IO4AB USER'S GUIDE

SNAP-PAC-S1
SNAP-PAC-S2
SNAP-PAC-R1
SNAP-PAC-R2
SNAP-PAC-EB1
SNAP-PAC-EB2
G4EB2
OPTOEMU-SNR-3V
OPTOEMU-SNR-DR1
OPTOEMU-SNR-DR2

Form 1909-170201—February 2017

OPTO 22
Automation made simple.

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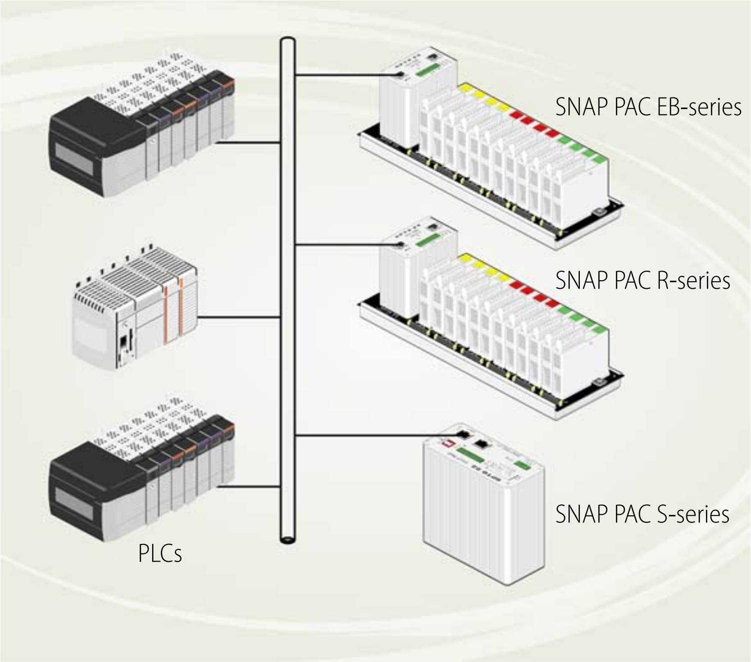
Opto 22
Automation Made Simple.

Table of Contents

1: Welcome

Welcome to the IO4AB User's Guide. Inside you'll find instructions on how to set up EtherNet/IP™ messaging between an Allen-Bradley® Logix™ controller and Opto 22's SNAP PAC I/O using Opto 22's EtherNet/IP Configurator as well as Allen-Bradley's RSLogix™ 5000 software. (For a list of supported Allen-Bradley platforms, see page 107.)

This guide assumes that you are already familiar with how to use Allen-Bradley's RSLogix 5000 software to configure Allen-Bradley devices.



EtherNet/IP automation environment with PLCs and Opto 22

Using this Guide

Chapter 1: Welcome—Provides information about this guide, where to find additional information, and how to reach Opto 22 Product Support.

Chapter 2: Introduction to IO4AB—An overview of Opto 22's implementation of EtherNet/IP, and the things you will need to get started.

Chapter 3: Getting Started—How to install Ethernet/IP Configurator, add an Opto_22 device to the network, and configure I/O modules and points.

Chapter 4: Setting Up Implicit Messaging—How to use EtherNet/IP Configurator and RSLogix 5000 software to set up implicit messaging between an Allen-Bradley controller and Opto 22 remote I/O.

Chapter 5: Setting Up Explicit Messaging—How to use the EtherNet/IP Configurator and RSLogix 5000 to implement explicit messaging.

Chapter 6: Connecting PAC Control and Allen-Bradley Systems—How to connect a SNAP-PAC-S controller with an Allen-Bradley ControlLogix programmable logic controller (PLC) in order to exchange data.

Chapter 7: Using EtherNet/IP Configurator—Additional information about EtherNet/IP Configurator not included previous chapters.

Appendix A: Supported Allen-Bradley Platforms—Lists the Allen-Bradley controllers that support EtherNet/IP.

Appendix B: Using Counts—Describes using counts with EtherNet/IP and linearizing the Pt100 and Pt1000 probes from resistance.

Appendix C: Worksheets and Calculations—Provides a variety of worksheets to help you determine your system's requirements.

Appendix D: Connecting with MicroLogix—Provides information for connecting to a MicroLogix 1100 or 1400 PLC.

Appendix E: Detecting I/O Communication Failures—Describes how ladder logic detects an I/O communication failure.

Appendix F: Generic Ethernet Module Options—Provides information on selecting a communications format.

Appendix G: Accessing Serial Data—Describes how to use a SNAP PAC controller to handle the communication with a SNAP PAC serial module and make the data accessible to an Allen-Bradley controller.

Documents and Online Help

You may also need the following Opto 22 hardware documentation, depending on your application:

For this information	See this guide	Form
Installing and using SNAP PAC brains	*SNAP PAC Brain User's Guide*	1690
Installing and using SNAP PAC R-series controllers	*SNAP PAC R-Series Controller User's Guide*	1595
Installing and using SNAP PAC S-series controllers	*SNAP PAC S-Series Controller User's Guide*	1592

For this information	See this guide	Form
Using the OptoMMP Communication Toolkit or the IEEE 1394-based OptoMMP memory-mapped protocol for programming	*OptoMMP Protocol Guide*	1465
Wiring, specifications, and installation information for SNAP Analog Input Modules	*SNAP Analog Input Modules Data Sheet*	1065
Wiring, specifications, and installation information for SNAP Analog Output Modules	*SNAP Analog Output Modules Data Sheet*	1066
Wiring, specifications, and installation information for SNAP High-Density Digital Modules	*SNAP High-Density Digital Modules Data Sheet*	1556
Wiring, specifications, and installation information for SNAP Digital Input Modules	*SNAP Digital Input Modules Data Sheet*	0773
Wiring, specifications, and installation information for SNAP Digital Output Modules	*SNAP Digital Output Modules Data Sheet*	1144
Wiring, specifications, and installation information for isolated analog input modules	*SNAP Isolated Analog Input Modules Data Sheet*	1182
Wiring, specifications, and installation information for serial modules	*SNAP Serial Communication Modules Data Sheet*	1184
Using EtherNet/IP commands with remote Opto 22 SNAP PAC I/O with an Allen-Bradley® Logix™ controller	*Ethernet/IP for SNAP PAC Protocol Guide*	1770
Latest release, installation, and system requirements information for EtherNet/IP Configurator.	*EtherNet/IP Configurator Release Notes. (See www.opto22.com for the latest form number.)*	

All documents are available on our website, www.opto22.com. The easiest way to find a document is to search on its form number.

Additional resources are also available on the Opto 22 Web site such as a demonstration video that shows how to configure and program an Allen-Bradley controller to talk to SNAP PAC I/O. If you are viewing this document online and have an internet connection, click the link. Or go to the Learn tab on the Opto 22 website, www.opto22.com, and click Learn About IO4AB.

Additional Resources for EtherNet/IP

For an overview of CIP and EtherNet/IP technology, see http://www.odva.org/Portals/0/Library/Publications_Numbered/PUB00138R2_CIP_Adv_Tech_Series_EtherNetIP.pdf

For information on the network infrastructure for EtherNet/IP, see http://www.odva.org/Portals/0/Library/Publications_Numbered/PUB00035R0_Infrastructure_Guide.pdf

For a good starting point for Ethernet/IP research on the ODVA web site, see http://www.odva.org/default.aspx?tabid=67

Product Support

If you have any questions about using EtherNet/IP to communicate with Opto 22 devices, you can call, fax, or email 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
Fax:	951-695-3017
Email:	support@opto22.com
Opto 22 website:	www.opto22.com

NOTE: Email messages and phone calls to Opto 22 Product Support are grouped together and answered in the order received.

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

- Version of this product
- PC configuration (type of processor, speed, memory, operating system)
- RSLogix 5000 version
- PLC model
- PLC firmware version
- Complete description of your hardware system, including:
  - Jumper configuration
  - Type of power supply
  - Types of I/O units installed
  - Controller firmware version
  - Specific error messages

2: Introduction to IO4AB

This chapter includes a brief introduction to Ethernet/IP and how it is implemented in Opto 22 products. It also provides guidance in selecting a messaging type.

Built on the standard TCP/IP suite of protocols, EtherNet/IP gets the "IP" part of its name from CIP™, the Common Industrial Protocol™. As the name implies, EtherNet/IP adapts CIP to standard Ethernet technology, and thus provides tools to deploy manufacturing applications on an enterprise network. Introduced in 2001, EtherNet/IP is now supported by hundreds of vendors around the world and is a standard networking solution in industrial automation.

In this Chapter

Opto 22 Advantage

Using EtherNet/IP, Allen-Bradley Logix controllers can communicate with remote Opto 22 I/O and take advantage of Opto 22's *distributed intelligence*. With distributed intelligence, a controller (such as an Allen-Bradley controller), handles overall control but does not have to attend to every detail of every process. The I/O's own onboard processor (also called a *brain* or *device*) has the intelligence to handle not only on/off control but also functions such as latching, counting, thermocouple linearization, even PID loops. With these functions running locally on the I/O unit, they still do their job even if communication to the controller is lost, and the load on the controller is reduced.

By connecting to Opto 22 devices as remote I/O, you can add the rich and sophisticated functionality of Opto 22 equipment to your EtherNet/IP systems. While other manufacturer's devices may report only states and counts, our SNAP PAC System devices can provide access to the following functions:

- Power consumption
- Power line monitoring
- PID loop control (up to 96 loops)
- Serial device control (RS-232/485)
- Analog scaling
- Offset and gain
- Analog ramping
- Output clamping
- Filter weight
- Minimum and maximum values
- Engineering unit conversion
- Thermocouple linearization
- Temperature conversion
- Quadrature counting
- Input latching
- Pulse generation and measurement
- High-speed counting (up to 20 kHz)
- Frequency and period measurement
- Digital and analog totalizing
- Watchdog timeout
- Time-proportional output
- Load cell

Opto 22 Products

You can use a variety of Ethernet-capable devices from the SNAP PAC family of products in an EtherNet/IP environment, including the latest generation of SNAP PAC controllers and brains. There are two basic approaches:

- Use SNAP PAC I/O with a SNAP PAC EB-series brain or R-series controller as intelligent remote I/O with an EtherNet/IP-enabled scanner such as an Allen-Bradley PLC. If you want a brain or controller with Factory Mutual approval, choose the part number with FM at the end, such as SNAP-PAC-EB1-FM.

  NOTE: SNAP PAC EB-series brains are equipped with LEDs that report the EtherNet/IP module status (MS) and network status (NS). For more information, see form 1690, the SNAP PAC Brains User's Guide.

- Use SNAP PAC S-series or R-series controllers to exchange scratch pad variable data with an EtherNet/IP-enabled scanner such as an Allen-Bradley PLC.

Architecture

In EtherNet/IP terminology, a device may function as either an *adapter* or a *scanner*. Our Opto 22 devices are implemented as adapters, and as such are able to send and receive data only when requested to do so by a scanner. The Opto 22 device (or adapter) is therefore a *target* of instructions and requests for information sent by a scanner, which is usually a PLC, but could be a PC running control software.

An *adapter* class device receives message requests from all other classes of products, and it can exchange peer data using messages with any class of device. However, an adapter cannot store or originate the data communications parameters necessary to establish a connection. Therefore, it cannot originate real-time I/O data connections, which is why it sends and receives I/O data only when it is requested to do so by a scanner.

A *scanner* is capable of originating I/O data connection requests with adapter class products, as well as with other scanner class products. Scanner class devices may also originate or be the targets of explicit connection requests to and from other classes of products, and they can send or receive messages to or from all other classes of products.

Implicit and Explicit Messaging

As adapters, SNAP-PAC-EB brains, and SNAP-PAC-R and SNAP-PAC-S controllers are able to exchange messages with scanners using both *explicit* and *implicit* messaging.

Explicit messages are used for request/response transactions between two nodes. The scanner sends a request and the adapter returns a response. Using TCP/IP, these messages can reach any network-accessible object attributes and services within a device. Once the modules and points are configured on an Opto 22 device, no additional configuration is required on an Opto 22 device. All programming is done in RSLogix.

Implicit messages transfer data at regular intervals established by the scanner. No request is required, the request is *implied*. Implicit messaging connections often are set up as one-to-many relationships and use UDP/IP to multicast application-specific I/O data at regular intervals. When properly configured, the data is always available to be scanned by the controller. In addition to configuring the modules and points on an Opto 22 device, you must also create input and output *assemblies*. An assembly provides the format for the implicit message packet that includes the information for the point or points you are interested in.

For help with choosing a messaging type, see the next section "Choosing the Messaging Type."

Choosing the Messaging Type

Implicit messaging is the normal way to communicate with I/O. However, there are times when explicit messaging is more appropriate. See the reasons below for why you might use one messaging type over the other. All of these apply for a properly configured Ethernet network (wired or wireless).

Reasons for Using Implicit Messaging

- For typical communications with I/O (also called *I/O messaging*) where an item is scanned or repeated
- For a simpler implementation and less programming in ladder logic. Programming in ladder logic is required for explicit messaging.
- If you want the SNAP I/O to send data at stated intervals to one or more PLCs without waiting for a request (input instance), or if you want the PLC to do the same (output instance)

For instructions for using implicit messaging, see "4: Setting Up Implicit Messaging" on page 23.

Reasons for Using Explicit Messaging

- If you want the PLC to initiate communication at specific points in your ladder logic
- For communication among controllers (such as exception, handshaking, and access)
- For more complex commands that are not suited to scanning. For example, Read and Clear Counters.
- To route messages over wide area connections. With explicit messaging, you can access a remote Opto 22 device over the Internet.
- For sending or receiving data on a serial communication module port using the Serial Port object
- If the quantity of data exchanged exceeds ~1000 bytes of input data or ~500 bytes of output data, which are the limits in RSLogix 5000 software, the excess must be exchanged via explicit messaging
- For some OEM applications, properly configured explicit messaging can require less programming and program management

For instructions for using explicit messaging, see "5: Setting Up Explicit Messaging" on page 33.

Using CIP Objects

EtherNet/IP accesses device data and functionality as a collection of object attributes and services. As much as possible, Opto 22 device data and functionality is exposed through standard CIP objects, extended for additional non-standard functions. In some cases vendor-specific objects are defined for functionality that is not within the scope of the standard objects.

The classes available for implicit messaging in the EtherNet/IP Configurator are a subset of the CIP classes, all of which are available through explicit messaging. For information on the CIP classes and attributes, see form 1770, *Ethernet/IP for SNAP PAC Protocol Guide*.

Specifications

The following specifications apply to any SNAP PAC Ethernet-based brain or controller used as a remote I/O unit for an Allen-Bradley PLC:

Description	Value
TCP/IP encapsulation connections	16
CIP Connections allowed per TCP/IP connection	2
Implicit Multicast Connections	16
Assembly instances supported	16
Assembly members in all assembly instances	4096

3: Getting Started

This chapter describes lists the things you will need in order to implement IO4AB. It also describes how to install EtherNet/IP Configurator and two procedures which you must do for both implicit and explicit messaging: adding an Opto_22 device to the network and configuring I/O modules and points.

In this Chapter

What You Will Need

- A SNAP PAC EB-series or R-series device loaded with firmware R8.3a or newer, installed on a mounting rack with I/O modules and connected to the network. See the documentation included with the Opto 22 hardware.

  NOTE: If you will be doing the exercises in "5: Setting Up Explicit Messaging" on page 33, and want to run your example Logix project, you will need a SNAP PAC Learning Center from Opto 22, either part number SNAP-IO4ABLC or SNAP-PACLC. However, if you do not plan to run your example project, you do not need a Learning Center.

  Make sure to assemble the Learning Center according to the instructions that are included. For more information about obtaining a SNAP PAC Learning Center, go the Opto 22 website, www.Opto22.com and search on the part number.

- EtherNet/IP Configurator installed on your computer (see below). EtherNet/IP Configurator is available as a free download from our website, www.opto22.com, and it is included with the CD that came with the Opto 22 device.
- RSLogix 5000, version V13 or newer installed on your computer
- ControlLogix PLC 1756-L6x with a 1756-ENBT/A, 1756-EN2T, or 1756-EM2F EtherNet/IP module. You can also use a CompactLogix 1769-L32E, a DriveLogix 700s Version 2, or a SoftLogix.

NOTE: If you have a MicroLogix 1100 or1400 (Series B FRN4 or newer), you can also connect the two systems and use Explicit Messaging to access data. For more information, see "D: Connecting with MicroLogix" on page 121.

- An industrial managed Ethernet switch

Installing EtherNet/IP Configurator

The easy-to-use EtherNet/IP Configurator provides the tools you need to configure modules and points, create input and output assemblies, and download a configuration to an Opto 22 device.

EtherNet/IP Configurator is available as a free download from our website, www.opto22.com, and it is included with the CD that came with your Opto 22 device.

If you are using the download, double-click the downloaded file. The installation wizard should start automatically. Follow directions to install the software.

If you are using the CD, insert the CD in your CD-ROM drive. The installation wizard should start automatically. If it doesn't, use Windows Explorer to navigate to your CD-ROM drive and then double-click setup.exe. Follow directions to install the software.

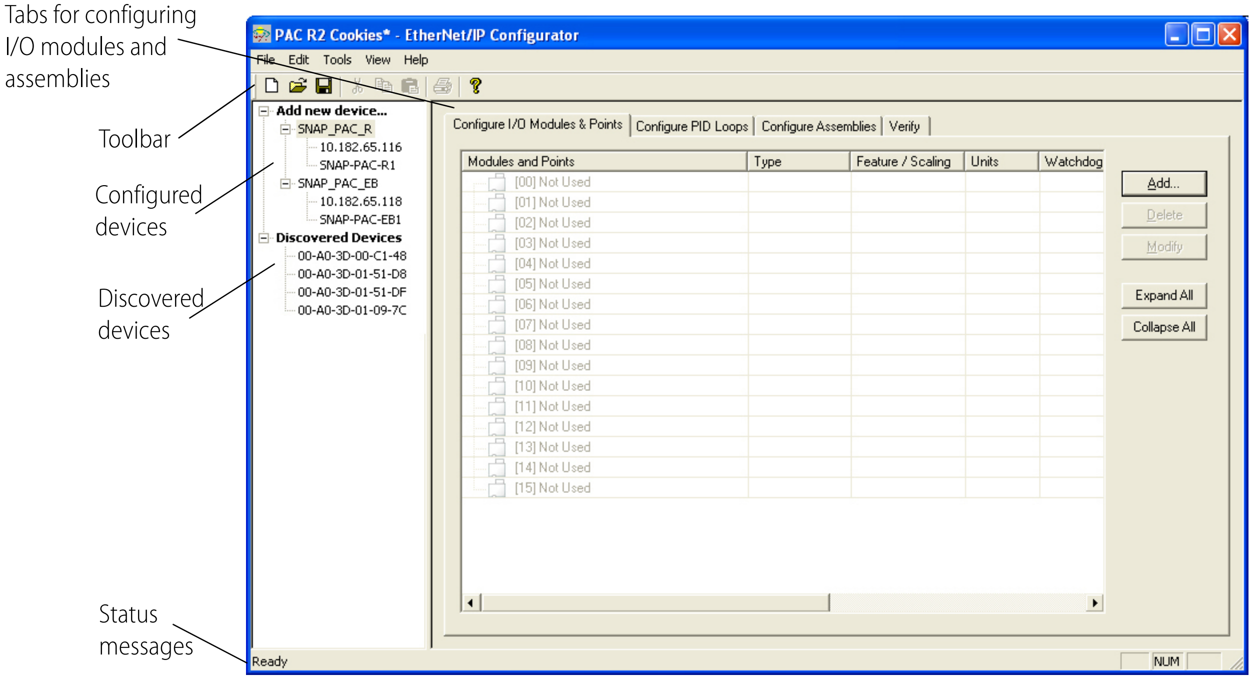
Adding an Opto 22 Device

The best way to add an Opto 22 device to the network (and also the configuration) is to allow EtherNet/IP Configurator to *discover* the device. (To add a device manually, see "Adding a Device Manually" on page 78.)

Perform the following tasks to open EtherNet/IP Configurator and add an Opto 22 device.

1. To open EtherNet/IP Configurator:

- In Windows 7 and Windows Vista, press the Windows Start key, and then click Programs > Opto 22 > PAC Project 9.6 > EtherNet-IP > EtherNet-IP Configurator.
- In Windows 10 and Windows 8.1, press the Windows Start key, type **`EtherNet-IP Configurator 9.6`** and then press the Enter key.

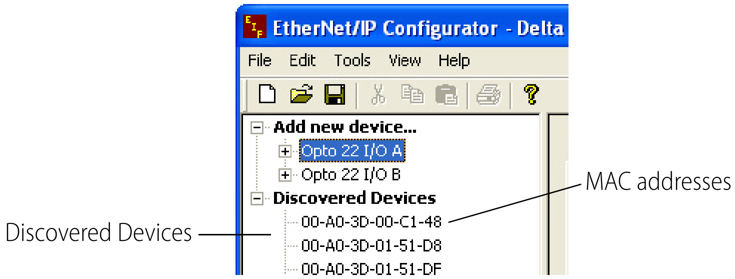


Add new device...
- SNAP_PAC_R
  - 10.182.65.116
  - SNAP-PAC-R1
- SNAP_PAC_EB
  - 10.182.65.118
  - SNAP-PAC-EB1

Discovered Devices
- 00-A0-3D-00-C1-48
- 00-A0-3D-01-51-D8
- 00-A0-3D-01-51-DF
- 00-A0-3D-01-09-7C

Modules and Points	Type	Feature / Scaling	Units	Watchdog
[00] Not Used				
[01] Not Used				
[02] Not Used				
[03] Not Used				
[04] Not Used				
[05] Not Used				
[06] Not Used				
[07] Not Used				
[08] Not Used				
[09] Not Used				
[10] Not Used				
[11] Not Used				
[12] Not Used				
[13] Not Used				
[14] Not Used				
[15] Not Used				

When installed and first turned on, an Opto 22 device sends out a BootP broadcast requesting an IP address. EtherNet/IP Configurator discovers each Opto 22 device on your network broadcasting a BootP request and lists the devices in the device tree.



Add new device...
- Opto 22 I/O A
- Opto 22 I/O B

Discovered Devices
- 00-A0-3D-00-C1-48
- 00-A0-3D-01-51-D8
- 00-A0-3D-01-51-DF

Like all Opto 22 Ethernet-based controllers and brains, each of the discovered devices has a unique hardware Media Access Control (MAC) address, which is displayed in the device list.

In order to add a discovered device to a configuration so that it can communicate on the network, you must give the device a name, a valid IP address, and a subnet mask.

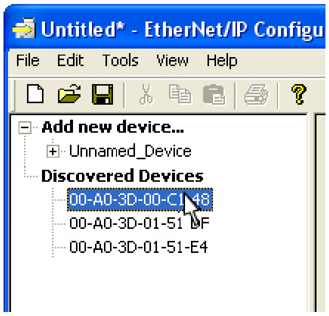
To add a discovered device:

1. Make sure the device is connected to the network and turned on.

   The device now broadcasts a BootP request for its configuration.

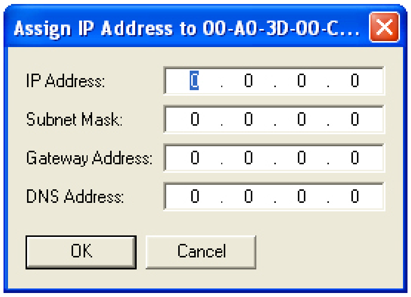
   Your SNAP-PAC-EB1 is identified by its MAC address, also written on a label attached to the side of the controller's housing. (The MAC addresses of Opto 22 devices begin with 00.a0.3d.) If no devices are listed under Discovered Devices, turn your Opto 22 device off and then turn it on again.

2. When the MAC address of the discovered device appears under Discovered Devices, double-click the MAC address.



CAUTION: EtherNet/IP Configurator lists ALL Opto 22 devices sending BootP or DHCP broadcasts. Assign IP addresses only to the ones you know are yours!

The Assign IP Address dialog box appears.



Assign IP Address to 00-A0-3D-00-C...

IP Address: 0 . 0 . 0 . 0

Subnet Mask: 0 . 0 . 0 . 0

Gateway Address: 0 . 0 . 0 . 0

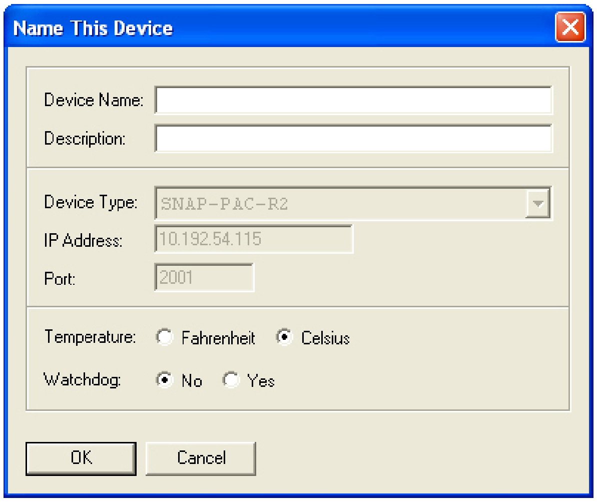
DNS Address: 0 . 0 . 0 . 0

3. Enter the IP Address and the Subnet Mask for the device. If it will be talking to a device on another subnet, enter the Gateway (router) address. If it will talk only on the local subnet, leave the gateway address all zeros (0.0.0.0). Leave the DNS address at 0.0.0.0 field blank.

WARNING! Each device on your network, including computers, routers, controllers, brains, and so on, must have a unique IP address. Failure to assign unique IP addresses may cause catastrophic network or hardware failures. If you don't know which IP addresses are safe to use, check with your system administrator.

4. When the IP address, subnet mask, and other fields are correct, click OK.

The Name This Device dialog box appears with the Device Type, IP Address and Port filled in automatically.



Name This Device

Device Name:

Description:

Device Type: SNAP-PAC-R2

IP Address: 10.192.54.115

Port: 2001

Temperature: ○ Fahrenheit ● Celsius

Watchdog: ● No ○ Yes

5. At minimum, enter a Device Name.

   You can also enter a description, select the temperature type, and whether you want to use a watchdog.

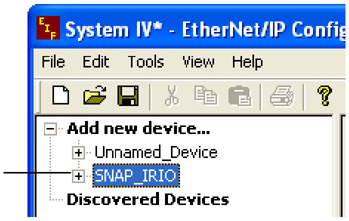
   Temperature. Choose whether temperatures will be handled in Fahrenheit or Celsius.

   Watchdog. Select whether you want a Watchdog on the unit. The default is No (disabled). If you select Yes, a new field appears; enter the Watchdog timeout value (in seconds). The default timeout is 0.5 seconds.

NOTE: If you want to enable Watchdog on a point, make sure to enable it here at the point level as well.

6. Click OK to confirm the changes.

   The new device appears in the device tree.



New device

Configuring I/O Modules and Points

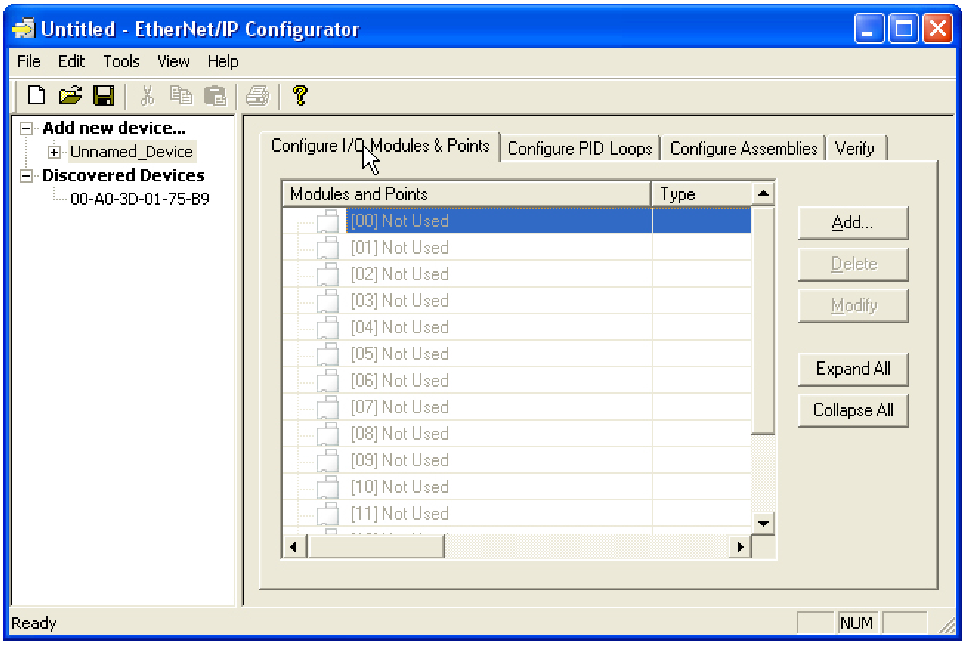
For both implicit and explicit messaging, once you have added a device, you need to configure its modules and points as described in the following sections:

- "Configuring Digital Points" (below)
- "Configuring Analog Points" on page 19

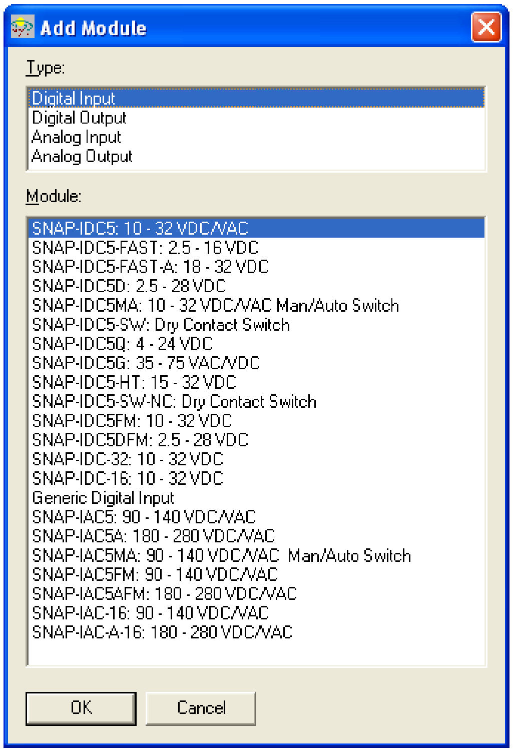
Configuring Digital Points

Use the following steps to configure digital points on all 4-channel and high-density SNAP digital modules.

1. In EtherNet/IP Configurator, click the Configure I/O Modules & Points tab.



2. Double-click the number that represents the digital module's position on the rack. For help, see "Referencing I/O Points on SNAP PAC Racks" on page 106.



Add Module

Type:

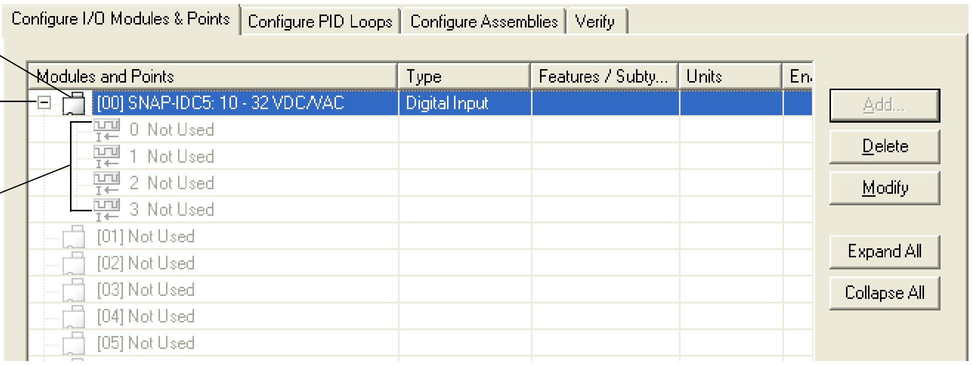
- Digital Input
- Digital Output
- Analog Input
- Analog Output

Module:

- SNAP-IDC5: 10 - 32 VDC/VAC
- SNAP-IDC5-FAST: 2.5 - 16 VDC
- SNAP-IDC5-FAST-A: 18 - 32 VDC
- SNAP-IDC5D: 2.5 - 28 VDC
- SNAP-IDC5MA: 10 - 32 VDC/VAC Man/Auto Switch
- SNAP-IDC5-SW: Dry Contact Switch
- SNAP-IDC5Q: 4 - 24 VDC
- SNAP-IDC5G: 35 - 75 VAC/VDC
- SNAP-IDC5-HT: 15 - 32 VDC
- SNAP-IDC5-SW-NC: Dry Contact Switch
- SNAP-IDC5FM: 10 - 32 VDC
- SNAP-IDC5DFM: 2.5 - 28 VDC
- SNAP-IDC-32: 10 - 32 VDC
- SNAP-IDC-16: 10 - 32 VDC
- Generic Digital Input
- SNAP-IAC5: 90 - 140 VDC/VAC
- SNAP-IAC5A: 180 - 280 VDC/VAC
- SNAP-IAC5MA: 90 - 140 VDC/VAC Man/Auto Switch
- SNAP-IAC5FM: 90 - 140 VDC/VAC
- SNAP-IAC5AFM: 180 - 280 VDC/VAC
- SNAP-IAC-16: 90 - 140 VDC/VAC
- SNAP-IAC-A-16: 180 - 280 VDC/VAC

3. In the Add Module dialog box, choose the module type and then the exact module part number from the lists. Click OK.

4. Back in the Configure I/O Modules & Points tab, click the plus sign next to the new module to expand it. Notice that the module icon is color-coded to reflect the type of module being configured: white for digital DC input, red for digital DC output, yellow for digital AC input, and black for digital AC output.



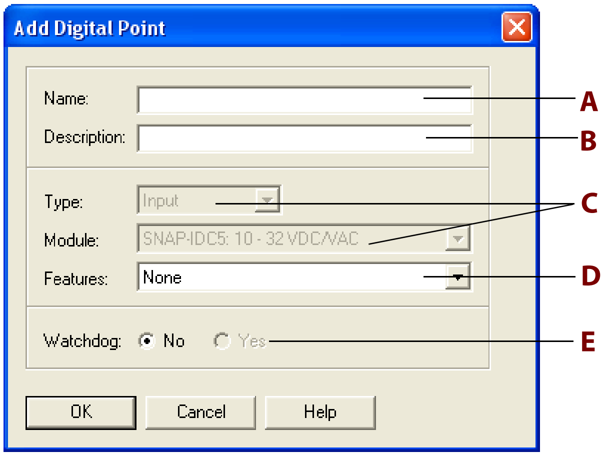
Module icon

Expand or collapse points on the module by clicking the + or - sign in the box.

Points

Modules and Points	Type	Features / Subty...	Units	En
[00] SNAP-IDC5: 10 - 32 VDC/VAC	Digital Input			
0 Not Used				
1 Not Used				
2 Not Used				
3 Not Used				
[01] Not Used				
[02] Not Used				
[03] Not Used				
[04] Not Used				
[05] Not Used				

5. Double-click the point you want to configure to open the Add Digital Point dialog box.



Add Digital Point

Name:

Description:

Type: Input

Module: SNAP-IDC5: 10 - 32 VDC/VAC

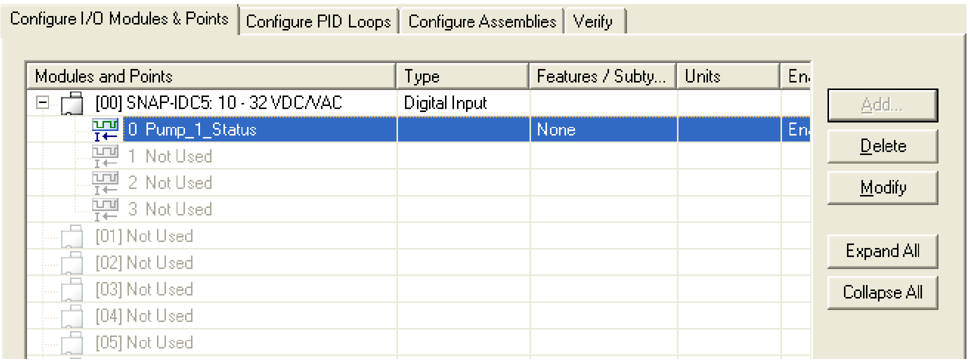
Features: None

Watchdog: ● No ○ Yes

6. Complete the fields as follows:
   - **A** **Name**: Enter a name for the point. The name must start with a letter and may contain letters, numbers, and underscores. Spaces are converted to underscores.
   - **B** **Description**: (Optional) Enter a description of the point.
   - **C** **Type, Module**: Type and module are already filled in for you.
   - **D** **Features**: To use a feature of the module, choose it from the drop-down list. For information about the available features, see "Using I/O Point Features" on page 104.
   - **E** **Watchdog**: (Output modules only) To configure a status (On or Off) the point should be set to if the Watchdog timer on this device expires, click Yes and choose On or Off from the drop-down list. In order for this to take effect, make sure Watchdog is enabled at the device level. To do this, double-click the device in the device tree to open the Modify Device Information dialog. Select Yes for Watchdog, choose a timeout, and then click OK.

7. When you have completed the fields, click OK.

   The new point appears in the list.



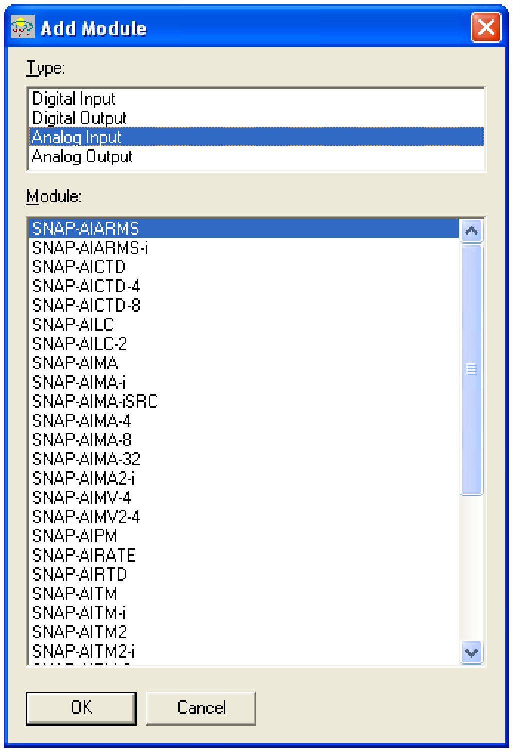
Modules and Points	Type	Features / Subty...	Units	En
[00] SNAP-IDC5: 10 - 32 VDC/VAC	Digital Input			
0 Pump_1_Status		None		En
1 Not Used				
2 Not Used				
3 Not Used				
[01] Not Used				
[02] Not Used				
[03] Not Used				
[04] Not Used				
[05] Not Used				

8. To configure more digital points, repeat the steps. To configure analog points, see the next section.

Configuring Analog Points

Use the following steps to configure analog points on all SNAP analog modules supported by the device.

1. In the Configure I/O Modules & Points tab, double-click the number that represents the analog module's position on the rack. For help, see "Referencing I/O Points on SNAP PAC Racks" on page 106.



Add Module

Type:

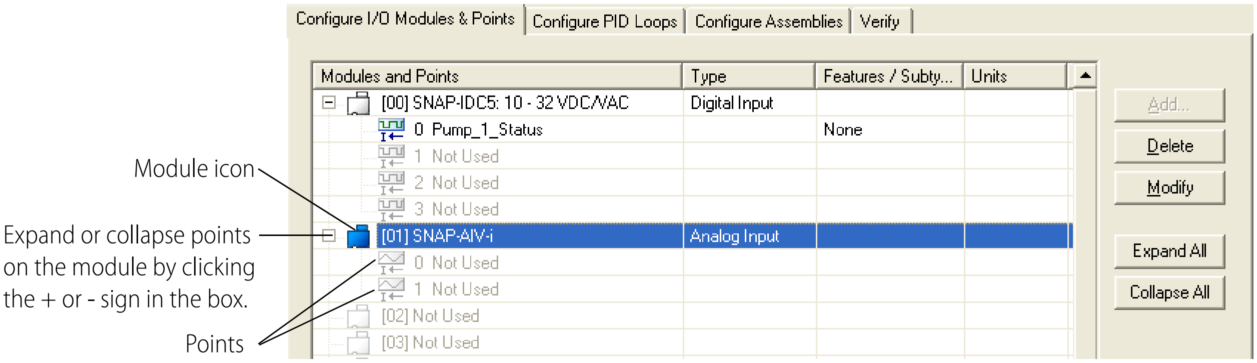
- Digital Input
- Digital Output
- Analog Input
- Analog Output

Module:

- SNAP-AIARMS
- SNAP-AIARMS-i
- SNAP-AICTD
- SNAP-AICTD-4
- SNAP-AICTD-8
- SNAP-AILC
- SNAP-AILC-2
- SNAP-AIMA
- SNAP-AIMA-i
- SNAP-AIMA-iSRC
- SNAP-AIMA-4
- SNAP-AIMA-8
- SNAP-AIMA-32
- SNAP-AIMA2-i
- SNAP-AIMV-4
- SNAP-AIMV2-4
- SNAP-AIPM
- SNAP-AIRATE
- SNAP-AIRTD
- SNAP-AITM
- SNAP-AITM-i
- SNAP-AITM2
- SNAP-AITM2-i

2. In the Add Module dialog box, choose Analog Input or Analog Output, and then choose the exact module part number from the list. Click OK.

3. In the Configure I/O Modules & Points tab, click the plus sign next to the new module to expand it. Notice that the module icon is color-coded to reflect the type of module being configured: blue for analog input, green for analog output.



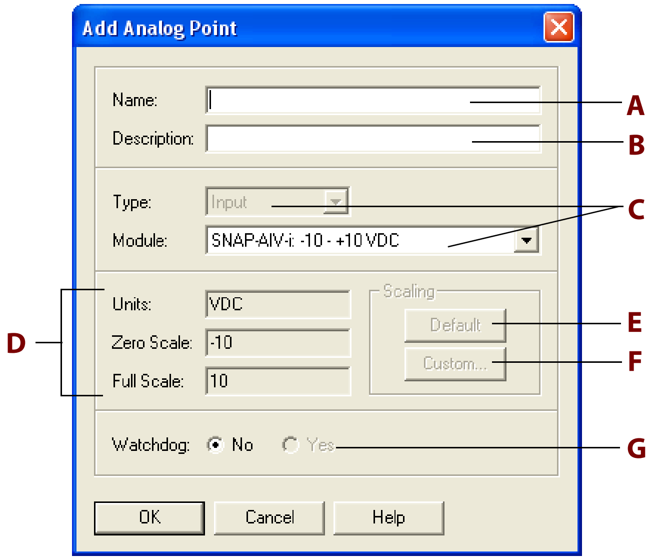
Modules and Points	Type	Features / Subty...	Units
[00] SNAP-IDC5: 10 - 32 VDC/VAC	Digital Input		
0 Pump_1_Status		None	
1 Not Used			
2 Not Used			
3 Not Used			
[01] SNAP-AIV-i	Analog Input		
0 Not Used			
1 Not Used			
[02] Not Used			
[03] Not Used			

Module icon

Expand or collapse points on the module by clicking the + or - sign in the box.

Points

4. Double-click the point you want to configure.



Name:

Description:

Type: Input

Module: SNAP-AIV-i: -10 - +10 VDC

Units: VDC

Zero Scale: -10

Full Scale: 10

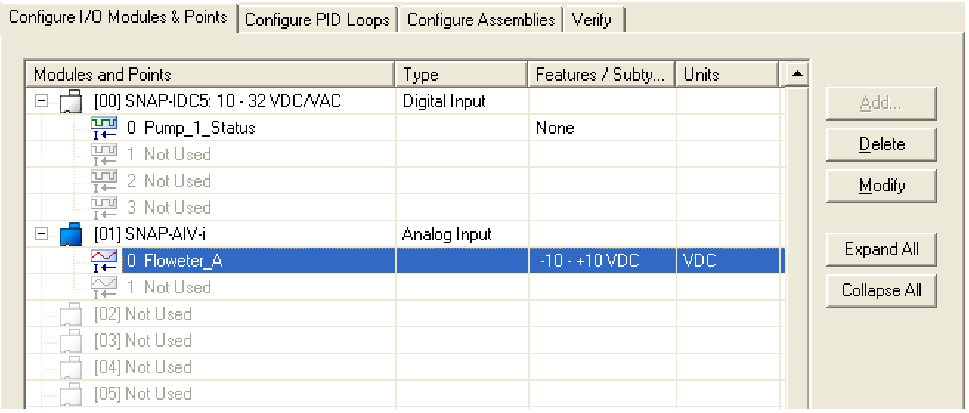
Watchdog: ● No ○ Yes

5. Complete the fields as follows:

- **A** **Name**: Enter a name for the point. The name must start with a letter and may contain letters, numbers, and underscores. (Spaces are converted to underscores.)
- **B** **Description**: (Optional) Enter a description of the point.
- **C** **Type, Module**: Type and module are inserted for you. You may be able to choose a different range from the drop-down list.
- **D** **Units, Scale**: Units and scaling for this module. See "Using Custom Scaling" on page 21.
- **E** **Scaling Default**: To return the unit's zero-scale value and full-scale value to the defaults for the module, click Default.
- **F** **Scaling Custom**: To assign custom units and values to the module, click Custom. For example, you could scale the voltage range of a -10 to +10 VDC module to be interpreted as engineering units of liters per second instead of volts. See "Using Custom Scaling" on page 21.
- **G** **Watchdog**: (Outputs only.) To configure a value this point should be set to if the Watchdog timer on this device expires, click Yes and enter the value. In order for this to take effect, make sure Watchdog is enabled at the device level. To do this, double-click the device in the device tree to open the Modify Device Information dialog. Select Yes for Watchdog, choose a timeout, and then click OK.

6. When you have completed the fields, click OK.

The new point is added.



Modules and Points	Type	Features / Subty...	Units
[00] SNAP-IDC5: 10 - 32 VDC/VAC	Digital Input		
0 Pump_1_Status		None	
1 Not Used			
2 Not Used			
3 Not Used			
[01] SNAP-AIV-i	Analog Input		
0 Floweter_A		-10 - +10 VDC	VDC
1 Not Used			
[02] Not Used			
[03] Not Used			
[04] Not Used			
[05] Not Used			

Point types and features are shown in the Features/Subtype column.

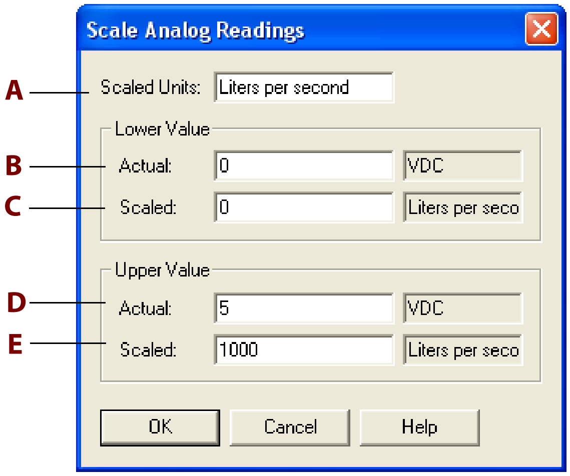
7. To add more analog points, repeat the steps. To add digital points, see "Configuring Digital Points" on page 16.

Using Custom Scaling

Analog modules can be set to show something other than the actual inputs or outputs. For example, you could scale the readings of a -10 to +10 VDC input point to measure its input as zero liters per second when the real-world reading is zero VDC, and 1000 liters per second when the real-world reading is five VDC.

NOTE: Custom scaling has no effect on the resolution or accuracy of the module.

1. In the Add Analog Point dialog box, click the Custom button in the Scaling area to open the Scale Analog Readings dialog box.



Scaled Units: Liters per second

Lower Value

Actual: 0 VDC

Scaled: 0 Liters per seco

Upper Value

Actual: 5 VDC

Scaled: 1000 Liters per seco

This example shows units scaled to liters per second. At an actual input of 0 VDC, the point will show 0 liters per second. At an actual input of 5 VDC, the point will show 1000 liters per second.

2. Complete the fields as follows:

   A **Scaled Units**: Enter new engineering units for the module. The example uses liters per second.

   B **Actual Lower Value**: Enter the actual real-world lower value that the scaled lower value corresponds to. Note that inputs typically have under-range capability, which means you can specify a lower actual value that is less than the zero-scale value. Outputs do not have under-range capability.

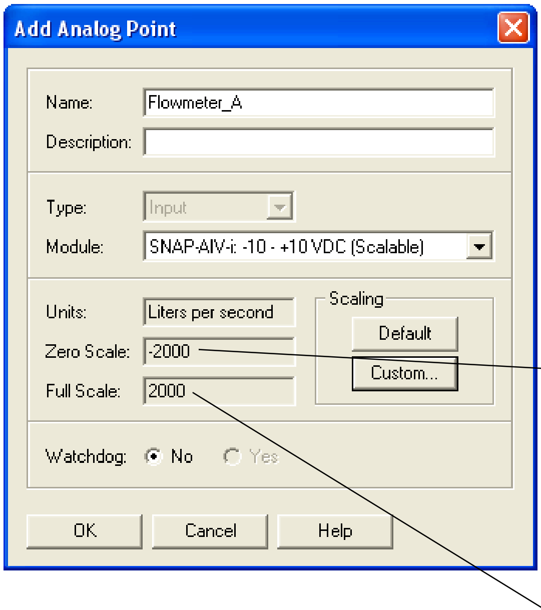
C **Scaled Lower Value**: Enter the new scaled lower value. This value can be any floating point value.

D **Actual Upper Value**: Enter the actual real-world upper value that the scaled upper value corresponds to. For inputs, you can specify an upper actual value greater than the full-scale value.

E **Scaled Upper Value**: Enter the new scaled upper value. This value can be any floating point value greater than the scaled lower value. This example uses 1000, which scales the output to 1000 liters per second when its actual reading is 5 VDC.

3. Click OK.

The new custom-scaled units appear in the Add Analog Point dialog box.



Add Analog Point

Name: Flowmeter_A

Description:

Type: Input

Module: SNAP-AIV-i: -10 - +10 VDC (Scalable)

Units: Liters per second

Zero Scale: -2000

Full Scale: 2000

Scaling

Watchdog: ● No ○ Yes

Notice the new units of liters per second and the new minimum-scale (“Zero Scale”) and maximum-scale (“Full Scale”) values of -2000 and +2000. The example connects a sensor with a range of 0–1000 liters per second, but an output of only 0–5 volts, to a SNAP-AIV module with an output of -10 to +10 volts. The figures shown in this dialog box reflect the total possible range of the module, not the sensor.

	Custom scale (Liters/sec)		Module’s scale (VDC)
Possible low value for module	–2000		–10
	–1000		–5
Upper & lower values entered in dialog box	0	=	0
	1000	=	5
Possible high value for module	2000		10

NOTE: On a bipolar module (for example, -10 VDC to +10 VDC), the minimum scale is always zero EU, not a negative number.

4: Setting Up Implicit Messaging

This chapter describes how to use EtherNet/IP Configurator and RSLogix 5000 software to set up implicit messaging between an Allen-Bradley controller and Opto 22 remote I/O. If you want to set up explicit messaging, see "5: Setting Up Explicit Messaging" on page 33. For help in choosing a messaging type, see "Choosing the Messaging Type" on page 8.

Before you begin, make sure you have done the following things:

- Installed your Opto 22 device and modules according to the instructions that came with the device and modules
- Added your Opto 22 device using EtherNet/IP Configurator (see "Adding an Opto 22 Device" on page 12)
- Configured the Opto 22 I/O module and points (see "Configuring I/O Modules and Points" on page 16)

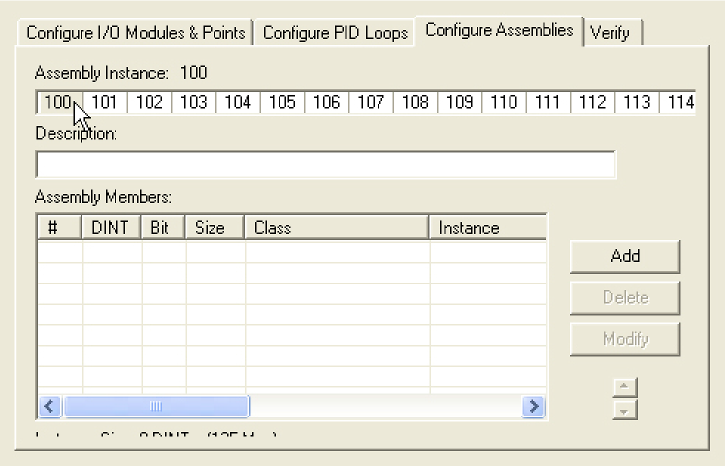
To set up implicit messaging you must use EtherNet/IP Configurator to create input and output *assemblies*. An assembly provides the format for the implicit message packet that includes the information for the point or points you are interested in. Once you have created the assemblies you will use RSLogix 5000 to complete the setup.

For a list of the basic things you will need, see "What You Will Need" on page 11.

In this Chapter

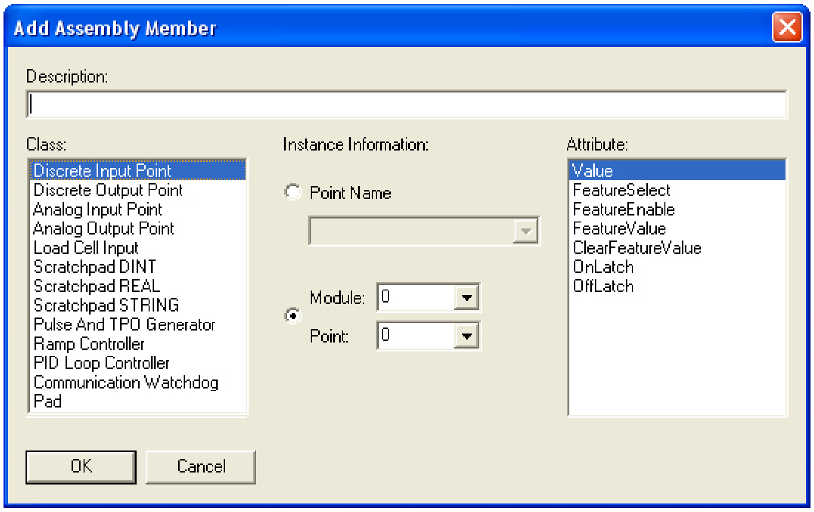
Creating an Input Assembly

1. In EtherNet/IP Configurator, click the Configure Assemblies tab, and then select an assembly instance number, for example assembly instance 100. Each assembly instance created requires a unique number. Unused assembly numbers have a white background.



Assembly Instance: 100

2. Click Add to open the Add Assembly Member dialog box.



Class: Discrete Input Point
- Discrete Output Point
- Analog Input Point
- Analog Output Point
- Load Cell Input
- Scratchpad DINT
- Scratchpad REAL
- Scratchpad STRING
- Pulse And TPO Generator
- Ramp Controller
- PID Loop Controller
- Communication Watchdog
- Pad

○ Point Name

● Module: 0

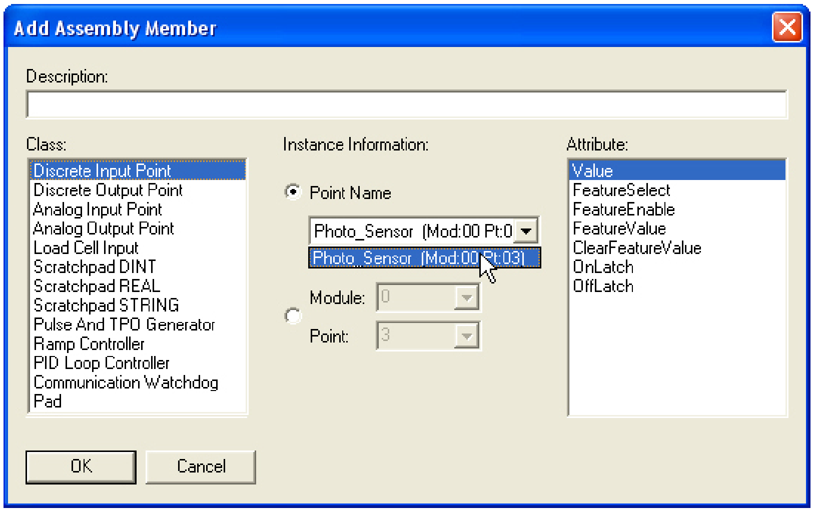
Point: 0

Attribute: Value
- FeatureSelect
- FeatureEnable
- FeatureValue
- ClearFeatureValue
- OnLatch
- OffLatch

3. Select a class such Discrete Input Point.

The classes available for implicit messaging in the EtherNet/IP Configurator are a subset of the CIP classes, all of which are available through explicit messaging. For information on the CIP classes and attributes, see form 1770, *Ethernet/IP for SNAP PAC Protocol Guide*.

4. Under Instance Information, select a point that you have configured. Otherwise, you can assign an assembly member to a specific module and point.


Add Assembly Member

Description:

Class: Discrete Input Point

Instance Information: ● Point Name: Photo_Sensor (Mod:00 Pt:03)

○ Module: 0 Point: 3

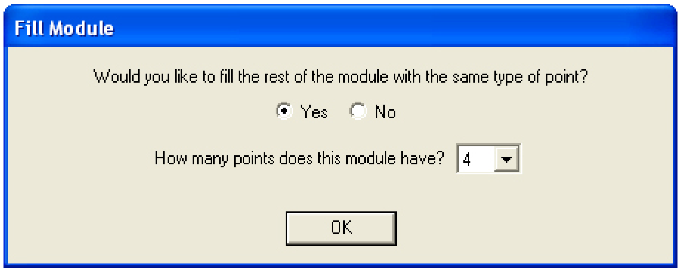
Attribute: Value

5. Under Attribute, select an item in the list.

The attribute list allows you to define what information from each point you want to have passed in the implicit message. In addition to value readings, you can get other data, such as the minimum or maximum value for an analog input/output.

6. Click OK and follow any directions that appear for the class.

For example, the Fill Module dialog box appears for Discrete Input Point and Analog Input Point.


Fill Module

Would you like to fill the rest of the module with the same type of point?

● Yes ○ No

How many points does this module have? 4

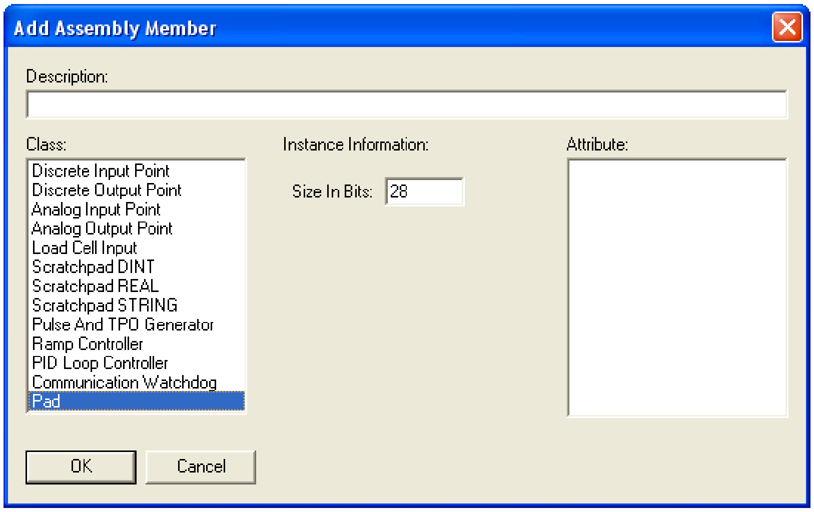
7. Click OK.

8. Continue to add elements as necessary.

NOTE: If an assembly member or group of members adds up to less than 32-bits, you will need to add padding.

9. To add a pad, click the Add button to open the Add/Modify dialog box.

10. Under Class, select Pad, enter the size of the pad (for example, 28), and click OK.



Size In Bits: 28

The pad appears as the last member of element 0 to complete the 32-bit word, also called a DINT. You can add up to 125 input DINTs.

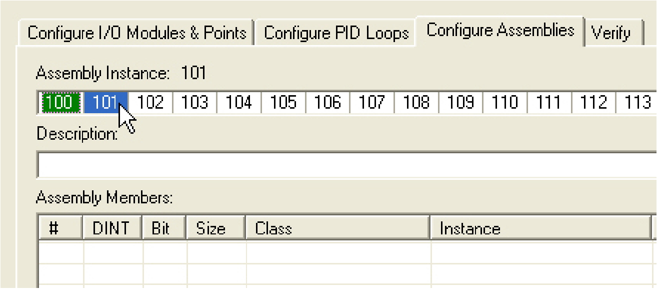
When you have completed an input assembly for implicit messaging, go to the next section to create an output assembly.

Creating an Output Assembly

Creating an output assembly is similar to creating an input assembly.

1. On the Configure Assemblies tab, click an assembly instance number other than the one used for the input assembly, for example assembly instance 101.

Notice that the assembly numbers you've already used have a green background.



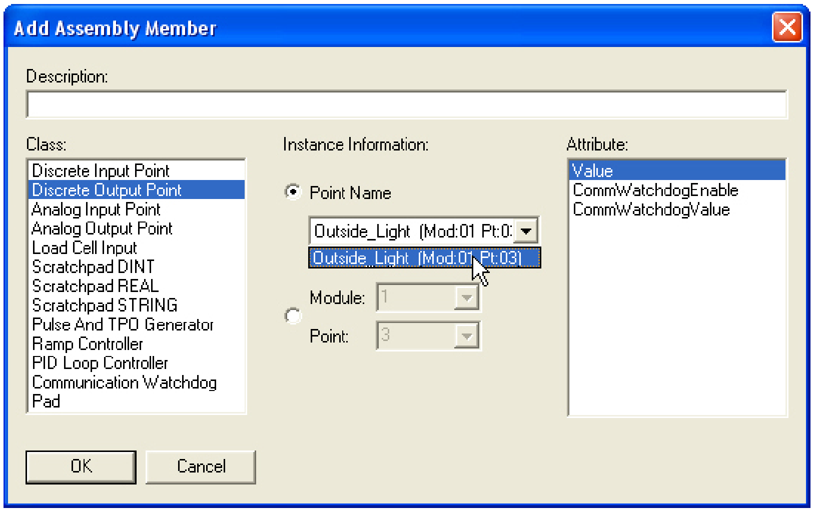
Assembly Instance: 101

#	DINT	Bit	Size	Class	Instance

2. Select a class such Discrete Output Point.

The classes available for implicit messaging in the EtherNet/IP Configurator are a subset of the CIP classes, all of which are available through explicit messaging. For information on the CIP classes and attributes, see form 1770, *Ethernet/IP for SNAP PAC Protocol Guide*.

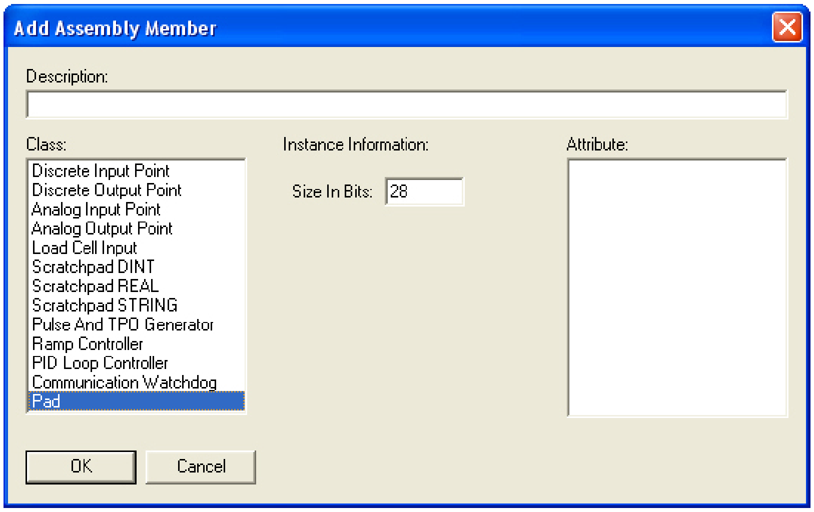
3. Under Instance Information, select a point that you have configured. Otherwise, you can assign an assembly member to a specific module and point.
4. Under Attribute, select an item in the list.



The attribute list allows you to define what information from each point you want to have passed in the implicit message. For example, in addition to writing a value to a point, you might want to change the watchdog value or set high or low clamps on an analog point.

NOTE: If an assembly member or group of members adds up to less than 32-bits, you will need to add padding.

5. To add a pad, click the Add button to open the Add/Modify dialog box.
6. Under Class, select Pad, enter the size of the pad (for example, 28), and click OK.

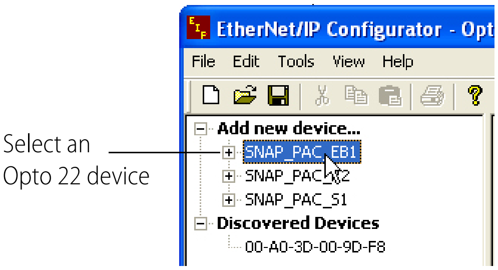


Size In Bits: 28

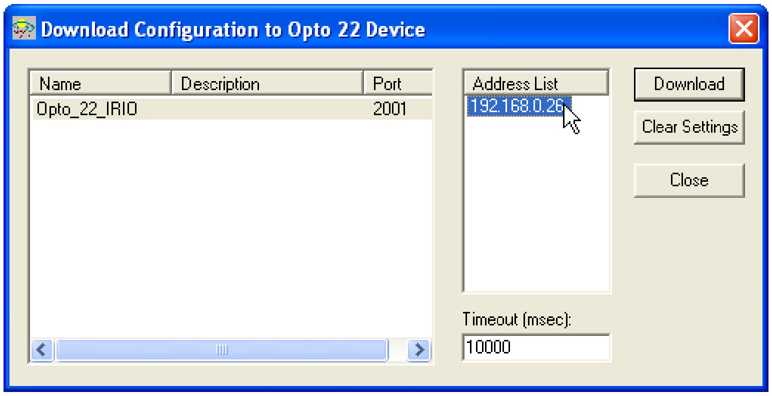
The pad appears as the last member of element 0 to complete the 32-bit word (or DINT). You can add up to 124 output DINTs.

When you've completed the output assembly instance, you are ready to download the configuration to the Opto 22 device. This is also a good time to save the configuration.

7. To save the configuration, choose File > Save As. Then browse to an appropriate directory, name the file (for example, Opto_IO), and then click Save.
8. Before you download the configuration, it is helpful to check for errors on an assembly configuration report:
   a. In the device tree, select an Opto 22 device.



   b. From the Tools menu, choose Assembly Configuration Report. A text file opens showing the configuration report.
9. To send the configuration to the device, choose Tools > Download Configuration to Opto 22 Device.
10. In the Download Configuration dialog box, select the device's IP address, and then click Download.



Name	Description	Port
Opto_22_IRIO		2001

Address List: 192.168.0.26

Timeout (msec): 10000

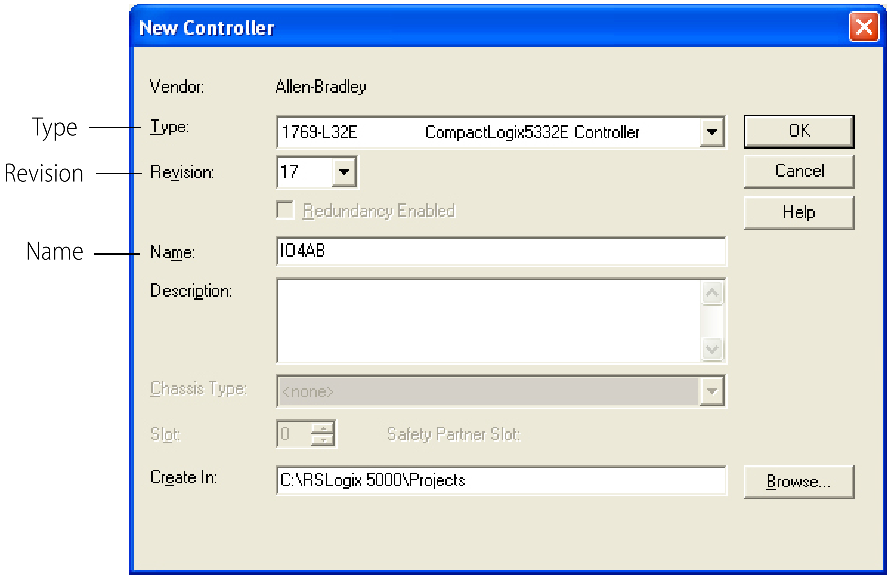
This completes the setup of the Opto 22 remote I/O for implicit messaging. In the next section, you will configure communications with the Allen-Bradley controller.

Configuring RSLogix for Implicit Messaging

In this section you will use RSLogix 5000 to configure an Ethernet-enabled Allen-Bradley controller to communicate with the remote Opto 22 I/O you configured in the previous sections. The following instructions show screens from version 17 of RSLogix 5000 software using a CompactLogix 1769-L32E PLC.

1. Open RSLogix 5000.

2. Select File > New.
3. On the New Controller dialog box, fill in the appropriate information for the Type, Revision, and Name fields.



Vendor: Allen-Bradley

Type: 1769-L32E CompactLogix5332E Controller

Revision: 17

□ Redundancy Enabled

Name: IO4AB

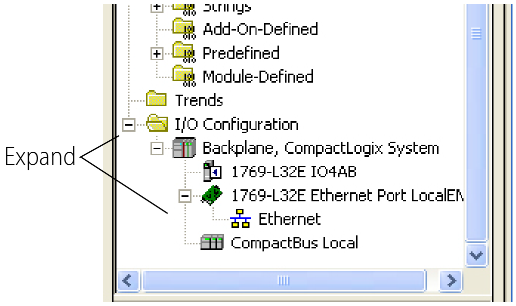
Description:

Chassis Type: <none>

Slot: 0 Safety Partner Slot:

Create In: C:\RSLogix 5000\Projects

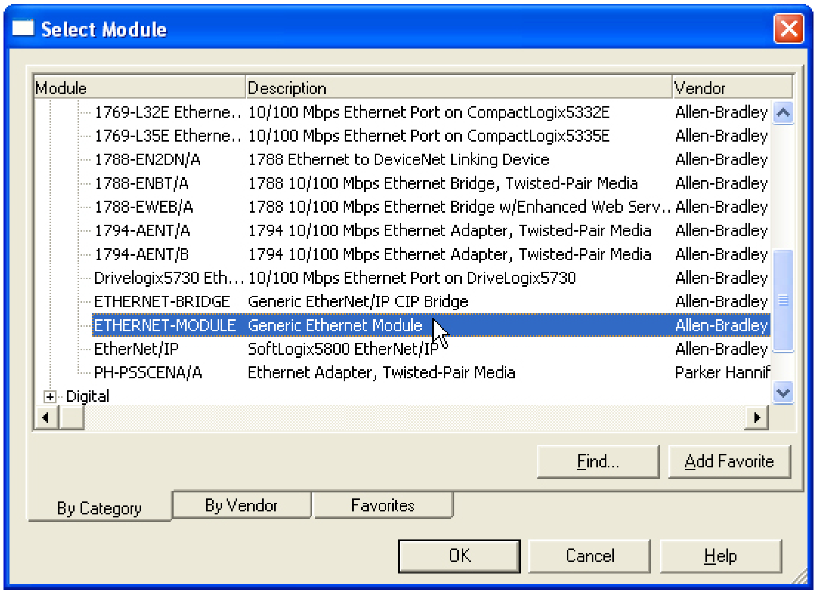
4. Browse to the folder you want to use, and then click OK.
5. In the controller organizer, expand I/O Configuration, Backplane, and 1769-L32E Ethernet Port LocalENB.



Strings
Add-On-Defined
Predefined
Module-Defined
Trends
I/O Configuration
Backplane, CompactLogix System
1769-L32E IO4AB
1769-L32E Ethernet Port LocalEN
Ethernet
CompactBus Local

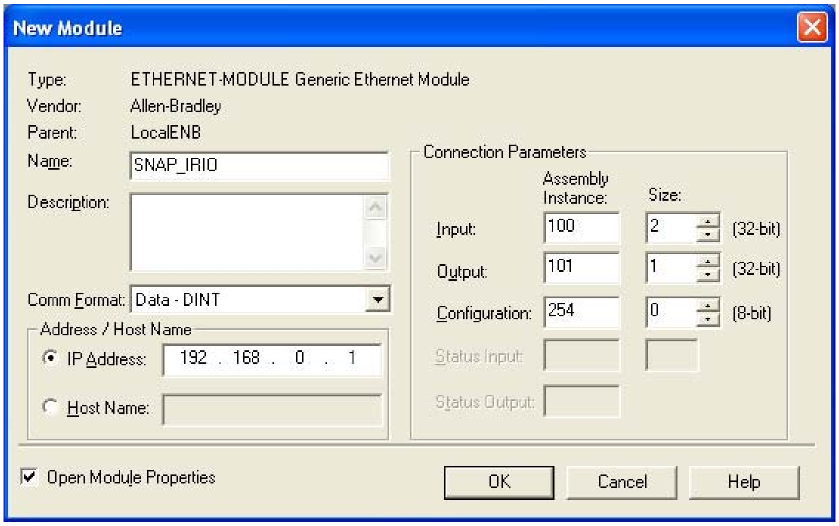
6. Right-click Ethernet and select New Module.

   This module will be used to add the Opto 22 device.
7. Expand Communications in the controller organizer to open the Select Module dialog box.



Module	Description	Vendor
1769-L32E Etherne..	10/100 Mbps Ethernet Port on CompactLogix5332E	Allen-Bradley
1769-L35E Etherne..	10/100 Mbps Ethernet Port on CompactLogix5335E	Allen-Bradley
1788-EN2DN/A	1788 Ethernet to DeviceNet Linking Device	Allen-Bradley
1788-ENBT/A	1788 10/100 Mbps Ethernet Bridge, Twisted-Pair Media	Allen-Bradley
1788-EWEB/A	1788 10/100 Mbps Ethernet Bridge w/Enhanced Web Serv..	Allen-Bradley
1794-AENT/A	1794 10/100 Mbps Ethernet Adapter, Twisted-Pair Media	Allen-Bradley
1794-AENT/B	1794 10/100 Mbps Ethernet Adapter, Twisted-Pair Media	Allen-Bradley
Drivelogix5730 Eth...	10/100 Mbps Ethernet Port on DriveLogix5730	Allen-Bradley
ETHERNET-BRIDGE	Generic EtherNet/IP CIP Bridge	Allen-Bradley
ETHERNET-MODULE	Generic Ethernet Module	Allen-Bradley
EtherNet/IP	SoftLogix5800 EtherNet/IP	Allen-Bradley
PH-PSSCENA/A	Ethernet Adapter, Twisted-Pair Media	Parker Hannif
⊞ Digital		

8. Scroll down to Generic Ethernet Module and then double-click it to open the New Module dialog box.



Type: ETHERNET-MODULE Generic Ethernet Module
Vendor: Allen-Bradley
Parent: LocalENB
Name: SNAP_IRIO
Description:
Comm Format: Data - DINT
● IP Address: 192 . 168 . 0 . 1
○ Host Name:

	Assembly Instance:	Size:	
Input:	100	2	(32-bit)
Output:	101	1	(32-bit)
Configuration:	254	0	(8-bit)
Status Input:			
Status Output:			

☑ Open Module Properties

9. Enter or select the following information:

- **Name**: An appropriate name such Opto_IO.
- **Comm Format**: Choose the format most appropriate for the implicit message data, usually Data - DINT or Data - REAL.

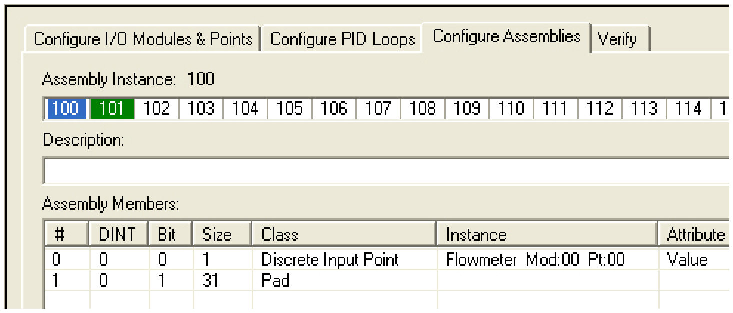
  NOTE: Once you select the Comm Format and then click OK, it cannot be changed.

- **IP Address**: IP address of the Opto 22 device.

10. For the Input Assembly Instance and the Output Assembly Instance, enter the assembly instance numbers you configured for the input and output assemblies in EtherNet/IP

Configurator. For example, you might have used 100 for the input assembly and 101 for the output assembly.

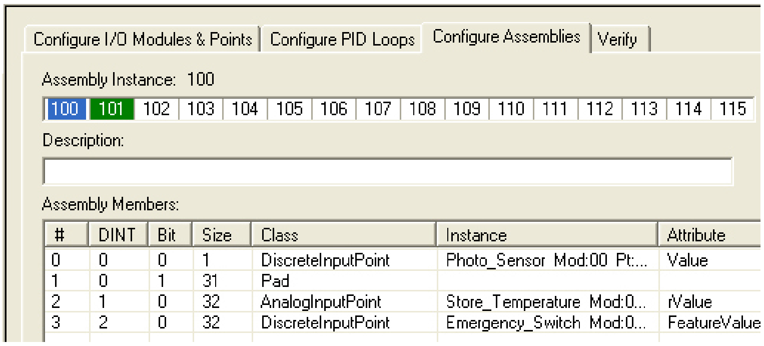
For the size of the input and output assemblies, enter the number of 32-bit words defined for each. For example, if you entered one 32-bit word for the input assembly in EtherNet/IP Configurator as shown here, you would enter 1 as the size of the input assembly on the New Module dialog box in RSLogix 5000.



Assembly Instance: 100

#	DINT	Bit	Size	Class	Instance	Attribute
0	0	0	1	Discrete Input Point	Flowmeter Mod:00 Pt:00	Value
1	0	1	31	Pad		

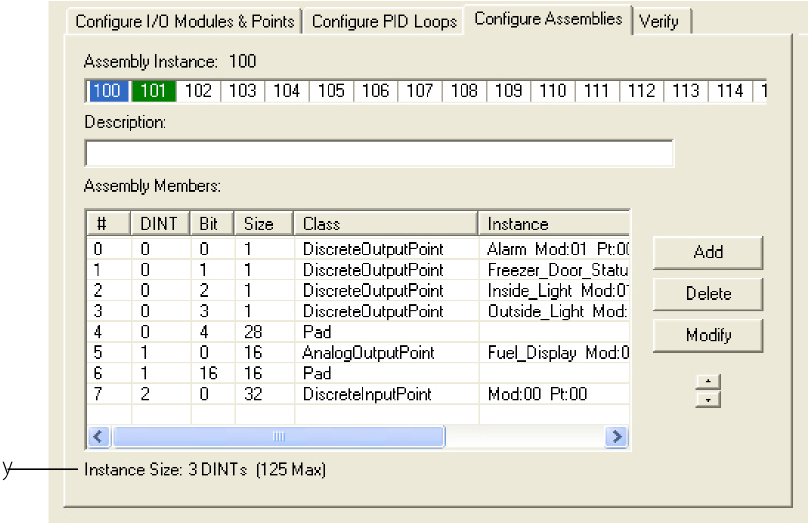
The following example assembly from EtherNet/IP Configurator has three 32-bit words, so you would enter a size of 3 in RSLogix 5000.



Assembly Instance: 100

#	DINT	Bit	Size	Class	Instance	Attribute
0	0	0	1	DiscreteInputPoint	Photo_Sensor Mod:00 Pt:...	Value
1	0	1	31	Pad		
2	1	0	32	AnalogInputPoint	Store_Temperature Mod:0...	rValue
3	2	0	32	DiscreteInputPoint	Emergency_Switch Mod:0...	FeatureValue

EtherNet/IP Configurator indicates the size of the assembly instance at the bottom of the screen as shown here.



Assembly Instance: 100

#	DINT	Bit	Size	Class	Instance
0	0	0	1	DiscreteOutputPoint	Alarm Mod:01 Pt:0(
1	0	1	1	DiscreteOutputPoint	Freezer_Door_Statu
2	0	2	1	DiscreteOutputPoint	Inside_Light Mod:0'
3	0	3	1	DiscreteOutputPoint	Outside_Light Mod:
4	0	4	28	Pad	
5	1	0	16	AnalogOutputPoint	Fuel_Display Mod:0
6	1	16	16	Pad	
7	2	0	32	DiscreteInputPoint	Mod:00 Pt:00

Instance Size: 3 DINTs (125 Max)

Size of assembly instance

11. For the Configuration fields, enter 254 for the Assembly Instance and 0 for the size. These Configuration values are not used, but they must be entered.

NOTE: The Input Instance is an RSLogix READ assembly, and the Output Instance is an RSLogix WRITE assembly. The Configuration values are not used, but they must be entered.

12. Click OK.

The Module Properties dialog box opens showing the Connection tab for you to enter the Requested Packet Interval (RPI). The RPI is basically the scan time of the Opto 22 device.

13. Set the RPI to a reasonable value (range is 10-3200 ms), then click OK.

The Opto 22 remote I/O has now been configured and added to the RSLogix 5000 software as a generic Ethernet module.

14. Select Communications > Download to download the RSLogix program to the controller, and then click Download in the next two dialog boxes that appear.

Once the download is complete, the program will run automatically on the controller.

5: Setting Up Explicit Messaging

This chapter describes how to use the EtherNet/IP Configurator and RSLogix 5000 to implement explicit messaging over EtherNet/IP in order to access data from SNAP PAC I/O and SNAP PAC controllers. If you want to set up implicit messaging, see "4: Setting Up Implicit Messaging" on page 23. For help choosing a messaging type, see "Choosing the Messaging Type" on page 8.

Opto 22's implementation of Allen-Bradley's explicit messaging is an EtherNet/IP version of an earlier messaging protocol, CIP Messaging over ControlNet. Similar in some ways to explicit messaging, CIP messaging also used the MSG instruction. Along with implicit messaging, explicit messaging is supported on controller platforms such the ControlLogix® and CompactLogix™. It is also supported on other Allen-Bradley platforms that do not support implicit messaging.

For information on the objects available using explicit messaging in an IO4AB system, see form 1770, *Ethernet/IP for SNAP PAC Protocol Guide*.

For a list of the basic things you will need, see "What You Will Need" on page 11. Note that the examples in this chapter are based on the I/O contained in a SNAP PAC Learning Center. It is not required that you have a Learning Center to do the majority of the steps. However, if you want to obtain a SNAP PAC Learning Center in order to run your Logix project and exchange data with Opto 22 I/O, go the Opto 22 website, www.Opto22.com and search on the part number, either SNAP-IO4ABLC or SNAP-PACLC.

In this Chapter

Creating an Assembly Instance

This section provides an example of how to use EtherNet/IP Configurator to configure modules and points on an Opto 22 device such that the data can be accessed by the Allen-Bradley Logix architecture.

This section includes the following topics:

- "Using EtherNet/IP Configurator to Add and Configure a SNAP-AICTD Module" on page 34
- "Configuring the SNAP-AICTD Module Input Assembly" on page 36
- "Configuring the SNAP-AOV27 Module Output Assembly" on page 38
- "Downloading the Configuration to the SNAP PAC I/O Unit." on page 39

Using EtherNet/IP Configurator to Add and Configure a SNAP-AICTD Module

In this section you will use EtherNet/IP Configurator to import the Opto 22 SNAP PAC Learning Center's ioCookies I/O configuration and then configure the SNAP-AICTD module in slot 3 of the module configuration.

In order to configure the ioCookies I/O module configuration in EtherNet/IP Configurator, you must first use PAC Control to export the I/O configuration as an Opto Tag Database (.otg) file.

Creating an I/O Configuration Export File

1. To open PAC Control:
   - In Windows 7 and Windows Vista, press the Windows Start key ⊞, and then click Programs > Opto 22 > PAC Project 9.6 > PAC Control.
   - In Windows 10 and Windows 8.1, press the Windows Start key ⊞, type **`PAC Control 9.6`** and then press the Enter key.
2. In PAC Control, open the PAC Control version of the ioCookies strategy.

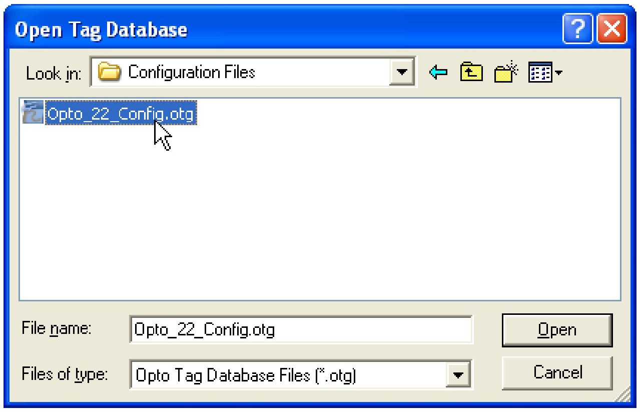
   The ioCookies strategy is usually located on your local hard drive at Program Files > Opto22 > PAC Project > Control Basic Examples > ioCookies.
3. Create a new I/O unit for your SNAP PAC R-series controller and move all of the I/O points from the existing I/O unit (Mixed_IO_Unit) to the new I/O unit, as follows:
   a. Choose Configure > I/O to open the Configure I/O Units dialog box.
   b. Select Mixed_IO_Unit, and then click the I/O Points button to open the Configure I/O Points dialog box.
   c. Expand Module 00, highlight the point in slot 0, and then click the Move To button to open the Move Point dialog box.
   d. Select the new I/O unit, select the first available target channel, and then click OK.
   e. Repeat this process for each point (highlighting the point and moving it to the new I/O unit) until you have moved all of the I/O points to the new I/O unit.
   f. Close all of the open dialog boxes in PAC Control.
4. In the strategy tree, right-click the old I/O unit and choose Delete to remove it.
5. In the strategy tree, right-click the I/O Units folder and choose Export from the pop-up menu.

   The Export I/O Units to an Opto Tag Database dialog box appears.

6. Navigate to the location where you want to place the export file. Type the file name, and click Save to create the export file.

Importing the Configuration File into EtherNet/IP

1. In the EtherNet/IP Configurator main window, click the Open button 🗋 or choose File > Open to open the Open Tag Database dialog box.



Look in: Configuration Files

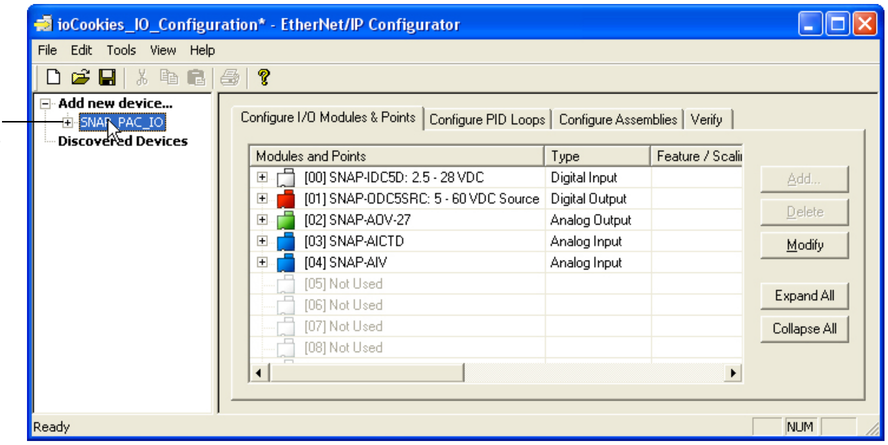
Opto_22_Config.otg

File name: Opto_22_Config.otg

Files of type: Opto Tag Database Files (*.otg)

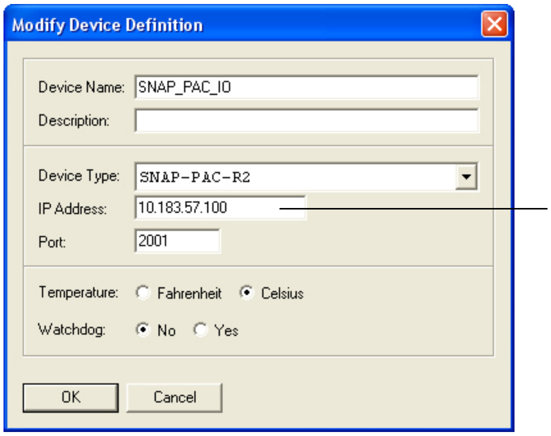
2. Locate the I/O configuration (otg) file and click Open to import the file.
3. Double-click the device name to open the Modify Device Definition dialog box.

Double-click device name



Modules and Points	Type	Feature / Scali
[00] SNAP-IDC5D: 2.5 - 28 VDC	Digital Input	
[01] SNAP-ODC5SRC: 5 - 60 VDC Source	Digital Output	
[02] SNAP-AOV-27	Analog Output	
[03] SNAP-AICTD	Analog Input	
[04] SNAP-AIV	Analog Input	
[05] Not Used		
[06] Not Used		
[07] Not Used		
[08] Not Used		

4. Enter the correct IP address for the PAC R controller.



Modify Device Definition

Device Name: SNAP_PAC_IO
Description:
Device Type: SNAP-PAC-R2
IP Address: 10.183.57.100
Port: 2001
Temperature: ○ Fahrenheit ● Celsius
Watchdog: ● No ○ Yes

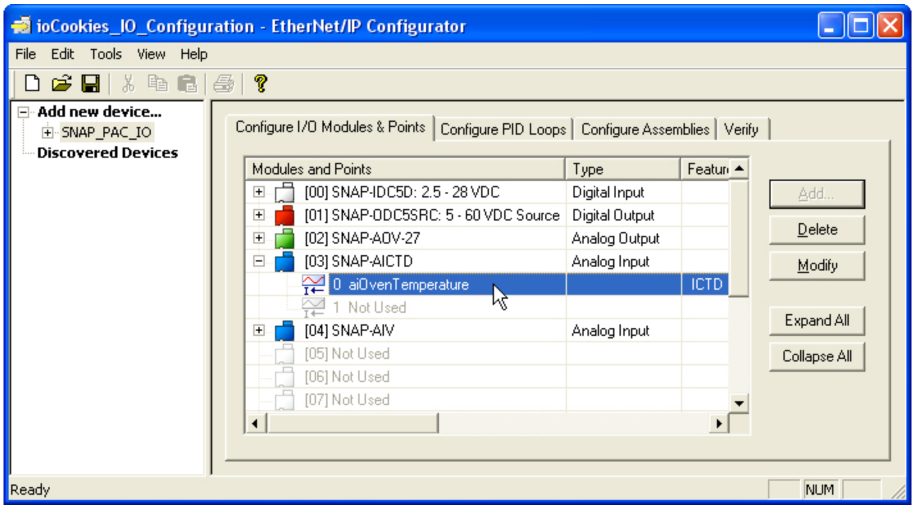
Enter the PAC R's IP address

This is important because the imported configuration will likely have the local loopback address for the I/O unit (127.0.0.1) instead of the IP address for the PAC R. In order to communicate with the PAC R, EtherNet/IP Configurator needs the device's IP address.

Configuring the SNAP-AICTD Module Input Assembly

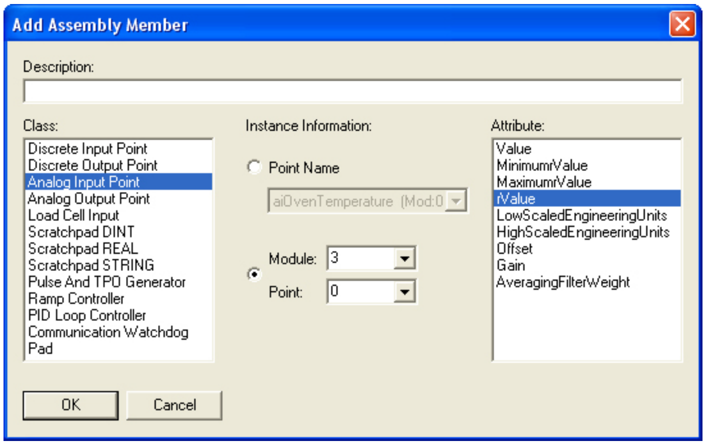
The input assembly's role in this exercise is to read the temperature as a REAL (a 32-bit float).

1. In EtherNet/IP Configurator, open the ioCookies I/O configuration as described in the previous section, then expand the configuration for the SNAP-AICTD module in slot 3.
2. Notice that point 0 of slot 3 connects to the process temperature probe.



Modules and Points	Type	Featur
[00] SNAP-IDC5D: 2.5 - 28 VDC	Digital Input	
[01] SNAP-ODC5SRC: 5 - 60 VDC Source	Digital Output	
[02] SNAP-AOV-27	Analog Output	
[03] SNAP-AICTD	Analog Input	
0 aiOvenTemperature		ICTD
1 Not Used		
[04] SNAP-AIV	Analog Input	
[05] Not Used		
[06] Not Used		
[07] Not Used		

3. Click the Configure Assemblies tab, select assembly instance 100, and click the Add button to open the Add Assembly Member dialog box.
4. Make the following selections:
   - **Class**: Analog Input Point
   - **Instance Information**: Module 3, Point 0
   - **Attribute**: rValue



Add Assembly Member

Description:

Class:
- Discrete Input Point
- Discrete Output Point
- Analog Input Point (selected)
- Analog Output Point
- Load Cell Input
- Scratchpad DINT
- Scratchpad REAL
- Scratchpad STRING
- Pulse And TPO Generator
- Ramp Controller
- PID Loop Controller
- Communication Watchdog
- Pad

Instance Information:

○ Point Name: aiOvenTemperature (Mod:0

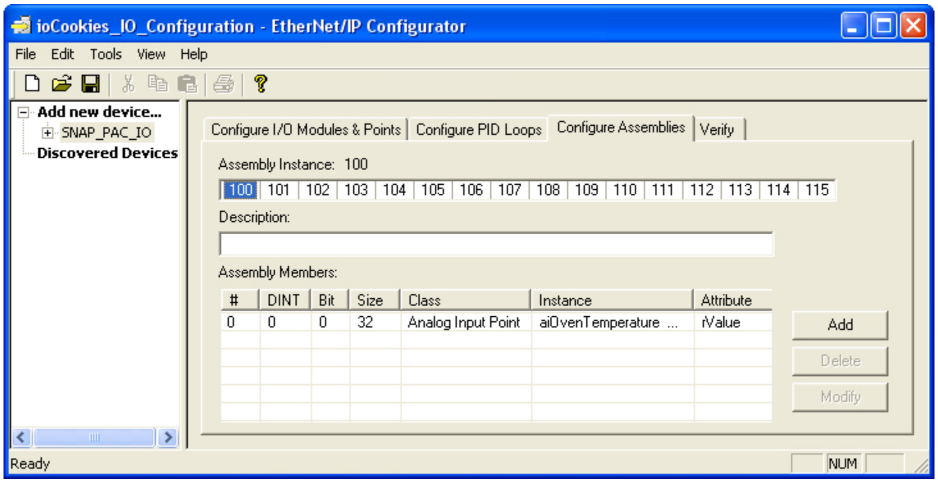
● Module: 3

Point: 0

Attribute:
- Value
- MinimumValue
- MaximumValue
- rValue (selected)
- LowScaledEngineeringUnits
- HighScaledEngineeringUnits
- Offset
- Gain
- AveragingFilterWeight

5. Click OK.

As shown below, the assembly instance 100 has a single value, the rValue of module 3, point 0. This corresponds to the Process Temperature input, which is the first of two channels on the SNAP-AICTD module.



ioCookies_IO_Configuration - EtherNet/IP Configurator

Assembly Instance: 100

100 | 101 | 102 | 103 | 104 | 105 | 106 | 107 | 108 | 109 | 110 | 111 | 112 | 113 | 114 | 115

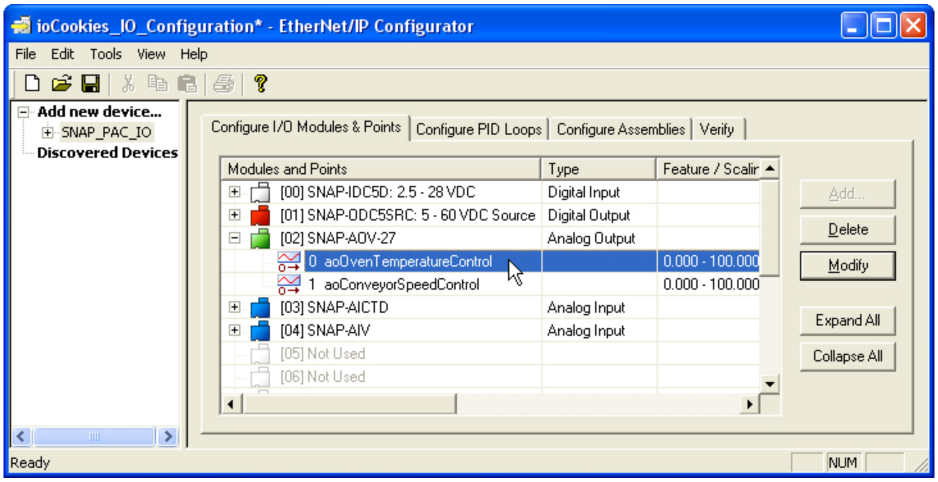
Description:

Assembly Members:

#	DINT	Bit	Size	Class	Instance	Attribute
0	0	0	32	Analog Input Point	aiOvenTemperature ...	rValue

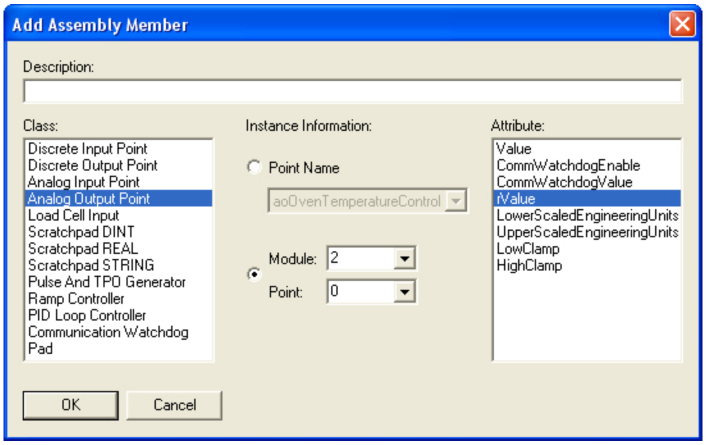
Configuring the SNAP-AOV27 Module Output Assembly

1. Click the Configure I/O Modules & Points tab and expand the configuration for the SNAP-AOV-27 module in slot 2.



Modules and Points	Type	Feature / Scalir
[00] SNAP-IDC5D: 2.5 - 28 VDC	Digital Input	
[01] SNAP-ODC5SRC: 5 - 60 VDC Source	Digital Output	
[02] SNAP-AOV-27	Analog Output	
0 aoOvenTemperatureControl		0.000 - 100.000
1 aoConveyorSpeedControl		0.000 - 100.000
[03] SNAP-AICTD	Analog Input	
[04] SNAP-AIV	Analog Input	
[05] Not Used		
[06] Not Used		

2. Click the Configure Assemblies tab, select assembly instance 101, and then click the Add button.
3. On the Add Assembly Member dialog box, make the following selections:
   - **Class**: Analog Output Point
   - **Instance Information**: Module 2, Point 0
   - **Attribute**: rValue



Class: Analog Output Point

○ Point Name

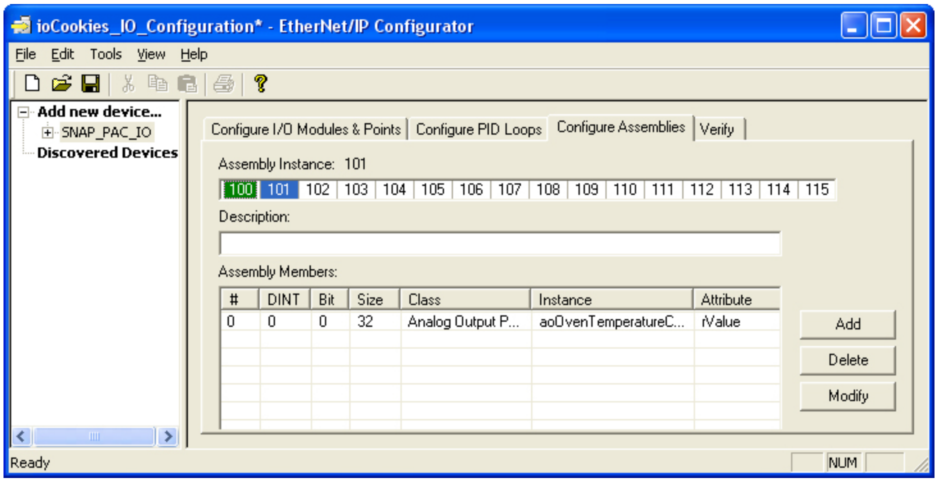
● Module: 2

Point: 0

Attribute: rValue

4. Click OK.
5. On the Fill Module dialog box, select No, and then click OK.

   This rValue will be a type REAL, just like the analog input.



Assembly Instance: 101

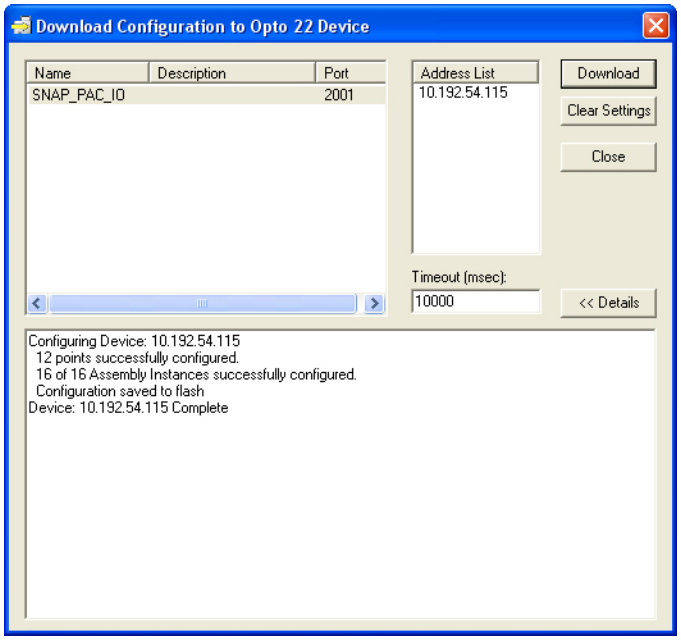
Description:

Assembly Members:

#	DINT	Bit	Size	Class	Instance	Attribute
0	0	0	32	Analog Output P...	aoOvenTemperatureC...	rValue

Downloading the Configuration to the SNAP PAC I/O Unit.

1. Choose Tools > Download Configuration to Opto 22 Device to open the Download Configuration dialog box.
2. If this is the first time you are downloading an EtherNet/IP configuration, click the Clear Settings button to erase all prior configurations, reset the PAC R to its factory default settings, and restart the I/O unit.
3. Click the Download button to download the new configuration.



Name	Description	Port
SNAP_PAC_IO		2001

Address List: 10.192.54.115

Timeout (msec): 10000

```
Configuring Device: 10.192.54.115
  12 points successfully configured.
  16 of 16 Assembly Instances successfully configured.
  Configuration saved to flash
Device: 10.192.54.115 Complete
```

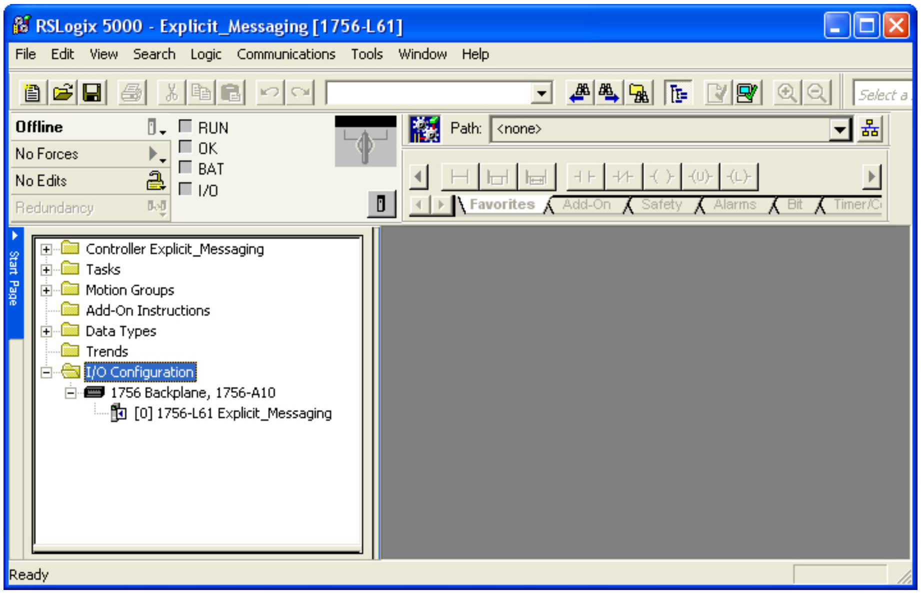
When the configuration has downloaded successfully to the device, you are ready to configure an EtherNet/IP module using RSLogix.

Configuring an EtherNet/IP Module

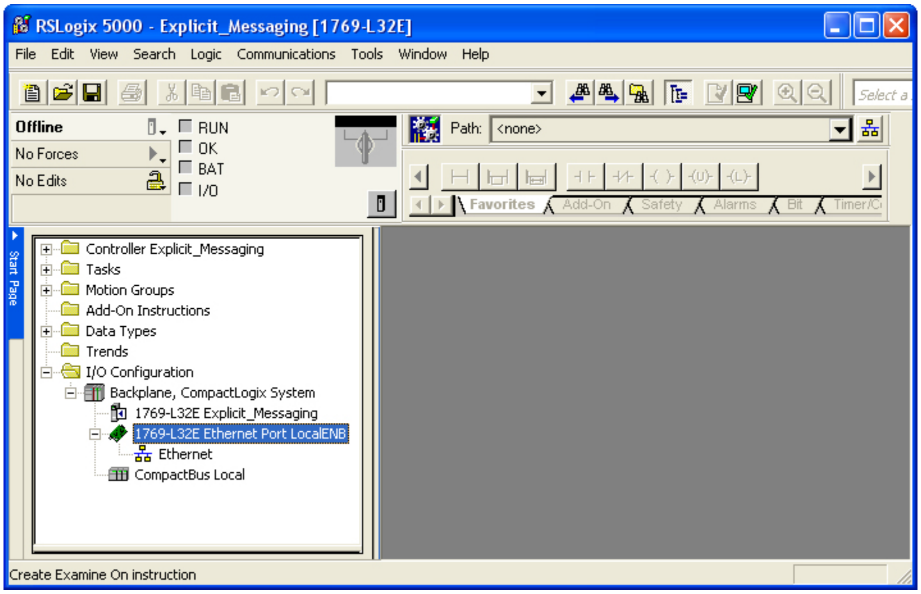
The instructions in this example exercise are primarily for a ControlLogix 1756-L61. However, you can also use a CompactLogix 1769-L32E. Any differences for the 1769-L32E are included.

1. Create a new RSLogix project named "Explicit_Messaging."
2. For ControlLogix, select the I/O Configuration folder in the controller organizer, and manually add an EtherNet/IP interface.

   The interface is added to the I/O configuration folder.



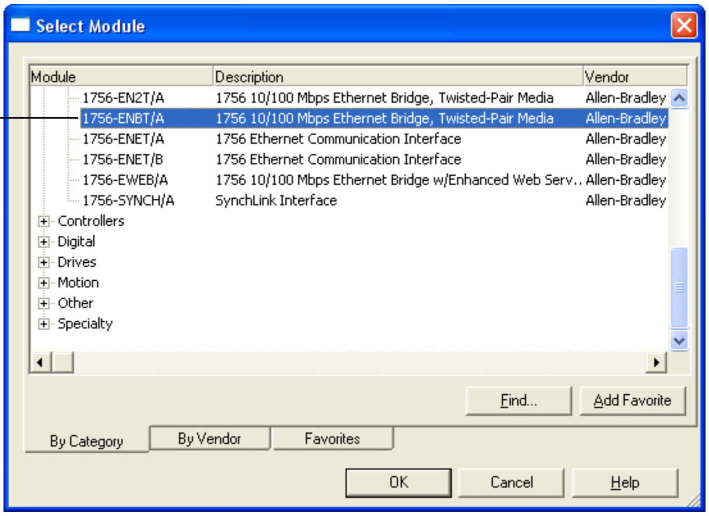
For a CompactLogix 1769-L32E PLC, when you create a new project in RSLogix, an Ethernet interface named "LocalENB" is automatically created at slot 1.


RSLogix 5000 - Explicit_Messaging [1769-L32E]
File Edit View Search Logic Communications Tools Window Help
Offline
No Forces
No Edits
RUN
OK
BAT
I/O
Path: <none>
Favorites
Add-On
Safety
Alarms
Bit
Timer/C
Start Page
Controller Explicit_Messaging
Tasks
Motion Groups
Add-On Instructions
Data Types
Trends
I/O Configuration
Backplane, CompactLogix System
1769-L32E Explicit_Messaging
1769-L32E Ethernet Port LocalENB
Ethernet
CompactBus Local
Create Examine On instruction

In this example, there is a 1756-ENBT/A (Revision 3.9) in Slot 1 of the Logix chassis. You will need this information to complete the next set of dialogs.

3. To add the 1756-ENBT/A, right-click the I/O Configuration folder and choose New Module… from the popup menu to open the Select Module dialog box.
4. Expand the Communications group, select the 1756-ENBT/A adapter, and click OK.

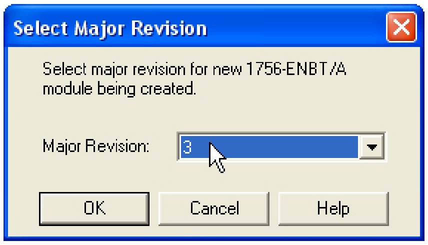
Select the 1756-ENBT/A adapter



Select Module

Module	Description	Vendor
1756-EN2T/A	1756 10/100 Mbps Ethernet Bridge, Twisted-Pair Media	Allen-Bradley
1756-ENBT/A	1756 10/100 Mbps Ethernet Bridge, Twisted-Pair Media	Allen-Bradley
1756-ENET/A	1756 Ethernet Communication Interface	Allen-Bradley
1756-ENET/B	1756 Ethernet Communication Interface	Allen-Bradley
1756-EWEB/A	1756 10/100 Mbps Ethernet Bridge w/Enhanced Web Serv…	Allen-Bradley
1756-SYNCH/A	SynchLink Interface	Allen-Bradley
⊞ Controllers		
⊞ Digital		
⊞ Drives		
⊞ Motion		
⊞ Other		
⊞ Specialty		

5. In the Select Major Revision dialog box that appears, select the major revision of the 1756-ENBT/A module, which is 3 for the module used in this example.

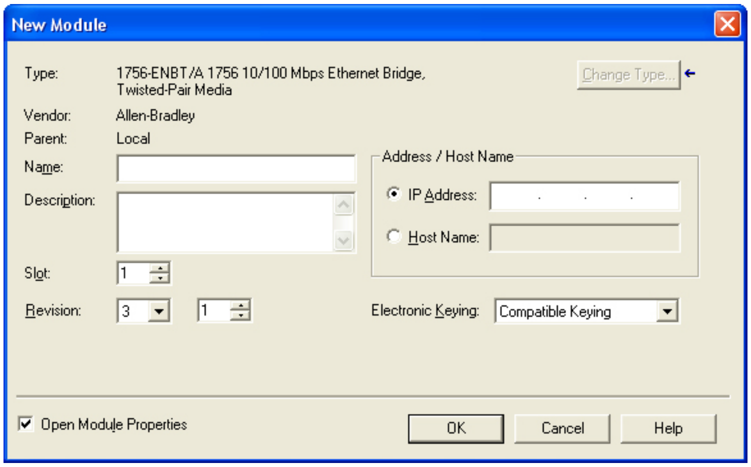


Select Major Revision

Select major revision for new 1756-ENBT/A module being created.

Major Revision: 3

6. Click OK to open the New Module dialog box.



New Module

Type: 1756-ENBT/A 1756 10/100 Mbps Ethernet Bridge, Twisted-Pair Media

Vendor: Allen-Bradley

Parent: Local

Name:

Description:

Slot: 1

Revision: 3 1

Address / Host Name

● IP Address: . . .

○ Host Name:

Electronic Keying: Compatible Keying

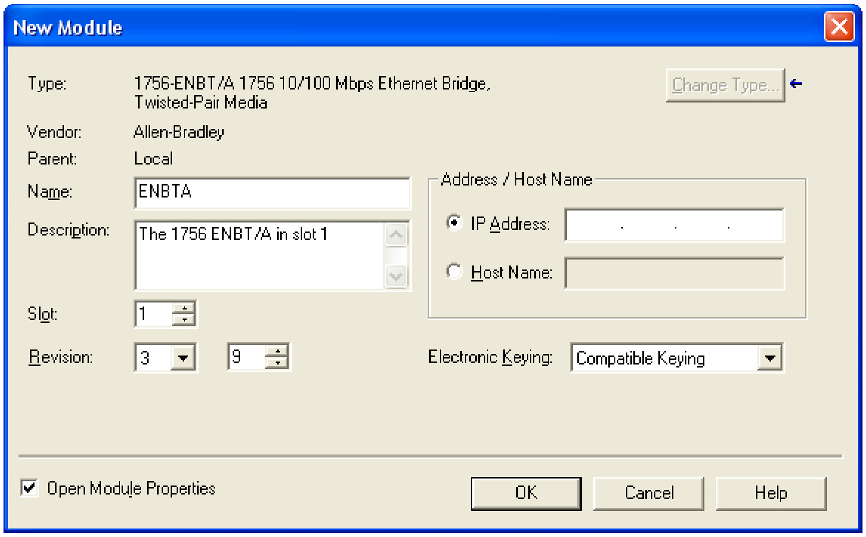
☑ Open Module Properties

7. Enter or select the following:

- **Name**: ENBTA
- **Description**: The 1756 ENBT/A in slot 1
- **Slot**: 1
- **Revision** (minor): 9.

  Recall that our EtherNet/IP module has a revision of 3.9. The 9 is the minor revision number.

The other parameters are not necessary, so leave the other fields blank. The completed dialog box should look like this:



New Module

Type: 1756-ENBT/A 1756 10/100 Mbps Ethernet Bridge, Twisted-Pair Media

Vendor: Allen-Bradley

Parent: Local

Name: ENBTA

Description: The 1756 ENBT/A in slot 1

Slot: 1

Revision: 3 9

Address / Host Name

● IP Address: . . .

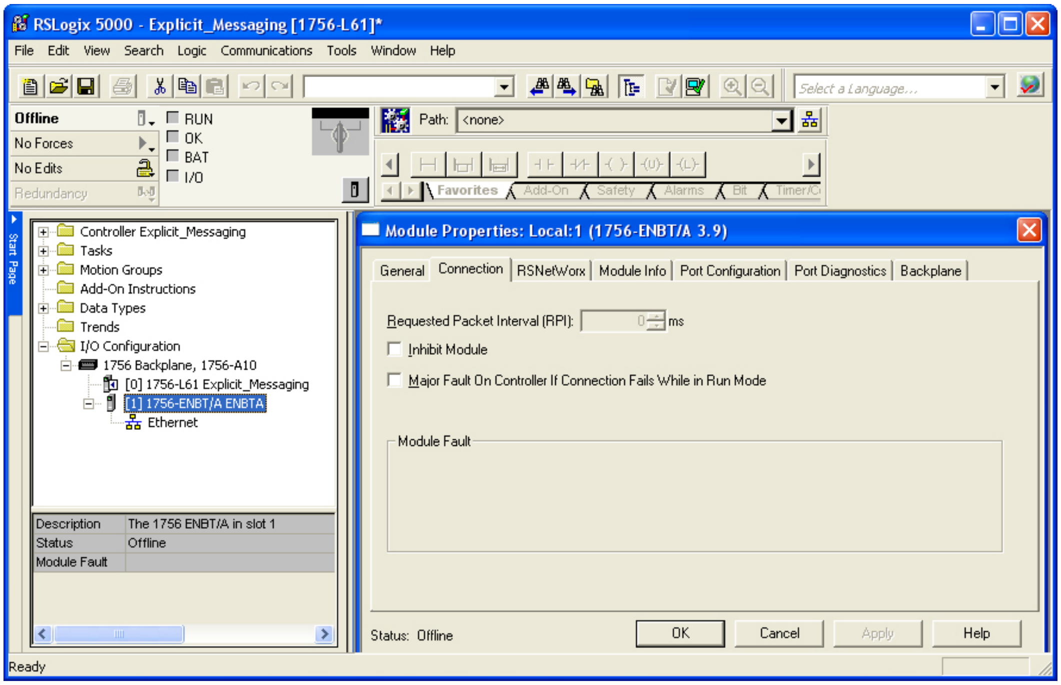
○ Host Name:

Electronic Keying: Compatible Keying

☑ Open Module Properties

8. Click OK.

The RSLogix window should now look like this:



RSLogix 5000 - Explicit_Messaging [1756-L61]*

Offline
No Forces
No Edits
Redundancy

□ RUN
□ OK
□ BAT
□ I/O

Path: <none>

Controller Explicit_Messaging
Tasks
Motion Groups
Add-On Instructions
Data Types
Trends
I/O Configuration
1756 Backplane, 1756-A10
[0] 1756-L61 Explicit_Messaging
[1] 1756-ENBT/A ENBTA
Ethernet

Description	The 1756 ENBT/A in slot 1
Status	Offline
Module Fault	

Module Properties: Local:1 (1756-ENBT/A 3.9)

Requested Packet Interval (RPI): 0 ms
□ Inhibit Module
□ Major Fault On Controller If Connection Fails While in Run Mode

Module Fault

Status: Offline

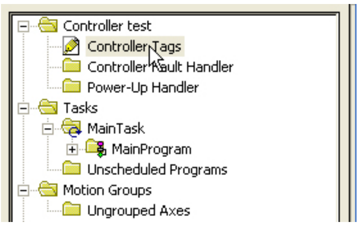
Ready

9. Click OK again to close the Module Properties dialog box.

Creating a MESSAGE Object

In RSLogix, an explicit message is created using a MESSAGE tag.

1. In RSLogix 5000, open the controller organizer, right-click Controller Tags, and then choose New Tag.

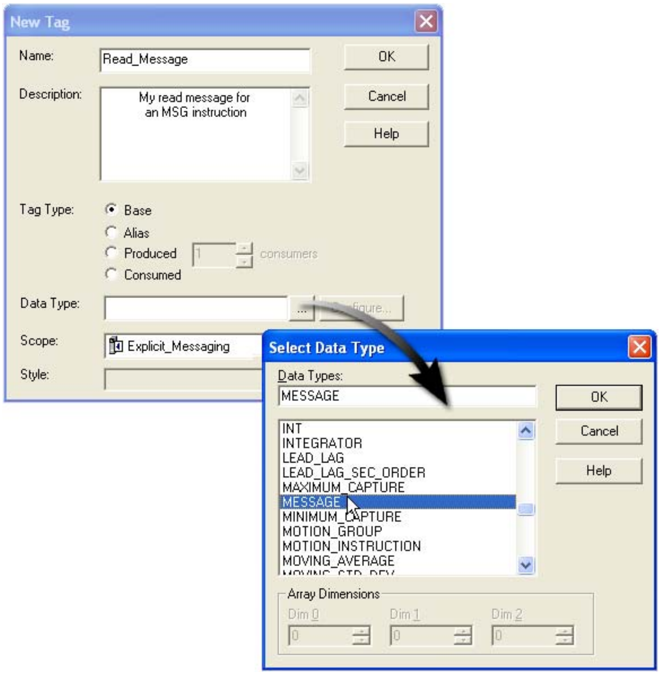


Controller test
Controller Tags
Controller Fault Handler
Power-Up Handler
Tasks
MainTask
MainProgram
Unscheduled Programs
Motion Groups
Ungrouped Axes

2. In the New Tag dialog box, enter or select the following:

- **Name**: Read Message
- **Description**: My read message for an MSG instruction
- **Tag Type**: Base
- **Data Type**: MESSAGE

To select MESSAGE, click the Data Type button, ... to open the Select Data Type dialog box.



New Tag

Name: Read_Message

Description: My read message for an MSG instruction

Tag Type: ● Base ○ Alias ○ Produced ○ Consumed

Data Type:

Scope: Explicit_Messaging

Style:

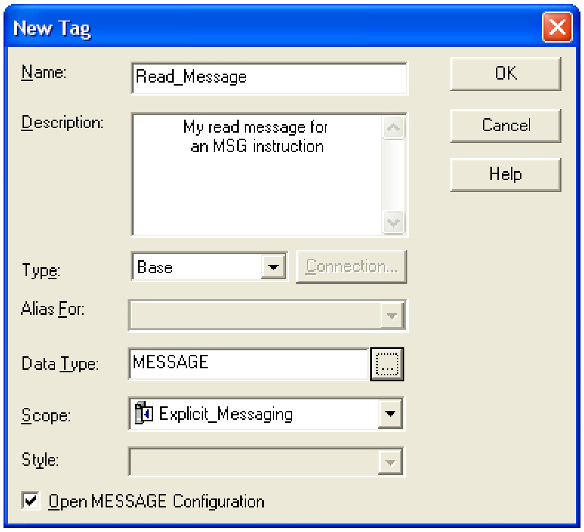
Select Data Type

Data Types: MESSAGE

INT
INTEGRATOR
LEAD_LAG
LEAD_LAG_SEC_ORDER
MAXIMUM_CAPTURE
MESSAGE
MINIMUM_CAPTURE
MOTION_GROUP
MOTION_INSTRUCTION
MOVING_AVERAGE

Array Dimensions: Dim 0: 0 Dim 1: 0 Dim 2: 0

The completed dialog box should look like this:



New Tag

Name: Read_Message

Description: My read message for an MSG instruction

Type: Base

Alias For:

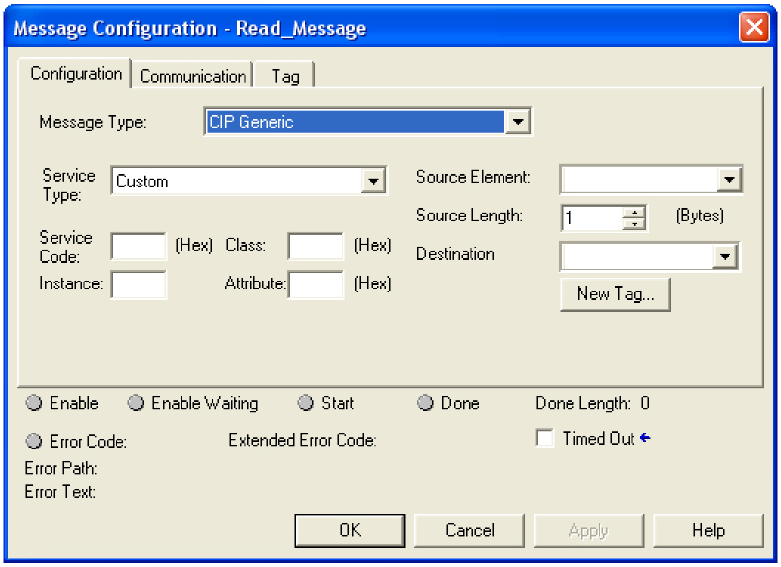
Data Type: MESSAGE

Scope: Explicit_Messaging

Style:

☑ Open MESSAGE Configuration

3. At the bottom of the dialog box, select Open MESSAGE Configuration.
4. Click OK to close the New Tag dialog box and open the Message Configuration dialog box.



Message Configuration - Read_Message

Configuration | Communication | Tag

Message Type: CIP Generic

Service Type: Custom

Service Code: (Hex) Class: (Hex)

Instance: Attribute: (Hex)

Source Element:

Source Length: 1 (Bytes)

Destination

New Tag...

○ Enable ○ Enable Waiting ○ Start ○ Done Done Length: 0

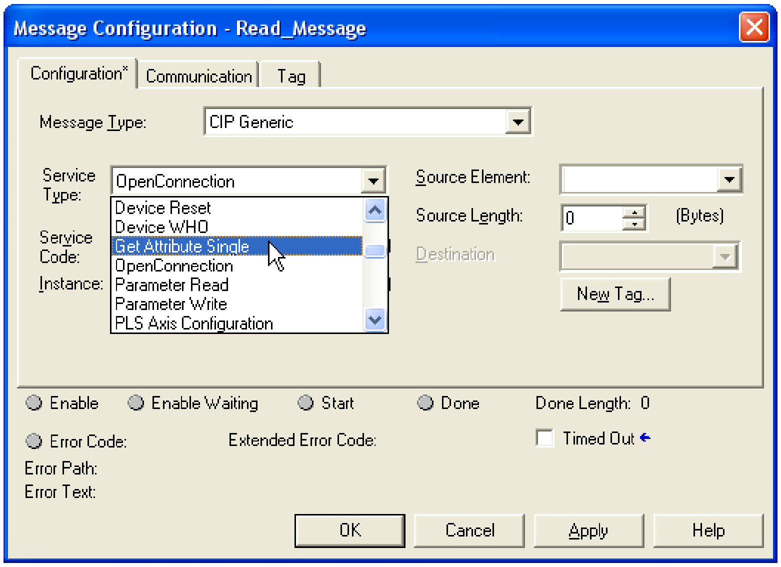
○ Error Code: Extended Error Code: □ Timed Out

Error Path:

Error Text:

OK Cancel Apply Help

5. Select Get Attribute Single for the Service Type.



Message Configuration - Read_Message

Configuration* | Communication | Tag

Message Type: CIP Generic

Service Type: OpenConnection

- Device Reset
- Device WHO
- Get Attribute Single
- OpenConnection
- Parameter Read
- Parameter Write
- PLS Axis Configuration

Service Code:

Instance:

Source Element:

Source Length: 0 (Bytes)

Destination

New Tag...

○ Enable ○ Enable Waiting ○ Start ○ Done Done Length: 0

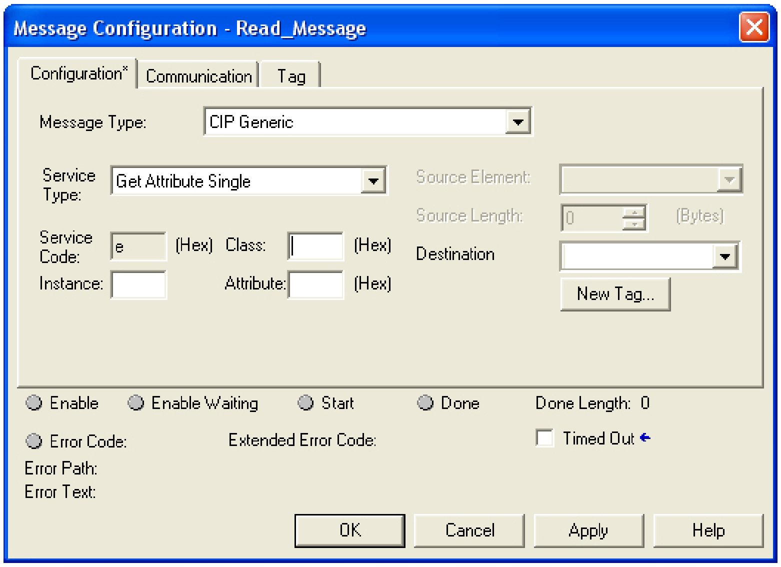
○ Error Code: Extended Error Code: □ Timed Out

Error Path:

Error Text:

OK Cancel Apply Help

Notice that the Source Element and Source Length fields are now inactive.



Message Configuration - Read_Message

Configuration* | Communication | Tag

Message Type: CIP Generic

Service Type: Get Attribute Single

Service Code: e (Hex) Class: (Hex)

Instance: Attribute: (Hex)

Source Element:

Source Length: 0 (Bytes)

Destination

New Tag...

○ Enable ○ Enable Waiting ○ Start ○ Done Done Length: 0

○ Error Code: Extended Error Code: □ Timed Out

Error Path:

Error Text:

OK | Cancel | Apply | Help

6. Populate the Class, Attribute, and Instance fields as follows:

– **Class**: 4 (Hex)

  To Read an assembly instance is a Class 4 (Hexadecimal) Assembly operation.

– **Attribute**: 3 (Hex)

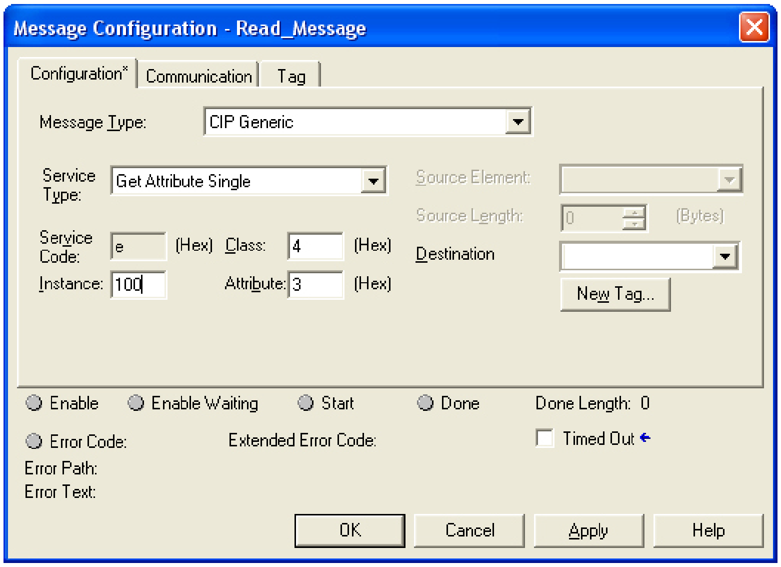
  This is a set Attribute option.

– **Instance**: 100

  This is assembly instance 100 that you configured within the EtherNet/IP Configurator.

  For more information on the Class and Attributes, see form 1770, *Ethernet/IP for SNAP PAC Protocol Guide*.

So far, the Message Configuration dialog box should look like this:



Message Configuration - Read_Message

Configuration* | Communication | Tag

Message Type: CIP Generic

Service Type: Get Attribute Single

Service Code: e (Hex) Class: 4 (Hex)

Instance: 100 Attribute: 3 (Hex)

Source Element:

Source Length: 0 (Bytes)

Destination

New Tag...

○ Enable ○ Enable Waiting ○ Start ○ Done Done Length: 0

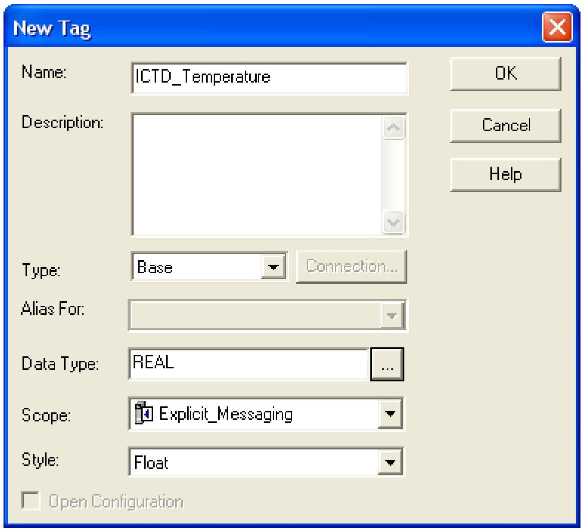
○ Error Code: Extended Error Code: □ Timed Out

Error Path:

Error Text:

OK | Cancel | Apply | Help

7. For the Destination, click the New Tag button to open the New Tag dialog box.
8. Create a variable with the following attributes:
   - **Name**: ICTD_Temperature
   - **Data Type**: REAL
   - **Scope:** Explicit_Messaging
9. Click OK to close the New Tag dialog box.



Name: ICTD_Temperature

Description:

Type: Base

Alias For:

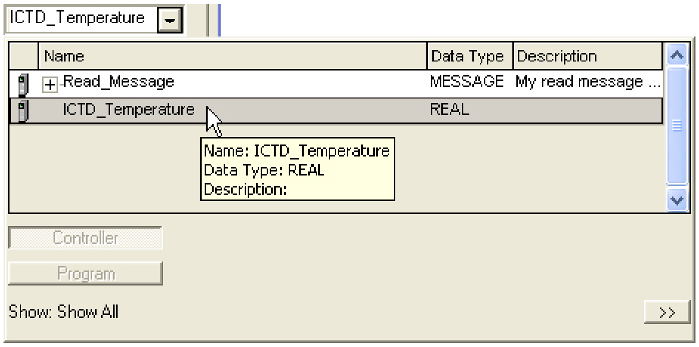
Data Type: REAL

Scope: Explicit_Messaging

Style: Float

□ Open Configuration

10. In the Destination field, select the new controller-scoped tag. In a MESSAGE object, the Source Element and Destination must be controller-scoped tags.



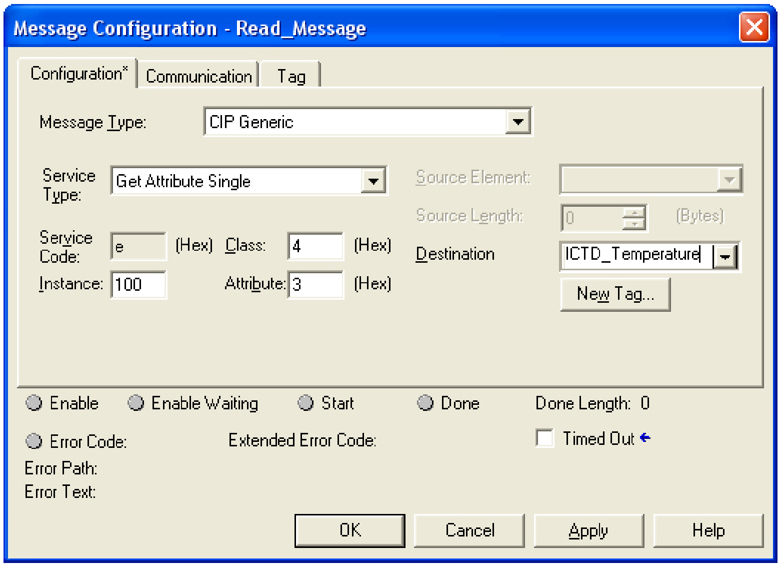
ICTD_Temperature

Name	Data Type	Description
+ Read_Message	MESSAGE	My read message ...
ICTD_Temperature	REAL	

Name: ICTD_Temperature
Data Type: REAL
Description:

Show: Show All

The completed Configuration tab should like this:



Message Configuration - Read_Message

Configuration* | Communication | Tag

Message Type: CIP Generic

Service Type: Get Attribute Single

Service Code: e (Hex) Class: 4 (Hex)

Instance: 100 Attribute: 3 (Hex)

Source Element:

Source Length: 0 (Bytes)

Destination: ICTD_Temperature

New Tag...

○ Enable ○ Enable Waiting ○ Start ○ Done Done Length: 0

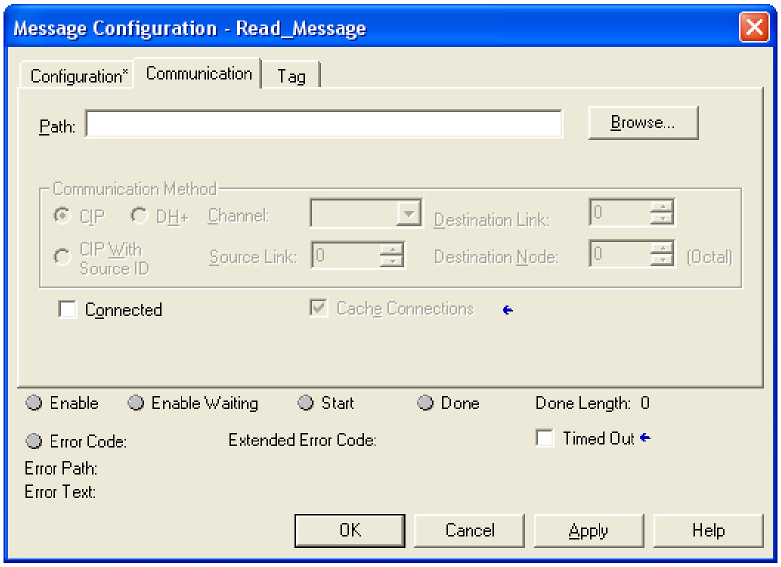
○ Error Code: Extended Error Code: □ Timed Out ←

Error Path:

Error Text:

OK | Cancel | Apply | Help

11. Click the Communication tab.



Message Configuration - Read_Message

Configuration* | Communication | Tag

Path: Browse...

Communication Method

● CIP ○ DH+ Channel: Destination Link: 0

○ CIP With Source ID Source Link: 0 Destination Node: 0 (Octal)

□ Connected ☑ Cache Connections ←

○ Enable ○ Enable Waiting ○ Start ○ Done Done Length: 0

○ Error Code: Extended Error Code: □ Timed Out ←

Error Path:

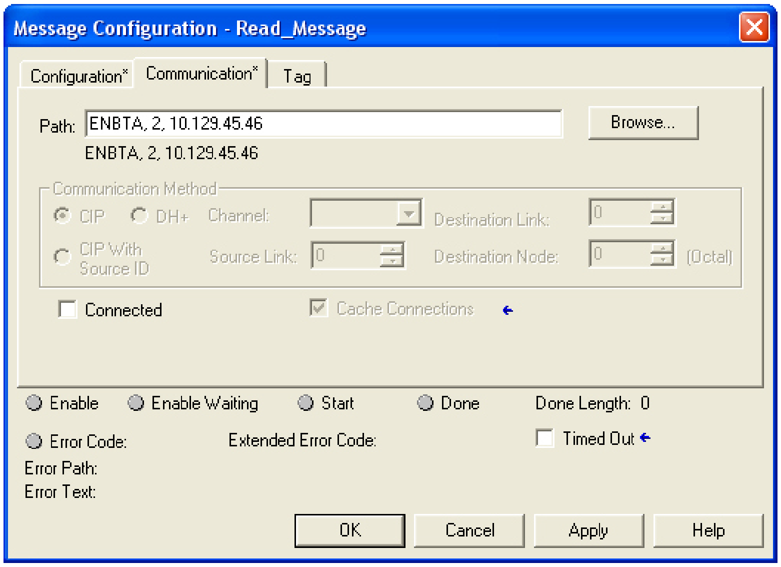
Error Text:

OK | Cancel | Apply | Help

12. For a ControlLogix controller (1756-L61 with a 1756-ENBT/A) implementation, enter the communication path, **ENBTA, 2, 000.000.000.000**, where:

- **ENBTA** is the name of the EtherNet/IP communication module in slot 1 of our chassis.
- **2** indicates this is an external message.
- **000.000.000.000** is the IP address of your PAC remote I/O unit.

Leave the Connected checkbox unchecked.



Message Configuration - Read_Message

Path: ENBTA, 2, 10.129.45.46

ENBTA, 2, 10.129.45.46

Communication Method: ● CIP ○ DH+ ○ CIP With Source ID

Channel:

Destination Link: 0

Source Link: 0

Destination Node: 0 (Octal)

□ Connected ☑ Cache Connections

Done Length: 0

□ Timed Out

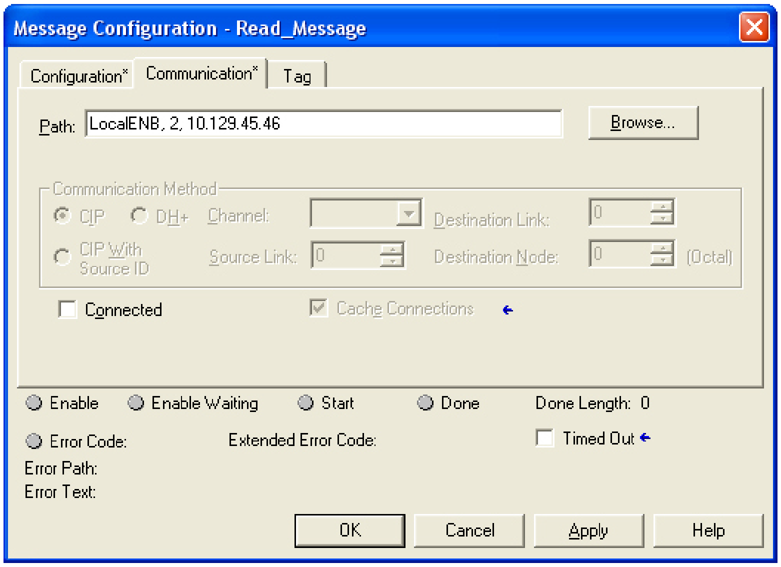
Extended Error Code:

Error Code:

Error Path:

Error Text:

For a CompactLogix controller (1769-32E) with an embedded EtherNet/IP Communication module, the path changes slightly. RSLogix automatically names the embedded EtherNet/IP module “LocalENB.” All other values of the path are the same.



Message Configuration - Read_Message

Path: LocalENB, 2, 10.129.45.46

Communication Method: ● CIP ○ DH+ ○ CIP With Source ID

Channel:

Destination Link: 0

Source Link: 0

Destination Node: 0 (Octal)

□ Connected ☑ Cache Connections

Done Length: 0

□ Timed Out

Extended Error Code:

Error Code:

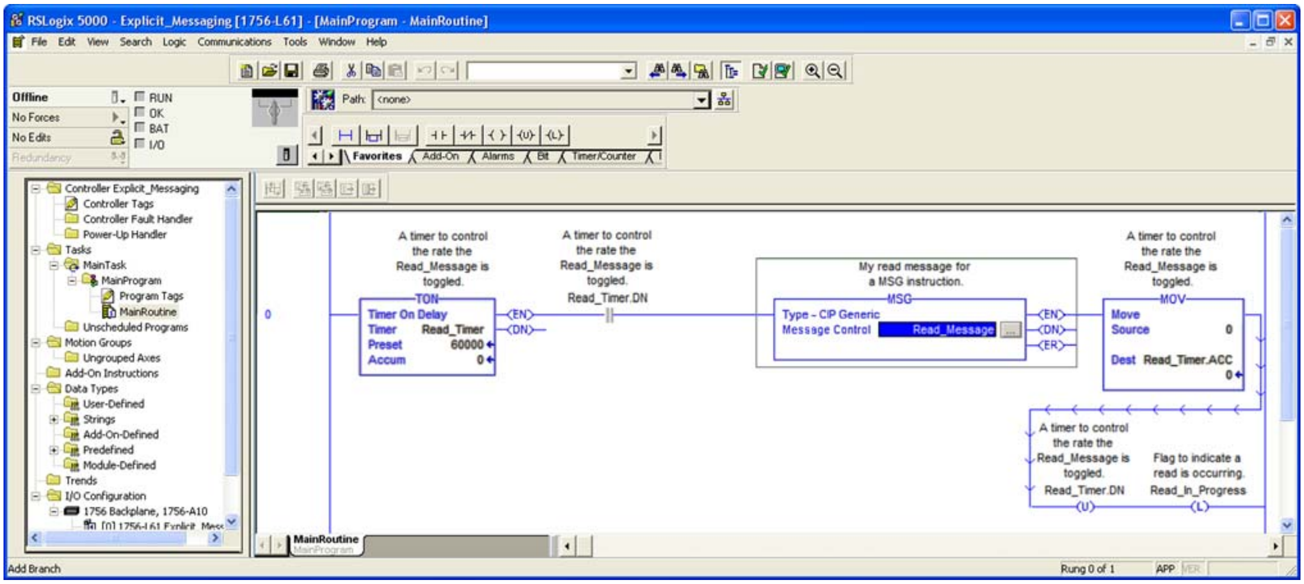
Error Path:

Error Text:

13. Click OK to close the dialog box and save the module configuration.

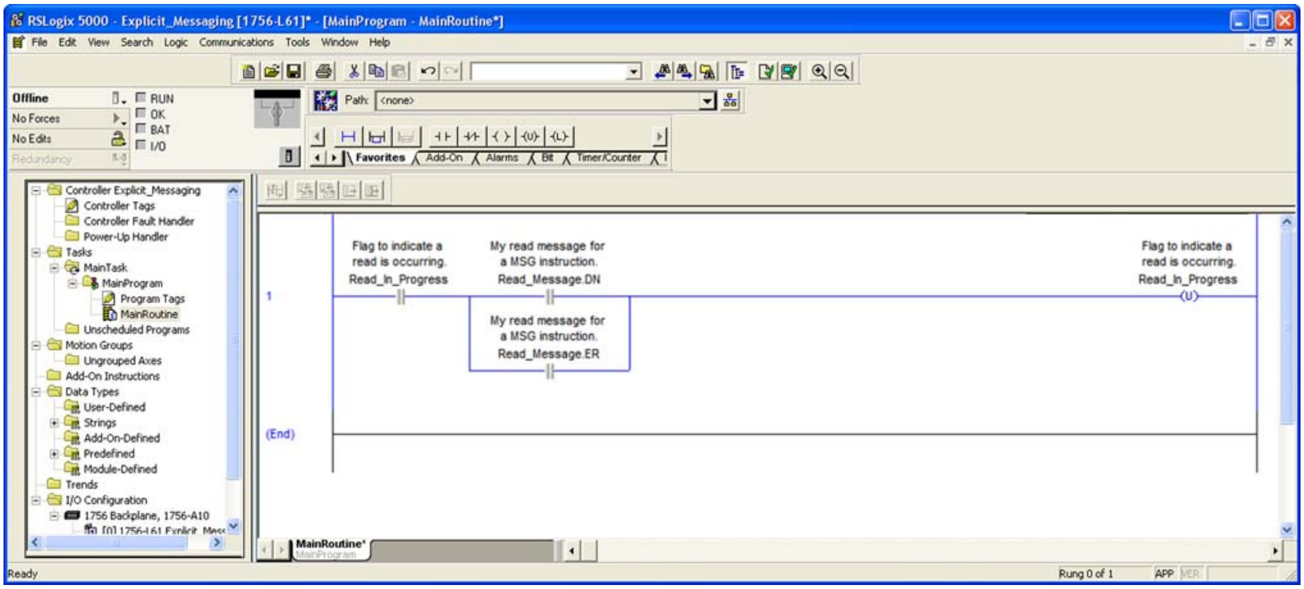
Adding the MSG Instruction

An MSG instruction is used to trigger an explicit message. It starts only when the input rung condition transitions from off to on, which is different than most other ladder instructions. Once the MSG is triggered, the message occurs asynchronously. You do not need to keep the rung condition true to the MSG instruction on. This will cause more logic time to be consumed each time the ladder runs.



In the example, a timer is used to control how often the MSG instruction is initiated. The timer creates a regular interval to read or write to the remote I/O. If the PLC and I/O are connected by very high bandwidth or reliable wide area networking, you can set the timer to a reasonable interval (e.g. 1 second). However, if the wide area networking is unreliable or fairly limited in bandwidth, set the timer for longer intervals such as 1 minute. The longer timer allows the message to complete fully, even if it ends in an error in response to a communication request.

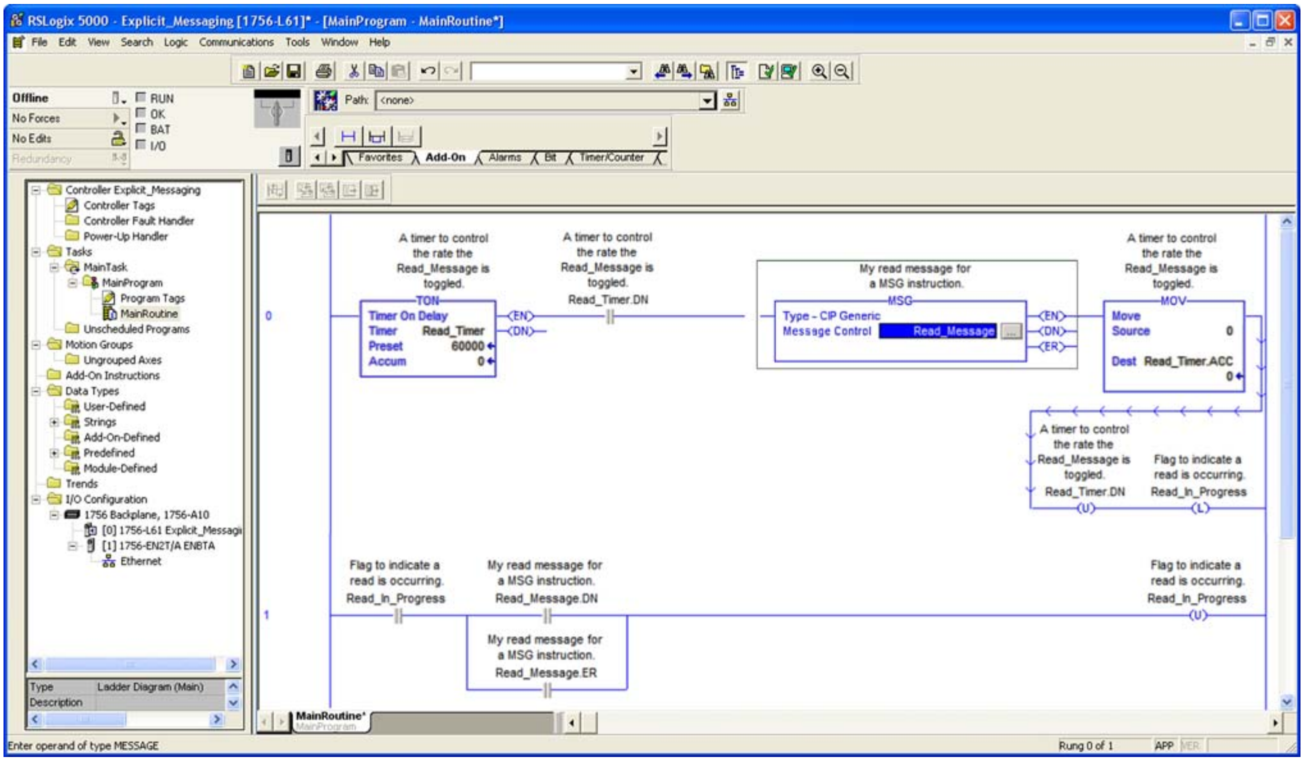
The ladder must now inspect to see when the message operation is complete or has completed in error. Check the Boolean attributes of either .DN or .ER to inspect whether the message is done or ended in an error.



Rung 1 in this example is incomplete. When the XIC for Read_Message.DN closes, the explicit data read is available. If the Explicit Message fails, the XIC for Read_Message.ER will close. In either case, the typical ladder implementation will add additional logic to handle both successful and unsuccessful communications.

The EtherNet/IP port is responsible for managing the TCP/IP communications of the explicit messaging. According to Rockwell documentation the default unconnected timeout for an explicit message is 30 seconds. This value may be changed by modifying the "UnconnectedTimeout" member of the MESSAGE object. This timeout should not be lower than five seconds on an optimally functioning network. Once an explicit message is initiated, it cannot be stopped.

Here are both rungs of the ladder in a single screen view.

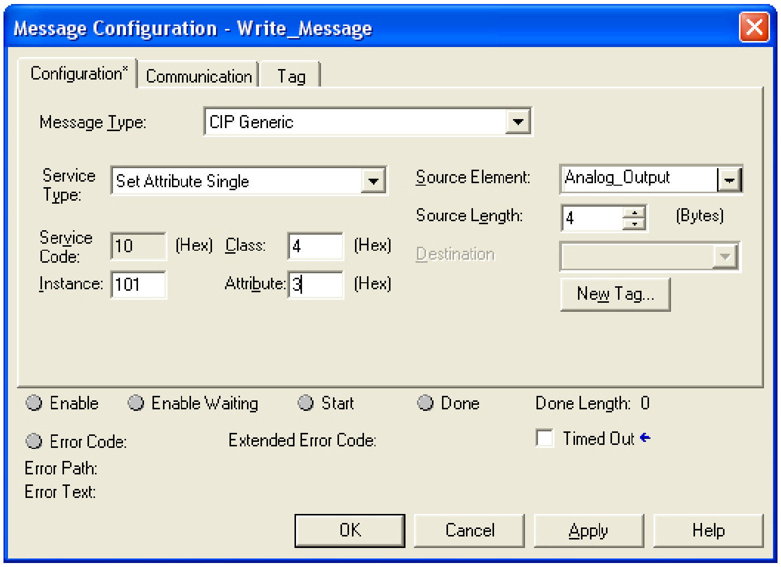

RSLogix 5000 - Explicit_Messaging [1756-L61]* - [MainProgram - MainRoutine*]
File Edit View Search Logic Communications Tools Window Help
Offline
No Forces
No Edits
Redundancy
RUN
OK
BAT
I/O
Path: <none>
Favorites
Add-On
Alarms
Bit
Timer/Counter
Controller Explicit_Messaging
Controller Tags
Controller Fault Handler
Power-Up Handler
Tasks
MainTask
MainProgram
Program Tags
MainRoutine
Unscheduled Programs
Motion Groups
Ungrouped Axes
Add-On Instructions
Data Types
User-Defined
Strings
Add-On-Defined
Predefined
Module-Defined
Trends
I/O Configuration
1756 Backplane, 1756-A10
[0] 1756-L61 Explicit_Messagi
[1] 1756-EN2T/A ENBTA
Ethernet
Type Ladder Diagram (Main)
Description
0
A timer to control the rate the Read_Message is toggled.
TON
Timer On Delay
Timer Read_Timer
Preset 60000
Accum 0
EN
DN
A timer to control the rate the Read_Message is toggled.
Read_Timer.DN
My read message for a MSG instruction.
MSG
Type - CIP Generic
Message Control Read_Message
EN
DN
ER
A timer to control the rate the Read_Message is toggled.
MOV
Move
Source 0
Dest Read_Timer.ACC
0
A timer to control the rate the Read_Message is toggled.
Read_Timer.DN
U
Flag to indicate a read is occurring.
Read_In_Progress
L
1
Flag to indicate a read is occurring.
Read_In_Progress
My read message for a MSG instruction.
Read_Message.DN
My read message for a MSG instruction.
Read_Message.ER
Flag to indicate a read is occurring.
Read_In_Progress
U
MainRoutine*
MainProgram
Enter operand of type MESSAGE
Rung 0 of 1
APP
VER

Configuring a MSG to Write an Assembly Instance

A write assembly instance is also triggered by a timer, the same as a read assembly instance. You should not use the message's .ER and .DN attributes to trigger the next message operation because that can cause erratic operation.

For more detailed information on creating a MESSSAGE object, see "Creating a MESSAGE Object" on page 43.

1. In the controller organizer, right-click Controller Tags, and choose New Tag.
2. In the New Tag dialog box, enter or select the following:
   - **Name**: Write Message
   - **Description**: My read message for an MSG instruction
   - **Tag Type**: Base
   - **Data Type**: MESSAGE
3. At the bottom of the dialog box, select Open MESSAGE Configuration.
4. Click OK to close the New Tag dialog box and open the Message Configuration dialog box.



Message Configuration - Write_Message

Configuration* | Communication | Tag

Message Type: CIP Generic

Service Type: Set Attribute Single

Service Code: 10 (Hex) Class: 4 (Hex)

Instance: 101 Attribute: 3 (Hex)

Source Element: Analog_Output

Source Length: 4 (Bytes)

Destination:

○ Enable ○ Enable Waiting ○ Start ○ Done Done Length: 0

○ Error Code: Extended Error Code: □ Timed Out

Error Path:

Error Text:

Note that this message is an Opto 22 Object Model Class 0x04, attribute 0xe, and references the assembly instance 101, where the output is configured.

5. Populate the fields as follows:

- **Service Type**: Set Attribute Single
- **Class**: 4 (Hex).

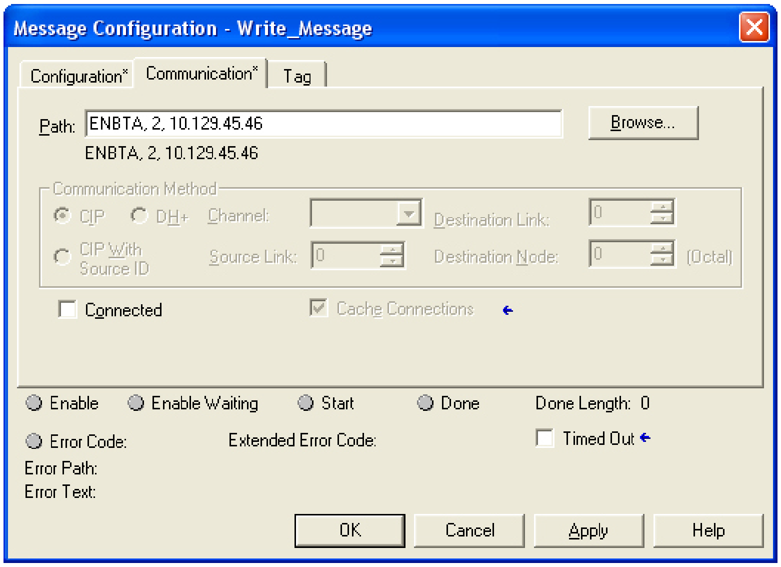
  To Read an assembly instance is a Class 4 (Hexadecimal) Assembly operation.
- **Attribute**: 3 (Hex)

  This is a set Attribute option.
- **Instance**: 101

  For more information on the Class and Attributes, see form 1770, *Ethernet/IP for SNAP PAC Protocol Guide*.

6. Click on the Communication tab, and enter the same connection path as you did for the read message.

In order to make this an *unconnected* message, do not check the Connected box. Unconnected messaging is the most efficient usage of TCP/IP encapsulation sessions in the Logix architecture.



Message Configuration - Write_Message

Path: ENBTA, 2, 10.129.45.46

ENBTA, 2, 10.129.45.46

Communication Method: ● CIP ○ DH+ ○ CIP With Source ID

Channel:

Destination Link: 0

Source Link: 0

Destination Node: 0 (Octal)

□ Connected

☑ Cache Connections

Done Length: 0

□ Timed Out

Error Code:

Extended Error Code:

Error Path:

Error Text:

7. Click OK to close the dialog box and save the module configuration.

Using User Data Types (UDTs)

If you are using version 16 or newer of RSLogix 5000, UDTs offer Explicit Messaging the ability to access assembly instance data with system meaningful attributes. By giving an attribute to each object within the UDT, it is much easier understand what an assembly instance is.

For example, compare these two data statements:

- PAC:O.Data[2].3
- PAC.Turn_Conveyor_Off

The second statement is easier to understand than the first one. UDTs also permit mixed data types within a single object; you can place REALs, DINTs, INTs, and BOOLs throughout the UDT. These values may be read or written at will, as a single block of data.

When implementing digital I/O states to map to the EtherNet/IP Configurator’s assembly instances, use the BOOL data type in the UDT definition.

Remember that RSLogix 5000 will collect continuous BOOL definitions in the UDT into rounded 32-bit data sizes. We recommend that you create a BOOL padding in the UDT, or else create a BOOL array of 32 values to clearly indicate the extension of the BOOL data. This will avoid confusion to data mismatches between the assembly instance and the MSG operation. To match this padding, the assembly instance configuration must also have an appropriate pad to fill out a block of 32-bits.

Summary

Explicit messaging is simply a manual method of acquiring I/O data. In combination with the EtherNet/IP configurator, you are still able to read and write I/O values to configure or manipulate I/O states.

Explicit messaging provides a way of accessing data upon demand, and it isn't necessarily difficult. It requires a couple rungs of ladder to implement, a bit more effort than with implicit messaging.

The ladder controls when incoming and outgoing messaging occurs and the messaging occurs over TCP/IP. This is very useful for implementing very remote or expansive network monitoring and control systems.

Explicit messaging is the only method for accessing SNAP PAC I/O in Allen-Bradley PLC lines outside of the Logix 5000 family such as the MicroLogix 1100 and 1400 families, which do not support implicit (I/O) messaging.

6: Connecting PAC Control and Allen-Bradley Systems

In this chapter you'll learn how to connect a SNAP PAC controller with an Allen-Bradley ControlLogix programmable logic controller (PLC) so that you can use either implicit or explicit messaging to exchange data between these two automation systems.

Connecting the two systems includes the following activities:

- Modifying the PAC Control strategy.
- Creating and downloading EtherNet/IP assembly instances.
- Modifying the RSLogix ladder.

Each of these activities is demonstrated using a simple example.

In addition to the things listed on page 11 you will need:

- PAC Project Basic or PAC Project Professional. PAC Project Basic is free. Both versions are available on the Opto 22 website, www.opto22.com.
- A SNAP PAC -S series or -R series controller, or a SNAP PAC EB-series brain.

In this Chapter

Exchanging Values

By doing the example exercises in this chapter, you will learn how to exchange several values between an Opto 22 automation system and an Allen-Bradley PLC. Each system has a few variables that need to be exchanged between each other. The example assumes that the control systems already exist and the parameter sharing simply "marries" the two systems together.

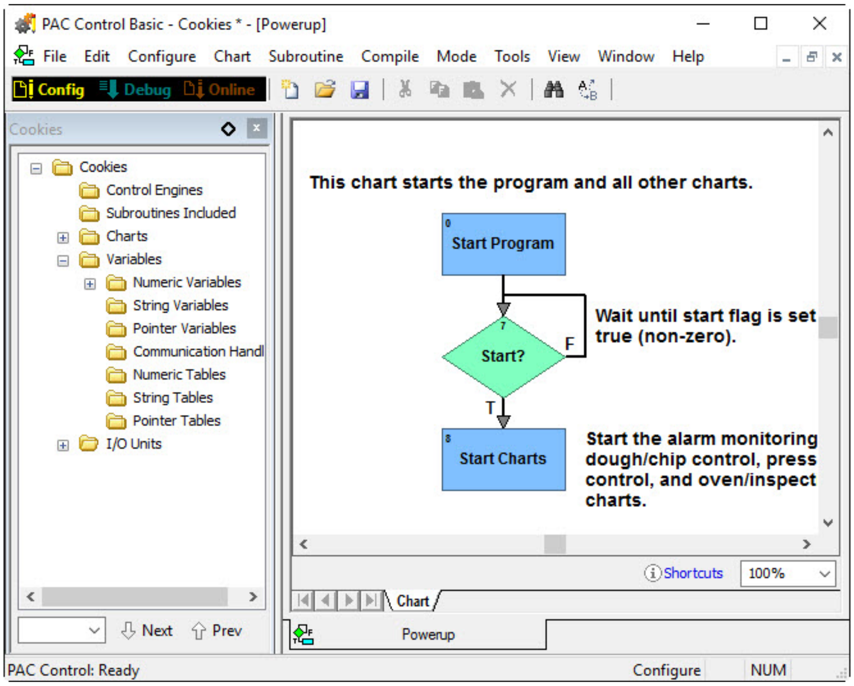
Modifying PAC Control

Your PAC Control strategy needs to be modified slightly to allow data to be read from and written to the Allen-Bradley PLC. For small data-sharing applications, the modifications will take only a few minutes.

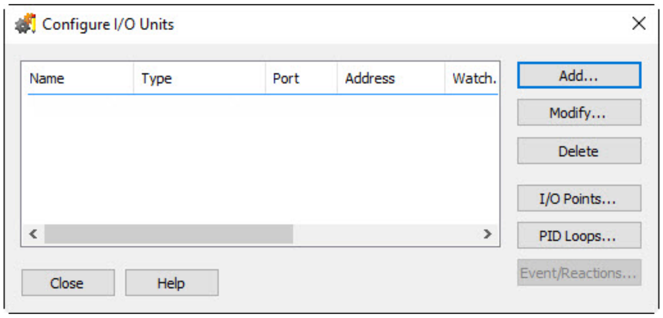
Adding an OptoMMP Device

The first thing to do is add an I/O unit to your PAC Control strategy.

1. If PAC Control isn't open, start it as follows:
   - In Windows 7 and Windows Vista, press the Windows Start key, and then click Programs > Opto 22 > PAC Project 9.6 > PAC Control.
   - In Windows 10 and Windows 8.1, press the Windows Start key, type **`PAC Control 9.6`** and then press the Enter key.
2. Open your strategy in PAC Control.



3. Double-click the I/O Units folder to open the Configure I/O Units dialog box.



4. Click the Add button to open the Add I/O Unit dialog box.
5. Add or select the following information, depending on the type of OptoMMP device you're using.

   For S-series controllers:

   – **Name**: Type a name for the device. In this exercise, our device is named "ioLocal."

   – **Type**: Select "Generic OptoMMP Device."

   – **IP Address**: Check the box for "Local (loopback)."

   For R-series controllers or EB-series brains:

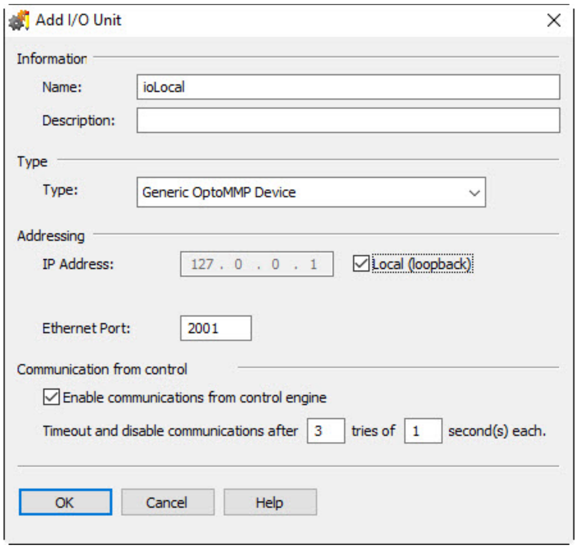
   – **Name**: Type a name for the device. In this exercise, our device is named "ioLocal."

   – **Type**: Select the part number for your SNAP PAC device.

   – **IP Address**: Enter the IP address of your SNAP PAC device.

   If you are using PAC Control Professional, leave the Secondary Address blank.

   If you are using an S-series controller and PAC Control Basic, the completed dialog box should look like this:



Name: ioLocal

Description:

Type: Generic OptoMMP Device

IP Address: 127 . 0 . 0 . 1 ☑ Local (loopback)

Ethernet Port: 2001

☑ Enable communications from control engine

Timeout and disable communications after 3 tries of 1 second(s) each.

Now, you're ready to modify the chart as described in the next section.

Modifying the Chart

In this section you will learn how to modify a strategy to exchange data. In the example, you will create a new chart, but you can modify an existing chart the same way. The new chart will read and write shared values to and from the scratchpad registers in the local I/O unit.

The PAC Controller has 32-bit integer, 32-bit float, and string registers. 32-bit integers are synonymous to the DINT data type. Opto 22 32-bit float data type is the same as the Logix REAL.

1. Before adding some code to the PAC Control strategy, create a couple of tables similar to the ones below to show which scratchpad registers will hold what particular values.

32-bit Integer Scratchpads

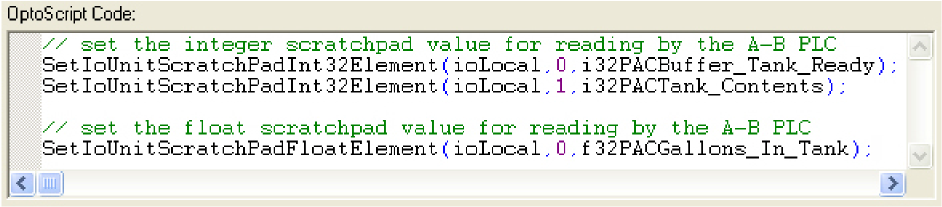
Index	Variable
0	i32PACBuffer_Tank_Ready
1	i32PACTank_Contents
2	dABFill_Tank
3	dABBottles_Filled

32-bit Float Scratchpads

Index	Variable
0	f32PACGallons_In_Tank
1	rABGallons_Requested

2. Using either an OptoScript block or an action block, create code to write PAC Control values to the scratchpad. When the data is present on the scratchpad, it is available to be read by other applications such as the Logix PLC.

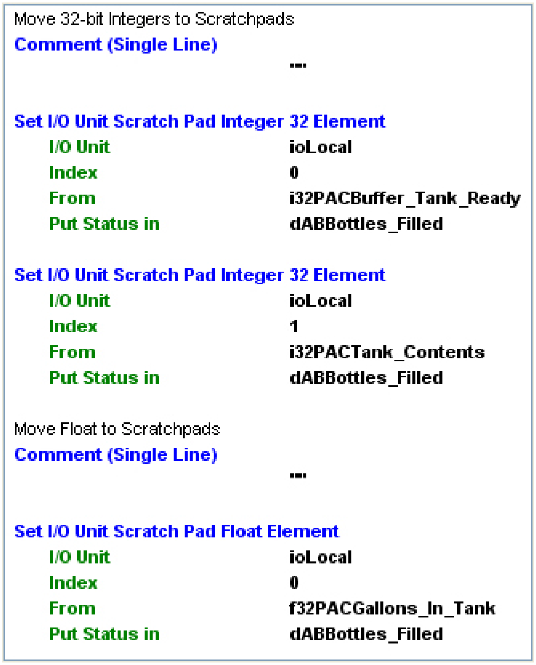
Using an OptoScript block:



OptoScript Code:

```
// set the integer scratchpad value for reading by the A-B PLC
SetIoUnitScratchPadInt32Element(ioLocal,0,i32PACBuffer_Tank_Ready);
SetIoUnitScratchPadInt32Element(ioLocal,1,i32PACTank_Contents);

// set the float scratchpad value for reading by the A-B PLC
SetIoUnitScratchPadFloatElement(ioLocal,0,f32PACGallons_In_Tank);
```

Using an action block to achieve the same thing:

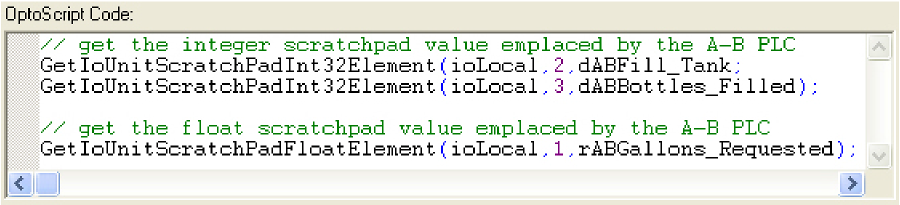


```
Move 32-bit Integers to Scratchpads
Comment (Single Line)
                                  ...

Set I/O Unit Scratch Pad Integer 32 Element
     I/O Unit                     ioLocal
     Index                        0
     From                         i32PACBuffer_Tank_Ready
     Put Status in                dABBottles_Filled

Set I/O Unit Scratch Pad Integer 32 Element
     I/O Unit                     ioLocal
     Index                        1
     From                         i32PACTank_Contents
     Put Status in                dABBottles_Filled

Move Float to Scratchpads
Comment (Single Line)
                                  ...

Set I/O Unit Scratch Pad Float Element
     I/O Unit                     ioLocal
     Index                        0
     From                         f32PACGallons_In_Tank
     Put Status in                dABBottles_Filled
```

3. Once again using either an OptoScript block or an action block, this time create code that reads the values the Allen-Bradley PLC writes to the scratchpads of the SNAP PAC controller.

   The PAC Control environment reads the values emplaced by the A-B PLC and moves them into similarly named variables.

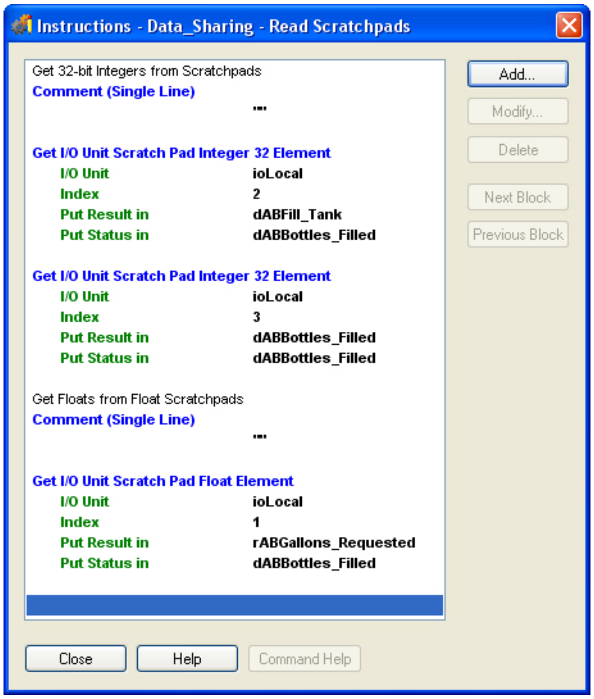
   Using an OptoScript block:



OptoScript Code:

```
// get the integer scratchpad value emplaced by the A-B PLC
GetIoUnitScratchPadInt32Element(ioLocal,2,dABFill_Tank;
GetIoUnitScratchPadInt32Element(ioLocal,3,dABBottles_Filled);

// get the float scratchpad value emplaced by the A-B PLC
GetIoUnitScratchPadFloatElement(ioLocal,1,rABGallons_Requested);
```

Using an action block sequence of commands to retrieve the A-B PLC scratchpad values:



```
Get 32-bit Integers from Scratchpads
Comment (Single Line)
                                  ...

Get I/O Unit Scratch Pad Integer 32 Element
    I/O Unit                      ioLocal
    Index                         2
    Put Result in                 dABFill_Tank
    Put Status in                 dABBottles_Filled

Get I/O Unit Scratch Pad Integer 32 Element
    I/O Unit                      ioLocal
    Index                         3
    Put Result in                 dABBottles_Filled
    Put Status in                 dABBottles_Filled

Get Floats from Float Scratchpads
Comment (Single Line)
                                  ...

Get I/O Unit Scratch Pad Float Element
    I/O Unit                      ioLocal
    Index                         1
    Put Result in                 rABGallons_Requested
    Put Status in                 dABBottles_Filled
```

See the next section for more scratchpad read and right commands.

Scratchpad Read and Write Commands

Here is a complete list of the PAC Control scratchpad read and write commands.

Scratchpad Read Commands:

- Get I/O Unit Scratch Pad Float Element
- Get I/O Unit Scratch Pad Float Table
- Get I/O Unit Scratch Pad Integer 32 Element
- Get I/O Unit Scratch Pad Integer 32 Table
- Get I/O Unit Scratch Pad String Element
- Get I/O Unit Scratch Pad String Table

Scratchpad Write Commands:

- Set I/O Unit Scratch Pad Float Element
- Set I/O Unit Scratch Pad Float Table
- Set I/O Unit Scratch Pad Integer 32 Element
- Set I/O Unit Scratch Pad Integer 32 Table
- Set I/O Unit Scratch Pad String Element
- Set I/O Unit Scratch Pad String Table

Creating Scratchpad Assemblies with EtherNet/IP Configurator

For this section you will need to use EtherNet/IP Configurator to create assemblies to exchange between the PAC controller and the Allen-Bradley PLC.

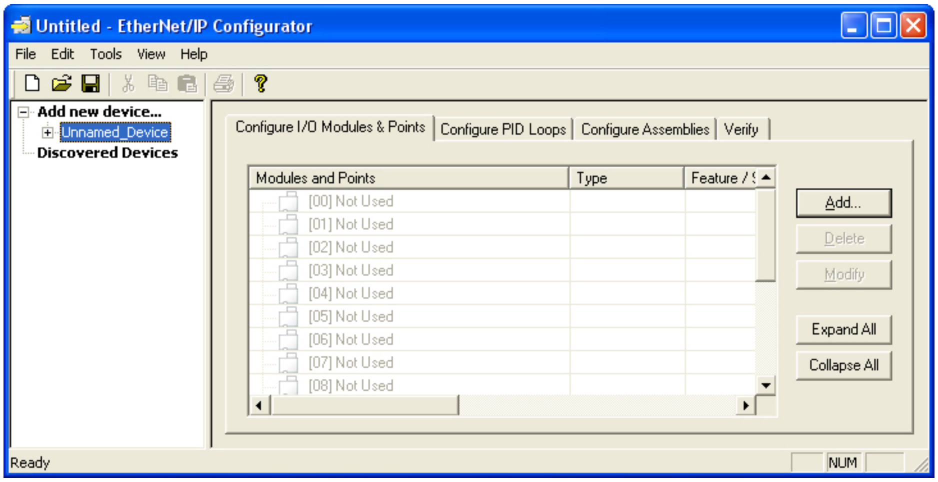
Creating an Assembly to Send Data to the PLC

1. If EtherNet/IP Configurator isn't open, start it as follows:

– In Windows 7 and Windows Vista, press the Windows Start key, and then click Programs > Opto 22 > PAC Project 9.6 > EtherNet-IP > EtherNet-IP Configurator.

– In Windows 10 and Windows 8.1, press the Windows Start key, type **`EtherNet-IP Configurator 9.6`** and then press the Enter key.

Starting EtherNet/IP Configurator immediately creates a new configuration.



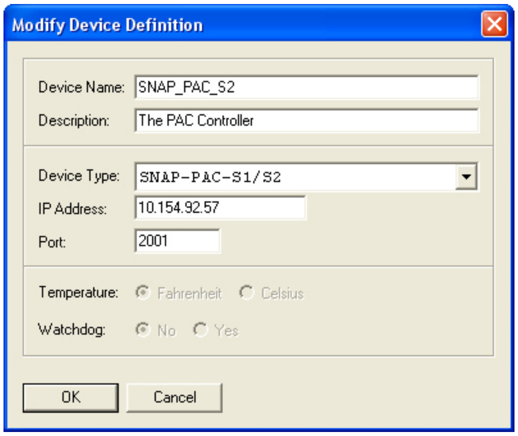
Modules and Points	Type	Feature / S
[00] Not Used		
[01] Not Used		
[02] Not Used		
[03] Not Used		
[04] Not Used		
[05] Not Used		
[06] Not Used		
[07] Not Used		
[08] Not Used		

2. Double-click the Unnamed_Device in the device tree to open the Modify Device Definition dialog box.

3. Select the Device Type that matches your controller.

4. Enter the IP address of the SNAP PAC controller in the IP Address field.

The example uses a SNAP-PAC-S2 with the IP address of 10.154.92.57, but you can use any R-series or S-series controller, or EB-series brain.



Device Name: SNAP_PAC_S2

Description: The PAC Controller

Device Type: SNAP-PAC-S1/S2

IP Address: 10.154.92.57

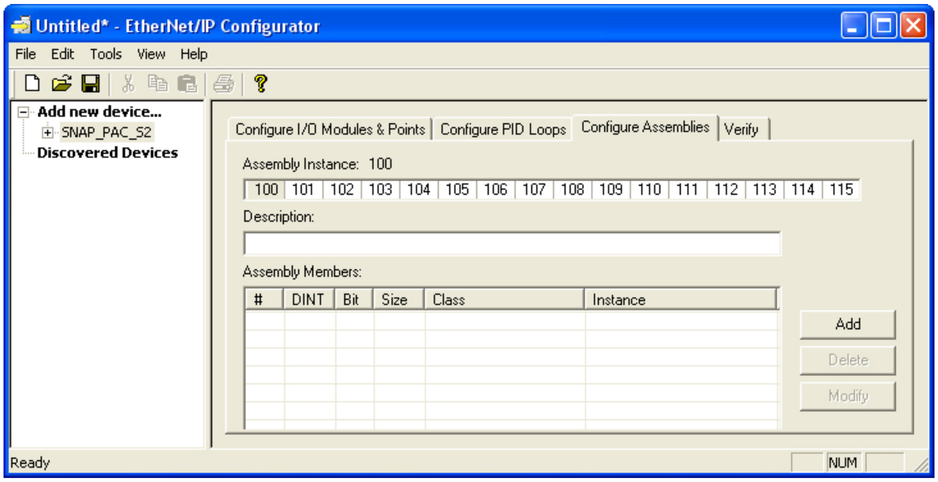
Port: 2001

Temperature: ● Fahrenheit ○ Celsius

Watchdog: ● No ○ Yes

5. Click OK to close the dialog box, then click the Configure Assemblies tab.

   The tab opens assembly instance 100, which you will use to send the appropriate scratchpad data to the Allen-Bradley PLC.



Assembly Instance: 100

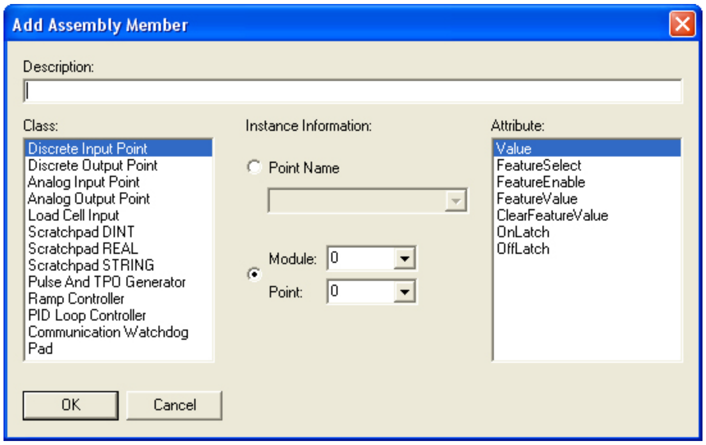
100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115

Description:

Assembly Members:

#	DINT	Bit	Size	Class	Instance

6. Begin populating assembly instance 100 by clicking the Add button to open the Add Assembly Member dialog box.



Description:

Class:

Discrete Input Point
Discrete Output Point
Analog Input Point
Analog Output Point
Load Cell Input
Scratchpad DINT
Scratchpad REAL
Scratchpad STRING
Pulse And TPO Generator
Ramp Controller
PID Loop Controller
Communication Watchdog
Pad

Instance Information:

○ Point Name

● Module: 0

Point: 0

Attribute:

Value
FeatureSelect
FeatureEnable
FeatureValue
ClearFeatureValue
OnLatch
OffLatch

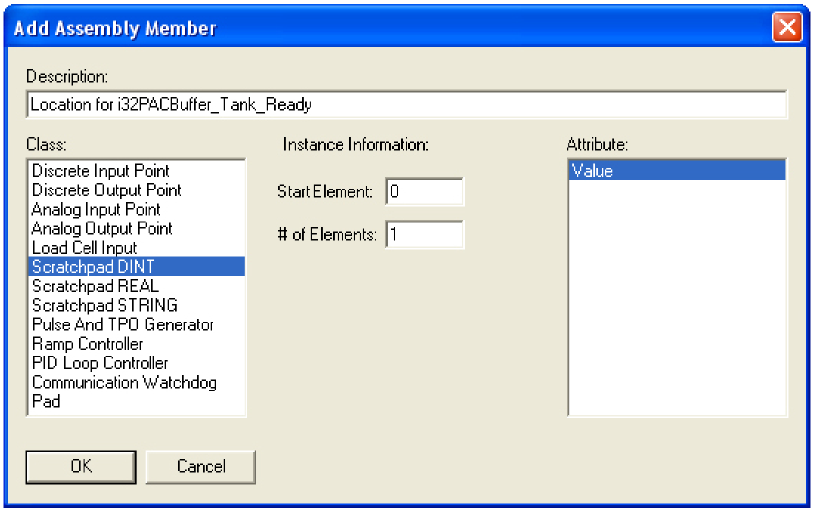
7. Select the following items:

– **Class**: ScratchpadDINT (Notice that the available fields change.)

– **Instance Information**
Start Element: 0
# of Elements: 1

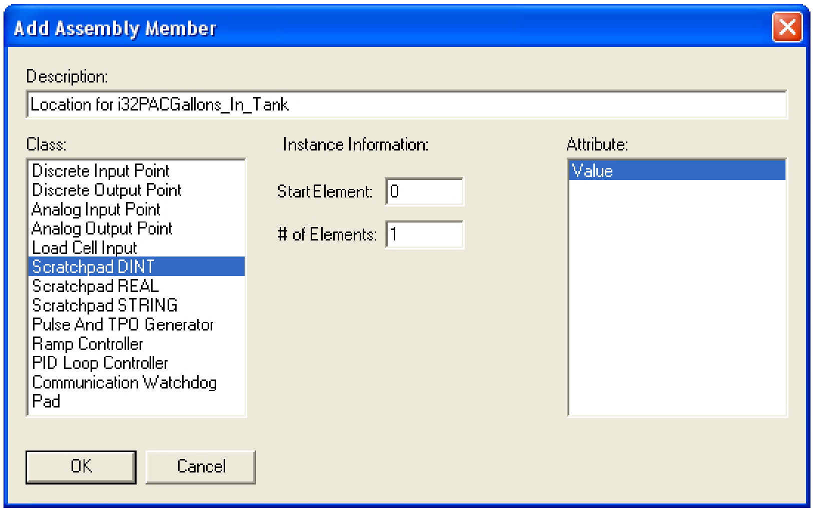
– **Attribute**: Value

– **Description**: Add a comment such as "Location for i32PACBuffer_Tank Ready" to indicate which value this scratchpad location will transfer. The example is the scratchpad element for the PAC Control variable i32PACBuffer_Tank Ready.



Description: Location for i32PACBuffer_Tank_Ready
Class: Scratchpad DINT
Start Element: 0
# of Elements: 1
Attribute: Value

8. In the same manner, add ScratchpadDINT element #2 for "i32PACGallons_In_Tank."

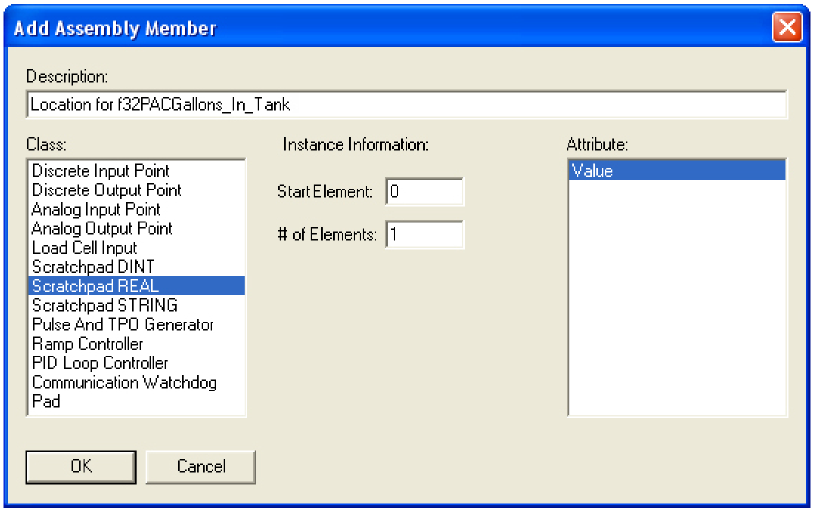


Description: Location for i32PACGallons_In_Tank
Class: Scratchpad DINT
Start Element: 0
# of Elements: 1
Attribute: Value

9. To add the float variable, click again and select the following items in the Add Assembly Member dialog box:

– **Class**: ScratchpadREAL

- **Start Element**: 0
- **Description**: Location for f32PACGallons_In_Tank



Add Assembly Member

Description: Location for f32PACGallons_In_Tank

Class: Scratchpad REAL

Instance Information:

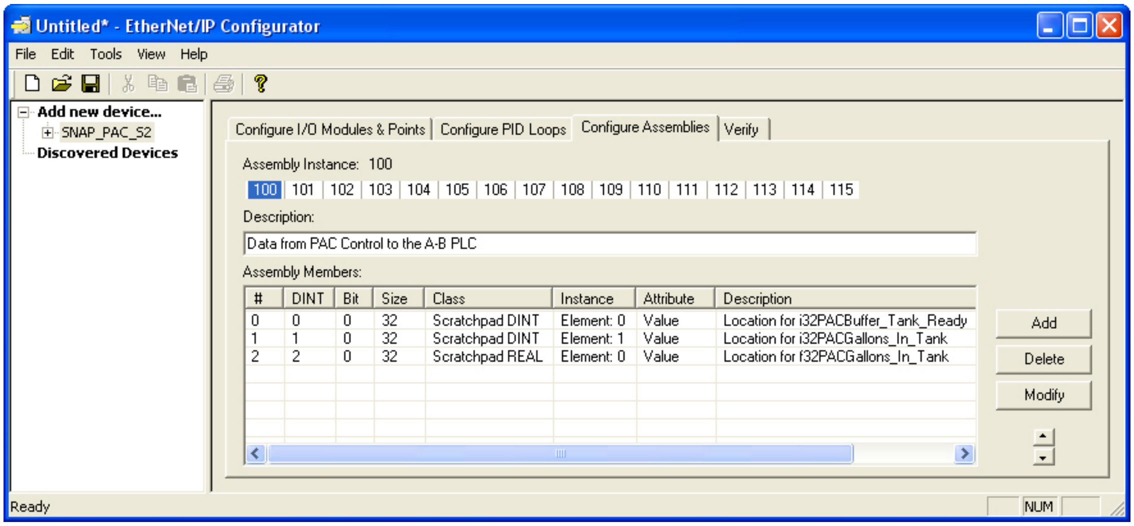
Start Element: 0

# of Elements: 1

Attribute: Value

10. Click OK.

Your completed assembly instance 100 should look similar to this:



Untitled* - EtherNet/IP Configurator

Assembly Instance: 100

Description: Data from PAC Control to the A-B PLC

Assembly Members:

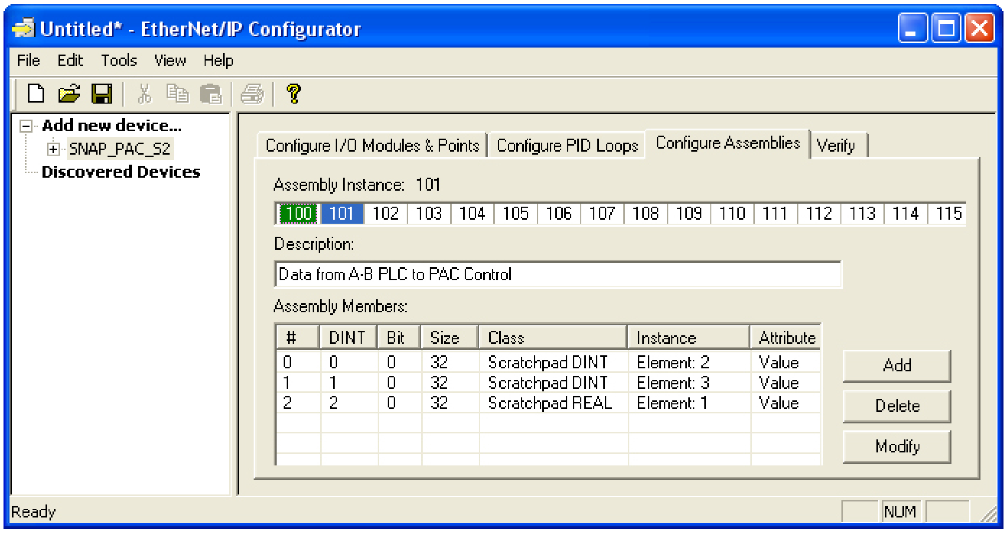
#	DINT	Bit	Size	Class	Instance	Attribute	Description
0	0	0	32	Scratchpad DINT	Element: 0	Value	Location for i32PACBuffer_Tank_Ready
1	1	0	32	Scratchpad DINT	Element: 1	Value	Location for i32PACGallons_In_Tank
2	2	0	32	Scratchpad REAL	Element: 0	Value	Location for f32PACGallons_In_Tank

Creating an Assembly to Accept Data from the PLC

This section describes how to create assembly instance 101, which will be used to accept data from the Allen-Bradley PLC. This is similar to creating assembly instance 100.

1. Follow the directions in the previous section for creating assembly instance 100, except note the minor differences for the Element values.

When completed, assembly 101 should look similar to this:



Assembly Instance: 101

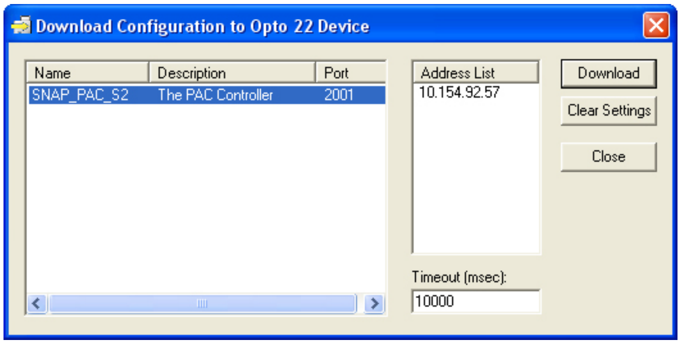
Description: Data from A-B PLC to PAC Control

Assembly Members:

#	DINT	Bit	Size	Class	Instance	Attribute
0	0	0	32	Scratchpad DINT	Element: 2	Value
1	1	0	32	Scratchpad DINT	Element: 3	Value
2	2	0	32	Scratchpad REAL	Element: 1	Value

2. To download the configuration to the PAC controller, choose Tools > Download Configuration to Opto 22 Device.

   The following dialog box appears.



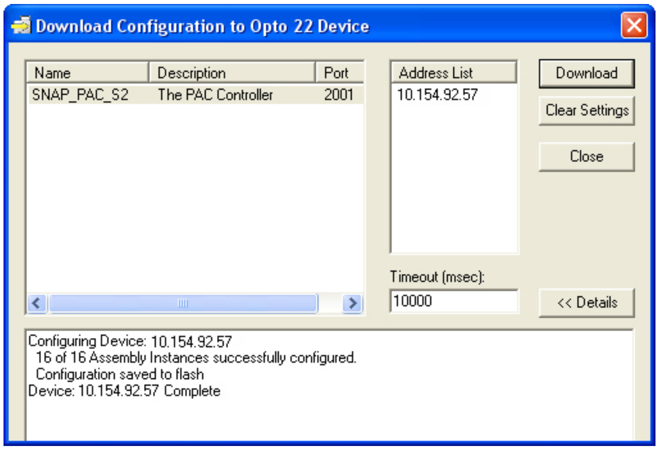
Name	Description	Port
SNAP_PAC_S2	The PAC Controller	2001

Address List: 10.154.92.57

Timeout (msec): 10000

3. Click the Download button.

   The following status information should appear showing that the configuration has been successfully saved to flash.



Name	Description	Port
SNAP_PAC_S2	The PAC Controller	2001

Address List
10.154.92.57

Timeout (msec): 10000

```
Configuring Device: 10.154.92.57
  16 of 16 Assembly Instances successfully configured.
  Configuration saved to flash
Device: 10.154.92.57 Complete
```

4. If you haven't already done so, choose File > Save As to give your configuration project a name and to save it for later use.

Once you have created assemblies 100 and 101 using EtherNet/IP Configurator, the next step is to use RSLogix 5000 to add some code to exchange data with the Assembly Instances you just created.

Modifying the RSLogix 5000 Ladder

In this section you will do the final step of integrating the two systems together by adding functionality to the PLC's ladder. The instructions are for a ControlLogix PLC (1756-L61).

In previous sections you modified the scratchpad read and write values in the PAC Control strategy, and you used EtherNet/IP Configurator to configure the PAC Controller to expose the scratchpads with Assembly Instances 100 and 101.

In the following exercise you will add the interface to RSLogix 5000.

1. Add a Generic Ethernet Module to the Logix PLC's EtherNet/IP module using the following settings.

– **Name**: PAC

– **Comm Format**: Data - DINT

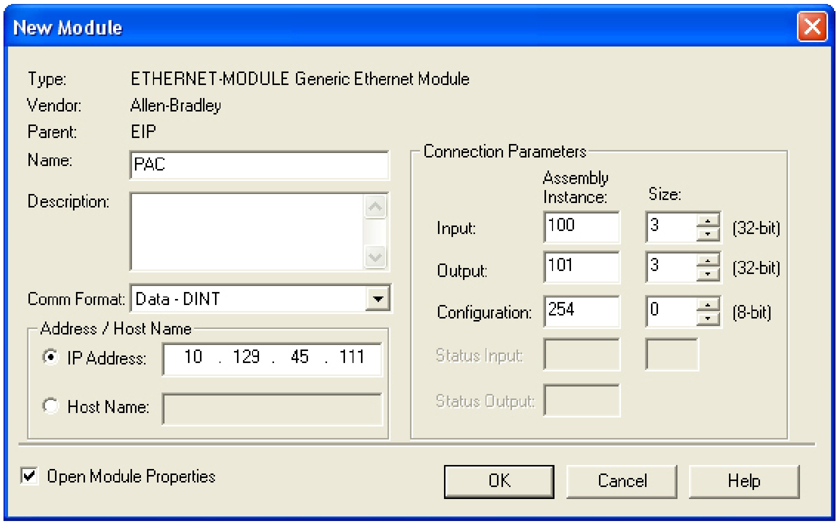
– **IP Address**: *Use the address of your PAC Controller*

– **Connection Parameters**

	Assembly Instance	Size
Input	100	3
Output	101	3
Configuration	254	0

The Input and Output Assembly Instance information is based on the Assembly Instances created in the EtherNet/IP Configurator software.

Leave the Configuration Assembly Instance to 254 and the size to 0 because the configuration assembly is not used. These settings tell RSLogix 5000 to ignore it.



New Module

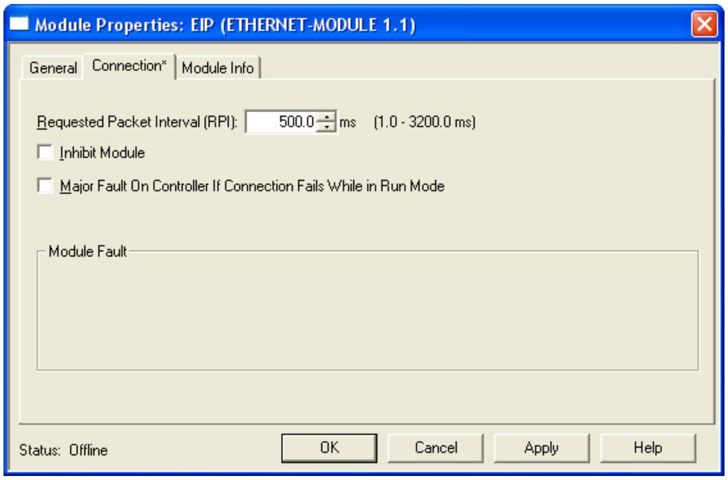
Type: ETHERNET-MODULE Generic Ethernet Module
Vendor: Allen-Bradley
Parent: EIP
Name: PAC
Description:
Comm Format: Data - DINT
Address / Host Name
● IP Address: 10 . 129 . 45 . 111
○ Host Name:

Connection Parameters

	Assembly Instance:	Size:	
Input:	100	3	(32-bit)
Output:	101	3	(32-bit)
Configuration:	254	0	(8-bit)
Status Input:			
Status Output:			

☑ Open Module Properties

2. Click OK to open the Module Properties dialog box.
3. Click on the Connection tab and set the RPI to 500 milliseconds for demonstrating the data exchange.



Module Properties: EIP (ETHERNET-MODULE 1.1)

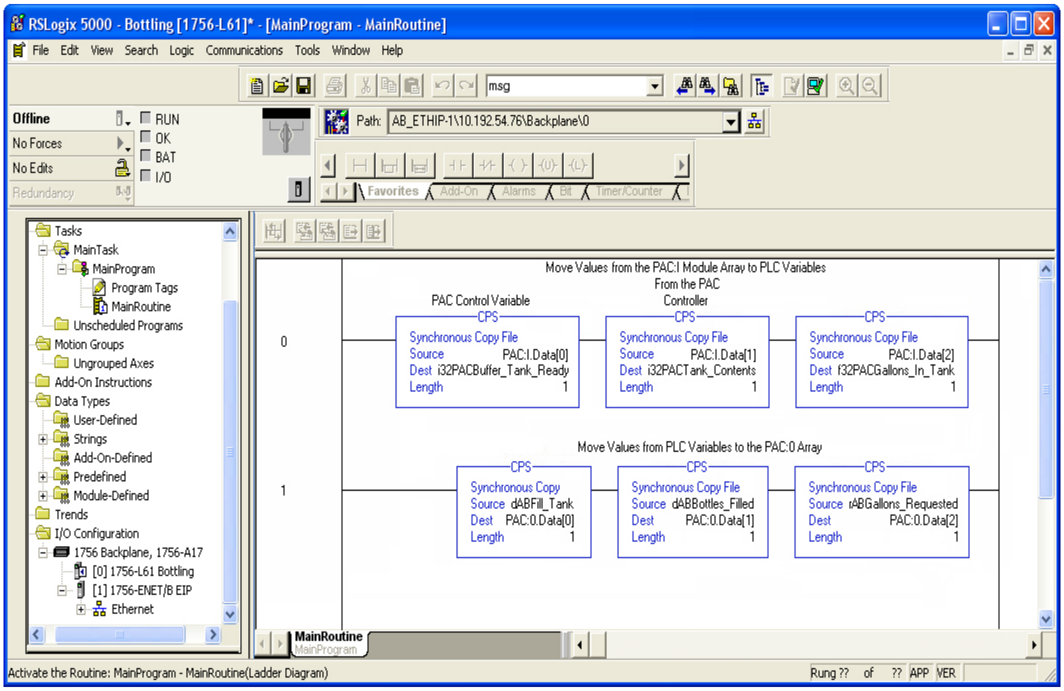
Requested Packet Interval (RPI): 500.0 ms (1.0 - 3200.0 ms)
□ Inhibit Module
□ Major Fault On Controller If Connection Fails While in Run Mode

Module Fault

Status: Offline

4. You're almost done. Now you just need to add a few CPS commands to copy the Generic Ethernet Module's data to and from local variables of the ladder.

Here's a screen shot of the complete CPS instructions in the ladder.



Path: AB_ETHIP-1\10.192.54.76\Backplane\0

Rung 0 — Move Values from the PAC:I Module Array to PLC Variables

PAC Control Variable

CPS	Synchronous Copy File	
Source	PAC:I.Data[0]	
Dest	i32PACBuffer_Tank_Ready	
Length	1	

From the PAC Controller

CPS	Synchronous Copy File
Source	PAC:I.Data[1]
Dest	i32PACTank_Contents
Length	1

CPS	Synchronous Copy File
Source	PAC:I.Data[2]
Dest	f32PACGallons_In_Tank
Length	1

Rung 1 — Move Values from PLC Variables to the PAC:0 Array

CPS	Synchronous Copy
Source	dABFill_Tank
Dest	PAC:0.Data[0]
Length	1

CPS	Synchronous Copy File
Source	dABBottles_Filled
Dest	PAC:0.Data[1]
Length	1

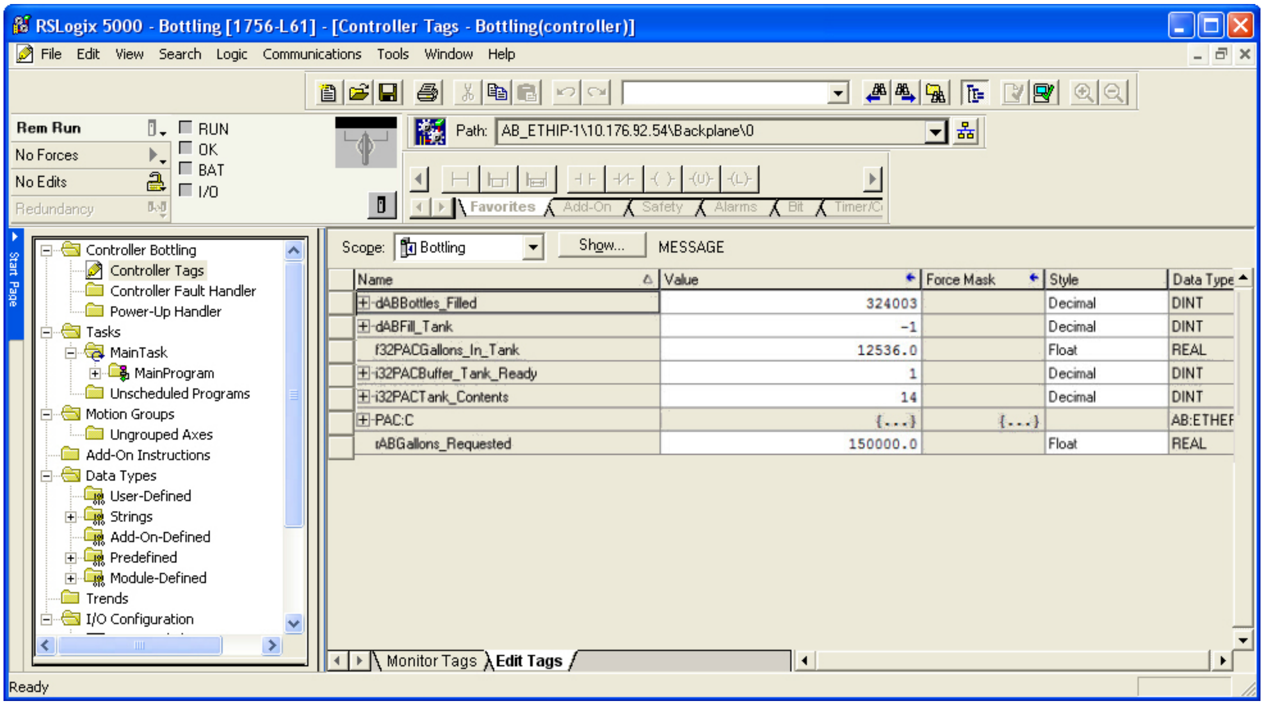
CPS	Synchronous Copy File
Source	rABGallons_Requested
Dest	PAC:0.Data[2]
Length	1

Activate the Routine: MainProgram - MainRoutine(Ladder Diagram)

Now the ladder is ready to be downloaded.

Exchanging Data Online

When online, RSLogix will populate value fields something like this:

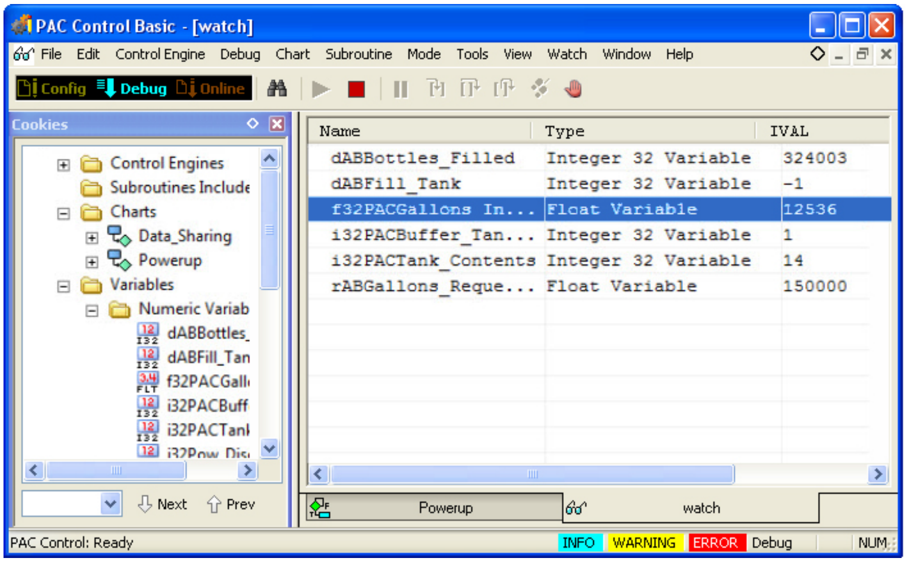


Path: AB_ETHIP-1\10.176.92.54\Backplane\0

Scope: Bottling MESSAGE

Name	Value	Force Mask	Style	Data Type
dABBottles_Filled	324003		Decimal	DINT
dABFill_Tank	-1		Decimal	DINT
f32PACGallons_In_Tank	12536.0		Float	REAL
i32PACBuffer_Tank_Ready	1		Decimal	DINT
i32PACTank_Contents	14		Decimal	DINT
PAC:C	{...}	{...}		AB:ETHEF
rABGallons_Requested	150000.0		Float	REAL

As shown here, you can create a watch window in PAC Control to see the exchanged values.



Name	Type	IVAL
dABBottles_Filled	Integer 32 Variable	324003
dABFill_Tank	Integer 32 Variable	-1
f32PACGallons_In...	Float Variable	12536
i32PACBuffer_Tan...	Integer 32 Variable	1
i32PACTank_Contents	Integer 32 Variable	14
rABGallons_Reque...	Float Variable	150000

More Ideas for Accessing Data

Once the data is exposed into the PAC Controller's scratchpads, the following methods are available to access it.

OptoOPCServer

The Opto 22 OptoOPCServer is a high-performance, multithreaded OPC DA 2.0 complaint data server. Using SCADAs and OPC Clients to access data, the scratchpad registers created in the example exercise are accessible using the OptoOPCServer. The following table translates which variables belong to the appropriate tags:

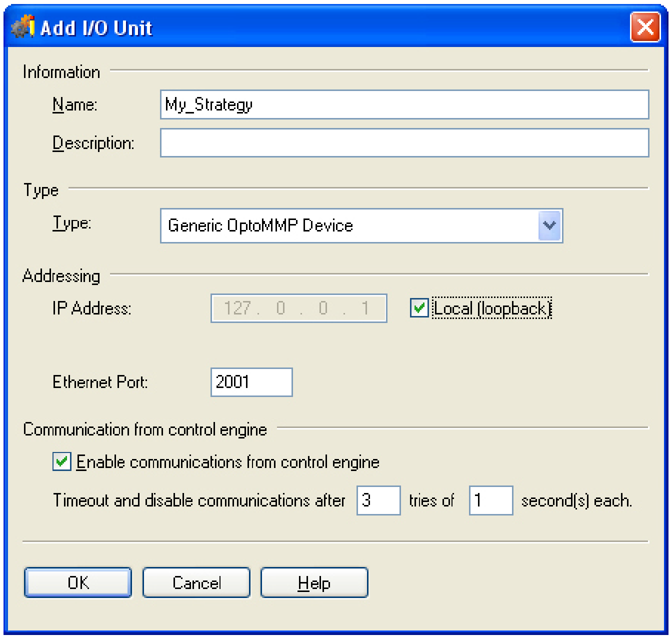
Shared Variable	OPC Item ID
i32PACBuffer_Tank_Ready	[mmio|ip|tcp:10.192.54.75:2001]sp_integer[0]
i32PACTank_Contents	[mmio|ip|tcp:10.192.54.75:2001]sp_integer[1]
dABFill_Tank	[mmio|ip|tcp:10.192.54.75:2001]sp_integer[2]
dABBottles_Filled	[mmio|ip|tcp:10.192.54.75:2001]sp_integer[3]
f32PACGallons_In_Tank	[mmio|ip|tcp:10.192.54.75:2001]sp_float[0]
rABGallons_Requested	[mmio|ip|tcp:10.192.54.75:2001]sp_float[1]

PAC Display

Once the data is available in the scratchpads, they may also be displayed in PAC Display, Opto 22's HMI package. To access the scratchpads of the PAC controller, download and install both PAC Display Basic and PAC Control Basic, both free software packages available on the Opto 22 website, www.Opto22.com.

Using PAC Control Basic, doing the following:

1. Create a new strategy (File > New Strategy).
2. Right-click the I/O units folder and choose Add to open the Add I/O Unit dialog box.
3. Provide a name, and select the Type as follows:
   - For a SNAP-PAC-S series controller, select the Generic OptoMMP Device.
   - For a SNAP-PAC-R1 or SNAP-PAC-EB1, select SNAP-PAC-R1.
   - For a SNAP-PAC-R2 or SNAP-PAC-EB2, select SNAP-PAC-R2.



Add I/O Unit

Information

Name: My_Strategy

Description:

Type

Type: Generic OptoMMP Device

Addressing

IP Address: 127 . 0 . 0 . 1 ☑ Local (loopback)

Ethernet Port: 2001

Communication from control engine

☑ Enable communications from control engine

Timeout and disable communications after 3 tries of 1 second(s) each.

4. Save and close your strategy.

Use your new strategy as the tag database into PAC Display.

Using the Free Opto MMP Toolkit

If you wish to use a custom PC application to access the data, use the OptoMMP Communication Toolkit to access the scratchpad registers. The free kit is available on the Opto 22 website, www.Opto22.com. Search for part number IOP-DEV-OPTOMMP.

7: Using EtherNet/IP Configurator

This chapter expands on the information in the previous chapters about EtherNet/IP Configurator and includes additional topics not covered there.

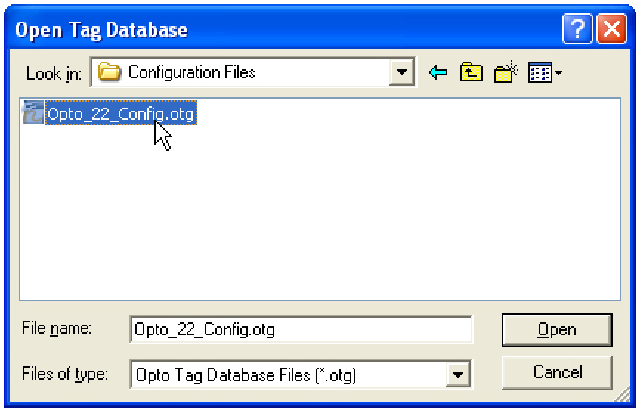
In this Chapter

Importing an Existing Configuration

If you have an I/O configuration created in EtherNet/IP Configurator, you can import its otg (Opto Tag Database) file and from it create a new configuration.

NOTE: You can also use an otg file created in Opto 22*'s PAC Control or PAC Manager. For more information, see the user's guides for those products, form 1700 (for PAC Control) and form 1704 (for PAC Manager).*

1. In the EtherNet/IP Configurator main window, click the Open button 🗋 or choose File > Open to open the Tag Database dialog box.



Open Tag Database

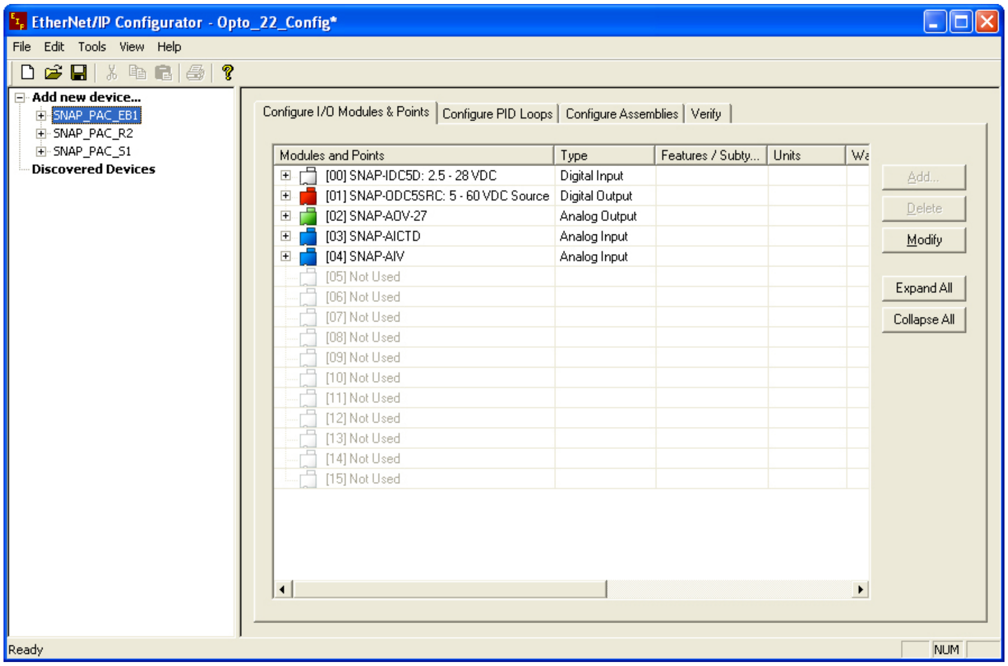
Look in: Configuration Files

Opto_22_Config.otg

File name: Opto_22_Config.otg

Files of type: Opto Tag Database Files (*.otg)

2. Locate the configuration (otg) file and click Open.



EtherNet/IP Configurator - Opto_22_Config*

Modules and Points	Type	Features / Subty...	Units	Wa
[00] SNAP-IDC5D: 2.5 - 28 VDC	Digital Input			
[01] SNAP-ODC5SRC: 5 - 60 VDC Source	Digital Output			
[02] SNAP-AOV-27	Analog Output			
[03] SNAP-AICTD	Analog Input			
[04] SNAP-AIV	Analog Input			
[05] Not Used				
[06] Not Used				
[07] Not Used				
[08] Not Used				
[09] Not Used				
[10] Not Used				
[11] Not Used				
[12] Not Used				
[13] Not Used				
[14] Not Used				
[15] Not Used				

Uploading a Configuration from an Opto 22 Device

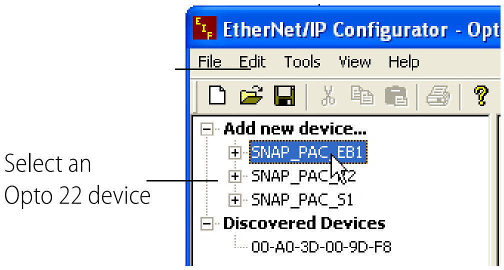
If there is an existing configuration that you want to use loaded on an Opto 22 device, you can upload it to EtherNet/IP Configurator, and then modify it (if necessary) and reuse it on another device.

NOTE: When uploading EtherNet/IP configurations from PAC devices, the following information is not stored on the I/O unit and thus is lost during the upload.

- *PID names*
- *PID descriptions*
- *Point descriptions*
- *4-channel digital module types*
- *Assembly Instance descriptions*

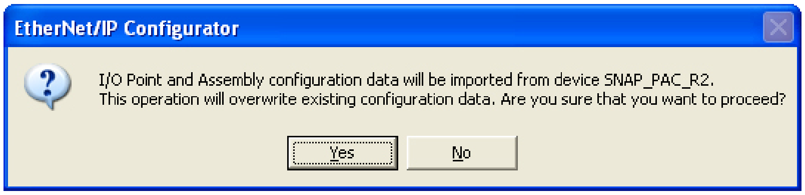
To upload a configuration:

1. In the device tree, select the Opto 22 device with the configuration you want to load.



2. Choose Tools > Upload Configuration from Opto 22 Device.

   The following dialog box appears.



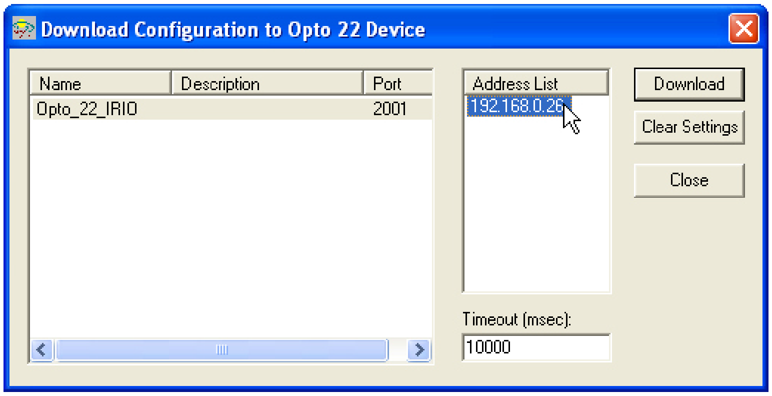
EtherNet/IP Configurator

I/O Point and Assembly configuration data will be imported from device SNAP_PAC_R2.
This operation will overwrite existing configuration data. Are you sure that you want to proceed?

3. Click Yes to upload the configuration data. This action overwrites the device's existing configuration data for any module position that is the same as the new configuration data.

Downloading a Configuration

1. To save the configuration, choose File > Save As, browse to an appropriate directory, name the file (for example, Opto_IO), and then click Save.
2. Click the Verify tab and then click the Download button. (Or you can choose Tools > Download Configuration to Opto 22 Device.)
3. In the Download Configuration dialog box, select the device's IP address, and then click Download.



Name	Description	Port
Opto_22_IRIO		2001

Address List: 192.168.0.26

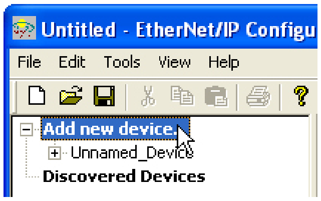
Timeout (msec): 10000

4. When the configuration has downloaded successfully, click Close.

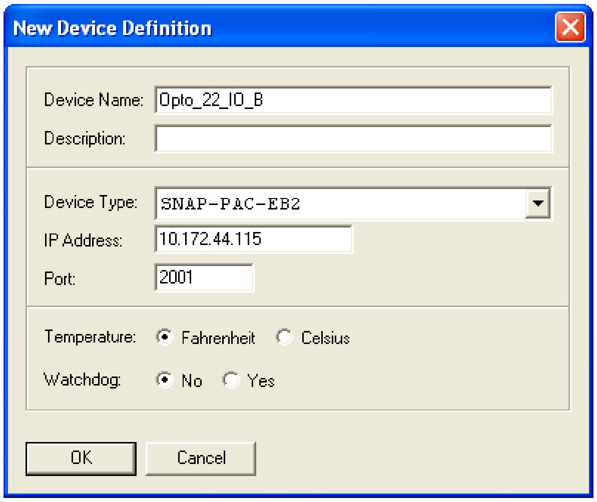
Adding a Device Manually

In addition to being able to add a discovered device, you can also add a device manually. To add a discovered device, see "Adding an Opto 22 Device" on page 12.

1. In the device tree, double-click Add new device.



2. In the New Device Definition dialog box, at *minimum* enter the Device Name, select the Device Type, and enter the IP address for the device.



New Device Definition

Device Name: Opto_22_IO_B

Description:

Device Type: SNAP-PAC-EB2

IP Address: 10.172.44.115

Port: 2001

Temperature: ● Fahrenheit ○ Celsius

Watchdog: ● No ○ Yes

Device Name. Enter a name for the remote I/O. The name must start with a letter and may contain letters, numbers, and underscores. (Spaces are converted to underscores.)

Device Type. Choose the part number of the Opto 22 device from the drop-down list.

IP Address. Enter the IP address of the device.

NOTE: Changing the IP address in this dialog box does not change the IP address on the device. If you want to change the IP address on the device, see "Changing a Device's IP Address" on page 80.

Port. The default Ethernet port number is 2001 for communication with the Opto 22 device. If you have changed this port for security purposes, also change it here. (See the device's user guide for details.)

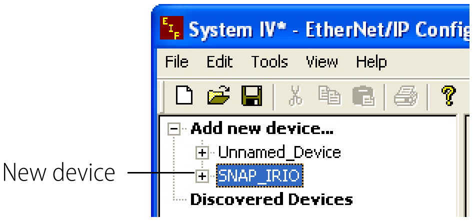
Temperature. Choose whether temperatures will be handled in Fahrenheit or Celsius.

Watchdog. Select whether you want a Watchdog on the unit. The default is No (disabled). If you select Yes, a new field appears; enter the Watchdog timeout value (in seconds). The default timeout is 0.5 seconds.

NOTE: If you want to enable Watchdog on a point, make sure to enable it here at the device level as well.

3. Click OK.

The new device appears in the device tree.



System IV* - EtherNet/IP Config

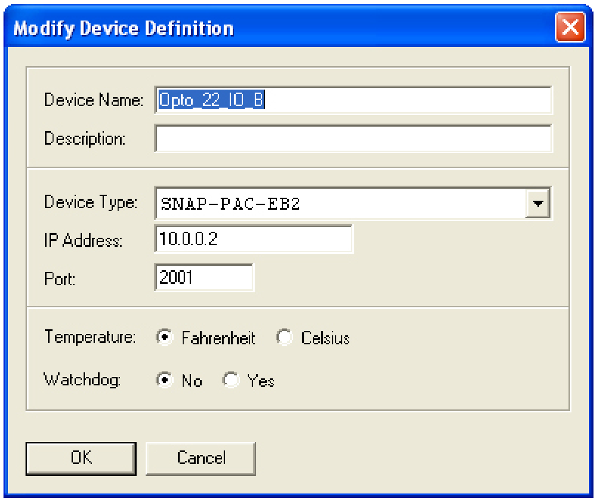
Add new device...
- Unnamed_Device
- SNAP_IRIO

Discovered Devices

Modifying a Device

Do the following steps to change a device's information.

1. In the device tree, double-click the device to open the Modify Device Information dialog box.
2. See "Adding an Opto 22 Device" on page 12 for tips on how to use this dialog box.



Modify Device Definition

Device Name: Opto_22_IO_B

Description:

Device Type: SNAP-PAC-EB2

IP Address: 10.0.0.2

Port: 2001

Temperature: ● Fahrenheit ○ Celsius

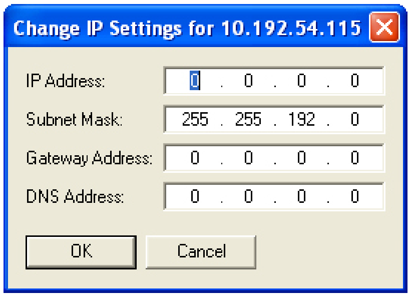
Watchdog: ● No ○ Yes

NOTE: Changing the IP address in this dialog box does not change the IP address on the device. If you want to change the IP address on the device, see "Changing a Device's IP Address" (below).

3. Click OK to confirm the changes.

Changing a Device's IP Address

1. Right-click the device in the device tree and choose Change IP Settings to open the Change IP Settings dialog box.



Change IP Settings for 10.192.54.115

IP Address: 0 . 0 . 0 . 0

Subnet Mask: 255 . 255 . 192 . 0

Gateway Address: 0 . 0 . 0 . 0

DNS Address: 0 . 0 . 0 . 0

2. Enter the IP Address and the Subnet Mask for the device. If it will be talking to a device on another subnet, enter the Gateway (router) address. If it will talk only on the local subnet, leave the gateway address all zeros (0.0.0.0). Leave the DNS address at 0.0.0.0 and the Host Name field blank.

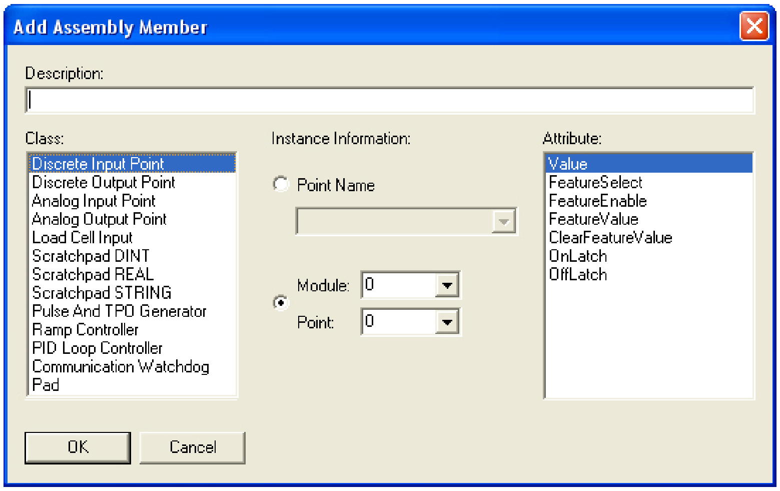
NOTE: Make sure the EB1 is on the same subnet as the computer and the PLC.

WARNING! Each device on your network, including computers, routers, controllers, brains, and so on, must have a unique IP address. Failure to assign unique IP addresses may cause catastrophic network or hardware failures. If you don't know which IP addresses are safe to use, check with your system administrator.

3. When the IP address, subnet mask, and other fields are correct, click OK.

Adding and Deleting Assembly Elements

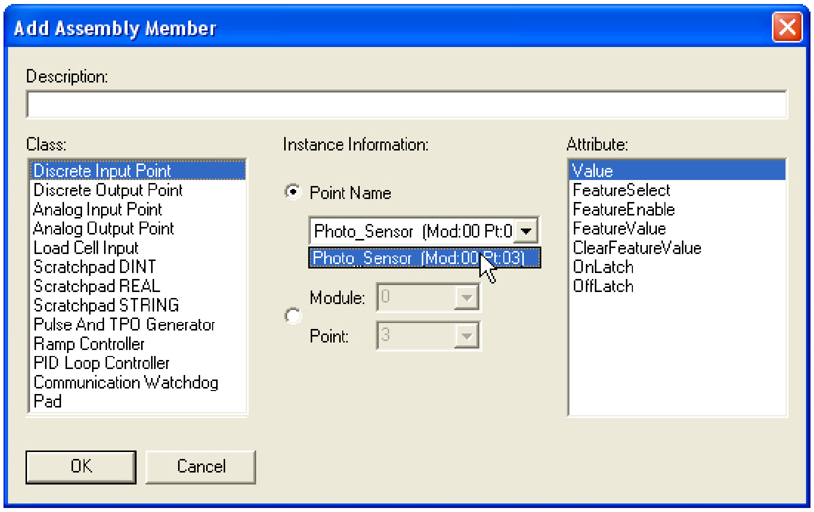
1. Click the Configure Assemblies tab, and then click the Add button to open the Add/Modify dialog box.



2. Select a class from the list on the left.

The classes available for implicit messaging in the EtherNet/IP Configurator are a subset of the CIP classes, all of which are available through explicit messaging. For information on the CIP classes and attributes, see form 1770, *Ethernet/IP for SNAP PAC Protocol Guide*.

3. Under Instance Information, select a point that you have configured. Otherwise, you can assign an assembly member to a specific module and point based on their position on the rack. (See page 106 for module and point addressing.)



Add Assembly Member

Description:

Class:

- Discrete Input Point
- Discrete Output Point
- Analog Input Point
- Analog Output Point
- Load Cell Input
- Scratchpad DINT
- Scratchpad REAL
- Scratchpad STRING
- Pulse And TPO Generator
- Ramp Controller
- PID Loop Controller
- Communication Watchdog
- Pad

Instance Information:

● Point Name

Photo_Sensor (Mod:00 Pt:0

Photo_Sensor (Mod:00 Pt:03)

○ Module: 0

Point: 3

Attribute:

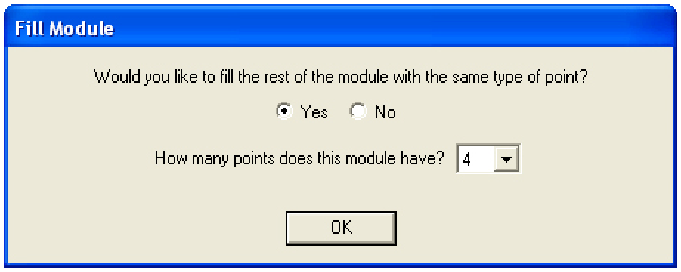
- Value
- FeatureSelect
- FeatureEnable
- FeatureValue
- ClearFeatureValue
- OnLatch
- OffLatch

4. Under Attribute, select an item in the list.

   The attribute list allows you to define what information from each point you want to have passed in the implicit message. In addition to value readings, you can get other data, such as the minimum or maximum value that the point has ever reached. This is a great way to attain an alarm level without having to write logic in your RSLogix program that stores the high value.

5. Click OK and follow any directions that appear for the class.

   For example, the Fill Module dialog box appears for Discrete Input Point and Analog Input Point.



Fill Module

Would you like to fill the rest of the module with the same type of point?

● Yes ○ No

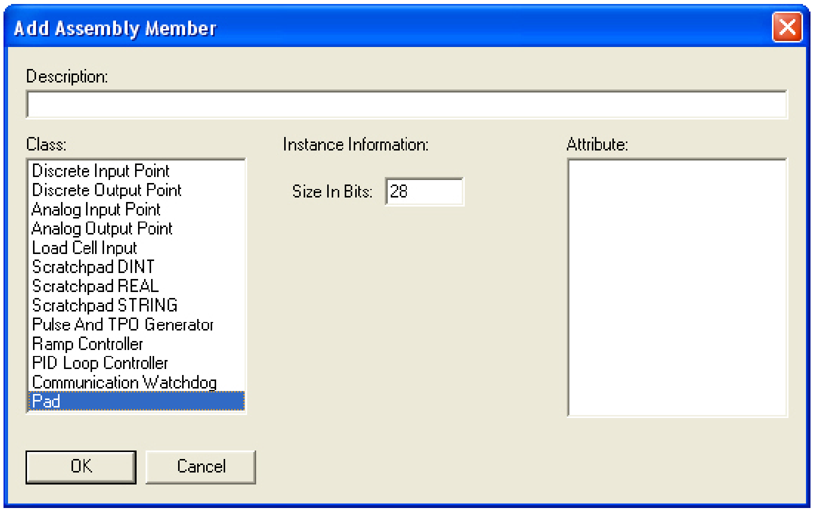
How many points does this module have? 4

6. Click OK.
7. Continue to add elements as necessary.

   NOTE: If an assembly member or group of members adds up to less than 32-bits, you will need to add padding.

8. To add a pad, click the Add button to open the Add/Modify dialog box.

9. Under Class, select Pad, enter size of the pad (for example, 28), and click OK.



Class: Pad

Size In Bits: 28

The pad appears as the last member of element 0 to complete the 32-bit word.

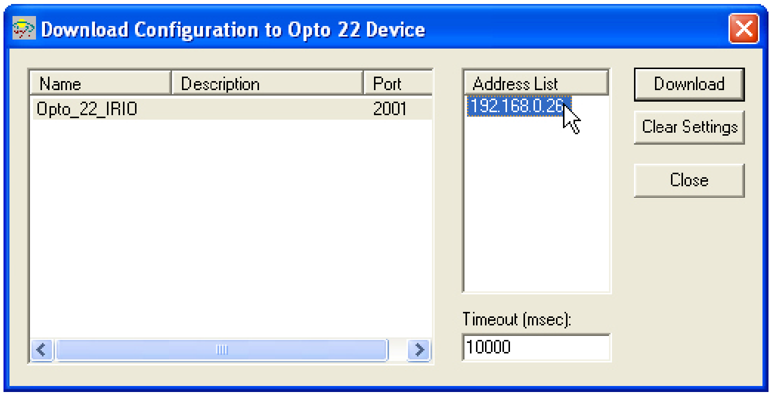
10. To save the configuration, choose File > Save As, browse to an appropriate directory, name the file (for example, Opto_IO), and then click Save.

11. Click the Verify tab and then click the Download button. (Or you can choose Tools > Download Configuration to Opto 22 Device.)

12. In the Download Configuration dialog box, select the device's IP address, and then click Download.

NOTE: Make sure that the SNAP I/O is properly configured with a SNAP PAC EB-series or R-series brain loaded with firmware R8.3a or newer, and that the proper I/O modules are installed. Otherwise, errors will occur.

The configuration is permanently stored in the device.

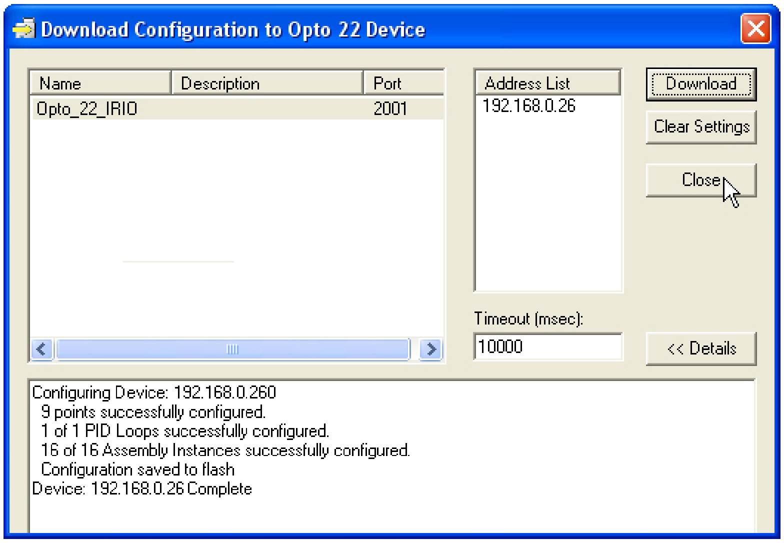


Name	Description	Port
Opto_22_IRIO		2001

Address List: 192.168.0.26

Timeout (msec): 10000

13. When the configuration has downloaded successfully, click Close.



Name	Description	Port
Opto_22_IRIO		2001

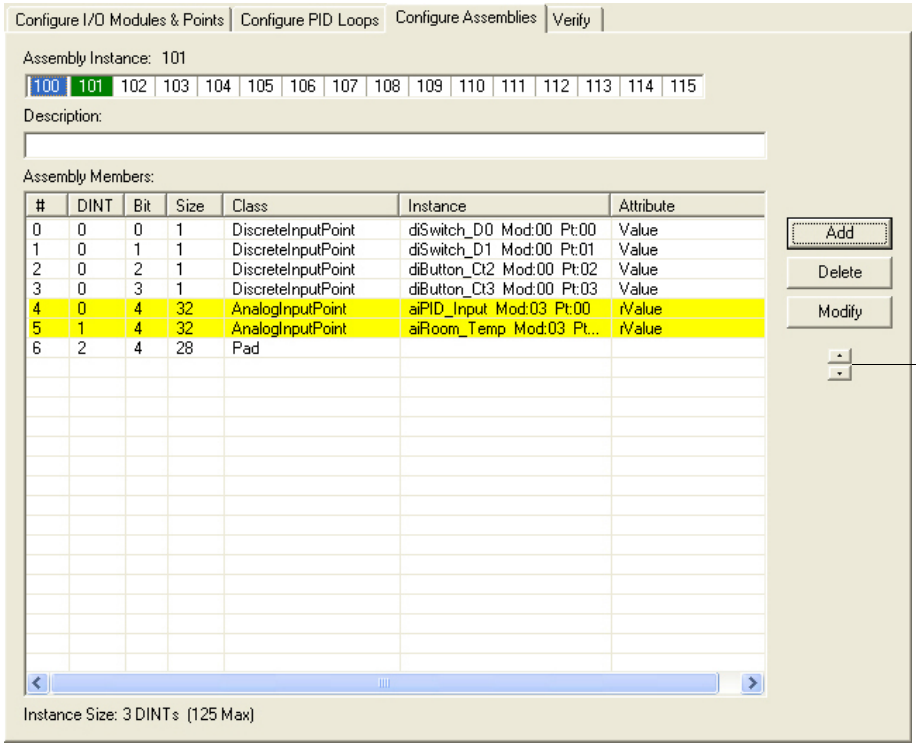
Address List: 192.168.0.26

Timeout (msec): 10000

```
Configuring Device: 192.168.0.260
 9 points successfully configured.
 1 of 1 PID Loops successfully configured.
 16 of 16 Assembly Instances successfully configured.
 Configuration saved to flash
Device: 192.168.0.26 Complete
```

Moving Assembly Members

The Up and Down arrows allow you to move assembly members up and down in the assembly. For example, if a pad is in the wrong place, some of the assembly members will be highlighted in yellow as shown here:



Assembly Instance: 101

Description:

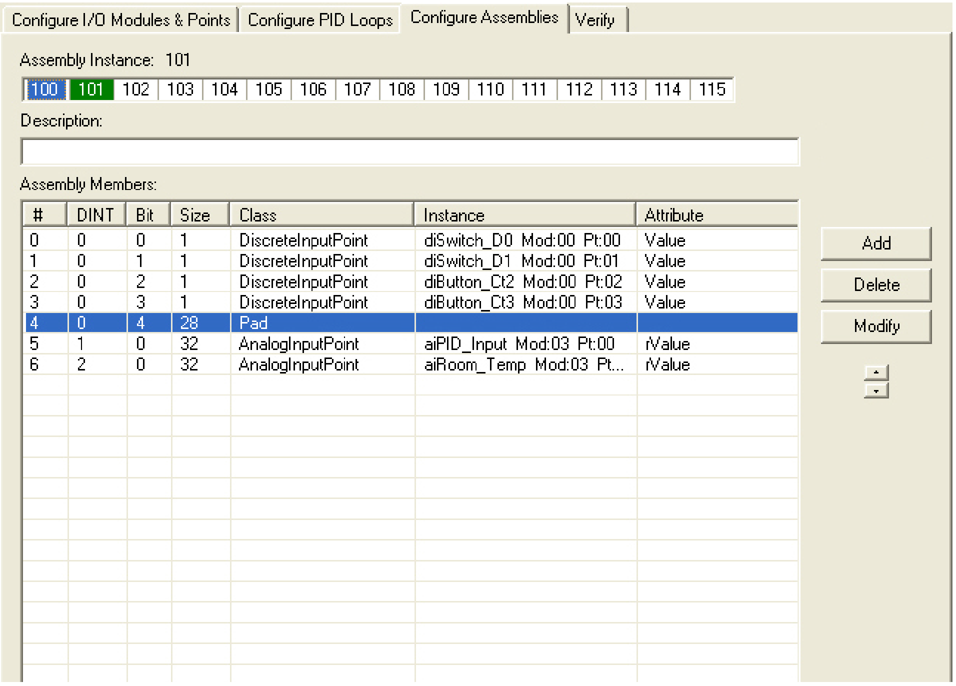
Assembly Members:

#	DINT	Bit	Size	Class	Instance	Attribute
0	0	0	1	DiscreteInputPoint	diSwitch_D0 Mod:00 Pt:00	Value
1	0	1	1	DiscreteInputPoint	diSwitch_D1 Mod:00 Pt:01	Value
2	0	2	1	DiscreteInputPoint	diButton_Ct2 Mod:00 Pt:02	Value
3	0	3	1	DiscreteInputPoint	diButton_Ct3 Mod:00 Pt:03	Value
4	0	4	32	AnalogInputPoint	aiPID_Input Mod:03 Pt:00	fValue
5	1	4	32	AnalogInputPoint	aiRoom_Temp Mod:03 Pt...	fValue
6	2	4	28	Pad		

Instance Size: 3 DINTs (125 Max)

Up and Down arrows

To move the pad, select it and click the appropriate arrow to move the pad into its proper place.



Assembly Instance: 101

Description:

Assembly Members:

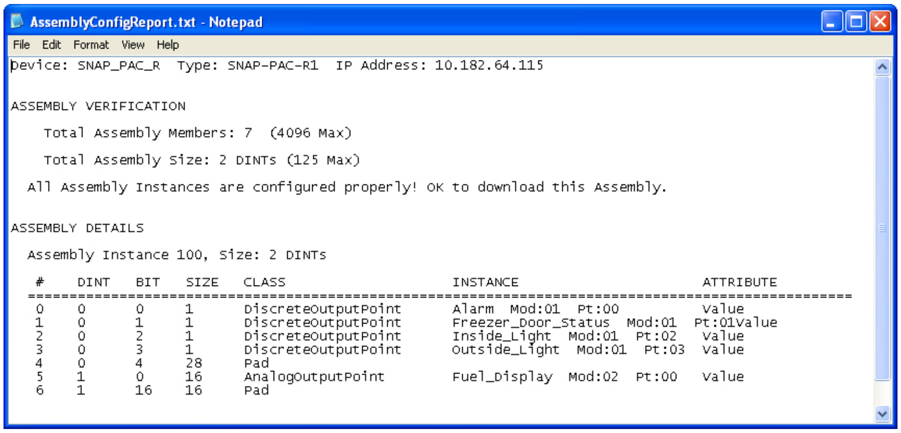
#	DINT	Bit	Size	Class	Instance	Attribute
0	0	0	1	DiscreteInputPoint	diSwitch_D0 Mod:00 Pt:00	Value
1	0	1	1	DiscreteInputPoint	diSwitch_D1 Mod:00 Pt:01	Value
2	0	2	1	DiscreteInputPoint	diButton_Ct2 Mod:00 Pt:02	Value
3	0	3	1	DiscreteInputPoint	diButton_Ct3 Mod:00 Pt:03	Value
4	0	4	28	Pad		
5	1	0	32	AnalogInputPoint	aiPID_Input Mod:03 Pt:00	rValue
6	2	0	32	AnalogInputPoint	aiRoom_Temp Mod:03 Pt...	rValue

The input assembly instance is now once again formatted properly with 32-bit words.

Viewing a Configuration Report

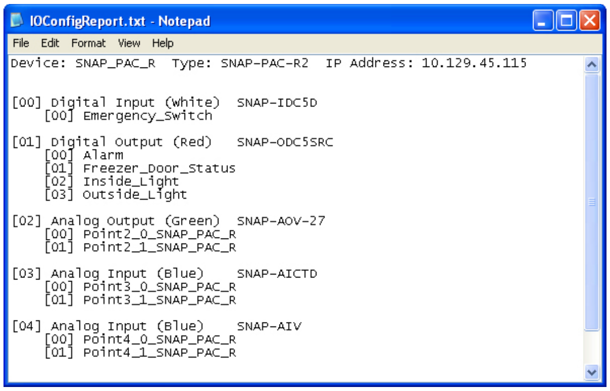
Available in the Tools menu are reports that provide a snapshot view of the configured assemblies and I/O.

An *Assembly Configuration Report* shows all of the entries contained in the current assembly instance, including the element number, bit size, and description. It also indicates any errors and whether or not the assembly is configured properly for download. It is helpful to check for errors in this report *before you download the configuration* to the device.


AssemblyConfigReport.txt - Notepad
File Edit Format View Help

```
Device: SNAP_PAC_R   Type: SNAP-PAC-R1   IP Address: 10.182.64.115


ASSEMBLY VERIFICATION

    Total Assembly Members: 7  (4096 Max)

    Total Assembly Size: 2 DINTs (125 Max)

  All Assembly Instances are configured properly! OK to download this Assembly.


ASSEMBLY DETAILS

  Assembly Instance 100, Size: 2 DINTs

   #    DINT   BIT   SIZE   CLASS                     INSTANCE                      ATTRIBUTE
  ==================================================================================================
   0    0      0     1      DiscreteOutputPoint       Alarm  Mod:01  Pt:00          Value
   1    0      1     1      DiscreteOutputPoint       Freezer_Door_Status  Mod:01  Pt:01Value
   2    0      2     1      DiscreteOutputPoint       Inside_Light  Mod:01  Pt:02   Value
   3    0      3     1      DiscreteOutputPoint       Outside_Light  Mod:01  Pt:03  Value
   4    0      4     28     Pad
   5    1      0     16     AnalogOutputPoint         Fuel_Display  Mod:02  Pt:00   Value
   6    1      16    16     Pad
```

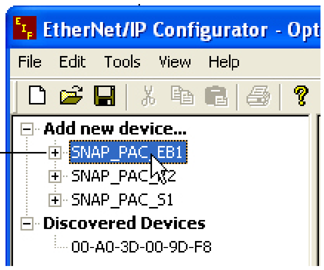
The *I/O Modules and Points Configuration Report* lists the modules and points configured for the selected device.



```
Device: SNAP_PAC_R  Type: SNAP-PAC-R2  IP Address: 10.129.45.115


[00] Digital Input (White)  SNAP-IDC5D
    [00] Emergency_Switch

[01] Digital Output (Red)   SNAP-ODC5SRC
    [00] Alarm
    [01] Freezer_Door_Status
    [02] Inside_Light
    [03] Outside_Light

[02] Analog Output (Green)  SNAP-AOV-27
    [00] Point2_0_SNAP_PAC_R
    [01] Point2_1_SNAP_PAC_R

[03] Analog Input (Blue)    SNAP-AICTD
    [00] Point3_0_SNAP_PAC_R
    [01] Point3_1_SNAP_PAC_R

[04] Analog Input (Blue)    SNAP-AIV
    [00] Point4_0_SNAP_PAC_R
    [01] Point4_1_SNAP_PAC_R
```

To view a configuration report:

1. In the device tree, select an Opto 22 device.



Select an Opto 22 device

2. From the Tools menu, choose either Assembly Configuration Report or I/O Modules and Points Configuration Report.

   A text file opens showing the configuration report.

Configuring PID Loops

PID loops (or simply PIDs) are used to drive an input (a process variable) toward a particular value (the setpoint) and keep the input very close to that value by controlling an output. For example, consider temperature control, where the input is a measurement of ambient temperature, the setpoint is the desired temperature, and the output is a heater. The PID for this system will use a mathematical formula that controls the output to maintain a desired temperature, efficiently adjust to changes in setpoint, and compensate for changes in load, such as the influx of cold air. In this example, a temperature sensor (analog input), a thermostat (analog input), and a heater control (analog output) are components of one system, controlled by a PID loop.

This guide assumes that you are already familiar with using PIDs. PID calculations are complex and the physical qualities of systems suitable for PID control differ greatly. This guide includes only basic information for configuring PIDs.

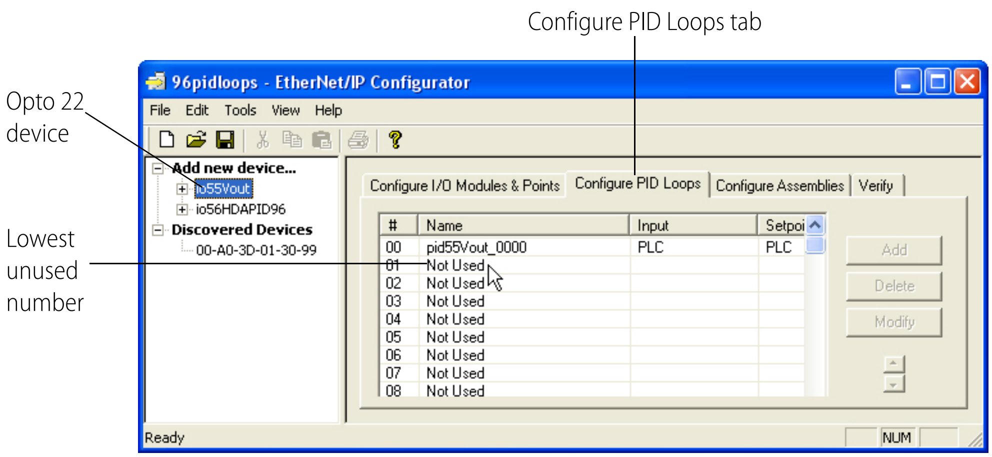
SNAP PAC I/O units support 96 PID loops. PIDs can control isolated systems or be part of cascaded systems where one loop controls the setpoints or input variables of others.

Adding a PID Loop

The PID operates at the I/O unit, independently of the controller. Once configured and downloaded to the brain, a PID operates until the I/O unit loses power. Remember that changes are not written to the I/O unit until the configuration is downloaded to the Opto 22 device. Each PID loop must be individually configured and tuned.

Tuning steps are described in "Inspecting and Tuning PID Loops" on page 92. For additional information, see form 1641, *OptoTutorial: SNAP PAC PID*.

1. In EtherNet/IP Configurator, select the Opto 22 device, and then click the Configure PID Loops tab.



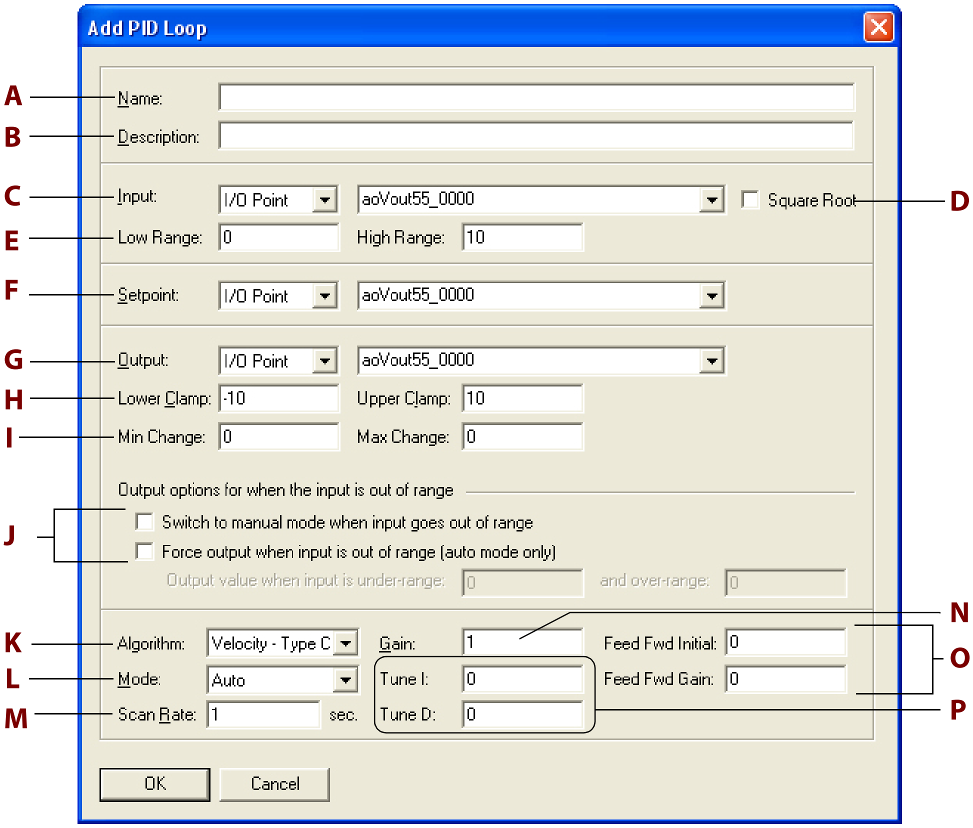
Configure PID Loops tab

Opto 22 device

Lowest unused number

#	Name	Input	Setpoi
00	pid55Vout_0000	PLC	PLC
01	Not Used		
02	Not Used		
03	Not Used		
04	Not Used		
05	Not Used		
06	Not Used		
07	Not Used		
08	Not Used		

2. Double-click the lowest unused number to open the Add PID Loop dialog box.
3. Complete the Add PID Loop dialog box as detailed below, and then click OK.



Add PID Loop

Name:

Description:

Input: I/O Point aoVout55_0000 □ Square Root

Low Range: 0 High Range: 10

Setpoint: I/O Point aoVout55_0000

Output: I/O Point aoVout55_0000

Lower Clamp: -10 Upper Clamp: 10

Min Change: 0 Max Change: 0

Output options for when the input is out of range

□ Switch to manual mode when input goes out of range

□ Force output when input is out of range (auto mode only)

Output value when input is under-range: 0 and over-range: 0

Algorithm: Velocity - Type C Gain: 1 Feed Fwd Initial: 0

Mode: Auto Tune I: 0 Feed Fwd Gain: 0

Scan Rate: 1 sec. Tune D: 0

A **Name**: Type a unique, descriptive name for the PID. The name must start with a letter and may contain letters, numbers, and underscores (spaces are converted to underscores).

B Description: (Optional) Enter a description of the PID.

C Input: Select the type of input: I/O Point, PLC, or PID Output.

- If the PID's process variable comes from an I/O point on the same unit, select I/O Point. Choose the point from the drop-down list or type a point name to configure a new point.
- If the PID's process variable comes from the Allen-Bradley controller, select PLC. Enter an initial value for the input.
- If the PID's process variable is the output of another PID on this brain (a cascading control loop), select PID Output. Choose the PID from the drop-down list.

D **Square Root**: (Optional) If you chose I/O Point or PID for step C, check this box if the error should be calculated based on the square root of the process variable (applies to flow control systems where volumetric flow is proportional to the square root of a signal from a flow transducer).

E **Low/High Range**: Set the valid range of the process variable by entering the low range and the high range. (See Output Options for optional responses to out-of-range input.)

F **Setpoint**: Choose the source for the setpoint: I/O Point, PLC, or PID Output.

- To control the setpoint using a device (on the same brain) such as a potentiometer, select I/O Point; choose an I/O point from the drop-down list or type a new point name.
- To control setpoint using the Allen-Bradley controller, select PLC. For Initial Value, *enter the most common operating value*.

- If another PID loop will control the setpoint, select PID Output and choose the PID from the drop-down list.

G **Output**: Choose the destination for the PID output: I/O Point or PLC. (To use the output for controlling the setpoint or input of another PID, choose PLC.)

H **Lower Clamp/Upper Clamp**: Enter upper and lower clamp values to prevent the output from exceeding a desirable range. These values should equal the range of the output point, if used. Or choose values to make sure that the output device doesn't shut off (for example, keeping a circulation pump running regardless of the PID output) or that the output never reaches a destructively high setting (for example, keeping a motor below maximum).

I **Min Change/Max Change**: (Optional) Enter minimum and maximum change values. The output won't respond until the minimum change is reached (for example, you may not want a heater to turn on to correct a 1 degree error). Maximum change prevents too drastic a change in output (for example, you could limit the increase in a pump's output to prevent pipe breakage). The default for both minimum and maximum is zero, which disables the feature.

J **Output Options**: Choose how the PID should respond if the input goes out of range. To have RSLogix logic or an operator respond, check Switch to manual mode. To force the output to a specific value, check that option and type the output values.

NOTE: If both boxes are checked (forced output and manual mode), the output will be forced and the PID put into manual mode; but if the PID is already in manual mode, the output will not be forced.

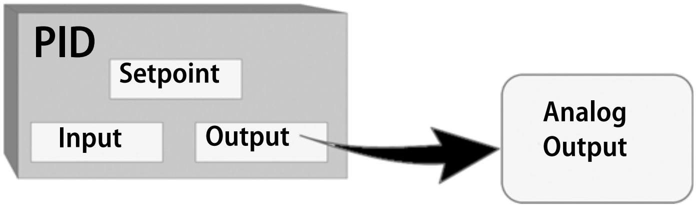
If neither box is checked and the PID input goes out of range (as defined by E– High/Low Range) then the output will freeze, but only while the input is out of range.

K **Algorithm**: Choose an algorithm: Velocity (Type C), ISA, Parallel, or Interacting. For details on algorithms, see "Algorithm Choices" on page 91.

L **Mode**: Choose the Mode you want the PID to be initialized to. The main difference between Automatic and Manual mode is that in Manual mode the PID loop stops its mathematical calculation. In both modes the PID's output value is still copied to the analog output.

- Auto mode: The PID makes calculations based on the difference between the input and the setpoint resulting in changes to the output, which causes the input to move toward the setpoint.
- Manual mode: The PID stops making changes to the output, but continues to write the PID output to the analog point (or configured destination for the PID output). Manual mode allows RSLogix logic or an operator to control the PID output, which in turn is written by the PID loop to the analog point (or configured destination of the PID output).

NOTE: If the value of the analog point or configured destination is changed, it will be overwritten by the PID output.



M **Scan Rate**: Enter a scan rate to determine how often the input is scanned and the controller output is calculated. Minimum value is 0.001 (1 ms). Scan time should be greater than system lag (the time it takes for the controller output to have a measurable effect on the system). Also consider other PIDs and tasks on the brain competing for processing power.

N **Gain**: Type a positive or negative value for Gain. Heating systems usually require a negative value and cooling systems a positive value.

NOTE: Gain is usually refined during the tuning process.

O **Fd Fwd Initial/Fd Fwd Gain**: (Optional) Enter Feed forward Initial and Feed forward gain values if you need to offset the controller output in your application. These values are constants that are multiplied and added to the controller output; often they are not used in PIDs.

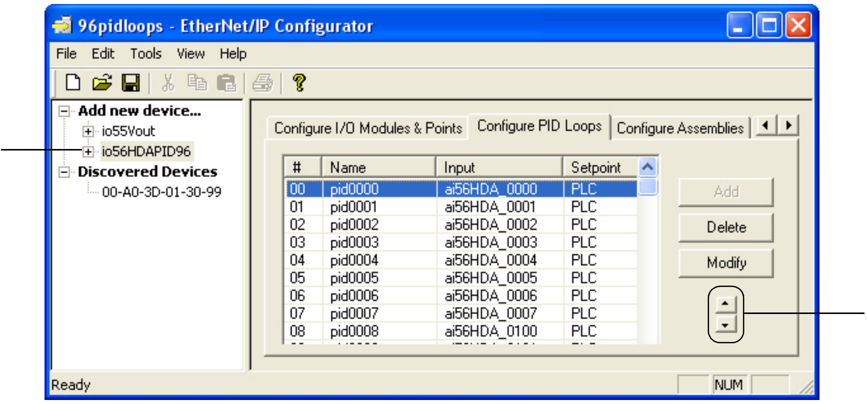
P **Tune I/Tune D**: (Optional) Type Integral and Derivative settings if you know the desirable settings. However, Integral and Derivative are not essential to basic configuration and are better determined in the tuning process.

Changing a PID Loop

You can change the PID loop's configuration and its position in the I/O unit.

1. In EtherNet/IP Configurator, select the Opto 22 device, and then click the Configure PID Loops tab.

The Configure PID Loops tab lists all configured PID loops. Remember that the number of PID loops available depends on the Opto 22 device.



#	Name	Input	Setpoint
00	pid0000	ai56HDA_0000	PLC
01	pid0001	ai56HDA_0001	PLC
02	pid0002	ai56HDA_0002	PLC
03	pid0003	ai56HDA_0003	PLC
04	pid0004	ai56HDA_0004	PLC
05	pid0005	ai56HDA_0005	PLC
06	pid0006	ai56HDA_0006	PLC
07	pid0007	ai56HDA_0007	PLC
08	pid0008	ai56HDA_0100	PLC

Selected device

Up- and down-arrows

PID loops are scanned by the I/O unit in the order that they appear in this list.

2. To move the PID loop to a different position on the I/O unit, use the up- and down-arrows in the dialog box.
3. To change the PID loop's configuration, double-click its name to open the Edit PID Loop dialog box. Change the fields as necessary.

   For help in completing the fields, see "Adding a PID Loop" on page 87.

Deleting a PID Loop

Only PID loops that have a reference count of zero can be deleted. Be careful when deleting PID loops; you cannot undo a deletion.

1. In EtherNet/IP Configurator, select the Opto 22 device, and then click the Configure PID Loops tab.
2. Right-click the name of the PID loop and choose Delete from the pop-up menu.

   The PID loop is deleted.

   You can also delete a PID loop in the Configure PID Loops dialog box by highlighting it and clicking Delete.

Algorithm Choices

When you configure a PID loop, choose one of these algorithms[1]:

- Velocity (Type C)
- ISA
- Parallel
- Interacting

Velocity (Type C) is typically used to perform velocity control. The ISA, Parallel, and Interacting algorithms are derived from the article "A Comparison of PID Control Algorithms" by John P. Gerry in *Control Engineering* (March 1987). These three equations are the same except for the tuning coefficients; converting from one equation to another is merely a matter of converting the tuning coefficients.

[1] The following obsolete algorithms support PID loops configured before PAC Project R9.5 (for details, see Opto-KnowledgeBase article KB82058):

- Velocity (Type B) Obsolete
- ISA (Obsolete)
- Parallel (Obsolete)
- Interacting (Obsolete)

You can continue to use these obsolete algorithms, but Opto 22 recommends you use the new algorithms when configuring new PID loops.

Key to Terms Used in Equations

`PV`	Process variable; the input to the PID
`SP`	Setpoint

`InLo,`
`InHi`
	Range of the input

`OutLo,`
`OutHi`
	Range of the output

`Gain`	Proportional tuning parameter. Unitless. May be negative.
`TuneI`	Integral tuning parameter. In units of seconds. Increasing magnitude increases influence on output.

`TuneD`	Derivative tuning parameter. In units of seconds. Increasing magnitude increases influence on output.
`Output`	Output from the PID
`Err_1`	The Error (PV – SP) from the previous scan
`Integral`	Integrator. Anti-windup is applied after the output is determined to be within bounds.
`PV1, PV2`	PV from the previous scan and the scan before that.
`ScanTime`	Actual scan time (time since previous scan)

Equations Common to All Algorithms

```
Err = PV - SP
Span = (OutHi - OutLo) / (InHi - InLo)
Output = Output + FeedForward * TuneFF
```

Equations Common to ISA, Parallel, and Interacting

```
Integral = Integral + Err
TermP = Err
TermI = TuneI * ScanTime * Integral
TermD = (TuneD / ScanTime) * ( PV - PV1 )
```

Velocity (Type C) Algorithm

```
ΔTermP = ( PV - PV1 )
ΔTermI = TuneI * ScanTime * Err
```

In this part of the formula, you adjust ***TuneI****.*

```
ΔTermD = TuneD / ScanTime * ( PV - 2 * PV1 + PV2 )
```

In this part of the formula, you adjust ***TuneD****.*

```
ΔOutput = Span * Gain * ( ΔTermP + ΔTermI + ΔTermD )
```

In this part of the formula, you adjust ***Gain****.*

ISA (or “Ideal”) Algorithm

```
Output = Span * Gain * ( TermP + TermI + TermD )
```

Parallel (or “Independent”) Algorithm

```
Output = Span * ( Gain * TermP + TermI + TermD )
```

Interacting (or “Classic”) Algorithm

```
Output = Span * Gain * ( TermP + TermI ) * ( 1 + TermD )
```

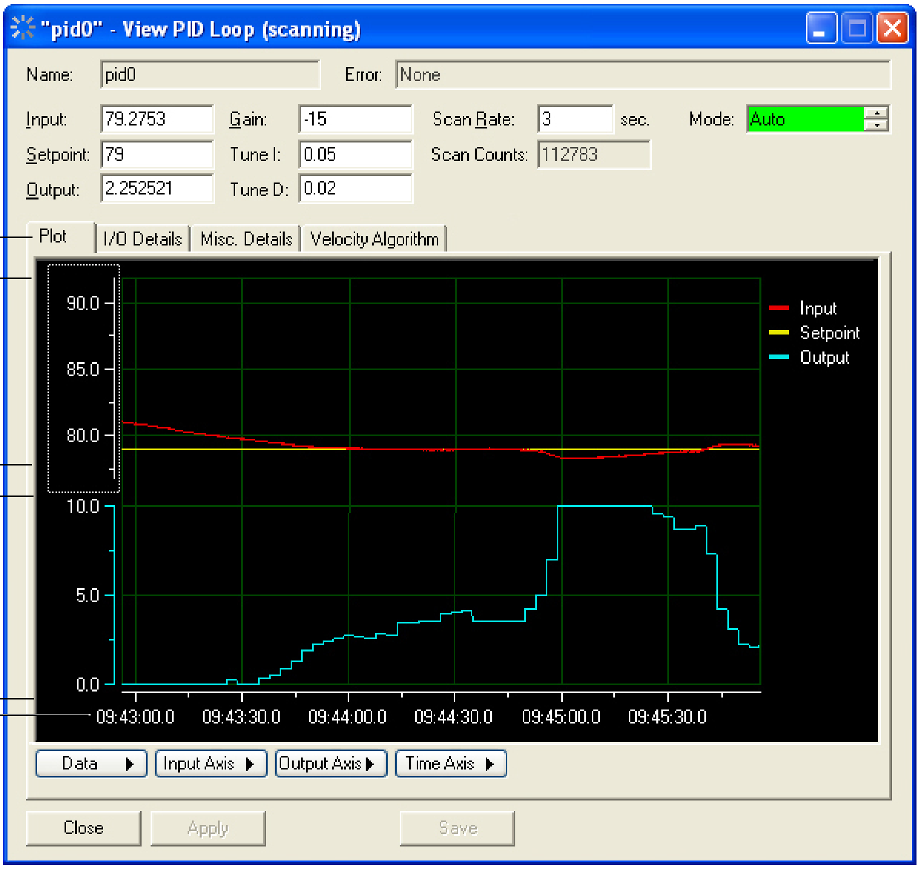
Inspecting and Tuning PID Loops

Using EtherNet/IP Configurator, you can view PID loops and tune them. This section gives you basic steps for inspecting PIDs, determining system lag, and tuning PIDs. See also, Opto 22 form 1641, *OptoTutorial: SNAP PAC PID*, which we highly recommend for detailed information on PIDs on

Ethernet-based I/O units. Form 1641 is available for download from our website at www.opto22.com.

Inspecting a PID

1. With a configured PID downloaded and running on the brain, click the Configure PID Loops tab.
2. Highlight the PID, and then click the Tuning button.



"pid0" - View PID Loop (scanning)

Name: pid0 Error: None

Input: 79.2753 Gain: -15 Scan Rate: 3 sec. Mode: Auto

Setpoint: 79 Tune I: 0.05 Scan Counts: 112783

Output: 2.252521 Tune D: 0.02

Click a tab to see or change additional data.

Setpoint and Input plot. Adjust resolution using the Input Axis button below the plot. Click and drag on the scale to move the line.

Output plot. Adjust resolution using the Output Axis button. Click and drag on the scale to move the line.

Time axis. Adjust resolution using the Time Axis button. Click and drag left or right to see other times.

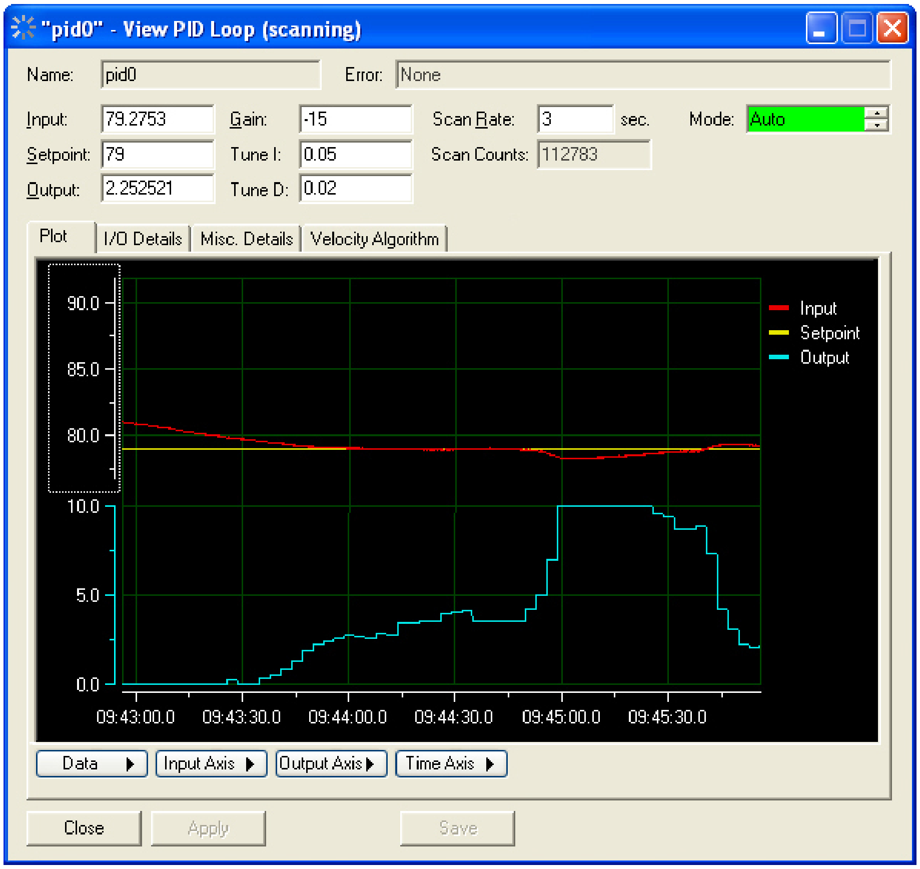
3. View or change PID parameters as necessary. Click the other tabs to see additional data. To tune the PID, see page 98.
4. To save, copy, or print the current plot, click the Data button and choose from the popup menu.
5. To save changes to any of the PID configuration parameters, click Save Tuning.

Determining System Lag

You can directly control the PID output to determine system lag, which is essential to setting the PID scan rate. Also see Opto 22 form 1641, *OptoTutorial: SNAP PAC PID*, available for download from our website at www.opto22.com.

1. Determine two significantly different output settings that are within the capabilities of your system.

2. With a configured PID downloaded and running on the brain, click the Configure PID Loops tab.
3. Highlight the PID, and then click the Tuning button.



"pid0" - View PID Loop (scanning)

Name: pid0
Error: None
Input: 79.2753
Gain: -15
Scan Rate: 3 sec.
Mode: Auto
Setpoint: 79
Tune I: 0.05
Scan Counts: 112783
Output: 2.252521
Tune D: 0.02

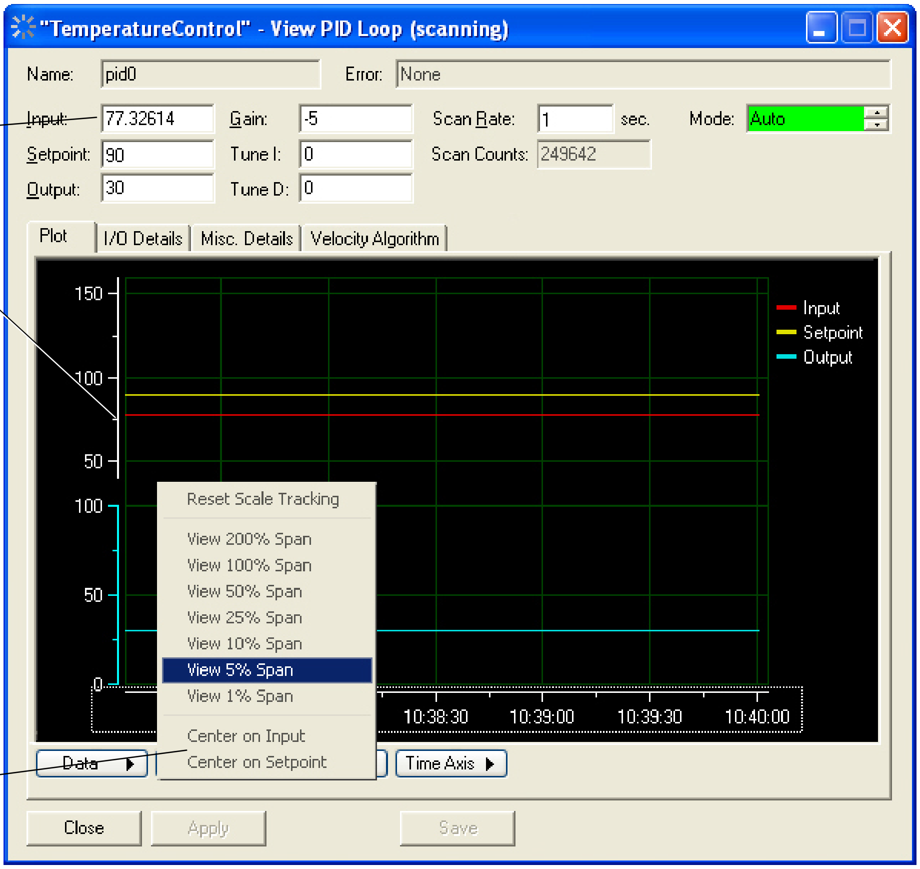
4. Set the Mode to Manual (if not set already) and click Apply.
5. In the Output field, type one of your two output settings and click Apply.

   Use an output value typical of your system but low enough to allow you to change output by 20%.
6. Reset your time axis, if necessary, by clicking the Time Axis and choosing from the popup menu. Then choose Reset Scale Tracking from the same menu.

   The span setting varies according to your system; a 3-minute span is often suitable. Until you are familiar with the PID plot, it is recommended that you avoid using the shortest settings (10-seconds or 1-second). After you've observed a change in the input, you can zoom in on the graph, which is described later.
7. Wait for your system to stabilize.

The system is stable when the Input value does not vary significantly (some drift can be expected). Stabilization may take several minutes, depending on the system.

A stable system exhibits little change in the Input value, which is shown numerically and graphically.



Name: pid0
Error: None
Input: 77.32614
Gain: -5
Scan Rate: 1 sec.
Mode: Auto
Setpoint: 90
Tune I: 0
Scan Counts: 249642
Output: 30
Tune D: 0

Adjust resolution of the Input Axis by clicking the Input Axis button.

8. Increase the resolution of the Input Axis by clicking the Input Axis menu and choosing a span setting of 1 or 5 percent.

9. Center the Input Axis, if necessary, by clicking the red line at its left end and dragging it up or down until the plot is visible.

10. Under the Time Axis menu, choose Reset Scale Tracking.

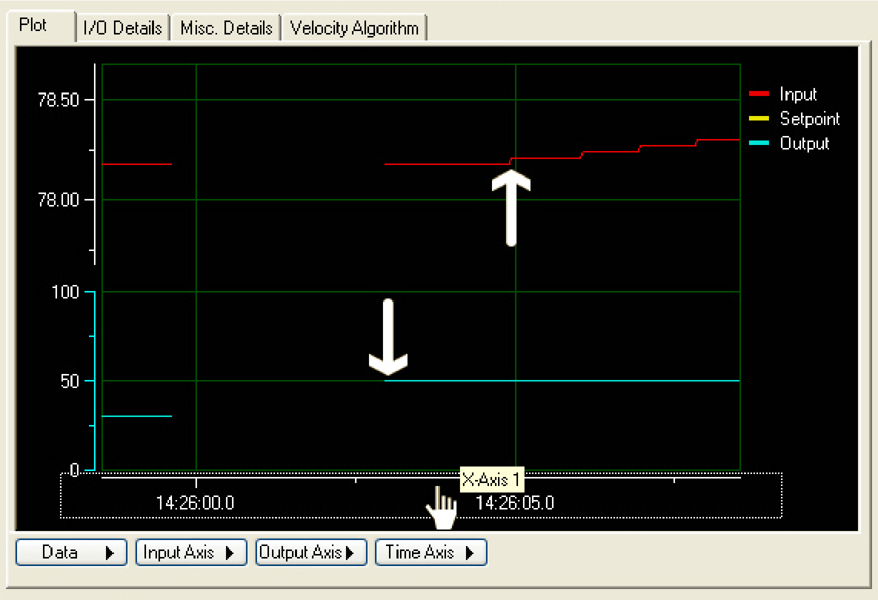
This is a precautionary step, as changing settings on the plot can fix the plot at a certain point in time. Resetting the time axis ensures that you are viewing the real-time values.

11. In the Output field, type the other of your two output settings and click Apply.

A 20% percent increase is a moderate, detectable change for most systems. Your system may require a larger or a smaller change to stay within safety constraints.

12. Wait for a discernible change in the Input axis.

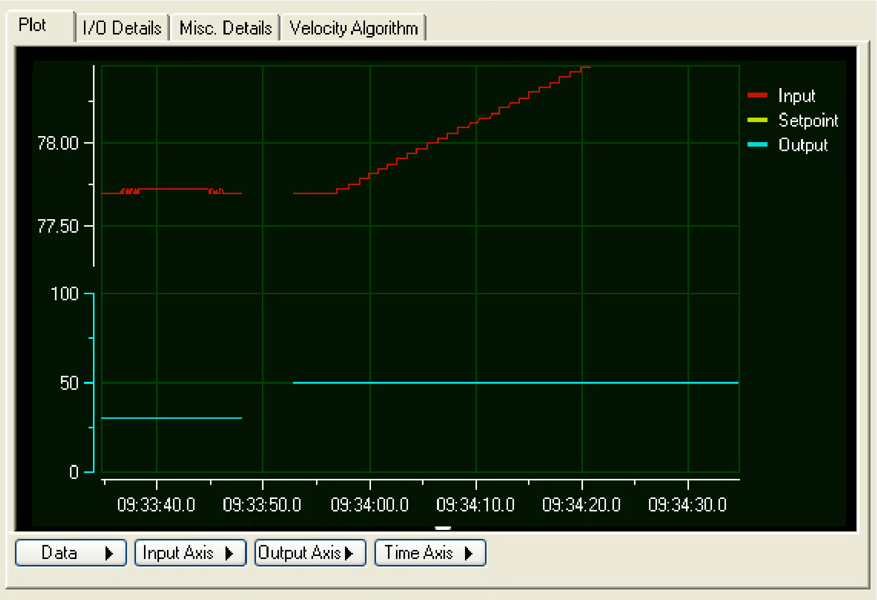
The Input axis (indicated by the upper white arrow added to this picture) begins to respond to the change in output (lower white arrow).



13. Increase the resolution of the Time Axis by clicking the Time Axis button and choosing a lower percentage, such as View 1 Minute Span.

14. Scroll the Time Axis to locate the point at which you changed the Output.

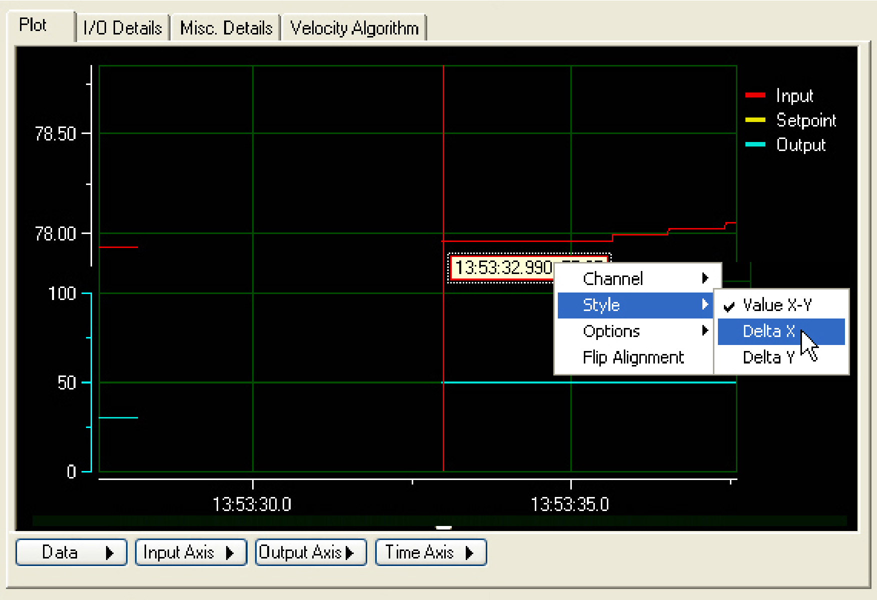
Both the time and input axes should display the point at which the Output changed, the lag, and the point the input changed. If not, adjust the Input axis and Time axis, until this information is displayed.



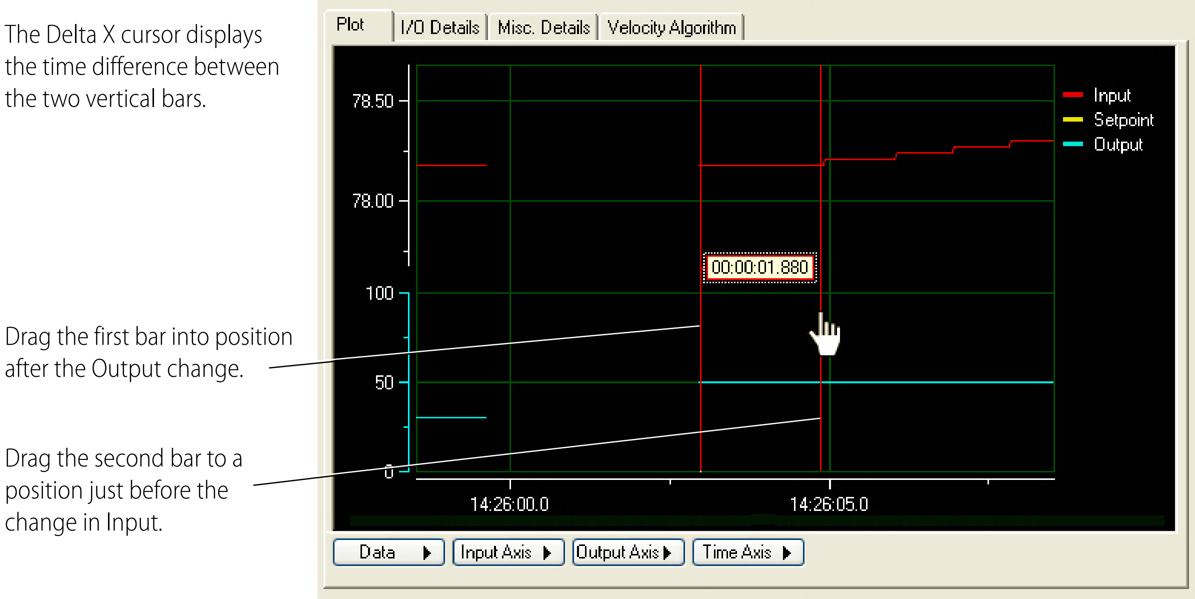
15. From the Data menu, select Cursor.

The data cursor, a line with a value bar attached to it, appears on the plot.

16. Right-click the data cursor and choose Delta X from the Style submenu, as shown below.



17. To measure the system lag (the time between the change in output and the change in input), click and drag the first vertical red bar to just after the output change. Drag the second bar to just before the change in input.



The Delta X cursor displays the time difference between the two vertical bars.

Drag the first bar into position after the Output change.

Drag the second bar to a position just before the change in Input.

If you are unable to get the precision you want, you can view the plot at a lower time span, such as 10 seconds. You will need to reposition your plot and the measurement bars of the Delta X cursor.

The example above shows a system lag of 1.88 seconds. Generally, a suitable scan rate can be anywhere from one-third the system lag to two times the system lag. Considerations in setting scan rate are:

- Slower scan intervals may be easier to tune. The PID controller has time to see the effect of the previous output before calculating a new output.
- Faster scan rates may be necessary to achieve the desired response. When scan intervals are shorter than the system lag, tuning must compensate for any over-correction from the controller output.

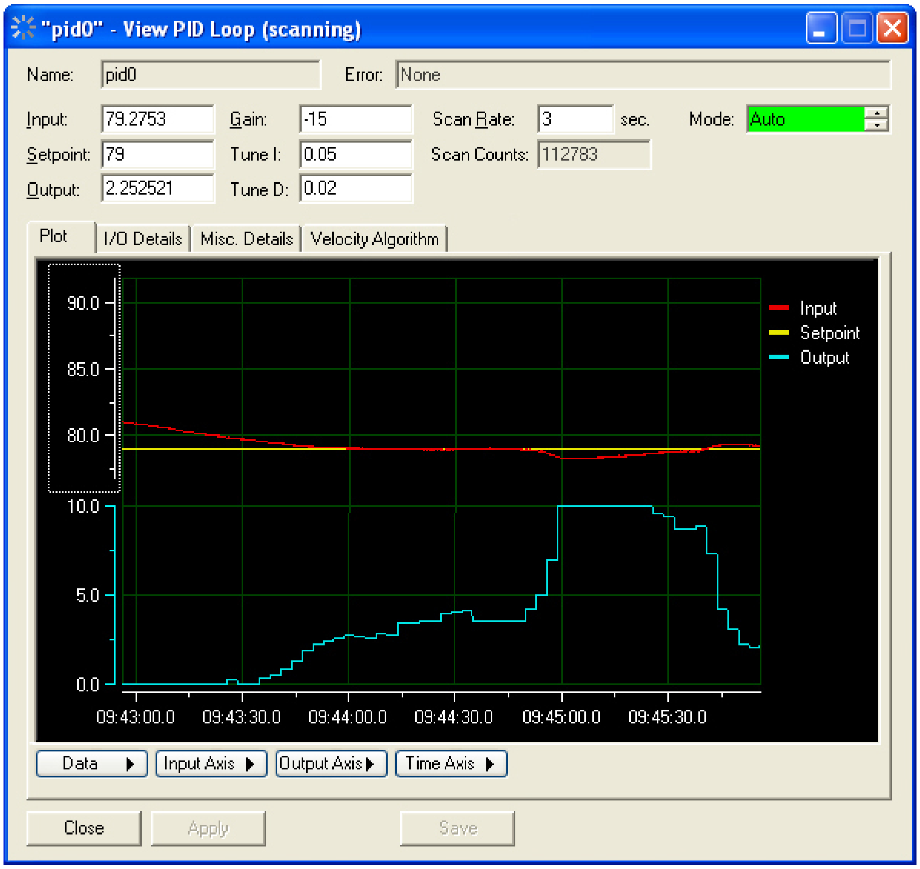
Tuning a PID Loop

Tuning a PID involves manipulating the P, I, and D constants in real time. The following steps should be viewed as general suggestions to show you features that are available for tuning. We highly recommend Opto 22 form 1641, *OptoTutorial: SNAP PAC PID*, for more detailed information. Form 1641 is available for download from our website at www.opto22.com.

CAUTION: Before following these procedures, make sure you know the limits of the equipment being controlled and monitored by your PID loop. Also, make sure that these points are configured properly. Any values suggested in these steps are for example only and must be modified according to the capabilities and constraints of your system.

1. Make sure the following PID features have already been configured:
   - Scan Rate
   - Input
   - Input low range and high range
   - Output
   - Output lower and upper clamp
   - Algorithm
   - Setpoint. If your setpoint changes during normal operation, tune your PID with the setpoint configured to host, so you can simulate setpoints from an input point or from another PID.
   - Gain. A final gain constant will be determined by tuning, but before you can tune your PID, your gain constant must be either a positive or negative number according to the type of system you have. For example, a heating system reports a negative error when heat needs to be applied; a negative gain constant turns this error into a positive output for the heater. Alternatively, a cooling system reports a positive error when the input exceeds the setpoint; a positive gain constant maintains the positive output to the chiller.
   - Optional, depending on your system: Minimum and maximum changes to Output and Output forcing when the Input is out of range.
2. With a configured PID downloaded and running on the brain, click the Configure PID Loops tab.

3. Highlight the PID, and then click the Tuning button.



"pid0" - View PID Loop (scanning)

Name: pid0 Error: None

Input: 79.2753 Gain: -15 Scan Rate: 3 sec. Mode: Auto

Setpoint: 79 Tune I: 0.05 Scan Counts: 112783

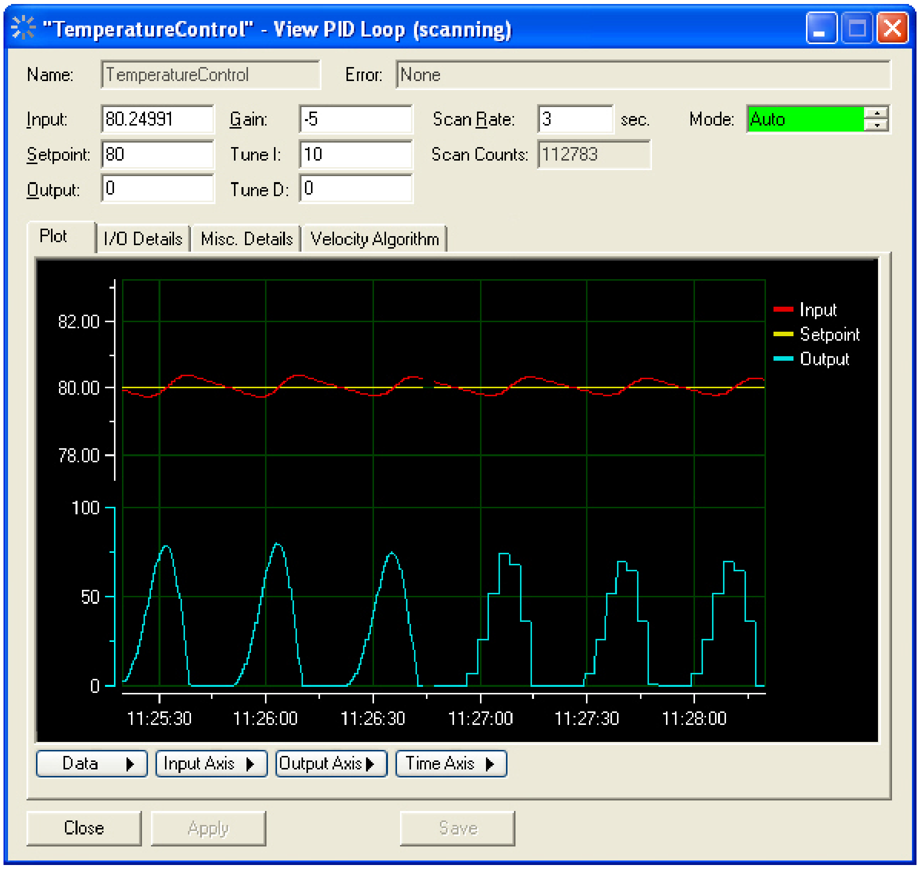
Output: 2.252521 Tune D: 0.02

4. Set the PID Mode to Auto (if not set already) and click Apply.
5. Change the Setpoint, if desired, by typing a new setpoint and clicking Apply. (Setpoint must be configured as Host.)

   Depending on the type of system, your PID may maintain a setpoint or respond to changes in setpoint. Experiment with setpoint changes again after tuning the P, I, and D constants.
6. Adjust the span of the input, output, and time axes according to how much change you expect from your system. To set a span, click the axis button and choose from the popup menu.
7. If desired, type a new Scan Rate and click Apply.

   For most systems, you should use an appropriate scan rate based on the system lag (see "Determining System Lag" on page 93). However, you can experiment with Scan Rates before tuning the P, I, and D constants or adjust scan rate after tuning.

Here is an example for Scan Rate:



"TemperatureControl" - View PID Loop (scanning)

Name: TemperatureControl Error: None

Input: 80.24991 Gain: -5 Scan Rate: 3 sec. Mode: Auto

Setpoint: 80 Tune I: 10 Scan Counts: 112783

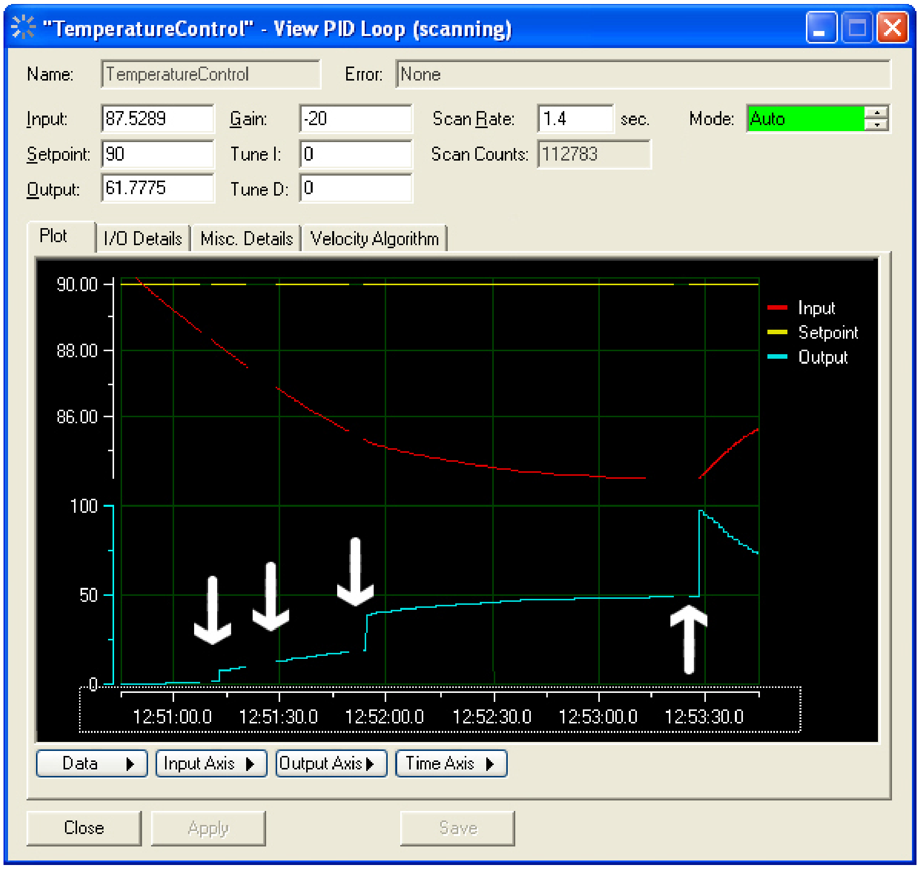
Output: 0 Tune D: 0

The lag for this system was determined to be about 2 seconds. The left half of the plot reflects a 0.5-second scan rate, while the right half shows a 3-second scan rate. Notice both scan rates have the same effect on the input; however, the 3-second scan rate is using less of the processor's resources.

8. Experiment with gain settings by typing a new value in the Gain field and clicking Apply.

The easiest way to tune most PIDs is to experiment with the gain constant first. Try various gains to see how well the system stays at setpoint and responds to setpoint changes.

The white arrows in the example below show where gain constants of -2, -5, -10, and -20 were applied:



"TemperatureControl" - View PID Loop (scanning)

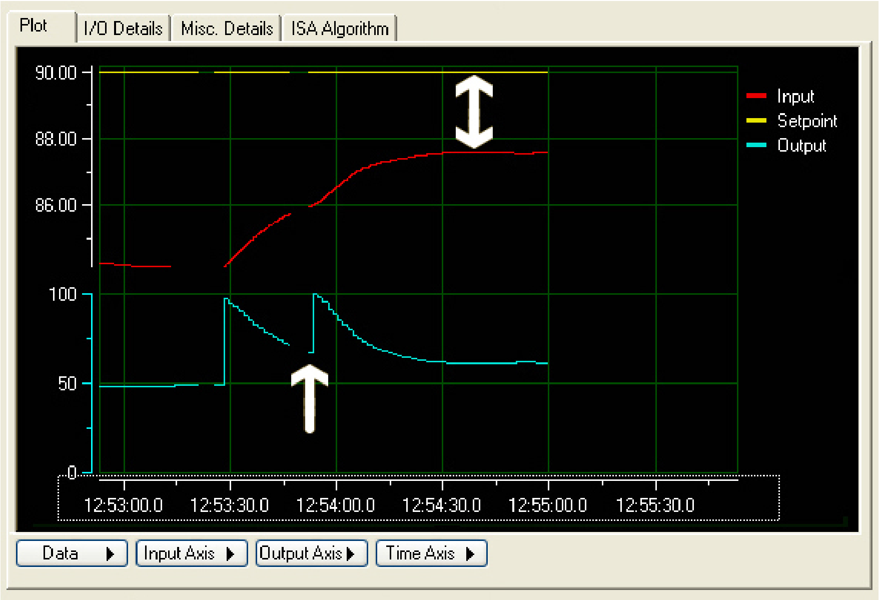
Name: TemperatureControl Error: None

Input: 87.5289 Gain: -20 Scan Rate: 1.4 sec. Mode: Auto

Setpoint: 90 Tune I: 0 Scan Counts: 112783

Output: 61.7775 Tune D: 0

In this example, a gain setting of -30 revealed an offset error:

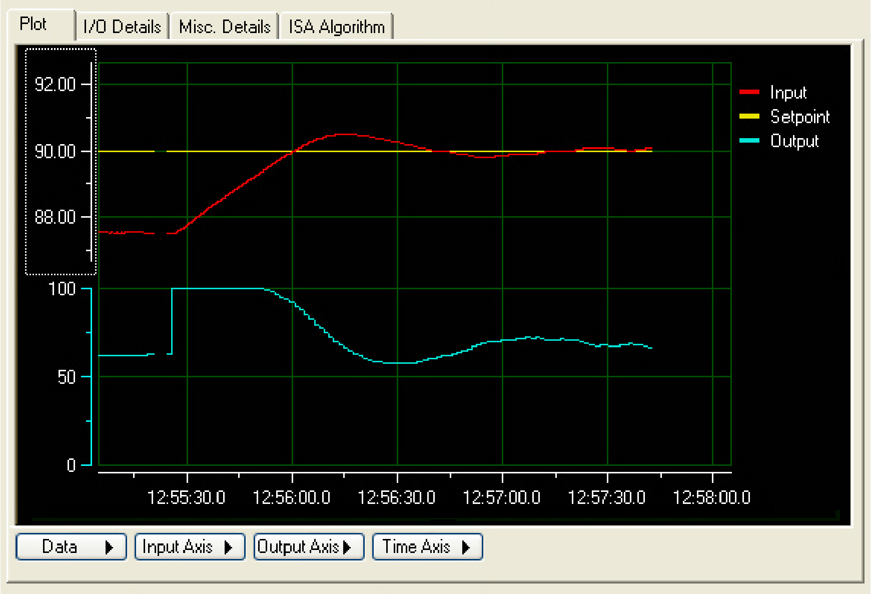


With only a gain constant applied, the input often stabilizes at an incorrect value. In this heating example, a gain setting of -30 drove the input close to the setpoint, but subsequent increases failed to eliminate the offset. It is time to try integral constants to eliminate the offset error.

9. Experiment with the integral constant: in the Tune I field, type a number between 0 and 1 and click Apply. (Your PID may require larger numbers.)

In this example, an integral constant of 0.1 corrected the offset error.

The far left side of the plot shows the offset before an integral constant of 0.1 was applied. This setting eliminated the offset. In many applications, a minor fluctuation around the setpoint is acceptable, and these applications use gain and integral only. In some applications, however, the fluctuations at the setpoint indicate that the gain is too high (too much gain makes a system unstable) or that a derivative constant is required.

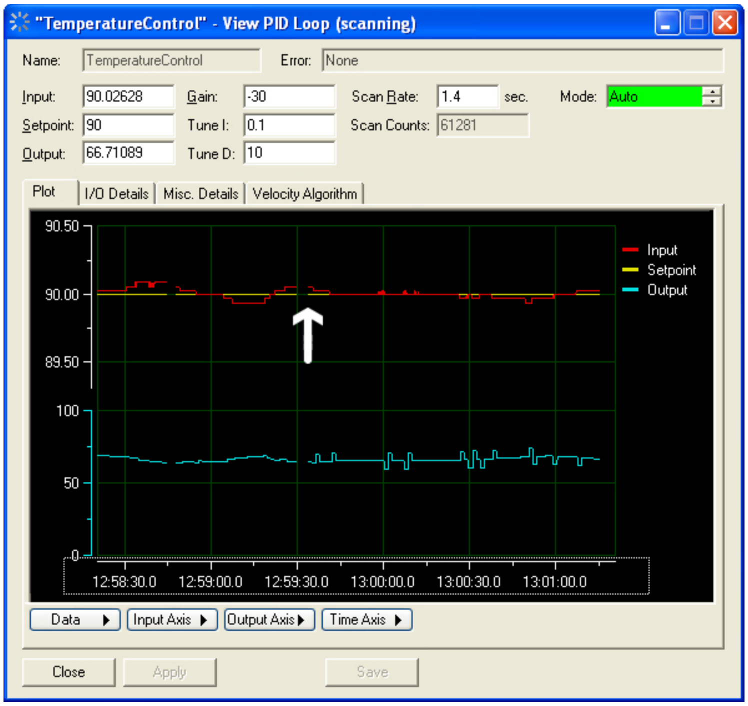


10. If derivative correction is needed, experiment with the derivative constant: in the Tune D field, type 1 and click Apply. (Your PID loop may require a larger number.)

In this example, a derivative of 10 makes a noticeable difference in keeping the input near the setpoint.

Many PID systems are effectively controlled with gain and integral constants only and no derivative constant. In this example, the gain and integral settings are maintaining the temperature at 0.06 from setpoint. To demonstrate the effect of the derivative constant, the resolution of the input axis was increased to show a 1 percent span. At this resolution, the plot reveals changes of 0.01 degrees F.

The left side of the plot shows the effect of gain at -30, integral at 0.1, and no derivative constant. The arrow shows when a derivative constant of 10 was applied. The right side of the plot shows how the derivative constant is keeping the input closer to setpoint.



"TemperatureControl" - View PID Loop (scanning)

Name: TemperatureControl

Error: None

Input: 90.02628

Gain: -30

Scan Rate: 1.4 sec.

Mode: Auto

Setpoint: 90

Tune I: 0.1

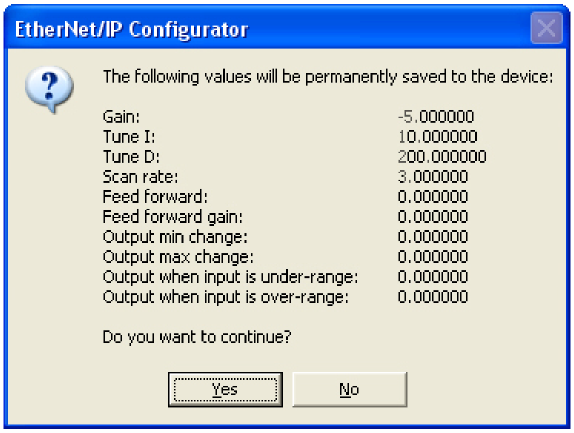
Scan Counts: 61281

Output: 66.71089

Tune D: 10

11. Click Save to save your tuning parameters to the configuration.

Changes are lost unless you save them. You may wish to save your tuning parameters when you see any improvement in performance, even if they are not final.


EtherNet/IP Configurator

The following values will be permanently saved to the device:

```
Gain:                                  -5.000000
Tune I:                                10.000000
Tune D:                                200.000000
Scan rate:                             3.000000
Feed forward:                          0.000000
Feed forward gain:                     0.000000
Output min change:                     0.000000
Output max change:                     0.000000
Output when input is under-range:      0.000000
Output when input is over-range:       0.000000
```

Do you want to continue?

12. Click Yes.

Values are saved to the EtherNet/IP configuration file. Remember to download the configuration to the Opto 22 device. (See "Downloading a Configuration" on page 78.)

Using I/O Point Features

The I/O point features available on remote I/O depends on the combined capabilities of the device (brain or on-the-rack controller). See the device's data sheet for supported features.

The following tables define the digital and analog features that are supported. For more information, see form 1704, the *PAC Manager User's Guide*. See also form 1798, the *SNAP IO4AB Learning Center User's Guide*.

To see a video demonstration of using I/O point features, go to the Learn tab on the Opto 22 website, www.opto22.com, and click Learn About IO4AB.

Digital Features

Feature	Description
Counters	(input)—A counter keeps track of the number of times a digital input changes from off to on. The count accumulates until it reaches the maximum count available in the remote I/O or until you reset the counter to zero. For example, to count the number of widgets produced per shift, you would clear the counter at the start of each shift and read it at the end of each shift. For points on a 4-channel module, the speed of the counter depends upon the brain or controller's capabilities and the speed of the module used. For points on a high-density module, counting is done in the module.
Frequency measurement	(input)—Frequency is the speed with which a digital point changes state and is usually measured in counts per second. For example, reading the frequency can help you determine the speed of rotating machinery.
Latches	(input)—When the value of a digital input point changes from off to on, an on-latch is automatically set. While the value of the point may return to off, the on-latch remains set, as a record of the change, until you clear it. Similarly, an off-latch is set when the value of a digital point changes from on to off, and it remains set until cleared.
Period measurement	(input)—Period refers to the elapsed time for a complete on-off-on transition on a digital point. Measurement starts on the first transition (either off-to-on or on-to-off) and stops on the next transition of the same type (one-time or continuous or both).
Pulse duration measurement	(input)—A pulse is a brief on (or off) state, usually repeated at a specific interval. The brain can measure the first pulse, that is, the amount of time the input stays on (or stays off).
Quadrature counters	(input)—A quadrature counter requires a SNAP quadrature input module, which is attached to the encoder device. The module sends a pulse to the remote I/O upon each change in quadrature state, and the remote I/O counts the pulses and keeps track of the direction and rotation.
States	(input and output)—Automatic, not configurable. A digital point is either on or off. You can read the current state of a digital input or write an on/off state to a digital output.
Time-proportional output (TPO)	(output)—Time-proportional output varies the duty cycle and the percentage of on time within that cycle. TPO is often combined with a PID loop and used to control the output, for example in a heater or oven.
Watchdog	(digital and analog points)—A watchdog monitors communication to the device. If nothing accesses the port for the length of time set in the watchdog, the remote I/O automatically sets designated digital and analog I/O points to the values you have determined. A watchdog helps make sure that a communication failure doesn't result in disaster. If no communication is received for the length of time set in the watchdog, the watchdog makes sure the process is automatically brought to a safe state. For example, a valve could automatically close to avoid completely emptying a tank.

Feature	Description
Totalizers	Digital totalizers track the total time a specific input point has been on or off. For example, you could track how long a pump, fan, or motor has been on. Digital totalizers are useful for periodic maintenance. Before using a totalizer, you must configure the point with this feature. The availability of totalizers depends on the brain; see the brain's data sheet for more information.

Analog Features

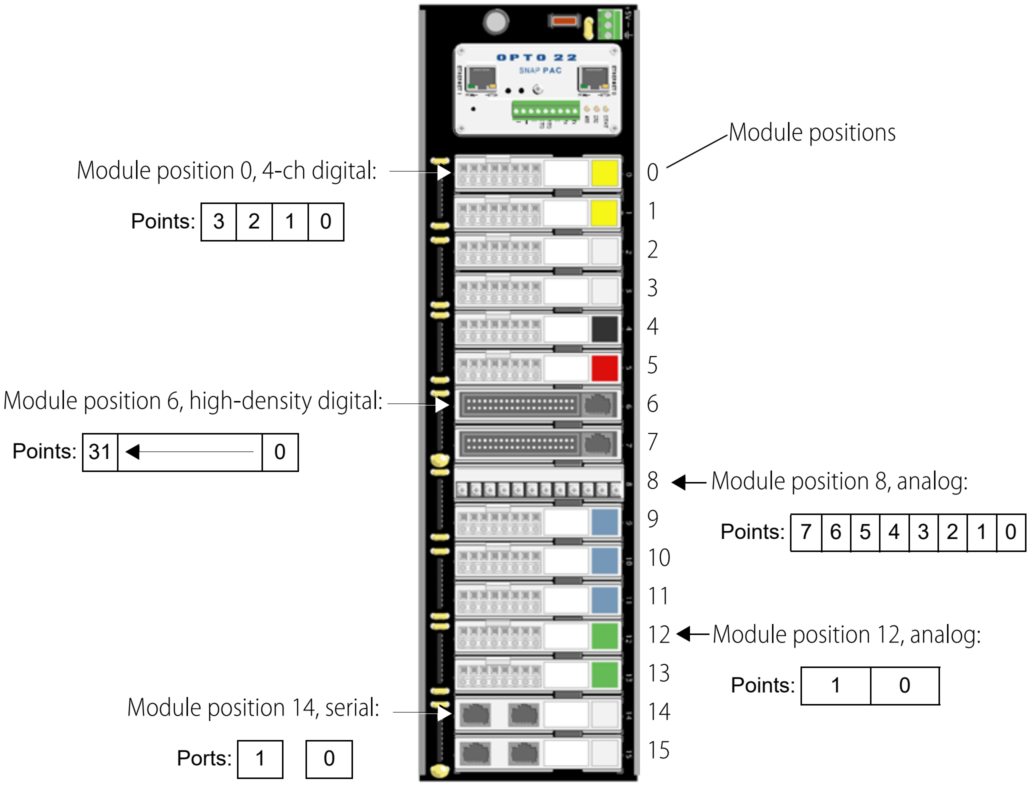
Feature	Description
Average filter weight	(analog inputs)—A filter weight smooths analog input signals that are erratic or change suddenly.
Clamping	(analog output)—Clamping limits values that can be sent to analog output points so they do not go above or below a specific value. For example, if you are using a 0–10 VDC output module, but the device attached to one of its points can only handle a maximum of 5 VDC, you can set an upper clamp of 5 VDC for that point. The values for upper and lower clamp are set in engineering units.
Minimum and maximum values	(analog input)—Minimum and maximum values are sometimes called peaks and valleys. You can read these values at any time, for example, to record minimum and maximum temperatures. You can also reset min/max values. For example, if you want to record the maximum temperature at point 2 in each 24-hour period, you must reset the values after they are read each day.
Offset and gain	(analog input)—Offset and gain calculations are used to calibrate analog points. If a -50 mV to +50 mV input receives signals that are slightly off (not exactly -50 mV at the lowest point, for example), the offset and gain can be calculated so that values will appear accurately when read.
PID loop control	(analog points)—Proportional integral derivative (PID) loops are used to drive an input toward a particular value (the setpoint) and keep the input very close to that value by controlling an output. PID loops are often used in temperature control.
Ramping	(analog output)—Some devices attached to analog outputs should not be abruptly stepped up or down, because a sudden change might damage the equipment or cause other problems. Instead, you can gradually ramp the device up or down to the desired value.
Scaling	(analog input and output)—Analog input and output points can be scaled as needed. For example, you can scale a -5 V to +5 V input point to reflect 0% to 100%
Thermocouple linearization	(analog input)—Automatic, not configurable. The remote I/O automatically converts the thermocouple junction's millivolt values into temperature values, so you don't have to. Choose the appropriate module and make sure you configure the point as the correct thermocouple type (E, K, etc.) for your purpose.
Watchdog	(digital and analog points)—A watchdog monitors communication to the device. If nothing accesses the port for the length of time set in the watchdog, the remote I/O automatically sets designated digital and analog I/O points to the values you have determined. A watchdog helps make sure that a communication failure doesn't result in disaster. If no communication is received for the length of time set in the watchdog, the watchdog makes sure the process is automatically brought to a safe state. For example, a valve could automatically close to avoid completely emptying a tank.

Referencing I/O Points on SNAP PAC Racks

This section shows input and output point numbers for SNAP PAC mounting racks, which can hold up to 4, 8, 12, or 16 Opto 22 SNAP I/O modules.

Each module contains 1 to 32 points (channels), depending on the module. Examples of modules are shown in the following diagram.

NOTE: Each channel of a SNAP PAC I/O module provides connectivity to one point of I/O. Each channel of a SNAP PAC communication module provides connectivity to one communication port.


Module positions
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Module position 0, 4-ch digital:
Points: 3 2 1 0
Module position 6, high-density digital:
Points: 31 0
Module position 8, analog:
Points: 7 6 5 4 3 2 1 0
Module position 12, analog:
Points: 1 0
Module position 14, serial:
Ports: 1 0
OPTO 22
SNAP PAC

A: Supported Allen-Bradley Platforms

Opto 22 supports using the ControlLogix® and CompactLogix™ controller platforms, V13-17, with Opto 22 SNAP I/O. Both of these platforms support Implicit Messaging (also known as I/O messaging) and Explicit Messaging.

The following Allen-Bradley platforms also support EtherNet/IP. While some controllers in these platforms only support explicit messaging, Opto 22 may be able to assist you in using them.

- MicroLogix™ 1100 and 1400 (Series B FRN4 or newer)

NOTE: Some Allen-Bradley controller platforms have only specific models that support EtherNet/IP or require an adapter module or card.

For a complete and up-to-date list of Allen-Bradley platforms that support EtherNet/IP, and more information on which platforms support Implicit Messaging or Explicit Messaging only, contact Rockwell Automation.

B: Using Counts

This appendix describes using counts with EtherNet/IP and linearizing the Pt100 and Pt1000 probes from resistance.

In this Appendix

Using Counts with EtherNet/IP

While Opto 22's SNAP PAC IO4AB implementation provides many configurable options for reading and writing I/O (including robust scaled units) as an Allen-Bradley user you can still use counts if you want to. However, using counts has various limitations due to the brain's capability to linearize the counts provided by the modules.

How to Retrieve Counts

When creating assembly instances in the EtherNet/IP Configurator, there are two types of values for analog inputs and outputs, *rValue* and *Value*. Selecting *rValue* will report the value as a 32-bit float or a Logix REAL data type. *Value* is the 16-bit integer value of counts as an input.

In the SNAP PAC architecture, the notion of counts varies with the particular module being used.

Most Analog Inputs

Most SNAP analog input modules provide a counts range of 0 to 24,999 counts for unipolar modules (which read zero to a positive valued input) and –24,999 to 24,999 counts for bipolar modules (which read a negative to positive input range).

The analog input range determines the limits of the counts. For example, a SNAP-AIV has either a ±10 VDC or a ±5 VDC input range. This range is selectable in the EtherNet/IP configuration. When set to the ±10 VDC input range, 24,999 counts is 10 VDC and –24,999 counts is –10 VDC. If the module is set to the ±5 VDC, 5 VDC is 24,999 counts and –5 VDC is –24,999 counts.

Opto 22’s SNAP analog inputs also allow 10% over range. This means that for the SNAP-AIV module, the actual maximum range is ±11 VDC or ±5.5 VDC. This absolute range is 10% beyond the advertised module limit, which means the counts may have a maximum magnitude of 27,499 counts.

NOTE: Any range outside of 27,499 counts magnitude is considered an invalid and out-of-bounds condition.

Analog Input Exceptions

This section applies to the following modules and associated modes (including any –FM designated parts):

SNAP-AICTD

SNAP-AICTD-8

SNAP-AITM (in thermocouple mode)

SNAP-AITM2 (in thermocouple mode)

SNAP-AITM-i (in thermocouple mode)

SNAP-AITM2-i (in thermocouple mode)

SNAP-AITM-8 (in thermocouple mode)

When these modules are configured in their temperature mode, they will output counts that are 10 times the linearized temperature value.

For example, if a SNAP-AITM has a “J” thermocouple input and it is reading 123.4F, the counts reported with 1234 (as a 16-bit signed integer).

Resistance Temperature Inputs

SNAP-AIRTD I/O modules (including the SNAP-AIRTD-1K and SNAP-AIRTD-10), the SNAP-AIR40K-4, and the SNAP-AIR400K-8 are resistance modules.

Linearized temperature for SNAP-AIRTD modules is available for Pt100 and specific nickel based probes. The SNAP-AIR40K-4 and SNAP-AIR400K-8 are strictly resistance modules but may be used for higher impedance probes, such as a Pt1000.

To read the temperature linearized SNAP-AIRTD modules, read the scaled engineering units. If counts are used, they will represent the input value as wire compensated ohms. Wire compensation means that the module provides instrumentation wire resistance compensation internally. For the SNAP-AIRTD modules, 0 counts means 0 ohms. 24,999 counts indicate 400 ohms. A 10% over range is provided so 27,499 will be reported for 440 ohms of input resistance.

If you are using counts for the SNAP-AIRTD modules, the SNAP-AIR40K-4, or the SNAP-AIR400K-8, you must provide your own linearization. In this case, using scaled engineering is recommended.

For additional information on determining the temperature from the probe resistance, see “Linearizing the Pt100 and Pt1000 Probes from Resistance” on page 111.

Load Cell Inputs

When using the SNAP-AILC and SNAP-AILC2 load cell modules, *only* use the scaled engineering units. These modules output a higher resolution as counts, which is too large of a number for a 16-bit signed integer (a type INT) too handle.

NOTE: Firmware versions R8.5 and newer support the load cell module. Use the Load Cell assembly class (not the Analog Input class) for load cell values.

Analog Outputs

SNAP analog output modules are based on 12-bits. Unipolar output modules have a range of 0 counts to 4095 counts. Bipolar have a counts range of –4096 to 4095. Analog outputs do not have the 10% over range that analog inputs have.

Linearizing the Pt100 and Pt1000 Probes from Resistance

If you would like to use counts strictly for the SNAP-AIRTD and thermistors for the SNAP-AIR40K modules, tables in slope-intercept format are provided below. The Pt100 probe table may also be used for Pt1000 applications. For Pt1000 applications, divide the resistance by 10. The SNAP-AIRTD should be used for the Pt100 and the SNAP-AIR40K should be used for the Pt1000. When using the Pt1000, use the 0-5000 Ohm input range with the SNAP-AIR40K.

To use these tables, start by searching from the lowest resistance value of the table. Compare the resistance value until you reach the last value before the table's resistance exceeds your measured value.

Take the slope and intercept and compute this equation using floating-point variables.

temperature = (slope from table) × (measured resistance) + (intercept from table)

To convert from Celsius to Fahrenheit, use this equation:

Temperature(F) = Temperature(C) × (1.8) + 32

For better accuracy using probes with the SNAP-AIR40K module, short the leads at the probe's terminal blocks and record the resistance measurement. This is the resistance offset due to the instrumentation wiring. Subtract this value from the resistance measurement before using the linearization table.

Table 1: 100 Ohm Nickel RTD -60 to 250 °C

Table Range 68.0 to 291.0 Ohms

Resistance	Slope	Intercept
68.0	-208.2	2.13121
73.0	-203.397	2.065415
78.0	-198.394	2.001275
84.0	-193.147	1.938809
90.0	-188.091	1.882628
96.0	-182.791	1.82742
103.0	-177.189	1.77304
110.0	-171.674	1.722901
117.0	-166.205	1.676152
124.0	-160.374	1.629129
132.0	-154.119	1.581747
140.0	-147.819	1.536746
148.0	-141.452	1.493727
156.0	-135.005	1.452396
164.0	-128.069	1.410108
173.0	-120.599	1.366925
182.0	-113.014	1.325248
191.0	-105.321	1.284971
200.0	-97.5315	1.246025
209.0	-89.6599	1.208362
218.0	-81.2915	1.169975
228.0	-72.4124	1.131032
238.0	-63.4985	1.093578
248.0	-54.5737	1.057591
258.0	-45.6613	1.023047
268.0	-36.3519	0.98831
279.0	-26.2247	0.952012

Table 2: 120 Ohm Nickel RTD -80 TO 260 °C

Table Range 65.0 to 381.0 Ohms

Resistance	Slope	Intercept
65.0	-182.127	1.533316
87.0	-179.959	1.508399
100.0	-176.723	1.476043
110.0	-172.557	1.438171
119.0	-167.486	1.395552
128.0	-162	1.352695
137.0	-156.357	1.311506
146.0	-150.64	1.272347
155.0	-144.621	1.233515
165.0	-138.325	1.195359
175.0	-131.967	1.159026
186.0	-125.596	1.124774
197.0	-119.322	1.092927
208.0	-112.759	1.061371
220.0	-105.979	1.030556
232.0	-99.093	1.000874
245.0	-92.0848	0.972269
258.0	-84.7268	0.943749
271.0	-76.8096	0.914535
284.0	-68.4858	0.885226
297.0	-59.9087	0.856347
310.0	-51.1933	0.828232
323.0	-42.291	0.800671
337.0	-33.3737	0.77421
351.0	-24.5218	0.748991
366.0	-15.9767	0.725644

Table 3: Pt100 Platinum RTD -200 TO 850 °C, Alpha = 0.00385

Table Range from 17.0 to 391.0 Ohms

Resistance	Slope	Intercept
17.0	-242.952	2.323969
26.0	-243.957	2.362626
35.0	-245.257	2.399766
45.0	-246.907	2.436427
56.0	-248.793	2.47011
67.0	-250.836	2.500594
79.0	-253.104	2.529302
92.0	-255.638	2.556855
106.0	-258.572	2.584534
120.0	-261.869	2.612006
133.0	-265.501	2.639312
146.0	-269.615	2.667492
159.0	-274.242	2.696595
172.0	-279.416	2.726672
185.0	-284.944	2.756555
197.0	-290.783	2.786194
209.0	-297.182	2.81681
221.0	-304.176	2.848458
233.0	-311.804	2.881198
245.0	-319.755	2.913648
256.0	-327.971	2.945745
267.0	-336.831	2.978926
278.0	-346.374	3.013254
289.0	-356.646	3.048797
300.0	-367.181	3.083915
310.0	-377.91	3.118524
320.0	-389.366	3.154325
330.0	-401.597	3.191389
340.0	-414.654	3.22979
350.0	-427.878	3.267574
359.0	-441.182	3.304632
368.0	-455.294	3.34298
377.0	-470.266	3.382694
386.0	-482.558	3.414538

C: Worksheets and Calculations

This appendix provides a variety of worksheets to help you determine your system's requirements.

In this Appendix

EtherNet/IP TCP/IP Requirements PLC Worksheet

Each EtherNet/IP application should be reviewed for its TCP/IP connection requirements. The following worksheet will assist in determining the number of connections required for *each* Allen-Bradley PLC within the system.

TCP/IP Connections (for each PLC in the system)

Question	**Quantity**
RSLogix connection to the PLC using EtherNet/IP (enter 1 here)	_____
How many RSLinx or 3rd Party OPC/DDE Servers?	_____
How many PAC devices will be accessed via an unconnected MSG instruction?	_____
How many other (non Opto 22) EtherNet/IP devices?	_____
How many Logix to other EtherNet/IP PLC TCP/IP connections?	_____
How many remote PLCs will connect to this PLC using a TCP/IP connection?	_____
How many Generic Ethernet Modules are defined?	_____
Total number of TCP/IP connections (sum the “Quantity” column together)	_____

Depending on the specific PLC or EtherNet/IP module, your application could exceed the TCP/IP connection resources. If you are using ControlLogix, you can use additional EtherNet/IP modules.

Typically, ControlLogix modules may support 64 (1756-ENBT) or 128 (1756-EN2T or 1756-EN2F) TCP/IP connections. CompactLogix typically supports 32 connections.

For the specific TCP/IP limitations of your PLC, see Allen-Bradley form *enet-um001_-en-p.pdf*.

MicroLogix PLCs such as the 1100 and 1400 support 8 TCP/IP connections. This limit is described in each product’s published specifications.

EtherNet/IP Multicast Requirements PLC Worksheet

Each EtherNet/IP application should be reviewed for its multicast requirements. The following worksheet will assist in determining the number of connections required for *each* Allen-Bradley PLC within the system.

Multicast Connections (for each PLC in the system):

	Quantity		**Total**
How many "Generic Ethernet Modules," with status?	__________	×2	__________
How many remaining "Generic Ethernet Modules?"	__________		__________
How many consumed tags to other EtherNet/IP PLCs?	__________		__________
How many produced tags to other EtherNet/IP PLCs?	__________		__________
Total Number of Multicast Connections (add "Total" column together)			__________

This total reflects the total number of CIP connections required for the application. Use the latest version of the EtherNet/IP Capacity Tool to accurately determine limits of your application. This is only necessary in applications that have large numbers of I/O especially when PLCs themselves are producing and consuming tags.

NOTE: Only some of the ControlLogix EtherNet/IP modules support implicit messaging. The modules that support implicit messaging are the 1756-ENBT, 1756-EN2T and the 1756-EN2F EtherNet/IP modules.

SNAP PAC Connection Worksheets

Complete the following worksheet for each SNAP PAC brain or controller used within an EtherNet/IP system.

EtherNet/IP SNAP PAC Multicast Connection Worksheet

The SNAP PAC brain or controller supports 16 multicast connections. If this limit is exceeded, EtherNet/IP modules will have difficulties connecting to the SNAP PAC brain or controller.

	Quantity		Total
How many "Generic Ethernet Modules," with status?	__________	×2	__________
How many remaining "Generic Ethernet Modules?"	__________		__________
Total number of Multicast Connections (add "Total" column together)			__________

EtherNet/IP SNAP PAC Encapsulation Connections

The SNAP PAC brain or controller supports 16 CIP encapsulation connections (for EtherNet/IP). The following worksheet will assist to determine the application requirements for each SNAP PAC device within the Allen-Bradley system.

Typically for explicit messaging, a PLC will create one encapsulation using TCP/IP connection to the PAC. Use only unconnected messaging (configured in the MSG instruction). This will ensure that the PLC will not quickly exceed the encapsulation connection limit of the PAC.

The PLC will also create a UDP encapsulation connection for each implicit messaging multicast session.

	Quantity		Total
Number of PLCs with Explicit Messaging access			__________
Total Generic Ethernet Modules w/Status accessing this device	__________	×2	__________
Total Generic Ethernet Modules accessing this device			__________
Total Number of Encapsulation Connections Consume			__________

EtherNet/IP Module Packet Rate Limits

Implicit Messaging Volume

To determine the total volume of packets generated by the implicit messaging, use one of the following equations. You will need to know the requested packet interval (RPI, in milliseconds) of each Generic Ethernet Module.

When using a Generic Ethernet Module with Status:

Packet Rate per Second (for each Generic Ethernet Module) = 4000 / RPI

When using all other Generic Ethernet Modules:

Packet Rate per Second = 2000 / RPI

The total implicit messaging packet rate is the sum of all of the packet rates of all the configured modules on the PLC.

Explicit Messaging Volume

Explicit messaging is determined by the rate the PLC logic decides when to initiate a message sequence. By determining the maximum number of MSG commands per second, you can use this number to estimate the maximum packet rate as follows:

Packet Rate per Second = 2 × maximum MSG commands per second

The total packet rate generated by implicit and explicit messaging is the sum of the implicit message packet rate and the explicit message packet rate.

IO Packet Rate = Implicit Packet Rate + Explicit Packet Rate

Typically a ControlLogix 1756-ENBT module has a maximum packet rate of 5,000 packets per second. A CompactLogix PLC has a throughput of 4,000 packets per second. Allen-Bradley form ENET-AP001D-EN-P specifies the entire calculated rate should not exceed 90% of the maximum packet rate of the EtherNet/IP module.

The calculations described above only accumulate a portion of the EtherNet/IP messaging rate. We strongly recommend reviewing Allen-Bradley forms *ENET-AP001* and *1756-RM094* to ensure that all other sources of EtherNet/IP traffic are considered when validating your system design.

The Ethernet topology and switches are also responsible for the response rate and maximum throughput of an EtherNet/IP implementation. We encourage you to evaluate the performance of your Ethernet network topology.

D: Connecting with MicroLogix

This appendix provides information for connecting to a MicroLogix 1100 or 1400 PLC.

You can use a MicroLogix 1100 (Series-B) or 1400 to read and write I/O data using IO4AB. Assembly Instances configured in the EtherNet/IP Configurator may be read and written using the MSG instruction.

Each MSG instruction must have its own RIX Extended Routing Information and Message files. Add these files before configuring the MSG instruction in the ladder.

To add more Message files follow these instructions:

1. While offline, select the data files folder in the RSLogix Micro project pane followed by a right mouse click.
2. Select New...
3. Add a new file of the type Message.
4. Give the file a name such as "Message1."
5. If desired, enter a description.
6. Elements should be set to 1, the default.
7. Select Global, the default.
8. Press OK.

To add additional Extended Routing Information files follow these instructions:

1. While offline, select the data files folder in the RSLogix Micro project pane followed by a right mouse click.
2. Select New...
3. Add a new file of the type Extended Routing Information.
4. Give the file a name such as "RIX1."
5. If desired, enter a description.
6. Elements should be set to 1, the default.
7. Select Global, the default.
8. Press OK.

Now you can add the MSG instruction to the ladder. See below for descriptions of the values when configuring the MSG instruction.

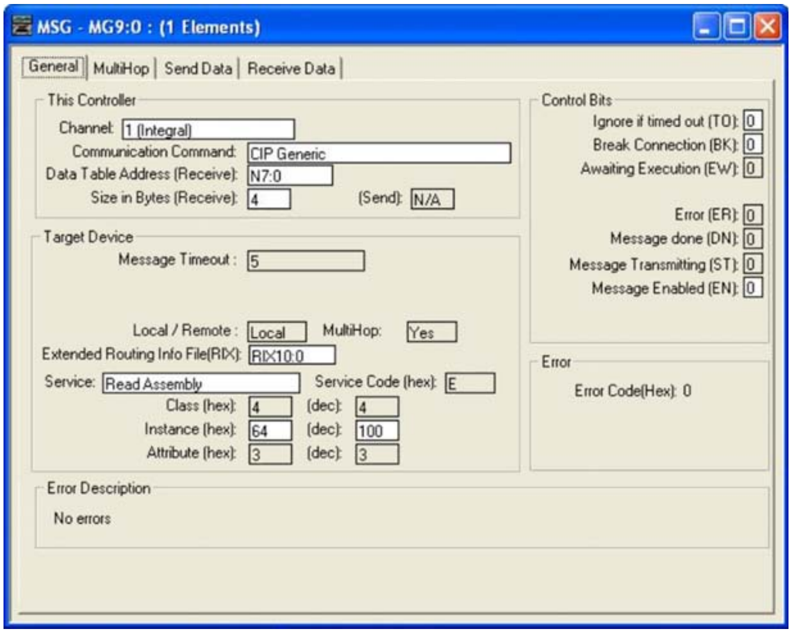
General Tab

This Controller

Field	Description
Channel:	1 (Integral)
Communication Command:	CIP Generic
Data Table Address:	Insert the address to read or write data
Number of Elements	

Target Device

Field	Description
Message Timeout:	This is automatically set.
Extended Routing Info File:	Routing Register File (create a unique file for each MSG)
Service:	Either “Read Assembly” or “Write Assembly”
Class:	4 (hex)
Instance:	Use the E/IP Configurator’s Assembly Instance number (from 100 to 115)
Attribute:	3 (hex)



This Controller

Channel: 1 (Integral)

Communication Command: CIP Generic

Data Table Address (Receive): N7:0

Size in Bytes (Receive): 4 (Send): N/A

Target Device

Message Timeout : 5

Local / Remote : Local MultiHop: Yes

Extended Routing Info File(RIX): RIX10:0

Service: Read Assembly Service Code (hex): E

Class (hex): 4 (dec): 4

Instance (hex): 64 (dec): 100

Attribute (hex): 3 (dec): 3

Control Bits

Ignore if timed out (TO): 0

Break Connection (BK): 0

Awaiting Execution (EW): 0

Error (ER): 0

Message done (DN): 0

Message Transmitting (ST): 0

Message Enabled (EN): 0

Error

Error Code(Hex): 0

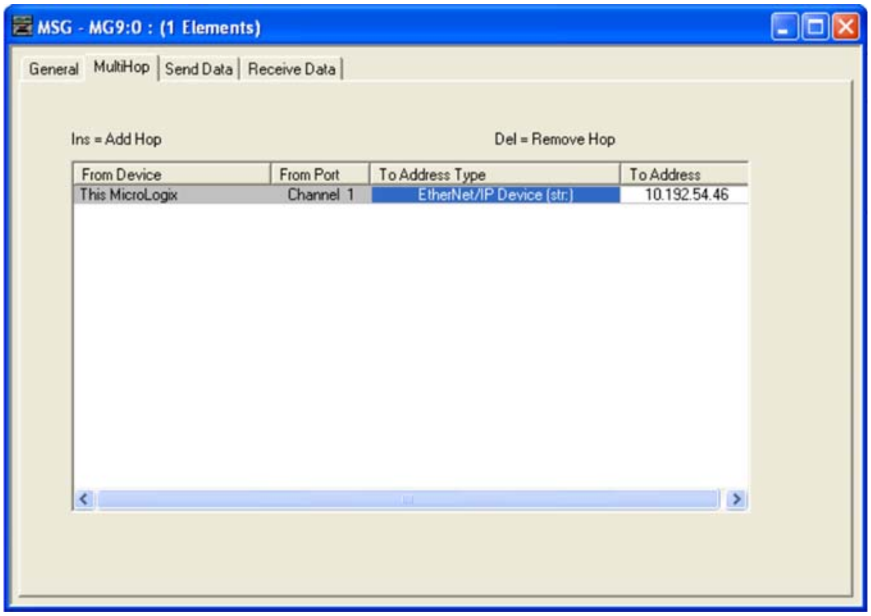
Error Description

No errors

MultiHop

Add Hop

Field	Description
From Device:	This MicroLogix
From Port:	Channel 1
To Address Device:	EtherNet/IP Device (str:)
To Address:	(insert IP address of PAC device)



Ins = Add Hop

Del = Remove Hop

From Device	From Port	To Address Type	To Address
This MicroLogix	Channel 1	EtherNet/IP Device (str:)	10.192.54.46

The MSG has a limit of 124 16-bit words. However, when working with the EtherNet/IP Configurator, there is a lower limit for each assembly. For the MicroLogix family, an assembly instance may not exceed 62 DINTs (32-bit integers).

For additional information, see "Using Counts with EtherNet/IP" on page 109.

NOTE. MicroLogix 1100 must use firmware FRN 4 (OS Series B) or newer to enable CIP Generic messaging through the Ethernet port. MicroLogix 1400 already has CIP Generic Messaging support.

E: Detecting I/O Communication Failures

One important function ladder logic should perform is to detect when an I/O communication failure occurs. This function is crucial so the control system may properly react and notify when such a failure occurs.

When using implicit messaging, the PLC automatically restores the communications with the I/O units. This automatic nature allows the ladder to function on stale values even when the communication fails.

The only physical indicator of this failure on the PLC is the blinking I/O Status indicator on the front panel. If the panel is out of reach or is not convenient to be inspected, a failure will go unnoticed.

Detecting the I/O Status Indicator State

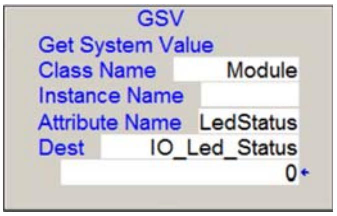
ControlLogix and CompactLogix provide a way to gain access to the value that controls the I/O Status indicator on the front panel of the Logix controller. The command is the GSV or Get System Value instruction.

The following GSV instruction options allow the retrieval of the I/O Status indicator. This front panel PLC indicator offers a global status of all module connections.

When implementing the GSV instruction, use these attributes:

Attribute	Description
Class Name:	“Module”
Instance Name:	leave blank
Attribute Name:	“LedStatus”
Destination:	An INT variable to receive the status

Here is an RSLogix screen capture of a configured GSV instruction to read the module’s LedStatus.



GSV
Get System Value
Class Name Module
Instance Name
Attribute Name LedStatus
Dest IO_Led_Status
0

The return values are (excerpted from Allen-Bradley document *1756-RM003*):

Value	Description
0	LED Off: No MODULE objects are configured for the controller (there are no modules in the I/O Configuration section of the controller organizer).
1	Flashing red: None of the MODULE objects are Running.
2	Flashing green: At least one MODULE object is not Running.
3	Solid green: All the Module objects are Running.

Detecting Each Generic Ethernet Module's State

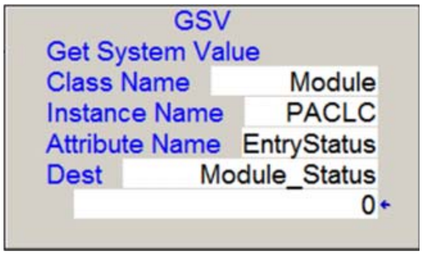
Many system integrators will want to know precisely which I/O module failed. RSLogix provides the ability to check on the status of each Generic Ethernet Module. This is another extension of the GSV command.

To inspect the current status of the Generic Ethernet Module, additional ladder instructions need to be added for each module in the PLC configuration.

These are the arguments for the GSV module:

Argument	Description
Class Name:	"Module"
Instance Name:	The Generic Ethernet Module you want to test.
Attribute Name:	EntryStatus
Destination:	An INT variable to receive the bitmask.

Here is a screenshot of the GSV instruction configured within the Ladder. The Instance Name "PACLC" is a Generic Ethernet Module already defined within the ladder.



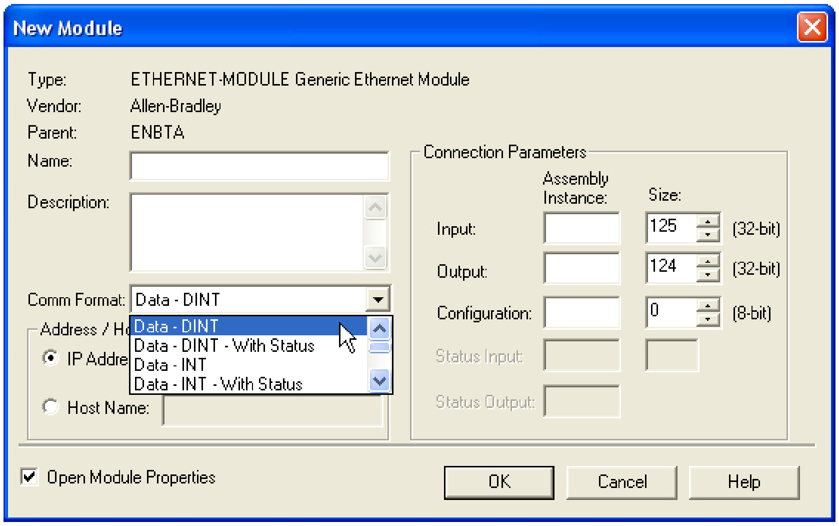
GSV
Get System Value
Class Name Module
Instance Name PACLC
Attribute Name EntryStatus
Dest Module_Status
0

The GSV instruction may add a burden to the ladder's scan time. As a result, the detection of I/O failures should be implemented efficiently. Consider using a timer as a time period check to evaluate the status of the PLC's I/O indicator. If this indicator should indicate a failure, then a routine should be called to test the status of the I/O units. Calling a routine after knowing there is a failure will reduce the number of GSV and conditional tests the ladder will have to perform.

For more information on the expected values reported by this instruction, see Allen-Bradley form 1756-rm003.

F: Generic Ethernet Module Options

When creating a GENERIC-ETHERNET module, you may select the Comm Format. This field controls the assumed type and the amount of data that may be transacted on this module. The communications format selection is dependent on the data type and the amount of data that your E/IP configuration will read or write.



New Module

Type: ETHERNET-MODULE Generic Ethernet Module
Vendor: Allen-Bradley
Parent: ENBTA
Name:
Description:
Comm Format: Data - DINT

Connection Parameters

	Assembly Instance:	Size:	
Input:		125	(32-bit)
Output:		124	(32-bit)
Configuration:		0	(8-bit)
Status Input:			
Status Output:			

☑ Open Module Properties

Once this dialog is completed, the Comm Format cannot be changed, so make this data selection decision carefully.

Data Selection for the Communication Format

For IO4AB, the communication format data type will usually be REAL (4-Bytes), DINT (32-bit integers), or INT (16-bit integers). The selected data type always applies to both the input and output assembly. Should a communication format be chosen with the status input assembly, this data is always considered a DINT format.

The four primary communication format types are as follows:

Input Data. A single assembly instance of inputs from the SNAP PAC I/O.

Input Data with Status. Two assembly instances. The primary Input instance's data may be selected. The status assembly instance is assumed to be DINT.

Data. This is the most typical selection. There is an input assembly and an output assembly. The user may select the data type for the input and output assembly.

Data with Status. Maximum data transfer possible. There is an input, output, and a status assembly. The user may select the native data type for the input and output assemblies. The status assembly is assumed to be a DINT.

The following table describes the communication format data types available for the Opto 22 I/O for A-B implementation.

Comm Format	Typical Use
REAL	The assembly instances are *only* comprised of REAL values or scaled engineering units of analog inputs or outputs.
DINT	The assembly instances contain *any* BOOL type data (for digital inputs or outputs).
INT	The assembly instances are filled with analog inputs as type "value" (32-bit integer in the E/IP configurator) and Boolean values.

Use the data type in the communication format that is closest to the data contained in your assembly instances.

Determining the Number of Assembly Instances

An RSLogix ETHERNET-MODULE, Generic Ethernet Module may have at least one and up to three assemblies of data. The three assembly types are Input, Output, and Status Input. An Input assembly is required for all configurations. Most Module configurations will have two assemblies, Input and Output. If additional Input data is required than Input assembly's 125 32-bit DINT limit, you may use the Status Input for additional data. The status input will permit up to 124 32-bit words in DINT format only.

Assembly	Max (Quantity of DINTs)	Description
Input	125	Input data from the remote I/O unit.
Output	124	Output data to the remote I/O unit.
Status	Typically two less than the size of the Output Assembly Size.	Status input data from the remote I/O unit. Data is always in DINT format.

Opto 22’s Mixed Architecture and the A-B Comm Format

Opto 22’s architecture is based around a mixed analog and digital architecture so that assembly instances usually have a combination of digital and analog data.

Since the Comm format will force the entire assembly to be represented as a single data type, this means that some of the values are not adequately represented. For example, a REAL will be contained in a DINT (bitwise) and vice versa.

RSLogix contains some methods to convert the data types.

Using CPS with Simple Data Types

For cases where the there is a minority data type in an assembly the ladder command, the CPS command may be used to translate a REAL contained in a DINT to a REAL. The same applies if a DINT was contained in a REAL. It may be converted to a DINT by using the CPS command.

In this case, the CPS command is a 4-byte transfer. The instruction does not convert the data, rather it moves the binary value of the variable to the destination.

Using CPS with a UDT

If there are many mixed data types in the assembly instance, CPS may be used to copy the entire module data array to (or from) a user-defined data type (UDT). The UDT’s definition must perfectly align to the assembly’s data types.

G: Accessing Serial Data

While it is possible to use IO4AB with a serial module, it has to be done with explicit messaging, which is not nearly as straightforward as the normal data types that can be handled using implicit messaging.

A better approach is to use a SNAP PAC controller to handle the communication with the SNAP PAC serial module and make the data accessible via the SNAP PAC controller's Scratch Pad. The Allen-Bradley controller can then access the data in the Scratch Pad using the normal implicit messaging method.

To use this approach you will need to develop a small PAC Control strategy to communicate directly with a SNAP serial module on one of the controller and I/O unit combinations:

- A SNAP PAC S-series controller with a SNAP PAC EB-series I/O unit
- A SNAP PAC R-series combination controller and I/O unit

Follow these steps:

1. Write a small PAC Control logic strategy to communicate directly with the SNAP serial module. Your strategy should do the following:
   - Read the values from the PLC via the Scratch Pad registers and create a string message to transmit.
   - Process the serial message transmission and parse the received data using a TCP/IP communication handle.
   - Publish the data to the Scratch Pad.
   - Indicate communication status using a simple 32-bit integer status value. Publish the communication status value to the Scratch Pad registers, which can be read by the PLC.
2. In the EtherNet/IP Configurator, add the Scratch Pad registers to an EtherNet/IP assembly instance so that the PLC can read the data from the Scratch Pad. You can use either implicit or explicit messaging to retrieve these values. For implicit message, use Generic Ethernet Module. For explicit messaging, use a MESSAGE object and MSG instructions.
3. To send data from the PLC to the SNAP-PAC controller, create another assembly instance on the controller to allow the PLC to write data (numeric or string) to the SNAP-PAC controller's Scratch Pad registers. Again, you can use either explicit or implicit messaging."

For an example of how to exchange data between the PLC and a PAC Controller, see Chapter 6: Connecting PAC Control and Allen-Bradley Systems on page 57.

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