

**MTS Master Custom
Communications
Protocol**

APPLICATION NOTES



MTS Master Custom Communications Protocol

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MTS Master Custom Communications Protocol

INTRODUCTION

Implementation of the MTS Master Custom Communications Protocol is achieved by configuring a Custom Port and installing a set of custom PROMs possessing the MTS Master Protocol. Any number of Custom modules and custom ports may be used in the MTS Master Mode.

This document assumes familiarity with the MTS Level Plus Direct Digital Access (DDA) Gauge as well as its associated terminology and documentation. For additional information on this product, the user is advised to consult the appropriate supplemental documentation listed in Appendix A.

ACCOL TERMINAL ASSIGNMENTS

The following describes the terminal values appropriate for the Custom Module when configured for the MTS Master Custom Protocol.

MODE	A value of <i>20.0</i> indicates MTS Master Mode.
LIST	The number of the signal list which contains the signals used by this module to control the interface. This signal list is referred to as the 'Protocol Signal List'. It is described in greater detail in the <i>MTS Protocol Signal List</i> portion of this document.
STATUS	The value of this terminal indicates the MTS Master communications status. The section of this document referred to as <i>Status Code Definitions</i> contains a list of possible status codes & their descriptions.

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MTS PROTOCOL SIGNAL LIST

Signal 1 Port Number

An analog signal whose value identifies the port to be used for communications with the DDA slaves. This must be a Custom Port configured for mode = 20, indicating an MTS Master.

The values are assigned as follows:

<u>Signal Value</u>	<u>Port Used for Communication</u>
1.0	A
2.0	B
3.0	C
4.0	D

Signal 2 Slave Address

An analog signal whose value specifies the address of the DDA Gauge Slave. *Slave addresses may range from 192 to 253.*

Signal 3 Command

An analog signal whose value specifies a DDA Gauge Slave command. Valid commands are detailed in the *Commands* section of this document.

Signal 4 Input / Output List Number

An analog signal containing the number of the signal list used to control input and / or output of data.

Signal 5 Reply Time

An analog signal value which specifies the amount of time in milliseconds to wait for a DDA command sequence to complete (*please refer to the DDA*

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Gauge Specification for timing information). The value can range from 1 to 65535 milliseconds. System time resolution is 4 milliseconds.

Signal 6 Done

An analog signal used to indicate that the Status terminal contains status detailing the completion or error termination of a communication request. The value of this required signal is incremented by 1 when the request is complete.

COMMUNICATIONS INTERFACE

The MTS gauge operates on a EIA-485 2-wire differential communications interface, thus all data transfers are half-duplex. Only one device (either the master, or one gauge) may transfer data at any given time.

Multiple gauges can be connected to a single master port and multiple ports of the BBI controller may be configured as MTS Master ports to one or more DDA gauges.

The MTS gauge supports enabling and disabling (via switch or firmware) of a 5-digit checksum, plus a future Cyclical Redundancy Check (CRC). The MTS Master Custom Protocol currently supports only the 5-digit checksum configuration, thus the MTS gauge's *internal switch number 2* must be set to the *ON* position to enable Data Error Detection.

NOTE: For the six switches (numbers 4 through 9), the ON position represents a '0' in bits 2 through 7 (BBI numbering) of the Base Address.

The 33XX communication engine board(s) for the configured MTS Master Protocol ports should have jumpers W6 and W7 removed.

The RS-485 network must be properly configured and appropriately terminated with a Network Interface Box (as described in the BBI Customer Instruction listed as *reference 2, Appendix A* of this document), to maintain the correct line state during periods of inactive transmissions.

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Line Parameter Information

- Communication takes place at 4800 baud.
- All characters are transmitted serially as 11 bits including: 1 start bit, 8 data bits, 1 even parity bit, and 1 stop bit. These parameters are not programmable from ACCOL. The MTS gauge numbers bits within the 8 data bits as D1 through D8, corresponding to D0 through D7 in the BBI system.

VALID COMMANDS

The valid commands for the MTS Gauge are listed below. Each command is associated with a command group.

<u>Command Mnemonic</u>	<u>Value</u>	<u>Group</u>
Gauge Disable	0	1
Out_L1_0.1"	10	2
Out_L1_0.01"	11	2
Out_L1_0.001"	12	2
Out_L2_0.1"	13	2
Out_L2_0.01"	14	2
Out_L2_0.001"	15	2
Rd_Avg_@1.0F	25	2
Rd_Avg_@0.2F	26	2
Rd_Avg_@0.02F	27	2
Rd_gradient	76	2
Out_L1_L2 0.1"	16	3
Out_L1_L2 0.01"	17	3
Out_L1_L2 0.001	18	3

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<u>Command Mnemonic</u>	<u>Value</u>	<u>Group</u>
Out_L1_Avg_1.0F	40	3
Out_L1_Avg_0.2F	41	3
Out_L1_Avg_0.02F	42	3
Rd_Number_Of	75	3
Rd_Floats	77	3
Out_L12A_1.0F	43	4
Out_L12A_0.2F	44	4
Out_L12A_.02F	45	4
Rd_Temps1.0F	28	5
Rd_Temps0.2F	29	5
Rd_Temps.02F	30	5
Rd_RTDS	78	5
Rd_SN/Version	79	6
Rd_Hdw_Code 1	81	6
Wrt_Gradient	86	7
Wrt_Number_Of	85	8
Wrt_Float	87	8
Wrt_Flt_w/DDA	88	8
Wrt_RTD	89	8
Wrt_Fmw_Code_1	90	9
RAM_R/W_Test	65	10

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<u>Command Mnemonic</u>	<u>Value</u>	<u>Group</u>
ROM_CS_Test	66	10
Counter_Test	69	10
Analog_Test	70	10
Wave_Comp_Test	72	10
Wrt_Ref_Magnet	94	10
Comm_Hdw_Test	71	11
Wrt_Hdw_Code_1	91	12
Rd_Fmw_Code_1	80	13

All other command values produce *Invalid_Cmd* status unless a higher priority error is detected.

STATUS

The following status indications can be stored in the MTS Master Custom Protocol in the Status Signal. The status values from 0 to -31 are mutually exclusive and take priority in the order listed (errors in this range prevent or mask errors in the -32 through -98,304 range), while status codes from -32 through -98,304 are bias values summed into the status code to identify concurrently occurring errors in messages having more than one data field.

Within each Exxx_n, Len_n, NaN_n group, only one error is ever reported for a particular group_n, so there is no ambiguity to error value -96 (it indicates a Len_1 error); however, one of these errors can be reported for each group. For example, a -352 status value indicates that both a Len_1 (-96) and a NaN_2 (-256) error have occurred.

The status value is set to 1 when a command is initiated and remains 1 while the command is actively executing. When completed, the status is changed to either 0 (success) or a negative value indicating an error.

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<u>Status Mnemonic</u>	<u>Decimal Value</u>
Success	0
Unsupported Protocol	-1 (stored by the system if the protocol is not supported)
Bad_Proto	-2.00
Bad_Type	-3.00
Bad_Port	-4.00
Slv_Adrs_Err	-5.00
Invalid_Cmd	-6.00
Bad_IO_List	-7.00
Echo_Err	-8.00
Ck_Sum_Err	-9.00
Bad_NAK	-10.00
NAK	-11.00
Parity_Err	-16.00
Time_Out	-17.00
Overrun	-18.00
Framing_Err	-19.00
Exxx_1	-32 bias
NaN_1	-64 bias
Len_1	-96 bias
Exxx_2	-128 bias

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<u>Status Mnemonic</u>	<u>Decimal Value</u>
NaN_2	-256 bias
Len_2	-384 bias
Exxx_3	-512 bias
NaN_3	-1024 bias
Len_3	-1536 bias
Exxx_4	-2048 bias
NaN_4	-4096 bias
Len_4	-6144 bias
Exxx_5	-8192 bias
NaN_5	-16384 bias
Len_5	-24576 bias
Exxx_6	-32768 bias
NaN_6	-65536 bias
Len_6	-98304 bias

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COMMAND GROUP DESCRIPTIONS

The MTS Protocol is comprised of 43 commands which are organized into 13 distinct Command Groups. A Command Group includes all commands which share a common I/O Signal List format and transaction sequence.

The following sections detail the ACCOL interface to each Command Group. The following items are provided for each command within the group: command description, hexadecimal and decimal command representation, I/O list contents, Host outputs and DDA responses. In addition, appropriate Protocol Signal List, I/O Signal List and Status indicator descriptions are provided for each Command Group.

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Command Group 1

Command Group 1 consists solely of the Gauge Disable command. This command is used to disable an active gauge (*force the gauge back to sleep mode*). It may be used if other commands have left the gauge in active mode; but, since the MTS Master Protocol waits for the Reply Time to expire before reporting low-level communication level errors (*for example, parity error, framing error, but no Echo errors*) that could leave the gauge in its active mode, correct setting within the ACCOL program of the Reply Time value should eliminate the need for the Gauge Disable command in normal error recovery.

WARNING: If a Gauge Disable command is used with the address of a configured gauge, that gauge will not respond to the initial try of any subsequent command, i.e. the initial try of the subsequent command will time out. The retry (invisible to the ACCOL program) will function normally. It is therefore recommended that any Gauge Disable commands use a Slave address (in the Protocol Signal list) of a non-existent gauge.

<u>Command Description</u>	<u>Hex / Decimal</u>	<u>I / O List Contents</u>	<u>Host Output</u>	<u>DDA Response</u>
Gauge Disable	00h / 0	None	(Address) 00h	None, forced to sleep mode.

Protocol Signal List

The Protocol Signal List for Group 1 should be set up as follows:

<u>Signal Name</u>	<u>Signal Type</u>	<u>Contents</u>
port_num	analog	1, 2, 3, or 4
slv_adrs	analog	192 - 253
cmd	analog	0.00
io_list	analog	
rply_time	analog	0.00

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<u>Signal Name</u>	<u>Signal Type</u>	<u>Contents</u>
done	analog	Current done counter.

I / O Signal List

The I / O List is not referenced during the Gauge Disable command execution, but an analog signal (any value) must be present in the io_list position of the Protocol Signal List to satisfy the standard Custom Module validation of the Protocol List; otherwise, Bad_Proto status is returned.

Status

In the execution of Command Group 1 (Gauge Disable), the following status indications are possible:

<u>Status Mnemonic</u>	<u>Value</u>	<u>Meaning</u>
Success	0.00	Command successfully completed.
BAD_PROTO	-2.00	List terminal is <i>unwired</i> , the List terminal value is invalid, the Protocol List number is invalid, or the Protocol List has fewer than 6 signals.
BAD_TYPE	-3.00	One or more of the Protocol List signals is of the wrong type.
BAD_PORT	-4.00	The port number is not 1, 2, 3, or 4; or port is not mode=20.
SLV_ADRS_ERR	-5.00	Adrs Check detected invalid slv_adrs.

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Command Group 2

The ten commands which are included in Group 2 send an interrogation sequence (*slave address + command*) to the MTS gauge, which responds by echoing the interrogation sequence as well as providing the solicited data string bracketed by STX and ETX and followed by the checksum string. The data string length is dependent upon the particular command within Group 2.

<u>Command</u>	<u>Hex /</u>	<u>I / O List</u>	<u>Host Output</u>	<u>DDA Response</u>
<u>Description</u>	<u>Decimal</u>	<u>Contents</u>	<u>(Address)</u>	<u>(Address)</u>
Output Level 1 @ 0.1" resolution.	0Ah / 10	Rcv_String Rcv_Value	0Ah	0Ah STX dddd.d ETX cccc
Output Level 1 @ 0.01" resolution.	0Bh / 11	Rcv_String Rcv_Value	0Bh	0Bh STX dddd.dd ETX cccc
Output Level 1 @ 0.001" resolution.	0Ch / 12	Rcv_String Rcv_Value	0Ch	0Ch STX dddd.ddd ETX cccc
Output Level 2 @ 0.1" resolution.	0Dh / 13	Rcv_String Rcv_Value	0Dh	0Dh STX dddd.d ETX cccc

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<u>Command Description</u>	<u>Hex / Decimal</u>	<u>I / O List Contents</u>	<u>Host Output (Address)</u>	<u>DDA Response (Address)</u>
Output Level 2 @ 0.01" resolution.	0Eh /14	Rcv_String Rcv_Value	0Eh	0Eh STX dddd.dd ETX cccc
Output Level 2 @ 0.001" resolution.	0Fh /15	Rcv_String Rcv_Value	0Fh	0Fh STX dddd.ddd ETX cccc
Avg Temp. @ 1.0 °F resolution.	19h /25	Rcv_String Rcv_Value	19h	19h STX dddd ETX cccc
Avg Temp. @ 0.2 °F resolution.	1Ah /26	Rcv_String Rcv_Value	1Ah	1Ah STX dddd.d ETX cccc
Avg Temp. @ 0.02 °F resolution.	1Bh /27	Rcv_String Rcv_Value	1Bh	1Bh STX dddd.dd ETX cccc
Read gradient control variable.	4Ch /76	Rcv_String Rcv_Value	4Ch	4Ch STX d.ddddd ETX cccc

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Protocol Signal List

The Protocol Signal List for Group 2 should be set up as follows:

<u>Signal Name</u>	<u>Signal Type</u>	<u>Contents / Length</u>
port_num	analog	1, 2, 3, or 4
slv_adrs	analog	192 - 253
cmd	analog	10, 11, 12, 13, 14, 15, 25, 26, 27 or 76
io_list	analog	(see list below)
rply_time	analog	>gauge response time + transmission time
done	analog	Current done counter.

I/O Signal List

The I/O Signal List for Group 2 should be set up as follows:

<u>Signal Name</u>	<u>Signal Type</u>	<u>Contents / Length</u>
Rcv_string	string	string / 64
Rcv_value	analog	0.0

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Status

In the execution of Command Group 2, the following status indications are possible:

<u>Status Mnemonic</u>	<u>Value</u>	<u>Meaning</u>
Success	0.00	Command successfully completed.
BAD_PROTO	-2.00	List terminal is <i>unwired</i> , the List terminal value is invalid, the Protocol List number is invalid, or the Protocol List has fewer than 6 signals.
BAD_TYPE	-3.00	One or more of the Protocol List signals is of the wrong type.
BAD_PORT	-4.00	The port number is not 1, 2, 3, or 4; or port is not mode=20.
SLV_ADRS_ERR	-5.00	Adrs Check detected invalid slv_adrs.
Bad_IO_list	-7.00	The IO_List does not have the necessary number of signals, or one or more is of the wrong type.
ECHO_ERR	-8.00	The echo of the interrogation sequence sent to the MTS gauge differed from the interrogation sequence (slv_adrs + cmd).
CK_SUM_ERR	-9.00	The checksum string appended to the DDA response message was incorrect.
PARITY_ERR	-16.0	A receive data parity error detected by the driver terminated in the operation.
TIME_OUT	-17.00	The rply_time expired before the driver transaction was completed.

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<u>Status Mnemonic</u>	<u>Value</u>	<u>Meaning</u>
Overrun	-18.00	At least one input character was lost because characters were received by the SCC faster than the driver could service the SCC.
Framing_err	-19.00	After assembling a received character the STOP bit was a '0'.
Exxx_1	-32.00	The MTS gauge sent an Error Code instead of the expected data string.
Len_1	-96.00	The length of the data string sent by the MTS gauge was incorrect.
NaN_1	-64.00	The data string sent by the MTS gauge was not a number, e.g. the first character was not a valid digit, +, -, or decimal point.

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Command Group 3

The following table details the commands belonging to Group 3.

<u>Command Description</u>	<u>Hex / Decimal</u>	<u>I / O List Contents</u>	<u>Host Output</u> (Address)	<u>DDA Response</u> (Address)
Output Level 1 & Level 2 @ 0.1" res.	10h / 16	Rcv_String1 Rcv_Value1 Rcv_String2 Rcv_Value2	10h	10h STX dddd.d : dddd.d ETX cccc
Output Level 1 & Level 2 @ 0.01" res.	11h / 17	Rcv_String1 Rcv_Value1 Rcv_String2 Rcv_Value2	(Address) 11h	(Address) 11h STX dddd.dd : dddd.dd ETX cccc
Output Level 1 & Level 2 @ 0.001" res.	12h / 18	Rcv_String1 Rcv_Value1 Rcv_String2 Rcv_Value2	(Address) 12h	(Address) 12h STX dddd.ddd : dddd.ddd ETX cccc
Output Level 1 @ 0.1" res. & Avg Temp @ 1.0 °F res.	28h / 40	Rcv_String1 Rcv_Value1 Rcv_String2 Rcv_Value2	(Address) 28h	(Address) 28h STX dddd.d : dddd ETX cccc
Command	Hex /	I / O List	Host	DDA

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<u>Description</u>	<u>Decimal</u>	<u>Contents</u>	<u>Output</u>	<u>Response</u>
Output Level 1 @ 0.01" res. & Avg Temp @ 0.2 °F res.	29h / 41	Rcv_String1 Rcv_Value1 Rcv_String2 Rcv_Value2	(Address) 29h	(Address) 29h STX dddd.dd : dddd.d ETX cccc
Output Level 1 @ 0.001" res. & Avg Temp @ 0.02 °F res.	2Ah / 42	Rcv_String1 Rcv_Value1 Rcv_String2 Rcv_Value2	(Address) 2Ah	(Address) 2Ah STX dddd.ddd : dddd.dd ETX cccc
Read Number of floats & number of RTD's variables	4Bh /75	Rcv_String1 Rcv_Value1 Rcv_String2 Rcv_Value2	(Address) 4Bh	(Address) 4Bh STX d : d ETX cccc
Read float zero position data (float #1 & #2)	4Dh /77	Rcv_String1 Rcv_Value1 Rcv_String2 Rcv_Value2	(Address) 4Dh	(Address) 4Dh STX dddd.ddd : dddd.ddd ETX cccc

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Protocol Signal List

The Protocol Signal List for Group 3 should be set up as follows:

<u>Signal Name</u>	<u>Signal Type</u>	<u>Contents / Length</u>
port_num	analog	1, 2, 3, or 4
slv_adrs	analog	192-253
cmd	analog	16, 17, 18, 40, 41, 42, 75, 77
io_list	analog	see list below
rply_time	analog	>gauge response time + transmission time
done	analog	Current done counter

I/O Signal List

The I/O Signal List for Group 3 should be set up as follows:

<u>Signal Name</u>	<u>Signal Type</u>	<u>Contents / Length</u>
Rcv_String_1	string	string / 64
Rcv_Value1	analog	0.0
Rcv_String_2	string	string / 64
Rcv_Value_2	analog	0.0

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Status

In the execution of Command Group 3, the following status indications are possible:

<u>Status Mnemonic</u>	<u>Value</u>	<u>Meaning</u>
Success	0.00	Command successfully completed.
BAD_PROTO	-2.00	List terminal is <i>unwired</i> , the List terminal value is invalid, the Protocol List number is invalid, or the Protocol List has fewer than 6 signals.
BAD_TYPE	-3.00	One or more of the Protocol List signals is of the wrong type.
BAD_PORT	-4.00	The port number is not 1, 2, 3, or 4; or port is not mode=20.
SLV_ADRS_ERR	-5.00	Adrs Check detected invalid slv_adrs.
Bad_IO_list	-7.00	The IO_List does not have the necessary number of signals, or one or more is of the wrong type.
ECHO_ERR	-8.00	The echo of the interrogation sequence sent to the MTS gauge differed from the interrogation sequence (slv_adrs + cmd).
CK_SUM_ERR	-9.00	The checksum string appended to the DDA response message was incorrect.
PARITY_ERR	-16.0	A receive data parity error detected by the driver terminated in the operation.
TIME_OUT	-17.00	The rply_time expired before the driver transaction was completed.

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<u>Status Mnemonic</u>	<u>Value</u>	<u>Meaning</u>
Overrun	-18.00	At least one input character was lost because characters were received by the SCC faster than the driver could service the SCC.
Framing_err	-19.00	After assembling a received character the STOP bit was a '0'.
Exxx_1	-32.00	The MTS gauge sent an Error Code instead of the expected data string.
Len_1	-96.00	The length of the data string sent by the MTS gauge was incorrect.
NaN_1	-64.00	The data string sent by the MTS gauge was not a number, e.g. the first character was not a valid digit, +, -, or decimal point.
Exxx_2	-128.00	The MTS gauge sent an Error Code instead of the expected 2nd data string.
Len_2	-384.00	The length of the 2nd data string sent by the MTS gauge was incorrect.
NaN_2	-256.00	The 2nd data string sent by the MTS gauge was not a number, e.g. the first character was not a valid digit, +, - or decimal point.

Note: Status codes from -32 through -384 may be summed as previously described to report errors in multiple data fields. Only one error per data field can be reported.

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Command Group 4

The following table details the commands belonging to Group 4.

<u>Command Description</u>	<u>Hex / Decimal</u>	<u>I / O List Contents</u>	<u>Host Output</u>	<u>DDA Response</u>
Output Level 1, Level 2 @ 0.1 res & Avg Temp @ 1.0 °F res.	2Bh / 43	Rcv_String1 Rcv_Value1 Rcv_String2 Rcv_Value2 Rcv_String3 Rcv_Value3	(Address) 2Bh /43	(Address) 2Bh STX dddd.d : dddd.d : dddd ETX cccc
Output Level 1, Level 2 @ 0.01 res & Avg Temp @ 0.2 °F res.	2Ch / 44	Rcv_String1 Rcv_Value1 Rcv_String2 Rcv_Value2 Rcv_String3 Rcv_Value3	(Address) 2Ch /44	(Address) 2Ch STX dddd.dd : dddd.dd : dddd.d ETX cccc
Output Level 1, Level 2 @ 0.001 res & Avg Temp @ 0.02°F res.	2Dh / 43	Rcv_String1 Rcv_Value1 Rcv_String2 Rcv_Value2 Rcv_String3 Rcv_Value3	(Address) 2Dh /45	(Address) 2Dh STX dddd.ddd : dddd.ddd : dddd.dd ETX cccc

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Protocol Signal List

The Protocol Signal List for Group 4 should be set up as follows:

<u>Signal Name</u>	<u>Signal Type</u>	<u>Contents / Length</u>
port_num	analog	1, 2, 3, or 4
slv_adrs	analog	192-253
cmd	analog	43, 44, or 45
io_list	analog	(see list below)
rply_time	analog	>gauge response time + transmission time
done	analog	Current done counter

I/O Signal List

The I/O Signal List for Group 4 should be set up as follows:

<u>Signal Name</u>	<u>Signal Type</u>	<u>Contents / Length</u>
Rcv_String_1	string	string / 64
Rcv_Value1	analog	0.0
Rcv_String_2	string	string / 64
Rcv_Value_2	analog	0.0
Rcv_String_3	string	string / 64
Rcv_Value_3	analog	0.0

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Status

In the execution of Command Group 4, the following status indications are possible:

<u>Status Mnemonic</u>	<u>Value</u>	<u>Meaning</u>
Success	0.00	Command successfully completed.
BAD_PROTO	-2.00	List terminal is <i>unwired</i> , the List terminal value is invalid, the Protocol List number is invalid, or the Protocol List has fewer than 6 signals.
BAD_TYPE	-3.00	One or more of the Protocol List signals is of the wrong type.
BAD_PORT	-4.00	The port number is not 1, 2, 3, or 4; or port is not mode=20.
SLV_ADRS_ERR	-5.00	Adrs Check detected invalid slv_adrs.
Bad_IO_list	-7.00	The IO_List does not have the necessary number of signals, or one or more is of the wrong type.
ECHO_ERR	-8.00	The echo of the interrogation sequence sent to the MTS gauge differed from the interrogation sequence (slv_adrs + cmd).
CK_SUM_ERR	-9.00	The checksum string appended to the DDA response message was incorrect.
PARITY_ERR	-16.0	A receive data parity error detected by the driver terminated in the operation.
TIME_OUT	-17.00	The rply_time expired before the driver transaction was completed.

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<u>Status Mnemonic</u>	<u>Value</u>	<u>Meaning</u>
Overrun	-18.00	At least one input character was lost because characters were received by the SCC faster than the driver could service the SCC.
Framing_err	-19.00	After assembling a received character the STOP bit was a '0'.
Exxx_1	-32.00	The MTS gauge sent an error code instead of the expected data string.
Len_1	-96.00	The length of the data string sent by the MTS gauge was incorrect.
NaN_1	-64.00	The data string sent by the MTS gauge was not a number, e.g. the first character was not a valid digit, +, -, or decimal point.
Exxx_2	-128.00	The MTS gauge sent an Error Code instead of the expected 2nd data string.
Len_2	-384.00	The length of the 2nd data string sent by the MTS gauge is wrong.
NaN_2	-256.00	The 2nd data string sent by the MTS gauge was not a number, e.g. the first character was not a valid digit, +, - or decimal point.
Exxx_3	-512.00	The MTS gauge sent an Error code instead of the expected 3rd data string.
Len_3	-1536.00	The length of the 3rd data string sent by the MTS gauge was incorrect.
NaN_3	-1024.00	The 3rd data string sent by the MTS gauge was not a number.

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Command Group 5

The following table details the commands belonging to Group 5.

<u>Command Description</u>	<u>Hex / Decimal</u>	<u>I / O List Contents</u>	<u>Host Output</u> (Address)	<u>DDA Response</u> (Address)
Individual RTD Temp @ 1.0 °F res.	1Ch / 28	Rcv_String1 Rcv_Value1 Rcv_String2 Rcv_Value2 Rcv_String3 Rcv_Value3 Rcv_String4 Rcv_Value4 Rcv_String5 Rcv_Value5	1Ch	1Ch STX dddd : dddd : dddd : dddd : ETX cccc
Individual RTD Temp @ 0.2 °F res.	1Dh / 29	Rcv_String1 Rcv_Value1 Rcv_String2 Rcv_Value2 Rcv_String3 Rcv_Value3 Rcv_String4 Rcv_Value4 Rcv_String5 Rcv_Value5	(Address) 1Dh	(Address) 1Dh STX dddd.d : dddd.d : dddd.d : dddd.d : ETX cccc

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<u>Command Description</u>	<u>Hex / Decimal</u>	<u>I / O List Contents</u>	<u>Host Output</u> (Address)	<u>DDA Response</u> (Address)
Individual RTD Temp @ 0.02 °F res.	1Eh / 30	Rcv_String1	1Eh	1Eh
		Rcv_Value1		STX
		Rcv_String2		dddd.dd
		Rcv_Value2		:
		Rcv_String3		dddd.dd
		Rcv_Value3		:
		Rcv_String4		dddd.dd
		Rcv_Value4		:
		Rcv_String5		dddd.dd
		Rcv_Value5		:
				dddd.d
				ETX
				cccc
Read RTD position data (RTDs 1-5)	4Eh / 78	Rcv_String1	(Address)	(Address)
		Rcv_Value1	4Eh	4Eh
		Rcv_String2		STX
		Rcv_Value2		dddd.d
		Rcv_String3		:
		Rcv_Value3		dddd.d
		Rcv_String4		:
		Rcv_Value4		dddd.d
		Rcv_String5		:
		Rcv_Value5		dddd.d
				:
				dddd.d
				ETX
		cccc		

MTS Master Custom Communications Protocol

Protocol Signal List

The Protocol Signal List for Group 5 should be set up as follows:

<u>Signal Name</u>	<u>Signal Type</u>	<u>Contents / Length</u>
port_num	analog	1, 2, 3, or 4
slv_adrs	analog	192-253
cmd	analog	28, 29, 30 or 78
io_list	analog	(see list below)
rply_time	analog	>gauge response time + transmission time
done	analog	Current done counter

I/O Signal List

The I/O Signal List for Group 5 should be set up as follows:

<u>Signal Name</u>	<u>Signal Type</u>	<u>Contents / Length</u>
Rcv_String_1	string	string / 64
Rcv_Value1	analog	0.0
Rcv_String_2	string	string / 64
Rcv_Value_2	analog	0.0
Rcv_String_3	string	string / 64
Rcv_Value_3	analog	0.0
Rcv_String_4	string	string / 64
Rcv_Value_4	analog	0.0
Rcv_String_5	string	string / 64
Rcv_Value_5	analog	0.0

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Status

In the execution of Command Group 5, the following status indications are possible:

<u>Status Mnemonic</u>	<u>Value</u>	<u>Meaning</u>
Success	0.00	Command successfully completed.
BAD_PROTO	-2.00	List terminal is <i>unwired</i> , the List terminal value is invalid, the Protocol List number is invalid, or the Protocol List has fewer than 6 signals.
BAD_TYPE	-3.00	One or more of the Protocol List signals is of the wrong type.
BAD_PORT	-4.00	The port number is not 1, 2, 3, or 4; or port is not mode=20.
SLV_ADRS_ERR	-5.00	Adrs Check detected invalid slv_adrs.
Bad_IO_list	-7.00	The IO_List does not have the necessary number of signals, or one or more is of the wrong type.
ECHO_ERR	-8.00	The echo of the interrogation sequence sent to the MTS gauge differed from the interrogation sequence (slv_adrs + cmd).
CK_SUM_ERR	-9.00	The checksum string appended to the DDA response message was incorrect.
PARITY_ERR	-16.0	A receive data parity error detected by the driver terminated in the operation.
TIME_OUT	-17.00	The rply_time expired before the driver transaction was completed.

MTS Master Custom Communications Protocol

<u>Status Mnemonic</u>	<u>Value</u>	<u>Meaning</u>
Overrun	-18.00	At least one input character was lost because characters were received by the SCC faster than the driver could service the SCC.
Framing_err	-19.00	After assembling a received character the STOP bit was a '0'.
Exxx_1	-32.00	The MTS gauge sent an Error Code instead of the expected data string.
Len_1	-96.00	The length of the data string sent by the MTS gauge was incorrect.
NaN_1	-64.00	The data string sent by the MTS gauge was not a number, e.g. the first character was not a valid digit, +, -, or decimal point.
Exxx_2	-128.00	The MTS gauge sent an Error Code instead of the expected 2nd data string.
Len_2	-384.00	The length of the 2nd data string sent by the MTS gauge was incorrect.
NaN_2	-256.00	The 2nd data string sent by the MTS gauge was not a number, e.g. the first character was not a valid digit, +, - or decimal point.
Exxx_3	-512.00	The MTS gauge sent an Error code instead of the expected 3rd data string.
Len_3	-1536.00	The length of the 3rd data string sent by the MTS gauge was incorrect.

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<u>Status Mnemonic</u>	<u>Value</u>	<u>Meaning</u>
NaN_3	-1024.00	The 3rd data string sent by the MTS gauge was not a number.
Exxx_4	-2048.00	The MTS gauge sent an Error code instead of the expected 4th data string.
Len_4	-6144.00	The length of the 4th data string sent by the MTS gauge was incorrect.
NaN_4	-4096.00	The 4th data string sent by the MTS gauge was not a number.
Exxx_5	-8192.00	The MTS gauge sent an Error code instead of the expected 5th data string.
Len_5	-24576.00	The length of the 5th data string sent by the MTS gauge was incorrect.
NaN_5	-16384.00	The 5th data string sent by the MTS gauge was not a number.

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Command Group 6

The following table details the commands belonging to Group 6.

<u>Command Description</u>	<u>Hex / Decimal</u>	<u>I / O List Contents</u>	<u>Host Output</u> (Address)	<u>DDA Response</u> (Address)
Read factory serial number & S/W version.	4Fh / 79	Rcv_String	4Fh	4Fh STX ddddddddddd ddddddddddd dddddd ETX cccc
Read h/w control code #1.	51h/81	Rcv_string	(Address) 51h	(Address) 51h STX dddddd ETX cccc

Protocol Signal List

The Protocol Signal List for Group 6 should be set up as follows:

<u>Signal Name</u>	<u>Signal Type</u>	<u>Contents / Length</u>
port_num	analog	1, 2, 3, or 4
slv_adrs	analog	192-253
cmd	analog	79 or 81
io_list	analog	(See list below)
rply_time	analog	>gauge response time + transmission time
done	analog	Current done counter

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I/O Signal List

The I/O Signal List for Group 6 should be set up as follows:

<u>Signal Name</u>	<u>Signal Type</u>	<u>Contents / Length</u>
Rcv_String	string	string / 64

Status

In the execution of Command Group 6, the following status indications are possible:

<u>Status Mnemonic</u>	<u>Value</u>	<u>Meaning</u>
Success	0.00	Command successfully completed.
BAD_PROTO	-2.00	List terminal is <i>unwired</i> , the List terminal value is invalid, the Protocol List number is invalid, or the Protocol List has fewer than 6 signals.
BAD_TYPE	-3.00	One or more of the Protocol List signals is of the wrong type.
BAD_PORT	-4.00	The port number is not 1, 2, 3, or 4; or port is not mode=20.
SLV_ADRS_ERR	-5.00	Adrs Check detected invalid slv_adrs.
Bad_IO_list	-7.00	The IO_List does not have the necessary number of signals, or one or more is of the wrong type.
ECHO_ERR	-8.00	The echo of the interrogation sequence sent to the MTS gauge differed from the interrogation sequence (slv_adrs + cmd).
CK_SUM_ERR	-9.00	The checksum string appended to the DDA response message was incorrect.

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<u>Status Mnemonic</u>	<u>Value</u>	<u>Meaning</u>
PARITY_ERR	-16.0	A receive data parity error detected by the driver terminated in the operation.
TIME_OUT	-17.00	The rply_time expired before the driver transaction was completed.
Overrun	-18.00	At least one input character was lost because characters were received by the SCC faster than the driver could service the SCC.
Framing_err	-19.00	After assembling a received character the STOP bit was a '0'.
Exxx_1	-32.00	The MTS gauge sent an Error Code instead of the expected data string.
Len_1	-96.00	The length of the data string sent by the MTS gauge was incorrect.

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Command Group 7

The following table details the commands belonging to Group 7.

<u>Command Description</u>	<u>Hex / Decimal</u>	<u>I / O List Contents</u>	<u>Host Output</u>	<u>DDA Response</u>
Write gradient control variable.	56 h / 86	Out_value Recv_Exxx	[1st] (Address) 56h [2nd] SOH d.ddddd EOT [3rd] ENQ	[1st] (Address) 56h [2nd] STX d.ddddd ETX cccc [3rd] ACK 65630 or NAK Exxx ETX cccc

Protocol Signal List

The Protocol Signal List for Group 7 should be set up as follows:

<u>Signal Name</u>	<u>Signal Type</u>	<u>Contents / Length</u>
port_num	analog	1, 2, 3, or 4
slv_adrs	analog	192-253
cmd	analog	86
io_list	analog	(see list below)
rply_time	analog	>gauge response time + transmission time
done	analog	Current done counter

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I/O Signal List

The I/O Signal List for Group 7 should be set up as follows:

<u>Signal Name</u>	<u>Signal Type</u>	<u>Contents / Length</u>
Out_Value	analog	Value to be written to the gauge.
Rcv_Exxx	string	string / 64

Status

In the execution of Command Group 7, the following status indications are possible:

<u>Status Mnemonic</u>	<u>Value</u>	<u>Meaning</u>
Success	0.00	Command successfully completed.
BAD_PROTO	-2.00	List terminal is <i>unwired</i> , the List terminal value is invalid, the Protocol List number is invalid, or the Protocol List has fewer than 6 signals.
BAD_TYPE	-3.00	One or more of the Protocol List signals is of the wrong type.
BAD_PORT	-4.00	The port number is not 1, 2, 3, or 4; or port is not mode=20.
SLV_ADRS_ERR	-5.00	Adrs Check detected invalid slv_adrs.
Bad_IO_list	-7.00	The IO_List does not have the necessary number of signals, or one or more is of the wrong type.
ECHO_ERR	-8.00	The echo of the interrogation sequence sent to the MTS gauge differed from the interrogation sequence (slv_adrs + cmd).

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<u>Status Mnemonic</u>	<u>Value</u>	<u>Meaning</u>
CK_SUM_ERR	-9.00	The checksum string appended to the DDA response message was incorrect.
PARITY_ERR	-16.0	A receive data parity error detected by the driver terminated in the operation.
TIME_OUT	-17.00	The rply_time expired before the driver transaction was completed.
Overrun	-18.00	At least one input character was lost because characters were received by the SCC faster than the driver could service the SCC.
Framing_err	-19.00	After assembling a received character the STOP bit was a '0'.
Bad_NAK	-10.00	The DDA 3rd response was NAK, but not an Exxx error report.
NAK	-11.00	The DDA 3rd response was NAK <Exxx>. The Exxx error report is stored in the Exxx string (I/O list).

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Command Group 8

The following table details the commands belonging to Group 8.

<u>Command Description</u>	<u>Hex / Decimal</u>	<u>I / O List Contents</u>	<u>Host Output</u>	<u>DDA Response</u>
Write “number of floats & number of RTDs” to control variables.	55 h / 85	Out_value1 Out_value2 Rcv_Exxx	[1st]	[1st]
			(Address)	(Address)
			55h	55h
			[2nd]	[2nd]
			SOH	STX
			d:d	d:d
			EOT	ETX
				cccc
			[3rd]	[3rd]
			ENQ	ACK 65530 or NAK Exxx ETX cccc
Write float zero position data (float #1 or float #2).	57 h / 87	Out_Value1 Out_Value2 Rcv_Exxx	[1st]	[1st]
			(Address)	(Address)
			57h	57h
			[2nd]	[2nd]
			SOH	STX
			c	c
			:	:
			dddd.ddd	dddd.ddd
			EOT	ETX
				cccc
[3rd]	[3rd]			
ENQ	ACK 65530or NAK Exxx ETX cccc			

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<u>Command Description</u>	<u>Hex / Decimal</u>	<u>I / O List Contents</u>	<u>Host Output</u>	<u>DDA Response</u>
Write float zero position data (float #1 or float #2) using DDA calibrate mode.	58 h / 88	Out_Value1 Out_Value2 Rcv_Exxx	[1st] (Address) 58h [2nd] SOH c : dddd.ddd EOT [3rd] ENQ	[1st] (Address) 58h [2nd] STX c : dddd.ddd ETX cccc [3rd] ACK 65530 or NAK Exxx ETX cccc
Write RTD position data (RTD 1-5).	59 h / 89	Out_value1 Out_value2 Rcv_Exxx	[1st] (Address) 59h [2nd] SOH c : dddd.d EOT [3rd] ENQ	[1st] (Address) 59h [2nd] STX c : dddd.d ETX cccc [3rd] ACK 65530 or NAK Exxx ETX cccc

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Protocol Signal List

The Protocol Signal List for Group 8 should be set up as follows:

<u>Signal Name</u>	<u>Signal Type</u>	<u>Contents / Length</u>
port_num	analog	1, 2, 3, or 4
slv_adrs	analog	192-253
cmd	analog	85, 87, 88, or 89
io_list	analog	(See list below)
rply_time	analog	>gauge response time + transmission time
done	analog	Current done counter

I/O Signal List

The I/O Signal List for Group 8 should be set up as follows:

<u>Signal Name</u>	<u>Signal Type</u>	<u>Contents / Length</u>
Out_Value_1	analog	The 1st value to be written to the gauge.
Out_Value_2	analog	The 2nd value to be written to the gauge.
Rcv_Exxx	string	string / 64

Status

In the execution of Command Group 8, the following status indications are possible:

<u>Status Mnemonic</u>	<u>Value</u>	<u>Meaning</u>
Success	0.00	Command successfully completed.

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<u>Status Mnemonic</u>	<u>Value</u>	<u>Meaning</u>
BAD_PROTO	-2.00	List terminal is <i>unwired</i> , the List terminal value is invalid, the Protocol List number is invalid, or the Protocol List has fewer than 6 signals.
BAD_TYPE	-3.00	One or more of the Protocol List signals is of the wrong type.
BAD_PORT	-4.00	The port number is not 1, 2, 3, or 4; or port is not mode=20.
SLV_ADRS_ERR	-5.00	Adrs Check detected invalid slv_adrs.
Bad_IO_list	-7.00	The IO_List does not have the necessary number of signals, or one or more is of the wrong type.
ECHO_ERR	-8.00	The echo of the interrogation sequence sent to the MTS gauge differed from the interrogation sequence (slv_adrs + cmd).
CK_SUM_ERR	-9.00	The checksum string appended to the DDA response message was incorrect.
PARITY_ERR	-16.0	A receive data parity error detected by the driver terminated in the operation.
TIME_OUT	-17.00	The rply_time expired before the driver transaction was completed.
Overrun	-18.00	At least one input character was lost because characters were received by the SCC faster than the driver could service the SCC.
Framing_err	-19.00	After assembling a received character the STOP bit was a '0'.

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<u>Status Mnemonic</u>	<u>Value</u>	<u>Meaning</u>
Bad_NAK	-10.00	The DDA 3rd response was NAK, but not an Exxx error report.
NAK	-11.00	The DDA 3rd response was NAK <Exxx>. The Exxx error report is stored in the Exxx string (I/O list).

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Command Group 9

The following table details the commands belonging to Group 9.

<u>Command</u>	<u>Hex /</u> <u>Decimal</u>	<u>I / O List</u> <u>Contents</u>	<u>Host</u> <u>Output</u>	<u>DDA</u> <u>Response</u>
Write firmware control code #1.	5Ah / 90	Out_Value1 Out_Value2 Out_Value3 Out_Value4 Out_Value5 Out_Value6	[1st] (Address) 5Ah [2nd] SOH d: d: d: d: d: d EOT [3rd] ENQ	[1st] (Address) 5Ah [2nd] STX d: d: d: d: d ETX cccc [3rd] ACK 65530or... NAK Exxx ETX cccc

*Warning: Out_Value1 should always be set to 1.0 to enable the 16 bit checksum; otherwise, **the 16 bit checksum will be disabled and all subsequent commands, including all Write Firmware Control Code #1 commands, from the MTS Master Custom Protocol will fail with a timeout.** That is, if you do a Write Firmware Control Code #1 command with Out_Value1 not set to 1.0, you will no longer be able to communicate with and control the gauge. Some alternate communications means (such as the DDA Setup program from MTS, a PC to run it, an EIA-485 interface converter, and appropriate cabling) are required to correct the setup before continuing.*

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Protocol Signal List

The Protocol Signal List for Group 9 (Write firmware control code #1) should be set up as follows:

<u>Signal Name</u>	<u>Signal Type</u>	<u>Contents / Length</u>
port_num	analog	1, 2, 3, or 4
slv_adrs	analog	192-253
cmd	analog	90
io_list	analog	any valid list number
rply_time	analog	>gauge response time + transmission time
done	analog	Current done counter

I/O Signal List

The I/O Signal List for Group 9 should be set up as follows:

<u>Signal Name</u>	<u>Signal Type</u>	<u>Contents / Length</u>
Out_Value_1	analog	The 1st value to be written to the gauge.
Out_Value_2	analog	The 2nd value to be written to the gauge.
Out_Value_3	analog	The 3rd value to be written to the gauge.
Out_Value_4	analog	The 4th value to be written to the gauge.
Out_Value_5	analog	The 5th value to be written to the gauge.
Out_Value_6	analog	The 6th value to be written to the gauge.

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Status

In the execution of Command Group 9, the following status indications are possible:

<u>Status Mnemonic</u>	<u>Value</u>	<u>Meaning</u>
Success	0.00	Command successfully completed.
BAD_PROTO	-2.00	List terminal is <i>unwired</i> , the List terminal value is invalid, the Protocol List number is invalid, or the Protocol List has fewer than 6 signals.
BAD_TYPE	-3.00	One or more of the Protocol List signals is of the wrong type.
BAD_PORT	-4.00	The port number is not 1, 2, 3, or 4; or port is not mode=20.
SLV_ADRS_ERR	-5.00	Adrs Check detected invalid slv_adrs.
Bad_IO_list	-7.00	The IO_List does not have the necessary number of signals, or one or more is of the wrong type.
ECHO_ERR	-8.00	The echo of the interrogation sequence sent to the MTS gauge differed from the interrogation sequence (slv_adrs + cmd).
CK_SUM_ERR	-9.00	The checksum string appended to the DDA response message was incorrect.
PARITY_ERR	-16.0	A receive data parity error detected by the driver terminated in the operation.
TIME_OUT	-17.00	The rply_time expired before the driver transaction was completed.

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<u>Status Mnemonic</u>	<u>Value</u>	<u>Meaning</u>
Overrun	-18.00	At least one input character was lost because characters were received by the SCC faster than the driver could service the SCC.
Framing_err	-19.00	After assembling a received character the STOP bit was a '0'.
Bad_NAK	-10.00	The DDA 3rd response was NAK, but not an Exxx error report.
NAK	-11.00	The DDA 3rd response was NAK <Exxx>. The Exxx error report is stored in the Exxx string (I/O list).

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Command Group 10

The following table details the commands belonging to Group 10.

<u>Command Description</u>	<u>Hex / Decimal</u>	<u>I / O List Contents</u>	<u>Host Output</u>	<u>DDA Response</u>
RAM Read/Write Test.	41h / 65	Out_String1 = "DDAT1" Rcv_Exxx	[1st] (Address) 41h [2nd] SOH DDAT1 EOT	[1st] (Address) 41h [2nd] ACK 65530 or NAK Exxx ETX cccc
ROM Data Checksum Test.	42h / 66	Out_String1 = "DDAT2" Rcv_Exxx	[1st] (Address) 42h [2nd] SOH DDAT2 EOT	[1st] (Address) 42h [2nd] ACK 65530 or NAK Exxx ETX cccc
Counter Integrity Test.	45h / 69	Out_String1 = "DDAT5" Rcv_Exxx	[1st] (Address) 45h [2nd] SOH DDAT5 EOT	[1st] (Address) 45h [2nd] ACK 65530 or NAK Exxx ETX cccc

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<u>Command Description</u>	<u>Hex / Decimal</u>	<u>I / O List Contents</u>	<u>Host Output</u>	<u>DDA Response</u>
Analog Converter Test.	46h / 70	Out_String1 = "DDAT6" Rcv_Exxx	[1st] (Address) 46h [2nd] SOH DDAT2 EOT	[1st] (Address) 46h [2nd] ACK 65530 or NAK Exxx ETX cccc
Waveguide Driver / Amplifier / Comparator Test.	48h / 72	Out_String1 = "DDAT8" Rcv_Exxx	[1st] (Address) 48h [2nd] SOH DDAT8 EOT	[1st] (Address) 48h [2nd] ACK 65530 or NAK Exxx ETX cccc
Write (update) reference magnet position.	5Eh / 94	Out_String1 = "DDATR" Rcv_Exxx	[1st] (Address) 5Eh [2nd] SOH DDATR EOT	[1st] (Address) 5Eh [2nd] ACK 65530 or NAK Exxx ETX cccc

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Protocol Signal List

The Protocol Signal List for Group 10 should be set up as follows:

<u>Signal Name</u>	<u>Signal Type</u>	<u>Contents / Length</u>
port_num	analog	1, 2, 3, or 4
slv_adrs	analog	192-253
cmd	analog	65, 66, 69, 70, 72, or 94
io_list	analog	(See list below)
rply_time	analog	>gauge response time + transmission time
done	analog	Current done counter

I/O Signal List

The I/O Signal List for Group 10 should be set up as follows:

<u>Signal Name</u>	<u>Signal Type</u>	<u>Contents / Length</u>
Out_String_1	string	Output string; refer to individual command.
Rcv_Exxx	string	string / 64

MTS Master Custom Communications Protocol

Status

In the execution of Command Group 10, the following status indications are possible:

<u>Status Mnemonic</u>	<u>Value</u>	<u>Meaning</u>
Success	0.00	Command successfully completed.
BAD_PROTO	-2.00	List terminal is <i>unwired</i> , the List terminal value is invalid, the Protocol List number is invalid, or the Protocol List has fewer than 6 signals.
BAD_TYPE	-3.00	One or more of the Protocol List signals is of the wrong type.
BAD_PORT	-4.00	The port number is not 1, 2, 3, or 4; or port is not mode=20.
SLV_ADRS_ERR	-5.00	Adrs Check detected invalid slv_adrs.
Bad_IO_list	-7.00	The IO_List does not have the necessary number of signals, or one or more is of the wrong type.
ECHO_ERR	-8.00	The echo of the interrogation sequence sent to the MTS gauge differed from the interrogation sequence (slv_adrs + cmd).
CK_SUM_ERR	-9.00	The checksum string appended to the DDA response message was incorrect.
PARITY_ERR	-16.0	A receive data parity error detected by the driver terminated in the operation.
TIME_OUT	-17.00	The rply_time expired before the driver transaction was completed.

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<u>Status Mnemonic</u>	<u>Value</u>	<u>Meaning</u>
Overrun	-18.00	At least one input character was lost because characters were received by the SCC faster than the driver could service the SCC.
Framing_err	-19.00	After assembling a received character the STOP bit was a '0'.
Bad_NAK	-10.00	The DDA 2nd response was NAK, but not an Exxx error report.
NAK	-11.00	The DDA 2nd response was NAK <Exxx>. The Exxx error report is stored in the Exxx string (I/O list).

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Command Group 11

The following table details the commands belonging to Group 11.

<u>Command</u>	<u>Hex /</u> <u>Decimal</u>	<u>I / O List</u> <u>Contents</u>	<u>Host</u> <u>Output</u>	<u>DDA</u> <u>Response</u>
Communication Hardware Test.	47h / 71	Out_String_1="DDAT7" Rcv_String Rcv_Exxx	[1st] (Address) 47h [2nd] SOH DDAT7 EOT	[1st] (Address) 47h [2nd] SOH STX ETX EOT ENQ ACK NAK ABCDEFGHIJKLMNO PQRSTU VWXY. (space) 0123456789: ACK 65530 or NAK Exxx ETX cccc

The Rcv_string length is verified by the MTS Master Custom Protocol., but the string contents are not checked; if the correct length is received and no checksum or other error occurs, the string is placed in the Rcv_string signal of the I/O list.

Protocol Signal List

The Protocol Signal List for Group 11 should be set up as follows:

<u>Signal Name</u>	<u>Signal Type</u>	<u>Contents / Length</u>
port_num	analog	1, 2, 3, or 4
slv_adrs	analog	192-253

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<u>Signal Name</u>	<u>Signal Type</u>	<u>Contents / Length</u>
cmd	analog	71.00
io_list	analog	(See list below)
rply_time	analog	>gauge response time + transmission time
done	analog	Current done counter

I/O Signal List

The Protocol Signal List for Group 11 should be set up as follows:

<u>Signal Name</u>	<u>Signal Type</u>	<u>Contents / Length</u>
Out_String_1	string	"DDAT7" / 64
Rcv_String	string	string / 64
Rcv_Exxx	string	string / 64

Status

In the execution of Command Group 11, the following status indications are possible:

<u>Status Mnemonic</u>	<u>Value</u>	<u>Meaning</u>
Success	0.00	Command successfully completed.
BAD_PROTO	-2.00	List terminal is <i>unwired</i> , the List terminal value is invalid, the Protocol List number is invalid, or the Protocol List has fewer than 6 signals.
BAD_TYPE	-3.00	One or more of the Protocol List signals is of the wrong type.
BAD_PORT	-4.00	The port number is not 1, 2, 3, or 4; or port is not mode=20.

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<u>Status Mnemonic</u>	<u>Value</u>	<u>Meaning</u>
SLV_ADRS_ERR	-5.00	Adrs Check detected invalid slv_adrs.
Bad_IO_list	-7.00	The IO_List does not have the necessary number of signals, or one or more is of the wrong type.
ECHO_ERR	-8.00	The echo of the interrogation sequence sent to the MTS gauge differed from the interrogation sequence (slv_adrs + cmd).
CK_SUM_ERR	-9.00	The checksum string appended to the DDA response message was incorrect.
PARITY_ERR	-16.0	A receive data parity error detected by the driver terminated in the operation.
TIME_OUT	-17.00	The rply_time expired before the driver transaction was completed.
Overrun	-18.00	At least one input character was lost because characters were received by the SCC faster than the driver could service the SCC.
Framing_err	-19.00	After assembling a received character the STOP bit was a '0'.
Bad_NAK	-10.00	The DDA 2nd response was NAK, but not an Exxx error report.
NAK	-11.00	The DDA 2nd response was NAK <Exxx>. The Exxx error report is stored in the Exxx string (I/O list).

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Command Group 12

The following table details the commands belonging to Group 12.

<u>Command Description</u>	<u>Hex / Decimal</u>	<u>I / O List Contents</u>	<u>Host Output</u>	<u>DDA Response</u>
Write hardware control code #1.	5Bh / 91	Out_String Rcv_Exxx	[1st] (Address) 5Bh [2nd] SOH dddddd EOT [3rd] ENQ	[1st] (Address) 5Bh [2nd] STX dddddd ETX cccc [3rd] ACK 65530 or.... NAK Exxx ETX cccc

Protocol Signal List

The Protocol Signal List for Group 12 should be set up as follows:

<u>Signal Name</u>	<u>Signal Type</u>	<u>Contents / Length</u>
port_num	analog	1, 2, 3, or 4
slv_adrs	analog	192-253
cmd	analog	91.00
io_list	analog	(See list below)
rply_time	analog	>gauge response time + transmission time
done	analog	Current done counter

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I/O Signal List

The I/O Signal List for Group 12 should be set up as follows:

<u>Signal Name</u>	<u>Signal Type</u>	<u>Contents / Length</u>
Out_String	string	string to be written to the gauge / 64
Rcv_Exxx	string	string / 64

Status

In the execution of Command Group 12, the following status indications are possible:

<u>Status Mnemonic</u>	<u>Value</u>	<u>Meaning</u>
Success	0.00	Command successfully completed.
BAD_PROTO	-2.00	List terminal is <i>unwired</i> , the List terminal value is invalid, the Protocol List number is invalid, or the Protocol List has fewer than 6 signals.
BAD_TYPE	-3.00	One or more of the Protocol List signals is of the wrong type.
BAD_PORT	-4.00	The port number is not 1, 2, 3, or 4; or port is not mode=20.
SLV_ADRS_ERR	-5.00	Adrs Check detected invalid slv_adrs.
Bad_IO_list	-7.00	The IO_List does not have the necessary number of signals, or one or more is of the wrong type.
ECHO_ERR	-8.00	The echo of the interrogation sequence sent to the MTS gauge differed from the interrogation sequence (slv_adrs + cmd).

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<u>Status Mnemonic</u>	<u>Value</u>	<u>Meaning</u>
CK_SUM_ERR	-9.00	The checksum string appended to the DDA response message was incorrect.
PARITY_ERR	-16.0	A receive data parity error detected by the driver terminated in the operation.
TIME_OUT	-17.00	The rply_time expired before the driver transaction was completed.
Overrun	-18.00	At least one input character was lost because characters were received by the SCC faster than the driver could service the SCC.
Framing_err	-19.00	After assembling a received character the STOP bit was a '0'.
Bad_NAK	-10.00	The DDA 3rd response was NAK, but not an Exxx error report.
NAK	-11.00	The DDA 3rd response was NAK <Exxx>. The Exxx error report is stored in the Exxx string (I/O list).

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Command Group 13

The following table details the commands belonging to Group 13.

<u>Command Description</u>	<u>Hex / Decimal</u>	<u>I / O List Contents</u>	<u>Host Output</u>	<u>DDA Response</u>
Read Firmware control code #1.	50h / 80	Rcv_String1 Rcv_Value1 Rcv_String2 Rcv_Value2 Rcv_String3 Rcv_Value3 Rcv_String4 Rcv_Value4 Rcv_String5 Rcv_Value5 Rcv_String6 Rcv_Value6	[1st] (Address) 50h	[1st] (Address) 50h STX d><: d><: d><: d><: d><: d ETX cccc

Protocol Signal List

The Protocol Signal List for Group 13 should be set up as follows:

<u>Signal Name</u>	<u>Signal Type</u>	<u>Contents / Length</u>
port_num	analog	1, 2, 3, or 4
slv_adrs	analog	192-253
cmd	analog	80.00
io_list	analog	(See List Below)
rply_time	analog	>gauge response time + transmission time
done	analog	Current done counter

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I/O Signal List

The I/O Signal List for Group 13 should be set up as follows:

<u>Signal Name</u>	<u>Signal Type</u>	<u>Contents / Length</u>
Rcv_String_1	string	string / 64
Rcv_Value_1	analog	0.0
Rcv_String_2	string	string / 64
Rcv_Value_2	analog	0.0
Rcv_String_3	string	string / 64
Rcv_Value_3	analog	0.00
Rcv_String_4	string	string / 64
Rcv_Value_4	analog	0.0
Rcv_String_5	string	string / 64
Rcv_Value_5	analog	0.0
Rcv_String_6	string	string / 64
Rcv_Value_6	analog	0.0

Status

In the execution of Command Group 13, the following status indications are possible:

<u>Status Mnemonic</u>	<u>Value</u>	<u>Meaning</u>
Success	0.00	Command successfully completed.

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<u>Status Mnemonic</u>	<u>Value</u>	<u>Meaning</u>
BAD_PROTO	-2.00	List terminal is <i>unwired</i> , the List terminal value is invalid, the Protocol List number is invalid, or the Protocol List has fewer than 6 signals.
BAD_TYPE	-3.00	One or more of the Protocol List signals is of the wrong type.
BAD_PORT	-4.00	The port number is not 1, 2, 3, or 4; or port is not mode=20.
SLV_ADRS_ERR	-5.00	Adrs Check detected invalid slv_adrs.
Bad_IO_list	-7.00	The IO_List does not have the necessary number of signals, or one or more is of the wrong type.
ECHO_ERR	-8.00	The echo of the interrogation sequence sent to the MTS gauge differed from the interrogation sequence (slv_adrs + cmd).
CK_SUM_ERR	-9.00	The checksum string appended to the DDA response message was incorrect.
PARITY_ERR	-16.0	A receive data parity error detected by the driver terminated in the operation.
TIME_OUT	-17.00	The rply_time expired before the driver transaction was completed.
Overrun	-18.00	At least one input character was lost because characters were received by the SCC faster than the driver could service the SCC.
Framing_err	-19.00	After assembling a received character the STOP bit was a '0'.

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<u>Status Mnemonic</u>	<u>Value</u>	<u>Meaning</u>
Exxx_1	-32.00	The MTS gauge sent an Error code instead of the expected 1st data string.
NaN_1	-64.00	The 1st data string sent by the MTS gauge was not a number, e.g. the first character was not a valid digit, +, -, or decimal point.
Len_1	-96.00	The length of the 1st data string sent by the MTS gauge was incorrect.
Exxx_2	-128.00	The MTS gauge sent an Error code instead of the expected 2nd data string.
NaN_2	-256.00	The 2nd data string sent by the MTS gauge was not a number, e.g. the first character was not a valid digit, +, -, or decimal point.
Len_2	-384.00	The length of the 2nd data string sent by the MTS gauge was incorrect.
Exxx_3	-512.00	The MTS gauge sent an Error code instead of the expected 3rd data string.
NaN_3	-1024.00	The 3rd data string sent by the MTS gauge was not a number, e.g. the first character was not a valid digit, +, -, or decimal point.
Len_3	-1536.00	The length of the 3rd data string sent by the MTS gauge was incorrect.
Exxx_4	-2048.00	The MTS gauge sent an Error code instead of the expected 4th data string.

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<u>Status Mnemonic</u>	<u>Value</u>	<u>Meaning</u>
NaN_4	-4096.00	The 4th data string sent by the MTS gauge was not a number, e.g. the first character was not a valid digit, +, -, or decimal point.
Len_4	-6144.00	The length of the 4th data string sent by the MTS gauge was incorrect.
Exxx_5	-8192.00	The MTS gauge sent an Error code instead of the expected 5th data string.
NaN_5	-16384.00	The 5th data string sent by the MTS gauge was not a number, e.g. the first character was not a valid digit, +, -, or decimal point.
Len_5	-24576.00	The length of the 5th data string sent by the MTS gauge was incorrect.
Exxx_6	-32768.00	The MTS gauge sent an Error code instead of the expected 6th data string.
NaN_6	-65536.00	The 6th data string sent by the MTS gauge was not a number, e.g. the first character was not a valid digit, +, -, or decimal point.
Len_6	-98304.00	The length of the 6th data string sent by the MTS gauge was incorrect.

MTS Master Custom Communications Protocol

APPENDIX A ~ REFERENCES

- 1. MTS Level Plus Direct Digital Access (DDA) Gauge Manual, MTS Systems Corporation, 0592 550164, Revision B.*
- 2. BBI Customer Instruction, CI-3330 (or CI-3335) Specification.*
- 3. ACCOL II Reference Manual, D4044 Issue: Sept. 1992, PROM set: AF, ACCOL Software Revision 5.5.*
- 4. Custom Protocol Manual, D4066 Issue: Sept. 1993, PROM set: AH, ACCOL Software Revision 5.7.*

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APPENDIX B ~ TERMS & ABBREVIATIONS

ACCOL	Advanced Communication & Control Oriented Language
ack	acknowledge
AIC	ACCOL Interactive Compiler
ASCII	American Standard Code for Information Interchange
CRC	Cyclical Redundancy Check
DDA	Direct Digital Access
PROM	Programmable Read-Only Memory
ETX	End Transmission
F	Fahrenheit
Half-duplex	Transmission of data in a single direction.
NIB	Network Interface Box
RS 232 / RS 423	Recommended industry Standards for serial communications connections.
RTD	Remote Terminal Device
SCC	
STX	Start Transmission

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