Allen-Bradley

FLEX Ex HART Analog Modules

1797-IE8H, 1797-OE8H

User 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://literature.rockwellautomation.com) 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.

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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.
IMPORTANT	Identifies information that is critical for successful application and understanding of the product.
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
SHOCK HAZARD	Labels may be located on or inside the equipment to alert people that dangerous voltage may be present.
BURN HAZARD	Labels may be located on or inside the equipment to alert people that surfaces may be dangerous temperatures.

What's Changed

The following table lists items changed since the last printing.

Changes	See
Removed the word bit in Command 12	B-2
Removed the word bit in Command 17	B-2
Added Device-specific Commands	B-3 to B-24

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

Notes:

Chapter 3

How to Install Your FLEX Ex Analog Modules

Chapter 4

Input, Output and Configuration Files for the Analog I/O Modules on the ControlNet Network

Chapter 5

Calibrate Your Module

Chapter 6

Apply FLEX Ex Analog I/O Modules

Appendix E

Configure the 1797-IE8H Module in RSLogix 5000 Software Over the ControlNet Network

Appendix F

FLEX Ex HART Modules Network Messaging

Index

Why Read This Manual

This manual shows you how to use your FLEX Ex analog modules with the ControlNet Ex products and ControlNet network. The manual helps you install, program, and troubleshoot your module.

Who Should Read This Manual

You must be able to program and operate a ControlNet Ex product and ControlNet network to make efficient use of a FLEX Ex module.

About the Vocabulary

In this manual, we refer to the:

- 1797-IE8H as the input module
- 1797-OE8H as the output module

What This Manual Contains

The following chart lists each chapter with its corresponding title and a brief overview of the topics covered in that chapter.

Chapter	Title	Contents
1	About the FLEX Ex HART Analog Modules	Describes module functionality and physical features
2	Understand Configurable FLEX Ex Analog Module Features	Describes configurable module features and configuration bits
3	How to Install Your FLEX Ex Analog Modules	How to install and wire the modules
4	Input, Output and Configuration Files for the Analog I/O Modules on the ControlNet Network	Describes how to use these I/O modules over the ControlNet network
5	Calibrate Your Module	Lists the tools needed, and the methods used to calibrate the module
6	Apply FLEX Ex Analog I/O Modules	Describes how FLEX Ex is different from traditional control systems
7	Troubleshoot the FLEX Ex Analog I/O Modules	How to use the indicators to troubleshoot your module
Appendix	**Title**	**Contents**
A		Outlines module specifications and accuracy
B		Explains how to program the analog modules
C	Additional HART Protocol Information	Discusses the HART protocol and provides references for additional information.

D	Configure the 1797-OE8H Module in RSLogix 5000 Software Over the ControlNet Network	Provides the information necessary to configure the 1797-OE8H analog output module.
E	Configure the 1797-IE8H Module in RSLogix 5000 Software Over the ControlNet Network	Provides the information necessary to configure the 1797-IE8H analog input module.
F	FLEX Ex HART Modules Network Messaging	Discusses how to communicate with the HART modules via the MSG or CIO instruction, differences between attributes and assembly indexes, and enhancements to the HART frame.

For Additional Information

For additional information on FLEX Ex systems and modules, refer to the following documents.

Catalog Number	Description	Publications	
		Installation Instructions	User Manual
1797 Series	FLEX Ex Selection Guide	1794-SG002	
1797 Series	ControlNet Ex System Cable Guide	1797-6.2.1	
1797-TB3	FLEX Ex Terminal Base	1797-5.1	
1797-TB3S	FLEX Ex Spring Clamp Terminal Base		
1797-OE8H	FLEX Ex HART 8 Output Analog Module	1797-5.3	1797-6.5.3
1797-IRT8	FLEX Ex RTD/Thermocouple/mV Module	1797-5.4	1797-6.5.2
1797-IE8H	FLEX Ex HART 8 Input Analog Module	1797-5.5	1797-6.5.3
1797-OB4D	4 Output Module	1797-5.6	
1797-IBN16	FLEX Ex NAMUR Digital Input Module	1797-5.7	
1797-PS2E2	FLEX Ex Power Supply	1797-5.8	
1797-IJ2	2 Frequency Input Module	1797-5.9	1797-6.5.4
1797-PS2N2	FLEX Ex Power Supply	1797-5.12	
1797-BIC	FLEX Ex Bus Isolator	1797-5.13	
1797-CEC	FLEX Ex Flexbus Connector		
1797-ACNR15	ControlNet Ex Adapter	1797-5.14	1797-6.2.1
1797-RPA, -RPFM	Fiber Hub	1797-5.15	
1797-TPR, -TPRS, -TPYR, -TPYS	FLEX Ex Taps	1797-5.18	
1797-CE1S, -CE3S, -CEFTN, -CEFTE	Interconnect Cables	1797-5.20	
1797-EXMK	Marker Kit	1797-5.23	
1797-PS1E	FLEX Ex Power Supply	1797-5.33	
1797-PS1N	FLEX Ex Power Supply	1797-5.34	
1797-BCNR	FLEX Ex Redundant ControlNet Barrier Module	1797-5.35	

About the FLEX Ex HART Analog Modules

What This Chapter Contains

Read this chapter to familiarize yourself with the input and output analog modules.

What the FLEX Ex Analog I/O Modules Do

The 1797-IE8H module accepts up to 8 analog inputs. The inputs are non-isolated and will accept current in either of the following two ranges: 4 to 20 mA or 0 to 20mA. The default input range is 0 to 20 mA. The inputs have both fixed hardware filters and selectable firmware digital filters.

Similarly, the 1797-OE8H module provides as many as eight analog outputs. The outputs are nonisolated and will provide current in either of the following two ranges: 4 to 20 mA or 0 to 20 mA. The default output range is 0 to 20 mA.

Each module offers host of features including:

- Local microprocessor intelligence for advanced features
- Full functionality without switches or jumpers
- Multiple data ranges that can be independently programmed in channel groups
- Lead breakage detection
- Overrange/underrange alarms
- Remote transmitter alarm

How FLEX Ex Analog Modules Communicate with Programmable Controllers

FLEX Ex analog I/O modules provide best utility when used with ControlNet Ex products on the ControlNet network. Data connections are established between the I/O module and an Allen-Bradley programmable controller to transfer information between the two at a scheduled rate.

Input module information is then automatically made available in the PLC data table through the data connection. Reciprocally, output data information determined by the PLC program is also automatically transferred from the PLC data table to the output module through the data connection.

In addition, when the data connection is originally established, configuration information for the module is automatically transferred to it via the network.

Events After Cycling Power

You must apply intrinsically safe +/-V power to your FLEX Ex analog I/O modules. The following sequence of events occurs after power has initially been applied to your module:

- The module begins an internal diagnostic check. The channel 0 LED indicator turns ON to indicate the check has begun. The indicator turns OFF when the check is finished.
- After the diagnostic check, module configuration information, selected by the user and downloaded over the network, is applied by the module.

  For more information on configuration options, see Chapter 2.

- Following the module configuration download for the **1797-IE8H module**, the module begins producing runtime data for the PLC.
- Following the module configuration download for the **1797-OE8H module**, the module applies configuration data to output channels.
- If any diagnostics or alarms are generated during normal module operation, the data is returned to the PLC controller.

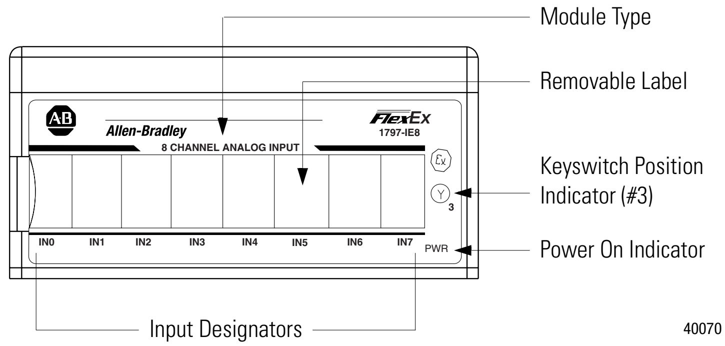
Physical Features of Your Analog I/O Module

The module label identifies the keyswitch position, wiring and module type. Use the removable label to note individual designations per your application.

Indicators

Indicators are provided to identify input or output fault conditions, and to show when power is applied to the module. For example, the 1797-IE8H module is shown below.

1797-IE8H



Using Alarms on the 1797-IE8H Module

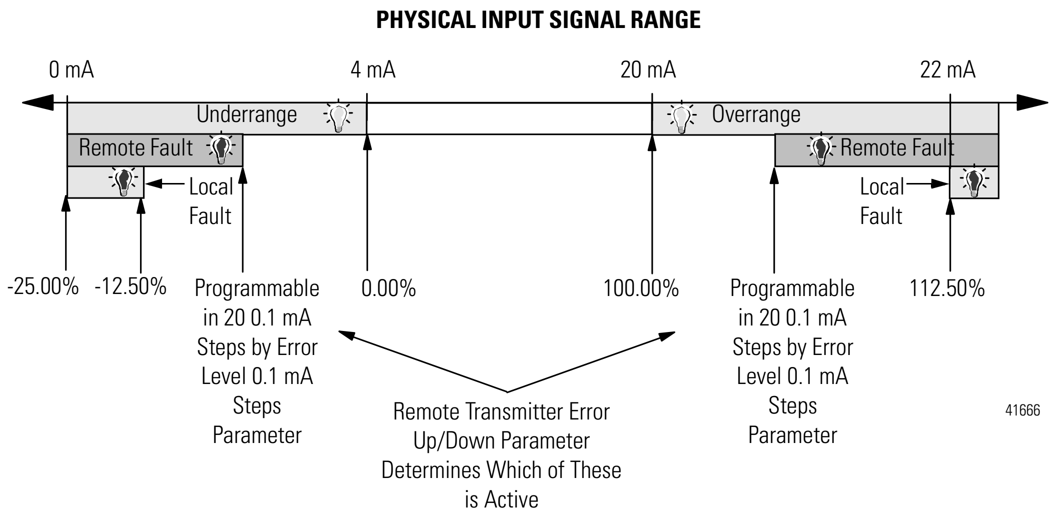
The 1797-IE8H FLEX Ex module is capable of generating four alarms:

- Underrange
- Overrange
- Remote Fault
- Local Fault

These alarm conditions are described in general terms and as they relate to bits on the FLEX Ex I/O module on the following pages. The following graphic shows at what values these alarms are generated for Data Format 4.

Data Format Alarm Example

In this example, the normal active data range is 4 to 20 mA. The alarms are generated in three overlapping bands.



Overrange Alarm

The Overrange alarm notifies you when module input is overrange. When the input signal exceeds 100% (20 mA), an Overrange Alarm is generated.

This alarm stays active at any value above 100% of range and is always enabled by the module.

Underrange Alarm

The Underrange alarm works in a fashion converse to the overrange. This feature notifies you when the input signal falls underrange. If the input signal falls below 0% (4 mA), an Underrange Alarm is generated.

This alarm stays active at any value below 0% of range and is always enabled by the module.

Remote Fault Alarm

The Remote Fault Alarm is primarily intended for use with remote transmitter loops.

For example, the remote transmitter may be measuring temperature and converting it to a standard mA signal. In such a loop, though, the input module cannot determine the state of the loop on the far side of the transmitter. However, the remote transmitter may be capable of diagnosing a problem in the remote loop and signal the input module local loop with a preprogrammed out of range (high or low) value.

The Remote Fault Alarm allows the 1797-IE8H module to work with transmitters like the one just described. You must use the Remote Transmitter Error Up or Down feature, see page 2-3, to configure your application for Remote Fault notification.

For example, you must determine if you want a remote fault to cause high out of range values or low out of range values to be returned to the controller.

IMPORTANT	Once the alarm is issued, it remains active as long as the input signal value remains above the programmed value.

Use Remote Fault Alarm to Determine High High or Low Low Alarm Levels

If you do not have a remote transmitter in your loop, this alarm can also be used to program a high high or low low alarm level between the levels which actuate the overrange or underrange alarms and the high or low local fault alarms.

IMPORTANT	When establishing high high or low low alarms, you can only select one side (high or low). You must use the Remote Transmitter Error Up or Down feature in conjunction with this alarm.

Program the Remote Fault Alarm

For the Remote Fault alarm, you must program the threshold in 0.1 mA steps at any level on the high or low end of input signal range. The Remote Fault alarm activates if your I/O module receives input signal values of:

- 100.63% (20.1 mA) to 111.88% (21.9 mA) on the high end of input signal range

  or

- -0.63% (3.9 mA) to -11.88% (2.1 mA) on the low end of input signal range

IMPORTANT	This alarm is only active for one band, either on the high side of normal operation or the low side.The Remote Transmitter Error Up/Down parameter determines which side is active. See page 2-3 for a description of the Remote Transmitter Error Up/Down feature.

Local Fault Alarm

The Local Fault alarm notifies you when the loop to the transmitter or field device, if no transmitter is used, is open or shorted.

IMPORTANT	Once the alarm is issued, it remains active as long as the input signal value remains in the programmed range.

- 112.50% (22 mA) or higher on the high end of input signal range - This value indicates a short in the loop.

  or

- -12.50% (2 mA) or lower on the low end of input signal range
  - This value indicates an open wire condition in the loop.

The Remote Fault and Local Fault alarms are issued with the same bit whether the cause is an under or overrange. Monitor the Overrange and Underrange bits in your programming software to determine if the problem is a high current or low current.

How to Use the HART Capabilities

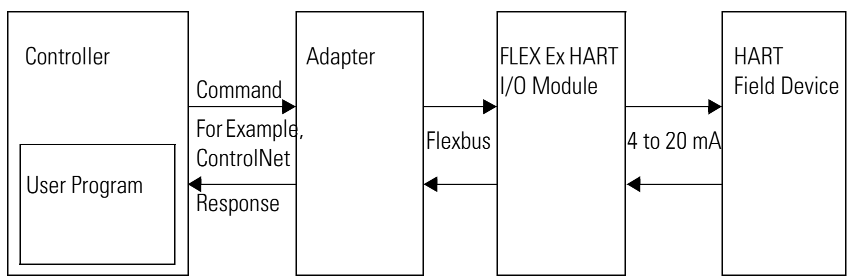
Before using the HART capabilities, be sure that:

- the I/O module and the associated field device are working properly in the analog 4 to 20 mA mode.
- the I/O module is configured for 4 to 20 mA range.
- the field device is HART capable.
- no more than one HART field device is connected to each channel.
- input filtering is set to a valid (defined) value.

HART Implementation Overview

The FLEX Ex HART modules act as intelligent HART multiplexers. Basically, the module learns which HART devices are attached to its channels and then routes HART messages, as appropriate, between the HART field devices and the Flexbus. Since the HART modules act as intelligent HART multiplexers, HART commands can be issued to the HART modules themselves.

Communication on the Flexbus occurs between the adapter and the HART module. The adapter converts these messages to the appropriate network format for communication with the controlling controller. The controlling controller gets its command from the user program, storing the responses in its memory.



In its basic form, your ladder-logic program issues an MSG instruction containing a HART command. The MSG instruction is routed to the appropriate adapter and FLEX Ex I/O module. Upon receiving the message, the HART module routes the message to the appropriate channel and gathers the HART field device response. To retrieve this response, your ladder-logic program issues another MSG instruction.

HART Commands

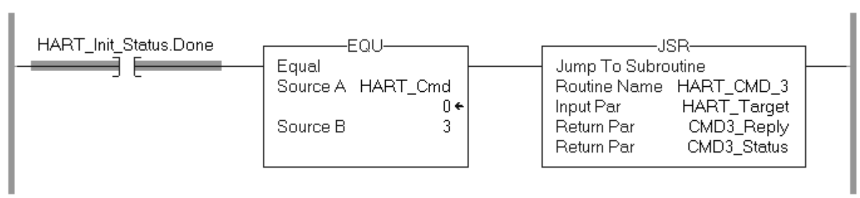
Building a usable HART command for the MSG instruction involves an understanding of how to create a standard HART command plus the additional knowledge of how to pack the message into a ControlNet frame. To simplify this process, you can download the ladder-logic program discussed here at http://www.ab.com/io. This ladder-logic program consists of a main program and several subroutines. Modify the main program to meet your application needs.

The first routine is HART_initialize. Use this routine after a power cycle or reset to enable HART functionality on a specific FLEX Ex HART module and to rebuild the associated HART loops to its field device(s). Once a FLEX Ex HART module is initialized, it remembers the HART addresses of the field devices and associates them to their corresponding analog channel. This routine calls the Get_Status_with_retry subroutine to poll an answer from the target I/O module.

The second routine is Send_Hart_SF. This routine accepts a generic HART message to a specific I/O channel and returns a generic HART response. This routine calls the Get_Message_with_retry subroutine to poll a response from the target I/O module.

The third routine is Purge. If a communication error is found, this routine is called to empty the HART buffer in the FLEX Ex HART I/O module.

Use the remaining routines to execute specific HART commands. Each routine is dedicated to its associated HART command. For example, the HART_CMD_3 issues a HART command 3 to the specified target device.



To issue a HART command, after the FLEX Ex HART I/O module is initialized, fill the tag HART_Target with the associated information to uniquely describe the path to the target. If the HART command requires information to be send to the target device, then fill a second tag with the appropriate information.

For example, to send a HART command 3, fill the HART_Target tag. As this is a HART read command, no other information is necessary. To send a HART command 35, fill the HART_Target tag. As this is a HART write command, also fill the CMD35_cmd tag with appropriate data.

HART Target Tags

The HART_Target tag consists of four members:

- Path — HART_Target.Path

  The Path specifies the direction the message follows to get to the desired target node. The data type is string.

- Slot — HART_Target.Slot

  The Slot indicates the specific place where the I/O module is attached to the FLEX Ex adapter. The data type is SINT.

  1 = the closest module to the adapter

  8 = the module farthest from the adapter

  0 = the adapter

- Channel

  The Channel indicates which analog channel, 0 to 7, is desired. The data type is SINT.

- Host_Group

  The FLEX Ex HART modules have two message-access ports into them allowing two systems to gather information from the module concurrently. The data type is SINT.

  The HART_Groups are numbered either 1 or 2. If there are no other systems accessing the FLEX Ex Hart I/O module, that is, an asset management system, then select the first HART_Group by setting this value to 1.

IMPORTANT If multiple owners access or control the same FLEX Ex HART I/O module and field device, they must maintain identical configurations.

HART Command Tags

The response from the HART command routines is located in their associated reply tags:

- CMDx_Status (x is the specific command)

Table 1.1 CMDx_Status Tags

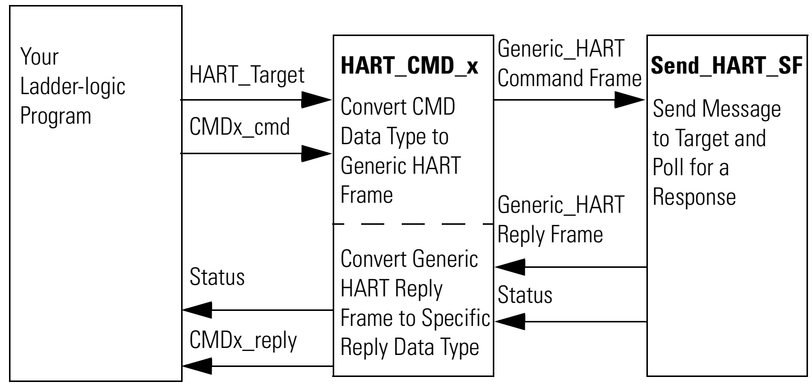
Tag Name	Description	Data Type
CMDx_Status.Started	Indicates when the command is in process	BOOL
CMDx_Status.Done	Indicates when the command has completed without error	
CMDx_Status.Error	Indicates when the command has completed with error	
CMDx_Status.Error_Code	If the CMDx_Status.Error bit is set, the associated error code is placed here	INT
CMDx_Status.Cmd_Performed	If the CMDx_Status.Done bit is set, the tag containing the HART command performed is placed here	

- CMDx_Reply (x is the specific command)

  This tag is only returned when the specific HART command has data in its reply. The CMDx_Reply tag contains the HART response reformatted to their associated data type.

Table 1.2 CMD3_Reply Tags Example

Tag Name	Description	Data Type
CMD3_Reply.Current_mA	The measured current value	REAL
CMD3_Reply.PV_Units_Code	The units code for the primary value	INT
CMD3_Reply.Primary_Value	The primary value	REAL
CMD3_Reply.SV_Units_Code	The units code for the secondary value	INT
CMD3_Reply.Secondary_Value	The secondary value	REAL
CMD3_Reply.TV_Units_Code	The units code for the third value	INT
CMD3_Reply.Third_Value	The third value	REAL
CMD3_Reply.FV_Units_Code	The units code for the fourth value	INT
CMD3_Reply.Fourth_Value	The fourth value	REAL



HART Initialize Tags

The HART_Target tag consists of four members:

- Path — HART_Target.Path

  The Path specifies the direction the message follows to get to the desired target node. The data type is string.

- Slot — HART_Target.Slot

  The Slot indicates the specific place where the I/O module is attached to the FLEX Ex adapter. The data type is SINT.

  1 = the closest module to the adapter

  8 = the module farthest from the adapter

  0 = the adapter

- Channel

  The Channel indicates which analog channel, 0 to 7, is desired. The data type is SINT.

- Host_Group

  The FLEX Ex HART modules have two message-access ports into them allowing two systems to gather information from the module concurrently.

  The HART_Groups are numbered either 1 or 2. If there are no other systems accessing the FLEX Ex Hart I/O module, that is, an asset management system, then select the first HART_Group by setting this value to 1. The data type is SINT.

IMPORTANT If multiple owners access or control the same FLEX Ex HART I/O module and field device, they must maintain identical configurations.

HART Initialize Channel Tags

The channel member of the HART_Target tag is a decimal number that indicates which channel is the target. The channels' member of the HART_initialize tag consists of eight one bit flags.

Ch 7	Ch 6	Ch 5	Ch 4	Ch 3	Ch 2	Ch 1	Ch 0

0 = Search for a HART Field Device on the Associated Channel

1 = Disables Searching for a HART Field Device on the Associated Channel

IMPORTANT To make the HART_initialize routine run effectively, only enable channels with active HART field devices.

Table 1.3 HART_Init_Status Tags

Tag Name	Description	Data Type
HART_Init_Status.Started	Indicates when the command is in process	BOOL
HART_Init_Status.Done	Indicates when the command has completed without error	
HART_Init_Status.Error	Indicates when the command has completed with error	
HART_Init_Status.Error_Code	If the CMDx_Status.Error bit is set, the associated error code is placed here	INT
HART_Init_Status.HART_Channels_Found	If the CMDx_Status.Done bit is set, the tag containing the list of channels with active HART field devices	

When these tags are initialized, a JSR to the HART_initialize routine is performed.

Modify Your Ladder-Logic Routine

With this background information, it is now time to modify the routine to meet the needs of your application. To do so, perform the following steps:

1. Make sure your wiring is correct and make note of your node address, the slot location of the FLEX Ex HART I/O module and the channel with your field device.
2. Load the program into Logix5000 software.
3. Modify the members of the HART_initialize tag to match your setup.
4. Modify the members of the HART_Target tag to match your setup.
5. If you plan to use a HART write command, which requires data to be sent to the field device, modify the associated CMDx_cmd tag with the associated data.
6. Download the program to the ControlLogix controller.

7. Place the controller into RUN mode.

   This assumes you will re-write the Main Routine to meet your application.

8. Refer to the following list of error codes if an error is returned from one of the following routines:

Table 1.4 HART_Initialize Routine

Error Code	Description
-1	Could not enable HART LEDs
-2	Could not rebuild HART loops
-3	Routine timed out
-4	Could not get status from Rebuild HART Loops command

Table 1.5 HART_CMD_x Routine

Error Code	Description
-1	Invalid slot number
-2	Invalid expected data size
-3	Invalid Host Group number
-4	Could not get a response

Once you have modified your ladder-logic routine, the ladder logic will now call the HART_initialize routine. The yellow LEDs on the associated channels of the selected FLEX Ex HART module will start to flash. This indicates that the module has received the command and is in the process of searching for HART field devices on the associated channels. Upon successful completion of the HART_initialize routine, the HART_Init_Status_Done flag is set. At this point, the ladder logic will examine the contents of the HART_Cmd tag and attempt to issue the HART command associated with the decimal number contained in this tag. Any HART replies are placed in their associated CMDx_reply tag. To issue a different command, change the value of the HART_Cmd tag to match the desired HART Command.

Selecting the Correct Path

The Path is a string that specifies the direction the message follows to get to a desired node. The MSG instruction requires a specific format for the string, consisting of a number sequence with each number separated by a $ sign. The message sequence is performed in sequential order from the perspective of the controller.

EXAMPLE

A path of $01$03$02$05 is interpreted as:
$01 = Go out the backplane port of the 1756 controller
$03 = Go to the module in slot 3 of the 1756 chassis(1)
$02 = Go out the front communications port of the module
$05 = Go to node address 5

(1) Assume that a 1756-CNB is in slot 3.

If you are using a ControlLogix system, the numbers $01 and the $02 will usually be in these sequence locations. The $03 may vary depending on the slot location of your network module. The $05 will vary according to your target address. If you need to bridge to other networks, then additional numbers will be needed in the sequence. For more details on this method, search in the Logix5000 Help.

Chapter Summary

In this chapter, you learned about FLEX Ex analog I/O modules and HART module capabilities. Move on to Chapter 2 to learn about configurable features on your module.

Notes:

Understand Configurable FLEX Ex Analog Module Features

What This Chapter Contains

Read this chapter to familiarize yourself with configurable features on the input and output analog modules.

HART configurable features described in this chapter include:

Table 2.1 Analog/Digital Configurable Features on the FLEX Ex Analog I/O Modules

1797-IE8H Input Module Features	1797-OE8H Output Module Features
Fault Mode	Output Enable
Remote Transmitter Error Up or Down	Module Fault State Mode
High Low Error Level	Local Fault Mode
Input Filter Cutoff	Digital Output
Data Format	Latch Retry Mode
	Global Reset
	Analog Digital State
	Analog Fault State
	Digital Fault State
	Data Format
	Fault Alarm

IMPORTANT You must use the I/O configuration portion of your PLC programming software to select and configure these features. This manual assumes familiarity with the programming software. A brief description of each module feature is provided here. For more information on your programming software, see the software user manual.

Selecting a 1797-IE8H FLEX Ex Analog Input Module's Operating Features

All features of the 1797-IE8H analog input module are independently configurable in two four-channel groups (channels 0 to 3 & channels 4 to 7).

IMPORTANT The default selection value for all parameters is 0.

Fault Mode

Your input modules are capable of indicating various fault conditions, depending on the input signal value. Use the Fault Mode feature to enable or disable two alarms:

- Remote Fault alarm
- Local Fault alarm

Use your programming software to set the Fault Mode bit to 0 to disable these alarms. Set the bit to 1 to enable them.

IMPORTANT Fault Mode will only enable or disable the Remote and Local Fault alarms. It does not affect the Underrange and Overrange alarms. They are always active.

For more information on the Remote Fault Alarm, see page 1-5. For more information on the Local Fault Alarm, see page 1-6.

Remote Transmitter Error Up or Down

A second feature of your input modules that affects use of the Remote Fault alarm is the Remote Transmitter Error Up or Down feature. Used in conjunction with the High Low Error level, this feature designates whether remote faults are displayed with input signal readings beyond the high or low signal levels normally used by the module.

When setting the Remote Transmitter Error Up or Down feature in your programming software, set this feature's bit to 0 to select up. Set the bit to 1 to select down.

For more information on the Remote Fault Alarm, see page 1-5. For more information on the Local Fault Alarm, see page 1-6.

High Low Error Level

High Low Error level sets the high and low signal levels at which your input modules will indicate a signal fault. This feature works in conjunction with the Remote Transmitter Error Up or Down.

If the Remote Fault Alarm feature is enabled and a remote fault occurs, the module will detect and report the fault, depending on how the High Low Error level is configured.

Use your programming software to set the high or low error levels.

Input Filter Cutoff

Eight available input filter settings allow you to choose the best rolloff frequency for input channels on your I/O module. When choosing a filter, remember that time filter selection affects your input signal's accuracy.

For example, if you choose the highest frequency of 10 Hz (filter 3), signal noise is more likely to affect the reading, but the slowest frequency of 0.5 Hz (filter 7) provides the most accurate signal due to incoming noise filtering.

See Table 2.2 to decide which input filter to use in your FLEX Ex analog I/O application:

Table 2.2 Input Filter Frequency

Filter	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Frequency	0.5 Hz (2 s)	1 Hz (1 s)	2 Hz (500 ms)	4 Hz (250 ms)	10 Hz (100 ms)	Reserved		

Choose the best input filter cutoff in your programming software.

Data Format

You must choose a module data format in your user program. Formats 8, 9, 10 and 15 are not used. If they are selected for a channel quad, a configuration fault will occur and will be reported as Diagnostic Data 2. All data for that channel quad will be set to zero (0).

- Formats 5, 12, 13 and 14 are 2's complement data formats, and will return data in that form.
- 12 Formats are available
- Default format is 0 to 20 mA
- The data format selected interprets input readings and returns them to the PLC controller

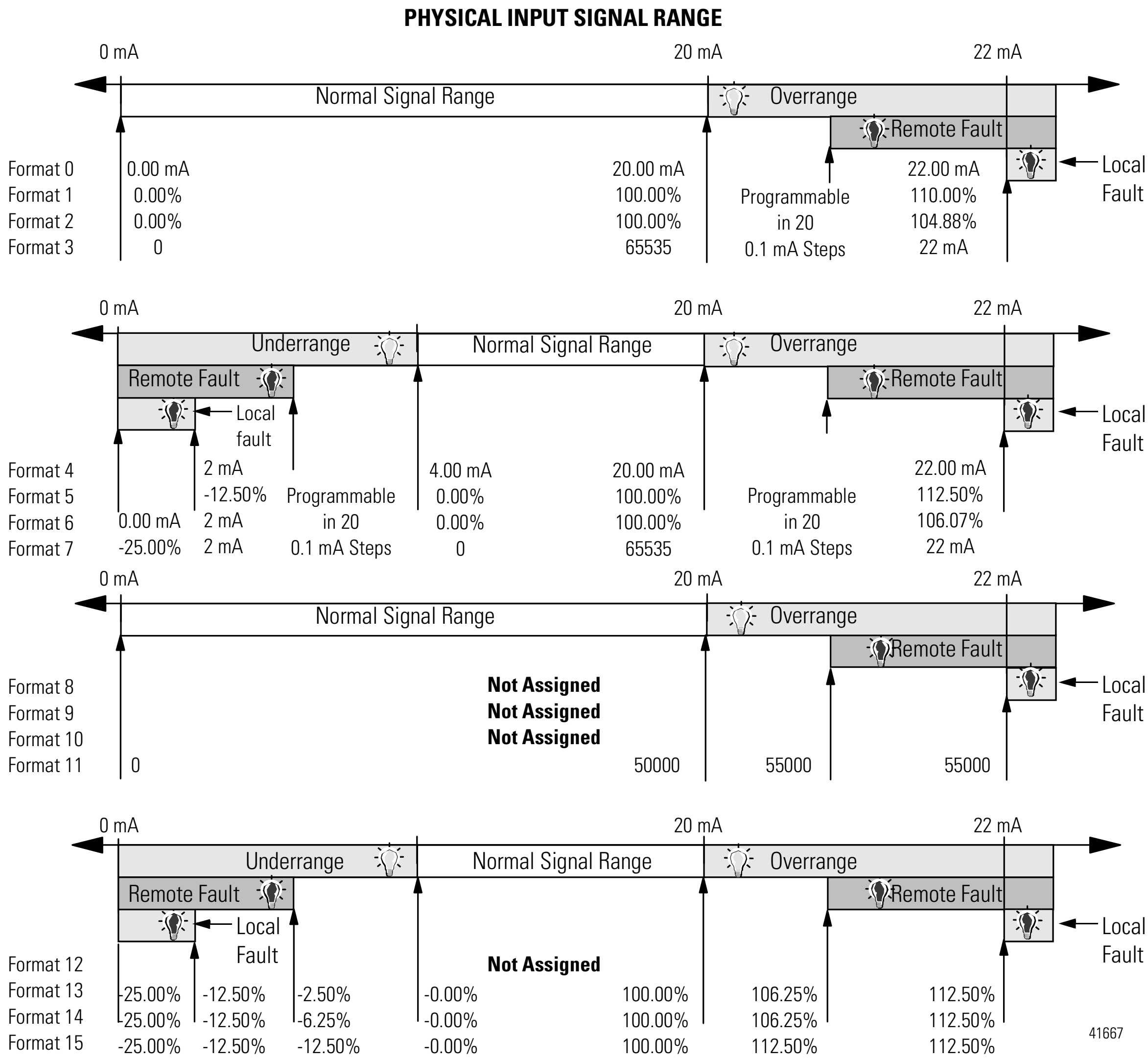
Table 2.3 1797-IE8H Data Formats

Data Format	Format	Resolution	Input Range	Module Data Processing	Data Table Value (Interpretation)	Count per mA	Error Steps
0	0…20 mA as mA	0.1% of 0…20 mA	0…22 mA	Datatable = 1000 (input)	0…22000 (0…22.000 mA)	1000	With error steps
1	0…20 mA as %	0.2% of 0…20 mA	0…22 mA	Datatable = 10000 $\left(\frac{\text{input}}{20}\right)$	0…11000 (0…110.00%)	500	
2	0…20 mA as √%	0.19% of 0…20 mA	0…22 mA	Datatable = 10000 $\sqrt{\frac{\text{input}}{20}}$ IF…Square_Root_Threshold < 10000 $\sqrt{\frac{\text{input}}{20}}$ Else…datatable = 0	0…10488 (0…104.88%)	524	
3	0…20 mA as unsigned integer	0.03% of 0…20 mA	0…20 mA	Datatable = 65535 $\left(\frac{\text{input}}{20}\right)$	0…65535 (0…22 mA)	3276	
4	4…20 mA as mA	0.1% of 4…20 mA	2…22 mA	Datatable = 1000 (input)	2000…22000 (2.000…22.000 mA)	1000	

Table 2.3 1797-IE8H Data Formats

Data Format	Format	Resolution	Input Range	Module Data Processing	Data Table Value (Interpretation)	Count per mA	Error Steps
5	4…20 mA as %	0.16% of 4…20 mA	2…22 mA	$\text{Datatable} = 10000\left(\frac{\text{input-4}}{16}\right)$	-1250…+11250 (2's complement) (-12.50% … +112.50%)	625	With error steps
6	4…20 mA as √%	0.17% of 4…20 mA	4…22 mA	$\text{Datatable} = 10000\sqrt{\frac{\text{input-4}}{16}}$ IF…Square_Root_Threshold $< 10000\sqrt{\frac{\text{input-4}}{16}}$ Else…datatable = 0	0…10607 (0…106.07%)	589	With error steps, under-range not allowed
7	4…20 mA as unsigned integer	0.03% of 4…20 mA	4…20 mA	$\text{Datatable} = 65535\left(\frac{\text{input-4}}{16}\right)$	0…65535 (4…20 mA)	4095	With error steps
8	Not assigned						
9							
10							
11	0…20 mA as A/D count	0.04% of 0…20 mA	0…22 mA	$\text{Datatable} = 55000\left(\frac{\text{input}}{22}\right)$	0…55000 (0…22 mA)	2500	All fixed
12	4…20 mA as %	0.16% of 4…20 mA	3.6…21 mA	$\text{Datatable} = 10000\left(\frac{\text{input-4}}{16}\right)$	-250…+10625 (2's complement) (-2.50… +106.25%)	625	NAMUR NE 4 all fixed
13	4…20mA as %	0.16% of 4…20 mA	3…21 mA	$\text{Datatable} = 10000\left(\frac{\text{input-4}}{16}\right)$	-625…+10625 (2's complement) (-6.25… +106.25%)		All fixed
14	4…20 mA as %	0.16% of 4…20 mA	2…22 mA	$\text{Datatable} = 10000\left(\frac{\text{input-4}}{16}\right)$	-1250…+11250 (2's complement) (-12.50… +112.50%)		
15	Not assigned						

Data Formats and Error Ranges



Selecting a 1797-OE8H FLEX Ex Analog Output Module's Operating Features

All features of the 1797-OE8H analog output module are independently configurable in two four-channel groups (channels 0 to 3 & channels 4 to 7).

IMPORTANT	The default selection value for all parameters is 0.

Local Fault Mode

The Local Fault Mode can be programmed to determine how the module responds to communications faults and internal module faults.

When setting the Local Fault Mode feature in your programming software, set this feature's bit to 0 to use the analog fault state or digital fault state only if a communications fault occurs. Set the bit to 1 to use the analog fault state or digital fault state if any fault occurs.

Latch Mode

Latch Mode determines channel operation under wire off or lead break fault conditions. This feature controls the operation of two channel groups, channels 0 to 3 and channels 4 to 7. Channel detection occurs on a continuous basis. If a fault is detected, the channel fault alarm is set.

If Latch Mode is enabled when a fault occurs, the fault will remain latched in its fault state until a Global Reset (see below) is issued. If Latch Mode is disabled when a fault occurs, the channel reports a fault until the fault is corrected. Global Reset is not necessary if Latch Mode is disabled.

When using your programming software, set the Latch Mode bit to 0 to disable the feature. Set the bit to 1 to enable it.

Global Reset

Global Reset works in conjunction with Latch Mode during fault conditions. If Latch Mode is enabled and a fault condition occurs, the channel operating with a fault remains in this condition (with analog or digital fault state implied) until a Global Reset is issued. The Global Reset feature resets all outputs of a particular channel group to accept normal system output data.

The Global Reset feature is an edge triggered signal. Use your programming software to set the Global Reset bit to 1 for normal operation. Resetting of outputs occurs during the 1 to 0 transition.

Analog Digital State

You can configure your FLEX Ex analog output modules to work in an analog mode or digital mode using the Analog Digital State feature. Depending on which state you choose for your application, additional parameters (see the descriptions of Analog Fault State and Digital Fault State on page 2-8) must be configured for your module to react to fault conditions.

Set the Analog Digital State bit in your programming software to 0 for your module to operate in an analog state. Set the bit to 1 for your module to operate in a digital state. A selection bit is available to each channel.

Analog Fault State

The Analog Fault State feature determines how your I/O module reacts to faults when a channel is used in analog mode. After a fault condition occurs, the module may got to minimum value, maximum value, hold last state or use analog fault state value.

Use your programming software to set the Analog Fault State bits on the I/O module for one of the following fault reactions:

- 0 = minimum value
- 1 = maximum value
- 2 = hold last state
- 3 = use analog fault state value

You can set these parameters independently for channels 0 to 1, 2 to 3, 4 to 5, 6 to 7.

Analog Fault State Value

Specifies the fault state value of the analog output data to the module. Specific format is controlled by the Module Data Format Control parameter. This data is used when the channel is in analog output mode and the analog fault state is configured to use analog fault state value.

Digital Fault State

The Digital Fault State feature determines how your I/O module reacts to faults when a channel is used in digital mode. After a fault condition occurs, the module may reset channel outputs or hold last state of the outputs.

Use your programming software to set the Digital Fault State bit to 0 to reset outputs. Set to 1 to hold last state of the outputs after a fault occurs. This feature is available on a per channel basis.

Data Format

You must choose a module data format in your user program. See 1797-OE8H Data Formats on page 2-10 for an explanation of each bit. Data Formats 2, 5, 6, 8, 9, 10, 12 and 15 are not assigned.

When choosing a data format, remember the following:

- If a non-assigned Analog Data Format is selected, the module sets Diagnostic Data to 2 for configuration failure and puts affected channels affected in the corresponding fault state.
- An unconfigured module channel pair can be assumed to have the default configuration Analog Data Format 0, 0 to 20 mA and Analog Mode Fault State minimum range. If a non-assigned format is selected, then the diagnostic 2 for configuration failure is set and the module channel pair goes to the default fault state minimum range.
- If the configuration had been changed, from the default, and then it was changed again to a non-assigned format, then the diagnostic bit 2 for configuration failure is set and the module goes to the fault state for the last valid configuration.
- Formats 13 and 14 are 2's complement data formats, and require data to the module in that form.
- Range: 0 to 15
- Default: 0
- Data Table Reference: data format, word 12 and 13, bits 0 to 3, bits 4 to 7

If data is sent to the module which is out of range, the value will be clipped and Diagnostic Data will be set to 11 data out of range.

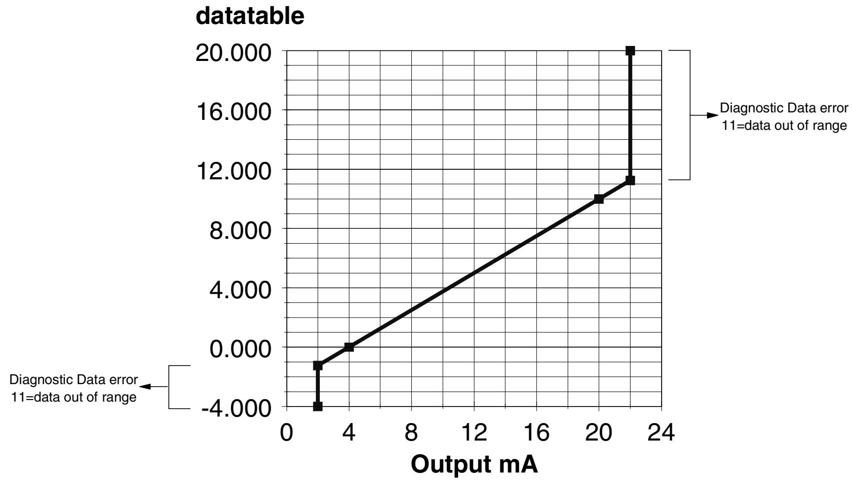


Table 2.4 1797-OE8H Data Formats

Data Format	Format	Resolution	Full Output Range	Module Data Processing	Data Table Value (Interpretation)	Count per mA	Analog Fault State
0	mA as 0…20 mA	0.1% of 0…20 mA	0…22 mA	$\text{Output} = \left(\frac{\text{datatable}}{1000}\right)$	0…22000 (0…22.000 mA)	1000	Min=0 mA Max=22 mA Hold last=hold 50%=11 mA
1	% as 0…20 mA	0.2% of 0…20 mA	0…22 mA	$\text{Output} = 20\left(\frac{\text{datatable}}{10000}\right)$	0…11000 (0…110.00%)	500	Min=0 mA Max=22 mA Hold last=hold 50%=11 mA
2	—	—	—	Not assigned	—	—	—
3	Unsigned integer as 0…20 mA	0.03% of 0…20 mA	0…20 mA	$\text{Output} = 20\left(\frac{\text{datatable}}{65535}\right)$	0…65535 (0…22 mA)	3276	Min=0 mA Max=20 mA Hold last=hold 50%=10 mA
4	mA as 4…20 mA	0.1% of 4…20 mA	2…22 mA	$\text{Output} = \left(\frac{\text{datatable}}{1000}\right)$	2000…22000 (2.000…22.000 mA)	1000	Min=2 mA Max=22 mA Hold last=hold 50%=12 mA
5	—	—	—	Not assigned	—	—	—
6							
7	Unsigned integer as 4…20 mA	0.03% of 4…20 mA	4…20 mA	$\text{Output} = 16\left(\frac{\text{datatable}}{65535}\right) + 4$	0…65535 (4…20 mA)	4095	Min=4 mA Max=20 mA Hold last=hold 50%=12 mA

Table 2.4 1797-OE8H Data Formats

Data Format	Format	Resolution	Full Output Range	Module Data Processing	Data Table Value (Interpretation)	Count per mA	Analog Fault State
8	—	—	—	Not assigned	—	—	—
9							
10							
11	D/A count as 0…20 mA	0.28% of 0…20 mA	0…22 mA	$\text{Output} = 22\left(\frac{\text{datatable}}{8000}\right)$	0…8000 (0…22 mA)	363	Min=0 mA Max=22 mA Hold last=hold 50%=11 mA
12	4…20 mA	—	—	Not assigned	—	—	—
13	% as 4…20 mA	0.16% of 4…20 mA	3…21 mA	$\text{Output} = 16\left(\frac{\text{datatable}}{10000}\right) + 4$	-625…+10625 (2's complement) (-6.25…+106.25 %)	625	Min=3 mA Max=21 mA Hold last=hold 50%=12 mA
14	% as 4…20 mA	0.16% of 4…20 mA	2…22 mA	$\text{Output} = 16\left(\frac{\text{datatable}}{10000}\right) + 4$	-1250…+11250 (2's complement) (-12.50…+112.50%)	625	Min=2 mA Max=22 mA Hold last=hold 50%=12 mA
15	—	—	—	Not assigned	—	—	—

Fault Alarm

Fault Alarm selects whether the channel pair fault detection is enabled or disabled. There is a 100 Hz (10 ms) filter for wire off/lead break detection.

Use your programming software to set the Fault Alarm. Set the feature bit to 0 to disable the alarm. Set the bit to 1 to enable wire off/lead break fault detection.

Understanding Image Table Mapping and Bit/Word Descriptions

Bit Descriptions

Use the table below to understand bits used in image table mapping and bit/word descriptions. Complete definitions of these feature documented below can be found in Chapter 2.

Table 2.5 Bit/Word Descriptions

Bit(s)	Location	Definition
Ch	1797-IE8H Input and output maps 1797-OE8H Input and output maps	Channel
Ovr Alm	1797-IE8H Input map	Overrange Alarm
Und Alm	1797-IE8H Input map	Underrange Alarm
Rm Flt	1797-IE8H Input map	Remote Fault
Lo Flt	1797-IE8H Input map	Local Fault
Res Flg	1797-IE8H Input map 1797-OE8H Input map	Response Flag
U/D	1797-IE8H Output map	Up/down
Flt Md	1797-IE8H Output map	Fault Module
Cd Flg	1797-IE8H Output map 1797-OE8H Output map	Command Flag
Flt Alm	1797-OE8H Input map	Fault Alarm
Glbl Rst	1797-OE8H Output map	Global Reset
Lo Flt Md	1797-OE8H Output map	Local Fault Module
Alg Flt Ste	1797-OE8H Output map	Analog Fault State
Lth Rty	1797-OE8H Output map	Latch Retry
Dig Flt Ste	1797-OE8H Output map	Digital Fault State
Alg Dig Md	1797-OE8H Output map	Analog Digital Module
Diagnostic Status	1797-IE8H Input map 1797-OE8H Input map	Diagnostic Status
HRBD	1797-IE8H Input map 1797-OE8H Input map	HART Rebuild Flag
HRB	1797-IE8H Input map 1797-OE8H Input map	HART Readback Flag
HFAIL	1797-IE8H Input map 1797-OE8H Input map	HART Failure Flag
HTMT	1797-IE8H Input map 1797-OE8H Input map	HART Transmitter Flag
HCM	1797-IE8H Input map 1797-OE8H Input map	HART Communication Flag

Analog Input Module (1797-IE8H) Image Table Mapping

Table 2.6 Input Map (Read Words)

Bit → / Word ↓	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
0	Channel 0 Input Data															
1	Channel 1 Input Data															
2	Channel 2 Input Data															
3	Channel 3 Input Data															
4	Channel 4 Input Data															
5	Channel 5 Input Data															
6	Channel 6 Input Data															
7	Channel 7 Input Data															
8	Ovr Alm ch 7	Ovr Alm ch 6	Ovr Alm ch 5	Ovr Alm ch 4	Ovr Alm ch 3	Ovr Alm ch 2	Ovr Alm ch 1	Ovr Alm ch 0	Und Alm ch 7	Und Alm ch 6	Und Alm ch 5	Und Alm ch 4	Und Alm ch 3	Und Alm ch 2	Und Alm ch 1	Und Alm ch 0
9	Rm Flt ch 7	Rm Flt ch 6	Rm Flt ch 5	Rm Flt ch 4	Rm Flt ch 3	Rm Flt ch 2	Rm Flt ch 1	Rm Flt ch 0	Lo Flt ch 7	Lo Flt ch 6	Lo Flt ch 5	Lo Flt ch 4	Lo Flt ch 3	Lo Flt ch 2	Lo Flt ch 1	Lo Flt ch 0
10	Reserved								H Rbd	Reserved			Diagnostic Status			
11	H Rb ch 7	H Rb ch 6	H Rb ch 5	H Rb ch 4	H Rb ch 3	H Rb ch 2	H Rb ch 1	H Rb ch 0	H Fail ch 7	H Fail ch 6	H Fail ch 5	H Fail ch 4	H Fail ch 3	H Fail ch 2	H Fail ch 1	H Fail ch 0
12	H Tmt ch 7	H Tmt ch 6	H Tmt ch 5	H Tmt ch 4	H Tmt ch 3	H Tmt ch 2	H Tmt ch 1	H Tmt ch 0	H Cm ch 7	H Cm ch 6	H Cm ch 5	H Cm ch 4	H Cm ch 3	H Cm ch 2	H Cm ch 1	H Cm ch 0

Where: ch = channel
Ovr Alm = Over Range Alarm
Und Alm = Under Range Alarm
Rm Flt = Remote Fault
Lo Flt = Local Fault
H Rbd = HART Rebuild
H Rb = HART Readback
H Fail = HART Failure
H Tmt = HART Transmitter
H Cm = HART Communication

Table 2.7 Configuration Map (Write Words)

Bit →	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Word ↓	Write															
0	Reserved		High and Low Error Level 0…3					U/D 0…3	Filter Cutoff 0…3			Data Format 0…3				Flt Md 0…3
1	Sqrt		High and Low Error Level 4…7					U/D 4…7	Filter Cutoff 4…7			Data Format 4…7				Flt Md 4…7

Where: U/D = up/down
Flt Md = Fault Module
Sqrt = Square Root

Bit/Word Description for the Analog Input Module (1797-IE8H)

Table 2.8 Fault Mode - Write Words 0 and 1

Word 0	Bit 00	Fault enable for channels 0…3
Word 1	Bit 00	Fault enable for channels 4…7

Where: 0 = disabled
1 = enable with wire-off and overload or short circuit

Table 2.9 Add-on Filter Selections - Write Words 0 and 1

Word	Bits			Description
0	07	06	05	Channels 0…3
1	07	06	05	Channels 4…7
	0	0	0	Reserved
	0	0	1	
	0	1	0	
	0	1	1	10 Hz (100 ms)
	1	0	0	4 Hz (250 ms)
	1	0	1	2 Hz (500 ms)
	1	1	0	1 Hz (1 s)
	1	1	1	0.5 Hz (2 s)

Table 2.10 Remote Transmitter Error Up/Down - Write Words 0 and 1

Word 0	Bit 08	Up/down channels 0…3
Word 1	Bit 08	Up/down channels 4…7

Where: 0 = remote fault is enabled by transmitter overrange
1 = remote fault is enabled by transmitter underrange

Table 2.11 Data Format - Write Words 0 and 1

	Bits				Description
Word 0	04	03	02	01	Data format for channels 0…3
Word 1	04	03	02	01	Data format for channels 4…7
	0	0	0	0	0…22 mA, w/error steps (default)
	0	0	0	1	0…22 mA = 0…110%, w/error steps
	0	0	1	0	0…22 mA = 0…104.8%, square root, w/error steps
	0	0	1	1	0…22 mA = 0…65,535, unsigned integer, w/error steps
	0	1	0	0	2…22 mA, w/error steps
	0	1	0	1	2…22 mA = -12.5…112.5%, w/error steps
	0	1	1	0	4…22 mA = 0…106%, square root, w/error steps
	0	1	1	1	4…20mA = 0…65,535, unsigned integer, w/error steps
	1	0	0	0	Not assigned
	1	0	0	1	Not assigned
	1	0	1	0	Not assigned
	1	0	1	1	0…22 mA = A/D count, w/fixed error
	1	1	0	0	3.6…21 mA = NAMUR NE 43, w/fixed error
	1	1	0	1	3…21 mA = -6.25…106.28% w/fixed error
	1	1	1	0	2…22 mA = -12.5…112.5% w/fixed error
	1	1	1	1	Not assigned

Table 2.12 Error Level 0.1mA Steps

	Bits					Description
Word 0	13	12	11	10	9	Error level channels 0…3
Word 1	13	12	11	10	9	Error level channels 4…7
	0	0	0	0	0	Disabled
						0.1 mA * step value = remote fault alarm threshold
						Examples
Data Format 2…22 mA -12.5…112.5%	0	0	1	1	1	Step value = 7, 0.1 mA * 7 = 0.7 mA Remote fault alarm at -4.38% or +104.38%
	0	1	1	1	1	Binary value = 15, 0.1 mA * 15 = 1.5 mA Remote fault alarm at -9.38% or + 109.38%

Analog Output Module (1797-OE8H) Image Table Mapping

Table 2.13 Input Map (Read Words)

Bit →	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Word ↓																
0	Flt Alm ch7	Flt Alm ch6	Flt Alm ch5	Flt Alm ch4	Flt Alm ch3	Flt Alm ch2	Flt Alm ch1	Flt Alm ch0	Reserved				Diagnostic Status			
1	Reserved															
2	H Rb ch 7	H Rb ch 6	H Rb ch 5	H Rb ch 4	H Rb ch 3	H Rb ch 2	H Rb ch 1	H Rb ch 0	H Fail ch 7	H Fail ch 6	H Fail ch 5	H Fail ch 4	H Fail ch 3	H Fail ch 2	H Fail ch 1	H Fail ch 0
3	H Tmt ch 7	H Tmt ch 6	H Tmt ch 5	H Tmt ch 4	H Tmt ch 3	H Tmt ch 2	H Tmt ch 1	H Tmt ch 0	H Cm ch 7	H Cm ch 6	H Cm ch 5	H Cm ch 4	H Cm ch 3	H Cm ch 2	H Cm ch 1	H Cm ch 0

Where: ch = channel
Flt Alm = Fault Alarm
H Rbd = HART Rebuild
H RB = HART Readback
H Fail = HART Failure
H Tmt = HART Transmitter
H Cm = HART Communication

Table 2.14 Output Map (Write Words)

Bit →	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Word ↓																
0	Reserved	Glbl Rst	Reserved						Dig Out ch 7	Dig Out ch 6	Dig Out ch 5	Dig Out ch 4	Dig Out ch 3	Dig Out ch 2	Dig Out ch 1	Dig Out ch 0
1	Channel 0 Output Data															
2	Channel 1 Output Data															
3	Channel 2 Output Data															
4	Channel 3 Output Data															
5	Channel 4 Output Data															
6	Channel 5 Output Data															
7	Channel 6 Output Data															
8	Channel 7 Output Data															

Where: ch = channel
Dig Out = Digital Output
Glbl Rst = Global Reset

Table 2.15 Configuration Map (Write Words)

Bit →	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Word ↓																
0	Lo Flt Md	Rese rved	Flt Md ch 2…3	Flt Md ch 0…1	Alg Flt Ste ch 2…3		Alg Flt Ste ch 0…1		Data Format ch 2…3				Data Format ch 0…1			
1	Lth Md ch 4…7	Lth Md ch 0…3	Flt Md ch 6…7	Flt Md ch 4…5	Alg Flt Ste ch 6…7		Alg Flt Ste ch 4…5		Data Format ch 6…7				Data Format ch 4…5			
2	Dig Flt Ste ch 7	Dig Flt Ste ch 6	Dig Flt Ste ch 5	Dig Flt Ste ch 4	Dig Flt Ste ch 3	Dig Flt Ste ch 2	Dig Flt Ste ch 1	Dig Flt Ste ch 0	Alg Dig Md ch 7	Alg Dig Md ch 6	Alg Dig Md ch 5	Alg Dig Md ch 4	Alg Dig Md ch 3	Alg Dig Md ch 2	Alg Dig Md ch 1	Alg Dig Md ch 0
3	Analog Fault State Value Channel 0															
4	Analog Fault State Value Channel 1															
5	Analog Fault State Value Channel 2															
6	Analog Fault State Value Channel 3															
7	Analog Fault State Value Channel 4															
8	Analog Fault State Value Channel 5															
9	Analog Fault State Value Channel 6															
10	Analog Fault State Value Channel 7															

Where: ch = channel
Lo Flt Md = Local Fault Mode
Flt Md = Fault Mode
Alg Flt Ste = Analog Fault State
Lth Md = Latch Mode
Dig Flt Ste = Digital Fault State
Alg Dig Md = Analog/Digital Mode
Cd Flg = Command Flag

Table 2.16 Data Format Control

Data Format				Range	Resolution	Full Range	Interpretation	Data Table Value	Count per mA
0	0	0	0	0…20 mA	0.1% of 0…20 mA	0…22 mA	0…22 mA	0…2000	1000
0	0	0	1		0.2% of 0…20 mA		0…110%	0…11000	500
0	0	1	0	Not assigned					
0	0	1	1	4…20 mA	0.03% of 0…20 mA	0…20 mA	Unsigned integer	0…65535	3276
0	1	0	0		0.1% of 4…20 mA	2…22 mA	2…22 mA	2000…22000	1000
0	1	0	1	Not assigned					
0	1	1	0						
0	1	1	1	4…20 mA	0.03% of 4…20 mA	4…20 mA	Unsigned integer	0…65535	4095
1	0	0	0	Not assigned					
1	0	0	1						
1	0	1	0						
1	0	1	1	0…20 mA	0.28% of 0…20 mA	0…22 mA	D/A count	0…8000	363
1	1	0	0	Not assigned					
1	1	0	1	4…20mA	0.16% of 4…20 mA	3…21 mA	-6.25…+106.25%	-625…+10625	625
1	1	1	0			2…22 mA	-12.5…+112.5%	-1250…+11250	625
1	1	1	1	Not assigned					

1797-IE8H and -OE8H Extended Configuration Data Table

The FLEX Ex HART modules are addressed by using an MSG or CIO instruction. When using one of these instructions, configure it to the following:

- Class: 0x7D
- Instance: Slot number (range from 1 to 8 with 1 being the I/O module closest to the adapter
- Attribute: 0x66
- Service: 0x0E for a get attribute single or 0x10 for a set attribute single

  Also, configure the communication path to the target I/O module.

For a set attribute single, configure two words as defined in the Extended Configuration Data Table to be sent to the I/O module.

For a get attribute single, two words configured as defined in the Extended Configuration Data Table will be returned from the instruction.

Table 2.17 1797-IE8H and -OE8H Extended Configuration Data Table

Bit →	**15**	**14**	**13**	**12**	**11**	**10**	**09**	**08**	**07**	**06**	**05**	**04**	**03**	**02**	**01**	**00**
Word ↓																
0	PMI ch 7	PMI ch 6	PMI ch 5	PMI ch 4	PMI ch 3	PMI ch 2	PMI ch 1	PMI ch 0	SME ch 7	SME ch 6	SME ch 5	SME ch 4	SME ch 3	SME ch 2	SME ch 1	SME ch 0
1	Reserved			HART Read Back Threshold ch 4…7					HS LED	HS Inht	50/ 60 Hz	HART Read Back Threshold ch 0…3				

Where: ch = channel
PMI = Primary Master Inhibit
SME = Secondary Master Enable
HS LED = HART Status LEDs
HS Inht = HART Status Inhibit

Secondary Master Enable (SME) and Primary Master Inhibit (PMI)

These two bits control a few module internal functions individually for channels 0 to 7.

Table 2.18

	Bits[1]	1 (Default)	2	3	4
PMI	8, 9, 10, 11, 12, 13, 14, 15	0	0	1	1
SME	0, 1, 2, 3, 4, 5, 6, 7	0	1	0	1
	HART Smooth Filter	Pulsed	On	Off	On
	Rebuild	On	On	Off	Off
	HART Read Back	On	On	Off	Off
	Primary Master	On	On	Off	Off
	Secondary Master	Off	On	Off	On

1 Where:
Ch0 - bits 0 and 8; Ch1 - bits 1 and 9; Ch2 - bits 2 and 10; Ch3 - bits 3 and 11;
Ch4 - bits 4 and 12; Ch5 - bits 5 and 13; Ch6 - bits 6 and 14; Ch7 - bits 7 and 15

HART Status LEDs

When this bit is set, the LEDs are used for HART diagnostics. LED behavior changes to show communication on HART with each LED representing a HART loop. A flashing yellow LED indicates that communication is currently being processed while a solid yellow LED means that this device is in the transmitter list.

HART Status Inhibit

When this bit is set, the HART communication status is not shown in the realtime data table to enable compatibility. The appropriate areas are cleared with zeroes.

50/60 Hz Filter

The values are:

- 0 = 50 Hz (default)
- 1 = 60 Hz

HART Read Back Threshold

This bit delivers the percentage value, in steps of 1%, of the threshold for forcing the HART read back indication. The maximum input signal deviation for HART analog modules is 31%.

If there is no HART transmitter on the loop or if the loop is not in the transmitter list, the function is switched off internally in the I/O module. The values are:

- 0 = disabled (default)
- 1 to 4 = not supported from the I/O module (set to 5 internally)
- 5 to 31 = percentage threshold data (5 to 31%)

Chapter Summary

In this chapter, we told you about the FLEX Ex system and the analog I/O modules, and how they communicate with programmable controllers. Move to Chapter 3 to learn how to install your FLEX Ex analog module.

Notes:

How to Install Your FLEX Ex Analog Modules

What This Chapter Contains

Read this chapter to install the input and output analog modules.

Before You Install Your Analog Module

Before installing your FLEX Ex analog module:

Table 3.1 Steps to Complete Before Installation

You Need To	As Described Under
Verify that the module will be installed in a suitable metal enclosure	Installation in Zone 1, page 3-3
Position the keyswitch on the terminal base	Installing the Module, page 3-9

ATTENTION

These modules do not receive primary operational power from the backplane. +/-V dc power must be applied to your module before installation. If power is not applied, the module position will appear to the adapter as an empty slot in your chassis.

Compliance to European Union Directives

If these products have the CE mark they are approved for installation within the European Union and EEA regions. They have been designed and tested to meet the following directives.

EMC Directive

These products are tested to meet the Council Directive 89/336/EC Electromagnetic Compatibility (EMC) as amended by 92/31/EC and 93/68/EEC, by applying the following standards:

- EN61000-6-4:2001, Electromagnetic Compatibility (EMC) - Part 6-4: Generic Standard for Industrial Environments (Class A)
- EN61000-6-2:2001, Electromagnetic Compatibility (EMC) - Part 6-2: Generic Standards - Immunity for Industrial Environments
- EN61326-1997 + A1-A2, Electrical Equipment For Measurement, Control, and Laboratory Use - Industrial EMC Requirements

ATEX Directive

These products are tested in conjunction with associated I/O modules to meet the Council Directive 94/9/EC (ATEX) Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres by applying the following standards:

- EN50014:1997 + A1-A2, Electrical Apparatus for Potentially Explosive Atmospheres
- EN50020:1994, Electrical Apparatus for Potentially Explosive Atmospheres - Intrinsic Safety “i”
- EN50284:1999, Special Requirements for Construction, Test and Marking of Electrical Apparatus of Equipment Group II, Category 1G
- EN50281-1-1:1998 + A1, Electrical Apparatus for Use in the Presence of Combustible Dust - Part 1-1: Protection by Enclosure

Installation in Zone 1

These modules must not be exposed to the environment. Provide a suitable metal enclosure. These modules have a protection factor of IP20.

WARNING

These modules cannot be used in an intrinsically safe environment after they have been exposed to nonintrinsically safe signals.

Installation in Zone 22

When the module is installed in Zone 22, the following cabinets must be used: IVK-ISRPI-V16LC; IVK-ISRPI-V8HYW; or IVK-ISRPI-V8LC. These cabinets can be purchased from:

Pepperl+Fuchs GmbH
Konigsberger Allee 85-87, D-68307
Mannheim, Germany
Attn: PA Sales Dept.
Kirsten Becker
Telephone +49 776 1298
www.pepperl-fuchs.com

The IS-RPI cabinets (type IVK2-ISRPI-V8LC, IVK2-ISRPI-V8HYW, or IVK-ISRPI-V16LC) ensures the basic protection for the intrinsically safe apparatus of the IS-RPI system for use in Zone 22. It corresponds with category 3D according to RL 94/9 EG and with the type label marked with the following information:

Pepperl+Fuchs GmbH
68301 Mannheim
IVK2-ISRPI-V8LC (or IVK2-ISRPI-V8HYW or IVK-ISRPI-V16LC)
Ex II 3D IP54 T 70°C
CE
Serial (manufacturing) number
Model

Electrostatic Charge

Protect the system against electrostatic charge. Post a sign near this module: **Attention! Avoid electrostatic charge.** For your convenience, a sign which can be cut out and posted is included in this user manual before the back cover.

Removal and Insertion Under Power

WARNING

These module are designed so you can remove and insert them under power. However, take special care when removing or inserting these modules in an active process. I/O attached to any module being removed or inserted can change states due to its input/output signal changing conditions.

If you insert or remove the terminal base while backplane power is on, an electrical arc can occur. This could cause an explosion in hazardous location installations.

Be sure that power is removed or the area is nonhazardous before proceeding.

Install the Module

Installation of the analog module consists of:

- Mounting the terminal base unit
- Installing the analog I/O module into the terminal base unit
- Installing the connecting wiring to the terminal base unit

If you are installing your module into a terminal base unit that is already installed, proceed to Mounting the Analog Modules on the Terminal Base on 3-9.

ATTENTION

Make certain that you power this terminal base module combination with an instrinsically safe power supply. Do not exceed the values listed in the specifications for the terminal base or module.

Do not use the unused terminals on the terminal base unit. Using the terminals as supporting terminals can result in damage to modules and/or unintended operation of your system.

Mount on a DIN Rail

ATTENTION

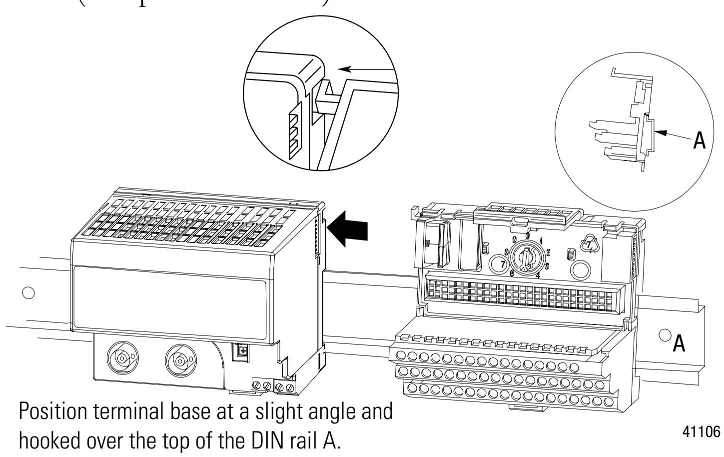
Do not remove or replace a terminal base unit when power is applied. Interruption of the flexbus can result in unintended operation or machine motion.

1. Remove the cover plug in the male connector of the unit to which you are connecting this terminal base unit.

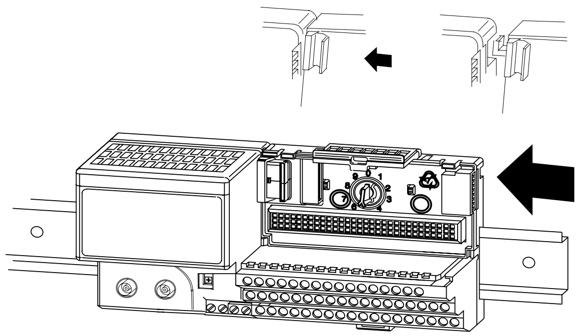
2. Check to make sure that the 16 pins in the male connector on the adjacent device are straight and in line so that the mating female connector on this terminal base unit will mate correctly.

3. Make certain that the female flexbus connector is **fully retracted** into the base unit.

4. Position the terminal base over the 35 x 7.5mm DIN rail **A** (A-B pt. no. 199-DR1).



Position terminal base at a slight angle and hooked over the top of the DIN rail A.



41107

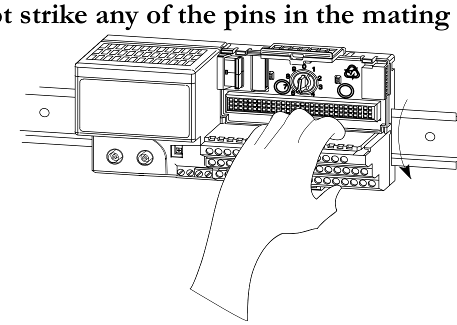
Slide the terminal base over tight against the adapter (or proceeding terminal base). Make sure the hook on the terminal base slides under the edge of the adapter (or proceeding terminal base) and the flexbus connector is fully retracted.

ATTENTION

Do not force the terminal base into the adjacent modules. Forcing the units together can bend or break the hook and allow the units to separate and break communication over the backplane.

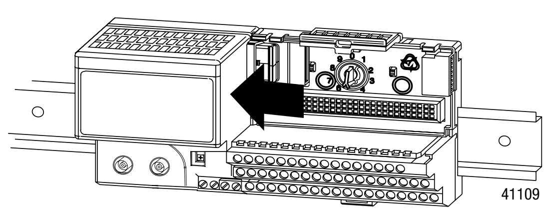
5. Rotate the terminal base onto the DIN rail with the top of the rail hooked under the lip on the rear of the terminal base.

   Use caution to make sure that the female flexbus connector does not strike any of the pins in the mating male connector.



41108

Press down on the terminal base unit to lock the terminal base on the DIN rail. If the terminal base does not lock into place, use a screwdriver or similar device to open the locking tab, press down on the terminal base until flush with the DIN rail and release the locking tab to lock the base in place.



41109

Gently push the flexbus connector into the side of the adapter (or proceeding terminal base) to complete the backplane connection.

6. For specific wiring information, refer to the installation instructions for the module you are installing in this terminal base unit.

   Terminal assignments are also given later in this chapter, see page 3-11.

7. Repeat the above steps to install the next terminal base.

8. Be sure the flexbus connector cover on the last terminal base is in place.

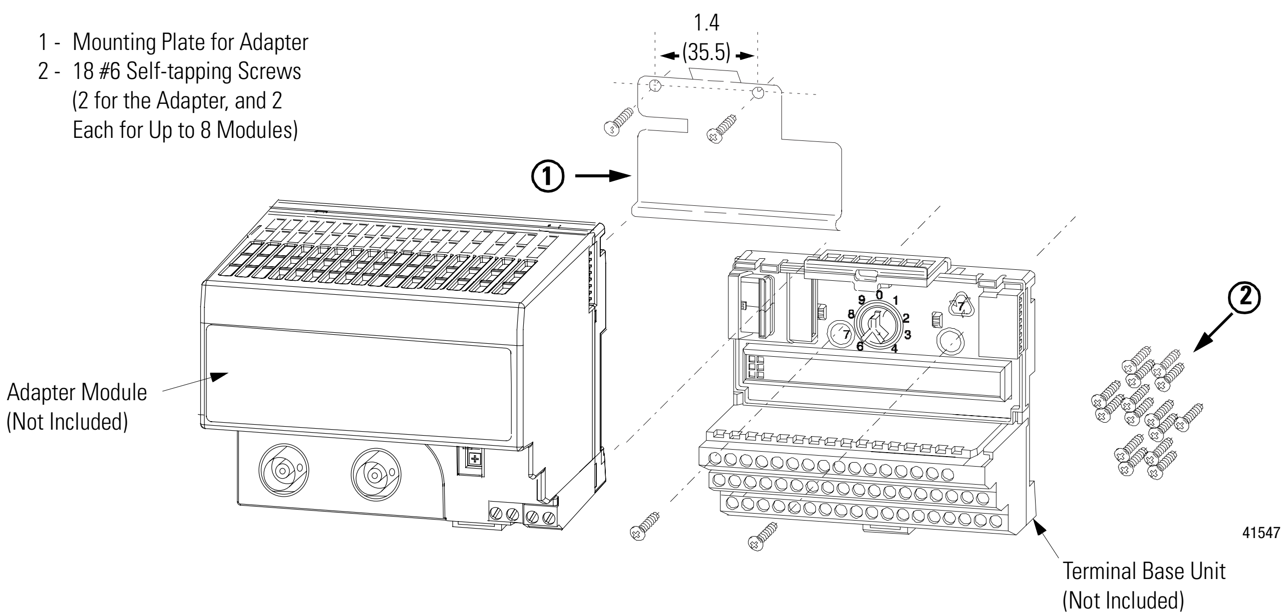
Panel/Wall Mount

Installation on a wall or panel consists of:

- Laying out the drilling points on the wall or panel
- Drilling the pilot holes for the mounting screws
- Mounting the adapter mounting plate
- Installing the terminal base units and securing them to the wall or panel

If you are installing your module into a terminal base unit that is already installed, proceed to Mounting the Analog Modules on the Terminal Base Unit on page 3-9.

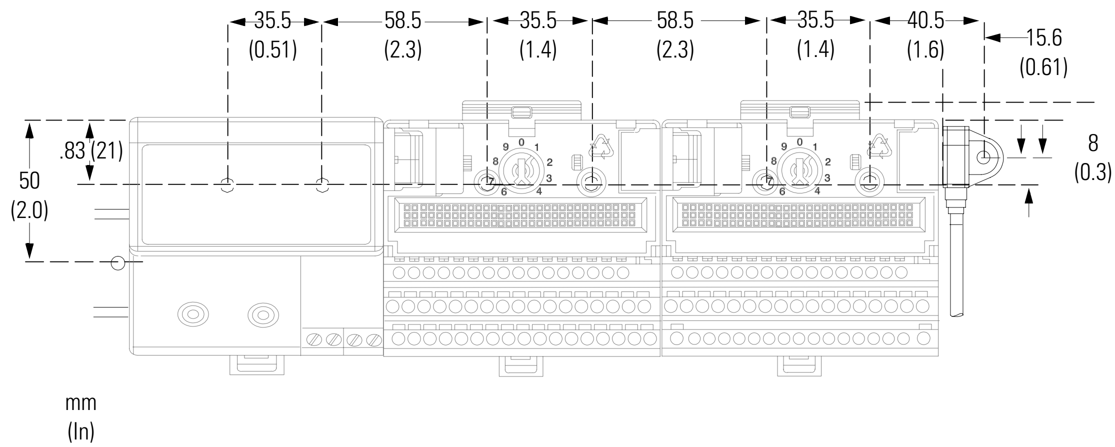
Use the mounting kit Cat. No. 1794-NM1 for panel/wall mounting.



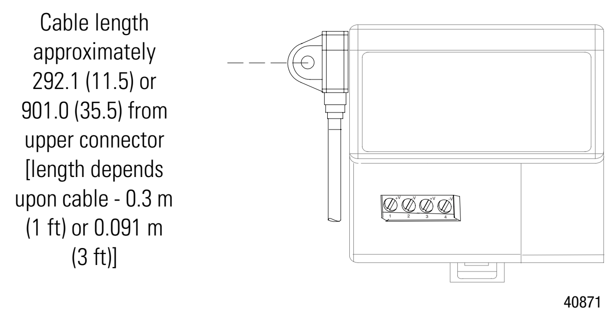
To install the mounting plate on a wall or panel:

1. Lay out the required points on the wall/panel as shown in the drilling dimension drawing.

Drilling Dimensions for Panel/Wall Mounting of FLEX Ex I/O



> **ATTENTION:** Be careful of metal chips when drilling cable mounting holes. Do not drill holes above a system that has any modules installed.



2. Drill the necessary holes for the #6 self-tapping mounting screws.

3. Mount the mounting plate (1) for the adapter module using two #6 self-tapping screws (18 included for mounting up to 8 modules and the adapter).

IMPORTANT	Make certain that the mounting plate is properly grounded to the panel. Refer to Industrial Automation Wiring and Grounding Guidelines, publication 1770-4.1.

4. Hold the adapter (2) at a slight angle and engage the top of the mounting plate in the indention on the rear of the adapter module.

5. Press the adapter down flush with the panel until the locking lever locks.

6. Position the terminal base unit up against the adapter and push the female bus connector into the adapter.

7. Secure to the wall with two #6 self-tapping screws.

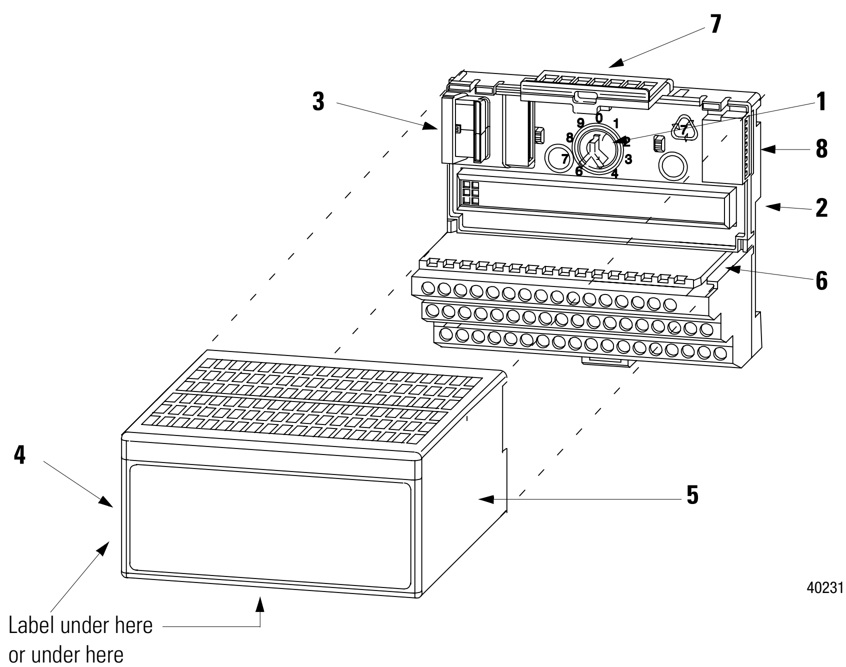
8. Repeat for each remaining terminal base unit.

Mounting the Analog Modules on the Terminal Base Unit

The analog input and output modules mount on a 1797-TB3 or TB3S intrinsically safe terminal base unit.

1. Rotate keyswitch (1) on terminal base unit (2) clockwise to position 3 for the 1797-IE8H or position 4 for the 1797-OE8H as required for each type of module.

   Do not change the position of the keyswitch after wiring the terminal base unit.



2. Make certain the flexbus connector (3) is pushed all the way to the left to connect with the neighboring terminal base/adapter. You cannot install the module unless the connector is fully extended.

3. Make sure the pins on the bottom of the module are straight so they will align properly with the connector in the terminal base unit.

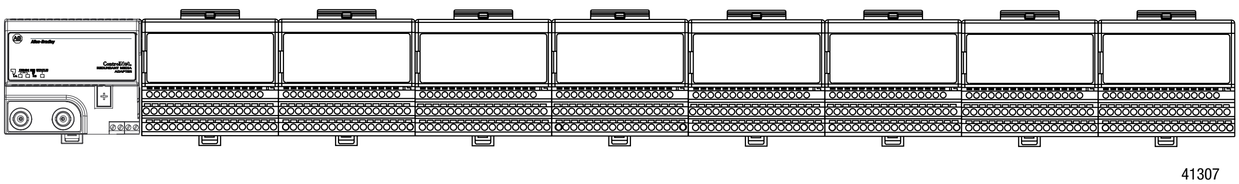
4. Position the module (4) with its alignment bar (5) aligned with the groove (6) on the terminal base.

5. Press firmly and evenly to seat the module in the terminal base unit. The module is seated when the latching mechanism (7) is locked into the module.

6. Make certain that you only connect terminal base units to other intrinsically safe system modules or adapters to maintain the integrity of the intrinsically-safe backplane.

7. Remove cap plug (8) and attach another intrinsically safe terminal base unit to the right of this terminal base unit if required.

   Make sure the last terminal base has the cap plug (8) in place.



The adapter is capable of addressing eight modules. Do not exceed a maximum of eight terminal base units in your system.

Wire the Terminal Base Units

Wiring the FLEX Ex I/O analog modules is done through the 1797-TB3 and 1797-TB3S terminal base units.

ATTENTION

The FLEX Ex analog I/O modules do not receive primary operational power from the backplane. +/-V dc power must be applied to your module before operation. If power is not applied, the module position will appear to the adapter as an empty slot in your chassis. If the adapter does not recognize your module after installation is completed, cycle power to the adapter.

Make certain that you power these modules with an intrinsically safe power supply. Do not exceed the values listed in the specifications for the modules.

Connecting Wiring to the FLEX Ex I/O Analog Modules

Inputs/Outputs

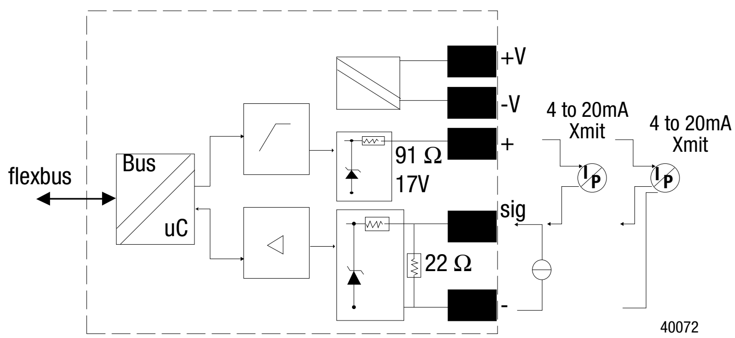
Each 1797-IE8H input can be operated from an analog field device signal, and each 1797-OE8H output channel can operate an analog field device. **Do not apply any non-intrinsically safe signals to these modules**.

IMPORTANT	When using an intrinsically safe electrical apparatus according to EN50020, the European Community directives and regulations must be followed.

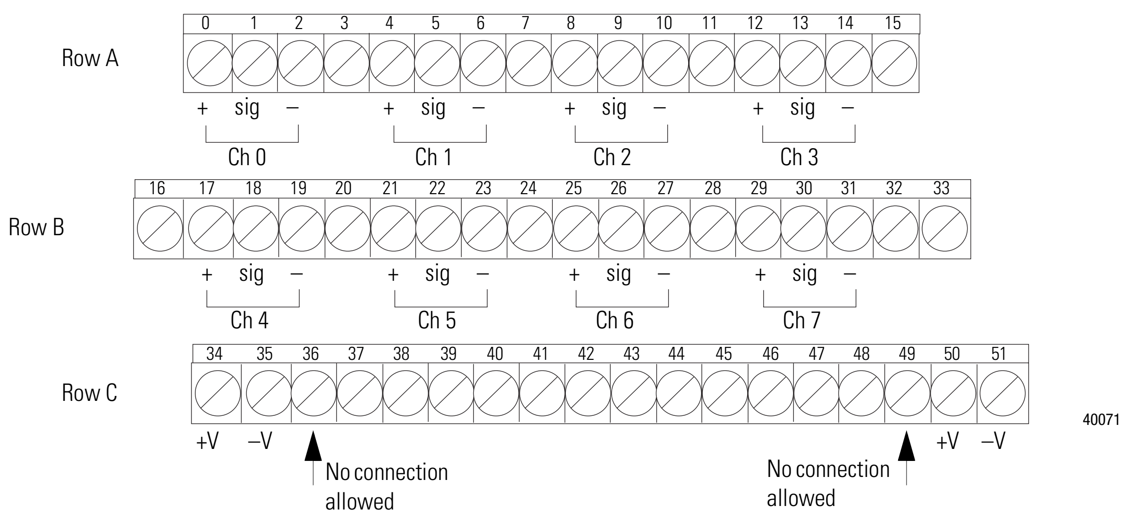
The channels of the 1797-IE8H are electrically connected to each other and have a common plus-line. The channels of the 1797-OE8H are electrically connected to each other.

IMPORTANT	When interconnecting several lines, you must consider the total accumulated power and check for intrinsic safety.

Connections for the 1797-IE8H Module



1797-IE8H Module



For Two-Wire Transmitter Devices

1. Connect the individual input wiring to (+) terminals (0, 4, 8, 12) on the 0 to 15 row (A) and on the 16 to 33 row (B) (terminals 17, 21, 25, 29) as indicated in the table below.

2. Connect the associated input to the corresponding (sig) terminal (1, 5, 9, 13) on the 0 to 15 row (A), and on the 16 to 33 row (B) (terminals 18, 22, 26, 30) for each input as indicated in the table below.

3. Connect +V dc power to terminal 34 on the 34 to 51 row (C).

4. Connect -V to terminal 35 on the 34 to 51 row (C).

5. If continuing power to the next terminal base unit, connect a jumper from terminal 50 (+V) on this base unit to terminal 34 on the next base unit.

6. If continuing common to the next terminal base unit, connect a jumper from terminal 51 (-V) on this base unit to terminal 35 on the next base unit.

Table 3.2 Wiring Connections for the 1797-IE8H Module

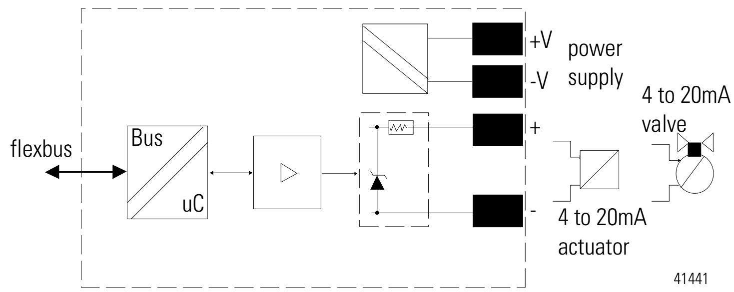
Input	Input Source	Input Signal	Input Return	Input	Input Source	Input Signal	Input Return
Input 0	A-0	A-1	A-2	Input 4	B-17	B-18	B-19
Input 1	A-4	A-5	A-6	Input 5	B-21	B-22	B-23
Input 2	A-8	A-9	A-10	Input 6	B-25	B-26	B-27
Input 3	A-12	A-13	A-14	Input 7	B-29	B-30	B-31
+V	Terminals 34 and 50						
-V	Terminals 35 and 51						

Terminals 16, 33, 40, 41, 42, 43, 44 and 45 are connected to chassis ground.

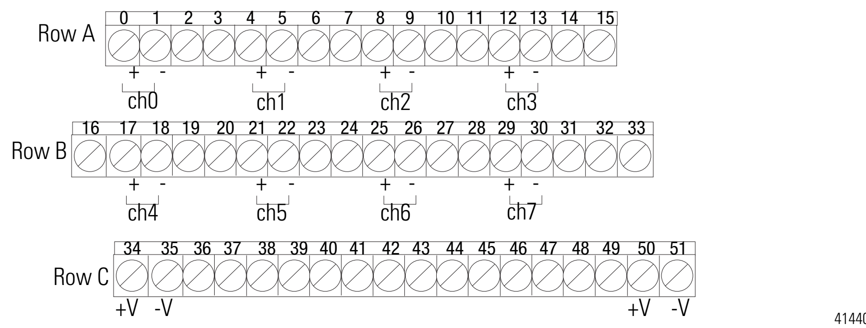
ATTENTION

Do not use the unused terminals on the terminal base unit. Using these terminals as supporting terminals can result in damage to the module and/or unintended operation of your system.

Connections for the 1797-OE8H Module



1797-OE8H Module



No connections allowed to terminals 2, 3, 6, 7, 10, 11, 14, 15, 19, 20, 23, 24, 27, 28, 31, 32, 36, 37, 38, 39, 46, 47, 48, 49

1. Connect the individual output wiring to (+) terminals (0, 4, 8, 12) on the 0 to 15 row (A) and on the 16 to 33 row (B) (terminals 17, 21, 25, 29) as indicated in the table below.

2. Connect the associated output to the corresponding (-) terminal (1, 5, 9, 13) on the 0 to 15 row (A), and on the 16 to 33 row (B) (terminals 18, 22, 26, 30) for each input as indicated in the following table.

3. Connect +V dc power to terminal 34 on the 34 to 51 row (C).

4. Connect -V to terminal 35 on the 34 to 51 row (C).

5. If continuing power to the next terminal base unit, connect a jumper from terminal 50 (+V) on this base unit to terminal 34 on the next base unit.

6. If continuing common to the next terminal base unit, connect a jumper from terminal 51 (-V) on this base unit to terminal 35 on the next base unit.

Table 3.3 Wiring connections for the 1797-OE8H Module

Output	Output +	Output –	Output	Output +	Output –
Output 0	A-0	A-1	Output 4	B-17	B-18
Output 1	A-4	A-5	Output 5	B-21	B-22
Output 2	A-8	A-9	Output 6	B-25	B-26
Output 3	A-12	A-13	Output 7	B-29	B-30
+V	Terminals 34 and 50				
-V	Terminals 35 and 51				

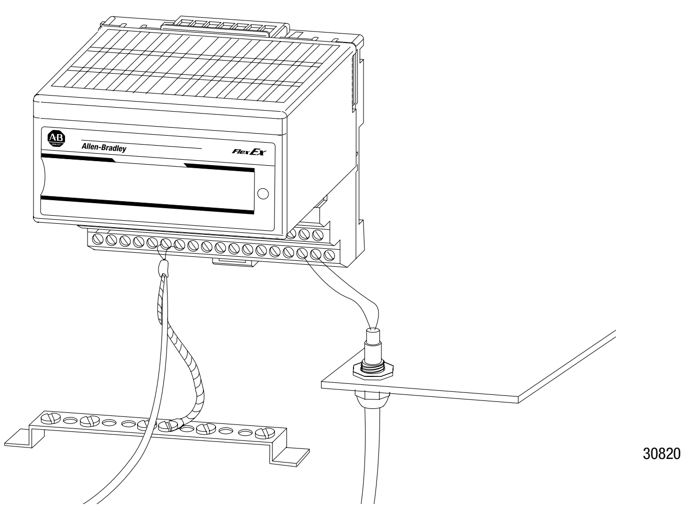
Terminals 16, 33, 40, 41, 42, 43, 44 and 45 are connected to chassis ground.

ATTENTION

Do not use the unused terminals on the terminal base unit. Using these terminals as supporting terminals can result in damage to the module and/or unintended operation of your system.

Ground the Module

All I/O wiring must use shielded wire. Shields must be terminated external to the module, such as bus bars and shield-terminating feed throughs.



Chapter Summary

In this chapter, we told you how to install your input module in an existing programmable controller system and how to wire to the terminal base units.

Move to chapter 4 to learn about input, output and configuration files for the analog I/O modules on ControlNet.

Notes:

Input, Output and Configuration Files for the Analog I/O Modules on the ControlNet Network

What This Chapter Contains

Read this chapter to familiarize yourself with input, output and configuration files for analog I/O modules on the ControlNet network.

In this chapter, you will learn about:

- Using software to configure the FLEX Ex I/O modules
- ControlNet Ex Adapter
- I/O structure
- Fault state data
- Communication fault data
- Idle state behavior
- Input data behavior upon module removal

IMPORTANT This chapter provides a brief description of the steps you must take in your programming software to configure FLEX Ex I/O modules and an overview of what occurs during configuration.

For a full explanation of how to use your programming software to perform module configuration, use the software online help.

Using Programming Software in Your FLEX Ex Application

When using FLEX Ex I/O analog modules, you must perform I/O mapping and configure the ControlNet network before generating configuration data for your I/O modules.

For example, you may use RSNetWorx software to connect FLEX Ex I/O modules to a ControlNet controller or scanner through a FLEX Ex ControlNet Ex adapter (cat. no. 1797-ACNR15). The I/O configuration portion of another programming software, for example RSLogix5 software could be used to generate the configuration data for each I/O module in the control system.

Configuration data is transferred from the controller to the I/O modules when communication to the modules is first established.

Follow these general guidelines when configuring I/O modules:

1. Perform I/O mapping.
2. Configure all I/O modules.
3. Change to Run mode to initiate communication
4. Download module configuration.

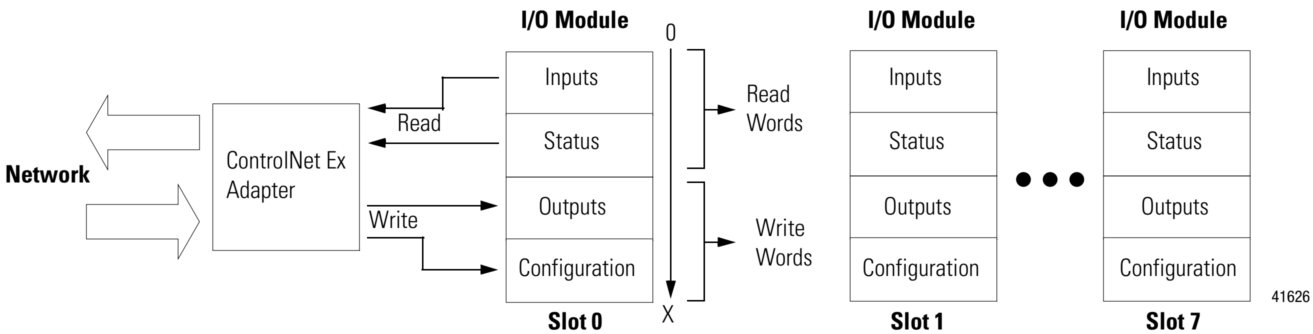
About the ControlNet Ex Adapter

The FLEX Ex ControlNet Ex adapter interfaces up to eight FLEX Ex modules to a ControlNet controller or scanner. The adapter can support ControlNet real-time data connections to individual modules or module groups. Each connection is independent of the others and can be from different controllers or scanners.

Communication Over the FLEX Ex Backplane

One 1797-ACNR15/B ControlNet Ex adapter can interface up to eight terminal base units with installed FLEX Ex modules, forming a FLEX Ex system of up to eight slots.

The adapter communicates to other network system components (typically one or more controllers or scanners, and/or programming terminals) over the ControlNet network. The adapter communicates with its I/O modules over the FLEX Ex backplane.



Configuration data is not continuously updated to the module.

Scheduled Data Transfer

Scheduled data transfer:

- is continuous.
- is asynchronous to the controller program scan.
- occurs at the actual rate displayed in the Actual Packet Interval field on the programming software ControlNet I/O mapping (monitor) dialog

Unscheduled Data Transfer

Unscheduled operations include:

- Unscheduled non-discrete I/O data transfers–through ControlNet I/O Transfer (CIO) instructions
- Peer-to-peer messaging–through message (MSG) instructions
- Messaging from programming devices

Unscheduled messaging on a ControlNet network is non-deterministic. Your application and your configuration, that is, the number of nodes, application program, NUT, amount of scheduled bandwidth used, determine how much time there is for unscheduled messaging.

Module I/O Mapping

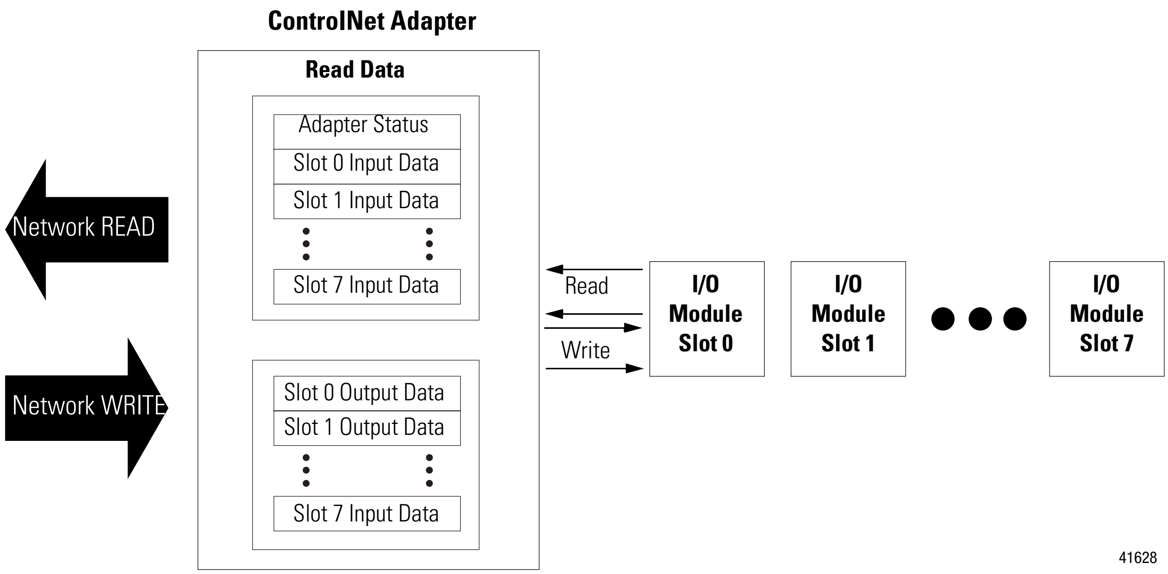
The I/O map for a module is divided into read words and write words. Read words consist of input and status words, and write words consist of output and configuration words. The number of read words or write words can be 0 or more.

The length of each I/O module's read words and write words vary in size depending on module complexity. Each I/O module will support at least 1 input word or 1 output word. Status and configuration are optional, depending on the module.

I/O Structure

Output data is received by the adapter in the order of the installed I/O modules. The output data for slot 0 is received first, followed by the output data for slot 1, and so on up to slot 7.

The first word of input data sent by the adapter is the Adapter status word. This is followed by the input data from each slot, in the order of the installed I/O modules. The input data from slot 0 is first after the status word, followed by input data from slot 1, and so on up to slot 7.



Adapter Status Word

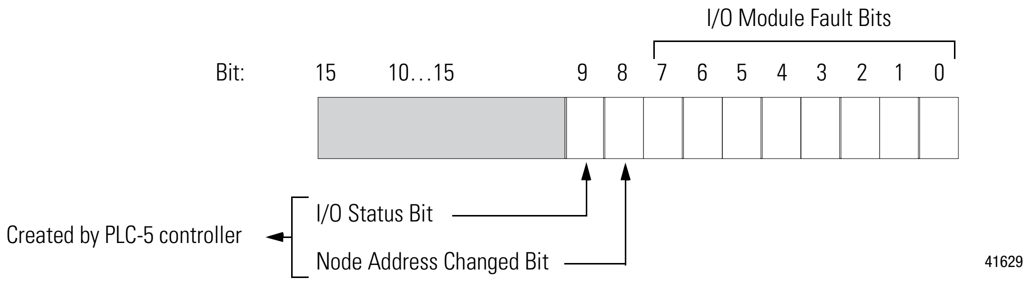
The status word consists of:

- I/O module fault bits – 1 status bit for each slot

Additionally, in the case of a PLC-5 controller, it adds:

- Node address changed – 1 bit (created by PLC-5 controller)
- I/O status – 1 bit (created by PLC-5 controller)

The following FLEX Ex adapter status word for a PLC-5 controller results.



As an example, in a PLC-5 system, the adapter status word bit descriptions are shown in the following table.

Table 4.1 Adapter Status Word Bit Descriptions

Bit Description	Bit	Explanation
I/O Module Fault	0	This bit is set (1) when an error is detected in slot position 0.
	1	This bit is set (1) when an error is detected in slot position 1.
	2	This bit is set (1) when an error is detected in slot position 2.
	3	This bit is set (1) when an error is detected in slot position 3.
	4	This bit is set (1) when an error is detected in slot position 4.
	5	This bit is set (1) when an error is detected in slot position 5.
	6	This bit is set (1) when an error is detected in slot position 6.
	7	This bit is set (1) when an error is detected in slot position 7.
Node Address Changed (Created by PLC-5 controller.)	8	This bit is set (1) when the node address switch setting has been changed since power-up.
I/O State (Created by PLC-5 controller.)	9	Bit = 0 - idle Bit = 1 - run
	10…15	Not used – set to 0

Possible causes for an I/O module fault are:

- Transmission errors on the FLEX Ex backplane
- Failed module
- Module removed from its terminal base
- Incorrect module inserted in a slot position
- Slot is empty
- Slot contains a non-discrete module

Fault State Data

The FLEX Ex HART modules provides storage for alternate module output data during communication faults or controller idle state. This fault state data assures that a known output will be applied to the output devices during the previously mentioned modes.

The controller or scanner software must include the means to specify this fault state data for each module. If applicable, this data is sent in the configuration block, see Image Table Mapping on page 2-12.

Device Actions

Device actions include:

- Communication fault behavior
- Idle state behavior
- Input data behavior upon module removal

Communication Fault Behavior

You can configure the response to a communication fault for each I/O module in its system. Upon detection of a communication fault, the module can:

- Leave the module output data in its last state (hold last state)
- Reset the module output data to zero (reset)
- Apply fault state data to the module output

Idle State Behavior

The FLEX Ex HART I/O module can detect the state of the controlling controller or scanner. Only 2 states can be detected: run mode, or program mode (idle).

When run mode is detected, the adapter copies the output data received from the controller to the corresponding module output. When program mode is detected, the I/O module can be configured to:

- Leave the module output data in its last state (hold last state)
- Reset the module output data to zero (reset)
- Apply fault state data to the module output

Chapter Summary

In this chapter you learned about input, output and configuration files for the analog I/O modules on ControlNet. Move to Chapter 5 to learn how to calibrate your module.

Calibrate Your Module

What This Chapter Contains

Use this chapter to calibrate the FLEX Ex analog I/O modules.

IMPORTANT This chapter provides a detailed method to perform module calibration with individual commands. This discussion is only given here to explain the general process.

In practice, you must use the I/O configuration portion of your programming software to calibrate your modules. The software executes the methodology explained here.

When and How to Calibrate Your FLEX Ex Analog I/O Module

Your module is shipped already calibrated. If a calibration check is required, the module must be in a FLEX Ex I/O system.

Perform module calibration periodically, based on your application. Module calibration may also be required to remove module error due to aging of components in your system.

ATTENTION

Your FLEX Ex analog I/O modules are intrinsically safe equipment. This module cannot be used in instrinsically safe environment after having been exposed to non-intrinsically safe signals.

Use one of these general methods to calibrate your module:

- Intrinsically safe equipment
- Factory trained personnel under controlled conditions with non-intrinsically safe equipment to maintain your module's intrinsic safety certification

ATTENTION

Calibration personnel must use extreme care to avoid compromising the intrinsically safe characteristics of the modules. This method may never be used in a hazardous environment.

Tools and Equipment

Use the following tools and equipment to calibrate your analog I/O modules:

Table 5.1 Tools for Calibration

Tool or Equipment	Description	
Precision Current Source	0…22 mA, 0.01 μA resolution	Used for input modules
Precision Current Meter	0…22 mA, 0.01 μA resolution	Used for output modules
Industrial Terminal and Interconnect Cable	Programming terminal for A-B family controllers	

1797-IE8H Calibration Features

The following features are unique to the 1797-IE8H module:

- There are two different values per channel that need to be calibrated: gain and offset at room temperature (25 °C).
- All values are stored in the I/O module non-volatile EEPROM.
- You can calibrate each channel separately or a specified number of channels together in respect of one value.
- If an offset value is calibrated, the corresponding gain value is invalid because the gain value depends on the actual offset value. Therefore, the gain values have to be calibrated after the offset values.
- After calibration, the actual date must be transmitted to the IOM and stored in the module non-volatile.
- The whole calibration can be set to default values by sending a reset command. The default date is Jan,01,2000.
- A specified calibration value can be set to default by sending a reset command for that channel.
- There is a special command to store the whole calibration data from RAM to EEPROM within the I/O module.
- If one value, except the calibration date, isn't calibrated yet, or if you set one value to default, the I/O module displays a calibration error within the Real Time Data diagnostic field.

1797-IE8H Calibration Command Structure

Calibration of the HART I/O module is performed using data structures and MSG Ladder-logic instructions. The MSG instruction sends the data structure to a dedicated attribute in the FLEX HART I/O module and the associated response is read from the same attribute. The data structure contains commands and its associated parameters. Depending on the command, they are either writable or readable. Only one access, either read or write, is executable at a time.

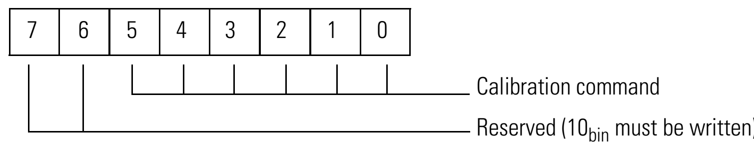
The Calibration data structure has four members: Command, Item, Data1, and Data2.

Table 5.2 Calibration Data Structure

Attribute	Field Size	Implementation	Description	Value (Hex)	Access
67_{hex}	4 byte	struct {		Conditional	Read or write
		USINT Command;	Calibration command;		
		USINT Item;	Additional command information;		
		USINT Data1;	Data according to command;		
		USINT Data2;	Data according to command		
		} Calibration;			

1797-IE8H Calibration Command Byte

The Calibration command byte uses the following format to **write** to the module:



The Calibration command byte uses the following format to **read** from the module:

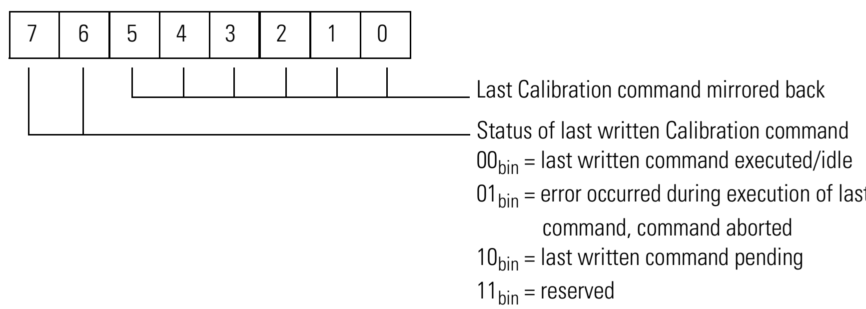


Table 5.3 1797-IE8H Calibration Command List

Calibration Command (Decimal) Bits 0…5	Function
0	Reserved
1	Calibrate offset at 25 °C
2	Calibrate gain at 25 °C
3…7	Reserved
8	Set all calibration values to default
9	Set one specified calibration value to default
10…13	Reserved(1)
14	Save calibration content to EEPROM
15…63	Reserved

(1) Used during manufacture of the product. Do not use.

Table 5.4 1797-IE8H Interpretation of Command Data Structure Content During Write Access

Command Byte			Item Byte	Data1 Byte	Data2 Byte
Reserved (Binary)	**Command Bits 0…5 (Decimal)**				
10[1]	1	Calibrate offset at 25 °C	Channel-Mask	Reserved[4]	Reserved[4]
	2	Calibrate gain at 25 °C			
	3…7	Reserved[2]	—	Reserved[2]	—
	8	Set all calibration values to default	Reserved[4]	Reserved[4]	Reserved[4]
	9	Set one specified calibration value to default	Value identifier (0)		
	10	Reserved[3]	Reserved[3]	Reserved[3]	Reserved[3]
	11	Reserved[4]			
	12	Reserved[4]			
	13	Reserved[4]			
	14	Save calibration content to EEPROM	Reserved[4]	Reserved[4]	Reserved[4]
	15…63	Reserved[2]	—	—	—

(1) Always must be 10_{bin}.

(2) Do not use. Designated for future use.

(3) Reserved. Used during manufacture of the product. Do not use.

(4) In attempt to write this byte, write 0.

Table 5.5 1797-IE8H Interpretation of Calibration Data Structure Content During Read Access (Idle Status)

Command Byte				Item Byte	Data1 Byte	Data2 Byte
Status (Binary)		Command Bits 0…5 (Decimal)				
00	Idle	0	Nothing is done. The state after power on.	0	0	0
		1	Calibration of offset at 25 °C is done according to channel-mask	Channel-Mask		
		2	Calibration of gain at 25 °C is done according to channel-mask			
		8	All calibration values are set to default	0		
		9	The specified calibration value is set to default	Value-identifier		
		10	Reserved[1]	Reserved[1]	Reserved[1]	Reserved[1]
		11	Reserved[1]			
		12	Reserved[1]			
		13	Reserved[1]			
		14	The calibration content is saved to EEPROM.	0	0	0

[1] Reserved. Used during manufacture of the product.

Table 5.6 1797-IE8H Interpretation of Calibration Data Structure Content During Read Access (Error Status)

Command Byte				Item Byte	Data1 Byte	Data2 Byte
Status (Binary)		Command Bits 0…5 (Decimal)				
01	Error	1	Calibration of offset at 25 °C according to channel-mask has failed	Channel-mask	0	0
		2	Calibration of gain at 25 °C according to channel-mask has failed			
		3…7	Unknown command is mirrored back	0		
		8	The calibration values are not set to default	0		
		9	The specified calibration value is not set to default	Value-identifier		
		10	Reserved[1]	Reserved[1]	Reserved[1]	Reserved[1]
		11	Reserved[1]			
		12	Reserved[1]			
		13	Reserved[1]			
		14	The calibration content could not be saved to EEPROM	0	0	0
		15…61	Unknown command is mirrored back			
		62	Reserved	Reserved	Reserved	Reserved
		63	Reserved			

[1] Reserved. Used during manufacture of the product. Do not use.

Table 5.7 1797-IE8H Interpretation of Calibration Data Structure Content During Read Access (Pending Status)

Command Byte				Item Byte	Data1 Byte	Data2 Byte
Status (Binary)		Command Bits 0…5 (Decimal)				
10	Pending	1	Calibration of offset at 25 °C is in process according to channel-mask	Channel-mask	0	0
		2	Calibration of gain at 25 °C is in process according to channel-mask			
		3…7	The unknown command is trying to be interpreted	x[2]	x[2]	x[2]
		8	All calibration values are set to default	0	0	0
		9	The specified calibration value is set to default	Value-identifier		
		10	Reserved[1]	Reserved[1]	Reserved[1]	Reserved[1]
		11	Reserved[1]			
		12	Reserved[1]			
		13	Reserved[1]			
		14	The calibration content is saved to EEPROM	x[2]	x[2]	x[2]
		15…61	Unknown command is mirrored back	0	0	0
		62	Reserved	Reserved	Reserved	Reserved
		63	Reserved			

(1) Reserved. Used during manufacture of the product. Do not use.

(2) The received values are mirrored back.

1797-IE8H Calibration Item Byte Channel-Mask

The Calibration item byte channel-mask uses each bit of the byte to correspond to one channel: where 1 is calibrate this channel and 0 is do not calibrate this channel. The LSB corresponds to channel 0, for example, 0x03 ≥ channel 0 and 1 have to be calibrated.

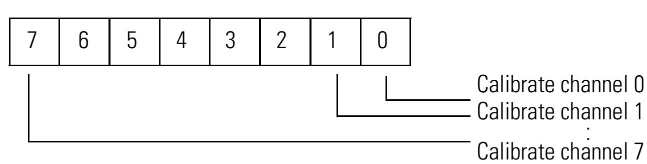
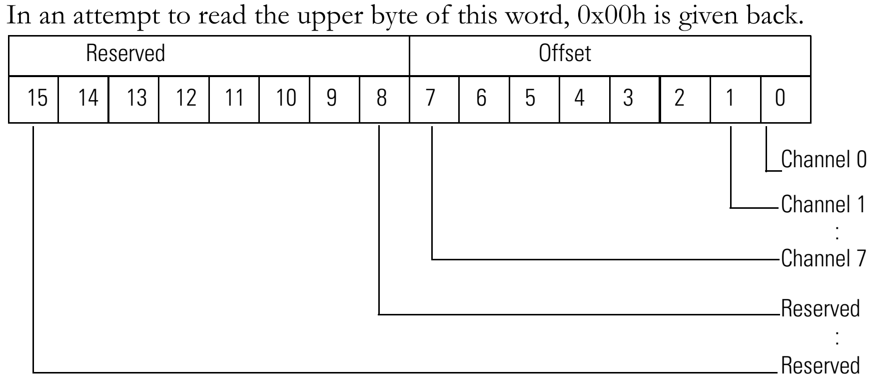


Table 5.8 1797-IE8HCalibration Item Byte Value Identifier List

Identifier (Decimal)	Value	Access Rule
0	Offset channel 0	Read/write
…	…	…
7	Offset channel 7	Read/write
8	Gain channel 0	
…	…	…
15	Gain channel 7	Read/write
16…47	Reserved	—
48	Status mask offset	Read/write
49	Status mask gain	
50	Calibration day	
51	Calibration month	
52	Calibration year	
53	Checksum over calibration values	Read
54…255	Reserved	—

1797-IE8H Calibration Item Byte Value Identifier 48 (Status Mask Offset)

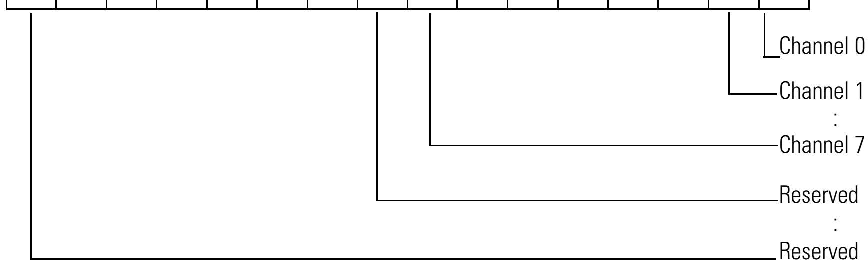
Each bit of the lower byte of this word corresponds to one channel. A logical 1 within the lower byte of the words means that this channel is calibrated according to offset at room temperature. A logical 0 means that this channel is not calibrating. In an attempt to write the upper byte of this word, write 0x00h. In an attempt to read the upper byte of this word, 0x00h is given back.



1797-IE8H Calibration Item Byte Value Identifier 49 (Status Mask Gain)

Each bit of the lower byte of this words corresponds to one channel. A logical 1 within the lower byte of the word means that this channel is calibrated according to gain at room temperature. A 0 means that this channel is not calibrating. In an attempt to write the upper byte of this word, write 0x00h. In an attempt to read the upper byte of this word, 0x00h is given back.

Reserved								Gain							
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0



1797-IE8H Calibration with Offset and Gain

You must calibrate the offset from a channel before gain is calibrated at the same channel, because the gain value depends on the offset value. During the calibration of offset, the corresponding gain value is declared invalid. Before all values are calibrated, there is a calibration error displayed within the Real Time Data in the diagnostic status. After calibration is complete, the calibrated values are stored in the RAM area by the I/O module. Therefore, a store command is necessary to cause the I/O module to transfer the RAM content to the EEPROM.

Use the following guidelines when setting the offset and gain calibrations:

- To calibrate a channel according to offset, the corresponding channel must be sorted, or opened, so that flow is 0.00 mA.
- To calibrate a channel according to gain, the corresponding channel must be supplied with 20.00 mA.
- Set the I/O module ambient temperature in the range of 25…±5 °C.
- Check the calibration status to see if it is idle or erroneous before sending the calibration command by reading attribute 67_{hex}.

Calibration Command Given Back by the I/O Module	Indicates
Idle or erroneous	Calibration is complete
Pending	Poll the status again and recheck
Does not correspond with the first written command	Access conflict with another calibration device or another access error — repeat the calibration command
Idle and it corresponds with the first written command	Successful calibration by the module

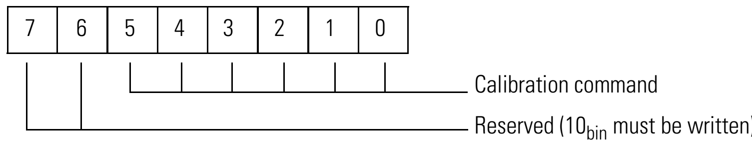
1797-OE8H Calibration Features

The following features are unique to the 1797-OE8H module:

- There are six values per channel that the I/O module uses to calculate the corresponding calibration values (offset and gain).
  - Min Scale DAC at 1500_{dec} about 1 mA
  - Max Scale DAC at 6700_{dec} about 20 mA
  - Current-read-back Min Scale at 1500_{dec} about 1 mA
  - Current-read-back Max Scale at 6700_{dec} about 20 mA
  - Voltage-read-back Min. Scale at 1500_{dec}
  - Voltage-read-back Max Scale at 6700_{dec}
- The module internally calculated calibration values are:
  - Offset DAC
  - Gain DAC
  - Offset I-read-back
  - Gain I-read-back
  - Offset U-read-back
  - Gain U-read-back
- All calibration values are stored in the module non-volatile EEPROM.
- Only one channel can be calibrated at a time according to one calibration value (max scale or min scale values).
- The actual date must be transmitted after calibration to the I/O module and stored in the module non-volatile EEPROM. The data can be read out over the EDT channel.
- The whole calibration can be set to default values by sending a reset command. The default date is Jan,01,2000.
- A specified calibration value can be set to default by sending a reset command for that channel.
- There is a special command to store the whole calibration data from RAM to EEPROM within the I/O module.
- If one value, except the calibration date, isn't calibrated yet, or if you set one value to default, the I/O module displays a calibration error within the Real Time Data diagnostic field.

1797-OE8H Calibration Command Byte

The Calibration command byte uses the following format to **write** to the module:



The Calibration command byte uses the following format to **read** from the module:

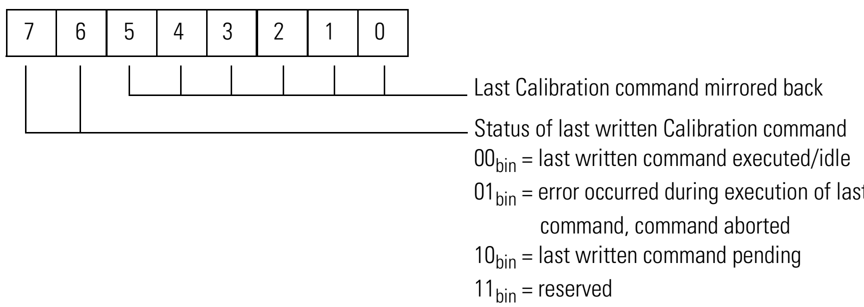


Table 5.9 1797-OE8H Calibration Command List

Calibration Command (Decimal) Bits 0…5	Function
0	Reserved
1	Calibration command min scale
2	Calibration command max scale
3	Write measured min scale value (Current, uA)
4	Write measured min scale value (Voltage, uV)
5	Write measured max scale value (Current, uA)
6	Write measured max scale value (Voltage, uV)
7	Reserved
8	Set all calibration values to default
9	Set one specified calibration value to default
10…13	Reserved(1)
14	Save calibration content to EEPROM
15…63	Reserved

(1) Used during manufacture of the product. Do not use.

Table 5.10 1797-OE8H Interpretation of Command Data Structure Content During Write Access

Command Byte			Item Byte	Data1 Byte	Data2 Byte
Reserved (Binary)	**Command Bits 0…5 (Decimal)**				
10[1]	1	Calibration command min scale	Channel-Mask	Reserved[4]	Reserved[4]
	2	Calibration command max scale			
	3	Write measured min scale value (Current, uA)		Value low-byte	Value high-byte
	4	Write measured min scale value (Voltage, uV)			
	5	Write measured max scale value (Current, uA)			
	6	Write measured max scale value (Voltage, uV)			
	7	Reserved[2]	—	—	—
	8	Set all calibration values to default	Reserved[4]	Reserved[4]	Reserved[4]
	9	Set one specified calibration value to default	Value identifier (0)		
	10	Reserved[3]	Reserved[3]	Reserved[3]	Reserved[3]
	11	Reserved[4]			
	12	Reserved[4]			
	13	Reserved[4]			
	14	Save calibration data to EEPROM	Reserved[4]	Reserved[4]	Reserved[4]
	15…63	Reserved[2]	—	—	—

(1) Always must be 10_{bin}.

(2) Do not use. Designated for future use.

(3) Reserved. Used during manufacture of the product. Do not use.

(4) In attempt to write this byte, write 0.

Table 5.11 1797-OE8H Interpretation of Calibration Data Structure Content During Read Access (Idle Status)

Command Byte				Item Byte	Data1 Byte	Data2 Byte
Status (Binary)		Command Bits 0…5 (Decimal)				
00	Idle	0	Nothing is done. The state after power on.	0	0	0
		1	The min scale value is supported at the outputs according to channel-mask	Channel-Mask		
		2	The max scale value is supported at the outputs according to channel-mask			
		3	The written min scale value of Current was accepted		Value low-byte	Value high-byte
		4	The written min scale value of Voltage was accepted			
		5	The written max scale value of Current was accepted			
		6	The written max scale value of Voltage was accepted			
		7	Reserved[1]	Reserved[1]	Reserved[1]	Reserved[1]
		8	All calibration values are set to default	0	0	0
		9	The specified calibration value is set to default	Value-identifier		
		10	Reserved[2]	Reserved[2]	Reserved[2]	Reserved[2]
		11	Reserved[2]			
		12	Reserved[2]			
		13	Reserved[2]			
		14	The calibration content is saved to EEPROM.	0	0	0

(1) Do not use. Designated for future use.

(2) Reserved. Used during manufacture of the product.

Table 5.12 1797-OE8H Interpretation of Calibration Data Structure Content During Read Access (Error Status)

Command Byte				Item Byte	Data1 Byte	Data2 Byte
Status (Binary)		**Command Bits 0…5 (Decimal)**				
01	Error	3	The written min scale value of Current was not accepted/internal read back erroneous	Channel-Mask	Value low-byte	Value high-byte
		4	The written min scale value of Voltage was not accepted/internal read back erroneous			
		5	The written max scale value of Current was not accepted/internal read back erroneous			
		6	The written max scale value of Voltage was not accepted/internal read back erroneous			
		7	Reserved(1)	Reserved(1)	Reserved(1)	Reserved(1)
		8	The calibration values are not set to default	0	0	0
		9	The specified calibration value is not set to default	Value-identifier		
		10	The specified calibration value is not written		Value low-byte	Value high-byte
		11	Reserved(2)	Reserved(2)	Reserved(2)	Reserved(2)
		12	Reserved(2)			
		13	Reserved(2)			
		14	Reserved(2)			
		15…61	Unknown command is mirrored back	0	0	0
		62	The specified setup value is not written(3)	Setup value-identifier	Value low-byte	Value high-byte
		63	The setup data could not be saved to EEPROM(3)	0	0	0

(1) Do not use. Designated for future use.

(2) Reserved. Used during manufacture of the product. Do not use.

(3) Only for internal use. Do not use for calibration purposes.

Table 5.13 1797-OE8H Interpretation of Calibration Data Structure Content During Read Access (Pending Status)

Command Byte				Item Byte	Data1 Byte	Data2 Byte
Status (Binary)		Command Bits 0…5 (Decimal)				
10	Pending	1	Calibration command number 1 is in interpretation now	Channel-Mask	0	0
		2	Calibration command number 2 is in interpretation now			
		3	The written min scale value of Current is in interpretation now		Value low-byte	Value high-byte
		4	The written min scale value of Voltage is in interpretation now			
		5	The written max scale value of Current is in interpretation now			
		6	The written max scale value of Voltage is in interpretation now			
		7	Reserved[1]	Reserved[1]	Reserved[1]	Reserved[1]
		8	All calibration values are set to default now	0	0	0
		9	The specified calibration value is set to default now	Value-identifier		
		10	Reserved[2]	Reserved[2]	Reserved[2]	Reserved[2]
		11	Reserved[2]			
		12	Reserved[2]			
		13	Reserved[2]			
		14	The calibration data is saved to EEPROM right now	0	0	0
		15…61	The unknown command is trying to be interpreted	x^2	x^2	x^2
		62	The specified setup-value is written now	Setup value-identifier	Value low-byte	Value high-byte
		63	The setup data is saved to EEPROM right now	0	0	0

(1) Do not use. Designated for future use.

(2) Reserved. Used during manufacture of the product. Do not use.

1797-OE8H Calibration Item Byte Channel-Mask

The Calibration item byte channel-mask uses each bit of the byte to correspond to one channel: where 1 is calibrate this channel and 0 is do not calibrate this channel. The LSB corresponds to channel 0, for example, 0x03 ≥ channel 0 and 1 have to be calibrated. Only one channel can be calibrated at a time. If there are more channels selected within the calibration commands, the I/O module signals an error.

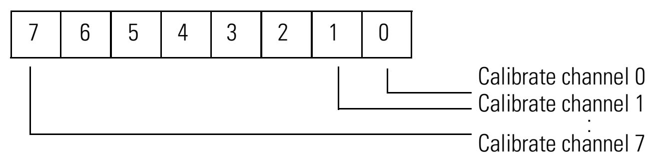


Table 5.14 1797-OE8HCalibration Item Byte Value Identifier List

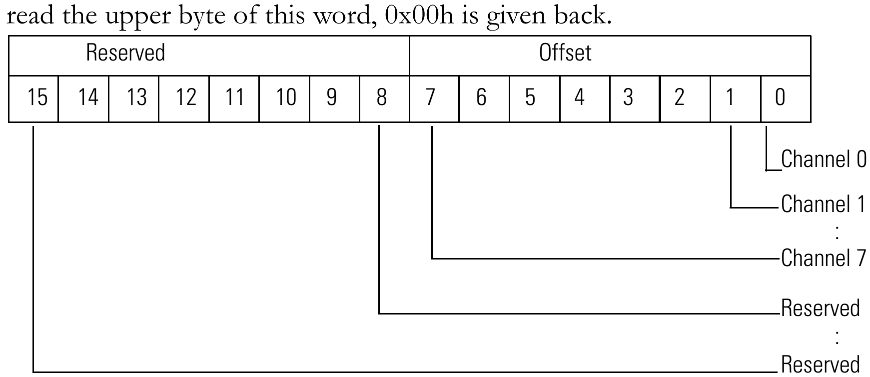
Identifier (Decimal)	Value	Access Rule
0	Offset channel 0	Read/write
…	…	
7	Offset channel 7	
8	Gain channel 0	
…	…	
15	Gain channel 7	
16	Offset current-read-back channel 0	
…	…	
23	Offset current-read-back channel 7	
24	Gain current-read-back channel 0	
…	…	
31	Gain current-read-back channel 7	
32	Offset voltage-read-back channel 0	
…	…	
39	Offset voltage-read-back channel 7	

Table 5.14 1797-OE8HCalibration Item Byte Value Identifier List

Identifier (Decimal)	Value	Access Rule
40	Gain voltage-read-back channel 0	Read/write
…	…	
47	Gain voltage-read-back channel 7	
48	Status mask calibration	
49	Reserved	
50	Calibration day	
51	Calibration month	
52	Calibration year	
53	Checksum over calibration values	Read
54…255	Reserved	—

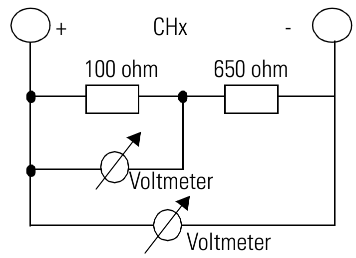
1797-OE8H Calibration Item Byte Value Identifier 48 (Status Mask Calibration)

Each bit of the lower byte of this word corresponds to one channel. A logical 1 within the lower byte of the words means that this channel is completely calibrated. A logical 0 means that this channel is not completely calibrated. In an attempt to write the upper byte of this word, write 0x00h. In an attempt to read the upper byte of this word, 0x00h is given back.

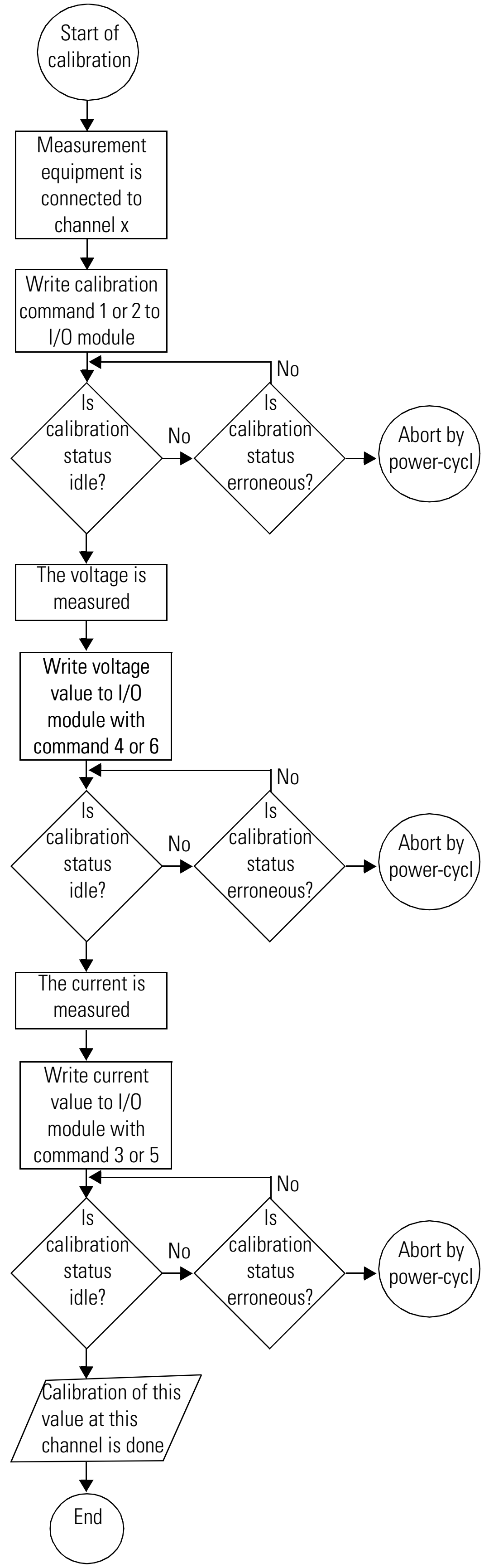


1797-OE8H Calibration Flowchart Procedure

Perform the calibration at ambient room temperature, 25 (±5) °C, according to the procedure flowchart. Each channel is calibrated one after the other. The current is measured indirectly via a precision voltmeter placed across a precision 100 ohm resistor.



Before all values are completely calibrated, a calibration error is displayed within the Real Time Data field in the diagnostic status field. After calibration is complete, the I/O module stores the calibrated values in the RAM area. Therefore, you must send a store command to cause the I/O module to transfer the RAM content to the EEPROM.



Start of calibration
Measurement equipment is connected to channel x
Write calibration command 1 or 2 to I/O module
Is calibration status idle?
No
Is calibration status erroneous?
No
Abort by power-cycl
The voltage is measured
Write voltage value to I/O module with command 4 or 6
Is calibration status idle?
No
Is calibration status erroneous?
No
Abort by power-cycl
The current is measured
Write current value to I/O module with command 3 or 5
Is calibration status idle?
No
Is calibration status erroneous?
No
Abort by power-cycl
Calibration of this value at this channel is done
End

Apply FLEX Ex Analog I/O Modules

What This Chapter Contains

Read this chapter to learn how to use entity parameters when electrically interconnecting your FLEX Ex analog I/O module in a hazardous area.

The FLEX Ex system is different from traditional control systems used the intrinsic safety in its ability to be located directly in hazardous areas and to embrace high speed network-based control.

Evaluate the Application

Follow these steps when designing a FLEX Ex system for your application:

1. Define the area classification.
2. Select protection method(s).
3. Match field devices and I/O modules.
4. Optimize power distribution.
5. Layout the ControlNet Ex network.

An explanation of each of these steps is provided in this chapter.

Define the Area Classification

Before you can determine what components will make up your FLEX Ex system, you must define the area in which that system will operate. You must determine the following:

- Classification method
- Hazard
- Temperature rating

Decide Classification Method

Your application location will usually decide whether the classification method is Zone or Class/Division, but the system designer may make this determination. **FLEX Ex is certified for zone method only**. Certification is pending for Division method.

Determine Hazard

Hazard–typically gas, dust, or fibers–is determined by the material being processed. For example, a coal mine will generally be rated for dust and methane gas hazards. **FLEX Ex is certified for gas hazard only**. Certification is pending for attaching wiring to FLEX Ex I/O modules from a dust and fiber hazardous area.

Determine Temperature Rating

The spontaneous ignition temperature of the hazard in your application determines the temperature rating. For example, an application with a hydrogen hazard may use equipment with a temperature rating of T1 because hydrogen's ignition temperature is 550 °C. **FLEX Ex is certified as a T4 system**.

Select Protection Method(s)

Although the FLEX Ex system primarily uses the Intrinsic Safety protection method, the system uses all methods listed below.

Table 6.1 Protection Methods for Hazardous Applications

Protection Method	Designation[1(1)]	Method of Achieving Protection
Intrinsic Safety	EEx_{ia}/EEx_{ib}	Energy Limiting
Encapsulation	EEx_m	Segregation
Increased Safety	EEx_e	Refined Mechanical Design
Flameproof	EEx_d	Containment

(1) In the Non-Incendive protection method, n: used locally in the United States and United Kingdom.
In the Intrinsic Safety method, ia: Zone 0, 1, 2 & ib: Zone 1, 2.

IMPORTANT As not all protection methods are applicable for all locations, consult local certifying agencies to determine acceptable protection methods for your application.

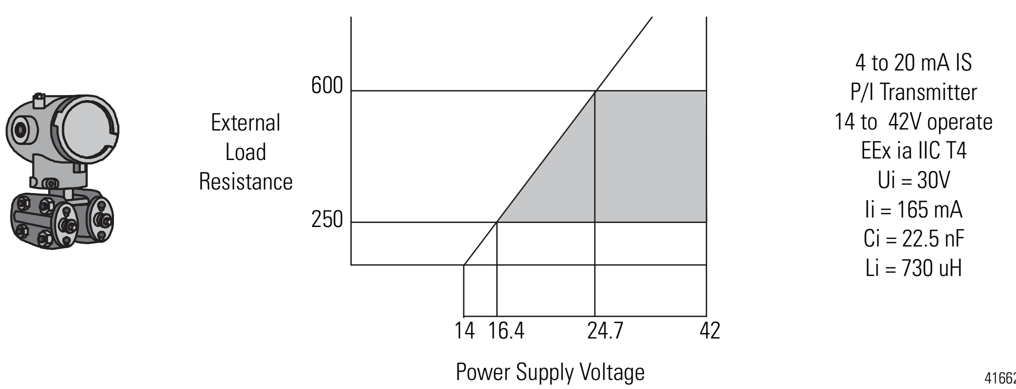
Match Field Devices and I/O Modules

You must match field devices and I/O modules for your application to function properly. Consider the following:

- Verify field device and I/O module operational characteristics
- Match entity parameters of field devices and I/O modules

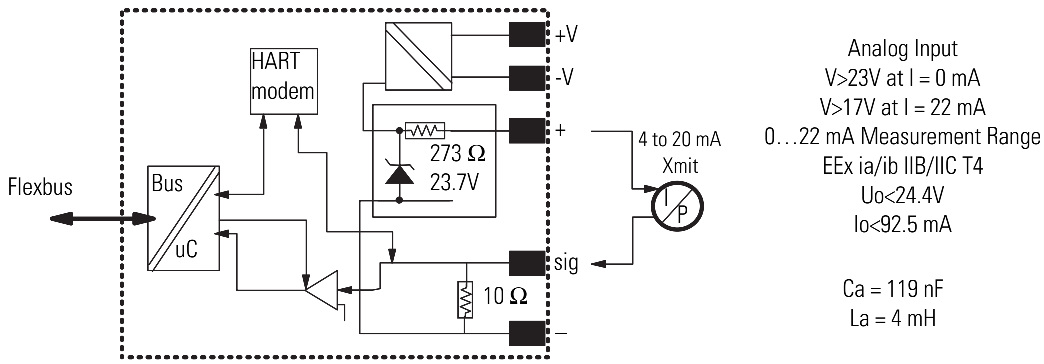
P/I Analog Transmitter Functional and IS Parameters

The figure below shows a typical pressure to current analog transmitter. Two types of characteristics are shown, functional and IS.



1797-IE8H Functional and IS Parameters

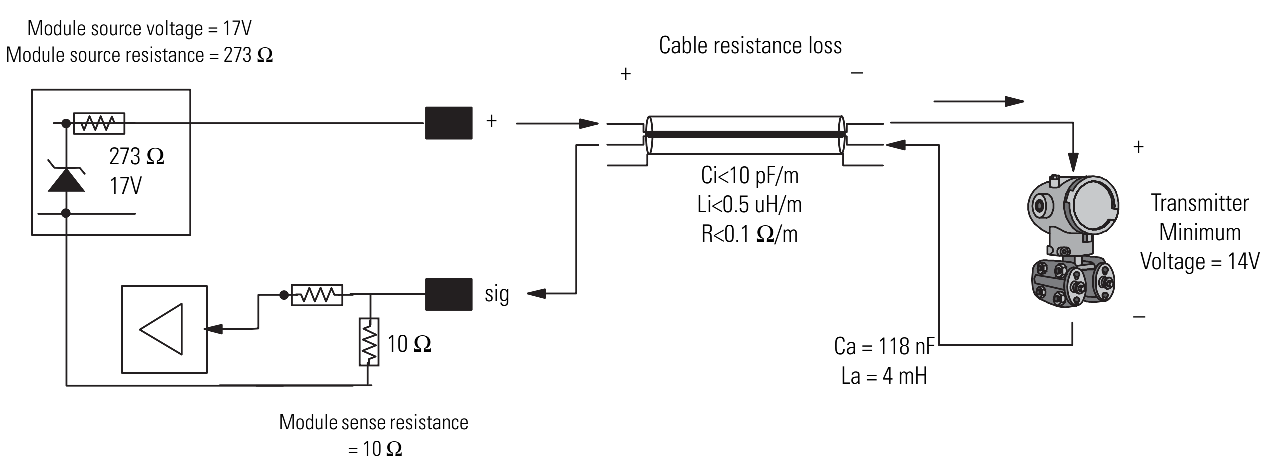
The figure below provides data, on the Flex Ex analog input modules, which can be matched to this transmitter.



Loop Functionality Verification

The functional characteristics will be checked first. The figure below shows the general situation which must be analyzed for proper loop function.

On the left are the module components of the voltage source to run the loop and its internal source resistance. In the center is the cable. It represents a loss with regard to its resistance. Cable resistance is a function of cable length. On the right is the transmitter, which has a minimum voltage it must see to function properly.



The loop must function properly under maximum signal current conditions, in this case 22 mA. As can be seen the key variable, which must be determined, is the total loop resistance. This may be determined with the following equation:

$$Rtotal = \frac{(23.7\text{-}14)}{0.022} = 440\ \Omega$$

Once Rtotal is known, you must determine the actual cable resistance that can be accommodated. This is the difference between Rtotal and the module internal source and sense resistances: Rcable=440-273-10=157 Ω

Rcable is used to determine the wiring length allowed between the module and the transmitter:

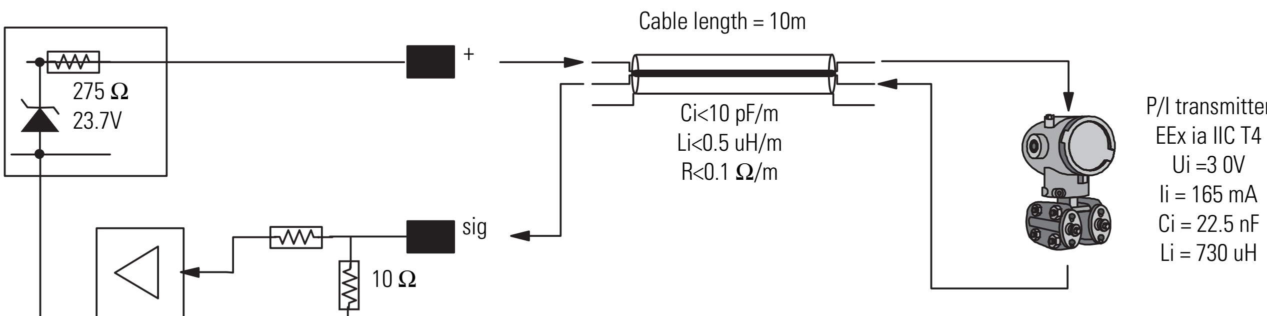
$$Cable\_length = \frac{157}{2*0.1} = 785\text{ m}$$

Note, the 2 in the denominator of the equation is necessary to account for the resistance of both cable conductors (signal source + and signal and return sig).

Intrinsic Safety Entity Verification

Next we must determine if the pressure to current analog transmitter and the Flex Ex analog input module are compatible from an IS perspective. We will make this determination for a IIC gas application.

The figure below shows an extraction of pertinent information from the figures on page 6-3.



Module		Total Loop		Total Loop		Distance		Cable
Uo	< or =	Ui	=	Ui				
Io	< or =	Ii	=	Ii				
Ca	> or =	Ci	=	Ci	+	(length	*	Ci per length)
La	> or =	Li	=	Li	+	(length	*	La per length)

Module		Module		Module		Distance		Cable
Uo<24.4V	< or =	Ui=30V	=	Ui=30V				
Io<92.5 mA	< or =	Ii=165	=	Ii=165				
Ca=119 nF	> or =	Ci=22.6 nF	=	Ci=22.5 nF	+	(10 m	*	Ci=10 pF/m)
La=4 mH	> or =	Li=735 uH	=	Li=735 uH	+	(10 m	*	La=0.5 uH/m)

In the figure above, three key items are shown, the field device the interconnecting cabling and the Flex Ex module (in this example, a 1797-IE8H). The entity verification is done for the gas group IIC. As the table shows, the module's entity parameters are compared to the combination of the transmitter and the wiring entity parameters.

The module's entity parameters are shown in the Module column on the left. They must be compared with the parameters shown in the Total Loop column, in the manner shown. The values in the Total Loop column are determined in the following manner:

- Total Loop U_i = Transmitter U_i
- Total Loop I_i = Transmitter I_i
- Total Loop C_i = (Transmitter C_i + Cabling C_i per length) X (cable length)
- Total Loop L_i = (Transmitter L_i + Cabling L_i per length) X (cable length)

As long as the Module and Total Loop entity parameters satisfy the inequalities shown the loop is acceptable for use in the hazardous environment.

I/O

The input and output modules comply fully to and provide simple entity parameters. These modules can directly interface with a wide variety of intrinsically safe controls and instrumentation. Because all field device power is supplied directly from the I/O module, no extra wiring or power sources are needed in a hazardous area.

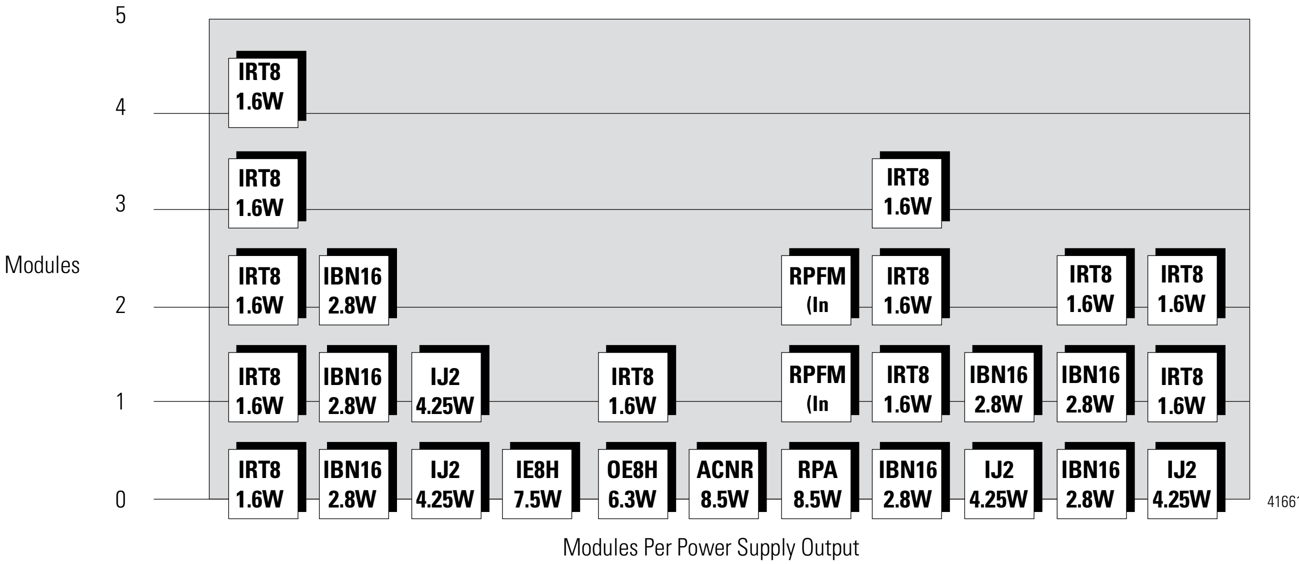
Finally, these modules maintain intrinsic safety in hazardous areas by providing isolation from other modules in the system as well as intrinsic safety segregation between channels on the same module.

Optimize Power Distribution

Your FLEX Ex system must use adequate power supplies to support the physical locations determined earlier in this chapter. Each FLEX Ex I/O module in the system is rated for input power, and the FLEX Ex power supply is rated in the number of output channels and power available from each channel.

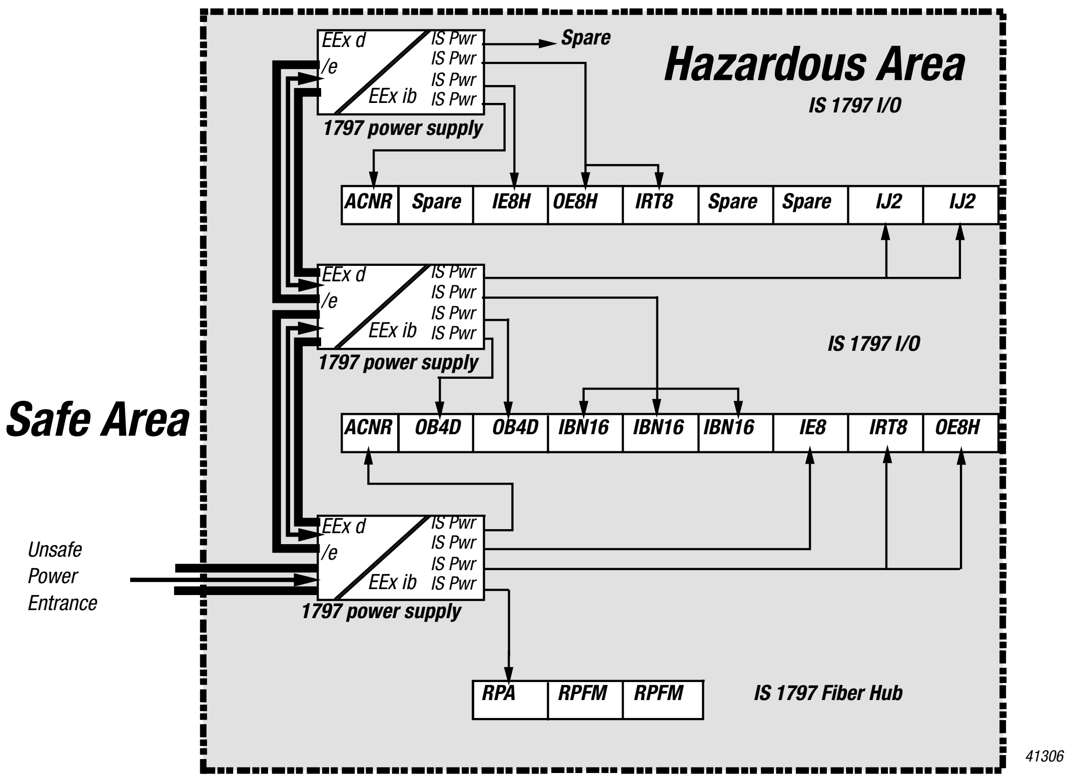
Assigning Power Supplies

Note the amount of power each module requires and assign it to a power supply output. Continue to assign modules to the power supply output until the supply's output power rating is consumed. The graphic below shows the number of modules per power supply output.



Each power supply output in the FLEX Ex system is rated for 8.5 W. Modules can be attached to the output until their combined power equals that number. Do not exceed the power supply maximum of 8.5 W.

Assign the next module to another output as before. When all four power supply outputs are utilized, add another power supply to the system, see the figure below.



ATTENTION

Power supply outputs can never be paralleled. Paralleling outputs voids all intrinsic safety certifications.

Power Supply Considerations

When applying power, consider the certain characteristics of the wire connecting the power supply output to a module’s power input. The wire cannot exhibit more than:

- 0.1 Ω of resistance (+V and -V combined)
- 800 nF of capacitance
- 10 μF of inductance

Typically, these restrictions will yield wiring lengths of not more than 3.5 m or 5.8 m (1.5 mm^2 and 2.5 mm^2 wire respectively) without the use of special wiring or wiring methods.

Chapter Summary

In this chapter you learned how to apply the FLEX Ex analog I/O modules. Move to Chapter 7 to learn about troubleshooting your modules.

Troubleshoot the FLEX Ex Analog I/O Modules

What This Chapter Contains

Read this chapter to troubleshoot your I/O module.

Status Indicators

1797-IE8H Module

The 1797-IE8H module has one power indicator that is on when power is applied to the module and one status indicator for each input.

A = Status indicators
B = Insertable labels for writing individual input designations
C = Power indicator

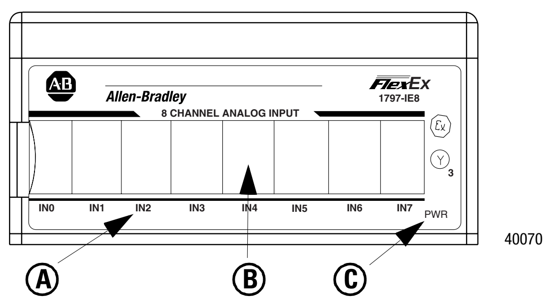


Table 7.1 1797-IE8H Status Indicators

Indicator	Color	State	Meaning
Status	Red	On	At cycle power – Channel 0 indicator lights when you cycle power until all internal diagnostics are checked. After successful power cycle, the indicator goes off if no fault is present. After successful powerup – Indicates a critical fault (for example, diagnostic failure)
		Blinking (when faults are enabled, and bit set)	Indicates a noncritical channel fault
	Yellow	On/blinking	HART device was found on the associated channel (when configured)
Power	—	Off	Module not powered
	Green	On	Module receiving power
		Blinking	No flexbus communication

1797-OE8H Module

The 1797-OE8H module has one power that is on when power is applied to the module and one status indicator for each input.

A = Status indicators
B = Insertable labels for writing individual input designations
C = Power indicator

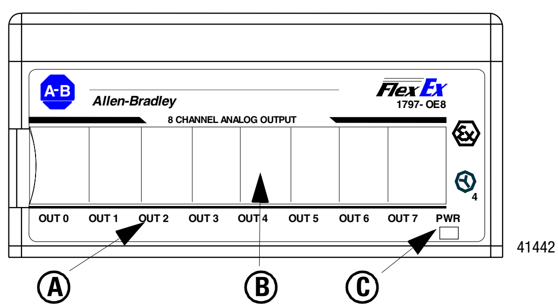


Table 7.2 1797-OE8H Status Indicators

Indicator	Color	State	Meaning
Status	Red	On	At power cycle – Channel 0 indicator lights when you cycle power until all internal diagnostics are checked. After successful power cycle, the indicator goes off if no fault is present. After successful powerup – Indicates a critical fault (for example, diagnostic failure)
		Blinking (when faults are enabled, and bit set)	Indicates a noncritical channel fault
	Yellow	On/blinking	HART device was found on the associated channel (when configured)
Power	—	Off	Module not powered
	Green	On	Module receiving power
		Blinking	No flexbus communication

Repair

This module is not field repairable. Any attempt to open this module will void the warranty and IS certification. If repair is necessary, return this module to the factory.

Chapter Summary

In this chapter you learned how to troubleshoot the FLEX Ex analog I/O modules. Move to Appendix A to see the specifications for your module.

Notes:

Specifications

1797-IE8H Input Module

Specifications

Number of Inputs	8 single-ended, non-isolated
IS Input Type	EEx ia IIB/IIC T4 AEx ia IIC T4 Class I, II, III Division 1 Groups A-G T4
IS Module Type	EEx ib IIB/IIC T4 AEx ib IIC T4 Class I Division 1 Groups A-D T4
Resolution	16 bits
Transfer Characteristics Accuracy at 20 °C (68 °F) Temperature Drift	 0.1% of output signal range 0.005%/C of output signal range
Functional Data Range	>17V @ 20 mA >21.5V @ 0 mA
Data Format	Configurable
Step Response to 99% of FS	60 ms (0…90% of the measured value by smallest filter setting)
Module from Adapter Best/Worst Update Time	50/1450 µs (Best case Flexbus-cycle time is 1.6 ms)
Indicators	8 red fault indicators 1 green power
Output (Intrinsically Safe) (16 pin male/female flexbus connector)	$U_i \leq 5.8V$ dc $I_i \leq 400$ mA L_i = Negligible $C_i \leq 1.35$ µF
Isolation Path Input to Power Supply Input to Flexbus Input to Input Power Supply to Flexbus	Isolation Type Galvanic to DIN EN50020 Galvanic to DIN EN50020 None Galvanic to DIN EN50020
Power Supply (+V, -V intrinsically safe)	$U_i \leq 9.5V$ dc $I_i \leq 1$ A L_i = Negligible C_i = Negligible
Module Field-side Power Consumption	7.5 W
Power Dissipation	5.2 W

Thermal Dissipation	17.75 BTU/hr
Module Location	Cat. No. 1797-TB3 or -TB3S
Conductor Wire Size	12 gauge (4 mm^2) stranded maximum 3/64 in (1.2 mm) insulation maximum
Dimensions	46 mm x 94 mm x 75 mm (1.8 in. x 3.7 in. x 2.95 in.)
Weight	200 g (approximately)
Keyswitch Position	3
Environmental Conditions Operational Temperature Storage Temperature Relative Humidity Shock Operating Nonoperating Vibration	 -20…+70 °C (-4…+158 °F) -40…+85 °C (-40…+185 °F) 5…95% noncondensing Tested to 15 g peak acceleration, 11(+1) ms pulse width Tested to 15 g peak acceleration, 11(+1) ms pulse width Tested 2 g @ 10…500 Hz per IEC68-2-6
Agency Certification CENELEC UL, C-UL FM	 II (1) 2G EEx ia/ib IIB/IIC T4 II (1D) (2D) Class I Division 1 & 2 Groups A-D T4 Class I Zone 1 & 2 AEx ib/[ia] IIC T4 Class I Division 1 Groups A-D T4 Class I Zone 1 AEx ib/[ia] IIC T4
Certificates CENELEC UL, C-UL FM	 DMT 98 ATEX E 020 X UL Certificate Number 99.19699 c UL us Class I Division 1 Hazardous FM Certificate Number 3009806

1797-IE8H CE, CENELEC I/O Entity Parameters

Measurement input (sig to -) for ch 0 to 7 (terminals: 1 to 2; 5 to 6; 9 to 10; 13 to 14; 18 to 19; 22 to 23; 26 to 27; 30 to 31)

	Protection	Group	Allowed Capacitance	Allowed Inductance
U_o = 5V I_o = 1 mA P_o = 1.3 mW	EEx ia	IIB	1000 µF	1 H
U_i = 28V I_i = 93 mA C_i and L_i negligible		IIC	100 µF	1 H

Source output (+ to sig) for ch 0 to 7 (terminals: 0 to 1; 4 to 5; 8 to 9; 12 to 13; 17 to 18; 21 to 22; 25 to 26; 29 to 30)

	Protection	Group	Allowed Capacitance	Allowed Inductance
U_o = 23.7V I_o = 92.5 mA P_o = 548 mW	EEx ia	IIB	560 nF	10 mH
		IIC	66 nF	2.5 mH
If concentrated capacitance and/or inductance are available, use the following values.	EEx ia	IIB	320 nF	10 mH
		IIC	60 nF	2 mH

Source output plus measurement input (+ to -) for ch 0 to 7 (terminals: 0 to 2; 4 to 6; 8 to 10; 12 to 14; 17 to 19; 21 to 23; 25 to 27; 29 to 31)

	Protection	Group	Allowed Capacitance	Allowed Inductance
U_o = 23.7V I_o = 93.5 mA P_o = 555 mW	EEx ia	IIB	560 nF	10 mH
		IIC	66 nF	2.5 mH
If concentrated capacitance and/or inductance are available, use the following values.	EEx ia	IIB	320 nF	10 mH
		IIC	60 nF	2 mH

1797-IE8H UL, C-UL I/O Entity Parameters

If this product has the UL/C-UL mark, it has been designed, evaluated, tested, and certified to meet the following standards:

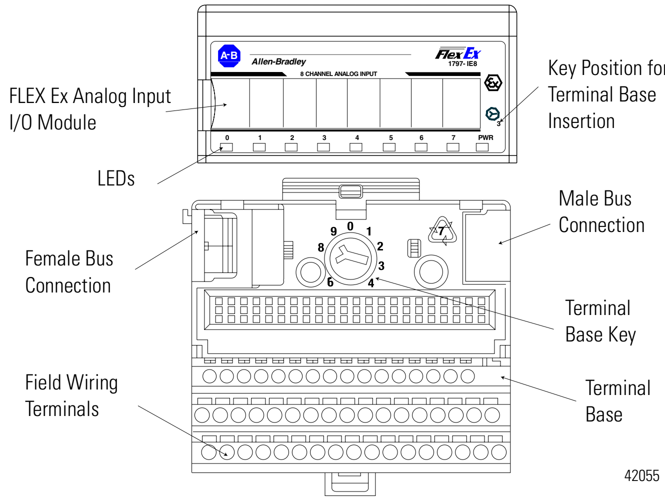
- UL 913, 1988, Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III Division 1, Hazardous (Classified) Locations
- UL 1203, Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations
- UL 2279, Electrical Equipment for Use in Class I, Zone 0, 1, and 2 Hazardous (Classified) Locations
- UL 508, Industrial Control Equipment
- CSA C22.2 No. 157-92, Intrinsically Safe and Non-Incendive Equipment for Use in Hazardous Locations
- CSA C22.2 No. 30-M1986, Explosion-Proof Enclosures for Use in Class I Hazardous Locations
- CSA-E79-0-95, Electrical Apparatus for Explosive Gas Atmospheres, Part 0: General Requirements
- CSA-E79-11-95, Electrical Apparatus for Explosive Gas Atmospheres, Part 11: Intrinsic Safety i
- CSA C22.2 No. 14-95, Industrial Control Equipment

Wiring Methods

- Wiring method 1 - Each channel is wired separately.
- Wiring method 2 - Multiple channels in one cable, providing each channel is separated in accordance with the National Electric Code (NEC) or Canadian Electric Code (CEC).

Table 1

Wiring Method	Channel	Terminals	V_{oc} (V)	I_{sc} (mA)	V_t (V)	I_t (mA)	Groups	C_a (μF)	L_a (mH)
1 and 2	Any one channel for example ch0	0(+), 1(sig)	23.7	92.5	—	—	A, B, IIC	0.06	2.0
							C, E, IIB	0.18	8.0
							D, F, G, IIA	0.48	16.0
		1(sig), 2(-)	5	1.0			A, B, IIC	100	1000
							C, E, IIB	300	1000
							D, F, G, IIA	800	1000
		0(+), 1(sig), 2(-)	—	—	23.7	93.5	A, B, IIC	0.06	2.0
							C, E, IIB	0.18	8.0
							D, F, G, IIA	0.48	16.0



IMPORTANT A terminal base may or may not have an I/O module installed.

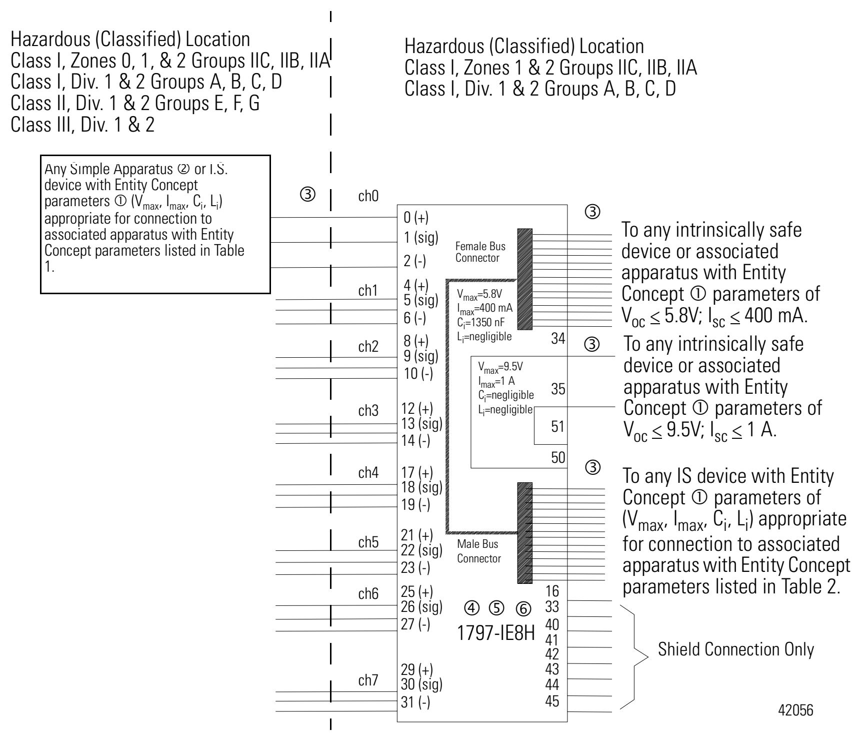


Table 2

Terminals	V_t (V)	I_t (mA)	Groups	C_a (μF)	L_a (μH)
Male Bus Connector	5.8	400	A-G	3.0	3.0

① The entity concept allows interconnection of intrinsically safe apparatus with associated apparatus not specifically examined in combination as a system when the approved values of V_{oc} and I_{sc} or V_t and I_t of the associated apparatus are less than or equal to V_{max} and I_{max} of the intrinsically safe apparatus and the approved values of C_a and L_a of the associated apparatus are greater than C_i + C_{cable} and L_i + L_{cable} respectively for the intrinsically safe apparatus.

② Simple apparatus is defined as a device which neither generates nor stores more than 1.2V, 0.1 A, 20 μJ, or 25 mW.

③ Wiring methods must be in accordance with the National Electric Code, ANSI/NFPA 70, Article 504 and 505 or the Canadian Electric Code CSA C22.1, Part 1, Appendix F. For additional information refer to ANSI/ISA RP12.6.

④ This module, 1797-IE8H, must be used with terminal base 1797-TB3 or 1797-TB3S.

⑤ Terminals 3, 7, 11, 15, 20, 24, 28, 32, 36 to 39, and 46 to 49 shall not be connected.

⑥ WARNING: Substitution of components may impair intrinsic safety. AVERTISSEMENT: La substitution de composant peut compromettre la securite intrinseque.

1797-IE8H FM I/O Entity Parameters

If this product has the FM mark, it has been designed, evaluated, tested, and certified to meet the following standards:

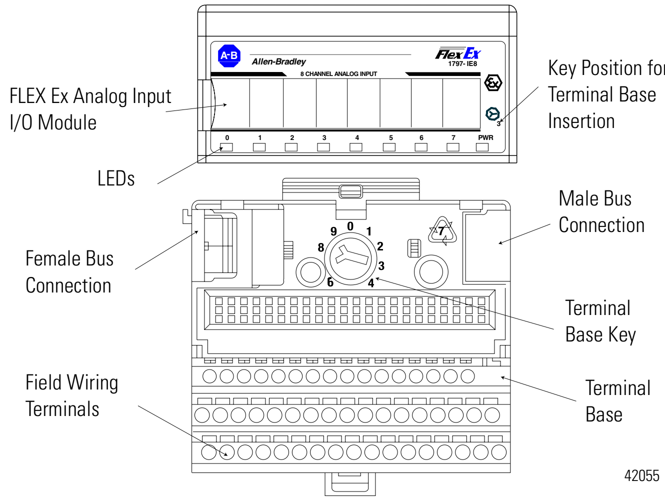
- FM C1. No.3600:1998, Electrical Equipment for Use in Hazardous (Classified) Locations General Requirements
- FM C1. No.3610:1999, Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, III Division 1 Hazardous (Classified) Locations
- FM C1. No.3615:1989, Explosionproof Electrical Equipment General Requirements
- FM C1. No.3810:1989, 1995, Electrical and Electronic Test, Measuring and Process Control Equipment
- ANSI/NEMA 250, 1991, Enclosures for Electrical Equipment

Wiring Methods

- Wiring method 1 - Each channel is wired separately.
- Wiring method 2 - Multiple channels in one cable, providing each channel is separated in accordance with the National Electric Code (NEC).

Table 1

Wiring Method	Channel	Terminals	V_{oc} (V)	I_{sc} (mA)	V_t (V)	I_t (mA)	Groups	C_a (μF)	L_a (mH)
1 and 2	Any one channel for example ch0	0(+), 1(sig)	23.7	92.5	—	—	A, B	0.15	4.0
							C, E	0.45	12.0
							D, F, G	1.20	32.0
		1(sig), 2(-)	5	1.0			A, B	100	1000
							C, E	300	1000
							D, F, G	800	1000
		0(+), 1(sig), 2(-)	—	—	23.7	93.5	A, B	0.15	4.0
							C, E	0.45	12.0
							D, F, G	1.20	32.0



IMPORTANT	A terminal base may or may not have an I/O module installed.

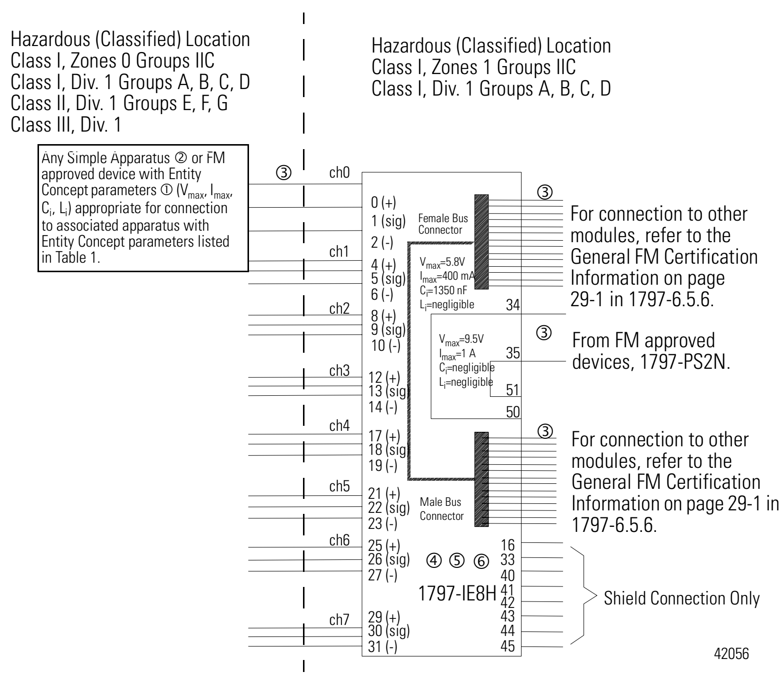


Table 2

Terminals	V_t (V)	I_t (mA)	Groups	C_a (μF)	L_a (μH)
Male Bus Connector	5.8	400	A-G	3.0	3.0

① The entity concept allows interconnection of intrinsically safe apparatus with associated apparatus not specifically examined in combination as a system when the approved values of V_{oc} and I_{sc} or V_t and I_t of the associated apparatus are less than or equal to V_{max} and I_{max} of the intrinsically safe apparatus and the approved values of C_a and L_a of the associated apparatus are greater than C_i + C_{cable} and L_i + L_{cable} respectively for the intrinsically safe apparatus.

② Simple apparatus is defined as a device which neither generates nor stores more than 1.2V, 0.1 A, 20 μJ, or 25 mW.

③ Wiring methods must be in accordance with the National Electric Code, ANSI/NFPA 70, Article 504 and 505. For additional information refer to ANSI/ISA RP12.6.

④ This module, 1797-IE8H, must be used with terminal base 1797-TB3 or 1797-TB3S.

⑤ Terminals 3, 7, 11, 15, 20, 24, 28, 32, 36-39, and 46 to 49 shall not be connected.

⑥ WARNING: Substitution of components may impair intrinsic safety.

1797-OE8H Output Module

Specifications

Number of Outputs	8 single-ended, non-isolated
Outputs Type of Protection	 EEx ia IIB/IIC T4
Module Type of Protection	 EEx ib IIB/IIC T4
Resolution	13 bits
Transfer Characteristics Accuracy at 20 °C (68 °F) Temperature Drift	 0.1% of output signal range 0.010%/C of output signal range
Load Range Current Voltage Available at 22 mA Load	 0…22 mA > 15V 0…680 Ω @ 22 mA, 0…770 Ω @ 20 mA
Data Format	Configurable
Step Response to 99% of FS	115 ms (in HART mode) 18 ms (in standard mode)
Module from Adapter Best/Worst Update Time	200 ms/1600 µs
Indicators	8 red fault indicators 1 green power 8 yellow HART comm indicators
Output Ch 0…Ch 7 (Intrinsically Safe) (Terminals: 0…1; 4…5; 8…9; 12…13; 17…18; 21…22; 25…26; 29…30)	$U_0 \leq 21.6V$ $I_0 \leq 92$ mA $P_0 \leq 500$ mW
Isolation Path Output to Power Supply Output to FLEXBus Output to Output Power Supply to FLEXBus	Isolation Type Galvanic to DIN EN50020 Galvanic to DIN EN50020 None Galvanic to DIN EN50020
Power Supply (+V, -V Intrinsically Safe) (Terminals: 34/50 (+); 35/51 (-))	$U_i \leq 9.5V$ dc $I_i \leq 1$ A L_i = Negligible C_i = 120 nF
Module Field-Side Power Consumption	6.1 W
Power Dissipation	5.4 W
Thermal Dissipation	20.8 BTU/hr
Module Location	Cat. No. 1797-TB3 or -TB3S Terminal Base Unit
Conductors Wire Size	12 gauge ($4mm^2$) stranded maximum 1.2 mm (3/64 in) insulation maximum
Dimensions	46 x 94 x 75 mm (1.8 x 3.7 x 2.95 in)
Weight	200 g (approximately)

Keyswitch Position	4
Environmental Conditions Operational Temperature Storage Temperature Relative Humidity Shock, Operating Shock, Non-Operating Vibration	 -20…+70 °C (-4…158 °F) -40…+85 °C (-40…185 °F) 5…95% noncondensing Tested to 15 g peak acceleration, 11 (+1)ms pulse width Tested to 15 g peak acceleration, 11 (+1)ms pulse width Tested 2 g @ 10…500 Hz per IEC 68-2-6
Agency Certification CENELEC	 II (1) 2G EEx ia/ib IIB/IIC T4 II (1D) (2D)
Certificates CENELEC	 DMT 00 ATEX E 042 X

1797-OE8H CENELEC I/O Entity Parameters

Signal output (+ to -) for ch 0 to ch 7 (terminals: 0 to 1; 4 to 5; 8 to 9; 12 to 13; 17 to 18; 21 to 22; 25 to 26; 29 to 30)

	Protection	Group	Allowed Capacitance	Allowed Inductance	Internal Capacitance	Internal Inductance
U_o = 21.6V I_o = 92 mA P_o = 500 mW	EEx ia	IIB	1.18 μF	1.18 μF	10 nF	0 mH
		IIC	164 nF	164 nF	10 nF	0 mH

Notes:

FLEX Ex HART Module Commands

What This Appendix Contains

Read this appendix to learn the module commands to and from FLEX Ex HART I/O modules.

Protocol Overview

HART field communication protocol is widely accepted in the industry as the standard for digitally enhanced 4…20 mA communication with smart field instruments. The HART protocol message structure, command set, and status are explained in this appendix.

The HART command set is organized into three groups and provides read/write access to a wide array of information available in smart field instruments:

- Universal commands provide access to information that is useful in normal plant operation such as the instrument manufacturer, model, tag, serial number, descriptor, range limits, and process variables. All HART devices must implement universal commands.
- Common practice commands provide access to functions that can be carried out by many devices, though not all.
- Device-specific commands provide access to functions that may be unique to a particular device.

Universal Commands

Table B.1 Universal HART Module Commands

Command		Action	Meaning
0	Read	Read unique device identification	12-byte device identifiers are given in the response.
1		Read HART variables (process values)	Commands are only supported for compatibility purposes and are without any meaning. The transmitters, that is, the SCAN function, have the following functions. • Read primary variable • Read primary variable as current (in mA) and percent range) • Primary variable is read as a current (in mA) and four predefined dynamic variables
2		—	—
3			
11		Read unique identifier associated with tag	The response is a 12-byte device identifier if the given tag matches the tag of the multiplexer.
12		Read message	Read the 32-bit message (also see 17).
13		Selection switch markings in hand, read description, and date	Read the 8-digit selection switch marking (tag) and the 16-digit time and date.
17	Write	Write message	The 32-digit message is written (also see 12).
18		Write tag, description, and date	Save an 8-digit (tag), a 16-digit description, and date.

Common Practice Commands

Table B.2 Common Practice HART Module Commands

Command		Action	Meaning
38	Write	Reset configuration changed flag	Delete status information.
41		Perform device self-test	Performs the device self-test similar to turning on the power supply. If no error occurs, the malfunction status message is deleted (if it had been set).
42		Perform device reset	Immediately after the command is confirmed, a reset of the device HART controller is performed.
48	Read	Read additional device status	—

Device-specific Commands

The following commands provide device-specific information on the HART I/O modules.

Command 128

Command 128 is Read Parameter Assignment of the Multiplexer. There are no request data bytes.

Table B.3 Command 128 Response Data Bytes

Byte		Description	Value
Response Data Bytes			
0	MAX_DR_PM	Max delayed response for primary master	1
1	MAX_DR_SM	Max delayed response for secondary master	0
2	NUM_DR_PM	Delayed response in use for primary master	—
3	NUM_DR_SM	Delayed response in use for secondary master	
4	CH_SIGN	Physical signalling on HART channels	0 = BELL 202
5	MAX_CH	Max number of HART channels	8
6…7	MAX_INST	Max number of HART instruments	8
8…9	NUM_INST	Number of HART instruments in the list	—
10…11	NUM_SCAN	Number of HART instruments scanned	
12	MODE	Master bit and timing	1 = Primary

Table B.3 Command 128 Response Data Bytes

Byte		Description	Value
13	LOC_MET	Locate method	0 = Single analog (short address 0 only).
14	SCAN_CMD	Scan command	1 = Command 1 2 = Command 2 3 = Command 3
15	SCAN_EN	General scan status	0 = Scan disabled 1 = Normal scan enabled 2 = Special scan enabled
16	BUSY_RETRY	Number of retries for a busy response from instrument	0…11
17	OTHER_RETRY	Number of retries for a other error from instrument	0…11
Command-specific Response Codes			
16	Error	Access restricted	
32	Error	Busy	

Command 129

With Command 129, Read Loop Status, the status of the current loop can be read out. The following information is supplied:

- Hardware fault
- Rebuild running for this loop
- SCAN activated for this loop
- Searching transmitter (due to disappeared)
- Transmitter not responding (due to disappeared)
- Transmitter responding again (due to appeared)
- Another transmitter responded instead (due to mismatched)

Table B.4 Command 129 Request and Response Data Bytes

Byte		Description	Value
Request Data Bytes			
0	CH_NUM	HART channel number	0…7

Table B.4 Command 129 Request and Response Data Bytes

Byte		Description	Value
Response Data Bytes			
0	CH_NUM	HART channel number	0…7
1	CH_STATUS	Channel status bit 7 HARD FAULT bit 6 REBUILDING bit 5…0 Reserved	 0 = No, 1 = yes 0 = No, 1 = yes
2[1]	COUNT_0	Byte before next item	—
3	SHORT_ADDR_0	Instrument 0 short address	
4…8	EXT_ADDR_0	Instrument 0 extended address	
9	INST_SCAN_0	Instrument 0 scan status bit 7 SCAN_ENABLE bit 6 SEARCHING bits 5…0 Reserved	 0 = No, 1 = yes 0 = No, 1 = yes
10	INST_FAULT_0	Instrument 0 scan faults bits 7…6 Reserved bit 5 DISAPPEARED bit 4 APPEARED bit 3 MISMATCHED bits 2…0 Reserved	 0 = No, 1 = yes 0 = No, 1 = yes 0 = No, 1 = yes
…	COUNT_I	Byte before next item	—
…	SHORT_ADDR_I	Instrument I short address	
…	EXT_ADDR_I	Instrument I extended address	
…	INST_SCAN_I	Instrument I scan status bit 7 SCAN_ENABLE bit 6 SEARCHING bits 5…0 Reserved	 0 = No, 1 = yes 0 = No, 1 = yes
…	INST_FAULT_I	Instrument I scan faults bits 7…6 Reserved bit 5 DISAPPEARED bit 4 APPEARED bit 3 MISMATCHED bits 2…0 Reserved	 0 = No, 1 = yes 0 = No, 1 = yes 0 = No, 1 = yes
Command-specific Response Codes			
2	Error	Invalid selection	
5	Error	Too few data bytes received	
16	Error	Access restricted	

[1] Data from byte 2 is present in the reply only if one instrument has been found on the requested channel.

Command 130

Channel 130, Read Instrument List From Index, indicates that the long frame addresses of the transmitters were recognized on the current loops and returned. A zero is returned if no device is detected.

The response of this command is also used to build a cross-reference between I/O module's loop number and the field device's user ID. For example, use this in the host software's project tree. There are no request data bytes.

Table B.5 Command 130 Response Data Bytes

Byte		Description	Value
Response Data Bytes			
0…4	EXT_ADDR_0	Extended address of instrument 0	—
5…9	EXT_ADDR_1	Extended address of instrument 1	
…	EXT_ADDR_I	Extended address of the instrument	
Command-specific Response Codes			
5	Error	Too few data bytes received	
16	Error	Access restricted	
32	Error	Busy	

Command 131

For the given long frame addresses, the Read Static Data of Transmitters command returns the following transmitter data:

- Current loop number, 0 to 15
- Polling address
- Supported HART revision
- Minimum count of required preambles, 5 to 20

There are no request data bytes.

Table B.6 Command 131 Response Data Bytes

Byte		Description	Value
Response Data Bytes			
0…4	EXT_ADDR_0	Extended address of instrument 0	—
5	ERROR_0	Error 0	0 = Instrument present. Data for that instrument is included in reply. 64 = Unknown instrument. Data for that instrument is not included in reply.
…	EXT_ADDR_I	Extended address I	—
…	ERRO_I	Error I	
…	…	…	
Command-specific Response Codes			
16	Error	Access restricted	
32	Error	Busy	

Command 132

Write Static Data of Transmitters command is set when a preamble length outside of the range 5 to 20 is set to 5 or 20. When written, the data of command 132 also invokes the functionality of command 133 (Remove instrument from list) internally. There are no response data bytes.

Table B.7 Command 132 Request Data Bytes

Byte		Description
0…4	EXT_ADDR_0	Extended address of instrument 0[1]
…	EXT_ADDR_I	Extended address of instrument 1
…	…	…
Command-specific Response Codes		
5	Error	Too few data bytes received
16	Error	Access restricted
32	Error	Busy

[1] 0, if it is attended to project no instrument.

Command 133

The Delete Transmitters From the Transmitter List command removes transmitters with the given long frame address from the transmitter list and the SCAN list. No more than 34 instruments may be requested.

Table B.8 Command 133 Request and Response Data Bytes

Byte		Description	Value
Request Data Bytes			
0…4	EXT_ADDR_0	Extended address of instrument 0	—
5	COUNT_0	Bytes before next item	
…	EXT_ADDR_I	Extended address of instrument I	
…	COUNT_I	Bytes before next item	
Response Data Bytes			
0…4	EXT_ADDR_0	Extended address of instrument 0	—
5	COUNT_0	Bytes before next item	
6	ERROR_0	Error 0	0 = Instrument present. 64 = Unknown instrument.

Table B.8 Command 133 Request and Response Data Bytes

Byte		Description	Value
7…11	EXT_ADDR_I	Extended address of instrument I	—
12	COUNT_I	Bytes before next item	
13	ERROR_I	Error I	

Command 134

The Read Scan List command returns the extended addresses of the transmitters. No more than 49 instruments will be returned. If the index is too large, no list is generated and only the index is present in the reply.

Table B.9 Command 134 Request and Response Bytes

Byte		Description	Value
Request Data Bytes			
0…1	INDEX	Instrument scan list index	—
Response Data Bytes			
0	INDEX	Instrument scan list index	—
2…6	EXT_ADDR_0	Extended address of first instrument	
7…11	EXT_ADDR_I	Extended address of instrument I	
Command-specific Response Codes			
5	Error	Too few data bytes received	
16	Error	Access restricted	
32	Error	Busy	

Command 135

For the given long frame addresses, the Read Dynamic Data of the Transmitters command returns the following transmitter data:

- Selected SCAN command
- Long frame address
- HART data

No more than seven instruments may be requested.

Table B.10 Command 135 Request and Response Data Bytes

Byte		Description	Value
Request Data Bytes			
0…4	EXT_ADDR_0	Extended address of instrument 0	—
5	COUNT_0	Bytes before next item	
…	EXT_ADDR_I	Extended address of instrument I	
…	COUNT_I	Bytes before next item	
…	…	…	
Response Data Bytes			
0	SCAN_CMD	Scan command used	1 = Command 1 2 = Command 2 3 = Command 3
1…5	EXT_ADDR_0	Extended address of instrument 0	—
6	COUNT_0	Bytes before next item	
7	ERROR_0	Error 0	0 = No error. 64 = The requested instrument is not on the scan list. No data is included for that instrument.
8	DATA_0	Reply from the instrument 0 (status bytes + data bytes)	—
…	EXT_ADDR_I	Extended address of instrument I	
…	COUNT_I	Bytes before next item	
…	ERROR_i	Error i	
…	DATA_i	Reply from the I-th instrument (status bytes + data bytes)	

Table B.10 Command 135 Request and Response Data Bytes

Byte		Description	Value
Command-specific Response Codes			
5	Error	Too few data bytes received	
16	Error	Access restricted	
17	Error	Too many items requested	
32	Error	Busy	

Command 136

For the given long frame addresses, the Read SCAN Status for the Transmitters command sets the SCAN status of the transmitters (0 = disable SCAN, 1 = enable SCAN). No more than 31 instruments may be requested.

Table B.11 Command 136 Request and Response Bytes

Byte		Description	Value
Request Data Bytes			
0…4	EXT_ADDR_0	Extended address of instrument 0	—
5	COUNT_0	Bytes before next item	
…	EXT_ADDR_I	Extended address of instrument I	
…	COUNT_I	Bytes before next item	
…	…	…	
Response Data Bytes			
0…4	EXT_ADDR_0	Extended address of instrument 0	—
5	COUNT_0	Bytes before next item	
6	ERROR_0	Error 0	0 = No error. 64 = Unknown instrument. No data is included for that instrument.
7	SCAN_0	Instrument 0 scan status	0 = Instrument is not scanned. 1 = Instrument is scanned.
…	EXT_ADDR_I	Extended address of instrument I	—
…	COUNT_I	Bytes before next item	
…	ERROR_I	Error I	
…	SCAN_I	Instrument I scan status	

Table B.11 Command 136 Request and Response Bytes

Byte		Description	Value
Command-specific Response Codes			
5	Error	Too few data bytes received	
16	Error	Access restricted	
17	Error	Too many items requested	
32	Error	Busy	

Command 137

For the given long frame addresses, the Write SCAN Status of the Transmitters command sets the SCAN status of the transmitters (0 = disable SCAN, 1 = enable SCAN). No more than 31 instruments may be requested.

Table B.12 Command 137 Request and Response Data Bytes

Byte		Description	Value
Request Data Bytes			
0…4	EXT_ADDR_0	Extended address of instrument 0	—
5	COUNT_0	Bytes before next item	
6	SCAN_0	Scan enable/disable on instrument 0	0 = Scan disable 1 = Scan enable
…	EXT_ADDR_I	Extended address of instrument I	—
…	COUNT_I	Bytes before next item	
…	SCAN_I	Scan enable/disable on instrument I	
…	…	…	
Response Data Bytes			
0…4	EXT_ADDR_0	Extended address of instrument 0	—
5	COUNT_0	Bytes before next item	
6	ERROR_0	Error 0	0 = No error. 31 = The scan value sent is identical to the current one. 64 = Unknown instrument. No data is included for that instrument. 65 = Scan value not allowed. No data included for that instrument.

Table B.12 Command 137 Request and Response Data Bytes

Byte		Description	Value
7	SCAN_0	Instrument 0 scan status	0 = Instrument is not scanned. 1 = Instrument is scanned.
…	EXT_ADDR_I	Extended address of instrument I	—
…	COUNT_I	Bytes before next item	
…	ERROR_I	Error I	
…	SCAN_I	Instrument I scan status	
…	…	…	
Command-specific Response Codes			
5	Error	Too few data bytes received	
16	Error	Access restricted	
17	Error	Too many items requested	
32	Error	Busy	

Command 138

With the Read Transmitter Cumulative Response command, no more than 27 instruments may be requested.

Table B.13 Command 138 Request and Response Data Bytes

Byte		Description	Value
Request Data Bytes			
0…4	EXT_ADDR_0	Extended address of instrument 0	—
5	COUNT_0	Bytes before next item	
…	EXT_ADDR_i	Extended address of instrument i	
…	COUNT_i	Bytes before next item	
…	…	…	
Response Data Bytes			
0…4	EXT_ADDR_0	Extended address of instrument 0	—
5	COUNT_0	Bytes before next item	
6	ERROR_0	Error 0	0 = No error. 64 = Unknown instrument. No data is included for that instrument.
7	COMM_ERR_0	OR of communication error in instrument 0 replies	—

Table B.13 Command 138 Request and Response Data Bytes

Byte		Description	Value
8	STATUS_0	OR of status byte in instrument 0 replies	—
…	EXT_ADDR_i	Extended address of instrument i	
…	COUNT_i	Bytes before next item	
…	ERROR_i	Error i	
…	COMM_ERR_i	OR of communication error in instrument i replies	
…	STATUS_i	OR of status byte in instrument i replies	
…	…	…	
Command-specific Response Codes			
5	Error	Too few data bytes received	
16	Error	Access restricted	
17	Error	Too many items requested	
32	Error	Busy	

Command 139

The Reset Transmitter Cumulative Responses command returns the OR combination of communication errors and status response bits. No more than 35 instruments may be requested.

Table B.14 Command 139 Request and Response Data Bytes

Byte		Description	Value
Request Data Bytes			
0…4	EXT_ADDR_0	Extended address of instrument 0	—
5	COUNT_0	Bytes before next item	
…	EXT_ADDR_i	Extended address of instrument i	
…	COUNT_i	Bytes before next item	
…	…	…	
Response Data Bytes			
0…4	EXT_ADDR_0	Extended address of instrument 0	—
5	COUNT_0	Bytes before next item	
6	ERROR_0	Error 0	0 = No error. 64 = Unknown instrument. No data is included for that instrument.
…	EXT_ADDR_i	Extended address of instrument i	—

Table B.14 Command 139 Request and Response Data Bytes

Byte		Description	Value
…	COUNT_i	Bytes before next item	—
…	ERROR_i	Error i	
…	…	…	
Command-specific Response Codes			
5	Error	Too few data bytes received	
16	Error	Access restricted	
17	Error	Too many items requested	
32	Error	Busy	

Command 140

The Read the Number of Command Requests and Errors of Transmitters command is a communication statistic that contains the number of commands sent to the transmitter and the number of commands that failed. No more than 16 instruments may be requested.

Table B.15 Command 140 Request and Response Data Bytes

Byte		Description	Value
Request Data Bytes			
0…4	EXT_ADDR_0	Extended address of instrument 0	—
5	COUNT_0	Bytes before next item	
…	EXT_ADDR_i	Extended address of instrument i	
…	COUNT_i	Bytes before next item	
…	…	…	
Response Data Bytes			
0…4	EXT_ADDR_0	Extended address of instrument 0	—
5	COUNT_0	Bytes before next item	
6	ERROR_0	Error 0	0 = No error. 64 = Unknown instrument. No data is included for that instrument.
7…10	TRIES_0	Number of commands sent to instrument 0 by IOM-HART	
11…14	FAILS_0	Number of commands that failed with instrument 0 (no reply or communication error)	
…	EXT_ADDR_i	Extended address of instrument i	

Table B.15 Command 140 Request and Response Data Bytes

Byte		Description	Value
…	COUNT_i	Bytes before next item	—
…	ERROR_i	Error i	
…	TRIES_i	Number of commands sent to instrument i by IOM-HART	
…	FAILS_i	Number of commands that failed with instrument i (no reply or communication error)	
…	…	…	
Command-specific Response Codes			
5	Error	Too few data bytes received	
16	Error	Access restricted	
17	Error	Too many items requested	
32	Error	Busy	

Command 141

The Delete the Number of Command Requests and Errors of the Transmitters command resets the communication statistic. No more than 35 instruments may be requested.

Table B.16 Command 141 Request and Response Data Bytes

Byte		Description	Value
Request Data Bytes			
0…4	EXT_ADDR_0	Extended address of instrument 0	—
5	COUNT_0	Bytes before next item	
…	EXT_ADDR_i	Extended address of instrument i	
…	COUNT_i	Bytes before next item	
…	…	…	
Response Data Bytes			
0…4	EXT_ADDR_0	Extended address of instrument 0	—
5	COUNT_0	Bytes before next item	
6	ERROR_0	Error 0	0 = No error. 64 = Unknown instrument.
…	EXT_ADDR_i	Extended address of instrument i	—
…	COUNT_i	Bytes before next item	
…	ERROR_i	Error i	
…	…	…	

Table B.16 Command 141 Request and Response Data Bytes

Byte		Description	Value
Command-specific Response Codes			
5	Error	Too few data bytes received	
16	Error	Access restricted	
17	Error	Too many items requested	
32	Error	Busy	

Command 143

The Reset Count of Host Communications command resets the communication statistic. There are no request or response data bytes.

Table B.17 Command 143 Command-specific Response Codes

Command-specific Response Codes		
16	Error	Access restricted
32	Error	Busy

Command 144

The Read Retry Limits command retries in case of busy with 0 to 11 (default is 0). It also retries in case of communication errors with 0 to 11 (default is 2). There are no request data bytes.

Table B.18 Command 144 Response Data Bytes

Byte		Description	Value
0	BUSY_RETRY	Number of retries for a busy response from instrument	0…11
1	OTHER_RETRY	Number of retries for another error instrument	0…11
Command-specific Response Codes			
16	Error	Access restricted	
32	Error	Busy	

Command 145

Command 145 is the Write Retry Limits command.

Table B.19 Command 145 Request and Response Data Bytes

Byte		Description	Value
Request Data Bytes			
0	BUSY_RETRY	Number of retries for a busy response from instrument	0…11
1	OTHER_RETRY	Number of retries for another error from instrument	0…11

Table B.19 Command 145 Request and Response Data Bytes

Byte		Description	Value
Response Data Bytes			
0	BUSY_RETRY	Number of retries for a busy response from instrument	0…11
1	OTHER_RETRY	Number of retries for another error from instrument	0…11
Command-specific Response Codes			
5	Error	Too few data bytes received	
9	Error	First parameter too large	
11	Error	Second parameter too large	
16	Error	Access restricted	
32	Error	Busy	

Command 146

With the Read Normal Scan command, during SCAN, HART commands 1, 2, or 3 (see Command 144) can be executed. There are no request data bytes.

Table B.20 Command 146 Response Data Bytes

Byte		Description	Value
Response Data Bytes			
0	SCAN_CMD	Scan command	1 = Command 1 2 = Command 2 3 = Command 3
Command-specific Response Codes			
16	Error	Access restricted	
32	Error	Busy	

Command 147

Command 147 is the Write Normal SCAN command.

Table B.21 Command 147 Request and Response Data Bytes

Byte		Description	Value
Request Data Bytes			
0	SCAN_CMD	Scan command	1 = Command 1 2 = Command 2 3 = Command 3
Response Data Bytes			
0	SCAN_CMD	Scan command	1 = Command 1 2 = Command 2 3 = Command 3
Command-specific Response Codes			
2	Error	Invalid selection	
5	Error	Too few data bytes received	
16	Error	Access restricted	
32	Error	Busy	

Command 148

Use the Read SCAN Status command to specify the status of the SCAN function. Where 0 = SCAN function disabled (default after you cycle power); 1 = normal SCAN function activated; and 2 = special SCAN function activated (see Command 158 and Command 159). There are no request data bytes.

Table B.22 Command 148 Response Data Bytes

Byte		Description	Value
Response Data Bytes			
0	SCAN_EN	General scan status	0 = All scanning disabled 1 = Normal scan enabled 2 = Special scan enabled
Command-specific Response Codes			
16	Error	Access restricted	
32	Error	Busy	

Command 149

Command 149 is the Write SCAN Status command.

Table B.23 Command 149 Request and Response Data Bytes

Byte		Description	Value
Request Data Bytes			
0	SCAN_EN	General scan enable/disable	0 = All scanning disabled 1 = Normal scan enabled 2 = Special scan enabled
Response Data Bytes			
0	SCAN_EN	Scan enable/disable	0 = All scanning disabled 1 = Normal scan enabled 2 = Special scan enabled
Command-specific Response Codes			
2	Error	Invalid selection	
5	Error	Too few data bytes received	
16	Error	Access restricted	
32	Error	Busy	

Command 152

The Read Loop Search Type command determines the polling address used to search for a device that has not responded after multiple requests (disappeared). Also see Command 129. The HART I/O module has a fixed setting where 1 = single transmitter, unknown (single unknown) short addresses of 0 to 15. There are no request data bytes.

Table B.24 Command 152 Response Data Bytes

Byte		Description	Value
Response Data Bytes			
0	LOC_MET	Locate method	0 = Single analog
Command-specific Response Codes			
16	Error	Access restricted	
32	Error	Busy	

Command 154

Command 154 is the Rebuild Up to 8 Specified Loops command.

Table B.25 Command 154 Request and Response Data Bytes

Byte		Description	Value
Request Data Bytes			
0	CH_NUM_0	Channel number 0	—
1	COUNT_0	Number of bytes before next item	
…	CH_NUM_i	Channel number i	
…	COUNT_i	Number of bytes before next item	
Response Data Bytes			
0	CH_NUM_0	Channel number 0	—
1	COUNT_0	Number of bytes before next item	
2	ERROR_0	Error 0	0 = Channel number invalid 64 = Invalid channel number
…	CH_NUM_i	Channel number i	—
…	COUNT_i	Number of bytes before next item	
…	ERROR_i	Error i	
…	…	…	
Command-specific Response Codes			
5	Error	Too few data bytes received	
16	Error	Access restricted	
17	Error	Too many items requested	
32	Error	Busy	

Command 158

The Read Special Loop SCAN Parameters command returns the transmitter data for the given loop, if available. These include:

- Loop number
- Error flag (0 = ok, 1 = special SCAN not active)
- Polling address (always 0, no multidrop)
- Selected SCAN command
- Long frame address
- Number of available data bytes
- Data bytes themselves (if any)

Table B.26 Command 158 Request and Response Data Bytes

Byte		Description	Value
Request Data Bytes			
0	CH_NUM	Channel number	0…7
Response Data Bytes			
0	CH_NUM	Channel number	0…7
1	ERROR	Error	0 = Special scan set up for the selected channel 1 = Special scan not set up (reply is truncated to 2 bytes)
2	SHORT_ADDR	Short address used	—
3	THRESH	Threshold data length for special scan	0…62
4	SCAN_CMD	Scan command being used	—
5…9	EXT_ADDR	Extended address of instrument	
10	LENGTH	Length of data bytes available	> 0 if data available
11…	DATA	Special scan data (if any)	—
Command-specific Response Codes			
2	Error	Invalid selection	
5	Error	Too few data bytes received	
16	Error	Access restricted	
32	Error	Busy	

Command 159

With the Write Special Loop SCAN Parameters command, the threshold data length (0 to 62) and the SCAN command to be used can be written for the given current loop and polling addresses (must be 0).

Table B.27 Command 159 Request and Response Data Bytes

Byte		Description	Value
Request Data Bytes			
0	CH_NUM	Channel number	0…7
1	SHORT_ADDR	Short address used for this channel	0…15
2	THRESH	Threshold data length for special scan	0…62
3	SCAN_CMD	Scan command to be used	—
Response Data Bytes			
0	CH_NUM	Channel number	0…7
1	SHORT_ADDR	Short address used for this channel	0…15
2	THRESH	Threshold data length for special scan	0…62
3	SCAN_CMD	Scan command being used	—
4…8	EXT_ADDR	Extended address of instrument at address SHORT_ADDR	
Command-specific Response Codes			
2	Error	Invalid selection	
5	Error	Too few data bytes received	
9	Error	First parameter too large (SHORT_ADDR out of range)	
11	Error	Second parameter too large (THRESH out of range)	
16	Error	Access restricted	
32	Error	Busy	
64	Error	Unknown (no instrument at specified SHORT_ADDR)	

Command 164

With the Cached Data Reply CMD 0, 13, 16 command, results of command 0, 13, and 16 are combined in a response protocol.

Additional HART Protocol Information

What This Appendix Contains

This appendix discusses the HART protocol and provides references for additional information about the protocol. The appendix provides:

- HART protocol background information
- Command practice command sets
- Extended command sets
- References to additional information

Message Structure

This section describes the transaction procedure, character coding, and message structure of the HART protocol. These correspond to layer 2, the data-link layer, of the OSI protocol reference model.

Master-slave Operation

HART is a master-slave protocol. This means that each message transaction is originated by the master; the slave (field) device only replies when it receives a command message addressed to it. The reply from the slave device acknowledges that the command has been received, and may contain data requested by the master.

Multiple Master Operation

The HART protocol allows for two active masters in a system, one primary and one secondary. The two masters have different addresses, therefore each can positively identify replies to its own command messages.

Transaction Procedure

HART is a half-duplex protocol; after completion of each message, the FSK carrier signal must be switched off, to allow the other station to transmit. The carrier control timing rules state that the carrier should be turned on not more than 5 bit times before the start of the message (that is, the preamble) and turned off not more than 5 bit times after the end of the last byte of the message (the checksum).

The master is responsible for controlling message transactions. If there is no reply to a command within the expected time, the master should retry the message. After a few retries, the master should abort the transaction, since presumably the slave device or the communication link has failed.

After each transaction is completed, the master should pause for a short time before sending another command, to allow an opportunity for the other master to break in if it wishes. This way, two masters (if they are present) take turns at communicating with the slave devices. Typical message lengths and delays allow two transactions per second.

Burst Mode (not supported)

To achieve a higher data rate, some field devices implement an optional burst mode. When switched into this mode, a slave device repeatedly sends a data message, as though it had received a specific command to do so. Special commands, 107, 108, and 109, are used to start and stop this mode of operation, and to choose which command should be assumed. If burst mode is implemented, commands 1, 2, and 3 must be supported; other commands are optional. There is a short pause after each burst message to allow a master device to send a command to stop the burst mode operation, or to initiate any other single transaction, after which burst messages will continue.

Generally, burst mode is only useful if there is just one field device attached to a pair of wires, since only one field device on a loop can be in burst mode at any one time. In burst mode, more than three messages can be transmitted per second.

The actual HART message between the FLEX Ex HART I/O module and the field device follows the standard HART messaging protocol.

Preamble	Start character	Address	Command	Byte count	[Response code]	Data	Checksum

Preamble

The preamble is a number of hexadecimal FF characters that precede all frames sent to the HART field device. The size depends on the field devices being used, but it can be from 2 to 32 hexadecimal. The default is 10. The Smart Transmitter Interface inserts the required preamble before each packet or frame transmission to the HART device. This is done automatically so you do not have to program the host controller to do this.

Start Character

The start character of a HART message indicates the frame's format, the source of the message, and if it is using burst mode.

Table C.1 Start Character Byte Definitions

Frame Type	Short Frame Addressing (hex)	Long Frame Addressing (hex)
Master to slave	02	82
Slave to master	06	86
Burst mode from slave	01	81

HART Address

The Smart Transmitter Interface addresses HART field devices using either a short or long frame address format, as specified by the HART delimiter byte. A short frame address is one byte long. A long frame address is five bytes long and includes a unique 32-bit identifier encoded within each field device by the manufacturer.

HART field device addressing is device dependent. Some devices do not support long frame addressing while others only recognize short frame addressing for HART Command 0. In this situation, use HART Command 0 to determine the long frame address, and then use long frame addressing for al other HART commands. Consult the documentation provided with your field device for details about the addressing formats it supports.

HART Command

This one-byte field specifies the HART command that is to be sent by the Smart Transmitter Interface to the field device. Many commands are device dependent. Consult the documentation provided with your field device for details about the commands supported. Set this field to a device-recognizable command before sending the packet to the Smart Transmitter Interface.

Table C.2 Representative of HART Universal Commands

Universal Command (dec)	Description	Expected Response
0	Read unique indentifier	Unique 32-bit device indentifier, revision levels, number of preambles required
1	Read primary variable	Primary variable in floating point (IEEE 754 format)
2	Read primary variable current and percent of range	Primary variable in milliamperes and percents
3	Read dynamic variables and primary variable current	Primary variable and up to 4 predefined dynamic variables
6	Write polling address	Assigned polling address - short form
11	Read unique identifier associated with tag	Unique 32-bit device identifier, revision levels, number of preambles required

Byte Count

This one-byte field indicates the number of bytes to follow this field excluding the check byte. Valid values are 0 to 113. Insert the number of bytes required for this packet before transmitting it.

Data

This field specifies a number of data bytes associated with the command number given in the command field. Set the number of data bytes to the appropriate value for the command in question. The valid range is from 0 to 113. Only use this field when writing data to the HART device.

Check Byte

The Smart Transmitter Interface calculates the value of this field and transmits it to the field device as the last byte of a packet. The field device verifies the integrity of the received data packet by checking this byte. Since the Smart Transmitter Interface calculates this byte, you can set this field to a null (00).

Response Code

This two-byte code contains the HART field device status as sent by that device. Field devices detecting a communications error set the most significant bit, bit 7, of the first byte and identify the error in the other seven bits. If the last message was received without error, the field device will clear bit 7 and return a device-dependent response in the other seven bits.

The second byte of this response code returns the operating status of HART field devices. This byte may default to 0 when a communications error occurs as indicated by bit 7 of the first byte being set.

IMPORTANT The host controller ignores any values in the data field when a communications error is detected.

Table C.3 HART Protocol — Communication Error Code

Bit	Error Code	Description
7	Communications error	If set, the field device has detected a communications error. Bits 0…6 indicate the type of error.
6	Vertical parity error	The parity of one or more of the bytes received by the HART field device is incorrect.
5	Overrun error	At least one byte of data in the receive buffer of the HART field device was over-written before it was read.
4	Framing error	The stop bit of one or more bytes received by the HART field device was not detected.
3	Longitudinal parity error	The longitudinal parity calculated by the HART field device does not match the longitudinal parity byte at the end of the packet.
2	Reserved	Set to 0.
1	Buffer overflow	The packet is too long for the receive buffer of the HART field device.
0	Undefined	Not defined.

Table C.4 HART Field Device Error Codes

Bit	Error Code	Description
7	Field device malfunction	An internal hardware error or failure has been detected by the HART field device.
6	Configuration changed	A write or set command has been executed by the HART field device.
5	Cold start	Power has been removed and reapplied, resulting in the reinstallation of the setup information. The first HART command to recognize this condition automatically resets this flag. This flag may also be set following a master reset or self test.
4	More status available	More status information is available and can be read using command #48. Read additional status information.
3	Primary variable analog output fixed	The analog and digital outputs for the primary variable are held at their requested value. They will not respond to the applied process.
2	Primary variable analog output saturated	The analog and digital outputs for the primary variables are beyond their limits and no longer represent the true applied process.
1	Non-primary variable out of limits	The process applied to a sensor, other than that of the primary variable, is beyond the operating limits of the device. To identify the variable, use command #48, read additional status information.
0	Primary variable out of limits	The process applied to the sensor for the primary variable is beyond the operating limits of the device.

Universal Commands

Table C.5 Universal Commands

Command		Data in Command			Data in Reply		
#	Function	Byte	Data	Type	Byte	Data	Type
0	Read unique identifier	—	None	—	0	254 (expansion)	—
					1	Manufacturer identification code	
					2	Manufacturer device type code(1)	
					3	Number of preambles required	
					4	Universal command revision	
					5	Device-specific command revision	
					6	Software revision	
					7	Hardware revision	
					8	Device function flags(2)	(H)
					9…11	Device ID number	(B)
1	Read primary variable	—	—	—	0	PV units code	—
					1…4	Primary variable	(F)
2	Read current and percent of range	—	None	—	0…3	Current (mA)	(F)
					4…7	Primary variable	
3	Read current and four (predefined) dynamic variables	—	None	—	0…3	Current (mA)	—
					4	PV units code	
					5…8	Primary variable	
					9	SV units code	
					10…13	Secondary variable(3)	
					14	TV units code	
					15…18	Third variable	
					19	FV units code	
					20…23	Fourth variable	
6	Write polling address	0	Polling address	—	—	As in command	—

Table C.5 Universal Commands

Command		Data in Command			Data in Reply		
#	Function	Byte	Data	Type	Byte	Data	Type
11	Read unique identifier associated with tag	0…5	Tag	(A)	0…11	As Command 0	—
12	Read message	—	None	—	0…23	Message (32 characters)	(A)
13	Read tag descriptor, date	—	None	—	0…5	Tag (8 characters)	(A)
					6…17	Descriptor (16 characters)	(A)
					18…20	Date	(D)
14	Read PV sensor information	—	None	—	0…2	Sensor serial number	—
					3	Units code for sensor limits and minimum span	
					4…7	Upper sensor limit	(F)
					8…11	Lower sensor limit	
					12…15	Minimum span	
15	Read output information	—	None	—	0	Alarm select code	—
					1	Transfer function code	
					2	PV/range limits code	
					3…6	Upper range value	
					7…10	Lower range value	
					11…14	Damping value (seconds)	(F)
					15	Write protect code	
					16	Private-label distributor code	
16	Read final assembly number	—	None	—	0…2	Final assembly number	—
17	Write message	0…23	Message (32 characters)	(A)	—	As in command	—
18	Write tag descriptor, date	0…5	Tag (8 characters)	(A)	—	As in command	—
		6…17	Descriptor (16 characters)				
		18…20	Date	(D)			
19	Write final assembly number	0…2	Final assembly number	—	—	As in command	—

(1) Bit 2 = protocol bridge device.

(2) Bit 0 = multisensor device, bit 1 = EEPROM control required.

(3) Truncated after last supported variable.

Common Practice Commands

Table C.6 Common Practice Commands

Command		Data in Command			Data in Reply		
#	Function	Byte	Data	Type(5)	Byte	Data	Type(5)
33	Read transmitter variables	—	None(2)	—	0	Transmitter variable code for slot 0	—
					1	Units code for slot 0	
					2…5	Variable for slot 0	(F)
					6	Transmitter variable code for slot 1	—
					7	Units code for slot 1	
					8…11	Variable for slot 1	(F)
					12	Transmitter variable code for slot 2(6)	—
					13	Units code for slot 2	
					14…17	Variable for slot 2	(F)
					18	Transmitter variable code for slot 3	—
					19	Units code for slot 3	
					20…23	Variable for slot 3	(F)
34	Write damping value	0…3	Damping value (seconds)	(F)	—	As in command	(F)
35	Write range values	0	Range units code	—	—	As in command	(F)
		1…4	Upper range value	(F)			—
		5…8	Lower range value				(F)
36	Set upper range value (push SPAN button)	—	None	—	—	None	—
37	Set lower range value (push ZERO button)	—	None	—	—	None	—
38	Reset configuration changed flag	—	None	—	—	None	—
39	EEPROM control	0(1)	EEPROM control code	—	—	As in command	—
40	Enter/edit fixed current mode	0…3	Current (mA)(3)	(F)	—	As in command	—
41	Perform device self-test	—	None	—	—	None	—
42	Perform master reset	—	None	—	—	None	—

Table C.6 Common Practice Commands

Command		Data in Command			Data in Reply		
#	Function	Byte	Data	Type(5)	Byte	Data	Type(5)
43	Set (trim) PV zero	—	None	—	—	None	—
44	Write PV units	0	PV units code	—	—	As in command	—
45	Trim DAC zero	0…3	Measured current (mA)	—	—	As in command	—
46	Trim DAC gain	0…3	Measured current (mA)	(F)	—	As in command	—
47	Write transfer function	0	Transfer function code	—	—	As in command	—
48	Read additional device status	—	None	—	0…5	Device-specific status	(B)
					6…7	Operational modes	—
					8…10	Analog outputs saturated(7)	(B)
					11…13	Analog outputs fixed.(8)	
					14…24	Device-specific status	
49	Write PV sensor serial number	0…2	Sensor serial number number	—	—	As in command	—
50	Read dynamic variable assignments	—	None	—	0	PV transmitter variable code	—
					1	SV transmitter variable code	
					2	TV transmitter variable code	
					3	FV transmitter variable code	
51	Write dynamic variable assignments	0	PV transmitter variable code	—	—	As in command	—
		1	SV transmitter variable code				
		2	TV transmitter variable code				
		3	FV transmitter variable code				
52	Set transmitter variable zero	0	Transmitter variable code	—	—	As in command	—
53	Write transmitter variable units	0	Transmitter variable code	—	—	As in command	—
		1	Transmitter variable units code				

Table C.6 Common Practice Commands

Command		Data in Command			Data in Reply		
#	Function	Byte	Data	Type(5)	Byte	Data	Type(5)
54	Read transmitter variable information	—	Transmitter variable code	—	0	Transmitter variable code	—
					1…3	Transmitter variable sensor serial number	
					4	Transmitter variable limit units code	
					5…8	Transmitter variable upper limit	(F)
					9…12	Transmitter variable lower limit	
					13…16	Transmitter variable damping value (seconds)	
					17…20	Transmitter variable minimum span	
55	Write transmitter variable damping value	0	Transmitter variable code	—	—	As in command	—
		1…4	Transmitter variable damping value (seconds)				
56	Write transmitter variable sensor serial number	0	Transmitter variable code	—	—	As in command	—
		1…3	Transmitter variable sensor				
57	Read unit tag, descriptor, date	—	None	—	0…5	As in command	(A)
					6…17		
					18…20		(D)
58	Write unit tag, descriptor, date	0…5	Unit tag (8 characters)	(A)	—	As in command	—
		6…17	Unit descriptor (16 characters)				
		18…20	Unit date	(D)			
59	Write number of response preambles	0	Number of response preambles	—	—	As in command	—
60	Read analog output and percent of range	0	Analog output number code	—	0	Analog output number code	—
					1	Analog output units code	
					2…5	Analog output level	
					6…9	Analog output percent of range	

Table C.6 Common Practice Commands

Command		Data in Command			Data in Reply		
#	Function	Byte	Data	Type(5)	Byte	Data	Type(5)
61	Read dynamic variables and PV analog output	—	None	—	0	PV analog output units code	—
					1…4	PV analog output level	(F)
					5	PV units code	—
					6…9	Primary variable	(F)
					10	SV units code	—
					11…14	Secondary variable	(F)
					15	TV units code	—
					16…19	Third variable	(F)
					20	FV units code	—
					21…24	Fourth variable	(F)
62	Read analog outputs	0	Analog output number code for slot 0	—	0	Slot 0 analog output number code	—
					1	Slot 0 units code	
					2…5	Slot 0 level	(F)
		1	Analog output number code for slot 1		6	Slot 1 analog output number code	—
					7	Slot 1 units code	
					8…11	Slot 1 level	(F)
		2	Analog output number code for slot 2		12	Slot 2 analog output number code	—
					13	Slot 2 units code	
					14…17	Slot 2 level	(F)
		3	Analog output number for slot 3		18	Slot 3 analog output number code	—
					19	Slot 3 units code	
					20…23	Slot 3 level	(F)

Table C.6 Common Practice Commands

Command		Data in Command			Data in Reply		
#	Function	Byte	Data	Type(5)	Byte	Data	Type(5)
63	Read analog output information	0	Analog output number code	—	0	Analog output number code	—
					1	Analog output alarm select code	
					2	Analog output transfer function code	
					3	Analog output range units code	
					4…7	Analog output upper range value	(F)
					8…11	Analog output lower range value	
					12…15	Analog output additional damping value (seconds)	
64	Write analog output additional damping value	0	Analog output number code	—	—	As in command	—
		1…4	Analog output additional damping value (seconds)	(F)			
65	Write analog output range value	0	Analog output number code	—	—	As in command	—
		1	Analog output range units code				
		2…5	Analog output upper range value	(F)			
		6…9	Analog output lower range value				
66	Enter/edit fixed analog output mode	0	Analog output number code	—	—	As in command	—
		1	Analog output units code				
		2…5	Analog output level(4)	(F)			
67	Trim analog output zero	0	Analog output number code	—	—	As in command	—
		1	Analog output units code				
		2…5	Externally measured analog output level	(F)			

Table C.6 Common Practice Commands

Command		Data in Command			Data in Reply		
#	Function	Byte	Data	Type(5)	Byte	Data	Type(5)
68	Trim analog output gain	0	Analog output number code	—	—	As in command	—
		1	Analog output units code				
		2…5	Externally measured analog output level	(F)			
69	Write analog output transfer function	0	Analog output number code	—	—	As in command	—
		1	Analog output transfer function code				
70	Read analog output end point values	0	Analog output number code	—	0	Analog output number code	—
					1	Analog output end point units code	
					2…5	Analog output upper end point value	
					6…9	Analog output lower end point value	
107	Write burst mode transmitter variables (for Command #33)	0	Transmitter variable code for slot 0	—	—	As in command	—
		1	Transmitter variable code for slot 1				
		2	Transmitter variable code for slot 2				
		3	Transmitter variable code for slot 3				
108	Write burst mode command number	0	Burst mode command number	—	—	As in command	—
109	Burst mode control	0	Burst mode control code (0 = exit, 1 = enter)	—	—	As in command	—

Table C.6 Common Practice Commands

Command		Data in Command			Data in Reply		
#	Function	Byte	Data	Type[5]	Byte	Data	Type[5]
110	Read all dynamic variables	—	None	—	0	PV units code	—
					1…4	PV value	(F)
					5	SV units code	—
					6…9	SV value	(F)
					10	TV units code	—
					11…14	TV value	(F)
					15	FV units code	—
					16…19	FV value	(F)

(1) 0 = burn EEPROM, 1 = copy EEPROM to RAM.

(2) Truncated after last requested code.

(3) 0 = edit fixed current mode.

(4) No a number when fixed output mode.

(5) A = ASCII string (packed 4 characters in 3 bytes).
F = floating point data type (4 bytes) per IEEE 754,
D = date (day, month, year-1900).
B = bit mapped flags.
Unmarked types are 8-, 16-, or 24-bit integers.

(6) Truncated after last requested variable.

(7) 24 bits each.

(8) LSB and MSB return to AO #1…#24.

Notes:

Configure the 1797-OE8H Module in RSLogix 5000 Software Over the ControlNet Network

What This Appendix Contains

This appendix provides the information needed to configure the 1797-OE8H analog output module in RSLogix 5000 software over the ControlNet network using version 13 or earlier and the generic profile.

Background Information

Make sure that your Comm-Format is set to Data - INT. In the FLEX generic profile, you need these sizes:

- Input - 0
- Output - 9
- Config - 11
- Status - 4

IMPORTANT	HART commands will only work when the Data Format control is configured for a 4 to 20 mA range. The default configuration when using the generic profile is 0, which configures the module for a 0 to 20 mA range.

Adapter Name is what you named the ControlNet adapter when it was originally created.

Slot is the position of the FLEX module in the rack, starting with zero.

Configuration

Refer to the following tables for Data Format control configuration.

Channel	Bits
0 and 1	[Adapter Name]:[Slot]:C.Data[1].0
	[Adapter Name]:[Slot]:C.Data[0].1
	[Adapter Name]:[Slot]:C.Data[0].2
	[Adapter Name]:[Slot]:C.Data[0].3
2 and 3	[Adapter Name]:[Slot]:C.Data[0].4
	[Adapter Name]:[Slot]:C.Data[0].5
	[Adapter Name]:[Slot]:C.Data[0].6
	[Adapter Name]:[Slot]:C.Data[0].7
4 and 5	[Adapter Name]:[Slot]:C.Data[1].0
	[Adapter Name]:[Slot]:C.Data[1].1
	[Adapter Name]:[Slot]:C.Data[1].2
	[Adapter Name]:[Slot]:C.Data[1].3
6 and 7	[Adapter Name]:[Slot]:C.Data[1].4
	[Adapter Name]:[Slot]:C.Data[1].5
	[Adapter Name]:[Slot]:C.Data[1].6
	[Adapter Name]:[Slot]:C.Data[1].7

Data Format Bits									
3	**2**	**1**	**0**						
7	**6**	**5**	**4**	**Range**	**Resolution**	**Full Range**	**Interpretation**	**Data Value Table**	**Count per mA**
0	0	0	0	0…20 mA	0.1% of 0…20 mA	0…22 mA	0…22 mA	0…22000	1000
0	0	0	1	0…20 mA	0.2% of 0…20 mA	0…22 mA	0…110%	0…11000	500
0	0	1	0	Not Valid	Not Valid	Not Valid	Not Valid	Not Valid	Not Valid
0	0	1	1	0…20 mA	0.3% of 0…20 mA	0…20 mA	Unsigned Integer	0…65535	3276
0	1	0	0	4…20 mA	0.1% of 4…20 mA	2…22 mA	2…22 mA	2000…22000	1000
0	1	0	1	Not Valid	Not Valid	Not Valid	Not Valid	Not Valid	Not Valid
0	1	1	0	Not Valid	Not Valid	Not Valid	Not Valid	Not Valid	Not Valid
0	1	1	1	4…20 mA	0.3% of 4…20 mA	4…20 mA	Unsigned Integer	0…65535	4095
1	0	0	0	Not Valid	Not Valid	Not Valid	Not Valid	Not Valid	Not Valid
1	0	0	1	Not Valid	Not Valid	Not Valid	Not Valid	Not Valid	Not Valid
1	0	1	0	Not Valid	Not Valid	Not Valid	Not Valid	Not Valid	Not Valid
1	0	1	1	0…20 mA	0.28% of 0…20 mA	0…22 mA	D/A Count	0…8000	363
1	1	0	0	Not Valid	Not Valid	Not Valid	Not Valid	Not Valid	Not Valid
1	1	0	1	4…20 mA	0.16% of 4…20 mA	3…21 mA	-6.25…+106.25%	-625…+10625	625
1	1	1	0	4…20 mA	0.16% of 4…20 mA	2…22 mA	-12.5…+112.5%	-1250…+11250	625
1	1	1	1	Not Valid	Not Valid	Not Valid	Not Valid	Not Valid	Not Valid

Analog Fault State

Analog Fault State Value for Channel	Bits
0	[Adapter Name]:[Slot]:C.Data[3]
1	[Adapter Name]:[Slot]:C.Data[4]
2	[Adapter Name]:[Slot]:C.Data[5]
3	[Adapter Name]:[Slot]:C.Data[6]
4	[Adapter Name]:[Slot]:C.Data[7]
5	[Adapter Name]:[Slot]:C.Data[8]
6	[Adapter Name]:[Slot]:C.Data[9]
7	[Adapter Name]:[Slot]:C.Data[10]

	Bits 9 or 11	Bits 8 or 10
Min Value of Data Range	0	0
Max Value of Data Range	0	1
Hold Last State	1	0
Analog Fault State Value	1	1

Fault Mode

Channel	Bits
0 and 1	[Adapter Name]:[Slot]:C.Data[0].12
2 and 3	[Adapter Name]:[Slot]:C.Data[0].13
4 and 5	[Adapter Name]:[Slot]:C.Data[1].12
6 and 7	[Adapter Name]:[Slot]:C.Data[1].13

Disabled	0
Enabled	1

Local Fault Mode

The Local Fault mode uses bit [Adapter Name]:[Slot]:C.Data[0].15.

Communications Fault	0
Any Fault	1

Latch Retry Mode

Channel	Bits
0…3	[Adapter Name]:[Slot]:C.Data[1].14
4…7	[Adapter Name]:[Slot]:C.Data[1].15

Retry	0
Latch	1

Analog/Digital Mode

Channel	Bits
0	[Adapter Name]:[Slot]:C.Data[2].0
1	[Adapter Name]:[Slot]:C.Data[2].1
2	[Adapter Name]:[Slot]:C.Data[2].2
3	[Adapter Name]:[Slot]:C.Data[2].3
4	[Adapter Name]:[Slot]:C.Data[2].4
5	[Adapter Name]:[Slot]:C.Data[2].5
6	[Adapter Name]:[Slot]:C.Data[2].6
7	[Adapter Name]:[Slot]:C.Data[2].7

Analog	0
Digital	1

Digital Fault State

Channel	Bits
0	[Adapter Name]:[Slot]:C.Data[2].8
1	[Adapter Name]:[Slot]:C.Data[2].9
2	[Adapter Name]:[Slot]:C.Data[2].10
3	[Adapter Name]:[Slot]:C.Data[2].11
4	[Adapter Name]:[Slot]:C.Data[2].12
5	[Adapter Name]:[Slot]:C.Data[2].13
6	[Adapter Name]:[Slot]:C.Data[2].14
7	[Adapter Name]:[Slot]:C.Data[2].15

Reset	0
Hold Last State	1

Analog Fault State Values

Channel	Bits
0	[Adapter Name]:[Slot]:C.Data[3]
1	[Adapter Name]:[Slot]:C.Data[4]
2	[Adapter Name]:[Slot]:C.Data[5]
3	[Adapter Name]:[Slot]:C.Data[6]
4	[Adapter Name]:[Slot]:C.Data[7]
5	[Adapter Name]:[Slot]:C.Data[8]
6	[Adapter Name]:[Slot]:C.Data[9]
7	[Adapter Name]:[Slot]:C.Data[10]

Output

Refer to the following tables for output information.

Digital Output Data

Channel	Bits
0	[Adapter Name]:[Slot]:O.Data[0].0
1	[Adapter Name]:[Slot]:O.Data[0].1
2	[Adapter Name]:[Slot]:O.Data[0].2
3	[Adapter Name]:[Slot]:O.Data[0].3
4	[Adapter Name]:[Slot]:O.Data[0].4
5	[Adapter Name]:[Slot]:O.Data[0].5
6	[Adapter Name]:[Slot]:O.Data[0].6
7	[Adapter Name]:[Slot]:O.Data[0].7

Global Reset Bit

The global reset bit goes in bit [Adapter Name]:[Slot]:O.Data[0].14.

Analog Output Data

Channel	Words
0	[Adapter Name]:[Slot]:O.Data[1]
1	[Adapter Name]:[Slot]:O.Data[2]
2	[Adapter Name]:[Slot]:O.Data[3]
3	[Adapter Name]:[Slot]:O.Data[4]
4	[Adapter Name]:[Slot]:O.Data[5]
5	[Adapter Name]:[Slot]:O.Data[6]
6	[Adapter Name]:[Slot]:O.Data[7]
7	[Adapter Name]:[Slot]:O.Data[8]

Input

Refer to the following tables for input information.

Diagnostic Status Data

	Bit 3	Bit 2	Bit 1	Bit 0
Normal	0	0	0	0
Calibration Failure	0	0	0	1
Configuration Failure	0	0	1	0
Message Failure	0	0	1	1
Lead Break Detection	0	1	0	0
EEPROM Failure	0	1	0	1
RAM Failure	0	1	0	1
ROM Failure	0	1	1	1
Calculation Failure	1	0	0	0
Data Out of Range	1	0	1	1

HART Rebuild Bit

The HART rebuild bit is [Adapter Name]:[Slot].I.Data[0].7.

Fault Alarm

Channel	Bits
0	[Adapter Name]:[Slot]:I.Data[0].8
1	[Adapter Name]:[Slot]:I.Data[0].9
2	[Adapter Name]:[Slot]:I.Data[0].10
3	[Adapter Name]:[Slot]:I.Data[0].11
4	[Adapter Name]:[Slot]:I.Data[0].12
5	[Adapter Name]:[Slot]:I.Data[0].13
6	[Adapter Name]:[Slot]:I.Data[0].14
7	[Adapter Name]:[Slot]:I.Data[0].15

HART Failure

Channel	Bits
0	[Adapter Name]:[Slot]:I.Data[2].0
1	[Adapter Name]:[Slot]:I.Data[2].1
2	[Adapter Name]:[Slot]:I.Data[2].2
3	[Adapter Name]:[Slot]:I.Data[2].3
4	[Adapter Name]:[Slot]:I.Data[2].4
5	[Adapter Name]:[Slot]:I.Data[2].5
6	[Adapter Name]:[Slot]:I.Data[2].6
7	[Adapter Name]:[Slot]:I.Data[2].7

HART Readback

Channel	Bits
0	[Adapter Name]:[Slot]:I.Data[2].8
1	[Adapter Name]:[Slot]:I.Data[2].9
2	[Adapter Name]:[Slot]:I.Data[2].10
3	[Adapter Name]:[Slot]:I.Data[2].11
4	[Adapter Name]:[Slot]:I.Data[2].12
5	[Adapter Name]:[Slot]:I.Data[2].13
6	[Adapter Name]:[Slot]:I.Data[2].14
7	[Adapter Name]:[Slot]:I.Data[2].15

HART Communication

Channel	Bits
0	[Adapter Name]:[Slot]:I.Data[3].0
1	[Adapter Name]:[Slot]:I.Data[3].1
2	[Adapter Name]:[Slot]:I.Data[3].2
3	[Adapter Name]:[Slot]:I.Data[3].3
4	[Adapter Name]:[Slot]:I.Data[3].4
5	[Adapter Name]:[Slot]:I.Data[3].5
6	[Adapter Name]:[Slot]:I.Data[3].6
7	[Adapter Name]:[Slot]:I.Data[3].7

HART Transmitter

Channel	Bits
0	[Adapter Name]:[Slot]:I.Data[3].8
1	[Adapter Name]:[Slot]:I.Data[3].9
2	[Adapter Name]:[Slot]:I.Data[3].10
3	[Adapter Name]:[Slot]:I.Data[3].11
4	[Adapter Name]:[Slot]:I.Data[3].12
5	[Adapter Name]:[Slot]:I.Data[3].13
6	[Adapter Name]:[Slot]:I.Data[3].14
7	[Adapter Name]:[Slot]:I.Data[3].15

Configure the 1797-IE8H Module in RSLogix 5000 Software Over the ControlNet Network

What This Appendix Contains

This appendix provides the information needed to configure the 1797-IE8H analog input module in RSLogix 5000 software over the ControlNet network using version 13 or earlier and the generic profile.

Background Information

Make sure that your Comm-Format is set to Input Data - INT so that you can set the output size to 0. In the FLEX generic profile, you need these sizes:

- Input - 8
- Output - 0
- Config - 2
- Status - 5

IMPORTANT HART commands will only work when the Data Format control is configured for a 4 to 20 mA range. The default configuration when using the generic profile is 0, which configures the module for a 0 to 20 mA range. The filter cutoff defaults to 0 as well, which is invalid. The filter cutoff must be set to a valid value for the module to operate in any mode.

Adapter Name is what you named the ControlNet adapter when it was originally created.

Slot is the position of the FLEX module in the rack, starting with zero.

Configuration

Refer to the following tables for configuration information.

Fault Mode

Channel	Bits
0…3	[Adapter Name]:[Slot]:C.Data[0].0
4…7	[Adapter Name]:[Slot]:C.Data[1].0

Fault Mode	Bit 0
Disabled	0
Enabled	1

Data Format Control

Channel	Bits
0…3	[Adapter Name]:[Slot]:C.Data[0].1
	[Adapter Name]:[Slot]:C.Data[0].2
	[Adapter Name]:[Slot]:C.Data[0].3
	[Adapter Name]:[Slot]:C.Data[0].4
4…7	[Adapter Name]:[Slot]:C.Data[1].1
	[Adapter Name]:[Slot]:C.Data[1].2
	[Adapter Name]:[Slot]:C.Data[1].3
	[Adapter Name]:[Slot]:C.Data[1].4

Data Format Bits									
4	**3**	**2**	**1**	**Range**	**Resolution**	**Full Range**	**Interpretation**	**Data Value Table**	**Count per mA**
0	0	0	0	0…20 mA	0.1% of 0…20 mA	0…22 mA	0…22 mA	0…22000	1000
0	0	0	1	0…20 mA	0.2% of 0…20 mA	0…22 mA	0…110%	0…11000	500
0	0	1	0	Not Valid	Not Valid	Not Valid	Not Valid	Not Valid	Not Valid
0	0	1	1	0…20 mA	0.3% of 0…20 mA	0…20 mA	Unsigned Integer	0…65535	3276
0	1	0	0	4…20 mA	0.1% of 4…20 mA	2…22 mA	2…22 mA	2000…22000	1000
0	1	0	1	Not Valid	Not Valid	Not Valid	Not Valid	Not Valid	Not Valid
0	1	1	0	Not Valid	Not Valid	Not Valid	Not Valid	Not Valid	Not Valid
0	1	1	1	4…20 mA	0.3% of 4…20 mA	4…20 mA	Unsigned Integer	0…65535	4095
1	0	0	0	Not Valid	Not Valid	Not Valid	Not Valid	Not Valid	Not Valid
1	0	0	1	Not Valid	Not Valid	Not Valid	Not Valid	Not Valid	Not Valid
1	0	1	0	Not Valid	Not Valid	Not Valid	Not Valid	Not Valid	Not Valid
1	0	1	1	0…20 mA	0.28% of 0…20 mA	0…22 mA	D/A Count	0…8000	363
1	1	0	0	Not Valid	Not Valid	Not Valid	Not Valid	Not Valid	Not Valid
1	1	0	1	4…20 mA	0.16% of 4…20 mA	3…21 mA	-6.25…+106.25%	-625…+10625	625
1	1	1	0	4…20 mA	0.16% of 4…20 mA	2…22 mA	-12.5…+112.5%	-1250…+11250	625
1	1	1	1	Not Valid	Not Valid	Not Valid	Not Valid	Not Valid	Not Valid

Filter Cutoff

The generic profile sets all of the filter bits to 0, which is an invalid value. You must set these bits to a valid value or you will get a diagnostic error value of 2.

Channel	Bits
0…3	[Adapter Name]:[Slot]:C.Data[0].5
	[Adapter Name]:[Slot]:C.Data[0].6
	[Adapter Name]:[Slot]:C.Data[0].7
4…7	[Adapter Name]:[Slot]:C.Data[1].5
	[Adapter Name]:[Slot]:C.Data[1].6
	[Adapter Name]:[Slot]:C.Data[1].7

Filter Cutoff Bits			Description
7	**6**	**5**	
0	0	0	Not Valid
0	0	1	Not Valid
0	1	0	Not Valid
0	1	1	10 Hz (100 ms)
1	0	0	4 Hz (250 ms)
1	0	1	2 Hz (500 ms)
1	1	0	1 Hz (1 s)
1	1	1	0.5 Hz (2 s)

Up/Down Bit

Channel	Bits
0…3	[Adapter Name]:[Slot]:C.Data[0].8
4…7	[Adapter Name]:[Slot]:C.Data[1].8

Up/Down Bit	Description
0	Up
1	Down

High and Low Error Level

Channel	Bits
0…3	[Adapter Name]:[Slot]:C.Data[0].9
	[Adapter Name]:[Slot]:C.Data[0].10
	[Adapter Name]:[Slot]:C.Data[0].11
	[Adapter Name]:[Slot]:C.Data[0].12
	[Adapter Name]:[Slot]:C.Data[0].13
4…7	[Adapter Name]:[Slot]:C.Data[1].9
	[Adapter Name]:[Slot]:C.Data[1].10
	[Adapter Name]:[Slot]:C.Data[1].11
	[Adapter Name]:[Slot]:C.Data[1].12
	[Adapter Name]:[Slot]:C.Data[1].13

High and Low Error Bits					Description
13	12	11	10	9	
0	0	0	0	0	Disabled
0	0	0	0	1	0.1 mA
0	0	0	1	0	0.2 mA
0	0	0	1	1	0.3 mA
0	0	1	0	0	0.4 mA
0	0	1	0	1	0.5 mA
0	0	1	1	0	0.6 mA
0	0	1	1	1	0.7 mA
0	1	0	0	0	0.8 mA
0	1	0	0	1	0.9 mA
0	1	0	1	0	1.0 mA
0	1	0	1	1	1.1 mA
0	1	1	0	0	1.2 mA
0	1	1	0	1	1.3 mA
0	1	1	1	0	1.4 mA
0	1	1	1	1	1.5 mA
1	0	0	0	0	1.6 mA
1	0	0	0	1	1.7 mA
1	0	0	1	0	1.8 mA
1	0	0	1	1	1.9 mA
1	0	1	0	0	2.0 mA

Square Root Threshold

Bits
[Adapter Name]:[Slot]:C.Data[1].14
[Adapter Name]:[Slot]:C.Data[1].15

15	14	Range
0	0	Disabled
0	1	2%
1	0	5%
1	1	10%

Input

Analog Input Data

Channel	Words
0	[Adapter Name]:[Slot]:I.Data[0]
1	[Adapter Name]:[Slot]:I.Data[1]
2	[Adapter Name]:[Slot]:I.Data[2]
3	[Adapter Name]:[Slot]:I.Data[3]
4	[Adapter Name]:[Slot]:I.Data[4]
5	[Adapter Name]:[Slot]:I.Data[5]
6	[Adapter Name]:[Slot]:I.Data[6]
7	[Adapter Name]:[Slot]:I.Data[7]

Underrange Alarm

Channel	Bits
0	[Adapter Name]:[Slot]:I.Data[8].0
1	[Adapter Name]:[Slot]:I.Data[8].1
2	[Adapter Name]:[Slot]:I.Data[8].2
3	[Adapter Name]:[Slot]:I.Data[8].3
4	[Adapter Name]:[Slot]:I.Data[8].4
5	[Adapter Name]:[Slot]:I.Data[8].5
6	[Adapter Name]:[Slot]:I.Data[8].6
7	[Adapter Name]:[Slot]:I.Data[8].7

Overrange Alarm

Channel	Bits
0	[Adapter Name]:[Slot]:I.Data[8].8
1	[Adapter Name]:[Slot]:I.Data[8].9
2	[Adapter Name]:[Slot]:I.Data[8].10
3	[Adapter Name]:[Slot]:I.Data[8].11
4	[Adapter Name]:[Slot]:I.Data[8].12
5	[Adapter Name]:[Slot]:I.Data[8].13
6	[Adapter Name]:[Slot]:I.Data[8].14
7	[Adapter Name]:[Slot]:I.Data[8].15

Local Fault

Channel	Bits
0	[Adapter Name]:[Slot]:I.Data[9].0
1	[Adapter Name]:[Slot]:I.Data[9].1
2	[Adapter Name]:[Slot]:I.Data[9].2
3	[Adapter Name]:[Slot]:I.Data[9].3
4	[Adapter Name]:[Slot]:I.Data[9].4
5	[Adapter Name]:[Slot]:I.Data[9].5
6	[Adapter Name]:[Slot]:I.Data[9].6
7	[Adapter Name]:[Slot]:I.Data[9].7

Remote Fault

Channel	Bits
0	[Adapter Name]:[Slot]:I.Data[9].8
1	[Adapter Name]:[Slot]:I.Data[9].9
2	[Adapter Name]:[Slot]:I.Data[9].10
3	[Adapter Name]:[Slot]:I.Data[9].11
4	[Adapter Name]:[Slot]:I.Data[9].12
5	[Adapter Name]:[Slot]:I.Data[9].13
6	[Adapter Name]:[Slot]:I.Data[9].14
7	[Adapter Name]:[Slot]:I.Data[9].15

Diagnostic Status

Bits
[Adapter Name]:[Slot]:I.Data[10].0
[Adapter Name]:[Slot]:I.Data[10].1
[Adapter Name]:[Slot]:I.Data[10].2
[Adapter Name]:[Slot]:I.Data[10].3

Diagnostic Description	Bit 3	Bit 2	Bit 1	Bit 0
Normal	0	0	0	0
Calibration Failure	0	0	0	1
Configuration Failure	0	0	1	0
Message Failure	0	0	1	1
Lead Break Detection	0	1	0	0
EEPROM Failure	0	1	0	1
RAM Failure	0	1	1	0
ROM Failure	0	1	1	1
Calculation Failure	1	0	0	0
Data Out of Range	1	0	1	1

FLEX Ex HART Modules Network Messaging

What This Appendix Contains

This appendix discusses:

- How to communicate with the FLEX Ex HART modules via the MSG or CIO instruction
- The differences between Attributes and Assembly Indexes
- Enhancements to the HART frame

Communication

The messaging between the controller and the HART I/O module is handled via MSG or CIO instructions, depending on the controller type. These ladder logic instructions need specific details for proper operation. In particular, they need four items:

- Class

  The Class value for FLEX Ex is 7D hex.

- Instance

  The Instance is a number between 1 and 8. This number indicates the module location relative to the adapter module. Use 1 for the module connected directly to the adapter.

- Service

  The Service value is 0E hex for Get Attribute Single and 10 hex for Set Attribute Single. Use a Service value of 0E hex to read data from the adapter and 10 hex to write data to the adapter.

- Attribute

  The Attribute value is based on the Attribute Values table.

Table F.1 Attribute Values

Attribute (Hex)	Assembly Index	Length (Byte)	Read/Write	Description
HART Common Group				
66	7	4	r	Extended configuration
67	8		r	Calibration
Host Access Group 1				
68	9	2	r/w	Grant for Group 1 access
69	10	6	r	Response Status Information Group 1
6A	11	16	r	Status of loops
6B	12	100	r/w	Hart request/Response buffer Group 1
6C	13	70	r/w	Hart request/Response buffer Group 1
6D	14	56	r/w	Hart request/Response buffer Group 1
6E	15	42	r/w	Hart request/Response buffer Group 1
6F	16	32	r/w	Hart request/Response buffer Group 1
70	17	24	r/w	Hart request/Response buffer Group 1
71	18	18	r/w	Hart request/Response buffer Group 1
72	19	14	r/w	Hart request/Response buffer Group 1
73	20	12	r/w	Hart request/Response buffer Group 1
74	21	8	r/w	Hart request/Response buffer Group 1
Host Access Group 2				
75	22	2	r/w	Grant for Group 2 access
76	23	6	r	Response Status Information Group 2
77	24	16	r	Status of loops
78	25	100	r/w	Hart request/Response buffer Group 2
79	26	70	r/w	Hart request/Response buffer Group 2
7A	27	56	r/w	Hart request/Response buffer Group 2
7B	28	42	r/w	Hart request/Response buffer Group 2
7C	29	32	r/w	Hart request/Response buffer Group 2
7D	30	24	r/w	Hart request/Response buffer Group 2
7E	31	18	r/w	Hart request/Response buffer Group 2
7F	32	14	r/w	Hart request/Response buffer Group 2
80	33	12	r/w	Hart request/Response buffer Group 2
81	34	8	r/w	Hart request/Response buffer Group 2

Differences Between Attributes and Assembly Indexes

The two Host Access Groups on the module let two different hosts communicate at the same time to the module and its associated field devices. The Attribute used by MSG or CIO instructions send the attribute number to the adapter module. The I/O modules use Assemblies. The adapter cross-references the requested Attribute to the corresponding Assembly and forwards it to the associated FLEX Ex HART module for processing.

Messages are sent and received through the multiple HART Request/Response buffers in the same Host Access Groups. To maximize data throughput, these buffers are different sizes.

EXAMPLE

If a message from the module was expected to have 23 bytes, the message would fit into Attributes 6B to 70 hex for Host Access Group 1. Therefore, the response could be obtained by reading any of these attributes.

If you read the Attribute, 100 bytes would be returned containing 23 expected bytes and 77 zero-filled bytes. Sending these extra 77 bytes takes additional time and slows down the response time. Therefore, use the Attribute that best fits the expected message size.

If you attempt to get the response from Attribute 74 hex, an error message would be reported. All messages containing HART commands and responses to and from the FLEX Ex I/O modules are enhanced while standard HART messages are used between the I/O module and the field device. The Error message is an example of these enhancements.

Table F.2 Standard HART Message

Preamble	Start Character	Address	Command	Byte Count	(Response Code)	Data	Checksum

The Preamble syncs the field devices to the I/O module. Once the HART message is received in the I/O module, the Preamble is no longer needed. The FLEX Ex HART modules can queue up to four HART commands, meaning that the module needs a method to identify the HART response to the associated command.

Table F.3 Write HART Command Contained in a MSG or CIO Instruction

Handle (1 Byte)	Start Character	Address	Command	Byte Count	(Response Code)	Data	Checksum

Handle replaces Preamble. Handle is a number you supply so that the module returns the Handle with the associated response from the HART command.

The response from the HART command is reformatted to add this handle and to add additional status information.

Figure F.4 Response from the HART Command

Status (6 Bytes)	Pass Through Handle	Start Character	Address	Command	Byte Count	(Response Code)	Data	Checksum

Byte	0		1	2	3	4					5		
Bit	**0…2**	**3…7**	**0…7**	**0…7**	**0…7**	**0…3**	**4**	**5**	**6**	**7**	**0**	**1**	**2…7**
	Resp Source	Next assy index		Ch	Handle	Resp Error	Assy Access Error	Chain Data	Req allow	Loop status avail	Lock	Cold Start	Res

The six header bytes are added in the front of the HART message response while the remaining format is unchanged. These six bytes contain the following information:

- Response Source

Value	Meaning
0	Not valid (default)
1	Source is HART response
2	Source is Scan data
3	CMD 48 response
4…7	Reserved

- Next Assembly

  Pointer to assembly for next access.

- Channel

The actual channel to which actual contents are related.

Value	Meaning
0…7	Channel of I/O module
0x20	FLEX Ex HART module itself

- Handle

  This indicates the Handle of the response.

- Response Error

  In the following table, values 6 through 10 are communication errors.

Value	Meaning
0	No error
1	Timeout on HART loop
2	Invalid long frame address
3	Locked
4	Request overflow
5	Response not available
6	Parity error
7	Overrun error
8	Framing error
9	Checksum error
10	Rx buffer overflow
11	No request
12…15	Reserved

- Assembly Access Error

Value	Meaning
0	Access to assembly is invalid
1	Access not valid; take next assembly (See next assembly pointer)

- Chained data

Value	Meaning
0	No chained data in next assembly
1	Chained data in next assembly

- Request allowed

Value	Meaning
0	Request not allowed
1	Request allowed

- Loop status available

  New loop status is available in Status of Loops assembly.

- Lock

  To protect against a second HART host communicating to modules, the HART_lock bit is set in the Group for Group assembly.

Value	Meaning
0	Not locked
1	Locked

- Cold Start

  Cold Start indicates that the HART I/O module has made a cold start and the bit is reset when it was first read.

HART Frame Enhancements

Attribute 69 hex for Host Access Group 1 contains only six bytes. Since every HART response starts with these six status bytes, this attribute only contains this information. In addition, you need to account for these six status bytes when selecting the associated response Attribute. Add six bytes to the size of the HART response to accommodate the status bytes.

If you do not know the size of the expected response from the HART module, read Attribute 69 hex for Host Access Group 1. The returned data indicates which Assembly Index contains the response. Once you get this index, issue a MSG or CIO to the associated Attribute. For example, if the Assembly Index is 14, issue a MSG or CIO to Attribute 6D hex.

The Response Error field indicates if the response is available. Once a HART command is issued, it takes a small amount of time to send the message via HART protocol to the field devices, time for the field device to interpret the command, and time to send the response back to the FLEX HART module. During this time, you could request the response prior to the module obtaining it from the field device. In this case, a Response Not Available response is returned in the Response Error field. The module assumes another request will gather the response.

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