RAA489206 R-BMS B Sample Code

Introduction

This manual provides instructions for setting up and evaluating the R-BMS B Sample Code for the RAA489206. The two described configuration options include using a resistor ladder as a battery emulator or actual battery cells. The behavior of the system is monitored using a serial terminal, a debugger, or both.

Contents

1. Overview

The Battery Management IC (BMIC) RAA489206 is an industrial grade battery manager IC that monitors up to 16 Li-based battery cells. Using a 16-bit ADC, it accurately measures cell voltage, temperature, and pack current. The additional features include internal or external cell balancing, charger and load detection, direct external control of the CFET and DFET using the GPIOs, and an Auto-scan and cell balance functionality that offers autonomous reaction to critical conditions and redundancy. The R-BMS B Sample code uses the features of the RAA489206 BMIC and the high-performance Renesas ARM-based MCU RA4E1 to demonstrate a battery management system with primary functions like voltage protections, temperature protections, current protections, and self-diagnostic; and it has secondary functions like cell balancing, capacity control, and a user interface. The R-BMS B sample code for the RAA489206 runs on the original evaluation kit RTKA489206DK0000BU with an ISO-DONGLE1Z Rev.D communications dongle.

1.1 Assumptions and Advisory Notes

The following are assumptions:

- A basic understanding of microcontrollers, embedded systems hardware, battery management systems, and Li-based battery cells.
- A prior experience working with Integrated Development Environments (IDEs) such as e^2 studio and terminal emulation programs such as Tera Term.
- And a familiarity with the following:
  - The Renesas RA family ARM Cortex-M microcontrollers
  - The *R-BMS B RAA489206 Sample Code Specification Manual*
  - The *ISO-DONGLE1Z Rev.D Software Manual*
  - The *RAA489206 Battery Front End Sample Code Manual*

1.2 Overview of the R-BMS B Sample Code for RAA489206

The R-BMS B sample code for RAA489206 includes an autonomous battery management system that runs cell balancing and calculates the remaining capacity based on open-circuit voltage. The state machine flow diagram is illustrated on Figure 1. It contains modes and states and depicts the possible transitions between them. A state executes its function and moves to the next mode or state, while a mode can remain static or loop inside until a valid condition for transition appears.

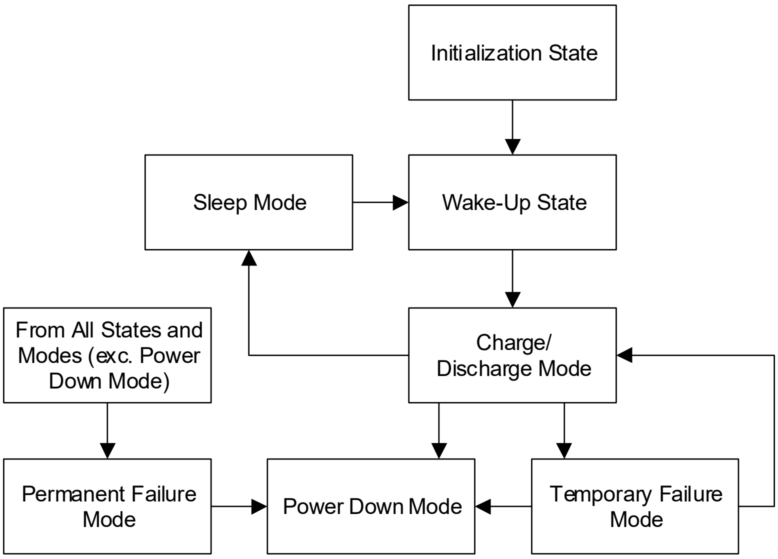

Figure 1. General Flowchart of R-BMS B for RAA489206

During normal operation, the systems stays in Charge/Discharge mode, where it can control the charging process, or in Sleep mode when current is flowing to or from the battery pack. There are two types of system failures: temporary faults when the condition is not critical allowing the system to recover (such as a short-circuit) and permanent failures when the battery pack is disabled and cannot be charged or discharged (such as critical over-temperature). The BMIC can detect a load and wake up the system by connecting a load. However, there is no communication with a charger or any special charger detection circuitry on the RTKA489206DE0000BU evaluation board. Therefore, a charger connection is emulated by pressing the **WAKEUP#** button. The system provides safety functions on different hardware and software levels and provides a redundancy of the protections. To verify the proper operation of these safety mechanisms, the system periodically runs a self-test of the BMIC, open-wire test, and a memory test that validates the content of the configuration registers. The control of the CFET and DFET is distributed between the BMIC and the MCU. The ON/OFF states of the FETs are controlled by the system state machine. However, the BMIC can turn off the FETs on its own as a reaction to a failure, and the MCU can turn off both FETs using a dedicated pin in addition to sending commands across the serial interface.

The system configuration parameters can be found in two separate files: src/apps/bal_data.c and src/apps/bms_data.c. The first one contains the settings of the BMIC Abstraction Layer that control the BMIC device. The second file contains the settings of the state machine, cell balancing application, and remaining capacity control application that control the system behavior. For example, changing the number of cells in series would require modifications of parameters in both files, but changing the voltage threshold for detecting a battery full charge requires modification of parameters only in the second file.

Important: Renesas recommends reviewing in details the *R-BMS B RAA489206 Sample Code Specification Manual* and the *RAA489206 Battery Front End Sample Code Manual* before making any changes of the system configuration parameters.

Also, the R-BMS B for the RAA489206 is a sample code for demonstration purposes. It can operate only when a terminal software is connected visualizing the user interface.

2. Running the R-BMS B Sample Code for RAA489206

2.1 Hardware Requirements

Table 1 shows the hardware setup required to run and evaluate the R-BMS B sample code for the RAA489206. The system runs on the RAA489206 evaluation kit, containing the RTKA489206DE0000BU evaluation board and the ISO_DONGLE_EV1Z Rev.D isolated communications dongle with a RA4E1 MCU. Renesas recommends using a four-quadrant power supply in combination with a resistor ladder (battery emulator) instead of real Li battery cells during the initial evaluation. An additional voltage and current limited power supply can be used as a charger while an electronic load can be used as a battery pack load. At a typical operating pack voltage of 36V (3.6V per cell), the resistor ladder and the evaluation board consumes around ~39mA when no current is flowing to or from the pack. By using the terminal, the software can be downloaded into the isolated communications dongle, and the system can run without a debugger (E2 emulator). A precision multimeter can be used as a voltmeter to monitor battery pack voltage, individual cell voltages, or other required voltages.

Important: Do not supply the evaluation board with more than 59V or less than 12V.

Table 1. Hardware Setup

#	Item	Qty.	Description
1	RTKA489206DE0000BU	1	RAA489206 Evaluation Board
2	BMS_PS_CELL16Z REV.B	1	16-cell resistor ladder board (or up to 16S battery pack)
3	ISO_DONGLE_EV1Z Rev.D	1	Isolated Communications Dongle
4	USB type B cable	1	Connection between the Isolated Communications Dongle dongle and a PC
5	Four-quadrant power supply	1	Four quadrant regulated DC power supply, 0V to 60V, > 1A
6	Power supply	1	Regulated DC power supply, 0V to 60V, > 1A
7	Electronic load	1	Regulated electronic load, 0V to 60V, > 1A
8	Personal computer or notebook	1	Running Windows or Linux with USB support
9	Renesas E2 (Lite) Emulator (optional)	1	On-chip debugging emulator
10	USB mini cable (optional)	1	Connection between the on-chip debugging emulator and a PC
11	Precision multimeter (optional)	1	Multipurpose DC voltmeter

2.1.1 Test Setup with a Resistor Ladder

Figure 2 shows the test setup when using a battery emulator. VBATT is the four-quadrant DC power supply powering the BMS-PS-CELL16Z (Rev.B) battery emulator. Verify that additional jumpers are installed on header J3 as shown on the diagram to reconfigure the ladder to emulate ten cells in series. On the BMIC evaluation board, RTKA489206DE0000BU jumpers J9 and J10 must be available so that the charge and discharge currents flow through header J11 and the battery emulator board. The position of switches S1 and SW1 must resemble Figure 2. Ensure that jumper JP1 on the isolated communications dongle ISO_DONGLE_EV1Z Rev.D is available. Connect the DC electronic load RL or the DC power supply ICH (charger) between J7 (Batt+) and J8 (Batt-). *Note*: If the outputs of load and charger are disabled, the impedance of the terminals can trigger the load detection circuit or result in a high current pulse when the CFET and DFET are turned on. The communications dongle provides a galvanic isolation; however, it is a good practice to also ground the connected computer.

Important: Ensure that connector P- is grounded. A floating or incorrectly grounded test setup results in ground loops and additional measurement errors, or it can cause damage in some rare cases.

Important: The battery emulator does not support cell balancing. Verify that cell balancing is disabled in the system settings.

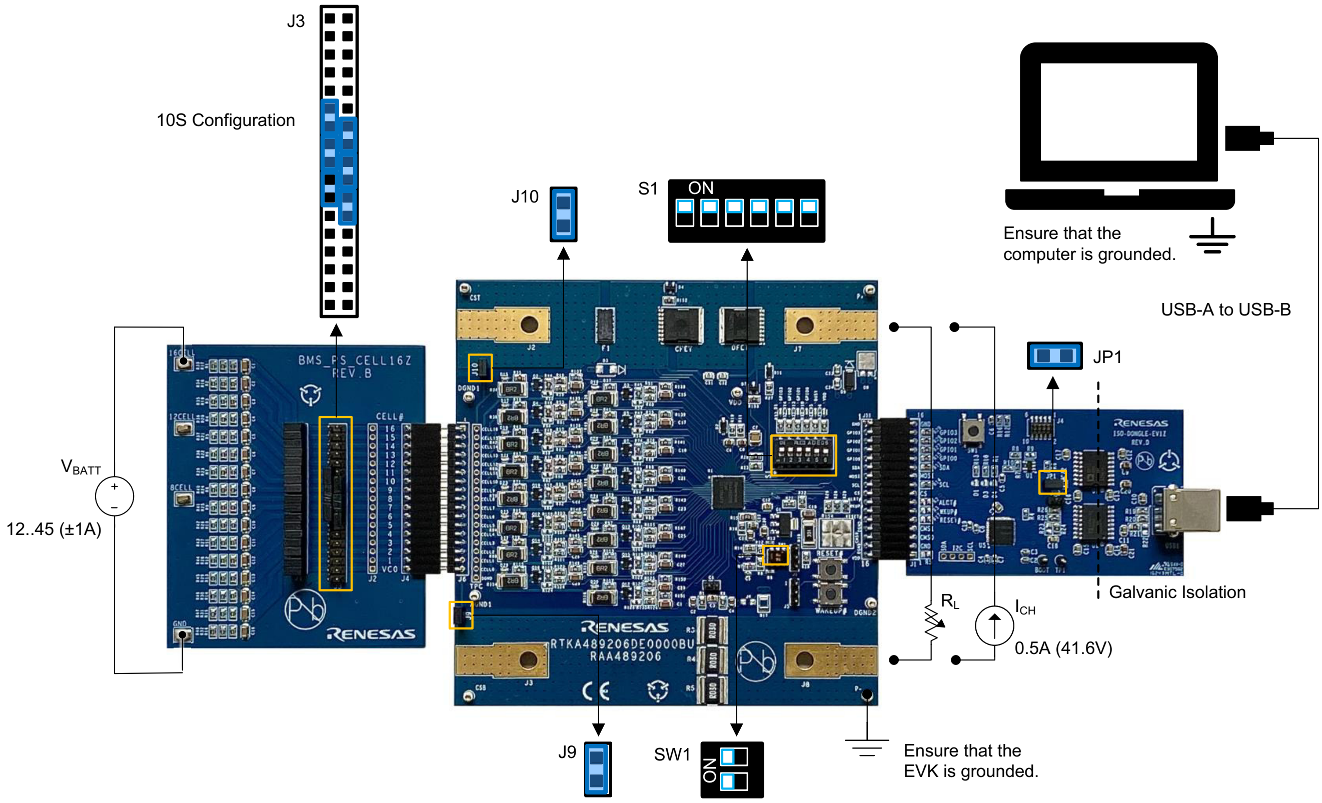

Figure 2. R-BMS B for RAA489206 Test Setup using a Battery Emulator (Resistor Ladder)

2.1.2 Test Setup with Battery Cells

Figure 3 shows the test setup when using ten Li-Ion battery cells, connected in series. The positive and negative terminals must be connected to terminals J2 and J3 of the BMIC evaluation board RTKA489206DE0000BU to provide a high current path for the charge and discharge currents.Ensure that jumpers J9 and J10 are removed! The measurement terminals of the cells must be connected to header J11 as shown on the figure. Ensure that pins #6 to #12 of header J11 are shorted together to reconfigure the evaluation board for 10S. Always verify the correct pinout on the battery side with a multimeter before connecting the evaluation board. The position of switches S1 and SW1 must be as shown in Figure 3. Ensure that jumper JP1 on the isolated communications dongle ISO_DONGLE_EV1Z Rev.D is available. Connect the DC electronic load RL or the DC power supply ICH (charger) between J7 (Batt+) and J8 (Batt-). Keep in mind that even if the outputs of the load or charger are disabled, the impedance of the terminals can trigger the load detection circuit or result in a high current spike when the CFET and DFET are turned on! The communications dongle provides a galvanic isolation. However, it is a good practice to ground the connected computer.

Important: Ensure that connector P- is grounded. Floating or incorrectly grounded test setup will result in ground loops and additional measurement errors or in some rare cases even damage.

Important: The configuration parameters of the system are tuned for a specific model of Li-Ion battery cell: Samsung INR18650-25R. When running tests with different batteries, ensure that the load current, charger current, voltage limit, and the system settings are tweaked accordingly. Renesas does not take responsibility for any problems that occurred during evaluation with Li-Ion battery cells. Renesas strongly recommends running the initial evaluation with a battery emulator.

Important: Always disconnect the battery cells after finishing the test and store them in a secure container.

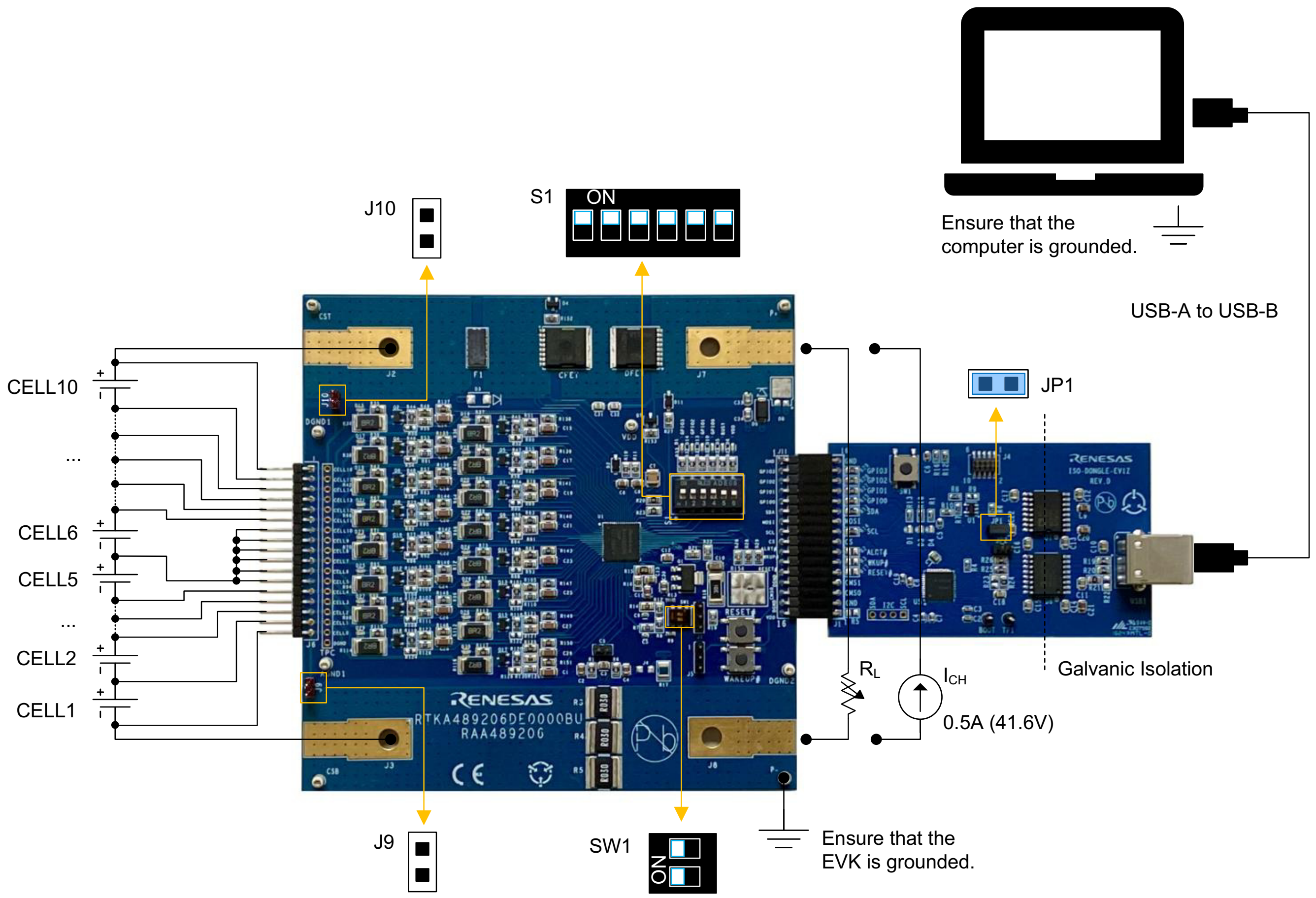

Figure 3. R-BMS B for RAA489206 Test Setup using Li-Ion Battery Cells

2.1.3 Adding a Debugger

Connecting a debugger tool to both test setups is possible from Figure 2 and Figure 3 as demonstrated on Figure 4. The debugger tool (E2/E2 Lite emulator) allows examining the R-BMS B software on a lower level and observing the system behavior in detail. The debugger must be connected directly to the 10-pin JTAG connector J4 of the communications dongle ISO_DONGLE_EV1Z Rev.D. ***Caution***: Keep the correct direction of the flat cable connector and do not rotate it 180 degrees.

Important: The debugger overrides the galvanic isolation of the ISO-DONGLE1Z Rev.D communications dongle. In this case, always ground the computer together with terminals P- of the evaluation board.

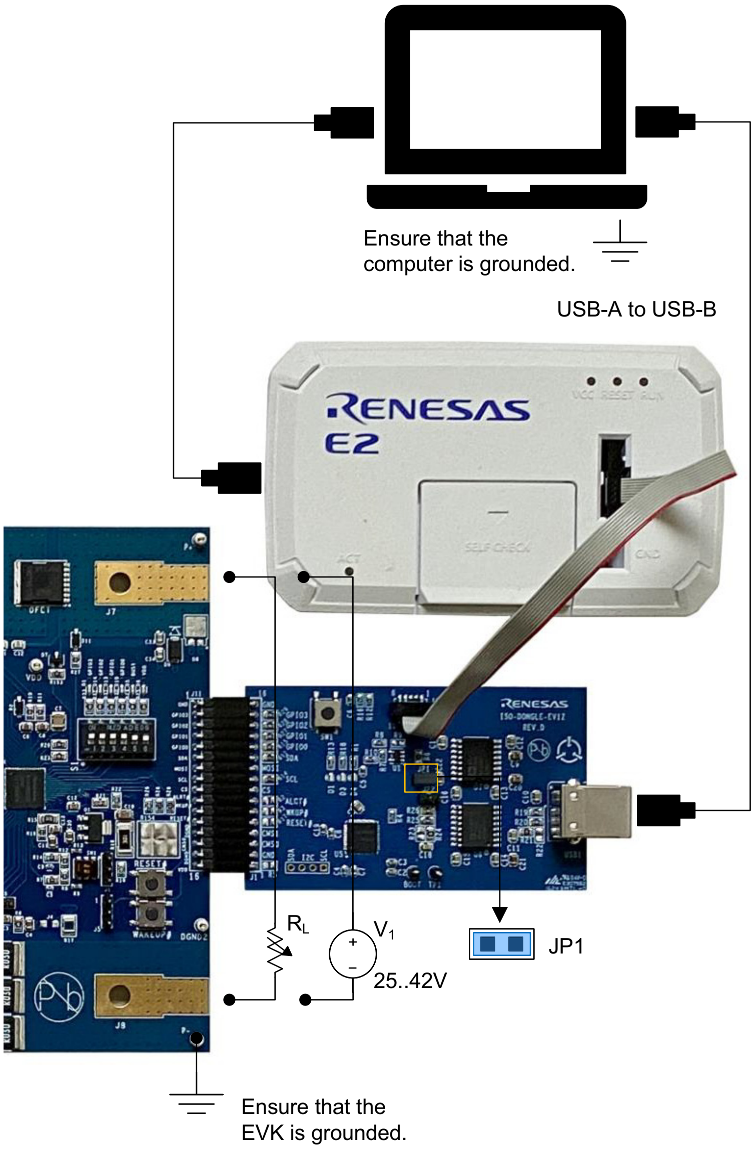

Figure 4. R-BMS B for RAA489206 Test Setup with E2 Emulator

2.2 Software Requirements

A terminal emulator program to connect to the communications dongle is required, so download the software image and open the user interface (UI). Renesas recommends using Tera Term, which can be downloaded from the Tera Term Home Page. This software is required to run the R-BMS B sample code for the RAA489206 and to show the serial connection settings. The PC user must have read/write access permission for the USB port. If Windows recognized the board correctly, it is listed in Tera Term as a serial connection. If the board is not listed at all or the Device Manager indicates an error, there might be a problem with the driver. See the latest support entry for this topic in the Renesas Knowledge Base to resolve this.

Table 2. Serial Connection (Terminal) Settings

Parameter	Value
New Line (Receive)	CR
New Line (Transmit)	CR
Terminal Mode	VT100
Baud Rate	115200
Data Bits	8 bits
Parity	none
Stop Bits	1 bit
Flow Control	none

If connecting a debugger or making any changes in the BMS settings is required, also install the latest version of Renesas e^2 studio Integrated Development Environment (IDE) with the GCC Arm® Embedded toolchain and Flexible Software Package (FSP). Visit e^2 studio for RA Family for instructions and more information.

2.3 Using the R-BMS B Sample Code for RAA489206

There are several ways of using the R-BMS B sample code for RAA489206 and downloading it into the ISO-DONGLE1Z Rev.D isolated communications dongle. Table 3 shows how to use the projects and software images available in the R-BMS B software package for RAA489206. Quickly and easy download the required variant of the R-BMS B software image into the dongle using the built-in bootloader and the terminal emulator. Using the r_bms_b_raa489206_ev1z_rev_d_v_1_0_img.zip e^2 studio project, the system settings can be customized to generate a custom image file. The most advance option for evaluation is to use the 'r_bms_b_raa489206_ev1z_rev_d_v_1_0.zip' end the Renesas e^2 (lite) emulator to debug the project. For detailed information and exact steps, review the *ISO-DONGLE1Z Rev.D Communications Dongle Software Manual*.

Table 3. Sample Code Variants and Downloading Options

#	File Name	Required Hardware	Required Software	Downloading Option	Note
1	raa489206_ev1z_rev_d_bms _v_1_0_img_no_cb.bin.signed	Figure 2, Figure 3	Terminal emulator (Tera Term)	Terminal emulator and Serial USB connection	Cell balancing is disabled.
2	raa489206_ev1z_rev_d_bms _v_1_0_img.bin.signed	Figure 3	Terminal emulator (Tera Term)	Terminal emulator and Serial USB connection	Cell balancing is enabled.
3	r_bms_b_raa489206_ev1z_rev_d _v_1_0_img.zip	None	Renesas e^2 studio IDE with FSP	None (Use the generated software image like options #1 or #2)	This project can be used to generate software images with custom settings! The generated image file can be found in the Debug folder of the project.
4	r_bms_b_raa489206_ev1z_rev_d _v_1_0.zip	Figure 2, Figure 3	Renesas e^2 studio IDE with FSP	IDE and Renesas E2 (Lite) Emulator	Used for debugging. This option erases the default bootloader.

2.4 Connecting and Powering Up the R-BMS B System for RAA489206

2.4.1 When Using a Battery Emulator

1. Verify that the outputs of the power supplies and the electronic load are disabled and that all USB cables are disconnected.

2. Connect the BMS_PS_CELL16Z REV.B battery emulator, RTKA489206DE0000BU BMIC evaluation board, and ISO_DONGLE_EV1Z Rev.D isolated communications dongle (see Figure 2). Ensure that all jumpers are installed and all the switches are in the correct position.
3. Connect the grounding wire.
4. Connect the VBATT four-quadrant power supply to the battery emulator, set the output voltage to 36V, and limit the current to 1A. ***Caution***: Do not enable the output of the power supply.
5. ***Optional***: Execute this step only when using a debugging tool. Connect the E2 emulator to the communication dongle and to the computer (see Figure 4).
6. Using the Tera Term terminal emulator, download the required software image in the communications dongle. (Skip this step if either using a debugger tool or if this procedure has been executed and the communications dongle has the correct software image).
7. Connect the USB cable between the isolated communications dongle and the computer. Ensure that LED D1 is illuminated.
8. ***Optional***: Execute this step only when using a debugging tool. Import the **r_bms_b_raa489206_ev1z_rev_d_v_1_0.zip** project in the Renesas e^2 studio IDE. Disable cell balancing in the system settings. Build the project, start a debugging session, and run the code.
9. Enable the output of the four-quadrant power supply. Ensure that LED VDD is illuminated.
10. On the computer, start the Tera Term terminal emulator and initiate a terminal session by opening a new connection.
11. In the terminal window, press **Enter** to activate the R-BMS B system. The UI must start displaying and periodically updating the important system status and data (Figure 5). When no load or charger is connected, the system enters Sleep mode after a short time (4s by default).

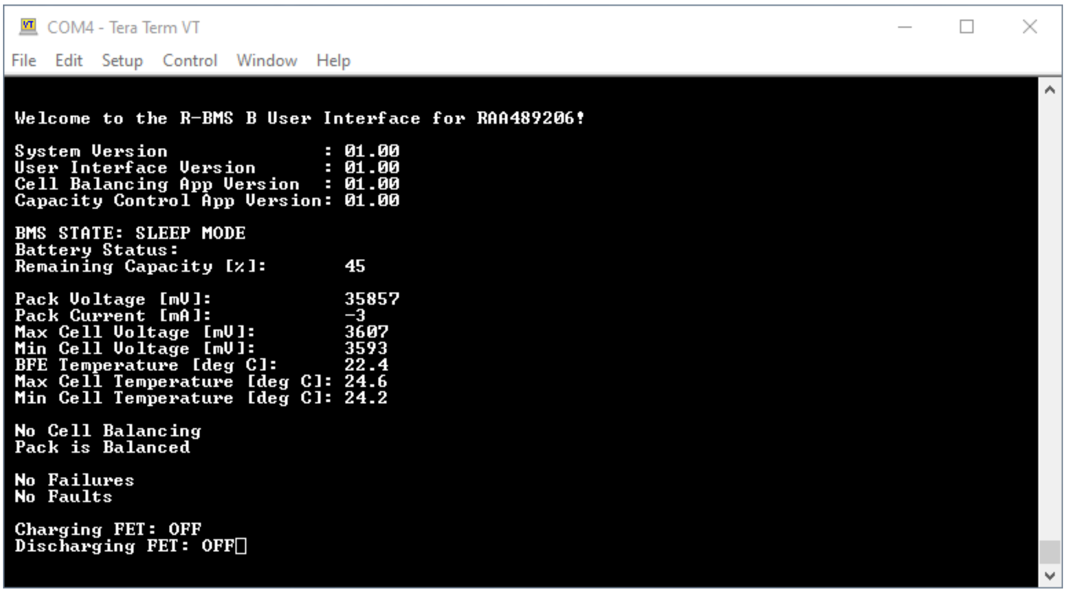

Figure 5. R-BMS B for RAA489206 User Interface – Sleep Mode

12. Connect a load or a charger.
    a. Set the electronic load to consume 0.5A, enable the output, and connect it to the RTKA489206DE0000BU BMIC evaluation board (see Figure 2). The system detects the low impedance of the load and wakes up (see Figure 6).

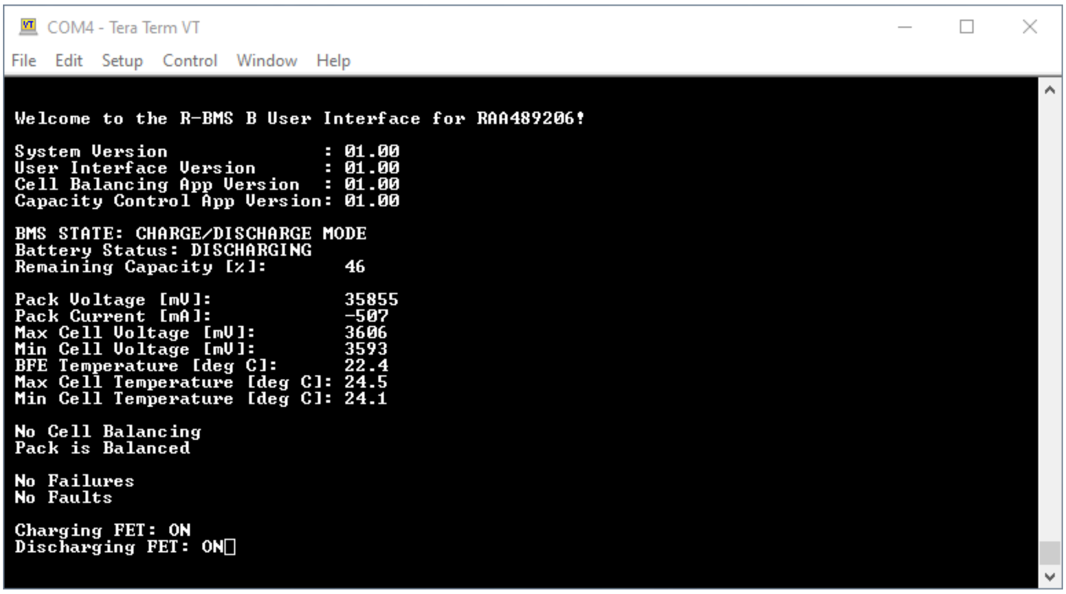

Figure 6. R-BMS B for RAA489206 User Interface – Discharging

b. Configure the ICH power supply to source 0.5A with a voltage limit of 41.6V, enable its output, and connect it to the RTKA489206DE0000BU BMIC evaluation board (see Figure 2). Press the **WAKEUP#** button of the board to emulate a charger detection. The system wakes up (Figure 7).

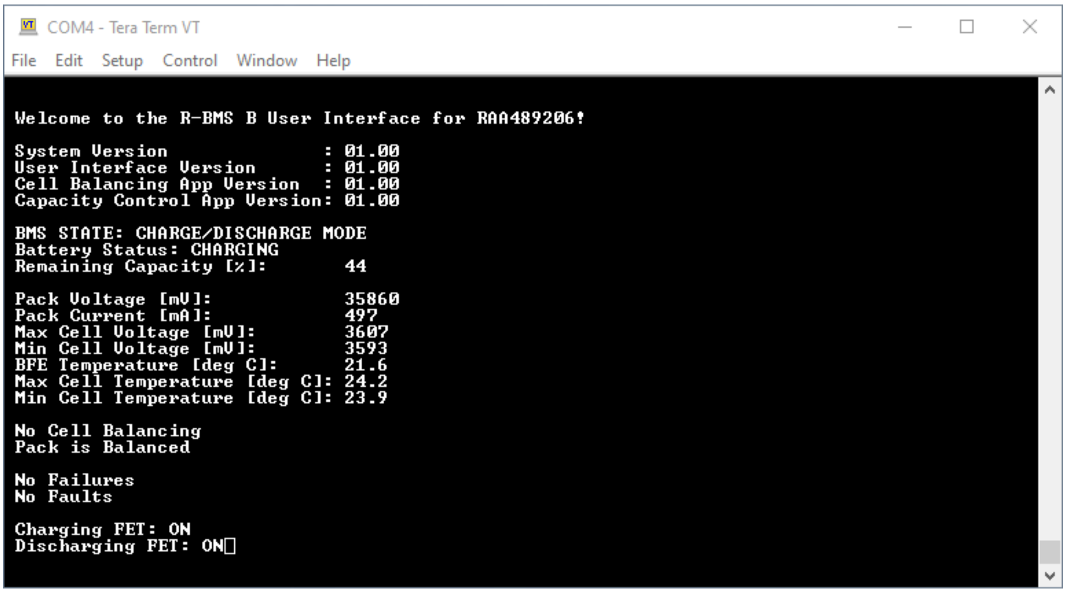

Figure 7. R-BMS B for RAA489206 User Interface – Charging

Note: A load or a charger can be connected and disconnected anytime when the R-BMS B system is active.

Note: When using the E2 emulator and the system goes to Power Down mode, the debugging session is terminated. In this case, disconnect all the USB cables and start again from Step 5.

2.4.2 When Using a Battery Pack[1][2]

1. Verify that the battery cells are disconnected, the outputs of the power supply and the electronic load are disabled, and all the USB cables are disconnected.
2. Connect the RTKA489206DE0000BU BMIC evaluation board and ISO_DONGLE_EV1Z Rev.D isolated communications dongle (see Figure 3). Ensure that all jumpers are installed and all the switches are in the correct position.
3. Connect the grounding wire.
4. ***Optional***: Execute this step only when using a debugging tool. Connect the E2 emulator to the communication dongle and to the computer (see Figure 4).
5. Using the Tera Term terminal emulator, download the desired software image in the communications dongle. (Skip this step if either using a debugger tool or if this procedure has been executed and the communications dongle has the correct software image).
6. Connect the USB cable between the isolated communications dongle and the computer. Ensure that LED D1 is illuminated.
7. ***Optional***: Execute this step only when using a debugging tool. Import the **r_bms_b_raa489206_ev1z_rev_d_v_1_0.zip** in Renesas e^2 studio IDE. Start a debugging session and run the code.
8. Connect the battery cells starting with the negative terminal (see Figure 3). Ensure that LED VDD is illuminated.
9. On the computer, start the Tera Term terminal emulator and initiate a terminal session by opening a new connection.
10. In the terminal window, press **Enter** to activate the R-BMS B system. The UI must start displaying and periodically updating the important system status and data (see Figure 5). When no load or charger is connected, the system enters Sleep mode after a short time (4s by default).
11. Connect a load or a charger.
    a. Set the electronic load to consume 0.5A, enable the output, and connect it to the RTKA489206DE0000BU BMIC evaluation board (see Figure 2). The system detects the low impedance of the load and wake-up (see Figure 6).
    b. Configure the ICH power supply to source 0.5A with a voltage limit of 41.6V, enable its output, and connect it to the RTKA489206DE0000BU BMIC evaluation board (see Figure 2). Press the **WAKEUP#** button of the board to emulate a charger detection. The system wakes up (see Figure 7).

Important: Do not leave the batteries connected and the system running unattended.

1. A load or a charger can be connected and disconnected anytime when the R-BMS B system is active.
2. When using the E2 emulator and the system goes to Power Down mode, the debugging session is terminated. In this case, disconnect all the USB cables and start again from Step 5.

2.5 R-BMS B System Indicators for RAA489206

The UI displays the status of the system, special events, and the state of the CFET and DFET (Figure 8). It also visualizes some highlighted data. When the system has detected a failure or fault, the corresponding field on the display is replaced with a decimal number. This decimal numbers represent the values of the **g_bms_failures.failures** or **g_bms_faults.faults** variables. These numbers can be decoded to identify the exact failure or fault flag. Check the *R-BMS B RAA489206 Sample Code Specification Manual*.

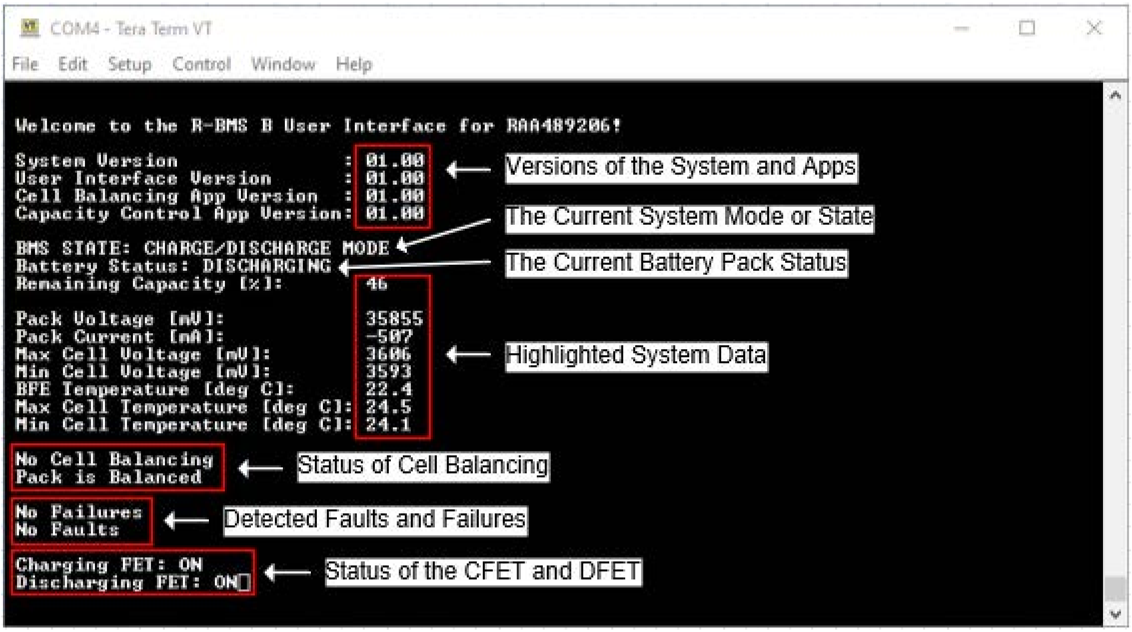

Figure 8. Description of the R-BMS B for RAA489206 User Interface

The LED indicators on the ISO_DONGLE_EV1Z Rev.D isolated communications dongle show the BMS state and Battery Status. Table 4 describes the various combinations and description.

Table 4. ISO-DONGLE1Z Rev.D Board LED Status

D1 Status	D3 Status	D4 Status	Description
OFF	OFF	OFF	The USB cable is disconnected and the MCU is not powered.
ON	OFF	OFF	The battery is disabled and the system is powered down.
ON	ON	OFF	The battery is fully charged.
ON	ON (blinking fast)	OFF	The battery is discharging.
ON	ON (blinking slow)	OFF	The battery is charging.
ON	ON (blinking occasionally)	OFF	The system is in Sleep mode.
ON	OFF	ON (blinking slow)	The system has detected a temporary failure.
ON	OFF	ON	The battery is disabled and the system has detected a permanent failure.

The LED indicators on the RTKA489206DE0000BU BMIC evaluation board show the status of the CFET and DFET, the BMIC voltage regulator and if the BMIC has detected a fault condition (Table 5).

Table 5. RTKA489206DE0000BU Board LED Status

Reference Designator	LED Status	Description
VDD	ON (fully lit)	The BMIC is in Idle or Scan mode
	ON (faded)	The BMIC is in Low Power mode
	OFF	The BMIC is off
BUSY	ON	A fault condition has been detected by the BMIC
	OFF	No fault condition is detected by the BMIC
GPIO0	ON	The CFET and DFET are turned OFF
	OFF	▪ When the BMIC is in Idle or Scan mode: Any FET is turned ON ▪ When the BMIC is in Low Power mode: All FETs are turned OFF
GPIO1	ON	Turning ON of the CFET or DFET is allowed by the MCU
	OFF	The FETs are forced OFF by the MCU
GPIO2	ON	The CFET is ON
	OFF	The CFET is OFF
GPIO3	ON	The DFET is ON
	OFF	The DFET is OFF

3. Revision History

Revision	Date	Description
1.00	May 22, 2025	Initial release.

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