TriStar 600V MPPT
MODBUS® Specification

V04
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Morningstar Corporation
8 Pheasant Run
Newtown, PA 18940
www.morningstarcorp.com
info@morningstarcorp.com

General Information

The TriStar MPPT 600V supports the industry standard MODBUS® application protocol via its serial RS-232 and EIA-485 interfaces and MODBUS TCP via the Ethernet port. This document assumes the user is familiar with both MODBUS® protocols. Please refer to the documents listed in the References section for more information. C and Java Script functions appear at the end of this document [ADD COMMANDS?].

Parameters

The TriStar MPPT 600V supports RTU mode only.
16-bit MODBUS addresses (per the modbus.org spec)

The serial communication parameters:

- BPS 9600 baud
- Parity None
- Data bits 8
- Stop bits 1 or 2*
- Flow control None

*The TriStar accepts either 1 or 2 stop bits. It will send 2 stop bits to provide extra byte padding. The connected PC can be set to receive either 1 or 2 stop bits.

The default TCP communication parameters:

DHCP	enabled
Port	502
MODBUS ID	1
NETBIOS address	tsmppt600v + serial number (no spaces)
LiveView Web address	http://tsmppt600vXXXXXXX (where X is the serial number)

If DHCP fails, the following default parameters will be assigned:

IP	192.168.1.253
Gateway	192.168.1.1
Primary DNS	192.168.1.1
Secondary DNS	192.168.1.1
Subnet Mask	255.255.255.0

Note: the TCP socket is closed by the TS-MPPT after each MODBUS response (change pending)

All addresses listed are for the request PDU.

The following tables are only for v13 and later software revisions. The v13 update introduced floating point representations that were fixed-point in prior versions. Both IEEE748-2008 single-precision (designated as float 32 or f32) and half-precision (designated as float 16 or f16) are used.

Supported MODBUS Functions

Read Holding Registers (0x03) and Read Input Registers (0x04)

RAM

PDU Addr	Logical Addr	Variable name	Variable description	Units	Signed	Scaling or Range
Scaling Values						
0x0000	1	V_PU hi	NOT USED IN FIRMWARE VERSIONS 19 and HIGHER	V		-
0x0001	2	V_PU lo		-		-
0x0002	3	I_PU hi		A		-
0x0003	4	I_PU lo		-		-
0x0004	5	ver_sw	Software Version	-		-
0x0005	6	ver_fpga	FPGA Version	-		-
0x0006	7	n-sys-v	System voltage multiplier (48V=4)			
0x0008 – 0x0017	8-24	RESERVED				
Filtered ADC						
0x0018	25	adc_vb_f_med	Battery voltage, filtered (τ ≈ ?s)	V	√	f16
0x0019	26	adc_vbterm_f	Batt. Terminal voltage, filtered (τ ≈ ?s)	V	√	f16
0x001A	27	adc_vbs_f	Battery Sense voltage, filtered (τ ≈ ?s)	V	√	f16
0x001B	28	adc_va_f_shadow	Array voltage, filtered (τ ≈ ?s)	V	√	f16
0x001C	29	adc_ib_f_shadow	Battery current, filtered (τ ≈ ?s)	A	√	f16
0x001D	30	adc_ia_f_shadow	Array current, filtered (τ ≈ ?s)	A	√	f16
0x001E	31	adc_p12_f	12 volt supply, filtered (τ ≈ ?s)	V	√	f16
0x001F	32	adc_p3_f	3 volt supply, filtered (τ ≈ ?s)	V	√	f16
0x0020	33	adc_pmeter_f	MeterBus voltage, filtered (τ ≈ ?s)	V	√	f16
0x0021	34	adc_p12ext_f	External 12V supply,filtered(τ ≈ s)	V	√	f16
0x0022	35	adc_fp12_f	?????	V	√	f16
Temperatures						
0x0023	36	T_hs	Heatsink temperature	C	√	f16
0x0024	37	T_rts	(NaN if not available)	C	√	f16
0x0025	38	T_batt	(NaN if not available)	C	√	f16
0x0026	39	adc_vb_f_1m	Battery voltage, filtered (τ ≈ 1min)	V	√	f16
0x0027	40	adc_ib_f_1m	Charging current, filtered (τ ≈ 1min)	A	√	f16
0x0028	41	vb_min	Minimum battery voltage	V	√	f16
0x0029	42	vb_max	Maximum battery voltage	V	√	f16
0x002A	43	hourmeter_hi	hourmeter, HI word	h		-
0x002B	44	hourmeter_lo	hourmeter, LO word	h		-
0x002C	45	fault_i_h	Controller faults bit-field - HI	-		-
0x002D	46	fault_i_l	Controller faults bit-field - LOW	-		
0x002E	47	alarm_i_h	Alarm bit-field – HI word	-		-
0x002F	48	alarm_i_l	Alarm bit-field – LO word	-		-
0x0030	49	powerboard_status_dipsw	DIP switch positions bit-field	-		-
0x0031	50	led_state	State of LED indications	-		-
Charger						
0x0032	51	mb_charge_state	Charging stage	-		-
0x0033	52	vb_ref	Target regulation voltage	V	√	f16

0x0034	53	Ahc_r_hi	Ah charge – resettable	Ah		f32
0x0035	54	Ahc_r _lo		-		
0x0036	55	Ahc_t_hi	Ah charge – total	Ah		f32
0x0037	56	Ahc_t_lo		-		
0x0038	57	kwhc_r	kWhr charge resettable	kWh		f16
0x0039	58	kwhc_t	kWhr charge total	kWh		f16
MPPT						
0x003A	59	mb_power_out	Output Power	W		f16
0x003B	60	mb_power_in	Input Power	W		f16
0x003C	61	sweep_Pin_max	Max. Power of last sweep	W		f16
0x003D	62	sweep_vmp	Vmp of last sweep	V	√	f16
0x003E	63	sweep_voc	Voc of last sweep	V	√	f16
0x003F	64	RESERVED				
Logger – Daily Values						
0x0040	65	vb_min_daily	Min. daily battery voltage	V	√	f16
0x0041	66	vb_max_daily	Max. daily battery voltage	V	√	f16
0x0042	67	va_max_daily	Max. daily input voltage	V	√	f16
0x0043	68	Ahc_daily	Total Ah charge daily	Ah		f16
0x0044	69	Whc_daily	Total Wh charge daily	Wh		
0x0045	70	flags_daily	Daily flags bit-field	-		
0x0046	71	Pout_max_daily	Max. Power Out, daily	W		f16
0x0047	72	Tb_min_daily	(NaN if not available)	C	√	f16
0x0048	73	Tb_max_daily	(NaN if not available)	C	√	f16
0x0049	74	fault_daily_i_h	Faults, daily	-		
0x004A	75	fault_daily_i_l	Faults, daily	-		
0x004B	76	alarm_daily_i_h	Daily alarms bit-field	-		
0x004C	77	alarm_daily_i._l	Daily alarms bit-field	-		
0x004D	78	time_ab_daily	Cumulative time in absorption, daily	s		
0x004E	79	time_eq_daily	Cumulative time in equalize, daily	s		
0x004F	80	time_fl_daily	Cumulative time in float, daily	s		
0x0050-0x0058	81-89	RESERVED				
Manual Control						
0x0059	90	vb_ref_slave	battery voltage regulation override	V	√	f16
0x005A	91	va_ref_fixed	Array V fixed voltage target	V	√	f16
0x005B	92	va_ref_fixed_pct	Ratio of Voc, 0=0%, 1.0=100%	%		f16 (0.0-1.0)
0x005C-0x0067	93-104	RESERVED				
0x0068	105	ib_ref_charge_slave	Array current regulation override	A	√	f16
Active TCP Network Settings						
0x1000 – 0x100E		RESERVED				
0x100F	4112	IPAddrByte [1][0]	IP Address Bytes	-		
0x1010	4113	IPAddrByte [3][2]	IP Address Bytes	-		
0x1011	4114	SubNetMask [1][0]	Subnet Mask Bytes	-		
0x1012	4115	SubNetMask [3][2]	Subnet Mask Bytes	-		
0x1013	4116	Gateway [1][0]	Gateway Bytes	-		
0x1014	4117	Gateway [3][2]	Gateway Bytes	-		
0x1015	4118	PrimaryDNS [1][0]	PrimaryDNS Bytes	-		
0x1016	4119	PrimaryDNS [3][2]	PrimaryDNS Bytes	-		
0x1017	4120	SecondaryDNS [1][0]	SecondaryDNS Bytes	-		
0x1018	4121	SecondaryDNS [3][2]	SecondaryDNS Bytes	-		
0x1019-0x101C		RESERVED				

0x101D–0x1024	4125 - 4132	ControllerID	String of 16 bytes, 00 terminates string	-		ASCII
0x1025	4133	NetFlags	0x4000=DHCP Enabled, 0x0=DHCP disabled	-		
0x1026	4134	MACAddress[1],[0]	MAC Address Bytes	-		
0x1027	4135	MACAddress[3],[2]	MAC Address Bytes	-		
0x1028	4136	MACAddress[5],[4]	MAC Address Bytes	-		
0x1029–0x1030	4137 - 4144	NetBIOS Name	String of 16 bytes, 00 terminates string	-		ASCII

EEPROM

PDU Addr	Logical Addr	Variable name	Variable description	Units	Signed	Scaling or Range
TCP Network Settings						
0x151B	5404	HTTPPort	HTTP Port Number	-		1 to 65535
0x151C	5405	MBIPPort	MODBUS IP Port Number	-		1 to 65535
0x151D	5406	NetRules	BIT0: IP Bridging Enabled	-		0 or 1
0x151E	5407	SNMPTrapRecPort	SNMP Trap Destination NMS Port	-		1 to 65535
0x151F	5408	Ethernet Power Save Mode	Bit0: Power Save On=1	-		
0x1520	5409	***BETA 8.21*** VLAN Enable	Bit0: Vlan Tagging regognition/sending = 1			
0x1521	5410	***BETA 8.21*** VLAN Parameters	Bit 0-11 VID 0-4094, 4095 reserved, Bit 12 CFI (usually 0) Bits 15-13 PCP Priority 0-7			
0x1522 – 0x1528	…	RESERVED				
0x152B – 0x1534	…	RESERVED				
Charge settings						
0xE000	57345	EV_absorp	Absorption voltage @ 25ºC	V	√	f16
0xE001	57346	EV_float	Float voltage @ 25ºC Set to zero to disable float	V	√	f16
0xE002	57347	Et_absorp	absorption time	s		$0-(2^{16}-1)$
0xE003	57348	Et_absorp_ext	absorption extension time	s		$0-(2^{16}-1)$
0xE004	57349	EV_absorp_ext	absorp. Extension threshold voltage	V	√	f16
0xE005	57350	EV_float_cancel	Voltage that cancels float	V	√	f16
0xE006	57351	Et_float_exit_cum	Exit float timer	s		$0-(2^{16}-1)$
0xE007	57352	EV_eq	Equalize V @ 25ºC Set 0 to disable	V	√	f16
0xE008	57353	Et_eqcalendar	days between eq cycles	days		0-255
0xE009	57354	Et_eq_above	equalize time limit above Vreg	s		$0-(2^{16}-1)$
0xE00A	57355	Et_eq_reg	equalize time limit at Veq	s		$0-(2^{16}-1)$
0xE00B	57356	Et_batt_service	battery service timer	days		
0xE00C	57357	RESERVED				
0xE00D	57558	EV_tempcomp	temp. compensation coefficient Note:2^-16 scaling, negative assumed	V		f16
0xE00E	57359	EV_hvd	Battery High Voltage Disconnect	V	√	f16
0xE00F	57360	EV_hvr	Battery High Voltage Reconnect	V	√	f16

0xE010	57361	Evb_ref_lim	battery charge reference limit	V	√	f16
0xE011	57362	ETb_max	max. temp comp limit	C	√	f16
0xE012	57363	ETb_min	min. temp comp limit	C	√	f16
0xE013	57364	RESERVED				
0xE014	57365	RESERVED				
0xE015	57366	EV_soc_g_gy	LED threshold: green to green/yellow	V	√	f16
0xE016	57367	EV_soc_gy_y	LED threshold: green/yellow to yellow	V	√	f16
0xE017	57368	EV_soc_y_yr	LED threshold: yel to yel/red	V	√	f16
0xE018	57369	EV_soc_yr_r	LED threshold: yellow/red to red	V	√	f16
0xE019	57370	Emodbus_id	MODBUS slave address	-		1-247
0xE01A	57371	Emeterbus_id	MeterBus address	-		1-15
0xE01B		RESERVED				
0xE01C		RESERVED				
0xE01D	57374	EIb_lim	Battery Current Limit	A	√	f16
0xE01E	57375	Esweep_va_max_lim		V		f16
0xE01F	57376	Esweep_va_min_lim		V		f16
0xE020	57377	EVa_ref_fixed_init	Array V fixed target voltage	V	√	f16
0xE021	57378	EVa_ref_fixed_pct_init	Ratio of Voc, 0=0%, 1.0=100%	%		f16 (0.0-1.0)
Read only section						
0xE080	57473	Ehourmeter_LO	hourmeter	h		0 to (2^{24}-1)
0xE081	57474	Ehourmeter_HI				
0xE082	57475	EAhc_r_LO	Ah charge resetable	Ah		n·0.1
0xE083	57476	EAhc_r_HI		-		
0xE084	57477	EAhc_t_LO	Ah charge total	Ah		n·0.1
0xE085	57478	EAhc_t_HI		-		
0xE086	57479	EkWhc_r_LO	kWh energy - resettable	kWh		f32
0xE087	57480	EkWhc_r_HI	kWh energy - resettable	kWh		
0xE088	57481	EVb_min	Vb minimum	V	√	f16
0xE089	57482	EVb_max	Vb maximum	V	√	f16
0xE08A	57483	EVa_max	Va maximum	V	√	f16
0xE08B	57484	Etmr_eqcalendar	days since last equalize	days		
0xE08C	57485	Etmr_batt_service	battery service timer	days		
0xE08D	57486	Elog_ptr	EE address at end of last log record			
0xE08E	57487	Ekwhc_t_LO	kWh energy - total	kWh		f32
0xE08F	57488	Ekwhc_t_HI	kWh energy - total	kWh		f32
…		RESERVED				
0xE0C0–0xE0C3	57537 – 57540	Eserial	Serial Number	-		
0xE0CC	57548	Emodel	Model: 0 = 48V, 1=120V version	-		0 or 1
0xE0CD	57549	Ehw_version	Hardware version, vMajor.Minor	-		none

Read Coils (0x01), Read Discrete Inputs (0x02), Write Single Coil (0x05)

PDU Addr	Logical Addr	Variable description
0x0000	1	Equalize triggered
0x0001	2	reserved
0x0002	3	Charge disconnect (1 will force charger into a disconnect state)
…	4-16	reserved
0x0010	17	Clear Ah resettable (set only, will always read 0)
0x0011	18	Clear Ah total (set only, will always read 0)
0x0012	19	Clear kWh 7esettable (set only, will always read 0)
0x0013	20	Reset battery service calendar
0x0014	21	Clear faults
0x0015	22	Clear Alarms
0x0016	23	Force EEPROM update (set only, will always read 0)
0x0017	24	reserved
0x0018	25	Clear kWh total (set only, will always read 0)
0x0019	26	Clear Vb_min and Vb_max (set only, will always read 0)
…	27-240	reserved
0x00F0	241	test a single phase (test mode only)
…	242-255	reserved
0x00FF	256	Reset control (respond and then reset?)
0x1000	4096	Send Test Notification 1
0x1001	4097	Send Test Notification 2
0x1002	4098	Send Test Notification 3
0x1003	4099	Send Test Notification 4
0x10FF	4351	Reset Communications Server

Write Single Register (0x06)

Any write to EEPROM will set an “EEPROM changed” fault. The control must be reset to clear this fault.
Note: No verify is performed on the write.

See EEPROM table in Read Input Registers(0x04).

Read Device Identification (0x2B, subcode 0x0E)

Only supports “basic device identification (stream access)” (ID code 0x01)

Object Id	Object Name/Description	Typical Value
0x00	VendorName	“Morningstar Corp.”
0x01	Product Code	“TS-MPPT-60-600V-48”
0x02	MajorMinorRevision (hardware major.minor. software revision)	“v01.01.01”

Variables and Definitions

Variable_name
[Logical Address][PDU Address] (Units). *Short description*.
Definition.

Read Holding and Read Input Registers
Located in processor RAM, updated continuously.

V_PU hi, V_PU lo **(NOT USED IN FIRMWARE VERSIONS 19 and HIGHER)**
[1,2][0x0000, 0x0001] (V). *voltage scaling.*
The scaling value for all voltages. The scaling value is defined as:

$V_{scaling}$ = whole.fraction = [V_PU hi].[V_PU lo]

Example:
V_PU hi = 0x004E = 78
V_PU lo = 0x03A6 = 934

V_PU lo must be shifted by 16 (divided by 2^16) and then added to V_PU hi

$V_{scaling}$ = 78 + 934/(2^16) = 78.01425

I_PU hi, I_PU lo **(NOT USED IN FIRMWARE VERSIONS 19 and HIGHER)**
[3,4][0x0002, 0x0003] (V). *current scaling.*
The scaling value for all currents. The scaling value is defined as:

$I_{scaling}$ = whole.fraction = [I_PU hi].[I_PU lo]

See the V_PU scaling example above

ver_sw
[5][0x0004] (). *Software version.*
Firmware version for the controller. The value is stored in binary coded decimal (BCD) format.
Decimal version 12 is thus stored as 0x0012 not as 0x000c.

ver_fpga
[5][0x0005] (). *FPGA version.*
Firmware version for the FPGA chip. The value is stored in binary coded decimal (BCD) format.
Decimal version 12 is thus stored as 0x0012 not as 0x000c.

Filtered ADC

Vb

[25][0x0018] (V). *battery voltage, filtered.*
Battery voltage used for regulation by the TS-MPPT. This voltage will be the same as the Battery Sense voltage if the sense connections are connected and valid. Otherwise, this value is the same as Vb_term voltage.

Vb_term

[26][0x0019] (V). *battery terminal voltage, filtered.*
Voltage measured directly at the battery power connections on the TriStar MPPT.

Vb_sense

[27][0x001A] (V). *battery sense voltage, filtered.*
Voltage measured by the Battery Sense connections on the TriStar MPPT.

Va

[28][0x001B] (V). *solar input voltage, filtered.*
Va is the terminal voltage of the solar input connection.

Ib

[29][0x001C] (A). *battery charge current, filtered.*
Charging current to the battery as measured by on-board shunts.

Ia

[30][0x001D] (A). *solar input current, filtered.*
Input current from the solar array.

Vp12

[31][0x001E] (V). *12 volt supply, filtered.*
12 Volt power supply voltage.

Vp3

[32][0x001F] (V). *3 volt supply, filtered.*
3 Volt power supply voltage.

Vmeter

[33][0x0020] (V). *MeterBus supply voltage, filtered.*
MeterBus power supply voltage.

Vp12_external

[34][0x0021] (V). *12 volt external supply, filtered.*
12 Volt external power supply voltage.

V_ref

[35][0x0022] (V). ADC *reference voltage, filtered.*
Voltage reference for ADC converters.

Temperatures

T_hs

[36][0x0023] (C). *Heatsink Temperature.*
Sunsaver MPPT Heatsink temperature. Reported in degrees C.

T_rts

[37][0x0024] (C). *RTS Temperature.*
Temperature as measured by the optional Remote Temperature Sensor (RTS). Reported in degrees C.

T_batt

[38][0x0025] (C). *Battery Temperature.*
Battery temperature as measured by the ambient temperature sensor or the optional RTS (if connected). Reported in degrees C.

Status

Vb_slow

[39][0x0026] (V). *battery voltage, slow filtered* ($\tau \approx 1\text{min}$) .
Heavily filtered battery voltage reading. Ideal for use in threshold alarms.

Ib_slow

[40][0x0027] (A). *battery charge current, slow filtered* ($\tau \approx 1$min) .
Heavily filtered charging current value.

Vb_min

[41][0x0028] (V). *minimum battery voltage.*
Long-term minimum battery voltage. Resets when Ah (resettable) is reset.

Vb_max

[42][0x0029] (V). *maximum battery voltage* .
Long-term maximum battery voltage. Resets when Ah (resettable) is reset.

hourmeter_HI / hourmeter_LO

[43, 44][0x002A, 0x002B] (hrs). H*our meter counter.*
Reports total hours of operation.

Faults

[45, 46][0x002C, 0x002D] (bit-fields). *TS-MPPT self-diagnostic faults.*
Reports faults identified by self-diagnostics. Each bit corresponds to a specific fault.

Faults Table

Bit	Fault
0	Over-current
1	FET short
2	Software bug
3	Battery HVD
4	Array HVD
5	DIP switch changed
6	Custom Settings Edit
7	RTS shorted
8	RTS disconnected
9	EEPROM re-try limit
10	Controller Reset
11	Charge Slave Control Time-out
12	RS-232 Serial to Meter Bridge
13	Battery LVD
14	Fault 15 (undefined)
15	Power-board communication fault
16	Fault 17 (software)
17	Fault 18 (software)
18	Fault 19 (software)
19	Fault 20 (software)
20	Fault 21 (software)

Faults Table (Cont.)	
Bit	Fault
21	Fault 22 (software)
22	FPGA Version
23	Current sensor reference out of range
24	Ia_ref Slave Mode Timeout
25	Fault 26 (undefined)
26	Fault 27 (undefined)
27	Fault 28 (undefined)
28	Fault 29 (undefined)
29	Fault 30 (undefined)
30	Fault 31 (undefined)
31	Fault 32 (undefined)

Example:
Bit 0 is the LSB
Faults = 0x0013 indicates the following faults have been detected:
[bit 0] over-current
[bit 1] MOSFETs shorted
[bit 4] array HVD

alarm_HI / alarm_LO

[47,48][0x002E, 0x002F] (bit-fields). *Controller self-diagnostics alarms.*
Reports alarms identified by self-diagnostics. Each bit corresponds to a specific alarm.

Alarms Table	
Bit	Alarm
0	RTS open
1	RTS shorted
2	RTS disconnected
3	Heatsink temp sensor open
4	Heatsink temp sensor shorted
5	High temperature current limit
6	Current limit
7	Current offset
8	Battery sense out of range
9	Battery sense disconnected
10	Uncalibrated
11	RTS mis-wire
12	High voltage disconnect
13	Undefined
14	System mis-wire
15	MOSFET(s) open
16	P12 voltage out of range
17	High array voltage current limit
18	Maximum ADC input value reached
19	Controller was reset

Alarms Table (Cont.)	
Bit	Alarm
20	Alarm 21 (internal)
21	P3 voltage out of range
22	De-rate limit
23	Array current offset
24	Alarm 25 (internal)
25	Ethernet alarm
26	LVD
27	Alarm 28 (software)
28	Alarm 29 (undefined)
29	Alarm 30 (undefined)
30	Alarm 31 (undefined)
31	Alarm 32 (undefined)

dip_switch

[49][0x0030] (bit-field). *switch settting positions.*
Each bit in the bit-field corresponds to an individual DIP switch setting. Useful for remote applications where access to the TriStar MPPT to verify DIP positions is not feasible. Bit 0 (LSB) corresponds to settings switch 1.

LED_state

[50][0x0031] (value).
Reports the LED state.

Value	LED State
0	LED_START
1	LED_START2
2	LED_BRANCH
3	FAST GREEN BLINK
4	SLOW GREEN BLINK
5	GREEN BLINK, 1HZ
6	GREEN_LED
7	GREEN-YELLOW_LED
8	YELLOW_LED
9	YELLOW-RED_LED
10	Not used
11	RED_LED
12	R-Y-G Sequencing ERROR
13	(R+Y) -G Sequencing ERROR
14	Not used
15	Not used
16	R-G Sequencing ERROR
17	(R+Y) – (G+Y) Sequencing ERROR
18	G+Y+R Flashing ERROR
19	(G+Y+R) Flashing 2 times

Charger

Charge_state

[51][0x0032] (value). *Charge state.*
Reports the charge state.

Value	Charge State
0	START
1	NIGHT_CHECK
2	DISCONNECT
3	NIGHT
4	FAULT
5	MPPT
6	ABSORPTION
7	FLOAT
8	EQUALIZE
9	SLAVE
10	FIXED

Vb_target

[52][0x0033] (V). *Target Voltage*.
Voltage to which the battery will be charged at any given time. This value changes with each charge stage and is temperature compensated.

Ahc_r_HI / Ahc_r_LO

[53, 54][0x0034, 0x0035] (ah). *Charge amp-hours (resettable counter).*
Reports solar amp-hours since last ah reset.

Ahc_t_HI / Ahc_t_LO

[55, 56][0x0036, 0x0037] (ah). *Charge amp-hours (Total cumulative counter).*
Reports total solar amp-hours since last total ah reset.

kWhc_r

[57][0x0038] (kWh).*Charge kilowatt-hours (resettable counter).*
Reports solar kilowatt-hours since last kWh reset.

kWhc_t

[58][0x0039] (kWh).*Charge kilowatt-hours (total counter).*
Reports total solar kilowatt-hours.

MPPT

Power_out

[59][0x003A] (W). *Charge output power.*
Output power to the battery.

Power_in

[60][0x003B] (W). *Array input power.*
Input power from the solar array. Input current is not measured by precision shunts, therefore the reported input power may have significant error.

Sweep_Pmax

[61][0x003C] (W). *Maximum array power.*
Maximum power output of the solar array found during last sweep.

Sweep_Vmp

[62][0x003D] (V). *Solar array Vmp.*
Maximum power voltage of the solar array found during last sweep.

Sweep_Voc

[63][0x003E] (V). *Solar array Voc.*
Open circuit voltage of the solar array found during last sweep.

Logger

Vb_min_daily

[65][0x0040] (V). *Today's minimum battery voltage.*
Minimum battery voltage measured today. This value is stored in the daily record at the end of each charging day. A new daily record is created X hours after NIGHT state.

Vb_max_daily

[66][0x0041] (V). *Today's maximum battery voltage.*
Maximum battery voltage measured today. This value is stored in the daily record at the end of each charging day. A new daily record is created X hours after NIGHT state.

Va_max_daily

[67][0x0042] (V). *Today's maximum array voltage.*
Maximum array voltage measured today. This value is stored in the daily record at the end of each charging day. A new daily record is created X hours after NIGHT state.

Ahc _daily

[68][0x0043] (Ah). *Today's total charge amp-hours.*
Total charging amp-hours accumulated today. This value is stored in the daily record at the end of each charging day. A new daily record is created X hours after NIGHT state.

Whc _daily

[69][0x0044] (Wh). *Today's total charge watt-hours.*
Total watt-hours accumulated today. This value is stored in the daily record at the end of each charging day. A new daily record is created at dawn the next day. Reports increments of 10 Whrs.

flags_daily

[70][0x0045] (bit-field). *Today's event flags (sticky).*
Reports daily flags, as defined below, that occurred today.

Bit	Flag
0 (LSB)	Reset detected
1	Equalize triggered
2	Float entered
3	an alarm occurred
4	a fault occurred
5	Flag 5 (undefined)
6	Flag 6 (undefined)
7	Flag 7 (undefined)

Pout_max_daily

[71][0x0046] (bit-field). *Maximum power out today.*
Reports maximum power delivered to the battery today.

Tb_min_daily

[72][0x0047] (bit-field). *Today's minimum battery temperature.*
Reports the lowest battery temperature that occurred today.

Tb_max_daily

[73][0x0048] (bit-field). *Today's maximum battery temperature.*
Reports the highest battery temperature that occurred today.

fault_daily

[74, 75][0x0049, 0x004A] (bit-fields). *Today's self-diagnostic faults (sticky).*
Reports faults identified by self-diagnostics that occurred today. Each bit corresponds to a specific fault. If a bit is set, that fault occurred at least once today. Bit order is identical to the **fault** bit-field.

alarm_HI_Daily / alarm_LO_Daily

[76, 77][0x004B, 0x004C] (bit-fields). *Today's controller self-diagnostics alarms (sticky).*
Reports alarms identified by self diagnostics that occurred today. Each bit corresponds to a specific alarm. If a bit is set, that alarm occurred at least once today. Bit order is identical to the **alarm_hi/alarm_lo** bit-field.

time_ab_daily

[78][0x004D] (s). *Cumulative time in Absorption today.*
Reports the cumulative number of seconds the battery has been in the Absorption charge stage today. Counter resets at night.

time_eq_daily

[79][0x004E] (s). *Cumulative time in Equalization today.*
Reports the cumulative number of seconds the battery has been in the Equalization charge stage today. Counter resets at night.

time_fl_daily

[80][0x004F] (s). *Cumulative time in Float today.*
Reports the cumulative number of seconds the battery has been in the Float charge stage today. Counter resets at night.

Vb_ref_slave

[90][0x0059] (V). *Battery regulation override*
Write a voltage value to this register to override the battery regulation. This allows for system control of 1 or more controllers via Modbus. Writing a non-zero value to this register forces the controller into "slave" state. The register value must be updated every 60 seconds or less, else the controller will fault. Writing to the register after a timeout will exit fault state and resume operation.

Va_ref_fixed

[91][0x005A] (V). *Array voltage fixed target*
Write a voltage value to this register to fix the Array input voltage to a specific value. If this register is a non-zero value, the MPPT function of the controller will stop (sweeping and tracking are disabled) and the array input will be fixed to the specified voltage. This value can be written at anytime during operation to adjust the array voltage target value. On start-up, this value is initialized with the non-volatile EEPROM value in register 0xE020.
Supported in processor A - V09 firmware and later.

Va_ref_fixed_pct

[92][0x005B] (%). *Array voltage percent of Voc voltage target*
Write a value to this register to fix the Array input voltage to a percent of the Array open circuit voltage. If this register is a non-zero value, the MPPT function of the controller will stop (sweeping and tracking are disabled) and the array target voltage will be fixed to the specified % of array Voc. The controller will perform periodic Voc checks and move the array voltage if needed to maintain the correct % target. If this register value is changed, the array voltage will not adjust until the next Voc check.
On start-up, this value is initialized with the non-volatile EEPROM value in register 0xE021.
Supported in processor A - V09 firmware and later.

Note: if the Va_ref_fixed (0x005A) register is non-zero, it will override this setting.

ib_ref_slave

[105][0x005C] (A). *Battery current regulation override*
Write a float16 current value to this register to override battery current regulation.Writing a non-zero value to this register forces the controller into “slave” state. The register value must be updated every 60 seconds or less, else the controller will fault. Writing to the register after a timeout will exit fault state and resume operation.
Note that other current regulators may set a lower current reference over-riding the desired current output (e.g. heatsink hot temperature current limit). The controller will regulate current to the *minimum* current reference of all regulator inputs.

EEPROM

TCP Network Settings

HTTPPort

[5404][0x151B](). *HTTP port number*
Port number assigned to the web server. Port 80 default.

MBIPPort

[5405][0x151C](). *MODBUS IP port number*
Port number used for MODBUS IP requests to the controller. Port 502 default.

NetRules

[5406][0x151D](). *Enable / Disable IP bridging to EIA-485*
Set the register bit 0 = 1 to enable bridging of MODBUS requests via Ethernet to the EIA-485 port. If this bit is set, any MODBUS requests received through Ethernet that are not addressed to the controller will be sent out to the EIA-485 port for other devices to receive/respond. All other bits reserved for future use.
Note: all requests, read and write, will be bridged to the EIA-485 network!

SNMPTrapRecPort

[5407][0x151E](). *Trap receive port*
Port number on which to broadcast a SNMP message. Port 162 default.

Ethernet Power Save Mode

[5408][0x151F](). *"Green Ethernet" feature on/off*
Set bit 0 = 1 to turn on the Green Ethernet feature. When on, the Ethernet port will power down unless an Ethernet connection is detected. The controller will check periodically for an established connection. Conserves power in systems with no Ethernet connection. Off by default.

Charge Settings

EV_absorp

[57345][0xE000](V). *Absorption voltage @ 25ºC.*
The battery will charge at 100% charge current until battery voltage reaches this set-point. The controller will begin to taper input current so that this set-point is maintained, but not exceeded.

EV_float

[57346][0xE001](V). *Float voltage @ 25ºC*
After Et_float seconds in absorption, when the battery is fully charged, the battery will transition to this lower voltage charge setting to reduce gassing.
Set to zero to disable float stage

Et_absorp

[57347][0xE002](seconds). *Time before entering float*
Defines the length of time in Absorption charge stage before transitioning to Float stage.

Et_absorp_ext

[57348][0xE003](seconds). *Time before entering float due to low battery*
If the battery voltage discharges too low during the previous night, this value allows the user to specify a longer period of time before entering float stage.

EV_absorp_ext

[57349][0xE004](V). *Voltage that triggers absorption extension time*
Battery voltage that will trigger a longer period of time (Et_absorp_ext) before entering float.

EV_float_cancel

[57350][0xE005](V). *Battery voltage threshold to cancel float*
A battery voltage threshold that will cancel float on the next charge cycle. If the battery discharged too low the previous night, the user may want to cancel float for the next day.

Et_float_exit_cum

[57351][0xE006](seconds). *Exit float timer*
Specify (cumulative) amount of time below float voltage before exiting the float stage. Battery voltage may drop below the target float voltage due to insufficient charge current or a system load draws more current from the battery than the array can provide.

EV_eq

[57352][0xE007](V). *Equalize voltage @ 25ºC*
Battery equalize voltage. Periodically equalizes cell voltages, gases the electrolyte, and helps prevent sulfation of the battery.
Set to zero to disable equalization

Et_eqcalendar

[57353][0xE008](days). D*ays between EQ cycles*
Specify the number of days between equalizations. Equalizing on a calendar basis ensures proper maintenance of batteries.

Et_eq_above

[57354][0xE009](seconds). E*qualize time limit above Vreg.*
Equalization will timeout after the specified number of seconds above PWM regulation voltage. If the battery is charged above absorption voltage but has not yet reached the equalization setting, this value serves as a safety timeout to prevent partial equalizations for extended periods of time.

Et_eq_reg

[57355][0xE00A](seconds). E*qualize time limit at Veq*
Equalization will stop after the specified number of seconds at the equalization set-point voltage.

Et_batt_service

[57356][0xE00B](days). B*attery service reminder*
Specifies the number of days between battery service reminders. Sets an alarm, prompting the user to check batteries for water, health, etc. Clear the alarm with the push-button, meter, or MODBUS alarm reset command.

EV_tempcomp

[57358][0xE00D](V/C). *Temperature compensation.*
Battery chemistry changes with temperature. Temperature compensation coefficient specifies the amount that regulation voltage will be shifted with temperature. 25ºC reference, the negative is implied (write a positive value). 12V lead-acid battery temperature compensation is approximately 0.03 V/C

EV_hvd

[57359][0xE00E](V). *High Voltage Disconnect @ 25ºC*
Flag a fault/alarm if the battery voltage exceeds this set-point. Also attempts to open the MOSFETs to stop charging. Set to zero to disable HVD

EV_hvr

[57360][0xE00F](V) *High Voltage Reconnect*
The HVD fault/alarm will be cleared once the battery voltage drops below this set-point.

Evb_ref_lim

[57361][0xE010](V) *Maximum regulation limit*
An absolute limit on the battery regulation voltage. This is not a temperature compensated value. Protects high voltage sensitive system loads. Set to zero to disable.

ETb_max

[57362][0xE011](C). *Maximum temperature compensation limit*
Maximum temperature to clamp temperature compensation.

ETb_min

[57363][0xE012](C). *Minimum temperature compensation limit*
Maximum temperature to clamp temperature compensation.

EV_soc_g_gy

[57366][0xE015](V). *green to green/yellow limit*
LED transition set-point. Specifies the battery voltage at which the LED state will change from Green to Green/Yellow.

EV_soc_gy_y

[57367][0xE016](V). *LED Green/Yellow to Yellow limit*
LED transition set-point. Specifies the battery threshold voltage at which the LEDs will change from green/yellow to yellow indication.

EV_soc_y_yr

[57368][0xE017](V). *LED Yellow to Yellow/Red limit*
LED transition set-point. Specifies the battery threshold voltage at which the LEDs will change from Yellow to Yellow/Red indication.

EV_soc_yr_r

[57369][0xE018](V). *LED Yellow/Red to Red limit*
LED transition set-point. Specifies the battery threshold voltage at which the LEDs will change from Yellow/Red to Red indication.

Emodbus _id

[57370][0xE019](value). *MODBUS ID*
MODBUS address which uniquely identifies the controller on the MODBUS network.

Emeter _id

[57371][0xE01A](value). *MeterBus ID.* Address which uniquely identifies the controller on the Morningstar proprietary Meter Bus network. Devices are daisy-chained on the Meter Bus network via the RJ-11 connections. Addresses are limited to the range of 1-15

EIb_lim

[57374][0xE01D](A). *Battery Current Limit*
Set to a non-zero value to limit the maximum battery current. Set to zero to use the default 60 Amp current limit.

EVa_ref_fixed_init

[57377][0xE020](V). *Array Voltage fixed target - initialize*
Write a voltage value to this register to fix the Array input voltage to a specific value. If this register is a non-zero value, the MPPT function of the controller will be disabled (sweeping and tracking are disabled) and the array input will be fixed to the specified voltage. On start-up, the value in this register is copied to the volatile RAM register 0x005A, which allows for real-time control of Va.

EVa_ref_fixed_pct_init

[57378][0xE021](%). *Array Voltage percent of Voc voltage target - initialize*
Write a value to this register to fix the Array input voltage to a percentage of the Array open-circuit voltage. If this register is a non-zero value, the MPPT function of the controller will be disabled (sweeping and tracking are disabled) and the array target voltage will be fixed to the specified % of array Voc. The controller will perform periodic Voc checks and move the array voltage if needed to maintain the correct % target. On start-up, the value in this register is copied to the volatile RAM register 0x005B, which allows for real-time control of Va.

Note: if the Va_ref_fixed_init (0xE021) register is non-zero, it will override this setting.

Read-Only Variables

Ehourmeter_LO / Ehourmeter_HI

[57473,57474][0xE080,0xE081](hours). *Hourmeter*
Cumulative hours the controller has been running. Non-volatile, written every 24hrs.

EAhc_r_LO / EAhc_r_HI

[57475,57476][0xE082,0xE083](amp-hours). Charge *resettable Ah*
Cumulative amp-hours typically used for short-term logging. Resettable.

EAhc_t_LO / EAhc_t_HI

[57477,57478][0xE084,0xE085](amp-hours). Charge *total Ah*
Cumulative amp-hours for long term logging. Can be reset if necessary.

EkWhc_r

[57479][0xE086](kWh). Energy *kilowatt-hours resettable*
Cumulative charging kilowatt-hours. Resettable counter.

EkWhc_t

[57480][0xE087](kWh). Energy *kilowatt-hours total*
Cumulative charging kilowatt-hours. Total counter.

EVb_min

[57481][0xE088](V). *Minimum battery voltage*
Minimum battery voltage over last 24 hours. Written once every 24 hrs.

EVb_max

[57482][0xE089](V). *Maximum battery voltage*
Maximum battery voltage over last 24 hours. Written once every 24 hrs.

EVa_max

[57483][0xE08A](V). *Maximum array voltage*
Maximum array voltage over last 24 hours. Written once every 24 hrs.

Etmr_eqcalendar

[57484][0xE08B](days). *Equalize calendar timer*
Number of days since last equalization.

Etmr_batt_service

[57485][0xE08C](days). *Days since last battery service*
Reports the number of days since the last battery service reminder.

Eserial

[57537-57540][0xE0C0 – 0xE0C3](ASCII). *Controller serial number*
ASCII string of characters that represents the serial number.

Example serial number: 01234567
0xE0C0 = 0x3130 [1][0]
0xE0C1 = 0x3332 [3][2]
0xE0C2 = 0x3534 [5][4]
0xE0C3 = 0x3736 [7][6]

Emodel

[57548][0xE0CC](). *Controller model flag.*
0 = TSMPPT-600V-48, 1= TSMPPT-600V-120

Ehw_version

[57549][0xE0CD](). *Hardware version.*
Not ASCII. Major version stored in upper byte, minor version stored in lower byte.
0xE0CD = 0x0102 → HW version: 1.2

Examples

Read Holding Register, Scaling a voltage value

Read and scale the following value:
Variable (RAM): Battery Voltage
Register Address: 0x0018

The voltage scaling term is stored in variable V_PU at addresses 0x0000 and 0x0001.

Suppose the following values are read from RAM:

Address	Value(hex)	Variable Name
0x0000	0x007B	V_PU HI byte
0x0001	0xE041	V_PU LO byte
0x0018	0x0DB0	Battery Voltage value

1. Compute voltage scaler
Whole term = 0x007B → 123
Fractional term = 0xE041 / 2^16 → 0.876
Voltage scaler = 123 + 0.876 = 123.876

Scaling for this variable is: n* V_PU * 2^{-15} (as listed in the table of RAM variables)

2. Convert hexadecimal Vbattery register value to decimal
0x0DB0 → 3504

3. Scale Vbattery value
Vbattery = (3504 * 123.876) / 32768 = 13.25 Volts

Read Holding Register, 2 Word values

Variable (RAM): hours (hourmeter)
LO Register Address: 0x002A
HI Register Address: 0x002B
Scaling for this variable: none

```
1. read LO Register value(hex):    0x13D8
2. read HI Register value(hex):    0x0022
3. combine register values(hex):   0x002213D8
4. Convert to decimal:             2,233,304 hours
```

JavaScript Float16 conversion example

```
/*
Converts a integer read by modbus to float16 (IEEE754 half-precision binary16)
Modbus result is likely sign extended but we will ignore that
*/
function ScaleF16(passedVal)
{
	var s = 0;	// sign
	var e = 0;	// exponent
	var currentVal = 0;	// mantissa/result

	currentVal = (passedVal & 0x03ff) / 1024.0; // 10 bit mantissa (normalized)
	passedVal >>= 10;
	e = (passedVal & 0x001f);	// 5 bit exponent (stored w/ 15 offset)
	passedVal >>= 5;
	s = passedVal & 0x0001;		// 1 bit sign

	if (e == 0) {	// zero or subnormal
		if (currentVal == 0) return(0);		// zero

		// else subnormal (no leading 1.xxx)
		currentVal *= Math.pow(2.0,-14);
		if (s != 0) currentVal *= -1.0;
		return (currentVal);
	}

	if (e == 0x1f) {	// infinity or NaN
		if (currentVal == 0) {
			if (s==0) return(Number.POSITIVE_INFINITY);	// +infinity
			else return (Number.NEGATIVE_INFINITY);		// -infinity
		} else return(Number.NaN);	// NaN
	}

	currentVal += 1.0;	// add in leading 1
	currentVal *= Math.pow(2.0,e-15);
	if (s != 0) currentVal *= -1.0;

	return (currentVal);
}
```

References

- Visit http://www.modbus-ida.org/ for full protocol documentation, news, and technical resources
- MODBUS® Protocol Reference Guide, Modicon, June 1996, PI-MODBUS-300 Rev.J
- MODBUS® Application Protocol Specification, modbus.org, 8May02,
- Modbus_application_protocol_v1

Document Revision History

v01: First Release

v02: (firmware version v16 and later) MAJOR SCALING CHANGES TO SELECT VALUES. Please review the document in full. Many variables now use Float16 scaling. Code samples are provided for conversion.

V03: added Ib_ref_charge_slave control register @ PDU address 0x0068