

# ETHERNET/IP PROGRAMMER'S GUIDE

## ACS Drive/Controller



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## 1.1 Introduction

**NOTE:** This document is intended to provide information on the EtherNet/IP protocol only. Please reference the ACS Hardware/Installation Guide for all electrical and hardware installation procedures, specifications, and safety instructions when operating the ACS Drive.

EtherNet/IP has been instrumental in realizing high performance and advanced automating manufacturing applications. Common Industrial Protocol (CIP) has enabled the enterprise for:

- Interoperability between legacy, multi-vendor internet technologies
- Near real-time network performance (including low latency, low jitter, and minimal packet loss)
- Security
- Reliability
- Manageability and ease-of-use features
- Ability to add innovative technologies such as mobile technologies

EtherNet/IP provides comprehensive messaging and services for control, safety, synchronization, motion, configuration and information that creates unified communication across manufacturing enterprise.

Tolomatic's implementation of EtherNet/IP connectivity conforms to the Open Systems Interconnection (OSI) model which defines the framework of implementing network protocols in seven layers. The ACS drive EtherNet/IP implementation conforms to Open DeviceNet Vendor Association (ODVA) standard (CIP version 3.10 and EtherNet/IP version 1.11). For more information regarding EtherNet/IP and CIP functionality and conformation standards as regulated by the ODVA, visit their website at [www.odva.org](http://www.odva.org).

## 1.2 Network

A typical EtherNet/IP network forms several point-to-point connections. A typical network in the factory would comprise of variety of complex devices such as HMIs, PLCs, motion controllers, bar code scanners to simple devices such as I/O. This configuration is represented in Figure 1-1.

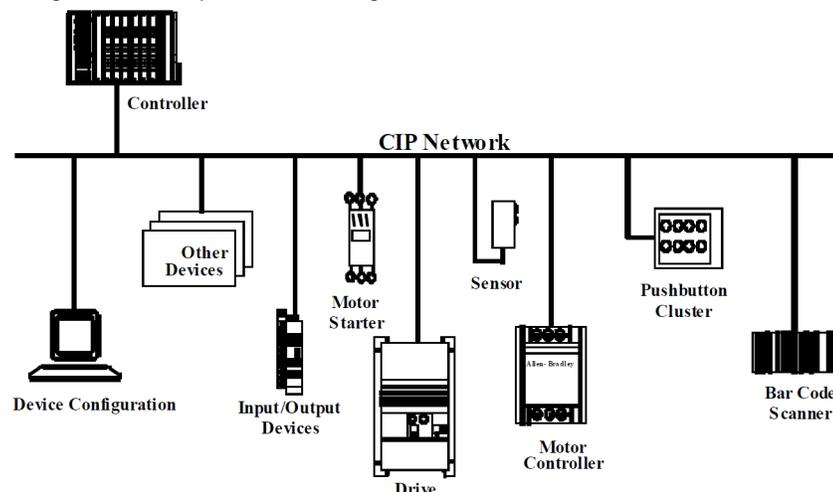


Figure 1.1: EtherNet/IP Network Example

## 1.3 Definitions

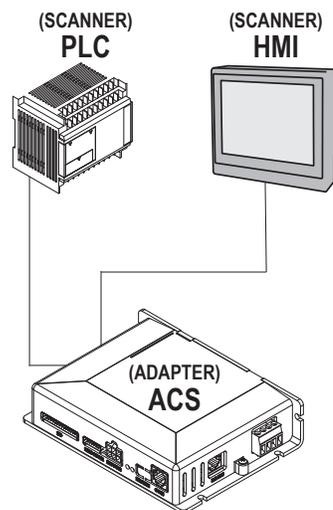
The following definitions provide a general context for terms used in this guide in the EtherNet/IP implementation

**Device:** A device is considered any product that supports the EtherNet/IP encapsulation of CIP.

**Connection:** A connection is a logic link between two devices that may share more than one connection.

**Scanner:** A master or controlling device that initiates a request or connection.

**Adapter:** A device that receives a connection request or an individual service request. Multiple adapters can be connected to one scanner on a network. The ACS drive is an adapter device (see Figure 1-2).



**Figure 1-2: ACS Drive as an Adapter Device.**

**Assembly:** A collection of pre-defined data that resides in an adapter. Each datapoint is identified by its own unique instance number, size and type. There are three types of assemblies: producing (data to be sent); consuming (data to be received); and configuration (how the data is to be consumed and interpreted).

**Explicit Messaging Connection:** A connection used for individual request/response transactions that are handled in the EtherNet/IP protocol via TCP.

For example, an explicit connection request from a scanner device results in a response from the adapter device indicating a successful or failed request. If data payload was part of the request, this information would also be included.

Requests from a scanner device is called a service request and these requests are identified by one-byte service codes inside the request packet. CIP specifications define the meaning of the majority of these service codes however, codes 0x4B through 0x63 have meanings specific to the destination object of the service request.

## 1: OVERVIEW

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Service request destinations are defined by a portion of the request packet, or path that is either an object description or an ASCII character string. The adapter device receiving a service request distinguishes between an object description path ASCII character string path by the path's header bytes.

Class (type of object reference), instance (object of the type), and the attribute numbers inside the path identify a request to an object. For example, a mixed carton of oatmeal contains 24 packages (objects) and are considered instances 1 through 24. Each object can have multiple attributes. In this example, the carton contains 6 different flavors or attributes 1 through 6. An example service request from a scanner would be to ask for the flavor of package or object number 12. Explicit message commands or data requests can also be sent from the scanner to individual target nodes via connected or unconnected messages. A connected message establishes a formal CIP connection between devices that allows each device to detect and report either established or failed connections. Unconnected messages are managed by the internal stack's Unconnected Message Manager (UCMM) and does not establish a periodic explicit connection.

***Implicit or I/O Connection:*** A connection that establishes a periodic exchange of data between a scanner and adapter. A repetition packet interval or RPI (normally expressed in milliseconds) is established by the scanner device in both directions. An I/O connection request also establishes the size of each assembly and the instance numbers of the assembly types (producing, consuming and configuration). To allow the adapter to interpret subsequent data exchange, an I/O connection may also contain data destined for the adapter's configuration assembly. In EtherNet/IP the I/O connection itself is established via TCP but the subsequent exchange of data uses UDP.

An I/O connection also determines how the adapter device should send its data, either point-to-point (addressed to the scanner only) or multicast (address group that includes the scanner), and allows other devices on the network to receive data from the adapter. NOTE: If the data is sent via multicast, the adapter device itself must support multicast or the connection will fail.

Both, explicit service requests and implicit I/O connections allow scanner access to parameters, however the process differs. Typically, the scanner device utilizes HMI or PLC software such as Allen Bradley's ControlLogix. PLC's normally will make both explicit and I/O connections.

## 1.4 Layer Structure

Figure 1-3 below shows the seven layers of protocol implementation. Tolomatic's ACS Drive user device profile resides on the seventh layer.

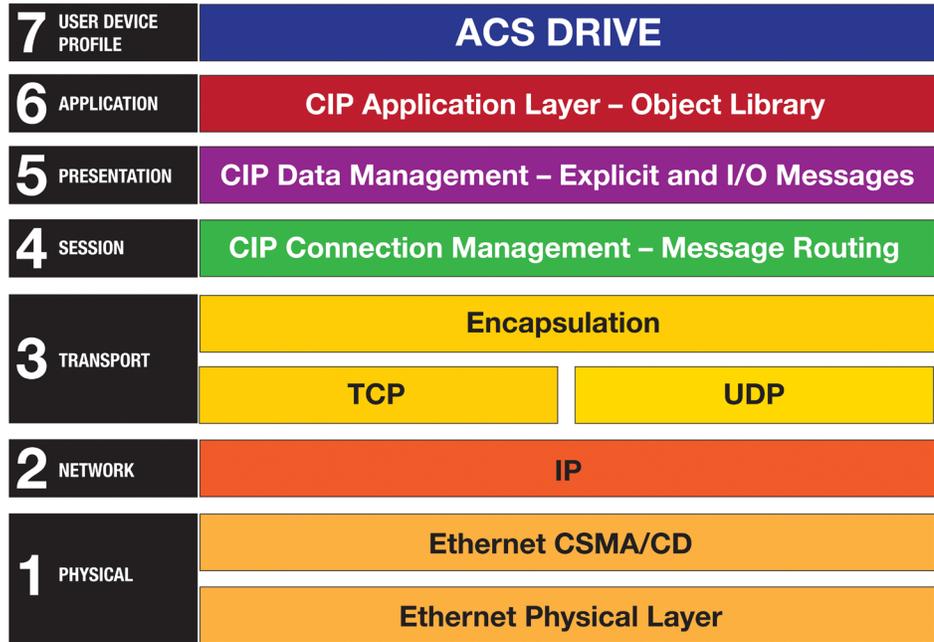


Figure 1-3: EtherNet/IP Layer Structure with the ACS Drive as the User Device Profile

## 1.5 References

- {1} The CIP Network Library Volume 1: Common Industrial Protocol, Edition 3.10, April 2011
- {2} The CIP Network Library Volume 2: EtherNet/IP Adaptation of CIP, Edition 1.11, April 2011

## 2.1 Definitions

ACS Drive & Controller Part Number 36049654 is the only part number with EtherNet/IP capability. ACS drive part number can be found on the label on the front cover.

## 2.2 Cabling

The selection of cable has a profound impact on network performance and reliability. Selecting the correct cable requires an understanding of the environment where the cable is installed.

Due to high data rate and reliability considerations, at the minimum, Cat5e cables should be used with the ACS drive. If the cables are made on site, they must be tested to meet performance criteria set according to TIA/EIA-568-B standard. This cable definition is the general cable requirements for copper and fiber cabling installations.

EtherNet/IP specifications limit the channel to 100 meters or up to 90 meters horizontal wiring with two 5-meter patch cords. Some applications will require longer patch cords. In these applications the total length of horizontal wiring must be adjusted to compensate for the added loss of each connector pair and additional patch cord length beyond 10m.

$$C = \frac{(102-H)}{(1 + D)} (1)$$

Where:

**C** is the maximum combined length (m) of the work area cable, equipment cable, and patch cord.

**H** is the length (m) of the horizontal cable ( $H + C \leq 100$  m).

**D** is a de-rating factor for the patch cord type (0.2 for 24 AWG UTP/24 AWG ScTP and 0.5 for 26 AWG ScTP). The derating factors are based on COMMERCIAL cables. Other constructions, such as high flex, may have different performance. Consult the manufacturer for information.

**W** is the maximum length (m) of the work area cable.

**T** is the total length of horizontal, patch and equipment cords.

The maximum stranded cable length is limited to 85mm for the channel with the standard 20% derating for standard stranded cables.

## 2: ACS ETHERNET/IP REQUIREMENTS

WIRE TYPE VERSUS LENGTH					
PATCH CABLE GAUGE	D	H	W	C	T
	PATCH DERATING	HORIZONTAL LENGTH (H+C<=100M)	PATCH LENGTH	TOTAL LENGTH PATCH AND EQUIPMENT	TOTAL LENGTH OF PATCH, EQUIPMENT AND HORIZONTAL
#24	0.2	100	0	0	100
#24	0.2	0	80	85	85
#24	0.2	25	59	64	89
#24	0.2	50	38	43	93
#26	0.5	0	63	68	68
#26	0.5	25	46	51	76
#26	0.5	50	30	35	85
#26	0.5	100	0	0	100

**Table 2-1: Cable Wire Type Versus Cable Length**

Please refer to Section 8-9.2.3.6 of the ODVA EtherNet/IP Standard v. 1.11 for additional information.

### 2.3 Tolomatic Motion Interface (TMI) Requirement

The TMI is used to configure the ACS Drive including setting up the Ethernet port.

PC HARDWARE MINIMUM REQUIREMENT	
Processor	1 GHz
RAM	512 MB
Disk Space	32-Bit 600 MB
Disk Space	64-Bit 1.5 GB
USB	1 USB Connection
USB to Serial Converter	1 USB to Serial Converter

**Table 2-2: Hardware Requirements**

The Tolomatic Motion Interface (TMI) is compatible with the following operating systems: Windows® 7 and Windows® XP.

For all platforms, it is recommended that you upgrade to the latest Windows Service Pack and critical updates from the Windows Update Web Site at <http://go.microsoft.com/fwlink/?LinkId=168461> to ensure the best compatibility and security.

The TMI software is not supported on IA-64-based (Itanium) systems.

### 2.4 Firmware Requirements

Features described in this manual require Tolomatic ACS Drive firmware version 2.0.0.0 or higher.

### 2.5 EDS File

A EtherNet/IP Electronic Data Sheet (EDS) file is available for ACS Drives that supports EtherNet/IP. Please download that from <http://www.tolomatic.com>

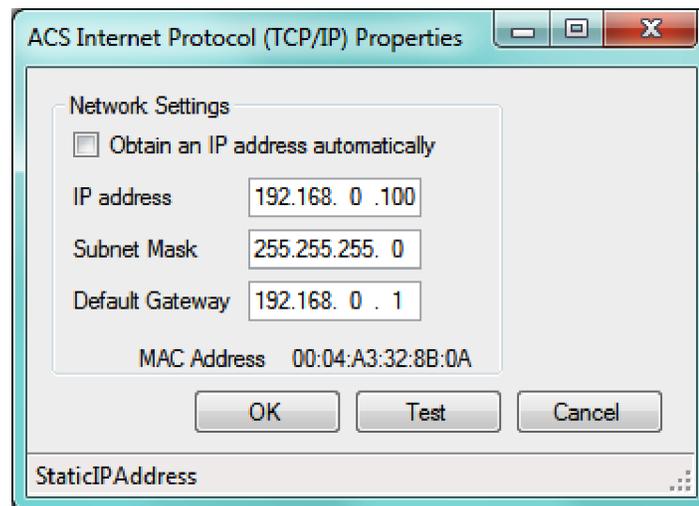
ACS Drive Configuration for EtherNet/IP is a 2-step process:

1. Using Tolomatic Motion Interface (TMI), assign an IP Address, Subnet Mask and Gateway.
2. Using TMI set the drive to EtherNet/IP mode.

For information related to setup, installation of Tolomatic Motion Interface, please refer to TMI User Manual.

## 3.1 Setup IP Address

Choose the Tools -> Ethernet menu selection or press the Configure Ethernet button in the toolbar.



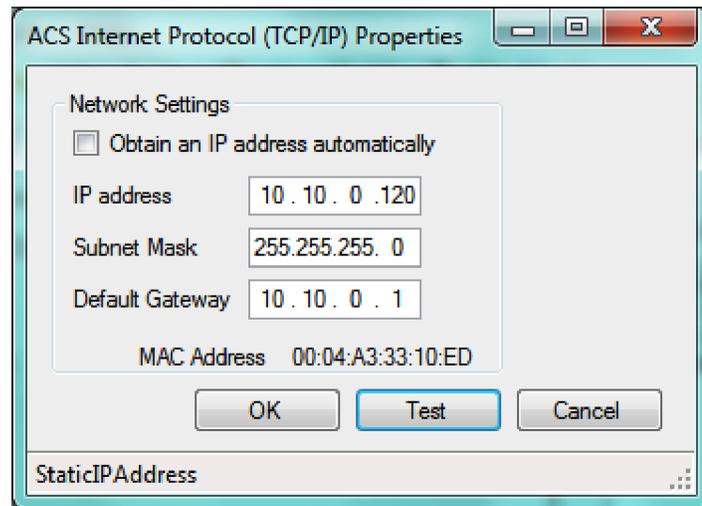
**Figure 3-1: Ready to Manually Enter the IP Address**

Enter the IP address, Subnet Mask and Default Gateway parameters for the network. (The values shown above are the factory default values for the ACS drive. Typically, at least the IP address and Default Gateway will need to be changed for the network.)

To test the Ethernet settings, the Test button can be used to download the Ethernet settings to the ACS drive and when the Test button is pressed, TMI will download the settings to the ACS drive and initiate the PC to Ping the drive.

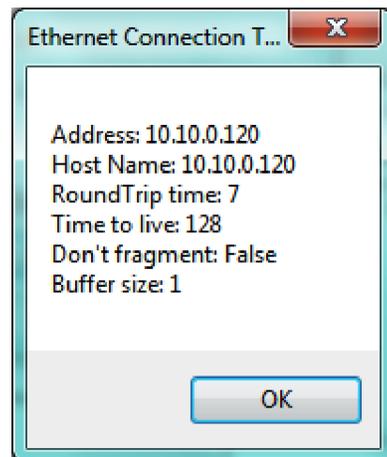
NOTE: An Ethernet cable must be connected from the PC to the ACS drive.

### 3: ACS DRIVE CONFIGURATION USING TMI



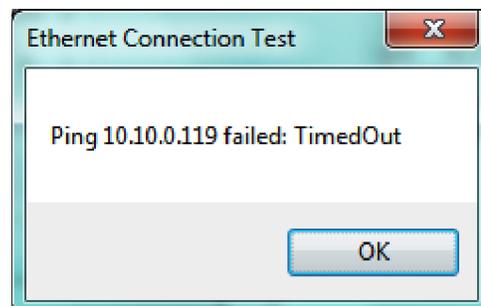
**Figure 3-2: A Manually Entered IP Address, Ready to Test**

If the Test worked, a screen will pop-up showing similar results to the following.



**Figure 3-3: Testing Verifies a Successful Ethernet Connection**

If the Test didn't work (in this example, the Ethernet cable was unplugged from the ACS drive) an error dialog will be shown.



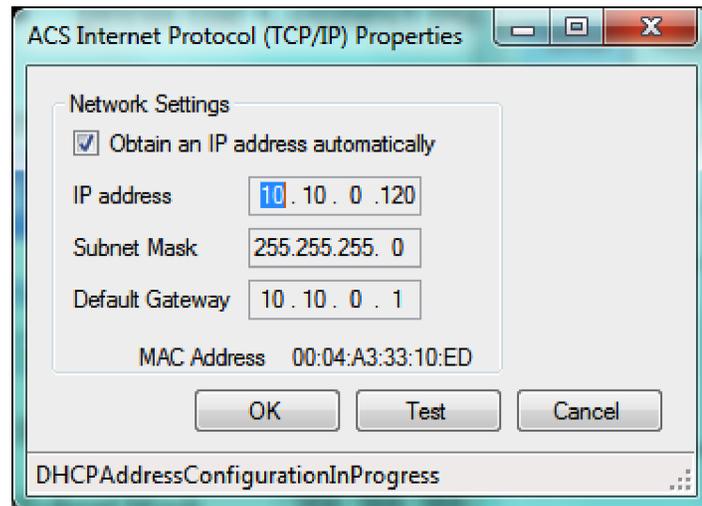
**Figure 3-4: Testing Indicates a Failed Attempt for Ethernet Connection**

### 3: ACS DRIVE CONFIGURATION USING TMI

To configure the ACS drive for DHCP server in order to dynamically assign an IP Address:

- check the “Obtain an IP address automatically” checkbox
- click OK on the ACS Internet Protocol (TCP/IP) Properties dialog
- click the Disconnect button on the TMI Drive tab (or press the Disconnect from Drive button on the toolbar)
- click Yes when asked “Update drive flash memory?”.
- cycle ACS drive power (turn off then turn on)
- press the Connect button on the TMI Drive tab (or press the Connect to Drive button on the toolbar)

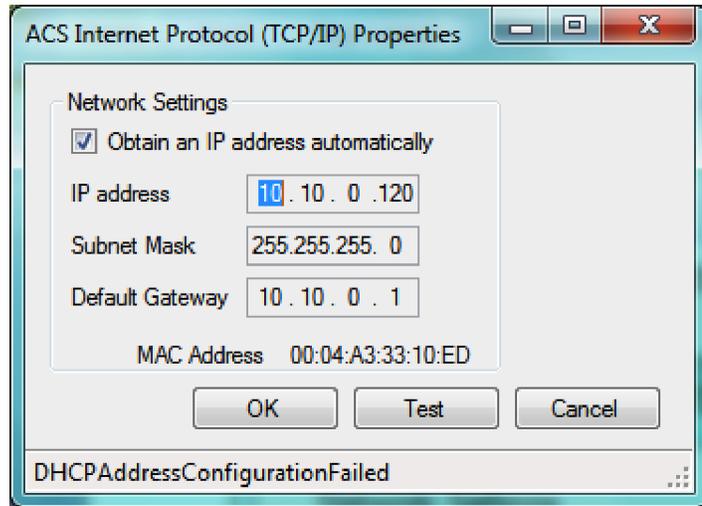
When the Ethernet configuration tool is opened, the status bar informs the status of the DHCP address configuration process. This is not dynamically updated. To see the current status, press Cancel (or OK), wait a bit, then open this tool again.



**Figure 3-5: Obtaining an IP Address Automatically**

If there is a problem and the ACS drive is unable to get an IP address from the DHCP server, the status bar will display the error message.

### 3: ACS DRIVE CONFIGURATION USING TMI



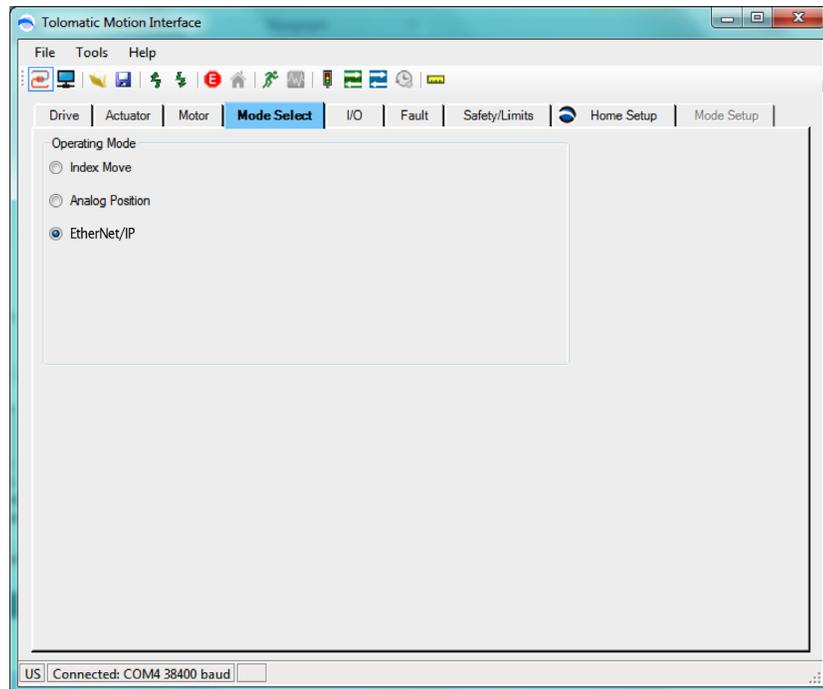
**Figure 3-6: Failed DHC Configuration**

When Ethernet configuration is complete, press OK.

## 3.2 Configure EtherNet/IP Mode

Once ACS drive is correctly setup with IP address, mask and gateway, input assemblies are available for scanner to consume. By putting ACS drive in EtherNet/IP mode, ACS drive is ready to consume output assemblies from the scanner.

In TMI, go to the Mode Select tab and select the EtherNet/IP radio button as shown here:



**Figure 3-7: Selecting Operating Mode of ACS Drive**

### 3: ACS DRIVE CONFIGURATION USING TMI

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Clicking on any other tab or navigating away from Mode Select tab will configure the ACS drive for EtherNet/IP mode.

At this point, the ACS Drive is ready to be integrated with any scanner.

The ACS drive will only allow two I/O connections. The ACS drive responds to connection and service requests from a scanner and no commands or parameters from the drive are required to allow these connections. However, certain commands and parameters from the ACS drive, allow a user or program to monitor the status and descriptions of the connections.

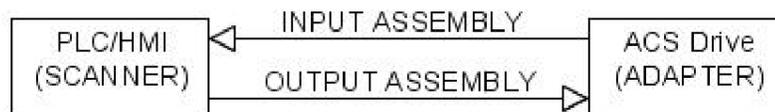
An implicit or I/O connection sets up the periodic exchange of data between the ACS drive and the data tags in scanner memory. Configuration of the number of parameters and which ones are used along with direction is set up at the scanner—normally part of the PLC configuration process—and separate from the PLC ladder programming.

An I/O messaging service request may result from a software driver implementation (such as EIP Scan from Pyramid Systems), or may be part of a message box inside a ladder rung of a PLC program. Service requests always contain a code (specifies what is being requested) and a path (specifies destination object of request). The paths of some of these service codes supported in the ACS drive, may take the form of an ASCII character string or tag. Other paths will require specification of class, instance and attribute.

Input and output directions are from the perspective of scanner device. Input assemblies are consumed by scanner devices and produced by adapter devices. Output assemblies are produced by a scanner device and consumed by an adapter device. Refer to Figure 4-1.

Output assemblies are commonly used for controlling the enable/disable state of the drive and for supplying the velocity or position reference.

Input assemblies are commonly used to monitor the drive status and run-time quantities such as current position and faults, if present.



**Figure 4-1 EtherNet/IP I/O Assembly**

## 4.1 Data Types

Data Types used in this Object Model are described in Table 4-1 below.

## 4: ETHERNET/IP & I/O CONNECTIONS

DATA TYPE	DESCRIPTION
USINT	Unsigned Short Integer (8-bit)
UINT	Unsigned Integer (16-bit)
UDINT	Unsigned Double Integer (32-bit)
SHORT STRING <sub>nn</sub>	Character String (1st byte is length; up to nn characters)
WORD	Bit String (16-bits)
DWORD	Bit String (32-bits)
REAL	IEEE 32-bit Single Precision Floating Point

**Table 4-1: Data Types**

### 4.2 Input Assembly

INSTANCE	ATTRIBUTE ID	BYTES	TYPE	VALUE
Input (T->0) Instance 100	1	0-3	REAL	Current Position
		4-7	DWORD	Drive Status (32 bitmap statuses)
		8-11	DWORD	Drive Faults (32 bitmap faults)
		12-15	DWORD	Digital Input (8 bits used out of 32)
		16-19	DWORD	Digital Output (4 bits used out of 32)
		20-23	REAL	Analog Input
		24-27	REAL	Analog Output

**Table 4-2: ACS EtherNet/IP Input Assembly**

ACS DRIVE STATUS	
BIT	DESCRIPTION
0	Drive Enable: 0 = Not Enable; 1 = Enable
1	Drive Homed: 0 = Not Homed; 1 = Homed
2	Drive In Motion: 0 = Motion Complete; 1 = In Motion
3	EStop: 0 = off; 1 = on
4	(internal use)
5	(internal use)
6	(internal use)
7	(internal use)
8	(internal use)
9	(internal use)
10-30	open
31	Drive Control: 0 = off (I/O, CTROFF), 1 = on (Host, CTRON)

**Table 4-3: ACS Drive Status**

## 4: ETHERNET/IP & I/O CONNECTIONS

ACS DRIVE FAULTS	
BIT	DESCRIPTION
0	Positive Limit
1	Negative Limit
2	E Stop
3	Position Error
4	Feedback Error
5	Overcurrent
6	Motor Overtemperature
7	Drive Overtemperature
8	Drive OverVolatage
9	Drive UnderVoltage
10	Flash Error
11-13	Open

Table 4-4: ACS Drive Faults

### 4.3 Output Assembly

INSTANCE	ATTRIBUTE ID	BYTES	TYPE	VALUE
Input (0->T) Instance 112	3	0	USINT	Network Outputs Bit 0: Enable Bit 1: Start Motion Bit 2: Home Bit 3: E-Stop Bit 4-7: Reserved
		1	USINT	Move Select (0-16)
		2-3	NA	Reserved

Table 4-5: ACS EtherNet/IP Output Assembly

## 4: ETHERNET/IP & I/O CONNECTIONS

INSTANCE	ATTRIBUTE ID	BYTES	TYPE	VALUE
Output (O->T) Instance 113	3	0	USINT	Network Outputs Bit 0: Enable Bit 1: Start Motion Bit 2: Home Bit 3: E-Stop Bit 4-7: Reserved
		1	USINT	Move Select (0-16)
		2-3	NA	Reserved
		4-7	REAL	Target 0 Position
		8-11	REAL	Target 0 Velocity
		12-15	REAL	Target 0 Acceleration
		16-19	REAL	Target 0 Deceleration
		20-23	REAL	Target 0 Force
		24-27	DWORD	Target 0 Motion Type (absolute or incremental)
		28-31	DWORD	Digital Output (4 bits used out of 32)

**Table 4-6: ACS EtherNet/IP Full Output Assembly**

# Explicit Messaging **5**

One of the explicit message objects is allocated as part of the predefined slave/adaptor connection set as defined in the Ethernet/IP specification.

The other may be allocated using the Unconnected Message Manager (UCMM) protocol.

**These objects can be used to access any ACS Drive parameter.**

OBJECT ID	OBJECT NAME	PURPOSE
1	Vendor Identity	Identifies the drive as ACS Drive & Controller
4	Assembly	ACS Drive currently supports two (2) Output assembly objects and one (1) Input assembly object as specified by EtherNet/IP standard
245	TCP	ACS Drive TCP/IP Interface Object provides information about TCP/IP network interface such as IP Address, Network Mask, Gateway, Host Name
246	Ethernet Link	ACS Drive Ethernet Link Object provides information about Speed and Duplex connection

**Table 5-1: Message Objects**

## 5.1 Identity Object

The following tables contain the attribute, status, and common services information for the Identity Object.

INSTANCE	ATTRIBUTE ID	NAME	CIP DATA TYPE	DATA VALUE
Class (Instance 0)	1	Revision	UINT	1
Instance 1	1	Vendor number	UINT	1230
	2	Device type	UINT	0
	3	Product code number	UINT	9046
	4	Product major revision	USINT	01
		Product minor revision	USINT	01
	5	Status	WORD	NA
	6	Serial number	UDINT	Unique 32 bit value
7	Product name	SHORT STRING32	ACS Drive & Controller	

**Table 5-2: Identity Object (01<sub>HEX</sub> - 1 Instance)**

Identity Object Common Services			
SERVICE CODE	IMPELEMENTED FOR		SERVICE NAME
	CLASS LEVEL	INSTANCE LEVEL	
01Hex	No	Yes	Get_Attribute_All
05Hex	No	Yes	Reset
0EHex	Yes	Yes	Get_Attribute_Single
10Hex	No	Yes	Set_Attribute_Single

**Table 5-3: Identity Objects Common Services**

### 5.2 Assembly Object

The following tables contain the attribute, instance, data mapping, and common services information for the Assembly Object.

INSTANCE	ATTRIBUTE ID	NAME	CIP DATA TYPE	DATA VALUE
Class (Instance 0)	1	Revision	UINT	2
	2	Max instance	UINT	129
Input (T->O) (Instance 100)	3	Refer to Table 4-2		
Output (O->T) (Instance 112)	3	Refer to Table 4-5		
Output (O->T) (Instance 113)	3	Refer to Table 4-6		
254 (0xFE)	4	Input only heartbeat <sup>1</sup>	Heartbeat	0
255 (0xFF)	5	Listen only heartbeat <sup>2</sup>	Heartbeat	0
253 (0xFD)	6	Output Only heartbeat <sup>3</sup>	Heartbeat	0

<sup>1</sup>This instance allows clients (PLCs) to monitor input data without providing output data.

<sup>2</sup>This instance allows clients (PLCs) to monitor input data without providing output data. To use this connection type, an owning connection must exist from a second client and the configuration of the connection must match exactly.

<sup>3</sup>This instance allows output data without providing input data.

**Table 5-4: Assembly Object (04<sub>HEX</sub> - 6 Instances)**

## 5: EXPLICIT MESSAGING

Assembly Object Common Services			
SERVICE CODE	IMPELEMENTED FOR		SERVICE NAME
	CLASS LEVEL	INSTANCE LEVEL	
E <sub>HEX</sub>	Yes	Yes	Get_Attribute_Single
10 <sub>HEX</sub>	No	Yes	Set_Attribute_Single

**Table 5-5: Assembly Objects Common Services**

### 5.3 TCP/IP Object

Please refer to Volume 2: EtherNet/IP Adaptation of CIP v. 1.11, 5-5.3 for exact format and interpretation of attributes.

INSTANCE	ATTRIBUTE ID	NAME	DATA TYPE	
Class (Instance 0)	1	Revision	UINT	
Instance 1	1	Status	DWORD	
	2	Configuration capability	DWORD	
	3	Configuration control	DWORD	
	4	Physical Link Object Structure of Path size Path	UINT Array of Word	
	5	Interface configuration Structure of IP Address Network Mask Gateway Address Name Server Name Server 2 Domain Name Size Domain Name	UDINT UDINT UDINT UDINT UDINT UINT STRING	
		6	Host name Structure of Host Name Size Host Name	UINT STRING

**Table 5-6: TCP/IP Object (0xF5<sub>HEX</sub> - 1 Instance)**

TCP/IP Object Common Services			
SERVICE CODE	IMPELEMENTED FOR		SERVICE NAME
	CLASS LEVEL	INSTANCE LEVEL	
E <sub>HEX</sub>	Yes	Yes	Get_Attribute_Single
10 <sub>HEX</sub>	No	Yes	Set_Attribute_Single

**Table 5-7: TCP/IP Object Common Services**

## 5.4 Ethernet Link Object

Please refer to Volume 2: EtherNet/IP Adaptation of CIP v. 1.11, Section 5-5.4 for exact format and interpretation of attributes.

INSTANCE	ATTRIBUTE ID	NAME	DATA TYPE
Class (Instance 0)	1	Revision	UINT
Instance 1	1	Interface speed	UDINT
	2	Interface flags	DWORD
	3	Physical address	USINT Array (6)

**Table 5-8: Ethernet Link Object (0xF6<sub>HEX</sub> - 1 Instance)**

Ethernet Link Object Common Services			
SERVICE CODE	IMPELEMENTED FOR		SERVICE NAME
	CLASS LEVEL	INSTANCE LEVEL	
E <sub>HEX</sub>	Yes	Yes	Get_Attribute_Single
10 <sub>HEX</sub>	No	Yes	Set_Attribute_Single

**Table 5-9: TCP/IP Object Common Services**

# Appendix

## Troubleshooting

SYMPTOM/TROUBLE	POSSIBLE CAUSE/RESOLUTION
No Ethernet Communication	<ol style="list-style-type: none"><li>1. Check Ethernet Cable.</li><li>2. Verify Ethernet Cable is plugged in securely.</li><li>3. Incorrect combination of IP Address, Subnet Mask, Gateway. Check with your network administrator to determine correct combination.</li><li>4. Try different Ethernet port on the drive.</li></ol>
No EtherNet/IP connectivity	<ol style="list-style-type: none"><li>1. Check your assembly configuration.</li><li>2. Check if Ethernet communication can be established with the drive using PING utility.</li><li>3. Check if Digital Outputs can be set/reset using EtherNet/IP O-&gt;T assembly.</li><li>4. Advanced Troubleshooting Tip: Check Ethernet packets received and sent to the PLC from and to the drive.</li></ol>
Motion cannot be executed over EtherNet/IP	<ol style="list-style-type: none"><li>1. Check if Drive Status, Drive Faults, Digital Inputs and Outputs can be queried over EtherNet/IP. If drive is not sending them, then troubleshoot Ethernet communication.</li><li>2. Check if drive is configured with EtherNet/IP communication mode using Tolomatic Motion Interface Software.</li><li>3. Check if Digital Outputs can be set/reset using EtherNet/IP O-&gt;T assembly. If the Digital Outputs of the drive cannot be set or reset using EtherNet/IP O-&gt;T assembly then troubleshoot the Ethernet communication.</li><li>4. Advanced Troubleshooting Tip: Try different EtherNet/IP scanner to interface with Tolomatic ACS Drive.</li></ol>

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