

**Revision A** 

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## **1** Description

Modbus protocol is mapped onto a RS-485 multi-drop bus in which the system controller (RS-485 gateway, industrial pc, laptop etc.) is the master (initiator) and the SolrenView<sup>™</sup> Weather Monitor is a slave (responder). The master initiates all communications and the slave(s) responds only to the inquiries that contain their specific id.

Slave ID must be set between 1-247. ID 0 is reserved for broadcast messages. Please refer to <u>Function</u> <u>Overview</u> for function-specific broadcast support and to <u>this document</u> for official MODBUS specifications

#### Abbreviations and terminology

MSB=Most Significant Byte ('high' byte); MSW=Most Significant Word or ('high' word)
 LSB =Least Significant Byte ('low' byte); LSW=Least Significant Word or ('low' word)
 Sn=Serial number
 CRC=Cyclic Redundancy Check
 Fn=Function

The term 'slave ID' may be interchanged with 'slave address', which is not to be confused with the address in 'parameter address' or 'register address'.

## 2 Physical Layer

The physical layer consists of an UART device in asynchronous communication mode.

Communication settings:

Modbus framing:	RTU (binary)
Baud rate:	19200   9600 baud
Number of data bits (fixed value):	8
Parity (fixed value):	none
Number of stop bits (fixed value):	1

## **3** Supported MODBUS Functions

#### **3.1 Function Overview**

<u>Fn</u>	Description	Broadcast	Error Code	Sub-Function
03h	Read Holding Registers	No	83h	No
06h	Set Single Register	Yes	86h	No
08h	Diagnostics	No	88h	0000h
10h	Set Multiple Registers	Yes	90h	No
11h	Report Slave ID	No	No	No
xxh	Non-supported functions	No	80h+ Fn	No

#### **3.2 Exception Codes**

Following a request from master to slave, possible outcomes from the slave are:

- 1. The slave processes the request successfully, a valid response is sent back.
- 2. The slave does not receive the request, no response is sent.
- 3. The slave receives the request CRC errors. No response is sent as the message is ignored.

4. The request is received with no communication error, but cannot be processed by the slave for another reason. An exception response is sent back.

Exception Code	MODBUS Name	MODBUS Meaning	Additional Comment
01h	Illegal Function	The function code received is not an allowable action for the slave	
02h	Illegal Data Address	The data address received is not an allowable address for the slave	
03h	Illegal Data Value		This error applies to the format/composition of the master's query, not the implied value of a specific register
07h	Negative Acknowledge		For our purpose, this simply means that the query is not accepted by the slave.

#### **Exception message format:**

[0]	[1]	[2]	[6]	[7]
xxh	86h	xxh	xxh	Xxh

ID Error Exception CRC CRC Code Code Isb msb

### 3.3 Function 03h – Read Holding Register

ID	03h	FIRST MSB	FIRST LSB	NUM MSB	NUM LSB	CRC LSB	CRC
							MSB

ID = slave address, FIRST = starting register address, NUM = number of registers to read Example read one register from 0eh (slave address),

Maste	er-to-sla	ave (ID=	=1):						
Index	[0]	[1]	[2]	[3]	[4]	[5]		[6]	[7]
	01h	03h	00h	0Eh	00h	01h	1	E5h	C9h
	ID	Fn	Registe	er Regist	er Num	Nur	n	CRC	CRC
			Start	Start	Regist	ers Reg	isters	s Isb	msb
			msb	lsb	msb	lsb			
Respo	nse:								
Index	[0]	[1]	[2]	[3]	[4]	[5]	[6]		
	01h	03h	02h	00h	01h	79h	84h	l	
	ID	Fn	Num	Registe	r Registe	r CRC	CRC	2	
			Bytes	Value	Value	lsb	msk	)	
				msb	lsb				

#### 3.4 Function 06h – Set Single Register

IDO6hADDR MSBADDR LSBVALUE MSBVALUE LSBCRC LSBCRC MSBID = slave address, ADDR = register address, VALUE = value to set register

Example- Set register from 0Eh (slave ID) from ID 1 to 2

Master-to-slave (ID=1):

Index	[0] <b>01h</b>	[1] <b>06h</b>	[2] <b>00h</b>	[3] <b>0eh</b>			[6] <b>69h</b>	[7] <b>C8h</b>
	ID	Fn	Register	r Register	r Set	Set	CRC	CRC
			Addr msb	Addr Isb	Value msb		lsb	msb

Response: Non-broadcast messages are echoed back exactly if there are no errors (register writes must be supported, value set is within supported range). Example: slave ID must be between 1-247.

In the event of an exception in the message, the slave will respond with an exception message instead (see <u>Exceptions</u>).

#### **3.5 Function 10h – Set Multiple Registers**

ID10hADDR MSBADDR LSBNUM MSBNUM LSBREG BYTES(DATA) ...CRC LSBCRC MSBID = slave address, ADDR = starting register address, NUM = number of registers to writeDATA= 2\*number of registers

Alternatively, the example used to set ID from 1 to 2 (see section above) may be processed with function 10h instead.

Index [0]	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]
01h	10h	00h	0eh	00h	01h	02h	00h	02h	26h	bfh
ID	Fn	Register	r Register	r Registers	Registers	s Register	Data[0]	Data[1]	CRC	CRC
		Addr	Addr	msb	lsb	Bytes			lsb	msb
		msb	lsb			(N)				
							[0	N-1]		

#### 3.6 Function 11h – Report Slave ID

ID	11h	CRC LSB	CRC MSB
ID = Slav	ve add	ress	

Response:

Index [0]	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[3+N]	[3+N+1]
xxh	11h	xxh	xxh	ffh	00h	90h	c2h	xxh	xxh	xxh	xxh	xxh	xxh
ID	Fn	N=Byte	Slave	Run	MAC	MAC	MAC	MAC	МАС	MAC	Description	CRC	CRC
		Count	ID	Status	ID	ID [1]	ID [2]	ID [3]	ID	ID	(ascii)	lsb	msb
		(from			[0]				[4]	[5]			
		[3])											

#### 3.7 Function 08h – Diagnostics: Echo Query Data

ID	08h	SUB FN MSB	SUB FN LSB	DATA N=BYTES	 CRC LSB	CRC MSB

ID = Slave address, SUB FN=2-byte Sub-Function

#### Supported Sub Function: 0000h Echo Query Data

The data passed in the query data field is to be returned (looped back) in the response. The entire response message should be identical to the query to verify communication on the serial line. Note: Slave ID and CRC checks must pass.

Example:

Master-To-Slave (ID 1):

Index		[1] <b>08h</b>	[2] <b>00h</b>	[3] <b>00h</b>	[4] <b>11h</b>	[5] <b>12h</b>	[6] <b>13h</b>	[7] <b>17h</b>	[8] <b>e0h</b>			
	ID	Fn	SubFn	SubFn	Echo	Echo	Echo	CRC	CRC			
			msb	lsb	Data[0]	Data[1]	Data[2]	] Isb	msb			
Slave-To-Master (ID 1):												
Index	[0]	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]			
	01h	08h	00h	00h	11h	12h	13h	17h	e0h			
	ID	Fn	SubFn	SubFn	Echo	Echo	Echo	CRC	CRC			
			msb	lsb	Data[0]	Data[1]	Data[2	] Isb	msb			

## **4 MODBUS Registers**

Each register/data point contains a raw 16-bit unsigned integer/word. The appropriate multiplier must be applied to each word to obtain the scaled representation indicated under the 'Conversion' column. Each word (Value) is ordered {MSB, LSB}.

## 4.1 Register Map

Register	Description	Conversion	Read	Write	Range	Notes
0	Reserved for internal use					
1	Reserved for internal use					
2	Reserved for internal use					
3	Reserved for internal use					
4	Reserved for internal use					
5	Reserved for internal use					
6	Reserved for internal use					
7	Reserved for internal use					
8	Reserved for internal use					
9	Reserved for internal use					
10	Reserved for internal use					
11	Reserved for internal use					
12	Reserved for internal use					
13	Reserved for internal use					
14	Slave Address/ID	Value * 1	03h	06h,10h	[1,247]	
15	Baud Rate	Value* 1 Baud	03h	06h,10h		Only 19200 or 9600 supported
16	Reserved for internal use					
17	Reserved for internal use					
18	Reserved for internal use					
19	Reserved for internal use					
20	Reserved for internal use					
21	Reserved for internal use					
22	Reserved for internal use					
23	Reserved for internal use					
24	Reserved for internal use					
25	Reserved for internal use					
26	Reserved for internal use					
27	Reserved for internal use					
28	Reserved for internal use					
29	Reserved for internal use					
30	Ambient Temperature	(Value* 0.1) K	03h	No	[218,398] K	See Invalid Value Notes
31	Panel Module Temperature	(Value* 0.1) K	03h	No	[218,398] K	See Invalid Value Notes
32	PCB Temperature	(Value* 0.1) K	03h	No	[218,398] K	See Invalid Value Notes
33	Irradiance	r í	03h	No		
34	Wind Direction	(Value*0.1) Degrees		No	[0,360) °	See Invalid Value Notes
35	Wind Speed	(Value*0.1) mph	03h	No	>=0	

Notes on Invalid Value: When the slave returns value=ffffh as the result, this indicates that the sensor for that register is not connected, which should be interpreted as 'NA' or 'value not available'.

#### 4.2 Register Map - SunSpec

SunSpec register blocks begin at Register 40,000 (or 9c40h). \*\*Note: This block is only available on Solrenview units with firmware dated 2012824 or newer\*\*

Each block is uniquely identified with Sunspec Device ID (DID) to indicate the block format

In this implementation, blocks included are:

DID#1	Common Model Bloc	kRegisters: [40000, 40069]
DID#307	Base Meteorological	Registers: [40070, 40082]
DID#308	Mini-Weather Block	Registers: [40083, 40088]
DID#FFFF	End Block	Registers: [40248, 40249]

Notes: Registers that are unimplemented or unavailable will return 8000h (signed) or FFFFh (unsigned).

For more information, see official specifications: <u>http://www.sunspec.org</u>.

Reg.	Description	Unit	Multiplier	<sup>-</sup> Туре	Write	Contents	Notes
40000 40001	SunSpec ID (4 bytes)	N/A	N/A	String (4 bytes)	No	"SunS"	Spells out "SunS" in ascii
40002	SunSpec DID (Common)	N/A	1	uint16	No	1	Value of 1 is specific to Sunspec DID for 'Common Block'
40003	SunSpec Length (Common)	N/A	1	uint16	No	66	Length left on current block. le Last of this block = 40003+66=40069
40004 40005 40006 40007 40008 40009 40010 40011 40012 40013 40014 40015 40016 40017 40018 40019	Manufacturer String (32 bytes)	N/A	N/A	String (32 bytes)	No	"Solren"	Indicates Solectria as manufacturer. Remaining registers after the last non-zero character are zero-padded
-	Common - Model (32 bytes)	N/A	N/A	String (32 bytes)	No	"WEATHER"	This indicates a Solrenview Weather station. Remaining registers after the last non-zero

MO22       Image: String 10 Exclosed of the strong polation         M0226       Image: String 10 Exclosed of the strong polation       Image: String 10 Exclosed of the strong polation         M0227       Image: String 10 Exclosed of the strong polation       Image: String 10 Exclosed of the strong polation         M0228       Image: String 10 Exclosed of the strong polation       Image: String 10 Exclosed of the strong polation         M0229       Image: String 10 Exclosed of the strong polation       Image: String 10 Exclosed of the strong polation         M0231       Image: String 10 Exclosed of the strong polation       Image: String 10 Exclosed of the strong polation         M0332       Image: String 10 Exclosed of the strong polation       Image: String 10 Exclosed of the strong polation         M0333       Image: String 10 Exclosed of the strong polation       Image: String 10 Exclosed of the strong polation         M0334       Image: String 10 Exclosed of the strong polation       Image: String 10 Exclosed of the strong polation         M0334       Image: String 10 Exclosed of the strong polation       Image: String 10 Exclosed of the strong polation         M0334       Image: String 10 Exclosed of the strong polation       Image: String 10 Exclosed of the strong polation of the strong polation         M034       Image: String 10 Exclosed of the strong polation of	40023	l	1	1	I		l	character are zero-padded
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40044       Version       N/A       N/A       String (16 bytes)       N/A       String (16 bytes)       N/A       String (16 bytes)       Particular (16 bytes)       Firmware version of device         40044       40045       40046       Anderset       N/A       String (16 bytes)       N/A       String (16 bytes)       N/A       N/A       String (16 bytes)       Particular (16 bytes)       Partinanterior (16 bytes)								
40045       bytes)		Version	N/A	N/A	String (16	No	"20121024"	Firmware version of device
40046       40047         40048       40049         40049       40049         40040       40040         40051       40051         40052       Device Serial Number       N/A         40053       1         40054       40053         40055       40054         40056       40057         40057       40058         40058       40059         40059       40059         40050       4005         40051       4005         40052       4005         40053       4005         40054       4005         40055       4005         40056       4006         40061       4006         40062       4006         40063       40064         40064       4006         40065       40066         40066       1         40068       140         40069       Pad register			<i>'</i>	,		-		
40047       40048       40049       40050       40051       40051       40052       Device Serial Number       N/A       N/A       String (32 bytes)       No       "00:90:C2:XX:XX:XX"       Device Serial number, contains full MAC Hardware ID.         40053       40054       40055       40057       40057       40058       40058       40059								
40048       Image: Second								
40049       A0049       Image: Second								
40050       Image: Serial Number       N/A       N/A       String (32 bytes)       No       "00:90:C2:XX:XX:XX" Device Serial number, contains full MAC Hardware ID.         40053       Image: Serial Number       N/A       N/A       String (32 bytes)       No       "00:90:C2:XX:XX:XX" Device Serial number, contains full MAC Hardware ID.         40054       Image: Serial Number       N/A       N/A       N/A       String (32 bytes)       No       "00:90:C2:XX:XX:XX" Device Serial number, contains full MAC Hardware ID.         40054       Image: Serial Number         40055       Image: Serial Number       Image: Serial Number <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>								
40051LowLowLowLow40052Device Serial NumberN/AN/AString (32 bytes)No"00:90:C2:XX:XX:X"Device Serial number, contains full MAC Hardware ID.40054LowLowLowString (32 bytes)No"00:90:C2:XX:XX:X"Device Serial number, contains full MAC Hardware ID.40055LowLowLowLowLowLowLowLow40056LowLowLowLowLowLowLowLow40059LowLowLowLowLowLowLowLow40060LowLowLowLowLowLowLowLow40063LowLowLowLowLowLowLowLow40064LowLowLowLowLowLowLowLow40068Slave AddressN/A1uint16YesLowFor purpose of aligning only,								
40052       Device Serial Number       N/A       N/A       String (32 bytes)       No       "00:90:C2:XX:XX:XX"       Device Serial number, contains full MAC Hardware ID.         40054       40055       (32 bytes)       No       "00:90:C2:XX:XX:XX"       Device Serial number, contains full MAC Hardware ID.         40056       40057								
400534005440055401 MAC Hardware ID.400544005540056400574010574010574005840059400594010574010574010574005040060400614010574010574010574006040061401057401057401057401057400604006140105740105740105740105740063401057401057401057401057401057400644010574010574010574010574010574006851200 AddressN/A1uint16Yes40069Pad registerN/AN/AN/AN00		Device Centel Number	N1 / A	NI / A	Chuine	NI -	1100.00.00.00.00.000.000	
40054400554005640056400574005740057400584005940060400614006140061400614006140063400644006440064400654006640065400664006640066400664006740068Slave AddressN/A1uint16Yes40060For purpose of aligning only,		Device Serial Number	N/A	N/A			"00:90:C2:XX:XX:XX"	
40055400564005740058400594006040061400624006340064400644006540066400664006740068Slave AddressN/A					(32 Dytes)			
400564005740058400594006040061400624006340064400644006540066400664006740068Slave AddressN/A140069Pad registerN/A								
40057 40058 40059 40060 40061 40062 40063 40064 40064 40065 40066 40066 40066 40068 Slave Address N/A 1 uint16 Yes For purpose of aligning only,								
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40059 40060 40061 40062 40063 40064 40065 40066 40066 40066 40067 40068 Slave Address N/A 1 uint16 Yes 40068 Slave Address N/A N/A N/A No 0 For purpose of aligning only,								
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40063 40064 40065 40066 40066 40067Image: Second State AddressImage: Second State AddressImage: Second State Address40068 40069Slave AddressN/A1uint16Yes40069Pad registerN/AN/AN/ANo0								
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40065 40066 40067Image: Second State St	40063							
40066       40067       Image: Constraint of the second se	40064							
40067         N/A         I         uint16         Yes           40068         Slave Address         N/A         1         uint16         Yes           40069         Pad register         N/A         N/A         N/A         No         0         For purpose of aligning only,	40065							
40067         N/A         I         uint16         Yes           40068         Slave Address         N/A         1         uint16         Yes           40069         Pad register         N/A         N/A         N/A         No         0         For purpose of aligning only,	40066							
40068       Slave Address       N/A       1       uint16       Yes								
40069 Pad register N/A N/A N/A NO O For purpose of aligning only,		Slave Address	N/A	1	uint16	Yes		
value is fixed to zero.								
								value is fixed to zero.

40070	SunSpec DID - Base Meteorological Model (DID 307)	N/A	1	uint16	No	307	Value of 307 is specific to Sunspec DID for 'Base Meteorological'
40071	SunSpec Length (Base Meteorological)	N/A	1	uint16	No	11	Length left on current block. le Last on this block = 40071+11=40082
40072	Ambient Temperature	°C	0.1	int16	No	Reading	Ambient Air Temperature (same as 40087)
40073	Relative Humidity	%u	1	int16	No	N/A	Unimplemented
40074	Barometric Pressure	Нра	1	int16	No	N/A	Unimplemented
40075	Wind Speed	m/s	1	int16	No	Reading	Wind Speed (same as 40088)
40076	Wind Direction	0	1	int16	No	Reading	Wind Direction
40077	Incremental rainfall	mm	1	int16	No	8000h	Unimplemented
40078	Incremental snowfall	mm	1	int16	No	8000h	Unimplemented
40079	Precipitation Type	N/A	1	int16	No	8000h	Unimplemented
40080	Electric Field	V/m	1	int16	No	8000h	Unimplemented
40081	Surface Wetness	kOhms	1	int16	No	8000h	Unimplemented
40082	Soil Moisture	%	1	int16	No	8000h	Unimplemented
40083	SunSpec DID - Mini-Weatherl (DID 308)	N/A	1	uint16	No	1	Value of 308 is specific to Sunspec DID for 'Mini-Weather Model'
40084	SunSpec Length (Mini-Weatherl)	N/A	1	uint16	No	4	Length left on current block. le Last on this block = 40084+4=40088
40085	Irradiance	W/m2	1	uint16	No	Reading	Irradiance
40086	PV Module Temperature	°C	0.1	int16	No	Reading	Module Temperature
40087	Ambient Temperature	°C	0.1	int16	No	Reading	Ambient Temperature (same as Register 40072
40088	Wind Speed	m/s	1	int16	No	Reading	Wind Speed (same as 40075)
40248	SunSpec DID for End block	N/A	1	uint16	No	FFFFh	Value of FFFFh marks this as the 'End' of SunSpec blocks
40249	SunSpec Length (End block)	N/A	1	uint16	No	0	Length left on current block. 0 is always the length for SunSpec End block (DID FFFFh)

## 4.3 Data Conversion

Wind Direction



Temperature Conversions from 16-bit Value:

To Kelvin:	<b>Т</b> к=Value x 0.1;
То °С:	<b>Τ</b> <sub>℃</sub> =273+Value x 0.1;
То °F:	<b>T</b> ≆=32+(9/5) x <b>T</b> €;

Wind Speed Conversions from 16-bit Value:

```
Miles Per Hour:S_{mph}=Value x 0.1;Meters Per Sec:S_{m/s} = S_{mph} \times 0.447= Value x 0.0447;Kilometers Per Hour:S_{kmph}= Value x 0.1609;
```

# 5 CRC-16 calculation

The following 'C' code listing implements the CRC-16 calculation intended to guarantee a distortionproof data transfer between master and slave. This CRC-16 implementation is consistent with the most commonly used CRC-16 'standard'.

unsigned short int calc\_crc(unsigned char \*sop, unsigned char \*eop){

```
unsigned int crc;
unsigned char bit count;
unsigned char *char ptr;
char ptr = sop;
crc = 0xffff;
                                              //initialize all 1's
do{
       crc^=((*char_ptr)&0x00ff);
                                              //make sure only 8-bits get modified
       bit count = 0;
       do{
               if(crc&0x0001){
                                              //test before shifting
                       crc>>=1;
                       crc^=0xA001;
                                              //reflected version of poly:0x8005
               }else{
                       crc>>=1;
               }
       }while(bit count++ < 7);</pre>
                                              //for every bit
                                              //for every byte
}while(char_ptr++ < eop);</pre>
return crc;
                                              //return 16 bits of crc
```

In the serial data frame, the CRC span ranges from the slave address (byte index 0) to the last byte of message NOT including the CRC bytes.

}

# 6 MODBUS RTU Timing

Each message must be framed by a minimum 3.5 bytes of silence. At the fixed baud rate of 19200, this yields a minimum silent time of 1.75 (~2) ms.

If N = total size of message:

[N-[0] [1] ... 2] [N-1]

~2 ms silence

~2 ms xxh xxh .. xxh xxh silence ID Fn .. CRC CRC Isb msb

For each message, the master must not transmit anything (stay silent) until the required silent time is reached at both the beginning and end of message.

For further information about MODBUS RTU timing, consult the "MODBUS over serial line specification and implementation guide V1.0" (section MODBUS Message RTU Framing), which is available online: <u>http://www.modbus.org/docs/Modbus\_over\_serial\_line\_V1.pdf</u>

## 7 More Example Messages

The following messages (all in hexadecimal) are composed from master to slave unit with ID 1 to read holding registers.

Read 6 register data points from address 30 (001eh) 01,03,00,1e,00,06,a5,ce

Set ID (use Fn 06h) from 1 to 2 01,06,00,0e,00,02,69,c8

Read baud rate (1 register data points from address 0fh) 01,03,00,0f,00,01,b4,09

Write baud rate to 19200 (4b00h) 01,06,00,0f,**4b,00**,8f,39

Write baud rate to 9600 (2580h) 01,06,00,0f,**25,80**,a2,f9