HART SNAP I/O MODULES USER'S GUIDE

Form 2132-160418—April 2016



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1: Introduction & Installation

Introduction

HART[®] SNAP I/O modules for analog current input and output provide communication with other Highway Addressable Remote Transducer (HART) current loop devices.



Two modules are available:

- The **SNAP-AIMA-iH** analog input module provides two channels of isolated current input with a range of 4–20 mA. External loop power supplies are required for current loops. This module is categorized by the HART protocol as a current input connection type, which means that the module is a low impedance device.
- The **SNAP-AOA-23-iH** analog output module provides two channels of isolated current output with a range of 4–20 mA. External loop power supplies are required for current loops. This module is categorized by the HART protocol as a current output device, which means that each channel controls the loop current and is a high impedance device.

OPTO

N N HART SNAP I/O modules mount on SNAP PAC racks alongside other SNAP I/O modules (analog, digital, and serial), so you have the combination of I/O you need at any location. The rack requires a SNAP PAC brain or rack-mounted controller for I/O processing and communications.

Designed to be part of the SNAP PAC System, HART SNAP I/O is most easily used with a SNAP PAC controller and PAC Control software, which includes specific commands for use with the HART protocol. Sample subroutines and a flowchart can be downloaded free from our website to give you a head start on communicating with HART smart devices.

HART SNAP I/O can also be used without PAC Control in a custom program you develop using our free HART Developer Toolkit, also available on our website, www.opto22.com.

What's in this Guide?

This guide assumes that you are familiar with the HART protocol and Opto 22's SNAP PAC System. Online resources are available for learning about HART. A good place to start is here on the HART Communication Foundation website:

http://en.hartcomm.org/hcp/tech/aboutprotocol/aboutprotocol_what.html

To learn more about the SNAP PAC System, visit the Opto 22 website at www.opto22.com.

This guide includes the following chapters:

- Chapter 1: Introduction & Installation—How HART SNAP I/O works with HART devices; installation; specifications
- Chapter 2: Using HART SNAP I/O with PAC Control—Using PAC Control sample subroutines and HART commands in PAC Control
- Chapter 3: Using HART SNAP I/O with a Custom Program—Resources for configuring modules and communicating with them using a program built with our Developer's Toolkit

For Help

If you have problems installing or using SNAP serial communication modules and cannot find help in this guide or on our website, you can contact Opto 22 Product Support.

Phone:	800-TEK-OPTO (800-835-6786 toll-free in the U.S. and Canada) 951-695-3080 Monday through Friday, 7 a.m. to 5 p.m. Pacific Time	NOTE: Email messages and phone calls to Opto 22 Product Support are grouped together and answered in the order received.
Fax:	951-695-3017	
Email:	support@opto22.com	
Opto 22 website:	www.opto22.com	

When calling for technical support, be prepared to provide the following information about your system to the Product Support engineer:

- Software and version being used
- Controller firmware version (if applicable)

- PC configuration
- A complete description of your hardware, including:
 - IP addresses and net masks for devices on the system
 - type of power supply (brand and model)
 - types of I/O units installed
 - third-party devices installed (for example, barcode readers)
 - jumper configuration, if applicable
 - accessories installed (such as expansion cards)
 - Specific error messages seen.

About HART and HART SNAP I/O

The HART (Highway Addressable Remote Transducer) protocol is used for sending and receiving digital information across analog wires (4–20 mA loops). HART devices are a combination of a digital communication device and a 4–20 mA analog device.

A 4–20 mA loop can have one or more 4–20 mA receivers, but only one 4–20 mA transmitter (that is, only one device can drive the 4–20 mA current).

Transmitters vs. Actuators

HART field devices are generally categorized as transmitters or actuators (receivers):

- Transmitters transmit, or drive, the 4–20 mA current.
- Actuators (receivers) receive the 4–20 mA signal.

A receiver is called an actuator because most third-party HART devices are field devices that have HART capability built in, for example, a value or motor with a HART interface. So the HART actuator is typically a field device that is actuated based on what it *receives* via the HART interface.

From an electrical standpoint:

- The SNAP-AOA-23-iH output module is a transmitter because it is transmitting the 4–20 mA signal. It should only be used in loops with HART actuators (receivers), since actuators do not try to set the analog loop current.
- The SNAP-AIMA-iH input module is an actuator because it receives the 4–20 mA signal. It can be used in a loop with a transmitter and other actuators.

NOTE: Our implementation is somewhat different from other HART devices that interface with field signals in that the "field" side of our HART modules is actually the SNAP PAC brain. The HART side is the 4–20 mA side.

HART on the Modules

Each channel on each module features an integrated HART modem that allows the channel to communicate digitally with a HART FSK (frequency-shift keying) signal superimposed onto the analog 4–20 mA current loop. The channel is a master device when used together with SNAP PAC

brains or controllers to communicate with other HART current loop devices in either point-to-point or multidrop configurations.

The SNAP-AOA-23-iH and SNAP-AIMA-iH differ only in their analog function (4–20 mA input or output). The HART component is the same for both modules. The parameters they can read and write using HART depend on the other HART devices they are communicating with.

- If the connected device is an actuator (receiver), you can write and read process variables (with Command 79 or a device-specific command) to control the field output of the device. Most HART actuators are like a converter taking in a HART signal and sending out an analog field signal.
- If the connected device is a transmitter, you can only read process variables, since the transmitter only reads in field values and does not output them. Most HART transmitters are like a converter taking in an analog field signal and sending out a HART signal.

For configuring, you can use HART to read and write configuration data for any HART device using Commands 0 and 13 or many of the Common Practice Commands.

For more information on the HART protocol, visit: http://en.hartcomm.org/hcp/tech/aboutprotocol/aboutprotocol_what.html

Installation

HART SNAP I/O modules mount on SNAP PAC racks with other SNAP I/O modules (analog, digital, and serial). These modules require a SNAP PAC brain or rack-mounted controller. They are not compatible with legacy brains and controllers.

Install the Module

HART SNAP I/O modules can be installed in any position on an Opto 22 SNAP PAC mounting rack.

1. Turn off power to the rack.

WARNING: Make sure power is off before continuing, or you will severely damage the module.

- 2. Remove the module from its packaging.
- Position the module over the connector on the rack, aligning the small slot at the base of the module with the retention bar on the rack. If it is next to another module, make sure the male and female module keys are aligned, as shown at right.
- **4.** Push straight down on the module to snap it into position.

If you need to remove the module, see page 7.



Wire the Module

Standard wiring for typical use is shown on this page.

SNAP-AIMA-iH



SNAP-AOA-23-iH



Alternate Wiring Diagram

Wiring shown on the previous page is typical use.

The wiring on this page is nonstandard. Use this page if:

- You are using the HART protocol but not using the analog signal.
- Your HART network includes too many devices for a standard 4–20 mA loop.

This alternative wiring makes sure all HART devices on your network have adquate power.

Multidrop Wiring—SNAP-AIMA-iH



Multidrop Wiring—SNAP-AOA-23-iH



Apply Power to the Rack

Power can usually be supplied by an Opto 22 SNAP-PS5 power supply; however, check total power requirements for all modules and the processor.

What's Next

If you're using PAC Control, continue with Chapter 2: Using HART SNAP I/O with PAC Control. If you're building a custom program, skip to Chapter 3: Using HART SNAP I/O with a Custom Program.

Removing a SNAP I/O Module

To remove a module, use the SNAP module tool that came with the module.

1. Turn off power to the rack.

WARNING: Make sure power is off before continuing, or you will severely damage the module.

2. Holding the SNAP module tool as shown in the illustration at right, insert it into the notch at the base of the module.

NOTE: If you are facing the rack with the processor on the left side, the notch is on the back of the module.

3. Squeeze the module tool against the module to open the release latch, and pull straight up on the module to remove it.



(RETAINING SCREW HOLE UNDER MODULE RELEASE LATCH)

Specifications

SNAP-AIMA-iH Analog Input

Input Range Nominal Full	4 to 20 mA 3.2 to 24 mA
Maximum Survivable Input	40 V or 160 mA
Impedance	230 Ohms nominal
Resolution	0.8 microamps
Accuracy	+/- 10 microamps
Response Time (% of span/delta l/delta time)	99.9%/20.7mA/10 ms
Gain Temperature Coefficient	30 ppm/ °C
Offset Temperature Coefficient	15 ppm/ °C
DC Common Mode Rejection	>-120 dB
AC Common Mode Rejection	>-120 dB @ 60 Hz
Maximum Operating Common Mode Voltage	250 V continuous 1500 V transient (1 s)
Isolation: Channel-Channel	250 V continuous 1500 V transient (1 s)
Power Requirements	5 VDC (+/- 0.15) @ 150 mA
Ambient Temperature: Operating Storage	-20 °C to 70 °C -40 °C to 85 °C
Torque, hold-down screws	4 in-lb (0.45 N-m)
Torque, connector screws	5.26 in-lb (0.6 N-m)
Agency Approvals	UL, CE, RoHS, DFARS
Warranty	Lifetime

SNAP-AOA-23-iH Analog Output

Output Range Nominal Full	4 to 20 mA 3.2 to 24 mA
External Loop Voltage Range Nominal	12-36 VDC 24 VDC
Maximum Load Resistance at Specified Loop Voltage 12 VDC 24 VDC 36 VDC	300 Ohms 850 Ohms 1350 Ohms
Resolution	5 microamps
Accuracy	+/- 20 microamps
Response Time (% of span/delta l/delta time)	99.9%/20.7 mA/400 ms
Gain Temperature Coefficient	-50 ppm/ °C
Offset Temperature Coefficient	-25 ppm/ °C
DC Common Mode Rejection	> 120 dB
Do common Mode Rejection	>-120 UB
AC Common Mode Rejection	>-120 dB @ 60 Hz
AC Common Mode Rejection Maximum Operating Com- mon Mode Voltage	 >-120 dB @ 60 Hz 250 V continuous 1500 V transient (1 s)
AC Common Mode Rejection Maximum Operating Com- mon Mode Voltage Common Mode Resistance	 >-120 dB @ 60 Hz 250 V continuous 1500 V transient (1 s) >1000 megohms
AC Common Mode Rejection Maximum Operating Com- mon Mode Voltage Common Mode Resistance Isolation: Channel-Channel	 >-120 dB @ 60 Hz 250 V continuous 1500 V transient (1 s) >1000 megohms 250 V continuous 1500 V transient (1 s)
AC Common Mode Rejection Maximum Operating Com- mon Mode Voltage Common Mode Resistance Isolation: Channel-Channel Power Requirements	 >-120 dB @ 60 Hz 250 V continuous 1500 V transient (1 s) >1000 megohms 250 V continuous 1500 V transient (1 s) 5 VDC (+/- 0.15) @ 150 mA
AC Common Mode Rejection Maximum Operating Com- mon Mode Voltage Common Mode Resistance Isolation: Channel-Channel Power Requirements Ambient Temperature: Operating Storage	 >-120 dB @ 60 Hz 250 V continuous 1500 V transient (1 s) >1000 megohms 250 V continuous 1500 V transient (1 s) 5 VDC (+/- 0.15) @ 150 mA -20 °C to 70 °C -40 °C to 85 °C
AC Common Mode Rejection Maximum Operating Com- mon Mode Voltage Common Mode Resistance Isolation: Channel-Channel Power Requirements Ambient Temperature: Operating Storage Torque, hold-down screws	 >-120 dB @ 60 Hz 250 V continuous 1500 V transient (1 s) >1000 megohms 250 V continuous 1500 V transient (1 s) 5 VDC (+/- 0.15) @ 150 mA -20 °C to 70 °C -40 °C to 85 °C 4 in-lb (0.45 N-m)
AC Common Mode Rejection Maximum Operating Com- mon Mode Voltage Common Mode Resistance Isolation: Channel-Channel Power Requirements Ambient Temperature: Operating Storage Torque, hold-down screws Torque, connector screws	 >-120 dB @ 60 Hz 250 V continuous 1500 V transient (1 s) >1000 megohms 250 V continuous 1500 V transient (1 s) 5 VDC (+/- 0.15) @ 150 mA -20 °C to 70 °C -40 °C to 85 °C 4 in-lb (0.45 N-m) 5.26 in-lb (0.6 N-m)
AC Common Mode Rejection Maximum Operating Com- mon Mode Voltage Common Mode Resistance Isolation: Channel-Channel Power Requirements Ambient Temperature: Operating Storage Torque, hold-down screws Torque, connector screws Agency Approvals	 >-120 dB @ 60 Hz 250 V continuous 1500 V transient (1 s) >1000 megohms 250 V continuous 1500 V transient (1 s) 5 VDC (+/- 0.15) @ 150 mA -20 °C to 70 °C -40 °C to 85 °C 4 in-lb (0.45 N-m) 5.26 in-lb (0.6 N-m) UL, CE, RoHS, DFARS

LEDs

Each module includes four LED indicators on the top of the module. LEDs 1 and 3 refer to channel 0; LEDs 2 and 4 refer to channel 1.

LED 1 or 2 Status	LED 3 or 4 Activity	Description
Solid Green	Blinking Green	HART channel is operational; loop voltage and current are within limits.
Solid Red	Blinking Red	 HART communication error: On a SNAP-AOA-23-iH, check loop voltage. Excessive load resistance or an incorrect loop power supply may cause voltage to be too low. On a SNAP-AIMA-iH, check loop current to make sure it is between 3.9 mA and 20.2 mA. NOTE: If loop voltage and current are correct, contact Product Support.
OFF		Current loop open or loop voltage is zero. Implies that the channel is not being used.

2: Using HART SNAP I/O with PAC Control

PAC Control Commands for HART SNAP I/O

HART SNAP I/O modules are designed for use with a SNAP PAC programmable automation controller and PAC Control automation software (version 9.4 and higher).

Several HART-specific PAC Control commands make it possible for these modules to communicate any HART command that adheres to the HART request-response model or the burst message model.

HART-specific PAC Control commands include:

- Get HART Unique Address
- Send/Receive HART Command
- Receive HART Response
- Receive HART Burst Response

In addition, you'll use the following string commands (also in PAC Control version 9.4 and higher) to build parameters in HART-specific commands:

- Pack Float into String
- Pack Integer 32 into String
- Pack Integer 64 into String
- Pack String into String
- Unpack String

For details and examples on all PAC Control commands, see the Command Help in PAC Control or form 1701, the *PAC Control Command Reference*, available at www.opto22.com.

Sample PAC Control Subroutines

In your PAC Control strategy you will need to assemble all request data sent to the module and to parse all response data returned by the module. Sample subroutines are available to help you see how to communicate with HART devices using PAC Control. They can be downloaded from our website here: HART Sample Subroutines for PAC Control. Or go to www.opto22.com and search on HART.

0 P T 0

N N Here's what's included in the download:

- 14 PAC Control subroutines—one subroutine for each of 14 universal HART commands
- An Example Chart using the subroutines

Requirements

Before using the subroutines and example strategy, you will need:

- A PC running PAC Control software and the HART Sample Subroutines
- PAC Project (Basic or Pro) 9.4 or newer
- SNAP PAC controller with firmware version 9.4 or newer
- SNAP-AIMA-IH, HART communication analog 4-20 mA input module

HART Commands Supported

The following universal HART commands are supported by the PAC Control subroutines included in the example strategy. For details on the PAC Control variables used in each subroutine, see "HART Commands and Subroutine Instructions and Variables" on page 17.

HART Command	Name	PAC Control Subroutine
0	Read Unique Identifier	HART_Command_0_ReadUniqueDeviceID
1	Read Primary Variable	HART_Command_1_ReadHartVariables
2	Read Loop Current and Percent of Range	HART_Command_2_ReadLoopCurrent_RangePercent
3	Read Dynamic Variables and Loop Current	HART_Command_3_ReadDynamicVAR_LoopCurrent
6	Write Polling Address	HART_Command_6_WritePollingAddress
7	Read Loop Configuration	HART_Command_7_ReadLoopConfiguration
8	Read Dynamic Variable Classifications	HART_Command_8_ReadDynamicVariableClassifications
12	Read Message	HART_Command_12_ReadMessage
13	Read Tag, Descriptor, Date	HART_Command_13_ReadTAGDescriptor_Date
14	Read Primary Variable Transducer Information	HART_Command_14_ReadPrimaryVariableTransducerInfo
15	Read Device information	HART_Command_15_ReadDeviceInfo
16	Read Final Assembly Number	HART_Command_16_ReadFinalAssemblyNumber
17	Write Message	HART_Command_17_WriteMessage

Installing the Example Strategy

To install the example strategy on your computer, extract the contents of the PACControlHARTSubroutines.zip file to a folder on your C: drive. A good location is to create a new folder in the PAC Project installation directory.



Using the Subroutines

Also see form 1700, the *PAC Control User's Guide* for detailed instructions on how to configure a controller, add an I/O unit, and use a subroutine.

Here are the basic steps to start reading data from your HART transmitter:

1. Open the strategy in PAC Control.

The following message appears.

Â	The subroutine files were not found in their original location. Archived copies were found at
	"C:\Users\sshimelash\Documents\My Projects\HARTExample\Subs\"
	Do you want to use the subroutines from this location?

2. Click Yes to use the subroutines from the location shown on the dialog box. Or click No to specify a new location for each subroutine file.

Once the strategy is installed and open in PAC Control, the contents of the Subroutines Included folder should look like this:

 → HART Subroutines → Control Engines → Subroutines Included → HART_Command_0_ReadUniqueDeviceID → HART_Command_12_ReadMessage → HART_Command_13_ReadTAGDescriptor_Date → HART_Command_14_ReadPrimaryVariableTransducerInfo → HART_Command_15_ReadDeviceInfo → HART_Command_16_ReadFinalAssemblyNumber
Subroutines Included ART_Command_0_ReadUniqueDeviceID ART_Command_12_ReadMessage ART_Command_13_ReadTAGDescriptor_Date HART_Command_14_ReadPrimaryVariableTransducerInfo ART_Command_15_ReadDeviceInfo ART_Command_16_ReadFinalAssemblyNumber
نظ HART_Command_0_ReadUniqueDeviceID نط HART_Command_12_ReadMessage نط HART_Command_13_ReadTAGDescriptor_Date نط HART_Command_14_ReadPrimaryVariableTransducerInfo نط HART_Command_15_ReadDeviceInfo نط HART_Command_16_ReadFinalAssemblyNumber
نظ HART_Command_12_ReadMessage نظ HART_Command_13_ReadTAGDescriptor_Date نظ HART_Command_14_ReadPrimaryVariableTransducerInfo نظ HART_Command_15_ReadDeviceInfo نظ HART_Command_16_ReadFinalAssemblyNumber
نص HART_Command_13_ReadTAGDescriptor_Date اص HART_Command_14_ReadPrimaryVariableTransducerInfo اص HART_Command_15_ReadDeviceInfo اص HART_Command_16_ReadFinalAssemblyNumber
نص HART_Command_14_ReadPrimaryVariableTransducerInfo المح HART_Command_15_ReadDeviceInfo المح HART_Command_16_ReadFinalAssemblyNumber
🛥 HART_Command_15_ReadDeviceInfo الطفي HART_Command_16_ReadFinalAssemblyNumber
HART_Command_16_ReadFinalAssemblyNumber
📥 HART_Command_17_WriteMessage
ART_Command_1_ReadHartVariables
HART_Command_2_ReadLoopCurrent_RangePercent
ART_Command_3_ReadDynamicVAR_LoopCurrent
ART_Command_6_WritePollingAddress
ART_Command_7_ReadLoopConfiguration
ART_Command_8_ReadDynamicVariableClassifications
🕀 🧰 Charts
🕀 🫅 Variables
🗉 🛅 I/O Units

- **3.** Right-click the I/O Units folder to add an I/O unit with an installed SNAP-AIMA-iH input module and configure the module's points. Also make sure the control engine is properly configured. For details, see form 1700, the *PAC Control User's Guide*.
- **4.** In Config mode, expand the Variables folder and the Numeric Variables folder to find the nPollingAddress variable.



5. Double-click the nPollingAddress variable and change the initial value to the transmitter's polling address.

You can find the polling address in the documents included with your transmitter.

Edit Variable	e 💌
Name:	nPollingAddress
Description:	
Type:	Integer 32 v
Initializatio	n
Initia	lize on strategy download
Initia	ize on strategy run
Persi:	stent
Initial Va	lue: 🖸
ОК	Cancel Help

- 6. Click OK to confirm and close the dialog box.
- 7. Click Debug.



The code is compiled and downloaded to your controller.

8. Once that's done, click Run Strategy.

Now that the strategy is running, you will be able to read the unique identification of your device as well as the Primary and Secondary variables and other status information.

9. To read the value of a variable, double-click the variable in the Numeric Variables folder or the String Variables folder.

HART Subroutines 🔷	
😑 🗁 HART Subroutines	
🕀 🛅 Control Engines	
🗉 🛅 Subroutines Included	
🕀 🛅 Charts	
🖃 🚞 Variables	
🕀 🛅 Numeric Variables	
🕀 🛅 String Variables	
🚞 Pointer Variables	
Communication Handles	
🛅 Numeric Tables	
📄 String Tables	
🚞 Pointer Tables	
🕀 🛅 I/O Units	

Here are some examples of the variables:

<u> </u>	UniqueIdentifier" (scanning)
Value:	370A130AE7
25 "ft_(COMD_3_LoopCurrent" (scanning)
Value:	7.897085
\$ <u>¦</u> ≉ "ft_0	COMD_3_PrimaryVariable" (scanning)
Value:	24.33511
312 "ft_	COMD_3_QuaternaryVariable" (scanning)
Value:	26.91841
\$ <u>.</u>	COMD_12_MessageRead" (scanning)
Value:	NEW HART MODULE, OPTO 22 09/2014

Unpacking Data Strings Received from HART Commands

In general, in order to unpack strings returned from the HART transmitter for specific HART commands, you will need to know which bytes to look at. However, if you are using the sample subroutines, this is done inside the subroutine; the specific HART command data is unpacked and copied to a variable in the example chart to ease the process of reading most common HART information. For details, refer to the HART documentation available on the HART Communication Foundation website, http://en.hartcomm.org

Command 3 Example

This graphic shows the subroutine response for Command 3.

312 "st_	{ "st_Comm3Res" (scanning)																																		
Name:	me: st_Comm3Res																																		
Width:	128 m	nax w	ridth	34 (current	wid	lth																												
Value:	86	в7	0A	13	OA E	7	03	1A	00	40	40	FB	5E	D6	20	41	C0	9A	20	20	C9	74	23	FO	20	C9	74	23	FO	20	41	D5	90	98	
Bytes:	0 4 12 16 20 24 28 32		86 0A 00 5E C0 20 F0 9C	B7 E7 40 D6 9A 74 C9 20 98	07 03 40 20 20 23 74 41		13 1A FB 41 20 F0 23 D5	t À	900 80 8 8 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1																										
Apph		Watc	h	HEX	•	(i	Mor	e Inf	0																										

The highlighted part is where the actual data begins (byte 10).

Command 3 fetches the following variables: Loop Current, Primary, Secondary, third and fourth Variable. These values can be temperature; pressure, etc. depending on the HART transmitter.

For the response (st_Comm3Res), bytes 0 - 9 are the HART header and status bytes. In the unpack command shown below (Command 3), it starts reading the Loop current from byte10. However, when looking at the HART command specification, the Loop current reads starting at byte 0 (the header is ignored). So there is an offset of 10 when unpacking the response in PAC Control. If the HART document states to start reading at byte 0, that's byte 10 in PAC Control. If the response data byte says to read byte 4, in PAC Control you start reading from byte 14 (for the Primary variable).



HART Commands and Subroutine Instructions and Variables

The command numbers are the same for all HART Transmitters. However, depending on what Dynamic Variables and commands a HART Device supports and the revision, the response might be slightly different from one device to another. Therefore, you will need to refer to the documentation for the specific HART transmitter being used and consider the information that is being read for that device.

Each HART command supported in the Sample Subroutines has an associated subroutine and PAC Control instruction. A table included with each command shows the variables used in the example chart to pass and receive HART information from the subroutine.

For additional information about the commands, see document numbers HCF_SPEC_127 and HCF_SPEC-151 on the HART Communication Protocol website, http://en.hartcomm.org/

HART Command	Page
Command 0: Read Unique Identifier	18
Command 1: Read Primary Variable	19
Command 2: Read Loop Current and Percent of Range	19
Command 3: Read Dynamic Variable and Loop Current	20
Command 6: Write Polling Address	20
Command 7: Read Loop Configuration	21
Command 8: Read Dynamic Variable Classifications	21
Command 12: Read Message	22
Command 13: Read Tag, Descriptor, Date	22
Command 14: Read Primary Variable Transducer Information	23
Command 15: Read Device Information	23
Command 16: Read Final Assembly Number	24
Command 17: Write Message	24

Command 0: Read Unique Identifier

This is an Identity Command. Returns identity information about the field device (the HART Transmitter). When devising a strategy to communicate with a HART transmitter, always start with Command 0 (subroutine HART_Command_0_ReadUniqueDeviceID) before using any of the other subroutines. Command 0 returns the unique ID for that device. The unique ID is used when calling a subroutine or HART command.

The Command 0 subroutine requires that you know the *Polling Address* of your HART Transmitter. The Polling Address is found in the documents provided with your transmitter.

PAC Control Instruction: HART_Command_0_ReadUniqueDeviceID

Passed Variable	Format	Description
HART I/O	AI	HART module on the rack
nPollingAddress	INT 32	Polling Address of the device
st_UniqueAddress	String	This is where the Unique Address is going to be saved.
nChartStatus	INT 32	Chart Status

Command 1: Read Primary Variable

Reads the Primary Variable. This value is returned along with its Units Code. **PAC Control Instruction**: HART_Command_1_ReadHartVariables

Passed Variable	Format	Description
HART I/O	Al	HART module on the rack
st_UniqueAddress	String	Unique Address of the device
n_COMD_1_PrimVar_Unit	INT32	Unit of Primary Variable
ft_COMD_1_PrimVar	Float	Primary Variable
st_Comm1Res	String	Entire Response
nChartStatus	INT 32	Chart Status

Command 2: Read Loop Current and Percent of Range

Reads the Loop Current and its associated Percent of Range. The Loop Current always matches the current that can be measured by the SNAP-AIMA-IH module.

PAC Control Instruction: HART_Command_2_ReadLoopCurrent_RangePercent

Passed Variable	Format	Description				
HART I/O	AI	HART module on the rack				
st_UniqueAddress	String	Unique Address of the device				
st_empty	String					
ft_COMD_2_LoopCurrent	Float	Primary variable Loop Current: 4 - 20mA				
ft_COMD_2_PrimVarPercent	Float	Primary variable Percent of Range (units of Percent)				
st_Comm2Res	String	Entire Response				
nChartStatus	INT 32	Chart Status				

Command 3: Read Dynamic Variable and Loop Current

Reads the Loop Current and up to four predefined Dynamic Variables. **PAC Control Instruction**: HART_Command_3_ReadDynamicVAR_LoopCurrent

Passed Variable	Format	Description
HART I/O	AI	HART module on the rack
st_UniqueAddress	String	Unique Address of the device
ft_COMD_3_LoopCurrent	Float	Primary variable Loop Current: 4 - 20mA
n_COMD_3_PrimaryVariable_UnitCode	Int32	Primary Variable Unit Code
ft_COMD_3_PrimVar	Float	Primary variable
n_COMD_3_SecondaryVariable_UnitCode	Int32	Secondary Variable Unit Code
ft_COMD_3_SecVar	Float	Secondary variable
n_COMD_3_TertiaryVariableUnitCode	Int32	Tertiary variable Unit Code
ft_COMD_3_TertiaryVariable	Float	Tertiary variable
n_COMD_3_QuaternaryVariableUnitCode	Int32	Quaternary variable Unit Code
ft_COMD_3_QuaternaryVariable	Float	Quaternary variable
st_Comm3Res	String	Entire Response
nChartStatus	Int32	Chart Status

Command 6: Write Polling Address

Writes the polling address and the loop current mode to the field device.

PAC Control Instruction: HART_Command_6_WritePollingAddress

Passed Variable	Format	Description				
HART I/O	AI	HART module on the rack				
st_UniqueAddress	String	Unique Address of the device				
nPer_COMD_6_PollingAddress	Int32	Polling Address of Device				
st_Comm6Res	String	Entire Response				
nChartStatus	Int32	Chart Status				

Command 7: Read Loop Configuration

Reads the polling address and the loop current mode.

PAC Control Instruction: HART_Command_7_ReadLoopConfiguration

Passed Variable	Format	Description
HART I/O	AI	HART module on the rack
st_UniqueAddress	String	Unique Address of the device
st_empty	String	
n_COMD_7_PollingAddress	Int32	Polling Address
n_COMD_7_LoopCurrentMode	Int32	Loop Current Mode
st_Comm7Res	String	Entire Response
nChartStatus	Int32	Chart Status

Command 8: Read Dynamic Variable Classifications

Reads the Classification associated with the Dynamic Variables

PAC Control Instruction: HART_Command_8_ReadDynamicVariableClassifications

Passed Variable	Format	Description
HART I/O	AI	HART module on the rack
st_UniqueAddress	String	Unique Address of the device
St_empty	String	-
n_COMD_8_PrimaryVarCalssification	Int32	Primary Variable Classification
n_COMD_8_SecondaryVarCalssification	Int32	Secondary Variable Classification
n_COMD_8_TertiaryVarClassification	Int32	Tertiary variable Classification
n_COMD_8_QuaternaryVarClassification	Int32	Quaternary variable Classification
st_Comm8Res	String	Entire Response
nChartStatus	Int32	Chart Status

Command 12: Read Message

Reads the Message contained within the device.

PAC Control Instruction: HART_Command_12_ReadMessage

Passed Variable	Format	Description
HART I/O	AI	HART module on the rack
st_UniqueAddress	String	Unique Address of the device
st_empty	String	
st_COMD_12_MessageRead	String	Message Read
st_Comm7Res	String	Entire Response
nChartStatus	Int32	Chart Status

Command 13: Read Tag, Descriptor, Date

Read Tag, Descriptor, Date contained within the device. Only the Tag (6 Bytes or 8 Packed ASCII Characters) is processed by this subroutine.

PAC Control Instruction: HART_Command_13_ReadTAGDescriptor_Date

Passed Variable	Format	Description
HART I/O	AI	HART module on the rack
st_UniqueAddress	String	Unique Address of the device
st_empty	String	-
st_COMD_13_TAG	String	Tag
st_COMD_13_Descriptor	String	Descriptor
st_COMD_13_Date	String	Date
st_Comm13Res	String	Entire Response
nChartStatus	Int32	Chart Status

Command 14: Read Primary Variable Transducer Information

Reads the Transducer Serial Number, Limits/Minimum Span Units Code, Upper Transducer Limit, Lower Transducer Limit and Minimum Span for the Primary Variable Transducer.

PAC Control Instruction: HART_Command_14_ReadPrimaryVariableTransducerInfo

Passed Variable	Format	Description
HART I/O	AI	HART module on the rack
st_UniqueAddress	String	Unique Address of the device
St_empty	String	-
n_COMD_14_TransducerSerialNumber	Int32	Serial Number
n_COMD_14_TransducerLimits_SpanUnitCode	Int32	Limits and Minimum Span Unit Code
ft_COMD_14_UpperTransducerLimit	Float	Upper Limit
ft_COMD_14_LowerTransducerLimit	Float	Lower Limit
ft_COMD_14_MinimumSpan	Float	Minimum Span
st_Comm14Res	String	Entire Response
nChartStatus	Int32	Chart Status

Command 15: Read Device Information

Reads the alarm selection code, transfer function code, range values units code upper range value, Primary Variable lower range value, damping vale and write protect code.

PAC Control Instruction: HART_Command_15_ReadDeviceInfo

Passed Variable	Format	Description
HART I/O	AI	HART module on the rack
st_UniqueAddress	String	Unique Address of the device
St_empty	String	-
n_COMD_15_AlarmSelectCode	Int32	PV Alarm Selection Code
n_COMD_15_TransferFunctionCode	Int32	PV Transfer Selection Code
n_COMD_15_UpperLowerRangeValuesUnitCode	Int32	PV Upper /Lower Range Values Unit Code
ft_COMD_15_UpperRangeValue	Float	PV Upper Range Value
ft_COMD_15_LowerRangeValue	Float	PV Lower Range Value
ft_COMD_15_DampingValueUnitSeconds	Float	PV Damping Value
n_COMD_15_WriteProtectCode	Int32	Write Protect Code
n_COMD_15_AnalogChannelFlags	Int32	PV Analog Channel Flags
st_Comm15Res	String	Entire Response
nChartStatus	Int32	Chart Status

Command 16: Read Final Assembly Number

Reads the final assembly number associated with the device.

PAC Control Instruction: HART_Command_16_ReadFinalAssemblyNumber

Passed Variable	Format	Description
HART I/O	AI	HART module on the rack
st_UniqueAddress	String	Unique Address of the device
st_empty	String	-
n_COMD_16_FinalAssemblyNumber	Int32	Final Assembly Number
st_Comm16Res	String	Entire Response
nChartStatus	Int32	Chart Status

Command 17: Write Message

Writes the Message into the device. To write a message to the transmitter or use Command 17, you need to move the message to the variable (st_COMD_17_MessagetoWrite). Command 17 accepts messages that are exactly 32 characters to write to the transmitter.

PAC Control Instruction: HART_Command_17_WriteMessage

Passed Variable	Format	Description
HART I/O	AI	HART module on the rack
st_UniqueAddress	String	Unique Address of the device
st_COMD_17_MessagetoWrite*	String	Message to write.
st_Comm17Res	String	Entire Response
nChartStatus	Int32	Chart Status

* Note: The Message string must be exactly 32 string characters.

3: Using HART SNAP I/O with a Custom Program

Resources for Custom Programming

HART SNAP I/O modules are typically used with an Opto 22 PAC Control strategy running on a SNAP PAC programmable automation controller. If you're not using PAC Control, however, you can develop your own custom program. Here's what you'll need:

- One or more HART SNAP I/O modules on a SNAP PAC rack with a SNAP PAC I/O processor (brain or rack-mounted controller). See Chapter 1, "1: Introduction & Installation."
- The free SNAP PAC .NET HART developer toolkit. This toolkit lets you integrate HART SNAP I/O modules into an existing .NET/Mono application. This toolkit is available for download on www.opto22.com. It includes complete documentation.
- PAC Manager software. This free configuration and troubleshooting utility comes on a CD with all SNAP PAC brains and controllers and is also available for download on our website, www.opto22.com. Install PAC Manager on a Windows PC on the same Ethernet network as the I/O unit. The *PAC Manager User's Guide* (form 1704) is included.
- The *OptoMMP Protocol Guide* (form 1465, available on www.opto22.com). OptoMMP is the memory map protocol used by SNAP PAC I/O processors. This guide shows you how to address modules on the rack and includes the complete memory map, which provides the addresses you'll use to configure and communicate with HART SNAP I/O modules.

Getting Started

Get Acquainted

In Chapter 2 of the *OptoMMP Protocol Guide*, read "Overview of Programming,""Understanding the Memory Map," and "Referencing SNAP I/O Points."

Assign an IP Address

If the SNAP PAC I/O processor doesn't have a fixed IP address yet, follow steps in the *PAC Manager* User's Guide to assign it.

0 P T 0

N N

Configure I/O Points

You can configure the two points on the HART SNAP I/O module in your custom program or in PAC Manager software.

In your program

1. If you want to configure analog point features—watchdog, custom scaling, or output clamping—on HART SNAP I/O modules, follow instructions in "Using I/O Point Features" (in Chapter 2 of the *OptoMMP Protocol Guide*).

If you're not using these features, you do not need to configure points. The I/O processor recognizes points automatically.

2. Configure HART settings using the memory map section, "HART Module Configuration— Read/Write" in the Memory Map Appendix.

NOTE: The only thing you cannot configure in your custom program is a change to the IP port number used by one of the module's points. If you need to change the IP port number, use PAC Manager and remember to save the configuration to flash memory. You must reboot the I/O processor for the change to take effect.

In PAC Manager—Inspect Window

For individual I/O units, use the steps shown below. If you have several similar I/O units, you may prefer to create a configuration file and download it to several I/O units at once. For this option, see "In PAC Manager—Configuration File" on page 29.

1. On the PC, choose Start > Programs > Opto 22 > PAC Project > PAC Manager.

PAC Manager	
File Tools View Help	
Ready	

2. In the PAC Manager main window, click Tools > Inspect.

If this is the first time you've used the Inspect window, it will be blank as shown below. If you've used it before, PAC Manager will try to connect to the last device you inspected and read its status.

Inspect Opto 22 Device					
Device Name:		✓ Options ► St	tatus:		8
Status Read	tus Read				
Status Write				VE120	Refresh
Wireless LAN				0.00 Received (0)	
Point Config				100.00	5
Digital Bank				L Electric deserver	
Digital Point				23.40 06.200.200.2	-
Analog Bank					
Analog Point					
High Density					
System 🕨					
Scratch Pad 🔸					
Data Log 🔸					
PID +					
Events +					
Communications >					
Other					-
Close Help				🗌 Auto Refi	resh 15000 msec

- **3.** In the Device Name field, enter the IP address you've assigned to the I/O unit with the HART module.
- **4.** Click the Point Config button in the left column. Click the module number and then the point you want to configure.

ce Name: 10.19	2.50.45	✓ Options ▶	Status: Point Configuration area	ast read at 10/20/14 14:00:33
Status Read	Point Configuration			
	Step 1: Choose a mod	ule		
Status Write	Module 0 1	2 3 4 5 6 7	8 9 10 11 12 13 14 15	Type: AIMA-iH (0x2A)
			5 5 10 11 12 15 11 15	.,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
ireless LAN 🔸	Step 2: Choose a poin	t on the selected module		Type: 4 to 20 mA (0x03)
	Point 0 1	2 3 4 5 6 7	B 9 10 11 12 13 14 15	Feature: None (0x00)
Point Config	16 17	18 19 20 21 22 23 2	4 25 26 27 28 29 30 31	Name:
Digital Bank	Address	Description	Value	Refresh
Digital Point		ALL POINTS		
-	0xFFFF F011 2000	Module Type	AIMA-iH (0x2A)	Apply
Analog Bank	0xFFFF F011 2004	Point Type	4 to 20 mA (0x03)	
	0xFFFF F011 2008	Point Feature	0x 0000000	
Analog Point	0xFFFF F011 2024	Watchdog Output Value	0.000	
High Density	0xFFFF F011 2028	Watchdog Enabled	Disabled	
ingritochorcy	0xFFFF F011 2030	Point Name		
Suctom	0VEEEE E011 200C	ANALOG ONLY	0.00000	
System +	0xFFFF F011 200C	Gain	0.00000	
cratch Pad 🔹 🕨	0xFFFF F011 2014	Upper Scaled Units	24.000	
	0xFFFF F011 2018	Lower Scaled Units	3.200	
Data Log 🔹 🕨	0xFFFF F011 2020	Filter Weight (0=disable)	0.000	
	0xFFFF F011 20BC	Upper Clamp	0.000	
FID F	0xFFFF F011 20B8	Lower Clamp	0.000	
Events 🕨				
nmunications 🕨				
Other				
ound .				

- **5.** If necessary, change Offset, Gain, Upper and Lower Scaled Units, and Filter Weight. When finished, click Apply.
- 6. In the left column, click Communications > HART Modules.
- **7.** Choose the module number from the dropdown list. Remember that the first module on the rack is numbered 0.

/ice Name: 10.19	2.50.45		us: HART Module area last read at 10/2	0/14 16:32:13
Status Read	HART Modules			
Status Write	HART MODULE NUMBER		lodule	
	Address	Description	Value	Refresh
WIREless LAIN		MODULE INFORMATION		
	0xFFFF F0C0 0600	Module Type	AIMA-iH (0x2A)	Apply
Point Config	0xFFFF F03A 7F60	Module Subtype	1 (Revision A)	
	0xFFFF F03A 7F62	Hardware Revision Date	2014-02-27	
Digital Bank	0xFFFF F03A 7F66	Loader Version	R1.0a	
Distal Dates	0xFFFF F03A 7F6A	Firmware Version	R1.0a	
Digital Point		PORT A		
Apples Pople	0xFFFF F03A 9640	Port Number	22512	
Analog bank	0xFFFF F03A 9644	Primary Master	1	
Analog Point	0xFFFF F03A 9648	Retry Limit	2	
Androg Fourie	0xFFFF F03A 964C	Burst Message	0	
High Density	0xFFFF F03A 9650	Promiscuous Mode	0	
	0xFFFF F03A 9654	Preambles Count	5	
Cuntum A		PORT B		
System •	0xFFFF F03A 9670	Port Number	22513	
Scratch Pad	0xFFFF F03A 9674	Primary Master	1	
Sudurrau /	0xFFFF F03A 9678	Retry Limit	2	
Data Log +	0xFFFF F03A 967C	Burst Message	0	
	0xFFFF F03A 9680	Promiscuous Mode	0	
PID 🕨	0xFFFF F03A 9684	Preambles Count	5	
Events +				
Communications 🕨				
Other +				

Choose module number.

8. Set parameters for each port to match the HART device it will communicate with:

Parameter	Description	Default
Port Number	TCP port number. NOTE: If you change the port number you must restart the I/O unit after you finish configuration.	See table on page 33
Primary Master	Master Address. 0 = Secondary Master, 1 = Primary Master Use 1 if you want the HART SNAP I/O module to be the per- manent master; you can temporarily attach another master device for configuration or troubleshooting.	1
Retry Limit	Number of times to retry communication. Valid values: 0 to 5 If the module does not receive a valid response from the slave device after the maximum number of retries, it reports an error.	2
Burst Message	0 = Don't report burst messages, 1 = Report burst messages Burst messages occur when a slave device in a special mode sends data without a request from a master.	0
Promiscuous Mode	miscuous Mode 0 = Don't report other master requests/responses, 1 = Report other master requests/responses 1 means that the module will report transactions initiated by the other master, including requests and responses.	

Parameter	Description	Default
Preambles Count	Valid values: 5 to 20 Older HART devices may requre more than 5 preamble char- acters. Verify using HART command 0.	5

9. When everything is correct, click Apply.

The configuration is sent to the I/O unit BUT is not saved to flash memory. If the I/O unit loses power or is turned off, you will have to reconfigure the HART modules.

- **10.** When you've finished configuring modules, save the configuration to flash:
 - a. Click Status Write in the left column.
 - **b.** In the Operation area halfway down the window, highlight Store configuration to flash.

vice Name: 10.19	92.50.45 • Options • Status: Status Write area	last read at 10/20/14 16:37:15	
Status Read	Status Write		
Charles Martin	Address Description	Value	Refresh
Status write	0xEEEE E038 0004 Always BootP/DHCP On Powerup	No. 🔽	1
	0xFFFF F038 0008 Degrees F/C	Degrees C 🔹	Apply
Wireless LAN	0xFFFF F038 0010 Comm Watchdog Time (msec), 0 = Disable	0	
	0xFFFF F038 0014 TCP Minimum Retransmission Timeout (msec)	250	
Point Config	0xFFFF F038 0018 TCP Initial Retransmission Timeout (msec)	3000	
	0xFFFF F038 001C TCP Retransmission Attempts	5	
Digital Bank	0xFFFF F038 0020 TCP Idle Session Timeout (msec), 0 = Disable	240000	
	0xFFFF F038 0294 Digital Feature Scan Interval (msec)	1	
Digital Point	0xFFFF F038 0050 Max Analog and High Density Digital Scan Interval (msec)	1000	
Analog Bank	0xFFFF F038 0298 Out Of Range Value	-32768.000	
	0xFFFF F038 0054 Scanner Flags	0x 0000000	
Analog Point	0xFFFF F038 0154 Host Name	-	r
Andioground			
High Density	Operation		
	OptoMMP Device Send Command		
Suctom 1	Restart Device from powerup		
System v	Store configuration to flash		
Scratch Pad	Erase configuration from flash		
	Reset to defaults and Restart Device		
Data Log 🕨	Store configuration and TD pattings to migra CD		
-	Store configuration and IP settings to microSD		
PID 🕨	Frase firmware from microSD		
	Erase strategy from microSD		
Events 🕨	Other		
Communications	Switch to loader mode		
	Clear Digital Events - Expanded configuration		
Other +	Clear Digital Events - Old configuration 👻		

- c. Click Send Command.
- **d. IMPORTANT:** If you have changed the TCP port number, highlight the operation Restart Device from powerup, and click Send Command again.

The configuration is stored to the I/O unit's flash memory, and you're ready to use the module.

In PAC Manager—Configuration File

If you have several similar I/O units, you can create a configuration file (also called a tag database) and download it to several I/O units at once. A sample configuration file is included in the Developer's Toolkit, which you can modify as needed. Or follow these steps to create a new file.

1. On the PC, choose Start > Programs > Opto 22 > PAC Project > PAC Manager.



2. In the PAC Manager main window, click the New button or choose File > New and create a new tag database (configuration file).



- **3.** In the tree, double-click the I/O Units folder. Follow steps in the *PAC Manager User's Guide* to add the I/O unit and configure its I/O modules and points. The SNAP-AIMA-iH is an analog input module; the SNAP-AOA-23-iH is an analog output module.
- **4.** In the Configure I/O Units dialog box, highlight the I/O unit the HART module is on and click the Modules button.

÷) Configure I/	O Units					×	
	Name	Туре	Port	Address	Watchdog	De	<u>A</u> dd	
	Preprocess	SNAP-PAC	Ethernet	10.192.54.110	Enabled		<u>M</u> odify	
							Delete	
							Import/ <u>C</u> opy	
							1/0 Points	
							PID Loops	
							Modules +	— Modules
							Events 🕨	button
						_	Scratch Pad 🔸	
1	•		III			•	Communications ►	
	Close	<u>H</u> elp					Others +	

5. Choose HART Modules from the pop-up menu.

Address	Description	Value
	PORT A	
0xFFFF F03A 9400	Port Number	22500
0xFFFF F03A 9404	Primary Master	0
0xFFFF F03A 9408	Retry Limit	2
0xFFFF F03A 940C	Burst Message	0
0xFFFF F03A 9410	Promiscuous Mode	0
0xFFFF F03A 9414	Preambles Count	5
	PORT B	
0xFFFF F03A 9430	Port Number	22501
0xFFFF F03A 9434	Primary Master	0
0xFFFF F03A 9438	Retry Limit	2
0xFFFF F03A 943C	Burst Message	0
0xFFFF F03A 9440	Promiscuous Mode	0
0xFFFF F03A 9444	Preambles Count	5

- **6.** In the Number field, choose the HART module's position from the drop-down list. Click to put a check mark in the Used box.
- 7. Configure all parameters for each port used.
 - **Port Number**: If you need to change port numbers, enter a new number for each port in the Port Number field.
 - Primary Master: 0 = Secondary Master, 1 = Primary Master
 A master is a device that is in control of the HART Bus. Either master (Primary or Secondary) can initiate a transaction with a slave field device attached to the bus.

If you want a permanent master connected to the HART bus, use Primary Master = 1. This allows you to temporarily attach another master device to configure a device or troubleshoot the HART bus.

- **Retry Limit**: 0, 1, 2, 3, 4, or 5

If the module does not receive a valid message from the slave device it is talking to, it will automatically send up to the configured number of retries until it gets a valid response. If it does not get a valid response after the maximum number of retries, it will report back that an error occurred.

- Burst Message: 0 = Don't report burst messages, 1 = Report burst messages
 A burst message occurs in a special mode where one slave device on the HART Bus is periodically sending data without a request generated by a master device.
- Promiscuous Mode: 0 = Don't report other master requests/responses, 1 = Report other master requests/responses.

When enabled (1), the module reports transactions initiated by the other master on the bus, including requests generated by the other master and responses to those requests by the addressed slave.

- **Preambles Count**: 5 to 20

Preamble characters are sent with every message to indicate that data is about to be transmitted. The default of 5 should work in most situations. However, you might need to increase the number if the slave device requires more preamble characters, which is generally true of older HART devices and can be determined using HART command 0.

- 8. When all HART modules are configured, click OK to close the dialog box.
- **9.** Choose File > Save to save the configuration file.
- **10.** When configuration is complete, choose Tools > Send Configuration to I/O Unit.

Send Configuration to Opto 22 Device								
Name HART_IO_unit	Description	Port 2001	Address List 192.168.0.1	Clear Flash Close Help				
✓ Save to Flash ☐ Restart Device			Timeout (msec):					

The list on the left shows all the I/O units in this configuration file. When you click a unit, the Address List shows the IP addresses for all I/O units to receive the same configuration.

- **11.** Highlight the I/O unit configuration(s) you want to send.
- 12. Highlight the IP addresses to receive the I/O unit configuration.

If you don't highlight any addresses, the configuration will be sent to the entire list.

NOTE: If you highlighted more than one unit configuration, each unit configuration will automatically be sent to all the IP addresses associated with it.

13. If necessary, change the Timeout field.

The timeout field shows how long, in milliseconds, PAC Manager will try to communicate with the I/O unit before returning a timeout error.

14. To save the configuration file to flash memory as well as to RAM, check Save to Flash. To also restart the unit, check Restart I/O Unit.

IMPORTANT: If you have changed an IP Port number, you must save the change to flash and restart the I/O unit.

15. Click Send.

The configuration data is sent to the I/O units.

HART Module and Port Numbers

For quick reference, the following table shows HART modules and ports, their default TCP port numbers, and their starting memory map addresses, beginning with FFFF F03A 9400. For more information about the memory map, see the *OptoMMP Protocol Guide*.

Module	Port	Default TCP port	Memory Map Address	Module	Port	Default TCP port	Memory Map Address
0	А	22500	9400	8	А	22516	9700
0	В	22501	9430	8	В	22517	9730
1	А	22502	9460	9	А	22518	9760
1	В	22503	9490	9	В	22519	9790
2	А	22504	94C0	10	А	22520	97C0
2	В	22505	94F0	10	В	22521	97F0
3	А	22506	9520	11	А	22522	9820
3	В	22507	9550	11	В	22523	9850
4	А	22508	9580	12	А	22524	9880
4	В	22509	95B0	12	В	22525	98B0
5	А	22510	95E0	13	А	22526	98E0
5	В	22511	9610	13	В	22527	9910
6	А	22512	9640	14	А	22528	9940
6	В	22513	9670	14	В	22529	9970
7	А	22514	96A0	15	А	22530	99A0
7	В	22515	96D0	15	В	22531	99D0