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

Industrial Grade:
Model 993EN-4016 Sixteen CH Single-Ended Current Inputs
Model 994EN-4016 Sixteen CH Single-Ended Voltage Inputs
Commercial Grade:
Model 993EN-4C16 Sixteen CH Single-Ended Current Inputs
Model 994EN-4C16 Sixteen CH Single-Ended Voltage Inputs

USER'S MANUAL



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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.

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QUICK START

Guide to Quickly Establishing Communication

If you already know the basics of connecting power, connecting a network cable, and using a web-browser, and you only need some help establishing communication, here is a brief outline of what you must do to start communicating with this device right away and where to go for help.

This is a web-enabled Ethernet device that allows you to use your web-browser to set it up and operate it. All Ethernet devices have a unique IP address that you are required to know in order to communicate with them using your web-browser.

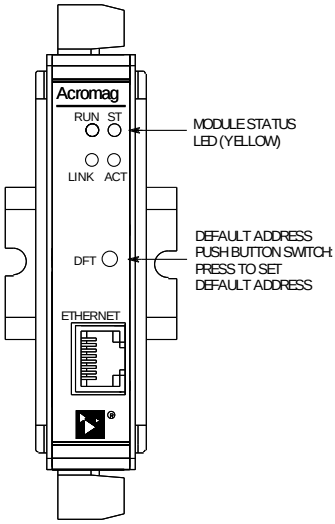
What if you do not already know the IP address of the unit?

All Acromag Ethernet devices include an alternate default mode of operation with a fixed IP address set to **128.1.1.100**. Additionally, the user-programmable IP address that is used outside of default mode is also initially set to 128.1.1.100 from the factory. If this unit is fresh from the factory, you can talk to it at this address in either mode.

If your unit is not as shipped from the factory and may have another IP address set, then…

You need to place the unit in its Default Mode, which allows you to address it at IP address 128.1.1.100 (**http://128.1.1.100**).

You place this unit into Default Mode by depressing the push button marked "DFT" for about 5 seconds (see front figure at right), just until the yellow STATUS LED starts blinking slowly to indicate the unit is in the Default Mode. Let go of DFT button when Status LED starts blinking.



Try browsing the unit with your web browser address at **http://128.1.1.100**. If your unit is in default mode, you should be presented with the home page (and your Status LED should continue to blink).

If you are using IP address 128.1.1.100, and you still can't talk to the unit…

You cannot talk to this device at IP address 128.1.1.100 if the Network Interface Card you are using to connect to our device is set to an IP address outside of the address domain established by this default address. You must set the IP address of your network interface to an address like 128.1.1.x, where x is an integer from 1 to 254, except 100 (our default address). This procedure is covered in document 8500-815 shipped with your unit. It is also detailed in Application Note 8500-734, which you can obtain from the CDROM shipped with your unit, or optionally via download from our web site at www.acromag.com.

You managed to browse to the unit's Home Page, but now you need to get to the Network Configuration Page to set your own IP address…

In order to access any of the other web configuration pages, like the Network Configuration Page, you will need to first enter a Username = **User**, and Password = **password00** to gain access (these are the default username and password settings for all BusWorks models and these entries are case-sensitive).

QUICK START

Guide to Quickly Establishing Communication

Your unit is not as shipped from the factory and you do not know the Username and Password settings…

If you forget your user name & password, you can always toggle the unit into default mode via the DFT toggle switch at the front of the unit (hold this toggle 4 seconds to invoke default mode). In this mode, the password and username will revert to the original defaults of "User" and "password00" (unit assumes an IP address of 128.1.1.100 in its default mode), allowing you to re-invoke the Password Configuration Page and change the username and password settings as required.

If after applying power, your green RUN LED is not solid ON and is blinking continuously, you need to do the following:

Normally on power-up, the green RUN LED will blink for about 24 seconds during initialization, then stay ON. But if you powered the unit up without making your network connection, the green RUN LED will continue to blink. If RUN continues to blink, first check that your network cable is connected to the unit and to your PC. If you replaced the network cable after powering-up, the RUN LED should stop blinking after about 15 seconds once a network link has been established. Once the link is established, the green RUN LED should not continue to blink and should stay ON. This applies even if you later remove the cable while powered up.

If you have checked your network connections and the green RUN LED continues to blink…Reset, Restore, Return:

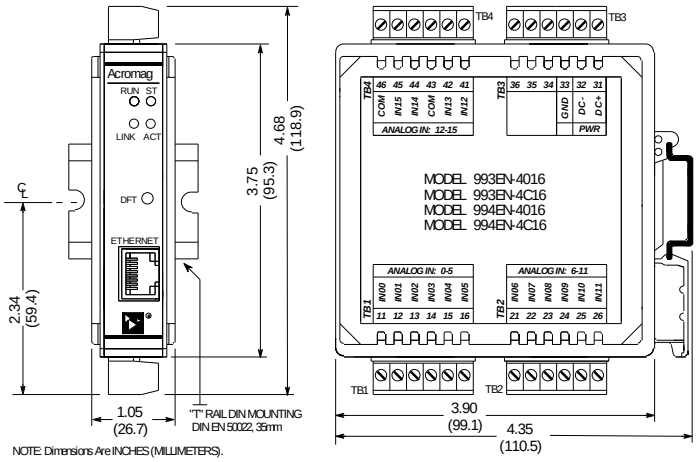
Reset: Try resetting the unit by cycling the power to the unit. After about 24 seconds, the green REN LED should remain ON

Restore: If you've tried resetting the unit and the green RUN LED still continues to blink, then you may need to follow the procedure for restoring the module to its initial configuration. This procedure is located at the end of the Trouble-Shooting section of this manual under "Getting Out Of Trouble" on page 32. Note that this is also the procedure used to sanitize the unit for de-commissioning. You should only do this as a last resort, as this procedure restores everything to its default state—all holding registers, network settings, and any calibration you may have performed.

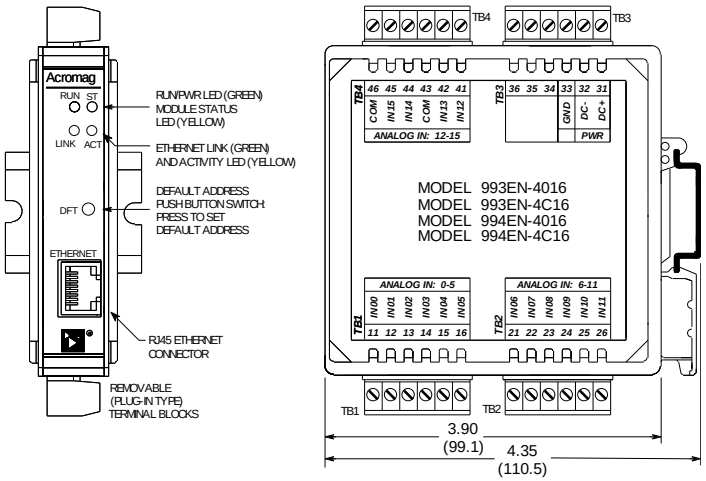
If you do use restore and want to return the unit to service, the calibration reference itself will additionally have to be "restored" separately via the Restore Factory Voltage Reference Value button of the Input Calibration Page. Inputs will be calibrated automatically by default, but any manual calibration you may have done to improve accuracy is lost after restore and may need to be rechecked.

Return: At this point, if the green RUN LED continues to blink after resetting and after restoring, then you may need to return the unit for repair.

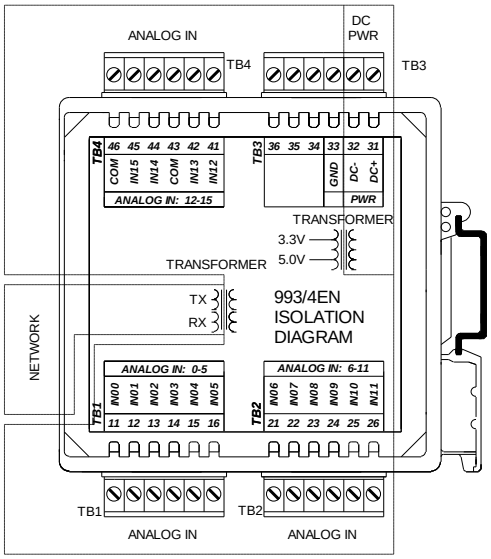
If you need additional help and you have already reviewed the material in this manual, please contact the factory.



MODEL 993/4EN ENCLOSURE DIMENSIONS



The front panel DFT 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 "password00". To activate, depress the DFT button for 5 seconds, until the ST LED blinks on/off slowly. To disable, depress the DFT button for 5 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.

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

Yellow ACT LED signals PHY network Activity (busy).

ISOLATION BARRIERS

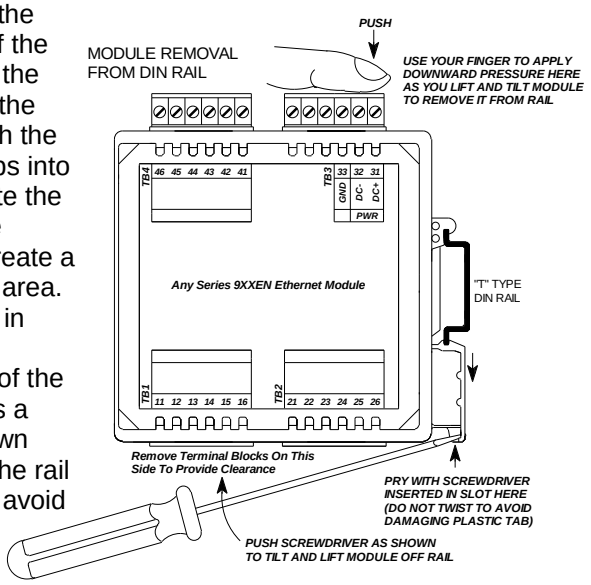
Dashed Lines denote isolation barriers.

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.

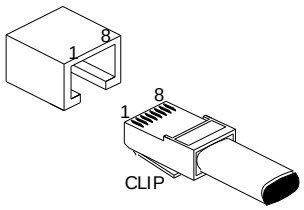
In either case, you are limited to 100 meters between any two devices.

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



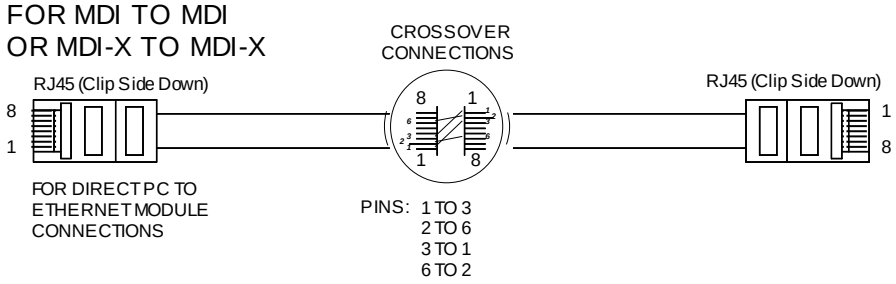
RJ-45 CONNECTOR

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



CONNECTIONS

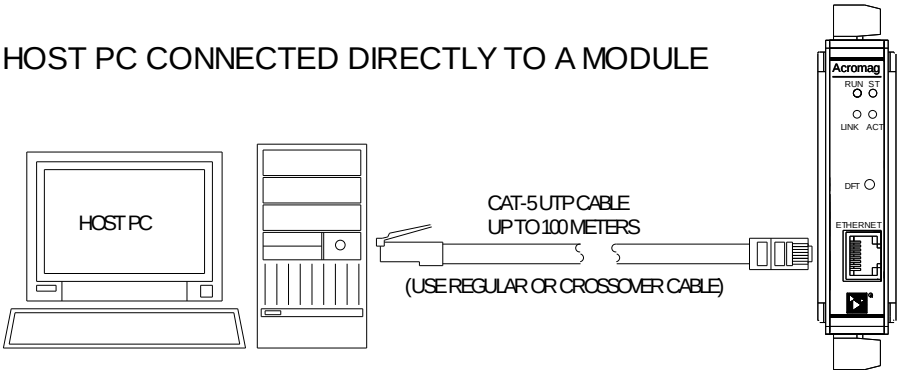
Network

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.

From the factory, the 993/4EN 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 993/4EN. 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 of the Acromag unit. That is, an address from 128.1.1.0 to 128.1.1.255, except for 128.1.1.0 which is typically reserved for servers, and 128.1.1.100, which is the default address of the 993/4EN 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 993/4EN
ETHERNET MODULE.

THE ETHERNET PORT OF THIS MODULE IS WIRED MDI-X, BUT SUPPORT AUTOMATIC CROSSOVER.

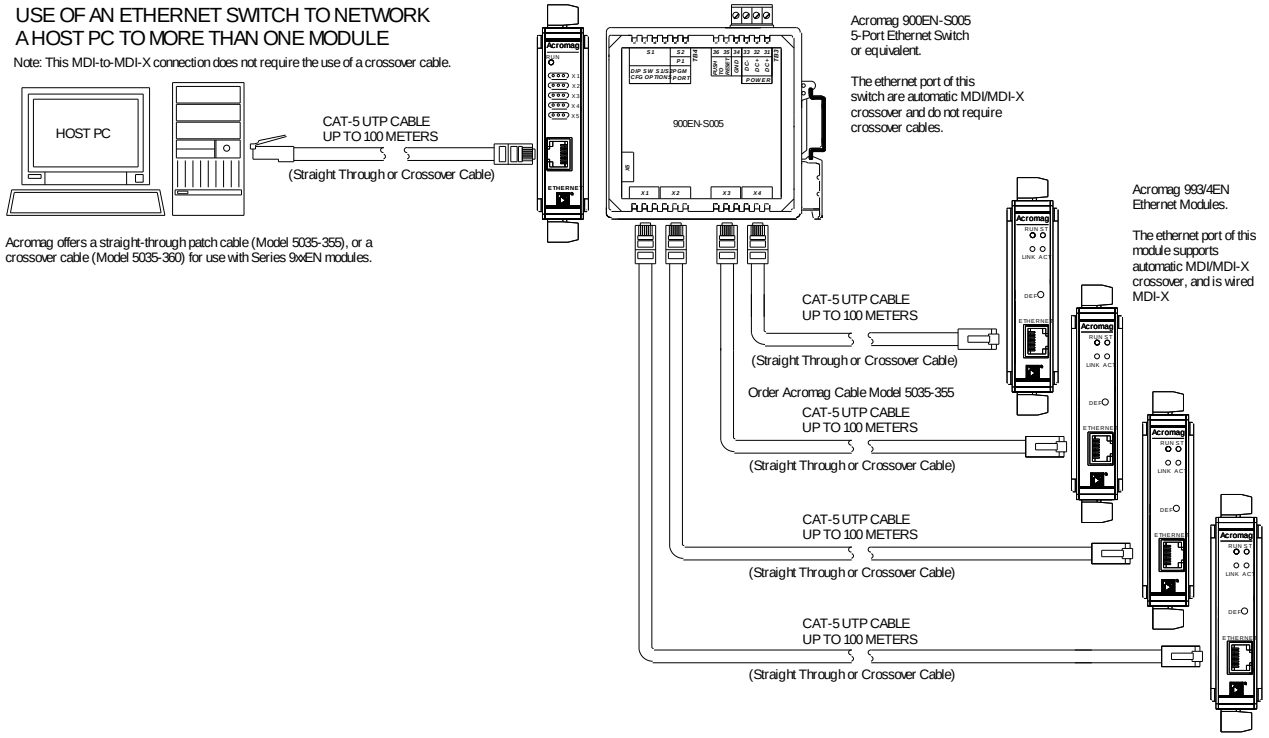
Refer to the Accessory Cables section at the back of this manual for more information on accessory cables including patch and crossover cables available from Acromag and other vendors.

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

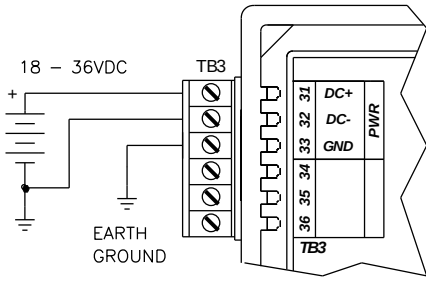
You can use an Ethernet switch or switching hub to build a network of Ethernet modules, similar to that shown below. This drawing shows how to network-connect these modules to a 5-port Ethernet switch (Acromag Model 900EN-S005). Note that the 900EN-S005 switch includes automatic MDI/MDI-X crossover and 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	82 mA	101 mA
24 VDC	63 mA	83 mA
36 VDC	44.8 mA	51 mA



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

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.*

Analog Inputs

The Common (C) terminal is connected to analog common of the circuit. This is used to reference analog input common to earth ground, and to reference the input channels to earth ground if they would otherwise be left floating.

✓ Connect Earth Ground as shown in the connection drawings on previous page. Additionally, connect the GND terminal (TB3-3) to earth ground.

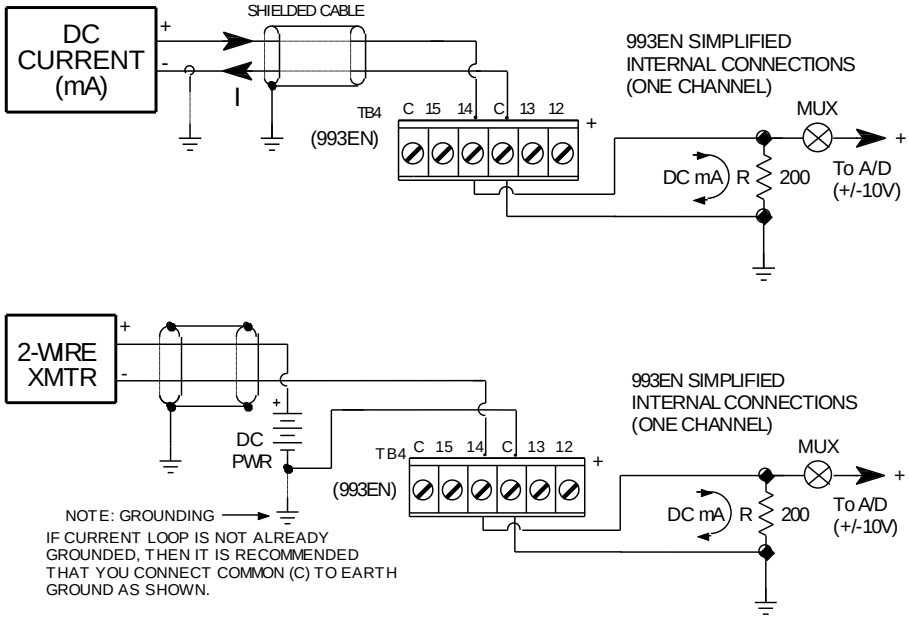
The ground connections noted are recommended for best results. If sensors are already grounded, use caution and avoid making additional ground connections which could create ground loops.

Transient energy is shunted to the GND terminal via isolation capacitors and transient voltage suppressors. You must connect earth ground to complete this path and ensure protection. Additional earth grounding is also recommended at input analog common (see connection drawings).

✓ Connect analog current (993EN), or voltage (994EN) signals to the input terminals as shown below. Input channels are single-ended. TB1 and TB2 each support 6 single-ended input channels while TB4 supports 4 single-ended inputs and two Common returns (C). The common connections are used to reference input channels to analog common. This terminal is also used to reference the input circuit common to earth ground if it would otherwise be floating.

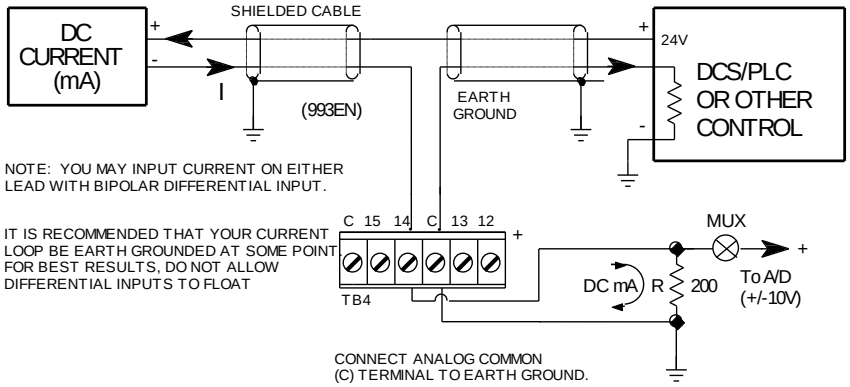
Current Inputs (993EN Models Only)

Input is bipolar with respect to common, which allows current to be input on either lead. Current (±20mA) is converted to voltage (±4.0V) via precision 200Ω shunt resistors inside the unit. This voltage drives a 16-bit A/D with a full-scale input range of ±10V.



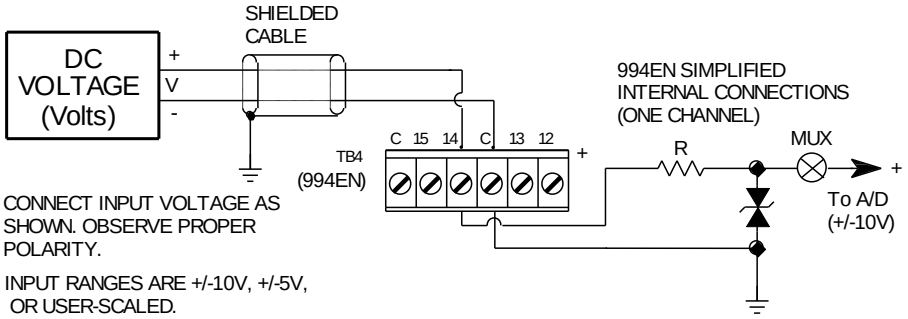
CONNECTIONS

Analog Inputs



Voltage Inputs (994EN Models Only)

You can set the channel to accept fixed voltage input ranges of ±10V, or ±5V. You may also rescale a portion of ±10V A/D range to a smaller sub-range, down to a minimum span 1/16th of the native 20V span in order to maintain minimum 12-bit performance.

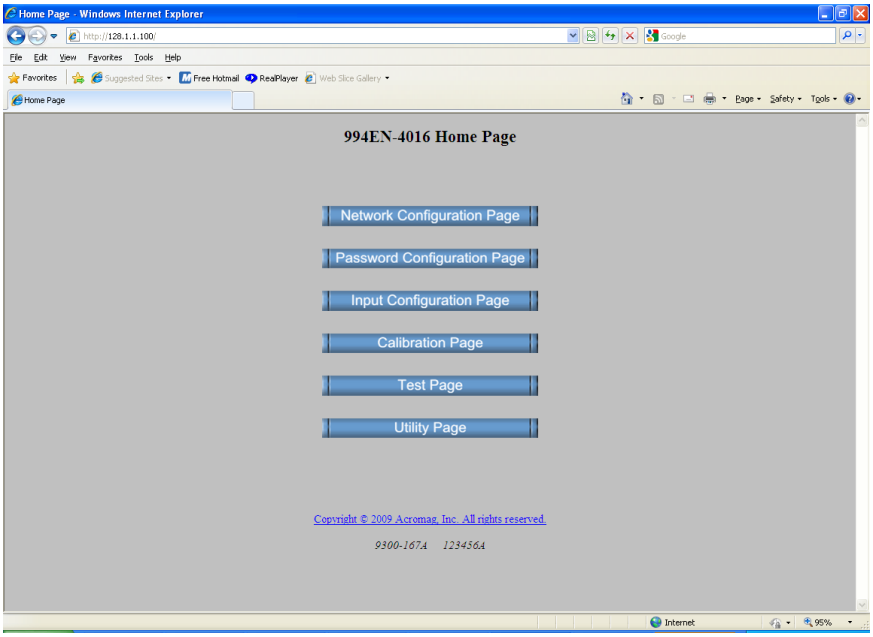


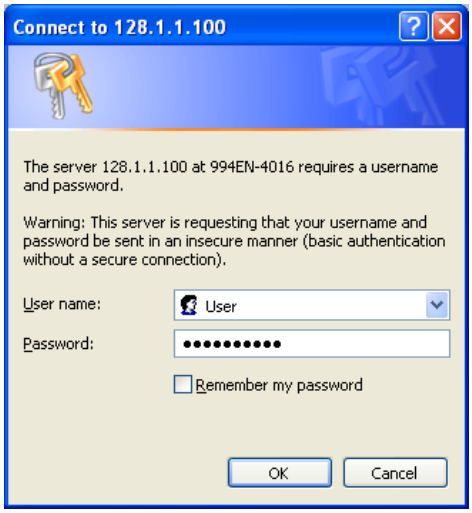
Connect input voltage to input positive (+) and negative (-) while observing proper polarity. If the input source is floating, it is recommended that you connect the negative input to the analog common terminal of the port (terminal C). Additionally, analog common (C) should also be connected to earth ground at one point.

Analog Common

✓ Plug-in terminal block TB4 includes two common connections marked "C". This connects to analog common of the input circuit and should also connect to earth ground. Check your signal grounding scheme, and if inputs are clamped or appear unstable, as you may need to add an earth ground connection at "C" if your input signals are not already earth grounded. Note that you only need to connect earth ground to one of these common terminals to earth ground the input circuit.

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:





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 "password00" respectively.** After entering these defaults, you may wish to invoke the Password Configuration Page to change these parameters to something more meaningful to you.

IMPORTANT: If you forget your user name & password, you can always toggle the unit into default mode via the DFT push-button at the front of the unit (hold this button for 5 seconds to invoke default mode). In this mode, the password and username will revert to the original defaults noted (unit assumes IP address 128.1.1.100), allowing you to re-invoke the Password Configuration Page and change the username and password as required.

WEB BROWSER

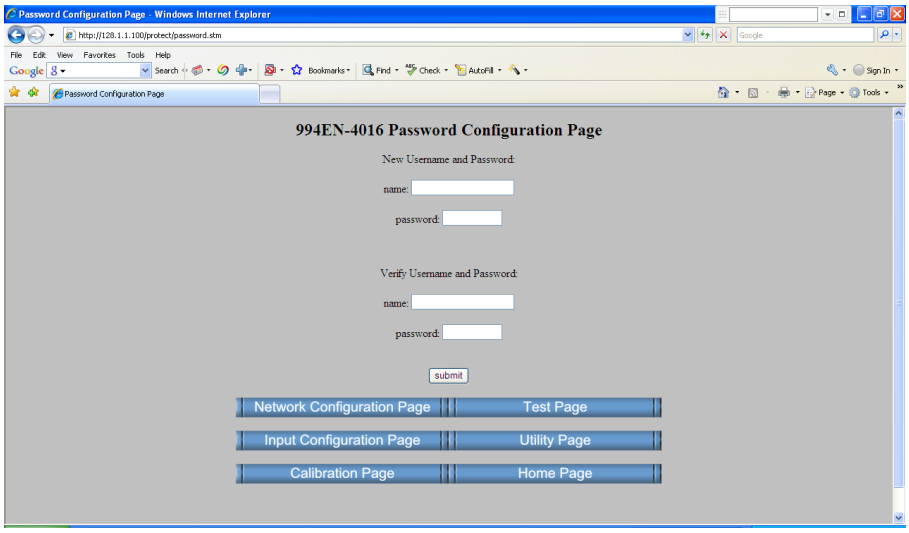
Home Page

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.

Note: If you cannot download the module's 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.

WEB BROWSER

Password Configuration Page



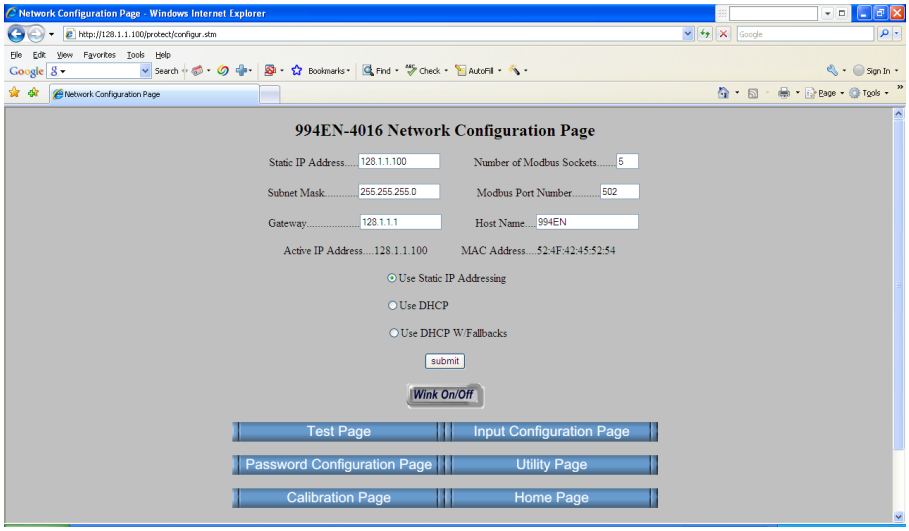
Use up to 20 alphanumeric characters (case sensitive) to specify your username, and 10 alphanumeric characters (case sensitive) to specify a password. You will have to type these entries in twice to help prevent errors.

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.

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 (these parameters cannot be set via Modbus registers). You may have to consult your network administrator to complete the contents of this page.



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).

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.

Note: If you are in Default Mode when you change the IP address noted, then when you click submit, your unit will leave the default mode and will assume the new IP address. This will look like you lost communication with your web browser, but you simply need to change the web browser address to continue communicating with the unit.

Note: In order to network your PC with an Acromag module, you may have to consult with your network administrator and either temporarily change the IP address in 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). This is because your IP address is likely set to an address that is outside of the address domain of the unit's default IP address. The necessary steps for setting up this interface address will vary with your operating system. Refer to Acromag Application Note 8500-734, or document 8500-815, for help accomplishing this (located on the CDROM shipped with your unit 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.

If this unit were an i2o target device (it has its outputs controlled by another units inputs), then each i2o message sent to this device will require a socket and the Number of Sockets must be increased to allow for this.

A **socket** is a software mechanism that connects an application to a network protocol (socket is a software object, not a physical object). For example, a Modbus application program can send and receive TCP/IP messages by opening a socket and reading and writing data to and from the socket.

On TCP/IP networks, a port is an endpoint to a logical connection (a connection port) and the way that a client program specifies a specific server program on a computer network.

For example, a Modbus program will open TCP port 502 to be readable from other Modbus devices on the network (which also use port 502 to establish a connection). A port may have more than one socket active at a time and this server device will allow up to 5 sockets to operate simultaneously over its contact port 502.

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.

WEB BROWSER

Network Configuration

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 "password00".

Note that Acromag Series 9xxEN Ethernet I/O modules may take up to 15 seconds to boot upon power-up, depending on your network configuration and whether a DHCP server is present.

WEB BROWSER

Network Configuration

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. 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. 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).

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.

A gateway is a device which links dissimilar networks and transfers data between them at the application layer level. In this way, Gateways essentially convert messages from one protocol to another.

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 MAC hardware of this device. All Ethernet devices have their own MAC address. This is a unique fixed address that was assigned to the MAC at its manufacture. It is not to be confused with the dynamically assigned 32-bit IP Address, commonly denoted as four 8-bit numbers separated by periods (e.g. 128.1.1.100). Every manufacturer producing Ethernet hardware, has by assignment, a series of 48-bit addresses to use. They are restricted to use only the addresses in their series, and only one time, thus ensuring that no two computers in the world will ever have the same network address.

An Ethernet packet will include two 48-bit address fields appended to it that represent the MAC address of the sending computer, and the destination computer. In IEEE 802 networks, the Data Link Control (DLC) layer of the OSI Reference Model is divided into two sub-layers: the Logical Link Control (LLC) layer, and the Media Access Control (MAC) layer. It is the MAC layer that interfaces directly with the network media and where this address distinction is applied (each different type of network media requires a different MAC layer).

Use Static IP Addressing tells this unit to fix the IP address setting to the Static IP Address specified. By default, the unit is set to use Static IP Addressing and a Static IP Address of 128.1.1.100.

You can optionally choose to have the IP address assigned dynamically via DHCP/BOOTP, or DHCP/BOOTP w/Fallbacks. This will also require that you specify a valid Host Name (see above).

Use DHCP tells the unit its IP address is to be obtained dynamically, and may change each time this device is connected to the network.

Use DHCP w/ Fallbacks works the same way, but will revert to the static IP address specified if your DHCP server cannot be found.

DHCP refers to Dynamic Host Configuration Protocol and its routine 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, and in some systems, the IP address can even change while it is still connected.

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

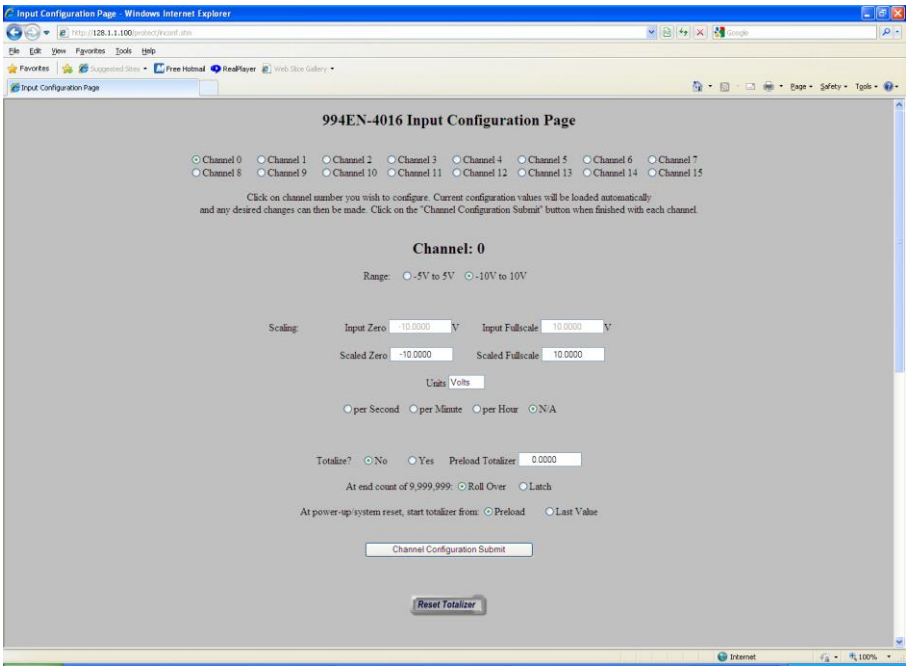
Click the **Wink On/Off** button to toggle the module in/out of "wink" ID mode. In this mode, the module's green RUN LED will blink to confirm identification.

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 put 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.

WEB BROWSER

Network Configuration

After completing the username & password assignment, plus the network configuration parameters, use the Input Configuration page to set your input ranges, rescale inputs, setup integration/totalization, setup floating point (required for scaling/integration/ totalization), reset the totalizer, and reset the unit.



Input Configuration Page

After completing the username & password assignment, plus the network configuration parameters, use the Input Configuration page to set your input ranges, rescale inputs, setup integration/totalization, setup floating point (required for scaling/integration/ totalization), reset the totalizer, enable/disable scan groups, and reset the unit.

Once you have carefully made your selections, click the "Channel Configuration Submit" button at the bottom of the page to activate your configuration (reconfiguration takes effect immediately following "Channel Configuration Submit").

Use the scroll bars on the right to scroll down the page.

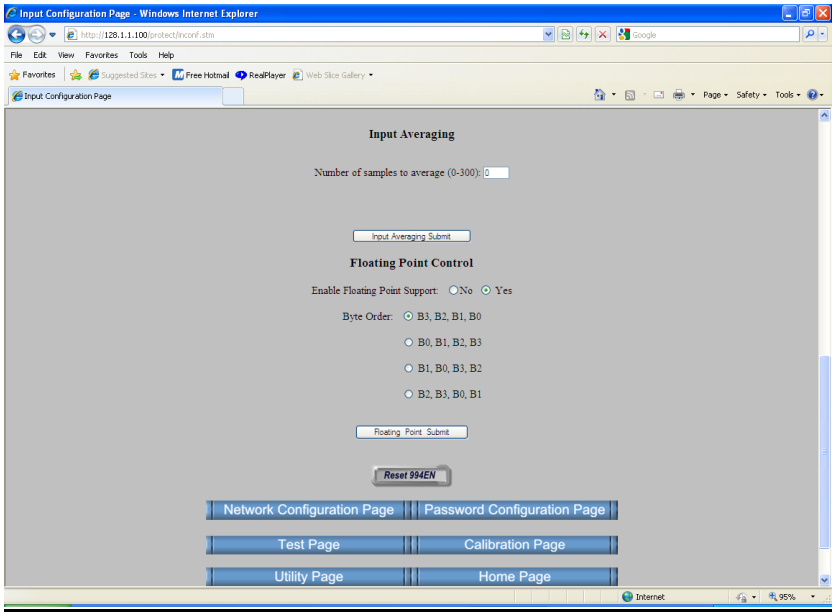
WEB BROWSER

Input Configuration

For the 994EN, you can select an input range of ±5V, or ±10V. Each of these ranges can be rescaled to your own engineering units.

For the 993EN, all current input ranges are sub-ranges of a native ±10V A/D input range, and utilize a precision 200Ω input shunt to convert input current to A/D voltage (±20mA into 200Ω yields ±4.0V to the A/D).

Once you have carefully made your selections, click the "Submit" button to activate your reconfiguration (reconfiguration takes effect immediately following clicking "Submit").



These models have 16 input channels of current (993EN), or voltage (994EN) input. The Input Configuration page of the 994EN voltage unit is shown above. The 993EN is identical, except that it refers to current ranges.

Input Configuration (Repeated Per Channel)
You must repeat your reconfiguration for each channel of interest.

Configuration involves first selecting the input channel, its input range, and optionally rescaling the input's zero and full-scale value to your own engineering units. You can also setup an integrator by specifying the scaled input units and a time base in order to totalize the input. You can enable/disable totalization of an input, set its preload and initial value, and reset the totalizer. After you have made your channel specific selections, click the Channel Configuration Submit button to apply your selections.

993EN Current Input Models

For the 993EN, all current input ranges are sub-ranges of the native ±10V A/D input range and utilize a precision 200Ω input shunt to convert input current to A/D voltage ±20mA into 200Ω yields ±4.0V to A/D).

Note: On 993EN models, a current input of ±20mA (22mA maximum) may be input at the positive or common input lead, but its sign is relative to current input at the + lead. A precision 200Ω shunt resistor converts 20mA to 4.0V at the A/D. The A/D has a native ±10V input range configured (16-bits). The ±20mA input is normalized to a count of ±20000 for ±100% (over-range is 2000 counts).
Input Range: The current unit utilizes the ±10V A/D input range and is designed for a unipolar current of 0-20mA. All input ranges are sub-ranges of the native 16-bit A/D range of ±10V (±20mA into 200Ω is ±4.0V for 14.6 bits of resolution, or 1 part in 26214).
Input Zero (Fixed per Range): Default is same as input range zero (20mA, 0mA, or 4mA) and this cannot be changed. The indicated value will correspond to 0% of signal and a normalized count of -20000 for ±20mA range, or 0 for the 0-20mA and 4-20mA ranges.

993EN Current Input Models…continued

WEB BROWSER

Input Configuration

Scaled Zero: Default is the same as input zero (-20mA, 0mA, or 4mA), but you can rescale this value as required for your application. Field is limited to a 32-bit number of up to 12 characters and a maximum of 4 decimal places. For each channel 0-15, enter your rescaled full-scale that is to correspond to 0% of input signal. You must also Enable Floating Point Support to accomplish rescaling. If you are using only a portion of this range, you may have to interpolate your scaled zero endpoint.
Input Full-Scale (Fixed per Range): Default is the same full-scale as input range (+20mA) and this cannot be changed. The full-scale indicated will correspond to 100% of input signal and a normalized count of +20000.
Scaled Full-Scale: Default is the same as input full-scale (+20mA), but you can rescale this value as required for your application. Field is limited to a 32-bit number with up to 12 characters and a maximum of 4 decimal places. For each channel 0-15, enter your rescaled full-scale that is to correspond to 100% of input signal. You must also Enable Floating Point Support to accomplish rescaling. If you are using only a portion of this range, you may have to interpolate your scaled full-scale.
Units (5 characters): Enter the units of measure for your rescaled input zero and full-scale and this is an arbitrary definition used only for reference.
NOTE (993EN): By default, all 993EN current ranges are sub-ranges of a larger 16-bit ±10V A/D input range. This bipolar input range allows the input current to be measured in either direction between the channel input and common terminals. The 993EN employs a 200Ω shunt resistor to convert the current signal to 4.0V full-scale (0.020A x200Ω). This approximates 14.6-bit of resolution with an A/D resolution of ±13107 parts for ±20mA.

994EN Voltage Input Models

Input Range: Select a 16-bit A/D input range of ±10V, or a 15-bit sub-range of ±5V.
Input Zero (Fixed per Range):: Default is the same as input range zero (-5V or -10V) and this cannot be changed. The voltage indicated corresponds to 0% of signal and a normalized count of -20000.
Scaled Zero: Default is the same as input zero (-5V or -10V), but you can rescale this value down to a minimum of -999999.0, as required for your application. Field is limited to a 32-bit number with up to 7 significant digits and a maximum of 4 decimal places. For each channel 0-15, enter your rescaled value in engineering units that is to correspond to 0% of input signal. You must also Enable Floating Point Support to accomplish rescaling. If you are using only a portion of this range, you may have to interpolate your scaled zero endpoint.
Input Full-Scale (Fixed per Range): Default is the same as input range full-scale (+5V or +10V) and this cannot be changed. The voltage indicated corresponds to 100% of signal and a normalized count of +20000.
Scaled Full-Scale: Default is the same as full-scale (+5V or +10V), but you can rescale this value up to +999999.0, as required for your application. Field is limited to a 32-bit number with up to 7 significant digits and a maximum of 4 decimal places. You must also Enable Floating Point Support to accomplish rescaling. If you are using only a portion of this range, you may have to interpolate your scaled full-scale.
Units: For reference, enter the units of measure for your rescaled zero and full-scale.

WEB BROWSER

Input Configuration

NOTE: *If you are rescaling the input signal to a sub-range of the input, you will have to interpolate the scaled endpoints to align with the fixed input zero and full-scale endpoints indicated.*

NOTE: *The Totalizer Option is NOT available on commercial models.*

IMPORTANT: *Your effective resolution will decrease proportionally as you reduce the nominal signal span through rescaling.*

Integration/Totalization (Per Channel, Industrial Grade Models Only)

You can optionally integrate an input signal by totalizing its time-sliced instantaneous value (with integration/totalization enabled at any channel, the instantaneous inputs of this unit are sampled at a fixed rate of 8ms for all 8 channels, or 20ms with Input Averaging > 1).

Time Base (per Second, per Minute, per Hour, No Application): With integration/totalization enabled, the instantaneous input is sampled at a slower rate of every 8ms. You can optionally integrate this signal by totalizing its time sliced instantaneous value. In order for the totalized value to accurately accumulate, you need to specify the time-base units of the input signal to perform the integration over. Select "per Second", "per Minute", "per Hour", or "NA". You must specify a time base other than NA for totalization to occur. Note that if "NA" is selected and Totalize=Yes, then 0.0 is added to the totalized value.

Totalize? & Preload Totalizer: Choose "Yes" for the Totalize? to totalize the input (this will also automatically enable floating point support). You can optionally choose to preload a totalized value on power-up or upon system reset by inserting a number in the Preload Totalizer field. In this way, you can choose that your post-power/reset preload value be taken from the Preload Totalizer field, or from the last totalizer value (before power-up or system reset). During operation, your incremental "time-sliced" measurement will be added to this total every 8ms. Note that in order totalize an input, you MUST also Enable Floating Point Support by selecting "Yes" to that query.

At the End Count of 9999999 (Rollover or Latch?): When your totalized value reaches the limit of its field, you can click to select Roll Over and continue totalizing from zero, or restart from the Preload Value, whichever is selected. Optionally, you can latch the totalized value. Note that if the added value exceeds the amount required to reach the limit of 9,999,999.0, the additional amount it is over will be added to the count it rolls over (it assumes a free running counter and rolls over while ignoring the preload value).

Note (Counter Operation): This counter is limited to 7 digits of accuracy & resolution, starting with 4 places before and after the decimal point (see below). Then, as the count grows beyond the least 7 digits, the least significant digit is zeroed as the most significant digit is incremented. For example (note the transitions and digit shift left), the counter starts at 0000.0000 and increments to 0999.9999, then 9999.9990 to 99999.9900, then 999999.9000 to 9,999,999.0000, then it rolls over or latches as specified. Thus, while the 4 decimal places will remail visible, their importance diminishes beyond 7 significant digits. The max counter value is thus 9,999,999.0.

At Power-Up, Start Totalizer From (Preload or Last Value?): When you power-up, reset the unit, you can direct the totalization to start from the Preload value in the Preload Totalizer field, or simply the last totalized value.

Note: A system reset always starts the totalizer from the preload value, or the last value, whichever is selected here. However, Reset Totalizer always restarts from the preload value, even if Last Value is selected here.

Channel Configuration Submit: Click this button to submit your channel configuration selections. Select another channel and repeat this process for each channel of this unit.

WEB BROWSER

Input Configuration

Reset Totalizer: Click this button to reset the current channel's totalized value to the Preload Totalizer value.

Totalization Calculation Example

During totalization on this model, an instantaneous input sample is gathered every 8ms if no input averaging is being done (see table of page 40). If the instantaneous scaled input value indicates 500, units are gallons, and time base is set to "per Minute". Then (500 gallons/minute)*(1 minute/60 seconds) equals a flow rate of 8.33 gallons/per second. Since a new sample is obtained every 8ms, multiply 8.33gallons/second by 0.008seconds/sample to get an incremental increase in volume of 0.0667gallons/sample, and this amount is added to the totalized value. The maximum possible totalized value is 9,999,999.9999 (12 characters including decimal portion).

Input Averaging (Global, Not Per Channel)

You can optionally specify the number of input samples to average together to form your input response. Increasing this number will help to filter the measured response of noisy input signals, but will increase the update time (to 20ms from 8ms).

Input Averaging: Enter the number of input samples to average together from 0-300 samples. Selecting 0 is equivalent to selecting 1 and designates that no averaging will be performed. You may increase this number to help filter the measured response of noisy input signals.

Note: The Test Page does not display the averaged response.

Floating Point Configuration (Global, Not Per Channel)

Floating Point Control - Enable Floating Point Support (No or Yes)?: This is normally set to "No" by default, but must be set to "Yes" if you are rescaling an input, or integrating/totalizing an input. Note that also selecting "Yes" to the Totalize query for any channel will automatically set this to "Yes", but if you later disable floating point, the totalizer will just add 0.0 to the totalized value. Disable IEEE Floating Point if you are not rescaling, integrating, or totalizing the input. Selecting "No" to disable floating point support will reduce the amount of calculations that have to be performed and gives the processor more time to do other tasks besides acquiring data and this is recommended when you are also not rescaling or integrating and totalizing the input. This can help to make critical control network applications more deterministic, particularly over networks with heavy traffic flow. Consider that input data is normally acquired every 8ms, or every 20ms if input averaging is greater than 1. Twenty percent of this time is used to convert the data for all 8 channels, leaving only 80% to process all the other tasks required to store this data into Modbus registers, run the web server, and serve this data over the network. You can increase the time devoted to servicing these other tasks by disabling floating point, effectively increasing network determinism. So leave it off if you don't need to rescale or totalize. Note that even with floating point disabled, the measured input value will still indicate a floating point number, but the scaling and totalizing field will indicate "Inactive".

WEB BROWSER

Input Configuration

Floating Point Configuration…continued

Floating Point Control - Byte Order: Different Modbus systems will use different byte orders for the two 16-bit Modbus registers used to store a 32-bit floating point value. Select the byte order compatible with your system. Note that B0 refers to the Least Significant Byte, and B3 to the Most Significant Byte.
Floating Point Submit Button: Click here to execute your floating point control selections.

Reset Unit Control (System Reset, Not Per Channel)

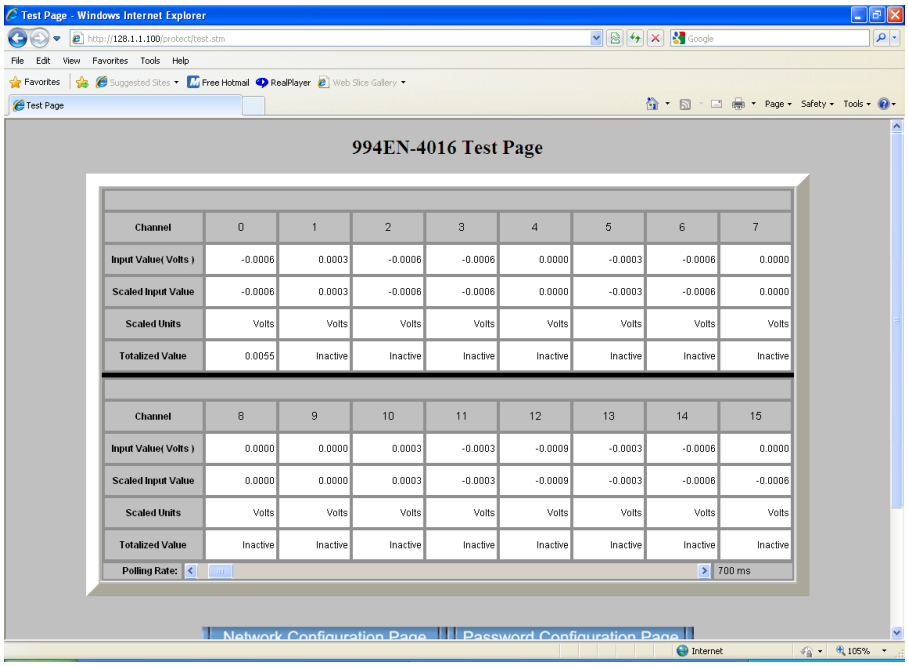
Reset Button: Click this button to remotely perform a system reset of the unit. Note that resetting a unit will also restart any totalizer channels (either to a preload value or the last value).

Test Page

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

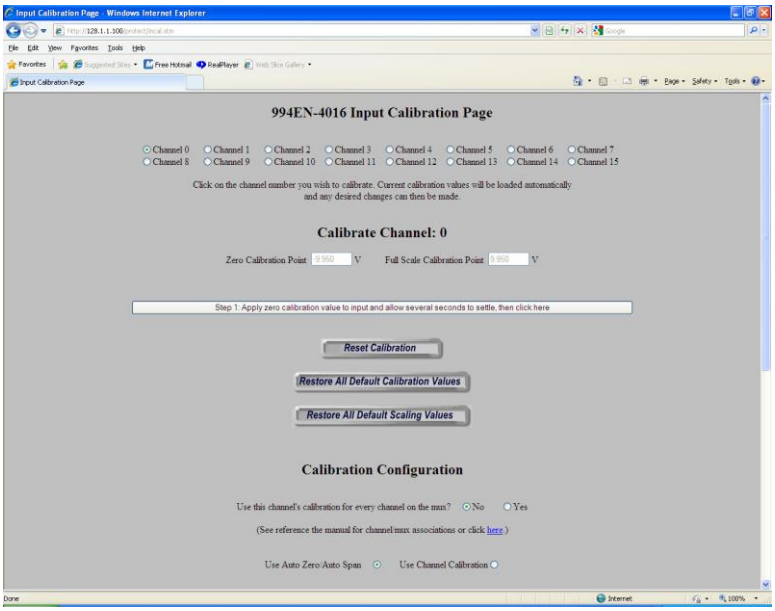
TIP: If you notice that the Input Test Page has stopped scanning I/O or appears to have halted, simply click the refresh button to restart the polling. This may happen if the unit is interrupted for a period of time and it causes the Java applet to time out and stop sending requests for data. Clicking your browser refresh button will restart the Java requests.

After completing the username/password assignments, plus the network and input configuration parameters, click the Test Page button to access the web-server Test Page and operate your unit. Here you are able to read the input values, scaled values, scaled units, and totalized values of the sixteen input channels of this unit. You can even set an input polling rate for the active Test Page at the bottom.

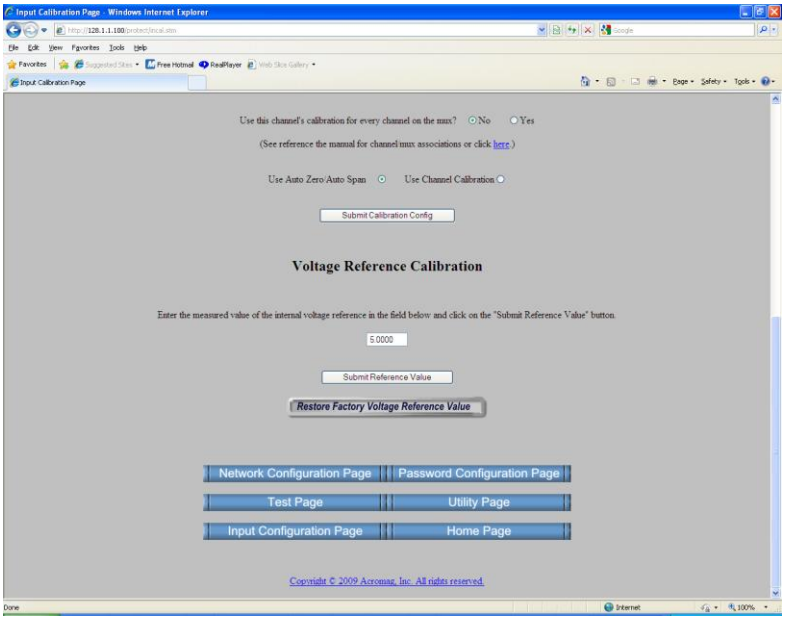


Voltage or Current Inputs: If the channel is not configured for floating point, which is necessary to accomplish scaling and totalizing, then "Inactive will be indicated for the scaled input value, scaled units, and Totalized value.
Polling Rate: The input values update continuously at the Polling Rate set via this slide control. Click and drag this control to set the rate at which you wish to read the inputs via this web page. The rate is indicated just to the right of this control. Disable input polling by dragging it to the far right.

Normally, this unit automatically re-calibrates its base A/D input range every time it scans its 16 input channels by reading its own calibration reference voltage at each multiplexer A/D channel. This reference has been precisely measured and its value stored inside the unit from the factory. This is sufficient to achieve rated accuracy using automatic calibration. The relative accuracy of calibration can be improved via software calibration facilitated with the controls of this page, or instead by issuing the appropriate Modbus register calibration commands. But if you need to calibrate to your own standard, or you want to check the accuracy of the internal calibration, then you can utilize the controls of this page to manually calibrate the inputs instead.



Use the scroll bars to the right to scroll down the page.



WEB BROWSER

Calibration Page

IMPORTANT: *This module normally performs an automatic calibration of zero and full-scale. Recalibration on a channel-by-channel basis is normally NOT required, except for calibration that must be done to a higher standard. Do not attempt to recalibrate a channel unless absolutely required, or to verify the accuracy of internal calibration, as inadvertent mis-calibration will negatively affect the channel's performance.*

WEB BROWSER

Calibration Page

For reference, one LSB of input signal is equivalent to the input full-scale voltage range divided by 65536 ([Full-Scale – Zero]/65536). In general, an uncalibrated A/D input can produce a zero offset error up to ±28LSB, and a full-scale error up to ±0.4%. Each port will match their zeros to within ±10LSB of each other, and their full-scale measurements to within ±15LSB.

During calibration, the unit uses a 100-sample averaged value when sampling the input and making its input response associations.

You have 3 options for accomplishing input calibration. The first option is to simply accept the default response of automatic input calibration. The second option will allow you to achieve better accuracy by manually calibrating one channel from the mux group, and using that channels response to represent all 8 channels of the mux. This effectively calibrates the A/D channel that the mux connects to and saves some time while improving accuracy. Your third option is to manually calibrate each input channel separately, using very accurate input signal and measurement equipment to achieve calibration. This would additionally compensate for the small errors contributed by the input filters, buffer amplifiers, and input multiplexers, as well as the initial inaccuracy of the input shunt resistor of current inputs. Which method you choose refers to your Calibration Configuration selected via controls on this page.

While the relative accuracy of calibration can be improved via software calibration facilitated with the controls of this page, or by instead issuing the appropriate Modbus register calibration commands, the Automatic calibration will be sufficient for most applications.

This page additionally allows the internal 5V calibration reference that is used to accomplish automatic calibration to be calibrated. An accurate voltage reference measurement is made between P1 header pins 1 and 2. The measured value representing the calibration voltage is recorded and stored inside FRAM memory that resides on the I/O board of the unit. The controls of this page allow a new value to be stored. This has already been done at the factory and should not need to be repeated unless miscalibration is suspected. In order to take this voltage measurement, it requires that the board assembly be carefully removed from the enclosure and this requires handling at an ESD-safe work station. **We do not recommend that you do this in the field as it invites potential damage to sensitive internal circuitry.**

The 16-bit A/D converter of this unit has a full-scale range of ±10V. There are two groups of eight channels each that are separately multiplexed to separate A/D channels. 993EN current models utilize the ±10V A/D range, but employ 200Ω input shunt resistors to drive ±4.0V to the A/D for the ±20mA input, while 994EN units drive the A/D directly (no divider).

Once you have selected an input channel to calibrate, and then a calibration configuration, you simply follow the instructions printed on the Calibrate Channel bar as you click the bar, making sure that you apply the zero and full-scale calibration point signals indicated at the appropriate times.

Manual Input Calibration - Voltage or Current Inputs

These web controls allow you to perform manual calibration on an input channel. Manual calibration is accomplished on a per channel basis, or optionally on a per port basis by calibrating one channel from each port (i.e. each A/D channel).

To begin, at the top of the Input Calibration Page, first select the channel to be calibrated. Next select the Calibration Configuration for the channel before continuing.

WEB BROWSER

Calibration Page

Channel Selector Bullets: Click to bullet the channel you wish to calibrate. Calibration is done on a per channel basis. Optionally, you can pick one channel from a mux group, and use that calibration to represent all 8 mux channels.
Zero Calibration Point Field: This field indicates the low calibration endpoint for the selected input range. This is the input signal that you have to apply to accomplish zero calibration. Your input source must be of an accuracy greater than 0.03% of span to achieve better results than auto-calibration.
Full Scale Calibration Point Field: This field indicates the high calibration endpoint for the selected input range and is the input signal to apply to accomplish full-scale calibration. Your input source must be of an accuracy greater than 0.03% of span to achieve better results than auto-calibration.
Calibration Step Button: You click this button in a sequence of three steps to accomplish input calibration via this web page. Specific instructions at each step appear printed on this button
Reset Calibration Button: Click this button if you make a mistake in the calibration sequence and wish to start over from step 1.
Restore All Default Calibration Values Button: Click this if you believe channel calibration has been done in error, or you are getting erratic results after recalibrating. This will affect all input channels at one time and the values restored are the ideal values, not the results of an actual calibration. You might choose this option if your calibration was done in error or produced unexpected results.
Restore All Default Scaling Values Button: Click this button if your own scaling produced unexpected results and you wish to return the input scaling values of the selected channel to their default values (typically the input range signal endpoints). Note that this will affect all input scaling values and will restores them to their ideal values.

Calibration Configuration

By default, zero and full-scale are calibrated automatically and this will be sufficient for most applications. You may optionally calibrate each channel separately to obtain the highest possible accuracy. Or to save time, you can calibrate one channel from a mux group and select an option to allow that channel's calibration to calibrate the response for all 8 channels of the mux (A/D channel). If more than one channel from a group is selected to represet the mux, then the calibration of the highest number channel applies.

MULTIPLEXER	CHANNELS OF MULTIPLEXER							
0 (Even CH)	00	02	04	06	08	10	12	14
1 (Odd CH)	01	03	05	07	09	11	13	15

Use this channel's calibration for all channels of the port (Yes or No): If you select "Yes", then the manual calibration already done for this channel will apply to all 16 mux channels (16 channels are multiplexed to two separate A/D channels, even channels to one A/D channels, odd channels to the other). This selection should be done only after calibrating this channel. This saves additional time by only requiring one manual calibration per mux. When done properly with very accurate signal sources and measurement equipment, this method of calibration is generally better than auto-calibration, but not as accurate as calibrating per channel, as calibrating each channel individually would additionally compensate for the small errors contributed by the input filters and input and input multiplexer.

IMPORTANT: *If you select Yes to "**Use this channel's calibration for all channels in the mux group?",** note that the channel must be calibrated first, before making this selection.*

WEB BROWSER

Calibration Page

Note: If calibrating one channel per mux, the other channel's of that mux should have "Use Channel Calibration" selected. Selecting "yes" automatically selects "Use Channel Calibration" for the remaining mux channels. You can still override this auto-selection, by subsequently selecting another option for any number of the other mux channels.
CAUTION – TRAP: If the channel that you selected "Yes" to represent the calibration of the multiplexer group is later changed to "No", the other 7 channels of the mux group will begin to use their default manual channel calibration, as they were initially automatically switched to "Use Channel Calibration". This will likely produce a less accurate response and may leave you wondering why the other mux channels appear to operate less accurately than before. So if you do change "Yes" to "No", be cognizant of the other multiplexer channels and either manually calibrate them, or simply set them to use automatic channel calibration.

Further, channels of a mux group that have a different input range than the one selected to represent them will be calibrated incorrectly. When you make use of this feature you should configure all channels of the mux group to the same input range.
Use Auto Zero/Auto Span Bullet: Clicking this bullet will use automatic calibration for the selected input channel (default behavior). With automatic calibration, the port utilizes the on-board 5V ±0.05% ±5ppm/°C reference source and ground to calibrate the input. Only the 0V and +5V range points are actually auto-calibrated, while calibration of -5V, and the ±10V range endpoints (994EN) are coincident (interpolated). The internal calibration reference was precisely measured at the factory and its voltage value is stored in the unit. Steering circuitry prior to the port input buffers allows the A/D channel to connect to this reference voltage, and alternately to analog common (for zero). The unit utilizes the corresponding raw A/D output count for both zero and the reference voltage to calibrate the input by defining the equation of a straight line used to predict the input signal for any given A/D count. Only the 0V and +5V range points are actually auto-calibrated, while calibration of -5V, and the ±10V range endpoints are coincident (interpolated). Automatic calibration will be sufficient for most applications. This method of calibrating the inputs is the most convenient and will achieve stated accuracy of ±0.05% for voltage inputs, and ±0.1% for current inputs. It is less accurate for current inputs because it does not compensate for the initial inaccuracy of the input current shunt resistor (200Ω ±0.05%±5ppm/°C).
Use Channel Calibration Bullet: Clicking this bullet will select manual (per-channel) calibration, which associates the current calibration with only the current channel. It is possible to achieve the greatest accuracy if you calibrate on a per channel basis and you have a precise input signal source and digital voltage meter with better than ±0.05% accuracy, but it takes more time to accomplish. Note that internally, 993EN models utilize a ±10V 16-bit A/D range. On the 993EN, your calibration endpoints will remain ±20mA even if you have selected a different input range.

Submit Calibration Configuration Button: Select your mode of calibration and click this button to write your selection to the unit. Then you can calibrate the channel as required, repeating it for each of the channels.

Voltage Reference Calibration
The on-board calibration reference used for automatic calibration can be separately calibrated by accurately measuring its value and entering it in the field provided in the Voltage Reference Calibration section of this page.

This has already been done at the factory and recalibration of this reference should not normally be required. You should not change the value indicated in this field unless authorized to do so, or performance may be negatively affected.

Voltage Reference Field (4.996 to 5.004): The internal calibration reference is precisely measured at the factory and its voltage value stored in the unit and indicated in this field. This reference voltage is 5V ±0.05% ±5ppm/°C, and should read between 4.996 and 5.004 (5V±0.08%). This value is used to make a correspondence between the A/D response (digital count), and the voltage signal itself, in order to calibrate its linear response. You can enter your own measured value in this field if you need to recalibrate it (not recommended).
Note: The internal 5V reference voltage can be measured via a two-pin header along the front-edge of the top circuit board near the LED's. This calibration has already been done at the factory in an ambient temperature near 25ºC and should not need to be repeated.
Submit Reference Value Button: Click this button after you have entered a measured reference voltage in the Voltage Reference field to store your measured value in non-volatile memory.
Restore Factor Voltage Reference Value Button: If you make a mistake and have entered the wrong value for the calibration reference, you can click this button to restore the original value measured from the factory. You would also click this button after you performed a system restore of the unit (see Troubleshooting – Getting Out of Trouble procedure).

A/D Input Calibration

The ideal A/D input voltages, raw counts, and normalized counts are indicated below (before re-scaling) for the range endpoints and midpoint, based on the 16-bit ±10V base input range of the A/D.

Zero & Full-Scale A/D Counts for A/D ranges & ±0.05% accuracy.

Full-Scale Range	Zero	0V/0mA	Full-Scale
±10V (994EN)	-10.000V+10mV	0V±10mV	+10.000V-10mV
Raw A/D Count	-32767+66	0±66LSB	+32768-66
Normalized Count	-20000+41	0±41	+20000-41
±5V (994EN)	-5.000V+5mV	0V±5mV	+5.000V-5mV
Raw A/D Count	-16384+33	0±33LSB	+16384-33
Normalized Count	-20000+36	0±36	+20000-36
±20mA (993EN)[1]	-20mA±20uA	0mA±20uA	+20mA±20uA
Raw A/D Count	-13107±14LSB	0±14LSB	+13107±14
Normalized Count	-20000±32	0±32	+20000±32

[1]The 993EN utilizes the ±10V native range of the A/D to process ±20mA. A precision 200Ω input shunt resistor (±0.05%, ±10ppm/ºC) is used to convert the input current to the A/D voltage. Thus, all 993EN input current ranges are actually sub-ranges of a 16-bit ±10V range. A full-scale current of 20mA will present a full-scale voltage of 4.0V to the A/D, yielding an effective internal resolution of one in 26214 parts for ±20mA (±13107parts), or one in 13107 parts for 0-20mA. For simplification, the raw A/D count for selected input ranges is normalized to a count of 0-20000.

WEB BROWSER

Calibration Page

Reference Measurement:
This procedure is not normally required and has already been done at the factory. The reference voltage is measured between the pins of a header along the front edge of the circuit near the LED's (do not disassemble mated boards). You will have to remove the unit from its enclosure to measure this voltage. This should only be performed at a static-safe workstation by qualified personnel, or damage to the unit may result.

WEB BROWSER

Calibration Page

If you are not satisfied with auto calibration, you can choose to use the web browser calibration page to achieve manual calibration (easier), or via direct Modbus register access as described in Method 2 of the following page.

If you perform manual calibration via the controls of this page, or you use the Modbus register commands to calibrate the inputs (see below), then this has the added benefit of being able to correct for any negative full-scale offset, as auto calibration only utilizes 0V and +5V to calibrate the bipolar input. For current inputs, manual calibration additionally compensates for the initial error of the input shunt resistor (up to ±0.05%).

IMPORTANT: Always allow the module to warm up a few minutes prior to calibration. At the bottom of the Input Calibration page, verify that the reference field indicates a voltage between 4.996 and 5.004 (5V±0.08%). If you suspect this voltage is inaccurate, this voltage may have to be precisely measured and then typed into this filed first, before calibrating the channel. Calibrating the reference requires that the unit be removed from its enclosure and is not recommended. See Optional Reference Calibration above.

Method 1 – Channel Calibration Using the Built-In Browser Interface:

1. Bring up the browser interface and select the Input Calibration Page.
2. Allow the module to warm-up a few minutes before continuing.
3. For best results, Zero is always calibrated before full-scale. Note the Zero Calibration Point indicated in its field. You must apply this exact input signal to the input channel being calibrated to proceed. Your signal source should be accurate to better than ±0.05% (auto calibration standard).
   993EN Units: The zero input signal is always -20mA. This produces an A/D calibration voltage of -4V.
   994EN Units: The zero input signal is a negative voltage of -9.95V or -5V, according to input range configuration.

   After applying the Zero Calibration signal to the channel, simply click the "Step 1…" button to calibrate the zero.

   If you make a mistake, you can always click the **"Reset Calibration"** button to start over from Calibrate Zero Step 1.
4. Note the Full-Scale Calibration Point indicated in its field. You must apply this exact input signal to the input channel being calibrated. Your signal source should be accurate to better than ±0.05% (auto calibration standard).
   993EN Units: The full-scale calibration input signal is always +20mA. This is equivalent to delivering 20mA to the + terminal and returning it at the Common terminal. This produces an A/D calibration voltage of +4.0V.
   994EN Units: The full-scale input signal is a positive voltage of +9.95V or +5V, according to your input configuration.

   After applying the correct Full-Scale Calibration signal to the channel, simply click the "Step 2…" button to calibrate the full-scale.

   If you make a mistake, you can always click the **"Reset Calibration"** button to start over from Zero calibration Step 1.

   The A/D ±5V or ±10V range is now calibrated for this channel. Note that the 993EN always uses ±20mA into its 200Ω shunt to drive 4.0V to the ±10V A/D input.

If your calibration configuration selected "No" for the query "Use this cannel calibration for all channels of this port", then you should repeat this procedure for the other channels. If "Yes" was selected for this query, then you do not need to repeat this procedure, as this calibration will be used to determine the response for the other port channels.

Method 2 – Input Calibration via The Modbus TCP/IP Interface:

1. Write the appropriate Channel Configuration Register to select the input range to be calibrated for the input channel. 994EN units can select ±5V or ±10V. 993EN models will always use the ±20mA range to calibrate, even if you select one of the other ranges. This optimizes calibration by using as much of the A/D range as possible and it will drive ±4.0V into the A/D which has a native 16-bit input range of ±10V.
2. Write 24106 (5E2AH) into the Calibration Access Register to remove write protection from the calibration registers.
3. For best results, Zero is calibrated before full-scale. You must apply the exact input zero signal to the input channel being calibrated to proceed. Your signal source should be accurate to better than ±0.05% (auto calibration standard).
   993EN Units: The zero input signal is always -20mA. This produces an A/D calibration voltage of -4V.
   994EN Units: The zero input signal is a negative voltage of -9.95V or -5V, according to input range configuration. Note that the ±10V does not use the exact input range endpoint, because the A/D may not be able to achieve its endpoint exactly.
4. Write a 16-bit word into the correct Zero Cal Trigger Register with a set bit in the bit position that corresponds to the channel you wish to calibrate zero at. You would write to the Zero Cal Trigger register to address channels 0-15. A set bit in these registers will trigger the unit to sample the corresponding channel, capture its zero signal, and store the count. The unit will replace calibration coefficients immediately, with no reset required.
5. You must apply the exact input full-scale signal to the input channel being calibrated. Your signal source should be accurate to better than ±0.05% (auto calibration standard).
   993EN Units: The full-scale calibration input signal is always +20mA. This is equivalent to delivering 20mA to the + terminal and returning it at the Common terminal. This produces an A/D calibration voltage of +4.0V.
   994EN Units: The full-scale input signal is a positive voltage of +9.95V or +5V, according to your input configuration.
6. Write a 16-bit word into the correct Span Cal Trigger Register with a set bit in the bit position that corresponds to the channel you wish to calibrate full-scale at. You would write to the Span Cal Trigger register to address channels 0-15. A set bit in these registers will trigger the unit to sample the corresponding channel, capture the full-scale signal, and store the digital count. The unit will replace calibration coefficients immediately, with no reset required.
7. Repeat these steps for the other input channels to be calibrated.
8. When finished calibrating, write 0x0000 to the Calibration Access Register to replace write protection for the calibration registers and to help prevent potential miscalibration.

WEB BROWSER

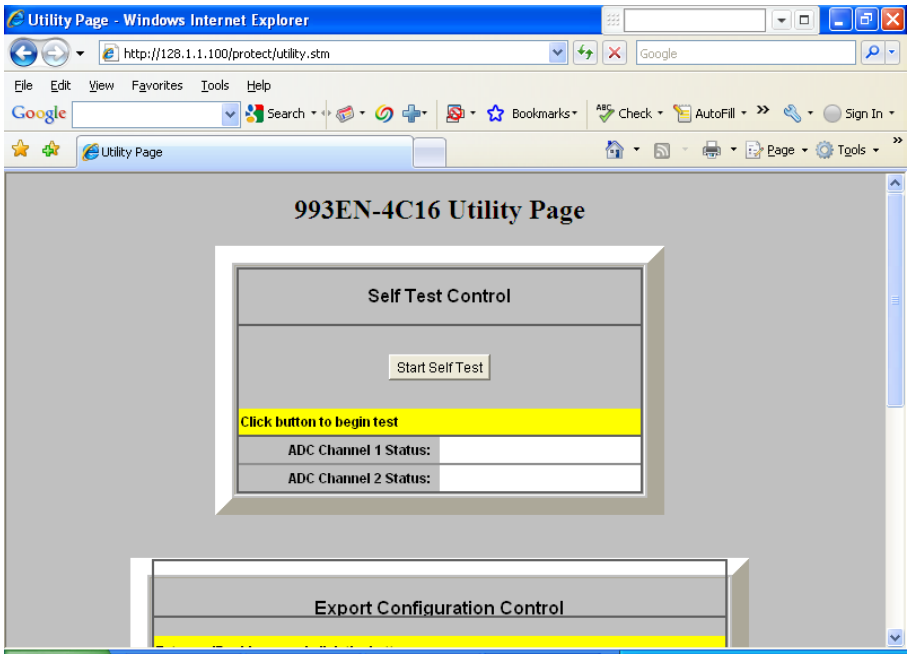
Calibration Page

WEB BROWSER

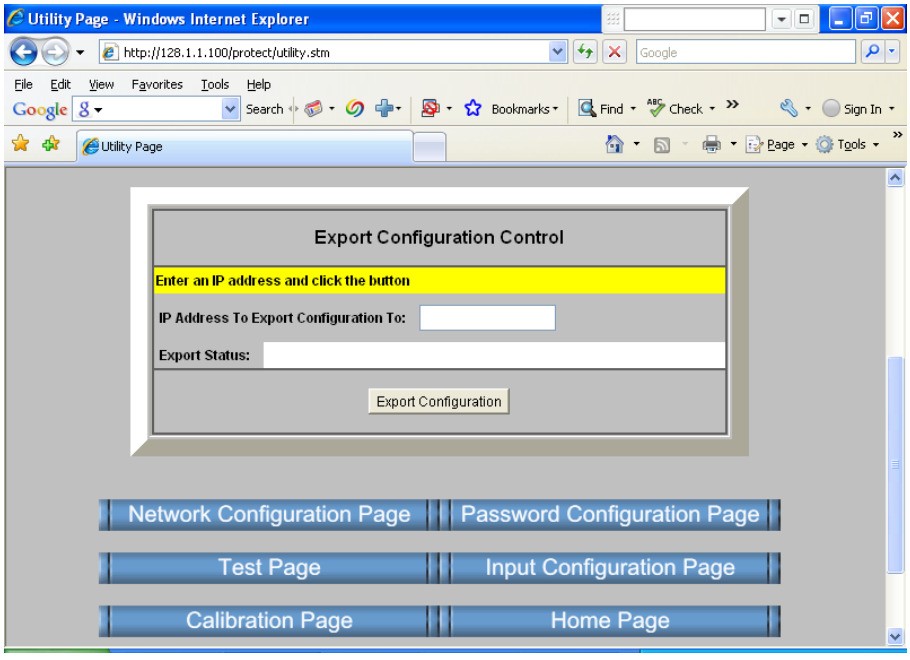
Utility Page

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 couple of built-in utilities that allows you to verify input operation without actually wiring to the inputs (self-test control), and allow you to export your configuration to an identical unit (export configuration control). 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:



Input Self Test Control

The Self-Test makes use of built-in calibration reference signals to check the operation of the input path, input buffers, and cal reference. If the Span and Zero values of an A/D channel are within the allowable specs, the unit will display "PASS". If the Span or the Zero is out of specification, the unit will display "FAIL". This can serve as a trouble-shooting aide if you are experiencing problems. It does not require that you connect anything to the input, and doing so will not affect the results of this test. Likewise, you do not have to disconnect your input signals to run this test.

Each channel is internally 8:1 multiplexed through an input buffer that drives a 16-bit ±10V A/D channel. The Self Test Control will test the relative accuracy of the two buffered input paths and their respective A/D channels by sampling the reference signals. Simply click the "Start Self Test" to begin testing. This triggers the unit to momentarily connect each A/D input channel's buffer (each mux channel) separately to the internal reference signals (0V and 5V) and measure the response. If the resultant measurement is within an acceptable level of error with respect to rated accuracy, then the A/D status will indicate "Passed". Note that this effectively tests the signal path of each channel as it tests the circuit operation beginning from the output side of the 8:1 input multiplexers. Thus, the Self-Test does not test operation of the multiplexer itself, or the integrity of the input filters, as the reference signal is multiplexed to the input buffer of an A/D channel, after the input multiplexer.

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. Likewise, it does not transfer scaled values, scaled units, preload values, nor any floating point information, or any items not represented in a register. The Export Status window will let you know if the configuration was received correctly at the remote station (destination stations may still require their own calibration).

Note: Unit will only export its configuration to **identical** model numbers. Thus, an industrial 994EN-4016 model cannot export to a commercial 994EN-4C16 model.

WEB BROWSER

Utility Page

Connecting field input signals during self-test will not harm the unit, as the input port multiplexer is disabled during self-test and no signal contention is possible.

TROUBLE-SHOOTING

Diagnostics Table

Upon power-up, after blinking momentarily the green "Run" LED should remain ON. 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.

POSSIBLE CAUSE	POSSIBLE FIX
Green RUN LED Does Not Light…	
Bad connections.	Recheck Power Connections
Try a system reset.	Cycle the power to the unit.
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.
Continuous Flashing Green RUN LED…	
A network link has not been established.	A normal unit will flash the green RUN LED and maintain a solid STATUS LED at startup until a link has been established. Check your cable and switch/hub connections. Once a link is established, the green Run LED should not continue to blink but remain ON. If it continues to blink, then the firmware may be in error.
Unit in "wink" mode.	Read Status register to verify "wink" status. Write 5555H to Wink 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 have a good network connection and proper power voltage.
Cannot Communicate…	
Power ON to the unit?	Check if green RUN LED is ON?
Fiber Connections not crossed over.	The auto-crossing feature does not apply to the fiber port. These connections must physically cross transmit to receive and visa-versa.
Cannot Communicate…	
Wrong IP Address	Change IP address of unit or host PC so they match domains. 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.
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 of next page).

POSSIBLE CAUSE	POSSIBLE FIX
Cannot Access Web Pages (Unit Won't Accept Username & Password)…	
Have you forgotten your username and password settings?	Return the unit to the Default Mode and use the default username and password to access the Password Configuration Page to reset them to something you can remember.
Communication To Unit is Lost…	
Was communication interrupted by severe interference or shock?	Reset the unit by cycling power.
Unit Fails to Start-up or Initialize…	
Input power voltage below 18V?	Check your power supply voltage and make sure that it is at least 18V and of sufficient capacity (select a current capacity at least 2x the maximum current draw of the unit).
Adding another unit to network slows web page interaction considerably…	
Does each unit have a unique MAC address? *All units are normally shipped with a unique MAC address assigned from the factory. An error in shipment could release a unit with a default MAC address (52:4F:42:45:52:54).*	Go to the Network Configuration Page and verify that each unit has a unique MAC address installed (should always be true). If you have 2 units with same MAC address, this will slow down communications considerably and you must contact the factory for MAC reassignment.
Inputs Appear Noisy or Unstable…	
Have you grounded your inputs? Note that un-grounded inputs and the Port Common terminal both require an earth-ground connection.	Connect the Port Common (C) terminal to earth ground. If input source is not already grounded, then try connecting the IN- lead to the port C terminal (which separately must also be connected to earth ground).
Have you tried Input Averaging?	You can use controls on the input configuration page to set the number of samples to average inputs over. Try increasing this number above 1 to minimize noise (up to 300).
Input Polarity is Wrong…	
Are your input terminals reversed?	Observe proper polarity for voltage inputs. Current can be input to the input (+) or input (-) terminals if a non-polarized range is selected.
Unit Fails Input Self Test…	
Internal calibration reference has failed or has been miscalibrated.	Check the reference field of the Calibration Page and make sure a voltage between 4.9965 and 5.0035 (5V±0.07%) is indicated. If not, you may attempt to calibrate this yourself, or return the unit to Acromag for calibration, repair, or replacement.
Current Inputs Have Greater Inaccuracy…	
Auto calibration of current inputs fails to compensate for errors in the current shunt resistor.	Refer to Input Cal Page and perform a manual cal of the input if auto calibration results are not sufficient.

TROUBLE-SHOOTING

Diagnostics Table

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.

TROUBLE-SHOOTING

Trouble Browsing Your Unit?

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:



So, your unit 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 993/4EN Unit to its Initial Configuration
(Also used if you wish to sanitize the unit and return it to original state)

IMPORTANT: Before attempting Restore, please try communicating with the unit after placing it in Default Mode (see Page 5). Then, if you are still unable to communicate with your module, you can utilize this procedure to try restoring its firmware configuration.

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

1. With unit power OFF, depress and hold the front-panel DFT push-button.
2. Keep DFT depressed and apply power.
3. Note that the green RUN LED will turn ON. Continue to hold the push-button depressed 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 1-20 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.

If you do use restore and want to return the unit to service, you will also have to separately restore the calibration reference.

TECHNICAL REFERENCE

KEY FEATURES

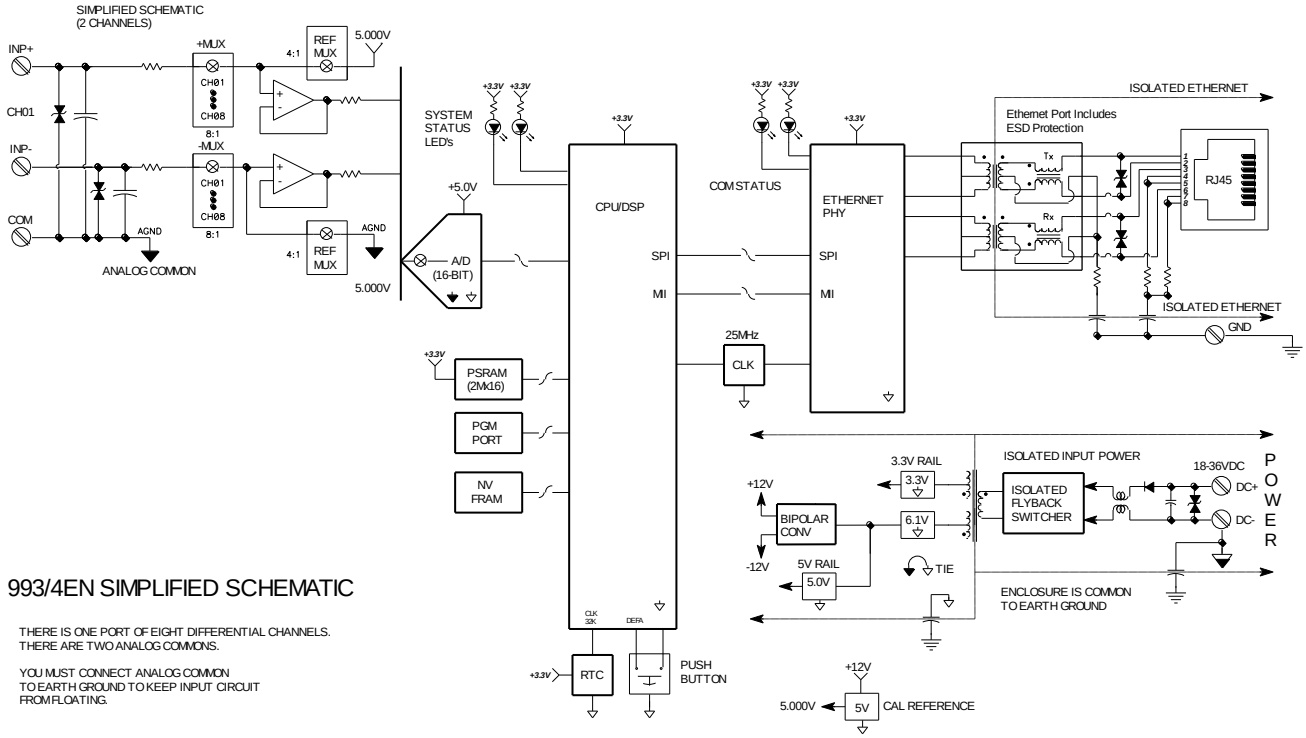
- **Safety Agency Approvals** – CE (all models), UL, & cUL listed, plus Class I; Division 2; Groups A, B, C, D approval (993EN-4016 and 994EN-4016 *ONLY*).
- **Sixteen Single-Ended Inputs** – for voltage or current, according to model.
- **Web-Browser Reconfiguration** allows a standard web-browser to be used to configure, control, monitor, and calibrate over Ethernet.
- **Fully Isolated** input channels (as a group), network ports, and power circuits for safety and increased noise immunity.
- **Wideband Inputs** can be processed in as fast as 8ms (125Hz) for all 16 channels.
- **16-bit A/D Converter** for high-accuracy and high-resolution.
- **Built-In Calibration Source** facilitates precise automatic calibration and self-test.
- **Integration and Totalization of Inputs is Possible** via scaling registers and non-volatile memory storage (***Industrial Models Only***).
- **Optional User-Scaling** allows inputs to rescale to user-defined sub-ranges or other engineering units to facilitate integration/totalization.
- **Selectable Modbus TCP/IP Protocol Support** for up to 5 sockets using Modbus TCP/IP.
- **Flexible IP Addressing** supports static, or DHCP.
- **10Base-T and 100Base-TX Support** with auto-negotiated 10/100Mbps, Half or Full Duplex.
- **Rugged Network Ports** are safety-isolated from each other and transient protected for ESD, EFT, and other transients.
- **Auto MDI/MDI-X Crossover** requires no special crossover cables to connect this device to your PC, or an external Ethernet switch, or hub.
- **Nonvolatile Reprogrammable Memory** allows the functionality of this device to be reliably reprogrammed thousands of times.
- **Operating & Diagnostic LED's Aide Troubleshooting** with two LED's to indicate power, operating mode, wink status, plus two communication LED's for port activity and link status
- **Internal Watchdog** timer is built into the microcontroller that causes it to initiate a self reset if the controller "locks up" or fails to return from an operation in a timely manner.
- **Convenient "Wink" ID Mode** will blink the green RUN LED as a tool to help identify specific remote units.
- **Wide Ambient Operation** from -40°C to +70°C (industrial models).
- **Hardened For Harsh Environments** and protection from RFI, EMI, ESD, EFT, & surges. Has low radiated emissions per CE requirements.
- **"Plug-In" Terminal Blocks** make wiring removal & replacement easy.
- **Enclosure Has Integrated DIN-Rail Mount** for "T" type DIN rail.
- **Wide-Range DC-Power** is series diode-coupled for use with redundant supplies, and/or battery back-up.

HOW IT WORKS

This circuit employs one pair of fault-tolerant 8:1 analog multiplexers to drive 16 channels of current or voltage inputs, through input buffers, to two single-ended channels of a 16-bit A/D converter. Odd channels drive one A/D channel, even channels the other. Additional circuitry can optionally connect each A/D input to 0V (zero), or a precision 5V reference to help accomplish calibration and self-test. The A/D has a native input 16-bit range of ±10V. 993EN models utilize the ±10V range (with 200Ω shunt resistors convert input current to A/D voltage and drive ±4V for ±20mA inputs). Units include an isolated 10/100Mbps Ethernet interface for configuration, monitoring, calibration, and control of the I/O. Embedded configuration parameters are stored in non-volatile memory.

The A/D rescales the inputs via an integrated resistor divider network utilizing a series 25KΩ resistor and a 17KΩ divider resistor, additionally coupled to an internal 4.096V A/D reference via a series 10KΩ resistor. The rescaled signals alternately connect to the ADC. The ADC uses a successive approximation algorithm and internal sample & hold circuit to convert the input signal to a 16-bit serial output stream which is transmitted to the CPU via an SPI interface.

The I/O terminals and the Ethernet port terminals also include transient suppression. Embedded configuration parameters are stored in non-volatile memory. A wide-input, high-efficiency, switching regulator (isolated flyback converter) provides isolated power to the unit. Refer to the simplified schematic on the following page to help gain a better understanding of circuit operation.



993/4EN SIMPLIFIED SCHEMATIC

THERE IS ONE PORT OF EIGHT DIFFERENTIAL CHANNELS.
THERE ARE TWO ANALOG COMMONS.

YOU MUST CONNECT ANALOG COMMON TO EARTH GROUND TO KEEP INPUT CIRCUIT FROM FLOATING.

MODBUS REGISTERS

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

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

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

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

Note: The ON/OFF state of discrete inputs and outputs is represented by a 1 or 0 value assigned to an individual bit in a 16-bit data word (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 993/4EN 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.

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.

MODBUS REGISTERS

Register Functions

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.

993/4EN-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]	17=993EN-4016
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 36 35 41 2C 39 39 33 45 4E 2D 34 30 31 36 ("ACROMAG,9300-165A,993EN-4016,*serial number&rev*,*six-byteMACID*")

[1]**Note:** Model 993EN-4016 uses slave ID "17" and firmware number: 9300-165. Model 993EN-4C16 uses slave ID "18" and firmware number: 9300-166 Model 994EN-4016 uses slave ID "19" and firmware number: 9300-167, Model 994EN-4C16 uses slave ID "20" and firmware number: 9300-168 (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 993/4EN 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:

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

MODBUS 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 993/4EN 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	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 993EN-4x16
Model 994EN-4x16

The following table outlines the register map for the 993/994EN 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
Input Registers (3x References, Read-Only)			
30001	0000	Unit Status *Use this register to check status of 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 12-0: 0 (Not Used)
30002	0001	CH 00 Status *(Over/Under-range, Input Range)*	Bit 15-4: 0 (Not Used) Bit 3: Over-Range Flag Bit 2: Under-Range Flag b1 b0 — 993EN — 994EN 0 0 — ±20mA — ±5V DC 0 1 — 0-20mA — ±10 VDC 1 0 — 4-20mA — *(Not Used)* 1 1 — *(Not Used)* — *(Not Used)*
30003	0002	CH 01 Status	*See CH0 explanation, apply to CH 1.*
30004	0003	CH 02 Status	*See CH0 explanation, apply to CH 2.*
30005	0004	CH 03 Status	*See CH0 explanation, apply to CH 3.*
30006	0005	CH 04 Status	*See CH0 explanation, apply to CH 4.*
30007	0006	CH 05 Status	*See CH0 explanation, apply to CH 5.*
30008	0007	CH 06 Status	*See CH0 explanation, apply to CH 6.*
30009	0008	CH 07 Status	*See CH0 explanation, apply to CH 7.*
30010	0009	CH 08 Status	*See CH0 explanation, apply to CH 8.*
30011	000A	CH 09 Status	*See CH0 explanation, apply to CH 9.*
30012	000B	CH 10 Status	*See CH0 explanation, apply to CH 10.*
30013	000C	CH 11 Status	*See CH0 explanation, apply to CH 11.*
30014	000D	CH 12 Status	*See CH0 explanation, apply to CH 12.*
30015	000E	CH 13 Status	*See CH0 explanation, apply to CH 13.*
30016	000F	CH 14 Status	*See CH0 explanation, apply to CH 14.*
30017	0010	CH 15 Status	*See CH0 explanation, apply to CH 15.*
Normalized Channel Data Registers			
30018	0011	CH 00 Data	16-bit Signed Integer Data
30019	0012	CH 01 Data	16-bit Signed Integer Data
30020	0013	CH 02 Data	16-bit Signed Integer Data
30021	0014	CH 03 Data	16-bit Signed Integer Data
30022	0015	CH 04 Data	16-bit Signed Integer Data
30023	0016	CH 05 Data	16-bit Signed Integer Data

The 16-bit Signed Integer Data stored here refers to the input range A/D count, but after normalizing it to ±20000 for ±100% of the selected input range (or 0-20000 for 0-100% of unipolar ranges).

Register Map

Model 993EN-4x16
Model 994EN-4x16

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Ref	Addr.	Description	Data Type/Format
Input Registers (3x References, Read-Only)			
Normalized Channel Data Registers			
30024	0017	CH 06 Data	16-bit Signed Integer Data
30025	0018	CH 07 Data	16-bit Signed Integer Data
30026	0019	CH 08 Data	16-bit Signed Integer Data
30027	001A	CH 09 Data	16-bit Signed Integer Data
30028	001B	CH 10 Data	16-bit Signed Integer Data
30029	001C	CH 11 Data	16-bit Signed Integer Data
30030	001D	CH 12 Data	16-bit Signed Integer Data
30031	001E	CH 13 Data	16-bit Signed Integer Data
30032	001F	CH 14 Data	16-bit Signed Integer Data
30033	0020	CH 15 Data	16-bit Signed Integer Data
Scaled Channel Low /High Data Words, 32-bit IEEE-754 Floating Point			
30034	0021	CH 00 Data LO	IEEE-754 Floating Point LO Bytes
30035	0022	CH 00 Data HI	IEEE-754 Floating Point HI Bytes
30036	0023	CH 01 Data LO	IEEE-754 Floating Point LO Bytes
30037	0024	CH 01 Data HI	IEEE-754 Floating Point HI Bytes
30038	0025	CH 02 Data LO	IEEE-754 Floating Point LO Bytes
30039	0026	CH 02 Data HI	IEEE-754 Floating Point HI Bytes
30040	0027	CH 03 Data LO	IEEE-754 Floating Point LO Bytes
30041	0028	CH 03 Data HI	IEEE-754 Floating Point HI Bytes
30042	0029	CH 04 Data LO	IEEE-754 Floating Point LO Bytes
30043	002A	CH 04 Data HI	IEEE-754 Floating Point HI Bytes
30044	002B	CH 05 Data LO	IEEE-754 Floating Point LO Bytes
30045	002C	CH 05 Data HI	IEEE-754 Floating Point HI Bytes
30046	002D	CH 06 Data LO	IEEE-754 Floating Point LO Bytes
30047	002E	CH 06 Data HI	IEEE-754 Floating Point HI Bytes
30048	002F	CH 07 Data LO	IEEE-754 Floating Point LO Bytes
30049	0030	CH 07 Data HI	IEEE-754 Floating Point HI Bytes
30050	0031	CH 08 Data LO	IEEE-754 Floating Point LO Bytes
30051	0032	CH 08 Data HI	IEEE-754 Floating Point HI Bytes
30052	0033	CH 09 Data LO	IEEE-754 Floating Point LO Bytes
30053	0034	CH 09 Data HI	IEEE-754 Floating Point HI Bytes
30054	0035	CH 10 Data LO	IEEE-754 Floating Point LO Bytes
30055	0036	CH 10 Data HI	IEEE-754 Floating Point HI Bytes
30056	0037	CH 11 Data LO	IEEE-754 Floating Point LO Bytes
30057	0038	CH 11 Data HI	IEEE-754 Floating Point HI Bytes
30058	0039	CH 12 Data LO	IEEE-754 Floating Point LO Bytes
30059	003A	CH 12 Data HI	IEEE-754 Floating Point HI Bytes
30060	003B	CH 13 Data LO	IEEE-754 Floating Point LO Bytes
30061	003C	CH 13 Data HI	IEEE-754 Floating Point HI Bytes
30062	003D	CH 14 Data LO	IEEE-754 Floating Point LO Bytes
30063	003E	CH 14 Data HI	IEEE-754 Floating Point HI Bytes
30064	003F	CH 15 Data LO	IEEE-754 Floating Point LO Bytes
30065	0040	CH 15 Data HI	IEEE-754 Floating Point HI Bytes
Totalized Chan Low/High Data Words, 32-bit IEEE-754 Floating Point			
30066	0041	CH 00 Data LO	IEEE-754 Floating Point LO Bytes
30067	0042	CH 00 Data HI	IEEE-754 Floating Point HI Bytes
30068	0043	CH 01 Data LO	IEEE-754 Floating Point LO Bytes
30069	0044	CH 01 Data HI	IEEE-754 Floating Point HI Bytes

Note: *Totalized Channel Registers are NOT available on commercial models.*

You MUST enable floating point in order to scale, integrate, and totalize. Turn it off if you do not need to rescale, integrate, or totalize inputs, as it will help to increase network determinism.

Ref	Addr.	Description	Data Type/Format
Input Registers (3x References, Read-Only)			
Totalized Chan Low/High Data Words, 32-bit IEEE-754 Floating Point			
30070	0045	CH 02 Data LO	IEEE-754 Floating Point LO Bytes
30071	0046	CH 02 Data LO	IEEE-754 Floating Point LO Bytes
30072	0047	CH 03 Data LO	IEEE-754 Floating Point LO Bytes
30073	0048	CH 03 Data HI	IEEE-754 Floating Point HI Bytes
30074	0049	CH 04 Data LO	IEEE-754 Floating Point LO Bytes
30075	004A	CH 04 Data HI	IEEE-754 Floating Point HI Bytes
30076	004B	CH 05 Data LO	IEEE-754 Floating Point LO Bytes
30077	004C	CH 05 Data HI	IEEE-754 Floating Point HI Bytes
30078	004D	CH 06 Data LO	IEEE-754 Floating Point LO Bytes
30079	004E	CH 06 Data HI	IEEE-754 Floating Point HI Bytes
30080	004F	CH 07 Data LO	IEEE-754 Floating Point LO Bytes
30081	0050	CH 07 Data HI	IEEE-754 Floating Point HI Bytes
30082	0051	CH 08 Data LO	IEEE-754 Floating Point LO Bytes
30083	0052	CH 08 Data HI	IEEE-754 Floating Point HI Bytes
30084	0053	CH 09 Data LO	IEEE-754 Floating Point LO Bytes
30085	0054	CH 09 Data HI	IEEE-754 Floating Point HI Bytes
30086	0055	CH 10 Data LO	IEEE-754 Floating Point LO Bytes
30087	0056	CH 10 Data HI	IEEE-754 Floating Point HI Bytes
30088	0057	CH 11 Data LO	IEEE-754 Floating Point LO Bytes
30089	0058	CH 11 Data HI	IEEE-754 Floating Point HI Bytes
30090	0059	CH 12 Data LO	IEEE-754 Floating Point LO Bytes
30091	005A	CH 12 Data HI	IEEE-754 Floating Point HI Bytes
30092	005B	CH 13 Data LO	IEEE-754 Floating Point LO Bytes
30093	005C	CH 13 Data HI	IEEE-754 Floating Point HI Bytes
30094	005D	CH 14 Data LO	IEEE-754 Floating Point LO Bytes
30095	005E	CH 14 Data HI	IEEE-754 Floating Point HI Bytes
30096	005F	CH 15 Data LO	IEEE-754 Floating Point LO Bytes
30097	0060	CH 15 Data HI	IEEE-754 Floating Point HI Bytes

Ref	Addr.	Description	Data Type/Format
Holding Registers (4x References, Read/Write)			
Channel Configuration Registers 40001-40016			
40001	0 (0000)	Channel 00 Configuration *(Default is 0019H, see shading)* *Note: Before setting bit 12, be sure to first calibrate the channel before using its calibration to also calibrate its entire mux group.*	Bit 15: 0 (Not Used) Bit 14: 0=Calibration use AZ/AS 1=Use Manual Calibration Bit 13: 0 (Not Used) Bit 12: 0=Do NOT use this CH Calibration for this port. *(see Note)* 1=Use this CH Cal for Calibrating this port. Bit 11: 0 (Not Used) Bit 10: 0 (Not Used) Bit 9: 0 (Not Used) Bit 8: Totalizer Initial Value* 0=Use Preload Value 1=Use Last Value Bit 7: Totalizer End Count* 0=Rollover 1=Latch Bit 6: Totalizer OFF/ON* 0=OFF 1=ON Bit 5: 0 (Not Used) Bits 4,3: Totalizer Time Base* 00 Per Second (Commercial - Default = Not Used) 01 Per Minute 10 Per Hour 11 No Action (Industrial - Default) Bit 2: 0 (Not Used) Bits 1,0: Input Range Selection. 993EN / 994EN 00 0=±20mA / 0=±5V 01 1=0-20mA / 1=±10V 10 2=4-20mA / *Reserved* 11 *Reserved* / *Reserved*
40002	0001	CH01 Config	*See explanation for channel 00 above.*
40003	0002	CH02 Config	*See explanation for channel 00 above.*
40004	0003	CH03 Config	*See explanation for channel 00 above.*
40005	0004	CH04 Config	*See explanation for channel 00 above.*
40006	0005)	CH05 Config	*See explanation for channel 00 above.*
40007	0006)	CH06 Config	*See explanation for channel 00 above.*
40008	0007	CH07 Config	*See explanation for channel 00 above.*
40009	0008	CH08 Config	*See explanation for channel 00 above.*
40010	0009	CH09 Config	*See explanation for channel 00 above.*
40011	000A	CH10 Config	*See explanation for channel 00 above.*
40012	000B	CH11 Config	*See explanation for channel 00 above.*
40013	000C	CH12 Config	*See explanation for channel 00 above.*

*Note: Totalizer option is not available on commercial models.

Register Map

Model 993EN-4x16
Model 994EN-4x16

Totalized inputs are sampled every 8ms (or 20ms with Input Averaging). Your input signal per time base is thus multiplied by 8ms per sample to get your incremental increase or decrease of volume that is added to your totalized value. The maximum totalized value possible is 9,999,999.9999.

Note: *Totalizer Options are NOT available on commercial models.*

Note: *You must separately enable floating point if you enable the totalizer here (see Floating Point Enable register).*

IMPORTANT: *If you set bit 12 to use this channel's calibration for the entire port, note that the channel must already be manually calibrated for this to work properly.*

Register Map

Model 993EN-4x16
Model 994EN-4x16

Note: *Floating Point cannot be disabled if any channel is totalizing*

Shaded registers from 40025 to 40056 are write-restricted and reserved for internal firmware and factory use (these registers are modified indirectly by the calibration registers 40112-40113). Do not attempt to directly modify the contents of these registers.

Ref	Addr.	Description	Data Type/Format
Holding Registers (4x References, Read/Write)			
Channel Configuration Registers 40001-40016			
40014	000D	CH13 Config	*See explanation for channel 00 above.*
40015	000E	CH14 Config	*See explanation for channel 00 above.*
40016	000F	CH15 Config	*See explanation for channel 00 above.*
Miscellaneous Unit Configuration Registers 40017-40021			
40017	(0010)	Input Averaging ***(Def = 0000H, No Averaging)***	Set to 0 or 1 for No Averaging. Set to an integer greater than 1 to specify the number of samples to average (300 samples maximum).
40018	(0011)	Global Floating Point Enable and Byte Order ***(Def = 0000H, disabled)***	Bit 15: Floating Point ON/OFF 0=OFF 1=ON Bits14..2 0 (Not Used) Bits 1,0: Data Word Byte Order 00 b3 b2 b1 b0 01 b0 b1 b2 b3 10 b1 b0 b3 b2 11 b2 b3 b0 b1
40019	(0012)	*Reserved*	*Reserved – Do Not Use*
40020	(0013)	*Reserved*	*Reserved – Do Not Use*
40021	(0014)	Wink Toggle & Cal Access & Restore Cal & Restore Scaling & System Reset Register	Write **21845 (5555H)** here 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". Use the Unit Status Register wink mode flag to determine the wink state. Write **24106 (5E2AH)** to remove write protection from the calibration registers that follow. Write **0 (0000H)** to apply write-protection to the calibration registers. Write **44718 (AEAEH)** to restore the default calibration coefficients. Write **60138 (EAEAH)** to restore the default scaling values. Write **41429 (A1D5H)** to this register to cause a system reset and reboot.
40022	(0015)	*Reserved*	*Reserved – Do Not Use*
40023	(0016)	*Reserved*	*Reserved – Do Not Use*
40024	(0017)	*Reserved*	*Reserved – Do Not Use*
Channel Calibration Value Registers 40025-40056			
40025	(0018)	CH0 ±5V Cal HI	16-bit Signed Integer Data
40026	(0019)	CH0 ±5V Cal LO	16-bit Signed Integer Data
40027	(001A)	CH0 ±10V Cal HI	16-bit Signed Integer Data
40028	(001B)	CH0 ±10V Cal LO	16-bit Signed Integer Data
40029	(001C)	CH1 ±5V Cal HI	16-bit Signed Integer Data
40030	(001D)	CH1 ±5V Cal LO	16-bit Signed Integer Data
40031	(001E)	CH1 ±10V Cal HI	16-bit Signed Integer Data
40032	(001F)	CH1 ±10V Cal LO	16-bit Signed Integer Data

Ref	Addr.	Description	Data Type/Format
Holding Registers (4x References, Read/Write)			
Channel Calibration Value Registers 40025-40088			
40033	(0020)	CH2 ±5V Cal HI	16-bit Signed Integer Data
40034	(0021)	CH2 ±5V Cal LO	16-bit Signed Integer Data
40035	(0022)	CH2 ±10V Cal HI	16-bit Signed Integer Data
40036	(0023)	CH2 ±10V Cal LO	16-bit Signed Integer Data
40037	(0024)	CH3 ±5V Cal HI	16-bit Signed Integer Data
40038	(0025)	CH3 ±5V Cal LO	16-bit Signed Integer Data
40039	(0026)	CH3 ±10V Cal HI	16-bit Signed Integer Data
40040	(0027)	CH3 ±10V Cal LO	16-bit Signed Integer Data
40041	(0028)	CH4 ±5V Cal HI	16-bit Signed Integer Data
40042	(0029)	CH4 ±5V Cal LO	16-bit Signed Integer Data
40043	(002A)	CH4 ±10V Cal HI	16-bit Signed Integer Data
40044	(002B)	CH4 ±10V Cal LO	16-bit Signed Integer Data
40045	(002C)	CH5 ±5V Cal HI	16-bit Signed Integer Data
40046	(002D)	CH5 ±5V Cal LO	16-bit Signed Integer Data
40047	(002E)	CH5 ±10V Cal HI	16-bit Signed Integer Data
40048	(002F)	CH5 ±10V Cal LO	16-bit Signed Integer Data
40049	(0030)	CH6 ±5V Cal HI	16-bit Signed Integer Data
40050	(0031)	CH6 ±5V Cal LO	16-bit Signed Integer Data
40051	(0032)	CH6 ±10V Cal HI	16-bit Signed Integer Data
40052	(0033)	CH6 ±10V Cal LO	16-bit Signed Integer Data
40053	(0034)	CH7 ±5V Cal HI	16-bit Signed Integer Data
40054	(0035)	CH7 ±5V Cal LO	16-bit Signed Integer Data
40055	(0036)	CH7 ±10V Cal HI	16-bit Signed Integer Data
40056	(0037)	CH7 ±10V Cal LO	16-bit Signed Integer Data
40057	(0038)	CH8 ±5V Cal HI	16-bit Signed Integer Data
40058	(0039)	CH8 ±5V Cal LO	16-bit Signed Integer Data
40059	(003A)	CH8 ±10V Cal HI	16-bit Signed Integer Data
40060	(003B)	CH8 ±10V Cal LO	16-bit Signed Integer Data
40061	(003C)	CH9 ±5V Cal HI	16-bit Signed Integer Data
40062	(003D)	CH9 ±5V Cal LO	16-bit Signed Integer Data
40063	(003E)	CH9 ±10V Cal HI	16-bit Signed Integer Data
40064	(003F)	CH9 ±10V Cal LO	16-bit Signed Integer Data
40065	(0040)	CH10 ±5V Cal HI	16-bit Signed Integer Data
40066	(0041)	CH10 ±5V Cal LO	16-bit Signed Integer Data
40067	(0042)	CH10 ±10V Cal HI	16-bit Signed Integer Data
40068	(0043)	CH10 ±10V Cal LO	16-bit Signed Integer Data
40069	(0044)	CH11 ±5V Cal HI	16-bit Signed Integer Data
40070	(0045)	CH11 ±5V Cal LO	16-bit Signed Integer Data
40071	(0046)	CH11 ±10V Cal HI	16-bit Signed Integer Data
40072	(0047)	CH11 ±10V Cal LO	16-bit Signed Integer Data
40073	(0048)	CH12 ±5V Cal HI	16-bit Signed Integer Data
40074	(0049)	CH12 ±5V Cal LO	16-bit Signed Integer Data
40075	(004A)	CH12 ±10V Cal HI	16-bit Signed Integer Data
40076	(004B)	CH12 ±10V Cal LO	16-bit Signed Integer Data
40077	(004C)	CH13 ±5V Cal HI	16-bit Signed Integer Data
40078	(004D)	CH13 ±5V Cal LO	16-bit Signed Integer Data
40079	(004E)	CH13 ±10V Cal HI	16-bit Signed Integer Data
40080	(004F)	CH13 ±10V Cal LO	16-bit Signed Integer Data

Register Map

Model 993EN-4x16
Model 994EN-4x16

Shaded registers from 40025 to 40056 are write-restricted and reserved for internal firmware and factory use (these registers are modified indirectly by the calibration registers 40112-40113). Do not attempt to directly modify the contents of these registers.

Ref	Addr.	Description	Data Type/Format
Holding Registers (4x References, Read/Write)			
Channel Calibration Value Registers: 40025-40088			
40081	(0050)	CH14 ±5V Cal HI	16-bit Signed Integer Data
40082	(0051)	CH14 ±5V Cal LO	16-bit Signed Integer Data
40083	(0052)	CH14 ±10V Cal HI	16-bit Signed Integer Data
40084	(0053)	CH14 ±10V Cal LO	16-bit Signed Integer Data
40085	(0054)	CH15 ±5V Cal HI	16-bit Signed Integer Data
40086	(0055)	CH15 ±5V Cal LO	16-bit Signed Integer Data
40087	(0056)	CH15 ±10V Cal HI	16-bit Signed Integer Data
40088	(0057)	CH15 ±10V Cal LO	16-bit Signed Integer Data
Reserved Registers: 40089-40109			
40089	(0058)	*Reserved*	*Reserved – Do Not Use*
.	.	.	.
.	.	.	.
40109	(006C)	*Reserved*	*Reserved – Do Not Use*
Totalizer Reset Register: 40110			
40110	(006D)	Reset Totalizer Trigger for Channels 15-0 *Register always reads back as 0000H*	Bits 15-0: 1=Reset Totalizer 0=No Action Bit position corresponds to input channels to reset totalizer at (lsb is lowest numbered channel).
40111	(006E)	*Reserved*	*Reserved – Do Not Use*
Calibration Trigger Registers: 40112-40113			
40112	(006F)	Zero Cal Trigger for Channels 15-0	Bit position corresponds to channel numbers. Write a set bit to this register to trigger the A/D to sample the corresponding input(s) and store the zero signal (lsb is lowest numbered channel of group). *First write 24106 to Calibration Access Register 40021 to remove write-protection from the calibration value registers before triggering.*
40113	(0070)	Span Cal Trigger Channels (Ch 15-0)	Bit position corresponds to channel number. Write a set bit to this register to trigger the A/D to sample the corresponding input(s) and store the positive calibration signal (lsb is lowest numbered channel of this group). *First write 24106 to Calibration Access Register 40021 to remove write-protection from the calibration value registers.*

Register Map

Model 993EN-4x16
Model 994EN-4x16

Ref	Addr.	Description	Data Type/Format
Holding Registers (4x References, Read/Write)			
Calibration Trigger Registers 40112-40113			
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.*

Notes (Register Map):

1. The 16-bit A/D range uses an A/D count of ±32768 counts for its native ±10V input range. To simplify, all input ranges are subsequently normalized to a count of ±20000 by the unit and this corresponds to ±100%, or 0-20000 corresponding to 0-100%.
2. 993EN Models have a fixed A/D range of ±10V, but use a 200Ω input shunt to drive 0-4.0V to the A/D representing 0-20mA input. Bipolar current ranges are normalized to ±20000 by the unit corresponding to ±100%. Unipolar current ranges are normalized to 0-20000 for 0-100%.

Default Register Settings

Here is a summary of the 993EN/994EN default register settings and corresponding default behavior.

993EN/994EN Default Register Settings

REGISTER	HEX	ACTION
Channel Configuration Registers	0019H	Use Auto-Zero/Span Cal
		Do not use CH Cal for Port
		Totalizer to use Preload
		Totalizer is OFF
		Totalizer Action is Rollover
		Totalizer Time Base is NA
		Input is 0-20mA or ±10V
Digital Filter/Input Averaging	0000H	0, No Input Averaging
Floating Point Enable & Byte Order	0000H	Disable, b3-b2-b1-b0 Order
Wink Register	0000H	OFF, Do Not Wink

Configuration Parameters Not Programmable Via Modbus Registers

Use the built-in web interface screens to set these parameters, which are generally required to setup communications.

Not all parameters of this device can be set via Modbus registers. In general, parameters related to I/O will have a Modbus register, while those related to network communication must be set via the web interface. Here is a list of configuration parameters which do not have a Modbus register.

Username & Password
Static IP Address
Number of Modbus Sockets
Subnet Mask
Gateway Address
Host Name
Select Static, DHCP, or DHCP w/Fallback Addressing
Wink On/Off
Self-Test Utility
Export Configuration & Export IP Address
Scaling Values
Scaling Units
Preload or Totalizer Value
Calibration Reference Measured Value

SPECIFICATIONS

A DIN-rail mount, industrial Ethernet I/O system providing 16 single-ended input channels for current (993EN), or voltage (994EN). Units have an isolated 10/100M Ethernet interface for monitoring, calibration, and control via Modbus TCP/IP. Unit is DC-powered with reverse polarity protection. Field inputs are wide-band, and multi-ranging. Sixteen bit A/D conversion is used and input ranges may be rescaled to sub-ranges or other engineering units to help facilitate integration/totalization. Input channels include transient protection. Input channels (as a group), network ports, and power circuits are isolated from each other, and from earth ground. Non-volatile reprogrammable memory in the unit stores configuration, calibration, and totalization data.

Model Numbers

993EN-4016
993EN-4C16
994EN-4016
994EN-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 or "C" = Commercial Model, "16" = 16 Channels.

Differences between Industrial and Commercial Models

	Industrial Models	Commercial Models
Operating Temp	-40°C to 70°C	0°C to 55°C
Accuracy	0.05% (Typ 993EN & 994EN)	0.1% (993EN & 994EN)
Approvals	CE, UL, cUL	CE only
Totalizer	Yes	Not Available

Analog Inputs

Current (993EN Model)
or
Voltage (994EN Model)

Sixteen single-ended input channels of input current (993EN), or input voltage (994EN), multiplexed by two 8:1 multiplexers to two buffered 16-bit A/D channels. Model 993EN input channels use precision 200Ω shunt resistors to convert input current to voltage, such that ±20mA will drive ±4.0V full-scale to a ±10V input channel of a 16-bit A/D. 994EN input channels drive the ±10V A/D directly with no dividers. Inputs are wideband (up to 125Hz) and include transient voltage suppression. Model 994EN voltage inputs are also fault-tolerant to ±25V.

Unit must be wired and configured for the intended input type and range (see Connections section for details). Inputs are bipolar single-ended and the signal can be input to either terminal and returned on the opposite terminal. The following paragraphs summarize this model's input types, ranges, and applicable specifications.

SPECIFICATIONS

Analog Inputs

Current (993EN Model)
or
Voltage (994EN Model)

DC Input Range: ±10V or ±5V (994EN); ±20mA, 0-20mA, 4-20mA (993EN). A nominal field range of ±10V is used on a per channel basis which corresponds to the full 16-bit A/D input range. An input sub-range of ±5V may be selected for the 994EN (15-bit). Note that the 994EN ±10V range may not be able to achieve the full-scale endpoints exactly. 993EN units also utilize the ±10V A/D range, but with 200Ω precision shunt resistors (0.125W) at the inputs to convert input current to voltage, such that ±20mA DC (±22mA Max) drives ±4V full-scale to the A/D. 993EN input sub-ranges of 0-20mA, and 4-20mA may also be selected. Inputs may optionally be rescaled to support sub-ranges of nominal ranges, or to accomplish integration and totalization of the input signal. All selectable input ranges are normalized to ±20000 for ±100% of range, or 0-20000 for 0-100% of range (over-range is 2000, or 2500 for 4-20mA range). Positive current or voltage is delivered to the (+) input terminal and returned at the common input terminal (C).

Input Resolution: 305.176uV/bit (±10V and ±5V), or 1.5259uA/bit (993EN). For simplicity, all input ranges are normalized to ±20000 counts, or 0-20000 counts by the firmware. Your effective resolution will vary with your range selection and input scaling.

Normalized Resolution for 994EN Input Ranges

RANGE	±10V	±5V
Resolution	305.176uV/bit	305.176uV/bit
PPM	15.26ppm	15.26ppm
Normalized	±20000 (15.2 bit)	±20000 (15 bit)

Normalized Resolution for 993EN Input Ranges[1]

RANGE	±20mA	0-20mA	4-20mA
Resolution	1.5259uA/bit	1.5259uA/bit	1.5259uA/bit
PPM	38.15ppm	76.30ppm	95.36ppm
Normalized	±20000 (14.6 bits)	0-20000 (13.6 bits)	0-20000 (13.3 bits)

[1]Input uses a 200Ω shunt and the ±10V (16-bit) A/D Range. Input ranges are normalized to ±20000 for ±100%, and 0-20000 for 0-100%.

Limits to Re-Scaling Nominal Ranges: To achieve a minimum acceptable resolution of 12 bits (±2048 parts), rescaling should not divide the nominal A/D base range of ±10V by more than 16 (0.0625x). 993EN input voltage equals input current x200Ω and the ±10V A/D range is used. For 4-20mA, a peak reading occurs at a normalized count of 22500 (22mA, 112.5%) with full-scale (20mA) corresponding to 20000 counts (100%).

RANGE	±10V (994EN)	±5V (994EN)	993EN (uses ±10V)
MIN SPAN (12-bit)	1.25V or ±0.625V	1.25V or ±0.625V	6.25mA or ±3.125mA

Input Reference Test Conditions: ±20mA (993EN), or ±10V (994EN) input; ambient temperature = 25°C; 24VDC supply.

Input Over Voltage Protection: Bipolar Transient Voltage Suppressors (TVS), clamp level less than 50V and greater than 18V.

SPECIFICATIONS

Analog Inputs

Current (993EN Model)
or
Voltage (994EN Model)

Input Impedance: 4MΩ minimum (994EN), 200Ω (993EN).

Voltage Input Reference Test Conditions: ±10V DC input; ambient temperature = 25°C; 24VDC supply.

Input Over voltage Protection: Bipolar Transient Voltage Suppressers (TVS), clamp level less than 50V.

Input Calibration: By default, the unit automatically calibrates zero and span every input cycle using precise on-board calibration reference signals sufficient for most applications. Optionally, inputs may be calibrated manually by driving the input channel externally. It is also possible to manually calibrate a group of channels based on the calibration of one channel from that group (a manual calibration time saver). Calibration is automatic, manual per channel or octet, and a unit can mix manual and automatic calibration among channels.

Input Accuracy: 993EN-4016: ±0.05% Typ. Better than ±0.1% of span.
993EN-4C16: Better than ±0.1% of span.
994EN-4016: Better than ±0.05% of span.
994EN-4C16: Better than ±0.1% of span.
The above specs use auto-calibration for nominal input ranges and reference test conditions. This includes the effects of repeatability, terminal point conformity, and linearization, but does not include sensor error. Note: relative accuracy can be improved with manual calibration.

Input Measurement Temperature Drift: Better than ±25ppm/°C (±0.0025%/°C).

Input Analog to Digital Converter (A/D): A 16-bit successive-approximation converter, Linear Technology LTC1856IG.

Input Conversion Rate: 8mS for all 16 channels with Input Averaging OFF. 20mS for all 16 channels with Input Averaging ON.

Input Filter: Normal mode filtering fixed per input type.

Input Filter Bandwidth: -3dB at 150KHz, typical. Bandwidth is dominantly restricted to the update rate of 16 channels (125Hz).

Input Cable Length: I/O port interface cables should not exceed 30m in length for rated performance.

Floating Point Enable/Disable: You must enable Floating Point support in order to rescale an input signal, or to accomplish integration/totalization. Disable it if you don't need to rescale or totalize. Disabling floating point support reduces the amount of calculations that have to be performed and gives the processor more time to do other tasks besides acquiring data. This can help to make critical control network applications more deterministic, particularly over networks with heavy traffic flow.

Byte Order: The unit allows you to specify the byte order for 32-bit floating point values. Different Modbus systems will use different byte orders for the two 16-bit registers used to store a 32-bit floating point value. Select the byte order compatible with your system. Note that B0 refers to the Least Significant Byte and B3 to the Most Significant Byte.

Input Integration/Totalization (Industrial Units Only): If totalization is enabled, the instantaneous input is sampled at a slower rate of every 8ms, and you can integrate this signal by totalizing its time sliced instantaneous value. To totalize, you must separately enable Floating Point Support and you also need to scale the input appropriately and specify the time-base perform the integration over ("per Second", "per Minute", "per Hour", to "NA"). You must specify a time base other than NA for totalization to occur. Note that if "NA" is selected and Totalize=Yes, then 0.0 is added to the totalized value. The totalized value is non-volatile and you can preload a totalized value on power-up, or system reset. By default, it totalizes from the last totalizer value before interrupting power or performing a system reset. During run time, your incremental "time-sliced" measurement value will be added to this total every 8ms. The software also gives the capability to reset the current totalized value to a preload value. For example, during totalization, we gather an instantaneous input sample every 8ms. If your instantaneous scaled input value indicates 500, and units are gallons, and the time base is set to "per Minute". Then (500 gallons/minute)*(1 minute/60 seconds) equals a flow rate of 8.33 gallons/per second. Since a new sample is obtained every 8ms, multiply 8.33 gallons/second by 0.008 seconds/sample to get an incremental increase of volume of 0.0666 gallons/sample, and this amount is added to your totalized value. Note that with floating point disabled, the measured input value will still indicate a floating point number, but the scaling and totalizing fields will indicate "Inactive".

SPECIFICATIONS

Analog Inputs

Memory

This unit contains both volatile and non-volatile solid-state memory. It does not contain any fixed or removable disk or tape drives, or memory cards. For security or sanitization considerations, review the following:

Flash Memory (Non-Volatile): 512 Kilobyte flash memory is used for storage register data, communication configuration parameters, and web-page information and is user-modified via reconfiguration. It is sanitized via the Restore procedure by holding the default switch while powering up the unit until the green Run LED turns OFF. At this time, the memory reverts to the factory default settings, except for the MAC ID and serial number which are fixed. Refer to "Getting Out of Trouble" section in this manual for more information.

FRAM (Non-Volatile): This 8 Kilobyte memory is resident on the I/O board and is used to store the channel configuration, calibration coefficients, and scaling information for the inputs. It is user-modified via channel setup and calibration. Its contents can be cleared to factory default calibration values by clicking the Restore All Default Calibration Values button of the Input Calibration web page.

SRAM (Volatile): This 96 Kilobyte memory is integrated within the central processor and is used as scratchpad memory by the processor during run time. Its contents are cleared at power-down.

PSRAM (Volatile): This 4 Megabyte memory is external to the central processor and used as the run time memory for high-speed execution of this unit's internal program. Its contents are cleared on power-down.

SPECIFICATIONS

Enclosure & Physical

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

Network Connector: 8-pin RJ-45 socket with metal shield (shield is isolated and bypassed to earth ground at the GND terminal with an isolation capacitor and TVS). Connections are wired MDI, but unit is auto-crossing. Use CAT-5 cable minimum to connect 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

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.

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 (993EN-4016 and 994EN-4016): 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 and 213-M1987), Hazardous Locations: Class I; Division 2; Groups A, B, C, and D

Safety Approvals (993EN-4C16 and 994EN-4C16): CE marked (EMC Directive 2004/108/EC)

ATEX Certified: Assessment by TUV Rheinland of North of America, Inc. per
ATEX Directive 94/9/EC.
Ex nA IIC T4 Gc
TUVNA 14 EX 0001X
x = Special Conditions

1) "WARNING-EXPLOSION HAZARD-DO NOT MAKE OR BREAK CONNECTIONS IN HAZARDOUS LOCATIONS OR AREAS"
2) "Warning: Must be installed in suitable enclosure with an Ingress Protection of IP54 minimum, in Hazardous Locations or Areas"

Environmental

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

External Fuse: *Select a high surge tolerant fuse rated for 250mA or less to protect unit.*

Operating Temp (Industrial Grade): -40°C to +70°C (-40°F to +149°F).

Operating Temp (Commercial Grade): 0°C to +55°C (+32°F to +131°F).

Storage Temp: -40°C to +85°C (-40°F to +185°F).

Relative Humidity: 5 to 95%, non-condensing.

Power Requirements: 18-36V DC SELV (Safety Extra Low Voltage), 1.944W maximum. Observe proper polarity. Keep DC power cables less than 10m in length. Divide power by your voltage to approximate maximum current and select a supply that can deliver at least twice this amount.

Supply	993EN-4016 / 994EN-4016 Current Draw
18V	82mA Typical, 99mA Maximum
24V	63mA Typical, 76mA Maximum
36V	45mA Typical, 54mA Maximum

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

Isolation: Input channels (as a group), power, and network circuits are isolated from each other for common-mode voltages up to 250VAC, or 354V DC off DC power ground, on a continuous basis (will withstand 1500VAC dielectric strength test for one minute without breakdown). Complies with test requirements of ANSI/ISA-82.01-1988 for voltage rating specified. Note that input channels are not isolated channel-to-channel.

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.

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, and 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. (Industrial Models ONLY)

WARNING – EXPLOSION HAZARD – Substitution of any components may impair suitability for Class I, Division 2.
WARNING – EXPLOSION HAZARD – Do not disconnect equipment unless power has been switched off or the area is known to be non-hazardous.

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 Seventeenth Edition & ISA 12.12.01:2000.

SPECIFICATIONS

Environmental

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

External Fuse: *Select a high surge tolerant fuse rated for 250mA or less to protect unit.*

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

Reliability Prediction

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

Temp	993EN-4016	994EN-4016
25ºC	590,384 hrs	571,184 hrs
40ºC	416,947 hrs	405,988 hrs

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

SPECIFICATIONS

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.
Modbus Port: Up to 5 sockets supported, uses port 502 (reserved for Modbus). The port number can be optionally changed to any number from 0 to 99999 to fit the application.
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.

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.

IP 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 trouble-shooting purposes.
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.

Controls & Indicators

Controls (Push-Button):

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 "password00". This switch can also be used to restore the module to its initial factory configuration by holding this switch in its default position for 5 seconds while powering up the unit (see "Getting Out Of Trouble" in the Troubleshooting section for more information).

Indicators (LED's):

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 and stays ON if an under/over-range condition occurs.
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).

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.

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).

ACCESSORY CABLES

Patch Cables & Crossover Cables

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 993/4EN 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

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

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

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

Revision History

The following table shows the revision history for this document:

Release Date	Version	EGR/DOC	Description of Revision
07 OCT 11	D	CAP/KLK	Updated cULus per latest standards (ECN 11D016).
04 JAN 13	E	TPH/KLK	Update input over/under range specifications (ECN 12A011).
21 APR 14	F	CAP/SRW	Update ATEX per latest standards (ECO 14D012).
10 JAN 2019	G	CAP/ARP	Update "WARNING - EXPLOSION HAZARD - Substitution of any components..." per uL.

Notes:

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