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## Industrial Li-ion Rechargeable Battery Module SIP24-23

(Model: FP01101MCB01A)

## **CAN Interface Specifications**



Rev.4

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### **Table of Contents**

1P1S Edition	2
2P1S Ed	28

# 1P1S

# Edition

#### 1P1S Table of Contents

1. Introduction	4
2. CAN Interface Overview	5
2.1 Protocol	
2.2 CAN Dassignment	6
3. CAN communication	7
3.1.1 Frame Details	10
3.2 Other Communications	17
3.2.1 Maintenance Newsletters	17
3.3 Module shutdown instruction and R2 register clear inst	ruction
	18
3.3.2 R2 Register Clear Overview	19
4. System Abnormality	
5. Checksum Calculation	27

#### 1. Introduction.

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

#### (Definitions and Abbreviations)

abbr	nam	Desc
eviati	е	riptio
on		n.
ENABLE Signal	Enable	Signal for BMS startup
		(Closed: <b>High</b> , 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 D).

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 Dassignment

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

Table 2-2-1 CAN DAssignment

CAN D0x000	From	То	Contents	communicatio
to 0x010	-	1	reserved	n 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 S00, 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.

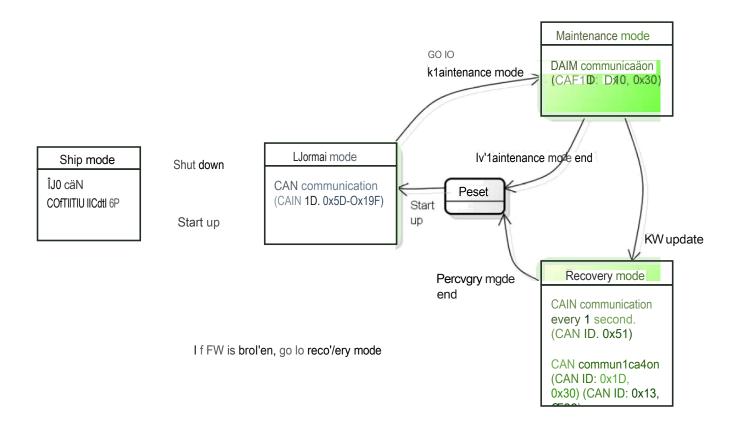


Figure 3-1 Overview of CAN communication status in each state

#### 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.

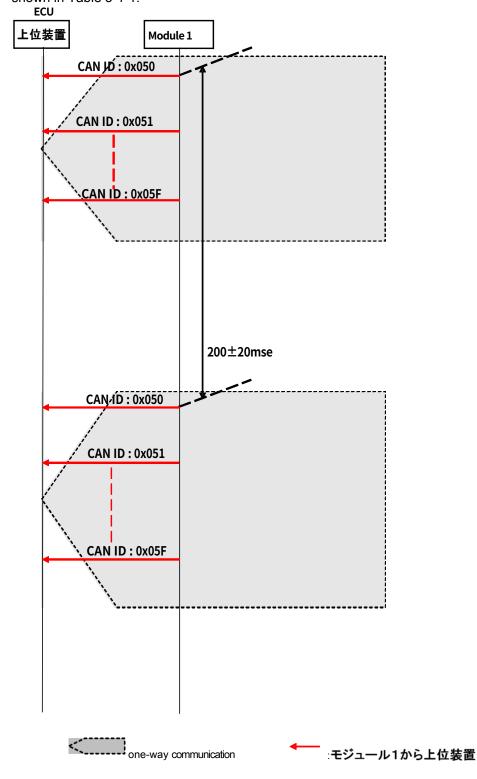


Figure 3-1-1 Communication sequence diagram in normal mode

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

	0byte	1 byte	2byte	3byte	4	5	6	7byte
CAN ID					bytes	bytes	bytes	
	same					check		
	period		data			SAM		
	counter							
0x050							module	
	Synchr onous			inter		I/O	address	See
	counter			er on time, s/digit)		signal status		chapter 5.
0x051	counter	Warnin	Abnor	Permane	Warnin	Abnor		
UXUST	Synchr	g	mality	nt	g	mality	active	See
	onous	Code	Code 1	anomaly	Code	Code 1	active	chapter 5.
	counter	(R1)	(R1)	code	(R2)	(R2)		Chapter 5.
		()	()	(R1)	()	()		
0x052		fault	fault	fault	fault	fault	fault	
	Synchr	code	code	code	code	code	code	See
	onous	1 <b>(</b> R1)	2 <b>(</b> R1)	3 <b>(</b> R1)	1(R2)	2(R2)	3(R2)	chapter 5.
	counter							
0x053	same	S	OC	SOC(%)	0x00	0x00	0x00	See
	period counter							chapter 5.
0x054	Synchr							
0,000	onous		(Rese	erved)		0x00	0x00	See
	counter							chapter 5.
0x055	same	Мо	dule			Module		
	period	tempe	erature	Circ		tempe	erature	See
	counter	(M	ax.)	temp	perature	(M	lin.)	chapter 5.
0x056	Synchr	Module	current	Module	voltage	0x00	0x00	See
	onous	Module	Current	Module	voitage	0,000	0,000	
	counter							chapter 5.
0x057	Synchr	Cell v	voltage 1	Cell v	oltage 2	Cell	voltage 3	See
	onous		3		3		0	chapter 5.
	counter							
0x058	same	Cell v	voltage 4	Cell v	oltage 5	Cell	voltage 6	See
	period							chapter 5.
0x059	counter Synchr							
บังบอิล	onous	Cell v	voltage 7	Cell v	oltage 8	Cell	voltage 9	See
	counter							chapter 5.
0x05A	same							
	period	Cell v	oltage 10	Cell v	oltage 11	0x00	0x00	See
	counter							chapter 5.

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0x05F	Synchr	(Reserved)	See	
	onous counter		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.

(data )	value	Cont ents	rema rks
item			
CAN ID	0x050	-	
synchronous	0x00-0xFF	The value is incremented by 1 for each frame transmitted.	-
counter	(Cyclic counter)	Starts from 0 at module startup.	
counter	0x00000000-	A counter that increments by 1 count every 0.1 second.	-
	0xFFFFFFFFF	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.	Changes within the control
ii o oiginai otatao	ONCO ONEO	b7 : ENABLE signal (On:1,	cycle are not guaranteed.
		Off:0) b6 : Discharge FET	oyolo aro not guarantooa.
		(On:1, Off:0) b5: Charge	
		FET (On:1, Off:0) b4:	
		Reserved	
		b3 : Reserved	
		b2 : Reserved b1 : Reserved	
		b0 : Reserved	
		201.000.000	
module	0x00-0x01	Module address assigned by CAN address signal	
address			
checksum	0x00-0xFF	-	See chapter 5.

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

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, ₱0x052

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

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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, D0x053

(data ) item	value	Cont ents	rema rks
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.

<sup>\*</sup>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), \$\tilde{D}\$0x054

(data ) item	value	Cont ents	rema rks
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, №0x055

(data	value	Cont	rema
)		ents	rks
item			
CAN ID	0x055	-	
synchronous	0x00-0xFF	The value is incremented by 1 for each frame transmitted.	-
counter	(Cyclic counter)	Starts from 0 at module startup.	
Module temperature	0x0000-0xFFFE	Moving average of cell temperature	The exception is 0xFFFE,
(Max.)		Measurable temperature range: -40 to 120degC	which is indefinite.
		Module temperature (°C) = (value - 0x8000)	
		x 0.1 (example) 0x8000: 0 deg.	
		0x7FFF: -0.1deg_C,.	
		0x8001: 0.1 deg.	
Circuit temperature	0x0000-0xFFFE	The highest moving average of the temperatures measured by	The exception is 0xFFFE,
		the thermistor in contact with the heat sink on which the FET is	which is indefinite.
		mounted.	
		Measurable temperature range: -40 to	
		120degC FET temperature (°C) =	
		(value - 0x8000) x 0.1	
		(Example) 0x8000: 0 deg.	
		C, Ox7FFF: -0.1 deg.	
		0x8001: 0.1 deg.	
Module temperature	0x0000-0xFFFE	Moving average of cell temperature	The exception is 0xFFFE,
(Min.)		Measurable temperature range: -40 to 120degC	which is indefinite.
		Module temperature (°C) = (value - 0x8000)	
		x 0.1 (example) 0x8000: 0 deg.	
		0x7FFF: -0.1deg.C,.	
		0x8001: 0.1 deg.C	
checksum	0x00-0xFF	-	See chapter 5.

Table 3-1-1-7 CAN Format: Current and Voltage Frames, №0x056

(data ) item	value	Cont ents	rema rks	
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), <code>00x057</code>

(data	value	Cont	rema	
)		ents	rks	
item				
CAN ID	0x057	-	-	
synchronous	0x00-0xFF	The value is incremented by 1 for each frame transmitted.	-	
counter	(Cyclic counter)	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.	

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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), <code>D0x058</code>

(data ) item	value	Cont ents	rema rks
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), \$\textstyle{0}\text{0x059}\$

(data ) item	value	Cont ents	rema rks	
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.	

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I	checksum	0x00-0xFF	-	See chapter 5.
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The value 0xFFFF shall be treated

as an invalid value.

See chapter 5.

checksum

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

Table 3-1-1-11 CAN format: cell voltage frame (cell 10 to 11), D0x05A

Table 3-1-1-12 CAN Format: Data Frame (RESERVE), \$\tilde{D}\$0x05F

The actual measurable voltage range is 0 to 5000.0916 mV.

(data ) item	value	Cont ents	rema rks
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

0x00-0xFF

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

I	CAN D	0byte	1 byte	2byte	3byte	4 bytes	5 bytes	6 bytes	7byte	remarks
		synchr onous counte r			da	ata			checksu m	

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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.

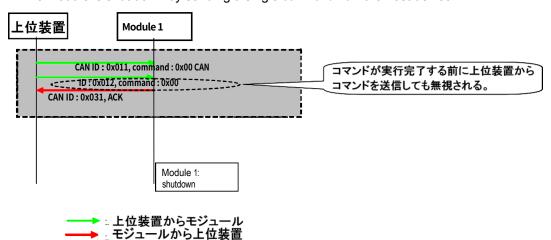


Figure .3-3-1-1 Communication sequence diagram when shutting down a module

#### 3.3.1.1 Module shutdown method

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

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

Module 1 s h a I I notify the host of the success (ACK)/failure (NACK) of the shutdown according to the following format.

ĺ	CAN D	OByte (Most	1Byte	2Byte	3Byte	4Byte	5Byte	6Byte	7Byte
ı		Significant)							(Lowest)

ID	status code	comman d 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.

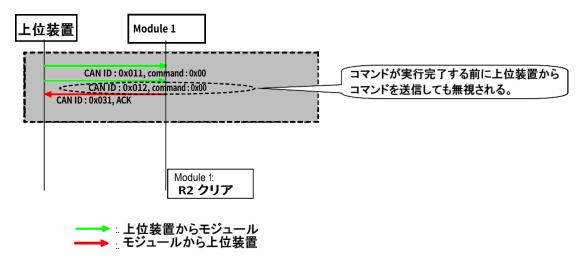


Figure 3-3-2-1 Communication sequence diagram when clearing R2 register

#### 3.3.2.1 R2 Register clear method

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

CAN ID	OByte (Most Significant)	1Byte	2Byte	3Byte	4Byte	5Byte	6Byte	7Byte (Lowest)
ID	ID (computer)		erved		Key		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 """.

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

CAN D	OByte (Most Significant)	1Byte	2Byte	3Byte	4Byte	5Byte	6Byte	7Byte (Lowest)
ID	status code	comman d code			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	Chata	Record to	register
Type of abnormality	State Definitions	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 a	fter judgment			After determination,	remarks
		terms	Hours.	terms	Hours.	CAN notice	Charging FET	Discharge FET	shut downstrea m	expected behavior of the host device	
В7	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  Minimum cell voltage in module 1.9V or less	400 to 600 [ms] (*1) 300 [s]. (*2)	Minimum cell voltage in module 2.1V or higher	400 to 600 [ms] (*1)	be just about to	ON	ON	local	Release the module's startupabandoned status (Turn off the switch, and then shuffle.	
В3	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	Maximum cell voltage in	400 to 600	Maximum cell voltage in	400 to 600	be just	ON	ON	local	Stop charging and	
	warning	module	[ms] (*1)	module	[ms] (*1)	about to				discharging	
		-Minimum cell voltage in		-Minimum cell voltage in							
		module 500mV min.		module 400mV or less							

<sup>(\*1):</sup> 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.

<sup>(\*2):</sup> 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 judgmer	nt		After determination,	remarks
		terms	Hours.	terms	Hours.	CAN notice	Charging FET	Discharge FET	shut downstrea m	expected behavior of the host device	
В7	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.	
В6	Low voltage abnormal	Minimum cell voltage in module 1.4V or less Minimum cell voltage in module 1.9V or less	400 to 600 [ms] (*1) 600[s]. (*4)	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)
B5	Overcharge current abnormal	Charging current greater than 125 A Charging current greater than 210A	220[s]. 2[s].	Module shutdown	N/A	be just about to	OFF	OFF	be just about to	-	
b4	Discharge overcurrent error	Discharge current greater than 125A Discharge current greater than 210A		Module shutdown	N/A	be just about to	OFF	OFF	be just about to	-	
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	-	

<sup>(\*1):</sup> 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	(data) item	judgment	judgment			Operation af	ter judgment			After determination,	remarks
positi		terms	Hours.	terms	Hours.	CAN notice	Charging	Discharge	shut downstrea	expected behavior	
on							FET	FET	m	of the host device	
B7	Overvoltage permanent	within a module	400 to 600	non-releasable	N/A	be just about	OFF	OFF	local	-	
	anomaly	Maximum cell voltage 3.0V or higher	[ms] (*1)			to					
B6	Low voltage permanent	within a module	1800-2000	non-releasable	N/A	be just about	OFF	OFF	local	-	
	anomaly	Minimum cell voltage 1.2V or less	[ms] (*2)			to					

<sup>(\*1):</sup> 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 a	after judgment			After determination,	remarks
		terms	terms	CAN notice	Charging FET	Discharge FET	shut downstrea m	expected behavior of the host device	
В7	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 at	fter judgment			After determination,	remarks
		terms	terms	CAN notice	Charging FET	Discharge FET	shut downstrea m	expected behavior of the host device	
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	-	
В3	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	OFF (*2)	ON	local	-	

<sup>(\*2):</sup> 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	er judgment			After determination,	remarks
		terms	terms	CAN notic e	Charging FET	Discharge FET	shut downstrea m	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</p>

CAN D: 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 D: 1 byte

(The CAN Dis 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 D: 0x0030

Data: 0x2B0000002B7B00

1. Obtain data for checksum calculation from

CAN (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. First of all	
1.1 About Parallel Connection	30
2. CAN Interface Overview	31
2.1 Protocol	31
2.2 CAN	32
3. CAN communication	33
3.1 Periodic transmission of the module's internal status to the ECU	
3.1.1 Frame Details	
3.2 Other Communications	
3.2.1 Maintenance Communication	45
3.3 Module shutdown instruction and R2 register clear instruction	45
3.3.2 R2 Register Clear Overview	47
4. System Abnormality	48
5. Checksum Calculation	56

#### 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 (1 1-bit  $\mathbb{D}$ ).

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 Dassignment

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

Table 2-2-1 CAN DAssignment

CAN ID	From	То	Contents	communication
0x000 ~ 0x010	-	-	reserved	n cycle -
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 S0C, 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.

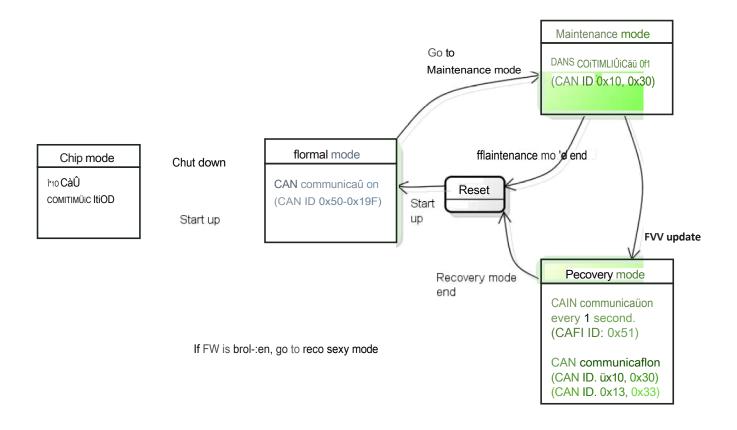


Figure 3-1 Overview of CAN communication status in each state

#### 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.

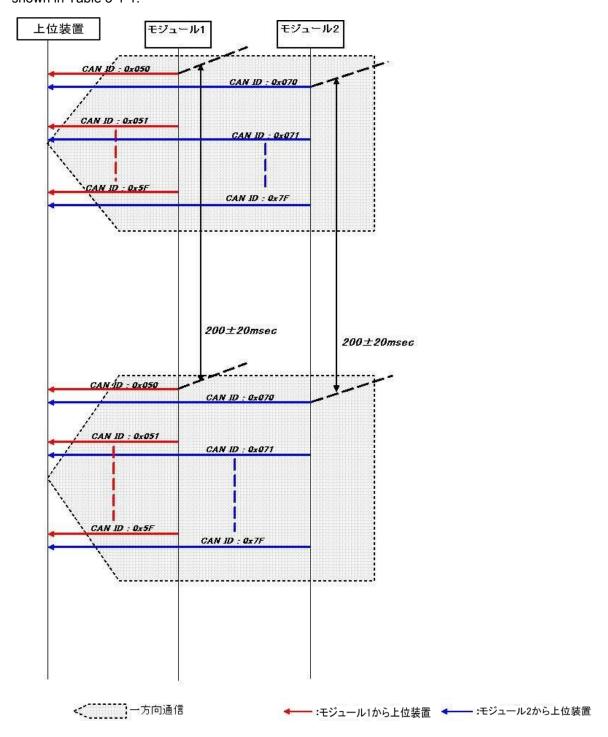


Figure 3-1-1 Communication sequence diagram in normal mode

(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

<u> </u>	e 3-1-1 CAN							<b>-</b> 1
CAN ID	0byte	1 byte	2byte	3byte	4 bytes	5byte	6 bytes	7byte
CAN II	same period counter	data						check SAM
0x050 (module 1) or 0x070 (module 2)	Synchr onous counter		(powe	inter er on time, s/digit)		I/O signal status	module address sea cucumber (Holothuroi dea spp.)	See chapter 5.
0x051 (module 1) or 0x071 (Module 2)	Synchr onous counter	Warnin g Code (R1)	Abnor mality Code 1 (R1)	Permane nt anomaly code (R1)	Warnin g Code (R2)	Fault code (R2)	active	See chapter 5.
0x052 (module 1) or 0x072 (module 2)	Synchr onous counter	Failur e code 1 <b>(</b> R1)	Failur e code 2 (R1)	Failur e code 3 (R1)	Failur e code 1 (R2)	Failur e code 2 (R2)	Failur e code 3 (R2)	See chapter 5.
0x053 (module 1) (module 2 is (Not used)	Synchr onous counter	S	OC	SOC(%)	0x00	0x00	0x00	See chapter 5.
0x054 (module 1) or 0x074 (module 2)	Synchr onous counter		(Reso	erved)		0x00	0x00	See chapter 5.
0x055 (module 1) or 0x075 (module 2)	Synchr onous counter	Module  temperatur  e (max)  Circuit  temperature		Module temperatur e (min)		See chapter 5.		
0x056 (module 1) or 0x076 (Module 2)	Synchr onous counter	Module	current	Module	voltage	0x00	0x00	See chapter 5.
0x057 (module 1) or 0x077 (module 2)	Synchr onous counter	Cell voltage 1 Cell voltage 2		Cell voltage 3		See chapter 5.		
0x058 (module 1) or 0x078 (module 2)	Synchr onous counter	Cell	voltage 4	Cell v	oltage 5	Cell	voltage 6	See chapter 5.

0x059 (module 1) or 0x079 (module 2)	Synchr onous counter	Cell voltage 7	Cell voltage 8	Cell v	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, 00x050, 0x070

CAN ID   Ox050 or 0x070   - Ox050 is module 1 Ox070 is module 2	l able 3-1	-1 CAN Format: Counte	r, I/O Status and CAN Address Frame,	UXU/U
titem  CAN D  Ox050 or 0x070  -  Ox050 is module 1  Ox070 is module 2  synchronous counter  Ox0000000- Counter  Ox00000000- OxFFFFFFFFF  A counter that incremented by 1 for each frame transmitted.  The value is incremented by 1 for each frame transmitted.  Starts from 0 at module startup.  -  Counter  Ox00000000- OxFFFFFFFFF  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.  Changes within the control cycle are not guaranteed.  Ox00-0xE0  Signal status is indicated. b7 : ENABLE signal (On:1, Off:0) b6 : Discharge FET (On:1, Off:0) b4 : Reserved b3 : Reserved b3 : Reserved b1 : Reserved b1 : Reserved b0 : Reserved	(data	value	Cont	rema
CAN D  Ox050 or 0x070  -  Ox050 is module 1 Ox070 is module 2  synchronous counter  Ox00-0xFF (Cyclic counter)  Counter  Ox0000000- OxFFFFFFFFF  The value is incremented by 1 for each frame transmitted.  Starts from 0 at module startup.  -  Counter  Ox00000000- OxFFFFFFFFF  This 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.  Changes within the control cycle are not guaranteed.  Off:0) b6: Discharge FET (On:1, Off:0) b5: Charge FET (On:1, Off:0) b4: Reserved b3: Reserved b3: Reserved b1: Reserved b1: Reserved b0: Reserved	)		ents	rks
synchronous counter  Ox00-0xFF (Cyclic counter)  The value is incremented by 1 for each frame transmitted.  Starts from 0 at module startup.  A counter that increments by 1 count every 0.1 second. OxFFFFFFFFF  This counter represents the elapsed time from the start of battery module use to the present.  I/O signal status  Ox00-0xE0  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 b3 : Reserved b1 : Reserved b1 : Reserved b1 : Reserved b1 : Reserved b0 : Reserved b1 : Reserved b3 : Reserved b4 : Reserved b5 : Reserved b6 : Reserved b7 : Reserved b8 : Reserved b9 : Reserved b1 : Reserved b7 : Reserved b8 : Reserved b9 : Reserved	item			
synchronous counter  Ox00-0xFF (Cyclic counter)  The value is incremented by 1 for each frame transmitted.  Starts from 0 at module startup.  A counter that increments by 1 count every 0.1 second. OxFFFFFFFFF This counter represents the elapsed time from the start of battery module use to the present.  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 b1 : Reserved b1 : Reserved b1 : Reserved b0 : Reserved	CAN ID	0x050 or 0x070	-	0x050 is module 1
counter (Cyclic counter)  Starts from 0 at module startup.  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.  Changes within the control 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 b1 : Reserved b1 : Reserved b1 : Reserved b0 : Reserved				0x070 is module 2
counter  0x00000000- 0xFFFFFFFFF  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.  Changes within the control battery of the present of the present.  Changes within the control cycle are not guaranteed.	synchronous	0x00-0xFF	The value is incremented by 1 for each frame transmitted.	-
OxFFFFFFFF  This counter represents the elapsed time from the start of battery module use to the present.    VO signal status   Ox00-0xE0	counter	(Cyclic counter)	Starts from 0 at module startup.	
OxFFFFFFFF  This counter represents the elapsed time from the start of battery module use to the present.    VO signal status   Ox00-0xE0				
battery module use to the present.   /O signal status   Ox00-0xE0   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   b4 : Reserved   b5 : Reserved   b5 : Reserved   b6 : Reserved   b6 : Reserved   b6 : Reserved   b6 : Reserved   b7 : Reserved   b8 : Reserved   b9 : Reser	counter	0x00000000-	A counter that increments by 1 count every 0.1 second.	_
Module Module address assigned by CAN address signal  Changes within the control cycle are not guaranteed.  Changes within the control cycle are not guaranteed.  Changes within the control cycle are not guaranteed.		0xFFFFFFFF	This counter represents the elapsed time from the start of	
Module Module address assigned by CAN address signal  Changes within the control cycle are not guaranteed.  Changes within the control cycle are not guaranteed.  Changes within the control cycle are not guaranteed.			battery module use to the present.	
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 b1 : Reserved b0 : Reserved				
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 b1 : Reserved b0 : Reserved				
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 b1 : Reserved b0 : Reserved				
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 b1 : Reserved b0 : Reserved				
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 b1 : Reserved b0 : Reserved				
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 b1 : Reserved b0 : Reserved	I/O signal status	0x00-0xE0	Signal status is indicated.	Changes within the control
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  b0 : Reserved	J			
(On:1, Off:0) b5 : Charge  FET (On:1, Off:0) b4 :  Reserved  b3 : Reserved  b2 : Reserved  b1 : Reserved  b0 : Reserved  b0 : Reserved				Cycle are not guaranteed.
FET (On:1, Off:0) b4: Reserved b3: Reserved b2: Reserved b1: Reserved b0: Reserved b0: Reserved				
Reserved b3: Reserved b2: Reserved b1: Reserved b0: Reserved b0: Reserved b0: Reserved				
b2 : Reserved b1 : Reserved b0 : Reserved  module  0x00-0x01  Module address assigned by CAN address signal				
b2 : Reserved b1 : Reserved b0 : Reserved  module  0x00-0x01  Module address assigned by CAN address signal			b3: Reserved	
b1 : Reserved b0 : Reserved  module				
module 0x00-0x01 Module address assigned by CAN address signal				
module 0x00-0x01 Module address assigned by CAN address signal				
	module	0x00-0x01	Module address assigned by CAN address signal	
	address			
checksum 0x00-0xFF - See chapter 5.	checksum	0x00-0xFF	_	See chapter 5

Table 3-1-1-2 CAN Format: Warning, Error and Permanent Error Frames, <code>0x051</code>, <code>0x071</code>

(data	value	Cont	rema
)		ents	rks
item			
CAN ID	0x051 or 0x071	-	0x051 is module 1
			0x071 is module 2
synchronous	0x00-0xFF	The value is incremented by 1 for each frame transmitted.	
counter	(Cyclic counter)	Starts from 0 at module startup.	
Warning	0x00-0xCF	b7:	If the value of a register differs
Code (R1)		Overvoltage	from module to module, the upper
		warning b6:	device should adopt the value
		Low voltage	obtained by the logical OR of the
		warning b5:	bits of each module.
		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	0x00-0xFF	b7: Overvoltage	If the value of a register differs
code 1 (R1)		error b6: Low	from module to module, the upper
		voltage error b5:	device should adopt the value
		Charging	obtained by the logical OR of the
		overcurrent error	bits of each module.
		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.	

Permanent	0x00-0xC0	b7: Overvoltage	If the value of a register differs
anomaly code		permanent error	from module to module, the upper
(R1)		b6: Low voltage	device should adopt the value
		permanent error	obtained by the logical OR of the
		b5: Reserved	bits of each module.
		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.	
Warning Code	0x00-0xCF	Latch each Bit of warning code (R1).	If the value of a register differs
(R2)			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	Cont ents	rema rks
Abnormality code 1 (R2)	0x00-0xFF  0x00-0x01	Latch each bit of abnormality code 1 (R1).  Notification of module operating status  b7-1: Reserved  b0 : Operation status (0: normal operation, 1: waiting	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.
checksum	0x00-0xFF	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.	See chapter 5.

Table 3-1-1-3 CAN Format: Fault Code Frame, №0x052, 0x072

(data	value	Cont	rema
)		ents	rks
item			
CAN ID	0x052 or 0x072	_	0x052 is module 1
67 tt 15	0.002 01 0.012		0x072 is module 2
	0.000.55		
synchronous	0x00-0xFF	The value is incremented by 1 for each frame transmitted.	-
counter	(Cyclic counter)	Starts from 0 at module startup.	
Failure and	0x00-0xF0	h7. MOU feiture (aplf	If the velve of a register differen
Failure code	000-000	b7: MPU failure (self-	If the value of a register differs
1 (R1)		diagnosis) b6: VTM	from module to module, the upper
		communication error	device should adopt the value
		b5: Module misconnection	obtained by the logical OR of the
		failure b4: Module	bits of each module.
		configuration failure b3:	
		Reserved	
		b2: Reserved	
		b1: Reserved	
		b0: Reserved	
		See Table 4-5 for each failure.	
Failure code	0x00-0xF7	b7: VTM failure (related to	If the value of a register differs
2 (R1)		temperature measurement	from module to module, the upper
		function) b6: Current detection	device should adopt the value
		circuit failure	obtained by the logical OR of the
		b5: EEPROM failure (critical	bits of each module.
		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.	
Failure code	0x00-0x50	b7: Reserved	If the value of a register differs
3 (R1)		b6: VTM failure (other than temperature and	from module to module, the
		voltage measurement function) b5: Reserved	upper device should adopt the
		b4: EEPROM failure (other than	value obtained by logical ORing
		critical part) b3: Reserved	of the bits of each module.
		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).	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	Cont ents	rema rks
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 5-1-1-4 CAN IOITIAL SOC ITAITIE, #0x055			
(data	value	Cont	rema	
)		ents	rks	
item				
CAN ID	0x053	-	0x053 is module 1 (module 2 is	
			not used)	
synchronous	0x00-0xFF	The value is incremented by 1 for each frame transmitted.	-	
counter	(Cyclic counter)	Starts from 0 at module startup.		
SOC*	0x0000-0xFFFE	SOC (State Of Charge) is the remaining capacity in the	As an exception, "0xFFFE" shall	
		battery (the amount of energy that can be output at the	be treated as "undefined value.	
		current battery temperature) in mAh. (0 - 22000mAh)	Outputs only module 1.	
		(Example.)		
		0x0000 : 0mAh		
		0x0001 : 1mAh		
		0x55F0 : 22000mAh		
		0xABE0 : 44000mAh		
SOC(%)*	0x00-0x64,0xFE	Remaining capacity in the battery expressed in (%).	As an exception, "0xFE" shall	
			be treated as "undefined	
		(Example.)	value.	
		0x00 : 0%	Outputs only module 1.	
		0x64 : 100% (0x64)		
checksum	0x00-0xFF	-	See chapter 5.	

<sup>\*</sup>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), \$\textit{D0x054}\$, 0x074

(data ) item	value	Cont ents	rema rks
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,  $\mathbb{D}0x055$ , 0x075

(data ) item	value	Cont ents	rema rks
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.  0x807FFF: -0.1 deg.  0x8001: 0.1 deg.	The exception is 0xFFFE, which is indefinite.

Module	0x0000-0xFFFE	Moving average of cell temperature	The exception is 0xFFFE, which
temperature		Measurable temperature range: -40 to 120degC	is indefinite.
(Min.)		Module temperature (°C) = (value - 0x8000)	
		x 0.1 (example) 0x8000: 0 deg.	
		Ox7FFF: -0.1deg.C,.	
		0x8001: 0.1 deg.C	
checksum	0x00-0xFF	-	See chapter 5.

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

(data ) item	value	Cont ents	rema rks
CAN D	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 (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), D0x057, 0x077

(data ) item	value	Cont ents	rema rks
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.

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checksum 0x00-0xFF	-	See chapter 5.
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Table 3-1-1-9 CAN format: cell voltage frame (cell 4 to 6), D 0x058, 0x078

(data ) item	value	Cont ents	rema rks
CAN ID	0x058 or 0x078	The value is incremented by 1 for each frame transmitted.	0x058 is module 1 0x078 is module 2
synchronous counter	(Cyclic counter)	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), D0x059, 0x079

(data ) item	value	Cont ents	rema rks
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	Cont ents	rema rks
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), D0x05F, 0x07F

(data ) item	value	Cont ents	rema rks
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).

0byte 1 byte 2byte 3byte 5byte 6 bytes 7byte CAN D bytes remarks synchr checksu data onous m counte 0x180 ~ synchr See These frames are located in FMInternal data for maintenance (not disclosed) module 1 chapt onous 0x19F counte er 5. Sent from 0x1A0 to synchr See These frames are located in FMInternal data for maintenance (not disclosed) module 2 onous chapt 0x1BF counte er 5. Sent from

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

- 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.

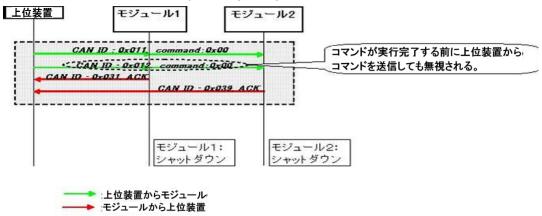


Figure 3-3-1-1 Communication sequence diagram when shutting down the module

#### 3.3.1.1 Module shutdown method

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

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

Module 1 s h a I I notify the host of the success (ACK)/failure (NACK) of the shutdown according to the following format.

CAN D	OByte (Most Significant)	1Byte	2Byte	3Byte	4Byte	5Byte	6Byte	7Byte (Lowest)
ID	status code	comman d 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 s h a II notify the upper device of the success (ACK)/failure (NACK) of the shutdown according to the

follo	CAN D	OByte (Most Significant)	1Byte	2Byte	3Byte	4Byte	5Byte	6Byte	7Byte (Lowest)
	ID	status code	comman d code		Reserved				
	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.

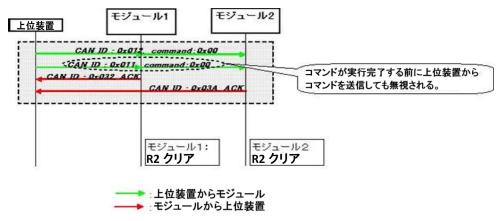


Figure 3-3-2-1 Communication sequence diagram when clearing R2 register

#### 3.3.2.1 R2 Register clear method

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

CAN D	OByte (Most Significant)	1Byte	2Byte	3Byte	4Byte	5Byte	6Byte	7Byte (Lowest)
ID	(computer)	Reserved			Key		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 """.

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

CAN D	OByte (Most Significant)	1Byte	2Byte	3Byte	4Byte	5Byte	6Byte	7Byte (Lowest)
ID	status code	comman d 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.

## **TOSHIBA**

CAN D	OByte (Most Significant)	1Byte	2Byte	3Byte	4Byte	5Byte	6Byte	7Byte (Lowest)
ID	status code	comman d code		ا	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	Chata	Record to	register
Type of abnormality	State  Definitions	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 a	after judgment	t		After determination,	remarks
		terms	Hours.	terms	Hours.	CAN notice	Charging FET	Discharge FET	shut downstrea m	expected behavior of the host device	
В7	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  Minimum cell voltage in module 1.9V or less	400 to 600 [ms] (*1) 300 [s]. (*2)	Minimum cell voltage in module 2.1V or higher	400 to 600 [ms] (*1)	be just about to	ON	ON	local	Stop discharge  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	Maximum cell voltage in	400 to 600	Maximum cell	400 to 600	be just	ON	ON	local	Stop charging and	
	warning	module	[ms] (*1)	voltage in module -	[ms] (*1)	about to				discharging	
		-Minimum cell voltage in		Minimum cell							
		module 500mV min.		voltage in module							
				400mV max.							

<sup>(\*1):</sup> 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.

<sup>(\*2):</sup> 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 a	fter judgment			After determination,	remarks
		terms	Hours.	terms	Hours.	CAN notice	Charging FET	Discharge FET	shut downstrea m	expected behavior of the host device	
В7	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  Minimum cell voltage in	400 to 600 [ms] (*1)	Minimum cell voltage in module	400 to 600 [ms] (*1)	be just	ON	OFF(*2)	do (*3)	Charging	
		module 1.9V or less	[s] (*6)	2.1V or higher		about to		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].								
В3	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	n after judgment			After determination,	remarks
		terms	Hours.	terms	Hours.	CAN notice	Charging FET	Discharge FET	shut downstrea m	expected behavior of the host device	
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	-	

("): In practice, this time is 400 to 600 ms. It takes another 20ms (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 (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,	remarks	
		terms	Hours.	terms	Hours.	CAN notice	Charging FET	Discharge FET	shutdo wn	expected behavior of the host device	
							121	1 - 1			
B7	Overvoltage	within a module	400 to 600	non-	N/A	be just	OFF	OFF	local	-	
	permanent anomaly	Maximum cell voltage 3.0V	[ms] (*1)	releasable		about to					
		or higher									
B6	Low voltage	within a module	1800-2000	non-	N/A	be just	OFF	OFF	local	-	
	permanent anomaly	Minimum cell voltage 1.2V	[ms] (*2)	releasable		about to					
		or less									

(\*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 a	after judgment		After determination,	remarks	
		terms	terms	CAN notice	Charging FET	Discharge FET	shut downstrea m	expected behavior of the host device	
В7	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	-	
В6	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	n after judgme	ent		After determination,	remarks
		terms	terms	CAN notice	Charging FET	Discharge FET	shut downstrea m	expected behavior of the host device	
В7	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.
В3	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 judgme	nt		After determination,	remarks
		terms	terms	CAN notice	Charging	Discharge	shut downstrea	expected behavior	
				Houce	FET	FET	m	of the host device	
B6	VTM Failure	If module self-diagnostics detect a failure	Module shutdown	be just	ON	ON	local	-	
	(except temperature and	in a function other than VTM		about to					
	voltage measurement function)	voltage/temperature measurement							
b4	EEPROM Failure	If the module's self-diagnosis detects a	Module shutdown	be just	ON	ON	local	-	
	(Normal location)	fault with respect to data other than		about to					
		critical data in the EEPROM							

#### 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</p>

CAN D: 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 D: 1 byte

(The CAN Dis 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 D: 0x0030

Data: 0x2B0000002B7B00

1. Obtain data for checksum calculation from

CAN  $\mathbb{D}$  (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

## 株式会社 東芝

February 8, 2017: first published April 15, 2021: 4th edition published