6 Serial Bus General Protocol Overview

6.1 Each message packet transmitted by any device on the bus must conform to the following format:

Single byte indices 3, 5, 9, … between data fields are comma (decimal 44) field separators.

Byte Index	Item	Description
0-2	Protocol Identifier	Uniquely identifies the set of application-specific messages to be expected from a device. It may imply the actual device type, model or version, but more than one may use the same protocol.
4	Message Type	Identifies purpose and contents of message. Unique for a single Protocol Identifier, but may be redefined for other Protocol Identifiers.
6-8	Message Length	Number of bytes (n) in the message, counting the Protocol Identifier as byte one (1) and the last data byte, immediately preceding the first CRC byte, as byte (n).
10-12	Message ID	Serialized unsigned integer incremented for each message. Actually initialized to zero on each reset or powerup.
14-to-n	Data	Command and data bytes specific to the Message Type. May be zero length if a simple command or query does not require data.
n+1, n+2, n+3, n+4	Fletcher's-16	4 byte hex representation of 16-bit Fletchers checksum value calculated on bytes 0 thru n, where n=13 if message does not contain any data bytes.
n+5, n+6	CR-LF	Carriage return / Line feed terminator (0x0D, 0x0A)

Table 2: BMS serial bus general packet format

7 Detail of User Bus Messages

The following message descriptions include general protocol and application-specific elements for clarity.

7.1 Periodic String Status Report

Single byte indices 3, 5, 9, … between data fields are comma (decimal 44) field separators.

Byte Index	Description	Value (ASCII string)	Data Type
0-2	Protocol Identifier	001	ASCII decimal
4	Message Type	'S'	ASCII character
6-8	Message Length	122	ASCII decimal
10-12	Message ID	000 - 999	ASCII decimal
14-15	String ID	00 - 99	ASCII decimal
17	String State: 'S' = Sleeping 'I' = Initializing 'O' = Off – not currently used 'R' = Ready 'D' = Discharging 'C' = Charging 'F' = Fault	'A' – 'Z'	ASCII character
19-21	String State of Charge (SOC) (percent)	000 - 100	ASCII decimal
23-25	String Temperature (degrees C) (typically the maximum module temperature)	-99 - 999	Signed ASCII decimal
27-32	String Voltage (millivolts)	000000 - 999999	ASCII decimal
34-38	String Amperes (Amperes X 10) (Negative value is charging) (Positive value is discharging)	-9999 – 99999	Signed ASCII decimal

40-47	Alarm and Status Bits bit 0 = String temperature warning bit 1 = String temperature fault bit 2 = String high current warning bit 3 = String high current fault bit 4 = String high voltage warning bit 5 = String high voltage fault bit 6 = String low voltage warning bit 7 = String low voltage fault bit 8 = Cell low voltage non-recoverable fault bit 9 = N/U bit 10 = N/U bit 11 = N/U bit 12 = String charge low warning bit 13 = String module communication error bit 14 = String module communication fault bit 15 = BMS self-check warning bit 16 = Under Volt disable bit 17 = Over Volt disable bit 18 = N/U bit 19 = N/U bit 20 = N/U bit 21 = N/U bit 22 = N/U bit 23 = N/U bit 24 = N/U bit 25 = N/U bit 26 = N/U bit 27 = N/U bit 28 = N/U bit 29 = N/U bit 30 = N/U bit 31 = String contactor or FET ON	00000000 - FFFFFFFF	ASCII hex
49-51	BMS Final assembly (Control) revision number	000 - 255	ASCII decimal
53-65	BMS Serial Number Chars 0-1: YY – year (00 = 2000, 99 = 2099) Chars 2-3: MM – month (01 - 12) Chars 4-5: DD – day of month (01 - 31) Chars 6-10: nnnnn – serial code (00000 - 99999) Chars 11-12: CC – facility code (00 - 99)	YYMMDDnnnnnCC	ASCII decimal
67-70	BMS Software version (Master)	0000 – 9999	ASCII decimal
72-75	BMS Software version (Slave)	0000 - 9999	ASCII decimal
77-82	String Watt-hours to Full Discharge	000000 – 999999	ASCII decimal
84-89	String Watt-hours to Full Charge	000000 – 999999	ASCII decimal
91-96	Min Cell Millivolts	000000 - 999999	ASCII decimal
98-103	Max Cell Millivolts	000000 - 999999	ASCII decimal
105-107	Front Power Connector Temperature	-99 - 999	ASCII decimal
109-120	Reserved by factory	undefined	ASCII character
122-125	Fletcher's-16	0000 – FFFF	ASCII hex
126-127	CR-LF	0x0D,0x0A (Line terminator)	Binary

Table 3: BMS serial bus periodic string status report format

NOTES:

1. Bit 0 of Alarm and Status bits is based on TMP75, the CellOverTempWarning or TMP77, the CellUnderTempWarning as evaluated by the BMS
2. Bit 1 of Alarm and Status bits is based on TMP74, the CellOverTempFault or TMP76, the CellUnderTempFault as evaluated by the BMS
3. Bit 2 of Alarm and Status bits is based on I81, the ChargeOverAmpWarning or I79, the DischargeOverAmpWarning as evaluated by the BMS
4. Bit 3 of Alarm and Status bits is based on I80, the ChargeOverAmpFault or I78, the DischargeOverAmpFault as evaluated by the BMS
5. Bit 4 of Alarm and Status bits is based on V71, the CellOverVoltWarning as evaluated by the BMS
6. Bit 5 of Alarm and Status bits is based on V70, the CellOverVoltFault as evaluated by the BMS
7. Bit 6 of Alarm and Status bits is based on V73, the CellUnderVoltWarning as evaluated by the BMS
8. Bit 7 of Alarm and Status bits is based on V72, the CellUnderVoltFault as evaluated by the BMS
9. Bit 8 of Alarm and Status bits is based on a fixed define of 2950 millivolts as evaluated by the BMS. This bit is one of the disables, once active nothing short of a reset will allow contactor to close again.
10. Bit 16 of Alarm and Status bits is based on Alarm 7, UnderVoltDisable being reported by a MODULE. This bit is one of the disables, once active nothing short of a reset will allow contactor to close again.
11. Bit 17 of Alarm and Status bits is based on Alarm 14, OverVoltDisable being reported by a MODULE. This bit is one of the disables, once active nothing short of a reset will allow contactor to close again.
12. Bit 12 of Alarm and Status bits is based on SOCLOW, as evaluated by the BMS
13. Bit 13 of Alarm and Status bits is based on the MODULES reporting of Slave Comm Failures
14. Bit 14 of Alarm and Status bits is based on one or more MODULES not having reported in 30 seconds or more as evaluated by BMS
15. Bit 15 of Alarm and Status bits is based on BMS self tests having failed one or more of the UL1998 safety tests
16. String State of ‘S’ means string is asleep based on dip switch command, State of ‘I’ means string is initializing, either after powerup or reset or coming out of sleep, string will be initializing until correct number of modules have been detected and no more, State of ‘R’ means string is ready, initialization is complete and conditions are normal and no substantial currents are yet flowing, State of ‘C’ means string is charging, based on current flow, State of ‘D’ means string is discharging based on current flow, State of ‘F’ means string is faulted, due to one or more of the strings Alarm and Status Fault bits being set indicating a fault condition.
17. In general ANY fault will cause contactors to open. When the fault condition is cleared, the contactors may close again. Disables are special in that even if the situation that caused the fault should change, the contactors remain open. Battery modules are designed such that once they have registered an OverVoltDisable or an UnderVoltDisable they will forever more continue to report this situation so as to prevent the over-stressed module from being used in any string.

7.2 Periodic Module Status Report

Single byte indices 3, 5, 9, … between data fields are comma (decimal 44) field separators.

Byte Index	Description	Value (decimal or ASCII)	Data Type
0-2	Protocol Identifier	001	ASCII decimal
4	Message Type	'M'	ASCII character
6-8	Message Length	122	ASCII decimal
10-12	Message ID	000 - 999	ASCII decimal
14-15	String ID	00 - 99	ASCII decimal
17-18	Module ID	00 - 99	ASCII decimal
20	Module State: 'S' = Sleeping 'I' = Initializing 'O' = Off – not currently used 'R' = Ready 'D' = Discharging 'C' = Charging 'F' = Fault	'A' – 'Z'	ASCII character
22-24	Module State of Charge (SOC) (percent)	000 - 100	ASCII decimal
26-28	Minimum Cell Temperature (degrees C)	-99 - 999	Signed ASCII decimal
30-32	Average Cell Temperature (degrees C)	-99 - 999	Signed ASCII decimal
34-36	Maximum Cell Temperature (degrees C)	-99 - 999	Signed ASCII decimal
38-43	Module Voltage (millivolts)	000000 - 999999	ASCII decimal
45-50	Minimum Cell Voltage (millivolts)	000000 - 999999	ASCII decimal
52-57	Average Cell Voltage (millivolts)	000000 - 999999	ASCII decimal
59-64	Maximum Cell Voltage (millivolts)	000000 - 999999	ASCII decimal
66-70	Module Amperes (Amperes X 10) (Negative value is charging) (Positive value is discharging)	-9999 – 99999	Signed ASCII decimal

72-79	Alarm and Status Bits bit 0 = Module temperature warning bit 1 = Module temperature fault bit 2 = Module high current warning bit 3 = Module high current fault bit 4 = Module high voltage warning bit 5 = Module high voltage fault bit 6 = Module low voltage warning bit 7 = Module low voltage fault bit 8 = Cell low voltage non-recoverable fault bit 9 = N/U bit 10 = N/U bit 11 = N/U bit 12 = Module charge low warning bit 13 = Module communication error bit 14 = Module communication fault bit 15 = N/U bit 16 = Under Volt disable bit 17 = Over Volt disable bit 18 = N/U bit 19 = N/U bit 20 = N/U bit 21 = N/U bit 22 = N/U bit 23 = N/U bit 24 = Cell 0 balancing bit 25 = Cell 1 balancing bit 26 = Cell 2 balancing bit 27 = Cell 3 balancing bit 28 = Cell 4 balancing bit 29 = Cell 5 balancing bit 30 = Cell 6 balancing bit 31 = N/U	00000000 - FFFFFFFF	ASCII hex
81-83	Module Final assembly (Control) revision number	000 - 255	ASCII decimal
85-97	Module Serial Number Chars 0-1: YY – year (00 = 2000, 99 = 2099) Chars 2-3: MM – month (01 - 12) Chars 4-5: DD – day of month (01 - 31) Chars 6-10: nnnnn – serial code (00000 - 99999) Chars 11-12: CC – facility code (00 - 99)	YYMMDDnnnnnCC	ASCII decimal
99-102	Software version (Master)	0000 – 9999	ASCII decimal
104-107	Software version (Slave)	0000 – 9999	ASCII decimal
109-111	Maximum Front Power Connector Temp	-99 - 999	ASCII decimal
113-120	Reserved by factory	undefined	ASCII character
122-125	Fletcher's-16	0000 – FFFF	ASCII hex
126-127	CR-LF	0x0D,0x0A (Line terminator)	Binary

Table 4: BMS serial bus periodic module status report format

NOTES:

1. Bit 0 of Alarm and Status bits is based on TMP75, the CellOverTempWarning or TMP77, the CellUnderTempWarning as evaluated by the BMS
2. Bit 1 of Alarm and Status bits is based on TMP74, the CellOverTempFault or TMP76, the CellUnderTempFault as evaluated by the BMS

3. Bit 2 of Alarm and Status bits is based on I81, the ChargeOverAmpWarning or I79, the DischargeOverAmpWarning as evaluated by the BMS
4. Bit 3 of Alarm and Status bits is based on I80, the ChargeOverAmpFault or I78, the DischargeOverAmpFault as evaluated by the BMS
5. Bit 4 of Alarm and Status bits is based on V71, the CellOverVoltWarning as evaluated by the BMS
6. Bit 5 of Alarm and Status bits is based on V70, the CellOverVoltFault as evaluated by the BMS
7. Bit 6 of Alarm and Status bits is based on V73, the CellUnderVoltWarning as evaluated by the BMS
8. Bit 7 of Alarm and Status bits is based on V72, the CellUnderVoltFault as evaluated by the BMS
9. Bit 8 of Alarm and Status bits is based on a fixed define of 2950 millivolts as evaluated by the BMS this bit is one of the disables, once active nothing short of a reset will allow contactor to close again.
10. Bit 16 of Alarm and Status bits is based on Alarm 7, UnderVoltDisable being reported by this MODULE. This bit is one of the disables, once active nothing short of a reset will allow contactor to close again
11. Bit 17 of Alarm and Status bits is based on Alarm 14, OverVoltDisable being reported by this MODULE. This bit is one of the disables, once active nothing short of a reset will allow contactor to close again
12. Bit 12 of Alarm and Status bits is based on SOCLOW, compared by BMS with SOC reported by this MODULE
13. Bit 13 of Alarm and Status bits is based on this MODULE reporting Slave Comm Failures
14. Bit 14 of Alarm and Status bits is based on this MODULE not having reported in 30 seconds or more to the BMS
15. Module State of ‘S’ means module is asleep based on dip switch command, State of ‘I’ means module is initializing, either after powerup or reset or coming out of sleep. State of ‘R’ means module is ready, initialization is complete and conditions are normal and no substantial currents are yet flowing, State of ‘C’ means module is charging, based on modules current flow, State of ‘D’ means module is discharging based on modules current flow, State of ‘F’ means module is faulted, due to one or more of the modules Alarm and Status Fault bits being set indicating a fault condition.

8 Serial Bus Factory Operational Overview

8.1 NAK

8.1.1 (M2H format)

Byte Index	Description	Value (decimal or ASCII)	Data Type
0-5	Error label	“ERROR “	ASCII string
6-to-n	Error Description	“Unknown cmd” “Unknown label” “Bad value” “Busy”	ASCII string
n+1, n+2	CR-LF	Line terminator (0x0D, 0x0A)	Binary

Table 5: BMS serial bus NAK message (H2M format)