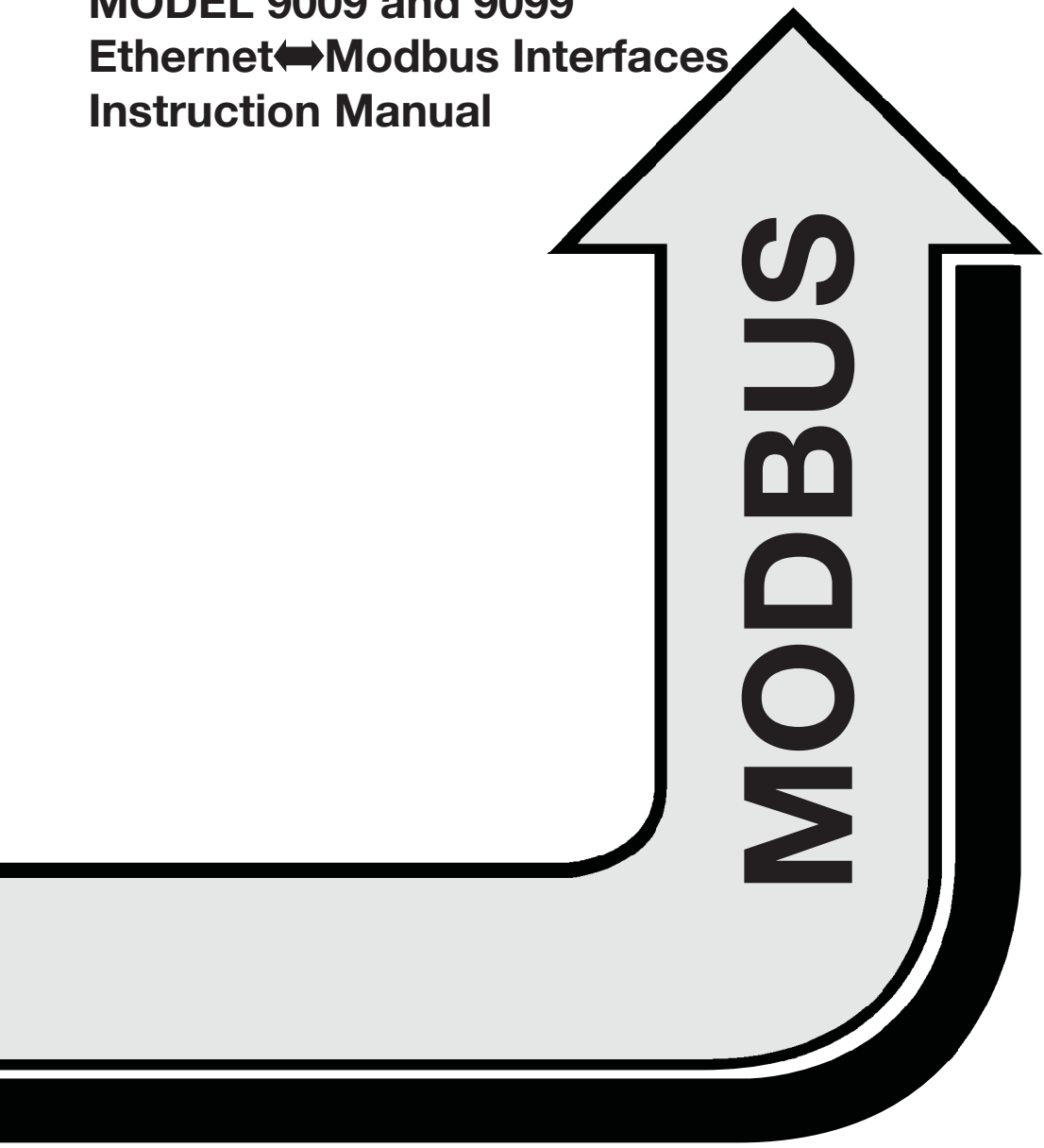
ICS
ELECTRONICS
a division of Systems West Inc.

MODEL 9009 and 9099
Ethernet⬌Modbus Interfaces
Instruction Manual



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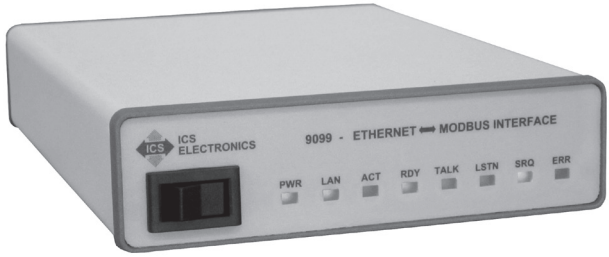
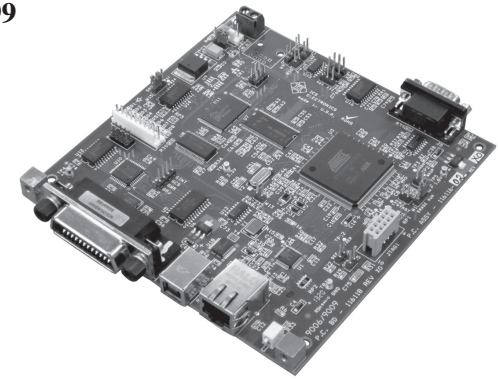


9099



9009

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LIMITED WARRANTY

Within 12 months of delivery, ICS Electronics will repair or replace this product, at our option, if any part is found to be defective in materials or workmanship (labor is included). Return this product to ICS Electronics, or other designated repair station, freight prepaid, for prompt repair or replacement. Contact ICS for a return material authorization (RMA) number prior to returning the product for repair.

CERTIFICATION

ICS Electronics certifies that this product was carefully inspected and tested at the factory prior to shipment and was found to meet all requirements of the specification under which it was furnished.

EMI/RFI WARNING

This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause interference to radio communications. The Model 9099 has been tested and found to comply with the limits for a Class A computing device pursuant to Subpart J of Part 15 of the FCC Rules and to comply with the EEC Standards EN 55022; VDE 0878-22:2011-12 and EN 55024:2010; VDE 0878-24:2010-09 which are designed to provide reasonable protection against such interference when operated in a commercial environment. Operation of this equipment in a residential area is likely to cause interference, in which case the user, at his own expense, will be required to take whatever measures may be required to correct the interference.

CE Certificate of Conformance reproduced in Figure 1-2.

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Contents

General Information

1.1 INTRODUCTION

This section provides a description and specifications for ICS's Model 9009 and 9099 Ethernet to Modbus Interfaces. All specifications and functional descriptions apply to both units unless otherwise stated.

1.2 DESCRIPTION

The Model 9009 and 9099 Ethernet to Modbus Interfaces provide a user with multiple ways to control Modbus RTU slave devices with RS-232 and RS-422/RS-485 signals. The Model 9009 is a PC board assembly with an Ethernet, GPIB and USB user interfaces. The Model 9099 is an enclosed unit that has an Ethernet user interface. Both units have a 9-pin connector with user selected RS-232 or RS-422/RS-485 signals for controlling Modbus RTU slave devices.

In both units, the Ethernet Interface provides a user with multiple protocols and conversion capability to control serial Modbus RTU devices. The Ethernet Interfaces support the VXI-11, raw-socket and Modbus TCP/IP conversion and include a webserver with HTML control pages for the more popular temperature controllers.

The VXI-11 and raw-socket protocols let the user send simple commands with ASCII values over a 10/100 Mbs TCP/IP network to control and query Modbus slave devices. The simple commands are converted into the Modbus RTU messages and the CRC checksum is added to make a complete Modbus RTU packet. The Modbus RTU packets are sent serially over a RS-232 link to a single Modbus slave device or over a RS-485 network to one or multiple Modbus devices. Responses are checked and valid response data from a query is returned when the 9099 is next addressed to talk.

The 9099 contains a number of advanced features that increase its flexibility and simplifies their use in test system applications. The 9099 is an IEEE-488.2 compatible interface with an expanded Status Reporting Structure that complies with the SCPI standard. SCPI commands are used to set the GPIB, USB and serial configuration, and to enable bits in the Status Reporting Structure to generate Service Requests. The user can also enter his own IDN message to personalize the unit as part of his assembly.

Modbus TCP/IP packets are automatically converted into Modbus RTU packets. The Modbus conversion is transparent and the 9099 does not restrict the Modbus addresses, functions or data but they are restricted by the capabilities of the slave device. Response data from the slave device is returned to the sender as a TCP/IP response packet. Message length is limited to 255 bytes.

The 9099 contains a webserver which provides the user with several types of webpages. The Welcome page displays information about the 9099 and displays its status. The Configuration Page provides a way to view the 9099's current settings and to change the network, serial and USB settings. There is some overlap with the SCPI setup commands. A rear panel 'LAN Reset' button allows the user to return the 9099 to its default network settings. Two Temperature Controller pages and a general Control page let a user view and control different processes and devices run by temperature controllers.

The 9099's GPIB and USB Interfaces access the 9099's parser as does the Ethernet interface and use the same simple commands to control and query Modbus slave devices as does the Ethernet interface. The GPIB interface is fully IEEE-488.2 compliant. The USB Interface uses Microsoft's Virtual COM port driver for easy communication with the 9099.

The 9099 and 9099 are VXI-11.3 compliant, can be used in systems with LXI devices and can be found with the LXI 'VXI-11 Discovery Method'.

The Model 9099 is a 5.5 x 5.5 inch PC board assembly that can be mounted on the rear panel or inside a host chassis. It accepts 5 to 15 Vdc power.

The Model 9099 is packaged in a small Minibox™ metal case that is less than 1U in height (1.6 inches) The front panel contains the power switch and LEDs which indicate the unit's status. The rear panel contains the Ethernet and serial connectors, LAN Reset button and a DC power jack. The 9099 accepts a wide range of DC voltages and is shipped with an universal power adapter and plugs.

1.3 MODEL SPECIFICATIONS

The following specifications apply to all 9009 and 9099 models. Options for your unit may be found by comparing the list below to those listed on the program label on your unit.

90x9 - X General Model Number

Option Codes

-6	Special settings
-7	Special Program
-8	Hardware modification
-9	Factory Rack Mounted
-U	Ship with Universal 115/230 Vac Adapter

1.4. VXI-11 CONFORMANCE

The 9099 complies with the VXI-11.3 Specification.

1.4.1 RPC Protocol

The RPC protocol conforms to ONC RPC Version 2.

1.4.2 Sockets

The 9099's VXI-11 service supports 15 TCP/IP sockets for client communication with a maximum of 4 active sockets. The sockets are normally opened and closed by the clients. The unit will close the socket and release all resources if a broken connection is detected or when the link count goes to zero if Auto Disconnect is enabled.

There is a separate socket for UDP RPC Port Mapper communication.

1.4.3 Channels

Supports Core, Abort and Interrupt channels. Core and Abort channels each use a socket connection. A reverse Interrupt channel is a TCP/IP socket connection that does not count against the 15 client communication sockets limit.

1.4.4 Device Links and Locks

The 9099 supports a maximum of 64 device links and 64 locks that can be used over multiple Core channels by one or more clients.

1.4.5 VXI-11 Interface Name

The 9099 has only one instrument personality and the default name is *inst0*. The name may be changed to any 8 character string.

1.4.6 VXI-11.3 Supported Functions

The 9099 supports all VXI-11.3 functions including:

create_link	destroy_link	create_intr_channel	destroy_intr_channel
device_lock	device_unlock	device_abort	
device_read	device_write	device_clear	device_trigger
device_remote	device_local	device_readstb	create_intr_channel
device_intr_SRQ	device_enable_SRQ		

1.5 ETHERNET INTERFACE

1.5.1 Type

IEEE-802.3 Compliant, Auto MDIX

1.5.2 Speed

Auto speed sensing, 10 Mbs with 10BaseT and 100 Mbs with 100BaseT

1.5.3 Network Address

Static: IP Address, Subnet Mask, and Gateway IPv4 values are user set from 0.0.0.0 to 255.255.255.255. Default values are listed in Table 1-3.

DHCP: Unit accepts IPv4 address from a DHCP Server or falls back to an AutoIP of 169.254.90.99. The 9009 falls back to 169.254.90.09.

1.5.4 KeepAlive Message

User enabled. Message sent if no activity for 120 minutes. Releases the socket and all associated resources if the connection is broken.

1.5.5 COMM Timeout

User set period of 0 to 2^{32} seconds. Releases socket and all associated resources if no activity occurred during the time period.

1.5.6 Port Usage

TABLE 1-1 9099 PORT USAGE

Port	Usage	Protocols	Notes
23	Raw socket	TCP	Configurable port#
80	Internal WebServer	HTML over TCP	Web Browser
111	RPC Port Mapper	RPC over TCP	
502	Modbus TCP/IP	TCP	
5555	Core Channel	RPC over TCP	
2000-2999	Abort Channel	RPC over TCP	
xxxx	Reverse Notification	RPC over TCP	Defined by user
5556	Configuration Port, Error Logger	RPC	

TABLE 1-2 FACTORY NETWORK SETTINGS

Function	Choices	Default	Command Source (1)
IP Address Mode	Static or Dynamic with autoIP fallback to 169.254.90.99 or 169.254.90.09.	Static	E
IP Address	0.0.0.0 to 255.255.255.255	192.168.0.254	E
Net Mask	0.0.0.0 to 255.255.255.255	255.255.255.0	E
Gateway IP	0.0.0.0 to 255.255.255.255	192.168.0.1	E
COMM Timeout		120 sec	E
IP KeepAlive	On or Off	On	E
Interface Name	Any string(4)	inst0	E
Auto Disconnect Sockets	On or Off	Off	E
User Description	any string	blank	E
Raw Socket Enable	On or Off	Off	E
Raw Socket Port#	0-65635	23	E
Raw Socket Echo Enable	On or Off	Off	E

Notes:
1. E = Set via Ethernet Interface using a web browser.
2. Function definitions are described in Table 2-1
3. The MAC Address is factory set and is not user changeable. The MAC Address can be read with the VXI-11 Configuration Utility or with a web browser.
4. The interface name defines the device type. Changing it may cause your application to stop working.
5. Setting Auto Disconnect on may cause your application to loose its connection to the 9099 if the application destroys all links.

1.5.7 Protocols

TCP/IP	for VXI-11, HTTP and RPC communication
UPD and TCP/IP	for RPC Port Mapper commands
Modbus TCP/IP	for Modbus RTU conversion
Raw Socket	for telnet compatible IP packet communication

1.5.8 Raw Socket

The 90x9's Raw Socket configuration is set to the following values:

Port	23
Sockets	4
Echo	Off
Prompt	None
Timeout	120 seconds fixed
Logon message	Message equal to *IDN? response.
Terminator	Linefeed character
Carriage Returns	Client generated carriage returns are ignored.
Backspace	Prior character deleted up to the start of the buffer.
Echo On command	Cntl-E
Echo off command	Cntl-F

The Raw Socket connection will be closed if there is no communication for 120 seconds. To prevent the Raw Socket from timing out and disconnecting, the client can issue a no change message like space-backspace or a Cntl-E-Cntl-F sequence, on an occasional basis, to restart the timeout counter.

If Echo was enabled, all client character will be echoed back to the client. The echo sequence for a backspace is a BS-space-BS to visually wipe the deleted character off of the telnet client screen.

The 9099's WebServer provides HTML web pages to W3C compliant browsers.

1.6.1 HTML Pages

The 9099's HTML pages conform to HTML version 4.01 or XHTML version 1.0. The WebServer serves the stored pages after substituting values for the variable placeholders. The variables are listed in Appendix 5. The standard pages are:

404.html	404 Error Page (required page)
501.html	501 Error Page (required page)
index.html	Welcome Page (required page)
config.html	Configuration Page
confirm.html	Confirmation Page
control.html	General purpose 9099 and Modbus device control page
reboot.html	Reboot Page
F4.html	Sample F4 Control Page
F4T.html	Sample F4T Control Page
EZ.html	Sample EZ Zone Control Page

1.6.3 Graphics

ICS'S HTML upload utility supports files with .gif, .jpg, .png or .hgl extensions. The standard graphic is:

ICS-Logo.gif	ICS Logo

1.6.4 HTML User Configurability

The user can replace the HTML pages and image files with modified pages or add additional pages and images to the unit. The user is responsible for assuring that any substituted HTML page conforms to HTML version 4.01 or XHTML version 1.0. Guidelines for modifying the pages, HTML files and the Upload Utility are described in Application Bulletin AB80-5.

File types supported	.html, .gif, .jpg, .png, .hgl and .xml
Number of files	32 maximum
File size	255 kbytes maximum for all files. 63 kbytes maximum for a single file.
File name size	25 characters including the extension.

1.7 GPIB INTERFACE (9009 ONLY)

1.7.1 488.1 Capabilities

The 9009's GPIB Bus interface meets the IEEE STD 488.1-1987 standard and has the following capabilities:

SH1, AH1, T6, L3, SR1, PP0, DC1, RL0, DT0, C0 and E1/E2 drivers.

1.7.2 Address Ranges

Primary addresses 0 - 30

1.7.3 Buffers

GPIB input	1 kbytes
GPIB output	1 kbytes

1.7.4 488.2 Common Commands

The 9009 conforms to IEEE STD 488.2-19A87. When addressed to listen in the command mode, the unit responds to the following 488.2 Common Commands:

*CLS, *ESE, *ESE?, *ESR?, *IDN?, *OPC, *OPC?, *PSC *RCL, *RST, *SAV, *SRE, *SRE?, *STB, *TST?, and *WAI.

1.7.5 SCPI Parser

The extended SCPI parser complies with the SCPI Standard Version 1994.0.

1.8 USB INTERFACE (9009 ONLY)

1.8.1 USB Driver

Provides USB control through a virtual COM Port using the Microsoft's standard driver for Virtual COM Ports.

1.8.2 Supported Operating Systems

Windows XP (SP2) or later,
Vista
Windows 7
Windows 8
Windows 10

1.8.3 Data Rates and Formats

Baud Rate:	115.2 Kbaud
Date bits	8
Parity	none
Stop bits	1

1.9 SERIAL MODBUS INTERFACE

The 9099's asynchronous serial Modbus interface provides RS-232 single-ended signals and RS-485 (RS-422) differential signals with an internal termination network. Signals are selected by internal jumpers.

1.9.1 Modbus RTU Message Format

Messages conform to the Modbus RTU format and include the device address, command, register number, data and CRC formatted as binary bytes. Supported Modbus commands when using VXI-11.3 or raw socket protocol are: 01, 02, 03, 04, 05, 06, 07, 08, and 16 for integer values and commands 03 and 16 for floating point 32-bit values.

Integer range	16 bits or 65,536
Floating point	IEEE-754

There are no Modbus command restrictions when using the Modbus TCP/IP protocol. Message size and responses cannot exceed the 255 byte packet size.

1.9.2 Baud Rates

Although Modbus RTU devices typically support only 9600 and 19200 baud, the 9099 is setable to the following baud rates. The 9099 selects the next higher standard rate when a nonstandard rate is entered.

1200, 2400, 4800, 9600, 19200, 38400, 57600, and 115200 baud.

1.9.3 Data Character Formats:

Data bits	7 or 8 data bits per character
Parity	none, even or odd
Stop bits	1 or 2 stop bits per character

1.9.4 RS-232 Specifications

All units have single-ended RS-232C drivers and receivers that are designed to operate with up to 50 feet of cable. Hardware handshaking is not supported. Signals have 15 Kv ESD protection.

Transmit Levels	+5 Vdc = Logic "0" or On -5 Vdc = Logic "1" or Off

Receive Levels	± 2.4 Vdc minimum, ± 25 Vdc maximum
Signals	AA, AB, BA, and BB

1.9.5 RS-422/RS-485 Specifications

The 9099 has balanced RS-485 line drivers and receivers that provide RS-422 and RS-485 compatible differential signal pairs. The line drivers and receivers are designed to operate with up to 1200 meters of twisted-pair cable. The transmitter can be set for continuous on operation or it can be tristated when not transmitting.

Modes	Transmitter always on (RS-485 Mode Off) or tristated when not transmitting (RS-485 mode On)
Transmit Levels	+2 Vdc differential for binary 0 or On -2 Vdc differential for binary 1 or Off
Receive Levels	± 0.2 Vdc minimum, ± 25 Vdc maximum, differential or single-ended input with other input line biased at mid-range.
Signals	SD, RD Signal pairs combined by internal jumpers.
Termination Network	3.3 volt Termination network with 100 Ω load resistor. Network selected by jumpers.

1.9.6 Alarm Inputs

The 9099 has two TTL signal inputs with 10 kohm pullups to +5 Vdc. Input levels should be < 0.6 Vdc for low and > 1 Vdc for high. The signals are sampled at a > 1 kHz rate and reported in the Operational Register in the Status Reporting Structure.

1.10 PROGRAMMABLE FUNCTIONS

Table 1-3 lists the 9099 and 9009's programmable interface and Modbus functions that can be set by external commands and/or a web browser. PCB jumpers are factory set for RS-232 signals.

TABLE 1-3 FACTORY CONFIGURATION

Command or Variable	Functions	Factory Setting
:ADDRess	Sets GPIB Address	4
:BAUD	Sets Modbus transmit/receive baud rate	9600 #
:BITs	Sets Modbus data bits per character	8 #
:SBITs	Sets Modbus stop bits/per character	1 #
:PARity	Sets Modbus parity type	NONE #
:RS485	Enables tristating Modbus serial transmitter when not transmitting.	OFF #
:FORMat	Sets talk format for response data	ASCii #
:PROMPt	Enables USB prompt.	1
:Echo	Enables echoing character in the USB port.	0
CAL:IDN	Sets OEM's IDN string	empty string #
*ESE	Enables Standard Event Status Register bits	0
*SRE	Enables Status Byte Register bits	0
D	Modbus Serial Timeout	300
C	Modbus slave device ID number	1
(subaddr)	Sets the substitute modbus slave address for programs written with slave address 0.	1
(enable)	Enables the 9099 to substitute its preset slave ID number for the ID number in the Modbus TCP/IP packet. This parameter can only be configured with a web browser.	OFF

Notes: # indicates a parameter that can be blocked by the LOCK command

1.11 INDICATORS

The 9099 has eight LED indicators that display the following conditions:

PWR	Indicates power on
LAN	Indicates that the unit is ready and is connected to an active LAN. Blinks at user request to identify the unit. Off when IP address has unexpectedly changed.
ACT	Indicates messages are being transferred between the unit and the LAN.
RDY	Indicates the unit has passed self test. Blinks when all sockets are used and the unit cannot open a new socket or link.
TALK	Indicates the unit was sent a device_read command
LSTN	Indicates the unit was sent a device_write command.
SRQ	On when the unit is requesting service. When a reverse Interrupt channel is established and Service requests are enabled, the SRQ LED will blink momentarily to indicate that the unit has sent an service request message to the host application.
ERR	Blinks on when the unit has detected a soft error condition such as a command error, device error or a communication problem. Steady on when any of the ESR Register error bits 2 thru 6 are set or LAN ip address unexpectedly changed.

When the unit is turned on, it performs an internal selftest and startup which takes about 7 seconds. Only the PWR LED is on during the self test-startup time.

The Model 9009 blinks is GPIB address as a binary value during the self test. The bit weights are:

RDY	TALK	LSTN	SRQ	ERR
16	8	4	2	1

At the end of a successful selftest, the unit turns the RDY LED on after the outputs have been configured. At this time the LAN and ACT LEDs display the unit's network status. LAN communication is immediate for static IP addresses. DHCP IP address assignment times add to the LAN startup time.

If the unit detects a hard self test error, it blinks the error code on its front panel LEDs. Refer to paragraph 5.4 for a description of the selftest errors and their possible causes.

1.12 PHYSICAL

1.12.1 9009 Board Assembly

Size	5.5" L x 5.5" W x .5" H (13.97 cm L x 13.97 cm W x 1.24 cm H) (See Figure 1-1)
Material	PC Board - FR406 Flame resistant Fiberglass Components - RoHS compliant
Construction	Lead Free
Weight	0.35 lbs (0.14 kg)
Temperature	
Operating	-10 °C to +55 °C
Storage	-40 °C to +70 °C
Humidity	0-90% RH without condensation
Power	5 ± 0.2 Vdc or 5.5 to 15 Vdc @ 400 mA
Connectors	
Ethernet	RJ45
GPIB	Standard 24-pin IEEE Conector with metric lock studs
Serial	Cinch DE-9S female connector with lock studs
USB	USB 'B' type
LEDs (J4)	ICS P/N 902279 or AMP 4-640440-0
Power (P2)	ICS P/N 902323 or AMP 640440-2

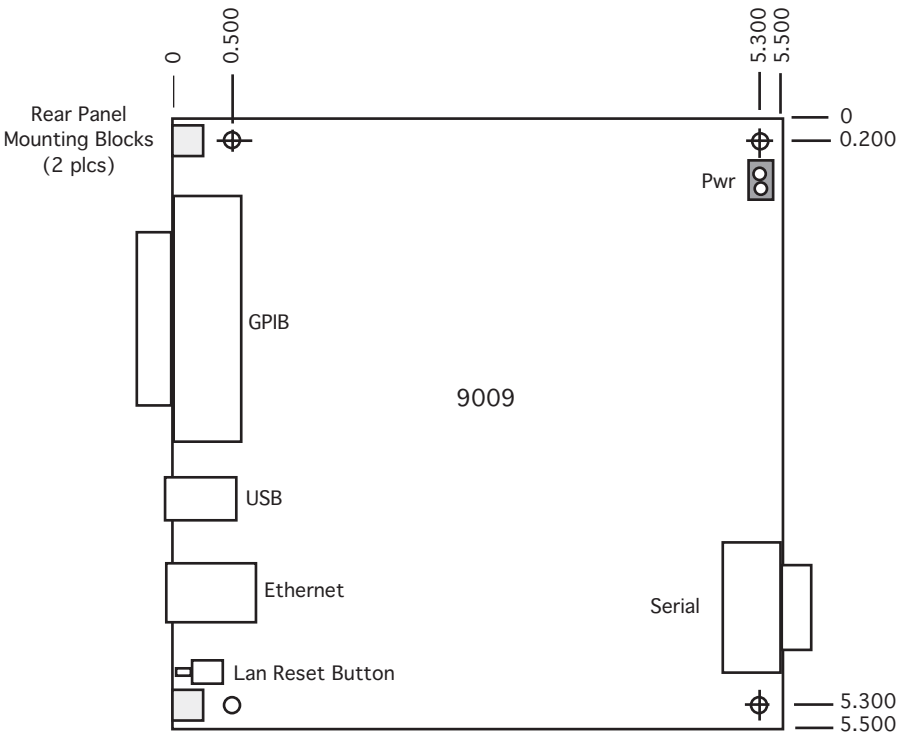

Figure 1-1 9009 Outline Dimensions

1.12.2 9099 Minibox

Size	7.45" L x 5.57" W x 1.52" H (18.92 cm L x 14.15 cm W x 3.86 cm H) (See Figure 1-2)
Material	PC Board - FR406 Flame resistant Fiberglass Components - RoHS compliant
Construction	Lead Free
Weight	3 lbs (1.4 kg) including adapter
Temperature	
Operating	-10 °C to +55 °C
Storage	-40 °C to +70 °C
Humidity	0-90% RH without condensation
Power	9 to 32 Vdc @ 3.5 VA
Connectors	
Ethernet	RJ-45
Serial	Cinch DE-9P male connector with lock studs

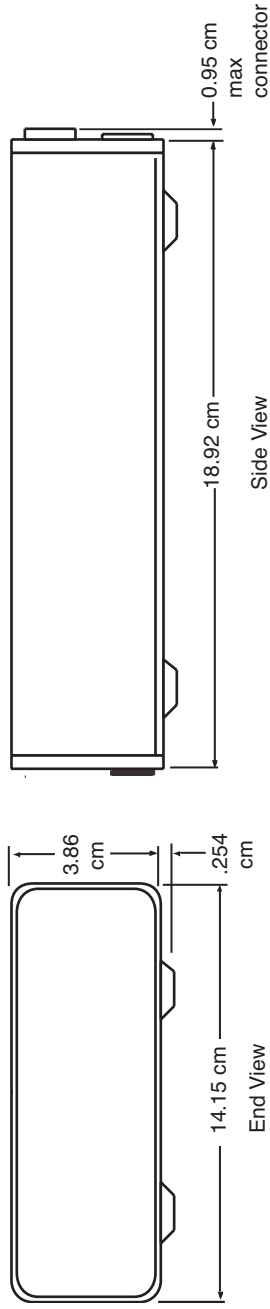

Figure 1-2 9099 Outline Drawing

1.13 CERTIFICATIONS OR APPROVALS

EMI/RFI — Meets limits for part 15, Class A of US FCC Docket 20780 and complies with EEC Standards EN 55022; VDE 0878-22:2011-12 and EN 55024:2010 VDE 0878-24:2010-09. CE Certificate of Compliances reproduced in Figure 1-2.

UL/CSA/VDE — AC Wall adapter has applicable UL/CSA/VDE and CE approval.

1.14 INCLUDED ACCESSORIES

120217	9009/9099 Instruction Manual
123038	Support CD-ROM with Configuration Program, Documentation, Sample Programs and Utilities.
895011	Ethernet Crossover Cable (5 feet long)
A/R	Power adapter with appropriate country plug (9099 only)

1.15 OPTIONAL ACCESSORIES

120217	9009/9099 Instruction Manual
895011	Ethernet Crossover Cable (5 feet long)
114210	Single Small Minibox Rack Mount Kit
114211	Dual Small Minibox Rack Mount Kit
114227	Large/Small Minibox Rack Mounting Kit

SCHWILLE - ELEKTRONIK
Produktions- und Vertriebs GmbH
Benzstrasse 1 A
85551 Kirchheim/ Germany

EMV Prüfbericht
EMC Testreport

Gegenstand *Equipment (EUT)*	Ethernet Modbus Interface
Hersteller *Manufacturer*	ICS Electronics
Typ *Type*	ICS 9099-U
Auftraggeber *Customer*	Meilhaus Electronic GmbH 82178 Puchheim
Anforderung *Requirement*	DIN EN 55022; VDE 0878-22:2011-12 - Einrichtungen der Informationstechnik - Funkstöreigenschaften - Grenzwerte und Messverfahren (CISPR 22:2008, modifiziert); Deutsche Fassung EN 55022:2010 DIN EN 55024; VDE 0878-24:2011-09 Einrichtungen der Informationstechnik - Störfestigkeitseigenschaften - Grenzwerte und Prüfverfahren (CISPR 24:2010); Deutsche Fassung EN 55024:2010
Ergebnis *Result*	Die Übereinstimmung mit den Anforderungen ist erfüllt. *The compliance with the requirements is fulfilled.*
Gesamt *Total*	45 Seiten *pages*

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Datum *Date*	Leiter des Laboratoriums *Head of the laboratory*
14.6.2013	i.A. Manfred Schiedrich

Figure 1-3 9099 Certificate of Compliance

Installation

2.1 INTRODUCTION

This section provides the user with directions for shipment verification, for installing and configuring the 9009 or 9099 and for connecting to its serial interface. All directions for the 9099 apply to the 9009 unless otherwise stated.

2.2 UNPACKING

When unpacking, check the unit for signs of shipping damage (damaged box, scratches, dents, etc.) If the unit is damaged or fails to meet specifications, notify ICS Electronics or your local sales representative immediately. Also, call the carrier immediately and retain the shipping carton and packing material for the carrier's inspection. ICS will make arrangements for the unit to be repaired or replaced without waiting for the claim against the carrier to be settled.

2.3 SHIPMENT VERIFICATION

Take a moment to verify that the following items were included with your unit:

(1) Model 9009 or 9099 Ethernet to Modbus Interface
(1) AC Power Adapter (9099 only)
(1) Instruction Manual
(1) Support CD-ROM
(1) Ethernet Crossover Cable

2.4 INSTALLATION GUIDES

2.4.1 9009 Installation Guide

The following steps should be used as to setup and use the 9009.

1. Review Section 2.9 to select or design the serial cable to the Modbus RTU Slave Device. Change the jumper positions on the 9009 as directed in Section 2.10 to match the selected signal type.

2. Select a convenient location to mount the 9009. The preferred location is flush against the rear panel so that its Ethernet, GPIB and USB connectors protrude through the rear panel and provide good RFI/EMI suppression. Use the cutouts and mounting dimensions shown in Figure 2-1 for rear panel mounting. Panels thicker than 0.050 inches will need counterboring to keep the lockstuds in their correct positions. Provide a 0.1 inch clearance between the 9009 and any metal surface. Mount away from any heat producing surface and high frequency, high current cables.

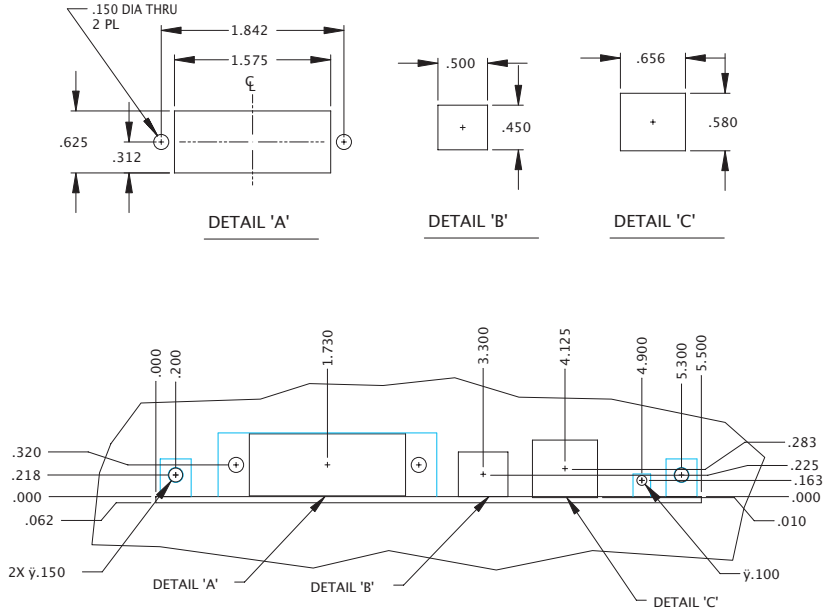


Figure 2-1 9009 Rear Panel Cutouts

3. Use a pair of #22-#24 twisted wires to connect DC power to the 9009's screw terminal strip. Set jumper W14 to REG for +5.5 to +15 Vdc power. Use the P1 position only for 5 Vdc regulated power.

4. Connect a PC to one of the 9009's interfaces and the serial cable to the Modbus slave device.

   To use the Ethernet interface, connect a cable to the 9009's RJ45 connector and follow the directions in Section 2.6 for setting the computer to communicate with the 9099. Use ICS's VXI-11kybd program or a web browser to access the 9099 at its default IP of 192.168.0.254. See Section 2.6 for detailed instructions.

   To use the GPIB interface, follow the SCPI Tree in Table 3-2 to configure the unit. Address the 9009 at its default GPIB address of 4. See Section 2.7 for detailed instructions.

   To use the USB interface, install Microsoft's Virtual COM Port Driver from the Support CD as directed in Section 2.8. Initialize the virtual COM port at 115,200 baud.

5. Send the 9009 an *IDN? query to readback its IDN message and to verify communication with the 9009.

6. Review the factory settings in Table 1-2 to determine if the baud rate or any other settings need to be changed for the Modbus slave device. Use the 'D' command (see Table 3-5) to set the Modbus timeout to 1000 for initial tests.

7. Obtain the register numbers from the Modbus slave device manufacturer. Use the Modbus read commands in Table 3-5 to query the Modbus slave device to verify communication. Try reading and writing to several registers to verify that you have good communication with the Modbus slave device.

8. Check with the Modbus slave device manufacturer to obtain the device's response times. If data is not available, use an oscilloscope or logic analyzer to measure the Modbus device response time from the end of a query to the end of the response message. Try several different queries. Set the timeout to the manufacturer's time or to the longest measured time plus an additional 25 milliseconds. Save the new setting with the '*SAV 0' command..

9. OEMs may want to change the 9009's IDN message to report the OEM's company and model number (See 3.8.15). Save the new IDN message and set CAL:LOCK On. The network settings can be left alone as the end user will need to change them for his company and location.

2.4.2 9099 Installation Guide

The following steps should be used as to setup and use the 9009.

1. Review Section 2.9 to select or design the serial cable to the Modbus RTU Slave Device. Change the jumper positions as directed in Section 2.10 to match the selected signal type.

2. Connect the AC adapter, serial cable and the Ethernet cable to the unit. Connect the other end of the Ethernet cable directly to a PC or to the PC through a switch that is not connected to your network as shown in Figure 2-2.

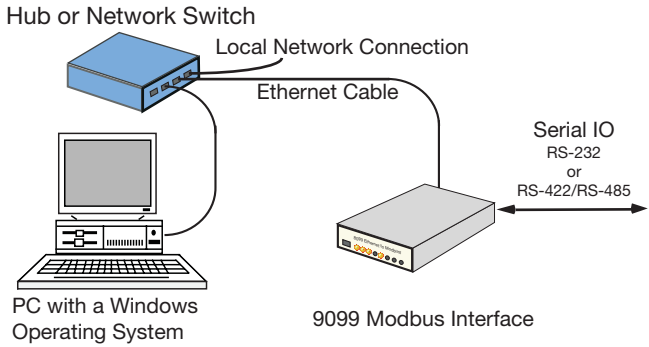


Figure 2-2 9099 with Local or Benchtop Connection

3. Follow the directions in Section 2.6 for setting the computer to communicate with the 9099. Use ICS's VXI-11kybd program to access the 9099 at its default IP of 192.168.0.254.

4. Send the 9009 an *IDN? query to readback its IDN message and to verify communication with the 9009.

5. Review the factory settings in Table 1-2 to determine if the baud rate or any other settings need to be changed for the Modbus slave device. Use the 'D' command (see Table 3-5) to set the Modbus timeout to 1000 for initial tests.

6. Obtain the register numbers from the Modbus slave device manufacturer. Use the Modbus read commands in Table 3-5 to query the Modbus slave device to verify communication. Try reading and writing to several registers to verify that you have good communication with the Modbus slave device.

7. Check with the Modbus slave device manufacturer to obtain the device's response times. If data is not available, use an oscilloscope or logic analyzer to measure the Modbus device response time from the end of a query to the end of the response message. Try several different queries. Set the timeout to the manufacturer's time or to the longest measured time plus an additional 25 milliseconds. Save the new setting with the '*SAV 0' command..

8. Check with the Modbus slave device manufacturer to obtain the device's response times. If data is not available, use an oscilloscope or logic analyzer to measure the Modbus device response time from the end of a query to the end of the response message. Try several different queries. Set the timeout to the manufacturer's time or to the longest measured time plus and additional 25 milliseconds. Save the new setting. Increase this value if you get Modbus timeout errors.

9. Configure the 9099's network settings for its permanent location. Consult with your network administrator to obtain the correct settings if it will be placed on the company network. Save the new settings.

2.5 THE SUPPORT CD-ROM

The Support CD ROM contains Keyboard, Utility and Example programs for ICS's Interface Products. Interactive Keyboard programs are available for the 9009 and 9099's Ethernet interface and for the 9009's GPIB and USB Interfaces. These programs let the user send simple commands and queries to the unit without having to write a program. They simplify the checkout process and should be used to test the Modbus slave device communication link.

CAUTION

Do not install ICS's GPIB drivers on your computer unless you are trying to install an ICS GPIB Controller. Installing ICS's drivers will cause other manufacturer's GPIB Controllers to stop working.

TABLE 2-1 CONFIGURATION SETTINGS

Setting	Choices	Comments
IP Address Mode	Static or DHCP with AutoIP	Static lets the user set the 90's IP Address, Net Mask and Gateway IP values. DHCP enables the 9099 to accept the IP values supplied by a DHCP Server or fallback to its AutoIP address of 169.254.90.99 if not connected to a DHCP Server. Model 9009's Auto-IP address is 169.254.90.09.
IP Address	Any	Any valid IP address setting. Must be four groups of numbers between 0.0.0.0 and 255.255.255.255.
Net Mask	Any	Same range as the IP Address
Gateway IP	Any	Same range as the IP Address.
COMM_Timeout	0 to 2^{32}-1 seconds	Sets the COMM timeout value. If the unit senses no client communication for more than the COMM_Timeout setting, the unit will close the socket, release any locks and reclaim all associated instrument resources. Use a short setting of 2-5 minutes when debugging programs to recover broken links faster and a longer setting of 10-60 minutes for debugged applications. A value of 0 disables COMM_Timeout. Value is 0 or 1 to 2^{32}-1.
IP KeepAlive	On or Off	Enables the unit's socket layer to send the client socket a short test message once every 120 minutes. If the client socket fails to reply, the unit will close the socket, release any locks and reclaim all associated instrument links. Do not enable Keep Alive if the network or the client do not support Keep Alive messages. The recommended setting is On.
User Description	any string	User description of item being controlled. e.g. "Oven #1".
Raw Socket Enable	On or Off	Enables Raw Socket protocol. Default is Off.
Raw Socket Port#	0-65535	Instrument raw socket port number, 0 to 65535. Default is port 23.
Raw Socket Echo Enable	On or Off	Enables raw socket commands to be echoed back to the sender. Default is Off.

Note: Default values are listed in Tables 1-2 and 1-3.
Table 2-1 continued on page 2-8.

2.6 USING THE ETHERNET INTERFACE

The 9009 and 9099's default network settings are listed in Table 1-2. Table 2-1 describes the configuration choices and their affect on the unit's operation. Review them with your network administrator and decide on which settings, if any, that need to be changed before connecting to the network. If the 9009 or 9099 is being used in an isolated test system, just set the network settings to be similar to those used with the other instruments.

The 9099's default serial settings are listed in Table 1-3. Compare the serial settings against the settings on the Modbus slave device. Adjust the serial settings so both units have the same settings.

Network settings can only be changed with a web browser. Serial, GPIB and USB settings can be changed with the SCPI commands listed in Table 3-3 or with the web browser.

2.6.1 Web Browser Configuration Method

This method uses a standard browser such as Firefox or Internet Explorer to view and change the current settings.

1. Use any Ethernet cable to connect the 9009 or 9099 directly to your PC or indirectly through a switch. Be sure the switch is disconnected from your company network as shown in Figure 2-1.

2. Check your computer's network settings to be sure its IP address is in the 192.168.0.xxx range so it can communicate with the 9009 or 9099's default IP address. If it is not, it must be set before proceeding. Use the values shown below. If your PC's IP address is in a different range, record the current settings and temporarily set the following network values:

Check	'Use the following IP Address'
IP Address	192.168.0.2
Subnet mask	255.255.255.0

3. Open the web browser and enter the default IP address of 192.168.0.254 for new units (or your last set address for older units) in the browser address window. A Welcome Page similar to the one shown Figure 2-3 should appear in your browser.

TABLE 2-1 CONFIGURATION SETTINGS CONT'D

Setting	Choices	Comments
9009 GPIB Address	0-30	9009 only - Sets the unit's GPIB primary address. Addresses 0 and 21 should be avoided as they are commonly used for the GPIB Controller's address. Default address is 4.
USB Prompt Enable	On or Off	9009 only - Enables 9009 to return a prompt sequence when ready for the next USB command. Prevents overrunning the USB port.
USB Echo Enable	On or Off	9009 only - Enables 9009 to return each character as its received.
Modbus Baud Rate	1.2-115.2K	Sets Modbus serial baud rate. Default is 9600.
Modbus Data Bits	7 or 8	Sets number of data bits in a character. Default is 8.
Modbus Stop Bits	1 or 2	Sets number of stop bits in a character. Default is 1.
Modbus Parity	None, even or odd	Sets Modbus serial parity. Default is none.
Modbus RS485 Mode	On or Off	Off or 0 keeps the transmitter continuously on for RS-232 and 4-wire RS-422/485 networks. On or 1 tristates the serial transmitter when not transmitting for 2-wire RS-422/485 networks. Default is Off.
Slave Device Address	0-255	Sets the address the 9099 will use to address the slave Modbus device. This value can also be set by the 9099's Modbus 'C' command and by a Modbus TCP/IP packet during Modbus TCP/IP operation. Default is 1.
Substitute Slave Address Enable	On or Off	When off, the slave device address in the Modbus TCP/IP packet is used to address the slave RTU device. When on, the 9099 replaces the slave device address in the Modbus TCP/IP packet with the Slave Device Address. Modbus TCP/IP examples often use a slave address of 0 which needs to be changed to the actual Slave Device address.

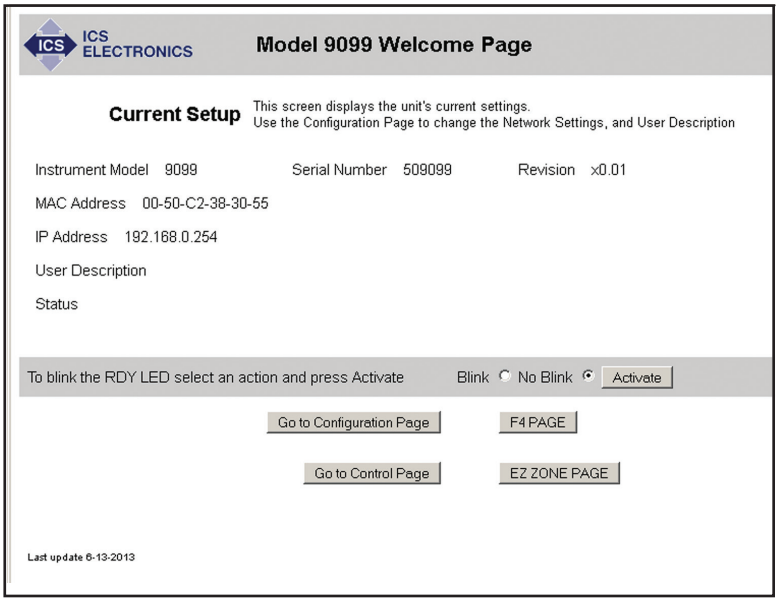


Figure 2-3 9099 Welcome Page

4. If you want to change any settings, press the 'Go To Configuration Page' button. A Configuration Page similar to the one shown in Figure 2-4 should appear in your browser.

5. Enter the new settings as desired. If you select DHCP with AutoIP Fallback for the TCP/IP Mode, the page blanks the IP, Net and Gateway addresses as they will be supplied by your DHCP server. Enter the serial settings in the lower half of the page. Only enter the Slave Device Address and enable the Substitute Slave Address if you are doing Modbus TCP/IP operation and want the 9099 to substitute a different slave device address for the one in the program you will be running. Check the entered values carefully as the unit's webserver does minimal error checking. Press the 'Update Flash' button when done. A Confirmation Page similar to the one shown in Figure 2-5 will appear in your browser.

6. The new settings have been saved in the unit's flash memory. The unit has to be rebooted or power cycled for the changes to take affect. Press the 'Reboot' button to reboot the unit now. A Rebooting Page will appear in your browser. If you changed the unit's IP address, you may have to reset your computer's network setting in order to relink with the 9009 or 9099.

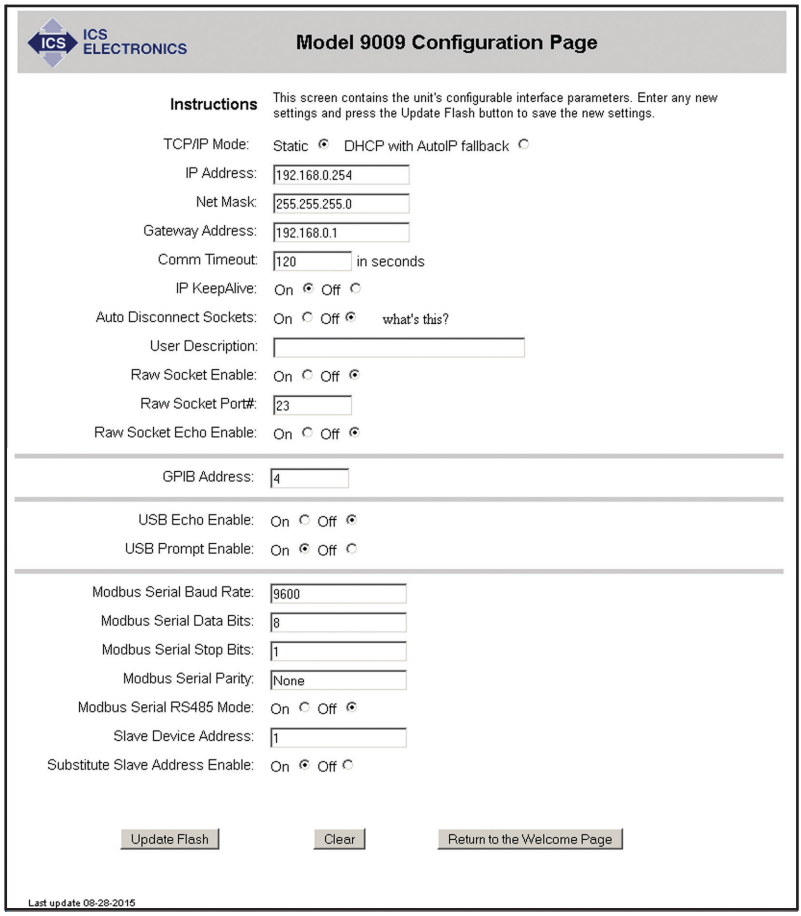


Figure 2-4 9009 Configuration Page

2.6.2 VXI-11 SCPI Configuration Method

This method uses an interactive VXI-11 utility such as ICS's VXI-11 Keyboard, Agilent's IO Connection Expert, or National Instruments' Measurement and Automation Explorer (MAX) to query and change the current settings using the SCPI commands in Table 3-3. Network setting changes can only be done with a web browser.

1. Connect the 9009 or 9099 directly to your PC or indirectly through a switch as described in step 1 above and setup the PC as described in step 2 above.

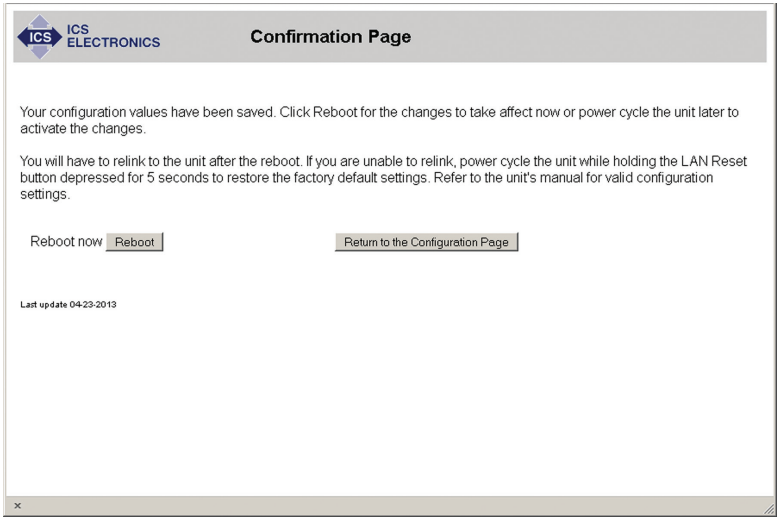


Figure 2-5 Confirmation Page

2. Find and link to the 9009 or 9099 at its IP address (192.168.0.254).

3. Link to inst0 if using ICS's VXI-11kybd program.

4. Do an *IDN? query to read the IDN message to verify communication to the 9009 or 9099.

5. Select the appropriate SCPI command from the SCPI Command Tree in Table 3-3 for the parameter you want to query or change. Put a question mark after the command to query its current setting. Send the command with a value to change the setting.

6. Repeat Step 5 for each parameter you want to query or change.

7. When done, send the unit a *SAV 0 command to save the new settings.

2.7 USING THE 9009's GPIB INTERFACE

The 9009 has a standard 24-pin GPIB connector with metric locking studs. The 9009's GPIB Interface is factory set to primary address 4. As part of the self test at power turn-on time, the 9009 blinks a binary display of its GPIB address on is diagnostic LEDs. The bit weights are:

RDY	TALK	LSTN	SRQ	ERR
16	8	4	2	1

The GPIB Interface has access to the same SCPI parameters as does the Ethernet Interface. The default GPIB and serial settings are listed in Table 1-3. Compare the serial settings against the settings on your slave Modbus device. Adjust the serial settings so both units have the same settings.

2.7.1 GPIB Configuration Method

This method uses an interactive utility such as ICS's GPIBkybd, Agilent IO Connection Expert or National Instruments' MAX to query and change the current settings using the SCPI commands in Table 3-3. GPIBkybd can be installed from the Support CD or downloaded from ICS's website.

1. Connect the 9009 to a GPIB Controller.

2. Run your utility program and find the 9009 (Default is address 4).

3. Do an *IDN? query to read the IDN message to verify communication with the 9009.

4. Select the appropriate SCPI command from the SCPI Command Tree in Table 3-3 for the parameter you want to query or change. Put a question mark after the command to query its current setting. Send the command with a value to change the setting.

5. Repeat Step 5 for each parameter you want to query or change.

6. When done, send the unit a *SAV 0 command to save the new settings.

2.8 USING THE 9009's USB INTERFACE

The 9009 has a standard USB 'B' connector. The 9009's USB Interface requires that the Microsoft Virtual COM Port Driver be installed on your Windows PC. Supported operating systems are a Windows XP (SP2), Vista, or Windows 7 or 8 operating system. Run the ICS_USB_Install program to install Microsoft's driver on your PC. Record the assigned COM port number for later use.

The USB Interface has access to the same SCPI parameters as does the Ethernet Interface. The default GPIB and serial settings are listed in Table 1-3. Compare the serial settings against the settings on your slave Modbus device. Adjust the serial settings so both units have the same settings.

2.8.1 USB Configuration Method

This method uses and interactive utility such as ICS's USBkybd program, Hyperterminal or a similar utility. USBkybd can be installed from the Support CD or downloaded from ICS's website.

1. Connect the 9009 to your PC.

2. Run the USBkybd and select the COM port noted during the driver installation. If the COM port number is lost, check the Device Manager to see the active COM port.

3. If you need a baud rate, select 115,200 baud.

4. Do an *IDN? query to read the IDN message to verify communication with the 9009.

5. Select the appropriate SCPI command from the SCPI Command Tree in Table 3-3 for the parameter you want to query or change. Put a question mark after the command to query its current setting. Send the command with a value to change the setting.

6. Repeat Step 5 for each parameter you want to query or change.

7. When done, send the unit a *SAV 0 command to save the new settings.

2.9 MODBUS SERIAL INTERFACE CONNECTIONS

2.9.1 9009 and 9099 Serial Port

The 9009 and 9099's serial port is a DTE (Data Terminal Equipment) interface on a 9-pin DE shell connector. The 9009 has a male connector, the 9099 has a female connector. The user selects RS-232 or RS-422/RS-485 signals by setting jumpers on the PC board and by using the SYST:COMM:SER:RS485 command to enable/disable tristating the Tx signal pair when not transmitting. Table 2-2 shows the signal-pin assignments and signal directions.

TABLE 2-2 SERIAL CONNECTOR PIN ASSIGNMENTS

Pin	RS-232	RS-422 RS-485	Signal	Direction In Out
1		RD(B)	Receive Data (B)+	←
2	BB (RxD)	RD(A)	Receive Data (A)-	←
3	BA (TxD)	SD(A)	Send Data (A)-	→
4		SD(B)	Send Data (B)+	→
5	AB (GND)		Ground	
6			not used	
7			not used	
8			Alarm input #1	←
9			Alarm input #2	←

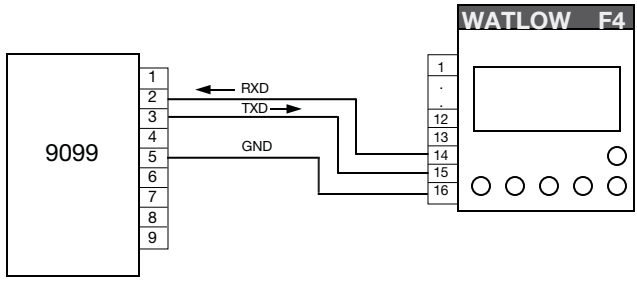
2.9.2 RS-232 Connections to a Modbus Device

The RS-232 connection uses just three lines to connect the unit to a Modbus slave device. The lines are transmit data (TxD), receive data (RxD), and Ground. Set the internal jumpers as shown in Table 2-3 for RS-232 signals.

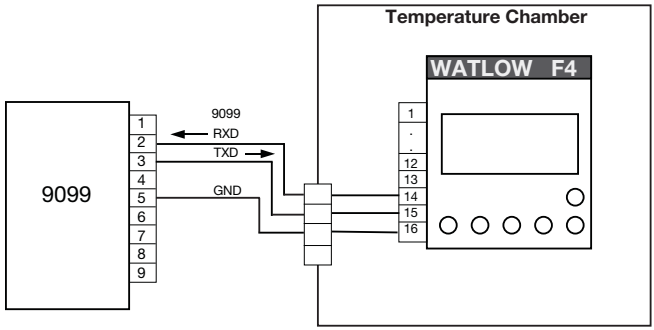
Figure 2-6a shows the RS-232 connection to a Watlow F4 Temperature Controller. Both interfaces transmit on pin 2 and receive on pin 3.

Figure 2-6b shows the same signals coming through a bulkhead connector on the temperature chamber wall. Obtain the bulkhead pins numbers from your Chamber manufacturer or use a voltmeter to determine the pin numbers before trying to connect the 9099 to the chamber with a 'standard' RS-232 cable. You may need a 'null-modem' or a specially wired cable to make the connections. Use an RS-232 Signal tracker or a DVM to find the Modbus TXD signal. The TXD signal will be -6 to -12 Vdc.

Figure 2-7 shows the RS-232 connections to a Watlow F4T Temperature Controller. The serial communications module plugs into slot 6 on the back of the F4T.



(a) Direct RS-232 Connections to a Watlow F4 Controller



(b) RS-232 Connections through a Bulkhead Connector

Figure 2-6 RS-232 Connections to a Watlow F4

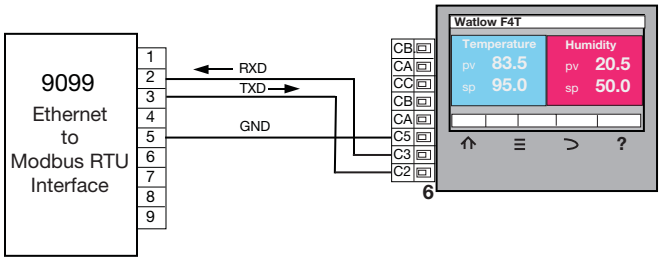


Figure 2-7 RS-232 Connections to a Watlow F4T

2.9.3 RS-485 Connections to a Modbus Device

2.9.3.1 4-Wire Connections

The 9009 and 9099's RS-422/RS-485 differential serial interface is a four-wire interface with transmit (SD) and receive (RD) signal pairs with an optional internal termination network on the receive pair. To interface the 9099 to a 4-wire Modbus device do not jumper the signal pairs together. Configure the unit for full-duplex, RS-485 operation. Use the "SYST:COMM:SER:RS485 OFF" command to configure the firmware. The OFF setting causes the unit to keep its serial transmitter on when not transmitting which keeps the receiving devices from receiving noise and eliminates the need to terminating networks at their end of the cable. The 9099's TX pair goes to each slave device's RX input. Set jumpers W4 and W8 for RS-485 and move the W13 jumper to W7 FD position as directed in Table 2-3.

2.9.3.2 2-Wire Connections

To interface the 9009 or 9099 to a 2-wire Modbus device or RS-485 network, the SD and RD signal pairs should be jumpered together internally as shown in Figure 2-8 and the unit has to be configured for half-duplex, RS-485 operation. Use the "SYST:COMM:SER:RS485 ON" command to configure the units. The ON setting tristates the serial transmitter when the 9099 is not transmitting which free's the network for the Modbus device's response. Add jumpers W9-W12 to jumper the signal pairs together and to use the internal termination network. Set jumper W7 to HD. See Table 2-3 for the complete jumper settings. Figures 2-8 through 2-10 show the two-wire RS-485 connections to various Watlow controllers.

2.9.3.3 Internal Termination Network

Two-wire RS-485 networks need a termination network to bias the lines in the 'mark' state when neither unit is transmitting. This prevents the receivers from inputting noise when nothing is being transmitted. The 9009 and 9099's have an internal termination network which is fine for cables up to 200 feet long. For longer cables, use a termination network at each end of the cable. Insert jumpers W11 and W12 to use the 9099's internal termination network.

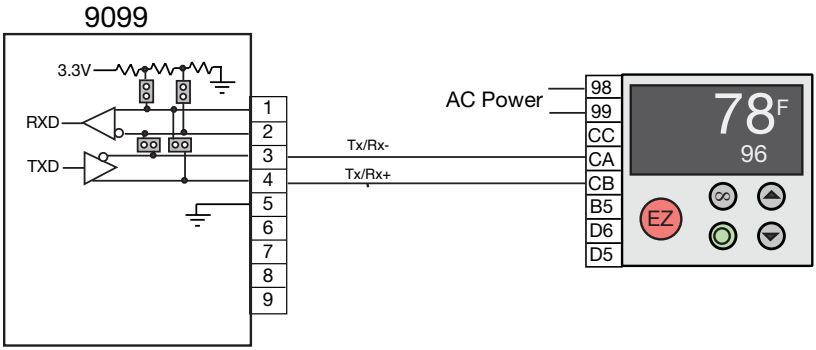


Figure 2-8 9099 RS-485 Connections to an F4 Controller

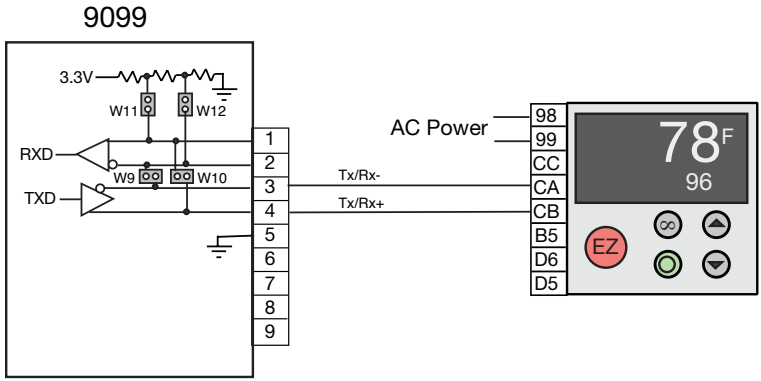


Figure 2-9 9099 RS-485 Connection to an EZ-Zone Controller

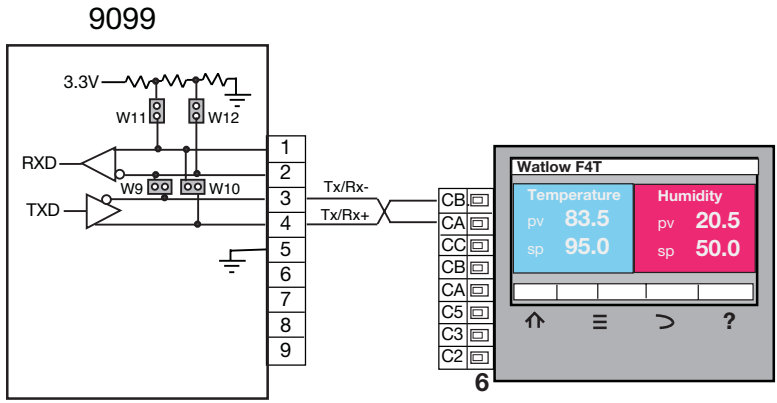


Figure 2-10 9099 RS-485 Connection to an F4T Controller

2.10 9009 CONNECTIONS

2.10.1 Power Connections

Power can be applied to the 9009 ether thorough a two screw terminal strip, P1, or through a friction lock connector, P2. Power can be regulated 5±0.2 Vdc or 5.5 to 15 Vdc at 400 mA. P2 is an AMP 640456-2 connector with male pins.

2.10.2 LED Connections

The 9009 has a 10-pin header, J4, for remoting its Diagnostic LEDs. The header has regulated 3.3 Vdc power, low true LED drive signals and ground. J4 is an AMP 1-640456-0 connector with male pins.

Table 2-3 lists the J4 signals. Connect the cathode of the remote LEDs to the LED drive signals and a resistor from the LED anode to +3.3 Vdc power. Select a resistor to limit the LED current to 10 mA. Refer to paragraph 1.11 for LED descriptions.

TABLE 2-3 9009 LED DRIVE SIGNALS

Pin	Signal	Comments
1	3.3 Vdc Power	Limit current to 100 mA
2	RDY LED	
3	LAN LED	
4	ACT LED	
5	TALK LED	
6	LSTN LED	
7	SRQ LED	
8	ERROR LED	
9	no pin	Key position
10	Ground	Signal ground

2.11 JUMPER SETTINGS

The 9009 and 9099 have the same jumper designations and positions as shown in Table 2-3 and in Figures 2-11 and 2-12. The factory setting is for RS-232 operation. The SYST:COMM:SER:RS485 command is factory set to OFF (0).

For 2-wire, RS-485 operation, set the jumpers as shown in the RS-485 column and set SYST:COMM:SER:RS485 to 1 or ON. For 4-wire RS-485 signals, use the RS-485 jumper settings but set W7 to FD, open W9 and W10 and set SYST:COMM:SER:RS485 to 0 or OFF.

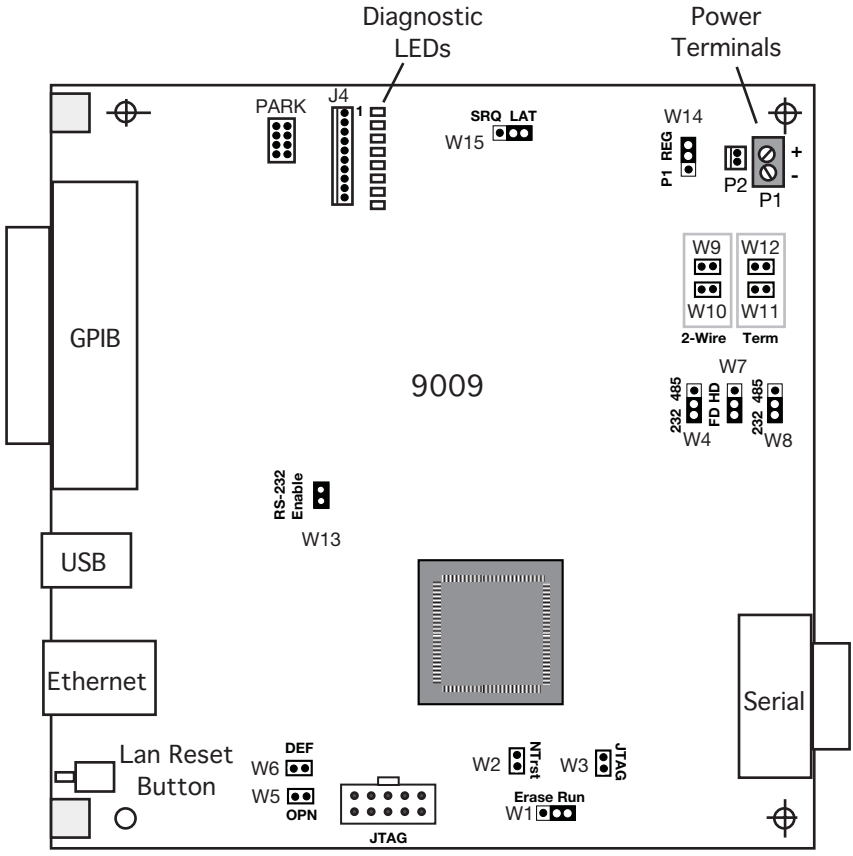


Figure 2-11 9009 Jumper Locations

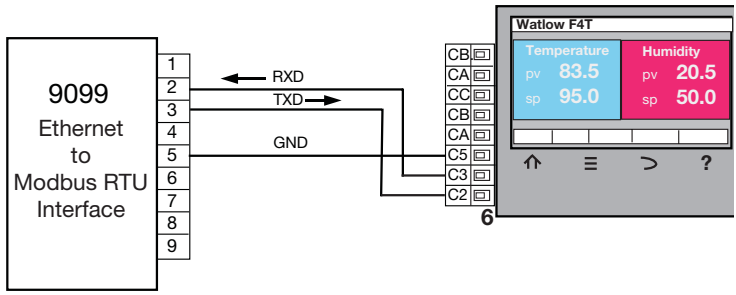


Figure 2-12 9099 Jumper Locations

TABLE 2-3 JUMPER SETTING TABLE

Jumper	Function	RS-232 Setting	RS-485 Setting
W1	Factory use only. Leave in Run position	Run	Run
W2	Factory use only. Leave open	Open	Open
W3	Factory use only. Leave open	Open	Open
W4 W8	Selects RS-232 or RS-485 signals. Selects RS-232 or RS-485 signals.	232 232	485 485
W5	Option Jumper. Not used in standard firmware.	Open	Open
W6	Restores digital IO default settings.	Open	Open
W7	Selects Full duplex (4-wire) or half-duplex (2-wire) operation. Set to FD for 4-wire RS-422 operation.	Open	HD
W9 W10	Connects transmit-receive pairs together for 2-wire operation. Leave open for 4-wire RS-422 operation.	Open Open	Install Install
W11 W12	Connects internal termination network to receive signal pair.	Open Open	Install Install
W13	RS-232 Enable. Open for RS-422 or RS-485 signals	Install	Open
W14	9009 Only - Selects DC power source. Use REG for 5.5 to 15 Vdc power, P1 for 5 Vdc power.	REG	REG
W15	9009 Only - Selects SRQ LED drive signal. Use SRQ for GPIB Bus signal, LAT for 9009 generated signal.	LAT	LAT

Spare jumpers are provided in the jumper Park.

2.12 9099 RACK MOUNTING INSTRUCTIONS

The Model 9099 is held in its rack mounting kit with a winged-'U' shaped bracket. Perform the following steps to install a 9099 in a rack mounting kit:

1. Hold the 9099 at a 30 degree nose down angle and place the front bezel through the rack mount kit from the rear of the kit. Push it forward through the opening until the rubber feet line up with the holes in the rack mounting kit. Push the unit down until it rests flat on the kit and the feet are in the four holes.

2. Repeat step 1 for a second unit if two units are being held in one rack mounting kit.

3. Align the unit(s) so the bezels are parallel with the front of the rack mount kit and protrude equally through the front panel of the rack mounting kit.

4. Set the bracket so its two holes line up with the holes in the rack mounting kit extrusion. Use the supplied 4-40 screws to hold the bracket to the extrusion. Do not overtighten.

5. Use the supplied 10-32 screws to bolt the rack mounting kit into the rack.

3

Programming Instructions

3.1 INTRODUCTION

This section describes the operation of the 9009 and 9099 Ethernet to Modbus Interfaces and how they control slave Modbus devices. The Model 9009 has additional GPIB and USB interfaces. Any description of the 9099's operation applies also to the 9009.

3.2 OPERATION

3.2.1 Overview

The 9009 or the 9099 and the slave Modbus RTU devices connected to it can be controlled by VXI-11 commands via rpc calls, by Modbus TCP/IP commands, by a raw socket connection or by a web browser using the HTML pages. The 9009 board has two additional interfaces: GPIB and USB. All interfaces and control methods have a common Status Reporting Structure and share a common parser with the same commands and settings. Only one method should be used to control the 9099 and its slave Modbus device(s) during a test to prevent the obvious conflicts.

3.2.2 General Concept

The 9099 is an VXI-11.3, IEEE-488.2 compatible device and responds to three types of commands: IEEE-488.2 Common Commands, SCPI Commands and a set of Modbus Commands to communicate with Modbus device(s). The IEEE-488.2 and SCPI commands are used to setup and configure the 9099's IEEE-488.2 Status Reporting Structure and its Serial parameters. Any command that ends in a '?' is a query and the 9099 responds by outputting the response to the client the next time it receives a device read message. (Similar to a GPIB Talk address). All messages are terminated with linefeeds.

Modbus devices are register based devices and they are controlled by writing values to registers that control different functions i.e. temperature setpoint, alarm settings, etc. Data is taken from Modbus devices by reading registers associated with those parameters i.e. temperature, humidity, etc. The 9099 can handle integer and floating point values. ICS has a set of Modbus commands for writing data to and reading data from Modbus devices which are listed in Table 3-5. When one of these Modbus commands is sent to the 9099, the 9099 sends the appropriate Modbus RTU packet to the selected Modbus device. Modbus commands should not be mixed or concatenated with IEEE-488.2 or SCPI commands.

If the 9099's message packet is successfully received by the Modbus device, the Modbus device will generate a response packet that either confirms receipt of the message or that contains the requested data. The 9099 receives the response packet and validates the packet. If the response packet is a valid response to a read command, the returned data is held and will be transmitted to the client the next time the 9099 is sent a device_read request If the message is an acknowledgment message, there is no further action.

The 9099 expects to receive a response from the Modbus device within a preset time period or it declares a timeout error. The timeout period is programmable and is factory set to 300 milliseconds.

If the message was not a valid message, or was an exception message, or was missing, then the 9099 sets the appropriate bit(s) in the Questionable Condition Register, puts a decimal value in the Modbus Error register and sets bit 6 in the ESR Register. Both registers are part of the 9099's Status Reporting Structure shown in Figure 1. If the appropriate register enable bits are set true, then the Service Request bit will be set and generate a *device_intr_srq* message (SRQs). If a Reverse Interrupt Channel exists, the *device_intr_srq* messages are sent to the Application over the Reverse Interrupt channel. The user can then query the Status Byte to determine the cause of the Service Request. Refer to Application Bulletin AB80-4 for information on setting up a VXI-11 Reverse Channel.

3.2.3 Operation with the VXI-11 Protocol

The VXI-11 protocol is a higher level Ethernet protocol that provides a pseudo GPIB interface. In addition it offers certain capabilities that allow simultaneous access by multiple clients at the same time without the clients interfering with each other (via LOCK and UNLOCK). Also note that the VXI-11 protocol being an RPC service means it supplies high level error handling and error

recovery. And note that since it is an RPC service, it is easily used on a Apple OS, Linux and Unix since RPC service/client support can be made an integral part of the OS.

The 9099 provides a VXI-11 service as the server in the client-server relationship. The core channel link to interface *inst0* in the 9099 is used for all commands and responses including 488.2, SCPI and Modbus commands. The 9099 does not have any additional interface personalities.

The 9099's VISA Resource String is:

TCPIP::*ip*::inst0::INSTR 'for commands and data transfer
where *ip* is the 9099's ip address

VXI-11 applications should open a session to the 9099, send and receive data and then close the session when exiting the program. PC application can make calls to a VXI-11 compliant VISA library such as those from Keysight (Agilent), National Instruments or Kikisui. Linux and Unix users can create VXI-11 library files for their machines as described in Application Bulletin AB80-3. Apple OS users can create VXI-11 library files for their MACs as described in AB80-12.

3.2.4 Operation with Raw Sockets

Raw socket operation is similar to the operation with serial communication. Use port 23 when making the raw socket connection. All of the 9099's SCPI and Modbus commands are available to the raw socket user and the handling of the Modbus slave device is the same as described in paragraph 3.2.2. Raw socket has access to the its Status Reporting Structure but does not have a way to handle Service Requests. The user has to query the Status and ESR Registers to check for service requests and errors.

Raw Sockets (telnet) offers little in the way of support that VXI-11 provides. For example error detection and error handling is non-existent other than what is provided by the base TCP protocol. Also important to note is that Raw Sockets do nothing in regards to potential conflict between multiple clients connecting.

The 9099's Raw Socket service is intended as a “connect to the device, perform an activity or series of activities, then disconnect” type service. It is not intended as a connect for a long period with periods of inactivity.

The Raw Socket service has limited resources and therefore has a fixed 120 second inactivity timeout. This means that if the client fails to send anything for a period of 120 seconds, the service will automatically close the socket which prevents further communication. This timeout can be reset by the sending of any data, for example sending of a CR (0x0D) will reset the timer with the CR being discarded by the service.

If you are connecting to the service and having periods of inactivity (such as editing of scripts or ending individual characters with long pauses) between actions, then this will result in loss of connectivity. The better way is to have the script perform a socket connection, perform the required actions and then disconnect the socket connection.

Raw Sockets default to No Echo, but Echo can be turned on by sending a ^E (0x05) or enabling Echo on the HTML Configuration Page with a browser.. This will result in each character being returned to the client as it is received. Default behavior is to not echo received data which means you will not see what you are typing when you manually telnet to the device. Other control characters are defined in the Raw Socket documentation.

Important to note is that the Raw Socket data must be terminated by a LF (0x0A). Sending data terminated by a CR will not be acted upon since a CR is simply discarded by the 9099's Raw Socket service. Therefore when using telnet you must type the command and then terminate it with a LF (use a CTRL-J) for the service to execute the typed command. Raw Socket clients like Hyperterminal must be configured to send a new line (linefeed) when pressing the Enter key.

Using scripting with Raw Sockets is not recommended. While scripting does send messages to the 9099, it often closes the socket immediately after sending the message which blocks any replies and part of an echoed message (if echo is enabled).

While using Raw Sockets (telnet) seems very simple, it must be understood that the ICS devices have very firm rules on usage. Most of these rules are as a result of the small amount of resources available for any embedded device. Limitations such as a maximum of 4 connections at a time, the 120 second inactivity timer and other such rules are in an attempt to maximize the functionality of the device while dealing with the limited resources of the embedded device. Please study the documentation regarding Raw Sockets before actually designing your application or using the device.

3.2.5 Operation with Modbus TCP/IP Protocol

The 9099 appears as a Modbus TCP/IP server (slave) to the Modbus TCP/IP client (master) and provides a transparent Modbus TCP/IP to Modbus RTU conversion. The 9099 will recognize the Modbus TCP / IP packet and extract parts of its Application Data Unit (ADU) and add a CRC to create the Modbus RTU packet The packet is then transmitted serially to the Modbus device. If the Modbus device returned a response, the information in the response packet is passed back to the Modbus TCP/IP master. The 9099 does not restrict the Modbus TCP/IP functions but they are limited by the capabilities of the slave Modbus RTU device(s) connected to the 9099. The maximum message size is limited to 255 bytes.

The Modbus TCP/IP operation starts by opening a socket to port 502 on the 9099. The controller has approximately 10 seconds to start communicating with the 9099. When the 9099 receives a Modbus TCP/IP packet its length parameter is checked. If a packet is not received within 10 seconds or if the message length is exceeded, the 9099 closes the socket.

In some cases, Modbus TCP/IP programs have been written for a slave address that the slave device cannot be set to. If Substitute Slave Address on the 9099's Configuration page is enabled, the slave address in the TCP/IP packet is replaced with the 9099's current slave device address when creating the RTU packet. The 9099's slave device address can be set with a web browser or with the Modbus “C " command.

Received Modbus RTU responses are checked for length and for a valid CRC. If the received response is a valid RTU response, a Modbus TCP response packet is created and the device address is restored if it had been changed. The packet is then transmitted to the Modbus TCP/IP master. Missing or invalid responses from the slave device will cause the 9099 to close the socket and set the appropriate bits in the Modbus and ESR registers.

Packets from multiple Modbus TCP/IP masters (clients) are queued and held until the current operation is completed. If a controller closes its socket while its packet is in the queue, it will not be processed. If the socket is closed while the packet is being processed, any slave response will be discarded.

The Modbus TCP/IP control method has its own Status Reporting Structure that can be controlled and queried with the SCPI Modbus Status commands from any other control method. Modbus TCP/IP does not have a way to handle Service Requests so the user has to query the Status and ESR Registers to check for errors.

3.2.6 Operation with a Web Browser

The 9099 includes a webserver that provides example webpages for the Watlow F4 and EZ-Zone Temperature Controllers and a general purpose Control page. The F4 and EZ-Zone were used for the example pages as they are widely used in environmental test chambers and in industrial processes.

CAUTION - Not all of the example page controls and functions may be implemented in your chamber or process. Check with your manufacturer to see which ones are applicable to your chamber or process.

The F4 or Ez-Zone page is reached by clicking on the appropriate button on the Welcome (index) page. Refreshing the F4 or Ez-Zone page will fetch new readings from the Temperature controller. Checking a box or entering a value and 'updating' the page will send the value to the Temperature Controller.

The general Control page is also accessed by clicking a button on the Welcome page. The Control page provides current ESR and Modbus Error Register contents so the user can immediately tell if his commands caused an error. Any of the 9099 commands can be entered in the Device Command textbox and executed by clicking the Send button. Responses are automatically displayed in the Device Command window.

The 9099 uses its current Modbus device address value when accessing the Modbus slave device. The Modbus device address can be set with a web browser on the 9099 Configuration page or with the Modbus “C" command.

The webserver has access to its Status reporting Structure but does not have a way to handle Service Requests so the user has to query the Status and ESR Registers to check for errors if the red ERR LED is illuminated.

3.2.7 Operation from the GPIB Bus (9009 Only)

The 9009's GPIB interface is fully IEEE-488.2 compatible and responds to all of the IEEE-488.2 Common Commands. The GPIB Interface has access to all of the 9009's SCPI and Modbus commands and to the its Status Reporting Structure. Service Requests can be used to report 9009 and Modbus errors by asserting the SRQ line on the GPIB bus. The handling of the Modbus slave device is the same as described in paragraph 3.2.2.

3.2.8 Operation from the USB Bus (9009 Only)

The 9009's USB interface is fully IEEE-488.2 compatible and responds to all of the IEEE-488.2 Common Commands. The USB Interface has access to all of the 9009's SCPI and Modbus commands and to the its Status Reporting Structure. Service Requests are not sent over the USB bus so the user has to query the Status and ESR Registers to check for errors. The handling of the Modbus slave device is the same as described in paragraph 3.2.2.

3.2.9 Modbus Serial Communication

The 9099's communication path to the Modbus RTU slave device is serial and requires that the user set the 9099 and the Modbus slave device to the same serial settings. Each Modbus device has its own address so that it can identify and respond to serial packets sent to its address. Although the typical Temperature Chamber or Process has only one Modbus Controller, the 9099 can drive multiple Modbus devices on an RS-485 network.

The 9099 uses a combination of internal jumpers and an RS-485 Enable setting to enable RS-232, RS-485 four-wire or RS-485 two-wire communication. The 9099 has an internal RS-485 termination network that can be switched onto the RX signal pair to maintain the RS-485 lines in the mark state when they are not being driven.

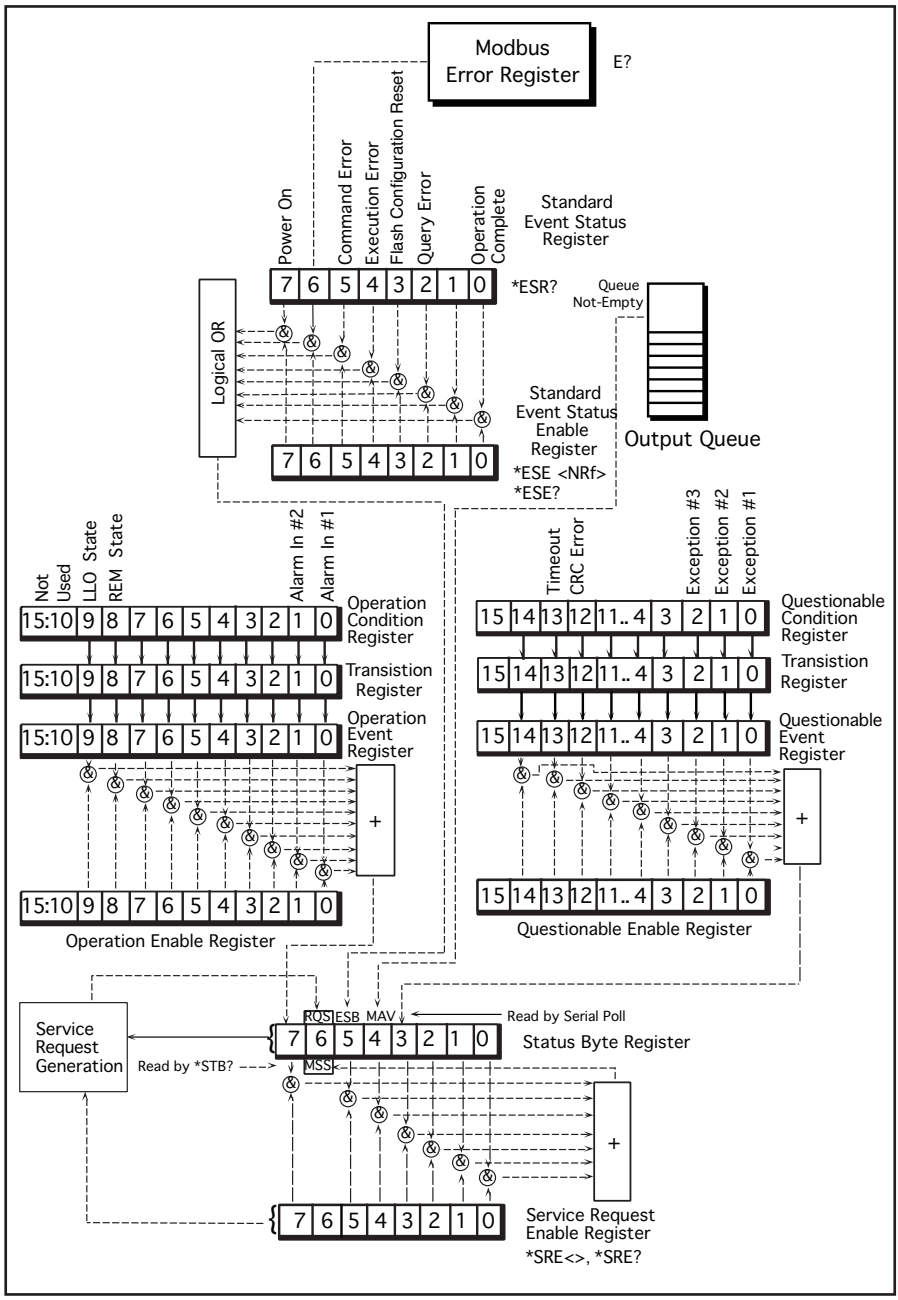


Figure 3-1 Status Reporting Structure

3.3 488.2 STATUS REPORTING STRUCTURE

The 9099 has multiple copies of the expanded IEEE-488.2 status reporting structure shown in Figure 3-1. The expanded status reporting structure conforms to the SCPI 1994.0 Specification and builds on the IEEE 488.2 Standard Status Reporting Structure by adding the Questionable and Operation registers. The Event and Status registers are controlled and queried with the IEEE-488.2 common commands. The Status Byte Register may also be read by serial polling the card. The Questionable and Operation registers are controlled and queried with SCPI commands. The Modbus Error register is read and cleared with the Modbus E? query. The register readings are the sum of the binary weights of the bits whose value is a '1'.

Instead of asserting the GPIB SRQ line, VXI-11.3 Instruments generate a Service Request message, *device_intr_SRQ*, when the RQS bit in the Status Byte Register becomes true. Service Requests (SRQs) are sent through the Interrupt Channel (if one has been setup) to alert the client that an event has occurred and/or that the device needs service. Service Request generation is a multilevel function and is determined by the occurrence of an event that has its corresponding enable bit set to '1'. The outputs from the event registers are summarized in separate bits in the Status Byte Register. The Event registers and the Output Queue are cleared when read or by the ***CLS** command.

Service Requests are not automatically sent to the user when using raw socket or the USB bus.

3.3.1 Event Registers

An event register **captures 0 to 1 transitions** in its associated condition register or in the standard event register. An event bit becomes TRUE (1) when the associated condition bit makes a **logical 0 to 1 transition**. Once an event bit is set it **is held** until the event register is read or cleared with the ***CLS** command.

Each event register contains eight or sixteen bits. When the register is read, its response is a decimal number that is the sum of the binary bit weights of the bits that are logical 1s.

e.g. 23 decimal = 0001 0111 or 0000 0000 0001 0111 binary

Each event register bit has a corresponding enable bit. The enabling bits are ANDed with the state of the event bits to create the summary condition in the

Status Byte Register. Unwanted conditions can be blocked from generating SRQs by setting their corresponding enabling bit to a '0'. The enabling bits are set by writing the value equal to the sum of all of the desired logic 1 bits to the enabling register. The value is normally decimal but can be expressed in HEX, OCTAL or BINARY by prefixing the number with a #H, #O or #B.

3.3.2 Event Status Register

The Event Status Register reports events that are common to all 488.2 devices. This includes events such as selftest errors, command errors, execution errors, power on and operation complete. The Power-on event occurs at power turn-on and can be used to signal a power off-on occurrence. The Modbus Error is included in the Event Status Register. Bit 6 is set when the Modbus Error Register is loaded with an error value. The 488.2 Operation Complete event has no meaning for the 9099.

TABLE 3-1 ESR BIT DEFINITIONS

Bit	Weight	Event	Description
7	128	PON	The Power-on event occurs at power turn-on and can be used to signal a power off-on occurrence.
6	64	Modbus Error	Modbus Error detected. Reading the Modbus Error Register clears this Error bit.
5	32	Cmd	Command Error, invalid command or value out of range.
4.	16	Exec	Execution Error, command could not be executed.
3	8	Flash	Flash configuration data corrupted. Do a CAL:DEFAULT, check and reload the configuration settings and do a CAL:DATE <date> command to clear bit 3. User and network settings lost and may need reloading. If ICS Serial Number or MAC address is lost, contact ICS Support.
2	4	Query	Query error, data not read or read attempt with no data present to be read.
1	2	-	not used
0	1	OPC	Operation Complete has no meaning in the 9099.

The Event Status Register is read and cleared with the ***ESR?** query and cleared with the ***CLS** command. Use the ***ESE** commands to set the Event Status Enable Register as shown in the following example:

```
*ESE 60          'enables error bits 2 through 5 for errors
*ESE 124         'enables error bits 2 through 6 for errors
*ESE?            'queries the enabling register setting
```

3.3.3 Modbus Error Register

The Modbus Error Register reports a decimal value of the last error detected with the Modbus message transmission or reported back from the Modbus slave device. A non-zero value sets bit 6 in the ESR Register. The Modbus Error Register and bit 6 in the ESR Register are cleared when read by the Modbus E? command. The *CLS and *RST commands have no affect on this register. Refer to Table 3-5 for the Modbus Error Register values. The following commands will generate a Service Request when a Modbus error occurs:

```
*ESE 64          'enables ESR bits 6
*SRE 32          'enables Status Byte bit 5

*ESR?            'reads ESR Register bits
 E?              'reads Modbus Error Register
```


3.3.4 Questionable Registers and Digital Inputs

The Questionable Registers lets the user read bits that report Modbus CRC errors, Exception message types or a timeout (no response message received). Bit assignments are shown in Figure 3-1. The Questionable Transition Register filters the inputs and passes only the enabled state changes to the Questionable Event Register. The Questionable Event Register bits becomes true (1) when the positive transition bit is enabled and the associated condition register bit makes a 0 to 1 transition. When both transitions are selected for the same bit, the corresponding Questionable Event Register bit sets whenever the digital input changes state. The Questionable Event Register is cleared when it is read or by the *CLS command. The Questionable Registers are queried with the SCPI STATUS branch commands.

The 9099 can be set to monitor the bits in the Questionable Register and generate a Service Request (SRQ) when they change state. The following example sets the Questionable Event register to monitor the CRC and Timeout bits by capturing a positive transition on bits 12 and 13. The decimal value for bit 12 is 4096 and the decimal value for bit 13 is 8192.

```
STAT:QUES:PTR 12298      'enables bits 12 and 13 to set
                         on a positive transition
```

Because summing large decimal values is confusing, it is better to use HEX values that are easier to write. i.e.

```
STAT:QUES:PTR #h3000     'same as 12298 decimal
```

The Questionable Enable Register enables set Event bits to be included in the summary output to the Status Byte Register. The following example enables bits 12 and 13:

```
STAT:QUES:ENAB #h3000      'enables Event bits 12 and 13
```

Note that the Questionable Event Register has to be cleared after an Service Request is generated either by reading the register or with the *CLS command. If the register is not cleared, the event bits will remain set and they will not generate another Service Request when the input again goes true.

```
STAT:QUES:COND?            'reads the questionable inputs
```

3.3.5 Operation Registers

The 488.2 Operation Registers lets the user read the Alarm inputs and local/remote status. The Operation Registers are similar to the Questionable Registers described in paragraph 3.3.4. The following commands demonstrate some possibilities of the Operation Registers:

```
STAT:OPER:COND?    'quires the Operation Condition Register
```

The 9099 can be set to monitor the Alarm inputs in the Operation Register and generate a Service Request (SRQ) when they change state. The following example sets the Operational Event register to monitor Alarm input #1 by capturing a negative transition on bit 1.

```
STAT:OPER:NTR 1      'enables bit 1 to set on a negative
                      transition
```

The Operation Enable Register enables set Event bits to be included in the summary output to the Status Byte Register. The following example enables bit 1:

```
STAT:OPER:ENAB 1     'enables Event bit 1
```

3.3.6 Output Queue

The Output Queue is used to output all responses back to the client(s). The Output Queue reports a '1' in bit 4 of the Status Byte Register when it contains message(s) to be read. Reading the contents of the Output Queue clears its summary bit. The Output Queue is used by the 9099 for a device_read message or by the webserver for the F4 and EZ Zone html pages. If the Output Queue is busy, the F4 and EZ Zone html pages will generate an error.

The recommendation is to follow each query by reading the result. Testing the 9099's Output Queue's summary bit before addressing the device to talk is not necessary or desirable.

3.3.7 Status Byte Register

The 9099 generates a Service Request (SRQ) whenever any of the enabled bits in the Status Byte Register become true. The Status Byte Register may be read with the device_readstb function or with the *STB? query. The device_readstb function resets the RQS bit; the *STB? query does not change the bit. The Status Byte Register is enabled by setting the corresponding bits in the Service Request Enable Register with the *SRE command. e.g.

```
*SRE 160        'Sets the SRE Register to 1010 0000 which
                 enables just the Event Status and Questionable
                 summary bits to generate SRQs.
```


3.3.8 Saving the Enable and Transition Register Values

When the PSC flag is set, the SRE, ESE and SCPI Enable and Transition Registers are cleared at power turn-on. When the PSC flag is cleared, the SRE, ESE, and SCPI Conditional and Operational Enable and Transition Register values are restored at power turn-on time to their values prior to the power turn-off. The PSC flag is defaulted to on. Use the ***PSC 0** command to disable the PSC flag and restore the current register values at power turn-on as shown in the example. e.g.

```
STAT:OPER:ENAB 1          'enables Status A bit
STAT:OPER:NTR 1           'enables negative transition
*PSC 0; ESE 96; SRE 32    'saves the PSC flag as off plus
                           the ESE and SRE values
                           and the Operational Enable and
                           Transition register values.
```

CAUTION: When the PSC flag is cleared, any change made to the SRE, ESE or SCPI Enable and Transition Registers are saved in nonvolatile memory. Excessive use of this save function can wear out the flash memory and shorten the unit's life.

3.3.9 488.2 Differences from 488.1 Devices

The IEEE 488.1 Device Clear command **does not** reset any device outputs as would be expected of a 488.1 device. To reset the device outputs, use the ***RST** (Reset) or ***RCL 0** command.

3.4 488.2 CONFORMANCE INFORMATION

The IEEE 488.2 Standard mandated a list of common commands that are common to all IEEE 488.2 compatible devices. The 9099 responds to these commands and to some optional common commands defined in the IEEE-488.2 Standard. Table 3-2 lists how the 9099 responds to these commands and describes their effect on the 9099 and its status reporting structures.

TABLE 3-2 IEEE-488.2 COMMON COMMANDS

COMMAND	NAME	DESCRIPTION
*** CLS**	Clear Status	Clears all event registers summarized in the status byte, except for "Message Available," which is cleared only if *CLS is the first message in the command line.
***ESE <value>**	Event Status Enable	Sets "Event Status Enable Register" to <value>. <value> is an integer between 0 and 255, whose binary equivalent corresponds to the state (1 or 0) of bits in the register. If <value> is not between 0 and 255, an Execution Error is generated. EXAMPLE: decimal 16 converts to binary 00010000 which sets bit 4 to a logical 1.
***ESE?**	Event Status Enable Query	9099 returns the <value> of the "Event Status Enable Register" set by the *ESE command. <value> is an integer whose binary equivalent corresponds to the state (1 or 0) of bits in the register.
***ESR?**	Event Status Register Query	9099 returns the <value> of the "Event Status Register" and then clears it. <value> is an integer whose binary equivalent corresponds to the state (1 or 0) of bits in the register.

TABLE 3-2 IEEE-488.2 COMMON COMMANDS (CONTINUED)

COMMAND	NAME	DESCRIPTION
***IDN?**	Identification Query	9099 returns its identification message as four fields separated by commas. These fields are: manufacturer, model, serial number and hardware-firmware version and date e.g. **ICS Electronics, 9099, S/N 1406021, Rev. 00.00 ver 13.05.17.** The IEEE-488.2 specification requires four fields, a max length of 72 characters and the word 'model' may not appear in the IDN message. 'S/N' may appear in the serial number field.
***OPC**	Operation Complete Command	Causes the 9099 to generate the operation complete message in the Standard Event Status Register when all pending selected 9099 operations have been finished.
***OPC?**	Operation Complete Query	Reads bit 0 in the Event Status Register when all pending selected 9099 operations have been finished.
***PSC<value>**	Power-On Status Clear	Controls the automatic power-on clearing of the ESE, SRE and SCPI Enable and Transition registers. *PSC 0 command clears the PSC flag, saves the ESE, SRE and the SCPI Transition and Enable register values and allows the 9099 to restore the saved register values and assert SRQ upon power turn-on. *PSC 1 command sets the PSC flag to 1 and enables the power-on clear of the saved registers. When the PSC flag is cleared, any change to the ESE, SRE and the SCPI Transition and Enable register values is saved in nonvolatile memory.
***PSC?**	Power-On Status Clear Query	Queries the PSC flag value. A value of 0 indicates the registers will retain their saved values. A value of 1 indicates the registers will be cleared at power turn-on.
***RCL <value>**	Recall	Restores the 9099 configuration from a copy stored in its Flash by the last *SAV or Configure Update command. *RCL 0 recalls the

TABLE 3-2 IEEE-488.2 COMMON COMMANDS (CONT'D)

COMMAND	NAME	DESCRIPTION
***RCL <value> continued**		saved configuration, updates all output levels and re-initializes the UART. It does not change the network interface. Allow the 9099 300 ms to complete the *RCL command.
***RST**	Reset	Restores the 9099 to its power-up state except that the state of the network interface, enable and event registers are unchanged, disables the trigger function and pulses the Reset output signal. Allow the 9099 300 ms to complete the *RST command.
***SAV <value>**	Save	Saves current 9099 configuration in the Flash. *SAV 0 saves the current setting as the new power on setting. <value>=0
***SRE <value>**	Service Request Enable	Sets the "Service Request Enable Register" to <value>. The value of bit six is ignored because it is not used by the Service Request Enable Register. <value> is an integer between 0 and 255, whose binary equivalent corresponds to the state (1 or 0) of bits in the register. If <value> is not between 0 and 255, an Execution Error is generated.
***SRE?**	Service Request Enable Query	9099 returns the <value> of the "Service Request Enable Register" (with bit six set to zero). <value> is an integer whose binary equivalent corresponds to the state (1 or 0) of bits in the register.
***STB?**	Read Status Byte	9099 returns the <value> of the "Status Byte" with bit six as the "Master Summary" bit. <value> is an integer whose binary equivalent corresponds to the state (1 or 0) of bits in the register.
***TRG**	Device Trigger	No operation in the 9099.
***TST?**	Self-Test Query	Queries the results of the last self test. A zero response indicates no failures. Other responses are not returned as the unit will be running in a blink LED loop and will be unable to respond to the query.
***WAI**	Wait-to-continue	No operation in the 9099.

3.5 SCPI CONFORMANCE INFORMATION

The 9099 accepts SCPI commands and command extensions to configure its Serial interface and to set the data formats. The SCPI commands conform to SCPI Standard 1994.0 and provide an industry standard, self-documenting form of code that makes it easy for the programmer to maintain the application program.

Table 3-3 shows the 9099's SCPI command tree. The command tree uses portions of the SCPI SYSTEM, STATUS, FORMAT, INITIATE, ABORT and CALIBRATE subsystems. The 9099 follows SCPI's hierarchal 'tree like' structure which starts with a root keyword and branches out to the final action keyword. Each command can be used as a query except where noted. The SCPI commands are **not** case sensitive. The portion of the command shown in capitals denotes the abbreviated form of the keyword. Either the abbreviated or whole keyword may be used when entering a complete command. Bracketed keywords are optional and may be omitted.

STATus:QUEStionable?	is the same as
STAT:QUES:EVEN?	or also as
stat:ques?	

There must be a space between the SCPI command and the parameter or channel list. Ending a SCPI command with a question mark '?' makes it a query and allows you to read back the command setting or current value. All queries should be followed by reading their response to avoid data loss.

SYST:COMM:SER:BAUD 9600	SCPI command
SYST:COMM:SER:BAUD?	query form of the command

Table 3-4 lists the SCPI keywords and describes their functions in detail. Keywords other than those listed in the table or locked keywords will have no effect on the 9099's operation and a command error will be reported. Refer to Appendix A-1 for additional information about SCPI commands.

TABLE 3-2 SCPI COMMAND TREE

Keyword	Parameter Form	Notes & Short Form Commands
SYSTem	System	
:COMMunicate		
:SERial		
:BAUD	<numeric value> [9600]	
:PARity	EVEN | ODD | [NONE]	
:BITS	7 | [8]	
:SBITs	[1] | 2	
:UPdate	no value-command only	
:RS485	1(On) | 0(Off) [0]	
:RAW		
:PORT	0 to 65535	
:ECHO	1(On) | 0(Off) [0]	
:GPIB		9009 Only
:ADDRess	0 to 30 [4]	
:USB		9009 Only
:ECHO	1(On) | 0(Off) [0]	
:PROMpt	1(On) | 0(Off) [1]	
:ERRor?	(0, "No error")	
:VERSion?	(1994.0)	
STATus		
:OPERation		Alarm Inputs,
[:EVENt]?	bits 0 and 1, 8 and 9 active (0)	
CONDition?	bits 0 and 1, 8 and 9 active (0)	
:ENABle	bits 0 and 1, 8 and 9 active (0)	
:ENABLE?		
:PTRansition	0-#h7FFF [All 1s]	
:PTRansition?		
:NTRansition	0-#h7FFF [0]	
:NTRansition?		
:QUEStionable		Modbus Error Bits
[:EVENt]?	bits 0-2, 12, 13 active (0)	
:CONDition?	bits 0-2, 12, 13 active (0)	
:ENABle	bits 0-2, 12, 13 active (0)	
:ENABLE?		
: PTRansition	0-#h7FFF [All 1s]	
:PTRansition?		
:NTRansition	0-#h7FFF [0]	
:NTRansition?		
:PRESet		

TABLE 3-2 SCPI COMMAND TREE (CONT'D)

Keyword	Parameter Form	Notes & Short Form Commands
:MODbus		**Modus TCP/IP**
:ESE		
:ESR?		
:SRE		
:STB?		
:OPERation		Alarm Inputs,
[:EVENt]?	bits 0 and 1, 8 and 9 active (0)	
:CONDition?	bits 0 and 1, 8 and 9 active (0)	
:ENABle	bits 0 and 1, 8 and 9 active (0)	
:ENABLE?		
:PTRansition	0-#h7FFF [All 1s]	
:PTRansition?		
:NTRansition	0-#h7FFF [0]	
:NTRansition?		
:QUEStionable	Modbus Error Bits	
[:EVENt]?	bits 0-2, 12, 13 active (0)	
:CONDition?	bits 0-2, 12, 13 active (0)	
:ENABle	bits 0-2, 12, 13 active (0)	
:ENABLE?		
:PTRansition	0-#h7FFF [All 1s]	
:PTRansition?		
:NTRansition	0-#h7FFF [0]	
:NTRansition?		
:PRESet		
FORMat	**Format Strings**	
[:DATA]		
:TALK	ASCii | HEXL	
	[ASCII]	FT
CALibrate	**Calibrate**	
:IDN	string	
:DATe	mm/dd/yy	
:DEFault		
:LOCK	1(On) | 0(Off) [0]	

Notes:

1. Parameter enclosed by [ ] - denotes factory default
2. Parameter enclosed by ( ) - denotes power on default
3. SCPI name ends with ? - denotes query only
4. Unless otherwise noted SCPI command is also a query
5. Keyword enclosed by [ ] - denotes optional use
6. Only a configuration command that has one of its parameters enclosed by [ ] can change its parameter setting and have this setting stored in the 9099's Flash (with the *SAV command).
7. The format for a SCPI list is (@1,2, n) or (@ 1:n). There must be a space between the @ and the first number and parenthesis are required. A list of numbers is separated by commas or uses a colon to denote a range of numbers.
8. Numeric entries conform to IEEE-488.2 section 7.7.2.4 for decimal numeric parameters.
9. ASCII formatted data is a series of decimal values (0-255) for each byte separated by commas. e.g. 64, 132, 8
10. The CAL:DATe command stores the CAL:DATe parameter and the current configuration in the 9099's memory
11. The CAL:DEFault command resets the 9099's settings to their default values. Caution - All user settings except network and the CAL:IDN string will be overridden by this command.
12. Most parameters can be output in various numeric formats (radix). The parameters with decimal 0-255 value ranges may also be output as HEX using #h00-#hFF or Binary using #b00000000-#b11111111. Conversely, the parameters shown with HEX (#h) values can also be output in Decimal.

TABLE 3-3 SCPI COMMANDS AND QUERIES

Keyword	Default Value	Description
SYSTem	-	Starts System Command Branch.
:COMMunicate	-	Identifies communication subsystem commands
:SERial		Identifies Serial Interface settings
:BAUD	9600	Sets serial baud rate. Values for the 9099 are 1200 to 115200 baud. See 1.9.2.
:PARity	NONE	Sets serial parity. Values = EVEN, ODD or NONE.
:BITS	8	Sets number of data bits per character. Values= 7 | 8.
:SBITs	1	Sets minimum number of stop bits between characters. Value = 1 | 2.
RS485	OFF	Tristates 9099 transmitter when not transmitting for two wire networks. Values are ON to enable tristating and OFF for transmitter held in mark state.
:RAW	-	Identifies Raw Socket settings
:PORT	23	Sets port number. Value range is 0 to 65,535. Default is 23.
:ECHO	OFF	Enables echo of raw socket data. Value is 1(On) | 0(Off).
:GPIB	-	Identifies GPIB interface settings
:ADDRess	4	Sets GPIB Primary address for the 9009. Values are 0-30.
:USB	-	Identifies USB interface settings.
:ECHO	OFF	Enables echo of mesage characters on the USB port. Value is 1(On)| 0(Off).

TABLE 3-3 SCPI COMMANDS AND QUERIES (CONTINUED)

Keyword	Default Value	Description
:PROMpt	ON	Enables generation of a prompt to tell the user that the 9009 is ready for the next command. Recommended for computer operation. Value is 1(On) | 0(Off).
:ERRor?	0, "No error"	Requests next entry in 9099's error queue. Error messages are: 0, "no error" -100, "Command error" -200, "Execution error" -400, "Query error"
:VERSion?	1994.0	Returns the <value> of the applicable SCPI version number.
STATus	-	Starts the Status Reporting Structure Branch
:OPERation	-	Identifies Operation registers.
:QUEStionable	-	Identifies Questionable registers.
[:EVENt?]		Returns contents of the event register. associated with the command.
:CONDition?		Returns contents of the condition register associated with the command.
:ENABle	0	Sets the enable mask which allows the true conditions in the associated event register to be reported in the summary bit. Value = 0 to #h7FFF in decimal or HEX.
:PTRansition	#h7FFF	Sets positive transition enable register. Value = 0 to #h7FFF in decimal or HEX.
:NTRansition	0	Sets the negative Transition register. Values = 0 to #h7FFF in decimal or HEX.
:PREset		Sets the selected Enable Register, PTR and NTR registers to their default values (0, #h7FFF)

TABLE 3-3 SCPI COMMANDS AND QUERIES (CONTINUED)

Keyword	Default Value	Description
:MODbus	-	Identifies Modbus TCP/IP Status Commands.
:ESE	0	Sets Modbus TCP/IP ESE register. Values are 0 to 255.
:ESR?	-	Queries Modbus TCP/IP ESR register.
:SRE	0	Sets Modbus TCP/IP SRE register.
:STB?	-	Queries Modbus TCP/IP register.
:OPERation	-	Identifies Modbus TCP/IP Operation registers.
:QUEStionable	-	Identifies Modbus TCP/IP Questionable
[:EVENt?]		Returns contents of the event register. associated with the command.
:CONDition?		Returns contents of the condition register associated with the command.
:ENABle	0	Sets the enable mask which allows the true conditions in the associated event register to be reported in the summary bit.
:PTRansition	#h7FFF	Sets positive transition enable register. Value = 0 to #h7FFF in decimal or HEX.
:NTRansition	0	Sets the negative Transition register. Values = 0 to #h7FFF in decimal or HEX.
:PREset		Sets the selected Transition Register, PTR and NTR registers to their default values (0, #h7FFF) and sets the selected Enable Register to 0.
FORMat		Starts String Format Branch.
:DATA		Optional digital data identifier
:TALK	ASCii	Sets talk string and data query response format. ASCII expresses a words input bit pattern as

TABLE 3-3 SCPI COMMANDS AND QUERIES (CONTINUED)

Keyword	Default Value	Description
		a decimal value equal to the binary sum of the data. Multiple words are separated by commas. HEXL converts each four bit nibble into the ASCII characters 0-9 and A-F. TABLE allows the user to define his own character set. All talk strings end with a linefeed. Values are ASCii | HEXL |. i.e. ASCii example = 128,5,255 HEXL example = 8000, 05FF
CALibrate		Starts the Calibrate Branch
:IDN <string>	blank	Sets the user IDN message. String is up to 72 characters and consists of four comma separated fields (manufacturer, model code, serial number and product revision) . e.g. **ICS Electronics, 9099, S/N 1509125, Rev 00.05 Ver 15.09.04** The word 'Model' may not be used in the IDN string. S/N is a non-case sensitive serial number identifier and must be present to display the user's serial number on the Welcome page.
:DATe <date>	00/00/0000	Saves the date and the current configuration. date is a 10 character string.
:DATe?		Queries the calibration date. The response is 00/00/00 when the unit is not calibrated. Enter a valid date to indicate when the unit is calibrated or configured.
DEFault		Resets the unit to its factory settings and resets CAL:DATE to 00/00/0000. The network settings and user IDN string are not reset. Do a CAL:DATE command to set the calibration date.
:LOCK	Off	Disables the lockable configuration commands listed in Table 1-3 when On. Locked commands are not visible to the user. Value is 1(On) | 0(Off).

3.6 MODBUS COMMANDS

The following commands are used to control Modbus slave devices. These Modbus Commands should not be mixed or concatenated with IEEE-488.2 or SCPI commands.

TABLE 3-5 MODBUS COMMANDS

Syntax	Meaning
C addr	Modbus Address Command. Sets Modbus slave device address for subsequent commands. Value for *addr* is 0 to 255. Default setting is 1.
RC[?] reg, ncoil	Read Coil Status Command (code 0x01). Reads the status of coils in a remote device. User specifies starting coil address in register *reg* and number of coils to be read *ncoil*. The [?] is an optional symbol for smart programs. (4) Values for *reg* are 0 to 65535. Values for *ncoil* are 1 to 2000. Responses are returned as a packed binary value with 1 bit per coil. 1 = ON.
RI[?] reg, ninp	Read Discrete Inputs Command (code 0x02). Reads discrete inputs. User specifies starting address in register *reg* and number of inputs to be read *ninp*. The [?] is an optional symbol for smart programs.(4) Values for *reg* are 0 to 65535. Values for *ninp* are 1 to 2000. Responses are returned as a packed binary value with 8 inputs per byte. 1 = ON.
R[?] reg, num	Read Register Command (code 0x03). Reads one or multiple Modbus device registers. User specifies starting register *reg* and number of registers to be read *num*. The [?] is an optional symbol for smart programs.(4) Values for *reg* are 0 to 65535. Values for *num* are 1 to 64. Responses are returned as signed 16-bit decimal or HEX values , +32767 to -32767, separated by commas. Output format selected with the Format command. i.e. R? 0,1 reads Watlow Model Number. Response is 5270 for Watlow Model F4 R? 0,3 reads three successive registers. Response is 5270, 0, 123 for the Watlow F4 Controller.
RR[?] reg, num	Read Input Register Command (code 0x04). Reads one or multiple Modbus device registers. User specifies starting register *reg* and number of registers to be read *num*. The [?] is an optional symbol for smart programs.(4) Values for *reg*

TABLE 3-5 MODBUS COMMANDS CONT'D

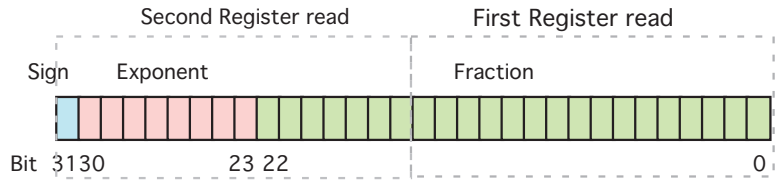
Syntax	Meaning
RR[?] reg, num continued	are 0 to 65535. Values for *num* are 1 to 64. Responses are returned as signed 16-bit decimal or HEX values, +32767 to -32767, separated by commas. Output format selected with the Format command. See the R? query above.
RE[?]	Read Exception Status Query (code 0x07). Reads eight exception status outputs from a remote device. The [?] is an optional symbol for smart programs.(4) Responses are returned as a packed binary value with the eight status bits in one byte.
RF? reg	Read Floating Point Value Command (code 0x03). Reads two sequential registers as an IEEE-754 32-bit floating point value in low word to high word order. The specified register contains the lower two bytes and the next higher register contains the upper two bytes. See note 5. Values for *reg* are 0 to 65535.
WC reg, b	Write Coil Command* (code 0x05). Writes a ON/OFF value, *b* to a single Modbus device register, *reg*. Values for reg are 0 to 65535. Values for *b* are 0/OFF or 1/ON/255. An example is: WC 1000, ON
W reg, w	Write Register Command (code 0x06). Writes a 16-bit value, *w* to a single Modbus device register, *reg*. Values for reg are 0 to 65535. Values for *w* are +32767 to -32767. An example is: W 100, 55 writes the decimal 55 to register 100.
WB reg, num, w(0),.w(n)	Write Block Command (code 0x10). Writes multiple 16-bit words, *w(i)* to multiple registers or 32-bit values to two adjacent registers. Starting register, *reg*. Values for *reg* are 0 to 65535. Number, *num* specifies how many words are to be written. Values for *num* are 1 to 64. Values for *w* are +32767 to -32767. *w(i)* values are separated by commas.
WF reg, num	Write Floating Point Value Command (0x10). Writes an IEEE 754 single precision 32-bit value to two registers in low word to high word order. *reg* specifies the low word. *reg + 1* is the high word. *num* is determined by the parameter being controlled and can range from 2^{127} to 2^{-127}

TABLE 3-5 MODBUS COMMANDS CONT'D

Syntax	Meaning
L[?] w	Loopback Command (code 0x08). Writes a 16-bit word, *w*, out to a Modbus device and returns a single response word to the GPIB bus. The question mark is optional for smart programs.(4) Value for *w* is 0 to 65535.
D time	Timeout Command. Sets timeout value of Modbus response message in milliseconds. Timeout is the total time for the message to be received by the 90x9. Value for *time* is 1 to 65,535 milliseconds. A value of 0 disables the timeout. The default value is 300 ms. Caution - Do not use 0 or values that exceed the Network timeout which is normally 3 to 10 seconds.
D?	Queries the current timeout setting.
E?	Read Error Command. Reads and clears the Modbus Error Register and bit 6 in the Event Status Register. Returns a error code whose value is 0 to 255. Current error values are: 0 No errors present 1-99 Exception Codes 1-99 100 CRC Error 101 Timeout Error indicates no characters received in the response message. 2nn Partial or corrupted message received. where nn is the number of received bytes.

Notes:

1. All values are in decimal. To enter HEX values, the value must be preceded with a #h . i.e. 100 decimal = #h64
2. Response parameter format is set by SCPI FORMat command. Default is ASCii.
3. Do not combine the Modbus commands in Table 3-5 with IEEE-488.2 commands or SCPI commands to avoid query errors or confusing the parser.
4. The [?] is an optional symbol for smart programs like ICS's VXI-11 Keyboard program that can recognize the command as a query and automatically read the response.
5. The IEEE-754 format and RF? register read order is:



3.7 LAN PROGRAMMING GUIDELINES

This section provides general directions for linking to the 9099 and hints for writing LAN programs. Refer to ICS's AB80 series Application Notes and the Appendix for additional information about programming VXI-11 devices.

3.7.1 LAN Programming and Timeouts

The VXI-11 protocol provides a way to send data packets and commands to an instrument and to receive data back from instruments over your company network or LAN. As with GPIB Programming, there are a couple things the user must do before using the 9099.

Windows users should:

1. Install a VXI-11 compliant VISA Library (from NI or Agilent).
2. Define the 9099 as a VISA TCP/IP Resource.
3. Write and test the Application Program

Linux/UNIX users should:

1. Install RPC client-side support.
2. Use the system's rpcgen utility to install VXI-11 RPC.
3. Write and test the program. See AB80-3 for RPC programming

Programs written for a LAN instrument need to be organized in the following manner:

1. Open a socket and link to the 9099 and to any other instruments.
2. Body of the test program with instrument reads, writes etc.
3. An exit routine that closes all links and sockets.

Leave the instrument links and channels open until the program is finished to avoid unnecessary program delays and exhausting the devices' resources. Error testing should be built into the program to verify that the called function worked as planned. Test your commands with ICS's VXI-11 keyboard program before adding them to your program. (See Section 3.9 for VXI11_kybd directions). ICS also provides a Error Log Utility to read back soft errors from the 9099 during program debugging. See Section 3.10 for more information about the ErrorLog Utility.

Example Visual Basic programs that make VISA calls are supplied on your Support CD and are available for downloading from ICS's website (www.icselect.com). Use these programs as a starting point for your program.

LAN systems have multiple timeouts. There is the VXI-11 IO_timeout which includes the wait-for-lock-release time and the delays in the module. In the case of the 9099 this also includes the modbus serial timeout value set by the D command. The VISA communication or RPC network timeouts are long timeouts designed to catch network failures.

COMM_Timeout is unique to ICS VXI-11 devices and refers to the time the device's service will go without getting a message from the other party before declaring the link dead. KeepAlive is a background function of the device's TCP/IP Stack to check the socket connection and is invisible to the application. Both of these functions will terminate a broken link or channel, release any locks and release the resources for use by another link. Else the device can run out of resources and become inaccessible. There is also a lock timeout that sets the time a command will wait for a device lock to be released before timing out.

COMM_Timeout should be set to a low period like 2 minutes (factory setting) when you are first debugging a program and tend to breakout of the program without properly closing the sockets. Power cycle a unit to clear up any open sockets. Later, with a finished program, extend the COMM_Timeout to several hours to avoid prematurely closing the socket while you are not communicating with the 9099. Hard wired systems are pretty dependable and you can safely extend the 9099's COMM_Timeout to a day. Do not set COMM_Timeout to 0, which disables the timeout, unless you have a way to physically reset the 9099 if it runs out of resources.

The 9099's Keep_Alive function should be enabled. Keep_Alive will put a short message on the network, once every 2 hours if there has been no traffic from the client in this time.

The recommendation is to install a background function in your test program to prevent unwanted socket closure during work breaks or unplanned test stoppages. This function can be set to perform some RPC VXI-11 activity through the socket when nothing has been done for a period of time less than the 9099's COMM_Timeout setting. The background functions should not alter the state of the devices or of the interface. Some non-altering actions are opening and closing a second link to the 9099. All channels need to be exercised once in each instruments' COMM_Timeout period.

3.7.2 VISA Libraries

VISA libraries provide a standardized application interface for user programs and outputs that communicate with standard hardware ports such as PC COM ports, PCI bus, and USB ports. VXI-11 compliant VISA libraries provide VXI-11 calls over the TCP/IP network to communicate with VXI-11 instruments as shown in Figure 3-2. Agilent, Kikusui and National Instruments (NI) provide VXI-11 capable VISA and SICL libraries. While all three VISA libraries run in WIN32 operating systems, VISA libraries variations are available for some UNIX, LINUX and other operating systems.

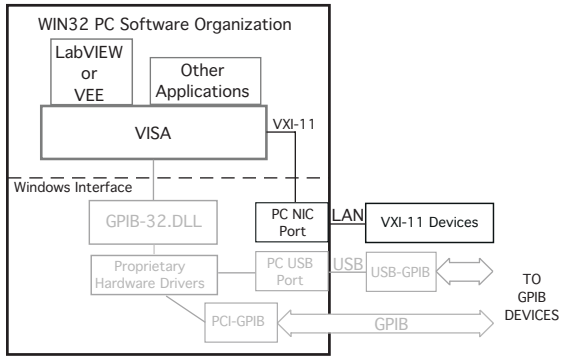


Figure 3-2 VISA to VXI-11 Communication Path

The VISA Resource String is:

TCPIP::*ip*::inst0::INSTR where *ip* is the ip address

CAUTION

The instructions given in this section are the general steps for using the Agilent and National Instruments software and may not be accurate for all versions of their software or for a particular operating system. Check with their support engineers if you run into any problems using their software.

3.7.3 Using Agilent's VISA

Use version 16.0 or later of Agilent's VISA. It includes VXI-11.2 and VXI-11.3 functions and has been rewritten to work better with VXI-11.3 instruments. You do have to be sure to keep the link to the 9099 open since Agilent's VISA will close the channel when the link count drops to zero. It also inserts non-VXI-11 commands in with valid commands while doing instrument discovery. Agilent is aware of these problems and may fix them in future releases.

Configure the 9099 with Auto-disconnect on when using Agilent's VISA.

Perform the following steps to make a connection to the 9099:

1. Open the Agilent Connection Expert
2. Verify that a LAN interface has been created else create a new LAN interface.
3. Highlight the LAN TCPIPO interface and change its properties. Select VXI-11 and reduce the default timeout to 10 seconds.
4. Click the Add Instrument button on the menu bar. The auto discovery algorithm should find the 9099 and display a list of found devices.
5. Select the 9099 from the resulting instrument list. Check Allow IDN query. Uncheck Host Names. Click OK
6. The Connection Expert should verify the device and add it to the Instrument IO tree.

The user should exit the Agilent Connection Expert after the device is found. Run ICS's VXI-Error Log Utility if you experience unstable operation, program hangups or see the 9099's ERR LED blinking often. Use the log to debug and modify your VISA program.

3.7.4 Using Agilent's SICL Library

Agilent' SICL Library includes a complete set of VXI-11.2 and VXI-11.3 functions and works well with C language and Visual Basic. It is very stable and has been around a long time. Agilent's SICL User's Guide lists all of SICL's functions and provides easy to follow instructions for creating a LAN Session and for controlling VXI-11 devices. The SICL help file provides detailed function explanations. ICS' Application Note, AB80-2, describes how to write an interactive Visual Basic program (SICL_kybd) using SICL functions. The example SICL program can be used as a starting point for your program. The Application Note, executable and source files may also be downloaded from ICS's website.

The hardest part about using the SICL library is setting up the open function to link to the 9099. The SICL_kybd program has a comboBox where the user can enter the 9099's IP address. The Create Link button calls the cmdLink function that closes any open interface links and then opens an interface link to the 9099's IP address.

The 9099 interface link format is:

```
intfc = iopen("lan;vxi-11[192.168.0.254]:inst0")
```

Establishing an alias like '9099' and then referring to the alias in the iopen command eliminates this problem.

Note that the command ends with 'inst0' which specifies the interface link to an instrument. The IP address shown in the above example is the 9099's default IP address and is a placeholder for the 9099's current IP address. The SICL_kybd program inserts the user supplied IP address from the comboBox, if the user had entered an address, or it uses the 9099 default IP address if no IP address was entered.

3.7.5 Using Kikusui VISA

Kikusui provides a VISA library that is compliant with IVI VISA specification 5.0. It supports USB, RS-232C, LAN, and GPIB interfaces. It has been tested and found to be compatible with ICS Electronics' GPIB and LAN interfaces. You can download the Kikusui Visa (ki-visa) from Kikusui's website at http://www.kikusui.co.jp/en/download/.

Use ICS's VISAkybd program with the Kikusui VISA to interactively control instruments. VISAkybd does not have a search and find feature so you will have to manually enter the instrument's GPIB address or LAN IP address.

3.7.6 Using National Instruments' VISA and MAX

National Instruments' VISA comes with the NI Measurement and Automation Explorer (MAX) and can be downloaded from NI's website. NI's VISA only has VXI-11.3 capability. When manually running the NI VISA Interactive Control Panel, run MAX first to define the TCP/IP Resource. Use LabVIEW version 8.5.1 or later, to minimize problems.

The following steps will let you use MAX to link to the 9099.

1. Run MAX.
2. Right click on Devices and Interfaces in the left hand window and select Create New.
2. Select VXI TCP/IP Resource from the pop up window. Press Next.
3. Select VXI-11 LAN Instrument. Press Next.
4. Select Auto-discovery. Press Next.
5. Select which instruments to add. Press Finish to save the instrument.

You can now run the VISA Interactive Control Panel.

1. Select the INSTR TCP/IP Resource you just entered.
2. Click the Open VISA Session button.
3. Select the BASIC I/O tab.
4. Select the Write tab. *IDN? is prefilled in the text box but you can change it to any command. Press Execute to send the command to the GPIB device.
5. Select the Read tab. Press Execute to read the device's response. Only execute the read function if you are expecting a reply from the device. Otherwise you will get a timeout error.
6. The remaining tabs let you send a Device Trigger or Device Clear to the device and Serial Poll the device.

3.7.7 Direct Control with TCP/IP

The 9099's WebServer communicates thru port 80. If you write a program to open a socket to port 80 on the 9099 and send a single line containing the parameter via the socket, it would be the same as having a browser communicate with the 9099. You can create a small program to visit, examine or control the html page variables. Refer to the html pages supplied with your 9099 for the variables names and to Application Bulletin AB80-17 for more detailed information on direct control with port 80. An example is:

```
GET/cgi?%input1%\r\n          'reads F4 temperature
```

3.8 9099 PROGRAMMING EXAMPLES

The following section provides information on how to configure the 9099 from a program, and how to send commands to the Modbus slave device using the VXI-11 protocol. New users should try these simple examples with ICS's VXI11_kybd program to become familiar with controlling the 9099 and Modbus device(s) over an Ethernet link. Refer to Appendix A1 and A2 for general information about VXI-11 programming and to Section 3.9 for directions on using the VXI11_Kybd program.

3.8.2 General Configuration Guidelines

New units are factory set so that they are ready to be used when received. Table 1-3 lists the Factory Settings for the Serial Interface. Verify that the 9099's setting match those in the Modbus device. Use the SCPI commands in Table 3-3 to query or change any 9099 setting.

```
SYST:COMM:SER:RS485?      'reads current 485 mode setting
SYST:COMM:SER:RS485 1     'sets 485 mode on
```

If the new setting did not verify or if the red ERR LED came on, query the ESR Register. The command was not executed if the ERR LED came on.

```
Send *ESR?                'reads Event Status Register
                          and clears the ERR LED.
```

Check the ESR reading against the bit pattern in Figure 3-1 to find the cause of the error. Correct and repeat the above steps for each parameter you are changing. When done save the new values.

```
Send "*SAV 0"             'save the new configuration
```

The *SAV 0 command will cause the 9099 to blink all but one of its LEDs. .

3.8.3 Setting the Modbus Device Address

The Modbus device address in the 9099 is set with the 'C' command to match the address set in the desired Modbus device. The 9099 remembers the Modbus address until it is changed so it is only necessary to send the 9099 the 'C' command at the start of the program. If the 9099 is being used with only one Modbus device, the address can be set and saved as part of the 9099's power on configuration. The 9099 and most Modbus devices default to a Modbus address of 1.

CAUTION

Modbus commands should not be mixed on the same command line with IEEE-488.2 and SCPI commands to prevent query errors and confusing the 9099 Interface.

```
C n              'sets device address to value n
*SAV 0           'optional save new default address
```

3.8.4 Querying a Modbus Device

The next step is to send a query to the 9099 and read back the response from the Modbus device. The R? command is the basic read command. With the Watlow F4 controller, register 0 is the Watlow Model number register. The '?' is optional and is included so programs like ICS's VXI-11 Keyboard control programs can automatically read back and display the response from a query. i.e.

```
R? 0,1           'reads Watlow model number
                 'Watlow F4 response is 5270
```

A more realistic command might be to read a measured value. Register numbers and functions vary with different Modbus devices so consult your Modbus device manual for its register numbers and functions. With the Watlow F4 series Controllers, register 100 is the measured temperature value.

```
R? 100,1         'reads temperature from a Watlow F4
```

3.8.5 Writing to the Modbus Device

The W command writes 16-bit integers to a register. The command parameters depend upon the specific Modbus device. In the following example, a value of 50 is written to register 300. i.e.

```
W 300, 50        'sets F4 temperature setpoint
```

The WB command writes to sequential Modbus registers. The Visual Basic TempCltr example program on the Support CD-ROM can be used as an example when writing Temperature Control programs.

3.8.6 32-Bit Variables

Most Modbus devices have 16-bit wide registers for setting a parameter and for reading back data. The prior command examples showed how to read and write

to 16-bit registers. Watlow's new Temperature Controllers like the Series SD and Series PD have 32-bit registers which are accessed as two 16-bit registers. The value is assumed to have three decimal places.

3.8.7 32-Bit Write

To write a set point of 1250 degrees (which is really 1250.000) to Registers 27 and 28, multiply the setpoint value (SP) by 1000 to get 1,250,000. Add 65536 to negative numbers. This produces the setpoint (SP) we want to send. To determine the most significant word (MSW) for Register 27, divide the SP by 65536. To determine the least significant word (LSW) for Register 28, subtract from the SP the result of multiplying the MSW by 65536. i.e.

SP = 1250 * 1000 = 1250000
MSW = 1250000 / 65536 = 19
LSW = 1250000 - (19 * 65536) = 4816

The 9099 can write each register separately with standard write commands or both registers can be written together with the Write Block command. Examples are:

```
W 27,19              'writes to register 27
W 28,4816            'writes to register 28
WB 27,2,19,4816      'writes to registers 27 and 28
```

3.8.8 32-Bit Read

To read a 32-bit value, two successive 16-bit registers are read and the user's program then puts the values together to form the 32-bit result. An example is reading a process variable from Registers 20 (MSW) and 21 (LSW). The 9099 can be used to read each register individually or to read two successive registers. The commands are:

```
R? 20,1              'reads register 20
R? 21,1              'reads register 21
R? 20,2              'reads registers 20 and 21
```

Both sequences return two numbers to the user. The MSW is returned from Register 20, the LSW from Register 21. Multiply the MSW by 2^16 or 65536 and add it to the LSW. Divide the result by 1000 to scale it to three decimal places.

Reading = ((MSW * 65536) + LSW)/1000

3.8.9 Floating Point Variables

Some new Modbus devices like Watlow's EZ-Zone PM series controllers use two consecutive register to control a value or to read back a process variable. The two registers hold an IEEE-754 32-bit floating point word. The registers are read and written to in the low word-upper word order.

3.8.10 Floating Point Write

The WF command writes the num value in floating point format to two consecutive registers starting with the low word register. The example writes to the EZ-Zone temperature setpoint registers.

```
WF 2160, 75          'writes to registers 2160 and 2161
```


3.8.11 Floating Point Read

The RF? query reads a 32-bit floating point value from two sequential register in low word-upper word order. The RF? does not require the number of register to read since it is fixed at two registers. The example reads the EZ-Zone temperature registers.

```
RF? 360              'reads registers 360 and 361
```

3.8.12 Setting Modbus Device Timeouts

The D command sets the time that the 9099 waits to receive a response from the Modbus device. If the 9099 does not receive a response within the time period, it assumes that the Modbus device is not responding and sets the timeout error. Timeout errors can be determined by reading the 9099's Modbus Error Register with the E? query. If the error code is 101 (Modbus timeout) then the timeout period should be lengthened. The command to change the timeout period is:

```
D 500                ‘sets timeout period to 500 ms
```

The default time period of 300 milliseconds has proved to be satisfactory for most Watlow controllers but should be verified carefully for your specific Modbus device. Some devices fail to respond within the default time period because they perform periodic calibrations. The recommendation is that your program should have a built-in recovery routine to handle modbus communication errors.

3.8.13 Locking Setup Parameters

Some of the 9099's configuration parameters can be locked to prevent accidental change by the end user. These lockable parameters are noted by a # symbol in Tables 1-3. Locked parameters cannot be queried or changed while locked. Any command that addresses a locked parameter is not executed, the Command Error bit in the Event Status Register is asserted and the ERR LED is lit. The lock function is saved by the *SAV 0 command.

An example is:

```
CAL:LOCK ON          'blocks unauthorized changes
*SAV 0               'saves lock condition

CAL:LOCK OFF         'unlocks setup parameters
```


While lock is enabled, the end-user can only change and save any non-locked parameter.

3.8.14 Generating Service Requests (SRQs) from Modbus Errors

Figure 3-1 shows the 9099's Status Reporting Structure. All Modbus Error codes are placed in the Modbus Error Register at the top of the figure. If the proper Event Status and Status Byte register bits are enabled, any Modbus Error code will generate a Service Request. The commands to enable the bits are:

```
*ESE 64              'enables ESR bit 6
*SRE 32              'enables Status Byte bit 5
```

Some Modbus Errors set specific bits in the Questionable Event Register. To generate a Service Request from a specific event, its bit must be enabled. The following commands enable Service Requests for Timeouts and CRC errors only:

```
STAT:QUES:PTR #h3000     'enables positive going bits 12
                         and 13 to set bits in the
                         Questionable Event Register
STAT:QUES:ENAB #h3000    'enables Event bits 12 and 13
*SRE 8                   'enables Status Byte bit 3
```

In both cases, the user needs to reset the event cause and clear the Service Request so another error will cause another Service Request. In case one, this is done by reading the Modbus Error Register with the E? query. In case two, the Questionable Event Register must be read to clear the set event bits.

The VXI-11 protocol requires that the user set up a reverse interrupt channel as described in paragraph A2.3. A simpler approach might be to periodically query the Status Byte Register with a *device_readstb?* query.

3.8.15 Personalizing the Unit's IDN Message

The 9099's IDN message can be changed to personalize the unit, to identify the overall assembly as being from your company or to record product history or revision dates. The IDN message is a lockable parameter and if locked, needs to be unlocked before being changed. The format for the IEEE 488.2 IDN message is four fields (company, model#, serial number and revision) separated by commas and a maximum of 72 characters long. The word "model" may not be used in an IEEE-488.2 IDN message. An example IDN message change sequence is:


```
CAL:LOCK OFF          'unlocks all parameters

CAL:IDN Acme Test Co, 101, s/n 007, Rev 1 07/08/30
                      'enters a new IDN message

CAL:LOCK ON           'relocks all parameters

*SAV 0                'saves IDN message and lock status
```

3.8.16 Saving the Configuration

The *SAV 0 command saves the current configuration in nonvolatile Memory. This includes all configuration settings and the current I/O settings. The saved configuration is recalled and the I/O settings restored to their saved state at power turn-on or by the *RCL 0 command. **WARNING - Because the Non-volatile Memory has a finite number of write cycles, the *SAV command should not be used inside a program loop.** Be sure all settings are correct before saving.

```
*SAV 0                'saves current values and configuration

*RCL 0                'recalls the saved configuration
```

3.9 VXI-11 KEYBOARD PROGRAM

The VXI-11 Keyboard Program (VXI11_kybd) is a utility program that lets a user interactively control VXI-11 instruments directly from the computer's keyboard. The VXI-11 Keyboard Program is the recommended way to test the 9099 after its installation or to try out commands before incorporating them into a program. The VXI-11 Keyboard Program (VXI11_kybd) runs on a WIN32 PC and is provided on the included Support CD.

3.9.1 VXI-11 Keyboard Installation

Select the 'Install VXI-11 Support' option to run the ICS_VXI-11_Install program. This program installs the VXI-11 Keyboard on your computer along with ICS's VXI-11.DLL, Microsoft's Visual Basic 6 Runtime Package and the VXI-11 support documentation.

3.9.2 VXI-11 Keyboard Operation

To run the VXI-11 Keyboard Program, double click the desktop VXI11_kybd icon or run it from the Window's Start menu by pointing to Programs and then to ICS_Electronics. Select VXI11_kybd from the submenu.

When the VXI-11 Keyboard Program launches, only the Find Server and Create Link buttons are enabled. The initial steps are to discover and link to the server (9099) and then to the desired instrument (*inst0*).

Press the Find Server button (located in the VXI-11 Server frame) to scan for servers. If you know the IP address, it can be manually entered in the VXI-11 Server window. The number of servers found is displayed in the Device Response window at the lower left. In the VXI-11 Server frame, use the pulldown arrow to display the found servers. Select the 9099's IP address and press the Select and Create Link button. If the 9099 is not found, use the directions in Section 2.6 to review and correct your network connections to the 9099.

The message in the Device Response window will tell you the link to the 9099 has been established and the number of instruments that have been discovered. Use the pull down arrow on the right side of the Instrument Resource Address window to expose the instruments in the 9099. Select *inst0* and press the Select Inst and Link button to link to the instrument. A message is displayed in the Device response window when the link has been created and the remaining VXI11_kybd buttons and controls are enabled.

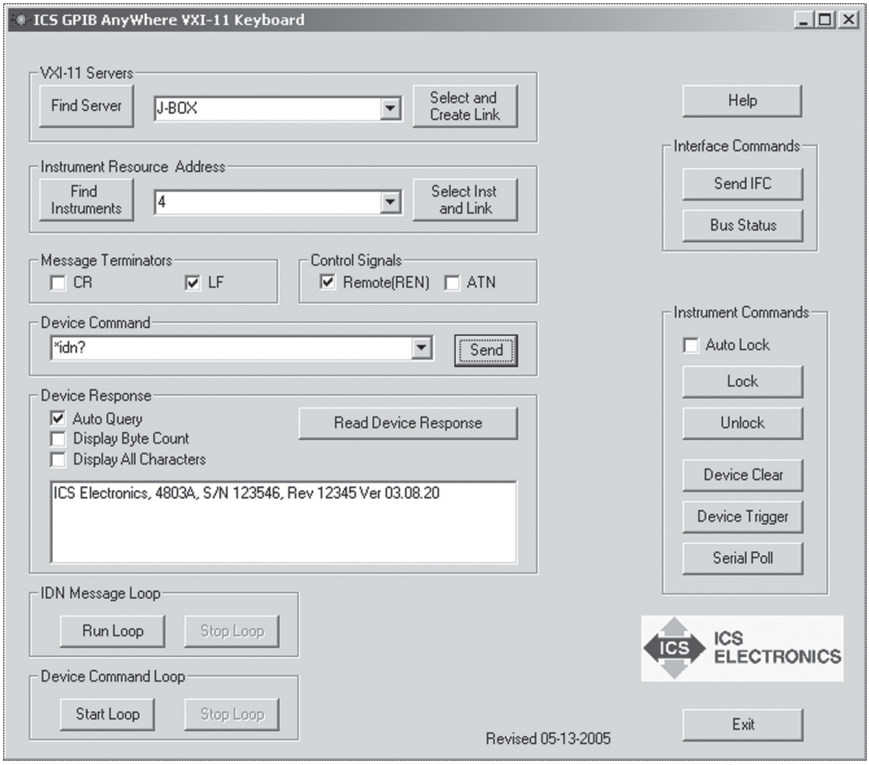


Figure 3-3 VXI-11 Keyboard Program Panel

Note

Some instruments have multiple instrument personalities. *inst0* is normally the main instrument and will normally, but not always, respond to an *IDN? query.

At this point, you can communicate with the linked instrument just like a GPIB device. The VXI11_kybd default setup appends a linefeed terminator to all outgoing messages, looks for an EOI or linefeed terminator and automatically reads the response to a query (any string that includes a question mark). The *ESR?, *IDN?, and *STB? queries only work with IEEE-488.2 compatible devices. Figure 3-3 shows the VXI11_kybd panel that has just read the *IDN response.

To output a message, enter the message in the Device Command window and press Send. If the message was a query (contains a '?'), the VXI11_kybd program automatically reads and displays the device response. To read a response manually, press the Read device response button. If you uncheck the Auto

Query button or if your query does not contain a question mark, you have to do a manual read after each query. If you do not read a response from a device and then send it another command or if you attempt to read when the device has nothing to output, you will generate a device query error in an IEEE-488.2 device. A read that does not get a response will produce a timeout error on the VXI11_kybd. (See Table 3-6 for a complete list or ICS's VXI-11 Errors.)

The Interface Command buttons on the right let you send commands to a GPIB Controller (like ICS's Model 9065) and do not apply to the 9099.

The Instrument Command buttons on the right let you Lock and Unlock the instrument. Locking an instrument prevents other clients from changing its status or giving it new commands while you are using it to perform an operation. Always Unlock the instrument when done with it. When the Auto Lock check box is checked, the VXI11_kybd program automatically locks the instrument when sending it a command and unlocks it when the command has been completed or when it has received a response to a query. A Red 'Locked' message is visible when the instrument is locked.

Device Clear clears the 9099's serial buffers. The Device Trigger has no function with Modbus slave devices. The Serial Poll button reads the instrument's Status Register and displays the results in the Device Response window.

Use the Help button in the upper right hand corner to access the VXI11_kybd Help File.

3.10 VXI-11 ERRORLOG UTILITY

ICS's VXI-11 ErrorLog Utility periodically queries an ICS VXI-11 device at its configuration port to see if it has any logged errors. If there are errors, they are read and listed by the ErrorLog Utility. ICS's VXI-11 ErrorLog Utility is designed to work with ICS Electronic's VXI-11 products. The ErrorLog Utility is not intended, nor will it work with VXI-11 products from other companies.

3.10.1 Error Types

An error is defined as a non-standard event. An error may be either a hard error or a soft error. A hard error is such that it prevents further operation of the device, resulting in a hang condition after which the device is no longer functional. Hard errors are shown by a blinking LED pattern if the processor is able to operate the LEDs. A soft error is an error condition that is of momentary condition and will not prevent the device from normal operation.

The occurrence of a soft error will cause the ICS VXI-11 device to momentary flicker the red ERR LED (typically 1/10th of a second). Multiple soft errors may extend the time the ERR LED is turned on. In addition, an error entry is made in the device internal error log. The error log is accessible through the ErrorLog utility. Launching the ErrorLog utility will clear the current contents of the device error log. Future error log entries will then be displayed by the ErrorLog utility.

The ErrorLog utility reports soft error conditions and provides some minimal information as to what the error condition means. It is not intended to provide in depth information as to the conditions causing the error. However, the fact that an error occurred and the nature of the error can quite often provide important information and allows the user to isolate the cause of the error and preventing future error conditions.

3.10.2 Running the ErrorLog Utility

To launch the ErrorLog utility, open an MSDOS window and navigate to the ICS Electronics VXI-11 Utilities folder. The ErrorLog utility requires a single command line parameter, which is the IP of the ICS VXI-11 device to be monitored. If the IP is not provided, the ErrorLog utility will default to 192.168.0.254, which is the default shipping address of ICS's VXI-11 products. The MSDOS window will display an error message if it fails to connect to the VXI-11 server.

TABLE 3-6 ERRORLOG ERROR CODES

Error Code	Error Description
1	VXI-11 Syntax Error
3	GPIB Device Not Accessible
4	Invalid VXI-11 Link ID
5	VXI-11 Parameter Error
6	Invalid VXI-11 Channel. Channel Not Established
8	Invalid VXI-11 Operation
9	Insufficient Resources (normally related to Link IDs or Locks)
11	Device Locked By Another Link ID
12	Device Not Locked
15	I/O Timeout Error
17	I/O Error
21	Invalid GPIB Address Specified
23	Operation Aborted (indicator, not a true error)
29	Channel Already Established
60	Channel Not Active
110	Device Already Locked
111	Timeout Attempting To Gain A Device Lock
999	Unspecified/unknown error
1000	VXI-11 Protocol Error
2000	RPC Protocol Error
2001	Unsupported RPC Function
2002	Insufficient RPC Message Length

NOTE: Usage of the Agilent I/O Library may result in some error log entries. Some of these errors occur when the IO Library tries to determine if the VXI-11 device is an Agilent instrument. Others are due to the incorrect usage of the VXI-11 protocol in the current revision of the library. Agilent is aware of these protocol errors and will correct these errors in later releases of the Agilent I/O Suite. These errors normally only show up during the opening of a SICL/VISA device and can be safely ignored.

The occurrence of a soft error will cause the ErrorLog utility to generate a single-line error report. It consists of a time/date that the error was detected, the numeric code of the error and a short English translation of the error code. The Error Log Error Codes are listed in Table 3-6.

Normal usage of the ErrorLog utility can provide two key pieces of information. The first is that an error did happen. Normal operation would not result in errors and the occurrence of an error can indicate an abnormal condition that should be investigated. Therefore it may be advantageous to have the ErrorLog utility operating over a period of time if unexpected errors occasionally happen and/or a new client utility is being developed.

The second way in which the ErrorLog may be of value is for client program debugging. Usually it is possible to single-step through a program, allowing the user to determine exactly which operation results in the error condition. Then the user can investigate the proper usage of the operation to prevent errors in the new program.

There are two basic types of soft errors. The first type is a RPC protocol type error which are usually not seen by the typical application developer. They are normally caused by communication protocol errors and should be reported to the developer of the communication package being used. Normally this would be a VISA library, RPC developer, or some other type of communication package.

The second type of error is a procedural type of error. An example of a procedural error is attempting to perform an I/O operation to/from a non-existent device or trying to read data that is not there. These errors are typically seen by the application developer and should be corrected.

3.11 OEM DOCUMENTATION AND CONFIGURATION

3.13.1 Firmware Settings

OEM users can set the module's IDN message to identify the company and product. The I/O configuration can be set to the power turn-on values and saved. The settings can then be locked so the end-user cannot change them.

3.11.2 WebServer Pages

The OEM can customize the WebServer html pages to identify the OEM's product and incorporate the OEM company logo by following the guidelines in Application Bulletin AB80-5.

3.11.3 End-User Documentation

OEM users of the this interface should provide the end-user with the instructions and utility programs necessary to operate the complete system. This is not done by passing the 9009/9099 manual onto the end-user since it does not relate to the end product nor document how the end product is operated. In most cases the end-user needs directions for:

1. Setting the product's Network (and or GPIB) Settings.
2. Resetting the Network (GPIB) Settings when he forgets them.
3. Using commands to control the overall device. (Includes sending outputs and reading inputs if applicable). The OEM needs to define the commands in terms of what they do to the overall product and show the end-user how to use them.
4. Using the 488.2 Status Reporting Structure. The OEM needs to define what the digital inputs mean if they are part of the product, how to enable Service Requests (SRQs) and how to read the registers.

The SCPI Standard requires that the SCPI command tree and SCPI conformance information be passed on to the end-user. This means only the active or applicable commands. Edit out all unused commands. All locked commands become invisible to the end-user and should be omitted from the end-user's SCPI command tree and list.

3.11.4 Utility Programs and Drivers

The following utility programs and drivers should be given to the end-user:

1. ICS's VXI-11 Keyboard Program
2. ICS's VXI-11 Error Log Utility
3. Any programs generated by the OEM to control the end product such as LabVIEW VIs, etc.

3.11.5 Copyright Release

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4

Theory of Operation

4.1 INTRODUCTION

This section describes the theory of operation of the 9009 and the 9099 Ethernet to Modbus RTU interfaces. The description of the 9099 applies to the 9009 unless otherwise stated.

4.2 FUNCTIONAL DESCRIPTION

The 9099 is a microprocessor based device that performs the VXI-11 service, raw socket service, Modbus TCP/IP conversion and webserver functions to control its Serial Interface and connected Modbus RTU slave devices from an IEEE-802.11 network. The 9099 is a microprocessor based device with LXI compatible firmware. The different services can simultaneously access multiple Modbus slave devices.

Incoming Ethernet messages are received by the LAN Interface chip. If the message is a Modbus command then it is converted into a series of binary characters to make up the Modbus RTU message packet. The Modbus message packet, shown in Figure 4-1, includes the slave device address, the command number, the registers and data (if any) that is being sent to the registers. A checksum is added to make up the complete Modbus RTU packet. The Modbus packet is then placed in the serial transmit buffer and outputted at the serial interface.

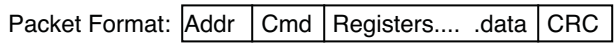

Figure 4-1 Modbus RTU Packet

If the message is a Modbus TCP/IP packet, the internal data from the packet is combined with the slave device address to create the Modbus RTU packet. A

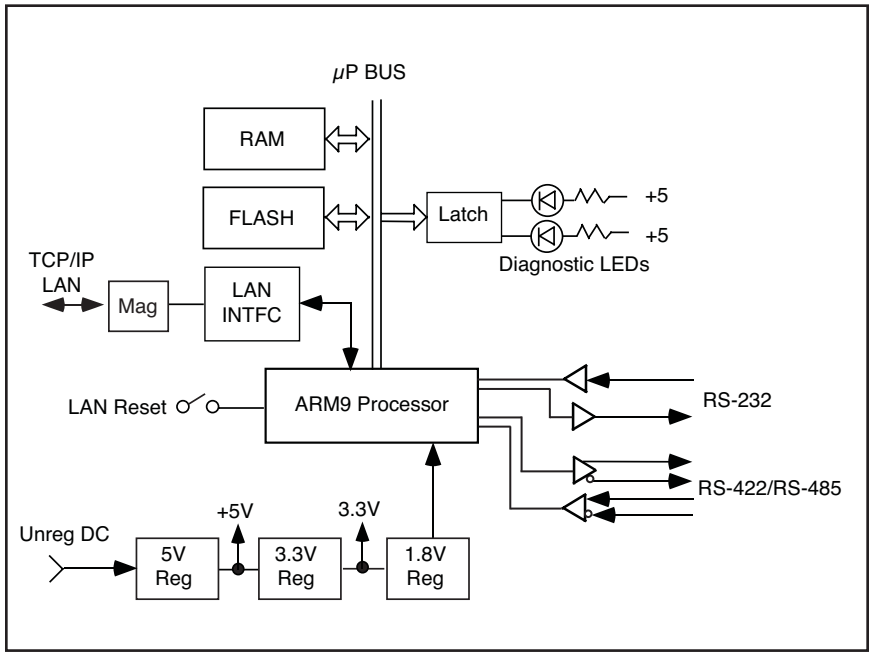

Figure 4-2 9099 Block Diagram

checksum is added to make up the complete Modbus RTU packet.

All Modbus packets are responded to by the Modbus device. The response packet is either an acknowledgement, an exception message or response data. Modbus RTU exception messages and transmission errors are saved in the Modbus Error Register. Response data is held in the output buffer until read by a VXI-11 device_read, by a raw socket read or by a webserver read. For Modbus TCP/IP, the response and acknowledgement are encapsulated in the return packet.

IEEE-488.2 and SCPI commands are parsed and used to set control parameters, perform an operation or query a parameter. Responses are placed in the output buffer so they can be returned to the client when the unit is next read. The other VXI-11.3 commands like Device Clear clears the serial buffers. Device Trigger has no affect on the 9099. The ReadSTB command causes the 9099 to respond as a GPIB device would to a Serial Poll.

4.3 BLOCK DIAGRAM DESCRIPTION

Figure 4-2 shows a block diagram of the 9099's internal logic. The 9099 is made up of seven major elements, most of which are interconnected to the ARM9 microprocessor by a common data, address and control signal bus.

Incoming network messages are received by the LAN Interface chip. The LAN Interface chip transfers the decoded data to the ARM9 microprocessor when it receives a message. Depending upon the message type, command characters are parsed and used to change/query the 9099's operational settings or to transfer data to or from the Serial Interface. Modbus TCP/IP packets are directly converted to Modbus RTU packets.

The 9099's Serial Interface has several UARTs, two of which are connected to the RS-232 and RS-485 transceivers. A separate RS-232 Enable jumper selects the active UART. The RS-232 transceiver produces or receives the RS-232 single ended, bipolar signals. Typical RS-232 output levels are ± 8 Vdc. Minimum input levels are ±5 Vdc. The RS-485 transceiver generates and receives differential RS-485 signals. The RS-485 driver has more drive capability than the older RS-422 drivers but it makes the same signal levels and thus the interface is RS-422 and RS-485 compatible. The two pairs of signals can be used as a 4-wire differential interface or jumpered internally to form a 2-wire RS-485 signal pair. The Rx signal pair can also be jumpered to an internal termination network that provides a pull-up, termination and pull-down resistors. For 2-wire operation, the HD/FD jumper is set to HD and the 9099's RS485 parameter is set ON so the 9099 will not drive the RS-485 network when it is not transmitting a message.

Incoming serial data from the Modbus slave device is received, converted into TTL levels by the appropriate transceiver chip and applied to the UART in the ARM9 microprocessor. The received RTU packet is then checked for a valid CRC termination. If the received packet is valid, any data in the received message is converted into the correct format and placed in the output buffer where the data can be transferred out when the client requests them (analogous when a GPIB device is addressed to talk) Messages that contain errors or Exception messages cause the 9099 to set bits in the Questionable Register and to place an error value in the Modbus Error Register. Modbus TCP/IP responses are formatted into a Modbus TCP/IP packet and transmitted back to the Modbus master.

The 9099 contains a multilevel Status Byte Register and Event Register structure for each interface which enables the 9099 to generate a Service Request when errors are detected.

Flash Memory contains all of the 9099's program instructions, command tables, and power turn-on/self test routines. At power turn-on, the 9099 performs a self test on each functional block to determine whether there is a gross system failure. Any self test error is displayed as a pattern of blinking LEDs on the front panel. The error pattern is repeated until the unit is turned off. The RDY LED becomes solid on to indicate a successful completion of the self test routine.

The 9099's configuration settings, serial number and other parameters that are subject to change are saved in a nonvolatile Flash sector. At power on time, the microprocessor copies the saved configuration to RAM where they is used to operate the unit. Any changes made to the settings during run time are not stored in the Flash sector until the user sends the 9099 the *SAV 0 command. Changes made by a web browser are saved in Flash when the user presses the Update Flash button.

In the 9099, the RAM is a 32-bit wide memory that is used for running the active program, data storage, operating variables and configuration settings. The 9099 data buffers are mechanized as straight buffers because of the Modbus command-response protocol. The buffers are larger than any anticipated message so no data loss ever occurs.

The 9099's power supply is a switching regulator that converts a unregulated 9 to 32 volt DC input to +5 Vdc to run the 9099's internal logic chips. The +5 Vdc is down regulated to make 3.3 and 1.8 Vdc for the ARM processor and the supporting chips that run on 3.3 Vdc power. A DC-DC charge pump converter in the RS-232 transceiver IC makes ± 9 Vdc to operate the RS-232 drivers.

4.3 9009 DIFFERENCES

The 9009 is a PC board assembly designed to be mounted against the rear panel on the inside of the host chassis. The 9009 has two additional interfaces, GPIB and USB, which can be used to control the Modbus slave devices(s) along with the 9099's Ethernet interface. The GPIB interface acts like the VXI-11 protocol but has the ability to receive a SRQ when a Service request occurs. The USB interface has similar capabilities to raw socket protocol in that it can send 488.2, SCPI and Modbus commands and receive the corresponding responses.

4.3.1 9009 Block Diagram Description

Figure 4-3 shows a block diagram of the 9009. The 9009 has a similar block diagram and core components as the 9099 plus the additional GPIB and USB interfaces.

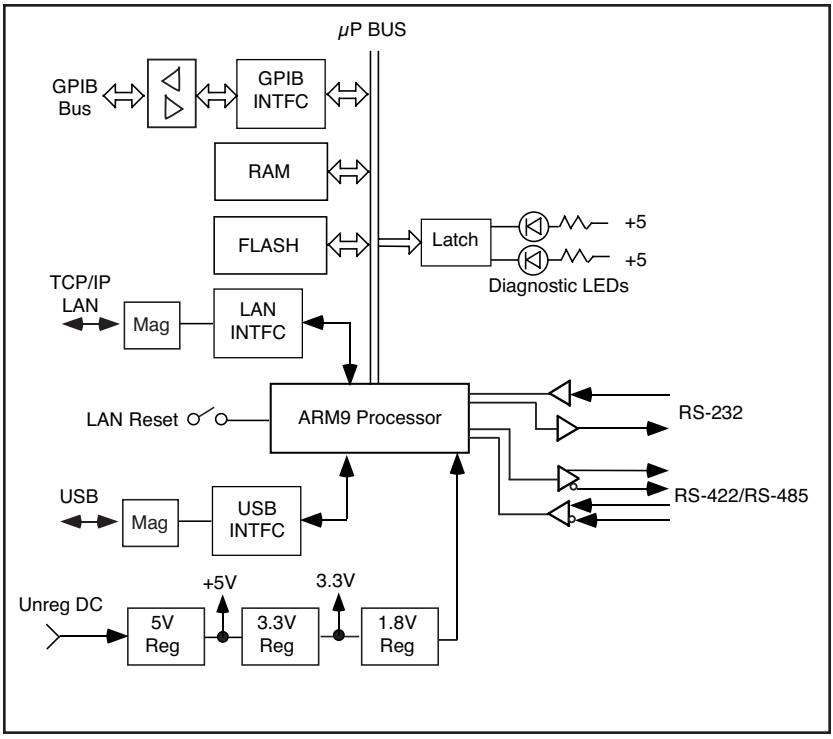

Figure 4-3 9009 Block Diagram

The GPIB interface uses industry standard GPIB bus transceivers and a 7210 type GPIB interface chip drive the GPIB bus with 5 Vdc signals. The 5 Vdc signals are buffered to prevent 5 Vdc from reaching the processor and memory chips.

The USB interface uses a USB to serial conversion chip that communicates serially with the processor at 115200 baud.

The 9009's accepts regulated 5 Vdc power or 5.5 to 15 Vdc unregulated power. The input power is passed thru a low dropout linear regulator with a 5 Vdc output. A jumper lets the user select the regulated or direct input DC power for the board. The resulting +5 Vdc power is down regulated to make 3.3 and 1.8 Vdc for the ARM9 processor and the supporting chips that run on 3.3 Vdc power. A DC-DC charge pump converter in the RS-232 transceiver IC makes ± 9 Vdc to operate the RS-232 drivers.

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5

Troubleshooting and Repair

5.1 INTRODUCTION

This section describes the maintenance testing, troubleshooting, and repair procedures for ICS's Model 9009 and 9099 Ethernet to Modbus RTU Interfaces. Any description or reference to the 9099 applies also to the 9009 unless otherwise noted.

5.2 MAINTENANCE

The 9009 and 9099 does not require periodic calibration and have no internal adjustments.

5.3 TROUBLESHOOTING

Troubleshooting is broken down into selftest errors and operating errors.

5.3.1 Self Test Errors

Self Test errors occur at power turn-on time. The 9099 indicates self- test errors by blinking one or more of its LEDs at a 2 Hz rate. Refer to paragraph 5.4 for more information about the Self-Test Errors. The Self Test error codes and their most likely causes are listed in Table 5-1

5.3.2 Operating Failures

Operating failures are those failures that occur while using a unit that has passed its power turn-on self test. Use the fault isolation information in Table 5-2 to narrow the problem down to a specific area. The majority of installation hookup faults can be fixed by following the table and making the suggested corrections to the installation wiring or to the application program.

Hardware failures after the unit has been properly installed and running can be isolated by substituting a known good unit in to the system. If the problem goes away, the fault lies with the removed board. Note the pin, signal or command that fails and contact ICS for repair information. See paragraph 5.9 for repair instructions. If the fault persists, check the wiring especially any flat ribbon cables for faulty or open connectors and the devices connected to the interface board for possible faults.

.

WARNING

If the fault isolation procedure requires internal measurements, always remove power when disassembling or assembling the unit. Use extreme caution during troubleshooting, adjustments, or repair to prevent shorting components and causing further damage to the unit.

5.4 SELF TEST ERROR CODES

At power turn on, the 9099 conducts a selftest of its major components. The test takes about 5 seconds. During the selftest the PWR LED is on and the RDY LED is off. The network LAN and ACT LEDs may be on during selftest. A successful test ends when the RDY LED on. Test failures are indicated by the blinking LED patterns shown in Table 5-1. If a self test failure occurs, turn the unit off for 10 seconds and turn power back on. If the failure persists, refer to paragraph 5.7 for repair instructions. Note that some of the failures could occur while the 9099 is running.

TABLE 5-1 9099 SELF TEST ERROR CODES

Card LEDs								Fault
RDY	LAN	ACT	RDY	TALK	LSTN	SQR	ERR	
⊕	–	–	–	–	–	–	–	fatal error (CPU, FLASH, RAM..etc.)
⊕	–	–	–	–	–	–	–	fatal error (power supply)
⊕	–	–	–	–	–	–	B	LAN IC, Network Socket Failure or DHCP. See 5.5
⊕	–	–	–	–	–	B	–	GPIB IC or GPIB Transceivers
⊕	–	–	–	–	–	B	B	Configuration Error or Flash Failure
⊕	–	–	–	–	B	–	–	OS Issued Exit
⊕	–	–	–	–	B	–	B	RAM IC or Memory overflow error
⊕	–	–	–	–	B	B	–	OS Error
⊕	–	–	–	–	B	B	B	Flash Error

Symbols: ⊕ = solid on, B = blinking

TABLE 5-2 TROUBLESHOOTING GUIDE

Symptom	Possible Fault	Action or Check
Unit will not turn on PWR LED off	Power supply not plugged in or on	Check for AC power at the power adapter.
	9009 missing jumper	W14 missing. Install per Section 2.7.
	Power on board	Check 5V (TP4) testpoint.
	3.3 volts missing	Check 3.3V (TP6) testpoint.
	1.8 volts missing	Check 1.8V (TP5) testpoint.
	Defective crystal	Check output of Y1 across resistor R6.
LEDs stuck on	Internal fault	Check TP4 (5V), TP6 (3.3 V) and TP5 (1.8V) for proper voltage.
	Defective unit	Return unit for repair.See 5.9.
Unit shows blinking LEDs at power turn-on	Self test fault	Refer to Self Test errors in Table 5-3.
No Network Activity	ACT LED never on	No network messages received. Check network router and gateways for proper settings.
		Wrong settings. PC and 9099's network setting must be in the same IP B or C
		Bad Ethernet cable. Try a different cable.
LAN LED off	No network	Check cable, switch or PC for proper operation.
	IP address changed	Unit in DHCP and may have been been given a new IP address by the DHCP server.

TABLE 5-2 TROUBLESHOOTING GUIDE

Symptom	Possible Fault	Action or Check
RDY LED Blinking	All sockets or links used.	Wait for the COMM timeout period or power cycle the unit if you are the only client connected to the unit. Check COMM_timeout setting to avoid this problem in the future.
No Modbus communication	Device Address	Check C setting and device address setting.
	Wrong serial settings	Check serial settings against modbus device settings.
	Wrong signal connections	Check cable wiring against the 9099 manual.
		Check 9099 internal jumper settings for correct signals.
	RS-485 missing network termination	W11 and W12 not installed. Install W11 and W12 jumpers.
	RS485 Mode wrong	Verify SCPI setup. RS485 must be on for 2-wire systems and off for 4-wire and RS-232 operation.
	Half-Full Duplex Error	W7 set wrong. Put in FD position for 4-wire signals, HD for 2-wire signals. Remove for RS-232 operation
	RS-232 not enabled	W13 missing. Install W13 for RS-232 operation. Remove W13 for RS-422 or RS-485 operation.
	Wiring error	Check RS-232 or RS-485 cable wiring against the wiring figures in Section 2. Modbus TXD signal must go to 90x9 receive input.

TABLE 5-2 TROUBLESHOOTING GUIDE

Symptom	Possible Fault	Action or Check
Modbus command fails	Wrong command or command syntax error	Recheck program. Query the ESR Register to check on the cause of the problem. Query the Modbus Error register to check on the cause of the problem.
	Wrong output value	Check Modbus device manual.
9099 unexpectedly drops socket connection	Auto-disconnect set on	Check 9099 settings and turn Auto-disconnect off.
	COMM_Timeout expired	9099 not accessed for a long time period. Extend 9099 COMM_Timeout period or add a background keepalive functon to the client program.
	Modbus TCP/IP faulty operation	Socket closed for no response from addressed device or for a faulty response.
9099 has to be reset often.	Program uses all 9099 resources	Check program for excess opening and closing of links. Rewrite program to keep links open until program ends. Note that opening and closing sockets and links is a time wasting operation and slows down your program. If possible, rewrite the program to avoid repeatedly opening and closing sockets and links.

TABLE 5-2 TROUBLESHOOTING GUIDE

Symptom	Possible Fault	Action or Check
9099 stops responding	Using Agilent IO Libraries	Agilent expects their instruments to disconnect when the link count goes to zero. Turn Auto-disconnect on for operation with Agilent VISA and programs.
	Program needlessly opens and closes links.	Note that opening and closing sockets and links is a time wasting operation and slows down your program. Rewrite the program to avoid repeatedly opening and closing sockets and links.

5.4 VXI-11 ERRORS

The 9099's ERR LED will blink when the unit detects a VXI-11 protocol or command error. These can be a command not appropriate for a VXI-11.3 instrument. Sometimes these are intentionally sent like when the Agilent IO Connection Expert is looking for VXI-11.2 and VXI-11.3 devices on the network. These types of errors should not occur when a test program is running. If the user is experiencing these errors when running a final program, use the ICS Error Logger to record the errors. Table 5-3 lists the VXI-11 Error Codes.

TABLE 5-3 VXI-11 ERRORS

Error	Meaning	Error	Meaning
0	No error	12	No lock held by this link
1	Syntax error	15	I/O timeout
3	Device not accessible	17	I/O error
4	Invalid link identifier	21	Invalid address
5	parameter error	23	Abort
6	Channel not established	29	Channel already established
8	Operation not supported		
9	Out of resources		
11	Device locked by another link		

5.6 REVERTING TO FACTORY SETTINGS

5.6.1 Factory Network Settings

The 9009 and 9099's network settings can be reset to the factory default settings listed in Table 1-2 by holding the rear panel LAN Reset Button in for approximately 10 seconds.

1. Connect the supplied AC adapter to the 9099 and to an AC power outlet. Connect the 9009 to a sutible DC power source.

2. Find a blunt non-metallic stick about 1/16 inch diameter (1.6 mm) that you can use to depress the rear panel LAN Reset button. (A wooden Q-tip handle works well.) You should be able to feel the Reset button move as you gently depress it.

3. Hold the Reset button depressed until the three front panel yellow LEDs blink. (Approximately 10 seconds)

5.6.2 Factory Serial I/O Configuration

The 9099's Serial IO configuration can be reset to the factory settings listed in Table 1-3 by sending the unit the CAL:DEFAULT command. The CAL:DEFAULT command resets the current values in RAM and saves them to Flash memory. CAL:DEFAULT does not change the network settings.

5.7 UPDATING THE FIRMWARE

The 9009 and 9099's firmware can be updated in the field without returning the unit to the factory.

1. Link to ICS Electronics website at http://www.icselect.com. Click on Downloads and select 90xx Product Updates. Locate the latest ICS_9099_ Update file. Download the .zip file to an temporary directory and unzip the file.

2. Connect the 9099 to a Windows PC as described in paragraph 2.6.1 and turn it on.

3. If the PC is already set to communicate with the 9099 skip this step. Else, disconnect the PC from your company network and change its Local Area Network setting to the 9099's static IP range as described in paragraph 2.6.1. If you do not know the 9099's IP address, reset it as described in paragraph 5.6.1.

4. Run the 9099 Update Utility that you just unzipped. If it will not run, download the Visual Basic 6 runtime package from ICS's website or copy it from the Support CD supplied with the 9099.

5. Enter the 9099's IP address in the IP Address window of the Update Program, highlight it and link to it.

6. Press the Prgm Flash button to start the update process. The three yellow LEDs (TALK, LSTN and SRQ) will blink while the new program is being downloaded. Follow the directions on the screen and re-link to the 9099 as required to complete the update process.

CAUTION
Do not exit the Update Program until told to do so. It will ask you to re- link to the unit twice to finish the update.

7. After exiting the Update Program, restore the PC's Local Area Network settings to their original values and restore its normal network connections.

5.8 SANITIZING PROCEDURE

The 9009 and the 9099 have the following memory elements:

RAM, 1 M x 16-bit memory
Flash, 2 M x 8-bit memory
Processor memory

The RAM and processor memory contents are lost when power is turned off. The Flash memory contents are held and restored to the system when power is applied to the unit. The 9099's flash contains one sector that holds user saved variables. The other sectors are used for the unit's firmware or are spare sectors for future program use. A user does not have access to the flash program or to the spare sectors.

The Flash memory variable sector can be restored to factory settings by performing the following steps:

1. If the PC is already set to communicate with the 9099 skip this step. Else, disconnect the PC from your company network and change its Local Area Network setting to the 9099's static IP range as described in paragraph 2.6.1. If you do not know the 9099's IP address, reset it as described in paragraph 5.6.1.

2. Use ICS's VXI11_kybd utility to link to the board. (See para 3.9)

3. Send the board the following commands with all capital letters:
   CAL:DATE UNCAL 'that is space and the word 'UNCAL'
   CAL:DEFAULT
   CAL:DATE mm-dd-yy 'use today's date

The RAM memory contents are lost when power is turned off for 30 seconds.

5.9 REPAIR PROCEDURE

Repair of the 9099 is done by the user or by returning the unit to the factory or to your local distributor. Units in warranty should **always** be returned to the factory or else repaired only after receiving permission to do so from an ICS customer service representative.

When returning a unit, a board assembly, or other products to ICS for repair, it is necessary to go through the following steps:

1. Contact the ICS customer service department and ask for a return material authorization (RMA) number. An ICS application engineer will want to discuss the problem at this time to verify that the unit needs to be returned, or to assist in correcting the problem. We have discovered that one-third of the difficulties customers call about can be resolved over the phone as opposed to returning a unit for repair.

2. Write a description of the problem and attach it to the material being returned. Describe the installation, system failure symptoms, and how it was being used. If the item being returned is a board assembly, describe how you isolated the fault to it. Include your name and phone number so we can call you if we have any questions. Remember, we need to locate the problem in order to fix it.

3. Pack the item with the fault description in a box large enough to accommodate a minimum of two inches of packing material on all four sides, the top, and the bottom of the box. Securely seal the box.

4. Mark the shipping label to the attention of the RMA#. The RMA number is very important since it is our way of identifying your unit in order to return it to you.

5. Ship the box to ICS freight prepaid. ICS does **not** pay freight to return the unit to ICS, but will prepay the freight to return the repaired item to you.

Appendix

A1

A1 VXI-11 Introduction

The VXI-11 Standard was created as a way to control instruments over a TCP/IP network. VXI-11 is the overall VXI-11 document and describes the network protocol. There are three sub-standards. VXI-11.1 is for a VXI chassis. The VXI-11.2 Standard is for an GPIB Instrument Gateway like ICS's Model 8065 or 9065 Ethernet-to-GPIB Controller. VXI-11.3 describes the control of LAN instruments and applies to ICS's 80xx and 90xx series Interfaces.

The VXI-11 protocol is based on the familiar IEEE-488 Standards and provides most of the command and functional capabilities found in a traditional GPIB instrument or system. VXI-11 commands include such familiar GPIB tasks as writing commands to or reading responses from an instrument, Selected Device Clear. Device Trigger (GET), set Remote or Local state (GTL), and Read Status Byte (Serial Poll). VXI-11 device command messages are similar to IEEE-488.2 messages in that can have a user embedded terminating character (linefeed) added to the end of the message and an End flag that can be asserted on the last character of the message. VXI-11 responses also adhere to the IEEE-488.2 Standard. ICS's 80xx series Interfaces follow all of the requirements in IEEE 488.2 Standard except where the difference between the TCP/IP-IEEE 488.2 Instrument Interface and IEEE 488.1 requires clarification. ICS's 80xx Interfaces also include an IEEE-488.2 Status Reporting Structure and SCPI Command Parser that are similar to those in ICS's GPIB Interfaces.

A1.1 IEEE 488.1 BUS

The IEEE Std 488 Bus, or GPIB as it is commonly referred to, provided a means of transferring data and commands between devices. The physical portion of the bus is not relevant to a VXI-11.3 Instrument but the message concepts are pertinent.

A.1.1.1 VXI-11 Relationship to IEEE-488.1

VXI-11.2 Gateways and VXI-11.3 Instruments are servers and respond to VXI-11 Remote Procedure Calls (RPCs) from the client application (program). The *device_write* and the *device_read* RPCs transfer Device-dependent messages which are used for device control and data transfer. Examples are IEEE-488.2 Common Commands, SCPI commands and other device dependent messages.

VXI-11.3 Instruments may act like talkers or listeners. **A** talker **sends device dependent messages, i.e., data, status. A** listener **accepts interface messages, bus commands and device-dependent messages, i.e., setup commands, data.**

VXI-11.3 Instruments are addressed by their IP addresses. They then are connected to by opening a socket connection to them. Finally a link is made to the Instrument Interface inside the VXI-11.3 Instrument. Each VXI-11.3 Instrument contains at least one Instrument Interface referred to as *inst0*. VXI-11.3 Instruments may have multiple Instrument Interfaces for sub-functions similar to the dual primary or secondary address capability in GPIB devices. These additional Instrument Interfaces are referred to as *inst1* to *instN*. The links are created and destroyed by the *create_link* and *destroy_link* RPCs.

VXI-11.3 Instruments have a remote/local capability that is controlled by the device_remote and device_local RPCs. This is equivalent to a GPIB device operation with the REN line and the LLO and GTL commands.

VXI-11.3 Instruments have the ability to generate Service Requests similar to SRQs in a GPIB device. The VXI-11.3 Instrument does this by acting as a client and sending the *device_intr_srq* RPC to a service running on the same computer with the client application. The service then handles the interrupt and often generates a flag for the client indicating what device wanted service. The user's client application can then Serial Poll the VXI-11.3 Instrument with the *device_readstb* RPC to learn the cause of the Service request.

VXI-11.3 Instruments respond to a Selected Device Clear message when they receive the *device_clear* RPC.

VXI-11.3 Instruments respond to a Device trigger message when they receive the *device_trigger* RPC. The instrument's response is conditioned by the SCPI INST and ABORT commands if they are supported by the Instrument.

VXI-11.3 Instruments have no equivalent functions for the following GPIB interface messages: SPE, SPD, PPC and PPU.

A.1.1.2 Additional VXI-11.3 Functions

VXI-11.3 Instruments have three additional functions not related to the GPIB bus or to the IEEE-488.1 Standard. They are:

The *device_abort* RPC causes the instrument to abort any operation associated with the link that sent the RPC.

The device_lock and device_unlock RPCs causes the instrument to block access to the instrument from other links while locked.

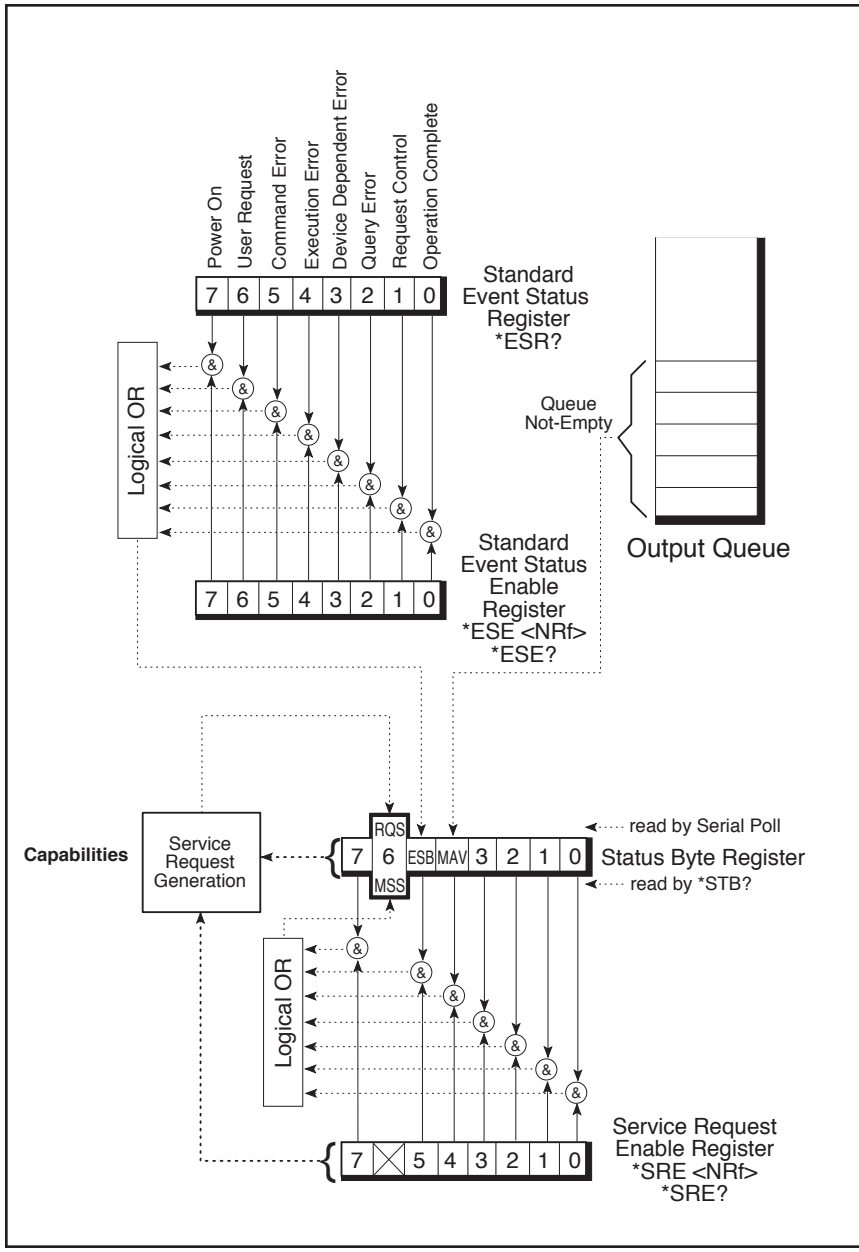

Figure A-1 488.2 Required Status Reporting Capabilities

A1.2 IEEE 488.2 STANDARD

A1.2.1 IEEE 488.2 Message Formats

The IEEE 488.2 Standard was established in 1987 to standardize message protocols, status reporting and define a set of common commands for use on the IEEE 488 bus. A VXI-11.3 TCP/IP-IEEE 488.2 Instrument Interface and its associated instrument follows all the requirements in IEEE 488.2 except where the difference between the TCP/IP-IEEE 488.2 Instrument Interface and IEEE 488.1 requires clarification.

IEEE 488.2 devices are supposed to receive messages in a more flexible manner than they send. A message sent from GPIB controller to GPIB device is called: PROGRAM MESSAGE. A message sent from device to controller is called: RESPONSE MESSAGE. As part of the protocol standardization the following rules were generated:

(;) Semicolons are used to separate messages.
(:) Colons are used to separate command words.
(,) Commas are used to separate data fields.
<nl> Line feed and/or EOI on last character terminates a 'program message'. Line feed (ASCII 10) and EOI terminates a RESPONSE MESSAGE.
(*) Asterisk defines a 488.2 common command.
(?) Ends a query where a reply is expected.

A1.2.2 IEEE 488.2 Reporting Structure

With IEEE 488.2, status reporting was enhanced from the simple serial poll response byte in IEEE 488.1 to the multiple register concept shown in Figure A-1. The IEEE 488.2 Standard standardized the bit assignments in the Status Byte Register, added eight more bits of information in the Event Status Register and introduced the concept of summary bits reporting to the Status Byte Register. The Status and Event registers have enabling registers that can control the generation of their summary reporting bits and ultimately SRQ generation. Each 488.2 device must implement a Status Byte Register, a Standard Event Status Register and an Output Message Queue as a minimum status reporting structure. A device may include any number of additional condition registers, event registers and enabling registers providing they follow the model shown in Figure A-1.

TABLE A-1 IEEE 488.2 COMMON COMMANDS

Required common commands are:

***CLS**	Clear Status Command
***ESE**	Standard Event Status Enable Command
***ESE?**	Standard Event Status Enable Query
***ESR?**	Standard Event Status Register Query
***IDN?**	Identification Query
***OPC**	Operation Complete Command
***OPC?**	Operation Complete Query
***RST**	Reset Command
***SRE**	Service Request Enable Command
***SRE?**	Service Request Enable Query
***STB?**	Status Byte Query
***TST?**	Self-Test Query
***WAI**	Wait-to-Continue Command

Devices that support parallel polls must support the following three commands:

***IST?**	Individual Status Query?
***PRE**	Parallel Poll Register Enable Command
***PRE?**	Parallel Poll Register Enable Query

Devices that support Device Trigger must support the following commands:

***TRG**	Trigger Command

Controllers must support the following command:

***PCB**	Pass Control Back Command

Devices that save and restore settings support the following commands:

***RCL**	Recall configuration
***SAV**	Save configuration

Devices that save and restore enable register settings support the following commands:

***PSC**	Saves enable register values and enables/disables recall
***PSC?**	PSC value query

A1.2.3 IEEE 488.2 Common Commands

The IEEE 488.2 Standard also mandated a list of required and optional Common Commands that all 488.2 devices could support. All of the Common Commands start with an asterisk. Commands that end with a question mark are queries. Query responses can be an ASCII number or an ASCII string. Other numerical formats are legal as long as the device supports the required ASCII format. Table A-1 lists the IEEE 488.2 Common Commands.

A1.2.4 IEEE 488.2 Differences From IEEE 488.1

The user who is familiar with the older 488.1 devices should take the following differences into account when programming a 488.2 device.

A 488.2 device outputs the Status Byte Register contents plus the RQS bit in response to a serial poll. The RQS bit is reset by the serial poll. The same 488.2 device outputs the Status Byte Register contents plus the MSS bit in response to a *STB? query. The MSS bit is cleared when the condition is cleared.

488.2 restricts the Device Clear to only clearing the device's buffers and pending operations. It does not clear the Status Reporting Structure or the output lines. Use *CLS to clear the Status Structure and *RST or *RCL to reset the outputs.

488.2 commands are really special data messages and are executed by the device's parser. Always allow sufficient time for the parser to execute the commands before sending the device a 488.1 command. i.e. a Device Clear sent too soon will erase any pending commands and reset the parser.

Enable Register values are only saved and restored if the *PSC command is 0. A *PSC command of 1 causes zeros to be loaded into the enable registers when the unit is next reset or powered on.

A1.3 SCPI COMMANDS

A1.3.1 Introduction

SCPI (Standard Commands for Programmable Instruments) builds on the programming syntax of 488.2 to give the programmer the capability handling a wide variety of instrument functions in a common manner. This gives all instruments of the same type a common "look and feel".

SCPI commands use common command words defined in the SCPI specification. Control of any instrument capability that is described in SCPI shall be implemented exactly as specified. Guidelines are included for adding new defined commands in the future as new instruments are introduced without causing programming problems.

SCPI is designed to be laid on top of the hardware - independent portion of the IEEE 488.2 and operates with any language or graphic instrument program generators. The obvious benefits of SCPI for the ATE programmer is in reducing the learning time on how to program multiple SCPI instruments since they all use a common command language and syntax.

A second benefit of SCPI is that its English like structure and words are self documenting, eliminating the needs for comments explaining cryptic instrument commands. A third benefit is the reduction in programming effort to replace one manufacturer's instrument with one from another manufacturer, where both instruments have the same capabilities.

This consistent programming environment is achieved by the use of defined program messages, instrument responses and data formats for all SCPI devices, regardless of the manufacturer.

A1.3.2 Command Structure and Examples

SCPI commands are based on a hierarchical structure that eliminates the need for most multi-word mnemonics. Each key word in the command steps the device parser out along the decision branch - similar to a squirrel hopping from the tree trunk out on the branches to the leaves. Subsequent keywords are considered to be at the same branch level until a new complete command is sent to the device. SCPI commands may be abbreviated as shown by the capital letters in Figure A-2 or the whole key word may be used when entering a command. Figure A-2 shows some single SCPI commands for setting up and querying a serial interface.

```
SYSTem:COMMunicate:SERial:BAUD 9600 <nl>
                                    'Sets the baud rate

SYST:COMM:SER:BAUD? <nl>            'Queries the current
                                    baud setting

SYST:COMM:SER:BITS 8 <nl>           'Sets character format
                                    to 8 data bits
```

Figure A-2 SCPI Command Examples

Multiple SCPI commands may be concatenated together as a compound command using semi colons as command separators. The first command is always referenced to the root node. Subsequent commands are referenced to the same tree level as the previous command. Starting the subsequent command with a colon puts it back at the root node. IEEE 488.2 common commands and queries can be freely mixed with SCPI messages in the same program message without affecting the above rules. Figure A-3 shows some compound command examples.

```
SYST:COMM:SER:BAUD 9600; BAUD? <nl>

SYST:COMM:SER:BAUD 9600; :SYST:COMM:SER:BITS 8
<nl>

SYST:COMM:SER:BAUD 9600; BAUD?; *ESR?; BIT 6; BIT?;
PACE XON; PACE?; *ESR?<nl>
```

Figure A-3 Compound Command Examples

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A typical response would be: 9600; 0; 8; XON; 32 <nl>

The response includes five items because the command contains 5 queries. The first item is 9600 which is the baud rate, the second item is ESR=0 which means no errors (so far). The third item is 8 (bit/word) which is the current setting. The BIT 6 command was not accepted because only 7 or 8 are valid for this command. The fourth item XON means that XON is active. The last item is 32 (ESR register bit 5) which means execution error - caused by the BIT 6 command.

A1.3.3 Variables and Channel Lists

SCPI variables are separated by a space from the last keyword in the SCPI command. The variables can be numeric values, boolean values or ASCII strings. Numeric values are typically decimal numbers unless otherwise stated. When setting or querying register values, the decimal variable represents the sum of the binary bit weights for the bits with a logic '1' value. e.g. a decimal value of 23 represents 16 + 4 + 2 + 1 or 0001 0111 in binary. Boolean values can be either 0 or 1 or else OFF or ON. ASCII strings can be any legal ASCII character between 0 and 255 decimal except for 10 which is the Linefeed character.

Channel lists are used as a way of listing multiple values. Channel lists are enclosed in parenthesis and start with the ASCII '@' character. The values are separated with commas. The length of the channel list is determined by the unit. A range of values can be indicated by the starting and stopping values separated by a colon.

```
(@1,2,3,4)          'lists sequential values
(@ 1:4)        'shows a range of sequential values
(@ 1,5,7,34)        'lists random values
```

Figure A-4 Channel List Examples

A1.3.4 Error Reporting

SCPI provides a means of reporting errors by responses to the SYST:ERR? query. If the SCPI error queue is empty, the unit responds with 0, "No error" message. The error queue is cleared at power turn-on, by a *CLS command or by reading all current error messages. The error messages and numbers are defined by the SCPI specification and are the same for all SCPI devices.

A1

A1.3.5 Additional Information

For more information about SCPI refer to the SCPI Standard or to the SCPI section in any SCPI compatible instrument manual.

A2 VXI-11 PROTOCOL AND EXAMPLE PROGRAM

This Appendix describes the VXI-11 Protocol, its applicability to ICS's 80xx series Interfaces and includes a C language VISA program.

The VXI-11 protocol uses Remote Procedure Calls (RPC) that provides an invisible communication medium allowing the developer to concentrate on his program. Remote Procedure Calls are requests sent from a client, such as the user's program, to a remote server to carry out the instruction. Responses are returned to every RPC so the client can be sure the request was accomplished.

Windows users can use VXI-11 compliant VISA libraries like those from National Instruments or Agilent that include the capability to make RPC calls VXI-11.3 Instruments like ICS's 80xx Interfaces. That way, VXI-11.3 Instruments can be programmed with familiar graphical applications like LabView or VEE. Both applications call a VISA layer that makes VXI-11 calls over the TCP/IP network. C and Visual Basic programs can be written with SICL or VISA calls to control VXI-11.3 Instruments.

Linux, UNIX or any other flavor of UNIX like SunOS, IBM-AIX, HP-UX, or Apple's OS X, can communicate with the VXI-11.3 Instruments through either with RPC over TCP/IP. The VXI-11 Specification, available at http://www.vxibus.org or from ICS Electronic's website, includes a RPCgen header file listing that can be used to generate RPC calls. RPC calls can be used with virtually any operating system that has TCP/IP communication capability and a RPCgen utility. Refer to ICS's Application Notes APB80-3 for more information about RPC Programming.

Java users can write RPC applications that run on nearly all computer platforms with the Java library from jGPIBenet project on SourceForge. Refer to ICS's Application Notes for detailed information on programming VXI-11 devices.

A2.1 Sockets, Channels and Links

VXI-11 devices, like ICS's 80xx and 90xx series Interfaces, use a socket connection for bi-directional communication with a client which is the application program running in a computer. Sockets maybe thought of as pipes that support multiple links. After the socket connection is established, the client must establish a link to the instrument to communicate with it.

ICS's 80xx and 90xx series Interfaces have 15 sockets for connection with multiple clients at a time and a 16th socket for UDP communication. UDP protocol may be used initially when the client scans for a VXI-11 server. The

TCP/IP socket communication is used when the client links to the unit. The 80xx and 90xx only supports VXI-11 commands via TCP and not via UDP.

The initial socket connection to an VXI-11 Instrument establishes the Core channel which can handle multiple device links and locks. The client can create an Abort channel to clear Core channel command hangups. The Abort channel uses an additional TCP/IP socket. An Interrupt channel can be created from the instrument, with the instrumentacting as an RPC client, to notify the application that a Service Request (SRQ) has occurred. Interrupt channels share a separate TCP/IP socket that does not count as one of the 15 Core or Abort sockets. If the unit runs out of resources (sockets, links or locks), it blinks its RDY LED until the shortage has been cured, typically by a socket or channel timeout.

The user normally links to the device's *inst0* instrument interface. Interface *inst0* is typically used for all configuration and data transfer commands. Once the link is made to *inst0*, the client can communicate with, control and query the 80xx just as he would do with a standard GPIB test program. The client can lock the link so that no other client can communicate with that instrument until he is finished with it. Locking is only recommended if the device connection is such that it could be operated by another user. Some VXI-11.3 instruments have additional interfaces, *inst1* to *instn*, that are used for other purposes. An example is the 8063 which uses *inst1* for transparent data transfer.

Sockets should be closed gracefully to prevent the VXI-11 Instrument from running out of resources. Graceful socket closure requires several socket layer messages between the client and server sockets. Most socket close commands just ask the operating system to close the socket. The sockets often stay open for tens of minutes until the operating system gets around to closing them. The best way to close a socket is to do an immediate graceful socket closure instead of just letting the operating system close the socket at some later time. Note that if a connection is broken while one of its links is locked, the link stays locked until either the broken connection is detected (by COMM_Timeout or KeepAlive) or the unit is power cycled. Reconnecting from the same client does not allow unlocking since the new connection is through a different socket. The new socket has its own channels, links and locks and cannot manipulate resources owned by another socket.

Two broken link discovery methods are COMM_Timeout and KeepAlive. The COMM_Timeout setting allows the VXI-11 device to recover channels that have not had any client activity for a set period of time. The KeepAlive setting allows the VXI-11 device to test the client socket connection on a periodic basis. When the device closes a socket, the socket and all of its resources (links and locks) become available to another client.

COMM_Timeout can be set to a low period like 3-5 minutes for quick socket recovery when the user is first debugging a program and tends to breakout of the program without properly closing the sockets. Later, with a finished program, extend the time to hours to avoid prematurely closing the socket when not communicating with the unit. Hard wired systems are pretty dependable and the user can safely extend COMM_Timeout to several hours or to even days. Do not set COMM_Timeout to 0, which disables the timeout, unless there is a way to physically reset the unit if it runs out of resources. A temporary setting of 0 is useful when debugging third party software.

A2.2 Auto-disconnect

Agilent Instruments have a non-standard behavior that closes (aborts) a socket whenever the link count goes to zero. This behavior is non-standard because the VXI-11 Specification and RPC only expect the client to close a socket. Some Agilent IO library programs rapidly open and close sockets when attempting to discover instruments or perform other functions. This quickly exhausts all of a VXI-11 device's resources because of the operating system's lag in closing sockets. To overcome this problem, ICS's VXI-11 Interfaces have a Auto-disconnect function that can be enabled for use with Agilent IO libraries programs that expect this behavior.

A2.3 Service Requests (SRQs)

VXI-11 Instruments can generate Service Requests in a fashion similar to the SRQ generation in a GPIB device. Instead of asserting the GPIB SRQ line, ICS's VXI-11.3 Instruments generate a Service Request message, *device_intr_SRQ*, when the RQS bit in the Status Byte Register becomes true. Service Requests (SRQs) are sent through a Reverse Interrupt Channel to alert the application that an event has occurred and/or that the device needs service. One method of handling this is for the user to set up a separate task in the program that can receive the message with the id key string (handle) and set a flag. The task will be a one-way RPC service that only has to receive a message and should not reply to the VXI-11 Interface. During the setup, the instrument is given the PC's IP address and initial port number. An RPC service is installed in the PC. The creation of the RPC service will provides the port number since the RPC handler will establish the TCP listening socket. The IP address can be obtained through a socket call, but it does require the user to know which NIC to use (remember that a PC can have multiple Ethernet NIC ports) which may require a configuration setup for the application. Refer to ICS's Application Note AB80-4 for more detailed information on RPC SRQ programming and interrupt handling.

A2.4 Transferring Data

ICS's 80xx and 90xx Interfaces normally transfer small amounts of data so there are no data transfer problems. However, when reading, the user should not limit the amount of data in a read operation unless the Interface specifically allows it. Otherwise, the unread data will be discarded.

NB In 80xx devices, Reading 10 bytes in a 22 byte data message will result in the loss of the last 12 bytes.

The 80xx and 90xx series Interfaces have a *maxRecvSize* of 1024 bytes that limits the amount of the data that can be transferred in device_write RPC operation. *maxRecvSize* is the last parameter returned when the link is created to the 80xx by the create_link function.

The user can transfer larger amounts of data or long commands to the interface by dividing the data size by the *maxRecvSize* and then sending *maxRecvSize* blocks of data until all of the data has been transferred. The device_write function has a flags parameter which is used to determine whether an END indicator (EOI) shall be set at the completion of the write operation. The END indicator (EOI) is only asserted on the last packet. The interface does not terminate a write operation until it receives a packet with the end condition set.

Reading large amounts of data from a GPIB device works the same way. The interface does not terminate a read operation until the end condition is met. There is no readdressing of the GPIB device between packets when multiple packets are used to transfer large amounts of data. The client can request a read of more than the maxRecvSize number of bytes but the inerface will only send a packet with 1024 bytes and with no reason bits set if there is more data to be sent. The client continues reading packets until it receives a packet with one or more reason bits set. See VXI-11 Rule B.6.23.

A2.5 An Example VISA Program

VXI-11.3 Instruments like the 80xx and 90xx series Interfaces can be programmed by making calls to a VISA library. VISA calls are currently the easiest way to program VXI-11.3 Instruments in a Windows environment. The following C language example applies to all VXI-11 compliant VISA libraries.

```
// Program:
//    The purpose of this program is to perform a continuous temp
//    query of a Watlow device using a VISA resource. Pass in the
//    VISA resource name via the command line. The easiest is to use
```

```
//      a VISA alias. Otherwise use a fully qualified VISA
//      resource. The VISA resource can be a GPIB, TCP/IP, or some
//      other resource. If a Watlow temp response can be obtained,
//      the response will be printed to the console.
//
// Fully Qualified VISA Resource name examples:
//      GPIB0::4::INSTR
//      TCPIP::localhost::gpib0,4::INSTR
//
// Notes:
//      1. To compile/link requires the VISA.H and VISA32.LIB files be
//         accessible. Normally the default directories would be
//         setup to include these.
//      2. If an error happens, the program will print the error condition
//         and then return an ERRORLEVEL of 1. If no error, the program
//         will print the temp every 10 seconds.

#include <windows.h>
#include <winbase.h>
#include <stdio.h>
#include <visa.h>
main (int argc, char *argv[])
   {
   int         retval, length, temp;
   char        *cp, result[1024];
   ViStatus    status;
   ViSession   rmSession, devSession;

   if (argc != 2)
      {
      printf ("Specify the VISA resource to use. This may be\n");
      printf ("either a fully defined VISA resource, or it may be a\n");
      printf ("VISA alias.\n");
      exit (1);
      }
   // Before we use any VISA fuctions, we must first open the
   // Resource Manager so it will initialize the VISA layer.
   if (viOpenDefaultRM (&rmSession) != VI_SUCCESS)
      {
      printf ("Unable to open a Resource Manager session\n");
      exit (1);
      }
   status = viOpen (rmSession, argv[1], VI_NULL, 1000, &devSession);

   if (status != VI_SUCCESS)
      {
      printf ("Unable to open a session with %s\n", argv[1]);
      retval = 1;
      }
   else
      {
      for (;;)
         {
```

Figure A-5 Example VISA Program

```
        status = viWrite (devSession, "R? 100,1", 8, &length);

        if (status != VI_SUCCESS)
           {
           printf ("Unable to send a temp query to %s\n", argv[1]);

           retval = 1;
           break;
           }
        else
           {
           status = viRead (devSession, result, sizeof(result), &length);

           if (status != VI_SUCCESS)
              {
             printf ("Error reading the temp query response from %s\n", argv[1]);
              retval = 1;
              break;
              }
           else
              {
              // Null terminate the received string since he viRead does not
              // auto-magically Null terminate the data. Note that this will
              // not remove the \n if one is included in the result string.
              result [length] = '\0';

              // If the result string contains a \n character, terminate the
              // string at that point - replacing the \n with a Null.
              cp = strchr (result, '\n');
              if (cp)
                 *cp = '\0';
              // Convert the response to a tempature
              sscanf (result, "%d", &temp);

              printf ("Temp: %d.%d\r", temp / 10, temp % 10);

              // Now pause for 10 seconds
              Sleep (10 * 1000);
              }
           }
        }
     }
// Close the Resource Manager now that we're done with using VISA.
viClose (rmSession);
return (retval);
}
```

Figure A-5 Example VISA Program Cont'd

A3 VXI-11 RPC PROTOCOL

The information about the RPC Protocol in Section C is reprinted from the VXI-11 Specification. Consult the VXI-11 Specification for more information about using the VXI-11 RPC Protocol.

A. Definitions

Channel A channel is a logical communication path. All client/server connections must have a Core Channel. In addition a client may establish an Abort Channel and a Reverse Channel.

Link A link is a virtual connection between the client and a named resource. All functions operate via a link ID.

Lock A mutex lock can be set to claim exclusive usage of a resource. While a resource is locked the only access is via the link ID used to lock the resource must be unlocked to allow access of the resource via other link IDs.

Gateway A VXI-11.2 device that executes VXI-11 functions or network instrument messages to communicate GPIB devices.

Instrument Here a device connected via a GPIB bus or with a LAN interface.

Client A client is the application on the computer. The client typically uses an I/O library (such as VISA, or an RPC package) to communicate with the Gateway or Instrument..

Server The gateway or instrument that responds to VXI-11.2 or VXI-11.3 functions or network instrument mesages.

B. Basic RPC Programming

The following steps are the general steps to create an RPC program.

1. Obtain the man page for RPC on your system. If it is not available, confirm that you have RPC installed. Many systems do not have RPC installed since it is frequently considered an option. The man page gives an overview of RPC usage and will usually provide information on additional resources such as “rpcgen”.

2. Obtain the AB80-3 application note from the ICS website. Study this application note, but do understand that it is intended as an overview and is not detailed. In the summary section you will note several URL references for detailed RPC information. Skim through them to determine what information is available should it be needed.

3. Obtain the VXI-11 RPCL from either the last 2-3 pages of the VXI-11 base specification or from paragraph C in this Appendix. This needs to be copy/pasted into a text file which will be fed into the rpcgen utility.

4. Use your system's rpcgen tool to process the VXI-11 RPCL definition file you created in step-3. The result should be a .H and .C pair of files. These files will be used by your client application to perform VXI-11 functions.

5. Study the VXI-11 functions as defined in the VXI-11 specification. In particular study the create_link, device_write and device_read. These are the core instructions required to do simple communication with a VXI-11 device.

6. Create a simple program to execute the following steps. Following the last step, you should have an IDN reply from the VXI-11 Device. The IDN reply provides an ASCII string defining the instrument model information.

a) Initialize the RPC layer.
b) Execute a create_link to the 80xx or 90xx.
c) Execute a device_write of "*IDN?" to the 80xx.
d) Execute a device_read from the 80xx or 90xx.

C VXI-11 RPCL

An ONC RPC protocol is described using RPCL. This section contains the complete listing of the protocols for the core, abort, and interrupt channels.

RULE C.1:
A network instrument host SHALL implement the following RPCL constructs.

C.1 Core and Abort Channel Protocol

```
/* Types */
typedef long Device_Link;
enum Device_AddrFamily {            /* used by interrupts */
DEVICE_TCP,
DEVICE_UDP
};
```

```
typedef long Device_Flags;              /* Error types */
typedef long Device_ErrorCode;
struct Device_Error {
Device_ErrorCode error;
};

struct Create_LinkParms {
long clientId;                          /* implementation specific value */
bool lockDevice;                        /* attempt to lock the device */
unsigned long lock_timeout;             /* time to wait on a lock */
string device<>;                        /* name of device */
};

struct Create_LinkResp {
Device_ErrorCode error;
Device_Link lid;
unsigned short abortPort;               /* for the abort RPC */
unsigned long maxRecvSize;              /* specifies max data size in bytes
};                                      device will accept on a write */

struct Device_WriteParms {
Device_Link lid;                        /* link id from create_link */
unsigned long io_timeout;               /* time to wait for I/O */
unsigned long lock_timeout;             /* time to wait for lock */
Device_Flags flags;
opaque data<>;                          /* the data length and the data
};                                      itself */

struct Device_WriteResp {
Device_ErrorCode error;
unsigned long size;                     /* Number of bytes written */
};

struct Device_ReadParms {
Device_Link lid;                        /* link id from create_link */
unsigned long requestSize;              /* Bytes requested */
unsigned long io_timeout;               /* time to wait for I/O */
unsigned long lock_timeout;             /* time to wait for lock */
Device_Flags flags;
char termChar;                          /* valid if flags & termchrset */
};

struct Device_ReadResp {
Device_ErrorCode error;
long reason;                    /* Reason(s) read completed */
```

```
opaque data<>;                          /* data.len and data.val */
};

struct Device_ReadStbResp {
Device_ErrorCode error;                 /* error code */
unsigned char stb;                      /* the returned status byte */
};

struct Device_GenericParms {
Device_Link lid;                /* Device_Link id from connect call */
Device_Flags flags;                     /* flags with options */
unsigned long lock_timeout;             /* time to wait for lock */
unsigned long io_timeout;               /* time to wait for I/O */
};

struct Device_RemoteFunc {
unsigned long hostAddr;                 /* Host servicing Interrupt */
unsigned short hostPort;                /* valid port # on client */
unsigned long progNum;                  /* DEVICE_INTR */
unsigned long progVers;                /* DEVICE_INTR_VERSION */
Device_AddrFamily progFamily;     /* DEVICE_UDP | DEVICE_
};                                      TCP  */

struct Device_EnableSrqParms {
Device_Link lid;
bool enable;                            /* Enable or disable interrupts */
opaque handle<40>;                      /* Host specific data */
};

struct Device_LockParms {
Device_Link lid         ;               /* link id from create_link */
Device_Flags flags;                     /* Contains the waitlock flag */
unsigned long lock_timeout;             /* time to wait to acquire lock */
};

struct Device_DocmdParms {
Device_Link lid;                        /* link id from create_link */
Device_Flags flags;                   /* flags specifying various options */
unsigned long io_timeout;             /* time to wait for I/O to complete */
unsigned long lock_timeout;           /* time to wait on a lock */
long cmd;                             /* which command to execute */
bool network_order;                   /* client's byte order */
long datasize;                        /* size of individual data elements */
opaque data_in<>;                      /* docmd data parameters */
};
```

```
struct Device_DocmdResp {
Device_ErrorCode error;                    /* returned status */
opaque data_out<>;                         /* returned data parameter */
};

program DEVICE_ASYNC{
version DEVICE_ASYNC_VERSION {
Device_Error device_abort (Device_Link) = 1;
} = 1;

} = 0x0607B0;
program DEVICE_CORE {
version DEVICE_CORE_VERSION {
Create_LinkResp create_link (Create_LinkParms) = 10;
Device_WriteResp device_write (Device_WriteParms) = 11;
Device_ReadResp device_read (Device_ReadParms) = 12;
Device_ReadStbResp device_readstb (Device_GenericParms) = 13;
Device_Error device_trigger (Device_GenericParms) = 14;
Device_Error device_clear (Device_GenericParms) = 15;
Device_Error device_remote (Device_GenericParms) = 16;
Device_Error device_local (Device_GenericParms) = 17;
Device_Error device_lock (Device_LockParms) = 18;
Device_Error device_unlock (Device_Link) = 19;
Device_Error device_enable_srq (Device_EnableSrqParms) = 20;
Device_DocmdResp device_docmd (Device_DocmdParms) = 22;
Device_Error destroy_link (Device_Link) = 23;
Device_Error create_intr_chan (Device_RemoteFunc) = 25;
Device_Error destroy_intr_chan (void) = 26;
} = 1;

} = 0x0607AF;
```

C.2 Interrupt Protocol

```
/* Types */
struct Device_SrqParms {
opaque handle<>;
};

program DEVICE_INTR {
version DEVICE_INTR_VERSION {
void device_intr_srq (Device_SrqParms) = 30;
}=1;

}= 0x0607B1;
```

A4 ICS CONFIGURATION RPC PROTOCOL

The following document describes ICS's Configuration RPC Protocol. This information is supplied to enable a RPC programmer to configure ICS 80xx and 90xx devices with RPC commands.

A4.1 INTRODUCTION

This document defines the configuration interface to ICS devices (hereafter referred to as the Edevice). The purpose of this document is to allow the communication between the controlling computer and the Edevice, for the purposes of modifying the operational characteristics of the Edevice. Edevices are ICS products whose Model number is in the 80xx and 90xx range. Note that not all commands are supported by all Edevices.

A4.2 SCOPE

This specification addresses the Edevice communication for the purposes of operational configuration.

This specification is to be considered an addendum to the VXI-11 specification for communication to the VXI-11 compliant ICS Edevice Interfaces. The Edevice follows the VXI-11.2 and/or VXI-11.3 specifications.

It is assumed the reader is conversant with ONC/RPC and XDR specifications as published by Sun Microsystems. All client/Edevice communication is performed through ONC/RPC and thus requires knowledge of both (ONC/RPC and XDR) specifications. In addition, it is assumed the reader is conversant with the VXI-11 and VXI-11.2 specifications as published by the VXIbus Consortium. In some cases, the reader will require an understanding of the GPIB (IEEE-488) specification as published in the IEEE Standards.

A4.3 SPECIFICATION OBJECTIVES

This specification has the following objectives:
1. To enable the creation of tools to perform Edevice configuration.
2. To enable applications to perform temporary modifications to the Edevice configuration.
3. To define the ONC/RPC protocol used by the Edevice configuration.

A4.4 REFERENCES

[1] IEEE Std 488.1-1987, IEEE Standard Digital Interface for Programmable Instrumentation.
[2] IEEE Std 488.2-1992, IEEE Standard Codes, Formats, Protocols, and Common Commands For Use With IEEE Std 488.1-1987, IEEE Standard Digital Interface for Programmable Instrumentation.
[3] XDR: External Data Representation Standard, Request for Comments 1014, Sun Microsystems, DDN Network Information Center, SRI International, June, 1987.
[4] RPC: Remote Procedure Call Protocol Specification, Request for Comments, 1057, Sun Microsystems, DDN Network Information Center, SRI International, June, 1988.

B EDEVICE CONFIGURATION PROTOCOL

The Edevice Configuration protocol uses the ONC remote procedure call (RPC) model. This model allows an application executing on one computer to conceptually call a function on another computer.

The client identifies the remote procedure by means of a program ID, program version, and procedure number. This information is encoded into an RPC communication packet with the procedure argument values. The message is then sent to the RPC service running on the server device, where the target procedure is then executed. The server is required to respond to all procedure calls with an RPC reply message containing any/all procedure return values.

Table B.1 lists the RPC messages used by the Edevice configuration protocol. Messages that apply to a specific device are marked by an 'x' in the device column. Section C provides detailed descriptions of each Configuration Message. Section D provides a summary RPCL listing for use with rpcgen utilities.

B.1 PROTOCOL BEHAVIOR

The client shall issue an RPC command to the Edevice directing the action to be taken. The Edevice shall attempt to execute the action and will then reply with an RPC reply.

All configuration messages pertaining to values or modes shall contain an Action boolean indicating whether the action is to be a read of the current setting or a modification of the current setting. Edevice default values are listed in Section 1 of this manual.

TABLE B CONFIGURATION RPC MESSAGES

Message	ID	Description	9099 Req'd	Reboot
interface_name	1	VXI-11 logical name	X	No
rpc_port_number	2	RPC TCP port		
core_port_number	3	VXI-11 core TCP port		
abort_port_number	4	VXI-11 abort TCP port		
config_port_number	5	configuration TCP port		
comm_timeout	6	TCP timeout	X	No
hostname	7	Edevice TCP hostname		
static_ip_mode	8	static/dynamic IP	X	Yes
ip_number	9	network IP number	X	Yes
netmask	10	network netmask	X	Yes
gateway	11	network gateway	X	Yes
keepalive	12	keepalive time	X	No
gpib_address	13	Edevice GPIB bus address		
system_controller	14	system controller		
ren_mode	15	REN active at boot		
eos_8bit_mode	16	EOS 8 bit comparison		
auto_eos_mode	17	automatic EOS on EOI		
eos_active	18	EOS active		
eos_char	19	EOS character		
reload_config	20	force reload of default config	X	No
commit_config	22	commit (write) current config	X	No
reboot	23	cause a reboot of the Eth488	X	No
idnreply	25	read IDN type string		
errorlogger	26	read current error log contents		

All configuration messages pertaining to actions shall respond with an RPC reply and then (if the status is No Error) execute the action.

All Edevice configuration commands will reply with statuses corresponding to Error Codes as defined by the VXI-11 (section B.5.2).

All Edevice configuration command data will use XDR encoding. Numerical values will be of 4-byte unsigned integer format. String and binary fields will be of opaque array format. Variable length string values will be NULL terminated and will contain a leading length numerical value defining the total length (inclusive of the NULL).

All Edevice configuration commands and replies will result in RPC messages which are multiples of 4-byte lengths. Padding will occur following the last data field and may consist of any byte value.

When the Action boolean signals a read of a mode/value setting, the RPC command must contain a dummy mode/value. While the mode/value in the RPC command is not used, it must exist. If the mode/value is not contained within the RPC command, an error status will result.

The successful modification of a configuration setting will result in the change taking effect immediately, except where noted. Thus, it is strongly advisable to not make configuration changes if VXI-11 device links are currently active. Doing so can cause unpredictable results and Edevice misbehavior. However, such dynamic modifications may be desirable and are possible at the discretion of the user. Messages that require rebooting will not take affect until the Edevice is rebooted.

B.2 Edevice PROGRAM ID AND VERSION

The Edevice configuration procedures shall use an RPC program ID of 1515151515 and an RPC version number of 1.

C.1 interface_name

The interface_name procedure is used to read/modify the current VXI-11 logical interface name.

```
struct Int_Name_Parms {
        unsigned        int     action;
        unsigned        int     length;
        opaque          name<>;
        };
struct Int_Name_Resp {
        unsigned        int     error;
        unsigned  int   length;
        opaque          name<>;
        };

Int_Name_Resp  interface_name (Int_Name_Parms) = 1;
```

The action value determines whether the client wishes to execute a read of the current setting, or a modification of the current value.
action = 0 = read of current value
action = 1 = modify current value

If the action value is other than 0 or 1, then an error value of 5 is returned.

If the RPC message is of insufficient length to satisfy the required length, an error value of 1 is returned.

The name string must be a NULL terminated string with a 32-byte maximum length (exclusive of the NULL). An error of 5 is returned and the Interface Name is unchanged if the name field exceeds 32-bytes.

The returned Int_Name_Resp structure will always contain the current Interface Name, irrespective of the error value.

error	Meaning
0	No error
1	Syntax error
5	Parameter error

C.2 rpc_port_number

The rpc_port_number procedure is used to read/modify the TCP port used by the RPC server.

```
struct Rpc_Port_Parms {
        unsigned        int     action;
        unsigned        int     port;
        };
struct Rpc_Port_Resp {
        unsigned        int     error;
        unsigned  int   port;
        };

Rpc_Port_Resp rpc_port_number (Rpc_Port_Parms) = 2;
```

The action value determines whether the client wishes to execute a read of the current setting, or a modification of the current value.
action = 0 = read of current value
action = 1 = modify current value

If the action value is other than 0 or 1, then an error value of 5 is returned.

If the RPC message is of insufficient length to satisfy the required length, an error value of 1 is returned.

The port value must be within the range of 0x0001 and 0xFFFF. An error of 5 is returned and the RPC Port value is unchanged if the port value is outside of this range.

The returned Rpc_Port_Resp structure will always contain the current RPC Port value, irrespective of the error value.

error	Meaning
0	No error
1	Syntax error
5	Parameter error

C.3 core_port_number

The core_port_number procedure is used to read/modify the TCP port used by the VXI-11 core channel.

```
struct Core_Port_Parms {
        unsigned        int     action;
        unsigned        int     port;
        };
struct Core_Port_Resp {
        unsigned        int     error;
        unsigned  int   port;
        };
```

Core_Port_Resp core_port_number (Core_Port_Parms) = 3;

The action value determines whether the client wishes to execute a read of the current setting, or a modification of the current value.
action = 0 = read of current value
action = 1 = modify current value

If the action value is other than 0 or 1, then an error value of 5 is returned.

If the RPC message is of insufficient length to satisfy the required length, an error value of 1 is returned.

The port value must be within the range of 0x0001 and 0xFFFF. An error of 5 is returned and the VXI-11 Core Port value is unchanged if the port value is outside of this range.

The returned Core_Port_Resp structure will always contain the current VXI-11 Core Port value, irrespective of the error value.

error	Meaning
0	No error
1	Syntax error
5	Parameter error

C.4 abort_port_number

The abort_port_number procedure is used to read/modify the TCP port used by the VXI-11 abort channel.

```
struct Abort_Port_Parms {
        unsigned        int     action;
        unsigned        int     port;
        };
struct Abort_Port_Resp {
        unsigned        int     error;
        unsigned  int   port;
        };
```

Abort_Port_Resp abort_port_number (Abort_Port_Parms) = 4;

The action value determines whether the client wishes to execute a read of the current setting, or a modification of the current value.
action = 0 = read of current value
action = 1 = modify current value

If the action value is other than 0 or 1, then an error value of 5 is returned.

If the RPC message is of insufficient length to satisfy the required length, an error value of 1 is returned.

The port value must be within the range of 0x0001 and 0xFFFF. An error of 5 is returned and the VXI-11 Abort Port value is unchanged if the port value is outside of this range.

The returned Abort_Port_Resp structure will always contain the current VXI-11 Abort Port value, irrespective of the error value.

error	Meaning
0	No error
1	Syntax error
5	Parameter error

C.5 config_port_number

The config_port_number procedure is used to read/modify the TCP port used by the Edevice configuration channel.

```
struct Config_Port_Parms {
        unsigned        int     action;
        unsigned        int     port;
        };
struct Config_Port_Resp {
        unsigned        int     error;
        unsigned  int   port;
        };
```

Config_Port_Resp config_port_number (Config_Port_Parms) = 5;

The action value determines whether the client wishes to execute a read of the current setting, or a modification of the current value.
action = 0 = read of current value
action = 1 = modify current value

If the action value is other than 0 or 1, then an error value of 5 is returned.

If the RPC message is of insufficient length to satisfy the required length, an error value of 1 is returned.

The port value must be within the range of 0x0001 and 0xFFFF. An error of 5 is returned and the VXI-11 Abort Port value is unchanged if the port value is outside of this range.

The returned Configt_Port_Resp structure will always contain the current VXI-11 Abort Port value, irrespective of the error value.

error	Meaning
0	No error
1	Syntax error
5	Parameter error

C.6 comm_timeout

The comm_timeout procedure is used to read/modify the TCP timeout value. An inactive TCP channel will be left open this length of time before being closed. A value of zero means no timeout checking.

```
struct Comm_Timeout_Parms {
        unsigned        int     action;
        unsigned        int     timeout;
        };
struct Comm_Timeout_Resp {
        unsigned        int     error;
        unsigned  int   int     timeout;
        };

Comm_Timeout_Resp comm_timeout (Comm_Timeout_Parms) = 6;
```

The action value determines whether the client wishes to execute a read of the current setting, or a modification of the current value.
action = 0 = read of current value
action = 1 = modify current value
If the action value is other than 0 or 1, then an error value of 5 is returned.

If the RPC message is of insufficient length to satisfy the required length, an error value of 1 is returned.

The timeout value is not range checked, thus it is possible to define an impossible timeout period. A timeout value of zero prevents timeout checking. If a channel remains inactive for the specified timeout period, then the channel is closed in the belief that the TCP connection is broken.

The comm_timeout procedure applies only to the VXI-11 core and Edevice configuration channels. The timeout period is defined as the number of seconds until a timeout is detected. The returned Comm_Timeout_Resp structure will always contain the current communication timeout value, irrespective of the error value.

error	Meaning
0	No error
1	Syntax error
5	Parameter error

C.7 hostname

The hostname procedure is used to read/modify the hostname used by the Edevice. The hostname is only applicable if a dynamic DNS service is available.

```
struct Hostname_Parms {
        unsigned        int     action;
        unsigned        int     length;
        opaque          name<>;
        };
struct Hostname_Resp {
        unsigned        int     error;
        unsigned  int   length;
        opaque          name<>;
        };

Hostname_Resp hostname (Hostname_Parms) = 7;
```

The action value determines whether the client wishes to execute a read of the current setting, or a modification of the current value.
action = 0 = read of current value
action = 1 = modify current value
If the action value is other than 0 or 1, then an error value of 5 is returned.

If the RPC message is of insufficient length to satisfy the required length, an error value of 1 is returned.

The name string must be a NULL terminated string with a 32-byte maximum length (exclusive of the NULL). An error of 5 is returned and the Interface Name is unchanged if the name field exceeds 32-bytes.

The returned Hostname_Resp structure will always contain the current hostname value, irrespective of the error value.

error	Meaning
0	No error
1	Syntax error
5	Parameter error

C.8 static_ip_mode

The static_ip_mode procedure is used to read/modify the static IP mode. If static_ip_mode is set TRUE, then the Edevice will use a static IP and will need a netmask and gateway IP.

```
struct Static_IP_Parms {
        unsigned        int     action;
        unsigned        int     mode;
        };
struct Static_IP_Resp {
        unsigned        int     error;
        unsigned        int     mode;
        };
```

Static_IP_Resp static_ip_mode (Static_IP_Parms) = 8;

The action value determines whether the client wishes to execute a read of the current setting, or a modification of the current value.
action = 0 = read of current value
action = 1 = modify current value

If the action value is other than 0 or 1, then an error value of 5 is returned.

If the RPC message is of insufficient length to satisfy the required length, an error value of 1 is returned.

The mode must be either 0 (dynamic) or 1 (static). An error of 5 is returned and the static IP mode is unchanged if the mode field is any other value.

The returned Static_IP_Resp structure will always contain the current static IP mode, irrespective of the error value.

error	Meaning
0	No error
1	Syntax error
5	Parameter error

C.9 ip_number

The ip_number procedure is used to read/modify the static IP number. If static_ip_mode is set TRUE, then the Edevice will use a static IP (see the static_ip_mode function) and will need a netmask and gateway IP.

```
struct IP_Number_Parms {
        unsigned        int     action;
        unsigned        char    ip[4];
        };
struct IP_Number_Resp {
        unsigned        int     error;
        unsigned        char    ip[4];
        };

IP_Number_Resp ip_number (IP_Number_Parms) = 9;
```

The action value determines whether the client wishes to execute a read of the current setting, or a modification of the current value.
action = 0 = read of current value
action = 1 = modify current value

If the action value is other than 0 or 1, then an error value of 5 is returned.

If the RPC message is of insufficient length to satisfy the required length, an error value of 1 is returned.

The ip must be exactly 4-bytes in length. An error of 5 is returned and the current IP is unchanged if the IP is determined to be invalid.

The returned IP_Number_Resp structure will always contain the current IP, irrespective of the error value.

* Note that the IP will only be used if Static IP is selected.

error	Meaning
0	No error
1	Syntax error
5	Parameter error

C.10 netmask

The netmask procedure is used to read/modify the netmask. If static_ip_mode is set TRUE, then the Edevice will use a static IP (see the static_ip_mode function) and will need a netmask and gateway IP.

```
struct Netmask_Parms {
        unsigned        int     action;
        unsigned        char    netmask[4];
        };
struct Netmask_Resp {
        unsigned        int     error;
        unsigned        char    netmask[4];
        };

Netmask_Resp netmask (Netmask_Parms) = 10;
```

The action value determines whether the client wishes to execute a read of the current setting, or a modification of the current value.
action = 0 = read of current value
action = 1 = modify current value

If the action value is other than 0 or 1, then an error value of 5 is returned.

If the RPC message is of insufficient length to satisfy the required length, an error value of 1 is returned.
The netmask must be exactly 4-bytes in length. An error of 5 is returned and the current netmask is unchanged if the netmask is determined to be invalid.
The returned Netmask_Resp structure will always contain the current netmask, irrespective of the error value.

* Note that the IP will only be used if Static IP is selected.

error	Meaning
0	No error
1	Syntax error
5	Parameter error

C.11 gateway

The gateway procedure is used to read/modify the gateway IP. If static_ip_mode is set TRUE, then the Edevice will use a static IP (see the static_ip_mode function) and will need a netmask and gateway IP.

```
struct Gateway_Parms {
        unsigned        int     action;
        unsigned        char    gateway[4];
        };
struct Gateway_Resp {
        unsigned        int     error;
        unsigned        char    gateway[4];
        };

Gateway_Resp gateway (Gateway_Parms) = 11;
```

The action value determines whether the client wishes to execute a read of the current setting, or a modification of the current value.
action = 0 = read of current value
action = 1 = modify current value
If the action value is other than 0 or 1, then an error value of 5 is returned.

If the RPC message is of insufficient length to satisfy the required length, an error value of 1 is returned.

The gateway must be exactly 4-bytes in length. An error of 5 is returned and the current gateway IP is unchanged if gateway is determined to be invalid. The returned Gateway_Resp structure will always contain the current gateway, irrespective of the error value.

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* Note that the IP will only be used if Static IP is selected.

error	Meaning
0	No error
1	Syntax error
5	Parameter error

C.12 keepalive

The keepalive procedure is used to read/modify the keepalive value. If set to zero, then keepalives will not be used. If used, then this is the time (in seconds) of inactivity prior to a keepalive being sent.

```
struct Keepalive_Parms {
        unsigned        int     action;
        unsigned        int     time;
        };
struct Keepalive_Resp {
        unsigned        int     error;
        unsigned        int     time;
        };

Keepalive_Resp keepalive (Keepalive_Parms) = 12;
```

The action value determines whether the client wishes to execute a read of the current setting, or a modification of the current value.
action = 0 = read of current value
action = 1 = modify current value
If the action value is other than 0 or 1, then an error value of 5 is returned.

If the RPC message is of insufficient length to satisfy the required length, an error value of 1 is returned.

The time value is not range checked, thus it is possible to define an impossible timeout period. A time value of zero prevents keepalive from being used. If a channel remains inactive for the specified time period, then a keepalive is sent (assuming time is non-zero). The returned Keepalive_Resp structure will always contain the current keepalive value, irrespective of the error value.

* Note that the Keepalive time may be fixed and not variable. If non-zero time is specified, Keepalive will be active regardless of time.

error	Meaning
0	No error
1	Syntax error
5	Parameter error

C.13 gpib_address

The gpib_address procedure is used to read/modify the Edevice GPIB bus address.

```
struct Gpib_Addr_Parms {
        unsigned        int     action;
        unsigned        int     address;
        };
struct Gpib_Addr_Resp {
        unsigned        int     error;
        unsigned        int     address;
        };

Gpib_Addr_Resp gpib_address (Gpib_Addr_Parms) = 13;
```

The action value determines whether the client wishes to execute a read of the current setting, or a modification of the current value.
action = 0 = read of current value
action = 1 = modify current value

If the action value is other than 0 or 1, then an error value of 5 is returned.

If the RPC message is of insufficient length to satisfy the required length, an error value of 1 is returned.

The address must be within the range of 0 and 30. An error of 5 is returned and the current GPIB address is unchanged if address is determined to be invalid.

The returned Gpib_Addr_Resp structure will always contain the current Edevice GPIB bus address, irrespective of the error value.

error	Meaning
0	No error
1	Syntax error
5	Parameter error

C.14 system_controller

The system_controller procedure is used to read/modify the system controller mode. If the system controller mode is set TRUE, then the Edevice will initialize at boot time as the GPIB bus controller.

```
struct Sys_Control_Parms {
        unsigned        int     action;
        unsigned        int     controller;
        };
struct Sys_Control_Resp {
        unsigned        int     error;
        unsigned        int     controller;
        };
```

Sys_Control_Resp system_controller (Sys_Control_Parms) = 14;

The action value determines whether the client wishes to execute a read of the current setting, or a modification of the current value.
action = 0 = read of current value
action = 1 = modify current value
If the action value is other than 0 or 1, then an error value of 5 is returned.

If the RPC message is of insufficient length to satisfy the required length, an error value of 1 is returned.

The controller mode must be either 0 or 1. An error of 5 is returned and the current system controller mode is unchanged if controller is determined to be invalid.

The returned Sys_Control_Resp structure will always contain the current system controller mode, irrespective of the error value.

error	Meaning
0	No error
1	Syntax error
5	Parameter error

C.15 ren_mode

The ren_mode procedure is used to read/modify the REN mode. If the REN mode is TRUE, then REN will be asserted at boot time.

```
struct Ren_Parms {
        unsigned        int     action;
        unsigned        int     ren;
        };
struct Ren_Resp {
        unsigned        int     error;
        unsigned        int     ren;
        };

Ren_Resp ren_mode (Ren_Parms) = 15;
```

The action value determines whether the client wishes to execute a read of the current setting, or a modification of the current value.
action = 0 = read of current value
action = 1 = modify current value

If the action value is other than 0 or 1, then an error value of 5 is returned.

If the RPC message is of insufficient length to satisfy the required length, an error value of 1 is returned.

The ren mode must be either 0 or 1. An error of 5 is returned and the current REN mode is unchanged if ren is determined to be invalid.

The returned Ren_Resp structure will always contain the current REN mode, irrespective of the error value.

* Note that this requires System Controller mode.

error	Meaning
0	No error
1	Syntax error
5	Parameter error

C.16 eos_8bit_mode

The eos_8bit_mode procedure is used to read/modify the 8-bit EOS compare mode. If the 8-bit compare mode is TRUE, then EOS compare will be 8-bits. If 8-bit compare mode is FALSE, then EOS compare will be 7-bits.

```
struct Eos_8bit_Parms {
        unsigned        int     action;
        unsigned        int     eos8bit;
        };
struct Eos_8bit_Resp {
        unsigned        int     error;
        unsigned        int     eos8bit;
        };
```

Eos_8bit_Resp eos_8bit_mode (Eos_8bit_Parms) = 16;

The action value determines whether the client wishes to execute a read of the current setting, or a modification of the current value.
action = 0 = read of current value
action = 1 = modify current value
If the action value is other than 0 or 1, then an error value of 5 is returned.

If the RPC message is of insufficient length to satisfy the required length, an error value of 1 is returned.

The eos8bit mode must be either 0 or 1. An error of 5 is returned and the current 8-bit EOS compare mode is unchanged if eos8bit is determined to be invalid.

The returned Eos_8bit_Resp structure will always contain the current 8-bit EOS compare mode, irrespective of the error value.

error	Meaning
0	No error
1	Syntax error
5	Parameter error

C.17 auto_eos_mode

The auto_eos_mode procedure is used to read/modify the automatic EOS on EOI mode. If the autoEos mode is TRUE, then an EOS character will be sent with EOI.

```
struct Auto_Eos_Parms {
        unsigned        int     action;
        unsigned        int     autoEos;
        };
struct Auto_Eos_Resp {
        unsigned        int     error;
        unsigned        int     autoEos;
        };
```

Auto_Eos_Resp auto_eos_mode (Auto_Eos_Parms) = 17;

The action value determines whether the client wishes to execute a read of the current setting, or a modification of the current value.
action = 0 = read of current value
action = 1 = modify current value

If the action value is other than 0 or 1, then an error value of 5 is returned.

If the RPC message is of insufficient length to satisfy the required length, an error value of 1 is returned.

The autoEos mode must be either 0 or 1. An error of 5 is returned and the current automatic EOS mode is unchanged if autoEos is determined to be invalid.

The returned Auto_Eos_Resp structure will always contain the current automatic EOS mode, irrespective of the error value.

error	Meaning
0	No error
1	Syntax error
5	Parameter error

C.18 eos_active_mode

The eos_active_mode procedure is used to read/modify the EOS active mode. If the EOS mode is TRUE, then an EOS character will terminate reads.

```
struct Eos_Active_Parms {
        unsigned        int     action;
        unsigned        int     eosActive;
        };
struct Eos_Active_Resp {
        unsigned        int     error;
        unsigned        int     eosActive;
        };

EosActive_Resp eos_active_mode (Eos_Active_Parms) = 18;
```

The action value determines whether the client wishes to execute a read of the current setting, or a modification of the current value.
action = 0 = read of current value
action = 1 = modify current value

If the action value is other than 0 or 1, then an error value of 5 is returned.

If the RPC message is of insufficient length to satisfy the required length, an error value of 1 is returned.

The eosActive mode must be either 0 or 1. An error of 5 is returned and the current automatic EOS mode is unchanged if eosActive is determined to be invalid.

The returned Eos_Active_Resp structure will always contain the current EOS mode, irrespective of the error value.

error	Meaning
0	No error
1	Syntax error
5	Parameter error

C.19 eos_char

The eos_char procedure is used to read/modify the EOS character.

```
struct Eos_Char_Parms {
        unsigned        int     action;
        unsigned        int     eos;
        };
struct Eos_Char_Resp {
        unsigned        int     error;
        unsigned        int     eos;
        };
```

Eos_Char_Resp eos_char (Eos_Char_Parms) = 19;

The action value determines whether the client wishes to execute a read of the current setting, or a modification of the current value.
action = 0 = read of current value
action = 1 = modify current value

If the action value is other than 0 or 1, then an error value of 5 is returned.

If the RPC message is of insufficient length to satisfy the required length, an error value of 1 is returned.

The eos character must be in the range of 0x00 through 0xFF. An error of 5 is returned and the current EOS char is unchanged if eos is determined to be invalid.

The returned Eos_Char_Resp structure will always contain the current automatic EOS character, irrespective of the error value.

error	Meaning
0	No error
1	Syntax error
5	Parameter error

C.20 reload_config

The reload_config procedure is used to cause a reload of the configuration settings. Any modified configuration settings will be restored to default settings.

```
struct Reload_Config_Resp {
        unsigned        int     error;
        };

Reload_Config_Resp reload_config (void) = 20;
```

If the RPC message is of insufficient length to satisfy the required length, an error value of 1 is returned.

The returned Reload_Config_Resp.error value determines whether the default configuration was reloaded.

error	Meaning
0	No error
1	Syntax error

C.21 commit_config

The commit_config procedure is used to cause the current configuration settings to be saved. Any modified configuration settings now become default settings and will be reloaded as the default settings with either reload_config or a reboot.

```
struct Commit_Config_Resp {
        unsigned int error;
        };

Commit_Config_Resp commit_config (void) = 22;
```

If the RPC message is of insufficient length to satisfy the required length, an error value of 1 is returned.

The returned Commit_Config_Resp.error value determines whether the current configuration was saved as the default configuration.

error	Meaning
0	No error
1	Syntax error

C.22 Reboot

The Reboot procedure is used to cause the Edevice to reboot. This causes all device links to be cleared, all connections closed, all resources released, and the default configuration to be loaded and used during initialization.

```
struct reboot_Resp {
        unsigned  int  error;
        };

reboot_Resp reboot (void) = 23;
```

If the RPC message is of insufficient length to satisfy the required length, an error value of 1 is returned.

The returned Reboot_Resp.error value determines whether the Edevice has initiated a reboot process. Note that the timing of the reboot process may block the RPC reply.

* Note that certain configuration settings are only set at boot time. Thus when setting configuration settings, it is recommended that the Reboot command always terminates the configuration setting.

error	Meaning
0	No error
1	Syntax error

C.23 idnReply

The idnReply procedure is used to obtain a response similar to the GPIB *IDN? string. It contains the FW revision, the ICS product model number, and other miscellaneous information.

```
struct Idn_Parms {
        };
struct Idn_Resp {
        unsigned int error;
        opaque idn<>;
        };

idn_resp  idnreply (idn_Parms) = 25;
```

Error	Meaning
0	No error

C.25 errorLogger

The errorLogger procedure is used to obtain the current contents of the error log.

```
struct error_log_Parms {
        };
struct Error_Log_Resp {
        unsigned int error;
        unsigned int count;
        unsigned int errors[100];
        };

error_log_Resp  errorlogger (error_log_Parms) = 26;
```

The error log will contain 100 entries. The count will signify how many are valid. The remaining values will be of indeterminate values.

Note this function returns all entries and flushes the error log. Do not run this function more than 5 times per second to avoid impacting the 80xx's or 90xx's performance and overloading the network.

Refer to the ErrorLogger utility for the error value definitions.

Error	Meaning
0	No error

D RPCL Listing

The following is a summary listing of ICS's EDevice Configuration RPC Messages.

```
/* IP-note: 4-byte IP's are packed into a 32 bit unsigned integer in
 * reverse network byte order.  XDR integers are in host byte order.
 */

/* Action parameter values */
%#define ICS_READ          0
%#define ICS_WRITE         1

/* The interface_name procedure is used to read/modify the current VXI-11
 * logical interface name.
 */
struct Int_Name_Parms {
   unsigned int action;
   opaque name<>;
};
struct Int_Name_Resp {
   unsigned int error;
   opaque name<>;
};

/* The rpc_port_number procedure is used to read/modify the TCP port used
 * by the RPC server.
 */
struct Rpc_Port_Parms {
   unsigned int action;
   unsigned int port;
};
struct Rpc_Port_Resp {
   unsigned int error;
   unsigned int port;
};
```

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```
/* The core_port_number procedure is used to read/modify the TCP port
 * used by the VXI-11 core channel.
 */
struct Core_Port_Parms {
  unsigned int action;
  unsigned int port;
};
struct Core_Port_Resp {
  unsigned int error;
  unsigned int port;
};

/* The abort_port_number procedure is used to read/modify the TCP port
 * used by the VXI-11 abort channel.
 */
struct Abort_Port_Parms {
  unsigned int action;
  unsigned int port;
};
struct Abort_Port_Resp {
  unsigned int error;
  unsigned int port;
};

/* The config_port_number procedure is used to read/modify the TCP port
 * used by the Edevice configuration channel.
 */
struct Config_Port_Parms {
  unsigned int action;
  unsigned int port;
};
struct Config_Port_Resp {
  unsigned int error;
  unsigned int port;
};

/* The comm_timeout procedure is used to read/modfiy the TCP timeout value.
 * An inactive TCP channel will be left open this length of time before
 * being closed.  A value of zero means no timeout checking.
 */
struct Comm_Timeout_Parms {
  unsigned int action;
  unsigned int timeout;
};
```

```
struct Comm_Timeout_Resp {
  unsigned int error;
  unsigned int timeout;
};

/* The hostname procedure is used to read/modify the hostname used by the
 * Edevice.  The hostname is only applicable if a dynamic DNS service is
 * available.
 */
struct Hostname_Parms {
  unsigned int action;
  opaque name<>;
};
struct Hostname_Resp {
  unsigned int error;
  opaque name<>;
};

/* The static_ip_mode procedure is used to read/modify the static IP mode.
 * If static_ip_mode is set TRUE, then the Edevice will use a static IP
 * and will need a netmask and gateway IP.
 */
struct Static_IP_Parms {
  unsigned int action;
  unsigned int mode;
};
struct Static_IP_Resp {
  unsigned int error;
  unsigned int mode;
};

/* The ip_number procedure is used to read/modify the static IP number.
 * If static_ip_mode is set TRUE, then the Edevice will use a static IP
 * (see the static_ip_mode function) and will need a netmask and gateway IP.
 */
struct IP_Number_Parms {
  unsigned int action;
  unsigned int ip; /* see IP-note above */
};
struct IP_Number_Resp {
  unsigned int error;
  unsigned int ip; /* see IP-note above */
};
```

```
/* The netmask procedure is used to read/modify the netmask.
 * If static_ip_mode is set TRUE, then the Edevice will use a static IP
 * (see the static_ip_mode function) and will need a netmask and gateway IP.
 */
struct Netmask_Parms {
  unsigned int action;
  unsigned int ip; /* see IP-note above */
};
struct Netmask_Resp {
  unsigned int error;
  unsigned int ip; /* see IP-note above */
};

/* The gateway procedure is used to read/modify the gateway IP.
 * If static_ip_mode is set TRUE, then the Edevice will use a static IP
 * (see the static_ip_mode function) and will need a netmask and gateway IP.
 */
struct Gateway_Parms {
  unsigned int action;
  unsigned int ip; /* see IP-note above */
};
struct Gateway_Resp {
  unsigned int error;
  unsigned int ip; /* see IP-note above */
};

/* The keepalive procedure is used to read/modify the keepalive value.
 * If set to zero, then keepalives will not be used.  If used, then this is
 * the time (in seconds) of inactivity prior to a keepalive being sent.
 */
struct Keepalive_Parms {
  unsigned int action;
  unsigned int time;
};
struct Keepalive_Resp {
  unsigned int error;
  unsigned int time;
};

/* The gpib_address procedure is used to read/modify the Edevice GPIB bus
 * address.
 */
struct Gpib_Addr_Parms {
```

```
  unsigned int action;
  unsigned int address;
};
struct Gpib_Addr_Resp {
  unsigned int error;
  unsigned int address;
};

/* The system_controller procedure is used to read/modify the system
 * controller mode.  If system controller mode is set to TRUE, then the
 * Edevice will initialize at boot time as the GPIB bus controller.
 */
struct Sys_Control_Parms {
  unsigned int action;
  unsigned int controller;
};
struct Sys_Control_Resp {
  unsigned int error;
  unsigned int controller;
};

/* The ren_mode procedure is used to read/modify the REN mode.  If the
 * REN mode is TRUE, then REN will be asserted at boot time.
 */
struct Ren_Parms {
  unsigned int action;
  unsigned int ren;
};
struct Ren_Resp {
  unsigned int error;
  unsigned int ren;
};

/* The eos_8_bit_mode procedure is used to read/modify the 8-bit EOS
 * compare mode.  If the 8-bit compare mode is TRUE, then EOS compare
 * will be 8-bits.  If 8-bit compare mode is FALSE, then EOS compare
 * will be 7-bits.
 */
struct Eos_8bit_Parms {
  unsigned int action;
  unsigned int eos8bit;
};
```

```
struct Eos_8bit_Resp {
  unsigned int error;
  unsigned int eos8bit;
};

/* The auto_eos_mode procedure is used to read/modify the automatic EOS
 * on EOI mode.  If the autoEos mode is TRUE, then an EOS character will
 * be sent wtih EOI.
 */
struct Auto_Eos_Parms {
  unsigned int action;
  unsigned int autoEos;
};
struct Auto_Eos_Resp {
  unsigned int error;
  unsigned int autoEos;
};

/* The eos_active_mode procedure is used to read/modify the EOS active mode.
 * If the EOS mode is TRUE, then an EOS character will terminate reads.
 */
struct Eos_Active_Parms {
  unsigned int action;
  unsigned int eosActive;
};
struct Eos_Active_Resp {
  unsigned int error;
  unsigned int eosActive;
};

/* The eos_char procedure is used to read/modify the EOS character.
 */
struct Eos_Char_Parms {
  unsigned int action;
  unsigned int eos;
};
struct Eos_Char_Resp {
  unsigned int error;
  unsigned int eos;
};
```

```
/* The reload_config procedure is used to cause a reload of the configuration
 * settings.  Any modified configuration settings will be restored to
 * default settings.
 */
struct Reload_Config_Resp {
  unsigned int error;
};

/* The commit_config procedure is used to cause the current configuration
 * settings to be saved.  Any modified configuration settings now become
 * default settings and will be reloaded as the default settings with either
 * reload_config or a reboot.
 */
struct Commit_Config_Resp {
  unsigned int error;
};

/* The reboot procedure is used to cause the Edevice to reboot.  This causes
 * all device links to be cleared, all connections closed, all resources
 * released, and the default configuration to be loaded and used during
 * initialization.
 */
struct Reboot_Resp {
  unsigned int error;
};

/* The idn_string procedure is used to obtain a response similar to the IEEE-488.2
* *IDN? string.  It contains the FW revision, the ICS product model number,
 * and ohter miscellaneous information.
 */
struct Idn_Resp {
  unsigned int error;
  opaque idn<>;
};

/* The error_logger procedure is used to obtain the current contents of the
 * error log.
 */
struct Error_Log_Resp {
  unsigned int error;
  unsigned int count;
  unsigned int errors[100];
};
```

```
program ICSCONFIG {
  version ICSCONFIG_VERSION {
    Int_Name_Resp interface_name (Int_Name_Parms) = 1;
    Rpc_Port_Resp rpc_port_number (Rpc_Port_Parms) = 2;
    Core_Port_Resp core_port_number (Core_Port_Parms) = 3;
    Abort_Port_Resp abort_port_number (Abort_Port_Parms) = 4;
    Config_Port_Resp config_port_number (Config_Port_Parms) = 5;
    Comm_Timeout_Resp comm_timeout (Comm_Timeout_Parms) = 6;
    Hostname_Resp hostname (Hostname_Parms) = 7;
    Static_IP_Resp static_ip_mode (Static_IP_Parms) = 8;
    IP_Number_Resp ip_number (IP_Number_Parms) = 9;
    Netmask_Resp netmask (Netmask_Parms) = 10;
    Gateway_Resp gateway (Gateway_Parms) = 11;
    Keepalive_Resp keepalive (Keepalive_Parms) = 12;
    Gpib_Addr_Resp gpib_address (Gpib_Addr_Parms) = 13;
    Sys_Control_Resp system_controller (Sys_Control_Parms) = 14;
    Ren_Resp ren_mode (Ren_Parms) = 15;
    Eos_8bit_Resp eos_8_bit_mode (Eos_8bit_Parms) = 16;
    Auto_Eos_Resp auto_eos_mode (Auto_Eos_Parms) = 17;
    Eos_Active_Resp eos_active (Eos_Active_Parms) = 18;
    Eos_Char_Resp eos_char (Eos_Char_Parms) = 19;
    Reload_Config_Resp reload_config (void) = 20;
    Commit_Config_Resp commit_config (void) = 21;
    Reboot_Resp reboot (void) = 22;
    Idn_Resp idn_string (void) = 23;
    Error_Log_Resp error_logger (void) = 24;
  } = 1;
} = 1515151515;

/*
 * vi:tabstop=4 shiftwidth=4 expandtab
 */
```

A5 HTML VARIABLES

The webserver in the 9009 and 9099 includes generic HTML pages for controlling Watlow F4, EZ Zone and F4T Temperature Controllers. This appendix lists the HTML substitution variables (%xx%) and replacement parameters (xxsp) used on the pages and their respective Modbus registers. Register functions are given in the respective Watlow Controller manual. Refer to ICS Application Note AB80-5 for instructions on customizing and replacing the 9009 and 9099 html pages.

A5.1 F4.html

This page is for the Watlow F4 Controller

Variable	Description	Register	Type
Temperature Humidity Variables			
%input1%	Process 1 Temperature Reading	100	16-bit R
%input1sp%	Process 1 Temperature Setpoint	300	16-bit RW
input1sp	Process 1 Temperature Setpoint	300	16-bit RW
%degCon%	Displays °C units	901	16-bit RW
%degCoff%	Displays °F units	901	16-bit RW
degC	Radio Values 'On' and 'Off'	901	16-bit RW
%input2%	Process 2 Humidity Reading	104	16-bit R
%input2sp%	Process 2 Humidity Setpoint	319	16-bit RW
input2sp	Process 2 Humidity Setpoint	319	16-bit RW
%input3%	Process 3 Auxilary Input	108	16-bit R
Output Control Variables			
%dout1on%	Displays Output 1 On	2000	16-bit RW
%dout1off%	Displays Output 1 Off	2000	16-bit RW
dout1	Radio Values 'On' and 'Off'	2000	16-bit RW
%dout2on%	Displays Output 2 On	2010	16-bit RW
%dout2off%	Displays Output 2 Off	2010	16-bit RW
dout2	Radio Values 'On' and 'Off'	2010	16-bit RW
%dout3on%	Displays Output 3 On	2020	16-bit RW
%dout3off%	Displays Output 3 Off	2020	16-bit RW
dout3	Radio Values 'On' and 'Off'	2020	16-bit RW

Variable	Description	Register	Type
%dout4on%	Displays Output 4 On	2030	16-bit RW
%dout4off%	Displays Output 4 Off	2030	16-bit RW
dout4	Radio Values 'On' and 'Off'	2030	16-bit RW
%dout5on%	Displays Output 5 On	2040	16-bit RW
%dout5off%	Displays Output 5 Off	2040	16-bit RW
dout5	Radio Values 'On' and 'Off'	2040	16-bit RW
%dout6on%	Displays Output 6 On	2050	16-bit RW
%dout6off%	Displays Output 6 Off	2050	16-bit RW
dout6	Radio Values 'On' and 'Off'	2050	16-bit RW
%dout7on%	Displays Output 7 On	2060	16-bit RW
%dout7off%	Displays Output 7 Off	2060	16-bit RW
dout7	Radio Values 'On' and 'Off'	2060	16-bit RW
%dout8on%	Displays Output 8 On	2070	16-bit RW
%dout8off%	Displays Output 8 Off	2070	16-bit RW
dout8	Radio Values 'On' and 'Off'	2070	16-bit RW

A5.2 EZ.html

This page is for the Watlow EZ Zone Controllers.

Variable	Description	Register	Type
Temperature Humidity Variables			
%EZinput1%	Process 1 Temperature Reading	360	Float R
%EZinput1sp%	Process 1 Temperature Setpoint	2160	Float RW
%EZinput2%	Process 2 Humidity Reading	440	Float R
Output Control Variables			
%EZdout5on%	Displays Output 5 On	1012	16-bit RW
%EZdout5off%	Displays Output 5 Off	1012	16-bit RW
EZdout5	Radio Values 'On' and 'Off'	1012	16-bit RW
%EZdout6on%	Displays Output 6 On	1042	16-bit RW
%EZdout6off%	Displays Output 6 Off	1042	16-bit RW
EZdout6	Radio Values 'On' and 'Off'	1042	16-bit RW

A5.3 F4T.html

This page is for the Watlow F4T Controller. Temperature units are switched by writing to three F4T registers that set the units for the display, Modbus RTU and Ethernet interfaces. Temperature units are displayed by reading from just the display register

Variable	Description	Register	Type
Temperature Humidity Variables			
%F4input1%	Analog Input-Temperature Rdg	27586	Float R
%F4input1sp%	Control Loop 1 Setpoint	2782	Float RW
%F4degCon%	Displays °C units	1328	16-bit RW
%F4degCoff%	Displays °F units	1328	16-bit RW
F4degC	Radio Values 'On' and 'Off' Display	1328	16-bit RW
	Radio Values 'On' and 'Off' Ethernet	6730	16-bit RW
	Radio Values 'On' and 'Off' Modbus	14080	16-bit RW
%F4input2%	Humidity Reading	28906	Float R
%F4input2sp%	Humidity Setpoint	2942	Float RW
Output Control Variables			
%F4dout1on%	Displays Output 1 On	16594	16-bit RW
%F4dout1off%	Displays Output 1 Off	16594	16-bit RW
F4dout1	Radio Values 'On' and 'Off'	16594	16-bit RW
%F4dout2on%	Displays Output 2 On	16596	16-bit RW
%F4dout2off%	Displays Output 2 Off	16596	16-bit RW
F4dout2	Radio Values 'On' and 'Off'	16596	16-bit RW
%F4dout3on%	Displays Output 3 On	16598	16-bit RW
%F4dout3off%	Displays Output 3 Off	16598	16-bit RW
F4dout3	Radio Values 'On' and 'Off'	16598	16-bit RW
%F4dout4on%	Displays Output 4 On	16600	16-bit RW
%F4dout4off%	Displays Output 4 Off	16600	16-bit RW
F4dout4	Radio Values 'On' and 'Off'	16600	16-bit RW
%F4dout5on%	Displays Output 5 On	16822	16-bit RW
%F4dout5off%	Displays Output 5 Off	16822	16-bit RW
F4dout5	Radio Values 'On' and 'Off'	16822	16-bit RW
%F4dout6on%	Displays Output 6 On	16824	16-bit RW
%F4dout6off%	Displays Output 6 Off	16824	16-bit RW
F4dout6	Radio Values 'On' and 'Off'	16824	16-bit RW

Variable	Description	Register	Type
%F4dout7on%	Displays Output 7 On	16826	16-bit RW
%F4dout7off%	Displays Output 7 Off	16826	16-bit RW
F4dout7	Radio Values 'On' and 'Off'	16826	16-bit RW
%F4dout8on%	Displays Output 8 On	16828	16-bit RW
%F4dout8off%	Displays Output 8 Off	16828	16-bit RW
F4dout8	Radio Values 'On' and 'Off'	16828	16-bit RW

A5.1 F4T_Ramps.html

This page is not linked to on the index page because it contains a large number of replacement and substitution variables that would not be found together in a normal F4T application. The F4T_Ramps page is done just to demonstrate the use of these variables.. The OEM user can copy the appropriate portions of the F4T_Ramps page to make his own html pages.

Closed Loop and Cascade Variables

%CLCh1input%	Closed-Loop Set Point, CH 1	2810	Float R
%CLCh2input%	Closed-Loop Set Point, CH 2	2970	Float R
%Cas1input%	Closed-Loop Set Point, Cascade 1	4188	Float R
%Cas1inputSP%	Set Point, CASCADE 1	4042	Float RW
Cas1inputSP	Set Point value	4042	Float RW
%OLPartinput%	Cascade Outer Loop 1 (part temp)	4180	Float R
%OLAirinput%	Cascade Outer Loop 1 (air temp)	4182	Float R
%Cas1inputAct%	Outer Loop Current Reading	4190	Float R

Ramp CH1 Variables

%Ramp1ActOff%	Displays Ramp Off	2794	16-bit RW
%Ramp1ActStart%	Displays Ramp Startup	2794	16-bit RW
%Ramp1ActSP%	Displays Ramp Setpoint	2794	16-bit RW
%Ramp1ActBoth%	Displays Ramp Both	2794	16-bit RW
Ramp1Act	Radio values 'Off', 'Startup', 'Setpoint' and 'Both'	2794	16-bit RW
%Ramp1UnitsMin%	Displays Ramp Scale Minutes	2796	16-bit RW
%Ramp1UnitsHr%	Displays Ramp Scale Hours	2796	16-bit RW
Ramp1Units	Radio values 'Minutes' and 'Hours'	2796	16-bit RW
%Ramp1RateSP%	Sets/displays ramp rate	2798	Float RW

Variable	Description	Register	Type
Ramp CH2 Variables			
%Ramp2ActOff%	Displays Ramp Off	2954	16-bit RW
%Ramp2ActStart%	Displays Ramp Startup	2954	16-bit RW
%Ramp2ActSP%	Displays Ramp Setpoint	2954	16-bit RW
%Ramp2ActBoth%	Displays Ramp Both	2954	16-bit RW
Ramp2Act	Radio values 'Off', 'Startup', 'Setpoint' and 'Both'	2954	16-bit RW
%Ramp2UnitsMin%	Displays Ramp Scale Minutes	2956	16-bit RW
%Ramp2UnitsHr%	Displays Ramp Scale Hours	2956	16-bit RW
Ramp2Units	Radio values 'Minutes' and 'Hours'	2956	16-bit RW
%Ramp2RateSP%	Sets/displays ramp rate	2758	Float RW
Ramp CH3 Cascade Variables			
%Ramp3ActOff%	Displays Ramp Off	4054	16-bit RW
%Ramp3ActStart%	Displays Ramp Startup	4054	16-bit RW
%Ramp3ActSP%	Displays Ramp Setpoint	4054	16-bit RW
%Ramp3ActBoth%	Displays Ramp Both	4054	16-bit RW
Ramp3Act	Radio values 'Off', 'Startup', 'Setpoint' and 'Both'	4054	16-bit RW
%Ramp3UnitsMin%	Displays Ramp Scale Minutes	4056	16-bit RW
%Ramp3UnitsHr%	Displays Ramp Scale Hours	4056	16-bit RW
Ramp3Units	Radio values 'Minutes' and 'Hours'	4056	16-bit RW
%Ramp3RateSP%	Sets/displays ramp rate	4058	Float RW

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