



OPC-F1-WiE Multiprotocol Wireless Ethernet Interface Instruction Manual

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No complex software or hardware system is perfect. Bugs may always be present in a system of any size. In order to prevent danger to life or property, it is the responsibility of the system designer to incorporate redundant protective mechanisms appropriate to the risk involved.

Preface

Thank you for purchasing the OPC-F1-WiE Multiprotocol Wireless Ethernet Interface. This instruction manual has been prepared to help you connect your FRENIC-Eco inverter to a variety of wireless Ethernet control networks.

This instruction manual does not contain inverter usage instructions. Please refer to this instruction manual in conjunction with the FRENIC-Eco Instruction Manual (INR-SI47-1225-E) in order to become familiar with the proper handling, installation and operation of this product. Improper handling or installation procedures may result in incorrect operation or premature product failure.

Please keep this instruction manual in a safe place.

Related Publications

Listed below are publications that are recommended for reference in conjunction with this instruction manual.

- RS-485 Communication User's Manual.....(MEH448)
- FRENIC-Eco Instruction Manual.....(INR-SI47-1225-E)

These documents are subject to change without notice. Please be sure to refer to the most recent available versions.

Safety precautions

Please read this instruction manual thoroughly prior to proceeding with installation, connections, operation, or maintenance and inspection. Additionally, ensure that all aspects of the system are fully understood, and familiarize yourself with all safety information and precautions before operating the inverter.

Safety precautions in this instruction manual are classified into the following two categories:

 WARNING	Failure to heed the information indicated by this symbol may lead to dangerous conditions, possibly resulting in death or serious bodily injuries.
 CAUTION	Failure to heed the information indicated by this symbol may lead to dangerous conditions, possibly resulting in minor or light bodily injuries and/or substantial property damage.

Failure to heed the information contained under the CAUTION title can also result in serious consequences. These safety precautions are of utmost importance and must be observed at all times.

Installation and wiring

WARNING

- To avoid electrical shock, remove all power from the inverter and wait at least five minutes prior to starting installation. Additionally, confirm that the DC link bus voltage as measured between the P (+) and N (-) terminals is less than 25 VDC.
- Installation should be performed only by qualified personnel.
- To avoid electrical shock, do not operate the inverter with the front cover or wiring cover removed, as accidental contact with exposed high-voltage terminals and internal components may occur.
- To prevent explosions or similar damage, ensure that all cables are properly connected to the correct terminals, and observe all wiring polarity indicators.

CAUTION

- Do not install or operate the interface if it is damaged or has parts missing.
- Prevent conductive items such as screws and metal fragments, or flammable substances such as oil, lint, paper fibers and sawdust from entering the inverter and interface card enclosure.
- Incorrect handling during installation or removal may cause equipment failure.
- Do not subject the cables to scratches, excessive stress, heavy loads or pinching.
- To prevent damage due to electrostatic discharge, always touch a grounded piece of metal prior to touching any equipment.
- Do not stand on or rest heavy objects on the equipment.
- To prevent burns from hot components, do not touch the inverter while power is on, or for some time after power is removed.
- Electrical noise may be emitted from the inverter, motor and wires. Always implement appropriate countermeasures to prevent nearby sensors and devices from malfunctioning due to such noise.

Operation

WARNING

- To avoid electrical shock, do not open the front cover of the inverter while power is on or while the inverter is running.
- To avoid electrical shock, do not operate switches with wet hands.
- If the inverter's function codes are incorrectly configured, or configured without adequate understanding of the FRENIC-Eco Instruction Manual (INR-SI47-1225-E) and FRENIC-Eco User's Manual (MEH532), the motor may rotate with a torque or at a speed not permitted for the machine. Confirm the settings of all function codes prior to running the inverter.

Maintenance, inspection, and parts replacement

WARNING

- To avoid electrical shock, remove all power from the inverter and wait at least five minutes prior to starting inspection. Additionally, confirm that the DC link bus voltage as measured between the P (+) and N (-) terminals is less than 25 VDC.
- Maintenance, inspection, and parts replacement should be performed only by qualified personnel.
- Remove all watches, rings and other metallic objects prior to starting work.
- To avoid electrical shock or other injuries, always use insulated tools.

Disposal

CAUTION

- Contact the local or state environmental agency in your area for details on the disposal of electrical components and packaging.

Other

WARNING

- Do not attempt to modify the equipment: doing so may cause electrical shock or injuries.
- For clarity purposes, illustrations in this manual may be drawn with covers or safety guards removed. Ensure all covers and safety guards are properly installed prior to starting operation.
- Do not perform hi-pot tests on the equipment.
- Performing a data initialization (function code H03) may reset all inverter function codes to their factory default settings. After performing this operation, remember to reenter any custom function code values prior to starting operation.

Icons

The following icons are used throughout this manual:



Indicates information which, if not heeded, can result in the product not operating to full efficiency, as well as information concerning incorrect operations and settings which may result in accidents.



Indicates information that can prove handy when performing certain settings or operations.



Indicates a reference to more detailed information.

1	PRE-OPERATION INSTRUCTIONS.....	8
1.1	Product Overview.....	8
1.2	Unpacking and Product Confirmation	10
1.2.1	Shipment Confirmation.....	10
1.2.2	Component Overview.....	11
1.3	LED Indicators.....	12
1.3.1	Network Status LED.....	12
1.3.2	Module Status LED.....	12
1.3.3	Link Integrity LED.....	12
1.3.4	Ethernet Activity LED.....	12
1.4	Environmental Specifications.....	13
2	INSTALLATION.....	14
2.1	Pre-Installation Instructions.....	14
2.2	Installation Procedure	15
2.3	Antenna Options	17
2.3.1	Standard Dipole Antenna.....	17
2.3.2	Optional #10694 Antenna Extension Cable.....	17
2.3.3	Optional #10693 Desktop/Magnetic Antenna.....	18
2.4	Initial Wireless Settings.....	19
2.5	Resetting the Wireless Settings to Factory Defaults.....	19
3	INVERTER FUNCTION CODE SETTINGS	20
3.1	RS-485 Communication Settings.....	20
3.2	Inverter Control-Related Settings.....	22
4	FINDER APPLICATION.....	23
4.1	Overview	23
4.2	Configuring the IP Address.....	24
4.2.1	Via the Finder Utility.....	24
4.2.2	Via the Web Page.....	24
5	EMBEDDED WEB SERVER.....	25
5.1	Overview	25
5.2	Authentication	26
5.3	Page Select Tabs.....	26
5.4	Monitor Tab.....	26
5.4.1	Information Window	26
5.4.2	Function Code Group Selection List.....	27
5.4.3	Function Code List.....	27
5.4.4	Function Code List Filter	28
5.4.5	Non-Scanned Function Code Refresh.....	29
5.4.6	Radix Selection.....	29
5.5	PROFINET Tab.....	29
5.6	BACnet Tab.....	30
5.6.1	Information Window	30
5.6.2	Device Identifiers	30

5.6.3	Submitting Changes.....	31
5.7	Config Tab.....	32
5.7.1	Information Window	32
5.7.2	Authentication Configuration	32
5.7.3	IP Address Configuration	33
5.7.4	MAC Address Configuration.....	33
5.7.5	Wireless Settings	33
5.7.6	Timeout Configuration.....	34
5.7.7	Submitting Changes.....	35
5.8	EtherNet/IP Tab	36
5.8.1	Information Window	36
5.8.2	Device Identification.....	36
5.8.3	Run/Idle Flag Behavior.....	37
5.8.4	Class 1 (I/O) Data Configuration Arrays	37
5.8.5	Submitting Changes.....	38
5.9	Alarm Tab.....	39
5.9.1	Information Window	39
5.9.2	Email Configuration.....	40
5.9.3	Alarm Configuration	41
5.9.4	Submitting Changes.....	42
5.10	Modbus Tab	43
5.10.1	Information Window	43
5.10.2	Supervisory Timer Selection	43
5.10.3	Register Remap Configuration	44
5.10.4	Submitting Changes.....	45
5.11	Dashboard Tab	46
5.11.1	Information Window	46
5.11.2	Virtual Keypad.....	47
5.11.3	Gauge Window Navigation.....	48
5.11.4	Gauge Window Configuration	48
5.11.5	Submitting Changes.....	51
6	FUNCTION CODE NUMBERING AND BEHAVIOR.....	52
6.1	Register Numbers	52
6.2	Scanned and Non-Scanned Registers	53
7	FILESYSTEM & FIRMWARE	55
7.1	Overview	55
7.2	Initiating FTP via the Finder Utility	56
7.3	Using FTP with Windows Explorer.....	56
7.4	Using FTP with a Windows Command Prompt	58
7.5	Using FTP with Core FTP LE.....	59
7.6	Loading New Application Firmware	60
8	PROTOCOL-SPECIFIC INFORMATION	61
8.1	Modbus/TCP	61
8.1.1	Overview.....	61
8.1.2	Coil & Discrete Input Mappings.....	62
8.2	EtherNet/IP	63
8.2.1	Overview.....	63
8.2.2	ODVA AC/DC Drive Profile	64

8.2.3	ControlLogix Examples: Setup	66
8.2.4	ControlLogix Example: I/O Messaging	67
8.2.5	ControlLogix Example: Generic Default I/O Add-On Instruction	70
8.2.6	ControlLogix Example: AC/DC Drive Profile Add-On Instruction	72
8.2.7	Explicit Messaging Tag Reference	74
8.2.8	ControlLogix Explicit Messaging Example: Read a Register Block.....	75
8.2.9	ControlLogix Explicit Messaging Example: Read a Single Register	80
8.2.10	ControlLogix Explicit Messaging Example: Multiple MSG Instructions	80
8.2.11	ControlLogix Explicit Messaging Example: Reading and Writing.....	81
8.3	Allen Bradley CSP	82
8.3.1	Overview.....	82
8.3.2	Tag Reference	82
8.3.3	SLC-5/05 Example: Read a Register Block.....	84
8.3.4	SLC-5/05 Example: Read a Single Register.....	87
8.3.5	SLC-5/05 Example: Multiple MSG Instructions.....	88
8.3.6	SLC-5/05 Example: Reading and Writing.....	89
8.4	BACnet/IP	90
8.4.1	Protocol Implementation Conformance Statement	90
8.4.2	Supported Objects	93
8.4.3	Supported Object Details	95
9	TROUBLESHOOTING	96

1 PRE-OPERATION INSTRUCTIONS

1.1 Product Overview

The OPC-F1-WiE wireless Ethernet multiprotocol communication interface allows information to be transferred seamlessly between a FRENIC-Eco inverter and several different wireless Ethernet-based fieldbus networks with minimal configuration requirements. The interface installs directly onto the inverter, and presents a standard 802.11b wireless Ethernet (Wi-Fi) antenna port for connection to the wireless network. In addition to the supported fieldbus protocols, the interface also hosts an embedded web server, which provides access to inverter information via a standard web browser for remote monitoring, configuration and control.

Before using the interface, please familiarize yourself with the product and be sure to thoroughly read the instructions and precautions contained in this manual. In addition, please make sure that this instruction manual is delivered to the end user of the interface, and keep this instruction manual in a safe place for future reference or unit inspection.

Note that different interface firmware versions may provide varying levels of support for the various protocols. When using this manual, therefore, always keep in mind that the firmware version running on your interface must match this manual's respective revision in order for all documented aspects to apply.

The primary features of the OPC-F1-WiE are as follows:

Wireless Ethernet

IEEE 802.11b wireless Ethernet compliant, operating in the 2.4GHz band with data rates up to 11Mbit/s. Supports multiple simultaneous protocols, and allows a variety of encryption options, such as WEP, WPA and WPA2.

Supported Protocols

The interface currently provides server support for the following fieldbus protocols:

- Modbus/TCP
- EtherNet/IP
- Allen Bradley CSP (also known as "PCCC" and "AB Ethernet")
- BACnet/IP

Antenna Options

The interface includes a detachable 2.4GHz omni-directional fully articulating dipole antenna with RP-SMA connector. The antenna can be rotated 360 degrees at its connection point and from 0 to 90 degrees at its knuckle. An optional desktop/magnetic base antenna (ICC part #10693) and 30cm antenna extension cable (ICC part #10694) are also available. Refer to section 2.3.

Adobe® Flash-Enabled Embedded Web Server

Interface configuration and real-time inverter register monitoring & control are provided via an embedded web server. The interface's web server feature provides direct data access and control via standard web browsers such as Microsoft Internet Explorer and Mozilla Firefox. The latest version of Adobe Flash Player browser plug-in is required. Refer to section 5.

XML Configuration File Upload/Download

All interface configuration files are stored in the unit's internal filesystem in XML format. These files can be transferred to/from a PC via the FTP protocol, which provides the capability for PC-based file backup and easy configuration copying to multiple units. Configuration files can also be viewed and edited via standard text editors, XML editors and web browsers. Refer to section 7.

Email-Based Alarm Notifications

Up to 20 configurable alarm conditions can be programmed into the interface. Value, logical comparison and time-based conditions can be provided for the interface to autonomously monitor any available inverter register. When an alarm condition is triggered, a notification email can be sent to up to four destination email addresses. Refer to section 5.9.

Dashboard GUI

A dashboard tab on the embedded web server provides 10 gauge windows, each of which can be configured to display any available scanned inverter register in a variety of meter, graph and gauge formats. A virtual keypad interface is also provided. Refer to section 5.11.

Network Timeout Action

A configurable network timeout action can be programmed that allows registers to have their own unique "fail-safe" conditions in the event of a network interruption. Refer to section 5.7.6.

Field-Upgradeable

As new firmware becomes available, the interface can be upgraded in the field by the end-user. Refer to section 7.6 for more information.

EtherNet/IP Data Access Options

The EtherNet/IP protocol provides access to inverter data via explicit messaging, user-defined I/O assembly instances, and the ODVA AC/DC drive profile. Refer to section 8.2 for more information.

1.2 Unpacking and Product Confirmation

1.2.1 Shipment Confirmation

Check the enclosed items. Confirm that the correct quantity of each item was received, and that no damage occurred during shipment.

- OPC-F1-WiE interface board with antenna (see Figure 1).
- Four nylon standoffs (see Figure 2).



1.2.2 Component Overview

Figure 3 shows an overview of the important interface card components.

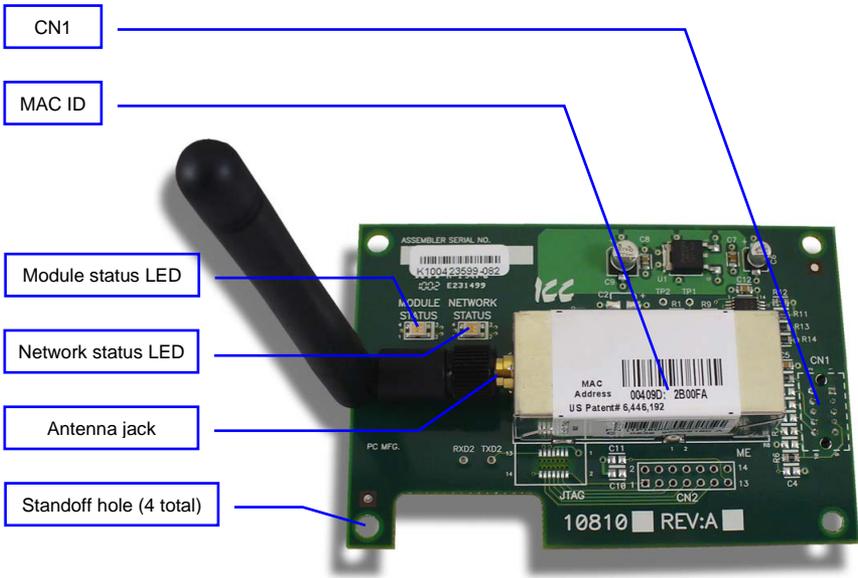


Figure 3: OPC-F1-WiE Component Overview

Network Status and Module Status LEDs

These LEDs indicate the current status of the interface card and protocols in use. Refer to section 1.3.

Antenna Module Housing with Embedded LEDs and MAC ID

The antenna is connected here, and the embedded LEDs provide insight into the wireless Ethernet network's status and activity. Refer to section 1.3. The unique MAC ID for the interface card is also located on a barcode sticker on top of the antenna module housing.

Connector CN1

Connects to the "Port A" connector on the inverter's control board. Refer to section 2.2.

Standoff Holes (4 Total)

Receive the ends of the four nylon standoffs used to mount the interface card to the inverter's control board.

1.3 LED Indicators

1.3.1 Network Status LED

- This LED conforms to the prescribed “network status LED” behavior as dictated in the EtherNet/IP specification, Volume 2, Chapter 9.

1.3.2 Module Status LED

- This LED conforms to the prescribed “module status LED” behavior as dictated in the EtherNet/IP specification, Volume 2, Chapter 9.
- Contact ICC technical support if a blinking red error code is observed.

1.3.3 Link Integrity LED

Refer to Figure 4. This amber LED:

- Is on solid whenever a connection (link integrity) has been established between the interface card and an access point (infrastructure mode.)
- Blinks slowly whenever the interface card is in ad hoc mode.
- Blinks quickly whenever the interface card is scanning for a network.

1.3.4 Ethernet Activity LED

- This green LED blinks briefly when network packets are sent or received. Refer to Figure 4.

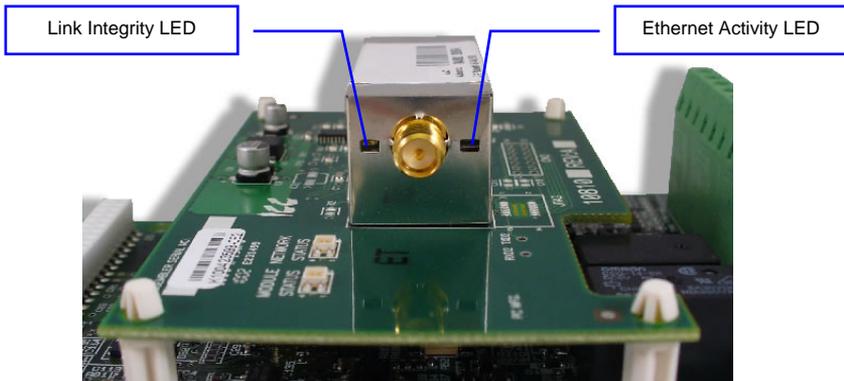


Figure 4: Wireless Network LED Indicators

1.4 Environmental Specifications

The interface's environmental specifications are detailed in Table 1.

Table 1: Environmental Specifications

Item	Specification
Operating Environment	Indoors, less than 1000m above sea level, do not expose to direct sunlight or corrosive / explosive gasses
Operating Temperature	-10 ~ +50°C (+14 ~ +122°F)
Storage Temperature	-40 ~ +85°C (-40 ~ +185°F)
Relative Humidity	20% ~ 90% (without condensation)
Vibration	5.9m/s ² (0.6G) or less (10 ~ 55Hz)
Cooling Method	Self-cooled
Communication Speed	Up to 11Mbps with automatic fallback



This device is lead-free / RoHS-compliant. *Lead Free*

2 INSTALLATION

2.1 Pre-Installation Instructions

WARNING

- To avoid electrical shock, remove all power from the inverter and wait at least five minutes prior to starting installation. Additionally, confirm that the DC link bus voltage as measured between the P (+) and N (-) terminals is less than 25 VDC.
- Installation should be performed only by qualified personnel.
- To avoid electrical shock, do not operate the inverter with the front cover or wiring cover removed, as accidental contact with exposed high-voltage terminals and internal components may occur.
- To prevent explosions or similar damage, ensure that all cables are properly connected to the correct terminals, and observe all wiring polarity indicators.

2.2 Installation Procedure



Before installing the interface card, perform all wiring for the main circuit terminals and control circuit terminals.

1. Remove the covers from the inverter to expose the control board.

Note: For inverters with capacities of 37kW and above, also open the keypad enclosure.

For removal instructions, refer to the FRENIC-Eco Instruction Manual (INR-SI47-1225-E), Chapter 2, Section 2.3 "Wiring."
2. Insert the four nylon standoffs into the four holes located on the inverter's control board. Ensure that the standoffs are fully seated into the circuit board.
3. Press the interface board onto the tops of the four nylon standoffs, while simultaneously aligning connector CN1 on the back of the interface board with the "Port A" connector on the inverter's control board. Ensure that the retention tabs on the standoffs protrude fully through the holes on the interface board, and that the CN1 and Port A connectors are fully seated. Refer to Figure 5 and Figure 6.
4. Connect the antenna of choice to the antenna jack (refer to section 2.3). The physical dimensions of the inverter will dictate the antenna options that can be used. Refer to Figure 7 for an example installation using the standard dipole antenna.
5. Reinstall all covers removed in step 1. Take a moment to confirm that any antenna cables are not being pinched and are not routed near any power-carrying wiring.

Note: For inverters with capacities of 37kW and above, also close the keypad enclosure.

For reinstallation instructions, refer to the FRENIC-Eco Instruction Manual (INR-SI47-1225-E), Chapter 2, Section 2.3 "Wiring."



Figure 5: Interface Board Installation Complete



Figure 6: CN1 and "Port A" Connectors Properly Seated



Figure 7: Example Installation Using Standard Dipole Antenna

2.3 Antenna Options

Depending on the capacity of the inverter, the installation environment and required signal strength/range, different antenna options are available to minimize routing issues and maximize signal integrity.

2.3.1 Standard Dipole Antenna

The interface card comes standard with one detachable 2.4GHz omni-directional fully articulating dipole antenna with RP-SMA connector (refer to Figure 8.) This antenna can be rotated 360 degrees at its connection point and from 0 to 90 degrees at its knuckle. In addition to being installable directly on the interface card, the standard antenna can also be used in conjunction with the optional #10694 antenna extension cable (refer to section 2.3.2.)

Specifications

Frequency..... 2.4–2.5 GHz
Power Output..... 2W
DB Gain..... 2dBi
VSWR..... < or = 2.0



Figure 8: Standard Dipole Antenna

2.3.2 Optional #10694 Antenna Extension Cable

ICC part #10694 is a 30cm-long antenna extension cable (refer to Figure 9). The #10694 antenna extension cable can be used with the optional #10693 desktop antenna (refer to section 2.3.3), but it is most commonly applied in conjunction with the standard dipole antenna (refer to section 2.3.1.) For this scenario, the dipole antenna is first disconnected from the interface card, the #10694 antenna extension cable inserted into the card's RP-SMA connector, and then the dipole antenna is reconnected to the end of the extension cable (refer to Figure 10.) For strain relief, the antenna must typically then be attached to some fixed object (such as a ventilation slot on the inverter's enclosure) with a plastic tie wrap.



Figure 9: Antenna Extension Cable



Figure 10: Extension Cable with Dipole Antenna

2.3.3 Optional #10693 Desktop/Magnetic Antenna

ICC part #10693 is a desktop/magnetic mount antenna with a 1m-long extension cable (refer to Figure 11 and Figure 12.) This antenna can be used in place of the standard dipole antenna for situations where mechanical clearances or environmental obstructions prohibit the successful application of the standard antenna. The desktop/magnetic antenna allows convenient mounting on any flat surface (Velcro® or double-sided tape may be required to prevent tipping or falling.) Its strong magnetic base even allows reliable vertical mounting on metallic surfaces.

Specifications

Frequency..... 2.4–2.5 GHz
Power Output..... 1W
DB Gain..... 1.8dBi
VSWR..... 1.92 max.



Figure 11: Desktop/Magnetic Antenna



Figure 12: Example Application

2.4 Initial Wireless Settings

In order to initially connect to a wireless device, the network's wireless access point or router must be configured such that it is compatible with the interface card's initial wireless settings. While these settings can be changed after initial connection, the interface card's factory-default wireless settings are:

SSID "Connect"
Network Type..... Infrastructure
Country Code..... United States
Channel AUTO
Enable Short Preamble..... Disabled
Authentication AUTO
Encryption..... AUTO
64-Bit WEP Key 012345ABCD
WPA/WPA2 Passphrase..... "wpa passphrase"

For further explanation regarding the above wireless configuration settings, refer to section 5.7.5.

2.5 Resetting the Wireless Settings to Factory Defaults

In rare situations, it may become necessary to reset the wireless configuration to factory-default values. This typically occurs if the wireless settings have been customized and subsequently forgotten, and the interface can therefore no longer be associated with a wireless network. Performing this operation will return all of the settings mentioned in section 2.4 to their indicated values, with the exception of the WPA/WPA2 passphrase (which is not modified by this procedure). Because of this, it is recommended that initial contact with the interface after performing this procedure be performed with either no encryption or 64-bit WEP encryption.

Resetting the wireless settings can be accomplished via the following procedure:

1. With the inverter unpowered, remove the necessary covers to gain access to the interface card.
2. Locate test points TP1 and TP2 on the upper-right hand side of the interface card, and short them together with a tool such as a flat-bladed screwdriver or paper clip (refer to Figure 13).



Figure 13: TP1 and TP2

3. Apply power to the inverter and observe the interface card's *Module Status* and *Network Status* LEDs. These LEDs should initially perform their standard red/green startup sequence. After this, both LEDs will simultaneously turn solid green, indicating that the wireless settings have been reset to factory defaults.
4. Remove the short between TP1 and TP2 and cycle power to the inverter. Upon boot-up, the interface card's wireless settings (again, with the exception of the WPA/WPA2 passphrase) will now be at their factory-default values.
5. Replace the inverter's covers that were removed in step 1.

At this point, the wireless router's configuration can be modified to be compatible with the interface card's default settings, the interface card can be located with the Finder utility, and the wireless settings can once again be customized via the web interface.

3 INVERTER FUNCTION CODE SETTINGS

The inverter function codes listed in Table 2 are critical for overall operation of the end-to-end communication system. Some of these function codes must be set to specific values, and some may have multiple allowable settings depending on the desired operation of the overall application. Although there may be many other function codes that will require configuration for your specific application, it is important to understand the manner in which the following function codes will impact successful communications with, and control of, the inverter.

 For further details regarding these function codes, please refer to the FRENIC-Eco Instruction Manual (INR-SI47-1225-E), Chapter 5 "FUNCTION CODES", FRENIC-Eco User's Manual, "y codes: Link Functions", and RS-485 Communication User's Manual (MEH448), Chapter 5, Section 5.2 "Data Formats."

Table 2: Function Code Settings Overview

Code	Name	Setting Range	Default Value	Required Value
H30	Communications Link Function (Mode Selection)	0 to 8	0	N/A
y11	RS-485 Station Address	1 to 255	1	1
y12	RS-485 Communications Error Processing	0 to 3	0	2 or 3
y13	RS-485 Communications Error Timer	0.0 to 60.0	2.0	60.0 (if y12=2)
y14	RS-485 Baud Rate	0 to 4	3	4
y16	RS-485 Parity	0 to 2	0	0
y18	RS-485 No-Response Error Detection Time	0, 1 to 60	0	N/A
y19	RS-485 Response Delay	0.00 to 1.00	0.01	0.00 or 0.01
y20	RS-485 Protocol Selection	0, 3, 4	0	0
Y98	Bus Link Function (Mode Selection)	0 to 3	0	N/A

3.1 RS-485 Communication Settings

Because the interface card communicates with the inverter via the Modbus RTU protocol on the control board's "Port A" connector, certain RS-485 -related inverter function codes must be set appropriately in order to allow the interface card to successfully exchange data with the inverter. If any of these function codes are not correctly configured, the interface card may not be able to communicate with the inverter.

RS-485 Station Address (y11)

Must be set to a value of "1" in order to allow the interface card to communicate with the inverter.

RS-485 Communications Error Processing (y12)

If operation command or frequency command is not configured to be from "RS-485 option card" (the interface card), then the setting of y12 is not relevant, as all error occurrences will be disregarded. On the other hand, if either operation command or frequency command is configured to be from "RS-485 option card", then y12 settings of 0 (trip immediately when an error is detected) and 1 (trip after y13 time setting when an error is detected) are not recommended. This is due to the fact that interface card communications to the inverter (the transmission of request packets) is performed asynchronously to other threads in the interface card's internal operating system. Some of these other threads are able to

reboot the interface card under certain circumstances (when commanded by the user via the Finder program, or after configuration changes are submitted via the web browser, for example). It is possible that the interface card may be in the middle of transmitting a request packet to the inverter when one of these asynchronous reboots is issued, thereby resulting in a single incomplete packet being received by the inverter. If the inverter is running at the time such an incomplete packet is received, then it will trip (either immediately if y12 is set to 0 or after the time set in y13 if y12 is set to 1). To eliminate the possibility of such "nuisance" trips, therefore, do not configure y12 with a value of 0 or 1.

If it is desired to trip the inverter when the inverter is controlled from the interface card, is currently running, and there is a "real" communication problem between the interface card and the inverter, then y12 can be set to a value of 2 (attempt recovery within the time set by y13). In such a scenario, however, it is also recommended to set y13 to a value of 60 (60 seconds). A retry time of 60 seconds will allow sufficient time for the interface card to successfully re-establish communications with the inverter when the outage is recoverable (when the interface card reboots after a new configuration is submitted via the web page, for example). This would also allow the inverter to trip after 60 seconds when an actual unrecoverable problem occurs.

If it is desired to ignore any communication errors between the interface card and the inverter, then set y12 to a value of 3 (continue to run).

RS-485 Communications Error Timer (y13)

As mentioned in the discussion of y12 above, the value of y13 is only relevant when y12 is set to 2 (attempt recovery within the time set by y13). The recommended value of y13 in this scenario is 60. If y12 is set to a value of 3 (continue to run), then y13 is not relevant and can be disregarded.

RS-485 Baud Rate (y14)

Determines the data rate at which the interface card will communicate to the inverter, and must be set to a value of "4" (38.4kbaud).

RS-485 Data Length (y15) and RS-485 Stop Bits (y17)

These function codes are not relevant and therefore can be disregarded.

RS-485 Parity (y16)

Determines the parity of the communication packets, and must be set to a value of "0" (no parity).

RS-485 No-Response Error Detection Time (y18)

Related to the discussion of function codes y12 and y13 above, the value of y18 will only be relevant when y12 is set to 2 (attempt recovery within the time set by y13). In this scenario, y18 works in conjunction with y13 to differentiate recoverable communication issues between the interface card and the inverter from those that are unrecoverable. When y13 is set to its recommended value of 60 seconds, the setting of y18 will only determine the speed with which the inverter will react to an unrecoverable communication fault. For example, if y18 is set to 2 seconds, then a timeout error will be triggered within 2 seconds of a communication interruption. If the cause of such an interruption was recoverable (the interface card had simply been rebooted, for example), then the 60-second "grace period" set by y13 will allow a normal recovery to take place, and the inverter will not trip as a result of the error. If, on the other hand, the cause of the interruption was unrecoverable, then the inverter will trip 62 seconds after the initial communication gap (2 seconds for the error to be signaled due to y18, and an additional 60 seconds due to y13 before the error is converted to an inverter trip).

RS-485 Response Delay (y19)

Sets a delay time that is added to the inverter's internal processing time before it will send a response packet to the interface card. While the factory default value of 0.01 (10ms) is acceptable, optimal performance can be achieved by setting y19 to 0.00. A setting of 0.00 will allow the inverter to respond to interface card requests immediately after it has completed its internal processing.

RS-485 Protocol Selection (y20)

Determines the RS-485 port protocol, and must be set to a value of "0" (Modbus RTU).

3.2 Inverter Control-Related Settings

The following function codes relate to whether or not the inverter is to be controlled (command word and/or frequency command) from the network, or whether the inverter will be locally-controlled, and only monitored and/or configured via the network.

Communications Link Function (Mode Selection) (H30)

If the inverter is to be controlled from the network (both command word and frequency command), then set the value of H30 to 8. Otherwise, set the value of H30 as appropriate for the chosen command and frequency command input sources.

Bus Link Function (Mode Selection) (y98)

If the inverter is to be controlled from the network, then set the value of y98 to 0 (follow H30 data). A setting of 0 for y98 may also be appropriate even if H30 is configured for an alternate (local) control scheme.

4 FINDER APPLICATION

4.1 Overview

The “ICC Finder” application is a simple Windows PC program (just a single .exe file, no installations, DLL’s etc.), which when executed discovers all ICC communication interfaces on the current Ethernet subnet, regardless of whether or not their network parameters are currently compatible with the subnet upon which they reside. Refer to Figure 14.

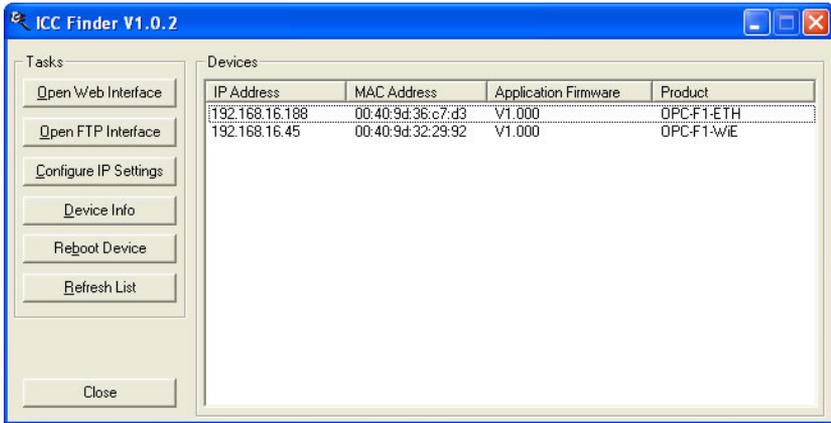


Figure 14: ICC Finder Discovery Utility

In order for the Finder application to discover devices, certain UDP Ethernet traffic must be allowed in and out of the computer, and firewall applications (such as Windows Firewall) are often configured to block such traffic by default. If the Finder is unable to discover any devices on the current subnet, be sure to check the computer’s firewall settings during troubleshooting, and add an exception to the firewall configuration if necessary.

All discovered devices can be organized in ascending or descending order by clicking on the desired sort header (IP Address, MAC Address, Application Firmware or Product). The buttons on the left side of the window perform the following actions:

Open Web Interface: Opens a web browser page of the selected device. Refer to section 5.

Open FTP Interface: Opens the computer’s default FTP application, which could be either Windows Explorer, a web browser, or a 3rd-party FTP program (whatever the computer/operating system is configured for by default). This allows you to interact directly with the unit’s on-board flash filesystem, enabling you to drag and drop files to/from the unit and upload new firmware. Refer to section 7.

Configure IP Settings: Allows configuration of whether the device will use static IP parameters or will obtain its IP parameters via DHCP. Refer to section 4.2 for more information.

Device Info: Opens a dialog box containing relevant device information.

Reboot Device: Opens a dialog box which prompts for a password to reboot the interface. Enter the case-sensitive system password (default is “icc”), then click **Reboot**. The reboot cycle has completed when the displayed status changes from “Rebooting” to “Ready” (note that this may require 30s or more to complete.) Clicking **Close** will then close the dialog box and cause the discovery utility to automatically rescan the network.

Refresh List: Causes the discovery utility to rescan the network.

Close: Closes the discovery utility.

4.2 Configuring the IP Address

Before you can access the interface from your web browser or begin using it as a part of your automation network, you must know its IP address. The interface comes from the factory configured to obtain an IP address dynamically (DHCP/BOOTP). You can determine the interface's current IP address using the *ICC Finder* application included on the CD provided with the interface, or available from the ICC website at <http://www.iccdesigns.com>.

4.2.1 Via the Finder Utility

To configure the interface to use a static IP address:

1. Apply power to the inverter. When the interface boots up, it will attempt to obtain an IP address from a DHCP server or, failing that, will fallback to either the last static IP address assigned, or a default static IP address of 192.168.16.102 if no static IP address has yet been assigned.
2. To determine the initial IP address of your interface, start the `ICC FINDER.EXE` discovery utility.
3. The discovery utility scans the network for ICC devices and then lists each device's **IP Address**, **MAC Address**, **Firmware Version** and **Product Name**. Refer to Figure 14 on page 23. Identify your device by its unique MAC address (printed on a label on the top of the antenna module housing).
4. To change the IP address, select the device in the list of detected devices and click the **Configure IP Settings** button.
5. In the dialog that appears, select **Manually configure network settings**.
6. Enter the desired **IP Address**, **Subnet Mask** and **Default Gateway** in the appropriate boxes, then click **Apply**.
7. Enter the case-sensitive system password (default is "icc") in the Authentication dialog box, then click **Submit**.
8. A popup dialog box will prompt you to reboot. Click **Reboot**. Rebooting may require 30s or more to complete. When the device status indicates "Ready", click **Close**.
9. The discovery utility will automatically rescan the network. Confirm that the new IP address has been accepted by the device.

4.2.2 Via the Web Page

Once an initial IP address has been assigned to the device and the configuration web page can be accessed, the IP address-related parameters can also be modified via the web page. Refer to section 5.7.3.

5 EMBEDDED WEB SERVER

5.1 Overview

The interface contains an embedded web server (also known as an HTTP server), which allows users to access the inverter's internal data in a graphical manner with web browsers such as Microsoft Internet Explorer or Mozilla Firefox. In this way, the inverter can be monitored, configured and controlled from across the room or from across the globe.

In order to view the interface's web page, the free Adobe (formerly Macromedia) Flash Player browser plug-in is required. If the plug-in is not already installed on your computer, then your browser will automatically be redirected to the appropriate Adobe download web site when you initially attempt to access the interface's web page. Alternatively, the plug-in can be downloaded directly by going to <http://www.adobe.com>, and choosing the "get Adobe Flash Player" link. Always ensure that you have the latest version of the Flash Player installed: if some aspect of the web page does not appear to be displayed properly, installing the latest Flash Player update usually resolves the problem.

To access an interface's embedded web server, either use the finder application (refer to section 4) and select the "Open Web Interface" button when the target unit is highlighted, or just directly enter the target unit's IP address into the address (URL) field of your web browser. Refer to Figure 15 for a representative screenshot of the web server interface.

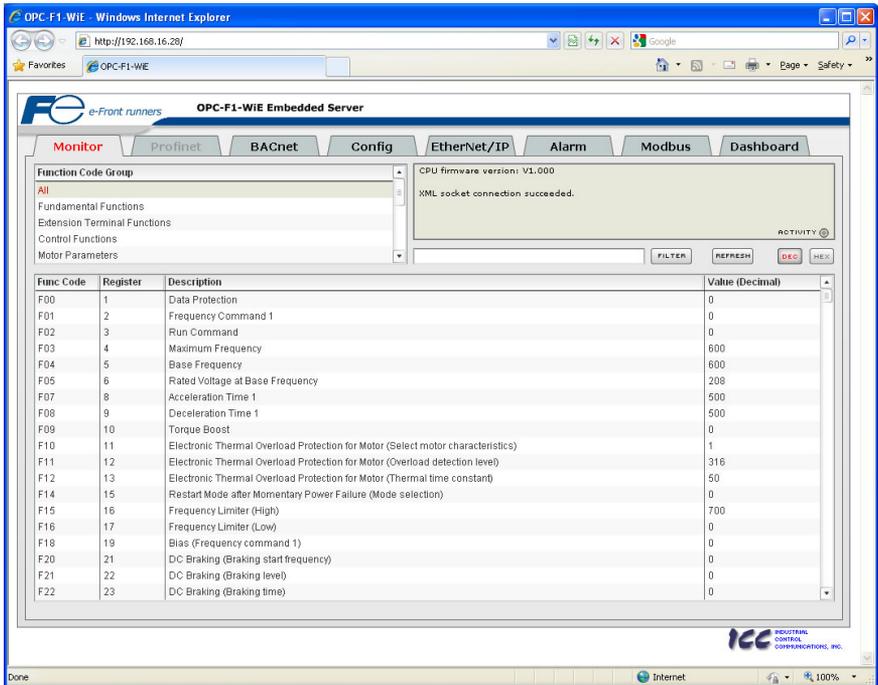


Figure 15: Embedded Web Server

In order to access the web server and view the function code values, destination TCP ports 80 and 2000 must be accessible from the client computer. If an "XML socket connection failed" error message is displayed in the information window, and no function code values are shown, this is typically indicative of port 2000 being blocked by a firewall or Ethernet router situated between the client computer and the interface card.

5.2 Authentication

For security, the interface requires valid user authentication whenever the web page is accessed. The authentication request will appear as a browser popup box that will request entry of a user name and password. Refer to Figure 16.

The factory-default user name is “root”, and the password is “icc”. Note that the username and password are case-sensitive, and that once authenticated, the authentication will remain in effect from that point until all browser windows are closed. The authentication credentials can also be changed from their default settings (refer to section 5.7.2.)



Figure 16: Web Server Authentication

5.3 Page Select Tabs

The web interface is subdivided into several different “tabs” of associated information, much the same as how folders in a filing cabinet are arranged. Refer to Figure 17. To change tabs, just click on the tab you wish to view. The title of the currently-selected tab is red. Note that because different protocols are supported by the interface with different firmware images, not all tabs may be accessible with the firmware image currently loaded. The titles of tabs that are not accessible are grayed-out, and clicking them has no effect.

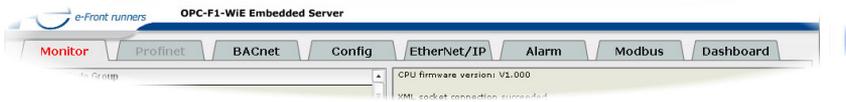


Figure 17: Page Select Tabs

5.4 Monitor Tab

5.4.1 Information Window

Figure 18 shows the Information Window, which is located in the upper-right hand corner of the monitor tab. This window displays various informational messages regarding the status of the interface card or web browser session. There is also an “activity” indicator located in the lower-right hand corner of the Information Window, which blinks periodically to show the status of data communication between the web browser and the interface card. If you do not observe the activity indicator blink at all for several seconds or more, it is possible that the web browser may have lost contact to the web server due to an inverter power cycle or a network problem: to reestablish communications, select “refresh” on your web browser.



Figure 18: Monitor Tab Information Window

5.4.2 Function Code Group Selection List

The Function Code Group Selection List is located in the upper-left hand corner of the Monitor Tab. Refer to Figure 19. Individual groups can be selected by clicking on the group name. Multiple groups may also be selected by holding down the CTRL key while clicking on the group names, or a range of groups can be selected by first selecting the starting group, and then holding down the SHIFT key while selecting the last group in the range. When a function code group is selected, the function codes contained in that group are displayed in the Function Code List (refer to section 5.4.3). The following function code groups are available:

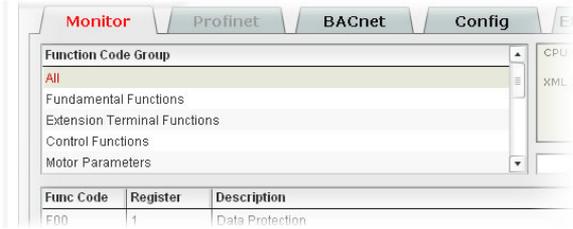


Figure 19: Function Code Group Selection List

All: All function codes/registers are available.

Fundamental Functions: F function codes are available.

Extension Terminal Functions: E function codes are available.

Control Functions: C function codes are available.

Motor Parameters: P function codes are available.

High Performance Functions: H function codes are available.

Command Data: S function codes are available.

Monitor Data 1: M function codes are available.

Application Functions: J function codes are available.

Link Functions: Y function codes are available.

Monitor Data 2: W function codes are available.

Alarm Data 1: X function codes are available.

Alarm Data 2: Z function codes are available.

Note that only the Command Data (S), Monitor Data 1 (M) and Monitor Data 2 (W) function code groups are scanned, and that all others are non-scanned. The values of non-scanned function codes are not continuously updated from the inverter. For more information regarding scanned vs. non-scanned function codes, refer to sections 5.4.5 and 6.2.

5.4.3 Function Code List

The bottom half of the Monitor tab contains the function code list (refer to Figure 20). The function codes that are displayed in the list at any given time depend on the function code groups that are currently selected (refer to section 5.4.2), as well as whether or not any filters have been applied (refer to section 5.4.4).

The first column of the Function Code List shows the inverter function code designation that is normally used when accessing a given function code via the inverter's keypad. Note that this column is for user convenience and inverter user's manual cross-reference only: function codes are not referenced through the interface card by their function code designations, but by their register numbers.

The second column of the Function Code List shows the register number that provides network access to each function code (refer to section 6). The third column contains the function code descriptions, which are used by the filter function. The last column performs two functions: it displays the current value of the function code, and (for writable function codes) also allows changing the function code's value by clicking on the number in the value column and entering the new value.

Func Code	Register	Description	Value (Decimal)
F00	1	Data Protection	0
F01	2	Frequency Command 1	0
F02	3	Run Command	0
F03	4	Maximum Frequency	800
F04	5	Base Frequency	800
F05	6	Rated Voltage at Base Frequency	208
F07	8	Acceleration Time 1	1124
F08	9	Deceleration Time 1	1124
F09	10	Torque Boost	0
F10	11	Electronic Thermal Overload Protection for Motor (Select motor characteristics)	1
F11	12	Electronic Thermal Overload Protection for Motor (Overload detection level)	316
F12	13	Electronic Thermal Overload Protection for Motor (Thermal time constant)	50
F14	15	Restart Mode after Momentary Power Failure (Mode selection)	0
F15	16	Frequency Limiter (High)	700
F16	17	Frequency Limiter (Low)	0
F18	19	Bias (Frequency command 1)	0
F20	21	DC Braking (Braking start frequency)	0
F21	22	DC Braking (Braking level)	0
F22	23	DC Braking (Braking time)	0

Figure 20: Function Code List

Some items to keep in mind when interacting with the Function Code List are:

- When entering new function code values, be sure that the number being entered is appropriate for the currently-selected radix (refer to section 5.4.6): for example, an entered value of “1000” in hexadecimal is equal to 4096 in decimal.
- If desired, the column widths can be changed by dragging the vertical bars that separate the header row’s cells to a different position.
- If you begin changing a function code value and then decide to abandon the change, pressing the ESC key on your keyboard will abandon the change and redisplay the current function code value.
- When editing a function code value, clicking someplace off the entry cell is equivalent to hitting the ENTER key.
- The values of all non-scanned function codes are only read from the inverter by the web browser when the “refresh” button is clicked (refer to section 5.4.5). Values of non-scanned function codes are immediately written down to the inverter when they are changed, however.

5.4.4 Function Code List Filter

A filter function provides Function Code List search capabilities. To use the filter function, simply type a word or portion of a word into the filter entry box and then click the “filter” button. Refer to Figure 21.

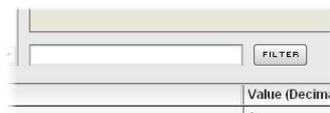


Figure 21: Function Code List Filter

The filter will then display only those function codes currently available in the Function Code List that satisfy the search criteria. For example, to find all monitor data 1 function codes that contain some derivative of the word “volt” (such as “voltage” or “volts”), select the “Monitor Data 1” group, enter “volt” in the filter entry box, and then click the “filter” button.

Once a filter has been entered, it will continue to be applied to all information normally displayed in the Function Code List for as long as the filter term is left in the filter entry box. Continuing the previous example where we filtered on the root term “volt” in the monitor data 1 group, we can then easily apply this filter to all available function codes simply by selecting the “All” function code group. The Function Code List will now display all command, monitor, configuration etc. function codes that contain the root term “volt”.

To remove the filter, delete any characters contained in the filter entry box and then click the “filter” button.

5.4.5 Non-Scanned Function Code Refresh

The values of all non-scanned function codes are only read from the inverter when the “refresh” button (shown in Figure 22) is clicked. Once clicked, the interface card will display the message “refreshing values...” in the Information Window (refer to section 5.4.1), and will begin to retrieve the values of all non-scanned function codes from the inverter. This process may require 5s-10s to complete. When completed, the current values of all non-scanned function codes will be updated in the Function Code List, and the Information Window will display the message “refresh completed.” For further details regarding scanned vs. non-scanned function codes, refer to section 6.2.



Figure 22: Refresh Button

5.4.6 Radix Selection

Figure 23 shows the radix selection buttons. These selection buttons allow changing the Function Code List “value” column data display and entry radix between decimal and hexadecimal formats.



Figure 23: Radix Selection

When “DEC” is selected, the “value” column heading will be “*Value (Decimal)*”, current function code values will be displayed in decimal, and values to be written to function codes must be entered in decimal format. For example, to change the inverter’s frequency command to 40.00Hz, enter the decimal value 4000.

Similarly, when “HEX” is selected, the “value” column heading will be “*Value (Hexadecimal)*”, current function code values will be displayed in hexadecimal, and values to be written to function codes must be entered in hexadecimal format. For example, to turn on bit #10 in the inverter’s operation command word, enter the hexadecimal number 0400.

5.5 PROFINET Tab

PROFINET is not currently supported on the OPC-F1-WIE.

5.6 BACnet Tab

The BACnet tab provides for the configuration of the device on a BACnet/IP network. Refer to Figure 24.

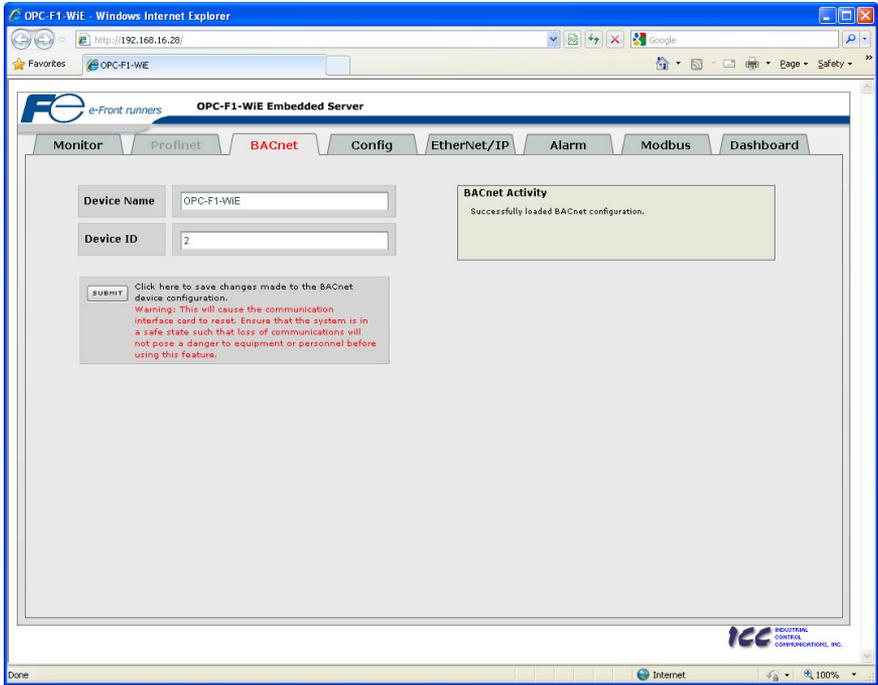


Figure 24: BACnet Tab

5.6.1 Information Window

Figure 25 shows the Information Window, which is located in the upper-right hand corner of the BACnet tab. This window displays various informational messages regarding the status of the BACnet configuration (loading or submitting).



Figure 25: BACnet Tab Information Window

5.6.2 Device Identifiers

A BACnet device's name and ID (the Object_Name and Object_Identifier properties, respectively, of the Device Object) must be unique across the entire BACnet network because they are used to uniquely identify BACnet devices. The text entry boxes shown in Figure 26 are used to configure these unique device identifiers on every inverter.



Figure 26: BACnet Device Identifiers

5.6.3 Submitting Changes

Whenever either of the BACnet configuration elements (Device Name or Device ID) has been changed, the "submit" button located in the left-hand portion of the web page must be clicked in order to write these settings to the interface card's filesystem.

Note that because these configuration elements are read from the filesystem only when the interface card boots up, the act of submitting configuration changes

will also reset the interface card. Please allow 30 seconds for the interface card to reboot, at which time it will then be operating with the recently-submitted configuration. Refer to Figure 27.

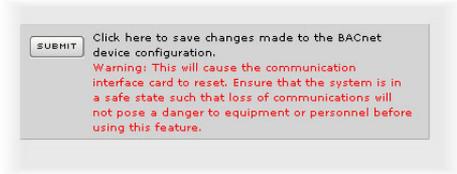


Figure 27: Submit BACnet Changes

5.7 Config Tab

The Config tab provides access to various configuration items. Refer to Figure 28.

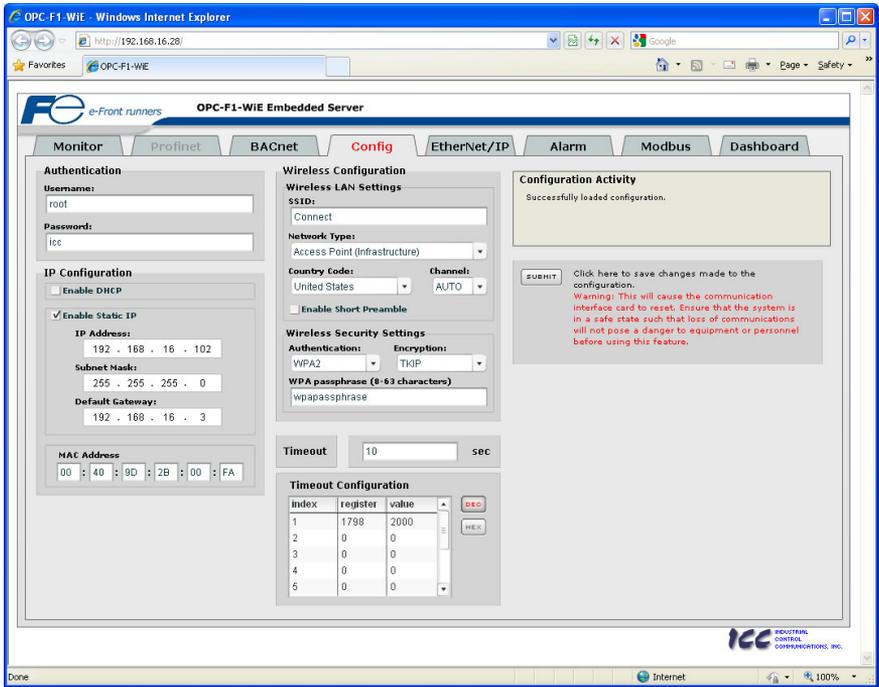


Figure 28: Config Tab

5.7.1 Information Window

Figure 29 shows the Information Window, which is located in the upper-right hand corner of the Config tab. This window displays various informational messages regarding the status of the configuration parameters (loading or submitting).



Figure 29: Config Tab Information Window

5.7.2 Authentication Configuration

Figure 30 shows the entry boxes used to modify the authentication credentials. The case-sensitive username and password can contain letters ("a".."z" and "A".."Z") and numbers ("0".."9"), and can each be up to 80 characters in length.

Be sure to make a note of the new settings whenever these credentials are changed, as they must be entered whenever the web page is accessed, an FTP session is initiated, or when a configuration change is performed via the Finder utility. Contact ICC for assistance if you have forgotten your customized credentials.

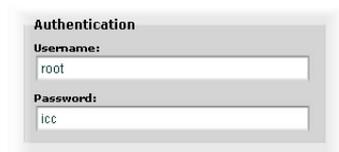


Figure 30: Authentication Configuration

5.7.3 IP Address Configuration

Figure 31 shows the configuration items used to modify the IP address-related parameters. Modification of these settings is consistent with the technique used with the Finder utility (refer to section 4.2.1).

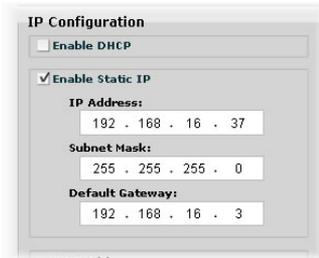


Figure 31: IP Address Configuration

5.7.4 MAC Address Configuration

Figure 32 shows the entry boxes that are used to view and/or modify the unique MAC address of the interface. The MAC address should not be changed without first consulting ICC Technical Support.



Figure 32: MAC Address Configuration

5.7.5 Wireless Settings

Figure 33 shows the wireless configuration items, which must be assigned to have values that are compatible with the remainder of the wireless network installation in order to allow communication. The wireless configuration is comprised of two basic subgroups: the [wireless LAN settings](#) and the [wireless security settings](#). The wireless LAN settings define the basic LAN parameters, and are not related to any specific security or encryption settings. The wireless security settings, on the other hand, define the specific authentication and encryption algorithms that are to be used to secure all communication that is carried on the LAN.

SSID: The SSID (Server Set Identifier) is the wireless network name shared among all points in a wireless network. The SSID must be identical for all devices in the wireless network. It is case-sensitive and must be comprised of 1 to 32 characters (any characters are valid). For added security, you should change the default SSID (“Connect”) to a unique name after initial configuration.

Network Type: By making the appropriate selection you can configure the interface card to either connect to access point (infrastructure) networks only, peer-to-peer (ad-hoc) networks only, or any available wireless network (infrastructure or ad-hoc).

Country Code: Availability of Wi-Fi channels and maximum allowable transmission power is regulated by country, constrained in part by how each country allocates radio spectrum to various services. By properly setting the country code to the country in which the interface is currently installed, the interface will automatically compensate for the legally-allowed channel set and transmission power.

Channel: The list of available channels will depend on the Country Code setting. Select a specific wireless channel, or select “auto” to allow the interface card to scan all available frequencies until it locates an available wireless network that it can join.

Enable Short Preamble: Using short preambles can boost wireless network throughput. Select this checkbox if your wireless network supports this feature.



Figure 33: Wireless Settings

Authentication: The interface supports five different types of authentication: NONE, WEP, WPA, WPA2 and AUTO. The default setting is AUTO.

NONE may be chosen if wireless security is not desired.

WEP (Wired Equivalency Privacy) and WPA/WPA2 (Wi-Fi Protected Access) offer different levels of security for wireless communication. A network encrypted with WPA/WPA2 is more secure than a network encrypted with WEP, because WPA/WPA2 uses dynamic key encryption. To protect the information as it passes over the airwaves, the highest level of encryption supported by the installed equipment should typically be enabled.

AUTO allows the interface to automatically detect and use the authentication method currently being enforced on the network (NONE, WEP, WPA or WPA2). Note that even though the authentication method and encryption (TKIP or AES for WPA/WPA2 and 64-bit or 128-bit key for WEP) will automatically be detected by the interface, the appropriate key information (WEP key or WPA passphrase) must still match the remainder of the network's settings. It is therefore expected that the AUTO setting will typically only be used during initial contact with the interface card, and that the network's pre-determined security settings will then be selected on the interface as part of the commissioning process.

Encryption: The encryption selection field options depend on the authentication algorithm currently selected. WEP supports two encryption methods: 64-bit and 128-bit. WPA/WPA2 also supports two encryption methods: TKIP (Temporal Key Integrity Protocol) and AES (Advanced Encryption Standard). The default encryption method for WEP is 64-bit, and for WPA/WPA2 is TKIP.

Passphrase/Key: The last remaining field in the wireless security settings group depends on the authentication and encryption methods selected. When 64-bit WEP is selected, this field allows entry of a WEP key comprised of 10 hexadecimal digits (0..9, A..F.) The default 64-bit key is 012345ABCD. When 128-bit WEP is selected, this field allows entry of a WEP key comprised of 26 hexadecimal digits. When WPA/WPA2 is selected (regardless of TKIP or AES encryption), this field allows entry of an 8-63 character passphrase (the default is "wppassphrase").

5.7.6 Timeout Configuration

The interface can be configured to perform a specific set of actions when network communications are lost. Support for this feature varies depending on the protocol: refer to the protocol-specific section of this manual for further information.

There are two separate elements that comprise the timeout configuration (refer to Figure 34):

- The timeout time
- The timeout configuration array

The **timeout time** is a floating-point number which allows adjustment down to 1/100th of a second (0.01 second increments). This time setting is used by certain protocols in order to determine abnormal loss-of-communications conditions and, optionally, to trigger a timeout processing event. The default timeout time is 10s.

The **timeout configuration array** allows up to 10 register/value pairs to be designated by the user. When a timeout event is triggered by a protocol, the timeout configuration array indexes are parsed. If the "register" field for an index is set to 0, then this index is "disabled" and therefore ignored. If, on the other hand, the "register" field is non-zero, then the value contained in the "value" field is automatically written to the designated register. This flexible mechanism allows up to 10 designated inverter registers to have their own unique "fail-safe" conditions in the event of a network interruption.

For example, Figure 34 shows a timeout time of 10s, and one timeout entry assignment. If a protocol that makes use of timeout processing triggers a timeout event, then a value of 2000 will automatically be written to inverter register 1798 (the frequency command). Provided the inverter has a valid "run" command and is currently configured to use the network frequency command as its master frequency command, it will ramp to 20.00Hz.

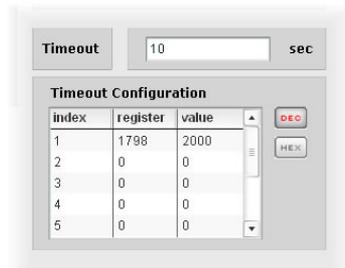


Figure 34: Timeout Configuration

If timeout/failsafe processing is not desired, just set the “register” fields for all indexes to 0 (disabled). This is the default condition.

“DEC” and “HEX” selection buttons are also available, and allow changing the “value” column data display and entry radix between decimal and hexadecimal formats, respectively. These buttons provide the ability to interact with the various inverter registers in their most natural radix (e.g. a hexadecimal command word vs. a decimal frequency command value).

5.7.7 Submitting Changes

Whenever any of the configuration elements has been changed, the “submit” button located in the right-hand portion of the web page must be clicked in order to write these settings to the interface card's filesystem.

Note that because these configuration elements are read from the filesystem only when the interface card boots up, the act of submitting configuration changes will also reset the interface card. Please allow 30 seconds for the interface card to reboot, at which time it will then be operating with the recently-submitted configuration. Refer to Figure 35.



Figure 35: Submit Configuration Changes

5.8 EtherNet/IP Tab

The EtherNet/IP tab provides access to configuration items related to communication on an EtherNet/IP network. Refer to Figure 36.

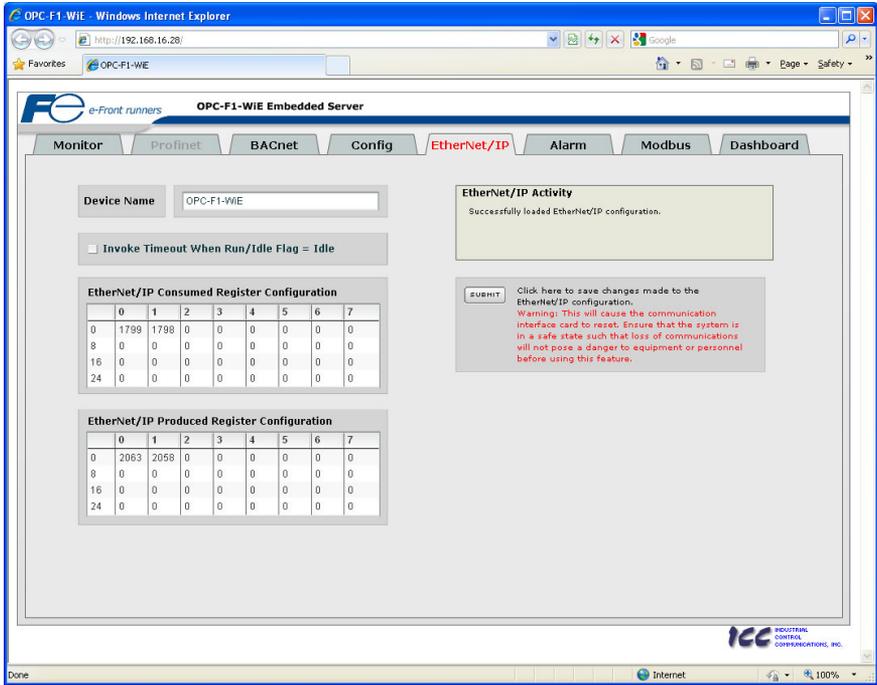


Figure 36: EtherNet/IP Tab

5.8.1 Information Window

Figure 37 shows the Information Window, which is located in the upper-right hand corner of the EtherNet/IP tab. This window displays various informational messages regarding the status of the EtherNet/IP configuration parameters (loading or submitting).



Figure 37: EtherNet/IP Tab Information Window

5.8.2 Device Identification

A text entry box is available which allows customization of the device's name for identification on the EtherNet/IP network. This string is accessible as the "product name" attribute of the identity object. Refer to Figure 38.



Figure 38: EtherNet/IP Device Identification

5.8.3 Run/Idle Flag Behavior

EtherNet/IP clients (such as PLCs) have the option of adding a 32-bit “run/idle” header to all class 1 (I/O) data packets sent to devices. Bit 0 of this header is called the “run/idle flag” by the EtherNet/IP specification, and is intended to signify when the client is in a “running” state or an “idle” state. A running state (run/idle flag = Run) is indicated whenever the client is performing its normal processing (e.g. scanning its ladder logic). An idle state (run/idle flag = Idle) is indicated otherwise. For example, Allen Bradley ControlLogix PLCs will set their run/idle flag to Idle whenever their processor keyswitch is placed in the “PROG” position, presumably in preparation to receive a new application program from RSLogix.



Figure 39: Run/Idle Flag Behavior Selection

The behavior of EtherNet/IP devices when they receive I/O data from a controller with the run/idle flag set to Idle is not specified in the EtherNet/IP specification. The interface card allows the option of two different behavioral responses when a run/idle flag = Idle condition is received, depending on the state of the checkbox indicated in Figure 39.

- If the checkbox is cleared (default setting), then the interface card will maintain the last I/O data values received from the client. For example, if the inverter was being commanded to run prior to the run/idle flag being set to Idle, then it will continue to run.
- If the checkbox is checked, then the interface card will invoke its user-configured timeout processing (refer to section 5.7.6). This setting allows the user to determine any inverter behavior they may desire (stop the inverter, fault the inverter, ramp to a preset speed, etc.)

5.8.4 Class 1 (I/O) Data Configuration Arrays

The interface card supports two different types of EtherNet/IP class 1 (I/O) data transfer. One type is included with the implementation of the AC/DC drive profile, and requires no user configuration. The other type, however, is entirely user-configurable, and is utilized when the client opens a connection to the interface using assembly instances 100 and 150.

The user-configurable data arrays consist of two separate elements (refer to Figure 40.) The consumed register configuration defines the structure of the command data sent from the EtherNet/IP controller (for example, a ControlLogix PLC) to the inverter, and the produced register configuration defines the structure of the status data sent from the inverter back to the controller. These arrays allow the creation of custom-built I/O data. Up to 32 command registers can be sent to the inverter, and up to 32 status registers can be sent back to the controller. Each box in an array is capable of containing a register number. Because all inverter registers are 16-bit data elements, each box therefore represents two bytes of consumed or produced data.

EtherNet/IP Consumed Register Configuration								
	0	1	2	3	4	5	6	7
0	1799	1798	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0

EtherNet/IP Produced Register Configuration								
	0	1	2	3	4	5	6	7
0	2063	2058	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0

Figure 40: EtherNet/IP Class 1 (I/O) Data Configuration

Each of the register array locations are numbered 0-31, and traverse from left to right across each row, and then increment to the left-most position on the next row. Clicking on a box in an array allows the user to enter a register number that will be referenced at that location when data is either consumed from the controller or produced to the network. Note that only scanned registers may be entered into the register array locations: if an attempt is made to enter a non-scanned register number, an error dialog box will appear (refer to section 6.2 for an explanation of scanned vs. non-scanned registers.) A value of 0 indicates that no register is referenced at that location, which will cause the corresponding consumed data to be ignored and produced data to be a default value of 0.

As an example, looking at the default configuration shown in Figure 40, we can see that each array contains two defined registers. Therefore, up to 4 “meaningful” bytes of data can be both received and sent (the qualifier “meaningful” is used here because the connection sizes configured in the controller

may request larger consumed and/or produced data sizes, but all unreferenced consumed data will be ignored, and all unreferenced produced data will contain dummy "0" values). The first word (two bytes) of consumed data will be written to register 1799 (operation command register) and the second word will be written to register 1798 (frequency command). Similarly, the first word of produced data will contain the value of register 2063 (status register) and the second word will contain the value of register 2058 (output frequency).

5.8.5 Submitting Changes

Whenever any of the EtherNet/IP configuration elements (Device Name, I/O array configurations etc.) have been changed, the "submit" button located in the right-hand portion of the web page must be clicked in order to write these settings to the interface card's filesystem.

Note that because these configuration elements are read from the filesystem only when the interface card boots up, the act of submitting configuration changes will also reset the interface card. Please allow 30 seconds for the interface card to reboot, at which time it will then be operating with the recently-submitted configuration. Refer to Figure 41.



Figure 41: Submit Configuration Changes

5.9 Alarm Tab

The Alarm tab provides a configurable mechanism by which the interface card can autonomously monitor any available inverter register and send emails to up to four recipients when a certain condition is detected. The alarm conditions have both value and time constraints, and can be configured to retrigger at a fixed interval as long as the alarm condition continues to be satisfied. Twenty individually-configurable alarms are available. Refer to Figure 42.

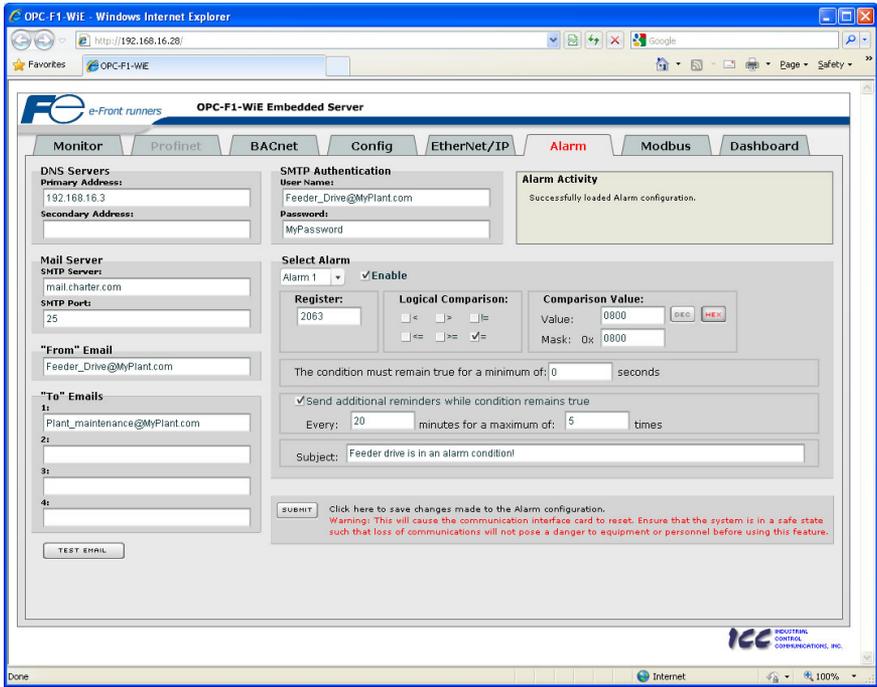


Figure 42: Alarm Tab

5.9.1 Information Window

Figure 43 shows the Information Window, which is located in the upper-right hand corner of the Alarm tab. This window displays various informational messages regarding the status of the Alarm configuration parameters (loading or submitting) and test emails.



Figure 43: Alarm Tab Information Window

5.9.2 Email Configuration

In order for an alarm trigger to successfully send a notification email, some network settings must first be configured properly (refer to Figure 44 and Figure 45.)

DNS Servers: Enter the dotted-decimal IP addresses of the primary and secondary DNS servers which will be used to resolve the configured SMTP server name. Only the primary DNS server is required, but if a secondary DNS server is entered, then it will be used if the primary server is inaccessible.

Mail Server: Enter the SMTP server address as a name or as a dotted-decimal IP address, and the SMTP port (default=25) that the SMTP server listens for incoming emails on.

“From” Email: Enter the email address that will appear as the sender’s email address in the email headers.

“To” Emails: Up to four recipients can be designated to receive alarm emails. Blank entries will not be processed by the interface.

“Test Email” Button: When the “Test Email” button is pressed, the interface card will use the information currently entered in the above-mentioned fields to send a test email. Note that you do not have to first “submit” the settings to the interface card’s filesystem (refer to section 5.9.4) in order to test them: fields can be changed and retested on-the-fly without affecting the operation of the interface card’s control protocols. When the correct settings have been confirmed with a successfully-sent test email, “submit” the changes at that time to commit them to the interface card’s filesystem: any changes made prior to submitting as described in section 5.9.4 are temporary only and will be lost if a different configuration tab is selected or if the web browser is closed.

SMTP Authentication: Some email servers require that clients wishing to send emails first authenticate themselves. If the email server in use requires authentication, then enter the user name and password as indicated in Figure 45. If the email server in use does not require authentication, then these entries can be disregarded.

When a test email transmission is initiated, completes successfully, or fails due to an error, the information window (refer to section 5.9.1) will display appropriate messages such as those shown in Figure 46 and Figure 47. Although the test email is sent immediately, note that due to internet and/or email server delays, it may take several minutes to receive test emails.

Figure 44: Email Configuration

Figure 45: SMTP AUTH Configuration

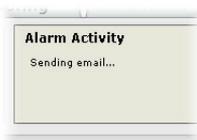


Figure 46: Information Window at Test Email Initiation

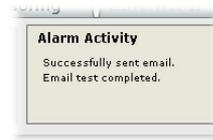


Figure 47: Information Window at Test Email Successful Completion

5.9.3 Alarm Configuration

The interface supports twenty independently-configurable alarms. As shown in Figure 48, each alarm has a variety of configuration elements, which will be explained further below.

Figure 48: Alarm Configuration Box

Alarm Selection: This drop-down box allows the selection of one of the twenty available alarms. When an alarm is selected, that alarm's current configuration parameters will be populated in the alarm configuration box.

“Enable” Check Box: If checked, this alarm is active and will be evaluated every second. If unchecked, this alarm is inactive and will therefore not be evaluated.

Register: Enter the inverter register number that this alarm will continuously monitor. For example, the alarm displayed in Figure 48 is configured to monitor register 2063, which is the operation status register. Note that only scanned registers may be used for alarms (refer to section 6.2).

Logical Comparison: Choose a comparison operator which will be used to compare the current value of the indicated “Register” with the reference “Comparison Value”. Available selections are “less than” (<), “less than or equal to” (<=), “greater than” (>), “greater than or equal to” (>=), “not equal to” (!=), and “equal to” (=).

Comparison Value: The reference comparison value is comprised of two subcomponents: a “Mask” field and a “Value” field. Each time the alarm is evaluated, the current value of the indicated “Register” is first bit-wise “AND”ed with the “Mask” field. The resulting derived value is then compared with the “Value” field by way of the “Logical Comparison” operator. While the “Mask” field is always a hexadecimal number, the display and entry radix of the “Value” field can be changed between decimal and hexadecimal with the associated “DEC” and “HEX” buttons.

Registers that correspond to “analog” process variables (e.g. frequencies, voltages, etc.) should typically have their “Mask” fields set to 0xFFFF, which causes all data bits to be retained for the “Value” field comparison. For registers that correspond to “enumerated” process variables (e.g. status words where each bit of the register indicates a different item), however, the “Mask” can be chosen to single out one or more specific data bits of the register. For example, the “Mask” value of 0x0800 displayed in Figure 48 isolates bit #11 of the operation status register, which indicates whether or not an inverter alarm exists. The “Value” field is also set to a hexadecimal value of 0x0800, so the alarm condition will be evaluated as “true” when bit #11 of the operation status register equals 1.

The Condition Must Remain True For A Minimum Of: Alarm analysis processing is performed by the interface card once per second. Enter the number of seconds that the condition must be continuously evaluated as “true” for the alarm to be triggered. A time of 0 seconds means that just a single evaluation of “true” will immediately trigger the alarm.

Send Additional Reminders While The Condition Remains True: If this check box is unchecked, then only one email transmission event will occur when an alarm condition is triggered: further email transmissions will not be attempted for this alarm unless the alarm condition is first evaluated as “false” (which resets the alarm), and then once again is triggered by a subsequent event.

If this check box is checked, then as long as the alarm condition continues to be evaluated as “true”, subsequent email transmissions will be automatically retrIGGERED every indicated number of minutes for

a maximum of the indicated number of times. If at any time during the subsequent transmissions the alarm condition is evaluated as “false”, then the alarm will be reset and email transmissions for this alarm will stop (until the next time the alarm is triggered, of course).

Subject: Enter a string of up to 128 characters in length which will appear in the “subject” line of the alarm email. The body of the alarm email is empty.

5.9.4 Submitting Changes

Whenever any of the Alarm configuration elements (alarm settings or email configuration parameters) have been changed, the “submit” button located in the lower right-hand portion of the web page must be clicked in order to write these settings to the interface card's filesystem.

Note that because these configuration elements are read from the filesystem only when the interface card boots up, the act of submitting configuration changes will also reset the interface card. Please allow 30 seconds for the interface card to reboot, at which time it will then be operating with the recently-submitted configuration. Refer to Figure 49.



Figure 49: Submit Configuration Changes

5.10 Modbus Tab

The Modbus tab provides access to configuration items related to communication on a Modbus/TCP network. Refer to Figure 50.

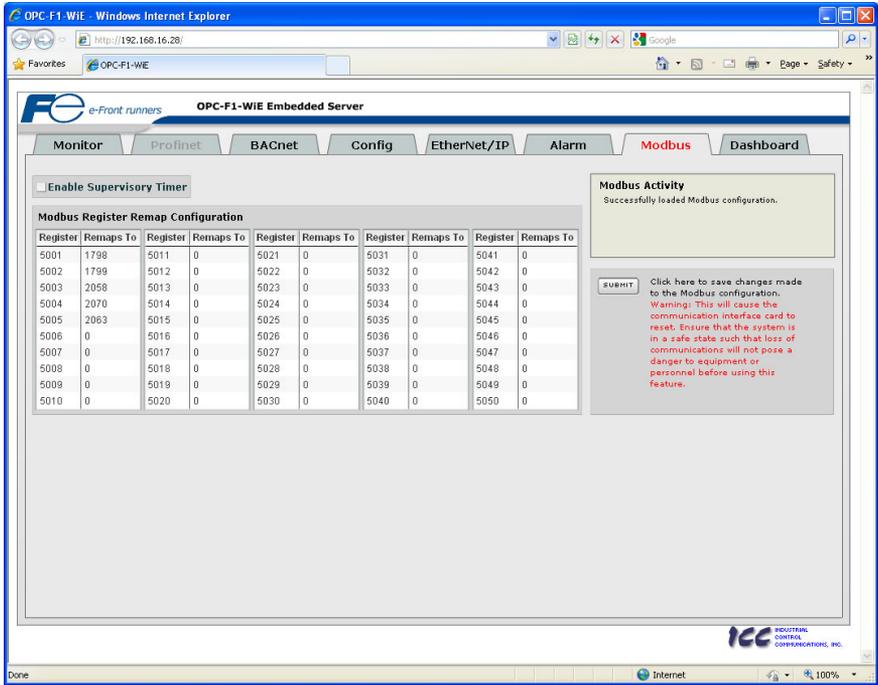


Figure 50: Modbus Tab

5.10.1 Information Window

Figure 51 shows the Information Window, which is located in the upper-right hand corner of the Modbus tab. This window displays various informational messages regarding the status of the Modbus configuration parameters (loading or submitting).

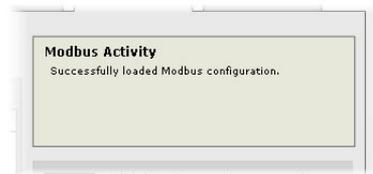


Figure 51: Modbus Tab Information Window

5.10.2 Supervisory Timer Selection

Figure 52 shows the checkbox which enables the interface card's Modbus "supervisory timer" function. This timer provides the ability for the interface card to monitor timeout occurrences between successive Modbus/TCP socket connections, as opposed to the standard timeout functionality (refer to section 5.7.6), which monitors timeout occurrences only within the scope of each client socket connection. While this feature provides an additional level of fail-safe functionality for those applications that require it, there are several ramifications that must be understood prior to enabling this capability. Before enabling this timer, therefore, it is suggested that users read the ICC whitepaper titled "[A Discussion of Modbus/TCP Server-Side Timeout Processing](http://www.iccdesigns.com)", which can be found in the documents section at <http://www.iccdesigns.com>.



Figure 52: Supervisory Timer Selection

5.10.3 Register Remap Configuration

At times, it may be convenient to access inverter registers in bulk Modbus transactions. This may be especially true in situations where it is desired to access certain registers that are natively non-contiguous. For example, if it were desired to read the inverter's operating frequency (register 2058), DC link bus voltage (register 2070), and operation status (register 2063), this could be accomplished in two different ways:

1. Implement three separate Modbus read transactions, each one reading one register only, or
2. Implement one single Modbus read transaction, starting at register 2058 for a quantity of 13 registers. Then, pick out the registers of interest and ignore the rest of the response data.

While both of these methods will certainly work, neither one of them is optimized for the task at hand, which is to access three specific register values. A fully optimized solution can be realized, however, by making use of the interface card's Modbus register remapping capabilities. This mechanism operates by allocating a block of 50 user-configurable registers (5001..5050) that remap to other inverter registers. In this way, non-contiguous inverter registers can be grouped together in any order and accessed efficiently via the Modbus/TCP "read multiple registers" and "write multiple registers" function codes. The net effect is one of being able to transfer larger blocks of registers using fewer Modbus transactions, which results in improved network utilization and simpler data manipulation code on the Modbus master device.

Figure 53 shows the register remap configuration array. Clicking on an entry field in the "Remaps To" column allows the user to enter an inverter register number that will then be accessible at the register indicated in the adjacent "Register" column. An assignment of 0 in the "Remaps To" column indicates that no inverter register is remapped at that location, which results in written values being ignored and read values returned as a default value of 0. Note that remapped inverter registers are still accessible at their original locations: remapping simply provides an additional means of accessing the original register's value.

Modbus Register Remap Configuration									
Register	Remaps To	Register	Remaps To	Register	Remaps To	Register	Remaps To	Register	Remaps To
5001	1798	5011	0	5021	0	5031	0	5041	0
5002	1799	5012	0	5022	0	5032	0	5042	0
5003	2058	5013	0	5023	0	5033	0	5043	0
5004	2070	5014	0	5024	0	5034	0	5044	0
5005	2063	5015	0	5025	0	5035	0	5045	0
5006	0	5016	0	5026	0	5036	0	5046	0
5007	0	5017	0	5027	0	5037	0	5047	0
5008	0	5018	0	5028	0	5038	0	5048	0
5009	0	5019	0	5029	0	5039	0	5049	0
5010	0	5020	0	5030	0	5040	0	5050	0

Figure 53: Modbus/TCP Register Remap Configuration

As an example, the configuration shown in Figure 53 reveals that a total of five inverter registers have been remapped: register 1798 (frequency command) has been remapped to register 5001, register 1799 (operation command word) has been remapped to register 5002, register 2058 (output frequency) has been remapped to register 5003, register 2070 (DC link bus voltage) has been remapped to register 5004, and register 2063 (operation status word) has been remapped to register 5005. With this configuration, it is now possible to efficiently interact with these five non-contiguous inverter registers via just two Modbus "read/write multiple registers" transactions. Writing to the frequency command and command word can be accomplished with a single "write multiple registers" transaction by writing a quantity of two registers starting at register 5001. Similarly, reading the output frequency, DC link bus voltage and operation status word (in that order) can be accomplished with a single "read multiple registers" transaction by reading a quantity of three registers starting at register 5003.

5.10.4 Submitting Changes

Whenever the Modbus configuration has been changed, the “submit” button located on the right-hand portion of the web page must be clicked in order to write these settings to the interface card’s filesystem. Refer to Figure 54.

Note that because these configuration elements are read from the filesystem only when the interface card boots up, the act of submitting configuration changes will also reset the interface card. Please allow 30 seconds for the interface card to reboot, at which time it will then be operating with the recently-submitted configuration.



Figure 54: Submit Configuration Changes

5.11 Dashboard Tab

The Dashboard Tab provides access to a virtual keypad, as well as a variety of gauges, meters and graphs that can be configured to provide an at-a-glance graphical overview of critical application variables in real-time. A total of 10 gauge windows are available (two at a time), and each gauge window can be configured to display any scanned register's value via one of six different gauge types. User-defined engineering units, scaling and range limits are also configurable. Refer to Figure 55.



Figure 55: Dashboard Tab

5.11.1 Information Window

Figure 56 shows the Information Window, which is located in the upper-right hand corner of the Dashboard Tab. This window displays various informational messages regarding the status of the Dashboard configuration parameters (loading or submitting).

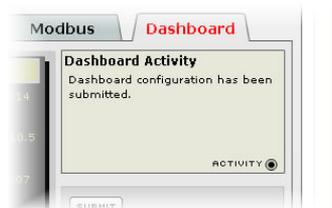


Figure 56: Dashboard Tab Information Window

5.11.2 Virtual Keypad

A "virtual keypad" is displayed on the left-hand side of the dashboard tab, and acts as an interface for several useful pieces of control and monitor information. For an overview of the virtual keypad interface, refer to Figure 57. Note that it is recommended to suspend all external protocol-based communications with PLC's, etc. when using the virtual keypad, as other protocols may simultaneously be writing to the inverter's frequency command and operation command word, resulting in seemingly unpredictable behavior.

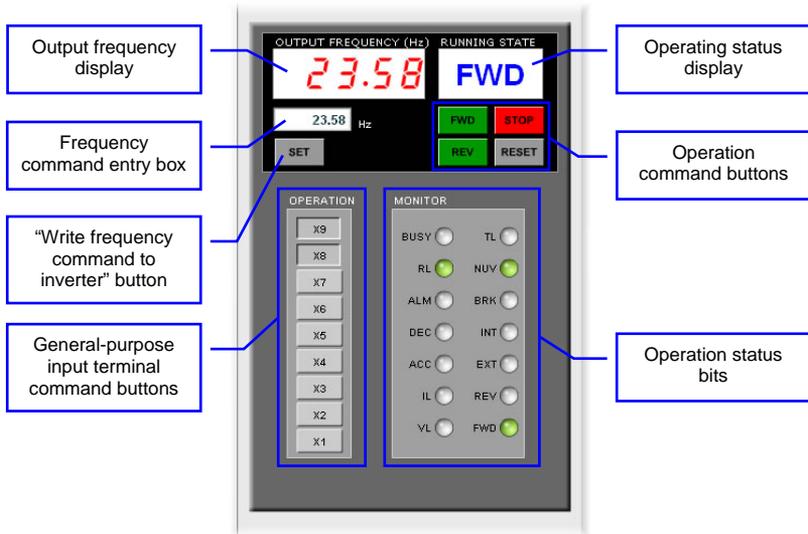


Figure 57: Virtual Keypad Overview

Output frequency display: Indicates the current output frequency of the inverter in large red numbers, as reported by inverter register 2058. The image in Figure 57 indicates that the associated inverter is currently running at 23.58Hz.

Frequency command entry box: Allows the user to enter a new frequency command for the inverter, which is subsequently scaled and written to inverter register 1798 when the "SET" button is clicked.

"SET" button: Clicking this button will scale and write the value contained in the frequency command entry box to inverter register 1798. Note that the inverter will use this frequency command as its master frequency reference only when configured accordingly (refer to section 3.2).

General-purpose input terminal command buttons: These buttons (labeled "X1" through "X9") map to the corresponding bits in the inverter's operation command word (register 1799, bit #2 .. bit #10). The usage of these bits varies depending on the configuration of inverter function codes E01 to E09. When a given button is clicked and shown in its depressed state, the corresponding bit is set to a "1". When clicked again (and therefore shown in its non-depressed state), the corresponding bit is set to a "0". As an example, the image in Figure 57 shows X1..X7 as OFF ("0"), and X8 and X9 as ON ("1"). Note that controlling these operation command word bits will only affect the inverter when it is configured accordingly (refer to section 3.2).

Operating status display: Indicates the current state of the inverter based on bits in the inverter operation status register (2063). Possible displays include "STOP", "FWD", "REV" and "FAULT".

Operation command buttons: Clicking on these buttons enables different control actions to be imposed on the inverter, as follows:

- **FWD:** sets bit #0 ("FWD") and clears bit #1 ("REV") in the operation command word (register 1799).

- **REV:** sets bit #1 (“REV”) and clears bit #0 (“FWD”) in the operation command word (register 1799).
- **STOP:** clears both bit #0 (“FWD”) and bit #1 (“REV”) in the operation command word (register 1799).
- **RESET:** writes a value of “1” to register 1807, which corresponds to inverter function code S14 (alarm reset command). This will reset a faulted inverter regardless of the current operation command mode (H30, Y98 etc.). Note that if the inverter was running (the “FWD” or “REV” buttons were the last buttons pressed on the virtual keypad before the fault occurred), the STOP button must be clicked prior to clicking the RESET button in order to clear the FWD and REV bits in the operation command word. The inverter will ignore reset commands issued through register 1807 as long as a valid run command still exists in the operation command word.

Note that the inverter will follow the FWD, REV and STOP button commands only when configured accordingly (refer to section 3.2).

Operation status bits: These “virtual LEDs” map to the corresponding bits of the same name in the inverter’s operation status word (register 2063). When a given bit in the status word is “1”, then its corresponding indicator will be lit. The indicator will not be lit if its status word bit is “0”. As an example, the image in Figure 57 shows FWD (bit #0), NUV (bit #5) and RL (bit #12) ON, and all other bits OFF.

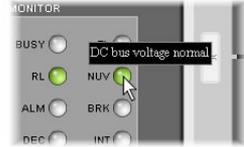


Figure 58: Virtual LED Tooltips



Hovering the cursor over the virtual LEDs will bring up a tooltip which provides a brief summary of the indicated function. Refer to Figure 58.

5.11.3 Gauge Window Navigation

Figure 59 shows the two buttons that provide for navigation of the gauge windows. Gauge windows are displayed two at a time in the Dashboard Tab, and by clicking the “right” or “left” buttons, the gauge windows will scroll in the corresponding direction.

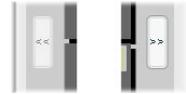


Figure 59: Gauge Window Navigation

5.11.4 Gauge Window Configuration

Each of the gauge windows can be independently configured to display a user-defined register with a variety of flexible configuration options. While the behavior and presentation may vary slightly depending on the specific gauge chosen, all of the gauges share the following common elements (refer to Figure 60 for an example):

Gauge Selector: A drop-down selection box in the upper left-hand corner of the gauge window, which allows the user to select the type of gauge that will be displayed.

Title: A text entry box located above the gauge, in which the user can enter a descriptive gauge title comprised of up to 16 characters.

Units: A text entry box in which the user can enter an engineering units string comprised of up to 8 characters. This units string will be appended to all locations in the gauge window that display the designated register’s current value.

Register: The designated register whose value is to be reflected on the gauge. Note that only scanned registers may be displayed in Dashboard gauges (refer to section 6.2 for a discussion of scanned registers).

Multiplier: The multiplier value is a floating-point number that is used to scale the raw value of a register. As its name suggests, the multiplier value is multiplied by the designated register’s current raw value in order to calculate the gauge’s indicated value. Negative values can also be used if desired.

Min Value: The gauge’s minimum indicated value. Negative values can be used if desired (e.g. if a negative Multiplier attribute is used to generate a negative indicated value). Not all gauges allow adjustment of the min value.

Max Value: The gauge's maximum indicated value. Similar to the Min Value attribute, negative values can be used if desired. Indicated value characteristics can even be inverted by setting the Max Value attribute to a value less than the Min Value attribute.

Update Button: Clicking the update button will apply the current configuration attribute settings to the gauge. Note, however, that simply updating the gauge's current display properties does not write these settings to the interface card's filesystem. To save the current configuration of all the gauge windows to the filesystem, the Dashboard tab's "submit" button must be selected (refer to section 5.11.5).

Current Value: The current indicated value of the designated register is numerically displayed with the configured Units string at the bottom of each gauge window.

The following is a summary of the different available gauge types:

Gauge: Refer to Figure 60. This type of meter implements a rotary dial-type display format. The indicated value and units are shown numerically on the face of the gauge, and via the red indicator needle. The yellow needle shows the previous indicated value, thereby providing a simple historical reference. The "Min Value" attribute is not configurable; this gauge always starts at 0.

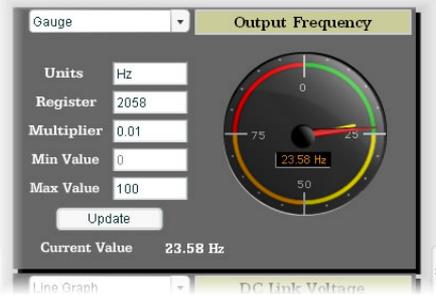


Figure 60: Gauge

BarGraph: Refer to Figure 61. This type of meter implements a linear bar graph display format. Hovering the mouse pointer over the red portion of the graph pops up a tooltip which displays the current indicated value and units.

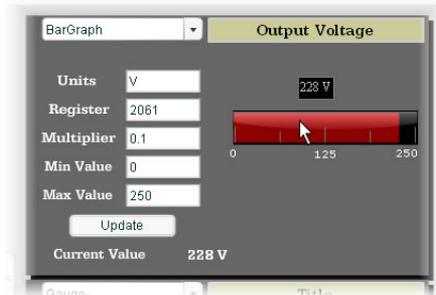


Figure 61: BarGraph

Meter: Refer to Figure 62. This type of meter implements a common panel meter-type display format. The units string is shown on the face of the meter. All raw register values are interpreted as positive numbers (i.e. 0..0xFFFF equates to 0..65535₁₀.)

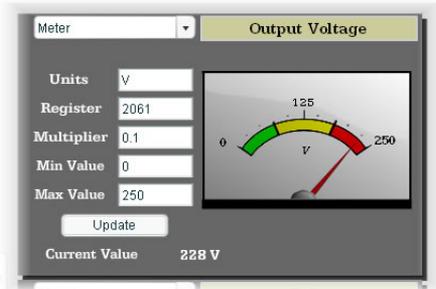


Figure 62: Meter

Pos/Neg Meter: Refer to Figure 63. Similar to the “meter” gauge, this type of meter also implements a common panel meter-type display format, but in this instance the indicated value can be positive or negative (two’s complement interpretation). In other words, raw register values of 0..0x7FFF equate to 0..32767₁₀, and values of 0x8000..0xFFFF equate to -32768..-1. Because the meter placard is always centered around zero, the “Min Value” attribute is not configurable, and the “Max Value” attribute is used for both the maximum positive indicated value as well as the maximum negative indicated value.



Figure 63: Pos/Neg Meter

Thermometer: Refer to Figure 64. This type of meter implements the universally-identifiable thermometer display format. Hovering the mouse pointer over the red “mercury” portion of the graph pops up a tooltip which displays the current indicated value and units.

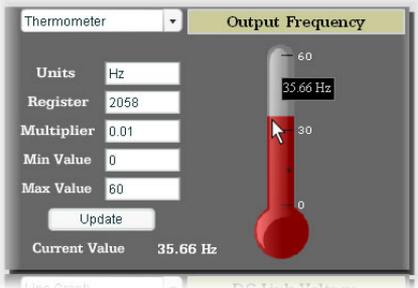


Figure 64: Thermometer

Line Graph: Refer to Figure 65. This type of graph implements a continuously-scrolling historical data logging line graph. Up to 80 seconds worth of historical data is available. Hovering the mouse pointer anywhere on the graph displays a vertical reference line at the corresponding time, and pops up a tooltip which displays the current indicated value at that time.

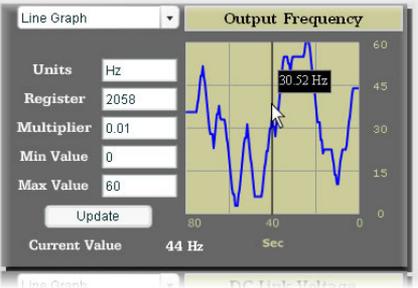


Figure 65: Line Graph



At times, it may be convenient to zoom in on a particular gauge or meter in order to more clearly see the indicator, or to fill the computer screen with a particular gauge's image. This can be easily accomplished with the web browser's Flash Player plug-in by right-clicking on the gauge and selecting the desired zoom level (refer to Figure 66).

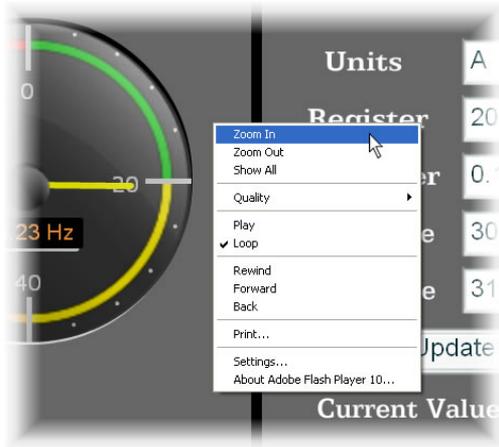


Figure 66: Zooming

5.11.5 Submitting Changes

Whenever any of the gauge window configuration items in the Dashboard Tab have been changed, the “submit” button located on the right-hand portion of the web page must be selected in order to write these settings to the interface card's filesystem. Refer to Figure 67. Note that submitting the Dashboard Tab configuration does not require rebooting of the interface card: the changes take effect immediately, and the interface card continues its operation without interruption.



Figure 67: Submit Dashboard Changes

6 FUNCTION CODE NUMBERING AND BEHAVIOR

6.1 Register Numbers

All accessible inverter function codes are referenced by their Modbus register indexes, as defined in the RS-485 User's Manual (MEH448), section 3 (Table 3.2). These same register numbers are used when accessing and configuring function codes via an Ethernet protocol. Because the RS-485 User's Manual contains information for several Fuji inverter families, the relevant information will be paraphrased here for the specific case of the FRENIC-Eco.

All inverter function codes are exposed as register indexes according to a mathematical conversion formula which combines two elements (a function code group number and function code offset) to create a unique register number for each function code. Each function code group ("E" / Extension Terminal Functions, for example) is assigned a specific function code group number (refer to Table 3). Each function code also has an offset number, which is the function code without the leading letter (the offset number for function code E05, for example, is 5). To determine the register number for a given function code, therefore, the group number is first multiplied by 256, then added to the offset number plus 1. This operation is expressed mathematically via Equation 1.

$$\text{register} = (\text{group number} \times 256) + \text{offset number} + 1 \quad \text{Equation 1}$$

As an example, let's calculate the register number for output frequency (function code M09). According to Table 3, the group number for the "M" function code group is 8. It is also evident that the offset number for M09 is 9. Inserting the group number and offset number into Equation 1, we arrive at the result indicated in Equation 2.

$$(8 \times 256) + 9 + 1 = 2058 \quad \text{Equation 2}$$

While manually calculating all of the register numbers for the function codes of interest is certainly possible by using Equation 1, it may be more convenient to simply reference the "Register" column on the monitor tab of the web interface (refer to section 5.4.3).

Note that not all of the available registers that exist in the interface card's register map have corresponding function codes that exist in the inverter. In other words, if a read from or write to a register number that does not correspond to an existing inverter function code takes place, the read/write may be successful (depending on the specific register accessed; refer to section 6.2), but the data will have no meaning. This feature is beneficial in situations where the accessing of non-contiguous registers can be made more efficient by accessing an all-inclusive block of registers (some of which correspond to inverter function codes and some of which do not), while only manipulating those in your local programming that are known to exist.

Table 3: Function Code-to-Register Conversion

Function Code Group		Group Number	Example
Code	Name		
F	Fundamental Functions	0	F07 (acceleration time 1): $(0 \times 256) + 7 + 1 = 8$
E	Extension Terminal Functions	1	E98 (terminal [FWD] function): $(1 \times 256) + 98 + 1 = 355$
C	Control Functions	2	C20 (jogging frequency): $(2 \times 256) + 20 + 1 = 533$
P	Motor Parameters	3	P03 (motor rated current): $(3 \times 256) + 3 + 1 = 772$
H	High Performance Functions	4	H11 (deceleration mode): $(4 \times 256) + 11 + 1 = 1036$
S	Command Data	7	S05 (frequency command): $(7 \times 256) + 5 + 1 = 1798$
M	Monitor Data 1	8	M09 (output frequency): $(8 \times 256) + 9 + 1 = 2058$
J	Application Functions	13	J03 (PID proportional gain): $(13 \times 256) + 3 + 1 = 3332$
Y	Link Functions	14	Y98 (bus link function): $(14 \times 256) + 98 + 1 = 3683$
W	Monitor Data 2	15	W32 (PID output): $(15 \times 256) + 32 + 1 = 3873$
X	Alarm Data 1	16	X00 (alarm history / latest): $(16 \times 256) + 0 + 1 = 4097$
Z	Alarm Data 2	17	Z53 (3 rd last alarm torque): $(17 \times 256) + 53 + 1 = 4406$

6.2 Scanned and Non-Scanned Registers

The interface card provides network access to inverter registers as two different classes. The first class, called “**scanned registers**” is comprised all Command Data (S), Monitor Data 1 (M) and Monitor Data 2 (W) function code groups. These registers are constantly being “scanned” by the interface card, which is to say that they are constantly being read and/or written (as applicable), and their current values are therefore mirrored in the interface card’s internal memory. Because these inverter registers are mirrored by the interface card, they have the following advantages:

- Access speed: when a network protocol accesses a scanned register (read or write), the value is available immediately. The interface card does not have to make a corresponding request to the inverter to resolve the network access.
- In the web browser’s monitor tab, the values of scanned registers are continuously updated. An explicit on-demand “refresh” does not have to be initiated in order to view the current inverter values (refer to section 5.4.5).
- Only scanned registers may be used when configuring alarm processing (section 5.9), dashboard gauges (section 5.11) and I/O protocols (such as EtherNet/IP consumed & produced data configuration arrays).

The principle disadvantage of scanned registers is that write data checking is not available. This means that when the value of a scanned register is modified via a network protocol or via the web browser’s monitor tab, the interface card itself is not able to determine if the new value will be accepted by the inverter (the value may be out-of-range, or the inverter may be in a state in which it will not accept new values being written via communications, etc.) For example, if a write is performed to a scanned command register with a data value that is out-of-range, the interface card will not generate a corresponding error. However, if end-to-end confirmation of such data writes is required, then the register can be read over the network at a later time to confirm that the written value “took hold” in the inverter. If the value was not accepted by the inverter, then the unsuccessful write can be observed by reading the current (unchanged) value of the register during a subsequent network transaction. If the

unsuccessful write was initiated via the web browser's monitor tab, then the displayed register will revert back to its original value automatically.

Accesses to any register in the scanned register range (1794..1807, 2050..2122, or 3842..3937) will always be successful. Even if an inverter function code corresponding to a given scanned register does not exist, the interface card still maintains a location in its internal mirroring memory for that register. This feature allows for the block access of non-contiguous registers as described in section 6.1.

The second class of registers is called "**non-scanned registers**", and is comprised of all inverter configuration function codes and alarm-related function codes. Non-scanned registers are not continuously accessed by the interface card. What this means is that for those protocols that allow accesses to non-scanned registers, such accesses will incur additional response latency, as the interface card must first forward the request to the inverter for it to process.

While the principle disadvantage of accessing non-scanned registers is the additional delay that is incurred, the unique advantage that non-scanned register accesses provide is that write data checking is available. Because all non-scanned register accesses must first be processed by the inverter itself, issues such as out-of-range data values will always be checked for, and any applicable errors will be immediately returned to the originating network protocol.

For those protocols (such as Modbus/TCP) that allow access to non-scanned registers, note that the inverter applies the following rules to these accesses:

- A maximum of 50 registers may be read or written in one transaction
- If only one non-scanned register is accessed in a particular transaction, then that register must exist in the inverter, or an error will be returned.
- Reading registers: if more than one non-scanned register is accessed in a particular transaction, then at least the starting register must exist in the inverter, or an error will be returned. Any non-existent registers accessed as a result of the remainder of the request will be returned with dummy "0" values.
- Reading registers: registers cannot be read across function code groups. Any multiple-register request will return dummy "0" values for all registers that extend past the last register in that group.
- Writing registers: if more than one non-scanned register is targeted in a particular transaction, then at least the starting register must exist in the inverter, or an error will be returned. Write data corresponding to any non-existent registers targeted as a result of the remainder of the request will be ignored.
- Writing registers: registers cannot be written across function code groups. Write data corresponding to any registers that extend past the last register in a group will be ignored.

7 FILESYSTEM & FIRMWARE

7.1 Overview

The interface card's on-board filesystem is used to store files for use by the application firmware. Currently, the application firmware's main use of the filesystem is to store XML-encoded configuration files that dictate the characteristics of the various protocols. Each protocol that requires configuration will have its own XML file stored on the filesystem. For easy identification, the filename will begin with the corresponding protocol which it configures. For example, a BACnet configuration file's filename will begin with "bacnet", and an Ethernet/IP file will begin with "eip".

Whenever the configuration for a specific protocol is completed, it is suggested that a backup copy of the configuration file be downloaded from the unit to a PC. One reason for this is in case it becomes necessary to restore a previous configuration at a later time. Another reason is that it may be desirable to load multiple units with the same configuration, as a downloaded configuration file can be uploaded again to any compatible unit, allowing the user to easily clone multiple units with the same configuration.

Each time the interface card boots up, it will search the filesystem for the configuration files required by the protocols currently operating in the unit. If it does not find a required file, it will create one and initialize it with factory-default values. Therefore, if it is ever desired to reset a protocol's configuration to factory-default values, this can be easily accomplished by simply deleting the appropriate configuration file from the filesystem and rebooting the unit.

Note that the application firmware uses specific filenames for the configuration files. This means that if a file with a different filename is loaded onto the unit, it will be stored correctly, but will not be used by the application firmware. Similarly, if an existing configuration file's filename is changed, then the unit will again create a default configuration file at next boot-up, which will be stored in the filesystem alongside the file with the changed name.

Configuration files are only read by the protocol drivers at unit boot-up. Therefore, if a new configuration file is loaded onto a unit's filesystem, that unit must be rebooted for the configuration file's settings to take effect. Rebooting a unit can be performed by power-cycling the inverter in which the card is installed, or by selecting the "Reboot Device" button in the Finder application.

Interacting with the filesystem is performed by use of the File Transfer Protocol (FTP). Using FTP allows the user to interact with the files on the interface card's filesystem in the same manner as though they were traditional files stored on a local or remote PC. While there are many different FTP applications available, the following sections will provide general examples of using some of the most commonly-available ones.

Note that certain routers or firewall applications (such as Windows Firewall) can block FTP traffic. If an FTP connection to the interface card cannot be established, be sure to check the computer's firewall settings during troubleshooting, and add an exception to the firewall configuration if necessary.

7.2 Initiating FTP via the Finder Utility

After discovering all interface cards on the current subnet as described in section 4, select the target interface card and then click on the “Open FTP Interface” button. This will open the computer’s default FTP application, which could be Windows Explorer, a web browser, or a 3rd-party FTP program (whatever the computer/operating system is configured for by default). This example will assume that a web browser (Microsoft Internet Explorer) is configured as the default FTP application.

An authentication dialog will appear (refer to Figure 68.) Enter the currently-configured user name and case-sensitive password (defaults are “root” and “icc”, respectively), then click “Log On.”

The web browser will then display the filesystem’s contents (refer to Figure 69.) FTP access via a web browser allows viewing and downloading files to a computer, but does not allow advanced file manipulation such as cut, paste, drag-and-drop, etc. For advanced file manipulation abilities, use of a different FTP application is required.

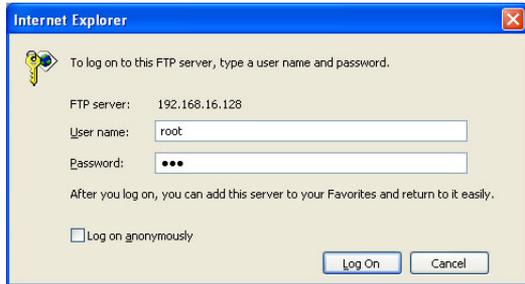


Figure 68: FTP Authentication



Figure 69: FTP Navigation with Internet Explorer

7.3 Using FTP with Windows Explorer

To use FTP with Microsoft Windows Explorer, first open either “Windows Explorer” or “My Computer”. Refer to Figure 70. Please note that the indicated procedure, prompts and capabilities outlined here can vary depending on such factors as the installed operating system, firewalls and service packs.

In the “Address” field, type in “ftp://root@” and then the IP address of the target interface card (if the user name has been changed from its default, then replace “root” in “ftp://root@” with the new user name.) Refer to Figure 71.



**Figure 70:
Accessing
Windows
Explorer**

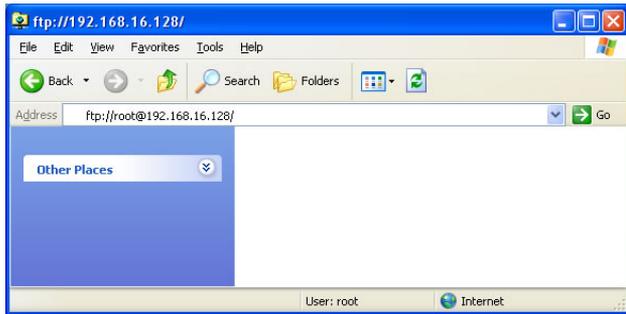


Figure 71: FTP Navigation with Windows Explorer

You will then be presented with an authentication dialog (refer to Figure 72.) The user name will already be filled-in. Enter the case-sensitive password (default is "icc") and click "Log On."

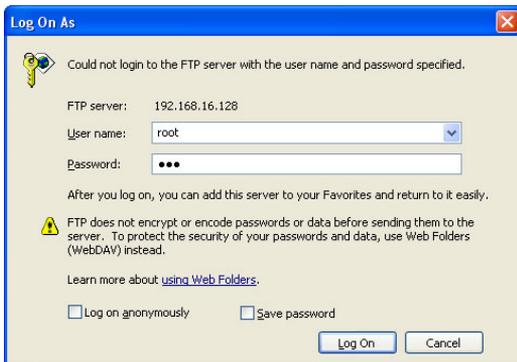


Figure 72: FTP Authentication

Windows Explorer will then display the filesystem's contents (refer to Figure 73.) You can now perform normal file manipulation actions on the available files (cut, copy, paste, open, rename, drag-and-drop transfers etc.) in the same manner as though you were manipulating any traditional file stored on your computer's hard drive.

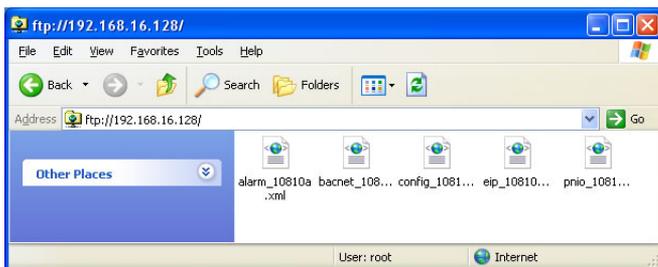


Figure 73: File Access via Windows Explorer

7.4 Using FTP with a Windows Command Prompt

To use FTP with a Windows command (DOS) prompt, first open a command prompt by either selecting *Start ...All Programs ...Accessories ...Command Prompt*, or by selecting *Start ...Run* and typing "cmd" in the "Run" dialog.

Once the command prompt opens, type "ftp" and the IP address of the target interface card. The FTP client will connect to the unit and then prompt for the username and case-sensitive password (defaults are "root" and "icc", respectively). Upon successful entry of the authentication information, you will be presented with an "ftp>" prompt. Refer to Figure 74.

```

C:\WINDOWS\system32\cmd.exe - ftp 192.168.16.128
Z:\>Ftp 192.168.16.128
Connected to 192.168.16.128.
220 NET+OS 7.3 FTP server ready.
User (192.168.16.128:(none)): root
331 User root OK, send password.
Password:
230 Password OK.
ftp>
    
```

Figure 74: FTP Initiation and Authentication

At this point, you can use standard Unix-style file and directory manipulation commands to perform such actions as listing files (Figure 75), copying files to your computer (Figure 76), and copying files to the unit (Figure 77).

```

C:\WINDOWS\system32\cmd.exe - ftp 192.168.16.128
ftp> ls
200 PORT command Ok.
150 File Listing Follows in ASCII mode
config_10640a.xml
alarm_10640a.xml
pnio_10640a.xml
bacnet_10640a.xml
eip_10640a.xml
226 Transfer complete.
ftp: 89 bytes received in 0.19Seconds 0.48Kbytes/sec.
ftp>
    
```

Figure 75: Listing Files with "ls" Command

```

C:\WINDOWS\system32\cmd.exe - ftp 192.168.16.128
ftp> get pnio_10640a.xml
200 PORT command Ok.
150 About to open data connection.
226 Transfer complete.
ftp: 1165 bytes received in 0.23Seconds 4.98Kbytes/sec.
ftp>
    
```

Figure 76: Copying a File from the Unit With "get" Command

```

C:\WINDOWS\system32\cmd.exe - ftp 192.168.16.128
ftp> put pnio_10640a.xml
200 PORT command Ok.
150 About to open data connection.
226 Transfer complete
ftp: 1165 bytes sent in 0.00Seconds 1165000.00Kbytes/sec.
ftp>
    
```

Figure 77: Copying a File to the Unit With "put" Command

7.5 Using FTP with Core FTP LE

Core FTP LE (Lite) is a third-party FTP application that can be downloaded for free from <http://www.coreftp.com>. Core FTP is just one example of the various commercial and freeware FTP client applications available on the internet.

After installing Core FTP LE, run the program. If the “Site Manager” window (Figure 78) does not automatically open, open it by choosing “File...connect”.

Click on the “New Site” button, then enter a Site Name, IP Address, username (default is “root”) and case-sensitive password (default is “icc”). The “Port”, “Timeout”, and “Retries” fields should already contain the default values. Click the “Connect” button when done.

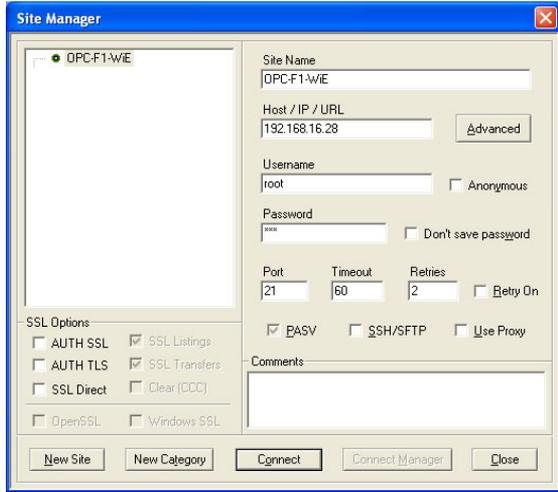


Figure 78: Core FTP Site Manager

Core FTP LE will then try to connect and authenticate to the FTP server, and if successful, will populate the right-hand side of the main page with the unit’s filesystem contents. Refer to Figure 79.

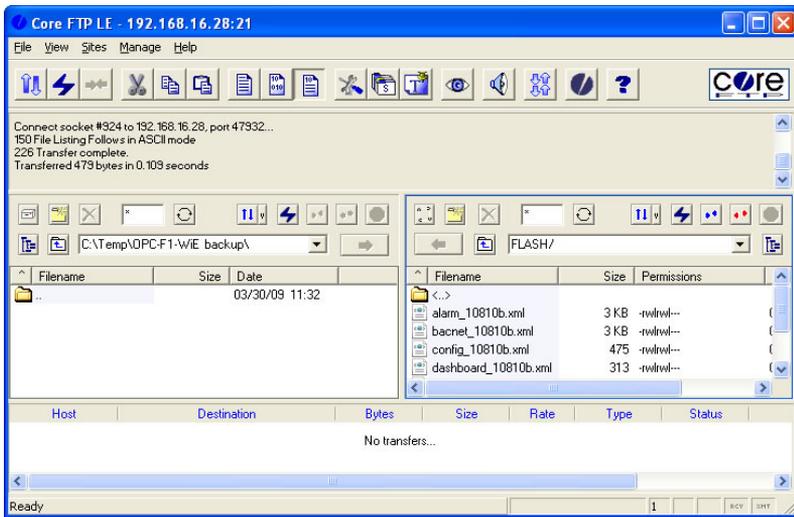


Figure 79: Core FTP in "Connected" State

Files can be easily downloaded from the unit by choosing the appropriate destination folder on your computer in the left-hand side of the main page, choosing the file to download, and then clicking the “download” button in the right-hand (source) side. Similarly, files can be easily uploaded to the

unit by choosing the file to upload and then clicking the “upload”  button in the left-hand (source) side of the main page.

Like most third-party FTP client applications, Core FTP LE has a wide array of configuration and file management capabilities, which are beyond the scope of this manual. Refer to the program's Help file for more detailed instructions.

7.6 Loading New Application Firmware

The interface card's embedded firmware resides in flash memory that can be updated in the field. Firmware updates may be released for a variety of reasons, such as custom firmware implementations, firmware improvements and added functionality as a result of user requests. Additionally, it may be necessary to load different firmware onto the unit in order to support various protocols.

ICC is continually striving to enhance the functionality and flexibility of our products, and we therefore periodically release new embedded firmware to achieve these goals and meet customer requests. Flash firmware files and all related documentation (such as updated user manuals) can be downloaded from <http://www.iccdesigns.com>. It is suggested that users check this Internet site prior to installation, and then periodically afterwards to determine if new firmware has been released and is available to upgrade their units.

Besides the new firmware file, firmware updates require only a PC with the same FTP client capabilities as described earlier in this section. The new firmware is loaded on the unit via the FTP protocol in the same manner as uploading a configuration (.XML) file. Some notes on uploading new firmware via FTP are:

- Please be sure to read the firmware release notes and updated user's manual for any important notices, behavior precautions or configuration requirements prior to updating your firmware. For example, upgrading to a new firmware version may affect user-defined configuration files: prior to starting an update procedure always back up your configuration file to a PC for later recovery if necessary.
- Because the FTP application firmware in the unit distinguishes application firmware files from XML configuration files by virtue of the filename, don't change the default name of the firmware file to be uploaded to the unit.
- Although the firmware file is uploaded from your PC to the unit in the same manner as configuration files are uploaded, the firmware cannot be downloaded from the unit, because the firmware does not reside in the unit's filesystem like configuration files do.
- After the firmware upload process has been completed (typically requiring 30-45 seconds), the unit will reset automatically 5s after the FTP connection is closed. When the unit boots up again, it will be running the new application firmware, which can be confirmed by observing the version displayed in the web server's information window (refer to section 5.4.1).
- Because the transferred firmware file is not written to the unit's flash memory until the FTP connection is closed, be sure to close the connection in order to trigger the write process. The method of closing an FTP connection differs depending on the FTP transfer mechanism used. For example, if using Windows Explorer, close the window. If using the command prompt method, type “quit” to close the connection. If using Core FTP, click on the “disconnect” button, etc.
- Because the interface's web pages may have changed with the new firmware version, it is recommended to clear your web browser's cache memory before accessing the web server after the firmware update. This will ensure that your web browser will load the updated web server pages directly from the interface, instead of just loading the local (old) copy stored in your computer's cache memory. To accomplish this in Internet Explorer, go to *Tools...Internet Options...Browsing History...Delete*, and delete all temporary internet files.

8 PROTOCOL-SPECIFIC INFORMATION

This section will discuss topics that are specific to each of the supported protocols.

8.1 Modbus/TCP

8.1.1 Overview

The interface card supports Schneider Electric's Modbus/TCP protocol, release 1.0. The interface is conformance class 0 and partial class 1 and class 2 compliant, and allows up to 8 simultaneous Modbus/TCP client connections (sockets). Other notes of interest are:

- Supported Modbus/TCP functions are indicated in Table 4.

Table 4: Supported Modbus/TCP Functions

Function Code	Function	Modbus/TCP Class
1	Read coils	1
2	Read input status	1
3	Read multiple registers	0
4	Read input registers	1
5	Write coil	1
6	Write single register	1
15	Force multiple coils	2
16	Write multiple registers	0

- Inverter registers can be addressed as either holding registers (4X references) or input registers (3X references). For example, accessing the output frequency involves accessing holding register 42058 or input register 32058 (i.e. offset 2058).
- Specific bits within inverter registers can be accessed as either coils (0X references) or discrete inputs (1X references).
- Because the transaction is handled locally within the interface card, write data checking is not available for scanned registers (refer to section 6.2.) For example, if a write is performed to a register with a data value that is out-of-range of the corresponding function code, no Modbus exception will be immediately returned.
- Both scanned and non-scanned registers can be freely accessed. The response time for scanned register accesses will be faster than that for non-scanned registers.
- The "unit identifier" (UI) field of the request packets is ignored.
- The socket timeout time is determined by the "timeout" setting on the web server's "Config" tab (refer to section 5.7.6). This means that if a particular open socket experiences no activity for more than the timeout time setting, then the interface assumes that the client or network has experienced some sort of unexpected problem, and will close that socket.
- Because the socket timeout determination is performed on a per-socket basis, note that a certain degree of caution must be exercised when using the network timeout feature to avoid "nuisance" timeouts from occurring. Specifically, do not perform inadvisable behavior such as sending a request from the master device to the interface, and then closing the socket prior to successfully receiving the unit's response. The reason for this is because the interface will then experience an error when attempting to respond via the now-closed socket, which will immediately trigger the timeout action. Always be sure to manage socket life cycles "gracefully", and do not abandon outstanding requests.
- If a socket timeout occurs (regardless of whether it was due to a communication lapse or abnormal socket error), the driver will trigger a timeout event as described in section 5.7.6.

8.1.2 Coil & Discrete Input Mappings

The Modbus/TCP driver provides read/write support for coils (0X references) and read-only support for discrete inputs (1X references). These will collectively be referred to from here on out as simply "discretes". Accessing discretes does not reference any new physical data: discretes are simply indexes into various bits of existing registers. What this means is that when a discrete is accessed, that discrete is resolved by the interface into a specific register, and a specific bit within that register. The pattern of discrete-to-register/bit relationships can be described as follows:

Discrete 1...16 map to register #1, bit0...bit15 (bit0=LSB, bit15=MSB)

Discrete 17...32 map to register #2, bit0...bit15, and so on.

Arithmetically, the discrete-to-register/bit relationship can be described as follows: For any given discrete, the register in which that discrete resides can be determined by Equation 3.

$$register = \left\lfloor \frac{discrete + 15}{16} \right\rfloor \quad \text{Equation 3}$$

Where the bracket symbols " $\lfloor \rfloor$ " indicate the "floor" function, which means that any fractional result (or "remainder") is to be discarded, with only the integer value being retained.

Also, for any given discrete, the targeted bit in the register in which that discrete resides can be determined by Equation 4.

$$bit = (discrete - 1) \% 16 \quad \text{Equation 4}$$

Where "discrete" $\in [1...65535]$, "bit" $\in [0...15]$, and "%" is the modulus operator, which means that any fractional result (or "remainder") is to be retained, with the integer value being discarded (i.e. it is the opposite of the "floor" function).

For clarity, let's use Equation 3 and Equation 4 in a calculation example. Say, for instance, that we are going to read coil #34. Using Equation 3, we can determine that coil #34 resides in register #3, as $\lfloor 3.0625 \rfloor = \lfloor 3 \text{ r } 1 \rfloor = 3$. Then, using Equation 4, we can determine that the bit within register #3 that coil #34 targets is $(34-1)\%16 = 1$, as $33\%16 = \text{mod}(2 \text{ r } 1) = 1$. Therefore, reading coil #34 will return the value of register #3, bit #1.

8.2 EtherNet/IP

8.2.1 Overview

The EtherNet/IP protocol is an application-level protocol implemented on top of the Ethernet TCP/IP and UDP/IP layers. It shares its object model with ControlNet and DeviceNet through the Common Industrial Protocol (CIP). This protocol allows the transfer of data and I/O over Ethernet.

EtherNet/IP incorporates both the TCP and UDP layers of Ethernet in the transmission of data. Because TCP/IP is a point-to-point topology, EtherNet/IP uses this layer only for explicit messaging; i.e. those messages in which the data field carries both protocol information and instructions for service performance. With explicit messaging, nodes must interpret each message, execute the requested task and generate responses. These types of messages can be used to transmit configuration, control and monitor data.

The UDP/IP protocol layer, which has the ability to multi-cast, is used for implicit (I/O) messaging. With I/O messaging, the data field contains only real-time I/O data; no protocol information is sent because the meaning of the data is pre-defined at the time the connection is established, which in turn minimizes the processing time of the node during run-time. I/O messages are short and have low overhead, which allows for the time-critical performance needed by controllers.

The interface card supports both explicit and I/O messaging. Further, two different types of I/O messaging are supported. One type (invoked when the client opens a connection to the interface using assembly instances 20 & 70 or 21 & 71) is included with the implementation of the AC/DC drive profile, and requires no user configuration. The other type, however, is entirely user-configurable, and is invoked when the client opens a connection to the interface using assembly instances 100 and 150.

The following sections demonstrate specific examples of how to use EtherNet/IP to transfer data between the inverter and Allen-Bradley Logix-brand PLCs.

Some other notes of interest are:

- The interface card supports the EtherNet/IP protocol, as administered by the Open DeviceNet Vendor Association (ODVA).
- This product has been self-tested by ICC, Inc. and found to comply with ODVA EtherNet/IP Conformance Test Software Version A-5.
- I/O connection sizes for assembly instances 100 and 150 are adjustable between 0 and 64 bytes (32 registers max @ 2 bytes per register = 64 bytes). Because registers are 16-bit elements, however, connection sizes cannot be odd (i.e. 1, 3, 5 etc.)
- The interface card's product type code is 2 (AC Drive).
- Supports unconnected messages (UCMM), and up to 16 simultaneous class 1 (I/O) or class 3 (explicit) connections.
- Assembly instances 100 and 150: if a register entry in the consumed data configuration array is 0, then any consumed data that corresponds to that location will be ignored. Conversely, if a register entry in the produced data configuration array is 0, then any produced data that corresponds to that location will be a default value of 0. Refer to section 5.8.4 for further information on the data configuration arrays.
- Class 1 implicit I/O supports both multicast and point-to-point (unicast) when producing data in the T→O direction.
- Point-to-point class 1 connected messages will be produced targeting the IP address of the device that instantiated the connection, UDP port 0x08AE (UDP port 2222).
- If a class 1 point-to-point connection is established in the (T→O) direction, no more class 1 connections can be established.
- If a class 1 connection's consuming half (O→T) times out, then the producing half (T→O) will also time-out and will stop producing.
- If a class 1 or class 3 connection timeout occurs, the driver will trigger a timeout event as described in section 5.7.6. The timeout value is dictated by the scanner/client and is at a minimum, four times the scan rate (Requested Packet Interval) for class 1. The typical timeout value for class 3 messaging is usually much larger and is also dictated by the scanner/client.

8.2.2 ODVA AC/DC Drive Profile

The interface card supports the ODVA AC/DC drive profile. No special EtherNet/IP configuration of the interface card is required when using the AC/DC drive profile: all that is needed is that the controller must target either assembly instances 20 & 70 or 21 & 71 in its connection parameters.

The AC/DC drive profile implementation provides support for several required CIP objects, which are specified in Table 5. While the various supported attributes of all of these objects are accessible via explicit messaging, the main intent of using the AC/DC drive profile is to interact with the predefined input and output assembly instances via an I/O connection. The structure of these assembly instances is defined by the EtherNet/IP specification in order to engender interoperability among different vendor's products. This section will focus primarily on the format of the AC/DC drive profile I/O assemblies supported by the interface card, and the inverter data which their various constituent elements map to.

Table 5: AC/DC Drive Profile-Related Objects

Class Code	Object Name
0x04	Assembly Object
0x28	Motor Data Object
0x29	Control Supervisor Object
0x2A	AC Drive Object

Output Instances

Table 6: Output Instances 20 and 21 Detail

Instance	Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
20	0						Fault Reset		Run Fwd
	1								
	2	Speed Reference (Low Byte)							
	3	Speed Reference (High Byte)							
21	0		NetRef	NetCtrl			Fault Reset	Run Rev	Run Fwd
	1								
	2	Speed Reference (Low Byte)							
	3	Speed Reference (High Byte)							

Output Instance Mapping Detail

Run Fwd: forward rotation command (0=forward rotation off, 1=forward rotation on). Maps to inverter register 1799, bit 0 (function code S06 / operation command word, FWD bit).

Run Rev: reverse rotation command (0=reverse rotation off, 1=reverse rotation on). Maps to inverter register 1799, bit 1 (function code S06 / operation command word, REV bit).

Fault Reset: Inverter reset command (0=no action, 0→1 rising edge=reset). Maps to inverter register 1799, bit 15 (function code S06 / operation command word, RST bit).

NetCtrl: Not used (value is ignored).

NetRef: Not used (value is ignored).

Speed Reference: Inverter speed reference in RPM. Maps to inverter register 1798 (function code S05 / frequency command). The speed reference component of the AC/DC drive profile output instances is always in units of RPM. Therefore, the interface card applies the RPM-to-Hz conversion indicated in Equation 5 in order to determine the appropriate frequency command value (in units of Hz) to be written to register 1798.

$$Hz = \frac{RPM \times \text{number of motor poles}}{120} \quad \text{Equation 5}$$

The “number of motor poles” term which appears in the numerator of Equation 5 is obtained from the setting of inverter function code P01 (Motor number of poles). Note that the value of P01 is read by the interface card only at boot-up, so if the value of this function code is changed, then the interface card must be rebooted in order for it to read the new value from the inverter.

Input Instances

Table 7: Input Instances 70 and 71 Detail

Instance	Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
70	0						Running1		Faulted
	1								
	2	Speed Actual (Low Byte)							
	3	Speed Actual (High Byte)							
71	0	At Reference	Ref from Net	Ctrl From Net	Ready	Running2 (REV)	Running1 (FWD)	Warning	Faulted
	1	Drive State							
	2	Speed Actual (Low Byte)							
	3	Speed Actual (High Byte)							

Input Instance Mapping Detail

Faulted: Inverter fault signal (0=not faulted, 1=faulted). Maps to inverter register 2063, bit 11 (function code M14 / operation status word, ALM bit).

Warning: This bit is not used (it is always 0).

Running1 (FWD): Running forward status signal (0=not running forward, 1=running forward). Maps to inverter register 2063, bit 0 (function code M14 / operation status word, FWD bit).

Running2 (REV): Running reverse status signal (0=not running reverse, 1=running reverse). Maps to inverter register 2063, bit 1 (function code M14 / operation status word, REV bit).

Ready: Inverter ready signal (0=not ready, 1=ready). The Ready bit will be 1 whenever the Drive State attribute (see below) is in the Ready, Enabled or Stopping state.

CtrlFromNet: This bit is not used (it is always 0).

RefFromNet: This bit is not used (it is always 0).

AtReference: Up-to-speed signal (0=not up-to-speed, 1=up-to-speed). Set to 1 if the inverter is running (either Running1 = 1 or Running2 = 1) and both the ACC bit (bit #9) and DEC bit (bit #10) in the operation status word (register 2063 / function code M14) are 0.

Drive State: Indicates the current state of the Control Supervisor Object state machine. Refer to the ODVA EtherNet/IP specification (object library) for detailed information on the Control Supervisor Object state machine.

Speed Actual: Inverter operating speed in RPM. Maps to inverter register 2058 (function code M09 / output frequency). The speed actual component of the AC/DC drive profile input instances is always in units of RPM. Therefore, the interface card applies the Hz-to-RPM conversion indicated in Equation 6 in order to determine the appropriate operating speed (in units of RPM) to be written to the network.

$$RPM = \frac{Hz \times 120}{\text{number of motor poles}} \quad \text{Equation 6}$$

The “number of motor poles” term which appears in the denominator of Equation 6 is obtained from the setting of inverter function code P01 (Motor number of poles). Note that the value of P01 is read by the interface card only at boot-up, so if the value of this function code is changed, then the interface card must be rebooted in order for it to read the new value from the inverter.

8.2.3 ControlLogix Examples: Setup

This section will demonstrate how to initially setup a ControlLogix PLC (such as a 1756-L61) coupled with a 1756-ENBT/A communication interface (adjust this procedure according to your specific equipment). Later sections will provide specific read/write examples using this configuration with I/O or explicit messaging.

- 1) Run RSLogix 5000, and create a new configuration.
- 2) To add a 1756-ENBT/A to your I/O configuration, first switch to offline mode.
- 3) Right click on the I/O Configuration node in the controller organizer view and choose “New Module...”
- 4) The “Select Module” window will open.
- 5) Under “Communications”, select “1756-ENBT/A”, and click OK. Refer to Figure 80.

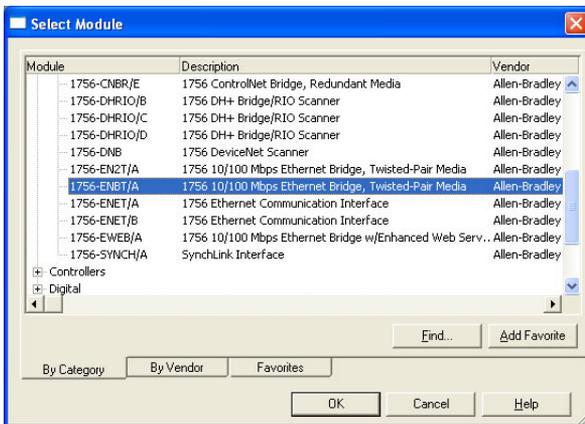


Figure 80: Adding a New 1756-ENBT/A Module

- 6) The “New Module” window will open. Refer to Figure 81.
- 7) Assign the Ethernet module a name (we will use “EIP”) and an IP address, deselect “Open Module Properties”, and click OK.
- 8) Download the configuration.

- 9) Switch to online mode. Right click on the 1756-ENBT/A module in the I/O Configuration and choose "Properties".
- 10) Select the Port Configuration tab from the Module Properties dialog box.
- 11) Confirm that the IP Address, Subnet Mask and Gateway Address fields are configured correctly. The IP Address must match the IP Address entered when the new module was first created. Refer to Figure 82.

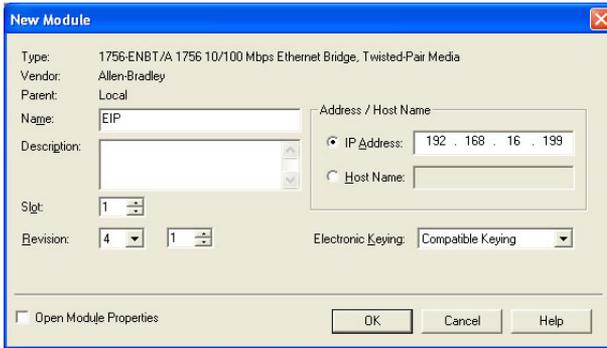


Figure 81: Configuring the New Module

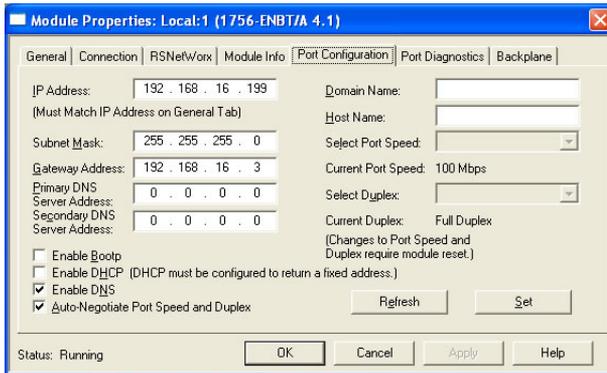


Figure 82: Confirming the Module's Properties

- 12) Apply any changes to the settings using the "Set" button.
- 13) You should now be able to confirm that the 1756-ENBT/A module is configured properly by (for example) opening the module's web interface in a web browser.

8.2.4 ControlLogix Example: I/O Messaging

This section will demonstrate how to setup and use an EtherNet/IP I/O connection via vendor-specific assembly instances 100 & 150. EtherNet/IP I/O messaging allows the inverter's registers to be directly mapped into tags in the ControlLogix PLC. Once an I/O connection is established, it is automatically synchronized at an interval defined by the Requested Packet Interval (RPI).

- 1) Switch to offline mode.

- 2) Right click on the 1756-ENBT/A node under the I/O Configuration in the controller organizer view and choose “New Module...”
- 3) Choose “Generic Ethernet Module” in the Select Module dialog box and click “OK”. Refer to Figure 83.

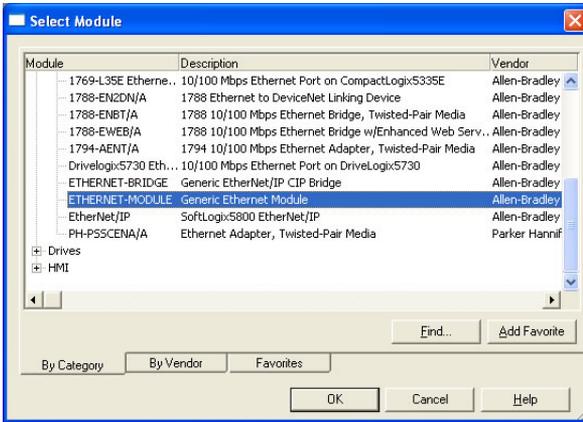


Figure 83: Adding a New Generic Ethernet Module

- 4) The module properties dialog box will open (refer to Figure 84). Enter a Name and Description which will allow easy identification of the inverter on the network (the tags created in RSLogix 5000 will be derived from this Name). Because all inverter data is stored as 16-bit registers, change the “Comm Format” selection to “Data-INT”. Enter the IP address of the targeted interface card.

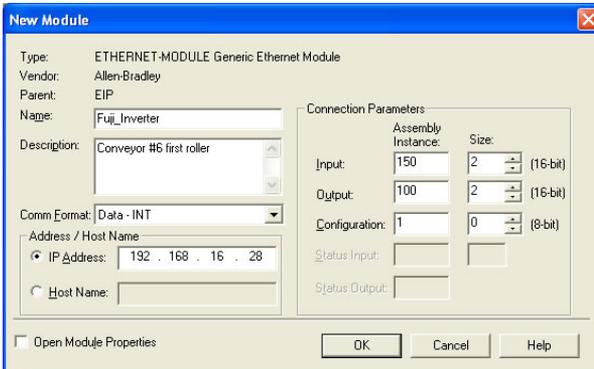


Figure 84: Interface Card Module Properties

In the “Connection Parameters” portion of the dialog box, enter the following information:

Input: The Input Assembly is the collection of monitor data that is produced by the interface card and is received as an input to the PLC. Its structure is defined by the Produced Register Configuration as described in section 5.8.4. The Input Assembly Instance must be set to 150 when connecting to the vendor-specific I/O assembly instances (or 70/71 when using the ODVA AC/DC drive profile), and the size must be set to the number of 16-bit registers that we wish to receive from the interface card. For the purposes of this example, we are assuming that the produced configuration array is defined as shown in Figure 40, with two relevant registers (2063 and 2058). We therefore set the Input Size to 2.

Output: The Output Assembly is the collection of command & configuration data that is sent as an output from the PLC and consumed by the interface card. Its structure is defined by the Consumed Register Configuration as described in section 5.8.4. The Output Assembly Instance must be set to 100 when connecting to the vendor-specific I/O assembly instances (or 20/21 when using the ODVA AC/DC drive profile), and the size must be set to the number of 16-bit registers that we wish to send to the interface card. For the purposes of this example, we are assuming that the consumed configuration array is defined as shown in Figure 40, with two relevant registers (1799 and 1798). We therefore set the Output Size to 2.

Configuration: The Configuration Assembly Instance is unused, and its instance number and size are therefore irrelevant (you can just enter “1” and “0”, respectively).

When done, click “OK”.

- 5) You should now see the new module (named “ETHERNET-MODULE Fuji_Inverter”) in the 1756-ENBT/A branch under the I/O Configuration in the controller organizer view. Right click on this new module, choose “Properties”, and select the Connection tab. Refer to Figure 85.

Confirm the setting of the Requested Packet Interval (RPI). The RPI defines the amount of time (in milliseconds) between data exchanges across an I/O connection. The smallest RPI supported by the interface card is 10ms.

When done, click “OK”.

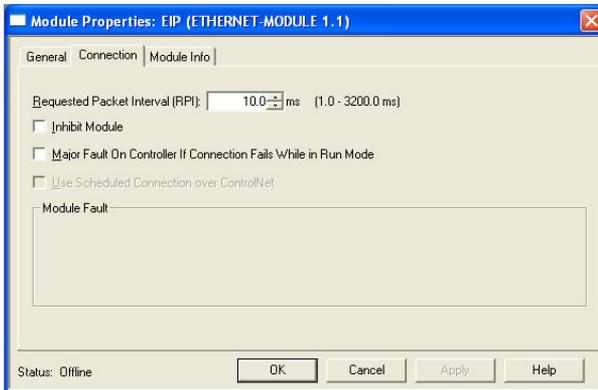


Figure 85: Interface Card Module Properties Connection Tab

- 6) After adding the I/O Module to the configuration, the full I/O Configuration tree should appear similar to Figure 86.
- 7) Switch to online mode and download the project to the PLC. Verify that the newly-added inverter is available and operating correctly by observing any indications shown on the inverter's icon. When the inverter's icon is selected, its status and any available error messages will be displayed in the area below the project tree. Refer to Figure 87. Also confirm that the interface card's “Network Status” LED should be solid green, indicating an “online/connected” state.

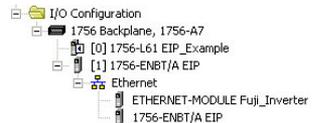


Figure 86: I/O Configuration Tree

- 8) By double-clicking “Controller Tags” in the project tree, it is possible to view the newly-added tags. Refer to Figure 88. The Fuji_Inverter:C configuration tag is unused, the Fuji_Inverter:I tag allows viewing of the input data, and the Fuji_Inverter:O tag allows modification of the output data. These tags will be synchronized with the inverter at whatever rate was established for the module's RPI.

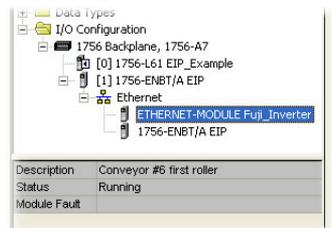


Figure 87: Online Module Status

We can directly interact with these tags in order to control and monitor the inverter. In Figure 88, for example, we can see that the first 16-bit word of output data (Fuji_Inverter.O.Data[0]) has been set to a hexadecimal value of 0x0001. Referring back to Figure 40, we can see that the first element of the consumed register configuration references register 1799, which is the inverter's operation command register. A value of 0x0001, therefore, means that the FWD (run forward) bit has been turned ON.

Similarly, we can see that the second 16-bit word of output data (Fuji_Inverter.O.Data[1]) has been set to a decimal value of 3558. Once again referring back to Figure 40, we can see that the second element of the consumed register configuration references register 1798, which is the inverter's frequency command register. A value of 3558, therefore, equates to a frequency command of 35.58Hz.

The input data from the inverter shows similar expected results. Values of 0x1021 and 3558 corresponding to registers 2063 (status register) and 2058 (output frequency), respectively, are consistent with the inverter running at the parameters commanded by the output tag.

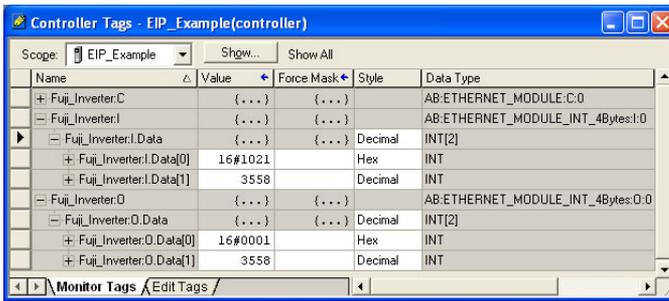


Figure 88: Controller Tags for I/O Access

8.2.5 ControlLogix Example: Generic Default I/O Add-On Instruction

The generic default I/O Add-On Instruction (AOI) is a simple interface to command and monitor the inverter. It is based on the vendor-specific I/O assembly instances 100 & 150 and the default produced and consumed data configuration arrays (refer to section 5.8.4).

- 1) Complete all the steps in section 8.2.4.
- 2) Right click on "Add-On Instructions" in the controller organizer view and select "Import Add-On Instruction". Browse and import the generic default I/O AOI. Refer to Figure 89.

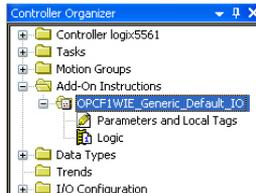


Figure 89: Generic Default IO AOI

- 3) Double click "Controller Tags" in the controller organizer view and select the "Edit Tags" tab at the bottom.
- 4) Create the tags in Figure 90.

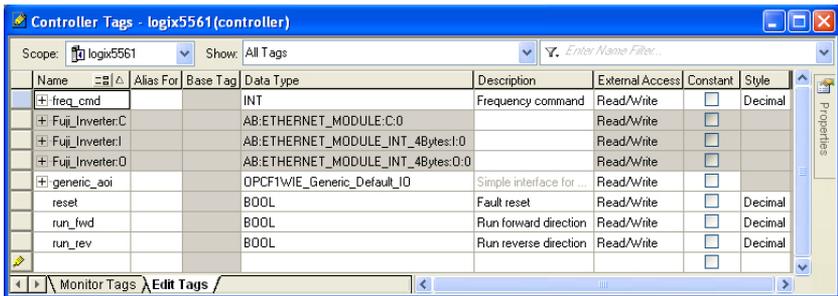


Figure 90: Create Generic Default AOI Tags

- 5) Double click “MainRoutine” under Tasks ...MainTask ...MainProgram in the controller organizer view.
- 6) Right click on the first ladder logic rung in the MainRoutine window and select “Add Ladder Element...”
- 7) The “Add Ladder Element” window appears.
- 8) Select the generic default I/O AOI in the Add-On folder. Refer to Figure 91.

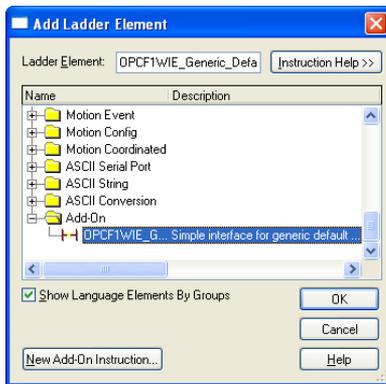


Figure 91: Add Generic Default AOI

- 9) Click OK.
- 10) Edit the add-on instruction according to Figure 92.

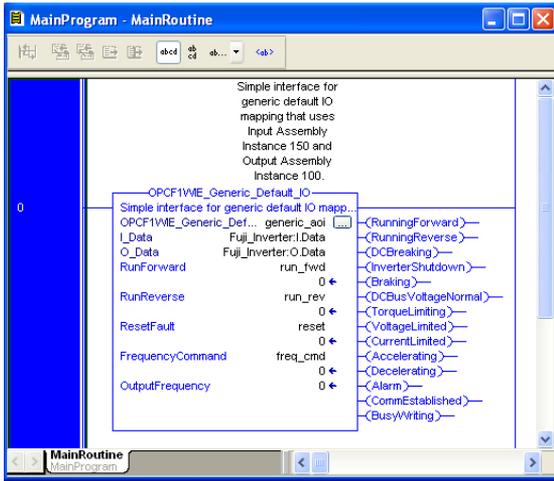


Figure 92: Configure Generic Default AOI

- 11) The program is now complete.
- 12) Save, download and run the program.

8.2.6 ControlLogix Example: AC/DC Drive Profile Add-On Instruction

The AC/DC drive profile Add-On Instruction (AOI) is a simple interface to command and monitor the inverter. It is based on the assembly instances 21 & 71.

- 1) Complete all the steps in section 8.2.4. Please note that the Assembly Input Instance must be changed to 71 and the Assembly Output Instance must be changed to 21. Refer to Figure 93.

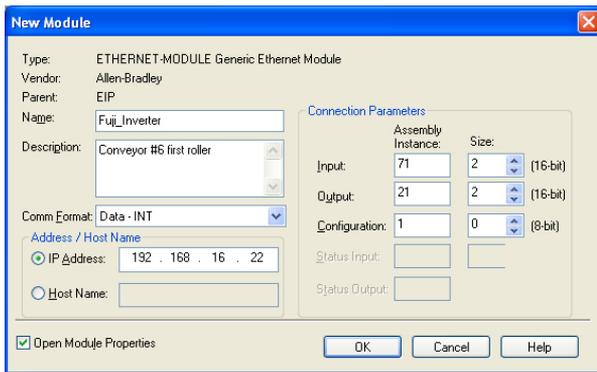


Figure 93: AC/DC Drive Profile Generic Ethernet Module Configuration

- 2) Right click on “Add-On Instructions” in the controller organizer view and select “Import Add-On Instruction”. Browse and import the AC/DC drive profile AOI. Refer to Figure 94.

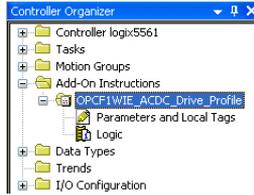


Figure 94: AC/DC Drive Profile AOI

- 3) Double click "Controller Tags" in the controller organizer view and select the "Edit Tags" tab at the bottom.
- 4) Create the tags in Figure 95.

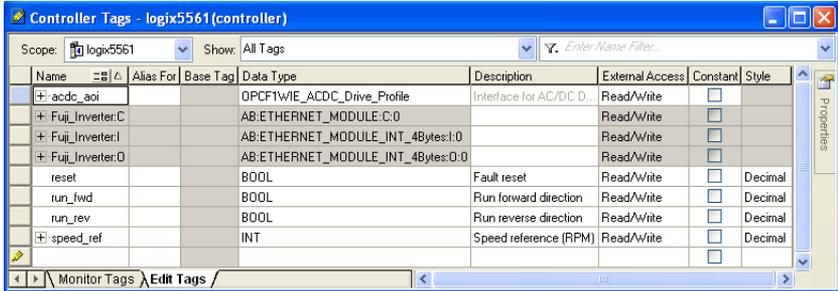


Figure 95: Create AC/DC Drive Profile AOI Tags

- 5) Double click "MainRoutine" under Tasks ...MainTask ...MainProgram in the controller organizer view.
- 6) Right click on the first ladder logic rung in the MainRoutine window and select "Add Ladder Element..."
- 7) The "Add Ladder Element" window appears.
- 8) Select the AC/DC drive profile AOI in the Add-On folder. Refer to Figure 96.

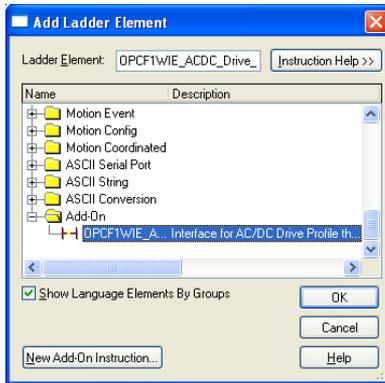


Figure 96: Add AC/DC Drive Profile AOI

- 9) Click OK.

10) Edit the add-on instruction according to Figure 97.

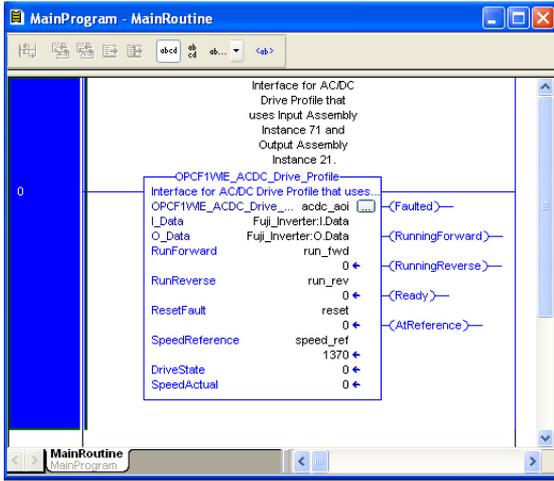


Figure 97: Configure AC/DC Drive Profile AOI

- 11) The program is now complete.
- 12) Save, download and run the program.

8.2.7 Explicit Messaging Tag Reference

When class 3 (explicit messaging) connections are used, register contents are read from and written to the interface card via EtherNet/IP by reference to “tag names”. Tags are read via the EtherNet/IP “data table read” service, and tags are written via the EtherNet/IP “data table write” service. Different tags exist for reading vs. writing.

Any given scanned or non-scanned register can be accessed with its own unique tag name, or an array tag can be used to access a group of registers with one PLC instruction. Tag names are generated according to the following structure:

[action prefix][_reg_][register number]

Where

[action prefix] is a 2-character field, and is equal to either “rd” for read tags, or “wr” for write tags. Although commonly followed for naming clarity, this “read vs. write” naming convention is not strictly enforced by the interface card, however: it is perfectly acceptable to write to a tag that starts with “rd” and read from a tag that starts with “wr”.

[_reg_] is just the 5-character sequence “_reg_”.

[register number] is a 1- to 4-character field (“1”, “2”...“1799”... “2058”..., etc.) corresponding to the referenced register number.

Examples

Write “acceleration time 1” (function code F07 / register #8) wr_reg_8
 Write “frequency command” (function code S05 / register #1798)..... wr_reg_1798
 Read “output frequency” (function code M09 / register #2058) rd_reg_2058
 Read “output voltage” (function code W06 / register #3847) rd_reg_3847

To read data from the interface card, the application PLC program must reference a “source element” from which to start reading and the “number of elements” to read. The “source element” will be a tag name constructed according to the naming convention shown above. The “source element” can be either a base tag (such as “rd_reg_2050”, which starts at register 2050), or an offset from a base tag

(such as "rd_reg_2050[8]", which starts at register 2050+8 = register 2058, the inverter's output frequency register).

In a similar manner, to write data to the interface card, the application PLC program must reference a "destination element" to which to start writing and the "number of elements" to write. Again, the "destination element" will be a tag name constructed according to the naming convention shown above.

Whether reading or writing, the "number of elements" can be any quantity of registers from 1 to the maximum allowable length.

8.2.8 ControlLogix Explicit Messaging Example: Read a Register Block

This example program will show how to continuously read a block of registers from the inverter with a single MSG instruction. Only one read request is outstanding at any given time.

1) Create new Tags.

a) Double click "Controller Tags" in the controller organizer view.

b) The "Controller Tags" window appears. Refer to Figure 98.



Figure 98: Create New Tags

c) Select the "Edit Tags" tab at the bottom.

d) Create a new tag by entering "connection" in the first blank Name field, and change its Data Type to "MESSAGE". This tag will contain configuration information for the MSG instruction.

e) Select the "Monitor Tags" tab. Expand the "connection" tag by clicking on the "+" sign next to the tag name. Scroll down to the connection.UnconnectedTimeout field and change its value from the default 30000000 (30s in 1uS increments) to 1000000 (1s). This value determines how long to wait before timing out and retransmitting a connection request if a connection failure occurs. Refer to Figure 99.

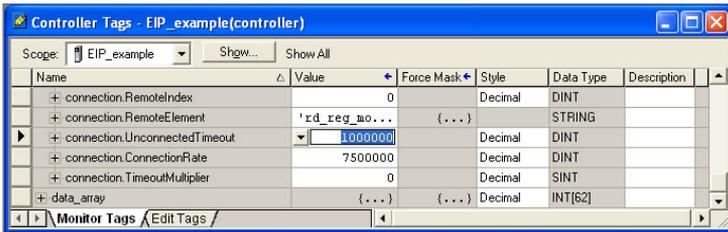


Figure 99: Reduce the UnconnectedTimeout Value

f) Collapse the "connection" tag again by clicking on the "-" sign next to the tag name.

g) Select the "Edit Tags" tab again. Create another new tag by entering "data_array" in the next blank Name field, and change its Data Type by typing in "INT[73]" in the Data Type field. This tag is an array of INTs that will be able to hold up to 73 16-bit registers from the inverter. Always make sure that the destination tag size is large enough to hold all elements to be read.

2) **Add a MSG instruction to the main program.**

- a) Double click "MainRoutine" under Tasks ...MainRoutine ...MainProgram in the controller organizer view.
- b) Right click on the first ladder logic rung in the MainRoutine window and select "Add Ladder Element..."
- c) The "Add Ladder Element" window appears.
- d) Select the "MSG" instruction in the Input/Output folder. Refer to Figure 100.
- e) Click OK.

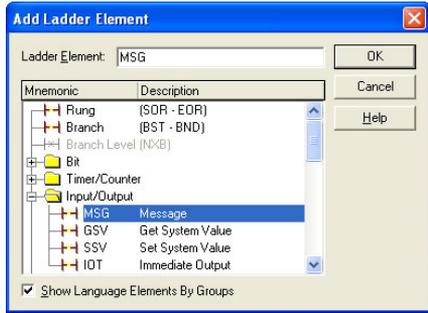


Figure 100: Adding a MSG Instruction

3) **Add an XIO element to the main program.**

- a) Right click on the ladder logic rung containing the MSG instruction in the MainRoutine window and select "Add Ladder Element..." again.
- b) The "Add Ladder Element" window appears.
- c) Select the "XIO" element in the Bit folder. Refer to Figure 101.
- d) Click OK.

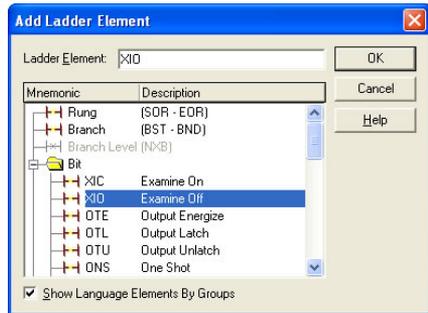


Figure 101: Adding an XIO Element

4) **Configure the MSG instruction.**

- a) Edit the "Message Control" field on the MSG instruction to use the previously-created "connection" tag. Refer to Figure 102.

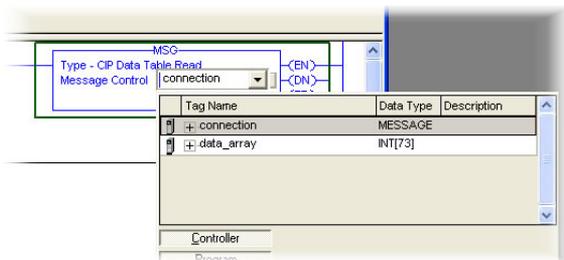


Figure 102: MSG Instruction Tag Assignment

- b) Click the message configuration button ("...") in the MSG instruction. The "Message Configuration" window will open. Refer to Figure 103.



Figure 103: MSG Instruction Configuration

- c) "Configuration" tab settings:
 - i) Change the "Message Type" to "CIP Data Table Read".
 - ii) In the "Source Element" field, enter the read tag you wish to access (refer to section 8.2.5.) In this example, we will be reading a total of 21 registers beginning at rd_reg_2050 (function code M01 / per-unit frequency reference – final command).
 - iii) Enter the Number Of Elements to read. In this example, we will read 21 registers.
 - iv) For the Destination Element, either directly type "data_array[50]", or select element #50 in the data_array tag via the drop-down box (refer to Figure 104). The destination could be any offset in the data_array tag, as long as the offset plus the Number Of Elements (21) does not exceed the tag's defined size (73).

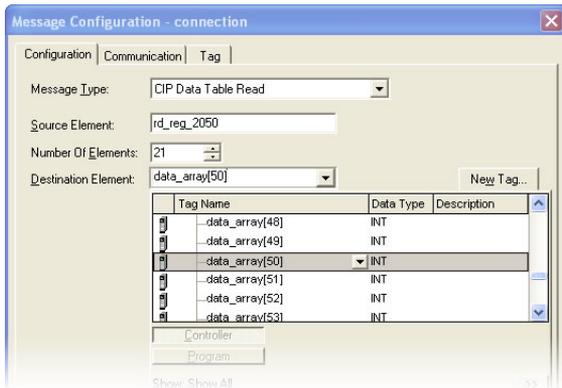


Figure 104: Selecting the Destination Element

- d) "Communication" tab settings (refer to Figure 105):
 - i) Enter the Path to the interface card. A typical path is formatted as "*Local_ENB,2,target_IP_address*", where:
 - *Local_ENB* is the name of the 1756-ENBx module in the local chassis (we named ours "EIP" in section 8.2.3),
 - 2 is the Ethernet port of the 1756-ENBx module in the local chassis, and
 - *target_IP_address* is the IP address of the target node.
 In our example, this path would be entered as "EIP,2,192.168.16.28".
 - ii) If "Cache Connections" is enabled (checked), the connection remains open after transmission. If disabled (unchecked), the connection is opened before and closed

after every transmission. For efficiency, it is recommended to enable "Cache Connections".

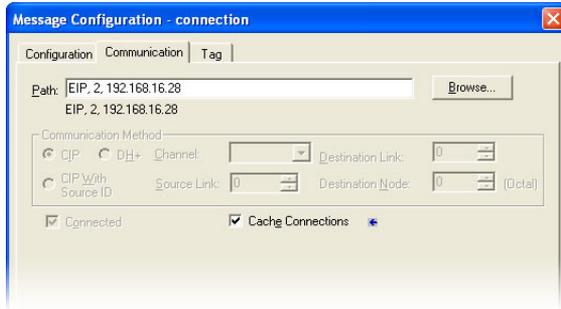


Figure 105: Setting the Communication Path

- e) Click "OK" to close the MSG Configuration dialog. At this stage, MainRoutine should look like Figure 106.

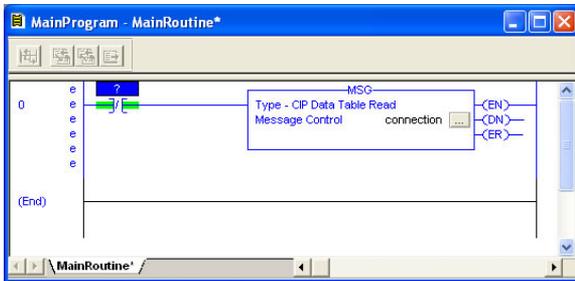


Figure 106: MainRoutine

5) Assign a tag to the XIO element.

- a) Double-click on the XIO element located to the left of the MSG block. In the drop-down box, double-click on the "connection.EN" field. Refer to Figure 107. This configuration causes the MSG instruction to automatically retrigger itself when it completes. While this is acceptable for the purposes of this example, it can produce high network utilization. In actual practice, it may be desirable to incorporate additional logic elements to allow triggering the MSG instruction at a specific rate or under specific conditions.

6) The program is now complete. Refer to Figure 108.

7) Save, download and run the program.

- a) To view the values of the registers being read from the interface card, double-click "Controller Tags" in the controller organizer view.
- b) Select the "Monitor Tags" tab.
- c) Expand the data_array tag. Refer to Figure 109.
- d) 21 register values starting at register #2050 are being continuously read from the interface card and placed in the 21 sequential offsets of data_array starting at the 50th offset (data_array[50]). In Figure 109, we can see that data_array[50] (function code M01 / register 2050 / per-unit frequency reference – final command) has a value of 11860 (11860/20000 = 59.3% of max frequency), data_array[58] (function code M09 / register 2058 / output frequency) has a value of 3558 (35.58Hz), etc.

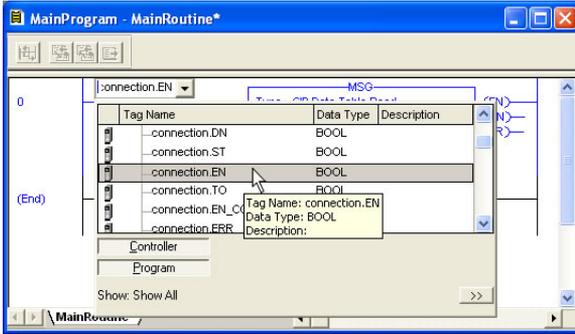


Figure 107: Configure XIO Element

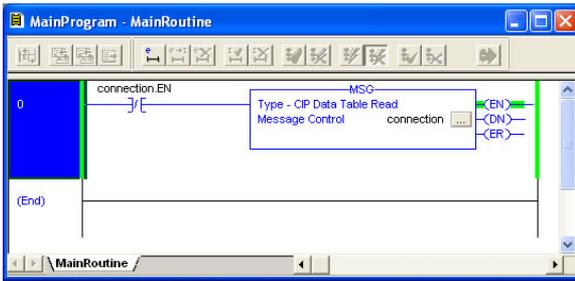


Figure 108: Complete Program

Name	Value	Force Mask	Style	Data Type	D
+ data_array[50]	11860		Decimal	INT	
+ data_array[51]	0		Decimal	INT	
+ data_array[52]	0		Decimal	INT	
+ data_array[53]	0		Decimal	INT	
+ data_array[54]	3558		Decimal	INT	
+ data_array[55]	11860		Decimal	INT	
+ data_array[56]	-178		Decimal	INT	
+ data_array[57]	0		Decimal	INT	
+ data_array[58]	3558		Decimal	INT	
+ data_array[59]	120		Decimal	INT	
+ data_array[60]	1		Decimal	INT	
+ data_array[61]	790		Decimal	INT	
+ data_array[62]	1		Decimal	INT	
+ data_array[63]	4129		Decimal	INT	
+ data_array[64]	1		Decimal	INT	
+ data_array[65]	36		Decimal	INT	
+ data_array[66]	0		Decimal	INT	
+ data_array[67]	0		Decimal	INT	
+ data_array[68]	0		Decimal	INT	
+ data_array[69]	1773		Decimal	INT	
+ data_array[70]	313		Decimal	INT	

Figure 109: Viewing the Register Values

8.2.9 ControlLogix Explicit Messaging Example: Read a Single Register

The configuration and execution for reading a single register is in general identical to that required for reading a block of registers as detailed in section 8.2.8. The only difference is in the configuration of the MSG instruction. Figure 110 shows an example MSG instruction's Configuration tab, which will read a single tag (rd_reg_2063 / function code M14, the inverter's operation status register) and place it in the first element (offset 0) of data_array.

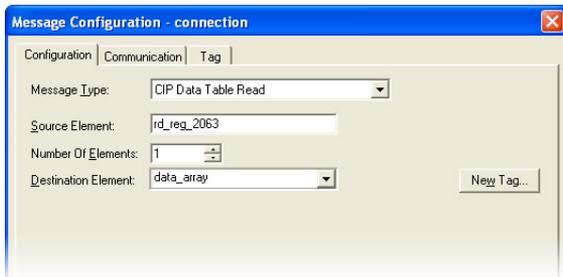


Figure 110: Read the Inverter's Operation Status Register

8.2.10 ControlLogix Explicit Messaging Example: Multiple MSG Instructions

At times, reading from different groups of registers may be necessary. For example, a specific application may require access to some registers in both the Monitor Data 1 and Monitor Data 2 function code groups. To accomplish this task, multiple MSG instructions will need to be implemented in the PLC program.

The configuration and execution for implementing multiple MSG instructions is in general identical to that required for implementing just one MSG instruction. Each MSG instruction will require its own message controller tag. In the case of read MSG instructions, more than one instruction may use the same Destination Element tag, but the storage locations must not overlap. Figure 111 shows an example of two MSG instructions, each accessing different read tags. It is evident from this logic that "rd_connection" and "rd_connection2" are the two independent message controller tags created for these instructions.

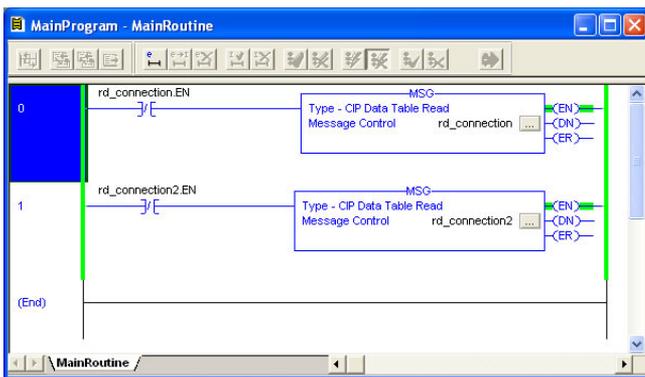


Figure 111: Reading Via Multiple MSG Instructions

8.2.11 ControlLogix Explicit Messaging Example: Reading and Writing

Often times, applications may need to both read data from and write data to the inverter. At a minimum, this will require two MSG instructions and two message controller tags. Figure 112 shows an example of three MSG instructions, one for reading and two for writing (the inverter's frequency command and operation command word). The only item of note that differentiates this example from the multiple-read example in section 8.2.10 is the addition of the en_xx_wr XIC elements. The reason for the addition of these elements is that while reading from a remote device is often continuously performed (monitoring), data is typically written to the remote device only when necessary (i.e. when the value to write has changed). This conserves both network bandwidth and potentially EEPROM lifespans on the target device. The en_xx_wr elements in this example, therefore, would typically be replaced in an actual application program by user-provided logic that controls the conditions under which write operations would be performed.

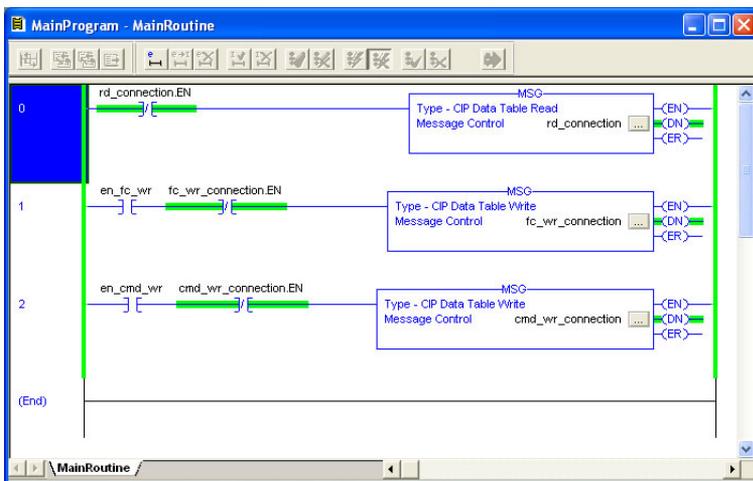


Figure 112: Reading and Writing via MSG Instructions

Figure 113 shows the configuration details of the example fc_wr_connection MSG instruction. Note that the chosen "Message Type" is "CIP Data Table Write", and that this instruction will only be writing to one inverter register: namely, the frequency command (Destination Element is wr_reg_1798 / function code S05). The Source Element in this case is the 2nd element (starting from index 0) of an INT array tag named "wr_data".



Figure 113: MSG Configuration for Writing

Note that when writing data via explicit messaging, use caution to ensure that the commanded registers are not also simultaneously being commanded in the background via I/O messaging. Indeterminate behavior can occur if MSG instructions and background I/O data transfers are both writing to the same registers. In other words, if the I/O messaging example procedure detailed in section 8.2.4 has already been implemented, and the same program is now being modified to implement explicit messaging, then it is recommended to inhibit the target module by selecting the "Inhibit Module" checkbox in the Connection tab of the Module Properties dialog.

8.3 Allen Bradley CSP

8.3.1 Overview

Ethernet-enabled Allen-Bradley legacy PLCs (such as the PLC5E and SLC-5/05 series) use a protocol called CSP (Client Server Protocol) to communicate over the Ethernet network. The flavor of CSP used by these PLCs is also known as “PCCC” (Programmable Controller Communication Commands) and “AB Ethernet”. The interface card supports CSP for direct connectivity to these PLCs.

If a connection timeout or socket-level error occurs, the driver will trigger a timeout event as described in section 5.7.6.

8.3.2 Tag Reference

Register contents are read from and written to the interface card via CSP by reference to an integer “file/section number” and an “offset/element” within that file. Reading is performed via the CSP “PLC5 Read” (DF1 protocol typed read) service, and writing is performed via the CSP “PLC5 Write” (DF1 protocol typed write) service.

The formula to calculate which register in the interface card is targeted in Equation 7.

$$\text{target register} = (\text{file number} - 10) \times 100 + \text{offset} \quad \text{Equation 7}$$

In Equation 7, “target register” $\in [1 \dots 4417]$, “file number” $\in [10 \dots 54]$ (which means N10...N54), and “offset” is restricted only by the limitations of the programming software (but is a value of 4417 max). Table 8 provides some examples of various combinations of file/section numbers and offsets/elements which can be used to access inverter registers. Note that there are multiple different combinations of file/section numbers and offsets/elements that will result in the same inverter register being accessed.

Table 8: CSP Target Register Examples

File/Section Number	Offset/Element	Start Target Register
N10	2	2
N12	62	262
N11	162	262
N27	98	1798
N20	798	1798
N54	17	4417
N10	4417	4417

In addition to providing access to the inverter registers in their “standard” numerical locations as mentioned above, the registers can also be accessed in a special “assembly object” type format by targeting integer file N60. What this means is that when N60 is targeted for reading, what is actually returned by the interface card is the user-defined register data as ordered by the EtherNet/IP produced register configuration array (refer to section 5.8.4). Similarly, when N60 is targeted for writing, the written data is disseminated to the inverter’s registers according to the definition contained in the EtherNet/IP consumed register configuration array. By appropriate configuration of the EtherNet/IP consumed and produced register configuration arrays, therefore, bulk access to non-contiguous but frequently-used inverter registers can be conveniently provided by performing only one read and/or write instruction targeting file N60.

Because both the EtherNet/IP consumed and produced register configuration arrays are comprised of 32 register definitions, the targeted “offset/element” must be within the range of 0 to 31 inclusive. Refer to Table 9 for some examples of N60 accesses.

Table 9: Examples of EtherNet/IP-Style Bulk Access via File N60

Offset/Element	Start Target Register of Configuration Array	Max Number of Accessible Elements
0	1 st	32
:	:	:
15	16 th	16
:	:	:
31	32 nd	1

The application PLC program uses a MSG instruction that is configured with a “Data Table Address” from which to start the access and a “Size in Elements” which determines the number of items to access (read or write). The “Data Table Address” is constructed by selecting a “File/Section Number” and an “Offset/Element” according to Equation 7. For example, a “File/Section Number” of N27 and “Offset/Element” of 99 = N27:99, which corresponds to register 1799 (the inverter’s operation command register).

8.3.3 SLC-5/05 Example: Read a Register Block

This example program will show how to continuously read a block of registers from the inverter with a single MSG instruction. Only one read request is outstanding at any given time.

- 1) Run RSLogix 500, and create a new configuration.
- 2) Create a control and a data file.
 - a) Right click Data Files and select New... The "Create Data File" dialog box appears (refer to Figure 114).
 - b) To create a control file, enter a file number (e.g. 20), set the type to "Integer", enter a descriptive name (e.g. "CONTROL"), and enter a number of elements (e.g. 100). Click OK to create the file. The control file is used to store configuration information pertaining to the functionality of the MSG instruction which will perform the data read.
 - c) Follow the same procedure to create a data file. This file will be used to store the incoming data read from the interface card. Enter a file number (e.g. 18), set the type to "Integer", enter a descriptive name (e.g. "DATA"), and enter a number of elements (e.g. 200). Refer to Figure 115. Click OK to create the file.

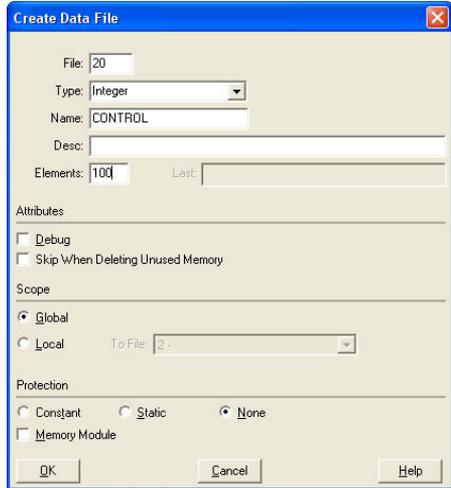


Figure 114: Creating a Control File

- 3) Add a MSG instruction to the program.
 - a) If not already visible, double-click "LAD2" under Project...Program Files in the controller organizer view to bring up the ladder logic program.
 - b) Right click on the default rung number on the left-hand side of the LAD2 window and select "Insert Rung".
 - c) Right click on the rung number of the new editible rung and select "Append Instruction".
 - d) Select the "MSG" instruction from the "Input/Output" classification, then click OK. Refer to Figure 116.

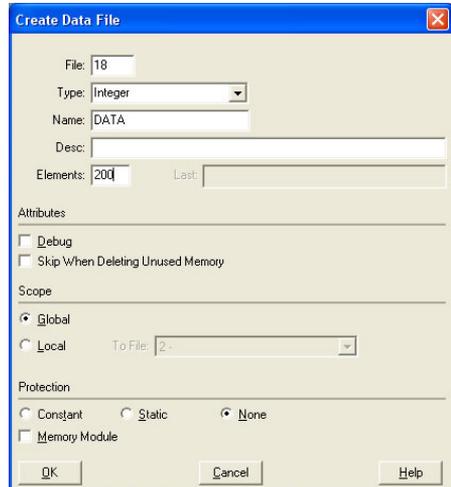


Figure 115: Creating a Data File

- 4) Add an XIO element to the program.
 - a) Right click on the rung number of the rung currently being edited and select "Append Instruction" again.
 - b) Select the "XIO" instruction from the "Bit" classification, then click OK. Refer to Figure 117.

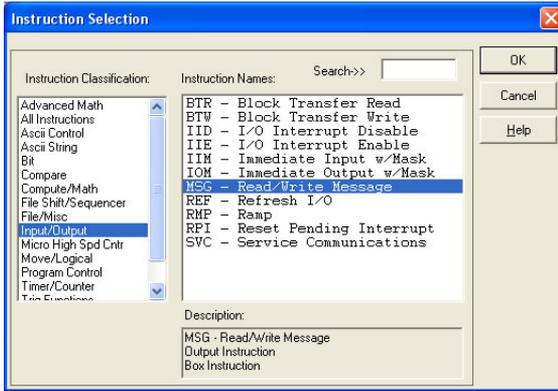


Figure 116: MSG Instruction Selection

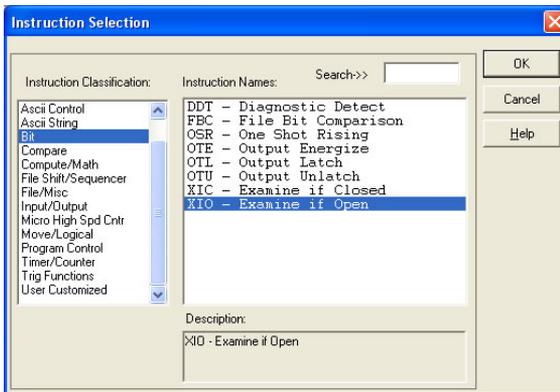


Figure 117: XIO Instruction Selection

5) **Configure the MSG instruction.**

- a) Set the "Read/Write" field to "Read", "Target Device" field to "PLC5", "Local/Remote" field to "Local", and "Control Block" to "N20:0".
- b) Upon hitting the <ENTER> key while in the "Control Block" entry box, the MSG Properties dialog box should appear (or it can be opened by clicking on the "Setup Screen" button at the bottom of the MSG instruction). Refer to Figure 118.
- c) In this example, we will be reading a total of 25 registers beginning at N30:50 (register 2050 / function code M01). To configure this, under "This Controller" set the "Data Table Address" field to N18:1, set the "Size in Elements" field to 25, and set the "Channel" field to 1 (Ethernet).
- d) Under "Target Device", set the "Data Table Address" field to N30:50 (starting target register=2050) and set the "MultiHop" field to Yes to cause the "MultiHop" tab to appear.
- e) Under the "MultiHop" tab settings, set the "To Address" in the first row to the inverter's IP address, and the "To Address" in the second row to 0. Refer to Figure 119.
- f) Close the dialog box. At this point, the program should appear as shown in Figure 120.

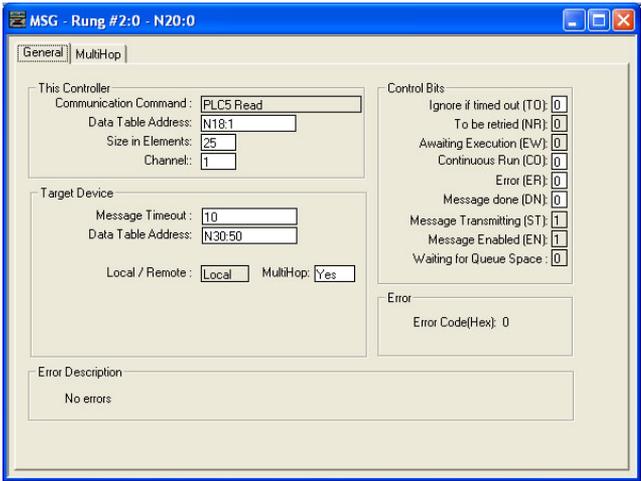


Figure 118: MSG Configuration, "General" Tab

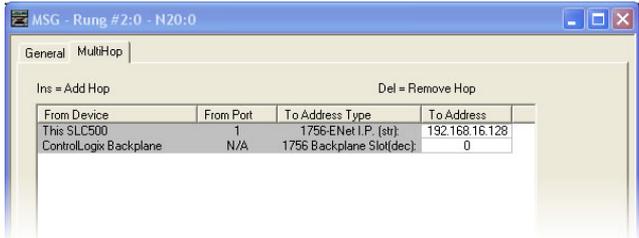


Figure 119: MSG Configuration, "MultiHop" Tab

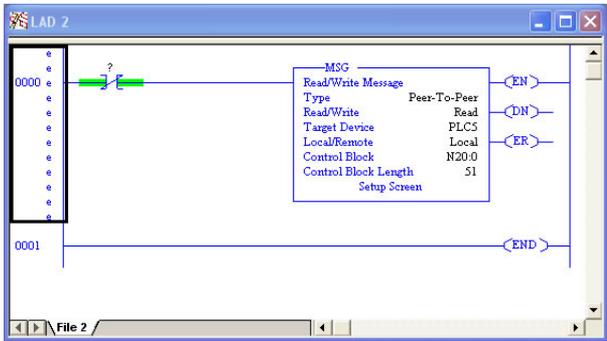


Figure 120: PLC Program after MSG Instruction Configuration

6) **Assign a tag to the XIO element.**

- a) Double-click on the XIO element located to the left of the MSG block. Type in N20:0/15 (MSG instruction's enable bit). This configuration causes the MSG instruction to automatically retrigger itself when it completes. While this is acceptable for the purposes of this example, it can produce high network utilization. In actual practice, it may be desirable to incorporate additional logic elements to allow triggering the MSG instruction at a specific rate or under specific conditions.

7) **The program is now complete. Refer to Figure 121.**

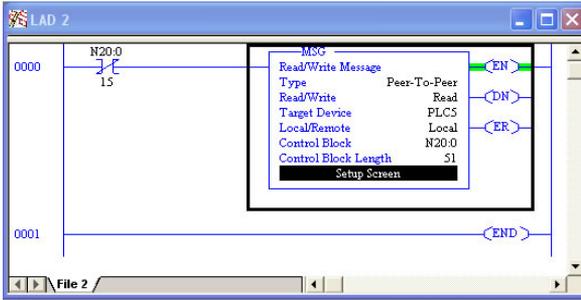


Figure 121: Completed PLC Program

8) **Save, download, and run the program.**

- a) To view the registers being read from the interface card, double-click the data file N18 under "Data Files" in the controller organizer view. 25 register values starting at register #2050 are being continuously read from the interface card and placed in the 25 sequential offsets of N18 starting at N18:1. Refer to Figure 122. We can see that N18:9 (register 2058 / output frequency) has a value of 610 (25.25Hz), N18:12 (register 2061 / output voltage) has a value of 610 (61.0V), etc.

Offset	0	1	2	3	4	5	6	7	8	9
N18:0	0	8417	0	0	0	2525	8417	-183	0	2525
N18:10	120	1	610	1	4129	1	36	0	0	0
N18:20	1796	311	0	17235	100	800	0	0	0	0

Figure 122: Monitoring the Data Being Read from the Inverter

8.3.4 SLC-5/05 Example: Read a Single Register

The configuration and execution for reading a single register is in general identical to that required for reading a block of registers as detailed in section 8.3.3. The only difference is in the configuration of the MSG instruction. Figure 123 shows an example MSG instruction's General tab, which will read a single element (N30:58, which corresponds to register 2058 / output frequency) and place it in the first element (offset 0) of N18.

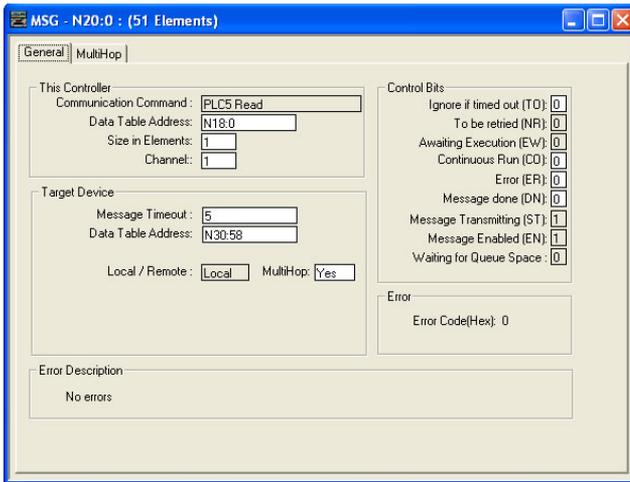


Figure 123: Read the Inverter’s Output Frequency Register

8.3.5 SLC-5/05 Example: Multiple MSG Instructions

At times, reading from different groups of registers may be necessary. For example, a specific application may require some registers located in various disjoint locations in the register map. To accomplish this task efficiently, multiple MSG instructions can be implemented in the PLC program.

The configuration and execution for implementing multiple MSG instructions is in general identical to that required for implementing just one MSG instruction. Each MSG instruction will require its own message control file. In the case of read MSG instructions, more than one instruction may use the same data file to store the received register values, but the storage locations must not overlap. Figure 124 shows an example of two MSG instructions, each accessing different target integer files. It is evident from this logic that N20 and N21 are the two independent message control files created for these instructions.

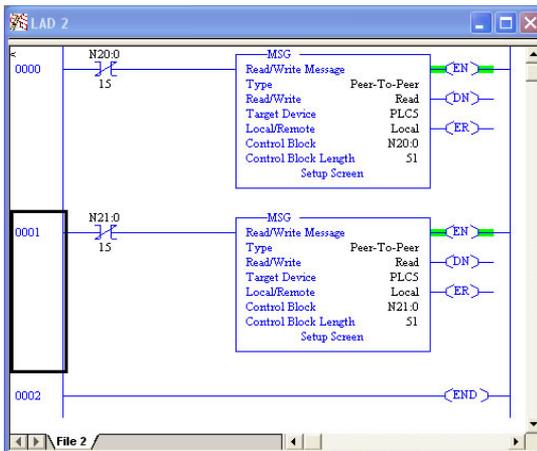


Figure 124: Multiple MSG Instructions

8.3.6 SLC-5/05 Example: Reading and Writing

Often times, applications may need to both read data from and write data to the inverter. At a minimum, this will require two MSG instructions and two message control files. Figure 125 shows an example of two MSG instructions, one for reading and one for writing. Note that the “Read/Write” field of each of the MSG instructions is set according to their function.

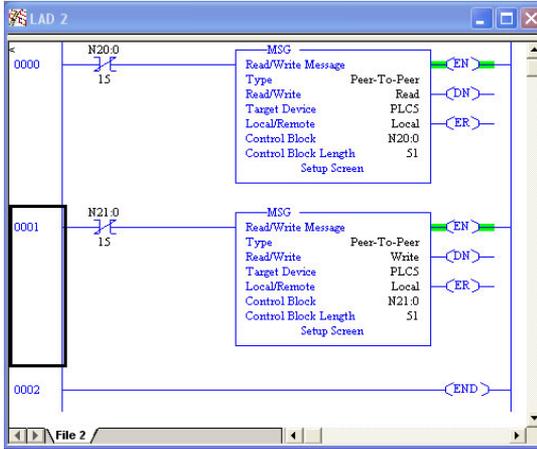


Figure 125: Reading and Writing via MSG Instructions

Figure 126 shows the configuration details of the “write” MSG instruction. Note that this instruction will only be writing to one inverter register: namely, register 1798 (function code S05 / frequency command). The source Data Table Address in this case is N18:30.

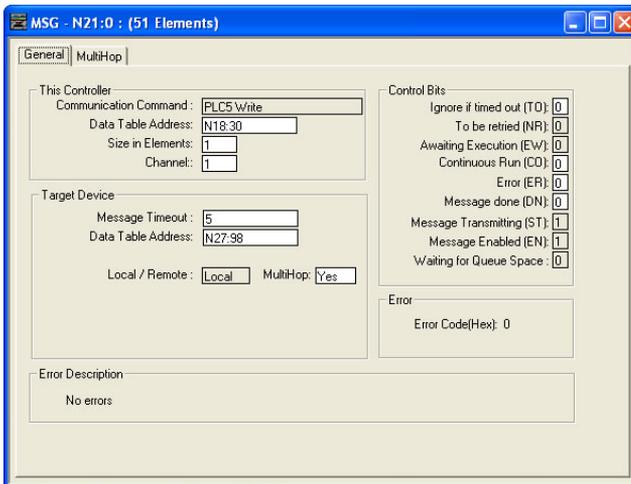


Figure 126: MSG Configuration for Writing

8.4 BACnet/IP

- The interface card supports the BACnet/IP (Annex J) protocol over Ethernet via UDP port 47808.
- The BACnet driver does not trigger timeout events (section 5.7.6).

8.4.1 Protocol Implementation Conformance Statement

BACnet Protocol

Date:	June 1, 2011
Vendor Name:	ICC, Inc.
Product Name:	Fuji Electric FRENIC-Eco Inverter
Product Model Number:	OPC-F1-WiE
Applications Software Version:	V1.100
Firmware Revision:	V1.100
BACnet Protocol Revision:	2
Product Description:	

The Fuji Electric FRENIC-Eco series is a family of high-performance, compact inverters. Other features include ROHS compliance, built-in EMC filter, and long-life design.

BACnet Standard Device Profile (Annex L):

- BACnet Operator Workstation (B-OWS)
- BACnet Building Controller (B-BC)
- BACnet Advanced Application Controller (B-AAC)
- BACnet Application Specific Controller (B-ASC)
- BACnet Smart Sensor (B-SS)
- BACnet Smart Actuator (B-SA)

BACnet Interoperability Building Blocks Supported (Annex K):

- Data Sharing – ReadProperty-B (DS-RP-B)
- Data Sharing – ReadPropertyMultiple-B (DS-RPM-B)
- Data Sharing – WriteProperty-B (DS-WP-B)
- Device Management – Dynamic Device Binding-B (DM-DDB-B)
- Device Management – Dynamic Object Binding-B (DM-DOB-B)

Segmentation Capability:

None

- Segmented requests supported Window Size _____
- Segmented responses supported Window Size _____

Standard Object Types Supported:

See “Object Types/Property Support Table”.

Data Link Layer Options:

- BACnet IP, (Annex J)
- BACnet IP, (Annex J), Foreign Device
- ISO 8802-3, Ethernet (Clause 7)
- ANSI/ATA 878.1, 2.5 Mb. ARCNET (Clause 8)
- ANSI/ATA 878.1, RS-485 ARCNET (Clause 8), baud rate(s) _____
- MS/TP master (Clause 9), baud rate(s): 9600, 19200, 38400, 76800
- MS/TP slave (Clause 9), baud rate(s): _____
- Point-To-Point, EIA 232 (Clause 10), baud rate(s): _____
- Point-To-Point, modem, (Clause 10), baud rate(s): _____



LonTalk, (Clause 11), medium: _____

Other: _____

Device Address Binding:

Is static device binding supported? (This is currently for two-way communication with MS/TP slaves and certain other device.) Yes No

Networking Options:

Router, Clause 6 - List all routing configurations

Annex H, BACnet Tunneling Router over IP

BACnet/IP Broadcast Management Device (BBMD)

Does the BBMD support registrations by Foreign Devices? Yes No

Character Sets Supported:

Indicating support for multiple character sets does not imply that they can all be supported simultaneously.

ANSI X3.4

IBM™/Microsoft™ DBCS

ISO 8859-1

ISO 10646 (UCS-2)

ISO 10646 (UCS-4)

JIS C 6226

If this product is a communication gateway, describe the types of non-BACnet equipment/networks(s) that the gateway supports: N/A

Datatypes Supported:

The following table summarizes the datatypes that are accepted (in the case of a write property service) and returned (in the case of a read property service) when targeting the present value property of each supported object type.

Object Type	Service	
	Read Property	Write Property
Analog Output	Real	Real, Unsigned, Integer, Null
Analog Input	Real	N/A
Binary Output	Enumerated	Enumerated, Boolean, Real, Unsigned, Integer, Null
Binary Input	Enumerated	N/A

Notes:

- The Null data type is used to relinquish a previously-commanded entry at the targeted priority in the priority array.
- When writing to Binary Output objects, all non-zero values are interpreted as a "1".

Object Types/Property Support Table

Table 10: BACnet Object Types /Properties Supported

Property	Object Type				
	Device	Binary Input	Binary Output	Analog Input	Analog Output
Object Identifier	R	R	R	R	R
Object Name	R	R	R	R	R
Object Type	R	R	R	R	R
System Status	R				
Vendor Name	R				
Vendor Identifier	R				
Model Name	R				
Firmware Revision	R				
Appl Software Revision	R				
Protocol Version	R				
Protocol Revision	R				
Services Supported	R				
Object Types Supported	R				
Object List	R				
Max APDU Length	R				
Segmentation Support	R				
APDU Timeout	R				
Number APDU Retries	R				
Max Master					
Max Info Frames					
Device Address Binding	R				
Database Revision	R				
Present Value		R	W	R	W
Status Flags		R	R	R	R
Event State		R	R	R	R
Reliability		R	R	R	R
Out-of-Service		R	R	R	R
Units				R	R
Priority Array			R		R
Relinquish Default			R		R
Polarity		R	R		
Active Text		R	R		
Inactive Text		R	R		

R – readable using BACnet services

W – readable and writable using BACnet services

8.4.2 Supported Objects

Table 11: Binary Input Object Instance Summary

Instance ID	Object Name	Description	Active/ Inactive Text
BI1	FWD_ROT_STATUS	Forward rotation status	forward/off
BI2	REV_ROT_STATUS	Reverse rotation status	reverse/off
BI3	EXT_STATUS	DC injection braking	braking/off
BI4	INVERTER_SHUTDOWN	Inverter shutdown	on/off
BI5	BRAKING	Braking	braking /off
BI6	NUV	DC bus voltage normal	on/off
BI7	TORQUE_LIMITING	Torque limited	on/off
BI8	VOLTAGE_LIMITING	Voltage limited	on/off
BI9	CURRENT_LIMITING	Current limited	on/off
BI10	ACCELERATING	Accelerating	on/off
BI11	DECELERATING	Decelerating	on/off
BI12	ALARM	Alarm	on/off
BI13	COMM_ESTABLISHED	Communications established	on/off
BI14	BUSY_WRITING	Busy writing	on/off

Table 12: Binary Output Object Instance Summary

Instance ID	Object Name	Description	Active/ Inactive Text
BO1	FWD_ROT_CMD	Forward rotation command	forward/off
BO2	REV_ROT_CMD	Reverse rotation command	reverse/off
BO3	X1	General purpose input	on/off
BO4	X2	General purpose input	on/off
BO5	X3	General purpose input	on/off
BO6	X4	General purpose input	on/off
BO7	X5	General purpose input	on/off
BO8	X6	General purpose input	on/off
BO9	X7	General purpose input	on/off
BO10	X8	General purpose input	on/off
BO11	X9	General purpose input	on/off
BO12	EN_TERMINAL	Enable terminal	on/off
BO13	XF_FWD	General purpose input	on/off
BO14	XR_REV	General purpose input	on/off
BO15	ALARM_RESET	Alarm reset	on/off

Table 13: Analog Input Object Instance Summary

Instance ID	Object Name	Description	Units
AI1	OUTPUT_FREQ	Output frequency	Hz
AI2	OUTPUT_CURRENT	Output current	Amps
AI3	OUTPUT_VOLTAGE	Output voltage	Volts
AI4	INPUT_POWER	Input power	kW
AI5	OUTPUT_POWER	Output power	kW

Table 14: Analog Output Object Instance Summary

Instance ID	Object Name	Description	Units
AO1	FREQ_REF	Frequency command	Hz
AO2	ACCEL_TIME	Acceleration time	Seconds
AO3	DECEL_TIME	Deceleration time	Seconds

8.4.3 Supported Object Details

Binary Input Objects

- BI1 Indicates whether the inverter is running forward. Corresponds to function code M14, bit 0.
- BI2 Indicates whether the inverter is running reverse. Corresponds to function code M14, bit 1.
- BI3 Indicates DC injection braking or pre-exciting. Corresponds to function code M14, bit 2.
- BI4 Indicates inverter shutdown. Corresponds to function code M14, bit 3.
- BI5 Indicates braking. Corresponds to function code M14, bit 4.
- BI6 Indicates normal DC bus voltage. Corresponds to function code M14, bit 5.
- BI7 Indicates torque limited. Corresponds to function code M14, bit 6.
- BI8 Indicates voltage limited. Corresponds to function code M14, bit 7.
- BI9 Indicates current limited. Corresponds to function code M14, bit 8.
- BI10 Indicates acceleration. Corresponds to function code M14, bit 9.
- BI11 Indicates deceleration. Corresponds to function code M14, bit 10.
- BI12 Indicates alarm. Corresponds to function code M14, bit 11.
- BI13 Indicates communications established. Corresponds to function code M14, bit 12.
- BI14 Indicates function code write in progress. Corresponds to function code M14, bit 15.

Binary Output Objects

- BO1 Forward command. Corresponds to function code S06, bit 0.
- BO2 Reverse command. Corresponds to function code S06, bit 1.
- BO3 X1 command. Corresponds to function code S06, bit 2.
- BO4 X2 command. Corresponds to function code S06, bit 3.
- BO5 X3 command. Corresponds to function code S06, bit 4.
- BO6 X4 command. Corresponds to function code S06, bit 5.
- BO7 X5 command. Corresponds to function code S06, bit 6.
- BO8 X6 command. Corresponds to function code S06, bit 7.
- BO9 X7 command. Corresponds to function code S06, bit 8.
- BO10 X8 command. Corresponds to function code S06, bit 9.
- BO11 X9 command. Corresponds to function code S06, bit 10.
- BO12 EN terminal command. Corresponds to function code S06, bit 11.
- BO13 XF (FWD) command. Corresponds to function code S06, bit 13.
- BO14 XR (REV) command. Corresponds to function code S06, bit 14.
- BO15 Activates the alarm reset. Corresponds to function code S06, bit 15.

Analog Input Objects

- A11 The output frequency of the inverter in 0.01 Hertz units (6000=60.00Hz). Corresponds to function code M09.
- A12 The output current of the inverter in 0.1 or 0.01 Amp units (depends on inverter capacity). Corresponds to function code W05.
- A13 The output voltage of the inverter in 0.1 Volt units (1000=100.0V). Corresponds to function code W06.
- A14 Input power of the inverter in 0.01 kW units. Corresponds to function code W21.
- A15 Output power of the inverter in 0.01 kW units. Corresponds to function code W22.

Analog Output Objects

- AO1 Frequency command of the inverter in 0.01 Hertz units. Corresponds to function code S05.
- AO2 Sets the acceleration time in 0.1 second units. Corresponds to function code S08.
- AO3 Sets the deceleration time in 0.1 second units. Corresponds to function code S09.

9 TROUBLESHOOTING

Although by no means exhaustive, Table 15 provides possible causes behind some of the most common errors experienced when using the interface card.

Table 15: Troubleshooting

Problem	Symptom	Solution
No communications between the interface card and the inverter	The interface card's "MODULE STATUS" LED blinks red at a regular interval of one blink per second	<ul style="list-style-type: none"> • Confirm that the interface card connector is properly seated. • Confirm that the inverter's station address, baud rate, protocol etc. function codes are set correctly (refer to section 3.1).
No communications between the network and the interface card	Communications cannot be established, or the Ethernet "activity" LED flashes only infrequently or not at all	<ul style="list-style-type: none"> • Confirm that the destination IP address programmed into the controller equipment or computer matches that of the interface card, as displayed by the finder utility. • Confirm that the wireless configuration parameters are correct. • Confirm that intermediate firewalls or routers have been configured to allow access to the interface via the applicable TCP/UDP ports. • If attempting to access the web server on a computer whose web browser is configured to use a proxy server, ensure that the proxy server is accessible to the computer, and that the interface card is accessible to the proxy server.
Firmware-generated error	"MODULE STATUS" LED is flashing red with an "x-y-z" 3-blink sequence. The number of LED flashes indicates an error code.	Contact ICC for further assistance.
XML socket connection failed	Message on a web server tab information window	TCP port 2000 is blocked by a firewall, router or some other intermediate network equipment.
Unable to control the inverter via network communications	Writing to command and frequency registers has no apparent effect on inverter operation	Confirm that the applicable inverter function codes are set to allow network control (refer to section 3.2).

ICC

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