WESCHLER INSTRUMENTS
DIVISION OF HUGHES CORP.

Advantage
Protocol Manual

Manual Part Number PMAMT200

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For use with Firmware AMTSYS0201 Revision 4 and Higher

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Firmware Covered by This Manual

AMTGxT0201 Rev 4 and higher (with and without DNP-3 and ModBus Communications). Advantage models which show rev 4a or 4b in the front-panel revision display will report as revision 3 in the AMTCMF software's Launch Pad screen. This is a known condition intended to allow the earlier revision launch pad to work with revision 4 firmware.

1.0 Introduction

Advantage IIE models with AMTGxT0201 firmware are triple protocol devices. They can communicate digitally using two of the three protocols simultaneously.

The Simple ASCII Protocol (SAP), which is a Weschler proprietary communications specification, is used by the Weschler configuration and monitoring programs, and may be incorporated into simple substation monitoring schemes where the more complex international protocols are not implemented. This protocol is provided free of charge. Beginning with AMTGxT200 firmware, revision 2 of the SAP was adopted. This is a more flexible protocol which allows for easy expansion in the future while retaining compatibility with all 200 series firmware. Revision 2 of the SAP is not compatible with any Advantage model running firmware earlier than 200 series.

The second protocol is DNP3, implemented as level 1, slave. This protocol enjoys widespread use in power transmission and distribution systems. The DNP3 protocol as implemented in Advantage is a master / slave architecture in which there may be one master and, depending upon the communications bus type, may have multiple slaves.

The third protocol is ModBus, implemented in the Advantage in RTU and ASCII versions. The ModBus protocol is used primarily within industrial complexes and generating facilities to control and monitor on-site equipment. The ModBus protocol as implemented in Advantage is a master / slave architecture in which there may be one master and, depending upon the communications bus type, may have multiple slaves.

The DNP3 and ModBus protocols must be specified at the time of order. The two protocols are sold together, and the choice of which one to use is field programmable, however; they may not be used simultaneously. The SAP may be used simultaneously with either one of DNP3 or ModBus.

2.0.0 Simple ASCII Protocol (SAP)

GENERAL

Section 2.1 .0 contains definitions for numerically encoded variables, limits and text strings. The numerical codes are used as shorthand in the various communication frames. The reference to variables themselves or the tables they appear in generally fall within the range column of the frame specification table. For example, in section 2.2 .1 the “n” parameter specifies values from 1 to MAXALM in the range column. In order to know the maximum number of alarms that can be configured you need to know the value of the MAXALM variable. Looking in table 1, it can be seen that the variable MAXALM is defined with a value of 12.

All characters are transmitted as 7-bit ACSII, with 1 start bit and the number of data and stop bits and parity declared in the COMM HRDWR set up loop. Reference figure 16G in the owner’s manual OMAMT200. All frames open with the start-of-command (SOC) character and close with the end-of-command (EOC) character, and the frame elements are comma delimited. Numeric data items are represented as ASCII encoded decimal numbers. Where byte(s) are used bitwise, the bit pattern will be converted to a decimal equivalent value from 0 to 255 prior to transmission. See the bitwise encoding example worked out for the bmapped parameter in section 2.2 .1.

Command frames are arranged into three fields; the header field, data item field and trailer field. The general form of the command frame is shown in section 2.2.0 and specific command frames are detailed in sections 2.2.1 through 2.2.9.

Special command frames are described in section 2.3 .0. Presently the UPL (upload firmware) and Winding Temperature Algorithm (WTA) acceleration commands are the only commands in this category.

Request frames comprise two fields, the header and trailer. Request frames are described in section 2.4 .0.

Special request frames are described in section 2.5 .0. Presently the P&V request (request Peak and Valley records) is the only request in this category.

Reply frames are arranged into three fields; the header field, data item field and trailer field. Reply frames are answers to the request frames described in section 2.4 .0. The general form of reply frames is given in section 2.6 .0. Specific reply frames are detailed in sections 2 .6 .1 through 2.6.10.

The unit ID is used to identify individual Advantage units on a common communications path with other units. The unit ID can have values of 00 to 99 which allows for up to 100 units on a common path. Note that the RS-485 specification only allows up to 32 units on one buffered pair of conductors. As a consequence several buffered branches will be needed in order to use all available unit ID’s.

When a radix is used, it will generally be assumed to occupy the position immediately to the left of the least significant digit (LSD), even though the actual radix is not transmitted. For example; the temperature 41.2 degrees will be transmitted as 412. The host software will need to replace the radix in its correct position when it receives the raw number. In CT-series models the radix will occupy 2 positions to the left of the LSD when specifying parameters of transformer weight and MVA power rating. In LTC and CT/LTC models the radix will occupy two positions to the left of the LSD when specifying the LTC step size.

Negative signs will be represented by ASCII code 45_{10}, and will take the frame position immediately preceding the most significant digit. The maximum range of most numeric values will thus be -99.9 to 999.9. In practice this full range cannot be used due to limitations of transformer operating ranges. For load current indication, since the radix is not used, the value may range up to 99999 amps. Leading zeroes will only be used in the unit ID, and the frame length will therefore vary as a function of variable type and magnitude.

In all frames the checksum is the sum of all character’s ASCII decimal codes from the SOC, up to and including the separator immediately preceding the checksum. The checksum is transmitted in ASCII. See the example checksum calculation shown in section 2.2 .0.

Commands and requests can be sent using the firmware upload utility which is part of the AMTCMF200 software. Reference the section on installing new firmware for graphic representations of the process. To enter a command manually, simply enter the command in the lower (Sent Data) screen and press the carriage return (enter) key on the PC keyboard. If the command or request was sent properly, the reply will appear in the upper (Received Data) screen.

2.1.0 Common Definitions

Table 1: Constants

Code	Description	Value
MAXALM	Maximum number of standard alarms	12
MAXRLY	Maximum number of relays	12
MAXLCAM	Maximum number of LCAM alarms	8
MAXRTX	Maximum number of analog retransmit channels	3
MAXWIN	Maximum number of windings	3
REQDEF	Required parameter “Default”	-1
REQCHG	Required parameter “Change”	-2
REQNA	Required parameter “Not Applicable”	-3
MAXSRC	Maximum number of source codes	23
MAXDSP	Maximum number of display codes	21
VALLOFF	Valley offset code for Peaks and Valleys records	128
DRAGOFF	Drag Hand offset for Peaks and Valley records	32

Table 2: Source and Display Codes

Code	Description	Code	Description
0	RTD Channel 1	12 [3][4]	LTC Deviation
1	Winding 1 Temperature	13 [1][3]	Discreet I/O or LCAM Channel 1 Input
2	Winding 2 Temperature	14 [1][3]	LCAM Channel 2
3	Winding 3 Temperature	15 [1][3]	LCAM Channel 3
4	Hottest Winding Temperature	16 [1][3]	LCAM Channel 4
5	Winding 1 Current	7 [1][3]	LCAM Channel 5
6	Winding 2 Current	18 [1][3]	LCAM Channel 6
7	Winding 3 Current	19 [1][3]	LCAM Channel 7
8	Highest Winding Current	20 [1][3]	LCAM Channel 8
9	RTD Channel 2	21 [2][3]	None
10	RTD Channel 3	22 [1][2][3]	Sensor failure
11 [4]	LTC Differential		

[1] Not available as Analog Retransmit sources.
[2] Not available as Display code.
[3] Not available as Peaks and Valleys codes.
[4] Code for LTC Differential is valid for Peak only. As Valley code, it refers to LTC Deviation.

Table 3: Time based Alarm Trigger Source Codes

Code	Description
0	None
1	Daily
2	Calendar
3	Both

Table 4: Advantage Model Codes

Code	Description	Code	Description
3	Advantage SC	7	Advantage DC
4	Advantage CT	8	Advantage CT/LTC
5	Advantage CTX	9	Advantage TC
6	Advantage LTC		

Table 5: RTD Channel Title Codes

Code	Description	Display Prompt
0	Channel OFF	None
1	Top Oil	TOPO
2	Winding	WINDG
3	Winding X	XWIND
4	Winding Y	YWIND
5	Winding H	HWIND
6	Bottom Oil	BOTTO
7	Ambient	AMBNT
8	Fluid	FLUID
9	Main Tank	MANTK
10	LTC Tank	LTCTK
11	Winding 1	WIND1
12	Winding 2	WIND2
13	Winding 3	WIND3

Table 6: Connected Equipment Codes

Code	Description	Code	Description
0	None	8	Supervisor
1	Alarm	9	Redundant 1
2	ONAF - Oil Natural Air Forced	10	Redundant 2
3	OFAN - Oil Forced Air Natural	11	Redundant 3
4	OFAF - Oil Forced Air Forced	12	Redundant 4
5	ODAN - Oil Directed Air Natural	13	Redundant 5
6	ODAF - Oil Directed Air Forced	14	Redundant 6
7	Spray	15	Force Change

Table 7: Winding Type Codes

Code	Description
0	Cylindric
1	Rectangular
2	Shell

Table 8: Fluid Type Codes

Code	Description
0	Silicon
1	Mineral
2	Organic

2.2.0 Standard Command Frames

Commands are sent to the Advantage unit to set configuration parameters or perform specific control functions and are generally defined as follows:

Header,Data,Trailer

Each section of the command is separated from the next by a comma.
More specifically, the command has this format:

Header	Separator	Data	Separator	Trailer
:*ddCx*	,	*data1*,*data2*,... ...*dataN*	,	*cs*,*CR*

In header <*:ddCx*>

- ":" is the start of communication (SOC) Character
- "*dd"* is the Unit ID - "00" to "99"
- *"C"* is the command identifier
- *"x"* is the code for the specific command being sent. Code options are:

  "C" => Standard Alarm parameters
  "D" => Relay parameters
  "E" => Analog Retransmit parameters
  "F" => Transformer parameters
  "G" => System Parameters
  "H" => LCAM Parameters
  "S" => Time and date setting
  "PVA" => Peak and Valley Save/Reset command

Data <*data1*,*data2*,... ...*dataN*>

- *data1 through dataN* is the payload of the command, and its number and value depends on each command being sent.
- *DataN* arguments in the command are separated by a comma.

Trailer <*cs,CR*>

- "cs" is the Checksum. It will be the last visible value in each command line. It is defined as the sum of the ASCII value of ***each*** character up to the *cs* value itself, including all commas. It is represented in ***decimal*** ASCII characters.
- *"CR"* is the carriage return code, 0x0D.
- *cs* and *CR* are separated by a comma.

After each Set Command Frame sent, the Advantage unit will reply with an acknowledgment (ACK) Frame (see frame definition in section 2.6.1).

Example checksum calculation using the command C example frame, from section 2.2.1.

:00CC,2,1,1027,750,50,0,0,0,2,1029,800,50,0,0,0,2345,<CR>

":" = 58 decimal ASCII. 1 x 58 = 58
"," = 44 decimal ASCII. 16 x 44 = 704
"C" = 67 decimal ASCII. 2 x 67 = 134
"0" = 48 decimal ASCII. 15 x 48 = 720
"1" = 49 decimal ASCII. 3 x 49 = 147
"2" = 50 decimal ASCII. 4 x 50 = 200
"5" = 53 decimal ASCII. 3 x 53 = 159
"7" = 55 decimal ASCII. 2 x 55 = 110
"8" = 56 decimal ASCII. 1 x 56 = 56
"9" = 57 decimal ASCII. 1 x 57 = 57

Checksum = 58 + 704 + 134 + 720 + 147 + 200 + 159 + 110 + 56 + 57 = 2345

2.2.1 "C" Command: Standard Alarms configuration

Section	Description	Repeat
Header	:*dd*CC	-
Data	n ...	-
	..., nr_alarm, bmapped, setpt, hysts, pikup, drpot, extra ...	n times
Trailer	cs, CR	-

Where:

Parameter	Description	Range
n	Number of alarms being configured with this command. Also defines how many times the next block will be repeated	1 to MAXALM
nr_alarm	Number of the alarm that will receive the parameters	1 to MAXALM
bmapped	Several functions coded into the bit representation of this 32 bits parameter: bit31 bit0 nnnnnnnn nnnnnnnr rrrrrfst toooooe n => Not used. Reserved for future expansions rrrrrr => Define the source signal for the alarm f => Enable / Disable sensor failure feature s => Enable / Disable setback feature tt => Trigger source for time based alarms oooooo => Operated relay number e => Enable / Disable alarm	 0 See table 1 1 / 0 1 / 0 See Table 3 0(1) to MAXRLY 1 / 0
setpt	Setpoint for the alarm. Value range depends on type of source selected for the alarm: 1) Current sources (Amperes) 2) Temperature sources (ºC times 10)	 0 to 99999 -400 to 2500
hysts	Hysteresis for the alarm drop off point 1) Current sources (Amperes) 2) Temperature sources (ºC times 10)	 0 to 200 0 to 200
pikup	Pick up time for the operated relay (seconds)	0 to 99999
drpot	Drop off time for the operated relay (seconds)	0 to 99999
extra	Reserved for future expansions	0

(1) "0" means no Operated relay is configured for the alarm.

An example alarm set-up command for alarms 1 and 2 of an Advantage with a unit ID of 00, using the following specifications:

	Alarm 1 Specifications:	Alarm 2 Specifications:
Source:	RTD channel 1	RTD channel 1
Sense Fail:	Enabled	Enabled
Setback:	Disabled	Disabled
Trigger Source:	None	None
Operate Relay No:	1	2
Enable/Disable:	Enable	Enable
Setpoint:	75.0 °C	80.0 °C
Hysteresis:	5.0 °C	5.0 °C
Pickup Delay:	None	None
Drop Out Delay:	None	None
Extra:	None	None

In this example, the bmapped data items are calculated as follows:

Alarm 1: 00000000 00000000 00000100 00000011 = 00 00 04 03 hex = 1027 Decimal
Alarm 2: 00000000 00000000 00000100 00000101 = 00 00 04 05 hex = 1029 Decimal

The Assembled Command Frame That Defines this Configuration (see checksum calculation in section 2.2.0):

:00CC,2,1,1027,750,50,0,0,0,2,1029,800,50,0,0,0,2345,<CR>

2.2.2 "D" Command: Relays configuration

Section	Description	Repeat
Header	:*dd*CD	-
Data	n ...	-
	..., nr_relay, bmapped, extra ...	n times
Trailer	cs, CR	-

Where:

Parameter	Description	Range
n	Number of relays being configured with this command. Also defines how many times the next block will be repeated	1 to MAXRLY
nr_relay	Number of the relay that will receive the parameters	1 to MAXRLY
bmapped	Several functions coded into the bit representation of this 32 bits parameter: bit31 bit0 nnnnnnnn nnnnnnnn nnnnqqqq qqskcffe n => Not used. Reserved for future expansions qqqqqq => Define the relay's connected equipment s => Enable / Disable alarm sequencing k => Enable / Disable Relay check feature c => Coil unalarmed state: Energized / De-Energized ff => Sensor Failure effect: Energized / De-Energized e => Enable / Disable relay	 0 See table 4 1 / 0 1 / 0 1 / 0 1 / 0 1 / 0
extra	Reserved for future expansions	0

2.2.3 "E" Command: Analog Retransmit configuration

Section	Description	Repeat
Header	:*dd*CE	-
Data	n ...	-
	..., nr_rtx, bmapped, RtxZero, RtxFull, rtz, rtf ...	n times
Trailer	cs, CR	-

Where:

Parameter	Description	Range
n	Number of analog retransmit channels being configured with this command. Also defines how many times the next block will be repeated	1 to MAXRTX
nr_rtx	Number of the channel that will receive the parameters	1 to MAXRTX
bmapped	Several functions coded into the bit representation of this 32 bits parameter: bit31 bit0 nnnnnnnn nnnnnnnn nnnnnnnn nrrrrrre n => Not used. Reserved for future expansions rrrrrr => Define the source signal for the analog retransmit channel e => Enable / Disable analog retransmit channel	 0 See table 1 1 / 0
RtxZero	Loop current Zero Scale (µA)	0 to 24000
RtxFull	Loop current Full Scale (µA)	0 to 24000
rtz	Reference value Zero Scale 1) Current sources (Amperes) 2) Temperature sources (ºC times 10)	 0 to 99999 -400 to 2500
rtf	Reference value Full Scale 1) Current sources (Amperes) 2) Temperature sources (ºC times 10)	 0 to 99999 -400 to 2500

2.2.4 "F" command: Transformer Configuration (CT series only)

Section	Description	Repeat
Header	:*dd*CF	-
Data	bmapped, fcap, weight, n ...	-
	..., nr_wind, ilmax, prmry, secnd, onan_ratng, onan_grad, onaf_ratng, onaf_grad, ofan_ratng, ofan_grad, ofaf_ratng, ofaf_grad, odan_ratng, odan_grad, odaf_ratng, odaf_grad ...	n times
Trailer	cs, CR	-

Where:

Parameter	Description	Range
bmapped	Several functions coded into the bit representation of this 32 bits parameter: bit31 bit0 nnnnnnnn nnnnnnnn nnnnnnnn niwwwfff n => Not used. Reserved for future expansions i => IEEE / IEC coeficients for WTA www => Winding type code fff => Fluid type code	 0 1 / 0 See table 5 See table 6
fcap	Fluid capacity (gallons)	500 to 50000
weight	Transformer weight (tons times 100)	1 to 99999
n	Number of windings being configured with this command. Also defines how many times the next block will be repeated	1 to MAXWIN
nr_wind	Number of the winding that will receive the parameters	1 to MAXWIN
ilmax	Maximum load current (Amperes)	1 to 99999
prmry	CT Primary current (Amperes)	1 to 99999
secnd	CT Secondary current (Amperes times 10)	10 to 200
xxxx_ratng [(1)]	Power rating for xxxx gradient (MVA times 100)	REQCHG, REQNA, 1 to 99999
xxxx_grad [(1)]	xxxx Temperature gradient (ºC times 10) Obs. ONAN gradient can also be set to REQDEF	REQCHG, REQNA, REQDEF, 0 to 750

(1) xxxx = gradient codes ONAN, ONAF, OFAN etc.

2.2.5 "G" command: System Configuration

Section	Description	Repeat
Header	:*dd*CG	-
Data	bmapped, step, idiff, delay, n ...	-
	..., nr_channel, title, offset, n_points ...	n times
Trailer	cs, CR	-

Where:

Parameter	Description	Range
bmapped	Several functions coded into the bit representation of this 32 bits parameter: bit31 bit0 nnnnnnnn nnnnnnnn nnnnnnnn cafodslp n => Not used. Reserved for future expansions c => Enable / Disable Display Conserver a => Enable / Disable auto delay in LTC mode (1) f => Enable / Disable Numeric over range flashing o => Enable / Disable Operator Setup d => Enable / Disable Daylight Savings s => Max temperature scale (250ºC / 200ºC) l => Enable / Disable LTC function (1) p => Hourly / Continuous - Peak & Valley mode	 0 1 / 0 1 / 0 1 / 0 1 / 0 1 / 0 1 / 0 1 / 0 1 / 0
step	LTC Step size (ºC times 100)	-2000 to -40
idiff	LTC Initial differential (ºC times 10)	-400 to 2000
delay	LTC Delay Length (Seconds)	0 to 99999
n	Number of RTD channels being configured with this command. Also defines how many times the next block will be repeated	1 to MAXRTD
nr_channel	Number of the RTD Channel that will receive the parameters	1 to MAXRTD
tilte	Title code for the RTD channel	See table 3
offset	Temperature to be added to the reading (ºC times 10)	-250 to 250
n_points	Number of points in calibration table for this channel	3 to 12

(1) Non-LTC models will ignore these bits.

2.2.6 "H" command: LCAM Alarm Configuration (LCAM module equipped units only)

Section	Description	Repeat
Header	:*dd*CH	-
Data	n ...	-
	..., nr_lcam, bmapped, scale, hysts, hithr, lothr, pikup, drpot, extra ...	n times
Trailer	cs, CR	-

Where:

Parameter	Description	Range
n	Number of LCAM alarms being configured with this command. Also defines how many times the next block will be repeated	1 to MAXLCAM
nr_lcam	Number of the LCAM Alarm that will receive the parameters	1 to MAXLCAM
bmapped	Several functions coded into the bit representation of this 32 bits parameter: bit31 bit0 nnnnnnnn nnnnniii iaaaaaat toooooe n => Not used. Reserved for future expansions iiii => Type of LCAM input aaaaaa => Associated relay number tt => Trigger source for time based alarms oooooo => Operated relay number e => Enable / Disable alarm	 0 See table below 0[1] to MAXRLY See table 2 0[1] to MAXRLY 1 / 0
scale	Full Scale values for input type 1) AC Volts (5V, 150V, 300V) 2) DC Volts (5V, 75V, 150V, 300V) 3) AC Amperes (current times 10) 4) DC Amperes (1mA, 20mA) 5) Dry Contact (10Vdc)	 500,1500,3000 500,7500,1500,3000 1 to 99999 100, 20000 100
hysts	Hysteresis of the alarm High and Low thresholds	0 to 20% Full Scale
hithr	Alarm High threshold (same as Full Scale)	0[2] to 1.5x Full Scale
lothr	Alarm Low threshold (same as Full Scale)	0 to 1.5x Full Scale[3]
pikup	Alarm pick up time (seconds)	0 to 99999
drpot	Alarm drop off time (seconds)	0 to 99999
extra	Reserved for future expansions	0

[1] "0" means no Operated or Associated relays is set to this alarm.
[2] Depends on value of Hysteresis and Low Threshold: $hithr_{min}$ = lothr + hysts
[3] Depends on value of Hysteresis and High Threshold: $lothr_{max}$ = hithr - hysts

LCAM Input Type Codes and Scale Values

Type Code	Description	Possible Scale Values
0	AC Volts	5V, 150V and 300V
1	DC Volts	5V, 75V, 150V and 75V
2	AC Amperes	1A to 9999.9A
3	DC Amperes	1mA, 20mA
4	Dry contact	10V

2.2.7 "PVA" command: Peak and Valley Reset/Save command

Section	Description	Repeat
Header	:*dd*CPVA	-
Data	pv_id	-
Trailer	cs, CR	-

Where:

Parameter	Description	Range
pv_id	Define the Peak or Valley to be saved and reset to current display value 1) Peaks 2) Valley	 Code per table 2 Peak Code + VALLOFF

2.2.8 "S" command: Time and Date configuration

Section	Description	Repeat
Header	:*dd*CS	-
Data	year, month, day, hour, minute, sec	-
Trailer	cs, CR	-

Where:

Parameter	Description	Range
year	Set Year	2000 to 2250
month	Set Month	1 to 12
day	Set Day	1 to 31[(1)]
hour	Set Hour	0 to 23
minute	Set Minutes	0 to 59
sec	Set Seconds	0 to 59

[(1)] Depends on month to set maximum limit: 28, 30 or 31.

2.2.9 "T" command: System Configuration

The "T" command is used to operate the relays remotely.

Format: Header,Data,Trailer
Reports back an ACK Frame.

Section	Description	Repeat
Header	:*dd*CT	-
Data	type,value1,value2	-
Trailer	cs, CR	-

Where:

Parameter	Description	Range
type	Defines type of command and what the next two values will represent: 1) Start Relay test 2) Stop Relay test	 0 1
value1	*type* specific value: *type* 0 => Relay number *type* 1 => Relay number	 0 [(1)] to MAXRLY 0 [(1)] to MAXRLY
value2	*type* specific value: *type* 0 => Energized / De-energized	 1 / 0

[(1)] Relay number *"0"* specifies that the command is to be applied to all relays.
[(2)] Same as "T" Reply Frame.

2.3.0 Special Command Frames

2.3.1 "UPL" Command: Upload Firmware

The UPL command is still an active command; however, the firmware upload procedure has become significantly more complex and the UPL command now initiates a series of actions and required responses. Because of the complexity of the sequence, the command has been superceded by an automated procedure. The firmware upgrade process is now performed using the firmware upgrade utility that is part of the AMTCMF200 software. Reference the SMAMT200 software manual for information on the operation of the utility.

It is strongly recommended that the UPL command not be used unless the user has been thoroughly instructed on its use.

2.3.2 Winding Temperature Algorithm (WTA) Acceleration Command

The WTA acceleration command speeds up the execution of the WTA for fast verification of parameters that define the transformer that the Advantage CT series model is monitoring. The WTA acceleration command frame is unique and is specified as follows:

:00CT,9,60,10800,889,

Where:

9 = Reserved code number

60 = Period that will elapse in 1 second, expressed in seconds. In this example, 60 seconds of real time will be compressed into 1 second.

10800 = Time (in seconds) until expiration of the speed-up. In this case, the speed up will revert to normal in 3 hours. The acceleration can also be forced back to real time by cycling instrument power.

889 = Checksum

Other timing can be specified, but the checksum will need to be recalculated.

2.4.0 Standard Request Frames

Request frames are sent to the Advantage unit to request information on status or configuration data and are defined as follows:

Header,Trailer

Each section of the command is separated from the next by a comma.
More specifically, the command has this format:

Header	,	Trailer
:*ddQDDx*	,	*cs*,*CR*

Header <*:ddQDDx*>
":" is the SOC Character
"*dd*" is the Unit ID - "00" to "99"
"*QDD*" is the request command identifier
"*x*" is the type of data being requested. Possible options are:

"B" => Advantage Status
"b" => Relay status
"R" => Relay ON time

"C" => Standard Alarms parameters
"D" => Relays parameters
"E" => Analog Retransmit parameters
"F" => Transformer parameters
"G" => System Parameters
"H" => LCAM Parameters
"V" => Firmware configuration

Trailer <*cs,CR*>

"*cs*" is the Checksum. It will be the last visible value in each command line. It is defined as the sum of the ASCII value of all characters up to the *cs* value itself, including all commas. It is represented in ASCII characters.
"*CR*" is the carriage return code, 0x0D.

cs and *CR* are separated by a comma.

A Request Frame shall be answered with a reply frame, as defined on section 2.6., or an ACK Frame, if requested data is incorrect.

2.5.0 Special Request Frames

Special request frames are formatted somewhat differently than standard request frames. They are defined below.

2.5.1 "P&V" Request: Return Peak and Valley Records

The peak and valley request is of the form ":*ddP&VCR*" with no spaces or commas, where:

":" is the start of communication (SOC) character.
"*dd*" is the unit ID (00 to 99)
"*P&V*" is the peak and valley request code.
"*CR*" is the carriage return.

The peak and valley request frame shall be answered with a special reply frame, as defined in section 2.7.0.

2.6.0 Standard Reply Frames

Reply frames are returned by the Advantage unit in response to Request Frames and are defined as follows:

Header,Data,Trailer

Each section of the command is separated from the next by a comma.
More specifically, the command has this format:

Header	,	Data	,	Trailer
:*ddAx*	,	*data1*,*data2*,... ...*dataN*	,	*cs*,*CR*

Header <*:ddAx*>

":" is the SOC Character
"dd" is the Unit ID - "00" to "99"
"A" is the answer identifier
"x" is the command being answered. Possible options are the same as defined by the request frame.

Data <*data1*,*data2*,... ...*dataN*>

data1 to *dataN* is the payload of the unit response and its number and value depends is in on each command being answered.

DataN arguments in the answer are separated by a comma.

Trailer <*cs,CR*>

"*cs*" is the Checksum. It will be the last visible value in each line. It is defined as the sum of the ASCII value of all characters up to the *cs* value itself, including all commas. It is represented in ASCII characters.
"*CR*" is the carriage return code, 0x0D.

cs and *CR* are separated by a comma.

2.6.1 Acknowledgment (ACK) Frames

Acknowledgment frames are special case replies sent by the Advantage unit in response to Command Frames, giving the user feedback that commands were received, executed or failed. Also, on Request Frames, some ACK Frames may be sent back if incorrectly formatted requests are received.

ACK Frames are defined as follows:

Header=Data Trailer

More specifically, the command has this format:

Header	=	Data	Trailer
:*ddACK*	=	*Message1,Message2*	*CR*

Header <:*ddACK*>
: is the SOC Character
dd is the Unit ID - "00" to "99"
ACK is the acknowledge identifier

Data <*Message1*,Message*2*>
Message1 is the main status for the ACK Frame
Message2 is optional and gives more information about the ACK Frame.
Message1 and Message*2* arguments are separated by a comma, if needed.

Current ACK messages are:

Data	Description
OK, Command Executed	Command correctly received and executed
ERR, Checksum Error	Checksum sent was incorrect
ERR, Command Unknown	Command is not recognized or supported
ERR, Value Error	One or more parameters was sent with an invalid value
ERR, No. Param. Error	Number of parameters sent is incorrect
ERR, Comm. Incomplete	Command sent is not complete
ERR, Flash Mem. Error	Error when saving data on Flash memory
ERR, EEPROM Mem.Error	Error when saving data on EEPROM memory
ERR, Command too long	Overflow on receiver command buffer
WAIT...	Command received. Wait for extra data

Trailer <*CR*>

CR is the carriage return code, 0x0D.

There is no checksum for the ACK Frame.

2.6.2 "B" Reply: Advantage Status

Sent in response to the *:ddQDDB,cs,CR* Request Frame:

Section	Description	Repeat
Header	*:ddAB*	-
Data	new_cfg, n_disp ...	-
	..., nr_disp, disp_val ...	n_disp times
	, n_pv ...	-
	..., pv_id, Peak_Val, month, day, year, hour, minute, sec ...	n_pv times
	..., pv_id, Valley_Val, month, day, year, hour, minute, sec ...	n_pv times
	, n_rly ...	-
	..., nr_rly, rly_coil, rly_active ...	n_rly times
Trailer	cs, CR	-

Where:

Parameter	Description	Range
new_cfg	Reports if configuration on unit has changed (New Configuration / Same Configuration)	1 / 0
n_disp	Number of measurements being reported. Also defines how many times the next block will be repeated	Depends on Advantage model
nr_disp	Code of source for measurement being reported	See table 1
disp_val	Value of the source defined by *nr_disp* 1) Current sources (Amperes) 2) Temperature sources (ºC times 10) 3) LCAM Sources (Depends on *input* and *Full Scale*)	0 to 99999 -800 to 2500 (1) 0 to 2x *Full Scale*
n_pv	Number of Peaks and Valleys being reported. Also defines how many times the next two blocks will be repeated	Depends on Advantage model
pv_id	Source code of the Peak or Valley current value 1) Peaks 2) Valleys	See table 1 VALLOFF + Peak code
Peak_Val	Current value of the Peak for the specified source 1) Current sources (Amperes) 2) Temperature sources (ºC times 10)	0 to 99999 -800 to 2500 (1)
month	Month of the Peak or Valley record	1 to 12
day	Day of the Peak or Valley record	1 to 31
year	Year of the Peak or Valley record	2000 to 2250
hour	Hour of the Peak or Valley record	0 to 23
minute	Minute of the Peak or Valley record	0 to 59
sec	Second of the Peak or Valley record	0 to 59
n_rly	Number of relays being reported. Also defines how many times the next block will be repeated	1 to MAXRLY
nr_rly	Relay number being reported	1 to MAX_RLY
rly_coil	Coil state of the relay (Energized / De-energized)	1 / 0
rly_active	Status of the relay (Alarmed / Not alarmed)	1 / 0

(1) If sensor failure, value will be reported as -8888 or 8888. Also, the maximum value for the range will be set by the "G" command at 200 or 250ºC

2.6.3 "b" Reply: Relay Status

Sent in response to the *:ddQDDb,cs,CR* Request Command Frame:

Section	Description	Repeat
Header	*:ddAb*	-
Data	n_rly ...	-
	..., nr_rly, rly_coil, rly_active ...	n_rly times
Trailer	cs, CR	-

Where:

Parameter	Description	Range
n_rly	Number of relays being reported. Also defines how many times the next block will be repeated	1 to MAXRLY
nr_rly	Relay number being reported	1 to MAX_RLY
rly_coil	Coil state of the relay (Energized / De-energized)	1 / 0
rly_active	Status of the relay (Alarmed / Not alarmed)	1 / 0

2.6.4 "R" Reply: Relay ON time

Sent in response to the *:ddQDDR,cs,CR* Request Command Frame:

Section	Description	Repeat
Header	*:ddAR*	-
Data	n_rly ...	-
	..., nr_rly, time ...	n_rly times
Trailer	cs, CR	-

Where:

Parameter	Description	Range
n_rly	Number of relays being reported. Also defines how many times the next block will be repeated	1 to MAXRLY
nr_rly	Relay number being reported	1 to MAX_RLY
time	ON time for the relay (seconds)	0 to 2^{32}

2.6.5 "C" Reply: Standard Alarms configuration

Sent in response to the *:ddQDDC,cs,CR* Request Command Frame:

Section	Description	Repeat
Header	*:dd*AC	-
Data	n ...	-
	..., nr_alarm, bmapped, setpt, hysts, pikup, drpot, extra ...	n times
Trailer	cs, CR	-

Data on "C" Reply Frame have the same description as on "C" Command Frame.

2.6.6 "D"Reply: Relays configuration

Sent in response to the *:ddQDDD,cs,CR* Request Command Frame:

Section	Description	Repeat
Header	*:dd*AD	-
Data	n ...	-
	..., nr_relay, bmapped, extra ...	n times
Trailer	cs, CR	-

Data on "D" Reply Frame have the same description as on "D" Set Command Frame.

2.6.7 "E" Reply: Analog Retransmit configuration

Sent in response to the *:ddQDDE,cs,CR* Request Command Frame:

Section	Description	Repeat
Header	:*dd*AE	-
Data	n ...	-
	..., nr_rtx, bmapped, RtxZero, RtxFull, rtz, rtf ...	n times
Trailer	cs, CR	-

Data on "E" Reply Frame have the same description as on "E" Set Command Frame.

2.6.8 "F" Reply: Transformer configuration (CT series only)

Sent in response to the *:ddQDDF,cs,CR* Request Command Frame:

Section	Description	Repeat
Header	:*dd*AF	-
Data	bmapped, fcap, weight, n ...	-
	..., nr_wind, ilmax, prmry, secnd, onan_ratng, onan_grad, onaf_ratng, onaf_grad, ofan_ratng, ofan_grad, ofaf_ratng, ofaf_grad, odan_ratng, odan_grad, odaf_ratng, odaf_grad ...	n times
Trailer	cs, CR	-

Data on "F" Reply Frame have the same description as on "F" Set Command Frame.

2.6.9 "G" Reply: RTD, LTC and other configurations

Sent in response to the *:ddQDDG,cs,CR* Request Command Frame:

Section	Description	Repeat
Header	:*dd*AG	-
Data	bmapped, step, idiff, delay, n ...	-
	..., nr_channel, title, offset, n_points ...	n times
Trailer	cs, CR	-

Data on "G" Reply Frame have the same description as on "G" Set Command Frame.

2.6.10 "H" Reply: LCAM alarms configuration

Sent in response to the *:ddQDDH,cs,CR* Request Command Frame:

Section	Description	Repeat
Header	:*dd*AH	-
Data	n ...	-
	..., nr_lcam, bmapped, scale, hysts, hithr, lothr, pikup, drpot, extra ...	n times
Trailer	cs, CR	-

Data on "H" Reply Frame have the same description as on "H" Set Command Frame.

2.7.0 SPECIAL REPLY FRAMES

Special reply frames are those which are formatted differently than the standard reply frame. Special reply frames are generally used to return large amounts of related data in a unique format.

2.7.1 Peak and Valley Reply Frame

The peak and valley reply frame is the response to the peak and valley request defined in the special requests

section 2.5.1. The peak and valley reply frame returns a text file consisting of an acknowledge frame, the number of records in the file, the records themselves contained in the reply data block, and a final acknowledgment frame indicating the end of the file.

The acknowledgment frame will appear as: ":*dd*ACK=WAIT..." where *dd* is the unit ID.
The number of records (n_rec) in the file will appear as 10 digits immediately below the acknowledgment frame. Following the number of records is the actual peak and valley data.

Reply Data Block:

The general format of the reply data block is:

Data,Trailer

Section	Description	Repeat
Data	rec_id, year, month, day, hour, minute, second, value	n_rec
Trailer	CR	-

After each data and trailers segment is sent, a counter is incremented to point to the next record. When the number of records (represented by n_rec) is reached, the command executed acknowledgment frame will be sent.

Where:

Parameter	Description	Range
rec_id	Record Identifier, defines which data is being reported	See table below
year	Year of the record	2000 to 2250
month	Month of the record	1 to 12
day	Day of the record	1 to 31
hour	Hour of the record	0 to 23
minute	Minute of the record	0 to 59
sec	Second of the record	0 to 59
value	Value of the record itself 1) Temperature sources (ºC times 10) 2) Current sources (Amperes) 3) Power Failure / Return	 -800 to 2500 (1) 0 to 99999 0 / 100

(1) If sensor failure, value will be reported as -8888 or 8888. Also, the maximum value for the range will be set by the "G" command at 200 or 250ºC

Example of a successful request:

Request: :00P&V*CR*

Receive: :00ACK=WAIT...
0000000003 Records
000,2008,01,02,15,29,43,702
000,2008,01,02,16,01,02,701
000,2008,01,02,17,00,02,701
:00ACK=OK, Command Executed

Peak & Valley Record Codes

Code	Description
0 to 11	Hourly Peak codes for source codes in table 2
Peak Code + DRAGOFF	Drag hand peak codes for source codes in table 2
Peak Code + VALLOFF	Hourly Valley codes for source codes in table 2
Peak Code + VALLOFF +DRAG_OFF	Drag Hand valley codes for source codes in table 2
400 to (400 + MAXRLY)	Relay Time ON
470	Power Failure / Return record

Section 3.0.0: Distributed Network Protocol Rev 3 (DNP3) Protocol

DNP V3.00

DEVICE PROFILE DOCUMENT

This table must be accompanied by a table having the following headings:

Object Group	Request Function Codes	Response Function Codes
Object Variation	Request Qualifiers	Response Qualifiers
	Object Name (optional)	

Vendor Name: Weschler Instruments

Device Name: Advantage Models SC, DC, TC, LTC, CT, CTX and CT/LTC

Highest DNP Level Supported:	Device Function:
For Requests: Level 1	☐ Master
For Responses: Level 1	■ Slave

Notable objects, functions and/or qualifiers supported in addition to the highest DNP levels Supported (the complete list is described in the attached table):

Maximum Data Link Frame Size (octets):	Maximum Application Fragment Size (octets):
Transmitted: 292 Received: 292	Transmitted: 249 Received: 249

Maximum Data Link Re-tries:	Maximum Application Layer Re-tries:
■ None ☐ Fixed at _____ ☐ Configurable, range ____ to ____	■ None ☐ Configurable, range _____ to _____ (fixed is not permitted)

Requires Data Link Layer Confirmation:

■ Never
☐ Always
☐ Sometimes If 'Sometimes', when? _____
☐ Configurable If 'Configurable', how? _____

Requires Application Layer Confirmation:

☐ Never
☐ Always (not recommended)
■ When reporting event data (Slave devices only)
☐ When sending multi-fragment responses (slave devices only)
☐ Sometimes If 'Sometimes', when? _____
☐ Configurable If 'Configurable', how? _____

Timeouts While Waiting For:

Data link confirm	■ None	☐ Fixed at ___	☐ Variable	☐ Configurable*
Complete application fragment	■ None	☐ Fixed at ___	☐ Variable	☐ Configurable*
Application confirm	■ None	☐ Fixed at ___	☐ Variable	☐ Configurable*
Complete application response	■ None	☐ Fixed at ___	☐ Variable	☐ Configurable*

Others _____

Attach an explanation if 'Variable' or 'Configurable' was checked for any timeout

Send / Executes Control Operations:

WRITE Binary Outputs	■ Never	☐ Always	☐ Sometimes	☐ Configurable*
SELECT / OPERATE	☐ Never	■ Always	☐ Sometimes	☐ Configurable*
DIRECT OPERATE	☐ Never	■ Always	☐ Sometimes	☐ Configurable*
DIRECT OPERATE - NO ACK	☐ Never	■ Always	☐ Sometimes	☐ Configurable*
Count > 1	■ Never	☐ Always	☐ Sometimes	☐ Configurable*
Pulse On	☐ Never	☐ Always	■ Sometimes	☐ Configurable*
Pulse Off	☐ Never	☐ Always	■ Sometimes	☐ Configurable*
Latch On	☐ Never	☐ Always	■ Sometimes	☐ Configurable*
Latch Off	☐ Never	☐ Always	■ Sometimes	☐ Configurable*
Queue	■ Never	☐ Always	☐ Sometimes	☐ Configurable*
Clear Queue	■ Never	☐ Always	☐ Sometimes	☐ Configurable*

* See attached point table for control operations checked as 'Sometimes'

FILL OUT THE FOLLOWING ITEMS FOR MASTER DEVICES ONLY

Expects Binary Input Change Events:

☐ Either time-tagged or non-time-tagged for a single event.
☐ Both time-tagged and non-time-tagged for a single event.
☐ Configurable (attach explanation).

FILL OUT THE FOLLOWING ITEM FOR SLAVE DEVICES ONLY

Reports binary input change events when no specific variation requested;

☐ Never
■ Only time-tagged
☐ Only non-time-tagged
☐ Configurable to send both, one, or the other (attach explanation)

Reports time-tagged binary input change events when no specific variation requested:

☐ Never
■ Binary input change with time
☐ Binary input change with relative time
☐ Configurable (attach explanation)

Sends Unsolicited Responses:	Sends Static Data in Unsolicited Responses
■ Never ☐ Configurable (attach explanation) ☐ Only certain objects ☐ Sometimes (attach explanation) ☐ ENABLE / DISABLE UNSOLICITED Function Codes Supported	■ Never ☐ When device restarts ☐ When status flags change No Other Options Are Permitted

Default Counter Object / Variation:	Counters Roll Over At:
☐ No counters reported ☐ Configurable (attach explanation) ■ Default object ___20___ Default Variation ___1___ ☐ Point-by-point list attached	☐ No counters reported ☐ Configurable (attach explanation) ☐ 16 Bits ■ 32 Bits ☐ Other value _____ ☐ point-by-point list attached
Sends Multi-Fragment Responses: ☐ Yes ■ No	

Advantage Implementation Table

OBJECT			REQUEST (slave must parse)		RESPONSE (master must parse)	
OBJECT GROUP	VARIATION	DESCRIPTION	Function Codes (decimal)	Qualifier Codes (hex)	Function Codes (decimal)	Qualifier Codes (hex)
1	2	Binary Input with Status			129	00,01
2	2	Binary Input Change with Time			129	17, 28
10	2	Binary Output Status			129	00, 01
12	1	Control Relay Output Block	3, 4, 5, 6	17, 28	129	echo of request
20	1	32 Bit Binary Counter			129	00, 01
30	1	32 Bit Analog Input			129	00, 01
40	2	16 Bit Analog Output status			129	00, 01
41	2	16 Bi8t Analog Output Block	3, 4, 5, 6	17, 28	129	echo of request
50	1	Time and Date	1, 2	07 quantity=1		
60	0	Class Zero Data Read		06		

Advantage Point Table

Object	Variation	Type	Point	Description
1	2	Binary Input with Status (Static, Read) Status Octet: Bit 7 = State (0, 1) Bit 6 = N/A Bit 5 = N/A Bit 4 = N/A Bit 3 = N/A Bit 2 = N/A Bit 1 = N/A Bit 0 = On / Off Line Bit 0: 0 = True (Off Line) 1 = False (On Line)	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39	Not Implemented LCAM Channel 1 LCAM Channel 2 LCAM Channel 3 LCAM Channel 4 LCAM Channel 5 LCAM Channel 6 LCAM Channel 7 LCAM Channel 8 LCAM Channel 1 (with relay association) LCAM Channel 2 (with relay association) LCAM Channel 3 (with relay association) LCAM Channel 4 (with relay association) LCAM Channel 5 (with relay association) LCAM Channel 6 (with relay association) LCAM Channel 7 (with relay association) LCAM Channel 8 (with relay association) Defined points will return a cleared bit 7 if unalarmed and a set bit 7 if in the alarm state. Points 24 - 31 will be in the alarmed state if the corresponding input measures a process value that is outside of the defined normal band. Points 32 - 39 will be in the alarmed state if the value of the process started by its associated relay is outside of the defined normal band. Points 32 - 39 are typically used to monitor cooling apparatus that is controlled by Advantage. Non-Implemented channels return 0 in bits 0 and 7.

Object	Variation	Type	Point	Description
2	2	Binary Input Change with Time (Read, Event) Status Octet: Bit 7 = State (0, 1) Bit 6 = N/A Bit 5 = N/A Bit 4 = N/A Bit 3 = N/A Bit 2 = N/A Bit 1 = N/A Bit 0 = On / Off Line Bit 0: 0 = True (Off Line) 1 = False (On Line)	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39	RTD Channel 1 Peak RTD Channel 2 Peak RTD Channel 3 Peak RTD Channel 1 Valley RTD Channel 2 Valley RTD Channel 3 Valley Winding Temperature 1 Peak (CT Series Only) Winding Temperature 2 Peak (CT Series Only) Winding Temperature 3 Peak (CT Series Only) Highest Winding Temperature Peak (CT Series Only) Winding Temperature 1 Valley (CT Series Only) Winding Temperature 2 Valley (CT Series Only) Winding Temperature 3 Valley (CT Series Only) Highest Winding Temperature Valley (CT Series Only) Current 1 Peak (CT Series Only) Current 2 Peak (CT Series Only) Current 3 Peak (CT Series Only) Highest Current Peak (CT Series Only) Current 1 Valley (CT Series Only) Current 2 Valley (CT Series Only) Current 3 Valley (CT Series Only) Highest Current Valley (CT Series Only) LTC Differential Temperature Peak (LTC and CT/LTC Only) Deviation Temp. (Change from initial differential, LTC and CT/LTC Only) Not Implemented Not Implemented Not Implemented Not Implemented Not Implemented Not Implemented Not Implemented Not Implemented Not Implemented Not Implemented Not Implemented Not Implemented Not Implemented Not Implemented Not Implemented Not Implemented Bit 7 is set, and the time is updated whenever a new peak or valley is recorded. The bit is cleared for a point immediately after the point's previous peak or valley is reset. Use this function in combination with object 30, variation 1 to time-stamp peak and valley values. Non-implemented channels return 0 in bits 0 and 7 and a 01/01/00 00:00:00.000 time stamp.

Object	Variation	Type	Point	Description
10	2	Binary Output With Status. (Static, Read) Status Octet: Bit 7 = State (0, 1) Bit 6 = N/A Bit 5 = N/A Bit 4 = N/A Bit 3 = N/A Bit 2 = N/A Bit 1 = N/A Bit 0 = On / Off Line Bit 0: 0 = Off Line 1 = On Line	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35	Relay 1 Remote Control. Enabled = 1, Disabled = 0 Relay 2 Remote Control. Enabled = 1, Disabled = 0 Relay 3 Remote Control. Enabled = 1, Disabled = 0 Relay 4 Remote Control. Enabled = 1, Disabled = 0 Relay 5 Remote Control. Enabled = 1, Disabled = 0 Relay 6 Remote Control. Enabled = 1, Disabled = 0 Relay 7 Remote Control. Enabled = 1, Disabled = 0 Relay 8 Remote Control. Enabled = 1, Disabled = 0 Relay 9 Remote Control. Enabled = 1, Disabled = 0 Relay 10 Remote Control. Enabled = 1, Disabled = 0 Relay 11 Remote Control. Enabled = 1, Disabled = 0 Relay 12 Remote Control. Enabled = 1, Disabled = 0 Relay 1 coil state. Energized = 1, De-energized = 0 Relay 2 coil state. Energized = 1, De-energized = 0 Relay 3 coil state. Energized = 1, De-energized = 0 Relay 4 coil state. Energized = 1, De-energized = 0 Relay 5 coil state. Energized = 1, De-energized = 0 Relay 6 coil state. Energized = 1, De-energized = 0 Relay 7 coil state. Energized = 1, De-energized = 0 Relay 8 coil state. Energized = 1, De-energized = 0 Relay 9 coil state. Energized = 1, De-energized = 0 Relay 10 coil state. Energized = 1, De-energized = 0 Relay 11 coil state. Energized = 1, De-energized = 0 Relay 12 coil state. Energized = 1, De-energized = 0 Relay 1 Normal Coil State. Energized = 1, De-energized = 0 Relay 2 Normal Coil State. Energized = 1, De-energized = 0 Relay 3 Normal Coil State. Energized = 1, De-energized = 0 Relay 4 Normal Coil State. Energized = 1, De-energized = 0 Relay 5 Normal Coil State. Energized = 1, De-energized = 0 Relay 6 Normal Coil State. Energized = 1, De-energized = 0 Relay 7 Normal Coil State. Energized = 1, De-energized = 0 Relay 8 Normal Coil State. Energized = 1, De-energized = 0 Relay 9 Normal Coil State. Energized = 1, De-energized = 0 Relay 10 Normal Coil State. Energized = 1, De-energized = 0 Relay 11 Normal Coil State. Energized = 1, De-energized = 0 Relay 12 Normal Coil State. Energized = 1, De-energized = 0

Object	Variation	Type	Point	Description
12	1	Control Relay Output Block. (Static, Write) Notes:	0 1 2 3 4 5 6 7 8 9 10 11	Relay 1. See supported control codes. Relay 2 . See supported control codes. Relay 3. See supported control codes Relay 4. See supported control codes Relay 5. See supported control codes Relay 6. See supported control codes Relay 7. See supported control codes Relay 8. See supported control codes Relay 9. See supported control codes Relay 10. See supported control codes Relay 11. See supported control codes Relay 12. See supported control codes Control Codes Supported: 0 = NUL 1 = Pulse on. Relay energized until timer times out. 2 = Pulse off. Relay de-energized until timer times out. 3 = Latch on. Local Control will not supercede if set point exceeded. 4 = Latch off. 5 through 15 are undefined. Queue, Clear and Trip/Close bits set to 0.
20	1	Binary Counter (Static, Read)	0 1 2	Advantage Model (3 to 9 = G3T to G9T) Firmware Version Number. (0-3E7 Hex) Firmware Revision Number (0-63 Hex)

Object	Variation	Type	Point	Description
30	1	32 Bit Analog Input with Status. (Static, Read) Status Octet: Bit 7 = N/A Bit 6 = Ref Check Bit 5 = N/A Bit 4 = N/A Bit 3 = N/A Bit 2 = N/A Bit 1 = N/A Bit 0 = Flag Bit 6: 0 = Normal 1 = Error Bit 0: 0 = True (Off Line) 1 = False (On Line)	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43	RTD Channel 1 Present Value. Bit 6 = Sensor, Internal Failure? RTD Channel 2 Present Value. Bit 6 = Sensor, Internal Failure? RTD Channel 3 Present Value. Bit 6 = Sensor, Internal Failure? Winding 1 Present Temperature (CT Series Only) Winding 2 Present Temperature (CT Series Only) Winding 3 Present Temperature (CT Series Only) Highest Present Winding Temperature (CT Series Only) Dedicated Current 1 Present Value.(CT Series Only) Bit 6 > 150%? Dedicated Current 2 Present Value.(CT Series Only) Bit 6 > 150%? Dedicated Current 3 Present Value.(CT Series Only) Bit 6 > 150%? Highest Present Current Value (CT Series Only) LTC Differential Present Temperature. Bit 0, 6 = Over Range? Deviation Temp. (Change from initial differential, LTC and CT/LTC Only) LCAM Channel 1 (general purpose aux input, non-CT series) LCAM Channel 2 (general purpose aux input) LCAM Channel 3 (general purpose aux input) LCAM Channel 4 (general purpose aux input) LCAM Channel 5 (general purpose aux input) LCAM Channel 6 (general purpose aux input) LCAM Channel 7 (general purpose aux input) LCAM Channel 8 (general purpose aux input) RTD Channel 1 Peak RTD Channel 2 Peak RTD Channel 3 Peak RTD Channel 1 Valley RTD Channel 2 Valley RTD Channel 3 Valley Winding 1 Peak Temperature (CT Series Only) Winding 2 Peak Temperature (CT Series Only) Winding 3 Peak Temperature (CT Series Only) Highest Winding Temperature Peak (CT Series Only) Winding 1 Valley Temperature (CT Series Only) Winding 2 Valley Temperature (CT Series Only) Winding 3 Valley Temperature (CT Series Only) Highest Winding Temperature Valley (CT Series Only) Current 1 Peak Value.(CT Series Only) Bit 6 = Beyond 150%? Current 2 Peak Value.(CT Series Only) Bit 6 = Beyond 150%? Current 3 Peak Value.(CT Series Only) Bit 6 = Beyond 150%? Highest Peak Current Value (CT Series Only) Current 1 Valley Value.(CT Series Only) Bit 6 = Beyond 150%? Current 2 Valley Value.(CT Series Only) Bit 6 = Beyond 150%? Current 3 Valley Value.(CT Series Only) Bit 6 = Beyond 150%? Highest Valley Current Value (CT Series Only) LTC Differential Peak Temperature. Bit 6 = Over Range? See object 2, variation 2 for peak and valley time-stamp capability. In cases where a model does not support a point, or the measurement function is disabled, bit zero will be cleared (offline indication) and a value of zero will be returned. LCAM channels 1-3 may be equipped to measure current only, or to serve as a general purpose inputs. When an Advantage model is NOT using these channels for winding current measurement, points 7, 8 and / or 9 will return a cleared bit zero and a zero value. If an Advantage model ***is*** using LCAM channels 1, 2 and / or 3 for winding current measurement, points 13, 14 and / or 15 respectively will return a cleared bit zero and a zero value

Object	Variation	Type	Point	Description
40	2	16 Bit Analog Output Status (Static, Read) Status Byte: Bit 7 = N/A Bit 6 = N/A Bit 5 = N/A Bit 4 = N/A Bit 3 = N/A Bit 2 = N/A Bit 1 = N/A Bit 0 = N/A See note 1 at the bottom of the table.	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23	Alarm 1 Set Point Alarm 2 Set Point Alarm 3 Set Point Alarm 4 Set Point Alarm 5 Set Point Alarm 6 Set Point Alarm 7 Set Point Alarm 8 Set Point Alarm 9 Set Point Alarm 10 Set Point Alarm 11 Set Point Alarm 12 Set Point Alarm 1 Hysteresis Alarm 2 Hysteresis Alarm 3 Hysteresis Alarm 4 Hysteresis Alarm 5 Hysteresis Alarm 6 Hysteresis Alarm 7 Hysteresis Alarm 8 Hysteresis Alarm 9 Hysteresis Alarm 10 Hysteresis Alarm 11 Hysteresis Alarm 12 Hysteresis
41	2	16 Bit Analog Output Block (Static, Write) Control Codes Supported: 0 = 0 (NUL) 1 = 0 2 = 0 3 = 0 4 = 0 5 through 15 are undefined. Queue = 0 Clear = 0 Trip/Close bit = 0 See note 2 at the bottom of the table.	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23	Alarm 1 Set Point Alarm 2 Set Point Alarm 3 Set Point Alarm 4 Set Point Alarm 5 Set Point Alarm 6 Set Point Alarm 7 Set Point Alarm 8 Set Point Alarm 9 Set Point Alarm 10 Set Point Alarm11 Set Point Alarm 12 Set Point Alarm 1 Hysteresis Alarm 2 Hysteresis Alarm 3 Hysteresis Alarm 4 Hysteresis Alarm 5 Hysteresis Alarm 6 Hysteresis Alarm 7 Hysteresis Alarm 8 Hysteresis Alarm 9 Hysteresis Alarm 10 Hysteresis Alarm 11 Hysteresis Alarm 12 Hysteresis
50	1	Time & Date (Read & Write)	0	Time and Date
60	1	Class 0 Data (Read)	All	Using qualification code 06 returns all static data.

Notes:

1. Actual load current set point and displayed values are allowed to range from 0 to 99999 amps. Set point values for DNP-3 level 1 slaves, however; are limited to the range of $\pm 2^{15} - 1$ ($\pm$ 32767). In order to remain within that range, and alarm up to 99990 amps, the load current read from the data point is 1/10 of the actual value. The range of values read directly would therefore be 0 to 9999 (no negative range for load current) and the user's application program must multiply by 10 to restore the actual value of the set point. This limitation applies to load current values only.

2. For the reasons expressed in note 1, load current values which are written to the set point must be 1/10 of the actual value, up to a maximum of 9999 amps. The user's application program must divide the desired set point value by 10 to create the value which is written to the set point. This limitation applies to load current values only.

Section 4.0.0: ModBus Protocol

4.0.1 General

Modbus is the undisputed first choice of end users and integrators when designing for power generation control systems. The Modbus/RTU protocol defines how a master device polls one or more slave devices to read and write data in real time over RS-232, RS-422, or RS-485 serial data communications busses. Although not the most powerful protocol available, its simplicity allows not only rapid implementation but also enough flexibility to be applied in a large number of industrial situations.

MODBUS is a request/reply protocol which offers services specified by function codes. MODBUS function codes are elements of MODBUS request/reply protocol data units (PDU's). A PDU comprises address, function code, data and error code fields.

The purpose of this section is to describe the function codes used within the framework of MODBUS transactions.

4.1.0 Register Definitions

4.1.1 Input Registers (Read Only - MODBUS Function 04):

Register Number(s)	Size (bytes)	Advantage Data Name	Notes
0	2	Advantage Model code	
1	2	Firmware Version	
2	2	Firmware Revision	
3 - 9	-	None	Free
10	2	RTD Channel 1 present value	(2)
11	2	RTD Channel 1 Peak Value	(2)
12 - 14	6	RTD Channel 1 Peak Date/Time	(1)
15	2	RTD Channel 1 Valley Value	(2)
16 - 18	6	RTD Channel 1 Valley Date/Time	(1)
19	2	RTD Channel 2 present value	(2)
20	2	RTD Channel 2 Peak Value	(2)
21 - 23	6	RTD Channel 2 Peak Date/Time	(1)
24	2	RTD Channel 2 Valley Value	(2)
25 - 27	6	RTD Channel 2 Valley Date/Time	(1)
28	2	RTD Channel 3 present value	(2)
29	2	RTD Channel 3 Peak Value	(2)
30 - 32	6	RTD Channel 3 Peak Date/Time	(1)
33	2	RTD Channel 3 Valley Value	(2)
34 - 36	6	RTD Channel 3 Valley Date/Time	(1)

Register Number(s)	Size (bytes)	Advantage Data Name	Notes
37 - 99	-	None	Free
100	2	Winding 1 Present Temperature	(2) - CT series only
101	2	Winding 1 Peak Temperature	(2) - CT series only
102 - 104	6	Winding 1 Peak Date/Time	(1) - CT series only
105	2	Winding 1 Valley Temperature	(2) - CT series only
106 - 108	6	Winding 1 Valley Date/Time	(1) - CT series only
109	2	Winding 2 Present Temperature	(2) - CT series only
110	2	Winding 2 Peak Temperature	(2) - CT series only
111 - 113	6	Winding 2 Peak Date/Time	(1) - CT series only
114	2	Winding 2 Valley Temperature	(2) - CT series only
115 - 117	6	Winding 2 Valley Date/Time	(1) - CT series only
118	2	Winding 3 Present Temperature	(2) - CT series only
119	2	Winding 3 Peak Temperature	(2) - CT series only
120 - 122	6	Winding 3 Peak Date/Time	(1) - CT series only
123	2	Winding 3 Valley Temperature	(2) - CT series only
124 - 126	6	Winding 3 Valley Date/Time	(1) - CT series only
127	2	Highest Winding Present Temperature	(2) - CT series only
128	2	Highest Winding Peak Temperature	(2) - CT series only
129 - 131	6	Highest Winding Peak Date/Time	(1) - CT series only
132	2	Highest Winding Valley Temperature	(2) - CT series only
133 - 135	6	Highest Winding Valley Date/Time	(1) - CT series only
136 / 137	4	Current 1 Present Value	(3) - CT series only
138 / 139	4	Current 1 Peak	(3) - CT series only
140 - 142	6	Current 1 Peak Date/Time	(1) - CT series only
143 / 144	4	Current 1 Valley	(3) - CT series only
145 - 147	6	Current 1 Valley Date/Time	(1) - CT series only
148 / 149	4	Current 2 Present Value	(3) - CT series only
150 / 151	4	Current 2 Peak	(3) - CT series only
152 - 154	6	Current 2 Peak Date/Time	(1) - CT series only
155 / 156	4	Current 2 Valley	(3) - CT series only
157 - 159	6	Current 2 Valley Date/Time	(1) - CT series only
160 / 161	4	Current 3 Present Value	(3) - CT series only

Register Number(s)	Size (bytes)	Advantage Data Name	Notes
162 / 163	4	Current 3 Peak	(3) - CT series only
164 - 166	6	Current 3 Peak Date/Time	(1) - CT series only
167 / 168	4	Current 3 Valley	(3) - CT series only
169 - 171	6	Current 3 Valley Date/Time	(1) - CT series only
172 / 173	4	Highest Current Present Value	(3) - CT series only
174 / 175	4	Highest Current Peak	(3) - CT series only
176 - 178	6	Highest Current Peak Date/Time	(1) - CT series only
179 / 180	4	Highest Current Valley	(3) - CT series only
181 - 183	6	Highest Current Valley Date/Time	(1) - CT series only
184	2	LTC Differential Present Temperature	(2) - LTC & CT/LTC Only
185	2	LTC Differential Peak Temperature	(2) - LTC & CT/LTC Only
186 - 188	6	LTC Differential Peak Date/Time	(1) - LTC & CT/LTC Only
189	2	LTC Deviation Temperature	(2) - LTC & CT/LTC Only
190 - 192	6	LTC Deviation Date/Time	(1) - LTC & CT/LTC Only
193 / 194	4	LCAM Channel 1 Present Value	(3)(4)
195 / 196	4	LCAM Channel 2 Present Value	(3)(4)
197 / 198	4	LCAM Channel 3 Present Value	(3)(4)
199 / 200	4	LCAM Channel 4 Present Value	(3)(4)
201 / 202	4	LCAM Channel 5 Present Value	(3)(4)
203 / 204	4	LCAM Channel 6 Present Value	(3)(4)
205 / 206	4	LCAM Channel 7 Present Value	(3)(4)
207 / 208	4	LCAM Channel 8 Present Value	(3)(4)

4.1.2 Holding Registers (Read / Write - MODBUS Functions 03 / 06):

Register Number(s)	Size (bytes)	Advantage Data Name	Notes
0 - 2	6	Current Date/Time	(1)
3 - 9	-	None	Free
10	2	Alarm 1 Setpoint	(5)
11	2	Alarm 1 Hysteresis	(5)
12	2	Alarm 1 Operated Relay	(6)
13	2	Alarm 2 Setpoint	(5)
14	2	Alarm 2 Hysteresis	(5)
15	2	Alarm 2 Operated Relay	(6)
16	2	Alarm 3 Setpoint	(5)
17	2	Alarm 3 Hysteresis	(5)
18	2	Alarm 3 Operated Relay	(6)
19	2	Alarm 4 Setpoint	(5)
20	2	Alarm 4 Hysteresis	(5)
21	2	Alarm 4 Operated Relay	(6)
22	2	Alarm 5 Setpoint	(5)
23	2	Alarm 5 Hysteresis	(5)
24	2	Alarm 5 Operated Relay	(6)
25	2	Alarm 6 Setpoint	(5)
26	2	Alarm 6 Hysteresis	(5)
27	2	Alarm 6 Operated Relay	(6)
28	2	Alarm 7 Setpoint	(5)
29	2	Alarm 7 Hysteresis	(5)
30	2	Alarm 7 Operated Relay	(6)
31	2	Alarm 8 Setpoint	(5)
32	2	Alarm 8 Hysteresis	(5)
33	2	Alarm 8 Operated Relay	(6)
34	2	Alarm 9 Setpoint	(5)
35	2	Alarm 9 Hysteresis	(5)
36	2	Alarm 9 Operated Relay	(6)
37	2	Alarm 10 Setpoint	(5)
38	2	Alarm 10 Hysteresis	(5)

Register Number(s)	Size (bytes)	Advantage Data Name	Notes
39	2	Alarm 10 Operated Relay	(6)
40	2	Alarm 11 Setpoint	(5)
41	2	Alarm 11 Hysteresis	(5)
42	2	Alarm 11 Operated Relay	(6)
43	2	Alarm 12 Setpoint	(5)
44	2	Alarm 12 Hysteresis	(5)
45	2	Alarm 12 Operated Relay	(6)
46 - 99	-	None	Free
100	2	Relay 1 Remote Control Function	(7)
101	2	Relay 2 Remote Control Function	(7)
102	2	Relay 3 Remote Control Function	(7)
103	2	Relay 4 Remote Control Function	(7)
104	2	Relay 5 Remote Control Function	(7)
105	2	Relay 6 Remote Control Function	(7)
106	2	Relay 7 Remote Control Function	(7)
107	2	Relay 8 Remote Control Function	(7)
108	2	Relay 9 Remote Control Function	(7)
109	2	Relay 10 Remote Control Function	(7)
110	2	Relay 11 Remote Control Function	(7)
111	2	Relay 12 Remote Control Function	(7)

4.1.3 Discrete Inputs Registers (Read Only - MODBUS Function 02):

Register Number(s)	Size (bits)	Advantage Data Name	Notes
0	1	Alarm 1 Status	0 => Not Alarmed 1 => Alarmed
1	1	Alarm 2 Status	
2	1	Alarm 3 Status	
3	1	Alarm 4 Status	
4	1	Alarm 5 Status	
5	1	Alarm 6 Status	
6	1	Alarm 7 Status	
7	1	Alarm 8 Status	
8	1	Alarm 9 Status	
9	1	Alarm 10 Status	
10	1	Alarm 11 Status	
11	1	Alarm 12 Status	
12 - 31	-	None	Free
32	1	LCAM 1 Alarm Status	0 => Not Alarmed 1 => Alarmed
33	1	LCAM 2 Alarm Status	
34	1	LCAM 3 Alarm Status	
35	1	LCAM 4 Alarm Status	
36	1	LCAM 5 Alarm Status	
37	1	LCAM 6 Alarm Status	
38	1	LCAM 7 Alarm Status	
39	1	LCAM 8 Alarm Status	
40 - 47	-	None	Free
48	1	Relay 1 Coil State	0 => De-energized 1 => Energized
49	1	Relay 2 Coil State	
50	1	Relay 3 Coil State	
51	1	Relay 4 Coil State	
52	1	Relay 5 Coil State	
53	1	Relay 6 Coil State	
54	1	Relay 7 Coil State	
55	1	Relay 8 Coil State	
56	1	Relay 9 Coil State	
57	1	Relay 10 Coil State	
58	1	Relay 11 Coil State	
59	1	Relay 12 Coil State	
60 - 79	-	None	Free

Register Number(s)	Size (bits)	Advantage Data Name	Notes
80	1	Relay 1 Coil Normal State	0 => De-energized 1 => Energized
81	1	Relay 2 Coil Normal State	
82	1	Relay 3 Coil Normal State	
83	1	Relay 4 Coil Normal State	
84	1	Relay 5 Coil Normal State	
85	1	Relay 6 Coil Normal State	
86	1	Relay 7 Coil Normal State	
87	1	Relay 8 Coil Normal State	
88	1	Relay 9 Coil Normal State	
89	1	Relay 10 Coil Normal State	
90	1	Relay 11 Coil Normal State	
91	1	Relay 12 Coil Normal State	
92 - 107	-	None	Free

4.2.0 Notes

(1) Date/Time structure

Three consecutive registers are used to report or set a date/time value:

Register		**Register + 1**		**Register + 2**	
High Byte	Low Byte	High Byte	Low Byte	High Byte	Low Byte
Year	Month	Day	Hour	Minute	Second
0 - 255	1 - 12	1 - 31	0 - 23	0 - 59	0 - 59

- Add 2000 to the value of a reported year when reconstructing the present year.
- Subtract 2000 from present year values, before writing to a register.

(2) Temperature Reading values

- All temperature sources will report their current values with a 16 bit signed register.
- If reading is available, reported value will be [temperature x 10].
- If reading is not available (as if requesting RTD channel 2 on a SC model), reported value will be -10000.
- If RTD sensor for temperature source is reporting a failure, reported value will be 8888 or -8888.

(3) High/Low values

Two consecutive registers are used to report a 32 bits signed value. Evaluation of value should only be performed as a 32 bits signed register.

Register	Register + 1
High Word	Low Word

(4) LCAM Readings

- If channel is configured as VOLTS AC or VOLTS DC, reading is given in [Volts x 100].
- If channel is configured as AMPS DC, reading is given in microamps.
- If channel is configured as AMPS AC, reading is given in [Amps x 10].
- If channel is configured as DRY CONTACT, the High Word reading will be [0] for closed contact and [1] for an opened contact. The Low Word reading is given in [Volts x 100] and reports the voltage across the LCAM input.
- If reading is not available (as if requesting a disabled or nonexistent channel, or a channel configured as Winding Current), reported value will be -10000.

(5) Alarm Setpoint and Hysteresis

- For temperature sources Setpoint or Hysteresis, write the [desired value x 10]. When reading, it will report [current setting x 10].
- For current sources Setpoint, write the [desired value / 10]. When reading, it will report [current setting / 10].
- For current sources Hysteresis, write the [desired value]. When reading, it will report [current setting].

(6) Alarm operated relay

Register Value	Function when writing	Function when reading
-10000 (0xD8F0)	Disable alarm	Alarm disabled
0	Enable alarm, with no operated relay	Alarm enabled. No operated relay selected
1 - 12	Enable alarm, operating relay [1 - 12]	Alarm enabled, operating relay [1 - 12]

(7) Relay Remote control

Register Value (HEX)	Function when writing	Function when reading
0x0000	Return to local control	Remote control OFF - Local control ON
0x0001 - 0x7FFE	Set Pulse ON time, in seconds	Remaining Pulse ON time, in seconds
0x7FFF	Latch ON	Remote control ON - Lached ON
0x8001 -0xFFFE	Set Pulse OFF time, in seconds (time is set value - 0x8000)	Remaining Pulse OFF time, in seconds (time is read value - 0x8000)
0xFFFF	Latch OFF	Remote control ON - Lached OFF