RAJ240xxx Group

Sample Code Specification

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Introduction

This sample code has been prepared for the user as a head start in designing battery related application. Users can create their own battery application by referring to this sample code. The basic functions that are included in this sample code are

- Current, voltage, and Temperature measurement
- RemainingCapacity(RC) Calculation
- Relative State Of Charge(RSOC) Calculation
- Over Current, Over Voltage, and Over Temperature protection
- Simplified mode transition
- Initial Calibration mode for accurate measurement

Threshold value like mode transition is defined in the fixed value. If user would like to change the value, user would well to change the definition, or change to the variable data by data flash.

Several threshold values for mode transition are define as variables. These values can be changed directly or by changing the definition to make these values into configurable data using FlashROM.

Target Device

RAJ240045 (Renesas Battery Management IC)

RAJ240075 (Renesas Battery Management IC)

RAJ240080 (Renesas Battery Management IC)

RAJ240090 (Renesas Battery Management IC)

RAJ240100 (Renesas Battery Management IC)

Contents

1. Outline of system

This sample source code is target for RAJ240xxx reference board. (It is also compatible with RAJ240xxx Evaluation board). This sample source code is integrated with SMBus (System Management Bus) interface and capable of returning the following data.

(1) Temperature
(2) Voltage
(3) Current
(4) RelativeStateOfCharge
(5) RemainingCapacity
(6) FullChargeCapacity
(7) FET Status
(8) Each AD values
(9) OperationStatus
(10) InitialCalibrationReference
(11) InitialCalibration
(12) Number of cells
(13) FirmwareVersion
Refer to chapter“7. SMBus command” for details.

Note 1: Data Flash library version 2.0 is included in the sample source code.
To use latest version, please obtained the latest files from the website link provided below. Install the following files in the source code project folder.
Data Flash Library Type04 for the RL78 Family”. (Install files: pdfl.lib, pfdl.h, pfdl_types.h)
https://www.renesas.com/en-us/products/software-tools/tools/self-programming-library/data-flash-libraries.html

Note 2: The **bold-fond with under line** in this document indicates FlashROM data.
For more detail, please refer to “12 Fixed data list”

Note 3: SMBus command data are set in italic with parentheses and no breaking spaces.
e.g.: *Current()*

Note 4: "Charging" and "Discharging" means as follows when there is no notation.

Charging	*ExtendedCurrent()* ≥ **Charge detection current**
Discharging	*ExtendedCurrent()* < 0 and |*ExtendedCurrent()*| ≥ **Discharge detection current**
Not charging	*ExtendedCurrent()* < **Charge detection current** (It includes discharging)

2. Safety function

Basic safety functions are included in this sample code and based on recommended Renesas Battery Management sample hardware.

Users are welcome to add / modified the safety functions. However, Renesas does not hold any responsibility on liability loss or damage after the modification.

3. General flow chart

Figure 1 shows the general flow chart of sample source code. The sample code consists of two main loops. One is the normal operation loop, and the other is the initial calibration loop. These two main loops are independent of each other.

At the start, the sample code will perform checks for the fixed data availability. If any one of Fixed Data is not available, the sample code will only accept SMBus boot jump (0x5A) command. Under such condition, an appropriate fixed data needs to be set for the missing fixed data area in order to pass the Fixed Data check, as shown in Figure 1. To set the missing values in the fixed data, please use 0x5A command to jump into SMBus boot mode.

Under condition where all fixed data are available, the sample code will switch to initial calibration check state.

If initial calibration is not complete, the sample code will switch to initial calibration main loop

The sample code will check the following calibration values. When all calibration values are available, the firmware will judge the calibration process status as complete.

- (1) Cell voltage reference value
- (2) Current reference value
- (3) Cell voltage AD value
- (4) Current AD value

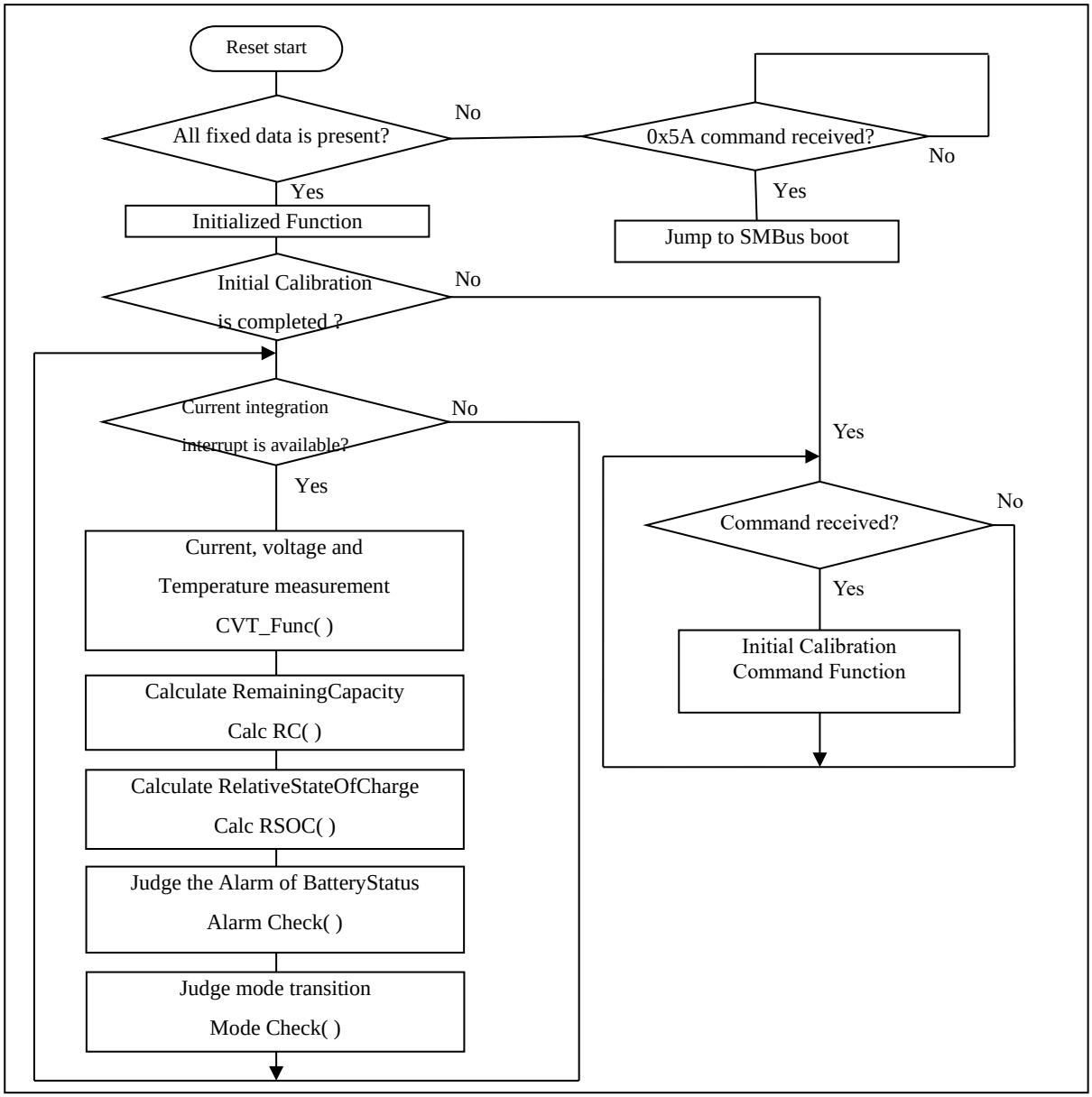


Figure 1. General flow chart

4. Operation Mode

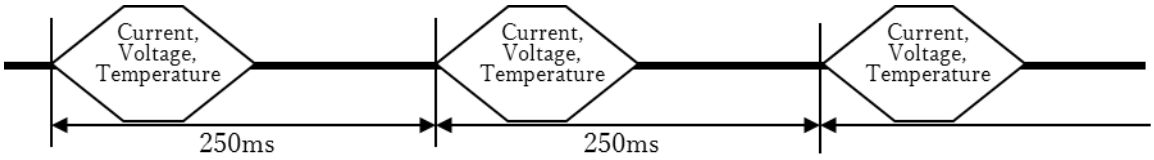
4.1 Operating State

(1) Normal State

Current, Voltage and temperature are measured at each 250ms cycle.

Each SMBus data are calculated at adequate cycle.

When the calculation ends, MCU will stops operating until the next cycle or interrupt.

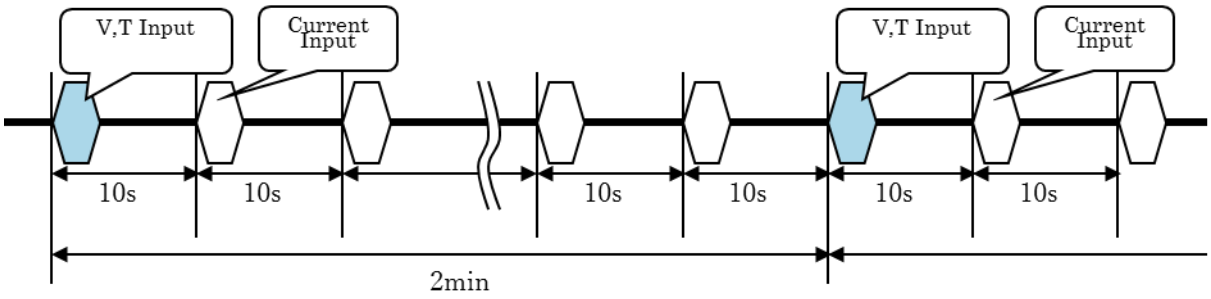


(2) Low Power State

The current value is checked every ten seconds, and switch to normal state in case that the discharge current value is bigger than the value of **Sleep Current**.

The MCU will stops operation after processing and wait for the next 10 seconds period.

Voltage and Temperature values are measured every two minutes to calculate the remainder capacity.



(3) Abnormal State

When the FGIC detected an abnormal current, voltage, or temperature, the sample code will switch to abnormal state.

(4) Power down

IC shut down state.

4.2 Mode transition

This section covers the operating mode associated to the state of the battery and the state of the FET.

Where,

- Table 1 below summarize the modes shown in Figure 1
- Figure 2 shows the mode transition chart for the state of FET in each mode.
- Table 2 is the condition for each mode transition.

Precaution The Power Down mode is a prioritize condition and can be change from any other operating mode. (Refer Figure 2 for details).

Table 1 Mode transition

Mode No	Mode name	Mode description
00	Init	Just after reset
01	WakeUp	Initial state on mode transition
02	Discharging	During discharging
03	Charging	During charging
05	Charge Terminate	Detect full charge voltage
06	Charge Wait	When Detect discharge stop
10	Charge Over Heat	Detect Charge Over temperature
11	Discharge Over Heat	Detect Discharge Over temperature
12	Over Charge Current	Detect Over Charge current
13	Over Discharge Current	Detect Over Discharge current
14	Short Current	Detect Short current
15	Over Voltage	Detect Over Voltage
16	2nd Th Over Heat	Detect Over Heat via 2nd thermistor
20	Initial Calibration	Wait AD calibration
30	Power Down	IC power down
99	Fixed Data Error	Fixed data error(parameter setting error)

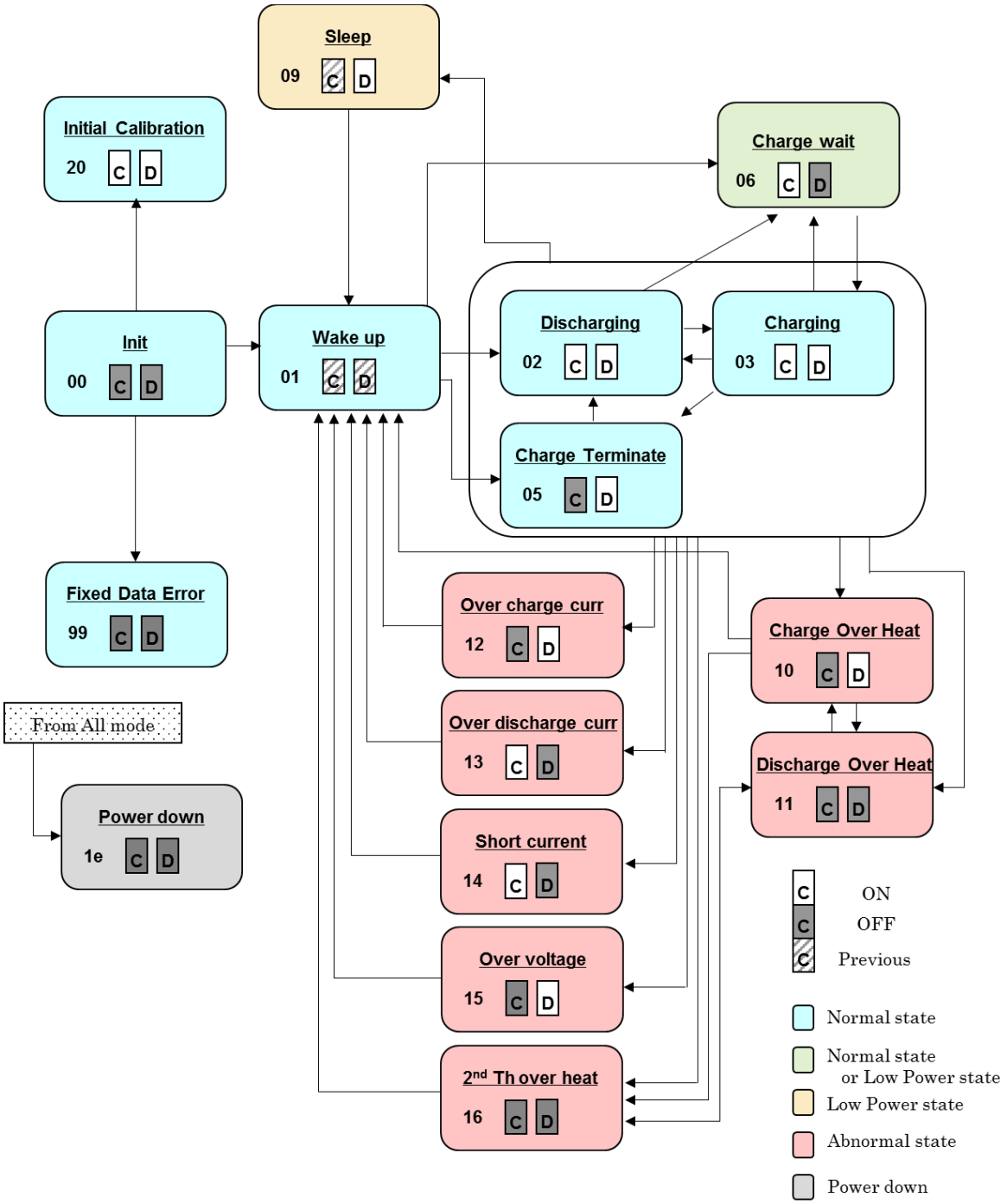


Figure 2. Mode transition chart

Table 2 Mode transition condition

(1/3)

From		To		Condition
00	Init	20	Initial calibration	When the calibration is not completed
		99	Fixed Data Error	When any one of Fixed Data does not exist
		01	WakeUp	When all Fixed data exist and calibration is completed
01	WakeUp	02	Discharging	MaxV < **Full judgement voltage** & **Discharge stop voltage** ≤ MinV
		05	Charge Terminate	MaxV ≥ **Full judgement voltage**
		06	Charge Wait	MinV < **Discharge stop voltage**
02	Discharging	03	Charging	Charging & (**Charge Over temperature(L)** ≤ temperature < **Charge Over temperature(H)**)
		06	Charge Wait	Not **c**harging & MinV < **Discharge stop voltage** continues 1 second
		10	Charge Over Heat	Charging & (temperature ≥ **Charge Over temperature(H)** or temperature < **Charge Over temperature(L)**)
03	Charging	02	Discharging	Discharging
		05	Charge Terminate	((MaxV ≥ (**Charging voltage**) - **Fullcharge taper voltage**) & (*ExtendedCurrent()* < **Fullcharge judgement current**)) continue **Fullcharge judgement time**
		07	Charge Wait	MinV < **Discharge stop voltage**
		10	Charge Over Heat	temperature ≥ **Charge Over temperature(H)** or temperature < **Charge Over temperature(L)**
05	Charge Terminate	02	Discharging	Discharging continues 2 seconds
06	Charge Wait	03	Charging	Charging & MinV ≥ **Discharge stop voltage**

(2/3)

From		To		Condition
-	02,03,05	09	Sleep	no SMBus communication detected for one minute or more & not charging & |*ExtendedCurrent()*| < **Sleep current**
		11	Discharge Over Heat	temperature ≥ **Discharge Over temperature(H)** or temperature < **Discharge Over temperature(L)**
		12	Over Charge Current	*ExtendedCurrent())* ≥ **Charge over current 1** continues for **Charge over current 1 judgement time**. *ExtendedCurrent()* ≥ **Charge over current 2** continues for **Charge over current 2 judgement time**. or When detected Over Charge Current by Current detection circuit
		13	Over Discharge Current	Discharging and | *ExtendedCurrent()*| ≥ **Discharge over current 1** continues for **Discharge over current 1 judgement time**. Discharging and | *ExtendedCurrent())*| ≥ **Discharge over current 2** continues for **Discharge over current 2 judgement time**. or When detected Over Discharge Current by Current detection circuit
		14	Short Current	When detected Short circuit Current by Current detection circuit
		15	Over voltage	MaxV ≥ **Charge protection voltage** continues for **Charge protection judgment time** & Charging
		16	2nd Th over heat	2nd Thermistor temperature ≥ **2nd Th over temperature**
-	All Mode	1e	Power down	MinV ≤ **Power Down Voltage** or When received forced Power down command via SMBus communication

(3/3)

From		To		Condition
09	Sleep	01	Wake up	There is a SMBus communication. Or |*ExtendedCurrent()*| ≥ 250[mA] (It check every 10sec.) or There is PON interrupt(Only RAJ240090/100 supports this function) or MinV < **Power Down Voltage**
10	Charge Over Heat	01	Wake up	Discharging or **(Charge Over temperature(L)** + **Charge Over temperature release hysteresis**) ≤ temperature < (**Charge Over temperature(H)** – **Charge Over temperature release hysteresis**))
		11	Discharge Over Heat	temperature ≥ **Discharge Over temperature(H)** or temperature < **Discharge Over temperature(L)**
		16	2nd Th Over Heat	2nd Thermistor temperature ≥ **2nd Thermistor Over temperature**
11	Discharge Over Heat	10	Charge Over Heat	**Discharge Over temperature(L)** + **Discharge Over temperature release hysteresis**) ≤ temperature < (**Discharge Over temperature(H)** – **Discharge Over temperature release hysteresis**)
		16	2nd Th Over Heat	2nd Thermistor temperature ≥ **2nd Thermistor Over temperature**
12	Over Charge Current	01	Wake up	*ExtendedCurrent()* < 100mA continues for 10 seconds or Discharging
13	Over Discharge Current	01	Wake up	|*ExtendedCurrent()*| < 100mA continues for 10 seconds or Charging
14	Short Current	01	Wake up	|*ExtendedCurrent()*| < 100mA continues for 10 seconds or Charging
15	Over voltage	01	Wake up	MaxV < **Full judgement voltage** or Discharging
16	2nd Th Over Heat	01	Wake up	2nd Thermistor temperature < (**2nd Thermistor Over temperature** – **2nd Thermistor Over temperature release hysteresis)** and **(Discharge Over temperature(L)** ≤ temperature < **Discharge Over temperature(H)**)
		11	Discharge Over Heat	2nd Thermistor temperature < (**2nd Thermistor Over temperature** – **2nd Thermistor Over temperature release hysteresis**) and (temperature ≥ **Discharge Over temperature(H)** or temperature < **Discharge Over temperature(L))**
1e	Power down	-	-	There is no mode transition condition.
99	Fixed Data Error	-	-	There is no mode transition condition.

Remark 1. MinV is the lowest voltage in the cells.

Remark 2. MaxV is the highest voltage in the cells.

Remark 3. Current is the result measured by shunt resistor. Positive value means charging, negative value means discharging

Remark 4. “Temperature” is the result measured by thermistor connected to AN0 terminal.

Remark 5. “2nd Thermistor temperature” is the result measured by thermistor connected to AN1 terminal.

5. Usage of timer

RAJ240090/100 has 1 timer array unit(3 channels). (Unit0)

Usage for this sample source code is as follows.

Table 3 Usage of timer interrupt

Timer	Usage
Unit0 Channel1	1 ms timer. It uses to check SMBus communication timeout.
Unit0 Channel2	not use
Unit0 Channel3	1 us timer It uses for wait time.

6. Main function

In the main route, current integration is a continuous process. The interrupt cycle is at every 250ms.

During each interrupt cycle, the sample code measures/calculates voltage (Cell, PACK, and Total) and temperature.

7. SMBus command

Table 4 below summarize the SMBus command used in the sample code.

SMBus slave address of the Fixed data is the device address. The protocol of these command are either Read/WriteWord or BlockRead.

Precaution 1) RAJ240090/100 supports all SMBus commands
2) RAJ240045, RAJ240075, and RAJ240080 does not support some of the SMBus commands.

Table 4 SMBus command list

Command	Protocol	Data	Unit	RAJ240045	RAJ240075 RAJ240080	RAJ240090 RAJ240100
0x00	Read/WriteWord	ExtraFunction		✓	✓	✓
0x08	ReadWord	Temperature(AN0)	0.1K	✓	✓	✓
0x09	ReadWord	Voltage(Total voltage)	mV	✓	✓	✓
0x0a	ReadWord	Current	mA	✓	✓	✓
0x0d	ReadWord	RelativeStateOfCharge	%	✓	✓	✓
0x0f	ReadWord	RemainingCapacity	mAh	✓	✓	✓
0x10	ReadWord	FullChargeCapacity	mAh	✓	✓	✓
0x14	ReadWord	ChargingCurrent	mA	✓	✓	✓
0x15	ReadWord	ChargingVoltage	mV	✓	✓	✓
0x16	ReadWord	BatteryStatus		✓	✓	✓
0x1f	ReadWord	Control Flag Status		✓	✓	✓
0x21	BlockRead	DeviceName	String	✓	✓	✓
0x24	BlockRead	ExtendedCurrent	mA	✓	✓	✓
0x25	ReadWord	Chip Temperature	0.1K	-	-	✓
0x30	ReadWord	Voltage of Cell 1	mV	✓	✓	✓
0x31	ReadWord	Voltage of Cell 2	mV	✓	✓	✓
0x32	ReadWord	Voltage of Cell 3	mV	✓	✓	✓
0x33	ReadWord	Voltage of Cell 4	mV	✓	✓	✓
0x34	ReadWord	Voltage of Cell 5	mV	-	✓	✓
0x35	ReadWord	Voltage of Cell 6	mV	-	-	✓
0x36	ReadWord	Voltage of Cell 7	mV	-	-	✓
0x37	ReadWord	Voltage of Cell 8	mV	-	-	✓
0x38	ReadWord	Voltage of Cell 9	mV	-	-	✓
0x39	ReadWord	Voltage of Cell 10	mV	-	-	✓
0x41	ReadWord	OperationStatus		✓	✓	✓
0x42	ReadWord	Total Cell Voltage	mV	-	-	✓
0x43	ReadWord	PACK voltage	mV	✓	✓	✓
0x44	ReadWord	2nd Thermistor	0.1K	✓	✓	✓
0x45	ReadWord	PackStatus		✓	✓	✓
0x46	ReadWord	CellBalancingStatus		✓	✓	✓
0x47	ReadWord	Battery Impedance	0.1mOhm	-	-	✓
0x48	ReadWord	Total Charged capacity	Ah	-	-	✓
0x49	ReadWord	Total Storage time	Hour	-	-	✓
0x4A	ReadWord	Total Storage time at High voltage	Hour	-	-	✓
0x4B	ReadWord	Total Storage time at High temp	Hour	-	-	✓
0x4C	ReadWord	Total Storage time at High voltage & High temp	Hour	-	-	✓

(continued)

Command	Protocol	Data	Unit	RAJ240045	RAJ240075 RAJ240080	RAJ240090/100
0x50	Read/WriteWord	AFE register Write		✓	✓	✓
0x51	Read/WriteWord	AFE register Read (Address set)		✓	✓	✓
0x52	ReadWord	AFE register Read(Data)		✓	✓	✓
0x57	Read/WriteWord	InitialCalibrationReference		✓	✓	✓
0x58	Read/WriteWord	InitialCalibration		✓	✓	✓
0x5a	WriteWord	SMBus boot jump		✓	✓	✓
0x5c	ReadWord	Number of cells	Number	✓	✓	✓
0x5d	WriteWord	Software Reset		✓	✓	✓
0x5e	WriteWord	Erase DataFlash		✓	✓	✓
0x5f	ReadWord	FirmwareVersion		✓	✓	✓
0x60	ReadWord	AD value of Cell 1		✓	✓	✓
0x61	ReadWord	AD value of Cell 2		✓	✓	✓
0x62	ReadWord	AD value of Cell 3		✓	✓	✓
0x63	ReadWord	AD value of Cell 4		✓	✓	✓
0x64	ReadWord	AD value of Cell 5		-	✓	✓
0x65	ReadWord	AD value of Cell 6		-	-	✓
0x66	ReadWord	AD value of Cell 7		-	-	✓
0x67	ReadWord	AD value of Cell 8		-	-	✓
0x68	ReadWord	AD value of Cell 9		-	-	✓
0x69	ReadWord	AD value of Cell 10		-	-	✓
0x71	ReadWord	AD value of AN0		✓	✓	✓
0x72	ReadWord	AD value of AN1		✓	✓	✓
0x73	ReadWord	AD value of PACK voltage		✓	✓	✓
0x74	ReadWord	AD value of MCU BG		-	-	✓
0x75	ReadWord	AD value of CREG2		-	-	✓
0x76	BlockRead	AD value of Current		✓	✓	✓

7.1 ExtraFunction (0x00)

Table 5 ExtraFunction

<table>
<tr><td>Command Code</td><td>0x00</td></tr>
<tr><td>Access</td><td>Read/Write Word</td></tr>
<tr><td>Unit</td><td></td></tr>
<tr><td>Description</td><td>Perform extended communication.
(1) Force PowerDown
Description: Force PowerDown mode and stop the MCU.
Procedure: Write the following data in continuous sequence.
<table>
<tr><td>Order</td><td>Data</td></tr>
<tr><td>1</td><td>0x2345</td></tr>
<tr><td>2</td><td>0x6789</td></tr>
</table>
Note: Both FET(C-FET,D-FET) are OFF.

(2) Force Sleep
Description: Force the MCU into sleep mode.
Procedure: Write the following data.
<table>
<tr><td>Data</td><td>Function</td></tr>
<tr><td>0x1234</td><td>Set the condition, forcing to sleep mode.</td></tr>
</table>
Release State: when any of the following conditions are detected.
- Slave address match
- SCLSDA interrupt
- PON interrupt
- |ExtendedCurrent() | > 250[mA]
Note: Only D-FET is ON during Force Sleep.

(3) FET test
Please refer section “7.1.1 FET test function”

(4) AD conversion in Initial calibration mode
Procedure: Write the following data to perform AD conversion during Initial calibration mode
<table>
<tr><td>Data</td></tr>
<tr><td>0x1237</td></tr>
</table>
After that, AD value can be read using AD value command (0x60 – 0x76).
Note: This command only valid during the initial calibration mode.</td></tr>
</table>

(5) Calibration skip in Initial calibration mode

Procedure: Write the following data to perform Calibration skip in only Initial calibration mode.

Data
0x1238

(6) Sleep mode current 1

Description: Force the MCU into sleep mode current 1.

Procedure: Write the following data.

Data	Function
0x1239	Set the condition, forcing to sleep mode.

Release State: when any of the following conditions are detected

- HardwareReset

- SoftwareReset command (0x5D), IC reset

Note: *This command only valid in RAJ24090/100.*

The consumption current of IC is 25uA(TYP.) in this mode.

(7) Sleep mode current 2

Description: Force the MCU into sleep mode current 2.

Procedure: Write the following data.

Data	Function
0x123A	Set the condition, forcing to sleep mode.

Release State: when any of the following conditions are detected

- HardwareReset

- SoftwareReset command (0x5D), IC reset

Note: *This command only valid in RAJ24090/100.*

The consumption current of IC is 50uA(TYP.) in this mode.

(8) Rewriting Flexible data

Description: battery control data and accumulated data is stored in Data Flash.

Procedure: Write the following data.

Data
0x123B

7.1.1 FET test function

Table 6 FET test function

<table>
<tr><td>Command Code</td><td>0x00</td></tr>
<tr><td>Access</td><td>Read/Write Word</td></tr>
<tr><td>Unit</td><td></td></tr>
<tr><td>Description</td><td>To control the mode transition of the FETs independently.
Procedure: Write the following data in sequence.
<table>
<tr><td>Order</td><td>Data</td><td>Remarks</td></tr>
<tr><td>1</td><td>0x1235</td><td>Turn off all FETs at this time.</td></tr>
<tr><td>2</td><td>0x**@@</td><td>@@ is FET control data.
Bit 0: D-FET (On=1, Off=0)
Bit 1: C-FET
Other Bits are reserved. (Must be set to 0.)
If the high byte is not 0xFF, the command is brushed off.</td></tr>
</table></td></tr>
</table>

After setting the FET control, the control is canceled when detecting either of the following condition

- 0x00 command is received and the data is 0x1236.

  Caution: FET Control could stop by other controls of ExtraFunction ()

  E.g) by SoftwareReset command (0x5D), IC reset

7.2 Temperature (0x08)

Table 7 Temperature

Command Code	0x08
Access	Read Word
Unit	0.1K
Description	Return the latest temperature value. ***Equation:*** Thermistor resistance = (B_TH25_AN0_REG * (ad_therm – tadvss)) / (tadvregpull – ad_therm) Where, B_TH25_AN0_REG : Data of AN0 Internal Pullup resister 25degC value ad_therm : AD value of AN0(Command(0x35)) tadvss : ADVSS AD value tadvregpull : VREG pullup AD value (AN0) ***Equation:*** Temperature = (((**THERM_TBL [**aidx**]** * 10) – Thermistor resistance) * 200) / ((**THERM_TBL [**aidx**]** * 10) – (**THERM_TBL [**aidx+1**]** * 10) + **ttempidx[**aidx**]** + tthoff) Where, Aidx : The number of elements of THERM_TBL when equal to or greater than Thermistor resistance. (Thermistor resistance >= THERM_TBL[aidx+1] * 10) tthoff : D_CALTHREF - D_CALTH D_CALTHREF : Calibration reference temperature value D_CALTH : Calibration temperature value

7.3 Voltage (0x09)

Table 8 Voltage

Command Code	0x09
Access	Read Word
Unit	mV
Description	Return the latest voltage value of battery pack. (Total voltage level of each cell)

7.4 Current (0x0A)

Table 9 Current

Command Code	0x0A
Access	Read Word
Unit	mA
Description	Return the latest current value. ***Equation:*** Current = ((D_0A – lcurr_ad) * D_CURRREF) / (D_CURR – D_0A) Where, D_0A : 0Acalibration value lcurr_ad : Command(0x76) D_CURRREF : Reference current value for initial calibration D_CURR : Discharge current counter value for initial calibration It looks upon the current value as 0mA if the value of absolute is **Mask current** or less.

7.5 RelativeStateOfCharge (0x0D)

Table 10 RelativeStateOfCharge

Command Code	0x0D
Access	Read Word
Unit	%
Description	Return remaining capacity percentage of the battery calculated based on FullChargeCapacity. ***Equation:*** RelativeStateOfCharge = RemainingCapacity / FullChargeCapacity * 100

7.6 RemainingCapacity (0x0F)

Table 11 RemainingCapacity

Command Code	0x0F
Access	Read Word
Unit	mAh
Description	Return remaining capacity of the battery. Refer to chapter “8. Remaining Capacity Control”.

7.7 FullChargeCapacity (0x10)

Table 12 FullChargeCapacity

Command Code	0x10
Access	Read Word
Unit	mAh
Description	Return full charge capacity of the battery. Initial value is INIT_FCC. This value is not updated.

7.8 ChargingCurrent (0x14)

Table 13 ChargingCurrent

Command Code	0x14
Access	Read Word
Unit	mA
Description	Return required charge current. When charging is permitted, this value is **ChargingCurrent** or **ChargingCurrent at Charge Wait**.

7.9 ChargingVoltage (0x15)

Table 14 ChargingVoltage

Command Code	0x15
Access	Read Word
Unit	mV
Description	Return required charge voltage. When charging is permitted, this value is **ChargingVoltage * Series number of cells**.

7.10 BatteryStatus (0x16)

Table 15 BatteryStatus

Command Code	0x16
Access	Read Word
Unit	bit
Description	Return Flag state of the battery. The description for each bit as shown in the following table.

Bit	Name	Set when	Cleared when
7-15	Reserved		
6	OVER_TEMP_ALARM	Abnormal temperature condition is detected	Returning to normal temperature condition
5	OVER_DISCHARGE_CURRENT_ALARM	Over discharge current is detected	Charging state
4	OVER_CHARGE_CURRENT_ALARM	Over charge current is detected	Discharging state
3	SHORT_CURRENT_ALARM	Short circuit is detected	Charging state
2	DISCHARGING	Discharging state	Stop discharging
1	FULLY_CHARGED	At full charge.	Discharging state
0	FULLY_DISCHARGED	Min V≤ **0% voltage**	Charging state

7.11 Control Flag Status (0x1F)

Table 16 Control Flag Status

Command Code	0x1F		
Access	Read Word		
Unit	-		
Description	Return Control Flag Status as follows.		
	Bit	Name	Description
	0	2NDTHERM	1(ON):Use, 0(OFF):Not use
	1	CELLBALANC	1(ON):Use, 0(OFF):Not use
	2	INITCALIB1P	1(ON):Use, 0(OFF):Not use
	3	INITCAP	1(ON):Use, 0(OFF):Not use
	4	F_SYSCONEN	1(ON):Use, 0(OFF):Not use
	5-15	-	Reserved

7.12 DeviceName (0x21)

Table 17 DeviceName

Command Code	0x21
Access	BlockRead
Unit	String
Description	Product name of battery pack. This data is Device Name of Fixed data.

7.13 ExtendedCurrent (0x24)

Table 18 DeviceName

Command Code	0x24
Access	BlockRead
Unit	mA
Description	The latest current value(4byte). It looks upon the current value as 0mA if the value of absolute is **Mask current** or less. ***Note***: This current value used for mode transition and capacity calculation.

7.14 ChipTemperature (0x25)

Table 19 ChipTemperature

Command Code	0x25
Access	Read Word
Unit	0.1K
Description	Return chip temperature using on-chip simplified temperature sensor.

7.15 Voltage of Cell (0x30-0x39)

Table 20 Voltage of Cell

<table>
<tr><td>Command Code</td><td>0x30-0x39</td></tr>
<tr><td>Access</td><td>Read Word</td></tr>
<tr><td>Unit</td><td>mV</td></tr>
<tr><td>Description</td><td>Return the latest Voltage of cell 1-10.
<table>
<tr><td>Data</td><td>Remarks</td></tr>
<tr><td>0x30</td><td>Voltage of Cell 1(Bottom last cell)</td></tr>
<tr><td>0x31</td><td>Voltage of Cell 2</td></tr>
<tr><td>0x32</td><td>Voltage of Cell 3</td></tr>
<tr><td>0x33</td><td>Voltage of Cell 4</td></tr>
<tr><td>0x34</td><td>Voltage of Cell 5</td></tr>
<tr><td>0x35</td><td>Voltage of Cell 6</td></tr>
<tr><td>0x36</td><td>Voltage of Cell 7</td></tr>
<tr><td>0x37</td><td>Voltage of Cell 8</td></tr>
<tr><td>0x38</td><td>Voltage of Cell 9</td></tr>
<tr><td>0x39</td><td>Voltage of Cell 10 (Top 1st cell)</td></tr>
</table>
Equation:
(<u>F_CALIB1P</u> : 0(OFF))
Voltage of Cell
= ((tad – D_LV[acell]) * (D_HVREF[acell] – D_LVREF[acell]) / (D_HV[acell] – D_LV[acell]) + D_LVREF[acell])

(<u>F_CALIB1P</u> : 1(ON))
Voltage of Cell
= tad * D_HVREF[acell] / D_HV[acell]

Where,
tad : Command(0x60-0x69)
acell : Cell series count
D_LV[] : Calibration AD value(Low side of Cell)
D_HV[] : Calibration AD value(High side of Cell)
D_LVREF[] : Calibration reference voltage value(Low side of Cell)
D_HVREF[] : Calibration reference voltage value(High side of Cell)

Note: Unsupported fixed value (0x00) data.
RAJ240045: does not support command from 0x34 to 0x39.
RAJ240075: does not support command from 0x35 to 0x39
RAJ240080: does not support command from 0x35 to 0x39.</td></tr>
</table>

7.16 OperationStatus (0x41)

Table 21 Operation Status

<table>
<tr><td>Command Code</td><td>0x41</td></tr>
<tr><td>Access</td><td>Read Word</td></tr>
<tr><td>Unit</td><td>-</td></tr>
<tr><td>Description</td><td>Return the Mode number.
Relation between mode number and mode name is below.
<table>
<tr><th>Mode number</th><th>Mode name</th></tr>
<tr><td>0x0000</td><td>Init</td></tr>
<tr><td>0x0001</td><td>WakeUp</td></tr>
<tr><td>0x0002</td><td>Discharging</td></tr>
<tr><td>0x0003</td><td>Charging</td></tr>
<tr><td>0x0005</td><td>Charge Terminate</td></tr>
<tr><td>0x0006</td><td>Charge Wait</td></tr>
<tr><td>0x0010</td><td>Charge Over Heat</td></tr>
<tr><td>0x0011</td><td>Discharge Over Heat</td></tr>
<tr><td>0x0012</td><td>Over Charge Current</td></tr>
<tr><td>0x0013</td><td>Over Discharge Current</td></tr>
<tr><td>0x0014</td><td>Short Current</td></tr>
<tr><td>0x0015</td><td>Over Voltage</td></tr>
<tr><td>0x0016</td><td>2nd Th Over Heat</td></tr>
<tr><td>0x001E</td><td>Power Down</td></tr>
<tr><td>0x0020</td><td>Initial calibration</td></tr>
<tr><td>0x0099</td><td>Fixed Data Error</td></tr>
</table></td></tr>
</table>

7.17 Total Cell Voltage (0x42)

Table 22 Total Cell Voltage

Command Code	0x42
Access	Read Word
Unit	mV
Description	Return the latest Total Cell voltage. ***Equation:*** (**F_CALIB1P** : 0(OFF)) Total Cell voltage = (((tad - D_TCLV) * trefhl_vin12) / thlvin12) + D_V12LVREF (**F_CALIB1P** : 1(ON)) Total Cell voltage = tad * D_TCHVREF / D_TCHV Where, tad : AD value D_TCLV : Calibration AD value(Low side of Total Cell voltage) D_TCHV : Calibration AD value(High side of Total Cell voltage) trefhl_tcv : D_TCHVREF - D_TCLVREF D_TCLVREF : Calibration reference voltage value (Low side of Total Cell voltage) D_TCHVREF : Calibration reference voltage value(High side of Total Cell voltage) thltcv : D_TCHV - D_TCLV ***Note:*** Only RAJ240090/100 supports this function. ***Precaution:*** List of unsupported devices 1) RAJ240045 2) RAJ240075 3) RAJ240080

7.18 PACKVoltage (0x43)

Table 23 PACKVoltage

Command Code	0x43
Access	Read Word
Unit	mV
Description	Return the latest PACK voltage. ***Equation:*** (**F_CALIB1P** : 0(OFF)) PACK voltage = (((tad - D_PACKLV) * trefhl_packv) / thlpackv) + D_PACKLVREF (**F_CALIB1P** : 1(ON)) PACK voltage = tad * D_PACKHVREF / D_PACKHV Where, tad : Command(0x73) – AD value of PACK voltage D_PACKLV : Calibration AD value(Low side of PACK voltage) D_PACKHV : Calibration AD value(High side of PACK voltage) trefhl_packv : D_PACKHVREF - D_PACKLVREF D_PACKLVREF : Calibration reference voltage value(Low side of PACK voltage) D_PACKHVREF : Calibration reference voltage value(High side of PACK voltage) thlpackv : D_PACKHV - D_PACKLV

7.19 2nd Thermistor (0x44)

Table 24 2nd Thermistor

Command Code	0x44
Access	ReadWord
Unit	0.1K
Description	Return the latest temperature value. ***Equation:*** Thermistor resistance = (B_TH25_AN1_REG * (ad_therm – tadvss)) / (tadvregpull – ad_therm) Where, B_TH25_AN0_REG : Data of AN1 Internal Pullup resister 25degC value ad_therm : AD value of AN1(Command(0x72)) tadvss : ADVSS AD value tadvregpull : VREG pullup AD value (AN1) Temperature = (((**THERM_TBL [**aidx**]** * 10) – Thermistor resistance) * 200) / ((**THERM_TBL [**aidx**]** * 10) – (**THERM_TBL [**aidx+1**]** * 10) + **ttempidx[**aidx**]** + tthoff) Where, aidx : The number of elements of THERM_TBL when equal to or greater than Thermistor resistance. (Thermistor resistance >= THERM_TBL[aidx+1] * 10) tthoff : D_CALTHREF - D_CALTH D_CALTHREF : Calibration reference temperature value D_CALTH : Calibration temperature value

Note. Tthoff value is the same as Temperature (0x08)

7.20 PackStatus (0x45)

Table 25 PackStatus

<table>
<tr><td>Command Code</td><td>0x45</td></tr>
<tr><td>Access</td><td>Read Word</td></tr>
<tr><td>Unit</td><td>Bit</td></tr>
<tr><td>Description</td><td>
<table>
<tr><th>Bit</th><th>Name</th><th>Description</th></tr>
<tr><td>0</td><td>DFET</td><td>Condition of D-FET. (0=OFF, 1=ON)</td></tr>
<tr><td>1</td><td>CFET</td><td>Condition of C-FET. (0=OFF, 1=ON)</td></tr>
<tr><td>2</td><td>SYS</td><td>Current SYS-connect status(0 = Disconnect, 1= Connect)
When SYS- connect enable flag = 0, Always 1</td></tr>
<tr><td>3</td><td>CP</td><td>Detecting condition of CP. (0=Not detect, 1=Detect)
Clear condition: During charging, RelativeStateOfCharge(0x0D) value is more than Capacity correction point level</td></tr>
<tr><td>4-15</td><td></td><td>Reserved</td></tr>
</table>
Precaution: RAJ2400075 does not support SYS function.

Note : The SYS function of each IC is assigned to the following pins.
1) RAJ240045 : SYSIN pin
2) RAJ240080 : SYSIN pin
3) RAJ240090/100 : HVP0 pin
4) RAJ240075 : NO assigned pin
</td></tr>
</table>

7.21 CellBalancingStatus (0x46)

Table 26 CellBalancingStatus

<table>
<tr><td>Command Code</td><td>0x46</td></tr>
<tr><td>Access</td><td>Read Word</td></tr>
<tr><td>Unit</td><td>Bit</td></tr>
<tr><td>Description</td><td>
<table>
<tr><th>Bit</th><th>Name</th><th>Description</th></tr>
<tr><td>0</td><td>CB1</td><td>Cell balancing in CELL 1(0=OFF, 1=ON)</td></tr>
<tr><td>1</td><td>CB2</td><td>Cell balancing in CELL 2(0=OFF, 1=ON)</td></tr>
<tr><td>2</td><td>CB3</td><td>Cell balancing in CELL 3(0=OFF, 1=ON)</td></tr>
<tr><td>3</td><td>CB4</td><td>Cell balancing in CELL 4(0=OFF, 1=ON)</td></tr>
<tr><td>4</td><td>CB5</td><td>Cell balancing in CELL 5(0=OFF, 1=ON)</td></tr>
<tr><td>5</td><td>CB6</td><td>Cell balancing in CELL 6(0=OFF, 1=ON)</td></tr>
<tr><td>6</td><td>CB7</td><td>Cell balancing in CELL 7(0=OFF, 1=ON)</td></tr>
<tr><td>7</td><td>CB8</td><td>Cell balancing in CELL 8(0=OFF, 1=ON)</td></tr>
<tr><td>8</td><td>CB9</td><td>Cell balancing in CELL 9(0=OFF, 1=ON)</td></tr>
<tr><td>9</td><td>CB10</td><td>Cell balancing in CELL 10(0=OFF, 1=ON)</td></tr>
<tr><td>10-15</td><td></td><td>Reserved</td></tr>
</table>
The function is enabled when <u>Cell balancing enable</u> = 1.
Then start discharging cell that satisfies the following condition by using AFE function.
• (cell voltage – minimum cell voltage) ≥ <u>Cell balancing ON voltage</u>
• max cell voltage < <u>Cell balancing enable voltage(H)</u>
• min cell voltage ≥ <u>Cell balancing enable voltage(L)</u>
• No load or Charging

The discharging continues until detecting either of the following conditions.
• (cell voltage – minimum cell voltage) < <u>Cell balancing OFF voltage</u>
• max cell voltage ≥ <u>Cell balancing enable voltage(H)</u>
• min cell voltage < <u>Cell balancing enable voltage(L)</u>
• Discharging
</td></tr>
</table>

7.22 Battery Impedance (0x47)

Command Code	0x47
Access	Read Word
Unit	0.1 mOhm
Description	Report worst Battery Impedance. Initial value is **<u>Initial Battery Impedance</u>**. Refer to section “9 Impedance calculation” for more details.

7.23 BatteryUsageCondition(0x48-0x4C)

Table 27 BatteryUsageCondition

<table>
<tr><td>Command Code</td><td>0x48-0x4C</td></tr>
<tr><td>Access</td><td>ReadWord</td></tr>
<tr><td>Unit</td><td>Binary</td></tr>
<tr><td>Description</td><td>Return the following parameters.
<table>
<tr><th>Command</th><th>Parameters</th><th>Range</th><th>Unit</th></tr>
<tr><td>0x48</td><td>Total charged capacity</td><td>0-65535</td><td>Ah</td></tr>
<tr><td>0x49</td><td>Total storage time</td><td>0-65535</td><td>Hour</td></tr>
<tr><td>0x4A</td><td>Storage time of cell voltage
≥ <u>ChargingVoltage per cell</u> – <u>Storage delta V</u></td><td>0-65535</td><td>Hour</td></tr>
<tr><td>0x4B</td><td>Storage time of 1st temperature ≥ <u>Storage temp</u></td><td>0-65535</td><td>Hour</td></tr>
<tr><td>0x4C</td><td>Storage time of cell voltage
≥ <u>ChargingVoltage per cell</u> – <u>Storage delta V</u>
& 1st temperature ≥ <u>Storage temp</u></td><td>0-65535</td><td>Hour</td></tr>
</table>
</td></tr>
</table>

7.24 AFE register Write (0x50)

Table 28 AFE register Write

<table>
<tr><td>Command Code</td><td>0x50</td></tr>
<tr><td>Access</td><td>Read Word / Write Word</td></tr>
<tr><td>Unit</td><td>-</td></tr>
<tr><td>Description</td><td>Write a data to specified AFE register. Followings are Write protocol.
<table>
<tr><td>Data</td><td>Cmd</td><td>Protocol</td><td>Remarks</td></tr>
<tr><td>0xYYXX</td><td>0x51</td><td>Write Word</td><td>XX: AFE register address (1byte).
YY: Write Data (1byte).</td></tr>
</table>
Can use to read the previous written data value.</td></tr>
</table>

7.25 AFE register Read (Address set) (0x51)

Table 29 AFE register Read (Address set)

<table>
<tr><td>Command Code</td><td>0x51</td></tr>
<tr><td>Access</td><td>Read Word / Write Word</td></tr>
<tr><td>Unit</td><td>-</td></tr>
<tr><td>Description</td><td>Read specified AFE register data. Followings are the Read protocol.
<table>
<tr><td>Order</td><td>Cmd</td><td>Data</td><td>Protocol</td><td>Remarks</td></tr>
<tr><td>1</td><td>0x51</td><td>0x00XX</td><td>Write Word</td><td>XX: AFE register address (1byte).</td></tr>
<tr><td>2</td><td>0x52</td><td>0x00ZZ</td><td>Read Word</td><td>ZZ: Read data (1byte)</td></tr>
</table>
After sending above data, set the value to 0x52 command data.
This data can be read by using AFE register Read command (0x52).
Read the previous written value.</td></tr>
</table>

7.26 AFE register Read (Data) (0x52)

Table 30 AFE register Read (Data)

<table>
<tr><td>Command Code</td><td>0x52</td></tr>
<tr><td>Access</td><td>Read Word</td></tr>
<tr><td>Unit</td><td>-</td></tr>
<tr><td>Description</td><td>Read AFE register value.
Refer to section “7.15. AFE register Read (Address)”.</td></tr>
</table>

7.27 InitialCalibrationReferense (0x57)

Table 31 InitialCalibrationReference

Command Code	0x57
Access	Read Word / Write Word
Unit	-
Description	Write / Read the calibration reference value of a specified item. Refer to chapter “10. Initial calibration”.

7.28 InitialCalibration (0x58)

Table 32 InitialCalibration

Command Code	0x58
Access	Read Word / Write Word
Unit	-
Description	Execute the initial calibration of a specified item. Refer to chapter “10. Initial calibration”.

7.29 SMBusbootjump (0x5A)

Table 33 SMBus boot jump

Command Code	0x5A
Access	Write Word
Unit	-
Description	Jump to the start address of the SMBus boot program. Sample code jumps to SMBus boot program by executing this command. Command format as follows. Data 0x2345 ***Note***: SMBus boot program can be FlashWrite by using I2C.

7.30 Number of cells (0x5C)

Table 34 Number of cells

Command Code	0x5C
Access	Read Word
Unit	-
Description	Return the number of CELL in series. This is configurable by modifying the parameter of the CELL series number in the Fixed Data.

7.31 SoftwareReset (0x5D)

Table 35 SoftwareReset

Command Code	0x5D
Access	Write Word
Unit	-
Description	Force the MCU to make software reset by executing illegal instruction. Sample code perform SoftwareReset by executing this command. Command format as follows. Data: 0x5678

7.32 Erase DataFlash (0x5E)

Table 36 Erase DataFlash

Command Code	0x5E
Access	Write Word
Unit	-
Description	Force the MCU to erases the data in Data flash memory block0, 1 or block 2. Data flash memory block 0 and block 1 are the flexible data area, and block 2 is the initial calibration value data area. Sample code perform FlashErase by executing the following command. Command format as follows. (1) Erase the flexible data area (block 0 and block 1)Data: 0xABCD (2) Erase the own data area (block 2) Data: 0x1234

7.33 FirmwareVersion (0x5F)

Table 37 FirmwareVersion

Command Code	0x5F
Access	Read Word
Unit	-
Description	Return the firmware version. Data: 0xXY Notes: X: Major version (1byte) Y: Minor version (1byte)

7.34 AD value (0x60-0x76)

Table 38 AD value (0x60-0x76)

Command Code	0x60-0x76
Access	Read Word/BlockRead
Unit	-
Description	Return the latest AD value. 0x76 Current protocol is BlockRead. The others are ReadWord.

Data	Remarks
0x60	Cell 1
0x61	Cell 2
0x62	Cell 3
0x63	Cell 4
0x64	Cell 5
0x65	Cell 6
0x66	Cell 7
0x67	Cell 8
0x68	Cell 9
0x69	Cell 10
0x71	AN0
0x73	PACK
0x74	MCU BG
0x75	CREG2
0x76	Current

Note: 1. Unmeasured data is the fixed value (0x00).

2. While in calibration mode, read the latest AD value by using ExtraFunction (0x00).

   Refer to section “7.1 ExtraFunction (0x00)” for more details.

3. Unsupported AD Value

   RAJ240045: unsupported value from 0x64 to 0x 69, 0x74 and 0x75.

   RAJ240075: unsupported value from 0x65 to 0x 69, 0x74 and 0x75.

   RAJ240080: unsupported value from 0x65 to 0x 69, 0x74 and 0x75.

7.35 CheckSUMofFW(0x78)

Table 39 CheckSUMofFW (0x78)

Command Code	0x78
Access	Read Word
Unit	-
Description	CheckSUM of sample code. It is the additional value of Firmware block by WORD unit.

7.36 CheckSUMofFixedData(0x79)

Table 40 CheckSUMofFixedData(0x79)

Command Code	0x79
Access	Read Word
Unit	-
Description	CheckSUM of Fixed data. It is the additional value of Firmware block by WORD unit.

8. Remaining Capacity Control

8.1 Initial capacity calculation

FullChargeCapacity, RemainingCapacity, RelativeStateOfCharge are calculated by following method when firmware starts from reset.

Table 41 Calculation method of initial capacity at each configuration

DF read enable flag (**Control flag 1** Bit7)	Flexible data	**InitCap table using flag** (**Control flag 1** Bit 3)	Calculation method
0	Do not care	0	FullChargeCapacity = **Initial FullChargeCapacity**
			RemainingCapacity = **Initial FullChargeCapacity** x **Initial RelativeStateOfCharge**
			RelativeStateOfCharge = **Initial FullChargeCapacity**
		1	FullChargeCapacity = **Initial FullChargeCapacity**
			RemainingCapacity = **Initial FullChargeCapacity** x calculated initial capacity / 100
			RelativeStateOfCharge = RemainingCapacity / **Initial FullChargeCapacity**
1	Recorded	Do not care	Use FullChargeCapacity value of Flexible data
	Not recorded	0	Same as when DF read enable flag = 0 & **InitCap table using flag** = 0
		1	Same as when DF read enable flag = 0 & **InitCap table using flag** = 1

Table 42 Initial capacity table

Min cell voltage	**Initial Voltage 0**	**Initial Voltage 1**	**Initial Voltage 2**	**Initial Voltage 3**	**Initial Voltage 4**	**Initial Voltage 5**
Initial Capacity	**Initial Capacity 0**	**Initial Capacity 1**	**Initial Capacity 2**	**Initial Capacity 3**	**Initial Capacity 4**	**Initial Capacity 5**

When minimum cell voltage is within from **Initial Voltage 0** to **Initial Voltage 5**, Initial Capacity is calculated by linear interpolation.
If minimum cell voltage is lower than **Initial Voltage 0**, RemainingCapacity() is set to 0. And if minimum cell voltage is higher than **Initial Voltage 5**, RemainingCapacity() is set to 99% of FullChargeCapacity().

8.2 Capacity calculation method

Remaining capacity calculation is as follows.

RemainingCapacity [mAh] = RemainingCapacity[mAh] ±

current [mA] [*2] / (60[min] * 60[sec] * (1000[msec] / 250[msec]))[hour]

RemainingCapacity never reaches a value that is larger than **FullChargeCapacity**.

When the voltage level of the cell which has the lowest voltage level drop is less than **Capacity correction point voltage** 8 times[*1] continuously while discharging, the Capacity correction point flag is set.

When RelativeStateOfCharge is higher than **Capacity correction point level** while charging, the Capacity correction point flag is clear.

When Capacity correction point flag is set, the RemainingCapacity is set as "**FullChargeCapacity** * **Capacity correction point level"** if RelativeStateOfCharge is more than **Capacity correction point level**.

In the condition where Capacity correction point flag is not set, RemainingCapacity does not reduce lower than "**FullChargeCapacity** * **Capacity correction point level"**.

After Capacity correction point flag is set, if the voltage level of the cell which has the lowest voltage level becomes less than **0% voltage** 8 times[*1] continuously while discharging, the capacity is considered as 0%, and Remaining capacity will turn to 0%.

Note: Descriptions written in bold and underline are constants.

Refer to Section "12. Fixed data list" for more details.

*1: Data is check for every current detection cycle. (250ms)

*2: This value is *ExtendedCurrent()* value.

8.3 Relearning when charging

(1) It starts capacity integration for charge relearning when 0% voltage is detected.

(2) When the full charge is detected without detecting the (3) state from (1) state,

processing is done as described below.

- FullChargeCapacity() ← Relearn capacity
- RelativeStateOfCharge() ← 100%

(3) It stops to relearn if it detects the following state.

- Detect the discharge or charge stops.
- Detect the wrong state as below.
  - Short current by H/W
  - Discharge over current by H/W
  - Charge over current by H/W
  - Charge over current by F/W
  - Over voltage
  - Charge over heat
  - Discharge over heat
  - 2th thermistor over heat

8.4 FCC update limit

Full charge capacity(FCC) updating is limited as follows,

-New FCC is (Previous FCC * 0.7) when New FCC is lower than Previous FCC * 0.7.

- There is no upper limit. Remaining Capacity does not exceed FCC until full charge detection.

After full charge detection, Remaining Capacity becomes New FCC value.

9. Impedance calculation

This function is enabled when **IMP calc enable flag** on **Control flag** = 1.
Battery Impedance (0x47) will be calculated once at NORMAL state. Initial value is **INIT_IMP**.

- Battery was fully discharged before charging.
- RSOC is increasing and achieved **RSOC IMP**
- **IMP Temp L** ≤ Temperature() ≤ **IMP_Temp_H**
- |Current()| ≥ **IMP_CURR** for 10sec or more

Battery Impedance calculation process is as follows.

(1) Measure each cell voltage() and Current() (hereafter C1) by main cycle.
Min cell voltage is used as V1 and record its cell number.
(2) Turn off C-FET, and wait for 1sec.
(3) Select cell index same as procedure (1) and measure its cell voltage, then set it as V2.
(4) Calculate Battery Impedance as below
Battery Impedance [0.1mOhm] = ((V1 – V2) / C1) x 10000
(5) Turn on C-FET.

Notice: This calculation will stop C-FET intentionally. Before using this function, be sure to consider system level impact on your side.

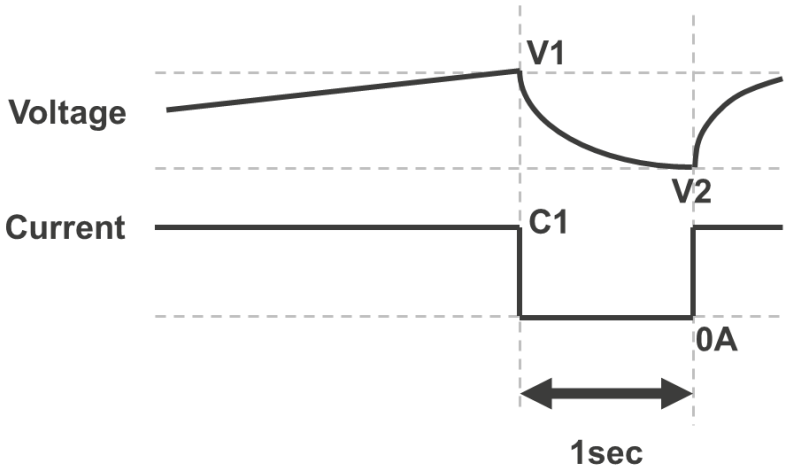
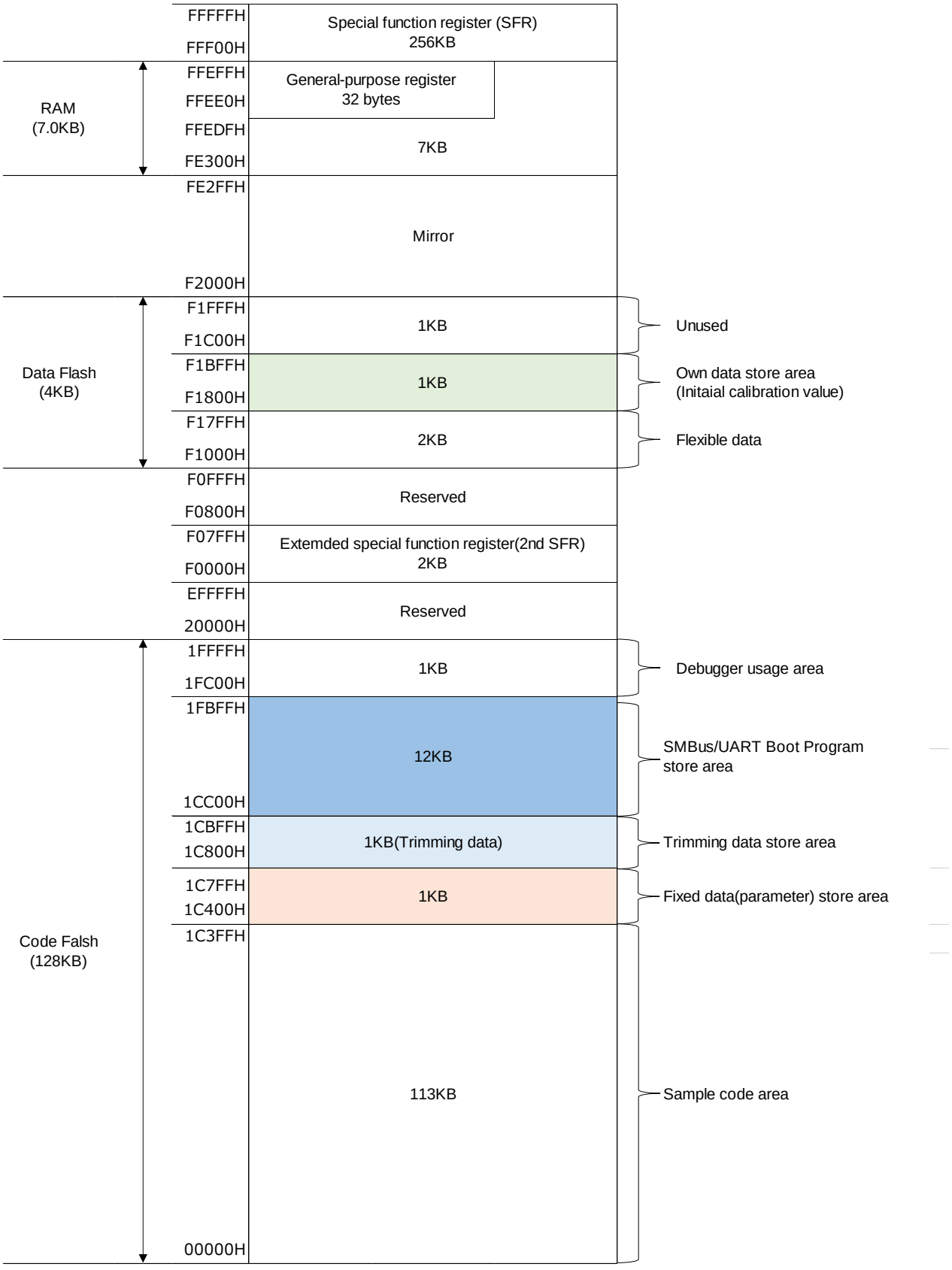


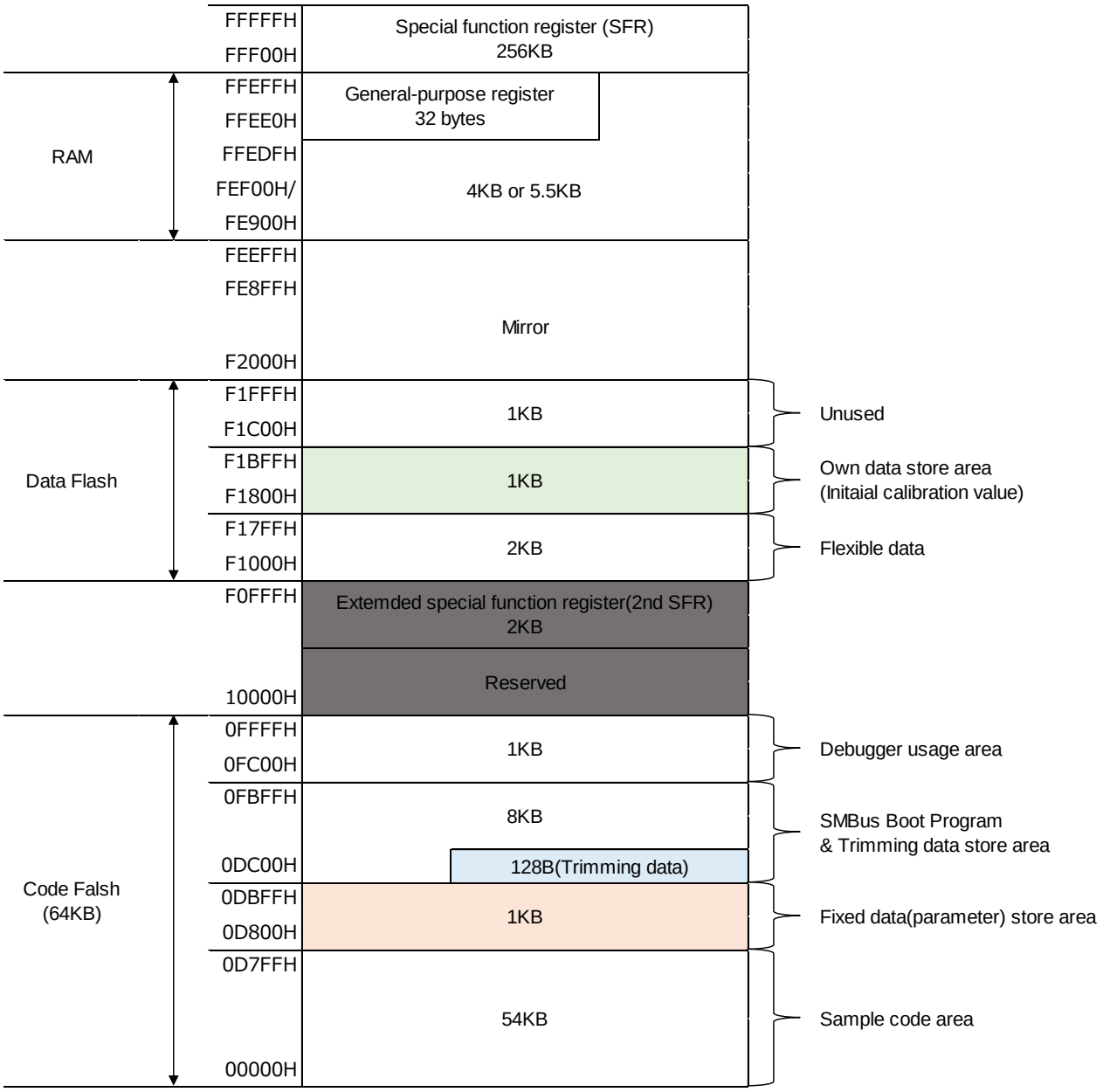
Figure 1 Voltage and Current transition during Impedance measurement

10. Memory map



RAJ240090/100(ROM 128KB RAM 7.0KB)

RAJ240045/75/80(ROM 64KB RAM 4.0KB/5.5KB)



11. Initial calibration

This system needs to perform initial calibration for precision voltage, and current measurement.

The transition condition of the initial calibration mode is as follows.

- Any one of the calibration data stored in DataFlash is 0xFFFF (except for Temperature).

Renesas will perform Initial calibration before the sample being ship to customer.

Precaution:

To ensure precision in voltage and current measurement, please perform Initial calibration whenever the evaluation board is changed. For more details, please refer to Section 10.1.

Note: 1. The skip command can be used to skip the initial calibration mode.

2. The sample code is using default value in FlashROM to perform initial calibration.

11.1 Calibration operation procedure

Table 35 below defined the initial calibration command, with command protocol (0x58, 0x57) as WriteWord.

Precaution 1) RAJ240090/100 supports all of data

2) RAJ240045, RAJ240080 does not support some of Data. (Refer to Table 43 below)

Note: The state will switch to reset waiting after the initial calibration.

Table 43 Initial calibration executing command (Write Data)

Command	Data	Function	RAJ240045	RAJ240075 RAJ240080	RAJ240090/100
0x58	0x0100	Low side of Cell 1	✓	✓	✓
	0x0101	Low side of Cell 2	✓	✓	✓
	0x0102	Low side of Cell 3	✓	✓	✓
	0x0103	Low side of Cell 4	✓	✓	✓
	0x0104	Low side of Cell 5	-	✓	✓
	0x0105	Low side of Cell 6	-	-	✓
	0x0106	Low side of Cell 7	-	-	✓
	0x0107	Low side of Cell 8	-	-	✓
	0x0108	Low side of Cell 9	-	-	✓
	0x0109	Low side of Cell 10	-	-	✓
	0x010a	Low side of Pack voltage	✓	✓	✓
	0x010b	High side of Pack voltage	✓	✓	✓
	0x010c	Low side of Cell 1 - Cell 10	✓	✓	✓
	0x010d	High side of Cell 1 - Cell 10	✓	✓	✓
	0x010e	Current 0A	✓	✓	✓
	0x010f	Discharge current	✓	✓	✓
	0x0110	Temperature	✓	✓	✓
	0x0120	High side of Cell 1	✓	✓	✓
	0x0121	High side of Cell 2	✓	✓	✓
	0x0122	High side of Cell 3	✓	✓	✓
	0x0123	High side of Cell 4	✓	✓	✓
	0x0124	High side of Cell 5	-	✓	✓
	0x0125	High side of Cell 6	-	-	✓
	0x0126	High side of Cell 7	-	-	✓
	0x0127	High side of Cell 8	-	-	✓
	0x0128	High side of Cell 9	-	-	✓
	0x0129	High side of Cell 10	-	-	✓
	0x012a	MCU BG	-	-	✓
	0x012b	CREG2	-	-	✓
	0x012c	Low side of TotalCellVoltage	-	-	✓
	0x012d	High side of TotalCellVoltage	-	-	✓

Note: 1. Initial calibration of the “Low side Cell” is executed either by command “0x0100-0x0109” or “0x010c”.

2. Initial calibration of the “High side Cell” is executed either by command “0x0120-0x0129”or “0x010d”.

3. The sample code has two options for voltage calibration:
   1. 1-point calibration: Simple yet with good accuracy.
   2. 2-point calibration: More complex, but better accuracy compares to 1 point calibration.

4. 2-point calibration uses Low and High, 2 voltage point to improve the accuracy. The voltage and current is calculated by using the value obtained during calibration mode.

Refer to Section “7.12. Voltage of Cell” and “7.4. Current” for the calculation equation.

The Calibration status can be confirmed by executing the initial calibration command (0x58).

The High byte is defined in Table 36 and Table 37 below.

Table 44 Initial calibration executing command(Read Data)

Command	Data	Function
0x58	0x01**	Now calibrating
	0x08**	Calibration completed
	0x04**	Calibration failed

Table 45 Initial calibration reference value setting command

Command	Function (Reference value)	Unit	Recommended value	RAJ240045	RAJ240075 RAJ240080	RAJ240090/100
0x57	Low side of Cell 1	mV	2500	✓	✓	✓
	Low side of Cell 2		2500	✓	✓	✓
	Low side of Cell 3		2500	✓	✓	✓
	Low side of Cell 4		2500	✓	✓	✓
	Low side of Cell 5		2500	-	✓	✓
	Low side of Cell 6		2500	-	-	✓
	Low side of Cell 7		2500	-	-	✓
	Low side of Cell 8		2500	-	-	✓
	Low side of Cell 9		2500	-	-	✓
	Low side of Cell 10		2500	-	-	✓
	Low side of PACK		2500***D_SERIES**	✓	✓	✓
	High side of PACK		4200***D_SERIES**	✓	✓	✓
	Low side of Cell 1 - Cell 10		2500	✓	✓	✓
	High side of Cell 1 - Cell 10		4200	✓	✓	✓
	Discharge current	mA	1000	✓	✓	✓
	Temperature	0.1K	2980	✓	✓	✓
	High side of Cell 1	mV	4200	✓	✓	✓
	High side of Cell 2		4200	✓	✓	✓
	High side of Cell 3		4200	✓	✓	✓
	High side of Cell 4		4200	✓	✓	✓
	High side of Cell 5		4200	-	✓	✓
	High side of Cell 6		4200	-	-	✓
	High side of Cell 7		4200	-	-	✓
	High side of Cell 8		4200	-	-	✓
	High side of Cell 9		4200	-	-	✓
	High side of Cell 10		4200	-	-	✓
	Low side of TotalCellVoltage		2500***D_SERIES**	-	-	✓
	High side of TotalCellVoltage		4200***D_SERIES**	-	-	✓

After receiving the command, initial calibration will start and data is stored to DataFlash.

Upon receiving 0x58 command, the sample code will need corresponding 0x58 command follow by 0x57 command.

Note: 1. Upon receiving the 0x5E command, the sample code will erase the initial calibration value.
2. During the Normal Operation, the program will use the value read after the reset start.
3. In order to recalibrate, it is necessary to perform SoftwareReset or Hardware Reset. Refer to “Figure3, 4, and 5” for further details.

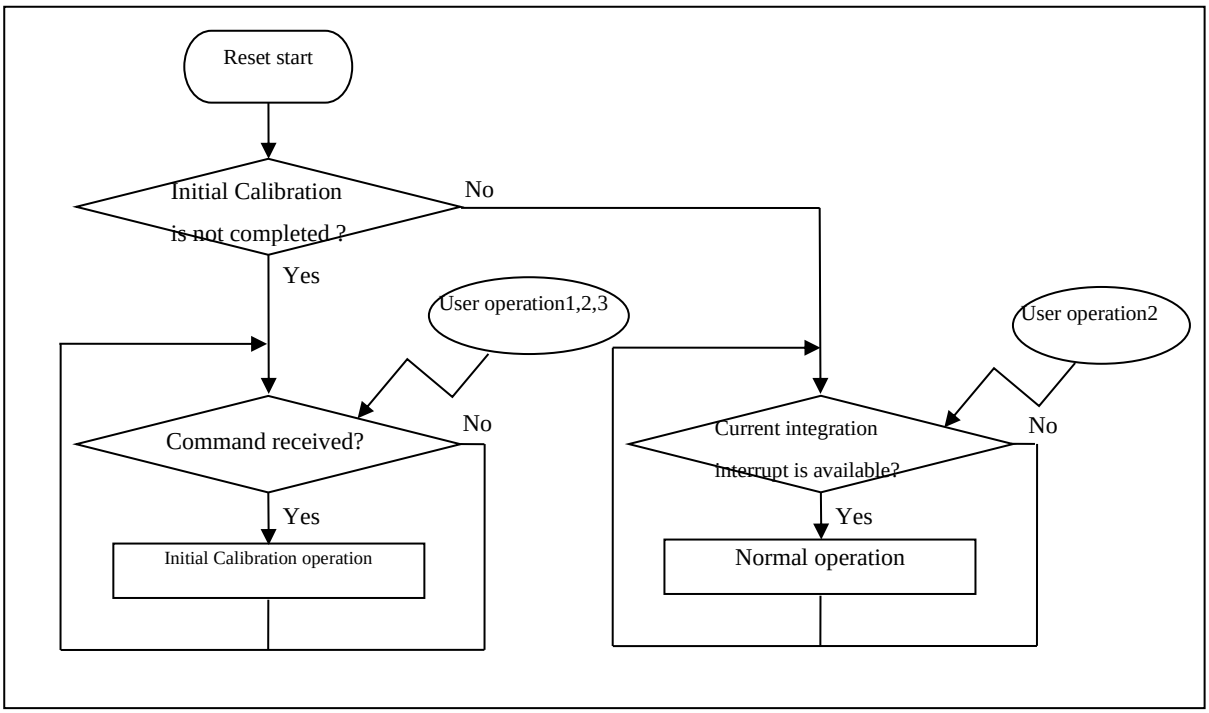


Figure 3. General flow chart with User operations

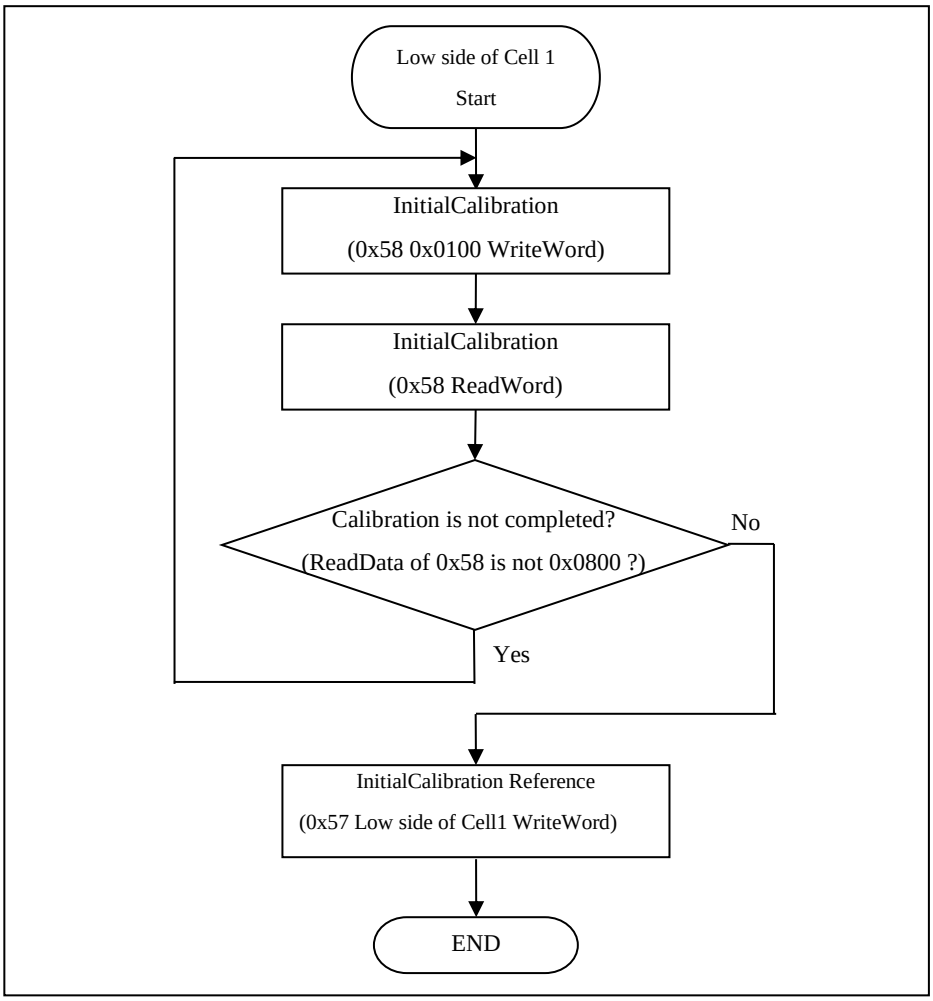


Figure 4. User operation1 (e.g. Low side of Cell 1 of Initial Calibration)

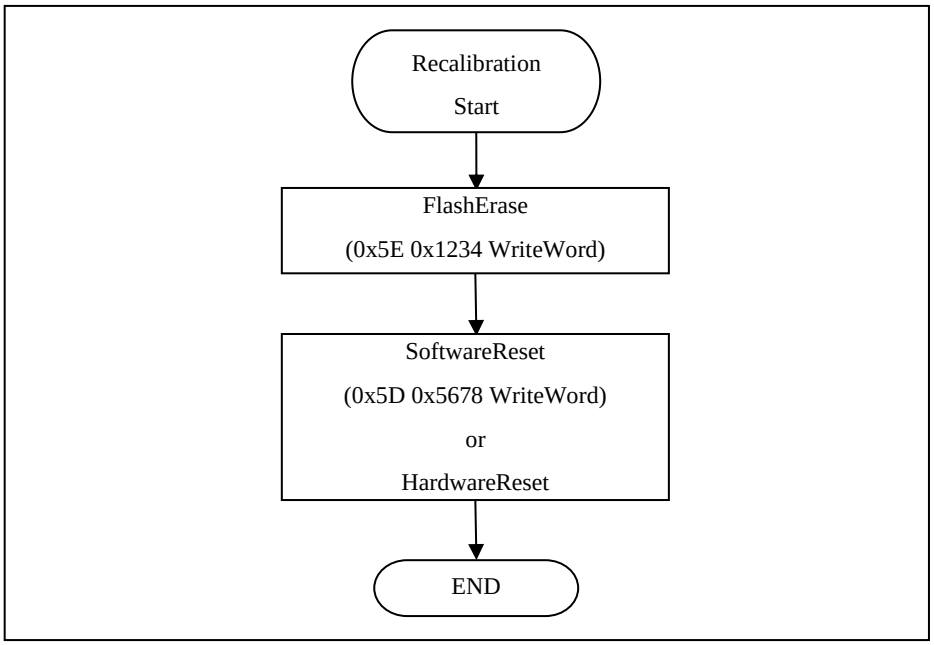
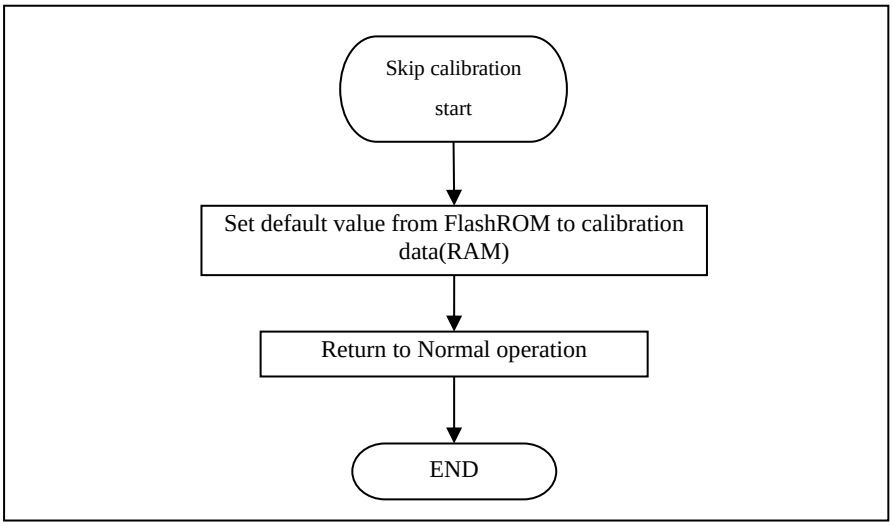


Figure 5. User operation2 (Recalibration)

Figure 6. User operation3 (Skip calibration)



The DataFlash map for initial calibration is refer to Table 46.

11.2 Initial Calibration by 1 Point

The voltage calibration point can be reduced by setting **F_CALIB1P**.

Under 1 point calibration method, the voltage calculation only uses the high side initial calibration data, while the Low side data will not be used. Under this calibration method Low side cells calibration is not required. During calibration, 0A calibration function process is perform during Cell1(high) calibration function or Cell1(high)-Cell10(high) calibration function.

Note: Sample code has two options for voltage calibration:

1. 1-point calibration: Simple, and pretty good accuracy.
2. 2-point calibration: More complex, but more accurate than 1-point calibration.

12. Battery cell voltage detection(H/W) (RAJ240100 only)

RAJ240100 has Battery cell & Temperature voltage detection by H/W.
Battery cell & Temperature voltage is measured by A/D converter. Then, the measurement result is compared with setting value of each register by digital comparator. When over/under voltage are detected by digital comparator, interrupt signal is generated and appropriate charge/discharge MOSFET is shut off.

12.1 Battery cell voltage detection Setting Procedure

This function is available when **BCVD enable flag**(Bit 5 of **control flag**) = ON
and then need to set following parameters defined in fixed data.
- **Over/Under Voltage Detection Control Register(OVUVDET)**
- **Voltage detection AD conversion time Register(VDCT)**
- **Voltage Detection Interval Time Register(VDIT)**
- **Under Voltage Detection Threshold**
- **Over Voltage Detection Threshold**

<How to set OVUVDET Register>
1. Set the OVUVDET Register according to the desired function.
2. OVUVSEL3 to OVUVSEL0 does not set some value.
   sample code uses **Series number of cell** for the value of OVUVSEL3 to OVUVSEL0

Symbol	7	6	5	4	3	2	1	0
OVUVDET	UVDETEN	OVDETEN	UVDFEN	OVCFEN	OVUVSEL3	OVUVSEL2	OVUVSEL1	OVUVSEL0

UVDETEN	Under voltage detection enable
0	Enable
1	Disable

OVDETEN	Over voltage detection enable
0	Enable
1	Disable

UVDFEN	Discharge FET control with the under voltage detection
0	Enable the Discharge FET control
1	Disable the Discharge FET control

OVCFEN	Charge FET control with the over voltage detection
0	Enable the Charge FET control
1	Disable the Charge FET control

OVUVSEL3 to OVUVSEL0	Measurement items selection of Over/under voltage detection
0H	Setting prohibited
1H	Battery Cell 1
2H	Battery Cell 1 to 2
3H	Battery Cell 1 to 3
4H	Battery Cell 1 to 4
5H	Battery Cell 1 to 5
6H	Battery Cell 1 to 6
7H	Battery Cell 1 to 7
8H	Battery Cell 1 to 8
9H	Battery Cell 1 to 9
AH	Battery Cell 1 to 10
BH to FH	Setting prohibited

<How to set VDCT Register>
1. Set the VDCT Register according to the desired function.

Symbol	7	6	5	4	3	2	1	0
VDCT	VDWTIME3	VDWTIME2	VDWTIME1	VDWTIME0	0	VDTIME2	VDTIME1	VDTIME0

VDWTIME3 to VDWTIME0	A/D conversion circuit setting time for the battery cell voltage detection circuit
0H	80us
1H	120us
2H	160us
3H	200us
4H	250us
5H	500us
6H	750us
7H	1000us
8H	36us
Other than the above	Setting prohibited

VDTIME2 to VDTIME0	A/D conversion time for the battery cell voltage detection circuit
0H	1ms
1H	2ms
2H	4ms
3H	8ms
4H	0.25ms
5H	0.5ms
Other than the above	Setting prohibited

<How to set VDIT Register>
1. Set the VDIT Register according to the desired function.

Symbol	7	6	5	4	3	2	1	0
VDIT	-	-	-	VDITIME4	VDITIME3	VDITIME2	VDITIME1	VDITIME0

VDITIME4 to VDITIME0	Voltage detection interval time
0H	1 second
1H	2 second
2H	3 second
	Interval time = n + 1(n:0H to 1FH)
7H	8 second
8H	9 second
1FH	32 second

12.2 Temperature voltage detection Setting Procedure

This function is available when **TVD enable flag**(Bit 6 of **control flag**) = ON
and then need to set following parameters defined in fixed data.
- **Over/Under Temperature Detection Control Register(OTUTDET)**
- **Voltage detection AD conversion time Register(VDCT)**
- **Voltage Detection Interval Time Register(VDIT)**
- **Under Temperature Detection Threshold**
- **Over Temperature Detection Threshold**

<How to set OTUTDET Register>
1. Set the OVUVDET Register according to the desired function.

Symbol	7	6	5	4	3	2	1	0
OTUTDET	UTDEN	OTDEN	TDDFEN	TDCFEN	-	AN2TDEN	AN1TDEN	AN0TDEN

UTDEN	Under temperature detection enable
0	Enable
1	Disable

OTDEN	Over temperature detection enable
0	Enable
1	Disable

TDDFEN	Discharge FET control with the over/under temperature detection
0	Enable the Discharge FET control
1	Disable the Discharge FET control

TDCFEN	Charge FET control with the over/under temperature detection
0	Enable the Charge FET control
1	Disable the Charge FET control

AN2TDEN	Control of over/under temperature detection by the AN2 port voltage
0	Enable
1	Disable

AN1TDEN	Control of over/under temperature detection by the AN1 port voltage
0	Enable
1	Disable

AN0TDEN	Control of over/under temperature detection by the AN0 port voltage
0	Enable
1	Disable

Note. AN2TDEN does not support by sample code.

<How to set VDCT Register>
1. Set the VDCT Register according to the desired function.

Symbol	7	6	5	4	3	2	1	0
VDCT	VDWTIME3	VDWTIME2	VDWTIME1	VDWTIME0	0	VDTIME2	VDTIME1	VDTIME0

VDWTIME3 to VDWTIME0	A/D conversion circuit setting time for the battery cell voltage detection circuit
0H	80us
1H	120us
2H	160us
3H	200us
4H	250us
5H	500us
6H	750us
7H	1000us
8H	36us
Other than the above	Setting prohibited

VDTIME2 to VDTIME0	A/D conversion time for the battery cell voltage detection circuit
0H	1ms
1H	2ms
2H	4ms
3H	8ms
4H	0.25ms
5H	0.5ms
Other than the above	Setting prohibited

<How to set VDIT Register>
1. Set the VDIT Register according to the desired function.

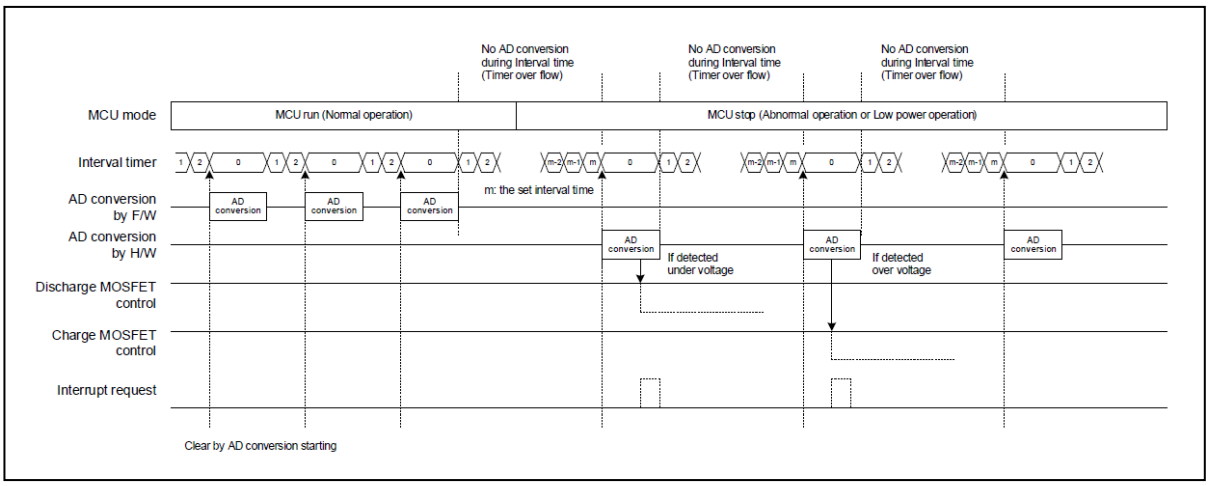
Symbol	7	6	5	4	3	2	1	0
VDIT	-	-	-	VDITIME4	VDITIME3	VDITIME2	VDITIME1	VDITIME0

VDITIME4 to VDITIME0	Voltage detection interval time
0H	1 second
1H	2 second
2H	3 second
	Interval time = n + 1(n:0H to 1FH)
7H	8 second
8H	9 second
1FH	32 second

12.3 Operation and Timing Chart

This function is only available in Low Power State. In Normal State, this function is invalid.

Figure 7. Operation timing of Battery cell voltage detection Timing Chart



13. Flash ROM

In this system, sample code has some setting parameter named Fixed data, Own data, and Flexible data.

Fixed data is parameter of fixed value on each model like Charging voltage and stored in Flash ROM area.

Own data is parameter of own value of each battery pack like AD value of Cell 1 (LOW)and stored in DataFlash area.

battery control data and accumulated data like remaining capacity, cycle count, etc are set and stored in Flash ROM area which consists of a part of Data Flash.

The allocation of the these data is shown in Chapter 9 [Memory map].

13.1 Fixed data

Following tables show the Fixed data list. The Fixed data is defined in the cell and MCU source file.

This sample code only checks once whether the fixed data is 0xFFFF or not, after each reset.

If detected any one of the data is 0xFFFF, the sample code will switch to [Fixed Data Error] mode.

Sample code does not switch to other modes in [Fixed Data Error] mode.

In Fixed Data Error mode, the sample code only accepts SoftwareReset (0x5D) and Operation Status (0x41) command.

13.1.1 RAJ240090/100 Fixed data

(1) **Fixed Data list for Battery management**

Address	Parameter name	Parameter symbol	Unit	Explanation
1C400 1C401	Charging voltage	NORMAL_CV	mV	The value per cell
1C402	Charging current	NORMAL_CC	mA	
1C403				
1C404 1C405	Charging current at Charge Wait	CHGWAIT_CC	mA	
1C406 1C407	Full judgement voltage	FULLCHGHV	mV	
1C408 1C409	Fullcharge taper voltage	FULLCHG_TV	mV	
1C40A 1C40B	Fullcharge judgement current	FULLCHG_CURR	mA	
1C40C 1C40D	Fullcharge judgement time	FULLCHG_T	250ms	
1C40E 1C40F	Discharge stop voltage	DISSTOPV	mV	
1C410 1C411	Power Down Voltage	D_PDVOLT	mV	
1C412 1C413	0% voltage	D_0PVOLT	mV	
1C414 1C415	Discharge detection current	D_DCDET	mA	
1C416 1C417	Charge detection current	D_CCDET	mA	
1C418 1C419	Sleep current	D_SLPCURR	mA	
1C41A 1C41B	Mask current	D_MSKCURR	mA	
1C41C	Discharge Over temperature(H)	DOTH	ºC	
1C41D	Discharge Over temperature(L)	DOTL	ºC	
1C41E	Discharge Over temperature release hysteresis	DTH_hys	ºC	
1C41F	Reserved			
1C420	Charge Over temperature(H)	COTH	ºC	
1C421	Charge Over temperature(L)	COTL	ºC	
1C422	Charge Over temperature release hysteresis	CTH_hys	ºC	
1C423	Reserved			
1C424	2nd Thermistor Over temperature	2NDTHM	ºC	
1C425	2nd Thermistor release temperature	2NDTHM_hys	ºC	

(continued)

Address	Parameter symbol	Parameter symbol	Unit	Explanation
1C426 1C427	Thermistor table	THERM_TBL[0]	10ohm	
1C428 1C429		THERM_TBL[1]		
1C42A 1C42B		THERM_TBL[2]		
1C42C 1C42D		THERM_TBL[3]		
1C42E 1C42F		THERM_TBL[4]		
1C430 1C431		THERM_TBL[5]		
1C432 1C433		THERM_TBL[6]		
1C434 1C435		THERM_TBL[7]		
1C436 1C437	Thermistor characteristic temperature index table	ttempidx[0]	0.1K	Y[K] = X[C] + 273
1C438 1C439		ttempidx[1]		
1C43A 1C43B		ttempidx[2]		
1C43C 1C43D		ttempidx[3]		
1C43E 1C43F		ttempidx[4]		
1C440 1C441		ttempidx[5]		
1C442 1C443		ttempidx[6]		
1C444 1C445		ttempidx[7]		

(continued)

Address	Parameter symbol	Parameter symbol	Unit	Explanation
1C446 1C447	2nd Thermistor table	2NDTHERM_TBL[0]	10ohm	
1C448 1C449		2NDTHERM_TBL[1]		
1C44A 1C44B		2NDTHERM_TBL[2]		
1C44C 1C44D		2NDTHERM_TBL[3]		
1C44E 1C44F		2NDTHERM_TBL[4]		
1C450 1C451		2NDTHERM_TBL[5]		
1C452 1C453		2NDTHERM_TBL[6]		
1C454 1C455		2ND THERM_TBL[7]		
1C456 1C457	2nd Thermistor Characteristic Temperature index table	2ndttempidx[0]	0.1K	Y[K] = X[C] + 273
1C458 1C459		2ndttempidx[1]		
1C45A 1C45B		2ndttempidx[2]		
1C45C 1C45D		2ndttempidx[3]		
1C45E 1C45F		2ndttempidx[4]		
1C460 1C461		2ndttempidx[5]		
1C462 1C463		2ndttempidx[6]		
1C464 1C465		2ndttempidx[7]		

(2) **Fixed Data list for Device information**

Address	Parameter name	Parameter symbol	Unit	Explanation
1C466	Series number of cell	D_SERIES		
1C467	Reserved	-		
1C468 | 1C487	ManufacturerName	MF_NAME		
1C488 | 1C4A7	Device Name	Dev_NAME		
1C4A8 | 1C4AB	Device Chemistry	Dev_chem		
1C4AC 1C4AD	SMBus slave address Reserved	SMB_addr -		
1C4AE 1C4AF	Control flag Bit0: 2^{nd} Thermistor enable Bit1: Cell balancing enable Bit2: Initial Calibration 1Point mode flag Bit3: InitCap table using flag Bit4: Sysin Connection enable flag Bit5: BCVD enable flag Bit6: TVD enable flag Bit7: DF read enable flag Bit8: IMP calc enable flag Bit9: Reserved Bit10: Reserved Bit11: Reserved Bit12: Reserved Bit13: Reserved Bit14: Reserved Bit15: Reserved	CONFLG		(1(ON):Use, 0(OFF):Not use) (1(ON):Use, 0(OFF):Not use) (1(ON):Use, 0(OFF):Not use) (1(ON):Use, 0(OFF):Not use) (1(ON):Use, 0(OFF):Not use) RAJ240075 does not support this function. (1(ON):Use, 0(OFF):Not use) (1(ON):Use, 0(OFF):Not use) (1(ON):Use, 0(OFF):Not use) (1(ON):Use, 0(OFF):Not use)

(3) **Fixed Data list for Capacity calculation**

Address	Parameter name	Parameter symbol	Unit	Explanation
1C4B0	Initial RelativeStateOfCharge	INIT_RSOC	%	
1C4B1	Reserved	-		
1C4B2 1C4B3	Initial FullChargeCapacity	INIT_FCC	mAh	
1C4B4 1C4B5	Capacity correction point voltage	CCP_V	mV	
1C4B6	Capacity correction point level	CCP_lvl	%	
1C4B7	Reserved	-		
1C4B8	Initial capacity table[0]	INITCAP_TBL[0]	%	
1C4B9	Initial capacity table[1]	INITCAP_TBL[1]		
1C4BA	Initial capacity table[2]	INITCAP_TBL[2]		
1C4BB	Initial capacity table[3]	INITCAP_TBL[3]		
1C4BC	Initial capacity table[4]	INITCAP_TBL[4]		
1C4BD	Initial capacity table[5]	INITCAP_TBL[5]		
1C4BE 1C4BF	Initial voltage table at initial capacity table[0]	INITV_TBL[0]		
1C4C0 1C4C1	Initial voltage table at initial capacity table[1]	INITV_TBL[1]		
1C4C2 1C4C3	Initial voltage table at initial capacity table[2]	INITV_TBL[2]		
1C4C4 1C4C5	Initial voltage table at initial capacity table[3]	INITV_TBL[3]		
1C4C6 1C4C7	Initial voltage table at initial capacity table[4]	INITV_TBL[4]		
1C4C8 1C4C9	Initial voltage table at initial capacity table[5]	INITV_TBL[5]		

(4) **Fixed Data list for Protection (Firmware)**

Address	Parameter name	Parameter symbol	Unit	Explanation
1C4CA 1C4CB	Cell balancing ON voltage	D_CBONV	mV	
1C4CC 1C4CD	Cell balancing OFF voltage	D_CBOFFV	mV	
1C4CE 1C4CF	Cell balancing enable voltage(H)	D_CBENVH	mV	
1C4D0 1C4D1	Cell balancing enable voltage(L)	D_CBENVL	mV	
1C4D2 1C4D3	Charge over current 1	OVERCH1	mA	
1C4D4	Charge over current 1 judgement time	OCC1JT	250ms	
1C4D5	Reserved			
1C4D6 1C4D7	Charge over current 2	OVERCH2	mA	
1C4D8	Charge over current 2 judgement time	OCC2JT	250ms	
1C4D9	Reserved			
1C4DA 1C4DB	Discharge over current 1	OVERDI1	mA	
1C4DC	Discharge over current 1 judgement time	ODC1JT	250ms	
1C4DD	Reserved			
1C4DE 1C4DF	Discharge over current 2	OVERDI2	mA	
1C4E0	Discharge over current 2 judgement time	ODC2JT	250ms	
1C4E1	Reserved			
1C4E2 1C4E3	Charge protection voltage	CHGPV	mV	
1C4E4	Charge protection voltage judgement time	CHGPVJT	250ms	
1C4E5	Reserved			

(5) **Fixed Data list for Protection (Hardware)**

For RAJ240090/RAJ240100

Address	Parameter name	Parameter symbol	Unit	Explanation
1C4E6	HW OCD Protection control flag Bit0: Fixed data setting enable for OCC/ODC Bit1 to 7: Reserved	HWOCDFLG		0: Use firmware default 1: Use fixed data setting
1C4E7	Short-circuit Current detection Control Register (SCDCON)	D_SCDCON		
1C4E8	Short-circuit Current detection Time setting Register (SCDTIME)	D_SCDTIME		
1C4E9	Discharge Overcurrent Detection 1 Control Register (DOC1DCON)	D_DOC1DCON		
1C4EA	Discharge Overcurrent Detection 2 Control Register (DOC2DCON)	D_DOC2DCON		
1C4EB	Discharge Overcurrent Detection 3 Control Register (DOC3DCON)	D_DOC3DCON		
1C4EC	Discharge Overcurrent Detection 4 Control Register (DOC4DCON)	D_DOC4DCON		
1C4ED	Discharge Overcurrent Detection 1 Time Register 1 (DOC1DTIME1)	D_DOC1DTIME1		
1C4EE	Discharge Overcurrent Detection 1 Time Register 2 (DOC1DTIME2)	D_DOC1DTIME2		
1C4EF	Discharge Overcurrent Detection 2 Time Register 1 (DOC2DTIME1)	D_DOC2DTIME1		
1C4F0	Discharge Overcurrent Detection 2 Time Register 2 (DOC2DTIME2)	D_DOC2DTIME2		
1C4F1	Discharge Overcurrent Detection 3 Time Register 1 (DOC3DTIME1)	D_DOC3DTIME1		
1C4F2	Discharge Overcurrent Detection 3 Time Register 2 (DOC3DTIME2)	D_DOC3DTIME2		
1C4F3	Discharge Overcurrent Detection 4 Time Register 1 (DOC4DTIME1)	D_DOC4DTIME1		
1C4F4	Discharge Overcurrent Detection 4 Time Register 2 (DOC4DTIME2)	D_DOC4DTIME2		
1C4F5	Charge Overcurrent Detection Control Register (COCDCON)	D_COCDCON		
1C4F6	Charge Overcurrent Detection Time Register (COCDTIME)	D_COCDTIME		
1C4F7	Reserved			

(6) **Fixed Data list for Battery History Record**

Address	Parameter name	Parameter symbol	Unit	Explanation
1C4F8	Initial Battery Impedance	D_INIT_IMP	0.1 mOhm	
1C4F9				
1C4FA	Impedance current	D_IMP_CURR	mA	
1C4FB				
1C4FC	RSOC IMP	D_RSOC_IMP	%	
1C4FD	IMP Temp L	D_IMP_TEMPL	°C	
1C4FE	IMP Temp H	D_IMP_TEMPH	°C	
1C4FF	Storage temperature	D_ST_TEMP	ºC	
1C500	Storage delta Voltage	D_ST_DLTV	mV	
1C501				

(7) **Fixed Data list for BCVD function**

Address	Parameter name	Parameter symbol	Unit	Explanation
1C502	Over/Under Voltage Detection Control Register (OVUVDET)	D_OVUVDET		
1C503	Voltage detection AD conversion time Register (VDCT)	D_VDCT		
1C504	Voltage Detection Interval Time Register (VDIT)	D_VDIT		
1C505	Reserved			
1C506 1C507	Under Voltage Detection Threshold	D_UVDH	mV	
1C508 1C509	Over Voltage Detection Threshold	D_OVDH	mV	
1C50A 1C50B	Over/Under Temperature Detection Control Register (OTUTDET)	D_OTUTDET		
1C50C 1C50D	Under Temperature Detection Threshold	D_UTDH	0.1K	
1C50E 1C50F	Over Temperature Detection Threshold	D_OTDH	0.1K	

13.1.2 Fixed data other than RAJ240090/100

(1) **Fixed Data list for Battery management**

Address	Parameter name	Parameter symbol	Unit	Explanation
D800 D801	Charging voltage	NORMAL_CV	mV	The value per cell
D802	Charging current	NORMAL_CC	mA	
D803				
D804 D805	Charging current at Charge Wait	CHGWAIT_CC	mA	
D806 D807	Full judgement voltage	FULLCHGHV	mV	
D808 D809	Fullcharge taper voltage	FULLCHG_TV	mV	
D80A D80B	Fullcharge judgement current	FULLCHG_CURR	mA	
D80C D80D	Fullcharge judgement time	FULLCHG_T	250ms	
D80E D80F	Discharge stop voltage	DISSTOPV	mV	
D810 D811	Power Down Voltage	D_PDVOLT	mV	
D812 D813	0% voltage	D_0PVOLT	mV	
D814 D815	Discharge detection current	D_DCDET	mA	
D816 D817	Charge detection current	D_CCDET	mA	
D818 D819	Sleep current	D_SLPCURR	mA	
D81A D81B	Mask current	D_MSKCURR	mA	
D81C	Discharge Over temperature(H)	DOTH	ºC	
D81D	Discharge Over temperature(L)	DOTL	ºC	
D81E	Discharge Over temperature release hysteresis	DTH_hys	ºC	
D81F	Reserved			
D820	Charge Over temperature(H)	COTH	ºC	
D821	Charge Over temperature(L)	COTL	ºC	
D822	Charge Over temperature release hysteresis	CTH_hys	ºC	
D823	Reserved			
D824	2nd Thermistor Over temperature	2NDTHM	ºC	
D825	2nd Thermistor release temperature	2NDTHM_hys	ºC	

(continued)

Address	Parameter symbol	Parameter symbol	Unit	Explanation
D826 D827	Thermistor table	THERM_TBL[0]	10ohm	
D828 D829		THERM_TBL[1]		
D82A D82B		THERM_TBL[2]		
D82C D82D		THERM_TBL[3]		
D82E D82F		THERM_TBL[4]		
D830 D831		THERM_TBL[5]		
D832 D833		THERM_TBL[6]		
D834 D835		THERM_TBL[7]		
D836 D837	Thermistor characteristic temperature index table	ttempidx[0]	0.1K	Y[K] = X[C] + 273
D838 D839		ttempidx[1]		
D83A D83B		ttempidx[2]		
D83C D83D		ttempidx[3]		
D83E D83F		ttempidx[4]		
D840 D841		ttempidx[5]		
D842 D843		ttempidx[6]		
D844 D845		ttempidx[7]		

(continued)

Address	Parameter symbol	Parameter symbol	Unit	Explanation
D846 D847	2nd Thermistor table	2NDTHERM_TBL[0]	10ohm	
D848 D849		2NDTHERM_TBL[1]		
D84A D84B		2NDTHERM_TBL[2]		
D84C D84D		2NDTHERM_TBL[3]		
D84E D84F		2NDTHERM_TBL[4]		
D850 D851		2NDTHERM_TBL[5]		
D852 D853		2NDTHERM_TBL[6]		
D854 D855		2ND THERM_TBL[7]		
D856 D857	2nd Thermistor Characteristic Temperature index table	2ndttempidx[0]	0.1K	Y[K] = X[C] + 273
D858 D859		2ndttempidx[1]		
D85A D85B		2ndttempidx[2]		
D85C D85D		2ndttempidx[3]		
D85E D85F		2ndttempidx[4]		
D860 D861		2ndttempidx[5]		
D862 D863		2ndttempidx[6]		
D864 D865		2ndttempidx[7]		

(2) **Fixed Data list for Device information**

Address	Parameter name	Parameter symbol	Unit	Explanation
D866	Series number of cell	D_SERIES		
D867	Reserved	-		
D868 | D887	ManufacturerName	MF_NAME		
D888 | D8A7	Device Name	Dev_NAME		
D8A8 | D8AB	Device Chemistry	Dev_chem		
D8AC	SMBus slave address	SMB_addr		
D8AD	Reserved	-		
D8AE D8AF	Control flag Bit0: 2nd Thermistor enable Bit1: Cell balancing enable Bit2: Initial Calibration 1Point mode flag Bit3: InitCap table using flag Bit4: Sysin Connection enable flag Bit5: BCVD enable flag Bit6: TVD enable flag Bit7: DF read enable flag Bit8: IMP calc enable flag Bit9: Reserved Bit10: Reserved Bit11: Reserved Bit12: Reserved Bit13: Reserved Bit14: Reserved Bit15: Reserved	CONFLG		(1(ON):Use, 0(OFF):Not use) (1(ON):Use, 0(OFF):Not use) (1(ON):Use, 0(OFF):Not use) (1(ON):Use, 0(OFF):Not use) (1(ON):Use, 0(OFF):Not use) RAJ240075 does not support this function. (1(ON):Use, 0(OFF):Not use) (1(ON):Use, 0(OFF):Not use) (1(ON):Use, 0(OFF):Not use) (1(ON):Use, 0(OFF):Not use)

(3) **Fixed Data list for Capacity calculation**

Address	Parameter name	Parameter symbol	Unit	Explanation
D8B0	Initial RelativeStateOfCharge	INIT_RSOC	%	
D8B1	Reserved	-		
D8B2 D8B3	Initial FullChargeCapacity	INIT_FCC	mAh	
D8B4 D8B5	Capacity correction point voltage	CCP_V	mV	
D8B6	Capacity correction point level	CCP_lvl	%	
D8B7	Reserved	-		
D8B8	Initial capacity table[0]	INITCAP_TBL[0]	%	
D8B9	Initial capacity table[1]	INITCAP_TBL[1]		
D8BA	Initial capacity table[2]	INITCAP_TBL[2]		
D8BB	Initial capacity table[3]	INITCAP_TBL[3]		
D8BC	Initial capacity table[4]	INITCAP_TBL[4]		
D8BD	Initial capacity table[5]	INITCAP_TBL[5]		
D8BE D8BF	Initial voltage table at initial capacity table[0]	INITV_TBL[0]		
D8C0 D8C1	Initial voltage table at initial capacity table[1]	INITV_TBL[1]		
D8C2 D8C3	Initial voltage table at initial capacity table[2]	INITV_TBL[2]		
D8C4 D8C5	Initial voltage table at initial capacity table[3]	INITV_TBL[3]		
D8C6 D8C7	Initial voltage table at initial capacity table[4]	INITV_TBL[4]		
D8C8 D8C9	Initial voltage table at initial capacity table[5]	INITV_TBL[5]		

(4) **Fixed Data list for Protection (Firmware)**

Address	Parameter name	Parameter symbol	Unit	Explanation
D8CA D8CB	Cell balancing ON voltage	D_CBONV	mV	
D8CC D8CD	Cell balancing OFF voltage	D_CBOFFV	mV	
D8CE D8CF	Cell balancing enable voltage(H)	D_CBENVH	mV	
D8D0 D8D1	Cell balancing enable voltage(L)	D_CBENVL	mV	
D8D2 D8D3	Charge over current 1	OVERCH1	mA	
D8D4	Charge over current 1 judgement time	OCC1JT	250ms	
D8D5	Reserved			
D8D6 D8D7	Charge over current 2	OVERCH2	mA	
D8D8	Charge over current 2 judgement time	OCC2JT	250ms	
D8D9	Reserved			
D8DA D8DB	Discharge over current 1	OVERDI1	mA	
D8DC	Discharge over current 1 judgement time	ODC1JT	250ms	
D8DD	Reserved			
D8DE D8DF	Discharge over current 2	OVERDI2	mA	
D8E0	Discharge over current 2 judgement time	ODC2JT	250ms	
D8E1	Reserved			
D8E2 D8E3	Charge protection voltage	CHGPV	mV	
D8E4	Charge protection voltage judgement time	CHGPVJT	250ms	
D8E5	Reserved			

13.2 Own data

Table 46 DataFlash map of Initial calibration

Address	Item	Define	Unit	Address	Item	Define	Unit
F1800	AD value of Cell 1 (LOW)	D_LV[0]		F1820	AD value of Cell 1 (HIGH)	D_HV[0]	
F1801				F1821			
F1802	AD value of Cell 2 (LOW)	D_LV[1]		F1822	AD value of Cell 2 (HIGH)	D_HV[1]	
F1803				F1823			
F1804	AD value of Cell 3 (LOW)	D_LV[2]		F1824	AD value of Cell 3 (HIGH)	D_HV[2]	
F1805				F1825			
F1806	AD value of Cell 4 (LOW)	D_LV[3]		F1826	AD value of Cell 4 (HIGH)	D_HV[3]	
F1807				F1827			
F1808	AD value of Cell 5 (LOW)	D_LV[4]		F1828	AD value of Cell 5 (HIGH)	D_HV[4]	
F1809				F1829			
F180A	AD value of Cell 6 (LOW)	D_LV[5]		F182A	AD value of Cell 6 (HIGH)	D_HV[5]	
F180B				F182B			
F180C	AD value of Cell 7 (LOW)	D_LV[6]		F182C	AD value of Cell 7 (HIGH)	D_HV[6]	
F180D				F182D			
F180E	AD value of Cell 8 (LOW)	D_LV[7]		F182E	AD value of Cell 8 (HIGH)	D_HV[7]	
F180F				F182F			
F1810	AD value of Cell 9 (LOW)	D_LV[8]		F1830	AD value of Cell 9 (HIGH)	D_HV[8]	
F1811				F1831			
F1812	AD value of Cell 10 (LOW)	D_LV[9]		F1832	AD value of Cell 10 (HIGH)	D_HV[9]	
F1813				F1833			
F1814	reserved			F1834	reserved		
F1815				F1835			
F1816	reserved			F1836	reserved		
F1817				F1837			
F1818	reserved			F1838	reserved		
F1819				F1839			
F181A	reserved			F183A	reserved		
F181B				F183B			
F181C	reserved			F183C	reserved		
F181D				F183D			
F181E	reserved			F183E	reserved		
F181F				F183F			

Address	Item	Define	Unit
F1840 F1841	Reference value of Cell 1 (LOW)	D_LVREF[0]	mV
F1842 F1843	Reference value of Cell 2 (LOW)	D_LVREF[1]	mV
F1844 F1845	Reference value of Cell 3 (LOW)	D_LVREF[2]	mV
F1846 F1847	Reference value of Cell 4 (LOW)	D_LVREF[3]	mV
F1848 F1849	Reference value of Cell 5 (LOW)	D_LVREF[4]	mV
F184A F184B	Reference value of Cell 6 (LOW)	D_LVREF[5]	mV
F184C F184D	Reference value of Cell 7 (LOW)	D_LVREF[6]	mV
F184E F184F	Reference value of Cell 8 (LOW)	D_LVREF[7]	mV
F1850 F1851	Reference value of Cell 9 (LOW)	D_LVREF[8]	mV
F1852 F1853	Reference value of Cell 10 (LOW)	D_LVREF[9]	mV
F1854 F1855	Reserved		
F1856 F1857	Reserved		
F1858 F1859	Reserved		
F185A F185B	Reserved		
F185C F185D	Reserved		
F185E F185F	Reserved		

Address	Item	Define	Unit
F1860	Reference value of Cell 1 (HIGH)	D_HVREF[0]	mV
F1861			
F1862	Reference value of Cell 2 (HIGH)	D_HVREF[1]	mV
F1863			
F1864	Reference value of Cell 3 (HIGH)	D_HVREF[2]	mV
F1865			
F1866	Reference value of Cell 4 (HIGH)	D_HVREF[3]	mV
F1867			
F1868	Reference value of Cell 5 (HIGH)	D_HVREF[4]	mV
F1869			
F186A	Reference value of Cell 6 (HIGH)	D_HVREF[5]	mV
F186B			
F186C	Reference value of Cell 7 (HIGH)	D_HVREF[6]	mV
F186D			
F186E	Reference value of Cell 8 (HIGH)	D_HVREF[7]	mV
F186F			
F1870	Reference value of Cell 9 (HIGH)	D_HVREF[8]	mV
F1871			
F1872	Reference value of Cell 10(HIGH)	D_HVREF[9]	mV
F1873			
F1874	Reserved		
F1875			
F1876	Reserved		
F1877			
F1878	Reserved		
F1879			
F187A	Reserved		
F187B			
F187C	Reserved		
F187D			
F187E	Reserved		
F187F			

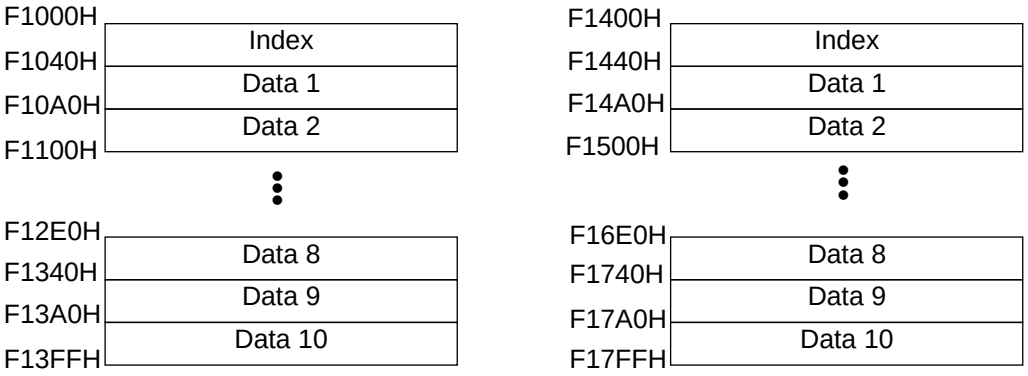
Address	Item	Define	Unit
F1880	AD value of Pack (LOW)	D_PACKLV	
F1881			
F1882	AD value of Pack (HIGH)	D_PACKHV	
F1883			
F1884	Reference value of Pack (LOW)	D_PACKLVREF	mV
F1885			
F1886	Reference value of Pack (HIGH)	D_PACKHVREF	mV
F1887			
F1888	AD value of 0A current	D_0A	
F1889			
F188A			
F188B			
F188C	AD value of discharging	D_CURR	
F188D			
F188E			
F188F			
F1890	Reference value of Current	D_CURRREF	mA
F1891			
F1892	Temperature calibration value	D_CALTH	
F1893			
F1894	Reference value of Temperature	D_CALTHREF	0.1K
F1895			
F1896	AD value of TotalCellVoltage (LOW)	D_TCLV	
F1897			
F1898	AD value of TotalCellVoltage (HIGH)	D_TCHV	
F1899			
F189A	Reference value of TotalCellVoltage (LOW)	D_TCLVREF	mV
F189B			
F189C	Reference value of TotalCellVoltage (HIGH)	D_TCHVREF	mV
F189D			
F189E	AD value of MCU BG	-	
F189F			

Address	Item	Unit
F18A0	AD value of CREG2	
F18A1		
F18A2	Reserved	
F18BF		

13.3 Flexible data

Two blocks of 1Kbyte are used to save Flexible data.

Dividing one block into 96Bytes units, and using odd 64Bytes area (assign to top area) as an index, and using other area sequentially as data.



The relationship between “index” and “data number” is as follows. (This is for 1st block.)

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
F1000H	1	2	3	4	5	6	7	8	9	10	*	*	*	*	*	*
F1010H	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
F1020H	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
F1030H	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

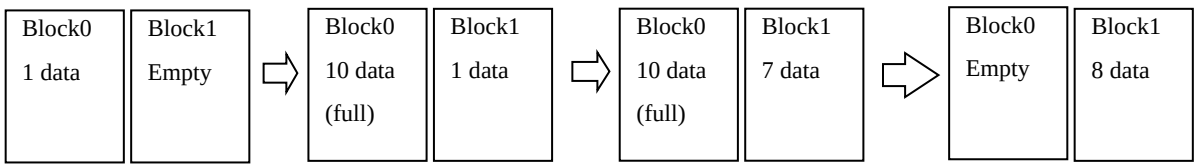
* : Not used.

The index links one byte and one data area. The index value means as follows.

Value	Means
0xFF	Empty
0xA0	Correct data
0x07	Write error
Other	Wrong data

When writing, search index of the last data and write to next area of the last data.

At first, it uses a block. Then, when the block becomes full, it uses another block. The data of full block will erase when 8th area of using block is written. But it will not be erased when it is in Permanent failure mode. And it stops updating flexible data.



When reading, search index of the last data and read the last data.

13.3.1 Timing of rewriting the Flexible data

Update the Flexible data when either of the following conditions is detected.

(1) When receiving the command which rewriting the Flexible data by using *ExtraFunction()*.

13.3.2 Flexible data definition

Address is variable because data block is repeatedly rewritten with 96 byte as one area.

The following map is a record of the area which starts from address 0xF1040.

Table 47 Flexible data definition (The address is just example for 1st data area of 1st block.)

Address	Data	Unit
F1040 F1041	Teperature(0x08)	0.1K
F1042 F1043	Voltage(0x09)	mV
F1044 F1045	Current(0x0a)	mA signed
F1046 F1047	RelativeStateOfCharge(0x0d)	%
F1048 F1049	RemainingCapacity(0x0f)	mAh
F104A F104B	FullChargeCapacity(0x10)	mAh
F104C F104F	Remaining capacity() correct work	mA 250ms
F1050 F1051	Battery Impedance (0x47)	0.1 mOhm
F1052 F1053	Total charged capacity (0x48)	Ah
F1054 F1055	Total storage time (0x49)	Hour
F1056 F1057	Storage time of cell voltage ≥ **ChargingVoltage per cell** – **Storage delta V** (0x4a)	Hour
F1058 F1059	Storage time of 1st temperature ≥ **Storage temp** (0x4b)	Hour
F105A F105B	Storage time of cell voltage ≥ **ChargingVoltage per cell** – **Storage delta V** & 1st temperature ≥ **Storage temp** (0x4c)	Hour
F105C | F109F	Reserved	

14. Function list

Function list is as follows.

Table 48 Function list (1/2)

Function Name	File Name	Function
hdwinit	main.c	Initialize IC settings
main		main function
Slowmain		Slow main function
OCO2LOCO		Clock switch(OCO -> LOCO)
LOCO2OCO		Clock switch(LOCO -> OCO)
Timer1msec_init		Initialize interval timer (1msec)
AFE_Timer1sec_init		Initialize AFE interval timer (1sec)
Serial_init		Initialize serial communication
AFE_init		Initialize AFE
AFE_OCDCalib_D		AFE Over current detection Calibration Process
AFE_OCDCalib_C		AFE Over current detection Calibration Process
AFE_DWUC_EN		AFE Wakeup discharge current setting Process
AFE_CWUC_EN		AFE Wakeup charge current setting Process
Calc_RSOC	datcalc.c	RelativeStateOfCharge() calculation function
Make_RC	datcalc_spl.c	Calculate RemainingCapacity
Calc_NormalRC		Function of capacity calculation while discharging and voltage is higher than CP_H
Calc_RC		RemainingCapacity() calculation function
Calc_IMP		Battery Impedance() calculation function
UsageCheck		Battery Usage record function
FlashWrite	dataflash.c	Write data flash memory
FlashErase		Erase data flash memory
Waittimer_us		wait timer function
_int_Timer1msec	int.c	1msec interval timer interrupt function
_int_AFE_CC		Current integration interrupt function
_int_AFE_HVP		High Voltage Port interrupt function
_int_AFE_TM		AFE interval timer interrupt function
_int_AFE_WU		AFE Wakeup interrupt function
OverCurrentSetting		over current setting function for interrupt
_int_AFE_CD		over current interrupt function
FlashWrite_Word	kousei.c	Data flash memory write function (2bytes)
FlashWrite_DWord		Data flash memory write function (4bytes)
Kousei		Calibration Process
InitCalib_Chk		Initial Calibration Data Check Process
GetCurrCalib		Acquisition Process for Current Calibration
GetVAD		Acquisition Process for voltage AD value
KouseiMain		Initial Calibration Main
Init_CalibDat		Initialized Process of initial Calibration Data
GetAD_Calib		Get AD value in initial Calibration
CalibSkip		Calibration skip process

Table 49 Function list (2/2)

Function Name	File Name	Function
CalcPackVolt	mcu_auto.c	Calculate PACK voltage
CalcTotalCellVolt		calculate Total Cell voltage
CVT_Func		Calling current, voltage and temperature detecting function
Calc_Temp		Calculate external thermistor temperature value
Calc_2ndTemp		Calculate external thermistor temperature value
ReadTemp		Temperature value acquisition processing
CalcVolt		Calculate a cell voltage value
CalcCurr		Current calculation function
PowerDown		PowerDown function
CB_Chk		Cell Balancing function
Mode_Chk	mode.c	Mode check processing function
FullCharge		Full Charge processing function
Chgwait_Chk		Charge Wait Check Processing Function
Set_ODC		OverDischargeCurrent set processing function
MainMode_Chk		MainMode check processing function
Set_FET		FET set processing function
Alarm_Chk		ALARM check processing function
Slow_Chk		Slow mode check function
Set_CCCV		Set CC & CV function
_int_SMBus	smbus.c	SMBus interrupt
Sad_Chk		SMBus communication Read slave address check
ComChk		SMBus communication command check
R_W_Chk,		SMBus communication Read / Write check
ReadRs_Sad		SMBus communication Read slave address check after re-start
Read_Com		SMBus communication Read Word return the data
ComErr		SMBus communication protocol error function
ComErrNak		SMBus communication protocol error with nak function
Write_Com		SMBus communication Write Word data receive
Write_Blk_Chk		SMBus communication Write Block check
AckSend		SMBus communication ACK send
SMB_Timeout		SMBus timeout function
Timeout_Chk		SMBus timeout check function
_int_SCLSDA		SCL/SDA interrupt function
SMBus_init		SMBus initialize
StoreRcvData	smbus_ex.c	SMBus communication received data function
ComExist_Chk		SMBus communication extra command check
SetSMBusRead		SMBus communication Read command function
Ext_Func		ExtraFunction processing
Read_CalRef		Read initial calibration data function
WriteFlash_CalRef		DataFlash writing for initial calibration
Write_CalRef		Reference value writing for initial calibration
InitFixed_Chk	Cell.c	Fixed Data Check Process

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Revision History

		Description	
Rev.	**Date**	**Page**	**Summary**
1.00	June.07th, 2017		First release
2.00	June 30th, 2017	4	Updated description for Outline of system
		28	Add Memory map
		41, 42	Updated table Fixed data list
3.00	Aug 9th, 2017		Significant revision
3.01	Sep 28th ,2017	9,11,48	Change parameter name Fullcharge detection voltage -> Full judgement voltage
		53	Change parameter name - Cell balancing enable voltage upper limit -> Cell balancing enable voltage(H) Cell balancing enable voltage lower limit -> Cell balancing enable voltage(L)
3.02	Oct 18th, 2017	20,30,51	Change parameter name CELL series number -> Series number of cell
3.03	Nov 1st ,2017	14,15,34, 36,37	Add RAJ240045, RAJ240080 information
3.04	Dec 15th ,2017	14,15,27, 34,36,37, 52	Add RAJ240075 information
3.05	Jan 10th , 2018	7,23	correction of erroneous description
3.06	Feb 1st , 2018	-	Polish All of sentence description
4.00	Feb 26th ,2018	-	The specification has not changed. (Modified the code.)
4.01	Mar 6th ,2018	32	Add Checksum function
4.02	Mar 12th, 2018	34	correction of erroneous description
4.03	Apr 25th , 2018	28	Add explanation of Cell balancing function
4.04	May 30th, 2018	9,10,11	correction of erroneous description
4.05	Aug 1st ,2018	19	Add explanation of Mask current
4.06	Oct 24th ,2018	11	Add explanation of FET states in Force PowerDown and Force Sleep
		16	Add condition of transition from Sleep to Wake up
		14,22	Add DeviceName(0x21) command
4.07	Apr 8th , 2019	17	Add Sleep mode current 1, Sleep mode current 2 function
		36	Add FCC update function
		4	Add definition of Current
		4	Add description of SMBus command data
		6,9-11, 16,29	Revised description of Current

4.08	May 31st , 2019	46-50,58	Add Battery cell voltage detection(H/W) function
		51-65	Merge the list of Fixed data, Own data in 12 Flash ROM
		64-65	Add description of Flexible data
			Change the current value used for mode transition and capacity calculation from Current(0x0a) to ExtendedCurrent(0x24)
		23	Add ExtendedCurrent(0x24) command
6.00	Apr 15th, 2021	21, 28, 29, 32, 35, 60	Add following functions 1. Chip temperature measurement (0x25) 2. Battery Impedance measurement (0x47) 3. Usage monitor (0x48 to 0x4c) 4. HW protection control by fixed data. Modify following functions 1. Erase DataFlash function (0x5e) 2. Initial capacity calculation
6.10	Mar 24th, 2022	-	The specification has not changed. (Modified the code.)
6.20	Nov 30th, 2022	42	Change fixed data area

General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

The following usage notes are applicable to all Microprocessing unit and Microcontroller unit products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

1. Precaution against Electrostatic Discharge (ESD)

   A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.
2. Processing at power-on

   The state of the product is undefined at the time when power is supplied. The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the time when power is supplied. In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the time when power is supplied until the reset process is completed. In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the time when power is supplied until the power reaches the level at which resetting is specified.
3. Input of signal during power-off state

   Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Follow the guideline for input signal during power-off state as described in your product documentation.
4. Handling of unused pins

   Handle unused pins in accordance with the directions given under handling of unused pins in the manual. The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of the LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible.
5. Clock signals

   After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is stabilized. When the clock signal is generated with an external resonator or from an external oscillator during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Additionally, when switching to a clock signal produced with an external resonator or by an external oscillator while program execution is in progress, wait until the target clock signal is stable.
6. Voltage application waveform at input pin

   Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (Max.) and V_{IH} (Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (Max.) and V_{IH} (Min.).
7. Prohibition of access to reserved addresses

   Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.
8. Differences between products

   Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

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