Solectria Renewables
Modbus for SolrenView Weather Station

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^{TM} 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 Function Overview for function-specific broadcast support and to this document 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

Fn	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	A value contained in the query data field is not an allowable value for the slave	This error applies to the format/composition of the master's query, not the implied value of a specific register
07h	Negative Acknowledge	The slave cannot perform the program function received in the query	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 Code*	*Exception Code*	*CRC lsb*	*CRC 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),

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Master-to-slave (ID=1):

Index	[0]	[1]	[2]	[3]	[4]	[5]	[6]	[7]
	01h	**03h**	**00h**	**0Eh**	**00h**	**01h**	**E5h**	**C9h**
	ID	Fn	Register Start msb	Register Start lsb	Num Registers msb	Num Registers lsb	CRC lsb	CRC msb

Response:

Index	[0]	[1]	[2]	[3]	[4]	[5]	[6]
	01h	**03h**	**02h**	**00h**	**01h**	**79h**	**84h**
	ID	Fn	Num Bytes	Register Value msb	Register Value lsb	CRC lsb	CRC msb

3.4 Function 06h – Set Single Register

ID	06h	ADDR MSB	ADDR LSB	VALUE MSB	VALUE LSB	CRC LSB	CRC MSB

ID = 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]	[1]	[2]	[3]	[4]	[5]	[6]	[7]
	01h	**06h**	**00h**	**0eh**	**00h**	**02h**	**69h**	**C8h**
	ID	Fn	Register Addr msb	Register Addr lsb	Set Value msb	Set Value lsb	CRC lsb	CRC 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 Exceptions).

3.5 Function 10h – Set Multiple Registers

ID	10h	ADDR MSB	ADDR LSB	NUM MSB	NUM LSB	REG BYTES	(DATA) …	CRC LSB	CRC MSB

ID = slave address, ADDR = starting register address, NUM = number of registers to write
DATA= 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 Addr msb	Register Addr lsb	Registers msb	Registers lsb	Register Bytes (N)	Data[0]	Data[1]	CRC lsb	CRC msb
								[0…	.. N-1]		

3.6 Function 11h – Report Slave ID

ID		11h	CRC LSB	CRC MSB

ID = Slave address

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 Count (from [3])	Slave ID	Run Status	MAC ID [0]	MAC ID [1]	MAC ID [2]	MAC ID [3]	MAC ID [4]	MAC ID [5]	Description (ascii)…	…	CRC lsb	CRC msb

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	[0]	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
	01h	**08h**	**00h**	**00h**	**11h**	**12h**	**13h**	**17h**	**e0h**
	ID	Fn	SubFn msb	SubFn lsb	Echo Data[0]	Echo Data[1]	Echo Data[2]	CRC lsb	CRC 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 msb	SubFn lsb	Echo Data[0]	Echo Data[1]	Echo Data[2]	CRC lsb	CRC 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	19200|9600	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	(Value*0.1) W/m2	03h	No		
34	Wind Direction	(Value*0.1) Degrees	03h	No	[0,360) °	See Invalid Value Notes
35	Wind Speed	(Value*0.1) mph	03h	No	>=0	

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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 Block Registers: [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: http://www.sunspec.org.

Reg.	Description	Unit	Multiplier	Type	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. Ie 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
40020 40021 40022	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

40023							character are zero-padded
40024							
40025							
40026							
40027							
40028							
40029							
40030							
40031							
40032							
40033							
40034							
40035							
40036	Common - Options	N/A	N/A	String (16 bytes)	No	""	Additional device model information, currently just an empty string
40037							
40038							
40039							
40040							
40041							
40042							
40043							
40044	Version	N/A	N/A	String (16 bytes)	No	"20121024"	Firmware version of device
40045							
40046							
40047							
40048							
40049							
40050							
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							
40056							
40057							
40058							
40059							
40060							
40061							
40062							
40063							
40064							
40065							
40066							
40067							
40068	Slave Address	N/A	1	uint16	Yes		
40069	Pad register	N/A	N/A	N/A	No	0	For purpose of aligning only, 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. Ie 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	Hpa	1	int16	No	N/A	Unimplemented
40075	Wind Speed	m/s	1	int16	No	Reading	Wind Speed (same as 40088)
40076	Wind Direction	°	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. Ie 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

<u>Wind Direction</u>

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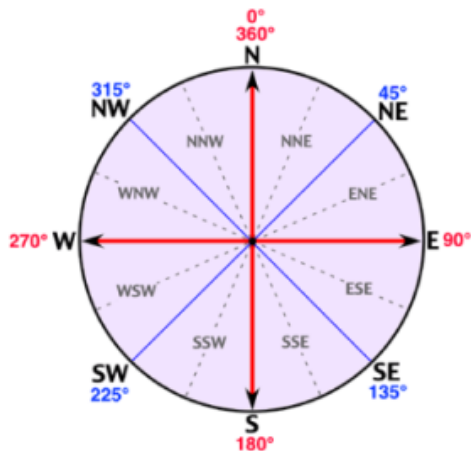
Temperature Conversions from 16-bit Value:

To Kelvin: T_K=Value x 0.1;

To °C: $T_{°C}$=273+Value x 0.1;

To °F: $T_{°F}$=32+(9/5) x $T_{°C}$;

Wind Speed Conversions from 16-bit Value:

Miles Per Hour: S_{mph}=Value x 0.1;

Meters Per Sec: $S_{m/s}$ = S_{mph} x 0.447

    = Value x 0.0447;

Kilometers Per Hour: S_{kmph} = S_{mph} x 1.609

        = Value x 0.1609;

5 CRC-16 calculation

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

```c
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);           //for every bit
        }while(char_ptr++ < eop);                  //for every byte
        return crc;                                //return 16 bits of crc
}
```
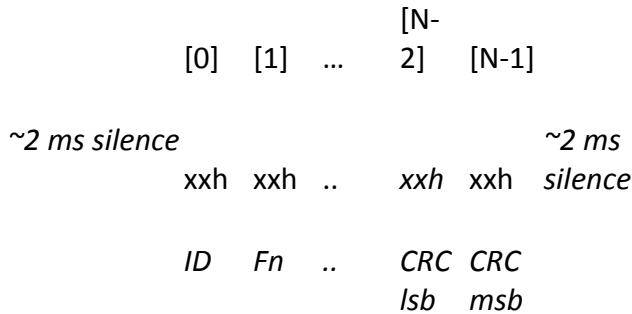
In the serial data frame, the CRC span ranges from the slave address (byte index 0) to the last byte of message NOT including the CRC bytes.

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 <u>minimum silent time of 1.75 (~2) ms.</u>

If N = total size of message:

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

~2 ms silence				*~2 ms*	
xxh	xxh	..	xxh	xxh	*silence*
ID	*Fn*	*..*	*CRC lsb*	*CRC 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: http://www.modbus.org/docs/Modbus_over_serial_line_V1.pdf

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