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# Data Communications with the Watlow Series 988 Family of Controllers

## User's Manual

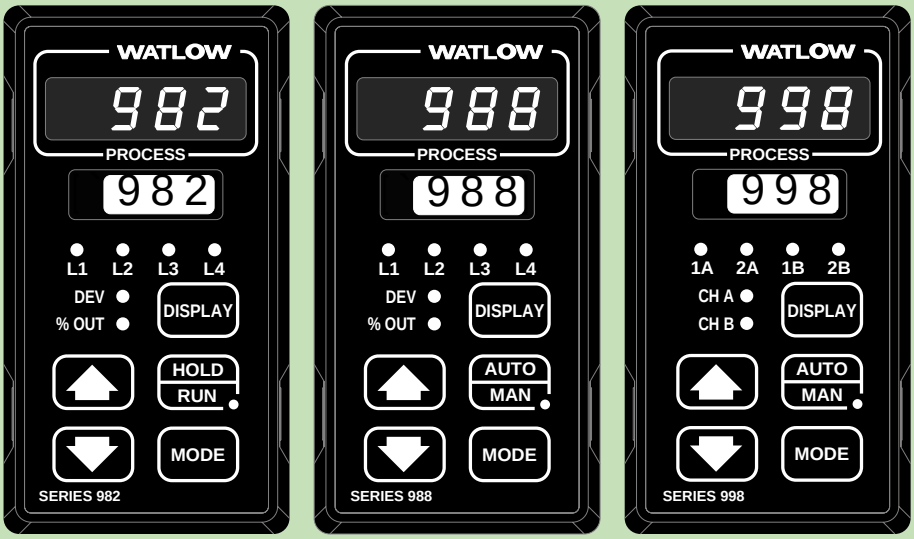
**Includes:**
**981-984 Ramping**
**986-989 Temperature or Process**
**996-999 Dual Channel**

**User Level Targeted:**

• New User..... Go to page 1.1
• Experienced User .....Go to page 2.1
• Expert User .....Go to page 5.1, 6.1 or 7.1

**Installer:**

• Wiring and installation..... Go to page 2.1
• Setup.....Go to page 3.1


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## Watlow Controls


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**0600-0009-0004 Rev B**
Supersedes: W98F-XUMN Rev A03
February 1998

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# About This Manual

## How to Use this Manual

We have designed this user's manual to be a helpful guide to your new Watlow controller. The headlines in the upper right and left corners indicate which tasks are explained on that page. If you are a new user, we suggest that your read the first four chapters of this manual.

## Notes, Cautions and Warnings

We use notes, cautions and warnings throughout this book to draw your attention to important operational and safety information.

A bold text **"NOTE"** marks a short message in the margin to alert you to an important detail.

A bold text **"CAUTION"** safety alert appears with information that is important for protecting your equipment and performance. **Be especially careful to read and follow all cautions that apply to your application.**

A bold text **"WARNING"** safety alert appears with information that is important for protecting you, others and equipment from damage. **Pay very close attention to all warnings that apply to your application.**

The ⚠ symbol (an exclamation point in a triangle) precedes a general CAUTION or WARNING statement.

The ⚠ symbol (a lightning bolt in a triangle) precedes an electric shock hazard CAUTION or WARNING safety statement.

## Technical Assistance

If you encounter a problem with your Watlow controller, review all of your configuration information for each step of the setup, to verify that your selections are consistent with your applications.

If the problem persists after checking all the steps, call for technical assistance: Watlow Controls, (507) 454-5300, between 7:00 a.m. and 5:00 p.m. Central Standard Time. Ask for an applications engineer. When you call, have the following information ready:

- the controller's model number (the 12-digit number is printed on the top of the stickers on each side of the controller case and on the right hand or top circuit board);
- this user's manual;
- all configuration information;
- the Diagnostics Menu readings.

## Comments and Suggestions

We welcome your comments and opinions about this user's manual and the Series 988 family of controllers. Send them to the Technical Editor, Watlow Controls, 1241 Bundy Boulevard, P.O. Box 5580, Winona, MN 55987-5580. Or call (507) 454-5300 or fax them to (507) 452-4507.

## Warranty and Returns

For information about the warranty covering the Series 988 family of controllers see the Appendix.

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# Table of Contents

## Data Communications with the Watlow Series 988 Family of Controllers


### Chapter 1
### Introduction to Data Communications
1.1 Machine-to-Machine Communication
1.1 Protocol
1.1 A Protocol Example
1.3 EIA-232, EIA-485 and EIA-422 Interfaces
1.4 ASCII
1.4 Parity Bit
1.5 Start and Stop Bits
1.5 Baud Rate
1.5 Computer Languages
1.5 Syntax
1.6 ASCII Control Character Definitions
1.6 Data Communications Conversation

### Chapter 2
### Hardware and Wiring
2.1 Serial Hardware Interfaces
2.1 Your Computer's Serial Interface
2.2 Communications Wiring
2.2 EIA-232 Interface Wiring
2.3 EIA-485 Interface Wiring
2.4 EIA-422 Interface Wiring

### Chapter 3
### Communications Setup
3.1 Connecting the Controller and Computer
3.1 Software Protocols and Device Addresses
3.1 Communications Software
3.2 Setup at the Controller's Front Panel

### Chapter 4
### Sending Commands
4.1 General Message Syntax
4.1 Message Syntax
4.1 Data Rules
4.1 Command List
4.2 Example Format
4.2 XON/XOFF Protocol for EIA-232
4.2 How to Communicate Using XON/XOFF
4.3 How to Communicate Using ANSI X3.28
4.4 Device Addresses
4.5 ANSI X3.28 Protocol Example
4.6 Modbus RTU
4.10 Cyclical Redundancy Checksum (CRC) Algorithm

### Chapter 5
### Command Summary of the Series 981-984
5.1 Complete Parameter Download Sequence
5.2 Run/Hold Mode and Prompt Accessibility
5.3 Ramping Controller Prompt Table
5.12 Ramping Controller MTR Command
5.13 Ramping Controller STP Command
5.14 Ramping Controller Commands Table
5.16 982 Modbus RTU Address Table

### Chapter 6
### Command Summary of the Series 986-989
6.1 Complete Parameter Download Sequence
6.2 Temperature/process Controller Prompt Table
6.13 988 Modbus RTU Address Table

### Chapter 7
### Command Summary of the Series 996-999
7.1 Complete Parameter Download Sequence
7.2 Dual Channel Controller Prompt Table
7.12 998 Modbus RTU Address Table

### Appendix
A.1 Handling Communications Error Codes
A.1 User Responsibility
A.2 ASCII Characters
A.3 Index

# NOTES

# **Chapter 1** Introduction to Data Communications

**NOTE:**
**This manual applies only to controllers with the data communications option (9___-____-_R__ or 9___-____-_S__ or 9___-____-_U__). Please use it in conjunction with the user's manuals.**

## Machine-to-Machine Communication

Humans use basic components to exchange messages. Computers and controllers also use certain elements in order to communicate: a character set; a common data link, or interface; and a protocol, to prevent confusion and errors.

**Serial communication** is the exchange of data one bit at a time on a single data line or channel. Serial contrasts with "parallel" communication, which sends several bits of information simultaneously over multiple lines or channels. Not only is serial data communication typically simpler than parallel, it generally costs less.

Computers need a connecting **interface** over which to communicate. They may use one pair of wires to send information in one direction and another pair to send in the opposite direction (full duplex). Or, they may use one pair to send in both directions (half duplex).

**Bit** is simply the contraction of "binary digit," either a "1" or a "0." A **byte** is a string of seven or eight bits, which a computer treats as a single "character." The ASCII (pronounced "asky") character set uses a unique, seven-bit byte to represent each letter, digit and punctuation mark.

## Protocol

Now we need a few rules to "talk" by. Protocol determines who gets to talk when. A protocol is a set of standards for formatting and timing information exchange between electronic systems.

Protocol describes how to initiate an exchange. It also prevents two machines from attempting to send data at the same time. There are a number of different data communications protocols, just as there are different human cultural protocols that vary according to the situation.

## A Protocol Example

Let's assume that we have a computer and controllers linked together. They all use ASCII and are connected via a common interface. In process control applications, one device often has greater function and memory capability than the devices it is communicating with. This "master" device always initiates exchanges between it and the connected "remote" devices.

Here's what happens: Imagine "PC-1," the master computer, sitting at the end of a long hallway with nine doors in it. Each door has a remote device behind it. PC-1 has a telephone line to all the devices. The remote devices are busy controlling heaters to specific set points. PC-1 monitors and changes the instructions that each remote device uses to control its heaters.

By your request PC-1 wants to talk with device "D-2" to change a set point. PC-1 must first identify D-2 on the line and inquire whether D-2 has time to talk. This electronic knocking on D-2's door is the "connection."

One of three scenarios may occur when PC-1 calls:

1) D-2 answers saying, "This is D-2, go ahead," and PC-1 begins to talk.
2) D-2 answers and says, "I'm too busy to talk now. Wait until I tell you I'm finished."
3) D-2 does not answer, which indicates a possible system malfunction.

Let's take the best-case scenario. Here is a simple version of what happens: D-2 answers and hears PC-1 say, "Hello, D-2. Do you have time to talk?"

D-2 acknowledges PC-1 with a "D-2 here, go ahead."

PC-1 then sends an ASCII-encoded message instructing D-2 to change a set point to 1,000°F. (message)

When PC-1 is finished with its message, it says in effect, "That's all, your turn."

D-2 replies, "OK," and carries out the instruction. D-2 then takes the protocol lead, and tells PC-1, "The new set point is 1,000°F." (message)

PC-1 says, "OK."

D-2 says, "That's all, your turn."

PC-1 then takes the protocol lead and says, "Thank you, that's all."

D-2 hangs up. (disconnect)

That's basically how the connect, message and disconnect protocols work in Watlow data communications.

The hallway in this example is really a communications bus — a common connection among a number of separate devices. A communications system with multiple devices on a common bus is called a multidrop system.

The exact connect-message-disconnect procedure assures that you are talking to the correct device.

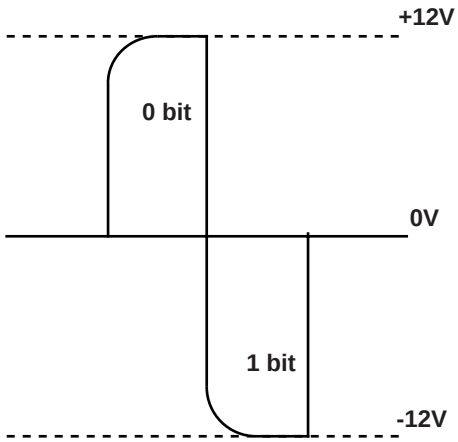
Protocol maintains system integrity by requiring a response to each message. It's like registered mail — you know that your letter has been received because the post office sends you a signed receipt.

In Watlow data communications, a dialog will continue successfully as long as the messages are in the correct form and responses are returned to the protocol leader. If the operator enters an incorrect message, or interference comes on to the data line, there will be no response. In that case the operator or the master must retransmit the message or go to a recovery procedure. If an operator continues to enter an incorrect message or interference continues on the data line, the system will halt until the problem is resolved.

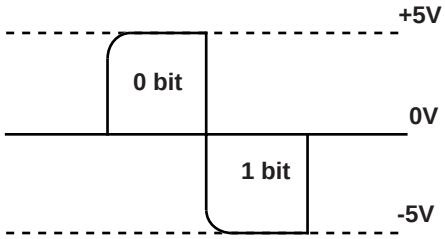
## EIA-232, EIA-485 and EIA-422 Interfaces

The three interfaces we're concerned with on this controller are EIA-232, EIA-485 and EIA-422.

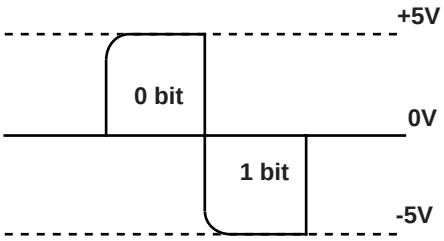
An EIA-232 interface uses three wires: a single transmit wire; a single receive wire; and a common line. Only two devices can use an EIA-232 interface. A -12 volt signal indicates a 1 and a +12 volt signal indicates a 0. The EIA-232 signal is referenced to the common line rather than to a separate wire, as in EIA-485 and EIA-422. An EIA-232 cable is limited to 50 feet, due to noise susceptibility.




**Bit signals on an EIA-232 interface.**




**Bit signals on an EIA-485 interface.**




**Bit signals on an EIA-422 interface.**

**Figure 1.3 - Interface bit signals.**

An EIA-485 interface uses three wires: a T+/R+; a T-/R-; and a common line. A -5-volt signal is interpreted as a 1, a +5-volt signal as a 0. Up to 32 remote devices can be connected to a master on a multi-drop network up to 4,000 feet long.

The EIA-422 interface uses five wires: a "talk" pair; a "listen" pair; and a common line. It can handle one master and up to ten remote devices in a multidrop network up to 4,000 feet long. EIA-422 uses the difference in voltage between the two wires to indicate a 1 or a 0 bit. A 1 is a difference of -5 volts, while a 0 is a difference of +5 volts.

Of these three interfaces, EIA-485 has the lowest impedance, a multiple-device capability, greatest noise immunity and the longest distance capability — up to 4,000 feet of total network cable length.

| | Maximum Net Length | Maximum Controllers | Cable Type |
|---|---|---|---|
| **EIA-232** | 50 feet | 1 | 3-wire |
| **EIA-485** | 4,000 feet | 32 | 3-wire |
| **EIA-422** | 4,000 feet | 10 | 5-wire |

**Table 1.4 - Comparing Interfaces.**

**NOTE:**
**The Modbus feature on the Series 988 controllers allows up to 247 controllers to share one EIA-485 network, by using network bridges. See Chapter 6 for more information on Modbus.**

## ASCII

The ASCII code defines 128 separate 7-bit characters — one for each letter, digit and punctuation mark. ASCII also includes control characters similar to those we find on computer keys, like "backspace," "shift" and "return." It also has ten communications control characters for "identification," "enquiry" (inquiry), "start of text," "end of text," "end of transmission," "acknowledge," "negative acknowledge" and "escape."

The ASCII code is sometimes written in a base-16 number system, called hexadecimal or "hex" for short. The first ten digits of this system are represented by the numbers 0 through 9, and the final six digits are represented by the letters A through F. The 128 ASCII character code with the decimal and hexadecimal equivalents is listed in the Appendix.

## Parity Bit

Remember that ASCII is a seven- or eight-bit code. What about that eighth bit? It's called the "parity" bit. A parity bit is added to the ASCII character to verify the accuracy of the first seven bits. Here's how: We are declaring that the number of 1s in the 8-bit character frame will be either always odd or always even. To do that, about half the time we'll have to add another 1 to get an odd or an even number of ones. The other half of the time we'll need to add a 0 so we don't change the total number of 1s.

This way we can detect a single error in the seven-bit group. Take a look at the representation of the transmitted upper case "W." In this case we have selected "odd" parity. The number of 1s in the first seven bits, plus the parity bit, must always total an odd number. The total number of 1s in the binary character 1010111 (W) is 5, already an odd number. Thus our parity bit will be a 0.

If we were transmitting the lower case "w" (binary 1110111), the parity bit would be a 1 because the total number of 1's in the character frame is 6, an even number. Adding the parity bit makes it odd, and consistent with the odd parity rule.

If a noise spike came onto the data line and changed the signal voltage level enough to reverse a 1 to a 0 in the character frame, the receiver would detect that

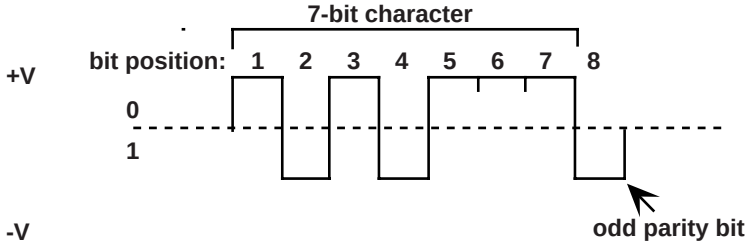



**Figure 1.4 - ASCII upper case "W" (1010111).**

error. The total number of 1s would be even and a violation of the odd-parity rule.

At Watlow, we use odd, even and no parity.

**Odd parity** sets the parity bit to 0 if there are an odd number of 1s in the first seven bits.

**Even parity** sets the parity bit to 0 if there are an even number of 1s in the first seven bits.

**No parity** ignores the parity bit.

## Start and Stop Bits

A "start" bit informs the receiving device that a character is coming, and a "stop" bit tells it that one is complete. The start bit is always a 0. The stop bit is always a 1. We've added the start and stop bits to the transmitted "W" example.

The human speaking equivalent of these bits could be a clearing of the throat to get someone's attention (start bit); and a pause at the end of a phrase (stop bit). Both help the listener understand the message.

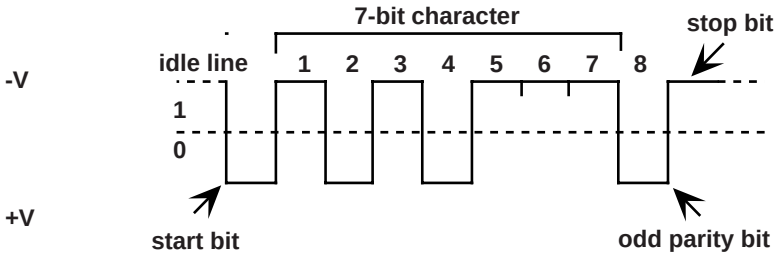



**Figure 1.5 - ASCII upper case "W" with start and stop bits.**

## Baud Rate

The baud rate refers to the speed of data transmission. When a change in signal represents one data bit, baud rate is equal to bits per second (bps). Our rates on the 988 Family of controllers are 300, 600, 1200, 2400, 4800 and 9600 baud.

## Computer Languages

Computer languages are simply sets of symbols and rules for their use. There are many computer languages and a wide variety of applications for them. Programmers use languages to enable computers to do real work. We're providing a pilot program written in Quick BASIC to demonstrate data communications with Watlow controllers. You can download the MS-DOS™ version files ("comms4.zip" and "comms4tm.zip" and com5set.exe) from the Watlow BBS, (507) 454-3958.

## Syntax

Syntax for a natural language dictates how we put words together to make phrases and sentences. In data communications, syntax also dictates how we order the parts of a message.

For example, the Series 986-989 parameter for set point information is SP1. The controller's panel will normally display SP1 and set point information whenever you physically press the DISPLAY key to reach SP1 in the parameter sequence. For a computer linked to a controller, "SP1" is part of the syntax for data communications.

If you type just "SP1" on the computer keyboard, the controller won't respond to your computer with the current set point 1 data. The syntax requires spaces and "fields" of specific size to be complete.

Plus, we need to add the protocol. It's like putting a message in an envelope and addressing it. The entire syntax of the SP1 command includes the message protocol's STX (Start of Text) control character, SP1, space, up to four decimal places of set-point data, and a protocol ETX (End of Text) control character.

The whole phrase would look like this:

**<STX> SP1 0500 <ETX>**

## ASCII Control Character Definitions

**ENQ** Enquiry (inquiry): Request for a data link.

**ACK** Acknowledge: Affirmative response from the receiver.

**NAK** Negative Acknowledge: Negative response from the receiver.

**STX** Start of Text: Precedes any message from the sender.

**ETX** End of Text: Follows any message from the sender.

**EOT** End of Transmission: Tells the other device that it is its turn to send a message.

**DLE** Data Link Escape: Disconnect signal from the master to devices on the network.

## A Data Communications Conversation

Now that you have a general grasp of the basic ideas and terms behind data communications, we'll take the example further to see how an actual conversation would take place.

The example on the next page follows the exchange between a computer (master) and a controller (remote) as the computer sends a set point data command to the controller.

That's really all there is to it. Remember — only the "master" may initiate exchanges and every message requires a response.

## An Example of a Data Communication Conversation

| | | |
|---|---|---|
| **The computer (the master) initiates an exchange with controller #2 (the remote).** | *computer*<br>**2 <ENQ>** | (#2, are you there?) |
| | *controller*<br>**2 <ACK>** | (I'm #2, I'm here.) |
| **The computer tells the controller to change its set point.** | *computer*<br>**<STX> = <space> SP1 <space> 500 <return> <ETX>** | ("Here comes a message."<br>"Make SP1 = 500°."<br>"I'm done with the message.") |
| | *controller*<br>**<ACK>** | ("I understand.") |
| **The computer queries the controller for the new set point.** | *computer*<br>**<STX> ? <space> SP1 <return> <ETX>** | ("Here comes a message."<br>"What is SP1 value?"<br>"I'm done with the message.") |
| | *controller*<br>**<ACK>** | ("I understand [the question].") |
| | *computer*<br>**<EOT>** | ("That's all, go ahead.") |
| **The controller confirms that the new set point.** | *controller*<br>**<STX> 500 <ETX>** | ( "Here comes the answer."<br>"The value is 500°."<br>"I'm done with the answer.") |
| | *computer*<br>**<ACK>** | ("I understand [the answer].") |
| | *controller*<br>**<EOT>** | ("That's all, go ahead.") |
| **The computer ends the session.** | *computer*<br>**<DLE> <EOT>** | ("Disconnect, please. That's all."<br>[master waits]) |

# Notes

# **Chapter 2** Hardware and Wiring

## Serial Hardware Interfaces

The Series 981-984, 986-989 and 996-999 controllers are factory-configured to function in a broad variety of applications. The specifics of each controller's configuration is encoded in its model number. Depending on your unit's model number, you have one of three hardware interfaces:

**NOTE:**
**This manual applies only to controllers with the data communications option (9___-____-_R__ or 9___-____-_S__ or 9___-____-_U__). Please use it in conjunction with the user's manuals.**

1) **EIA-232** (9___-____-_R__) provides one-on-one communication with a maximum network length of 50 feet connecting one controller to one computer.

2) **EIA-485** (9___-____-_S__) provides a "multidrop" or multiple-device network with up to 32 addresses with a 4,000-foot network length limit. **EIA-422** provides a multidrop network for up to ten devices with a 4,000-foot network length limit. **To select the multidrop interface**, enter the **Setup Menu** SEt. Use the up-arrow or down-arrow key to advance to the **Communications Menu** COMM. Press the **MODE** key until the **interface prompt** IntF appears. Select either **485 or 422**.

3) **EIA-232/EIA-485** (9___-____-_U__) If your controller is supplied with a "U" board, you can select via the comms menu either EIA-232 or EIA-485 operation. The IntF parameter is defaulted to EIA-232. **To select the multidrop interface**, enter the **Setup Menu** SEt. Use the up-arrow or down-arrow key to advance to the **Communications Menu** COMM. Press the **MODE** key until the **interface prompt** IntF appears. (Controllers equipped with the EIA-232 interface do not require an interface selection.)

## Your Computer's Serial Interface

You can connect a data communication-equipped Series 981-984, 986-989 or 996-999 to any computer with an EIA-422, EIA-232 or EIA-485 serial interface. A personal computer with an EIA-232 serial output card, for instance, can talk to a single EIA-232 equipped controller.

For a multiple-controller network with one personal computer, you'll need a converter to act as a bus, or multiple connection point.

For data communications serial interface converters for EIA-232 (RS-232), we recommend either of these two suppliers:

- **DATAFORTH Corp.** (formerly supplied by Burr-Brown):
  3331 E. Hemisphere Loop, Tuscon, AZ 85706
  Tel: 1-800-444-7644, or (520) 741-1404 or Fax: (520) 741-0762
  For EIA-422 (RS-422), part number: LDM 422
  with a power supply and the correct 25 pin connector for your computer.
  For EIA-485 (RS-485), part number: LDM 485
  with a power supply and the correct 25 pin connector for your computer.

- **B & B Electronics Manufacturing Company**
  707 Dayton Road, PO Box 1040, Ottawa, IL 61350
  Tel: (815) 433-5100 or Fax: (815) 434-7094 or Web: http://www.bb-elec.com
  For EIA-422/ EIA-485 (RS-422/ RS-485), part number: 485OIC
  with a power supply and the correct 25 pin connector for your computer.

## Communications Wiring

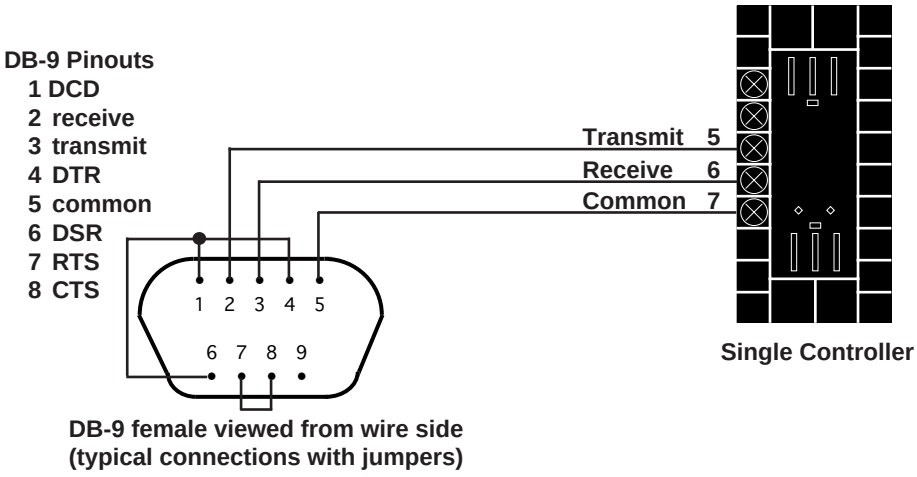
The rest of the chapter explains how to connect your controller to a computer. Consult the instruction manual for your computer's serial port or serial card for detailed serial port pin information. Industrial environments often contain a lot of electrical noise. Take care to isolate your control system.

**NOTE:**
**The Electronic Industry Association (EIA) RS-232 standard recommends a maximum 50-foot total point-to-point distance.**

## EIA-232 Interface Wiring

The EIA/-232 communications uses a three-wire, full-duplex system. There is a separate line for transmitting data, a line for receiving data and a common line between the computer and the controller. With EIA-232 you can have only one controller connected to a single computer.

This diagram is a **typical** wiring example. The connections on the host computer may vary, depending on the model. Refer to your computer or serial card user's manual for specific information.



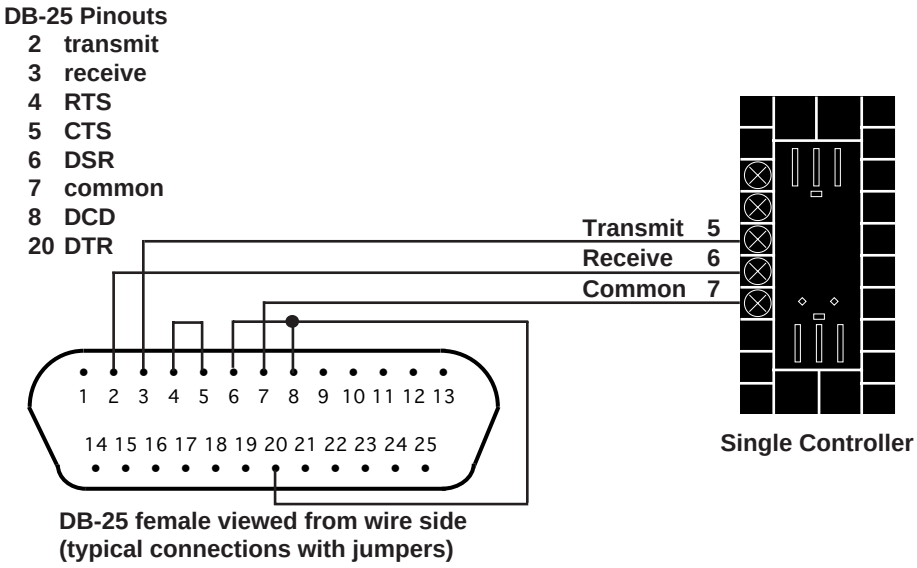



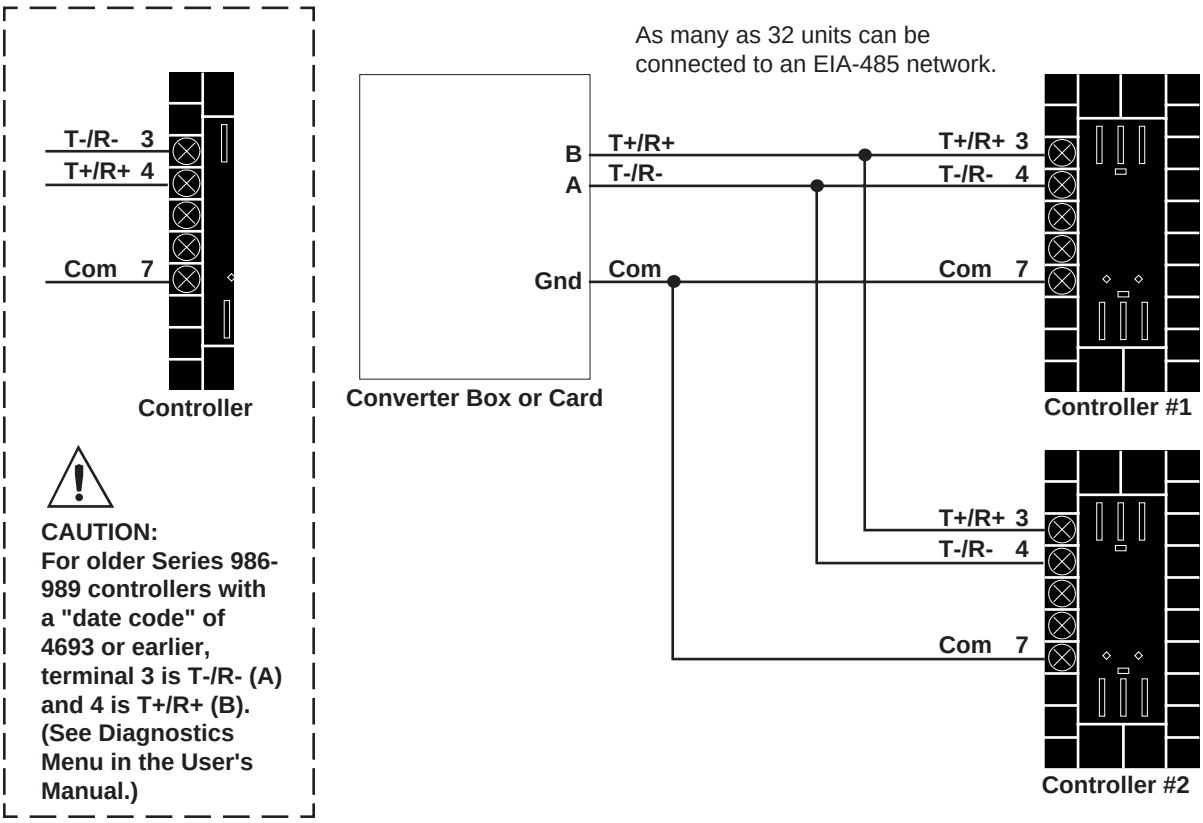

**Figure 2.2 - EIA-232 Interface Wiring Diagrams.**

## EIA-485 Interface Wiring

The EIA-485 communications uses a three-wire, half-duplex system. There are two lines for transmitting and receiving and a common line. Only one device, the computer or a controller, can be speaking at a time. **The controller requires at least a 7-millisecond delay between transmission and receipt of data.** With EIA-485 you can have from one to thirty-two controllers connected to a computer.

**NOTE:**
**The Electronic Industry Association EIA-485 standard recommends a maximum total network distance of 4,000 feet.**

This diagram is a **typical** wiring example for units shipped after 1993 (**see ⚠ Caution on this page**). The connections on the host computer may vary, depending on the model. Refer to your computer user's manual for specific information.



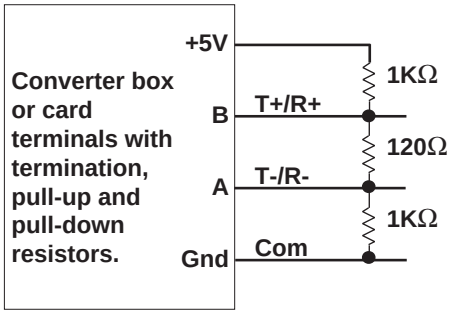




**Figure 2.3 - EIA-485 Interface Wiring Diagrams.**

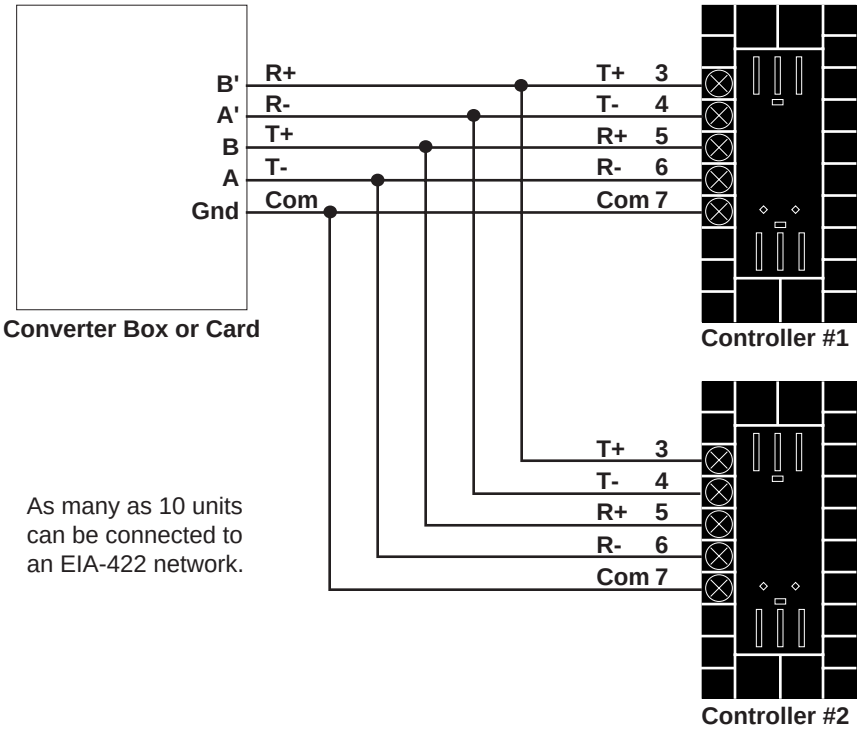
If the system does not work properly it may need termination resistors at each end of the network. A typical installation would require a 120-ohm resistor across the transmit/receive terminals (3 and 4) of the last controller in the network and the converter box or serial card. Pull-up and pull-down resistors may be needed to maintain the correct voltage during the idle state.

## EIA-422 Interface Wiring

The EIA-422 communications uses a five-wire, full-duplex system. There are two separate lines for transmitting, two lines for receiving and a common line between the computer and the controller. With EIA-422 you can connect from one to ten controllers to a single computer.

This diagram is a **typical** wiring example for units shipped after 1993 (**see ⚠ Caution on this page**). The connections to the converter box or computer may vary, depending on the model. Refer to the documentation for specific information.

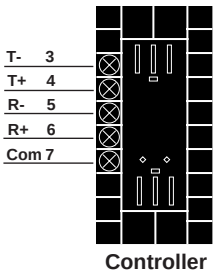
**NOTE:**
**The Electronic Industry Association (EIA) RS-422 standard recommends a maximum network distance of 4,000 feet.**

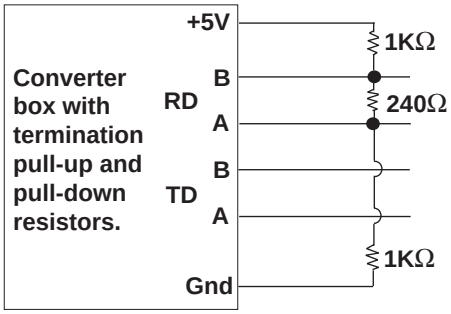



As many as 10 units can be connected to an EIA-422 network.

**Figure 2.4 - EIA-422 Interface Wiring Diagrams.**

**CAUTION:**
**For older Series 986-989 controllers with a "date code" of 4693 or earlier, terminal 3 is T-, 4 is T+, 5 is R- and 6 is R+. (See Diagnostics Menu in the User's Manual.)**




If the system does not work properly it may need termination resistors across the receive A and B terminals at the converter. A typical value would be 240Ω. Pull-up and pull-down resistors may be needed to maintain the correct voltage during the idle state.

# **Chapter 3** Communications Setup

## Connecting the Controller and the Computer

Remove power from both the controller and your computer before connecting them together. Assemble a cable and the appropriate wiring at your computer. Refer to the wiring in Chapter 2. As soon as you connect the data communications lines, you may apply power to your system.

## Software Protocols and Device Addresses

There are three communications protocols you may use. Depending on the type of network you need, you must use the correct combination of interface and protocol. Modbus works with all three interfaces.

To run a network with multiple devices Watlow uses the **ANSI X3.28 Protocol** (based on ANSI X3.28 - 1976 Subcategories 2.2, and A.3) with the EIA-422 and EIA-485 interface. ANSI X3.28 Protocol provides a response to every message. It will also work with the EIA-232 interface, but you are limited to one controller and a host computer.

To run a two-device network with an EIA-232 interface, you can also use **XON/XOFF Protocol**, a simpler protocol. XON/XOFF will also work with the EIA-422 and EIA-485 interface, **but the network is limited to two devices** — one computer and one controller. XON/XOFF Protocol does not require a device to respond to messages it receives.

To select the protocol, go to the Setup Menu SEt; use the up-arrow or down-arrow key to advance to the Communications Menu COMM. Press the MODE key until the protocol prompt Prot appears. Select either FULL, for ANSI X3.28 2.2 - A.3, On for XON/XOFF, or rtu, for Modbus RTU.

If you are using ANSI X3.28 Protocol, choose an address number for each controller using the address prompt Addr, which follows the protocol prompt Prot. This prompt will only appear if Prot is set to FULL or rtu.

## Communications Software

Watlow offers a Windows based configuration and monitoring software package for the 988/989 controllers. We also offer a simple MS-DOS™ communications demonstration program for the Series 981-984, 986-989, and 996-999. Ask your Watlow field sales representative for a copy of the "Comm 4" program, or you can download the files ("comms4.zip" and "comms4tm.zip" and com5set.exe) from the Watlow BBS, (507) 454-3958.




***(Communications)***

*Baud rate*

*Data bits and parity*

*Protocol type*

*Address*

*Interface type*

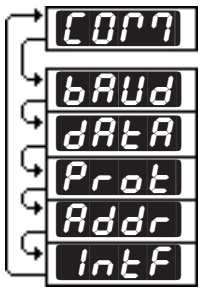



**Figure 3.2 - The Communications Menu.**

## Setup at the Controller's Front Panel

- Press the ▼ and ▲ keys simultaneously for three seconds.
- The SEt prompt appears in the lower display.
- Press the ▼ or ▲ key until the COM prompt appears.
- Press the MODE key to advance through the Communications Menu.
- Press the ▼ or ▲ key to select communications values from the table below.
- Document the setup parameters for each device on your network and label each device.
- Press the DISPLAY key to exit.

**NOTE: Selecting rtu automatically sets dAtA to 8n.**

| Prompt | Appears if… | Range | Factory default |
|---|---|---|---|
| bAUd | comms unit | (Baud rate) 300, 600, 1200, 2400, 4800, 9600 | 9600 |
| dAtA | comms unit | 7o = 7 data bits, odd parity<br>7E = 7 data bits, even parity<br>8n = 8 data bits, no parity<br>(Start bit = 1)<br>(Stop bit = 1) | 7o<br>(see note)<br><br>(Fixed)<br>(Fixed) |
| Prot | comms unit | FULL = ANSI X3.28 2.2 - A.3<br>On = XON / XOFF<br>rtu = Modbus | FULL |
| Addr | Prot = FULL<br>or<br>Prot = rtu | 0 to 31 (ASCII) if IntF = 485<br>0 to 9 (ASCII) if IntF = 422<br>1 to 247 if IntF = rtu | 0<br>0<br>1 |
| IntF | "S" hardware | 485 = EIA-485 Interface type<br>422 = EIA-422 Interface type | 485 |
| IntF | "U" hardware | 232 = EIA-232 Interface type<br>485 = EIA-485 Interface type | 232 |

**Table 3.2 - Communications Menu Prompts and Descriptions.**

# **Chapter 4** Sending Commands

## General Message Syntax

As soon as you link the devices, you can talk to the controllers using ASCII characters. They will respond to any Setup or Operation menu prompt, plus some others. The controller will respond to either upper or lower case ASCII characters from your computer.

Both protocol/interface combinations will respond to the general syntax if the commands or queries are correctly transmitted. However, the ANSI X3.28 Protocol requires beginning and ending characters, and the XON/XOFF protocol requires ending characters.

## Message Syntax

Messages from your computer to a controller must take this general form.

**Command <space> data.1 <space> data.2 <space> data.3... data.N**

"Command" is a character string. The brackets "<" and ">" enclose a non-literal description. The space character, <space> or <sp>, is simply a delimiter, an ASCII space character (hex 20). "Data fields" are prompts and values specific to the command. The number of data fields depends on the particular command. The first argument or parameter is abbreviated, "data.1," the next is "data.2," and so on.

In the syntax explanations that follow, we show you the specific arguments for each command. It will speed the process if you remember this general syntax.



**CAUTION:**
**Avoid writing <=> continuously, such as ramping set points or repetitive loops, to the controller's EEPROM memory. Continuous writes may result in premature control failure, system downtime and damage to processes and equipment.**

## Data Rules

Data fields are prompts and values specific to particular commands. Specific data for each command for each type of controller is listed after this chapter. These rules govern their use:

- Data will include the characters 0 through 9; a decimal point if needed; or a positive or negative sign.
- Data can include up to seven characters. A "+" or "-" sign, if used, must be first.
- Data can use leading zeros, up to the seven-character limit.
- The data.1 portion of message can be up to four total characters.

## Command List

These commands, represented by their respective ASCII characters, will enable you to program the controller from your computer. More detailed descriptions of the commands are in Chapters 5, 6 and 7.

**?** Returns the value of a specific prompt from the controller.
**=** Sets a specific prompt in the controller to a specific value.

## Example Format

This manual presents command examples in a consistent format. Information bracketed by < > indicates a description, rather than literal characters. We show each ASCII character that you must transmit to the controller, including space between the characters. (A <space>, or <sp>, is itself an ASCII character, hex 20).

For instance, in the example below, you want to set the Alarm 2 Low A2LO prompt to 500°. Notice how the syntax uses the "=" command.

**= <space> A2LO <space> 500 <carriage return>**

To send this message, key the ASCII characters into your computer, or write them into your program. Remember, your computer will send the ASCII character string for the number, not an actual number. The hex string for the line looks like this: 3D2041324C4F203530300D.

Notice that we have not mentioned protocol here, or any characters added to this syntax by a protocol. With XON/XOFF, the message above can be transmitted with only an additional carriage return <cr> (hex 0D) character at the end. However, the ANSI X3.28 Protocol requires an envelope of Start of Text <STX> (hex 02) and End of Text <ETX> (hex 03) characters around the information you see above. You will learn how to do that in the following pages.

## XON/XOFF Protocol for EIA-232

**XON/XOFF (flow control) protocol** allows a communicating device (either a controller or the host) to suspend transmission of all messages from the other device, and then to continue transmission when it's again ready.

The device that needs to suspend transmission sends the XOFF character (hex 13) to stop the other device's transmission, and XON (hex 11) to restart it. Any character will restart the transmission, but to avoid confusion use only the XON character.

Messages transmit according to the syntax described in the XON/XOFF formats that follow for each command.

The XON/XOFF protocol requires a carriage return <cr> character (hex 0D) at the end of every message.

## How To Communicate Using XON/XOFF

XON/XOFF protocol is used when one master is networked with only one controller. Your personal computer must generate the master's messages.

**"=" Command Example**

*Master:* **= <sp> A2LO <sp> 500 <cr>** (Set the A2LO prompt value to 500.)

*Remote:* **<XOFF>** (This will be returned once the device starts processing. The master must stay off line.)

*Remote:* **<XON>** (Processing is done. The master may send a new message. Note: The commands IN1, IN2 and CF may take up to two seconds to return this character. **Do not send another message until this character is received.**)

**"?" Command Example"**

*Master:* **? <sp> A2LO <cr>** (Request the A2LO prompt value.)

*Remote:* **<XOFF>** (The remote is preparing the response. The master must stay off-line.)

*Remote:* **<XON> 500 <cr>** (The value is returned and **the master may send another message once the <cr> is received.**)

or

**<XON>** (The message was not understood. The master may send a new message.)

**For maximum communications speed:**

- Do not use a typical delay to wait before looking for a response.
- Scan for returned characters until the correct response is received.
- Use a time out to end a session if a correct response is not received in three seconds.

**CAUTION:**
**Avoid writing <=> continuously, such as ramping set points or repetitive loops, to the controller's EEPROM memory. Continuous writes may result in premature control failure, system downtime and damage to processes and equipment.**

## How to Communicate Using ANSI X3.28

The ANSI X3.28 protocol provides high quality communications by requiring a response to every message. With a multiple-device or "multidrop" network, this protocol prevents confusion among the separate devices. Furthermore, if noise occurs somewhere in the system, no prompt will change because noise cannot comply with the protocol.

By placing messages inside a protocol envelope, the messages are protected. In the following examples you'll see how this works.

**ANSI X3.28 protocol rules:**

- Every remote device must have a unique address.
- Only the master can initiate a communication session, by addressing a specific remote device.
- Every message must be framed with an <STX> (start of transmission) character and an <ETX> (end of transmission) character.
- The master must wait for the remote device to respond to every message within a reasonable period. If no response occurs, retry the connection or pursue error recovery.

## Device Addresses

A Watlow EIA-422 multidrop network can handle up to 10 devices with this protocol. EIA-485 can handle up to 32 devices. Set the address number of the controller with the address prompt Addr under the Setup Menu SEt.

| Address | ASCII Equivalent |
|---|---|
| 0 | 0 |
| 1 | 1 |
| 2 | 2 |
| 3 | 3 |
| 4 | 4 |
| 5 | 5 |
| 6 | 6 |
| 7 | 7 |
| 8 | 8 |
| 9 | 9 |
| 10 | A |
| 11 | B |
| 12 | C |
| 13 | D |
| 14 | E |
| 15 | F |
| 16 | G |
| 17 | H |
| 18 | I |
| 19 | J |
| 20 | K |
| 21 | L |
| 22 | M |
| 23 | N |
| 24 | O |
| 25 | P |
| 26 | Q |
| 27 | R |
| 28 | S |
| 29 | T |
| 30 | U |
| 31 | V |

**Table 4.4 - Address to ASCII Conversion for ANSI X3.28 Protocol.**

## ANSI X3.28 Protocol Example

This example demonstrates communication between a master device and a remote device at address 4. Your personal computer must generate the master's messages.

**Establish Communications Link**

*Master:* **4 <ENQ>** (Attempt to link with device 4.)
*Remote:* **4 <ACK>** (The link is established.)

**End Communications Link**

*Master:* **<DLE> <ENQ>** (End data link.)
*Remote:* No response.

**"=" Command Example**

*Master:* **<STX> = <sp> A2LO <sp> 500 <ETX>** (Set A2LO prompt value to 500.)
*Remote:* **<ACK>** (This will be returned once the unit has completed the value change. Note: The commands IN1, IN2 and CF may take up to 2 seconds to return this character. Do not send another message until this character is received.)

**"?" Command Example**

*Master:* **<STX> ? <sp> A2LO <ETX>** (Request the A2LO prompt value.)
*Remote:* **<ACK>** (This will be returned once the device has the response ready. Do not send the <EOT> until this character has been received.)
or
**<NAK>** (The command was not understood. Re-send corrected message.)

*Master:* **<EOT>** (The host gives the device permission to respond.)
*Remote:* **<STX> 500 <ETX>** (The device sends back the requested value. Do not send a response until the <ETX> has been received.)

*Master:* **<ACK>** (The host received the message correctly.)
or
**<NAK>** (The host did not understand the response.Device will re-send it.)
*Remote:* **<EOT>** (The device returns control to the host. Do not send a new message until this character has been received.)

**For maximum communications speed:**

- Do not use a typical delay to wait before looking for a response.
- Scan for returned characters until the correct response is received.
- Use a time out to end a session if a correct response is not received in three seconds. Try again later.
- Protocols are not flexible. Outside of the <STX> <ETX> framing only the defined protocol characters are allowed. Some programming languages add <cr> to the end of transmissions. This must be disabled.
- End the communications link and re-establish it with <DLE> and <ENQ> only when changing to a new device at a different address. The master can communicate repeatedly with a specific device once the initial data link is established.

## Modbus Remote Terminal Unit (RTU)

Modbus RTU, available on the 988 family of controllers, expands the communications ability of the controller by enabling a computer to read and write directly to registers containing the controller's parameters.

Because of the wide array of choices available for setting up the 988 family of controllers, only a subset of the prompts contain parameters in a given situation. The Series 982, 988 and 998 User's Manuals explain the interrelations between prompts. If you try to write to an inactive prompt the controller will return an illegal data address message (02). (See "Exception Responses," pg. 4.9.)

If you already have a software application that uses Modbus, you can simply skip to the Temperature/process Controller Prompt Table or the Modbus RTU Address Table in this chapter for the address information your program will need. The rest of this section on the Modbus provides information for writing a software application that uses Modbus.

## Writing a Modbus Application

**NOTE:**
**Modbus register addresses are listed in the Controller Prompt Table later in this chapter and in the Modbus RTU Address Table at the end of this chapter.**

You need to code messages in eight-bit bytes, with no parity bit. Negative parameter values must be written in two's complement format. Parameters are stored in two-byte registers accessed with read and write commands to a relative address. Messages are sent in packets that are delimited by a pause at least as long as the time it takes to send 30 bits. To determine this time in seconds, divide 30 by your baud rate.

Because changing some parameters automatically changes or defaults other parameters, use the Complete Parameter Download Sequence table in this chapter to order write commands.

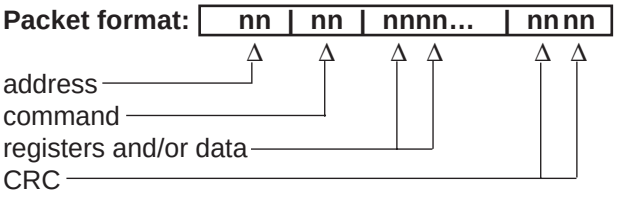
Using a controller address of 0x00 for a write command broadcasts that command to all the controllers in the network. This is a powerful feature if all the controllers on a network use all or most of the same parameters. No response is given to broadcast messages. Be sure to read each control to ensure it has received the command.

## Packet Syntax

Each message packet begins with a one-byte controller address, from 0x01 to 0xF7. The second byte in the message packet identifies the message command: read (0x03 or 0x04); write (0x06 or 0x10); or loop back (0x08).

The next n bytes of the message packet contain register addresses and/or data.

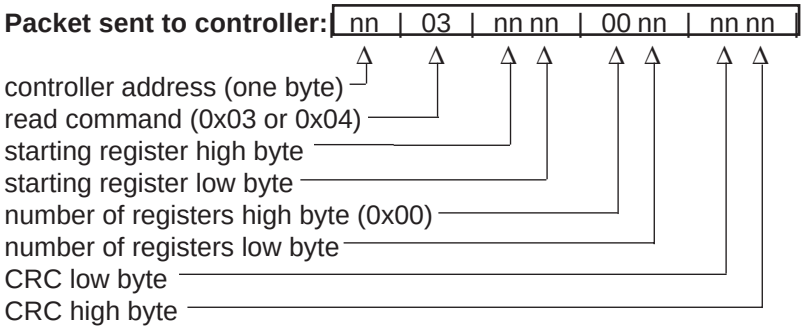
The last two bytes in the message packet contain a two-byte Cyclical Redundancy Checksum (CRC) for error detection.



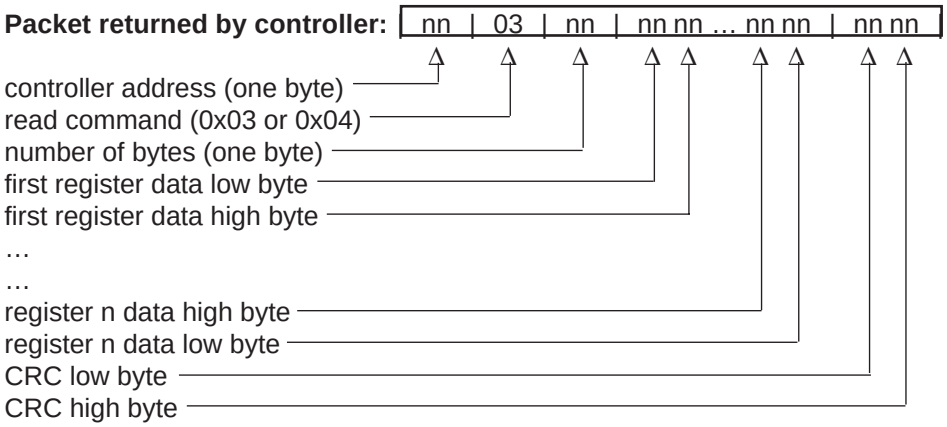
## Read Multiple Registers Command (0x03 or 0x04)

This command returns from 1 to 32 registers.

**Packet sent to controller:**




**Packet returned by controller:**




**NOTE:**
**Because the read command can only read 32 registers, the high byte for the number of registers will always be 0.**

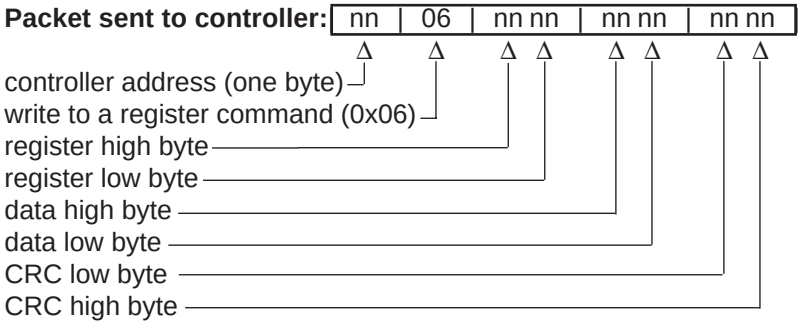
Example (988 only): Read register 0 (model number) of the controller at address 1.
Sent: `01 03 00 00 00 01 84 0A`
Received: `01 03 02 03 DC B9 2D`
Message: 988 (0x03DC).

Example (988 only): Read register 1 and 2 (Process 1 and 2 values) of controller at address 5.
Sent: `05 03 00 01 00 02 94 4F`
Received: `05 03 04 00 64 00 C8 FF BA`
Message: 100 (0x0064) and 200 (0x00C8).

## Write to a Single Register Command (0x06)

This command writes a parameter to a single register. The controller will echo back the command. An attempt to write to a read-only parameter returns an illegal data address error (0x02). (See “Exception Responses,” pg. 4.9.)

**Packet sent to controller:**



Example (988 only): Set register 7 (SPI) to 200 (0x00C8) on controller at address 9.
Sent: `09 06 00 07 00 C8 38 D5`
Received: `09 06 00 07 00 C8 38 D5`

## Write to Multiple Registers Command (0x10)

This command actually writes a parameter to only a single register. An attempt to write to a read-only parameter returns an illegal data address error (0x02). (See "Exception Responses," pg. 4.9.)

**Packet sent to controller:**

| nn | 10 | nn nn | 00 01 | 02 | nn nn | nn nn |
|---|---|---|---|---|---|---|

- controller address (one byte)
- write to multiple registers command (0x10)
- starting register high byte
- starting register low byte
- number of registers to write high byte (0x00)
- number of registers to write low byte (must be 0x01)
- number of data bytes (must be 0x02)
- data high byte
- data low byte
- CRC low byte
- CRC high byte

**NOTE:**
**Because the read command can only read 32 registers, the high byte for the number of registers will always be 0.**

**Packet returned by controller:**

| nn | 10 | nn nn | 00 01 | nn nn |
|---|---|---|---|---|

- controller address (one byte)
- write to multiple registers command (0x10)
- starting register high byte
- starting register low byte
- number of registers to write high byte (0x00)
- number of registers to write low byte (must be 0x01)
- CRC low byte
- CRC high byte

## Loop Back Command (0x08)

This command simply echoes the message. This serves as a quick way to check your wiring.

**Packet sent to controller:**

| nn | 08 | nn nn | nn nn |
|---|---|---|---|

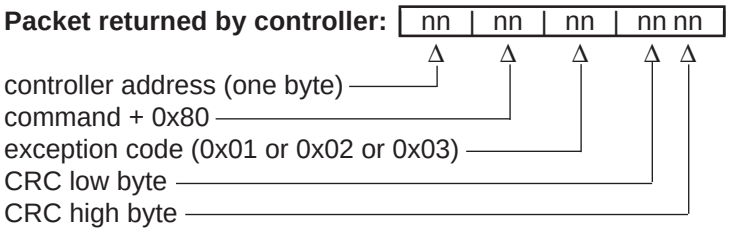
- controller address (one byte)
- loop back command (0x08)
- data high byte
- data low byte
- CRC low byte
- CRC high byte

Example: Run loop back test on controller at address 40 (0x28).
Sent: `28 08 55 66 77 88 31 B7`
Received: `28 08 55 66 77 88 31 B7`

## Exception Responses

When a controller cannot process a command it returns an exception response and sets the high bit (0x80) of the command.
0x01 illegal command
0x02 illegal data address
0x03 illegal data value

**Packet returned by controller:**




Messages with the wrong format, timing or CRC are ignored. A read command sent to an inactive parameter returns 0x0000.

Example: Exception 01 - Command 02 is not supported.
Sent: `01 02 00 01 00 02 A8 0B`
Received: `01 82 01 81 60`

Example: Exception 02 - The parameter at register 45 (0x002D) is inactive.
Sent: `01 06 00 2D 00 01 D8 C3`
Received: `01 86 02 C3 A1`

Example: Exception 03 - Cannot write 12,000 (0x2EE0) to register 7, out of range, illegal data value.
Sent: `01 06 00 07 2E E0 24 23`
Received: `01 86 03 02 61`

## Cyclical Redundancy Checksum (CRC) Algorithm

This C routine, calc_crc(), calculates the cyclical redundancy checksum, CRC, for a string of characters. The CRC is the result of dividing the string by 0xA001. Modbus applications calculate the packet's CRC then append it to the packet.

**NOTE:**
**When the CRC is added to the message packet be sure to put the low byte before the high byte.**

```
#define POLYNOMIAL 0xA001;

unsigned int calc_crc(unsigned char *start_of_packet, unsigned char
*end_of_packet)
{
     unsigned int crc;
     unsigned char bit_count;
     unsigned char *char_ptr;

/* Start at the beginning of the packet */

     char_ptr = start_of_packet;

/* Intitialize CRC */

     crc = 0xffff;

/* Loop through the entire packet */

     do{

/* Exlusive-OR the byte with the CRC */

          crc ^= (unsigned int)*char_ptr;

/* Loop through all 8 data bits */

          bit_count = 0;
          do{

/* If the LSB is 1, shift the CRC and XOR the poynomial mask with the CRC */

               if(crc & 0x0001){
                    crc >>= 1;
                    crc ^= POLYNOMIAL;
               }

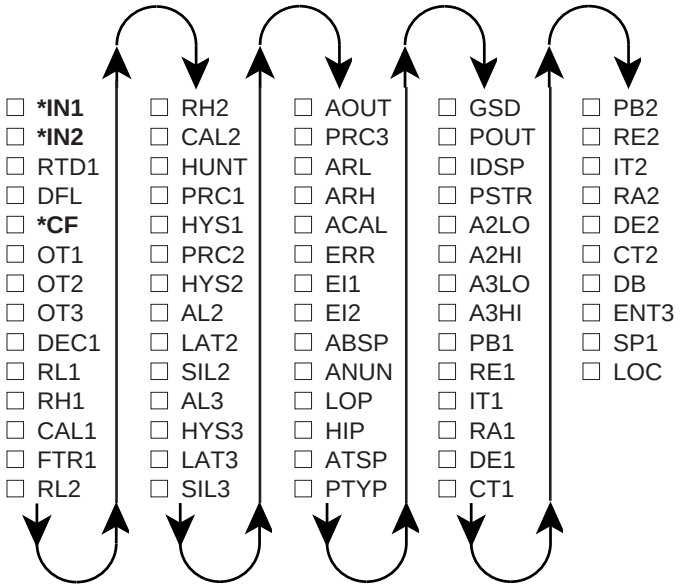
/* If the LSB is 0, shift the CRC only */

               else{
                    crc >>= 1;
               }
          } while(bit_count++ < 7);
     } while(char_ptr++ < end_of_packet);
return(crc);
}
```

# **Chapter 5** Command Summary of the Series 981-984

## Complete Parameter Download Sequence

When you download a complete set of parameters to a controller, **you must load them in this order**. The user's manual has more information about prompt interaction.




**CAUTION: Entering commands out of sequence will produce unexpected results, because some prompts change the values of other prompts. Copy this page and use the checkboxes.**

**Table 5.1 - Download Sequence.**

*** Wait at least two seconds after executing this command before going on to the next command.**

## Run/Hold Mode and Prompt Accessibility

Most Series 981-984 prompts are accessible via data communications while the controller is in its hold mode. Several are accessible when the controller is in either run or hold. A few are accessible only in the run mode. You can monitor the controller's mode with the RHS command.

Table 5.2 identifies the prompts accessible in run or hold, and those available in run only. Others not specifically identified are accessible in the hold mode only.

**CAUTION: Sending the Series 981-984 an invalid prompt for its present mode (run or hold) will result in a data communication error code ER2. Use the RHS prompt to monitor the controller mode.**

| RUN Only Mode | RUN or HOLD MODE |
|---|---|
| ? CSP | ? ALM |
| ? EJC | ? C1 |
| ? ENSP | ? C2 |
| ? MTR* | ? ENT3 |
| = HOLD 1 | ? ENT4 |
| | ? ER |
| | ? ER2 |
| | ? RHS |
| | ? SP1 |
| | ? DEV** |
| | ? MTR** |
| | ? PWR** |
| | = MOD x |
| | = SP1 |

**Table 5.2 - Run/Hold Mode Commands.**

Resetting the communication parameters is valid only in the hold mode.
* This command is accessible only in the run mode for software revisions before and including REV H.
** These commands are accessible in the run and hold modes for software revisions after and including REV I.

# Ramping Controller Prompt Table

## Command Summary Series 981-984 Data Communications

*Table 5.3 -*
**A2HI to AMB**

| Name data.1 / Modbus Address | Description | Read (?) and/or Write (=) Syntax | Range data.2 |
|---|---|---|---|
| **A2HI** 322 | **Output 2 Alarm High** | ? <sp> A2HI <cr><br>= <sp> A2HI <sp> data.2 <cr> | Process: A2LO to sensor high range<br>Deviation: 0 to 9999°<br>Rate: 0 to 9999°/minute<br>Default: RH, 999°, or 999°/min. |
| **A2LO** 321 | **Output 2 Alarm Low** | ? <sp> A2LO <cr><br>= <sp> A2LO <sp> data.2 <cr> | Process: sensor low range to A2HI<br>Deviation: -999 to 0°<br>Rate: -999 to 0°/minute<br>Default: RL, -999°, or -999°/min. |
| **A3HI** 341 | **Output 3 Alarm High** | ? <sp> A3HI<cr><br>= <sp> A3HI <sp> data.2 <cr> | Process: A3LO to sensor high range<br>Deviation: 0 to 9999°<br>Rate: 0 to 9999°/minute<br>Default: RH, 999°, or 999°/min. |
| **A3LO** 340 | **Output 3 Alarm Low** | ? <sp> A3LO <cr><br>= <sp> A3LO <sp> data.2 <cr> | Process: sensor low range to A3HI<br>Deviation: -999 to 0°<br>Rate: -999 to 0°/minute<br>Default: RL, -999°, or -999°/min. |
| **ABSP** 1211 | **Abort Set Point** | ? <sp> ABSP <cr><br>= <sp> ABSP <sp> data.2 <cr> | off<br>RL to RH |
| **ACAL** 746 | **Calibration Offset for Retransmit Output** | ? <sp> ACAL <cr><br>= <sp> ACAL <sp> data.2 <cr> | -999°F to 999°F<br>-555°C to 555°C<br>999 to 999 units<br>Default: 0°F, 0°C, or 0 units |
| **AL2** 719 | **Alarm 2 Type** | ? <sp> AL2 <cr><br>= <sp> AL2 <sp> data.2 <cr> | 0 = Process Alarm, Input 1<br>1 = Deviation Alarm, Input 1<br>2 = Rate Alarm, Input 1<br>Default: 0 |
| **AL3** 736 | **Alarm 3 Type** | ? <sp> AL3 <cr><br>= <sp> AL3 <sp> data.2 <cr> | 0 = Process Alarm, Input 1<br>1 = Deviation Alarm, Input 1<br>2 = Rate Alarm, Input 1<br>Default: 0 |
| **ALM** 106 or 110 | **Alarm Status** (Writing a 0 clears next alarm.) | ? <sp> ALM <cr><br>= <sp> ALM <sp> 0 <cr> | 0 = No alarms occurring (0000 0000)<br>Bit 1 = A2LO (0000 0001)<br>Bit 2 = A2HI (0000 0010)<br>Bit 3 = A3LO (0000 0100)<br>Bit 4 = A3HI (0000 1000)<br>106 = Alarm 2<br>0 = off<br>1 = HI<br>2 = LO<br>110 = Alarm 3<br>0 = off<br>1 = HI<br>2 = LO |
| **AMB** 1500 | **Ambient Terminal Temperature** | ? <sp> AMB <cr> | Input 1 terminals in 0.0°F |

**CAUTION:**
**Avoid writing <=> continuously, such as ramping set points or repetitive loops, to the Series 981-984 EEPROM memory. Continuous writes may result in premature control failure, system downtime and damage to processes and equipment.**

**NOTE:**
**The number of decimal places returned by many of these commands is determined by the DEC1 or IN1 setting. (This does not apply to Modbus Protocol.)**

# Ramping Controller Prompt Table

*Table 5.4 -*
**ANUN to DE1**

**CAUTION:**
**Avoid writing <=> continuously, such as ramping set points or repetitive loops, to the Series 981-984 EEPROM memory. Continuous writes may result in premature control failure, system downtime and damage to processes and equipment.**

**NOTE:**
**The number of decimal places returned by many of these commands is determined by the DEC1 or IN1 setting. (This does not apply to Modbus Protocol.)**

| Name data.1 / Modbus Address | Description | Read (?) and/or Write (=) Syntax | Range data.2 |
|---|---|---|---|
| **ANUN** 725 | **Alarm Annunciation** | ? <sp> ANUN <cr><br>= <sp> ANUN <sp> data.2 <cr> | 0 = off<br>1 = on<br>Default: on |
| **AOUT** 743 | **Analog Output 3 Retransmit Function** | ? <sp> AOUT <cr><br>= <sp> AOUT <sp> data.2 <cr> | 0 = Retransmit Process Input 1<br>1 = Retransmit Set Point 1<br>2 = off<br>3 = Retransmit Process Input 2<br>Default: 0 |
| **ARH** 745 | **Retransmit Range High** | ? <sp> ARH <cr><br>= <sp> ARH <sp> data.2 <cr> | ARL to 9999<br>Default: RH1 or RH2 per AOUT |
| **ARL** 744 | **Retransmit Range Low** | ? <sp> ARL <cr><br>= <sp> ARL <sp> data.2 <cr> | -999 to ARH<br>Default: RL1 or RL2 per AOUT |
| **ATSP** 304 | **Auto-tune Set Point %** | ? <sp> ATSP <cr><br>= <sp> ATSP <sp> data.2 <cr> | 50 to 150%<br>Default: 90% |
| **AUT** 305 | **Auto-tune** | ? <sp> AUT <cr><br>= <sp> AUT <sp> data.2 <cr> | 0 = No auto-tuning<br>1 = Tune PID<br>Default: off |
| **C1** 100 | **Input 1 Value** | ? <sp> C1 <cr> | Based on IN1 range ; RL1 to RH1 |
| **C2** 104 | **Input 2 Value** | ? <sp> C2 <cr> | Based on IN2 range ; RL2 to RH2 |
| **CAL1** 605 | **Input 1 Calibration Offset** | ? <sp> CAL1 <cr><br>= <sp> CAL1 <sp> data.2 <cr> | -999°F to 999°F<br>-555°C to 555°C<br>-999 units to 999 units<br>Default: 0 |
| **CAL2** 615 | **Input 2 Calibration Offset** | ? <sp> CAL2 <cr><br>= <sp> CAL2 <sp> data.2 <cr> | -999°F to 999°F<br>-555°C to 555°C<br>-999 units to 999 units<br>Default: 0 |
| **CF** 901 | **Degrees Select Display Loop** | ? <sp> CF <cr><br>= <sp> CF <sp> data.2 <cr> | 0 = Display °F<br>1 = Display °C<br>Default: 0 |
| **CSP** 1202 | **Current Profile Set Point** | ? <sp> CSP <cr> | RL1 to RH1 |
| **CT1** 506 | **Cycle Time Output 1** | ? <sp> CT1 <cr><br>= <sp> CT1 <sp> data.2 <cr> | S.S. relay or open col:<br>0.0 = Burst firing, or<br>0.1 to 999.9 sec. (time prop)<br>Mech relay: 5.0 to 999.9 sec.<br>Default: 1.0 or 10.0 sec. |
| **CT2** 516 | **Cycle Time Output 2** | ? <sp> CT2 <cr><br>= <sp> CT2 <sp> data.2 <cr> | S.S. relay or open col:<br>0.0 = Burst firing, or<br>0.1 to 999.9 sec. (time prop)<br>Mech relay: 5.0 to 999.9 sec.<br>Default: 1.0 or 10.0 sec. |
| **DATE** 5 | **Factory Test Date** | ? <sp> DATE <cr> | xxyy<br>xx = week<br>yy = year |
| **DB** 505 | **Dead Band PID Heat/Cool** | ? <sp> DB <cr><br>= <sp> DB <sp> data.2 <cr> | -999°F to 999°F<br>-555°C to 555°C<br>-999 units to 999 units<br>Default: 0°F, 0°C, or 0 units |
| **DE1** 503 | **Derivative Output 1 PID** | ? <sp> DE1 <cr><br>= <sp> DE1 <sp> data.2 <cr> | 0.00 to 9.99 minutes<br>Default: 0.00 |

# Ramping Controller Prompt Table

| Name data.1<br>Modbus Address | Description | Read (?) and/or Write (=) Syntax | Range<br>data.2 |
|---|---|---|---|
| **DE2**<br>513 | **Derivative Output 2 PID** | ? <sp> DE2<cr><br>= <sp> DE2 <sp> data.2 <cr> | 0.00 to 9.99 minutes<br>Default: 0.00 |
| **DEC1**<br>606 | **Decimal Point Process Input 1** | ? <sp> DEC1 <cr><br>= <sp> DEC1 <sp> data.2 <cr> | 0 = Decimal point 0<br>1 = Decimal point 0.0<br>2 = Decimal point 0.00<br>3 = Decimal point 0.000<br>Default: 0 |
| **DEV**<br>211 | **Process Deviation Display Loop (IN 1)** | ? <sp> DEV <cr> | Difference between SP1 and C1 |
| **DFL**<br>900 | **Default Unit Type** | ? <sp> DFL <cr><br>= <sp> DFL <sp> data.2 <cr> | 0 = US units<br>1 = Standard international units |
| **EI1**<br>1060 | **Event Input 1 Function** | ? <sp> EI1 <cr><br>= <sp> EI1 <sp> data.2 <cr> | 0 = None<br>1 = Lock out keyboard<br>2 = Alarm reset<br>3 = Turn control outputs off<br>4 = Hold profile<br>5 = Start file 1<br>6 = Start file 2<br>7 = Start file 3<br>8 = Start file 4<br>9 = ABSP<br>10 = Pause<br>11 = Waitfor Event<br>Default: 0 |
| **EI1S**<br>201 | **Event Input 1 Status** | ? <sp> EI1S <cr> | 0 = Open (off)<br>1 = Closed (on) |
| **EI2**<br>1062 | **Event Input 2 Function** | ? <sp> EI2 <cr><br>= <sp> EI2 <sp> data.2 <cr> | 0 = None<br>1 = Lock out keyboard<br>2 = Alarm reset<br>3 = Turn control outputs off<br>4 = Hold profile<br>5 = Start file 1<br>6 = Start file 2<br>7 = Start file 3<br>8 = Start file 4<br>9 = ABSP<br>10 = Pause<br>11 = Waitfor Event<br>Default: 0 |
| **EI2S**<br>213 | **Event Input 2 Status** | ? <sp> EI2S <cr> | 0 = Open (off)<br>1 = Closed (on) |
| **EJC**<br>1203 | **Elapsed Jump Count** | ? <sp> EJC <cr> | 0 to 255 |
| **ENSP**<br>1204 | **End Set Point** | ? <sp> ENSP <cr> | RL1 to RH1 |
| **ENT3**<br>1268 | **Event 3 Output State** | ? <sp> ENT3 <cr><br>= <sp> ENT3 <sp> data.2 <cr> | 0 = off<br>1 = on |
| **ER**<br>209 | **Error, Analog Input** (Multiple errors possible.) | ? <sp> ER <cr> | 0 = No error<br>1 = Input 1 A-D overflow<br>2 = Input 1 overrange<br>3 = Input 1 underrange<br>4 = Input 1 A-D underflow<br>5 = Input 2 A-D overflow<br>6 = Input 2 overrange<br>7 = Input 2 underrange<br>8 = Input 2 A-D underflow<br>9 = Ambient error |

*Table 5.5 -*
**DE2 to ER**

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**CAUTION:**
**Avoid writing <=> continuously, such as ramping set points or repetitive loops, to the Series 981-984 EEPROM memory. Continuous writes may result in premature control failure, system downtime and damage to processes and equipment.**

**NOTE:**
**The number of decimal places returned by many of these commands is determined by the DEC1 or IN1 setting. (This does not apply to Modbus Protocol.)**

# Ramping Controller Prompt Table

*Table 5.6 -*
**ER2 to HYS3**

**CAUTION:**
**Avoid writing <=> continuously, such as ramping set points or repetitive loops, to the Series 981-984 EEPROM memory. Continuous writes may result in premature control failure, system downtime and damage to processes and equipment.**

**NOTE:**
**The number of decimal places returned by many of these commands is determined by the DEC1 or IN1 setting. (This does not apply to Modbus Protocol.)**

| Name data.1<br>Modbus Address | Description | Read (?) and/or Write (=) Syntax | Range<br>data.2 |
|---|---|---|---|
| **ER2**<br>**n/a** | **Error, Communications** | ? <sp> ER2 <cr> | 0 = No error<br>1 = Transmit buffer overflow<br>2 = Receive buffer overflow<br>3 = Framing error<br>4 = Overrun error<br>5 = Parity error<br>6 = Talking out of turn<br>7 = Invalid reply error<br>8 = Noise error<br>20 = Command not found<br>21 = Prompt not found<br>22 = Incomplete command line<br>23 = Invalid character<br>24 = Number of chars. overflow<br>25 = Input out of limit<br>26 = Read only command<br>27 = Write allowed only<br>28 = Prompt not active<br>30 = Request to RUN invalid<br>31 = Request to HOLD invalid<br>32 = Command invalid in RUN Mode<br>33 = Command invalid in HOLD Mode<br>34 = Output 3 is not an Event<br>35 = Output 4 is not an Event<br>38 = Asterisk not allowed<br>39 = Infinite loop error |
| **ERR**<br>607 | **Error, Latching Enable** | ? <sp> ERR <cr><br>= <sp> ERR <sp> data.2 <cr> | 0 = Errors latching<br>1 = Errors non-latching<br>Default: 1 |
| **FTR1**<br>604 | **Filter Time Constant Process Input 1** | ? <sp> FTR1 <cr><br>= <sp> FTR1 <sp> data.2 <cr> | -60 to 60 seconds<br>Default: 0 |
| **GSD**<br>1205 | **Guaranteed Soak Deviation** | ? <sp> GSD <cr><br>= <sp> GSD <sp> data.2 <cr> | 0°F to 999°F<br>0°C to 999°C<br>0 to 999 units<br>0 = (disabled)<br>Default: 0°F, 0°C, or 0 units |
| **HIP**<br>714 | **High Power Limit** | ? <sp> HIP <cr><br>= <sp> HIP <sp> data.2 <cr> | LOP (%) to 100%<br>Default: 100 (heat/cool)<br>Default: 0 (cool only) |
| **HOLD**<br>1210 | **Simulate HOLD Key Press** | = <sp> HOLD <sp> data.2 <cr> | 1 = Holds current file# and step# |
| **HUNT**<br>1905 | **Slidewire Dead Band %** | ? <sp> HUNT <cr><br>= <sp> HUNT <sp> data.2 <cr> | 0.1% to 100.0%<br>Default: 1.0% |
| **HYS1**<br>507 | **Output 1 Hysteresis** | ? <sp> HYS1 <cr><br>= <sp> HYS1 <sp> data.2 <cr> | 0°F to 999°F<br>0°C to 555°C<br>0 units to 999 units<br>Default: 3°F, 2°C, or 3 units |
| **HYS2**<br>517<br>720 | **Output 2 Hysteresis** | ? <sp> HYS2 <cr><br>= <sp> HYS2 <sp> data.2 <cr> | 0°F to 999°F<br>0°C to 555°C<br>0 units to 999 units<br>Default: 3°F, 2°C, or 3 units |
| **HYS3**<br>737 | **Output 3 Hysteresis** | ? <sp> HYS3 <cr><br>= <sp> HYS3 <sp> data.2 <cr> | 0°F to 999°F<br>0°C to 555°C<br>0 units to 999 units<br>Default: 3°F, 2°C, or 3 units |

# Ramping Controller Prompt Table

*Table 5.7 -* **IDSP to LAT3**

| Name data.1<br>Modbus Address | Description | Read (?) and/or Write (=) Syntax | Range data.2 |
|---|---|---|---|
| **IDSP**<br>308 | **Idle Set Point After Power Outage** | ? <sp> IDSP <cr><br>= <sp> IDSP <sp> data.2 <cr> | RL1 to RH1 |
| **IN1**<br>601 | **Input 1 Type**<br><br>**Caution: Writing to IN1 or IN2 resets most prompts to their default values.** | ? <sp> IN1 <cr><br>= <sp> IN1 <sp> data.2 <cr> | 1 = J t/c; 32 to 1500°F/0 to 816°C<br>2 = K t/c; -328 to 2500°F/-200 to 1371°C<br>3 = T t/c; -328 to 750°F/-200 to 399°C<br>4 = N t/c; 32 to 2372°F/0 to 1300°C<br>5 = E t/c; -328 to 1470°F/-200 to 799°C<br>6 = C t/c (W3); 32 to 4200°F 0 to 2316°C<br>7 = D t/c (W5); 32 to 4200°F/0 to 2316°C<br>8 = Pt 2; 32 to 2543°F/0 to 1395°C<br>10 = R t/c; 32 to 3200°F/0 to 1760°C<br>11 = S t/c; 32 to 3200°F/0 to 1760°C<br>12 = B t/c; 1598 to 3300°F/870 to 1816°C<br>14 = 1° RTD (DIN); -328 to 1472°F/-200 to 800°C<br>15 = 0.1° RTD (DIN); -99.9 to 999.9°F/-99.9 to 700.0°C<br>17 = 4-20mA; -999 to 9999 units<br>18 = 0-20mA; -999 to 9999 units<br>19 = 0-5V⎓ (dc); -999 to 9999 units<br>20 = 1-5V⎓ (dc); -999 to 9999 units<br>21 = 0-10V⎓ (dc); -999 to 9999 units<br>23 = 0-50mV⎓ (dc); -999 to 9999 units<br>24 = 0-100mV⎓ (dc); -999 to 9999 units |
| **IN2**<br>611 | **Input 2 Type** | ? <sp> IN2 <cr><br>= <sp> IN2 <sp> data.2 <cr> | 26 = Slidewire off<br>27 = Slidewire; 100 to 1200<br>32 = Event input 2 off<br>33 = Event Input 2 on |
| **IT1**<br>501 | **Integral for Output 1** | ? <sp> IT1 <cr><br>= <sp> IT1 <sp> data.2 <cr> | 0.00 to 99.99 minutes per repeat<br>Default: 10.00 minutes per repeat |
| **IT2**<br>511 | **Integral for Output 2** | ? <sp> IT2 <cr><br>= <sp> IT2 <sp> data.2 <cr> | 0.00 to 99.99 minutes per repeat<br>Default: 10.00 minutes per repeat |
| **ITY1**<br>8 | **Input 1 Hardware Type** | ? <sp> ITY1 <cr> | 0 = None<br>1 = t/c only<br>4 = Input off<br>5 = Universal RTD<br>6 = Universal high gain t/c<br>7 = Universal low gain t/c<br>8 = Universal millivolts<br>9 = Universal process |
| **ITY2**<br>9 | **Input 2 Hardware Type** | ? <sp> ITY2 <cr> | 0 = None<br>3 = Slidewire<br>4 = Input off<br>10 = Event input |
| **LAT2**<br>721 | **Alarm 2 Latching** | ? <sp> LAT2 <cr><br>= <sp> LAT2 <sp> data.2 <cr> | 0 = Latching alarms<br>1 = Non-latching alarms<br>Default: 1 |
| **LAT3**<br>738 | **Alarm 3 Latching** | ? <sp> LAT3 <cr><br>= <sp> LAT3 <sp> data.2 <cr> | 0 = Latching alarms<br>1 = Non-latching alarms<br>Default: 1 |

**CAUTION:**
**Avoid writing <=> continuously, such as ramping set points or repetitive loops, to the Series 981-984 EEPROM memory. Continuous writes may result in premature control failure, system downtime and damage to processes and equipment.**

**NOTE:**
**The number of decimal places returned by many of these commands is determined by the DEC1 or IN1 setting.**

**NOTE:**
**(RTD setting)**
**For JIS curve, go to rtd1 prompt after selecting In1.**

# Ramping Controller Prompt Table

*Table 5.8 -*
**LOC to OT3**

**CAUTION:**
**Avoid writing <=> continuously, such as ramping set points or repetitive loops, to the Series 981-984 EEPROM memory. Continuous writes may result in premature control failure, system downtime and damage to processes and equipment.**

**NOTE:**
**The number of decimal places returned by many of these commands is determined by the DEC1 or IN1 setting. (This does not apply to Modbus Protocol.)**

| Name data.1<br>Modbus Address | Description | Read (?) and/or Write (=) Syntax | Range<br>data.2 |
|---|---|---|---|
| **LOC**<br>1300 | **Keyboard Lockout** | ? <sp> LOC <cr><br>= <sp> LOC <sp> data.2 <cr> | 0 = No lockout<br>1 = Lock out PID Menu and auto-tune prompt<br>2 = Lock out System, PID and Program Menus<br>3 = Lock out System, PID and Program Menus; and set point 1 slewing<br>Default: 0 |
| **LOP**<br>715 | **Low Power Limit** | ? <sp> LOP <cr><br>= <sp> LOP <sp> data.2 <cr> | -100% to HiP (%)<br>Default: -100% (heat/cool)<br>Default: 0% (heat only) |
| **LRNH**<br>1907 | **Learn High Slide-wire Resistance** | ? <sp> LRNH <cr><br>= <sp> LRNH <sp> data.2 <cr> | 0 = No function<br>1 = Learn<br>Default: 0 |
| **LRNL**<br>1906 | **Learn Low Slide-wire Resistance** | ? <sp> LRNL <cr><br>= <sp> LRNL <sp> data.2 <cr> | 0 = No function<br>1 = Learn<br>Default: 0 |
| **MDL**<br>0 | **Model Number** | ? <sp> MDL <cr> | 982 (981-984 ramping unit) |
| **MOD**<br>1900 | **Mode Key Action** | = <sp> MOD <sp> data.2 <cr> | 0 = Mode to previous prompt<br>1 = Mode to next prompt |
| **MTR**<br>1200 | **Monitor the currently running step.**<br><br>This key command responds with all step information for these step types:<br>• Set Point (time)<br>• Set Point (rate)<br>• Soak<br><br>These step types have zero-time duration; they will never respond to an MTR query:<br>• Jump-loop<br>• Link File<br>• End Step | ? <sp> MTR <cr> | See Key Command, "MTR," at the end of this chapter for full response syntax. |
| **OT1**<br>700 | **Output 1 Action** | ? <sp> OT1 <cr><br>= <sp> OT1 <sp> data.2 <cr> | 0 = Heat<br>1 = Cool |
| **OT2**<br>717 | **Output 2 Action** | ? <sp> OT2 <cr><br>= <sp> OT2 <sp> data.2 <cr> | 0 = Heat<br>1 = Cool<br>2 = None<br>3 = Alarm 2<br>4 = Alarm 2 reverse acting |
| **OT3**<br>734 | **Output 3 Action** | ? <sp> OT3 <cr><br>= <sp> OT3 <sp> data.2 <cr> | 0 = None<br>1 = Alarm 3<br>2 = Alarm 3 reverse acting<br>3 = Event 3 (ENT3) |

# Ramping Controller Prompt Table

*Table 5.9 -* **OTY1 to PSTR**

| Name data.1<br>Modbus Address | Description | Read (?) and/or Write (=) Syntax | Range data.2 |
|---|---|---|---|
| **OTY1**<br>16<br>**OTY2**<br>17<br>**OTY3**<br>18<br>**OTY4**<br>19 | **Output 1 Hardware**<br>**Output 2 Hardware**<br>**Output 3 Hardware**<br>**Output 4 Hardware** | ? <sp> <OTY1> <cr><br>? <sp> <OTY2> <cr><br>? <sp> <OTY3> <cr><br>? <sp> <OTY4> <cr> | 0 = None<br>1 = SSR 0.5A<br>2 = SSR 0.5A with suppression<br>5 = Dual SSR form A<br>6 = Switched dc<br>7 = Dual switched dc<br>8 = Relay 5A form C<br>9 = Relay 5A form C with suppression<br>10 = Relay 5A form A/B<br>11 = Relay 5A form A/B with suppr.<br>12 = Dual Relay form A<br>13 = Process output<br>14 = Voltage retransmit<br>15 = Current retransmit<br>16 = Power supply<br>17 = Comms EIA-232<br>18 = Comms EIA-485 / EIA-422<br>19 = Comms EIA-485 / EIA-232 |
| **PB1**<br>500 | **Proportional Band Output 1** | ? <sp> PB1 <cr><br>= <sp> PB1 <sp> data.2 <cr> | if DFL = 0 and CF = 1, then 0 to 555°C<br>if DFL = 0 and CF = 0, then 0 to 999°F<br>if DFL = 0 and In1 = a process value, then 0 to 999 units<br>if DFL = 1, then 0.0 to 99.9% of span<br>Default: 25°F, 14°C, 25 units, or 3.0% |
| **PB2**<br>510 | **Proportional Band Output 2** | ? <sp> PB2 <cr><br>= <sp> PB2 <sp> data.2 <cr> | if DFL = 0 and CF = 1, then 0 to 555°C<br>if DFL = 0 and CF = 0, then 0 to 999°F<br>if DFL = 0 and In1 = a process value, then 0 to 999 units<br>if DFL = 1, then 0.0 to 99.9% of span<br>Default: 25°F, 14°C, 25 units, or 3.0% |
| **POUT**<br>1206 | **Power Outage Response** | ? <sp> POUT <cr><br>= <sp> POUT <sp> data.2 <cr> | 0 = Continue<br>1 = Hold (HOLD)<br>2 = Abort<br>3 = Idle set point (IDSP)<br>4 = Reset |
| **PRC1**<br>701 | **Process Range Output 1** | ? <sp> PRC1 <cr><br>= <sp> PRC1 <sp> data.2 <cr> | 0 = 4-20mA<br>1 = 0-20mA<br>2 = 0-5V<br>3 = 1-5V⎓ (dc)<br>4 = 0-10V⎓ (dc)<br>Default: 0 |
| **PRC2**<br>718 | **Process Range Output 2** | ? <sp> PRC2 <cr><br>= <sp> PRC2 <sp> data.2 <cr> | 0 = 4-20mA<br>1 = 0-20mA<br>2 = 0-5V⎓ (dc)<br>3 = 1-5V⎓ (dc)<br>4 = 0-10V⎓ (dc)<br>Default: 0 |
| **PRC3**<br>735 | **Process Range Output 3** | ? <sp> PRC3 <cr><br>= <sp> PRC3 <sp> data.2 <cr> | 0 = 4-20mA<br>1 = 0-20mA<br>2 = 0-5V⎓ (dc)<br>3 = 1-5V⎓ (dc)<br>4 = 0-10V⎓ (dc)<br>Default: 0 |
| **PSTR**<br>1207 | **Program Start Point** | ? <sp> PSTR <cr><br>= <sp> PSTR <sp> data.2 <cr> | 0 = Start @ current process value<br>1 = Start @ hold mode set point<br>Default: 1 |

**CAUTION:**
**Avoid writing <=> continuously, such as ramping set points or repetitive loops, to the Series 981-984 EEPROM memory. Continuous writes may result in premature control failure, system downtime and damage to processes and equipment.**

**NOTE:**
**The number of decimal places returned by many of these commands is determined by the DEC1 or IN1 setting. (This does not apply to Modbus Protocol.)**

# Ramping Controller Prompt Table

*Table 5.10 -*
**PTYP to SOFT**

**CAUTION:**
**Avoid writing <=> continuously, such as ramping set points or repetitive loops, to the Series 981-984 EEPROM memory. Continuous writes may result in premature control failure, system downtime and damage to processes and equipment.**

**NOTE:**
**The number of decimal places returned by many of these commands is determined by the DEC1 or IN1 setting. (This does not apply to Modbus Protocol.)**

| Name data.1<br>Modbus Address | Description | Read (?) and/or Write (=) Syntax | Range data.2 |
|---|---|---|---|
| **PTYP**<br>1208 | **Program Type; Time-based, or Ramp rate-based** | ? <sp> PTYP <cr><br>= <sp> PTYP <sp> data.2 <cr> | 0 = Time-based; hour:min:sec<br>1 = Ramp rate-based; °/minute<br>Default: 0 |
| **PWR**<br>103 | **Percent Power Present Output** | ? <sp> PWR <cr> | -100% to 100%<br>Default: n/a |
| **RA1**<br>504 | **Rate Output 1** | ? <sp> RA1 <cr><br>= <sp> RA1 <sp> data.2 <cr> | 0.00 to 9.99 minutes<br>Default: 0.00 |
| **RA2**<br>514 | **Rate Output 2** | ? <sp> RA2 <cr><br>= <sp> RA2 <sp> data.2 <cr> | 0.00 to 9.99 minutes<br>Default: 0.00 |
| **RE1**<br>502 | **Reset Output 1** | ? <sp> RE1 <cr><br>= <sp> RE1 <sp> data.2 <cr> | 0.00 to 9.99 repeats/min.<br>Default: 0.10 repeats/min. |
| **RE2**<br>512 | **Reset Output 2** | ? <sp> RE2 <cr><br>= <sp> RE2 <sp> data.2 <cr> | 0.00 to 9.99 repeats/min.<br>Default: 0.10 repeats/min. |
| **RESU**<br>1209 | **Resume a Program** | = <sp> RESU <sp> data.2 <cr> | 1 = Resumes current file# and step# |
| **RH1**<br>603 | **Range High Input 1** | ? <sp> RH1 <cr><br>= <sp> RH1 <sp> data.2 <cr> | min. IN1 range to max. IN1 range<br>Default: sensor high range |
| **RH2**<br>613 | **Range High Input 2** | ? <sp> RH2 <cr><br>= <sp> RH2 <sp> data.2 <cr> | min. IN2 range to max. IN2 range<br>Default: sensor high range |
| **RHS**<br>200 | **Run/Hold Status** | ? <sp> <RHS> <cr> | 0 = Hold<br>1 = Run<br>2 = Pre-run |
| **RL1**<br>602 | **Range Low Input 1** | ? <sp> RL1 <cr><br>= <sp> RL1 <sp> data.2 <cr> | min. IN1 range to max. IN1 range<br>Default: sensor low range |
| **RL2**<br>612 | **Range Low Input 2** | ? <sp> RL2 <cr><br>= <sp> RL2 <sp> data.2 <cr> | min. IN2 range to max. IN2 range<br>Default: sensor low range |
| **RTD1**<br>609 | **RTD Calibration Curve Input 1** | ? <sp> RTd1 <cr><br>= <sp> RTd1 <sp> data.2 <cr> | 0 = JIS<br>1 = DIN<br>Default: 1 |
| **SIL2**<br>722 | **Alarm 2 Silence** | ? <sp> SIL2 <cr><br>= <sp> SIL2 <sp> data.2 <cr> | 0 = off/disabled<br>1 = on/enabled<br>Default: 0 |
| **SIL3**<br>739 | **Alarm 3 Silence** | ? <sp> SIL3 <cr><br>= <sp> SIL3 <sp> data.2 <cr> | 0 = off/disabled<br>1 = on/enabled<br>Default: 0 |
| **SRNB**<br>2 | **Serial Number Bottom Display**<br>Read the six-digit unit serial number in two segments, SNxx and xxxx, i.e., upper and lower front panel displays. | ? <sp> SRNB <cr> | xxxx =<br>0000 to 9999 |
| **SRNT**<br>1 | **Serial Number Top Display** | ? <sp> SRNT <cr> | SNxx =<br>00 to 99 |
| **SOFT**<br>4 | **Software Revision** | ? <sp> SOFT <cr> | 0 = Rev A<br>1 = Rev B<br>2 = Rev C<br>3 = Rev D<br>4 = Rev E<br>5 = Rev F<br>6 = Rev G<br>7 = Rev H<br>8 = Rev I<br>9 = Rev J<br>10 = Rev K<br>11 = Rev L<br>12 = Rev M<br>13 = Rev N<br>etc..... |

# Ramping Controller Prompt Table

*Table 5.11 -* **SP1 to TOUT**

| Name data.1<br>Modbus Address | Description | Read (?) and/or Write (=) Syntax | Range data.2 |
|---|---|---|---|
| **SP1**<br>300 | **Set Point 1** | ? <sp> SP1 <cr><br>= <sp> SP1 <sp> data.2 <cr> | RL1 to RH1<br>Default: per IN1 and hardware<br>set SP1 to RL1-1 to turn all outputs off |
| **SHYS**<br>1904 | **Slidwire Hysteresis** | ? <sp> SHYS <cr><br>= <sp> SHYS <sp> data.2 <cr> | 0 to Hunt |
| **STP**<br>Read: 1201<br>Write: 1250 | **Program a File Step.** This key command programs or queries all step information for all step types:<br>• Set Point (time)<br>• Set Point (rate)<br>• Soak<br>• Jump-loop<br>• Link File<br>• End | ? <sp> <STP> <sp> <FILE> <cr><br>= <sp> <STP> <sp> <FILE> data.2 <sp> ... data.n <cr><br>**See Key Command, "STP," at the end of this chapter for full syntax and data. See p. 5.14** | |
| **STRT**<br>1250 | **Start a File** | = <sp> STRT <sp> data.2 <sp> data.3 <sp> | data.2: 1 = File 1, 2 = File 2, 3 = File 3, 4 = File 4<br>data.3: 1 = Step 1, 2 = Step 2, 3 = Step 3, 4 = Step 4, 5 = Step 5, 6 = Step 6 |
| **TOUT**<br>1514 | **Test Outputs** | = <sp> TOUT <sp> data.2 <cr> | 0 = All off<br>1 = Output 1 on<br>2 = Output 2 on<br>3 = Output 3 on<br>4 = Output 4 on |

**CAUTION:**
**Avoid writing <=> continuously, such as ramping set points or repetitive loops, to the Series 981-984 EEPROM memory. Continuous writes may result in premature control failure, system downtime and damage to processes and equipment.**

**NOTE:**
**The number of decimal places returned by many of these commands is determined by the DEC1 or IN1 setting. (This does not apply to Modbus Protocol.)**

# Ramping Controller MTR Command

**Vertical lines represent <space> characters. Final vertical line represents a <space> and a <carriage return>. Each field must have data.**

| | data.1 | data.2 | data.3 | data.4 | data.5 | data.6 | data.7 | data.8 | data.9 | data.10 | data.11 |
|---|---|---|---|---|---|---|---|---|---|---|---|

**Monitor the Current Step for Current Process Information; response will parallel step type syntax below.**

| | | |
|---|---|---|
| **?** | **MTR** (Query current step info) | |

**MTR Response for a Set Point Step, Time-based** (PTYP = TI) Syntax

| **<FILE#>** | **<STEP#>** | **<STYP>** | **<SP>** | **<HOUR>** | **<MIN>** | **<SEC>** | **<ENT3>** | **<ENT4>** |
|---|---|---|---|---|---|---|---|---|
| 1 to 4 | 1 to 6 | (Step Type) 1= SP (Set Point) | RL to RH DFLT: 75°F/ 25°C/75 units, or RL if > the above. | 0 to 99 | 0 to 59 | 0 to 59 | (Event 3 Status) **"*"= disabled or unavailable** 0=off 1=on | (Event 4 Status) **"*"= disabled or unavailable** |

**MTR Response for a Set Point Step, Ramp Rate-based** (PTYP = RATE) Syntax

| **<FILE#>** | **<STEP#>** | **<STYP>** | **<SP>** | **<RATE>** | **<ENT3>** | **<ENT4>** |
|---|---|---|---|---|---|---|
| 1 to 4 | 1 to 6 | (Step Type) 1= SP (Set Point) | RL to RH DFLT: 75°F/ 25°C/75 units, or RL if > the above. | 0 to 360°F, 0 to 200°C, or 0 to 360 units | (Event 3 Status) **"*"= disabled or unavailable** 0=off 1=on | (Event 4 Status) **"*"= disabled or unavailable** |

**NOTE:**
**You must send an "*" if disabled or unavailable.**

**MTR Response for a Soak Step** Syntax

| **<FILE#>** | **<STEP#>** | **<STYP>** | **<HOUR>** | **<MIN>** | **<SEC>** | **<ENT3>** | **<ENT4>** | **<WE>** | **<WPR>** |
|---|---|---|---|---|---|---|---|---|---|
| 1 to 4 | 1 to 6 | (Step Type) 2= SOAH (Soak) | 0 to 99 | 0 to 59 | 0 to 59 | (Event 3 Status) **"*"= disabled or unavailable** 0=off 1=on | (Event 4 Status) **"*"= disabled or unavailable** | (Wait for Event) **"*"= disabled or unavailable** 0=off 1=on | (Wait for Process) **"*"= disabled or unavailable** Range: RL1 to RH1 |

**Note: MTR responses for Jump-loop, Link File and End Steps do not exist. These are zero time steps. The MTR will wait for next available set point or soak step type information.**

*Table 5.12 -*
**Key Command, MTR.**

**CAUTION:**
**Excessive use of the Monitor (MTR) command can slow Series 981-984 input sampling and output update rates. Avoid sending the MTR command more than once every five seconds.**

**CAUTION:**
**Avoid writing (=) continuously, such as ramping set points or repetitive loops, to the Series 981-984 EEPROM memory. Continuous writes may result in premature control failure, system downtime and damage to processes and equipment.**

# Ramping Controller STP Command

**Vertical lines represent <space> characters. Final vertical line represents a <space> and a <carriage return>. Each field must have data.**

| | data.1 | data.2 | data.3 | data.4 | data.5 | data.6 | data.7 | data.8 | data.9 | data.10 | data.11 |
|---|---|---|---|---|---|---|---|---|---|---|---|

**Query any Step for Programmed Information; response will parallel step type syntax below.**

| | | | |
|---|---|---|---|
| **?** | **STP**<br>(Query step info) | **<FILE#>**<br>1 to 4 | **<STEP#>**<br>1 to 6 |

**Program any Step per the Step Types below.**

**Set Point Step, Time-based** (PTYP = TI) Syntax

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **=** | **STP**<br>(Program a step) | **<File #>**<br>1 to 4 | **<STEP#>**<br>1 to 6 | **<STYP>**<br>(Step Type)<br>1= SP (Set Point) | **<SP>**<br>RL to RH<br>DFLT:<br>75°F/<br>25°C/<br>75 units | **<HOUR>**<br>0 to 23 | **<MIN>**<br>0 to 59 | **<SEC>**<br>0 to 59 | **<ENT3>**<br>(Event 3 Status)<br>**"*"= disabled or unavailable**<br>0=off<br>1=on | **<ENT4>**<br>(Event 4 Status)<br>**"*"= disabled or unavailable** |

**Set Point Step, Ramp Rate-based** (PtyP = rAtE) Syntax

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **=** | **STP**<br>(Program a step) | **<FILE#>**<br>1 to 4 | **<STEP#>**<br>1 to 6 | **<STYP>**<br>(Step Type)<br>1= SP (Set Point) | **<SP>**<br>RL to RH<br>DFLT:<br>75°F/<br>25°C/<br>75 units | **<RATE>**<br>0 to 360°F,<br>0 to 200°C or<br>0 to 360 units | **<ENT3>**<br>(Event 3 Status)<br>**"*"= disabled or unavailable**<br>0=off<br>1=on | **<ENT4>**<br>(Event 4 Status)<br>**"*"= disabled or unavailable** | **NOTE:**<br>**You must send an "*" if disabled or unavailable.** |

**Soak Step** Syntax

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **=** | **STP**<br>(Program a Step) | **<FILE#>**<br>1 to 4 | **<STEP#>**<br>1 to 6 | **<STYP>**<br>(Step Type)<br>2= SOAH (Soak) | **<HOUR>**<br>0 to 23 | **<MIN>**<br>0 to 59 | **<SEC>**<br>0 to 59 | **<ENT3>**<br>(Event 3 Status)<br>**"*"= disabled or unavailable**<br>0=off<br>1=on | **<ENT4>**<br>(Event 4 Status)<br>**"*"= disabled or unavailable** | **<WE>**<br>(Wait for Event)<br>**"*"= disabled or unavailable**<br>0=DSBL<br>1=on<br>2=off | **<WPR>**<br>(Wait for Process)<br>**"*"= disabled or unavailable**<br>Range:<br>RL1 to RH1;<br>(RLI-1) =DSBL |

**Jump-loop Step** Syntax

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **=** | **STP**<br>(Program a Step) | **<FILE#>**<br>1 to 4 | **<STEP#>**<br>1 to 6 | **<STYP>**<br>(Step Type)<br>3= JL (Jump-loop) | **<JF>**<br>(Jump to File)<br>1 to 4<br>DFLT: current file | **<JS>**<br>(Jump to Step)<br>1 to 5<br>DFLT: 1<br>Must be lower than current step #. | **<JC>**<br>(Jump Count)<br>Repeat 0 to 255 times<br>0 = infinite counts |

*Table 5.13 -*
**Key Command, STP.**

**Link File Step** Syntax

| | | | | | |
|---|---|---|---|---|---|
| **=** | **STP**<br>(Program a Step) | **<FILE#>**<br>1 to 4 | **<STEP#>**<br>1 to 6 | **<STYP>**<br>(Step Type)<br>4= LFIL (Link File) | **<LFIL>**<br>1 = FIL1<br>2 = FIL2<br>3 = FIL3<br>4 = FIL4 |

**End Step** Syntax

| | | | | | |
|---|---|---|---|---|---|
| **=** | **STP**<br>(Program a Step) | **<FILE#>**<br>1 to 4 | **<STEP#>**<br>1 to 6 | **<STYP>**<br>(Step Type)<br>0= End | **<END>**<br>(End Status)<br>0 = Hold<br>1 = off |

# Ramping Controller Commands

**MONITOR (MTR) Command**

READ only

Register: 1200 (You must request 23 registers)

**NOTE: "*" means the parameter is not available. The value will be -9999.**

**MTR response for a Set Point Step, Time-based(PTYP = TI)**

| Register # | 1200 | 1201 | 1202 | 1203 | 1204 | 1205 | 1206 | 1207 | 1208 | 1209 | 1210 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | File | Step | Type | SP | Hour | Min | Sec | * | * | * | * |

**MTR response for a Set Point Step, Rate-based(PTYP = RATE)**

| Register # | 1200 | 1201 | 1202 | 1203 | 1204 | 1205 | 1206 | 1207 | 1208 | 1209 | 1210 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | File | Step | Type | SP | * | * | * | Rate | * | * | * |

**MTR response for a Soak Step**

| Register # | 1200 | 1201 | 1202 | 1203 | 1204 | 1205 | 1206 | 1207 | 1208 | 1209 | 1210 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | File | Step | Type | * | Hour | Min | Sec | * | * | * | * |

**START (STRT) Command**

WRITE only

Register: 1250 1251 1252

Value: 1 File # Step #

**SET command, sets the current profile FILE and STEP.**

WRITE only

Register: 1250 1251 1252

Value: 3 File # Step #

**STEP (STP) Command**

READ the current file and step

Register: 1201 (You must request 23 registers)

Response will be the same as the PROGRAM commands below, (1201 = 1251, 1202 = 1252 etc.)

WRITE (program) the specified file and step.

(You must send a "*" (-9999) if a register is disabled or unavailable)

**NOTE: "*" means the parameter is not available. The value will be -9999.**

**PROGRAM command for a Set Point Step, Time-based(PTYP = TI)**

| Register # | 1250 | 1251 | 1252 | 1253 | 1254 | 1255 | 1256 | 1257 | 1258 | 1259 | 1260 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | 2 | File | Step | Type | SP | Hour | Min | Sec | * | * | * |

**PROGRAM command for a Set Point Step, Rate-based(PTYP = RATE)**

| Register # | 1250 | 1251 | 1252 | 1253 | 1254 | 1255 | 1256 | 1257 | 1258 | 1259 | 1260 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | 2 | File | Step | Type | SP | * | * | * | Rate | JF | * |

**PROGRAM command for a Soak Step**

| Register # | 1250 | 1251 | 1252 | 1253 | 1254 | 1255 | 1256 | 1257 | 1258 | 1259 | 1260 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | 2 | File | Step | Type | * | Hour | Min | Sec | * | * | * |

**PROGRAM command for a Jump Loop Step**

| Register # | 1250 | 1251 | 1252 | 1253 | 1254 | 1255 | 1256 | 1257 | 1258 | 1259 | 1260 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | 2 | File | Step | Type | * | * | * | * | * | JF | JS |

**PROGRAM command for a Link File Step**

| Register # | 1250 | 1251 | 1252 | 1253 | 1254 | 1255 | 1256 | 1257 | 1258 | 1259 | 1260 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | 2 | File | Step | Type | * | * | * | * | * | * | * |

**PROGRAM command for an End Step Step**

| Register # | 1250 | 1251 | 1252 | 1253 | 1254 | 1255 | 1256 | 1257 | 1258 | 1259 | 1260 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | 2 | File | Step | Type | * | * | * | * | * | * | * |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1211<br>* | 1212<br>* | 1213<br>* | 1214<br>* | 1215<br>* | 1216<br>* | 1217<br>ES3 | 1218<br>* | 1219<br>* | 1220<br>* | 1221<br>* | 1222<br>* |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1211<br>* | 1212<br>* | 1213<br>* | 1214<br>* | 1215<br>* | 1216<br>* | 1217<br>ES3 | 1218<br>* | 1219<br>* | 1220<br>* | 1221<br>* | 1222<br>* |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1211<br>* | 1212<br>* | 1213<br>WE | 1214<br>WP | 1215<br>* | 1216<br>* | 1217<br>ES3 | 1218<br>* | 1219<br>* | 1220<br>* | 1221<br>* | 1222<br>* |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1261<br>* | 1262<br>* | 1263<br>* | 1264<br>* | 1265<br>* | 1266<br>* | 1267<br>* | 1268<br>ES3 | 1269<br>* | 1270<br>* | 1271<br>* | 1272<br>* | 1273<br>* |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1261<br>* | 1262<br>* | 1263<br>* | 1264<br>* | 1265<br>* | 1266<br>* | 1267<br>* | 1268<br>ES3 | 1269<br>* | 1270<br>* | 1271<br>* | 1272<br>* | 1273<br>* |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1261<br>* | 1262<br>* | 1263<br>* | 1264<br>WE | 1265<br>WP | 1266<br>* | 1267<br>* | 1268<br>ES3 | 1269<br>* | 1270<br>* | 1271<br>* | 1272<br>* | 1273<br>* |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1261<br>JC | 1262<br>* | 1263<br>* | 1264<br>* | 1265<br>* | 1266<br>* | 1267<br>* | 1268<br>* | 1269<br>* | 1270<br>* | 1271<br>* | 1272<br>* | 1273<br>* |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1261<br>* | 1262<br>LF | 1263<br>* | 1264<br>* | 1265<br>* | 1266<br>* | 1267<br>* | 1268<br>* | 1269<br>* | 1270<br>* | 1271<br>* | 1272<br>* | 1273<br>* |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1261<br>* | 1262<br>* | 1263<br>ES | 1264<br>* | 1265<br>* | 1266<br>* | 1267<br>* | 1268<br>* | 1269<br>* | 1270<br>* | 1271<br>* | 1272<br>* | 1273<br>* |

*Table 5.16* - **Modbus RTU Addresses**

# Table 5.16 - 982 Modbus RTU Addresses

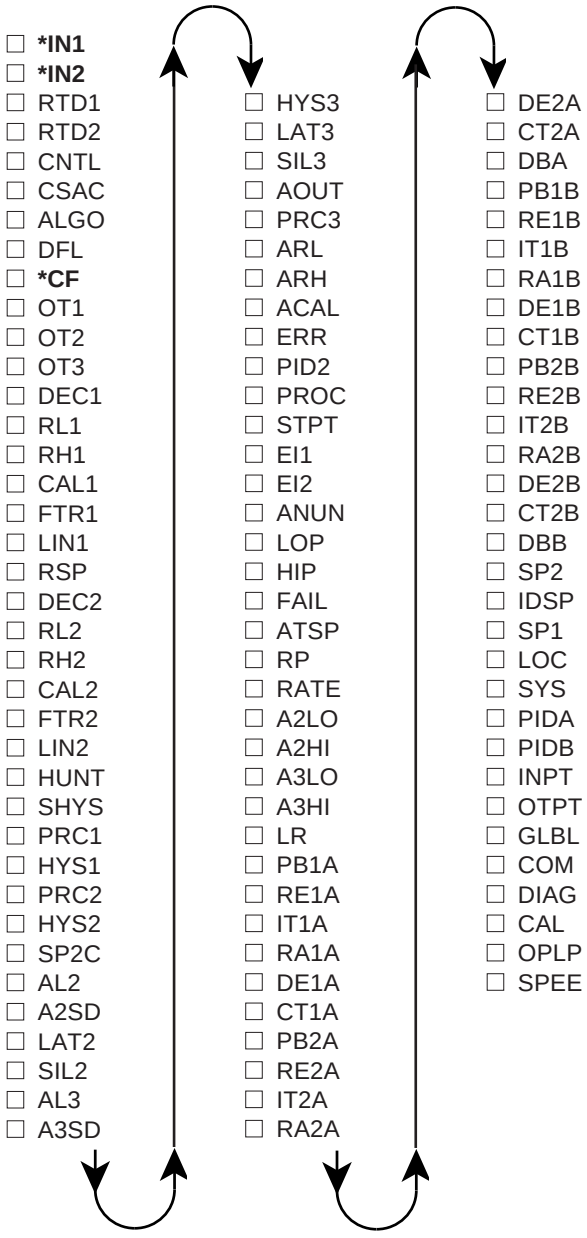
| Absolute Address | Relative Address | Parameter |
|---|---|---|
| 40001 | 0 | MDL (982) |
| 40002 | 1 | SRNT |
| 40003 | 2 | SRNB |
| 40005 | 4 | SOFT |
| 40006 | 5 | DATE |
| 40009 | 8 | ITY1 |
| 40010 | 9 | ITY2 |
| 40017 | 16 | OTY1 |
| 40018 | 17 | OTY2 |
| 40019 | 18 | OTY3 |
| 40020 | 19 | OTY4 |
| 40101 | 100 | C1 |
| 40104 | 103 | PWR |
| 40105 | 104 | C2 |
| 40107 | 106 | ALM |
| 40111 | 110 | ALM |
| 40201 | 200 | RHS |
| 40202 | 201 | EI1S |
| 40210 | 209 | ER |
| 40212 | 211 | DEV |
| 40214 | 213 | EI2S |
| 40301 | 300 | SP1 |
| 40305 | 304 | ATSP |
| 40306 | 305 | AUT |
| 40309 | 308 | IDSP |
| 40322 | 321 | A2LO |
| 40323 | 322 | A2HI |
| 40341 | 340 | A3LO |
| 40342 | 341 | A3HI |
| 40501 | 500 | PB1 |
| 40502 | 501 | IT1 |
| 40503 | 502 | RE1 |
| 40504 | 503 | DE1 |
| 40505 | 504 | RA1 |
| 40506 | 505 | DB |
| 40507 | 506 | CT1 |
| 40508 | 507 | HYS1 |
| 40511 | 510 | PB2 |
| 40512 | 511 | IT2 |
| 40513 | 512 | RE2 |
| 40514 | 513 | DE2 |
| 40515 | 514 | RA2 |
| 40517 | 516 | CT2 |
| 40518 | 517 | HYS2 |
| 40602 | 601 | IN1 |
| 40603 | 602 | RL1 |
| 40604 | 603 | RH1 |
| 40605 | 604 | FTR1 |
| 40606 | 605 | CAL1 |
| 40607 | 606 | DEC1 |
| 40608 | 607 | ERR |
| 40610 | 609 | RTD1 |
| 40612 | 611 | IN2 |
| 40613 | 612 | RL2 |
| 40614 | 613 | RH2 |
| 40616 | 615 | CAL2 |
| 40701 | 700 | OT1 |
| 40702 | 701 | PRC1 |
| 40715 | 714 | HIP |
| 40716 | 715 | LOP |
| 40718 | 717 | OT2 |
| 40719 | 718 | PRC2 |
| 40720 | 719 | AL2 |
| 40721 | 720 | HYS2 |
| 40722 | 721 | LAT2 |
| 40723 | 722 | SIL2 |
| 40726 | 725 | ANUN |
| 40735 | 734 | OT3 |
| 40737 | 736 | AL3 |
| 40738 | 737 | HYS3 |
| 40739 | 738 | LAT3 |
| 40740 | 739 | SIL3 |
| 40736 | 735 | PRC3 |
| 40744 | 743 | AOUT |
| 40745 | 744 | ARL |
| 40746 | 745 | ARH |
| 40747 | 746 | ACAL |
| 40901 | 900 | DFL |
| 40902 | 901 | CF |
| 41061 | 1060 | EI1 |
| 41063 | 1062 | EI2 |
| 41201 | 1200 | MTR |
| 41202 | 1201 | STP |
| 41203 | 1202 | CSP |
| 41204 | 1203 | EJC |
| 41205 | 1204 | ENSP |
| 41206 | 1205 | GSD |
| 41207 | 1206 | POUT |
| 41208 | 1207 | PSTR |
| 41209 | 1208 | PTYP |
| 41210 | 1209 | RESU |
| 41211 | 1210 | HOLD |
| 41212 | 1211 | ABSP |
| 41269 | 1268 | ENT3 |
| 41301 | 1300 | LOC |
| 41501 | 1500 | AMB |
| 41515 | 1514 | TOUT |
| 41901 | 1900 | MOD |
| 41902 | 1901 | DISP |
| 41905 | 1904 | SHYS |
| 41906 | 1905 | HUNT |
| 41907 | 1906 | LRNL |
| 41908 | 1907 | LRNH |

# **Chapter 6** Command Summary of the Series 986-989



## Complete Parameter Download Sequence

When you download a complete set of parameters to a controller, **you must load them in this order**. The user's manual has more information about prompt interaction.



| | | |
|---|---|---|
| ☐ ***IN1** | ☐ HYS3 | ☐ DE2A |
| ☐ ***IN2** | ☐ LAT3 | ☐ CT2A |
| ☐ RTD1 | ☐ SIL3 | ☐ DBA |
| ☐ RTD2 | ☐ AOUT | ☐ PB1B |
| ☐ CNTL | ☐ PRC3 | ☐ RE1B |
| ☐ CSAC | ☐ ARL | ☐ IT1B |
| ☐ ALGO | ☐ ARH | ☐ RA1B |
| ☐ DFL | ☐ ACAL | ☐ DE1B |
| ☐ ***CF** | ☐ ERR | ☐ CT1B |
| ☐ OT1 | ☐ PID2 | ☐ PB2B |
| ☐ OT2 | ☐ PROC | ☐ RE2B |
| ☐ OT3 | ☐ STPT | ☐ IT2B |
| ☐ DEC1 | ☐ EI1 | ☐ RA2B |
| ☐ RL1 | ☐ EI2 | ☐ DE2B |
| ☐ RH1 | ☐ ANUN | ☐ CT2B |
| ☐ CAL1 | ☐ LOP | ☐ DBB |
| ☐ FTR1 | ☐ HIP | ☐ SP2 |
| ☐ LIN1 | ☐ FAIL | ☐ IDSP |
| ☐ RSP | ☐ ATSP | ☐ SP1 |
| ☐ DEC2 | ☐ RP | ☐ LOC |
| ☐ RL2 | ☐ RATE | ☐ SYS |
| ☐ RH2 | ☐ A2LO | ☐ PIDA |
| ☐ CAL2 | ☐ A2HI | ☐ PIDB |
| ☐ FTR2 | ☐ A3LO | ☐ INPT |
| ☐ LIN2 | ☐ A3HI | ☐ OTPT |
| ☐ HUNT | ☐ LR | ☐ GLBL |
| ☐ SHYS | ☐ PB1A | ☐ COM |
| ☐ PRC1 | ☐ RE1A | ☐ DIAG |
| ☐ HYS1 | ☐ IT1A | ☐ CAL |
| ☐ PRC2 | ☐ RA1A | ☐ OPLP |
| ☐ HYS2 | ☐ DE1A | ☐ SPEE |
| ☐ SP2C | ☐ CT1A | |
| ☐ AL2 | ☐ PB2A | |
| ☐ A2SD | ☐ RE2A | |
| ☐ LAT2 | ☐ IT2A | |
| ☐ SIL2 | ☐ RA2A | |
| ☐ AL3 | | |
| ☐ A3SD | | |

**CAUTION: Entering commands out of sequence will produce unexpected results, because some prompts change the values of other prompts. Copy this page and use the checkboxes.**

**Table 6.1 - Download Sequence.**

*** Wait at least two seconds after executing this command before going on to the next command.**

# Temperature/process Controller Prompt Table

*Table 6.2 -*
**A2HI to ALM**



**CAUTION:**
**Avoid writing <=> continuously, such as ramping set points or repetitive loops, to the Series 986-989 EEPROM memory. Continuous writes may result in premature control failure, system downtime and damage to processes and equipment.**

**NOTE:**
**The number of decimal places returned by many of these commands is determined by the DEC1, DEC2, IN1 or IN2 setting. (This does not apply to Modbus Protocol.)**

| Name data.1<br>Modbus address | Description | Read (?) and/or Write (=) Syntax | Range data.2 |
|---|---|---|---|
| **A2HI**<br>14 | **Output 2 Alarm High** | ? <sp> A2HI <cr><br>= <sp> A2HI <sp> data.2 <cr> | Process: A2LO to sensor high range<br>Deviation: 0 to 9999°<br>Rate: 0 to 9999°/minute<br>Default: RH, 999°, or 999°/min. |
| **A2LO**<br>13 | **Output 2 Alarm Low** | ? <sp> A2LO <cr><br>= <sp> A2LO <sp> data.2 <cr> | Process: sensor low range to A2HI<br>Deviation: -999 to 0°<br>Rate: -9999 to 0°/minute<br>Default: RL, -999°, or -999°/min. |
| **A3HI**<br>16 | **Output 3 Alarm High** | ? <sp> A3HI<cr><br>= <sp> A3HI <sp> data.2 <cr> | Process: A3LO to sensor high range<br>Deviation: 0 to 9999°<br>Rate: 0 to 9999°/minute<br>Default: RH, 999°, or 999°/min. |
| **A3LO**<br>15 | **Output 3 Alarm Low** | ? <sp> A3LO <cr><br>= <sp> A3LO <sp> data.2 <cr> | Process: sensor low range to A3HI<br>Deviation: -999 to 0°<br>Rate: -999 to 0°/minute<br>Default: RL, -999°, or -999°/min. |
| **ACAL**<br>94 | **Analog Offset** | ? <sp> ACAL <cr><br>= <sp> ACAL <sp> data.2 <cr> | -999 to 999°F<br>-555 to 555°C<br>-999 to 999 units<br>Default: 0°F, 0°C, 0 units |
| **AL2**<br>74 | **Alarm 2 Type** | ? <sp> AL2 <cr><br>= <sp> AL2 <sp> data.2 <cr> | 0 = Deviation Alarm, Input 2<br>1 = Process Alarm, Input 2<br>2 = Process Alarm, Input 1<br>3 = Deviation Alarm, Input 1<br>4 = Rate Alarm, Input 1<br>Default: 2 |
| **AL3**<br>79 | **Alarm 3 Type** | ? <sp> AL3 <cr><br>= <sp> AL3 <sp> data.2 <cr> | 0 = Deviation Alarm, Input 2<br>1 = Process Alarm, Input 2<br>2 = Process Alarm, Input 1<br>3 = Deviation Alarm, Input 1<br>4 = Rate Alarm, Input 1<br>Default: 2 |
| **ALGO**<br>100 | **Algorithm** | ? <sp> ALGO <cr><br>= <sp> ALGO <sp> data.2 <cr> | 0 = two sets of PID prompts [Pid2]<br>1 = one set of PID prompts [Pid]<br>2 = prop/derivative w/manual reset [Pdr]<br>3 = 1 process output both heat or cool [dUPL]<br>Default: 1 |
| **ALM**<br>3 | **Alarm Status**<br>(Writing a 0 clears next alarm.) | ? <sp> ALM <cr><br>= <sp> ALM <sp> 0 <cr> | 0 = No alarms occurring (0000 0000)<br>Bit 1 = A2LO (0000 0001)<br>Bit 2 = A2HI (0000 0010)<br>Bit 3 = A3LO (0000 0100)<br>Bit 4 = A3HI (0000 1000) |

# Temperature/process Controller Prompt Table

| Name data.1<br>Modbus address | Description | Read (?) and/or Write (=) Syntax | Range data.2 |
|---|---|---|---|
| **AMB**<br>125 | **Ambient Terminal Temperature** | ? <sp> AMB <cr> | Input 1 terminals in 0.0°F |
| **ANUN**<br>106 | **Alarm Annunciation** | ? <sp> ANUN <cr><br>= <sp> ANUN <sp> data.2 <cr> | 0 = off<br>1 = on<br>Default: on |
| **AOUT**<br>90 | **Analog Output 3 Retransmit Function** | ? <sp> AOUT <cr><br>= <sp> AOUT <sp> data.2 <cr> | 0 = Retransmit Process Output 1<br>1 = Retransmit Set Point 1<br>2 = off<br>3 = Retransmit Process Output 2<br>Default: 0 |
| **ARH**<br>93 | **Retransmit Range High** | ? <sp> ARH <cr><br>= <sp> ARH <sp> data.2 <cr> | ARL to 9999<br>Default: RH1 or RH2 per AOUT |
| **ARL**<br>92 | **Retransmit Range Low** | ? <sp> ARL <cr><br>= <sp> ARL <sp> data.2 <cr> | -999 to ARH<br>Default: RL1 or RL2 per AOUT |
| **ATM**<br>10 | **Auto-Manual Key** (Any data.2 toggles ATM, like the pressing the AUTO/MAN key.) | ? <sp> ATM <cr><br>= <sp> ATM <sp> data.2 <cr> | 0 = Auto mode<br>4 = Manual mode<br>Default: n/a<br>Disabled if LOC = 2 or 3 |
| **AUT**<br>19 | **Auto-tune** | ? <sp> AUT <cr><br>= <sp> AUT <sp> data.2 <cr> | 0 = No auto-tuning<br>1 = Tune PID Set A<br>2 = Tune PID Set B<br>Default: off |
| **ATSP**<br>109 | **Auto-tune Set Point %** | ? <sp> ATSP <cr><br>= <sp> ATSP <sp> data.2 <cr> | 50 to 150%<br>Default: 90% |
| **C1**<br>1 | **Input 1 Value** | ? <sp> C1 <cr> | Based on IN1 range ; RL1 to RH1 |
| **C2**<br>2 | **Input 2 Value** | ? <sp> C2 <cr> | Based on IN2 range ; RL2 to RH2 |
| **CAL**<br>121 | **Lockout Calibration Menu** | ? <sp> CAL <cr><br>= <sp> CAL <sp> data.2 <cr> | 0 = No lockout<br>1 = Read only<br>2 = No read or write<br>Default: 0 |
| **CAL1**<br>51 | **Input 1 Calibration Offset** | ? <sp> CAL1 <cr><br>= <sp> CAL1 <sp> data.2 <cr> | -999 to 9999<br>Default: 0 |
| **CAL2**<br>59 | **Input 2 Calibration Offset** | ? <sp> CAL2 <cr><br>= <sp> CAL2 <sp> data.2 <cr> | -999 to 9999<br>Default: 0 |
| **CF**<br>95 | **Degrees Select Display Loop** | ? <sp> CF <cr><br>= <sp> CF <sp> data.2 <cr> | 0 = Display °F<br>1 = Display °C<br>Default = 0 |
| **CNTL**<br>98 | **Control Function** | ? <sp> CNTL <cr><br>= <sp> CNTL <sp> data.2 <cr> | 0 = Normal<br>1 = Cascade<br>2 = Ratio<br>3 = Differential<br>Default = 0 |
| **COM**<br>119 | **Lockout Comms Menu** | ? <sp> COM <cr><br>= <sp> COM <sp> data.2 <cr> | 0 = No lockout<br>1 = Read only<br>2 = No read or write<br>Default: 0 |
| **CSAC**<br>99 | **Cascade Action** | ? <sp> CSAC <cr><br>= <sp> CSAC <sp> data.2 <cr> | 0 = direct action<br>1 = reverse action |

*Table 6.3 -*
**AMB to CSAC**





**CAUTION:**
**Avoid writing <=> continuously, such as ramping set points or repetitive loops, to the Series 986-989 EEPROM memory. Continuous writes may result in premature control failure, system downtime and damage to processes and equipment.**

**NOTE:**
**The number of decimal places returned by many of these commands is determined by the DEC1, DEC2, IN1 or IN2 setting. (This does not apply to Modbus Protocol.)**

# Temperature/process Controller Prompt Table

*Table 6.4 -*
**CT1A to DIAG**



**CAUTION:**
**Avoid writing <=> continuously, such as ramping set points or repetitive loops, to the Series 986-989 EEPROM memory. Continuous writes may result in premature control failure, system downtime and damage to processes and equipment.**

**NOTE:**
**The number of decimal places returned by many of these commands is determined by the DEC1, DEC2, IN1 or IN2 setting. (This does not apply to Modbus Protocol.)**

| Name data.1<br>Modbus address | Description | Read (?) and/or Write (=) Syntax | Range data.2 |
|---|---|---|---|
| **CT1A**<br>26 | **Cycle Time**<br>**Output 1 PID Set A** | ? <sp> CT1A <cr><br>= <sp> CT1A <sp> data.2 <cr> | S.S. relay or open col:<br>0.0 = Burst firing, or<br>0.1 to 999.9 sec. (time prop)<br>Mech relay: 5.0 to 999.9 sec.<br>Default: 1.0 or 10.0 sec. |
| **CT1B**<br>39 | **Cycle Time**<br>**Output 1 PID Set B** | ? <sp> CT1B <cr><br>= <sp> CT1B <sp> data.2 <cr> | S.S. relay or open col:<br>0.0 = Burst firing (brSt), or<br>0.1 to 999.9 sec. (time prop)<br>Mech relay: 5.0 to 999.9 sec.<br>Default: 1.0 or 10.0 sec. |
| **CT2A**<br>32 | **Cycle Time**<br>**Output 2 PID Set A** | ? <sp> CT2A <cr><br>= <sp> CT2A <sp> data.2 <cr> | S.S. relay or open col:<br>0.0 = Burst firing (brSt), or<br>0.1 to 999.9 sec. (time prop)<br>Mech relay: 5.0 to 999.9 sec.<br>Default: 1.0 or 10.0 sec. |
| **CT2B**<br>45 | **Cycle Time**<br>**Output 2 PID Set B** | ? <sp> CT2B <cr><br>= <sp> CT2B <sp> data.2 <cr> | S.S. relay or open col:<br>0.0 = Burst firing (brSt), or<br>0.1 to 999.9 sec. (time prop)<br>Mech relay: 5.0 to 999.9 sec.<br>Default: 1.0 or 10.0 sec. |
| **DATE**<br>122 | **Factory**<br>**Test Date** | ? <sp> DATE <cr> | xxyy<br>xx = week<br>yy = year |
| **DBA**<br>33 | **Deadband**<br>**PID Set A** | ? <sp> DBA <cr><br>= <sp> DBA <sp> data.2 <cr> | -999°F to 999°F<br>-555°C to 555°C<br>-999 units to 999 units<br>Default: 0°F, 0°C, or 0 units |
| **DBB**<br>46 | **Deadband**<br>**PID Set B** | ? <sp> DBB <cr><br>= <sp> DBB <sp> data.2 <cr> | -999°F to 999°F<br>-555°C to 555°C<br>-999 units to 999 units<br>Default: 0°F, 0°C, or 0 units |
| **DE1A**<br>25 | **Derivative**<br>**Output 1 PID Set A** | ? <sp> DE1A <cr><br>= <sp> DE1A <sp> data.2 <cr> | 0.00 to 9.99 minutes<br>Default: 0.00 |
| **DE2A**<br>31 | **Derivative**<br>**Output 2 PID Set A** | ? <sp> DE2A <cr><br>= <sp> DE2A <sp> data.2 <cr> | 0.00 to 9.99 minutes<br>Default: 0.00 |
| **DE1B**<br>38 | **Derivative**<br>**Output 1 PID Set B** | ? <sp> DE1B <cr><br>= <sp> DE1B <sp> data.2 <cr> | 0.00 to 9.99 minutes<br>Default: 0.00 |
| **DE2B**<br>44 | **Derivative**<br>**Output 2 PID Set B** | ? <sp> DE2B <cr><br>= <sp> DE2B <sp> data.2 <cr> | 0.00 to 9.99 minutes<br>Default: 0.00 |
| **DEC1**<br>48 | **Decimal Point**<br>**Process Input 1** | ? <sp> DEC1 <cr><br>= <sp> DEC1 <sp> data.2 <cr> | 0 = Decimal point 0<br>1 = Decimal point 0.0<br>2 = Decimal point 0.00<br>3 = Decimal point 0.000<br>Default: 0 |
| **DEC2**<br>56 | **Decimal Point**<br>**Process Input 2** | ? <sp> DEC2 <cr><br>= <sp> DEC2 <sp> data.2 <cr> | 0 = Decimal point 0<br>1 = Decimal point 0.0<br>2 = Decimal point 0.00<br>3 = Decimal point 0.000<br>Default: 0 |
| **DEV**<br>5 | **Process Deviation**<br>**Display Loop (IN 1)** | ? <sp> DEV <cr> | Difference between SP1 and C1 |
| DFL<br>140 | Default Unit Type | ? <sp> DFL <cr><br>= <sp> DFL <sp> data.2 <cr> | 0 = US units<br>1 = Standard International units |
| **DIAG**<br>120 | **Lockout**<br>**Diagnostics Menu** | ? <sp> DIAG <cr><br>= <sp> DIAG <sp> data.2 <cr> | 0 = No lockout<br>1 = Read only<br>2 = No read or write<br>Default: 0 |

# Temperature/process Controller Prompt Table

| Name data.1<br>Modbus address | Description | Read (?) and/or Write (=) Syntax | Range data.2 |
|---|---|---|---|
| **EI1**<br>11 | **Event Input 1 Function** | ? <sp> EI1 <cr><br>= <sp> EI1 <sp> data.2 <cr> | Software Revision<br>thru M N and later<br>0 0 = Switch PID Sets<br>1 1 = None<br>2 2 = Lock out keyboard<br>3 3 = Alarm reset<br>N/A 4 = Auto/manual select<br>4 5 = Turn control outputs off<br>5 6 = Reverse Output 1<br>6 7 = Activate Idle Set Point<br>7 8 = Activate Remote Set Pt<br>Default: 1 |
| **EI1S**<br>104 | **Event Input 1 Status** | ? <sp> EI1S <cr> | 0 = off (open)<br>1 = on (closed) |
| **EI2**<br>12 | **Event Input 2 Function** | ? <sp> EI2 <cr><br>= <sp> EI2 <sp> data.2 <cr> | Software Revision<br>thru M N and later<br>0 0 = Switch PID Sets<br>1 1 = None<br>2 2 = Lock out keyboard<br>3 3 = Alarm reset<br>N/A 4 = Auto/manual select<br>4 5 = Turn control outputs off<br>5 6 = Reverse Output 1<br>6 7 = Activate Idle Set Point<br>7 8 = Activate Remote Set Pt<br>Default: 1 |
| **EI2S**<br>105 | **Event Input 2 Status** | ? <sp> EI2S <cr> | 0 = off (open)<br>1 = on (closed) |
| **ER**<br>4 | **Error, Analog Input** (Multiple errors possible.) | ? <sp> ER <cr> | 0 = No error<br>1 = Input 1 A-D overflow<br>2 = Input 1 overrange<br>3 = Input 1 underrange<br>4 = Input 1 A-D underflow<br>5 = Input 2 A-D overflow<br>6 = Input 2 overrange<br>7 = Input 2 underrange<br>8 = Input 2 A-D underflow<br>9 = Ambient error<br>10 = Heater<br>11 = Open loop |
| **ER2**<br>n/a | **Error, Communications** | ? <sp> ER2 <cr> | 0 = No error<br>1 = Transmit buffer overflow<br>2 = Receive buffer overflow<br>3 = Framing error<br>4 = Overrun error<br>5 = Parity error<br>6 = Talking out of turn<br>7 = Invalid reply error<br>8 = Noise error<br>20 = Command not found<br>21 = Prompt not found<br>22 = Incomplete command line<br>23 = Invalid character<br>24 = Number of chars. overflow<br>25 = Input out of limit<br>26 = Read only command<br>27 = Write allowed only<br>28 = Prompt not active |
| **ERR**<br>97 | **Error, Latching Enable** | ? <sp> ERR <cr><br>= <sp> ERR <sp> data.2 <cr> | 0 = Errors latching<br>1 = Errors non-latching<br>Default = 1 |
| **FAIL**<br>96 | **Sensor Failure Output Function** | ? <sp> FAIL <cr><br>= <sp> FAIL <sp> data.2 <cr> | Bumpless = LOP - 1%<br>Heat/cool manual = -100 to 100%<br>Heat only manual = 0% to 100%<br>Cool only manual = -100% to 0%<br>Default = Bumpless |

*Table 6.5 -*
**EI1 to FAIL**

**CAUTION:**
**Avoid writing <=> continuously, such as ramping set points or repetitive loops, to the Series 986-989 EEPROM memory. Continuous writes may result in premature control failure, system downtime and damage to processes and equipment.**

**NOTE:**
**The number of decimal places returned by many of these commands is determined by the DEC1, DEC2, IN1 or IN2 setting. (This does not apply to Modbus Protocol.)**

# Temperature/process Controller Prompt Table

*Table 6.6 -*
**FTR1 to IN1**



**CAUTION:**
**Avoid writing <=> continuously, such as ramping set points or repetitive loops, to the Series 986-989 EEPROM memory. Continuous writes may result in premature control failure, system downtime and damage to processes and equipment.**

**NOTE:**
**The number of decimal places returned by many of these commands is determined by the DEC1, DEC2, IN1 or IN2 setting.**

**NOTE:**
**(RTD setting)**
**For JIS curve, go to rtd1 prompt after selecting In1.**

| Name data.1<br>Modbus address | Description | Read (?) and/or Write (=) Syntax | Range data.2 |
|---|---|---|---|
| **FTR1**<br>53 | **Process Input 1 Filter Time Constant** | ? <sp> FTR1 <cr><br>= <sp> FTR1 <sp> data.2 <cr> | -60 to 60 seconds<br>Default: 0 |
| **FTR2**<br>63 | **Process Input 2 Filter Time Constant** | ? <sp> FTR2 <cr><br>= <sp> FTR2 <sp> data.2 <cr> | -60 to 60 seconds<br>Default: 0 |
| **GLBL**<br>118 | **Lockout Global Menu** | ? <sp> GLBL <cr><br>= <sp> GLBL <sp> data.2 <cr> | 0 = No lockout<br>1 = Read only<br>2 = No read or write<br>Default: 0 |
| **HIP**<br>108 | **High Power Limit** | ? <sp> HIP <cr><br>= <sp> HIP <sp> data.2 <cr> | LOP (%) to 100%<br>Default: 100 (Heat / cool)<br>Default: 0 (Cool only) |
| **HUNT**<br>65 | **Slidewire Deadband %** | ? <sp> HUNT <cr><br>= <sp> HUNT <sp> data.2 <cr> | 0.1% to 100.0%<br>Default: 1.0% |
| **HYS1**<br>69 | **Output 1 Hysteresis** | ? <sp> HYS1 <cr><br>= <sp> HYS1 <sp> data.2 <cr> | 0°F to 999°F<br>0°C to 555°C<br>0 units to 999 units<br>Default: 3°F, 2°C, or 3 units |
| **HYS2**<br>72 | **Output 2 Hysteresis** | ? <sp> HYS2 <cr><br>= <sp> HYS2 <sp> data.2 <cr> | 0°F to 999°F<br>0°C to 555°C<br>0 units to 999 units<br>Default: 3°F, 2°C, or 3 units |
| **HYS3**<br>81 | **Output 3 Hysteresis** | ? <sp> HYS3 <cr><br>= <sp> HYS3 <sp> data.2 <cr> | 0°F to 999°F<br>0°C to 555°C<br>0 units to 999 units<br>Default: 3°F, 2°C, or 3 units |
| **IDSP**<br>9 | **Idle Set Point** | ? <sp> IDSP <cr><br>= <sp> IDSP <sp> data.2 <cr> | RL1 to RH1 |
| **IN1**<br>47 | **Input 1 Type**<br><br>(Caution: Writing to IN1 resets most prompts to their default state.) | ? <sp> IN1 <cr><br>= <sp> IN1 <sp> data.2 <cr> | 1 = J t/c; 32 to 1500°F/0 to 816°C<br>2 = K t/c; -328 to 2500°F/-200 to 1371°C<br>3 = T t/c; -328 to 750°F/-200 to 399°C<br>4 = N t/c; 32 to 2372°F/0 to 1300°C<br>5 = E t/c; -328 to 1470°F/-200 to 799°C<br>6 = C t/c (W3); 32 to 4200°F 0 to 2316°C<br>7 = D t/c (W5); 32 to 4200°F/0 to 2316°C<br>8 = Pt 2; 32 to 2543°F/0 to 1395°C<br>10 = R t/c; 32 to 3200°F/0 to 1760°C<br>11 = S t/c; 32 to 3200°F/0 to 1760°C<br>12 = B t/c; 1598 to 3300°F/870 to 1816°C<br>14 = 1° RTD (DIN); -328 to 1472°F/ -200 to 800°C<br>15 = 0.1° RTD (DIN); -99.9 to 999.9°F/ -99.9 to 700.0°C<br>17 = 4-20mA; -999 to 9999 units<br>18 = 0-20mA; -999 to 9999 units<br>19 = 0-5V⎓ (dc); -999 to 9999 units<br>20 = 1-5V⎓ (dc); -999 to 9999 units<br>21 = 0-10V⎓ (dc); -999 to 9999 units<br>23 = 0-50mV⎓ (dc); -999 to 9999 units<br>24 = 0-100mV⎓ (dc); -999 to 9999 units<br>34 = 0-50mV⎓ (dc); -999 to 9999 units |

# Temperature/process Controller Prompt Table

| Name data.1<br>Modbus address | Description | Read (?) and/or Write (=) Syntax | Range data.2 |
|---|---|---|---|
| **IN2**<br>55 | **Input 2 Type**<br><br>(Caution: Writing to IN2 resets most prompts to their default state.) | ? <sp> IN2 <cr><br>= <sp> IN2 <sp> data.2 <cr> | 0 = t/c Low Gain off<br>1 = J t/c; 32 to 1500°F/0 to 816°C<br>2 = K t/c; -328 to 2500°F/-200 to 1371°C<br>3 = T t/c; -328 to 750°F/-200 to 399°C<br>4 = N t/c; 32 to 2372°F/0 to 1300°C<br>5 = E t/c; -328 to 1470°F/-200 to 799°C<br>6 = C t/c (W3); 32 to 4200°F 0 to 2316°C<br>7 = D t/c (W5); 32 to 4200°F/0 to 2316°C<br>8 = Pt 2; 32 to 2543°F/0 to 1395°C<br>9 = t/c High Gain off<br>10 = R t/c; 32 to 3200°F/0 to 1760°C<br>11 = S t/c; 32 to 3200°F/0 to 1760°C<br>12 = B t/c; 1598 to 3300°F/870 to 1816°C<br>13 = RTD off<br>14 = 1° RTD (DIN); -328 to 1472°F/ -200 to 800°C<br>15 = 0.1° RTD (DIN); -99.9 to 999.9°F/ -99.9 to 700.0°C<br>16 = Process off<br>17 = 4-20mA; -999 to 9999 units<br>18 = 0-20mA; -999 to 9999 units<br>19 = 0-5V⎓ (dc); -999 to 9999 units<br>20 = 1-5V⎓ (dc); -999 to 9999 units<br>21 = 0-10V⎓ (dc); -999 to 9999 units<br>22 = Millivolts off<br>23 = 0-50mV⎓ (dc); -999 to 9999 units<br>24 = 0-100mV⎓ (dc); -999 to 9999 units<br>26 = Resistance off<br>27 = Slidewire; 100 to 1200Ω<br>28 = Potentiometer; 0 to 1200Ω<br>29 = Heater current off<br>30 = Heater Current; 0 to 50A<br>31 = Open loop detect<br>32 = Event input 2 off<br>33 = Event input 2 on |
| **INPT**<br>116 | **Lockout Input Menu** | ? <sp> INPT <cr><br>= <sp> INPT <sp> data.2 <cr> | 0 = No input menu lockout<br>1 = Read only<br>2 = No read or write allowed<br>Default: 0 |
| **IT1A**<br>24 | **Integral for Output 1 PID Set A** | ? <sp> IT1A <cr><br>= <sp> IT1A <sp> data.2 <cr> | 0.00 to 99.99 minutes per repeat<br>Default: 0.00 minutes per repeat |
| **IT2A**<br>30 | **Integral for Output 2 PID Set A** | ? <sp> IT2A <cr><br>= <sp> IT2A <sp> data.2 <cr> | 0.00 to 99.99 minutes per repeat<br>Default: 0.00 minutes per repeat |
| **IT1B**<br>37 | **Integral for Output 1 PID Set B** | ? <sp> IT1B <cr><br>= <sp> IT1B <sp> data.2 <cr> | 0.00 to 99.99 minutes per repeat<br>Default: 0.00 minutes per repeat |
| **IT2B**<br>43 | **Integral for Output 2 PID Set B** | ? <sp> IT2B <cr><br>= <sp> IT2B <sp> data.2 <cr> | 0.00 to 99.99 minutes per repeat<br>Default: 0.00 minutes per repeat |
| **INSP**<br>144 | **Cascade Inner SP** | ? <sp> INSP <cr> | RL1 to RH1, or<br>if CNTL = 2 (ratio), then 0.0 to 20.0<br>if CNTL = 3 (differential), then -999 to 999<br>if ATM = 1, then 0 to 100%<br>Default: per IN1 and hardware |
| **ITY1**<br>130 | **Input 1 Hardware Type** | ? <sp> ITY1 <cr> | 0 = None<br>1 = t/c only<br>2 = Current<br>3 = Slide wire<br>4 = Input off<br>5 = Universal RTD<br>6 = Universal high gain t/c<br>7 = Universal low gain t/c<br>8 = Universal millivolts<br>9 = Universal process |

*Table 6.7 -*
**IN2 to ITY1**

**CAUTION:**
**Avoid writing <=> continuously, such as ramping set points or repetitive loops, to the Series 986-989 EEPROM memory. Continuous writes may result in premature control failure, system downtime and damage to processes and equipment.**

**NOTE:**
**(RTD setting)**
**For JIS curve, go to rtd1 prompt after selecting In1.**

**NOTE:**
**The number of decimal places returned by many of these commands is determined by the DEC1, DEC2, IN1 or IN2 setting.**

# Temperature/process Controller Prompt Table

*Table 6.8 -*
**ITY2 to OT2**



**CAUTION:**
**Avoid writing <=> continuously, such as ramping set points or repetitive loops, to the Series 986-989 EEPROM memory. Continuous writes may result in premature control failure, system downtime and damage to processes and equipment.**

**NOTE:**
**The number of decimal places returned by many of these commands is determined by the DEC1, DEC2, IN1 or IN2 setting. (This does not apply to Modbus Protocol.)**

| Name data.1<br>Modbus address | Description | Read (?) and/or Write (=) Syntax | Range data.2 |
|---|---|---|---|
| **ITY2**<br>131 | **Input 2 Hardware Type** | ? <sp> ITY2 <cr> | 0 = None<br>1 = t/c only<br>2 = Current<br>3 = Slide wire<br>4 = Input off<br>5 = Universal RTD<br>6 = Universal high gain t/c<br>7 = Universal low gain t/c<br>8 = Universal millivolts<br>9 = Universal process<br>10 = Event input |
| **LAT2**<br>76 | **Alarm 2 Latching** | ? <sp> LAT2 <cr><br>= <sp> LAT2 <sp> data.2 <cr> | 0 = Latching alarms<br>1 = Non-latching alarms<br>Default: 1 |
| **LAT3**<br>82 | **Alarm 3 Latching** | ? <sp> LAT3 <cr><br>= <sp> LAT3 <sp> data.2 <cr> | 0 = Latching alarms<br>1 = Non-latching alarms<br>Default: 1 |
| **LIN1**<br>54 | **Linearization Process Input 1** | ? <sp> LIN1 <cr><br>= <sp> LIN1 <sp> data.2 <cr> | 0 = None<br>1 = Square root extraction<br>Default: 0 |
| **LIN2**<br>64 | **Linearization Process Input 2** | ? <sp> LIN2 <cr><br>= <sp> LIN2 <sp> data.2 <cr> | 0 = None<br>1 = Square root extraction<br>Default: 0 |
| **LOC**<br>112 | **Keyboard Lockout** | ? <sp> LOC <cr><br>= <sp> LOC <sp> data.2 <cr> | 0 = No lockout<br>1 = Lock out mode key<br>2 = Lock out mode and auto/manual keys<br>3 = Lock out all single keys<br>Default: 0 |
| **LOP**<br>107 | **Low Power Limit** | ? <sp> LOP <cr><br>= <sp> LOP <sp> data.2 <cr> | -100% to HIP (%)<br>Default: -100% (Heat / cool)<br>Default: 0% (Heat only) |
| **LRNH**<br>62 | **Learn High Slide-wire Resistance** | ? <sp> LRNH <cr><br>= <sp> LRNH <sp> data.2 <cr> | 0 = No function<br>1 = Learn<br>Default: 0 |
| **LRNL**<br>61 | **Learn Low Slide-wire Resistance** | ? <sp> LRNL <cr><br>= <sp> LRNL <sp> data.2 <cr> | 0 = No function<br>1 = Learn<br>Default: 0 |
| **LR**<br>20 | **Local-Remote Set Point Select** | ? <sp> LR <cr><br>= <sp> LR <sp> data.2 <cr> | 0 = Local set point<br>1 = Remote set point<br>Default: 0 |
| **MDL**<br>0 | **Model Number** | ? <sp> MDL <cr> | 988 (986-989 units) |
| **OT1**<br>67 | **Output 1 Action** | ? <sp> OT1 <cr><br>= <sp> OT1 <sp> data.2 <cr> | 0 = Heat<br>1 = Cool |
| **OT2**<br>70 | **Output 2 Action** | ? <sp> OT2 <cr><br>= <sp> OT2 <sp> data.2 <cr> | 0 = Heat<br>1 = Cool<br>2 = None<br>3 = Alarm 2<br>4 = Alarm 2 reverse acting |

# Temperature/process Controller Prompt Table

| Name data.1<br>Modbus address | Description | Read (?) and/or Write (=) Syntax | Range data.2 |
|---|---|---|---|
| **OT3**<br>78 | **Output 3 Action** | ? <sp> OT3 <cr><br>= <sp> OT3 <sp> data.2 <cr> | 0 = None<br>1 = Alarm 3<br>2 = Alarm 3 reverse acting |
| **OTPT**<br>117 | **Lockout Output Menu** | ? <sp> OTPT <cr><br>= <sp> OTPT <sp> data.2 <cr> | 0 = No lockout<br>1 = Read only<br>2 = No read or write<br>Default: 0 |
| **OTY1**<br>132<br>**OTY2**<br>133<br>**OTY3**<br>134<br>**OTY4**<br>135 | **Output 1 Hardware**<br><br>**Output 2 Hardware**<br><br>**Output 3 Hardware**<br><br>**Output 4 Hardware** | ? <sp> OTY1 <cr><br><br>? <sp> OTY2 <cr><br><br>? <sp> OTY3 <cr><br><br>? <sp> OTY4 <cr> | 0 = None<br>1 = SSR 0.5A<br>2 = SSR 0.5A with suppression<br>6 = Switched dc<br>8 = Relay 5A Form C<br>9 = Relay 5A Form C with suppr.<br>10 = Relay 5A Form A/B<br>11 = Relay 5A Form A/B with suppr.<br>13 = Process output<br>14 = Voltage retransmit<br>15 = Current retransmit<br>16 = Power supply<br>17 = Comms EIA-232<br>18 = Comms EIA -485 / EIA-422<br>19 = Comms EIA-485 / EIA-232 |
| **PB1A**<br>21 | **Proportional Band Output 1 PID Set A** | ? <sp> PB1A <cr><br>= <sp> PB1A <sp> data.2 <cr> | if DFL = 0, then 0 to 9999<br>if DFL = 1, then 0.0 to 99.9% of span<br>Default: 25°F, 14°C, 25 units or 3.0% |
| **PB1B**<br>34 | **Proportional Band Output 1 PID Set B** | ? <sp> PB1B <cr><br>= <sp> PB1B <sp> data.2 <cr> | if DFL = 0, then 0 to 9999<br>if DFL = 1, then 0.0 to 99.9% of span<br>Default: 25°F, 14°C, 25 units or 3.0% |
| **PB2A**<br>27 | **Proportional Band Output 2 PID Set A** | ? <sp> PB2A <cr><br>= <sp> PB2A <sp> data.2 <cr> | if DFL = 0, then 0 to 9999<br>if DFL = 1, then 0.0 to 99.9% of span<br>Default: 25°F, 14°C, 25 units or 3.0% |
| **PB2B**<br>40 | **Proportional Band Output 2 PID Set B** | ? <sp> PB2B <cr><br>= <sp> PB2B <sp> data.2 <cr> | if DFL = 0, then 0 to 9999<br>if DFL = 1, then 0.0 to 99.9% of span<br>Default: 25°F, 14°C, 25 units or 3.0% |
| **PIDA**<br>114 | **Lockout PID Set A Menu** | ? <sp> PIDA <cr><br>= <sp> PIDA <sp> data.2 <cr> | 0 = No lockout<br>1 = Read only<br>2 = No read or write<br>Default: 0 |
| **PIDB**<br>115 | **Lockout PID Set B Menu** | ? <sp> PIDB <cr><br>= <sp> PIDB <sp> data.2 <cr> | 0 = No lockout<br>1 = Read only<br>2 = No read or write<br>Default: 0 |

*Table 6.9 -*
**OT3 to PIDB**

**CAUTION:**
**Avoid writing <=> continuously, such as ramping set points or repetitive loops, to the Series 986-989 EEPROM memory. Continuous writes may result in premature control failure, system downtime and damage to processes and equipment.**

**NOTE:**
**The number of decimal places returned by many of these commands is determined by the DEC1, DEC2, IN1 or IN2 setting. (This does not apply to Modbus Protocol.)**

# Temperature/process Controller Prompt Table



*Table 6.10 -*
**PID2 to RH2**

**CAUTION:**
**Avoid writing <=> continuously, such as ramping set points or repetitive loops, to the Series 986-989 EEPROM memory. Continuous writes may result in premature control failure, system downtime and damage to processes and equipment.**

**NOTE:**
**The number of decimal places returned by many of these commands is determined by the DEC1, DEC2, IN1 or IN2 setting. (This does not apply to Modbus Protocol.)**

| Name data.1<br>Modbus address | Description | Read (?) and/or Write (=) Syntax | Range data.2 |
|---|---|---|---|
| **PID2**<br>101 | **PID Set Crossover Source Selection** | ? <sp> PID2 <cr><br>= <sp> PID2 <sp> data.2 <cr> | 0 = Process<br>1 = Set point<br>2 = None<br>Default: 0 |
| **PRC1**<br>68 | **Process Range Output 1** | ? <sp> PRC1 <cr><br>= <sp> PRC1 <sp> data.2 <cr> | 0 = 4-20mA<br>1 = 0-20mA<br>2 = 0-5V⎓ (dc)<br>3 = 1-5V⎓ (dc)<br>4 = 0-10V⎓ (dc)<br>Default: 0 |
| **PRC2**<br>71 | **Process Range Output 2** | ? <sp> PRC2 <cr><br>= <sp> PRC2 <sp> data.2 <cr> | 0 = 4-20mA<br>1 = 0-20mA<br>2 = 0-5V⎓ (dc)<br>3 = 1-5V⎓ (dc)<br>4 = 0-10V⎓ (dc)<br>Default: 0 |
| **PRC3**<br>91 | **Process Range Output 3** | ? <sp> PRC3 <cr><br>= <sp> PRC3 <sp> data.2 <cr> | 0 = 4-20mA<br>1 = 0-20mA<br>2 = 0-5V⎓ (dc)<br>3 = 1-5V⎓ (dc)<br>4 = 0-10V⎓ (dc)<br>Default: 0 |
| **PROC**<br>102 | **Process Value for PID A <-> B Switch** | ? <sp> PROC <cr><br>= <sp> PROC <sp> data.2 <cr> | RL1 to RH1<br>Default: per IN1 and hardware |
| **PWR**<br>6 | **Percent Power Present Output** | ? <sp> PWR <cr> | -100% to 100%<br>n/a |
| **RA1A**<br>23 | **Rate Output 1 PID Set A** | ? <sp> RA1A <cr><br>= <sp> RA1A <sp> data.2 <cr> | 0.00 to 9.99 minutes<br>Default: 0.00 |
| **RA1B**<br>36 | **Rate Output 1 PID Set B** | ? <sp> RA1B <cr><br>= <sp> RA1B <sp> data.2 <cr> | 0.00 to 9.99 minutes<br>Default: 0.00 |
| **RA2A**<br>29 | **Rate Output 2 PID Set A** | ? <sp> RA2A <cr><br>= <sp> RA2A <sp> data.2 <cr> | 0.00 to 9.99 minutes<br>Default: 0.00 |
| **RA2B**<br>42 | **Rate Output 2 PID Set B** | ? <sp> RA2B <cr><br>= <sp> RA2B <sp> data.2 <cr> | 0.00 to 9.99 minutes<br>Default: 0.00 |
| **RE1A**<br>22 | **Reset Output 1 PID Set A** | ? <sp> RE1A <cr><br>= <sp> RE1A <sp> data.2 <cr> | if ALGO = 0, 1, or 3, then<br>0.00 to 9.99 repeats/min.<br>if ALGO = 2, then -100.0% to 100.0%<br>Default: 0.00 repeats/min. or 0.0% |
| **RE1B**<br>35 | **Reset Output 1 PID Set B** | ? <sp> RE1B <cr><br>= <sp> RE1B <sp> data.2 <cr> | if ALGO = 0, 1, or 3, then<br>0.00 to 9.99 repeats/min.<br>if ALGO = 2, then -100.0% to 100.0%<br>Default: 0.00 repeats/min. or 0.0% |
| **RE2A**<br>28 | **Reset Output 2 PID Set A** | ? <sp> RE2A <cr><br>= <sp> RE2A <sp> data.2 <cr> | if ALGO = 0, 1, or 3, then<br>0.00 to 9.99 repeats/min.<br>if ALGO = 2, then -100.0% to 100.0%<br>Default: 0.00 repeats/min. or 0.0% |
| **RE2B**<br>41 | **Reset Output 2 PID Set B** | ? <sp> RE2B <cr><br>= <sp> RE2B <sp> data.2 <cr> | if ALGO = 0, 1, or 3, then<br>0.00 to 9.99 repeats/min.<br>if ALGO = 2, then -100.0% to 100.0%<br>Default: 0.00 repeats/min. or 0.0% |
| **RH1**<br>50 | **Range High Input 1** | ? <sp> RH1 <cr><br>= <sp> RH1 <sp> data.2 <cr> | min. IN1 range to to max. IN1 range<br>Default: Sensor high range |
| **RH2**<br>58 | **Range High Input 2** | ? <sp> RH2 <cr><br>= <sp> RH2 <sp> data.2 <cr> | min. IN2 range to to max. IN2 range<br>Default: Sensor high range |

# Temperature/process Controller Prompt Table

| Name data.1<br>Modbus address | Description | Read (?) and/or Write (=) Syntax | Range data.2 |
|---|---|---|---|
| **RL1**<br>49 | **Range Low Input 1** | ? <sp> RL1 <cr><br>= <sp> RL1 <sp> data.2 <cr> | min. IN1 range to to max. IN1 range<br>Default: Sensor low range |
| **RL2**<br>57 | **Range Low Input 2** | ? <sp> RL2 <cr><br>= <sp> RL2 <sp> data.2 <cr> | min. IN2 range to to max. IN2 range<br>Default: Sensor low range |
| **RP**<br>110 | **Ramping Initiation** | ? <sp> RP <cr><br>= <sp> RP <sp> data.2 <cr> | 0 = off<br>1 = on startup<br>2 = on startup and set point change<br>Default: 0 |
| **RSP**<br>142 | **Remote Set Point** | ? <sp> RSP <cr><br>= <sp> RSP <sp> data.2 <cr> | 0 = off<br>1 = on<br>Default: 0 |
| **RATE**<br>111 | **Ramp Rate** | ? <sp> RATE <cr><br>= <sp> RATE <sp> data.2 <cr> | 0 to 9999°/minute<br>Default: 100°/minute |
| **RTD1**<br>52 | **RTD Calibration Curve Input 1** | ? <sp> RTD1 <cr><br>= <sp> RTD1 <sp> data.2 <cr> | 0 = JIS<br>1 = DIN<br>Default: 1 |
| **RTD2**<br>60 | **RTD Calibration Curve Input 2** | ? <sp> RTD2 <cr><br>= <sp> RTD2 <sp> data.2 <cr> | 0 = JIS<br>1 = DIN<br>Default: 1 |
| **SHYS**<br>66 | **Slidewire Hysteresis** | ? <sp> SHYS <cr><br>= <sp> SHYS <sp> data.2 <cr> | 0 to HUNT |
| **SIL2**<br>77 | **Alarm 2 Silence** | ? <sp> SIL2 <cr><br>= <sp> SIL2 <sp> data.2 <cr> | 0 = off/disabled<br>1 = on/enabled<br>Default: 0 |
| **SIL3**<br>83 | **Alarm 3 Silence** | ? <sp> SIL3 <cr><br>= <sp> SIL3 <sp> data.2 <cr> | 0 = off/disabled<br>1 = on/enabled<br>Default: 0 |
| **SRNB**<br>124 | **Serial Number Bottom Display**<br>Read the six-digit unit serial number in two segments, "SNxx" and "xxxx," i.e., as in the upper and lower front panel displays. | ? <sp> SRNB <cr> | xxxx = 0000 to 9999 |
| **SRNT**<br>123 | **Serial Number Top Display** | ? <sp> SRNT <cr> | SNxx = 00 to 99 |
| **SOFT**<br>141 | **Software Revision** | ? <sp> SOFT <cr> | 0 = Rev A, 1 = Rev B, 2 = Rev C, 3 = Rev D, 4 = Rev E, 5 = Rev F, 6 = Rev G, 7 = Rev H, 8 = Rev I, 9 = Rev J, 10 = Rev K, 11 = Rev L, 12 = Rev M, 13 = Rev N, 14 = Rev O, 15 = Rev P, 16 = Rev Q, 17 = Rev R, 18 = Rev S, 19 = Rev T, 20 = Rev U etc. |
| **SP1**<br>7 | **Set Point 1** | ? <sp> SP1 <cr><br>= <sp> SP1 <sp> data.2 <cr> | RL1 to RH1, or<br>if CNTL = 2 (ratio), then 0.0 to 20.0<br>if CNTL = 3 (differential), then -999 to 999<br>if ATM = 1, then 0 to 100%<br>Default: per IN1 and hardware |

*Table 6.11 -*
**RL1 to SP1**

**CAUTION:**
**Avoid writing <=> continuously, such as ramping set points or repetitive loops, to the Series 986-989 EEPROM memory. Continuous writes may result in premature control failure, system downtime and damage to processes and equipment.**

**NOTE:**
**The number of decimal places returned by many of these commands is determined by the DEC1, DEC2, IN1 or IN2 setting. (This does not apply to Modbus Protocol.)**

# Temperature/process Controller Prompt Table



*Table 6.12 -*
**SP2 to TOUT**

| Name data.1<br>Modbus address | Description | Read (?) and/or Write (=) Syntax | Range data.2 |
|---|---|---|---|
| **SP2**<br>8 | **Set Point 2 Heat/Heat or Cool/Cool Only** | ? <sp> SP2 <cr><br>= <sp> SP2 <sp> data.2 <cr> | RL1 to RH1<br>Default: per input range (?) |
| **SP2C**<br>73 | **Set Point 2 Type** | ? <sp> SP2C <cr><br>= <sp> SP2C <sp> data.2 <cr> | 0 = Process<br>1 = Deviation<br>Default: 0 |
| **SPEE**<br>143 | **Write Set Point to EEPROM** | ? <sp> SPEE <cr><br>= <sp> SPEE <sp> data.2 <cr> | 0 = Saves set point in EEPROM<br>1 = Does not save set point in EEPROM<br>Default: 0 **(See Note 1)** |
| **STPT**<br>103 | **Set Point Value PID A <-> B Switch** | ? <sp> STPT <cr><br>= <sp> STPT <sp> data.2 <cr> | RL1 to RH1<br>Default: Sensor type low range |
| **SYS**<br>113 | **Lockout System Menu** | ? <sp> SYS <cr><br>= <sp> SYS <sp> data.2 <cr> | 0 = No lockout<br>1 = Read only<br>2 = No read or write<br>Default: 0 |
| **TOUT**<br>137 | **Test Outputs** | = <sp> TOUT <sp> data.2 <cr> | 1 = Output 1 on<br>2 = Output 2 on<br>3 = Output 3 on<br>4 = Output 4 on |

**NOTE 1:**
**Turning the controller off and on again resets SPEE to 0 and restores the last stored set point.**

**CAUTION:**
**Avoid writing <=> continuously, such as ramping set points or repetitive loops, to the Series 986-989 EEPROM memory. Continuous writes may result in premature control failure, system downtime and damage to processes and equipment.**

**NOTE 2:**
**The number of decimal places returned by many of these commands is determined by the DEC1, DEC2, IN1 or IN2 setting. (This does not apply to Modbus Protocol.)**

# Table 6.13 - 988 Modbus RTU Addresses

| Absolute Address | Relative Address | Parameter |
|---|---|---|
| 40001 | 0 | MODEL (988) |
| 40002 | 1 | C1 (input 1 value) |
| 40003 | 2 | C2 (input 2 value) |
| 40004 | 3 | ALM (alarm status) |
| 40005 | 4 | ER (system error) |
| 40006 | 5 | PROCESS DEVIATION |
| 40007 | 6 | OUTPUT POWER |
| 40008 | 7 | SP1 |
| 40009 | 8 | SP2 |
| 40010 | 9 | IDSP |
| 40011 | 10 | ATM (A/M mode) |
| 40012 | 11 | EI1 |
| 40013 | 12 | EI2 |
| 40014 | 13 | A2LO |
| 40015 | 14 | A2HI |
| 40016 | 15 | A3LO |
| 40017 | 16 | A3HI |
| 40020 | 19 | AUT |
| 40021 | 20 | L R |
| 40022 | 21 | PB1A |
| 40023 | 22 | RE1A |
| 40024 | 23 | RA1A |
| 40025 | 24 | IT1A |
| 40026 | 25 | DE1A |
| 40027 | 26 | CT1A |
| 40028 | 27 | PB2A |
| 40029 | 28 | RE2A |
| 40030 | 29 | RA2A |
| 40031 | 30 | IT2A |
| 40032 | 31 | DE2A |
| 40033 | 32 | CT2A |
| 40034 | 33 | DBA |
| 40035 | 34 | PB1B |
| 40036 | 35 | RE1B |
| 40037 | 36 | RA1B |
| 40038 | 37 | IT1B |
| 40039 | 38 | DE1B |
| 40040 | 39 | CT1B |
| 40041 | 40 | PB2B |
| 40042 | 41 | RE2B |
| 40043 | 42 | RA2B |
| 40044 | 43 | IT2B |
| 40045 | 44 | DE2B |
| 40046 | 45 | CT2B |
| 40047 | 46 | DBB |
| 40048 | 47 | IN1 |
| 40049 | 48 | DEC1 |
| 40050 | 49 | RL1 |
| 40051 | 50 | RH1 |
| 40052 | 51 | CAL1 |
| 40053 | 52 | RTD1 |
| 40054 | 53 | FTR1 |
| 40055 | 54 | LIN1 |
| 40056 | 55 | IN2 |
| 40057 | 56 | DEC2 |
| 40058 | 57 | RL2 |
| 40059 | 58 | RH2 |
| 40060 | 59 | CAL2 |
| 40061 | 60 | RTD2 |
| 40062 | 61 | LRNL |
| 40063 | 62 | LRNH |
| 40064 | 63 | FTR2 |
| 40065 | 64 | LIN2 |
| 40066 | 65 | HUNT |
| 40067 | 66 | SHYS |
| 40068 | 67 | OT1 |
| 40069 | 68 | PRC1 |
| 40070 | 69 | HYS1 |
| 40071 | 70 | OT2 |
| 40072 | 71 | PRC2 |
| 40073 | 72 | HYS2 |
| 40074 | 73 | SP2C |
| 40075 | 74 | AL2 |
| 40076 | 75 | A2SD |
| 40077 | 76 | LAT2 |
| 40078 | 77 | SIL2 |
| 40079 | 78 | OT3 |
| 40080 | 79 | AL3 |
| 40081 | 80 | A3SD |
| 40082 | 81 | HYS3 |
| 40083 | 82 | LAT3 |
| 40084 | 83 | SIL3 |
| 40091 | 90 | AOUT |
| 40092 | 91 | PRC3 |
| 40093 | 92 | ARL |
| 40094 | 93 | ARH |
| 40095 | 94 | ACAL |
| 40096 | 95 | C F |
| 40097 | 96 | FAIL |
| 40098 | 97 | ERR |
| 40099 | 98 | CNTL |
| 40100 | 99 | CSAC |
| 40101 | 100 | ALGO |
| 40102 | 101 | PID2 |
| 40103 | 102 | PROC |
| 40104 | 103 | STPT |
| 40105 | 104 | EI1 STATUS |
| 40106 | 105 | EI2 STATUS |
| 40107 | 106 | ANUN |
| 40108 | 107 | LOP |
| 40109 | 108 | HIP |
| 40110 | 109 | ATSP |
| 40111 | 110 | RP |
| 40112 | 111 | RATE |
| 40113 | 112 | LOC |
| 40114 | 113 | LOCK SYS |
| 40115 | 114 | LOCK PIDA |
| 40116 | 115 | LOCK PIDB |
| 40117 | 116 | LOCK INPT |
| 40118 | 117 | LOCK OTPT |
| 40119 | 118 | LOCK GLBL |
| 40120 | 119 | LOCK COM |
| 40121 | 120 | LOCK DIAG |
| 40122 | 121 | LOCK CAL |
| 40123 | 122 | DATE |
| 40124 | 123 | SN TOP |
| 40125 | 124 | SN BOTTOM |
| 40126 | 125 | AMB TEMP, °F |
| 40127 | 126 | AMB COUNTS |
| 40128 | 127 | GND COUNTS |
| 40129 | 128 | CH 1 COUNTS |
| 40130 | 129 | CH 2 COUNTS |
| 40131 | 130 | ITY1 |
| 40132 | 131 | ITY2 |
| 40133 | 132 | OTY1 |
| 40134 | 133 | OTY2 |
| 40135 | 134 | OTY3 |
| 40136 | 135 | OTY4 |
| 40137 | 136 | DISP |
| 40138 | 137 | TOUT |
| 40139 | 138 | OPLP |
| 40140 | 139 | RST |
| 40141 | 140 | DFL |
| 40142 | 141 | SOFT |
| 40143 | 142 | RSP |
| 40144 | 143 | SPEE |
| 40145 | 144 | INSP |

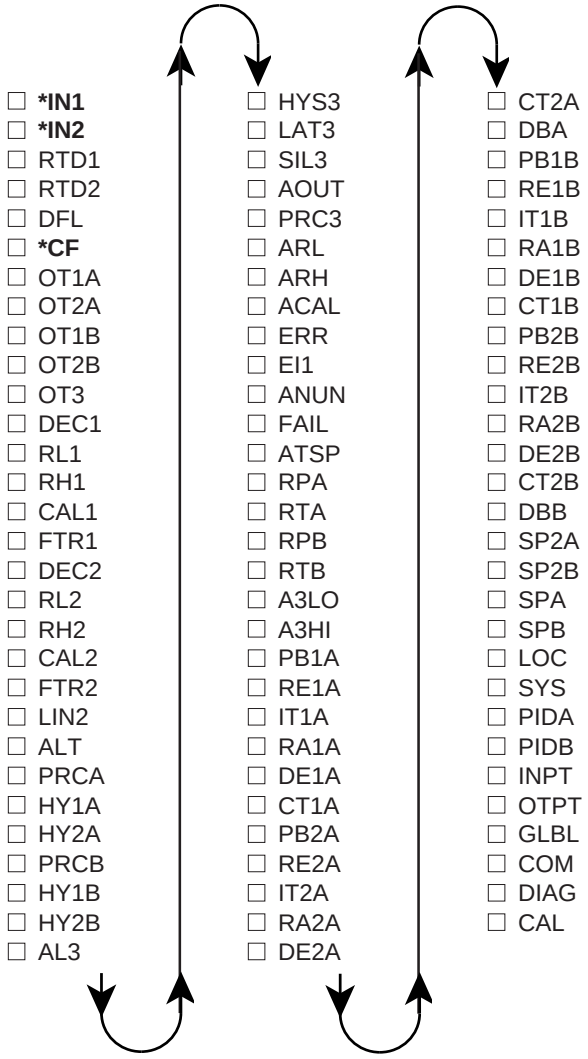
# Notes

# **Chapter 7** Command Summary of the Series 996-999

## Complete Parameter Download Sequence

When you download a complete set of parameters to a controller, **you must load them in this order.** The user's manual has more information about prompt interaction.

*Table 7.1 -* **Download Sequence**



| | | |
|---|---|---|
| ☐ ***IN1** | ☐ HYS3 | ☐ CT2A |
| ☐ ***IN2** | ☐ LAT3 | ☐ DBA |
| ☐ RTD1 | ☐ SIL3 | ☐ PB1B |
| ☐ RTD2 | ☐ AOUT | ☐ RE1B |
| ☐ DFL | ☐ PRC3 | ☐ IT1B |
| ☐ ***CF** | ☐ ARL | ☐ RA1B |
| ☐ OT1A | ☐ ARH | ☐ DE1B |
| ☐ OT2A | ☐ ACAL | ☐ CT1B |
| ☐ OT1B | ☐ ERR | ☐ PB2B |
| ☐ OT2B | ☐ EI1 | ☐ RE2B |
| ☐ OT3 | ☐ ANUN | ☐ IT2B |
| ☐ DEC1 | ☐ FAIL | ☐ RA2B |
| ☐ RL1 | ☐ ATSP | ☐ DE2B |
| ☐ RH1 | ☐ RPA | ☐ CT2B |
| ☐ CAL1 | ☐ RTA | ☐ DBB |
| ☐ FTR1 | ☐ RPB | ☐ SP2A |
| ☐ DEC2 | ☐ RTB | ☐ SP2B |
| ☐ RL2 | ☐ A3LO | ☐ SPA |
| ☐ RH2 | ☐ A3HI | ☐ SPB |
| ☐ CAL2 | ☐ PB1A | ☐ LOC |
| ☐ FTR2 | ☐ RE1A | ☐ SYS |
| ☐ LIN2 | ☐ IT1A | ☐ PIDA |
| ☐ ALT | ☐ RA1A | ☐ PIDB |
| ☐ PRCA | ☐ DE1A | ☐ INPT |
| ☐ HY1A | ☐ CT1A | ☐ OTPT |
| ☐ HY2A | ☐ PB2A | ☐ GLBL |
| ☐ PRCB | ☐ RE2A | ☐ COM |
| ☐ HY1B | ☐ IT2A | ☐ DIAG |
| ☐ HY2B | ☐ RA2A | ☐ CAL |
| ☐ AL3 | ☐ DE2A | |

**CAUTION: Entering commands out of sequence will produce unexpected results, because some prompts change the values of other prompts. Copy this page and use the checkboxes.**

**996, 997, 998, 999**

*** Wait at least two seconds after executing this command before going on to the next command.**

# Dual Channel Controller Prompt Table

## Command Summary Series 996-999 Data Communications

*Table 7.2 -*
**A3HI to ARL**



**CAUTION:**
**Avoid writing <=> continuously, such as ramping set points or repetitive loops, to the Series 996-999 EEPROM memory. Continuous writes may result in premature control failure, system downtime and damage to processes and equipment.**

**NOTE:**
**The number of decimal places returned by many of these commands is determined by the DEC1, DEC2, IN1 or IN2 setting. (This does not apply to Modbus Protocol.)**

| Name data.1<br>Modbus Address | Description | Read (?) and/or Write (=) Syntax | Range data.2 |
|---|---|---|---|
| **A3HI**<br>341 | **Output 3 Alarm High** | ? <sp> A3HI<cr><br>= <sp> A3HI <sp> data.2 <cr> | Process: A3LO to sensor high range<br>Deviation: 0 to 9999°<br>Default: RH or 999° |
| **A3LO**<br>340 | **Output 3 Alarm Low** | ? <sp> A3LO <cr><br>= <sp> A3LO <sp> data.2 <cr> | Process: sensor low range to A3HI<br>Deviation: -999 to 0°<br>Default: RL or -999° |
| **ACAL**<br>746 | **Analog Offset** | ? <sp> ACAL <cr><br>= <sp> ACAL <sp> data.2 <cr> | -999 to 999°F<br>-555 to 555°C<br>-999 to 999 units<br>Default: 0°F, 0°C, 0 units |
| **AL3**<br>736 | **Alarm 3 Type** | ? <sp> AL3 <cr><br>= <sp> AL3 <sp> data.2 <cr> | 0 = Process Alarm, Input 2 (CH B)<br>1 = Deviation Alarm, Input 2 (CH B)<br>2 = Process Alarm, Input 1 (CH A)<br>3 = Deviation Alarm, Input 1 (CH A)<br>Default: 2 |
| **ALM**<br>110 | **Alarm Status**<br>(Writing a 0 clears next alarm.) | ? <sp> ALM <cr><br>= <sp> ALM <sp> 0 <cr> | 0 = No alarms occurring (0000 0000)<br>Bit 3 = A3LO (0000 0100)<br>Bit 4 = A3HI (0000 1000)<br>110 = Alarm 3<br>0 = off<br>1 = HI<br>2 = LO |
| **ALT**<br>1902 | **Altitude Compensation** | ? <sp> ALT <cr><br>= <sp> ALT <sp> data.2 <cr> | 0 = 0<br>1 = 2500 feet<br>2 = 5000 feet<br>default: 0 |
| **AMB**<br>1500 | **Ambient Terminal Temperature** | ? <sp> AMB <cr> | Input 1 terminals in 0.0°F |
| **ANUN**<br>742 | **Alarm Annunciation** | ? <sp> ANUN <cr><br>= <sp> ANUN <sp> data.2 <cr> | 0 = off<br>1 = on<br>Default: on |
| **AOUT**<br>743 | **Analog Output 3 Retransmit Function** | ? <sp> AOUT <cr><br>= <sp> AOUT <sp> data.2 <cr> | 0 = Retransmit Process Channel A<br>1 = Retransmit Set Point Channel A<br>2 = off<br>3 = Retransmit Process Channel B<br>4 = Retransmit Set Point Channel B<br>Default: 0 |
| **ARH**<br>745 | **Retransmit Range High** | ? <sp> ARH <cr><br>= <sp> ARH <sp> data.2 <cr> | ARL to 9999<br>Default: RH1 or RH2 per AOUT |
| **ARL**<br>744 | **Retransmit Range Low** | ? <sp> ARL <cr><br>= <sp> ARL <sp> data.2 <cr> | -999 to ARH<br>Default: RL1 or RL2 per AOUT |

# Dual Channel Controller Prompt Table

| Name data.1<br>Modbus Address | Description | Read (?) and/or Write (=) Syntax | Range data.2 |
|---|---|---|---|
| **ATM**<br>301 | **Auto-Manual Key** | ? <sp> ATM <cr><br>= <sp> ATM <sp> data.2 <cr> | 0 = Auto Mode Channels A and B<br>1 = Manual Mode Chan. A, Auto Chan. B<br>2 = Manual Mode Chan. B, Auto Chan. A<br>3 = Manual Mode Channels A and B<br>Default: n/a<br>Disabled if LOC = 2 or 3 |
| **ATSP**<br>304 | **Auto-tune Set Point %** | ? <sp> ATSP <cr><br>= <sp> ATSP <sp> data.2 <cr> | 50 to 150%<br>Default: 90% |
| **AUT**<br>305 | **Auto-tune** | ? <sp> AUT <cr><br>= <sp> AUT <sp> data.2 <cr> | 0 = No auto-tuning<br>1 = Tune Channel A PID<br>2 = Tune Channel B PID<br>Default: off |
| **C1**<br>100 | **Input 1 Value** | ? <sp> C1 <cr> | Based on IN1 range ; RL1 to RH1 |
| **C2**<br>104 | **Input 2 Value** | ? <sp> C2 <cr> | Based on IN2 range ; RL2 to RH2 |
| **CAL**<br>1305 | **Lockout Calibration Menu** | ? <sp> CAL <cr><br>= <sp> CAL <sp> data.2 <cr> | 0 = No lockout<br>1 = Read only<br>2 = No read or write<br>Default: 0 |
| **CAL1**<br>605 | **Input 1 Calibration Offset** | ? <sp> CAL1 <cr><br>= <sp> CAL1 <sp> data.2 <cr> | -999°F to 999°F<br>-555°C to 555°C<br>-999 Units to 999 Units<br>Default: 0 |
| **CAL2**<br>615 | **Input 2 Calibration Offset** | ? <sp> CAL2 <cr><br>= <sp> CAL2 <sp> data.2 <cr> | -999°F to 999°F<br>-555°C to 555°C<br>-999 Units to 999 Units<br>Default: 0 |
| **CF**<br>901 | **Degrees Select Display Loop** | ? <sp> CF <cr><br>= <sp> CF <sp> data.2 <cr> | 0 = Display °F<br>1 = Display °C<br>Default = 0 |
| **COM**<br>1312 | **Lockout Comms Menu** | ? <sp> COM <cr><br>= <sp> COM <sp> data.2 <cr> | 0 = No lockout<br>1 = Read only<br>2 = No read or write<br>Default: 0 |
| **CT1A**<br>506 | **Cycle Time Output 1 PID Channel A** | ? <sp> CT1A <cr><br>= <sp> CT1A <sp> data.2 <cr> | S.S. relay or open collector:<br>0.9 = Burst firing, or<br>1.0 to 999.9 sec. (Time prop)<br>Mech relay: 5.0 to 999.9 sec.<br>Default: 1.0 or 30.0 sec. |
| **CT1B**<br>526 | **Cycle Time Output 1 PID Channel B** | ? <sp> CT1B <cr><br>= <sp> CT1B <sp> data.2 <cr> | S.S. relay or open collector:<br>0.9 = Burst firing, or<br>1.0 to 999.9 sec. (Time prop)<br>Mech relay: 5.0 to 999.9 sec.<br>Default: 1.0 or 30.0 sec. |
| **CT2A**<br>516 | **Cycle Time Output 2 PID Channel A** | ? <sp> CT2A <cr><br>= <sp> CT2A <sp> data.2 <cr> | S.S. relay or open collector:<br>0.9 = Burst firing, or<br>1.0 to 999.9 sec. (Time prop)<br>Mech relay: 5.0 to 999.9 sec.<br>Default: 1.0 or 30.0 sec. |
| **CT2B**<br>536 | **Cycle Time Output 2 PID Channel B** | ? <sp> CT2B <cr><br>= <sp> CT2B <sp> data.2 <cr> | S.S. relay or open collector:<br>0.9 = Burst firing, or<br>1.0 to 999.9 sec. (Time prop)<br>Mech relay: 5.0 to 999.9 sec.<br>Default: 1.0 or 30.0 sec. |
| **DATE**<br>5 | **Factory Test Date** | ? <sp> DATE <cr> | xxyy<br>xx = Week<br>yy = Year |

*Table 7.3 -*
**ATM to DATE**

**CAUTION:**
**Avoid writing <=> continuously, such as ramping set points or repetitive loops, to the Series 996-999 EEPROM memory. Continuous writes may result in premature control failure, system downtime and damage to processes and equipment.**

**NOTE:**
**The number of decimal places returned by many of these commands is determined by the DEC1, DEC2, IN1 or IN2 setting. (This does not apply to Modbus Protocol.)**

# Dual Channel Controller Prompt Table

*Table 7.4 -*
**DBA to ER**

**CAUTION:**
**Avoid writing <=> continuously, such as ramping set points or repetitive loops, to the Series 996-999 EEPROM memory. Continuous writes may result in premature control failure, system downtime and damage to processes and equipment.**

**NOTE:**
**The number of decimal places returned by many of these commands is determined by the DEC1, DEC2, IN1 or IN2 setting. (This does not apply to Modbus Protocol.)`**

| Name data.1 / Modbus Address | Description | Read (?) and/or Write (=) Syntax | Range data.2 |
|---|---|---|---|
| **DBA** 505 | **Deadband PID Channel A** | ? <sp> DBA <cr><br>= <sp> DBA <sp> data.2 <cr> | -999°F to 999°F<br>-555°C to 555°C<br>-999 units to 999 units<br>Default: 0°F, 0°C, or 0 units |
| **DBB** 525 | **Deadband PID Channel B** | ? <sp> DBB <cr><br>= <sp> DBB <sp> data.2 <cr> | -999°F to 999°F<br>-555°C to 555°C<br>-999 units to 999 units<br>Default: 0°F, 0°C, or 0 units |
| **DE1A** 503 | **Derivative Output 1 PID Channel A** | ? <sp> DE1A <cr><br>= <sp> DE1A <sp> data.2 <cr> | 0.00 to 9.99 minutes<br>Default: 0.00 |
| **DE1B** 523 | **Derivative Output 1 PID Channel B** | ? <sp> DE1B <cr><br>= <sp> DE1B <sp> data.2 <cr> | 0.00 to 9.99 minutes<br>Default: 0.00 |
| **DE2A** 513 | **Derivative Output 2 PID Channel A** | ? <sp> DE2A <cr><br>= <sp> DE2A <sp> data.2 <cr> | 0.00 to 9.99 minutes<br>Default: 0.00 |
| **DE2B** 533 | **Derivative Output 2 PID Channel B** | ? <sp> DE2B <cr><br>= <sp> DE2B <sp> data.2 <cr> | 0.00 to 9.99 minutes<br>Default: 0.00 |
| **DEC1** 606 | **Decimal Point Process Input 1** | ? <sp> DEC1 <cr><br>= <sp> DEC1 <sp> data.2 <cr> | 0 = Decimal point 0<br>1 = Decimal point 0.0<br>2 = Decimal point 0.00<br>3 = Decimal point 0.000<br>Default: 0 |
| **DEC2** 616 | **Decimal Point Process Input 2** | ? <sp> DEC2 <cr><br>= <sp> DEC2 <sp> data.2 <cr> | 0 = Decimal point 0<br>1 = Decimal point 0.0<br>2 = Decimal point 0.00<br>3 = Decimal point 0.000<br>Default: 0 |
| **DFL** 900 | **Default Unit Type** | ? <sp> DFL <cr><br>= <sp> DFL <sp> data.2 <cr> | 0 = US units<br>1 = Standard International units<br>Default: 0 |
| **DIAG** 1313 | **Lockout Diagnostics Menu** | ? <sp> DIAG <cr><br>= <sp> DIAG <sp> data.2 <cr> | 0 = No lockout<br>1 = Read only<br>2 = No read or write<br>Default: 0 |
| **EI1** 1060 | **Event Input 1 Function** | ? <sp> EI1 <cr><br>= <sp> EI1 <sp> data.2 <cr> | 0 = No<br>1 = LOC<br>2 = Alarm reset<br>3 = Toggle Auto/manual<br>4 = Turn control outputs off<br>Default: No |
| **EI1S** 201 | **Event Input 1 Status** | ? <sp> EI1S <cr> | 0 = off (open)<br>1 = on (closed) |
| **ER** 209 | **Error, Analog Input** (Multiple errors possible.) | ? <sp> ER <cr> | 0 = No error<br>1 = Input 1 A-D overflow<br>2 = Input 1 overrange<br>3 = Input 1 underrange<br>4 = Input 1 A-D underflow<br>5 = Input 2 A-D overflow<br>6 = Input 2 overrange<br>7 = Input 2 underrange<br>8 = Input 2 A-D underflow<br>9 = Ambient error |

# Dual Channel Controller Prompt Table

| Name data.1<br>Modbus Address | Description | Read (?) and/or Write (=) Syntax | Range data.2 |
|---|---|---|---|
| **ER2**<br>**n/a** | **Error, Communications** | ? <sp> ER2 <cr> | 0 = No error<br>1 = Transmit buffer overflow<br>2 = Receive buffer overflow<br>3 = Framing error<br>4 = Overrun error<br>5 = Parity error<br>6 = Talking out of turn<br>7 = Invalid reply error<br>8 = Noise error<br>20 = Command not found<br>21 = Prompt not found<br>22 = Incomplete command line<br>23 = Invalid character<br>24 = Number of chars. overflow<br>25 = Input out of limit<br>26 = Read only command<br>27 = Write allowed only<br>28 = Prompt not active |
| **ERR**<br>607 | **Error, Latching Enable** | ? <sp> ERR <cr><br>= <sp> ERR <sp> data.2 <cr> | 0 = Errors latching<br>1 = Errors non-latching<br>Default: 1 |
| **FAIL**<br>902 | **Sensor Failure Output Function**<br>Failure mode can be bumpless transfer or manual (% Power) control. See user's manual, Error Code Actions. | ? <sp> FAIL <cr><br>= <sp> FAIL <sp> data.2 <cr> | Bumpless = LOP - 1%<br>Heat/cool manual = -100 to 100%<br>Heat only manual = 0% to 100%<br>Cool only manual = -100% to 0%<br>Default: Bumpless |
| **FTR1**<br>604 | **Process Input 1 Filter Time Constant** | ? <sp> FTR1 <cr><br>= <sp> FTR1 <sp> data.2 <cr> | -60 to 60 seconds<br>Default: 0 |
| **FTR2**<br>614 | **Process Input 2 Filter Time Constant** | ? <sp> FTR2 <cr><br>= <sp> FTR2 <sp> data.2 <cr> | -60 to 60 seconds<br>Default: 0 |
| **GLBL**<br>1311 | **Lockout Global Menu** | ? <sp> GLBL <cr><br>= <sp> GLBL <sp> data.2 <cr> | 0 = No lockout<br>1 = Read only<br>2 = No read or write<br>Default: 0 |
| **HY1A**<br>507 | **Output 1A Hysteresis** | ? <sp> HY1A <cr><br>= <sp> HY1A <sp> data.2 <cr> | 0°F to 999°F<br>0°C to 555°C<br>0 units to 999 units<br>Default: 3°F, 2°C or 3 units |
| **HY1B**<br>527 | **Output 1B Hysteresis** | ? <sp> HY1B <cr><br>= <sp> HY1B <sp> data.2 <cr> | 0°F to 999°F<br>0°C to 555°C<br>0 units to 999 units<br>Default: 3°F, 2°C or 3 units |
| **HY2A**<br>517 | **Output 2A Hysteresis** | ? <sp> HY2A <cr><br>= <sp> HY2A <sp> data.2 <cr> | 0°F to 999°F<br>0°C to 555°C<br>0 units to 999 units<br>Default: 3°F, 2°C or 3 units |
| **HY2B**<br>537 | **Output 2B Hysteresis** | ? <sp> HY2B <cr><br>= <sp> HY2B <sp> data.2 <cr> | 0°F to 999°F<br>0°C to 555°C<br>0 units to 999 units<br>Default: 3°F, 2°C or 3 units |
| **HYS3**<br>737 | **Output 3 Hysteresis** | ? <sp> HYS3 <cr><br>= <sp> HYS3 <sp> data.2 <cr> | 0°F to 999°F<br>0°C to 555°C<br>0 units to 999 units<br>Default: 3°F, 2°C or 3 units |

*Table 7.5 -*
**ER2 to HYS3**

**CAUTION:**
**Avoid writing <=> continuously, such as ramping set points or repetitive loops, to the Series 996-999 EEPROM memory. Continuous writes may result in premature control failure, system downtime and damage to processes and equipment.**

**NOTE:**
**The number of decimal places returned by many of these commands is determined by the DEC1, DEC2, IN1 or IN2 setting. (This does not apply to Modbus Protocol.)**

# Dual Channel Controller Prompt Table

*Table 7.6 -*
**IN1 to INPT**

**CAUTION:**
**Avoid writing <=> continuously, such as ramping set points or repetitive loops, to the Series 996-999 EEPROM memory. Continuous writes may result in premature control failure, system downtime and damage to processes and equipment.**

**NOTE:**
**The number of decimal places returned by many of these commands is determined by the DEC1, DEC2, IN1 or IN2 setting.**

**NOTE:**
**(RTD setting)**
**For JIS curve, go to rtd1 prompt after selecting In1.**

| Name data.1<br>Modbus Address | Description | Read (?) and/or Write (=) Syntax | Range<br>data.2 |
|---|---|---|---|
| **IN1**<br>601 | **Input 1 Type**<br><br>(Caution: Writing to IN1 resets most prompts to their default state.) | ? <sp> IN1 <cr><br>= <sp> IN1 <sp> data.2 <cr> | 1 = J t/c; 32 to 1500°F/0 to 816°C<br>2 = K t/c; -328 to 2500°F/-200 to 1371°C<br>3 = T t/c; -328 to 750°F/-200 to 399°C<br>4 = N t/c; 32 to 2372°F/0 to 1300°C<br>5 = E t/c; -328 to 1470°F/-200 to 799°C<br>6 = C t/c (W3); 32 to 4200°F 0 to 2316°C<br>7 = D t/c (W5); 32 to 4200°F/0 to 2316°C<br>8 = Pt 2; 32 to 2543°F/0 to 1395°C<br>10 = R t/c; 32 to 3200°F/0 to 1760°C<br>11 = S t/c; 32 to 3200°F/0 to 1760°C<br>12 = B t/c; 1598 to 3300°F/870 to 1816°C<br>14 = 1° RTD (DIN); -328 to 1472°F/ -200 to 800°C<br>15 = 0.1° RTD (DIN); -99.9 to 999.9°F/ -99.9 to 700.0°C<br>17 = 4-20mA; -999 to 9999 units<br>18 = 0-20mA; -999 to 9999 units<br>19 = 0-5V⎓ (dc); -999 to 9999 units<br>20 = 1-5V⎓ (dc); -999 to 9999 units<br>21 = 0-10V⎓ (dc); -999 to 9999 units<br>23 = 0-50mV⎓ (dc); -999 to 9999 units<br>24 = 0-100mV⎓ (dc); -999 to 9999 units |
| **IN2**<br>611 | **Input 2 Type**<br><br>(Caution: Writing to IN2 resets most prompts to their default states.) | ? <sp> IN2 <cr><br>= <sp> IN2 <sp> data.2 <cr> | 0 = t/c Low Gain off<br>1 = J t/c; 32 to 1500°F/0 to 816°C<br>2 = K t/c; -328 to 2500°F/-200 to 1371°C<br>3 = T t/c; -328 to 750°F/-200 to 399°C<br>4 = N t/c; 32 to 2372°F/0 to 1300°C<br>5 = E t/c; -328 to 1470°F/-200 to 799°C<br>6 = C t/c (W3); 32 to 4200°F 0 to 2316°C<br>7 = D t/c (W5); 32 to 4200°F/0 to 2316°C<br>8 = Pt 2; 32 to 2543°F/0 to 1395°C<br>10 = R t/c; 32 to 3200°F/0 to 1760°C<br>11 = S t/c; 32 to 3200°F/0 to 1760°C<br>12 = B t/c; 1598 to 3300°F/870 to 1816°C<br>14 = 1° RTD (DIN); -328 to 1472°F/ -200 to 800°C<br>15 = 0.1° RTD (DIN); -99.9 to 999.9°F/ -99.9 to 700.0°C<br>17 = 4-20mA; -999 to 9999 units<br>18 = 0-20mA; -999 to 9999 units<br>19 = 0-5V⎓ (dc); -999 to 9999 units<br>20 = 1-5V⎓ (dc); -999 to 9999 units<br>21 = 0-10V⎓ (dc); -999 to 9999 units<br>23 = 0-50mV⎓ (dc); -999 to 9999 units<br>24 = 0-100mV⎓ (dc); -999 to 9999 units |
| **INPT**<br>1309 | **Lockout Input Menu** | ? <sp> INPT <cr><br>= <sp> INPT <sp> data.2 <cr> | 0 = No input menu lockout<br>1 = Read only<br>2 = No read or write allowed<br>Default: 0 |

# Dual Channel Controller Prompt Table

| Name data.1 / Modbus Address | Description | Read (?) and/or Write (=) Syntax | Range data.2 |
|---|---|---|---|
| **IT1A** 501 | **Integral for Output 1 PID Channel A** | ? <sp> IT1A <cr><br>= <sp> IT1A <sp> data.2 <cr> | 0.00 to 99.99 minutes per repeat<br>Default: 0.00 minutes per repeat |
| **IT1B** 521 | **Integral for Output 1 PID Channel B** | ? <sp> IT1B <cr><br>= <sp> IT1B <sp> data.2 <cr> | 0.00 to 99.99 minutes per repeat<br>Default: 0.00 minutes per repeat |
| **IT2A** 511 | **Integral for Output 2 PID Channel A** | ? <sp> IT2A <cr><br>= <sp> IT2A <sp> data.2 <cr> | 0.00 to 99.99 minutes per repeat<br>Default: 0.00 minutes per repeat |
| **IT2B** 531 | **Integral for Output 2 PID Channel B** | ? <sp> IT2B <cr><br>= <sp> IT2B <sp> data.2 <cr> | 0.00 to 99.99 minutes per repeat<br>Default: 0.00 minutes per repeat |
| **ITY1** 8 | **Input 1 Hardware Type** | ? <sp> ITY1 <cr> | 0 = None<br>1 = t/c only<br>4 = Input off<br>5 = Universal RTD<br>6 = Universal high gain t/c<br>7 = Universal low gain t/c<br>8 = Universal millivolts<br>9 = Universal process |
| **ITY2** 9 | **Input 2 Hardware Type** | ? <sp> ITY2 <cr> | 0 = None<br>1 = t/c only<br>4 = Input off<br>5 = Universal RTD<br>6 = Universal high gain t/c<br>7 = Universal low gain t/c<br>8 = Universal millivolts<br>9 = Universal process |
| **LAT3** 738 | **Alarm 3 Latching** | ? <sp> LAT3 <cr><br>= <sp> LAT3 <sp> data.2 <cr> | 0 = Latching alarms<br>1 = Non-latching alarms<br>Default: 1 |
| **LIN2** 618 | **Linearization Process Input 2** | ? <sp> LIN2 <cr><br>= <sp> LIN2 <sp> data.2 <cr> | 0 = None<br>1 = Wet bulb<br>2 = Vaisala HMM-30C<br>3 = Rotronic H260<br>Default: 0 |
| **LOC** 1300 | **Keyboard Lockout** | ? <sp> LOC <cr><br>= <sp> LOC <sp> data.2 <cr> | 0 = No lockout<br>1 = Lock out mode key<br>2 = Lock out mode & auto/man keys<br>3 = Lock out all single keys<br>Default: 0 |
| **MDL** 0 | **Model Number** | ? <sp> MDL <cr> | 998 (996 - 999 dual channel unit) |
| **MOD** 1900 | **Mode Key Action** | = <sp> MOD <sp> 1 <cr> | 0 = Mode to previous prompt<br>1 = Mode to next prompt |
| **OT1A** 700 | **Output 1 Channel A Action** | ? <sp> OT1A <cr><br>= <sp> OT1A <sp> data.2 <cr> | 0 = Heat<br>1 = Cool<br>2 = None |
| **OT1B** 717 | **Output 1 Channel B Action** | ? <sp> OT1B <cr><br>= <sp> OT1B <sp> data.2 <cr> | 0 = Heat<br>1 = Cool<br>2 = None |
| **OT2A** 716 | **Output 2 Channel A Action** | ? <sp> OT2A <cr><br>= <sp> OT2A <sp> data.2 <cr> | 0 = Heat<br>1 = Cool<br>2 = None |
| **OT2B** 733 | **Output 2 Channel B Action** | ? <sp> OT2B <cr><br>= <sp> OT2B <sp> data.2 <cr> | 0 = Heat<br>1 = Cool<br>2 = None |
| **OT3** 734 | **Output 3 Action** | ? <sp> OT3 <cr><br>= <sp> OT3 <sp> data.2 <cr> | 0 = None<br>1 = Alarm 3<br>2 = Alarm 3 reverse acting |

*Table 7.7 -*
**IT1A to OT3**

**CAUTION:**
**Avoid writing <=> continuously, such as ramping set points or repetitive loops, to the Series 996-999 EEPROM memory. Continuous writes may result in premature control failure, system downtime and damage to processes and equipment.**

**NOTE:**
**The number of decimal places returned by many of these commands is determined by the DEC1, DEC2, IN1 or IN2 setting. (This does not apply to Modbus Protocol.)**

# Dual Channel Controller Prompt Table

*Table 7.8 -*
**OT3S to PB2B**

**CAUTION:**
**Avoid writing <=> continuously, such as ramping set points or repetitive loops, to the Series 996-999 EEPROM memory. Continuous writes may result in premature control failure, system downtime and damage to processes and equipment.**

**NOTE:**
**The number of decimal places returned by many of these commands is determined by the DEC1, DEC2, IN1 or IN2 setting. (This does not apply to Modbus Protocol.)**

| Name data.1<br>Modbus Address | Description | Read (?) and/or Write (=) Syntax | Range<br>data.2 |
|---|---|---|---|
| **OT3S**<br>1903 | **Output 3 Status** | ? <sp> OT3S <cr> | 0 = off<br>1 = on |
| **OTPT**<br>1310 | **Lockout Output Menu** | ? <sp> OTPT <cr><br>= <sp> OTPT <sp> data.2 <cr> | 0 = No lockout<br>1 = Read only<br>2 = No read or write<br>Default: 0 |
| **OTY1**<br>16<br>**OTY2**<br>17<br>**OTY3**<br>18<br>**OTY4**<br>19 | **Output 1 Hardware**<br><br>**Output 2 Hardware**<br><br>**Output 3 Hardware**<br><br>**Output 4 Hardware** | ? <sp> OTY1 <cr><br><br>? <sp> OTY2 <cr><br><br>? <sp> OTY3 <cr><br><br>? <sp> OTY4 <cr> | 0 = None<br><br>1 = SSR 0.5A<br><br>2 = SSR 0.5A with suppression<br><br>5 = Dual SSR Form A<br>6 = Switched dc<br>7 = Dual Switched dc<br>8 = Relay 5A Form C<br>9 = Relay 5A Form C with suppression<br>10 = Relay 5A Form A/B<br>11 = Relay 5A Form A/B with suppression<br>12 = Dual Relay Form A<br>13 = Process output<br>14 = Voltage retransmit<br>15 = Current retransmit<br>16 = Power supply<br>17 = Comms EIA-232<br>18 = Comms EIA -485 / EIA 422<br>19 = Comms EIA -485 / EIA-232 |
| **PB1A**<br>500 | **Proportional Band Output 1 PID Channel A** | ? <sp> PB1A <cr><br>= <sp> PB1A <sp> data.2 <cr> | if DFL = 0 and CF = 1, then 0 to 555°C<br>if DFL = 0 and CF = 0, then 0 to 999°F<br>if DFL = 0 and IN1 = a process value, then 0 to 999 units<br>if DFL = 1, then 0.0 to 99.9% of span<br>Default: 25°F, 14°C, 25 units, or 3.0% |
| **PB1B**<br>520 | **Proportional Band Output 1 PID Channel B** | ? <sp> PB1B <cr><br>= <sp> PB1B <sp> data.2 <cr> | if DFL = 0 and CF = 1, then 0 to 555°C<br>if DFL = 0 and CF = 0, then 0 to 999°F<br>if DFL = 0 and IN1 = a process value, then 0 to 999 units<br>if DFL = 1, then 0.0 to 99.9% of span<br>Default: 25°F, 14°C, 25 units, or 3.0% |
| **PB2A**<br>510 | **Proportional Band Output 2 PID Channel A** | ? <sp> PB2A <cr><br>= <sp> PB2A <sp> data.2 <cr> | if DFL = 0 and CF = 1, then 0 to 555°C<br>if DFL = 0 and CF = 0, then 0 to 999°F<br>if DFL = 0 and IN1 = a process value, then 0 to 999 units<br>if DFL = 1, then 0.0 to 99.9% of span<br>Default: 25°F, 14°C, 25 units, or 3.0% |
| **PB2B**<br>530 | **Proportional Band Output 2 PID Channel B** | ? <sp> PB2B <cr><br>= <sp> PB2B <sp> data.2 <cr> | if DFL = 0 and CF = 1, then 0 to 555°C<br>if DFL = 0 and CF = 0, then 0 to 999°F<br>if DFL = 0 and IN1 = a process value, then 0 to 999 units<br>if DFL = 1, then 0.0 to 99.9% of span<br>Default: 25°F, 14°C, 25 units, or 3.0% |

# Dual Channel Controller Prompt Table

| Name data.1<br>Modbus Address | Description | Read (?) and/or Write (=) Syntax | Range data.2 |
|---|---|---|---|
| **PIDA**<br>1307 | **Lockout Channel A**<br>**PID Menu** | ? <sp> PIDA <cr><br>= <sp> PIDA <sp> data.2 <cr> | 0 = No lockout<br>1 = Read only<br>2 = No read or write<br>Default: 0 |
| **PIDB**<br>1308 | **Lockout Channel B**<br>**PID Menu** | ? <sp> PIDB <cr><br>= <sp> PIDB <sp> data.2 <cr> | 0 = No lockout<br>1 = Read only<br>2 = No read or write<br>Default: 0 |
| **PRCA**<br>701 | **Process Range**<br>**Output Channel A** | ? <sp> PRCA <cr><br>= <sp> PRCA <sp> data.2 <cr> | 0 = 4-20mA<br>1 = 0-20mA<br>2 = 0-5V⎓ (dc)<br>3 = 1-5V⎓ (dc)<br>4 = 0-10V⎓ (dc)<br>Default: 0 |
| **PRCB**<br>718 | **Process Range**<br>**Output Channel B** | ? <sp> PRCB <cr><br>= <sp> PRCB <sp> data.2 <cr> | 0 = 4-20mA<br>1 = 0-20mA<br>2 = 0-5V⎓ (dc)<br>3 = 1-5V⎓ (dc)<br>4 = 0-10V⎓ (dc)<br>Default: 0 |
| **PRC3**<br>735 | **Process Range**<br>**Output 3** | ? <sp> PRC3 <cr><br>= <sp> PRC3 <sp> data.2 <cr> | 0 = 4-20mA<br>1 = 0-20mA<br>2 = 0-5V⎓ (dc)<br>3 = 1-5V⎓ (dc)<br>4 = 0-10V⎓ (dc)<br>Default: 0 |
| **RA1A**<br>504 | **Rate Output 1**<br>**PID Channel A** | ? <sp> RA1A <cr><br>= <sp> RA1A <sp> data.2 <cr> | 0.00 to 9.99 minutes<br>Default: 0.00 |
| **RA1B**<br>524 | **Rate Output 1**<br>**PID Channel B** | ? <sp> RA1B <cr><br>= <sp> RA1B <sp> data.2 <cr> | 0.00 to 9.99 minutes<br>Default: 0.00 |
| **RA2A**<br>514 | **Rate Output 2**<br>**PID Channel A** | ? <sp> RA2A <cr><br>= <sp> RA2A <sp> data.2 <cr> | 0.00 to 9.99 minutes<br>Default: 0.00 |
| **RA2B**<br>534 | **Rate Output 2**<br>**PID Channel B** | ? <sp> RA2B <cr><br>= <sp> RA2B <sp> data.2 <cr> | 0.00 to 9.99 minutes<br>Default: 0.00 |
| **RE1A**<br>502 | **Reset Output 1**<br>**PID Channel A** | ? <sp> RE1A <cr><br>= <sp> RE1A <sp> data.2 <cr> | 0.00 to 9.99 repeats/minute<br>Default: 0.10 repeats/minute |
| **RE1B**<br>522 | **Reset Output 1**<br>**PID Channel B** | ? <sp> RE1B <cr><br>= <sp> RE1B <sp> data.2 <cr> | 0.00 to 9.99 repeats/minute<br>Default: 0.10 repeats/minute |
| **RE2A**<br>512 | **Reset Output 2**<br>**PID Channel A** | ? <sp> RE2A <cr><br>= <sp> RE2A <sp> data.2 <cr> | 0.00 to 9.99 repeats/minute<br>Default: 0.10 repeats/minute |
| **RE2B**<br>532 | **Reset Output 2**<br>**PID Channel B** | ? <sp> RE2B <cr><br>= <sp> RE2B <sp> data.2 <cr> | 0.00 to 9.99 repeats/minute<br>Default: 0.10 repeats/minute |
| **RH1**<br>603 | **Range High**<br>**Input 1** | ? <sp> RH1 <cr><br>= <sp> RH1 <sp> data.2 <cr> | min. IN1 range to to max. IN1 range<br>Default: Sensor high range |
| **RH2**<br>613 | **Range High**<br>**Input 2** | ? <sp> RH2 <cr><br>= <sp> RH2 <sp> data.2 <cr> | min. IN2 range to to max. IN2 range<br>Default: Sensor high range |
| **RL1**<br>602 | **Range Low**<br>**Input 1** | ? <sp> RL1 <cr><br>= <sp> RL1 <sp> data.2 <cr> | min. IN1 range to to max. IN1 range<br>Default: Sensor low range |
| **RL2**<br>612 | **Range Low**<br>**Input 2** | ? <sp> RL2 <cr><br>= <sp> RL2 <sp> data.2 <cr> | min. IN2 range to to max. IN2 range<br>Default: Sensor low range |

*Table 7.9 -*
**PIDA to RL2**

**CAUTION:**
**Avoid writing <=> continuously, such as ramping set points or repetitive loops, to the Series 996-999 EEPROM memory. Continuous writes may result in premature control failure, system downtime and damage to processes and equipment.**

**NOTE:**
**The number of decimal places returned by many of these commands is determined by the DEC1, DEC2, IN1 or IN2 setting. (This does not apply to Modbus Protocol.)**

# Dual Channel Controller Prompt Table

*Table 7.10 -*
**RPA to SYS**

**CAUTION:**
**Avoid writing <=> continuously, such as ramping set points or repetitive loops, to the Series 996-999 EEPROM memory. Continuous writes may result in premature control failure, system downtime and damage to processes and equipment.**

**NOTE:**
**The number of decimal places returned by many of these commands is determined by the DEC1, DEC2, IN1 or IN2 setting. (This does not apply to Modbus Protocol.)**

| Name data.1<br>Modbus Address | Description | Read (?) and/or Write (=) Syntax | Range data.2 |
|---|---|---|---|
| **RPA**<br>1100 | **Ramping Initiation Channel A** | ? <sp> RPA <cr><br>= <sp> RPA <sp> data.2 <cr> | 0 = off<br>1 = On startup<br>2 = On startup and set point change<br>Default: 0 |
| **RPB**<br>1104 | **Ramping Initiation Channel B** | ? <sp> RPB <cr><br>= <sp> RPB <sp> data.2 <cr> | 0 = off<br>1 = On startup<br>2 = On startup and set point change<br>Default: 0 |
| **RTA**<br>1101 | **Ramp Rate Channel A** | ? <sp> RTA <cr><br>= <sp> RTA <sp> data.2 <cr> | 0 to 9999°/minute<br>Default: 100°/minute |
| **RTB**<br>1105 | **Ramp Rate Channel B** | ? <sp> RTB <cr><br>= <sp> RTB <sp> data.2 <cr> | 0 to 9999°/minute<br>Default: 100°/minute |
| **RTD1**<br>609 | **RTD Calibration Curve Input 1** | ? <sp> RTD1 <cr><br>= <sp> RTD1 <sp> data.2 <cr> | 0 = JIS<br>1 = DIN<br>Default: 1 |
| **RTD2**<br>619 | **RTD Calibration Curve Input 2** | ? <sp> RTD2 <cr><br>= <sp> RTD2 <sp> data.2 <cr> | 0 = JIS<br>1 = DIN<br>Default: 1 |
| **SIL3**<br>739 | **Alarm 3 Silence** | ? <sp> SIL3 <cr><br>= <sp> SIL3 <sp> data.2 <cr> | 0 = off / disabled<br>1 = on / enabled<br>Default: 0 |
| **SRNB**<br>2 | **Serial Number Bottom Display**<br>Read the six-digit unit serial number in two segments, "SNxx" and "xxxx," i.e., as in the upper and lower front panel displays. | ? <sp> SRNB <cr> | xxxx =<br>0000 to 9999 |
| **SRNT**<br>1 | **Serial Number Top Display** | ? <sp> SRNT <cr> | SNxx =<br>00 to 99 |
| **SOFT**<br>4 | **Software Revision** | ? <sp> SOFT <cr> | 0 = Rev A 7 = Rev H<br>1 = Rev B 8 = Rev I<br>2 = Rev C 9 = Rev J<br>3 = Rev D 10 = Rev K<br>4 = Rev E 11 = Rev L<br>5 = Rev F 12 = Rev M<br>6 = Rev G 13 = Rev N<br>etc. |
| **SPA**<br>300 | **Set Point Channel A** | ? <sp> SPA <cr><br>= <sp> SPA <sp> data.2 <cr> | RL1 to RH1<br>Default: per IN1 and hardware |
| **SPB**<br>319 | **Set Point Channel B** | ? <sp> SPB <cr><br>= <sp> SPB <sp> data.2 <cr> | RL2 to RH2<br>Default: per IN1 and hardware |
| **SP2A**<br>309 | **Set Point 2 Channel A**<br>Heat/Heat or Cool/Cool Only | ? <sp> SP2A <cr><br>= <sp> SP2A <sp> data.2 <cr> | RL1 to RH1<br>Default: per input range |
| **SP2B**<br>328 | **Set Point 2 Channel B**<br>Heat/Heat or Cool/Cool Only | ? <sp> SP2B <cr><br>= <sp> SP2B <sp> data.2 <cr> | RL2 to RH2<br>Default: per input range |
| **SYS**<br>1306 | **Lockout System Menu** | ? <sp> SYS <cr><br>= <sp> SYS <sp> data.2 <cr> | 0 = No lockout<br>1 = Read only<br>2 = No read or write<br>Default: 0 |

| Name data.1<br>Modbus Address | Description | Read (?) and/or Write (=) Syntax | Range data.2 |
|---|---|---|---|
| **TOUT**<br>1514 | **Test Outputs** | = <sp> TOUT <sp> data.2 <cr> | 0 = All off<br>1 = Output 1A on<br>2 = Output 2A on<br>3 = Output 1B on<br>4 = Output 2B on<br>5 = Output 3 on<br>6 = Output 4 on |

*Table 7.11 -*
**SYS to TOUT**



**CAUTION:**
**Avoid writing <=> continuously, such as ramping set points or repetitive loops, to the Series 996-999 EEPROM memory. Continuous writes may result in premature control failure, system downtime and damage to processes and equipment.**

**NOTE:**
**The number of decimal places returned by many of these commands is determined by the DEC1, DEC2, IN1 or IN2 setting. (This does not apply to Modbus Protocol.)**

# Table 7.12 - 998 Modbus RTU Addresses

*Table 7.12 -* **Modbus RTU Addresses**

| Absolute Address | Relative Address | Parameter |
|---|---|---|
| 40001 | 0 | MDL (998) |
| 40002 | 1 | SRNT |
| 40003 | 2 | SRNB |
| 40005 | 4 | SOFT |
| 40006 | 5 | DATE |
| 40009 | 8 | ITY1 |
| 40010 | 9 | ITY2 |
| 40017 | 16 | OTY1 |
| 40018 | 17 | OTY2 |
| 40019 | 18 | OTY3 |
| 40020 | 19 | OTY4 |
| 40025 | 24 | SPEE |
| 40101 | 100 | C1 |
| 40105 | 104 | C2 |
| 40111 | 110 | ALM |
| 40202 | 201 | EI1S |
| 40210 | 209 | ER |
| 40301 | 300 | SPA |
| 40302 | 301 | ATM |
| 40305 | 304 | ATSP |
| 40306 | 305 | AUT |
| 40310 | 309 | SP2A |
| 40320 | 319 | SPB |
| 40329 | 328 | SP2B |
| 40341 | 340 | A3LO |
| 40342 | 341 | A3HI |
| 40501 | 500 | PB1A |
| 40502 | 501 | IT1A |
| 40503 | 502 | RE1A |
| 40504 | 503 | DE1A |
| 40505 | 504 | RA1A |
| 40506 | 505 | DBA |
| 40507 | 506 | CT1A |
| 40508 | 507 | HY1A |
| 40511 | 510 | PB2A |
| 40512 | 511 | IT2A |
| 40513 | 512 | RE2A |
| 40514 | 513 | DE2A |
| 40515 | 514 | RA2A |
| 40517 | 516 | CT2A |
| 40518 | 517 | HY2A |
| 40521 | 520 | PB1B |
| 40522 | 521 | IT1B |
| 40523 | 522 | RE1B |
| 40524 | 523 | DE1B |
| 40525 | 524 | RA1B |
| 40526 | 525 | DBB |
| 40527 | 526 | CT1B |
| 40528 | 527 | HY1B |
| 40531 | 530 | PB2B |
| 40532 | 531 | IT2B |
| 40533 | 532 | RE2B |
| 40534 | 533 | DE2B |
| 40535 | 534 | RA2B |
| 40537 | 536 | CT2B |
| 40538 | 537 | HY2B |
| 40602 | 601 | IN1 |
| 40603 | 602 | RL2 |
| 40604 | 603 | RH1 |
| 40605 | 604 | FTR1 |
| 40606 | 605 | CAL1 |
| 40607 | 606 | DEC1 |
| 40608 | 607 | ERR |
| 40610 | 609 | RTD1 |
| 40612 | 611 | IN2 |
| 40613 | 612 | RL2 |
| 40614 | 613 | RH2 |
| 40615 | 614 | FTR2 |
| 40616 | 615 | CAL2 |
| 40617 | 616 | DEC2 |
| 40619 | 618 | LIN2 |
| 40620 | 619 | RTD2 |
| 40701 | 700 | OT1A |
| 40702 | 701 | PRCA |
| 40717 | 716 | OT2A |
| 40718 | 717 | OT1B |
| 40719 | 718 | PRCB |
| 40734 | 733 | OT2B |
| 40735 | 734 | OT3 |
| 40737 | 736 | AL3 |
| 40738 | 737 | HYS3 |
| 40739 | 738 | LAT3 |
| 40740 | 739 | SIL3 |
| 40743 | 742 | ANUN |
| 40736 | 735 | PRC3 |
| 40744 | 743 | AOUT |
| 40745 | 744 | ARL |
| 40746 | 745 | ARH |
| 40747 | 746 | ACAL |
| 40901 | 900 | DFL |
| 40902 | 901 | C F |
| 40903 | 902 | FAIL |
| 41061 | 1060 | EI1 |
| 41101 | 1100 | RPA |
| 41102 | 1101 | RTA |
| 41105 | 1104 | RPB |
| 41106 | 1105 | RTB |
| 41301 | 1300 | LOC |
| 41306 | 1305 | CAL |
| 41307 | 1306 | SYS |
| 41308 | 1307 | PIDA |
| 41309 | 1308 | PIDB |
| 41310 | 1309 | INPT |
| 41311 | 1310 | OTPT |
| 41312 | 1311 | GLBL |
| 41313 | 1312 | COM |
| 41314 | 1313 | DIAG |
| 41501 | 1500 | AMB |
| 41515 | 1514 | TOUT |
| 41901 | 1900 | MOD |
| 41902 | 1901 | DISP |
| 41903 | 1902 | ALT |
| 41904 | 1903 | OT3S |

# Appendix

## Handling Communication Error Codes (ER2)

All communications-related error codes are ER2 error codes, that is, they are not considered cause for a shutdown of the unit itself. There is always a communications error code generated when a <NAK> character is sent under ANSI X3.28 protocol. With XON/XOFF flow control, error codes may be generated, but there will be no standard indication of this fact.

When your message is "not acknowledged" (NAK) in EIA-422 or EIA-485 with ANSI X3.28 Protocol, you may clear ER2 codes by reading it. Use the " ? <sp> ER2 <cr>" command.

Then try the message again; you may have made a syntax error. See the ER2 error code list in Chapters 5, 6 and 7.

With XON/XOFF protocol and the EIA-232 interface, the Series 981-984, 986-989 and 996-999 sends no feedback on commands. Therefore, you may want to query the status of ER2 after each command you send.



**CAUTION: Sending commands to a particular controller for which it is not equipped may cause damage to equipment and/or processes.**



**CAUTION: Avoid writing <=> continuously, such as ramping set points or repetitive loops, to the controller's EEPROM memory. Continuous writes may result in premature control failure, system downtime and damage to processes and equipment.**

## User Responsibility 

Users must refrain from altering prompts that do not appear on the controller's front panel or are not included on the specific model. For example, do not send an A2LO command to a unit not equipped with an alarm for output 2.

## Warranty

The Watlow Series 988 family of controllers is warranted to be free of defects in material and workmanship for 36 months after delivery to the first purchaser for use, providing that the units have not been misapplied. Since Watlow has no control over their use, and sometimes misuse, we cannot guarantee against failure. Watlow's obligations hereunder, at Watlow's option, are limited to replacement, repair or refund of purchase price, and parts which upon examination prove to be defective within the warranty period specified. This warranty does not apply to damage resulting from transportation, alteration, misuse or abuse.

# ASCII

## ASCII Character Set

| Dec | Hex | Char | Dec | Hex | Char | Dec | Hex | Char | Dec | Hex | Char |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 00 | 00 | NUL | 16 | 10 | DLE | 32 | 20 | SP | 48 | 30 | 0 |
| 01 | 01 | SOH | 17 | 11 | DC1 | 33 | 21 | ! | 49 | 31 | 1 |
| 02 | 02 | STX | 18 | 12 | DC2 | 34 | 22 | " | 50 | 32 | 2 |
| 03 | 03 | ETX | 19 | 13 | DC3 | 35 | 23 | # | 51 | 33 | 3 |
| 04 | 04 | EOT | 20 | 14 | DC4 | 36 | 24 | $ | 52 | 34 | 4 |
| 05 | 05 | ENQ | 21 | 15 | NAK | 37 | 25 | % | 53 | 35 | 5 |
| 06 | 06 | ACK | 22 | 16 | SYN | 38 | 26 | & | 54 | 36 | 6 |
| 07 | 07 | BEL | 23 | 17 | ETB | 39 | 27 | ' | 55 | 37 | 7 |
| 08 | 08 | BS | 24 | 18 | CAN | 40 | 28 | ( | 56 | 38 | 8 |
| 09 | 09 | HT | 25 | 19 | EM | 41 | 29 | ) | 57 | 39 | 9 |
| 10 | 0A | LF | 26 | 1A | SUB | 42 | 2A | * | 58 | 3A | : |
| 11 | 0B | VT | 27 | 1B | ESC | 43 | 2B | + | 59 | 3B | ; |
| 12 | 0C | FF | 28 | 1C | FS | 44 | 2C | , | 60 | 3C | < |
| 13 | 0D | CR | 29 | 1D | GS | 45 | 2D | - | 61 | 3D | = |
| 14 | 0E | SO | 30 | 1E | RS | 46 | 2E | . | 62 | 3E | > |
| 15 | 0F | SI | 31 | 1F | US | 47 | 2F | / | 63 | 3F | ? |

| Dec | Hex | Char | Dec | Hex | Char | Dec | Hex | Char | Dec | Hex | Char |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 64 | 40 | @ | 80 | 50 | P | 96 | 60 | ` | 112 | 70 | p |
| 65 | 41 | A | 81 | 51 | Q | 97 | 61 | a | 113 | 71 | q |
| 66 | 42 | B | 82 | 52 | R | 98 | 62 | b | 114 | 72 | r |
| 67 | 43 | C | 83 | 53 | S | 99 | 63 | c | 115 | 98 | s |
| 68 | 44 | D | 84 | 54 | T | 100 | 64 | d | 116 | 74 | t |
| 69 | 45 | E | 85 | 55 | U | 101 | 65 | e | 117 | 75 | u |
| 70 | 46 | F | 86 | 56 | V | 102 | 66 | f | 118 | 76 | v |
| 71 | 47 | G | 87 | 57 | W | 103 | 67 | g | 119 | 77 | w |
| 72 | 48 | H | 88 | 58 | X | 104 | 68 | h | 120 | 78 | x |
| 73 | 49 | I | 89 | 59 | Y | 105 | 69 | i | 121 | 79 | y |
| 74 | 4A | J | 90 | 5A | Z | 106 | 6A | j | 122 | 7A | z |
| 75 | 4B | K | 91 | 5B | [ | 107 | 6B | k | 123 | 7B | { |
| 76 | 4C | L | 92 | 5C | \ | 108 | 6C | l | 124 | 7C | \| |
| 77 | 4D | M | 93 | 5D | ] | 109 | 6D | m | 125 | 7D | } |
| 78 | 4E | N | 94 | 5E | ^ | 110 | 6E | n | 126 | 7E | ~ |
| 79 | 4F | O | 95 | 5F | _ | 111 | 6F | o | 127 | 7F | DEL |

**Table A.2a - ASCII Character Set.**

## ASCII Control Characters (Partial Set)

| ASCII Char. | Ctrl Key Equiv. | Definition | Dec. Equiv. | Hex. Equiv. |
|---|---|---|---|---|
| **ENQ** | Ctrl E | Enquiry | 5 | 05 |
| **ACK** | Ctrl F | Acknowledge | 6 | 06 |
| **NAK** | Ctrl U | Neg. Acknowledge | 21 | 15 |
| **STX** | Ctrl B | Start of Text | 2 | 02 |
| **ETX** | Ctrl C | End of Text | 3 | 03 |
| **EOT** | Ctrl D | End of Transmission | 4 | 04 |
| **DLE** | Ctrl P | Data Link Escape | 16 | 10 |
| **CR** | Ctrl M | Carriage Return | 13 | 0D |
| **DC1** | Ctrl Q | XON | 17 | 11 |
| **DC3** | Ctrl S | XOFF | 19 | 13 |

**Table A.2b - ASCII Control Characters (Partial Set).**

# Index


**Symbols**

**+ 4.1**
**- 4.1**
**< > 4.1, 4.2**
**<cr> 4.2**
**<space> 4.2**
**= Command 4.1-4.3, 4.5**
**? Command 4.1, 4.3, 4.5**
**7E 3.2**
**7o 3.2**
**8n 3.2**
**Addr 3.2**
**bAUd 3.2**
**COM9 3.2**
**dAtA 3.2**
**FULL 3.2**
**IntF 3.2**
**rMod 3.2**
**On 3.2**
**Prot 3.2**
**SEt 3.2**

**A**

**A2LO A.1**
**Abort Set Point 5.3**
**ACK 1.6-1.7**
**acknowledge <ACK> 1.6-1.7**
**Action**
Output 1
981-984 [OT1] 5.8
986-989 [OT1] 6.13
996-999 [OT1A], [OT1B] 7.7
Output 2
981-984 [OT2] 5.8
986-989 [OT2] 6.13
996-999 [OT2A], [OT2B] 7.7
**address prompt 3.1, 4.4**
**Addr** 3.2
**Alarm**
Annunciation [ANUN]
981-984 5.4
986-989 6.8
996-999 7.2
Status [ALM]
981-984 5.3
986-989 6.7
996-999 7.2
**Alarm 2**
Latching [LAT2]
981-984 5.7
986-989 6.13
Silence [SIL2]
981-984 5.10
986-989 6.16
Type [AL2]
981-984 5.3
986-989 6.7
**Alarm 3**
Latching [LAT3]
981-984 5.7
986-989 6.13
996-999 7.7
Silence [SIL3]
981-984 5.10
986-989 6.16
996-999 7.10
Type [AL3]
981-984 5.3
986-989 6.7
996-999 7.2
**Algorithm** [ALGO]
986-989 6.7
**Altitude Compensation** [ALT]
996-999 7.2
**Ambient Terminal Temperature** [AMB]
981-984 5.3
986-989 6.8
996-999 7.2
**Analog**
Offset [ACAL]
986-989 6.7
996-999 7.2
Output 3 Retransmit [AOUT]
981-984 5.4
986-989 6.8
996-999 7.2
**ANSI X3.28 Protocol 3.1-3.2, 4.1-4.5, A.1**
**ANSI X3.28 Protocol rules 4.3-4.5**
**ASCII characters 1.4, 4.1, A.2**
**ASCII control characters A.2**
**Auto-Manual Key [ATM]**
986-989 6.8
996-999 7.3
**Auto-tune [AUT]**
981-984 5.4
986-989 6.8
996-999 7.3
**Auto-tune Set Point % [ATSP]**
981-984 5.4
986-989 6.8
996-999 7.3

**B**

**baud rate 1.5, 3.2**
**bAUd** 3.2
**Black Box 2.1**
**brackets [ < > ] 4.1**
**Burr Brown LDM 422A converter 2.4**
**Burr-Brown 2.1**
**bus 1.2**

**C**

**Calibration Menu Lockout [CAL]**
986-989 6.8
996-999 7.3
**Calibration Offset**
Retransmit Output [ACAL]
981-984 5.3
Input 1 [CAL1]
981-984 5.4
986-989 6.8
996-999 7.3
Input 2 [CAL2]
981-984 5.4
986-989 6.8
996-999 7.3
**Carriage Return < cr > 4.2**
**Cascade Action [CSAC] 6.8**
**Channel A PID Lockout [PIDA]**
996-999 7.9
**Channel B PID Lockout [PIDB]**
996-999 7.9
**character set A.2**
**COM Menu COM9 3.2**
Prompts 3.2
**command list 4.1**
**Comms Menu Lockout [COM]**
986-989 6.8
996-999 7.3
**communications software 3.1**
**Communications Menu 2.1**
**connecting 3.1**
**control character definitions 1.6**
**control characters 1.4, A.2**
**Control Function [CNTL]**
986-989 6.8
**Current Profile Set Point [CSP]**
981-984 5.4
**Cyclical Redundancy Checksum (CRC) 6.1-6.3, 6.5**
algorithm 6.5
**Cycle Time**
Output 1 [CT1]
981-984 5.4
Output 1 PID [CT1A], [CT1B]
986-989 6.8, 6.9
996-999 7.3
Output 2 [CT2]
981-984 5.4
Output 2 PID [CT2A], [CT2B]
986-989 6.9
996-999 7.3

**D**

**data bits dAtA 3.2**
**data fields 4.1**
**Data Link Escape <DLE> 1.4**
**data rules 4.1**
**data.n 4.1**
**Dead Band PID**
981-984 [DB] 5.4
986-989 [DBA], [DBB] 6.9
996-999 [DBA], [DBB] 7.4
**Decimal Point**
Input 1 [DEC1]
981-984 5.5
986-989 6.9
996-999 7.4
Input 2 [DEC2]
986-989 6.9
996-999 7.4
**Default Unit Type [DFL]**
981-984 5.5
986-989 6.9
996-999 7.4
**Degrees Select Display Loop [CF]**
981-984 5.4
986-989 6.8
996-999 7.3
**delay 5.1, 6.6, 7.1**
**Derivative PID**
Output 1
981-984 [DE1] 5.4
986-989 [DE1A], [DE1B] 6.9
996-999 [DE1A], [DE1B] 7.4
Output 2
981-984 [DE2] 5.5
986-989 [DE2A], [DE2B] 6.9
996-999 [DE2A], [DE2B] 7.4
**device address 4.4**
**Diagnostics Menu Lockout [DIAG]**
986-989 6.9
996-999 7.4
**DISPLAY key 1.6**

# Index


**DLE 1.6-1.7**
**download sequence**
981-984 5.1
986-989 6.6
996-999 7.1

**E**

**EIA-232 1.3, 2.1, 4.2**
**EIA-422 1.3, 2.1, A.1**
**EIA-422 wiring 2.4**
**EIA-485 1.3, 2.1, A.1**
**EIA-485 wiring 2.3**
**Elapsed Jump Count [EJC]**
981-984 5.5
**End of Text <ETX> 1.6-1.7, 4.2**
**End of Transmission <EOT> 1.6-1.7**
**End Set Point [ENSP]**
981-984 5.5
**ENQ 1.6-1.7**
**enquiry <ENQ> 1.7**
**EOT 1.6-1.7**
**ER2 A.1**
**Error**
Analog Input [ER]
981-984 5.5
986-989 6.10
996-999 7.4
Codes A.1
Communications [ER2]
981-984 5.6
986-989 6.10
996-999 7.5
Latching Enable [ERR]
981-984 5.6
986-989 6.10
996-999 7.5
**establish communications 4.5**
**ETX 1.6-1.7, 4.2**
**even parity 1.5**
**Event 3 Output State [ENT3]**
981-984 5.5
**Event 4 Output State [ENT4]**
981-984 5.5
**Event Input 1**
Function [EI1]
981-984 5.5
986-989 6.10
996-999 7.4
Status [EI1S]
981-984 5.5
986-989 6.10
996-999 7.4
**Event Input 2**
Function [EI2]
981-984 5.5
986-989 6.10
Status [EI2S]
981-984 5.5
986-989 6.10
**example format 4.2**

**F**

**Factory Test Date [DATE]**
981-984 5.4
986-989 6.9
996-999 7.3
**Filter Time Constant**
981-984 [FTR1] 5.6
986-989 [FTR1], [FTR2] 6.11
996-999 [FTR1], [FTR2] 7.5
**flow control 4.2**
**front panel, controller 3.2**

**G**

**Global Menu Lockout [GLBL]**
986-989 6.11
996-999 7.5
**Guaranteed Soak Deviation [GSD]**
981-984 5.6

**H**

**Hardware Type**
Input 1 [ITY1]
981-984 5.7
986-989 6.12
996-999 7.7
Input 2 [ITY2]
981-984 5.7
986-989 6.13
996-999 7.7
Output 1 [OTY1]
981-984 5.9
986-989 6.14
996-999 7.8
Output 2 [OTY2]
981-984 5.9
986-989 6.14
996-999 7.8
Output 3 [OTY3]
981-984 5.9
986-989 6.14
996-999 7.8
Output 4 [OTY4]
981-984 5.9
986-989 6.14
996-999 7.8
**hex string 4.2**
**hexadecimal [hex] 1.4**
**High Power Limit [HIP]**
981-984 5.6
986-989 6.11
**Hysteresis**
Output 1
981-984 [HYS1] 5.6
986-989 [HYS1] 6.11
996-999 [HY1A], [HY1B] 7.5
Output 2
981-984 [HYS2] 5.6
986-989 [HYS2] 6.11
996-999 [HY2A], [HY2B] 7.5
Output 3 [HYS3]
981-984 5.6
986-989 6.11
996-999 7.5

**I**

**Idle Set Point [IDSP]**
981-984 5.7
986-989 6.11
**increment key 2.1**
**Input 1**
Calibration Offset [CAL1]
981-984 5.4
986-989 6.8
996-999 7.3
Decimal Point [DEC1]
981-984 5.5
986-989 6.9
996-999 7.4
Event Function [EI1]
981-984 5.5
986-989 6.10
996-999 7.4
Event Status [EI1S]
981-984 5.5
986-989 6.10
996-999 7.4
Hardware Type [ITY1]
981-984 5.7
986-989 6.12
996-999 7.7
Range High [RH1]
981-984 5.10
986-989 6.15
996-999 7.9
Range Low [RL1]
981-984 5.10
986-989 6.16
996-999 7.9
RTD Calibration [RTD1]
981-984 5.10
986-989 6.16
996-999 7.10
Type [IN1]
981-984 5.7
986-989 6.11
996-999 7.6
Value [C1]
981-984 5.4
986-989 6.8
996-999 7.3
**Input 2**
Calibration Offset [CAL2]
981-984 5.4
986-989 6.8
996-999 7.3
Decimal Point [DEC2]
986-989 6.9
996-999 7.4
Event Function [EI2]
981-984 5.5
986-989 6.10
Event Status [EI2S]
981-984 5.5
986-989 6.12
Hardware Type [ITY2]
981-984 5.7
986-989 6.13
996-999 7.7
Range High [RH2]
981-984 5.10
986-989 6.15
996-999 7.9
Range Low [RL2]
981-984 5.10
986-989 6.16
996-999 7.9
RTD Calibration [RTD2]
986-989 6.16
996-999 7.10
Type [IN2]
981-984 5.7
986-989 6.12
996-999 7.6
Value [C2]

981-984 5.4
986-989 6.8
996-999 7.3
**Input Menu Lockout [INPT]**
986-989 6.12
996-999 7.6
**Integral**
Output 1
981-984 [IT1] 5.7
986-989 [IT1A], [IT1B] 6.12
996-999 [IT1A], [IT1B] 7.7
Output 2
981-984 [IT2] 5.7
986-989 [IT2A], [IT2B] 6.12
996-999 [IT2A], [IT2B] 7.7
**interface prompt intF 2.1**
**interface type intF 3.2**

**K**

**Keyboard Lockout [LOC]**
981-984 5.8
986-989 6.13
996-999 7.7

**L**

**leading zeros 4.1**
**Learn High Slide Wire [LRNH]**
981-984 5.8
986-989 6.13
**Learn Low Slide Wire [LRNL]**
981-984 5.8
986-989 6.13
**Linearization Process Input 1 [LIN1]**
986-989 6.13
**Linearization Process Input 2 [LIN2]**
986-989 6.13
996-999 7.7
**Local-Remote Set Point [LR]**
986-989 6.13
**Lockout**
Calibration Menu [CAL]
986-989 6.8
996-999 7.3
Channel A PID [PIDA]
996-999 7.9
Channel B PID [PIDB]
996-999 7.9
Comms Menu [COM]
986-989 6.8
996-999 7.3
Diagnostics Menu [DIAG]
986-989 6.9
996-999 7.4
Global Menu [GLBL]
986-989 6.11
996-999 7.5
Input Menu [INPT]
986-989 6.12
996-999 7.6
Output Menu [OTPT]
986-989 6.14
996-999 7.8
PID Set A Menu [PIDA]
986-989 6.14
PID Set B Menu [PIDB]
986-989 6.14
System Menu [SYS]
986-989 6.17
996-999 7.11
**Low Power Limit [LOP]**
981-984 5.8
986-989 6.13

**M**

**master device 1.1**
**maximum communications speed 4.3, 4.5**
**message syntax 4.1**
**Modbus Mod 3.2, 6.1-6.5**
address table 6.18
**MODE key 2.1**
**Mode Key Action [MOD]**
981-984 5.8
986-989 6.13
996-999 7.7
**Model Number [MDL]**
981-984 5.8
986-989 6.13
**Monitor Command [MTR]**
981-984 5.8, 5.12
**multidrop**
interface 2.1
network 2.1
system 1.3
**multiple devices 1.2**

**N**

**NAK 1.6, A.1**
**Negative Acknowledge <NAK> 1.6, A.1-A.2**
**no parity 1.5**
**not acknowledged 1.6, A.1**

**O**

**odd parity 1.5**
**Output 1**
Action
981-984 [OT1] 5.8
986-989 [OT1] 6.13
996-999 [OT1A], [OT1B] 7.7
Derivative PID
981-984 [DE1] 5.4
986-989 [DE1A], [DE1B] 6.9
996-999 [DE1A], [DE1B] 7.4
Hardware Type [OTY1]
981-984 5.9
986-989 6.14
996-999 7.8
Hysteresis
981-984 [HYS1] 5.6
986-989 [HYS1] 6.11
996-999 [HY1A], [HY1B] 7.5
Integral
981-984 [IT1] 5.7
986-989 [IT1A], [IT1B] 6.12
996-999 [IT1A], [IT1B] 7.7
Process Range [PRC1]
981-984 5.9
986-989 6.15
Proportional Band
981-984 [PB1] 5.9
986-989 [PB1A], [PB1B] 6.14
996-999 [PB1A], [PB1B] 7.8
Rate
981-984 [RA1] 5.10
986-989 [RA1A], [RA1B] 6.15
996-999 [RA1A], [RA1B] 7.9
Reset [RE1]
981-984 5.10
Reset PID [RE1A], [RE1B]
986-989 6.15
996-999 7.9
**Output 2**
Action
981-984 [OT2] 5.8
986-989 [OT2] 6.13
996-999 [OT2A], [OT2B] 7.7
Alarm High [A2HI]
981-984 5.3
986-989 6.7
Alarm Low [A2LO]
981-984 5.3
986-989 6.7
Derivative PID
981-984 [DE2] 5.4
986-989 [DE2A], [DE2B] 6.9
996-999 [DE2A], [DE2B] 7.4
Hardware Type [OTY2]
981-984 5.9
986-989 6.14
996-999 7.8
Hysteresis
981-984 [HYS2] 5.6
986-989 [HYS2] 6.11
996-999 [HY2A], [HY2B] 7.5
Integral
981-984 [IT2] 5.7
986-989 [IT2A], [IT2B] 6.12
996-999 [IT2A], [IT2B] 7.7
Process Range [PRC2]
981-984 5.9
986-989 6.15
Proportional Band
981-984 [PB2] 5.9
986-989 [PB2A], [PB2B] 6.14
996-999 [PB2A], [PB2B] 7.8
Rate
981-984 [RA2] 5.10
986-989 [RA2A], [RA2B] 6.15
996-999 [RA2A], [RA2B] 7.9
Reset [RE2]
981-984 5.10
Reset PID {RE2A], RE2B]
986-989 6.15
996-999 7.9
**Output 3**
Action [OT3]
981-984 5.8
986-989 6.14
996-999 7.8
Alarm High [A3HI]
981-984 5.3
986-989 6.7
996-999 7.2
Alarm Low [A3LO]
981-984 5.3
986-989 6.7
996-999 7.2
Analog Retransmit [AOUT]
981-984 5.4
986-989 6.8
996-999 7.2

# Index


Hardware Type [OTY3]
981-984 5.9
986-989 6.14
996-999 7.8
Hysteresis [HYS3]
981-984 5.6
986-989 6.11
996-999 7.5
Process Range [PRC3]
981-984 5.9
986-989 6.15
996-999 7.9
Status [OT3S]
996-999 7.8
**Output 4**
Hardware Type [OTY4]
981-984 5.9
986-989 6.14
996-999 7.8
**Output Menu Lockout [OTPT]**
986-989 6.14
996-999 7.8
**Output Process Range**
Channel A [PRCA]
996-999 7.9
Channel B [PRCB]
996-999 7.9
**Output State**
Event 3 981-984 [ENT3] 5.5
Event 4 981-984 [ENT4] 5.5
**Outputs, Test [TOUT]**
981-984 5.11
986-989 6.17
996-999 7.11

**P**

**parity 3.2**
**parity bit 1.4**
**Percent Power Output [PWR]**
981-984 5.10
986-989 6.15
**PID Set A Menu Lockout [PIDA]**
986-989 6.14
**PID Set B Menu Lockout [PIDB]**
986-989 6.14
**PID Set Crossover [PID2]**
986-989 6.15
**Power Outage Response [POUT]**
981-984 5.9
**Process Deviation Display [DEV]**
981-984 5.5
986-989 6.9
**Process Range**
Output [PRCA], [PRCB]
996-999 7.9
Output 1 [PRC1]
981-984 5.9
986-989 6.15
Output 2 [PRC2]
981-984 5.9
986-989 6.15
Output 3 [PRC3]
981-984 5.9
986-989 6.15
996-999 7.9
**Process Value for PID Switch [PROC]**
986-989 6.15
**Program a File Step [STP]**
981-984 5.11
**Program Start Point [PSTR]**
981-984 5.9
**Program Type [PTYP]**
981-984 5.9
**Prompts, COM Menu 3.2**
**Proportional Band**
Output 1
981-984 [PB1] 5.9
986-989 [PB1A], [PB1B] 6.14
996-999 [PB1A], [PB1B] 7.8
Output 2
981-984 [PB2] 5.9
986-989 [PB2A], [PB2B] 6.14
996-999 [PB2A], [PB2B] 7.8
**Protocol 1.1**
prompt Prot 3.1-3.2
XON/XOFF RS-232 4.2
**pull-down resistors 2.3**

**Q**

**Query Any Step**
Program [STP] 5.13
**Quick BASIC 1.5**

**R**

**Ramp Rate**
986-989 [RATE] 6.16
996-999 [RTA], [RTB] 7.10
**Ramping Initiation**
986-989 [RP] 6.16
996-999 [RPA], [RPB] 7.10
**Range High**
Input 1 [RH1]
981-984 5.10
986-989 6.15
996-999 7.9
Input 2 [RH2]
981-984 5.10
986-989 6.15
996-999 7.9
Retransmit [ARH]
981-984 5.4
986-989 6.8
996-999 7.2
**Range Low**
Input 1 [RL1]
981-984 5.10
986-989 6.16
996-999 7.9
Input 2 [RL2]
981-984 5.10
986-989 6.16
996-999 7.9
Retransmit [ARL]
981-984 5.4
986-989 6.8
996-999 7.2
**Rate**
Output 1
981-984 [RA1] 5.10
986-989 [RA1A], [RA1B] 6.15
996-999 [RA1A], [RA1B] 7.9
Output 2
981-984 [RA2] 5.10
986-989 [RA2A], [RA2B] 6.15
996-999 [RA2A], [RA2B] 7.9
**remote device 1.1**
**Remote Set Point [RSP]**
986-989 6.16
**Reset**
Output 1 [RE1]
981-984 5.10
Output 1 PID [RE1A], [RE1B]
986-989 6.15
996-999 7.9
Output 2 [RE2]
981-984 5.10
Output 2 PID {RE2A], RE2B]
986-989 6.15
996-999 7.9
**Resume a Program [RESU]**
981-984 5.10
**Retransmit**
Range High [ARH]
981-984 5.4
986-989 6.8
996-999 7.2
Range Low [ARL]
981-984 5.4
986-989 6.8
996-999 7.2
**RTD Calibration**
Input 1 [RTD1]
981-984 5.10
986-989 6.16
996-999 7.10
Input 2 [RTD2]
986-989 6.16
996-999 7.10
**rules, data 4.1**
**run/hold mode**
981-984 5.2
**Run/Hold Status [RHS]**
981-984 5.10

**S**

**Sensor Failure Output [FAIL]**
986-989 6.10
996-999 7.5
**serial interface 2.1**
**Serial Number [SRNB], [SRNT]**
981-984 5.10
986-989 6.16
996-999 7.10
**Set Point 1 [SP1]**
986-989 6.16
**Set Point 2**
986-989 [SP2] 6.16
996-999 [SP2A], [SP2B] 7.10
**Set Point 2 Type [SP2C]**
986-989 6.17
**Set Point Channel A [SPA]**
996-999 7.10
**Set Point Channel B [SPB]**
996-999 7.10
**Set Point Value PID Switch [STPT]**
986-989 6.17
**Setup Menu SEt 2.1, 3.2, 4.4**
**Simulate HOLD Key [HOLD]**
981-984 5.6
**Slidewire Dead Band % [HUNT]**
981-984 5.6
986-989 6.11

**Slidewire Hysteresis [SHYS] 6.16**
**Software Revision [SOFT]**
981-984 5.10
986-989 6.16
996-999 7.10
**SP1 1.6-1.7**
**space <sp> 4.2**
**Start a File [STRT]**
981-984 5.11
**start bit 1.5**
**Start of Text <STX> 1.6-1.7**
**Status**
Output 3 [OT3S]
996-999 7.8
**Step Command [STP]**
981-984 5.13
**stop bit 1.5**
**STX 1.6-17, 4.2**
**syntax 1.5, 4.1**
**Syntax Query [MTR] 5.12**
**System Menu Lockout [SYS]**
986-989 6.17
996-999 7.11

**T**

**termination resistors 2.3, 2.4**
**Test Outputs [TOUT]**
981-984 5.11
986-989 6.17
996-999 7.11
**total characters 4.1**
**Type**
Input 1 [IN1]
981-984 5.7
986-989 6.11
996-999 7.6
Input 2 [IN2]
981-984 5.7
986-989 6.12
996-999 7.6

**U**

**user responsibility A.1**

**V**

**Value [C1]**
Input 1 [C1]
981-984 5.4
986-989 6.8
996-999 7.3
Input 2 [C2]
981-984 5.4
986-989 6.8
996-999 7.3

**W**

**waitfor event 5.5**
**wiring 2.1**

**X**

**XOFF character 4.2**
**XON character 4.2**
**XON/XOFF protocol 3.1-3.2, 4.2-4.3, A.1**

# Notes

# Notes

# Notes

Notes

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