RTK0EF0201DK00001BU

RAA489255 BMS Reference Design Kit for 5-Cell Battery Management Applications

Introduction

This manual provides instructions on how to set up and evaluate the R-BMS B firmware for the RAA489255 reference design. 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 the R-BMS B Monitor Tool.

Contents

1. Introduction

The RAA489255 is an industrial-grade battery manager IC that monitors 3 to 5 Li-based battery cells. Using a 12-bit ADC it accurately measures pack voltage, cell voltage, and temperature. The additional features include pack current detection, high-voltage GPIOs, a trigger button input, and self-testing capabilities. The R-BMS B firmware uses the features of the RAA489255 Battery Management IC (BMIC) and the ultra-low power Renesas ARM-based MCU RA0E1 to demonstrate a battery management system with primary functions like voltage and temperature protection; self-diagnostic and secondary functions like SMBus communication; capacity control and data logging of system events. The R-BMS B firmware for the RAA489255 is designed to run on the RTK0EF0201D00001BU reference board and to communicate with the R-BMS Tool through the Renesas USB SMBus Converter.

1.1 Assumptions and Advisory Notes

- User must possess basic understanding of microcontrollers, embedded systems hardware, battery management systems, and Li-based battery cells.
- User must be familiar with the R-BMS B RAA489255 Firmware Specification.
- User must be familiar with the Renesas RA family ARM Cortex-M microcontrollers.
- User must have prior experience working with Integrated Development Environments (IDEs) such as e^2 studio.
- User must be familiar with the RAA489255 Battery Front End Sample Code Manual.

1.2 Overview of the R-BMS B Firmware for the RAA489255

The R-BMS B firmware for the RAA489255 includes an autonomous battery management system that protects the battery cells, calculates the remaining capacity based on open-circuit voltage, performs data logging on the system parameters and responds to SMBus communication. The state machine flowchart is illustrated in 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.

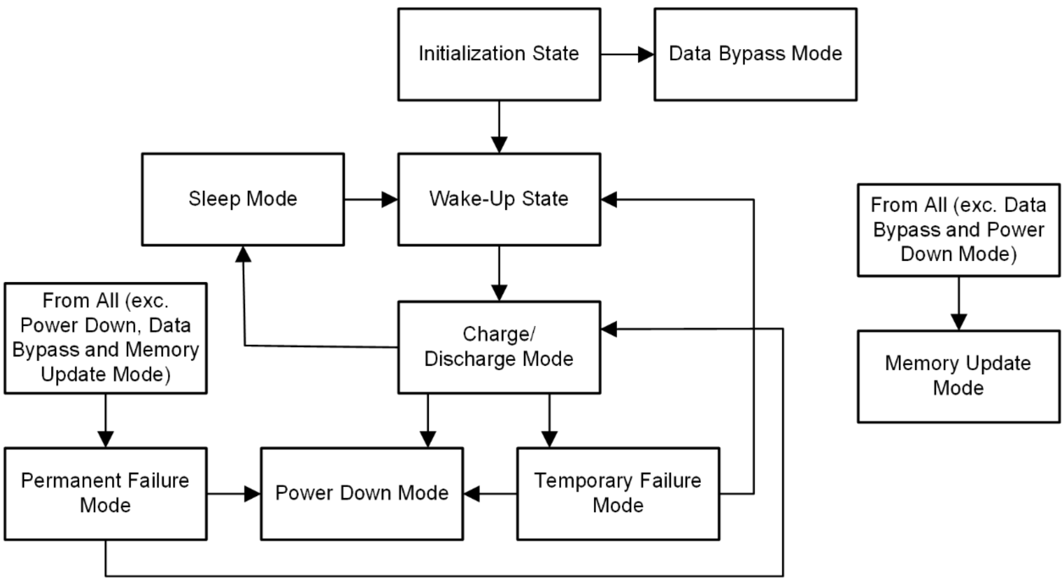

Figure 1. General Flowchart of R-BMS B for RAA489255

During normal operation, the system remains in Charge/Discharge Mode, where it monitors the charging/discharging process. When no pack current is flowing, the system moves to Sleep mode.
There are two types of system failures:

- Temporary faults — When the condition is not critical and the system can recover (that is, undervoltage)
- Permanent failures — When the battery pack is disabled and should not be charged or discharged anymore (that is, critical over-temperature).

The system can wake up by detecting pack current, pressing the **FUNC** or **WKUP** buttons. The system is designed to provide safety functions on different hardware and software levels. It periodically runs self-tests (a self-test of the BMIC, open-wire test and a memory test that validates the content of the configuration registers) to verify the proper operation of these safety mechanisms. The primary safety mechanism is informing the external system (a load or charger) about the detected fault condition. However, in critical situations when the cell voltage is high enough the system can enable the fuse-blowing circuit to permanently disconnect the battery cells from any charger or load and therefore disable the battery pack.

Note: When the fuse blowing circuit is connected and HVGPIO5 is pulled up to pack voltage, the **WKUP** button does not wake up the system because of RAA489255 hardware limitations. In this case, use the **FUNC** button!

The system configuration parameters can be found in two separate files: `src/apps/bal_data.c` and `src/apps/bms_data.c`. The former contains the settings of the BMIC Abstraction Layer that control the BMIC device. The latter contains the system settings. For example, changing the wake-up current threshold requires modifications of parameters in the first file but changing the overvoltage threshold requires modification of parameters in the second file.

Important: Before making any changes to the system configuration parameters, Renesas recommends reviewing the *R-BMS B RAA489255 Firmware Specification* and *RAA489255 Battery Front End Sample Code Manual.*

Important: The R-BMS B firmware is preprogrammed on the RTK0EF0201D00001BU reference board!

2. System Setup for the RAA489255 R-BMS B Firmware

2.1 Hardware Requirements

Table 1 shows the hardware setup required to run and evaluate the R-BMS B firmware for the RAA489255. Renesas recommends during the initial evaluation to use a four-quadrant power supply in combination with the integrated cell emulator (resistor ladder) instead of Lithium battery cells. Another voltage and current limited power supply can be used as a charger and an electronic load as a battery pack load. At a typical operating pack voltage of 18V (3.6V per cell), the reference board (including the integrated cell emulator) consumes around 22mA. Use a precision multimeter as a voltmeter to monitor the battery pack voltage, individual cell voltages, or another voltage of interest.

Important: Do not supply the reference board with more than 21.5V or less than 6V!

Table 1. Hardware Setup

#	Item	Qty.	Description
1	RTK0EF0201D00001BU	1	RAA489255 Reference Board
2	USB SMBus Converter (I/F)	1	Renesas USB SMBus interface adapter
3	USB mini cable	1	USB cable for the USB SMBus Interface
4	SMBus cable	1	SMBus cable for the USB SMBus Interface
5	Four-quadrant power supply	1	Regulated DC power supply, 0V to 30V, 3A
6	Power supply	1	Regulated DC power supply, 0V to 30V, 3A
7	Electronic load	1	Regulated electronic load, 0V to 30V, 3A
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 Renesas E2 (Lite) Emulator and a PC

2.2 Reference Board

2.2.1 Board Overview

The R-BMS B software for RAA489255 runs on the RTK0EF0201D00001BU reference board that contains a RAA489255 BMIC and RA0E1 MCU. The board has a built-in resistor ladder that acts as the emulator for battery cells and is designed to facilitate the user to turn on the system with minimum effort. The high-current connectors, paths and a fuse allow working with real Lithium battery cells. The flexibility of the configuration allows recreation of different application cases and test scenarios. Figure 2 shows a picture of the reference board where all main components relevant to the R-BMS B firmware are highlighted.

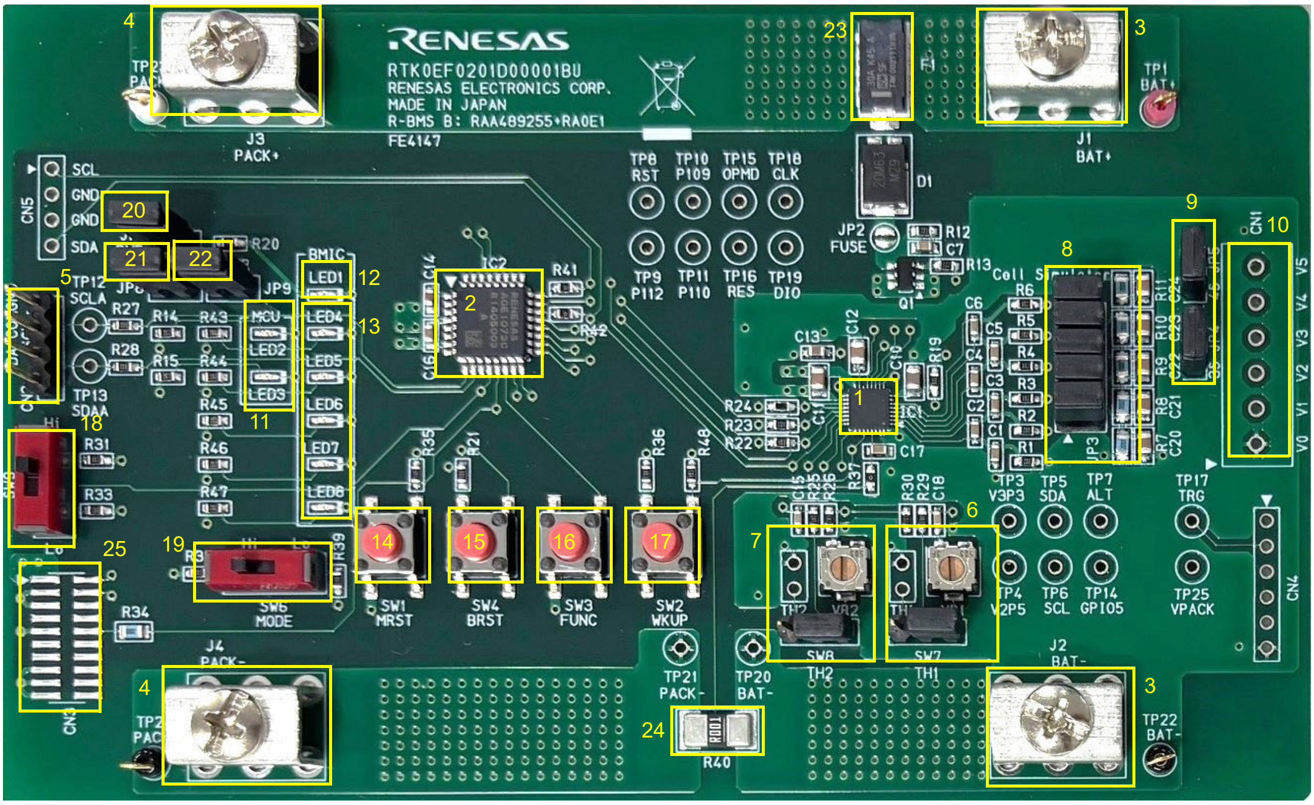

Figure 2. RTK0EF0201D00001BU Reference Board

Table 2 provides a description of the reference board components.

Table 2. Description of the Reference Board

#	Designator	Description
1	IC1	Battery Management IC (RAA489255)
2	IC2	ARM MCU (RA0E1)
3	BAT+, BAT-	Battery connector
4	PACK+, PACK-	Pack connector
5	CN2	SMBus connector
6	TH1	Selection jumper and alternative potentiometer for Thermistor 1
7	TH2	Selection jumper and alternative potentiometer for Thermistor 2
8	JP3	Cell Emulator selection jumpers
9	JP4, JP5	Number of cell configuration jumpers
10	CN1	Cell connection header
11	LED2, LED3	LEDs connected to the MCU (Connected through JP8)

Table 2. Description of the Reference Board (Cont.)

#	Designator	Description
12	LED1	Power LED (Connected through JP1)
13	LED4, LED5, LED6, LED7, LED8	LEDs connected to the BMIC (Connected through JP9)
14	SW1	MCU Reset Button
15	SW4	BMIC Reset Button
16	SW3	FUNC Button
17	SW2	Wake-Up Button
18	SW9	Operation Mode selection switch (Data Bypass Mode Selection)
19	SW6	Firmware Mode selection switch (System/Bootloader)
20	JP1	Power LED activation jumper
21	JP8	MCU LEDs activation jumper
22	JP9	BMIC LEDs activation jumper
23	F1	Self-control protector (fuse)
24	R40	Shunt resistor
25	CN3	Debug connector

2.2.2 Power and Cell Connectors

When using the built-in cell emulator ensure that all jumpers on the header JP3 are placed and the power supply is connected between terminals J1 (BAT+) and J2 (BAT-).

When using battery cells instead of the emulator, ensure that all jumpers on the header JP6 are removed to prevent complete discharging and damage of the battery cells. The high-current wires from the positive and negative terminals of the battery pack must be connected to terminals J1 (BAT+) and J2 (BAT-). The low-current measurement wires coming from each cell must be connected to header CN1.

The reference board supports from 3S to 5S cell configurations. Table 3 shows how to connect the battery cells to CN1 and the state of jumpers JP4 and JP5 to change the number of cells in series.

Important: 3S or 4S configuration are possible only when the specific version of the BMIC and the R-BMS B software are supporting it! The default RAA489255 and R-BMS B software support only 5S!

Table 3. Cell Connection and Configuration for 3S-5S

# of cells[1]	JP4[1]	JP5[1]	Cell1	Cell2	Cell3	Cell4	Cell5
5	Open	Open	V0-V1 (CN1)	V1-V2 (CN1)	V2-V3 (CN1)	V3-V4 (CN1)	V4-V5 (CN1)
4	Open	Closed	V0-V1 (CN1)	V1-V2 (CN1)	V2-V3 (CN1)	V3-V4 (CN1)	-
3	Closed	Closed	V0-V1 (CN1)	V1-V2 (CN1)	V2-V3 (CN1)	-	-

1. When using the battery emulator, ignore the cell connections listed in the table.

2.2.3 Thermistor Inputs

The BMIC has two thermistor inputs (THERM1 and THERM2). The reference board has variable resistors VR1 and VR2 that simulate 10kΩ thermistors. However, it also supports the connecting of real thermistors that must be soldered to pads TH1 and TH2. The user can select between the two options using jumpers SW7 and SW8 (Figure 3). Shorting the left two pins selects the thermistor and shorting the right two pins selects the variable resistor.

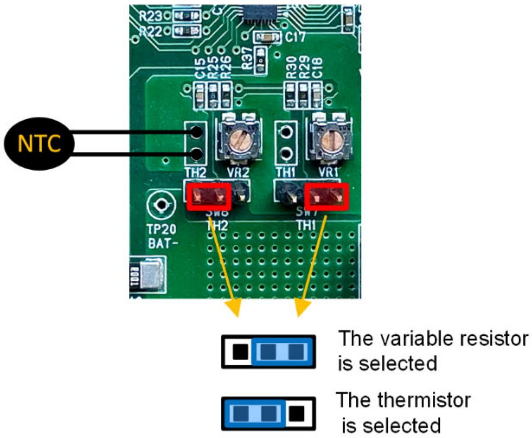

Figure 3. Thermistor Connection Example

2.2.4 Configuration Switches

The reference board has two configuration switches that select between different software options. Table 4 shows the description of the switches and software modes.

Table 4. Description of the Software Configuration Switches

Designator	Name	Description	
		Hi State	Lo State
SW6	MODE	Not used	Not used
SW9	OPMD	Select BMS Operation	Select Data Bypass Mode

2.2.5 Buttons

The reference board has four push buttons with the following functions:

- SW1 (MRST) – MCU reset button: This button pulls down the U2-RES/P206 pin and resets the MCU. It can be used to reset the whole R-BMS B system at any moment of operation.
  Note: After MCU reset and during system initialization, the MCU sends a software reset command to the BMIC.
- SW4 (BRST) – BMIC reset button: This button pulls the U1-THREM2 pin up to V3P3 and resets the BMIC.
  Note: This also resets the voltage regulator supplying the MCU.
- SW3 (FUNC) – Function button: This button pulls the U2-P201 pin down. In the R-BMS B for the RAA489255 firmware, pressing this button enables the LED7-LED11 bar to display the state of charge of the battery pack. It also wakes up the system from Sleep Mode.
- SW2 (WKUP) – System wake-up button: This button pulls the U1-TRIGGER pin up to wake up the BMIC and the whole R-BMS B system. When the fuse blowing circuit is connected and HVGPIO5 is pulled up to pack voltage, the **WKUP** button becomes inactive because of hardware limitations of the RAA489255. In this case, use the **FUNC** button to wake up the device.

2.2.6 LEDs

The LEDs on the reference board can be divided into two groups: connected to the BMIC (LED1, LED4-LED8) and to the MCU (LED2 and LED3). They can be enabled and disabled using jumpers JP1(PWR), JP9(BPWR) and JP8(MPWR).

Table 5 shows the details and purpose of each LED.

Table 5. Reference Board LEDs Description

Designator	Color	Connection	Enable Jumper	Description
LED1	Red	U1-V3P3 (BMIC)	JP1	Power Indicator
LED2	Red	U2-P008 (MCU)	JP8	System alert indicator (see Table 6)
LED3	Green	U2-P009 (MCU)	JP8	System status indicator (see Table 6)
LED4	Red	U1-HVGPIO0 (BMIC)	JP9	Battery State of Charge indicator. The LED bar depicts how full the battery is.
LED5	Green	U1-HVGPIO1 (BMIC)	JP9	
LED6	Green	U1-HVGPIO2 (BMIC)	JP9	
LED7	Green	U1-HVGPIO3 (BMIC)	JP9	
LED8	Green	U1-HVGPIO4 (BMIC)	JP9	

Table 6 describes the status of the system LED2 and LED3.

Table 6. System LEDs Status

LED2 Status	LED3 Status	Description
OFF	ON	The battery is fully charged.
OFF	ON (blinking: 1s period)	The battery is discharging.
OFF	ON (blinking: 2s period)	The battery is charging.
OFF	ON (blinking: on for 1s)	The system is in Sleep mode.
ON (blinking: 2s period)	OFF	The system has detected a temporary failure.
ON	OFF	The system has detected a permanent failure (the battery is disabled).
OFF	OFF	The system is powered down and unresponsive.

2.2.7 SMBus Connector

The reference board has a SMBus connector (Table 7). Using this connector the R-BMS B system can be connected to the Renesas USB SMBus interface adapter, a load, charger or another external device, supporting SMBus communication.

Table 7. SMBus Connector (CN2) Pin Assignments

CN2 Pin	CN2 Signal	U2 (MCU) Pin	Port/Signal
1	COMGND	-	P408/SCL3, P102/SCK0
2	SCL	9	P914/SCLA0_A
3	SDA	10	P913/SDAA0_A
4	N/C	-	-

2.2.8 Debug Connector

The reference board has a 20-pin Cortex® Debug Connector CN3 that provides access to the SWD interface of the MCU. Table 8 describes the pinout of the connector.

Note: The SWD interface GNDDetect pin #9 is hardwired to GND. Renesas recommends using the Renesas E2 (Lite) Emulator to debug the RA0E1 MCU.

Table 8. Debug Connector Description

Debug Connector (CN3)		RTK0EF0201D00001BU
Pin	**SWD Pin Name**	**Signal/Bus**
1	VTref	VCC
2	SWDIO	U2-P108/ SWDIO
3	GND	AGND
4	SWCLK	U2-P300/ SWCLK
5	GND	AGND
6	N.C.	N.C.
7	N.C.	N.C.
8	N.C.	N.C.
9	GNDDetect	AGND
10	nRESET	U2-RES/P206
11	N.C.	N.C.
12	N.C.	N.C.
13	N.C.	N.C.
14	N.C.	N.C.
15	GND	AGND
16	N.C.	N.C.
17	GND	AGND
18	N.C.	N.C.
19	GND	AGND
20	N.C.	N.C.

2.3 Test Setup with a Resistor Ladder

Figure 4 shows the test setup when using the integrated battery emulator. V_{BATT} is a four-quadrant DC power supply powering the reference board. It is connected between J1 (BAT+) and J2 (BAT-). Ensure that all jumpers are installed on header JP3 and no jumpers are installed on JP4 and JP5 to enable the cell emulator for 5 cells in series (see Figure 4). Jumpers JP1, JP8 and JP9 must be installed to enable all LEDs. The jumpers on the thermistor selection headers SW7 and SW8 must be installed on the right to short the middle and the right pins and connect the variable resistors to the thermistor inputs of the BMIC. Selector switches SW6 and SW9 must be set to Hi. Connect the DC electronic load R_L or the DC power supply I_{CH} (charger) between J4 (PACK-) and J2 (BAT-).

Note: With the 1mΩ shunt resistor and because of BMIC hardware limitations, the system might not be able to detect current smaller than 2A. Connect the Renesas USB SMBus interface adapter to header CN2, bearing in mind that pin # 1 is the communication ground.

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

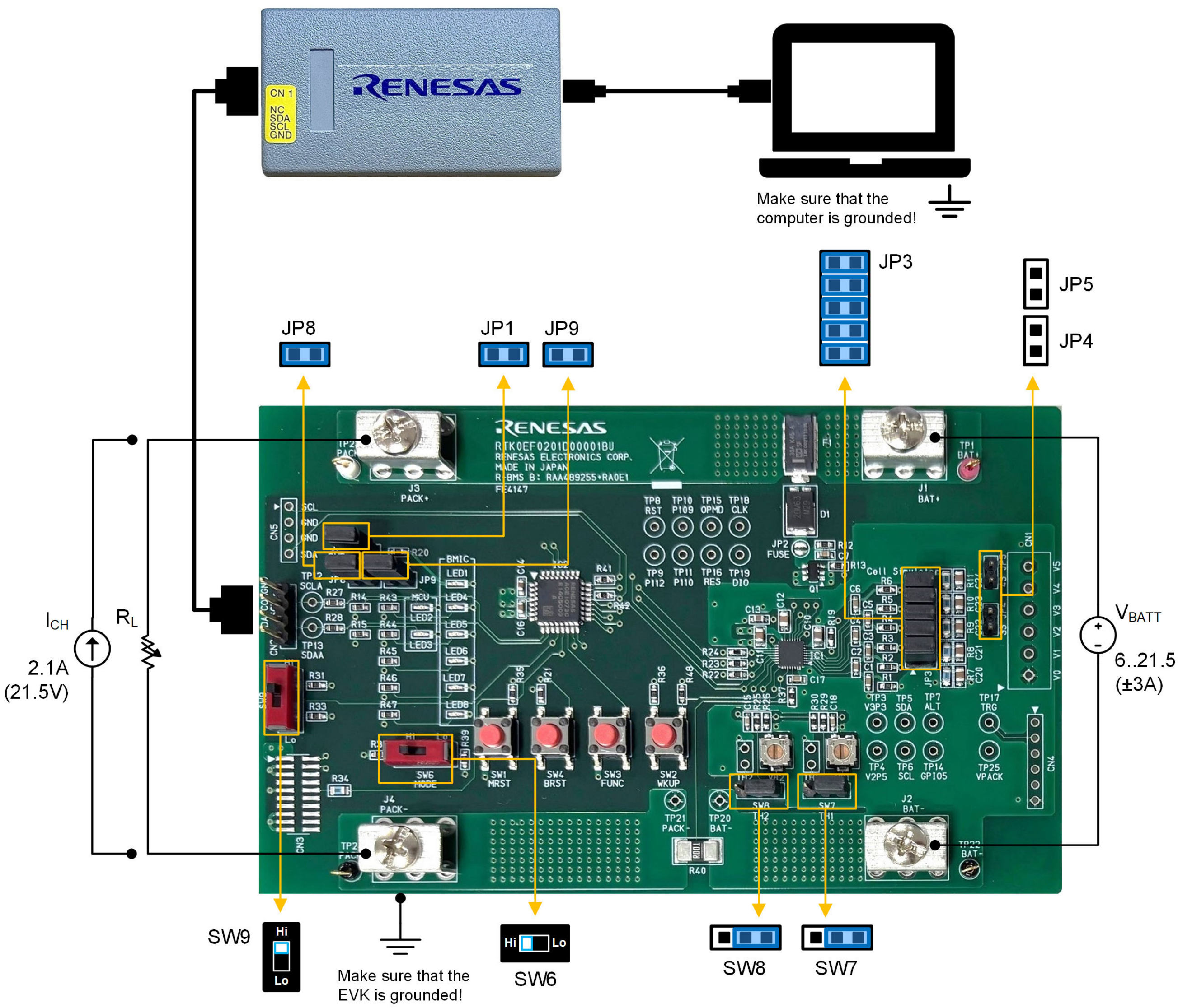

Figure 4. R-BMS B for the RAA489255 Test Setup for 5S using the Integrated Cell Emulator

2.4 Test Setup with Battery Cells

Figure 5 shows the test setup when using five Li-Ion battery cells, connected in series. The positive and negative terminals must be connected between J1 (BAT+) and J2 (BAT-) of the reference board to provide a high current path for the charge and discharge currents.

Important: Ensure that all jumpers on headers JP3, JP4, and JP5 are removed!

The measurement terminals of the cells must be connected to header CN1 as shown in the figure. Always verify the correct pinout on the battery side with a multimeter before connecting the evaluation board. Jumpers JP1, JP8, and JP9 must be installed to enable all LEDs. The jumpers on the thermistor selection headers SW7 and SW8 must be installed on the right to short the middle and the right pins and connect the variable resistors to the thermistor inputs of the BMIC. Selector switches SW6 and SW9 must be set to Hi by default. Connect the DC electronic load R_L or the DC power supply I_{CH} (charger) between J4 (PACK-) and J2 (BAT-).

Note: With the 1mΩ shunt resistor and because of BMIC hardware limitations, the system may be unable to detect current smaller than 2A. Connect the Renesas USB SMBus interface adapter to header CN2, noting that pin # 1 is the communication ground.

Important: Ensure that connector PACK- is grounded. Floating or incorrectly grounded test setup results 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. When running tests with battery cells ensure that the voltage and temperature limits are tweaked accordingly. Renesas does not take responsibility for any problems that may occur during evaluation with Li-Ion battery cells! Renesas strongly recommends running the initial evaluation with the integrated cell emulator.

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

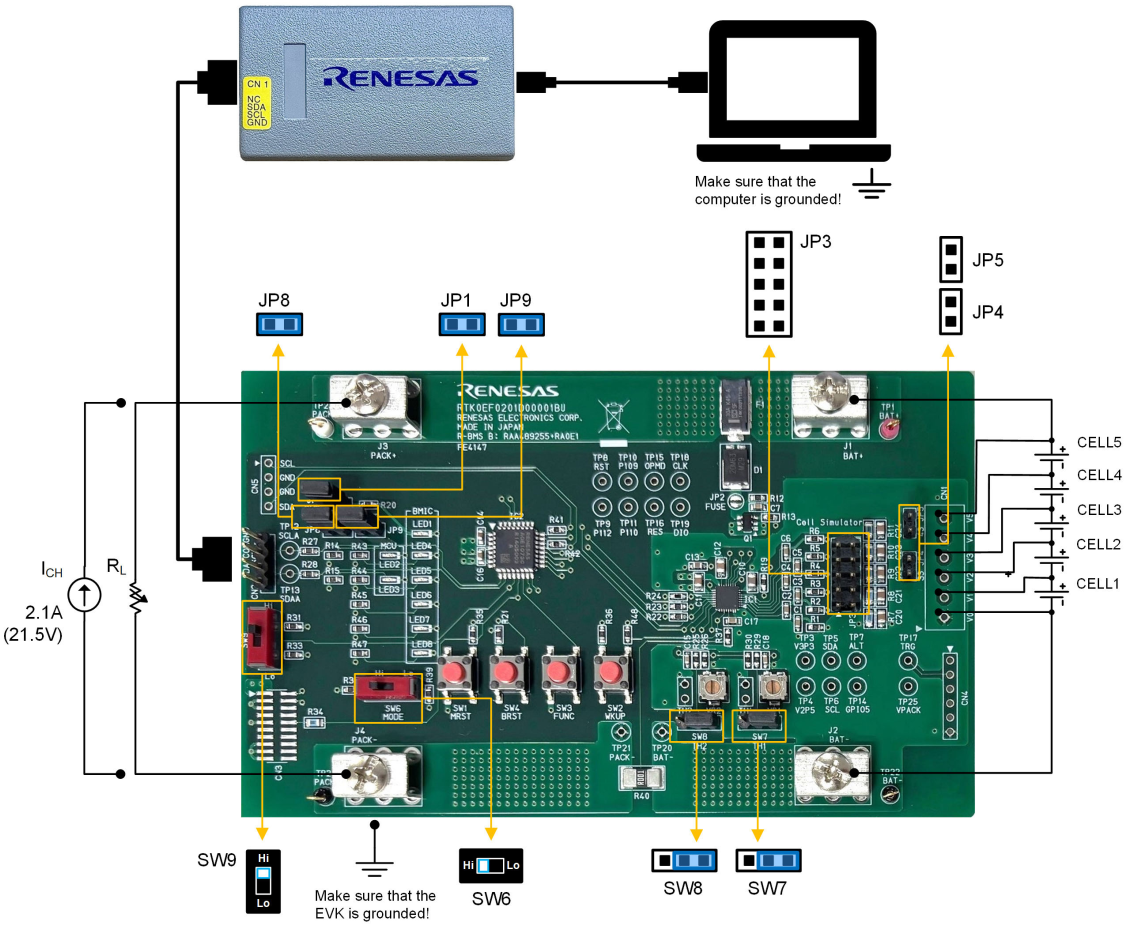

Figure 5. R-BMS B for the RAA489255 Test Setup for 5S using Li-Ion Battery Cells

2.4.1 Adding a Debugger

If required, connect a debugger tool to the test setup as displayed in Figure 6. The E2/E2 Lite emulator allows debugging of the R-BMS B software and observing the system behavior in detail. It is also the recommended option to update the firmware in the MCU memory. The debugger must be connected directly to the 20-pin JTAG connector CN3 of the reference board.

Important: Ensure that the connector is not rotated by 180° and pin 1 is corresponding to the indicator on the silkscreen! When connecting a debugger, always ensure that the evaluation board is grounded.

Figure 6. RTK0EF0201D00001BU Reference Board with E2 Emulator

2.5 Software Requirements

2.5.1 Monitoring Tool

A specialized GUI facilitates the evaluation of the R-BMS B firmware and the RTK0EF0201D00001BU reference board. Use the software tool called R-BMS Monitor Tool GUI to monitor and configure the R-BMS B system (Figure 7). The GUI tool in can be found in the `R-BMS_Monitor_Tool/R-BMS_Monitor_Tool.exe` package. For more information about using the tool, refer to the *R-BMS Monitor Tool GUI Software Manual*.

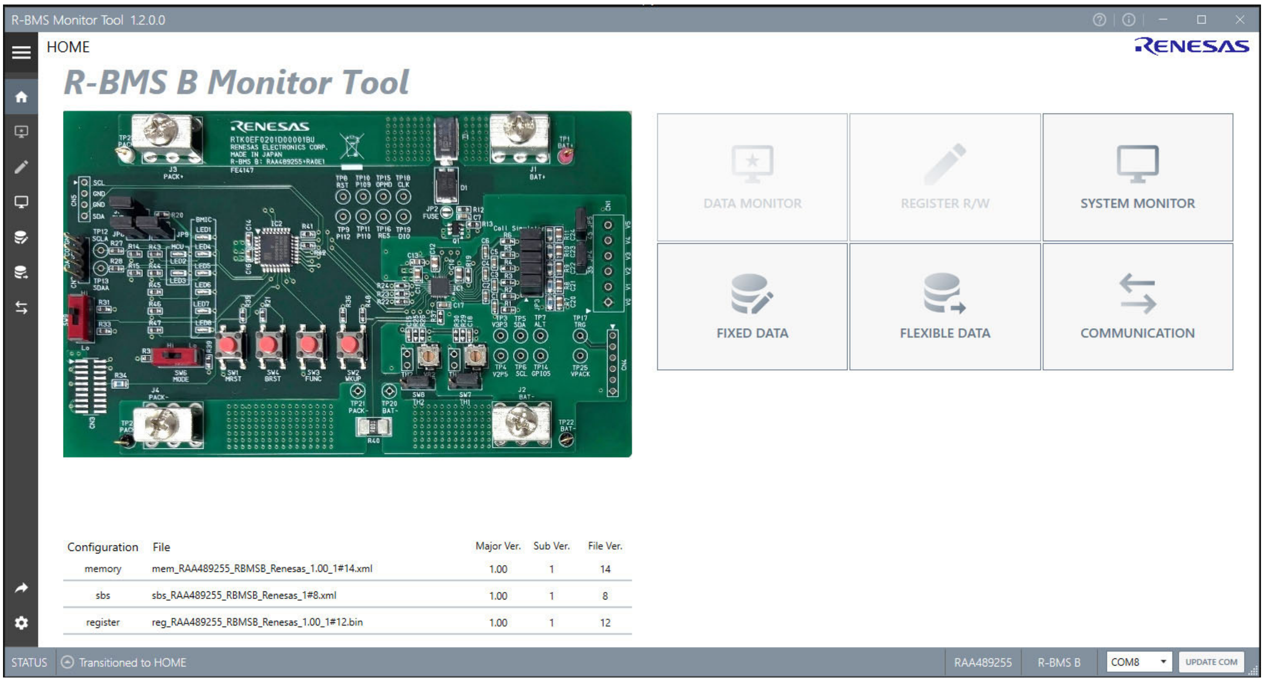

Figure 7. Home Screen of the R-BMS Monitor Tool GUI

The R-BMS Monitor Tool GUI connects to the reference board using the USB SMBus converter (see Figure 4). To use this converter, the USB SMBus interface driver must be installed. To install the tool, complete the following steps:

1. Connect USB SMBus interface to the PC with the USB cable.
2. Complete the following steps depending on the PC OS version.
   a. Windows 10 or Windows 11: The driver is automatically installed to the PC.
   b. Windows 7:
      i. Click on the **Start Menu**, right click on **Computer**, and select **Manage**.
      ii. Select **Device Manager** from the left, look for **Unknown Device** or **CDC USB Demonstration** under **Other devices**. Some OS detects RTK0EF0029Z0000xBx from the beginning.
      iii. Right click on the **CDC USB Demonstration** and choose the **Update Driver Software** option.
      iv. Choose the **Browse my computer for Driver software** option.
      v. Move to the extracted file folder and look for USB SMBus interface driver and select the driver file. (`RTK0EF0029Z0000xBx_Win7.inf`).
      vi. When the installation is successful, it should be in Ports (COM & LPT) category and device name should be RTK0EF0029Z0000xBx.
   c. Windows 8: Steps are the same as Windows 7. Instead of selecting `RTK0EF0029Z0000xBx_Win7.inf`, select `RTK0EF0029Z0000xBx_Win8.inf` in **Win8** folder.

Note: The device driver is included in the installation package!

2.5.2 Updating the Firmware

The R-BMS B firmware for the RAA489255 can be updated on the RTK0EF0201D00001BU Reference Board with E2/E2 Lite Emulator and Renesas Flash Programmer. To download the programming tool and find out how to use it, click here. The object file with the firmware for programming the RA0E1 ARM MCU is available in the package `src/r_bms_b_rtk0ef0201d_v_X_X.srec`.

2.5.3 Debugging the System

If connecting a debugger or making any changes in the R-BMS B software are required, install the latest version of Renesas e^2 studio Integrated Development Environment (2025-04 or greater) with GCC Arm® Embedded toolchain and Flexible Software Package (version 6.0.0). For more information and instructions, see e^2 studio for RA Family. The software project `src/r_bms_b_rtk0ef0201d_v_X_X.zip` is available in the package and can be directly imported in e^2 studio.

Note: The FSP version for the RAA489255 R-BMS B firmware is fixed to 6.0.0.

3. Using the RAA489255 R-BMS B Firmware

3.1 Powering Up the R-BMS B System with the Built-In Battery Emulator

1. Ensure that the outputs of the power supplies are disabled and all USB cables are disconnected.
2. Connect the RTK0EF0201D00001BU reference board and USB SMBus Converter interface adapter as shown in Figure 4. Ensure that all jumpers are installed as shown in the figure and all switches are in the correct position.

   Important: If using Data Bypass Mode is required, set SW9 to Lo. In any other case, ensure that it is set to Hi.
3. Connect the grounding wire to PACK-.
4. Connect the V_{BATT} regulated DC power supply to the BAT+ and BAT- terminals of the reference board. Set the output voltage to 18V and limit the current to 3A. 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 CN3 debugging connector and to the computer as shown in Figure 6.

6. Connect the USB cable between the USB SMBus Converter and the computer.
7. (Optional: Execute this step only when using a debugging tool) Import the `r_bms_b_rtk0ef0201d_v_1_0.zip` project into the Renesas e[2] studio IDE. Build the project, start a debugging session, and run the code.
8. Enable the output of the regulated DC power supply V_{BATT}. Ensure that LED1 is illuminated.
9. Open the R-BMS B Monitor Tool on the computer.
10. In the R-BMS Monitor Tool GUI, ensure that in **TOOL SETTINGS** the selected operation mode is **BMIC + MCU** and then go to **DATA MONITOR** section and click on the **Monitoring** button. The GUI starts reading the SMBus registers and displays the system status and data (see Figure 8). When no current is flowing to or from the battery pack, the system enters Sleep mode after a short time (4s by default).
11. Connect a load or a charger
    d. Set the electronic load to consume 2.1A, enable its output and connect it to the PACK- and BAT- terminals of the reference board as shown in Figure 4.
    e. Configure the I_{CH} power supply to source 2.1A with a voltage limit of 21.5V, enable its output and connect it to the PACK- and BAT- terminals of the reference board as shown in Figure 4.

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

Note: When the fuse blowing circuit is connected and HVGPIO5 is pulled up to pack voltage, the **WKUP** button does not wake up the system because of hardware limitations of RAA489255. In this case, use the **FUNC** button.

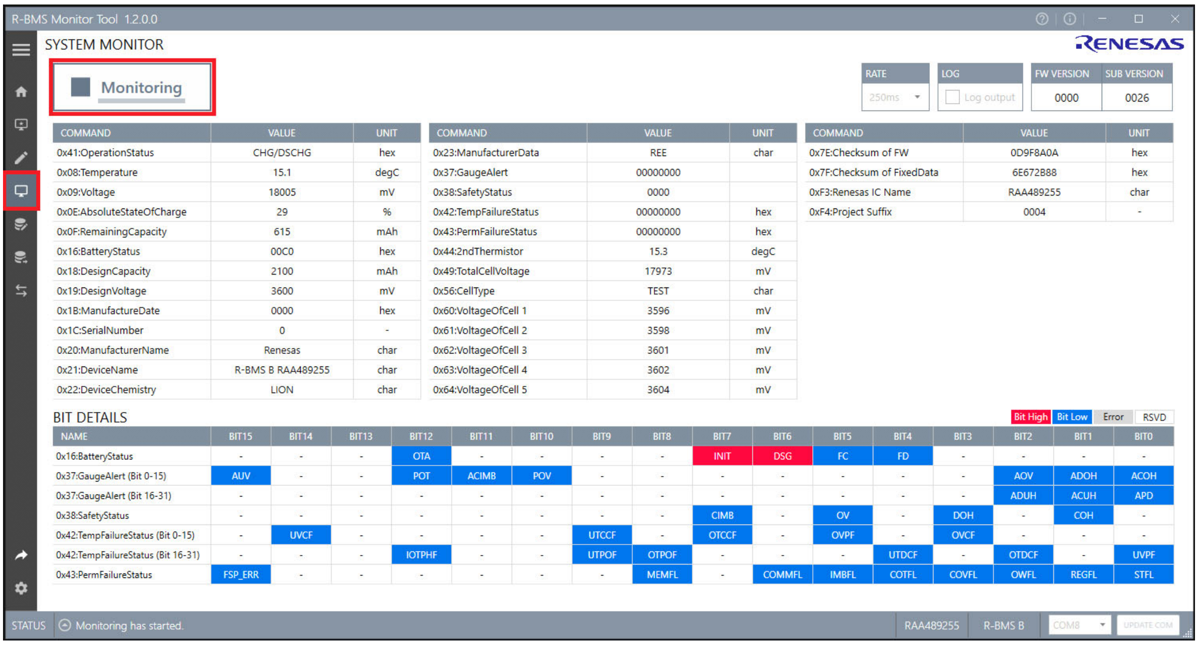

Figure 8. SYSTEM MONITOR Screen in R-BMS Monitor Tool GUI

3.2 Powering Up the R-BMS B System with Battery Cells

1. Ensure that the battery cells are disconnected, the outputs of the power supply and the electronic load are disabled, and all USB cables are disconnected.
2. Connect the RTK0EF0201D00001BU reference board and USB SMBus Converter interface adapter as shown in Figure 5. Ensure that all jumpers are installed as shown in the figure and all switches are in the correct position (There must be no jumpers on SW3, SW4, and SW5).

   Important: If using Data Bypass Mode is required, set SW9 to Lo. In any other case, ensure that it is set to Hi.
3. Connect the grounding wire.
4. (Optional: Execute this step only when using a debugging tool) Connect the E2 emulator to the CN3 debugging connector and to the computer as shown in Figure 6.
5. Connect the USB cable between the USB SMBus Converter and the computer.
6. (Optional: Execute this step only when using a debugging tool) Import the `r_bms_b_rtk0ef0201d_v_1_0.zip` project into the Renesas e^2 studio IDE. Build the project, start a debugging session, and run the code.
7. Connect the battery cells as shown in Figure 5, starting with the negative terminal. Ensure that LED1 is illuminated.
8. Open the R-BMS B Monitor Tool GUI on the computer.
9. In the R-BMS Monitor Tool GUI, ensure that in **TOOL SETTINGS** the selected operation mode is **BMIC + MCU** and then go to the **DATA MONITOR** section and click on the **Monitoring** button. The GUI starts reading the SMBus registers and displays the system status and data (see Figure 8). When no current is flowing to or from the battery pack, the system enters Sleep mode after a short time (4s by default).
10. Connect a load or a charger.
    a. Set the electronic load to consume 2.1A, enable its output and connect it to the PACK- and BAT- terminals of the reference board as shown in Figure 5.
    b. Configure the I_{CH} power supply to source 2.1A with a voltage limit of 21.5V, enable its output and connect it to the PACK- and BAT- terminals of the reference board as shown in Figure 5.

Important: DO NOT leave the batteries connected and the system running unattended!

Note: Connect and disconnect a load or a charger any time 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 USB cables and start again from Step 5.

3.3 Updating the R-BMS B System

1. Ensure that the outputs of the power supplies are disabled and all USB cables are disconnected.
2. Connect the RTK0EF0201D00001BU reference board as shown in Figure 6. Ensure that 20-pin JTAG connector is on the correct position and not rotated.
3. Connect the USB cable between the E2/E2 Lite Emulator and the computer.
4. On the computer open the Renesas Flash Programmer and program the `src/r_bms_b_rtk0ef0201d_v_X_X.srec` object file.

   Important: Ensure that the E2/E2 Lite Emulator is configured to supply the MCU with 3.3V (**Connection Settings → Tool Details… → Power Supply → 3.3V**).

4. RTK0EF0201D00001BU Reference Board

4.1 Schematic

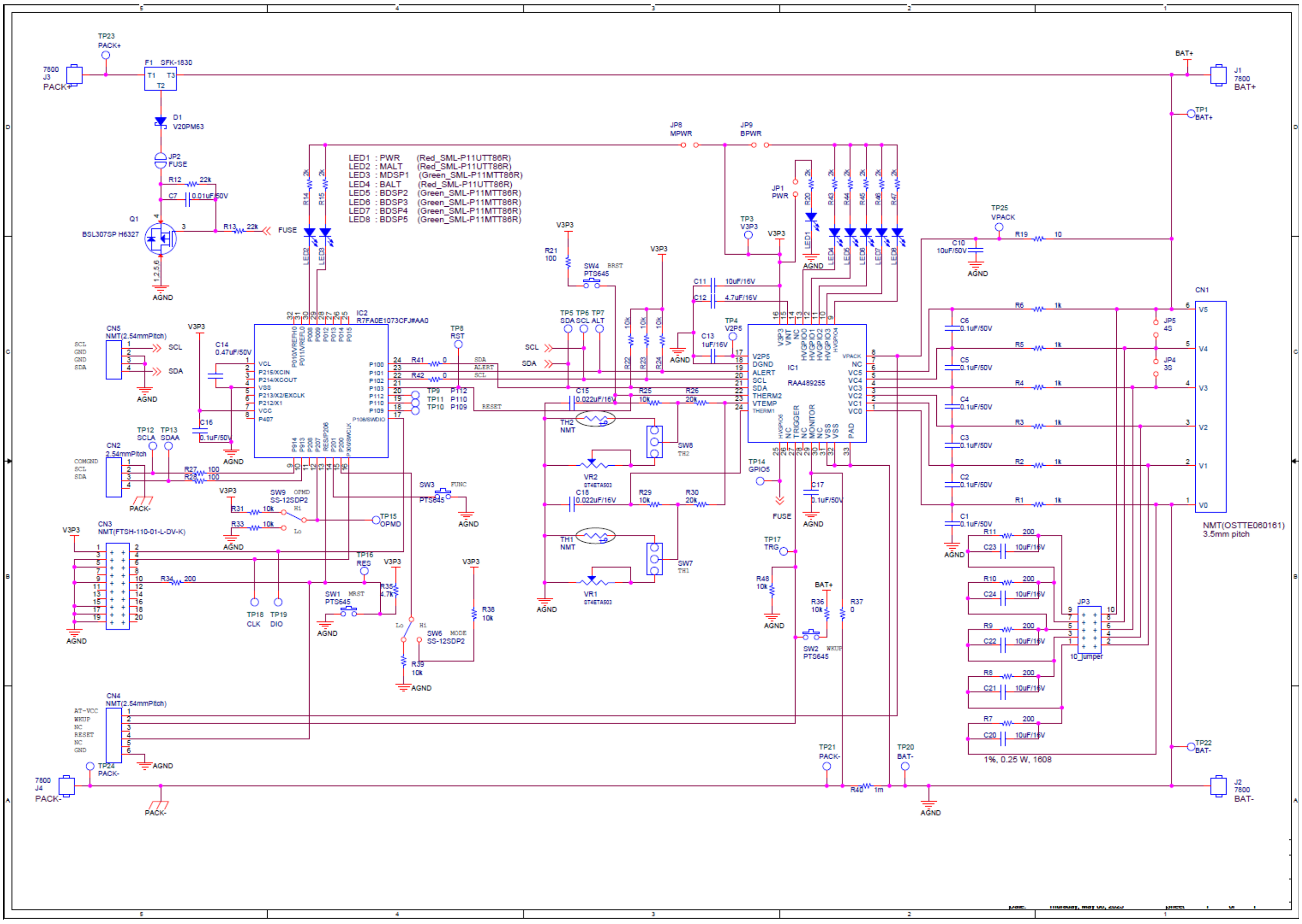

Figure 9. RAA489255 Reference Board Schematic

4.2 Bill of Materials

Table 9. RAA489255 Reference Board Bill of Materials

Designator	Quantity	Value	Description	Manufacturer	Manufacturer Number
R37, R41, R42	3	0	RES SMD 0Ω, JUMPER 1/10W 1608	Rohm	MCR03EZPJ000
R19	1	10	RES SMD 10Ω 1%, 1/10W 1608	Rohm	MCR03EZPFX10R0
R21, R27, R28	3	100	RES SMD 100Ω 1%, 1/10W 1608	Rohm	MCR03EZPFX1000
R1, R2, R3, R4, R5, R6	6	1k	RES SMD 1kΩ 1%, 1/10W 1608	Rohm	MCR03EZPFX1001
R14, R15, R20, R43, R44, R45, R46, R47	8	2k	RES SMD 2kΩ 1%, 1/10W 1608	Rohm	MCR03EZPFX2001
R35	1	4.7k	RES SMD 4.7kΩ 1%, 1/10W 1608	Rohm	MCR03EZPFX4701
R22, R23, R24, R25, R29, R31, R33, R36, R38, R39, R48	10	10k	RES SMD 10kΩ 1%, 1/10W 1608	Rohm	MCR03EZPFX1002
R26, R30	2	20k	RES SMD 20kΩ 1%, 1/10W 1608	Rohm	MCR03EZPFX2002
R12, R13	2	22k	RES SMD 22kΩ 1%, 1/10W 1608	Rohm	MCR03EZPFX2202
R7, R8, R9, R10, R11, R34	6	200	RES 200Ω 1%, 1/4W 2012	KOA	RK73H2ATTD2000F
R40	1	1m	Shunt resistor	Bourns	CRE2512-FZ-R001E-3
VR1, VR2	2	50k	Trimmer Resistor, SMD 50kW 4mm SMD	NIDEC COPAL ELECTRONICS	ST-4EA503
C7	1	0.01µF	CAP CER 0.01µF 50V, X7R 1608	Murata	GCM188R71H103KA37D
C15, C18	2	0.022µF	CAP CER 0.022µF 50V X7R 1608	Murata	GCM188R71H223KA37D
C1, C2, C3, C4, C5, C6, C16, C17	8	0.1µF	CAP CER 0.1µF 50V, X7R 1608	Murata	GRM188R71H104KA93D
C14	1	0.47µF	CAP CER 0.47µF 25V, X7R 1608	TDK	CGA3E3X7R1E474K080AB
C13	1	1µF	CAP CER 1µF 50V, X7R 1608	TDK	CGA3E3X5R1H105K080AB
C12	1	4.7µF	CAP CER 4.7µF 50V, X6S 2012	TDK	C2012X6S1H475K125AC
C11, C20.C21, C22, C23, C24	6	10µF	CAP CER 10µF 16V, X7S 2012	TDK	CGA4J1X7S1C106M125AC
C10	1	10µF	CAP CER 10µF 50V, X5R 2012	Murata	GRM21BR61H106KE43K
D1	1	60V	DIODE SCHOTTKY 60V, 4.9A TO277A	Vishay	V20PM63HM3/H
LED1, LED2	2	RED	LED RED, CLEAR 1005 SMD	Rohm	SML-P11UTT86R
LED3, LED4, LED5, LED6, LED7, LED8	6	GREEN	LED GREEN, CLEAR 1005 SMD	Rohm	SML-P11MTT86R
IC1	1	-	Renesas BMIC	RENESAS	RAA4892553GNP#AA5
IC2	1	-	Renesas MCU	RENESAS	R7FA0E1073CFJ#AA0
Q1	1	30V	MOSFET P-CH 30V, 5.5A 6TSOP	Infineon Technologies	BSL307SPH6327XTSA1
F1	1	30A	Self-Control Protector, 30A	Dexerials	SFK-1830
SW1, SW2, SW3, SW4	4	-	SWITCH TACTILE, SPST-NO 0.05A 12V	Littelfuse	PTS645SK50SMTR92 LFS
SW6, SW9	2	-	SWITCH SLIDE, SPDT 100MA 30V	OMRON	SS-12SDP2
SW7, SW8	2	-	CONN HEADER, VERT 3POS 2.54MM	OMRON	A2-3PA-2.54DSA(71)
J1, J2, J3, J4	4	-	TERM SCREW M4, 6 PIN PCB	KEYSTONE	7800
CN2	1	-	CONN HEADER, VERT 4POS 2.54MM	HIROSE	A2-4PA-2.54DSA(71)
JP3	1	-	CONN HEADER, VERT 5POS 2.54MM	MAC8	WLW-8

Table 9. RAA489255 Reference Board Bill of Materials

Designator	Quantity	Value	Description	Manufacturer	Manufacturer Number
JP1, JP4, JP5, JP8JP9	5	-	CONN HEADER, VERT 2POS 2.54MM	HIROSE	A2-2PA-2.54DSA(71)
JP1, JP3, JP4, JP5, JP8, JP9, SW7, SW8	12	-	CONN SHUNT 2.54MM, GOLD 6.5MM BLK	ASSMANN WSW	AKSCT/G BLACK
TP1	1	-	Test Pin	MAC8	LC-33-G BLACK
TP23	1	-	Test Pin	MAC8	LC-33-G BLACK
TP22, TP24	2	-	Test Pin	MAC8	LC-33-G BLACK

5. Ordering Information

Orderable Part Number	Description
RTK0EF0201DK00001BU	Reference Design Kit (RTK0EF0201D00001BU, Cables, Dongle)

6. Revision History

Revision	Date	Description
1.00	Jun 18, 2026	Initial release.

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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