	N50:33	N50:50/1
2	N50:2	N50:48/2	18	N50:18	N50:49/2	34	N50:34	N50:50/2
3	N50:3	N50:48/3	19	N50:19	N50:49/3	35	N50:35	N50:50/3
4	N50:4	N50:48/4	20	N50:20	N50:49/4	36	N50:36	N50:50/4
5	N50:5	N50:48/5	21	N50:21	N50:49/5	37	N50:37	N50:50/5
6	N50:6	N50:48/6	22	N50:22	N50:49/6	38	N50:38	N50:50/6
7	N50:7	N50:48/7	23	N50:23	N50:49/7	39	N50:39	N50:50/7
8	N50:8	N50:48/8	24	N50:24	N50:49/8	40	N50:40	N50:50/8
9	N50:9	N50:48/9	25	N50:25	N50:49/9	41	N50:41	N50:50/9
10	N50:10	N50:48/10	26	N50:26	N50:49/10	42	N50:42	N50:50/10
11	N50:11	N50:48/11	27	N50:27	N50:49/11	43	N50:43	N50:50/11
12	N50:12	N50:48/12	28	N50:28	N50:49/12	44	N50:44	N50:50/12
13	N50:13	N50:48/13	29	N50:29	N50:49/13	45	N50:45	N50:50/13
14	N50:14	N50:48/14	30	N50:30	N50:49/14	46	N50:46	N50:50/14
15	N50:15	N50:48/15	31	N50:31	N50:49/15	47	N50:47	N50:50/15

The element number displayed on the DAT corresponds to the data register as illustrated in the table. The protection bit defines whether the data is read/write or read-only. When the protection bit is set (1), the corresponding data address is considered read-only by the DAT. The Protected LED illuminates whenever a read-only element is active on the DAT display. When the protection bit is clear (0) or the protection bit does not exist, the Protected LED is off and the data within the corresponding address is editable from the DAT keypad.

IMPORTANT Although the DAT does not allow protected data to be changed from its keypad, the control program or other communication devices do have access to this data. Protection bits do not provide any overwrite protection to data within the target integer file. It is entirely the user's responsibility to ensure that data is not inadvertently overwritten.

TIP

- Remaining addresses within the target file can be used without restrictions (addresses N50:51 and above, in this example).
- The DAT always starts at word 0 of a data file. It cannot start at any other address within the file.

Target Bit File (TBF)

The value stored in the TBF location identifies the bit file with which the DAT will interface. The DAT can read or write to any valid bit file within the controller. Valid bit files are B3 through B255. When the DAT reads a valid bit file number, it can access the first 48 bits (0 to 47) of the specified file on its display screen. The next 48 bits (48 to 95) are used to define the read-only or read/write privileges for the first 48 bits.

The only bit file that the DAT interfaces with is the file specified in the TBF location. The TBF location can only be changed by a program download.

IMPORTANT Use your programming software to ensure that the bit file you specify in the TBF location, as well as the appropriate number of elements, exist in the MicroLogix 1500 user program.

The example table below shows how the DAT uses the configuration information with bit file number 51 (DAT:0.TBF=51).

Bit Number	Data Address	Protection Bit	Bit Number	Data Address	Protection Bit	Bit Number	Data Address	Protection Bit
0	B51/0	B51/48	16	B51/16	B51/64	32	B51/32	B51/80
1	B51/1	B51/49	17	B51/17	B51/65	33	B51/33	B51/81
2	B51/2	B51/50	18	B51/18	B51/66	34	B51/34	B51/82
3	B51/3	B51/51	19	B51/19	B51/67	35	B51/35	B51/83
4	B51/4	B51/52	20	B51/20	B51/68	36	B51/36	B51/84
5	B51/5	B51/53	21	B51/21	B51/69	37	B51/37	B51/85
6	B51/6	B51/54	22	B51/22	B51/70	38	B51/38	B51/86
7	B51/7	B51/55	23	B51/23	B51/71	39	B51/39	B51/87
8	B51/8	B51/56	24	B51/24	B51/72	40	B51/40	B51/88
9	B51/9	B51/57	25	B51/25	B51/73	41	B51/41	B51/89
10	B51/10	B51/58	26	B51/26	B51/74	42	B51/42	B51/90
11	B51/11	B51/59	27	B51/27	B51/75	43	B51/43	B51/91
12	B51/12	B51/60	28	B51/28	B51/76	44	B51/44	B51/92
13	B51/13	B51/61	29	B51/29	B51/77	45	B51/45	B51/93
14	B51/14	B51/62	30	B51/30	B51/78	46	B51/46	B51/94
15	B51/15	B51/63	31	B51/31	B51/79	47	B51/47	B51/95

The bit number displayed on the DAT corresponds to the data bit as illustrated in the table. The protection bit defines whether the data is editable or read-only. When the protection bit is set (1), the corresponding data address is considered read-only by the DAT. The Protected LED illuminates whenever a read-only element is active on the DAT display. When the protection bit is clear (0) or the protection bit does not exist, the Protected LED is off and the data within the corresponding address is editable from the DAT keypad.

IMPORTANT Although the DAT does not allow protected data to be changed from its keypad, the control program or other communication devices do have access to this data. Protection bits do not provide any overwrite protection to data within the target bit file. It is entirely the user's responsibility to ensure that data is not inadvertently overwritten.

TIP

- Remaining addresses within the target file can be used without restrictions (addresses B51/96 and above, in this example).
- The DAT always starts at bit 0 of a data file. It cannot start at any other address within the file.

Base Hardware Information Function File

The base hardware information (BHI) file is a read-only file that contains a description of the MicroLogix 1200 Controller or the MicroLogix 1500 Base Unit.

Base Hardware Information Function File (BHI)

Address	Description
BHI:0.CN	CN - Catalog Number
BHI:0.SRS	SRS - Series
BHI:0.REV	REV - Revision
BHI:0.FT	FT - Functionality Type

Communications Status File

The Communications Status (CS) File is a read-only file that contains information on how the controller communication parameters are configured and status information on communications activity.

The communications status file uses:

Communications Status File Size

Controller	Number of Word Elements
MicroLogix 1500 1764-LSP Series A Processor	44 1-word elements
MicroLogix 1200 MicroLogix 1500 1764-LSP Series B and 1764-LRP Processors	71 1-word elements

There is one Communications Status File for each communications port. Communications Status File CS0 corresponds to Channel 0 on the controller. Communications Status File CS1 corresponds to Channel 1 on the 1764-LRP processor.

TIP You can use the Communications Status File information as a troubleshooting tool for communications issues.

The data file is structured as:

Communications Status File

Word	Description	Applies to Controller	Details on Page
0 to 5	General Channel Status Block	MicroLogix 1200 and 1500	85
6 to 22	DLL Diagnostic Counters Block	MicroLogix 1200 and 1500	88
23 to 42	DLL Active Node Table Block	MicroLogix 1200 and 1500	98
words 43 to 70 when using DF1 Full-Duplex, DF1 Half-Duplex, DH-485, or ASCII [(1)]*:*			
43	End of List Category Identifier Code (always 0)	MicroLogix 1200 and 1500	--
43 to 70	Reserved	• MicroLogix 1200 • MicroLogix 1500 1764-LSP Series B and 1764-LRP Processors	--

Communications Status File

Word	Description	Applies to Controller	Details on Page
words 43 to 70 when using Modbus RTU Slave:			
43 to 69	Modbus Slave Diagnostic Counters Block	• MicroLogix 1200 • MicroLogix 1500 1764-LSP Series B and 1764-LRP Processors	93
70	End of List Category Identifier Code (always 0)	• MicroLogix 1200 • MicroLogix 1500 1764-LSP Series B and 1764-LRP Processors	--

(1) ASCII can only be used with the MicroLogix 1200 and MicroLogix 1500 1764-LSP Series B (and higher) and 1764-LRP Processors.

The following tables show the details of each block in the Communications Status File.

General Status Block of Communications Status File

General Channel Status Block

Word	Bit	Description
0	-	Communications Channel General Status Information Category Identifier Code
1	-	Length
2	-	Format Code
3	-	Communications Configuration Error Code

General Channel Status Block

4	0	ICP – Incoming Command Pending Bit This bit is set (1) when the controller determines that another device has requested information from this controller. Once the request has been satisfied, the bit is cleared (0).
	1	MRP – Incoming Message Reply Pending Bit This bit is set (1) when the controller determines that another device has supplied the information requested by a MSG instruction executed by this controller. When the appropriate MSG instruction is serviced (during end-of-scan, SVC, or REF), this bit is cleared (0).
	2	MCP – Outgoing Message Command Pending Bit This bit is set (1) when the controller has one or more MSG instructions enabled and in the communication queue. This bit is cleared (0) when the queue is empty.
	3	SSB – Selection Status Bit This bit indicates that the controller is in the System Mode. It is always set.
	4	CAB – Communications Active Bit This bit is set (1) when at least one other device is on the DH-485 network. If no other devices are on the network, this bit is cleared (0).
	5 to 14	Reserved
	15	Communications Toggle Push Button Communications Defaults Active. This bit is set (1) whenever Channel 0 is in the default communications mode. The bit is cleared (0) when Channel 0 is in user configured communications mode. (Always 0 for 1764-LRP Processor Channel 1) *This bit is not available with the Series A controllers.*
5	0 to 7	Node Address - This byte value contains the node address of your controller on the network.
	8 to 15	Baud Rate - This byte value contains the baud rate of the controller on the network.

Diagnostic Counter Block of Communications Status File

With RSLogix 500 version 6.10.10 and later, formatted displays of the diagnostic counters for each configured channel are available under Channel Status. These displays include a Clear button that allows you to reset the diagnostic counters while monitoring them online with the programming software.

TIP

For the MicroLogix 1500 LRP with OS Series C, FRN 8, and higher, clicking on the Clear button while online monitoring Channel Status of either channel 0 or channel 1 will reset all of the channel status diagnostic counters for both channels to zero.

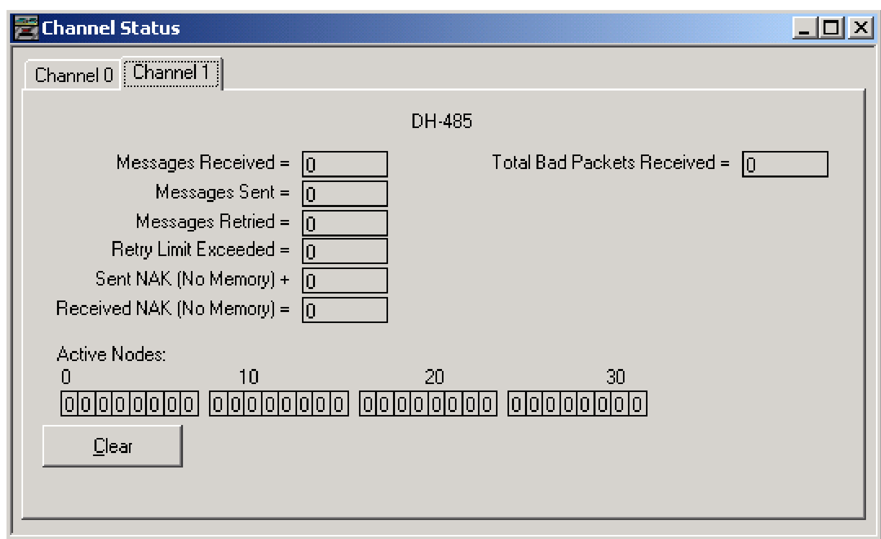
Prior to OS Series C, FRN 8, the only channel status diagnostic counters that are reset when the Clear button is clicked are the ones on the channel that the programming terminal is connected through. For instance, if your programming terminal is connected online via channel 0 and you are monitoring the Channel Status of channel 1, when you click on the Clear button, only the channel 0 diagnostic counters will be reset - the channel 1 diagnostic counters will not be reset.

Diagnostic Counter Blocks are shown for:

- DH-485 (on page 88)
- DF1 Full-Duplex (on page 89)
- DF1 Half-Duplex Slave (on page 90)
- DF1 Half-Duplex Master (on page 91)
- DF1 Radio Modem (on page 92)
- Modbus RTU Slave (on page 93)
- Modbus RTU Master (on page 95)
- ASCII (on page 97)

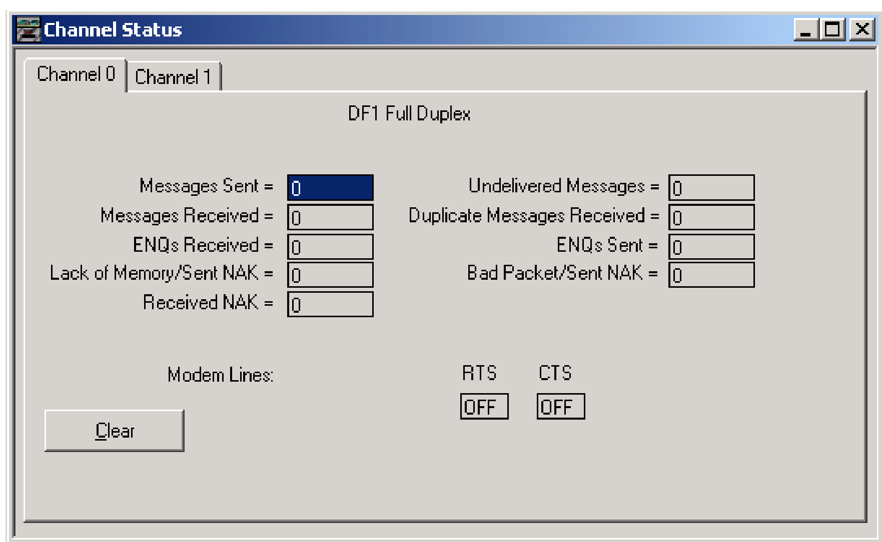
DH-485 Diagnostic Counters Block

Word	Bit	Description
6	-	Diagnostic Counters Category Identifier Code (always 2)
7	-	Length (always 30)
8	-	Format Code (always 0)
9	-	Total Message Packets Received
10	-	Total Message Packets Sent
11	0 to 7	Message Packet Retries
	8 to 15	Retry Limit Exceeded (Non-Delivery)
12	0 to 7	NAK – No Memories Sent
	8 to 15	NAK – No Memories Received
13	0 to 7	Total Bad Message Packets Received
	8 to 15	Reserved
14 to 22	-	Reserved



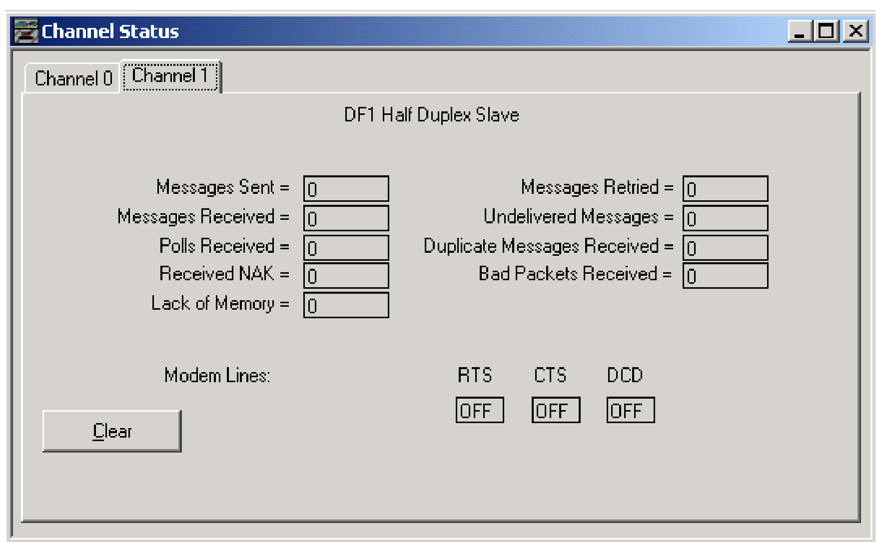
DF1 Full-Duplex Diagnostic Counters Block

Word	Bit	Description
6	-	Diagnostic Counters Category Identifier Code (always 2)
7	-	Length (always 30)
8	-	Format Code (always 1)
9	0	CTS
	1	RTS
	2	Reserved
	3	Channel 0 - Reserved, Channel 1 - DCD
	4 to 15	Reserved
10	-	Total Message Packets Sent
11	-	Total Message Packets Received
12	-	Undelivered Message Packets
13	-	ENQuiry Packets Sent
14	-	NAK Packets Received
15	-	ENQuiry Packets Received
16	-	Bad Message Packets Received and NAKed
17	-	No Buffer Space and NAK'ed
18	-	Duplicate Message Packets Received
19 to 22	-	Reserved



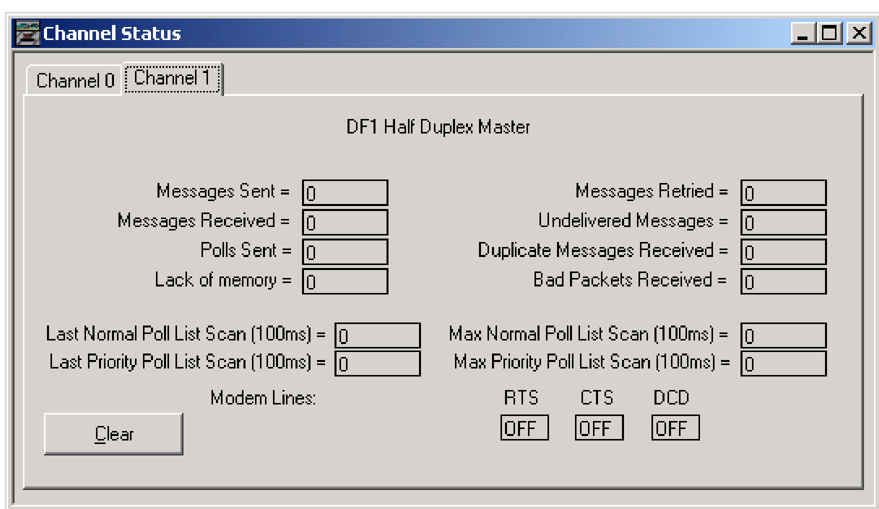
DF1 Half-Duplex Slave Diagnostic Counters Block

Word	Bit	Description
6	-	Diagnostic Counters Category Identifier Code (always 2)
7	-	Length (always 30)
8	-	Format Code (always 2)
9	0	CTS
	1	RTS
	2	Reserved
	3	Channel 0 - Reserved, Channel 1 - DCD
	4 to 15	Reserved
10	-	Total Message Packets Sent
11	-	Total Message Packets Received
12	-	Undelivered Message Packets
13	-	Message Packets Retried
14	-	NAK Packets Received
15	-	Polls Received
16	-	Bad Message Packets Received
17	-	No Buffer Space
18	-	Duplicate Message Packets Received
19 to 22	-	Reserved



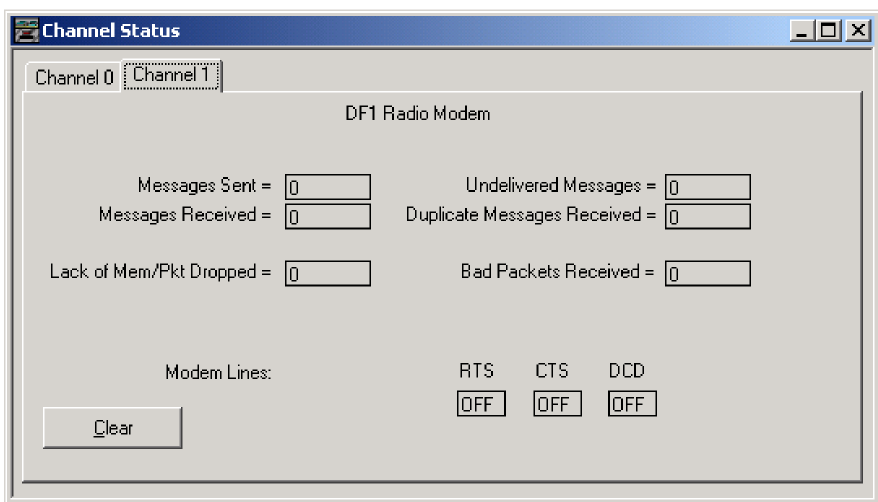
DF1 Half-Duplex Master Diagnostic Counters Block
(MicroLogix 1200, FRN 7 and higher
MicroLogix 1500 1764-LSP, FRN 8 and higher
MicroLogix 1500 1764-LRP, FRN 8 and higher [Channel 1 only])

Word	Bit	Description
6	-	Diagnostic Counters Category Identifier Code (always 2)
7	-	Length (always 30)
8	-	Format Code (always 3)
9	0	CTS
	1	RTS
	2	Reserved
	3	Channel 0 - Reserved, Channel 1 - DCD
	4 to 15	Reserved
10	-	Total Message Packets Sent
11	-	Total Message Packets Received
12	-	Undelivered Message Packets
13	-	Message Packets Retried
14	-	Reserved
15	-	Polls Sent
16	-	Bad Message Packets Received
17	-	No Buffer Space, Received Packet Dropped
18	-	Duplicate Message Packets Received
19	-	Last Normal Poll List Scan
20	-	Max. Normal Poll List Scan
21	-	Last Priority Poll List Scan
22	-	Max. Priority Poll List Scan



DF1 Radio Modem Diagnostic Counters Block
(MicroLogix 1200, FRN 7 and higher
MicroLogix 1500 1764-LSP, FRN 8 and higher
MicroLogix 1500 1764-LRP, FRN 8 and higher [Channel 1 only]

Word	Bit	Description
6	-	Diagnostic Counters Category Identifier Code (always 2)
7	-	Length (always 30)
8	-	Format Code (always 1)
9	0	CTS
	1	RTS
	2	Reserved
	3	Channel 0 - Reserved, Channel 1 - DCD
	4 to 15	Reserved
10	-	Total Message Packets Sent
11	-	Total Message Packets Received
12	-	Undelivered Message Packets
13 to 15	-	Reserved
16	-	Bad Message Packets Received
17	-	No Buffer Space, Received Packet Dropped
18	-	Duplicate Message Packets Received
19 to 22	-	Reserved



Modbus RTU Slave Diagnostic Counters Block (Data Link Layer)
(MicroLogix 1200 Controllers, and MicroLogix 1500 1764-LSP Series B and 1764-LRP Processors)

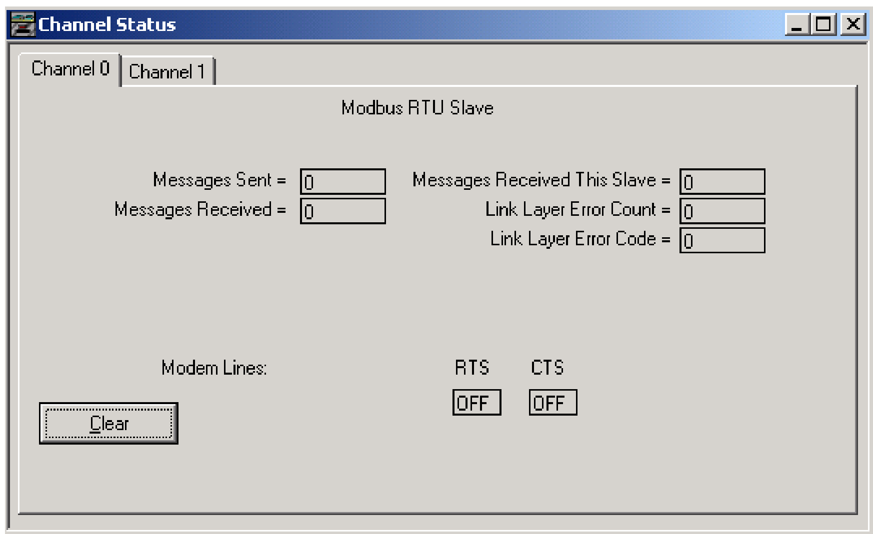
Word	Bit	Description
6	-	Diagnostic Counters Category Identifier Code (always 2)
7	-	Length (always 30)
8	-	Format Code (always 4)
9	0	CTS
	1	RTS
	2	Reserved
	3	Channel 0 - Reserved, Channel 1 - DCD
	4 to 15	Reserved
10	-	Total Message Packets Sent
11	-	Total Message Packets Received for This Slave
12	-	Total Message Packets Received
13	-	Link Layer Error Count
14	-	Link Layer Error Code
15 to 22	-	Reserved

Modbus RTU Slave Diagnostic Counters Block (Presentation Layer)
(MicroLogix 1200 Controllers, and MicroLogix 1500 1764-LSP Series B and 1764-LRP Processors)

Word	Bit	Description
43	-	Diagnostic Counters Category Identifier Code (always 10)
44	-	Length (always 14)
45	-	Format Code (always 0)
46	-	Pre-Send Time Delay
47	0 to 7	Node Address
	8 to 15	Reserved
48	-	Inter-Character Timeout
49	-	RTS Send Delay
50	-	RTS Off Delay
51	0 to 7	Baud Rate
	8 and 9	Parity
	10 to 15	Reserved
52	-	Diagnostic Counters Category Identifier Code (always 6)
53	-	Length (always 32)
54	-	Format Code (always 0)
55	-	Presentation Layer Error Code
56	-	Presentation Layer Error Count
57	-	Execution Function Error Code
58	-	Last Transmitted Exception Code
59	-	Data File Number of Error Request
60	-	Element Number of Error Request
61	-	Function Code 1 Message Counter
62	-	Function Code 2 Message Counter
63	-	Function Code 3 Message Counter
64	-	Function Code 4 Message Counter

Modbus RTU Slave Diagnostic Counters Block (Presentation Layer)
(MicroLogix 1200 Controllers, and MicroLogix 1500 1764-LSP Series B and 1764-LRP Processors)

Word	Bit	Description
65	-	Function Code 5 Message Counter
66	-	Function Code 6 Message Counter
67	-	Function Code 8 Message Counter
68	-	Function Code 15 Message Counter
69	-	Function Code 16 Message Counter

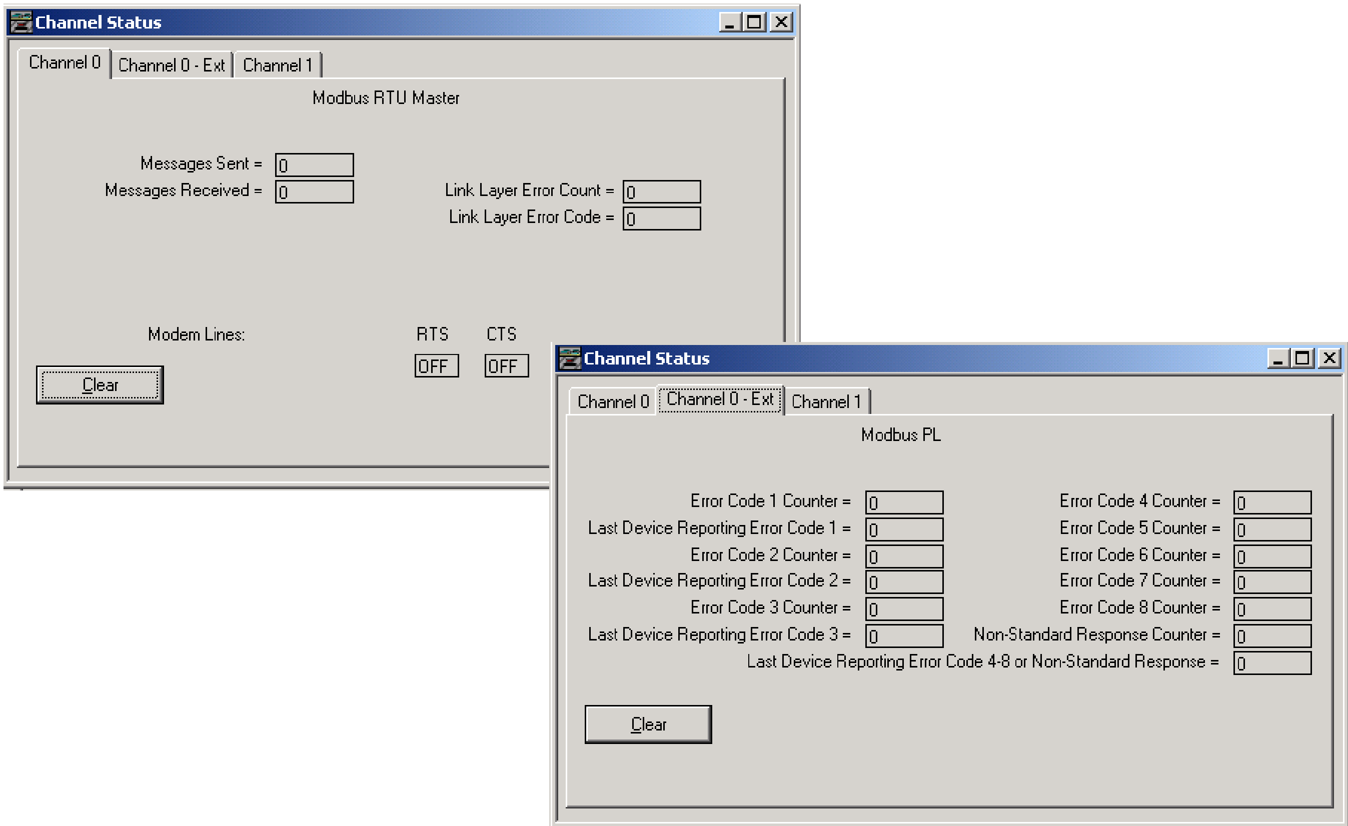


Modbus RTU Master Diagnostic Counters Block (Data Link Layer)
(MicroLogix 1200, FRN 8 and higher
MicroLogix 1500 1764-LSP, FRN 9 and higher
MicroLogix 1500 1764-LRP, FRN 9 and higher)

Word	Bit	Description
6	-	Diagnostic Counters Category Identifier Code (always 2)
7	-	Length (always 30)
8	-	Format Code (always 9)
9	0	CTS
	1	RTS
	2	Reserved
	3	Channel 0 - Reserved, Channel 1 - DCD
	4 to 15	Reserved
10	-	Total Message Packets Sent
11	-	Reserved
12	-	Total Message Packets Received
13	-	Link Layer Error Count
14	-	Link Layer Error Code
15 to 22	-	Reserved

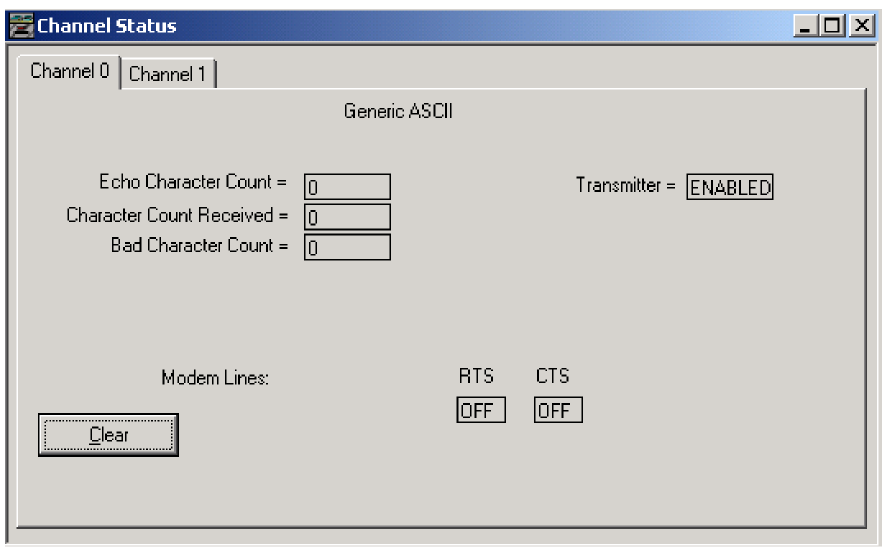
Modbus RTU Master Diagnostic Counters Block (Presentation Layer)
(MicroLogix 1200, FRN 8 and higher
MicroLogix 1500 1764-LSP, FRN 9 and higher
MicroLogix 1500 1764-LRP, FRN 9 and higher)

Word	Bit	Description
52	-	Diagnostic Counters Category Identifier Code (always 6)
53	-	Length (always 32)
54	-	Format Code (always 0)
55	-	ERR 1: Illegal Function
56	-	Last Device Reporting ERR 1
57	-	ERR 2: Illegal Data Address
58	-	Last Device Reporting ERR 2
59	-	ERR 3: Illegal Data Value
60	-	Last Device Reporting ERR 3
61	-	ERR 4: Slave Device Failure
62	-	ERR 5: Acknowledge
63	-	ERR 6: Slave Device Busy
64	-	ERR 7: Negative Acknowledgement
65	-	ERR 8: Memory Parity Error
66	-	Non-Standard Response
67	-	Last Device Reporting ERR 4 to ERR 8 or Non-Standard Response
68 and 69	-	Reserved (always 0)


Channel Status
Channel 0
Channel 0 - Ext
Channel 1
Modbus RTU Master
Messages Sent = 0
Messages Received = 0
Link Layer Error Count = 0
Link Layer Error Code = 0
Modem Lines:
RTS
CTS
OFF
OFF
Clear
Channel Status
Channel 0
Channel 0 - Ext
Channel 1
Modbus PL
Error Code 1 Counter = 0
Last Device Reporting Error Code 1 = 0
Error Code 2 Counter = 0
Last Device Reporting Error Code 2 = 0
Error Code 3 Counter = 0
Last Device Reporting Error Code 3 = 0
Error Code 4 Counter = 0
Error Code 5 Counter = 0
Error Code 6 Counter = 0
Error Code 7 Counter = 0
Error Code 8 Counter = 0
Non-Standard Response Counter = 0
Last Device Reporting Error Code 4-8 or Non-Standard Response = 0
Clear

ASCII Diagnostic Counters Block
(MicroLogix 1200 Series B Controllers, and MicroLogix 1500 1764-LSP Series B and 1764-LRP Processors)

Word	Bit	Description
6	-	DLL Diagnostic Counters Category Identifier code (always 2)
7	-	Length (always 30)
8	-	Format Code (always 5)
9	0	CTS
	1	RTS
	2	Reserved
	3	Channel 0 - Reserved, Channel 1 - DCD
	4 to 15	Reserved
10	0	Software Handshaking Status
	1 to 15	Reserved
11	-	Echo Character Count
12	-	Received Character Count
13 to 18	-	Reserved
19	-	Bad Character Count
20 to 22	-	Reserved

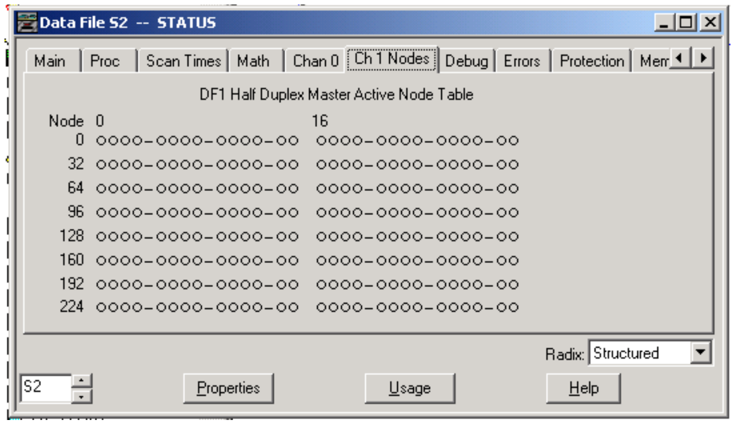


Active Node Table Block of Communications Status File

Active Node Table Block

Word	Description
23	Active Node Table Category Identifier Code (always 3)
24	Length: • always 4 for DH-485 • always 18 for DF1 Half-Duplex Master • always 0 for DF1 Full-Duplex, DF1 Half-Duplex Slave, Modbus RTU Slave, Modbus RTU Master, and ASCII
25	Format Code (always 0)
26	Number of Nodes: • always 32 for DH-485 • always 255 for DF1 Half-Duplex Master • always 0 for DF1 Full-Duplex, DF1 Half-Duplex Slave, Modbus RTU Slave, Modbus RTU Master, and ASCII
27	Active Node Table (DH-485 and DF1 Half-Duplex Master) – Nodes 0 to 15 (CS0:27/1 is node 1, CS0:27/2 is node 2, etc.) This is a bit-mapped register that displays the status of each node on the network. If a bit is set (1), the corresponding node is active on the network. If a bit is clear (0), the corresponding node is inactive.
28	Active Node Table (DH-485 and DF1 Half-Duplex Master) – Nodes 16 to 31 (CS0:28/1 is node 16, CS0:28/2 is node 17, etc.)
29	Active Node Table (DF1 Half-Duplex Master) – Nodes 32 to 47 (CS0:29/1 is node 32, CS0:29/2 is node 33, etc.)
⋮	
42	Active Node Table (DF1 Half-Duplex Master) – Nodes 240 to 255 (CS0:42/1 is node 240, CS0:42/2 is node 241, etc.)

If you are using RSLogix 500 version 6.10.10 or higher, you can view the active node table by clicking on “Processor Status” and then selecting the tab for the configured channel.



Input/Output Status File

The input/output status (IOS) file is a read-only file in the controller that contains information on the status of the embedded and local expansion I/O. The data file is structured as:

I/O Status File

Word	Description
0	Embedded Module Error Code – Always zero
1 to 6	Expansion Module Error Code – The word number corresponds to the module's slot number. Refer to the I/O module's documentation for specific information. *(MicroLogix 1200)*
1 to 16[1]	Expansion Module Error Code – The word number corresponds to the module's slot number. Refer to the I/O module's documentation for specific information. *(MicroLogix 1500)*

(1) 1 to 8 for Series A Base Units.

Programming Instructions Overview

Instruction Set

The following table shows the MicroLogix 1200 and 1500 programming instructions listed within their functional group.(1)

Functional Group	Description	Page
High-Speed Counter	HSL, RAC – The high-speed counter instructions (along with the HSC function file) allow you to monitor and control the high-speed outputs. Generally used with DC inputs.	109
High-Speed Outputs	PTO, PWM – The high-speed output instructions (along with the PTO and PWM function files) allow you to monitor and control the high-speed outputs. Generally used with FET outputs (BXB units).	147
Relay-Type (Bit)	XIC, XIO, OTE, OTL, OTU, OSR, ONS, OSF – The relay-type (bit) instructions monitor and control the status of bits.	177
Timer and Counter	TON, TOF, RTO, CTU, CTD, RES – The timer and counter instructions control operations based on time or the number of events.	185
Compare	EQU, NEQ, LES, LEQ, GRT, GEQ, MEQ, LIM – The compare instructions compare values by using a specific compare operation.	195
Math	ADD, SUB, MUL, DIV, NEG, CLR, ABS, SQR, SCL, SCP, SWP – The math instructions perform arithmetic operations.	203
Conversion	DCD, ENC, TOD, FRD, GCD – The conversion instructions multiplex and de-multiplex data and perform conversions between binary and decimal values.	219
Logical	AND, OR, XOR, NOT – The logical instructions perform bit-wise logical operations on words.	231
Move	MOV, MVM – The move instructions modify and move words.	237
File	CPW, COP, FLL, BSL, BSR, FFL, FFU, LFL, LFU – The file instructions perform operations on file data.	245
Sequencer	SQC, SQO, SQL – Sequencer instructions are used to control automatic assembly machines that have consistent and repeatable operations.	267
Program Control	JMP, LBL, JSR, SBR, RET, SUS, TND, MCR, END – The program flow instructions change the flow of ladder program execution.	277
Input and Output	IIM, IOM, REF – The input and output instructions allow you to selectively update data without waiting for the input and output scans.	283
User Interrupt	STS, INT, UID, UIE, UIF – The user interrupt instructions allow you to interrupt your program based on defined events.	289
Process Control	PID – The process control instruction provides closed-loop control.	315
ASCII	ABL, ACB, ACI, ACL, ACN, AEX, AHL, AIC, ARD, ARL, ASC, ASR, AWA, AWT – The ASCII instructions convert and write ASCII strings. They cannot be used with MicroLogix 1500 1764-LSP Series A processors.	349
Communications	MSG, SVC – The communication instructions read or write data to another station.	385
Recipe *(MicroLogix 1500 only)*	RCP – The recipe instruction allows you to transfer a data set between the recipe database and a set of user-specified data table elements.	445
Data Logging *(MicroLogix 1500 1764-LRP only)*	DLG – The data logging instruction allow you to capture time-stamped and date-stamped data.	445

(1) The RTA - Real Time Clock Adjust Instruction appears on page 74 following the Real-Time Clock Function File information.

Using the Instruction Descriptions

Throughout this manual, each instruction (or group of similar instructions) has a table similar to the one shown below. This table provides information for all sub-elements (or components) of an instruction or group of instructions. This table identifies the type of compatible address that can be used for each sub-element of an instruction or group of instructions in a data file or function file. The definitions of the terms used in these tables are listed below this example table.

Valid Addressing Modes and File Types - Example Table

Parameter	Data Files											Function Files									CS - Comms	IOS - I/O	DLS - Data Log	Address Mode(1)			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DATI	TPI				Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Source A	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•	
Source B	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•	
Destination	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•			•						•	•		•	•	

(1) See Important note about indirect addressing.

IMPORTANT You cannot use indirect addressing with: S, ST, MG, PD, RTC, HSC, PTO, PWM, STI, EII, BHI, MMI, DAT, TPI, CS, IOS, and DLS files.

The terms used within the table are defined as follows:

- Parameter - The parameter is the information you supply to the instruction. It can be an address, a value, or an instruction-specific parameter such as a timebase.
- Data Files - See Data Files on page 62.
- Function Files - See Function Files on page 69.
- CS - See Communications Status File on page 84.
- IOS - See Input/Output Status File on page 99.
- DLS - See Data Log Status File on page 458.
- Address Mode - See Addressing Modes on page 103.
- Addressing Level - Address levels describe the granularity at which an instruction allows an operand to be used. For example, relay type instructions (XIC, XIO, etc.) must be programmed to the bit level, timer instructions (TON, TOF, etc.) must be programmed to the element level (timers have 3 words per element) and math instructions (ADD, SUB, etc.) must be programmed to the word or long word level.

Addressing Modes

The MicroLogix 1200 and MicroLogix 1500 support three types of data addressing:

- Immediate
- Direct
- Indirect

The MicroLogix 1200 and 1500 do not support indexed addressing. Indexed addressing can be duplicated with indirect addressing. See Example - Using Indirect Addressing to Duplicate Indexed Addressing on page 107.

How or when each type is used depends on the instruction being programmed and the type of elements specified within the operands of the instruction. By supporting these three addressing methods, the MicroLogix 1200 and 1500 allow incredible flexibility in how data can be monitored or manipulated. Each of the addressing modes are described below.

Immediate Addressing

Immediate addressing is primarily used to assign numeric constants within instructions. For example: You require a 10 second timer, so you program a timer with a 1 second time base and a preset value of 10. The numbers 1 and 10 in this example are both forms of immediate addressing.

Direct Addressing

When you use direct addressing, you define a specific data location within the controller. Any data location that is supported by the elements of an operand within the instruction being programmed can be used. In this example we are illustrating a limit instruction, where:

- Low Limit = Numeric value (from -32,768 to 32,767) entered from the programming software.
- Test Value = TPI:0.POT0 (This is the current position/value of trim pot 0.)
- High Limit = N7:17 (This is the data resident in Integer file 7, element 17.)

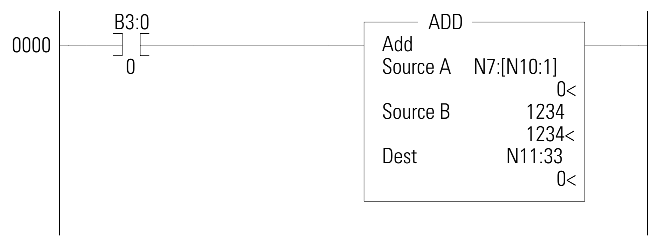
The Test Value (TPI:0.POT0) and High Limit (N7:17) are direct addressing examples. The Low Limit is immediate addressing.

Indirect Addressing

Indirect addressing allows components within the address to be used as pointers to other data locations within the controller. This functionality can be especially useful for certain types of applications, recipe management, batch processing and many others. Indirect addressing can also be difficult to understand and troubleshoot. It is recommended that you only use indirect addressing when it is required by the application being developed.

The MicroLogix 1200 and 1500 support indirection (indirect addressing) for Files, Words and Bits. To define which components of an address are to be indirected, a closed bracket “[ ]” is used. The following examples illustrate how to use indirect addressing.

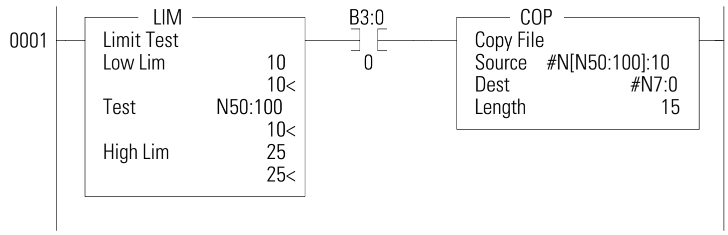
Indirect Addressing of a Word



- Address: N7:[N10:1]
- In this example, the element number to be used for source A in the ADD instruction is defined by the number located in N10:1. If the value of location N10:1 = 15, the ADD instruction operates as “N7:15 + Source B”.
- In this example, the element specified by N10:1 must be between 0 and 255, because all data files have a maximum individual size of 256 elements.

TIP If a number larger than the number of elements in the data file is placed in N10:1 (in this example), data integrity cannot be guaranteed, because a file boundary will be crossed. This may not generate a controller fault, but the data location is invalid/unknown.

Indirect Addressing of a File

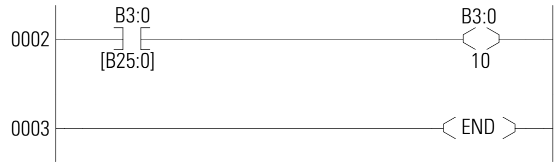


- Address: N[N50:100]:10
- Description: In this example, the source of the COP instruction is indirected by N50:100. The data in N50:100 defines the data file number to be used in the instruction. In this example, the copy instruction source A is defined by N[N50:100]:10. When the instruction is scanned, the data in N50:100 is used to define the data file to be used for the COP instruction. If the value of location N50:100 = 27, this instruction copies 15 elements of data from N27:10 (N27:10 to N27:24) to N7:0 (N7:0 to N7:14)

TIP If a number larger than 255 is placed in N50:100 in this example, a controller fault occurs. This is because the controller has a maximum of 255 data files. In addition, the file defined by the indirection should match the file type defined by the instruction, in this example an integer file.

TIP This example also illustrates how to perform a limit check on the indirect address. The limit instruction at the beginning of the rung is monitoring the indirect element. If the data at N50:100 is less than 10 or greater than 25, the copy instruction is not processed. This procedure can be used to make sure an indirect address does not access data an unintended location.

Indirect Addressing of Bit



- Address: B3/[B25:0]
- Description: In this example, the element to be used for the indirection is B25:0. The data in B25:0 defines the bit within file B3. If the value of location B25:0 = 1017, the XIC instruction is processed using B3/1017.

TIP If a number larger than 4096 (or larger than the number of elements in the data file) is placed in B25:0 in this example, data integrity cannot be guaranteed. Exceeding the number of elements in the data file would cause the file boundary to be crossed.

These are only some of the examples that can be used; others include:

- File and Element Indirection: N[N10:0]:[N25:0]
- Input Slot Indirection: I1:[N7:0].0

Each group of instructions may or may not allow indirection. Please review the compatibility table for each instruction to determine which elements within an instruction support indirection.

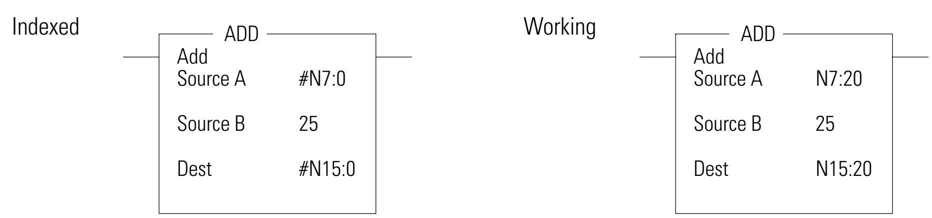
IMPORTANT You must exercise extreme care when using indirect addressing. Always be aware of the possibility of crossing file boundaries or pointing to data that was not intended to be used.

Example - Using Indirect Addressing to Duplicate Indexed Addressing

In this section, an indexed addressing example is shown first. Then an equivalent indirect addressing example is shown. Indexed addressing is supported by SLC 500 and MicroLogix 1000 programmable controllers. The MicroLogix 1200 and 1500 do not support indexed addressing. This example is shown for comparison purposes.

Indexed Addressing Example

The following ADD instruction uses an indexed address in the Source A and Destination addresses. If the indexed offset value is 20 (stored in S:24), the controller uses the data stored at the base address plus the indexed offset to perform the operation.



In this example, the controller uses the following addresses:

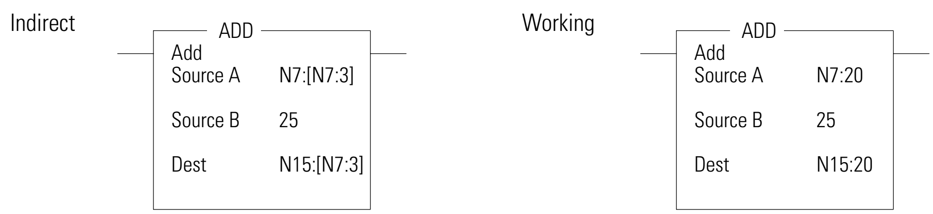
Operand	Base Address	Offset Value in S:24	Working Address
Source A	N7:0	20	N7:20
Destination	N15:0	20	N15:20

TIP In the SLC and ML1000 controllers, there are some instructions that clear S:24 after the instruction completes. For this reason, you must insure that the index register is loaded with the intended value prior to the execution of an indexed instruction.

Indirect Addressing Example

An equivalent example using indirect addressing is shown below. In place of using the index register, S:24, the user can designate any other valid word address as the indirect address. Multiple indirect addresses can be used within an instruction.

The following ADD instruction uses an indirect address in the Source A and Destination addresses. If the indirect offset value is 20 (stored in N7:3), the controller uses the data stored at the base address plus the indirect offset to perform to instruction.



In this example, the controller uses the following addresses:

Operand	Base Address	Offset Value in N7:3	Working Address
Source A	N7:0	20	N7:20
Destination	N7:0	20	N15:20

Using the High-Speed Counter and Programmable Limit Switch

High-Speed Counter Overview

The MicroLogix 1200 has one 20 kHz high-speed counter; the MicroLogix 1500 has two. Functionally, the counters are identical. Each counter has four dedicated inputs that are isolated from other inputs on the controller. HSC0 utilizes inputs 0 through 3 and HSC1 (*MicroLogix 1500 only*) utilizes inputs 4 through 7. Each counter operates independently from the other.

TIP HSC0 is used in this document to define how any HSC works. The MicroLogix 1500's HSC1 is identical in functionality.

IMPORTANT The HSC function can only be used with the controller's embedded I/O. It cannot be used with expansion I/O modules.

This chapter describes how to use the HSC function and also contains sections on the HSL and RAC instructions, as follows:

- High-Speed Counter (HSC) Function File on page 110.
- HSL - High-Speed Counter Load on page 139.
- RAC - Reset Accumulated Value on page 140.

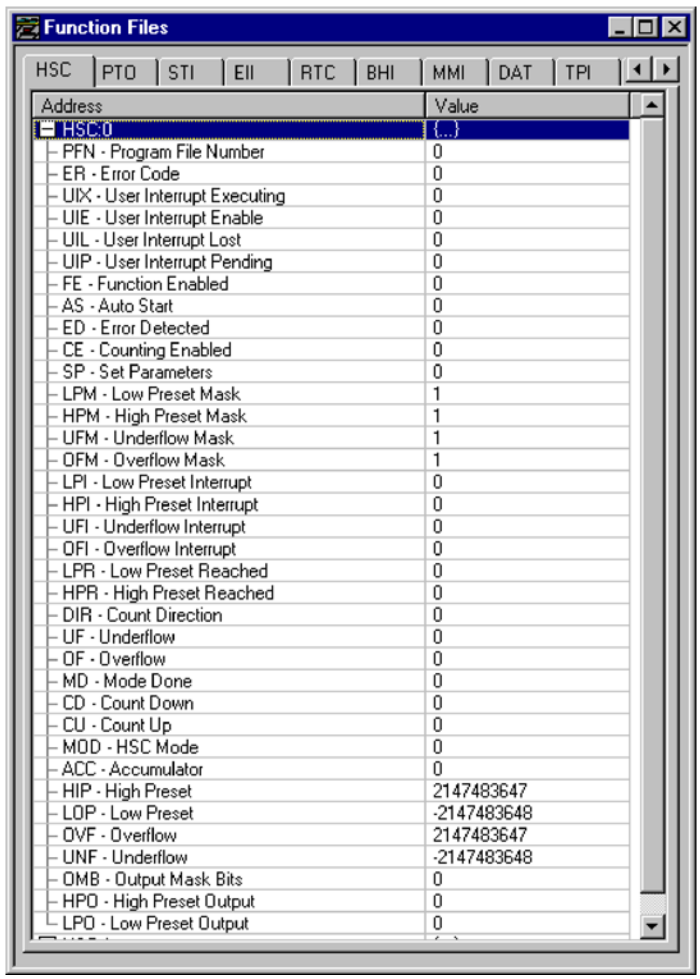
Programmable Limit Switch Overview

The Programmable Limit Switch function allows you to configure the High-Speed Counter to operate as a PLS (programmable limit switch) or rotary cam switch. See page 141 for more information.

High-Speed Counter (HSC) Function File

Within the RSLogix 500 Function File Folder, you see a HSC Function File. This file provides access to HSC configuration data, and also allows the control program access to all information pertaining to each of the High-Speed Counters.

TIP If the controller is in the run mode, the data within sub-element fields may be changing.

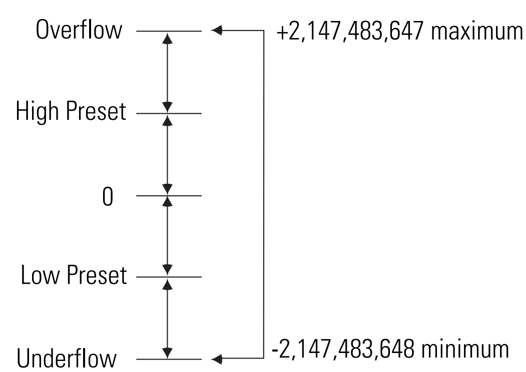


The HSC function, along with the PTO and PWM instructions, are different than most other controller instructions. Their operation is performed by custom circuitry that runs in parallel with the main system processor. This is necessary because of the high performance requirements of these functions.

The HSC is extremely versatile; the user can select or configure each HSC for any one of eight (8) modes of operation. (Operating Modes are discussed later in this chapter. See section HSC Mode (MOD) on page 128). Some of the enhanced capabilities of the High-Speed Counters are:

- 20 kHz operation
- High-speed direct control of outputs
- 32-bit signed integer data (count range of ± 2,147,483,647)
- Programmable High and Low presets, and Overflow and Underflow setpoints
- Automatic Interrupt processing based on accumulated count
- Run-time editable parameters (from the user control program)

The High-Speed Counter function operates as described in the following diagram.



High-Speed Counter Function File Sub-Elements Summary

Each HSC is comprised of 36 sub-elements. These sub-elements are either bit, word, or long word structures that are used to provide control over the HSC function, or provide HSC status information for use within the control program. Each of the sub-elements and their respective functions are described in this chapter. A summary of the sub-elements is provided in the following table. All examples illustrate HSC0. Terms and behavior for HSC1 are identical.

High-Speed Counter Function File (HSC:0 or HSC:1)

Sub-Element Description	Address	Data Format	HSC Modes(1)	Function	User Program Access	For More Information
PFN - Program File Number	HSC:0.PFN	word (INT)	0 to 7	control	read only	113
ER - Error Code	HSC:0.ER	word (INT)	0 to 7	status	read only	113
UIX - User Interrupt Executing	HSC:0/UIX	bit	0 to 7	status	read only	118
UIE - User Interrupt Enable	HSC:0/UIE	bit	0 to 7	control	read/write	118
UIL - User Interrupt Lost	HSC:0/UIL	bit	0 to 7	status	read/write	119
UIP - User Interrupt Pending	HSC:0/UIP	bit	0 to 7	status	read only	119
FE - Function Enabled	HSC:0/FE	bit	0 to 7	control	read/write	115
AS - Auto Start	HSC:0/AS	bit	0 to 7	control	read only	115
ED - Error Detected	HSC:0/ED	bit	0 to 7	status	read only	115
CE - Counting Enabled	HSC:0/CE	bit	0 to 7	control	read/write	117
SP - Set Parameters	HSC:0/SP	bit	0 to 7	control	read/write	117
LPM - Low Preset Mask	HSC:0/LPM	bit	2 to 7	control	read/write	120
HPM - High Preset Mask	HSC:0/HPM	bit	0 to 7	control	read/write	122
UFM - Underflow Mask	HSC:0/UFM	bit	2 to 7	control	read/write	123
OFM - Overflow Mask	HSC:0/OFM	bit	0 to 7	control	read/write	126
LPI - Low Preset Interrupt	HSC:0/LPI	bit	2 to 7	status	read/write	120
HPI - High Preset Interrupt	HSC:0/HPI	bit	0 to 7	status	read/write	122
UFI - Underflow Interrupt	HSC:0/UFI	bit	2 to 7	status	read/write	124
OFI - Overflow Interrupt	HSC:0/OFI	bit	0 to 7	status	read/write	126
LPR - Low Preset Reached	HSC:0/LPR	bit	2 to 7	status	read only	121
HPR - High Preset Reached	HSC:0/HPR	bit	2 to 7	status	read only	123
DIR - Count Direction	HSC:0/DIR	bit	0 to 7	status	read only	127
UF - Underflow	HSC:0/UF	bit	0 to 7	status	read/write	123
OF - Overflow	HSC:0/OF	bit	0 to 7	status	read/write	124
MD - Mode Done	HSC:0/MD	bit	0 or 1	status	read/write	127
CD - Count Down	HSC:0/CD	bit	2 to 7	status	read only	127
CU - Count Up	HSC:0/CU	bit	0 to 7	status	read only	128
MOD - HSC Mode	HSC:0.MOD	word (INT)	0 to 7	control	read only	128
ACC - Accumulator	HSC:0.ACC	long word (32-bit INT)	0 to 7	control	read/write	134
HIP - High Preset	HSC:0.HIP	long word (32-bit INT)	0 to 7	control	read/write	134
LOP - Low Preset	HSC:0.LOP	long word (32-bit INT)	2 to 7	control	read/write	134
OVF - Overflow	HSC:0.OVF	long word (32-bit INT)	0 to 7	control	read/write	135
UNF - Underflow	HSC:0.UNF	long word (32-bit INT)	2 to 7	control	read/write	135
OMB - Output Mask Bits	HSC:0.OMB	word (16-bit binary)	0 to 7	control	read only	136
HPO - High Preset Output	HSC:0.HPO	word (16-bit binary)	0 to 7	control	read/write	138
LPO - Low Preset Output	HSC:0.LPO	word (16-bit binary)	2 to 7	control	read/write	138

(1) For Mode descriptions, see HSC Mode (MOD) on page 128.
n/a = not applicable

HSC Function File Sub-Elements

All examples illustrate HSC0. Terms and behavior for HSC1 are identical.

Program File Number (PFN)

Description	Address	Data Format	HSC Modes(1)	Type	User Program Access
PFN - Program File Number	HSC:0.PFN	word (INT)	0 to 7	control	read only

(1) For Mode descriptions, see HSC Mode (MOD) on page 128.

The PFN (Program File Number) variable defines which subroutine is called (executed) when HSC0 counts to High Preset or Low Preset, or through Overflow or Underflow. The integer value of this variable defines which program file will run at that time. A valid subroutine file is any program file (3 to 255).

See also:Interrupt Latency on page 293.

Error Code (ER)

Description	Address	Data Format	HSC Modes(1)	Type	User Program Access
ER - Error Code	HSC:0.ER	word (INT)	0 to 7	status	read only

(1) For Mode descriptions, see HSC Mode (MOD) on page 128.

The ERs (Error Codes) detected by the HSC sub-system are displayed in this word. Errors include:

HSC Error Codes

Error Code	Name	Mode(1)	Description
1	Invalid File Number	n/a	Interrupt (program) file identified in HSC:0.PFN is less than 3, greater than 255, or does not exist
2	Invalid Mode	n/a	Invalid Mode(1)
3	Invalid High Preset	0,1	High preset is less than or equal to zero (0)
		2 to 7	High preset is less than or equal to low preset
4	Invalid Overflow	0 to 7	High preset is greater than overflow

(1) For Mode descriptions, see HSC Mode (MOD) on page 128.

Function Enabled (FE)

Description	Address	Data Format	HSC Modes(1)	Type	User Program Access
FE - Function Enabled	HSC:0/FE	bit	0 to 7	control	read/write

(1) For Mode descriptions, see HSC Mode (MOD) on page 128.

The FE (Function Enabled) is a status/control bit that defines when the HSC interrupt is enabled, and that interrupts generated by the HSC are processed based on their priority.

This bit can be controlled by the user program or is automatically set by the HSC sub-system if auto start is enabled.

See also:Priority of User Interrupts on page 292.

Auto Start (AS)

Description	Address	Data Format	HSC Modes(1)	Type	User Program Access
AS - Auto Start	HSC:0/AS	bit	0 to 7	control	read only

(1) For Mode descriptions, see HSC Mode (MOD) on page 128.

The AS (Auto Start) is configured with the programming device and stored as part of the user program. The auto start bit defines if the HSC function automatically starts whenever the controller enters any run or test mode. The CE (Counting Enabled) bit must also be set to enable the HSC.

Error Detected (ED)

Description	Address	Data Format	HSC Modes(1)	Type	User Program Access
ED - Error Detected	HSC:0/ED	bit	0 to 7	status	read only

(1) For Mode descriptions, see HSC Mode (MOD) on page 128.

The ED (Error Detected) flag is a status bit that can be used in the control program to detect if an error is present in the HSC sub-system. The most common type of error that this bit represents is a configuration error. When this bit is set (1), you should look at the specific error code in parameter HSC:0.ER.

This bit is maintained by the controller and is set and cleared automatically.

Counting Enabled (CE)

Description	Address	Data Format	HSC Modes(1)	Type	User Program Access
CE - Counting Enabled	HSC:0/CE	bit	0 to 7	control	read/write

(1) For Mode descriptions, see HSC Mode (MOD) on page 128.

The CE (Counting Enabled) control bit is used to enable or disable the High-Speed Counter. When set (1), counting is enabled, when clear (0, default) counting is disabled. If this bit is disabled while the counter is running, the accumulated value is held; if the bit is then set, counting resumes.

This bit can be controlled by the user program and retains its value through a power cycle. This bit must be set for the high-speed counter to operate.

Set Parameters (SP)

Description	Address	Data Format	HSC Modes(1)	Type	User Program Access
SP - Set Parameters	HSC:0/SP	bit	0 to 7	control	read/write

(1) For Mode descriptions, see HSC Mode (MOD) on page 128.

The SP (Set Parameters) control bit is used to load new variables to the HSC sub-system. When an OTE instruction with the address of HSC:0/SP is solved true (off-to-on rung transition), all configuration variables currently stored in the HSC function are checked and loaded into the HSC sub-system. The HSC sub-system then operates based on those newly loaded settings.

This bit is controlled by the user program and retains its value through a power cycle. It is up to the user program to set and clear this bit. SP can be toggled while the HSC is running and no counts are lost.

User Interrupt Enable (UIE)

Description	Address	Data Format	HSC Modes(1)	Type	User Program Access
UIE - User Interrupt Enable	HSC:0/UIE	bit	0 to 7	control	read/write

(1) For Mode descriptions, see HSC Mode (MOD) on page 128.

The UIE (User Interrupt Enable) bit is used to enable or disable HSC subroutine processing. This bit must be set (1) if the user wants the controller to process the HSC subroutine when any of the following conditions exist:

- Low preset reached
- High preset reached
- Overflow condition - count up through the overflow value
- Underflow condition - count down through the underflow value

If this bit is cleared (0), the HSC sub-system does not automatically scan the HSC subroutine. This bit can be controlled from the user program (using the OTE, UIE, or UID instructions).

ATTENTION

If you enable interrupts during the program scan via an OTL, OTE, or UIE, this instruction *must* be the *last* instruction executed on the rung (last instruction on last branch). It is recommended this be the only output instruction on the rung.

User Interrupt Executing (UIX)

Description	Address	Data Format	HSC Modes(1)	Type	User Program Access
UIX - User Interrupt Executing	HSC:0/UIX	bit	0 to 7	status	read only

(1) For Mode descriptions, see HSC Mode (MOD) on page 128.

The UIX (User Interrupt Executing) bit is set (1) whenever the HSC sub-system begins processing the HSC subroutine due to any of the following conditions:

- Low preset reached
- High preset reached
- Overflow condition - count up through the overflow value
- Underflow condition - count down through the underflow value

The HSC UIX bit can be used in the control program as conditional logic to detect if an HSC interrupt is executing.

The HSC sub-system will clear (0) the UIX bit when the controller completes its processing of the HSC subroutine.

User Interrupt Pending (UIP)

Description	Address	Data Format	HSC Modes(1)	Type	User Program Access
UIP - User Interrupt Pending	HSC:0/UIP	bit	0 to 7	status	read only

(1) For Mode descriptions, see HSC Mode (MOD) on page 128.

The UIP (User Interrupt Pending) is a status flag that represents an interrupt is pending. This status bit can be monitored or used for logic purposes in the control program if you need to determine when a subroutine cannot be executed immediately.

This bit is maintained by the controller and is set and cleared automatically.

User Interrupt Lost (UIL)

Description	Address	Data Format	HSC Modes(1)	Type	User Program Access
UIL - User Interrupt Lost	HSC:0/UIL	bit	0 to 7	status	read/write

(1) For Mode descriptions, see HSC Mode (MOD) on page 128.

The UIL (User Interrupt Lost) is a status flag that represents an interrupt has been lost. The controller can process 1 active and maintain up to 2 pending user interrupt conditions.

This bit is set by the controller. It is up to the control program to utilize, track if necessary, and clear the lost condition.

Low Preset Mask (LPM)

Description	Address	Data Format	HSC Modes(1)	Type	User Program Access
LPM - Low Preset Mask	HSC:0/LPM	bit	2 to 7	control	read/write

(1) For Mode descriptions, see HSC Mode (MOD) on page 128.

The LPM (Low Preset Mask) control bit is used to enable (allow) or disable (not allow) a low preset interrupt from occurring. If this bit is clear (0), and a Low Preset Reached condition is detected by the HSC, the HSC user interrupt is not executed.

This bit is controlled by the user program and retains its value through a power cycle. It is up to the user program to set and clear this bit.

Low Preset Interrupt (LPI)

Description	Address	Data Format	HSC Modes(1)	Type	User Program Access
LPI - Low Preset Interrupt	HSC:0/LPI	bit	2 to 7	status	read/write

(1) For Mode descriptions, see HSC Mode (MOD) on page 128.

The LPI (Low Preset Interrupt) status bit is set (1) when the HSC accumulator reaches the low preset value and the HSC interrupt has been triggered. This bit can be used in the control program to identify that the low preset condition caused the HSC interrupt. If the control program needs to perform any specific control action based on the low preset, this bit would be used as conditional logic.

This bit can be cleared (0) by the control program and is also be cleared by the HSC sub-system whenever these conditions are detected:

- High Preset Interrupt executes
- Underflow Interrupt executes
- Overflow Interrupt executes
- Controller enters an executing mode

Low Preset Reached (LPR)

Description	Address	Data Format	HSC Modes(1)	Type	User Program Access
LPR - Low Preset Reached	HSC:0/LPR	bit	2 to 7	status	read only

(1) For Mode descriptions, see HSC Mode (MOD) on page 128.

The LPR (Low Preset Reached) status flag is set (1) by the HSC sub-system whenever the accumulated value (HSC:0.ACC) is less than or equal to the low preset variable (HSC:0.LOP).

This bit is updated continuously by the HSC sub-system whenever the controller is in an executing mode.

High Preset Mask (HPM)

Description	Address	Data Format	HSC Modes(1)	Type	User Program Access
HPM - High Preset Mask	HSC:0/HPM	bit	0 to 7	control	read/write

(1) For Mode descriptions, see HSC Mode (MOD) on page 128.

The HPM (High Preset Mask) control bit is used to enable (allow) or disable (not allow) a high preset interrupt from occurring. If this bit is clear (0), and a High Preset Reached condition is detected by the HSC, the HSC user interrupt is not executed.

This bit is controlled by the user program and retains its value through a power cycle. It is up to the user program to set and clear this bit.

High Preset Interrupt (HPI)

Description	Address	Data Format	HSC Modes(1)	Type	User Program Access
HPI - High Preset Interrupt	HSC:0/HPI	bit	0 to 7	status	read/write

(1) For Mode descriptions, see HSC Mode (MOD) on page 128.

The HPI (High Preset Interrupt) status bit is set (1) when the HSC accumulator reaches the high preset value and the HSC interrupt is triggered. This bit can be used in the control program to identify that the high preset condition caused the HSC interrupt. If the control program needs to perform any specific control action based on the high preset, this bit is used as conditional logic.

This bit can be cleared (0) by the control program and is also cleared by the HSC sub-system whenever these conditions are detected:

- Low Preset Interrupt executes
- Underflow Interrupt executes
- Overflow Interrupt executes
- Controller enters an executing mode

High Preset Reached (HPR)

Description	Address	Data Format	HSC Modes(1)	Type	User Program Access
HPR - High Preset Reached	HSC:0/HPR	bit	2 to 7	status	read only

(1) For Mode descriptions, see HSC Mode (MOD) on page 128.

The HPR (High Preset Reached) status flag is set (1) by the HSC sub-system whenever the accumulated value (HSC:0.ACC) is greater than or equal to the high preset variable (HSC:0.HIP).

This bit is updated continuously by the HSC sub-system whenever the controller is in an executing mode.

Underflow (UF)

Description	Address	Data Format	HSC Modes(1)	Type	User Program Access
UF - Underflow	HSC:0/UF	bit	0 to 7	status	read/write

(1) For Mode descriptions, see HSC Mode (MOD) on page 128.

The UF (Underflow) status flag is set (1) by the HSC sub-system whenever the accumulated value (HSC:0.ACC) has counted through the underflow variable (HSC:0.UNF).

This bit is transitional and is set by the HSC sub-system. It is up to the control program to utilize, track if necessary, and clear (0) the underflow condition.

Underflow conditions do not generate a controller fault.

Underflow Mask (UFM)

Description	Address	Data Format	HSC Modes(1)	Type	User Program Access
UFM - Underflow Mask	HSC:0/UFM	bit	2 to 7	control	read/write

(1) For Mode descriptions, see HSC Mode (MOD) on page 128.

The UFM (Underflow Mask) control bit is used to enable (allow) or disable (not allow) a underflow interrupt from occurring. If this bit is clear (0), and a Underflow Reached condition is detected by the HSC, the HSC user interrupt is not executed.

This bit is controlled by the user program and retains its value through a power cycle. It is up to the user program to set and clear this bit.

Underflow Interrupt (UFI)

Description	Address	Data Format	HSC Modes(1)	Type	User Program Access
UFI - Underflow Interrupt	HSC:0/UFI	bit	2 to 7	status	read/write

(1) For Mode descriptions, see HSC Mode (MOD) on page 128.

The UFI (Underflow Interrupt) status bit is set (1) when the HSC accumulator counts through the underflow value and the HSC interrupt is triggered. This bit can be used in the control program to identify that the underflow condition caused the HSC interrupt. If the control program needs to perform any specific control action based on the underflow, this bit is used as conditional logic.

This bit can be cleared (0) by the control program and is also cleared by the HSC sub-system whenever these conditions are detected:

- Low Preset Interrupt executes
- High Preset Interrupt executes
- Overflow Interrupt executes
- Controller enters an executing mode

Overflow (OF)

Description	Address	Data Format	HSC Modes(1)	Type	User Program Access
OF - Overflow	HSC:0/OF	bit	0 to 7	status	read/write

(1) For Mode descriptions, see HSC Mode (MOD) on page 128.

The OF (Overflow) status flag is set (1) by the HSC sub-system whenever the accumulated value (HSC:0.ACC) has counted through the overflow variable (HSC:0.OF).

This bit is transitional and is set by the HSC sub-system. It is up to the control program to utilize, track if necessary, and clear (0) the overflow condition.

Overflow conditions do not generate a controller fault.

Overflow Mask (OFM)

Description	Address	Data Format	HSC Modes(1)	Type	User Program Access
OFM - Overflow Mask	HSC:0/OFM	bit	0 to 7	control	read/write

(1) For Mode descriptions, see HSC Mode (MOD) on page 128.

The OFM (Overflow Mask) control bit is used to enable (allow) or disable (not allow) an overflow interrupt from occurring. If this bit is clear (0), and an overflow reached condition is detected by the HSC, the HSC user interrupt is not executed.

This bit is controlled by the user program and retains its value through a power cycle. It is up to the user program to set and clear this bit.

Overflow Interrupt (OFI)

Description	Address	Data Format	HSC Modes(1)	Type	User Program Access
OFI - Overflow Interrupt	HSC:0/OFI	bit	0 to 7	status	read/write

(1) For Mode descriptions, see HSC Mode (MOD) on page 128.

The OFI (Overflow Interrupt) status bit is set (1) when the HSC accumulator counts through the overflow value and the HSC interrupt is triggered. This bit can be used in the control program to identify that the overflow variable caused the HSC interrupt. If the control program needs to perform any specific control action based on the overflow, this bit is used as conditional logic.

This bit can be cleared (0) by the control program and is also cleared by the HSC sub-system whenever these conditions are detected:

- Low Preset Interrupt executes
- High Preset Interrupt executes
- Underflow Interrupt executes
- Controller enters an executing mode

Count Direction (DIR)

Description	Address	Data Format	HSC Modes(1)	Type	User Program Access
DIR - Count Direction	HSC:0/DIR	bit	0 to 7	status	read only

(1) For Mode descriptions, see HSC Mode (MOD) on page 128.

The DIR (Count Direction) status flag is controlled by the HSC sub-system. When the HSC accumulator counts up, the direction flag is set (1). Whenever the HSC accumulator counts down, the direction flag is cleared (0).

If the accumulated value stops, the direction bit retains its value. The only time the direction flag changes is when the accumulated count reverses.

This bit is updated continuously by the HSC sub-system whenever the controller is in a run mode.

Mode Done (MD)

Description	Address	Data Format	HSC Modes(1)	Type	User Program Access
MD - Mode Done	HSC:0/MD	bit	0 or 1	status	read/write

(1) For Mode descriptions, see HSC Mode (MOD) on page 128.

The MD (Mode Done) status flag is set (1) by the HSC sub-system when the HSC is configured for Mode 0 or Mode 1 behavior, and the accumulator counts up to the High Preset.

Count Down (CD)

Description	Address	Data Format	HSC Modes(1)	Type	User Program Access
CD - Count Down	HSC:0/CD	bit	2 to 7	status	read only

(1) For Mode descriptions, see HSC Mode (MOD) on page 128.

The CD (Count Down) bit is used with the bidirectional counters (modes 2 to 7). If the CE bit is set, the CD bit is set (1). If the CE bit is clear, the CD bit is cleared (0).

Count Up (CU)

Description	Address	Data Format	HSC Modes[(1)]	Type	User Program Access
CU - Count Up	HSC:0/CU	bit	0 to 7	status	read only

(1) For Mode descriptions, see HSC Mode (MOD) on page 128.

The CU (Count Up) bit is used with all of the HSCs (modes 0 to 7). If the CE bit is set, the CU bit is set (1). If the CE bit is clear, the CU bit is cleared (0).

HSC Mode (MOD)

Description	Address	Data Format	Type	User Program Access
MOD - HSC Mode	HSC:0.MOD	word (INT)	control	read only

The MOD (Mode) variable sets the High-Speed Counter to one of 8 types of operation. This integer value is configured through the programming device and is accessible in the control program as a read-only variable.

HSC Operating Modes

Mode Number	Type
0	Up Counter - The accumulator is immediately cleared (0) when it reaches the high preset. A low preset cannot be defined in this mode.
1	Up Counter with external reset and hold - The accumulator is immediately cleared (0) when it reaches the high preset. A low preset cannot be defined in this mode.
2	Counter with external direction
3	Counter with external direction, reset, and hold
4	Two input counter (up and down)
5	Two input counter (up and down) with external reset and hold
6	Quadrature counter (phased inputs A and B)
7	Quadrature counter (phased inputs A and B) with external reset and hold

HSC Mode 0 - Up Counter

HSC Mode 0 Examples[1]

Input Terminals	I1:0.0/0 (HSC0) I1:0.0/4 (HSC1)				I1:0.0/1 (HSC0) I1:0.0/5 (HSC1)				I1:0.0/2 (HSC0) I1:0.0/6 (HSC1)				I1:0.0/3 (HSC0) I1:0.0/7 (HSC1)				CE Bit	Comments
Function	**Count**				**Not Used**				**Not Used**				**Not Used**					
Example 1	⇑																on (1)	HSC Accumulator + 1 count
Example 2	⇑	on (1)	⇓	off (0)													off (0)	Hold accumulator value

(1) HSC1 only applies to the MicroLogix 1500.

Blank cells = don't care, ⇑ = rising edge, ⇓ = falling edge

TIP Inputs I1:0.0/0 through I1:0.0/7 are available for use as inputs to other functions regardless of the HSC being used.

HSC Mode 1 - Up Counter with External Reset and Hold

HSC Mode 1 Examples[1]

Input Terminals	I1:0.0/0 (HSC0) I1:0.0/4 (HSC1)				I1:0.0/1 (HSC0) I1:0.0/5 (HSC1)				I1:0.0/2 (HSC0) I1:0.0/6 (HSC1)				I1:0.0/3 (HSC0) I1:0.0/7 (HSC1)				CE Bit	Comments
Function	**Count**				**Not Used**				**Reset**				**Hold**					
Example 1	⇑									on (1)	⇓	off (0)				off (0)	on (1)	HSC Accumulator + 1 count
Example 2										on (1)	⇓	off (0)		on (1)				Hold accumulator value
Example3										on (1)	⇓	off (0)					off (0)	Hold accumulator value
Example 4		on (1)	⇓	off (0)						on (1)	⇓	off (0)						Hold accumulator value
Example 5									⇑									Clear accumulator (=0)

(1) HSC1 only applies to the MicroLogix 1500.

Blank cells = don't care, ⇑ = rising edge, ⇓ = falling edge

TIP Inputs I1:0.0/0 through I1:0.0/7 are available for use as inputs to other functions regardless of the HSC being used.

HSC Mode 2 - Counter with External Direction

HSC Mode 2 Examples[(1)]

Input Terminals	I1:0.0/0 (HSC0) I1:0.0/4 (HSC1)				I1:0.0/1 (HSC0) I1:0.0/5 (HSC1)				I1:0.0/2 (HSC0) I1:0.0/6 (HSC1)				I1:0.0/3 (HSC0) I1:0.0/7 (HSC1)				CE Bit	Comments
Function	**Count**				**Direction**				**Not Used**				**Not Used**					
Example 1	⇑							off (0)									on (1)	HSC Accumulator + 1 count
Example 2	⇑					on (1)											on (1)	HSC Accumulator - 1 count
Example3																	off (0)	Hold accumulator value

(1) HSC1 only applies to the MicroLogix 1500.

Blank cells = don't care, ⇑ = rising edge, ⇓ = falling edge

TIP Inputs I1:0.0/0 through I1:0.0/7 are available for use as inputs to other functions regardless of the HSC being used.

HSC Mode 3 - Counter with External Direction, Reset, and Hold

HSC Mode 3 Examples[(1)]

Input Terminals	I1:0.0/0 (HSC0) I1:0.0/4 (HSC1)				I1:0.0/1 (HSC0) I1:0.0/5 (HSC1)				I1:0.0/2 (HSC0) I1:0.0/6 (HSC1)				I1:0.0/3 (HSC0) I1:0.0/7 (HSC1)				CE Bit	Comments
Function	**Count**				**Direction**				**Reset**				**Hold**					
Example 1	⇑							off (0)		on (1)	⇓	off (0)				off (0)	on (1)	HSC Accumulator + 1 count
Example 2	⇑					on (1)				on (1)	⇓	off (0)				off (0)	on (1)	HSC Accumulator - 1 count
Example3										on (1)	⇓	off (0)		on (1)				Hold accumulator value
Example 4										on (1)	⇓	off (0)					off (0)	Hold accumulator value
Example 5		on (1)	⇓	off (0)						on (1)	⇓	off (0)						Hold accumulator value
Example 6									⇑									Clear accumulator (=0)

(1) HSC1 only applies to the MicroLogix 1500.

Blank cells = don't care, ⇑ = rising edge, ⇓ = falling edge

TIP Inputs I1:0.0/0 through I1:0.0/7 are available for use as inputs to other functions regardless of the HSC being used.

HSC Mode 4 - Two Input Counter (up and down)

HSC Mode 4 Examples(1)

Input Terminals	I1:0.0/0 (HSC0) I1:0.0/4 (HSC1)				I1:0.0/1 (HSC0) I1:0.0/5 (HSC1)				I1:0.0/2 (HSC0) I1:0.0/6 (HSC1)				I1:0.0/3 (HSC0) I1:0.0/7 (HSC1)				**CE Bit**	**Comments**
Function	**Count Up**				**Count Down**				**Not Used**				**Not Used**					
Example 1	⇑					on (1)	⇓	off (0)									on (1)	HSC Accumulator + 1 count
Example 2		on (1)	⇓	off (0)	⇑												on (1)	HSC Accumulator - 1 count
Example3																	off (0)	Hold accumulator value

(1) HSC1 only applies to the MicroLogix 1500.

Blank cells = don't care, ⇑ = rising edge, ⇓ = falling edge

TIP Inputs I1:0.0/0 through I1:0.0/7 are available for use as inputs to other functions regardless of the HSC being used.

HSC Mode 5 - Two Input Counter (up and down) with External Reset and Hold

HSC Mode 5 Examples(1)

Input Terminals	I1:0.0/0 (HSC0) I1:0.0/4 (HSC1)				I1:0.0/1 (HSC0) I1:0.0/5 (HSC1)				I1:0.0/2 (HSC0) I1:0.0/6 (HSC1)				I1:0.0/3 (HSC0) I1:0.0/7 (HSC1)				**CE Bit**	**Comments**
Function	**Count**				**Direction**				**Reset**				**Hold**					
Example 1	⇑					on (1)	⇓	off (0)		on (1)	⇓	off (0)				off (0)	on (1)	HSC Accumulator + 1 count
Example 2		on (1)	⇓	off (0)	⇑					on (1)	⇓	off (0)				off (0)	on (1)	HSC Accumulator - 1 count
Example3										on (1)	⇓	off (0)		on (1)				Hold accumulator value
Example 4										on (1)	⇓	off (0)					off (0)	Hold accumulator value
Example 5		on (1)	⇓	off (0)						on (1)	⇓	off (0)						Hold accumulator value
Example 6									⇑									Clear accumulator (=0)

(1) HSC1 only applies to the MicroLogix 1500.

Blank cells = don't care, ⇑ = rising edge, ⇓ = falling edge

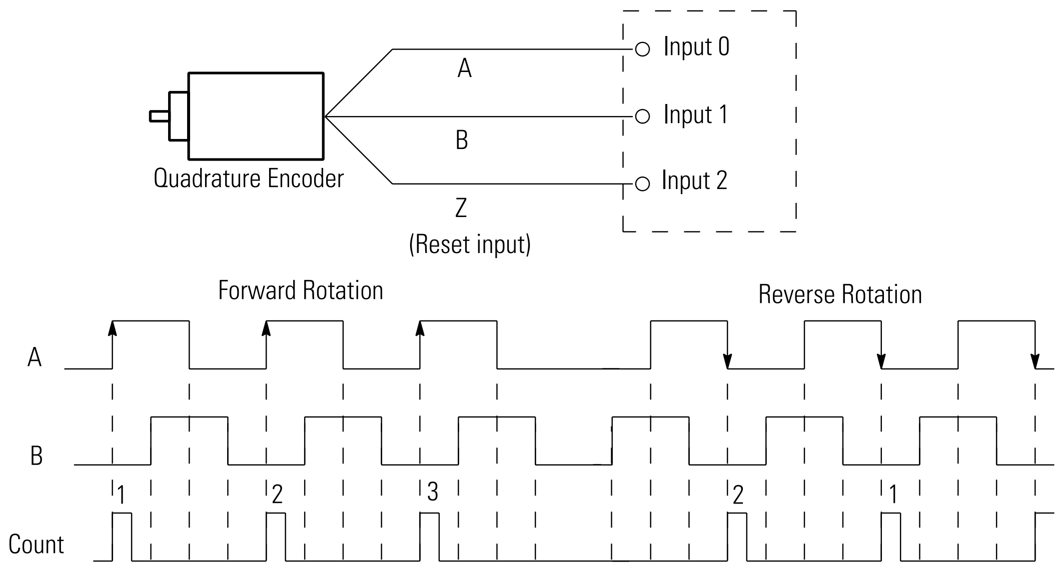
TIP Inputs I1:0.0/0 through I1:0.0/7 are available for use as inputs to other functions regardless of the HSC being used.

Using the Quadrature Encoder

The Quadrature Encoder is used for determining direction of rotation and position for rotating, such as a lathe. The Bidirectional Counter counts the rotation of the Quadrature Encoder.

The figure below shows a quadrature encoder connected to inputs 0, 1, and 2. The count direction is determined by the phase angle between A and B. If A leads B, the counter increments. If B leads A, the counter decrements.

The counter can be reset using the Z input. The Z outputs from the encoders typically provide one pulse per revolution.



HSC Mode 6 - Quadrature Counter (phased inputs A and B)

HSC Mode 6 Examples(1)

Input Terminals	I1:0.0/0 (HSC0) I1:0.0/4 (HSC1)				I1:0.0/1 (HSC0) I1:0.0/5 (HSC1)				I1:0.0/2 (HSC0) I1:0.0/6 (HSC1)				I1:0.0/3 (HSC0) I1:0.0/7 (HSC1)				**CE Bit**	**Comments**
Function	**Count A**				**Count B**				**Not Used**				**Not Used**					
Example 1(2)	⇈							off (0)									on (1)	HSC Accumulator + 1 count
Example 2(3)			⇓					off (0)									on (1)	HSC Accumulator - 1 count
Example3				off (0)														Hold accumulator value
Example 4		on (1)																Hold accumulator value
Example 5						on (1)												Hold accumulator value
Example 6																	off (0)	Hold accumulator value

(1) HSC1 only applies to the MicroLogix 1500.

(2) Count input A leads count input B.

TIP Inputs I1:0.0/0 through I1:0.0/7 are available for use as inputs to other functions regardless of the HSC being used.

HSC Mode 7 - Quadrature Counter (phased inputs A and B) With External Reset and Hold

(3) Count input B leads count input A.
Blank cells = don't care, ⇑ = rising edge, ⇓ = falling edge

HSC Mode 7 Examples(1)

Input Terminals	I1:0.0/0 (HSC0) I1:0.0/4 (HSC1)				I1:0.0/1 (HSC0) I1:0.0/5 (HSC1)				I1:0.0/2 (HSC0) I1:0.0/6 (HSC1)				I1:0.0/3 (HSC0) I1:0.0/7 (HSC1)				**CE Bit**	**Comments**
Function	**Count A**				**Count B**				**Z reset**				**Hold**					
Example 1(2)	⇑							off (0)								off (0)	on (1)	HSC Accumulator + 1 count
Example 2(3)			⇓					off (0)				off (0)				off (0)	on (1)	HSC Accumulator - 1 count
Example3			⇓	off (0)				off (0)		on (1)								Reset accumulator to zero
Example 4		on (1)																Hold accumulator value
Example 5						on (1)												Hold accumulator value
Example 6												off (0)		on (1)				Hold accumulator value
Example 7												off (0)					off (0)	Hold accumulator value

(1) HSC1 only applies to the MicroLogix 1500.

(2) Count input A leads count input B.

(3) Count input B leads count input A.

Blank cells = don't care, ⇑ = rising edge, ⇓ = falling edge

TIP Inputs I1:0.0/0 through I1:0.0/7 are available for use as inputs to other functions regardless of the HSC being used.

Accumulator (ACC)

Description	Address	Data Format	Type	User Program Access
ACC - Accumulator	HSC:0.ACC	long word (32-bit INT)	control	read/write

The ACC (Accumulator) contains the number of counts detected by the HSC sub-system. If either mode 0 or mode 1 is configured, *the value of the software accumulator is cleared* (0) when a high preset is reached or when an overflow condition is detected.

High Preset (HIP)

Description	Address	Data Format	Type	User Program Access
HIP - High Preset	HSC:0.HIP	long word (32-bit INT)	control	read/write

The HIP (High Preset) is the upper setpoint (in counts) that defines when the HSC sub-system generates an interrupt. To load data into the high preset, the control program must do one of the following:

- Toggle (low to high) the Set Parameters (HSC:0/SP) control bit. When the SP bit is toggled high, the data currently stored in the HSC function file is transferred/loaded into the HSC sub-system.
- Load new HSC parameters using the HSL instruction. See HSL - High-Speed Counter Load on page 139.

The data loaded into the high preset must be less than or equal to the data resident in the overflow (HSC:0.OVF) parameter or an HSC error is generated.

Low Preset (LOP)

Description	Address	Data Format	Type	User Program Access
LOP - Low Preset	HSC:0.LOP	long word (32-bit INT)	control	read/write

The LOP (Low Preset) is the lower setpoint (in counts) that defines when the HSC sub-system generates an interrupt. To load data into the low preset, the control program must do one of the following:

- Toggle (low to high) the Set Parameters (HSC:0/SP) control bit. When the SP bit is toggled high, the data currently stored in the HSC function file is transferred/loaded into the HSC sub-system.

- Load new HSC parameters using the HSL instruction. See HSL - High-Speed Counter Load on page 139.

The data loaded into the low preset must greater than or equal to the data resident in the underflow (HSC:0.UNF) parameter, or an HSC error is generated. (If the underflow and low preset values are negative numbers, the low preset must be a number with a smaller absolute value.)

Overflow (OVF)

Description	Address	Data Format	Type	User Program Access
OVF - Overflow	HSC:0.OVF	long word (32-bit INT)	control	read/write

The OVF (Overflow) defines the upper count limit for the counter. If the counter's accumulated value increments past the value specified in this variable, an overflow interrupt is generated. When the overflow interrupt is generated, the HSC sub-system rolls the accumulator over to the underflow value and the counter continues counting from the underflow value (counts are not lost in this transition). The user can specify any value for the overflow position, provided it is greater than the underflow value and falls between -2,147,483,648 and 2,147,483,647.

To load data into the overflow variable, the control program must toggle (low to high) the Set Parameters (HSC:0.0/SP) control bit. When the SP bit is toggled high, the data currently stored in the HSC function file is transferred/loaded into the HSC sub-system.

TIP Data loaded into the overflow variable must be greater than the data resident in the high preset (HSC:0.HIP) or an HSC error is generated.

Underflow (UNF)

Description	Address	Data Format	Type	User Program Access
UNF - Underflow	HSC:0.UNF	long word (32-bit INT)	control	read/write

The UNF (Underflow) defines the lower count limit for the counter. If the counter's accumulated value decrements past the value specified in this variable, an underflow interrupt is generated. When the underflow interrupt is generated, the HSC sub-system resets the accumulated value to the overflow value and the counter then begins counting from the overflow value (counts are not lost in this transition). The user can specify any value for the underflow position, provided it is less than the overflow value and falls between -2,147,483,648 and 2,147,483,647.

To load data into the underflow variable, the control program must toggle (low to high) the Set Parameters (HSC:0.0/SP) control bit. When the SP bit is toggled high, the data currently stored in the HSC function file is transferred/loaded into the HSC sub-system.

TIP Data loaded into the overflow variable must be greater than the data resident in the high preset (HSC:0.HIP) or an HSC error is generated.

Output Mask Bits (OMB)

Description	Address	Data Format	Type	User Program Access
OMB - Output Mask Bits	HSC:0.OMB	word (16-bit binary)	control	read only

The OMB (Output Mask Bits) define which outputs on the controller can be directly controlled by the high-speed counter. The HSC sub-system has the ability to directly (without control program interaction) turn outputs ON or OFF based on the HSC accumulator reaching the High or Low presets. The bit pattern stored in the OMB variable defines which outputs are controlled by the HSC and which outputs are not controlled by the HSC.

The bit pattern of the OMB variable directly corresponds to the output bits on the controller. Bits that are set (1) are enabled and can be turned on or off by the HSC sub-system. Bits that are clear (0) cannot be turned on or off by the HSC sub-system. The mask bit pattern can be configured only during initial setup.

The table below illustrates this relationship:

Affect of HSC Output Mask on Base Unit Outputs

Output Address	16-Bit Signed Integer Data Word															
	15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
HSC:0.HPO (high preset output)					0	1	1	0	1	0	0	1	1	0	0	1
HSC:0.OMB (output mask)					1	0	0	0	0	1	1	1	0	0	1	1
O0:0.0					**0**					**0**	**0**	**1**			**0**	**1**

The outputs shown in the black boxes are the outputs under the control of the HSC sub-system. The mask defines which outputs can be controlled. The high preset output or low preset output values (HPO or LPO) define if each output is either ON (1) or OFF (0). Another way to view this is that the high or low preset output is written through the output mask, with the output mask acting like a filter.

The bits in the gray boxes are unused. The first 12 bits of the mask word are used and the remaining mask bits are not functional because they do not correlate to any physical outputs on the base unit.

The mask bit pattern can be configured only during initial setup.

High Preset Output (HPO)

Description	Address	Data Format	Type	User Program Access
HPO - High Preset Output	HSC:0.HPO	word (16-bit binary)	control	read/write

The HPO (High Preset Output) defines the state (1 = ON or 0 = OFF) of the outputs on the controller when the high preset is reached. See Output Mask Bits (OMB) on page 136 for more information on how to directly turn outputs on or off based on the high preset being reached.

The high output bit pattern can be configured during initial setup, or while the controller is operating. Use the HSL instruction or the SP bit to load the new parameters while the controller is operating.

Low Preset Output (LPO)

Description	Address	Data Format	Type	User Program Access
LPO - Low Preset Output	HSC:0.LPO	word (16-bit binary)	control	read/write

The LPO (Low Preset Output) defines the state (1 = “on”, 0 = “off”) of the outputs on the controller when the low preset is reached. See Output Mask Bits (OMB) on page 136 for more information on how to directly turn outputs on or off based on the low preset being reached.

The low output bit pattern can be configured during initial setup, or while the controller is operating. Use the HSL instruction or the SP bit to load the new parameters while the controller is operating.

HSL - High-Speed Counter Load

```
HSL
High Speed Counter Load
HSC Number            HSC0
High Preset           N7:0
Low Preset            N7:1
Output High Source    N7:2
Output Low Source     N7:3
```

Instruction Type: output

Controller	Data Size	Execution Time When Rung Is:	
		True	False
MicroLogix 1200	word	46.7 µs	0.0 µs
	long word	47.3 µs	0.0 µs
MicroLogix 1500	word	39.7 µs	0.0 µs
	long word	40.3 µs	0.0 µs

The HSL (High-Speed Load) instruction allows the high and low presets, and high and low output source to be applied to a high-speed counter. These parameters are described below:

- Counter Number - Specifies which high-speed counter is being used; 0 = HSC0 and 1 = HSC1 (*MicroLogix 1500 only*).
- High Preset - Specifies the value in the high preset register. The data ranges for the high preset are -32786 to 32767 (word) and -2,147,483,648 to 2,147,483,647 (long word).
- Low Preset - Specifies the value in the low preset register. The data ranges for the low preset are -32786 to 32767 (word) and -2,147,483,648 to 2,147,483,647 (long word).
- Output High Source - Specifies the value in the HPO - high preset output register. The data range for the output high source is from 0 to 65,535.
- Output Low Source - Specifies the value in the LPO - low preset output register. The data range for the output low source is from 0 to 65,535.

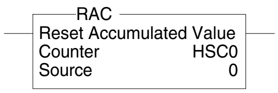
Valid Addressing Modes and File Types are shown below:

HSL Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files											Function Files									CS - Comms	IOS - I/O	DLS - Data Log	Address Mode			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI				Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Counter Number																								•						
High Preset	•	•		•	•	•			•															•	•	•		•	•	
Low Preset	•	•		•	•	•			•															•	•	•		•	•	
Output High Source	•	•		•	•	•			•															•	•	•		•	•	
Output Low Source	•	•		•	•	•			•															•	•	•		•	•	

RAC - Reset Accumulated Value



Instruction Type: output

Controller	Execution Time When Rung Is:	
	True	False
MicroLogix 1200	21.2 µs	0.0 µs
MicroLogix 1500	17.8 µs	0.0 µs

The RAC instruction resets the high-speed counter and allows a specific value to be written to the HSC accumulator. The RAC instruction uses the following parameters:

- Counter Number - Specifies which high-speed counter is being used:
  - Counter Number 0 = HSC0 (*MicroLogix 1200 and 1500*)
  - Counter Number 1 = HSC1 (*MicroLogix 1500 only*)
- Source - Specifies the location of the data to be loaded into the HSC accumulator. The data range is from -2,147,483,648 to 2,147,483,647.

Valid Addressing Modes and File Types are shown below:

RAC Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files											Function Files									CSF - Comms	IOS - I/O	DLS - Data Log	Address Mode			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI				Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Counter Number																								•						
Source									•															•	•	•			•	

Programmable Limit Switch (PLS) File

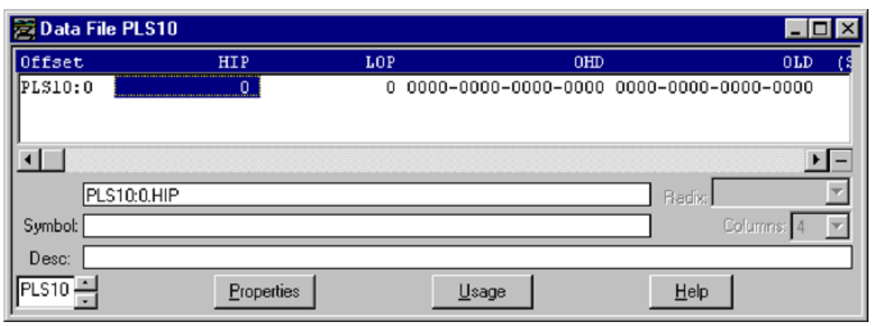
The Programmable Limit Switch function allows you to configure the High-Speed Counter to operate as a PLS (programmable limit switch) or rotary cam switch.

When PLS operation is enabled, the HSC (High-Speed Counter) uses a PLS data file for limit/cam positions. Each limit/cam position has corresponding data parameters that are used to set or clear physical outputs on the controller's base unit. The PLS data file is illustrated below.

IMPORTANT	The PLS Function only operates in tandem with the HSC of a MicroLogix 1200 or 1500. To use the PLS function, an HSC must first be configured.

PLS Data File

Data files 9 to 255 can be used for PLS operations. Each PLS data file can be up to 256 elements long. Each element within a PLS file consumes 6 user words of memory. The PLS data file is shown below:



PLS Operation

When the PLS function is enabled, and the controller is in the run mode, the HSC will count incoming pulses. When the count reaches the first preset (High - HIP or Low - LOP) defined in the PLS file, the output source data (High - OHD or Low - OLD) will be written through the HSC mask.

At that point, the next preset (High - HIP or Low - LOP) defined in the PLS file becomes active.

When the HSC counts to that new preset, the new output data is written through the HSC mask. This process continues until the last element within the PLS file is loaded. At that point the active element within the PLS file is reset to zero. This behavior is referred to as circular operation.

TIP The Output High Data (OHD) is only written when the High preset (HIP) is reached. The Output Low Data (OLD) is written when the low preset is reached.

TIP Output High Data is only operational when the counter is counting up. Output Low Data is only operational when the counter is counting down.

If invalid data is loaded during operation, an HSC error is generated (within the HSC function file). The error will not cause a controller fault. If an invalid parameter is detected, it will be skipped and the next parameter will be loaded for execution (provided it is valid).

You can use the PLS in Up (high), Down (low), or both directions. If your application only counts in one direction, simply ignore the other parameters.

The PLS function can operate with all of the other HSC capabilities. The ability to select which HSC events generate a user interrupt are not limited.

Addressing PLS Files

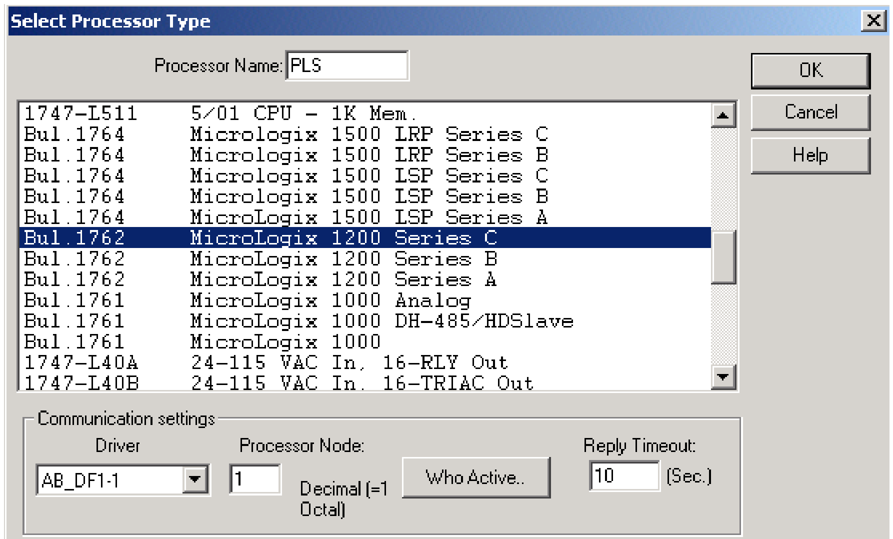
The addressing format for the PLS file is shown below.

Format	Explanation		
PLSf:e.s	**PLS**	Programmable Limit Switch file	
	f	File number	The valid file number range is from 9 to 255.
	:	Element delimiter	
	e	Element number	The valid element number range is from 0 to 255.
	.	Sub-Element delimiter	
	s	Sub-Element number	The valid sub-element number range is from 0 to 5
Examples:	**PLS10:2**		**PLS File 10, Element 2**
	PLS12:36.5		**PLS File 12, Element 36, Sub-Element 5 (Output Low Source)**

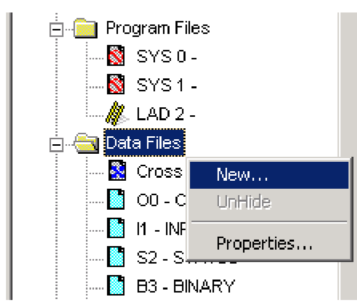
PLS Example

Setting up the PLS File

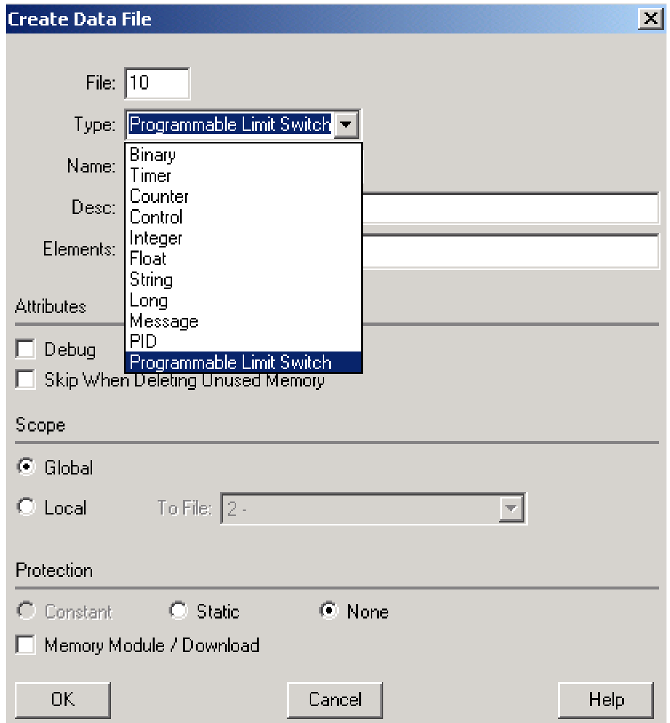
1. Using RSLogix 500, create a new project, give it a name and select the appropriate controller.

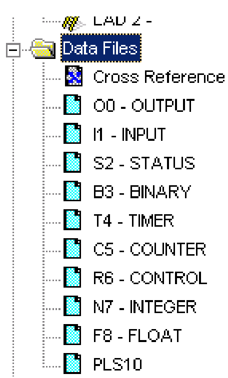


2. Right click on *Data Files* and select *New*.



3. Enter a file number (9 to 255) and select *Programmable Limit Switch* as the type. A Name and/or Description may be entered as well, but is not required.



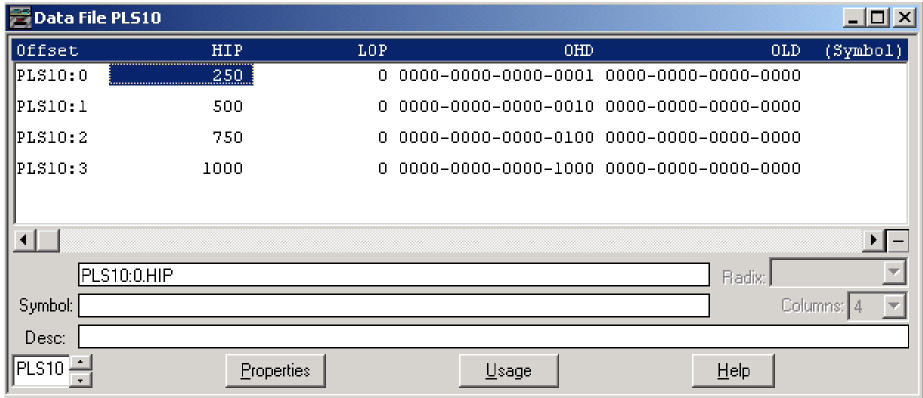


4. *Elements* refers to the number of PLS steps. For this example enter a value of 4.

   If more steps are required at a later time, simply go to the properties for the PLS data file and increase the number of elements.

5. Under Data Files, *PLS10* should appear as shown to the left.

6. Double-click on *PLS10* under Data Files. For this example, enter the values as illustrated below.


Data File PLS10
Offset HIP LOP OHD OLD (Symbol)
PLS10:0 250 0 0000-0000-0000-0001 0000-0000-0000-0000
PLS10:1 500 0 0000-0000-0000-0010 0000-0000-0000-0000
PLS10:2 750 0 0000-0000-0000-0100 0000-0000-0000-0000
PLS10:3 1000 0 0000-0000-0000-1000 0000-0000-0000-0000
PLS10:0.HIP
Radix:
Symbol:
Columns: 4
Desc:
PLS10
Properties
Usage
Help

PLS Data File Definitions:

Data	Description	Data Format
HIP	High Preset	32-bit signed integer
LOP	Low Preset	
OHD	Output High Data	16-bit binary
OLD	Output Low Data	(bit 15--> 0000 0000 0000 0000 <--bit 0)

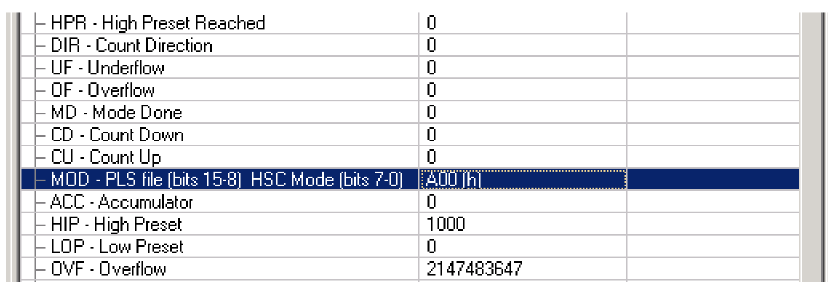
Once the values above have been entered for HIP and OHD, the PLS is configured.

Configuring the HSC for Use with the PLS

1. Under Controller, double-click on *Function Files*.

2. For *HSC:0*, configure the HSC.MOD to use PLS10 and for the HSC to operate in mode 00.

IMPORTANT	The value for MOD must be entered in Hexadecimal. For example, PLS10 = 0A and HSC Mode = 00



HPR - High Preset Reached	0	
DIR - Count Direction	0	
UF - Underflow	0	
OF - Overflow	0	
MD - Mode Done	0	
CD - Count Down	0	
CU - Count Up	0	
MOD - PLS file (bits 15-8) HSC Mode (bits 7-0)	A00 (h)	
ACC - Accumulator	0	
HIP - High Preset	1000	
LOP - Low Preset	0	
OVF - Overflow	2147483647	

PLS Operation for This Example

When the ladder logic first runs, HSC.ACC equals 0, therefore PLS10:0.OLD's data is sent through the HSC.OMB mask and sets all the outputs off.

When HSC.ACC equals 250, the PLS10:0.OHD is sent through the HSC.OMB mask and energizes the outputs.

This will repeat as the HSC.ACC reaches 500, 750, and 1000. Once completed, the cycle resets and repeats.

Using High-Speed Outputs

The high-speed output instructions allow you to control and monitor the PTO and PWM functions which control the physical high-speed outputs.

Instruction	Used To:	Page
PTO - Pulse Train Output	Generate stepper pulses	148
PWM - Pulse Width Modulation	Generate PWM output	169

PTO - Pulse Train Output

IMPORTANT The PTO function can only be used with the controller's embedded I/O. It cannot be used with expansion I/O modules.

IMPORTANT The PTO instruction should only be used with MicroLogix 1200 and 1500 BXB units. Relay outputs are not capable of performing very high-speed operations.

Instruction Type: output

Execution Time for the PTO Instruction

Controller	When Rung Is:	
	True	False
MicroLogix 1200	75.6 µs	24.4 µs
MicroLogix 1500	72.6 µs	21.1 µs

Pulse Train Output Function

The MicroLogix 1200 1762-L24BXB and 1762-L40BXB controllers each support one high-speed output. A MicroLogix 1500 controller utilizing a 1764-28BXB Base Unit supports two high-speed outputs. These outputs can be used as standard outputs (not high-speed) or individually configured for PTO or PWM operation. The PTO functionality allows a simple motion profile or pulse profile to be generated directly from the controller. The pulse profile has three primary components:

- Total number of pulses to be generated
- Accelerate/decelerate intervals
- Run interval

The PTO instruction, along with the HSC and PWM functions, are different than most other controller instructions. Their operation is performed by custom circuitry that runs in parallel with the main system processor. This is necessary because of the high performance requirements of these functions.

In this implementation, the user defines the total number of pulses to be generated (which corresponds to distance traveled), and how many pulses to use for each acceleration/deceleration period. The number of pulses not used in the acceleration/deceleration period defines how many pulses are generated during the run phase. In this implementation, the acceleration/deceleration intervals are the same.

TIP With MicroLogix 1200 FRN 8, MicroLogix 1500 FRN 9 and RSLogix 500 version 6.10.10 and higher, the accelerate/decelerate intervals are no longer required to be the same. Independent values can now be defined for these intervals. The ADI bit in the PTO function file is used to enable this feature. See page 154.

Within the PTO function file, there are PTO element(s). An element can be set to control either output 2 (O0:0/2 on 1762-L24BXB, 1762-L40BXB and 1764-28BXB) or output 3 (O0:0/3 on 1764-28BXB only).

The interface to the PTO sub-system is accomplished by scanning a PTO instruction in the main program file (file number 2) or by scanning a PTO instruction in any of the subroutine files. A typical operating sequence of a PTO instruction is as follows:

1. The rung that a PTO instruction is on is solved true.

2. The PTO instruction is started, and pulses are produced based on the accelerate/decelerate (ACCEL) parameters, which define the number of ACCEL pulses and the type of profile: s-curve or trapezoid.

3. The ACCEL phase completes.

4. The RUN phase is entered and the number of pulses defined for RUN are output.

5. The RUN phase completes.

6. Decelerate (DECEL) is entered, and pulses are produced based on the accelerate/decelerate parameters, which define the number of DECEL pulses and the type of profile: s-curve or trapezoid.

7. The DECEL phase completes.

8. The PTO instruction is DONE.

While the PTO instruction is being executed, status bits and information are updated as the main controller continues to operate. Because the PTO instruction is actually being executed by a parallel system, status bits and other information are updated each time the PTO instruction is scanned while it is running. This provides the control program access to PTO status while it is running.

TIP	PTO status is only as fresh as the scan time of the controller. Worst case latency is the same as the maximum scan of the controller. This condition can be minimized by placing a PTO instruction in the STI (selectable timed interrupt) file, or by adding PTO instructions to your program to increase how often a PTO instruction is scanned.

The charts in the following examples illustrate the typical timing sequence/behavior of a PTO instruction. The stages listed in each chart have nothing to do with controller scan time. They simply illustrate a sequence of events. In actuality, the controller may have hundreds or thousands of scans within each of the stages illustrated in the examples.

Conditions Required to Start the PTO

The following conditions must exist to start the PTO:

- The PTO instruction must be in an idle state.
- For idle state behavior, all of the following conditions must be met:
  - Jog Pulse (JP) bit must be off
  - Jog Continuous (JC) bit must be off
  - Enable Hard Stop (EH) bit must be off
  - Normal Operation (NS) bit must be off

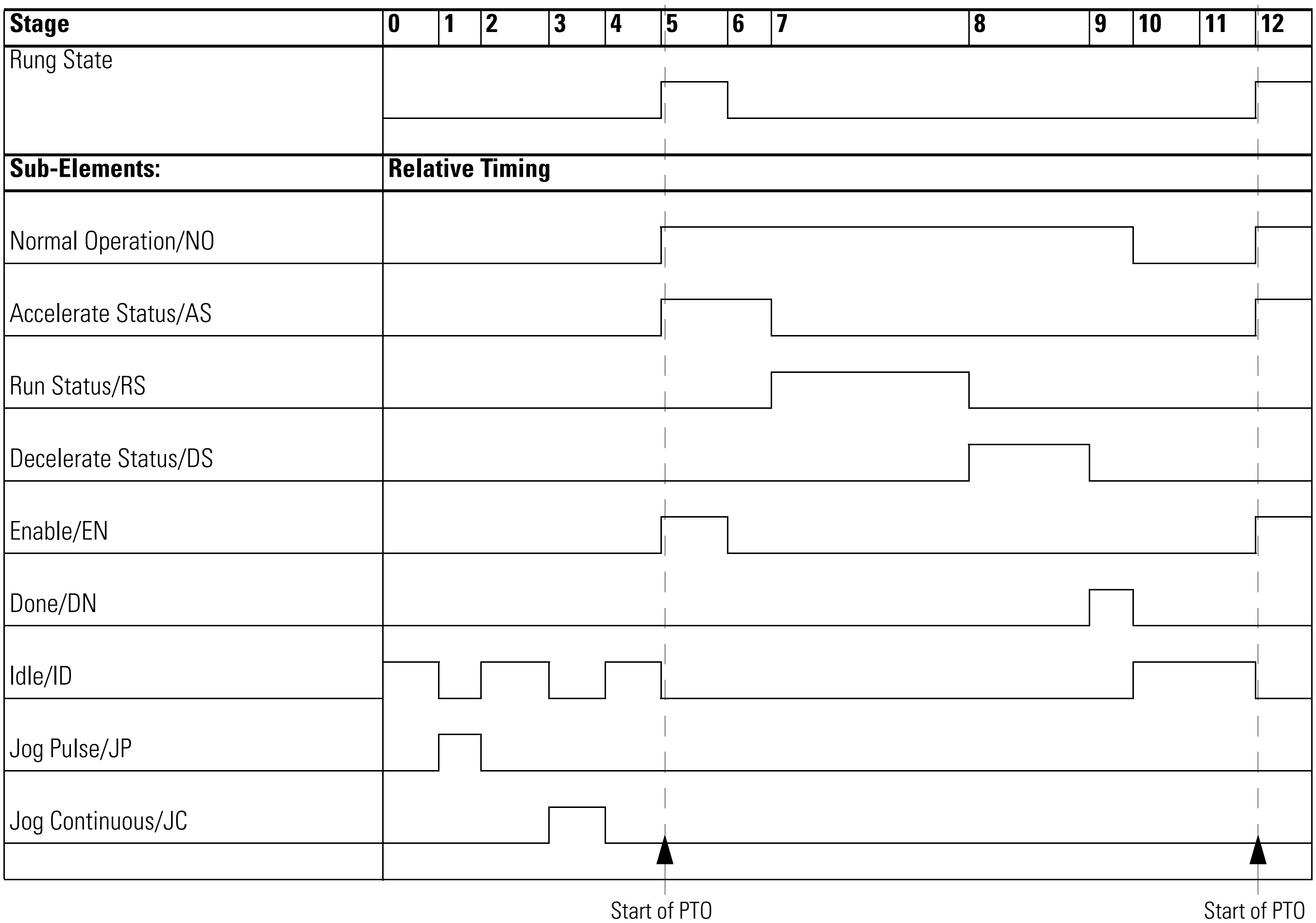
– The output cannot be forced

- The rung it is on must transition from a False state (0) to a True state (1).

Momentary Logic Enable Example

In this example, the rung state is a momentary or transitional type of input. This means that the false-to-true rung transition enables the PTO instruction and then returns to a false state prior to the PTO instruction completing its operation.

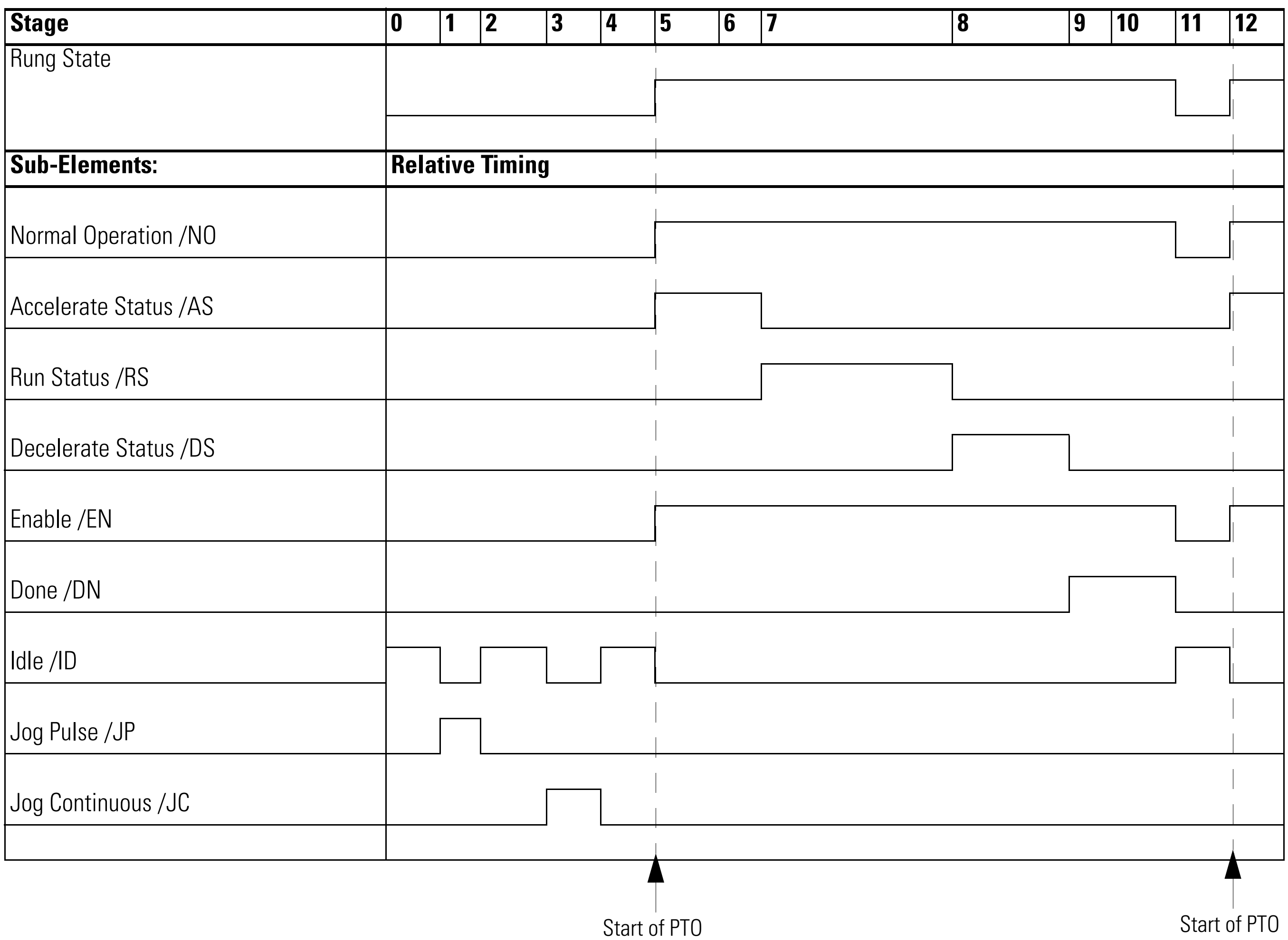
If a transitional input to the PTO instruction is used, the Done (DN) bit turns on when the instruction completes, but only remains on until the next time the PTO instruction is scanned in the user program. The structure of the control program determines when the DN bit goes off. So, to detect when the PTO instruction completes its output, you can monitor the Done (DN), Idle (ID), or Normal Operation (NO) status bits.



Standard Logic Enable Example

In this example, the rung state is a maintained type of input. This means that it enables the PTO instruction Normal Operation (NO) and maintains its logic state until after the PTO instruction completes its operation. With this type of logic, status bit behavior is as follows:

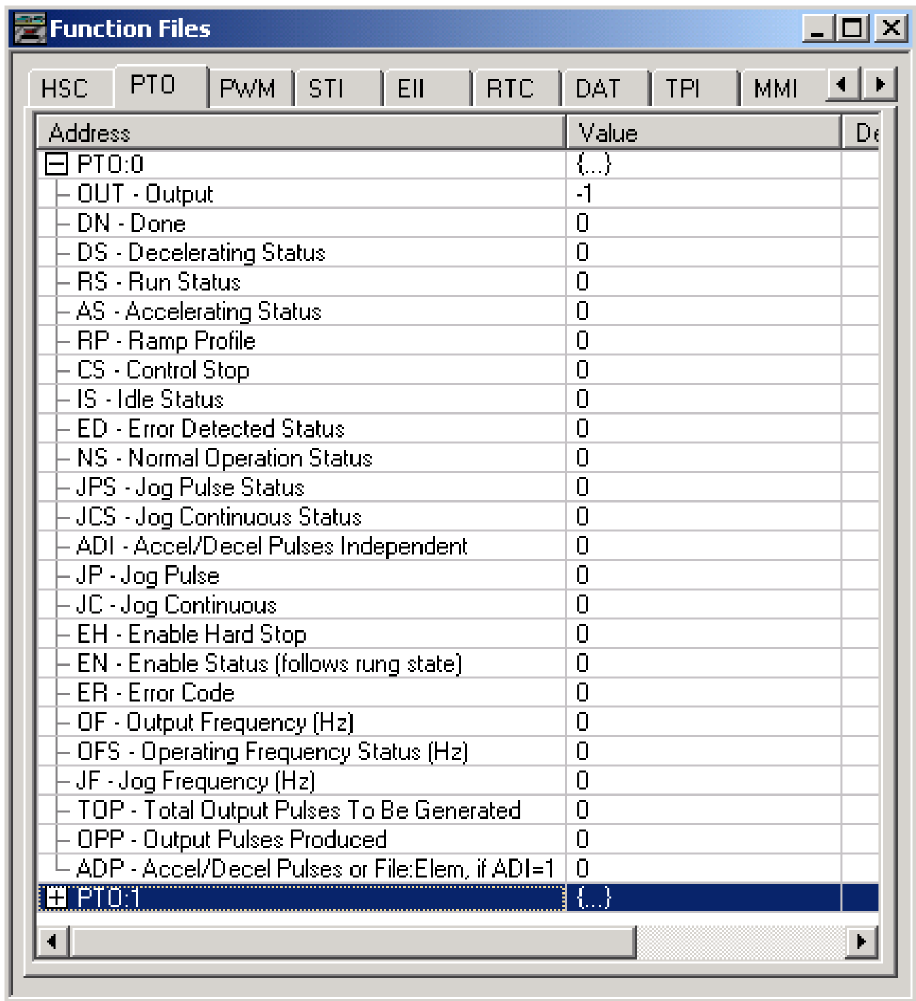
The Done (DN) bit becomes true (1) when the PTO completes and remains set until the PTO rung logic is false. The false rung logic re-activates the PTO instruction. To detect when the PTO instruction completes its output, monitor the done (DN) bit.



Pulse Train Outputs (PTO) Function File

Within the RSLogix 500 Function File Folder, you see a PTO Function File with two elements, PTO0 (1762-L24BXB, 1762-L40BXB, and 1764-28BXB) and PTO1 (1764-28BXB only). These elements provide access to PTO configuration data and also allow the control program access to all information pertaining to each of the Pulse Train Outputs.

TIP If the controller mode is run, the data within sub-element fields may be changing.



Pulse Train Output Function File Sub-Elements Summary

The variables within each PTO sub-element, along with what type of behavior and access the control program has to those variables, are listed individually below. All examples illustrate PTO 0. Terms and behavior for PTO 1 (MicroLogix 1500 only) are identical.

Pulse Train Output Function File (PTO:0)

Sub-Element Description	Address	Data Format	Range	Type	User Program Access	For More Information
OUT - Output	PTO:0.OUT	word (INT)	2 or 3	control	read only	155
DN - Done	PTO:0/DN	bit	0 or 1	status	read only	155
DS - Decelerating Status	PTO:0/DS	bit	0 or 1	status	read only	156
RS - Run Status	PTO:0/RS	bit	0 or 1	status	read only	156
AS - Accelerating Status	PTO:0/AS	bit	0 or 1	status	read only	156
RP - Ramp Profile	PTO:0/RP	bit	0 or 1	control	read/write	157
IS - Idle Status	PTO:0/IS	bit	0 or 1	status	read only	157
ED - Error Detected Status	PTO:0/ED	bit	0 or 1	status	read only	158
NS - Normal Operation Status	PTO:0/NS	bit	0 or 1	status	read only	158
JPS - Jog Pulse Status	PTO:0/JPS	bit	0 or 1	status	read only	165
JCS - Jog Continuous Status	PTO:0/JCS	bit	0 or 1	status	read only	166
ADI - Accel/Decel Pulses Independent	PTO:0/ADI	bit	0 or 1	control	read/write	161
JP - Jog Pulse	PTO:0/JP	bit	0 or 1	control	read/write	165
JC - Jog Continuous	PTO:0/JC	bit	0 or 1	control	read/write	166
EH - Enable Hard Stop	PTO:0/EH	bit	0 or 1	control	read/write	158
EN - Enable Status (follows rung state)	PTO:0/EN	bit	0 or 1	status	read only	159
ER - Error Code	PTO:0.ER	word (INT)	-2 to 7	status	read only	167
OF - Output Frequency (Hz)	PTO:0.OF	word (INT)	0 to 20,000	control	read/write	159
OFS - Operating Frequency Status (Hz)	PTO:0.OFS	word (INT)	0 to 20,000	status	read only	160
JF - Jog Frequency (Hz)	PTO:0.JF	word (INT)	0 to 20,000	control	read/write	165
TOP - Total Output Pulses To Be Generated	PTO:0.TOP	long word (32-bit INT)	0 to 2,147,483,647	control	read/write	160
OPP - Output Pulses Produced	PTO:0.OPP	long word (32-bit INT)	0 to 2,147,483,647	status	read only	160
ADP - Accel/Decel Pulses	PTO:0.ADP	long word (32-bit INT)	see p. 162	control	read/write	162
CS - Controlled Stop	PTO:0/CS	bit	0 or 1	control	read/write	163

PTO Output (OUT)

Sub-Element Description	Address	Data Format	Range	Type	User Program Access
OUT - Output	PTO:0.OUT	word (INT)	2 or 3	control	read only

The PTO OUT (Output) variable defines the output (O0:0/2 or O0:0/3) that the PTO instruction controls. This variable is set within the function file folder when the control program is written and cannot be set by the user program.

- When OUT = 2, PTO pulses output 2 (O0:0.0/2) of the embedded outputs (1762-L24BXB, 1762-L40BXB, and 1764-28BXB).
- When OUT = 3, PTO pulses output 3 (O0:0.0/3) of the embedded outputs (1764-28BXB only).

TIP Forcing an output controlled by the PTO while it is running stops all output pulses and causes a PTO error.

PTO Done (DN)

Sub-Element Description	Address	Data Format	Range	Type	User Program Access
DN - Done	PTO:0/DN	bit	0 or 1	status	read only

The PTO DN (Done) bit is controlled by the PTO sub-system. It can be used by an input instruction on any rung within the control program. The DN bit operates as follows:

- Set (1) - Whenever a PTO instruction has completed its operation successfully.
- Cleared (0) - When the rung the PTO is on is false. If the rung is false when the PTO instruction completes, the Done bit is set until the next scan of the PTO instruction.

PTO Decelerating Status (DS)

Sub-Element Description	Address	Data Format	Range	Type	User Program Access
DS - Decelerating Status	PTO:0/DS	bit	0 or 1	status	read only

The PTO DS (Decel) bit is controlled by the PTO sub-system. It can be used by an input instruction on any rung within the control program. The DS bit operates as follows:

- Set (1) - Whenever a PTO instruction is within the deceleration phase of the output profile.
- Cleared (0) - Whenever a PTO instruction is not within the deceleration phase of the output profile.

PTO Run Status (RS)

Sub-Element Description	Address	Data Format	Range	Type	User Program Access
RS - Run Status	PTO:0/RS	bit	0 or 1	status	read only

The PTO RS (Run Status) bit is controlled by the PTO sub-system. It can be used by an input instruction on any rung within the control program. The RS bit operates as follows:

- Set (1) - Whenever a PTO instruction is within the run phase of the output profile.
- Cleared (0) - Whenever a PTO instruction is not within the run phase of the output profile.

PTO Accelerating Status (AS)

Sub-Element Description	Address	Data Format	Range	Type	User Program Access
AS - Accelerating Status	PTO:0/AS	bit	0 or 1	status	read only

The PTO AS (Accelerating Status) bit is controlled by the PTO sub-system. It can be used by an input instruction on any rung within the control program. The AS bit operates as follows:

- Set (1) - Whenever a PTO instruction is within the acceleration phase of the output profile.

- Cleared (0) - Whenever a PTO instruction is not within the acceleration phase of the output profile.

PTO Ramp Profile (RP)

Sub-Element Description	Address	Data Format	Range	Type	User Program Access
RP - Ramp Profile	PTO:0/RP	bit	0 or 1	control	read/write

The PTO RP (Ramp Profile) bit controls how the output pulses generated by the PTO sub-system accelerate to and decelerate from the Output Frequency that is set in the PTO function file (PTO:0.OF). It can be used by an input or output instruction on any rung within the control program. The RP bit operates as follows:

- Set (1) - Configures the PTO instruction to produce an S-Curve profile.
- Cleared (0) - Configures the PTO instruction to produce a Trapezoid profile.

PTO Idle Status (IS)

Sub-Element Description	Address	Data Format	Range	Type	User Program Access
IS - Idle Status	PTO:0/IS	bit	0 or 1	status	read only

The PTO IS (Idle Status) is controlled by the PTO sub-system. It can be used in the control program by an input instruction. The PTO sub-system must be in an idle state whenever any PTO operation needs to start.

The IS bit operates as follows:

- Set (1) - PTO sub-system is in an idle state. The idle state is defined as the PTO is not running and no errors are present.
- Cleared (0) - PTO sub-system is not in an idle state (it is running)

PTO Error Detected (ED)

Sub-Element Description	Address	Data Format	Range	Type	User Program Access
ED - Error Detected Status	PTO:0/ED	bit	0 or 1	status	read only

The PTO ED (Error Detected Status) bit is controlled by the PTO sub-system. It can be used by an input instruction on any rung within the control program to detect when the PTO instruction is in an error state. If an error state is detected, the specific error is identified in the error code register (PTO:0.ER). The ED bit operates as follows:

- Set (1) - Whenever a PTO instruction is in an error state
- Cleared (0) - Whenever a PTO instruction is not in an error state

PTO Normal Operation Status (NS)

Sub-Element Description	Address	Data Format	Range	Type	User Program Access
NS - Normal Operation Status	PTO:0/NS	bit	0 or 1	status	read only

The PTO NS (Normal Operation Status) bit is controlled by the PTO sub-system. It can be used by an input instruction on any rung within the control program to detect when the PTO is in its normal state. A normal state is ACCEL, RUN, DECEL or DONE, with no PTO errors. The NS bit operates as follows:

- Set (1) - Whenever a PTO instruction is in its normal state
- Cleared (0) - Whenever a PTO instruction is not in its normal state

PTO Enable Hard Stop (EH)

Sub-Element Description	Address	Data Format	Range	Type	User Program Access
EH - Enable Hard Stop	PTO:0/EH	bit	0 or 1	control	read/write

The PTO EH (Enable Hard Stop) bit is used to stop the PTO sub-system immediately. Once the PTO sub-system starts a pulse sequence, the only way to stop generating pulses is to set the enable hard stop bit. The enable hard stop aborts any PTO sub-system operation (idle, normal, jog continuous or jog pulse) and generates a PTO sub-system error. The EH bit operates as follows:

- Set (1) - Instructs the PTO sub-system to stop generating pulses immediately (output off = 0)
- Cleared (0) - Normal operation

PTO Enable Status (EN)

Sub-Element Description	Address	Data Format	Range	Type	User Program Access
EN - Enable Status (follows rung state)	PTO:0/EN	bit	0 or 1	status	read only

The PTO EN (Enable Status) is controlled by the PTO sub-system. When the rung preceding the PTO instruction is solved true, the PTO instruction is enabled and the enable status bit is set. If the rung preceding the PTO instruction transitions to a false state before the pulse sequence completes its operation, the enable status bit resets (0). The EN bit operates as follows:

- Set (1) - PTO is enabled
- Cleared (0) - PTO has completed, or the rung preceding the PTO is false

PTO Output Frequency (OF)

Sub-Element Description	Address	Data Format	Range	Type	User Program Access
OF - Output Frequency (Hz)	PTO:0.OF	word (INT)	0 to 20,000	control	read/write

The PTO OF (Output Frequency) variable defines the frequency of the PTO output during the RUN phase of the pulse profile. This value is typically determined by the type of device that is being driven, the mechanics of the application, or the device/components being moved. Data less than zero and greater than 20,000 generates a PTO error.

PTO Operating Frequency Status (OFS)

Sub-Element Description	Address	Data Format	Range	Type	User Program Access
OFS - Operating Frequency Status (Hz)	PTO:0.OFS	word (INT)	0 to 20,000	status	read only

The PTO OFS (Output Frequency Status) is generated by the PTO sub-system and can be used in the control program to monitor the actual frequency being produced by the PTO sub-system.

TIP The value displayed may not exactly match the value entered in the PTO:0.OF. This is because the PTO sub-system may not be capable of reproducing an exact frequency at some of the higher frequencies. For PTO applications, this is typically not an issue because, in all cases, an exact number of pulses are produced.

PTO Total Output Pulses To Be Generated (TOP)

Sub-Element Description	Address	Data Format	Range	Type	User Program Access
TOP - Total Output Pulses To Be Generated	PTO:0.TOP	long word (32-bit INT)	0 to 2,147,483,647	control	read/write

The PTO TOP (Total Output Pulses) defines the total number of pulses to be generated for the pulse profile (accel/run/decel *inclusive*).

PTO Output Pulses Produced (OPP)

Sub-Element Description	Address	Data Format	Range	Type	User Program Access
OPP - Output Pulses Produced	PTO:0.OPP	long word (32-bit INT)	0 to 2,147,483,647	status	read only

The PTO OPP (Output Pulses Produced) is generated by the PTO sub-system and can be used in the control program to monitor how many pulses have been generated by the PTO sub-system.

PTO Accel/Decel Pulses Independent (ADI)

Sub-Element Description	Address	Data Format	Range	Type	User Program Access
ADI - Accel/Decel Pulses Independent	PTO:0/ADI	bit	0 or 1	control	read/write

The PTO ADI (Accel/Decel Pulses Independent) bit is used to define whether the acceleration and deceleration intervals will be the same, or if each will have a unique value. When this bit is set (1), separate profiles are used. When this bit is clear (0), the PTO will operate with the deceleration profile as a mirror of the acceleration profile.

If separate acceleration and deceleration profiles are desired, you must choose a long integer file number and a starting element. There must be four long elements available in the file:

Element 1:	Acceleration Count
Element 2:	Deceleration Count
Elements 3 and 4:	reserved

The choice of selecting a common profile or separate profiles must be made at the time of programming. This cannot be changed once the program is downloaded into the controller. The selection of the ramp type must be made prior to going to run. The acceleration and deceleration counts must be entered before the PTO is enabled. If the four long elements are not properly identified, the controller will return a -3 error in the PTO function file when going to run.

PTO Accel / Decel Pulses or File:Elem, if ADI=1 (ADP)

Sub-Element Description	Address	Data Format	Range	Type	User Program Access
ADP - Accel/Decel Pulses	PTO:0.ADP	long word (32-bit INT)	see below	control	read/write

The PTO ADP (Accel/Decel Pulses) defines how many of the total pulses (TOP variable) will be applied to each of the ACCEL and DECEL components. The ADP will determine the acceleration and deceleration rate from 0 to the PTO Output Frequency (OF). The PTO Output Frequency (OF) defines the operating frequency in pulses/second during the run portion of the profile.

TIP

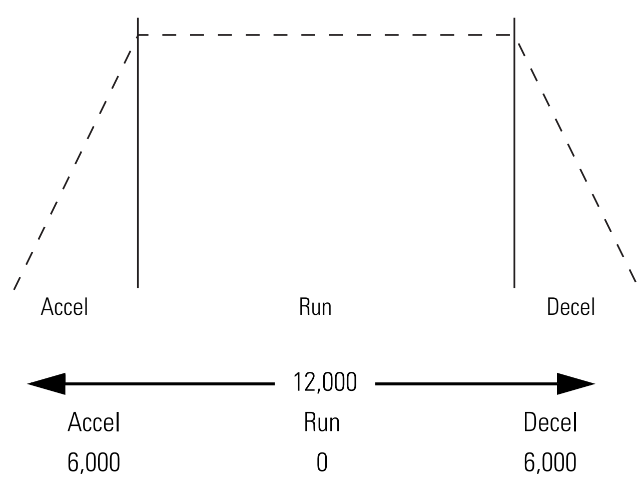
When entering the ADP parameters, the PTO will generate an Accel/Decel Error if one of the following conditions occur:

- The total pulses for the acceleration and deceleration phases is less than 0.
- The total pulses for the acceleration and deceleration phases is greater than the total output pulses to be generated (TOP).

Acceleration and deceleration values can either be identical (ADI = 0), or a unique value for each (ADI = 1).

In the example below,

- TOP (total output pulses) = 12,000
- ADP (accelerate/decelerate pulses)= 6,000 (This is the maximum ADP value that may be entered without causing a fault. The run portion will equal 0.)



In this example, the maximum value that could be used for accelerate/decelerate is 6000, because if both accelerate and decelerate are 6000, the total number of pulses = 12,000. The run component would be zero. This profile would consist of an acceleration phase from 0 to 6000. At 6000, the output frequency (OF variable) is generated and immediately enters the deceleration phase, 6000 to 12,000. At 12,000, the PTO operation would stop (output frequency = 0).

If you need to determine the ramp period (accelerate/decelerate ramp duration):

- 2 x ADP/OF = duration in seconds (OF = output frequency)

The following formulas can be used to calculate the maximum frequency limit for both profiles. The maximum frequency = the integer which is less than or equal to the result found below (OF = output frequency):

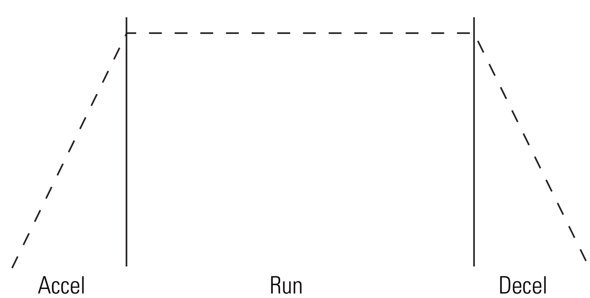
- For Trapezoid Profiles: [OF x (OF/4)] + 0.5
- For S-Curve Profiles: 0.999 x OF x SQRT(OF/6)

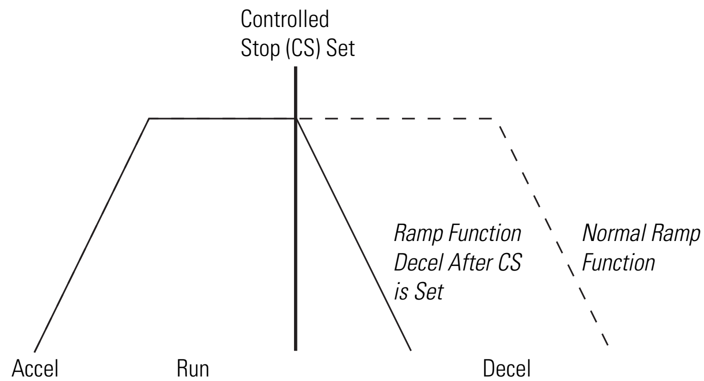
PTO Controlled Stop (CS)

Sub-Element Description	Address	Data Format	Range	Type	User Program Access
CS - Controlled Stop	PTO:0/CS	bit	0 or 1	control	read/write

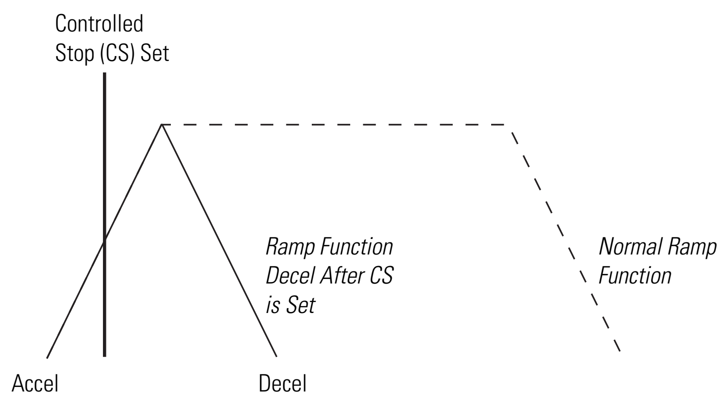
The PTO CS (Controlled Stop) bit is used to stop an executing PTO instruction, in the run portion of the profile, by immediately starting the decel phase. Once set, the decel phase completes without an error or fault condition.

Normal Ramp Function without CS





If the CS bit is set during the accel phase, the accel phase completes and the PTO immediately enters the decel phase.



PTO Jog Frequency (JF)

Sub-Element Description	Address	Data Format	Range	Type	User Program Access
JF - Jog Frequency (Hz)	PTO:0.JF	word (INT)	0 to 20,000	control	read/write

The PTO JF (Jog Frequency) variable defines the frequency of the PTO output during all Jog phases. This value is typically determined by the type of device that is being driven, the mechanics of the application, or the device/components being moved). Data less than zero and greater than 20,000 generates a PTO error.

PTO Jog Pulse (JP)

Sub-Element Description	Address	Data Format	Range	Type	User Program Access
JP - Jog Pulse	PTO:0/JP	bit	0 or 1	control	read/write

The PTO JP (Jog Pulse) bit is used to instruct the PTO sub-system to generate a single pulse. The width is defined by the Jog Frequency parameter in the PTO function file. Jog Pulse operation is only possible under the following conditions:

- PTO sub-system in idle
- Jog continuous not active
- Enable not active

The JP bit operates as follows:

- Set (1) - Instructs the PTO sub-system to generate a single Jog Pulse
- Cleared (0) - Arms the PTO Jog Pulse sub-system

PTO Jog Pulse Status (JPS)

Sub-Element Description	Address	Data Format	Range	Type	User Program Access
JPS - Jog Pulse Status	PTO:0/JPS	bit	0 or 1	status	read only

The PTO JPS (Jog Pulse Status) bit is controlled by the PTO sub-system. It can be used by an input instruction on any rung within the control program to detect when the PTO has generated a Jog Pulse.

The JPS bit operates as follows:

- Set (1) - Whenever a PTO instruction outputs a Jog Pulse
- Cleared (0) - Whenever a PTO instruction exits the Jog Pulse state

TIP The output (jog) pulse is normally complete with the JP bit set. The JPS bit remains set until the JP bit is cleared (0 = off).

PTO Jog Continuous (JC)

Sub-Element Description	Address	Data Format	Range	Type	User Program Access
JC - Jog Continuous	PTO:0/JC	bit	0 or 1	control	read/write

The PTO JC (Jog Continuous) bit instructs the PTO sub-system to generate continuous pulses. The frequency generated is defined by the Jog Frequency parameter in the PTO function file. Jog Continuous operation is only possible under the following conditions:

- PTO sub-system in idle
- Jog Pulse not active
- Enable not active

The JC bit operates as follows:

- Set (1) - Instructs the PTO sub-system to generate continuous Jog Pulses
- Cleared (0) - The PTO sub-system does not generate Jog Pulses

When the Jog Continuous bit is cleared, the current output pulse is truncated.

PTO Jog Continuous Status (JCS)

Sub-Element Description	Address	Data Format	Range	Type	User Program Access
JCS - Jog Continuous Status	PTO:0/JCS	bit	0 or 1	status	read only

The PTO JCS (Jog Continuous Status) bit is controlled by the PTO sub-system. It can be used by an input instruction on any rung within the control program to detect when the PTO is generating continuous Jog Pulses. The JCS bit operates as follows:

- Set (1) - Whenever a PTO instruction is generating continuous Jog Pulses
- Cleared (0) - Whenever a PTO instruction is not generating continuous Jog Pulses.

PTO Error Code (ER)

Sub-Element Description	Address	Data Format	Range	Type	User Program Access
ER - Error Code	PTO:0.ER	word (INT)	-3 to 7	status	read only

PTO ER (Error Codes) detected by the PTO sub-system are displayed in this register. The error codes are shown in the table below:

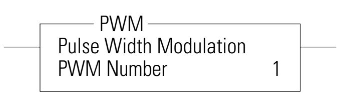
Pulse Train Output Error Codes

Error Code	Non-User Fault	Recoverable Fault	Instruction Errors	Error Name	Description
-3	No	Yes	Yes	Undefined Accel/ Decel	Acceleration Count and Deceleration not defined during going to run mode when Accel/Decel Pulses Independent (ADI) is set (1).
-2	Yes	No	No	Overlap Error	An output overlap is detected. Multiple functions are assigned to the same physical output. This is a configuration error. The controller faults and the User Fault Routine does not execute. Example: PTO0 and PTO1 are both attempting to use a single output.
-1	Yes	No	No	Output Error	An invalid output has been specified. Output 2 and output 3 are the only valid choices. This is a configuration error. The controller faults and the User Fault Routine does not execute.
0	---	---		Normal	Normal (0 = no error present)
1	No	No	Yes	Hardstop Detected	This error is generated whenever a hard stop is detected. This error does not fault the controller. To clear this error, scan the PTO instruction on a false rung and reset the EH (Enable Hard Stop) bit to 0.
2	No	No	Yes	Output Forced Error	The configured PTO output (2 or 3) is currently forced. The forced condition *must* be removed for the PTO to operate. This error does not fault the controller. It is automatically cleared when the force condition is removed.
3	No	Yes	No	Frequency Error	The operating frequency value (OFS) is less than 0 or greater than 20,000. This error faults the controller. It can be cleared by logic within the User Fault Routine.

Pulse Train Output Error Codes

Error Code	Non-User Fault	Recoverable Fault	Instruction Errors	Error Name	Description
4	No	Yes	No	Accel/ Decel Error	The accelerate/decelerate parameters (ADP) are: • less than zero • greater than half the total output pulses to be generated (TOP) • Accel/Decel exceeds limit (See page 162.) This error faults the controller. It can be cleared by logic within the User Fault Routine.
5	No	No	Yes	Jog Error	PTO is in the idle state and two or more of the following are set: • Enable (EN) bit set • Jog Pulse (JP) bit set • Jog Continuous (JC) bit set This error does not fault the controller. It is automatically cleared when the error condition is removed.
6	No	Yes	No	Jog Frequency Error	The jog frequency (JF) value is less than 0 or greater than 20,000. This error faults the controller. It can be cleared by logic within the User Fault Routine.
7	No	Yes	No	Length Error	The total output pulses to be generated (TOP) is less than zero. This error faults the controller. It can be cleared by logic within the User Fault Routine.

PWM - Pulse Width Modulation



IMPORTANT The PWM function can only be used with the controller's embedded I/O. It cannot be used with expansion I/O modules.

IMPORTANT The PWM instruction should only be used with MicroLogix 1200 and 1500 BXB units. Relay outputs are not capable of performing very high-speed operations.

Instruction Type: output

Execution Time for the PWM Instruction

Controller	When Rung Is:	
	True	False
MicroLogix 1200	126.6 µs	24.7 µs
MicroLogix 1500	107.4 µs	21.1 µs

PWM Function

The PWM function allows a field device to be controlled by a PWM wave form. The PWM profile has two primary components:

- Frequency to be generated
- Duty Cycle interval

The PWM instruction, along with the HSC and PTO functions, are different than all other controller instructions. Their operation is performed by custom circuitry that runs in parallel with the main system processor. This is necessary because of the high performance requirements of these instructions.

The interface to the PWM sub-system is accomplished by scanning a PWM instruction in the main program file (file number 2), or by scanning a PWM instruction in any of the subroutine files. A typical operating sequence of a PWM instruction is as follows:

1. The rung that a PWM instruction is on is solved true (the PWM is started).
2. A waveform at the specified frequency is produced.
3. The RUN phase is active. A waveform at the specified frequency with the specified duty cycle is output.
4. The rung that the PWM is on is solved false.
5. The PWM instruction is IDLE.

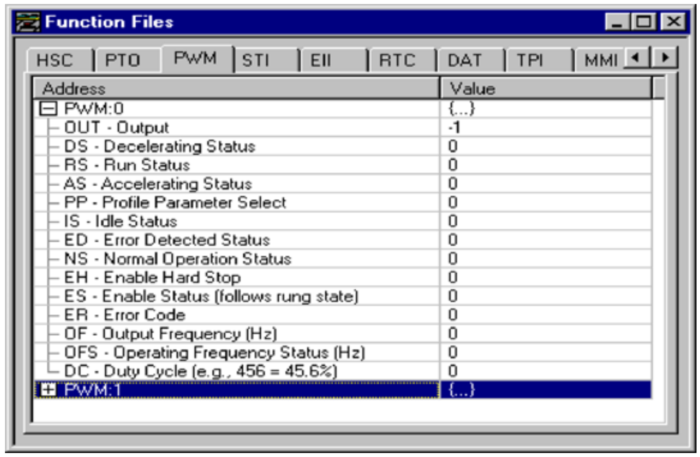
While the PWM instruction is being executed, status bits and data are updated as the main controller continues to operate. Because the PWM instruction is actually being executed by a parallel system, the status bits and other information are updated each time the PWM instruction is scanned while it is running. This provides the control program access to PWM status while it is running.

TIP

PWM status is only as fresh as the scan time of the controller. Worst case latency is the maximum scan of the controller. This condition can be minimized by placing a PWM instruction in the STI (selectable timed interrupt) file, or by adding PWM instructions to your program to increase how often a PWM instruction is scanned.

Pulse Width Modulation (PWM) Function File

Within the PWM function file are two PWM elements. Each element can be set to control either output 2 (O0:0/2 on 1762-L24BXB, 1762-L40BXB, and 1764-28BXB) or output 3 (O0:0/3 on 1764-28BXB only). Function file element PWM:0 is shown below.



Pulse Width Modulated Function File Elements Summary

The variables within each PWM element, along with what type of behavior and access the control program has to those variables, are listed individually below.

Element Description	Address	Data Format	Range	Type	User Program Access	For More Information
OUT - PWM Output	PWM:0.OUT	word (INT)	2 or 3	status	read only	171
DS - Decelerating Status	PWM:0/DS	bit	0 or 1	status	read only	171
RS - PWM Run Status	PWM:0/RS	bit	0 or 1	status	read only	171
AS - Accelerating Status	PWM:0/AS	bit	0 or 1	status	read only	172
PP - Profile Parameter Select	PWM:0/PP	bit	0 or 1	control	read/write	172
IS - PWM Idle Status	PWM:0/IS	bit	0 or 1	status	read only	173
ED - PWM Error Detection	PWM:0/ED	bit	0 or 1	status	read only	173
NS - PWM Normal Operation	PWM:0/NS	bit	0 or 1	status	read only	173
EH - PWM Enable Hard Stop	PWM:0/EH	bit	0 or 1	control	read/write	174
ES - PWM Enable Status	PWM:0/ES	bit	0 or 1	status	read only	174
OF - PWM Output Frequency	PWM:0.OF	word (INT)	0 to 20,000	control	read/write	174
OFS - PWM Operating Frequency Status	PWM:0.OFS	word (INT)	0 to 20,000	status	read only	175
DC - PWM Duty Cycle	PWM:0.DC	word (INT)	1 to 1000	control	read/write	175
DCS - PWM Duty Cycle Status	PWM:0.DCS	word (INT)	1 to 1000	status	read only	175
ADD - Accel/Decel Delay	PWM:0.ADD	word (INT)	0 to 32,767	control	read/write	176
ER - PWM Error Codes	PWM:0.ER	word (INT)	-2 to 5	status	read only	176

PWM Output (OUT)

Element Description	Address	Data Format	Range	Type	User Program Access
OUT - PWM Output	PWM:0.OUT	word (INT)	2 or 3	status	read only

The PWM OUT (Output) variable defines the physical output that the PWM instruction controls. This variable is set within the function file folder when the control program is written and cannot be set by the user program. The outputs are defined as O0:0/2 or O0:0/3 as listed below:

- O0:0.0/2: PWM modulates output 2 of the embedded outputs (1762-L24BXB, 1762-L40BXB, and 1764-28BXB)
- O0:0.0/3: PWM modulates output 3 of the embedded outputs (1764-28BXB only)

PWM Decelerating Status (DS)

Element Description	Address	Data Format	Range	Type	User Program Access
DS - Decelerating Status	PWM:0/DS	bit	0 or 1	status	read only

The PWM DS (Decel) bit is controlled by the PWM sub-system. It can be used by an input instruction on any rung within the control program. The DS bit operates as follows:

- Set (1) - Whenever a PWM output is within the deceleration phase of the output profile.
- Cleared (0) - Whenever a PWM output is not within the deceleration phase of the output profile.

PWM Run Status (RS)

Element Description	Address	Data Format	Range	Type	User Program Access
RS - PWM Run Status	PWM:0/RS	bit	0 or 1	status	read only

The PWM RS (Run Status) bit is controlled by the PWM sub-system. It can be used by an input instruction on any rung within the control program.

- Set (1) - Whenever the PWM instruction is within the run phase of the output profile.

- Cleared (0) - Whenever the PWM instruction is not within the run phase of the output profile.

PWM Accelerating Status (AS)

Element Description	Address	Data Format	Range	Type	User Program Access
AS - Accelerating Status	PWM:0/AS	bit	0 or 1	status	read only

The PWM AS (Accelerating Status) bit is controlled by the PWM sub-system. It can be used by an input instruction on any rung within the control program. The AS bit operates as follows:

- Set (1) - Whenever a PWM output is within the acceleration phase of the output profile.
- Cleared (0) - Whenever a PWM output is not within the acceleration phase of the output profile.

PWM Profile Parameter Select (PP)

Element Description	Address	Data Format	Range	Type	User Program Access
PP - Profile Parameter Select	PWM:0/PP	bit	0 or 1	control	read/write

The PWM PP (Profile Parameter Select) selects which component of the waveform is modified during a ramp phase:

- Set (1) - selects Frequency
- Cleared (0) - selects Duty Cycle

The PWM PP bit cannot be modified while the PWM output is running/ enabled. See PWM ADD on page 176 for more information.

PWM Idle Status (IS)

Element Description	Address	Data Format	Range	Type	User Program Access
IS - PWM Idle Status	PWM:0/IS	bit	0 or 1	status	read only

The PWM IS (Idle Status) is controlled by the PWM sub-system and represents no PWM activity. It can be used in the control program by an input instruction.

- Set (1) - PWM sub-system is in an idle state.
- Cleared (0) - PWM sub-system is not in an idle state (it is running).

PWM Error Detected (ED)

Element Description	Address	Data Format	Range	Type	User Program Access
ED - PWM Error Detection	PWM:0/ED	bit	0 or 1	status	read only

The PWM ED (Error Detected) bit is controlled by the PWM sub-system. It can be used by an input instruction on any rung within the control program to detect when the PWM instruction is in an error state. If an error state is detected, the specific error is identified in the error code register (PWM:0.ED).

- Set (1) - Whenever a PWM instruction is in an error state.
- Cleared (0) - Whenever a PWM instruction is not in an error state.

PWM Normal Operation (NS)

Element Description	Address	Data Format	Range	Type	User Program Access
NS - PWM Normal Operation	PWM:0/NS	bit	0 or 1	status	read only

The PWM NS (Normal Operation) bit is controlled by the PWM sub-system. It can be used by an input instruction on any rung within the control program to detect when the PWM is in its normal state. A normal state is defined as ACCEL, RUN, or DECEL with no PWM errors.

- Set (1) - Whenever a PWM instruction is in its normal state.
- Cleared (0) - Whenever a PWM instruction is not in its normal state.

PWM Enable Hard Stop (EH)

Element Description	Address	Data Format	Range	Type	User Program Access
EH - PWM Enable Hard Stop	PWM:0/EH	bit	0 or 1	control	read/write

The PWM EH (Enable Hard Stop) bit stops the PWM sub-system immediately. A PWM hard stop generates a PWM sub-system error.

- Set (1) - Instructs the PWM sub-system to stop its output modulation immediately (output off = 0).
- Cleared (0) - Normal operation.

PWM Enable Status (ES)

Element Description	Address	Data Format	Range	Type	User Program Access
ES - PWM Enable Status	PWM:0/ES	bit	0 or 1	status	read only

The PWM ES (Enable Status) is controlled by the PWM sub-system. When the rung preceding the PWM instruction is solved true, the PWM instruction is enabled, and the enable status bit is set. When the rung preceding the PWM instruction transitions to a false state, the enable status bit is reset (0) immediately.

- Set (1) - PWM is enabled.
- Cleared (0) - PWM has completed or the rung preceding the PWM is false.

PWM Output Frequency (OF)

Element Description	Address	Data Format	Range	Type	User Program Access
OF - PWM Output Frequency	PWM:0.OF	word (INT)	0 to 20,000	control	read/write

The PWM OF (Output Frequency) variable defines the frequency of the PWM function. This frequency can be changed at any time.

PWM Operating Frequency Status (OFS)

Element Description	Address	Data Format	Range	Type	User Program Access
OFS - PWM Operating Frequency Status	PWM:0.OFS	word (INT)	0 to 20,000	status	read only

The PWM OFS (Output Frequency Status) is generated by the PWM sub-system and can be used in the control program to monitor the actual frequency produced by the PWM sub-system.

PWM Duty Cycle (DC)

Element Description	Address	Data Format	Range	Type	User Program Access
DC - PWM Duty Cycle	PWM:0.DC	word (INT)	1 to 1000	control	read/write

The PWM DC (Duty Cycle) variable controls the output signal produced by the PWM sub-system. Changing this variable in the control program changes the output waveform. Typical values and output waveform:

- DC = 1000: 100% Output ON (constant, no waveform)
- DC = 750: 75% Output ON, 25% output OFF
- DC = 500: 50% Output ON, 50% output OFF
- DC = 250: 25% Output ON, 75% output OFF
- DC = 0: 0% Output OFF (constant, no waveform)

PWM Duty Cycle Status (DCS)

Element Description	Address	Data Format	Range	Type	User Program Access
DCS - PWM Duty Cycle Status	PWM:0.DCS	word (INT)	1 to 1000	status	read only

The PWM DCS (Duty Cycle Status) provides feedback from the PWM sub-system. The Duty Cycle Status variable can be used within an input instruction on a rung of logic to provide PWM system status to the remaining control program.

PWM Accel/Decel Delay (ADD)

Element Description	Address	Data Format	Range	Type	User Program Access
ADD - Accel/Decel Delay	PWM:0.ADD	word (INT)	0 to 32,767	control	read/write

PWM ADD (Accel/Decel Delay) defines the amount of time in 10 millisecond intervals to ramp from zero to the specified frequency or duration. Also specifies the time to ramp down to zero.

The PWM ADD value is loaded and activated immediately (whenever the PWM instruction is scanned on a true rung of logic). This allows multiple steps or stages of acceleration or deceleration to occur.

PWM Error Code (ER)

Element Description	Address	Data Format	Range	Type	User Program Access
ER - PWM Error Codes	PWM:0.ER	word (INT)	-2 to 5	status	read only

PWM ER (Error Codes) detected by the PWM sub-system are displayed in this register. The table identifies known errors.

Error Code	Non-User Fault	Recoverable Fault	Instruction Errors	Error Name	Description
-2	Yes	No	No	Overlap Error	An output overlap is detected. Multiple functions are assigned to the same physical output. This is a configuration error. The controller faults and the User Fault Routine does not execute. Example: PWM0 and PWM1 are both attempting to use a single output.
-1	Yes	No	No	Output Error	An invalid output has been specified. Output 2 and output 3 are the only valid choices. This is a configuration error. The controller faults and the User Fault Routine does not execute.
0				Normal	Normal (0 = no error present)
1	No	No	Yes	Hardstop Error	This error is generated whenever a hardstop is detected. This error does not fault the controller. It is automatically cleared when the hardstop condition is removed.
2	No	No	Yes	Output Forced Error	The configured PWM output (2 or 3) is currently forced. The forced condition *must* be removed for the PWM to operate. This error does not fault the controller. It is automatically cleared when the force condition is removed.
3	Yes	Yes	No	Frequency Error	The frequency value is less than 0 or greater than 20,000. This error faults the controller. It can be cleared by logic within the User Fault Routine.
4	Reserved				
5	Yes	Yes	No	Duty Cycle Error	The PWM duty cycle is either less than zero or greater than 1000. This error faults the controller. It can be cleared by logic within the User Fault Routine.

Chapter 7

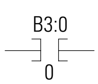
Relay-Type (Bit) Instructions

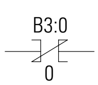
Use relay-type (bit) instructions to monitor and/or control bits in a data file or function file, such as input bits or timer control-word bits. The following instructions are described in this chapter:

Instruction	Used To:	Page
XIC - Examine if Closed	Examine a bit for an ON condition	177
XIO - Examine if Open	Examine a bit for an OFF condition	177
OTE - Output Enable	Turn ON or OFF a bit (non-retentive)	179
OTL - Output Latch	Latch a bit ON (retentive)	180
OTU - Output Unlatch	Unlatch a bit OFF (retentive)	180
ONS - One Shot	Detect an OFF to ON transition	181
OSR - One Shot Rising	Detect an OFF to ON transition	182
OSF - One Shot Falling	Detect an ON to OFF transition	182

These instructions operate on a single bit of data. During operation, the processor may set or reset the bit, based on logical continuity of ladder rungs. You can address a bit as many times as your program requires.

XIC - Examine if Closed
XIO - Examine if Open





Instruction Type: input

Execution Time for the XIC and XIO Instructions

Controller	When Instruction Is:	
	True	False
MicroLogix 1200	0.9 µs	0.8 µs
MicroLogix 1500	0.9 µs	0.7 µs

Use the XIC instruction to determine if the addressed bit is on. Use the XIO instruction to determine if the addressed bit is off.

When used on a rung, the bit address being examined can correspond to the status of real world input devices connected to the base unit or expansion I/O, or internal addresses (data or function files). Examples of devices that turn on or off:

- a push button wired to an input (addressed as I1:0/4)

- an output wired to a pilot light (addressed as O0:0/2)
- a timer controlling a light (addressed as T4:3/DN)
- a bit in the bit file (addressed as B3/16)

The instructions operate as follows:

XIO and XIC Instruction Operation

Rung State	Addressed Bit	XIC Instruction	XIO Instruction
True	Off	Returns a False	Returns a True
True	On	Returns a True	Returns a False
False	--	Instruction is not evaluated	Instruction is not evaluated

Addressing Modes and File Types can be used as shown in the following table:

XIC and XIO Instructions Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files											Function Files(1)									CS - Comms	IOS - I/O	DLS - Data Log(2)	Address Mode(3)			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI				Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Operand Bit	•	•	•	•	•	•			•	•		•	•	•	•	•	•	•	•	•	•	•	•		•	•	•			

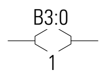
(1) DAT files are valid for the MicroLogix 1500 only. PTO and PWM files are only for use with MicroLogix 1200 and 1500 BXB units.

(2) The Data Log Status file can only be used by the MicroLogix 1500 1764-LRP Processor.

(3) See Important note about indirect addressing.

IMPORTANT	You cannot use indirect addressing with: S, ST, MG, PD, RTC, HSC, PTO, PWM, STI, EII, BHI, MMI, DAT, TPI, CS, IOS, and DLS files.

OTE - Output Energize



Instruction Type: output

Execution Time for the OTE Instructions

Controller	When Rung Is:	
	True	False
MicroLogix 1200	1.4 µs	1.1 µs
MicroLogix 1500	1.2 µs	0.0 µs

Use an OTE instruction to turn a bit location on when rung conditions are evaluated as true and off when the rung is evaluated as false. An example of a device that turns on or off is an output wired to a pilot light (addressed as O0:0/4). OTE instructions are reset (turned OFF) when:

- You enter or return to the program or remote program mode or power is restored.
- The OTE is programmed within an inactive or false Master Control Reset (MCR) zone.

TIP A bit that is set within a subroutine using an OTE instruction remains set until the OTE is scanned again.

ATTENTION If you enable interrupts during the program scan via an OTL, OTE, or UIE, this instruction *must* be the *last* instruction executed on the rung (last instruction on last branch). It is recommended this be the only output instruction on the rung.

ATTENTION Never use an output address at more than one place in your logic program. Always be fully aware of the load represented by the output coil.

Addressing Modes and File Types can be used as shown in the following table:

OTE Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files											Function Files(1)									CS - Comms	IOS - I/O	DLS - Data Log (2)	Address Mode(3)			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI				Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Destination Bit	•	•	•	•	•	•			•	•		•	•	•	•	•			•				•		•	•	•			

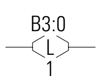
(1) DAT files are valid for the MicroLogix 1500 only. PTO and PWM files are only for use with MicroLogix 1200 and 1500 BXB units.

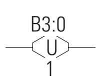
(2) The Data Log Status file can only be used by the MicroLogix 1500 1764-LRP Processor.

(3) See Important note about indirect addressing.

IMPORTANT You cannot use indirect addressing with: S, ST, MG, PD, RTC, HSC, PTO, PWM, STI, EII, BHI, MMI, DAT, TPI, CS, IOS, and DLS files.

OTL - Output Latch
OTU - Output Unlatch





Instruction Type: output

Execution Time for the OTL and OTU Instructions

Controller	OTL - When Rung Is:		OTU - When Rung Is:	
	True	False	True	False
MicroLogix 1200	1.0 µs	0.0 µs	1.1 µs	0.0 µs
MicroLogix 1500	0.9 µs	0.0 µs	0.9 µs	0.0 µs

The OTL and OTU instructions are retentive output instructions. OTL turns on a bit, while OTU turns off a bit. These instructions are usually used in pairs, with both instructions addressing the same bit.

ATTENTION If you enable interrupts during the program scan via an OTL, OTE, or UIE, this instruction *must* be the *last* instruction executed on the rung (last instruction on last branch). It is recommended this be the only output instruction on the rung.

Since these are latching outputs, once set (or reset), they remain set (or reset) regardless of the rung condition.

ATTENTION

In the event of a power loss, any OTL controlled bit (including field devices) energizes with the return of power if the OTL bit was set when power was lost.

ATTENTION

Under error conditions, physical outputs are turned off. Once the error conditions are cleared, the controller resumes operation using the data table value.

Addressing Modes and File Types can be used as shown in the following table:

OTL and OTU Instructions Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files											Function Files(1)												Address Mode(3)			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI	CS - Comms	IOS - I/O	DLS - Data Log(2)	Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Operand Bit	•	•	•	•	•	•			•	•		•	•	•	•	•			•				•		•	•	•			

(1) DAT files are valid for the MicroLogix 1500 only. PTO and PWM files are only for use with MicroLogix 1200 and 1500 BXB units.

(2) The Data Log Status file can only be used by the MicroLogix 1500 1764-LRP Processor.

(3) See Important note about indirect addressing.

IMPORTANT

You cannot use indirect addressing with: S, ST, MG, PD, RTC, HSC, PTO, PWM, STI, EII, BHI, MMI, DAT, TPI, CS, IOS, and DLS files.

ONS - One Shot

N7:1
-[ONS]-
0

Instruction Type: input

Execution Time for the ONS Instructions

Controller	When Rung Is:	
	True	False
MicroLogix 1200	2.6 µs	1.9 µs
MicroLogix 1500	2.2 µs	1.7 µs

TIP

The ONS instruction for the MicroLogix 1200 and 1500 provides the same functionality as the OSR instruction for the MicroLogix 1000 and SLC 500 controllers.

The ONS instruction is a retentive input instruction that triggers an event to occur one time. After the false-to-true rung transition, the ONS instruction remains true for one program scan. The output then turns OFF and remains OFF until the logic preceding the ONS instruction is false (this re-activates the ONS instruction).

The ONS Storage Bit is the bit address that remembers the rung state from the previous scan. This bit is used to remember the false-to-true rung transition.

ONS Instruction Operation

Rung Transition	Storage Bit	Rung State after Execution
false-to-true (one scan)	storage bit is set	true
true-to-true	storage bit remains set	false
true-to-false, false-to-false	storage bit is cleared	false

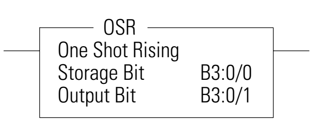
Addressing Modes and File Types can be used as shown in the following table:

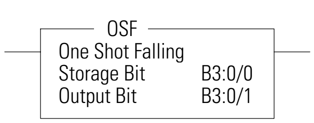
ONS Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files											Function Files									CS - Comms	IOS - I/O	DLS - Data Log	Address Mode			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI				Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Storage Bit				•		•																			•		•			

OSR - One Shot Rising
OSF - One Shot Falling





Instruction Type: output

Execution Time for the OSR and OSF Instructions

Controller	OSR - When Rung Is:		OSF - When Rung Is:	
	True	False	True	False
MicroLogix 1200	3.4 µs	3.0 µs	2.8 µs	3.7 µs
MicroLogix 1500	3.2 µs	2.8 µs	2.7 µs	3.4 µs

TIP The OSR instruction for the MicroLogix 1200 and 1500 *does not* provide the same functionality as the OSR instruction for the MicroLogix 1000 and SLC 500 controllers. For the same functionality as the OSR instruction for the MicroLogix 1000 and SLC 500 controllers, use the ONS instruction.

Use the OSR and OSF instructions to trigger an event to occur one time. These instructions trigger an event based on a change of rung state, as follows:

- Use the OSR instruction when an event must start based on the false-to-true (rising edge) change of state of the rung.
- Use the OSF instruction when an event must start based on the true-to-false (falling edge) change of state of the rung.

These instructions use two parameters, Storage Bit and Output Bit.

- Storage Bit - This is the bit address that remembers the rung state from the previous scan.
- Output Bit - This is the bit address which is set based on a false-to-true (OSR) or true-to-false (OSF) rung transition. The Output Bit is set for one program scan.

To re-activate the OSR, the rung must become false. To re-activate the OSF, the rung must become true.

OSR Storage and Output Bit Operation

Rung State Transition	Storage Bit	Output Bit
false-to-true (one scan)	bit is set	bit is set
true-to-true	bit is set	bit is reset
true-to-false and false-to-false	bit is reset	bit is reset

OSF Storage and Output Bits Operation

Rung State Transition	Storage Bit	Output Bit
true-to-false (one scan)	bit is reset	bit is set
false-to-false	bit is reset	bit is reset
false-to-true and true-to-true	bit is set	bit is reset

Addressing Modes and File Types can be used as shown in the following table:

OSR and OSF Instructions Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files											Function Files									CS - Comms	IOS - I/O	DLS - Data Log	Address Mode			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI				Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Storage Bit				•		•																			•		•			
Output Bit	•	•		•	•	•			•																•		•			

Timer and Counter Instructions

Timers and counters are output instructions that let you control operations based on time or a number of events. The following Timer and Counter Instructions are described in this chapter:

Instruction	Used To:	Page
TON - Timer, On-Delay	Delay turning on an output on a true rung	188
TOF - Timer, Off-Delay	Delay turning off an output on a false rung	188
RTO - Retentive Timer On	Delay turning on an output from a true rung. The accumulator is retentive.	189
CTU - Count Up	Count up	192
CTD - Count Down	Count down	192
RES - Reset	Reset the RTO and counter's ACC and status bits (not used with TOF timers).	193

For information on using the High-Speed Counter output(s), see Using the High-Speed Counter and Programmable Limit Switch on page 109.

Timer Instructions Overview

Timers in a controller reside in a timer file. A timer file can be assigned as any unused data file. When a data file is used as a timer file, each timer element within the file has three sub-elements. These sub-elements are:

- Timer Control and Status
- Preset - This is the value that the timer must reach before the timer times out. When the accumulator reaches this value, the DN status bit is set (TON and RTO only). The preset data range is from 0 to 32767. The minimum required update interval is 2.55 seconds regardless of the time base.
- Accumulator - The accumulator counts the time base intervals. It represents elapsed time. The accumulator data range is from 0 to 32767.

Timers can be set to any one of three time bases:

Timer Base Settings

Time Base	Timing Range
0.001 seconds	0 to 32.767 seconds
0.01 seconds	0 to 327.67 seconds
1.00 seconds	0 to 32,767 seconds

Each timer address is made of a 3-word element. Word 0 is the control and status word, word 1 stores the preset value, and word 2 stores the accumulated value.

Timer File

Word	Bit															
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Word 0	EN	TT	DN	Internal Use												
Word 1	Preset Value															
Word 2	Accumulated Value															

EN = Timer Enable Bit

TT = Timer Timing Bit

DN = Timer Done Bit

ATTENTION

Do not copy timer elements while the timer enable bit (EN) is set. Unpredictable machine operation may occur.

Addressing Modes and File Types can be used as shown in the following table:

Timer Instructions Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files(1)											Function Files									CS - Comms	IOS - I/O	DLS - Data Log	Address Mode			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI				Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Timer					•																				•					•
Time Base																								•						•
Preset																								•				•		
Accumulator																								•				•		

(1) Valid for Timer Files only.

TIP Use an RES instruction to reset a timer's accumulator and status bits.

Timer Accuracy

Timer accuracy refers to the length of time between the moment a timer instruction is enabled and the moment the timed interval is complete.

Timer Accuracy

Time Base	Accuracy
0.001 seconds	-0.001 to 0.00
0.01 seconds	-0.01 to 0.00
1.00 seconds	-1.00 to 0.00

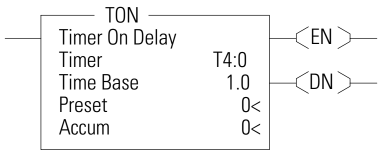
If your program scan can exceed 2.5 seconds, repeat the timer instruction on a different rung (identical logic) in a different area of the ladder code so that the rung is scanned within these limits.

Repeating Timer Instructions

Using the enable bit (EN) of a timer is an easy way to repeat its complex conditional logic at another rung in your ladder program.

TIP Timing could be inaccurate if Jump (JMP), Label (LBL), Jump to Subroutine (JSR), or Subroutine (SBR) instructions skip over the rung containing a timer instruction while the timer is timing. If the skip duration is within 2.5 seconds, no time is lost; if the skip duration exceeds 2.5 seconds, an undetectable timing error occurs. When using subroutines, a timer must be scanned at least every 2.5 seconds to prevent a timing error.

TON - Timer, On-Delay



Instruction Type: output

Execution Time for the TON Instructions

Controller	When Rung Is:	
	True	**False**
MicroLogix 1200	18.0 µs	3.0 µs
MicroLogix 1500	15.5 µs	2.5 µs

Use the TON instruction to delay turning on an output. The TON instruction begins to count time base intervals when rung conditions become true. As long as rung conditions remain true, the timer increments its accumulator until the preset value is reached. When the accumulator equals the preset, timing stops.

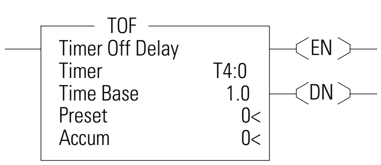
The accumulator is reset (0) when rung conditions go false, regardless of whether the timer has timed out. TON timers are reset on power cycles and mode changes.

Timer instructions use the following control and status bits:

Timer Control and Status Bits, Timer Word 0 (Data File 4 is configured as a timer file for this example.)

Bit		Is Set When:	And Remains Set Until One of the Following Occurs:
bit 13 - T4:0/DN	**DN - timer done**	accumulated value ≥ preset value	rung state goes false
bit 14 - T4:0/TT	**TT - timer timing**	rung state is true and accumulated value < preset value	• rung state goes false • DN bit is set
bit15 - T4:0/EN	**EN - timer enable**	rung state is true	rung state goes false

TOF - Timer, Off-Delay



Instruction Type: output

Execution Time for the TOF Instructions

Controller	When Rung Is:	
	True	**False**
MicroLogix 1200	2.9 µs	13.0 µs
MicroLogix 1500	2.5 µs	10.9 µs

Use the TOF instruction to delay turning off an output. The TOF instruction begins to count time base intervals when rung conditions become false. As long as rung conditions remain false, the timer increments its accumulator until the preset value is reached.

The accumulator is reset (0) when rung conditions go true, regardless of whether the timer is timed out. TOF timers are reset on power cycles and mode changes.

Timer instructions use the following control and status bits:

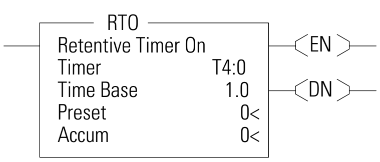
Timer Control and Status Bits, Timer Word 0 (Data File 4 is configured as a timer file for this example.)

Bit		Is Set When:	And Remains Set Until One of the Following Occurs:
bit 13 - T4:0/DN	**DN - timer done**	rung conditions are true	rung conditions go false and the accumulated value is greater than or equal to the preset value
bit 14 - T4:0/TT	**TT - timer timing**	rung conditions are false and accumulated value is less than the preset value	rung conditions go true or when the done bit is reset
bit15 - T4:0/EN	**EN - timer enable**	rung conditions are true	rung conditions go false

ATTENTION

Because the RES instruction resets the accumulated value and status bits, do not use the RES instruction to reset a timer address used in a TOF instruction. If the TOF accumulated value and status bits are reset, unpredictable machine operation may occur.

RTO - Retentive Timer, On-Delay



Instruction Type: output

Execution Time for the RTO Instructions

Controller	When Rung Is:	
	True	False
MicroLogix 1200	18.0 µs	2.4 µs
MicroLogix 1500	15.8 µs	2.2 µs

Use the RTO instruction to delay turning “on” an output. The RTO begins to count time base intervals when the rung conditions become true. As long as the rung conditions remain true, the timer increments its accumulator until the preset value is reached.

The RTO retains the accumulated value when the following occur:

- rung conditions become false
- you change the controller mode from run or test to program
- the processor loses power
- a fault occurs

When you return the controller to the RUN or TEST mode, and/or the rung conditions go true, timing continues from the retained accumulated value. RTO timers are retained through power cycles and mode changes.

Timer instructions use the following control and status bits:

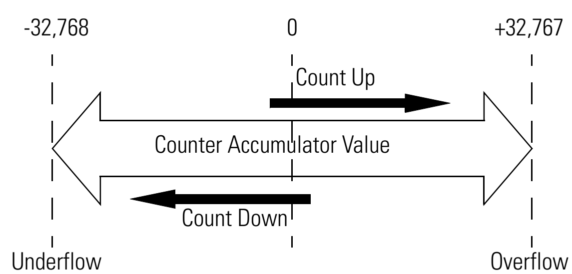
Counter Control and Status Bits, Timer Word 0 (Data File 4 is configured as a timer file for this example.)

Bit		Is Set When:	And Remains Set Until One of the Following Occurs:
bit 13 - T4:0/DN	**DN - timer done**	accumulated value ≥ preset value	the appropriate RES instruction is enabled
bit 14 - T4:0/TT	**TT - timer timing**	rung state is true and accumulated value < preset value	• rung state goes false, or • DN bit is set
bit15 - T4:0/EN	**EN - timer enable**	rung state is true	rung state goes false

To reset the accumulator of a retentive timer, use an RES instruction. See RES - Reset on page 193.

How Counters Work

The figure below demonstrates how a counter works. The count value must remain in the range of -32,768 to +32,767. If the count value goes above +32,767, the counter status overflow bit (OV) is set (1). If the count goes below -32,768, the counter status underflow bit (UN) is set (1). A reset (RES) instruction is used to reset (0) the counter.



Using the CTU and CTD Instructions

Counter instructions use the following parameters:

- Counter - This is the address of the counter within the data file. All counters are 3-word data elements. Word 0 contains the Control and Status Bits, Word 1 contains the Preset, and Word 2 contains the Accumulated Value.

Word	Bit															
	15	**14**	**13**	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Word 0	CU	CD	DN	OV	UN	Not Used										
Word 1	Preset Value															
Word 2	Accumulated Value															

CU = Count Up Enable Bit

CD = Count Down Enable Bit

DN = Count Done Bit

OV = Count Overflow Bit

UN = Count Underflow Bit

- Preset - When the accumulator reaches this value, the DN bit is set. The preset data range is from -32768 to 32767.
- Accumulator - The accumulator contains the current count. The accumulator data range is from -32768 to 32767.

  The accumulated value is incremented (CTU) or decremented (CTD) on each false-to-true rung transition. The accumulated value is retained when the rung condition again becomes false, and when power is cycled on the controller. The accumulated count is retained until cleared by a reset (RES) instruction that has the same address as the counter.

TIP The counter continues to count when the accumulator is greater than the CTU preset and when the accumulator is less than the CTD preset.

Addressing Modes and File Types can be used as shown in the following table:

CTD and CTU Instructions Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files(1)											Function Files												Address Mode			Address Level			
	O	**I**	**S**	**B**	**T, C, R**	**N**	**F**	**ST**	**L**	**MG, PD**	**PLS**	**RTC**	**HSC**	**PTO, PWM**	**STI**	**EII**	**BHI**	**MMI**	**DAT**	**TPI**	**CS - Comms**	**IOS - I/O**	**DLS - Data Log**	**Immediate**	**Direct**	**Indirect**	**Bit**	**Word**	**Long Word**	**Element**
Counter					•																				•					•
Preset																								•				•		
Accumulator																								•				•		

(1) Valid for Counter Files only.

Using Counter File Control and Status Bits

Like the accumulated value, the counter status bits are also retentive until reset, as described below.

CTU Instruction Counter Control and Status Bits, Counter Word 0
(Data File 5 is configured as a timer file for this example.)

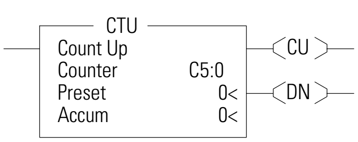
Bit		Is Set When:	And Remains Set Until One of the Following Occurs:
bit 12 - C5:0/OV	**OV - overflow indicator**	the accumulated value wraps from +32,767 to -32,768 and continues to count up	a RES instruction with the same address as the CTU instruction is enabled
bit 13 - C5:0/DN	**DN - done indicator**	accumulated value ≥ preset value	• accumulated value < preset value or, • a RES instruction with the same address as the CTU instruction is enabled
bit 15 - C5:0/CU	**CU - count up enable**	rung state is true	• rung state is false • a RES instruction with the same address as the CTU instruction is enabled

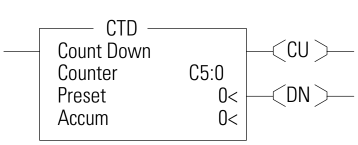
CTD Instruction Counter Control and Status Bits, Counter Word 0
(Data File 5 is configured as a timer file for this example.)

Bit		Is Set When:	And Remains Set Until One of the Following Occurs:
bit 11 - C5:0/UN	**UN - underflow indicator**	the accumulated value wraps from -32,768 to +32,767 and continues to count down	a RES instruction with the same address as the CTD instruction is enabled
bit 13 - C5:0/DN	**DN - done indicator**	accumulated value ≥ preset value	• accumulated value < preset value or, • a RES instruction with the same address as the CTU instruction is enabled
bit 14 - C5:0/CD	**CD - count down enable**	rung state is true	• rung state is false • a RES instruction with the same address as the CTD instruction is enabled

CTU - Count Up
CTD - Count Down

Instruction Type: output





Execution Time for the CTU and CTD Instructions

Controller	CTU - When Rung Is:		CTD - When Rung Is:	
	True	False	True	False
MicroLogix 1200	9.0 µs	9.2 µs	9.0 µs	9.0 µs
MicroLogix 1500	6.4 µs	8.5 µs	7.5 µs	8.5 µs

The CTU and CTD instructions are used to increment or decrement a counter at each false-to-true rung transition. When the CTU rung makes a false-to-true transition, the accumulated value is incremented by one count. The CTD instruction operates the same, except the count is decremented.

TIP If the signal is coming from a field device wired to an input on the controller, the on and off duration of the incoming signal must not be more than twice the controller scan time (assuming 50% duty cycle). This condition is needed to enable the counter to detect false-to-true transitions from the incoming device.

RES - Reset

R6:0
-< RES >-

Instruction Type: output

Execution Time for the RES Instructions

Controller	When Rung Is:	
	True	False
MicroLogix 1200	5.9 µs	0.0 µs
MicroLogix 1500	4.8 µs	0.0 µs

The RES instruction resets timers, counters, and control elements. When the RES instruction is executed, it resets the data defined by the RES instruction.

The RES instruction has no effect when the rung state is false. The following table shows which elements are modified:

RES Instruction Operation

When using a RES instruction with a:		
Timer Element	**Counter Element**	**Control Element**
The controller resets the:	The controller resets the:	The controller resets the:
ACC value to 0	ACC value to 0	POS value to 0
DN bit	OV bit	EN bit
TT bit	UN bit	EU bit
EN bit	DN bit	DN bit
	CU bit	EM bit
	CD bit	ER bit
		UL bit

ATTENTION

Because the RES instruction resets the accumulated value and status bits, do not use the RES instruction to reset a timer address used in a TOF instruction. If the TOF accumulated value and status bits are reset, unpredictable machine operation or injury to personnel may occur.

Addressing Modes and File Types can be used as shown in the following table:

RES Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files											Function Files												Address Mode			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI	CS - Comms	IOS - I/O	DLS - Data Log	Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Structure					•																				•					•

Compare Instructions

Use these input instructions when you want to compare values of data.

Instruction	Used To:	Page
EQU - Equal	Test whether two values are equal (=)	197
NEQ - Not Equal	Test whether one value is not equal to a second value (≠)	197
LES - Less Than	Test whether one value is less than a second value (<)	198
LEQ - Less Than or Equal To	Test whether one value is less than or equal to a second value (≤)	199
GRT - Greater Than	Test whether one value is greater than a second value (>)	198
GEQ - Greater Than or Equal To	Test whether one value is greater than or equal to a second value (≥)	199
MEQ - Mask Compare for Equal	Test portions of two values to see whether they are equal	200
LIM - Limit Test	Test whether one value is within the range of two other values	201

Using the Compare Instructions

Most of the compare instructions use two parameters, Source A and Source B (MEQ and LIM have an additional parameter and are described later in this chapter). Both sources cannot be immediate values. The valid data ranges for these instructions are:

-32768 to 32767 (word)

-2,147,483,648 to 2,147,483,647 (long word)

Addressing Modes and File Types can be used as shown in the following table:

EQU, NEQ, GRT, LES, GEQ and LEQ Instructions
Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files											Function Files(1)									CS - Comms	IOS - I/O	DLS - Data Log(2)	Address Mode(3)			Address Level			
	O	I	S	B	T, C, R	N	F(4)	ST	L	MG, PD	PLS	RTC	HSC(5)	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI				Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Source A	•	•	•	•	•	•	•		•	•		•	•	•	•	•	•	•	•	•	•	•	•		•	•		•	•	
Source B	•	•	•	•	•	•	•		•	•		•		•	•	•	•	•	•	•	•	•	•	•	•	•		•	•	

(1) DAT files are valid for the MicroLogix 1500 only. PTO and PWM files are only for use with MicroLogix 1200 and 1500 BXB units.

(2) The Data Log Status file can only be used by the MicroLogix 1500 1764-LRP Processor.

(3) See Important note about indirect addressing.

(4) The F file is valid for MicroLogix 1200 and 1500 Series C and higher controllers only.

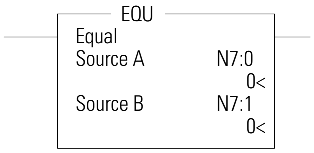
(5) Only use the High Speed Counter Accumulator (HSC.ACC) for Source A in GRT, LES, GEQ and LEQ instructions.

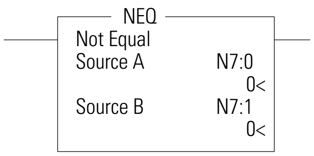
IMPORTANT	You cannot use indirect addressing with: S, ST, MG, PD, RTC, HSC, PTO, PWM, STI, EII, BHI, MMI, DAT, TPI, CS, IOS, and DLS files.

When at least one of the operands is a Floating Data Point value:

- For EQU, GEQ, GRT, LEQ, and LES - If either Source is not a number (NAN), then rung state changes to false.
- For NEQ - If either Source is not a number (NAN), then rung state remains true.

EQU - Equal
NEQ - Not Equal





Instruction Type: input

Execution Time for the EQU and NEQ Instructions

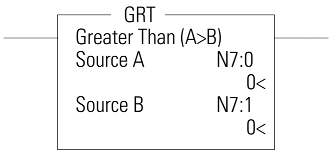
Controller	Instruction	Data Size	When Rung Is:	
			True	False
MicroLogix 1200	EQU	word	1.3 µs	1.1 µs
		long word	2.8 µs	1.9 µs
	NEQ	word	1.3 µs	1.1 µs
		long word	2.5 µs	2.7 µs
MicroLogix 1500	EQU	word	1.2 µs	1.1 µs
		long word	2.6 µs	1.9 µs
	NEQ	word	1.2 µs	1.1 µs
		long word	2.3 µs	2.5 µs

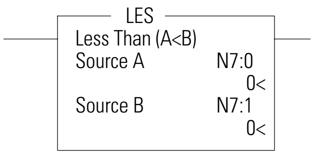
The EQU instruction is used to test whether one value is equal to a second value. The NEQ instruction is used to test whether one value is not equal to a second value.

EQU and NEQ Instruction Operation

Instruction	Relationship of Source Values	Resulting Rung State
EQU	A = B	true
	A ≠ B	false
NEQ	A = B	false
	A ≠ B	true

GRT - Greater Than
LES - Less Than





Instruction Type: input

Execution Time for the GRT and LES Instructions

Controller	Data Size	When Rung Is:	
		True	**False**
MicroLogix 1200	word	1.3 µs	1.1 µs
	long word	2.8 µs	2.7 µs
MicroLogix 1500	word	1.2 µs	1.1 µs
	long word	2.6 µs	2.5 µs

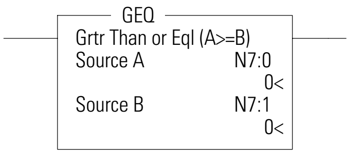
The GRT instruction is used to test whether one value is greater than a second value. The LES instruction is used to test whether one value is less than a second value.

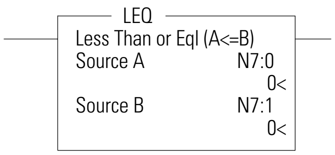
GRT and LES Instruction Operation

Instruction	Relationship of Source Values	Resulting Rung State
GRT	A > B	true
	A ≤ B	false
LES	A ≥ B	false
	A < B	true

IMPORTANT	Only use the High Speed Counter Accumulator (HSC.ACC) for Source A in GRT, LES, GEQ and LEQ instructions.

GEQ - Greater Than or Equal To
LEQ - Less Than or Equal To





Instruction Type: input

Execution Time for the GEQ and LEQ Instructions

Controller	Data Size	When Rung Is:	
		True	False
MicroLogix 1200	word	1.3 µs	1.1 µs
	long word	2.8 µs	2.7 µs
MicroLogix 1500	word	1.2 µs	1.1 µs
	long word	2.6 µs	2.5 µs

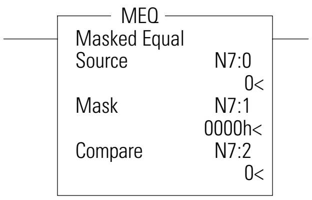
The GEQ instruction is used to test whether one value is greater than or equal to a second value. The LEQ instruction is used to test whether one value is less than or equal to a second value.

GEQ and LEQ Instruction Operation

Instruction	Relationship of Source Values	Resulting Rung State
GEQ	$A \geq B$	true
	$A < B$	false
LEQ	$A > B$	false
	$A \leq B$	true

IMPORTANT	Only use the High Speed Counter Accumulator (HSC.ACC) for Source A in GRT, LES, GEQ and LEQ instructions.

MEQ - Mask Compare for Equal



Instruction Type: input

Execution Time for the MEQ Instructions

Controller	Data Size	When Rung Is:	
		True	**False**
MicroLogix 1200	word	1.9 µs	1.8 µs
	long word	3.9 µs	3.1 µs
MicroLogix 1500	word	1.7 µs	1.7 µs
	long word	3.5 µs	2.9 µs

The MEQ instruction is used to compare whether one value (source) is equal to a second value (compare) through a mask. The source and the compare are logically ANDed with the mask. Then, these results are compared to each other. If the resulting values are equal, the rung state is true. If the resulting values are not equal, the rung state is false.

For example:

Source:																Compare:															
1	1	1	1	1	0	1	0	0	0	0	0	1	1	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
Mask:																Mask:															
1	1	0	0	1	1	1	1	1	1	0	0	0	0	1	1	1	1	0	0	1	1	1	1	1	1	0	0	0	0	1	1
Intermediate Result:																Intermediate Result:															
1	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0
Comparison of the Intermediate Results: not equal																															

The source, mask, and compare values must all be of the same data size (either word or long word). The data ranges for mask and compare are:

- -32768 to 32767 (word)
- -2,147,483,648 to 2,147,483,647 (long word)

The mask is displayed as a hexadecimal unsigned value from 0000 to FFFF FFFF.

Addressing Modes and File Types can be used as shown in the following table:

MEQ Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files											Function Files(1)												Address Mode(3)			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI	CS - Comms	IOS - I/O	DLS - Data Log(2)	Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Source	•	•	•	•	•	•			•	•		•	•	•	•	•	•	•	•	•	•	•	•		•	•		•	•	
Mask	•	•	•	•	•	•			•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•	
Compare	•	•	•	•	•	•			•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•	

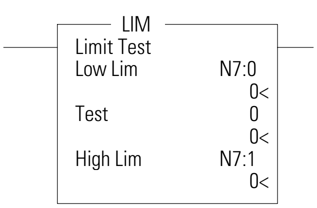
(1) DAT files are valid for the MicroLogix 1500 only. PTO and PWM files are only for use with MicroLogix 1200 and 1500 BXB units.

(2) The Data Log Status file can only be used by the MicroLogix 1500 1764-LRP Processor.

(3) See Important note about indirect addressing.

IMPORTANT You cannot use indirect addressing with: S, ST, MG, PD, RTC, HSC, PTO, PWM, STI, EII, BHI, MMI, DAT, TPI, CS, IOS, and DLS files.

LIM - Limit Test



Instruction Type: input

Execution Time for the LIM Instructions

Controller	Data Size	When Rung Is:	
		True	False
MicroLogix 1200	word	6.4 µs	6.1 µs
	long word	14.4 µs	13.6 µs
MicroLogix 1500	word	5.5 µs	5.3 µs
	long word	12.2 µs	11.7 µs

The LIM instruction is used to test for values within or outside of a specified range. The LIM instruction is evaluated based on the Low Limit, Test, and High Limit values as shown in the following table.

LIM Instruction Operation Based on Low Limit, Test, and High Limit Values

When:	And:	Rung State
Low Limit ≤ High Limit	Low Limit ≤ Test ≤ High Limit	true

LIM Instruction Operation Based on Low Limit, Test, and High Limit Values

When:	And:	Rung State
Low Limit ≤ High Limit	Test < Low Limit or Test > High Limit	false
High Limit < Low Limit	High Limit < Test < Low Limit	false
High Limit < Low Limit	Test ≥ High Limit or Test ≤ Low Limit	true

The Low Limit, Test, and High Limit values can be word addresses or constants, restricted to the following combinations:

- If the Test parameter is a constant, both the Low Limit and High Limit parameters must be word or long word addresses.
- If the Test parameter is a word or long word address, the Low Limit and High Limit parameters can be either a constant, a word, or a long word address. But the Low Limit and High Limit parameters cannot both be constants.

When mixed-sized parameters are used, all parameters are put into the format of the largest parameter. For instance, if a word and a long word are used, the word is converted to a long word.

The data ranges are:

- -32768 to 32767 (word)
- -2,147,483,648 to 2,147,483,647 (long word)

Addressing Modes and File Types can be used as shown in the following table:

LIM Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files											Function Files(1)													Address Mode(3)			Address Level			
	O	I	S	B	T, C, R	N	F(4)	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI	CS - Comms	IOS - I/O	DLS - Data Log(2)	Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Low Limit	•	•	•	•	•	•			•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•	
Test	•	•	•	•	•	•			•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•	
High Limit	•	•	•	•	•	•			•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•	

(1) DAT files are valid for the MicroLogix 1500 only. PTO and PWM files are only for use with MicroLogix 1200 and 1500 BXB units.

(2) The Data Log Status file can only be used by the MicroLogix 1500 1764-LRP Processor.

(3) See Important note about indirect addressing.

(4) The F file is valid for MicroLogix 1200 and 1500 Series C and higher controllers only.

IMPORTANT You cannot use indirect addressing with: S, ST, MG, PD, RTC, HSC, PTO, PWM, STI, EII, BHI, MMI, DAT, TPI, CS, IOS, and DLS files.

Math Instructions

General Information

Before using math instructions, become familiar with the following topics at the beginning of this chapter:

- Using the Math Instructions
- Updates to Math Status Bits
- Using the Floating Point (F) Data File

Instructions

Use these output instructions to perform computations using an expression or a specific arithmetic instruction.

Instruction	Used To:	Page
ADD - Add	Add two values	210
SUB - Subtract	Subtract two values	210
MUL - Multiply	Multiply two values	211
DIV - Divide	Divide one value by another	211
NEG - Negate	Change the sign of the source value and place it in the destination	212
CLR - Clear	Set all bits of a word to zero	212
ABS - Absolute Value	Find the absolute value of the source value	213
SQR - Square Root	Find the square root of a value	218
SCL - Scale	Scale a value	215
SCP - Scale with Parameters	Scale a value to a range determined by creating a linear relationship	216

Using the Math Instructions

Most math instructions use three parameters, Source A, Source B, and Destination (additional parameters are described where applicable, later in this chapter). The mathematical operation is performed using both Source values. The result is stored in the Destination.

When using math instructions, observe the following:

- Source and Destination can be different data sizes. Sources are evaluated at the highest precision (word or long word) of the operands. Then the result is converted to the size of the destination. If the signed value of the Source does not fit in the Destination, the overflow shall be handled as follows:
  - If the Math Overflow Selection Bit is clear, a saturated result is stored in the Destination. If the Source is positive, the Destination is +32767 (word) or +2,147,483,647 (long word). If the result is negative, the Destination is -32768 (word) or -2,147,483,648 (long word).
  - If the Math Overflow Selection Bit is set, the unsigned truncated value of the Source is stored in the Destination.
- Sources can be constants or an address, but both sources cannot be constants.
- Valid constants are -32768 to 32767 (word) and -2,147,483,648 to 2,147,483,647 (long word).

Addressing Modes and File Types can be used as shown in the following table:

Math Instructions (ADD, SUB, MUL, DIV, NEG, CLR) Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files											Function Files[1]									CS - Comms	IOS - I/O	DLS - Data Log[2]	Address Mode[3]			Address Level			
	O	I	S	B	T, C, R	N	F[4]	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI				Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Source A	•	•	•	•	•	•	•		•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•	
Source B	•	•	•	•	•	•	•		•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•	
Destination	•	•	•	•	•	•	•		•	•		•	•	•	•	•			•						•	•		•	•	

(1) DAT files are valid for the MicroLogix 1500 only. PTO and PWM files are only for use with MicroLogix 1200 and 1500 BXB units.

(2) The Data Log Status file can only be used by the MicroLogix 1500 1764-LRP Processor for the following math instructions: ADD, SUB, MUL, DIV, NEG, and SCP.

(3) See Important note about indirect addressing.

(4) The F file is valid for MicroLogix 1200 and 1500 Series C and higher controllers only.

IMPORTANT You cannot use indirect addressing with: S, ST, MG, PD, RTC, HSC, PTO, PWM, STI, EII, BHI, MMI, DAT, TPI, CS, IOS, and DLS files.

Updates to Math Status Bits

After a math instruction is executed, the arithmetic status bits in the status file are updated. The arithmetic status bits are in word 0 in the processor status file (S2).

Math Status Bits

With this Bit:		The Controller:
S:0/0	Carry	sets if carry is generated; otherwise resets
S:0/1	Overflow	sets when the result of a math instruction does not fit into the destination, otherwise resets
S:0/2	Zero Bit	sets if result is zero, otherwise resets
S:0/3	Sign Bit	sets if result is negative (MSB is set), otherwise resets
S:2/14	Math Overflow Selected[1]	examines the state of this bit to determine the value of the result when an overflow occurs
S:5/0	Overflow Trap[1]	sets if the Overflow Bit is set, otherwise resets

(1) Control bits.

Overflow Trap Bit, S:5/0

Minor error bit (S:5/0) is set upon detection of a mathematical overflow or division by zero. If this bit is set upon execution of an END statement or a Temporary End (TND) instruction, the recoverable major error code 0020 is declared.

In applications where a math overflow or divide by zero occurs, you can avoid a controller fault by using an unlatch (OTU) instruction with address S:5/0 in your program. The rung must be between the overflow point and the END or TND statement.

The following illustration shows the rung you can use to unlatch the overflow trap bit.

Using the Floating Point (F) Data File

File Description

Floating point files contain IEEE-754 floating point data elements. One floating point element is shown below. You can have up to 256 of these elements in each floating point file.

Floating Point Data File Structure

Floating Point Element																															
31	**30**	**29**	**28**	**27**	**26**	**25**	**24**	**23**	**22**	**21**	**20**	**19**	**18**	**17**	**16**	**15**	**14**	**13**	**12**	**11**	**10**	**09**	**08**	**07**	**06**	**05**	**04**	**03**	**02**	**01**	**00**
S(1)	Exponent Value								Mantissa																						
High Word																Low Word															

(1) S = Sign Bit

Floating point numbers are represented using the IEEE-754 format, where:

- Bit 31 is the sign bit. This bit is set for negative numbers (note that negative zero is a valid value).
- Bits 23 to 30 are the exponent.
- Bits 0 to 22 are the mantissa.

The value represented by a 32-bit floating point number (not one of the exception values defined on page 207) is given by the following expression. Note the restoration of the suppressed most significant bit of the mantissa.

$$(-1)^s \times 2^{e - 127} \times (1 + m)$$

where:

s is the sign bit (0 or 1)

e is the exponent (1 to 254)

m is the mantissa ($0 \leq f < 1$)

The valid range for floating point numbers is from -3.4028×10^{38} to $+3.4028 \times 10^{38}$.

Definitions

Overflow - occurs when the result of an operation produces an exponent that is greater than 254.

Underflow - occurs when the result of an operation produces an exponent that is less than one.

Floating Point Exception Values

Zero - represented by an exponent and a mantissa of zero. Both positive and negative zero are valid.

Denormalized - represented by an exponent of zero and a non-zero mantissa part. Since denormalized numbers have very small, insignificant values, they are treated as zero when used as source operand for most instructions. This reduces execution time. Denormalized numbers are not generated by the instructions (but are propagated by some instructions). Zero is generated on an underflow.

Infinity - represented by an exponent of 255 and a mantissa part of zero. Both positive and negative infinity are generated when operations overflow. Infinity is propagated through calculations.

NAN (not a number) - is represented by an exponent of 255 and a non-zero mantissa part. NANs are used to indicate results that are mathematically undefined such as 0/0 and adding plus infinity to minus infinity. All operations given a NAN as input must generate a NAN as output.

LSB Round-to-Even Rule

Floating point operations are rounded using the round-to-even rule. If the bits of the result to the right of the least significant bit (LSB) represent a value less than one-half of the LSB, then the result remains as is. If the bits to the right of the LSB represent a value greater than one-half of the LSB, the result is rounded up by adding one LSB. If the bits to the right of the LSB represent a value of exactly one-half LSB, the result is rounded up or down so that the LSB is an even number.

Addressing Floating Point Files

The addressing format for floating point data files is shown below.

Format	Explanation		
Ff:e	**F**	Floating Point file	
	f	File number	The valid file number range is from 8 (default) to 255.
	:	Element delimiter	
	e	Element number	The valid element number range is from 0 to 255.
Examples:	**F8:2** **F10:36**		**Floating Point File 8, Element 2** **Floating Point File 10, Element 36**

Programming Floating Point Values

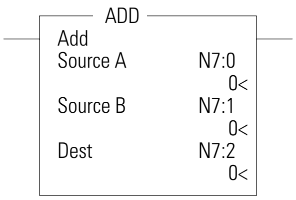
The following table shows items to consider when using floating point data.

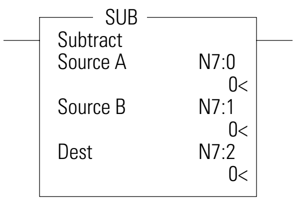
IMPORTANT These rules do not apply to the SCP instruction. See page 217 for the rules for that instruction.

Considerations When Using Floating Point Data
When at least one of the operands is a Floating Data Point value: • If either Source is NAN, then the result is NAN. • All overflows result in infinity with the correct sign. • All underflows result in plus zero. • All denormalized Source values are treated as plus zero. • Results are always rounded using the Round to Even rule. • If Destination is an integer and the result is NAN or infinity, a saturated result (-32768 or +32767 for word or -2,147,836,648 or +2,147,836,647 for long word) is stored in Destination and the Math Overflow Selection Bit is ignored. • If Destination is an integer, the rounded result is stored. If an overflow occurs after rounding, a saturated result is stored in Destination and the Math Overflow Selection Bit is ignored. The saturated results are: – If Destination is an integer and the result is positive, overflow Destination is +32767 (word) or +2,147,483, 648 (long word). – If Destination is an integer and the result is negative, overflow Destination is -32767 (word) or -2,147,483, 648 (long word).

Considerations When Using Floating Point Data
Updates to Math Status Bits: • Carry - is reset • Overflow - Is set if the result is infinity, NAN, or if a conversion to integer overflows; otherwise it is reset. • Zero - Is set if the lower 31 bits of the Floating Point Data result is all zero's, otherwise it is reset. • Sign - Is set if the most significant bit of the Destination is set (bit 15 for word, bit 31 for long word or floating point data); otherwise it is reset. • Overflow Trap - The Math Overflow Trap Bit is only set if the Overflow bit is set. Otherwise, it remains in its last state.

ADD - Add
SUB - Subtract





Instruction Type: output

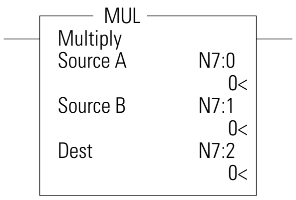
Execution Time for the ADD and SUB Instructions

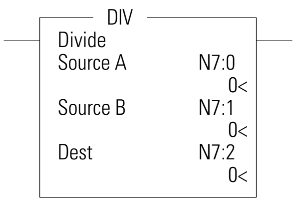
Controller	Instruction	Data Size	When Rung Is:	
			True	False
MicroLogix 1200	ADD	word	2.7 µs	0.0 µs
		long word	11.9 µs	0.0 µs
	SUB	word	3.4 µs	0.0 µs
		long word	12.9 µs	0.0 µs
MicroLogix 1500	ADD	word	2.5 µs	0.0 µs
		long word	10.4 µs	0.0 µs
	SUB	word	2.9 µs	0.0 µs
		long word	11.2 µs	0.0 µs

Use the ADD instruction to add one value to another value (Source A + Source B) and place the sum in the Destination.

Use the SUB instruction to subtract one value from another value (Source A - Source B) and place the result in the Destination.

MUL - Multiply
DIV - Divide





Instruction Type: output

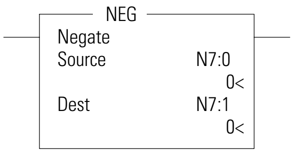
Execution Time for the MUL and DIV Instructions

Controller	Instruction	Data Size	When Rung Is:	
			True	False
MicroLogix 1200	MUL	word	6.8 µs	0.0 µs
		long word	31.9 µs	0.0 µs
	DIV	word	12.2 µs	0.0 µs
		long word	42.8 µs	0.0 µs
MicroLogix 1500	MUL	word	5.8 µs	0.0 µs
		long word	27.6 µs	0.1 µs
	DIV	word	10.3 µs	0.0 µs
		long word	36.7 µs	0.0 µs

Use the MUL instruction to multiply one value by another value (Source A x Source B) and place the result in the Destination.

Use the DIV instruction to divide one value by another value (Source A/ Source B) and place the result in the Destination. If the Sources are single words and the Destination is directly addressed to S:13 (math register), then the quotient is stored in S:14 and the remainder is stored in S:13. If long words are used, then the results are rounded.

NEG - Negate



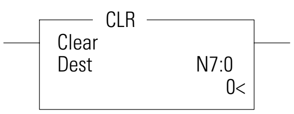
Instruction Type: output

Execution Time for the NEG Instruction

Controller	Data Size	When Rung Is:	
		True	**False**
MicroLogix 1200	word	2.9 µs	0.0 µs
	long word	12.1 µs	0.0 µs
MicroLogix 1500	word	1.9 µs	0.0 µs
	long word	10.4 µs	0.0 µs

Use the NEG instruction to change the sign of the Source and place the result in the Destination.

CLR - Clear



Instruction Type: output

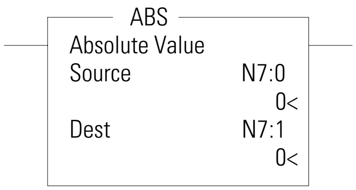
Execution Time for the CLR Instruction

Controller	Data Size	When Rung Is:	
		True	**False**
MicroLogix 1200	word	1.3 µs	0.0 µs
	long word	6.3 µs	0.0 µs
MicroLogix 1500	word	1.2 µs	0.0 µs
	long word	5.5 µs	0.0 µs

Use the CLR instruction to set the Destination to a value of zero.

ABS - Absolute Value

Instruction Type: output



Execution Time for the ABS Instruction

Controller	When Rung Is:	
	True	False
MicroLogix 1200	3.8 µs	0.0 µs
MicroLogix 1500	3.1 µs	0.0 µs

The ABS instruction takes the absolute value of the Source and places it in the Destination. The data range for this instruction is -2,147,483,648 to 2,147,483,647 or IEEE-754 floating point value.

Source and Destination do not have to be the same data type. However, if the signed result does not fit in Destination, the following will occur.

ABS Result Does Not Fit in Destination

When Both Operands Are Integers	When At Least One Operand is Floating Point Data
• If the Math Overflow Selection Bit is clear, a saturated result (32767 for word or 2,147,836,647 for long word) is stored in the Destination. • If the Math Overflow Selection Bit is set, the unsigned truncated value of the result is stored in the Destination.	• The ABS instruction clears the sign bit. No operation is performed on the remaining bits. • If Destination is an integer and Source is NAN or infinity, a saturated result (32767 for word or 2,147,836,647 for long word) is stored in Destination and the Math Overflow Selection Bit is ignored. • If Destination is an integer, the rounded result is stored. If an overflow occurs after rounding, a saturated result (32767 for word or 2,147,836,647 for long word) is stored in Destination and the Math Overflow Selection Bit is ignored.

The following table shows how the math status bits are updated upon execution of the ABS instruction:

Updates to Math Status Bits

When Both Operands Are Integers	When At Least One Operand is Floating Point Data
• Carry - Is set if input is negative, otherwise resets. • Overflow - Is set if the signed result cannot fit in the Destination; otherwise it is reset. • Zero - Is set if Destination is all zero's, otherwise it is reset. • Sign - Is set if the most significant bit of the Destination is set, otherwise it is reset. • Overflow Trap - The Math Overflow Trap Bit is only set if the Overflow bit is set. Otherwise, it remains in its last state.	• Carry - Is reset. • Overflow - Is set if the signed result is infinity, NAN, or cannot fit in the Destination; otherwise it is reset. • Zero - Is set if Destination is all zero's, otherwise it is reset. • Sign - Is set if the most significant bit of the Destination is set, otherwise it is reset. • Overflow Trap - The Math Overflow Trap Bit is only set if the Overflow bit is set. Otherwise, it remains in its last state.

Addressing Modes and File Types are shown in the following table:

ABS Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 4-2.

Parameter	Data Files											Function Files									CS - Comms	IOS - I/O	DLS - Data Log	Address Mode(1)			Address Level				
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI				Immediate	Direct	Indirect	Bit	Word	Long Word	Floating Point	Element
Source	•	•	•	•	•	•	•		•	•	•	•	•	•	•	•	•	•		•	•	•		•	•	•		•	•	•	
Destination	•	•	•	•	•	•	•		•	•	•	•	•	•	•	•									•	•		•	•	•	

(1) See Important note about indirect addressing.

IMPORTANT You cannot use indirect addressing with: S, MG, PD, RTC, HSC, PTO, PWM, STI, EII, BHI, MMI, DAT, TPI, CS, IOS, and DLS files.

SCL - Scale

```
SCL
Scale
Source            N7:0
                    0<
Rate [/10000]     N7:1
                    0<
Offset            N7:2
                    0<
Dest              N7:3
                    0<
```

Instruction Type: output

Execution Time for the SCL Instruction

Controller	When Rung Is:	
	True	False
MicroLogix 1200	10.5 µs	0.0 µs
MicroLogix 1500	8.7 µs	0.0 µs

The SCL instruction causes the value at the Source address to be multiplied by the Rate (slope) value. The resulting value is added to the Offset and the rounded result is placed in the Destination.

The following equations express the linear relationship between the input value and the resulting scaled value:

scaled value = [(rate x source)/10000] + offset, where

- rate = (scaled max. - scaled min.)/(input max. - input min.)
- offset = scaled min. - (input min. x rate)

Rate and Offset can both be immediate values. The data range for rate and offset is -32768 to 32767.

Addressing Modes and File Types can be used as shown in the following table:

SCL Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files											Function Files									CS - Comms	IOS - I/O	DLS - Data Log	Address Mode (1)			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI				Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Source	•	•		•	•	•																			•	•		•		
Rate	•	•		•	•	•																		•	•	•		•		
Offset	•	•		•	•	•																		•	•	•		•		
Destination	•	•		•	•	•																			•	•		•		

(1) See Important note about indirect addressing.

IMPORTANT	You cannot use indirect addressing with: S, ST, MG, PD, RTC, HSC, PTO, PWM, STI, EII, BHI, MMI, DAT, TPI, CS, IOS, and DLS files.

IMPORTANT	Do not use the High Speed Counter Accumulator (HSC.ACC) for the Destination parameter in the SCL instruction.

SCP - Scale with Parameters

Instruction Type: output

```
SCP
Scale w/Parameters
Input            N7:0
                   0<
Input Min.       N7:1
                   0<
Input Max.       N7:2
                   0<
Scaled Min.      N7:3
                   0<
Scaled Max.      N7:4
                   0<
Output           N7:5
                   0<
```

Execution Time for the SCP Instruction

Controller	Data Size	When Rung Is:	
		True	False
MicroLogix 1200	word	31.5 µs	0.0 µs
	long word	52.2 µs	0.0 µs
MicroLogix 1500	word	27.0 µs	0.0 µs
	long word	44.7 µs	0.0 µs

The SCP instruction produces a scaled output value that has a linear relationship between the input and scaled values. This instruction solves the following equation listed below to determine scaled output:

$$y = [(y_1 - y_0)/(x_1 - x_0)](x - x_0) + y_0$$

Addressing Modes and File Types can be used as shown in the following table:

SCP Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files											Function Files(1)												Address Mode(2)			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI	CS - Comms	IOS - I/O	DLS - Data Log	Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Input (x)	•	•	•	•	•	•	•		•	•		•	•	•	•	•	•	•	•	•	•	•			•	•		•	•	
Input Min. (x_0)	•	•		•	•	•	•		•															•	•	•		•	•	
Input Max. (x_1)	•	•		•	•	•	•		•															•	•	•		•	•	
Scaled Min. (y_0)	•	•		•	•	•	•		•															•	•	•		•	•	
Scaled Max. (y_1)	•	•		•	•	•	•		•															•	•	•		•	•	
Output (y)	•	•	•	•	•	•	•		•	•		•		•	•	•			•						•	•		•	•	

(1) DAT files are valid for the MicroLogix 1500 only. PTO and PWM files are only recommended for use with MicroLogix 1200 and 1500 BXB units.

(2) See Important note about indirect addressing.

IMPORTANT You cannot use indirect addressing with: S, ST, MG, PD, RTC, HSC, PTO, PWM, STI, EII, BHI, MMI, DAT, TPI, CS, IOS, and DLS files.

IMPORTANT Do not use the High Speed Counter Accumulator (HSC.ACC) for the Scaled Output parameter in the SCP instruction.

Special Considerations when Using Floating Point Parameters

If any of the parameters (except Output) are NAN (not a number), Infinity, or De-normalized; then the result is -NAN.

If y_1 - y_0 or x_1 - x_0 result in an overflow, then the result is -NAN

Other Considerations

If y_1 - y_0 = 0, the Result becomes the Scaled Start value

If x_1 - x_0 = 0 and x = x_0, the Result becomes the Scaled Start value

If x_1 - x_0 = 0 and x does not equal x_0, The Result becomes a negative overflow (for integer values) or a negative NAN (for floating point values)

SQR - Square Root

```
SQR
Square Root
Source        N7:0
                0<
Dest          N7:1
                0<
```

Instruction Type: output

Execution Time for the SQR Instruction

Controller	Data Size	When Rung Is:	
		True	**False**
MicroLogix 1200	word	26.0 µs	0.0 µs
	long word	30.9 µs	0.0 µs
MicroLogix 1500	word	22.3 µs	0.0 µs
	long word	26.0 µs	0.0 µs

The SQR instruction calculates the square root of the absolute value of the source and places the rounded result in the destination.

The data ranges for the source is -32768 to 32767 (word) and -2,147,483,648 to 2,147,483,647 (long word). The Carry Math Status Bit is set if the source is negative. See Updates to Math Status Bits on page 205 for more information.

SQR Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files											Function Files									CS - Comms	IOS - I/O	DLS - Data Log	Address Mode(1)			Address Level			
	O	I	S	B	T, C, R	N	ST	F	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI				Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Source	•	•		•	•	•		•	•															•	•	•		•	•	
Destination	•	•		•	•	•		•	•																•	•		•	•	

(1) See Important note about indirect addressing.

IMPORTANT You cannot use indirect addressing with: S, ST, MG, PD, RTC, HSC, PTO, PWM, STI, EII, BHI, MMI, DAT, TPI, CS, IOS, and DLS files.

Conversion Instructions

The conversion instructions multiplex and de-multiplex data and perform conversions between binary and decimal values.

Instruction	Used To:	Page
DCD - Decode 4 to 1-of-16	Decodes a 4-bit value (0 to 15), turning on the corresponding bit in the 16-bit destination.	220
ENC - Encode 1-of-16 to 4	Encodes a 16-bit source to a 4-bit value. Searches the source from the lowest to the highest bit and looks for the first set bit. The corresponding bit position is written to the destination as an integer.	221
FRD - Convert From Binary Coded Decimal	Converts the BCD source value to an integer and stores it in the destination.	222
TOD - Convert to Binary Coded Decimal	Converts the integer source value to BCD format and stores it in the destination.	226

Using Decode and Encode Instructions

Addressing Modes and File Types can be used as shown in the following table:

Conversion Instructions Valid Addressing Modes and File Types

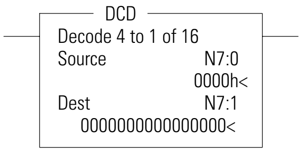
For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files											Function Files									CS - Comms	IOS - I/O	DLS - Data Log	Address Mode(1)			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI				Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Source	•	•		•	•	•																			•	•		•		
Destination	•	•		•	•	•																			•	•		•		

(1) See Important note about indirect addressing.

IMPORTANT	You cannot use indirect addressing with: S, ST, MG, PD, RTC, HSC, PTO, PWM, STI, EII, BHI, MMI, DAT, TPI, CS, IOS, and DLS files.

DCD - Decode 4 to 1-of-16



Instruction Type: output

Execution Time for the DCD Instruction

Controller	When Rung Is:	
	True	False
MicroLogix 1200	1.9 µs	0.0 µs
MicroLogix 1500	0.9 µs	0.0 µs

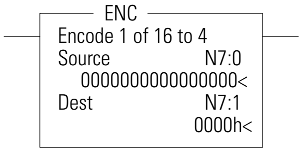
The DCD instruction uses the lower four bits of the source word to set one bit of the destination word. All other bits in the destination word are cleared. The DCD instruction converts the values as shown in the table below:

Decode 4 to 1-of-16

Source Bits					Destination Bits															
15 to 04	03	02	01	00	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
x	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
x	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
x	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
x	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
x	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
x	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
x	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
x	0	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
x	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
x	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
x	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
x	1	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
x	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
x	1	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
x	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
x	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

x = not used

ENC - Encode 1-of-16 to 4



Instruction Type: output

Execution Time for the ENC Instruction

Controller	When Rung Is:	
	True	False
MicroLogix 1200	7.2 µs	0.0 µs
MicroLogix 1500	6.8 µs	0.0 µs

The ENC instruction searches the source from the lowest to the highest bit, looking for the first bit set. The corresponding bit position is written to the destination as an integer. The ENC instruction converts the values as shown in the table below:

Encode 1-of-16 to 4

Source Bits																Destination Bits				
15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00	15 to 04	03	02	01	00
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	1	0	0	0	0	0
x	x	x	x	x	x	x	x	x	x	x	x	x	x	1	0	0	0	0	0	1
x	x	x	x	x	x	x	x	x	x	x	x	x	1	0	0	0	0	0	1	0
x	x	x	x	x	x	x	x	x	x	x	x	1	0	0	0	0	0	0	1	1
x	x	x	x	x	x	x	x	x	x	x	1	0	0	0	0	0	0	1	0	0
x	x	x	x	x	x	x	x	x	x	1	0	0	0	0	0	0	0	1	0	1
x	x	x	x	x	x	x	x	x	1	0	0	0	0	0	0	0	0	1	1	0
x	x	x	x	x	x	x	x	1	0	0	0	0	0	0	0	0	0	1	1	1
x	x	x	x	x	x	x	1	0	0	0	0	0	0	0	0	0	1	0	0	0
x	x	x	x	x	x	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1
x	x	x	x	x	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
x	x	x	x	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
x	x	x	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
x	x	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1
x	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1

x = determines the state of the flag

TIP If source is zero, the destination is zero and the math status is zero, the flag is set to 1.

Updates to Math Status Bits

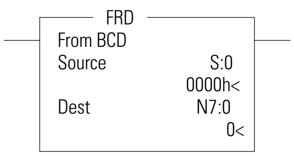
Math Status Bits

With this Bit:		The Controller:
S:0/0	Carry	always resets
S:0/1	Overflow	sets if more than one bit in the source is set; otherwise resets. The math overflow bit (S:5/0) is not set.

Math Status Bits

With this Bit:		The Controller:
S:0/2	Zero Bit	sets if result is zero, otherwise resets
S:0/3	Sign Bit	always resets

FRD - Convert from Binary Coded Decimal (BCD)



Instruction Type: output

Execution Time for the FRD Instructions

Controller	When Rung Is:	
	True	**False**
MicroLogix 1200	14.1 µs	0.0 µs
MicroLogix 1500	12.3 µs	0.0 µs

The FRD instruction is used to convert the Binary Coded Decimal (BCD) source value to an integer and place the result in the destination.

Addressing Modes and File Types can be used as shown in the following table:

FRD Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files											Function Files													Address Mode(1)			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI	CS - Comms	IOS - I/O	DLS - Data Log	Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Source	•	•	•	•	•	•																			•	•		•		(2)
Destination	•	•		•	•	•																			•	•		•		

(1) See Important note about indirect addressing.

(2) See FRD Instruction Source Operand on page 223.

IMPORTANT You cannot use indirect addressing with: S, ST, MG, PD, RTC, HSC, PTO, PWM, STI, EII, BHI, MMI, DAT, TPI, CS, IOS, and DLS files.

FRD Instruction Source Operand

The source can be either a word address or the math register. The maximum BCD source values permissible are:

- 9999 if the source is a word address (allowing only a 4-digit BCD value)
- 32768 if the source is the math register (allowing a 5-digit BCD value with the lower 4 digits stored in S:13 and the high order digit in S:14).

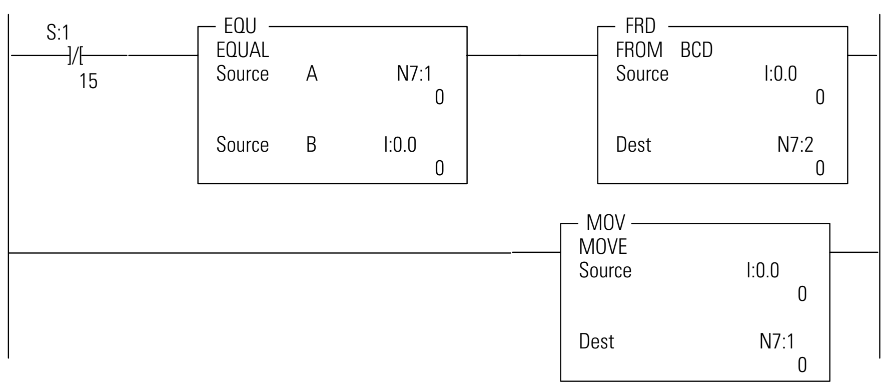
If the source is the math register, it must be directly addressed as S:13. S:13 is the only status file element that can be used.

Updates to Math Status Bits

Math Status Bits

With this Bit:		The Controller:
S:0/0	Carry	always resets
S:0/1	Overflow	sets if non-BCD value is contained at the source or the value to be converted is greater than 32,767; otherwise resets. On overflow, the minor error flag is also set.
S:0/2	Zero Bit	sets if result is zero, otherwise resets
S:0/3	Sign Bit	always resets

TIP Always provide ladder logic filtering of all BCD input devices prior to performing the FRD instruction. The slightest difference in point-to-point input filter delay can cause the FRD instruction to overflow due to the conversion of a non-BCD digit.

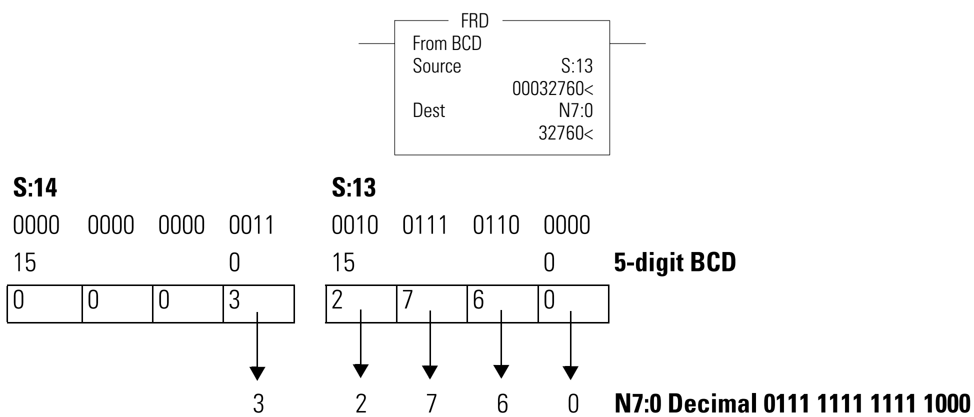


The two rungs shown cause the controller to verify that the value I:0 remains the same for two consecutive scans before it executes the FRD. This prevents the FRD from converting a non-BCD value during an input value change.

TIP To convert numbers larger than 9999 BCD, the source must be the Math Register (S:13). You must reset the Minor Error Bit (S:5.0) to prevent an error.

Example

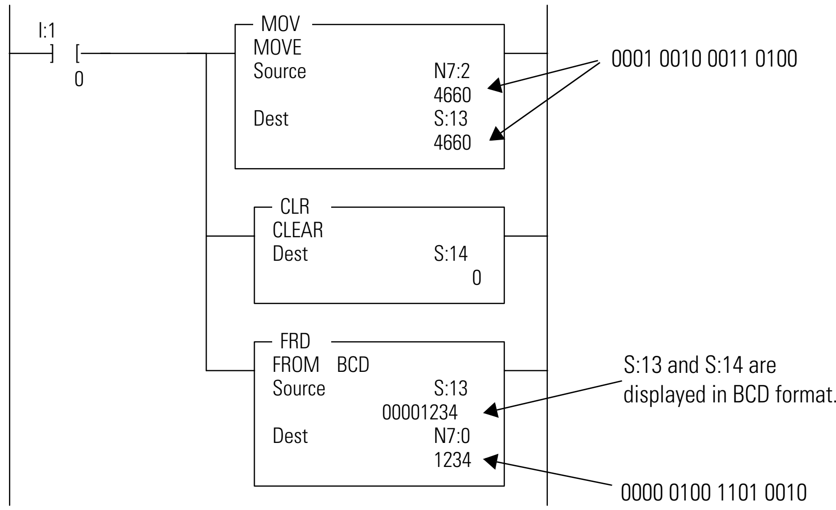
The BCD value 32,760 in the math register is converted and stored in N7:0. The maximum source value is 32767 (BCD).



You should convert BCD values to integer before you manipulate them in your ladder program. If you do not convert the values, the controller manipulates them as integers and their value may be lost.

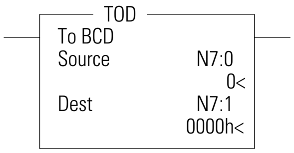
TIP If the math register (S:13 and S:14) is used as the source for the FRD instruction and the BCD value does not exceed four digits, be sure to clear word S:14 before executing the FRD instruction. If S:14 is not cleared and a value is contained in this word from another math instruction located elsewhere in the program, an incorrect decimal value is placed in the destination word.

Clearing S:14 before executing the FRD instruction is shown below:



When the input condition I:0/1 is set (1), a BCD value (transferred from a 4-digit thumbwheel switch for example) is moved from word N7:2 into the math register. Status word S:14 is then cleared to make certain that unwanted data is not present when the FRD instruction is executed.

TOD - Convert to Binary Coded Decimal (BCD)



Instruction Type: output

Execution Time for the TOD Instructions

Controller	When Rung Is:	
	True	False
MicroLogix 1200	17.2 µs	0.0 µs
MicroLogix 1500	14.3 µs	0.0 µs

The TOD instruction is used to convert the integer source value to BCD and place the result in the destination.

Addressing Modes and File Types can be used as shown in the following table:

TOD Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files										Function Files									CS0 - Comms	IOS - I/O	DLS - Data Log	Address Mode(1)			Address Level			
	O	I	S	B	T, C, R	N	F	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI				Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Source	•	•		•	•	•																		•	•		•		
Destination	•	•	•	•	•	•																		•	•		•		(2)

(1) See Important note about indirect addressing.

(2) See TOD Instruction Destination Operand below.

IMPORTANT	You cannot use indirect addressing with: S, ST, MG, PD, RTC, HSC, PTO, PWM, STI, EII, BHI, MMI, DAT, TPI, CS, IOS, and DLS files.

TOD Instruction Destination Operand

The destination can be either a word address or math register.

The maximum values permissible once converted to BCD are:

- 9999 if the destination is a word address (allowing only a 4-digit BCD value)
- 32768 if the destination is the math register (allowing a 5-digit BCD value with the lower 4 digits stored in S:13 and the high order digit in S:14).

If the destination is the math register, it must be directly addressed as S:13. S:13 is the only status file element that can be used.

Updates to Math Status Bits

Math Status Bits

With this Bit:		The Controller:
S:0/0	Carry	always resets
S:0/1	Overflow	sets if BCD result is larger than 9999. On overflow, the minor error flag is also set.
S:0/2	Zero Bit	sets if result is zero, otherwise resets
S:0/3	Sign Bit	sets if the source word is negative; otherwise resets

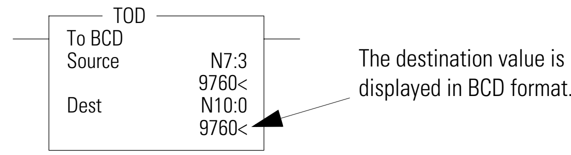
Changes to the Math Register

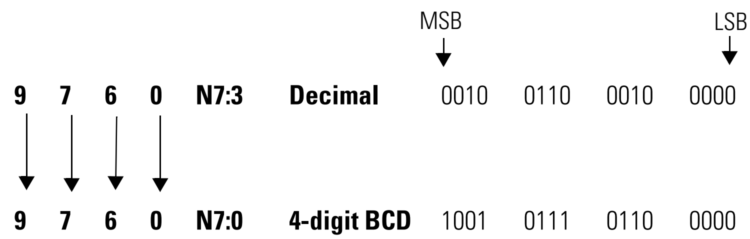
Contains the 5-digit BCD result of the conversion. This result is valid at overflow.

TIP To convert numbers larger than 9999 decimal, the destination must be the Math Register (S:13). You must reset the Minor Error Bit (S:5/0) to prevent an error.

Example

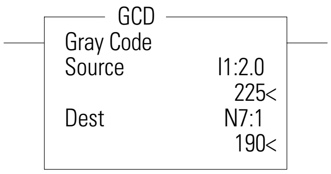
The integer value 9760 stored at N7:3 is converted to BCD and the BCD equivalent is stored in N7:0. The maximum BCD value is 9999.


TOD
To BCD
Source
N7:3
9760<
Dest
N10:0
9760<
The destination value is displayed in BCD format.


MSB
LSB
9 7 6 0 N7:3 Decimal 0010 0110 0010 0000
9 7 6 0 N7:0 4-digit BCD 1001 0111 0110 0000

GCD - Gray Code

Instruction Type: output



Execution Time for the GCD Instructions

Controller	When Rung Is:	
	True	False
MicroLogix 1200	9.5 µs	0.0 µs
MicroLogix 1500	8.2 µs	0.0 µs

The GCD instruction converts Gray code data (Source) to an integer value (Destination). If the Gray code input is negative (high bit set), the Destination is set to 32767 and the overflow flag is set.

Addressing Modes and File Types are shown in the following table:

GCD Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 4-2.

Parameter	Data Files											Function Files									CS - Comms	IOS - I/O	DLS - Data Log	Address Mode			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI				Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Source	•	•		•	•	•																			•	•		•		
Destination	•	•		•	•	•																			•	•		•		

Updates to Math Status Bits

Math Status Bits

With this Bit:		The Controller:
S:0/0	Carry	always reset
S:0/1	Overflow	set if the Gray code input is negative, otherwise is reset
S:0/2	Zero Bit	set if the destination is zero, otherwise reset
S:0/3	Sign Bit	always reset
S:5/0	Overflow Trap	set if the Overflow Bit is set, otherwise reset

Notes:

Logical Instructions

The logical instructions perform bit-wise logical operations on individual words.

Instruction	Used To:	Page
AND - Bit-Wise AND	Perform an AND operation	233
OR - Logical OR	Perform an inclusive OR operation	234
XOR - Exclusive OR	Perform an Exclusive Or operation	235
NOT - Logical NOT	Perform a NOT operation	236

Using Logical Instructions

When using logical instructions, observe the following:

- Source and Destination must be of the same data size (i.e. all words or all long words).

IMPORTANT	Do not use the High Speed Counter Accumulator (HSC.ACC) for the Destination parameter in the AND, OR, and XOR instructions.

- Source A and Source B can be a constant or an address, but both cannot be constants.
- Valid constants are -32768 to 32767 (word) and -2,147,483,648 to 2,147,483,647 (long word).

Addressing Modes and File Types can be used as shown in the following table:

Logical Instructions Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files											Function Files(1)									CS - Comms	IOS - I/O	DLS - Data Log(2)	Address Mode(3)			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI				Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Source A	•	•	•	•	•	•			•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•	
Source B(4)	•	•	•	•	•	•			•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•	
Destination	•	•	•	•	•	•			•	•		•		•	•	•			•						•	•		•	•	

(1) DAT files are valid for the MicroLogix 1500 only. PTO and PWM files are valid for MicroLogix 1200 and 1500 BXB units.

(2) The Data Log Status file can only be used by the MicroLogix 1500 1764-LRP Processor.

(3) See Important note about indirect addressing.

(4) Source B does not apply to the NOT instruction. The NOT instruction only has one source value.

IMPORTANT	You cannot use indirect addressing with: S, ST, MG, PD, RTC, HSC, PTO, PWM, STI, EII, BHI, MMI, DAT, TPI, CS, IOS, and DLS files.

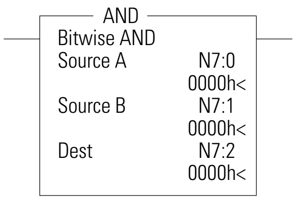
Updates to Math Status Bits

After a logical instruction is executed, the arithmetic status bits in the status file are updated. The arithmetic status bits are in word 0 bits 0-3 in the processor status file (S2).

Math Status Bits

With this Bit:		The Controller:
S:0/0	Carry	always resets
S:0/1	Overflow	always resets
S:0/2	Zero Bit	sets if result is zero, otherwise resets
S:0/3	Sign Bit	sets if result is negative (MSB is set), otherwise resets

AND - Bit-Wise AND



Instruction Type: output

Execution Time for the AND Instruction

Controller	Data Size	When Rung Is:	
		True	False
MicroLogix 1200	word	2.2 µs	0.0 µs
	long word	9.2 µs	0.0 µs
MicroLogix 1500	word	2.0 µs	0.0 µs
	long word	7.9 µs	0.0 µs

The AND instruction performs a bit-wise logical AND of two sources and places the result in the destination.

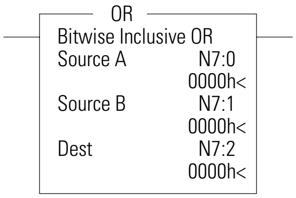
Truth Table for the AND Instruction

Destination = A AND B															
Source: A															
1	1	1	1	1	0	1	0	0	0	0	0	1	1	0	0
Source: B															
1	1	0	0	1	1	1	1	1	1	0	0	0	0	1	1
Destination:															
1	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0

IMPORTANT Do not use the High Speed Counter Accumulator (HSC.ACC) for the Destination parameter in the AND, OR, and XOR instructions.

For more information, see Using Logical Instructions on page 231 and Updates to Math Status Bits on page 232.

OR - Logical OR



Instruction Type: output

Execution Time for the OR Instruction

Controller	Data Size	When Rung Is:	
		True	**False**
MicroLogix 1200	word	2.2 µs	0.0 µs
	long word	9.2 µs	0.0 µs
MicroLogix 1500	word	2.0 µs	0.0 µs
	long word	7.9 µs	0.0 µs

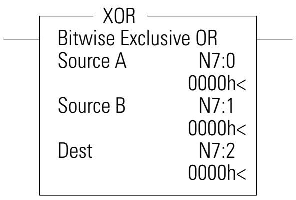
The OR instruction performs a logical OR of two sources and places the result in the destination.

Truth Table for the OR Instruction

Destination = A OR B															
Source: A															
1	1	1	1	1	0	1	0	0	0	0	0	1	1	0	0
Source: B															
1	1	0	0	1	1	1	1	1	1	0	0	0	0	1	1
Destination:															
1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1

IMPORTANT Do not use the High Speed Counter Accumulator (HSC.ACC) for the Destination parameter in the AND, OR, and XOR instructions.

XOR - Exclusive OR



Instruction Type: output

Execution Time for the XOR Instruction

Controller	Data Size	When Rung Is:	
		True	**False**
MicroLogix 1200	word	3.0 µs	0.0 µs
	long word	9.9 µs	0.0 µs
MicroLogix 1500	word	2.3 µs	0.0 µs
	long word	8.9 µs	0.0 µs

The XOR instruction performs a logical exclusive OR of two sources and places the result in the destination.

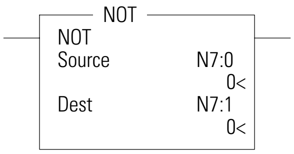
Truth Table for the XOR Instruction

Destination = A XOR B															
Source: A															
1	1	1	1	1	0	1	0	0	0	0	0	1	1	0	0
Source: B															
1	1	0	0	1	1	1	1	1	1	0	0	0	0	1	1
Destination:															
0	0	1	1	0	1	0	1	1	1	0	0	1	1	1	1

IMPORTANT Do not use the High Speed Counter Accumulator (HSC.ACC) for the Destination parameter in the AND, OR, and XOR instructions.

For more information, see Using Logical Instructions on page 231 and Updates to Math Status Bits on page 232.

NOT - Logical NOT



Instruction Type: output

Execution Time for the NOT Instruction

Controller	Data Size	When Rung Is:	
		True	**False**
MicroLogix 1200	word	2.4 µs	0.0 µs
	long word	9.2 µs	0.0 µs
MicroLogix 1500	word	2.4 µs	0.0 µs
	long word	8.1 µs	0.0 µs

The NOT instruction is used to invert the source bit-by-bit (one's complement) and then place the result in the destination.

Truth Table for the NOT Instruction

Destination = A NOT B															
Source:															
1	1	1	1	1	0	1	0	0	0	0	0	1	1	0	0
Destination:															
0	0	0	0	0	1	0	1	1	1	1	1	0	0	1	1

For more information, see Using Logical Instructions on page 231 and Updates to Math Status Bits on page 232.

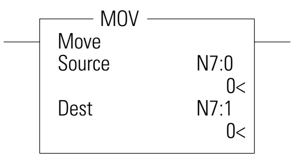
Chapter 13

Move Instructions

The move instructions modify and move words.

Instruction	Used to:	Page
MOV - Move	Move the source value to the destination.	237
MVM - Masked Move	Move data from a source location to a selected portion of the destination.	240

MOV - Move



Instruction Type: output

Execution Time for the MOV Instruction

Controller	Data Size	When Rung Is:	
		True	False
MicroLogix 1200	word	2.4 µs	0.0 µs
	long word	8.3 µs	0.0 µs
MicroLogix 1500	word	2.3 µs	0.0 µs
	long word	6.8 µs	0.0 µs

The MOV instruction is used to move data from the source to the destination. As long as the rung remains true, the instruction moves the data each scan.

Using the MOV Instruction

When using the MOV instruction, observe the following:

- Source and Destination can be different data sizes. The source is converted to the destination size when the instruction executes. If the signed value of the Source does not fit in the Destination, the overflow is handled as follows:
  - If the Math Overflow Selection Bit is clear, a saturated result is stored in the Destination. If the Source is positive, the Destination is 32767 (word). If the result is negative, the Destination is -32768.

  - If the Math Overflow Selection Bit is set, the unsigned truncated value of the Source is stored in the Destination.
- Source can be a constant or an address.
- Valid constants are -32768 to 32767 (word) and -2,147,483,648 to 2,147,483,647 (long word).

Addressing Modes and File Types can be used as shown in the following table:

MOV Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files(1)											Function Files(2)												Address Mode(4)			Address Level			
	O	I	S	B	T, C, R	N	F(5)	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI	CS - Comms	IOS - I/O	DLS - Data Log(3)	Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Source	•	•	•	•	•	•	•	•	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•	
Destination	•	•	•	•	•	•	•	•	•	•			(6)	(6)	(6)	(6)									•	•		•	•	

(1) The ST file is not valid for MicroLogix 1500 1764-LSP Series A processors.

(2) DAT files are valid for the MicroLogix 1500 only. PTO and PWM files are valid for MicroLogix 1200 and 1500 BXB units.

(3) The Data Log Status file can only be used by the MicroLogix 1500 1764-LRP Processor.

(4) See Important note about indirect addressing.

(5) The F file is valid for MicroLogix 1200 and 1500 Series C and higher controllers only.

(6) Some elements can be written to. Consult the function file for details.

IMPORTANT	You cannot use indirect addressing with: S, ST, MG, PD, RTC, HSC, PTO, PWM, STI, EII, BHI, MMI, DAT, TPI, CS, IOS, and DLS files.

Updates to Math Status Bits

After a MOV instruction is executed, the arithmetic status bits in the status file are updated. The arithmetic status bits are in word 0, bits 0 to 3 in the processor status file (S2).

Math Status Bits

With this Bit:		The Controller:
S:0/0	Carry	always resets
S:0/1	Overflow	sets when an overflow, infinity, or NAN (not a number) condition is detected, otherwise resets
S:0/2	Zero Bit	sets if result is zero, otherwise resets
S:0/3	Sign Bit	sets if result is negative (MSB is set), otherwise resets

Math Status Bits

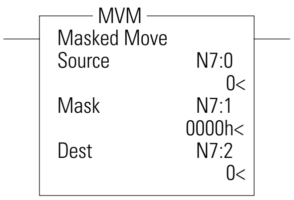
With this Bit:		The Controller:
S:5/0	Math Overflow Trap Bit[1]	sets Math Overflow Trap minor error if the Overflow bit is set, otherwise it remains in last state

(1) Control bit.

TIP

If you want to move one word of data without affecting the math flags, use a copy (COP) instruction with a length of 1 word instead of the MOV instruction.

MVM - Masked Move



Instruction Type: output

Execution Time for the MVM Instruction

Controller	Data Size	When Rung Is:	
		True	False
MicroLogix 1200	word	7.8 µs	0.0 µs
	long word	11.8 µs	0.0 µs
MicroLogix 1500	word	7.2 µs	0.0 µs
	long word	10.0 µs	0.0 µs

The MVM instruction is used to move data from the source to the destination, allowing portions of the destination to be masked. The mask bit functions as follows:

Mask Function for MVM Instruction

Source Bit	Mask Bit	Destination Bit
1	0	last state
0	0	last state
1	1	1
0	1	0

Mask data by setting bits in the mask to zero; pass data by setting bits in the mask to one. The mask can be a constant, or you can vary the mask by assigning a direct address. Bits in the Destination that correspond to zeros in the Mask are not altered.

Using the MVM Instruction

When using the MVM instruction, observe the following:

- Source, Mask, and Destination must be of the same data size (i.e. all words or all long words).

  To mask data, set the mask bit to zero; to pass data, set the mask bit to one. The mask can be a constant value, or you can vary the mask by assigning a direct address.

TIP Bits in the destination that correspond to zeros in the mask are not altered as shown in the shaded areas in the following table.

Mask Example (Word Addressing Level)

Word	Value in Hexadecimal	Value in Binary															
		15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Value in Destination Before Move	FFFF	1	1	1	1	**1**	**1**	**1**	**1**	1	1	1	1	**1**	**1**	**1**	**1**
Source Value	5555	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
Mask	F0F0	1	1	1	1	**0**	**0**	**0**	**0**	1	1	1	1	**0**	**0**	**0**	**0**
Value in Destination After Move	5F5F	0	1	0	1	**1**	**1**	**1**	**1**	0	1	0	1	**1**	**1**	**1**	**1**

- Valid constants for the mask are -32768 to 32767 (word) and -2,147,483,648 to 2,147,483,647 (long word). The mask is displayed as a hexadecimal unsigned value from 0000 0000 to FFFF FFFF.

Addressing Modes and File Types can be used as shown in the following table:

MVM Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files(1)											Function Files												Address Mode(2)			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L(3)	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI	CS - Comms	IOS - I/O	DLS - Data Log	Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Source	•	•		•	•	•		•	•																•	•		•	•	
Mask	•	•		•	•	•		•	•															•	•	•		•	•	
Destination	•	•		•	•	•		•	•																•	•		•	•	

(1) The ST file is not valid for MicroLogix 1500 1764-LSP Series A processors.

(2) See Important note about indirect addressing.

(3) In earlier firmware versions, when the MVM instruction was configured to execute with a Long Word Source value set to zero, the processor could potentially lose communications or hard fault. This was corrected in MicroLogix 1200 FRN 7 and MicroLogix 1500 FRN 8 firmware.

IMPORTANT	You cannot use indirect addressing with: S, ST, MG, PD, RTC, HSC, PTO, PWM, STI, EII, BHI, MMI, DAT, TPI, CS, IOS, and DLS files.

Updates to Math Status Bits

After a MVM instruction is executed, the arithmetic status bits in the status file are updated. The arithmetic status bits are in word 0 bits 0-3 in the processor status file (S2).

Math Status Bits

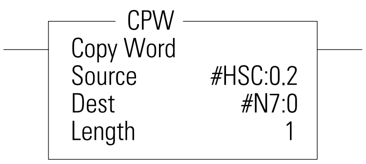
With this Bit:		The Controller:
S:0/0	Carry	always resets
S:0/1	Overflow	always resets
S:0/2	Zero Bit	sets if destination is zero, otherwise resets
S:0/3	Sign Bit	sets if the MSB of the destination is set, otherwise resets

Notes:

File Instructions

The file instructions perform operations on file data.

CPW - Copy Word



Instruction Type: output

Execution Time for the CPW Instruction

Controller	When Rung Is:	
	True	**False**
MicroLogix 1200 Series C and higher only	18.3 µs + 0.8 µs/word	0.0 µs
MicroLogix 1500 Series C and higher only	15.8 µs + 0.7 µs/word	0.0 µs

The CPW instruction copies words of data, in ascending order, from one location (Source) to another (Destination). Although similar to the File Copy (COP) instruction, the CPW instruction allows different source and destination parameters. Examples include:

- integer to long word
- long word to floating point
- long word to integer
- integer to PTO function file

Observe the following restrictions when using the CPW instruction:

- The length of the data transferred cannot exceed 128 words.
- Function files can be used for Source or Destination, but not both.
- When referencing either a PLS file or a function file, addressing must be specified to the sub-element level.
- You can reference a sub-element of bits in a function file containing a combination of read-only and read/write bits.
- You cannot directly reference the high word of a long word as an operand in the CPW instruction.
- A Major fault (003F) is generated if the execution of the instruction exceeds the data table space.
- A Major fault (0044) is generated if a write attempt fails to the RTC function file. This only occurs when attempting to write invalid data to the RTC function file. Examples of invalid data are: setting the Day of Week to zero or setting the Date to February 30th.

Addressing Modes and File Types are shown in the following table:

CPW Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 4-2.

Parameter	Data Files											Function Files									CS - Comms	IOS - I/O	DLS - Data Log	Address Mode(1)			Address Level			
	O	I	S	B	T, C, R	N	F(2)	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI				Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Source	•	•		•		•	•		•		•	•	•	•	•	•	•	•		•					•	•				•
Destination	•	•		•		•	•		•		•	•	•	•	•	•									•	•				•
Length																								•						

(1) See Important note about indirect addressing.

(2) The F file is valid for MicroLogix 1200 and 1500 Series C and higher controllers only.

IMPORTANT You cannot use indirect addressing with: S, MG, PD, RTC, HSC, PTO, PWM, STI, EII, BHI, MMI, DAT, TPI, CS, IOS, and DLS files.

COP - Copy File

```
COP
Copy File
Source      #N7:0
Dest        #N7:1
Length          1
```

Instruction Type: output

Execution Time for the COP Instruction

Controller	When Rung Is:	
	True	**False**
MicroLogix 1200	19.08 µs + 0.8 µs/word	0.0 µs
MicroLogix 1500	15.9 µs + 0.67 µs/word	0.0 µs

The COP instruction copies blocks of data from one location into another.

COP Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files(1)											Function Files												Address Mode(2)			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI	CS - Comms	IOS - I/O	DLS - Data Log	Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Source	•	•		•	•	•	•	•	•																•	•				•
Destination	•	•		•	•	•	•	•	•																•	•				•
Length																								•						

(1) The ST file is not valid for MicroLogix 1500 1764-LSP Series A processors.

(2) See Important note about indirect addressing.

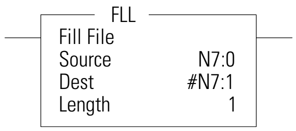
IMPORTANT You cannot use indirect addressing with: S, MG, PD, RTC, HSC, PTO, PWM, STI, EII, BHI, MMI, DAT, TPI, CS, IOS, and DLS files.

The source and destination file types must be the same except bit (B) and integer (N); they can be interchanged. It is the address that determines the maximum length of the block to be copied, as shown in the following table:

Maximum Lengths for the COP Instruction

Source/Destination Data Type	Range of Length Operand
1 word elements (ie. word)	1 to 128
2 word elements (ie. long word)	1 to 64
3 word elements (ie. counter)	1 to 42
42 word elements (ie. string)	1 to 3

FLL - Fill File

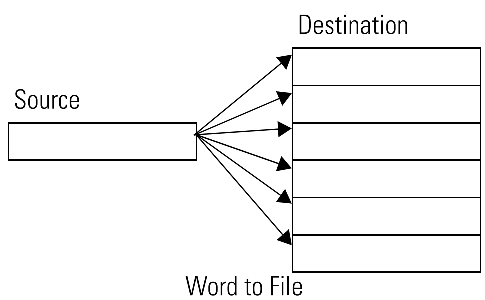


Instruction Type: output

Execution Time for the FLL Instruction

Controller	Data Size	When Rung Is:	
		True	False
MicroLogix 1200	word	14 + 0.6 µs/word	0.0 µs
	long word	15 + 1.2 µs/long word	0.0 µs
MicroLogix 1500	word	12.1 + 0.43 µs/word	0.0 µs
	long word	12.3 + 0.8 µs/long word	0.0 µs

The FLL instruction loads elements of a file with either a constant or an address data value for a given length. The following figure shows how file instruction data is manipulated. The instruction fills the words of a file with a source value. It uses no status bits. If you need an enable bit, program a parallel output that uses a storage address.



This instruction uses the following operands:

- Source - The source operand is the address of the value or constant used to fill the destination. The data range for the source is from -32768 to 32767 (word) or -2,147,483,648 to 2,147,483,647 (long word), or any IEEE-754 32-bit value.

TIP A constant cannot be used as the source in a timer (T), counter (C), or control (R) file.

- Destination - The starting destination address where the data is written.
- Length - The length operand contains the number of elements. The length can range from 1 to 128 (word), 1 to 64 (long word), or 1 to 42 (3 word element such as counter).

TIP The source and destination operands must be of the same file type, unless they are bit (B) and integer (N).

Addressing Modes and File Types can be used as shown in the following table:

FLL Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

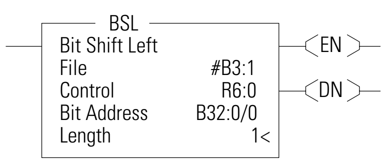
Parameter	Data Files											Function Files									CS - Comms	IOS - I/O	DLS - Data Log	Address Mode(1)			Address Level			
	O	I	S	B	T, C, R	N	F(2)	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI				Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Source	•	•		•	•	•	•		•															•	•	•		•	•	•
Destination	•	•		•	•	•	•		•																•	•				•
Length																								•						

(1) See Important note about indirect addressing.

(2) The F file is valid for MicroLogix 1200 and 1500 Series C and higher controllers only.

IMPORTANT You cannot use indirect addressing with: S, ST, MG, PD, RTC, HSC, PTO, PWM, STI, EII, BHI, MMI, DATI, TPI, CS, IOS, and DLS files.

BSL - Bit Shift Left

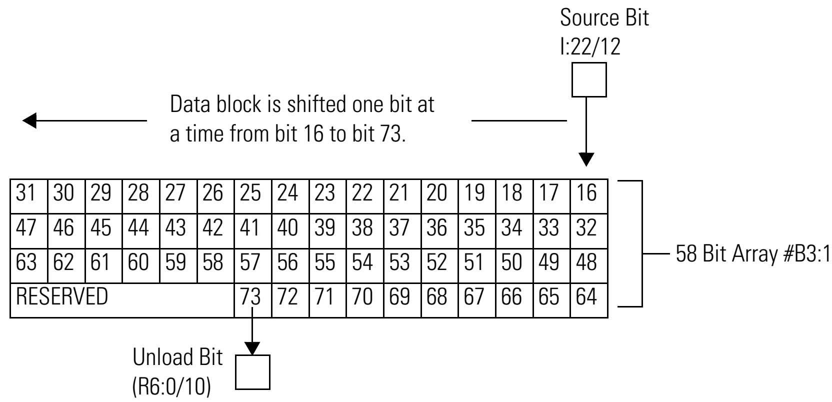


Instruction Type: output

Execution Time for the BSL Instruction

Controller	When Rung Is:	
	True	False
MicroLogix 1200	32 µs + 1.3 µs/word	1.3 µs
MicroLogix 1500	26.1 µs + 1.06 µs/word	1.4 µs

The BSL instruction loads data into a bit array on a false-to-true rung transition, one bit at a time. The data is shifted left through the array, then unloaded, one bit at a time. The following figure shows the operation of the BSL instruction.



If you wish to shift more than one bit per scan, you must create a loop in your application using the JMP, LBL, and CTU instructions.

This instruction uses the following operands:

- File - The file operand is the address of the bit array that is to be manipulated.
- Control - The control operand is the address of the BSL's control element. The control element consists of 3 words:

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Word 0	EN(1)	--	DN(2)	--	ER(3)	UL(4)	not used									
Word 1	Size of bit array (number of bits).															
Word 2	not used															

(1) EN - Enable Bit is set on false-to-true transition of the rung and indicates the instruction is enabled.

(2) DN - Done Bit, when set, indicates that the bit array has shifted one position.

(3) ER - Error Bit, when set, indicates that the instruction detected an error such as entering a negative number for the length or source operand.

(4) UL - Unload Bit is the instruction's output. Avoid using the UL (unload) bit when the ER (error) bit is set.

- Bit Address - The source is the address of the bit to be transferred into the bit array at the first (lowest) bit position.
- Length - The length operand contains the length of the bit array in bits. The valid data range for length is from 0 to 2048.

Addressing Modes and File Types can be used as shown in the following table:

BSL Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

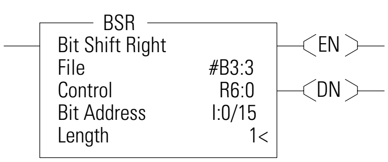
Parameter	Data Files											Function Files										CS - Comms	IOS - I/O	DLS - Data Log	Address Mode(1)			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI					Immediate	Direct	Indirect	Bit	Word	Long Word	Element
File	•	•		•		•			•																	•	•		•	•	
Control					(2)																					•					•
Length																									•				•		
Source	•	•		•	•	•			•																	•	•	•			

(1) See Important note about indirect addressing.

(2) Control file only. Not valid for Timers and Counters.

IMPORTANT You cannot use indirect addressing with: S, ST, MG, PD, RTC, HSC, PTO, PWM, STI, EII, BHI, MMI, DATI, TPI, CS, IOS, and DLS files.

BSR - Bit Shift Right



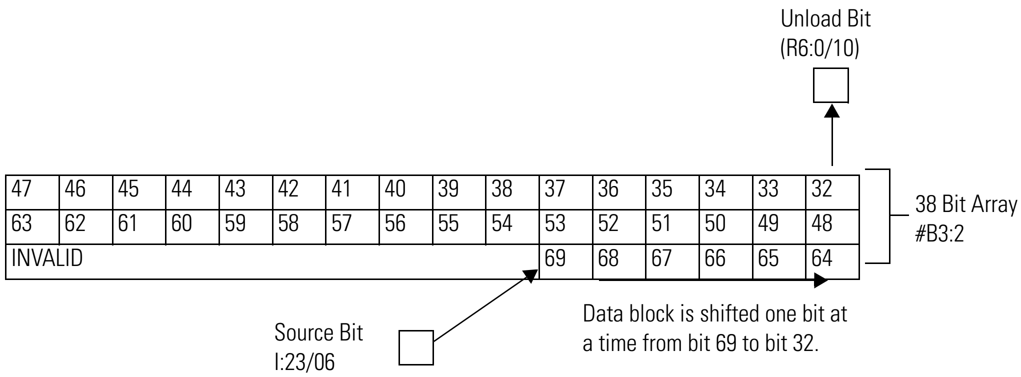
Instruction Type: output

Execution Time for the BSR Instruction

Controller	When Rung Is:	
	True	False
MicroLogix 1200	32 µs + 1.3 µs/word	1.3 µs
MicroLogix 1500	26.1 µs + 1.07 µs/word	1.4 µs

If you wish to shift more than one bit per scan, you must create a loop in your application using the JMP, LBL, and CTU instructions.

The BSR instruction loads data into a bit array on a false-to-true rung transition, one bit at a time. The data is shifted right through the array, then unloaded, one bit at a time. The following figure shows the operation of the BSR instruction.



This instruction uses the following operands:

- File - The file operand is the address of the bit array that is to be manipulated.
- Control - The control operand is the address of the BSR's control element. The control element consists of 3 words:

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Word 0	EN(1)	--	DN(2)	--	ER(3)	UL(4)	not used									
Word 1	Size of bit array (number of bits).															
Word 2	not used															

(1) EN - Enable Bit is set on false-to-true transition of the rung and indicates the instruction is enabled.

(2) DN - Done Bit, when set, indicates that the bit array has shifted one position.

(3) ER - Error Bit, when set, indicates that the instruction detected an error such as entering a negative number for the length or source operand.

(4) UL - Unload Bit is the instruction's output. Avoid using the UL (unload) bit when the ER (error) bit is set.

- Bit Address - The source is the address of the bit to be transferred into the bit array at the last (highest) bit position.
- Length - The length operand contains the length of the bit array in bits. The data range for length is from 0 to 2048.

Addressing Modes and File Types can be used as shown in the following table:

BSR Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

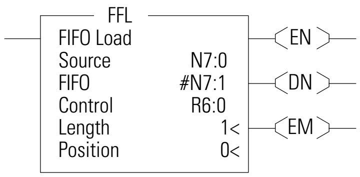
Parameter	Data Files											Function Files									CS - Comms	IOS - I/O	DLS - Data Log	Address Mode(1)			Address Level			
	O	I	S	B	T, C, R	N	F	L	ST	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI				Immediate	Direct	Indirect	Bit	Word	Long Word	Element
File	•	•		•		•		•																	•	•		•	•	
Control					(2)																				•					•
Length																								•				•		
Source	•	•		•	•	•		•																	•	•	•			

(1) See Important note about indirect addressing.

(2) Control file only. Not valid for Timers and Counters.

IMPORTANT You cannot use indirect addressing with: S, ST, MG, PD, RTC, HSC, PTO, PWM, STI, EII, BHI, MMI, DAT, TPI, CS, IOS, and DLS files.

FFL - First In, First Out (FIFO) Load

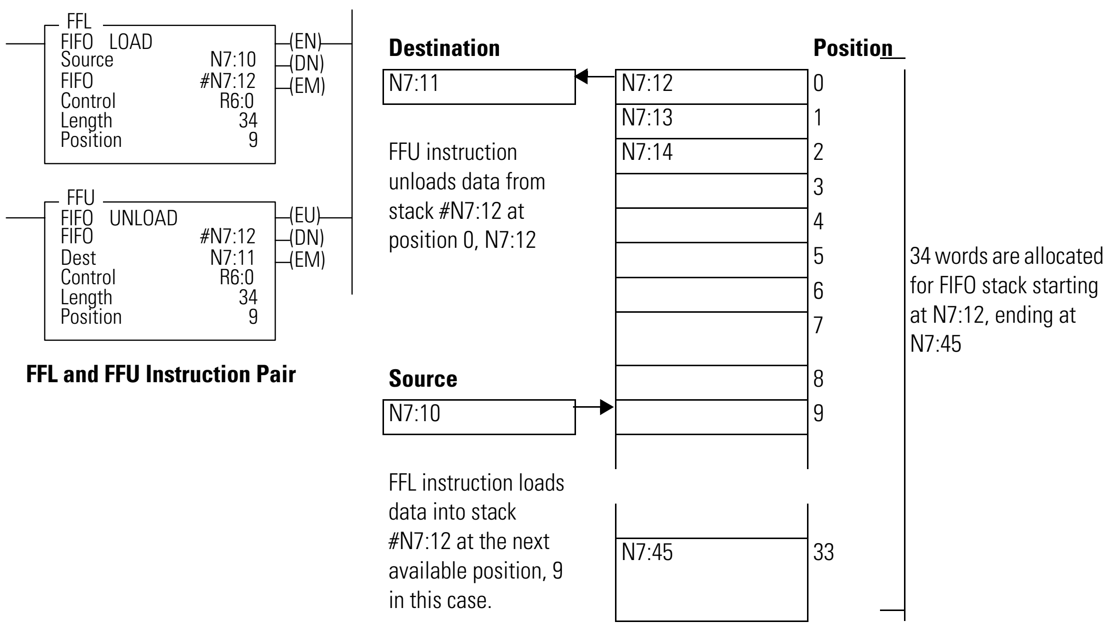


Instruction Type: output

Execution Time for the FFL Instruction

Controller	Data Size	When Rung Is:	
		True	False
MicroLogix 1200	word	11.3 µs	11.1 µs
	long word	11.7 µs	11.2 µs
MicroLogix 1500	word	10.0 µs	9.8 µs
	long word	10.9 µs	9.7 µs

On a false-to-true rung transition, the FFL instruction loads words or long words into a user-created file called a FIFO stack. This instruction's counterpart, FIFO unload (FFU), is paired with a given FFL instruction to remove elements from the FIFO stack. Instruction parameters have been programmed in the FFL - FFU instruction pair shown below.



FFL and FFU Instruction Pair

Loading and Unloading of Stack #N7:12

This instruction uses the following operands:

- Source - The source operand is a constant or address of the value used to fill the currently available position in the FIFO stack. The address level of the source must match the FIFO stack. If FIFO is a word size file, source must be a word value or constant. If FIFO is a long word size file, source must be a long word value or constant. The data range for the source is from -32768 to 32767 (word) or -2,147,483,648 to 2,147,483,647 (long word).
- FIFO - The FIFO operand is the starting address of the stack.
- Control - This is a control file address. The status bits, stack length, and the position value are stored in this element. The control element consists of 3 words:

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Word 0	EN(1)	--	DN(2)	EM(3)	not used											
Word 1	Length - maximum number of words or long words in the stack.															
Word 2	Position - the next available location where the instruction loads data.															

(1) EN - Enable Bit is set on false-to-true transition of the rung and indicates the instruction is enabled.

(2) DN - Done Bit, when set, indicates that the stack is full.

(3) EM - Empty Bit, when set, indicates FIFO is empty.

- Length - The length operand contains the number of elements in the FIFO stack to receive the value or constant found in the source. The length of the stack can range from 1 to 128 (word) or 1 to 64 (long word). The position is incremented after each load.
- Position - This is the current location pointed to in the FIFO stack. It determines the next location in the stack to receive the value or constant found in source. Position is a component of the control register. The position can range from 0 to 127 (word) or 0 to 63 (long word).

Addressing Modes and File Types can be used as shown in the following table:

FFL Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

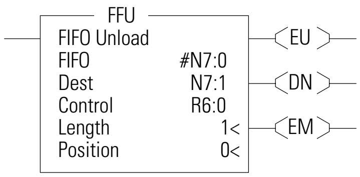
Parameter	Data Files											Function Files									CS - Comms	IOS - I/O	DLS - Data Log	Address Mode(1)			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI				Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Source	•	•		•	•	•			•															•	•	•		•	•	
FIFO	•	•		•		•			•																•	•		•	•	
Control					(2)																				•					•
Length																								•				•		
Position																								•				•		

(1) See Important note about indirect addressing.

(2) Control file only. Not valid for Timers or Counters.

IMPORTANT You cannot use indirect addressing with: S, ST, MG, PD, RTC, HSC, PTO, PWM, STI, EII, BHI, MMI, DAT, TPI, CS, IOS, and DLS files.

FFU - First In, First Out (FIFO) Unload

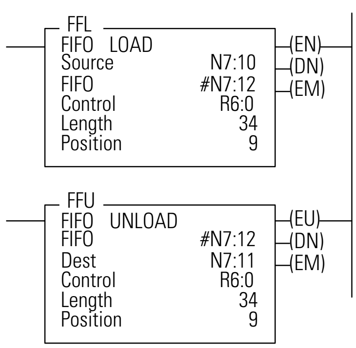


Instruction Type: output

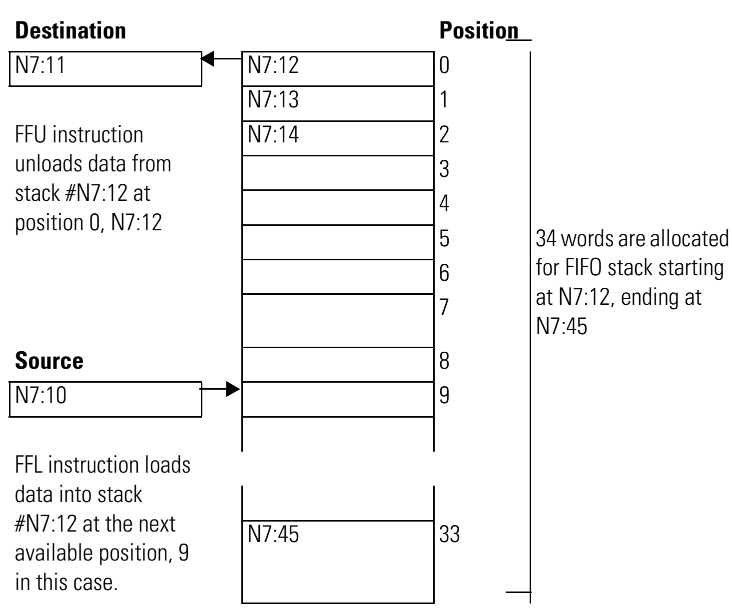
Execution Time for the FFU Instruction

Controller	Data Size	When Rung Is:	
		True	**False**
MicroLogix 1200	word	33 µs + 0.8 µs/word	10.4 µs
	long word	36 µs + 1.5 µs/ long word	10.4 µs
MicroLogix 1500	word	27.7 µs + 0.65 µs/word	9.7 µs
	long word	29.4 µs + 1.25 µs/long word	9.7 µs

On a false-to-true rung transition, the FFU instruction unloads words or long words from a user-created file called a FIFO stack. The data is unloaded using first-in, first-out order. After the unload completes, the data in the stack is shifted one element toward the top of the stack and the last element is zeroed out. Instruction parameters have been programmed in the FFL - FFU instruction pair shown below.



FFL and FFU Instruction Pair



Loading and Unloading of Stack #N7:12

This instruction uses the following operands:

- FIFO - The FIFO operand is the starting address of the stack.

- Destination - The destination operand is a word or long word address that stores the value which exits from the FIFO stack. The FFU instruction unloads this value from the first location on the FIFO stack and places it in the destination address. The address level of the destination must match the FIFO stack. If FIFO is a word size file, destination must be a word size file. If FIFO is a long word size file, destination must be a long word size file.
- Control - This is a control file address. The status bits, stack length, and the position value are stored in this element. The control element consists of 3 words:

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Word 0	--	EU(1)	DN(2)	EM(3)	not used											
Word 1	Length - maximum number of words or long words in the stack.															
Word 2	Position - the next available location where the instruction unloads data.															

(1) EU - Enable Unload Bit is set on false-to-true transition of the rung and indicates the instruction is enabled.

(2) DN - Done Bit, when set, indicates that the stack is full.

(3) EM - Empty Bit, when set, indicates FIFO is empty.

- Length - The length operand contains the number of elements in the FIFO stack. The length of the stack can range from 1 to 128 (word) or 1 to 64 (long word).
- Position - Position is a component of the control register. The position can range from 0 to 127 (word) or 0 to 63 (long word). The position is decremented after each unload. Data is unloaded at position zero.

Addressing Modes and File Types can be used as shown in the following table:

FFU Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

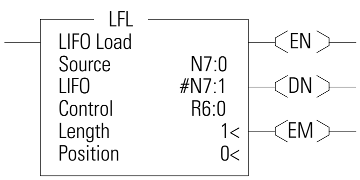
Parameter	Data Files											Function Files													Address Mode(1)			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI	CS - Comms	IOS - I/O	DLS - Data Log	Immediate	Direct	Indirect	Bit	Word	Long Word	Element
FIFO	•	•		•		•			•																•	•		•	•	
Destination	•	•		•	•	•			•																•	•		•	•	
Control					(2)																				•					•
Length																								•				•		
Position																								•				•		

(1) See Important note about indirect addressing.

(2) Control file only. Not valid for Timers and Counters.

IMPORTANT	You cannot use indirect addressing with: S, ST, MG, PD, RTC, HSC, PTO, PWM, STI, EII, BHI, MMI, DAT, TPI, CS, IOS, and DLS files.

LFL - Last In, First Out (LIFO) Load

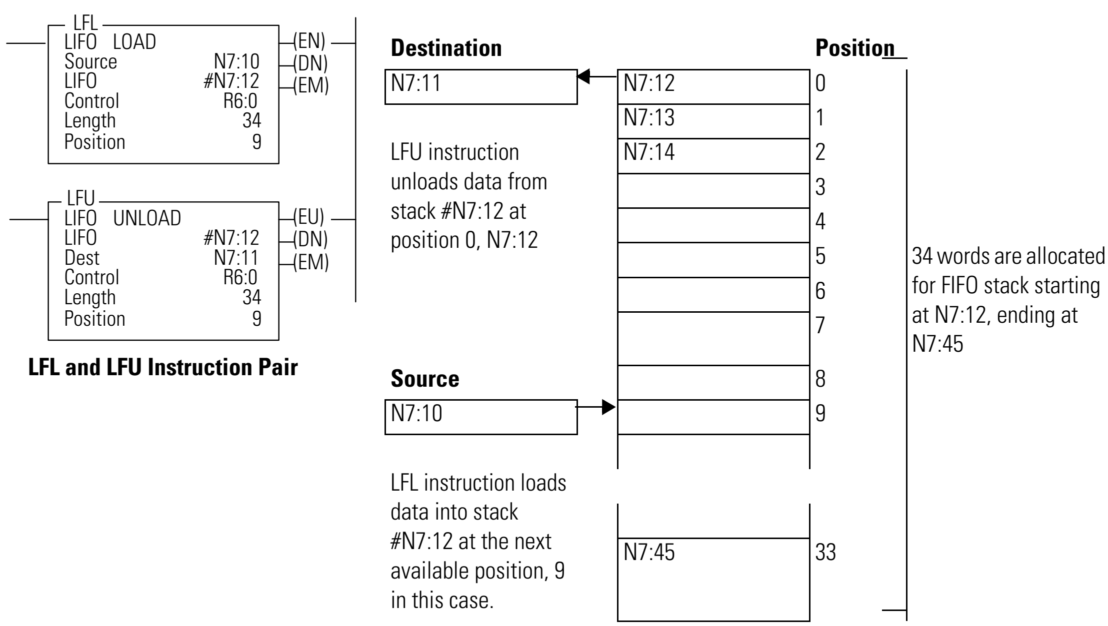


Instruction Type: output

Execution Time for the LFL Instruction

Controller	Data Size	When Rung Is:	
		True	False
MicroLogix 1200	word	25.5 µs	10.4 µs
	long word	31.6 µs	10.4 µs
MicroLogix 1500	word	22.2 µs	9.7 µs
	long word	27.4 µs	9.7 µs

On a false-to-true rung transition, the LFL instruction loads words or long words into a user-created file called a LIFO stack. This instruction's counterpart, LIFO unload (LFU), is paired with a given LFL instruction to remove elements from the LIFO stack. Instruction parameters have been programmed in the LFL - LFU instruction pair shown below.



LFL and LFU Instruction Pair

Loading and Unloading of Stack #N7:12

This instruction uses the following operands:

- Source - The source operand is a constant or address of the value used to fill the currently available position in the LIFO stack. The data size of the source must match the LIFO stack. If LIFO is a word size file, source must be a word value or constant. If LIFO is a long word size file, source must be a long word value or constant. The data range for the source is from -32768 to 32767 (word) or -2,147,483,648 to 2,147,483,647 (long word).
- LIFO - The LIFO operand is the starting address of the stack.
- Control - This is a control file address. The status bits, stack length, and the position value are stored in this element. The control element consists of 3 words:

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Word 0	EN(1)	--	DN(2)	EM(3)	not used											
Word 1	Length - maximum number of words or long words in the stack.															
Word 2	Position - the next available location where the instruction loads data.															

(1) EN - Enable Bit is set on false-to-true transition of the rung and indicates the instruction is enabled.

(2) DN - Done Bit, when set, indicates that the stack is full.

(3) EM - Empty Bit, when set, indicates that LIFO is empty.

- Length - The length operand contains the number of elements in the FIFO stack to receive the value or constant found in the source. The length of the stack can range from 1 to 128 (word) or 1 to 64 (long word). The position is incremented after each load.
- Position - This is the current location pointed to in the LIFO stack. It determines the next location in the stack to receive the value or constant found in source. Position is a component of the control register. The position can range from 0 to 127 (word) or 0 to 63 (long word).

Addressing Modes and File Types can be used as shown in the following table:

LFL Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

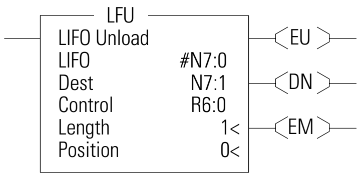
Parameter	Data Files											Function Files												Address Mode(1)			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI	CS - Comms	IOS - I/O	DLS - Data Log	Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Source	•	•		•	•	•			•															•	•	•		•	•	
LIFO	•	•		•		•			•																•	•		•	•	
Control					(2)																				•					•
Length																								•				•		
Position																								•				•		

(1) See Important note about indirect addressing.

(2) Control file only. Not valid for Timers and Counters.

IMPORTANT	You cannot use indirect addressing with: S, ST, MG, PD, RTC, HSC, PTO, PWM, STI, EII, BHI, MMI, DAT, TPI, CS, IOS, and DLS files.

LFU - Last In, First Out (LIFO) Unload

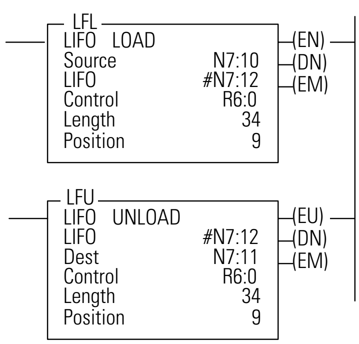


Instruction Type: output

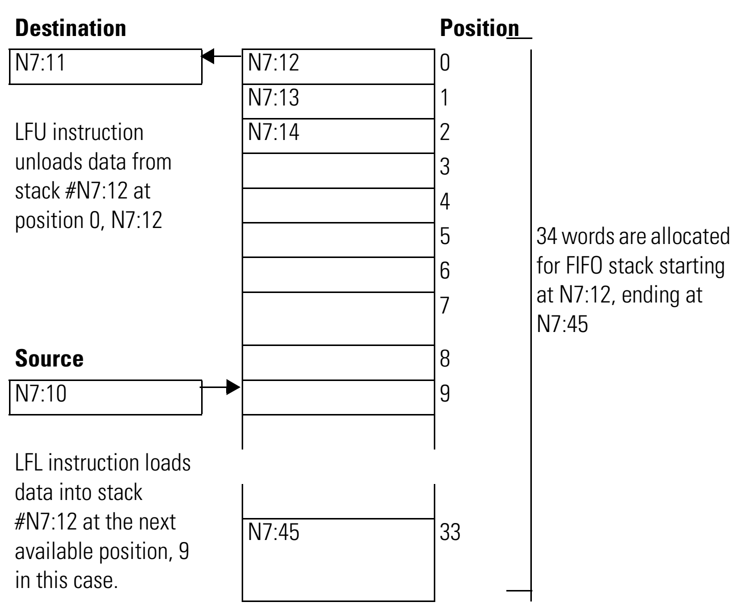
Execution Time for the LFU Instruction

Controller	Data Size	When Rung Is:	
		True	False
MicroLogix 1200	word	29.1 µs	10.4 µs
	long word	31.6 µs	10.4 µs
MicroLogix 1500	word	25.6 µs	9.7 µs
	long word	27.4 µs	9.7 µs

On a false-to-true rung transition, the LFU instruction unloads words or long words from a user-created file called a LIFO stack. The data is unloaded using last-in, first-out order. Instruction parameters have been programmed in the LFL - LFU instruction pair shown below.



LFL and LFU Instruction Pair



Loading and Unloading of Stack #N7:12

This instruction uses the following operands:

- LIFO - The LIFO operand is the starting address of the stack.

- Destination - The destination operand is a word or long word address that stores the value which exits from the LIFO stack. The LFU instruction unloads this value from the last location on the LIFO stack and places it in the destination address. The address level of the destination must match the LIFO stack. If LIFO is a word size file, destination must be a word size file. If LIFO is a long word size file, destination must be a long word size file.
- Control - This is a control file address. The status bits, stack length, and the position value are stored in this element. The control element consists of 3 words:

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Word 0	--	EU(1)	DN(2)	EM(3)	not used											
Word 1	Length - maximum number of words or double words in the stack.															
Word 2	Position - the next available location where the instruction unloads data.															

(1) EU - Enable Unload Bit is set on false-to-true transition of the rung and indicates the instruction is enabled.

(2) DN - Done Bit, when set, indicates that the stack is full.

(3) EM - Empty Bit, when set, indicates LIFO is empty.

- Length - The length operand contains the number of elements in the LIFO stack. The length of the stack can range from 1 to 128 (word) or 1 to 64 (long word).
- Position - This is the next location in the LIFO stack where data will be unloaded. Position is a component of the control register. The position can range from 0 to 127 (word) or 0 to 63 (long word). The position is decremented after each unload.

LFU Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files											Function Files												Address Mode(1)			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI	CS - Comms	IOS - I/O	DLS - Data Log	Immediate	Direct	Indirect	Bit	Word	Long Word	Element
LIFO	•	•		•		•			•																•	•		•	•	
Destination	•	•		•	•	•			•																•	•		•	•	
Control					(2)																				•					•
Length																								•				•		
Position																								•				•		

(1) See Important note about indirect addressing.

(2) Control file only. Not valid for Timers and Counters.

IMPORTANT	You cannot use indirect addressing with: S, ST, MG, PD, RTC, HSC, PTO, PWM, STI, EII, BHI, MMI, DAT, TPI, CS, IOS, and DLS files.

SWP - Swap

```
SWP
Swap
Source    #ST10:1.DATA[0]
Length                 13
```

Instruction Type: output

Execution Time for the SWP Instruction

Controller	When Rung Is:	
	True	False
MicroLogix 1200 Series B and higher	13.7 µs + 2.2 µs/swapped word	0.0 µs
MicroLogix 1500 Series B and higher	11.7 µs + 1.8 µs/swapped word	0.0 µs

Use the SWP instruction to swap the low and high bytes of a specified number of words in a bit, integer, or string file. The SWP instruction has 2 operands:

- Source is the word address containing the words to be swapped.
- Length is the number of words to be swapped, regardless of the file type. The address is limited to integer constants. For bit and integer filetypes, the length range is 1 to 128. For the string filetype, the length range is 1 to 41. Note that this instruction is restricted to a single string element and cannot cross a string element boundary.

Addressing Modes and File Types can be used as shown in the following table:

SWP Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files											Function Files									CS - Comms	IOS - I/O	DLS - Data Log	Address(1) Mode			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI				Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Source				•		•		•																	•			•		
Length																								•				•		

(1) See Important note about indirect addressing.

IMPORTANT You cannot use indirect addressing with: S, ST, MG, PD, RTC, HSC, PTO, PWM, STI, EII, BHI, MMI, DAT, TPI, CS, IOS, and DLS files.

Example:

```
SWP
Swap
Source    #ST10:1.DATA[0]
Length                 13
```

Source Value before executing SWP instruction: a b c d e f g h i j k l m n o p q r s t u v w x y z a b c d e f g

Source Value before executing SWP instruction: b a d c f e h g j i l k n m p o r q t s v u x w z y a b c d e f g

The underlined characters show the 13 words where the low byte was swapped with the high byte.

Sequencer Instructions

Sequencer instructions are used to control automatic assembly machines or processes that have a consistent and repeatable operation. They are typically time based or event driven.

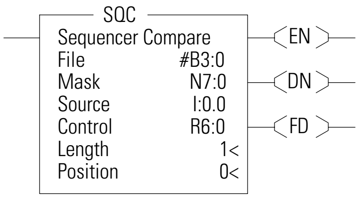
Instruction	Used To:	Page
SQC - Sequencer Compare	Compare 16-bit data with stored data	268
SQO - Sequencer Output	Transfer 16-bit data to word addresses	271
SQL - Sequencer Load	Load 16-bit data into a file	274

Use the sequencer compare instruction to detect when a step is complete; use the sequencer output instruction to set output conditions for each step. Use the sequencer load instruction to load data into the sequencer file.

The primary advantage of sequencer instructions is to conserve program memory. These instructions monitor and control 16 (word) or 32 (long word) discrete outputs at a time in a single rung.

You can use bit integer or double integer files with sequencer instructions.

SQC- Sequencer Compare



Instruction Type: output

Execution Time for the SQC Instruction

Controller	Data Size	When Rung Is:	
		True	False
MicroLogix 1200	word	23.5 µs	7.1 µs
	long word	26.3 µs	7.1 µs
MicroLogix 1500	word	20.1 µs	6.3 µs
	long word	22.7 µs	6.3 µs

On a false-to-true rung transition, the SQC instruction is used to compare masked source words or long words with the masked value at a reference address (the sequencer file) for the control of sequential machine operations.

When the status of all non-masked bits in the source word match those of the corresponding reference word, the instruction sets the found bit (FD) in the control word. Otherwise, the found bit (FD) is cleared.

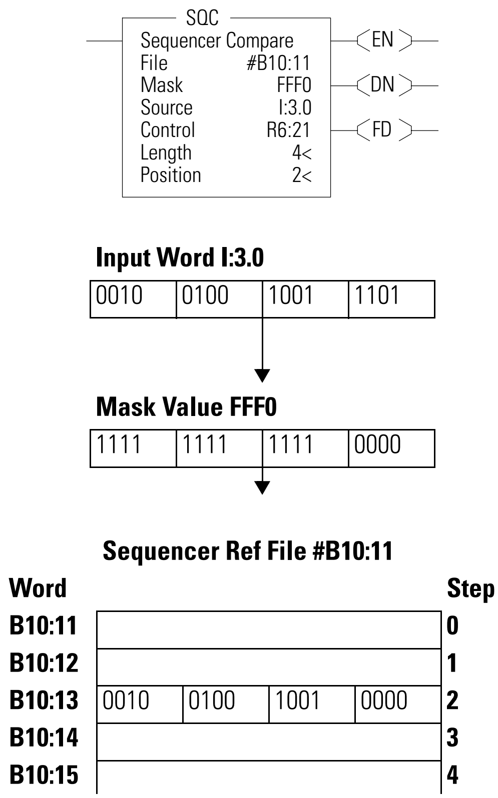
The bits mask data when reset (0) and pass data when set (1).

The mask can be fixed or variable. If you enter a hexadecimal code, it is fixed. If you enter an element address or a file address (direct or indirect) for changing the mask with each step, it is variable.

When the rung goes from false-to-true, the instruction increments to the next step (word) in the sequencer file. Data stored there is transferred through a mask and compared against the source for equality. While the rung remains true, the source is compared against the reference data for every scan. If equal, the FD bit is set in the SQCs control counter.

Applications of the SQC instruction include machine diagnostics.

The following figure explains how the SQC instruction works.



SQC FD bit is set when the instruction detects that an input word matches (through mask) its corresponding reference word.

The FD bit R6:21/FD is set in the example, since the input word matches the sequencer reference value using the mask value.

This instruction uses the following operands:

- File - This is the sequencer reference file. Its contents, on an element-by-element basis, are masked and compared to the masked value stored in source.

TIP If file type is word, then mask and source must be words. If file type is long word, mask and source must be long words.

- Mask - The mask operand contains the mask constant, word, or file which is applied to both file and source. When mask bits are set to 1, data is allowed to pass through for comparison. When mask bits are reset to 0, the data is masked (does not pass through to for comparison). The immediate data ranges for mask are from 0 to 0xFFFF or 0 to 0xFFFFFFFF.

.

TIP If mask is direct or indirect, the position selects the location in the specified file.

- Source - This is the value that is compared to file.
- Control - This is a control file address. The status bits, stack length, and the position value are stored in this element. The control element consists of 3 words:

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Word 0	EN(1)	--	DN(2)	--	ER(3)	not used		FD(4)	not used							
Word 1	Length - contains the number of steps in the sequencer reference file.															
Word 2	Position - the current position in the sequence															

(1) EN - Enable Bit is set by a false-to-true rung transition and indicates that the instruction is enabled.

(2) DN - Done Bit is set after the instruction has operated on the last word in the sequencer file. It is reset on the next false-to-true rung transition after the rung goes false.

(3) ER - Error Bit is set when the controller detects a negative position value, or a negative or zero length value. When the ER bit is set, the minor error bit (S2:5/2) is also set.

(4) FD - Found bit is set when the status of all non-masked bits in the source address match those of the word in the sequencer reference file. This bit is assessed each time the SQC instruction is evaluated while the rung is true.

- Length - The length operand contains the number of steps in the sequencer file (as well as Mask and/or Source if they are file data types). The length of the sequencer can range from 1 to 256.
- Position - This is the current location or step in the sequencer file (as well as Mask and/or Source if they are file data types). It determines the next location in the stack to receive the current comparison data. Position is a component of the control register. The position can range from 0 to 255 for words and 0 to 127 for long words. The position is incremented on each false-to-true transition.

Addressing Modes and File Types can be used as shown in the following table:

SQC Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

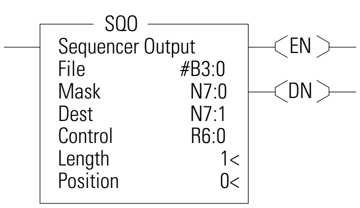
Parameter	Data Files											Function Files									CS - Comms	IOS - I/O	DLS - Data Log	Address Mode(1)			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI				Immediate	Direct	Indirect	Bit	Word	Long Word	Element
File	•	•		•		•			•																•	•		•	•	
Mask	•	•		•	•	•			•															•	•	•		•	•	
Source	•	•		•	•	•			•																•	•		•	•	
Control					(2)																				•					•
Length																								•				•		
Position																								•				•		

(1) See Important note about indirect addressing.

(2) Control file only.

IMPORTANT	You cannot use indirect addressing with: S, ST, MG, PD, RTC, HSC, PTO, PWM, STI, EII, BHI, MMI, DAT, TPI, CS, IOS, and DLS files.

SQO- Sequencer Output



Instruction Type: output

Execution Time for the SQO Instruction

Controller	Data Size	When Rung Is:	
		True	False
MicroLogix 1200	word	23.2 µs	7.1 µs
	long word	26.6 µs	7.1 µs
MicroLogix 1500	word	20.0 µs	6.3 µs
	long word	23.1 µs	6.3 µs

On a false-to-true rung transition, the SQO instruction transfers masked source reference words or long words to the destination for the control of sequential machine operations. When the rung goes from false-to-true, the instruction increments to the next step (word) in the sequencer file. Data stored there is transferred through a mask to the destination address specified in the instruction. Data is written to the destination word every time the instruction is executed.

The done bit is set when the last word of the sequencer file is transferred. On the next false-to-true rung transition, the instruction resets the position to step one.

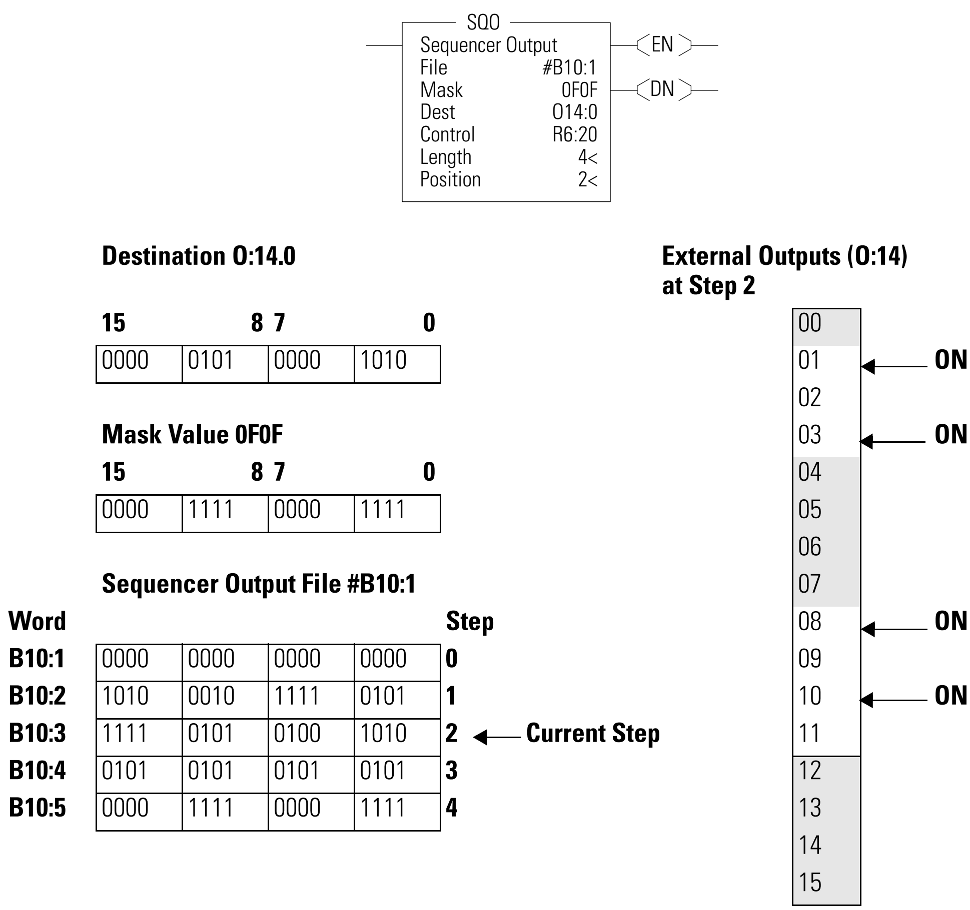
If the position is equal to zero at start-up, when you switch the controller from the program mode to the run mode, the instruction operation depends on whether the rung is true or false on the first scan.

- If the rung is true, the instruction transfers the value in step zero.
- If the rung is false, the instruction waits for the first rung transition from false-to-true and transfers the value in step one.

The bits mask data when reset (0) and pass data when set (1). The instruction will not change the value in the destination word unless you set mask bits.

The mask can be fixed or variable. It is fixed if you enter a hexadecimal code. It is variable if you enter an element address or a file address (direct or indirect) for changing the mask with each step.

The following figure indicates how the SQO instruction works.



This instruction uses the following operands:

- File - This is the sequencer reference file. Its contents, on an element-by-element, basis are masked and stored in the destination.

TIP If file type is word, then mask and source must be words. If file type is long word, mask and source must be long words.

- Mask - The mask operand contains the mask value. When mask bits are set to 1, data is allowed to pass through to destination. When mask bits are reset to 0, the data is masked (does not pass through to destination). The immediate data ranges for mask are from 0 to 0xFFFF (word) or 0 to 0xFFFFFFFF (long word).

TIP If mask is direct or indirect, the position selects the location in the specified file.

- Destination - The destination operand is the sequencer location or file.
- Control - This is a control file address. The status bits, stack length, and the position value are stored in this element. The control element consists of 3 words:

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Word 0	EN[1]	--	DN[2]	--	ER[3]	not used		FD	not used							
Word 1	Length - contains the index of the last element in the sequencer reference file															
Word 2	Position - the current position in the sequence															

(1) EN - Enable Bit is set by a false-to-true rung transition and indicates that the instruction is enabled.

(2) DN - Done Bit is set after the instruction has operated on the last word in the sequencer file. It is reset on the next false-to-true rung transition after the rung goes false.

(3) ER - Error Bit is set when the controller detects a negative position value, or a negative or zero length value. When the ER bit is set, the minor error bit (S2:5/2) is also set.

- Length - The length operand contains the number of steps in the sequencer file (as well as Mask and/or Destination if they are file data types). The length of the sequencer can range from 1 to 256.
- Position - This is the current location or step in the sequencer file (as well as Mask and/or Destination if they are file data types). It determines the next location in the stack to be masked and moved to the destination. Position is a component of the control register. The position can range from 0 to 255. Position is incremented on each false-to-true transition.

Addressing Modes and File Types can be used as shown in the following table:

SQO Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files											Function Files									CS - Comms	IOS - I/O	DLS - Data Log	Address Mode[1]			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI				Immediate	Direct	Indirect	Element	Bit	Word	Long Word
File[2]	•	•		•		•			•																•	•			•	•
Mask[2]	•	•		•	•	•			•															•	•	•			•	•
Destination[2]	•	•		•	•	•			•																•	•			•	•
Control					(3)																				•		•			
Length																								•					•	
Position																								•					•	

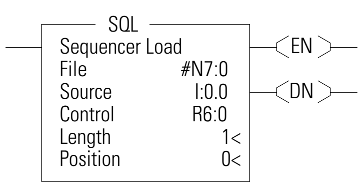
(1) See Important note about indirect addressing.

(2) File Direct and File Indirect addressing also applies.

(3) Control file only.

IMPORTANT You cannot use indirect addressing with: S, ST, MG, PD, RTC, HSC, PTO, PWM, STI, EII, BHI, MMI, DAT, TPI, CS, IOS, and DLS files.

SQL - Sequencer Load



Instruction Type: output

Execution Time for the SQL Instruction

Controller	Data Size	When Rung Is:	
		True	False
MicroLogix 1200	word	21.7 µs	7.0 µs
	long word	24.3 µs	7.1 µs
MicroLogix 1500	word	19.1 µs	6.3 µs
	long word	21.1 µs	6.3 µs

On a false-to-true rung transition, the SQL instruction loads words or long words into a sequencer file at each step of a sequencer operation. This instruction uses the following operands:

- File - This is the sequencer reference file. Its contents are received on an element-by-element basis from the source.

TIP If file type is word, then mask and source must be words. If file type is long word, mask and source must be long words.

- Source - The source operand is a constant or address of the value used to fill the currently available position sequencer file. The address level of the source must match the sequencer file. If file is a word type, then source must be a word type. If file is a long word type, then source must be a long word type. The data range for the source is from -32768 to 32767 (word) or -2,147,483,648 to 2,147,483,647 (long word).
- Control - This is a control file address. The status bits, stack length, and the position value are stored in this element. The control element consists of 3 words:

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Word 0	EN[1]	--	DN[2]	--	ER[3]	not used		FD	not used							
Word 1	Length - contains the index of the last element in the sequencer reference file															
Word 2	Position - the current position in the sequence															

(1) EN - Enable Bit is set by a false-to-true rung transition and indicates that the instruction is enabled.

(2) DN - Done Bit is set after the instruction has operated on the last word in the sequencer file. It is reset on the next false-to-true rung transition after the rung goes false.

(3) ER - Error Bit is set when the controller detects a negative position value, or a negative or zero length value. When the ER bit is set, the minor error bit (S2:5/2) is also set.

- Length - The length operand contains the number of steps in the sequencer file (this is also the length of source if it is a file data type). The length of the sequencer can range from 1 to 256.
- Position - This is the current location or step in the sequencer file (as well as source if it is a file data type). It determines the next location in the stack to receive the value or constant found in source. Position is a component of the control register. The position can range from 0 to 255.

Addressing Modes and File Types can be used as shown in the following table:

SQL Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files											Function Files									CS - Comms	IOS - I/O	DLS - Data Log	Address Mode(1)			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI				Immediate	Direct	Indirect	Bit	Word	Long Word	Element
File(2)	•	•		•		•			•																•	•		•	•	
Source(2)	•	•		•		•			•															•	•	•		•	•	
Control					(3)																				•					•
Length																								•				•		
Position																								•				•		

(1) See Important note about indirect addressing.

(2) File Direct and File Indirect addressing also applies.

(3) Control file only.

IMPORTANT You cannot use indirect addressing with: S, ST, MG, PD, RTC, HSC, PTO, PWM, STI, EII, BHI, MMI, DAT, TPI, CS, IOS, and DLS files.

Chapter 16

Program Control Instructions

Use these instructions to change the order in which the processor scans a ladder program. Typically these instructions are used to minimize scan time, create a more efficient program, and troubleshoot a ladder program.

Instruction	Used To:	Page
JMP - Jump to Label	Jump forward/backward to a corresponding label instruction	277
LBL - Label		278
JSR - Jump to Subroutine	Jump to a designated subroutine and return	278
SBR - Subroutine Label		279
RET - Return from Subroutine		279
SUS - Suspend	Debug or diagnose your user program	280
TND - Temporary End	Abort current ladder scan	280
END - Program End	End a program or subroutine	281
MCR - Master Control Reset	Enable or inhibit a master control zone in your ladder program	281

JMP - Jump to Label

Q2:0
JMP

Instruction Type: output

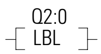
Execution Time for the JMP Instruction

Controller	When Rung Is:	
	True	False
MicroLogix 1200	1.0 µs	0.0 µs
MicroLogix 1500	1.0 µs	0.0 µs

The JMP instruction causes the controller to change the order of ladder execution. Jumps cause program execution to go to the rung marked LBL *label number*. Jumps can be forward or backward in ladder logic within the same program file. Multiple JMP instructions may cause execution to proceed to the same label.

The immediate data range for the label is from 0 to 999. The label is local to a program file.

LBL - Label



Instruction Type: input

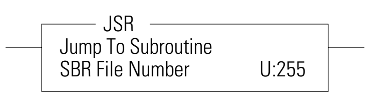
Execution Time for the LBL Instruction

Controller	When Rung Is:	
	True	False
MicroLogix 1200	1.0 µs	1.0 µs
MicroLogix 1500	1.0 µs	1.0 µs

The LBL instruction is used in conjunction with a jump (JMP) instruction to change the order of ladder execution. Jumps cause program execution to go to the rung marked LBL *label number*.

The immediate data range for the label is from 0 to 999. The label is local to a program file.

JSR - Jump to Subroutine



Instruction Type: output

Execution Time for the JSR Instruction

Controller	When Rung Is:	
	True	False
MicroLogix 1200	8.4 µs	0.0 µs
MicroLogix 1500	8.0 µs	0.0 µs

The JSR instruction causes the controller to start executing a separate subroutine file within a ladder program. JSR moves program execution to the designated subroutine (SBR *file number*). After executing the SBR, control proceeds to the instruction following the JSR instruction.

The immediate data range for the JSR file is from 3 to 255.

SBR - Subroutine Label

Instruction Type: input

Execution Time for the SBR Instruction

Controller	When Rung Is:	
	True	False
MicroLogix 1200	1.0 µs	1.0 µs
MicroLogix 1500	1.0 µs	1.0 µs

The SBR instruction is a label which is not used by the processor. It is for user subroutine identification purposes as the first rung for that subroutine. This instruction is the first instruction on a rung and is always evaluated as true.

RET - Return from Subroutine

Instruction Type: output

Execution Time for the RET Instruction

Controller	When Rung Is:	
	True	False
MicroLogix 1200	1.0 µs	0.0 µs
MicroLogix 1500	1.0 µs	0.0 µs

The RET instruction marks the end of subroutine execution or the end of the subroutine file. It causes the controller to resume execution at the instruction following the JSR instruction, user interrupt, or user fault routine that caused this subroutine to execute.

SUS - Suspend

Instruction Type: output

The SUS instruction is used to trap and identify specific conditions for program debugging and system troubleshooting. This instruction causes the processor to enter the suspend idle mode, causing all outputs to be de-energized. The suspend ID and the suspend file (program file number or subroutine file number identifying where the suspend instruction resides) are placed in the status file (S:7 and S:8).

The immediate data range for the suspend ID is from -32768 to 32767.

TND - Temporary End

Instruction Type: output

Execution Time for the TND Instruction

Controller	When Rung Is:	
	True	False
MicroLogix 1200	0.9 µs	0.0 µs
MicroLogix 1500	1.0 µs	0.0 µs

The TND instruction is used to denote a premature end-of-ladder program execution. The TND instruction cannot be executed from a STI subroutine, HSC subroutine, EII subroutine, or a user fault subroutine. This instruction may appear more than once in a ladder program.

On a true rung, TND stops the processor from scanning the rest of the program file. In addition, this instruction performs the output scan, input scan, and housekeeping aspects of the processor scan cycle prior to resuming scanning at rung 0 of the main program (file 2). If this instruction is executed in a nested subroutine, it terminates execution of all nested subroutines.

END - Program End

–⟨ END ⟩–

Instruction Type: output

The END instruction must appear at the end of every ladder program. For the main program file (file 2), this instruction ends the program scan. For a subroutine, interrupt, or user fault file, the END instruction causes a return from subroutine.

MCR - Master Control Reset

–⟨ MCR ⟩–

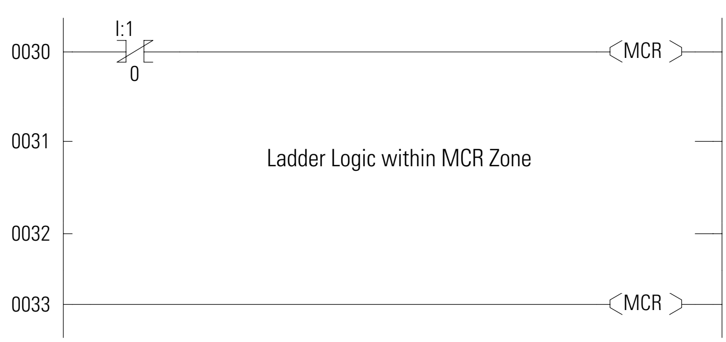
Instruction Type: output

Execution Time for the MCR Instructions

Controller	Instruction	When Rung Is:	
		True	False
MicroLogix 1200	MCR Start	1.2 µs	1.2 µs
	MCR End	1.6 µs	1.6 µs
MicroLogix 1500	MCR Start	0.8 µs	0.8 µs
	MCR End	1.0 µs	1.0 µs

The MCR instruction works in pairs to control the ladder logic found between those pairs. Rungs within the MCR zone are still scanned, but scan time is reduced due to the false state of non-retentive outputs. Non-retentive outputs are reset when the rung goes false.

This instruction defines the boundaries of an MCR Zone. An MCR Zone is the set of ladder logic instructions bounded by an MCR instruction pair. The start of an MCR zone is defined to be the rung that contains an MCR instruction preceded by conditional logic. The end of an MCR zone is defined to be the first rung containing just an MCR instruction following a start MCR zone rung as shown below.



While the rung state of the first MCR instruction is true, execution proceeds as if the zone were not present. When the rung state of the first MCR instruction is false, the ladder logic within the MCR zone is executed as if the rung is false. All non-retentive outputs within the MCR zone are reset.

MCR zones let you enable or inhibit segments of your program, such as for recipe applications.

When you program MCR instructions, note that:

- You must end the zone with an unconditional MCR instruction.
- You cannot nest one MCR zone within another.
- Do not jump into an MCR zone. If the zone is false, jumping into it activates the zone.

TIP The MCR instruction is not a substitute for a hard-wired master control relay that provides emergency stop capability. You still must install a hard-wired master control relay to provide emergency I/O power shutdown.

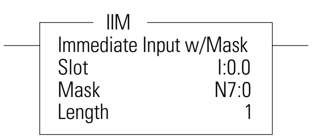
ATTENTION If you start instructions such as timers or counters in an MCR zone, instruction operation ceases when the zone is disabled. Re-program critical operations outside the zone if necessary.

Input and Output Instructions

The input and output instructions allow you to selectively update data without waiting for the input and output scans.

Instruction	Used To:	Page
IIM - Immediate Input with Mask	Update data prior to the normal input scan.	283
IOM - Immediate Output with Mask	Update outputs prior to the normal output scan.	285
REF - I/O Refresh	Interrupt the program scan to execute the I/O scan (write outputs, service communications, read inputs)	286

IIM - Immediate Input with Mask



Instruction Type: output

TIP This instruction is used for embedded I/O only. It is not designed to be used with expansion I/O.

Execution Time for the IIM Instruction

Controller	When Rung Is:	
	True	False
MicroLogix 1200	26.4 µs	0.0 µs
MicroLogix 1500	22.5 µs	0.0 µs

The IIM instruction allows you to selectively update input data without waiting for the automatic input scan. This instruction uses the following operands:

- **Slot** - This operand defines the location where data is obtained for updating the input file. The location specifies the slot number and the word where data is to be obtained. For example, if slot = I:0, input data from slot 0 starting at word 0 is masked and placed in input data file I:0 starting at word 0 for the specified length. If slot = I0.1, word 1 of slot 0 is used, and so on.

IMPORTANT	Slot 0 is the only valid slot number that can be used with this instruction. IIM cannot be used with expansion I/O.

- **Mask** - The mask is a hex constant or register address containing the mask value to be applied to the slot. If a given bit position in the mask is a “1”, the corresponding bit data from slot is passed to the input data file. A “0” prohibits corresponding bit data in slot from being passed to the input data file. The mask value can range from 0 to 0xFFFF.

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Real Input	Input Word															
Mask	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
Input Data File	Data is Not Updated								Updated to Match Input Word							

- **Length** - This is the number of masked words to transfer to the input data file.

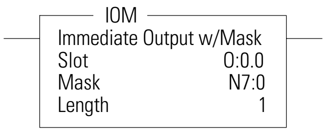
Addressing Modes and File Types can be used as shown below:

IIM Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files											Function Files									CS - Comms	IOS - I/O	DLS - Data Log	Address Mode			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI				Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Slot		•																							•			•		
Mask	•	•		•	•	•																		•	•	•		•		
Length																								•						

IOM - Immediate Output with Mask



Instruction Type: output

TIP This instruction is used for embedded I/O only. It is not designed to be used with expansion I/O.

Execution Time for the IOM Instruction

Controller	When Rung Is:	
	True	False
MicroLogix 1200	22.3 µs	0.0 µs
MicroLogix 1500 1764-LSP	18.4 µs	0.0 µs
MicroLogix 1500 1764-LRP	19.4 µs	0.0 µs

The IOM instruction allows you to selectively update output data without waiting for the automatic output scan. This instruction uses the following operands:

- **Slot** - The slot is the physical location that is updated with data from the output file.

IMPORTANT Slot 0 is the only valid slot number that can be used with this instruction. IOM cannot be used with expansion I/O.

- **Mask** - The mask is a hex constant or register address containing the mask value to be applied. If a given bit position in the mask is a “1”, the corresponding bit data is passed to the physical outputs. A “0” prohibits corresponding bit data from being passed to the outputs. The mask value can range from 0 to 0xFFFF.

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Output Data	Output Word															
Mask	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
Real Outputs	Data is Not Updated								Updated to Match Output Word							

- **Length** - This is the number of masked words to transfer to the outputs.

Addressing Modes and File Types can be used as shown below:

IOM Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files											Function Files									CS - Comms	IOS - I/O	DLS - Data Log	Address Mode			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI				Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Slot	•																								•			•		
Mask	•	•		•	•	•																		•	•	•		•		
Length																								•						

REF- I/O Refresh

–(REF)–

Instruction Type: output

Execution Time for the REF Instruction

Controller	When Rung Is:	
	True	False
MicroLogix 1200	see p. 469	0.0 µs
MicroLogix 1500	see p. 477	0.0 µs

The REF instruction is used to interrupt the program scan to execute the I/O scan and service communication portions of the operating cycle for all communication channels. This includes: write outputs, service communications (all communication channels, communications toggle push-button, DAT *[MicroLogix 1500 only]*, and comms housekeeping), and read inputs.

The REF instruction has no programming parameters. When it is evaluated as true, the program scan is interrupted to execute the I/O scan and service communication portions of the operating cycle. The scan then resumes at the instruction following the REF instruction.

The REF instruction cannot be executed from an STI subroutine, HSC subroutine, EII subroutine, or a user fault subroutine.

TIP Using an REF instruction may result in input data changing in the middle of a program scan. This condition needs to be evaluated when using the REF instruction.

ATTENTION

The watchdog and scan timers are reset when executing the REF instruction. You must insure that the REF instruction is not placed inside a non-terminating program loop. Do not place the REF instruction inside a program loop unless the program is thoroughly analyzed.

Notes:

Using Interrupts

Interrupts allow you to interrupt your program based on defined events. This chapter contains information about using interrupts, the interrupt instructions, and the interrupt function files. The chapter is arranged as follows:

See also: Using the High-Speed Counter and Programmable Limit Switch on page 109.

Information About Using Interrupts

The purpose of this section is to explain some fundamental properties of the User Interrupts, including:

- What is an interrupt?
- When can the controller operation be interrupted?
- Priority of User Interrupts
- Interrupt Latency
- User Fault Routine

What is an Interrupt?

An interrupt is an event that causes the controller to suspend the task it is currently performing, perform a different task, and then return to the suspended task at the point where it suspended. The Micrologix 1200 and MicroLogix 1500 support the following User Interrupts:

- User Fault Routine
- Event Interrupts (4)
- High-Speed Counter Interrupts[1]
- Selectable Timed Interrupt

An interrupt must be configured and enabled to execute. When any one of the interrupts is configured (and enabled) and subsequently occurs, the user program:

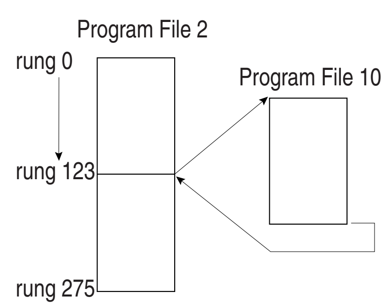
1. suspends its execution
2. performs a defined task based upon which interrupt occurred
3. returns to the suspended operation.

Interrupt Operation Example

Program File 2 is the main control program.

Program File 10 is the interrupt routine.

- An Interrupt Event occurs at rung 123.



(1) The MicroLogix 1200 has one HSC Interrupt, HSC0. The MicroLogix 1500 has two, HSC0 and HSC1.

Specifically, if the controller program is executing normally and an interrupt event occurs:

1. the controller stops its normal execution
2. determines which interrupt occurred
3. goes immediately to rung 0 of the subroutine specified for that User Interrupt
4. begins executing the User Interrupt subroutine (or set of subroutines if the specified subroutine calls a subsequent subroutine)
5. completes the subroutine(s)
6. resumes normal execution from the point where the controller program was interrupted

When Can the Controller Operation be Interrupted?

The Micrologix 1200 and 1500 controllers only allow interrupts to be serviced during certain periods of a program scan. They are:

- At the start of a ladder rung
- Anytime during End of Scan
- Between data words in an expansion I/O scan

The interrupt is only serviced by the controller at these opportunities. If the interrupt is disabled, the pending bit is set at the next occurrence of one of the three occasions listed above.

ATTENTION	If you enable interrupts during the program scan via an OTL, OTE, or UIE, this instruction (OTL, OTE, or UIE) *must* be the *last* instruction executed on the rung (last instruction on last branch). It is recommended this be the only output instruction on the rung.

Priority of User Interrupts

When multiple interrupts occur, the interrupts are serviced based upon their individual priority.

When an interrupt occurs and another interrupt(s) has already occurred but has not been serviced, the new interrupt is scheduled for execution based on its priority relative to the other pending interrupts. At the next point in time when an interrupt can be serviced, all the interrupts are executed in the sequence of highest priority to lowest priority.

If an interrupt occurs while a lower priority interrupt is being serviced (executed), the currently executing interrupt routine is suspended, and the higher priority interrupt is serviced. Then the lower priority interrupt is allowed to complete before returning to normal processing.

If an interrupt occurs while a higher priority interrupt is being serviced (executed), and the pending bit has been set for the lower priority interrupt, the currently executing interrupt routine continues to completion. Then the lower priority interrupt runs before returning to normal processing.

The priorities from highest to lowest are:

User Fault Routine	**highest priority**
Event Interrupt 0	
Event Interrupt 1	
High-Speed Counter Interrupt 0	
Event Interrupt 2	
Event Interrupt 3	
High-Speed Counter Interrupt 1 (*MicroLogix 1500 only.*)	
Selectable Timed Interrupt	**lowest priority**

Interrupt Latency

Interrupt Latency is defined as the worst case amount of time elapsed from when an interrupt occurs to when the interrupt subroutine starts to execute. The tables below show the interaction between an interrupt and the controller operating cycle.

Program Scan Activity	When an Interrupt Can Occur
Input Scan	Between word updates
Ladder Scan	Start of Rung
Output Scan	Between word updates
Communications Service	Anytime(1)(2)
Housekeeping	Anytime

(1) Communications Services includes 80 µs to get into a subroutine

(2) Communication Service includes 60 µs for a time tick.

To determine the interrupt latency:

1. First determine the execution time for the longest executing rung in your control program (maximum rung time). See MicroLogix 1200 Memory Usage and Instruction Execution Time on page 463 or MicroLogix 1500 Memory Usage and Instruction Execution Time on page 471 for more information.

2. Multiply the maximum rung time by the Communications Multiplier corresponding to your configuration in the MicroLogix 1200 Scan Time Worksheet on page 469, or MicroLogix 1500 Scan Time Worksheet on page 477.

Evaluate your results as follows:

Controller	If the time calculated in step 2 is:	Then the Interrupt Latency is:
MicroLogix 1200	less than 133 µs	411 µs
	greater than 133 µs	the value calculated in step 2 plus 278 µs
MicroLogix 1500	less than 100 µs	360 µs
	greater than 100 µs	the value calculated in step 2 plus 260 µs

User Fault Routine

The user fault routine gives you the option of preventing a controller shutdown when a specific user fault occurs. The fault routine is executed when any recoverable or non-recoverable user fault occurs. The fault routine is not executed for non-user faults.

Faults are classified as recoverable, non-recoverable, and non-user faults. A complete list of faults is shown in Fault Messages and Error Codes on page 507. The basic types of faults are described below:

Recoverable	Non-Recoverable	Non-User Fault
Recoverable Faults are caused by the user and may be recovered from by executing logic in the user fault routine. The user can attempt to clear the Major Error Halted bit, S:1/13. **Note:** You may initiate a MSG instruction from the controller to another device to identify the fault condition of the controller.	Non-Recoverable Faults are caused by the user, and cannot be recovered from. The user fault routine executes when this type of fault occurs. However, the fault cannot be cleared. **Note:** You may initiate a MSG instruction to another device to identify the fault condition of the controller.	Non-User Faults are caused by various conditions that cease ladder program execution. The user fault routine does not execute when this type of fault occurs.

Status File Data Saved

The Arithmetic Flags (Status File word S:0) are saved on entry to the user fault subroutine and re-written upon exiting the subroutine.

Creating a User Fault Subroutine

To use the user fault subroutine:

1. Create a subroutine file. Program Files 3 to 255 can be used.
2. Enter the file number in word S:29 of the status file.

Controller Operation

The occurrence of recoverable or non-recoverable faults causes the controller to read S:29 and execute the subroutine number identified by S:29. If the fault is recoverable, the routine can be used to correct the problem and clear the fault bit S:1/13. The controller then continues in its current executing mode. The routine does not execute for non-user faults.

User Interrupt Instructions

Instruction	Used To:	Page
INT - Interrupt Subroutine	Use this instruction to identify a program file as an interrupt subroutine (INT label) versus a regular subroutine (SBR label). This should be the first instruction in your interrupt subroutine.	295
STS - Selectable Timed Start	Use the STS (Selectable Timed Interrupt Start) instruction to the start the STI timer from the control program, rather than starting automatically.	296
UID - User Interrupt Disable	Use the User Interrupt Disable (UID) and the User Interrupt Enable (UIE) instructions to create zones in which I/O interrupts cannot occur.	297
UIE - User Interrupt Enable		299
UIF - User Interrupt Flush	Use the UIF instruction to remove selected pending interrupts from the system.	300

INT - Interrupt Subroutine

Instruction Type: input

Execution Time for the INT Instruction

Controller	When Rung Is:	
	True	False
MicroLogix 1200	1.0 µs	1.0 µs
MicroLogix 1500	1.0 µs	1.0 µs

The INT instruction is used as a label to identify a user interrupt service routine (ISR). This instruction is placed as the first instruction on a rung and is always evaluated as true. Use of the INT instruction is optional.

STS - Selectable Timed Start

Instruction Type: output

Execution Time for the STS Instruction

Controller	When Rung Is:	
	True	False
MicroLogix 1200	57.5 µs	0.0 µs
MicroLogix 1500	50.7 µs	0.0 µs

The STS instruction can be used to start and stop the STI function or to change the time interval between STI user interrupts. The STI instruction has one operand:

- **Time** - This is the amount of time (in milliseconds) which must expire prior to executing the selectable timed user interrupt. A value of zero disables the STI function. The time range is from 0 to 65,535 milliseconds.

The STS instruction applies the specified set point to the STI function as follows:

- If a zero set point is specified, the STI is disabled and STI:0/TIE is cleared (0).
- If the STI is disabled (not timing) and a value greater than 0 is entered into the set point, the STI starts timing to the new set point and STI:0/TIE is set (1).
- If the STI is currently timing and the set point is changed, the new setting takes effect immediately and the STI continues to time until it reaches the new set point.

  Note that if the new setting is less than the current accumulated time, the STI times-out immediately. For example, if the STI has been timing for 15 microseconds, and the STI set point is changed from 20 microseconds to 10 microseconds, an STI user interrupt occurs at the next start-of-rung.

Addressing Modes and File Types can be used as shown below:

STS Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files											Function Files									CS - Comms	IOS - I/O	DLS - Data Log	Address(1) Mode			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI				Immediate	Direct	Indirect	Element	Bit	Word	Long Word
Time	•	•		•	•	•																		•	•	•			•	

(1) See Important note about indirect addressing.

IMPORTANT	You cannot use indirect addressing with: S, ST, MG, PD, RTC, HSC, PTO, PWM, STI, EII, BHI, MMI, DAT, TPI, CS, IOS, and DLS files.

UID - User Interrupt Disable

Instruction Type: output

Execution Time for the UID Instruction

Controller	When Rung Is:	
	True	False
MicroLogix 1200	0.8 µs	0.0 µs
MicroLogix 1500	0.8 µs	0.0 µs

The UID instruction is used to disable selected user interrupts. The table below shows the types of interrupts with their corresponding disable bits:

Types of Interrupts Disabled by the UID Instruction

Interrupt	Element	Decimal Value	Corresponding Bit
EII - Event Input Interrupts	Event 0	64	bit 6
EII - Event Input Interrupts	Event 1	32	bit 5
HSC - High-Speed Counter	HSC0	16	bit 4
EII - Event Input Interrupts	Event 2	8	bit 3
EII - Event Input Interrupts	Event 3	4	bit 2
HSC - High-Speed Counter[1]	HSC1	2	bit 1
STI - Selectable Timed Interrupts	STI	1	bit 0
Note: Bits 7 to 15 must be set to zero.			

(1) The MicroLogix 1200 has one HSC Interrupt, HSC0. The MicroLogix 1500 has two, HSC0 and HSC1.

To disable interrupt(s):

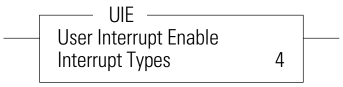
1. Select which interrupts you want to disable.
2. Find the Decimal Value for the interrupt(s) you selected.
3. Add the Decimal Values if you selected more than one type of interrupt.
4. Enter the sum into the UID instruction.

For example, to disable EII Event 1 and EII Event 3:

EII Event 1 = 32, EII Event 3 = 4

32 + 4 = 36 (enter this value)

UIE - User Interrupt Enable



Instruction Type: output

Execution Time for the UIE Instruction

Controller	When Rung Is:	
	True	False
MicroLogix 1200	0.8 µs	0.0 µs
MicroLogix 1500	0.8 µs	0.0 µs

The UIE instruction is used to enable selected user interrupts. The table below shows the types of interrupts with their corresponding enable bits:

Types of Interrupts Disabled by the UIE Instruction

Interrupt	Element	Decimal Value	Corresponding Bit
EII - Event Input Interrupts	Event 0	64	bit 6
EII - Event Input Interrupts	Event 1	32	bit 5
HSC - High-Speed Counter	HSC0	16	bit 4
EII - Event Input Interrupts	Event 2	8	bit 3
EII - Event Input Interrupts	Event 3	4	bit 2
HSC - High-Speed Counter(1)	HSC1	2	bit 1
STI - Selectable Timed Interrupts	STI	1	bit 0
Note: Bits 7 to 15 must be set to zero.			

(1) The MicroLogix 1200 has one HSC Interrupt, HSC0. The MicroLogix 1500 has two, HSC0 and HSC1.

To enable interrupt(s):

1. Select which interrupts you want to enable.
2. Find the Decimal Value for the interrupt(s) you selected.
3. Add the Decimal Values if you selected more than one type of interrupt.
4. Enter the sum into the UIE instruction.

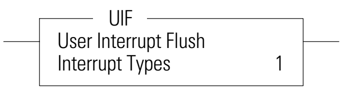
For example, to enable EII Event 1 and EII Event 3:

EII Event 1 = 32, EII Event 3 = 4
32 + 4 = 36 (enter this value)

ATTENTION

If you enable interrupts during the program scan via an OTL, OTE, or UIE, this instruction *must* be the *last* instruction executed on the rung (last instruction on last branch). It is recommended this be the only output instruction on the rung.

UIF - User Interrupt Flush



Instruction Type: output

Execution Time for the UIF Instruction

Controller	When Rung Is:	
	True	False
MicroLogix 1200	12.3 µs	0.0 µs
MicroLogix 1500	10.6 µs	0.0 µs

The UIF instruction is used to flush (remove pending interrupts from the system) selected user interrupts. The table below shows the types of interrupts with their corresponding flush bits:

Types of Interrupts Disabled by the UIF Instruction

Interrupt	Element	Decimal Value	Corresponding Bit
EII - Event Input Interrupts	Event 0	64	bit 6
EII - Event Input Interrupts	Event 1	32	bit 5
HSC - High-Speed Counter	HSC0	16	bit 4
EII - Event Input Interrupts	Event 2	8	bit 3
EII - Event Input Interrupts	Event 3	4	bit 2
HSC - High-Speed Counter(1)	HSC1	2	bit 1
STI - Selectable Timed Interrupts	STI	1	bit 0
Note: Bits 7 to 15 must be set to zero.			

(1) The MicroLogix 1200 has one HSC Interrupt, HSC0. The MicroLogix 1500 has two, HSC0 and HSC1.

To flush interrupt(s):

1. Select which interrupts you want to flush.
2. Find the Decimal Value for the interrupt(s) you selected.
3. Add the Decimal Values if you selected more than one type of interrupt.

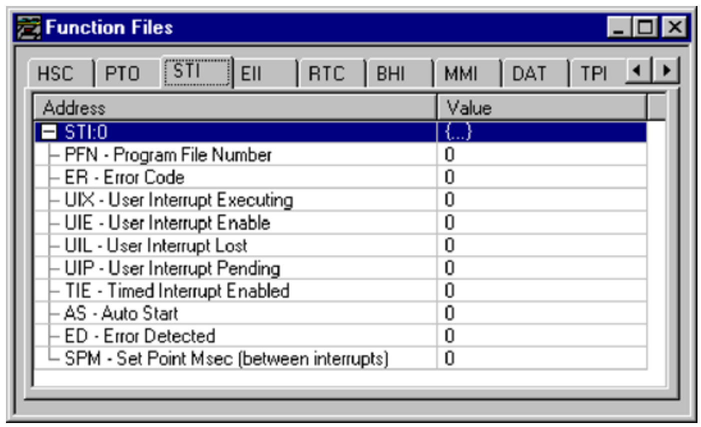
4. Enter the sum into the UIF instruction.

For example, to disable EII Event 1 and EII Event 3:

EII Event 1 = 32, EII Event 3 = 4

32 + 4 = 36 (enter this value)

Using the Selectable Timed Interrupt (STI) Function File



The Selectable Timed Interrupt (STI) provides a mechanism to solve time critical control requirements. The STI is a trigger mechanism that allows you to scan or solve control program logic that is time sensitive.

Example of where you would use the STI are:

- PID type applications, where a calculation must be performed at a specific time interval.
- A motion application, where the motion instruction (PTO) needs to be scanned at a specific rate to guarantee a consistent acceleration/deceleration profile.
- A block of logic that needs to be scanned more often.

How an STI is used is typically driven by the demands/requirements of the application. It operates using the following sequence:

1. The user selects a time interval.

2. When a valid interval is set and the STI is properly configured, the controller monitors the STI value.

3. When the time period has elapsed, the controller's normal operation is interrupted.

4. The controller then scans the logic in the STI program file.

5. When the STI file scan is completed, the controller returns to where it was prior to the interrupt and continues normal operation.

Selectable Time Interrupt (STI) Function File Sub-Elements Summary

Selectable Timed Interrupt Function File (STI:0)

Sub-Element Description	Address	Data Format	Type	User Program Access	For More Information
PFN - Program File Number	STI:0.PFN	word (INT)	control	read only	303
ER - Error Code	STI:0.ER	word (INT)	status	read only	303
UIX - User Interrupt Executing	STI:0/UIX	binary (bit)	status	read only	304
UIE - User Interrupt Enable	STI:0/UIE	binary (bit)	control	read/write	304
UIL - User Interrupt Lost	STI:0/UIL	binary (bit)	status	read/write	304
UIP - User Interrupt Pending	STI:0/UIP	binary (bit)	status	read only	306
TIE - Timed Interrupt Enabled	STI:0/TIE	binary (bit)	control	read/write	306
AS - Auto Start	STI:0/AS	binary (bit)	control	read only	306
ED - Error Detected	STI:0/ED	binary (bit)	status	read only	307
SPM - Set Point Msec	STI:0.SPM	word (INT)	control	read/write	307

STI Function File Sub-Elements

STI Program File Number (PFN)

Sub-Element Description	Address	Data Format	Type	User Program Access
PFN - Program File Number	STI:0.PFN	word (INT)	control	read only

The PFN (Program File Number) variable defines which subroutine is called (executed) when the timed interrupt times out. A valid subroutine file is any program file (3 to 255).

The subroutine file identified in the PFN variable is not a special file within the controller; it is programmed and operates the same as any other program file. From the control program perspective it is unique, in that it is automatically scanned based on the STI set point.

STI Error Code (ER)

Sub-Element Description	Address	Data Format	Type	User Program Access
ER - Error Code	STI:0.ER	word (INT)	status	read only

Error codes detected by the STI sub-system are displayed in this register. The table below explains the error codes.

STI Error Code

Error Code	Recoverable Fault (Controller)	Description
1	Invalid Program File Number	Program file number is less than 3, greater than 255, or does not exist.

STI User Interrupt Executing (UIX)

Sub-Element Description	Address	Data Format	Type	User Program Access
UIX - User Interrupt Executing	STI:0/UIX	binary (bit)	status	read only

The UIX (User Interrupt Executing) bit is set whenever the STI mechanism completes timing and the controller is scanning the STI PFN. The UIX bit is cleared when the controller completes processing the STI subroutine.

The STI UIX bit can be used in the control program as conditional logic to detect if an STI interrupt is executing.

STI User Interrupt Enable (UIE)

Sub-Element Description	Address	Data Format	Type	User Program Access
UIE - User Interrupt Enable	STI:0/UIE	binary (bit)	control	read/write

The UIE (User Interrupt Enable) bit is used to enable or disable STI subroutine processing. This bit must be set if you want the controller to process the STI subroutine at the configured time interval.

If you need to restrict when the STI subroutine is processed, clear the UIE bit. An example of when this is important is if a series of math calculations need to be processed without interruption. Before the calculations take place, clear the UIE bit. After the calculations are complete, set the UIE bit and STI subroutine processing resumes.

STI User Interrupt Lost (UIL)

Sub-Element Description	Address	Data Format	Type	User Program Access
UIL - User Interrupt Lost	STI:0/UIL	binary (bit)	status	read/write

The UIL (User Interrupt Lost) is a status flag that indicates an interrupt was lost. The controller can process 1 active and maintain up to 2 pending user interrupt conditions before it sets the lost bit.

This bit is set by the controller. It is up to the control program to utilize, track if necessary, and clear the lost condition.

STI User Interrupt Pending (UIP)

Sub-Element Description	Address	Data Format	Type	User Program Access
UIP - User Interrupt Pending	STI:0/UIP	binary (bit)	status	read only

The UIP (User Interrupt Pending) is a status flag that represents an interrupt is pending. This status bit can be monitored or used for logic purposes in the control program if you need to determine when a subroutine cannot execute immediately.

This bit is automatically set and cleared by the controller. The controller can process 1 active and maintain up to 2 pending user interrupt conditions before it sets the lost bit.

STI Timed Interrupt Enabled (TIE)

Sub-Element Description	Address	Data Format	Type	User Program Access
TIE - Timed Interrupt Enabled	STI:0/TIE	binary (bit)	control	read/write

The TIE (Timed Interrupt Enabled) control bit is used to enable or disable the timed interrupt mechanism. When set (1), timing is enabled, when clear (0) timing is disabled. If this bit is cleared (disabled) while the timer is running, the accumulated value is cleared (0). If the bit is then set (1), timing starts.

This bit is controlled by the user program and retains its value through a power cycle.

STI Auto Start (AS)

Sub-Element Description	Address	Data Format	Type	User Program Access
AS - Auto Start	STI:0/AS	binary (bit)	control	read only

The AS (Auto Start) is a control bit that can be used in the control program. The auto start bit is configured with the programming device and stored as part of the user program. The auto start bit automatically sets the STI Timed Interrupt Enable (TIE) bit when the controller enters any executing mode.

STI Error Detected (ED)

Sub-Element Description	Address	Data Format	Type	User Program Access
ED - Error Detected	STI:0/ED	binary (bit)	status	read only

The ED (Error Detected) flag is a status bit that can be used by the control program to detect if an error is present in the STI sub-system. The most common type of error that this bit represents is a configuration error. When this bit is set, the user should look at the error code in parameter STI:0.ER

This bit is automatically set and cleared by the controller.

STI Set Point Milliseconds Between Interrupts (SPM)

Sub-Element Description	Address	Data Format	Range	Type	User Program Access
SPM - Set Point Msec	STI:0.SPM	word (INT)	0 to 65,535	control	read/write

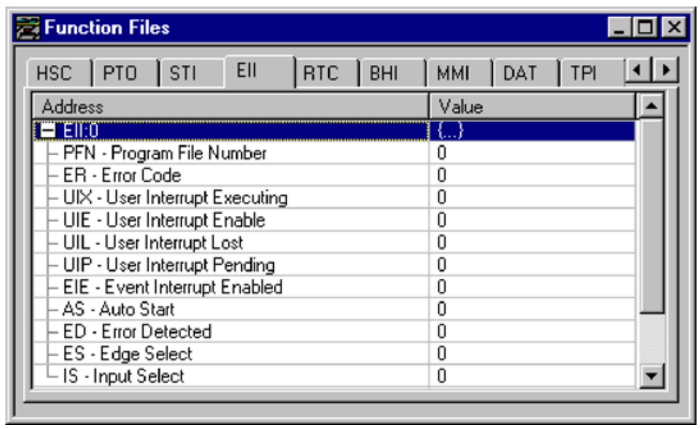
When the controller transitions to an executing mode, the SPM (set point in milliseconds) value is loaded into the STI. If the STI is configured correctly, and enabled, the program file identified in the STI variable PFN is scanned at this interval. This value can be changed from the control program by using the STS instruction.

TIP The minimum value cannot be less than the time required to scan the STI program file (STI:0.PFN) plus the Interrupt Latency.

Using the Event Input Interrupt (EII) Function File

The EII (event input interrupt) is a feature that allows the user to scan a specific program file (subroutine) when an input condition is detected from a field device.

Within the function file section of RSLogix 500, the user sees an EII folder. Within the folder are four EII elements. Each of these elements (EII:0, EII:1, EII:2, and EII:3) are identical; this explanation uses EII:0 as shown below.



Each EII can be configured to monitor any one of the first eight inputs (I1:0.0/0 to I1:0.0/7). Each EII can be configured to detect rising edge or falling edge input signals. When the configured input signal is detected at the input terminal, the controller immediately scans the configured subroutine.

Event Input Interrupt (EII) Function File Sub-Elements Summary

Event Input Interrupt Function File (EII:0)

Sub-Element Description	Address	Data Format	Type	User Program Access	For More Information
PFN - Program File Number	EII:0.PFN	word (INT)	control	read only	309
ER - Error Code	EII:0.ER	word (INT)	status	read only	309
UIX - User Interrupt Executing	EII:0/UIX	binary (bit)	status	read only	310
UIE - User Interrupt Enable	EII:0/UIE	binary (bit)	control	read/write	310
UIL - User Interrupt Lost	EII:0/UIL	binary (bit)	status	read/write	310
UIP - User Interrupt Pending	EII:0/UIP	binary (bit)	status	read only	311
EIE - Event Interrupt Enabled	EII:0/EIE	binary (bit)	control	read/write	312
AS - Auto Start	EII:0/AS	binary (bit)	control	read only	312

Event Input Interrupt Function File (EII:0)

Sub-Element Description	Address	Data Format	Type	User Program Access	For More Information
ED - Error Detected	EII:0/ED	binary (bit)	status	read only	312
ES - Edge Select	EII:0/ES	binary (bit)	control	read only	313
IS - Input Select	EII:0.IS	word (INT)	control	read only	313

EII Function File Sub-Elements

EII Program File Number (PFN)

Sub-Element Description	Address	Data Format	Type	User Program Access
PFN - Program File Number	EII:0.PFN	word (INT)	control	read only

PFN (Program File Number) defines which subroutine is called (executed) when the input terminal assigned to EII:0 detects a signal. A valid subroutine file is any program file (3 to 255).

The subroutine file identified in the PFN variable is not a special file within the controller. It is programmed and operated the same as any other program file. From the control program perspective it is unique, in that it is automatically scanned based on the configuration of the EII.

EII Error Code (ER)

Sub-Element Description	Address	Data Format	Type	User Program Access
ER - Error Code	EII:0.ER	word (INT)	status	read only

Any ER (Error Code) detected by the EII sub-system is displayed in this register. The table below explains the error codes.

EII Error Codes

Error Code	Recoverable Fault (Controller)	Description
1	Invalid Program File Number	Program file number is less than 3, greater than 255, or does not exist
2	Invalid Input Selection	Valid numbers must be 0, 1, 2, 3, 4, 5, 6, or 7.
3	Input Selection Overlap	EIIs cannot share inputs. Each EII must have a unique input.

EII User Interrupt Executing (UIX)

Sub-Element Description	Address	Data Format	Type	User Program Access
UIX - User Interrupt Executing	EII:0/UIX	binary (bit)	status	read only

The UIX (User Interrupt Executing) bit is set whenever the EII mechanism detects a valid input and the controller is scanning the PFN. The EII mechanism clears the UIX bit when the controller completes its processing of the EII subroutine.

The EII UIX bit can be used in the control program as conditional logic to detect if an EII interrupt is executing.

EII User Interrupt Enable (UIE)

Sub-Element Description	Address	Data Format	Type	User Program Access
UIE - User Interrupt Enable	EII:0/UIE	binary (bit)	control	read/write

The UIE (User Interrupt Enable) bit is used to enable or disable EII subroutine processing. This bit must be set if you want the controller to process the EII subroutine when an EII event occurs.

If you need to restrict when the EII subroutine is processed, clear the UIE bit. An example of when this is important is if a series of math calculations need to be processed without interruption. Before the calculations take place, clear the UIE bit. After the calculations are complete, set the UIE bit and EII subroutine processing resumes.

EII User Interrupt Lost (UIL)

Sub-Element Description	Address	Data Format	Type	User Program Access
UIL - User Interrupt Lost	EII:0/UIL	binary (bit)	status	read/write

UIL (User Interrupt Lost) is a status flag that represents an interrupt has been lost. The controller can process 1 active and maintain up to 2 pending user interrupt conditions before it sets the lost bit.

This bit is set by the controller. It is up to the control program to utilize, track, and clear the lost condition.

EII User Interrupt Pending (UIP)

Sub-Element Description	Address	Data Format	Type	User Program Access
UIP - User Interrupt Pending	EII:0/UIP	binary (bit)	status	read only

UIP (User Interrupt Pending) is a status flag that represents an interrupt is pending. This status bit can be monitored, or used for logic purposes, in the control program if you need to determine when a subroutine cannot execute immediately.

This bit is automatically set and cleared by the controller. The controller can process 1 active and maintain up to 2 pending user interrupt conditions before it sets the pending bit.

EII Event Interrupt Enable (EIE)

Sub-Element Description	Address	Data Format	Type	User Program Access
EIE - Event Interrupt Enabled	EII:0/EIE	binary (bit)	control	read/write

EIE (Event Interrupt Enabled) allows the event interrupt function to be enabled or disabled from the control program. When set (1), the function is enabled, when cleared (0, default) the function is disabled.

This bit is controlled by the user program and retains its value through a power cycle.

EII Auto Start (AS)

Sub-Element Description	Address	Data Format	Type	User Program Access
AS - Auto Start	EII:0/AS	binary (bit)	control	read only

AS (Auto Start) is a control bit that can be used in the control program. The auto start bit is configured with the programming device and stored as part of the user program. The auto start bit automatically sets the EII Event Interrupt Enable (EIE) bit when the controller enters any executing mode.

EII Error Detected (ED)

Sub-Element Description	Address	Data Format	Type	User Program Access
ED - Error Detected	EII:0/ED	binary (bit)	status	read only

The ED (Error Detected) flag is a status bit that can be used by the control program to detect if an error is present in the EII sub-system. The most common type of error that this bit represents is a configuration error. When this bit is set, look at the specific error code in parameter EII:0.ER

This bit is automatically set and cleared by the controller.

EII Edge Select (ES)

Sub-Element Description	Address	Data Format	Type	User Program Access
ES - Edge Select	EII:0/ES	binary (bit)	control	read only

The ES (Edge Select) bit selects the type of trigger that causes an Event Interrupt. This bit allows the EII to be configured for rising edge (off-to-on, 0-to-1) or falling edge (on-to-off, 1-to-0) signal detection. This selection is based on the type of field device that is connected to the controller.

The default condition is 1, which configures the EII for rising edge operation.

EII Input Select (IS)

Sub-Element Description	Address	Data Format	Type	User Program Access
IS - Input Select	EII:0.IS	word (INT)	control	read only

The IS (Input Select) parameter is used to configure each EII to a specific input on the controller. Valid inputs are 0 to 7, which correspond to I1:0.0/0 to I1:0.0/7.

This parameter is configured with the programming device and cannot be changed from the control program.

Notes:

Process Control Instruction

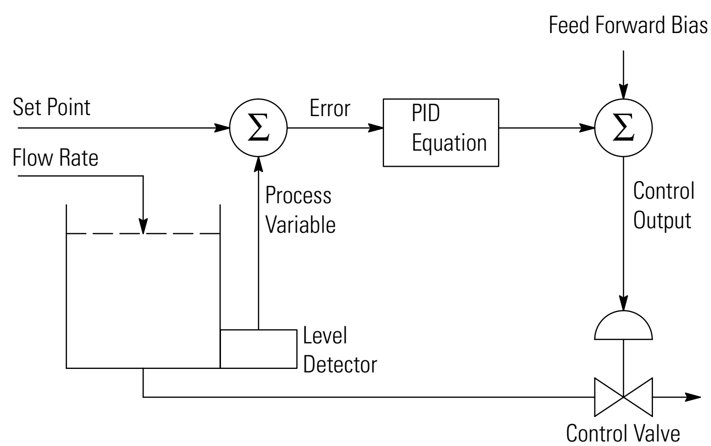
This chapter describes the MicroLogix 1200 and MicroLogix 1500 Proportional Integral Derivative (PID) instruction. The PID instruction is an output instruction that controls physical properties such as temperature, pressure, liquid level, or flow rate using process loops.

The PID Concept

The PID instruction normally controls a closed loop using inputs from an analog input module and providing an output to an analog output module. For temperature control, you can convert the analog output to a time proportioning on/off output for driving a heater or cooling unit. An example appears on page 337.

The PID instruction can be operated in the timed mode or the Selectable Time Interrupt (STI mode). In the timed mode, the instruction updates its output periodically at a user-selectable rate. In the STI mode, the instruction should be placed in an STI interrupt subroutine. It then updates its output every time the STI subroutine is scanned. The STI time interval and the PID loop update rate must be the same in order for the equation to execute properly. See Using the Selectable Timed Interrupt (STI) Function File on page 301 for more information on STI interrupts.

PID closed loop control holds a process variable at a desired set point. A flow rate/fluid level example is shown below.



The PID equation controls the process by sending an output signal to the control valve. The greater the error between the setpoint and process variable input, the greater the output signal. Alternately, the smaller the error, the smaller the output signal. An additional value (feed forward or bias) can be added to the control output as an offset. The PID result (control variable) drives the process variable toward the set point.

The PID Equation

The PID instruction uses the following algorithm:

Standard equation with dependent gains:

$$Output = K_C\left[(E) + \frac{1}{T_I}\int(E)dt + T_D \cdot \frac{d(PV)}{dt}\right] + bias$$

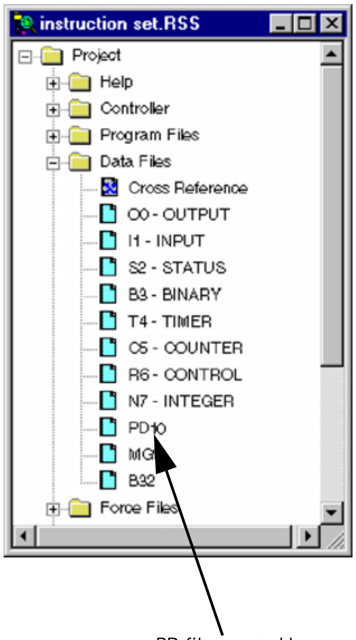
Standard Gains constants are:

Term	Range (Low to High)	Reference
Controller Gain K_C	0.01 to 327.67 (dimensionless)[1]	Proportional
Reset Term $1/T_I$	327.67 to 0.01 (minutes per repeat)[1]	Integral
Rate Term T_D	0.01 to 327.67 (minutes)[1]	Derivative

(1) Applies to MicroLogix 1200 and 1500 PID range when Reset and Gain Range (RG) bit is set to 1. For more information on reset and gain, see PLC 5 Gain Range (RG) on page 332.

The derivative term (rate) provides smoothing by means of a low-pass filter. The cut-off frequency of the filter is 16 times greater than the corner frequency of the derivative term.

PD Data File



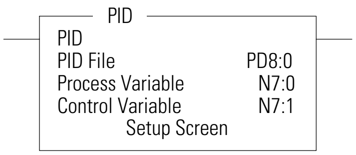
PD file created by RSLogix 500.

The PID instruction implemented by the MicroLogix 1200 and 1500 controllers is virtually identical in function to the PID implementation used by the Allen-Bradley SLC 5/03 and higher processors. Minor differences primarily involve enhancements to terminology. The major difference is that the PID instruction now has its own data file. In the SLC family of processors, the PID instruction operated as a block of registers within an integer file. The Micrologix 1200 and 1500 PID instruction utilizes a PD data file.

You can create a PD data file by creating a new data file and classifying it as a PD file type. RSLogix automatically creates a new PD file or a PD sub-element whenever a PID instruction is programmed on a rung. The PD file then appears in the list of Data Files as shown in the illustration.

Each PD data file has a maximum of 255 elements and each PID instruction requires a unique PD element. Each PD element is composed of 20 sub-elements, which include bit, integer and long integer data. All of the examples in this chapter use PD file 10 sub-element 0.

PID - Proportional Integral Derivative



Instruction Type: output

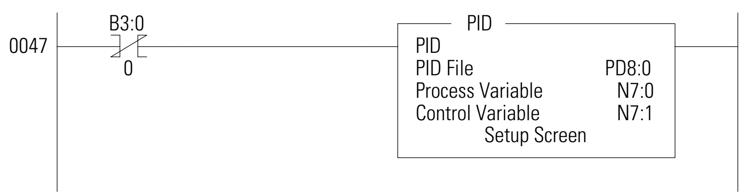
Execution Time for the PID Instruction

Controller	When Rung Is:	
	True	**False**
MicroLogix 1200	295.8 µs	11.0 µs
MicroLogix 1500	251.8 µs	8.9 µs

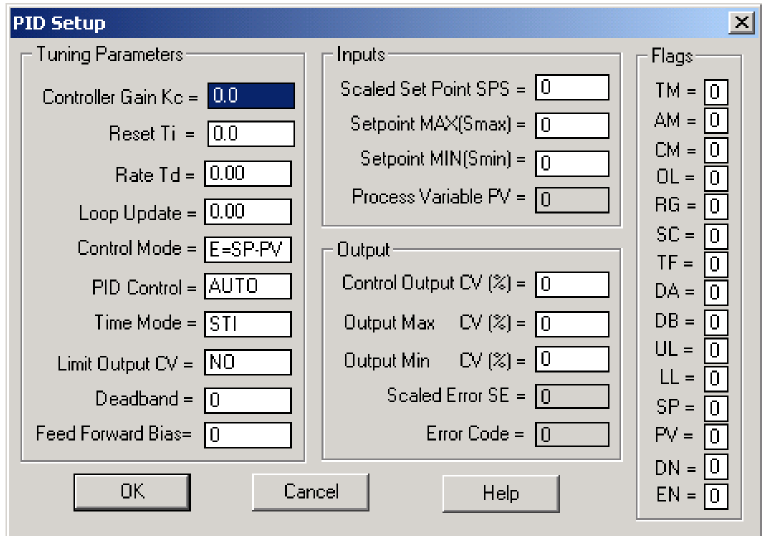
It is recommended that you place the PID instruction on a rung without any conditional logic. If conditional logic exists, the Control Variable output remains at its last value, and the CVP CV% term and integral term are both cleared when the rung is false.

TIP	In order to stop and restart the PID instruction, you need to create a false-to-true rung transition.

The example below shows a PID instruction on a rung with RSLogix 500 programming software.



When programming, the setup screen provides access to the PID instruction configuration parameters. The illustration below shows the RSLogix 500 setup screen.



Input Parameters

The table below shows the input parameter addresses, data formats, and types of user program access. See the indicated pages for descriptions of each parameter.

Input Parameter Descriptions	Address	Data Format	Range	Type	User Program Access	For More Information
SPS - Setpoint	PD10:0.SPS	word (INT)	0 to 16383(1)	control	read/write	320
PV - Process Variable	user defined	word (INT)	0 to 16383	control	read/write	320
MAXS - Setpoint Maximum	PD10:0.MAXS	word (INT)	-32,768 to +32,767	control	read/write	320
MINS - Setpoint Minimum	PD10:0.MINS	word (INT)	-32,768 to +32,767	control	read/write	321
OSP - Old Setpoint Value	PD10:0.OSP	word (INT)	-32,768 to +32,767	status	read only	321
OL - Output Limit	PD10:0/OL	binary	1 = enabled 0 = disabled	control	read/write	322
CVH - Control Variable High Limit	PD10:0.CVH	word (INT)	0 to 100%	control	read/write	322
CVL - Control Variable Low Limit	PD10:0.CVL	word (INT)	0 to 100%	control	read/write	323

(1) The range listed in the table is for when scaling is not enabled. With scaling, the range is from minimum scaled (MINS) to maximum scaled (MAXS).

Setpoint (SPS)

Input Parameter Descriptions	Address	Data Format	Range	Type	User Program Access
SPS - Setpoint	PD10:0.SPS	word (INT)	0 to 16383[1]	control	read/write

(1) The range listed in the table is for when scaling is not enabled. With scaling, the range is from minimum scaled (MINS) to maximum scaled (MAXS).

The SPS (Setpoint) is the desired control point of the process variable.

Process Variable (PV)

Input Parameter Descriptions	Address	Data Format	Range	Type	User Program Access
PV - Process Variable	user defined	word (INT)	0 to 16383	control	read/write

The PV (Process Variable) is the analog input variable.

Setpoint MAX (MAXS)

Input Parameter Descriptions	Address	Data Format	Range	Type	User Program Access
MAXS - Setpoint Maximum	PD10:0.MAXS	word (INT)	-32,768 to +32,767	control	read/write

If the SPV is read in engineering units, then the MAXS (Setpoint Maximum) parameter corresponds to the value of the setpoint in engineering units when the control input is at its maximum value.

Setpoint MIN (MINS)

Input Parameter Descriptions	Address	Data Format	Range	Type	User Program Access
MINS - Setpoint Minimum	PD10:0.MINS	word (INT)	-32,768 to +32,767	control	read/write

If the SPV is read in engineering units, then the MINS (Setpoint Minimum) parameter corresponds to the value of the setpoint in engineering units when the control input is at its minimum value.

TIP *MinS - MaxS* scaling allows you to work in engineering units. The deadband, error, and SPV are also displayed in engineering units. The process variable, PV, must be within the range of 0 to 16383. Use of *MinS - MaxS* does not minimize PID PV resolution.

Scaled errors greater than +32767 or less than -32768 cannot be represented. If the scaled error is greater than +32767, it is represented as +32767. If the scaled error is less than -32768, it is represented as -32768.

Old Setpoint Value (OSP)

Input Parameter Descriptions	Address	Data Format	Range	Type	User Program Access
OSP - Old Setpoint Value	PD10:0.OSP	word (INT)	-32,768 to +32,767	status	read only

The OSP (Old Setpoint Value) is substituted for the current setpoint, if the current setpoint goes out of range of the setpoint scaling (limiting) parameters.

Output Limit (OL)

Output Parameter Descriptions	Address	Data Format	Range	Type	User Program Access
OL - Output Limit	PD10:0/OL	binary	1 = enabled 0 = disabled	control	read/write

An enabled (1) value enables output limiting to the values defined in PD10:0.CVH (Control Variable High) and PD10.0.CVL (Control Variable Low).

A disabled (0) value disables OL (Output Limiting).

Control Variable High Limit (CVH)

Output Parameter Descriptions	Address	Data Format	Range	Type	User Program Access
CVH - Control Variable High Limit	PD10:0.CVH	word (INT)	0 to 100%	control	read/write

When the output limit bit (PD10:0/OL) is enabled (1), the CVH (Control Value High) you enter is the maximum output (in percent) that the control variable attains. If the calculated CV exceeds the CVH, the CV is set (overridden) to the CVH value you entered and the upper limit alarm bit (UL) is set.

When the output limit bit (PD10:0/OL) is disabled (0), the CVH value you enter determines when the upper limit alarm bit (UL) is set.

If CV exceeds the maximum value, the output is not overridden and the upper limit alarm bit (UL) is set.

Control Variable Low Limit (CVL)

Output Parameter Descriptions	Address	Data Format	Range	Type	User Program Access
CVL - Control Variable Low Limit	PD10:0.CVL	word (INT)	0 to 100%	control	read/write

When the output limit bit (PD10:0/OL) is enabled (1), the CVL (Control Value Low) you enter is the minimum output (in percent) that the Control Variable attains. If the calculated CV is below the minimum value, the CV is set (overridden) to the CVL value you entered and the lower limit alarm bit (LL) is set.

When the output limit bit (PD10:0/OL) is disabled (0), the CVL value you enter determines when the lower limit alarm bit (LL) is set. If CV is below the minimum value, the output is not overridden and the lower limit alarm bit (LL) is set.

Output Parameters

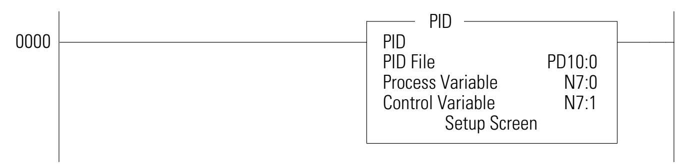
The table below shows the output parameter addresses, data formats, and types of user program access. See the indicated pages for descriptions of each parameter.

Output Parameter Descriptions	Address	Data Format	Range	Type	User Program Access	For More Information
CV - Control Variable	User-defined	word (INT)	0 to 16,383	control	read/write	324
CVP - Control Variable Percent	PD10:0.CVP	word (INT)	0 to 100	control	read/write	324
SPV - Scaled Process Variable	PD10:0.SPV	word (INT)	0 to 16383	status	read only	325

Control Variable (CV)

Output Parameter Descriptions	Address	Data Format	Range	Type	User Program Access
CV - Control Variable	User-defined	word (INT)	0 to 16,383	control	read/write

The CV (Control Variable) is user-defined. See the ladder rung below.



Control Variable Percent (CVP)

Output Parameter Descriptions	Address	Data Format	Range	Type	User Program Access
CVP - Control Variable Percent	PD10:0.CVP	word (INT)	0 to 100	control	status read

CVP (Control Variable Percent) displays the control variable as a percentage. The range is 0 to 100%.

If the PD10:0/AM bit is off (automatic mode), CVP tracks the control variable (CV) output being calculated by the PID equation.

If the PD10:0/AM bit is on (manual mode), CVP tracks the value that can be manipulated in the Control Variable (CV) data word.

The only way for a programmer to have control of the PID CV is to place the PID instruction in manual mode and write to the CV word via the control program or programming software. If no change is made to CV while in manual mode, the CVP will display the last value calculated by the PID equation.

Scaled Process Variable (SPV)

Input Parameter Descriptions	Address	Data Format	Range	Type	User Program Access
SPV - Scaled Process Variable	PD10:0.SPV	word (INT)	0 to 16383	status	read only

The SPV (Scaled Process Variable) is the analog input variable. If scaling is enabled, the range is the minimum scaled value (MinS) to maximum scaled value (MaxS).

If the SPV is configured to be read in engineering units, then this parameter corresponds to the value of the process variable in engineering units. See Analog I/O Scaling on page 337 for more information on scaling.

Tuning Parameters

The table below shows the tuning parameter addresses, data formats, and types of user program access. See the indicated pages for descriptions of each parameter.

Tuning Parameter Descriptions	Address	Data Format	Range	Type	User Program Access	For More Information
KC - Controller Gain - K_c	PD10:0.KC	word (INT)	0 to 32,767	control	read/write	327
TI - Reset Term - T_i	PD10:0.Ti	word (INT)	0 to 32,767	control	read/write	327
TD - Rate Term - T_d	PD 10:0.TD	word (INT)	0 to 32,767	control	read/write	327
TM - Time Mode	PD10:0.TM	binary	0 or 1	control	read/write	329
LUT - Loop Update Time	PD10:0.LUT	word (INT)	1 to 1024	control	read/write	329
ZCD - Zero Crossing Deadband	PD10:0.ZCD	word (INT)	0 to 32,767	control	read/write	330
FF - Feed Forward Bias	PD10:0.FF	word (INT)	-16,383 to +16,383	control	read/write	330
SE - Scaled Error	PD10:0.SE	word (INT)	-32,768 to +32,767	status	read only	330
AM - Automatic/Manual	PD10:0/AM	binary (bit)	0 or 1	control	read/write	331
CM - Control Mode	PD10:0/CM	binary (bit)	0 or 1	control	read/write	331
DB - PV in Deadband	PD10:0/DB	binary (bit)	0 or 1	status	read/write	331
RG - PLC 5 Gain Range	PD10:0/RG	binary (bit)	0 or 1	control	read/write	332
SC - Setpoint Scaling	PD10:0/SC	binary (bit)	0 or 1	control	read/write	332
TF - Loop Update Too Fast	PD10:0/TF	binary (bit)	0 or 1	status	read/write	333
DA - Derivative Action Bit	PD10:0/DA	binary (bit)	0 or 1	control	read/write	333
UL - CV Upper Limit Alarm	PD10:0/UL	binary (bit)	0 or 1	status	read/write	333
LL - CV Lower Limit Alarm	PD10:0/LL	binary (bit)	0 or 1	status	read/write	334
SP - Setpoint Out of Range	PD10:0/SP	binary (bit)	0 or 1	status	read/write	334
PV - PV Out of Range	PD10:0/PV	binary (bit)	0 or 1	status	read/write	334
DN - Done	PD10:0/DN	binary (bit)	0 or 1	status	read only	334
EN - Enable	PD10:0/EN	binary (bit)	0 or 1	status	read only	335
IS - Integral Sum	PD10:0.IS	long word (32-bit INT)	-2,147,483,648 to 2,147,483,647	status	read/write	335
AD - Altered Derivative Term	PD10:0.AD	long word (32-bit INT)	-2,147,483,648 to 2,147,483,647	status	read only	335

Controller Gain (K_c)

Tuning Parameter Descriptions	Address	Data Format	Range	Type	User Program Access
KC - Controller Gain - K_c	PD10:0.KC	word (INT)	0 to 32,767	control	read/write

Gain K_c (word 3) is the proportional gain, ranging from 0 to 3276.7 (when RG = 0), or 0 to 327.67 (when RG = 1). Set this gain to one-half the value needed to cause the output to oscillate when the reset and rate terms (below) are set to zero.

TIP Controller gain is affected by the reset and gain range (RG) bit. For information, see PLC 5 Gain Range (RG) on page 332.

Reset Term (T_i)

Tuning Parameter Descriptions	Address	Data Format	Range	Type	User Program Access
TI - Reset Term - T_i	PD10:0.Ti	word (INT)	0 to 32,767	control	read/write

Reset T_i (word 4) is the Integral gain, ranging from 0 to 3276.7 (when RG = 0), or 327.67 (when RG = 1) minutes per repeat. Set the reset time equal to the natural period measured in the above gain calibration. A value of 1 adds the maximum integral term into the PID equation.

TIP Reset term is affected by the reset and gain range (RG) bit. For information, see PLC 5 Gain Range (RG) on page 332.

Rate Term (T_d)

Tuning Parameter Descriptions	Address	Data Format	Range	Type	User Program Access
TD - Rate Term - T_d	PD 10:0.TD	word (INT)	0 to 32,767	control	read/write

Rate T_d (word 5) is the Derivative term. The adjustment range is 0 to 327.67 minutes. Set this value to 1/8 of the integral gain T_i.

TIP This word is not effected by the reset and gain range (RG) bit. For information, see PLC 5 Gain Range (RG) on page 332.

Time Mode (TM)

Tuning Parameter Descriptions	Address	Data Format	Range	Type	User Program Access
TM - Time Mode	PD10:0.TM	binary	0 or 1	control	read/write

The time mode bit specifies when the PID is in timed mode (1) or STI mode (0). This bit can be set or cleared by instructions in your ladder program.

When set for timed mode, the PID updates the CV at the rate specified in the loop update parameter (PD10:0.LUT).

When set for STI mode, the PID updates the CV every time the PID instruction is scanned in the control program. When you select STI, program the PID instruction in the STI interrupt subroutine. The STI routine should have a time interval equal to the setting of the PID "loop update" parameter (PD10:0.LUT). Set the STI period in word STI:0.SPM. For example, if the loop update time contains the value 10 (for 100 ms), then the STI time interval must also equal 100 (for 100 ms).

TIP When using timed mode, your processor scan time should be at least ten times faster than the loop update time to prevent timing inaccuracies or disturbances.

Loop Update Time (LUT)

Tuning Parameter Descriptions	Address	Data Format	Range	Type	User Program Access
LUT - Loop Update Time	PD10:0.LUT	word (INT)	1 to 1024	control	read/write

The loop update time (word 13) is the time interval between PID calculations. The entry is in 0.01 second intervals. Enter a loop update time five to ten times faster than the natural period of the load. The natural period of the load is determined by setting the reset and rate parameters to zero and then increasing the gain until the output begins to oscillate. When in STI mode, this value must equal the STI time interval value loaded in STI:0.SPM. The valid range is 0.01 to 10.24 seconds.

Zero Crossing Deadband (ZCD)

Tuning Parameter Descriptions	Address	Data Format	Range	Type	User Program Access
ZCD - Zero Crossing Deadband	PD10:0.ZCD	word (INT)	0 to 32,767	control	read/write

The deadband extends above and below the setpoint by the value entered. The deadband is entered at the zero crossing of the process variable and the setpoint. This means that the deadband is in effect only after the process variable enters the deadband *and* passes through the setpoint.

The valid range is 0 to the scaled maximum, or 0 to 16,383 when no scaling exists.

Feed Forward Bias (FF)

Tuning Parameter Descriptions	Address	Data Format	Range	Type	User Program Access
FF - Feed Forward Bias	PD10:0.FF	word (INT)	-16,383 to +16,383	control	read/write

The feed forward bias is used to compensate for disturbances that may affect the CV output.

Scaled Error (SE)

Tuning Parameter Descriptions	Address	Data Format	Range	Type	User Program Access
SE - Scaled Error	PD10:0.SE	word (INT)	-32,768 to +32,767	status	read only

Scaled error is the difference between the process variable and the setpoint. The format of the difference (E = SP-PV or E = PV-SP) is determined by the control mode (CM) bit. See Control Mode (CM) on page 331.

Automatic / Manual (AM)

Tuning Parameter Descriptions	Address	Data Format	Range	Type	User Program Access
AM - Automatic/Manual	PD10:0/AM	binary (bit)	0 or 1	control	read/write

The auto/manual bit can be set or cleared by instructions in your ladder program. When off (0), it specifies automatic operation. When on (1), it specifies manual operation. In automatic operation, the instruction controls the control variable (CV). In manual operation, the user/control program controls the CV. During tuning, set this bit to manual.

TIP Output limiting is also applied when in manual.

Control Mode (CM)

Tuning Parameter Descriptions	Address	Data Format	Range	Type	User Program Access
CM - Control Mode	PD10:0/CM	binary (bit)	0 or 1	control	read/write

Control mode, or forward-/reverse-acting, toggles the values E=SP-PV and E=PV-SP.

Forward acting (E=PV-SP) causes the control variable to increase when the process variable is greater than the setpoint.

Reverse acting (E=SP-PV) causes the control variable to decrease when the process variable is greater than the setpoint.

PV in Deadband (DB)

Tuning Parameter Descriptions	Address	Data Format	Range	Type	User Program Access
DB - PV in Deadband	PD10:0/DB	binary (bit)	0 or 1	status	read/write

This bit is set (1) when the process variable is within the zero-crossing deadband range.

PLC 5 Gain Range (RG)

Tuning Parameter Descriptions	Address	Data Format	Range	Type	User Program Access
RG - PLC 5 Gain Range	PD10:0/RG	binary (bit)	0 or 1	control	read/write

When set (1), the reset (TI) and gain range enhancement bit (RG) causes the reset minute/repeat value and the gain multiplier (KC) to be divided by a factor of 10. That means a reset multiplier of 0.01 and a gain multiplier of 0.01.

When clear (0), this bit allows the reset minutes/repeat value and the gain multiplier value to be evaluated with a reset multiplier of 0.1 and a gain multiplier of 0.1.

Example with the RG bit set: The reset term (TI) of 1 indicates that the integral value of 0.01 minutes/repeat (0.6 seconds/repeat) is applied to the PID integral algorithm. The gain value (KC) of 1 indicates that the error is multiplied by 0.01 and applied to the PID algorithm.

Example with the RG bit clear: The reset term (TI) of 1 indicates that the integral value of 0.1 minutes/repeat (6.0 seconds/repeat) is applied to the PID integral algorithm. The gain value (KC) of 1 indicates that the error is multiplied by 0.1 and applied to the PID algorithm.

TIP The rate multiplier (TD) is not affected by this selection.

Setpoint Scaling (SC)

Tuning Parameter Descriptions	Address	Data Format	Range	Type	User Program Access
SC - Setpoint Scaling	PD10:0/SC	binary (bit)	0 or 1	control	read/write

The SC bit is cleared when setpoint scaling values are specified.

Loop Update Too Fast (TF)

Tuning Parameter Descriptions	Address	Data Format	Range	Type	User Program Access
TF - Loop Update Too Fast	PD10:0/TF	binary (bit)	0 or 1	status	read/write

The TF bit is set by the PID algorithm if the loop update time specified cannot be achieved by the controller due to scan time limitations.

If this bit is set, correct the problem by updating your PID loop at a slower rate or move the PID instruction to an STI interrupt routine. Reset and rate gains will be in error if the instruction operates with this bit set.

Derivative Action Bit (DA)

Tuning Parameter Descriptions	Address	Data Format	Range	Type	User Program Access
DA - Derivative Action Bit	PD10:0/DA	binary (bit)	0 or 1	control	read/write

When set (1), the derivative (rate) action (DA) bit causes the derivative (rate) calculation to be evaluated on the error instead of the process variable (PV). When clear (0), this bit allows the derivative (rate) calculation to be evaluated where the derivative is performed on the PV.

CV Upper Limit Alarm (UL)

Tuning Parameter Descriptions	Address	Data Format	Range	Type	User Program Access
UL - CV Upper Limit Alarm	PD10:0/UL	binary (bit)	0 or 1	status	read/write

The control variable upper limit alarm bit is set when the calculated CV output exceeds the upper CV limit.

CV Lower Limit Alarm (LL)

Tuning Parameter Descriptions	Address	Data Format	Range	Type	User Program Access
LL - CV Lower Limit Alarm	PD10:0/LL	binary (bit)	0 or 1	status	read/write

The control variable lower limit alarm bit is set (1) when the calculated CV output is less than the lower CV limit.

Setpoint Out Of Range (SP)

Tuning Parameter Descriptions	Address	Data Format	Range	Type	User Program Access
SP - Setpoint Out of Range	PD10:0/SP	binary (bit)	0 or 1	status	read/write

This bit is set (1) when the setpoint:

- exceeds the maximum scaled value, or
- is less than the minimum scaled value.

PV Out Of Range (PV)

Tuning Parameter Descriptions	Address	Data Format	Range	Type	User Program Access
PV - PV Out of Range	PD10:0/PV	binary (bit)	0 or 1	status	read/write

The process variable out of range bit is set (1) when the unscaled process variable

- exceeds 16,383, or
- is less than zero.

Done (DN)

Tuning Parameter Descriptions	Address	Data Format	Range	Type	User Program Access
DN - Done	PD10:0/DN	binary (bit)	0 or 1	status	read only

The PID done bit is set (1) for one scan when the PID algorithm is computed. It resets (0) whenever the instruction is scanned and the PID algorithm was not computed (applies to timed mode only).

Enable (EN)

Tuning Parameter Descriptions	Address	Data Format	Range	Type	User Program Access
EN - Enable	PD10:0/EN	binary (bit)	0 or 1	status	read only

The PID enabled bit is set (1) whenever the PID instruction is enabled. It follows the rung state.

Integral Sum (IS)

Tuning Parameter Descriptions	Address	Data Format	Range	Type	User Program Access
IS - Integral Sum	PD10:0.IS	long word (32-bit INT)	-2,147,483,648 to 2,147,483,647	status	read/write

This is the result of the integration $\frac{K_C}{T_I}\int E(dt)$.

Altered Derivative Term (AD)

Tuning Parameter Descriptions	Address	Data Format	Range	Type	User Program Access
AD - Altered Derivative Term	PD10:0.AD	long word (32-bit INT)	-2,147,483,648 to 2,147,483,647	status	read only

This long word is used internally to track the change in the process variable within the loop update time.

Runtime Errors

Error code 0036 appears in the status file when a PID instruction runtime error occurs. Code 0036 covers the following PID error conditions, each of which has been assigned a unique single byte code value that appears in the MSB of the second word of the control block. The error code is also displayed on the PID Setup Screen in RSLogix 500.

Error Code	Description of Error Condition or Conditions	Corrective Action
11H	1. Loop update time $D_t > 1024$	Change loop update time $0 < D_t \leq 1024$
	2. Loop update time $D_t = 0$	
12H	Proportional gain $K_c < 0$	Change proportional gain K_c to $0 < K_c$
13H	Integral gain (reset) $T_i < 0$	Change integral gain (reset) T_i to $0 \leq T_i$
14H	Derivative gain (rate) $T_d < 0$	Change derivative gain (rate) T_d to $0 \leq T_d$
15H	Feed Forward Bias (FF) is out-of-range.	Change FF so it is within the range -16383 to +16383.
23H	Scaled setpoint min MinS > Scaled setpoint max MaxS	Change scaled setpoint min MinS to -32768 ≤ MinS ≤ MaxS ≤ +32767
31H	If you are using setpoint scaling and MinS > setpoint SP > MaxS, or If you are not using setpoint scaling and 0 > setpoint SP > 16383, then during the initial execution of the PID loop, this error occurs and bit 11 of word 0 of the control block is set. However, during subsequent execution of the PID loop if an invalid loop setpoint is entered, the PID loop continues to execute using the old setpoint, and bit 11 of word 0 of the control block is set.	If you are using setpoint scaling, then change the setpoint SP to MinS ≤ SP ≤ MaxS, or If you are not using setpoint scaling, then change the setpoint SP to 0 ≤ SP ≤ 16383.
41H	**Scaling Selected** 1. Deadband < 0, or 2. Deadband > (MaxS – MinS) **Scaling Deselected** 1. Deadband < 0, or 3. Deadband > 16383	**Scaling Selected** Change deadband to 0 ≤ deadband ≤ (MaxS - MinS) ≤ 16383 **Scaling Deselected** Change deadband to 0 ≤ deadband ≤ 16383
51H	1. Output high limit < 0, or 2. Output high limit > 100	Change output high limit to 0 ≤ output high limit ≤ 100
52H	1. Output low limit < 0, or 2. Output low limit > 100	Change output low limit to 0 ≤ output low limit ≤ output high limit ≤ 100
53H	Output low limit > output high limit	Change output low limit to 0 ≤ output low limit ≤ output high limit ≤ 100

Analog I/O Scaling

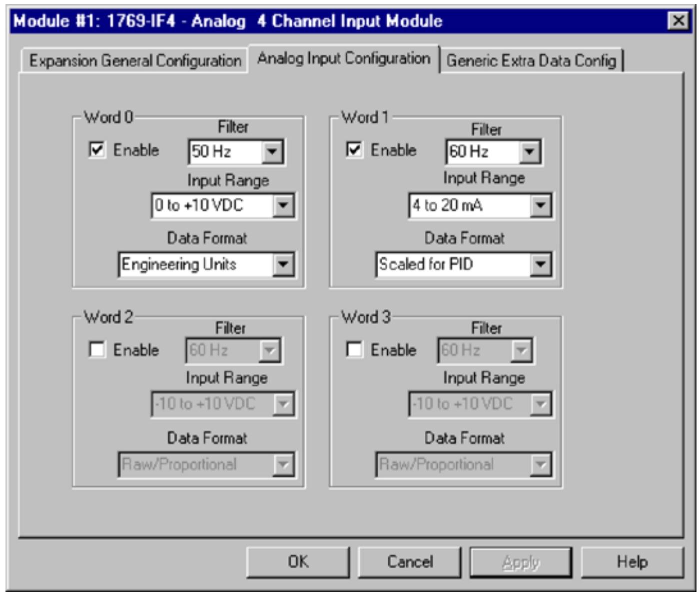
To configure an analog input for use in a PID instruction, the analog data must be scaled to match the PID instruction parameters. In the MicroLogix 1200 and 1500, the process variable (PV) in the PID instruction is designed to work with a data range of 0 to 16,383. The 1769 Compact I/O analog modules (1769-IF4 and 1769-OF2) are capable of on-board scaling. Scaling data is required to match the range of the analog input to the input range of the PID instruction. The ability to perform scaling in the I/O modules reduces the amount of programming required in the system and makes PID setup much easier.

The example shows a 1769-IF4 module. The IF4 has 4 inputs, which are individually configurable. In this example, analog input 0 is configured for 0 to 10V and is scaled in engineering units. Word 0 is not being used in a PID instruction. Input 1 (word 1) is configured for 4 to 20 mA operation with scaling configured for a PID instruction. This configures the analog data for the PID instruction.

Field Device Input Signal	Analog Register Scaled Data
> 20.0 mA	16,384 to 17,406
20.0 mA	16,383
4.0 mA	0
< 4.0 mA	-819 to -1

The analog configuration screen is accessed from within RSLogix 500. Simply double click on the I/O configuration item in the “Controller” folder, and then double click on the specific I/O module.

The configuration for the analog output is virtually identical. Simply address the PID control variable (CV) to the analog output address and configure the analog output to “Scaled for PID” behavior.



Application Notes

The following paragraphs discuss:

- Input/Output Ranges
- Scaling to Engineering Units
- Zero-crossing Deadband
- Output Alarms
- Output Limiting with Anti-reset Windup
- The Manual Mode
- Feed Forward

ATTENTION

Do not alter the state of any PID control block value unless you fully understand its function and how it will affect your process. Unexpected operation could result with possible equipment damage and/or personal injury.

Input/Output Ranges

The input module measuring the process variable (PV) must have a full scale binary range of 0 to 16383. If this value is less than 0 (bit 15 set), then a value of zero is used for PV and the “Process var out of range” bit is set (bit 12 of word 0 in the control block). If the process variable is greater than 16383 (bit 14 set), then a value of 16383 is used for PV and the “Process var out of range” bit is set.

The Control Variable, calculated by the PID instruction, has the same range of 0 to 16383. The Control Output (word 16 of the control block) has the range of 0 to 100%. You can set lower and upper limits for the instruction's calculated output values (where an upper limit of 100% corresponds to a Control Variable limit of 16383).

Scaling to Engineering Units

Scaling lets you enter the setpoint and zero-crossing deadband values in engineering units, and display the process variable and error values in the same engineering units. Remember, the process variable PV must still be within the range 0 to 16383. The PV is displayed in engineering units, however.

Select scaling as follows:

1. Enter the maximum and minimum scaling values MaxS and MinS in the PID control block. The MinS value corresponds to an analog value of zero for the lowest reading of the process variable. MaxS corresponds to an analog value of 16383 for the highest reading. These values reflect the process limits. Setpoint scaling is selected by entering a non-zero value for one or both parameters. If you enter the same value for both parameters, setpoint scaling is disabled.

   For example, if measuring a full scale temperature range of -73°C (PV=0) to +1156°C (PV=16383), enter a value of -73 for MinS and 1156 for MaxS. Remember that inputs to the PID instruction must be 0 to 16383. Signal conversions could be as follows:

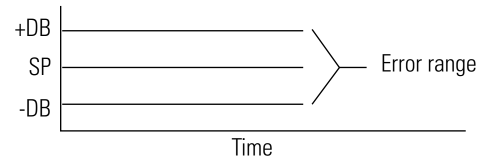
Example Values	
Process limits	-73 to +1156°C
Transmitter output (if used)	+4 to +20 mA
Output of analog input module	0 to 16383
PID instruction, MinS to MaxS	-73 to +1156°C

2. Enter the setpoint (word 2) and deadband (word 9) in the same scaled engineering units. Read the scaled process variable and scaled error in these units as well. The control output percentage (word 16) is displayed as a percentage of the 0 to 16383 CV range. The actual value transferred to the CV output is always between 0 and 16383.

When you select scaling, the instruction scales the setpoint, deadband, process variable, and error. You must consider the effect on all these variables when you change scaling.

Zero-Crossing Deadband DB

The adjustable deadband lets you select an error range above and below the setpoint where the output does not change as long as the error remains within this range. This lets you control how closely the process variable matches the setpoint without changing the output.



Zero-crossing is deadband control that lets the instruction use the error for computational purposes as the process variable crosses into the deadband until it crosses the setpoint. Once it crosses the setpoint (error crosses zero and changes sign) and as long as it remains in the deadband, the instruction considers the error value zero for computational purposes.

Select deadband by entering a value in the deadband storage word (word 9) in the control block. The deadband extends above and below the setpoint by the value you enter. A value of zero inhibits this feature. The deadband has the same scaled units as the setpoint if you choose scaling.

Output Alarms

You may set an output alarm on the control variable at a selected value above and/or below a selected output percent. When the instruction detects that the control variable has exceeded either value, it sets an alarm bit (bit LL for lower limit, bit UL for upper limit) in the PID instruction. Alarm bits are reset by the instruction when the control variable comes back inside the limits. The instruction does not prevent the control variable from exceeding the alarm values unless you select output limiting.

Select upper and lower output alarms by entering a value for the upper alarm (CVH) and lower alarm (CVL). Alarm values are specified as a percentage of the output. If you do not want alarms, enter zero and 100% respectively for lower and upper alarm values and ignore the alarm bits.

Output Limiting with Anti-Reset Windup

You may set an output limit (percent of output) on the control variable. When the instruction detects that the control variable has exceeded a limit, it sets an alarm bit (bit LL for lower limit, bit UL for upper limit), and prevents the control variable from exceeding either limit value. The instruction limits the control variable to 0 and 100% if you choose not to limit.

Select upper and lower output limits by setting the limit enable bit (bit OL), and entering an upper limit (CVH) and lower limit (CVL). Limit values are a percentage (0 to 100%) of the control variable.

The difference between selecting output alarms and output limits is that you must select output limiting to enable limiting. Limit and alarm values are stored in the same words. Entering these values enables the alarms, but not limiting. Entering these values and setting the limit enable bit enables limiting and alarms.

Anti-reset windup is a feature that prevents the integral term from becoming excessive when the control variable reaches a limit. When the sum of the PID and bias terms in the control variable reaches the limit, the instruction stops calculating the integral sum until the control variable comes back in range. The integral sum is contained in element, IS.

The Manual Mode

In the MANUAL mode, the PID algorithm does not compute the value of the control variable. Rather, it uses the value as an input to adjust the integral sum (IS) so that a smooth transfer takes place upon re-entering the AUTO mode.

In the MANUAL mode, the programmer allows you to enter a new CV value from 0 to 100%. This value is converted into a number from 0 to 16383 and written to the Control Variable address. If your ladder program sets the manual output level, design your ladder program to write to the CV address when in the MANUAL mode. Remember that the new CV value is in the range of 0 to 16383, not 0 to 100. Writing to the CV percent (CVP) with your ladder program has no effect in the MANUAL mode.

PID Rung State

If the PID rung is false, the integral sum (IS) is cleared and CV remains in its last state.

Feed Forward or Bias

Applications involving transport lags may require that a bias be added to the CV output in anticipation of a disturbance. This bias can be accomplished using the processor by writing a value to the Feed Forward Bias element (word FF). (See page 330.) The value you write is added to the output, allowing a feed forward action to take place. You may add a bias by writing a value between -16383 and +16383 to word 6 with your programming terminal or ladder program.

Application Examples

PID Tuning

PID tuning requires a knowledge of process control. If you are inexperienced, it will be helpful if you obtain training on the process control theory and methods used by your company.

There are a number of techniques that can be used to tune a PID loop. The following PID tuning method is general and limited in terms of handling load disturbances. When tuning, we recommend that changes be made in the MANUAL mode, followed by a return to AUTO. Output limiting is applied in the MANUAL mode.

TIP

- This method requires that the PID instruction controls a non-critical application in terms of personal safety and equipment damage.
- The PID tuning procedure may not work for all cases. It is strongly recommended to use a PID Loop tuner package for the best result (i.e. RSTune, Rockwell Software catalog number 9323-1003D).

Procedure

1. Create your ladder program. Make certain that you have properly scaled your analog input to the range of the process variable PV and that you have properly scaled your control variable CV to your analog output.

2. Connect your process control equipment to your analog modules. Download your program to the processor. Leave the processor in the program mode.

ATTENTION

Ensure that all possibilities of machine motion have been considered with respect to personal safety and equipment damage. It is possible that your output CV may swing between 0 and 100% while tuning.

TIP

If you want to verify the scaling of your continuous system and/or determine the initial loop update time of your system, go to the procedure on page 345.

3. Enter the following values: the initial setpoint SP value, a reset T_i of 0, a rate T_d of 0, a gain K_c of 1, and a loop update of 5.

   Set the PID mode to STI or Timed, per your ladder diagram. If STI is selected, ensure that the loop update time equals the STI time interval.

   Enter the optional settings that apply (output limiting, output alarm, MaxS - MinS scaling, feed forward).

4. Get prepared to chart the CV, PV, analog input, or analog output as it varies with time with respect to the setpoint SP value.

5. Place the PID instruction in the MANUAL mode, then place the processor in the RUN mode.

6. While monitoring the PID display, adjust the process manually by writing to the CO percent value.

7. When you feel that you have the process under control manually, place the PID instruction in the AUTO mode.

8. Adjust the gain while observing the relationship of the output to the setpoint over time.

9. When you notice that the process is oscillating above and below the setpoint in an even manner, record the time of 1 cycle. That is, obtain the natural period of the process.

   Natural Period $\cong$ 4x deadtime

   Record the gain value. Return to the MANUAL mode (stop the process if necessary).

10. Set the loop update time (and STI time interval if applicable) to a value of 5 to 10 times faster than the natural period.

    For example, if the cycle time is 20 seconds, and you choose to set the loop update time to 10 times faster than the natural rate, set the loop update time to 200, which would result in a 2-second rate.

11. Set the gain K_c value to 1/2 the gain needed to obtain the natural period of the process. For example, if the gain value recorded in step 9 was 80, set the gain to 40.

12. Set the reset term T_i to approximate the natural period. If the natural period is 20 seconds, as in our example, you would set the reset term to 3 (0.3 minutes per repeat approximates 20 seconds).

13. Now set the rate T_d equal to a value 1/8 that of the reset term. For our example, the value 4 is used to provide a rate term of 0.04 minutes per repeat.

14. Place the process in the AUTO mode. If you have an ideal process, the PID tuning is complete.

15. To make adjustments from this point, place the PID instruction in the MANUAL mode, enter the adjustment, then place the PID instruction back in the AUTO mode.

    This technique of going to MANUAL, then back to AUTO, ensures that most of the "gain error" is removed at the time each adjustment is made. This allows you to see the effects of each adjustment immediately. Toggling the PID rung allows the PID instruction to restart itself, eliminating all of the integral buildup. You may want to toggle the PID rung false while tuning to eliminate the effects of previous tuning adjustments.

Verifying the Scaling of Your Continuous System

To ensure that your process is linear, and that your equipment is properly connected and scaled, do the following:

1. Place the PID instruction in MANUAL and enter the following parameters:

    – type: `0` for MinS
    – type: `100` for MaxS
    – type: `0` for CO%

2. Enter the REM RUN mode and verify that PV=0.

3. Type: `20` in CO%

4. Record the PV = _______

5. Type: `40` in CO%.

6. Record the PV = _______

7. Type: `60` in CO%.

8. Record the PV = _______

9. Type: `80` in CO%.

10. Record the PV = _______

11. The values you recorded should be offset from CO% by the same amount. This proves the linearity of your process. The following example shows an offset progression of fifteen.
    – CO 20% = PV 35%
    – CO 40% = PV 55%
    – CO 60% = PV 75%
    – CO 80% = PV 95%

If the values you recorded are not offset by the same amount:

- Either your scaling is incorrect, or
- the process is not linear, or
- your equipment is not properly connected and/or configured.

Make the necessary corrections and repeat steps 2-10.

Determining the Initial Loop Update Time

To determine the approximate loop update time that should be used for your process, perform the following:

1. Place the normal application values in MinS and MaxS.

2. Type: `50` in CO%.

3. Type: `60` in CO% and immediately start your stopwatch.

4. Watch the PV. When the PV starts to change, stop your stopwatch. Record this value. It is the deadtime.

5. Multiply the deadtime by 4. This value approximates the natural period. For example, if deadtime = 3 seconds,
   then 4 x 3 = 12 seconds (≅ natural period)

6. Divide the value obtained in step 5 by 10. Use this value as the loop updated time. For example, if:

   natural period = 12 seconds, then 12/10 = 1.2 seconds.

   Therefore, the value 120 would be entered as the loop update time. (120 x 10 ms = 1.2 seconds)

7. Enter the following values: the initial setpoint SP value, a reset T_i of 0, a rate T_d of 0, a gain K_c of 1, and the loop update time determined in step 17.

   Set the PID mode to STI or Timed, per your ladder diagram. If STI is selected, ensure that the loop update time equals the STI time interval.

   Enter the optional settings that apply (output limiting, output alarm, MaxS - MinS scaling, feed forward).

8. Return to page 344 and complete the tuning procedure starting with step 4.

Notes:

Chapter 20

ASCII Instructions

This chapter contains general information about the ASCII instructions and explains how they function in your control program. This chapter is arranged into the following sections:

General Information

ASCII Instructions

The ASCII instructions are arranged so that the Write instructions precede the Read instructions.

Instruction	Function	Valid Controller(s)	Page
ACL - ASCII Clear Buffer	Clear the receive and/or transmit buffers.	• MicroLogix 1200 • MicroLogix 1500 Series B, FRN 4 or later	355
AIC - Integer to String	Convert an integer value to a string.		357
AWA - ASCII Write with Append	Write a string with user-configured characters appended.		358
AWT - ASCII Write	Write a string.		361
ABL - Test Buffer for Line	Determine the number of characters in the buffer, up to and including the end-of-line character.	• MicroLogix 1200 Series B, FRN 3 or later • MicroLogix 1500 Series B, FRN 4 or later	365
ACB - Number of Characters in Buffer	Determine the total number of characters in the buffer.		366
ACI - String to Integer	Convert a string to an integer value.		367
ACN - String Concatenate	Link two strings into one.		369
AEX - String Extract	Extract a portion of a string to create a new string.		370
AHL - ASCII Handshake Lines	Set or reset modem handshake lines.		372
ARD - ASCII Read Characters	Read characters from the input buffer and place them into a string.		374
ARL - ASCII Read Line	Read one line of characters from the input buffer and place them into a string.		375
ASC - String Search	Search a string.		378
ASR - ASCII String Compare	Compare two strings.		379

Instruction Types and Operation

There are two types of ASCII instructions, ASCII string control and ASCII port control. The string control instruction type is used for manipulating data and executes immediately. The port control instruction type is used for transmitting data and makes use of the ASCII queue. More details are provided below.

ASCII String Control

These instructions are used to manipulate string data. When a string control instruction is encountered in a ladder logic program, it executes immediately. It is never sent to the ASCII queue to wait for execution. The following tables list the ASCII string control instructions used by the MicroLogix 1200 and 1500 controllers:

MicroLogix 1200 Series A
AIC (Integer to String)

MicroLogix 1200 Series B, FRN 3 and later MicroLogix 1500 Series B, FRN 4 and later	
ACI (String to Integer)	AIC (Integer to String)
ACN (String Concatenate)	ASC (String Search)
AEX (String Extract)	ASR (ASCII String Compare)

ASCII Port Control

These instructions use or alter the communication channel for receiving or transmitting data. The following tables list the ASCII port control instructions used by the MicroLogix 1200 and 1500 controllers:

MicroLogix 1200 Series A[1]
ACL (ASCII Clear Buffer)
AWA (ASCII Write with Append)
AWT (ASCII Write)

(1) For the MicroLogix 1200 Series A, these instructions only transmit data.

MicroLogix 1200 Series B, FRN 3 and later MicroLogix 1500 Series B, FRN 4 and later	
ABL (Test Buffer for Line)	ARD (ASCII Read Characters)
ACB (Number of Characters in Buffer)	ARL (ASCII Read Line)
ACL (ASCII Clear Buffer)	AWA (ASCII Write with Append)
AHL (ASCII Handshake Lines)	AWT (ASCII Write)

When the ACL (ASCII Clear Buffer) instruction is encountered in a ladder logic program, it executes immediately and causes all instructions to be removed from the ASCII queue, including stopping execution of the ASCII instruction currently executing. The ER (error) bit is set for each instruction that is removed from the ASCII queue.

When any of the other port control instructions are encountered in a ladder logic program, it may or may not execute immediately depending on the contents of the ASCII queue. The ASCII queue is a FIFO (first-in, first-out) queue which can contain up to 16 instructions. The ASCII queue operates as follows:

- When the instruction is encountered on a rung and the ASCII queue is empty, the instruction executes immediately. It may take several program scans for the instruction to complete.
- When the instruction is encountered on a rung and there are from 1 to 15 instructions in the ASCII queue, the instruction is put into the ASCII queue and is executed when the preceding instructions are completed. If the ASCII queue is full, the instruction waits until the next program scan to determine if it can enter the ASCII queue. The controller continues executing other instructions while the ASCII port control instruction is waiting to enter the queue.

Programming ASCII Instructions

When programming ASCII output instructions, always precede the ASCII instruction with conditional logic that detects when new data needs to be sent or, send data on a time interval. If sent on a time interval, use an interval of 0.5 second or greater. Do not continuously generate streams of ASCII data out of a communications port.

IMPORTANT	If ASCII write instructions execute continuously, you may not be able to re-establish communications with RSLogix 500 when the controller is placed into the RUN mode.

Protocol Overview

MicroLogix 1200 Series A and MicroLogix 1500 Series A

The AWA and AWT instructions only successfully transmit an ASCII string out of the RS-232 port when the channel is configured for DF1 Full-Duplex protocol. If the RS-232 port is configured for any protocol other than DF1 Full-Duplex, the AWA and AWT instructions will error out with an error code of 9.

DF1 Full-Duplex packets take precedence over ASCII strings, so if an AWA or AWT instruction is triggered while a DF1 Full-Duplex packet is being transmitted, the ASCII instruction will error out with an error code of 5.

See on page 522 for the DF1 Full-Duplex protocol parameters that you set via the *Channel 0* configuration screens in your programming software. Configuration of the two append characters for the AWA instruction can be found in the *General* tab of *Channel Configuration* option in RSLogix 500.

MicroLogix 1200 Series B, FRN 3 and later, and MicroLogix 1500 Series B, FRN 4 and later

For the AWA and AWT instructions, you can use DF1 Full-Duplex protocol as described above. To use the full ASCII instruction set, use ASCII protocol as described below.

See on page 558 for the ASCII parameters that you set via the *Channel 0* (and Channel 1 for the 1764-LRP) configuration screens in your programming software. Configuration of the two append characters for the AWA instruction can be found in the *General* tab of *Channel Configuration* option in RSLogix 500.

String (ST) Data File

File Description

The string data file is used by the ASCII instructions to store ASCII character data. The ASCII data can be accessed by the source and destination operands in the ASCII instructions. The string data file can also be used by the copy (COP) and move (MOV, MVM) instructions.

String files consist of 42-word elements. One string file element is shown below. You can have up to 256 of these elements in the string file.

String Data File Structure

	String Element															
Bit	**15**	**14**	**13**	**12**	**11**	**10**	**09**	**08**	**07**	**06**	**05**	**04**	**03**	**02**	**01**	**00**
Word	***upper byte***								***lower byte***							
0	String Length - number of characters (range is from 0 to 82)															
1	character 0								character 1							
2	character 2								character 3							
↓	↓								↓							
40	character 78								character 79							
41	character 80								character 81							

Addressing String Files

The addressing scheme for the string data file is shown below.

Format	**Explanation**		
	ST	String file	
STf:e.s	**f**	File number	The valid file number range is from 3 to 255.
	:	Element delimiter	
	e	Element number	The valid element number range is from 0 to 255. Each element is 42 words in length as shown in .
	.	Subelement delimiter	
	s	Subelement number	The valid subelement number range is from 0 to 41. You can also specify .LEN for word 0 and .DATA[0] through .DATA[40] for words 1 to 41. The subelement represents a word address.
Examples:	**ST9:2** **ST17:1.LEN** **ST13:7.DATA[1]**		**String File 9, Element 2** **String File 17, Element 1, LEN Variable** **String File 13, Element 7, word 2 (characters 2 and 3)**

Control Data File

File Description

The control data element is used by ASCII instructions to store control information required to operate the instruction. The control data element for ASCII instructions includes status and control bits, an error code byte, and two character words as shown below:

ASCII Instructions Control Data File Elements

	Control Element															
Word	**15**	**14**	**13**	**12**	**11**	**10**	**09**	**08**	**07**	**06**	**05**	**04**	**03**	**02**	**01**	**00**
0	EN(1)	EU(2)	DN(3)	EM(4)	ER(5)	UL(6)	RN(7)	FD(8)	Error Code Byte							
1	Number of characters specified to be sent or received (LEN)															
2	Number of characters actually sent or received (POS)															

(1) EN = Enable Bit - indicates that an instruction is enabled due to a false-to-true transition. This bit remains set until the instruction completes execution or generates an error.

(2) EU = Queue Bit - when set, indicates that an ASCII instruction was placed in the ASCII queue. This action is delayed if the queue is already filled.

(3) DN = Asynchronous Done Bit - is set when an instruction successfully completes its operation.

(4) EM = Synchronous Done Bit - not used

(5) ER = Error Bit - when set, indicates that an error occurred while executing the instruction.

(6) UL = Unload Bit - when this bit is set by the user, the instruction does not execute. If the instruction is already executing, operation ceases. If this bit is set while an instruction is executing, any data already processed is sent to the destination and any remaining data is not processed. Setting this bit will not cause instructions to be removed from the ASCII queue. This bit is only examined when the instruction is ready to start executing.

(7) RN = Running Bit - when set, indicates that the queued instruction is executing.

(8) FD = Found Bit - when set, indicates that the instruction has found the end-of-line or termination character in the buffer. (only used by the ABL and ACB instructions)

NOTE: The RN bit is not addressable via the Control (R) file.

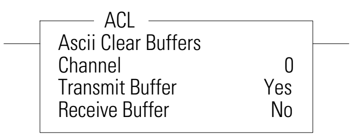
Addressing Control Files

The addressing scheme for the control data file is shown below.

Format	**Explanation**		
	R	Control file	
R:e.s/b	**f**	File number	The valid file number range is from 3 to 255.
	:	Element delimiter	
	e	Element number	The valid element number range is from 0 to 255. Each element is 3 words in length as shown in .
	.	Subelement delimiter	
	s	Subelement number	The valid subelement number range is from 0 to 2. You can also specify .LEN or .POS.

Format	Explanation		
	/	Bit delimiter	
	b	Bit number	The valid bit number range is from 0 to 15. The bit number is the bit location within the string file element. Bit level addressing is not available for words 1 and 2 of the control element.
Examples:	**R6:2** **R6:2.0/13** **R18:1.LEN** **R18:1.POS**		**Element 2, control file 6** **Bit 13 in sub-element 0 of element 2, control file 6** **Specified string length of element 1, control file 18** **Actual string length of element 1, control file 18**

ACL - ASCII Clear Buffers



Instruction Type: output

Execution Time for the ACL Instruction

Controller	When Instruction Is:	
	True	**False**
MicroLogix 1200	clear buffers: both 249.1 µs receive 28.9 µs transmit 33.6 µs	0.0 µs
MicroLogix 1500 Series B, FRN 4 or later	clear buffers: both 203.9 µs receive 24.7 µs transmit 29.1 µs	0.0 µs

The ACL instruction clears the Receive and/or Transmit buffer(s). This instruction also removes instructions from ASCII queue.

TIP

For MicroLogix 1200 FRN 7 and MicroLogix 1500 FRN 8 and higher, the ACL instruction can also be used to clear the DF1 communication buffers when the channel is configured for any of the DF1 communication drivers.

Select 0 for the channel number that is configured for DF1 *(or 1 for channel 1 on the 1764-LRP only)* and Yes for both the Receive and Transmit Buffers. When the ACL instruction is executed, any pending outgoing DF1 replies, any pending incoming DF1 commands and any pending outgoing DF1 commands are flushed. Any MSG instructions in progress on that channel will error out with an error code of 0x0C.

This instruction executes immediately upon the rung transitioning to a true state. Any ASCII transmissions in progress are terminated when the ACL instruction executes.

TIP

The ASCII queue may contain up to 16 instructions that are waiting to run.

Entering Parameters

Enter the following parameters when programming this instruction:

- **Channel** is the number of the RS-232 port, Channel 0. (*For the 1764-LRP only, you can select either Channel 0 or Channel 1*).
- **Receive Buffer** clears the Receive buffer when set to “Yes” and removes the Receive ASCII port control instructions (ARL and ARD) from the ASCII queue.
- **Transmit Buffer** clears the Transmit buffer when set to “Yes” and removes the Transmit ASCII port control instructions (AWA and AWT) from the ASCII queue.

Addressing Modes and File Types can be used as shown below:

ACL Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files(1)											Function Files									CS - Comms	IOS - I/O	DLS - Data Log	Address Mode			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI				Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Channel																								•				•		
Receive Buffer																								•				•		
Transmit Buffer																								•				•		

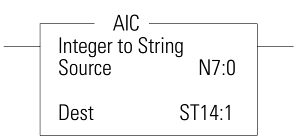
(1) The Control data file is the only valid file type for the Control Element.

Instruction Operation

When Clear Receive Buffer and Clear Transmit Buffer are both set to Yes, all Receive and Transmit instructions (ARL, ARD, AWA, and AWT) are removed from the ASCII queue.

When instructions are removed from the ASCII queue, the following bits are set: ER = 1, RN = 0, EU = 0, and ERR = 0x0E.

AIC - ASCII Integer to String



Instruction Type: output

Execution Time for the AIC Instruction

Controller	Data Size	When Instruction Is:	
		True	False
MicroLogix 1200	word	29.3 µs + 5.2 µs/character	0.0 µs
	long word	82.0 µs	0.0 µs
MicroLogix 1500 Series B, FRN 4 or later	word	25 µs + 4.3 µs/character	0.0 µs
	long word	68.7 µs	0.0 µs

The AIC instruction converts an integer or long word value (source) to an ASCII string (destination). The source can be a constant or an address. The source data range is from -2,147,483,648 to 2,147,483,647.

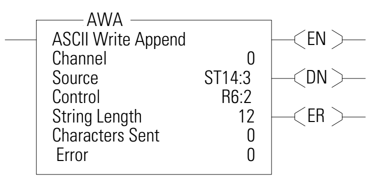
Addressing Modes and File Types can be used as shown below:

AIC Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files											Function Files									CS - Comms	IOS - I/O	DLS - Data Log	Address Mode			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI				Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Source	•	•		•	•	•			•															•	•			•	•	
Destination								•																	•					•

AWA - ASCII Write with Append



Instruction Type: output

Execution Time for the AWA Instruction

Controller	When Instruction Is:	
	True	**False**
MicroLogix 1200	268 µs + 12 µs/character	14.1 µs
MicroLogix 1500 Series B, FRN 4 or later	236 µs + 10.6 µs/character	12.5 µs

Use the AWA instruction to write characters from a source string to an external device. This instruction adds the two appended characters that you configure on the Channel Configuration screen. The default is a carriage return and line feed appended to the end of the string.

TIP You configure append characters via the Channel Configuration screen. The default append characters are carriage return and line feed.

Programming AWA Instructions

When programming ASCII output instructions, always precede the ASCII instruction with conditional logic that detects when new data needs to be sent or, send data on a time interval. If sent on a time interval, use an interval of 0.5 second or greater. Do not continuously generate streams of ASCII data out of a communications port.

IMPORTANT	If ASCII write instructions execute continuously, you may not be able to re-establish communications with RSLogix 500 when the controller is placed into the RUN mode.

This instruction will execute on either a false or true rung. However, if you want to repeat this instruction, the rung must go from false-to-true.

When using this instruction you can also perform in-line indirection. See page 382 for more information.

Entering Parameters

Enter the following parameters when programming this instruction:

- **Channel** is the number of the RS-232 port, Channel 0. (*For the 1764-LRP only, you can select either Channel 0 or Channel 1*).
- **Source** is the string element you want to write.
- **Control** is the control data file. See page 354.
- **String Length** (.LEN) is the number of characters you want to write from the source string (0 to 82). If you enter a 0, the entire string is written. This is word 1 in the control data file.
- **Characters Sent** (.POS) is the number of characters that the controller sends to an external device. This is word 2 in the control data file. Characters Sent (.POS) is updated after all characters have been transmitted.

  The valid range for .POS is from 0 to 84. The number of characters sent to the destination may be smaller or greater than the specified String Length (.LEN) as described below:

  – Characters Sent (.POS) may be smaller than String Length (.LEN) if the length of the string sent is less than what was specified in the String Length (.LEN) field.
  – Characters Sent (.POS) can be greater than the String Length (.LEN) if the appended characters or inserted values from in-line indirection are used. If the String Length (.LEN) is greater than 82, the string written to the destination is truncated to 82 characters plus the number of append characters (this number could be 82, 83, or 84 depending on how many append characters are used).
- **Error** displays the hexadecimal error code that indicates why the ER bit was set in the control data file. See page 383 for error code descriptions.

Addressing Modes and File Types can be used as shown below:

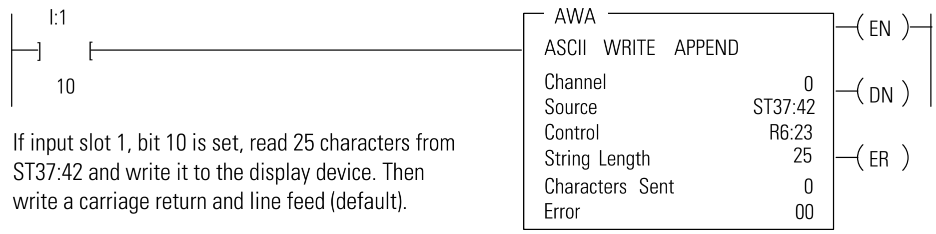
AWA Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files(1)											Function Files													Address Mode			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI	CS - Comms	IOS - I/O	DLS - Data Log	Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Channel																								•				•		
Source								•																	•					•
Control					•																				•					•

(1) The Control data file is the only valid file type for the Control Element.

Example



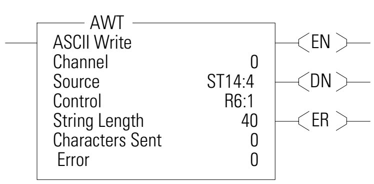
In this example, when the rung goes from false-to-true, the control element Enable (EN) bit is set. When the instruction is placed in the ASCII queue, the Queue bit (EU) is set. The Running bit (RN) is set when the instruction is executing**.** The DN bit is set on completion of the instruction.

The controller sends 25 characters from the start of string ST37:42 to the display device and then sends user-configured append characters. The Done bit (DN) is set and a value of 27 is present in .POS word of the ASCII control data file.

When an error is detected, the error code is written to the Error Code Byte and the Error Bit (ER) is set. See ASCII Instruction Error Codes on page 383 for a list of the error codes and recommended action to take.

TIP For information on the timing of this instruction, see the timing diagram on page 381.

AWT - ASCII Write



Instruction Type: output

Execution Time for the AWT Instruction

Controller	When Instruction Is:	
	True	False
MicroLogix 1200	268 µs + 12 µs/character	14.1 µs
MicroLogix 1500 Series B, FRN 4 or later	237 µs + 10.6 µs/character	12.8 µs

Use the AWT instruction to write characters from a source string to an external device.

Programming AWT Instructions

When programming ASCII output instructions, always precede the ASCII instruction with conditional logic that either detects when new data needs to be sent or, send data on a time interval. If sent on a time interval, use an interval of 0.5 second or greater.

IMPORTANT	Do not continuously generate streams of ASCII data out of a communications port. If ASCII write instructions execute continuously, you may not be able to re-establish communications with RSLogix 500 when the controller is placed into the RUN mode.

This instruction executes on a true rung. Once started, if the rung goes false, the instruction continues to completion. If you want to repeat this instruction, the rung must transition from false-to-true.

When using this instruction you can also perform in-line indirection. See page 382 for more information.

Entering Parameters

Enter the following parameters when programming this instruction:

- **Channel** is the number of the RS-232 port, Channel 0. (*For the 1764-LRP only, you can select either Channel 0 or Channel 1*).
- **Source** is the string element you want to write.
- **Control** is the control data file. See page 354.
- **String Length** (.LEN) is the number of characters you want to write from the source string (0 to 82). If you enter a 0, the entire string is written. This is word 1 in the control data file.
- **Characters Sent** (.POS) is the number of characters that the controller sends to an external device. This is word 2 in the control data file. Characters Sent (.POS) is updated after all characters have been transmitted.

  The valid range for .POS is from 0 to 82. The number of characters sent to the destination may be smaller or greater than the specified String Length (.LEN) as described below:

  – Characters Sent (.POS) may be smaller than String Length (.LEN) if the length of the string sent is less than what was specified in the String Length (.LEN) field.

– Characters Sent (.POS) can be greater than the String Length (.LEN) if inserted values from in-line indirection are used. If the String Length (.LEN) is greater than 82, the string written to the destination is truncated to 82 characters.

- **Error** displays the hexadecimal error code that indicates why the ER bit was set in the control data file. See page 383 for error code descriptions.

Addressing Modes and File Types can be used as shown below:

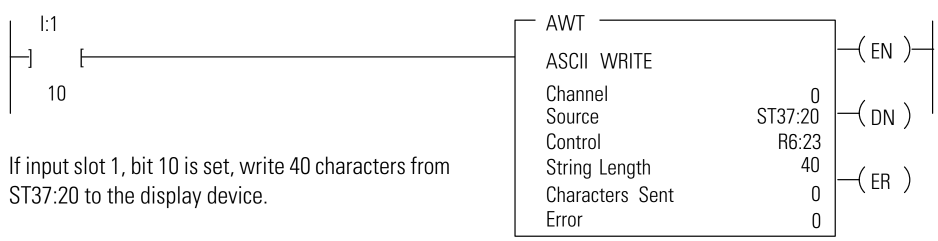
AWT Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files(1)											Function Files													Address Mode			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI	CS - Comms	IOS - I/O	DLS - Data Log	Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Channel																								•				•		
Source								•																	•					•
Control					•																				•					•

(1) The Control data file is the only valid file type for the Control Element.

Example



If input slot 1, bit 10 is set, write 40 characters from ST37:20 to the display device.

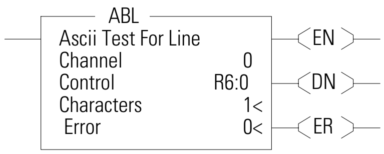
In this example, when the rung goes from false-to-true, the control element Enable (EN) bit is set. When the instruction is placed in the ASCII queue, the Queue bit (EU) is set. The Running bit (RN) is set when the instruction is executing. The DN bit is set on completion of the instruction.

Forty characters from string ST37:40 are sent through channel 0. The Done bit (DN) is set and a value of 40 is present in the POS word of the ASCII control data file.

When an error is detected, the error code is written to the Error Code Byte and the Error Bit (ER) is set. See ASCII Instruction Error Codes on page 383 for a list of the error codes and recommended action to take.

TIP For information on the timing of this instruction, see the timing diagram on page 381.

ABL - Test Buffer for Line



Instruction Type: output

Execution Time for the ABL Instruction

Controller	When Instruction Is:	
	True	**False**
MicroLogix 1200 Series B, FRN 3 or later	115 µs + 8.6 µs/character	12.5 µs
MicroLogix 1500 Series B, FRN 4 or later	94 µs + 7.6 µs/character	11.4 µs

The ABL instruction is used to determine the number of characters in the receive buffer of the specified communication channel, up to and including the end-of-line characters (termination). This instruction looks for the two termination characters that you configure via the channel configuration screen. On a false-to-true transition, the controller reports the number of characters in the POS field of the control data file. The channel configuration must be set to ASCII.

Entering Parameters

Enter the following parameters when programming this instruction:

- **Channel** is the number of the RS-232 port, Channel 0. (*For the 1764-LRP only, you can select either Channel 0 or Channel 1*).
- **Control** is the control data file. See page 354.
- **Characters** are the number of characters in the buffer that the controller finds (0 to 1024). This parameter is read-only and resides in word 2 of the control data file.
- **Error** displays the hexadecimal error code that indicates why the ER bit was set in the control data file. See page 383 for error code descriptions.

Addressing Modes and File Types can be used as shown below:

ABL Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files(1)											Function Files									CS - Comms	IOS - I/O	DLS - Data Log	Address Mode			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI				Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Channel																								•				•		
Control					•																				•					•

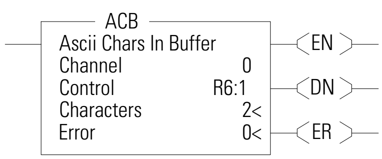
(1) The Control data file is the only valid file type for the Control Element.

Instruction Operation

When the rung goes from false-to-true, the Enable bit (EN) is set. The instruction is put in the ASCII instruction queue, the Queue bit (EU) is set, and program scan continues. The instruction is then executed outside of the program scan. However, if the queue is empty the instruction executes immediately. Upon execution, the Run bit (RN) is set.

The controller determines the number of characters (up to and including the termination characters) and puts this value in the POS field of the control data file. The Done bit (DN) is then set. If a zero appears in the POS field, no termination characters were found. The Found bit (FD) is set if the POS field is set to a non-zero value.

ACB - Number of Characters in Buffer



Instruction Type: output

Execution Time for the ACB Instruction

Controller	When Instruction Is:	
	True	**False**
MicroLogix 1200 Series B, FRN 3 or later	103.1	12.1
MicroLogix 1500 Series B, FRN 4 or later	84.2 µs	11.0 µs

Use the ACB instruction to determine the number of characters in the buffer. On a false-to-true transition, the controller determines the total number of characters and records it in the POS field of the control data file. The channel configuration must be set to ASCII.

Entering Parameters

Enter the following parameters when programming this instruction:

- **Channel** is the number of the RS-232 port, Channel 0. (*For the 1764-LRP only, you can select either Channel 0 or Channel 1*).
- **Control** is the control data file. See page 354.
- **Characters** are the number of characters in the buffer that the controller finds (0 to 1024). This parameter is read-only.
- **Error** displays the hexadecimal error code that indicates why the ER bit was set in the control data file. See page 383 for error descriptions.

Addressing Modes and File Types can be used as shown below:

ACB Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files[1]											Function Files												Address Mode			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI	CS - Comms	IOS - I/O	DLS - Data Log	Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Channel																								•				•		
Control					•																				•					•

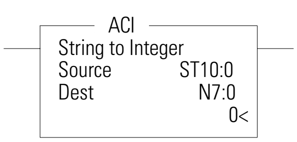
(1) The Control data file is the only valid file type for the Control Element.

Instruction Operation

When the rung goes from false-to-true, the Enable bit (EN) is set. When the instruction is placed in the ASCII queue, the Queue bit (EU) is set. The Running bit (RN) is set when the instruction is executing. The Done bit (DN) is set on completion of the instruction.

The controller determines the number of characters in the buffer and puts this value in the POS field of the control data file. The Done bit (DN) is then set. If a zero appears in the POS field, no characters were found. The Found bit (FD) is set when the POS filed is set to a non-zero value

ACI - String to Integer



Instruction Type: output

Execution Time for the ACI Instruction

Controller	Data Size	When Instruction Is:	
		True	False
MicroLogix 1200 Series B, FRN 3 or later	word	17.6 µs + 7.2 µs/character	0.0 µs
	long word	24.6 µs + 11.6 µs/character	0.0 µs
MicroLogix 1500 Series B, FRN 4 or later		14.2 µs + 6.3 µs/character	0.0 µs

Use the ACI instruction to convert a numeric ASCII string to an integer (word or long word) value.

Entering Parameters

Enter the following parameters when programming this instruction:

- **Source** - The contents of this location are converted to an integer value.
- **Destination** - This is the location which receives the result of the conversion. The data range is from -32,768 to 32,767 if the destination is a word and from -2,147,483,648 to 2,147,483,647 if the destination is a long word.

Addressing Modes and File Types can be used as shown below:

ACI Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files(1)											Function Files													Address Mode			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI	CS - Comms	IOS - I/O	DLS - Data Log	Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Source								•																	•					•
Destination	•	•		•	•				•																•			•	•	

(1) The Control data file is the only valid file type for the Control Element.

Instruction Operation

The controller searches the source (file type ST) for the first character between 0 and 9. All numeric characters are extracted until a non-numeric character or the end of the string is reached. Action is taken *only* if numeric characters are found. The string length is limited to 82 characters. Commas and signs (+, -) are allowed in the string. However, only the minus sign is displayed in the data table.

This instruction sets the following math flags in the controller status file:

Math Flag		Description
S:0/1	Overflow (V)	Flag is set if the result is outside of the valid range.
S:0/2	Zero (Z)	Flag is set if the result is zero.
S:0/3	Sign (S)	Flag is set if the result is negative.
S:5/0	Overflow Trap	Flag is set when the Overflow flag (S:0/1) is set.
S:5/15	ASCII String Manipulation Error	Flag is set if the Source string exceeds 82 characters. When S:5/15 is set, the Invalid String Length Error (1F39H) is written to the Major Error Fault Code (S:6).

ACN - String Concatenate

ACN
String Concatenate
Source A ST10:11
Source B ST10:12
Dest ST10:10

Instruction Type: output

Execution Time for the ACN Instruction

Controller	When Instruction Is:	
	True	False
MicroLogix 1200 Series B, FRN 3 or later	22.6 µs + 11.5 µs/character	0.0 µs
MicroLogix 1500 Series B, FRN 4 or later	17.9 µs + 10.2 µs/character	0.0 µs

The ACN instruction combines two ASCII strings. The second string is appended to the first and the result stored in the destination.

Entering Parameters

Enter the following parameters when programming this instruction:

- **Source A** is the first string in the concatenation procedure.
- **Source B** is the second string in the concatenation procedure.
- **Destination** is where the result of Source A and B is stored.

Addressing Modes and File Types can be used as shown below:

ACN Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

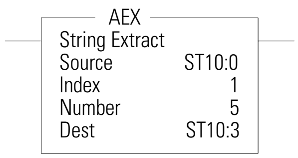
Parameter	Data Files[1]											Function Files										CS - Comms	IOS - I/O	DLS - Data Log	Address Mode			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI				Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Source A								•																	•					•
Source B								•																	•					•
Destination								•																	•					•

(1) The Control data file is the only valid file type for the Control Element.

Instruction Operation

This instruction executes on a false-to-true rung transition. Source B is appended to Source A and the result is put in the Destination. Only the first 82 characters (0 to 81) are written to the destination. If the string length of Source A, Source B, or Destination is greater than 82, the ASCII String Manipulation Error bit S:5/15 is set and the Invalid String Length Error (1F39H) is written to the Major Error Fault Code word (S:6).

AEX - String Extract



Instruction Type: output

Execution Time for the AEX Instruction

Controller	When Instruction Is:	
	True	**False**
MicroLogix 1200 Series B, FRN 3 or later	14.8 µs + 2.9 µs/character	0.0 µs
MicroLogix 1500 Series B, FRN 4 or later	12.4 µs + 2.6 µs/character	0.0 µs

The AEX instruction creates a new string by taking a portion of an existing string and storing it in a new string.

Entering Parameters

Enter the following parameters when programming this instruction:

- **Source** is the existing string. The Source value is not affected by this instruction.
- **Index** is the starting position (from 1 to 82) of the string you want to extract. (An index of 1 indicates the left-most character of the string.)
- **Number** is the number of characters (from 1 to 82) you want to extract, starting at the indexed position. If the Index plus the Number is greater than the total characters in the source string, the Destination string will be the characters from the Index to the end of the Source string.
- **Destination** is the string element (ST) where you want the extracted string stored.

Addressing Modes and File Types can be used as shown below:

AEX Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files(1)											Function Files												Address Mode			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI	CS - Comms	IOS - I/O	DLS - Data Log	Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Source								•																	•					•
Index	•	•		•	•	•																		•				•		
Number	•	•		•	•	•																		•				•		
Destination								•																	•					•

(1) The Control data file is the only valid file type for the Control Element.

Instruction Operation

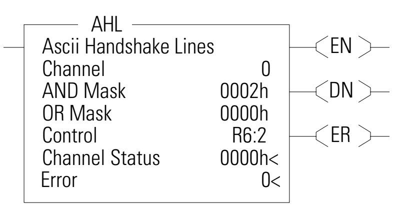
This instruction executes on a true rung.

The following conditions cause the controller to set the ASCII String Manipulation Error bit (S:5/15):

- Source string length is less than 1 or greater than 82
- Index value is less than 1 or greater than 82
- Number value is less than 1 or greater than 82
- Index value greater than the length of the Source string

The Destination string is not changed in any of the above error conditions. When the ASCII String Manipulation Error bit (S:5/15) is set, the Invalid String Length Error (1F39H) is written to the Major Error Fault Code word (S:6).

AHL - ASCII Handshake Lines



Instruction Type: output

Execution Time for the AHL Instruction

Controller	When Instruction Is:	
	True	**False**
MicroLogix 1200 Series B, FRN 3 or later	109.4 µs	11.9 µs
MicroLogix 1500 Series B, FRN 4 or later	89.3 µs	10.8 µs

The AHL instruction is used to set or reset the RS-232 Request to Send (RTS) handshake control line for a modem. The controller uses the two masks to determine whether to set or reset the RTS control line, or leave it unchanged. The channel configuration must be set to ASCII.

TIP Make sure the automatic modem control used by the port does not conflict with this instruction.

Entering Parameters

Enter the following parameters when programming this instruction:

- **Channel** is the number of the RS-232 port, Channel 0. (*For the 1764-LRP only, you can select either Channel 0 or Channel 1.*)
- **AND Mask** is the mask used to *reset* the RTS control line. Bit 1 corresponds to the RTS control line. A value of "2" in the AND mask resets the RTS control line; a value of "0" leaves the line unchanged.
- **OR Mask** is the mask used to *set* the RTS control line. Bit 1 corresponds to the RTS control line. A value of "2" in the OR mask sets the RTS control line; a value of "0" leaves the line unchanged.
- **Control** is the control data file. See page 354.
- **Channel Status** displays the current status (0000 to 001F) of the handshake lines for the specified channel. This status is read-only and resides in the .POS field in the control data file. The following shows how to determine the channel status value. In this example, the value is 001F.

Channel Status Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Handshake Control Line Setting	reserved											--	DCD[1]	--	RTS	CTS
	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1
Channel Status	0				0				1				F			
	Word 2 of the Control Element = 001F															

(1) The DCD handshake line is only supported on Channel 1.

- **Error** displays the hexadecimal error code that indicates why the ER bit was set in the control data file. See page 383 for error code descriptions.

Addressing Modes and File Types can be used as shown below:

AHL Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

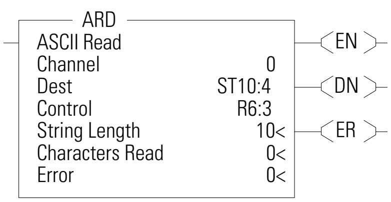
Parameter	Data Files[1]											Function Files									CS - Comms	IOS - I/O	DLS - Data Log	Address Mode			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI				Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Channel																								•				•		
AND Mask	•	•		•	•	•																		•	•			•		
OR Mask	•	•		•	•	•																		•	•			•		
Control					•																				•					•

(1) The Control data file is the only valid file type for the Control Element.

Instruction Operation

This instruction executes on either a false or true rung. However a false-to-true rung transition is required to set the EN bit to repeat the instruction.

ARD - ASCII Read Characters



Instruction Type: output

Execution Time for the ARD Instruction

Controller	When Instruction Is:	
	True	**False**
MicroLogix 1200 Series B, FRN 3 or later	132.3 μs + 49.7 μs/character	11.8 μs
MicroLogix 1500 Series B, FRN 4 or later	108 μs + 44 μs/character	10.7 μs

Use the ARD instruction to read characters from the buffer and store them in a string. To repeat the operation, the rung must go from false-to-true.

Entering Parameters

Enter the following parameters when programming this instruction:

- **Channel** is the number of the RS-232 port, Channel 0. (*For the 1764-LRP only, you can select either Channel 0 or Channel 1*).
- **Destination** is the string element where you want the characters stored.
- **Control** is the control data file. See page 354.
- **String Length** (LEN) is the number of characters you want to read from the buffer. The maximum is 82 characters. If you specify a length larger than 82, only the first 82 characters will be read. If you specify 0 characters, LEN defaults to 82. This is word 1 in the control data file.
- **Characters Read** (POS) is the number of characters that the controller moved from the buffer to the string (0 to 82). This field is updated during the execution of the instruction and is read-only. This is word 2 in the control data file.
- **Error** displays the hexadecimal error code that indicates why the ER bit was set in the control data file. See page 383 for error code descriptions.

Addressing Modes and File Types can be used as shown below:

ARD Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files(1)											Function Files												Address Mode			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI	CS - Comms	IOS - I/O	DLS - Data Log	Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Channel																								•				•		
Destination								•																	•					•
Control					•																				•					•

(1) The Control data file is the only valid file type for the Control Element.

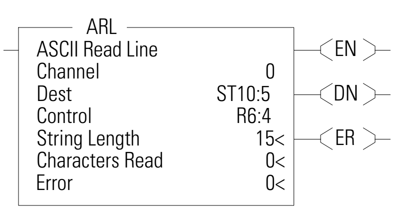
Instruction Operation

When the rung goes from false-to-true, the Enable bit (EN) is set. When the instruction is placed in the ASCII queue, the Queue bit (EU) is set. The Running bit (RN) is set when the instruction is executing. The DN bit is set on completion of the instruction.

Once the requested number of characters are in the buffer, the characters are moved to the destination string. The number of characters moved is put in the POS field of the control data file. The number in the POS field is continuously updated and the Done bit (DN) is not set until all of the characters are read.

TIP For information on the timing of this instruction, see the timing diagram on page 381.

ARL - ASCII Read Line



Instruction Type: output

Execution Time for the ARL Instruction

Controller	When Instruction Is:	
	True	False
MicroLogix 1200 Series B, FRN 3 or later	139.7 µs + 50.1 µs/character	11.7 µs
MicroLogix 1500 Series B, FRN 4 or later	114 µs + 44.3 µs/character	10.6 µs

Use the ARL instruction to read characters from the buffer, up to and including the Termination characters, and store them in a string. The Termination characters are specified via the Channel Configuration screen.

Entering Parameters

Enter the following parameters when programming this instruction:

- **Channel** is the number of the RS-232 port, Channel 0. (*For the 1764-LRP only, you can select either Channel 0 or Channel 1*).
- **Destination** is the string element where you want the string stored.
- **Control** is the control data file. See page 354.
- **String Length** (LEN) is the number of characters you want to read from the buffer. The maximum is 82 characters. If you specify a length larger than 82, only the first 82 characters are read and moved to the destination. (A length of “0” defaults to 82.) This is word 1 in the control data file.

- **Characters Read** (POS) is the number of characters that the controller moved from the buffer to the string (0 to 82). This field is read-only and resides in word 2 of the control data file.
- **Error** displays the hexadecimal error code that indicates why the ER bit was set in the control data file. See page 383 for error code descriptions.

Addressing Modes and File Types can be used as shown below:

ARL Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files(1)											Function Files													Address Mode			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI	CS - Comms	IOS - I/O	DLS - Data Log	Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Channel																								•				•		
Destination								•																	•					•
Control					•																				•					•

(1) The Control data file is the only valid file type for the Control Element.

Instruction Operation

When the rung goes from false-to-true, the control element Enable (EN) bit is set. When the instruction is placed in the ASCII queue, the Queue bit (EU) is set. The Running bit (RN) is set when the instruction is executing. The DN bit is set on completion of the instruction.

Once the requested number of characters are in the buffer, all characters (including the Termination characters) are moved to the destination string. The number of characters moved is stored in the POS word of the control data file. The number in the Characters Read field is continuously updated and the Done bit (DN) is not set until all of the characters have been read. Exception: If the controller finds termination characters before done reading, the Done bit (DN) is set and the number of characters found is stored in the POS word of the control data file.

TIP For information on the timing of this instruction, see the timing diagram on page 381.

ASC - String Search

```
ASC
String Search
Source          ST10:6
Index                5
String Search   ST10:7
Result            N7:1
                    0<
```

Instruction Type: output

Execution Time for the ASC Instruction

Controller	When Instruction Is:	
	True	False
MicroLogix 1200 Series B, FRN 3 or later	16.2 µs + 4.0 µs/matching character	0.0 µs
MicroLogix 1500 Series B, FRN 4 or later	13.4 µs + 3.5 µs/matching character	0.0 µs

Use the ASC instruction to search an existing string for an occurrence of the source string. This instruction executes on a true rung.

Entering Parameters

Enter the following parameters when programming this instruction:

- **Source** is the address of the string you want to find.
- **Index** is the starting position (from 1 to 82) within the search string. (An index of 1 indicates the left-most character of the string.)
- **Search** is the address of the string you want to examine.
- **Result** is the location (from 1 to 82) that the controller uses to store the position in the Search string where the Source string begins. If no match is found, result is set equal to zero.

Addressing Modes and File Types can be used as shown below:

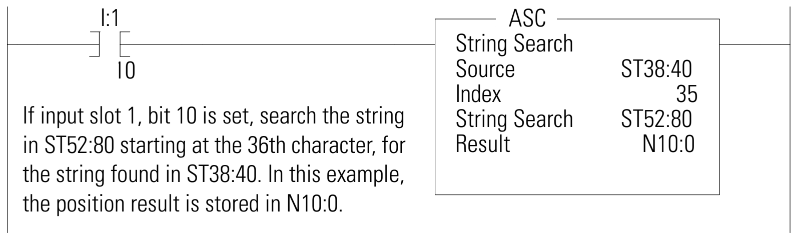
ASC Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

Parameter	Data Files(1)											Function Files									CS - Comms	IOS - I/O	DLS - Data Log	Address Mode			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI				Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Source	•	•		•	•	•																		•	•			•		
Index								•																	•					•
Search								•																	•					•
Result	•	•		•	•	•																			•			•		

(1) The Control data file is the only valid file type for the Control Element.

Example



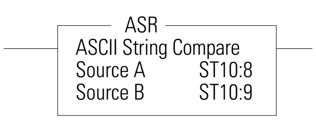
Error Conditions

The following conditions cause the controller to set the ASCII Error bit (S:5/15).

- Source string length is less than 1 or greater than 82.
- Index value is less than 1 or greater than 82.
- Index value is greater than Source string length.

The destination is not changed in any of the above conditions. When the ASCII String Manipulation Error bit (S:5/15) is set, the Invalid String Length Error (1F39H) is written to the Major Error Fault Code word (S:6).

ASR - ASCII String Compare



Instruction Type: input

Execution Time for the ASR Instruction

Controller	When Instruction Is:	
	True	**False**
MicroLogix 1200 Series B, FRN 3 or later	9.2 µs + 4.0 µs/matching character	0.0 µs
MicroLogix 1500 Series B, FRN 4 or later	7.5 µs + 3.5 µs/matching character	0.0 µs

Use the ASR instruction to compare two ASCII strings. The controller looks for a match in length and upper/lower case characters. If two strings are identical, the rung is true; if there are any differences, the rung is false.

Entering Parameters

Enter the following parameters when programming this instruction:

- **Source A** is the location of the first string used for comparison.
- **Source B** is the location of the second string used for comparison.

Addressing Modes and File Types can be used as shown below:

ASR Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 102.

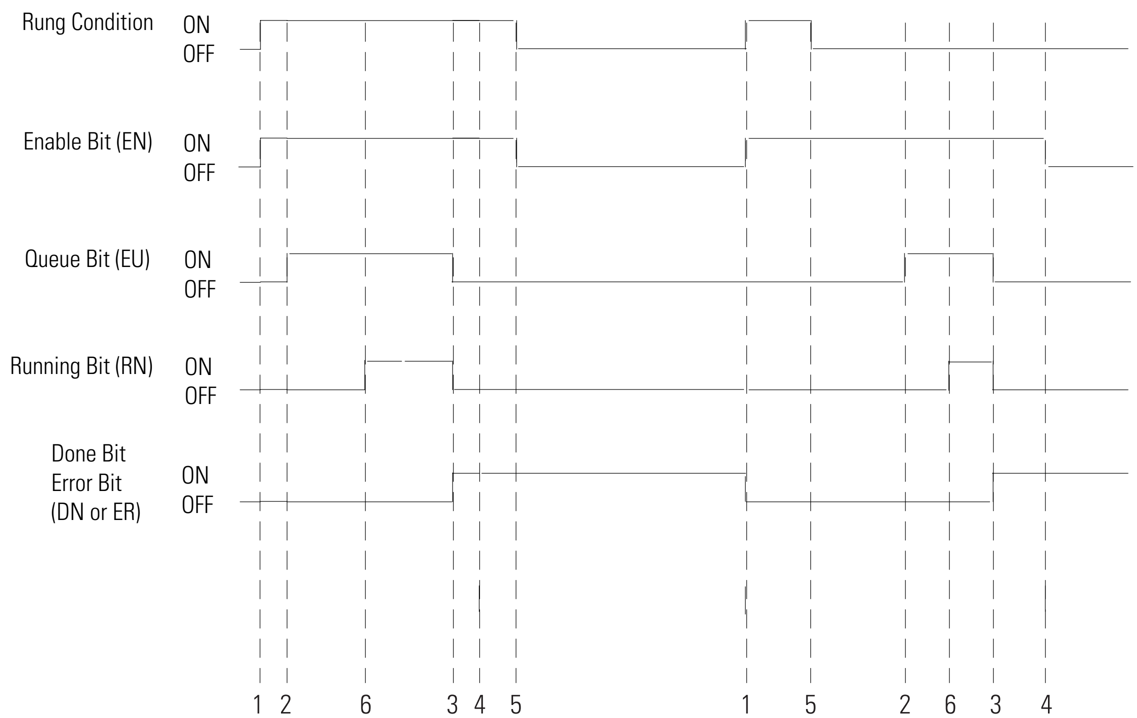
Parameter	Data Files[1]											Function Files												Address Mode			Address Level			
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	PLS	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI	CS - Comms	IOS - I/O	DLS - Data Log	Immediate	Direct	Indirect	Bit	Word	Long Word	Element
Source A								•																	•					•
Source B								•																	•					•

(1) The Control data file is the only valid file type for the Control Element.

Instruction Operation

If the string length of Source A or Source B exceeds 82 characters, the ASCII String Manipulation Error bit (S:5/15) is set and the rung goes false.

Timing Diagram for ARD, ARL, AWA, and AWT Instructions



NOTE: The RN bit is not addressable via the Control (R) file.

1 - rung goes true
2 - instruction successfully queued
3 - instruction execution complete
4 - instruction scanned for the first time after execution is complete
5 - rung goes false
6 - instruction execution starts

Using In-line Indirection

This allows you to insert integer and long word values into ASCII strings. The Running bit (RN) must be set before the string value can be used.

The following conditions apply to performing in-line indirection:

- All valid integer (N) and long word (L) files can be used. Valid range is from 3 to 255.
- File types are not case sensitive and can include either a colon (:) or semicolon (;)
- Positive value symbol (+) and leading zeros are not printed. Negative values (-) are printed with a leading minus sign. Commas are not inserted where they would normally appear in numbers greater than one thousand.

Examples

For the following examples:
N7:0 = 25
N7:1 = -37
L8:0 = 508000
L8:1 = 5

Valid in-line direction:	
Input:	Flow rate is currently [N7:0] liters per minute and contains [L8:0] particles per liter contaminants.
Output:	Flow rate is currently 25 liters per minute and contains 508000 particles per liter contaminants.
Input:	Current position is [N7:1] at a speed of [L8:1] RPM.
Output:	Current position is -37 at a speed of 5 RPM.
Invalid in-line indirection:	
Input:	Current position is [N5:1] at a speed of [L8:1] RPM.
Output:	Current position is [N5:1] at a speed of 5 RPM.

.

TIP Truncation occurs in the output string if the indirection causes the output to exceed 82 characters. The appended characters are always applied to the output.

ASCII Instruction Error Codes

The following error codes indicate why the Error bit (ER) is set in the control data file.

Error Code		Description	Recommended Action
decimal	hexadecimal		
0	0x00	No error. The instruction completed successfully.	None Required.
3	0x03	The transmission cannot be completed because the CTS signal was lost.	Check the modem and modem connections.
5	0x05	While attempting to perform an ASCII transmission, a conflict with the configured communications protocol was detected.	Reconfigure the channel and retry operation.
7	0x07	The instruction cannot be executed because the communications channel has been shut down via the channel configuration menu.	Reconfigure the channel and retry operation.
8	0x08	The instruction cannot be executed because another ASCII transmission is already in progress.	Resend the transmission.
9	0x09	Type of ASCII communications operation requested is not supported by the current channel configuration.	Reconfigure the channel and retry operation.
10	0x0A	The unload bit (UL) is set, stopping instruction execution.	None required.
11	0x0B	The requested number of characters for the ASCII read was too large or negative.	Enter a valid string length and retry operation.
12	0x0C	The length of the Source string is invalid (either a negative number or a number greater than 82).	Enter a valid string length and retry operation.
13	0x0D	The requested length in the Control field is invalid (either a negative number or a number greater than 82).	Enter a valid length and retry operation.
14	0x0E	Execution of an ACL instruction caused this instruction to abort.	None required.
15	0x0F	Communications channel configuration was changed while instruction was in progress.	None required.

ASCII Character Set

The table below lists the decimal, hexadecimal, octal, and ASCII conversions.

Standard ASCII Character Set

Column 1					Column 2				Column 3				Column 4			
Ctrl-	DEC	HEX	OCT	ASC	DEC	HEX	OCT	ASC	DEC	HEX	OCT	ASC	DEC	HEX	OCT	ASC
^@	00	00	000	NUL	32	20	040	SP	64	40	100	@	96	60	140	\
^A	01	01	001	SOH	33	21	041	!	65	41	101	A	97	61	141	a
^B	02	02	002	STX	34	22	042	“	66	42	102	B	98	62	142	b
^C	03	03	003	ETX	35	23	043	#	67	43	103	C	99	63	143	c
^D	04	04	004	EOT	36	24	044	$	68	44	104	D	100	64	144	d
^E	05	05	005	ENQ	37	25	045	%	69	45	105	E	101	65	145	e
^F	06	06	006	ACK	38	26	046	&	70	46	106	F	102	66	146	f
^G	07	07	007	BEL	39	27	047	'	71	47	107	G	103	67	147	g
^H	08	08	010	BS	40	28	050	(	72	48	110	H	104	68	150	h
^I	09	09	011	HT	41	29	051	)	73	49	111	I	105	69	151	i
^J	10	0A	012	LF	42	2A	052	*	74	4A	112	J	106	6A	152	j
^K	11	0B	013	VT	43	2B	053	+	75	4B	113	K	107	6B	153	k
^L	12	0C	014	FF	44	2C	054	,	76	4C	114	L	108	6C	154	l
^M	13	0D	015	CR	45	2D	055	-	77	4D	115	M	109	6D	155	m
^N	14	0E	016	SO	46	2E	056	.	78	4E	116	N	110	6E	156	n
^O	15	0F	017	SI	47	2F	057	/	79	4F	117	O	111	6F	157	o
^P	16	10	020	DLE	48	30	060	0	80	50	120	P	112	70	160	p
^Q	17	11	021	DC1	49	31	061	1	81	51	121	Q	113	71	161	q
^R	18	12	022	DC2	50	32	062	2	82	52	122	R	114	72	162	r
^S	19	13	023	DC3	51	33	063	3	83	53	123	S	115	73	163	s
^T	20	14	024	DC4	52	34	064	4	84	54	124	T	116	74	164	t
^U	21	15	025	NAK	53	35	065	5	85	55	125	U	117	75	165	u
^V	22	16	026	SYN	54	36	066	6	86	56	126	V	118	76	166	v
^W	23	17	027	ETB	55	37	067	7	87	57	127	W	119	77	167	w
^X	24	18	030	CAN	56	38	070	8	88	58	130	X	120	78	170	x
^Y	25	19	031	EM	57	39	071	9	89	59	131	Y	121	79	171	y
^Z	26	1A	032	SUB	58	3A	072	:	90	5A	132	Z	122	7A	172	z
^[	27	1B	033	ESC	59	3B	073	;	91	5B	133	[	123	7B	173	{
^\	28	1C	034	FS	60	3C	074	<	92	5C	134	\	124	7C	174		
^]	29	1D	035	GS	61	3D	075	=	93	5D	135	]	125	7D	175	}
^^	30	1E	036	RS	62	3E	076	>	94	5E	136	^	126	7E	176	~
^_	31	1F	037	US	63	3F	077	?	95	5F	137	_	127	7F	177	DEL

The standard ASCII character set includes values up to 127 decimal (7F hex). The MicroLogix 1200 and 1500 Controllers also support an extended character set (decimal 128 to 255). However, the extended character set may display different characters depending on the platform you are using.

Decimal values 0 through 31 are also assigned Ctrl- codes.

Communications Instructions

This chapter contains information about the Message (MSG) and Service Communications (SVC), communication instructions. This chapter provides information on:

The communication instructions read or write data to another station.

Instruction	Used To:	Page
SVC	Interrupt the program scan to execute the service communications part of the operating cycle. The scan then resumes at the instruction following the SVC instruction.	387
MSG	Transfer data from one device to another.	391

Messaging Overview

The communication architecture is comprised of three primary components:

- Ladder Scan
- Communications Buffers
- Communication Queue

These three components determine when a message is transmitted by the controller. For a message to transmit, it must be scanned on a true rung of logic. When scanned, the message and the data defined within the message (if it is a write message) are placed in a communication buffer. The controller continues to scan the remaining user program. The message is processed and sent out of the controller via the communications port after the ladder logic completes, during the Service Communications part of the operating cycle, unless an SVC is executed.

If a second message instruction is processed before the first message completes, the second message and its data are placed in one of the three remaining communication buffers. This process repeats whenever a message instruction is processed, until all four buffers are in use.

When a buffer is available, the message and its associated data are placed in the buffer immediately. If all four buffers for the channel are full when the next (fifth) message is processed, the message request, not the data, is placed in the channel's communications queue. The queue is a message storage area that keeps track of messages that have not been allocated a buffer. The queue operates as a first-in first-out (FIFO) storage area. The first message request stored in the queue is the message that is allocated a buffer as soon as a buffer becomes available. The queue can accommodate all MSG instructions in a ladder program.

When a message request in a buffer is completed, the buffer is released back to the system. If a message is in the queue, that message is then allocated a buffer. At that time, the data associated with the message is read from within the controller.

TIP If a message instruction was in the queue, the data that is actually sent out of the controller may be different than what was present when the message instruction was first processed.

The buffer and queue mechanisms are completely automatic. Buffers are allocated and released as the need arises, and message queuing occurs if buffers are full.

The controller initiates read and write messages through available communication channels when configured for the following protocols:

- DH-485
- DF1 Full-Duplex
- DF1 Half-Duplex Master
- DF1 Half-Duplex Slave
- Modbus RTU Master

For a description of valid communication protocols, see Protocol Configuration on page 517.

SVC - Service Communications

SVC
Service Communications
Channel Select 1

Instruction Type: output

Execution Time for the SVC Instruction

Controller	When Rung Is:(1)	
	True	False
MicroLogix 1200	208 µs + 1.6 µs per word	0.0 µs
MicroLogix 1500 1764-LSP or 1764-LRP with one channel selected	166 µs + 1.4 µs per word	0.0 µs
MicroLogix 1500 1764-LRP Processor with both channels selected	327 µs + 1.4 µs per word	0.0 µs

(1) This value for the SVC instruction is for when the communications servicing function is accessing a data file. The time increases when accessing a function file.

Under normal operation the controller processes communications once every time it scans the control program. If you require the communications port to be scanned more often, or if the ladder scan is long, you can add an SVC (Service Communications) instruction to your control program. The SVC instruction is used to improve communications performance/throughput, but also causes the ladder scan to be longer.

Simply place the SVC instruction on a rung within the control program. When the rung is scanned, the controller services any communications that need to take place. You can place the SVC instruction on a rung without any preceding logic, or you can condition the rung with a number of communications status bits. The table on page 389 shows the available status file bits.

TIP The amount of communications servicing performed is controlled by the Communication Servicing Selection Bit (CSS) and Message Servicing Selection Bit (MSS) in the Channel 0 Communication Configuration File.

For best results, place the SVC instruction in the middle of the control program. You may not place an SVC instruction in a Fault, DII, STI, or I/O Event subroutine.

Channel Select

When using the SVC instruction, you must select the channel to be serviced. The channel select variable is a one-word bit pattern that determines which channel is serviced. Each bit corresponds to a specific channel. For example, bit 0 equals channel 0. When any bit is set (1), the corresponding channel is serviced.

Controller	Channel Select Setting	Channel(s) Serviced
MicroLogix 1200	1	0
MicroLogix 1500 with 1764-LSP Processor	1	0
MicroLogix 1500 with 1764-LRP Processor	1	0
	2	1
	3	both 0 and 1

Communication Status Bits

The following communication status bits allow you to customize or monitor communications servicing. See General Channel Status Block on page 85 for additional status information.

Communication Status Bits

Address		Description
Channel 0	Channel 1(1)	
CS0:4/0	CS1:4/0	ICP - Incoming Command Pending
CS0:4/1	CS1:4/1	MRP - Incoming Message Reply Pending
CS0:4/2	CS1:4/2	MCP - Outgoing Message Command Pending
CS0:4/4	CS1:4/4	CAB - Communications Active Bit

(1) Channel 1 is valid for MicroLogix 1500 1764-LRP only.

Application Example

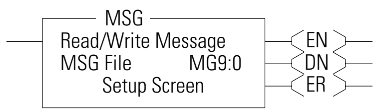
The SVC instruction is used when you want to execute a communication function, such as transmitting a message, prior to the normal service communication portion of the operating scan.

You can place this rung after a message write instruction. CS0:4/MCP is set when the message instruction is enabled and put in the communications queue. When CS0:4/MCP is set (1), the SVC instruction is evaluated as true and the program scan is interrupted to execute the service communication’s portion of the operating scan. The scan then resumes at the instruction following the SVC instruction.

The example rung shows a conditional SVC, which is processed only when an outgoing message is in the communications queue.

TIP You may program the SVC instruction unconditionally across the rungs. This is the normal programming technique for the SVC instruction.

MSG - Message



Instruction Type: output

Execution Time for the MSG Instruction

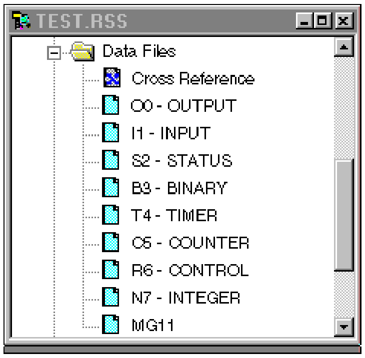
Controller	Rung Condition	When Rung Is:	
		True	**False**
MicroLogix 1200	Steady State True	20.0 µs	6.0 µs
	False-to-True Transition for Reads	230.0 µs	
	False-to-True Transition for Writes	264 µs + 1.6 µs per word	
MicroLogix 1500 1764-LSP	Steady State True	17.0 µs	6.0 µs
	False-to-True Transition for Reads	205.0 µs	
	False-to-True Transition for Writes	228 µs + 1.4 µs per word	
MicroLogix 1500 1764-LRP	Steady State True	17.0 µs	6.0 µs
	Communications via base unit or 1764-LRP communications port:		
	False-to-True Transition for Reads	234.0 µs	6.0 µs
	False-to-True Transition for Writes	257 µs + 1.4 µs per word	
	Communications via Compact I/O communication module, i.e. 1769-SDN:		
	False-to-True Transition for Reads	206.0 µs	6.0 µs
	False-to-True Transition for Writes	234 µs + 1.4 µs per word	

Any preceding logic on the message rung must be solved true before the message instruction can be processed. The example below shows a message instruction.

If B3/0 is on (1), the MSG rung is true, and MG11:0 is not already processing a message; then MG11:0 is processed. If one of the four buffers is available, the message and its associated data are processed immediately.

TIP How quickly the message is actually sent to the destination device depends on a number of issues, including the selected channel's communication protocol, the baud rate of the communications port, the number of retries needed (if any), and the destination device's readiness to receive the message.

The Message Element



The MSG instruction built into the controller uses a MG data file to process the message instruction. The MG data file, shown at left, is accessed using the MG prefix. Each message instruction utilizes an element within a MG data file. For example, MG11:0 is the first element in message data file 11.

Message File Sub-Elements

Each MSG instruction must use a unique Element in a MSG File. The MSG element for each MSG instruction holds all of the parameters and status information for that particular MSG instruction.

Each MSG File Element consists of Sub-Elements 0 through 24 as shown in the following table.

Message File Element

Sub-Element	Name	Description	Parameter	Size	User Program Access[(1)]
0 to 1		Reserved		Word	read only
2		Messaging Type: 0 (for PCCC), 1 (for CIP), 2 (for Modbus Master)		Word	read only
3		for PCCC Messaging: bits 07-00 (CMD code), bits 15-08 (FNC code) for CIP Messaging: bits 07-00 (Service Code), bits 15-08 (Supplemental Object Path Data Count) for Modbus Master: bits 07-00 (Function Code), bits 15-08 (reserved)	derived	Word	read only
4		Internal Physical Address		Word	read only
5	MG11:0.RBL	PCCC: Remote Bridge Link ID CIP: Supplemental Object Path Data bytes 0 and 1 Modbus Master: not used	Y	Word	read only
6	MG11:0.LBN	PCCC: Local Bridge Node Address CIP: Supplemental Object Path Data bytes 2 and 3 Modbus Master: not used	Y	Word	read only
7	MG11:0.RBN	PCCC: Remote Bridge Node Address CIP: Supplemental Object Path Data bytes 4 and 5 Modbus Master: not used	Y	Word	read only
8	MG11:0.CHN	Channel: bits 07-00 (0 for Channel 0,1 for Channel 1) Slot: bits 15-08 (0 to 16)	Y	Word	read/write
9	MG11:0.NOD	Target Node Number	Y	Word	read/write

Message File Element

Sub-Element	Name	Description	Parameter	Size	User Program Access(1)
10	MG11:0.MTO	Message timeout setting or preset in seconds	Y	Word	read/write
11		PCCC and CIP: Number of bytes to read/write Modbus Master: Number of Modbus elements to read/write		Word	read only
12		Target Location information (See tables on page 393 for options)	Y	Word	read only
13	MG11:0.TFN		Y	Word	read/write
14	MG11:0.ELE		Y	Word	read/write
15			Y	Word	read only
16		Control bits (See Control Bits table on page 395 for details)	N	16-bits	read/write
17		Status bits and Range parameter (See table on page 396 for details)	Mixed	16-bits	read only
18	MG11:0.ERR	Error code (See Error Codes on page 441)	N	Word	read only
19		Time since message started in seconds	N	Word	read only
20		Reserved		Word	read only
21		Internal message start time in seconds	N	Word	read only
22		Enhanced error information. The low byte is the same as element 18 (ERR). The high byte contains an additional error code. For comms module messaging, the high byte contains the actual error code returned by the comms module when ERR is 0xE0. For Modbus Master, the high byte contains the non-standard Modbus exception reply returned by the slave when ERR is 0x89. Codes returned with other errors are for internal use only.	N	Word	read only
23		*Only used for MicroLogix 1500 1764-LRP Series C and higher.* Extended Status Error Code from expansion I/O communications module.			
24		*Only used for MicroLogix 1500 1764-LRP Series C and higher.* Supplemental Routing Path Data Address: bits 7 to 0: Starting Element, bits 15 to 8: File Number			

(1) User access refers to user program access (MSG File word or bit used as an operand for an instruction in a ladder program) or access via Comms while in any mode other than download (via Programming Software or Memory Module).

The Target file information contained in Sub-Elements 12 through 15 of the MSG File Element depend upon the message type, as shown in the tables below.

Message File Target Location Information

Target Device = 485 CIF

Sub-Element	Name	Description	Parameter	Size	User Program Access
12		Reserved	Y	Word	read only

Message File Target Location Information

Target Device = 485 CIF

Sub-Element	Name	Description	Parameter	Size	User Program Access
13	MG11:0.TFN	Target File Number	Y	Word	read/write
14	MG11:0.ELE	Offset in elements into CIF	Y	Word	read/write
15		Reserved	Y	Word	read only

Message File Target Location Information

Target Device = 500CPU or PLC 5

Sub-Element	Address	Description	Parameter	Size	User Program Access
12		Target File Type	Y	Word	read only
13	MG11:0.TFN	Target File Number(1)	Y	Word	read/write
14	MG11:0.ELE	Target File Element Number for B, S, N, F(2), T, C, R, L, ST and RTC(3) files; or Target File Slot Number for O and I files.	Y	Word	read/write
15		Target File Element Number for O and I files. Set to zero for any file other than O or I.	Y	Word	read only

(1) The file number for RTC function files is set to 0 by the programming software.

(2) The F file is only permitted in the MSG instruction for MicroLogix 1200 and 1500 Series C and higher controllers.

(3) RTC and ST are only permitted in the MSG instruction for MicroLogix 1200 and 1500 Series B and higher controllers.

Message File Target Location Information

Target Device = CIP Generic

MicroLogix 1500 1764-LRP Series C, FRN 6 and higher Processor only.

Sub-Element	Name	Description	Parameter	Size	User Program Access
12		Target Class	Y	Word	read only
13	MG11:0.TFN	Target Instance	Y	Word	read/write
14	MG11:0.ELE	CIP Send Data Count	Y	Word	read/write
15		Reserved	Y	Word	read only

Message File Target Location Information

Target Device = Modbus Device

MicroLogix 1500 1764-LRP Series C, FRN 9 and higher Processor only.

Sub-Element	Name	Description	Parameter	Size	User Program Access
12		starting bit address for coils and inputs	Y	Word	read only
13	MG11:0.TFN	Modbus Target Data Address - 1	Y	Word	read/write
14		Reserved	Y	Word	read/write
15		Reserved	Y	Word	read only

The Control Bits, Sub-Element 16, of the MSG File Element are defined below:

Message File Sub-Element 16 - Control Bits

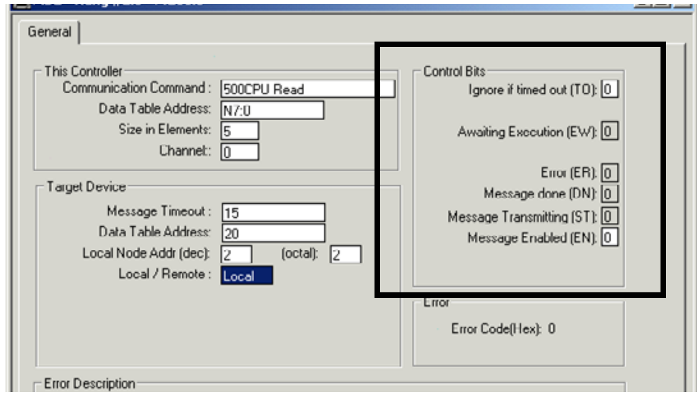
Bit	Address	Description	Parameter	Size	User Program Access
15	MG11:0.0/EN	Enable 1=MSG enabled 0=MSG not enabled	N	bit	read/write
9 to 14		Reserved	N	bit	read/write
8	MG11:0.0/TO	Time Out 1=MSG time out by user 0=no user MSG time out	N	bit	read/write
0 to 7		Reserved	N	bit	read/write

The Status Bits, Sub-Element 17, of the MSG File Element are defined below.

Message File Sub-Element 17 - Status Bits

Bit	Address	Description	Parameter	Size	User Program Access
15		Reserved	N	bit	read only
14	MG11:0.0/ST	Start: 1 = MSG transmitted and acknowledged by target device 0 = MSG has not been received by target	N	bit	read only
13	MG11:0.0/DN	Done 1 = MSG completed successfully 0 = MSG not complete	N	bit	read only
12	MG11:0.0/ER	Error 1 = error detected 0 = no error detected	N	bit	read only
11		Reserved	N	bit	read only
10	MG11:0.0/EW	Enabled and Waiting: 1=MSG Enabled and Waiting 0=MSG not Enabled and Waiting	N	bit	read only
1 to 9		Reserved	N	bit	read only
0	MG11:0.0/R	For PCCC Messaging: Range (1 = Local, 0 = Remote) For CIP Messaging: Target (1 = Comms Module, 0 = Network Device) For Modbus Messaging: Range (1 = Local)	Y	bit	read only

"Control Bits" Parameters



Ignore if Timed Out (TO)

Address	Data Format	Range	Type	User Program Access
MG11:0/TO	Binary	On or Off	Control	Read / Write

The Timed Out Bit (TO) can be set in your application to remove an active message instruction from processor control. You can create your own timeout routine by monitoring the EW and ST bits to start a timer. When the timer times out, you can set the TO bit, which removes the message from the system. The controller resets the TO bit the next time the associated MSG rung goes from false to true.

An easier method is to use the message timeout variable described on page 415, because it simplifies the user program. This built-in timeout control is in effect whenever the message timeout is non-zero. It defaults to 5 seconds, so unless you change it, the internal timeout control is automatically enabled.

When the internal timeout is used and communications are interrupted, the MSG instruction will timeout and error after the set period of time expires. This allows the control program to retry the same message or take other action, if desired.

To disable the internal timeout control, enter zero for the MSG instruction timeout parameter. If communications are interrupted, the processor waits indefinitely for a reply. If an acknowledge (ACK) is received, indicated by the ST bit being set, but the reply is not received, the MSG instruction appears to be locked up, although it is actually waiting for a reply from the target device.

Enable (EN)

Address	Data Format	Range	Type	User Program Access
MG11:0/EN	Binary	On or Off	Control	Read / Write

The Enable Bit (EN) is set when rung conditions go true and the MSG is enabled. The MSG is enabled when the command packet is built and put into one of the MSG buffers, or the request is put in the MSG queue. It remains set until the message transmission is completed and the rung goes false. You may clear this bit when either the ER or DN bit is set in order to re-trigger a MSG instruction with true rung conditions on the next scan.

IMPORTANT Do not set this bit from the control program.

Enabled and Waiting (EW)

Address	Data Format	Range	Type	User Program Access
MG11:0/EW	Binary	On or Off	Status	Read Only

The Enabled and Waiting Bit (EW) is set after the enable bit is set and the message is in the buffer (not in the queue) and waiting to be sent. The EW bit is cleared after the message has been sent and the processor receives acknowledgement (ACK) from the target device. This is before the target device has processed the message and sent a reply.

Error (ER)

Address	Data Format	Range	Type	User Program Access
MG11:0/ER	Binary	On or Off	Status	Read Only

The Error Bit (ER) is set when message transmission has failed. An error code is written to the MSG File. The ER bit and the error code are cleared the next time the associated rung goes from false to true.

Done (DN)

Address	Data Format	Range	Type	User Program Access
MG11:0/DN	Binary	On or Off	Status	Read Only

The Done Bit (DN) is set when the message is transmitted successfully. The DN bit is cleared the next time the associated rung goes from false to true.

Start (ST)

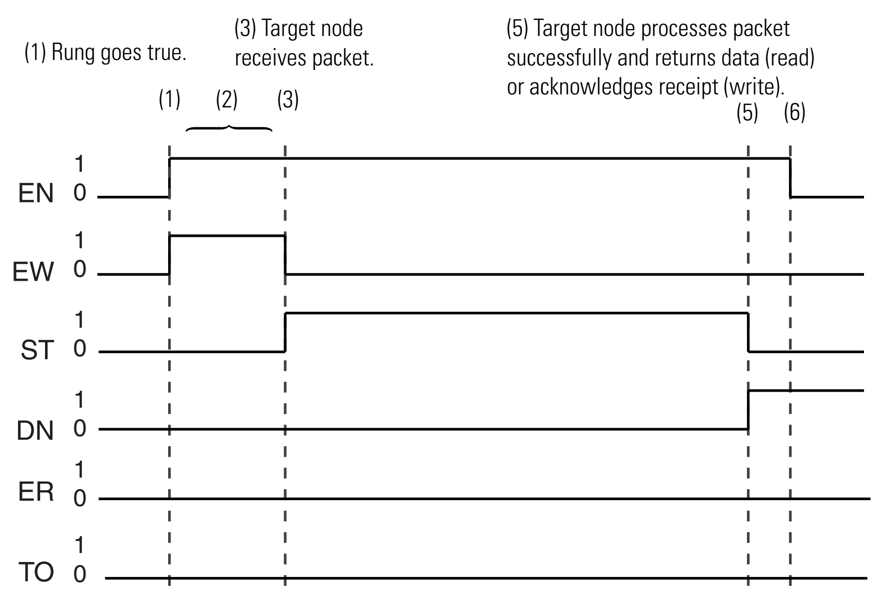
Address	Data Format	Range	Type	User Program Access
MG11:0/ST	Binary	On or Off	Status	Read Only

The Start Bit (ST) is set when the processor receives acknowledgment (ACK) from the target device. The ST bit is cleared when the DN, ER, or TO bit is set.

The DF1 Radio Modem and Modbus RTU Master protocols do not have acknowledgements. When the channel that the MSG instruction is being initiated on is configured for either of these two drivers, the Start Bit (ST) is set when the message has been successfully transmitted.

Timing Diagram for the MSG Instruction

The following section describes the timing diagram for a message instruction.



1. If there is room in any of the four active message buffers when the MSG rung becomes true and the MSG is scanned, the EN and EW bits for this message are set. If this is a MSG write instruction, the source data is transferred to the message buffer at this time.

   (Not shown in the diagram.) If the four message buffers are in use, the message request is put in the message queue and only the EN bit is set. The message queue works on a first-in, first-out basis that allows the controller to remember the order in which the message instructions were enabled. When a buffer becomes available, the first message in the queue is placed into the buffer and the EW bit is set (1).

TIP The control program does not have access to the message buffers or the communications queue.

Once the EN bit is set (1), it remains set until the entire message process is complete and either the DN, ER, or TO bit is set (1). The MSG Timeout period begins timing when the EN bit is set (1). If the timeout period expires before the MSG instruction completes its function, the ER bit is set (1), and an error code (37H) is placed in the MG File to inform you of the timeout error.

2. At the next end of scan, REF, or SVC instruction, the controller determines if it should examine the communications queue for another instruction. The controller bases its decision on the state of the channel's Communication Servicing Selection (CSS) and Message Servicing Selection (MSS) bits, the network communication requests from other nodes, and whether previous message instructions are already in progress. If the controller determines that it should not access the queue, the message instruction remains as it was. Either the EN and EW bits remain set (1) or only the EN bit is set (1) until the next end of scan, REF, or SVC instruction.

   If the controller determines that it has an instruction in the queue, it unloads the communications queue entries into the message buffers until all four message buffers are full. If an invalid message is unloaded from the communications queue, the ER bit in the MG file is set (1), and a code is placed in the MG file to inform you of an error. When a valid message instruction is loaded into a message buffer, the EN and EW bits for this message are set (1).

   The controller then exits the end of scan, REF, or SVC portion of the scan. The controller's background communication function sends the messages to the target nodes specified in the message instruction. Depending on the state of the CSS and MSS bits, you can service up to four active message instructions per channel at any given time.

3. If the target node successfully receives the message, it sends back an acknowledge (ACK). The ACK causes the processor to clear (0) the EW bit and set (1) the ST bit. The target node has not yet examined the packet to see if it understands your request.

   Once the ST bit is set (1), the controller waits for a reply from the target node. The target node is not required to respond within any given time frame.

TIP If the Target Node faults or power cycles during the message transaction, you will never receive a reply. This is why you should use a Message Timeout value in your MSG instruction.

4. Step 4 is not shown in the timing diagram. If you do not receive an ACK, step 3 does not occur. Instead, either no response or a negative acknowledge (NAK) is received. When this happens, the ST bit remains clear (0).

   No response may be caused by:

   - the target node is not there
   - the message became corrupted in transmission
   - the response was corrupted in response transmission

   A NAK may be caused by:

   - target node is busy
   - target node received a corrupt message
   - the message is too large

   When a NAK occurs, the EW bit is cleared (0), and the ER bit is set (1), indicating that the message instruction failed.

5. Following the successful receipt of the packet, the target node sends a reply packet. The reply packet contains one of the following responses:
   - successful write request.
   - successful read request with data
   - failure with error code

   At the next end of scan, REF, or SVC instruction, following the target node's reply, the controller examines the message from the target device. If the reply is successful, the DN bit is set (1), and the ST bit is cleared (0). If it is a successful read request, the data is written to the data table. The message instruction function is complete.

   If the reply is a failure with an error code, the ER bit is set (1), and the ST bit is cleared (0). The message instruction function is complete.

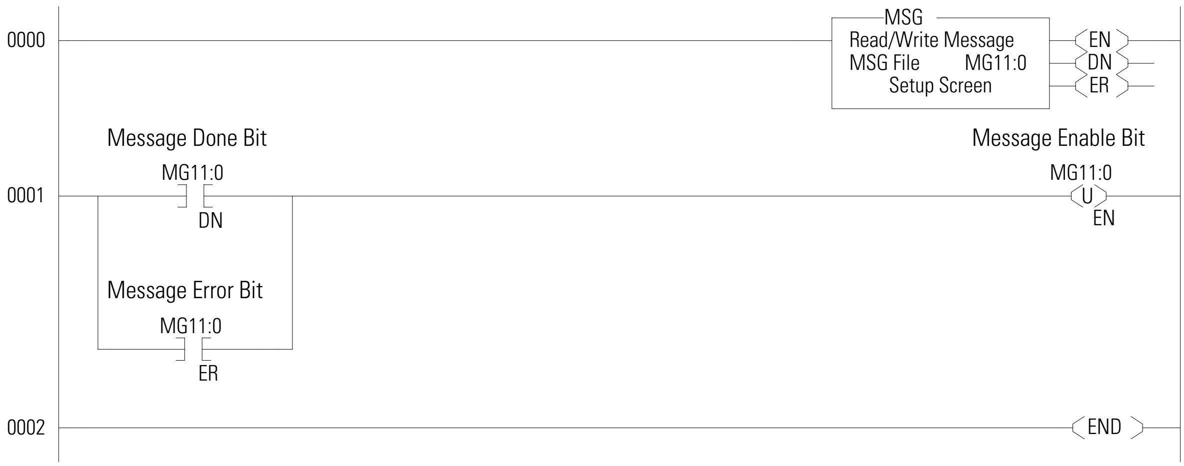
6. If the DN or ER bit is set (1) and the MSG rung is false, the EN bit is cleared (0) the next time the message instruction is scanned.

See MSG Instruction Ladder Logic on page 403 for examples using the message instruction.

MSG Instruction Ladder Logic

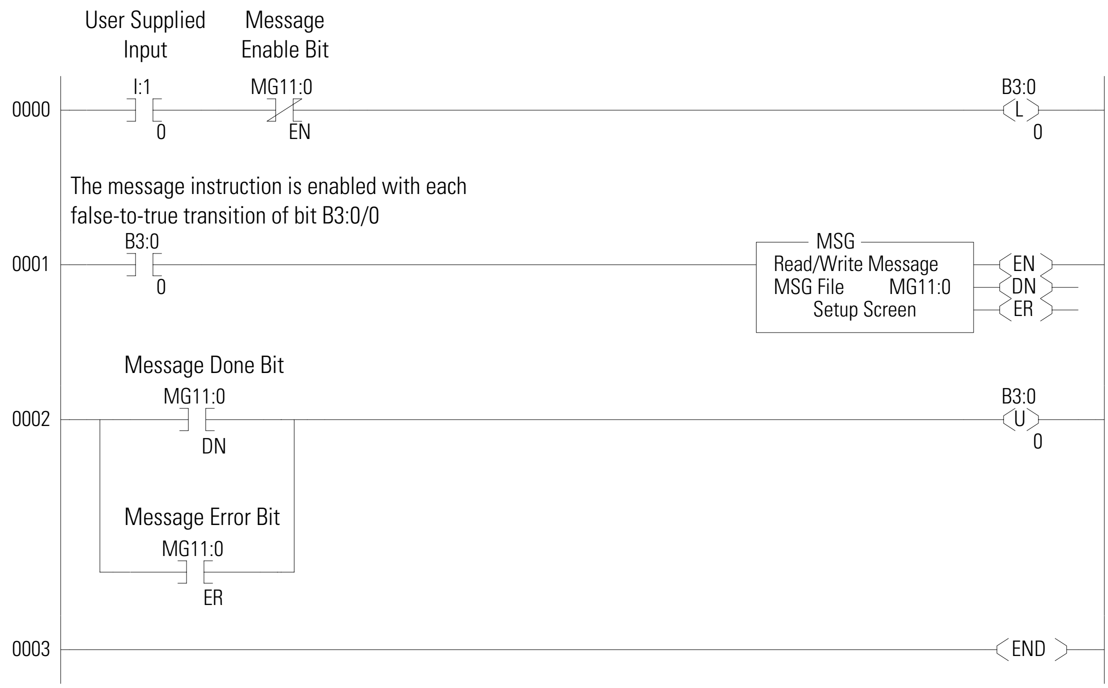
Enabling the MSG Instruction for Continuous Operation

The message instruction is enabled during the initial processor program scan and each time the message completes. For example, when the DN or ER bit is set.



Enabling the MSG Instruction Via User Supplied Input

This is an example of controlling when the message instruction operates. Input I:1/0 could be any user-supplied bit to control when messages are sent. Whenever I:1/0 is set and message MG11:0 is *not enabled*, the message instruction on rung 0001 is enabled.


User Supplied Input
Message Enable Bit
I:1
0
MG11:0
EN
B3:0
L
0
0000
The message instruction is enabled with each false-to-true transition of bit B3:0/0
B3:0
0
0001
MSG
Read/Write Message
MSG File MG11:0
Setup Screen
EN
DN
ER
Message Done Bit
MG11:0
DN
0002
B3:0
U
0
Message Error Bit
MG11:0
ER
0003
END

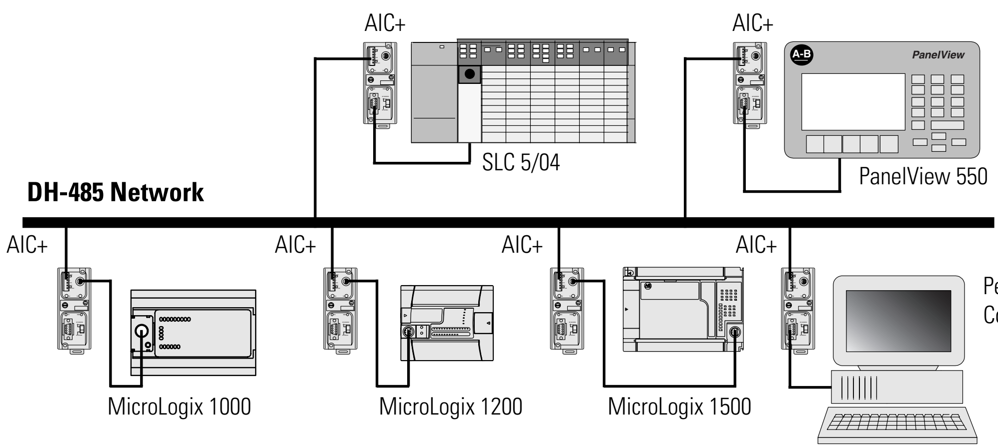
Local Messages

The controller is capable of communicating using local or remote messages. With a local message, all devices are accessible without a separate device acting as a bridge. Different types of electrical interfaces may be required to connect to the network, but the network is still classified as a local network. Remote messages use a remote network, where devices are accessible only by passing or routing through a device to another network. Remote networks are discussed on page 434.

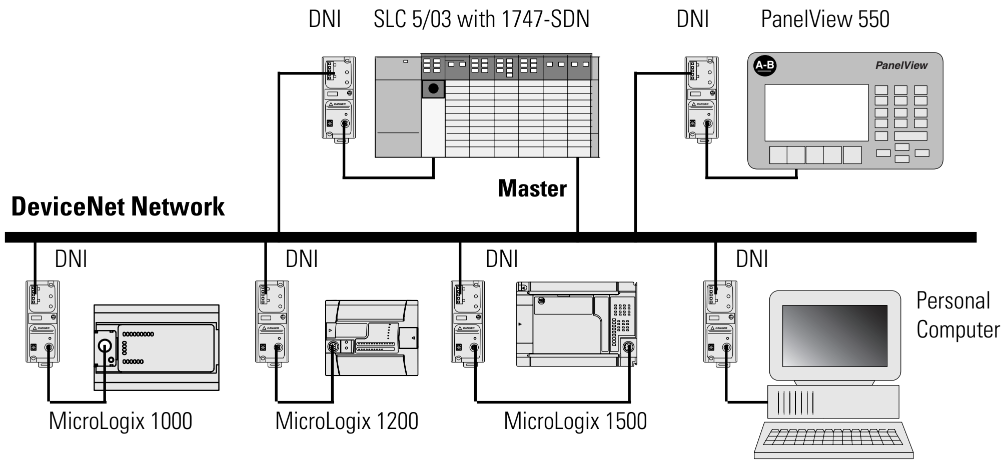
Local Networks

The following three examples represent different types of local networks.

Example 1 - Local DH-485 Network with AIC+ (1761-NET-AIC) Interface

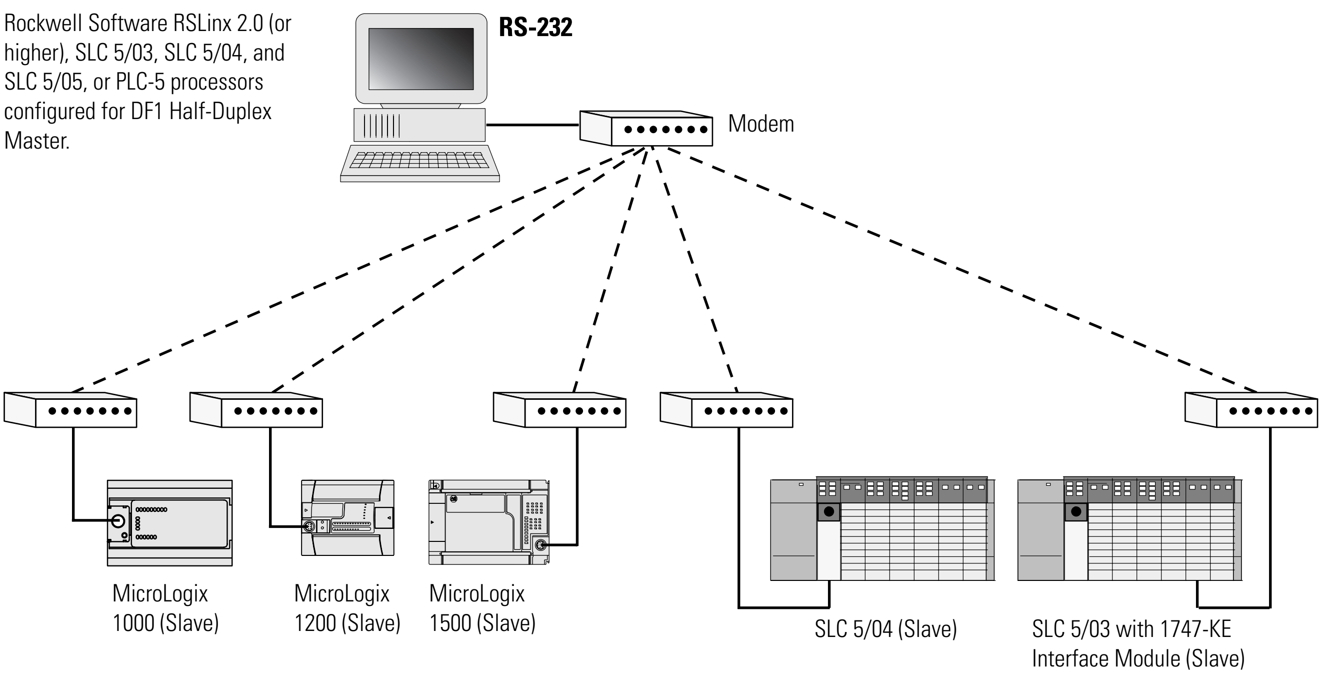


Example 2 - Local DeviceNet Network with DeviceNet Interface (1761-NET-DNI)



Example 3 - Local DF1 Half-Duplex Network

Rockwell Software RSLinx 2.0 (or higher), SLC 5/03, SLC 5/04, and SLC 5/05, or PLC-5 processors configured for DF1 Half-Duplex Master.

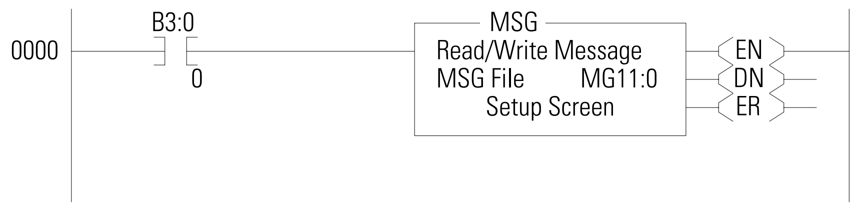


TIP It is recommended that isolation (1761-NET-AIC) be provided between the controller and the modem.

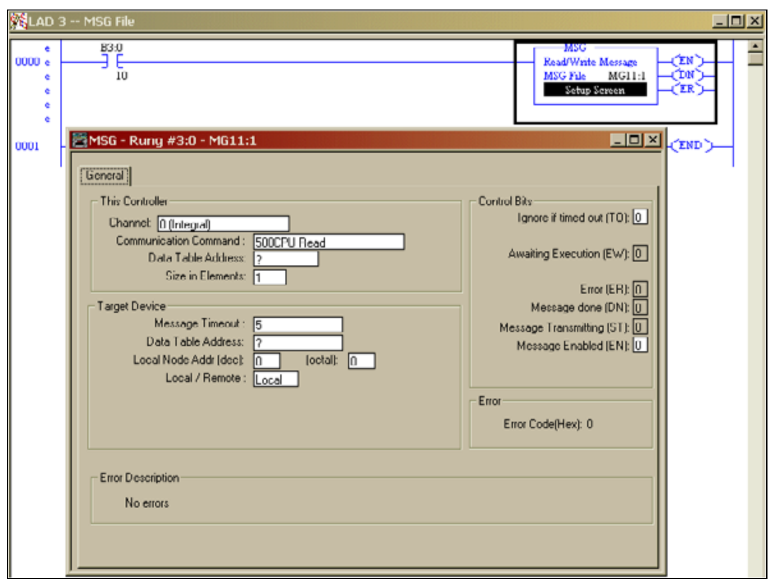
Configuring a Local Message

Message Setup Screen

The rung below shows a MSG instruction preceded by conditional logic. Access the message setup screen by double-clicking *Setup Screen*.



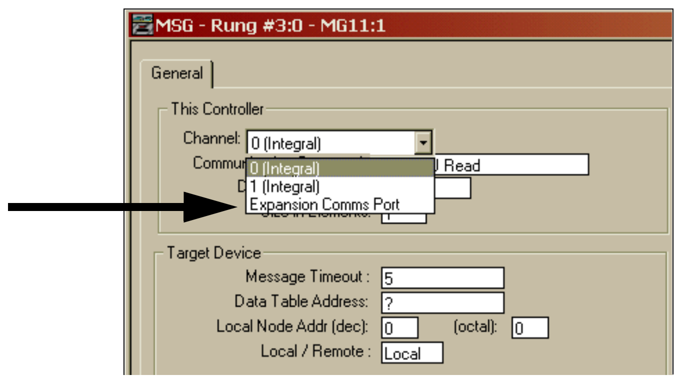
The RSLogix Message Setup Screen is shown below. This screen is used to setup "This Controller", "Target Device", and "Control Bits". Descriptions of each of the elements follow.



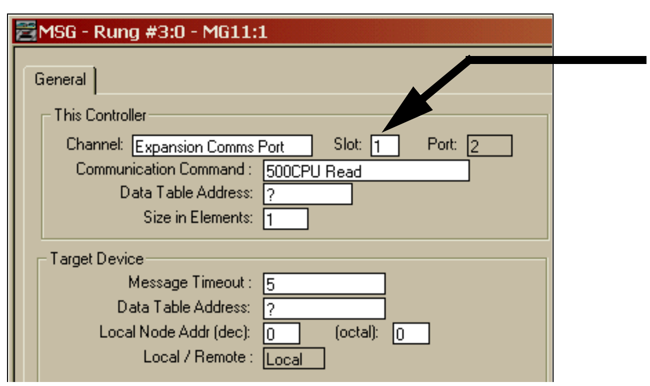
"This Controller" Parameters

Channel

The MicroLogix 1200 and MicroLogix 1500 1764-LSP support Channel 0 messaging only. The MicroLogix 1500 1764-LRP supports three different pathways for messaging. Channels 0 and 1 are RS-232 ports and are functionally identical to Channel 0 on the MicroLogix 1200 and MicroLogix 1500 1764-LSP controllers. The 1764-LRP also supports backplane communications through the Expansion Communication Port (ECP) as illustrated below. ECP messaging is supported through the 1769-SDN DeviceNet scanner and 1769-SM1 DPI/SCANport communications modules.



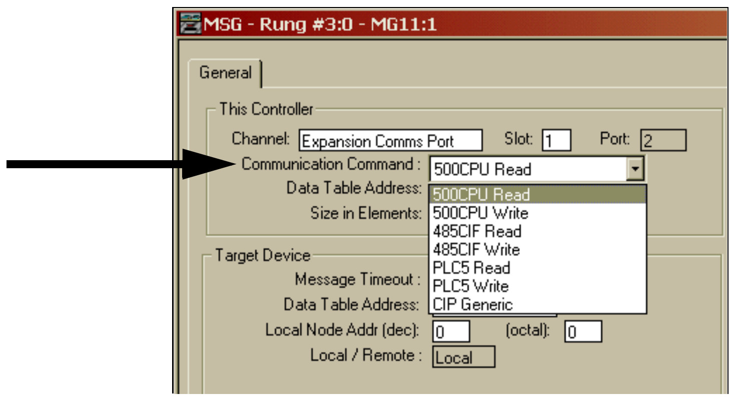
When ECP is chosen, you are able to select which slot position (1 to 16) the communications module resides in. The 1764-LRP processor can support up to two communications modules with full messaging functionality.



TIP	You can use multiple communications modules in a 1764-LRP MicroLogix 1500 system, but you can only message through the first two. A communications module physically positioned after the first two can only be used for I/O scanning.

If Channel 0 or Channel 1 is selected with that channel configured for Modbus RTU Master, then the next line will display “Modbus Command”. Otherwise, the next line displays “Communication Command”.

Communication Command



The controller supports six (seven for MicroLogix 1500 1764-LRP Series C and higher) different types of communications commands. If the target device supports any of these command types, the controller should be capable of exchanging data with the device. Supported commands include:

Communication Command Types

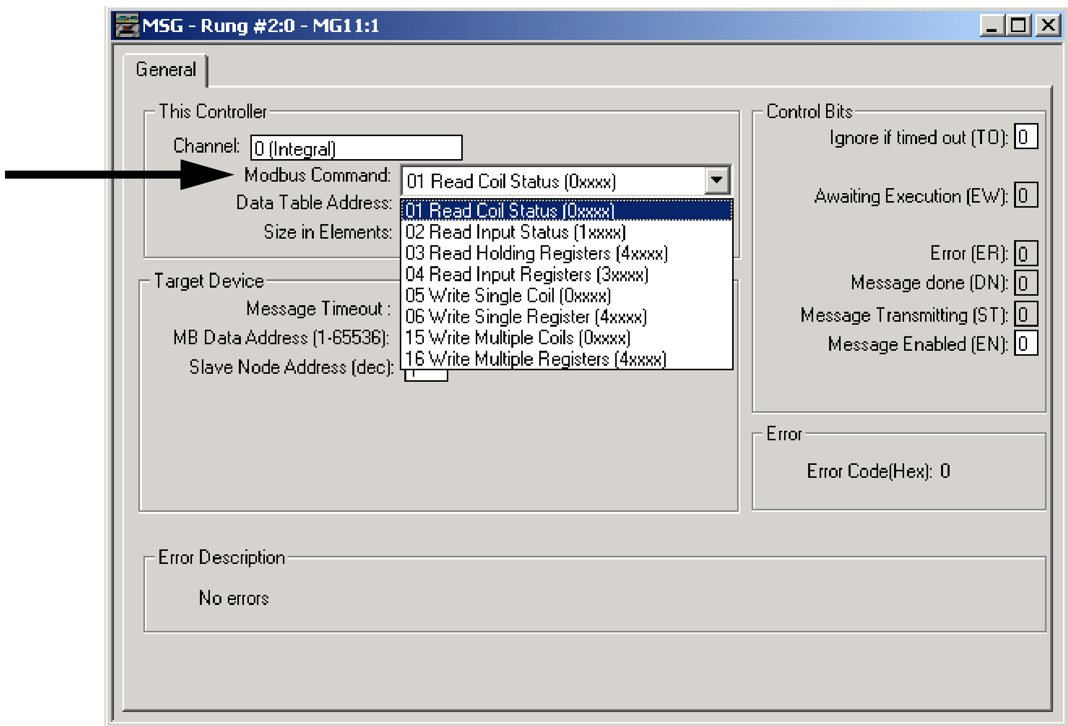
Communication Command	Description	Used For
500CPU Read	The target device is compatible with and supports the SLC 500 command set (all MicroLogix controllers).	reading data
500CPU Write	The target device is compatible with and supports the SLC 500 command set (all MicroLogix controllers).	sending data
485CIF Read(1)	The target device is compatible with and supports the 485CIF (PLC2).	reading data
485CIF Write(1)	The target device is compatible with and supports the 485CIF (PLC2).	sending data
PLC5 Read	The target device is compatible with and supports the PLC5 command set.	reading data
PLC5 Write	The target device is compatible with and supports the PLC5 command set.	sending data
CIP Generic(2)	The target device is compatible with and supports the CIP command set on DeviceNet (1769-SDN) or DPI/SCANport (1769-SM1).	Sending and receiving data

(1) See Important note below.

(2) MicroLogix 1500 1764-LRP Series C, FRN 6 and higher for DeviceNet messaging and DPI/SCANport messaging.

IMPORTANT	The Common Interface File (CIF) in the MicroLogix 1200, 1500, and SLC 500 processors is File 9. The CIF in the MicroLogix 1000 controller is Integer File 7.

Modbus Command



The controller supports eight Modbus commands. If the target device supports any of these Modbus command types, the controller should be capable of exchanging data with the device. Supported Modbus commands include:

Modbus(1) Command Types

Modbus Command	Used For
01 Read Coil Status	reading bits
02 Read Input Status	reading bits
03 Read Holding Registers	reading words
04 Read Input Registers	reading words
05 Write Single Coil	writing 1 bit

Modbus[1] Command Types

Modbus Command	Used For
06 Write Single Register	writing 1 word
15 Write Multiple Coil	writing multiple bits
16 Write Multiple Registers	writing multiple words

(1) MicroLogix 1200 Series C, FRN 8 and higher; and MicroLogix 1500 Series C, FRN 9 and higher.

Data Table Address

This variable defines the starting address in the local controller. Valid file types for the Data Table Address are shown below:

Message Read	Message Write
Bit (B)	Output (O)
Timer (T)	Input (I)
Counter (C)	Bit (B)
Control (R)	Timer (T)
Integer (N)	Counter (C)
Floating Point (F)(1)	Control (R)
Long Word (L)	Integer (N)
	Floating Point (F)(1)
	Long Word (L)
	String (ST)(2)(3)
	Real-Time Clock (RTC)(2)(4)

(1) Applies to MicroLogix 1200 Series C and later, and 1500 Series C and later only. Message Type must be 500CPU or PLC5. The Local File Type and Target File Type must both be Floating Point.

(2) Applies to MicroLogix 1200 Series B and later, and 1500 Series B and later only.

(3) 485CIF write ST-to-485CIF only.

(4) 500CPU write RTC-to-Integer or RTC-to-RTC only.

TIP Only Bit (B) and Integer (N) file types are valid for Modbus Command messages. Modbus bit commands require a starting bit address for the Data Table Address.

Size in Elements

This variable defines the amount of data (in elements) to exchange with the target device.

The maximum amount of data that can be transferred via a MSG instruction is 103 words (120 words for Modbus commands) and is determined by the destination data type. The destination data type is defined by the type of message: read or write.

- For Read Messages: When a read message is used, the destination file is the data file in the local or originating processor.

TIP Input, output, string, and RTC file types are not valid for read messages.

- For Write Messages: When a write message is used, the destination file is the data file in the target processor.

The maximum number of elements that can be transmitted or received are shown in the following table. You cannot cross file types when sending messages. For example, you cannot read a timer into an integer file and you cannot write counters to a timer file. The only exceptions to this rule are that:

- long integer data can be read from or written to bit or integer files, and
- RTC files can be written to integer files (*MicroLogix 1200 Series B and later, and 1500 Series B and later only*).

TIP The table below is not intended to illustrate file compatibility, only the maximum number of elements that can be exchanged in each case.

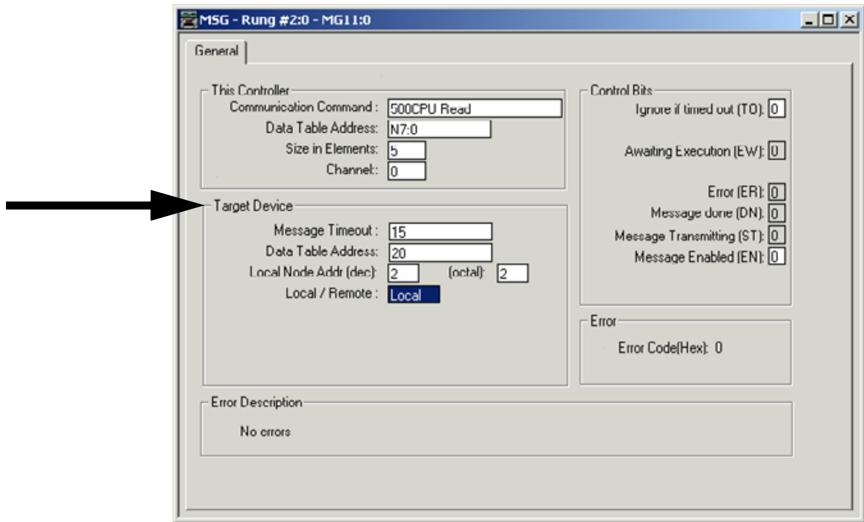
Message Type	File Type	Element Size	Maximum Number of Elements per Message
485CIF	O, I, B, N	1-word	103
	L	2-word	51
	T, C, R	3-word	34
	ST	42-word	2 (write only)
500CPU	O, I, B, N	1-word	103
	F(1), L	2-word	51
	T, C, R	3-word	34
	RTC	8-word	1 (write only)
PLC5	O, I, B, N	1-word	103
	F(1), L	2-word	51
	T	5-word	20
CIP	B, N	1-word	126
	F, L	2-words	63

Message Type	File Type	Element Size	Maximum Number of Elements per Message
Modbus Commands(2)	B, N (command 5)	1-bit	1
	B, N (command 6)	1-word	1
	B, N (commands 1, 2, and 15)	1-bit	1920 Modbus bit elements (120 words) (Commands 1 and 2 are read only, 15 is write only.)
	B, N (commands 3, 4, and 16)	multi-register	120 Modbus register elements (120 words) (Commands 3 and 4 are read only, 16 is write only.)

(1) Applies to MicroLogix 1200 Series C and later, and 1500 Series C and later only. Message Type must be 500CPU or PLC5. The Local File Type and Target File Type must both be Floating Point.

(2) MicroLogix 1200 Series C, FRN 8 and higher; MicroLogix 1500 Series C, FRN 9 and higher.

"Target Device" Parameters



Message Timeout

This value defines how long, in seconds, the message instruction has to complete its operation once it has started. Timing begins when the false-to-true rung transition occurs, enabling the message. If the timeout period expires, the message errors out. The default value is 5 seconds (2 seconds for Modbus commands). The maximum timeout value is 255 seconds.

If the message timeout is set to zero, the message instruction will never timeout. Set the Time Out bit (TO = 1) to flush a message instruction from its buffer if the destination device does not respond to the communications request.

Data Table Address/Offset

This variable defines the starting address in the target controller. The data table address is used for a 500CPU and PLC5 type messages. A valid address is any valid, configured data file within the target device whose file type is recognized by the controller. Valid combinations are shown below:

Message Type	Local File Type	Target File Type
500CPU and PLC5	O, I, B, N, F[1], L	O, I, S, B, N, F[1], L
	T	T
	C	C
	R	R
	RTC[2]	N, RTC

(1) Applies to MicroLogix 1200 Series C and later, and 1500 Series C and later only. Message Type must be 500CPU or PLC5. The Local File Type and Target File Type must both be Floating Point.

(2) 500CPU write RTC-to-Integer or RTC-to-RTC only. Applies to MicroLogix 1200 Series B and later, and 1500 Series B and later only.

The data table offset is used for 485CIF type messages. A valid offset is any value in the range 0 to 255 and indicates the word or byte offset into the target's Common Interface File (CIF). The type of device determines whether it is a word or byte offset. MicroLogix controllers and SLC processors use word offset; PLC-5 and ControlLogix processors use byte offset.

Modbus - MB Data Address (1-65536)

Modbus addressing is limited to 16 bits per memory group, each with a range of 1 to 65,536. There are four memory groups, one for each function:

- coils (generally addressed as **0**xxxx)
- contacts (**1**xxxx)
- input registers (**3**xxxx)
- holding registers (**4**xxxx)

Coils and contacts are addressed at the bit level. Coils are outputs and can be read and written. Contacts are inputs and are read-only.

Input registers and holding registers are addressed at the word level. Input registers are generally used for internally storing input values. They are read-only. Holding registers are general purpose and can be both read and written.

The most significant digit of the address is considered a prefix, and does not get entered into the MB Data Address field when configuring the message instruction.

When the message is sent, the address is decremented by 1 and converted into a 4-character hex number to be transmitted via the network (with a range of 0-FFFFh); the slave increments the address by 1, and selects the appropriate memory group based on the Modbus function.

TIP

Modbus protocol may not be consistently implemented in all devices. The Modbus specification calls for the addressing range to start at 1; however, some devices start addressing at 0.

The Modbus Data Address in the Message Setup Screen may need to be incremented by one to properly access a Modbus slave's memory, depending on that slave's implementation of memory addressing.

Local/Slave Node Address

This is the destination device's node number if the devices are on a DH-485 (using 1761-NET-AIC), DeviceNet (using 1761-NET-DNI), DF1, or Modbus network.

TIP

To initiate a broadcast message on a DH-485, DF1 Half-Duplex, or DF1 Radio Modem network, set the local node address to -1.

To initiate a broadcast message on a Modbus network, set the slave node address to 0. Do not initiate more than one Modbus broadcast message at a time. When sequentially triggering multiple Modbus broadcast messages, insert at least 10 msec. delay in between each message.

Local/Remote

This variable defines the type of communications that is used. Always use local when you need point-to-point communications via DF1 Full-Duplex or network communications such as Ethernet/IP (using 1761-NET-ENI), DeviceNet (using 1761-NET-DNI), DF1 Half-Duplex, or DF1 Radio Modem. For DH-485, use local if the target node is on the same DH-485 network as this controller, or remote if the path to the target node goes through one or more communication bridges.

Local Messaging Examples

Five examples of local messaging are shown in this section:

- 500CPU message type
- 485CIF message type
- PLC5 message type
- CIP Generic message type over DeviceNet via 1747-SDN
- Modbus RTU Message type

A summary of the message instruction configuration parameters is shown in the following table.

Parameter		Description
This Controller	Channel	Identifies the communication channel. Always Channel 0 (*or Channel 1 or Expansion Communications Port for MicroLogix 1500 1764-LRP Processor only.*)
	Communication Command (500CPU, 485CIF, PLC5, and ECP message types)	Specifies the type of message. Valid types are: • 500CPU Read • 500CPU Write • 485CIF Read • 485CIF Write • PLC5 Read • PLC5 Write • CIP Generic
	Modbus Command	Specifies the type of message. Valid types are: • 01 Read Coil Status • 02 Read Input Status • 03 Read Holding Registers • 04 Read Input Registers • 05 Write Single Coil • 06 Write Single Register • 15 Write Multiple Coils • 16 Write Multiple Registers
	Data Table Address	For a Read, this is the starting address which receives data. Valid file types are B, T, C, R, N, and L (for Modbus commands, B and N only).
		For a Write, this is the starting address which is sent to the target device. Valid file types are O, I, B, T, C, R, N, L, ST(1)(2), and RTC(2)(3) (for Modbus commands, B and N only).
	Size in elements	Defines the length of the message in elements. • 1-word elements; valid size: 1 to 103. • 2-word elements; valid size: 1 to 51. • 8-word RTC elements; valid size: 1 • 42-word String elements; valid size 1 to 2 • Timer (500CPU and 485CIF), Counter, and Control elements; valid size: 1 to 34. • PLC-5 Timer elements; valid size: 1 to 20 • Modbus bit elements: 1 to 1920 • Modbus register elements: 1 to 120

Parameter		Description
Target Device	Message Timeout	Defines the amount of time the controller waits for the reply before the message errors. A timeout of 0 seconds means that the controller waits indefinitely for a reply. Valid range is from 0 to 255 seconds.
	Data Table Address (500CPU and PLC5 message types)	For a Read, this is the address in the processor which is to return data. Valid file types are S, B, T, C, R, N, and L.
		For a Write, this is the address in the processor which receives data. Valid file types are I, O, S, B, T, C, R, N, L, and RTC(2)(4).
	Data Table Offset (485CIF message types)	This is the word offset value in the common interface file (byte offset for PLC device) in the target processor, which is to send the data.
	MB Data Address	Specifies the Modbus address in the target device. Valid range is from 1 to 65,536.
	Local Slave Node Address	Specifies the node number of the device that is receiving the message. Valid range is 0 to 31 for DH-485 protocol, 0 to 254 for DF1 protocol, 0 to 63 for DeviceNet, or 0 to 247 for Modbus.
	Local/Remote	Specifies whether the message is local or remote. (Modbus messages are local only.)

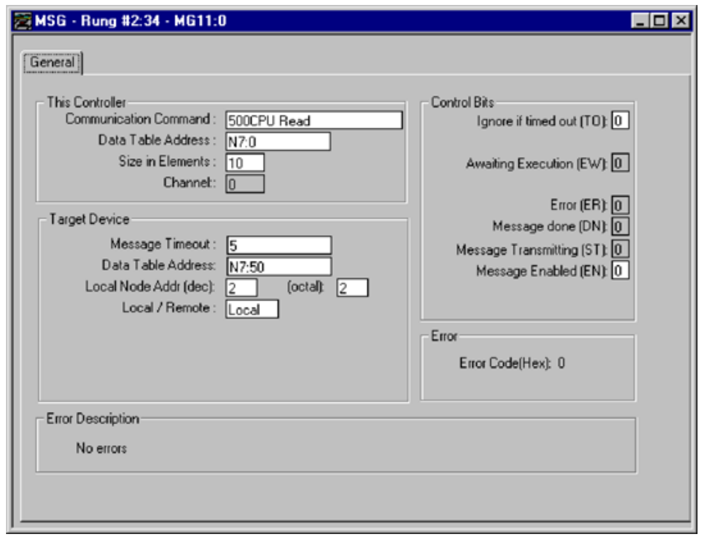
(1) Applies to MicroLogix 1200 Series B and later, and 1500 Series B and later.

(2) 485CIF write ST-to-485CIF only.

(3) 500CPU write RTC-to-Integer or RTC-to-RTC only.

Example 1 - Local Read from a 500CPU

Message Instruction Setup



In this example, the controller reads 10 elements from the target's (Local Node 2) N7 file, starting at word N7:50. The 10 words are placed in the controller's integer file starting at word N7:0. If five seconds elapse before the message completes, error bit MG11:0/ER is set, indicating that the message timed out.

Valid File Type Combinations

Valid transfers between file types are shown below for MicroLogix messaging:

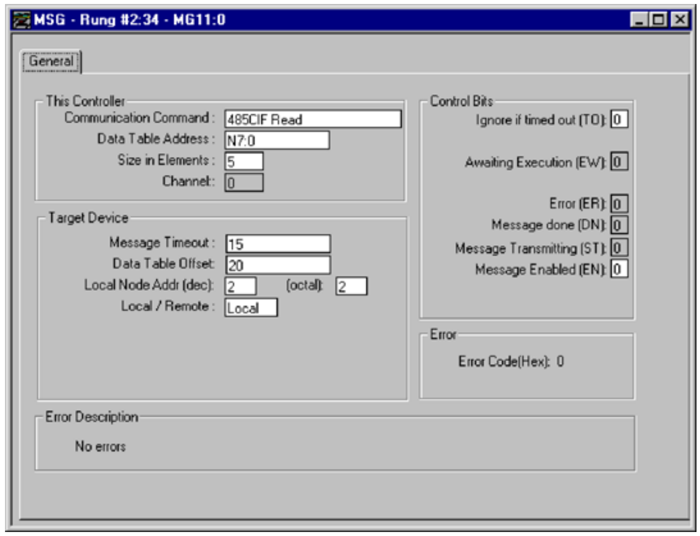
Local Data Types	Communication Type	Target Data Types
O[1], I[1], B, N, L	<---> read/write	O, I, S, B, N, L
T	<---> read/write	T
C	<---> read/write	C
R	<---> read/write	R
RTC[2]	---> write	N, RTC

(1) Output and input data types are not valid local data types for read messages.

(2) 500CPU write RTC-to-Integer or RTC-to-RTC only. Applies to MicroLogix 1200 Series B and later, and 1500 Series B and later only.

Example 2 - Local Read from a 485CIF

Message Instruction Setup



In this example, the controller reads five elements (words) from the target device's (Local Node 2) CIF file, starting at word 20 (or byte 20 for non-SLC 500 devices). The five elements are placed in the controller's integer file starting at word N7:0. If 15 seconds elapse before the message completes, error bit MG11:0/ER is set, indicating that the message timed out.

Valid File Type Combinations

Valid transfers between file types are shown below for MicroLogix messaging:

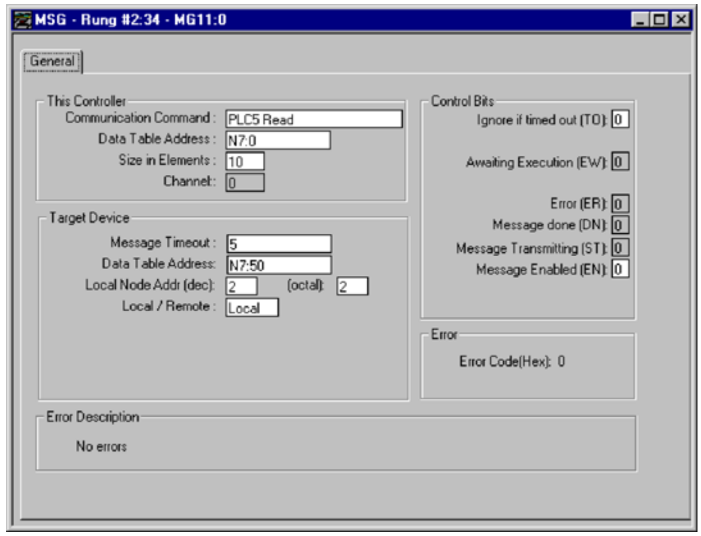
Local Data Types	Communication Type	Target Data Types
O(1), I(1), B, N, L	<---> read/write	485CIF
T	<---> read/write	485CIF
C	<---> read/write	485CIF
R	<---> read/write	485CIF
ST(2)	---> write	485CIF

(1) Output and input data types are not valid local data types for read messages.

(2) Applies to MicroLogix 1200 Series B and later, and 1500 Series B and later only.

Example 3 - Local Read from a PLC-5

Message Instruction Setup



In this example, the controller reads 10 elements from the target device's (Local Node 2) N7 file, starting at word N7:50. The 10 words are placed in the controller's integer file starting at word N7:0. If five seconds elapse before the message completes, error bit MG11:0/ER is set, indicating that the message timed out.

Valid File Type Combinations

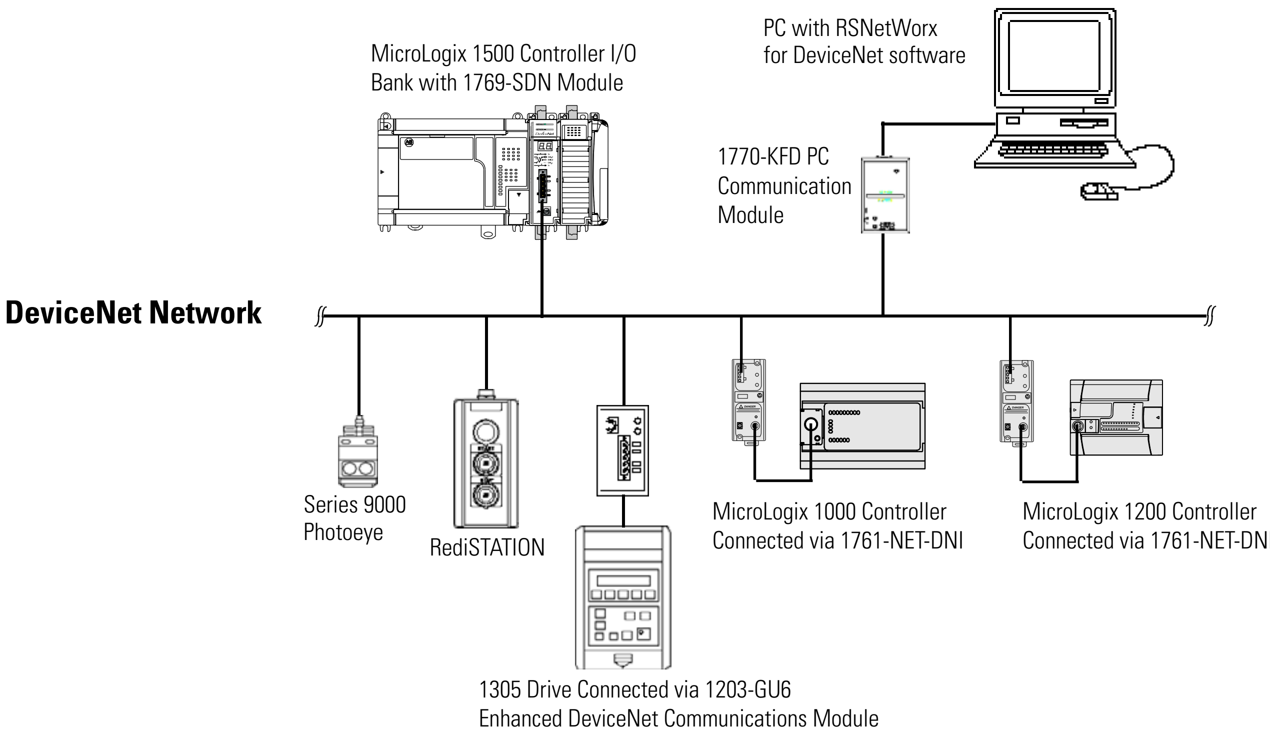
Valid transfers between file types are shown below for MicroLogix messaging:

Local Data Types	Communication Type	Target Data Types
O(1), I(1), B, N, L	<---> read/write	O, I, S, B, N, L
T	<---> read/write	T
C	<---> read/write	C
R	<---> read/write	R

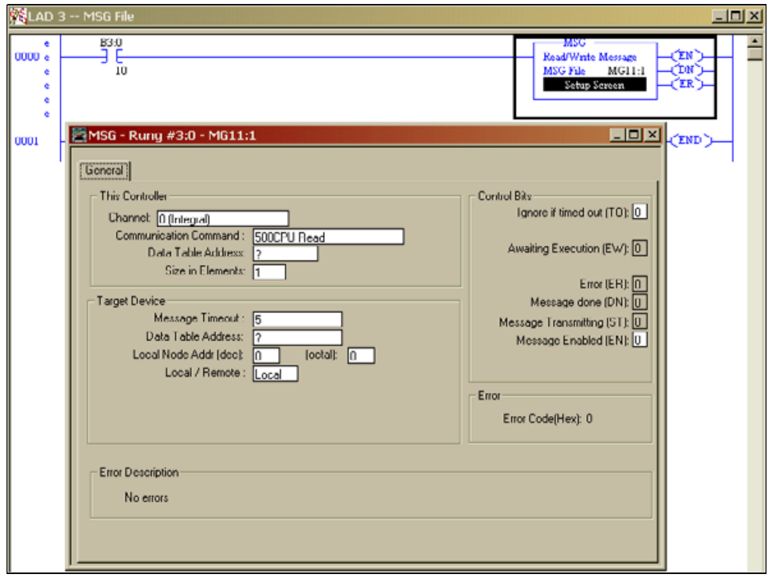
(1) Output and input data types are not valid local data types for read messages.

Example 4 - Configuring a Local DeviceNet Message

This section describes how to configure a local message using the scanner and a MicroLogix 1500 1764-LRP processor. An example network is shown below:



Message Setup Screen



Rung 0 shows a standard RSLogix 500 message (MSG) instruction preceded by conditional logic.

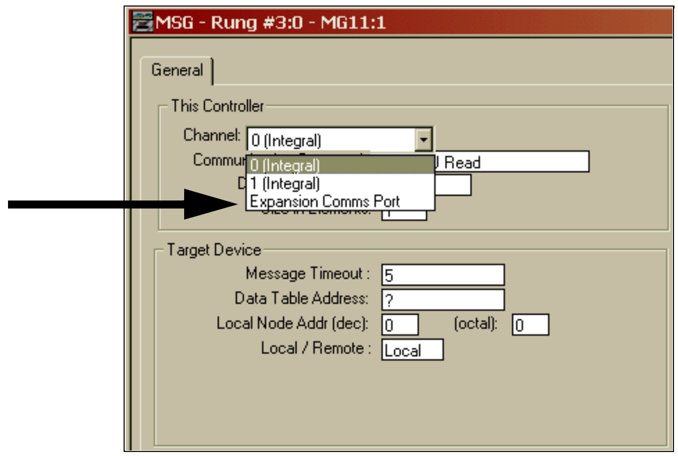
1. Access the message setup screen by double-clicking Setup Screen.

2. The RSLogix 500 Message Setup Screen appears. This screen is used to setup or monitor message parameters for “This Controller”, “Target Device”, and “Control Bits”. Descriptions of each of these sections follow.

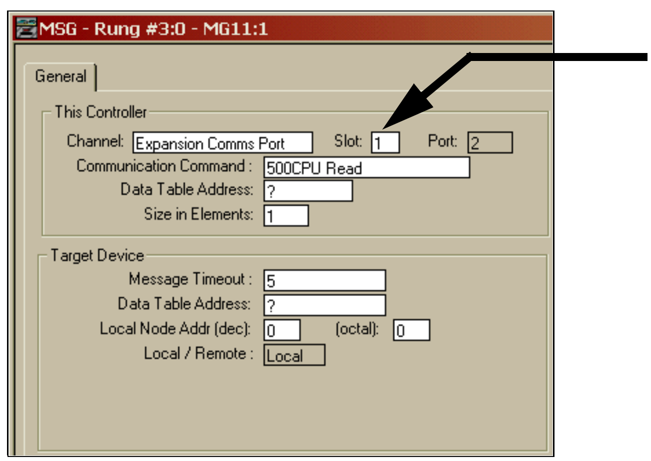
"This Controller" Parameters

Channel

The 1764-LRP supports three different pathways for messaging, channels 0 and 1 are RS-232 ports and are functionally identical to MicroLogix 1200 and MicroLogix 1500 1764-LSP controllers. The 1764-LRP also supports backplane communications through the Expansion Communication Port (ECP) as illustrated below.

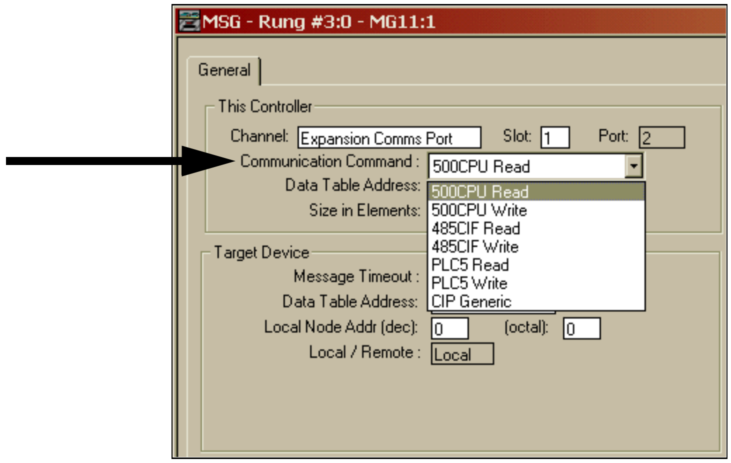


When ECP is chosen, you are able to select which slot position (1 to 16) the scanner resides in. The 1764-LRP processor can support up to two 1769-SDN scanner modules with full messaging functionality.



TIP	You can use multiple 1769-SDN scanner modules in a 1764-LRP MicroLogix 1500 system, but you can only message through the first two. A scanner physically positioned after the first two can only be used for I/O scanning.

CIP Generic Communication Command

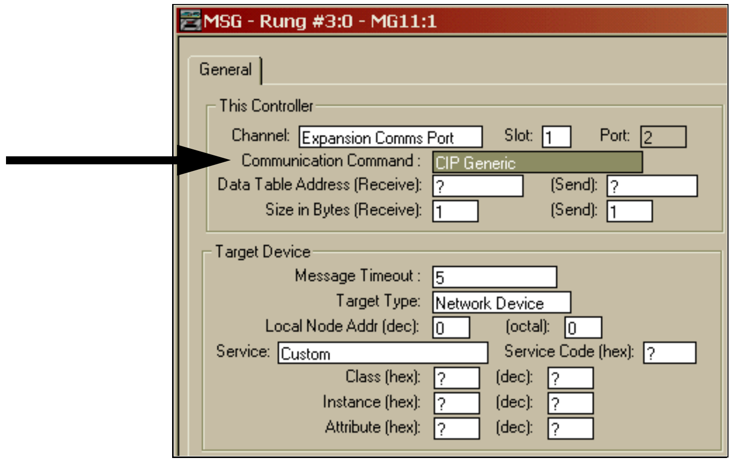


The 1764-LRP processor supports the six standard types of communications commands (same as all other MicroLogix 1200 and 1500 controllers) and CIP Generic on the Expansion Comms Port. When any of the six standard commands are chosen, you can initiate standard messages to destination devices connected to DeviceNet products that support PCCC messaging (including MicroLogix and SLC controllers using 1761-NET-DNI's, 1203-GU6 drive interface, and other MicroLogix 1500 controllers using 1769-SDN scanner modules). You can initiate reads, writes, program upload/download and online monitoring across DeviceNet. This is functionally identical to DH-485 and DH+ networking.

CIP stands for "Common Industrial Protocol". CIP is a newer and more versatile protocol than PCCC. It is an open protocol that is supported by newer Allen-Bradley controllers and third-party products.

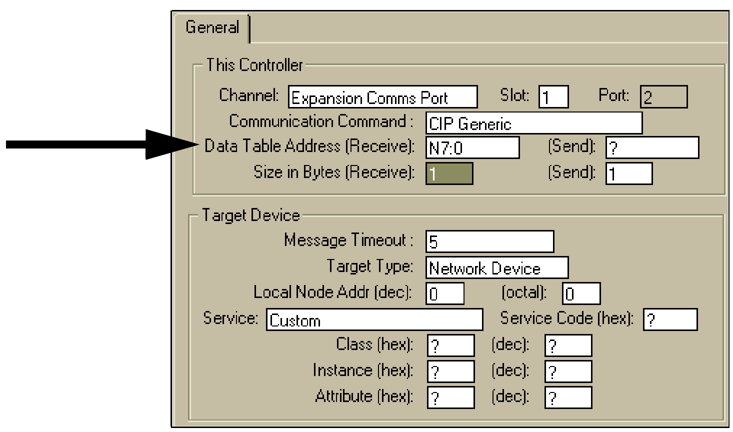
CIP messaging is the native messaging format for DeviceNet. All DeviceNet devices are compliant with CIP messaging. The MicroLogix 1500 1764-LRP processor (Series C) has an enhanced message instruction that provides simple, easy to use CIP messaging.

Selecting CIP Generic configures the message instruction to communicate with DeviceNet devices that do not support PCCC messaging. When CIP Generic is chosen, you will notice that a number of message parameters change and many new ones become available depending upon the service selected.



Data Table Address (Receive and Send)

This value identifies the data file location within the 1764-LRP controller that will receive data from the DeviceNet device, and/or the starting data file location that will be sent to the destination DeviceNet device.

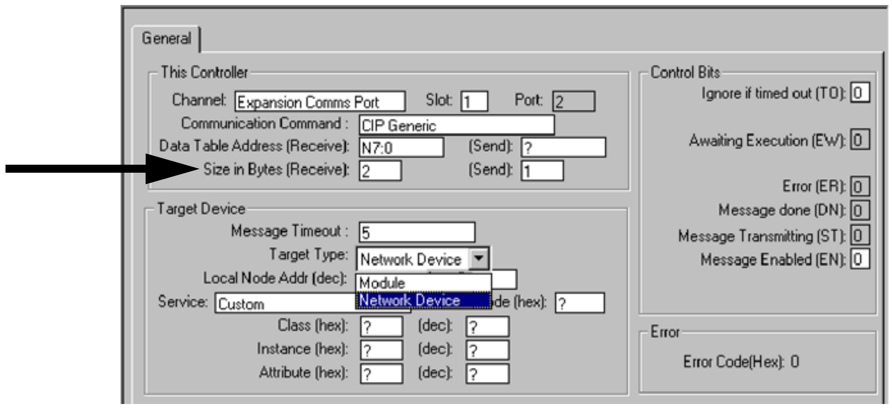


Size in Bytes (Receive and Send)

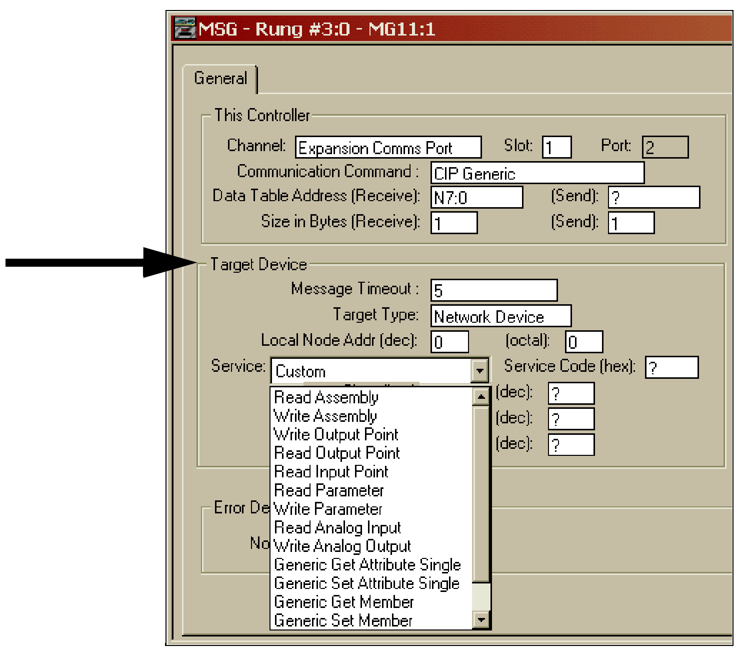
Since all data transmitted on DeviceNet is byte based, you must enter the number of bytes that will be received and sent. You must make sure that enough memory is available in the destination device. Word elements within 1764-LRP controllers contain 2 bytes each. These include Bit and Integer data files. Long word and Floating point elements contain 4 bytes each.

For receive, the Size in bytes entered must be greater than or equal to the number of bytes than the DeviceNet device will return. DeviceNet devices return a fixed number of bytes depending on the Class and Service. If more data is returned than expected, the message will error and no data will be written. If less data is returned than expected, the data will be written and the remainder of the bytes will be filled with zeros.

In the example screen shown below, N7:0 will receive 2 bytes (1 word) of data.



Target Device



Message Timeout

Message timeout is specified in seconds. If the target does not respond within this time period, the message instruction will generate a specific error (see MSG Instruction Error Codes on page 441). The amount of time that is acceptable should be based on application requirements and network capacity/loading.

Target Type

You can select either Module or Network Device. If you need to message to a device on DeviceNet, select Network Device. If you need to message to a DeviceNet parameter on the scanner, select Module. This allows the control program access to module parameters.

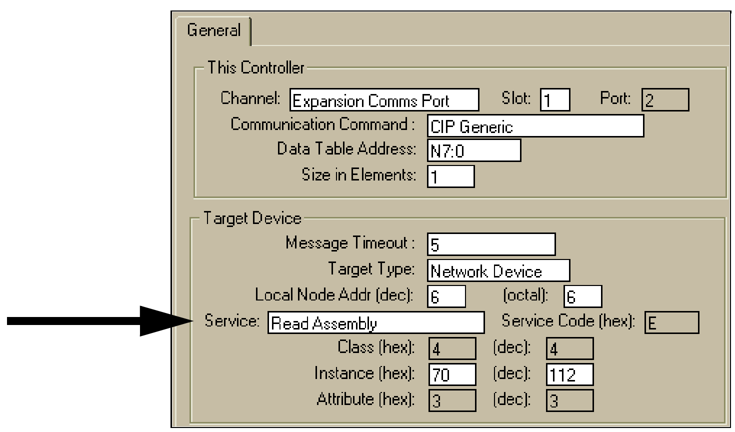
TIP	Note, many module parameters are not editable, and some can only be edited when the module is in Idle Mode.

Local Node address

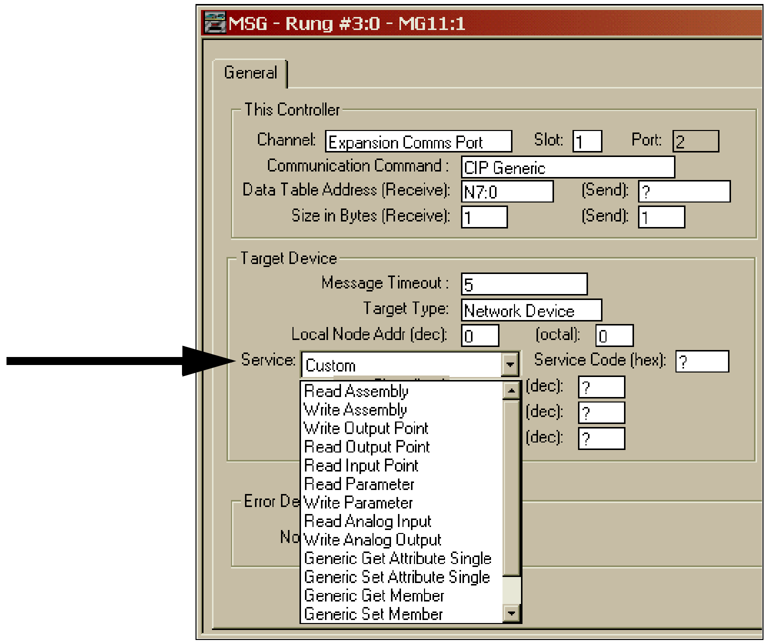
This is the target device's DeviceNet node number.

Service

DeviceNet uses services to provide specific messaging functions. A number of standard services with their corresponding parameters have been preconfigured for ease of use.



If you need to use a service that is not available, select one of the Generic services. The Generic service allows you to enter specific service code parameters. Information on what services a target device supports is usually provided in the device’s documentation.

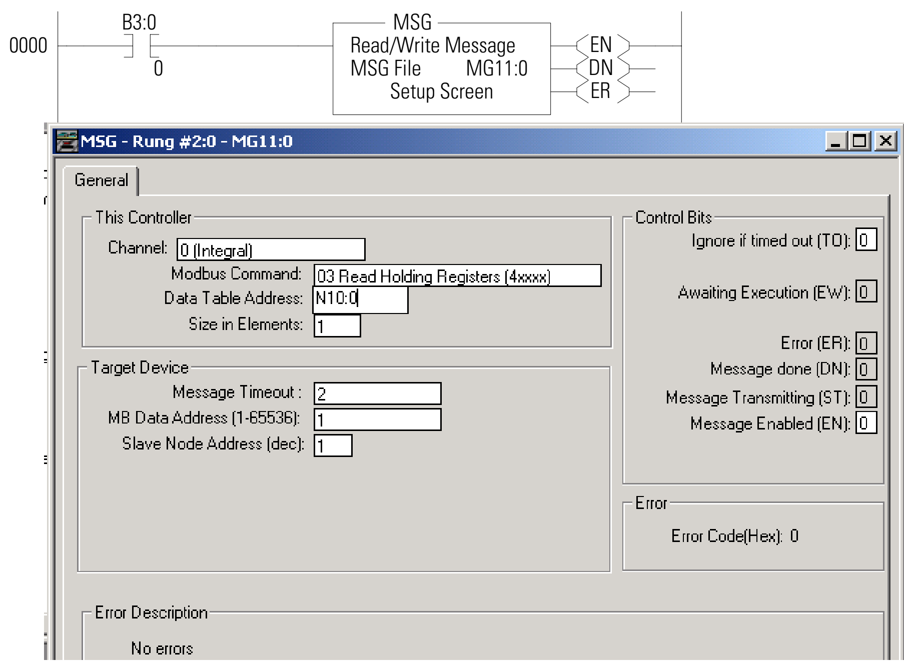


Example 5 - Configuring a Modbus Message

This section describes how to configure a local message using the Modbus communication commands. Since configuration options are dependent on which channel is selected, the programming software has been designed to only show the options available for the selected channel.

Before configuring the MSG instruction, open the Channel Configuration screen and set the Driver to Modbus RTU Master. For more information on Channel Configuration, see Modbus RTU Master Configuration on page 545.

Message Setup Screen



Rung 0 shows a standard RSLogix 500 message (MSG) instruction preceded by conditional logic.

1. Access the message setup screen by double-clicking Setup Screen.

2. The RSLogix 500 Message Setup Screen appears. This screen is used to setup or monitor message parameters for “This Controller”, “Target Device”, and “Control Bits”. Descriptions of each of these sections follow.

"This Controller" Parameters

If a Channel configured for Modbus Master is selected in the Channel field of the Message Setup Screen, the following Modbus Command options will become available:

- 01 Read Coil Status (0xxxx)
- 02 Read Input Status (1xxxx)
- 03 Read Holding Registers (4xxxx)
- 04 Read Input Registers (3xxxx)
- 05 Write Single Coil (0xxxx)
- 06 Write Single Register (4xxxx)
- 15 Write Multiple Coils (0xxxx)
- 16 Write Multiple Registers (4xxxx)

Data Table Address

Local file types must be Binary (B) or Integer (N) for Modbus commands. Starting data table address for coil/input bit commands (1, 2, 5 and 15) require a bit address. Starting data table addresses for register commands (3, 4, 6 and 16) require a word address.

Size in Elements

Size in elements defaults to "1". For coil/input commands (1, 2, 5 and 15), elements are in bits. For register commands (3, 4, 6 and 10), elements are in words.

Target Device

Message Timeout

Message timeout is specified in seconds. If the target does not respond within this time period, the message instruction will generate a specific error (see MSG Instruction Error Codes on page 441). The amount of time that is acceptable should be based on application requirements and network capacity/loading. A 2-second message timeout is generally sufficient, as long as only one message is triggered at a time.

Modbus Data Address (decimal)

The default Modbus Data Address is 1. The Range is 1 to 65,536.

Slave Node Address (decimal)

The default Slave Node Address is 1. The Range is 0 to 247. Zero is the Modbus broadcast address and is only valid for Modbus write commands (5, 6, 15 and 16).

Remote Messages

The controller is also capable of remote or off-link messaging. Remote messaging is the ability to exchange information with a device that is not connected to the local network. This type of connection requires a device on the local network to act as a bridge or gateway to the other network.

Remote Networks

DH-485 and DH+ Networks

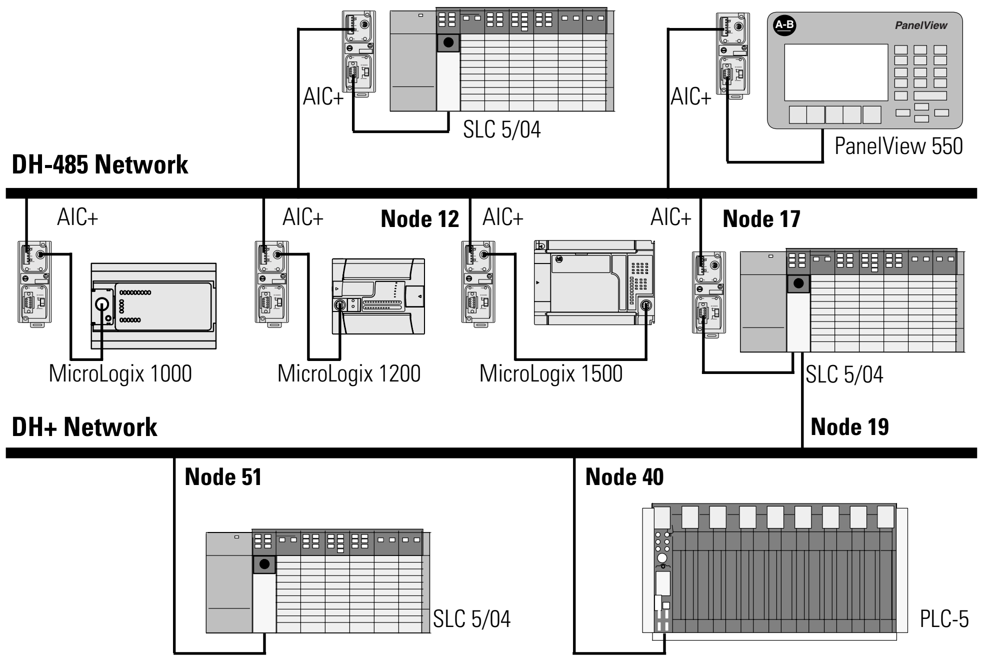
The illustration below shows two networks, a DH-485 and a DH+ network. The SLC 5/04 processor at DH-485 node 17 is configured for passthru operation. Devices that are capable of remote messaging and are connected on either network can initiate read or write data exchanges with devices on the other network, based on each device's capabilities. In this example, node 12 on DH-485 is a MicroLogix 1500. The MicroLogix 1500 can respond to remote message requests from nodes 40 or 51 on the DH+ network and it can initiate a message to any node on the DH+ network.

TIP The MicroLogix 1000 can respond to remote message requests, but it cannot initiate them.

TIP The MicroLogix 1200 capabilities are the same as the MicroLogix 1500 in this example.

This functionality is also available on Ethernet by replacing the SLC 5/04 at DH-485 node 17 with an SLC 5/05 processor.

DH-485 and DH+ Networks

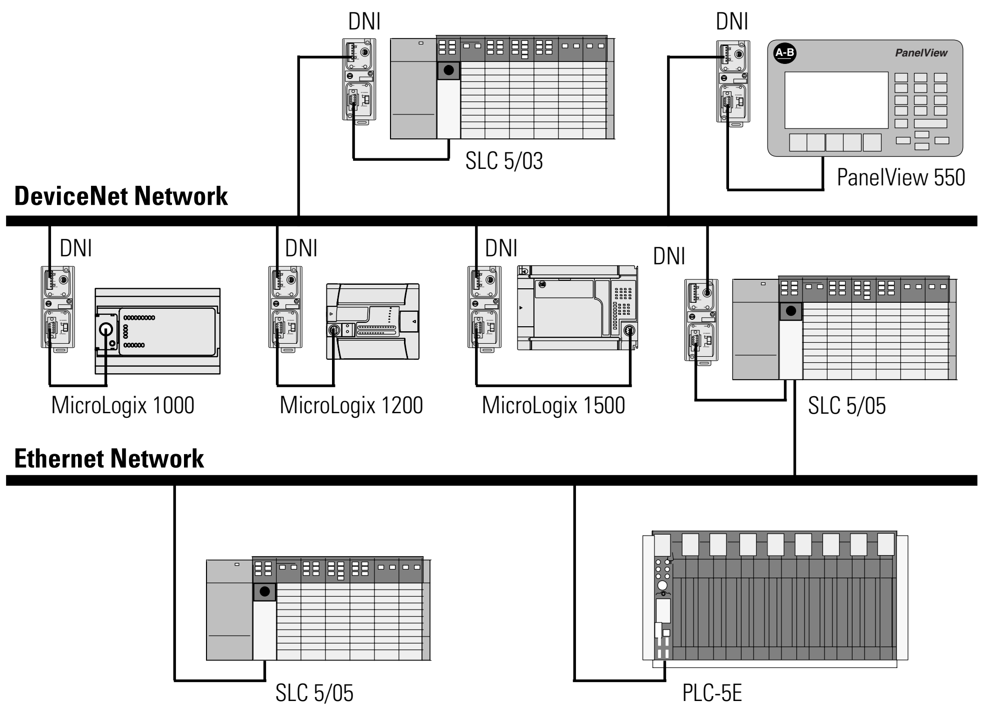


AIC+
SLC 5/04
AIC+
PanelView
PanelView 550
DH-485 Network
AIC+
AIC+
Node 12
AIC+
AIC+
Node 17
MicroLogix 1000
MicroLogix 1200
MicroLogix 1500
SLC 5/04
DH+ Network
Node 19
Node 51
Node 40
SLC 5/04
PLC-5

DeviceNet and Ethernet Networks

The illustration below shows a DeviceNet network using DeviceNet Interfaces (1761-NET-DNI) connected to an Ethernet network using an SLC 5/05. In this configuration, controllers on the DeviceNet network can reply to requests from devices on the Ethernet network, but cannot initiate communications to devices on Ethernet.

DeviceNet and Ethernet Networks



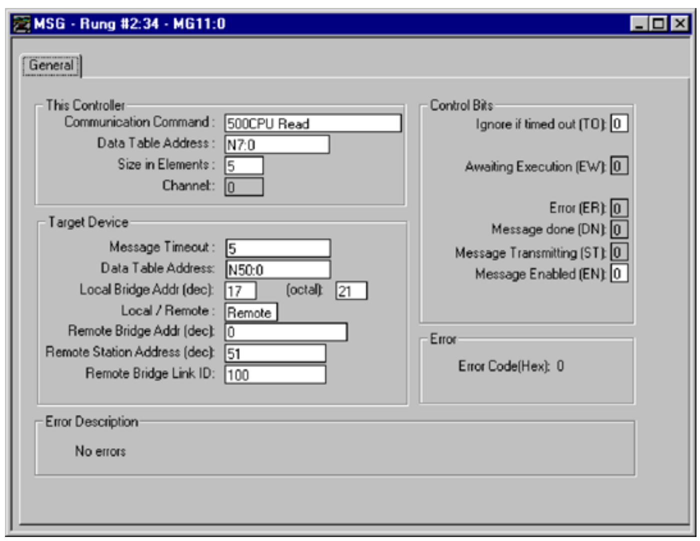
Configuring a Remote Message

You configure for remote capability in the RSLogix 500 Message Setup screen.

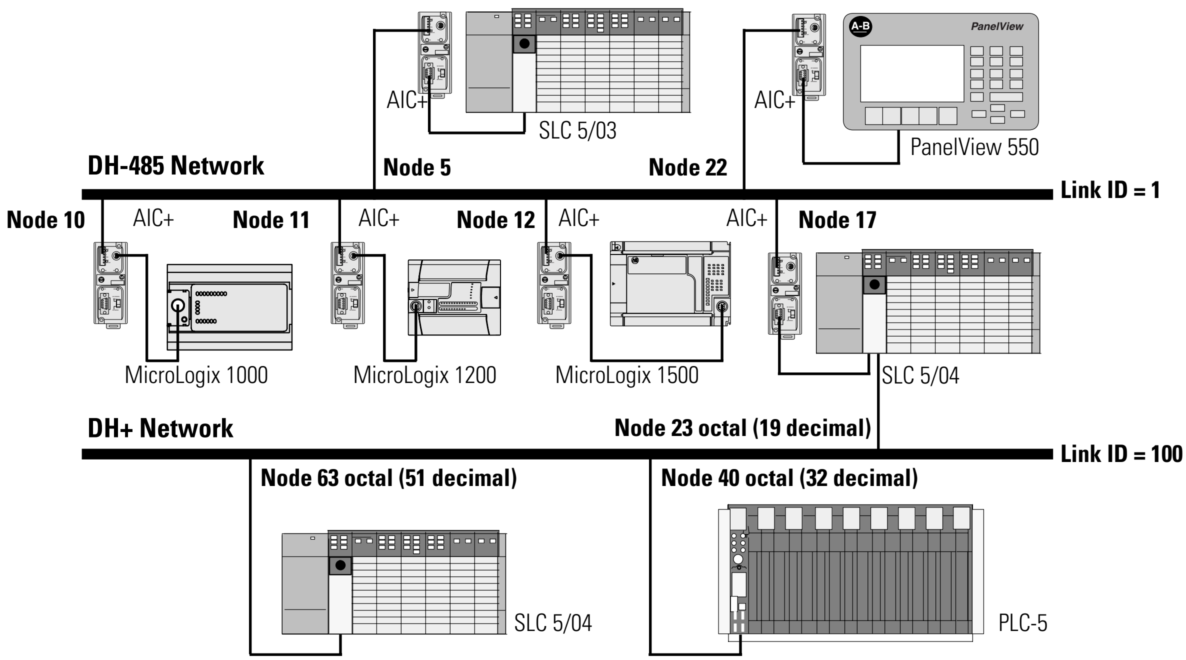
Example Configuration Screen and Network

The message configuration shown below is for the MicroLogix 1500 at node 12 on the DH-485 network. This message reads five elements of data from the SLC 5/04 (node 51 on the DH+ network) starting at address N:50:0. The SLC 5/04 at Node 23 of the DH+ network is configured for passthru operation.

TIP The MicroLogix 1200 capabilities are the same as the MicroLogix 1500 in this example.



DH-485 and DH+ Example Network



"This Controller" Parameters

See "Target Device" Parameters on page 415.

"Control Bits" Parameters

See "Control Bits" Parameters on page 397.

"Target Device" Parameters

Message Timeout

See Message Timeout on page 415.

Data Table Address

See Data Table Address/Offset on page 415.

Local Bridge Address

This variable defines the bridge address on the local network. In the example, DH-485 node 12 (MicroLogix 1500 on Link ID 1) is writing data to node 51 (SLC 5/04 on Link ID 100). The SLC 5/04 at node 17 is the bridge device.

This variable sends the message to local node 17.

Remote Bridge Address

This variable defines the remote node address of the bridge device. In this example, the remote bridge address is set to zero, because the target device, SLC 5/04 at node 63 (octal) is a remote-capable device. If the target device is remote-capable, the remote bridge address is not required. If the target device is not remote-capable (SLC 500, SLC 5/01, SLC 5/02, and MicroLogix 1000 Series A, B and C), the remote bridge address is required.

Remote Station Address

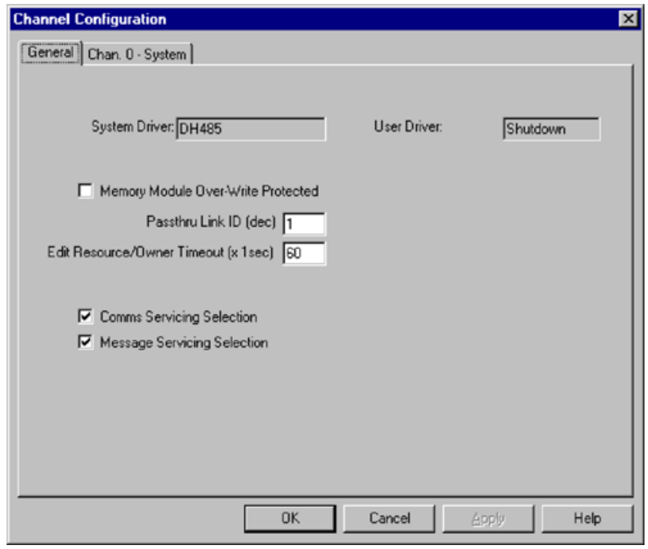
This variable is the final destination address of the message instruction. In this example, integer file 50 elements 0 to 4 of the SLC 5/04 on Link ID 100 at node 63 (octal) receives data from the MicroLogix 1500 controller at node 12 on Link ID 1.

Remote Bridge Link ID

This variable is a user-assigned value that defines the remote network as a number. This number must be used by any device initiating remote messaging to that network. In the example, any controller on Link ID 1 sending data to a device on Link ID 100 must use the remote bridge link ID of the passthru device. In this example, the SLC 5/04 on Link ID1, node 17 is the passthru device.

Passthru Link ID

Set the Passthru Link ID in the General tab on the Channel Configuration screen. The Link ID value is a user-defined number between 1 and 65,535. All devices that can initiate remote messages and are connected to the local network must have the same number for this variable.


Channel Configuration
General
Chan. 0 - System
System Driver:
DH485
User Driver:
Shutdown
Memory Module Over-Write Protected
Passthru Link ID (dec)
1
Edit Resource/Owner Timeout (x 1sec)
60
Comms Servicing Selection
Message Servicing Selection
OK
Cancel
Apply
Help

MSG Instruction Error Codes

When the processor detects an error during the transfer of message data, the processor sets the ER bit and enters an error code that you can monitor from your programming software.

Error Code	Description of Error Condition
02H	Target node is busy. NAK No Memory retries by link layer exhausted.
03H	Target node cannot respond because message is too large.
04H	Target node cannot respond because it does not understand the command parameters OR the control block may have been inadvertently modified.
05H	Local processor is off-line (possible duplicate node situation).
06H	Target node cannot respond because requested function is not available.
07H	Target node does not respond.
08H	Target node cannot respond.
09H	Local modem connection has been lost.
0BH	Target node does not accept this type of MSG instruction.
0CH	Received a master link reset (one possible source is from the DF1 master).
0FH	DCOMM button was activated while an ASCII instruction was waiting to execute.
10H	Target node cannot respond because of incorrect command parameters or unsupported command.
12H	Local channel configuration protocol error exists.
13H	Local MSG configuration error in the Remote MSG parameters.
15H	Local channel configuration parameter error exists.
16H	Target or Local Bridge address is higher than the maximum node address.
17H	Local service is not supported.
18H	Broadcast is not supported.
20H	PCCC Description: Host has a problem and will not communicate.
21H	Bad MSG file parameter for building message.
30H	PCCC Description: Remote station host is not there, disconnected, or shutdown.
37H	Message timed out in local processor.
39H	Local communication channel reconfigured while MSG active.
3AH	STS in the reply from target is invalid.
40H	PCCC Description: Host could not complete function due to hardware fault.
45H	MSG reply cannot be processed. Either Insufficient data in MSG read reply or bad network address parameter.
50H	Target node is out of memory.
60H	Target node cannot respond because file is protected.
70H	PCCC Description: Processor is in Program Mode.
80H	PCCC Description: Compatibility mode file missing or communication zone problem.
81H	Modbus Error 1: Illegal Function
82H	Modbus Error 2: Illegal Data Address
83H	Modbus Error 3: Illegal Data Value
84H	Modbus Error 4: Slave Device Failure
85H	Modbus Error 5: Acknowledge
86H	Modbus Error 6: Slave Device Busy
87H	Modbus Error 7: Negative Acknowledge
88H	Modbus Error 8: Memory Parity Error
89H	Modbus Error: Non-standard reply. Actual code returned can be found in the upper byte of sub-element 22.
90H	PCCC Description: Remote station cannot buffer command.

Error Code	Description of Error Condition
B0H	PCCC Description: Remote station problem due to download.
C0H	PCCC Description: Cannot execute command due to active IPBs.
D0H	One of the following: • No IP address configured for the network. • Bad command - unsolicited message error. • Bad address - unsolicited message error. • No privilege - unsolicited message error.
D1H	Maximum connections used - no connections available.
D2H	Invalid internet address or host name.
D3H	No such host / Cannot communicate with the name server.
D4H	Connection not completed before user–specified timeout.
D5H	Connection timed out by the network.
D7H	Connection refused by destination host.
D8H	Connection was broken.
D9H	Reply not received before user–specified timeout.
DAH	No network buffer space available.
E0H	Expansion I/O Communication Module Error. The error code returned can be found in the upper byte of sub-element 22.
E1H	PCCC Description: Illegal Address Format, a field has an illegal value.
E2H	PCCC Description: Illegal Address format, not enough fields specified.
E3H	PCCC Description: Illegal Address format, too many fields specified.
E4H	PCCC Description: Illegal Address, symbol not found.
E5H	PCCC Description: Illegal Address Format, symbol is 0 or greater than the maximum number of characters support by this device.
E6H	PCCC Description: Illegal Address, address does not exist, or does not point to something usable by this command.
E7H	Target node cannot respond because length requested is too large.
E8H	PCCC Description: Cannot complete request, situation changed (file size, for example) during multi–packet operation.
E9H	PCCC Description: Data or file is too large. Memory unavailable.
EAH	PCCC Description: Request is too large; transaction size plus word address is too large.
EBH	Target node cannot respond because target node denies access.
ECH	Target node cannot respond because requested function is currently unavailable.
EDH	PCCC Description: Resource is already available; condition already exists.
EEH	PCCC Description: Command cannot be executed.
EFH	PCCC Description: Overflow; histogram overflow.
F0H	PCCC Description: No access.
F1H	Local processor detects illegal target file type.
F2H	PCCC Description: Invalid parameter; invalid data in search or command block.
F3H	PCCC Description: Address reference exists to deleted area.
F4H	PCCC Description: Command execution failure for unknown reason; PLC-3 histogram overflow.
F5H	PCCC Description: Data conversion error.
F6H	PCCC Description: The scanner is not able to communicate with a 1771 rack adapter. This could be due to the scanner not scanning, the selected adapter not being scanned, the adapter not responding, or an invalid request of a "DCM BT (block transfer)".
F7H	PCCC Description: The adapter is not able to communicate with a module.
F8H	PCCC Description: The 1771 module response was not valid size, checksum, etc.
F9H	PCCC Description: Duplicated Label.

Error Code	Description of Error Condition
FAH	Target node cannot respond because another node is file owner (has sole file access).
FBH	Target node cannot respond because another node is program owner (has sole access to all files).
FCH	PCCC Description: Disk file is write protected or otherwise inaccessible (off-line only).
FDH	PCCC Description: Disk file is being used by another application; update not performed (off-line only).
FFH	Local communication channel is shut down.

TIP

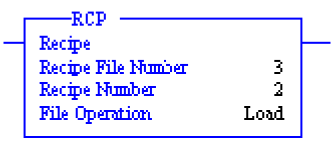
For 1770-6.5.16 DF1 Protocol and Command Set Reference Manual users: The MSG error code reflects the STS field of the reply to your MSG instruction.

- Codes E0 to EF represent EXT STS codes 0 to F.
- Codes F0 to FC represent EXT STS codes 10 to 1C.

Recipe (MicroLogix 1500 only) and Data Logging (MicroLogix 1500 1764-LRP Processor only)

This chapter describes how to use the Recipe and Data Logging functions.

RCP - Recipe (MicroLogix 1500 only)



Instruction Type: output

Execution Time for the RCP Instruction

Controller	Operation	When Rung Is:	
		True	False
MicroLogix 1500	Load	30.7 µs + 7.9 µs/word + 13.8 µs/long word or floating point	0.0 µs
	Store	28.5 µs + 8.5 µs/word + 15.1 µs/long word or floating point	0.0 µs

The RCP file allows you to save custom lists of data associated with a recipe. Using these files along with the RCP instruction lets you transfer a data set between the recipe database and a set of user-specified locations in the controller file system.

When you create a recipe file, you chose whether to store the recipe data in User Program memory or Data Log Queue memory.

IMPORTANT	The Data Log Queue option can only be used with 1764-LRP MicroLogix 1500 Series C or higher controllers. If you are using a 1764-LSP MicroLogix 1500 controller, you must select User Program.

This section contains the following topics:

- Recipe File and Programming Example on page 447
- Example Queue 0 on page 452
- Example Queue 5 on page 453
- Retrieval Tools on page 460
- Information for Creating Your Own Application on page 461

The following reasons may help you chose which type of memory to use:

- The advantage to using User Program memory is that you can save the recipe data to the controller's memory module. If you use Data Log Queue, you cannot save the recipe data to the controller's memory module.
- The advantage to using Data Log Queue memory is that the recipe data will not consume User Program space. If you are not using the data logging function, choosing Data Log Queue memory allows you more memory (up to 48K bytes) for RCP files. *You can use the Data Log Queue for data logging and recipe data, but the total cannot exceed 48K bytes.*
- If you choose to use the Data Log Queue for one RCP file, all the RCP files in your project will also use the Data Log Queue memory space.

See step 2, "Create a RCP File" on page 447 for the recipe file procedure.

The RCP instruction uses the following parameters:

- Recipe File Number - this is the file number that identifies the custom list of addresses associated with a recipe.
- Recipe Number - specifies the number of the recipe to use. If the recipe number is invalid, a user fault (code 0042) is generated.
- File Operation - identifies whether the operation is a Load from the database or a Store to the database.

When executed on a True rung, the RCP instruction transfers data between the recipe database and the specified data locations.

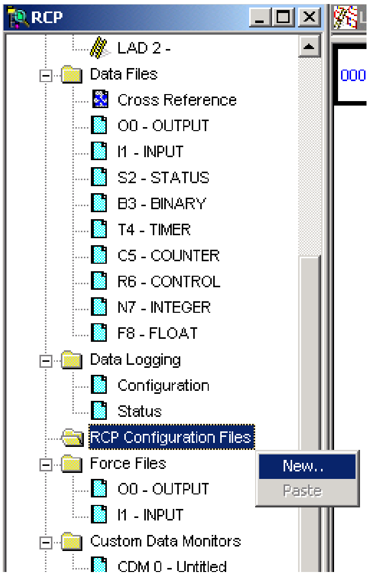
Addressing Modes and File Types are shown in the following table:

RCP Instruction Valid Addressing Modes and File Types

For definitions of the terms used in this table see Using the Instruction Descriptions on page 4-2.

Parameter	Data Files										Function Files									PLS - Programmable L/S	CS - Comms	IOS - I/O	Address Mode			Address Level				
	O	I	S	B	T, C, R	N	F	ST	L	MG, PD	RTC	HSC	PTO, PWM	STI	EII	BHI	MMI	DAT	TPI				Immediate	Direct	Indirect	Bit	Word	Long Word	Floating Point	Element
Recipe Number																							•							
File	•	•		•		•																	•	•			•			

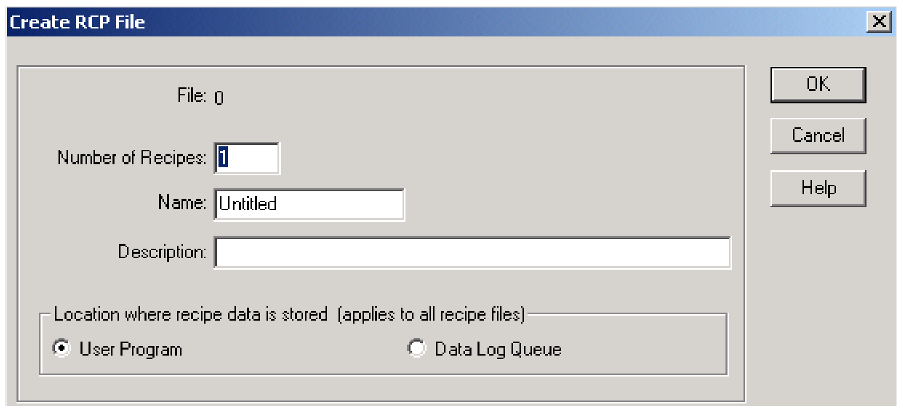
Recipe File and Programming Example



Configuring the RCP file

1. Using RSLogix 500, locate and select *RCP Configuration Files*. Right-click and select *New*.

2. Create a RCP File.



- File - This is the number identifying the RCP file. It is the *Recipe File Number* used in the RCP instruction in your ladder program and identifies the recipe database.
- Number of Recipes - This is the number of recipes contained in the RCP file. This can never be more than 256. This is the *Recipe Number* used in the RCP instruction in your ladder program.
- Name - This is a descriptive name for the RCP file. Do not exceed 20 characters.
- Description - This is the file description (optional).
- Location where recipe data is stored (applies to all recipe files) - This allows you to designate a memory location for your RCP files.
- User Program - You can allocate User Program (ladder logic) memory for recipe operations. Once User Program memory is assigned for recipe use, it cannot be used for ladder logic.

TIP User Program memory can be changed back from recipe operations to ladder logic.

IMPORTANT When User Program memory is used for recipe data, the usage is as follows:

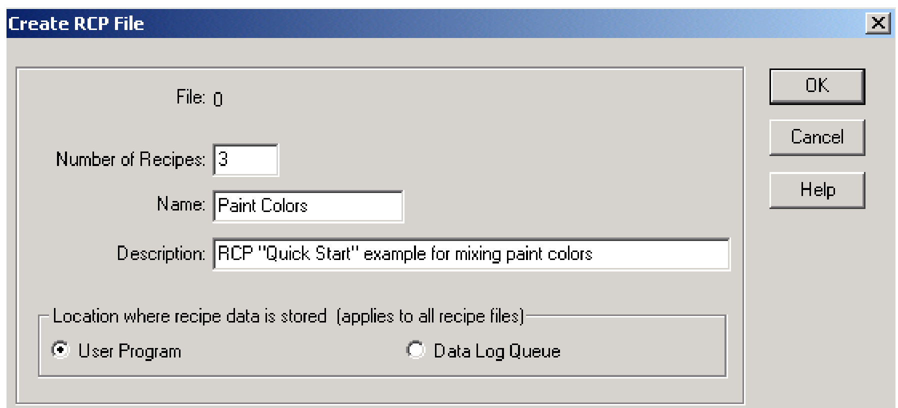
1K words of User Program memory =
5K words of recipe data memory

Like your ladder logic, the recipe data stored in User Program memory can be saved to the controller's memory module (1764-MM1, -MM2, -MM1RTC, -MM2RTC).

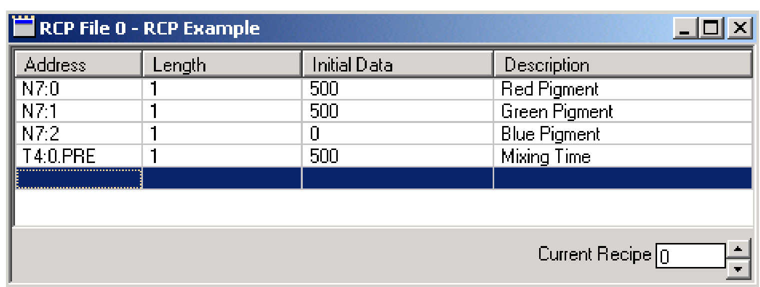
- Data Log Queue - For 1764-LRP processors, you can store recipe data in the data log memory space (48K bytes).

IMPORTANT	While recipe data stored in User Program memory can be saved to the controller's memory module, recipe data stored in Data Log Queue memory cannot be saved to a memory module. Data Log Queue memory is battery-backed, but cannot be saved to a memory module.

3. Enter the RCP file parameters as shown below. When finished click on *OK*.



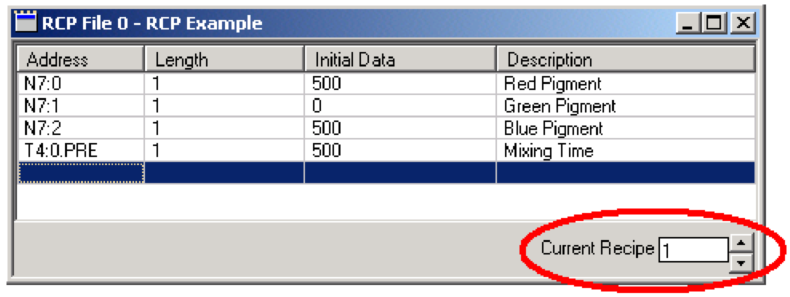
4. A new window will appear. In this window, enter the values as shown below.



5. Change the Current Recipe from 0 to 1. Notice the addresses were duplicated, but the data was not.

6. Enter the data for Recipe 1 as shown below.

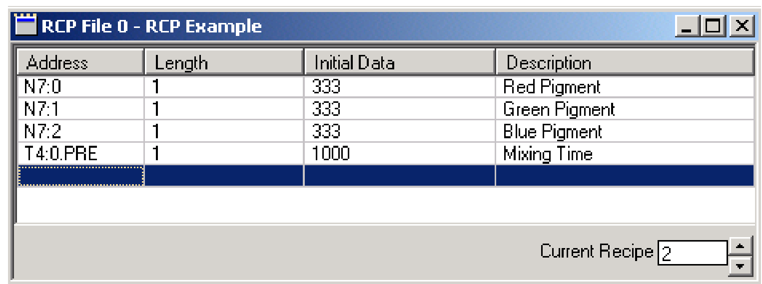
7. Change from Recipe 1 to Recipe 2 and enter the following data.



RCP File 0 - RCP Example

Address	Length	Initial Data	Description
N7:0	1	500	Red Pigment
N7:1	1	0	Green Pigment
N7:2	1	500	Blue Pigment
T4:0.PRE	1	500	Mixing Time

Current Recipe 1



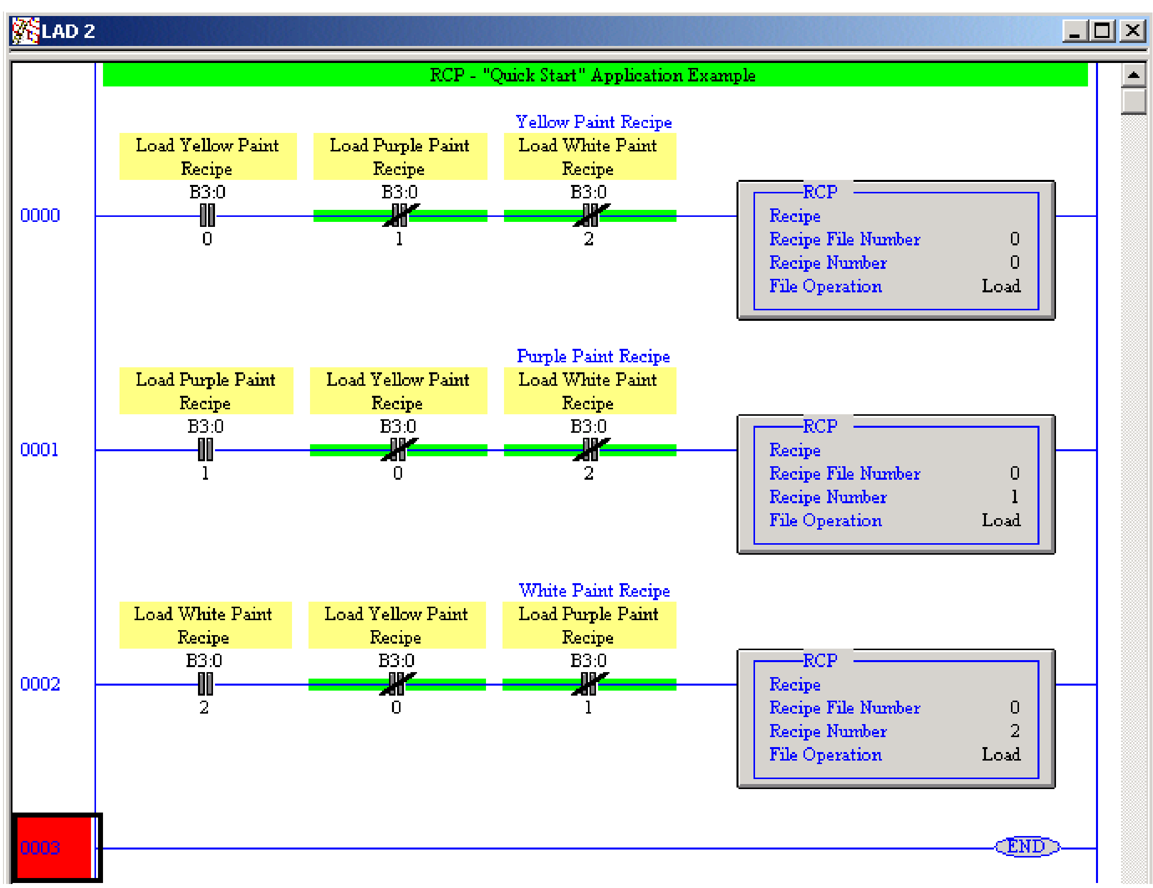
RCP File 0 - RCP Example

Address	Length	Initial Data	Description
N7:0	1	333	Red Pigment
N7:1	1	333	Green Pigment
N7:2	1	333	Blue Pigment
T4:0.PRE	1	1000	Mixing Time

Current Recipe 2

The Recipes are now configured.

8. Create the following ladder logic.



Application Explanation of Operation

When B3:0/0 is energized and B3:0/1 and B3:0/2 are de-energized, Recipe File 0:Recipe number 0 is executed loading the following values to create Yellow paint.

- N7:0 = 500
- N7:1 = 500
- N7:2 = 0
- T4:0.PRE = 500

When B3:0/1 is energized and B3:0/0 and B3:0/2 are de-energized, Recipe File 0:Recipe number 1 is executed loading the following values to create Purple paint.

- N7:0 = 500
- N7:1 = 0
- N7:2 = 500
- T4:0.PRE = 500

When B3:0/2 is energized and B3:0/0 and B3:0/1 are de-energized, Recipe File 0:Recipe number 2 is executed loading the following values to create White paint.

- N7:0 = 333
- N7:1 = 333
- N7:2 = 333
- T4:0.PRE = 1000

Monitor the N7 data file. Notice the values change after each bit is toggled.

This example describes *loading* values from a RCP file to data table addresses. However, note that by changing the RCP file operation from *Load* to *Store,* values can be loaded by ladder logic into the recipe database for each Recipe number.

Data Logging

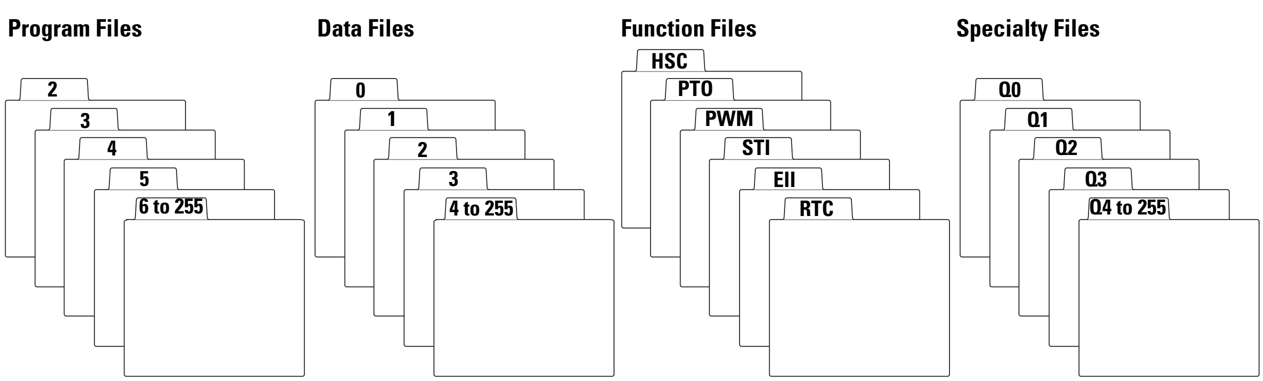
Data Logging allows you to capture (store) application data as a record for retrieval at a later time. Each record is stored in a user-configured queue in battery backed memory (B-Ram). Records are retrieved from the 1764-LRP processor via communications. This chapter explains how Data Logging is configured and used.

This section contains the following topics:

Queues and Records

The 1764-LRP processor has 48K bytes (48 x 1024) of additional memory for data logging purposes. Within this memory, you can define up to 256 (0 to 255) data logging queues. Each queue is configurable by size (maximum number of records stored), and by length (each record is 1 to 80 characters). The length and the maximum number of records determine how much memory is used by the queue. You can choose to have one large queue or multiple small queues.

The memory used for data logging is independent of the rest of the processor memory and cannot be accessed by the User Program. Each record is stored as the instruction is executed and is non-volatile (battery-backed) to prevent loss during power-down.



Example Queue 0

This queue is used to show how to calculate the string length of each record and maximum number of records.

Queue 0 (Date = ✔, Time = ✔, Delimiter = ,)

	Date		Time		N7:11		L14:0		T4:5.ACC		I1:3.0		B3:2
Record 0	01/10/2000	,	20:00:00	,	2315	,	103457	,	200	,	8190	,	4465
Record 1	01/10/2000	,	20:30:00	,	2400	,	103456	,	250	,	8210	,	4375
Record 2	01/10/2000	,	21:00:00	,	2275	,	103455	,	225	,	8150	,	4335
Record 3	01/10/2000	,	21:30:00	,	2380	,	103455	,	223	,	8195	,	4360
Record 4	01/10/2000	,	22:00:00	,	2293	,	103456	,	218	,	8390	,	4375
Record 5	01/10/2000	,	22:30:00	,	2301	,	103455	,	231	,	8400	,	4405
Record 6	01/10/2000	,	23:00:00	,	2308	,	103456	,	215	,	8100	,	4395
Record 7	01/10/2000	,	23:30:00	,	2350	,	103457	,	208	,	8120	,	4415
Record 8	01/11/2000	,	00:00:00	,	2295	,	103457	,	209	,	8145	,	4505
Record 9	01/11/2000	,	00:30:00	,	2395	,	103456	,	211	,	8190	,	4305
Record 10	01/11/2000	,	01:00:00	,	2310	,	103455	,	224	,	8195	,	4455
Record 11	01/11/2000	,	01:30:00	,	2295	,	103456	,	233	,	8190	,	4495

String Length of Record

The size of a record is limited so that the length of the maximum formatted string does not exceed 80 characters. The following table can be used to determine the formatted string length.

Data	Memory Consumed	Formatted String Size
delimiter	0 bytes	1 character
word	2 bytes	6 characters
long word	4 bytes	11 characters
date	2 bytes	10 characters
time	2 bytes	8 characters

For queue 0, the formatted string length is 59 characters, as shown below:

Data	Date		Time		N7:11		L14:0		T4:5.ACC		I1:3.0		I1:2.1
Characters	10	1	8	1	6	1	11	1	6	1	6	1	6

= 10 + 1 + 8 + 1 + 6 + 1 + 11 + 1 + 6 + 1 + 6 + 1 + 6
= 59 characters

Number of Records

Using Queue 0 as an example, each record consumes:

Record Field	Memory Consumption
Date	2 bytes
Time	2 bytes
N7:11	2 bytes
L14:0	4 bytes
T4:5.ACC	2 bytes
I1:3.0	2 bytes
B3:2	2 bytes
Integrity Check	2 bytes
Total	**18 bytes**

In this example, each record consumes 18 bytes. So if one queue was configured, the maximum number of records that could be stored would be 2730. The maximum number of records is calculated by:

Maximum Number of Records = Data Log File Size/Record Size
= 48K bytes/18 bytes
= (48)(1024)/18
= 2730 records

Example Queue 5

Queue 5 (Time = ✔, Delimiter = TAB)

	Time		N7:11		I1:3.0		I1:2.1
Record 0	20:00:00	TAB	2315	TAB	8190	TAB	4465
Record 1	20:30:00	TAB	2400	TAB	8210	TAB	4375
Record 2	21:00:00	TAB	2275	TAB	8150	TAB	4335
Record 3	21:30:00	TAB	2380	TAB	8195	TAB	4360
Record 4	22:00:00	TAB	2293	TAB	8390	TAB	4375
Record 5	22:30:00	TAB	2301	TAB	8400	TAB	4405
Record 6	23:00:00	TAB	2308	TAB	8100	TAB	4395

String Length of Record

The size of a record is limited so that the length of the maximum formatted string does not exceed 80 characters. The following table can be used to determine the formatted string length.

Data	Memory Consumed	Formatted String Size
delimiter	0 bytes	1 character
word	2 bytes	6 characters
long word	4 bytes	11 characters
date	2 bytes	10 characters
time	2 bytes	8 characters

For queue 5, the formatted string length is 29 characters, as shown below:

Data	Time		N7:11		I1:3.0		I1:2.1
Characters	8	1	6	1	6	1	6

= 8 + 1 + 6 + 1 + 6 + 1 + 6 = 29 characters

Number of Records

Using Queue 5 as an example, each record consumes:

Record Field	Memory Consumption
Time	2 bytes
N7:11	2 bytes
I1:3.0	2 bytes
I1:2.1	2 bytes
Integrity Check	2 bytes
Total	**10 bytes**

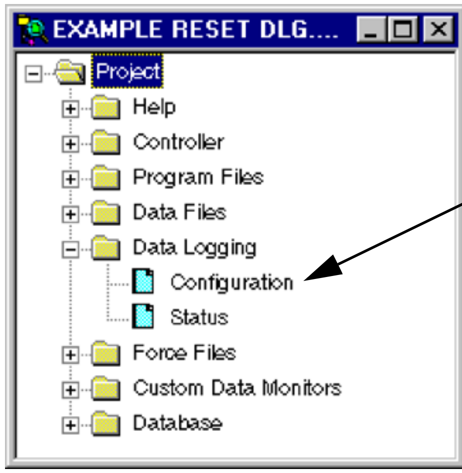
Each record consumes 10 bytes. So if only one queue was configured, the maximum number of records that could be stored would be 4915. The maximum number of records is calculated by:

Maximum Number of Records = Data Log File Size/Record Size
= 48K bytes/10 bytes
= (48)(1024)/10
= 4915 records

Configuring Data Log Queues

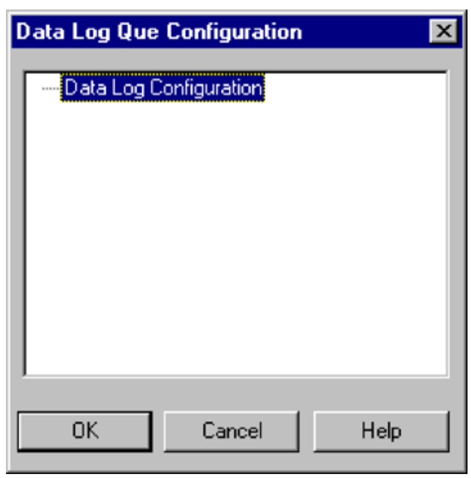
Data Logging is configured using RSLogix 500 programming software version V4.00.00 or later.

1. Open a 1764-LRP application. The first step in using Data Logging is to configure the data log queue(s). Access to this function is provided via the RSLogix 500 Project tree:



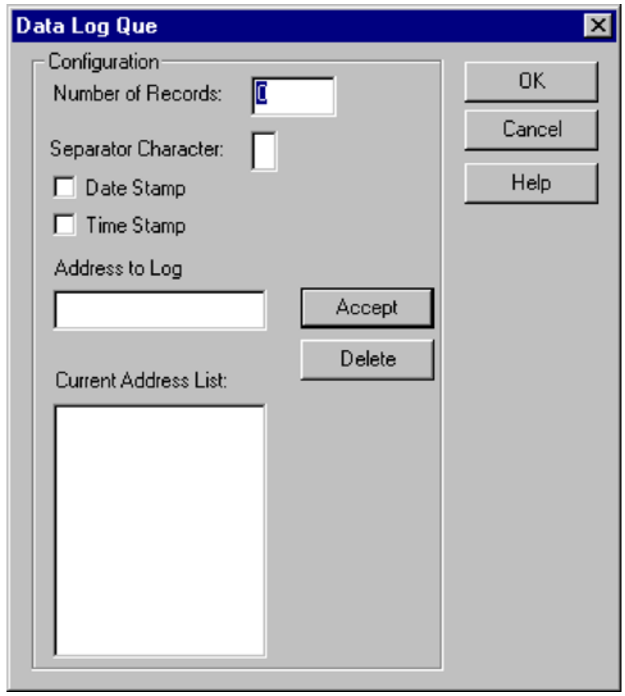
Double-click *Configuration* to access Data Log Configuration.

2. The Data Log Que window appears. Double-click on Data Log Configuration.



Appearance of Data Log Que Configuration window before creating a queue.

3. The Data Log Que dialog box appears as shown below. Use this dialog box to enter the queue information.



Enter the following information:

Data Log Queue Configuration Parameter	Description
Number of Records	Defines the number of records (data sets) in the queue.
Separator Character	Choose the character to act as the separator for the data in this queue (tab, comma, or space). The separator character may be the same or different for each queue configured.
Date Stamp (optional)	if selected, the date is recorded in mm/dd/yyyy format[(1)].
Time Stamp (optional)	if selected, the time is recorded in hh:mm:ss format[(1)].
Address to Log	Enter the address of an item to be recorded and click on *Accept* to add the address to the *Current Address List*. The address can be any 16 or 32-bit piece of data.
Current Address List	This is the list of items to be recorded. Record size can be up to 80 bytes. You can use the *Delete* button to remove items from this list. See page 452 for information on record size.
A record consists of configured Date Stamp, Time Stamp, Current Address List, and Separator Characters.	

(1) If the real-time clock is not present on the controller and Date Stamp and Time Stamp are selected (enabled), the date is recorded as 00/00/0000 and the time as 00:00:00.

4. After entering all the information for the data log queue, click on OK. The queue is added to the Data Log Que window with a corresponding queue number. This is the queue number to use in the DLG instruction.

DLG - Data Log Instruction

Instruction Type: output

Execution Time for the DLG Instruction

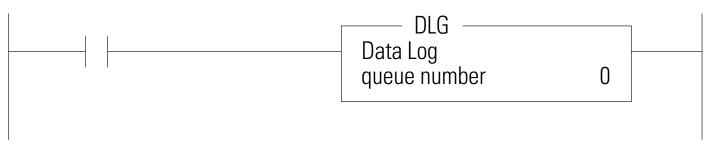
Controller	When Rung Is:	
	True	**False**
MicroLogix 1500 1764-LRP	67.5 µs + 11.8 µs/date stamp + 12.4 µs/time stamp + 9.1 µs/word logged + 16.2 µs/long word logged	6.7 µs

IMPORTANT You must configure a data log queue before programming a DLG instruction into your ladder program.

The DLG instruction triggers the saving of a record. The DLG instruction has one operand:

Queue Number - Specifies which data log queue captures a record.

The DLG instruction only captures data on a false-to-true rung transition. The DLG rung must be reset (scanned false) before it will capture data again. Never place the DLG instruction alone on a rung. It should always have preceding logic, as shown below:



Data Log Status File

There is a Data Log Status (DLS) file element for each Data Log Queue. The DLS file does not exist until a data log queue has been configured.

The Data Log Status file has 3-word elements. Word 0 is addressable by bit only through ladder logic. Words 1 and 2 are addressable by word and/or bit through ladder logic.

The number of DLS file elements depends upon the number of queues specified in the application. The status bits and words are described below.

Data Log Status (DLS) File Elements

	Control Element															
Word	**15**	**14**	**13**	**12**	**11**	**10**	**09**	**08**	**07**	**06**	**05**	**04**	**03**	**02**	**01**	**00**
0	EN(1)	0	DN(2)	OV(3)	0	0	0	0	0	0	0	0	0	0	0	0
1	FSZ = File Size (number of records allocated)															
2	RST = Records Stored (number of records recorded)															

(1) EN = Enable Bit

(2) DN = Done Bit

(3) OV = Overflow Bit

Data Logging Enable (EN)

When the DLG instruction rung is true, the Data Logging Enable (EN) is set (1) and the DLG instruction records the defined data set. To address this bit in ladder logic, use the format: DLS0:Q/EN, where Q is the queue number.

Data Logging Done (DN)

The Data Logging Done (DN) bit is used to indicate when the associated queue is full. This bit is set (1) by the DLG instruction when the queue becomes full. This bit is cleared when a record is retrieved from the queue. To address this bit in ladder logic, use the format: DLS0:Q/DN, were Q is the queue number.

Data Logging Overflow (OV)

The Data Logging Overflow (OV) bit is used to indicate when a record gets overwritten in the associated queue. This bit is set (1) by the DLG instruction when a record is overwritten. Once set, the OV bit remains set until you clear (0) it. To address this bit in ladder logic, use the format: DLS0:Q/OV, where Q is the queue number.

File Size (FSZ)

File Size (FSZ) shows the number of records that are allocated for this queue. The number of records is set when the data log queue is configured. FSZ can be used with RST to determine how full the queue is. To address this word in ladder logic, use the format: DLS0:Q.FSZ, where Q is the queue number.

Records Stored (RST)

Records Stored (RST) specifies how many data sets are in the queue. RST is decremented when a record is read from a communications device. To address this word in ladder logic, use the format: DLS0:Q.RST, where Q is the queue number.

TIP If a queue is full and another record is saved, the oldest record is over-written. Queue behavior is the same as a FIFO stack—first in, first out. If a queue is full and an additional record is saved, the "first" record is deleted.

DLS information can be used in the following types of instructions:

Instruction Type	Operand
Relay (Bit)	Destination Output Bit
Compare	Source A
	Source B
	Low Limit (LIM instruction)
	Test (LIM instruction)
	High Limit (LIM instruction)
	Source (MEQ instruction)
	Mask (MEQ instruction)
	Compare (MEQ instruction)
Math	Source A
	Source B
	Input (SCP instruction)
Logical	Source A
	Source B
Move	Source

Retrieving (Reading) Records

Data is retrieved from a data logging queue by sending a logical read command that addresses the Data Log retrieval file. The oldest record is retrieved first and then, deleted. The record is deleted as soon as it is queued for transmission. If there is a power failure before the transmission is complete, the record is lost.

The data is retrieved as an ASCII string with the following format:

<date><UDS><time><UDS><1st Data><UDS><2nd Data><UDS>…<UDS><Last Data><NUL>

- where:
  <date> = mm/dd/yyyy - ASCII characters (date is optional)
  <time> = hh:mm:ss - ASCII characters (time is optional)
  <UDS> = User Defined Separator (TAB, COMMA, or SPACE)
  <X Data> = ASCII decimal representation of the value of the data
  <NUL> = record string is null terminated
- If the Real Time Clock module is not present in the controller, <date> is formatted as 00/00/0000, and <time> is formatted as 00:00:00.
- The Communications Device determines the number of sets of data that have been recorded but not retrieved. See the Data Log Status File on page 458.
- The controller performs a the data integrity check for each record. If the data integrity check is invalid, a failure response is sent to the Communications Device. The data set is deleted as soon as the failure response is queued for transmission.

TIP	For easy use with Microsoft Excel, use the TAB character as the separator character.

Accessing the Retrieval File

You can use a dedicated retrieval tool or create your own application.

Retrieval Tools

There are a number of retrieval tools designed for use with Palm™ OS, Windows™ CE, Windows 9x, and Windows NT. You can download these free tools from our web site. Visit http://www.ab.com/micrologix.

Information for Creating Your Own Application

Controller Receives Communications Packet

Command Structure

DST	SRC	CMD 0f	STS	TNS	FNC A2	Byte Size	File No.	File Tpe	Ele. No.	S/Ele. No.

Field	Function	Description
DST	Destination Node	
SRC	Source Node	
CMD	Command Code	
STS	Status Code	Set to zero (0)
TNS	Transaction Number	Always 2 bytes
FNC	Function Code	
Byte Size	Number of bytes to be read	Formatted string length (see equation below)
File Number		Always set to zero (0)
File Type		Must be A5 (hex)
Element Number	Queue number	Determines the queue to be read (0 to 255)
Sub/Element Number		Always set to zero (0)

Equation

Record Field 1	+ Record Field 2	+ Record Field 3	...	+ Record Field 7	=	Formatted String Length

Record Field Sizes

Data Type	Maximum Size
Word	7 bytes (characters)
Long Word	12 bytes (characters)
Date Field	11 bytes (characters)
Time Field	9 bytes (characters)

TIP The formatted string length cannot exceed 80 bytes in length.

TIP The last byte will be a zero value representing the terminator character.

Controller Responds with Reply

Reply Structure

SRC	DST	CMD 4f	STS	TNS	DATA	EXT STS

Field	Function	Description
SRC	Source Node	
DST	Destination Node	
CMD	Command Code	
STS	Status Code	
TNS	Transaction Number	Always 2 bytes
DATA		Formatted string

If the data integrity check fails, the record is deleted and an error is sent with STS of 0xF0 and ext STS of 0x0E.

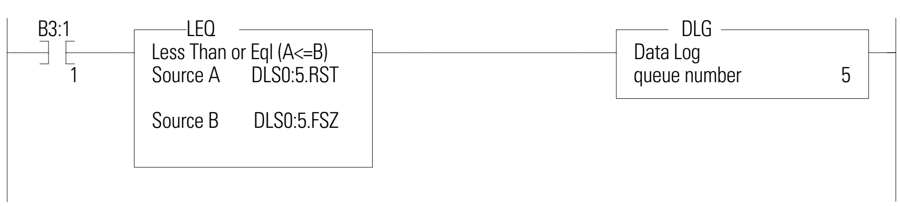
For more information on writing a DF1 protocol, refer to Allen-Bradley publication 1770-6.5.16, *DF1 Protocol and Command Set Reference Manual* (available from www.theautomationbookstore.com).

Conditions that Will Erase the Data Retrieval File

IMPORTANT The data in the retrieval file can only be read once. Then it is erased from the processor.

The following conditions will cause previously logged data to be lost:

- Program download from RSLogix 500 to controller.
- Memory Module transfer to controller *except for Memory Module autoload of the same program*.
- Full Queue - when a queue is full, new records are recorded over the existing records, starting at the beginning of the file. You can put the following rung in your ladder program to prevent this from happening:



MicroLogix 1200 Memory Usage and Instruction Execution Time

This appendix contains a complete list of the MicroLogix 1200 programming instructions. The list shows the memory usage and instruction execution time for each instruction. Execution times using indirect addressing and a scan time worksheet are also provided.

Programming Instructions Memory Usage and Execution Time

The table below lists the execution times and memory usage for the programming instructions. These values depend on whether you are using *word* or *long word* as the data format

MicroLogix 1200 Memory Usage and Instruction Execution Time for Programming Instructions

Programming Instruction	Instruction Mnemonic	Word			Long Word		
		Execution Time in µs		Memory Usage in Words	Execution Time in µs		Memory Usage in Words
		False	True		False	True	
ASCII Test Buffer for Line(1)	**ABL**	12.5	115 + 8.6/ char.	3.3	Long Word addressing level does not apply.		
ASCII Number of Characters in Buffer(1)	**ACB**	12.1	103.1	3.3			
Absolute Value	**ABS**	0.0	3.8				
ASCII String to Integer(1)	**ACI**	0.0	17.6 + 7.2/ char.	1.5	0.0	24.6 + 11.6/char.	1.5
ASCII Clear Buffer	**ACL**	0.0	clear: both 249.1 receive 28.9 transmit 33.6	1.2	Long Word addressing level does not apply.		
ASCII String Concatenate(1)	**ACN**	0.0	22.6 + 11.5/ char.	2.0			
Add	**ADD**	0.0	2.7	3.3	0.0	11.9	3.5
ASCII String Extract(1)	**AEX**	0.0	14.8 + 2.9/ char.	2.5	Long Word addressing level does not apply.		
ASCII Handshake Lines(1)	**AHL**	11.9	109.4	5.3			
ASCII Integer to String	**AIC**	0.0	29.3 +5.2/ char.	1.4	0.0	82.0	1.6
And	**AND**	0.0	2.2	2.8	0.0	9.2	3.0

MicroLogix 1200 Memory Usage and Instruction Execution Time for Programming Instructions

Programming Instruction	Instruction Mnemonic	Word			Long Word		
		Execution Time in µs		Memory Usage in Words	Execution Time in µs		Memory Usage in Words
		False	True		False	True	
ASCII Read Characters[1]	**ARD**	11.8	132.3 + 49.7/ char.	4.3	Long Word addressing level does not apply.		
ASCII Read Line[1]	**ARL**	11.7	139.7 + 50.1/ char.	4.3			
ASCII String Search[1]	**ASC**	0.0	16.2 + 4.0/ matching char.	6.0	Long Word addressing level does not apply.		
ASCII String Compare[1]	**ASR**	0.0	9.2 + 4.0/ matching char.	1.8			
ASCII Write with Append	**AWA**	14.1	268 + 12/char.	3.4			
ASCII Write	**AWT**	14.1	268 + 12/char.	3.4			
Bit Shift Left	**BSL**	1.3	32 + 1.3/word	3.8			
Bit Shift Right	**BSR**	1.3	32 + 1.3/word	3.8			
Clear	**CLR**	0.0	1.3	1.0	0.0	6.3	1.0
File Copy	**COP**	0.0	19 + 0.8/word	2.0	Long Word addressing level does not apply.		
Copy Word	**CPW**	0.0	18.3 + 0.8/ word				
Count Down	**CTD**	9.0	9.0	2.4			
Count Up	**CTU**	9.2	9.0	2.4			
Decode 4-to-1 of 16	**DCD**	0.0	1.9	1.9			
Divide	**DIV**	0.0	12.2	2.0	0.0	42.8	3.5
Encode 1-of-16 to 4	**ENC**	0.0	7.2	1.5	Long Word addressing level does not apply.		
Equal	**EQU**	1.1	1.3	1.3	1.9	2.8	2.6
FIFO Load	**FFL**	11.1	11.3	3.4	11.2	11.7	3.9
FIFO Unload	**FFU**	10.4	33 + 0.8/word	3.4	10.4	36 + 1.5/long word	3.4
Fill File	**FLL**	0.0	14 + 0.6/word	2.0	0.0	15 + 1.2/long word	2.5
Convert from BCD	**FRD**	0.0	14.1	1.5	Long Word addressing level does not apply.		
Gray Code	**GCD**	0.0	9.5				
Greater Than or Equal To	**GEQ**	1.1	1.3	1.3	2.7	2.8	2.9
Greater Than	**GRT**	1.1	1.3	1.3	2.7	2.8	2.4
High-Speed Load	**HSL**	0.0	46.7	7.3	0.0	47.3	7.8
Immediate Input with Mask	**IIM**	0.0	26.4	3.0	Long Word addressing level does not apply.		
Interrupt Subroutine	**INT**	1.0	1.0	0.3			
Immediate Output with Mask	**IOM**	0.0	22.3	3.0			
Jump	**JMP**	0.0	1.0	0.5			
Jump to Subroutine	**JSR**	0.0	8.4	1.5			
Label	**LBL**	1.0	1.0	0.5			
Less Than or Equal To	**LEQ**	1.1	1.3	1.3	2.7	2.8	2.9
Less Than	**LES**	1.1	1.3	1.3	2.7	2.8	2.9
LIFO Load	**LFL**	10.4	25.5	3.4	10.4	31.6	3.9
LIFO Unload	**LFU**	10.4	29.1	3.4	10.4	31.6	3.4
Limit	**LIM**	6.1	6.4	2.3	13.6	14.4	4.0

MicroLogix 1200 Memory Usage and Instruction Execution Time for Programming Instructions

Programming Instruction	Instruction Mnemonic	Word			Long Word		
		Execution Time in µs		Memory Usage in Words	Execution Time in µs		Memory Usage in Words
		False	True		False	True	
Master Control Reset	MCR (Start)	1.2	1.2	1.0	Long Word addressing level does not apply.		
	MCR (End)	1.6	1.6	1.5			
Masked Comparison for Equal	MEQ	1.8	1.9	1.8	3.1	3.9	3.5
Move	MOV	0.0	2.4	2.5	0.0	8.3	2.0
Message, Steady State	MSG	6.0	20.0	2.9	Long Word addressing level does not apply.		
Message, False-to-True Transition for Reads			230.0				
Message, False-to-True Transition for Writes			264 + 1.6/ word				
Multiply	MUL	0.0	6.8	2.0	0.0	31.9	3.5
Masked Move	MVM	0.0	7.8	2.0	0.0	11.8	3.0
Negate	NEG	0.0	2.9	3.0	0.0	12.1	3.0
Not Equal	NEQ	1.1	1.3	1.3	2.7	2.5	2.5
Not	NOT	0.0	2.4	2.5	0.0	9.2	2.5
One Shot	ONS	1.9	2.6	3.5	Long Word addressing level does not apply.		
Or	OR	0.0	2.2	2.8	0.0	9.2	3.0
One Shot Falling	OSF	3.7	2.8	5.4	Long Word addressing level does not apply.		
One Shot Rising	OSR	3.0	3.4	5.4			
Output Enable	OTE	1.1	1.4	1.6			
Output Latch	OTL	0.0	1.0	0.6			
Output Unlatch	OTU	0.0	1.1	0.6			
Proportional Integral Derivative	PID	11.0	295.8	2.4			
Pulse Train Output(1)	PTO	24.4	85.6	1.9			
Pulse Width Modulation(1)	PWM	24.7	126.6	1.9			
Reset Accumulator	RAC	Word addressing level does not apply.			0.0	21.2	2.0
I/O Refresh	REF	0.0	see p. 469	0.5	Long Word addressing level does not apply.		
Reset	RES	0.0	5.9	1.0			
Return	RET	0.0	1.0	0.3			
Real Time Clock Adjust	RTA	3.7	4.7 (556.2 false-to-true-transition)				
Retentive Timer On	RTO	2.4	18.0	3.4			
Subroutine	SBR	1.0	1.0	0.3			
Scale	SCL	0.0	10.5	2.5			
Scale with Parameters	SCP	0.0	31.5	3.8	0.0	52.2	6.0
Sequencer Compare	SQC	7.1	23.5	3.9	7.1	26.3	4.4
Sequencer Load	SQL	7.0	21.7	3.4	7.1	24.3	3.9
Sequencer Output	SQO	7.1	23.2	3.9	7.1	26.6	4.4
Square Root	SQR	0.0	26.0	1.5	0.0	30.9	2.5
Selectable Timed Interrupt Start	STS	0.0	57.5	1.0	Long Word addressing level does not apply.		
Subtract	SUB	0.0	3.4	3.3	0.0	12.9	3.5

MicroLogix 1200 Memory Usage and Instruction Execution Time for Programming Instructions

Programming Instruction	Instruction Mnemonic	Word			Long Word		
		Execution Time in µs		Memory Usage in Words	Execution Time in µs		Memory Usage in Words
		False	True		False	True	
Suspend	**SUS**	n/a	n/a	1.5	Long Word addressing level does not apply.		
Service Communications	**SVC**	0.0	208 + 1.6/ word(2)	1.0			
Swap(1)	**SWP**	0.0	13.7 + 2.2/ swapped word	1.5			
Temporary End	**TND**	0.0	0.9	0.5			
Convert to BCD	**TOD**	0.0	17.2	1.8	Long Word addressing level does not apply.		
Off-Delay Timer	**TOF**	13.0	2.9	3.9			
On-Delay Timer	**TON**	3.0	18.0	3.9			
User Interrupt Disable	**UID**	0.0	0.8	0.9			
User Interrupt Enable	**UIE**	0.0	0.8	0.9			
User Interrupt Flush	**UIF**	0.0	12.3	0.9			
Examine if Closed	**XIC**	0.8	0.9	1.0			
Examine if Open	**XIO**	0.8	0.9	1.0			
Exclusive Or	**XOR**	0.0	3.0	2.8	0.0	9.9	3.0

(1) Only valid for MicroLogix 1200 Series B Controllers.

(2) This value for the SVC instruction is for when the communications servicing function is accessing a data file. The time increases when accessing a function file.

Indirect Addressing

The following sections describe how indirect addressing affects the execution time of instructions for the Micrologix 1200 controllers. The timing for an indirect address is affected by the form of the indirect address.

For the address forms in the following table, you can interchange the following file types:

- Input (I) and Output (O)
- Bit (B), Integer (N)
- Timer (T), Counter (C), and Control (R)

Execution Times for the Indirect Addresses

For most types of instructions that contain an indirect address(es), look up the form of the indirect address in the table below and *add* that time to the execution time of the instruction.

[*] indicates that an indirect reference is substituted.

MicroLogix 1200 Instruction Execution Time Using Indirect Addressing

Address Form	Operand Time (µs)	Address Form	Operand Time (µs)
O:1.[*]	5.8	B3:1/[*]	6.8
O:[*].0	15.0	B3:[*]/[*]	7.6
O:[*].[*]	15.1	B[*]:1/[*]	25.9
B3:[*]	5.8	B[*]:[*]/[*]	26.2
B[*]:1	24.3	L8:[*]/2	6.5
B[*]:[*]	24.5	L[*]:1/2	24.6
L8:[*]	6.1	L[*]:[*]/2	25.3
L[*]:1	24.4	L8:1/[*]	6.8
L[*]:[*]	24.3	L8:[*]/[*]	7.7
T4:[*]	6.0	L[*]:1/[*]	26.0
T[*]:1	24.0	L[*]:[*]/[*]	25.9
T[*]:[*]	24.2	T4:[*]/DN	6.6
T4:[*].ACC	6.5	T[*]:1/DN	24.4
T[*]:1.ACC	24.4	T[*]:[*]/DN	24.9
T[*]:[*].ACC	24.9	T4:[*].ACC/2	7.4
O:1.[*]/2	6.3	T[*]:1.ACC/2	24.4
O:[*].0/2	15.2	T[*]:[*].ACC/2	25.9
O:[*].[*]/2	15.9	T4:1/[*]	6.5
O:1.0/[*]	6.8	T4:[*]/[*]	8.3
O:1.[*]/[*]	7.6	T[*]:1/[*]	26.1
O:[*].0/[*]	16.6	T[*]:[*]/[*]	26.8
O:[*].[*]/[*]	16.9	T4:1.ACC/[*]	6.9
B3:[*]/2	6.3	T4:[*].ACC/[*]	8.9

MicroLogix 1200 Instruction Execution Time Using Indirect Addressing

Address Form	Operand Time (µs)	Address Form	Operand Time (µs)
B[*]:1/2	24.5	T[*]:1.ACC/[*]	26.1
B[*]:[*]/2	25.3	T[*]:[*].ACC/[*]	27.3

Execution Time Example – Word Level Instruction Using and Indirect Address

ADD Instruction Addressing

- Source A: N7:[*]
- Source B: T4:[*].ACC
- Destination: N[*]:[*]

ADD Instruction Times

- ADD Instruction: 2.7 µs
- Source A: 5.8 µs
- Source B: 6.5 µs
- Destination: 24.5 µs

Total = 36.5 µs

Execution Time Example – Bit Instruction Using an Indirect Address

XIC B3/[*]

- XIC: 0.9 µs + 5.8 µs = 6.7 µs True case
- XIC: 0.9 µs + 5.8 µs = 6.7 µs False case

MicroLogix 1200 Scan Time Worksheet

Calculate the scan time for your control program using the worksheet below.

Input Scan (sum of below)		
Overhead (if expansion I/O is used)	= 55 µs	
Expansion Input Words X 10 µs (or X 14 µs if Forcing is used)	=	
Number of modules with Input words X 80 µs	=	
	Input Scan Sub-Total	=
Program Scan		
Add execution times of all instructions in your program when executed true	=	
Program Scan Sub-Total		=
Output Scan (sum of below)		
Overhead (if expansion I/O used)	= 30 µs	
Expansion Output Words X 3 µs (or X 7 µs if Forcing is used)	=	
	Output Scan Sub-Total	=
Communications Overhead(1)		
Worst Case	=1470 µs	
Typical Case	= 530 µs	
Use this number if the communications port is configured, but not communicating to any other device.	= 200 µs	
Use this number if the communications port is in “Shutdown” mode.	= 0 µs	
	Communications Overhead Sub-Total	=
System Overhead		
Add this number if your system includes a 1762-RTC or 1762-MM1RTC.	= 100 µs	
Housekeeping Overhead	= 270 µs	
	System Overhead Sub-Total	=
Totals		
	Sum of all sub-totals	
	Multiply by Communications Multiplier from Table	X
	Total Estimated Scan Time	=

(1) Communications Overhead is a function of the device connected to the controller. This will not occur every scan.

Communications Multiplier Table

Protocol	Multiplier at Various Baud Rates								
	38.4K	**19.2K**	**9.6K**	**4.8K**	**2.4K**	**1.2K**	**600**	**300**	**Inactive**(1)
DF1 Full-Duplex	1.50	1.27	1.16	1.12	1.10	1.09	1.09	1.08	1.00
DF1 Half Duplex	1.21	1.14	1.10	1.09	1.08	1.08	1.08	1.07	1.01
DH-485	N/A	1.16	1.11	N/A	N/A	N/A	N/A	N/A	1.10 at 19.2K 1.07 at 9.6K

Modbus™	1.22	1.13	1.10	1.09	1.09	1.09	1.09	1.09	1.00
ASCII	1.55	1.33	1.26	1.22	1.21	1.19	1.19	1.18	1.01
Shut Down	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

(1) Inactive is defined as No Messaging and No Data Monitoring. For DH-485 protocol, inactive means that the controller is not connected to a network.

MicroLogix 1500 Memory Usage and Instruction Execution Time

This appendix contains a complete list of the MicroLogix 1500 programming instructions. The list shows the memory usage and instruction execution time for each instruction. Execution times using indirect addressing and a scan time worksheet are also provided.

Programming Instructions Memory usage and Execution Time

The tables below lists the execution times and memory usage for the programming instructions. These values depend on whether you are using *word* or *long word* as the data format.

MicroLogix 1500 Controllers - Memory Usage and Instruction Execution Time for Programming Instructions

Programming Instruction	Instruction Mnemonic	Word			Long Word		
		Execution Time in µs		Memory Usage in Words	Execution Time in µs		Memory Usage in Words
		False	True		False	True	
ASCII Test Buffer for Line[1]	**ABL**	11.4	94 + 7.6/char.	3.3	Long Word addressing level does not apply.		
Absolute Value	**ABS**	0.0	3.1				
ASCII Number of Characters in Buffer[1]	**ACB**	11.0	84.2	3.3	Long Word addressing level does not apply.		
ASCII String to Integer[1]	**ACI**	0.0	14.2 + 6.3/ char.	1.5	0.0	20.3 + 9.5/char.	1.5
ASCII Clear Buffer[1]	**ACL**	0.0	clear: both 203.9 receive 24.7 transmit 29.1	1.2	Long Word addressing level does not apply.		
ASCII String Concatenate[1]	**ACN**	0.0	17.9 + 10.2/ char.	2.0			
Add	**ADD**	0.0	2.5	3.3	0.0	10.4	3.5
ASCII String Extract[1]	**AEX**	0.0	12.4 + 2.6/ char.	2.5	Long Word addressing level does not apply.		
ASCII Handshake Lines[1]	**AHL**	10.8	89.3	5.3			
ASCII Integer to String[1]	**AIC**	0.0	25 + 4.3/char.	1.4	0.0	68.7	1.6
And	**AND**	0.0	2.0	2.8	0.0	7.9	3.0

MicroLogix 1500 Controllers - Memory Usage and Instruction Execution Time for Programming Instructions

Programming Instruction	Instruction Mnemonic	Word			Long Word		
		Execution Time in µs		Memory Usage in Words	Execution Time in µs		Memory Usage in Words
		False	True		False	True	
ASCII Read Characters(1)	**ARD**	10.7	108 + 44/char.	4.3	Long Word addressing level does not apply.		
ASCII Read Line(1)	**ARL**	10.6	114 + 44.3/ char.	4.3			
ASCII String Search(1)	**ASC**	0.0	13.4 + 3.5/ matching char.	6.0			
ASCII String Compare(1)	**ASR**	0.0	7.5 + 3.5/ matching char.	1.8	Long Word addressing level does not apply.		
ASCII Write with Append(1)	**AWA**	12.5	236 + 10.6/ char.	3.4			
ASCII Write(1)	**AWT**	12.8	237 + 10.6/ char.	3.4			
Bit Shift Left	**BSL**	1.4	26.4 + 1.06/ word	3.8			
Bit Shift Right	**BSR**	1.4	26.1 + 1.07/ word	3.8			
Clear	**CLR**	0.0	1.2	1.0	0.0	5.5	1.0
File Copy	**COP**	0.0	15.9 + 0.67/ word	2.0	Long Word addressing level does not apply.		
Copy Word	**CPW**	0.0	15.8 + 0.7/ word				
Count Down	**CTD**	8.5	7.5	2.4			
Count Up	**CTU**	8.5	6.4	2.4			
Decode 4-to-1 of 16	**DCD**	0.0	0.9	1.9			
Divide	**DIV**	0.0	10.3	2.0	0.0	36.7	3.5
Data Log	**DLG**	6.7	67.5 + 11.8/ date stamp +12.4/time stamp +9.1/word logged	2.4	6.7	67.5 + 11.8/date stamp +12.4/time stamp +16.2/long word logged	2.4
Encode 1-of-16 to 4	**ENC**	0.0	6.8	1.5	Long Word addressing level does not apply.		
Equal	**EQU**	1.1	1.2	1.3	1.9	2.6	2.6
FIFO Load	**FFL**	9.8	10.0	3.4	9.7	10.9	3.9
FIFO Unload	**FFU**	9.7	27.7 + 0.65/ word	3.4	9.7	29.4 + 1.25/long word	3.4
Fill File	**FLL**	0.0	12.1 + 0.43/ word	2.0	0.0	12.3 + 0.8/long word	2.5
Convert from BCD	**FRD**	0.0	12.3	1.5	Long Word addressing level does not apply.		
Gray Code	**GCD**	0.0	9.5				
Greater Than or Equal To	**GEQ**	1.1	1.2	1.3	2.5	2.6	2.9

MicroLogix 1500 Controllers -
Memory Usage and Instruction Execution Time for Programming Instructions

Programming Instruction	Instruction Mnemonic	Word			Long Word		
		Execution Time in µs		Memory Usage in Words	Execution Time in µs		Memory Usage in Words
		False	True		False	True	
Greater Than	**GRT**	1.1	1.2	1.3	2.5	2.6	2.4
High-Speed Load	**HSL**	0.0	39.7	7.3	0.0	40.3	7.8
Immediate Input with Mask	**IIM**	0.0	22.5	3.0	Long Word addressing level does not apply.		
Interrupt Subroutine	**INT**	1.0	1.0	0.3			
Immediate Output with Mask	**IOM**	0.0	19.4	3.0			
Jump	**JMP**	0.0	1.0	0.5			
Jump to Subroutine	**JSR**	0.0	8.0	1.5			
Label	**LBL**	1.0	1.0	0.5			
Less Than or Equal To	**LEQ**	1.1	1.2	1.3	2.5	2.6	2.9
Less Than	**LES**	1.1	1.2	1.3	2.5	2.6	2.9
LIFO Load	**LFL**	9.7	22.2	3.4	9.7	27.4	3.9
LIFO Unload	**LFU**	9.7	25.6	3.4	9.7	27.4	3.4
Limit	**LIM**	5.3	5.5	2.3	11.7	12.2	4.0
Master Control Reset	**MCR (Start)**	0.8	0.8	1.0	Long Word addressing level does not apply.		
	MCR (End)	1.0	1.0	1.5			
Masked Comparison for Equal	**MEQ**	1.7	1.7	1.8	2.9	3.5	3.5
Move	**MOV**	0.0	2.3	2.5	0.0	6.8	2.0
Message, Steady State	**MSG**	6.0	17.0	2.9	Long Word addressing level does not apply.		
Message, False-to-True Transition for Reads			198.0				
Message, False-to-True Transition for Writes			226 + 1.4/ word				
Multiply	**MUL**	0.0	5.8	2.0	0.1	27.6	3.5
Masked Move	**MVM**	0.0	7.2	2.0	0.0	10.0	3.0
Negate	**NEG**	0.0	1.9	3.0	0.0	10.4	3.0
Not Equal	**NEQ**	1.1	1.2	1.3	2.5	2.3	2.5
Not	**NOT**	0.0	2.4	2.5	0.0	8.1	2.5
One Shot	**ONS**	1.7	2.2	3.5	Long Word addressing level does not apply.		
Or	**OR**	0.0	2.0	2.8	0.0	7.9	3.0
One Shot Falling	**OSF**	3.4	2.7	5.4	Long Word addressing level does not apply.		
One Shot Rising	**OSR**	2.8	3.2	5.4			
Output Enable	**OTE**	0.0	1.2	1.6			
Output Latch	**OTL**	0.0	0.9	0.6			
Output Unlatch	**OTU**	0.0	0.9	0.6			
Proportional Integral Derivative	**PID**	8.9	251.8	2.4			
Pulse Train Output	**PTO**	21.1	72.6	1.9			
Pulse Width Modulation	**PWM**	21.1	107.4	1.9			
Reset Accumulator	**RAC**	Word addressing level does not apply.			0.0	17.8	2.0

MicroLogix 1500 Controllers -
Memory Usage and Instruction Execution Time for Programming Instructions

Programming Instruction	Instruction Mnemonic	Word			Long Word		
		Execution Time in µs		Memory Usage in Words	Execution Time in µs		Memory Usage in Words
		False	True		False	True	
I/O Refresh	**REF**	0.0	see p. 477	0.5	Long Word addressing level does not apply.		
Reset	**RES**	0.0	4.8	1.0			
Return	**RET**	0.0	1.0	0.3			
Real Time Clock Adjust	**RTA**	2.6	4.1 (426.8 false-to-true-transition)				
Retentive Timer On	**RTO**	2.2	15.8	3.4			
Subroutine	**SBR**	1.0	1.0	0.3			
Scale	**SCL**	0.0	8.7	2.5			
Scale with Parameters	**SCP**	0.0	27.0	3.8	0.0	44.7	6.0
Sequencer Compare	**SQC**	6.3	20.1	3.9	6.3	22.7	4.4
Sequencer Load	**SQL**	6.3	19.1	3.4	6.3	21.1	3.9
Sequencer Output	**SQO**	6.3	20.0	3.9	6.3	23.1	4.4
Square Root	**SQR**	0.0	22.3	1.5	0.0	26.0	2.5
Selectable Timed Interrupt Start	**STS**	0.0	50.7	1.0	Long Word addressing level does not apply.		
Subtract	**SUB**	0.0	2.9	3.3	0.0	11.2	3.5
Suspend	**SUS**	N/A	N/A	1.5	Long Word addressing level does not apply.		
Service Communications (service one channel)	**SVC**(2)	0.0	166 + 1.4/ word	1.0			
Service Communications (service two channels)		0.0	327 + 1.4/ word	1.0			
Swap(1)	**SWP**	0.0	11.7 + 1.8/ swapped word	1.5			
Temporary End	**TND**	0.0	1.0	0.5			
Convert to BCD	**TOD**	0.0	14.3	1.8			
Off-Delay Timer	**TOF**	10.9	2.5	3.9			
On-Delay Timer	**TON**	2.5	15.5	3.9			
User Interrupt Disable	**UID**	0.0	0.8	0.9			
User Interrupt Enable	**UIE**	0.0	0.8	0.9			
User Interrupt Flush	**UIF**	0.0	10.6	0.9			
Examine if Closed	**XIC**	0.0	0.9	1.0			
Examine if Open	**XIO**	0.0	0.9	1.0			
Exclusive Or	**XOR**	0.0	2.3	2.8	0.0	8.9	3.0

(1) Only valid for MicroLogix 1500 Series B Processors.

(2) This value for the SVC instruction is for when the communications servicing function is accessing a data file. The time increases when accessing a function file.

Indirect Addressing

The following sections describe how indirect addressing affects the execution time of instructions in the Micrologix 1500 processor. The timing for an indirect address is affected by the form of the indirect address.

For the address forms in the following table, you can interchange the following file types:

- Input (I) and Output (O)
- Bit (B), Integer (N)
- Timer (T), Counter (C), and Control (R)

Execution Times for the Indirect Addresses

For most types of instructions that contain an indirect address(es), look up the form of the indirect address in the table below and **add** that time to the execution time of the instruction.

[*] indicates that an indirect reference is substituted.

MicroLogix 1500 Controllers
Instruction Execution Time Using Indirect Addressing

Address Form	Operand Time (µs)	Address Form	Operand Time (µs)	Address Form	Operand Time (µs)
O:1.[*]	4.8	O:[*].[*]/2	13.3	L[*]:1/[*]	21.6
O:[*].0	12.3	O:1.0/[*]	5.9	L[*]:[*]/[*]	21.9
O:[*].[*]	12.4	O:1.[*]/[*]	6.5	T4:[*]/DN	5.7
B3:[*]	4.8	O:[*].0/[*]	14.1	T[*]:1/DN	20.4
B[*]:1	19.9	O:[*].[*]/[*]	14.5	T[*]:[*]/DN	20.7
B[*]:[*]	20.1	B3:[*]/2	5.4	T4:[*].ACC/2	6.4
L8:[*]	5.2	B[*]:1/2	20.4	T[*]:1.ACC/2	20.4
L[*]:1	20.4	B[*]:[*]/2	21.0	T[*]:[*].ACC/2	21.6
L[*]:[*]	20.1	B3:1/[*]	5.9	T4:1/[*]	5.9
T4:[*]	4.9	B3:[*]/[*]	6.5	T4:[*]/[*]	7.1
T[*]:1	19.7	B[*]:1/[*]	21.6	T[*]:1/[*]	21.8
T[*]:[*]	19.8	B[*]:[*]/[*]	22.3	T[*]:[*]/[*]	22.4
T4:[*].ACC	5.1	L8:[*]/2	5.5	T4:1.ACC/[*]	6.0
T[*]:1.ACC	19.9	L[*]:1/2	20.4	T4:[*].ACC/[*]	7.5
T[*]:[*].ACC	20.5	L[*]:[*]/2	21.0	T[*]:1.ACC/[*]	21.8
O:1.[*]/2	5.4	L8:1/[*]	5.9	T[*]:[*].ACC/[*]	22.9
O:[*].0/2	12.8	L8:[*]/[*]	6.5		

Execution Time Example – Word Level Instruction Using an Indirect Address

ADD Instruction Addressing	ADD Instruction Times
	ADD Instruction: 2.5 µs
Source A: N7:[*]	Source A: 4.8 µs
Source B: T4:[*].ACC	Source B: 5.1 µs
Destination: N[*]:[*]	Destination: 20.1 µs
	Total = 32.5 µs

Execution Time Example – Bit Instruction Using an Indirect Address

XIC B3/[*]

- XIC: 0.9 µs + 4.8 µs = 5.7 µs True case
- XIC: 0.0 µs + 4.8 µs = 4.8 µs False case

MicroLogix 1500 Scan Time Worksheet

Calculate the scan time for your control program using the worksheet below.

Input Scan (sum of below)		
Overhead (if expansion I/O is used)	= 53 µs	
Expansion Input Words X 3 µs (or X 7.5 µs if Forcing is used)	=	
Number of modules with Input words X 10 µs	=	
	Input Scan Sub-Total	=
Program Scan		
Add execution times of all instructions in your program when executed true	=	
	Program Scan Sub-Total	=
Output Scan (sum of below)		
Overhead (if expansion I/O used)	= 29 µs	
Expansion Output Words X 2 µs (or X 6.5 µs if Forcing is used)	=	
	Output Scan Sub-Total	=
Communications Overhead[1]		
Worst Case	= 1100 µs	
Typical Case	= 400 µs	
Use this number if the communications port is configured, but not communicating to any other device	= 150 µs	
Use this number if the communications port is in Shutdown mode	= 0 µs	
Pick one of the four numbers for Channel 0		
Pick one of the four numbers for Channel 1		
	Communications Overhead Sub-Total	=
System Overhead		
Add this number if your system includes a 1764-RTC, 1764-MM1RTC, or MM2RTC.	= 80 µs	
Add this number if your system includes a 1764-DAT	= 530 µs	
Housekeeping Overhead	= 240 µs	240
	System Overhead Sub-Total	=
Totals		
	Sum of all	
	Multiply by Communications Multiplier from Table	X
	Time Tick Multiplier (X1.02)	
	Total Estimated Scan Time	=

(1) Communications Overhead is a function of the device connected to the controller. This will not occur every scan.

Communications Multiplier Table

	Multiplier at Various Baud Rates								
Protocol	**38.4K**	**19.2K**	**9.6K**	**4.8K**	**2.4K**	**1.2K**	**600**	**300**	**Inactive**[1]
DF1 Full Duplex	1.39	1.20	1.13	1.10	1.09	1.08	1.08	1.08	1.00
DF1 Half Duplex	1.18	1.12	1.09	1.08	1.07	1.07	1.06	1.06	1.01

DH-485	N/A	1.14	1.10	N/A	N/A	N/A	N/A	N/A	1.06 at 19.2K 1.09 at 9.6K
Modbus(2)	1.21	1.12	1.09	1.08	1.08	1.08	1.08	1.08	1.00
ASCII(2)	1.52	1.33	1.24	1.20	1.19	1.18	1.18	1.17	1.00
Shut Down	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

(1) Inactive is defined as No Messaging and No Data Monitoring. For DH-485 protocol, inactive means that the controller is not connected to a network.

(2) Applies to MicroLogix 1500 Series B Processors only.

System Status File

The status file lets you monitor how your controller works and lets you direct how you want it to work. This is done by using the status file to set up control bits and monitor both hardware and programming device faults and other status information.

IMPORTANT	Do not write to reserved words in the status file. If you intend writing to status file data, it is imperative that you first understand the function fully.

Status File Overview

The status file (S:) contains the following words:

Address	Function	Page
S:0	Arithmetic Flags	481
S:1	Controller Mode	482
S:2	STI Mode	488
S:2/9	Memory Module Program Compare	489
S:2/15	Math Overflow Selection	489
S:3H	Watchdog Scan Time	490
S:4	Free Running Clock	491
S:5	Minor Error Bits	492
S:6	Major Error Code	495
S:7	Suspend Code	496
S:8	Suspend File	496
S:9	Active Nodes (Nodes 0 to 15)	496
S:10	Active Nodes (Nodes 16 to 31)	497
S:13, S:14	Math Register	497
S:15L	Node Address	497
S:15H	Baud Rate	498
S:22	Maximum Scan Time	498
S:29	User Fault Routine File Number	498
S:30	STI Set Point	499
S:31	STI File Number	499
S:33	Channel 0 Communications	499
S:35	Last 100 µSec Scan Time	501
S:36/10	Data File Overwrite Protection Lost	501
S:37	RTC Year	501
S:38	RTC Month	502
S:39	RTC Day of Month	502
S:40	RTC Hours	502
S:41	RTC Minutes	503
S:42	RTC Seconds	503
S:53	RTC Day of Week	503
S:57	OS Catalog Number	504
S:58	OS Series	504
S:59	OS FRN	504
S:60	Processor Catalog Number	504
S:61	Processor Series	504
S:62	Processor Revision	505
S:63	User Program Functionality Type	505
S:64L	Compiler Revision - Build Number	505
S:64H	Compiler Revision - Release	505

Status File Details

Arithmetic Flags

The arithmetic flags are assessed by the processor following the execution of any math, logical, or move instruction. The state of these bits remains in effect until the next math, logical, or move instruction in the program is executed.

Carry Flag

Address	Data Format	Range	Type	User Program Access
S:0/0	binary	0 or 1	status	read/write

This bit is set (1) if a mathematical carry or borrow is generated. Otherwise the bit remains cleared (0). When a STI, High-Speed Counter, Event Interrupt, or User Fault Routine interrupts normal execution of your program, the original value of S:0/0 is restored when execution resumes.

OverFlow Flag

Address	Data Format	Range	Type	User Program Access
S:0/1	binary	0 or 1	status	read/write

This bit is set (1) when the result of a mathematical operation does not fit in the destination. Otherwise the bit remains cleared (0). Whenever this bit is set (1), the overflow trap bit S:5/0 is also set (1). When an STI, High-Speed Counter, Event Interrupt, or User Fault Routine interrupts normal execution of your program, the original value of S:0/1 is restored when execution resumes.

Zero Flag

Address	Data Format	Range	Type	User Program Access
S:0/2	binary	0 or 1	status	read/write

This bit is set (1) when the result of a mathematical operation or data handling instruction is zero. Otherwise the bit remains cleared (0). When an STI, High-Speed Counter, Event Interrupt, or User Fault Routine interrupts normal execution of your program, the original value of S:0/2 is restored when execution resumes.

Sign Flag

Address	Data Format	Range	Type	User Program Access
S:0/3	binary	0 or 1	status	read/write

This bit is set (1) when the result of a mathematical operation or data handling instruction is negative. Otherwise the bit remains cleared (0). When a STI, High-Speed Counter, Event Interrupt, or User Fault Routine interrupts normal execution of your program, the original value of S:0/3 is restored when execution resumes.

Controller Mode

User Application Mode

Address	Data Format	Range	Type	User Program Access
S:1/0 to S:1/4	binary	0 to 1 1110	status	read only

Bits 0 through 4 function as follows:

S:1/0 to S:1/4					Mode ID	Controller Mode	Use by MicroLogix Controller(1)	
S:1/4	S:1/3	S:1/2	S:1/1	S:1/0			1200	1500
0	0	0	0	0	0	remote download in progress	•	•
0	0	0	0	1	1	remote program mode	•	•
0	0	0	1	1	3	remote suspend mode (operation halted by execution of the SUS instruction)	•	•
0	0	1	1	0	6	remote run mode	•	•
0	0	1	1	1	7	remote test continuous mode	•	•
0	1	0	0	0	8	remote test single scan mode	•	•
1	0	0	0	0	16	download in progress	N/A	•
1	0	0	0	1	17	program mode	N/A	•
1	1	0	1	1	27	suspend mode (operation halted by execution of the SUS instruction)	N/A	•
1	1	1	1	0	30	run mode	N/A	•

(1) Valid modes are indicated by the (•) symbol. N/A indicates an invalid mode for that controller.

Forces Enabled

Address	Data Format	Range	Type	User Program Access
S:1/5	binary	1	status	read only

This bit is always set (1) by the controller to indicate that forces are enabled.

Forces Installed

Address	Data Format	Range	Type	User Program Access
S:1/6	binary	0 or 1	status	read only

This bit is set (1) by the controller to indicate that 1 or more inputs or outputs are forced. When this bit is clear, a force condition is not present within the controller.

Fault Override At Power-Up

Address	Data Format	Range	Type	User Program Access
S:1/8	binary	0 or 1	control	read only

When set (1), causes the controller to clear the Major Error Halted bit (S:1/13) at power-up. The power-up mode is determined by the controller mode switch *(MicroLogix 1500 only)* and the Power-Up Mode Behavior Selection bit (S:1/12).

See also:FO - Fault Override on page 78.

Startup Protection Fault

Address	Data Format	Range	Type	User Program Access
S:1/9	binary	0 or 1	control	read only

When set (1) and the controller powers up in the RUN or REM RUN mode, the controller executes the User Fault Routine prior to the execution of the first scan of your program. You have the option of clearing the Major Error Halted bit (S:1/13) to resume operation. If the User Fault Routine does not clear bit S:1/13, the controller faults and does not enter an executing mode. Program the User Fault Routine logic accordingly.

TIP When executing the startup protection fault routine, S:6 (major error fault code) contains the value 0016H.

Load Memory Module On Error Or Default Program

Address	Data Format	Range	Type	User Program Access
S:1/10	binary	0 or 1	control	read only

For this option to work, you must set (1) this bit in the control program before downloading the program to a memory module. When this bit it set in the memory module and power is applied, the controller downloads the memory module program when the control program is corrupt or a default program exists in the controller

.

TIP If you clear the controller memory, the controller loads the default program.

The mode of the controller after the transfer takes place is determined by the controller mode switch *(MicroLogix 1500 only)* and the Power-Up Mode Behavior Selection bit (S:1/12).

See also:LE - Load on Error on page 79.

Load Memory Module Always

Address	Data Format	Range	Type	User Program Access
S:1/11	binary	0 or 1	control	read only

For this option to work, you must set (1) this bit in the control program before downloading the program to a memory module. When this bit is set in the memory module and power is applied, the controller downloads the memory module program.

The mode of the controller after the transfer takes place is determined by the controller mode switch *(MicroLogix 1500 only)* and the Power-Up Mode Behavior Selection bit (S:1/12).

See also:LA - Load Always on page 79.

Power-Up Mode Behavior

Address	Data Format	Range	Type	User Program Access
S:1/12	binary	0 or 1	control	read only

If Power-Up Mode Behavior is clear (0 = Last State), the mode at power-up is dependent upon the:

- position of the mode switch *(MicroLogix 1500 only)*
- state of the Major Error Halted flag (S:1/13)
- mode at the previous power down

If Power Up Mode Behavior is set (1 = Run), the mode at power-up is dependent upon the:

- position of the mode switch *(MicroLogix 1500 only)*
- state of the Major Error Halted flag (S:1/13)

IMPORTANT If you want the controller to power-up and enter the Run mode, regardless of any previous fault conditions, you must also set the Fault Override bit (S:1/8) so that the Major Error Halted flag is cleared before determining the power up mode.

The following table shows the Power-Up Mode under various conditions

MicroLogix 1200	Major Error Halted	Power-Up Mode Behavior	Mode at Last Power-Down	Power-Up Mode
Remote	False	Last State	REM Download, Download, REM Program, Program or Any Test mode	REM Program
			REM Suspend or Suspend	REM Suspend
			REM Run or Run	REM Run
		Run	Don't Care	REM Run
	True	Don't Care	Don't Care	REM Program w/Fault

MicroLogix 1500 - Mode Switch Position at Power-Up	Major Error Halted	Power-Up Mode Behavior	Mode at Last Power-Down	Power-Up Mode
Program	False	Don't Care	Don't Care	Program
	True			Program w/Fault
Remote	False	Last State	REM Download, Download, REM Program, Program or Any Test mode	REM Program
			REM Suspend or Suspend	REM Suspend
			REM Run or Run	REM Run
		Run	Don't Care	REM Run
	True	Don't Care	Don't Care	REM Program w/Fault
Run	False	Last State	REM Suspend or Suspend	Suspend
			Any Mode except REM Suspend or Suspend	Run
		Run	Don't Care	Run
	True	Don't Care	Don't Care	Run w/Fault[1]

(1) Run w/Fault is a fault condition, just as if the controller were in the Program /w Fault mode (outputs are reset and the controller program is not being executed). However, the controller enters Run mode as soon as the Major Error Halted flag is cleared.

See also:MB - Mode Behavior on page 79.

Major Error Halted

Address	Data Format	Range	Type	User Program Access
S:1/13	binary	0 or 1	status	read/write

The controller sets (1) this bit when a major error is encountered. The controller enters a fault condition and word S:6 contains the Fault Code that can be used to diagnose the condition. Any time bit S:1/13 is set, the controller:

- turns all outputs off and flashes the FAULT LED,
- or, enters the User Fault Routine allowing the control program to attempt recovery from the fault condition. If the User Fault Routine is able to clear S:1/13 and the fault condition, the controller continues to execute the control program. If the fault cannot be cleared, the outputs are cleared and the controller exits its executing mode and the FAULT LED flashes.

ATTENTION

If you clear the Major Error Halted bit (S:1/13) when the controller mode switch *(MicroLogix 1500 only)* is in the RUN position, the controller immediately enters the RUN mode.

Future Access (OEM Lock)

Address	Data Format	Range	Type	User Program Access
S:1/14	binary	0 or 1	status	read only

When this bit is set (1), it indicates that the programming device must have an exact copy of the controller program.

SeeAllow Future Access Setting (OEM Lock) on page 68 for more information.

First Scan Bit

Address	Data Format	Range	Type	User Program Access
S:1/15	binary	0 or 1	status	read/write

When the controller sets (1) this bit, it indicates that the first scan of the user program is in progress (following entry into an executing mode). The controller clears this bit after the first scan.

.

TIP The First Scan bit (S:1/15) is set during execution of the start-up protection fault routine. Refer to S:1/9 for more information.

STI Mode

STI Pending

Address(1)	Data Format	Range	Type	User Program Access
S:2/0	binary	0 or 1	status	read only

(1) This bit can only be accessed via ladder logic. It cannot be accessed via communications (such as a Message instruction from another device).

This address is duplicated at STI:0/UIP. SeeUsing the Selectable Timed Interrupt (STI) Function File on page 301 for more information.

STI Enabled

Address(1)	Data Format	Range	Type	User Program Access
S:2/1	binary	0 or 1	control	read/write

(1) This bit can only be accessed via ladder logic. It cannot be accessed via communications (such as a Message instruction from another device).

This address is duplicated at STI:0/TIE. SeeUsing the Selectable Timed Interrupt (STI) Function File on page 301 for more information.

STI Executing

Address(1)	Data Format	Range	Type	User Program Access
S:2/2	binary	0 or 1	control	read only

(1) This bit can only be accessed via ladder logic. It cannot be accessed via communications (such as a Message instruction from another device).

This address is duplicated at STI:0/UIX. SeeUsing the Selectable Timed Interrupt (STI) Function File on page 301 for more information.

Memory Module Program Compare

Address	Data Format	Range	Type	User Program Access
S:2/9	binary	0 or 1	control	read only

When this bit is set (1) in the controller, its user program and the memory module user program must match for the controller to enter an executing mode.

If the user program does not match the memory module program, or if the memory module is not present, the controller faults with error code 0017H on any attempt to enter an executing mode.

An RTC module does not support program compare. If program compare is enabled and an RTC-only module is installed, the controller does not enter an executing mode.

See also:LPC - Load Program Compare on page 79.

Math Overflow Selection

Address	Data Format	Range	Type	User Program Access
S:2/14	binary	0 or 1	control	read/write

Set (1) this bit when you intend to use 32-bit addition and subtraction. When S:2/14 is set, and the result of an ADD, SUB, MUL, or DIV instruction cannot be represented in the destination address (underflow or overflow),

- the overflow bit S:0/1 is set,
- the overflow trap bit S:5/0 is set,
- and the destination address contains the unsigned truncated least significant 16 or 32 bits of the result.

The default condition of S:2/14 is cleared (0). When S:2/14 is cleared (0), and the result of an ADD, SUB, MUL, or DIV instruction cannot be represented in the destination address (underflow or overflow),

- the overflow bit S:0/1 is set,
- the overflow trap bit S:5/0 is set,
- the destination address contains +32,767 (word) or +2,147,483,647 (long word) if the result is positive; or -32,768 (word) or -2,147,483,648 (long word) if the result is negative.

To provide protection from inadvertent alteration of your selection, program an unconditional OTL instruction at address S:2/14 to ensure the new math overflow operation. Program an unconditional OTU instruction at address S:2/14 to ensure the original math overflow operation.

Watchdog Scan Time

Address	Data Format	Range	Type	User Program Access
S:3H	Byte	2 to 255	control	read/write

This byte value contains the number of 10 ms intervals allowed to occur during a program cycle. The timing accuracy is from -10 ms to +0 ms. This means that a value of 2 results in a timeout between 10 and 20 ms.

If the program scan time value equals the watchdog value, a watchdog major error is generated (code 0022H).

Free Running Clock

Address	Data Format	Range	Type	User Program Access
S:4	binary	0 to FFFF	status	read/write

This register contains a free running counter. This word is cleared (0) upon entering an executing mode.

Bits in status word 4 can be monitored by the user program. The bits turn on and off at a particular rate (cycle time). The On/Off times are identical, and are added together to determine the cycle time.

S:4 Free Running Clock Comparison for SLC 500 and MicroLogix Controllers

The Free Running Clocks in the SLC 500 and MicroLogix controllers function the same, but have different resolutions. The resolution of the Free Running Clock depends upon which controller you are using.

- SLC 500 and MicroLogix 1000: 10 ms/bit (0.010 seconds/bit)
- MicroLogix 1200 and MicroLogix 1500: 100 µs/bit (0.0001 seconds/bit)

The following table illustrates the differences.

Free Running Clock Cycle Times (all Times are in Seconds)

Bit	SLC 500 and MicroLogix 1000		MicroLogix 1200 and MicroLogix 1500	
	On/Off Time	Cycle Time	On/Off Time	Cycle Time
S:4/0	0.010	0.020	0.0001	0.0002
S:4/1	0.020	0.040	0.0002	0.0004
S:4/2	0.040	0.080	0.0004	0.0008
S:4/3	0.080	0.160	0.0008	0.0160
S:4/4	0.160	0.320	0.0016	0.0320
S:4/5	0.320	0.640	0.0032	0.0640
S:4/6	0.640	1.280	0.0064	0.1280
S:4/7	1.280	2.560	0.0128	0.2560
S:4/8	2.560	5.120	0.0256	0.5120
S:4/9	5.120	10.240	0.0512	0.1024
S:4/10	10.240	20.480	0.1024	0.2048
S:4/11	20.480	40.960	0.2048	0.4096
S:4/12	40.960	81.92	0.4096	0.8192
S:4/13	81.92	163.84	0.8192	1.6384
S:4/14	163.84	327.68	1.6384	3.2768
S:4/15	327.68	655.36	3.2768	6.5536

For example, if bit S:4/7 is monitored in an SLC 500, then that bit will be on for 1.28 seconds and off for 1.28 seconds for a total cycle time of 2.56 seconds. If bit S:4/7 is monitored in a MicroLogix 1500, then that bit will be on for 0.0128 seconds and off for 0.0128 seconds for a total cycle time of 0.0256 seconds.

Minor Error Bits

Overflow Trap Bit

Address	Data Format	Range	Type	User Program Access
S:5/0	binary	0 or 1	status	read/write

If this bit is ever set (1) upon execution of the END or TND instruction, a major error (0020H) is generated. To avoid this type of major error from occurring, examine the state of this bit following a math instruction (ADD, SUB, MUL, DIV, NEG, SCL, TOD, or FRD), take appropriate action, and then clear bit S:5/0 using an OTU instruction with S:5/0.

Control Register Error

Address	Data Format	Range	Type	User Program Access
S:5/2	binary	0 or 1	status	read/write

The LFU, LFL, FFU, FFL, BSL, BSR, SQO, SQC, and SQL instructions are capable of generating this error. When bit S:5/2 is set (1), it indicates that the error bit of a control word used by the instruction has been set.

If this bit is ever set upon execution of the END or TND instruction, major error (0020H) is generated. To avoid this type of major error from occurring, examine the state of this bit following a control register instruction, take appropriate action, and then clear bit S:5/2 using an OTU instruction with S:5/2.

Major Error Detected in User Fault Routine

Address	Data Format	Range	Type	User Program Access
S:5/3	binary	0 or 1	status	read/write

When set (1), the major error code (S:6) represents the major error that occurred while processing the User Fault Routine due to another major error.

Memory Module Boot

Address	Data Format	Range	Type	User Program Access
S:5/8	binary	0 or 1	status	read/write

When this bit is set (1) by the controller, it indicates that a memory module program has been transferred due to S:1/10 (Load Memory Module on Error or Default Program) or S:1/11 (Load Memory Module Always) being set in an attached memory module user program. This bit is not cleared (0) by the controller.

Your program can examine the state of this bit on the first scan (using bit S:1/15) on entry into an Executing mode to determine if the memory module user program has been transferred after a power-up occurred. This information is useful when you have an application that contains retentive data and a memory module has bit S:1/10 or bit S:1/11 set.

Memory Module Password Mismatch

Address	Data Format	Range	Type	User Program Access
S:5/9	binary	0 or 1	status	read/write

At power-up, if Load Always is set, and the controller and memory module passwords do not match, the Memory Module Password Mismatch bit is set (1).

SeePassword Protection on page 66 for more information.

STI Lost

Address(1)	Data Format	Range	Type	User Program Access
S:5/10	binary	0 or 1	status	read/write

(1) This bit can only be accessed via ladder logic. It cannot be accessed via communications (such as a Message instruction from another device).

This address is duplicated at STI:0/UIL. SeeUsing the Selectable Timed Interrupt (STI) Function File on page 301 for more information.

Retentive Data Lost (MicroLogix 1200 only)

Address	Data Format	Range	Type	User Program Access
S:5/11	binary	0 or 1	status	read/write

This bit is set (1) whenever retentive data is lost. This bit remains set until you clear (0) it. The controller validates retentive data at power up. If user data is invalid, the controller sets the Retentive Data Lost indicator. The data in the controller are the values that were in the program when the program was last transferred to the controller. If the Retentive Data Lost bit is set, a fault occurs when entering an executing mode, but only if the Fault Override bit (S:1/8) is not set.

Processor Battery Low (MicroLogix 1500 only)

Address	Data Format	Range	Type	User Program Access
S:5/11	binary	0 or 1	status	read only

This bit is set (1) when the battery is low.

IMPORTANT Install a replacement battery immediately. See your hardware manual for more information.

See also: RTC Battery Operation on page 72.

Input Filter Selection Modified

Address	Data Format	Range	Type	User Program Access
S:5/13	binary	0 or 1	status	read/write

This bit is set (1) whenever the discrete input filter selection in the control program is not compatible with the hardware.

ASCII String Manipulation Error

Address	Data Format	Range	Type	User Program Access
S:5/15	binary	0 or 1	status	read

This bit is set (1) whenever an invalid string length occurs. When S:5/15 is set, the Invalid String Length Error (1F39H) is written to the Major Error Fault Code word (S:6).

This bit applies to the MicroLogix 1200 and 1500 Series B Controllers.

Major Error Code

Address	Data Format	Range	Type	User Program Access
S:6	word	0 to FFFF	status	read/write

This register displays a value which can be used to determine what caused a fault to occur. SeeIdentifying Controller Faults on page 507 to learn more about troubleshooting faults.

Suspend Code

Address	Data Format	Range	Type	User Program Access
S:7	word	-32,768 to +32,767	status	read/write

When the controller executes an Suspend (SUS) instruction, the SUS code is written to this location, S:7. This pinpoints the conditions in the application that caused the Suspend mode. The controller does not clear this value.

Use the SUS instruction with startup troubleshooting, or as runtime diagnostics for detection of system errors.

Suspend File

Address	Data Format	Range	Type	User Program Access
S:8	word	0 to 255	status	read/write

When the controller executes an Suspend (SUS) instruction, the SUS file is written to this location, S:8. This pinpoints the conditions in the application that caused the Suspend mode. The controller does not clear this value.

Use the SUS instruction with startup troubleshooting, or as runtime diagnostics for detection of system errors.

Active Nodes (Nodes 0 to 15)

Address(1)	Data Format	Range	Type	User Program Access
S:9	word	0 to FFFF	status	read only

(1) This bit can only be accessed via ladder logic. It cannot be accessed via communications (such as a Message instruction from another device).

This address is duplicated in the Communications Status File (CSx:0.27). SeeActive Node Table Block on page 98 for more information.

Active Nodes (Nodes 16 to 31)

Address(1)	Data Format	Range	Type	User Program Access
S:10	word	0 to FFFF	status	read only

(1) This bit can only be accessed via ladder logic. It cannot be accessed via communications (such as a Message instruction from another device).

This address is duplicated in the Communications Status File (CSx:0.28). SeeActive Node Table Block on page 98 for more information.

Math Register

Address	Data Format	Range	Type	User Program Access
S:13 (low byte)	word	-32,768 to +32,767	status	read/write
S:14 (high byte)	word	-32,768 to +32,767	status	read/write

These two words are used in conjunction with the MUL, DIV, FRD, and TOD math instructions. The math register value is assessed upon execution of the instruction and remains valid until the next MUL, DIV, FRD, or TOD instruction is executed in the user program.

Node Address

Address(1)	Data Format	Range	Type	User Program Access
S:15 (low byte)	byte	0 to 255	status	read only

(1) This byte can only be accessed via ladder logic. It cannot be accessed via communications (such as a Message instruction from another device).

This address is duplicated in the Communications Status File (CSx:0.5/0 through CSx:0.5/7). SeeGeneral Channel Status Block on page 85 for more information.

Baud Rate

Address(1)	Data Format	Range	Type	User Program Access
S:15 (high byte)	byte	0 to 255	status	read only

(1) This byte can only be accessed via ladder logic. It cannot be accessed via communications (such as a Message instruction from another device).

This address is duplicated in the Communications Status File (CSx:0.5/8 through CSx:0.5/15). SeeGeneral Channel Status Block on page 85 for more information.

Maximum Scan Time

Address	Data Format	Range	Type	User Program Access
S:22	word	0 to 32,767	status	read/write

This word indicates the maximum observed interval between consecutive program scans.

The controller compares each scan value to the value contained in S:22. If a scan value is larger than the previous, the larger value is stored in S:22.

This value indicates, in 100 us increments, the time elapsed in the longest program cycle of the controller. Resolution is -100 µs to +0 µs. For example, the value 9 indicates that 800 to 900 us was observed as the longest program cycle.

User Fault Routine File Number

Address	Data Format	Range	Type	User Program Access
S:29	word	0 to 255	status	read only

This register is used to control which subroutine executes when a User Fault is generated.

STI Set Point

Address[1]	Data Format	Range	Type	User Program Access
S:30	word	0 to 65535	status	read only

(1) This bit can only be accessed via ladder logic. It cannot be accessed via communications (such as a Message instruction from another device).

This address is duplicated at STI:0/SPM. SeeUsing the Selectable Timed Interrupt (STI) Function File on page 301 for more information.

STI File Number

Address[1]	Data Format	Range	Type	User Program Access
S:31	word	0 to 65535	status	read only

(1) This bit can only be accessed via ladder logic. It cannot be accessed via communications (such as a Message instruction from another device).

This address is duplicated at STI:0/PFN. SeeUsing the Selectable Timed Interrupt (STI) Function File on page 301 for more information.

Channel 0 Communications

Incoming Command Pending

Address[1]	Data Format	Range	Type	User Program Access
S:33/0	binary	0 or 1	status	read only

(1) This bit can only be accessed via ladder logic. It cannot be accessed via communications (such as a Message instruction from another device).

This address is duplicated in the Communications Status File at CS0:0.4/0. SeeGeneral Channel Status Block on page 85 for more information.

Message Reply Pending

Address[1]	Data Format	Range	Type	User Program Access
S:33/1	binary	0 or 1	status	read only

(1) This bit can only be accessed via ladder logic. It cannot be accessed via communications (such as a Message instruction from another device).

This address is duplicated in the Communications Status File at CS0:0.4/1. SeeGeneral Channel Status Block on page 85 for more information.

Outgoing Message Command Pending

Address(1)	Data Format	Range	Type	User Program Access
S:33/2	binary	0 or 1	status	read only

(1) This bit can only be accessed via ladder logic. It cannot be accessed via communications (such as a Message instruction from another device).

This address is duplicated in the Communications Status File at CS0:0.4/2. SeeGeneral Channel Status Block on page 85 for more information.

Communications Mode Selection

Address(1)	Data Format	Range	Type	User Program Access
S:33/3	binary	0 or 1	status	read only

(1) This bit can only be accessed via ladder logic. It cannot be accessed via communications (such as a Message instruction from another device).

This address is duplicated in the Communications Status File at CS0:0.4/3. SeeGeneral Channel Status Block on page 85 for more information.

Communications Active

Address(1)	Data Format	Range	Type	User Program Access
S:33/4	binary	0 or 1	status	read only

(1) This bit can only be accessed via ladder logic. It cannot be accessed via communications (such as a Message instruction from another device).

This address is duplicated in the Communications Status File at CS0:0.4/4. SeeGeneral Channel Status Block on page 85 for more information.

Scan Toggle Bit

Address	Data Format	Range	Type	User Program Access
S:33/9	binary	0 or 1	status	read/write

The controller changes the status of this bit at the end of each scan. It is reset upon entry into an executing mode.

Last 100 µSec Scan Time

Address	Data Format	Range	Type	User Program Access
S:35	word	0 to 32,767	status	read/write

This register indicates the elapsed time for the last program cycle of the controller (in 100 µs increments).

Data File Overwrite Protection Lost

Address	Data Format	Range	Type	User Program Access
S:36/10	binary	0 or 1	status	read/write

When clear (0), this bit indicates that at the time of the last program transfer to the controller, protected data files in the controller were not overwritten, or there were no protected data files in the program being downloaded.

When set (1), this bit indicates that data has been overwritten. SeeUser Program Transfer Requirements on page 64 for more information.

SeeSetting Download File Protection on page 63 for more information.

RTC Year

Address(1)	Data Format	Range	Type	User Program Access
S:37	word	1998 to 2097	status	read only

(1) This bit can only be accessed via ladder logic. It cannot be accessed via communications (such as a Message instruction from another device).

This address is duplicated in the Real-Time Clock Function File at RTC:0.YR. SeeReal-Time Clock Function File on page 71 for more information. **Note:** *This value will not update while viewing online in RSLogix 500. Monitor address in function file to see online values.*

RTC Month

Address(1)	Data Format	Range	Type	User Program Access
S:38	word	1 to 12	status	read only

(1) This bit can only be accessed via ladder logic. It cannot be accessed via communications (such as a Message instruction from another device).

This address is duplicated in the Real-Time Clock Function File at RTC:0.MON. SeeReal-Time Clock Function File on page 71 for more information. **Note:** *This value will not update while viewing online in RSLogix 500. Monitor address in function file to see online values.*

RTC Day of Month

Address(1)	Data Format	Range	Type	User Program Access
S:39	word	1 to 31	status	read only

(1) This bit can only be accessed via ladder logic. It cannot be accessed via communications (such as a Message instruction from another device).

This address is duplicated in the Real-Time Clock Function File at RTC:0.DAY. SeeReal-Time Clock Function File on page 71 for more information. **Note:** *This value will not update while viewing online in RSLogix 500. Monitor address in function file to see online values.*

RTC Hours

Address(1)	Data Format	Range	Type	User Program Access
S:40	word	0 to 23	status	read only

(1) This word can only be accessed via ladder logic. It cannot be accessed via communications (such as a Message instruction from another device).

This address is duplicated in the Real-Time Clock Function File at RTC:0.HR. SeeReal-Time Clock Function File on page 71 for more information. **Note:** *This value will not update while viewing online in RSLogix 500. Monitor address in function file to see online values.*

RTC Minutes

Address(1)	Data Format	Range	Type	User Program Access
S:41	word	0 to 59	status	read only

(1) This word can only be accessed via ladder logic. It cannot be accessed via communications (such as a Message instruction from another device).

This address is duplicated in the Real-Time Clock Function File at RTC:0.MIN. SeeReal-Time Clock Function File on page 71 for more information. **Note:** *This value will not update while viewing online in RSLogix 500. Monitor address in function file to see online values.*

RTC Seconds

Address(1)	Data Format	Range	Type	User Program Access
S:42	word	0 to 59	status	read only

(1) This word can only be accessed via ladder logic. It cannot be accessed via communications (such as a Message instruction from another device).

This address is duplicated in the Real-Time Clock Function File at RTC:0.SEC. SeeReal-Time Clock Function File on page 71 for more information. **Note:** *This value will not update while viewing online in RSLogix 500. Monitor address in function file to see online values.*

RTC Day of Week

Address(1)	Data Format	Range	Type	User Program Access
S:53	word	0 to 6	status	read only

(1) This word can only be accessed via ladder logic. It cannot be accessed via communications (such as a Message instruction from another device).

This address is duplicated in the Real-Time Clock Function File at RTC:0.DOW. SeeReal-Time Clock Function File on page 71 for more information. **Note:** *This value will not update while viewing online in RSLogix 500. Monitor address in function file to see online values.*

OS Catalog Number

Address	Data Format	Range	Type	User Program Access
S:57	word	0 to 32,767	status	read only

This register identifies the Catalog Number for the Operating System in the controller.

OS Series

Address	Data Format	Range	Type	User Program Access
S:58	ASCII	A to Z	status	read only

This register identifies the Series letter for the Operating System in the controller.

OS FRN

Address	Data Format	Range	Type	User Program Access
S:59	word	0 to 32,767	status	read only

This register identifies the FRN of the Operating System in the controller.

Processor Catalog Number

Address	Data Format	Range	Type	User Program Access
S:60	ASCII	"A" to "ZZ"	status	read only

This register identifies the Catalog Number for the processor.

Processor Series

Address	Data Format	Range	Type	User Program Access
S:61	ASCII	A to Z	status	read only

This register identifies the Series of the processor.

Processor Revision

Address	Data Format	Range	Type	User Program Access
S:62	word	0 to 32,767	status	read only

This register identifies the revision (Boot FRN) of the processor.

User Program Functionality Type

Address	Data Format	Range	Type	User Program Access
S:63	word	0 to 32,767	status	read only

This register identifies the level of functionality of the user program in the controller.

Compiler Revision - Build Number

Address	Data Format	Range	Type	User Program Access
S:64 (low byte)	byte	0 to 255	status	read only

This register identifies the Build Number of the compiler which created the program in the controller.

Compiler Revision - Release

Address	Data Format	Range	Type	User Program Access
S:64 (high byte)	byte	0 to 255	status	read only

This register identifies the Release of the compiler which created the program in the controller.

Notes:

Fault Messages and Error Codes

This chapter describes how to troubleshoot your controller. Topics include:

- identifying controller faults
- contacting Rockwell Automation for assistance

Identifying Controller Faults

While a program is executing, a fault may occur within the operating system or your program. When a fault occurs, you have various options to determine what the fault is and how to correct it. This section describes how to clear faults and provides a list of possible advisory messages with recommended corrective actions.

Automatically Clearing Faults

You can automatically clear a fault by cycling power to the controller when the Fault Override at Power-Up bit (S:1/8) is set in the status file.

You can also configure the controller to clear faults and go to RUN every time the controller is power cycled. This is a feature that OEMs can build into their equipment to allow end users to reset the controller. If the controller faults, it can be reset by simply cycling power to the machine. To accomplish this, set the following bits in the status file:

- S2:1/8 - Fault Override at Power-up
- S2:1/12 - Mode Behavior

If the fault condition still exists after cycling power, the controller re-enters the fault mode. For more information on status bits, see System Status File on page 479.

TIP You can declare your own application-specific major fault by writing your own unique value to S:6 and then setting bit S:1/13 to prevent reusing system defined codes. The recommended values for user-defined faults are FF00 to FF0F.

Manually Clearing Faults Using the Fault Routine

The occurrence of recoverable or non-recoverable user faults can cause the user fault subroutine to be executed. If the fault is recoverable, the subroutine can be used to correct the problem and clear the fault bit S:1/13. The controller then continues in the Run or test mode.

The subroutine does not execute for non-user faults. See User Fault Routine on page 294 for information on creating a user fault subroutine.

Fault Messages

This section contains fault messages that can occur during operation of the MicroLogix 1200 and MicroLogix 1500 programmable controllers. Each table lists the error code description, the probable cause, and the recommended corrective action.

Error Code (Hex)	Advisory Message	Description	Fault Classification	Recommended Action
0001	NVRAM ERROR	The default program is loaded to the controller memory. This occurs: • if a power down occurred during program download or transfer from the memory module. • RAM integrity test failed. • FLASH integrity test failed *(MicroLogix 1200 only).*	Non-User	• Re-download or transfer the program. • Verify battery is connected *(MicroLogix 1500 only).* • Contact your local Rockwell Automation representative if the error persists.
0002	UNEXPECTED RESET	• The controller was unexpectedly reset due to a noisy environment or internal hardware failure. • The default program is loaded. *(MicroLogix 1500 only)* • Retentive Data is lost. See page 493. *(MicroLogix 1200 only)*	Non-User	• Refer to proper grounding guidelines and using surge suppressors in your controller's User Manual. • Verify battery is connected *(MicroLogix 1500 only).* • Contact your local Rockwell Automation representative if the error persists.
0003	MEMORY MODULE USER PROGRAM IS CORRUPT	Memory module memory error. This error can also occur when going to the Run mode.	Non-User	Re-program the memory module. If the error persists, replace the memory module.
0004	MEMORY INTEGRITY ERROR	While the controller was powered up, ROM or RAM became corrupt.	Non-User	• Cycle power on your unit. Then, re-download your program and start up your system. • Refer to proper grounding guidelines and using surge suppressors in your controller's User Manual. • Contact your local Rockwell Automation representative if the error persists.

Error Code (Hex)	Advisory Message	Description	Fault Classification	Recommended Action
0005	RETENTIVE DATA IS LOST *(MicroLogix 1200 only)*	Retentive Data is lost. See page 493.	Recoverable	Contact your local Rockwell Automation representative if the error persists.
0006	MEMORY MODULE HARDWARE FAULT	The memory module hardware faulted or the memory module is incompatible with OS.	Non-User	• Upgrade the OS to be compatible with memory module. • Obtain a new memory module.
0007	MEMORY MODULE TRANSFER ERROR	Failure during memory module transfer.	Non-User	Re-attempt the transfer. If the error persists, replace the memory module.
0008	FATAL INTERNAL SOFTWARE ERROR	An unexpected software error occurred.	Non-User	• Cycle power on your unit. Then, re-download your program and re-initialize any necessary data. • Start up your system. • Refer to proper grounding guidelines and using surge suppressors in your controller's User Manual. • Contact your local Rockwell Automation representative if the error persists.
0009	FATAL INTERNAL HARDWARE ERROR	An unexpected hardware error occurred.	Non-User	• Cycle power on your unit. Then, re-download your program and re-initialize any necessary data. • Start up your system. • Refer to proper grounding guidelines and using surge suppressors in your controller's User Manual. • Contact your local Rockwell Automation representative if the error persists.
000A	OS MISSING OR CORRUPT	The operating system required for the user program is corrupt or missing.	Non-User	• Download a new OS using ControlFlash. • Contact your local Rockwell Automation representative for more information about available operating systems your controller.
000B	BASE HARDWARE FAULT	The base hardware faulted or is incompatible with the OS.	Non-User	• Upgrade the OS using ControlFlash. • Replace the Controller *(MicroLogix 1200 only)*. • Replace the Base Unit *(MicroLogix 1500 only)*. • Contact your local Rockwell Automation representative for more information about available operating systems your controller.
0011	EXECUTABLE FILE 2 IS MISSING	Ladder File 2 is missing from the program.	Non-User	• Re-compile and reload the program.

Error Code (Hex)	Advisory Message	Description	Fault Classification	Recommended Action
0012	LADDER PROGRAM ERROR	The ladder program has a memory integrity problem.	Non-User	• Reload the program or re-compile and reload the program. If the error persists, be sure to use RSI programming software to develop and load the program. • Refer to proper grounding guidelines and using surge suppressors in your controller's User Manual.
0015	I/O CONFIGURATION FILE ERROR	The user program I/O configuration is invalid.	Non-User	Re-compile and reload the program, and enter the Run mode. If the error persists, be sure to use RSI programming software to develop and load the program.
0016	STARTUP PROTECTION FAULT	The user fault routine was executed at power-up, prior to the main ladder program. Bit S:1/13 (Major Error Halted) was not cleared at the end of the User Fault Routine. The User Fault Routine ran because bit S:1/9 was set at power-up.	Recoverable	• Either reset bit S:1/9 if this is consistent with the application requirements, and change the mode back to RUN, or • clear S:1/13, the Major Error Halted bit, before the end of the User Fault Routine.
0017	NVRAM/MEMORY MODULE USER PROGRAM MISMATCH	Bit S:2/9 is set in the controller and the memory module user program does not match the controller user program.	Non-Recoverable	Transfer the memory module program to the controller and then change to Run mode.
0018	MEMORY MODULE USER PROGRAM INCOMPATIBLE WITH OS	The user program in the memory module is incompatible with the OS.	Non-User	• Upgrade the OS using ControlFlash to be compatible with the memory module. • Obtain a new memory module. • Contact your local Rockwell Automation representative for more information about available operating systems your controller.
001A	USER PROGRAM INCOMPATIBLE WITH OS AT POWER-UP	The user program is incompatible with the OS.	Non-User	• Upgrade the OS using ControlFlash. • Contact your local Rockwell Automation representative for more information about available operating systems your controller.
0020	MINOR ERROR AT END-OF-SCAN DETECTED	A minor fault bit (bits 0-7) in S:5 was set at the end of scan.	Recoverable	• Correct the instruction logic causing the error. • Enter the status file display in your programming software and clear the fault. • Enter the Run mode.

Error Code (Hex)	Advisory Message	Description	Fault Classification	Recommended Action
0021	EXPANSION POWER FAIL (EPF) *(MicroLogix 1500 only)*	A power failure is present on the expansion I/O bank. This error code is present when the controller is powered, and power is not applied to the expansion I/O bank. This is a self-clearing error code. When power is re-applied to the expansion I/O bank, the fault is cleared. See Important note below.	Non-User	Re-apply power to the expansion I/O bank. See Important note below.
	IMPORTANT	If this fault occurs while the system is in the RUN mode, the controller faults. When expansion I/O power is restored, the controller clears the fault and re-enters the RUN mode. If you change the mode switch while this fault is present, the controller may not re-enter the RUN mode when expansion I/O power is restored. If an EPF condition is present and expansion I/O power is OK, toggle the mode switch to PROGRAM and then to RUN. The fault should clear and the controller enters the RUN mode.		
	TIP	This error may also occur if there is a hardware failure on the bus with either a MicroLogix 1200 or MicroLogix 1500 controller.		• Cycle power on your unit. • Contact your local Rockwell Automation representative if the error persists.
0022	WATCHDOG TIMER EXPIRED, SEE S:3	The program scan time exceeded the watchdog timeout value (S:3H).	Non-Recoverable	• Determine if the program is caught in a loop and correct the problem. • Increase the watchdog timeout value in the status file.
0023	STI ERROR	An error occurred in the STI configuration.	Recoverable	See the Error Code in the STI Function File for the specific error.
0028	INVALID OR NONEXISTENT USER FAULT ROUTINE VALUE	• A fault routine number was entered in the status file, number (S:29), but either the fault routine was not physically created, or • the fault routine number was less than 3 or greater than 255.	Non-User	• Either clear the fault routine file number (S:29) in the status file, or • create a fault routine for the file number reference in the status file (S:29). The file number must be greater than 2 and less than 256.
0029	INSTRUCTION INDIRECTION OUTSIDE OF DATA SPACE	An indirect address reference in the ladder program is outside of the entire data file space.	Recoverable	Correct the program to ensure that there are no indirect references outside data file space. Re-compile, reload the program and enter the Run mode.
002E	EII ERROR	An error occurred in the EII configuration.	Recoverable	See the Error Code in the EII Function File for the specific error.
0030	SUBROUTINE NESTING EXCEEDS LIMIT	The JSR instruction nesting level exceeded the controller memory space.	Non-User	Correct the user program to reduce the nesting levels used and to meet the restrictions for the JSR instruction. Then reload the program and Run.
0031	UNSUPPORTED INSTRUCTION DETECTED	The program contains an instruction(s) that is not supported by the controller.	Non-User	• Modify the program so that all instructions are supported by the controller. • Re-compile and reload the program and enter the Run mode.

Error Code (Hex)	Advisory Message	Description	Fault Classification	Recommended Action
0032	SQO/SQC/SQL OUTSIDE OF DATA FILE SPACE	A sequencer instruction length/ position parameter references outside of the entire data file space.	Recoverable	• Correct the program to ensure that the length and position parameters do not point outside data file space. • Re-compile, reload the program and enter the Run mode.
0033	BSL/BSR/FFL/FFU/LFL/ LFU CROSSED DATA FILE SPACE	The length/position parameter of a BSL, BSR, FFL, FFU, LFL, or LFU instruction references outside of the entire data file space.	Recoverable	• Correct the program to ensure that the length and position parameters do not point outside of the data space. • Re-compile, reload the program and enter the Run mode.
0034	NEGATIVE VALUE IN TIMER PRESET OR ACCUMULATOR	A negative value was loaded to a timer preset or accumulator.	Recoverable	• If the program is moving values to the accumulated or preset word of a timer, make certain these values are not negative. • Reload the program and enter the Run mode.
0035	ILLEGAL INSTRUCTION IN INTERRUPT FILE	The program contains a Temporary End (TND), Refresh (REF), or Service Communication instruction in an interrupt subroutine (STI, EII, HSC) or user fault routine.	Non-Recoverable	• Correct the program. • Re-compile, reload the program and enter the Run mode.
0036	INVALID PID PARAMETER	An invalid value is being used for a PID instruction parameter.	Recoverable	See page 315, Process Control Instruction for more information about the PID instruction.
0037	HSC ERROR	An error occurred in the HSC configuration.	Recoverable	See the Error Code in the HSC Function File for the specific error.
003B	PTO ERROR	An error occurred in the PTO instruction configuration.	Recoverable or Non-User	See the Error Code in the PTO Function File for the specific error.
003C	PWM ERROR	An error occurred in the PWM instruction configuration.	Recoverable or Non-User	See the Error Code in the PWM Function File for the specific error.
003D	INVALID SEQUENCER LENGTH/POSITION	A sequencer instruction (SQO, SQC, SQL) length/position parameter is greater than 255.	Recoverable	Correct the user program, then re-compile, reload the program and enter the Run mode.
003E	INVALID BIT SHIFT OR LIFO/FIFO PARAMETER	A BSR or BSL instruction length parameter is greater than 2048 or an FFU, FFL, LFU, LFL instruction length parameter is greater than 128 (word file) or greater than 64 (double word file)	Recoverable	Correct the user program or allocate more data file space using the memory map, then reload and Run.
003F	COP/CPW/FLL OUTSIDE OF DATA FILE SPACE	A COP, CPW or FLL instruction length parameter references outside of the entire data space.	Recoverable	• Correct the program to ensure that the length and parameter do not point outside of the data file space. • Re-compile, reload the program and enter the Run mode.
0042	INVALID RECIPE NUMBER	Number of Recipes specified is greater than 256.	Recoverable	• Correct the value for Number of Recipes. • Re-compile, reload the program and enter the Run mode.

Error Code (Hex)	Advisory Message	Description	Fault Classification	Recommended Action
0044	INVALID WRITE TO RTC FUNCTION FILE	Write attempt to RTC function file failed. This only occurs when attempting to write invalid data to the RTC function file. Examples of invalid data are: setting the Day of Week to zero, or setting the Date to February 30th.	Recoverable	• Correct the invalid data. • Re-compile, reload the program and enter the Run mode.
0050	CONTROLLER TYPE MISMATCH	A particular controller type was selected in the user program configuration, but did not match the actual controller type.	Non-User	• Connect to the hardware that is specified in the user program, or • Reconfigure the program to match the attached hardware.
0051	BASE TYPE MISMATCH	A particular hardware type (AWA, BWA, BXB) was selected in the user program configuration, but did no match the actual base.	Non-User	• Connect to the hardware that is specified in the user program, or • Reconfigure the program to match the attached hardware.
0052	MINIMUM SERIES ERROR	The hardware minimum series selected in the user program configuration was greater than the series on the actual hardware.	Non-User	• Connect to the hardware that is specified in the user program, or • Reconfigure the program to match the attached hardware.
0070	EXPANSION I/O TERMINATOR REMOVED *(MicroLogix 1500 only)*	The required expansion I/O terminator was removed.	Non-Recoverable	• Check the expansion I/O terminator on the last I/O module. • Cycle power.
xx71[1]	EXPANSION I/O HARDWARE ERROR	The controller cannot communicate with an expansion I/O module.	Non-Recoverable	• Check connections. • Check for a noise problem and be sure proper grounding practices are used. • Replace the module. • Cycle power.
xx79[1]	EXPANSION I/O MODULE ERROR	An expansion I/O module generated an error.	Non-Recoverable	• Refer to the I/O Module Status (IOS) file. • Consult the documentation for your specific I/O module to determine possible causes of a module error.
0080	EXPANSION I/O TERMINATOR REMOVED *(MicroLogix 1500 only)*	The required expansion I/O terminator was removed.	Non-User	• Check expansion I/O terminator on last I/O module. • Cycle power.
xx81[1]	EXPANSION I/O HARDWARE ERROR	The controller cannot communicate with an expansion I/O module.	Non-User	• Check connections. • Check for a noise problem and be sure proper grounding practices are used. • Replace the module. • Cycle power.
0083	MAX I/O CABLES EXCEEDED	The maximum number of expansion I/O cables allowed was exceeded.	Non-User	• Reconfigure the expansion I/O system so that it has an allowable number of cables. • Cycle power.

Error Code (Hex)	Advisory Message	Description	Fault Classification	Recommended Action
0084	MAX I/O POWER SUPPLIES EXCEEDED	The maximum number of expansion I/O power supplies allowed was exceeded.	Non-User	• Reconfigure the expansion I/O system so that it has the correct number of power supplies.
0085	MAX I/O MODULES EXCEEDED	The maximum number of expansion I/O modules allowed was exceeded.	Non-User	• Reconfigure the expansion I/O system so that it has an allowable number of modules. • Cycle power.
xx86[1]	EXPANSION I/O MODULE BAUD RATE ERROR	An expansion I/O module could not communicate at the baud rate specified in the user program I/O configuration.	Non-User	• Change the baud rate in the user program I/O configuration, and • Re-compile, reload the program and enter the Run mode, or • Replace the module. • Cycle power.
xx87[1]	I/O CONFIGURATION MISMATCH	• The expansion I/O configuration in the user program did not match the actual configuration, or • The expansion I/O configuration in the user program specified a module, but one was not found, or • The expansion I/O module configuration data size for a module was greater than what the module is capable of holding.	Non-User	• Either correct the user program I/O configuration to match the actual configuration, or • With power off, correct the actual I/O configuration to match the user program configuration.
xx88[1]	EXPANSION I/O MODULE CONFIGURATION ERROR	The number of input or output image words configured in the user program exceeds the image size in the expansion I/O module.	Non-User	• Correct the user program I/O configuration to reduce the number of input or output words, and • Re-compile, reload the program and enter the Run mode.
xx89[1][2]	EXPANSION I/O MODULE ERROR	An expansion I/O module generated an error.	Non-User	• Refer to the I/O status file. • Consult the documentation for your specific I/O module to determine possible causes of a module error.
xx8A[1][2]	EXPANSION I/O CABLE CONFIGURATION MISMATCH ERROR	• Either an expansion I/O cable is configured in the user program, but no cable is present, or • an expansion I/O cable is configured in the user program and a cable is physically present, but the types do not match.	Non-User	• Correct the user program to eliminate a cable that is not present • Re-compile, reload the program and enter the Run mode, or • Add the missing cable. • Cycle power.

Error Code (Hex)	Advisory Message	Description	Fault Classification	Recommended Action
xx8B[1][2]	EXPANSION I/O POWER SUPPLY CONFIGURATION MISMATCH ERROR	• Either an expansion I/O power supply is configured in the user program, but no power supply is present, or • an expansion I/O power supply is configured in the user program and a power supply is physically present, but the types do not match.	Non-User	• Correct the user program to eliminate a power supply that is not present • Re-compile, reload the program and enter the Run mode, or • With power removed, add the missing power supply.
xx8C[1][2]	EXPANSION I/O OBJECT TYPE MISMATCH	An expansion I/O object (i.e. cable, power supply, or module) in the user program I/O configuration is not the same object type as is physically present.	Non-User	• Correct the user program I/O configuration so that the object types match the actual configuration, and • Re-compile, reload the program and enter the Run mode. Or • Correct the actual configuration to match the user program I/O configuration. • Cycle power.
0x1F39	INVALID STRING LENGTH[3]	The first word of string data contains a negative, zero, or value greater than 82.	Recoverable	Check the first word of the string data element for invalid values and correct the data.

(1) xx indicates module number. If xx = 0, problem cannot be traced to a specific module.

(2) The xx in this error code means that the error occurs at the location of the last properly configured Expansion I/O module +1. You should use this information in conjunction with the specific error code to determine the source of the problem.

(3) Applies to MicroLogix 1500 1764-LSP Series B and 1764-LRP Processors.

Contacting Rockwell Automation for Assistance

If you need to contact Rockwell Automation or local distributor for assistance, it is helpful to obtain the following information ready:

- controller type, series letter, and revision letter of the base unit
- series letter, revision letter, and firmware (FRN) number of the processor (on bottom side of processor unit)

TIP You can also check the FRN by looking at word S:59 (Operating System FRN) in the Status File.

- controller LED status
- controller error codes (found in S2:6 of status file).

Rockwell Automation phone numbers are listed on the back cover of this manual.

To contact us via the Internet, go to http://www.rockwellautomation.com.

Protocol Configuration

Use the information in this appendix for configuring communication protocols. The following protocols are supported from any RS-232 communication channel:

- DH-485
- DF1 Full-Duplex
- DF1 Half-Duplex
- DF1 Radio Modem
- Modbus™ RTU
- ASCII

This appendix is organized into the following sections:

See your controller’s User Manual for information about required network devices and accessories.

DH-485 Communication Protocol

The information in this section describes the DH-485 network functions, network architecture, and performance characteristics. It also helps you plan and operate the controller on a DH-485 network.

DH-485 Network Description

The DH-485 protocol defines the communication between multiple devices that coexist on a single pair of wires. DH-485 protocol uses RS-485 Half-Duplex as its physical interface. (RS-485 is a definition of electrical characteristics; it is *not* a protocol.) RS-485 uses devices that are capable of co-existing on a common data circuit, thus allowing data to be easily shared between devices.

The DH-485 network offers:

- interconnection of 32 devices
- multi-master capability
- token passing access control
- the ability to add or remove nodes without disrupting the network
- maximum network length of 1219 m (4000 ft.)

The DH-485 protocol supports two classes of devices: initiators and responders. All initiators on the network get a chance to initiate message transfers. To determine which initiator has the right to transmit, a token passing algorithm is used.

The following section describes the protocol used to control message transfers on the DH-485 network.

DH-485 Token Rotation

A node holding the token can send a message onto the network. Each node is allowed a fixed number of transmissions (based on the Token Hold Factor) each time it receives the token. After a node sends a message, it passes the token to the next device.

The allowable range of node addresses 0 to 31. There must be at least one initiator on the network (such as a MicroLogix controller, or an SLC 5/02 or higher processor).

DH-485 Broadcast Messages

A broadcast write command is sent as a DH-485 Send Data No Acknowledgement (SDN) packet. No acknowledgement or reply is returned.

DH-485 Configuration Parameters

When communications are configured for DH-485, the following parameters can be changed:

Parameter	Options	Programming Software Default
Baud Rate	9600, 19.2K	19.2K
Node Address	1 to 31 decimal	1
Token Hold Factor	1 to 4	2
Max Node Address	1 to 31	31

The major software issues you need to resolve before installing a network are discussed in the following sections.

Software Considerations

Software considerations include the configuration of the network and the parameters that can be set to the specific requirements of the network. The following are major configuration factors that have a significant effect on network performance:

- number of nodes on the network
- addresses of those nodes
- baud rate

The following sections explain network considerations and describe ways to select parameters for optimum network performance (speed). Refer to your programming software's documentation for more information.

Number of Nodes

The number of nodes on the network directly affects the data transfer time between nodes. Unnecessary nodes (such as a second programming terminal that is not being used) slow the data transfer rate. The maximum number of nodes on the network is 32.

Setting Node Addresses

The best network performance occurs when node addresses are assigned in sequential order. Initiators, such as personal computers, should be assigned the lowest numbered addresses to minimize the time required to initialize the network. The valid range for the MicroLogix controllers is 1 to 31 (controllers cannot be node 0). The default setting is 1. The node address is stored in the controller Communications Status file (CS0:5/0 to CS0:5/7). Configure the node address via *Channel Configuration* using RSLogix 500. Select the *Channel 0* tab. The node address is listed as *Source ID*.

Setting Controller Baud Rate

The best network performance occurs at the highest baud rate, which is 19200. This is the default baud rate for a MicroLogix devices on the DH-485 network. All devices must be at the same baud rate. This rate is stored in the controller Communications Status file (CS0:5/8 to CS0:5/15). Configure the baud rate via *Channel Configuration* using RSLogix 500. Select the *Channel 0* tab.

Setting Maximum Node Address

Once you have an established network set up, and are confident that you will not be adding more devices, you may enhance performance by adjusting the maximum node address of your controllers. It should be set to the highest node address being used.

IMPORTANT	All devices should be set to the same maximum node address.

MicroLogix 1200 and 1500 Remote Packet Support

These controllers can respond and initiate with device's communications (or commands) that do not originate on the local DH-485 network. This is useful in installations where communication is needed between the DH-485 and DH+ networks.

DF1 Full-Duplex Protocol

DF1 Full-Duplex protocol provides a point-to-point connection between two devices. DF1 Full-Duplex protocol combines data transparency (American National Standards Institute ANSI - X3.28-1976 specification subcategory D1) and 2-way simultaneous transmission with embedded responses (subcategory F1).

The MicroLogix controllers support the DF1 Full-Duplex protocol via RS-232 connection to external devices, such as computers, or other controllers that support DF1 Full-Duplex.

DF1 is an open protocol. Refer to *DF1 Protocol and Command Set Reference Manual*, Allen-Bradley publication 1770-6.5.16, for more information.

DF1 Full-Duplex Operation

DF1 Full-Duplex protocol (also referred to as DF1 point-to-point protocol) is useful where RS-232 point-to-point communication is required. This type of protocol supports simultaneous transmissions between two devices in both directions. DF1 protocol controls message flow, detects and signals errors, and retries if errors are detected.

When the system driver is DF1 Full-Duplex, the following parameters can be changed:

DF1 Full-Duplex Configuration Parameters
(All MicroLogix 1200 and MicroLogix 1500 Controllers)

Parameter	Options	Programming Software Default
Channel	MicroLogix 1200 and MicroLogix 1500 1764-LSP: Channel 0 MicroLogix 1500 1764-LRP: Channel 0 or 1	0 (1200 & LSP) 0 or 1 (LRP)
Driver	DF1 Full Duplex	DF1 Full Duplex
Baud Rate	300, 600, 1200, 2400, 4800, 9600, 19.2K, 38.4K	19.2K
Parity	none, even	none
Source ID (Node Address)	0 to 254 decimal	1
Control Line	no handshaking, Full-Duplex modem	no handshaking
Error Detection	CRC, BCC	CRC
Embedded Responses	auto detect, enabled	auto detect
Duplicate Packet (Message) Detect	enabled, disabled	enabled
ACK Timeout (x20 ms)	1 to 65535 counts (20 ms increments)	50 counts
NAK retries	0 to 255	3 retries
ENQ retries	0 to 255	3 retries
Stop Bits	not a setting, always 1	1

DF1 Half-Duplex Protocol

With MicroLogix 1200 FRN 7 and MicroLogix 1500 FRN 8, a DF1 Half-Duplex Master driver has been added to complement the DF1 Half-Duplex Slave driver already available in the MicroLogix 1200 and 1500 controllers.

TIP

DF1 Half-Duplex Master driver can be used with the following controllers:

- MicroLogix 1200, FRN 7 and higher
- MicroLogix 1500, 1764-LSP, FRN 8 and higher
- MicroLogix 1500, 1764-LRP, FRN 8 and higher (Channel 1 only)

DF1 Half-Duplex Protocol

DF1 Half-Duplex protocol provides a multi-drop single master/multiple slave network. In contrast to the DF1 Full-Duplex protocol, communication takes place in one direction at a time. You can use the RS-232 port on the MicroLogix controller as both a Half-Duplex programming port, and a Half-Duplex peer-to-peer messaging port.

MicroLogix 1200 and 1500 controllers support Half-Duplex modems using RTS/CTS hardware handshaking.

DF1 Half-Duplex supports up to 255 devices (addresses 0 to 254, with address 255 reserved for master broadcasts). *Note: When configuring a message instruction, set the target node address to -1 for broadcast messages.*

Broadcast messages are handled as follows:

DF1 Half-Duplex Master Driver Broadcast Messages

A broadcast write command initiated by the DF1 half-duplex master is received and executed by all DF1 half-duplex slaves. A broadcast write command received by the DF1 half-duplex master after polling a DF1 half-duplex slave is received, acknowledged and re-broadcast without being executed by the DF1 half-duplex master. It is treated like any other slave-to-slave command, except that no acknowledgement is expected after re-broadcast.

DF1 Half-Duplex Slave Driver Broadcast Messages

When a broadcast write command is initiated by a DF1 half-duplex slave, it is queued up just like any other MSG command until it receives a poll from the DF1 half-duplex master. After transmitting the broadcast write command, the DF1 half-duplex slave receives an acknowledgement that the DF1 half-duplex master received the packet without error. When the DF1 half-duplex master re-broadcasts the broadcast write command, the initiating DF1 half-duplex slave receives and executes the command along with all of the other slave nodes receiving the broadcast packet. No acknowledgement or reply is returned.

Choosing a Polling Mode for DF1 Half-Duplex Master

A master station can be configured to communicate with slave stations in either Message-based polling mode or Standard polling mode. The pros and cons of each polling mode are described below.

Message-Based Polling Mode

Message-based polling mode is best used in networks when communication with the slave stations is not time critical and where the user needs to be able to limit when and how often the master station communicates with each slave station. It is ***not*** recommended for larger systems that require time critical communication between the master and all the slave stations, or for systems where slave station-initiated messages are going to be used.

With Message-Based polling mode, the only time a master station communicates with a slave station is when a message (MSG) instruction in ladder logic is triggered to that particular slave station's address. This polling mode gives the user complete control (through ladder logic) over when and how often to communicate with each slave station.

If multiple MSG instructions are triggered "simultaneously," they will be executed in order, one at a time, to completion (i.e., the first MSG queued up will be transmitted and completed to done or error before the next queued up MSG is transmitted). Any time a message is triggered to a slave station that cannot respond (for instance, if its modem fails), the message will go through retries and time-outs that will slow down the execution of all the other queued up messages. The minimum time to message to every responding slave station increases linearly with the number of slave stations that cannot respond.

If the Message-based selection is "*allow* slaves to initiate messages," a slave station can initiate a message to the master station *(polled report by exception messaging*) or to another slave station *(slave-to-slave messaging)*. The MSG command packet will remain in that slave station's transmit queue until the master station triggers its own MSG command packet to it (which could be seconds, minutes or hours later, depending on the master's ladder logic).

If the Message-based selection is "*don't allow* slaves to initiate messages," then even if a slave station triggers and queues up a MSG instruction in its ladder logic, the master station will not process it.

Standard Polling Mode

Standard polling mode is *strongly* recommended for larger systems that require time critical communication between the master and all the slave stations, or for any system where slave station-initiated messages are going to be used (this includes slave programming over the network, since this uses the same mechanism that slave-to-slave messaging uses). The Active Node Table "automatically" keeps track of which slaves are (and are not) communicating. Standard polling mode should *not* be used in cases where the user needs to be able to limit when and how often the master station communicates with each slave station.

Standard polling mode causes the master station to continuously send one or more 4-byte poll packets to each slave station address configured by the user in the poll list(s) in round robin fashion – as soon as the end of the polling list is reached, the master station immediately goes back and starts polling slave stations from the top of the polling list over again. This is independent and asynchronous to any MSG instructions that might be triggered in the master station ladder logic. In fact, this polling continues even while the master station is in program mode!

When a MSG instruction is triggered while the master station is in run mode, the master station will transmit the message packet just after it finishes polling the current slave station in the poll list and before it starts polling the next slave station in the poll list (no matter where it currently is in the poll list). If multiple MSG instructions have been triggered "simultaneously," at least four message packets may be sent out between two slave station polls. Each of these messages will have an opportunity to complete when the master polls the slave station that was addressed in the message packet as it comes to it in the poll list.

If each of the transmitted message packets is addressed to a different slave station, the order of completion will be based upon which slave station address comes up next in the poll list, not the order in which the MSG instructions were executed and transmitted.

When a slave station receives a poll packet from the master station, if it has one or more message packets queued up to transmit (either replies to a command received earlier or MSG commands triggered locally in ladder logic), the slave station will transmit the first message packet in the transmit queue.

If the standard mode selection is "*single* message per poll scan," then the master station will then go to the next station in the poll list. If the standard mode selection is "*multiple* messages per poll scan," the master station will continue to poll this slave station until its transmit queue is empty.

The master station "knows" the slave station has no message packets queued up to transmit when the slave station responds to the master poll packet with a 2-byte poll response.

Every time a slave station responds or fails to respond to its poll packet, the master station "automatically" updates its Active Node Table (again, even if it's in program mode). In this list, one bit is assigned to each possible slave station address (0 to 254). If a slave station does not respond when it is polled, its Active Node Table bit is cleared. If it does respond when it is polled, its Active Node Table bit is set. Besides being an excellent online troubleshooting tool, two common uses of the Active Node Table are to report good/bad communication status for all slave stations to an operator interface connected to the master station for monitoring, alarming and logging purposes, and to precondition MSG instructions to each particular slave.

This second use is based on the supposition that if a slave station did not respond the last time it was polled, it may not be able to receive and respond to a MSG instruction now, and so it would most likely process the maximum number of retries and time-outs before completing in error. This slows down both the poll scan and any other messaging going on. Using this technique, the minimum time to message to every responding slave station actually *decreases* as the number of slave stations that can't respond *increases*.

IMPORTANT	In order to remotely monitor and program the slave stations over the half-duplex network while the master station is configured for Standard polling mode, the programming computer DF1 slave driver (typically Rockwell Software RSLinx™) station address must be included in the master station poll list.

About Polled Report-by-Exception

Polled report-by-exception lets a slave station initiate data transfer to its master station, freeing the master station from having to constantly read blocks of data from each slave station to determine if any slave input or data changes have occurred. Instead, through user programming, the slave station monitors its own inputs for a change of state or data, which triggers a block of data to be written to the master station when the master station polls the slave.

About Slave-to-Slave Messaging

If one slave station has a message to send to another, it simply includes the destination slave station's address in the message instruction's destination field in place of the master station's address when responding to a poll. The master station checks the destination station address in every packet header it receives from any slave station. If the address does not match the slave's own station address, the entire message is forwarded back onto the telemetry network to the appropriate slave station, without any further processing.

Addressing Tips

Each station on the network, including the master station, must have a unique address. The address range is 0 to 254, so you can have a maximum of 255 stations on a single telemetry network. Station address 255 is the broadcast address, which you cannot select as a station's individual address.

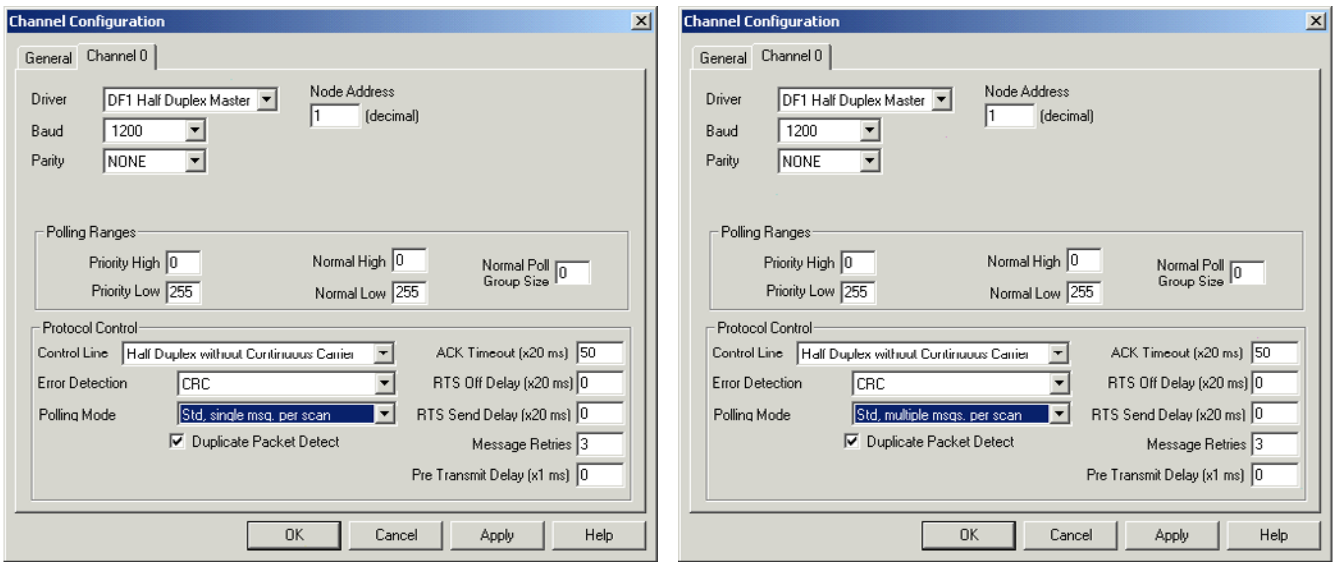
DF1 Half-Duplex Master Standard Polling Mode

With standard polling mode, the master device initiates all communication by polling each slave address configured in the priority and normal polling ranges. The slave device may only transmit message packets when it is polled by the master. Based on a slave's inclusion in the priority and/or normal poll ranges, the master polls each slave on a regular and sequential basis to allow slave devices an opportunity to communicate. During a polling sequence, the master polls a slave either repeatedly until the slave indicates that it has no more message packets to transmit ("standard polling mode, multiple messages per scan") or just one time per polling sequence ("standard polling mode, single message per scan"), depending on how the master is configured.

The polling algorithm polls all of the priority slave addresses each poll scan (priority low to priority high) and a subset of the normal slave address range. The number of normal slave addresses to poll each poll scan is determined by the Normal Poll Group Size configuration parameter. In order to poll all of the slave addresses each poll scan with equal priority, you may define the entire slave address range in either the Priority Poll Range or the Normal Poll Range, and leave the other range disabled. The Polling Range is disabled by defining the low address as 255.

An additional feature of the DF1 Half-Duplex protocol in Standard Polling Mode operation is that it is possible for a slave device to enable a MSG instruction in its ladder program to send or request data to/from the master or another slave. When the initiating slave is polled, the message command is sent to the master. If the message is addressed to the master, then the master replies to the message. If the master recognizes that the message is not intended for it, but for another slave, the master immediately re-broadcasts the message so that it can be received by the intended slave. This slave-to-slave transfer is a built-in function of the master device and can also be used by programming software to upload and download programs to processors on the DF1 Half-Duplex link.

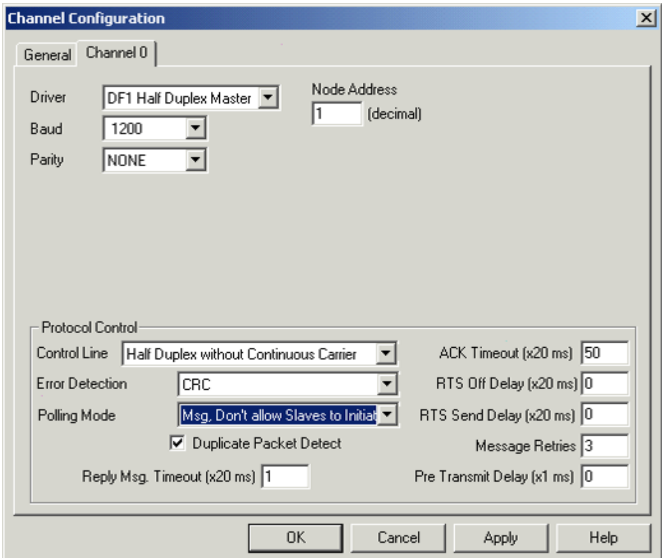
Standard Mode Channel Configuration

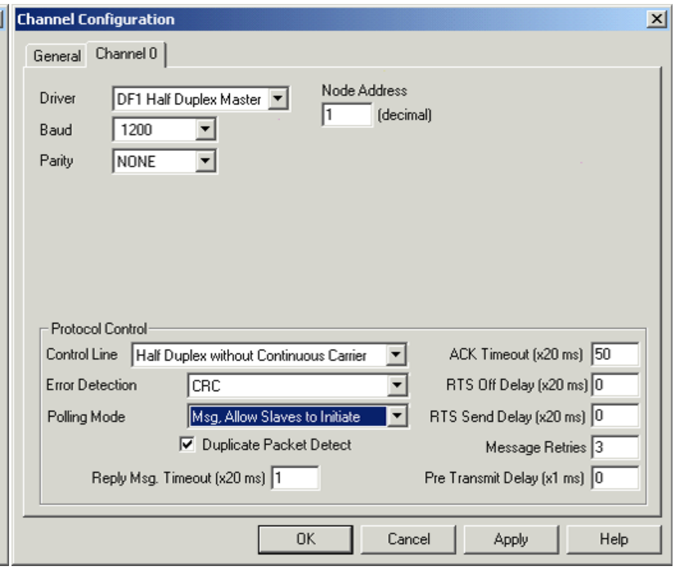


DF1 Half-Duplex Master MSG-based Polling Mode Operation

With MSG-based Polling Mode, the master device only initiates communication with a slave when a MSG instruction to that slave is triggered in ladder logic. Once the read or write command has been transmitted, the master waits the Reply MSG Timeout period and then polls that slave for a reply to its command. The master can be configured either to ignore (“MSG-based Polling, don’t allow slaves to initiate”) or to accept (“MSG-based Polling, allow slaves to initiate”) MSGs that may have been triggered and queued up in the slave.

Message-Based Polling Mode Channel Configuration





When the system driver is DF1 Half-Duplex Master, the following parameters can be changed:

DF1 Half-Duplex Master Configuration Parameters
(MicroLogix 1200, FRN 7 and higher
MicroLogix 1500, 1764-LSP, FRN 8 and higher
MicroLogix 1500, 1764-LRP, FRN 8 and higher [Channel 1 only])

Parameter	Options	Programming Software Default
Channel	MicroLogix 1200 and MicroLogix 1500 1764-LSP: Channel 0 MicroLogix 1500 1764-LRP: Channel 1 only	0 (1200 & LSP) 1 (LRP)
Driver	DF1 Half Duplex Master	
Baud Rate	300, 600, 1200, 2400, 4800, 9600, 19.2K, 38.4K	19.2K
Parity	none, even	none
Node Address	0 to 254 decimal (255 is reserved for broadcast)	1
Control Line	No Handshaking, Half-Duplex Modem (RTS/CTS Handshaking), Full-Duplex Modem (RTS on)	No Handshaking
Error Detection	CRC, BCC	CRC
Duplicate Packet Detect	enabled, disabled Detects and eliminates duplicate responses to a message. Duplicate packets may be sent under noisy communication conditions if the sender's Message Retries are set greater than 0.	enabled

DF1 Half-Duplex Master Configuration Parameters
(MicroLogix 1200, FRN 7 and higher
MicroLogix 1500, 1764-LSP, FRN 8 and higher
MicroLogix 1500, 1764-LRP, FRN 8 and higher [Channel 1 only])

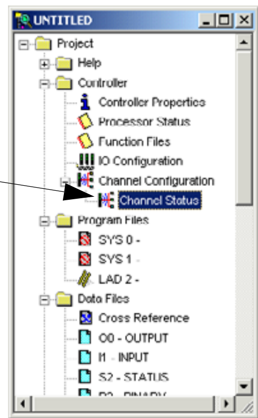
Parameter	Options	Programming Software Default
RTS Off Delay (x20 ms)	0 to 65535 (can be set in 20 ms increments) – only with control line set to "Half Duplex Modem (RTS/CTS Handshaking)" Specifies the delay time between when the last serial character is sent to the modem and when RTS is deactivated. Gives the modem extra time to transmit the last character of a packet.	0
RTS Send Delay (x20 ms)	0 to 65535 (can be set in 20 ms increments) – only with control line set to "Half Duplex Modem (RTS/CTS Handshaking)" Specifies the time delay between setting RTS until checking for the CTS response. For use with modems that are not ready to respond with CTS immediately upon receipt of RTS.	0
Message Retries	0 to 255 Specifies the number of times the master device attempts to re-send a message packet when it does not receive an ACK from the slave device. For use in noisy environments where acknowledgements may become corrupted in transmission.	3
Pre Transmit Delay (x1 ms)	0 to 65535 (can be set in 1 ms increments) When the Control Line is set to "No Handshaking", this is the delay time before transmission. Required for 1761-NET-AIC physical Half-Duplex networks. The 1761-NET-AIC needs 2 ms of delay time to change from transmit to receive mode. When the Control Line is set to "Half-Duplex Modem (RTS/CTS Handshaking)", this is the minimum time delay between receiving the last character of a packet and the next RTS assertion.	0
ACK Timeout (x20 ms)	0 to 255 (can be set in 20 ms increments) Specifies the amount of time the master will wait for an acknowledgement to a message it has transmitted before it retries the message or errors out the message instruction. This timeout value is also used for the poll response timeout.	50
Reply MSG Timeout (x 20 ms)	0 to 255 (can be set in 20 ms increments) – only with MSG-based Polling Modes Specifies the amount of time the master will wait after receiving an ACK to a master-initiated MSG before polling the slave station for its reply.	1
Priority Polling Range – High	Select the last slave station address to priority poll – only with Standard Polling Modes.	0
Priority Polling Range – Low	Select the first slave station address to priority poll. Entering 255 disables priority polling – only with Standard Polling Modes.	255
Normal Polling Range – High	Select the last slave station address to normal poll – only with Standard Polling Modes.	0
Normal Polling Range – Low	Select the first slave station address to normal poll. Entering 255 disables normal polling – only with Standard Polling Modes.	255
Normal Poll Group Size	Enter the quantity of active stations located in the normal poll range that you want polled during a scan through the normal poll range before returning to the priority poll range. If no stations are configured in the Priority Polling Range, leave this parameter at 0.	0

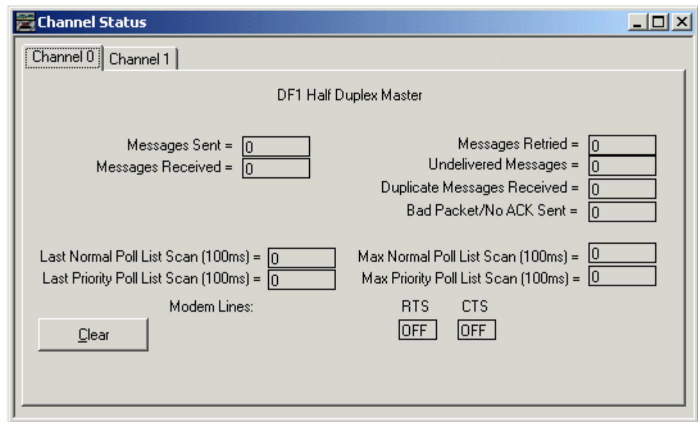
DF1 Half-Duplex Master Channel Status

Channel Status data is stored in the Communication Status Function File.

Viewing Channel Status Data for DF1 Half-Duplex Master

Double-click on the Channel Status Icon Located beneath the Configuration icon to bring up the Channel Status screen.





Communication Status Function DF1 Half-Duplex Master Channel Status

Status Field	Status File Location[1]	Definition
Messages Sent	CSx:10	The total number of DF1 messages sent by the processor (including message retries)
Messages Received	CSx:11	The number of messages received with no errors
Polls Sent	CSx:15	The number of poll packets sent by the processor
Lack of Memory	CSx:17	The number of times the processor could not receive a message because it did not have available memory
Last Normal Poll List Scan	CSx:19	Time in 100 ms increments of last scan through Normal Poll List
Last Priority Poll List Scan	CSx:21	Time in 100 ms increments of last scan through Priority Poll List
Message Retry	CSx:13	The number of message retries sent by the processor
Undelivered Messages	CSx:12	The number of messages that were sent by the processor but not acknowledged by the destination device
Duplicate Messages Received	CSx:18	The number of times the processor received a message packet identical to the previous message packet
Bad Packets Received	CSx:16	The number of incorrect data packets received by the processor for which no ACK was returned
Max Normal Poll List Scan	CSx:20	Maximum time in 100 ms increments to scan the Normal Poll List
Max Priority Poll List Scan	CSx:22	Maximum time in 100 ms increments to scan the Priority Poll List

Communication Status Function DF1 Half-Duplex Master Channel Status

Status Field	Status File Location(1)	Definition
RTS (Request to Send)	CSx:9/1	The status of the RTS handshaking line (asserted by the processor)
CTS (Clear to Send)	CSx:9/0	The status of the CTS handshaking line (received by the processor)
DCD (Data Carrier Detect)	CSx:9/3	*Channel 1 of 1764-LRP only:* The status of the DCD handshaking line (received by the processor)

(1) x equals the Channel number.

Monitor Active Stations

To see which slave stations are active when the channel is configured for Standard Polling Mode (either single or multiple message per scan), view the DF1 Half-Duplex Master Active Node Table. The table is stored in the Communications Status Function File, words CSx:27 to CSx:42, where x is the channel number (x = 0 for MicroLogix 1200 and MicroLogix 1500 1764-LSP; x = 1 for MicroLogix 1500 1764-LRP). Each bit in the table represents a station on the link, from 0 to 254, starting with CSx:27/0 for address 0 and CSx:42/14 for address 254. The bit for address 255 (CSx:42/15) is never set, since it is the broadcast address, which never gets polled.

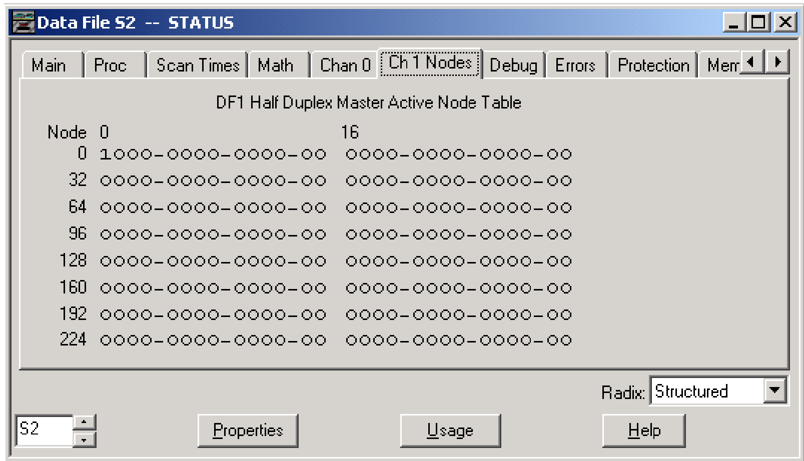
When valid Normal and/or Priority Poll Ranges are defined:

- if a slave responded the last time it was polled by the master, the bit corresponding to its address is set (1 = active).
- if a slave didn't respond the last time it was polled by the master, the bit corresponding to its address is cleared (0 = inactive).

TIP The bit corresponding to the address configured for the DF1 Master is always cleared because the master address never gets polled.

If you are using RSLogix 500 version 6.10.10 or higher, you can view the active node table by clicking on "Processor Status" and then selecting the tab for the DF1 Master channel.

Example Active Node Table



At power-up or after reconfiguration, the master station assumes that all slave stations are inactive. A station is shown active only after it responds to a poll packet.

DF1 Half-Duplex Slave Configuration

When the system driver is DF1 Half-Duplex Slave, the following parameters can be changed:

DF1 Half-Duplex Slave Configuration Parameters
(All MicroLogix 1200 and MicroLogix 1500 Controllers)

Parameter	Options	Programming Software Default
Channel	MicroLogix 1200 and MicroLogix 1500 1764-LSP: Channel 0 MicroLogix 1500 1764-LRP: Channel 0 or 1	0 (1200 & LSP) 0 or 1 (LRP)
Driver	DF1 Half Duplex Slave	
Baud Rate	300, 600, 1200, 2400, 4800, 9600, 19.2K, 38.4K	19.2K
Parity	none, even	none
Node Address	0 to 254 decimal (255 is reserved for broadcast)	1
Control Line	No Handshaking, Half-Duplex Modem	No Handshaking
Error Detection	CRC, BCC	CRC
EOT Suppression	enabled, disabled When EOT Suppression is enabled, the slave does not respond when polled if no message is queued. This saves modem transmission power when there is no message to transmit.	disabled

DF1 Half-Duplex Slave Configuration Parameters
(All MicroLogix 1200 and MicroLogix 1500 Controllers)

Parameter	Options	Programming Software Default
Duplicate Packet (Message) Detect	enabled, disabled Detects and eliminates duplicate responses to a message. Duplicate packets may be sent under noisy communication conditions if the sender's Message Retries are set greater than 0.	enabled
Poll Timeout (x20 ms)	0 to 65535 (can be set in 20 ms increments) Poll timeout only applies when a slave device initiates a MSG instruction. It is the amount of time that the slave device waits for a poll from the master device. If the slave device does not receive a poll within the Poll Timeout, a MSG instruction error is generated, and the ladder program needs to re-queue the MSG instruction. If you are using a MSG instruction, it is recommended that a Poll Timeout value of zero is not used. Poll Timeout is disabled when set to zero.	3000
RTS Off Delay (x20 ms)	0 to 65535 (can be set in 20 ms increments) – only with control line set to "Half Duplex Modem (RTS/CTS Handshaking)" Specifies the delay time between when the last serial character is sent to the modem and when RTS is deactivated. Gives the modem extra time to transmit the last character of a packet.	0
RTS Send Delay (x20 ms)	0 to 65535 (can be set in 20 ms increments) – only with control line set to "Half Duplex Modem (RTS/CTS Handshaking)" Specifies the time delay between setting RTS until checking for the CTS response. For use with modems that are not ready to respond with CTS immediately upon receipt of RTS.	0
Message Retries	0 to 255 Specifies the number of times the master device attempts to re-send a message packet when it does not receive an ACK from the slave device. For use in noisy environments where acknowledgements may become corrupted in transmission.	3
Pre Transmit Delay (x1 ms)	0 to 65535 (can be set in 1 ms increments) When the Control Line is set to "No Handshaking", this is the delay time before transmission. Required for 1761-NET-AIC physical Half-Duplex networks. The 1761-NET-AIC needs 2 ms of delay time to change from transmit to receive mode. When the Control Line is set to "Half-Duplex Modem (RTS/CTS Handshaking)", this is the minimum time delay between receiving the last character of a packet and the next RTS assertion.	0

DF1 Radio Modem Protocol

TIP DF1 Radio Modem driver can be used with the following controllers:

- MicroLogix 1200, FRN 7 and higher
- MicroLogix 1500, 1764-LSP, FRN 8 and higher
- MicroLogix 1500, 1764-LRP, FRN 8 and higher (Channel 1 only)

This driver implements a protocol, optimized for use with radio modem networks, that is a hybrid between DF1 Full-Duplex and DF1 Half-Duplex protocols and is not compatible with either protocol.

The primary advantage of using DF1 Radio Modem protocol for radio modem networks is in transmission efficiency. Each read/write transaction (command and reply) requires only one transmission by the initiator (to send the command) and one transmission by the responder (to return the reply). This minimizes the number of times the radios need to “key-up” to transmit, which maximizes radio life and minimizes radio power consumption. It also maximizes communication throughput. In contrast, DF1 Half-Duplex protocol requires five transmissions for the DF1 Master to complete a read/write transaction with a DF1 Slave – three by the master and two by the slave.

IMPORTANT The DF1 Radio Modem driver should only be used among devices that support and are configured for the DF1 Radio Modem protocol. As of the release of this firmware, no other devices besides the MicroLogix 1200 with FRN7, the MicroLogix 1500 with FRN8 and SLC 5/03, SLC 5/04, and SLC 5/05 processors with Series C FRN6 or higher support DF1 Radio Modem protocol.

Like DF1 Full-Duplex protocol, DF1 Radio Modem allows any node to initiate to any other node at any time (if the radio modem network supports full-duplex data port buffering and radio transmission collision avoidance). Like DF1 Half-Duplex protocol, up to 255 devices are supported, with unique addresses from 0 to 254. A node ignores any packets received that have a destination address other than its own, with the exception of broadcast packets. A broadcast write command initiated by any DF1 radio modem node is executed by all of the other DF1 radio modem nodes that receive it. No acknowledgement or reply is returned.

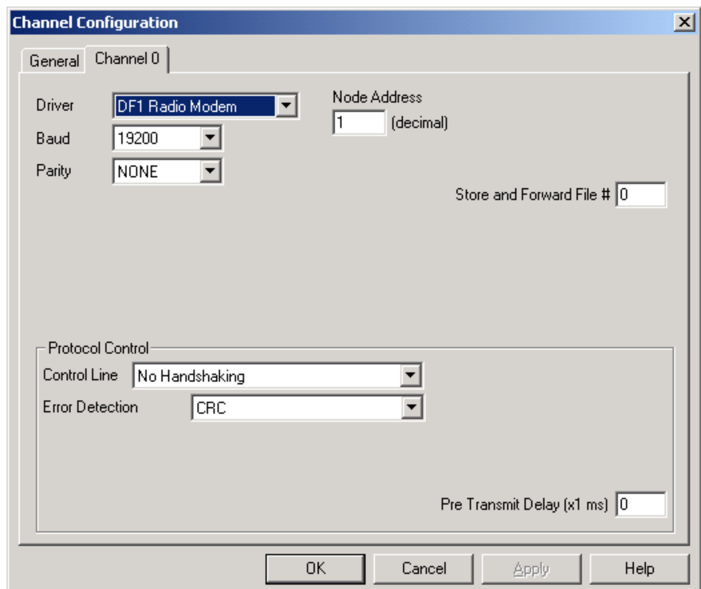
Unlike either DF1 Full-Duplex or DF1 Half-Duplex protocols, DF1 Radio Modem protocol does not include ACKs, NAKs, ENQs, or poll packets. Data integrity is ensured by the CRC checksum.

Using the DF1 Radio Modem

Using RSLogix 500 version 6.10.10 or higher, the DF1 Radio Modem driver can be configured as the system mode driver for Channel 0 in MicroLogix 1200 (FRN 7 or higher) and MicroLogix 1500 1764-LSP (FRN 8 or higher) and for Channel 1 in MicroLogix 1500 1764-LRP (FRN 8 or higher).

Channel configuration appears as follows. Figure shows Channel 0 configuration, and Figure shows Channel 1 configuration options.

DF1 Radio Modem Channel 0 Configuration (MicroLogix 1200 and MicroLogix 1500, 1764-LSP



When the system driver is DF1 Radio Modem, the following parameters can be changed for Channel 0.

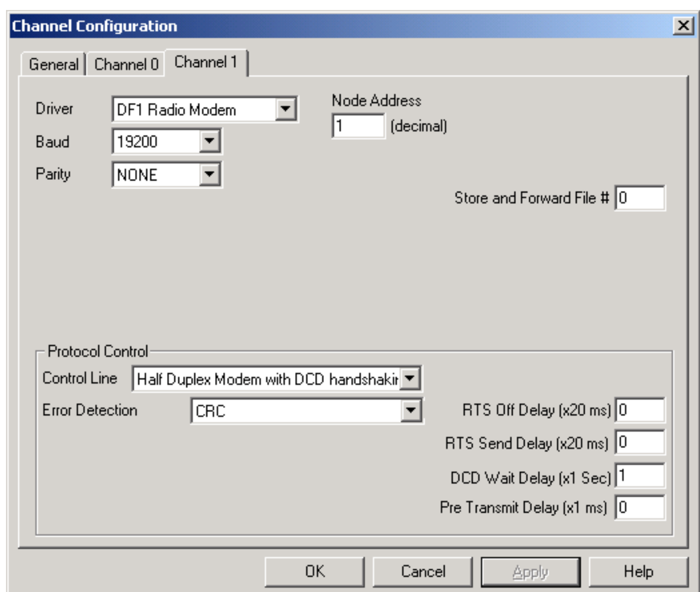
DF1 Radio Modem Channel 0 Configuration Parameters
(MicroLogix 1200 FRN 7 and higher, and MicroLogix 1500 1764-LSP FRN 8 and higher)

Parameter	Options	Programming Software Default
Channel	MicroLogix 1200 and MicroLogix 1500 1764-LSP: Channel 0	0
Driver	DF1 Radio Modem	
Baud Rate	300, 600, 1200, 2400, 4800, 9600, 19.2K, 38.4K	19.2K
Parity	none, even	none
Node Address	0 to 254 decimal (255 is reserved for broadcast)	1

DF1 Radio Modem Channel 0 Configuration Parameters
(MicroLogix 1200 FRN 7 and higher, and MicroLogix 1500 1764-LSP FRN 8 and higher)

Parameter	Options	Programming Software Default
Store and Forward File Number	Store and Forward allows messages between two out-of-radio-range nodes to be routed through one or more in-radio-range nodes. This is the data table file number used for the Store & Forward Table.	0
Control Line	No Handshaking, Half-Duplex Modem (RTS/CTS Handshaking)	No Handshaking
Error Detection	CRC, BCC	CRC
Pre Transmit Delay (x1 ms)	0 to 65535 (can be set in 1 ms increments) When the Control Line is set to “No Handshaking”, this is the delay time before transmission. Required for 1761-NET-AIC physical Half-Duplex networks. The 1761-NET-AIC needs 2 ms of delay time to change from transmit to receive mode. When the Control Line is set to “Half-Duplex Modem (RTS/CTS Handshaking)”, this is the minimum time delay between receiving the last character of a packet and the next RTS assertion.	1

DF1 Radio Modem Channel 1 Configuration (MicroLogix 1500, 1764-LRP



When the system driver is DF1 Radio Modem, the following parameters can be changed for Channel 1.

DF1 Radio Modem Channel 1 Configuration Parameters
(MicroLogix 1500 1764-LRP FRN 8 and higher)

Parameter	Options	Programming Software Default
Channel	MicroLogix 1500 1764-LRP: Channel 1 only	1
Driver	DF1 Radio Modem	
Baud Rate	300, 600, 1200, 2400, 4800, 9600, 19.2K, 38.4K	19.2K
Parity	none, even	none
Node Address	0 to 254 decimal (255 is reserved for broadcast)	1
Store and Forward File Number	Store and Forward allows messages between two out-of-radio-range nodes to be routed through one or more in-radio-range nodes. This is the starting address for the Store & Forward Table.	0
Control Line	No Handshaking, Half Duplex Modem (RTS/CTS) Handshaking, Half Duplex Modem with DCD Handshaking	No Handshaking
Error Detection	CRC, BCC	CRC
RTS Off Delay (x20 ms)	0 to 65535 (can be set in 20 ms increments) – only with control line set to "Half Duplex Modem (RTS/CTS Handshaking)" Specifies the delay time between when the last serial character is sent to the modem and when RTS is deactivated. Gives the modem extra time to transmit the last character of a packet.	0
RTS Send Delay (x20 ms)	0 to 65535 (can be set in 20 ms increments) – only with control line set to "Half Duplex Modem (RTS/CTS Handshaking)" Specifies the time delay between setting RTS until checking for the CTS response. For use with modems that are not ready to respond with CTS immediately upon receipt of RTS.	0
DCD Wait Delay	0 to 255 Specifies the number of times the master device attempts to re-send a message packet when it does not receive an ACK from the slave device. For use in noisy environments where acknowledgements may become corrupted in transmission.	1
Pre Transmit Delay (x1 ms)	0 to 65535 (can be set in 1 ms increments) When the Control Line is set to "No Handshaking", this is the delay time before transmission. Required for 1761-NET-AIC physical Half-Duplex networks. The 1761-NET-AIC needs 2 ms of delay time to change from transmit to receive mode. When the Control Line is set to "Half-Duplex Modem (RTS/CTS Handshaking)", this is the minimum time delay between receiving the last character of a packet and the next RTS assertion.	0

With RSLogix 500 version 6.10.10 and higher, the MicroLogix 1500 1764-LRP offers a "Half-Duplex Modem with DCD Handshaking" Control Line selection. This allows messaging to occur in a Report-by-Exception mode with radio modems using hardware handshaking, based on the status of the DCD. Transmission can only occur when DCD is low, indicating that no other nodes are currently transmitting. Received characters are considered valid while DCD is high.

A DCD Wait Timeout parameter configures the length of time, after triggering a MSG, that the DCD must go low in order for a message to be transmitted. Otherwise, the MSG will error out with a 09 error code.

The DF1 Radio Modem driver can be used in a “pseudo” Master/Slave mode with any radio modems, as long as the designated “Master” node is the only node initiating MSG instructions, and as long as only one MSG instruction is triggered at a time.

For modern serial radio modems that support full-duplex data port buffering and radio transmission collision avoidance, the DF1 Radio Modem driver can be used to set up a “Masterless” peer-to-peer radio network, where any node can initiate communications to any other node at any time, as long as all of the nodes are within radio range so that they receive each other’s transmissions.

Using Store & Forward Capability

DF1 Radio Modem also supports Store & Forward capability in order to forward packets between nodes that are outside of radio range of each other. Each node that is enabled for Store & Forward has a user-configured Store & Forward Table to indicate which received packets it should re-broadcast, based on the packet’s source and destination addresses.

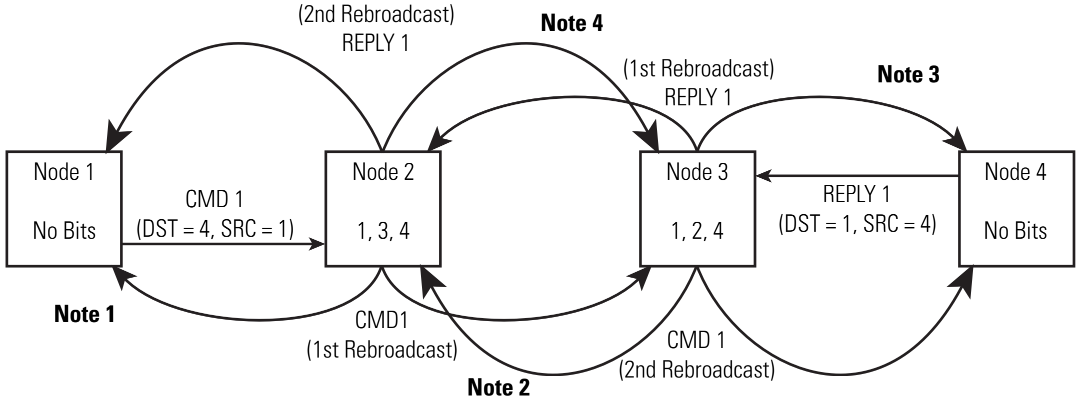
IMPORTANT	RSLogix 500 version 6.10.10 allows you to configure the MicroLogix DF1 Radio Modem driver, but does not allow you to configure the Store & Forward Table file. In order to use the Store & Forward capability with RSLogix version 6.10.10, you must download a pre-configured default ladder file for your particular processor from the MicroLogix web site (**www.ab.com/micrologix**), which has a binary file (B3:0-15) pre-configured for the DF1 Radio Modem Store & Forward Table file.

Configuring the Store & Forward Table

The Store & Forward Table can be configured to use any valid binary data table file (B3, B9 through B255) of length 16 words. Each bit in the file corresponds to a DF1 Radio Modem node address. In order to configure a MicroLogix to Store & Forward message packets between two other nodes, the bits corresponding to the addresses of those two other nodes must be set. For instance, if node 2 is used to Store & Forward message packets between nodes 1 and 3, then both bits Bx/1 and Bx/3 (where x is the configured data table file number) would have to be set in the Store & Forward Table file (see Figure). You can set bit 255 to enable Store & Forward of broadcast packets, as well.

IMPORTANT	Once Store & Forward is enabled, duplicate packet detection is also automatically enabled. Whenever Store & Forward is used within a radio modem network, every node should have a Store & Forward Table file configured, even if all of the bits in the file are cleared, so that duplicate packets will be ignored.

Applying DF1 Radio Modem Protocol



Note 1 – The link layer of Node 1 blocks the re-transmission of a packet that is received with the SRC byte equal to the receiving node's station address. Packets received that originate from the receiving node should never be re-transmitted.

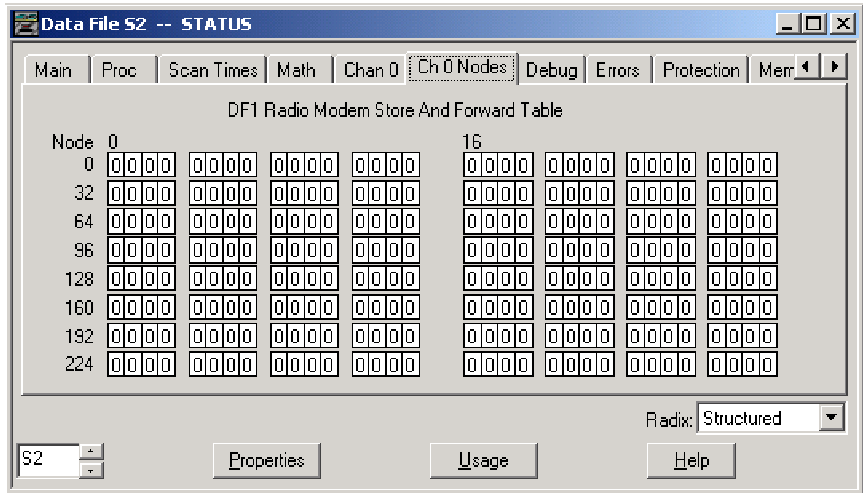
Note 2 – To prevent Node 2 from re-transmitting a duplicate packet, the link layer of Node 2 updates the duplicate packet table with the last 20 packets received.

Note 3 – The link layer of Node 4 blocks the re-transmission of a packet that is received with the SRC byte equal to the receiving node's station address. Packets received that originate from the receiving node should never be re-transmitted.

Note 4 – To prevent Node 3 from re-transmitting a duplicate packet, the link layer of Node 3 updates the duplicate packet table with the last 20 packets received.

If you are using RSLogix 500 version 6.10.10 or higher, you can view the store & forward table by clicking on “Processor Status” and then selecting the tab for the DF1 Master channel.

Example Store & Forward Table

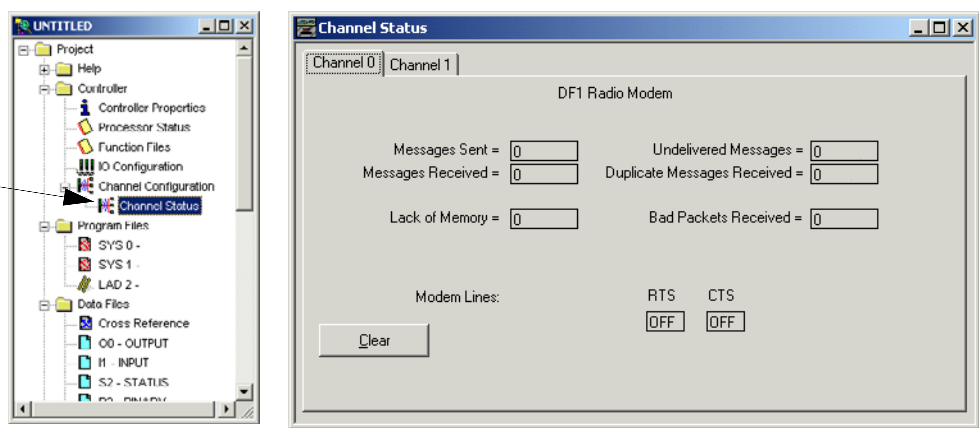


DF1 Radio Modem Channel Status

Channel Status data is stored in the Communication Status Function File.

Viewing Channel Status for DF1 Radio Modem

Double-click on the Channel Status Icon Located beneath the Configuration icon to bring up the Channel Status screen.



Communication Status Function DF1 Radio Modem Channel Status

Status Field	Diagnostic File Location(1)	Definition
Messages Sent	CSx:10	The total number of DF1 messages sent by the processor (including message retries)
Messages Received	CSx:11	The number of messages received with no errors
Lack of Memory	CSx:17	The number of times the processor could not receive a message because it did not have available memory

Communication Status Function DF1 Radio Modem Channel Status

Status Field	Diagnostic File Location(1)	Definition
Undelivered Messages	CSx:12	The number of messages that could not be sent by the processor due to bad modem handshake signals
Duplicate Messages Received	CSx:18	The number of times the processor received a message packet identical to the previous message packet
Bad Packet Received	CSx:16	The number of data packets received by the processor that had bad checksum or were truncated
RTS (Request to Send)	CSx:9/1	The status of the RTS handshaking line (asserted by the processor)
CTS (Clear to Send)	CSx:9/0	The status of the CTS handshaking line (received by the processor)
DCD (Data Carrier Detect)	CSx:9/3	*1764-LRP only:* The status of the DCD handshaking line (received by the processor)

(1) x equals Channel number

DF1 Radio Modem System Limitations

The following questions need to be answered in order to determine if you can implement the new DF1 Radio Modem driver in your radio modem network:

1. Are all of the devices MicroLogix 1200 or 1500 controllers, or SLC 5/03, 5/04 or 5/05 processors?

   In order to be configured with the DF1 Radio Modem driver, using RSLogix 6.0 or higher, MicroLogix 1200 controllers must be at FRN 7 or higher and MicroLogix 1500 controllers must be at FRN 8 or higher.

   SLC 5/03, 5/04 or 5/05 processors must all be at FRN C/6 or higher in order to be configured with the DF1 Radio Modem driver using RSLogix 500 version 5.50 or higher.

2. Does each node receive the radio transmissions of every other node, being both within radio transmission/reception range and on a common receiving frequency (either via a "Simplex" radio mode or via a single, common, full-duplex repeater)?

   If so, then go to question #3 to see if you can use the DF1 Radio Modem driver to set up a peer-to-peer radio network. If not, then you may still be able to use the DF1 Radio Modem driver, by configuring intermediary nodes as Store & Forward nodes.

3. Do the radio modems handle full-duplex data port buffering and radio transmission collision avoidance?

   If so, and the answer to #2 is yes as well, then you can take full advantage of the peer-to-peer message initiation capability in every node (i.e., the ladder logic in any node can trigger a MSG instruction to any other node at any time). If not, then you may still be able to use the DF1 Radio Modem driver, but only if you limit MSG instruction initiation to a single "master" node whose transmission can be received by every other node.

4. Can I take advantage of the SLC 5/03, 5/04 and 5/05 channel-to-channel passthru to remotely program the other SLC nodes using RSLinx and RSLogix 500 running on a PC connected to a local SLC processor via DH+ or Ethernet?

   Yes, with certain limitations imposed based on the radio modem network. Refer to the *SLC™ 500 Instruction Set Reference Manual,* publication number 1747-RM001, for more passthru details and limitations when using the DF1 Radio Modem driver.

Modbus RTU Protocol

This section shows the configuration parameters for Modbus RTU (*Remote Terminal Unit* transmission mode) protocol. For more information about the Modbus RTU protocol, see the Modbus Protocol Specification (available from http://www.modbus.org).

The driver can be configured as Modbus RTU Master or Modbus RTU Slave. The Modbus RTU Slave driver maps the four Modbus data types—coils, contacts, input registers, and holding registers—into four binary and/or integer data table files created by the user.

Modbus RTU Master

TIP Modbus RTU Master driver can be used with the following controllers:

- MicroLogix 1200, FRN 8 and higher
- MicroLogix 1500, FRN 9 and higher

Message instructions are used to transfer information between the data files in the Modbus RTU Master and the Modbus RTU Slaves. Refer to Chapter 21 for detailed information about configuring a MSG instruction for Modbus Communications.

Modbus addressing is limited to 16 bits per memory group, each with a range of 1 to 65,536. There are four memory groups, one for each function:

- coils (generally addressed as **0**xxxx)
- contacts (**1**xxxx)
- input registers (**3**xxxx)
- holding registers (**4**xxxx)

Coils and contacts are addressed at the bit level. Coils are like outputs and can be read and written to. Contacts are like inputs and are read-only. Input registers and holding registers are addressed at the word level. Input registers are generally used for internally storing input values. They are read-only. Holding registers are general purpose and can be both read and written to.

The most significant digit of the address is considered a prefix, and does not get entered into the Modbus Data Address field when configuring the message instruction.

When the message is sent, the address is decremented by 1 and converted into a 4-character hex number to be transmitted via the network (with a range of 0-FFFFh); the slave increments the address by 1, and selects the appropriate memory group based on the Modbus function.

TIP

Modbus protocol may not be consistently implemented in the field. The Modbus specification calls for the addressing range to start at 1; however, some devices start addressing at 0.

The Modbus Data Address in the Message Setup Screen may need to be incremented by one to properly access a Modbus slave's memory, depending on that slave's implementation of memory addressing.

Modbus RTU Slave

TIP

Modbus RTU Slave driver can be used with the following controllers:

- All MicroLogix 1200 controllers
- MicroLogix 1500 1764-LSP Series B and higher
- All MicroLogix 1500 1764-LRP

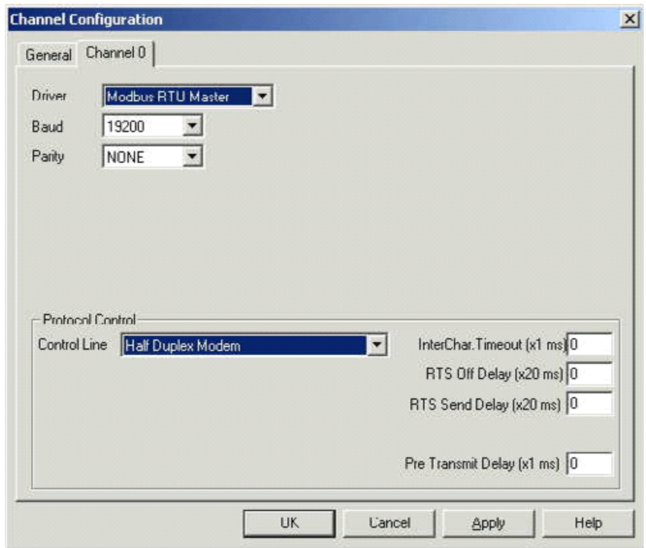
The coil and contact files can contain up to 4096 coils or contacts in each register when the data table file is configured for a maximum size of 256 words. Each input register and holding register file can contain up to 256 registers when the data table file is configured for a maximum size of 256 words. With the "Expanded" box checked, the controllers can be specifically configured to use up to six 256-word data table files for a total of 1536 Modbus Holding registers.

TIP

A request to access a group of holding registers that span across two files is permitted. Note that the maximum number of registers in a command does not allow for more than two files to be accessed during a single Modbus command.

Modbus RTU Master Configuration

Select the Modbus RTU Master from the Channel Configuration menu as shown below.



The Baud defaults to 19200.

The Control Line can be configured as:

- No Handshaking
- Full-Duplex Modem (RTS on)
- Half-Duplex Modem (RTS/CTS handshaking).

The Protocol Control defaults are:

- No Handshaking
- InterChar. Timeout = 0
- Pre Transmit Delay = 0.

When the system driver is Modbus RTU Master, the following communication port parameters can be changed:

Modbus RTU Master Communications Configuration Parameters
(MicroLogix 1200 FRN 8 and higher, MicroLogix 1500 FRN 9 and higher)

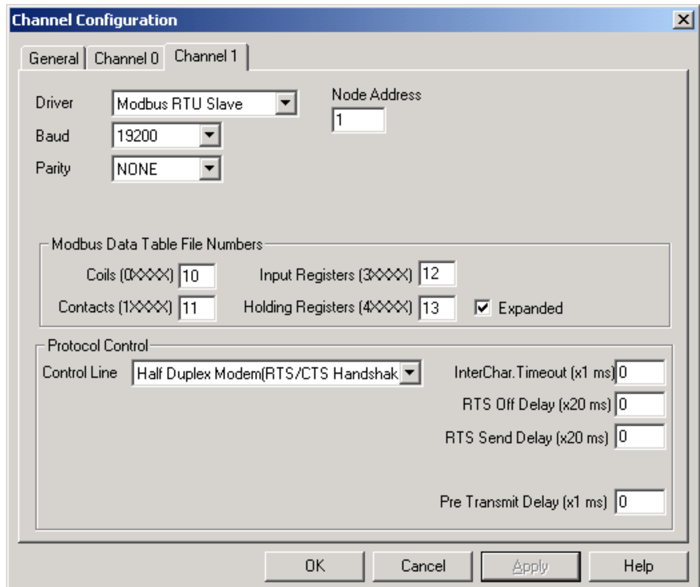
Parameter	Options	Programming Software Default
Channel	MicroLogix 1200 FRN 8 and higher: Channel 0 MicroLogix 1500 FRN 9 and higher: Channel 0 or 1	0 (1200 & LSP) 0 or 1 (LRP)
Driver	Modbus RTU Master	
Baud Rate	300, 600, 1200, 2400, 4800, 9600, 19.2K, 38.4K	19.2K

Modbus RTU Master Communications Configuration Parameters
(MicroLogix 1200 FRN 8 and higher, MicroLogix 1500 FRN 9 and higher)

Parameter	Options	Programming Software Default
Parity	none, even, odd	none
Control Line	No Handshaking, Full-Duplex Modem (RTS on), Half-Duplex Modem (RTS/CTS handshaking)	No Handshaking
Inter-character Timeout (x1 ms)	0 to 65535 (can be set in 1 ms increments); 0 = 3.5 character times Specifies the minimum delay between characters that indicates the end of a message packet.	0
RTS Off Delay (x20 ms)	0 to 65535 (can be set in 20 ms increments) Specifies the delay time between when the last serial character is sent to the modem and when RTS is deactivated. Gives the modem extra time to transmit the last character of a packet.	0
RTS Send Delay (x20 ms)	0 to 65535 (can be set in 20 ms increments) Specifies the time delay between setting RTS until checking for the CTS response. For use with modems that are not ready to respond with CTS immediately upon receipt of RTS.	0
Pre Transmit Delay (x1 ms)	0 to 65535 (can be set in 1 ms increments) When the Control Line is set to *No Handshaking*, this is the delay time before transmission. Required for 1761-NET-AIC physical Half-Duplex networks. The 1761-NET-AIC needs 2 ms of delay time to change from receive to transmit mode. When the Control Line is set to *Half-Duplex Modem or Full-Duplex Modem*, this is the minimum time delay between receiving the last character of a packet and the RTS assertion.	0

Modbus RTU Slave Configuration

The Modbus configuration screen and configuration procedure are shown below:



1. To set up Channel 0 and data files for Modbus communication, select the Channel 0 Configuration tab. *For the 1764-LRP only, you can select either Channel 0 or Channel 1.*

2. Choose “Modbus RTU Slave” driver and assign driver characteristics.

3. Enter Modbus Data Table File Numbers. Select the Expansion check box to utilize multiple holding register data files. *(MicroLogix 1200 Series C FRN6 and higher, and MicroLogix 1500 Series C FRN7 and higher only. Requires RSLogix 500 version 5.50 or higher to program.)*

TIP

The controller default is one data file of 256 registers. The Expansion check box enables an additional five files and 1280 holding registers.

The five additional tables do not need to be individually defined, but sequentially follow the first integer or bit file. For example, if the first file is N10 (or B10), then the additional five files will be N11 (or B11), N12 (or B12), N13 (or B13), N14 (or B14), and N15 (or B15).

4. Enter the data table size and type for each required file. The data table file(s) (not including the five additional tables if Expanded is checked) will be created automatically.

When the system driver is Modbus RTU Slave, the following communication port parameters can be changed:

Modbus RTU Slave Communications Configuration Parameters
(MicroLogix 1200 Controllers and MicroLogix 1500 Series B and higher Processors only)

Parameter	Options	Programming Software Default
Channel	MicroLogix 1200: Channel 0 MicroLogix 1500 1764-LSP Series B and higher: Channel 0 and 1 MicroLogix 1500 1764-LRP: Channel 0 and 1	0 (1200 & LSP) 1 (LRP)
Driver	Modbus RTU Slave	
Baud Rate	300, 600, 1200, 2400, 4800, 9600, 19.2K, 38.4K	19.2K
Parity	none, even, odd	none
Node Address	1 to 247 decimal	1
Control Line	No Handshaking, Half-Duplex Modem (RTS/CTS Handshaking)	No Handshaking
Inter-character Timeout (x1 ms)	0 to 6553 (can be set in 1 ms increments); 0 = 3.5 character times Specifies the minimum delay between characters that indicates the end of a message packet.	0
Modbus Data Table File Number Assignment (Must be Binary or Integer file type)	Coils (Discrete outputs, Modbus addresses 0001 to 4096) range = 3 to 255, 0 = no file	0
	Contacts (Discrete inputs, Modbus addresses 10001 to 14096) range = 3 to 255, 0 = no file	0
	Input Registers (Read Only, Modbus addresses 30001 to 30256) range = 3 to 255, 0 = no file	0
	Holding Registers (Read/Write, Modbus addresses 40001 to 40256) range = 3 to 255, 0 = no file	0
RTS Off Delay (x20 ms)	0 to 65535 (can be set in 20 ms increments) Specifies the delay time between when the last serial character is sent to the modem and when RTS is deactivated. Gives the modem extra time to transmit the last character of a packet.	0
RTS Send Delay (x20 ms)	0 to 65535 (can be set in 20 ms increments) Specifies the time delay between setting RTS until checking for the CTS response. For use with modems that are not ready to respond with CTS immediately upon receipt of RTS.	0
Pre Transmit Delay (x1 ms)	0 to 65535 (can be set in 1 ms increments) When the Control Line is set to *No Handshaking*, this is the delay time before transmission. Required for 1761-NET-AIC physical Half-Duplex networks. The 1761-NET-AIC needs 2 ms of delay time to change from receive to transmit mode. When the Control Line is set to *Half-Duplex Modem*, this is the minimum time delay between receiving the last character of a packet and the RTS assertion.	0

Modbus Slave Memory Map

The modbus Memory map is summarized in and detailed in :

Modbus to MicroLogix Memory Map - Summary
(MicroLogix 1200 Controllers and MicroLogix 1500 1764-LSP Series B and 1764-LRP Processors only)

Modbus Addressing	Description	Valid MicroLogix Addressing		
		File Type	**Data File Number**	**Address**
0001 to 4096	Read/Write Modbus Coil Data space	Bit (B) or Integer (N)	3 to 255	bits 0 to 4095
10001 to 14096	Read-Only Modbus Contact Data space	Bit (B) or Integer (N)	3 to 255	bits 0 to 4095
30001 to 30256	Read-Only Modbus Input Register space	Bit (B) or Integer (N)	3 to 255	words 0 to 255
30501 to 30532	Modbus Communication Parameters	Communication Status File	-	-
31501 to 31566	Read-Only System Status File space	Status (S)	2	words 0 to 65
40001 to 40256	Read/Write Modbus Holding Register space	Bit (B) or Integer (N)	3 to 255	words 0 to 255
40257 to 41280(1)	Read/Write Modbus Holding Register space	Bit (B) or Integer (N)	3 to 255	words 0 to 255 of four Holding Register files
41501 to 41566	Read/Write System Status File space	Status (S)	2	words 0 to 65
41793 to 42048(1)	Read/Write Modbus Holding Register space	Bit (B) or Integer (N)	3 to 255	words 0 to 255 of the last Holding Register file

(1) These addresses only become active when specially configured for expanded holding registers.

Modbus Slave to MicroLogix Memory Map - Detail
(MicroLogix 1200 Controllers and MicroLogix 1500 1764-LSP Series B and 1764-LRP Processors only)

Modbus Addressing	Modbus Address Reference	Modbus Function Code (decimal)
0001 to 4096	Read/Write Modbus Coil Data space	1, 5, 15
10001 to 14096	Read Only Modbus Contact Data space	2
30001 to 30256	Read Modbus Input Register space	4
30501	Modbus Data Table Coil File Number	4
30502	Modbus Data Table Contact File Number	4
30503	Modbus Data Table Input Register File Number	4
30504	Modbus Data Table Holding Register File Number	4
30506	Pre-Send Delay	4
30507	Modbus Slave Address	4
30508	Inter-character Timeout	4
30509	RTS Send Delay	4
30510	RTS Off Delay	4
30511	Parity	4
30512	Presentation Layer Error Code	4
30512	Presentation Layer Error Code	4
30513	Presentation Layer Error Count	4
30514	Executed Function Code Error	4
30515	Last Transmitted Exception Code	4
30516	File Number of Error Request	4
30517	Element Number of Error Request	4
30518	Function Code 1 Message Counter - Read Single Output Coil	4
30519	Function Code 2 Message Counter - Read Discrete Input Image	4
30520	Function Code 3 Message Counter - Read Single Holding Register	4
30521	Function Code 4 Message Counter - Read Single Input Register	4
30522	Function Code 5 Message Counter - Set/Clear Single Output Coil	4
30523	Function Code 6 Message Counter - Read/Write Single Holding Register	4
30524	Function Code 8 Message Counter - Run Diagnostics	4
30525	Function Code 15 Message Counter - Set/Clear for Block of Output Coils	4
30526	Function Code 16 Message Counter - Read/Write for Block of Holding Registers	4
30527	Modem Status	4
30528	Total messages responded to by this slave	4
30529	Total messages to this Slave	4
30530	Total Messages Seen	4
30531	Link Layer Error Count	4
30532	Link Layer Error	4
31501 to 31566	Read Only System Status File	4
40001 to 40256	Read/Write Modbus Holding Register space (1st Holding Register file).	3, 6, 16
40257 to 40512	Read/Write Modbus Holding Register space (2nd Holding Register file).	3, 6, 16
40513 to 40768	Read/Write Modbus Holding Register space (3rd Holding Register file).	3, 6, 16
40769 to 41024	Read/Write Modbus Holding Register space (4th Holding Register file).	3, 6, 16

Modbus Slave to MicroLogix Memory Map - Detail
(MicroLogix 1200 Controllers and MicroLogix 1500 1764-LSP Series B and 1764-LRP Processors only)

Modbus Addressing	Modbus Address Reference	Modbus Function Code (decimal)
41025 to 41280	Read/Write Modbus Holding Register space (5th Holding Register file).	3, 6, 16
41501 to 41566	Read/Write System Status File	3, 6, 16
41793 to 42048	Read/Write Modbus Holding Register space (6th Holding Register file).	3, 6, 16

Modbus Commands

The controller configured for Modbus RTU Slave responds to the Modbus command function codes listed in below:

Supported Modbus Commands as a Modbus RTU Slave
(MicroLogix 1200 Controllers and MicroLogix 1500 1764-LSP Series B and 1764-LRP Processors only)

Command	Function Code (decimal)	Subfunction Code (decimal)
Read Coil Status	1	-
Read Input Status	2	-
Read Holding Registers	3	-
Read Input Registers	4	-
Write Single Coil(1)	5	-
Write Single Holding Register(1)	6	-
Echo Command Data	8	0
Clear Diagnostic Counters	8	10
Write Multiple Coils(1)	15	-
Write Multiple Holding Registers(1)	16	-

(1) Broadcast is supported for this command.

Supported Modbus Commands as a Modbus RTU Master
(MicroLogix 1200 FRN 8 and higher, MicroLogix 1500 FRN 9 and higher)

Command	Function Code (decimal)	Subfunction Code (decimal)
Read Coil Status	1	-
Read Input Status	2	-
Read Holding Registers	3	-
Read Input Registers	4	-
Write Single Coil(1)	5	-
Write Single Holding Register(1)	6	-
Write Multiple Coils(1)	15	-
Write Multiple Holding Registers(1)	16	-

(1) Broadcast is supported for this command.

Modbus Error Codes

Upon receiving a Modbus command that is not supported or improperly formatted, the controller configured for Modbus RTU Slave will respond with one of the exception codes listed in below:

Modbus Error Codes Returned by Modbus RTU Slave
(MicroLogix 1200 Controllers and MicroLogix 1500 1764-LSP Series B and 1764-LRP Processors only)

Error Code	Error	Description	Transmitted Exception Code(1)
0	No error.		none
1	Function Code cannot Broadcast.	The function does not support Broadcast.	nothing transmitted
2	Function Code not supported.	The controller does not support this Modbus function or subfunction.	1
3	Bad Command Length.	The Modbus Command is the wrong size.	3
4	Bad Length.	The function attempted to read/write past the end of a data file.	3
5	Bad parameter	The function cannot be executed with these parameters.	1
6	Bad File Type	The file number being referenced is not the proper file type.	2
7	Bad File Number	The file number does not exist	2
8	Bad Modbus Address	The function attempted to access an invalid Modbus address.(2)	3
9	Table Write protected	The function attempted to write to a read-only file.	3
10	File Access Denied	Access to this file is not granted.	2
11	File Already Owned	Data file is already owned by another process.	2

(1) If Modbus Command is sent with a valid Broadcast address, then no exception reply will be sent for Error Codes 2 through 11.

(2) See on page 551 for valid Modbus memory mapping.

Modbus Error Codes in Modbus RTU Master MSG Instruction
(MicroLogix 1200 FRN 8 and higher, MicroLogix 1500 FRN 9 and higher)

Error Code	Error	Description	Received Exception Code
81	Illegal Function	The function code sent by the Master is not supported by the slave or has an incorrect parameter.	1
82	Illegal Data Address	The data address referenced in the Master command does not exist in the slave, or access to that address is not allowed.	2
83	Illegal Data Value	The data value being written is not allowed, either because it is out of range, or it is being written to a read-only address.	3
84	Slave Device Failure	An unrecoverable error occurred while the slave was attempting to perform the requested action.	4
85	Acknowledge	The slave has accepted the request, but a long duration of time will be required to process the request.	5
86	Slave Device Busy	The slave is currently processing a long-duration command.	6

Modbus Error Codes in Modbus RTU Master MSG Instruction
(MicroLogix 1200 FRN 8 and higher, MicroLogix 1500 FRN 9 and higher)

Error Code	Error	Description	Received Exception Code
87	Negative Acknowledge	The slave cannot perform the program function received in the command.	7
88	Memory Parity Error	The slave attempted to read extended memory, but detected a parity error in the memory.	8
89	Non-standard Error Code	An error code greater than 8 was returned by the slave.	>8

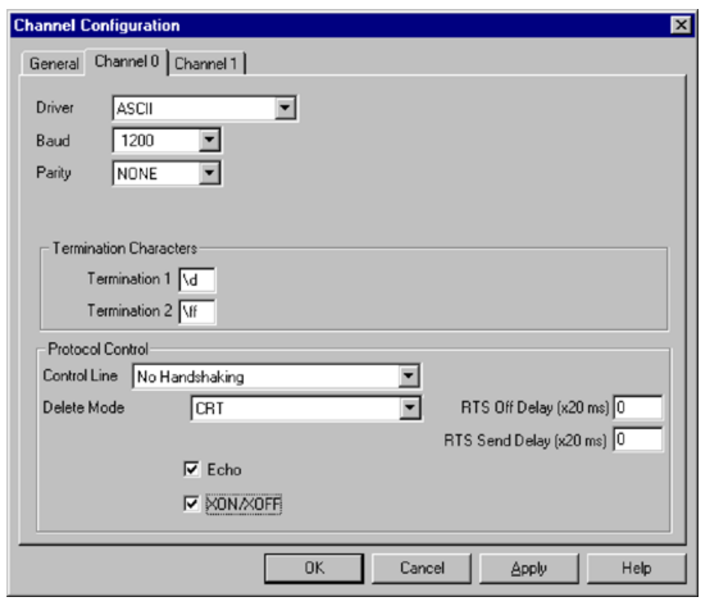
ASCII Driver

The ASCII driver provides connection to other ASCII devices, such as bar code readers, weigh scales, serial printers, and other intelligent devices.

You can use ASCII by configuring the RS-232 port, channel 0 for ASCII driver (*For the 1764-LRP only, you can select either Channel 0 or Channel 1*). When configured for ASCII, all received data is placed in a buffer. To access the data, use the ASCII instructions in your ladder program. See ASCII Instructions on page 349 for information on using the ASCII instructions. You can also send ASCII string data to most attached devices that accept ASCII data/characters.

TIP Only ASCII instructions can be used when a channel is configured for ASCII. If you use a Message (MSG) instruction that references the channel, an error occurs.

The channel configuration screen is shown below:



The controller updates changes to the channel configuration at the next execution of a Service Communications (SVC) instruction, I/O Refresh (REF) instruction, or when it performs Communications Servicing, whichever comes first.

When the driver is set to ASCII, the following parameters can be changed:

ASCII Channel Configuration Parameters
(MicroLogix 1200; MicroLogix 1500 1764-LSP Series B and higher, and MicroLogix 1500 1764-LRP)

Parameter	Description	Programming Software Default
Channel	MicroLogix 1200, and MicroLogix 1500 1764-LSP Series B and higher: Channel 0 MicroLogix 1500 1764-LRP: Channel 0 or 1	0 (1200 & LSP) 0 or 1 (LRP)
Driver	ASCII	
Baud Rate	Toggles between the communication rate of 300, 600, 1200, 2400, 4800, 9600, 19.2K, and 38.4K.	1200
Parity	Toggles between None, Odd, and Even.	None
Termination 1	Specifies the first termination character. The termination character defines the one or two character sequence used to specify the end of an ASCII line received. Setting the first ASCII termination character to undefined (\ff) indicates no ASCII receiver line termination is used.	\d
Termination 2	Specifies the second termination character. The termination character defines the one or two character sequence used to specify the end of an ASCII line received. Setting the second ASCII Termination character to undefined (\ff) and the first ASCII Termination character to a defined value (\d) indicates a single character termination sequence.	\ff
Control Line	Toggles between No Handshaking, Half-Duplex Modem, and Full-Duplex Modem	No Handshaking
Delete Mode	The Delete Mode allows you to select the mode of the "delete" character. Toggles between Ignore, CRT, and Printer. Delete Mode affects the characters echoed back to the remote device. When Delete Mode is enabled, the previous character is removed from the receive buffer. • In CRT mode, when a delete character is encountered, the controller echos three characters to the device: backspace, space, and backspace. This erases the previous character on the terminal. • In Printer Mode, when a delete character is encountered, the controller echos the slash character, then the deleted character. Enable the Echo parameter to use Delete Mode.	Ignore
Echo	When Echo Mode is enabled, all of the characters received are echoed back to the remote device. This allows you to view characters on a terminal connected to the controller. Toggles between Enabled and Disabled.	Disabled
XON/XOFF	Allows you to Enable or Disable XON/ XOFF software handshaking. XON/XOFF software handshaking involves the XON and XOFF control characters in the ASCII character set. When the receiver receives the XOFF character, the transmitter stops transmitting until the receiver receives the XON character. If the receiver does not receive an XON character after 60 seconds, the transmitter automatically resumes sending characters. Also, when the receive buffer is more than 80% full, an XOFF character is sent to the remote device to pause the transmission. Then, when the receive buffer drops to less than 80% full, an XON character is sent to the remote device to resume the transmission.	Disabled
RTS Off Delay (x20 ms)	Allows you to select the delay between when a transmission is ended and when RTS is dropped. Specify the RTS Off Delay value in increments of 20 ms. Valid range is 0 to 65535.	0
RTS Send Delay (x20 ms)	Allows you to select the delay between when RTS is raised and the transmission is initiated. Specify the RTS Send Delay value in increments of 20 ms. Valid range is 0 to 65535.	0

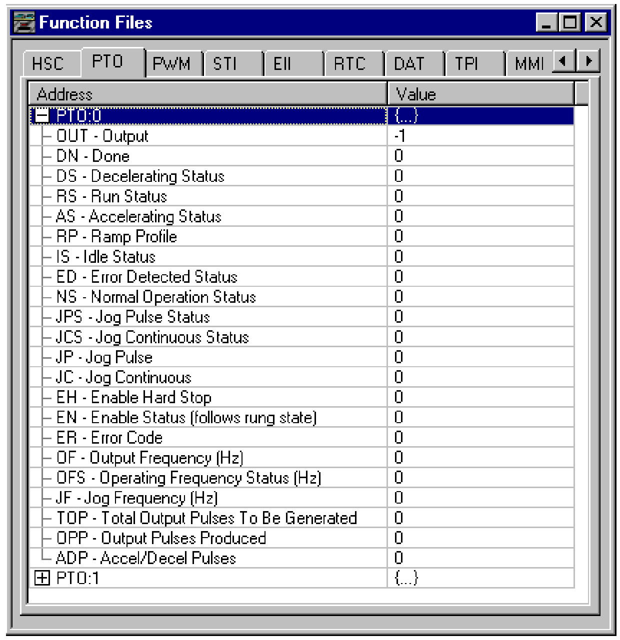
Knowledgebase Quick Starts

The following Quick Start topics are included:

17583 “Quick Start” Pulse Train Output (PTO)

NOTE: The PWM function is only available when using the BXB models of the MicroLogix 1200 or 1500

Locate the Function Files under Controller in RSLOGIX 500 v4.00 or later and select the PTO tab, then select the [+] next to PTO:0 (See Below).

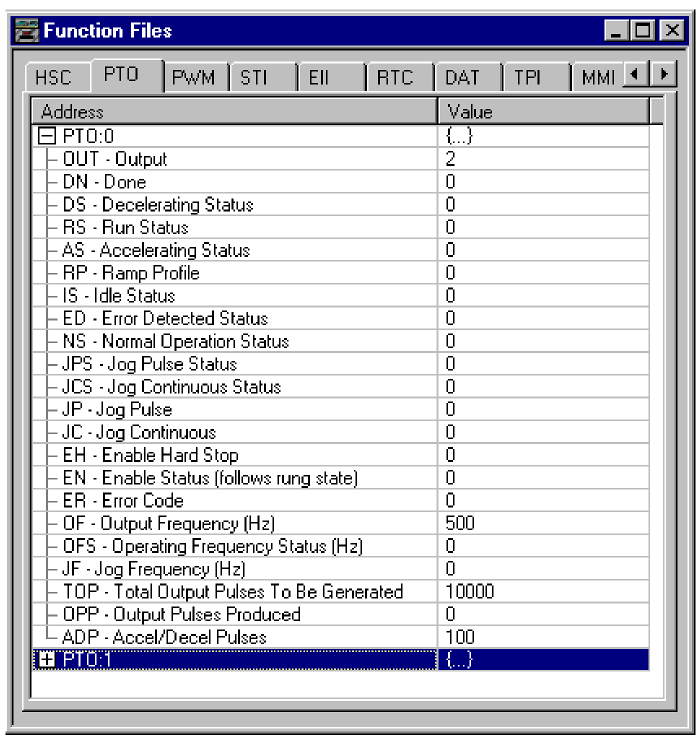

Function Files
HSC
PTO
PWM
STI
EII
RTC
DAT
TPI
MMI
Address
Value
PTO:0
{...}
OUT - Output
-1
DN - Done
0
DS - Decelerating Status
0
RS - Run Status
0
AS - Accelerating Status
0
RP - Ramp Profile
0
IS - Idle Status
0
ED - Error Detected Status
0
NS - Normal Operation Status
0
JPS - Jog Pulse Status
0
JCS - Jog Continuous Status
0
JP - Jog Pulse
0
JC - Jog Continuous
0
EH - Enable Hard Stop
0
EN - Enable Status (follows rung state)
0
ER - Error Code
0
OF - Output Frequency (Hz)
0
OFS - Operating Frequency Status (Hz)
0
JF - Jog Frequency (Hz)
0
TOP - Total Output Pulses To Be Generated
0
OPP - Output Pulses Produced
0
ADP - Accel/Decel Pulses
0
PTO:1
{...}

Enter the following parameters as the “Minimum Configuration” required for the PTO to generate pulses.

PTO:0.OUT	Select Destination Output for pulses: Output O:0/2 or O:0/3
PTO:0.OF	Output Frequency - Frequency of pulses: 0 to 20,000 Hz Data less then zero and greater then 20,000 generates a PTO error
PTO:0.TOP	Total Output Pulses - Determines total number of pulses to be generated by the controller
PTO:0.ADP	Accel/Decel Pulses - How many of the total pulses will be used for the Accel/Decel component

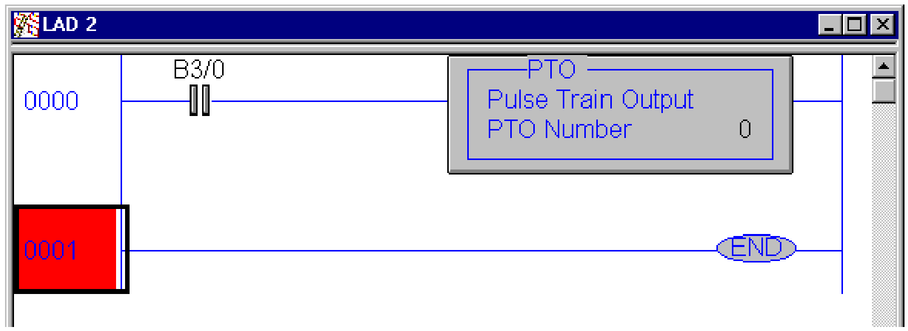
Example

The following example will generate 10,000 pulses on Output O:0/2 at a frequency of 500Hz and 100 pulses will be used for Accelerating and 100 pulses will be used for Decelerating.



Address	Value
PTO:0	{...}
OUT - Output	2
DN - Done	0
DS - Decelerating Status	0
RS - Run Status	0
AS - Accelerating Status	0
RP - Ramp Profile	0
IS - Idle Status	0
ED - Error Detected Status	0
NS - Normal Operation Status	0
JPS - Jog Pulse Status	0
JCS - Jog Continuous Status	0
JP - Jog Pulse	0
JC - Jog Continuous	0
EH - Enable Hard Stop	0
EN - Enable Status (follows rung state)	0
ER - Error Code	0
OF - Output Frequency (Hz)	500
OFS - Operating Frequency Status (Hz)	0
JF - Jog Frequency (Hz)	0
TOP - Total Output Pulses To Be Generated	10000
OPP - Output Pulses Produced	0
ADP - Accel/Decel Pulses	100
PTO:1	{...}

The following ladder logic will need to be entered into File #2



By toggling Bit B3/0 the PTO can be activated. Once running the PTO will generate the number of pulses entered into the PTO:0.TOP word and then stop. To restart, toggle B3/0.

General Information on the PTO

Once running the PTO will continue to generate pulses until all pulses have been generated or the PTO:0/EH (Enable Hard Stop) bit has been activated.

Once the EH bit is set the instruction will generate a PTO error of 1 (hard stop detected). In order to clear this error the PTO instruction must be scanned on a false rung of logic, and the EH bit must be off.

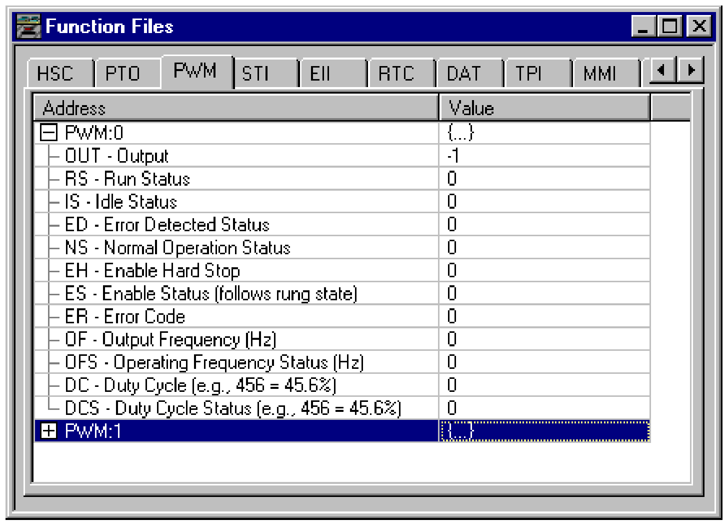
To change the Total Output Pulses Generated in a working program a new value can be moved into PTO:0.TOP by using the MOV command.

Important Note: Once the PTO has been initiated and is generating pulses a new TOP value will not take effect until the PTO has either completed generating pulses and has been restarted or has been Hard Stopped using PTO:0/EH bit and been restarted.

17585 "Quick Start" Pulse Width Modulation (PWM)

NOTE: The PWM function is only available when using the BXB models of the MicroLogix 1200 or 1500

Locate the Function Files under Controller in RSLOGIX 500 v4.50.00 or later and select the PWM tab, then select the [+] next to PWM:0 (See Below).



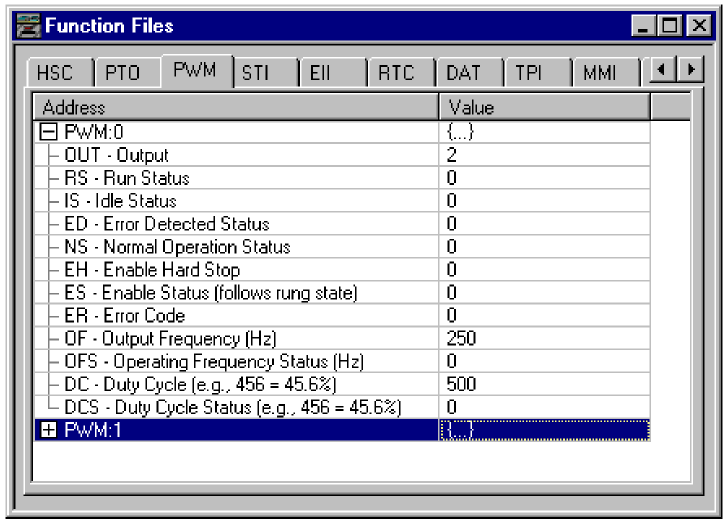
Enter the following parameters as the "Minimum Configuration" required for the PWM to generate a waveform at the specified frequency.

PWM:0.OUT	Select Destination Output for pulses: Output O:0/2 or O:0/3
PWM:0.OFS	Output Frequency - Frequency of the PWM: 0 to 20,000 Hz
PWM:0.DC	PWM Duty Cycle - Controls the output signal of the PWM: 1 to 1000

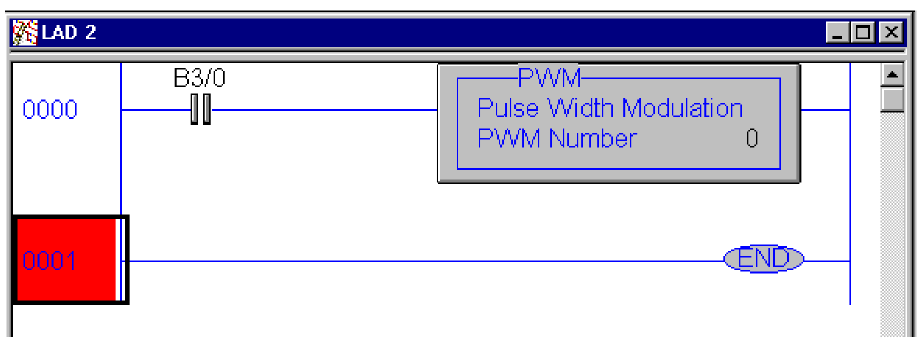
DC = 1000	100%	Output **ON**	(Constant no waveform)
DC = 0750	075%	Output **ON**	025% Output **OFF**
DC = 0500	050%	Output **ON**	050% Output **OFF**
DC = 0250	025%	Output **ON**	075% Output **OFF**
DC = 0000	000%	Output **OFF**	(Constant no Waveform)

Example

The following example will generate a waveform on Output O:0/2 at a frequency of 250Hz and a 50% Duty Cycle.



The following ladder logic will need to be entered into File #2



By toggling Bit B3/0 the PWM can be activated.

Note: Once activated the PWM will continue to generate a waveform until B3/0 is toggled OFF or the PWM:0/EH (Enable Hard Stop) bit has been activated.

17586 "Quick Start" High Speed Counter (HSC)

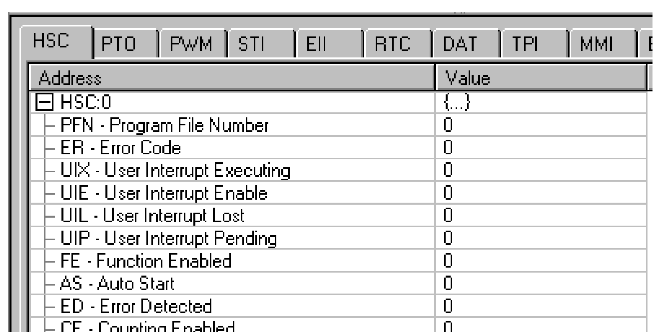
General Information

The **MicroLogix 1200** has one 20Khz high-speed counter. The counter has four dedicated inputs that are isolated from all other inputs on the unit. The HSC can utilize inputs 0 through 3. Input device connection depends on the counter mode selected. The MicroLogix 1200 uses a 32-bit signed integer for the HSC this allows for a count range of (+/-) 2,147,483,647.

The **MicroLogix 1500** has two 20Khz high-speed counters. Each counter has four dedicated inputs that are isolated from all other inputs on the base unit. HSC:0 can utilize inputs 0 through 3, and HSC: 1 can utilize inputs 4 through 7. Input device connection depends on the counter mode selected. Each counter is completely independent and isolated from the other. The MicroLogix 1500 uses a 32-bit signed integer for the HSC this allows for a count range of (+/-) 2,147,483,647.

Getting Started

Locate the Function Files under Controller in RSLOGIX 500 and select the HSC tab, then select the [+] next to HSC:0 (See Below)



Enter the following parameters for the **"Minimum Configuration"** required for the HSC to count pulses.

Note: There is no additional ladder logic required to enable the High Speed Counter. In other words there is no HSC instruction needed for the ladder logic program.

HSC:0.PFN	Program File Number defines which subroutine is executed when the HSC:0 accumulated count equals the High or Low preset or passes through Overflow or Underflow. The Integer number entered must be a valid sub-routine program file (3 to 255).
HSC:0/AS	Auto-Start defines if the HSC function will automatically start when the MicroLogix enters run or test.
HSC:0/CE	Counting Enabled control bit is used to enable or disable the HSC
HSC:0.HIP	High Preset is the upper set point (in counts) that defines when the HSC will generate an interrupt and execute the PFN sub-routine.

Example

The following example uses the HSC in **Mode 0** - “Up Counter”. The **“Up Counter”** clears the accumulated value (0) when it reaches the High Preset (HIP). This mode configures I1:0.0/0 (I:0/0) as the HSC:0 input.

Note: Each mode for the HSC will configure the inputs for different functionality.

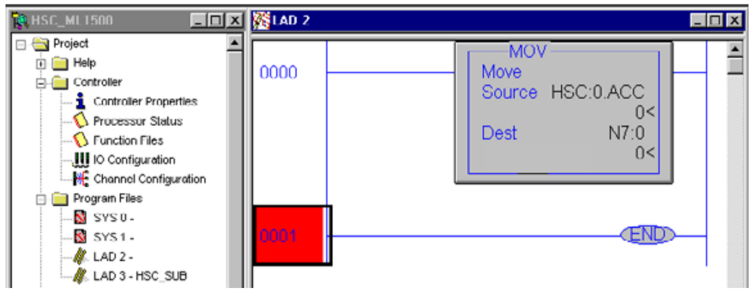
In this example the HSC will count input pulses coming into I:0/0, when the total number of pulses counted equals the High Preset (HIP) the HSC will jump to subroutine file #3

The HIP is set for 5000 pulses in this example, Also once the HIP is reached the HSC will then reset HSC:0.ACC to zero (0) and start counting again.

Important: It is assumed that the user has connected a device to I:0/0 to generate pulses.

Note: The following ladder logic does not need to be entered into File #2, however this allows for easy viewing of the accumulated counts from the HSC:0.ACC.

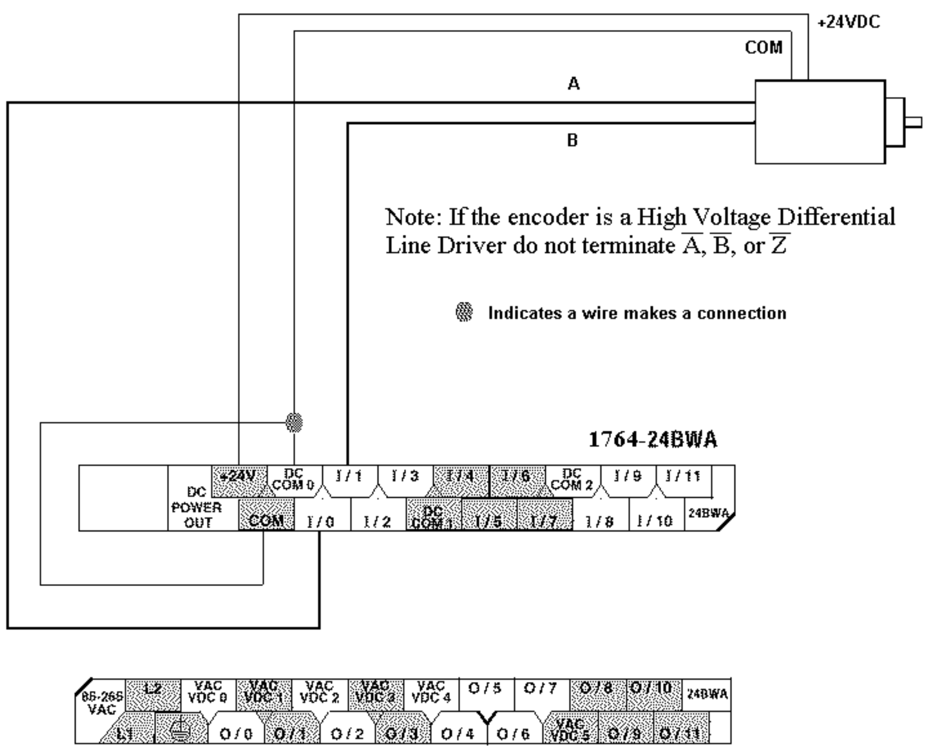
IMPORTANT: Ladder Logic Subroutine file #3 must be created in order for this example to work. If the subroutine is not created the CPU will fault due to an HSC **Error Code 1** - *Invalid File Number for PFN has been entered.*



Proper wiring of a single ended encoder (Typical Allen-Bradley 845TK) when configuring HSC.MOD for **Mode 6 (Quadrature Counter)**

The following diagram illustrates connecting an encoder to the MicroLogix 1500, but the same wiring can be applied for the MicroLogix 1200.

The minimum configuration required for **Mode 6** operation is to enter a file number for the PFN parameter, set the AS and CE bits to a (1) and enter a (6) for the MOD parameter.



TROUBLESHOOTING

Problem #1: The input LEDS on the Micrologix Base unit turn on and off, but no counts are seen in the HSC accumulator.

Solution: The input filter frequency may need to be adjusted in order to capture the input pulses.

Follow the steps below....

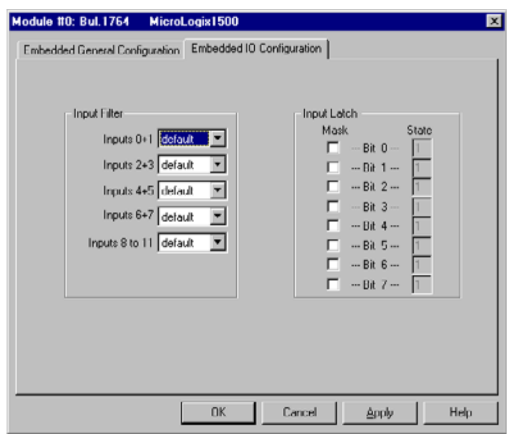
Select “I/O Configuration”

Highlight the “1764-Micrologix 1500“

Select “Adv Config“

Select the “Embedded I/O Configuration” Tab

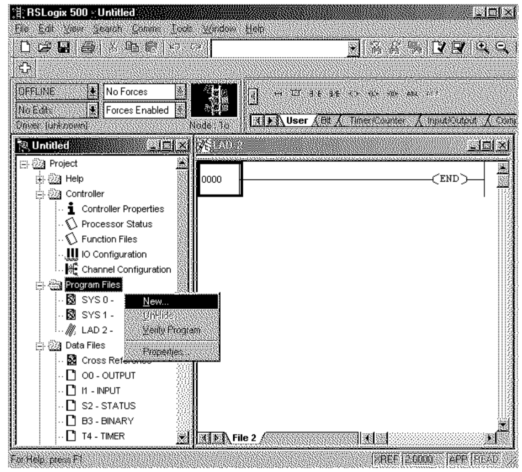
Adjust Input filters as needed



Problem #2: The HSC instruction does not accumulate counts and the Error Code (ER) shows a value of (1).

Solution:A file number was entered into (PFN) but the value entered was less then (3) or greater then (255) or the file number entered was correct, however the file does not exist.

Create the **NEW** program file by “**Right**” mouse clicking on “**Program Files**”



Problem #3: Some of my outputs will not turn On or Off when the ladder logic appears to indicate that they should.

Solution: **OMB (Output Mask Bits).** Verify what the OMB has been configured for in the HSC function file. If an output(s) has been assigned to the HSC for control, then the output(s) will not be controlled anywhere else in the ladder program. Only the HSC will have control over these outputs.

17605 "Quick Start" Message (MSG)

Communications Specifications:

The MicroLogix 1200 & 1500 processors contain a total of (12) Message Buffers.

(8) Incoming	Any incoming MSG's, Communications, and/or responses to a command the ML1200/1500 initiated.
(4) Outgoing	Any outgoing MSG's, Communications and/or responses to incoming request for data.

The Outgoing queue also supports unlimited queuing. This means that even if a buffer is not available the MSG will simply wait until one of the outgoing buffers becomes available and then transmit.

NOTE:If a message has been waiting in the queue, at the moment of buffer availability, the most current data will be sent, not the data that was available at the time the message instruction was first scanned true.

How quickly a message is actually sent or received to/by a destination device depends on a number of issues, including the selected channels communication protocol, baud rate of the communications port, number of retries, destination devices readiness to receive, ladder logic scan time, etc.

Definition of the Message (MSG) instruction:

The message instruction (MSG) is an output instruction which when configured correctly allows data to be sent or received to other compatible devices.

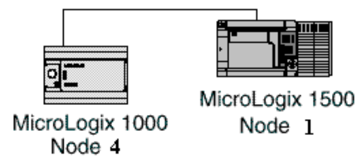
The MSG instruction in the MicroLogix 1200/1500 controller uses a Data File MG to process the message instruction. All message elements are accessed using the MG prefix (example: MSG done bit = MG11:0/DN).

Continuous Message Example:

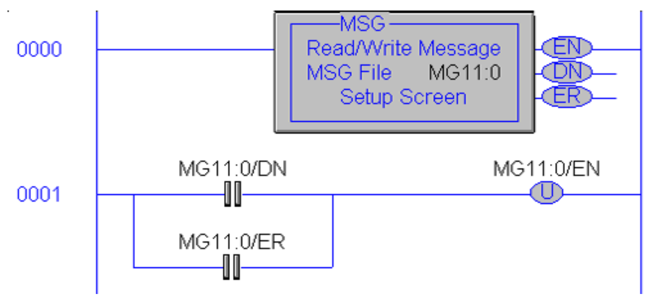
The following example illustrates how, by using the MSG Done (DN) and Error (ER) bits to unlatch the Enable (EN) bit the MSG instruction can be configured for continuous execution.

This example uses MG11:0 for the MSG file and will require two MicroLogix controllers one a ML1500 and the other either a ML1000 or ML1500. The ML1500 will need to be configured as Node 1 and the other processor as node 4.

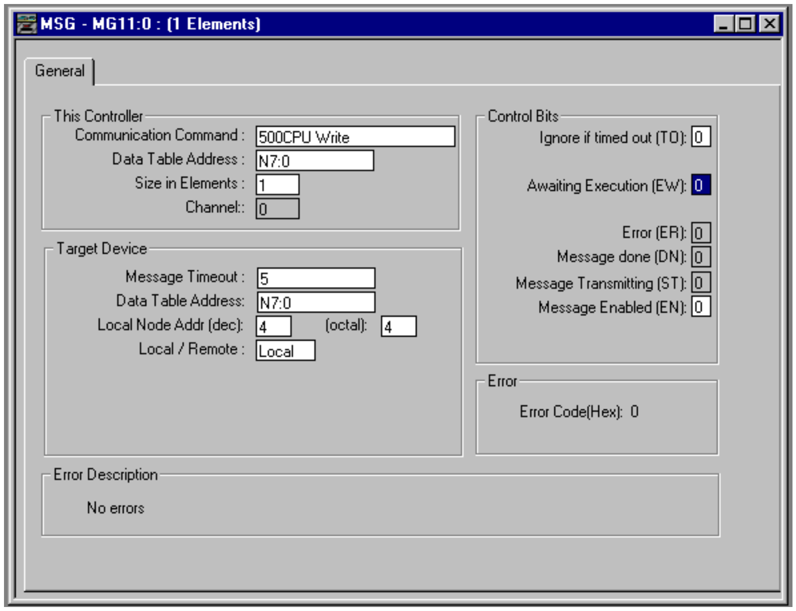
The processor at node 1 will contain the ladder logic below and transfer data from it's N7:0 Integer file to the processor at node 4's N7:0 Integer file. Since N7:0 is the source file for this example, data must be entered into this register for node 1. For this example Locate N7:0 in the ML1500 (Node 1) and enter the value 63.



Micrologix 1500 (Node 1) Ladder Logic



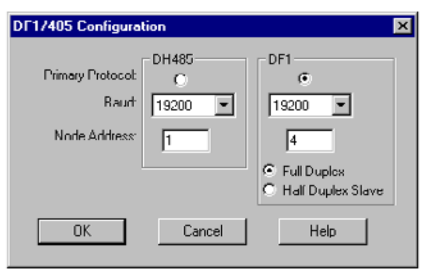
MSG Setup Screen



Micrologix 1000 (Node 4) Ladder Logic

No ladder logic is required in the destination processor, however the communications channel must be configured to match the source processor. Since the default settings for the ML1500 communications channel is DF1 protocol, 19,200 Kbaud the ML1000 must be configured to match. (See Below)

Micrologix 1000 Channel Configuration



<u>Important Note:</u>After the ladder logic has been entered into the ML1500 and the ML1000 channel configuration has been changed, in order for this example to function connect the controllers using a 1761-CBL-HM02 cable, leave connected until the COMM 0 LED on the ML1500 starts to blink.

Verifying data has been sent:

To verify the data has been sent to node 4 disconnect the HM02 cable and connect the PC running RSLogix 500 to the ML1000 (Node 4). Go to N7:0 and view the data, this should match the data in N7:0 of node 1.

Another way to verify the data is being sent to node 4 is to replace the **Target Device Data Table Address** with an output modules address. In this example the output module is a ML1000, the address would be O:0.0 This will display, in binary on the output LEDS, what ever number that was entered into N7:0 of the ML1500.

IMPORTANT NOTE: By addressing O:0.0 the outputs of the destination processor will be energized upon successful transmission of data. Verify that nothing is connected to the outputs to ensure safe operation of the controller.

If a 16 Point MicroLogix 1000 is being used as the destination processor (Node 1), and the number **63** is entered into the above example, all the outputs will be energized or turn. If the number entered is greater then 63 then a fault may occur with an error stating that the extended I/O bit (S:0/8) was not set. In this case clear the fault, go offline, set bit (S:0/8) and re-download the ladder program.

The above example uses the DF1 Full Duplex protocol. This is a point to point or One Device to One Device protocol, using this protocol no other devices can be connected. To create a network of multiple processors or devices use the DH485 protocol and 1761-NET-AIC devices.

Note: This example was written using a ML1500 communicating to a ML1000, however any DF1 or DH485 device could have been substituted for the ML1000. (i.e. MicroLogix 1200, SLC 5/03, 5/04, 5/05, PLC-5, Bar Code Scanners, etc.)

17653 "Quick Start" Selectable Timed Interrupt (STI)

What is an Interrupt?

An interrupt is an event that causes the processor to suspend the task it is currently performing, perform a different task, and then return to the suspend task at the point where it suspended.

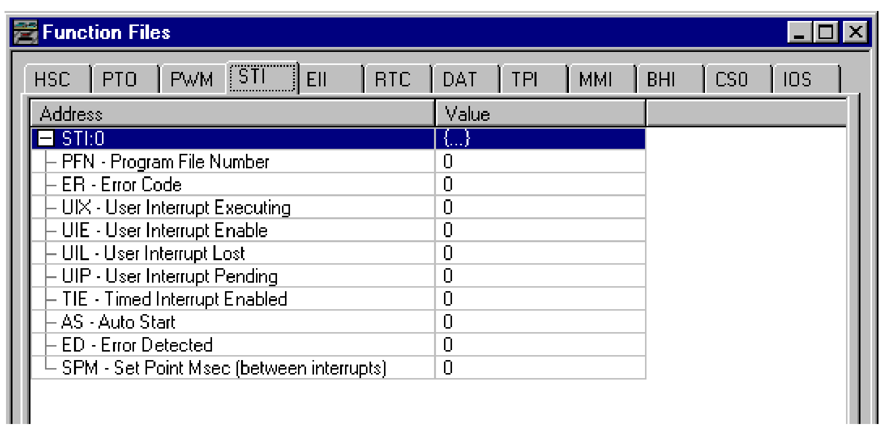
STI Definition

The STI provides a mechanism to solve time critical control requirements. The STI is a trigger mechanism that allows you to scan or solve control program logic that is time sensitive.

Example: A Block of logic that needs to be scanned more often then the rest of the ladder program.

Getting Started:

Locate the Function Files under Controller in RSLOGIX 500 v4.00 or later and select the STI tab (See Below)



Enter the following parameters as the "Minimum Configuration" required for the STI

STI:0.PFN Program File Number defines which subroutine is executed when the SPM value has timed out. The Integer number entered must be a valid sub-routine program file (3 to 255).

STI:0/AS Auto-Start defines if the STI function will automatically start when the MicroLogix 1500 enters run or test.

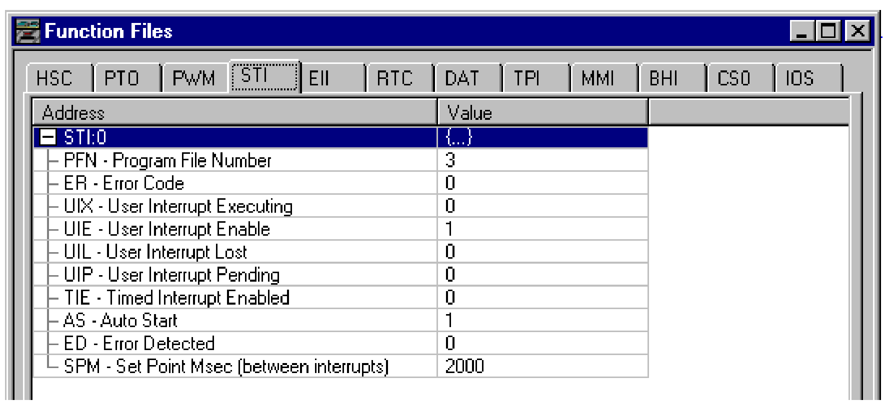
STI:0/UIE User Interrupt Enabled control bit is used to enable or disable the STI subroutine from processing.

STI:0.SPM Setpoint (in milliseconds) defines the interval that the interrupt will scan the PFN sub-routine.

Example

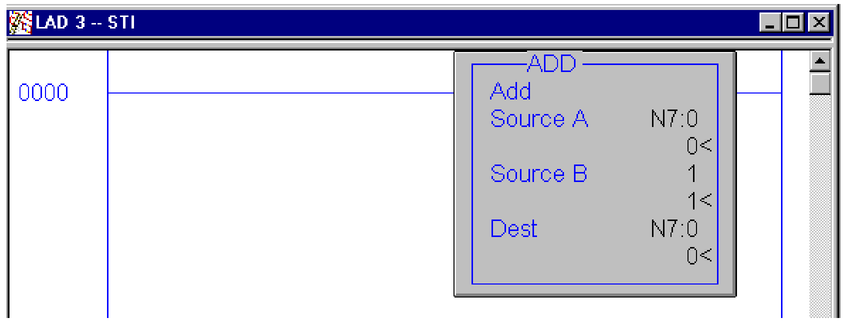
The following example configures the STI to execute sub-routine file #3 (PFN=3) every 2 seconds (SPM=2000). In the subroutine file there is an ADD instruction simply adding the value of 1 to N7:0 each time the sub-routine is scanned.

This example also sets the User Interrupt Enable bit and the Auto Start bit allowing the STI to execute.



Address	Value
STI:0	{...}
PFN - Program File Number	3
ER - Error Code	0
UIX - User Interrupt Executing	0
UIE - User Interrupt Enable	1
UIL - User Interrupt Lost	0
UIP - User Interrupt Pending	0
TIE - Timed Interrupt Enabled	0
AS - Auto Start	1
ED - Error Detected	0
SPM - Set Point Msec (between interrupts)	2000

IMPORTANT: Ladder Logic Subroutine file #3 must be created in order for this example to work. If the subroutine is not created the CPU will fault due to a STI **Error Code 1** - *Invalid File Number for PFN has been entered.*



Notes on using Interrupt bits

If the Auto Start bit (AS) is set this will start the interrupt on power up and set the Timed Interrupt Enabled bit (TIE) automatically, allowing the interrupt to execute. *Shown in the above example.*

If the AS bit is not set then the TIE bit must be set through the ladder logic in order for the interrupt to execute.

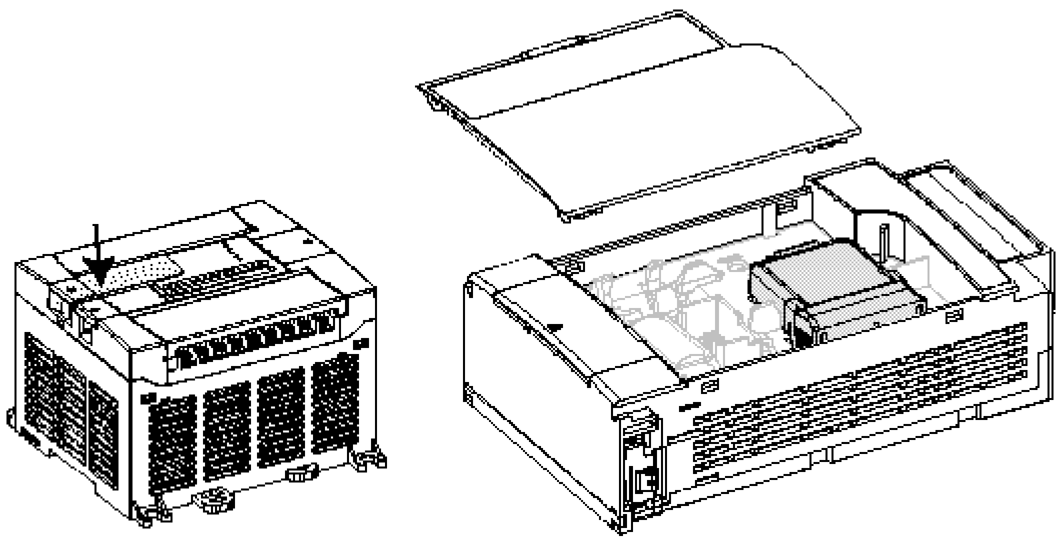
The User Interrupt Enable bit (UIE) determines if the interrupt executes or not.

17655 "Quick Start" Real Time Clock (RTC)

General Information:

The RTC provides Year, Month, Day, Day of Month, Day of Week, Hour, Minute, and Second information to the RTC Function file in the controller.

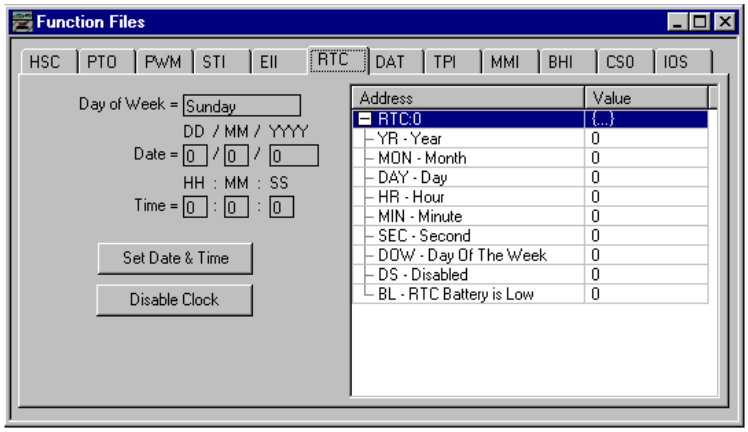
The RTC module is located in the processor unit, under the processor cover (Shown Below). Like the Memory Module the RTC can be removed or inserted under power without risk of damage to the RTC or the processor module. If the module is installed while the ML1200/1500 is executing, the module will not be recognized until a power cycle occurs or the controller is placed into program mode or faults.



ML1200 **ML1500**

Getting Started:

Locate the Function Files under Controller in RSLOGIX 500 v4.00 or later and select the RTC tab (See Below)

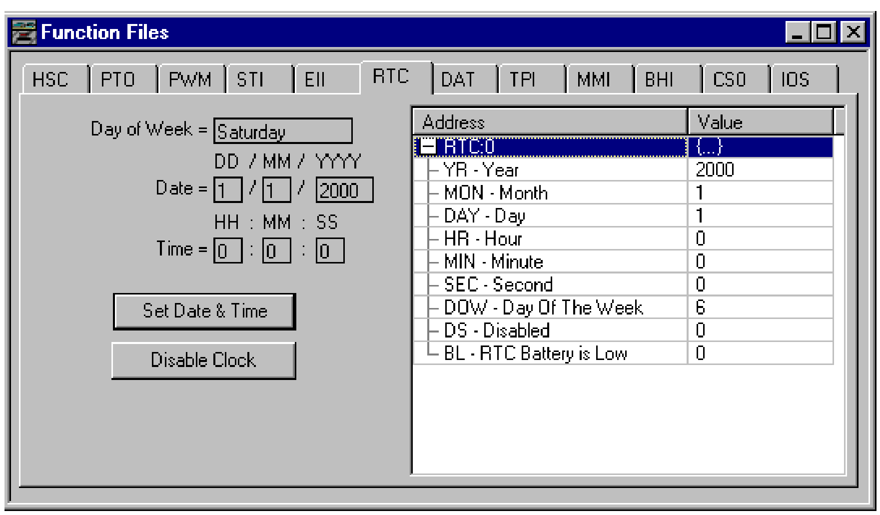


Values can be entered for the Year, Month, Day, Hour, Minute, and Seconds offline, once downloaded the values will take effect immediately.

Note: The Day of the week is calculated by the RTC Online

Pressing 

this will set the ML1200/1500 clock to the same Date & Time as the PC connected online.



Pressing 

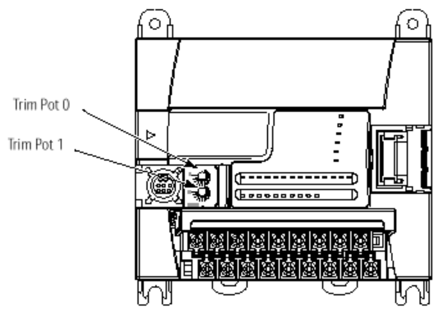
will disable the RTC from functioning and decrease the drain on the battery during storage.

RTC:0/BL The Battery Low bit will be set (1) when the battery is low. This means that the battery will fail in less than 14 Days after which the RTC data may become invalid. At this time the RTC module will need to be replaced.

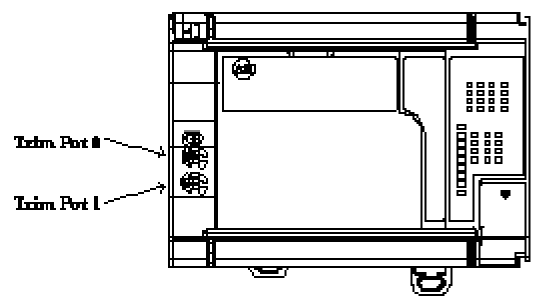
17657 "Quick Start" Trim Pots

General

On the ML1200 the trim pots are located next to the communication port. On the ML1500 the trim pots are located below the mode switch under the left access door of the processor. Each of the trim pots can be used to manipulate data within the controller. The data value of the trim pots can be used throughout the control program as timer, counter, analog presets, etc.

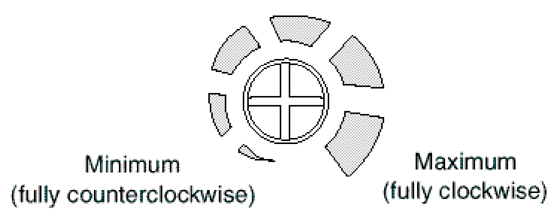


ML1200



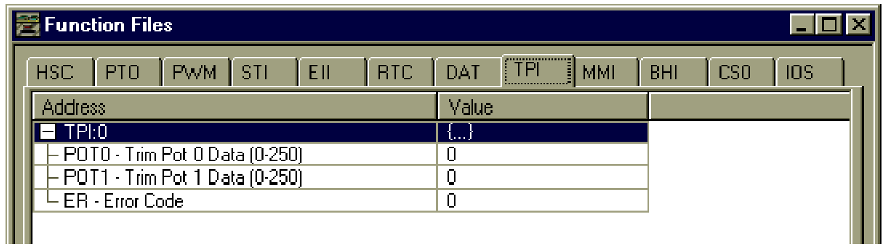
ML1500

Adjust the trim pots using a small flathead screwdriver. By turning the trim pot the data will change within a range of 0 to 250 (fully clockwise). The maximum rotation of each pot is three quarters of a turn.



Getting Started:

Locate the Function Files under Controller in RSLOGIX 500 v4.00 or later and select the TPI tab (See Below)

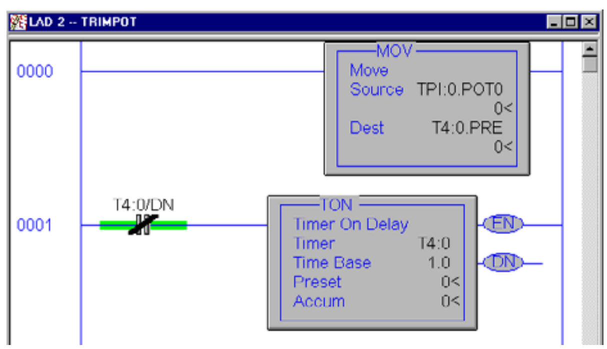


There is no configuration needed for the trim pots. The values are read only. While online, turn the trim pots and watch the values change.

Trim Pot Example Ladder Logic

The following example will MOVe the value from trim pot 0 (POT0) into the preset word of the "free running" timer at T4:0

Note: Since the trim pots only adjust from 0 to 250 the timer preset is only adjustable from 0 to 250 seconds.



Using a trim pot to adjust a value larger then 250

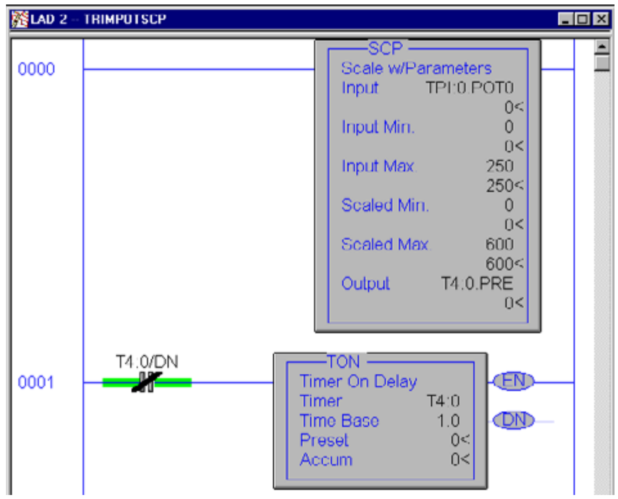
By using the SCP instruction a ladder program can be written which will allow the trim pot to adjust between:

-32768 to 32767 using standard word

-2,147,483,648 to 2,147,483,647 using long words

<u>Important:</u> Remember that the trim pots only have 3/4 of a turn resolution.

The following example takes the input value of trim pot 0 (0 - 250) and scales it from 0 to 600 using the Scale with Parameters instruction (SCP). The scaled value is placed in the preset of the “free running” timer at T4:0. This allows for POT 0 to adjust from 0 to 10 minutes (600 Sec.).



17712 “Quick Start” User Interrupt Disable (UID)

The UID instruction can be used as an output instruction to disable selected user interrupts.

Once a user interrupt is disabled the User Interrupt Enable bit (UIE) for the selected interrupt will be cleared or reset to a zero (0). This stops the interrupt from executing.

To re-enable an interrupt the UIE bit must be set to a one (1), or a UIE instruction must be used.

The following table indicates the types of interrupts disabled by the UID.

Interrupt	Element	Decimal Value	Corresponding Bit
EII - Event Input Interrupts	Event 0	64	bit 6
EII - Event Input Interrupts	Event 1	32	bit 5
HSC - High Speed Counter	HSC0	16	bit 4
EII - Event Input Interrupts	Event 2	8	bit 3
EII - Event Input Interrupts	Event 3	4	bit 2
HSC - High Speed Counter	HSC1	2	bit 1
STI - Selectable Timed Interrupts	STI	1	bit 0
Note: Bits 7 to 15 must be set to zero.			

To disable interrupt(s) follow these steps....

1. Select which Interrupt(s) to disable from the above table.

2. Locate the decimal value for each Interrupt(s).

3. Add the decimal values together if more then one Interrupt was selected.

4. Enter the sum into the UID instruction.

For example, to disable EII Event 1 and EII Event 3....

EII Event 1 = 32 EII Event 3 = 04

32 + 04 = 36 (Enter this value in the UID instruction)

Notes on using Interrupt bits

If the Auto Start bit (AS) is set this will start the interrupt on power up and set the Timed Interrupt Enabled bit (TIE) automatically, allowing the interrupt to execute. *Shown in the above example.*

If the AS bit is not set then the TIE bit must be set through the ladder logic in order for the interrupt to execute.

The User Interrupt Enable bit (UIE) determines if the interrupt executes or not.

18689 "Quick Start" RTC Synchronization Between Controllers

The following example illustrates a message write from an SLC 5/03 or higher processor to a Micrologix 1500 processor with an installed RTC module that has been enabled.

This example can also be applied for messaging between Micrologix 1200 and 1500 controllers. When messaging from a Micrologix 1200/1500 controller to another Micrologix 1200/1500 it is recommended that RTC:0 be used as the source instead of (S:37 - S:42).

Minimum Hardware/Software requirements

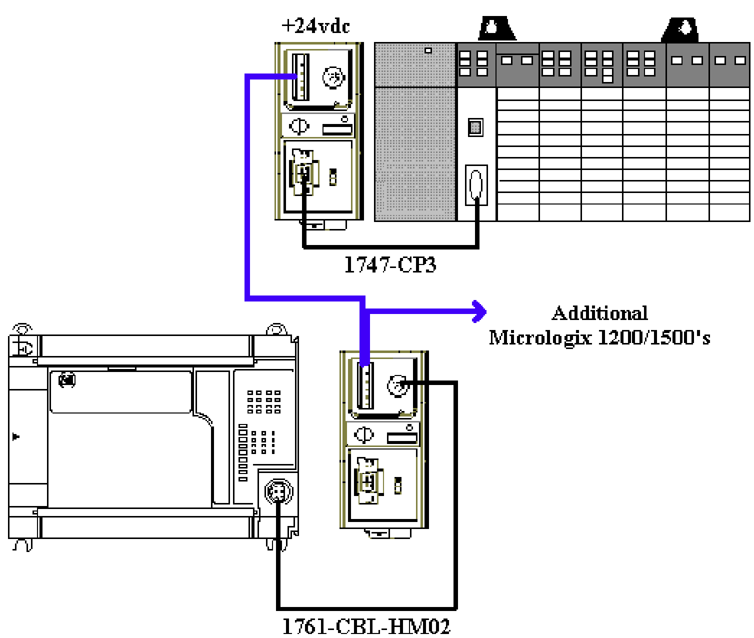
Micrologix 1200 Series B FRN 2

Micrologix 1500 Series B FRN 4

RSLOGIX 500 is 4.10.00.02

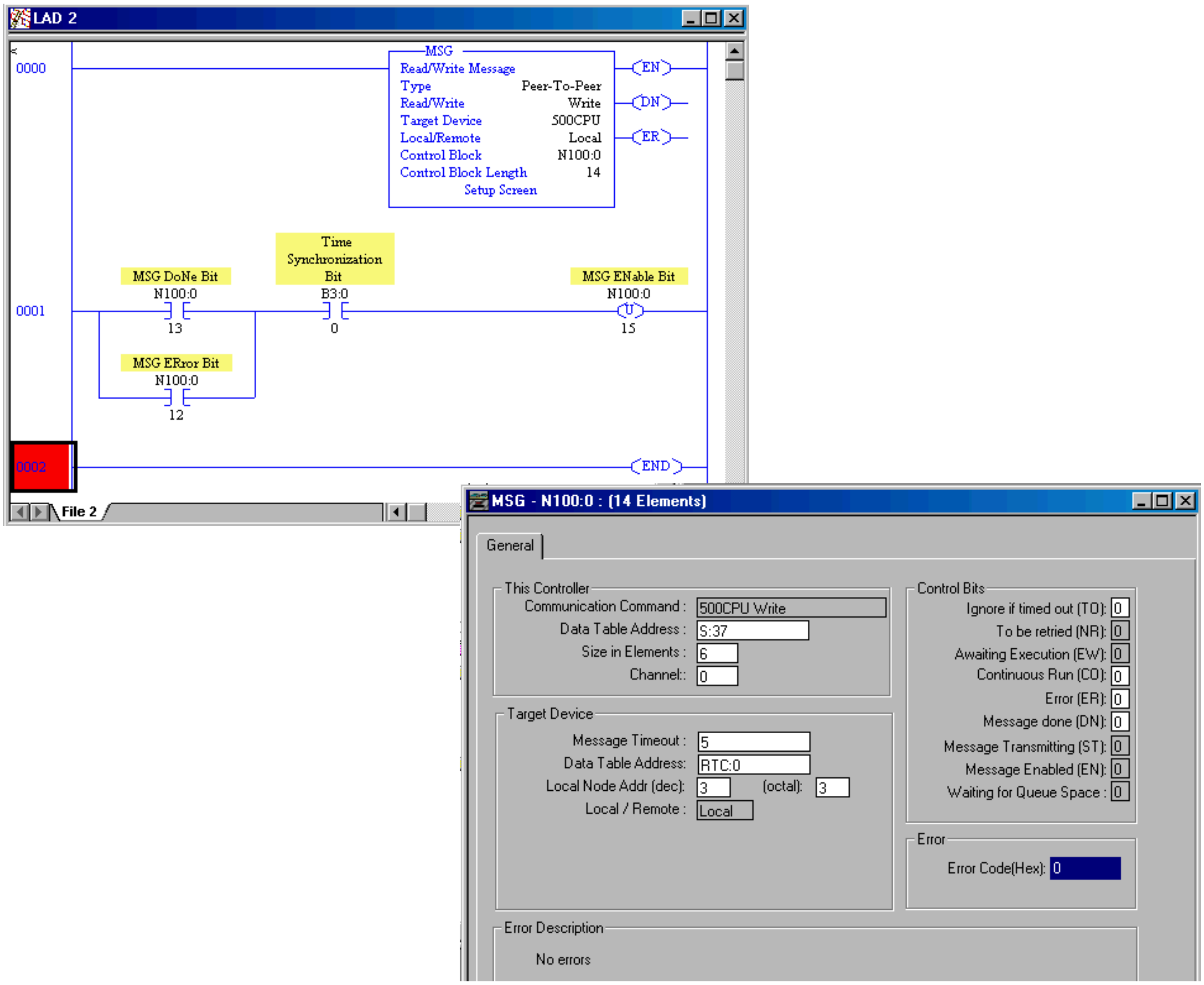
Example

The example shows network connections using DH-485, however DF1 Full or Half Duplex will also work.



1) Configure the SLC's Channel 0 port for DH-485 protocol.

2) Enter the following ladder logic into the SLC processor.



The example above messages the SLC 500 Date and Time data (S:37 - S:42)to the Micrologix 1500 RTC, each time the SLC processor is powered up and placed into the RUN mode or each time the Time Synchronization Bit (B3:0/0) is enabled.

ATTENTION

Valid years for the Micrologix 1200 and 1500 begin with 1998. Any date/ time/year values, prior to 1998, that are sent to a Micrologix controller will generate a MSG Error Code 10h.

For each processor that requires its RTC to be synchronized a MSG write will be required. This is done simply by duplicating the above ladder logic, referencing a different Control Block (i.e. N100:0 = MSG1 | N100:20 = MSG2 | N100:40 = MSG3, etc.) and specifying a different node address in the MSG set-up screen.

18728 "Quick Start" Data Logging (DLG)

General Information

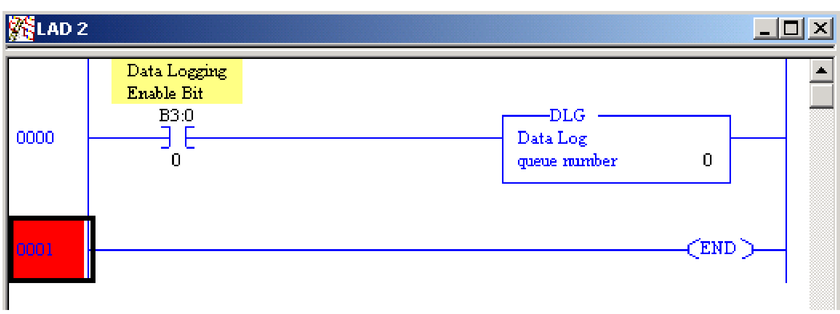
The Data logging feature allows the creation of memory queues to capture or store application data as a record for later retrieval. Each record is stored in a user-configured battery backed queue. The size of memory where queues are stored is 48K bytes, this is independent of the rest of the processor memory.

The Data logging feature allows the capture or storage of application data as a record for later retrieval. Each record is stored in a user-configured battery backed queue. The size of the queue is 48K bytes, independent of the rest of the processor memory.

Configuring the DLG instruction in the Micrologix 1500 (LRP)

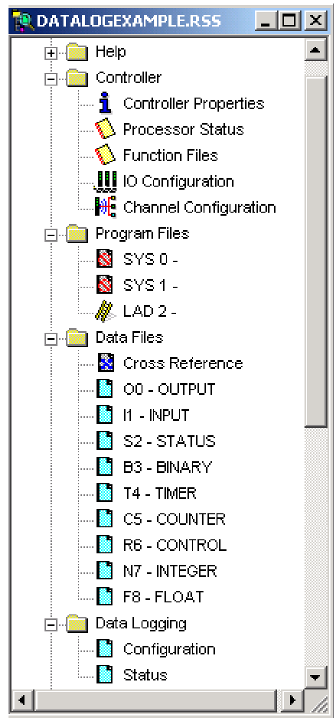
1. Create a new RSLogix 500 project for the 1764-LRP processor

2. Create a new rung of ladder logic in File 2 as shown below.



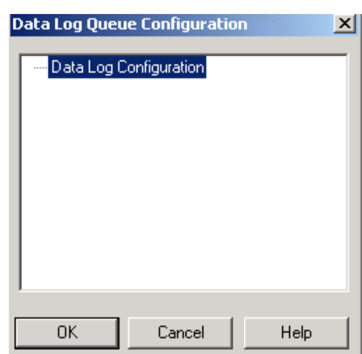
FYI - The DLG instruction ONLY captures data on a false-to-true rung transition.

3. Double Click ***Data Logging*** - ***Configuration*** in the controller organizer to access the Data Log Queue Configuration window

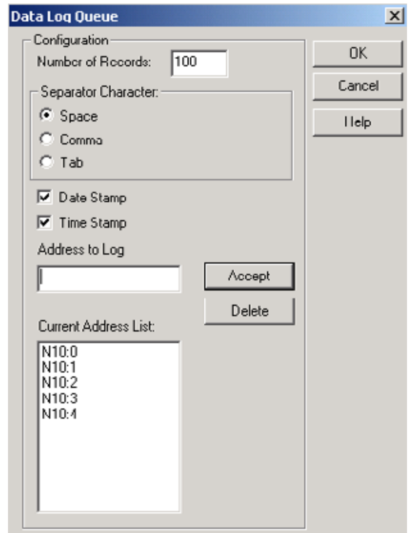


FYI - Every time ***Configuration*** above is double-clicked a new queue is added. To delete queues, simply select the queue with the mouse and press the <delete> key on the keyboard.

4. Double-Click on ***Data Log configuration*** to open the ***Configuration*** window**.**



5. Complete the ***Data Log Queue*** as shown below. *The Number of records and Addresses selected were arbitrary for this example.*

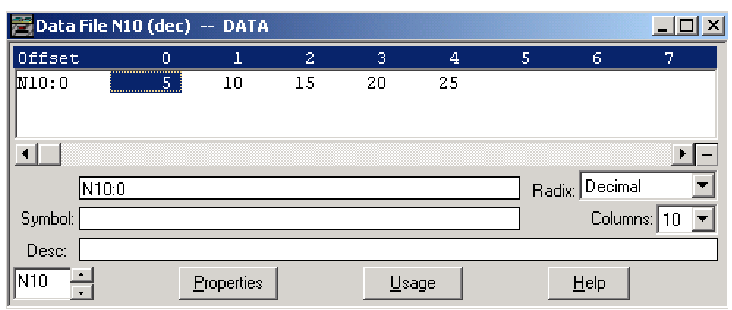


IMPORTANT NOTE - Integer file N10 must be created with a length of 5 or the software will not compile the ladder program. Also a 1764-RTC, 1764-MM1RTC, 1764-MM2RTC must be installed and configured if the Date and Time stamp are to be used. If an RTC module is not installed & configured the data for these fields will contain zeros.

6. Click ***OK*** when completed

7. Click ***OK*** and accept the ***Data Log Que*** window

8. Once the N10 file has been created enter the following values for each



9. Download the program to your MicroLogix 1500 LRP.

10. Go On-Line

11. Toggle the *Data Logging Enable(B3:0/0)* bit **Off to On** a total of *5 times*.

Using the Data Logging Utility Software to recover data

ATTENTION

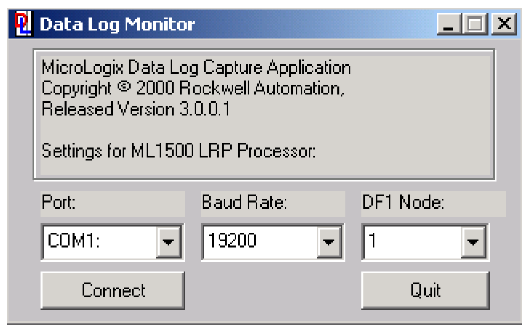
If any other software package, such as RSLINX has control of the computers communication port or if the wrong COM port is selected or a processor other then the 1764-LRP is connected to the computer you will not be able to continue.

The Data Logging utility is the only supported method for retrieving data, that has been stored in the processor.

1. Install the DLOG utility (found at http://www.ab.com/plclogic/micrologix/)

2. Execute **DLCA1764.EXE**

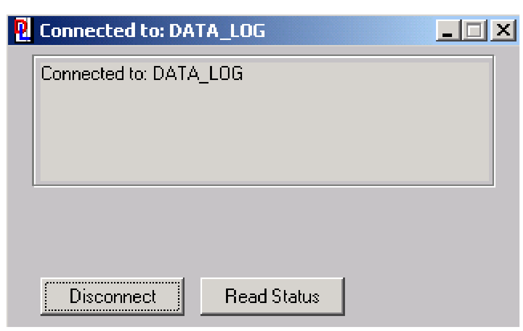
3. Configure ***Port, Baud Rate***, and ***DF1 Node*** as shown below.



4. Click “Connect”.

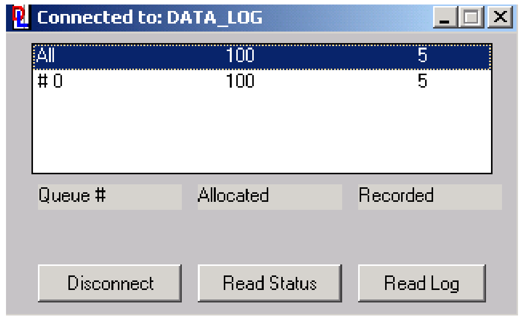
   FYI - By default the MicroLogix 1500 communications are configured for 19200 baud If using defaults select 19200 above, otherwise select the baud rate configured in the MicroLogix Channel Configuration Screen.

If a correct configuration has been selected the utility software will indicate that it has connected to the processor as shown below.



5. Click ***Read Status*** once a valid connection is established

The DLOG utility will now retrieve the status information from the ML1500 processor.



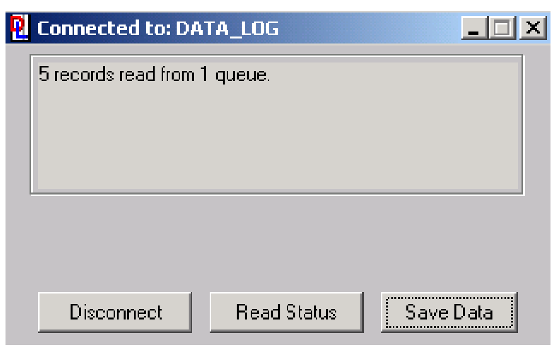
In this example you can see that Que#0 has 100 records allocated and 5 recorded.

IMPORTANT - If you do not see 5 records verify your *Data Logging Enable* bit was toggled 5 times causing the 5 entries to be recorded in the Que.

6. Select ***Read Log***. This will retrieve the data from the ML1500 processor

   FYI - Data **CANNOT** be viewed in the Data Log Utility. The utility only allows retrieval of the data stored in the Queues and creates an off-line file.

Once the Read Log has completed the following screen will appear confirming the number of records that have been read from the Queue(s)

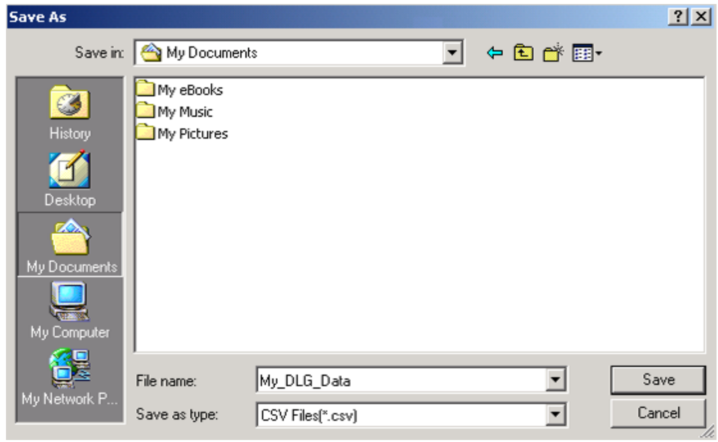


FYI - Remember that once the data records have been read from the MicroLogix the queue is automatically cleared.

7. Click ***Save Data.***

8. Enter a file name. In our example "My_DLG_Data" was used.

Make note of the filename about to be created and the directory it is being saved to for later reference.



9. Using Microsoft Excel open the data file that was created.

FYI - If you are unable to locate your file in Excel, remember "Files of type" must be changed to "Text Files" or "All files (*.*)" in order to locate your saved file.

(The headings for each column are not stored in the data file these were added for readability.)

QUE #	Date	Time	N10:0	N10:1	N10:2	N10:3	N10:4
Queue 0	5/1/2000	8:00:00	5	10	15	20	25
Queue 0	5/1/2000	8:00:02	5	10	15	20	25
Queue 0	5/1/2000	8:00:05	5	10	15	20	25
Queue 0	5/1/2000	8:00:07	5	10	15	20	25

Each time the DLG instruction receives a false-to-true transition another entry is saved in the Data Logging queue. The above data reflects that the DLG instruction was executed 5 times. The above data also reflects that no data points had changed during each DLG execution.

Frequently Asked Questions

Q1: Can I write my own software application to retrieve the data stored in the Data Logging queue?

A1: Yes - In the MicroLogix 1200/1500 Instruction Set Reference manual, under the Data Logging chapter, all the information necessary to create your own software application, for retrieving the data stored in the processors Data Logging queue, is shown.

Q2: Can the MicroLogix 1500 - LRP processor automatically send the information stored in the Data Logging queue directly to a printer?

A2: No - To retrieve the data either the free Data Logging Utility software must be used or a custom application must be created by the user. If the data does not need to be stored in the processor, but sent directly to a printer then use the ASCII instructions of the MicroLogix processor to send out the data.

Using the DATALOG Utility to retrieve data remotely via a Remote Access Modem Kit (RAD)

For more information on Remote Access Modem Kits visit…….. **http://support.rockwellautomation.com/modem/modem_Main.asp**

The following outlines the configuration and steps that can be used to read data log records from an MicroLogix 1500 (1764-LRP) controller remotely via a 1747CH0RAD (Remote Access Modem Kit)

This example assumes that the programmer has configured the DLG instruction in the ML1500 to log data and that HyperTerminal is installed, configured and the user is familiar with its use.

ESTABLISHING CONNECTIONS

1. Connect the modem to Channel 1 of the 1764-LRP

2. Configure Channel 1 (9-Pin) for DF1 Full Duplex, 9600 baud, no parity, and full duplex modem handshaking. This setting is critical, as the system will not communicate if *full duplex modem* handshaking isn't applied to the comms channel connected to the modem.

3. Configure HyperTerminal for direct connection to the PC COMM port the modem is connected to. Make sure the HyperTerminal connection is configured for 9600 baud.

4. Save configuration as “DataLog “.

5. Send the following dial-out string using HyperTerminal to dial the modem and establish the connection:

   AT&C1DT(Phone number of destination Modem) then *press enter*

   your modem will respond: **CONNECT 9600**

Once the connection is established, exit HyperTerminal by selecting File/Exit from the pull-down menu. When asked “Do you want to close connection” select Yes. This will only close the connection from HyperTerminal to the RS-232 port. The connection will remain active.

FYI - It will appear as though HyperTerminal has disconnected. It has not; the connection is still established only HyperTerminal is no longer running.

6. Open the Data Logging Utility.

7. Select in the DLG Utility the COMM port that the PC modem is configured for.

8. Click Connect.

DISCONNECTING MODEM

1. 1. Ensure the DLG Utility has been shutdown.

2. 2.Start HyperTerminal (Do not re-connect)

3. 3.Open the previously configured “Datalog “

4. Type “**+++”** to place modem in command mode,

   Do not press the ENTER KEY!

   Your modem will respond: **OK**

5. Type **“ATH** “

6. Press ***Enter***. This will send the disconnect command to modem.

Glossary

The following terms are used throughout this manual. Refer to the *Allen-Bradley Industrial Automation Glossary*, Publication Number AG-7.1, for a complete guide to Allen-Bradley technical terms.

address

A character string that uniquely identifies a memory location. For example, I:1/0 is the memory address for data located in Input file word 1, bit 0.

AIC+ Advanced Interface Converter

A device that provides RS-232 isolation to an RS-485 Half-Duplex communication link. (Catalog Number 1761-NET-AIC.)

application

1) A machine or process monitored and controlled by a controller. 2) The use of computer- or processor-based routines for specific purposes.

ASCII

American Standard Code for Information Interchange. A standard for defining codes for information exchange between equipment produced by different manufacturers. The basis of character sets used in most microcomputers; a string of 7 binary digits represents each character.

baud rate

The speed of communication between devices. Baud rate is typically displayed in *K baud*. For example, 19.2K baud = 19,200 bits per second.

bit

The smallest unit of memory used in discrete or binary logic, where the value 1 represents ON and 0 represents OFF.

block diagrams

A method used to illustrate logic components or a sequence of events.

Boolean operators

Logical operators such as AND, OR, NAND, NOR, NOT, and Exclusive-OR that can be used singularly or in combination to form logic statements or circuits. Can have an output response of T or F.

branch

A parallel logic path within a rung of a ladder program. Its primary use is to build OR logic.

communication scan

A part of the controller's operating cycle. Communication with devices (such as other controllers and operator interface devices) takes place during this period.

control program

User logic (the application) that defines the controller's operation.

controller

A device, such as a programmable controller, used to control output devices.

controller overhead

A portion of the operating cycle used for housekeeping purposes (memory checks, tests, communications, etc.).

control profile

The means by which a controller determines which outputs turn on under what conditions.

counter

A device that counts the occurrence of some event.

CPU (Central Processing Unit)

The decision-making and data storage section of a programmable controller.

data table

The part of processor memory that contains I/O status and files where user data (such as bit, integer, timers, and counters) is monitored, manipulated, and changed for control purposes.

DIN rail

Manufactured according to Deutsche Industrie Normenausshus (DIN) standards, a metal railing designed to ease installation and mounting of your devices.

download

The transfer of program or data files to a device.

DTE

Data Terminal Equipment

EMI

Electromagnetic interference.

embedded I/O

Embedded I/O is the controller's on-board I/O. For MicroLogix controllers, embedded I/O is all I/O residing at slot 0.

expansion I/O

Expansion I/O is I/O that is connected to the controller via a bus or cable. MicroLogix 1200 controllers use Bulletin 1762 expansion I/O. MicroLogix 1500 controllers use Bulletin 1769 expansion I/O. For MicroLogix controllers, embedded I/O is all I/O residing at slot 1 and higher.

encoder

A device that detects position, and transmits a signal representing that position.

executing mode

Any run or test mode.

false

The status of an instruction that does not provide a continuous logical path on a ladder rung.

FET

Field Effect Transistor. DC output capable of high-speed operation.

FIFO (First-In-First-Out)

The order that data is stored and retrieved from a file.

file

A collection of data or logic organized into groups.

full-duplex

A mode of communication where data may be transmitted and received simultaneously (contrast with half-duplex).

half-duplex

A mode of communication where data transmission is limited to one direction at a time.

hard disk

A storage device in a personal computer.

high byte

Bits 8 to 15 of a word.

housekeeping

The portion of the scan when the controller performs internal checks and services communications.

input device

A device, such as a push button or a switch, that supplies an electrical signal to the controller.

input scan

The controller reads all input devices connected to the input terminals.

inrush current

The temporary surge of current produced when a device or circuit is initially energized.

instruction

A mnemonic defining an operation to be performed by the processor. A rung in a program consists of a set of input and output instructions. The input instructions are evaluated by the controller as being true or false. In turn, the controller sets the output instructions to true or false.

instruction set

The set of instructions available within a controller.

I/O

Input and Output

jump

Changes the normal sequence of program execution. In ladder programs a JUMP (JMP) instruction causes execution to jump to a specific rung in the user program.

ladder logic

A graphical programming format resembling a ladder-like diagram. The ladder logic programing language is the most common programmable controller language.

least significant bit (LSB)

The element (or bit) in a binary word that carries the smallest value of weight.

LED (Light Emitting Diode)

Used as status indicator for processor functions and inputs and outputs.

LIFO (Last-In-First-Out)

The order that data is stored and retrieved from a file.

low byte

Bits 0 to 7 of a word.

logic

A general term for digital circuits or programmed instructions to perform required decision making and computational functions.

Master Control Relay (MCR)

A hard-wired relay that can be de-energized by any series-connected emergency stop switch.

mnemonic

A simple and easy to remember term that is used to represent a complex or lengthy set of information.

Modbus™ RTU Slave

A half-duplex serial communication protocol.

modem

Modulator/demodulator. Equipment that connects data terminal equipment to a communication line.

modes

Selected methods of operation. Example: run, test, or program.

negative logic

The use of binary logic in such a way that “0” represents the desired voltage level.

network

A series of stations (nodes) connected by some type of communication medium. A network may be made up of a single link or multiple links.

nominal input current

The typical amount of current seen at nominal input voltage.

normally closed

Contacts on a relay or switch that are closed when the relay is de-energized or deactivated. They are open when the relay is energized or the switch is activated.

normally open

Contacts on a relay or switch that are open when the relay is de-energized or the switch is deactivated. They are closed when the relay is energized or the switch is activated.

off-delay time

The OFF delay time is a measure of the time required for the controller logic to recognize that a signal has been removed from the input terminal of the controller. The time is determined by circuit component delays and by any applied filter.

offline

When a device is not scanning/controlling or when a programming device is not communicating with the controller.

offset

A continuous deviation of a controlled variable from a fixed point.

off-state leakage current

When a mechanical switch is opened (off-state), no current flows through the switch. Semiconductor switches and transient suppression components which are sometimes used to protect switches, have a small current flow when they are in the off state. This current is referred to as the off-state leakage current. To ensure reliable operation, the off-state leakage current rating must be less than the minimum operating current rating of the device that is connected.

on-delay time

The ON delay time is a measure of the time required for the controller logic to recognize that a signal has been presented at the input terminal of the controller.

one shot

A programming technique that sets a bit ON or OFF for one program scan.

online

When a device is scanning/controlling or when a programming device is communicating with the controller.

operating voltage

For inputs, the voltage range needed for the input to be in the On state. For outputs, the allowable range of user-supplied voltage.

output device

A device, such as a pilot light or a motor starter coil, that receives a signal or command from the controller.

output scan

The controller turns on, off, or modifies the devices connected to the output terminals.

PCCC

Programmable Controller Communications Commands

processor

A Central Processing Unit. (See CPU.)

processor files

The set of program and data files resident in the controller.

program file

Areas within a processor that contain the logic programs. MicroLogix controllers support multiple program files.

program mode

When the controller is not scanning the control program.

program scan

A part of the controller's operating cycle. During the program scan, the logic program is processed and the Output Image is updated.

programming device

Programming package used to develop ladder logic diagrams.

protocol

The rules of data exchange via communications.

read

To acquire data. For example, the processor reads information from other devices via a read message.

relay

An electrically operated device that mechanically switches electrical circuits.

relay logic

A representation of binary or discrete logic.

restore

To transfer a program from a device to a controller.

reserved bit

A location reserved for internal use.

retentive data

Information (data) that is preserved through power cycles.

RS-232

An EIA standard that specifies electrical, mechanical, and functional characteristics for serial binary communication circuits.

run mode

An executing mode during which the controller scans or executes the logic program.

rung

A rung contains input and output instructions. During Run mode, the inputs on a rung are evaluated to be true or false. If a path of true logic exists, the outputs are made true (energized). If all paths are false, the outputs are made false (de-energized).

RTU

Remote Terminal Unit

save

To save a program to a computer hard disk.

scan

The scan is made up of four elements: input scan, program scan, output scan, and housekeeping.

scan time

The time required for the controller to complete one scan.

sinking

A term used to describe current flow between two devices. A sinking device provides a direct path to ground.

sourcing

A term used to describe current flow between two devices. A sourcing device or circuit provides a power.

status

The condition of a circuit or system.

terminal

A point on an I/O module that external devices, such as a push button or pilot light, are wired to.

throughput

The time between when an input turns on and a corresponding output turns on or off. Throughput consists of input delays, program scan, output delays, and overhead.

true

The status of an instruction that provides a continuous logical path on a ladder rung.

upload

Data is transferred from the controller to a programming or storage device.

watchdog timer

A timer that monitors a cyclical process and is cleared at the conclusion of each cycle. If the watchdog runs past its programmed time period, it causes a fault.

write

To send data to another device. For example, the processor writes data to another device with a message write instruction.

D

L

M

W

X

Z

MicroLogix 1200 and 1500 List of Instructions and Function Files

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