



SERIES  
**16C**  
TEMPERATURE/PROCESS  
CONTROLLER

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*Standard Options and  
Digital Communications  
User's Guide*

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*For information and instructions related to basic operations, refer to the Series C operator's manual supplied with your controller.*

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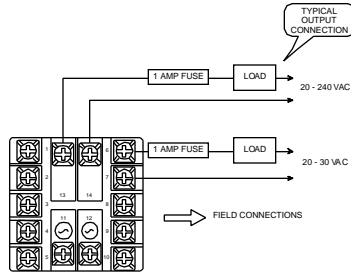
### **Guide to Digital Communications**

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## Dual Alarm Outputs

### Option #10: Dual Alarm Output, N.O. Option #22: Dual Alarm Output, N.C.

This optional hardware module provides two alarm drive outputs. LED indicators A1 and A2 are used to indicate alarm conditions as configured in the Alarm Menu.



#### Option Description:

Option 10: Dual alarm, N.O.

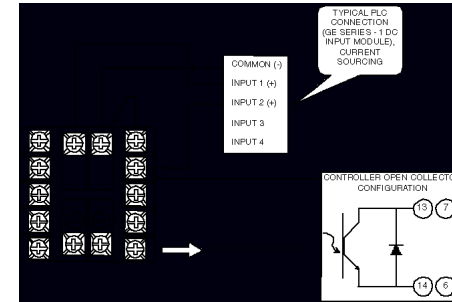
Option 22: Dual alarm, N.C. (Note: NC only when power is applied to unit; otherwise NO)

#### Load Limits:

Max. Load Current	1 A rms
Min. Load Current	0.5 mA rms
Power Factor Range	0.2 to 1.0 (can drive small motors, solenoids, valves, and contactors)
Max. Surge Current	
Non-repeating for 1 second	7.5 A
Max. I <sup>2</sup> T for fusing (0.01 sec)	4.5 amp-squared seconds (1 A - ABC1 typical fuse)

## Dual Open Collector Alarms

### Option #20: Dual Open Collectors, NPN, Isolated with Clamping Diode



**Option Description:** Dual open collectors, NPN, isolated, with clamping diode

#### Recommended operating conditions:

**Supply Voltage** Pins 13 & 14; 200 working Vdc max. (Never exceed 300 Vdc)

**Collector Current** 50 mA max.

#### Specifications:

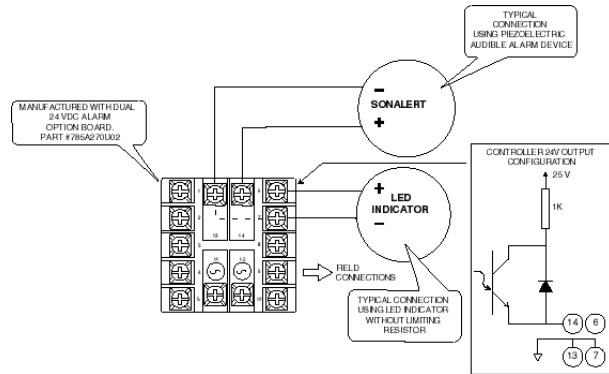
**Saturation Voltage** 0.3 Vdc min.  
1.2 V max.

**Collector-Emitter Breakdown** 300 V min.

**Isolation** Isolation 300 volts ac/dc output-to-output or output-to-controller

## Dual 24 Vdc Alarm Outputs

### Option #21: Dual 24 Vdc Alarm Outputs

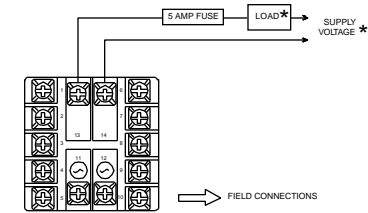


**Option Description:** Dual 24 V outputs with clamping diodes  
Pins 13 & 7 are connected internally  
Source current is limited to 25 mA (1000 ohm resistor)  
Open circuit voltage is 25 volts

**Isolation:** Isolation 300 volts ac/dc either output to instrument

## Relay, N.O. Alarm Output

### Option #23: Relay, N.O. Alarm Output



**Option Description:** NO (Normally open) relay contact is closed when either alarm is active. Jumpers on the board can be removed to activate the output for a single alarm only:  
JP1 - Alarm A1  
JP2 - Alarm A2

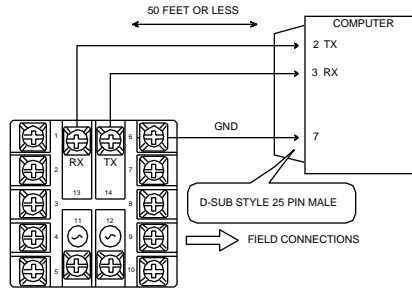
The relay life is greater than 100,000 operations at 5 operations per second switching full load.

\*Connect load and supply voltage per the following table:

Load Type	5 A Voltage Limit
Resistive DC	30 Vdc
Inductive DC (L/R = 7 ms)	20 Vdc
Resistive AC	250 Vac
Inductive AC (pF = 0.4)	150 Vac
Motor, AC, 1/6 hp	250 Vac
Tungsten Lamp, 360 W	120 Vac

**RS-232**  
Communications

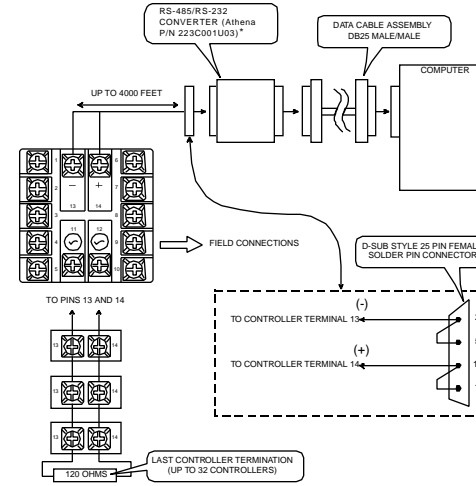
**Option #30: RS-232 (one-to-one) Communications**



**Option Description:** Provides a one-to-one connection between the controller and an RS-232 port. Computers, PLCs, or dumb terminals may be used to set and access controller data.

**RS-485**  
Communications

**Option #31: RS-485 (one-to-many) Communications**



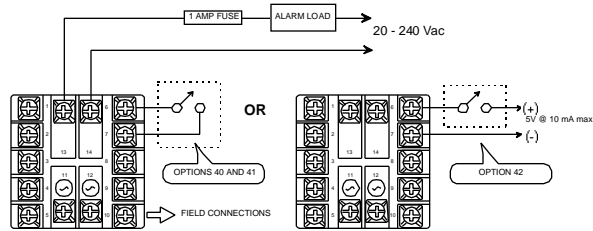
**Option Description:** Provides one-to-many communications.

Terminate the controller furthest from the computer by connecting a 120-ohm, 1/4-watt resistor between terminals 13 and 14.

\* Converter is supplied with a wallplug-mount power transformer.

## Contact/Digital Input with Alarm

### Options #40, #41, #42: Contact/Digital Input with Alarm



#### Option Description:

Dual function board (functions unrelated)

- Output alarm is energized when either A1 or A2 is active.
- Digital input controls Remote Standby, Ramp-Soak Run/Hold, OR Second Setpoint Select.

Option 40: Active when switch closed.

Option 41: Active when switch open.

Option 42: Active when 5 V input present

#### Load Limits:

Max. Load Current:

1 A rms

Min. Load Current:

0.5 mA rms

Power Factor Range:

0.2 to 1.0 (can drive small motors, solenoids, valves, and contactors)

Max. Surge Current,

Non-Repeating for

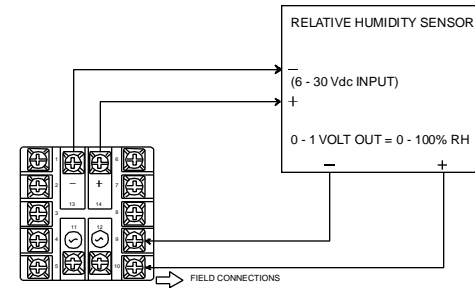
1 second: 7.5 A

Max. I<sup>2</sup>T for fusing (0.01 sec):

4.5 amp-squared secs (1A - ABC1 typical fuse)

## Transducer Excitation

### Option #50, #51, #52, #53: Transducer Excitation



#### Option Description:

The transducer excitation option provides power to remote transducers. The transducer outputs, in turn, provide a signal to the controller input which can be scaled in the appropriate engineering units.

Option 50: 10 Vdc

Option 51: 12 Vdc

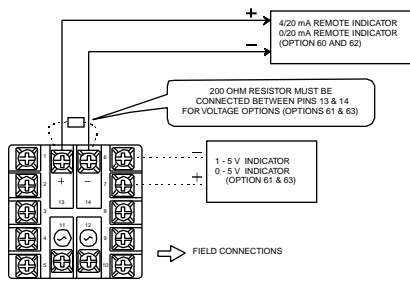
Option 52: 15 Vdc

Option 53: 5 Vdc

All options will provide at least 20 mA. The transducer circuitry is thermally protected from short circuits.

## Auxiliary Output

### Option #60, #61, #62, #63: Auxiliary Output



**Option Description:** The Setpoint Variable or Process Variable is transmitted to a remote device (chart recorders, indicators, data recorders, computers, process controllers, etc.) with 1 of 4 different interfaces:

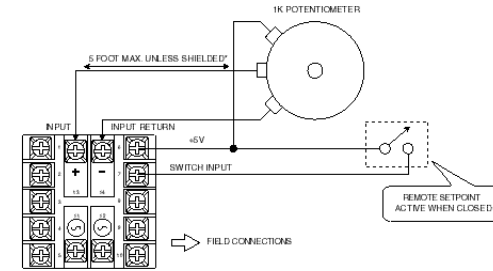
- Option 60: 4-20 mA
- Option 61: 1-5 V
- Option 62: 0-20 mA
- Option 63: 0-5 V

The output signal is scalable in the Auxiliary Output Menu. Multiple remote indicators may be driven by the controller. However, current and voltage outputs cannot be used simultaneously.

For current (mA) options, the remote indicators are connected in series. The sum of the input resistance for all remote indicators must be less than 400 ohms. For voltage options, the remote indicators are connected in parallel. The sum of the currents for all remote indicators must be less than 10 mA.

## Remote Analog Setpoint

### Option #80, #81, #82, #83, #84: Remote Analog Setpoint



**Option Description:** Remote setpoints use either voltage or current inputs, depending on the specified option:

- Option 80: 0-5 V
- Option 81: 1-5 V
- Option 82: 0-20 mA
- Option 83: 4-20 mA
- Option 84: 0-10 V

The input signal is scalable in the Remote Analog Setpoint Menu. Activation of the analog setpoint causes the F1 indicator to illuminate. For current (mA) options, the input resistance is 255 ohms. For voltage input options, the input resistance is greater than 10K ohms.

\*Ground shield at one end, taking care not to run wires next to power circuitry. Maximum length will be determined by noise performance.



**ATHENA**<sup>®</sup>

Series  
**16C**

*with*

Digital  
Communications  
Option

## Digital Communications Option

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*Three remote communications options are available for the 16C which allow interfacing to remote devices utilizing the most common industry standards: RS232, RS422, and RS485.*

### **Remote Communications Options**

#### **RS-232**

This method allows bidirectional data transfer via a three-conductor cable consisting of signal ground, receive input and transmit output. It is recommended for communication distances less than 50 feet between the computer terminal and the instrument. Note: Multiple instruments cannot be connected to the same port.

The RS232 port is optically isolated to eliminate ground loop problems. Typically, "Data Out" of the computer/terminal connects to the "RCV" terminal. "Data In" connects to the "XMT" terminal. If shielded cable is used, it should be connected to the frame ground at one end only. Signal ground is to be connected at appropriate ground terminals (refer to wiring diagram on next page).

#### **RS-422**

This method allows bidirectional data transfer via a four-wire conductor cable for distances over 50 feet between the computer terminal and the instrument. A signal ground wire is not required.

#### **RS-485**

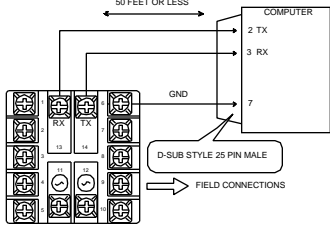
The RS485 multipoint capability allows up to 32 controllers to be connected together in a half-duplex network or up to 100 controllers with an appropriate communications repeater.

## Digital Communications Option

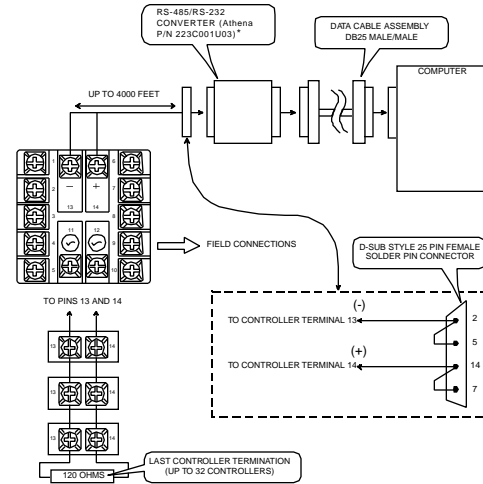
*Note: Call factory for a recommended RS485 converter.*

This method allows bidirectional data transfer over a twisted pair cable. The twisted pair cable is a transmission line; therefore, terminating resistors are required at the most distant ends of the line to minimize reflections (typically 120 ohms at each end). The RS485 circuit is fully optically isolated, eliminating ground loop problems. Parallel drops from the transmission lines should be kept as short as possible; however, the line may be daisy-chained at each controller. The polarity of the line is important and each device will specify an "A" (+) and "B" (-) connection.

**Figure 1a. Wiring diagram for RS-232 digital communications.**



**Figure 1b. Wiring diagram for RS-485 digital communications.**



## Digital Communications Option

### Athena+ Protocol

The Athena+ Protocol provides an easy way to query and modify controller parameters using a personal computer and the optional digital communications option of the 16C.

In this manual, the word "host" refers to the personal computer that's communicating with the controllers in the serial link, and the word "slave" refers to the controllers themselves.

All transactions between the host and the slaves are done with messages consisting of only printable ASCII characters. There are only two primary types of messages: Requests and Responses. Messages coming from the host are called requests and messages coming from the slaves are called responses.

With the exception of a broadcast request, for every request sent from the host, the slave will send back a response. If a slave does not respond within 100 milliseconds, then the request can be considered lost.

A broadcast request is a request having an ID of '00' (see Message Formats on next page). It is used to address all slaves on the network. All slaves on the network will perform the actions requested in a broadcast message. However, a response message will not be returned. Therefore, the host can only broadcast Write or Auxiliary Command Requests. All slaves will ignore all Read Broadcast Requests.

### Message Formats

All Athena+ messages adhere to the general format of:

[START CHAR][ID][ZONE][TYPE][PARAM][ERROR]  
[DATA][CHKSUM][END CHAR]

#### START CHAR

This is a single character which designates the start of the message. For a Request message, this character is the ASCII '\$' and for a Response message, this character is the ASCII '%'.

#### ID

This is a two-character ID identifying the receiving controller. Controller IDs go from 1-255 inclusively and all slaves in the network must have unique IDs. The ID number of '00', when used in a request, designates a broadcast message that is used to address all controllers in the network. See the section Request Message for an explanation of the broadcast message.

In order to represent 255 with just two ASCII characters, a number system known as the Message Code Numbering System is used. In this system, the most significant digit is represented with the numbers 0-9 and the letters A-Z and the least significant digit is represented with the numbers 0-9.

The numbers 0-9 have the same values as their decimal counterparts and the letters A-Z have the values of 100 - 350 inclusively in increments of 10.

Example:

Message Code Value	=	Decimal Value
00		0 + 0 = 00
99		90 + 9 = 99
A0		100 + 0 = 100
A2		100 + 2 = 102
B8		110 + 8 = 118
P5		250 + 5 = 255

#### Zone

This is a two character ID identifying the Zone number in multi-zone capable controllers. For the 16C, this number must be 01.

**Type**

This is a single character identifying the type of message. The following table lists the type characters for all messages.

TYPE character	Message Type
R	Read Request or Read Response Returning a Positive Result
r	Read Response Returning a Negative Result
W	Write Positive Value Request and Response
w	Write Negative Value Request and Response
A	Auxiliary Command

For further information, see following sections on the different message types.

**PARAM**

This is a two character, message specific, parameter ID. For a Read/Write Request or Response message, this ID identifies the controller parameter. For an Auxiliary Command Request or Response message, this ID specifies the command.

**STATUS**

This is a single-character field used in all response messages, containing a status code specifying the status of the request message received.

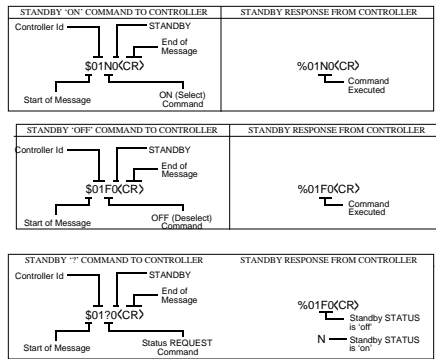
**DATA**

This field contains the ASCII representation of the value of the parameter. For the Auxiliary Request or Response messages, this field either contains the ASCII representation of a numeric value or just ASCII data. The length of this field depends on the message type. The discussion on the specific message types gives the exact requirements for this field.

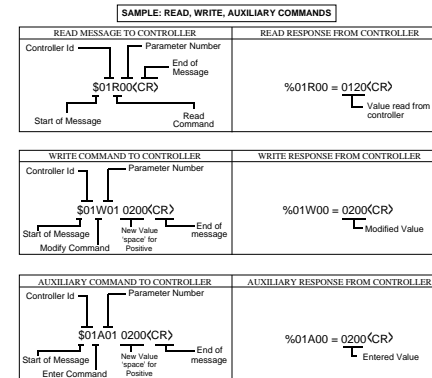
All ASCII representations of numeric values must be done using the characters '0'-'9', and '.'. Any use of other ASCII characters, including ' ' and '-' will result in a bad message. Negative numbers CANNOT be represented by preceding the number with '-' character. Instead, a special message type is used. See subsequent sections for more information.

**IMPORTANT:** The data field in the Read and Write Request and Response messages must and will only contain the characters '0'-'9', and the decimal point '.'. All other characters are considered illegal. When the data field is listed as Unused or Ignored in an auxiliary command, it does not mean that the field can be skipped when sending in the request message. Instead, this field must be padded with any 10 alphanumeric (only letters and numbers are allowed) ASCII characters.

**Figure 2. Sample Communications Commands**



**Figure 3. Requesting a Parameter from a Controller**



Examples of valid numeric representations for a 6 character data field:

Numeric Value	ASCII Representation
3	3.0000
	000003
	003.00
100	100.00
	0100.0
	000100
3.2	003.20
	0003.2

Examples of invalid numeric representations for 6 character data field: (B represents a blank, or a space, character)

Numeric Value	Bad ASCII Representation	Why?
3	BBBBB3	Leading blanks are not allowed.
	3.0BBBB	Trailing blanks are not allowed.
-3.2	-3.20000	'-' is not allowed.

### CHKSUM

This is a two character Message Code Numbering System, representing the sum of all the ASCII values of all the characters (excluding the START, CHAR, the END CHAR, and the CHKSUM themselves) in the message. The sum is computed using the following formula:

$$\text{CHKSUM} = \text{SUM}(\text{All Message Characters}) \% 256$$

% represents the modulus operator.

### END CHAR

This is a single character designating the end of the message. For all messages, the character used is <CR>, the carriage return.

### Request Messages:

Request Messages are sent from the host to the slaves. Each request will have an ID identifying the intended recipient of the request. If the ID is '00' (zero), then the request is a broadcast message. All slaves will perform the action requested in the broadcast request. However, a response message will not be returned. Therefore, it only makes sense to send Write or Auxiliary Command Requests as broadcast requests. There are three types of Request Messages: Read, Write, and Auxiliary Commands.

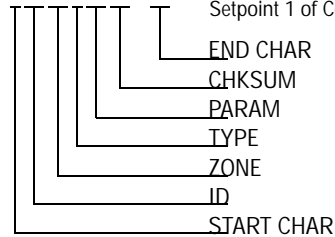
**The Read Request:**

The Read Request is used to query parameter values and it has the following message format:

[START CHAR][ID][ZONE][TYPE][PARAM][CHKSUM][END CHAR]

Field Description: TYPE Must contain the uppercase letter 'R'.

Request Message	Description
\$0101R05C1<CR>	Queries the value of the Process Variable of Controller #1.
\$0101R09C5<CR>	Queries the value of the EEPROM Setpoint 1 of Controller #1
\$0201R09C6<CR>	Queries the value of the EEPROM Setpoint 1 of Controller #2.



Examples of the responses to these requests are given in later sections on Response Messages.

**The Write Request:**

The Write Request is used to modify parameter values and it has the following message format: [START CHAR][ID][ZONE]

[TYPE][PARAM][DATA][CHKSUM][END CHAR]

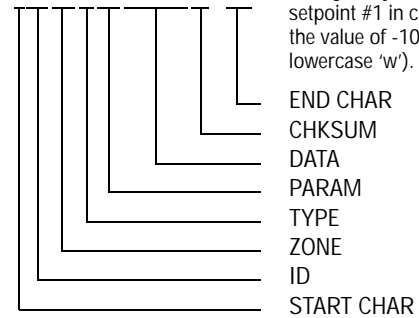
Field Description: TYPE This field must contain one of the following two characters.

- W – Value in DATA is a positive value.
- w – Value in DATA is a negative value.

DATA A six-character ASCII representation of a numeric value.

Request Message	Description
\$0101W0910.123G7<CR>	Change both the RAM and EEPROM copies of Setpoint #1 in controller #1 to the value of 10.123

\$0101w1010.123J1<CR> Change only the RAM copy of setpoint #1 in controller #1 to the value of -10.123 (notice the lowercase 'w').



***The Auxiliary Command Request:***

The Auxiliary Command Request is used to issue commands to the controllers and it has the following message format:

- Field Description: TYPE This field must contain the uppercase letter 'A'  
 DATA A ten-character ASCII representation of a numeric value or 10 alphanumeric ASCII characters.

Request Message	Description
\$0101A01XXXXXXXXXXL2<CR>	Tell controller #1 to load all parameters with their defaults. The 10 X's are padding characters.
\$0201A020001.0000069<CR>	Tell controller #2 to perform a low RTD calibration.
	END CHAR
	CHKSUM
	DATA
	PARAM
	TYPE
	ZONE
	ID
	START CHAR

***Response Messages:***

Response Messages are replies to the requests sent from the host. For each request received, the slave will reply back with a response.

For all requests, the Athena+ Protocol specifies a maximum response time of 100 milliseconds. If a response is not received after 100 milliseconds, that request can be considered lost.

There are three types of Response Messages: Read, Write, and Auxiliary Commands.

**The Read Response:**

The Read Response will be sent in response to a Read Request. Some examples:

Request Message	Description
%0101R05021.123K8<CR>	The value of the Process Variable is 21.123 Degrees C.
%0201R101G7<CR>	A serial transmission has occurred: Framing Error
%0101r09021.000N8<CR>	The value of the EEPROM setpoint #1 is -21 Degrees C (notice the lowercase 'r').

END CHAR  
CHKSUM  
DATA  
STATUS  
PARAM  
TYPE  
ZONE  
ID  
START CHAR

**The Write Response:**

The Write Response will be sent in response to a Write Request. Some examples:

Request Message	Description
%0101W093I1<CR>	A serial transmission error has occurred: Parity error. Write failed.
%0101w100K2<CR>	RAM copy of setpoint #1 modified successfully.

END CHAR  
CHKSUM  
STATUS  
PARAM  
TYPE  
ZONE  
ID  
START CHAR

## The Auxiliary Command Response:

The Auxiliary Command Response will be sent in response to an Auxiliary Command Request.

Some examples are:

Request Message	Description
%0101A010XXXXXXXXXX04<CR>	Default load all parameters has started.
%0201A0200.00000000B6<CR>	RTD low calibration on controller #2 has started.
	END CHAR
	CHKSUM
	DATA
	STATUS
	PARAM
	TYPE
	ZONE
	ID
	START CHAR

Table 1. Communications Parameter List (Athena+ Protocol)

Parameter Number	Description	Parameter Number	Description
1	Controller Type	19	Manual Control
2	Software Version	20	2 Percentage
3	Communications Version	21	Output 1 Deadband
4	Status Byte	22	Output 1 Hysteresis
5	Process Value	23	Output 1 Proportional Band
6	Operating Mode	23	Output 2 Proportional Band
7	Access Level	30	Rate/Derivative Action
8	Contact/Digital Input State	32	Reset/Integral Action
9	Setpoint - RAM, EEPROM	34	Manual Reset/Internal Action
10	Setpoint - RAM Only	37	Output 2 Deadband
11	Second Setpoint - RAM, EEPROM	38	Output 2 Hysteresis
12	Second Setpoint - RAM Only	39	Autotune Damping
13	Remote Analog Setpoint	40	Recipe Option
14	Recipe Setpoint	41	Single Setpoint Ramp Time
16	Output 1 Percentage	42	Ramp Time 1
17	Output 2 Percentage	43	Ramp Time 2
18	Manual Control 1 Percentage	44	Ramp Time 3
		45	Ramp Time 4
		46	Ramp Time 5
		47	Ramp Time 6
		48	Ramp Time 7

*Table 1. Continued*

Parameter Number	Description	Parameter Number	Description
49	Ramp Time 8	73	Soak Time 8
50	Ramp Event 1	74	Soak Event 1
51	Ramp Event 2	75	Soak Event 2
52	Ramp Event 3	76	Soak Event 3
53	Ramp Event 4	77	Soak Event 4
54	Ramp Event 5	78	Soak Event 5
55	Ramp Event 6	79	Soak Event 6
56	Ramp Event 7	80	Soak Event 7
57	Ramp Event 8	81	Soak Event 8
58	Soak Level 1	82	Recycle Number
59	Soak Level 2	83	Holdback Band
60	Soak Level 3	84	Termination State
61	Soak Level 4	85	Power Resume
62	Soak Level 5	86	Input Bias
63	Soak Level 6	87	Input Low Scale
64	Soak Level 7	88	Input High Scale
65	Soak Level 8	89	Lower Setpoint Limit
66	Soak Time 1	90	Upper Setpoint Limit
67	Soak Time 2	91	Input Filter
68	Soak Time 3	92	Input Type
69	Soak Time 4	94	Output 1 Type
70	Soak Time 5	95	Output 1 Action
71	Soak Time 6	96	Output 1 Alarm Action
72	Soak Time 7		

*Table 1. Continued*

Parameter Number	Description	Parameter Number	Description
97	Output 1 Alarm Operation	B6	TC/RTD Decimal Position
98	Output 1 Alarm Delay	B7	Linear Decimal Position
99	Output 1 Alarm Inhibit	B8	Display Filter
A0	Output 1 Process Alarm Setpoint	B9	Display Units
A1	Output 1 Deviation Alarm Setpoint	C1	Display Blanking
A2	Output 1 Cycle Time	C2	Alarm 1 Action
A3	Output 1 Low Limit	C3	Alarm 1 Operation
A4	Output 1 High Limit	C4	Alarm 1 Delay
A5	Output 2 Type	C5	Alarm 1 Inhibit
A6	Output 2 Action	C6	Alarm 1 Process Setpoint
A7	Output 2 Alarm Action N/A	C7	Alarm 1 Deviation Setpoint
A8	Output 2 Alarm Operation	C8	Alarm 2 Action
A9	Output 2 Alarm Delay N/A	C9	Alarm 2 Operation
B0	Output 2 Alarm Inhibit	D0	Alarm 2 Delay
B1	Output 2 Process Alarm Setpoint	D1	Alarm 2 Inhibit
B2	Output 2 Deviation Alarm Setpoint	D2	Alarm 2 Process Setpoint
B3	Output 2 Cycle Time	D3	Alarm 2 Deviation Setpoint
B4	Output 2 Low Limit	D4	Communication Protocol
B5	Output 2 High Limit	D5	Communication ID
		D6	Communication Baud Rate
		D7	Communication Data Format
		D8	Communication Transmit Delay
		E1	Output 1 Failsafe %
		E2	Output 2 Failsafe %

*Table 1. Continued*

Parameter Number	Description	Parameter Number	Description
E3	Loop Break Time	G7	Contact/Digital Switch Function
E4	Highest Reading	H2	Autotune State
E5	Lowest Reading	H3	Recipe State
E8	Option Selection N/A	H5	Current Recipe Segment
E9	TC Zero Calibration	H6	Active Setpoint
F0	TC Span Calibration	H7	Resume Exhaustion Flag
F1	RTD Zero Calibration	F4	Low-Voltage Span
F2	RTD Span Calibration	H8	LED Status Indicator
F3	Low-Voltage Zero Calibration	H9	RTD (with decimal support) Zero Calibration
F4	Low-Voltage Span Calibration	I0	RTD (with decimal support) Span Calibration
F5	High-Voltage Zero Calibration		
F6	High-Voltage Span Calibration		
F7	Current Zero Calibration		
F8	Current Span Calibration		
G1	Auxiliary Output Variable		
G2	Auxiliary Output Scale Low		
G3	Auxiliary Output Scale High		
G5	RAS Scale Low		
G6	RAS Scale High		

**Auxiliary Commands:**

Command:	Load Parameter Defaults
Parameter #:	01
Description:	Restore all menu parameters to their default values.
Request Data Field:	Ignored.
Response Data Field:	Ignored.
Command:	Perform Process Low Calibration
Parameter #:	02
Description:	Performs a Low Calibration. The data field in the request message specifies the process. Make sure the prerequisite for the calibration is satisfied before issuing a calibration command. For instance, the RTD calibration command must only be used when the input sensor type is chosen as RTD or RTD w/ Decimal.

Request Data Fields:	A 10 character ASCII representation of a numeric value specifying what to calibrate. 0 - Thermocouple 1 - RTD, Resistive Thermal Device 2 - Linear 3 - RAS, Remote Analog Setpoint
Response Data Field:	Ignored.
Command:	Perform Process High Calibration
Parameter #:	03
Description:	Performs a High Calibration. The data field in the request message specifies the process. Make sure the prerequisite for the calibration is satisfied before issuing a calibration command. For instance, the RTD calibration command must only be used when the input sensor type is chosen as RTD or RTD w/ Decimal.
Request Data Field:	A 10 character ASCII representation of a numeric value specifying what to calibrate.

	0 - Thermocouple 1 - RTD, Resistive Thermal Device 2 - Linear 3 - RAS, Remote Analog Setpoint
Command:	Retrieve Display
Parameter #:	05
Description:	Retrieves the string currently displayed on the slave's display. The data field in the request message specifies which display and the data field in the response message contains the string.
Request Data Field:	A 10 character ASCII representation of a numeric value specifying which display to retrieve data from. 0 - Lower Display 1 - Upper Display
Response Data Field:	The ASCII string.
Command:	Clear Latched Alarms
Parameter #:	10
Description:	Clear all latched alarms.
Request Data Field:	Ignored.
Response Data Field:	Ignored.





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