SunSpec Alliance Interoperability Specification

String Combiner Model

SunSpec Alliance String Combiner Workgroup

John Blair, John Nunneley, Steve Lewis, Rafal Pabich, Alessio Costantini, Aaron McNally, Aaron Parker, Lynn Linse, Lior Handelsman, Yaron Binder, Ronnie Petterson, Bob Schmitt, Matthew Perry, Bryan Thomas, Peter Rexelius, Steve Drouilhet, Martin Beran, Bob Fox, Cliff Baumann

Version 0.72

ABSTRACT

This document describes the string combiner model of the SunSpec Alliance interoperability specification

Introduction

This SunSpec Alliance Interoperability Specification describes the data models and MODBUS register mappings for string combiner devices used in Photovoltaic systems. The specification is broken into two sections: A basic device map and an advanced device map. Both maps may contain any number of combiner inputs and are therefore variable in length. Combiner units that support environmental measurements should include an appropriate block from the SunSpec Environmental Models specification.

Implementations should leave unused or unsupported datapoints set to the "not implemented" value specified in the SunSpec Common Model. For example, the Not Implemented value for a 16 bit signed integer is 0x8000.

String Combiner Device Block

The following data elements are provided to describe string combiners (SC). This model supports a variable number of string combiner inputs.

- **C_SunSpec_DID –** A well-known value that uniquely identifies this block as a basic (401) or advanced string combiner block (402).
- **C_SunSpec_Length** – The length of the string combiner block in registers.
- **SC_DC_xxxx** –DC values.
- **SC_Event_xxxx** – Event Flags
- **SC_Input_xxxx** – Input values

Combiner and Input String Event Flag Values

The string combiner specific flags are defined here. Any number of events may be active at the same time, and as a result the **SC_Event** value is implemented as a bit-map. The SC_Event field applies to the Combiner as a whole while the SC_Input_Event field applies to the specific string combiner input. Events at the SC_Input_Event level are logically OR'd to produce the corresponding SC_Event value. Users can trigger on the combiner level SC_EVENT and then drill down to the SC_Input_Event level to determine which string(s) are at fault. The bit-map values specifically called out as SC_EVENT_COMBINER_ only apply to the combiner unit as a whole.

Event Name	Flag Value	Description
SC_EVENT_LOW_VOLTAGE	0x00000001	Low voltage detected
SC_EVENT_LOW_POWER	0x00000002	Low power detected
SC_EVENT_LOW_EFFICIENCY	0x00000004	Low efficiency detected
SC_EVENT_CURRENT	0x00000008	Current out of range
SC_EVENT_VOLTAGE	0x00000010	Voltage out of range
SC_EVENT_POWER	0x00000020	Power out of range
SC_EVENT_PR	0x00000040	Performance ratio out of range
SC_EVENT_DISCONNECTED	0x00000080	Disconnect switch is open

SC_EVENT_FUSE_FAULT	0x00000100	Input fuse blown on one or more inputs. See SC_Input_Events for details.
SC_EVENT_COMBINER_FUSE_FAULT	0x00000200	Combiner output fuse blown.
SC_EVENT_COMBINER_CABINET_OPEN	0x00000400	Combiner cabinet open
SC_EVENT_COMBINER_TEMP	0x00000800	Combiner internal temp out of range.
SC_EVENT_GROUNDFAULT	0x00001000	Groundfault detected
SC_EVENT_REVERSED_POLARITY	0x00002000	Reversed polarity detected
SC_EVENT_INCOMPATIBLE	0x00004000	Incompatible input detected
SC_EVENT_COMM_ERROR	0x00008000	Subsystem Communication Error
SC_EVENT_INTERNAL_ERROR	0x00010000	Internal Self –Test Failed. See SC_Vendor_Status for details
SC_EVENT_THEFT	0x00020000	Theft detected
SC_EVENT_ARC_DETECTED	0x00040000	Arc detected.
SC_EVENT_RESERVED	0xFFF80000	Reserved for SunSpec

John Nunneley 3/2/11 3:28 PM
Deleted: output fuse blown.

MODBUS Register Mappings

BASIC String Combiner MODBUS Mapping

The Basic String Combiner MODBUS Mapping is a variable length model. The model supports combiners of any number of inputs. Combiner level readings provide combined values for Current, AmpHours, Voltage, Status, and Events. Individual string readings are provided for the Current and Events.

Start	End	Size	R/W	Name	Type	Units	Scale Factor	Contents	Description
1	1	1	R	C_SunSpec_DID	uint16	N/A	N/A	401	Uniquely identifies this as a BASIC SunSpec String Combiner MODBUS register map.
2	2	1	R	C_SunSpec_Length	uint16	Registers	N/A	14+N*8	Variable model length block. 14=number of Combiner registers N=# of combiner inputs. 8=length of combiner input block.

3	3	1	R	SC_DC_Current_SF	int16	SF	N/A	Configured	DC Current Scalefactor
4	4	1	R	SC_DC_AH_SF	int16	SF	N/A	Configured	DC AmpHour Scalefactor
5	5	1	R	SC_DC_Voltage_SF	int16	SF	N/A	Configured	DC Voltage Scalefactor
6	6	1	R	SC_DC_Current_Max	uint16	Amps	_SF	Configured	Maximum DC Current Rating for the combiner
7	7	1	R	SC_Num_Inputs	uint16	N/A	N/A	Configured	(N) Number of String inputs to this combiner. This register must be supported but may have a zero value.
8	9	2	R	SC_Event	uint32	Bitfield	N/A	SC_EVENT_	Combiner event code
10	11	2	R	SC_Event_Vendor	uint32	Bitfield	N/A	Vendor	Vendor specific event code
12	12	1	R	SC_DC_Current	int16	Amps	_SF	Measured	Combined current value
13	14	2	R	SC_DC_AmpHour	uint32	AH	_SF	Metered	Accumulated amps supplied by Combiner
15	15	1	R	SC_DC_Voltage	uint16	Volts	_SF	Measured	Combined voltage value
16	16	1	R	SC_Internal_Temp	uint16	°C	N/A	Measured	Internal Temperature of the Combiner
Input String Values Repeated for each String as configured by SC_Num_Inputs									
17	17	1	R	SC_Input_ID	uint16	N/A	N/A	Configured	The id of this input string.
18	19	2	R	SC_Input_Event	uint32	Bitfield	N/A	SC_EVENT_	Input event flags
20	21	2	R	SC_Input_Event_Vendor	uint32	Bitfield	N/A	SC_EVENT_	Vendor input event flags
22	22	1	R	SC_Input_DC_Current	int16	Amps	_SF	Measured	DC Current value. Maybe negative due to ground fault.
23	24	2	R	SC_Input_DC_AmpHout	uint32	AH	_SF	Metered	Accumulated Amps for this string

ADVANCED String Combiner MODBUS Mapping

The Advanced String Combiner MODBUS Mapping is a variable length model. The model supports combiners of any number of inputs. Advanced measurements and metered values for Voltage, Power, Energy, and Performance Ratio are provided at the Combiner and Input String level.

Performance Ratio is defined to be the Actual Performance / Expected Peformance. Actual Performance is measured and metered by the device. The Expected Performance is calculated based on a variety of factors. The method of calculation for the Expected and Actual Performance is not part of this specification and is vendor specific.

Start	End	Size	R/W	Name	Type	Units	Scale Factor	Contents	Description
1	1	1	R	C_SunSpec_DID	uint16	N/A	N/A	402	Uniquely identifies this as a Advanced SunSpec String Combiner MODBUS register map.
2	2	1	R	C_SunSpec_Length	uint16	Registers	N/A	20+N*14	Variable model length block. 20=number of Combiner registers N=# of combiner inputs. 14=length of combiner input block.
3	3	1	R	SC_DC_Current_SF	int16	SF	N/A	Configured	DC Current Scalefactor
4	4	1	R	SC_DC_AH_SF	int16	SF	N/A	Configured	DC AmpHout Scalefactor
5	5	1	R	SC_DC_Voltage_SF	int16	SF	N/A	Configured	DC Voltage Scalefactor
6	6	1	R	SC_DC_Power_SF	int16	SF	N/A	Configured	DC Power Scalefactor
7	7	1	R	SC_DC_Energy_SF	int16	SF	N/A	Configured	DC Energy Scalefactor
8	8	1	R	SC_DC_Current_Max	uint16	Amps	_SF	Configured	Maximum DC Current Rating for the combiner
9	9	1	R	SC_Num_Inputs	uint16	N/A	N/A	Configured	(N) Number

									of String inputs to this combiner. This register must be supported but may have a zero value.
10	11	2	R	SC_Event	uint32	Bitfield	N/A	SC_EVENT_	Combiner event code
12	13	2	R	SC_Event_Vendor	uint32	Bitfield	N/A	Vendor	Vendor specific event code
14	14	1	R	SC_DC_Current	int16	Amps	_SF	Measured	Combined current value
15	16	2	R	SC_DC_AmpHour	uint32	AH	_SF	Metered	Accumulated amps supplied by Combiner
17	17	1	R	SC_DC_Voltage	uint16	Volts	_SF	Measured	Combined voltage value
18	18	1	R	SC_Internal_Temp	uint16	°C	N/A	Measured	Internal temperature of the combiner
19	19	1	R	SC_DC_Power	int16	Watts	_SF	Measured	Combined power value
20	20	1	R	SC_DC_PR	uint16	%	N/A	Metered	Performance Ratio value
21	22	2	R	SC_DC_Energy	uint32	WH	_SF	Metered	Accumulated Watt-hours supplied by Combiner
Input String Values									
23	23	1	R	SC_Input_ID	uint16	N/A	N/A	Configured	The id of this input string.
24	25	2	R	SC_Input_Event	uint32	Bitfield	N/A	SC_EVENT_	Input event flags
26	27	2	R	SC_Input_Event_Vendor	uint32	Bitfield	N/A	SC_EVENT_	Vendor input event flags
28	28	1	R	SC_Input_DC_Current	int16	Amps	_SF	Measured	DC Current value. Maybe negative due to ground fault.
29	30	2	R	SC_Input_DC_AmpHour	uint32	AH	_SF	Metered	Accumulated Amp-hours supplied by

									this Input
31	31	1	R	SC_Input_DC_Voltage	uint16	Volts	_SF	Measured	DC Voltage value
32	32	1	R	SC_Input_DC_Power	int16	Watts	_SF	Measured	DC Power value
33	34	2	R	SC_Input_DC_Energy	uint32	WH	_SF	Metered	Accumulated Watt-hours supplied by this Input
35	35	1	R	SC_Input_DC_PR	uint16	%	N/A	Metered	Performance Ratio value for the string
36	36	1	R	SC_Input_Num_Modules	unit16	N/A	N/A	Configured	Number of modules in the string
37	…	…	R	Next Input String ID					The Input String values are repeated for each combiner input.