UM12287

MR-BMS771 reference design

Rev. 1.0 — 30 June 2025 User manual

Document information

Information	Content
Keywords	BMS771, battery management, MR, S32K146, MC33771, UJA1169, NTAG 5, SE051, Mobile Robotics, CAN, NFC, display
Abstract	This user manual describes package contents, programing environments, instructions, board block diagram, and configurations.

1 Introduction

This document is the user manual for the MR-BMS771 reference design. This document is intended for the engineers involved in the evaluation, design, implementation, and validation of MC33771C, 14-channel Li-ion battery cell controller, S32K1 MCU and NTAG 5 near-field communication (NFC) interface.

The scope of this document is to provide the user with information that covers interfacing with the hardware, install the GUI software, using other tools, and configure the board for the application environment.

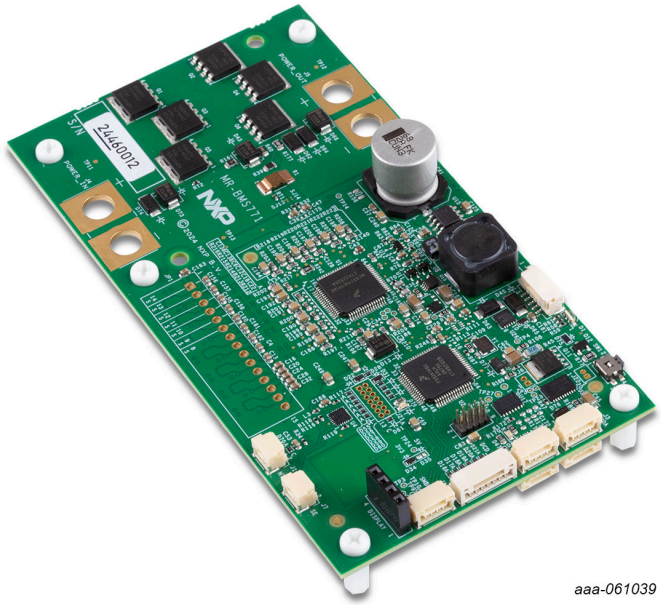

Figure 1. MR-BMS771 board

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2 Finding kit resources and information on the NXP website

NXP Semiconductors provides online resources for this reference design and its supported devices on http://www.nxp.com.

The information page for the MR-BMS771 reference design is at http://www.nxp.com/MR_BMS771. The information page provides overview information, documentation, software and tools, parametric, ordering information and a **Getting Started** tab. The **Getting Started** tab provides quick reference information applicable to using the MR-BMS771 reference design, including the downloadable assets referenced in this document.

2.1 Collaborate in the NXP community

The NXP community is for sharing ideas and tips, ask and answer technical questions, and receive input on just about any embedded design topic.

The NXP community is at http://community.nxp.com.

3 Getting ready

Working with the MR-BMS771 requires the kit contents, additional hardware, and a PC workstation with installed software.

3.1 Kit contents

- Assembled and tested MR-BMS771 in an antistatic bag
- Controller area network (CAN) bus termination resistor (DRONE-CAN-TERM)
- Unmounted cell connectors for 8S to 14S with precrimped wires
- 4-pin JST-GH to 4-pin JST-GH 300 mm cable (CAN)
- Power input and power output connectors
- External thermistor with cable
- Small SSD1306 OLED display
- Quick start guide
- Small cell count selector interposer boards (7 cells to 14 cells)
- An NFC antenna

3.2 Additional hardware

In addition to the kit contents, the following hardware is necessary or beneficial when working with this kit.

- Battery pack (7S to 14S with cell balancing connector), with a range of 15 V to 59 V and a current limit of 30 A DC (up to 30 A DC has been tested)
- Suitable charger for the battery
- Soldering iron to configure the board
- PEmicro multilink universal or SEGGER J-Link mini debugger or other suitable debugger
- Optional: The DCD-LZ adapter

Note: *The MR-BMS771 board is able to open the charge circuit when the battery is overcharging. Therefore, the charger does not need to have a battery management system (BMS) connector.*

3.3 Software

Installing software is necessary to work with this reference design. All listed software is available on the reference design information page at http://www.nxp.com/MR-BMS771.

- S32 Design Studio for Arm-based MCUs (recommended)
- Model-based design toolbox (MBDT) example (recommended)

4 Getting to know the hardware

4.1 MR-BMS771 overview

The MR-BMS771 is a standalone BMS reference design suitable for mobile robotics, such as drones and rovers, supporting 7 cells to 14 cells batteries.

The device performs analog-to-digital conversion on the differential cell voltages and currents. It is capable of accurate battery charge coulomb counting and battery temperature measurements. Also, it could communicate with a flight management unit (FMU) through DroneCAN/CyphalCAN and/or a system management bus (SMBus).

4.2 MR-BMS771 features

The MR-BMS771 integrates the following functions and features:

- Supports battery from 7S to 14S, with stack voltage ranging from 15 V to 59 V
- Measures battery stack and cell voltages, battery charge or discharge current up to 30 A DC tested
- Passive cell balancing option over ~66 Ω balance resistors per cell
- Offers a deep sleep mode (for transportation and storage) with low leakage current, and an automatic sleep mode with low current consumption on the battery
- Allows CAN, I^2C and NFC communication
- Implements serial wire debug (SWD) and joint test action group (JTAG) debugging interfaces, works with standard J-Link and other debuggers
- Implements DCD-LZ combined debug console interface for use with PX4 Dronecode and HoverGames platforms

4.3 Block diagram

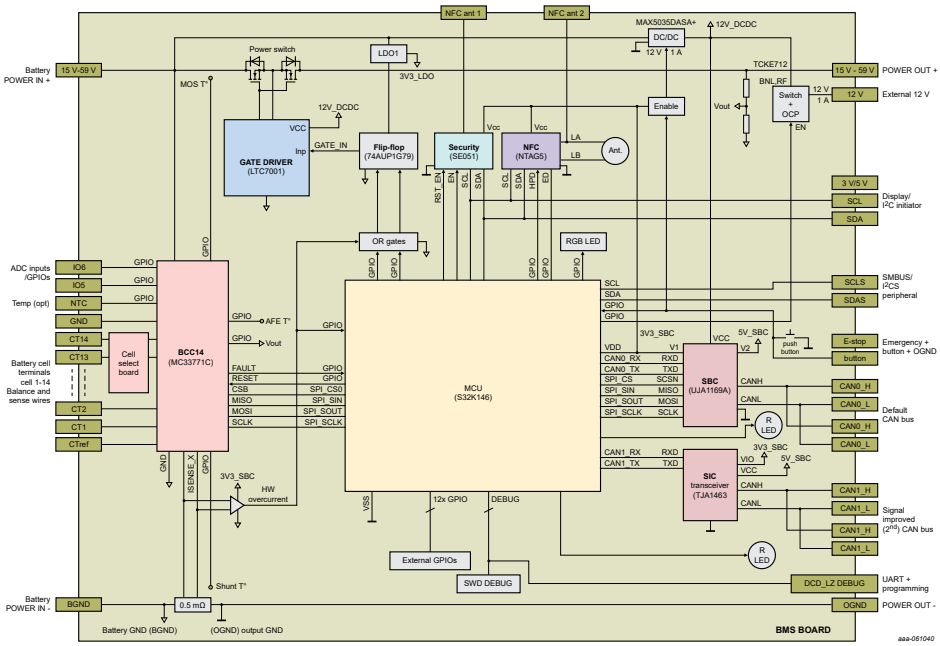

Figure 2. Block diagram

4.4 MR-BMS771 board characteristics

The MR-BMS771 board has been designed and optimized for the operating conditions described in Table 1. Usage of the MR-BMS771 boards out of the range can lead to malfunction and damage.

Table 1. Maximum ratings

Parameter	Min	Max	Unit
Battery input voltage	15	59	V
Battery charge/discharge current (DC)[1]	-	30	A

[1] Up to 30 A DC has been tested with this board.

4.5 Featured components

Figure 3 and Figure 4 identify important components on the board.

Ref D block diagram top

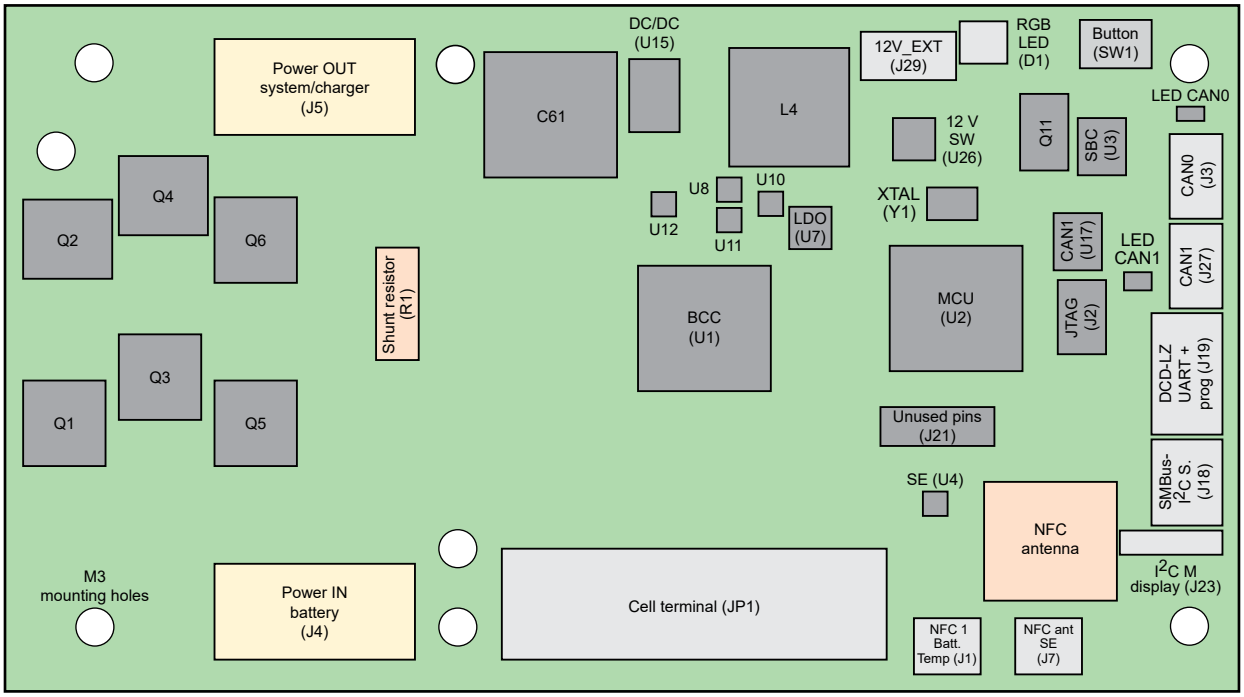

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Figure 3. Featured component placement block diagram (top)

Ref D block diagram bottom

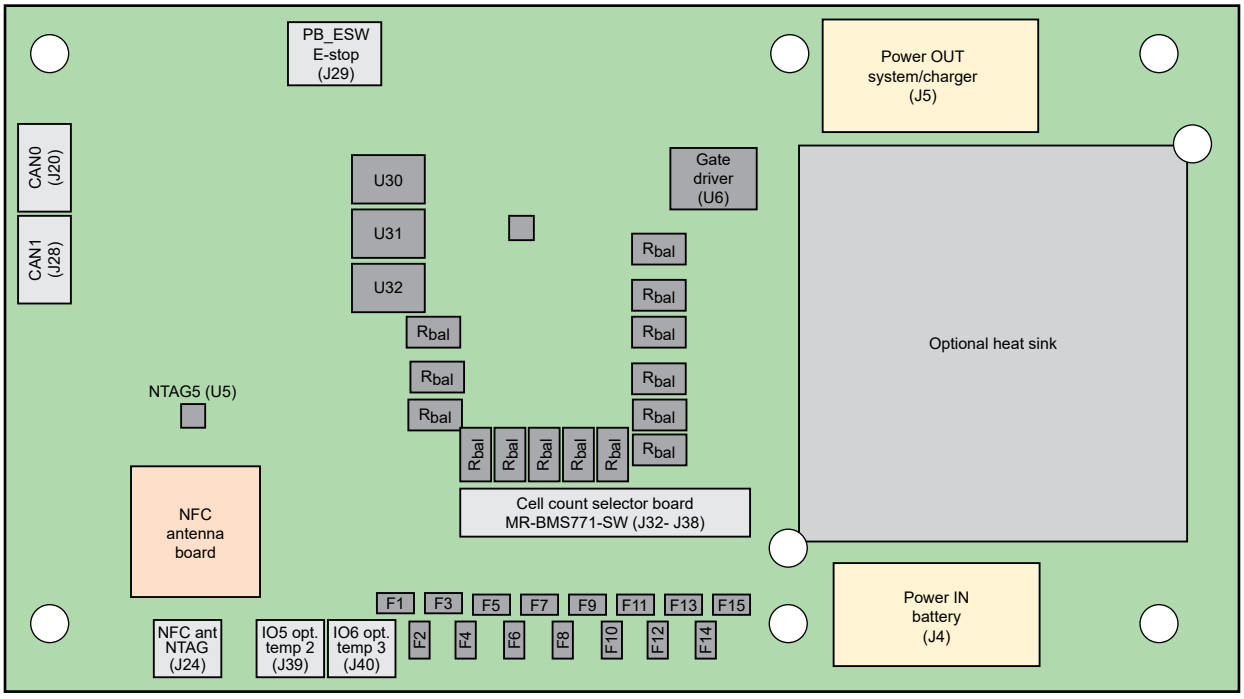

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Figure 4. Featured component placement block diagram (bottom)

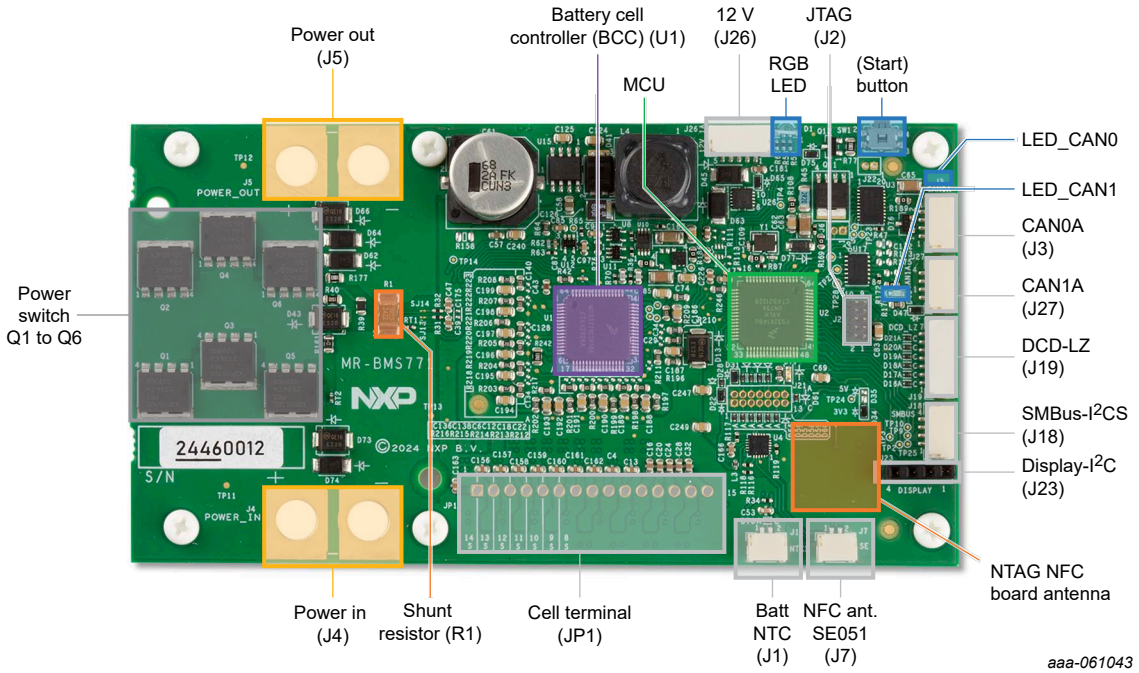

Figure 5. Featured component placement (top)

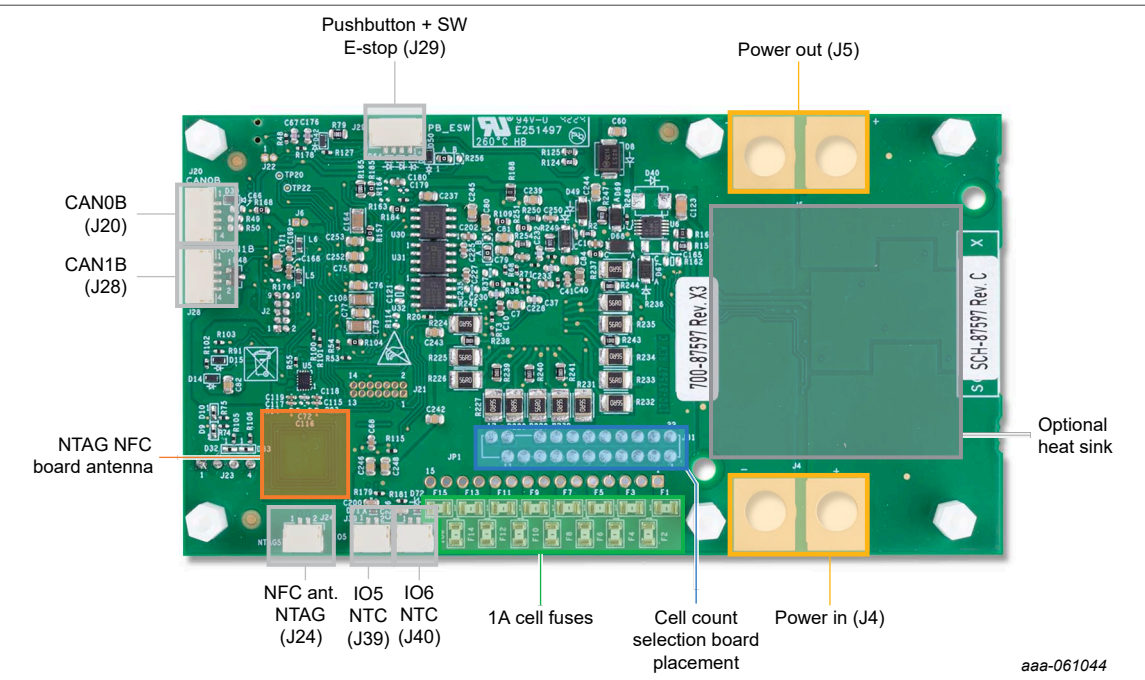

Figure 6. Featured component placement (bottom)

The main featured devices are listed in Table 2:

Table 2. Featured devices

Label	Description	Reference
U1	battery cell controller (BCC)	MC33771CTP1AE
U2	microcontroller unit (MCU)	FS32K146UAT0VLHT
U3	system basis chip (SBC)	UJA1169ATK/F/3
U4	security	SE051
U5[1]	near-field communication (NFC)	NTA53321G10FHK
U17	CAN signal improvement capability (SIC) transceiver	TJA1463ATK

[1] The NTAG 5 chip is not installed for the first batch.

4.5.1 MC33771C: 14-channel Li-ion battery cell controller

4.5.1.1 General description

The MC33771C is a Li-ion battery cell controller IC designed for automotive applications, such as hybrid electric vehicle (HEV) and electric vehicle (EV) along with industrial applications, such as energy storage system (ESS) and uninterruptible power supply (UPS) systems.

The device performs analog-to-digital conversions of the differential cell voltages and current, as well as battery coulomb counting and battery temperature measurements. The information is digitally transmitted through the serial peripheral interface (SPI) or transport protocol link (TPL) to a microcontroller for processing.

4.5.1.2 Features

- 9.6 V ≤ VPWR ≤ 63 V operation, 75 V transient
- 7 cells to 14 cells management
- Isolated 2.0 Mbit/s differential communication or 4.0 Mbit/s SPI
- Addressable on initialization
- Bidirectional transceiver to support up to 63 nodes in daisy chain
- 0.8 mV maximum total voltage measurement error
- Synchronized cell voltage/current measurement with coulomb count
- Averaging of cell voltage measurements
- Total stack voltage measurement
- Seven general-purpose input/output (GPIO)/temperature sensor inputs
- 5.0 V at 5.0 mA reference supply output
- Automatic overvoltage and undervoltage and temperature detection routable to fault pin
- Integrated sleep mode overvoltage and undervoltage and temperature monitoring
- Onboard 300 mA passive cell balancing with diagnostics
- Hot plug capable
- Detection of internal and external faults, such as open lines, shorts, and leakages
- Designed to support ISO 26262, up to ASIL D safety system
- Qualified in compliance with AEC-Q100

4.5.2 Connectors

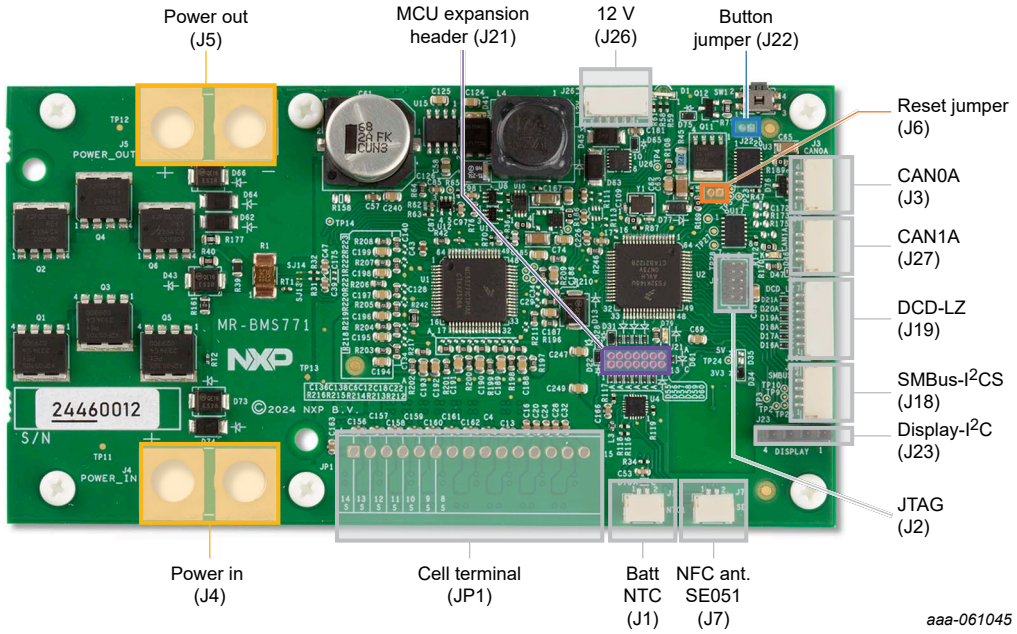

Figure 7. Connectors placements (top)

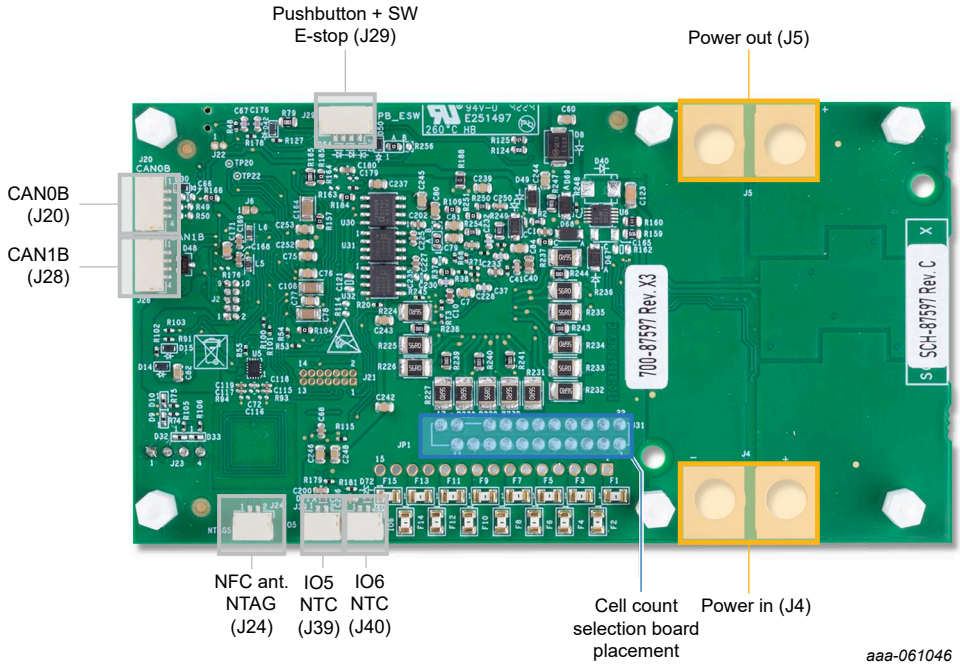

Figure 8. Connectors placements (bottom)

Table 3. Reference design connector description

Label	Description	Manufacturer	Reference	Populated or DNP[1]
JP1	cell terminal connector	J.S.T. Mfg. Co., Ltd.	SxB-XH-A(LF)(SN)	DNP
J1	external temperature sensor	J.S.T. Mfg. Co., Ltd.	SM02B-GHS-TB(LF)(SN)	populated
J2	JTAG debugger	SMD header 10 position 0.050"/1.27 mm (several manufacturers, for example, FTS-105-01-F-D by Samtec)		populated
J3	CAN0 bus	J.S.T. Mfg. Co., Ltd.	SM04B-GHS-TB(LF)(SN)	populated
J4	battery power input	XT90 connectors (several manufacturers, for example, FIT0588 by DFRobot)		DNP
J5	battery power output			DNP
J6	reset jumper	FCI	68000-202HLF	DNP
J7	SE051 antenna connector	J.S.T. Mfg. Co., Ltd.	SM02B-GHS-TB(LF)(SN)	populated
J18	SMBus (I^2C peripheral bus)	J.S.T. Mfg. Co., Ltd.	SM04B-GHS-TB(LF)(SN)	populated
J19	DCD-LZ debugger	J.S.T. Mfg. Co., Ltd.	SM07B-GHS-TB(LF)(SN)	populated
J20	additional CAN0 bus	J.S.T. Mfg. Co., Ltd.	SM04B-GHS-TB(LF)(SN)	populated
J21	MCU expansion header	Sullins Connector Solutions	GRPB072VWVN-RC	DNP
J22	wake jumper	FCI	68000-202HLF	DNP
J23	I^2C controller bus	Würth Elektronik	61300411821	DNP
J24	NTAG 5 antenna connector	J.S.T. Mfg. Co., Ltd.	SM02B-GHS-TB(LF)(SN)	populated
J26	external 12 V output	J.S.T. Mfg. Co., Ltd.	SM05B-GHS-TB(LF)(SN)	populated
J27	CAN1 bus	J.S.T. Mfg. Co., Ltd.	SM04B-GHS-TB(LF)(SN)	populated
J28	additional CAN1 bus	J.S.T. Mfg. Co., Ltd.	SM04B-GHS-TB(LF)(SN)	populated
J29	pushbutton and SW E-stop	J.S.T. Mfg. Co., Ltd.	SM04B-GHS-TB(LF)(SN)	populated
J30	cell select board 7S / MR-BMS771-SW	-	-	-
J31	cell select board place / MR-BMS771-INTERPOSER	-	-	DNP
J32	cell select board 10S / MR-BMS771-SW	-	-	-
J33	cell select board 12S / MR-BMS771-SW	-	-	-
J34	cell select board 13S / MR-BMS771-SW	-	-	-
J35	cell select board 14S / MR-BMS771-SW	-	-	-
J36	cell select board 11S / MR-BMS771-SW	-	-	-
J37	cell select board 8S / MR-BMS771-SW	-	-	-

Table 3. Reference design connector description*...continued*

Label	Description	Manufacturer	Reference	Populated or DNP[1]
J38	cell select board 9S / MR-BMS771-SW	-	-	-
J39	IO5 / ext. temp. sensor 2	J.S.T. Mfg. Co., Ltd.	SM02B-GHS-TB(LF)(SN)	populated
J40	IO6 / ext. temp. sensor 3	J.S.T. Mfg. Co., Ltd.	SM02B-GHS-TB(LF)(SN)	populated

[1] DNP: do not populate.

Note: *Hardware configuration of the board is done via cell selector boards to solder (J32 to J38 on J31).*

4.5.3 Programming and debug

There are two ways to program and debug the MR-BMS771 board:

- Through the DCD-LZ connector (J19)
- Through the JTAG connector (J2)

Note: *The DCD-LZ combines a debug interface with a debug serial console. It is used on RDDRONE-FMUK66 (HoverGames). For more information, see HoverGames gitbook.*

4.5.4 LED

The MR-BMS771 has an RGB LED that can be used for status indications. Various color combinations and blink patterns are used to indicate the state of the battery and system.

There are two red CAN LEDs that could indicate the CAN bus status.

4.5.5 External display

An external display could be used to display important battery information. This display can be connected to J23. This header could be supplied with 3.3 V (D34) or 5.0 V (D35). By switching the diode, 3.3 V or 5 V could be used.

An SSD1306 OLED display is provided with the MR-BMS771 board kit.

4.5.6 External and additional components

4.5.6.1 External components

An optional external temperature sensor can be added onto the MR-BMS771 board using connector J1, J39, or J40. An example of application for this external sensor is used to monitor the cells temperature inside the battery pack.

4.5.6.2 Additional components

Some components are included in the design but are not mounted on the MR-BMS771 original board. They are marked DNP on the schematics and the BOM.

Table 4 provides the list of additional components that can be implemented in the design and their use:

Table 4. Additional features

Feature	Description	Label
Heat sinks	To dissipate more power, a heat sink can be mounted on the bottom side of the board. The recommended part is HSB30-373710.	none
Optional termination resistor network on CAN bus	One 60.4 Ω resistor on each CAN line connected to a 4700 pF capacitor wired to the ground (split termination).	R49, R50, C66
Capacitors on cell measurements connections	A filter can be added to the cell voltage measurements connections, according to the number of cells in use.	C6, C12, C18, C22, C26, C29, C34
Capacitors on external temperature sensor	If the external temperature sensor is implemented, two capacitors can be added on the external temperature sensor low-pass filter for more electromagnetic compatibility (EMC) demanding applications.	C49, C54
Capacitor on cell balancing connections	Capacitors can be added on the cell balancing circuit for EMC, according to the number of cells in use.	C99, C100, C101, C102, C103, C104, C105, C106, C107
External NFC antenna	coil as an alternative option for the printed-circuit board (PCB) NFC antenna for extended range operations	L2
Resistor on gate driver RS pin	resistor to link RS pin on gate driver to MCU	R99
MCU expansion header	Additional MCU pins are wired to a 2 × 7 header slot. Possible uses: additional battery level LEDs, emergency button, and more	J21
Wake jumper	jumper for SBC wake-up (in parallel to the button)	J22

4.5.7 Test points definition

Figure 9 and Figure 10 show the location of the test points on the board.

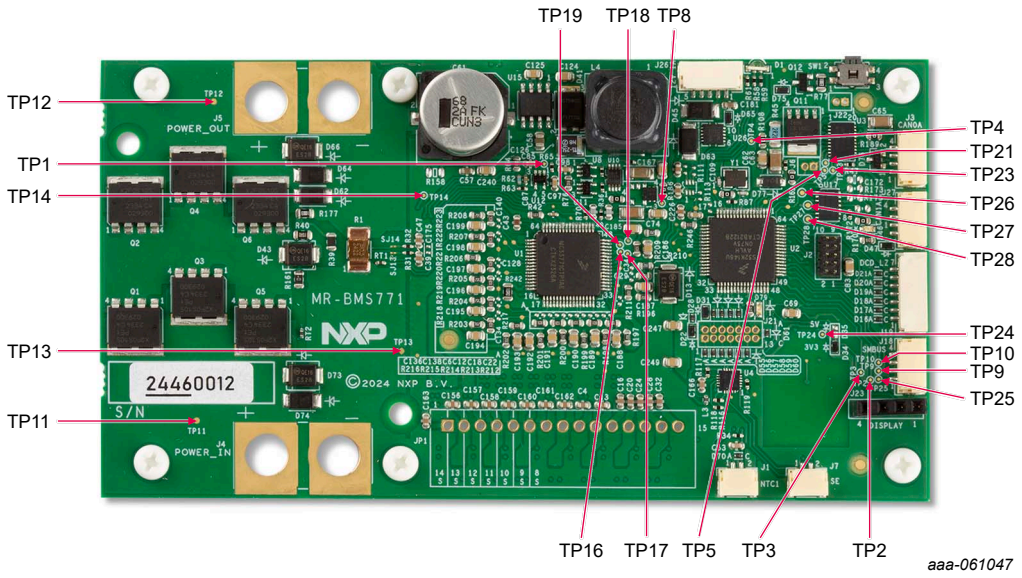

Figure 9. Test points (top)

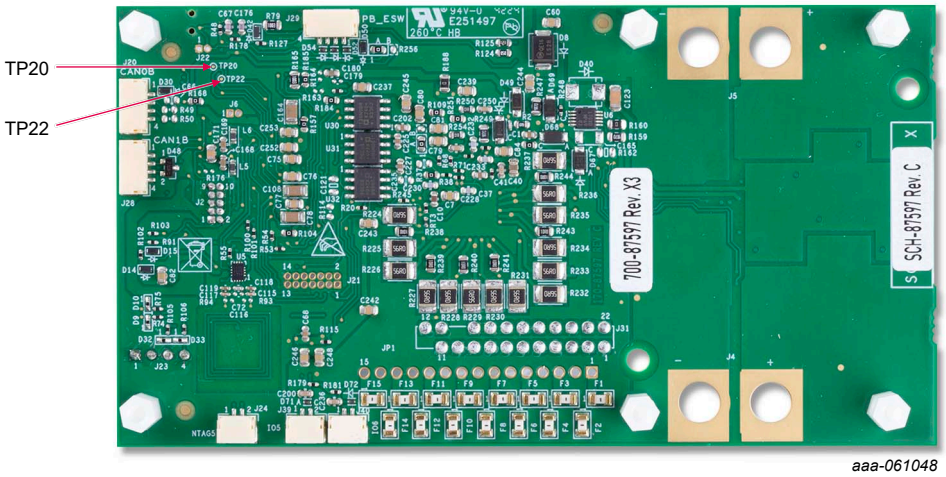

Figure 10. Test points (bottom)

Table 5. Test points

Test point name	Signal name	Description
TP1	OVERCURRENT	overcurrent signal
TP2	SE_NFC_SCL	secure element and NTAG NFC I^2C bus clock signal
TP3	SE_NFC_SDA	secure element and NTAG NFC I^2C bus data signal
TP4	VCC_3V3_SBC	SBC 3.3 V regulator output
TP5	RST_N	reset signal (active LOW)
TP8	VCC_3V3_LDO1	low dropout (LDO) 3.3 V regulator output
TP9	SMBUS_SCL	SMBus I^2C bus clock signal
TP10	SMBUS_SDA	SMBus I^2C bus data signal
TP11	VBAT_IN	voltage input
TP12	VBAT_OUT	voltage output
TP13	BGND	battery ground reference
TP14	Gate	power switches gate command
TP16	BCC_CIPO	BCC SPI bus CIPO out signal
TP17	BCC_CS	BCC SPI bus chip select signal
TP18	BCC_SCLK	BCC SPI bus clock signal
TP19	BCC_COPI	BCC SPI bus COPI input signal
TP20	SBC_CS	SBC SPI bus chip select signal
TP21	SBC_CIPO	SBC SPI bus CIPO signal
TP22	SBC_COPI	SBC SPI bus COPI signal
TP23	SBC_SCK	SBC SPI bus clock signal
TP24	VCC_HARVEST	antenna energy harvesting output
TP25	N/A	SMBus connector pin 1

Table 5. Test points...*continued*

Test point name	Signal name	Description
TP26	CAN1_TX	CAN bus 1 TX signal
TP27	CAN1_RX	CAN bus 1 RX signal
TP28	CAN1_INH	INH pin of U17 (TJA1463ATK)

4.6 CAN bus termination resistor

The MR-BMS771 board does have a CAN termination resistor on the board but this resistor is not placed by default. The board needs a termination resistor network (DRONE-CAN-TERM) to provide termination on any CAN bus. It is used on the last CAN device on the daisy chain, providing a termination at both ends of a CAN bus.

Figure 11. DRONE-CAN-TERM

4.7 Schematic, board layout, and bill of materials

The schematic, board layout, and bill of materials for the MR-BMS771 board are available at http://www.nxp.com/MR-BMS771.

5 Configuring the hardware

5.1 Power connectors

As the MR-BMS771 board aims to be adaptable for every battery setup, power and battery cell termination connectors are not mounted on the PCB. The user can configure the board with the connector.

The power connectors footprints on the design correspond to the DFRobot FIT0588 connector. They are also used for soldering typical silicone insulation heavy gage power wires. TE Connectivity provides a line unmanned power (UMP) connector specifically for professional high-power mobile systems.

5.2 Cell terminal connection

The MR-BMS771 board is configurable to fit 7S to 14S battery packs.

Depending on the desired configuration, some adjustments must be done on the board:

- The correct cell terminal connector must be soldered as JP1 on the top side (7S to 14S connectors are provided in the kit).
- By soldering the correct small cell count selector interposer board, the connection to the cell terminal circuit is done.

5.3 Shunt resistor

The shunt resistor (R1) can be disconnected from the overcurrent protection circuit and the BCC by opening the SJ13 and SJ14 jumpers. Both jumpers are closed by default.

5.4 External NFC antenna

The external antenna is selected by default.

The onboard NTAG 5 chip is designed to provide active antenna matching and amplification and gives enhanced performance when the battery is present and providing power. However, for extended range operation, an external NFC antenna can replace the PCB antenna.

To use the PCB antenna, the user must reconfigure the board using the following steps:

- Place both 0.75 Ω resistors R93 and R94
- Replace C72 (56 pF capacitor) by an 82 pF capacitor and place C116 (680 pF capacitor).

The NTAG 5 chip is not installed for the first batch.

5.5 Optional components

5.5.1 Heat sink

Depending on the application, the user can add an optional heat sink onto the MR-BMS771 board. The recommended part to use as a heat sink is the HSB30-373710.

It is advised to use an electrically isolated layer, but good thermal conductive layer (for example, special adhesive tape) between the BMS771 and the heat sink. The thermal conductive layer improves the thermal conductivity.

6 Startup checklist

6.1 First startup

Figure 12 and Figure 13 present a typical hardware configuration.

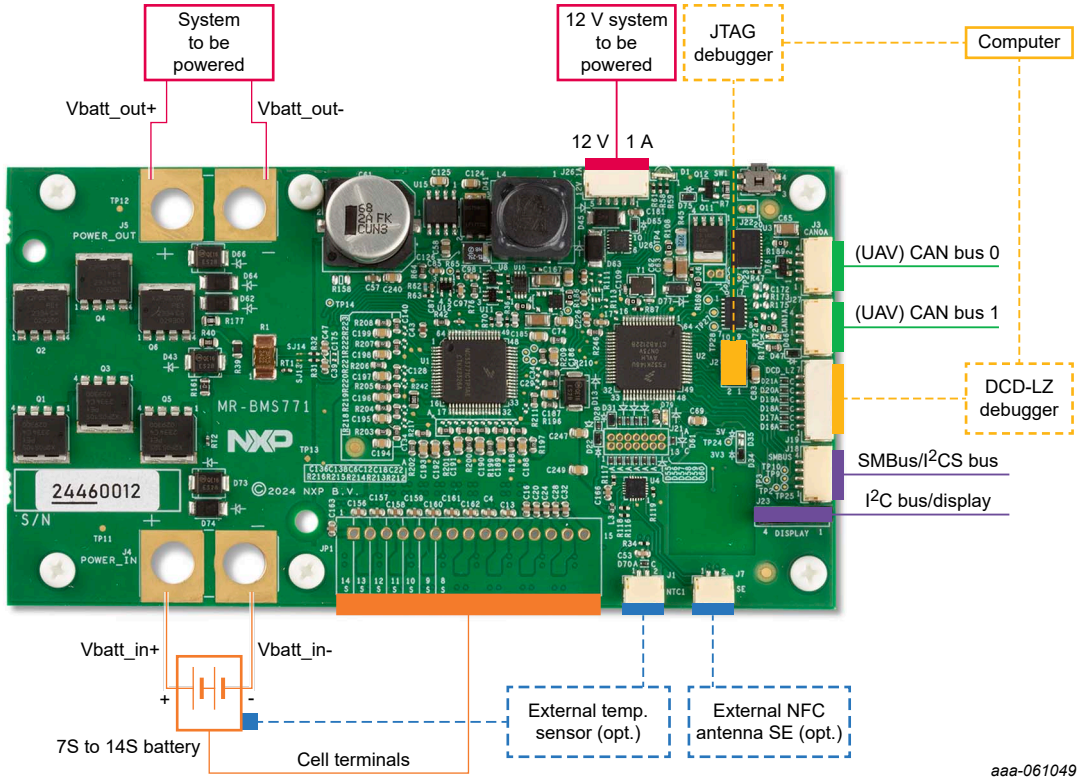

Figure 12. Board components (top)

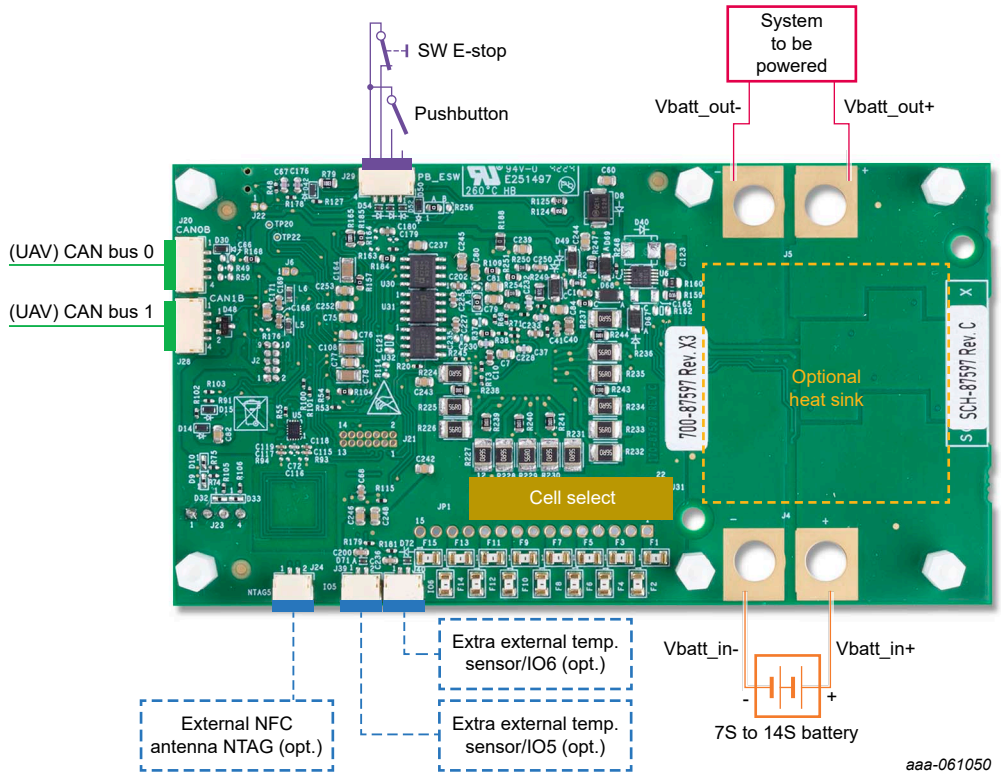

Figure 13. Board components (bottom)

Before the first startup, make sure that the board is configured properly:

1. Solder the correct cell terminal connector at the JP1 location. Ensure it is correctly positioned and aligned.
2. Configure the board for your application by soldering the corresponding small cell count selector interposer board for the cell count.
3. Solder your power in and power out connectors or wires on the J4 and J5 footprints.
4. Configure the board with additional and/or optional components as described in Section 5 "Configuring the hardware" to fit the application requirements.

6.2 Powering the MR-BMS771 board

Once the board is configured properly (see Section 5 "Configuring the hardware" for more details about configuration), connect the board.

To power on the MR-BMS771 board, connect the battery (or power source) to the power input connector (J4) first and then the cell terminal connector (JP1). The correct order protects the boards from internal damage due to hot plugging. Press the small pushbutton (SW1) on the side for the BMS to power the MCU and other electronics. The pushbutton is located next to the 12 V connector.

Similarly, to disconnect the battery from the board, disconnect the cell terminal connector (JP1) first. The power input (J4) can then be disconnected.

7 References

[1] **MR-BMS771** — detailed information on this board, including documentation, downloads, and software and tools http://www.nxp.com/MR-BMS771

[2] **MC33771C** — product information on MC33771C, 14-channel Li-ion battery cell controller IC http://www.nxp.com/MC33771C

[3] **UJA1169** — product information on UJA1169ATK, Mini high-speed CAN system basis chip http://www.nxp.com/products/UJA1169ATK

[4] **S32K** — product information on S32K1 microcontrollers for general purpose http://www.nxp.com/S32K

[5] **NTAG** — product information on NTAG 5 boost, NFC forum-compliant I^2C bridge for tiny devices http://www.nxp.com/NTAG5-BOOST

[6] **TJA1463** — product information on TJA1463 CAN signal improvement capability transceiver with sleep mode http://www.nxp.com/products/TJA1463

[7] **SE051** — product information on the EdgeLock SE051 device http://www.nxp.com/products/SE051

8 Revision history

Table 6. Revision history

Document ID	Release date	Description
UM12287 v.1.0	30 June 2025	initial version

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