UM11930

RD33772C14VEVM 14 V battery management system

Rev. 1 — 25 September 2023 User manual

Document information

Information	Content
Keywords	14VBMS, MC33772C, S32K344, FS26
Abstract	The RD33772C14VEVM is a reference design for 14 V battery management systems in electric vehicle applications. Targeting to meet ASIL C functional safety level requirements.

Revision history

Rev	Date	Description
1	20230925	initial version

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1 Introduction

This document is the user guide for the RD33772C14VEVM reference design. This document is intended for the engineers involved in the evaluation, design, implementation, and validation of a 14 V battery management system (BMS) in a vehicle. The scope of this document is to provide the user with information to evaluate the features of the 14 V BMS device. This document covers the hardware connection steps, software and tools installation and environment configuration for the kit usage. The RD33772C14VEVM allows the user to connect to a 14 V power supply for voltage sensing, current sensing, temperature sensing and the diagnostic of contactor status.

2 Finding kit resources and information on the NXP website

The NXP analog product development boards provide an easy-to-use platform for evaluating NXP products. The boards support a range of analog, mixed-signal, and power solutions. They incorporate monolithic integrated circuits and system-in-package devices that use proven high-volume technology. NXP products offer longer battery life, a smaller form factor, reduced component counts, lower cost, and improved performance in powering state-of-the-art systems.

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

The information page for RD33772C14VEVM user manual is at http://www.nxp.com/RD33772C14VEVM. The information page provides overview information, technical and functional specifications, ordering information, documentation, and software. The Getting Started tab provides quick-reference information applicable to using the RD33772C14VEVM user manual, including the downloadable assets.

2.1 Collaborate in the NXP community

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3 Getting ready

Working with the RD33772C14VEVM requires the kit contents, additional hardware, and a Windows PC workstation with installed software.

3.1 Kit contents

- Evaluation board in an antistatic bag
- Several cables
- Quick start guide

3.2 Additional hardware

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

- Low-voltage power supply 5 V to 14 V with current limit set initially to 1.5 A
- Current load, 0 A to 500 A
- Controller area network (CAN) card and cable
- Multilink FX debugger cable

3.3 Minimum system requirements

This reference design requires a Windows PC workstation. The kit requires the following to function properly with the demo software:

- Windows 10, 8 or 7 compatible PC with a USB port

3.4 Software

Installing software is necessary to work with this reference design. All listed software is available on http://www.nxp.com/RD33772C14VEVM.

- S32 design studio integrated development environment (IDE) for Arm

4 Getting to know the hardware

4.1 Kit overview

The RD33772C14VEVM is a hardware tool for evaluation and development. It is ideal for rapid prototyping of a 14 V BMS. This board can be used to evaluate the features of the MC33772C device.

4.2 Board features

- Power supply input from 9 V to 18 V
- Up to 10 channels temperature sensing
- Up to 4 channels pack voltage measurement
- Redundant current measurement
- External positive temperature coefficient (PTC) for self-heating function of lithium-ion battery
- Hardware short circuit protection and software (SW) overcurrent protection
- 1 channel CAN and 1 channel local interconnect network (LIN) communication with vehicle control unit (VCU)

4.3 Board functions implemented

Table 1. Board functions

Functions	Description
Voltage measurement	cell voltage
	up to 4 channels pack voltage
Current measurement	1 channel by MC33772C
	1 channel by MCU
Temperature measurement	3 channels for cell
	1 channel for metal-oxide-semiconductor field-effect transistor (MOSFET)
	1 channel for shunt resistor
	1 channel for cell balancing
	3 channels reserved
Communication	serial peripheral interface (SPI) (internal)
	1 channel LIN (external)
	1 channel CAN (external)

Table 1. Board functions*...continued*

Functions	Description
Load path	2 parallel MOSFETs
	MOSFET diagnostic
	pre-driver
PTC	self-heating for battery cell

4.4 Device features

This reference design features the following NXP products:

Table 2. Device features

Device	Description	Features
MC33772C	6-channel Li-ion battery cell controller IC	• 5.0 V ≤ VPWR ≤ 30 V operation, 40 V transient • 3 to 6 cells management • 0.8 mV total cell voltage measurement error • Isolated 2.0 Mbit/s differential communication or 4.0 Mbit/s SPI • Addressable on initialization • Synchronized cell voltage and current measurement with coulomb count • Total stack voltage measurement • Seven general-purpose input/output (GPIO) or temperature sensor inputs • 5.0 V reference supply output with 5 mA capability • Automatic over/undervoltage and temperature detection routable to fault pin • Integrated sleep mode over/undervoltage and temperature monitoring • Onboard 300 mA passive cell balancing with diagnostics • Hot plug capable • Detection of internal and external faults, as open lines, shorts, and leakages • Designed to support ISO 26262 up to automotive safety integrity level (ASIL) D safety system • Fully compatible with the MC33771 for a maximum of 14 cells • Qualified in compliance with AEC-Q100

Table 2. Device features*...continued*

Device	Description	Features
S32K344	AEC-Q100 qualified 32-bit Arm Cortex-M7-based MCUs targeted for general purpose automotive and high-reliability industrial applications	• Single, multiple, or lockstep Cortex-M7 cores, 120 MHz to 240 MHz + floating point unit (FPU) • 512 kB to 8 MB flash with error correcting code (ECC) • Firmware over-the-air (FOTA): A/B firmware swap with zero downtime and roll-back support; automatic address translation • 12-bit 1 Msps analog-to-digital converter (ADC), 16-bit enhanced modular input/output system (eMIOS) timer with logic control unit for motor control • Low-power Run and Standby modes, fast wake-up, clock, and power gating • −40 °C to +125 °C AEC-Q100 • Minimum 15-year longevity • Safety, security, and connectivity • ISO 26262 up to ASIL B/D • Fault collection and control unit • Hardware and software watchdogs, clock/power/temperature monitors • Safety documentation and SafeAssure community support • Hardware security engine (HSE) security engine - AES-128/192/256, Rivest, Shamir, and Adleman public key cryptosystem (RSA), ECC, secure boot, and key storage; side channel protection; ISO 21434 intended • Ethernet TSN/AVB (10/100 Mbit/s), I3C, controller area network flexible data rate (CAN FD), flexible input/output (FlexIO) (SPI/IIC/IIS/SENT protocol), serial audio interface (SAI), quadruple serial peripheral interface (QSPI)
FS26	safety system basis chip (SBC) with low power fit for ASIL D	• Input supply up to 40 V DC • HV buck, adjustable step down DC-DC converter 3.2 V to 6.35 V (50 mV step), 1.5 A DC • VCORE, adjustable step down DC-DC converter 0.8 V to 3.3 V (10 mV step), 800 mA to 1500 mA • Boost controller 5.5 V to 17 V, external switch • LDO1 and LDO2, configurable 3.3 V or 5.0 V, up to 300 mA DC output current capability • Voltage reference (VREF), accurate voltage reference 3.3 V or 5 V, 1 %, 30 mA DC output current capability • 2 trackers, 10 mV offset, 125 mA DC output current capability • 32 bits SPI [including cyclic redundancy check (CRC)] • Long duration timer (with dedicated part number) • Third-generation fail-safe state machine with independent safety monitoring unit • Target < 25 µA in Low-power mode in LPOFF and < 50 µA in Standby (MCU powered) • AMUX: battery, internal safety critical voltages, precise reference voltage and temperature, GPIOs • GPIO: wake-up or HS/LS driver

Table 2. Device features*...continued*

Device	Description	Features
TJA1021	LIN2.1/Society of Automotive Engineers (SAE) J2602 transceiver	• LIN 2.1/SAE J2602 compliant • Baud rate up to 20 kBd • Very low electromagnetic emission (EME) • High electromagnetic immunity (EMI) • Passive behavior in unpowered state • Input levels compatible with 3.3 V and 5 V devices • Integrated termination resistor for LIN follower applications • Wake-up source recognition (local or remote) • K-line compatible • Very low current consumption in Sleep mode with local and remote wake-up • High electrostatic discharge (ESD) robustness: ±6 kV according to IEC 61000-4-2 for pins LIN, VBAT, and WAKE_N • Transmit data (TXD) dominant time-out function • Bus terminal and battery pin protected against transients in the automotive environment (ISO 7637)
TJA1145	high speed CAN transceiver	• ISO 11898-2:2016 and SAE J2284-1 to SAE J2284-5 compliant • Data rates up to 5 Mbit/s in the CAN FD fast phase • Autonomous bus biasing • Fully compatible with the TJA1145, with improved electromagnetic compatibility (EMC) performance • ±6 kV ESD protection, according to IEC TS 62228 on pins BAT and WAKE and on the CAN bus pins • CAN bus pins short-circuit proof to ±58 V • Suitable for use in 12 V and 24 V systems • AEC-Q100 qualified

4.5 Block diagram

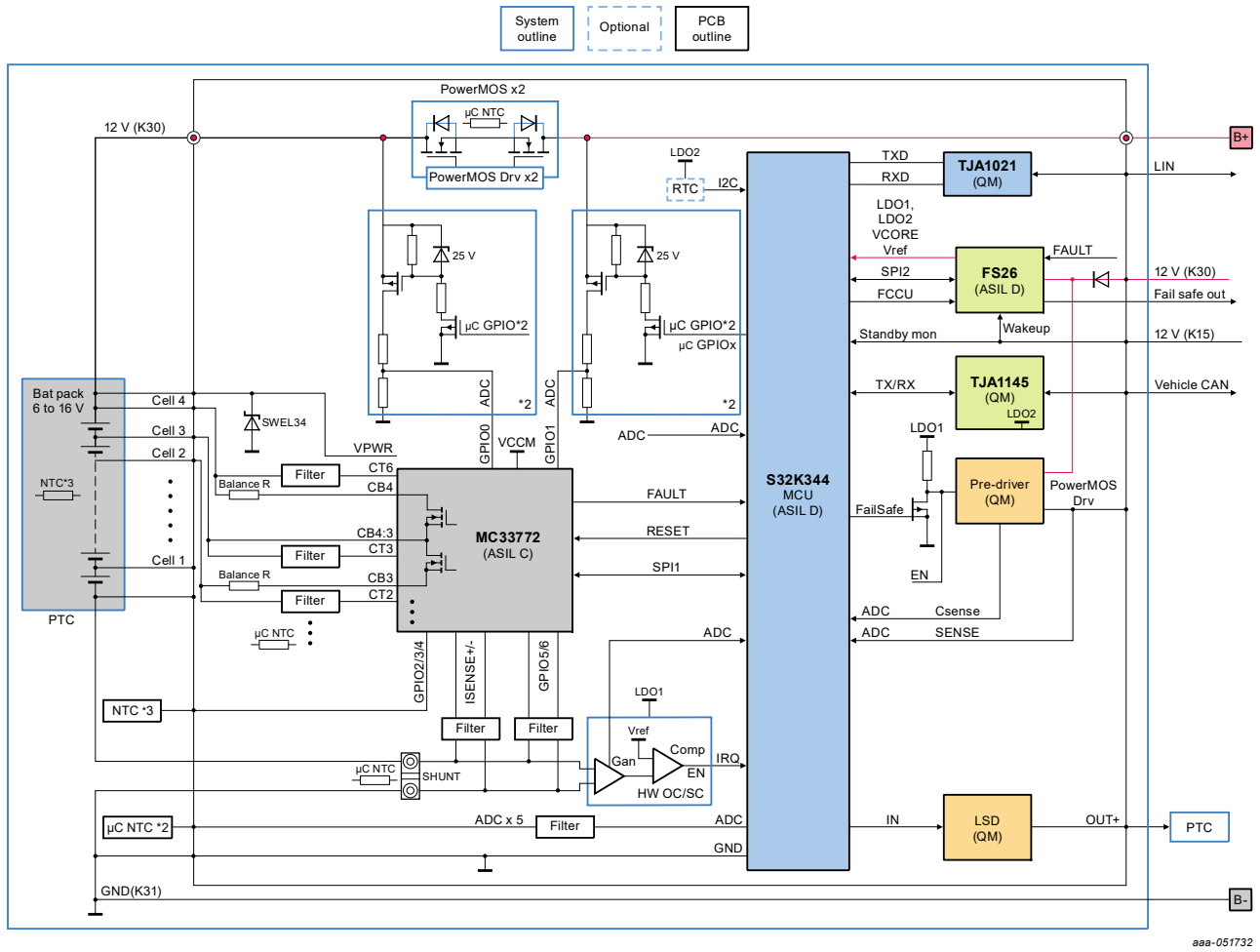

Figure 1. Block diagram

4.6 Connectors

Figure 2 shows the location of connectors on the board. Table 3, Table 4, and Table 5 list the pinouts for J2, J5, and J6.

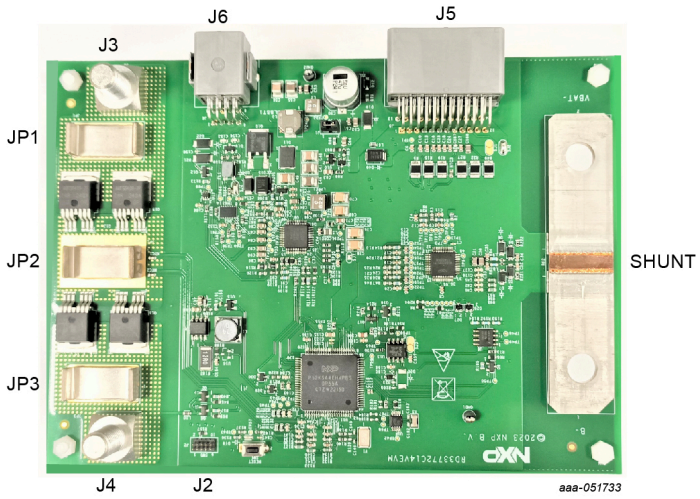

Figure 2. Connectors

Table 3. Joint Test Access Group (JTAG) connector (J2) description

Pin	Name	Description
1	J2_1	VCC
2	J2_2	JTAG_SWDIO/TMS
3	J2_3	GND
4	J2_4	JTAG_SWDCLK/TCK
5	J2_5	GND
6	J2_6	JTAG_SWO/TDO
7	J2_7	KEY
8	J2_8	JTAG_NC/TDI
9	J2_9	GND_Detect
10	J2_10	JTAG_nRESET

Table 4. J5 connector description

Pin	Name	Description
1	J5_1	K30_12V_L
2	J5_2	K30_12V_L
3	J5_3	K30_12V_L
4	J5_4	CELL_4
5	J5_5	CELL_3

Table 4. J5 connector description*...continued*

Pin	Name	Description
6	J5_6	CELL_2
7	J5_7	CELL_1
8	J5_8	CELL_0
9	J5_9	GND_KL31_UP
10	J5_10	GND_KL31_UP
11	J5_11	GND_KL31_DOWN
12	J5_12	GND_KL31_DOWN
13	J5_13	BCC_NTCIN_1
14	J5_14	GND
15	J5_15	BCC_NTCIN_2
16	J5_16	GND
17	J5_17	BCC_NTCIN_3
18	J5_18	GND
19	J5_19	MCU_NTCIN_1
20	J5_20	GND
21	J5_21	MCU_NTCIN_2
22	J5_22	GND
23	J5_23	GND_KL31_DOWN
24	J5_24	GND_KL31_DOWN

Table 5. J6 connector description

Pin	Name	Description
1	J6_1	KL15_WAKE
2	J6_2	LSD_OUT
3	J6_3	SBC_FS0B
4	J6_4	SBC_FS1B
5	J6_5	LIN
6	J6_6	GND
7	J6_7	CAN_H
8	J6_8	CAN_L

5 Configuring the hardware

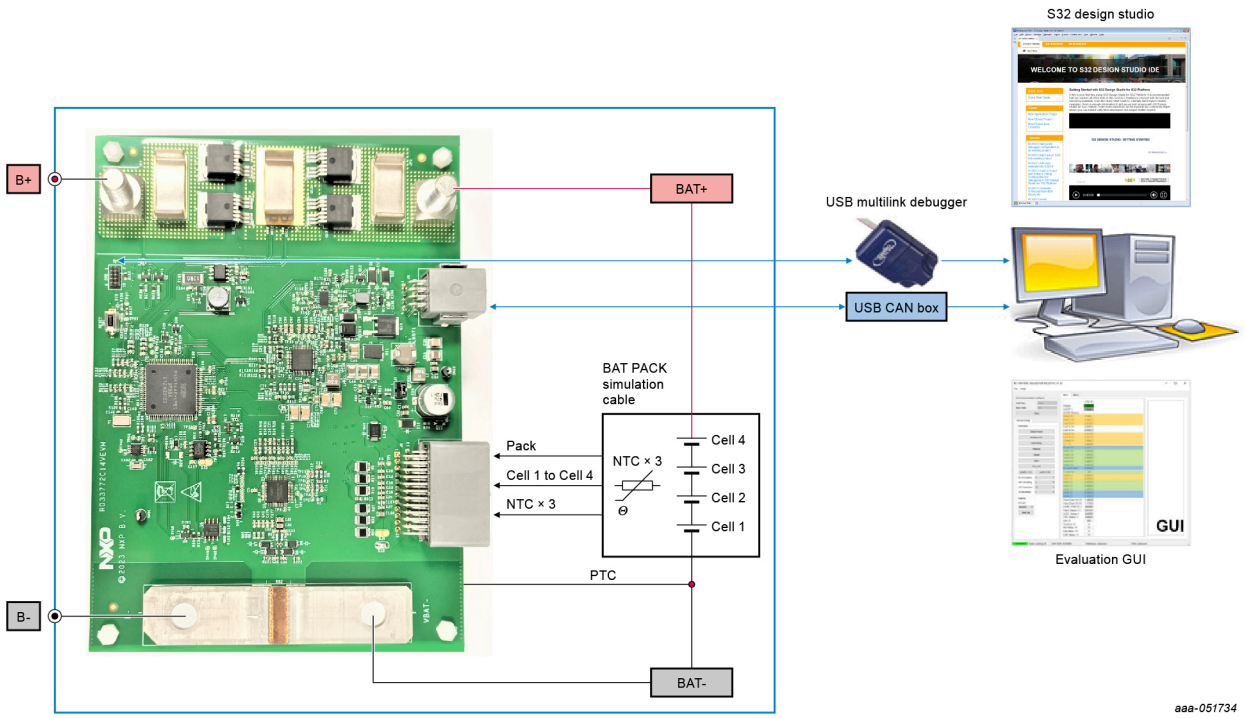

Figure 3. Hardware configuration and connection

The RD33772C14VEVM is used in a standalone configuration. There is no connector to add an expansion board. All required cables are included in the kit.

- For power on the board, need an external 12 V DC power source supply B+ and B−
- Connect the low-voltage connector to J6, the CAN/local interconnect network (LIN) wire communicates with PC with external CAN/LIN tool
- Connect battery simulation cable to J5 and source from 12 V DC
- Connect the debug tool to J2 for software purpose

6 References

[1] MC33772C product summary page http://www.nxp.com/MC33772C

[2] S32K344 product summary page http://nxp.com/s32k3

[3] FS26 product summary page http://nxp.com/fs26

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