TriStar MODBUS Specification

Morningstar Corporation

V 02

19 October 2005

Contents

Parameters

The TriStar supports communication via its serial RS-232 interface and uses the industry standard MODBUS application protocol. This document assumes the user is familiar with the MODBUS protocol and its terminology. Please refer to the documents listed in the References section for more information.

Modbus™ is a trademark of Modicon, Inc.

The TriStar supports RTU mode only.
16bit MODBUS addresses (per the modbus.org spec)
The serial communication parameters are

- BPS: 9600 baud
- Parity: None
- Data bits: 8
- Stop bits: 2
- Flow control: None

All addresses listed are for the request PDU.
The TriStar defaults to server address of 0x01.

Supported Modbus Functions

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

RAM

PDU Addr	Logical Addr	Variable name	Variable description	Units	Scaling or Range
0x0000	1		Internal Use		
0x0001	2		Internal Use		
0x0002	3		Internal Use		
0x0003	4		Internal Use		
0x0004	5		Internal Use		
0x0005	6		Internal Use		
0x0006	7		Internal Use		
0x0007	8		Internal Use		
0x0008	9	adc_vb_f	Battery voltage, filtered ($\tau \approx 2.5s$)	V	$n \cdot 96.667 \cdot 2^{-15}$
0x0009	10	adc_vs_f	Battery sense voltage, filtered ($\tau \approx 2.5s$)	V	$n \cdot 96.667 \cdot 2^{-15}$
0x000A	11	adc_vx_f	Array/Load voltage, filtered ($\tau \approx 2.5s$)	V	$n \cdot 139.15 \cdot 2^{-15}$
0x000B	12	adc_ipv_f	Charging current, filtered ($\tau \approx 2.5s$)	A	$n \cdot 66.667 \cdot 2^{-15}$
0x000C	13	adc_iload_f	Load current, filtered ($\tau \approx 2.5s$)	A	$n \cdot 316.67 \cdot 2^{-15}$
0x000D	14	Vb_f	Battery voltage, slow filter ($\tau \approx 25s$)	V	$n \cdot 96.667 \cdot 2^{-15}$
0x000E	15	T_hs	Heatsink temperature	ºC	-128 to +127
0x000F	16	T_batt	Battery temperature (RTS connected) (0x80 if not connected)	ºC	-127 to +127
0x0010	17	V_ref	Charge regulator reference voltage	V	$n \cdot 96.667 \cdot 2^{-15}$
0x0011	18	Ah_r_HI	Ah resetable, HI word	Ah	n·0.1
0x0012	19	Ah_r_LO	Ah resetable, LO word	-	
0x0013	20	Ah_t_HI	Ah total, HI word	Ah	n·0.1
0x0014	21	Ah_t_LO	Ah total, LO word	-	
0x0015	22	hourmeter_HI	hourmeter, HI word	h	0 to $(2^{24}-1)$
0x0016	23	hourmeter_LO	hourmeter, LO word	-	
0x0017	24	Alarm_LO	alarm bitfield	-	
0x0018	25	fault	fault bitfield	-	
0x0019	26	dip_switch	dip switch settings at power on switch[1..8] in bits[0..7]	-	
0x001A	27	control_mode	Control mode (0=charge, 1=load, 2=diversion)	-	
0x001B	28	control_state	Control state	-	
0x001C	29	d_filt	PWM Duty Cycle	-	0-255
0x001D	30	Alarm_HI*	Alarm bitfield (continued from 0x0017)	-	

***Note:** Alarm_HI(0x001D) not addressable for software version 1.04.02 or older.

EEPROM

PDU Addr	Logical Addr	Variable name	Variable description	Write allowed	Units	Scaling or Range
			Charge and diversion mode			
0xE000	57345	EV_reg	Regulation voltage @ 25ºC	✓	V	$n \cdot 96.667 \cdot 2^{-15}$
0xE001	57346	EV_float	Float voltage @ 25ºC Set to zero to disable float	✓	V	$n \cdot 96.667 \cdot 2^{-15}$
0xE002	57347	Et_float	time before entering float	✓	s	$0-(2^{16}-1)$
0xE003	57348	Et_floatlb	time before entering float due to low battery	✓	s	$0-(2^{16}-1)$
0xE004	57349	EV_floatlb_trip	Voltage that triggers low battery float time	✓	V	$n \cdot 96.667 \cdot 2^{-15}$
0xE005	57350	EV_float_cancel	Voltage that cancels float	✓	V	$n \cdot 96.667 \cdot 2^{-15}$
0xE006	57351	EV_eq	Equalize voltage @ 25ºC Set to zero to disable equalize	✓	V	$n \cdot 96.667 \cdot 2^{-15}$
0xE007	57352	Et_eqcalendar	days between eq cycles	✓	days	0-255
0xE008	57353	Et_eq_above	equalize time limit above Vreg	✓	s	$0-(2^{16}-1)$
0xE009	57354	Et_eq_reg	equalize time limit at Veq	✓	s	$0-(2^{16}-1)$
0xE00A	57355	EV_tempcomp	LSB only (note 2^{-16} scaling, negative sign is assumed)	✓	V	$n \cdot 96.667 \cdot 2^{-16}$
0xE00B	57356	EV_hvd	High Voltage Disconnect @ 25ºC Set to zero to disable HVD	✓	V	$n \cdot 96.667 \cdot 2^{-15}$
0xE00C	57357	EV_hvr	High Voltage Reconnect	✓	V	$n \cdot 96.667 \cdot 2^{-15}$
0xE00D	57358	Etmr_eqcalendar	days since last equalize	✓	days	0-255
0xE00E	57359	Et_float_exit_cum	Cum. time at 100% duty cycle, exit float	✓	s	$0-(2^{16}-1)$
0xE041	57410	Ed_float_enter	Duty Cycle to begin Float transition counter	✓	%	0-100
0xE042	57411	Eb_diversion_pwm	Diversion regulation type (PWM or On-Off)	✓	-	0 or 1
			Load mode			
0xE00F	57360	EV_lvd	Low Voltage Disconnect	✓	V	$n \cdot 96.667 \cdot 2^{-15}$
0xE010	57361	EV_lvr	Low Voltage Reconnect	✓	V	$n \cdot 96.667 \cdot 2^{-15}$
0xE011	57362	EV_lhvd	Load High Voltage Disconnect Set to zero to disable HVD	✓	V	$n \cdot 96.667 \cdot 2^{-15}$
0xE012	57363	EV_lhvr	Load High Voltage Reconnect	✓	V	$n \cdot 96.667 \cdot 2^{-15}$
0xE013	57364	ER_icomp	LVD Load current compensation	✓	Ω	$n \cdot 0.305 \cdot 2^{-16}$
0xE014	57365	Et_lvd_warn	LVD warning timeout	✓	s	n*0.1
			Lighting Mode			
0xE015	57366	Et_sun1	Lighting Time after sunset	✓	Min	
0xE016	57367	Et_sun2	Lighting time before sunrise	✓	Min	
0xE017	57368	Eb_light_config	Lighting Configuration Bits	✓	-	
0xE018	57369	EV_night_max	Night time threshold – Array Voc	✓	V	$n \cdot 96.667 \cdot 2^{-15}$
0xE019	57370	EV_day_min	Morning threshold for timing – Array Voc	✓	V	$n \cdot 96.667 \cdot 2^{-15}$
0xE01A	57371	EV_relaxed_day	Morning threshold for lighting – Array Voc	✓	V	$n \cdot 96.667 \cdot 2^{-15}$
			Common Values			
0xE01B	57372	EV_soc_g_gy	common, LED green to green/yellow limit	✓	V	$n \cdot 96.667 \cdot 2^{-15}$
0xE01C	57373	EV_soc_gy_y	LED green/yellow to yellow limit	✓	V	$n \cdot 96.667 \cdot 2^{-15}$
0xE01D	57374	EV_soc_y_yr	LED yellow to yellow/red limit	✓	V	$n \cdot 96.667 \cdot 2^{-15}$
0xE01E	57375	EV_soc_yr_r	LED yellow/red to red limit	✓	V	$n \cdot 96.667 \cdot 2^{-15}$
0xE01F	57376	ETb_max	Max battery temp compensation limit	✓	ºC	-128 to +127
0xE020	57377	ETb_min	Min battery temp compensation limit	✓	ºC	-128 to +127
0xE021	57378	Emb_tristar_id	Modbus TriStar server ID	✓	-	1-247
0xE022	57379	Et_batt_service	days between battery service intervals	✓	days	0-255
0xE023	57380	Etmr_batt_service	days since last battery service	✓	days	0-255
0xE024	57381	Ehourmeter_LO	hourmeter		h	0 to $(2^{24}-1)$
0xE025	57382	Ehourmeter_HI				

0xE026	57383	EAh_r_LO	Resetable Ah low byte		Ah	n·0.1
0xE027	57384	EAh_r_HI	Resetable Ah high byte			
0xE028	57385	EAh_t_LO	Total Ah low byte		Ah	n·0.1
0xE029	57386	EAh_t_HI	Total Ah high byte			
0xE02A	57387	EkWh	Kilowatt hours			
0xE02B	57388	EVb_min	Minimum battery voltage		V	$n \cdot 96.667 \cdot 2^{-15}$
0xE02C	57389	EVb_max	Maximum battery voltage		V	$n \cdot 96.667 \cdot 2^{-15}$
0xE040	57409	Emb_meterbus_id	TriStar MeterBus ID	✓	-	1-15

Calibration Values

PDU Addr	Logical Addr	Variable name	Variable description	Scaling or Range
0xF000	61441	serial[1],[0]	serial number (8 byte ASCII string)	
0xF001	61442	serial[3],[2]		
0xF002	61443	serial[5],[4]		
0xF003	61444	serial[7],[6]		
0xF004	61445	K_gain_adc_vb48	Battery voltage divider calibration, 48V mode	$n \cdot 2^{-15}$
0xF005	61446	K_gain_adc_vb1224	Battery voltage divider calibration, 12/24V mode	$n \cdot 2^{-15}$
0xF006	61447	K_gain_adc_ic	Charge current calibration	$n \cdot 2^{-15}$
0xF007	61448	K_gain_adc_il	Load current calibration	$n \cdot 2^{-15}$
0xF008	61449	K_gain_adc_vs	Sense voltage calibration	$n \cdot 2^{-15}$
0xF009	61450	K_gain_adc_vx	Array/Load voltage divider calibration	$n \cdot 2^{-15}$
0xF00A	61451	K_hw ver[major, minor]	MSB: hardware version major LSB: hardware version minor	
0xF00B	61452	calib_state, K_amp60	MSB: calib_state = 0x5A if calibrated LSB: K_amp60 = 0x01 if TS60, 0x00 if TS45	
0xF00C-0xF03F	61453-61504	unused		

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

PDU Addr	Logical Addr	Variable description
0x0000	1	Equalize triggered
0x0001	2	Disconnect (1 will force control into a disconnect state)
...	3-16	reserved
0x0010	17	Clear Ah resetable (set only, will always read 0)
0x0011	18	Clear Ah total (set only, will always read 0)
0x0012	19	Clear kWh (set only, will always read 0)
0x0013	20	Reset batt service reminder (set only, will always read 0)
0x0014	21	Clear faults (set only, will always read 0)
0x0015	22	Clear alarms (set only, will always read 0)
0x0016	23	Force EEPROM update (set only, will always read 0)
0x0017	24	LVD override for one cycle (set only, will always read 0)
...	25-254	reserved
0x00FF	256	Reset control

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-45" or "TS-60"
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.

adc_vb_f
[09][0x008] (V). *battery voltage, filtered.*
Voltage measured directly at the battery connection on the TriStar.

adc_vs_f
[10][0x009] (V). *battery sense voltage*.
Voltage reading at the Battery Sense terminals. Battery sense provides the processor with an accurate reading of the battery voltage directly at the battery. The Battery Sense wires carry little current and therefore do not have a significant voltage drop between the battery and controller, providing accurate battery voltage measurement.

adc_vx_f
[11][0x00A] (V). *solar or load voltage.*
Depending on the control mode(Solar, Load, Diversion), Vx is the terminal voltage of the PV or load connection.

adc_ipv_f
[12][0x00B] (A). *solar current, filtered.*
Slow filtered charging current value as measured by on-board shunts.

adc_iload_f
[13][0x00C] (A). *load current, filtered.*
Slow filtered load current value as measured by on-board shunts.

Vb_f
[14][0x00D] (V). *battery voltage, slow filtered.*
Voltage measured directly at the battery connection on the TriStar. This value is heavily filtered and takes several seconds to settle if changes in voltage occur.

T_hs

[15][0x00E] (C). *heatsink temperature.*
An on-board thermistor reports the measured temperature of the heatsink. This value is used for over temperature protections.

T_batt

[16][0x00F] (C). *battery temperature.*
If the optional battery temperature sensor is attached, this variable reports measured battery temperature.

V_ref

[17][0x010] (V). Regulation Voltage. Target voltage to which the battery will be charged. This value is temperature compensated.

Ah_r_HI / Ah_r_LO

[18,19][0x011,0x012] (Ah). *Resetable amp-hours.*
High and low bytes that record accumulated amp-hours. This amp-hour counter can be reset often to track short term Ah accumulations.

Ah_t_Hi / Ah_t_LO

[20,21][0x013, 0x014] (Ah).*total amp-hours. .*
High and low bytes that record accumulated amp-hours. This amp-hour counter tracks accrued Ah for extensive periods of time.

hourmeter_HI / hourmeter_LO

[22,23][0x015, 0x016] ().*hour meter counter.*
Reports total hours of operation since installed.

alarm_HI / alarm_LO

[30,24][0x01D,0x017] (bit-field).*self diagnostic alarms.*
Reports alarms identified by self diagnostics. Each bit corresponds to a specific alarm. See appendix for alarm bits definitions.
Note: Alarm_HI(0x001D) not addressable for software version 1.04.02 or older.

fault

[25][0x018] (bit-field). *self diagnostic faults.*
Reports faults identified by self diagnostics. Each bit corresponds to a specific fault. See appendix for fault bits definitions.

dip_switch

[26][0x019] (bit-field). *dip switch positions.*
Each bit in the bit-field corresponds to an individual DIP switch setting. Useful for remote applications where access to TriStar to verify DIP positions is not feasible.

control_mode

[27][0x01A] (V).
Reports the mode in which the controller is running.

0x00=charge
0x01=load
0x02=diversion
0x03=lighting

control_state

[28][0x01B] (V).
Reports the current software state.

Value	Control State
Charge and Diversion Modes	
0	START
1	NIGHT CHECK
2	DISCONNECT
3	NIGHT
4	FAULT
5	BULK
6	PWM
7	FLOAT
8	EQUALIZE
Load and Lighting Modes	
0	START
1	NORMAL
2	LVD WARN
3	LVD
4	FAULT
5	DISCONNECT
6*	NORMAL OFF
7*	OVERRIDE LVD

* these states apply only to Lighting Mode

d_filt

[29][0x01C] (%) *duty cycle.* Reports the PWM regulation duty cycle, 0 to 100%.
The value ranges from 0 to 255, with 0 for 0% and 230 for 100% (values above 230 are also 100%).

EEPROM Values

EEPROM values that require updating are done so once every 24 hours.

Charging and Diversion Mode

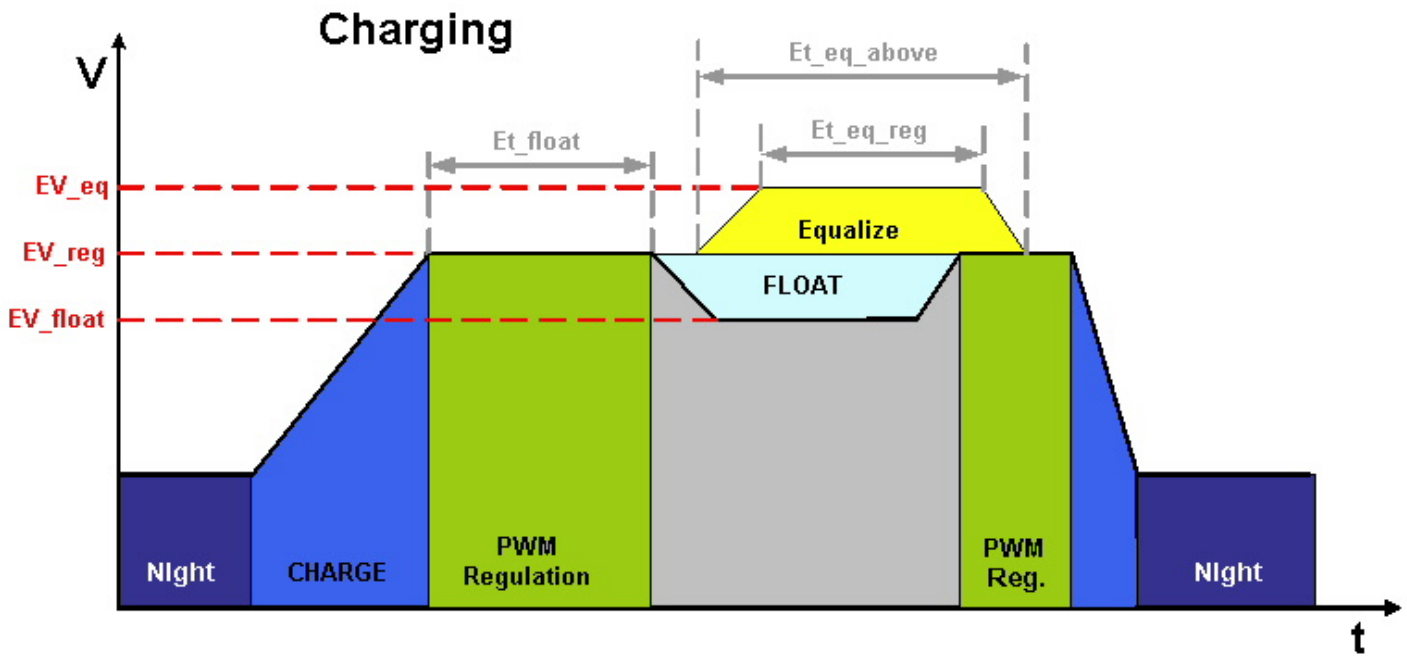


Diagram A Charging stages and defining variables.

EV_reg

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

EV_float

[57346][0xE001](V). *Float voltage @ 25ºC*
After some period of time in regulation when the battery is fully charged, the battery will drop down to this lower setpoint to reduce gassing. See diagram A.
Set to zero to disable float stage

Et_float

[57347][0xE002] *time before entering float*
Defines the length of time in regulation before dropping down to the float stage. See diagram A.

Et_floatlb

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

EV_floatlb_trip

[57349][0xE004](V). *Voltage that triggers low battery float time*
Setpoint that will trigger a longer period of time before entering float. - See Et_floatlb -

EV_float_cancel

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

EV_eq

[57351][0xE006](V). *Equalize voltage @ 25ºC*
The voltage setpoint to which the battery will be equalized. Periodic equalization equalizes cell voltages, bubbles the electrolyte, and helps prevent sulfation of the battery. See diagram A.
Set to zero to disable equalization

Et_eqcalendar

[57352][0xE007](days). *days between eq cycles*
Specify the number of days between equalizations. Equalizing on a calendar basis ensures proper maintenance of certain batteries.

Et_eq_above

[57353][0xE008]() *equalize time limit above Vreg*
Equalization will timeout after the specified number of minutes above PWM regulation voltage. If the battery is charged above PWM regulation voltage but has not yet reached the equalization setpoint, this value serves as a safety timeout to prevent partial equalizations for extended periods of time. See diagram A.
NOTE: if the regulation method is set to ON-OFF, this variable alone will determine the equalization length.

Et_eq_reg

[57354][0xE009] *equalize time limit at Veq*
Equalization will stop after the specified number of minutes at the equalization setpoint voltage. See diagram A.

EV_tempcomp

[57355][0xE00A](V/C). *temperature compensation.*
Battery chemistry changes with temperature. Determines the amount that regulation voltages will be shifted with temperature

EV_hvd

[57356][0xE00B] *High Voltage Disconnect @ 25ºC*
Flag a fault/alarm if the battery voltage exceeds this setpoint. Also attempts to open the MOSFETs to stop charging/diversion.
Set to zero to disable HVD

EV_hvr

[57357][0xE00C] *High Voltage Reconnect*
The HVD fault/alarm will be cleared once the battery voltage drops below this setpoint.

Etmr_eqcalendar

[57358][0xE00D](days) days since last equalize
Counter that indicates the number of days since the last equalization was administered to the batteries.

Et_float_exit_cum

[57359][0xE00E](sec) *Cum. time at 100% duty cycle, exit float.* Specifies the cumulative amount of time at 100% duty cycle(i.e. not regulating input current), before the controller leaves the float stage. Reasons why the controller may reach 100% duty cycle include: a load on the battery or decrease in input current.

Ed_float_enter

[57410][0xE041](%) *PWM duty cycle threshold that begins the Absorption to Float transition timer (Et_float, Et_floatlb).* Specify a duty cycle value between 0 and 100%. Default is 15%. Battery is more charged at lower duty cycles. High duty cycle values (~90%) will begin float timer almost as soon as battery reaches regulation. **Addressable in firmware v1.04.08 or higher.**

Eb_diversion_pwm

[57411][0xE042](flag) *Specify PWM or On/Off method of regulation in Diversion Control mode*. A value of "1" written to this register will force the TriStar to regulate in On/Off regulation mode with a switching frequency of ~1Hz. For systems that experience PWM noise issues that cannot be resolved through other means, On/Off regulation forces the TriStar to switch very slowly, eliminating noise. Any other value written to the register specifies the default PWM regulation method (recommended). **Addressable in firmware v1.04.09 or higher.**

Load Mode

EV_lvd

[57360][0xE00F](V). *Low Voltage Disconnect*
Setpoint to determine the load turn off voltage. When the battery has discharged too far, the load should be turned off to prevent over-discharge of the battery.

EV_lvr

[57361][0xE010](V). *Low Voltage Reconnect*
Battery setpoint that determines when the load will be reconnected. After the battery recharges to this setpoint, the load will be reconnected.

EV_lhvd

[57362][0xE011](V). *Load High Voltage Disconnect*
Disconnect the loads if the battery voltage rises too high. This function can protect DC loads that are sensitive to high input voltage.
Set to zero to disable HVD

EV_lhvr

[57363][0xE012](V). *Load High Voltage Reconnect*
Setpoint at which the loads will reconnect after a high voltage condition.

ER_icomp

[57364][0xE013](V/A). *LVD Load current compensation*
The LVD setpoint can be compensated in proportion to load current, lowering the disconnect value when the battery is under load. Note that the LED setpoints are also compensated accordingly.

Et_lvd_warn

[57365][0xE014](sec). *LVD warning timeout*
Defines the period of time to wait before disconnecting the loads, once battery voltage has dropped to the Low Voltage Disconnect setpoint.

Lighting Mode

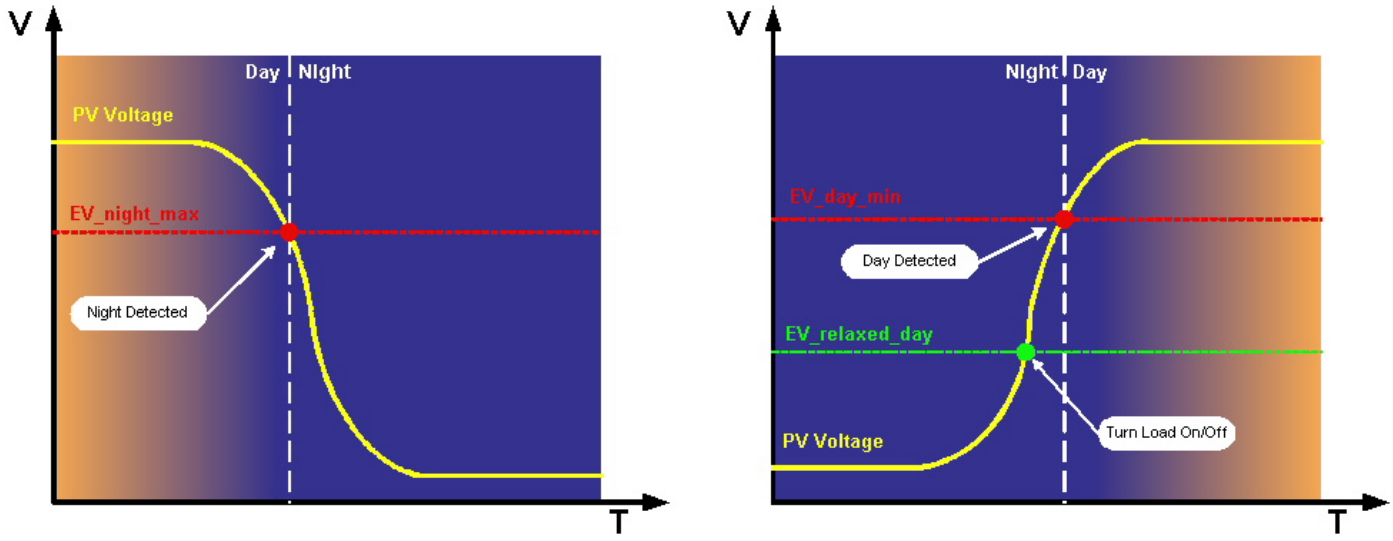


Diagram B Day/Night detection for lighting mode

Et_sun1

[57366][0xE015](min). *Lighting Timer for sunset.* Normally operates relative to sunset. For a negative value, it toggles the load BEFORE the predicted sunset time. For a positive value, it toggles the load AFTER sunset.

Et_sun2

[57367][0xE016](min). *Lighting Timer for sunrise.* Normally operates relative to sunrise. For a negative value, it toggles the load BEFORE the predicted sunrise time. For a positive value, it toggles the load AFTER sunrise.

Eb_light_config

[57368][0xE017](bit-field). *Lighting Configuration Bits.* Four bits that determine if the load will toggle on or off when sunrise or sunset occurs. Also determines at which event (sunrise or sunset), each timer will start. See Appendix Lighting Bits Configuration for examples and description.

EV_night_max

[57369][0xE018](V). *Night time threshold*
Array voltage setpoint at which night is determined.
See Diagram B.

Note: solar sense input on the sense terminals must be divided in half with an external resistor divider for 48V applications. Choose setpoints accordingly. Refer to lighting documentation for more info.

EV_day_min

[57370][0xE019](V). *Morning threshold for timing*
Array voltage setpoint at which dawn is determined.
See Diagram B.

Note: solar sense input on the sense terminals must be divided in half for 48V applications. Choose setpoints accordingly. Refer to lighting documentation for more info.

EV_relaxed_day

[57371] [0xE01A](V). *Morning threshold for lighting*
Array voltage setpoint at which the load will be toggled ON/OFF. This setpoint is typically lower than the dawn voltage setpoint(EV_day_min), which is used for night length computation. This variable allows the user to increase the dawn detect sensitivity 10minutes before expected dawn.
See Diagram B.

Note: solar sense input on the sense terminals must be divided in half for 48V applications. Choose setpoints accordingly. Refer to lighting documentation for more info.

Common

EV_soc_g_gy

[57372][0xE01B](V). *green to green/yellow limit*
LED transition setpoint. Specifies the battery voltage at which the LED state will change from Green to Green/Yellow.

EV_soc_gy_y

[57373][0xE01C](V). *green/yellow to yellow limit*
LED transition setpoint. Specifies the battery voltage at which the LED state will change from Green/Yellow to Yellow.

EV_soc_y_yr

[57374][0xE01D](V). *yellow to yellow/red limit*
LED transition setpoint. Specifies the battery voltage at which the LED state will change from Yellow to Yellow/Red.

EV_soc_yr_r

[57375][0xE01E](V). *yellow/red to red limit*
LED transition setpoint. Specifies the battery voltage at which the LED state will change from Yellow/Red to Red.

ETb_max

[57376][0xE01F](C). *Max battery temp compensation limit*
Upper temperature setpoint at which the controller will no longer temperature compensate. Refer to graph .

ETb_min

[57377][0xE020](C). *Min battery temp compensation limit*
Lower temperature setpoint at which the controller will no longer temperature compensate. Refer to graph .

Emb_tristar_id

[57378][0xE021](). *Modbus TriStar server ID*
Modbus address which uniquely identifies the controller on the MODBUS network.

Et_batt_service

[57379][0xE022](days). *days between battery service intervals*
Specifies the number of days between battery service reminders. Sets an alarm, prompting the user to check his batteries for water, health, etc. Clear the alarm with the pushbutton, meter, or MODBUS alarm reset command.

Etmr_batt_service

[57380][0xE023](days). *days since last battery service*
Reports the number of days since the last battery service reminder.

Ehourmeter_LO / Ehourmeter_HI

[57381,57382][0xE024,0xE025](). *Hourmeter*
Cumulative hours the controller has been running. Non-volatile, written every 24hrs.

EAh_r_LO / EAh_r_HI

[57383,57384][0xE026,0xE027](). *Resetable Ah*
Cumulative amp-hours typically used for short-term logging. Resetable.

EAh_t_LO / EAh_t_HI

[57385,57386][0xE028,0xE029](). *Total Ah*
Cumulative amp-hours for long term logging. Can be reset if needed.

EkWh

[57387][0xE02A](kWh). *Kilowatt hours*
Cumulative kilowatt hours.

EVb_min

[57388][0xE02B](V). *Minimum battery voltage*
Minimum battery voltage over last 24 hours. Written once every 24hrs.

EVb_max

[57389][0xE02C](V). *Maximum battery voltage*
Maximum battery voltage over last 24 hours. Written once every 24hrs.

Emb_meterbus_id

[57409][0xE040](). *TriStar Meter Bus 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

Calibration Values

serial[1],[0] / serial[3],[2] / serial[5],[4] / serial[7],[6]

[61441, 61442, 61443, 61444] [0xF000, 0xF001, 0xF002, 0xF003]
serial number (8 byte ASCII string)

K_gain_adc_vb48

[61445] [0xF004] Battery voltage divider calibration, 48V mode

K_gain_adc_vb1224

[61446] [0xF005] Battery voltage divider calibration, 12/24V mode

K_gain_adc_ic

[61447] [0xF006] Charge current calibration

K_gain_adc_il

[61448] [0xF007] Load current calibration

K_gain_adc_vs

[61449] [0xF008] Sense voltage calibration

K_gain_adc_vx

[61450] [0xF009] Array/Load voltage divider calibration

K_hw ver (major, minor)

[61451] [0xF00A]
MSB: hardware version major
LSB: hardware version minor

calib_state, K_amp60

[61452] [0xF00B]
MSB: calib_state = 0x5A if calibrated
LSB: K_amp60 = 0x01 if TS60, 0x00 if TS45

Coils

Equalize triggered

[1] [0x0000] Trigger a manual equalize.
Will equalize while value =1. Reset value to 0 to stop equalize. Equalize will still timeout if not reset to 0.

Disconnect

[2] [0x0001]
Force software into DISCONNECT state. Turns off MOSFETs and waits. To resume normal operation, set to 0.
(1 will force control into a disconnect state)

Clear Ah resetable

[17][0x0010]
Reset the resetable amp-hour counter back to 0.
(set only, will always read 0)

Clear Ah total

[18] [0x0011]
Reset the total amp-hour counter back to 0.
(set only, will always read 0)

Clear kWh

[19] [0x0012]
Reset the total kilowatt-hour counter back to 0.
(set only, will always read 0)

Reset batt service reminder

[20] [0x0013]
Reset the days since last battery service counter to 0.
(set only, will always read 0)

Clear faults

[21] [0x0014]
Clears the faults bit field. Certain faults require 10sec before retry(short circuit, over-current, etc). Control will not allow reset of these faults until 10sec counter has expired. Faults that require a power cycle or controller reset cannot be cleared by this coil (e.g. DIP SW change)
(set only, will always read 0)

Clear alarms

[22] [0x0015]
Clears the alarms bit field.
(set only, will always read 0)

Force EEPROM update

[23] [0x0016]
Force the controller to update EEPROM with RAM values.
(set only, will always read 0)

LVD override

[24] [0x0017]
Force the controller out of LVD in Load and Lighting mode. If Vbatt is still below LVD the load will run for a length of time specified by Et_lvd_warn, then return to the LVD state. If Vbatt is above LVD, the load will remain connected.
(set only, will always read 0)

Reset control

[256] [0x00FF]
Reset control will force a reboot of the processor software. Useful for clearing faults/alarms after settings changes, or firmware updates.

Examples

Scaling

Scaling Battery voltage, filtered ($\tau \approx 2.5s$)
Read Holding Register Value: 0x1007
Scaling for this variable: $n \cdot 96.667 \cdot 2^{-15}$

```
1007 hex → 4103 dec
(4103 x 96.667) / 32768  = 12.1V
```

Appendix

Alarm Bits Table

Alarm Bit field PDU addresses `0x0017(LO) and 0x001D(HI)`

BIT	ALARM
0	RTS open
1	RTS shorted
2	RTS disconnected
3	Ths disconnected
4	Ths shorted
5	TriStar hot
6	Current limit
7	Current offset
8	Battery Sense
9	Batt Sense disc
10	Uncalibrated
11	RTS miswire
12	HVD
13	high d
14	miswire
15	FET open
16	P12*
17	Load Disc.*
18	Alarm 19*
19	Alarm 20*
20	Alarm 21*
21	Alarm 22*
22	Alarm 23*
23	Alarm 24*

***Note:** Alarm_HI(0x001D) not addressable for software version 1.04.02 or older.

Fault Bits Table

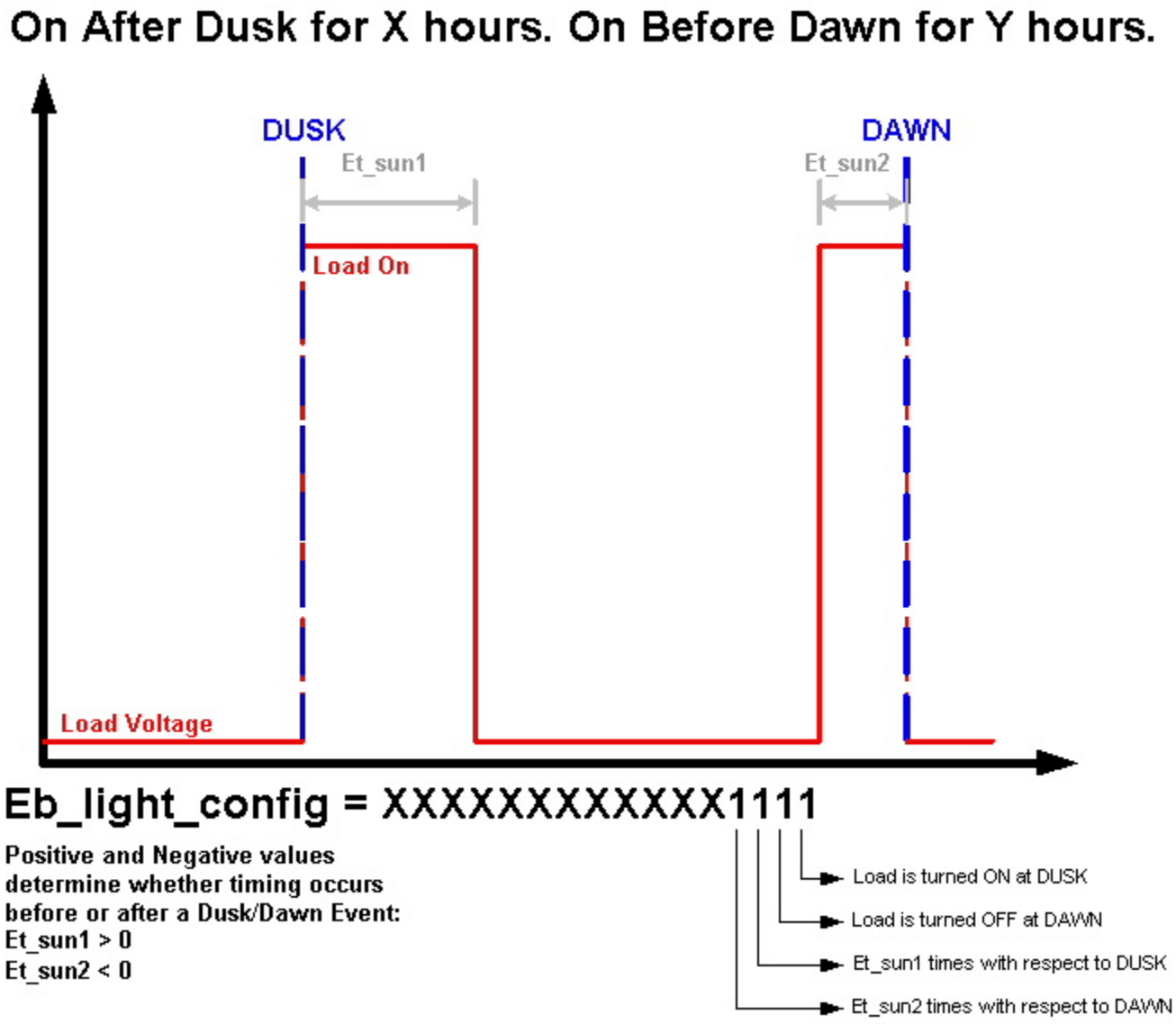
Fault Bit field PDU address 0x0018

BIT	FAULT
0	External Short
1	Overcurrent
2	FET short
3	Software
4	HVD
5	TriStar hot
6	DIP sw changed
7	Setting edit
8	reset?
9	Miswire
10	RTS shorted
11	RTS disconnected
12	Fault 12
13	Fault 13
14	Fault 14
15	Fault 15

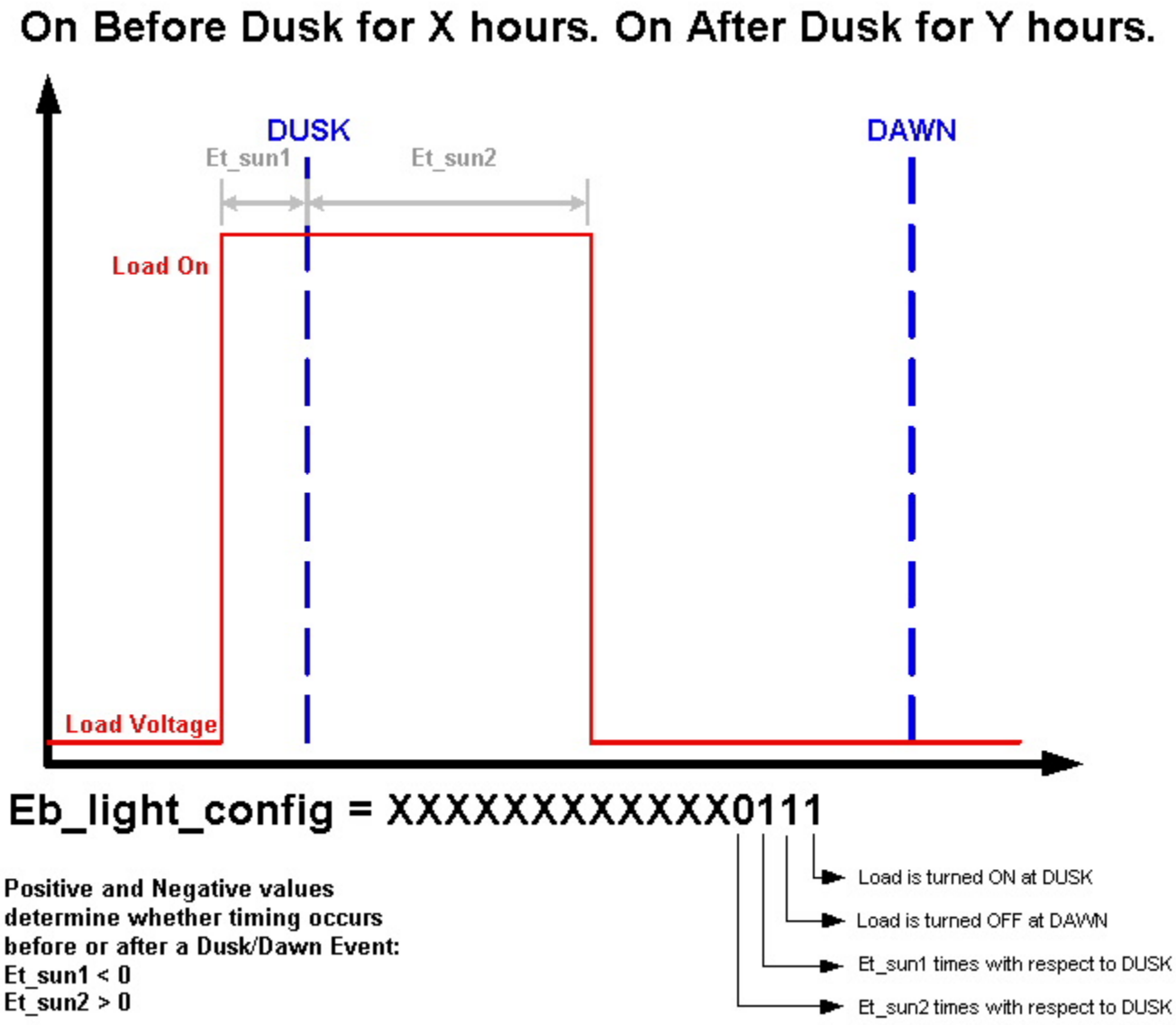
Lighting Bits Configuration

Following are a few examples to illustrate the function of the lighting configuration bits, which are the 4 LSBs of Eb_light_config. All other bits in the field are ignored.

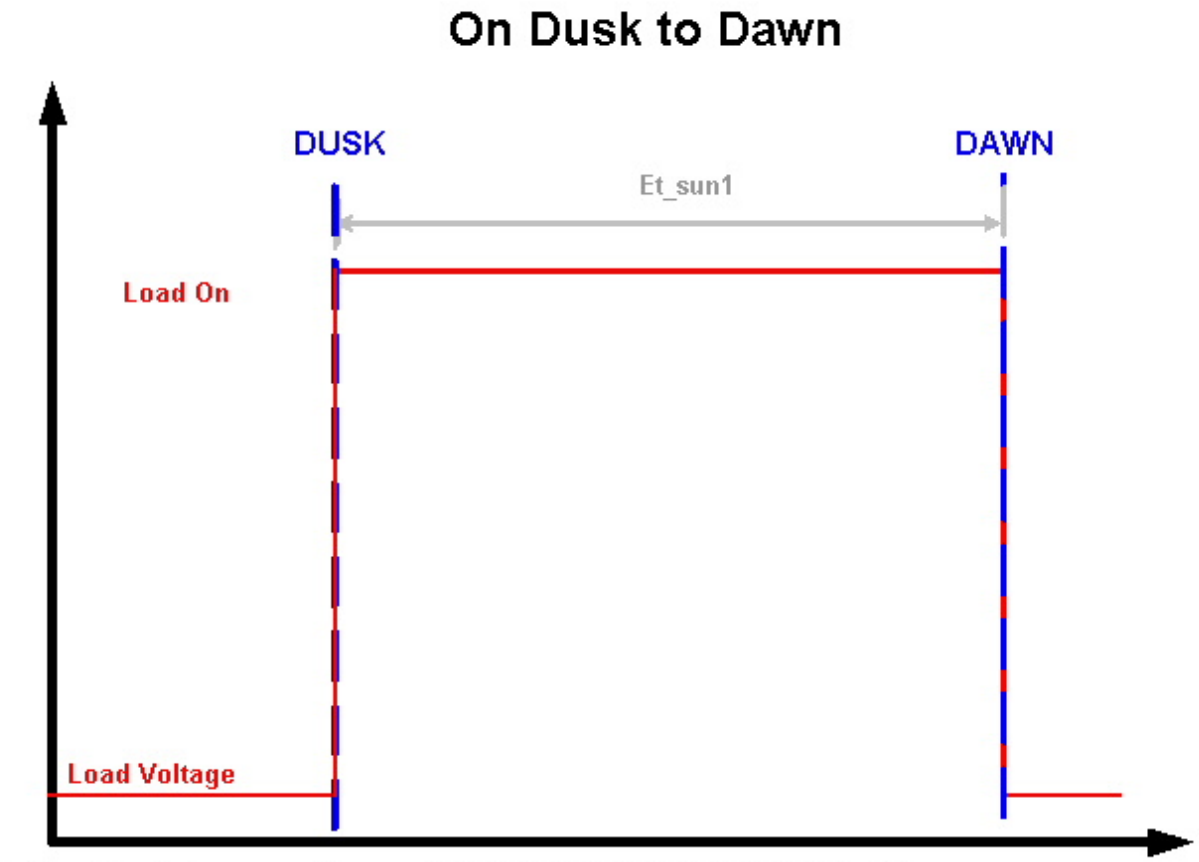
Example 1



Example 2


On Before Dusk for X hours. On After Dusk for Y hours.
DUSK
DAWN
Et_sun1
Et_sun2
Load On
Load Voltage
Eb_light_config = XXXXXXXXXXXX0111
Positive and Negative values
determine whether timing occurs
before or after a Dusk/Dawn Event:
Et_sun1 < 0
Et_sun2 > 0
Load is turned ON at DUSK
Load is turned OFF at DAWN
Et_sun1 times with respect to DUSK
Et_sun2 times with respect to DUSK

Example 3



Eb_light_config = XXXXXXXXXXXXX111

Positive and Negative values determine whether timing occurs before or after a Dusk/Dawn Event:
Et_sun1 > Night Length
Et_sun2 = 0

- Load is turned ON at DUSK
- Load is turned OFF at DAWN
- Et_sun1 times with respect to DUSK
- Since Et_sun2 is set to zero, this bit no longer matters.

References

- 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

1.0.0 (up to firmware version 1.04.06)

- First release

1.0.1 (firmware version 1.04.08 and later)

- Added EEPROM value *Ed_float_enter*. Allows modification of PWM% threshold to begin float stage transition timer.

1.0.2 (firmware version 1.04.09 and later)

- Added EEPROM value *Emb_meterbus_id*. Allows modification of TriStar id on the Meter Bus network.
- Added EEPROM value Eb_diversion_pwm. Allows adjustment of regulation type in Diversion mode. PWM or On-Off charging. Charging Mode uses DIP switches for this setting, diversion mode does not have a DIP switch for this setting. 0 = PWM, 1 = On/Off.
- Correction of scaling for Ah HI and LO in EEPROM