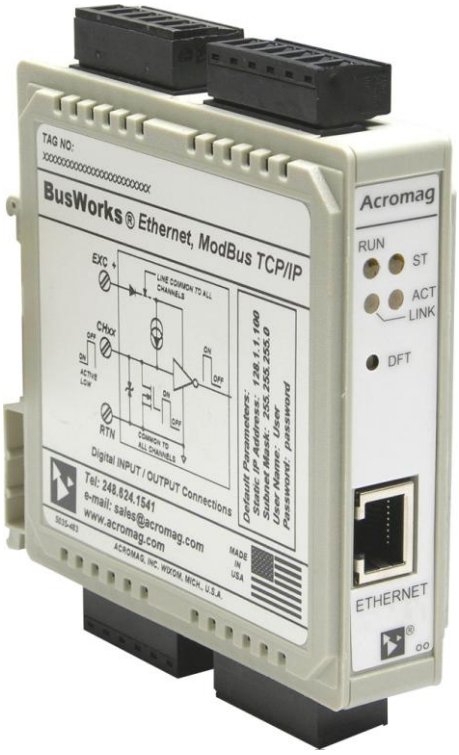
BusWorks® 900EN Series
Modbus TCP/IP 10/100MB Industrial Ethernet I/O Modules

Model 989EN-4016 16 CH DI/O w/ Event Counters (Industrial Grade)
Model 989EN-4C16 16 CH DI/O (Commercial Grade)

USER'S MANUAL



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8500-805-H12A011

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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.

This product is compatible with Internet Explorer 7 and Mozilla Firefox v2.0

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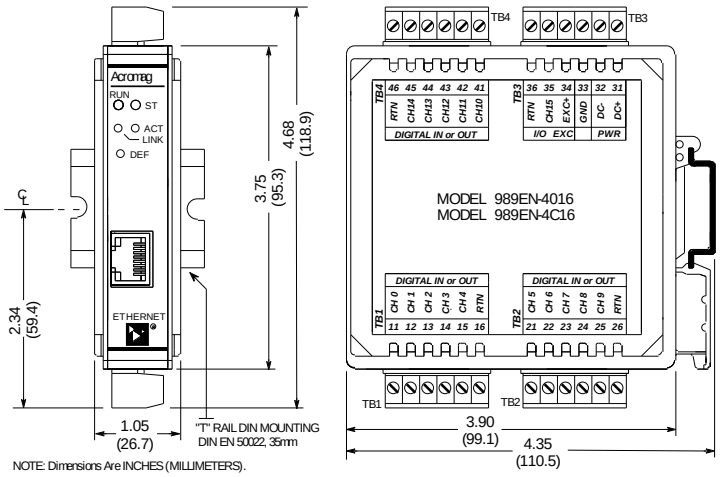
IMPORTANT SAFETY CONSIDERATIONS

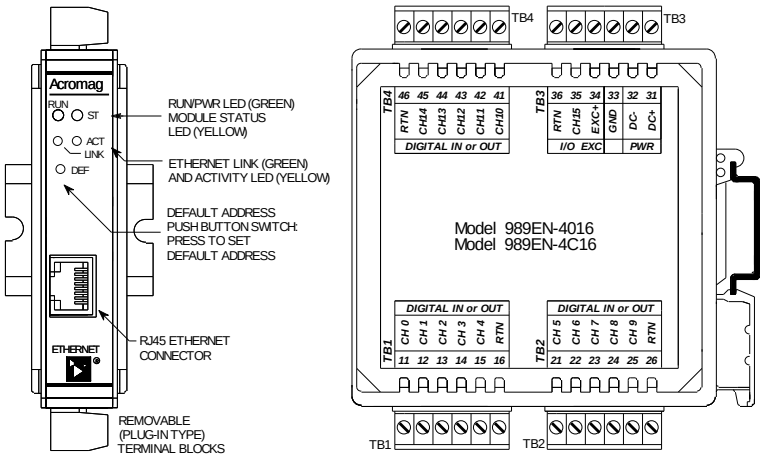
You must consider the possible negative effects of power, component, wiring, sensor, or software failure in the design of any type of monitoring or control system. This is very important where property loss or human life is involved. It is important that you perform satisfactory overall system design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

GETTING STARTED

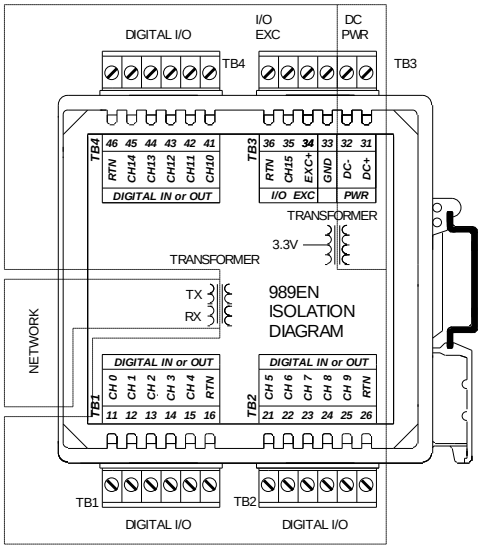
TECHNICAL REFERENCE



MODEL 989EN ENCLOSURE DIMENSIONS



The push-button is used to toggle the module into or out of Default Mode. In Default Communication Mode, 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 "password". To activate it, hold down the DFT button on the front panel for five seconds (until the ST LED blinks on/off slowly. To disable this feature, hold the DFT button for another five seconds or until the ST LED stops blinking.



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 slowly if module is in default communication mode, and blinks rapidly if a watchdog timeout has occurred.

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

Yellow ACT LED signals PHY network Activity (busy).

ISOLATION BARRIERS

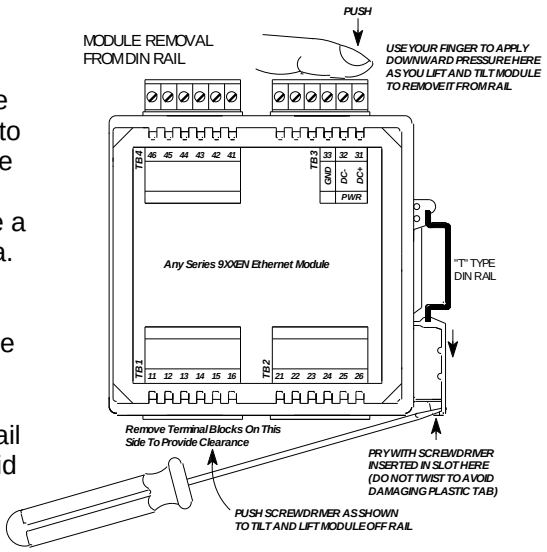
Dashed Lines denote isolation barriers.

The I/O circuit, network, and power circuits 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, at a minimum, use data grade Unshielded Twisted-Pair (UTP) wiring that has a 100Ω characteristic impedance and meets the EIA/TIA Category 5 wire specifications.

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

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

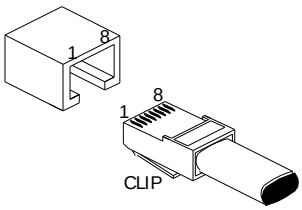
In either case, you are limited to 100 meters between any two devices.

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

ETHERNET PORT



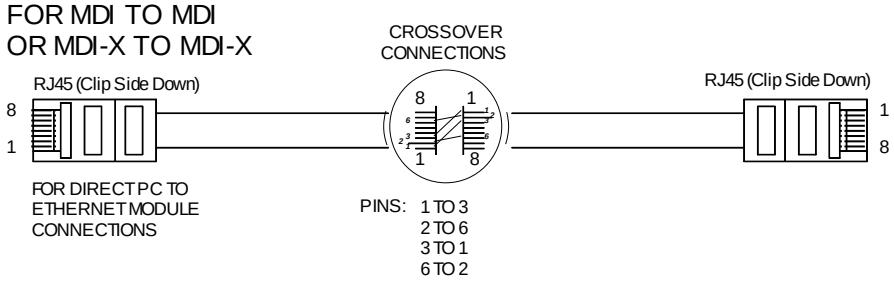
RJ-45 CONNECTOR

MINIMUM RECOMMENDED CABLE

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

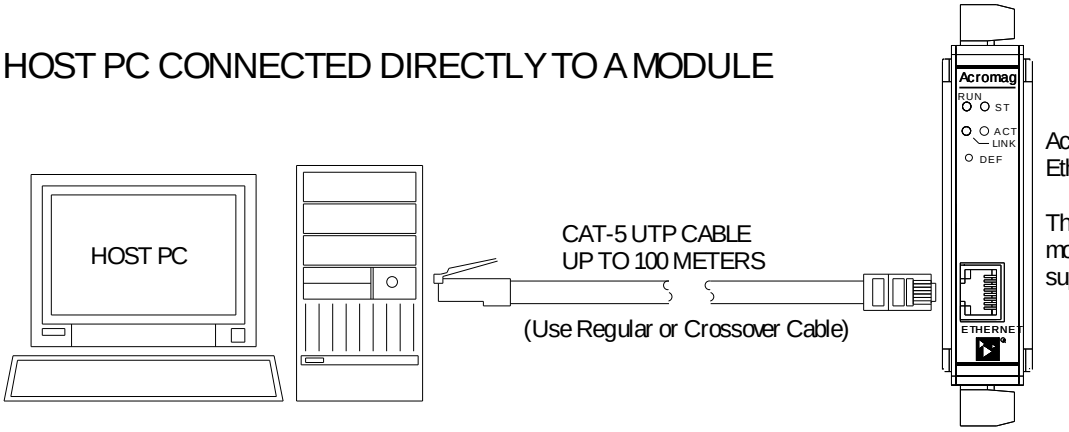
The Ethernet port of this unit is wired MDI-X by default, but includes automatic crossover (the Ethernet port of your PC is typically wired MDI). Thus, you can use either a straight-through or crossover cable to connect this device directly to a PC, Ethernet switch, or another unit.

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



From the factory, the 989EN unit has a default IP address setting of 128.1.1.100, and a class C subnet mask of 255.255.255.0. This defines a restricted default address domain that your current network cannot address directly, unless you first create an exclusive subnet targeted to the 989EN. This typically involves a process by which you either change the address of your current network interface card (which will temporarily disable it from your own network), install a second network interface card, or obtain an unused PC or laptop with a NIC installed. In any case, you must set the address of your network interface card to an address within the default address domain. That is, an address from 128.1.1.0 to 128.1.1.255, except for 128.1.1.100, which is the default address of the 989EN itself. Once you are able to address the unit at its default address, you can then reconfigure its IP address setting to an address more meaningful to your own network. Application Note 8500-734 is downloadable from the Acromag website and covers this process in greater detail.

HOST PC CONNECTED DIRECTLY TO A MODULE



Acromag 989EN-4016 Ethernet Module.

The ethernet port of this module is wired MDI-X, but supports automatic crossover.

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.

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.

CONNECTIONS

Network

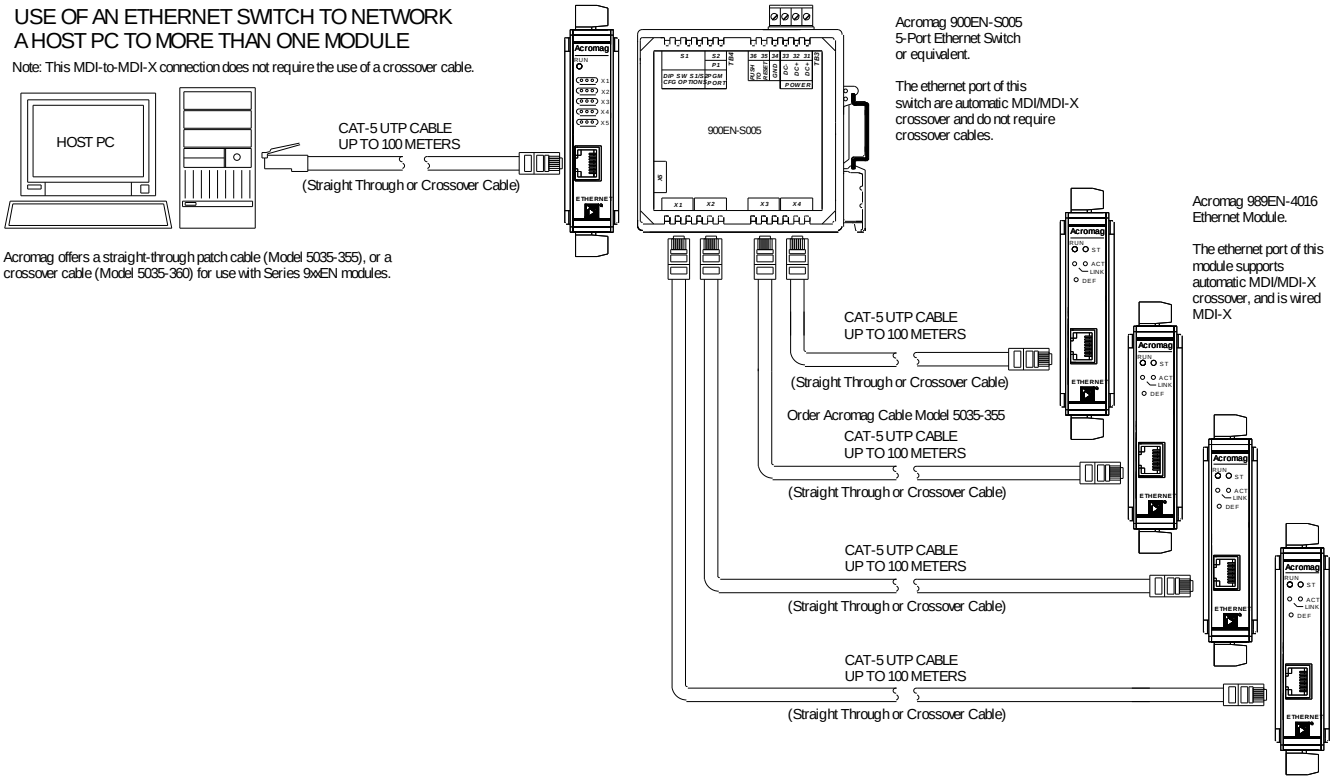
A crossover cable simply connects the differential transmit pair on each end, to the receive pair on the opposite end.

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

CONNECTIONS

Network

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 these modules to a 5-port Ethernet switch (Acromag Model 900EN-S005). Note that the 900EN-S005 switch includes automatic MDI/MDI-X crossover and straight-through or crossover cable(s) may be used, but it is generally not good practice to use crossover cables when connecting to an auto-crossing switch.

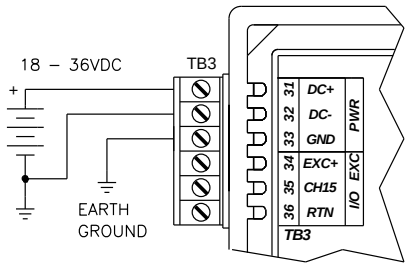


Power

✓ Connect 18-36V 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.

Voltage	Current (Typ)	Current (Max)
18 VDC	66 mA	73 mA
24 VDC	49 mA	54 mA
36 VDC	33 mA	37 mA

Note: *Current draw figures do not include excitation current.*



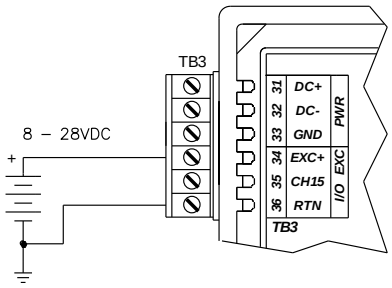
CAUTION: Risk of Electric Shock – More than one disconnect switch may be required to de-energize equipment before servicing.
IMPORTANT – External Fuse: If unit is powered from a supply capable of delivering more than 1A to the unit, it is recommended that this current be limited via a high surge tolerant fuse rated for a maximum current of 1A or less (for example, see Bel Fuse MJS1).

CONNECTIONS

Excitation

✓ Connect 8-28V DC to the excitation terminals labeled EXC+ and RTN. Optionally you can jump DC input power to Exc+ as long as it does not exceed 28VDC. Observe proper polarity. For supply connections, use No. 14 AWG wires rated for at least 75°C. **CAUTION:** Do not exceed 35VDC peak.

IMPORTANT: You MUST connect an excitation supply to the excitation (EXC) and Return (RTN) terminals in order to operate I/O.



Note: *Excitation can be optionally be sourced from the input power supply.*

CAUTION: *Excitation voltages greater than 28V do not guarantee I/O operation. Make sure that if you jump input power to excitation, that it is less than or equal to 28VDC.*

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

Earth Ground

✓ Connect Earth Ground as shown in the connection drawings on previous page. 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 module housing is plastic and does not require its own 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 negatively affect performance.*

Digital Inputs

✓ Connect digital input signals to the input terminals as shown on the following page. The tandem outputs must remain OFF in order to drive inputs externally.

To drive the inputs from an external source, you must turn the corresponding outputs OFF, or the output channel will be in contention with your external input signal.

IMPORTANT: You MUST connect an excitation supply to the excitation (EXC) and Return (RTN) terminals in order to operate I/O. External excitation should be from 8 to 28V and must provide 36mA (288mA peak), plus any output load current.

Inputs source wetting current to sense switch closure. By default, this current is set to switch to 16mA for 20ms after crossing the 4V input threshold, then return to 2mA continuous. The higher level of initial current will help to prevent oxide buildup on external switch contacts. The current can also be set to only source 2mA continuous. This current can also be turned OFF by tri-stating the port inputs.

Inputs are active-low, with 4V thresholds (3.7-4.3V range).

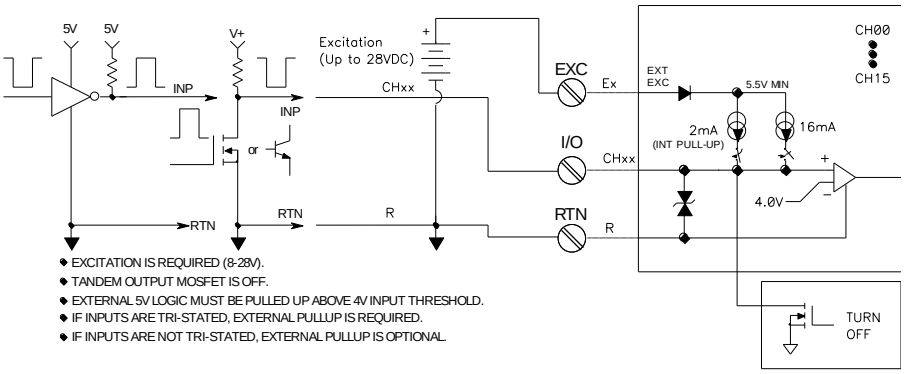
Input connections require an external excitation source. Limit input voltages to less than 31VDC maximum.

Inputs include wetting current pull-ups to sense switch closure, which also allows the open-drain output to operate without adding a pull-up.

CONNECTIONS

Digital Inputs

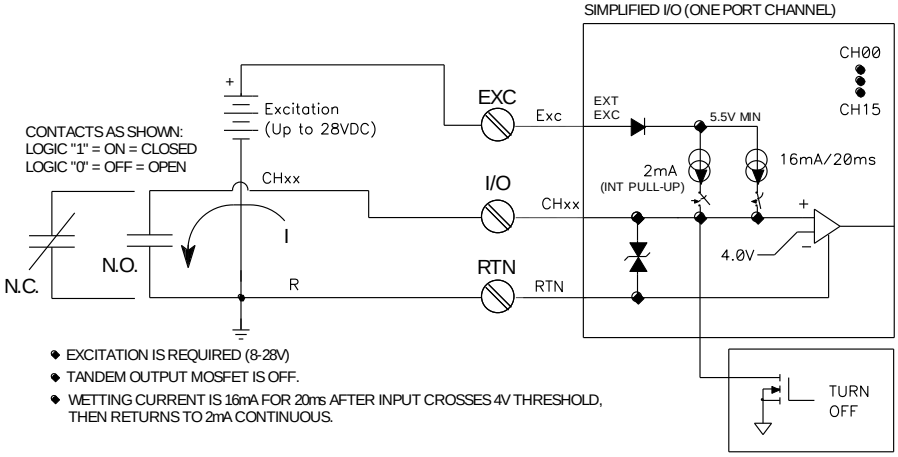
SIMPLE DIGITAL INPUT CONNECTIONS



Normally Open (N.O.) or Normally Closed (N.C.) Dry Contact Relay.

Inputs use wetting current to sense external contact state. This current normally goes to 16mA when the input descends below the 4V threshold, for 20ms, then returns to 2mA continuous.

DRY-CONTACT RELAY CONNECTIONS - NORMALLY OPEN OR CLOSED

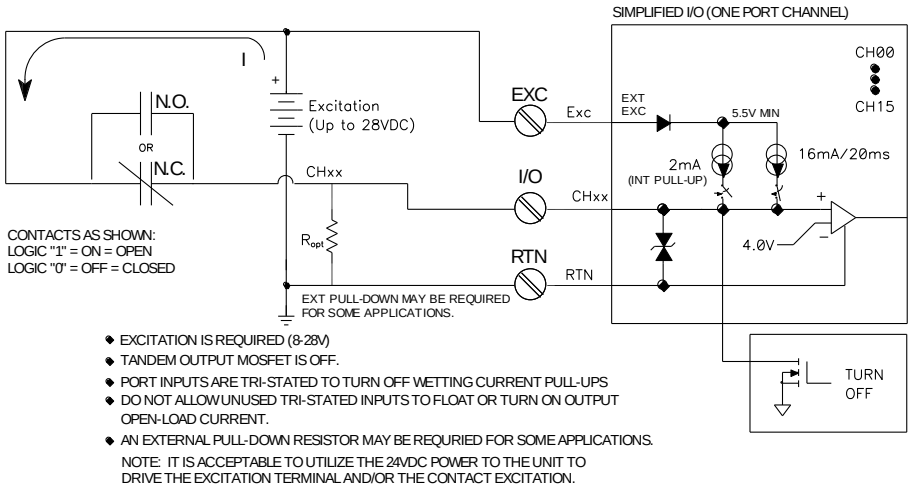


Refer to the examples that follow for other types of input connections.

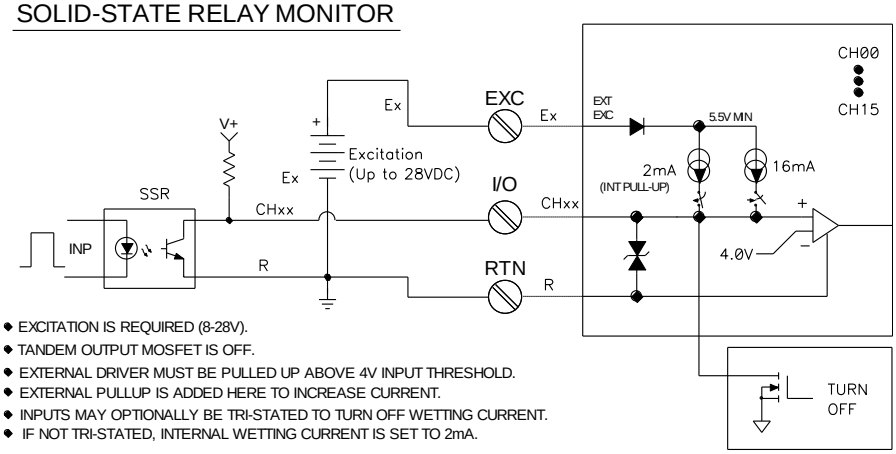
DRY-CONTACT RELAY CONNECTIONS - NORMALLY OPEN
OR CLOSED WITH EXTERNAL SERIES CONTACT EXCITATION

Normally-Closed Dry Contact Relay with Series Contact excitation

Do not exceed 31V at the inputs.



SOLID-STATE RELAY MONITOR



- EXCITATION IS REQUIRED (8-28V).
- TANDEM OUTPUT MOSFET IS OFF.
- EXTERNAL DRIVER MUST BE PULLED UP ABOVE 4V INPUT THRESHOLD.
- EXTERNAL PULLUP IS ADDED HERE TO INCREASE CURRENT.
- INPUTS MAY OPTIONALLY BE TRI-STATED TO TURN OFF WETTING CURRENT.
- IF NOT TRI-STATED, INTERNAL WETTING CURRENT IS SET TO 2mA.

TIP: You can increase wetting currents by paralleling I/O channels, or by adding an external pull-up resistor from I/O to an external excitation source.

TIP: Unused tri-stated inputs can be pulled to the ON state if you also enable the tandem output open-load detection (this adds 50uA pull-downs in the output OFF state).

Note that wetting currents are slightly lower than 2mA/16mA for excitation voltages below 8V. They will also vary slightly with the number of channels turned ON. Use external excitation equal to or above 8V to properly regulate this current to 2mA/16mA.

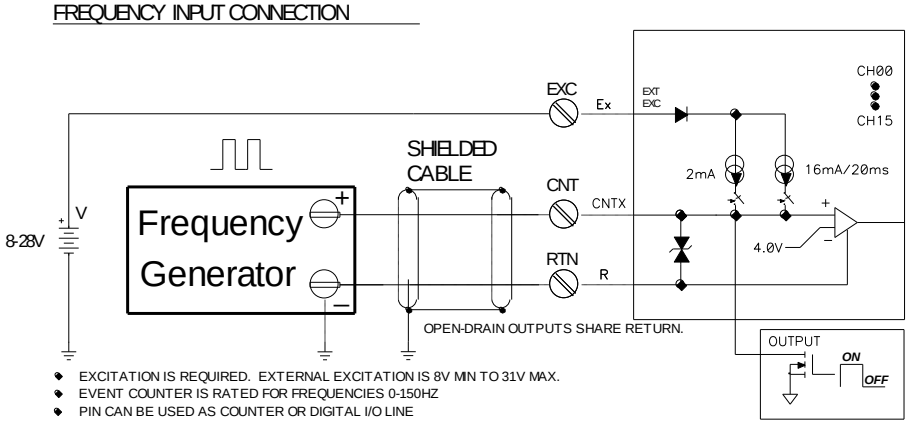
CONNECTIONS

Digital Inputs

Solid-State Relay (SSR) Monitoring

Tri-stating the inputs will turn off the wetting current pull-ups and the input will then act like a high-impedance comparator with a 4V logic threshold. If tri-stated inputs are left unconnected, the I/O channels float and will need to be tied OFF to properly register the OFF state (you could optionally use output open-load detection to pull-down unused tri-stated inputs—see TIP below).

FREQUENCY INPUT CONNECTION



- EXCITATION IS REQUIRED. EXTERNAL EXCITATION IS 8V MIN TO 31V MAX.
- EVENT COUNTER IS RATED FOR FREQUENCIES 0-150HZ
- PIN CAN BE USED AS COUNTER OR DIGITAL I/O LINE

Frequency Input Connection (989EN-4016 Only)

Input Event Counters are rated from 0 to 150 Hz with signal voltages from 0 to 28 VDC (4V Threshold). Your excitation voltage determines your input voltage signal range maximum. These 32-bit counters are additionally equipped with a programmable debounce, up/down counting, selectable edge, and count auto-restore after a power reset.

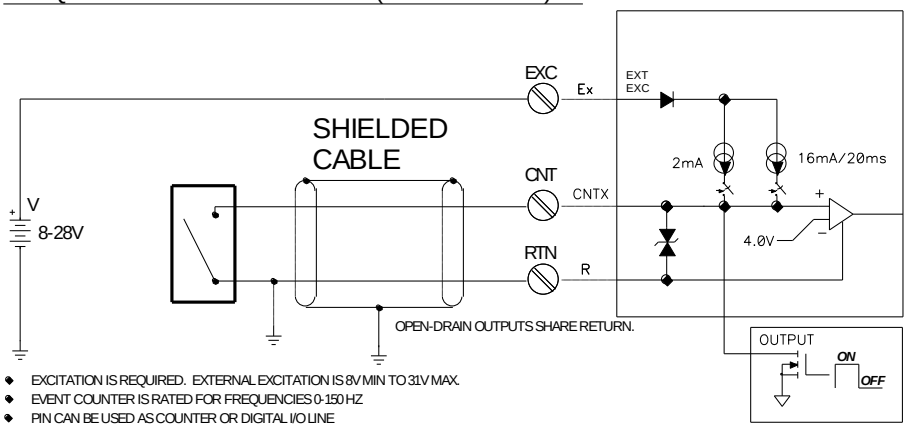
CONNECTIONS

Digital Inputs

Dry Contact Frequency Input Connection (989EN-4016 Only)

To accommodate dry-contact relays, counters are equipped with programmable debounce. The debounce time can be set from 0 to 65535 ms. The debounce time represents the amount of time an input must remain stable to increment the count.

FREQUENCY INPUT CONNECTION (DRY CONTACT)



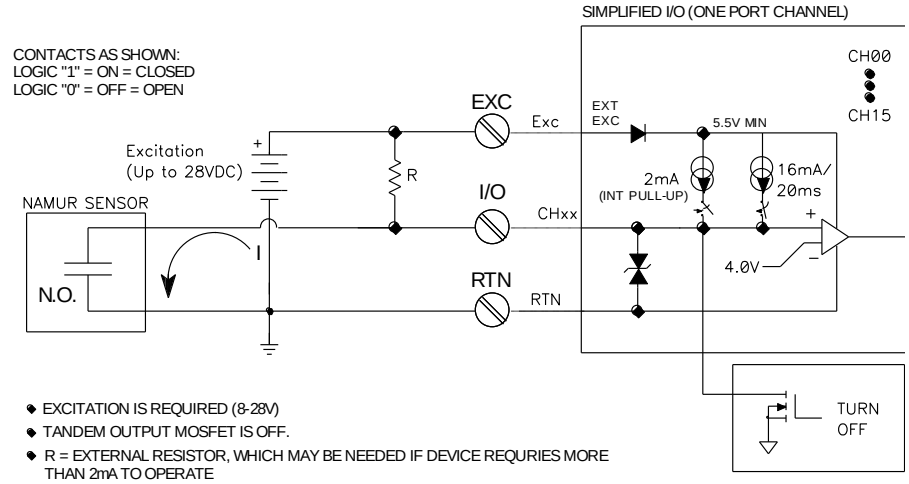
- EXCITATION IS REQUIRED. EXTERNAL EXCITATION IS 8V MIN TO 31V MAX.
- EVENT COUNTER IS RATED FOR FREQUENCIES 0-150 HZ
- PIN CAN BE USED AS COUNTER OR DIGITAL I/O LINE

Note – Counters will auto restore count values from non-volatile memory after a power loss. This option can be disabled through the webpage or via Modbus if desired.

2-Wire Namur/Proximity Sensor Connection (989EN-4016 Only)

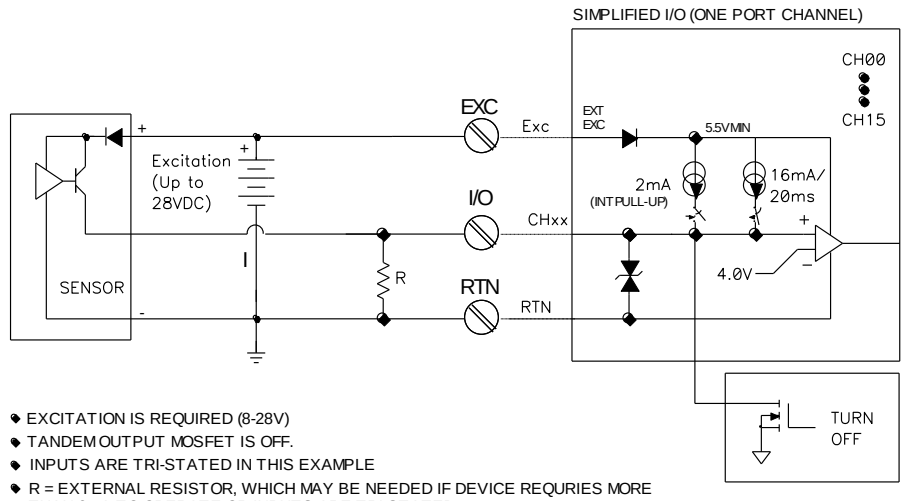
To accommodate Namur/Proximity sensors, the 989EN can source current to drive the sensor. If the device requires more than 2mA to operate, an external pull-up can be added between Excitation and the Counter Channel to ensure proper current.

2-WIRE NAMUR / PROXIMITY SENSOR NORMALLY OPEN



- EXCITATION IS REQUIRED (8-28V)
- TANDEM OUTPUT MOSFET IS OFF.
- R = EXTERNAL RESISTOR, WHICH MAY BE NEEDED IF DEVICE REQURIES MORE THAN 2mA TO OPERATE

3-WIRE SOURCING PROXIMITY SENSOR

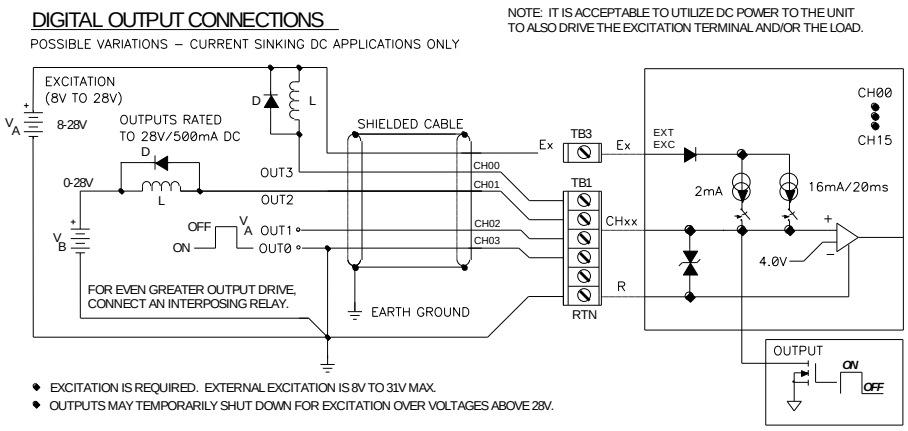


- EXCITATION IS REQUIRED (8-28V)
- TANDEM OUTPUT MOSFET IS OFF.
- INPUTS ARE TRI-STATED IN THIS EXAMPLE
- R = EXTERNAL RESISTOR, WHICH MAY BE NEEDED IF DEVICE REQURIES MORE THAN 2mA TO OPERATE OR INPUTS ARE TRI-STATED

CONNECTIONS

Digital Outputs

✓ Connect your output load to the output terminals as shown below.

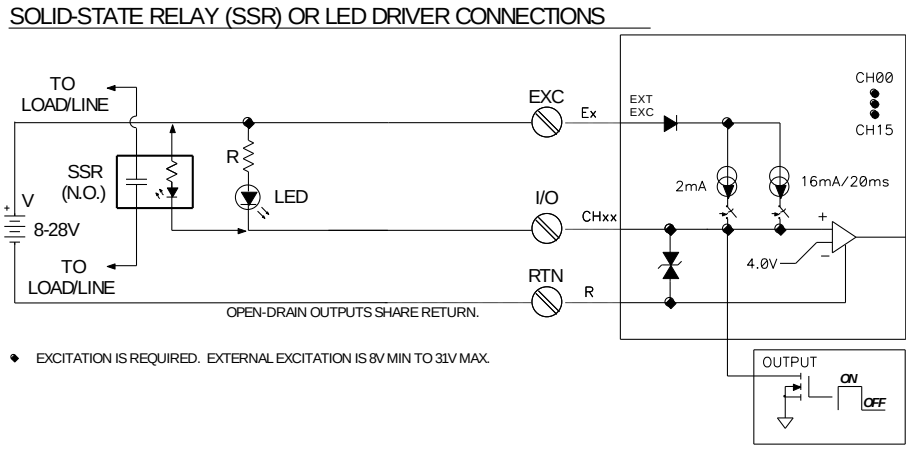


Note - You must connect port excitation to operate I/O. Your excitation voltage should be greater than your load voltage. Outputs may temporarily shut down for excitation voltages over 28V, or load voltages greater than 31V.

IMPORTANT – Add Protection With Inductive Loads: Outputs should include reverse-bias shunt diodes to help protect the output switch from damage due to the high reverse-bias voltages normally generated when switching inductive loads. You should add external protection near the inductive load to prevent these transients from being sent along the connection wires. Place a diode (1N4006 or equivalent) across an inductive load with the cathode to (+) and the anode to (-).

LOAD GROUNDING: If your load is connected at some distance from the unit, or your load currents are high, earth grounding the return lead should be done local to the I/O terminals to allow the built-in transient protection to effectively shunt to earth via a low impedance path not affected by IR losses.

Refer to the examples below for other types of output connections.



Outputs are the open-drains of mosfet switches and are intended for DC current-sinking applications only.

Note: *Outputs will turn OFF (open) following a software reset or power interruption to the unit.*

Do NOT connect outputs to voltages greater than 31V or damage to the I/O port may result. The 31V limit is the working voltage limit of the built-in transient voltage suppressors at each I/O channel.

Solid-State Relay (SSR) or LED Driver

You should also consider whether open-load detection feature should be enabled, as this can pull 50uA of drive current through the load in the OFF state.

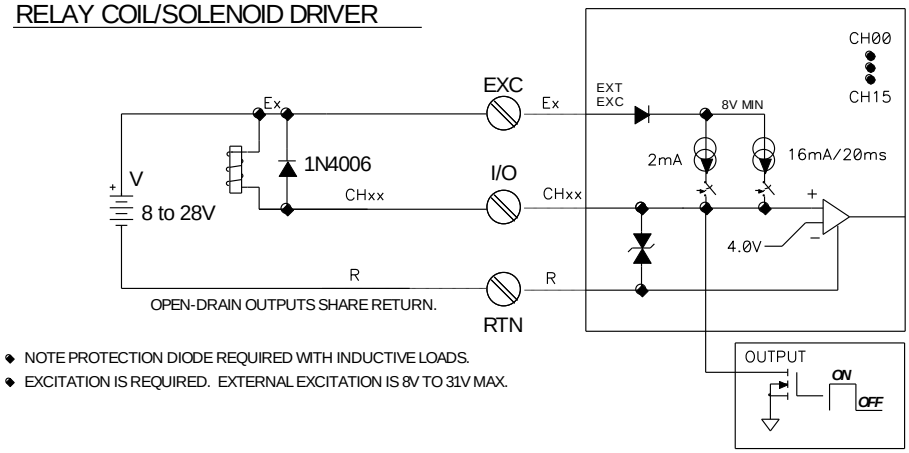
CONNECTIONS

Digital Outputs

CAUTION: If Output Open Load Detection is enabled, up to 50uA of current will be pulled through the load with the output in the OFF state. Do not enable open-load detection if you are driving loads that cannot tolerate 50uA of "leakage" current in the OFF state, or if you do not want inputs pulled to the ON state.

Relay Coil or Solenoid Driver (Note Protection – External "Snubbing" Diode at Coil)

RELAY COIL/SOLENOID DRIVER



- NOTE PROTECTION DIODE REQUIRED WITH INDUCTIVE LOADS.
- EXCITATION IS REQUIRED. EXTERNAL EXCITATION IS 8V TO 31V MAX.

Digital Counter Output Alarms

Alarm outputs are the open-drains of mosfet switches and are intended for DC current-sinking applications only.

Digital Counter Alarm Outputs (989EN-4016 Only):

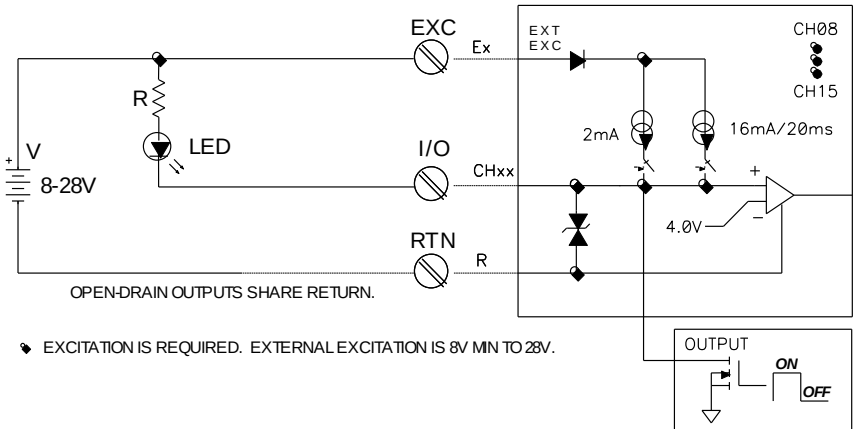
Each of the eight counter channels on the 989EN-4016 has a corresponding Alarm Output (8 Channels). These counters can be set to toggle the output state upon alarm. They can be programmed to be reset either by the next event count (momentary alarm), or by a manual reset (latching alarm). Operation of the Alarm output is the same as standard Digital Outputs.
***Note**:* Excitation is required for Alarm Outputs to operate.

Alarm Output LED Driver

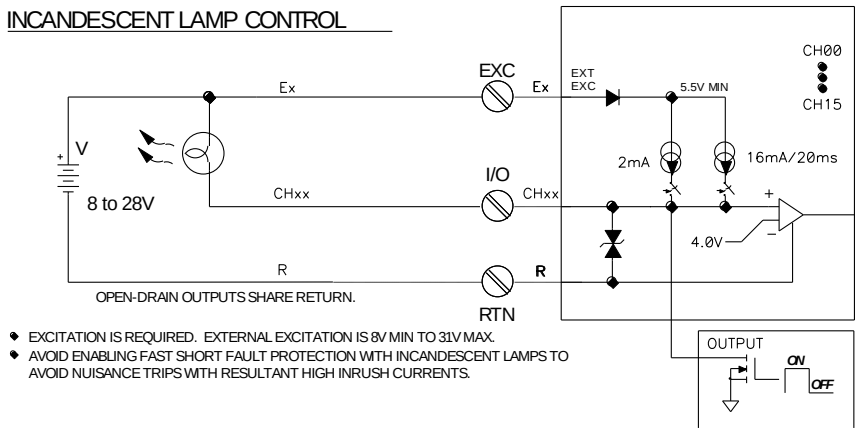
Alarm Outputs have the same characteristics as all the other Digital Outputs.

***Note:** Alarm Outputs must be enabled in order to operate.*

ALARM OUTPUT LED DRIVER CONNECTIONS



- EXCITATION IS REQUIRED. EXTERNAL EXCITATION IS 8V MIN TO 28V.



Other Considerations For Output Control

- Built-in protection in the outputs will automatically shut-down specific output operation for current-limit, thermal overload, excitation over-voltage, and output drain over-voltage conditions. The outputs can optionally be programmed to automatically retry their control, or remain OFF following a thermal or over-voltage shut-down (default response).
- If you enable open-load detection, a 50uA pull-down current will be present with the output in the OFF state. This opposes the input wetting current pull-up, so inputs must be tri-stated for this to work. You may wish to reconsider enabling this detection if you happen to be driving loads sensitive to small currents, or you cannot tolerate unused inputs being pulled to the ON state.

You can select a faster responding 100-450us shutdown mechanism that is triggered based on output Vds measurement (default), as opposed to a thermal shutdown which allows the output to heat-up. Normally if an output drives a shorted load, built-in thermal protection will kick-in to protect the output. This effectively allows output port protection to be tailored to incandescent lamp loads (thermal), or inductive loads (faster). However, the fast shutdown may not trigger the thermal fault flag, as it acts too fast to capture. But fast action does limit repeated thermal stresses which helps preserve the life of the output driver.

CONNECTIONS

Digital Outputs

Incandescent Lamp Control

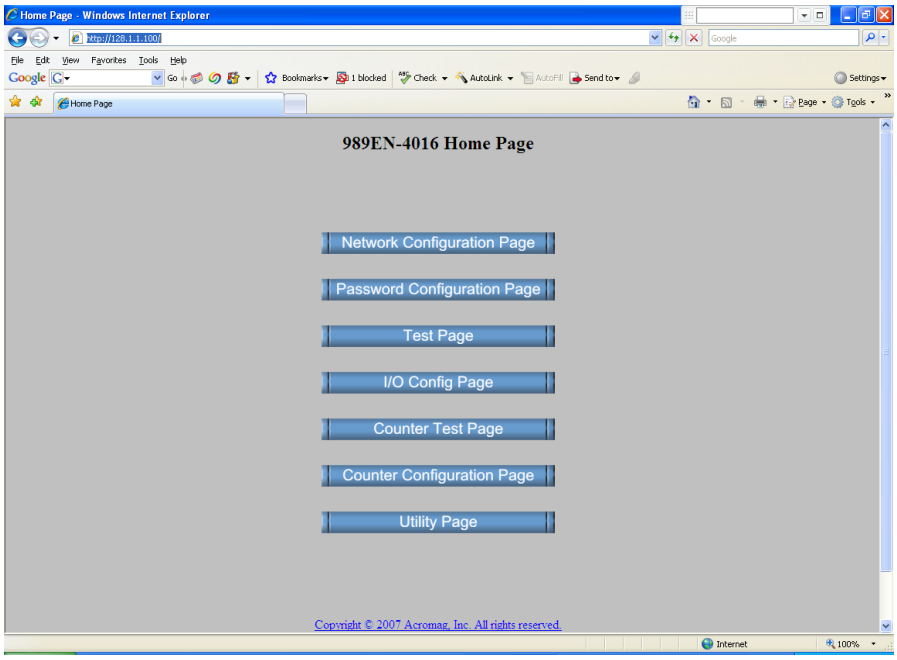
To drive lamps, you may avoid using the fast short-fault protection mode as it might cause nuisance shut-downs as a result of high ON inrush currents.

Although selecting fast shutdown helps limit repeated thermal stress on the output driver, it acts too fast to report it via the output fault flags.

WEB BROWSER

Home Page

This module supports Modbus over TCP/IP. You may use your own software to issue Modbus commands 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 and control 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:



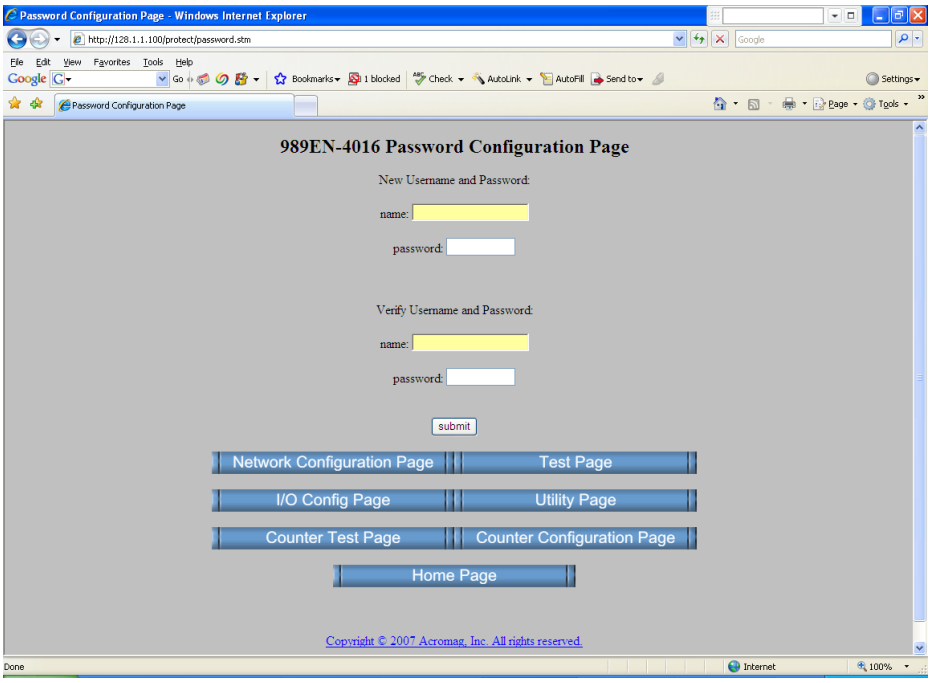
The Home Page provides buttons to access the other web pages of this module that are used to configure the network parameters, change the user name and password, and operate the module. For each new browser session that accesses the Home Page of this module, you will be presented with a window prompting you to enter the current User Name and Password as shown on the following page. This information is required before the program will allow you to make any other selections. **The default user name and password is "User" and "password" respectively.** After entering these defaults, you may wish to invoke the Password Configuration Page to change these parameters to something more meaningful for you.

Note: If you cannot download the module web page, it may be that the address of your network interface adapter is not set to a valid IP address within the module's default address domain. Refer to Applications Note 8500-734 for information on how to accomplish this.

IMPORTANT: If you forget your user name and password, you can always toggle the module into default mode via the default mode push-button at the front of the module, and the password and username will revert to the original defaults noted on the previous page (unit assumes IP address 128.1.1.100), thus allowing you to re-invoke the Password Configuration Page and change the username and password as required.

WEB BROWSER

Home Page



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.

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.

WEB BROWSER

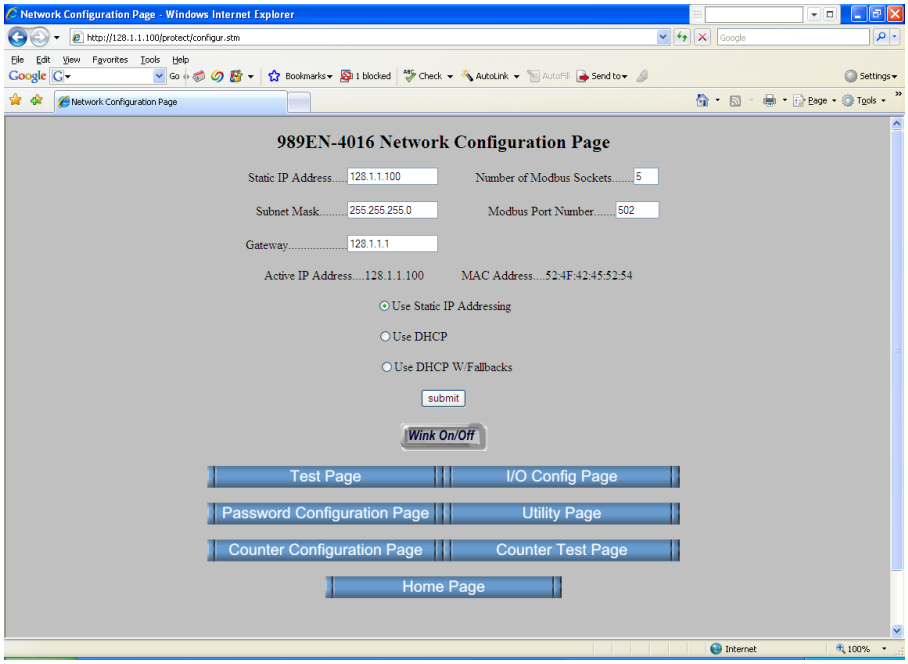
Network Configuration

After setting your username and password, you can click the "Network Configuration Page" button and a screen similar to that shown below will appear. Use this screen to set the network configuration parameters for your module. You may have to consult your network administrator to complete the contents of this page.

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 Mode static IP address assigned to this module is 128.1.1.100 (refer to product side label).

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



This module can be placed into a default communication mode via the DFT push-button at the front of the module. To activate, hold the DFT button for 5 seconds. The Status LED will start a slow blinking to indicate default mode.

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 "password".

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 or document 8500-815 to help accomplish this (located on the CDROM shipped with your module or via download from our web site at www.acromag.com).

The **Number of Modbus Sockets** refers to the number (1-5) of Modbus TCP/IP access points to allow for this host. The default allows up to 5 sockets, but you can restrict access by reducing this number

The **Modbus Port Number** is set to port 502 by default, which has been reserved for Modbus applications. Port numbers represents an endpoint or "channel" for network communications. In this way, every IP address is divided into many ports, and when one computer sends data to another computer, it sends the data from a port of an IP address to a port on another IP address. Any one port can only be used by one program at a time. The use of port numbers allows different applications on the same computer to utilize network resources without interfering with one another. The port number could range from 0-99999, but most popular applications will use port numbers at the low end of this range already set aside for specific applications (such as 502 for Modbus, or 80 for HTTP). For example, ports make it possible for you to check your email and browse the web at the same time, because web browsers use port 80, while retrieving your email uses port 110.

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 **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. In 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).

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, or DHCP w/Fallbacks. This will also require that you specify a valid Host Name. Note that DHCP w/Fallback will revert to the static IP address if your DHCP server cannot be found at the address specified.

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. For example, DHCP with fallback will revert to a static IP address if the DHCP server cannot be found.

WEB BROWSER

Network Configuration

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 "password".

WEB BROWSER

Network Configuration

The unit includes a default address push-button to cause the module to assume a fixed default static IP address (128.1.1.100). This button is at the front of the module and is used to toggle the module into, or out of Default Mode. If you use the push-button 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.

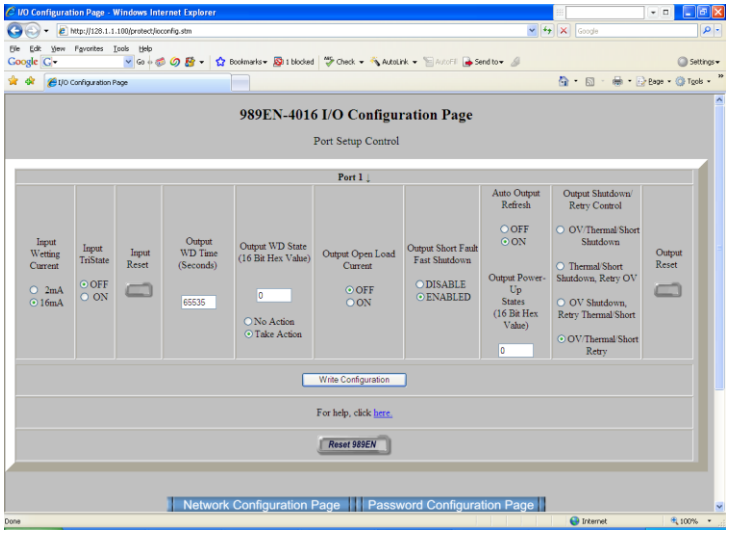
Click the **Wink On/Off** button to toggle the module in/out of "wink" ID mode. In this mode, the module's green RUN LED will blink to confirm identification.

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

I/O Configuration Page

After completing the username/password assignment, plus the network configuration parameters, you can use the I/O configuration page to setup your I/O.

You can select from various modes of operation for the input and output channels of each port. Once you have carefully made your selections, click the "Write Configuration" button at the bottom of the page to activate your configuration (reconfiguration takes effect immediately following "Write Configuration").

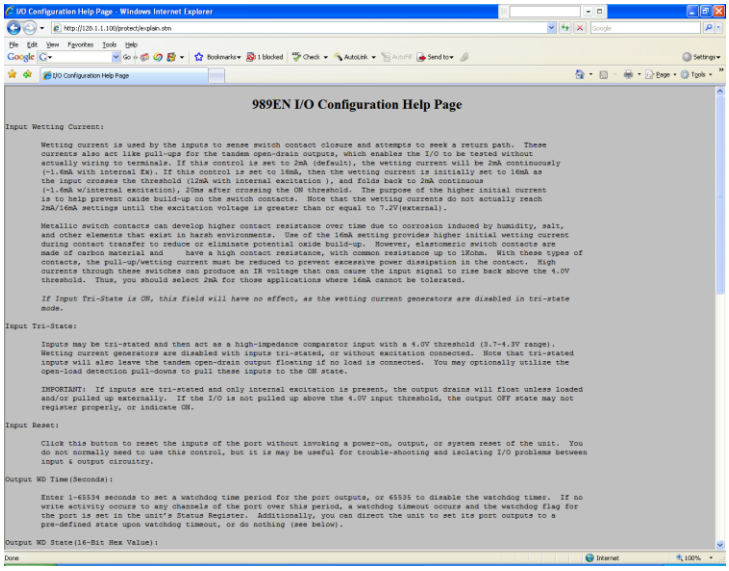


Note: The 989EN is equipped with one I/O Port of 16 channels and configuration is done on a port-wide basis.

I/O Configuration Page Help

By clicking on the link at the bottom of the I/O Configuration Page, a quick reference help page will appear. This is useful for obtaining a description of available options.

To go back to the I/O Configuration Page, scroll to the bottom of the Help Page, and there will be a link back. Alternatively, you can click on the back button on your internet browser.



I/O Configuration Page: Help – At the bottom of the I/O Configuration Page is a help page to provide readily available answers to questions about the controls. Each control is described in detail as on the next page, but also obtainable via your internet browser.

Refer to the following definitions and the Modbus Memory Map for information on optional modes of operation:

Input Functions

Input Wetting Current 2mA/16mA – Wetting current is used by the inputs to sense switch contact closure and will attempt to seek a return path. These currents also act like pull-ups for the tandem open-drain outputs, which enables the I/O to be tested without actually wiring to the I/O terminals. If this control is set to 2mA, the wetting current will be 2mA continuously. If this control is set to 16mA(default), then the wetting current is initially set to 16mA as the input crosses the threshold, and folds back to 2mA continuous, 20ms after crossing the ON threshold. The purpose of the higher initial current is to help prevent oxide build-up on external switch contacts.

Metallic switch contacts can develop higher contact resistance over time due to corrosion induced by humidity, salt, and other elements that exist in harsh environments. Use of the 16mA setting provides higher initial wetting current during contact transfer to reduce or eliminate potential oxide build-up. However, elastomeric switch contacts are made of carbon material and have a high contact resistance, with common resistance up to 1KΩ. With these types of contacts, the pull-up/wetting current must be reduced to prevent excessive power dissipation in the contact. High currents through these switches can produce an IR voltage that can cause the input signal to rise back above the 4.0V threshold. Thus, you should select 2mA for those applications where 16mA cannot be tolerated.

If Input Tri-State is ON, this field will have no effect, as the wetting current generators are disabled in tri-state mode.

Input Tri-State OFF (Default)/ON – Inputs may be tri-stated and then act as a high-impedance comparator input with a 4.0V threshold (3.7-4.3V range). Wetting current generators are disabled with inputs tri-stated, or without excitation connected. Note that tri-stated inputs will also leave the tandem open-drain output floating if no load is connected. You may optionally utilize the open-load detection pull-downs to pull these inputs to the ON state.

IMPORTANT: If inputs are tri-stated, excitation must be above 8V, or the output drains will float unless loaded and/or pulled up externally. If the I/O is not pulled up above the 4.0V input threshold, the output OFF state may not register properly, or indicate ON.

Input Reset – Click this button to reset the inputs without invoking a power-on, output, or system reset of the unit. You do not normally need to use this control, but it may be useful for trouble-shooting and isolating I/O problems between input & output circuitry.

WEB BROWSER

I/O Configuration Page Help

I/O Configuration

The built-in wetting current generators do not operate without excitation, or with inputs tri-stated.

Without a driver, load, or pull-up connected to the I/O, the tri-stated I/O is essentially floating and may not register the OFF state correctly. In this state, you will have to use I/O pull-ups to pull the OFF state signal above 4.3V in order to be able to read back the correct I/O state.

Note that wetting currents are reduced low excitation voltages below 8V.

***TIP:** Unused tri-stated inputs may utilize the built-in open-load detection pull-downs to pull to the ON state.*

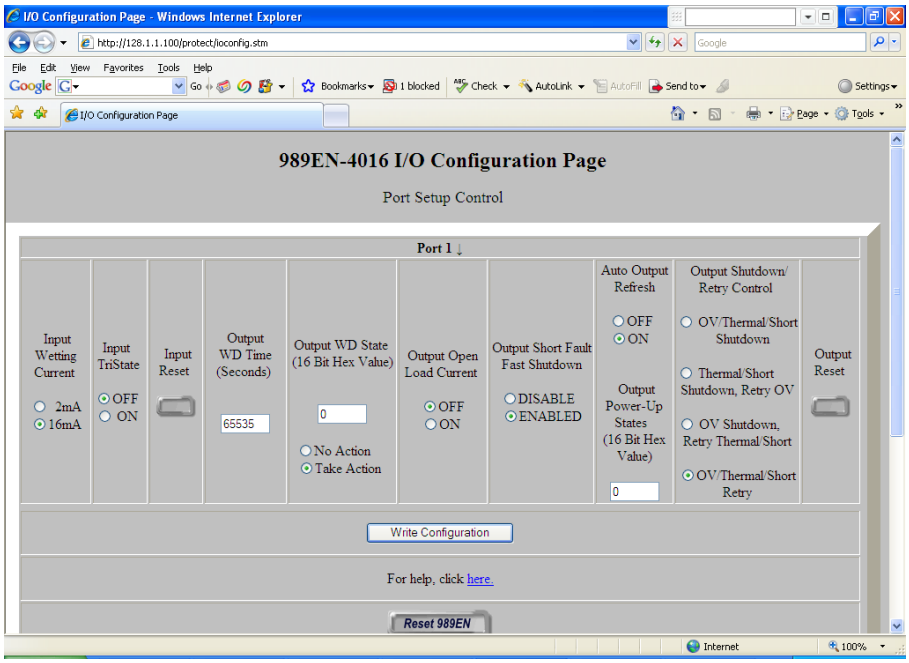
***TIP:** You can increase wetting currents by paralleling inputs, or connecting to an external excitation supply and adding an I/O pull-up to the excitation voltage rail.*

WEB BROWSER

I/O Configuration

Output Functions

Output WD Time (seconds) – Enter 1-65534 seconds to set a watchdog time period for the outputs, or 0, or 65535 to disable the watchdog timer. If no write activity occurs to any channels over this period, a watchdog timeout occurs and the watchdog flag for the port is set in the Status Register. Additionally, you can direct the unit to set its port outputs to a pre-defined state upon watchdog timeout, or do nothing (see below).



Output Functions…continued

Output WD State (16 bit Hex Value) – Upon watchdog timeout, you can direct the unit to set its outputs to this pre-defined state with "Take Action" also selected, or do nothing to the outputs with "No Action" selected. You must enter four hex digits that represent the bit settings for the 16 channels on the module. The lsb corresponds to the lowest numbered channel of the port, the msb to the highest numbered channel.

"0" = 0000, "1"= 0001, "2" = 0010, "3" = 0011, "4" = 0100, "5" = 0101, "6" = 0110, "7" = 0111, "8" = 1000, "9" = 1001, "A" =1010, "B" = 1011, "C" = 1100, "D" = 1101, "E" = 1110, "F" = 1111.

For example, enter "FFFF" to turn all port outputs ON following timeout.

Output Open-Load Current (OFF/Default or ON) – Set this ON to add a 50uA pull-down to the source to be used to detect open load faults when the inputs are tri-stated. If ON, an open output load fault is flagged by a fault bit in the port's I/O status register. This pull-down current is separate from the wetting current generators (pull-ups) of the tandem inputs. If you are driving loads sensitive to low current in the OFF state, leave this feature OFF.

Output Short-Fault Protection (Thermal or Fast Shutdown) – Outputs include over-current protection normally triggered thermally, which allows the output driver to heat up for a shorted load before shutting down the output. The long-term effect of this is that it may induce thermal stress in the output IC that can shorten its life for repeated faults. This protection also acts slower, as it requires the part to heat up before shutting down. However, if you enable Short-Fault Fast Shutdown, a faster method of triggering a thermal fault is used that instead relies on output Vds measurement, not self-heating. A fast shutdown of the output will occur within 100-450us after a turn on into a short-circuit with this protection enabled. This feature is generally used to provide protection for loads that experience higher than average currents and require a fast shutdown, or to preserve an external series fuse. But a fast shutdown could become bothersome if the output happens to be driving incandescent lamps which may experience higher "inrush" currents, as opposed to inductive loads with a slower current response. Note that a fast shutdown also acts too quickly to be captured and reported via the "Any Output Fault" and Output "Thermal Fault" bits of the I/O Status register.

Output Shutdown/Retry Control – Use the Global Shutdown & Retry Control register to select how you would like the outputs to react following a thermal, output over-voltage, or excitation over-voltage fault shutdown. The output driver has built-in over-current limiting, with thermally-triggered shutdown protection, and over-voltage triggered shutdown protection. That is, an output channel may shut-down operation for output faults that occur either as a "thermal fault", or "over-voltage fault". You can elect to keep the output shut-down (if auto-refresh is also OFF), or automatically retry its control following a shutdown. If the fault has been removed, normal operation can be automatically recovered. That is, a thermal shutdown may retry the output once the part has cooled sufficiently, or the short-fault has been removed.

Auto Output Refresh – Outputs can be optionally refreshed every 5 seconds to help ensure that outputs retain their programmed states if EMI or ESD should cause an inadvertent state change. By default, this is turned OFF and it is recommended to be turned OFF to improve counter performance if you are using counters. Disabling refresh also allows an output to remain OFF following a fault condition (see Global Shutdown & Retry Control register). Note that each output includes a transient voltage suppressor that will clamp short-duration transient voltages above 31V without failure. However, sustained drain-to-source voltages above 31V will eventually destroy the TVS if no method of limiting the peak current is employed. The built-in over-voltage protection mechanism only shuts-down the output driver circuit and does not affect the parallel transient voltage suppressor.

Reset 989EN – A system reset button is included (Reset 989EN), which will reset the entire system, sending all outputs to the specified power-up/reset state.

WEB BROWSER

I/O Configuration

The Open-Load Detect feature is only useful with inputs tri-stated, as it adds a pull-down that opposes the pull-up of the input wetting current generators. Note that with inputs tri-stated, it also pulls to the ON state.

Outputs that utilize fast shutdown, as opposed to thermal shutdown, are not subject to the automatic retry control. That is, faulted outputs that are shutdown fast do not retry their control until reset, or optionally via the Auto-Output Refresh cycle.

The over-voltage shutdown may retry its control after the output drain-to-source voltage has returned to normal (below its 50V internal limit), and/or the excitation voltage below 28V. Note that this shutdown/retry control only applies to the internal output driver, not the coincident input channel circuitry (inputs will still operate normally).

WEB BROWSER

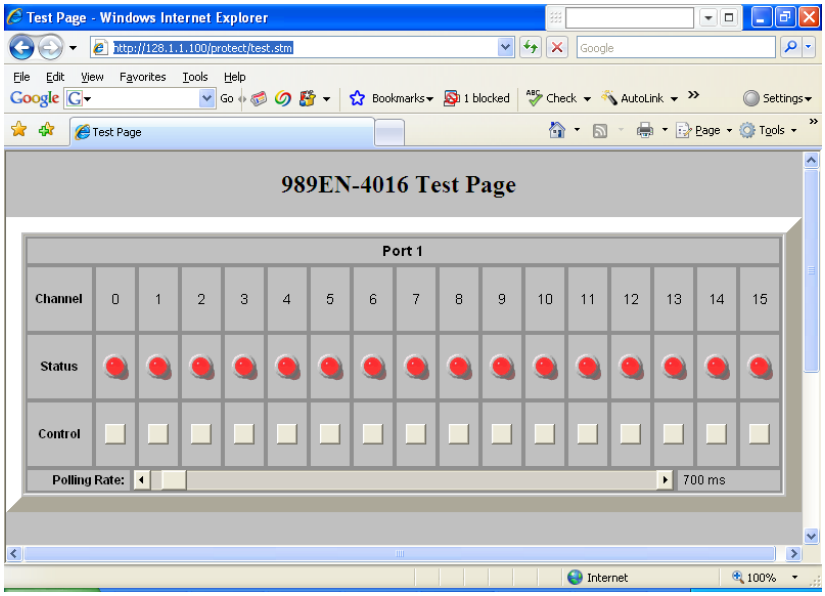
I/O Configuration

Output Reset - Click this button to reset only the output circuitry without invoking a power-on, input, or system reset of the entire unit. Note that any shut-down outputs will attempt to recover operation following a reset of the port. This control is not normally needed, but is sometimes useful for trouble-shooting and isolating I/O problems between input & output circuitry. It is also helpful to restore operation to an output that was shutdown fast, or by an output or excitation fault, without having to reset the entire system.

I/O Test Page

After completing username and password assignment, plus the network configuration parameters, and I/O configuration, you can use the Test Page to operate your module. The Test Page will allow you to read inputs, turn outputs on and off, and even set a polling rate.

When you first enter a page that includes controls like this, you may note that your first click on a control is ignored. This is because the first click activates the control.



The LED's of this page reflect the input level relative to a 4V threshold, not necessarily the ON/OFF status of the tandem output mosfet.

The state of an I/O channel is indicated by a simulated LED (bright red for "ON") below the channel number. Simply click the white control button below the LED to toggle the corresponding channel ON or OFF, as required.

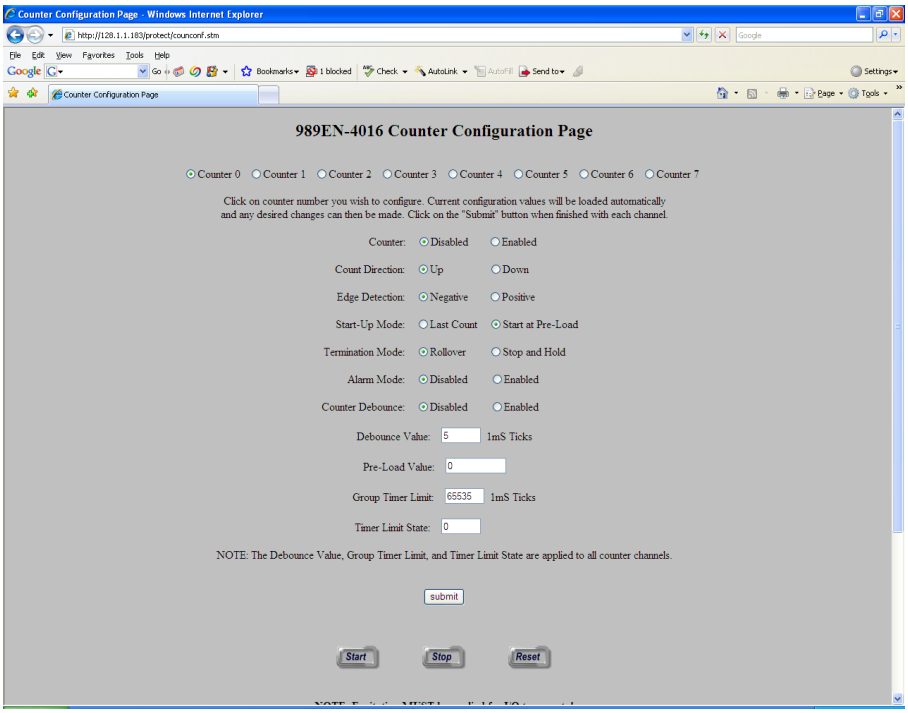
You can speed-up or slow-down the polling rate of the I/O by clicking and dragging the polling rate slide control at the bottom of the Test Page screen (rate varies from 500ms to 10000ms, rightmost setting disables polling).

TIP: *You can use the mouse to point and click on a control to toggle the corresponding output on/off, or you can use the spacebar to toggle the last output control you pointed to.*

TIP: If you ever notice that an output has shut-down its operation unexpectedly, you should review the information given on the I/O configuration page and note that an output can shut-down for conditions induced by over-current, over-heating, driving a short-circuit, and output over-voltage. Outputs can also shutdown temporarily for excitation over-voltages greater than 28V. However, outputs can also be directed to automatically retry their control once a fault condition has been removed.

A watchdog timeout is triggered if no output channel write occurs for one or more channels of a port within the time period specified. You can use the watchdog Timer Control to specify Time from 0001H to FFFEH seconds (1 to 65534s). A time value of 0000H or FFFFH (0 or 65535) will disable the timer for the port I/O. You can also define the state the outputs are to assume following a timeout. For example, enter a state value of "0" to turn OFF (open) all port outputs (failsafe state) upon watchdog timeout. You would enter "1" to turn all port outputs ON upon watchdog timeout.

The Counter Configuration Page allows you to configure each of the eight event counters. Select the counter channel at the top of the page and the configuration for that channel will be displayed below. After you've set up the channel, scroll to the bottom of the page and click submit.



Input Counter (Default = OFF) – Certain inputs may be used as event counters for signals up to 150 Hz (channels 0-7). Excitation must be connected and be 8V or above to function properly. Once a counter is enabled, the output function is disabled until the counter is disabled.
Count Direction (Default = Up) – Input signal pulses can be either counted up (Default), or counted down from a pre-loaded value.
Count Edge Direction (Default = Negative) – Input signal pulses can be detected on either a rising edge or falling edge (Default).
Start-Up Count Mode (Default = Pre-Load) – Input event counts can be configured to be stored in non-volatile memory, allowing the event count on a given input channel to be restored after a power-loss. Event counts can also be enabled to start-up with its preload value after power-loss (Default).
Counter Debounce (Default = Disabled) – Event Counters are equipped with a programmable debounce for noisy input signals such as electro-mechanical relay contact bounce.
Counter Debounce Time - Debounce Time can be set from 0 to 65535ms.

WEB BROWSER

I/O Test Page

Counter Configuration Page

The input event counters must cross the 4V threshold in order to register a count.

Note: *This page is not available on the 989EN-4C16 model.*

Note: *In order for counters to operate, proper excitation must be provided.*

WEB BROWSER

Counter Configuration Page

Note: *After a counter is enabled, the output for that channel is automatically disabled.*

Note: *Debounce time applies to all enabled channels.*

Note: *This page is not available on the 989EN-4C16 model.*

Note: *Input signals must be stable longer than the debounce time to avoid missing counts.*

Counter Pre-Load Value – Each channel can be pre-loaded with a start value for the counter from 0 – 4,294,967,295.
Counter Alarm Enable (Default = Disabled) – Event counters are equipped with alarms that can toggle the alarm output state upon reaching the termination value of 0 or 4,294,967,295.
Count Termination Mode – The outputs can be programmed to either reset the alarm after next count (auto-rollover default), or hold the alarm state until a reset is issued (latched).
Note: Once the counter has rolled-over, it will return to the pre-load value.
Group Timer Limit – This control is used to set the maximum time for the pulse timer. This value can be set from 0 to 65535ms. For further explanation of the Pulse Timer, please see the Counter Test Page section.
Timer Limit State – This control sets the state value of the timer after the Timer Limit has been reached. This value can be set from 0 to 65535.
Start Counter Button – This button will allow counting on the selected enabled counter. ***Note:*** *When counters are first enabled, counters are automatically started.*
Stop Counter Button – This button will stop the counting on the selected enabled counter. To restart the counters, click on the Start button.
Reset Counter Button – This button resets the selected counter.

Counter Configuration Examples:

IMPORTANT: Counters MUST be reset to reload the Pre-Load Value.

Problem: Configure channel 4 to be an up counter, trigger on a rising edge, with last count restore.
Solution:
Web Interface:

1. Select the Channel 4 button at the top of the page.
2. In the Counter Configuration Page, locate the Counter Enable option and select "Enabled".
3. For the Count Direction option, select "Up".
4. For the Edge Detection option, select "Positive".
5. For the Start-up Mode option, select "Last Count".
6. Click on the "Submit" button at the bottom.

Modbus:

1. To enable Counter 4, write 0010H to register 40010.
2. To configure the counter for "Up Counting", write 0000H to register 40013.
3. To configure the counter for "Positive" edge counts, write 0010H to register 40012.
4. To configure the counter for "Last Count" restore, write 0000H to register 40011.

Problem: Configure all counter channels to count up, on a falling edge, with last count restore, a momentary alarm, and a start value of 1048592.
Solution:
Web Interface:

1. In the Counter Configuration Page, for the first counter, locate the Counter Enable option, and select "Enabled".
2. For the Count Direction, select "Up".
3. For the Edge Detection option, select "Negative".
4. For the Start-Up Mode option, select "Last Count".
5. For the Alarm Mode, select "Enabled"
6. For the Termination Mode select "Rollover"
7. Type in "1048592" in the "Pre-Load Value" Edit Box.
8. Click on the "Submit" button" at the bottom.
9. Repeat Steps 1-8 for the remaining channels.

Modbus:

1. To enable all counters, write 00FFH to register 40010.
2. To configure the counters for "Up" counting, write 0000H to register 40013.
3. To configure the counters for "Negative" edge counting, write 0000H to register 40012.
4. To configure the counters for "Last Count" restore, write 0000H to register 40011.
5. To enable counter "Alarms", write 00FFH to register 40015.
6. To configure the counters for "Rollover" alarms, write 0000H to register 40014
7. Set the Pre-Load Value by writing 0010H to registers 40016-40031.

Problem: Configure all counter channels to count down, on a falling edge, with Pre-Load Value start-up, a latching alarm, and a start value of 1,000.
Solution:
Web Interface:

1. In the Counter Configuration Page, for the first counter, locate the Counter Enable option, and select "Enabled".
2. For the Count Direction option, select "Down".
3. For the Edge Detection option, select "Negative".
4. For the Start-Up Mode, select "Start at Pre-Load".
5. For the Alarm Mode, select "Enabled".
6. For the Termination Mode, select "Stop and Hold".
7. Type in "1000" in the "Pre-Load Value" Edit Box
8. Click on the "Submit Changes" box at the bottom.
9. Repeat Steps 1-8 for the remaining channels.

Modbus:

1. To enable all the counters, write 00FFH to register 40010.
2. To configure the counters for "Down" counting", write 00FFH to register 40013.
3. To configure the counters for "Negative" edge counting, write 0000H to register 40012.
4. To configure the counters for "Pre-Load" start-up, write 00FFH to register 40011.
5. To enable the counter "Alarms", write 00FFH to register 40015
6. To enable the Latching Alarm, write 00FFH to register 40014
7. To set the "Pre-Load Value", write 03E8H to registers 40017, 40019, 40021, 40023, 40025, 40027, 40029, 40031, and 40033.

WEB BROWSER

Counter Configuration Page

Note: *Counters can be configured through the webpage, or via the Modbus registers.*

WEB BROWSER

Counter Configuration Page

Problem: Configure counters 0 to 3 to count down, with a debounce time of 100ms, starting at a value of 256.

Solution:

Web Interface:

1. In the Counter Configuration Page, for the first counter, locate the Counter Enable and select "Enabled".
2. For the Count Direction option, select "Down".
3. For the Counter Debounce option, select "Enabled".
4. Type in "100" in the "Debounce Value" Edit Box.
5. Type in "256" in the "Pre-Load Value" Edit Box.
6. Click on the "Submit" button at the bottom.
7. Repeat Steps 1-6 for the remaining channels.

Modbus:

1. To enable counters 0-3, write 000FH to register 40010.
2. To configure the counters for "Down" counting, write 000FH to register 40013.
3. To enable "Debounce", write 000FH to register 40032.
4. To configure the counters "Debounce Value", write 0064H to register 40033.
5. To set a Pre-Load Value, write 0100H to Register 40017, 40019, 40021, and 40023.

Counter Test Page

When you first enter a page that includes controls like this, you may note that your first click on a control is ignored. This is because the first click only activates the control.

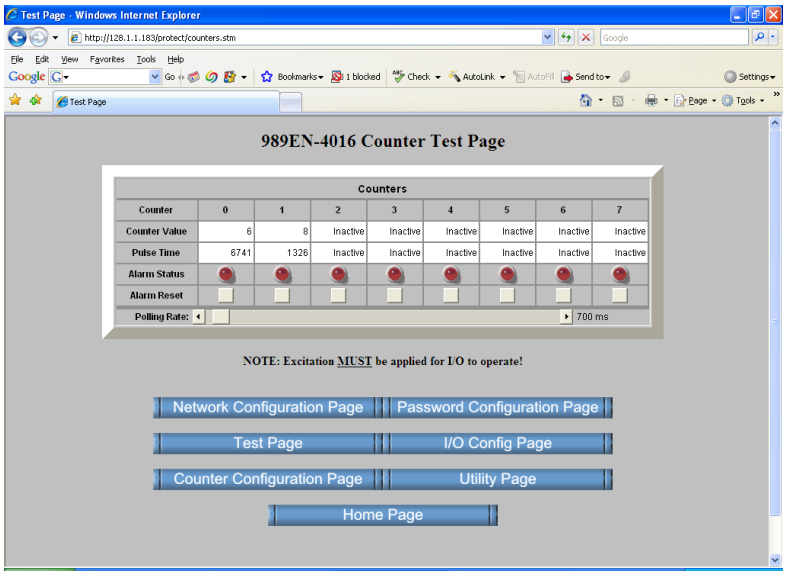
The Counter boxes represent the current count value for each input counter. Below the LED's of this page reflect the Alarm outputs associated with each event counter.

The Pulse Time will display the time (in milliseconds) between the last two count values. The time is updated with each incoming count. It only holds the current pulse time.

***Note:** This page is not available on the 989EN-4C16 model.*

***TIP:** For a faster refresh rate, use the Modbus registers to read the Pulse Time.*

After configuring your counters, you can use the counter test page to operate them. This page allows you to monitor counter values, view alarm status, and reset counters.



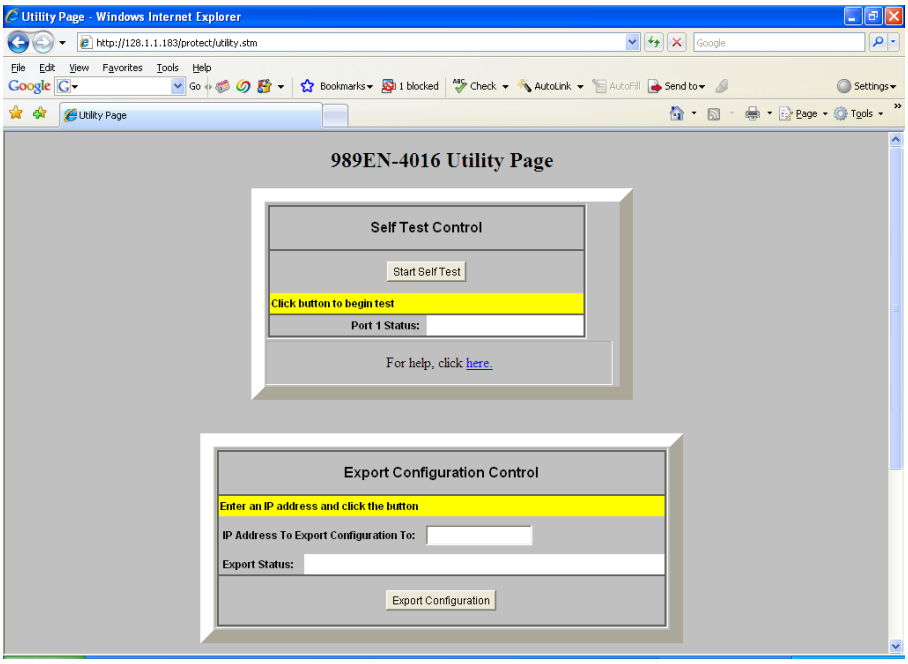
The Counter Boxes display the current value for each channel. The value "Inactive" means that the counter on this channel has been disabled. Below the Counter Value box is the Pulse Time which measures the time (in milliseconds) between counts. When a pulse is received, the timer updates with the time from the current pulse to the last pulse. The timer will restart and wait for the next pulse, but will continue to display the previous time. Under the timer, the state of an alarm channel is indicated by a simulated LED (bright red for "ON") below the channel number. The Alarm Reset will reset an alarm state as well as reset the counter to the Pre-Loaded Value.

WEB BROWSER

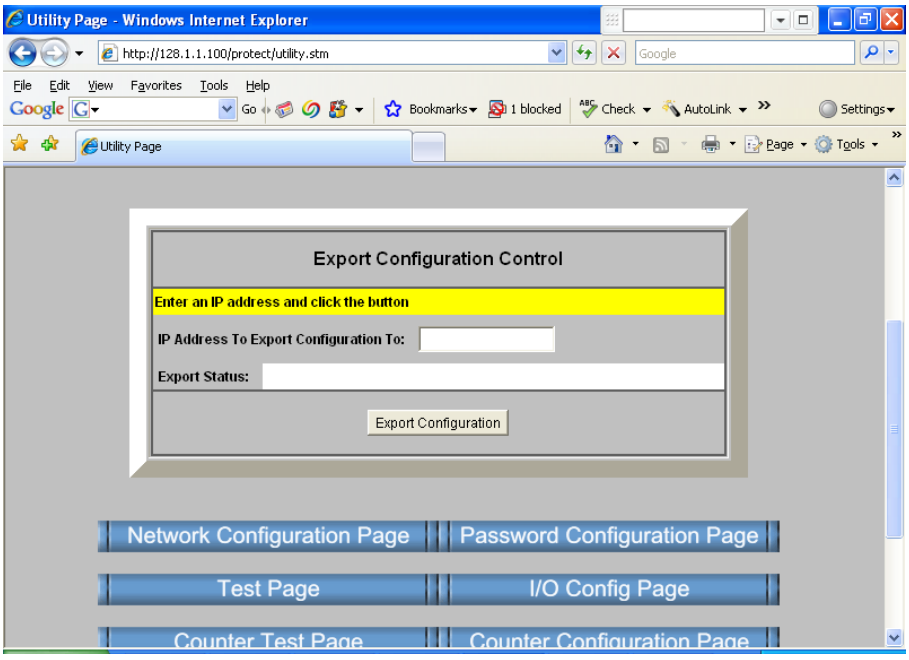
Utility Page

When you first enter a page that includes controls like this, you may note that your first click on a control is ignored. This is because the first click only activates the control.

You may also access a Utility Page that includes a configuration built-in utility that allows you to verify I/O operation without actually wiring to the I/O (self-test control). Also included on the Page is an export configuration tool which allows you to copy the configuration of this module to another 989EN. You can select the Utility Page button from the Test Page screen to display a screen similar to that shown here:



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



WEB BROWSER

Utility Page

Floating I/O (i.e. inputs tri-stated) may cause the I/O to improperly read the OFF state, as the input threshold is 4V and inputs must be pulled above this value in order to register as OFF.

*Excitation **MUST** be provided to properly execute I/O Self Test.*

Do not use the self-test with the inputs tri-stated and be sure to turn all outputs OFF prior to test.

I/O Self Test Control

IMPORTANT: External excitation ***MUST*** be provided to properly run the I/O Self Test.
CAUTION: If you have I/O wiring present, then you should disconnect this wiring (except excitation) to avoid potential signal contention during the I/O test, as this test controls the outputs to drive the input channels using excitation. You must turn all outputs OFF and disable any tri-stated input ports prior to test.

The I/O self-test feature of this page takes advantage of the separate input and output channels of this device, and the built-in wetting current sources at each input, to test I/O operation right up to the field screw without having to do any wiring. This is a useful trouble-shooting aide if you are experiencing problems. Make sure that all outputs are OFF and disconnect I/O port field wiring to the unit. Then click the Start Self Test button to check I/O operation. Note that this test still requires external excitation as I/O cannot operate without excitation. This represents a true test of the I/O, as the input comparator is tied directly to the output mosfet drain terminal of the channel.

Export Configuration Control

Enter the IP address of the destination unit you are trying to replicate this configuration at. This unit must be already connected to the network. Refer to Network Connections for examples of how to network connect units.

The export function is a real time-saver when commissioning multiple units in similar fashion. Simply enter the IP address of the unit you wish to send your I/O configuration to (it is assumed that you have already communicated with it and setup its network parameters). Click the Export Configuration button to transmit your I/O configuration. With reference to the Modbus Memory Map for this device, this function sends the contents of all Holding Registers (4xxxx registers), right up to the wink register, to the IP address indicated (it does not send network configuration parameters which must be preset via the web browser). The Export Status window will let you know if the configuration was received correctly or not at the remote I/O station.

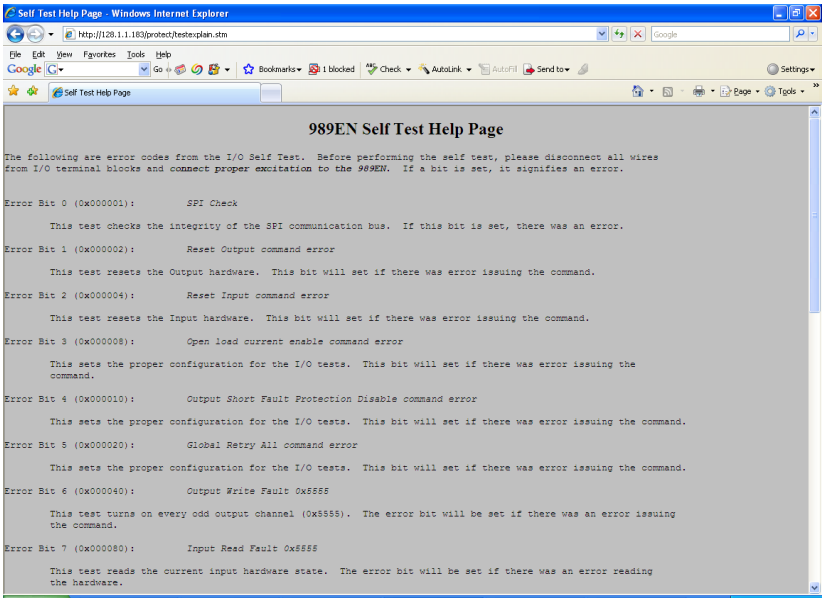
I/O Self Test Control Error Codes

The "Walk 1" Test will shift the "off" state through all the channels while the other channels remain "on".

The "Walk 0" Test will shift an "on" state through all the channels while the other channels remain "off".

Bit #:	***Description of Error***
Bit 0:	SPI Check – SPI Communication error
Bit 1:	Reset Output command error
Bit 2:	Reset Input command error
Bit 3:	Open load current enable command error
Bit 4:	Output Short Fault Protection Disable command error
Bit 5:	Global Retry All command error
Bit 6:	Output Write Fault *0x5555* – Write outputs command error
Bit 7:	Input Read Fault – Read inputs command error
Bit 8:	Write/Read mismatch – Input did not read *0x5555*
Bit 9:	Output Write Fault *0xAAAA* – Write outputs command error
Bit 10:	Input Read Fault *0xAAAA* – Read inputs command error
Bit 11:	Write/Read mismatch – Input did not read *0xAAAA*
Bit 12:	Output Write Fault (Walk 1) – Write outputs command error
Bit 13:	Input Read Fault (Walk 1) - Read inputs command error
Bit 14:	Write/Read mismatch – Input did not match output (any failure)
Bit 15:	Output Write Fault (Walk 0) – Write outputs command error

Bit #:	Description of Error
Bit 16:	Input Read Fault (Walk 0) – Read inputs command error
Bit 17:	Write/Read Mismatch – Input did not match output (any failure)



I/O Self Test Page Help: – At the bottom of the Self Test function is a link to a help page to provide error codes for the Self Test.

SYMPTOM…	
POSSIBLE CAUSE	**POSSIBLE FIX**
Green RUN LED Does Not Light…	
Bad connections.	Recheck Power Connections
Internal +3.3V power has failed or a fatal processor (firmware) error has occurred.	Return unit for repair.
Input Power TVS has failed. This could occur for a sustained voltage surge or continuous over-voltage at the power terminals.	Return unit for repair. Power should be fused externally or current-limited to a safe operating level no less than twice the maximum input current.
Input Wetting Currents are Low, or Not 2mA/16mA…	
You are using less than 8V of external excitation.	This is normal for excitation voltages below 8V.
Continuous Flashing Green RUN LED…	
Unit in "wink" mode.	Read Unit Status register to verify "wink" status. Write 5555H to Wink Mode Toggle Register to toggle wink mode off/on.
Unit failed to boot firmware.	A continuously flashing green Run LED can signify the unit has failed to initialize and may require repair if you are sure you are using a good network connection and proper power voltage.

WEB BROWSER

Utility Page

I/O Self Test Help Page

By clicking on the link at the bottom of the Self Test Control, a quick reference help page will appear. This is useful to obtain descriptions of the error codes for the Self Test.

To go back to the Utility Page, scroll to the bottom of the Help Page, and there will be a link back. Alternatively, you can click on the back button on your internet browser.

TROUBLE-SHOOTING

Diagnostics Table

TROUBLE-SHOOTING

Diagnostics Table …continued

SYMPTOM…	
POSSIBLE CAUSE	**POSSIBLE FIX**
Continuous Flashing Green RUN LED…	
Ethernet link was not established	Unit will flash green RUN LED and maintain a solid STATUS LED at startup until an Ethernet link has been established.
Cannot Communicate…	
Power ON to the unit?	Check if green RUN LED is ON?
Wrong IP Address	Change IP address of the unit or host PC so they both match. Try the default unit address of 128.1.1.100.
Many Communication Errors…	
Is cable segment longer than 100M?	Distance between two Ethernet nodes is limited to 100 meters with approved cable.
Correct Cable?	Shielded CAT-5/5E cable or equivalent is recommended.
Missing earth ground connection.	Connect earth ground to TB3 GND terminal adjacent to power terminal.
Inputs Not Reading Back Correct OFF State…	
Excitation is below 8V, or inputs are tri-stated and floating.	The built-in wetting current sources that function as input pull-ups are not operable without proper excitation, or with the inputs tri-stated. Connect an excitation voltage, or pull the input signal up above the 4.3V maximum input threshold as required.
Unit Fails I/O Self Test…	
Field wiring has been left connected, one or more outputs are turned ON, inputs are tri-stated, excitation is not present, or excitation is below 8V?	Do not float I/O as inputs must pull above the 4V threshold in the OFF state to read as OFF. Tri-stated inputs float without an external connection or with open-load detection OFF—do not tri-state inputs prior to this test. I/O requires proper excitation voltage (8-28V) to function.
Input Event Counters Are Not Working…	
Are the Counting Inputs Enabled?	You must enable the counter inputs either via the webpage or through the Modbus registers (Reg: 40010). **Note**: 989EN-4C16 is not equipped with Event Counters.
Are the Counting Inputs Stopped?	You must start the counters either via the webpage or through the Modbus registers (Reg: 40043).
Is your debounce time too long?	Set the debounce time to be less than half of your input pulse width.
Excitation is below 8V, or inputs are tri-stated and floating.	The built-in wetting current sources that function as input pull-ups are not operable without proper excitation, or with the inputs tri-stated. Connect an excitation voltage, or pull the input signal up above the 4.3V maximum input threshold as required.

SYMPTOM…	
POSSIBLE CAUSE	**POSSIBLE FIX**
Outputs Don't Stay Shutdown After Fault with GSRC Register Bit Clear…	
Internal refresh cycle is enabled? (see also Global Shutdown & Retry Control Register)	Also disable the Auto Output Refresh cycle if you want outputs to stay shutdown after a fault.
Outputs Not Working…	
Missing external excitation?	You must connect an excitation supply between the EXC+ & Return (RTN) terminals to power the output circuit.
Have you checked I/O operation via self-test feature?	To verify I/O is operational and has not been damaged, use the Self Test feature (see Utility Page). Be sure to unplug the terminals to avoid signal contention with external I/O signals.
Output Fault has occurred. (Outputs may shutdown in response to a fault—see the Global Shutdown & Retry Control register)	Review the info of the I/O Config Page and note outputs may shut-down for over- current, temperature, and voltage faults. Identify any potential faults or shorts and correct them. Remove output field wiring to see if operation is restored.
Output TVS has failed? (Note – The TVS working voltage limit is 31V)	Outputs include transient voltage suppressors that will squelch over-voltage of short duration, but may fail for sustained over-voltage fault conditions without current-limiting. In this case, the unit must be returned to the factory to replace this TVS.
Cannot Browse Unit…	
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 on bottom of page).
I/O Status Flags Appear Intermittent…	
Your unit is periodically retrying its control while a fault is present.	Auto-refresh should be OFF if you wish faulted outputs to stay OFF. See the Global Shutdown & Retry Control register to affect this behavior.
Unit Fails to Start-up or Initialize…	
Input power voltage below 18V minimum?	Check your power supply voltage and make sure that it is at least 18V.
Communication To Unit is Lost…	
Was communication interrupted by severe interference or shock?	Reset the unit via cycling power.

TROUBLE-SHOOTING

Diagnostics Table …continued

Upon power-up, after blinking momentarily the green "Run" LED should remain ON and the "Status" LED turns OFF. This indicates the unit is properly powered and operating normally. If RUN continues to blink, then the unit may not be connected to the network or the cable is bad. Otherwise, a continuous blinking RUN LED can indicate unit is in "wink" ID mode, or it may be indicative of a firmware initialization error.

TROUBLE-SHOOTING

Diagnostics Table …continued

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 unit with a known good unit. Acromag's Application Engineers can provide further technical assistance if required. Complete repair services are also available from Acromag.

Refer to Acromag Application Note 8500-734 for help in setting up network communication with your unit (see CDROM shipped with unit or down-load it from www.acromag.com). This document gives details for changing your PC's TCP/IP configuration in order to communicate with hardware similar to your unit (see TCP/IP Properties of Network Configuration in Windows).

If you have carefully followed this procedure and you still cannot browse your unit, 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" pull-down 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 unit 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 limited built-in error checking to prevent you from writing invalid values to a configuration register. If you inadvertently write an invalid value to an internal register, operation may become unpredictable under certain conditions. If resetting the unit fails to restore order, then to regain control of the unit, the unit can either be re-downloaded at the factory, or you can try restoring its initial configuration by following this procedure:

Trouble Browsing Your Unit?

So, your 989EN has apparently "gone wild", and power cycling the unit did not correct your problem, then follow this procedure to restore it to its initial configuration and regain control.

Procedure For Restoring any 989EN Unit to its Initial Configuration

IMPORTANT: Before reading on, please follow the default mode activation procedure located on page 3. If you are still unable to communicate to the module, please continue reading.

WARNING: Use this only as a last resort, as this procedure will reset everything to its default state--all holding registers, and network settings (the permanently coded MAC ID does not change).

1. With unit power OFF, press and hold the front-panel DEFAULT push-button.
2. While still pressing the push-button switch in, apply power.
3. Note that the green RUN LED will turn ON. Continue to press the push-button for about 5 seconds until the green RUN LED turns OFF. Release the DFT push-button at this point and the RUN LED will blink for 1-10 seconds as the unit acquires its address, then remains ON for normal operation (normal boot). At this point, the unit is not in the default communication mode, but all registers are reset back to their default factory state.
4. If the green RUN LED never turned OFF while you held the DFT push-button during power-up, then reinitializing the unit has failed and you should try it again. This time, make sure that the DFT push-button switch is completely depressed and held until RUN turns OFF while powering the unit.

TECHNICAL REFERENCE

KEY FEATURES

- **Safety Agency Approvals** – CE, UL, & cUL listed, plus Class I; Division 2; Groups A, B, C, D approval. (989EN-4016 *ONLY*)
- **Fully Isolated** – I/O channels, network, and power are all isolated from each other for safety and increased noise immunity.
- **Modbus TCP/IP Protocol Support –** Supports up to 5 sockets/ masters using port number 502 (Modbus TCP/IP Default).
- **Flexible IP Addressing** – Supports static or DHCP.
- **Built-In Web Pages -** Allow unit to optionally be configured, controlled, and monitored via access with a standard web browser over Ethernet.
- **Convenient "Wink" ID Mode Support** – Blinks green RUN LED in wink mode as a tool to help identify specific remote units.
- **Network Port is Transient Protected** – Shielded RJ45 port includes transient protection from ESD, EFT, and other transients.
- **10Base-T and 100Base-TX Support** – Auto-negotiated 10/100Mbps, Half or Full Duplex.
- **Input Event Counters** – Input channels can be used as a 32-bit event counter for signals up to 150 Hz. Counters have selectable up/down counting, selectable count edge, and programmable debounce. *This feature is only available on the 989EN-4016 model.*
- **Programmable Debounce** – Event counters are equipped with programmable debounce from 0 – 65535 ms. This function is useful for eliminating false counts from electro-mechanical relay contact bounce and other mechanical effects.
- **Counter Alarm Output** – Counters can be set to output upon rollover condition. The output will toggle state, and reset either upon next event count (momentary alarm), or from a manual reset (latched alarm).
- **Nonvolatile Counter Memory** – Allows the count value to be restored after power loss to model.
- **Last Count Timer** – Event counters are equipped with a timer that will display the last count value up to 65535ms. The timer has the option of setting a time limit to identify a stoppage in incoming pulses.
- **Plug-In Terminal Blocks & DIN-Rail Mount -** Make mounting, removal, and replacement easy.
- **Flexible Discrete Inputs & Outputs** - High voltage/current open-drain outputs provide direct (low-side) control of external devices. Buffered inputs allow outputs to be read back, or input levels to be monitored.
- **Outputs Have Built-in Protection** – Over-temperature/current shut-down protection is built-in and includes active clamping circuitry for switching inductive loads.
- **Nonvolatile Reprogrammable Memory** – Allows the functionality of this device to be reliably reprogrammed thousands of times.
- **Tandem Input/Output Circuitry for Loopback Monitoring** - Input buffers are connected in tandem with open-drain outputs for convenient loop-back monitoring of the output states.
- **Inputs Have Programmable "Wetting" Current Sources Built-In –** Inputs have built-in current sources that eliminate the need to add pull-ups. This also facilitates I/O self-test without adding wiring other than the required external excitation. Wetting current is used to sense switch closure at an input and can be set to 16mA or 2mA. By default, it will fold back from 16mA to 2mA, 20ms after the input crosses the 4V threshold. This is to provide higher levels of current during switch closure, which helps to reduce oxide buildup on switch contacts.

KEY FEATURES

- **Built-In Self-Test for Port I/O Read/Write –** Useful for troubleshooting I/O and internal communications for diagnostic purposes.
- **Built-in Output Thermal, Over-Current, & Over-Voltage Protection -** Inputs also include thermal protection. Status flags report these faults.
- **Inputs May Be Optionally Tri-Stated** – The inputs may be tri-stated to a high-impedance state (disables wetting current). Tri-stated inputs act as simple comparators with a 4.0V threshold.
- **Outputs Include Selectable Fast Short-Fault Protection –** By default, if an output drives a shorted load, built-in thermal protection will kick-in to protect the output. Optionally, this device allows you to specify whether a port is to rely on the internal thermal protection mechanism, or implement a faster responding 100-450us shutdown mechanism based on the output drain-to-source voltage. This effectively allows output port protection to be tailored to incandescent lamp loads, or inductive loads. Limiting thermal stresses also helps preserve the life of the output driver.
- **Failsafe Mode Support w/Watchdog Time Control** – Outputs can be sent to a failsafe state if the host fails and a watchdog timeout occurs.
- **Output Open-Load Detect** – Outputs include 50uA current sinks (pull-downs) that can be enabled to flag an open load with inputs tri-stated.
- **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 power for use with redundant supplies, and/or battery back-up.
- **Hardened For Harsh Environments** - For protection from RFI, EMI, ESD, EFT, and surges. Has low radiated emissions per CE requirements.
- **Wide Ambient Operation** – Reliable over a wide temperature range.

HOW IT WORKS

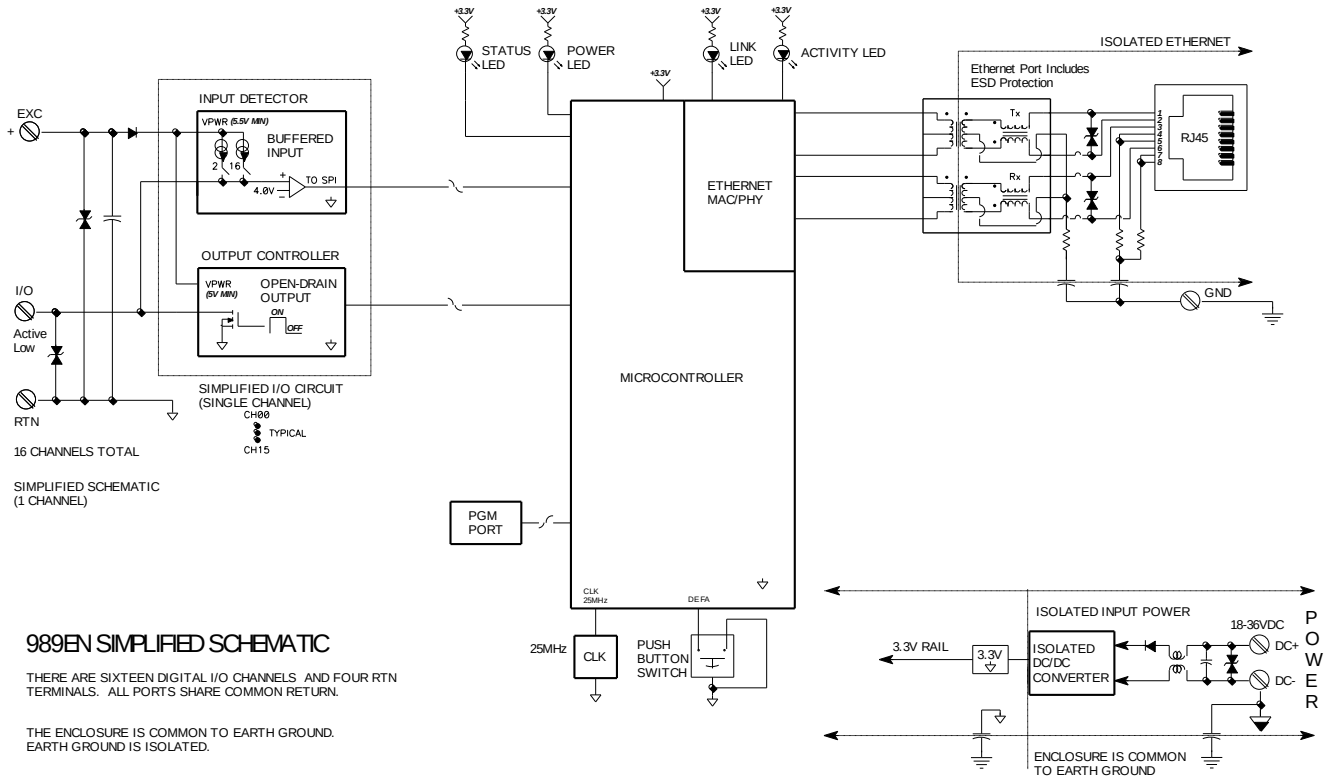
The 989EN digital I/O module will interface with any mix of up to sixteen digital input and/or output signals, and provide an isolated 10/100Mbps Ethernet interface for configuration, monitoring, and control of the I/O. Inputs and outputs are connected in tandem with each other. An internal microcontroller will switch outputs ON/OFF and sample the digital inputs. The eight 32-bit event counters capture signals up to 150 Hz, and include a programmed debounce, selectable up/down counting, selectable edge, and eight alarm outputs managed by the microcontroller (*available on the 989EN-4016 model only*). Input counts and configuration parameters are stored in non-volatile memory. With outputs turned OFF, channels operate either as active-low, wide-range voltage inputs or up to eight event counters. Otherwise, inputs monitor the state of the corresponding open-drain output for independent "loop-back" monitoring of the output.

Outputs of these models are the open-drains of n-channel mosfets (low-side switches). Inputs are active-low. A buffered input comparator is connected in tandem with each drain circuit and compares this signal to a 4.0V reference voltage. Inputs sense switch closure via built-in wetting current generators (2mA). These current sources can initially provide a higher level of current during switch closure (16mA). This helps to minimize oxide buildup on external switch contacts. These sources also eliminate the need to pull-up the tandem open-drain mosfets of the output circuitry. Optionally, these current sources can be disabled and the input will operate as a simple high-impedance comparator with a 4.0V threshold.

HOW IT WORKS

The I/O terminals and the Ethernet port terminals also include transient suppression. An internal microcontroller will switch outputs ON/OFF and sample the digital inputs. Embedded configuration parameters are stored in non-volatile memory integrated within the micro-controller. A wide-input, high-efficiency, DC to DC converter provides isolated power to the unit. Most I/O power is actually derived from the excitation supply, requiring excitation to be present to operate the I/O. Refer to the simplified schematic on the following page to help gain a better understanding of circuit operation.

There are 16 I/O channels across 4 terminal blocks. All I/O terminals include transient suppression. The I/O circuitry has built in thermal, over-voltage, and over-current protection. The excitation terminal also has built-in transient and reverse polarity protection.



989EN SIMPLIFIED SCHEMATIC

THERE ARE SIXTEEN DIGITAL I/O CHANNELS AND FOUR RTN TERMINALS. ALL PORTS SHARE COMMON RETURN.

THE ENCLOSURE IS COMMON TO EARTH GROUND. EARTH GROUND IS ISOLATED.

ABOUT MODBUS TCP/IP

Modbus TCP/IP actually refer to a set of complimentary protocols that operate on your data. Modbus itself is the *application protocol* and it defines the rules for organizing and interpreting the data. TCP is the *transport protocol*, responsible for transmitting and receiving the data (a message received via TCP, will get a response via TCP). IP is a *network protocol*, responsible for addressing and delivering the data.

SIMPLIFIED TCP/IP STACK LAYER REFERENCE MODEL

TX	LAYER	RX
5 ↓	Application	↑ 5
4 ↓	Transport	↑ 4
3 ↓	Internet/Network	↑ 3
2 ↓	Data Link	↑ 2
1→	Physical	→1

A transmitted message is wrapped at each layer as it passes down the stack, while the received message is unwrapped at each layer as it passes up the stack.

Referring to the OSI Network Model (a simplified model is shown at left), we see that these protocols reside at different layers, with the application layer at the top. As data is transmitted, each lower layer adds its own header information to the front of the packet that it receives from the next higher layer. The higher layer data is essentially encapsulated by the lower layers, according to the different protocols that operate at these levels and whose service is requested. With respect to Modbus TCP/IP, the application layer data of Modbus is encapsulated by the transport layer data of TCP, which is then encapsulated by the network layer data of IP. This process of wrapping outgoing messages with layer frames as the message is passed down the stack changes to a process of peeling back the layer frames at each layer for a received message as it is subsequently passed up the stack to the application layer.

For the 989EN modules, Modbus serves as the *application protocol* and it defines the rules for organizing and interpreting the data. It is essentially a messaging structure that is independent of an underlying physical layer. The transport layer resides just below this application layer and is responsible for the transmission, reception, and error checking of the data. While there are a number of transport layer protocols that may operate at this layer, the primary one of interest to us is TCP.

TCP is a connection-oriented transport layer protocol. By connection-oriented, we mean that TCP establishes a secure connection between two network stations for the duration of the data transmission. TCP works via the Client-Server communication model. That is, whichever network station takes the initiative and establishes the connection is referred to as the *TCP Client*. The station to which the connection is made is called the *TCP Server.* The server does nothing on its own, but just waits for the client to make contact with it. The client then makes use of the service offered by the server (depending on the service, one server may accommodate several clients at one time).

TCP verifies the sent user data with a checksum and assigns a sequential number to each packet sent. The receiver of a TCP packet will use the checksum to verify having received the data correctly. Once the TCP server has correctly received the packet, it uses a predetermined algorithm to calculate an acknowledgement number from the sequential number. The acknowledgement number is returned to the client with the next packet it sends as an acknowledgement. The server also assigns a sequential number to the packet it sends, which is then subsequently acknowledged by the client with an acknowledgement number. This process helps to ensure that any loss of TCP packets will be noticed and that if needed, they can then be re-sent in the correct sequence.

ABOUT MODBUS TCP/IP

Note that with TCP, the transmitter expects the receiver to acknowledge receipt of the data packets. Failure to acknowledge receipt of the packet will cause the transmitter to send the packet again, or the communication link to be broken. Because each packet is numbered, the receiver can also determine if a data packet is missing data, or it can reorder packets not received in the correct order. If any data is detected as missing, all subsequent received data will be buffered. Complete data will be passed up the protocol stack to the application, but only when it is complete and in the correct order.

TCP/IP refers to Transmission Control Protocol and Internet Protocol, and serves as the foundation for the world-wide web. TCP/IP allows blocks of binary data to be reliably 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. We see that the TCP/IP combination does not define what the data means or how the data is to be interpreted, it is only concerned with transporting and delivering the data.

Again, referring to the OSI Network Model, the Network Layer or Internet Layer resides just below the Transport Layer and is responsible for routing the packets to the network. There are many network layer protocols such as ICMP, IGMP, ARP, RARP, but our focus here is on IP.

An IP packet is a chunk of data transferred over the Internet using standard Internet Protocol (IP). The Internet Protocol (IP) is responsible for the actual addressing and delivery of the data packets. IP packets vary in length depending on the data being transmitted, but each packet begins with a header containing addressing and system control information. Similar to UDP, IP is a connectionless and unacknowledged method for sending data packets between two devices on a network. IP does not guarantee delivery of the data packet, but relies on a transport layer protocol (like TCP), or application layer protocol (like Modbus) to do that. The IP addressing scheme also makes it possible to assemble an indefinite number of individual networks into a larger overall network, without regard to the physical implementation of the sub networks. The data can then be sent from one network station to another, regardless of these differences.

The IP specific header (MBAP of the Modbus TCP/IP specification) is the same for Modbus/UDP as for Modbus/TCP, and is 7 bytes long and comprised of the following fields:

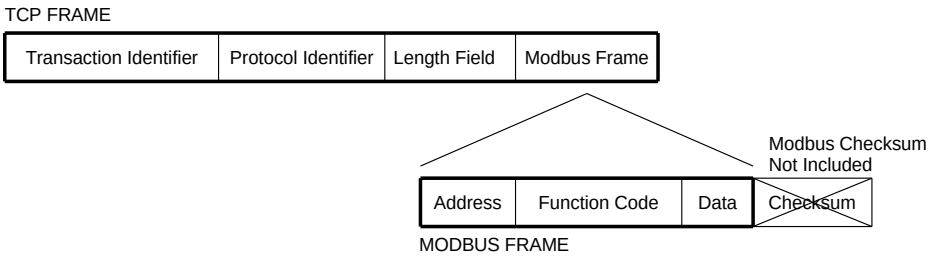
- Invocation Identification/Transaction Identifier (2 bytes).
- Protocol Identifier (2 bytes) - Set to 0 for Modbus by default and other settings are reserved for future extensions.
- Length (2 bytes) - Represents a byte count of all following bytes.
- Unit Identifier (1 byte) - Used to identify a remote unit located on a non-TCP/IP network.

Modbus uses TCP/IP 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).

ABOUT MODBUS TCP/IP

A Modbus TCP/IP message is simply a Modbus communication encapsulated in an Ethernet TCP/IP wrapper

To illustrate, Modbus TCP embeds a Modbus data frame into a TCP frame, sans 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.

With respect to the 989EN I/O devices, these devices normally operate as network slaves (information servers) and do not initiate transactions on their own.

IP Addressing

A host is used to refer to any device on any network. On TCP/IP networks, each host has one or more unique IP addresses. A 989EN unit connected to an Ethernet network acts as a host.

An IP Address is a unique identification number for any host (this unit) 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).

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, while the last IP address in a subnet is always used as a broadcast address. Anything sent to the last IP address of a subnet is sent to every host on the subnet.

ABOUT MODBUS TCP/IP

IP Addressing

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 generally 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 unit 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.

TIP: The first node (0), node 10, and the last node (255 for our example) are typically reserved for servers and may yield poor results if used.

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 subnetwork address, and the remaining bits the host or node address.

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 sub-network (0110), then we would use "11111111.11111111.11111111. 11110000" as our subnet mask. This would effectively subdivide our Class C network into 14 sub-networks of up to 14 possible nodes each.

With respect to the default settings of this device:

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)

The subnetwork address of 128.1.1.0 has 254 possible unique node addresses (we are using node 100 of 254 possible). Nodes 0, 10, and 255 are typically reserved for servers and may yield poor results if used.

Dynamic Host Configuration Protocol (DHCP)

DHCP refers to Dynamic Host Configuration Protocol and is a method used to assign temporary numeric IP addresses as required. A DHCP server maintains a pool of shared IP addresses which are dynamically assigned and 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 IP addresses will ensure a connection every time, but dynamic addresses do not.

ABOUT MODBUS TCP/IP

Domain Name System (DNS)

DNS refers to the Domain Name System or Domain Name Server. This 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. These servers contain information on some segment of the domain name space and make this information available to clients called *resolvers*. For example, the DNS allows us to use "Acromag.com" as an IP address rather than a complicated number string.

MODBUS REGISTERS

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

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.

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.

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 (port). 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 port and channel numbers increase sequentially as you move towards the msb.

All I/O values are accessed via the 16-bit Input Registers or 16-bit Holding Registers given in the Register Map. Input registers contain information that is read-only. 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 function operating at an input, or an output value for an output channel.

Register Functions

Each 989EN unit has a default factory configuration as noted in the Specifications section. Your application will likely differ from the default configuration provided and the unit will need to be reconfigured. You may reconfigure most features of this unit 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 unit to perform basic I/O & reconfiguration.

MODBUS REGISTERS

Register Functions

Below is a subset of standard Modbus functions that are supported by this unit along with the reference register address group 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 standard Modbus functions operate on register map registers to monitor, configure, and control unit 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 unit, 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.

989EN-4016 Report Slave ID Example Response[1]

FIELD	DESCRIPTION
Unit ID	Echo Unit ID Sent In Query
Function Code	11
Byte Count	43
Slave ID (Model No.)[1]	11=989EN-4x16
Run Indicator Status	FFH (ON)
Firmware Number String (Additional Data Field)[1]	41 43 52 4F 4D 41 47 2C 39 33 30 30 2D 31 33 36 41 2C 39 38 39 45 4E 2D 34 30 31 36 ("ACROMAG,9300-136A,989EN-4016,*serial number&rev*,*six-byteMACID*")

[1]**Note:** Model 989EN-4016 uses slave ID "11" and firmware number: 9300-136. Model 989EN-4C16 uses slave ID "12" and firmware number: 9300-137 (The firmware model numbers are also indicated on the home page of the web browser).

For detailed information on Modbus, feel free to download our technical reference 8500-648, "Introduction To Modbus", at www.acromag.com*. You can also find more information specific to Modbus TCP/IP by downloading whitepaper 8500-765, "Introduction To Modbus TCP/IP". Additional information regarding Ethernet can also be found in our whitepaper 8500-747, "Introduction To Ethernet/IP".*

Register Mirroring

For your convenience, the 989EN mirrors the contents/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 can 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:

MODBUS REGISTERS

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

Register Mirroring

For 3xxxx Input Registers, the format of the registers is 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, the return data is reformatted to match the Holding Register format. For example: if you request the Input Status for 16 digital inputs, instead of getting 2 bytes returned with the 16 bits representing the 16 digital inputs, you will get 16 separate words, each set to either 0000H (OFF), or FFFFH (ON).

For the 0xxxx Coil Registers, 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.

Data Types

I/O values for 989EN units are represented by the following simple data types for temperature, percentage, and discrete on/off.

Summary Of Data Types Used By 9xxEN Models

Data Types	Description
Discrete (This Model)	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 for this model. 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 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).
Normalized Data Count	A 16-bit signed integer value is used to represent ±20000 counts for bipolar input ranges and 0-20000 counts for unipolar input ranges. For example, -1V, 0V and +1V 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.

Register Map

Model 989EN-4x16

The following table outlines the register map for the 989EN I/O processor. The Modbus functions operate on these registers using the data types noted above (except for the Reset Slave and Report Slave ID functions).

Not all programmable features of this device will include a corresponding Modbus configuration register. Some functionality must be programmed via the built-in web browser interface. For example, parameters related to network communications do not have a Modbus register and are programmed solely through the built-in web interface.

Ref	Addr.	Description	Data Type/Format
Coil Registers (0x References, Read/Write)			
00001 Thru **0**0016	0-15 (0000-000F)	16 Discrete Outputs (CH00-15) **(Default=0)**	*Data Format:* 16-bit Unsigned Integer Discrete Output Value. Addresses a specific bit of a 16-bit word that controls/monitors the ON/OFF status for the corresponding output (gate signal of the n-channel mosfet). 0=OFF; 1=ON. The lsb is channel 0.
Note: This signal corresponds to the digital gate signal of the n-channel output mosfet. Thus, a read of this register may not reflect the actual output level at the drain of the mosfet for certain conditions. You can read the Contact Registers to obtain the actual output state(s) via closed loop feedback. ***I/O will not operate without excitation.***			The bit position also corresponds to the output channel number (i.e. output 0 uses bit 0 of the 16-bit word at address 0, output 1 uses bit 1 of the 16-bit word at address 1, etc.) A set bit (1) means the output is turned ON (sinking current). A clear bit (0) means output is turned OFF (open). After reset, these registers read 0 (outputs OFF) and these registers are not maintained in FLASH.
Ref	**Addr.**	**Description**	**Data Type/Format**
Contact Registers/Input Status (1x References, Read-Only)			
10001 Thru **1**0016	0-15 (0000-000F)	16 Discrete Inputs 0-15	*Data Format:* 16-bit Unsigned Integer Discrete Input Value. Addresses a specific bit of a 16-bit word that flags the ON/OFF status for the corresponding input or tandem output. 0=OFF; 1=ON. The lsb is channel 0.
Note: This signal reflects the actual state of the corresponding input signal relative to a 4.0V threshold, or the drain of the tandem output. This signal is active-low below 4V. ***I/O will not operate without excitation.***			The bit position corresponds to the input channel number for the port (i.e. input 0 uses bit 0 of the 16-bit word at address 0, input 1 uses bit 1 of the 16-bit word at address 1, etc.). A set bit (1) means input is ON (active-low < 4V threshold). A clear bit (0) means input is OFF (high, > 4V threshold).

Register Map

Model 989EN-4x16

A drain-to-source voltage greater than 50V, or an excitation voltage between 28-35V could trigger the output over-voltage only flag (and the "Any Fault" flag).

Note that if output fault fast shutdown is selected, the output error status flag may not get set.

The error status flag is only set while the output attempts to drive the fault. The output will shut down, then the error status flag will clear as the part cools. If auto-retry and/or auto-refresh are enabled via the Global Shutdown & Retry Control register, the error status flag may appear to be intermittent while the fault condition remains. This is because the output periodically retries its drive, shuts-down, then recycles with each retry.

Ref	Addr.	Description	Data Type/Format
Input Registers (3x References, Read-Only)			
30001	0000	Unit Status *Use this register to check for wink mode, default mode, or watchdog timeout.*	*Data Format:* 16-bit Unsigned Integer Bit 15: **NV Memory Fault** 1 = Non-Volatile Memory failed initialization Bit 14: **Wink Mode** Flag 1 = Wink (Blinks Run LED for ID) (See Wink Unit Register) Bit 13: **Default Mode** Flag 1 = Default Mode Indication Bits 12-1: 0 (Not Used) Bit 0: **WD Fault** (CH 00-15) 1 = Watchdog Fault
30002	1 (0001)	I/O Error Status *Use this register to check for output thermal fault, output over-voltage, excitation over-voltage, open output load, or input thermal fault.*	*Data Format:* 16-bit Unsigned Integer This register reflects the fault status for I/O channels 0-15. Bit 15-3: 0 (Not Used) Bit 2: Output "Any Fault" flag including thermal fault, excitation over-voltage, open-load detected, and output over-voltage. Bit 1: Output over-voltage only flag (drain-source or EXC over-voltage). Bit 0: Input Thermal Fault Flag. ***Note that only the faulted output(s) will shut-down if a fault flag is set, not the entire port. If excitation over-voltage is tripped, all channels are shutdown. Open-load detection does not shut down the output.***
30003	2 (0002)	Input Change Detect (Latching)	*Data Format:* 16-bit Unsigned Integer The bit position corresponds to the input channel number for the port. A set bit (1) means the corresponding channel of the port has changed states. Reading this register will clear all bits to 0. The lsb is channel 0.
30004	3 (0003)	CH 0 Input Count High Value (Most Significant Word)	*Data Format:* 16-bit Unsigned Integer This registers reflects the upper word count value of Channel 0. **Note that this register cannot be changed directly. To preset a count value use Holding Register 40015.** ***This is only available on the 989EN-4016 model.***

Ref	Addr.	Description	Data Type/Format
Input Registers (3x References, Read-Only)			
30005	4 (0004)	CH 0 Input Count Low Value (*Least Significant Word*)	*Data Format:* 16-bit Unsigned Integer This registers reflects the lower word count value of Channel 0.
30006	5 (0005)	CH 1 Input Count High Value *MSW*	*See explanation for CH 0 above, but apply to CH 1.*
30007	6 (0006)	CH 1 Input Count Low Value *LSW*	*See explanation for CH 0 above, but apply to CH 1.*
30008	7 (0007)	CH 2 Input Count High Value *MSW*	*See explanation for CH 0 above, but apply to CH 2.*
30009	8 (0008)	CH 2 Input Count Low Value *LSW*	*See explanation for CH 0 above, but apply to CH 2.*
30010	9 (0009)	CH 3 Input Count High Value *MSW*	*See explanation for CH 0 above, but apply to CH 3.*
30011	10 (000A)	CH 3 Input Count Low Value *LSW*	*See explanation for CH 0 above, but apply to CH 3.*
30012	11 (000B)	CH 4 Input Count High Value *MSW*	*See explanation for CH 0 above, but apply to CH 4.*
30013	12 (000C)	CH 4 Input Count Low Value *LSW*	*See explanation for CH 0 above, but apply to CH 4.*
30014	13 (000D)	CH 5 Input Count High Value *MSW*	*See explanation for CH 0 above, but apply to CH 5.*
30015	14 (000E)	CH 5 Input Count Low Value *LSW*	*See explanation for CH 0 above, but apply to CH 5.*
30016	15 (000F)	CH 6 Input Count High Value *MSW*	*See explanation for CH 0 above, but apply to CH 6.*
30017	16 (0010)	CH 6 Input Count Low Value *LSW*	*See explanation for CH 0 above, but apply to CH 6.*
30018	17 (0011)	CH 7 Input Count High Value *MSW*	*See explanation for CH 0 above, but apply to CH 7.*
30019	18 (0012)	CH 7 Input Count Low Value *LSW*	*See explanation for CH 0 above, but apply to CH 7.*

Register Map

Model 989EN-4x16

Note: *A timeout can only be cleared via a write to any output channel, or upon a software or power-on reset of the unit or by resetting the outputs. Clearing a timeout via an I/O write does not return the output(s) to their initial state. They remain in their timeout states until otherwise written.*

Register Map

Model 989EN-4x16

Note: *A timeout can only be cleared via a write to any output channel, or upon a software or power-on reset of the unit or by resetting the outputs. Clearing a timeout via an I/O write does not return the output(s) to their initial state. They remain in their timeout states until otherwise written.*

Ref	Addr.	Description	Data Type/Format
Input Registers (3x References, Read-Only)			
30020	19 (0013)	Counter Alarm Status	*Data Format:* 16-bit Unsigned Integer This register reflects the Alarm Status for Input Counters 0-7. Each alarm output (Ch. 8-15) has a one-to-one correspondence to an associated counter (Ch. 0-7). Bits 15-8 = Not Used Bit 7-0 = Alarm Status of Channels 15-8 respectively
30021	20 (0014)	CH 0 Input Count Timer Value	*Data Format:* 16-bit Unsigned Integer This registers reflects the time (in milliseconds) between input pulses for CH 0. *Note: The register is updated after every input count edge.*
30022	21 (0015)	CH 1 Input Count Timer Value	*See explanation for CH 0 above, but apply to CH 1.*
30023	22 (0016)	CH 2 Input Count Timer Value	*See explanation for CH 0 above, but apply to CH 2.*
30024	23 (0017)	CH 3 Input Count Timer Value	*See explanation for CH 0 above, but apply to CH 3.*
30025	24 (0018)	CH 4 Input Count Timer Value	*See explanation for CH 0 above, but apply to CH 4.*
30026	25 (0019)	CH 5 Input Count Timer Value	*See explanation for CH 0 above, but apply to CH 5.*
30027	26 (001A)	CH 6 Input Count Timer Value	*See explanation for CH 0 above, but apply to CH 6.*
30028	27 (001B)	CH 7 Input Count Timer Value	*See explanation for CH 0 above, but apply to CH 7.*

Ref	Addr.	Description	Data Type/Format
Holding Registers (4x References, Read/Write)			
40001	0 (0000)	CH 00-15 Watchdog WD Time **Def=FFFFH (Disabled)**	*Data Format*: 16-bit Unsigned Integer Set a watchdog time from 1 to 65534 seconds in 1 second intervals. Set to 65535 (FFFFH) or 0 (0000H) to disable the watchdog timer.

Ref	Addr.	Description	Data Type/Format
Holding Registers (4x References, Read/Write)			
40002	1 (0001)	CH 00-15 Timeout/TO State **Def=0000H**	*Data Format*: 16-bit Unsigned Integer The bits of this 16-bit register value define the state that the output channels of Port 1 will be programmed to following a watchdog timeout. Bit 0 corresponds to channel 0 (lsb), bit 1 to channel 1, bit 2 to channel 2, and so on.
40003	2 (0002)	CH 00-15 Timeout (TO) Action **Def=FFFFH (Change)**	*Data Format:* 16-bit Unsigned Integer Tells what to do to the outputs of Port 1 CH 0-15 upon watchdog timeout. 0000H = Do Not Change Port 1 Outputs FFFFH = Change Port 1 Outputs per Timeout State Register settings.
40004	3 (0003)	Wetting Current Select Register DI0-15 Increasing wetting current helps to prevent oxide buildup on switched contacts. **Def=FFFFH (16mA)**	*Data Format:* 16-bit Unsigned Integer Each input channel has two levels of wetting current, 16mA and 2mA. These bits are used to change the wetting currents for all input channels of the port on the fly. Actual wetting current levels are reduced for excitation voltages below 8V Set this register to 0000H to set all 16 channels of the port to 2mA continuous. Set this register to FFFFH to temporarily set all 16 channels to 16mA for 20ms, upon crossing the 4V input threshold, then return to 2mA continuous. **Note:** The 16mA wetting current selection is subject to a built-in timer which will automatically change the wetting current back to 2mA, 20ms after the input crosses the 4V threshold.
40005	4 (0004)	Input Tri-State DI 0-15 This function disables the input wetting current. ***Def=0000H (Tri-State Disabled)***	*Data Format:* 16-bit Unsigned Integer Inputs may optionally be set to a high-impedance state. In this state the wetting current source will be turned off and the input will function as a simple comparator with a 4.0V threshold (3.7-4.3V range). 0000H= Tri-State Disabled. FFFFH= Tri-State Enabled. Inputs are set to high impedance and wetting currents are disabled.

Register Map

Model 989EN-4x16

Note: *A timeout can only be cleared via a write to any output channel, or upon a software or power-on reset of the unit or by resetting the outputs. Clearing a timeout via an I/O write does not return the output(s) to their initial state. They remain in their timeout states until otherwise written.*

TIP: *Critical applications subject to conditions of severe shock or interference should utilize the built-in watchdog timer to signal an interruption in communication.*

Note*: Tri-stated inputs operate as a high-impedance comparator input with a 4.0V threshold.*

With inputs tri-stated, wetting current is turned OFF and unconnected I/O may be left floating. Unused I/O should be pulled above the 4V threshold in order to properly register the OFF state.

IMPORTANT: *If inputs are set to a high impedance state (tri-stated), the tandem output drain of the channel may be left floating and will require a pull-up or load connection to operate properly. In general, tri-stated inputs should not be left floating.*

You can optionally utilize the open-load detect pull-downs built into the unit to pull the unused tri-stated inputs to the ON state.

Register Map

Model 989EN-4x16

Ref	Addr.	Description	Data Type/Format
Holding Registers (4x References, Read/Write)			
40006	05 (0005)	Output Open-Load Current Enable for DO0-15 *Enables ~50uA pull-down currents at the outputs for open-load detection with inputs tri-stated.* ***Def=0000H (Open-Load Disabled)***	*Data Format:* 16-bit Unsigned Integer For open-load detection with inputs tri-stated, this register allows you to enable/disable a 50uA open-load detection pull-down current at the port outputs. This only works if inputs are tri-stated (wetting current pull-ups are disabled). 0000H= Disable open-load pull-down currents for the port (default). FFFFH= Enable open-load pull-down currents for open-load detection. *Note that open-load detection pulls unused inputs to the ON state. Do not enable if driving loads that may be sensitive to ~50uA in OFF state.*
40007	06 (0006)	Short Fault Protection Control (SFPC) Output DO 0-15 *Enables a fast output shut-down without using an over-temperature trigger.* *This allows the protection to be tailored for inductive versus incandescent lamp loads.* *This is also useful in helping prevent a shorted load from blowing an external series fuse.* *Fast fault protection is not reflected in the I/O Error Status bits.* ***Def=FFFFH (Enable Fast)***	*Data Format:* 16-bit Unsigned Integer Outputs already have built-in current-limiting and thermal shutdown protection with programmable retry. This is not the same thermal limiting that applies to inputs. This register is used to optionally select a fast shutdown of the outputs when over-current conditions are detected, but thermal limits have not been reached, such as with a shorted load. Thus, it would be useful for tailoring outputs to inductive loads or incandescent lamp loads. 0000H = Thermal Only (Slower) – Output will rely on over-temperature shutdown only (this is slower than Vds based trigger). Outputs that shutdown thermally are reported in the port I/O status registers and can optionally be automatically retried via the GSRC register controls. FFFFH = Drain-to-Source Voltage (Faster) – Output will shut down after 100-450us during turn-on into a short circuit. The decision for shutdown is based on an output drain-to-source voltage > 2.7V. This provides protection for loads that experience higher than expected current and require a fast shutdown. It is also useful to prevent a shorted load from blowing a series fuse.

IMPORTANT: *Outputs that utilize fast shutdown are not subject to the automatic retry mechanism of the GSRC register. That is, faulted outputs that are shutdown fast do not retry their control until reset, or optionally via the output refresh cycle (when enabled).*

Outputs that were shutdown fast in response to a fault are also not reported in the Port I/O Error Status registers.

Ref	Addr.	Description	Data Type/Format
Holding Registers (4x References, Read/Write)			
40008	07 (0007)	Global Shut-Down & Retry Control (GSRC) Register Output DO 0-15 *Use this register to pick an output thermal or over-voltage shut-down recovery strategy.* ***Def=0003H (Refresh OFF, Retry Out, Restore Out)***	*Data Format:* 16-bit Unsigned Integer This register selects the output fault & recovery strategy to be applied for over-voltage and thermal protection. Bit 15: 1=Enable Output Refresh, 0=Disable Refresh (default). Bits 14-2: Not Used (Set to 0) Bit 1: **Thermal over-load/short-circuit action** – If port output power dissipation exceeds its internal limit, the output will temporarily shut down. This bit determines how the outputs act after they cool. 0=Outputs turn OFF at thermal limit & remain OFF even after cooling. 1=Outputs turn OFF at thermal limit & retry their prior state after cooling. Bit 0: **Excitation & output over-voltage action** – When the port excitation voltage exceeds 28V minimum, port outputs temporarily shut down. This bit determines how they act after the excitation or output over-voltage fault is removed. 0=Force port outputs OFF after drain or Ex voltage returns to normal. 1=Send port outputs to their previous state after drain/Ex returns to normal.
40009	08 (0008)	*CH 0-15 Output Power-Up State* ***Def=0000H (All Clear)***	*Data Format:* 16-bit Unsigned Integer The bits of this 16-bit register value define the state that the output channels of Port 1 upon power-up. Bit 0 corresponds to channel 0 (lsb), bit 1 to channel 1, and so on.
40010	09 (0009)	*CH 0-7 Counter Enable* ***Def=0000H (All Counters Disabled)***	*Data Format:* 16-bit Unsigned Integer Bits 7-0 can be set to enable counters on channels 7-0. Note: After a counter is enabled, the output for that channel is automatically disabled. Bits 15-8: Not Used Bit 7: 0 = Disabled, 1 = Enabled Bit 6: 0 = Disabled, 1 = Enabled Bit 5: 0 = Disabled, 1 = Enabled Bit 4: 0 = Disabled, 1 = Enabled Bit 3: 0 = Disabled, 1 = Enabled Bit 2: 0 = Disabled, 1 = Enabled Bit 1: 0 = Disabled, 1 = Enabled Bit 0: 0 = Disabled, 1 = Enabled

Register Map

Model 989EN-4x16

This device includes an automatic output refresh cycle that occurs every 5 seconds to help ensure that outputs recover their programmed state if EMI or ESD ever causes an inadvertent state change without resetting the system (an output or system reset will always cause the outputs to turn OFF) It is recommended to keep output refresh turned OFF to improve counter performance.

The automatic output refresh cycle is enabled by default (GSRC bit 15 is set to 1).

If you elect to leave outputs OFF after an output fault has occurred via the GSRC register controls (bits 1 and/or 0), then you should also turn off the internal automatic output refresh cycle via bit 15 of the GSRC register or outputs will not stay OFF.

Outputs that utilize fast shutdown, as opposed to thermal shutdown (see SFPC register) are not subject to the automatic retry mechanism of the GSRC register. That is, outputs shutdown fast in response to a fault do not retry their control until reset, or optionally via the output refresh cycle.

Note: *Shaded registers are only available on the 989EN-4016 industrial model.*

Note: *After a counter is enabled, the output for that channel is automatically disabled.*

Register Map

Model 989EN-4x16

Note: *Shaded registers are only available on the 989EN-4016 industrial model.*

Ref	Addr.	Description	Data Type/Format
Holding Registers (4x References, Read/Write)			
40011	10 (000A)	*Start-Up Count Mode* ***Def=FFFFH (All Counters Start at Pre-Load Value)***	*Data Format:* 16-bit Unsigned Integer The lower byte of this 16-bit register value defines whether the value of the count register will start at the stored value in non-volatile memory, or start at the pre-load value. Bits 15-8: Not Used Bit 7: 0 = Last Count, 1 = Pre-Load Bit 6: 0 = Last Count, 1 = Pre-Load Bit 5: 0 = Last Count, 1 = Pre-Load Bit 4: 0 = Last Count, 1 = Pre-Load Bit 3: 0 = Last Count, 1 = Pre-Load Bit 2: 0 = Last Count, 1 = Pre-Load Bit 1: 0 = Last Count, 1 = Pre-Load Bit 0: 0 = Last Count, 1 = Pre-Load
40012	11 (000B)	*Edge Detection* ***Def= 0000H (Negative Edge)***	*Data Format:* 16-bit Unsigned Integer The lower byte of this 16-bit register defines the edge the counter triggers on. Bits 15-8: Not Used Bit 7: 0 = Negative, 1 = Positive Bit 6: 0 = Negative, 1 = Positive Bit 5: 0 = Negative, 1 = Positive Bit 4: 0 = Negative, 1 = Positive Bit 3: 0 = Negative, 1 = Positive Bit 2: 0 = Negative, 1 = Positive Bit 1: 0 = Negative, 1 = Positive Bit 0: 0 = Negative, 1 = Positive
40013	12 (000C)	*Count Direction* ***Def= 0000H (Count Up)***	*Data Format:* 16-bit Unsigned Integer The lower byte of this 16-bit register defines the direction of the counter. After a pulse to the counter, Up counting will increment the value, and Down counting decrements the count Bits 15-8: Not Used Bit 7: 0 = Up, 1 = Down Bit 6: 0 = Up, 1 = Down Bit 5: 0 = Up, 1 = Down Bit 4: 0 = Up, 1 = Down Bit 3: 0 = Up, 1 = Down Bit 2: 0 = Up, 1 = Down Bit 1: 0 = Up, 1 = Down Bit 0: 0 = Up, 1 = Down

Ref	Addr.	Description	Data Type/Format
Holding Registers (4x References, Read/Write)			
40014	13 (000D)	*Count Termination Mode* ***Def= 0000H (All Rollover)***	*Data Format:* 16-bit Unsigned Integer Bits 15-8: Not Used Bit 7: 0 = Rollover, 1 = Stop and Hold Bit 6: 0 = Rollover, 1 = Stop and Hold Bit 5: 0 = Rollover, 1 = Stop and Hold Bit 4: 0 = Rollover, 1 = Stop and Hold Bit 3: 0 = Rollover, 1 = Stop and Hold Bit 2: 0 = Rollover, 1 = Stop and Hold Bit 1: 0 = Rollover, 1 = Stop and Hold Bit 0: 0 = Rollover, 1 = Stop and Hold
40015	14 (000E)	*Counter Alarm Enable* ***Def= 0000H (All Alarms Disabled)***	*Data Format:* 16-bit Unsigned Integer The lower byte of this 16-bit register (bits 7-0) enables counter output alarms on channel 15-8. Bits 15-8: Not Used Bit 7: 0 = Disabled, 1 = Enabled Bit 6: 0 = Disabled, 1 = Enabled Bit 5: 0 = Disabled, 1 = Enabled Bit 4: 0 = Disabled, 1 = Enabled Bit 3: 0 = Disabled, 1 = Enabled Bit 2: 0 = Disabled, 1 = Enabled Bit 1: 0 = Disabled, 1 = Enabled Bit 0: 0 = Disabled, 1 = Enabled
40016	15 (000F)	*Counter 0 Pre-Load High Value* **Def=0000H**	*Data Format:* 16-bit Unsigned Integer This 16-bit register defines the upper word of the Pre-Load value for counter 0.
40017	16 (0010)	*Counter 0 Pre-Load Low Value* **Def=0000H**	*Data Format:* 16-bit Unsigned Integer This 16-bit register defines the lower word of the Pre-Load value for counter 0.
40018	17 (0011)	*Counter 1 Pre-Load High Value*	*See explanation for counter 0 above, but apply to counter 1*
40019	18 (0012)	*Counter 1 Pre-Load Low Value*	*See explanation for counter 0 above, but apply to counter 1*
40020	19 (0013)	*Counter 2 Pre-Load High Value*	*See explanation for counter 0 above, but apply to counter 2*
40021	20 (0014)	*Counter 2 Pre-Load Low Value*	*See explanation for counter 0 above, but apply to counter 2*
40022	21 (0015)	*Counter 3 Pre-Load High Value*	*See explanation for counter 0 above, but apply to counter 3*

Register Map

Model 989EN-4x16

Note: *Shaded registers are only available on the 989EN-4016 industrial model.*

Register Map

Model 989EN-4x16

Note: *Shaded registers are only available on the 989EN-4016 industrial model.*

Ref	Addr.	Description	Data Type/Format
Holding Registers (4x References, Read/Write)			
40023	22 (0016)	*Counter 3 Pre-Load Low Value*	*See explanation for counter 0 above, but apply to counter 3*
40024	23 (0017)	*Counter 4 Pre-Load High Value*	*See explanation for counter 0 above, but apply to counter 4*
40025	24 (0018)	*Counter 4 Pre-Load Low Value*	*See explanation for counter 0 above, but apply to counter 4*
40026	25 (0019)	*Counter 5 Pre-Load High Value*	*See explanation for counter 0 above, but apply to counter 5*
40027	26 (001A)	*Counter 5 Pre-Load Low Value*	*See explanation for counter 0 above, but apply to counter 5*
40028	27 (001B)	*Counter 6 Pre-Load High Value*	*See explanation for counter 0 above, but apply to counter 6*
40029	28 (001C)	*Counter 6 Pre-Load Low Value*	*See explanation for counter 0 above, but apply to counter 6*
40030	29 (001D)	*Counter 7 Pre-Load High Value*	*See explanation for counter 0 above, but apply to counter 7*
40031	30 (001E)	*Counter 7 Pre-Load Low Value*	*See explanation for counter 0 above, but apply to counter 7*
40032	31 (001F)	*Counter Debounce Enable* ***Def= 0000H (All Debounce Disabled)***	*Data Format:* 16-bit Unsigned Integer The lower byte of this 16-bit register (bits 7-0) enables counter debounce on channels 7-0. Bits 15-8: Not Used Bit 7: 0 = Disabled, 1 = Enabled Bit 6: 0 = Disabled, 1 = Enabled Bit 5: 0 = Disabled, 1 = Enabled Bit 4: 0 = Disabled, 1 = Enabled Bit 3: 0 = Disabled, 1 = Enabled Bit 2: 0 = Disabled, 1 = Enabled Bit 1: 0 = Disabled, 1 = Enabled Bit 0: 0 = Disabled, 1 = Enabled
40033	32 (0020)	*Counter Debounce Value* ***Def= 0005H (5 milliseconds)***	*Data Format:* 16-bit Unsigned Integer Set a debounce time from 1 to 65534 milliseconds in 1 millisecond intervals. Set to 65535 (FFFFH) or 0 (0000H) to disable the watchdog timer. *Note: Debounce Value is applied to ALL channels enabled with debounce.*

Ref	Addr.	Description	Data Type/Format
Holding Registers (4x References, Read/Write)			
40034	33 (0021)	*Timer Limit Value* ***Def = FFFFH***	*Data Format:* 16-bit Unsigned Integer Set a timer limit time from 1 to 65535 milliseconds in 1 millisecond intervals. This time represents the time to wait for a valid count edge. When the value is reached, Timer Value is set to value in timer limit state *Note: Timer Limit Value is applied to ALL channels with counters enabled.*
40035	34 (0022)	*Timer Limit State* ***Def = 0000H***	*Data Format:* 16-bit Unsigned Integer The bits of this 16-bit register value define the state that the timer value of each counter will be programmed to once the timer limit is reached. Bit 0 corresponds to channel 0 (lsb), bit 1 to channel 1, and so on. *Note: Timer Limit Value is applied to ALL channels with counters enabled.*
40036	35 (0023)	*Reserved*	*Reserved – Do Not Use*
40037	36 (0024)	*Reserved*	*Reserved – Do Not Use*
40038	37 (0025)	Wink Unit Toggle Register *Used to help identify network units.*	*Data Format:* 16-bit Unsigned Integer Write 21845 (5555H) to this register to cause the unit to "wink" its green Run LED in order to ID the unit. Write the same value a second time to stop "winking". This register will always read back as 0000H. Use the Unit Status Register wink mode flag (bit 14) to determine the wink state.
40039	38 (0026)	*Digital Inputs 0-15*	*Data Format:* 16-bit Unsigned Integer *Bit field (Read Only) – The 16 bits of this field correspond to the states of channels 0-15, with the bit position corresponding to the input channel number (lsb is channel 0). A clear bit (0) is OFF, while a set bit (1) is ON.*
40040	39 (0027)	*Digital Outputs 0-15*	*Data Format:* 16-bit Unsigned Integer *Bit field (Read/Write) – The 16 bits of this field correspond to channels 0-15. The bit position corresponds to the output channel number (lsb is ch. 0). A clear bit (0) is OFF, while a set bit (1) is ON.*

Register Map

Model 989EN-4x16

Note: *Shaded registers are only available on the 989EN-4016 industrial model.*

Register Map

Model 989EN-4x16

Port Input and Output resets are normally not required, but are sometimes useful in troubleshooting I/O and will reset the input or output circuitry independent of each other, a power-on, system, CPU, or communication controller reset.

Ref	Addr.	*Description*	Data Type/Format
Holding Registers (4x References, Read/Write)			
40041	40 (0028)	*Input Reset DI 0-15* *(Inputs Only)*	*Data Format:* 16-bit Unsigned Integer Inputs of the module may be independently reset with this command (does not reset the outputs or controller). This is useful for trouble-shooting. Writing FFFFH to this register (all bits set) will trigger a reset of the port. FFFFH = Reset All Port Inputs 0000H = Do Not Reset Port.
40042	41 (0029)	*Output Reset DO 0-15* *(Outputs Only)*	*Data Format:* 16-bit Unsigned Integer Outputs of the module may be independently reset with this command (does not reset the inputs or controller). This is useful for trouble-shooting. Writing FFFFH to this register (all bits set) will trigger a reset of the port FFFFH = Reset All Port Inputs. 0000H = Do Not Reset Port.
40043	42 (002A)	*Counter Start*	*Data Format:* 16-bit Unsigned Integer The lower byte of this 16-bit register (bits 7-0) starts the counting of counter channels 7-0 respectively. This register will always read back as FFFFH. Bits 15-8: Not Used Bit 7: 0 = Don't Start, 1 = Start Bit 6: 0 = Don't Start, 1 = Start Bit 5: 0 = Don't Start, 1 = Start Bit 4: 0 = Don't Start, 1 = Start Bit 3: 0 = Don't Start, 1 = Start Bit 2: 0 = Don't Start, 1 = Start Bit 1: 0 = Don't Start, 1 = Start Bit 0: 0 = Don't Start, 1 = Start

Register Map

Model 989EN-4x16

Ref	Addr.	*Description*	Data Type/Format
Holding Registers (4x References, Read/Write)			
40044	42 (002B)	*Counter Stop*	*Data Format:* 16-bit Unsigned Integer The lower byte of this 16-bit register (bits 7-0) stops the counting of counter channels 7-0 respectively. This register will always read back as FFFFH. Bits 15-8: Not Used Bit 7: 0 = Don't Stop, 1 = Stop Bit 6: 0 = Don't Stop, 1 = Stop Bit 5: 0 = Don't Stop, 1 = Stop Bit 4: 0 = Don't Stop, 1 = Stop Bit 3: 0 = Don't Stop, 1 = Stop Bit 2: 0 = Don't Stop, 1 = Stop Bit 1: 0 = Don't Stop, 1 = Stop Bit 0: 0 = Don't Stop, 1 = Stop
40045	42 (002C)	*Counter Reset*	*Data Format:* 16-bit Unsigned Integer The lower byte of this 16-bit register (bits 7-0) enables reset of counters channels 7-0 respectively. This register will always read back as FFFFH. Bits 15-8: Not Used Bit 7: 0 = Don't Reset, 1 = Reset Bit 6: 0 = Don't Reset, 1 = Reset Bit 5: 0 = Don't Reset, 1 = Reset Bit 4: 0 = Don't Reset, 1 = Reset Bit 3: 0 = Don't Reset, 1 = Reset Bit 2: 0 = Don't Reset, 1 = Reset Bit 1: 0 = Don't Reset, 1 = Reset Bit 0: 0 = Don't Reset, 1 = Reset
41001 . . .		This block Mirrors 1xxxx Registers.	Refer to Register Mirroring. 1xxxx Input Status Registers are mapped to the 41xxx Holding Register space using an address offset of 41000.
42001 . . .		This block Mirrors 0xxxx Registers.	Refer to Register Mirroring. 0xxxx Coil Registers are mapped to the 42xxx Holding Register space using an address offset of 42000.
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.

SPECIFICATIONS

These DIN-rail mount, industrial Ethernet, digital I/O modules include sixteen combination digital I/O / counter inputs (989EN), and provide an isolated 10/100BaseT/TX Ethernet port for monitoring and control. Units are DC-powered and include reverse polarity protection. Outputs are open-drain, low-side switches, while inputs are active-low. Channel I/O, network, and power circuits are isolated. Outputs have high voltage/current capacity for discrete on/off control of external devices. Non-inverting, buffered inputs provide support for digital level sensing, or for simply reading back the tandem output. I/O channels share common. The first eight inputs may function as 32-bit event counters (up to 150 Hz) with programmable debounce and non-volatile count. Non-volatile reprogrammable memory in the module stores configuration information.

Model Numbers

989EN-4016
989EN-4C16

The BusWorks model prefix "900" denotes the Series 900 network I/O family. The "EN" suffix denotes EtherNet. The four digit suffix of this model number represents the following options, respectively: "4" = Modbus; "0" = Industrial Model; "C" = Commercial Model; "16" = 16 Channels.

Digital Inputs

CAUTION: *Failure to pull the I/O channel above the 4.3V maximum threshold when the output is OFF, or with the input tri-stated, can result in the OFF output state being erroneously indicated as ON. Likewise, attempting to drive output loads with IR exceeding 4V will cause the input to indicate an OFF state with the mosfet ON, as the input threshold crosses back above 4V (there is up to 16mA of wetting current per channel).*

IMPORTANT: Inputs and Outputs will not operate without excitation.

Note: *Excitation of 8V or greater is required to deliver the full 2mA/16mA of wetting current.*

Note: *Input Counters are only available on the 989EN-4016 model ONLY.*

The 989EN models include 16, active-low, buffered inputs. Inputs are connected in tandem with the open-drains of output mosfets (see below). Eight inputs also function as 32-bit event counters (up to 150 Hz) with programmable debounce. Inputs also include transient voltage suppression and are intended for DC voltage applications only. An external excitation supply connection between EXC and RTN (Return) is required for I/O operation. Inputs include programmable wetting current pull-ups for sensing switch closure (see below), and inputs may be optionally tri-stated (disables wetting current). The wetting current generators also allow the tandem open-drain output to operate without adding a pull-up. Integrated wetting current helps facilitate an I/O self-test without actual wiring.
IMPORTANT: Inputs (and outputs) will not operate without port excitation. External port excitation of 8-31V is required (40mA minimum).

Input Signal Voltage Range: 0 to 31V maximum. Input operating range is first limited by the I/O transient protection (31V), then the input circuitry itself (38V), then the tandem output mosfet drain-source voltage (50V).

Input Signal Threshold: Voltage signals below 4.0V DC (3.7 to 4.3V range) are ON. Voltages above 4V (3.7 to 4.3V range) are OFF.

Input Event Counters: Events are counted in 32-bit registers and optionally stored in non-volatile memory. Event counters are rated from 0-150 Hz. Additionally the counters are equipped with programmable debounce (0-65535ms), output alarms, selectable count edge, and up/down counting. *(***Note:** *Only available on 989EN-4016 model)*

Input Counter Debounce: Event counters can each be enabled to debounce an input for a specific period of time. Debounce time can be set from 0 to 65535ms and applied to all counters with debounce enabled.

Input Counter Direction: Each event counter can set the count direction to either up counting (default), or down counting from a pre-load value.

Input Counter Edge: Each counter can be set to detect the incoming pulse on the rising edge or falling edge (default),.

Input Counter Pre-Load Value: Each Input Counter has an associated Pre-Load Value to start counting from. After a roll-over / reset, the counter will default back to this value.

Input Pulse Time: Each Input Counter is equipped with a timer which will display the time (in milliseconds) between pulses.

Input Timer Limit: The timer limit sets the maximum allowable value between pulses (0-65535ms). Once the limit is reached, the timer value is set to a programmable value (0-65535).

Input "Wetting" Current (2mA, 16mA, or OFF): Input wetting current sources are used to sense contact closure and act like I/O pull-ups to excitation. Wetting current is set to 16mA by default. This current is drawn from the external excitation supply. This current can be set to provide a higher initial current level during contact transfer to help keep the external switch contacts from building up oxides that can form on the contact surface and eventually impede connection. The input wetting current can be set to 2mA continuous, or 16mA/20ms (default, switches from 2mA to 16mA for 20ms as the input crosses the 4V threshold, then returns to 2mA). This current can also be disabled by tri-stating the inputs. A built-in 20ms timer controls the amount of time the current stays at 16mA before switching back to 2mA in order to limit power dissipation. In addition, the use of excitation below 8V will cause the wetting current levels to be reduced.

Input "Tri-State" (Disables Wetting Current): Inputs may be set to a high impedance state via the Input Tri-State register. In this state, the wetting current sources are disabled and the input acts like a simple comparator with a 4.0V threshold. Unused inputs in the high impedance state should not be allowed to float, as they may indicate the wrong I/O state. External pull-up resistors may be needed for some applications. You can also enable open-load detection to pull-down unused tri-stated inputs.

Input Thermal Limiting: With multiple switch inputs closed, high ambient, and many wetting currents set to 16mA, there is a small potential for excessive input port power dissipation. When dissipation is such that the input port die temperature rises above the thermal limit (155°C to 185°C), a built-in temperature monitor will generate an interrupt, force any 16mA current sources to 2mA continuous, set the thermal flag bit in the input state register, and still maintain operation. The input thermal bit will be cleared when the die temperature has cooled ~10°C below the thermal limit (with 5-15°C of hysteresis range). The device will then return to its previous programmed settings.

Input Excitation: **Inputs will not operate without excitation.** Excitation is normally connected between the port Exc and Return terminals and must be a DC voltage from 8 to 28V DC (31V Maximum). The tandem outputs may temporarily shut down for excitation voltages above 28V. The excitation input includes transient protection and filtering. Note that the input wetting currents are sourced from the excitation supply and your input signal maximum is determined by your excitation voltage level.

Input Scan Time: Input updates are obtained every 1ms, typical.

All 989EN models include 16, open-drain, mosfet switches with a common source. Outputs are connected in tandem with buffered inputs (see above). Outputs include transient voltage suppression and are intended for low-side, DC voltage switching applications only. Outputs also include integrated over-voltage, over-temperature, and over-current protection (see below). An external excitation supply connected between port Excitation (EXC) and Return (RTN) terminal is required for output operation. The open-drain outputs can operate without external pull-ups as the tandem input circuit includes "wetting current" generators (integrated pull-ups). You can add pull-ups to increase output current drive capability beyond 2mA/channel.

SPECIFICATIONS

Digital Inputs

Note: *For input-only operation, the corresponding tandem output channel must be turned OFF to avoid contention with an externally driven input signal.*

SPECIFICATIONS

Digital Inputs

Input Timer Accuracy:

Frequency ≥ 1 Hz	Frequency < 1 Hz
≤ ±1 ms	±0.1% or better

Digital Outputs

IMPORTANT: Inputs and Outputs will not operate without excitation.

To control higher voltages and/or currents, or for controlling AC, an interposing relay may be used.

Output "OFF" Voltage Range: 0 to 28V DC, 31V maximum. Output control voltage range is first limited to 28V or the excitation voltage level, whichever is less, then the transient voltage suppression (31V, see below), then the input circuitry (38V), then the output driver (50V). Built-in over-voltage protection limits the output operating range (see below) and may temporarily shut the output down for excitation voltages greater than 28V, or output drain-source voltages greater than 50V.

Output Drain-to-Source ON Resistance (Rds): 0.55Ω typical (25°C), 1.1Ω maximum (125°C junction temperature).

Output "ON" Current Range: 1mA to 500mA maximum DC continuous, each output. The sixteen outputs share 3 common return terminals (RTN) which are limited to 2A combined total (giving 0.125A /16ch or 0.5A/4ch). No deration is required at elevated ambient temperature. Individual outputs also have internal over-current fault limits of 1.2A typical (0.9A to 2.5A range) that will limit current until the internal over-temperature limit is reached, triggering a thermal shutdown of the output (see below). Note the input wetting current is additive to the load current (2mA/16mA), but may be optionally turned off (with inputs tri-stated).

Output "OFF" Leakage Current: 10uA typical, 20uA maximum. This increases by 50uA if open-load detection is enabled.

Output Excitation: Excitation is connected between the Exc and Return terminals and must be a DC voltage from 8 to 28V DC. Inputs and outputs will not operate without excitation. The excitation input includes transient protection and filtering, plus a series connected reverse polarity blocking diode. The port input wetting current and internal logic currents are all sourced from the excitation supply.

Output Over-Voltage Protection: Outputs are intended to switch voltages within the excitation voltage range, but will shutdown operation for excitation over-voltage conditions above 28V (30V typical, 35V max), and any drain-to-source voltages greater than 50V. Normal operation will resume following shutdown upon return to proper voltage level. Note that sustained voltages above 31V can damage the transient voltage suppressor. Following a fault shutdown, the outputs may be configured to retry the previous state, or remain OFF, depending on the settings of the Output Global Shutdown/Retry Control register.

Output Over-Current Protection: The outputs have internal self-limiting ON state currents of 1.2A typical (0.9A to 2.5A range). An output will limit fault current in this range until the output thermal limit is reached and the output enters over-temperature shutdown. A thermal fault flag will be set. Only the faulted output will shut-down, not every outputs. Upon removal of the fault condition, the output will automatically return to its previous state, or stay OFF, based upon the control bit settings in the Output Global Shutdown/Retry Control Register.

WARNING: Individual output current is limited to 500mA maximum. You should not attempt to operate outputs above these limits or you may exceed the safe operating range for the foils of the circuit board, which may result in permanent damage to the unit.

SPECIFICATIONS

Output Over-Temperature Protection: The outputs have internal over-temperature limits that trigger for a junction temperature of 165°C (155°C to 180°C range). Only the output experiencing an over-temperature condition will shut-down. Upon return to normal temperature (a 10°C typical hysteresis applies, 5-20°C range), the output will automatically resume its prior setting, or remain OFF according to the control bit settings in the Port Output Global Shutdown/Retry Register.

Output Open-Load Detection (w/Inputs Tri-Stated): Outputs may utilize ~50uA current sink pull-downs to facilitate open load detection when the tandem inputs are tri-stated. These are also useful to help keep the tandem tri-stated input from floating (but note that they pull to the ON state). This protection is disabled by default and would not be appropriate where 50uA of OFF state current cannot be tolerated, where pulling to the ON-state is not appropriate, or if the tandem inputs are not tri-stated (as tri-stating the inputs turns OFF the opposing wetting current pull-ups that are also built-in).

Do not enable open-load detection without tri-stating the inputs, as this adds a pull-down to the I/O channel that opposes the pull-up present outside of tri-state mode.

Output Refresh Cycle: Output states automatically refreshed every 5 seconds if not rewritten. This is done to help ensure that outputs recover their programmed state if EMI or ESD ever causes an inadvertent state change without resetting the system. By default, this is turned OFF and it is recommended to be turned OFF to improve counter performance if you are using counters. Turning output refresh OFF allows outputs that experience a fault to stay off after the fault is removed, rather than retry their control (see Global Shutdown and Retry Control Register).

It is recommended to turn output refresh OFF to improve counter performance, or if you wish outputs to remain OFF following a shutdown due to a fault condition.

Counter Alarm Output – Upon counter rollover condition, an alarm can optionally be triggered. The output will toggle its state, and reset either upon next event count (momentary alarm), or from a manual reset (latched alarm).

General Specifications

Excitation (External): External voltage is required between EXC and RTN terminals from 8 – 28V (31V MAX).

Enclosure and 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 isolated and bypassed to earth ground at the GND terminal with an isolation TVS and capacitor). Connections are wired MDI or MDI-X. A CAT-5 cable is recommended to connect this module to a PC.

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

SPECIFICATIONS

Enclosure and Physical

Case Material: Self-extinguishing NYLON type 6.6 polyamide thermoplastic UL94 V-2, color beige; general purpose NEMA Type 1 enclosure.
Printed Circuit Boards: Military grade FR-4 epoxy glass.
Shipping Weight: 1 pound (0.45 Kg) packed.

Agency Approvals

Safety Approvals: CE marked (EMC Directive 2004/108/EC), UL Listed (UL508-17th Edition, ANSI/ISA 12.12.01-2007), cUL Listed (Canada Standard C22.2, Nos. 142-M1987 & 213-M1987), Hazardous Locations: Class I; Division 2; Groups A, B, C, D.
Safety Approvals (989EN-4C16): CE marked (EMC Directive 2004/108/EC)

Environmental

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

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

Note: *Current draw does not include excitation current draw.*

Operating Temperature (989EN-4016): -40°C to +65°C (-40°F to +149°F).
Operating Temperature (989EN-4C16): 0°C to +55°C (+32°F to +131°F).
Storage Temperature (989EN-4016): -40°C to +85°C (-40°F to +185°F).
Storage Temperature (989EN-4C16): 0°C to +70°C (+32°F to +158°F).
Relative Humidity: 5 to 95%, non-condensing.
Power Requirements: 18-36V DC SELV (Safety Extra Low Voltage). Observe proper polarity. See table for current.

Supply	989EN-4016 Current Draw
18V	66mA Typical, 73mA Maximum
24V	49mA Typical, 55mA Maximum
36V	33mA Typical, 37mA Maximum

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

Note that I/O channels are not isolated channel-to-channel.

Isolation: I/O channel, 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): Inputs/outputs have demonstrated resistance to inadvertent state changes with interference from switching solenoids, commutator motors, and drill motors.
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.

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

Emissions Per European Norm BS EN 61000-6-4:2007
Radiated Frequency Emissions: 30 to 1000MHz per CISPR16 Class A
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. (Model 989EN-4016 ONLY)

WARNING – EXPLOSION HAZARD – Substitution of 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.

Reference Standard: CNR indicates investigation to Canadian Standard C22.2, No's. 142-M1987 & 213-M1987; USR indicates investigation to United States UL Standards 508 and 1604.

MTBF (Mean Time Between Failure): MTBF in hours using MIL-HDBK-217F, FN2.

Temp	989EN-4016
25ºC	444,109 hrs
40ºC	276,904 hrs

Per MIL-HDBK-217, Ground Benign, Controlled, G_BG_C

SPECIFICATIONS

Environmental

Ethernet Interface

Connector: Shielded RJ-45 socket, 8-pin, 10BaseT/100BaseTX.
Wiring: Wired MDI-X w/ Auto-Crossover support.
Protocol: Modbus TCP/IP w/Web Browser Configuration.
IP Address: Default mode static IP address is 128.1.1.100.
Port: Up to 5 sockets supported, uses port 502 (reserved for Modbus).
Transient Protection: Transient Voltage Suppressors are applied differentially at both the transmit and receive channels. The metal shield is capacitively coupled to earth ground terminal via an isolation TVS and capacitor.
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 5 sockets may be selected. Web pages for configuration and control are built-in and may be accessed over Ethernet via a standard web browser. Most module functionality is configured via memory map registers or web pages, but some functionality may only be configured via web pages.
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.
Address: The module IP address can be preset by the user (static) and loaded from internal non-volatile memory, or it can be automatically acquired at startup via a network server using a 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.

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.

SPECIFICATIONS

Controls & Indicators

LED Indicators:

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

ST (Orange) – Slowly blinks ON/OFF in default mode, blinks rapidly if a watchdog timeout has occurred, and stays solid for counter alarm state.

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

ACT (Orange) – Indicates current activity on the Ethernet port (ON if data is being transmitted or received).

Controls:

Default Address Switch: This momentary push-button switch is located on the front panel and is used to toggle the module into, or out of Default Communication Mode. In Default Mode, the module assumes the fixed static IP address "128.1.1.100", a default subnet mask "255.255.255.0", a default username of "User", and a default password of "password". 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) cables. There are 3 main categories of cable – Category 3, Category 4, and Category 5. The differences in classification are found in their electrical performance and this is documented in the TIA/EIA 568A standard. Category 5 cable includes four twisted wire pairs at eight twists per foot.

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: 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 cable and double-shielded cable. 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. Some variations will also include a drain wire that encircles the outer foil. The double-shielded version adds an outer wire screen that wraps around 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. The metal shield of these connectors 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, this shield contacts earth ground via a high voltage capacitor and transient voltage suppressor. In addition to minimizing radio frequency and electromagnetic interference, this arrangement also has the added benefit of enhanced 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. It is rated for frequencies up to 200MHz, double the rate of Category 5. Category 5e cable also has a greater number of turns-per-inch in its twisted pairs, making its performance more suitable for applications that make use of all four wire pairs for simultaneous bidirectional data transmission (full-duplex). 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, or if you're using the Acromag 900EN-S005 switch, as the 989EN is auto-crossing.

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.

Notes: