NSSPCM: P12408

Communication Protocol Specification

V 005

Contents

Document Modifications		
Revision	**Date**	**Modifications**
001	2012-02-08	Document Creation.
002	2012-02-20	Added minor text changes. Modified design to use raw ADC value instead of converted value and CRC8 instead of CRC16.
003	2012-03-21	Added messages for MCU VCC and internal temp sensor.
004	2012-04-19	Added charging and discharging currents to messages.
005	2012-05-17	Added PING_RETURN function.

1. Protocol Overview

The NSSPCM uses a modified MODBUS protocol over a two wire RS-485 connection between the module and the payload. MODBUS is a master-slave protocol which is appropriate for use with the NSSPCM. The payload is the master node while the NSSPCM is a slave node. The MODBUS frame is simple and easily implemented on microcontrollers without a large amount of overhead. Using a physical connection over RS-485, MODBUS exists on the data link layer and interfaces directly with a program on the application layer.

Layer	ISO/OSI Model	
7	Application	MODBUS Application Protocol
6	Presentation	Empty
5	Session	Empty
4	Transport	Empty
3	Network	Empty
2	Data Link	MODBUS Serial Line Protocol
1	Physical	EIA/TIA-485 (or EIA/TIA-232)

Figure 1: MODBUS Protocols and ISO/OSI Model [1:5]

2. Physical Layer

The NSSPCM uses RS-485 (TIA/EIA-485) for external serial communication. RS-485 uses differential signaling and is typically set to a baud rate from 100 kbps to 10 mbps with a signaling voltage level from -7 Volts to +12 Volts. RS-485 requires a multipoint infrastructure with additional nodes connected in parallel and does not support star or ring topologies. The ends of the RS-485 bus must be terminated to prevent reflections. For twisted pair wire, 120 Ohm termination resistors are sufficient. [3:13]

2.1 RS-485 Configuration

The NSSPCM utilizes the half-duplex two wire implementation of RS-485 and uses two pins, A (inverting) and B (non-inverting), as well as a common ground for reference for a total of three wires. The module is equipped with a Maxim IC MAX3483 and configured for half-duplex communications guaranteed up to 250 kbps. The NSSPCM contains a 120 Ohm resistor across its communication terminals as it assumes that it is located at a terminating end of the communication bus. A 120 Ohm resistor is required at the other terminating end of the bus. If the payload is the other terminating end of the bus, it should have a 120 Ohm resistor across its communication terminals.

3. Data Link Layer

Since the MODBUS protocol is a master-slave protocol, the payload will exist as the only master on the serial bus. The MODBUS protocol specifies that a communication is always initiated by the master node and that a slave node will never transmit data without receiving a request from the master first. The NSSPCM deviates from this specification because the NSSPCM must be allowed to send alert messages to the payload when a fault occurs. The method by which this will be accomplished is detailed in Section 3.2 on Addressing.

3.1 Frame Description

The MODBUS frame consists of a start marker, four fields and a stop marker. Each device listens to the bus for the start marker. Upon receiving the start marker, each device decodes the address field to determine if it is the intended recipient of the message. If the device is the intended recipient, it continues decoding the message. If the device is not the intended recipient, it discards the message and waits for the next start marker. Bits are transmitted least significant bit (LSB) first. Each byte is transmitted with 1 start bit, 8 data bits and 2 stop bits (8N2).

Start	Address	Function	Data	CRC	END
3.5 c	8 bits	8 bits	n * 8 bits	8 bits	3.5 c

Table 1: Modified MODBUS Frame

3.2 Addressing

Slave devices are issued addresses 1 to 247 (0x01 to 0xF7). The range of 248 to 255 is reserved. The address 0 is the broadcast address. All slave nodes must be able to receive a broadcast message. The master node does not have an address and listens on all addresses. A master node can communicate with the slave nodes in a unicast mode or a broadcast mode. In the unicast mode, only one slave receives a request using the slave's unique address. In the broadcast mode, all slaves receive the request. When a slave responds to a request, it uses its own address in the address field to identify itself to the master node. The NSSPCM is set to address 0xA1.

3.3 Instruction Set

The function field can hold values from 1 to 255. The code contained in the function field tells the slave which operation to execute. When a slave node responds to a master node's request, it uses the function field to indicate a normal response or an error response. For a normal response, the function field is the same code as the request. For an error response, the most significant bit (MSB) of the function code is set to 1. Exception information is then contained within the data field. Additional information about the exception data is contained within Section 3.4.

The NSSPCM does not use the MODBUS protocol's function codes. It uses a custom set of functions shown in the sections below and in Appendix A. The table shows the function code and the defined name of the function. It also shows the expected return values from the NSSPCM to the payload. The size of the data field is also indicated. The table also shows alert messages from the NSSPCM in case of faults. The messages are broadcast on the communication bus and received by the payload since it is listening on all addresses. The instruction set also contains a PING command which can be sent from either the NSSPCM or the payload to determine if the other device is online.

3.3.1 GET_SOLAR (0x01)

Description

Get the current of the solar panel.

Query

The query message is initiated from the payload to the NSSPCM and consists of no data bits.

Name	Length (bits)	Function
Address	8	Slave Address
Function	8	Instruction Code
CRC	8	Error Check

Response

The solar panel current is returned. The current is transmitted in two 8-bit sections of a 16-bit integer. The 8-bit sections must be reconstructed at the receiving device.

Name	Length (bits)	Function
Address	8	Slave Address
Function	8	Instruction Code
Data	16	Solar Panel Current
CRC	8	Error Check

3.3.2 GET_BATT (0x02)

Description

Get the current and voltage of the battery.

Query

The query message is initiated from the payload to the NSSPCM and consists of no data bits.

Name	Length (bits)	Function
Address	8	Slave Address
Function	8	Instruction Code
CRC	8	Error Check

Response

The battery voltage and current are returned. The voltage and current are each transmitted in two 8-bit sections of a 16-bit integer. The 8-bit sections must be reconstructed at the receiving device.

Name	Length (bits)	Function
Address	8	Slave Address
Function	8	Instruction Code
Data	16	Battery Voltage
Data	16	Battery Charge Current
Data	16	Battery Discharge Current
CRC	8	Error Check

3.3.3 GET_OUTPUT (0x03)

Description

Get the current and voltage of the NSSPCM output.

Query

The query message is initiated from the payload to the NSSPCM and consists of no data bits.

Name	Length (bits)	Function
Address	8	Slave Address
Function	8	Instruction Code
CRC	8	Error Check

Response

The NSSPCM output voltage and current are returned. The voltage and current are each transmitted in two 8-bit sections of a 16-bit integer. The 8-bit sections must be reconstructed at the receiving device.

Name	Length (bits)	Function
Address	8	Slave Address
Function	8	Instruction Code
Data	16	Output Voltage
Data	16	Output Current
CRC	8	Error Check

3.3.4 GET_INT_TEMP (0x04)

Description

Get the internal temperature of the NSSPCM.

Query

The query message is initiated from the payload to the NSSPCM and consists of no data bits.

Name	Length (bits)	Function
Address	8	Slave Address
Function	8	Instruction Code
CRC	8	Error Check

Response

The temperature is returned. The temperature is transmitted in two 8-bit sections of a 16-bit integer. The 8-bit sections must be reconstructed at the receiving device.

Name	Length (bits)	Function
Address	8	Slave Address
Function	8	Instruction Code
Data	16	Internal Temperature
CRC	8	Error Check

3.3.5 GET_EXT_TEMP (0x05)

Description

Get the external temperature of the NSSPCM.

Query

The query message is initiated from the payload to the NSSPCM and consists of no data bits.

Name	Length (bits)	Function
Address	8	Slave Address
Function	8	Instruction Code
CRC	8	Error Check

Response

The temperature is returned. The temperature is transmitted in two 8-bit sections of a 16-bit integer. The 8-bit sections must be reconstructed at the receiving device.

Name	Length (bits)	Function
Address	8	Slave Address
Function	8	Instruction Code
Data	16	Internal Temperature
CRC	8	Error Check

3.3.6 GET_MCU_TEMP (0x06)

Description

Get the temperature of the NSSPCM's microcontroller.

Query

The query message is initiated from the payload to the NSSPCM and consists of no data bits.

Name	Length (bits)	Function
Address	8	Slave Address
Function	8	Instruction Code
CRC	8	Error Check

Response

The temperature is returned. The temperature is transmitted in two 8-bit sections of a 16-bit integer. The 8-bit sections must be reconstructed at the receiving device.

Name	Length (bits)	Function
Address	8	Slave Address
Function	8	Instruction Code
Data	16	Internal Temperature
CRC	8	Error Check

3.3.7 GET_MCU_VCC (0x07)

Description

Get the voltage of the NSSPCM's microcontroller.

Query

The query message is initiated from the payload to the NSSPCM and consists of no data bits.

Name	Length (bits)	Function
Address	8	Slave Address
Function	8	Instruction Code
CRC	8	Error Check

Response

The voltage is returned. The voltage is transmitted in two 8-bit sections of a 16-bit integer. The 8-bit sections must be reconstructed at the receiving device.

Name	Length (bits)	Function
Address	8	Slave Address
Function	8	Instruction Code
Data	16	MCU Voltage
CRC	8	Error Check

3.3.8 GET_STATUS (0x08)

Description

Get the status of the NSSPCM. The status information includes:

- *Current Operation Mode/Fault Status*
- *Microcontroller Voltage*
- *Solar Panel Current*
- *Battery Charge/Discharge Current and Voltage*
- *Output Current and Voltage*
- *Internal Temperature*
- *External Temperature*
- *Microcontroller Temperature*

Query

The query message is initiated from the payload to the NSSPCM and consists of no data bits.

Name	Length (bits)	Function
Address	8	Slave Address
Function	8	Instruction Code
CRC	8	Error Check

Response

The NSSPCM status is returned. Integer values are transmitted in two 8-bit sections of a 16-bit integer. The 8-bit sections must be reconstructed at the receiving device.

Name	Length (bits)	Function
Address	8	Slave Address
Function	8	Instruction Code
Data	16	Current Mode/Fault
Data	16	MCU VCC
Data	16	Solar Panel Current
Data	16	Battery Voltage
Data	16	Battery Charge Current
Data	16	Battery Discharge Current
Data	16	Output Voltage
Data	16	Output Current
Data	16	Internal Temperature
Data	16	External Temperature
Data	16	MCU Temperature
CRC	8	Error Check

3.3.9 RESET_OUTPUT (0x09)

Description

Shut off the NSSPCM output for 5 seconds.

Query

The query message is initiated from the payload to the NSSPCM and consists of no data bits.

Name	Length (bits)	Function
Address	8	Slave Address
Function	8	Instruction Code
CRC	8	Error Check

Response

No response is required.

3.3.10 INT_TEMP_WARN (0x0A)

Description

NSSPCM alert broadcast to payload because NSSPCM internal temperature is outside of ideal parameters.

Query

The query message is broadcast from the NSSPCM to the payload and consists of the NSSPCM internal temperature status and the NSSPCM internal temperature value.

Name	Length (bits)	Function
Address	8	Slave Address
Function	8	Instruction Code
Data	8	High/Low Code
Data	16	Internal Temp
CRC	8	Error Check

Response

No response is required.

3.3.11 INT_TEMP_CRITICAL (0x0B)

Description

NSSPCM alert broadcast to payload because NSSPCM internal temperature is outside of operational parameters.

Query

The query message is broadcast from the NSSPCM to the payload and consists of the NSSPCM internal temperature status and the NSSPCM internal temperature value.

Name	Length (bits)	Function
Address	8	Slave Address
Function	8	Instruction Code
Data	8	High/Low Code
Data	16	Internal Temp
CRC	8	Error Check

Response

No response is required.

3.3.12 BATT_LOW (0x0C)

Description

NSSPCM battery voltage is below low threshold.

Query

The query message is broadcast from the NSSPCM to the payload and consists of the NSSPCM battery current and voltage.

Name	Length (bits)	Function
Address	8	Slave Address
Function	8	Instruction Code
Data	16	Battery Voltage
Data	16	Battery Current
CRC	8	Error Check

Response

No response is required.

3.3.13 PING (0x0D) / PING_RESPONSE (0x0E)

Description

Sends an empty message for the purposes of determining if a communication link exists.

Query

The query message is initiated from any device and consists of no data bits.

Name	Length (bits)	Function
Address	8	Slave Address
Function	8	Instruction Code
CRC	8	Error Check

Response

The response is a ping response function.

Name	Length (bits)	Function
Address	8	Slave Address
Function	8	Instruction Code (0x0E)
CRC	8	Error Check

3.4 Exceptions

As outlined in Section 3.3, the slave node changes the MSB of the function code to 1 if an error occurs. The exception codes contained within the data field are shown in Table 3. The payload will be expected to handle the declared exceptions. If there is a communication error, the slave node transmits no response and causes the master node to timeout. If the slave node detects a CRC error, the slave node transmits no response and causes the master node to timeout.

Code	Name	Description
0x01	ILLEGAL_FUNCTION	The function code received in the request is not an allowable action.
0x02	ILLEGAL_DATA_ADDRESS	The data received in the address field is out of range.
0x03	ILLEGAL_DATA_VALUE	A value in the data field is not allowable.
0x04	SLAVE_DEVICE_FAILURE	An unrecoverable error occurred while the slave was attempting to process the request.
0x05	ACKNOWLEDGE	The slave has accepted the request and is processing it but it will take longer than the timeout to process.
0x06	SLAVE_DEVICE_BUSY	The slave node is busy processing a long duration request.
0x07	NEGATIVE_ACKNOWLEDGE	That slave node cannot perform the request.
0x08	MEMORY_PARITY_ERROR	The slave attempted to read extended memory but detected a parity error.

Table 2: Exception Codes

3.5 Timing

A MODBUS message begins with a start marker of 3.5 characters of silence which is indicated by 2.97 ms at 9600 baud and 1.458 ms at 19200 baud of silence. After the start marker, the address field is transmitted. After the CRC check field, the end marker is indicated by 3.5 characters of silence which is indicated by 2.97 ms at 9600 baud and 1.458 ms at 19200 baud of silence. If there is a silence interval during the message of more than 1.5 characters (1.25 ms at 9600 baud and 0.625 ms at 19200 baud), the receiving node flushes the message buffer and waits for a new start marker. “Typically, the response time-out is set from 1 second to several seconds at 9600 bps; and the turnaround delay is from 100 ms to 200 ms.” [1:10] The NSSPCM recommends that the payload master node be set to a 2 second time-out. The NSSPCM is set to communicate at 19200 baud. Figure 2 shows a sample timing diagram for a GET_INT_TEMP request. At 19200 baud, the entire request completes in approximately 5 milliseconds.

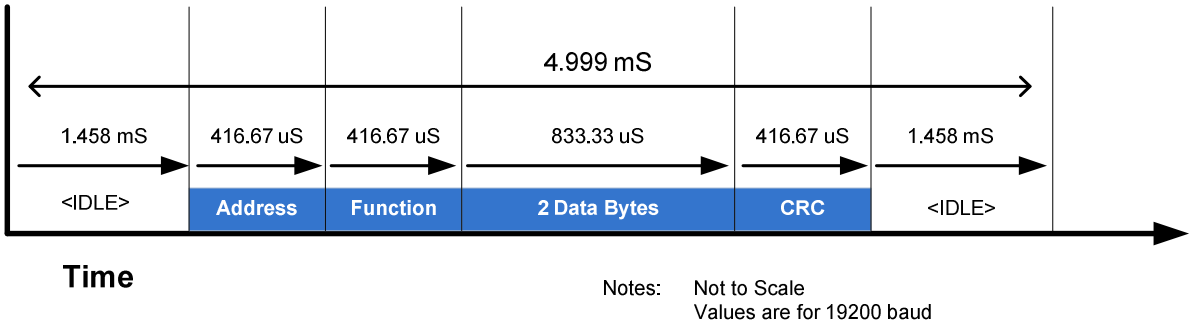

Figure 2: Timing Diagram

3.6 Error Checking

Each MODBUS message is checked for errors using a Cyclical Redundancy Check (CRC). MODBUS uses a CRC16 and the NSSPCM uses a CRC8. The 8 bit CRC value is contained in the CRC field at the end of the message. The transmitting node calculates the CRC before sending and the receiving node calculates the CRC after receiving the message. After the receiving node receives the entire message, the two CRCs are compared to check for errors. If no errors are encountered, the message is processed. If there is a CRC mismatch, the message is discarded.

4. References

[1] “MODBUS over Serial Line Specification and Implementation Guide V1.02.” Internet: www.modbus.org/docs/Modbus_over_serial_line_V1_02.pdf, Dec. 20, 2006 [Jan. 30, 2012]

[2] “Modicon Modbus Protocol Reference Guide.” PI-MBUS-300 Rev. J. Internet: http://modbus.org/docs/PI_MBUS_300.pdf, June 1996 [Jan. 30, 2012]

[3] “MAXIM 3.3V-Powered, 10Mbps and Slew-Rate-Limited True RS-485/RS-422 Transceivers datasheet.” Internet: http://datasheets.maxim-ic.com/en/ds/MAX3483-MAX3491.pdf, Dec. 1994 [Feb. 2, 2012

Appendix A - Instruction Set

Instruction Set

Code	Name	Description	Data Value - Sent with Instruction			Return Value - Received from Response			Type
			Data Size (Bits)	Value	Message Size (Bits)	Data Size (bits)	Value (Type)	Message Size (Bits)	
0x01	GET_SOLAR	Get Solar Panel Current	0	--	24	16	Current (int)	40	Query from Payload
0x02	GET_BATT	Get Battery Voltage and Current	0	--	24	48	Voltage (int) + Charge/Discharge Current (int)	72	Query from Payload
0x03	GET_OUTPUT	Get Output Voltage and Current	0	--	24	32	Voltage (int) + Current (int)	56	Query from Payload
0x04	GET_INT_TEMP	Get Internal Temperature	0	--	24	16	Internal Temperature (int)	40	Query from Payload
0x05	GET_EXT_TEMP	Get External Temperature	0	--	24	16	External Temperature (int)	40	Query from Payload
0x06	GET_MCU_TEMP	Get MCU Temperature	0	--	24	16	MCU Temperature (int)	40	Query from Payload
0x07	GET_MCU_VCC	Get Voltage of the MCU	0	--	24	16	MCU Voltage (int)	40	Query from Payload
0x08	GET_STATUS	Returns Status of Module	0	--	24	176	11 Integers	200	Query from Payload
0x09	RESET_OUTPUT	Toggles the Power Output	0	--	24	0	--	24	Command from Payload
0x0A	INT_TEMP_WARN	Internal Temperature Warning	24	High/Low (char) + Int_Temp (int)	48	--	--	--	Alert from Module
0x0B	INT_TEMP_CRITICAL	Internal Temperature Critical	24	High/Low (char) + Int_Temp (int)	48	--	--	--	Alert from Module
0x0C	BATT_LOW	Battery Level is Low	32	Voltage (int) + Current (int)	56	--	--	--	Alert from Module
0x0D	PING	Sends a ping	0	--	24	--	--	--	Module/Payload
0x0E	PING_RETURN	Returns a ping	0	--	24	--	--	--	Module/Payload
0x0F									