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Find the *Acromag BusWorks 972EN-4004* at our website: *Click HERE*

BusWorks® 900EN Series – Modbus TCP/IP 10/100M Industrial Ethernet I/O Modules

Model 972EN-4004 Four Channel Current Output
Model 972EN-4006 Six Channel Current Output

Model 973EN-4004 Four Channel Voltage Output
Model 973EN-4006 Six Channel Voltage Output

USER'S MANUAL



TARGET DEVICE

ACROMAG INCORPORATED
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Symbols on equipment:



Means "Refer to User's Manual (this manual) for additional information".

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For additional information, please visit our web site at www.acromag.com and download our whitepaper 8500-765, Introduction To Modbus TCP/IP, or 8500-648, Introduction to Modbus.

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IMPORTANT SAFETY CONSIDERATIONS

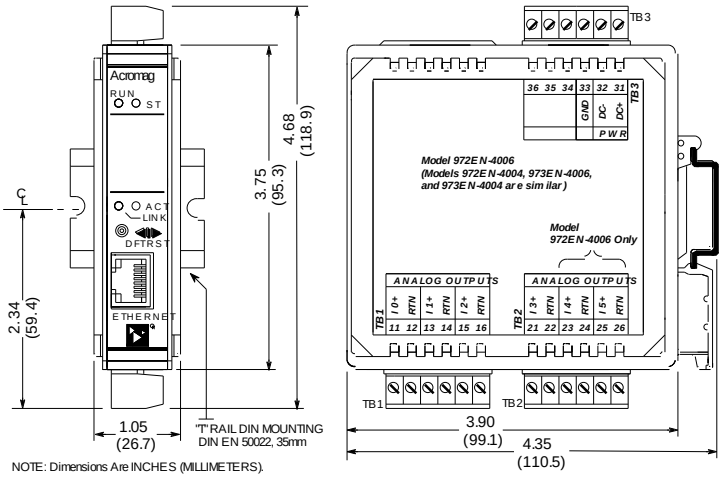
You must consider the possible negative effects of power, wiring, component, sensor, or software failure in the design of any type of control or monitoring system. This is very important where property loss or human life is involved. It is important that you perform satisfactory overall system design and it is agreed between you and Acromag, that this is your responsibility.

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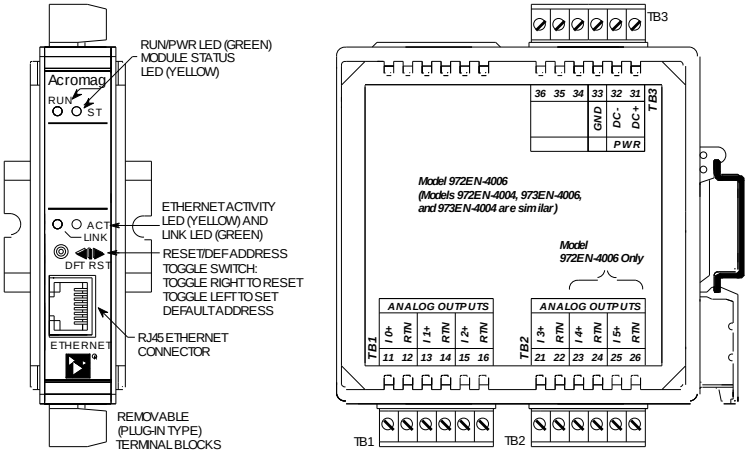
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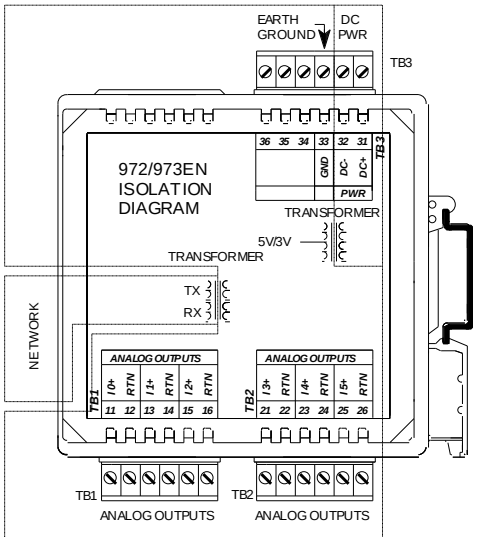


NOTE: Dimensions Are INCHES (MILLIMETERS).

MODEL 972/973EN ENCLOSURE DIMENSIONS



The toggle switch is used to toggle the module into or out of Default Mode (toggle left), or to reset the module (toggle right). In Default Communication Mode, the yellow ST LED blinks slowly and the module assumes a fixed static IP address of "128.1.1.100", a default subnet mask of "255.255.255.0", a default username of "User", and a default password of "password00".



MOUNTING AND DIMENSIONS

Unit mounts to "T" type DIN rails (35mm, type EN50022).

Units may be mounted side-by-side on 1-inch centers.

WARNING: *IEC Safety Standards may require that this device be mounted within an approved metal enclosure or sub-system, particularly for applications with exposure to voltages greater than or equal to 75VDC or 50VAC.*

CONTROLS & INDICATORS

Green Run LED is ON if power is on and will blink in "wink" ID mode.

Yellow ST LED blinks ON/OFF if module is in default mode and blinks more rapidly following a watchdog timeout.

Green LINK LED is ON if auto-negotiation has successfully established a connection.

Yellow ACT LED signals PHY network Activity (busy).

ISOLATION BARRIERS

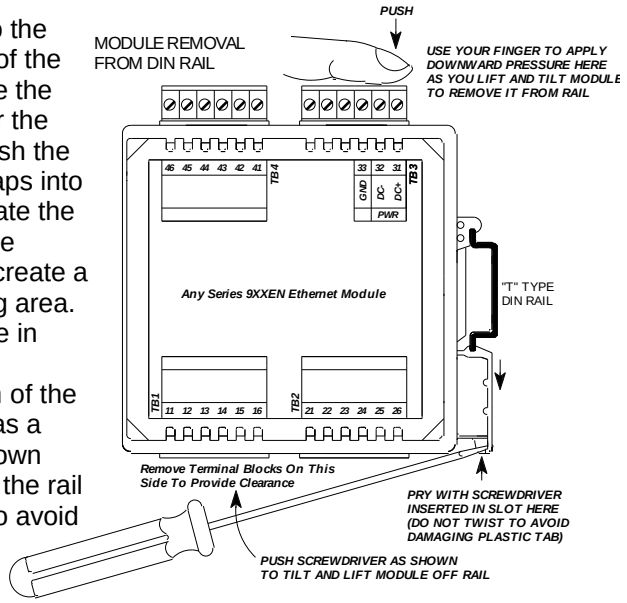
Dashed Lines denote isolation barriers.

The output circuit, network, and power circuit are isolated from each other for safety and noise immunity.

CONNECTIONS

DIN-Rail Mounting & Removal

When attaching the module to the T-type DIN rail, angle the top of the unit towards the rail and locate the top groove of the adapter over the upper lip of the rail. Firmly push the unit towards the rail until it snaps into place. To remove, first separate the input terminal block(s) from the bottom side of the module to create a clearance to the DIN mounting area. Next, while holding the module in place from above, insert a screwdriver into the lower arm of the DIN rail connector and use it as a lever to force the connector down until the unit disengages from the rail (do not twist the screwdriver to avoid damaging plastic).



Network

For 100Base-TX systems, use data grade Unshielded Twisted-Pair (UTP) wiring that has a 100Ω characteristic impedance and meets the EIA/TIA Category Five wire specifications.

It is recommended that you use a crossover CAT-5 cable to connect this device to your PC.

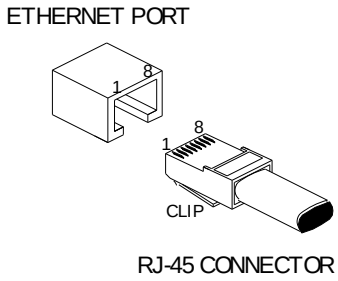
For 10Base-T systems, you may use Category 3, Category 4, or Category 5 UTP cable.

In either case, you are limited to 100 meters between any two devices.

RJ45 MDI AND MDI-X CONNECTIONS

PIN	MDI WIRING	MDI-X WIRING
1	Transmit +	Receive +
2	Transmit -	Receive -
3	Receive +	Transmit +
4	Not Used	Not Used
5	Not Used	Not Used
6	Receive -	Transmit -
7	Not Used	Not Used
8	Not Used	Not Used

Note Crossover Connections



RECOMMENDED CABLE

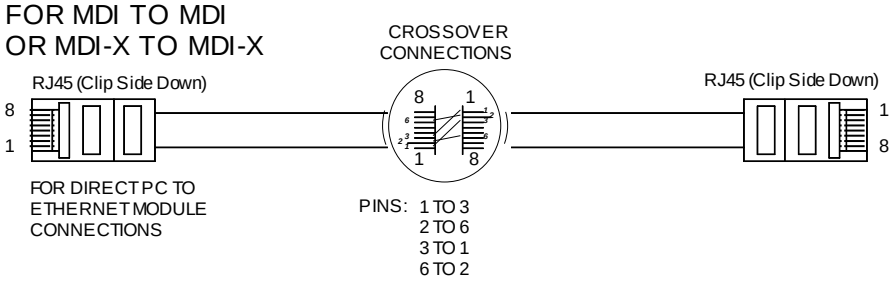
SPEED	DISTANCE	CABLE
10Base-T	100M	CAT 3, CAT 4, or CAT 5 UTP
100Base-T	100M	CAT 5/5e UTP/STP

The Ethernet port of this module is wired MDI and does not include automatic crossover. The Ethernet port of your PC is also wired MDI and may not include automatic crossover. As such, you must use a crossover cable like that shown below when connecting this device directly to a PC.

A crossover cable simply connects the differential transmit pair on each end, to the receive pair on the opposite end.

Use a standard (direct) cable when connecting to a hub or switch port, which are generally wired MDI-X.

CROSSOVER CABLE FOR MDI TO MDI OR MDI-X TO MDI



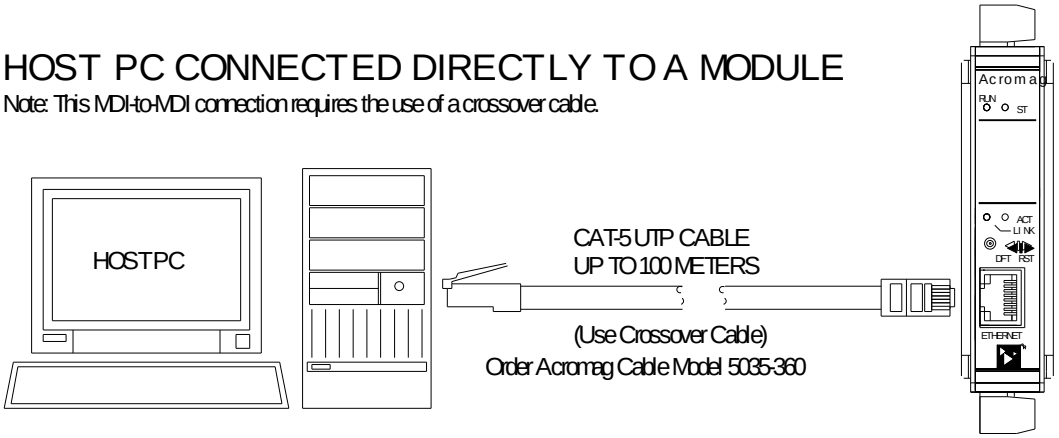
Refer to the Accessory Cables section at the back of this manual for more information on accessory cables, including patch and crossover cables available from Acromag and other vendors.

CONNECTIONS

Network

HOST PC CONNECTED DIRECTLY TO A MODULE

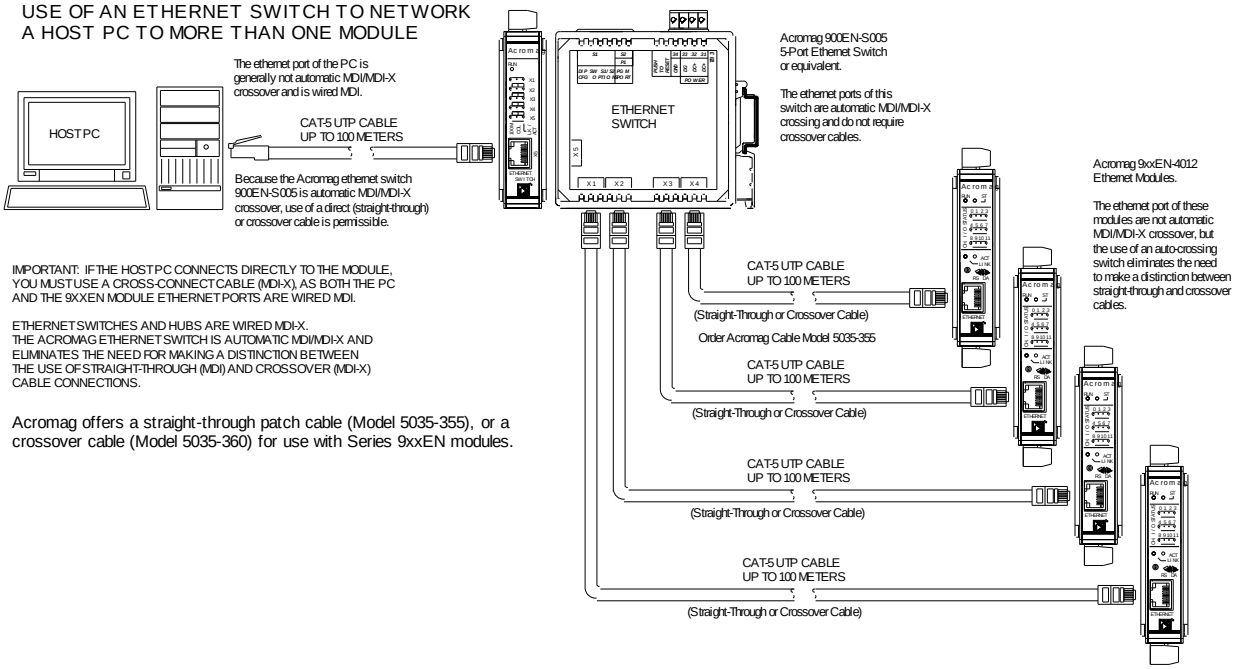
Note: This MDI-to-MDI connection requires the use of a crossover cable.



TIP: You can significantly enhance the EMI/RFI performance of your network connections by using Category 5E STP cable (Shielded Twisted Pair) with shielded RJ45 plug connectors. This will also help to protect your installation from damage due to ESD (Electro-Static Discharge). The use of shielded cable is strongly recommended for installations in harsh industrial environments and/or in the presence of strong electrical fields.

You can use an Ethernet switch or switching hub to build a network of Ethernet modules, similar to that shown below. This drawing shows how to network-connect Acromag Series 9xxEN modules to a 5-port Ethernet switch (Acromag Model 900EN-S005). Note that the 900EN-S005 switch includes automatic MDI/MDI-X crossover and a straight-through or crossover cable(s) may be used to connect to the modules and the PC.

USE OF AN ETHERNET SWITCH TO NETWORK A HOST PC TO MORE THAN ONE MODULE



IMPORTANT: IF THE HOST PC CONNECTS DIRECTLY TO THE MODULE, YOU MUST USE A CROSS-CONNECT CABLE (MDI-X), AS BOTH THE PC AND THE 9XXEN MODULE ETHERNET PORTS ARE WIRED MDI.

ETHERNET SWITCHES AND HUBS ARE WIRED MDI-X. THE ACROMAG ETHERNET SWITCH IS AUTOMATIC MDI/MDI-X AND ELIMINATES THE NEED FOR MAKING A DISTINCTION BETWEEN THE USE OF STRAIGHT-THROUGH (MDI) AND CROSSOVER (MDI-X) CABLE CONNECTIONS.

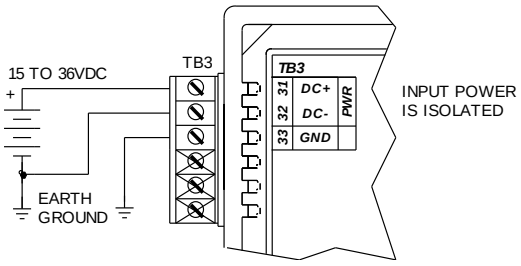
Acromag offers a straight-through patch cable (Model 5035-355), or a crossover cable (Model 5035-360) for use with Series 9xxEN modules.

CONNECTIONS

Power

Voltage	Current
972EN-4006	
15VDC	312mA
18VDC	255mA
24VDC	189mA
36VDC	128mA
973EN-4006	
15VDC	140mA
18VDC	117mA
24VDC	89mA
36VDC	65mA

✓ Connect 15-36V DC to the power terminals labeled DC+ & DC-. Observe proper polarity. For supply connections, use No. 14 AWG wires rated for at least 75°C. **CAUTION:** Do not exceed 36VDC peak.



CAUTION: Risk of Electric Shock – More than one disconnect switch may be required to de-energize equipment before servicing.

IMPORTANT – External Fuse: If unit is powered from a supply capable of delivering more than 1A to the unit, it is recommended that this current be limited via a high surge tolerant fuse rated for a maximum current of 1A or less (for example, see Bel Fuse MJS1).

Analog Outputs

Output is DC Current (972EN) or DC Voltage (973EN).

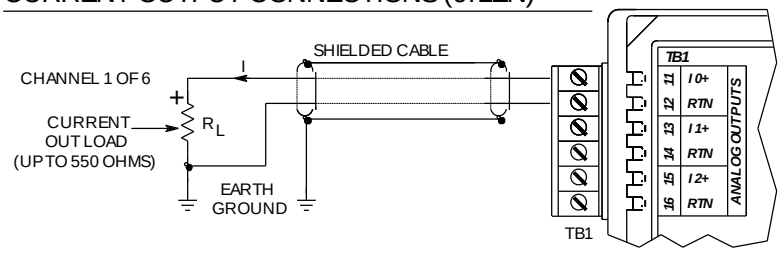
Outputs are not isolated channel-to-channel and share a common return (RTN).

Current outputs may drive up to 21mA into 500Ω (972EN).

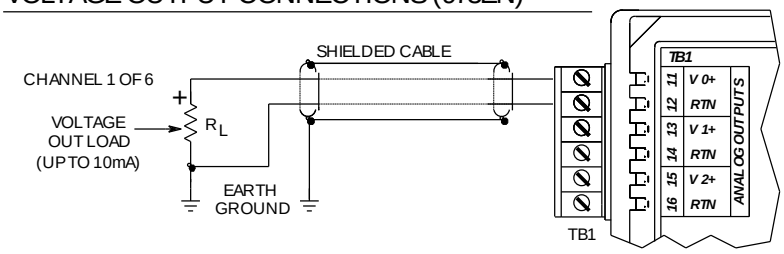
Voltage outputs may deliver up to 10V into 1KΩ, or 10mA (973EN).

✓ Connect analog outputs at the output terminals as shown below according to your model.

CURRENT OUTPUT CONNECTIONS (972EN)



VOLTAGE OUTPUT CONNECTIONS (973EN)



Earth Ground

Warning: *To comply with safety and performance standards, use shielded cable and connect earth ground as noted. Failure to use good wiring and grounding practices may be unsafe and hurt performance.*

✓ Connect Earth Ground as shown in the connection drawings above. Additionally, connect the GND terminal (TB3-33) to earth ground.

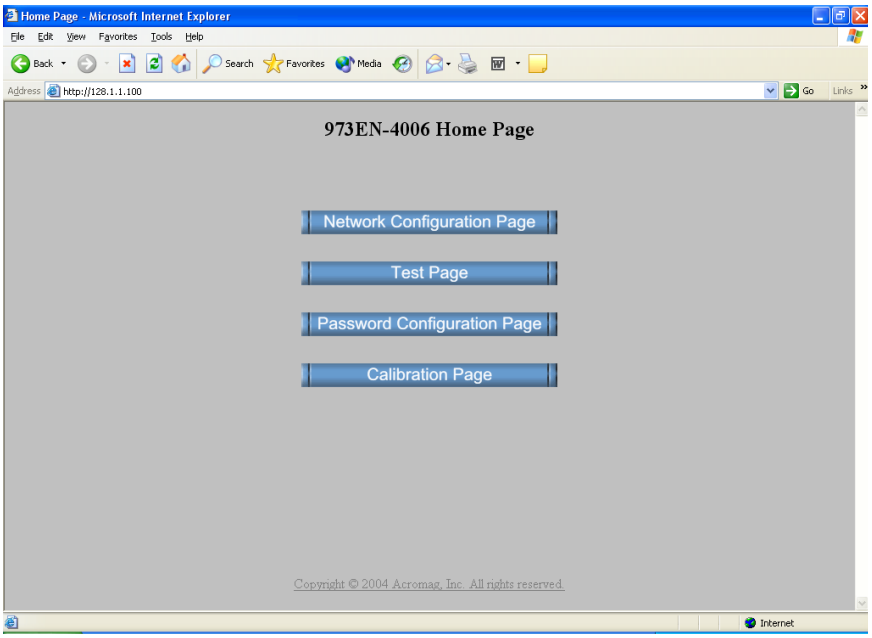
The ground connections noted are recommended for best results. If sensors are already grounded, use caution and avoid making additional ground connections which could create ground loops.

The plastic module housing does not require earth ground.

WEB BROWSER

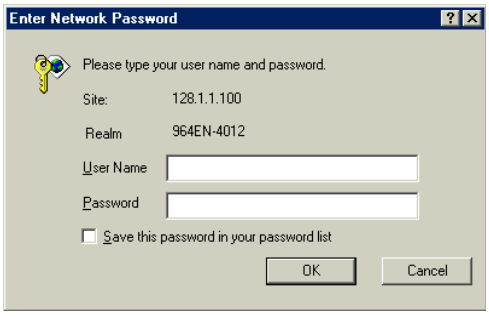
Home Page

This module supports Modbus over TCP/IP. You may use your own software to issue Modbus command to this module (see Modbus Registers), or you may use a standard web browser, as these modules have built-in web pages that allow you to setup, control, and calibrate the module. Simply execute your web browser, type the IP address assigned to your module in the "Address" window (http://128.1.1.100/ for our example), click [Go], and you will be presented with a Home Page window similar to that shown below:



The Home Page provides buttons to access the other web pages of this module that are used to configure the network parameters, change the user name and password, calibrate the module, and operate/test the module.

For each new browser session that accesses the Home Page of this module, you will be presented with a window prompting you to enter the current User Name and Password as shown below. This information is required before the program will allow you to make any other selections. **The default user name and password is "User" and "password00" respectively.** After entering these defaults, you may wish to invoke the Password Configuration Page to change these parameters to something more meaningful to you. Note that these entries are case-sensitive.



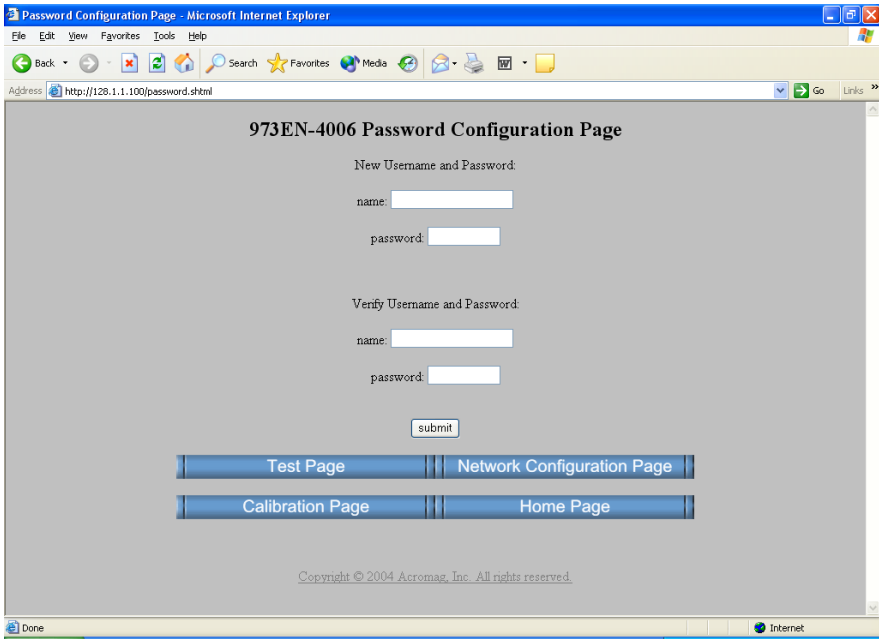
IMPORTANT: If you forget your installed user name & password, you can always toggle the module into default mode via the default mode toggle switch at the front of the module. Then the password and username will revert to the original defaults noted above, allowing you to re-invoke the Password Configuration Page and change the username and password settings as required.

WEB BROWSER

Password Configuration Page

Use up to 20 alphanumeric characters (case sensitive) to specify your username, and 10 alphanumeric characters (case sensitive) to specify a password. You will have to type in these entries twice to help prevent errors (yes, I know this is annoying).

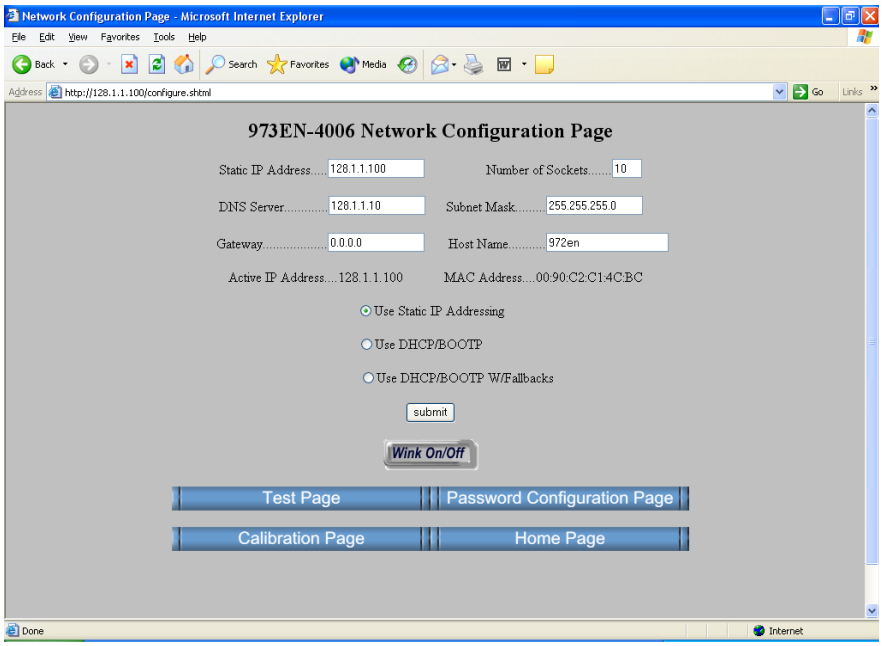
*Click the **submit** button to write your changes to the module.*



After completing your username/password changes, click on the appropriate button at the bottom of the page to select another web page. If you made changes, you may be prompted to re-enter your new username and password before being permitted to move to other pages.

Network Configuration

After setting your username and password, you can click the "Network Configuration Page" button to set the network configuration parameters for the module. You may have to consult your network administrator for help to complete the contents of this page.



WEB BROWSER

Network Configuration

An **IP Address** is a unique identification number for any host (this module) on any TCP/IP network (including the internet). The IP address is made up of four octets (8 bits), each octet having a value between 0-255 (00H-FFH). It is expressed here in decimal form, with a period placed between octets.

A **Static IP Address** is as the name implies—*static*, and represents a unique fixed IP Address that is generally assigned by your service provider or system administrator. The default static IP address assigned to this module from the factory is 128.1.1.100 (refer to product side label).

NOTE: In order to network your PC with an Acromag module, you may have to consult with your network administrator and either temporarily change your TCP/IP configuration (see TCP/IP Properties of Network Configuration in Windows), or create a separate private network using a second network adapter installed in your PC (recommended). The necessary steps will vary with your operating system. Refer to Acromag Application Note 8500-734 to help accomplish this (located on the CDROM shipped with your module or via download from our web site at www.acromag.com).

Note that Acromag Series 9xxEN Ethernet I/O modules may take from 3-30 seconds to boot upon power-up, depending on your network configuration and whether a DHCP server is present.

The **Number of Sockets** refers to the number (1-10) of Modbus TCP/IP access points to allow for this host. The default allows up to 10 sockets, but you can restrict access by reducing this number. Internally, the module uses port number 502 which is reserved for Modbus.

This module can be placed into a default communication mode via the DFT toggle switch at the front of the module.

The **DNS Server** refers to the IP address of the Domain Name Server used on this network. A DNS server relates symbolic names to actual IP addresses, while the DHCP server is responsible for dynamically passing out IP addresses.

Default Mode uses a static IP address of "128.1.1.100", a default subnet mask of "255.255.255.0", a default username "User", and a default password "password00".

A **Subnet Mask** is used to subdivide the host portion of the IP address into two or more subnets. The subnet mask will flag the bits of the IP address that belong to the network address, and the remaining bits correspond to the host portion of the address. The unique subnet to which an IP address refers to is recovered by performing a bitwise AND operation between the IP address and the mask itself, with the result being the sub-network address.

Gateway refers to the IP Address of the gateway, if your local area network happens to be isolated by a gateway. Typically, it is assigned the first host address in the subnet. If a gateway is not present, then this field should contain an unused address within the host subnet address range.

The **Host Name** is the name to be assigned to this host if its address happens to be assigned dynamically using DHCP.

The **Active IP Address** refers to the current IP Address being used by this host, as opposed to any new assignments being made via this page.

The **MAC Address** refers to the Media Access Control Address that uniquely identifies the hardware of this device. This is a unique fixed address assigned to this module at the factory. On IEEE 802 networks, the Data Link Control (DLC) layer of the OSI Reference Model is divided into two sublayers: the Logical Link Control (LLC) layer, and the Media Access Control (MAC) layer. The MAC layer interfaces directly with the network media (each different type of network media requires a different MAC layer).

WEB BROWSER

Network Configuration

By default, the module is setup to use **Static IP Addressing and a Static IP Address of 128.1.1.100**. You can optionally choose to have the IP address assigned dynamically via DHCP/BOOTP, or DHCP/BOOTP w/Fallback. This will also require that you specify a valid Host Name. Note that DHCP/BOOTP w/Fallback will revert to the static IP address if your DHCP or BOOTP server cannot be found at the address specified.

In general, BOOTP (Bootstrap Protocol) refers to an internet protocol that enables a diskless workstation to discover its own IP address, the address of a BOOTP server on the network, and a file to be loaded into memory to boot the machine. This enables the workstation or device server to boot without requiring a hard or floppy disk drive. BOOTP works similar to DHCP, but is usually found in older systems. This protocol is defined by RFC 951.

DHCP (Dynamic Host Configuration Protocol) refers to a protocol for assigning dynamic IP addresses to devices on a network. With dynamic addressing, a device can have a different IP address every time it connects to the network. In some systems, it can even change while it is still connected. DHCP also supports a combination of static and dynamic IP addresses. DHCP/BOOTP with fallback will revert to static IP addressing if the DHCP or BOOTP server cannot be found.

The Default Communication Mode uses a static IP address of "128.1.1.100", a default subnet mask of "255.255.255.0", a default username of "User", and a default password of "password00".

The unit includes a default address toggle switch to cause the module to assume a preset default factory address. This switch is at the front of the module and is used to toggle the module into, or out of Default Mode. If you use the toggle switch at the front of the module to place the module in default mode, then "Default Communications Mode" will be indicated at the bottom of this screen.

Click the **Submit** button to complete any changes made on this page.

Click the **Wink On/Off** button to toggle the module in/out of "wink" ID mode. In this mode, the module's green RUN LED will blink to confirm identification as an aide to locating a specific module on a network.

Refer to the Technical Reference section of this manual to learn more about IP Addressing terms and concepts.

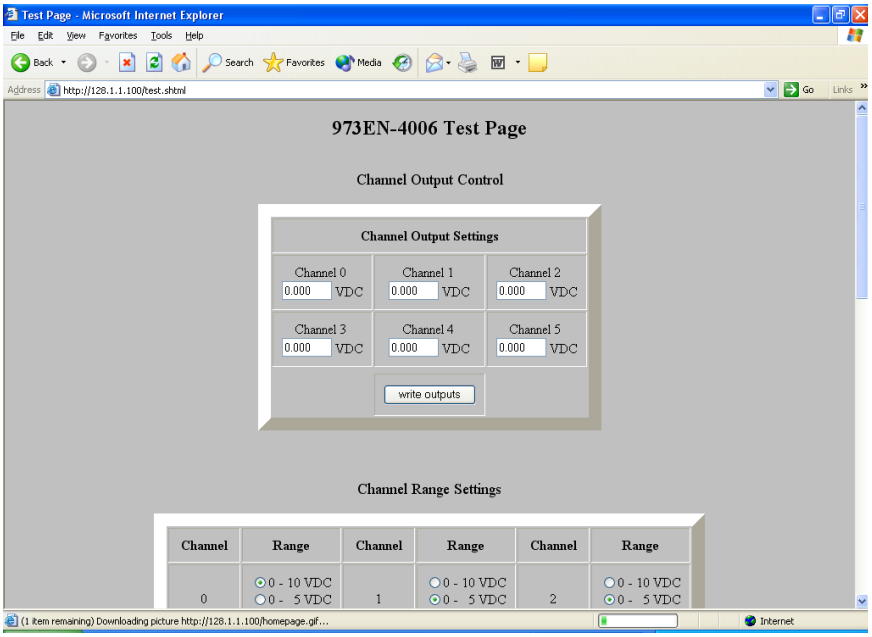
I/O Mapping (Optional i2o Function)

The 972EN-4006 and 973EN-4006 analog output models are target output devices for Acromag 9xxEN input modules with input-to-output mapping capability. That is, i2o equipped input modules may be configured to write their input levels to compatible output modules via the network connection. Acromag 961EN-4006, 962EN-4006, 965EN-4006, and 966EN-4006 input modules may be configured to control the outputs of these models.

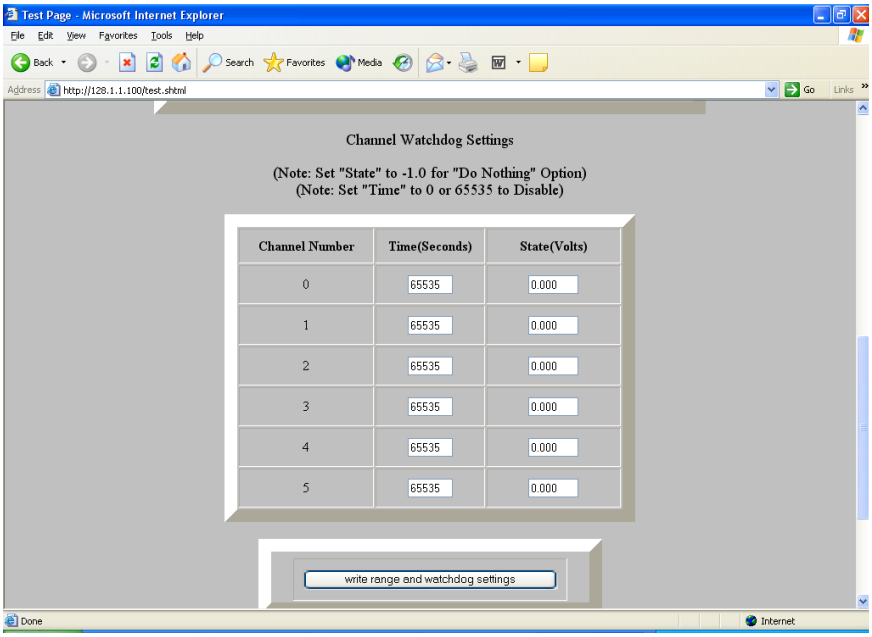
WEB BROWSER

Test Page

After completing your username & password assignment, plus your network configuration parameters, you can use the Test Page to operate your module. The Test Page will allow you to write the outputs, change your output range, and configure your watchdog parameters.



Use the scroll bar on the right to scroll down the page as shown below:



You can also use the Configuration Control of this page to change the output range for each channel. For the 973EN shown, you may select 0-10V, 0-5V, or 0-1V. For the 972EN, you may select 0-20mA, 4-20mA, or 0-1mA. You may also set your watchdog time and output timeout level. Click on "write range and watchdog settings" to execute your changes.

TIP: *Viewing a module's web page is treated similar to viewing a web page on the internet. The first time you open a page, its image is stored as a temporary internet file in PC memory. However, each subsequent attempt to view that page will need to automatically update that image, especially when making configuration changes. With Internet Explorer, click the "Internet Options" of the "Tools" menu, select the "General" tab, locate the "Temporary Internet Files" information and click on the "Settings" button. Then select "Automatically" under "Check for newer versions of stored pages:". Then click [OK] to return to the "General" screen, and click [OK] again to save your settings.*

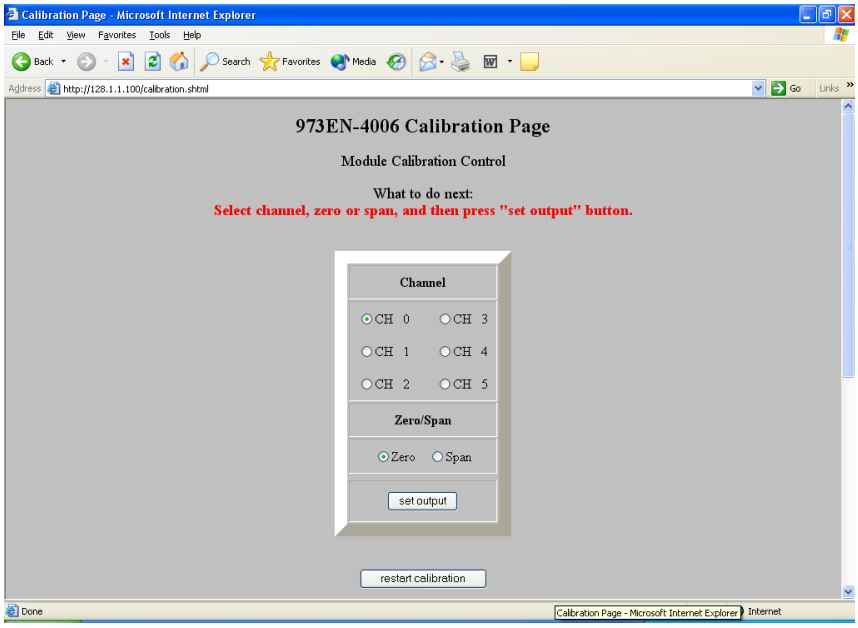
IMPORTANT: *The input signal indicated only reflects the level of the outputs at the moment this screen is invoked and this does not continuously update. <u>You can click your browser's refresh button to get a new output update</u>.*

WEB BROWSER

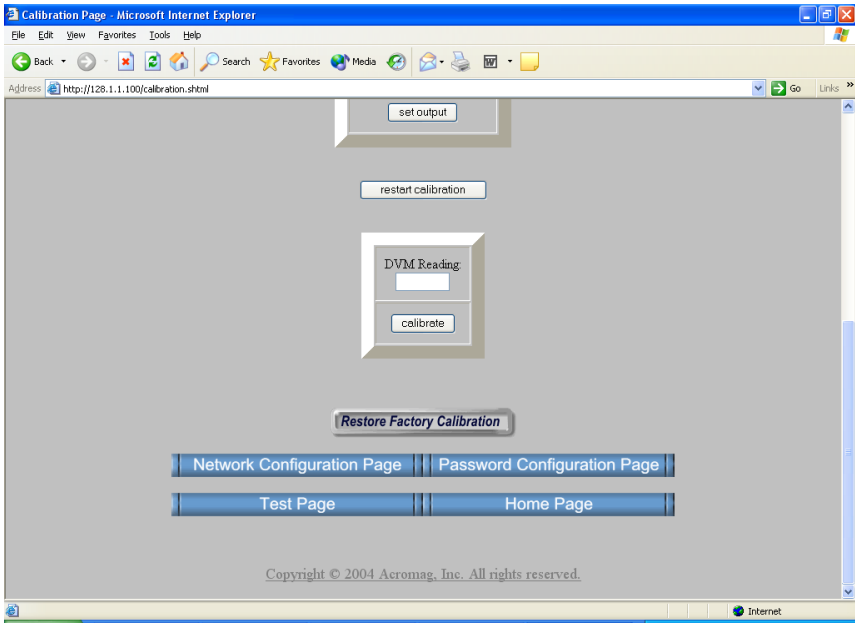
Calibration Page

IMPORTANT: *This module has already been calibrated at the factory and recalibration is not normally required, except as necessary to correct for long term component aging, or to satisfy your company's maintenance requirements. Do not attempt to recalibrate this module unless absolutely required, as miscalibration will negatively affect the module's performance.*

The Calibration Page will allow you to recalibrate each channel's output zero and span signal as required. Simply select the channel to be calibrated. Choose zero or span and set the output. Measure the zero or full-scale endpoint signal and enter this value in the space provided. Then click calibrate. Repeat this procedure for the other endpoint, and other channels, as required. For best results, always calibrate zero before span.



Use the scroll bar on the right to scroll down the page as shown below:



The following table gives the calibration values for the base output range of these models.

Your success in recalibrating the output will strongly depend upon the accuracy and precision of your measurement system.

WEB BROWSER

Calibration Page

		Cal LOW (Zero)		Cal HIGH (Full-Scale)	
Model	**Range**	**Signal**	**~Write %**	**Signal**	**~Write %**
972EN	4-20mA	4.000mA	0	20.000mA	20000
973EN	0-10V	0.000V	0	10.000V	20000

Notes:

1. With 16-bit signed integers, a count of 0-7FFFH is a positive number, while 8000-FFFFH is a negative number. The 0-10V DC output range values are represented by 0-20000 counts. For example when using a 973EN, 0V and 10V are represented by integer values 0 & +20000, respectively.
2. For calibration via the Modbus TCP/IP interface, the "Write %" values noted above are the ideal values written to the output word of the channel and may only approximate the actual value required to produce the actual calibration endpoint signals. During calibration, you will need to adjust these values to precisely reproduce the endpoint signals. For calibration via the web browser, "Write %" values noted above are actual values written to the output word of the channel during calibration. Uncalibrated, they approximate the required endpoint signal. Your measured value is then used to adjust the count values as required to precisely reproduce the endpoint signals.
3. Calibration of the current (0-20mA, 0-1mA), and voltage (0-5V, 0-1V) subranges are internally interpolated from the resultant calibration of the base range noted in the table above for each model. Additionally, since resolution is degraded for the sub-ranges, it is very important that high accuracy be ensured for the primary base calibration when making output adjustments and measurements, as subranges are linearly interpolated from these results.

The Series 972/973EN output modules are calibrated using a single base output range with fixed calibration endpoints. The calibration of the module's sub-ranges are automatically interpolated based on these results. Prior to calibration, the 972EN models must have the 4-20mA output range selected, and the 973EN must have the 0-10V output range selected. Calibration is then performed by adjusting the output signal level until its measured value precisely matches the low or high calibration range endpoint indicated. With the output level precisely adjusted to the Calibration LOW or HIGH range endpoint signal, the module is triggered to store the output channel's raw DAC count by toggling the corresponding channel's Cal HIGH (upper byte) or Cal LOW (lower byte) calibration register.

Output Calibration

You can choose to use the web browser calibration page (Method 1) to accomplish calibration (easiest), or via direct register access using the Modbus TCP/IP interface as described in Method 2 below:

IMPORTANT: For best results, you must measure the output signal via an external current or volt meter that is at least as accurate as the module itself (better than ±0.1% of span). Always calibrate the low value before the high value and allow the module to warm up a few minutes prior to calibration.

Output Calibration

Method 1 – Calibration Using The Built-In Browser Interface:

1. Make sure the base output range is currently selected. This is 4-20mA for 972EN models, or 0-10V for 973EN models. You can go back and use the Test Page controls to change the output range as required.
2. Bring up the browser interface and select the Calibration Page.
3. Select an output channel, then select Zero.
4. Click the "Set Output" button and an "ideal" zero count will be written to the DAC. The output will go to approximately zero.

   At this point, you will lose control of the output and must complete the procedure, or simply click "restart calibration" to start over. If you picked the wrong output channel, or the wrong endpoint, click "restart calibration" to start over.

5. With a meter connected to measure the output signal, measure the actual output level and enter this value into the edit box labeled "DVM Reading". Then click the "Calibrate" button to complete calibration of the zero endpoint.
6. Next select Span (for best results, always calibrate zero before span).
7. Click the "Set Output" button and an "ideal" full-scale count (20000) will be written to the DAC. The output will go to approximately full-scale.

   At this point, you will again lose control of the output and must complete the procedure, or simply click "restart calibration" to start over. If you picked the wrong output channel, or wrong endpoint, click "restart calibration" to start over.

8. With a meter connected to measure the output signal, measure the actual output and enter this value into the edit box labeled "DVM Reading". Then click the "Calibrate" button to complete calibration of the full-scale endpoint.
9. Repeat steps 3-8 for the other output channels to be calibrated.

Method 2 - Calibration Via The Modbus TCP/IP Interface:

1. Write to the appropriate Output Range Register to select the output base range for each channel to be calibrated. Select 4-20mA for 972EN models, or 0-10V for 973EN models.
2. Write 24106 (5E2AH) into the Calibration Access Register to remove write protection from the calibration registers.
3. Write the zero calibration % value to the output to be calibrated and adjust this value as necessary to precisely reproduce the Cal LOW (zero) signal (see table of prior page). Allow the output to settle a few seconds.
4. Write a 16-bit value to the Zero Calibration Register with a set bit in the bit position that corresponds to the channel number to be calibrated (one channel at a time). If you were calibrating the zero of channel 5, you would write 0x0010 to the Zero Calibration Register. The module will replace calibration coefficients immediately, no reset needed.
5. Write the full-scale calibration signal % value to the output to be calibrated and allow the output to settle about 10 seconds.
6. Write a 16-bit value to the Span Calibration Register with a set bit in the bit position that corresponds to the channel number of the channel to be calibrated (one channel at a time). For example, if you wanted to calibrate the span of channel 0, write 0x0001 to the "Span Cal Register".

   Note that the calibration of the output sub-ranges are automatically interpolated based on the calibration of the base range just completed.

Method 2 - Calibration Via The Modbus TCP/IP Interface…continued:

7. Repeat steps 3-6 for the other output channels as required.
8. When finished calibrating, write 0x0000 to the Calibration Access Register to replace write protection for the calibration registers and help prevent miscalibration.

   You may then check the calibration of the alternate range(s) for the output(s). Note that the alternate ranges are calibrated by interpolating their calibration endpoints from those of the base range. If significant error is noted, then you must perform the calibration procedure a second time, making sure that you precisely adjust your output signal for zero and span as required.

Output Calibration

TROUBLE-SHOOTING

Upon power-up, the green RUN LED should light. A continuous blinking Run LED indicates "wink" ID mode. If the Run LED remains OFF and correct power has been applied, then either the internal power supply has failed or a fatal processor error (firmware) has occurred.

Diagnostics Table

SYMPTOM	POSSIBLE CAUSE	POSSIBLE FIX
Green RUN LED does not light.	Internal +3.3V power has failed.	Return module for repair.
Continuous flashing green RUN LED.	Module in "wink" mode.	Read Module Status register to verify "wink" status. Write 5555H to Wink Mode Toggle Register to toggle wink mode off/on.
Cannot communicate.	Power ON at the module?	Check power. Is green RUN LED ON?
	Connecting cable is not a crossover cable. ***TIP:*** *To check cable type, hold both ends in same position and read the wire colors through the clear portion of the plug from left to right. If colors are arranged in the same order, you have a straight cable.*	This module's ethernet port is wired MDI. You must use a crossover cable when connecting this module to your PC or another device also wired MDI. If you are connecting to an Ethernet switch or hub, then a direct cable is used. **Note:** If your Link LED is ON, you have connected using the correct type of cable, but it could still be defective.
	Wrong IP Address	Change the IP address of module or PC so that both match. Try default module address of 128.1.1.100. For the PC NIC, try using another address.
Cannot Browse Module.	Your browser may be setup to use a proxy server for LAN communications.	Temporarily disable the use of a proxy server by your browser (see procedure of next page).

If your problem still exists after checking your wiring and reviewing this information, or if other evidence points to another problem with the unit, an effective and convenient fault diagnosis method is to exchange the module with a known good unit. Acromag's Application Engineers can provide further technical assistance if required. Complete repair services are also available from Acromag.

TROUBLE-SHOOTING

Diagnostics Table

SYMPTOM	POSSIBLE CAUSE	POSSIBLE FIX
Many Communication Errors.	Is cable segment longer than 100M?	Maximum distance between two nodes is limited to 100 meters using approved cable.
	Correct Cable?	Shielded CAT-5/5E cable or equivalent is recommended.
	Missing earth ground connection.	Connect earth ground to TB3-33 GND terminal adjacent to power terminal.

Trouble Browsing Your Module?

Please refer Acromag Application Note 8500-734 for help in setting up network communication with your module (located on the CDROM shipped with your module or via download from our web site at www.acromag.com). This document gives details for changing your PC's TCP/IP configuration in order to communicate with your module (see TCP/IP Properties of Network Configuration in Windows).

If you have carefully followed this procedure and you still cannot browse your module, you may have the web browser of your laptop or PC setup to use a proxy server when browsing the web. If you are using Internet Explorer, Refer to the "Tools" pulldown menu, select "Internet options…", click the "Connections" tab, then click the "LAN Settings" button. Locate the Proxy server information and uncheck the box next to the statement "Use a proxy server for your LAN". Then click [OK] to return to the "Connections" screen, and click [OK] again to save your settings.

You should now be able to use Internet Explorer to browse the module as required. However, to later restore your PC's connection to your company network, you may have to re-enable the use of a proxy server for your LAN.

Getting Out Of Trouble

There is no built-in error detection to prevent you from writing invalid values to a configuration register. As such, if you inadvertently write an invalid value to an internal register, you could cause the module to become inoperable under certain conditions. If this happens, in order to regain control of the module, the module can either be re-downloaded at the factory, or you can try restoring the module to its initial configuration by following this procedure:

So, your module's "gone wild", follow this procedure to restore it to its initial configuration and regain control.

Procedure For Restoring any 9xxEN Module to its Initial Configuration

1. While module power is OFF, press and hold the front-panel toggle switch in the default (DFT left) position.
2. While continuing to hold the toggle switch in the default position, apply power to the module.
3. After a few seconds, the Status LED will begin to blink quickly and you can release the default switch at this point. The module will continue to boot itself as it normally does. That is, the green RUN LED will blink for 1-10 seconds as the unit acquires its address, then remain ON for normal operation.
4. If the STATUS LED fails to blink rapidly after a few seconds and the RUN LED just blinks for a few moments as it normally does, then reinitializing the module has failed and you should try it again. This time, make sure that the DFT switch is completely depressed and held while powering the unit. Also make sure that you are pressing the DFT toggle in the DFT direction (left), rather than the RST direction (right).

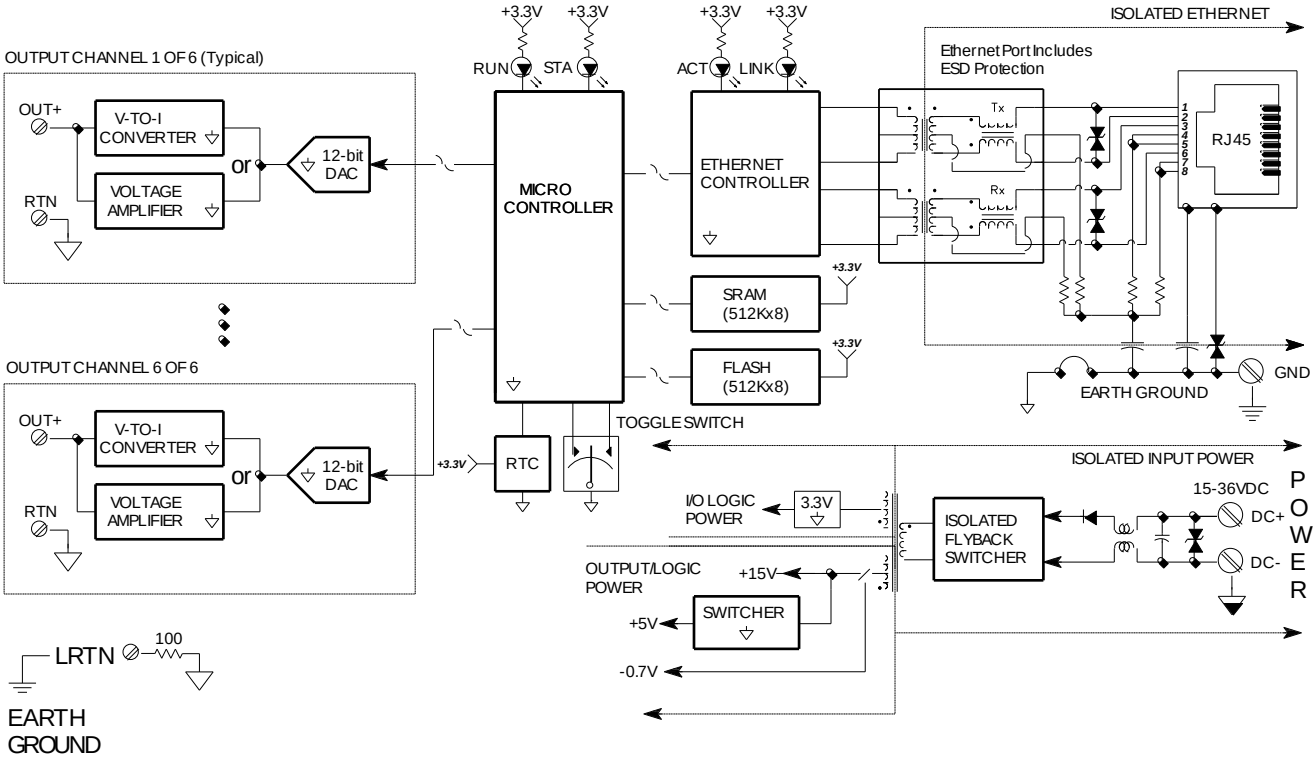
TECHNICAL REFERENCE

KEY FEATURES

- **Safety Agency Approvals** – CE, UL, & cUL listed, plus Class I; Division 2; Groups A, B, C, D approval.
- **Modbus TCP/IP Protocol Support –** Supports up to 10 master sockets (maximum number is user-selectable) using port number 502 (Modbus TCP/IP Default).
- **Built-In Web Pages -** Allows unit to optionally be configured, controlled, calibrated, and monitored via a standard web browser over ethernet.
- **Convenient "Wink" ID Mode Support** – Blinks green RUN LED in wink mode as a visual tool to help identify specific remote units on a network.
- **Fully Independent w/ Direct I/O Connection** – Self-contained with no special bus couplers, power supply, or rack mount required to operate.
- **Isolated Network Interface** – Immune to noise & can operate over long distances. Allows many modules to network together.
- **Network Port is Transient Protected** – Shielded RJ45 port includes transient protection from ESD, EFT, and other transients.
- **10Base-T and 100Base-TX Support** – Integrated IEEE 802.3/802.3u 100Base-TX/10Base-T.
- **Auto-Negotiated 10/100Mbps, Half or Full Duplex.**
- **Flexible Process Current Output (972EN) –** Generates up to 6 process current signals in 3 ranges.
- **Flexible DC Voltage Output (973EN) –** Generates up to 6 DC voltage signals in 3 ranges.
- **Selected Ranges May Vary Channel-to-Channel** – Multiple channels may have different ranges configured.
- **Precise High-Resolution D/A Conversion** – Modules use high resolution (12-bit), low noise, digital-to-analog conversion for high accuracy and reliability.
- **Nonvolatile Reprogrammable Memory** – Allows the functionality of this device to be reliably reprogrammed thousands of times.
- **Fully Isolated** – Output channels (as a group), network, and power are all isolated from each other for safety and increased noise immunity.
- **Plug-In Terminal Blocks & DIN-Rail Mount -** Make mounting, removal, and replacement easy.
- **Operation/Diagnostic LED Indicators Aide Troubleshooting** – Yellow ACT LED indicates port activity (busy). Green LNK LED indicates link (auto-negotiation complete and connection established). Green RUN LED indicates power is ON or wink ID mode (blinking). Yellow ST LED indicates module status.
- **Internal Watchdog** - A hardware watchdog timer is built into the microcontroller that causes it to initiate a self reset if the controller ever "locks up" or fails to return from an operation in a timely manner.
- **Wide-Range DC-Power** – Wide range diode-coupled for use with redundant supplies, and/or battery back-up.
- **Hardened For Harsh Environments** - For protection from RFI, EMI, ESD, EFT, & surges. Has low radiated emissions per CE requirements.
- **Wide Ambient Operation** – Reliable over a wide temperature range.

HOW IT WORKS

These transmitters will drive up to six analog current outputs (972EN), or six analog voltage outputs (973EN), and provide an isolated 10/100 Ethernet interface for configuration, monitoring, and control of the outputs. The microcontroller completes the output transfer function according to the output type & range per its embedded program, and sends output values to two, 12-bit, quad-output DAC's (Digital-to-Analog Converters). The corresponding DAC output voltages are sent to individual voltage-to-current converter circuits (972EN), or to non-inverting output amplifiers (973EN). Outputs share a common return and are not isolated channel-to-channel. Output configuration and calibration parameters are stored in non-volatile memory integrated within the microcontroller. A dedicated Ethernet controller handles Ethernet communication. The I/O terminals and the Ethernet port terminals also include transient suppression. A wide input switching regulator (isolated flyback) provides isolated power to the output circuit and the Ethernet controller. A second switcher converts the 15V output supply to a 5V logic supply. Refer to the simplified schematic shown below to help gain a better understanding of the circuit.



ABOUT MODBUS TCP/IP

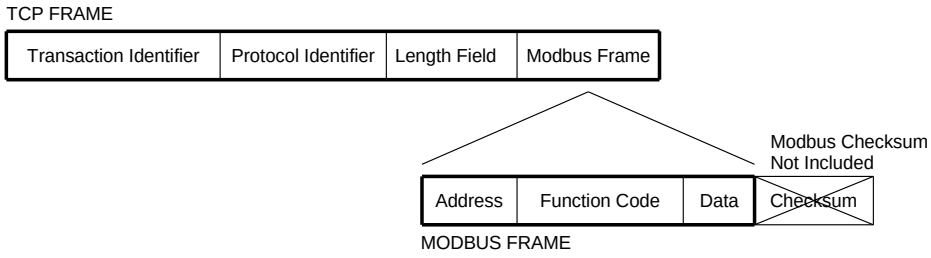
TCP/IP is the foundation for the World Wide Web and refers to the Transmission Control Protocol and Internet Protocol. TCP/IP allows blocks of binary data to be exchanged between computers. The primary function of TCP is to ensure that all packets of data are received correctly, while IP makes sure that messages are correctly addressed and routed. Note that the TCP/IP combination does not define what the data means or how the data is to be interpreted, it is merely a *transport protocol*.

Modbus is an *application protocol*. It defines rules for organizing and interpreting data and is essentially a messaging structure that is independent of the underlying physical layer. It is freely available and accessible to anyone, easy to understand, and widely supported by many manufacturers.

You can find more information on Modbus TCP/IP by visiting our web site and down-loading whitepaper 8500-765, Introduction To Modbus TCP/IP.

Modbus TCP/IP uses TCP/IP and Ethernet to carry the data of the Modbus message structure between devices. That is, Modbus TCP/IP combines a physical network (Ethernet), with a networking standard (TCP/IP), and a standard method of representing data (Modbus). A Modbus TCP/IP message is simply a Modbus communication encapsulated in an Ethernet TCP/IP wrapper.

In practice, Modbus TCP embeds a Modbus data frame into a TCP frame, without the Modbus checksum, as shown in the following diagram. The Modbus checksum is not used, as the standard ethernet TCP/IP link layer checksum methods are instead used to guaranty data integrity.



Note that the Modbus address field is referred to as the *Unit Identifier* in Modbus TCP. In a typical slave application, the Unit ID is ignored and just echoed back in the response.

The operation of the 972/973EN industrial Ethernet modules is similar to Acromag's 917/918MB Modbus modules. The operation over Ethernet is essentially transparent to the Modbus register/command structure. If you are already familiar with Modbus or with Acromag Series 900MB modules, then you are already familiar with the operation of the 972/973EN modules.

IP Addressing

A host is any device on any network. On TCP/IP networks, each host has one or more unique IP addresses. This module connected to an ethernet network is a host.

An IP Address is a unique identification number for any host (this module) on any TCP/IP network (including the internet). The IP address is made up of four octets (8 bits), each octet having a value between 0-255 (00H-FFH). The IP address is comprised of two parts: the network address (first part) and the host address (last part). The number of octets of the four total that belong to the network address depend on the Class definition (see below).

IP Addressing

A *Static IP Address* is as the name implies—static. That is, it is a unique IP Address that is assigned by a service provider and never changes.

A *Dynamic IP Address* is an address that is temporarily assigned to a user by a service provider each time a user connects.

A *Subnet* is a contiguous string of IP addresses. The first IP address in a subnet is used to identify the subnet and usually addresses the server for the subnet. The last IP address in a subnet is always used as a broadcast address and anything sent to the last IP address of a subnet is sent to every host on that subnet.

Subnets are further broken down into three size classes based on the 4 octets that make up the IP address. A Class A subnet is any subnet that shares the first octet of the IP address. The remaining 3 octets of a Class A subnet will define up to 16,777,214 possible IP addresses ($2^{24} – 2$). A Class B subnet shares the first two octets of an IP address (providing $2^{16} – 2$, or 65534 possible IP addresses). Class C subnets share the first 3 octets of an IP address, giving 254 possible IP addresses. Recall that the first and last IP addresses are always used as a network number and broadcast address respectively, and this is why we subtract 2 from the total possible unique addresses that are defined via the remaining octet(s).

For our example, the default IP address of this module is 128.1.1.100. If we assume that this is a Class C network address (based on the default Class C subnet mask of 255.255.255.0), then the first three numbers represent this Class C network at address 128.1.1.0, the last number identifies a unique host/node on this network (node 100) at address 128.1.1.100.

A *Subnet Mask* is used to determine which subnet an IP address belongs to. The use of a subnet mask allows the network administrator to further divide the host part of this address into two or more subnets. The subnet mask flags the network address portion of the IP address, plus the bits of the host part that are used for identifying the sub-network. By convention, the bits of the mask that correspond to the sub-network address are all set to 1's (it would also work if the bits were set exactly as in the network address). It's called a mask because it can be used to identify the unique subnet to which an IP address belongs to by performing a bitwise AND operation between the mask itself, and the IP address, with the result being the sub-network address, and the remaining bits the host or node address.

Note that the first node address (0) and node 10 are typically reserved for servers and should not be used. The last node (255) is a broadcast address. Node 100 is the default address of this module. Use of these node addresses for any other purpose may yield poor performance.

For our Example, if we wish to further divide this network into 14 subnets, then the first 4 bits of the host address will be required to identify the subnetwork (0110), then we would use "11111111.11111111.11111111. 11110000" as our subnet mask. This would effectively subdivide our Class C network into 14 subnetworks of up to 14 possible nodes each.

With respect to the default settings of this module:
Subnet Mask 255.255.255.0 (11111111.11111111.11111111.00000000)
IP Address: 128.1.1.100 (10000000.00000001.00000001.01100100)
Subnet Address: 128.1.1.0 (1000000.00000001.00000001.00000000)

Subnetwork address 128.1.1.0 has 254 possible unique node addresses. We are using node 100 of 254 possible for our module.

Dynamic Host Configuration Protocol (DHCP)

DHCP refers to Dynamic Host Configuration Protocol and is a method used to dynamically assign temporary numeric IP addresses as required. A DHCP server maintains a pool of shared IP addresses which are recycled. When a DHCP device wants to use a TCP/IP application, it must request an IP address from the DHCP server. The DHCP server will check the shared supply, and if all addresses are in use, the server will send a busy signal to the client which tells it to try again later. Static addresses will ensure a connection every time, but dynamic addresses do not.

Domain Name System (DNS)

DNS refers to the Domain Name System or Domain Name Server and refers to the system used to associate an alphanumeric character string with a numeric IP address. The DNS is actually a distributed database of domain names and corresponding IP addresses. The DNS allows us to use Acromag.com as an IP address rather than a complicated string of numbers. Note that name servers contain information on some segment of the domain name space and make this information available to clients called *resolvers*.

MODBUS REGISTERS

Modbus registers are organized into reference types identified by the leading number of the reference address:

Reference	Description
0xxxx	Read/Write Discrete Outputs or Coils. A 0x reference address is used to drive output data to a digital output channel.
1xxxx	Read Discrete Inputs. The ON/OFF status of a 1x reference address is controlled by the corresponding digital input channel.
3xxxx	Read Input Registers. A 3x reference register contains a 16-bit number received from an external source—e.g. an analog signal.
4xxxx	Read/Write Output or Holding Registers. A 4x register is used to store 16-bits of numerical data (binary or decimal), or to send the data from the CPU to an output channel.

The "x" following the leading character represents a four-digit address location in user data memory.

The leading character is generally implied by the function code and omitted from the address specifier for a given function. The leading character also identifies the I/O data type.

Note: The ON/OFF state of discrete inputs and outputs is represented by a 1 or 0 value assigned to an individual bit in a 16-bit data word. This is sixteen 0x or 1x references per data word. With respect to mapping, the LSB of the word maps to the lowest numbered channel of a group and channel numbers increase sequentially as you move towards the MSB. Unused bit positions are set to zero.

All I/O values are accessed via the 16-bit Input or Holding Registers given in the Register Map. Input registers contain read-only information. For example, the current input value read from a channel, or the states of a group of digital inputs. Holding registers contain read/write information that may be configuration data or output data. For example, the high limit value of an alarm operating at an input, or an output value for an output channel.

Register Functions

Each module has a default factory configuration as noted in the SPECIFICATIONS section. Your application will likely differ from the default configuration and the module will need to be reconfigured. You may reconfigure this module by issuing the appropriate Modbus functions to Register Map registers, as required by your application. You may also use a standard web browser to access the built-in web pages of the module to perform basic operations.

Register Functions

Below is a subset of standard Modbus functions that are supported by this module along with the reference register addresses that the function operates on. Use these functions to access these registers as outlined in the Register Map for sending and retrieving data.

The following Modbus functions operate on register map registers to monitor, configure, and control module I/O:

CODE	FUNCTION	REFERENCE
01 (01H)	Read Coil (Output) Status	0xxxx
02 (02H)	Read Input Status	1xxxx
03 (03H)	Read Holding Registers	4xxxx
04 (04H)	Read Input Registers	3xxxx
05 (05H)	Force Single Coil (Output)	0xxxx
06 (06H)	Preset Single Register	4xxxx
15 (0FH)	Force Multiple Coils (Outputs)	0xxxx
16 (10H)	Preset Multiple Registers	4xxxx
17 (11H)	Report Slave ID (See Below)	*Hidden*

If an unsupported function code is sent to a module, exception code 01 (Illegal Function) will be returned in the response. If a holding register is written with an invalid value, exception code 03 (Illegal Data Value) will be returned in the response message. You may refer to the Modbus specification for a complete list of possible error codes.

972EN-4006 Report Slave ID Example Response

FIELD	DESCRIPTION
Unit ID	Echo Unit ID Sent In Query
Function Code	11
Byte Count	42
Slave ID (Model No.)	08=972EN-4004 (4 Current Outputs) 09=972EN-4006 (6 Current Outputs) 0A=973EN-4004 (4 Voltage Outputs) 0B=973EN-4006 (6 Voltage Outputs)
Run Indicator Status	FFH (ON)
Firmware Number String (Additional Data Field)	41 43 52 4F 4D 41 47 2C 39 33 30 30 2D **31 32 37** 2C 39 **37 32** 45 4E 2D **34 30 30 36** 2C *30 31 32 33 34 35 41* 2C *30 31 32 33 34 35* ("ACROMAG,9300-**127**,9**72**EN-**4006**,*serial number&rev*,*six-byteMACID*")

For detailed information on Modbus, feel free to download our technical reference 8500-648, "Introduction To Modbus", and 8500-765, "Introduction To Modbus TCP/IP" at www.acromag.com.

Register Mirroring

For your convenience, 9xxEN Ethernet modules mirror the contents and operation of registers 0xxxx, 1xxxx, & 3xxxx (as applicable) into holding register space for systems and controllers that cannot directly access registers 0xxxx, 1xxxx, & 3xxxx.

All Modbus registers of this model can now be written to, or read from, using either the standard methods described in the Modbus specification, or through mapping (mirroring) to the Holding Registers. The registers are mapped as follows and specifics follow the mapping:

Register Mirroring

0xxxx Coil Registers are mapped to 42xxx Holding Registers
1xxxx Input Status Registers are mapped to 41xxx Holding Registers
3xxxx Input Registers are mapped to 43xxx Holding Registers

For 3xxxx Input Registers, the format of the registers are identical and you only need to offset your address by 43000. For example: if you want to read Input Register 1 through the Holding Registers, you would use the "Read Holding Registers" function with an address of 43001.

For the 1xxxx Input Status Registers (where supported), the return data is reformatted to match the Holding Register format. For example: if you request the Input Status for 12 digital inputs, instead of getting 2 bytes returned with the first 12 bits representing the 12 digital inputs, you will get 12 separate words, each set to either 0000H (OFF), or FFFFH (ON).

For the 0xxxx Coil Registers (where supported), reads are handled in the same way as the 1xxxx Input Status Registers. You can also write to the coil registers by using the "Preset Single Register" function with an address offset of 42000. Setting the data to 0000H will turn the coil OFF, while setting the data to FF00H will turn the coil ON. Writing to multiple coils is not supported via register mirroring, you must use the "Write Multiple Coils" function for that.

Note that with respect to Acromag 9xxMB Modbus RTU modules, only 3xxxx Input Registers are mirrored into 4xxxx space, not Coil or Input Status registers as noted here for 9xxEN models.

Data Types

I/O values for Series 900EN modules are represented by the following simple data types for temperature, percentage, and discrete on/off.

Summary Of Data Types Used By 900MB/900EN Modules

Data Types	Description
Normalized Data Count (This Model)	A 16-bit signed integer value is used to represent ±20000 counts for bipolar output ranges and 0-20000 counts for unipolar output ranges. For example, -10V, 0V and +10V are represented by integer values –20000, 0, and 20000 for bipolar devices, respectively.
Temperature	A 16-bit signed integer value with resolution of 0.1°C/lsb represents the range of a TC type measured in degrees C. For example, a JTC type has a range of -210 to 760C, which read -2100 to 7600 counts within the data register respectively.
Discrete	A discrete value is generally indicated by a single bit of a 16-bit word. The bit number/position typically corresponds to the discrete channel number. Unless otherwise defined for outputs, a 1 bit means the corresponding output is closed or ON, a 0 bit means the output is open or OFF. For active-low inputs, a value of 1 means the input is ON (Active low near 0V), while a value of 0 specifies the input is OFF or in its high state (usually >> 0V).

Register Map

Model 972EN-4006
Model 972EN-4004
Model 973EN-4006
Model 973EN-4004

The following table outlines the register map for the Model 972EN-400X and 973EN-400X network output modules. The Modbus functions operate on these registers using the data types noted above (except for the Reset Slave and Report Slave ID functions).

Ref	Addr.	Description	Data Type/Format
Input Registers (3x References, Read-Only)			
30001	0000	Module Status	Bit 15: 0 (Not Used) Bit 14: Wink Mode Flag 1 = Wink Mode (Blinks Run LED for ID) 0 = Normal Operation (See Wink Module Register) Bit 13: Default Mode Flag 1 = Default Mode Indicator 0 = Not Default Mode Bit 12-6: 0 (Not Used) Bit 5: 1=Watchdog Timeout Channel 5 0=Timeout Cleared. Bit 4: 1=Watchdog Timeout Channel 4 0=Timeout Cleared. Bit 3: 1=Watchdog Timeout Channel 3 0=Timeout Cleared. Bit 2: 1=Watchdog Timeout Channel 2 0=Timeout Cleared. Bit 1: 1=Watchdog Timeout Channel 1 0=Timeout Cleared. Bit 0: 1=Watchdog Timeout Channel 0 0=Timeout Cleared.
30002	0001	CH 0 Range	Bit 15-2: *0 (Not Used)* **Bits 1,0: 972EN 973EN** 00 0=0-20mA 0=0-10V 01 1=4-20mA 1=0-5V 10 2=0-1mA 2=0-1V 11 3=Reserved 3=Reserved
30003	0002	CH 1 Range	*Format is same as for CH0 above.*
30004	0003	CH 2 Range	*Format is same as for CH0 above.*
30005	0004	CH 3 Range	*Format is same as for CH0 above.*
30006	0005	CH 4 Range **972EN-4006** **973EN-4006**	*Format is same as for CH0 above.*
30007	0006	CH 5 Range **972EN-4006** **973EN-4006**	*Format is same as for CH0 above.*
30008	0007	CH00 Count	*Corrected DAC Count*
30009	0008	CH01 Count	*Corrected DAC Count*
30010	0009	CH02 Count	*Corrected DAC Count*
30011	000A	CH03 Count	*Corrected DAC Count*
30012	000B	CH04 Count **972EN-4006** **973EN-4006**	*Corrected DAC Count*
30013	000C	CH05 Count **972EN-4006** **973EN-4006**	*Corrected DAC Count*

Ref	Addr.	Description	Data Type/Format
Holding Registers (4x References, Read/Write)			
40001	0000	CH0 Output Range	*Bit 15-2:* *0 (Not Used)* **Bits 1,0:** **972EN** **973EN** 00 0=0-20mA 0=0-10V 01 1=4-20mA 1=0-5V 10 2=0-1mA 2=0-1V 11 3=Reserved 3=Reserved
40002	0001	CH1 Output Range	*Same format as CH0 (See Register 40001).*
40003	0002	CH2 Output Range	*Same format as CH0 (See Register 40001).*
40004	0003	CH3 Output Range	*Same format as CH0 (See Register 40001).*
40005	0004	CH4 Output Range **972EN-4006** **973EN-4006**	*Same format as CH0 (See Register 40001).*
40006	0005	CH5 Output Range **972EN-4006** **973EN-4006**	*Same format as CH0 (See Register 40001).*
40007	0006	Output 0 Watchdog Time	Can be set from 1 to 65534 seconds. Set to 65535 (FFFFH) or 0 (0000H) to disable watchdog timer.
40008	0007	Output 1 Watchdog Time	Can be set from 1 to 65534 seconds. Set to 65535 (FFFFH) or 0 (0000H) to disable watchdog timer.
40009	0008	Output 2 Watchdog Time	Can be set from 1 to 65534 seconds. Set to 65535 (FFFFH) or 0 (0000H) to disable watchdog timer.
40010	0009	Output 3 Watchdog Time	Can be set from 1 to 65534 seconds. Set to 65535 (FFFFH) or 0 (0000H) to disable watchdog timer.
40011	000A	Output 4 Watchdog Time	Can be set from 1 to 65534 seconds. Set to 65535 (FFFFH) or 0 (0000H) to disable watchdog timer.
40012	000B	Output 5 Watchdog Time	Can be set from 1 to 65534 seconds. Set to 65535 (FFFFH) or 0 (0000H) to disable watchdog timer.
40013	000C	CH0 Timeout Value	Count. This is the level that the output will be programmed to upon watchdog timeout. Write 32767 (7FFFH) to leave this output unchanged following a timeout.
40014	000D	CH1 Timeout Value	Count - *Same format as CH0 (See Register 40013).*
40015	000E	CH2 Timeout Value	Count - *Same format as CH0 (See Register 40013).*

Register Map

Model 972EN-4006
Model 972EN-4004
Model 973EN-4006
Model 973EN-4004

Note (972EN): *The 0-20mA output range may not precisely go to the 0mA endpoint, but will typically approach 0mA within 0.25% of span (50uA).*

Register Map

Model 972EN-4006
Model 972EN-4004
Model 973EN-4006
Model 973EN-4004

Shaded 4xxxx register entries are Read-Only.

Note that clearing a watchdog timeout does not return an output to its pre-timeout level, it remains at its timeout level until otherwise written.

Ref	Addr.	Description	Data Type/Format
Holding Registers (4x References, Read/Write)			
40016	000F	CH3 Timeout Value	Count - *Same format as CH0 (See Register 40013).*
40017	0010	CH4 Timeout Value **972EN-4006 973EN-4006**	Count - *Same format as CH0 (See Register 40013).*
40018	0011	CH5 Timeout Value **972EN-4006 973EN-4006**	Count - *Same format as CH0 (See Register 40013).*
40019	0012	CH0 Output Value	Count . *This is the programmed output value.*
40020	0013	CH1 Output Value	Count *Same format as CH0 (See Register 40019).*
40021	0014	CH2 Output Value	Count *Same format as CH0 (See Register 40019).*
40022	0015	CH3 Output Value	Count *Same format as CH0 (See Register 40019).*
40023	0016	CH4 Output Value **972EN-4006 973EN-4006**	Count *Same format as CH0 (See Register 40019).*
40024	0017	CH5 Output Value **972EN-4006 973EN-4006**	Count *Same format as CH0 (See Register 40019).*
40025	0018	*Reserved*	*Do Not Use*
40026	0019	*Reserved*	*Do Not Use*
40027	001A	*Reserved*	*Do Not Use*
40028	001B	*Reserved*	*Do Not Use*
40029	001C	*Reserved*	*Do Not Use*
40030	001D	*Reserved*	*Do Not Use*

Ref	Addr.	Description	Data Type/Format
Holding Registers (4x References, Read/Write)			
40031	001E	Calibration Access And Wink Mode Toggle And Restore Factory Calibration	*Writing 24106 (5E2AH) here immediately removes write protection from the calibration registers that follow. Write 0 to apply write protection to the calibration registers.* *Writing 21845 (5555H) to this register will cause the module to "Wink" its Run LED. Writing this value a second time will stop "Wink" (Toggles Wink ON/OFF).* *Writing 44718 (AEAEH) will cause the module to restore its factory calibration. This can only be done after "Save Factory Calibration" has been done at the factory.* *Writing 43981 (ABCDH) is reserved for factory use.* ***This should not be performed by anyone else or operation will be degraded.*** *This register always reads back 0. After a reset, this register is set back to 0 (write protection enabled and no wink).* *This register is not maintained in flash.*
40032	001F	*CH0 Cal Hi*	*Raw DAC Count Value .*
40033	0020	*CH0 Cal Lo*	*Raw DAC Count Value .*
40034	0021	*CH1 Cal Hi*	*Raw DAC Count Value .*
40035	0022	*CH1 Cal Lo*	*Raw DAC Count Value .*
40036	0023	*CH2 Cal Hi*	*Raw DAC Count Value .*
40037	0024	*CH2 Cal Lo*	*Raw DAC Count Value .*
40038	0025	*CH3 Cal Hi*	*Raw DAC Count Value .*
40039	0026	*CH3 Cal Lo*	*Raw DAC Count Value .*

Register Map

Model 972EN-4006
Model 972EN-4004
Model 973EN-4006
Model 973EN-4004

Shaded 4xxxx register entries are Read-Only.

Register Map

Model 972EN-4006
Model 972EN-4004
Model 973EN-4006
Model 973EN-4004

Shaded 4xxxx register entries are Read-Only.

Ref	Addr.	Description	Data Type/Format
Holding Registers (4x References, Read/Write)			
40040	0027	*CH4 Cal Hi* ***972EN-4006 973EN-4006***	*Raw DAC Count Value .*
40041	0028	*CH4 Cal Lo* ***972EN-4006 973EN-4006***	*Raw DAC Count Value .*
40042	0029	*CH5 Cal Hi* ***972EN-4006 973EN-4006***	*Raw DAC Count Value .*
40043	002A	*CH5 Cal Lo* ***972EN-4006 973EN-4006***	*Raw DAC Count Value .*
40044 . . **4**0049	002B . . 0030	*Reserved* . . .	*Do Not Use* . . .
40050	0031	*Span Cal Register*	*A 16-Bit value whose bit position when set indicates the channel to be calibrated for span. For example: to calibrate span of channel 0, write 0001H to this register. To calibrate span of channel 11, write 0800H to this register.* ***IMPORTANT:*** *You must FIRST write 5E2AH into the Calibration Access Register (Register 40031) before attempting calibration.*
40051	0032	*Zero Cal Register*	*A 16-Bit value whose bit position when set indicates the channel to be calibrated for zero. For example: to calibrate zero of channel 0, write 0001H to this register. To calibrate zero of channel 11, write 0800H to this register.* ***IMPORTANT:*** *You must FIRST write 5E2AH into the Calibration Access Register (Register 40031) before attempting calibration.*
43001 . . .	. . .	*This block Mirrors 3xxxx Registers.*	*Refer to Register Mirroring. 3xxxx Input Registers are mapped to the 43xxx Holding Register space using an address offset of 43000.*

Note (Register Map):
A 16-bit signed integer value is used to represent ±20000 counts for bipolar output ranges and 0-20000 counts for unipolar output ranges. For example, -10V, 0V and +10V are represented by integer values –20000, 0, and 20000 for bipolar devices, respectively.The Corrected DAC Count refers to the actual count required to set the DAC output after making adjustments for calibration. The Raw DAC count is the count value required to set the endpoints of the nominal range. Refer to "DAC Count" in Specifications for more information.

SPECIFICATIONS

These DIN-rail mount, industrial Ethernet, output modules will drive up to six process current, or voltage signals, according to the model, and provide an isolated 10/100BaseT Ethernet port for monitoring and control of the outputs. Units are DC-powered and include reverse polarity protection. Outputs share a common return connection and are not isolated channel-to-channel. Outputs (as a group), network, and power are isolated from each other. Non-volatile reprogrammable memory in the module stores configuration and calibration information.

Model Numbers

The BusWorks model prefix "900" denotes the Series 900 network I/O family. The "EN" suffix denotes EtherNet. Select 972EN for current output, and 973EN for voltage output. Select 4 or 6 channel output models. The four digit suffix of this model number represents the following options, respectively: "4" = Ethernet; "0" = Default; "04" or "06" = 4 or 6 Channels, respectively.

972EN-4006 (6 I Output)
972EN-4004 (4 I Output)

973EN-4006 (6 V Output)
973EN-4004 (4 V Output)

Analog Outputs

Four or six analog output channels for current or voltage according to model number. The unit must be wired and configured for the intended output type and range (see Connections Section for details). The following paragraphs summarize this model's output types, ranges, and applicable specifications.

Current Output Specifications (972EN Only):

Output Ranges: Select 0-20mA DC, 4-20mA DC, or 0-1mA DC. The 0-20mA and 0-1mA ranges are sub-ranges of the 4-20mA range.
Note: The 0-20mA and 0-1mA output ranges may not precisely go to the 0mA endpoint. The 0-20mA range will typically approach 0mA within 0.25% of span (50uA). As such, do not use exactly 0 as a calibration endpoint.
Output Maximum Current: ~21.1mA typical (DAC count ~3812).
Output Accuracy: See Resolution & Accuracy Table under General Specifications.
Output Compliance: 12V Minimum, 13V Typical.
Output Load Resistance Range: 0 to 625Ω, typical.
Response Time: 11ms typical into 500Ω, for measurement to reach 98% of the final value in response to a step command. Actual response time will vary with load.
Output Resolution: 12 bits, or 1 part in 4096 based on a theoretical 22.67mA over-range value. This is 5.535uA/bit (22.67mA/4096bits). Note the over-range DAC count is internally limited to approximately 3812, or 21.1mA. See below for effective resolution calculations.
DAC Count (Current): Internal DAC count can be approximated by multiplying the output current by 180680. The resultant value (rounded) can be used to calculate the effective resolution and to approximate the required output register program value (see below). The over-range DAC count is internally limited to approximately 3812, or 21.1mA.

Internal DAC Count Versus Current Output Range

Range	DAC 0%	DAC 100%	DAC Span
0-1mA	0	181	181
4-20mA	723	3614	2891
0-20mA	0	3614	3614

The effective resolution is 1 part in the DAC Span. The resolution and accuracy for the 0-1mA range is significantly less than the other ranges.

Analog Outputs

Register Program Value: Output values use integers with ±20000 representing ±100%. The required output register program value can be approximated using the DAC values shown above via the formula: Register Value = 20000 * (DAC Count – DAC 0%)/DAC Span.

Ideal Current Output Register Program Value

Range	Output Current				
	0mA	1mA	4mA	12mA	20mA
0-1mA	0	20000	---	---	---
4-20mA	---	---	0	10000	20000
0-20mA	0	1000	4000	12000	20000

Voltage Output Specifications (973EN Only):

Output Range: Select 0-10V DC, 0-5V DC, or 0-1V DC. Ranges are sub-ranges of nominal 0-11.1V design limit (which includes approximately 11% of over-range).
Output Maximum Voltage: 11.1V, typical.
Output Accuracy: See Resolution and Accuracy Table under General Specifications.
Output Current: 0-10mA DC maximum.
Output Impedance: 1Ω.
Output Short Circuit Protection: Included
Response Time: 110us rise time typical, 150us fall time typical, unloaded, for output to reach 98% of the final value in response to a step command. Actual response time will vary with load.
Output Resolution: 1 part in 4046 based on 11.368V full-scale, or 2.81mV/bit (11.368V/4046bits).
DAC Count (Voltage): The internal DAC count can be calculated by multiplying 355.96 by the sum of the output voltage and 0.1393. The resultant value (rounded) can be used to calculate the effective resolution and to approximate the required output register program value (see below). The effective resolution is 1 part in the DAC Span.

Internal DAC Count Versus Voltage Output Range

Range	DAC 0%	DAC 100%	DAC Span
0-1V	50	406	356
0-5V	50	1829	1779
0-10V	50	3609	3559

Register Program Value: Output values use integers with ±20000 representing ±100%. The required output register program value can be approximated using the DAC values shown above via the following formula: Register Value = 20000 * (DAC Count – DAC 0%)/DAC Span.

Ideal Voltage Output Register Program Value

Range	Output Voltage				
	0V	1V	2.5V	5V	10V
0-1V	0	20000	---	---	---
0-5V	0	4000	10000	20000	---
0-10V	0	2000	5000	10000	20000

General Specifications

Accuracy: Outputs are accurate to better than ±0.1% of output span, typical, for 4-20mA, 0-20mA, 0-10V, and 0-5V ranges (see table below). This includes the effects of repeatability, terminal point conformity, and linearization.

Ambient Temperature Effect: Better than ±0.005% of output span per °C (±50ppm/°C), or ±1.0uV/°C, whichever is greater.

Digital-to-Analog Converter: Burr-Brown/Texas Instruments DAC7615, 12-bit. Monotonic to 12 bits.

Integral Non-Linearity: ±0.1% of span or ±2 LSB typical, whichever is larger, for spans greater than or equal 16mA (972EN), or 5V (973EN).

Analog Output Range Resolution & Accuracy

Calibrated Output Range	Effective Resolution	Inaccuracy as a Percent-of-Span
Model 972EN-4004 or 972EN-4006		
0 to 20mA DC	.028%, 1/3614	±0.1% span (±0.02mA)
4 to 20mA DC	.035%, 1/2891	±0.1% span (±0.02mA)
0 to 1mA DC	.552%, 1/181	±1.6% span (±0.016mA)
Model 973EN-4004 or 973EN-4006		
0-10V DC	.028%, 1/3559	±0.1% span (±10mV)
0-5V DC	.056%, 1/1779	±0.1% span (±5mV)
0-1V DC	.281%, 1/356	±0.8% span (±8mV)

Note (0-1mA & 0-1V ranges only): Due to the possible inability of the output to precisely adjust to the ideal range endpoints as a result of the low resolution for the 0-1mA & 0-1V ranges, effective inaccuracy may be as high as 2.2% & 1.1% respectively for these sub-ranges.

Data Type: Input range- A 16-bit signed integer value with resolution of 0.005%/lsb. ±20000 is used to represent ±100%. For example, -100%, 0%, & +100% are represented by decimal values –20000, 0, & 20000, respectively.

Enclosure & Physical

Dimensions: 1.05 inches wide, 4.68 inches tall, 4.35 inches deep. Refer to the dimensions drawing at the front of this manual.

DIN Rail Mount: Type EN50022; "T" rail (35mm).

I/O Connectors: Removable plug-in type terminal blocks rated for 15A/300V; AWG #12-24 stranded or solid copper wire.

Network Connector: 8-pin RJ-45 connector socket with metal shield (shield is bypassed to earth ground at the GND terminal via an isolation capacitor and TVS). Connections are wired MDI, as opposed to MDI-X. You must use a CAT-5 crossover cable to connect this module to a PC. Otherwise you may use an auto-crossing Ethernet switch, such as the Acromag 900EN-S005 to make connections.

RJ-45	Signal (MDI)	Description
1	Tx+	Transmit Positive
2	Tx-	Transmit Negative
3	Rx+	Receive Positive
4	Not Used	Connects to Pin 5
5	Not Used	Connects to Pin 4
6	Rx-	Receive Negative
7	Not Used	Connects to Pin 8
8	Not Used	Connects to Pin 7

Case Material: Self-extinguishing NYLON type 6.6 polyamide thermoplastic UL94 V-2, color beige; general purpose NEMA Type 1 enclosure.

Enclosure & Physical

Printed Circuit Boards: Military grade FR-4 epoxy glass.
Shipping Weight: 1 pound (0.45 Kg) packed.

Agency Approvals

Safety Approvals: : UL Listed (USA & Canada). Hazardous Locations- Class I, Division 2, Groups A, B, C, D. Consult factory.
ATEX Certified: Assessment by TUV Rheinland of North of America, Inc. per
ATEX Directive 94/9/EC.
Ex nA IIC T4 Gc
TUVNA 14 EX 0001X
x = Special Conditions
1) "WARNING-EXPLOSION HAZARD-DO NOT MAKE OR BREAK CONNECTIONS IN HAZARDOUS LOCATIONS OR AREAS"
2) "Warning: Must be installed in suitable enclosure with an Ingress Protection of IP54 minimum, in Hazardous Locations or Areas"

Environmental

Operating Temperature: 972EN: -25°C to +60°C (-13°F to +140°F); 973EN: -25°C to +70°C (-13°F to +158°F).
Storage Temperature: -40°C to +85°C (-40°F to +185°F).
Relative Humidity: 5 to 95%, non-condensing.
Power Requirements: 15-36V DC SELV (Safety Extra Low Voltage). Observe proper polarity. See table for current. Data provided is with all current outputs (972EN) set full-scale (20mA), and all voltage outputs (973EN) set to 10V across 1KΩ (10mA).

CAUTION: *Do not exceed 36VDC peak, to avoid damage to the module.*

Power Supply	972EN-4004 Current Typical/Maximum	972EN-4006 Current Typical/Maximum
15V	224mA/246mA	284mA/312mA
18V	184mA/202mA	232mA/255mA
24V	138mA/152mA	172mA/189mA
36V	95mA/105mA	116mA/128mA

External Fuse: *Select a high surge tolerant fuse rated for 1A or less to protect unit.*

Power Supply	973EN-4004 Current Typical/Maximum	973EN-4006 Current Typical/Maximum
15V	175mA/193mA	207mA/228mA
18V	145mA/160mA	171mA/188mA
24V	110mA/121mA	129mA/142mA
36V	78mA/86mA	90mA/99mA

CAUTION: Risk of Electric Shock – More than one disconnect switch may be required to de-energize equipment before servicing.

Output channels are not isolated channel-to-channel.

Isolation: Output channels (as a group), power, and network circuits are isolated from each other for common-mode voltages up to 250VAC, or 354V DC off DC power ground, on a continuous basis (will withstand 1500VAC dielectric strength test for one minute without breakdown). Complies with test requirements of ANSI/ISA-82.01-1988 for voltage rating specified.
Installation Category: Designed to operate in an installation in a Pollution Degree 2 environment with an installation category (over-voltage category) II rating.

Electromagnetic Interference Immunity (EMI): Unit has demonstrated less than ±0.25% of output shift for interference from switching solenoids, commutator motors, and drill motors.

Environmental

These limits represent the minimum requirements of the standard, but product has typically been tested to comply with higher standards in some cases.

Electromagnetic Compatibility (EMC) -
Immunity Per European Norm BS EN 61000-6-2:2005:
- **Electrostatic Discharge (ESD) Immunity:** 4KV direct contact and 8KV air-discharge to the enclosure port per IEC61000-4-2.
- **Radiated Field Immunity (RFI):** 10V/M, 80 to 1000MHz AM, 1.4 to 2GHz 3V/M, and 2 to 2.7GHz 1V/M, per IEC61000-4-3.
- **Electrical Fast Transient Immunity (EFT):** 2KV to power, and 1KV to signal I/O per IEC61000-4-4.
- **Conducted RF Immunity (CRFI):** 10Vrms, 150KHz to 80MHz, per IEC61000-4-6.
- **Surge Immunity:** 0.5KV per IEC61000-4-5.

Emissions Per European Norm BS EN 61000-6-4:2007
- **Radiated Frequency Emissions:** 30 to 1000MHz per CISPR16 Class A

EMC – CE Marked

Electromagnetic Compatibility (EMC): CE marked, per EMC Directive 2004/108/EC. Consult factory.
Immunity per BS EN 61000-6-2:
1) Electrostatic Discharge Immunity (ESD), per IEC 61000-4-2.
2) Radiated Field Immunity (RFI), per IEC 61000-4-3.
3) Electrical Fast Transient Immunity (EFT), per IEC 61000-4-4.
4) Surge Immunity, per IEC 61000-4-5.
5) Conducted RF Immunity (CRFI), per IEC 61000-4-6.

Emissions per BS EN 61000-6-4:
1) Enclosure Port, per CISPR 16.
2) Low Voltage AC Mains Port, Per CISPR 16.
3) Telecom / Network Port, per CISPR 22.

WARNING: This is a Class A product. In a domestic environment, this product may cause radio interference in which the user may be required to take adequate measures.

IMPORTANT: Power, input, and output (I/O) wiring must be in accordance with Class I, Division 2 wiring methods of Article 501-4(b) of the National Electrical Code, NFPA 70 for installations in the US, or as specified in section 18-1J2 of the Canadian Electrical Code for installations within Canada and in accordance with the authority having jurisdiction.

This equipment is suitable for use in Class I, Division 2, Groups A, B, C, and D, or non-hazardous locations only.

WARNING – EXPLOSION HAZARD – Substitution of any components may impair suitability for Class I, Division 2.

WARNING – EXPLOSION HAZARD – Do not disconnect equipment unless power has been switched off or the area is known to be non-hazardous.

Ethernet Interface

Connector: Shielded RJ-45 socket, 8-pin, 10BaseT/100BaseTX.
Wiring: Wired MDI. Unit does NOT support auto-crossover.
Protocol: Modbus TCP/IP w/Web Browser Configuration.
IP Address: Default static IP address is 128.1.1.100.
Port: Up to 10 sockets supported. Uses port 502 (reserved for Modbus).

Transient Protection: Transient Voltage Suppressors (TVS) are applied differentially at the transmit and receive channels. Additionally, the metal shield is coupled to the earth ground terminal via an isolation capacitor and TVS.

Data Rate: Auto-sensed, 10Mbps or 100Mbps.

Duplex: Auto-negotiated, Full or Half Duplex.

Compliance: IEEE 802.3, 802.3u, 802.3x.

Modbus TCP/IP Protocol Support: Up to 10 sockets may be selected. Web page for configuration and control is built-in and may be accessed over ethernet via a standard web browser.

Rx/Tx Memory: 8K bytes internal SRAM memory for receive and transmit buffers (FIFO).

Communication Distance: The distance between two devices on an Ethernet network is generally limited to 100 meters using recommended copper cable. Distances may be extended using hubs, switches, or fiber optic transmission. However, the total round trip delay time must not exceed 512 bit times for collision detection to work properly with CSMA/CD (half-duplex).

Ethernet Interface

Refer to Acromag Application Note 8500-734 for instructions on how to change the IP address of your PC network interface card in order to talk to an Acromag module.

Port Status Indicators: Green LED indicates link status (ON if auto-negotiation has successfully established a connection), yellow LED indicates activity (ethernet connection is busy/traffic is present).

Address: The module IP address can be preset by the user and loaded from internal non-volatile memory (static), or it can be automatically (dynamically) acquired at startup via a network server using a BOOTP (Bootstrap Protocol), or DHCP (Dynamic Host Configuration Protocol). The unit also includes a default mode toggle switch to cause the module to assume a "known" fixed static IP address of 128.1.1.100 for troubleshooting purposes.

Controls & Indicators

LED Indicators:

RUN (Green) - Constant ON if power is on. Continuous flashing ON/OFF indicates unit is in "wink" ID mode.

ST (Yellow) – Blinks ON/OFF in default communication mode, and blinks more rapidly following a watchdog timeout.

LINK (Green) – Indicates Ethernet *link* status (ON if auto-negotiation has successfully established a connection).

ACT (Yellow) – Indicates Ethernet *activity* (Ethernet connection is busy/traffic is present).

Controls:

Reset/Default Address Switch: This momentary toggle switch is located on the front panel and is used to either reset the module (toggle right), or cause the module to assume a default IP address (toggle left). Static module address is initially set to 128.1.1.100 at the factory, or may be preset by the user. This switch can also be used to restore the module to its initial factory configuration by holding this switch in its default position while powering up the unit (see "Getting Out Of Trouble" in the Troubleshooting section for more information).

ACCESSORY CABLES

The minimum cable required for full operation of this device is Category 5. The term "Category" refers to classifications of UTP (Unshielded Twisted Pair) and STP (Shielded Twisted Pair) cables. There are 3 main categories of cable – Category 3, Category 4, and Category 5. The differences in

classification is found in their electrical performance and this is documented in the TIA/EIA 568-A standard.

This device is designed for use in harsh industrial environments. Acromag recommends the use of shielded cable when wiring to this device. Select STP (Shielded Twisted Pair) cable rather than UTP (Unshielded Twisted Pair). The use of shielded cable will help protect the data being transmitted from harmful EMI (Electromagnetic Interference) and RFI (Radio Frequency Interference). It will also help to lower your radiated emissions by keeping the cable from emitting EMI and RFI.

There are two types of cable conductors: solid cable and stranded cable. Stranded cables are more flexible than solid cables. But since attenuation is higher for stranded cables than solid conductor cables, these are generally reserved for short runs and patch applications less than 6 meters.

ACCESSORY CABLES

Currently there are two types of shielding employed in Category 5 STP cable: single-shielded and double-shielded. Both of these cables have the same core and jacket as UTP cables, but also include a thin foil outer shield that covers all four twisted-wire pairs. Variations may include a drain wire that encircles the outer jacket. A double-shielded version adds an outer wire screen that surrounds the foil shield and also functions as a drain wire. The drain wire or wire screen typically makes contact at each end of the cable with the metal shield around special RJ45 plug connectors. This shield then makes contact with the metal shield of shielded RJ45 sockets. The socket shield may make direct contact with earth ground, or it may be capacitively coupled to earth ground. In the Acromag 9xxEN modules, it makes contact with earth ground via a high voltage capacitor and transient voltage suppressor. In addition to separately isolating the shield, this helps to minimize radio frequency and electromagnetic interference, and has the added benefit of protection from ESD (Electro-Static Discharge).

Further, Acromag recommends the use of *enhanced* Category 5 cable (CAT-5e). This cable has all the characteristics of Category 5, but includes enhancements that help to minimize crosstalk. Category 5e cable has a greater number of turns-per-inch in its twisted pairs and its performance is also more suitable for applications that make use of all four wire pairs for simultaneous bidirectional data transmission (full-duplex). As such, it is rated for frequencies up to 200MHz, double the rate of Category 5. This cable is defined in TIA/EIA-568A-5 (Addendum 5).

Patch Cable & Crossover Cable

Acromag offers the following cable accessories for use with this module:

Cable Model 5035-355 – A yellow, 3 foot long, single-shielded Category 5e STP patch cable with drain wire and an RJ45 plug at both ends. Use this cable to connect an Acromag 9xxEN I/O module to the Acromag 900EN-S005 switch.
Cable Model 5035-360 – A green, 5 foot long, single-shielded Category 5e STP crossover cable with a drain wire and an RJ45 plug at both ends. This cable performs the Ethernet crossover function and is used to connect a PC directly to an Acromag Series 9xxEN I/O module.

Note that you do not need to use a crossover cable to connect your PC to this module if the Acromag 900EN-S005 switch is used between the PC and module, as the switch is auto-crossing. However, you must use a crossover

cable when directly connecting your PC to a Series 9xxEN I/O Module without the use of an auto-crossing switch or hub.

You may obtain cable in other lengths and colors as required for your application from other vendors. For example, shielded CAT-5e cable is available from the following vendors:

- L-com Connectivity Products, www.L-com.com
- Pro-Link, www.prolink-cables.com

Patch Cable & Crossover Cable

For very noisy environments or in the presence of strong electrical fields, you can obtain double-shielded CAT-5e cable and shielded RJ45 plugs from the following vendors:

- L-com Connectivity Products, www.L-com.com, see cable model TFSC2004 and shielded plug T8P8CSR.
- Regal Electronics, www.regalusa.com, see shielded plug model 1003B-8P8CSR-C5.

Complete premium double-shielded Category 5e standard and crossover cables in variable lengths can be obtained from Lumberg at www.lumbergusa.com (refer to their etherMate line). For example, specify RJ45S-RJ45S-656/B/3M for a double-shielded, 3 meter straight cable. Specify RJ45S-RJ45S-656/BX/3M for a double-shielded, 3 meter crossover cable.

Revision History

The following table shows the revision history for this document:

Release Date	Version	EGR/DOC	Description of Revision
21 JUN 12	F	TPH/KLK	Updated input over/under range specifications (ECN 12A011).
04 JAN 13	G	CAP/BNB	Added ATEX and updated CE specifications (ECN 12L019).
21 APR 14	H	CAP/SRW	Update ATEX per latest standards (ECO 14D012).
09 JAN 2019	J	CAP/ARP	Update "WARNING - EXPLOSION HAZARD - Substitution of any components..." per uL.

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