UM12146

RDBESS774A3EVB featuring the MC33774A battery cell controller integrated circuit

Rev. 1.0 — 20 September 2024 User manual

Document information

Information	Content
Keywords	MC33774A, HVBESS cell monitoring unit, centralized evaluation board
Abstract	This user manual describes the RDBESS774A3EVB. The board features three MC33774A battery cell controller ICs. With the evaluation board (EVB), the key functions of the MC33774A can be explored.

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1 Introduction

This user manual describes the RDBESS774A3EVB. The board features three MC33774A battery-cell controller integrated circuits (IC).

NXP analog product development boards provide an easy-to-use platform for evaluating NXP products. These development boards support a range of analog, mixed-signal, and power solutions. These boards incorporate monolithic ICs and system-in-package devices that use proven high-volume technology.

2 Finding kit resources and information on the NXP website

NXP Semiconductors provides online resources for this evaluation board and its supported device(s) on http://www.nxp.com.

The information page for the RDBESS774A3EVB evaluation board is at http://www.nxp.com/RDBESS774A3EVB. The information page provides overview information, documentation, software and tools, parametrics, ordering information and a Getting Started tab. The Getting Started tab provides quick-reference information applicable to using the RDBESS774A3EVB evaluation board, including the downloadable assets referenced in this document.

The tool summary page for RDBESS774A3EVB is HVBESS Cell Monitoring Unit (CMU). The overview tab on this page provides an overview of the device, a list of device features, a description of the kit contents, links to supported devices and a Getting Started section.

The Getting Started section provides information applicable to using the RDBESS774A3EVB.

1. Go to http://www.nxp.com/RDBESS774A3EVB.
2. On the Overview tab, locate the Jump To navigation feature on the left side of the window.
3. Select the Getting Started link.
4. Review each entry in the Getting Started section.
5. Download an entry by clicking the linked title.

After reviewing the Overview tab, visit the other related tabs for additional information:

- **Documentation**: Download current documentation.
- **Software and Tools**: Download current hardware and software tools.
- **Buy/Parametrics**: Purchase the product and view the product parametrics.

After downloading files, review each file, including the user guide, which includes setup instructions.

3 Getting ready

Working with the RDBESS774A3EVB requires the kit contents, additional hardware, and a Windows PC workstation with installed software.

3.1 Kit contents

The kit contents include:

- Assembled and tested evaluation board/module in antistatic bag
- Three cell terminal cables
- One transformer physical layer (TPL) cable

3.2 Additional hardware

To use this kit, the following hardware is required:

- A 4-cell to 18-cell battery pack or a battery pack emulator, such as BATT-18CEMULATOR[1].
- A TPL communication system. If a user-specific system is not available, the evaluation setup or the 1500 V HVBESS reference design can be used.
  - The 1500 V HVBESS reference design consist of the HVBESS battery management unit (RD-BESSK358BMU [2]) and the 1500 V HVBESS battery junction box (RDBESS772BJBEVB[3]). For the 1500 V HVBESS reference design, a graphical user interface (GUI) is available.
  - The evaluation setup consists of the FRDM665SPIEVB (EVB for MC33665A)[4] in combination with the S32K3X4EVB-T172 (S32K3X4 EVB)[5]
  - For the evaluation setup, EvalGUI 7[6] is available.

4 Getting to know the hardware

4.1 Kit overview

The RDBESS774A3EVB is a hardware evaluation tool supporting the NXP MC33774A device. The RDBESS774A3EVB implements three MC33774A battery cell controller ICs. The MC33774A is a battery-cell controller that monitors up to 18 Li-ion battery cells. It is designed for use in both automotive and industrial applications. The device performs analog-to-digital conversions (ADC) on the differential cell voltages. It is also capable of temperature measurements and can forward communication via an I^2C-bus to other devices. The RDBESS774A3EVB is an ideal platform for rapid prototyping of MC33774A-based applications that involve voltage and temperature sensing.

The RDBESS774A3EVB measures the pressure of the battery module using the onboard FXPS7250A4ST1 pressure sensor. The RDBESS774A3EVB converts the battery module voltage to 12 V using the TEA1721AT/N1, 118 flyback controller, then converts the 12 V to 5 V to supply the pressure sensor.

The RDBESS774A3EVB uses inductive isolation for offboard communication. The galvanic isolation for onboard communication is established via capacitors.

The RDBESS774A3EVB is also used as part of the 1500 V high-voltage battery energy storage system (HVBESS) reference design consisting of the HVBESS battery management unit (BMU)[2] and the 1500 V HVBESS battery junction box (BJB)[3].

4.1.1 Board description

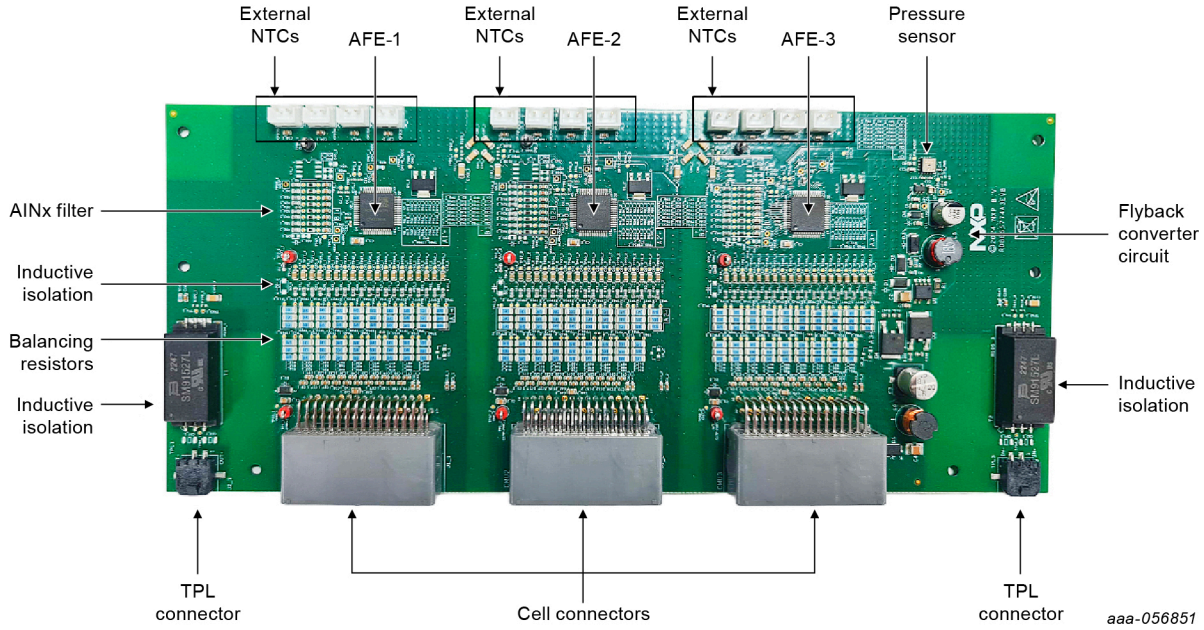

Figure 1. Board description

With the RDBESS774A3EVB, the user can explore all functions of the MC33774A battery-cell controller.

4.2 Board features

The main features of RDBESS774A3EVB are:

- Reference design with three MC33774A, showing an optimized bill of materials (BOM) as outlined in the data sheet

- Capacitive isolation for onboard communication
- Based on NXP core layout for MC33774A; core layout is used for NXP internal electromagnetic compatibility (EMC) and hotplug tests
- Four-layer board, all components are assembled only on the top side
- Cell electrostatic discharge (ESD) capacitors package 0805
- 0805 packages used for all signals with a voltage higher than approximately 25 V
- Three 1206 surface mounted device (SMD) resistors per balancing channel for individual cell-voltage balancing
- All eight external thermistor inputs are available
- Onboard high-performance, high-precision absolute pressure sensor
- Placeholder for I^2C-bus EEPROM
- Can be used together with the 1500 V HVBESS reference design or the evaluation setup

4.2.1 Pressure sensor power circuit

The RDBESS774A3EVB measures the pressure of the battery module using the onboard FXPS7250A4ST1 pressure sensor. The RDBESS774A3EVB converts the battery module voltage to 12 V using the TEA1721AT/N1,118 flyback controller then converts the 12 V to 5 V to supply the pressure sensor.

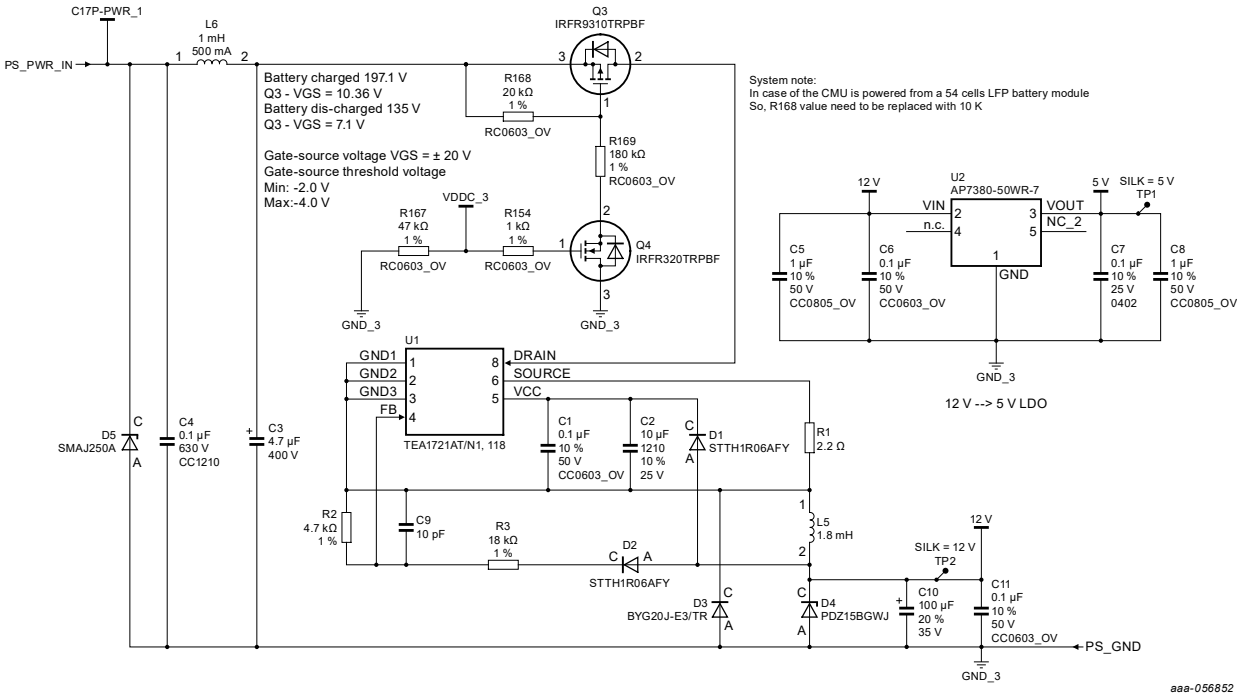

Figure 2. Pressure sensor power circuit

The RDBESS774A3EVB is designed to be used in conjunction with the 18-cell battery emulator board, BATT-18EMULATOR[1].The battery emulation board powers the RDBESS774A3EVB board through it's 5 V power supply.

In the case of replacing the battery emulation board with a battery module that consists of 54 LFP cells in series, the nominal battery module voltage will change to around 173 V on the RDBESS774A3EVB board. Therefore, R168 (20k ohm) should be replaced with 2 0k ohm 0603 resistor for the proper operation of the MOSFET.

4.3 Block diagram

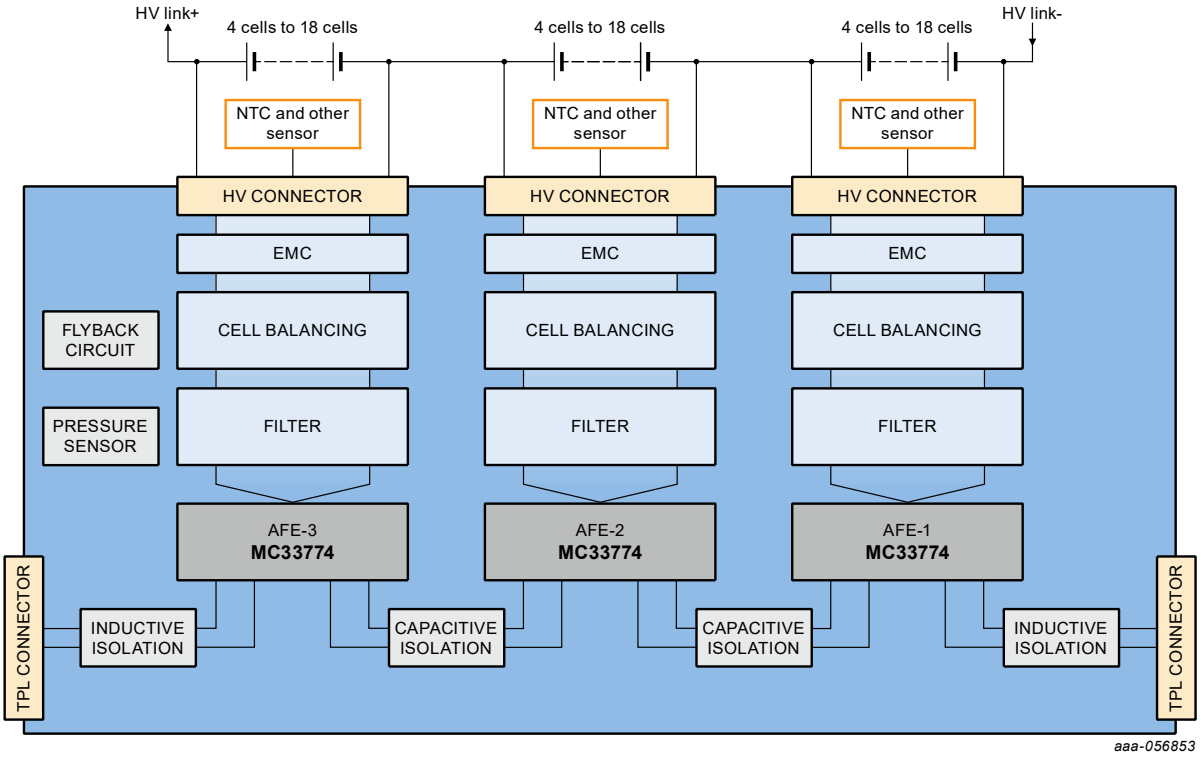

Figure 3. Block diagram

4.4 Kit featured components

- The MC33774A is a battery-cell controller IC designed to monitor battery characteristics, such as voltage and temperature. The MC33774A contains all the circuit blocks necessary to perform battery cell voltage, cell temperature measurement, and integrated cell balancing. The device supports the following functions:
  - AEC-Q100 grade 1 qualified: –40 °C to 125 °C ambient temperature range
  - ISO 26262 ASIL D support for cell voltage and cell temperature measurements from the host microcontroller unit (MCU) to the cell
- Cell voltage measurement
- 4 cells to 18 cells per device
- Supports bus bars voltage measurement with 5/-3 V input voltage
- 16-bit resolution and ±1 mV typical measurement accuracy with ultra-low, long-term drift
- 136 µs synchronicity of cell voltage measurements
- Integrated configurable digital filter
  - External temperature and auxiliary voltage measurements
- One analog input for absolute measurement, 5 V input range
- Eight analog inputs configurable as absolute or ratiometric, 5 V input range
- 16-bit resolution and ±5 mV typical measurement accuracy
- Integrated configurable digital filter
  - Module voltage measurement
- 9.6 V to 81 V input range

- 16-bit resolution and 0.3 % measurement accuracy
- Integrated configurable digital filter
  - Internal measurement
- Two redundant internal temperature sensors
- Supply voltages
- External transistor current
  - Cell-voltage balancing
- 18 internal balancing field effect transistors (FET), up to 150 mA average with 0.5 Ω RDSon per channel (typ.)
- Support for simultaneous passive balancing of all channels with automatic odd/even sequence
- Global balancing timeout timer
- Timer-controlled balancing with individual timers with 10 s resolution and up to 45 h duration
- Voltage-controlled balancing with global and individual undervoltage thresholds
- Temperature controlled balancing; if balancing resistors are in overtemperature, balancing is interrupted
- Configurable pulse width modulation (PWM) duty cycle balancing
- Automatic pause of balancing during measurement with configurable filter settling time
- Configurable delay of the start of balancing after transition to sleep
- Automatic discharge of the battery pack (emergency discharge)
- Constant current cell balancing to compensate the balancing current variation due to cell-voltage variation
- Deep sleep mode (15 µA typ.)
  - Battery module pressure monitoring
- Absolute pressure range: 20 kPa to 250 kPa
- Operating temperature range: –40 °C to 130 °C
- Analog output for monitoring of the absolute pressure signal
- Pressure transducer and digital signal processor (DSP)
- Internal self-test
- Capacitance to voltage converter with antialiasing filter
- Sigma delta ADC plus sinc filter
- 800 Hz or 1000 Hz low-pass filter for absolute pressure
- Lead-free, 16-pin HQFN, 4 mm x 4 mm x 1.98 mm package
  - I^2C-bus master interface to control external devices, for example, EEPROMs and security ICs
  - Configurable alarm output
  - Cyclic wake-up to supervise the pack during sleep and balancing
  - Capability to wake up the host MCU via daisy chain in a fault event
  - Host interface supporting SPI or transformer physical layer 3 (TPL3)
    - 2 Mbit data rate for TPL3 interface
    - 4 Mbit data rate for SPI
- TPL3 communication supports
  - Two-wire daisy chain with capacitive and inductive isolation
  - Protocol supporting up to six daisy chains and 62 nodes per chain
- Unique device ID
- Operation modes
  - Active mode (12 mA typ.)
  - Sleep mode (60 µA typ.)

4.4.1 Connectors

The cells and NTCs connections are available on J1_1, J1_2 and J1_3. See Figure 4. Additional NTCs connections are available on J3_X, J4_X, J5_X, J6_X.

Cell0 is connected between C0M(cell0M) and C1M(cell0P); Cell1 is connected between C1M(cell1M) and C2M(cell1P), and so on ... Cell17 is connected between C17M (cell17M) and C17P (cell17P). C17P-PWR and GND (pin21) are used to supply the AFE and are separated from C17P and C0M respectively, to avoid any voltage drop due to the EVB current consumption.

Optional external 10 KΩ NTCs can be connected between each NTCx terminal and one GND terminal.

- Connector type: JAE MX34032NF2 (32 pins/right angle version)
- Corresponding mate connector reference: MX34032SF1
- Crimp reference for the mate connector: M34S7C4F1c
- Additional NTCs connector type is JST B2B-XH-A(LF)(SN) (two pins/top mount version)
- Corresponding mate connector reference: XHP-2
- Crimp reference for the mate connector: SXH-001T-P0.6N

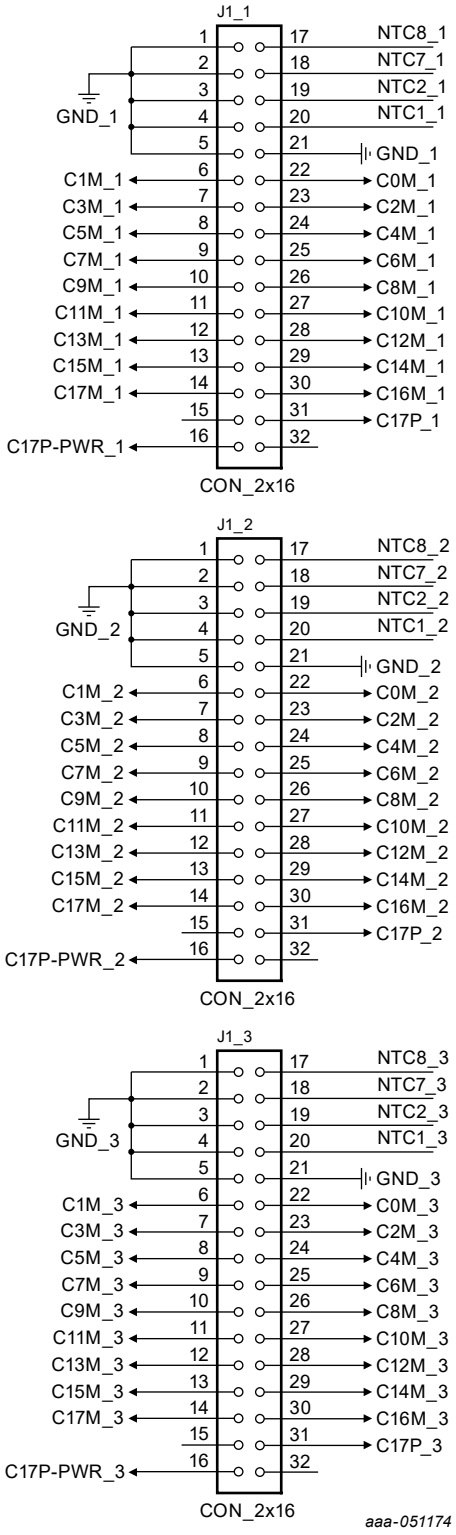

Figure 4. Pinout cell connectors

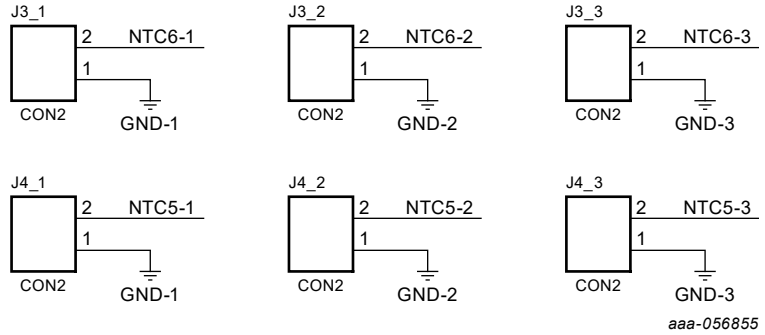

Figure 5. Additional NTCs connectors

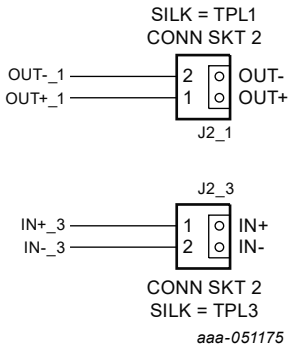

Figure 6. TPL connectors

The TPL connections are available on J2_1 and J2_3. See Figure 6

- Connector type: Molex Micro-fit 3.0, 43650-0213
- Corresponding mate connector reference: 0436450200
- Crimp reference for the mate connector: 0436450201
- Figure 1 shows the location of connectors on the board.

4.5 Schematic, board layout, and bill of materials

The schematic, board layout, and bill of materials for the RDBESS774A3EVB evaluation board are available at http://www.nxp.com/RDBESS774A3EVB.

4.6 Accessory boards

4.6.1 NXP 1500 V HVBESS reference design

The NXP 1500 V HVBESS reference design is a scalable SIL 2 architecture for high-voltage applications, composed of three modules: BMU, CMU, and BJB.

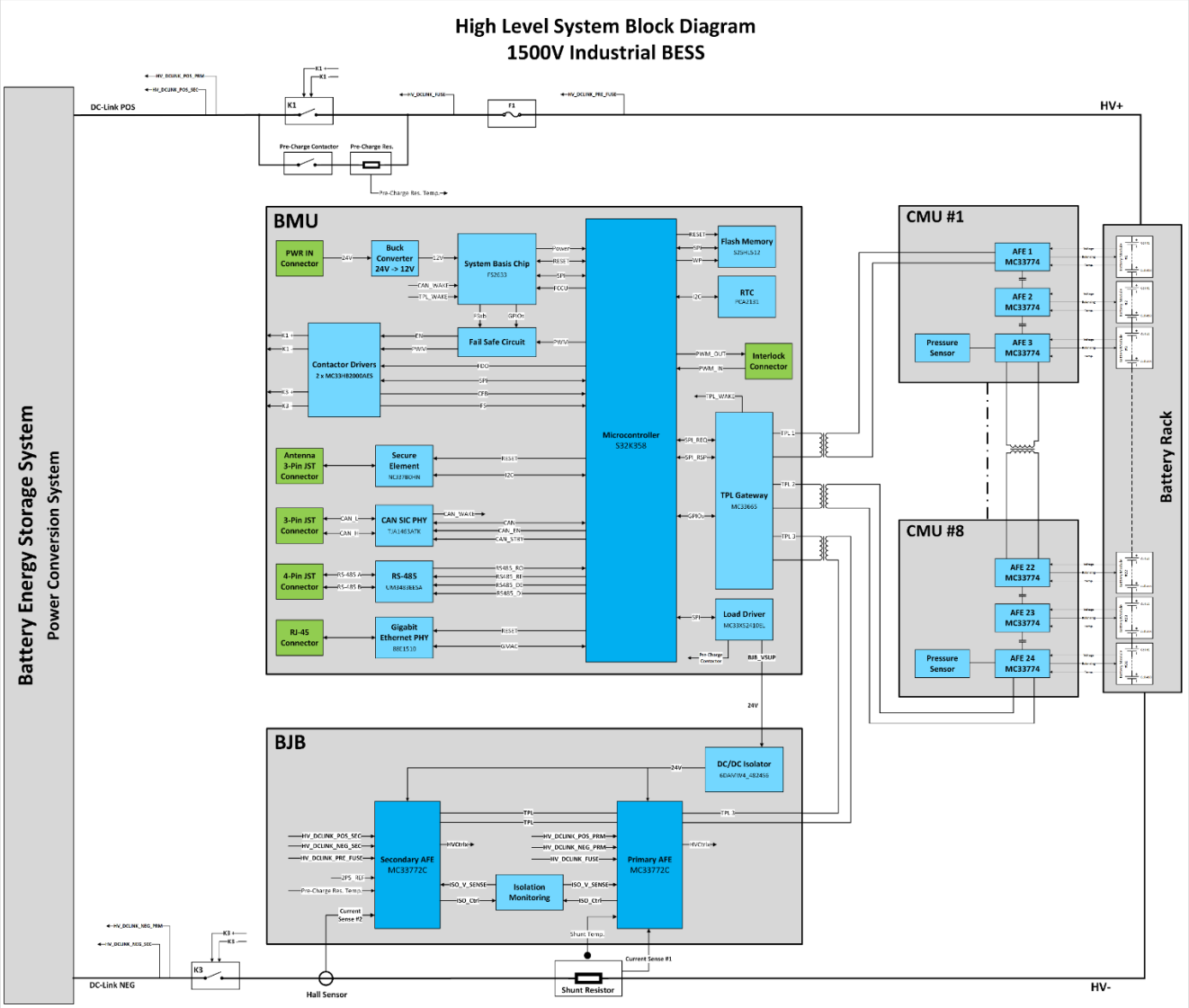

Figure 7. BESS reference design

4.6.2 FRDM665SPIEVB

The RDBESS774A3EVB kit is designed for use with the FRDM665SPIEVB[4]. The FRDM665SPIEVB is an evaluation board for MC33665A, a gateway router that can route TPL messages from the microcontroller (MCU) to four different TPL ports. It is designed for use in both automotive and industrial applications. The device can route both TPL2 and TPL3 messages. The FRDM665SPIEVB is an ideal board for rapid prototyping of the MC33665A for SPI interface to an MCU. The onboard TPL interface for four TPL ports has transformer isolation.

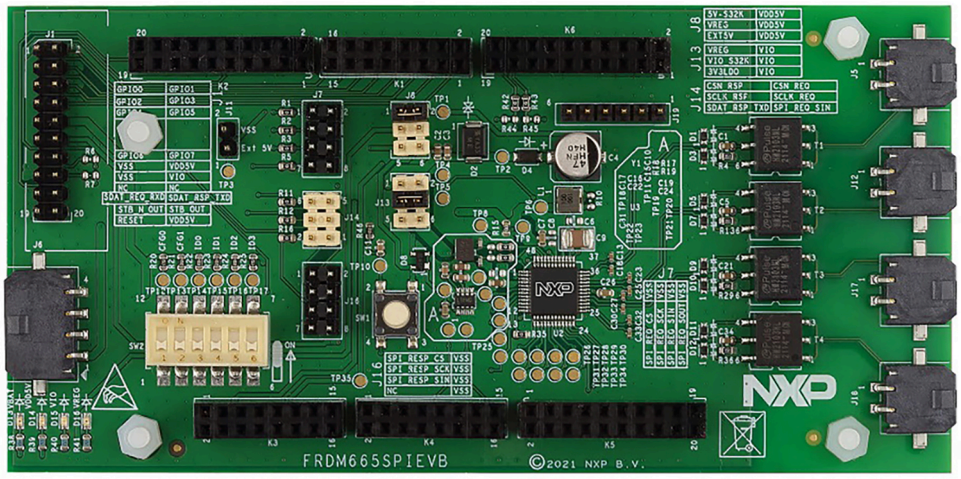

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Figure 8. FRDM665SPIEVB

4.6.3 S32K3X4EVB-T172

The S32K3X4EVB[5] provides the control signals for the FRDM665SPIEVB.

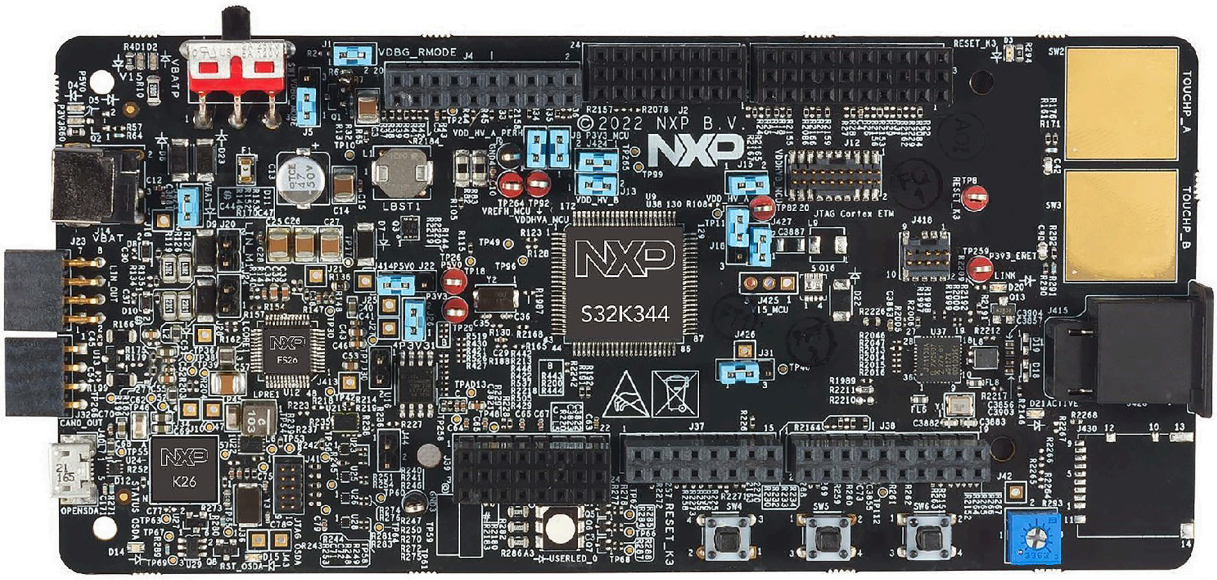

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Figure 9. S32K3X4evaluation board

5 Configuring the hardware

5.1 Battery emulator connection

A minimum of four cells and a maximum of 18 cells can be monitored by one MC33774A. NXP provides an 18-cell battery emulator board, BATT-18EMULATOR [1]. This board provides an intuitive way to change the voltage across any of the 18 cells of an emulated battery pack. The board RDBESS774A3EVB can be connected to an 18-cell battery emulator board using the connectors J1_1, J1_2 and J1_3, with the provided supply cable.

See Figure 10.

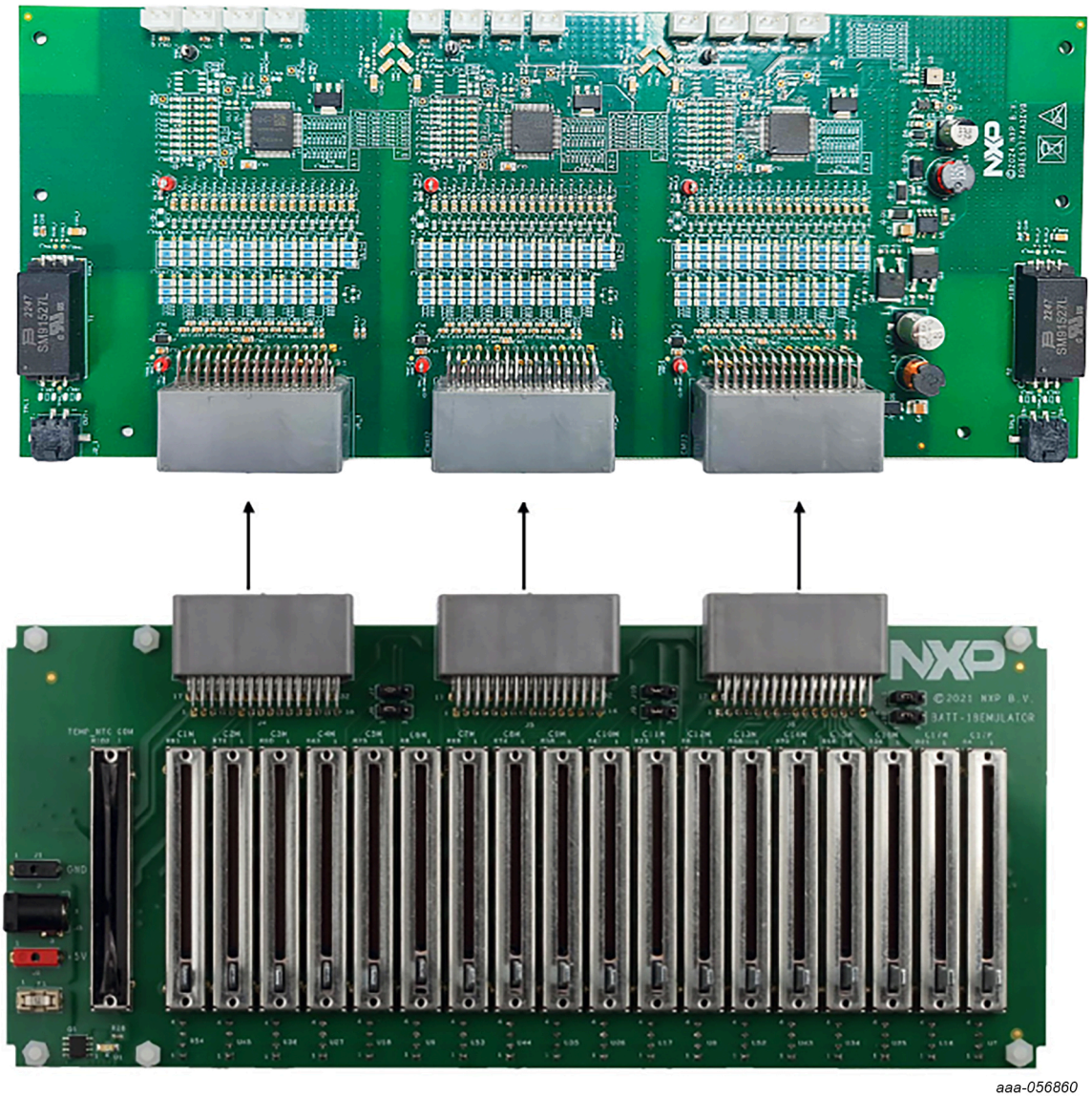

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Figure 10. Battery emulator connection

5.2 TPL communication connection

In a high-voltage isolated application with a daisy chain configuration, up to 63 RDBESS774A3EVB boards may be connected.

The TPL connections use the COMM connectors J1 and J2 of the FRDM665SPIEVB[4] and J2_1 and J2_3 of the RDBESS774A3EVB.

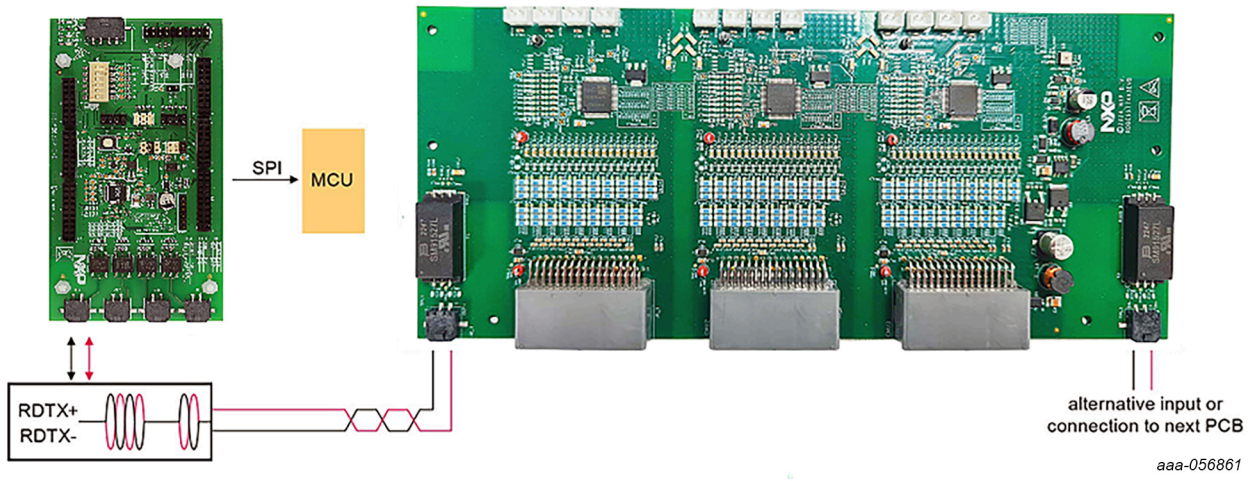

Figure 11. FRDM665SPIEVBsetup

6 References

1. **Tool summary page for battery emulators** — BATT-18EMULATOR
2. **RD-BESSK358BMU —** HVBESS Battery Management Unit (BMU) https://https://www.nxp.com/part/RD-K358BMU
3. **RDBESS772BJBEVB** — HVBESS Battery Junction Box (BJB) https://www.nxp.com/design/designs/HVBESS-battery- junction-box-bjb:RD772BJBTPL8EVB
4. **Tool summary page for evaluation board for MC33665A with SPI and TPL Communication** — FRDM665SPIEVB
5. **Tool summary page for S32K3X4 evaluation board** — https://www.nxp.com/design/development-boards/automotive-development-platforms/s32k-mcu-platforms/s32k3x4evb-t172-evaluation-board-for-automotive-general-purpose:S32K3X4EVB-T172
6. **Tool summary page for RDBESS774A3EVB evaluation board** — https://www.nxp.com/RDBESS774A3EVB

7 Revision history

Table 1. Revision history

Document ID	Release date	Description
UM12146 v.1.0	20 September 2024	Initial version

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