secret	Authorized party only	Rank	C

Industrial Li-ion Rechargeable Battery Module

SIP24-23

(Model : FP01101MCB01A)

CAN Interface Specifications

SCiB™

Rev.4

株式会社 東芝

Table of Contents

1P1S

Edition

1P1S Table of Contents

1. Introduction.

This specification describes the CAN communication specifications for the 23Ah 11 direct battery module.

(Definitions and Abbreviations)

abbr eviati on	nam e	Desc riptio n.
ENABLE Signal	Enable	Signal for BMS startup (Closed: High, Open: Low)
R1	Register 1	Register representing the current system abnormality status.
R2	Register 2	The register represents the state of the system, including past system abnormalities.
SJW	reSynchronization Jump Width	Resynchronization jump width, 1-bit error detected in CAN communication Number of samplings to be
SOC	State Of Charge	Battery charge status. Displayed in remaining battery charge (mAh)
Tq.	Time quantum	bit time
VTM	Voltage Temperature Monitor	Function to measure cell voltage and temperature

2. CAN Interface Overview

2.1 protocol

CAN communication between the host and the module conforms to CAN2.0B (ISO11898-2). Data frames are standard frames (11-bit ID).

The communication rate is 250 kbps. The sampling point is 70% of bit time and SJW is 2 (Tq).

Each data field is transferred starting with the most significant byte.

2.2 CAN ID assignment

Table 2-2-1 shows the various CANID assignments.

Table 2-2-1 CAN ID Assignment

CAN ID 0x000 to 0x010	From –	To –	Contents reserved	communication cycle -
0x011	high-level equipment	module	Shutdown of each module	at any time
0x012	high-level equipment	module	Clear R2 register of each module	at any time
0x013 to 0x030	–	–	reserved	-
0x031	module	high-level equipment	Module 1 response to a command from a host device （Module 1 shutdown)	at any time
0x032	module	high-level equipment	Module 1 response to a command from a host device (Module 1 R2 register clear)	at any time
0x033 to 0x04F	–	–	reserved	-
0x050 to 0x05F	module	high-level equipment	Elapsed time, input/output status, error/failure code, and SOC, temperature, current, voltage, module information	200±20ms
0x060 to 0x17F	–	–	reserved	-
0x180 to 0x19F	module	–	Internal data for maintenance	200±20ms
0x1A0 to 0x1FF	–	–	reserved	-

3. CAN Communication

An overview diagram of the CAN communication status according to each state is shown below.

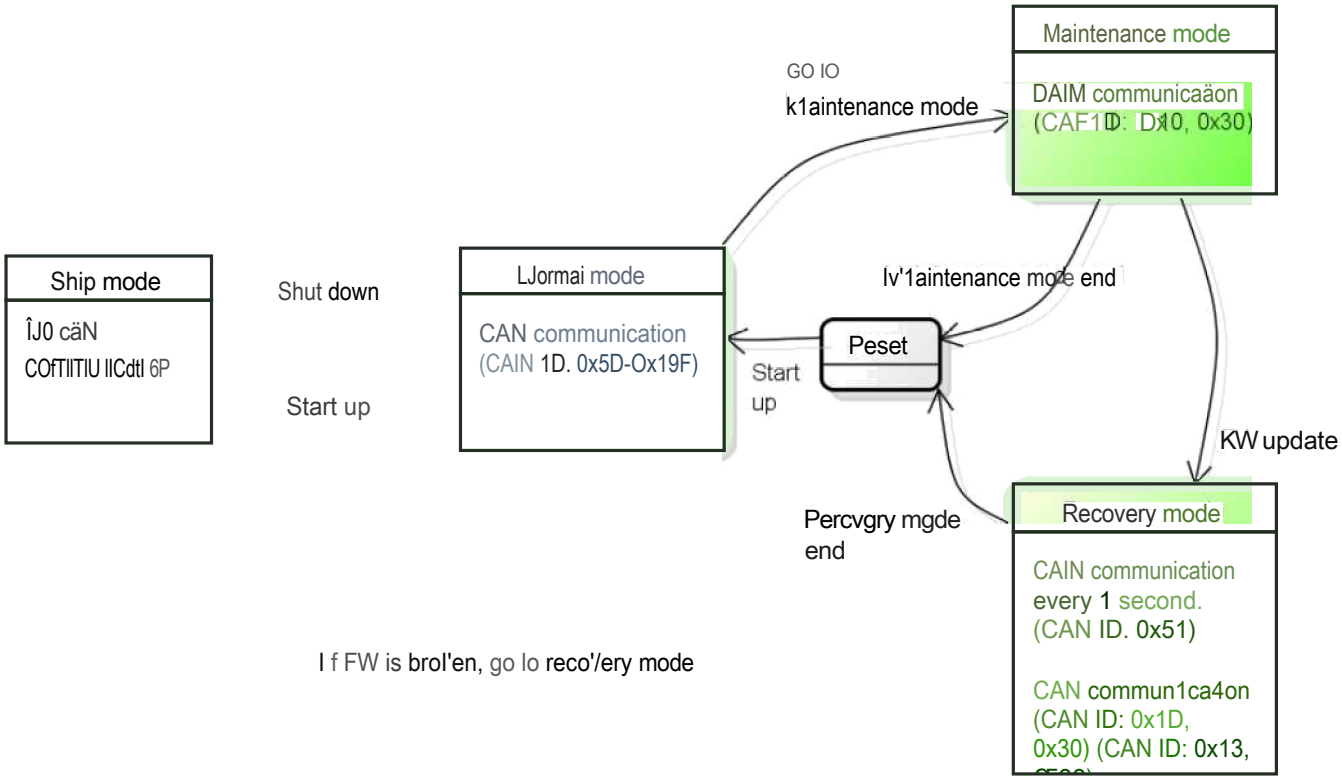

Figure 3-1 Overview of CAN communication status in each state

3.1 Periodic transmission of the module's internal status to the host device

Figure 3-1-1 shows a sequence diagram of communication in normal mode. The CAN data format is shown in Table 3-1-1.

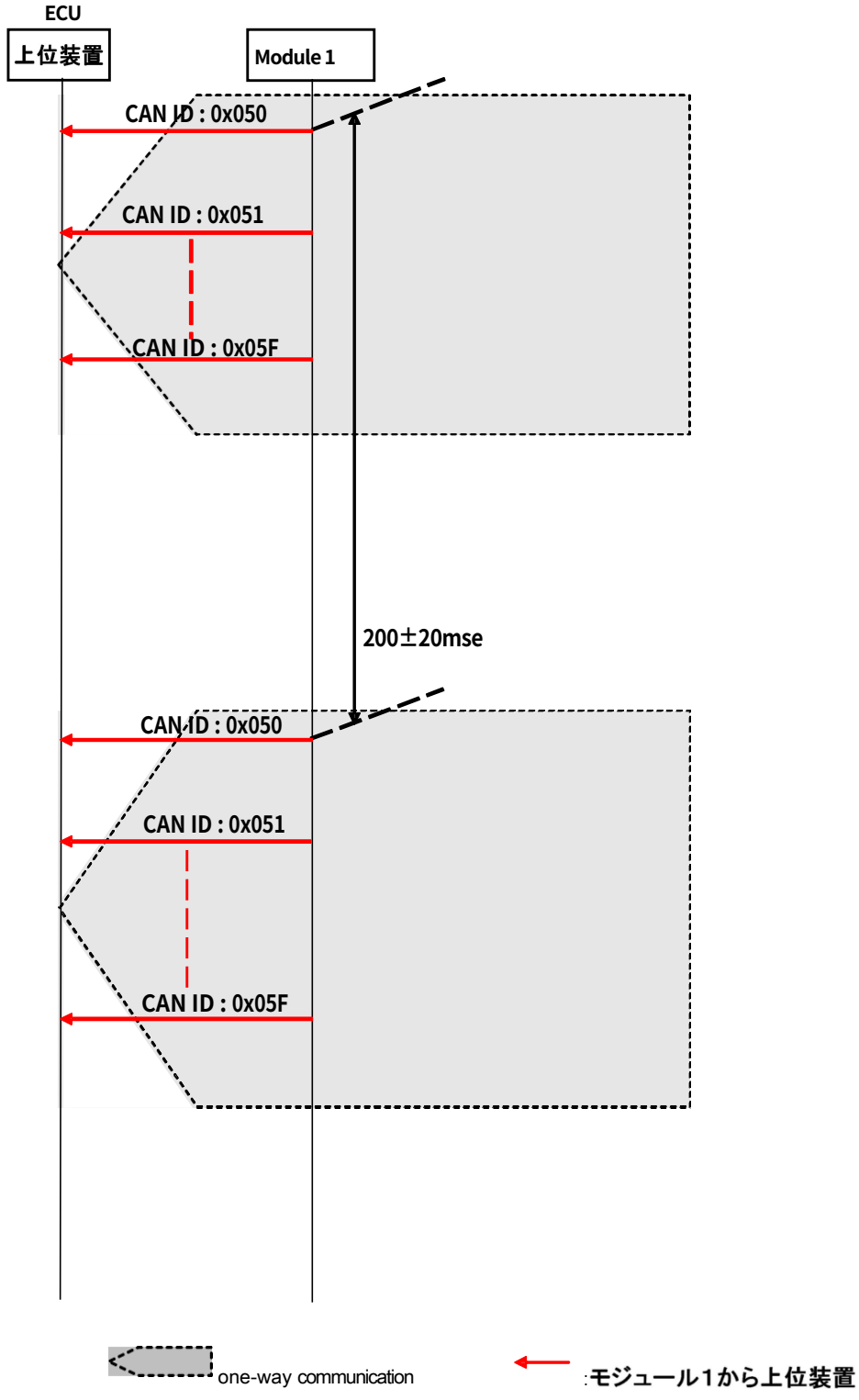

Figure 3-1-1 Communication sequence diagram in normal mode

Table 3-1-1 CAN data format to be sent from the module to the host device

CAN ID	0byte	1 byte	2byte	3byte	4 bytes	5 bytes	6 bytes	7byte
	same period counter	data						check SAM
0x050	Synchronous counter	counter (power on time, 100ms/digit)				I/O signal status	module address	See chapter 5.
0x051	Synchronous counter	Warning Code (R1)	Abnormality Code 1 (R1)	Permanent anomaly code (R1)	Warning Code (R2)	Abnormality Code 1 (R2)	active	See chapter 5.
0x052	Synchronous counter	fault code 1(R1)	fault code 2(R1)	fault code 3(R1)	fault code 1(R2)	fault code 2(R2)	fault code 3(R2)	See chapter 5.
0x053	same period counter	SOC		SOC(%)	0x00	0x00	0x00	See chapter 5.
0x054	Synchronous counter	(Reserved)				0x00	0x00	See chapter 5.
0x055	same period counter	Module temperature (Max.)		Circuit temperature		Module temperature (Min.)		See chapter 5.
0x056	Synchronous counter	Module current		Module voltage		0x00	0x00	See chapter 5.
0x057	Synchronous counter	Cell voltage 1		Cell voltage 2		Cell voltage 3		See chapter 5.
0x058	same period counter	Cell voltage 4		Cell voltage 5		Cell voltage 6		See chapter 5.
0x059	Synchronous counter	Cell voltage 7		Cell voltage 8		Cell voltage 9		See chapter 5.
0x05A	same period counter	Cell voltage 10		Cell voltage 11		0x00	0x00	See chapter 5.

0x05F	Synchr onous counter	(Reserved)	See chapter 5.

3.1.1 Frame Details

Detailed contents of each frame are shown below. For abnormal conditions and fault diagnosis, refer to Chapter 4, See Chapter 5 for more information on checksums.

Table 3-1-1 CAN Format: Counter, I/O Status and CAN Address Frame, ID 0x050

(data) item	value	Contents	remarks
CAN ID	0x050	–	
synchronous counter	0x00-0xFF (Cyclic counter)	The value is incremented by 1 for each frame transmitted. Starts from 0 at module startup.	–
counter	0x00000000-0xFFFFFFFFFF	A counter that increments by 1 count every 0.1 second. This counter represents the elapsed time from the start of battery module use to the present.	–
I/O signal status	0x00-0xE0	Signal status is indicated. b7 : ENABLE signal (On:1, Off:0) b6 : Discharge FET (On:1, Off:0) b5 : Charge FET (On:1, Off:0) b4 : Reserved b3 : Reserved b2 : Reserved b1 : Reserved b0 : Reserved	Changes within the control cycle are not guaranteed.
module address	0x00-0x01	Module address assigned by CAN address signal	
checksum	0x00-0xFF	–	See chapter 5.

Table 3-1-1-2 CAN Format: Warning, Error and Permanent Error Frames, ID 0x051

(data) item	value	Contents	remarks
CAN ID	0x051	–	
synchronous counter	0x00-0xFF (Cyclic counter)	The value is incremented by 1 for each frame transmitted. Starts from 0 at module startup.	–
Warning Code (R1)	0x00-0xCF	b7: Overvoltage warning b6: Low voltage warning b5: Reserved b4: Reserved b3: Module high temperature warning b2: Module low temperature warning b1: Circuit high temperature warning b0: Cell voltage difference warning	Refer to Table 4-2 for the judgment of each warning, cancellation, and operation after judgment.
Abnormality code 1 (R1)	0x00-0xFE	b7: Overvoltage error b6: Low voltage error b5: Charging overcurrent error b4: Discharge overcurrent error b3: Module high temperature abnormal b2: Module low temperature abnormal b1: Circuit high temperature abnormal b0: Reserved	Refer to Table 4-3 for the judgment of each abnormality, cancellation, and operation after judgment.
Permanent anomaly code (R1)	0x00-0xC0	b7: Overvoltage permanent error b6: Low voltage permanent error b5: Reserved b4: Reserved b3: Reserved b2: Reserved b1: Reserved b0: Reserved	Refer to Table 4-4 for the judgment of each abnormality, cancellation, and operation after judgment.

Warning code (R2)	0x00-0xCF	Latch each Bit of warning code (R1).	-
Abnormality code 1 (R2)	0x00-0xFE	Latch each bit of abnormality code 1 (R1).	-
active	0x00-0x01	Notification of module operating status b7-1: Reserved b0 : Operation status (0: normal operation, 1: waiting for firmware update (*)) (*) When waiting for firmware update is notified, all other data (synchronous counter, counter, I/O signal status) except operation status and checksum are 0x00.	-
checksum	0x00-0xFF	-	See chapter 5.

Table 3-1-1-3 Fault code frame, ID 0x052

(data) item	value	Contents	remarks
CAN ID	0x052	-	
synchronous counter	0x00-0xFF (Cyclic counter)	The value is incremented by 1 for each frame transmitted. Starts from 0 at module startup.	-
Failure code 1 (R1)	0x00-0xF0	b7: MPU failure (self-diagnosis) b6: VTM communication error b5: Module misconnection failure b4: Module configuration failure b3: Reserved b2: Reserved b1: Reserved b0: Reserved See Table 4-5 for each failure.	-
Failure code 2 (R1)	0x00-0xE7	b7: VTM failure (related to temperature measurement function) b6: Current detection circuit failure b5: EEPROM failure (critical point) b4: CAN communication error between modules b3: Reserved b2: VTM failure (related to voltage measurement function) b1: Circuit temperature measurement failure b0: AD converter failure See Table 4-6 for each failure.	b4: CAN communication error between modules is not functional for stand-alone use.
Failure code 3 (R1)	0x00-0x50	b7: Reserved b6: VTM failure (other than temperature and voltage measurement function) b5: Reserved b4: EEPROM failure (other than critical part) b3: Reserved b2: Reserved b1: Reserved b0: Reserved See Table 4-7 for each failure.	-

Failure code 1 (R2)	0x00-0xF0	Latch each Bit of failure code 1 (R1).	-
Failure code 2 (R2)	0x00-0xEF	Latch each Bit of failure code 2 (R1).	-
Failure code 3 (R2)	0x00-0x70	Latch each Bit of Failure Code 3 (R1).	-
checksum	0x00-0xFF	-	See chapter 5.

Table 3-1-1-4 CAN format: SOC frame, ID 0x053

(data) item	value	Contents	remarks
CAN ID	0x053	-	
synchronous counter	0x00-0xFF (Cyclic counter)	The value is incremented by 1 for each frame transmitted. Starts from 0 at module startup.	-
SOC*	0x0000-0xFFFE	SOC (State Of Charge) is the remaining capacity in the battery (the amount of energy that can be output at the current battery temperature) in mAh. (0 - 22000mAh) (Example.) 0x0000 : 0mAh 0x0001 : 1mAh 0x55F0 : 22000mAh	As an exception, "0xFFFE" shall be treated as "undefined value.
SOC(%)*	0x00-0x64,0xFE	Remaining capacity in the battery expressed in (%). (Example.) 0x00 : 0% 0x64 : 100% (0x64)	As an exception, "0xFE" shall be treated as "undefined value.
checksum	0x00-0xFF	-	See chapter 5.

*SOC is output as a reference value. It does not mean that the exact value can be calculated and output in any case, Especially under certain conditions such as low temperature environment and continuous operation condition, the error may be larger.

Table 3-1-1-5 CAN Format: Data Frame (RESERVE), ID 0x054

(data) item	value	Contents	remarks
CAN ID	0x054	-	
synchronous counter	0x00-0xFF (Cyclic counter)	The value is incremented by 1 for each frame transmitted. Starts from 0 at module startup.	-
checksum	0x00-0xFF	-	See chapter 5.

Table 3-1-1-6 CAN Format: Temperature Frame, ID 0x055

(data) item	value	Contents	remarks
CAN ID	0x055	-	
synchronous counter	0x00-0xFF (Cyclic counter)	The value is incremented by 1 for each frame transmitted. Starts from 0 at module startup.	-
Module temperature (Max.)	0x0000-0xFFFE	Moving average of cell temperature Measurable temperature range: -40 to 120degC Module temperature (°C) = (value - 0x8000) x 0.1 (example) 0x8000: 0 deg.C, 0x7FFF: -0.1deg.C, 0x8001: 0.1 deg.C	The exception is 0xFFFE, which is indefinite.
Circuit temperature	0x0000-0xFFFE	The highest moving average of the temperatures measured by the thermistor in contact with the heat sink on which the FET is mounted. Measurable temperature range: -40 to 120degC FET temperature (°C) = (value - 0x8000) x 0.1 (Example) 0x8000: 0 deg.C, 0x7FFF: -0.1 deg.C, 0x8001: 0.1 deg.C	The exception is 0xFFFE, which is indefinite.
Module temperature (Min.)	0x0000-0xFFFE	Moving average of cell temperature Measurable temperature range: -40 to 120degC Module temperature (°C) = (value - 0x8000) x 0.1 (example) 0x8000: 0 deg.C, 0x7FFF: -0.1deg.C, 0x8001: 0.1 deg.C	The exception is 0xFFFE, which is indefinite.
checksum	0x00-0xFF	-	See chapter 5.

Table 3-1-1-7 CAN Format: Current and Voltage Frames, ID 0x056

(data) item	value	Contents	remarks
CAN ID	0x056	-	
synchronous counter	0x00-0xFF (Cyclic counter)	The value is incremented by 1 for each frame transmitted. Starts from 0 at module startup.	-
Module current	0x0000-0xFFFF	Module current (A) = (value-0x8000) x 0.01119 value : 0x0000 to 0xFFFD (Example) 0x0000 = -366.67392A 0x8000 = 0A 0xFFFD = 366.64035A	In the case of discharge, the sign of the current is negative. The value 0xFFFE shall be treated as an indefinite value. The value 0xFFFF shall be treated as an invalid value.
Module voltage	0x0000-0xFFFF	Module voltage value Module voltage (mV) = value X 4.8832	The value 0xFFFE shall be treated as an indefinite value. The value 0xFFFF shall be treated as an invalid value.
checksum	0x00-0xFF	-	See chapter 5.

Table 3-1-1-8 CAN format: cell voltage frame (cells 1 to 3), ID 0x057

(data) item	value	Contents	remarks
CAN ID	0x057	-	-
synchronous counter	0x00-0xFF (Cyclic counter)	The value is incremented by 1 for each frame transmitted. Starts from 0 at module startup.	-
Cell voltage 1	0x0000-0xFFFF	Value of cell voltage 1 Cell voltage 1 (mV) = value X 0.3052 The actual measurable voltage range is 0 to 5000.0916 mV.	The value 0xFFFE shall be treated as an indefinite value. The value 0xFFFF shall be treated as an invalid value.
Cell voltage 2	0x0000-0xFFFF	Value of cell voltage 2 Cell voltage 2 (mV) = value X 0.3052 The actual measurable voltage range is 0 to 5000.0916 mV.	The value 0xFFFE shall be treated as an indefinite value. The value 0xFFFF shall be treated as an invalid value.

Cell voltage 3	0x0000-0xFFFF	Value of cell voltage 3 Cell voltage 3 (mV) = value X 0.3052 The actual measurable voltage range is 0 to 5000.0916 mV.	The value 0xFFFE shall be treated as an indefinite value. The value 0xFFFF shall be treated as an invalid value.
checksum	0x00-0xFF	-	See chapter 5.

Table 3-1-1-9 CAN format: cell voltage frame (cells 4 to 6), ID 0x058

(data) item	value	Contents	remarks
CAN ID	0x058	-	-
synchronous counter	0x00-0xFF (Cyclic counter)	The value is incremented by 1 for each frame transmitted. Starts from 0 at module startup.	-
Cell voltage 4	0x0000-0xFFFF	Value of cell voltage 4 Cell voltage 4 (mV) = value X 0.3052 The actual measurable voltage range is 0 to 5000.0916 mV.	The value 0xFFFE shall be treated as an indefinite value. The value 0xFFFF shall be treated as an invalid value.
Cell voltage 5	0x0000-0xFFFF	Value of cell voltage 5 Cell voltage 5 (mV) = value X 0.3052 The actual measurable voltage range is 0 to 5000.0916 mV.	The value 0xFFFE shall be treated as an indefinite value. The value 0xFFFF shall be treated as an invalid value.
Cell voltage 6	0x0000-0xFFFF	Value of cell voltage 6 Cell voltage 6 (mV) = value X 0.3052 The actual measurable voltage range is 0 to 5000.0916 mV.	The value 0xFFFE shall be treated as an indefinite value. The value 0xFFFF shall be treated as an invalid value.
checksum	0x00-0xFF	-	See chapter 5.

Table 3-1-1-10 CAN format: cell voltage frame (cells 7 to 9), ID 0x059

(data) item	value	Contents	remarks
CAN ID	0x059	-	-
synchronous counter	0x00-0xFF (Cyclic counter)	The value is incremented by 1 for each frame transmitted. Starts from 0 at module startup.	-
Cell voltage 7	0x0000-0xFFFF	Cell voltage 7 value Cell voltage 7 (mV) = value X 0.3052 The actual measurable voltage range is 0 to 5000.0916 mV.	The value 0xFFFE shall be treated as an indefinite value. The value 0xFFFF shall be treated as an invalid value.
Cell voltage 8	0x0000-0xFFFF	Cell voltage 8 Value Cell voltage 8 (mV) = value X 0.3052 The actual measurable voltage range is 0 to 5000.0916 mV.	The value 0xFFFE shall be treated as an indefinite value. The value 0xFFFF shall be treated as an invalid value.
Cell voltage 9	0x0000-0xFFFF	Cell voltage 9 value Cell voltage 9 (mV) = value X 0.3052 The actual measurable voltage range is 0 to 5000.0916 mV.	The value 0xFFFE shall be treated as an indefinite value. The value 0xFFFF shall be treated as an invalid value.

checksum	0x00-0xFF	–	See chapter 5.

Table 3-1-1-11 CAN format: cell voltage frame (cell 10 to 11), ID 0x05A

(data) item	value	Contents	remarks
CAN ID	0x05A	-	-
synchronous counter	0x00-0xFF (Cyclic counter)	The value is incremented by 1 for each frame transmitted. Starts from 0 at module startup.	-
Cell voltage 10	0x0000-0xFFFF	Cell voltage Value of 10 Cell voltage 10 (mV) = value X 0.3052 The actual measurable voltage range is 0 to 5000.0916 mV.	The value 0xFFFE shall be treated as an indefinite value. The value 0xFFFF shall be treated as an invalid value.
Cell voltage 11	0x0000-0xFFFF	Cell voltage 11 value Cell voltage 11 (mV) = value X 0.3052 The actual measurable voltage range is 0 to 5000.0916 mV.	The value 0xFFFE shall be treated as an indefinite value. The value 0xFFFF shall be treated as an invalid value.
checksum	0x00-0xFF	-	See chapter 5.

Table 3-1-1-12 CAN Format: Data Frame (RESERVE), ID 0x05F

(data) item	value	Contents	remarks
CAN ID	0x05F	-	-
synchronous counter	0x00-0xFF (Cyclic counter)	The value is incremented by 1 for each frame transmitted. Starts from 0 at module startup.	-
checksum	0x00-0xFF	-	See chapter 5.

3.2 Other Communications

3.2.1 Maintenance Newsletters

The CAN frames in the table below are used for firmware maintenance (contents not disclosed).

Table 3-2-1-1 Format of CAN data communication of modules

CAN ID	0byte	1 byte	2byte	3byte	4 bytes	5 bytes	6 bytes	7byte	remarks
	synchronous counter	data						checksum	

0x180 ~ 0x19F	synchronous counter	F/W Internal data for maintenance (not disclosed)	See chapter 5.	These frames are located in module 1 Sent from

3.3 Module shutdown instruction and R2 register clear instruction

The module receives, decodes, and executes commands from the host device,

The success or failure is notified to the upper layer device by ACK (success) or NACK (failure). (Caution)

(1) The host device shall recognize that the command has been executed with an ACK response from the module. (2) If the command is sent before the execution is completed, the module ignores the command.

3.3.1 Module Shutdown Overview

The module is shut down by sending a single command from the host device.

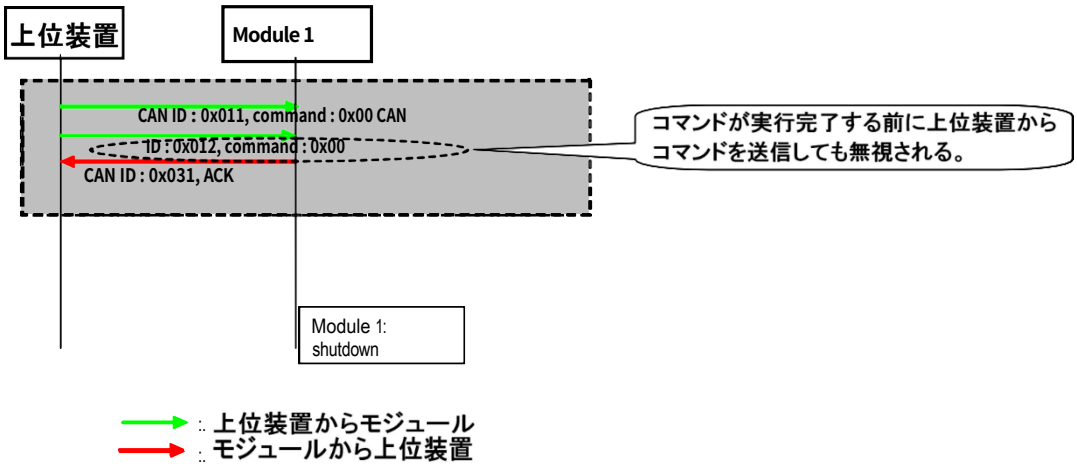

Figure.3-3-1-1 Communication sequence diagram when shutting down a module

3.3.1.1 Module shutdown method

The following commands are sent from the host device to module 1.

CAN ID	0Byte (Most Significant)	1Byte	2Byte	3Byte	4Byte	5Byte	6Byte	7Byte (Lowest)
ID	(computer) command	Reserved		Key code				checksum
0x011	0x00	0x00	0x00	0xC2	0xED	0xCA	0xEB	Checksum (calculated by the method in Chapter 5)

Module 1 shall notify the host of the success (ACK)/failure (NACK) of the shutdown according to the following format.

CAN ID	0Byte (Most Significant)	1Byte	2Byte	3Byte	4Byte	5Byte	6Byte	7Byte (Lowest)

ID	status code	command code	Reserved					checksum
0x031	0x01(ACK) or 0x00(NACK)	0x00	0x00	0x00	0x00	0x00	0x00	Checksum (calculated by the method in Chapter 5)

A response timeout of at least 3 sec. from the module is recommended.

3.3.2 R2 Register Clear Overview

One command sent from the host device clears the R2 register of the module.

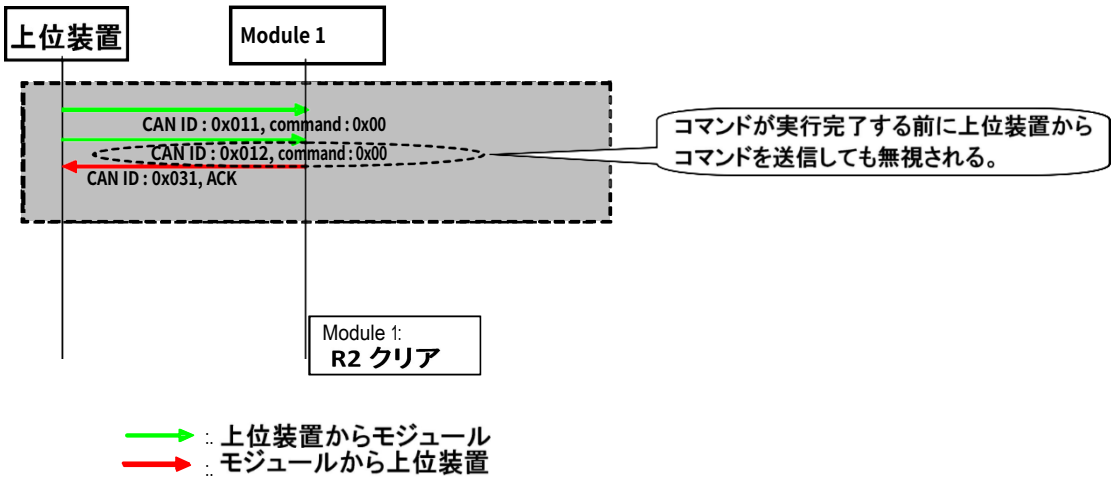

Figure 3-3-2-1 Communication sequence diagram when clearing R2 register

3.3.2.1 R2 Register clear method

The following commands are sent from the host device to module 1.

CAN ID	0Byte (Most Significant)	1Byte	2Byte	3Byte	4Byte	5Byte	6Byte	7Byte (Lowest)
ID	(computer) command	Reserved		Key code				checksum
0x12	0x00	0x00	0x00	0xC2	0xED	0xCA	0xEB	Checksum(5 Calculated using the method in Chapter 2)

(Attention.)

Even if this command is sent, the R2 register is not cleared if each bit of the R1 register is "1".

Module 1 notifies the success (ACK)/failure (NACK) of the R2 register clear to the host device according to the following format.

CAN ID	0Byte (Most Significant)	1Byte	2Byte	3Byte	4Byte	5Byte	6Byte	7Byte (Lowest)
ID	status code	command code	Reserved					checksum
0x032	0x01(ACK) or 0x00(NACK)	0x00	0x00	0x00	0x00	0x00	0x00	Checksum (calculated by the method in Chapter 5)

A response timeout of at least 3 sec. from the module is recommended.

4. system fault

A system anomaly means an abnormality, failure, or warning.

Table 4-1 shows the definitions of warning, abnormality, permanent abnormality, and failure.

Table 4-1. Definitions of Warning, Abnormal, Permanent Abnormality, and Failure

system Type of abnormality	State Definitions	Record to register	
		R1	R2
Warning.	Condition before abnormality	Recorded in.	Recorded in.
abnormality	Abnormal conditions related to cell voltage/temperature, current, or communications	Recorded in.	Recorded in.
permanent anomaly	Significant abnormal condition related to cell voltage/temperature	Recorded in.	-
failure	Abnormal operation of major components	Recorded in.	Recorded in.

- The R2 register is cleared by a CAN command from the host device.
- R2 register is not cleared at module shutdown.
- Permanent anomalies are not cleared.

These system error items are periodically transmitted from the module to the host device via CAN communication. When an abnormality occurs in CAN communication, such as frequent synchronous counter resets or long-term communication stoppage, the host device should stop charge/discharge regeneration.

Table 4-2 Warning Codes

bit position	(data) item	judgment		release		Operation after judgment				After determination, expected behavior of the host device	remarks
		terms	Hours.	terms	Hours.	CAN notice	Charging FET	Discharge FET	shut downstream		
B7	Overvoltage warning	within a module Maximum cell voltage 2.70V min.	400 to 600 [ms] (*1)	Maximum cell voltage in module 2.55V or less	400 to 600 [ms](*1)	be just about to	ON	ON	local	Stop charging	
B6	Low voltage warning	Minimum cell voltage in module 1.5V or less	400 to 600 [ms] (*1)	Minimum cell voltage in module 2.1V or higher	400 to 600 [ms] (*1)	be just about to	ON	ON	local	Stop discharge	
		Minimum cell voltage in module 1.9V or less	300 [s]. (*2)							Release the module's startup-abandoned status (Turn off the switch, and then shuffle. to be down)	
B3	Module High Temperature Warning	Module temperature 55°C min.	400 to 600 [ms] (*1)	Module temperature 50°C max.	400 to 600 [ms] (*1)	be just about to	ON	ON	local	Stop charging and discharging	
b2	Module Low Temperature Warning	Module temperature -30°C max.	400 to 600 [ms] (*1)	Module temperature -25°C min.	400 to 600 [ms] (*1)	be just about to	ON	ON	local	Stop charging and discharging	
b1	Circuit High Temperature Warning	FET or shunt temperature higher than 90°C	400 to 600 [ms] (*1)	The higher FET or shunt temperature is less than 85°C	400 to 600 [ms] (*1)	be just about to	ON	ON	local	Stop charging and discharging	

b0	Cell voltage difference warning	Maximum cell voltage in module -Minimum cell voltage in module 500mV min.	400 to 600 [ms] (*1)	Maximum cell voltage in module -Minimum cell voltage in module 400mV or less	400 to 600 [ms] (*1)	be just about to	ON	ON	local	Stop charging and discharging	

(*1): In practice, this time is 400 to 600 ms. It takes another 200ms (typ.) from this time until the upper device is notified via CAN.

(*2): This time is actually 300s. It will take another 200ms (typ.) until the upper device is notified via CAN. (Applicable to products manufactured in May 2019 whose serial number has "G123" at the beginning of the serial number.)

Table 4-3 Abnormality Codes

bit position	(data) item	judgment		release		Operation after judgment				After determination, expected behavior of the host device	remarks
		terms	Hours.	terms	Hours.	CAN notice	Charging FET	Discharge FET	shut downstream		
B7	Overvoltage abnormal	Max. cell voltage in module 2.8V min.	400 to 600 [ms] (*1)	Maximum cell voltage in module 2.55V max.	400 to 600 [ms] (*1)	be just about to	OFF	ON	local	Discharge.	
B6	Low voltage abnormal	Minimum cell voltage in module 1.4V or less	400 to 600 [ms] (*1)	Minimum cell voltage in module 2.1V or higher	400 to 600 [ms] (*1)	be just about to	ON	OFF(*2)	do (*3)	Charging	(*2)
		Minimum cell voltage in module 1.9V or less	600[s]. (*4)					OFF			
B5	Overcharge current abnormal	Charging current greater than 125 A	220[s].	Module shutdown	N/A	be just about to	OFF	OFF	be just about to	–	
		Charging current greater than 210A	2[s].								
b4	Discharge overcurrent error	Discharge current greater than 125A	220[s].	Module shutdown	N/A	be just about to	OFF	OFF	be just about to	–	
		Discharge current greater than 210A	2[s].								
B3	Module high temperature abnormal	Module temperature 66°C min.	400 to 600 [ms] (*1)	Module shutdown	N/A	be just about to	OFF	OFF	be just about to	–	
b2	Abnormal module low temperature	Module temperature -35 °C max.	400 to 600 [ms] (*1)	Module shutdown	N/A	be just about to	OFF	OFF	be just about to	–	
b1	Circuit high temperature abnormal	FET or shunt temperature higher than 95°C	400 to 600 [ms] (*1)	Module shutdown	N/A	be just about to	OFF	OFF	be just about to	–	

(*1): In practice, this time is 400 to 600 ms. It takes another 200ms (typ.) from this time until the upper device is notified via CAN.

(*2): ON if detected immediately after startup, and OFF if the minimum cell voltage decreases by 20mV or more for more than 10 seconds after the low-voltage error is fixed, and the discharge FET is turned off. (Applicable to products manufactured in May 2019 whose serial number has "G123" at the beginning of the serial number)

(*3): If a charging current exceeding 1.6A cannot be confirmed within 60sec, the system shuts down.

(*4): The judgment time is 600 sec. It will take another 200msec (typ.) until the customer's device is notified via CAN. (Applies to products manufactured in May 2019 whose serial number has "G123" at the beginning.)

Table **4-4** Permanent anomaly codes

bit position	(data) item	judgment		release		Operation after judgment				After determination, expected behavior of the host device	remarks
		terms	Hours.	terms	Hours.	CAN notice	Charging FET	Discharge FET	shut downstream		
B7	Overvoltage permanent anomaly	within a module Maximum cell voltage 3.0V or higher	400 to 600 [ms] (*1)	non-releasable	N/A	be just about to	OFF	OFF	local	–	
B6	Low voltage permanent anomaly	within a module Minimum cell voltage 1.2V or less	1800-2000 [ms] (*2)	non-releasable	N/A	be just about to	OFF	OFF	local	–	

(*1): In practice, this time is 400 to 600 ms. It takes another 200ms (typ.) until the upper device is notified via CAN. (*2): In practice, this time is 1800 to 2000 ms. It takes another 200 ms (typ.) until the upper-level device is notified via CAN.

Table 4-5 Failure Code 1

bit position	Error Type	judgment	release	Operation after judgment				After determination,	remarks
		terms	terms	CAN notice	Charging FET	Discharge FET	shut downstream	expected behavior of the host device	
B7	MPU failure (self-diagnosis)	When an abnormality related to the MPU is detected in the module's self-diagnosis	Module shutdown	Depends on the failure site.	OFF	OFF	local	–	
B6	VTM communication error	When an abnormality related to VTM communication is detected in the module's self-diagnosis	Module shutdown	be just about to	OFF (*2)	ON	local	–	
B5	Module misconnection failure	When a module combination error is detected	Module shutdown	be just about to	OFF	OFF	local	–	
b4	module configuration failure	When an abnormality of an element constituting a module is detected (e.g., terminator not connected)	Module shutdown	be just about to	OFF	OFF	local	–	

(*2): The charging FET is forcibly turned off one minute after a failure notification by CAN. However, if any of the following conditions are met, the charging FET is immediately turned off.

When a current of 15A or more is applied for 2 seconds or longer

When the current integrated value has increased by 0.1Ah or more since the failure occurred.

When an ammeter failure and a cell voltage measurement failure occur simultaneously

Table 4-6 Failure Code 2

bit position	Error Type	judgment	release	Operation after judgment				After determination, expected behavior of the host device	remarks
		terms	terms	CAN notice	Charging FET	Discharge FET	shut downstream		
B7	VTM Failure (Temperature measurement section)	Module self-diagnosis of VTM When a failure related to the temperature measurement function is detected	Module shutdown	be just about to	OFF (*2)	ON	local	–	
B6	Current detection circuit failure	When an abnormality related to the current detection circuit is detected in the module's self-diagnosis	Module shutdown	be just about to	OFF (*2)	ON	local	–	
B5	EEPROM Failure (critical location)	Module self-diagnosis of EEPROM If an error is detected with respect to critical data	Module shutdown	be just about to	OFF (*2)	ON	local	–	
b4	Abnormal CAN communication between modules	N/A (No function when used alone.)	N/A (No function when used alone.)	local	ON	ON	local	–	
B3	Reserved	–	–	–	–	–	–	–	
b2	VTM Failure (voltage measurement section)	Module self-diagnosis of VTM If a fault is detected with respect to the voltage measurement function	Module shutdown	be just about to	OFF (*2)	ON	local	–	
b1	Circuit temperature measurement failure	When a failure related to the circuit temperature measurement function is detected in the module's self-diagnosis	Module shutdown	be just about to	OFF (*2)	ON	local	–	
b0	AD converter failure	When an abnormality related to the AD converter is detected in the module self-diagnosis	Module shutdown	be just about to	OFF (*2)	ON	local	–	

(*2): The charging FET is forcibly turned off one minute after a failure notification by CAN. However, if any of the following conditions are met, the charging FET is immediately turned off.

When a current of 15A or more is applied for 2 seconds or longer

When the current integrated value has increased by 0.1Ah or more since the failure occurred.

When an ammeter failure and a cell voltage measurement failure occur simultaneously

Table 4-7 Failure Code 3

bit position	Error Type	judgment	release	Operation after judgment				After determination,	remarks
		terms	terms	CAN notice	Charging FET	Discharge FET	shut downstream	expected behavior of the host device	
B6	VTM Failure (except temperature and voltage measurement function)	If module self-diagnostics detect a failure in a function other than VTM voltage/temperature measurement	Module shutdown	be just about to	ON	ON	local	–	
b4	EEPROM Failure (Normal location)	If the module's self-diagnosis detects a fault with respect to data other than critical data in the EEPROM	Module shutdown	be just about to	ON	ON	local	–	

5. Checksum Calculation

One byte is allocated to each CAN frame as a checksum. The checksum is calculated based on the total of each byte of the CAN frame excluding itself. The calculation method is as follows

<Checksum calculation target

CAN ID: 11 bits

Data: 7 bytes (not including checksum bytes)

<Calculation Method

1. Seek the data to be calculated

   The checksum is calculated in units of 1 byte (8 bits).

   For each CAN frame, 9 bytes of data are obtained.

   2 bytes from CAN ID: 1 byte

   (The CAN ID is 11 bits long. (The CAN ID is 11 bits long.)

   This is considered the lower 11 bits of the data, and the remaining 5 bits are set to 0.

   See example below)

   7 bytes from frame data

   (Do not exclude data in Reserve area)

2. Calculate the sum of these data

   Find the sum of the individual data. Ignore carryover.

3. Calculation of checksum value

   The two's complement is calculated. The result is the checksum.

<Example.

CAN ID: 0x0030

Data: 0x2B0000002B7B00

1. Obtain data for checksum calculation from

   CAN ID (0x0030) => 0x00, 0x30

   From data (0x2B0000002B7B00) => 0x2B, 0x00, 0x00, 0x2B, 0x7B, 0x00

2. Calculate the sum of each data

   0x00 + 0x30 + 0x2B + 0x00 + 0x00 + 0x2B + 0x7B + 0x00 = 0x101

3. Calculation of checksum value

   Ignore carry : 0x101 & 0xFF = 0x01

   Find 2's complement : inv(0x01) + 1 = 0xFF

2P1S Edition

2P1S Table of Contents

1. Introduction.

This specification describes the CAN communication specifications for the 23Ah 11 direct battery module.

(Definitions and Abbreviations)

abbr eviati on	nam e	Desc riptio n.
ENABLE Signal	Enable	Signal for BMS startup (Closed: High, Open: Low)
R1	Register 1	Register representing the current system abnormality status.
R2	Register 2	The register represents the state of the system, including past system abnormalities.
SJW	reSynchronization Jump Width	Resynchronization jump width, 1-bit error detected in CAN communication Number of samplings to be
SOC	State Of Charge	Battery charge status. Displayed in remaining battery charge (mAh)
Tq.	Time quantum	bit time
VTM	Voltage Temperature Monitor	Function to measure cell voltage and temperature

1.1 About Parallel Connection

When two modules are connected in parallel to a host device, lateral flow may occur from the module with the higher voltage to the module with the lower voltage, possibly damaging the battery. To prevent this, a voltage difference judgment (judgment time: 1 s) between the modules is performed when the battery system is started up.

2. CAN Interface Overview

2.1 protocol

CAN communication between the host and the module conforms to CAN2.0B (ISO11898-2). Data frames are standard frames (11-bit ID).

The communication rate is 250 kbps. The sampling point is 70% of bit time and SJW is 2(Tq).

Each data field is transferred starting with the most significant byte.

2.2 CAN ID assignment

Table 2-2-1 shows the various CANID assignments.

Table 2-2-1 CAN ID Assignment

CAN ID	From	To	Contents	communication cycle
0x000 ~ 0x010	-	-	reserved	-
0x011	high-level equipment	(All) module	Shutdown of each module	at any time
0x012	high-level equipment	(All) module	Clear R2 register of each module	at any time
0x013 to 0x030	-	-	reserved	-
0x031	Module 1	high-level equipment	Module 1 response to a command from a host device (Module 1 shutdown)	at any time
0x032	Module 1	high-level equipment	Module 1 response to a command from a host device (Module 1 R2 register clear)	at any time
0x033 to 0x038	-	-	reserved	-
0x039	Module 2	high-level equipment	Module 2 response to a command from a host device (Module 2 shutdown)	at any time
0x03A	Module 2	high-level equipment	Module 2 response to a command from a host device (Module 2 R2 register clear)	at any time
0x03B to 0x04F	-	-	reserved	-
0x050 to 0x05F	Module 1	high-level equipment	Elapsed time, input/output status, error/failure code, and SOC, temperature, current, voltage, module information	200±20ms
0x060 to 0x06F	-	-	reserved	-
0x070 to 0x07F	Module 2	high-level equipment	Elapsed time, input/output status, error/failure code, and SOC, temperature, current, voltage, module information	200±20ms
0x080 to 0x17F	-	-	reserved	-
0x180 to 0x1BF	module 1,2	-	Internal data for maintenance	200±20ms
0x1C0 to 0x1FF	-	-	reserved	-

3. CAN communication

An overview diagram of the CAN communication status according to each state is shown below.

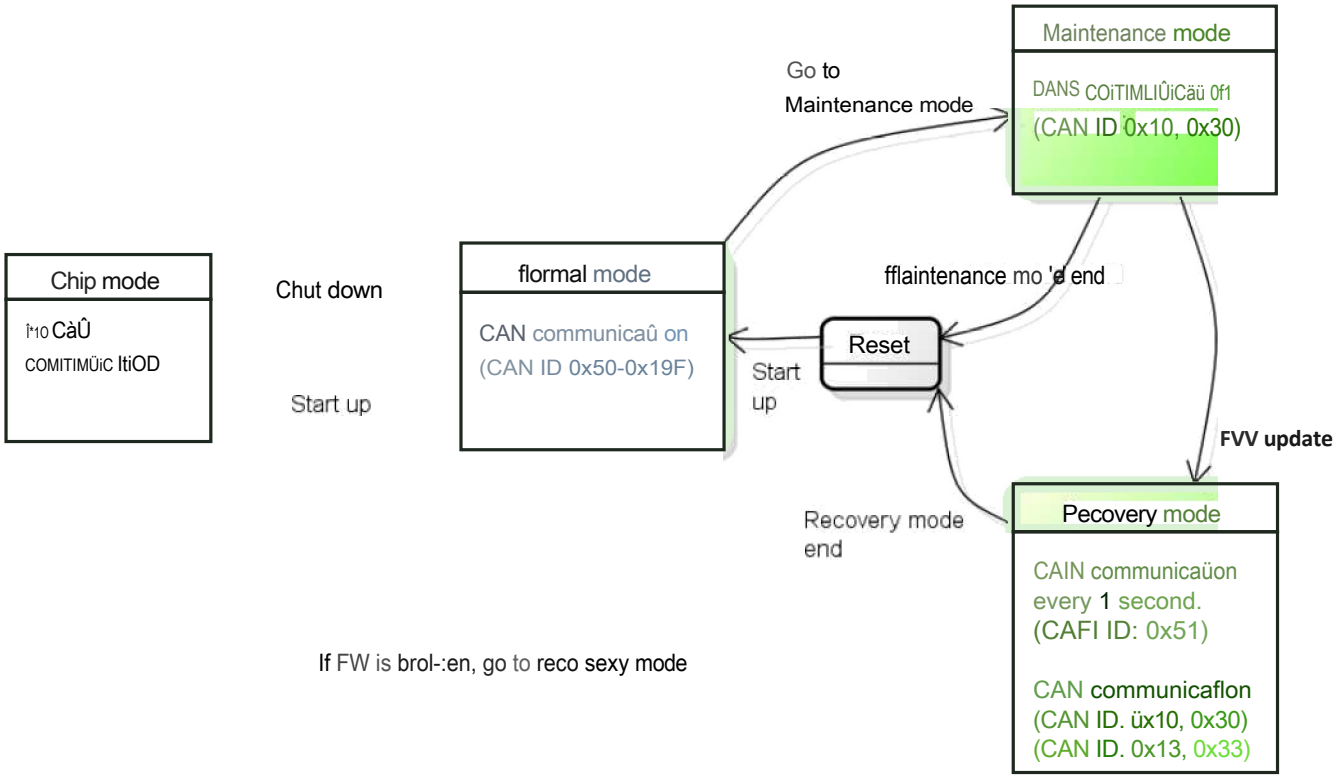

Figure 3-1 Overview of CAN communication status in each state

3.1 Periodic transmission of the module's internal status to the host device

Figure 3-1-1 shows a sequence diagram of communication in normal mode. The CAN data format is shown in Table 3-1-1.

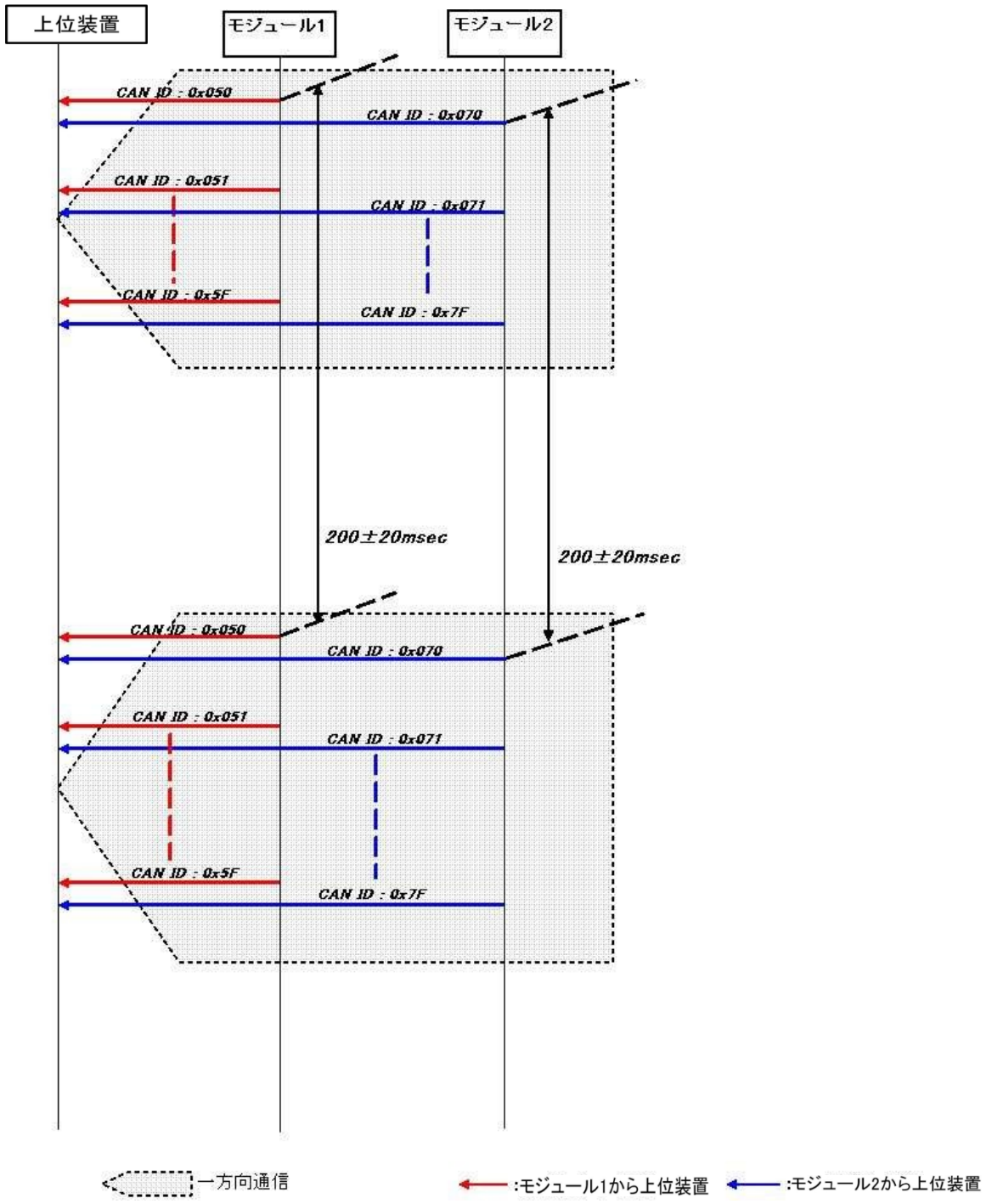

Figure 3-1-1 Communication sequence diagram in normal mode

(Each module has an independent clock, so the transmission timing between modules varies.)

Table 3-1-1 CAN data format to be sent from the module to the host device

CAN ID	0byte	1 byte	2byte	3byte	4 bytes	5byte	6 bytes	7byte
	same period counter	data						check SAM
0x050 (module 1) or 0x070 (module 2)	Synchronous counter	counter (power on time, 100ms/digit)				I/O signal status	module address sea cucumber (Holothuroidea spp.)	See chapter 5.
0x051 (module 1) or 0x071 (Module 2)	Synchronous counter	Warning Code (R1)	Abnormality Code 1 (R1)	Permanent anomaly code (R1)	Warning Code (R2)	Fault code (R2)	active	See chapter 5.
0x052 (module 1) or 0x072 (module 2)	Synchronous counter	Failure code 1 (R1)	Failure code 2 (R1)	Failure code 3 (R1)	Failure code 1 (R2)	Failure code 2 (R2)	Failure code 3 (R2)	See chapter 5.
0x053 (module 1) (module 2 is (Not used)	Synchronous counter	SOC		SOC(%)	0x00	0x00	0x00	See chapter 5.
0x054 (module 1) or 0x074 (module 2)	Synchronous counter	(Reserved)				0x00	0x00	See chapter 5.
0x055 (module 1) or 0x075 (module 2)	Synchronous counter	Module temperature (max)		Circuit temperature		Module temperature (min)		See chapter 5.
0x056 (module 1) or 0x076 (Module 2)	Synchronous counter	Module current		Module voltage		0x00	0x00	See chapter 5.
0x057 (module 1) or 0x077 (module 2)	Synchronous counter	Cell voltage 1		Cell voltage 2		Cell voltage 3		See chapter 5.
0x058 (module 1) or 0x078 (module 2)	Synchronous counter	Cell voltage 4		Cell voltage 5		Cell voltage 6		See chapter 5.

0x059 (module 1) or 0x079 (module 2)	Synchr onous counter	Cell voltage 7	Cell voltage 8	Cell voltage 9		See chapter 5.
0x05A (module 1) or 0x07A (module 2)	Synchr onous counter	Cell voltage 10	Cell voltage 11	0x00	0x00	See chapter 5.
0x05F (module 1) or 0x07F (module 2)	Synchr onous counter	(Reserved)				See chapter 5.

3.1.1 Frame Details

Detailed contents of each frame are shown below. For abnormal conditions and fault diagnosis, refer to Chapter 4, See Chapter 5 for more information on checksums.

Table 3-1-1 CAN Format: Counter, I/O Status and CAN Address Frame, ID 0x050, 0x070

(data) item	value	Contents	remarks
CAN ID	0x050 or 0x070	-	0x050 is module 1 0x070 is module 2
synchronous counter	0x00-0xFF (Cyclic counter)	The value is incremented by 1 for each frame transmitted. Starts from 0 at module startup.	-
counter	0x00000000- 0xFFFFFFFFFF	A counter that increments by 1 count every 0.1 second. This counter represents the elapsed time from the start of battery module use to the present.	-
I/O signal status	0x00-0xE0	Signal status is indicated. b7 : ENABLE signal (On:1, Off:0) b6 : Discharge FET (On:1, Off:0) b5 : Charge FET (On:1, Off:0) b4 : Reserved b3 : Reserved b2 : Reserved b1 : Reserved b0 : Reserved	Changes within the control cycle are not guaranteed.
module address	0x00-0x01	Module address assigned by CAN address signal	
checksum	0x00-0xFF	-	See chapter 5.

Table 3-1-1-2 CAN Format: Warning, Error and Permanent Error Frames, ID 0x051, 0x071

(data) item	value	Contents	remarks
CAN ID	0x051 or 0x071	-	0x051 is module 1 0x071 is module 2
synchronous counter	0x00-0xFF (Cyclic counter)	The value is incremented by 1 for each frame transmitted. Starts from 0 at module startup.	-
Warning Code (R1)	0x00-0xCF	b7: Overvoltage warning b6: Low voltage warning b5: Reserved b4: Reserved b3: Module high temperature warning b2: Module low temperature warning b1: Circuit high temperature warning b0: Cell voltage difference warning Refer to Table 4-2 for the judgment of each warning, cancellation, and operation after judgment.	If the value of a register differs from module to module, the upper device should adopt the value obtained by the logical OR of the bits of each module.
Abnormality code 1 (R1)	0x00-0xFF	b7: Overvoltage error b6: Low voltage error b5: Charging overcurrent error b4: Discharge overcurrent error b3: Module high temperature abnormal b2: Module low temperature abnormal b1: Circuit high temperature abnormal b0: Module voltage difference abnormal Refer to Table 4-3 for the judgment of each abnormality, cancellation, and operation after judgment.	If the value of a register differs from module to module, the upper device should adopt the value obtained by the logical OR of the bits of each module.

Permanent anomaly code (R1)	0x00-0xC0	b7: Overvoltage permanent error b6: Low voltage permanent error b5: Reserved b4: Reserved b3: Reserved b2: Reserved b1: Reserved b0: Reserved Refer to Table 4-4 for the judgment of each abnormality, cancellation, and operation after judgment. Teru.	If the value of a register differs from module to module, the upper device should adopt the value obtained by the logical OR of the bits of each module.
Warning Code (R2)	0x00-0xCF	Latch each Bit of warning code (R1).	If the value of a register differs from module to module, the upper device should adopt the value obtained by the logical OR of the bits of each module.

(data) item	value	Contents	remarks
Abnormality code 1 (R2)	0x00-0xFF	Latch each bit of abnormality code 1 (R1).	If the value of a register differs from module to module, the upper device should adopt the value obtained by the logical OR of the bits of each module.
active	0x00-0x01	Notification of module operating status b7-1: Reserved b0 : Operation status (0: normal operation, 1: waiting for firmware update (*)) (*) When waiting for firmware update is notified, all other data (synchronous counter, counter, I/O signal status) except operation status and checksum are 0x00.	-
checksum	0x00-0xFF	-	See chapter 5.

Table 3-1-1-3 CAN Format: Fault Code Frame, ID 0x052，0x072

(data) item	value	Contents	remarks
CAN ID	0x052 or 0x072	-	0x052 is module 1 0x072 is module 2
synchronous counter	0x00-0xFF (Cyclic counter)	The value is incremented by 1 for each frame transmitted. Starts from 0 at module startup.	-
Failure code 1 (R1)	0x00-0xF0	b7: MPU failure (self-diagnosis) b6: VTM communication error b5: Module misconnection failure b4: Module configuration failure b3: Reserved b2: Reserved b1: Reserved b0: Reserved See Table 4-5 for each failure.	If the value of a register differs from module to module, the upper device should adopt the value obtained by the logical OR of the bits of each module.
Failure code 2 (R1)	0x00-0xF7	b7: VTM failure (related to temperature measurement function) b6: Current detection circuit failure b5: EEPROM failure (critical point) b4: CAN communication error between modules b3: Reserved b2: VTM failure (related to voltage measurement function) b1: Circuit temperature measurement failure b0: AD converter failure See Table 4-6 for each failure.	If the value of a register differs from module to module, the upper device should adopt the value obtained by the logical OR of the bits of each module.
Failure code 3 (R1)	0x00-0x50	b7: Reserved b6: VTM failure (other than temperature and voltage measurement function) b5: Reserved b4: EEPROM failure (other than critical part) b3: Reserved b2: Reserved b1: Reserved b0: Reserved See Table 4-7 for each failure.	If the value of a register differs from module to module, the upper device should adopt the value obtained by logical ORing of the bits of each module.

Failure code 1 (R2)	0x00-0xF0	Latch each Bit of failure code 1 (R1).	If the value of a register differs from module to module, the upper device should adopt the value obtained by the logical OR of the bits of each module.
Failure code 2 (R2)	0x00-0xF7	Latch each Bit of failure code 2 (R1).	If the value of a register differs from module to module, the host device performs a logical OR of the bits in each module. The value taken should be adopted.

(data) item	value	Contents	remarks
Failure Code 3 (R2)	0x00-0x50	Latch each Bit of Failure Code 3 (R1).	register by the module. If the values are different, the host device will use a different value for each The logical OR of the bits in the module The value taken should be adopted.
checksum	0x00-0xFF	-	See chapter 5.

Table 3-1-1-4 CAN format: SOC frame, ID 0x053

(data) item	value	Contents	remarks
CAN ID	0x053	-	0x053 is module 1 (module 2 is not used)
synchronous counter	0x00-0xFF (Cyclic counter)	The value is incremented by 1 for each frame transmitted. Starts from 0 at module startup.	-
SOC*	0x0000-0xFFFE	SOC (State Of Charge) is the remaining capacity in the battery (the amount of energy that can be output at the current battery temperature) in mAh. (0 - 22000mAh) (Example.) 0x0000 : 0mAh 0x0001 : 1mAh 0x55F0 : 22000mAh 0xABE0 : 44000mAh	As an exception, "0xFFFE" shall be treated as "undefined value. Outputs only module 1.
SOC(%)*	0x00-0x64，0xFE	Remaining capacity in the battery expressed in (%). (Example.) 0x00 : 0% 0x64 : 100% (0x64)	As an exception, "0xFE" shall be treated as "undefined value. Outputs only module 1.
checksum	0x00-0xFF	-	See chapter 5.

*SOC is output as a reference value. It does not mean that the exact value can be calculated and output in any case, Especially under certain conditions such as low temperature environment and continuous operation condition, the error may be larger.

Table 3-1-1-5 CAN Format: Data Frame (RESERVE), ID 0x054, 0x074

(data) item	value	Contents	remarks
CAN ID	0x054 or 0x074	-	0x054 is module 1 0x074 is module 2
synchronous counter	0x00-0xFF (Cyclic counter)	The value is incremented by 1 for each frame transmitted. Starts from 0 at module startup.	-
checksum	0x00-0xFF	-	See chapter 5.

Table 3-1-1-6 CAN Format: Temperature Frame, ID 0x055, 0x075

(data) item	value	Contents	remarks
CAN ID	0x055 or 0x075	-	0x055 is module 1 0x075 is module 2
synchronous counter	0x00-0xFF (Cyclic counter)	The value is incremented by 1 for each frame transmitted. Starts from 0 at module startup.	-
Module temperature (Max.)	0x0000-0xFFFE	Moving average of cell temperature Measurable temperature range: -40 to 120degC Module temperature (°C) = (value - 0x8000) x 0.1 (example) 0x8000: 0 deg. 0x7FFF: -0.1deg.C,. 0x8001: 0.1 deg.	The exception is 0xFFFE, which is indefinite.
Circuit temperature	0x0000-0xFFFE	The highest moving average of the temperatures measured by the thermistor in contact with the heat sink on which the FET is mounted. Measurable temperature range: -40 to 120degC FET temperature (°C) = (value - 0x8000) x 0.1 (Example) 0x8000: 0 deg. C, 0x7FFF: -0.1 deg. 0x8001: 0.1 deg.	The exception is 0xFFFE, which is indefinite.

Module temperature (Min.)	0x0000-0xFFFE	Moving average of cell temperature Measurable temperature range: -40 to 120degC Module temperature (°C) = (value - 0x8000) x 0.1 (example) 0x8000: 0 deg. 0x7FFF: -0.1deg.C,. 0x8001: 0.1 deg.C	The exception is 0xFFFE, which is indefinite.
checksum	0x00-0xFF	-	See chapter 5.

Table 3-1-1-7 CAN Format: Current and Voltage Frames, ID 0x056, 0x076

(data) item	value	Contents	remarks
CAN ID	0x056 or 0x076	-	0x056 is module 1 0x076 is module 2
synchronous counter	0x00-0xFF (Cyclic counter)	The value is incremented by 1 for each frame transmitted. Starts from 0 at module startup.	-
Module current	0x0000-0xFFFF	Module current (A) = (value-0x8000) x 0.01119 value : 0x0000 to 0xFFFD (Example) 0x0000 = -366.67392A 0x8000 = 0A 0xFFFD = 366.64035A	In the case of electric discharge, the sign of the current is negative. The value 0xFFFE shall be treated as an indefinite value. The value 0xFFFF shall be treated as an invalid value.
Module voltage	0x0000-0xFFFF	Module voltage value Module voltage (mV) = value X 4.8832	The value 0xFFFE shall be treated as an indefinite value. The value 0xFFFF shall be treated as an invalid value.
checksum	0x00-0xFF	-	See chapter 5.

Table 3-1-1-8 CAN format: cell voltage frame (cells 1 to 3), ID 0x057, 0x077

(data) item	value	Contents	remarks
CAN ID	0x057 or 0x077	-	0x057 is module 1 0x077 is module 2
synchronous counter	0x00-0xFF (Cyclic counter)	The value is incremented by 1 for each frame transmitted. Starts from 0 at module startup.	-
Cell voltage 1	0x0000-0xFFFF	Value of cell voltage 1 Cell voltage 1 (mV) = value X 0.3052 The actual measurable voltage range is 0 to 5000.0916 mV.	The value 0xFFFE shall be treated as an indefinite value. The value 0xFFFF shall be treated as an invalid value.
Cell voltage 2	0x0000-0xFFFF	Value of cell voltage 2 Cell voltage 2 (mV) = value X 0.3052 The actual measurable voltage range is 0 to 5000.0916 mV.	The value 0xFFFE shall be treated as an indefinite value. The value 0xFFFF shall be treated as an invalid value.
Cell voltage 3	0x0000-0xFFFF	Value of cell voltage 3 Cell voltage 3 (mV) = value X 0.3052 The actual measurable voltage range is 0 to 5000.0916 mV.	The value 0xFFFE shall be treated as an indefinite value. The value 0xFFFF shall be treated as an invalid value.

checksum	0x00-0xFF	-	See chapter 5.

Table 3-1-1-9 CAN format: cell voltage frame (cell 4 to 6),ID 0x058，0x078

(data) item	value	Contents	remarks
CAN ID	0x058 or 0x078	-	0x058 is module 1 0x078 is module 2
synchronous counter	0x00-0xFF (Cyclic counter)	The value is incremented by 1 for each frame transmitted. Starts from 0 at module startup.	-
Cell voltage 4	0x0000-0xFFFF	Value of cell voltage 4 Cell voltage 4 (mV) = value X 0.3052 The actual measurable voltage range is 0 to 5000.0916 mV.	The value 0xFFFE shall be treated as an indefinite value. The value 0xFFFF shall be treated as an invalid value.
Cell voltage 5	0x0000-0xFFFF	Value of cell voltage 5 Cell voltage 5 (mV) = value X 0.3052 The actual measurable voltage range is 0 to 5000.0916 mV.	The value 0xFFFE shall be treated as an indefinite value. The value 0xFFFF shall be treated as an invalid value.
Cell voltage 6	0x0000-0xFFFF	Value of cell voltage 6 Cell voltage 6 (mV) = value X 0.3052 The actual measurable voltage range is 0 to 5000.0916 mV.	The value 0xFFFE shall be treated as an indefinite value. The value 0xFFFF shall be treated as an invalid value.
checksum	0x00-0xFF	-	See chapter 5.

Table 3-1-1-10 CAN format: cell voltage frame (cell 7 to 9),ID 0x059，0x079

(data) item	value	Contents	remarks
CAN ID	0x059 or 0x079	-	0x059 is module 1 0x079 is module 2
synchronous counter	0x00-0xFF (Cyclic counter)	The value is incremented by 1 for each frame transmitted. Starts from 0 at module startup.	-
Cell voltage 7	0x0000-0xFFFF	Cell voltage 7 value Cell voltage 7 (mV) = value X 0.3052 The actual measurable voltage range is 0 to 5000.0916 mV.	The value 0xFFFE shall be treated as an indefinite value. The value 0xFFFF shall be treated as an invalid value.
Cell voltage 8	0x0000-0xFFFF	Cell voltage 8 Value Cell voltage 8 (mV) = value X 0.3052 The actual measurable voltage range is 0 to 5000.0916 mV.	The value 0xFFFE shall be treated as an indefinite value. The value 0xFFFF shall be treated as an invalid value.

Cell voltage 9	0x0000-0xFFFF	Cell voltage 9 value Cell voltage 9 (mV) = value X 0.3052 The actual measurable voltage range is 0 to 5000.0916 mV.	The value 0xFFFE shall be treated as an indefinite value. The value 0xFFFF shall be treated as an invalid value.
checksum	0x00-0xFF	-	See chapter 5.

Table 3-1-1-11 CAN format: cell voltage frame (cell 10 to 11), ID 0x05A, 0x07A

(data) item	value	Contents	remarks
CAN ID	0x05A or 0x07A	-	0x05A is module 1 0x07A is module 2
synchronous counter	0x00-0xFF (Cyclic counter)	The value is incremented by 1 for each frame transmitted. Starts from 0 at module startup.	-
Cell 10 Voltage	0x0000-0xFFFF	Cell 10 Voltage Value Cell 10 Voltage (mV) = value X 0.3052 The actual measurable voltage range is 0 to 5000.0916 mV.	The value 0xFFFE shall be treated as an indefinite value. The value 0xFFFF shall be treated as an invalid value.
Cell 11 Voltage	0x0000-0xFFFF	Cell 11 Voltage Value Cell 11 voltage (mV) = value X 0.3052 The actual measurable voltage range is 0 to 5000.0916 mV.	The value 0xFFFE shall be treated as an indefinite value. The value 0xFFFF shall be treated as an invalid value.
checksum	0x00-0xFF	-	See chapter 5.

Table 3-1-1-12 CAN Format: Data Frame (RESERVE), ID 0x05F, 0x07F

(data) item	value	Contents	remarks
CAN ID	0x05F , 0x07F	-	0x05F is module 1 0x07F is module 2
synchronous counter	0x00-0xFF (Cyclic counter)	The value is incremented by 1 for each frame transmitted. Starts from 0 at module startup.	-
checksum	0x00-0xFF	-	See chapter 5.

3.2 Other Communications

3.2.1 Maintenance Newsletters

The CAN frames in the table below are used for firmware maintenance (contents not disclosed).

Table 3-2-1-1 Format of CAN data communication between modules

CAN ID	0byte	1 byte	2byte	3byte	4 bytes	5byte	6 bytes	7byte	remarks
	synchronous counter	data						checksum	
0x180 ~ 0x19F	synchronous counter	F/W Internal data for maintenance (not disclosed)						See chapter 5.	These frames are located in module 1 Sent from
0x1A0 to 0x1BF	synchronous counter	F/W Internal data for maintenance (not disclosed)						See chapter 5.	These frames are located in module 2 Sent from

3.3 The module receives, decodes, and executes the command from the high-level equipment and notifies the success or failure to the high-level equipment by ACK (success) or NACK (failure).

(Notes.)

(1) The host device shall recognize that the command has been executed with an ACK response from the module. (2) If the command is sent before the execution is completed, the module ignores the command.

3.3.1 Module Shutdown Overview

All modules are shut down by sending a single command from the host device.

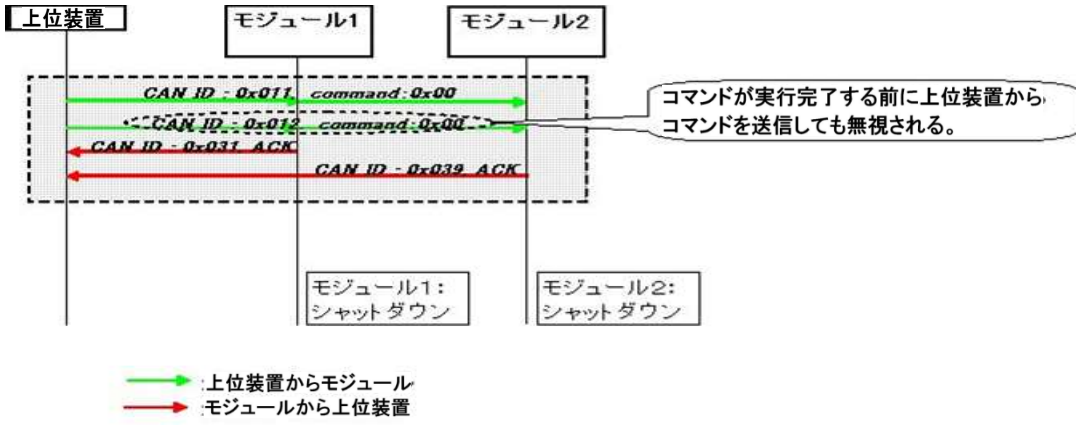

Figure 3-3-1-1 Communication sequence diagram when shutting down the module

3.3.1.1 Module shutdown method

The following commands are sent from the host device to modules 1 and 2.

CAN ID	0Byte (Most Significant)	1Byte	2Byte	3Byte	4Byte	5Byte	6Byte	7Byte (Lowest)
ID	(computer) command	Reserved		Key code				checksum
0x011	0x00	0x00	0x00	0xC2	0xED	0xCA	0xEB	Checksum (calculated by the method in Chapter 5)

Module 1 shall notify the host of the success (ACK)/failure (NACK) of the shutdown according to the following format.

CAN ID	0Byte (Most Significant)	1Byte	2Byte	3Byte	4Byte	5Byte	6Byte	7Byte (Lowest)
ID	status code	command code	Reserved					checksum
0x031	0x01(ACK) or 0x00(NACK)	0x00	0x00	0x00	0x00	0x00	0x00	Checksum (calculated by the method in Chapter 5)

Module 2 shall notify the upper device of the success (ACK)/failure (NACK) of the shutdown according to the follo

CAN ID	0Byte (Most Significant)	1Byte	2Byte	3Byte	4Byte	5Byte	6Byte	7Byte (Lowest)
ID	status code	command code	Reserved					checksum
0x039	0x01(ACK) or	0x00	0x00	0x00	0x00	0x00	0x00	Checksum (calculated by the

A response timeout of at least 3 sec. from the module is recommended.

3.3.2 R2 Register Clear Overview

A single command sent from the host device clears the R2 registers of all modules.

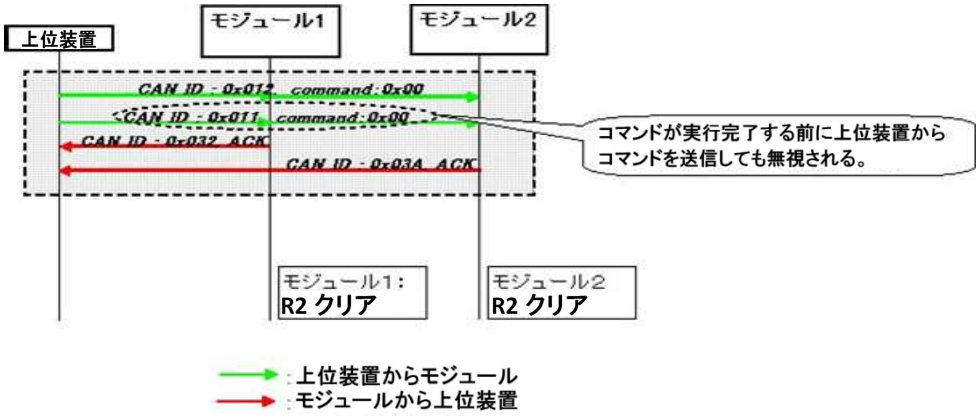

Figure 3-3-2-1 Communication sequence diagram when clearing R2 register

3.3.2.1 R2 Register clear method

The following commands are sent from the host device to modules 1 and 2.

CAN ID	0Byte (Most Significant)	1Byte	2Byte	3Byte	4Byte	5Byte	6Byte	7Byte (Lowest)
ID	(computer) command	Reserved		Key code				checksum
0x12	0x00	0x00	0x00	0xC2	0xED	0xCA	0xEB	Checksum(5 Calculated using the method in Chapter 2)

(Attention.)

Even if this command is sent, the R2 register is not cleared if each bit of the R1 register is "1".

Module 1 notifies the success (ACK)/failure (NACK) of the R2 register clear to the host device according to the following format.

CAN ID	0Byte (Most Significant)	1Byte	2Byte	3Byte	4Byte	5Byte	6Byte	7Byte (Lowest)
ID	status code	command code	Reserved					checksum
0x032	0x01(ACK) or 0x00(NACK)	0x00	0x00	0x00	0x00	0x00	0x00	Checksum (calculated by the method in Chapter 5)

Module 2 notifies the success (ACK)/failure (NACK) of the R2 register clear to the host device according to the following format.

CAN ID	0Byte (Most Significant)	1Byte	2Byte	3Byte	4Byte	5Byte	6Byte	7Byte (Lowest)
ID	status code	command code	Reserved					checksum
0x03A	0x01(ACK) or 0x00(NACK)	0x00	0x00	0x00	0x00	0x00	0x00	Checksum (calculated by the method in Chapter 5)

A response timeout of at least 3 sec. from the module is recommended.

4. system fault

A system anomaly means an abnormality, failure, or warning.

Table 4-1 shows the definitions of warning, abnormality, permanent abnormality, and failure.

Table 4-1. Definitions of Warning, Abnormal, Permanent Abnormality, and Failure

system Type of abnormality	State Definitions	Record to register	
		R1	R2
Warning.	Condition before abnormality	Recorded in.	Recorded in.
abnormality	Abnormal conditions related to cell voltage/temperature, current, or communications	Recorded in.	Recorded in.
permanent anomaly	Significant abnormal condition related to cell voltage/temperature	Recorded in.	-
failure	Abnormal operation of major components	Recorded in.	Recorded in.

- The R2 register is cleared by a CAN command from the host device.
- R2 register is not cleared at module shutdown.
- Permanent anomalies are not cleared.

These system error items are periodically sent from the module to the host device via CAN communication. When abnormalities occur in CAN communication, such as frequent synchronous counter resets or long-term communication stoppages,
The higher-level equipment should stop charging and discharging regeneration.

Table 4-2 Warning Codes

bit position	(data) item	judgment		release		Operation after judgment				After determination, expected behavior of the host device	remarks
		terms	Hours.	terms	Hours.	CAN notice	Charging FET	Discharge FET	shut downstream		
B7	Overvoltage warning	Maximum cell voltage in module 2.70V min.	400 to 600 [ms] (*1)	Maximum cell voltage in module 2.55V max.	400 to 600 [ms](*1)	be just about to	ON	ON	local	Stop charging	
B6	Low voltage warning	Minimum cell voltage in module 1.5V or less	400 to 600 [ms] (*1)	Minimum cell voltage in module 2.1V or higher	400 to 600 [ms] (*1)	be just about to	ON	ON	local	Stop discharge	
		Minimum cell voltage in module 1.9V or less	300 [s]. (*2)							Release the module from the state of startup and abandonment. (Turn off the switch and shut to be down)	
B3	Module High Temperature Warning	Module temperature 55°C min.	400 to 600 [ms] (*1)	Module temperature 50°C max.	400 to 600 [ms] (*1)	be just about to	ON	ON	local	Stop charging and discharging	
b2	Module Low Temperature Warning	Module temperature -30°C max.	400 to 600 [ms] (*1)	Module temperature -25°C or higher	400 to 600 [ms] (*1)	be just about to	ON	ON	local	Stop charging and discharging	
b1	Circuit High Temperature Warning	FET or shunt temperature higher than 90°C	400 to 600 [ms] (*1)	The higher FET or shunt temperature is less than 85°C	400 to 600 [ms] (*1)	be just about to	ON	ON	local	Stop charging and discharging	

b0	Cell voltage difference warning	Maximum cell voltage in module -Minimum cell voltage in module 500mV min.	400 to 600 [ms] (*1)	Maximum cell voltage in module - Minimum cell voltage in module 400mV max.	400 to 600 [ms] (*1)	be just about to	ON	ON	local	Stop charging and discharging	

(*1): In practice, this time is 400 to 600 ms. It takes another 200ms (typ.) from this time until the upper device is notified via CAN.

(*2): This time is actually 300s. It will take another 200ms (typ.) until the upper device is notified via CAN. (Applicable to products manufactured in May 2019 whose serial number has "G123" at the beginning of the serial number.)

Table 4-3

Abnormality Codes

bit position	(data) item	judgment		release		Operation after judgment				After determination, expected behavior of the host device	remarks
		terms	Hours.	terms	Hours.	CAN notice	Charging FET	Discharge FET	shut downstream		
B7	Overvoltage abnormal	Maximum cell voltage in module 2.8V or higher	400 to 600 [ms] (*1)	Maximum cell voltage in module 2.55V max.	400 to 600 [ms] (*1)	be just about to	OFF	ON	local	-	
B6	Low voltage abnormal	Minimum cell voltage in module 1.4V or less	400 to 600 [ms] (*1)	Minimum cell voltage in module 2.1V or higher	400 to 600 [ms] (*1)	be just about to	ON	OFF(*2)	do (*3)	Charging	
		Minimum cell voltage in module 1.9V or less	600 [s] (*6)					OFF			
B5	Overcharge current abnormal	Charging current greater than 125A	220[s].	Module shutdown	N/A	be just about to	OFF	OFF	be just about to	-	
		Charging current greater than 210A	2[s].								
		Charging current is more than 30A	400 to 600 [ms](*1,*4)								
b4	Discharge overcurrent error	Discharge current greater than 125A	220[s].	Module shutdown	N/A	be just about to	OFF	OFF	be just about to	-	
		Discharge current greater than 210A	2[s].								
B3	Module high temperature abnormal	Module temperature 66°C min.	400 to 600 [ms] (*1)	Module shutdown	N/A	be just about to	OFF	OFF	be just about to	-	
b2	Abnormal module low temperature	Module temperature -35°C max.	400 to 600 [ms] (*1)	Module shutdown	N/A	be just about to	OFF	OFF	be just about to	-	

bit position	(data) item	judgment		release		Operation after judgment				After determination, expected behavior of the host device	remarks
		terms	Hours.	terms	Hours.	CAN notice	Charging FET	Discharge FET	shut downstream		
b1	Circuit high temperature abnormal	FET or shunt temperature higher than 95°C	400 to 600 [ms] (*1)	Module shutdown	N/A	be just about to	OFF	OFF	be just about to	-	
b0	Abnormal module voltage difference	Determined at startup Voltage difference between modules exceeds 0.3V	1[s].	Voltage difference is less than 0.3V and current less than 30A	N/A	be just about to	OFF (*5)	OFF	local	-	

(*1): In practice, this time is 400 to 600 ms. It takes another 200ms (typ.) from this time until the upper device is notified via CAN.

(*2): ON if detected immediately after startup, and OFF if the minimum cell voltage decreases by 20mV or more for more than 10 seconds after the low-voltage error is confirmed. (Applicable to products manufactured in May 2019 whose serial number has "G123" at the beginning of the serial number)

(*3): If a charging current exceeding 1.6A cannot be confirmed within 60 seconds, the system shuts down. (*4): When an abnormal inter-module voltage difference occurs and the charging current flows 30A or more, an overcharge current error occurs.

(*5): Only the module on the lower voltage side in the 2P1S configuration has the charge FET turned on to enable charging. For details, refer to the instruction manual (SPC-COM-E0050).

(*6): In practice, this time is 300s. It will take another 200ms (typ.) until the upper device is notified via CAN. (Applies to products manufactured in May 2019 whose serial number has "G123" at the beginning of the serial number.)

Table **4-4** Permanent anomaly codes

bit position	(data) item	judgment		release		Operation after judgment				After determination, expected behavior of the host device	remarks
		terms	Hours.	terms	Hours.	CAN notice	Charging FET	Discharge FET	shutdown		
B7	Overvoltage permanent anomaly	within a module Maximum cell voltage 3.0V or higher	400 to 600 [ms] (*1)	non-releasable	N/A	be just about to	OFF	OFF	local	–	
B6	Low voltage permanent anomaly	within a module Minimum cell voltage 1.2V or less	1800-2000 [ms] (*2)	non-releasable	N/A	be just about to	OFF	OFF	local	–	

(*1): In practice, this time is 400 to 600 ms. It takes another 200ms (typ.) until the upper device is notified via CAN. (*2): In practice, this time is 1800 to 2000 ms. It takes another 200 ms (typ.) until the upper-level device is notified via CAN.

Table 4-5 Failure

Code 1

bit position	Error Type	judgment	release	Operation after judgment				After determination, expected behavior of the host device	remarks
		terms	terms	CAN notice	Charging FET	Discharge FET	shut downstream		
B7	MPU failure (self-diagnosis)	When an abnormality related to the MPU is detected in the module's self-diagnosis	Module shutdown	Depends on the failure site.	OFF	OFF	local	–	
B6	VTM communication error	When an abnormality related to VTM communication is detected in the module's self-diagnosis	Module shutdown	be just about to	OFF (*2)	ON	local	–	
B5	Module misconnection failure	When a module combination error is detected	Module shutdown	be just about to	OFF	OFF	local	–	
b4	module configuration failure	When an abnormality of an element constituting a module is detected (e.g., terminator not connected)	Module shutdown	be just about to	OFF	OFF	local	–	

(*2): The charging FET is forcibly turned off one minute after a failure notification by CAN. However, if any of the following conditions are met, the charging FET is immediately turned off.

When a current of 15A or more is applied for 2 seconds or longer

When the current integrated value has increased by 0.1Ah or more since the failure occurred.

When an ammeter failure and a cell voltage measurement failure occur simultaneously

Table 4-6 Failure

Code 2

bit position	Error Type	judgment	release	Operation after judgment				After determination, expected behavior of the host device	remarks
		terms	terms	CAN notice	Charging FET	Discharge FET	shut downstream		
B7	VTM Failure (Temperature measurement section)	When module self-diagnosis detects a failure related to the temperature measurement function of the VTM	Module shutdown	be just about to	OFF (*2)	ON	local	–	
B6	Current detection circuit failure	When an abnormality related to the current detection circuit is detected in the module's self-diagnosis	Module shutdown	be just about to	OFF (*2)	ON	local	–	
B5	EEPROM Failure (critical location)	Module self-diagnosis of EEPROM If an error is detected with respect to critical data	Module shutdown	be just about to	OFF (*2)	ON	local	–	
b4	Abnormal CAN communication between modules	When CAN transmission from another module cannot be received for more than 2 s or when normal data cannot be received for more than 2 s	Module shutdown	be just about to	OFF	ON	Do (*1)	–	(*1) Shut down the system if it continues for more than 30 minutes.
B3	Reserved	–	–	–	–	–	–	–	
b2	VTM Failure (voltage measurement section)	If the module's self-diagnostics detect a failure with respect to the voltage measurement function of the VTM	Module shutdown	be just about to	OFF (*2)	ON	local	–	
b1	Circuit temperature measurement failure	Circuit temperature with module self-diagnosis When a failure related to the measurement function is detected	Module shutdown	be just about to	OFF (*2)	ON	local	–	
b0	AD converter failure	When an abnormality related to the AD converter is detected in the module self-diagnosis	Module shutdown	be just about to	OFF (*2)	ON	local	–	

(*2): The charging FET is forcibly turned off one minute after a failure notification by CAN. However, if any of the following conditions are met, the charging FET is immediately turned off.

When a current of 15A or more is applied for 2 seconds or longer

When the current integrated value has increased by 0.1Ah or more since the failure occurred.

When an ammeter failure and a cell voltage measurement failure occur simultaneously

Table 4-7 Failure

Code 3

bit position	Error Type	judgment	release	Operation after judgment				After determination, expected behavior of the host device	remarks
		terms	terms	CAN notice	Charging FET	Discharge FET	shut downstream		
B6	VTM Failure (except temperature and voltage measurement function)	If module self-diagnostics detect a failure in a function other than VTM voltage/temperature measurement	Module shutdown	be just about to	ON	ON	local	–	
b4	EEPROM Failure (Normal location)	If the module's self-diagnosis detects a fault with respect to data other than critical data in the EEPROM	Module shutdown	be just about to	ON	ON	local	–	

5. Checksum Calculation

One byte is allocated to each CAN frame as a checksum. The checksum is calculated based on the total of each byte of the CAN frame excluding itself. The calculation method is as follows

<Checksum calculation target

CAN ID: 11 bits

Data: 7 bytes (not including checksum bytes)

<Calculation Method

1. Seek the data to be calculated

   The checksum is calculated in units of 1 byte (8 bits).

   For each CAN frame, 9 bytes of data are obtained.

   2 bytes from CAN ID: 1 byte

   (The CAN ID is 11 bits long. (The CAN ID is 11 bits long.)

   This is considered the lower 11 bits of the data, and the remaining 5 bits are set to 0.

   See example below)

   7 bytes from frame data

   (Do not exclude data in the Reserve area)

2. Calculate the sum of these data

   Find the sum of the individual data. Ignore carryover.

3. Calculation of checksum value

   The two's complement is calculated. The result is the checksum.

<Example.

CAN ID: 0x0030

Data: 0x2B0000002B7B00

1. Obtain data for checksum calculation from

   CAN ID (0x0030) => 0x00, 0x30

   From data (0x2B0000002B7B00) => 0x2B, 0x00, 0x00, 0x2B, 0x7B, 0x00

2. Calculate the sum of each data

   0x00 + 0x30 + 0x2B + 0x00 + 0x00 + 0x2B + 0x7B + 0x00 = 0x101

3. Calculation of checksum value

   Ignore carry : 0x101 & 0xFF = 0x01

   Find 2's complement : inv(0x01) + 1 = 0xFF

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