SunSaver Duo MODBUS Specification

V03
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Contents

General Information

The SunSaver Duo supports the industry standard MODBUS application protocol via its Meterbus RJ-11 interface. A *Meterbus to Serial Converter* (MSC) is required to adapt the Meterbus interface to an isolated RS-232 interface**. 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.

**** The MSC MeterBus adapter is a Morningstar accessory. Contact your local dealer for more information.**

Parameters

The SunSaver Duo 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 SunSaver Duo default server address: 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	vb1	Battery 1 voltage, filtered (τ ≈ 2.5s)	V	n / 1800
0x0001	2	vb2	Battery 2 voltage, filtered (τ ≈ 2.5s)	V	n / 1800
0x0002	3	va	Solar voltage, filtered (τ ≈ 2.5s)	V	n / 1032
0x0003	4	ia1	Charge current battery 1	A	n / 673
0x0004	5	ia2	Charge current battery 2	A	n / 673
0x0005	6		internal use		
0x0006	7		internal use		
0x0007	8		internal use		
0x0008	9	vref1	Charging reference voltage, Battery 1	V	n / 1800
0x0009	10	vref2	Charging reference voltage, Battery 2	V	n / 1800
0x000A	11	dutcyc1	PWM duty cycle, Battery 1	%	0 - 417
0x000B	12	dutcyc2	PWM duty cycle, Battery 2	%	0 - 417
0x000C	13	vmaxb1	Maximum battery 1 voltage	V	n / 1800
0x000D	14	vminb1	Minimum battery 1 voltage	V	n / 1800
0x000E	15	vmaxb2	Maximum battery 2 voltage	V	n / 1800
0x000F	16	vminb2	Minimum battery 2 voltage	V	n / 1800
0x0010	17	iamax	Maximum solar current	A	n / 673
0x0011	18		internal use		
0x0012	19		internal use		
0x0013	20	hours_HI	Hourmeter HI word	hrs	
0x0014	21	hours_LO	Hourmeter LO word	hrs	
0x0015	22	ah.total_HI	Total amp-hours, HI word	Ah	n / 10
0x0016	23	ah.total_LO	Total amp-hours, LO word	Ah	n / 10
0x0017	24	ah.b1_HI	Battery 1 amp-hours, HI word	Ah	
0x0018	25	ah.b1_LO	Battery 1 amp-hours, LO word	Ah	
0x0019	26	ah.b2_HI	Battery 2 amp-hours, HI word	Ah	
0x001A	27	ah.b2_LO	Battery 2 amp-hours, LO word	Ah	
			Battery 1Present configuration		
0x001B	28	tcompcoef	Temperature compensation coefficient	V	n / 1800
0x001C	29	priority	Charging priority, battery 1 percentage	%	0 - 417
0x001D	30	vabs1	Absorption voltage, battery 1	V	n / 1800
0x001E	31	veql1	Equalize voltage, battery 1	V	n / 1800
0x001F	32	vfloat1	Float voltage, battery 1	V	n / 1800
0x0020	33	vclamp1	Max. regulation voltage, battery 1	V	n / 1800
0x0021	34	tfloat1	Float timer, battery 1	min	
0x0022	35	teq1	Equalize timer, battery 1	min	
			Battery 2 Present configuration		
0x0023	36	vabs2	Absorption voltage, battery 2	V	n / 1800
0x0024	37	veql2	Equalize voltage, battery 2	V	n / 1800
0x0025	38	vfloat2	Float voltage, battery 2	V	n / 1800

0x0026	39	vclamp2	Max. regulation voltage, battery 2	V	n / 1800
0x0027	40	tfloat2	Float timer, battery 2	min	
0x0028	41	teq2	Equalize timer, battery 2	min	
			Pre-scaled Values		
0x0100	257	ta_F	Ambient temperature, local temp sensor	F	
0x0101	258	ta_C	Ambient temperature, local temp sensor	C	
0x0102	259	tr_F	Remote temperature, RTS	F	
0x0103	260	tr_C	Remote temperature, RTS	C	
0x0104	261	ths_F	Heatsink temperature	F	
0x0105	262	ths_C	Heatsink temperature	C	
0x0106	263	dc1	Duty cycle, battery 1	%	
0x0107	264	dc2	Duty cycle, battery 2	%	
0x0108	265	state	SS Duo state: 1=normal, 3=night, 4=Fault	-	
0x0109	266	faults	controller faults bitfield	bits	(see faults table)
0x010A	267	flags	controller flags bitfield	bits	(see flags table)
0x010B	268	DIPs	DIP switch positions	bits	(see DIPs table)
0x010C	269		internal use		
0x010D	270	b1_state	Battery 1 state: 0=normal, 1=Eq, 2=Float	-	
0x010E	271	b2_state	Battery 2 state: 0=normal, 1=Eq ,2=Float	-	
0x010F	272	b1_detect	Batt.1 detection,0=disconnected,1=connected	-	
0x0110	273	b2_detect	Batt.2 detection,0=disconnected,1=connected	-	

EEPROM

PDU Addr	Logical Addr	Variable name	Variable description	Write allowed	Units	Scaling or Range
			Custom configuration, Common values			
0xE000	57345	mt_id	meterbus id (address)	✓	-	1 - 247
0xE001	57346	mb_id	modbus id (address)	✓	-	1 - 15
0xE002	57347	priority_off	Battery 1 priority, DIP 3 OFF	✓	%	0 - 417
0xE003	57348	priority_on	Battery 1 priority, DIP 3 ON	✓	%	0 - 417
0xE004	57349	tcompcoef	temperature compensation coefficient	✓	V	n / 1800
0xE005	57350		internal use			
			Custom configuration, Battery1, DIP 1 OFF			
0xE006	57351	v_absorption	absorption voltage	✓	V	n / 1800
0xE007	57352	v_equalize	equalize voltage	✓	V	n / 1800
0xE008	57353	v_float	float voltage	✓	V	n / 1800
0xE009	57354	v_reg_max	maximum regulation voltage	✓	V	n / 1800
0xE00A	57355	t_float	Time until float	✓	min	
0xE00B	57356	t_equalize	Equalization timer	✓	min	
			Custom configuration, Battery1, DIP 1 ON			
0xE00C	57357	v_absorption	absorption voltage	✓	V	n / 1800
0xE00D	57358	v_equalize	equalize voltage	✓	V	n / 1800
0xE00E	57359	v_float	float voltage	✓	V	n / 1800
0xE00F	57360	v_reg_max	maximum regulation voltage	✓	V	n / 1800
0xE010	57361	t_float	Time until float	✓	min	
0xE011	57362	t_equalize	Equalization timer	✓	min	
			Custom configuration, Battery2, DIP 2 OFF			
0xE012	57363	v_absorption	absorption voltage	✓	V	n / 1800
0xE013	57364	v_equalize	equalize voltage	✓	V	n / 1800
0xE014	57365	v_float	float voltage	✓	V	n / 1800
0xE015	57366	v_reg_max	maximum regulation voltage	✓	V	n / 1800
0xE016	57367	t_float	Time until float	✓	min	
0xE017	57368	t_equalize	Equalization timer	✓	min	
			Custom configuration, Battery2, DIP 2 ON			
0xE018	57369	v_absorption	absorption voltage	✓	V	n / 1800
0xE019	57370	v_equalize	equalize voltage	✓	V	n / 1800
0xE01A	57371	v_float	float voltage	✓	V	n / 1800
0xE01B	57372	v_reg_max	maximum regulation voltage	✓	V	n / 1800
0xE01C	57373	t_float	Time until float	✓	min	
0xE01D	57374	t_equalize	Equalization timer	✓	min	

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

PDU Addr	Logical Addr	Variable description
0x0010	17	reset amp-hours
0x0014	21	clear faults
0x0016	23	force EE update
0x0017	24	reset min / max volts and amps
0x00F1	242	switch to meterbus protocol
0x00FF	256	reset controller

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).

Tables

Bit 0 = LSB

Faults Table	
Bit	Fault
0	Reverse polarity solar connection
1	Reverse polarity battery 1
2	Reverse polarity battery 2
3	Damaged local temperature sensor
4	damaged or removed RTS
5	Over-current condition
6	High Temperature disconnect
7	High Voltage disconnect

Flags Table	
Bit	Flag
0	internal use
1	internal use
2	internal use
3	Regulation
4	Valid RTS
5	alternating
6	On / Off regulation
7	Started

DIP Switch Table	
Bit	DIP Switch
0	DIP 1
1	DIP 2
2	DIP 3
3	DIP 4
4	DIP 5
5	0
6	0
7	0

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.

vbx

[01,02][0x0000,0x0001] (V). *battery voltage, filtered.*
Voltage measured directly at the battery 1 or battery 2 connection on the SunSaver Duo.

va

[03][0x0002] (V). *solar voltage.*
Va is the terminal voltage of the solar input connection.

iax

[04,05][0x0003,0x0004] (A). *solar current, filtered.*
Charging current to each battery as measured by on-board shunt.

vrefx

[09,10][0x0008,0x0009] (V). *Reference Voltage*.
Target voltage to which the battery will be charged. This value is temperature compensated.

dutcycx

[11,12][0x000A,0x000B] (%) *duty cycle.* Reports the PWM regulation duty cycle for each battery, 0 to 100%.
The value ranges from 0 to 417, with 0 = 0% and 417 = 100% (values above 417 are also 100%).

vmaxbx

[13,15][0x000C,0x000E] (V). *Maximum battery voltage.*
Maximum battery voltage measured since last min/max clear.

vminbx

[14,16][0x000D,0x000F] (V). *Maximum battery voltage.*
Maximum battery voltage measured since last min/max clear.

iamax

[17][0x0010] (A). *Maximum solar current* .
Maximum solar charge current measured since last min/max clear.

hours_HI / hours_LO

[13,14][0x0020, 0x0021] ().*hour meter counter.*
Reports total hours of operation since installed.

ah.total_HI / ah.total_LO

[15,16][0x0022,0x0023] (ah).*Total amp-hours.*
Reports total solar amp-hours since last ah reset.

ah.bx_HI / ah.bx_LO

[24 - 27][0x0017 - 0x001A] (ah).*Battery amp-hours.*
Reports amp-hours to each battery since last ah reset.

tcompcoef

[28][0x001B] (V). *Temperature compensation coefficient* .
Battery regulation compensation per 12V battery per degree C. This is the compensation value currently used for charging.

priority

[29][0x001C] (%). *Charging priority, battery 1* .
Charging priority that is selected for battery 1.

vabs1

[30][0x001D] (V). *Absorption Voltage, battery 1* .
The absorption voltage setpoint assigned to battery 1.

veq1

[31][0x001E] (V). *Equalize Voltage, battery 1* .
The equalize voltage setpoint assigned to battery 1.

vfloat1

[32][0x001F] (V). *Float Voltage, battery 1* .
The float voltage setpoint assigned to battery 1.

vclamp1

[33][0x0020] (V). *Maximum regulation voltage, battery 1* .
The max. regulation voltage setpoint assigned to battery 1.

tfloat1

[34][0x0021] (V). *Float timer, battery 1* .
The float timer setpoint assigned to battery 1.

teq1

[35][0x0022] (V). *Equalize timer, battery 2.*
The equalize timer setpoint assigned to battery 1.

vabs2

[36][0x0023] (V). *Absorption Voltage, battery 2.*
The absorption voltage setpoint assigned to battery 2.

veq2

[37][0x0024] (V). *Equalize Voltage, battery 2.*
The equalize voltage setpoint assigned to battery 2.

vfloat2

[38][0x0025] (V). *Float Voltage, battery 2 .*
The float voltage setpoint assigned to battery 2.

vclamp2

[39][0x0026] (V). *Maximum regulation voltage, battery 2.*
The max. regulation voltage setpoint assigned to battery 2.

tfloat2

[40][0x0027] (V). *Float timer, battery 2.*
The float timer setpoint assigned to battery 2.

teq2

[41][0x0028] (V). *Equalize timer, battery 2.*
The equalize timer setpoint assigned to battery 2.

ta_F, ta_C

[257,258][0x0100,0x0101] (F,C). *Ambient Temperature.*
Ambient temperature as measured by local temperature sensor. Reported in degrees C and degrees F.

ta_F, ta_C

[259,260][0x0102,0x0103] (F,C). *Remote Temperature.*
Remote battery temperature as measured by optional RTS. Reported in degrees C and degrees F.

ths_F, ths_C

[261,262][0x0104,0x0105] (F,C). *Heatsink Temperature.*
Sunsaver Duo Heatsink temperature. Reported in degrees C and degrees F.

dc1

[263][0x0106] (%). *Duty cycle, battery 1.*
PWM duty cycle for battery 1.

dc2

[264][0x0107] (%). *Duty cycle, battery 2.*
PWM duty cycle for battery 2.

state

[265][0x0108] ( ).
Reports the current software state.

Value	Control State
1	NORMAL
3	NIGHT
4	FAULT

faults

[266][0x0109] (bit-field). *self diagnostic faults.*
Reports faults identified by self diagnostics. Each bit corresponds to a specific fault. See *Tables* section on page 7 for fault bits definitions.

flags

[267][0x010A] (bit-field). *Software flags.*
Reports software flags. Each bit corresponds to a specific even. See *Tables* section on page 7 for flag bits definitions.

dip_switch

[268][0x010B] (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 SunSaver Duo to verify DIP positions is not feasible. See *Tables* section on page 7 for DIP bits definitions.

b1_state

[270][0x010D] ( ). *Battery 1 state.*
Reports the current Battery 1 charge state.

Value	Control State
0	NORMAL
1	EQUALIZE
2	FLOAT

b2_state

[271][0x010E] ( ). *Battery 2 state.*
Reports the current Battery 2 charge state.

Value	Control State
0	NORMAL
1	EQUALIZE
2	FLOAT

b1_detect

[270][0x010D] ( ). *Battery 1 detection.*
Reports status of battery 1.

Value	Control State
0	DISCONNECTED
1	CONNECTED

b2_detect

[271][0x010E] ( ). *Battery 2 detection.*
Reports status of battery 2.

Value	Control State
0	DISCONNECTED
1	CONNECTED

EEPROM Values

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

mt_id

[57345][0xE000](). *SunSaver Duo 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

mb_id

[57346][0xE001](). SunSaver Duo *Modbus server ID*
Modbus address which uniquely identifies the controller on the MODBUS network.

priority_off

[57347][0xE002](%). *Battery 1 Priority, DIP 3 OFF.*
Defines the percentage of available charge current to battery 1 when both batteries are recharging. It follows that the percentage of charge to battery 2 is 100% - X. This priority will be used when DIP switch 3 is in the off position. A different custom priority setting can be defined when DIP switch 3 is in the ON position. See *priority_on* variable.

priority_on

[57348][0xE003](%). *Battery 1 Priority, DIP 3 ON.*
Defines the percentage of available charge current to battery 1 when both batteries are recharging. It follows that the percentage of charge to battery 2 is 100% - X. This custom priority will be used when DIP switch 3 is in the off position. A different custom priority setting can be defined when DIP switch 3 is in the ON position. See *priority_on* variable.

tcompcoef

[57349][0xE004](V/C). *temperature compensation.*
Battery chemistry changes with temperature. Determines the amount that regulation voltage will be shifted with temperature. Typical value for a 12V battery is 0.030 V/degree C.

v_absorption

[57351][0xE006](V). *Absorption 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.

v_equalize

[57352][0xE007](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.
Set to zero to disable equalization

v_float

[57353][0xE008](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.

v_reg_max

[57354][0x0009] (V). *Maximum regulation voltage* .
The max. regulation voltage limits regulation voltage (absorption, equalize) to a ceiling value, regardless of temperature compensation. Regulation voltage will not exceed v_reg_max under any conditions.

t_float

[57355][0xE00A] (min) *Time before entering float*
Defines the length of time in regulation before dropping down to the float stage. To disable float stage, set t_float to 1440 minutes.

t_equalize

[57356][0xE00B] *Equalization duration.*
Equalization will stop after the specified number of minutes at the equalization setpoint voltage.

Coils

Reset amp-hours

[10] [0x0017]
Reset the solar, battery 1, and battery 2 amp-hour counters back to 0.
(set only, will always read 0)

Clear faults

[21] [0x0014]
Clears the faults bit field. Certain faults require 30sec before retry(e.g. over-current). Control will not allow reset of these faults until 30sec counter has expired. (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)

Reset min/max volts and amps

[24] [0x0017]
Resets the solar max amps. Also resets battery 1 and battery 2 min/max voltages.
(set only, will always read 0)

Switch to Meterbus Protocol

[242] [0x00F1]
Manually switches the meter port protocol to Meterbus (for use with Morningstar Remote Meter). The SunSaver Duo also has protocol auto-detection for Meterbus/Modbus.

Reset control

[256] [0x00FF]
Reset control will force a reboot of the processor software.

Examples

Read Holding Register, Scaling

Variable (RAM): Battery Voltage 1, filtered ($\tau \approx 2.5s$)
Register Address: 0x0000
Scaling for this variable: n / 1800

```
1. read Register value(hex):   0x5CD0
2. Convert to decimal:         23760
3. Scale decimal value:        23760 / 1800  = 13.20 Volts
```

Read Holding Register, 2 Word values

Variable (RAM): hours (hourmeter)
LO Register Address: 0x0013
HI Register Address: 0x0014
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
```

Write Single Register, Scaling

Variable (EEPROM): priority_off
Register Address: 0xE002
Range for this variable: 0 – 417
Desired Battery1 priority: 60%

```
1. scale desired priority:     60/100 = X/417
                               X = (60*417)/100 = 250.2
2. Convert decimal to hex:     0x00FA
3. write register with hex value
```

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

v01 First Release
v02
v03 Hourmeter, Ah Total, Batt Ah 1&2: Hi and LO word addresses swapped. Corrected documentation.