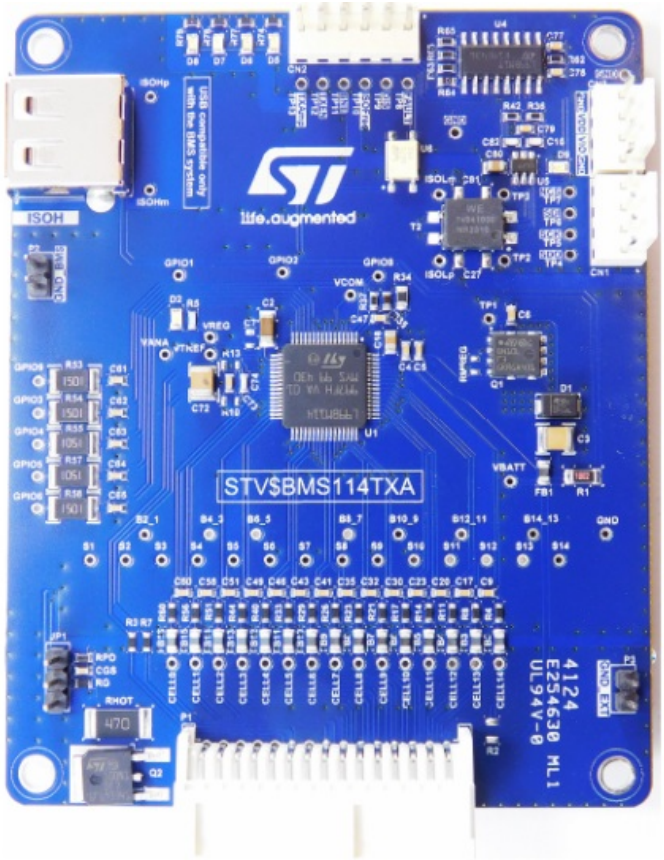
Contents [hide]

STMicroelectronics UM3424 Battery Management System Evaluation Board

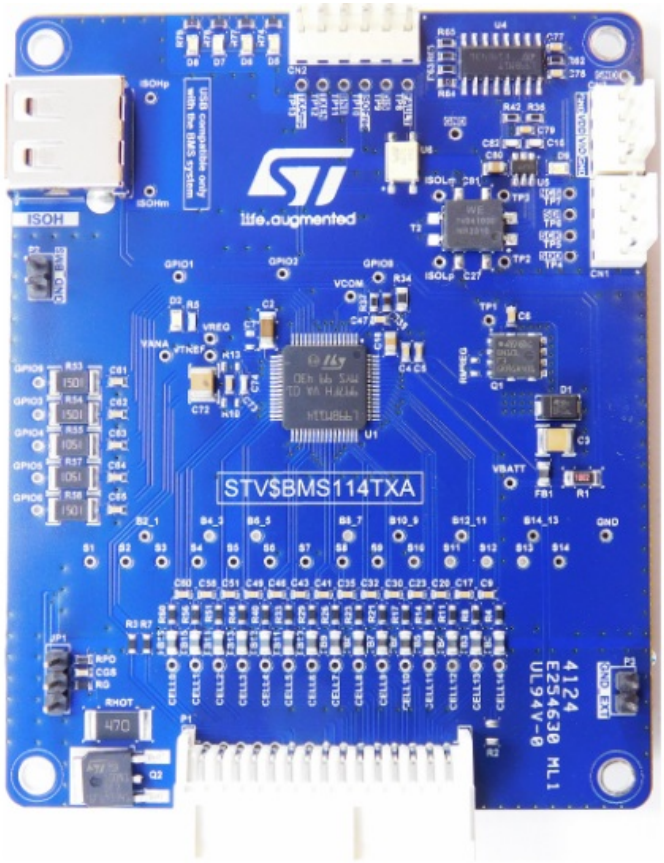


Getting started with the battery management system module based on L99BM114 and L99BM1T

Introduction

- The STEVAL-L99BM114TX is a battery management system (BMS) evaluation board that manages from 4 to 14 battery cells.
- The main advantage of this evaluation board is ensuring isolated connection to an external MCU, thanks to the embedded transceiver.
- The board is based on the L99BM114 Li-ion battery monitoring and protection chip for high-reliability applications and the L99BM1T general purpose SPI to isolated SPI bidirectional transceiver.
- The main activity of the L99BM114 is monitoring the cells and battery node status through stack voltage measurement, cell voltage measurement, temperature measurement, and coulomb counting.
- Measurement and diagnostic tasks can be executed either on demand or at set intervals.
- Measurement data are available for an external microcontroller to perform charge balancing and to compute the state of charge (SOC) and the state of health (SOH).

- The L99BM1T general purpose SPI to isolated SPI bidirectional transceiver can transfer communication data incoming from a traditional 4-wire based SPI interface to a 2-wire isolated interface (and vice versa). In our board, the transceiver is configured as a slave.
- Figure 1. STEVAL-BMS114TX evaluation board



Notice:

For dedicated assistance, submit a request through our online support portal at www.st.com/support.

BMS evaluation board overview

Features

- Hosts the L99BM114 multicell battery monitoring and balancing IC
- Hosts the L99BM1T general purpose SPI to isolated SPI bidirectional transceiver
- Voltage monitoring of every single cell and of the entire battery node
- Current sensing of the entire battery node
- 5 GPIOs to connect temperature sensors as NTCs
- CN1 connector that allows establishing communication with an MCU board via SPI

- CN2 connector that interfaces directly to an MCU board for control and diagnostic functions
- Passive balancing
- Compact size: 100 x 76 mm

Main components

1. ISOH port to connect the board to an STEVAL-BMS114 in a daisy chain
2. Connector for MCU ADCs dedicated to the NTC sensors reading
3. L99BM1T general-purpose SPI to isolated SPI transceiver
4. CN2 connector for diagnostic functions
5. CN1 connector to communicate with an MCU board via SPI
6. Balancing resistors
7. Connector for the battery pack
8. Hot plug protection
9. GPIOs for external NTC connection handled by L99BM114
10. L99BM114 multicell battery monitoring and balancing IC

Figure 2. **STEVAL-L99BM114TX main components**

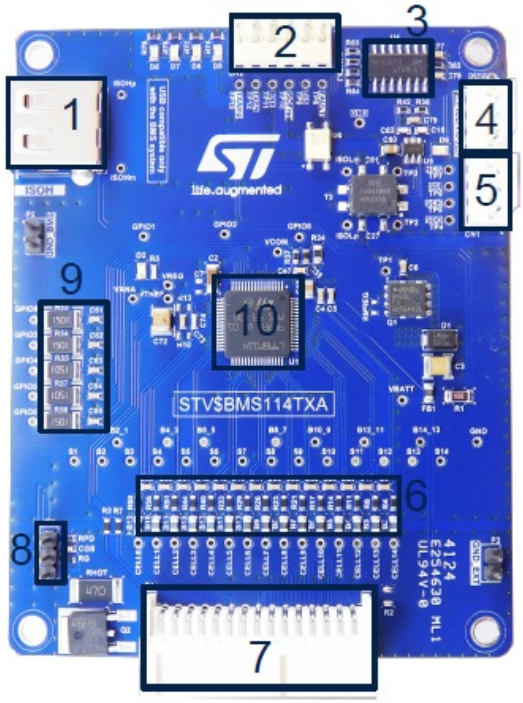


Table 1. STEVAL-L99BM114TX connector details

Name	Description	Type

ISOH	Isolated serial communication port: 1. VBUS 2. ISOHm 3. ISOHp 4. FaultH	USB Type A connector
	Battery connector: 1. VBAT_CELL 2. Cell 14 3. Cell 13 4. Cell 12 5. Cell 11 6. Cell 10 7. Cell 9 8. Cell 8 9. Cell 7 10. Cell 6 11. Cell 5 12. Cell 4 13. Cell 3 14. Cell 2 15. Cell 1	

P1	16. Cell 0 17. External Ground 18. External Ground 19. ISENSEP (external shunt resistor) 20. ISENSEN (external shunt resistor) 21. NTC 1+ 22. NTC 1- 23. NTC 2+ 24. NTC 2- 25. NTC 3+ 26. NTC 3- 27. NTC 4+ 28. NTC 4- 29. NTC 5+ 30. NTC 5-	Multi pin connector
P2	GND_BMS test point	1-2 shorted to GND_BMS
P3	GND_EXT test point	1-2 shorted to GND_EXT
JP1	Hot plug protection reference voltage	1-2 VREG (default) 2-3 VTREG

CN1	External SPI connector 1 – SDO 2 – SCK 3 – SDI 4 – SCN	Multi pin connector

Name	Description	Type
CN2	L99BM1T Transceiver configuration signal 1 – FAULT line 2 – DIS 3 – ISOFreq 4 – BNE 5 – TXEN 6 – TXAmp	Multi pin connector
CN3	1 – GND 2 – VIO 3 – VDD 4 – GND	Multi pin connector

Embedded devices

L99BM114

- The L99BM114 is intended for operation in systems using lithium battery packs. The IC embeds all the features needed to perform battery management. A single device

can monitor from 4 up to 14 cells.

- The device can be supplied with the same battery it monitors, and its main activity consists of monitoring cells and battery pack status through stack voltage measurement, cell voltage measurement, temperature measurement, and coulomb counting. Measurement and diagnostic tasks can be executed either on demand or periodically, with a programmable cycle interval.
- Measurement data is available for an external microcontroller to perform charge balancing and to compute the state of health (SOH) and state of charge (SOC).
- The IC works in normal mode performing measurement conversions, diagnostics, and communication. The device can also be put into a cyclic wakeup state in order to reduce the current consumption from the battery.
- Passive cell balancing can be performed either via internal discharge path or via external MOSFETs. The controller can either manually control the balancing drivers or start a balancing task with a fixed duration. In the second
- case, the balancing may be programmed to continue also when the IC enters a low power mode called silent balancing, to avoid unnecessary current absorption from the battery pack.
- Thanks to the GPIOs, the device also offers the possibility to operate a distributed cell temperature sensing via external NTCs resistances.
- The external microcontroller can communicate with L99BM114 via SPI protocol. The physical layer can either be a traditional 4-wire based SPI or 2-wire transformer/capacitive based isolated interface through a dedicated isolated transceiver device.
- The L99BM114 performs automatic validation of any failure involving the cells or the whole battery pack. The device can detect the loss of the connection to a cell or GPIO terminal. Moreover, it features a hardware self-check (HWSC) that verifies the correct functionality of the internal analog comparators and the ADCs. All these checks are automatically performed in case a failure involving both cells or when the battery pack is detected. The current sensing interface used for coulomb counting is also capable of detecting failures such as open wires and overcurrent in sleep mode. The cell balancing terminals can detect any short/open fault and the internal power MOS are protected against overcurrent.

L99BM1T

- L99BM1T is a general purpose SPI to isolated SPI transceiver intended to create a communication bridge between devices located into different voltage domains.
- L99BM1T is able to transfer communication data incoming from a classical 4-wire based SPI interface to a 2-wire isolated interface (and viceversa).
- The transceiver supports both transformer and capacitive isolation, since the isolated signal generated according to a proprietary protocol is suitable to be transmitted over both decoupling circuitries.
- The device can be configured either as Slave or as Master of the SPI bus and supports any protocol made of SPI frames 8 to 64 bit long. The transceiver manages the transfer of the information without performing any protocol check. SPI peripheral can work up to 10 MHz when configured as Slave. SPI clock frequency can be programmed among (250 kHz; 1 MHz; 4 MHz; 8 MHz) when configured as Master.
- Isolated SPI peripheral features two different operating modes: slow @333 kbps and fast @2.66 Mbps.
- The asynchronicity between the two sides is internally managed, allowing all possible configuration frequencies on both peripherals to be used in application.
- L99BM1T features an internal queue of 3 slots for the frames received on the SPI port and a queue of 20 slots for the ones received on the isolated SPI side. This allows buffering and decoupling the two different clock domains.
  The device is natively compatible with L99BM114 isolated SPI, allowing its usage in the BMS applications.
- L99BM1T is compatible with both 3.3 V and 5 V internal logics.

Voltage operating range

- In our BMS evaluation boards, the maximum voltage range for each cell is 4.2 V.
- The power supply range is from 9.6 V to a maximum of 64 V.
- Linear regulators
- The STEVAL-BMS114 features several linear voltage regulators, which are switched on according to a specific sequence at power-up (see Figure 1).

VREG

- This linear regulator exploits an external MOS to decrease the power dissipation

inside the L99BM114.
- It acts as a pre-regulator, supplying all other internal regulators (VANA, VCOM, VTREF, and VDIG). It is switched off in low power modes (sleep, silent balancing, off phase of the cyclic wakeup).

VANA

- This low drop regulator supplies all the INTERNAL ADC, comparators, monitors, main bandgap, current generator, and other analogic blocks.

VCOM

- The isolated communication receiver/transmitter and the GPIO output buffers are supplied by this low drop regulator.

VTREF

- This low drop regulator is used to supply external components such as NTCs for temperature sensing.
- The recommended application circuit in NTC analog front end guarantees that each NTC channel sinks no more than 500 µA.
- VTREF regulator is disabled by default. Its operation can be controlled via SPI.
- In absolute measurements, there is no reference value, while the ratiometric measurement is based on reference value defined by the VTREF regulator. If the VTREF goes low in case of an error, the VTREF varies to compensate this error.
- All of the above regulators have dedicated UV/OV diagnostics.

BMS topologies

- The BMS boards can work in two different daisy chain topologies: single access and dual access ring.

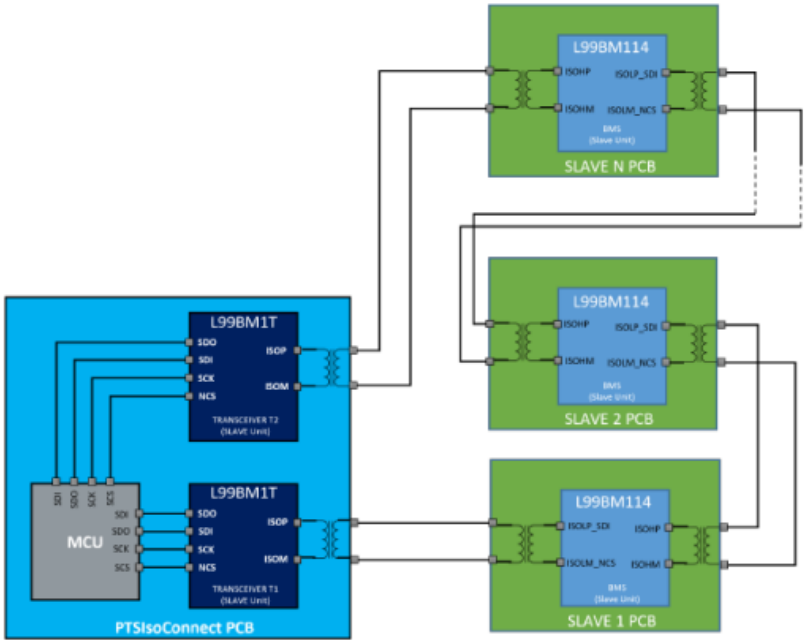
Single access configuration

- In a single access daisy chain configuration, a series of BMS is connected to an MCU board through a single transceiver connected to the STEVAL-BMS114 isolated ISOL

port. The BMS are connected to each other through the isolated ISOH port.

- The MCU communicates with the STEVAL-BMS1T hosted L99BM1T transceiver through the SPI protocol. The transceiver converts these signals into ISO SPI signals to communicate with the BMS.
- Figure 3. Single access BMS diagram

Figure 4. **Dual access ring BMS diagram**

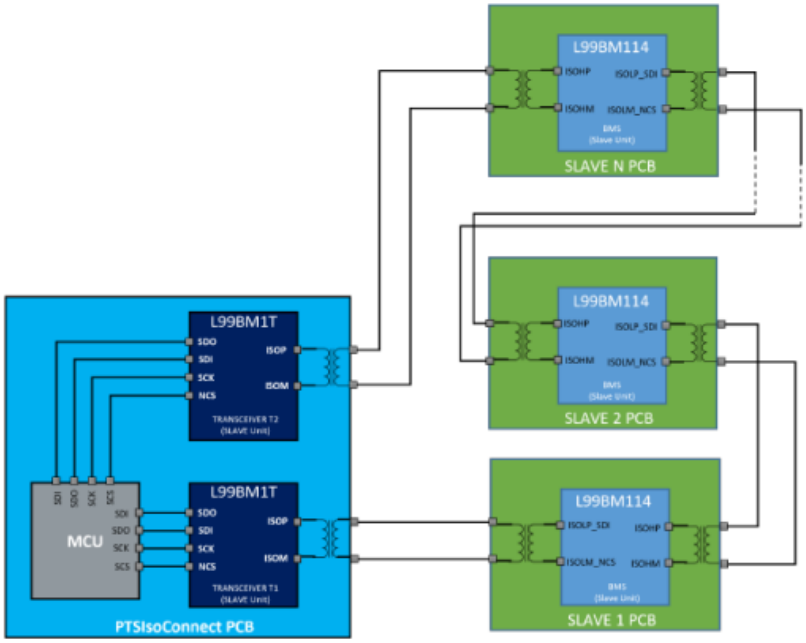


Dual access ring configuration

A dual access ring configuration is implemented by adding another transceiver that makes the communication bidirectional. The secondary transceiver is used as a backup in case the primary transceiver fails. Data moves in opposite directions around the rings, and each ring remains independent of the other unless the primary ring fails. The two rings are connected to continue the flow of data traffic.

Figure 4. Dual access ring BMS diagram

Figure 4. **Dual access ring BMS diagram**

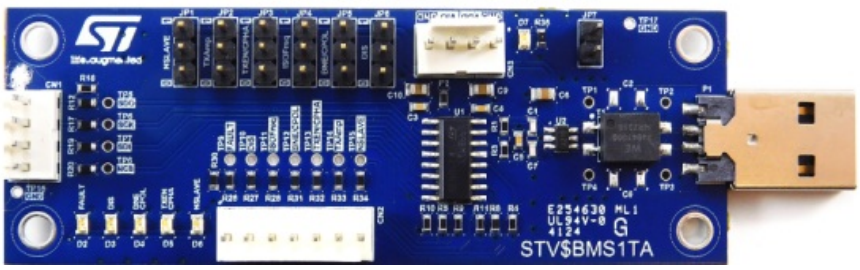


Cell current measurement

- The current flowing into the external shunt resistance RSENSE is measured through a differential amplifier stage (connected between ISENSEP/ISENSEM pins) feeding a 18-bit ADC.
- The current conversion chain can be enabled through the CoulombCounter_en bit and runs in background to perform the Coulomb Counting Routine.
- Moreover, L99BM114 also allows you to synchronize the Voltage Conversion Routine and the Coulomb Counting Routine for a precise State Of Charge estimation. Every time an on-demand voltage conversion is requested by setting SOC = 1, the actual conversion start is delayed until the first useful current conversion takes place. This might result in a maximum delay of TCYCLEADC_CUR, which must be taken into account by user software only in the case that current ADC is enabled.

Fault condition in daisy chains

Figure 5. **Fault LED on the STEVAL-BMS1T**



The fault LED on the STEVAL-BMS1T is related to the state of all the BMS nodes in the

daisy chain. If an undervoltage, overvoltage, overcurrent, or overtemperature occurs on any cell of a BMS, a fault condition is detected. To solve this condition, diagnosis via software code must be activated.

The overcurrent detection is linked to a threshold defined in the application, not in the software driver. The threshold must be modified according to the load.
For further details, refer to the L99BM114 datasheet.

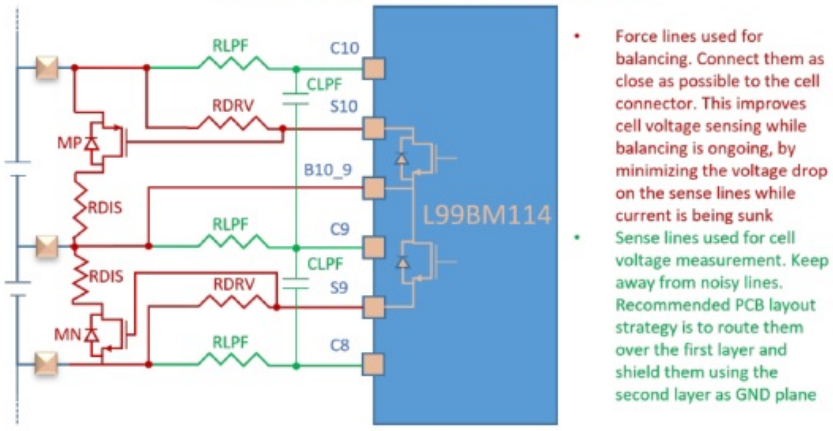
Cell balancing

In the L99BM114, the Sx and Bx_x-1 pins are used to balance the charge of the cells by discharging the ones with a higher SOC. Balancing can be performed either with external resistors or internal MOSFETs.
Cell balance drivers are powered by VBAT stack voltage. Hence, balancing is theoretically possible even at low cell voltages, except for cell 14. In case VCELL14 < VCELL14_BAL_MIN, the corresponding balancing circuitry does not operate properly, and false overcurrent detection may occur.

Passive cell balancing with internal MOSFETs

The board is designed using internal MOSFETs.

Figure 6. **Cell monitoring with internal balancing**

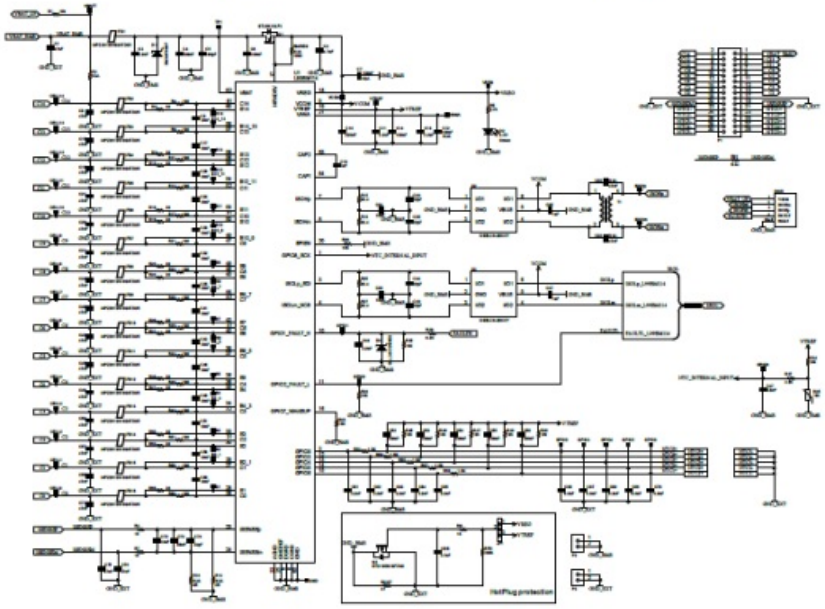


The on-chip MOSFETs are switched on to sink a current from the cell, thus dissipating charge on RDIS. The affordable balancing current is restricted by the thermal relief on the current source circuits.
The maximum balance current on each cell is 200 mA. All cells can be balanced simultaneously, if the junction temperature does not exceed the maximum operating

defined in the datasheet. To prevent thermal overstress, the die temperature diagnostic and overtemperature protections are implemented.

STEVAL-BMS114TX schematic diagrams

Figure 7. **STEVAL-BMS114TX circuit schematic (1 of 2)**



STEVAL-BMS114TX bill of materials

Table 2. STEVAL-BMS114TX bill of materials

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
1	18	C1, C8, C15, C19, C21, C29, C31, C33, C40, C42, C45, C48, C50, C57, C59, C71, C75, C76	47nF	0603 – 50 V – X7R Class II	WE	885012206093

2	1	C2	4.7uF	1206 – 50 V – X7R Class II	WE	885012208094
3	1	C3	2.2uF	1210 – 100V – X7R Class II	WE	885012209071
4	3	C4, C6, C14	100nF	0603 – 100V – X7R Class II	WE	885012206120
5	1	C5	100pF	0603 – 100V – X7R Class II	WE	885012206102
6	2	C7, C12	N.M.	0603	N.A.	N.A.

7	17	C9, C17, C20, C23, C24, C30, C32, C35, C36, C41, C43, C46, C49, C51, C58, C60, C79	10nF	0603 – 50 V – X7R Class II	WE	885012206089
8	1	C10	220nF	0603 – 50 V – X7R Class II	WE	885012206125
9	2	C11, C13	2.2uF	0805 – 25 V – X7R Class II	WE	885012207079
10	6	C16, C22, C26, C34, C39, C82	22pF	0603 – 50 V – NP0 Class I	WE	885012006053
11	6	C18, C25, C37, C80, C83, C84	1uF	0805 – 50 V – X7R Class II	WE	885012207103

12	4	C27, C28, C38, C81	N.M.	1206	N.A.	N.A.
13	6	C44, C61, C62, C63, C64, C65	2.2nF	0603 – 50 V – X7R Class II	WE	885012206085
14	6	C47, C66, C67, C68, C69, C70	6.8nF	0603 – 50 V – X7R Class II	WE	885012206088
15	7	C52, C53, C54, C55, C56, C77, C78	100nF	0603 – 50 V – X7R Class II	WE	885012206095
16	1	C72	10uF	1210 – 50 V – X7R Class II	WE	885012209073
17	1	C73	68nF	0603 – 50 V – X7R Class II	WE	885012206094

18	1	C74	33pF	0603 – 50 V – NP0 Class I	WE	885012006054
19	1	CGS	4.7nF	0603 – 50 V – X7R Class II	WE	885012206087
20	2	CN1, CN3		2.54mm – 1 row – KK254 – Male	WE	61900411121

Item	**Q.ty**	**Ref.**	**Part/value**	**Description**	**Manufacturer**	**Order code**
21	1	CN2		2.54mm – 1 row – KK254 – Male	WE	61900611121
22	2	D1, D4	SMA6T68AY, SMA	Automotive 600 W, 68V TVS in SMA	ST	SMA6T68AY

23	2	D2, D9	Green	0805 – Led Green – 3.2V	WE	150080GS75000
24	1	D3	SZMM3Z4V7T1 G	4.7V Zener Voltage Regulators, 300mW	Onsemi	SZMM3Z4V7T1G
25	1	D5	Red	0805 – Led Red – 2V	WE	150080RS75000
26	1	D6	Amber	0805 – Led Amber – 2V	WE	150080AS75000
27	1	D7	Yellow	0805 – Led Yellow – 2V	WE	150080YS75000
28	1	D8	Blue	0805 – Led Blue – 3.2V	WE	150080BS75000

29	16	FB1, FB2, FB3, FB4, FB5, FB6, FB7, FB8, FB9, FB10, FB11, FB12, FB13, FB14, FB15, FB16	1K@100MHz	Ferrite Beads Multi-Layer Power 1KOhm 25% 100MHz 1.5A 0.15 Ohm DCR 0805	TDK	MPZ2012S102ATD25
30	1	ISOH	61400416021	USB 2.0 Type A, Receptacle, Horizontal, THT	WE	61400416021
31	1	JP1		THT Vertical 3 pins Header, Pitch 2.54 mm, Single Row	WE	61300311121

32	1	P1		2.00mm – WR- WTB – Male Dual Row Horizontal Shrouded Header w. positive locking	WE	62403021722
33	2	P2, P3	61300211121	2.54mm – WR- PHD Pin Header, THT, pitch 2.54mm, Single Row, Vertical, 2p	WE	61300211121

34	1	Q1	STL8N10LF3, PowerFLAT 5×6 WF	Automotive- grade N-channel 100 V, 25 mΩ typ., 7.8 A STripFET™ F3 Power MOSFET in a PowerFLAT™ 5×6 package	ST	STL8N10LF3

Item	**Q.ty**	**Ref.**	**Part/value**	**Description**	**Manufacturer**	**Order code**

35	1	Q2	STD100N10F7, DPAK	N-channel 100 V, 6.8 mΩ typ., 80 A STripFET F7 Power MOSFETs in D2PAK, DPAK, TO-220FP, I2PAK and TO-220 packages STripFET™ F7 Power MOSFET in a DPAK package	ST	STD100N10F7
36	4	Q3, Q4, Q5, Q6	BSS138Q	N-Channel Enhancement Mosfet	NEXPERIA	BSS138Q-7-F
37	1	R1	10k	1206 – ±1 % – 0.66W	Panasonic	ERJUP8F1002V
38	2	R2, R88	N.M.	0805	N.A.	N.A.

39	2	R3, R7	10	0603 – ±1 % – 0.25W	Panasonic	ERJPA3F10R0V
40	25	R4, R8, R11, R14, R17, R21, R23, R26, R29, R33, R40, R44, R51, R56, R60, R69, R70, R72, R73, R75, R76, R80, R82, R83, R84	100	0603 – ±1 % – 0.25W	Panasonic	ERJPA3F1000V
41	1	R5	2.7k	0603 – ±1 % – 0.125W	Vishay	MCT06030C2701FP500
42	14	R6, R9, R12, R16, R19, R22, R24, R28, R31, R38, R41, R50, R52, R59	39	2010 – ±1 % – 1.25W	TE Connectivity	CRGP2010F39R
43	3	R10, R13, RMREG	N.M.	0603	N.A.	N.A.

44	6	R15, R18, R25, R27, R36, R42	60.4	0603 – ±1 % – 0.1W	Panasonic	ERJ3EKF60R4V
45	11	R20, R39, R43, R62, R63, R65, R66, R71, R85, R86, R87	10K	0603 – ±1 % – 0.2W	Panasonic	ERJP03F1002V
46	2	R30, R67	6.2K	0805 – ±1 % – 0.5W	Panasonic	ERJP06F6201V
47	1	R32	18K	0603 – ±1 % – 0.2W	Panasonic	ERJP03F1802V
48	6	R34, R45, R46, R47, R48, R49	10k	0805 – ±1 % – 0.5W	Panasonic	ERJP6WF1002V
49	1	R35	10k	0603 – ±1 % – 0.1W	TDK	NTCG163JH103HTDS

50	1	R37	3.9k	0603 – ±1 % – 0.1W	Panasonic	ERJ3EKF3901V

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
51	5	R53, R54, R55, R57, R58	1.5K	2010 – ±1 % – 2W	TE Connectivity	35021K5FT
52	1	R61	N.M.	N.A.	N.A.	N.A.
53	1	R64	0	0603 – ±1 % – 0.1W	Panasonic	ERJ3GEY0R00V
54	3	R68, R79, R89	750	0603 – ±0.5% – 0.25W, 0603 – ±1% – 0.25W	Panasonic	ERJUP3D7500V
55	3	R74, R77, R78	1.1k	0603 – ±1 % – 0.25W	Panasonic	ERJPA3F1101V

56	1	R81	110K	0603 – ±1 % – 0.25W	Panasonic	ERJPA3F1103V
57	1	RG	1K	0603 – ±1 % – 0.25W	Panasonic	ERJPA3F1001V
58	1	RHOT	47	2512 – ±5 % – 1W	TE Connectivity	352047RJT
59	1	RPD	100K	0603 – ±1 % – 0.25W	Panasonic	ERJP03F1003V
60	2	T1, T2	125uH	Pulse Transformers 125uH	WE	74941000
61	1	U1	L99BM114, TQFP 64 10x10x1.0	Multicell battery monitoring and balancing IC	ST	L99BM114

62	3	U2, U3, U5	USBLC6-2SC6 Y, SOT23-6L	Automotive ESD protection for high speed interfaces.	ST	USBLC6-2SC6Y
63	1	U4	L99BM1T, SO-16	General purpose SPI to isolated SPI transceiver	ST	L99BM1T
64	1	U6	140357145300	WL-OCPT Optocoupler Phototransistor, SOP4, 1 Channel, DC, 35V, 60mA	WE	140357145300
65	1	for blister	60900213421	WR-PHD 2.54 mm Multi-Jumper Jumper with Test Point	WE	60900213421

66	4	for blister	970080365	WA-SPAII Plastic Spacer Stud, metric, internal/ internal	WE	970080365
67	4	for blister	97790603211	WA-SCRW Pan Head Screw w. cross slot M3	WE	97790603211
68	1	for blister	624030213322	WR-WTB 2.00 mm Female Dual Row Terminal Housing w. positive locking	WE	624030213322

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code

69	30	for blister	62400113722	WR-WTB 2.00 mm Female Dual Row Crimp Contact	WE	62400113722
70	2	for blister	61900411621	WR-WTB 2.54 mm Female Terminal Housing	WE	61900411621
71	1	for blister	61900611621	WR-WTB 2.54 mm Female Terminal Housing	WE	61900611621
72	14	for blister	61910113722	WR-WTB 2.54 mm Female Crimp Contact	WE	61910113722

Board versions

Table 3. STEVAL-BMS114TX versions

Finished good	Schematic diagrams	Bill of materials
STV$BMS114TXA(1)	STV$BMS114TXA schematic diagrams	STV$BMS114TXA bill of materials

This code identifies the STEVAL-BMS114TX evaluation board first version

Regulatory compliance information

- Notice for US Federal Communication Commission (FCC)
- For evaluation only; not FCC approved for resale

FCC NOTICE – This kit is designed to allow:

1. Product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and
2. Software developers to write software applications for use with the end product.

This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter 3.1.2.

- Notice for Innovation, Science and Economic Development Canada (ISED)
- For evaluation purposes only. This kit generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to Industry Canada (IC) rules..
- Notice for the European Union
- This device is in conformity with the essential requirements of the Directive 2014/30/EU (EMC) and of the Directive 2011/65/EU (RoHS II), including subsequent revisions and additions, as well as amended by the Delegated

- Directive 2015/863/EU (RoHS III). Compliance to EMC standards in Class A (industrial intended use).
- Notice for the United Kingdom
- This device is in compliance with the UK Electromagnetic Compatibility Regulations 2016 (UK S.I. 2016 No. 1091) and with the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment
- Regulations 2012 (UK S.I. 2012 No. 3032). Compliance to EMC standards in Class A (industrial intended use)

Revision history

Table 4. Document revision history

Date	Version	Changes
10-Jan-2025	1	Initial release.

- Information in this document supersedes and replaces information previously supplied in any prior versions of this document.
-

Documents / Resources

	STMicroelectronics UM3424 Battery Management System Evaluation Board [pdf] User Manual L99BM114, L99BM1T, UM3424 Battery Management System Evaluation Board, UM3424, Battery Management System Evaluation Board, Management System Evaluation Board, System Evaluation Board, Evaluation Board, Board

References

- User Manual

STMicroelectronics

Battery Management System Evaluation Board, Board, Evaluation Board, L99BM114, L99BM1T, Management System Evaluation Board, STMicroelectronics, System Evaluation Board, UM3424, UM3424 Battery Management System Evaluation Board

Leave a comment

Your email address will not be published. Required fields are marked *

Comment *

Name

Email

Website

Save my name, email, and website in this browser for the next time I comment.

Post Comment

Search:

e.g. whirlpool wrf535swhz

Search