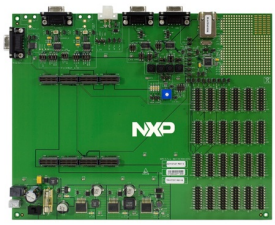

NXP UM11930 14 V Battery Management System User Manual

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

IMPORTANT NOTICE
For engineering development or evaluation purposes only

NXP provides the product under the following conditions:
This evaluation kit or reference design is for use of ENGINEERING DEVELOPMENT OR EVALUATION PURPOSES ONLY.
It is provided as a sample IC pre-soldered to a printed circuit board to make it easier to access inputs, outputs, and supply terminals. This evaluation kit or reference design may be used with any development system or other source of I/O signals by connecting it to the host MCU or computer board via off-the-shelf cables. Final device in an application will be heavily dependent on proper printed circuit board layout and heat sinking design as well as attention to supply filtering, transient suppression, and I/O signal quality.
The product provided may not be complete in terms of required design, marketing, and or manufacturing related protective considerations, including product safety measures typically found in the end device incorporating the product. Due to the open construction of the product, it is the responsibility of the user to take all appropriate precautions for electric discharge. To minimize risks associated with the customers' applications, adequate design and operating safeguards must be provided by the customer to minimize inherent or procedural hazards. For any safety concerns, contact NXP sales and technical support services.

Contents

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.

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

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**.

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

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-M 7-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

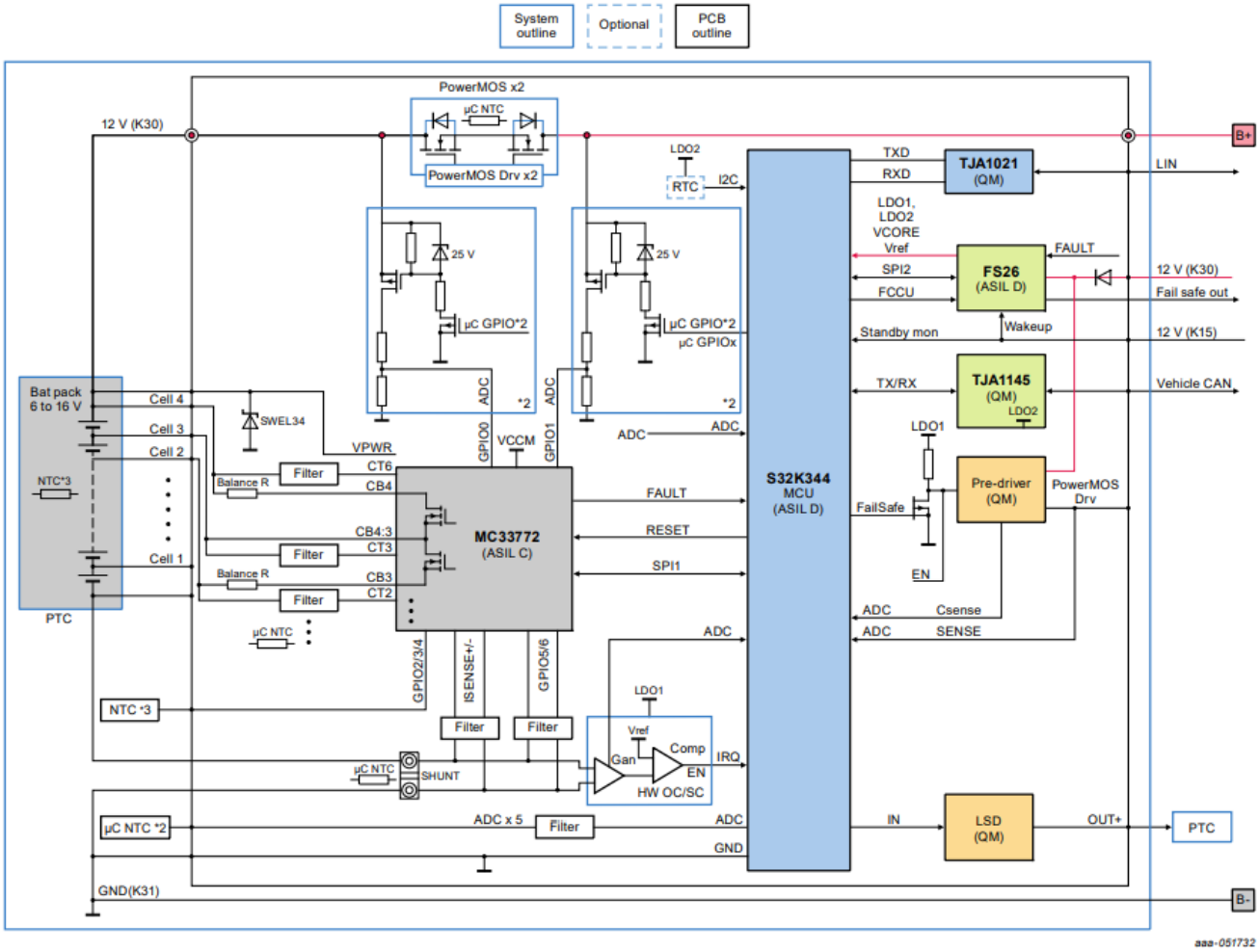

Figure 1. Block diagram

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.

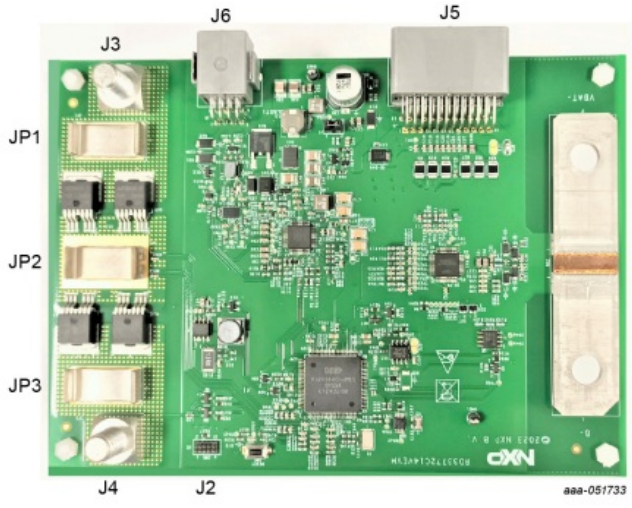

Figure 2. Connectors

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

Configuring the hardware

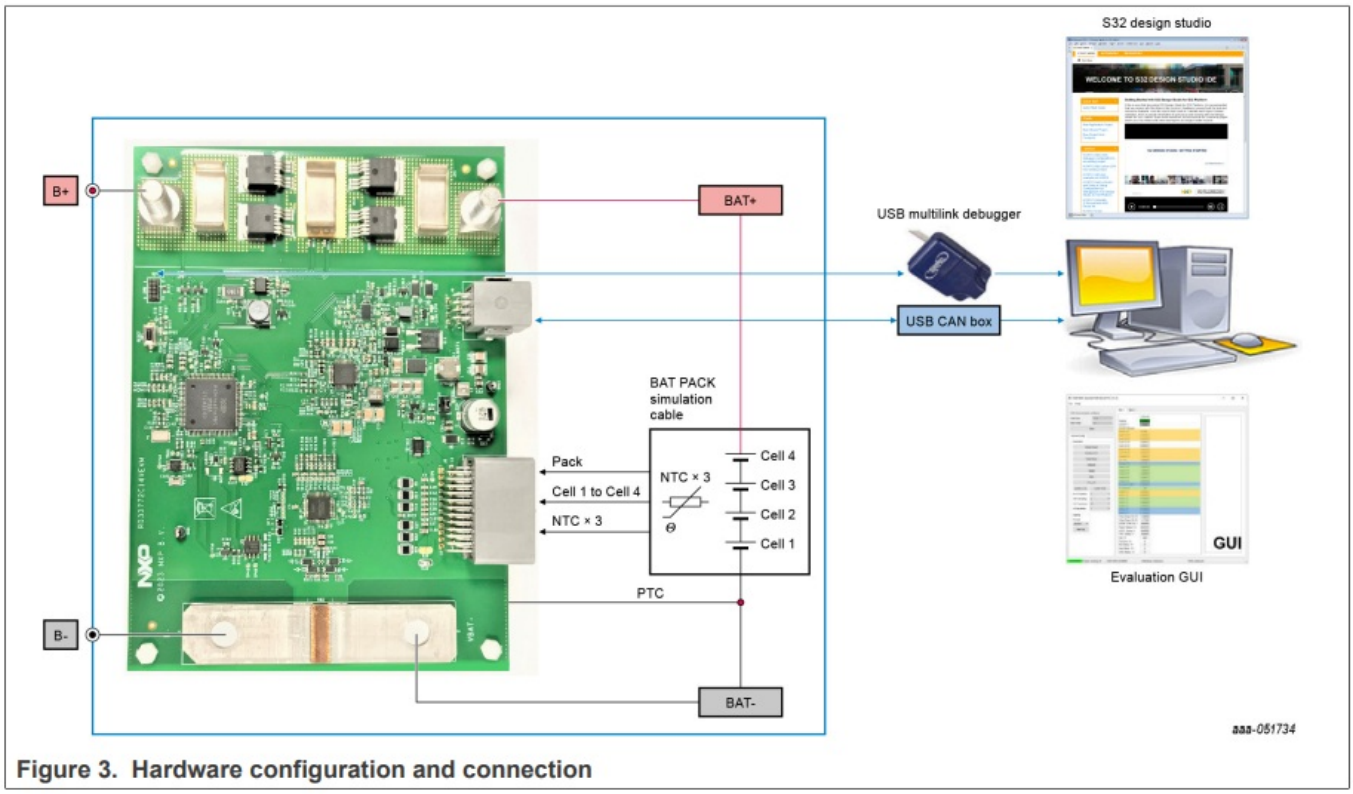

Figure 3. Hardware configuration and connection

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

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**

Legal information

7.1 Definitions

Draft — A draft status on a document indicates that the content is still under internal review and subject to formal approval, which may result in modifications or additions. NXP Semiconductors does not give any representations or warranties as to the accuracy or completeness of information included in a draft version of a document and shall have no liability for the consequences of use of such information.

7.2 Disclaimers

Limited warranty and liability — Information in this document is believed to be accurate and reliable. However, NXP Semiconductors does not give any representations or warranties, expressed or implied, as to the accuracy or completeness of such information and shall have no liability for the consequences of use of such information. NXP Semiconductors takes no responsibility for the content in this document if provided by an information source outside of NXP Semiconductors. In no event shall NXP Semiconductors be liable for any indirect, incidental, punitive, special or consequential damages (including – without limitation lost profits, lost savings, business interruption, costs related to the removal or replacement of any products or rework charges) whether or not such damages are based on tort (including negligence), warranty, breach of contract or any other legal theory. Notwithstanding any damages that customer might incur for any reason whatsoever, NXP Semiconductors' aggregate and cumulative liability towards customer for the products described herein shall be limited in accordance with the Terms and conditions of commercial sale of NXP Semiconductors.

Right to make changes — NXP Semiconductors reserves the right to make changes to information published in this document, including without limitation specifications and product descriptions, at any time and without notice. This document supersedes and replaces all information supplied prior to the publication hereof. Applications — Applications that are described herein for any of these products are for illustrative purposes only. NXP Semiconductors makes no representation or warranty that such applications will be suitable for the specified use without further testing or modification. Customers are responsible for the design and operation of their applications and products using NXP Semiconductors products, and NXP Semiconductors accepts no liability for any assistance with applications or customer product design. It is customer's sole responsibility to determine whether the NXP Semiconductors product is suitable and fit for the customer's applications and products planned, as well as for the planned application and use of customer's third party customer(s). Customers should provide appropriate design and operating safeguards to minimize the risks associated with their applications and products. NXP Semiconductors does not accept any liability related to any default, damage, costs or problem which is based on any weakness or default in the customer's applications or products, or the application or use by customer's third party customer(s). Customer is responsible for doing all necessary testing for the customer's applications and products using NXP Semiconductors products in order to avoid a default of the applications and the products or of the application or use by customer's third party customer(s). NXP does not accept any liability in this respect. Terms and conditions of commercial sale — NXP Semiconductors products are sold subject to the general terms and conditions of commercial sale, as published at **http://www.nxp.com/profile/terms**, unless otherwise agreed in a valid written individual agreement. In case an individual agreement is concluded only the terms and conditions of the respective agreement shall apply. NXP Semiconductors hereby expressly objects to applying the customer's general terms and conditions with regard to the purchase of NXP Semiconductors products by customer.

Export control — This document as well as the item(s) described herein may be subject to export control regulations. Export might require a prior authorization from competent authorities. Evaluation products — This product is provided on an "as is" and "with all faults" basis for evaluation purposes only. NXP Semiconductors, its affiliates and their suppliers expressly disclaim all warranties, whether express, implied or statutory, including but not limited to the implied warranties of noninfringement, merchantability and fitness for a particular purpose. The entire risk as to the quality, or arising out of the use or performance, of this product remains with customer. In no event shall NXP Semiconductors, its affiliates or their suppliers be liable to customer for any special, indirect, consequential, punitive or incidental damages (including without limitation damages for loss of business, business interruption, loss of use, loss of data or information, and the like) arising out the use of or inability to use the product, whether or not based on tort (including negligence), strict liability, breach of contract, breach of warranty or any other theory, even if advised of the possibility of such damages. Notwithstanding any damages that customer might incur for any reason whatsoever (including without limitation, all damages referenced above and

all direct or general damages), the entire liability of NXP Semiconductors, its affiliates and their suppliers and customer's exclusive remedy for all of the foregoing shall be limited to actual damages incurred by customer based on reasonable reliance up to the greater of the amount actually paid by customer for the product or five dollars (US$5.00). The foregoing limitations, exclusions and disclaimers shall apply to the maximum extent permitted by applicable law, even if any remedy fails of its essential purpose. Translations — A non-English (translated) version of a document, including the legal information in that document, is for reference only. The English version shall prevail in case of any discrepancy between the translated and English versions.

Security — Customer understands that all NXP products may be subject to unidentified vulnerabilities or may support established security standards or specifications with known limitations. Customer is responsible for the design and operation of its applications and products throughout their lifecycles to reduce the effect of these vulnerabilities on customer's applications and products. Customer's responsibility also extends to other open and/or proprietary technologies supported by NXP products for use in customer's applications. NXP accepts no liability for any vulnerability. Customer should regularly check security updates from NXP and follow up appropriately. Customer shall select products with security features that best meet rules, regulations, and standards of the intended application and make the ultimate design decisions regarding its products and is solely responsible for compliance with all legal, regulatory, and security related requirements concerning its products, regardless of any information or support that may be provided by NXP. NXP has a Product Security Incident Response Team (PSIRT) (reachable at **PSIRT@nxp.com**) that manages the investigation, reporting, and solution release to security vulnerabilities of NXP products.

Suitability for use in automotive applications (functional safety) — This NXP product has been qualified for use in automotive applications. It has been developed in accordance with ISO 26262, and has been ASIL classified accordingly. If this product is used by customer in the development of, or for incorporation into, products or services (a) used in safety critical applications or (b) in which failure could lead to death, personal injury, or severe physical or environmental damage (such products and services hereinafter referred to as "Critical Applications"), then customer makes the ultimate design decisions regarding its products and is solely responsible for compliance with all legal, regulatory, safety, and security related requirements concerning its products, regardless of any information or support that may be provided by NXP. As such, customer assumes all risk related to use of any products in Critical Applications and NXP and its suppliers shall not be liable for any such use by customer. Accordingly, customer will indemnify and hold NXP harmless from any claims, liabilities, damages and associated costs and expenses (including attorneys' fees) that NXP may incur related to customer's incorporation of any product in a Critical Application.

NXP B.V. — NXP B.V. is not an operating company and it does not distribute or sell products.

7.3 Trademarks

Notice: All referenced brands, product names, service names, and trademarks are the property of their respective owners.

NXP — wordmark and logo are trademarks of NXP B.V.

AMBA, Arm, Arm7, Arm7TDMI, Arm9, Arm11, Artisan, big.LITTLE, Cordio, CoreLink, CoreSight, Cortex, DesignStart, DynamIQ, Jazelle, Keil, Mali, Mbed, Mbed Enabled, NEON, POP, RealView, SecurCore, Socrates, Thumb, TrustZone, ULINK, ULINK2, ULINK-ME, ULINKPLUS, ULINKpro, µVision, Versatile — are trademarks and/or registered trademarks of Arm Limited (or its subsidiaries or affiliates) in the US and/or elsewhere. The related technology may be protected by any or all of patents, copyrights, designs and trade secrets. All rights reserved.

Please be aware that important notices concerning this document and the product(s) described herein, have been included in section 'Legal information'.

For more information, please visit: **http://www.nxp.com**

Date of release: 25 September 2023

Documents / Resources

	**NXP UM11930 14 V Battery Management System** [pdf] User Manual RD33772C14VEVM, 14VBMS, MC33772C, S32K344, FS26, UM11930, UM11930 14 V Battery Management System, 14 V Battery Management System, Battery Management System, Management System, System