

Getting started with AutoDevKit battery management system (BMS) evaluation boards

Introduction

In a multicell battery pack, placing cells in series augments the possibilities of cell imbalance, which equates to a slower but persistent degradation of the battery.

There are always slight differences in the state of charge (SOC), self-discharge rate, capacity, impedance, and temperature characteristics, even for cells of the same model from the same manufacturer and even from the same batch of production.

These differences can lead to a divergence in a battery cell voltage over time. Cells with lower capacity or higher internal impedance tend to have higher voltage than the rest of the series cells at full charge. These cells are weakened further by continuous overcharge cycles. The higher voltage of weak cells at charge completion causes accelerated capacity degradation.

On the other hand, in discharge, the weak cells tend to have lower voltage than the other cells, due to either higher internal resistance or the faster rate of discharge that results from their smaller capacity. This means that if any of the weak cells hits the cell undervoltage-protection limit while the pack voltage is still sufficient to power the system, the full capacity of the battery is not used.

One of the emerging technologies for enhancing battery safety and extending battery life is advanced cell balancing. Since new cell balancing technologies track the amount of balancing needed by individual cells, the usable life of battery packs is increased, and overall battery safety is enhanced.

A battery management system (BMS) can manage battery cells, enhancing their safety and duration.

A BMS combines hardware and software to monitor and send acquired data to a dedicated device to protect the battery from overload or over discharge, lengthening its life cycle.

In the earlier BMSs, the SOC estimation was based only on the voltage reading.

Nowadays, instead, this estimation is based on Kalman filters, which provide more accurate data on the SOC by reading the voltage, the current, and the temperature of battery cells.

The modern BMS includes functions such as cell monitoring, balancing, safety and protection of the batteries, the state of charge estimation and thermal management:

- Cell monitoring: this function is based on the acquisition of the current, the voltage, and the temperature of each cell of the battery pack.
- Cell balancing: consists of distributing the energy and maintaining the SOC of the cells at a similar level. There are two different types of balancing: active and passive. Active balancing consists of transferring the exceeding energy of cells with a higher SOC to cells with a lower SOC to reach the same level. Passive balancing dissipates the exceeding energy of cells with a higher SOC, generating heat. Cell balancing is a key function to maintain the battery capacity and lengthen its duration.
- Battery safety and protection: a BMS ensures that the battery works in safe conditions for the users and the battery itself.
- State of charge (SOC) and state of health (SOH): an accurate SOC estimation is necessary to lengthen the battery life cycle, prevent battery damage, and ensure efficiency and accurate calculations of the SOH and cell balancing.

We offer a variety of BMS evaluation boards ([AEK-POW-BMS63EN](#), [AEK-POW-BMSNOTX](#), [AEK-POW-BMSWTX](#), [AEK-POW-BMSCC](#), [AEK-POW-BMSCCTX](#), and [AEK-POW-BMS63EM](#)) to meet various customers' needs and help designers build different types of BMS chain topologies fit for any end-user application.

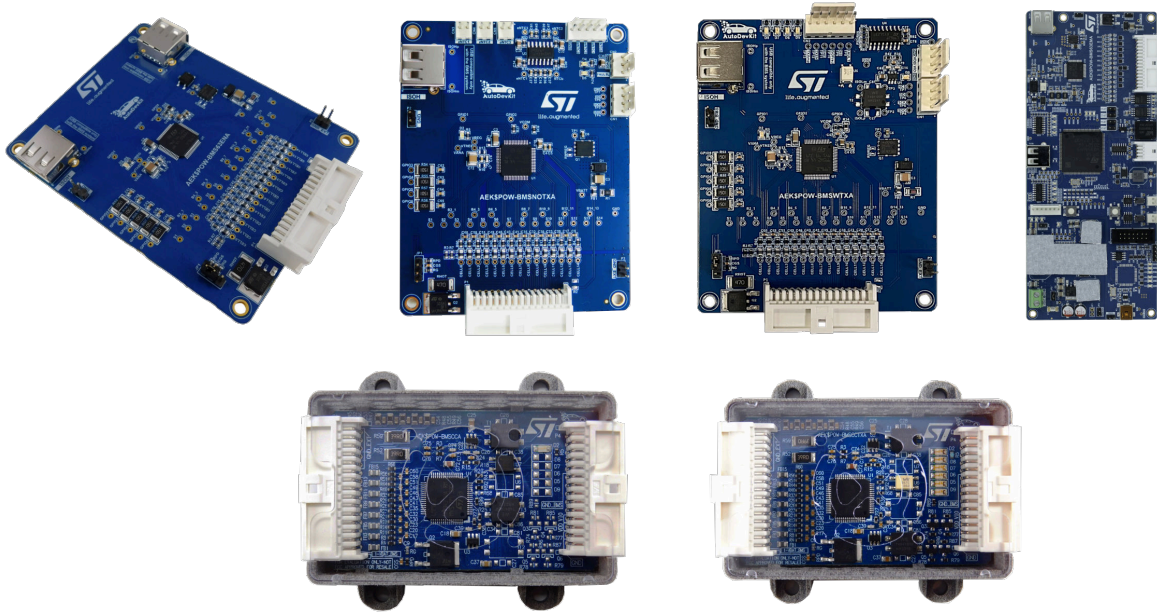
These boards are included in the AutoDevKit ecosystem to make design and prototyping even faster and easier. Next chapters focus on a comprehensive and detailed description of all the boards belonging to our BMS range and the various topologies of BMS chains you can experimenting with.

We also developed a specific GUI to monitor the state of charge, voltage, current, balancing status of selected chains and nodes.

Note: *The evaluation boards described in this user manual are designed for R&D laboratory use only. They are not intended for field use in vehicles.*

Moreover, they are not reference designs. Their purpose is evaluation and not production as stated in our [Terms of use](#).

Figure 1. AutoDevKit BMS evaluation board range



Note: For dedicated assistance, please submit a request in our [AutoDevKit Community](#).

1 BMS evaluation board overview

1.1 AEK-POW-BMS63EN overview

Our **AEK-POW-BMS63EN** is a battery management system (BMS) evaluation board that can handle from 1 to 31 Li-ion battery nodes. Each battery node manages from 4 to 14 battery cells, for a voltage range between 48 V and 800 V.

The board is based on the **L9963E**, which is designed for operation in both hybrid (HE) and full electric (BE) vehicles using lithium battery packs, but its use can be extended to other Transportation and Industrial applications.

The L9963E is an ASIL-D, AEC-Q1000 qualified device, compliant with ISO26262.

The main activity of the L9963E is monitoring 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 periodically, with a programmable cycle interval. 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 AEK-POW-BMS63EN can measure 5 values of temperature through 5 GPIOs (which can be configured as analog inputs to connect NTCs).

The AEK-POW-BMS63EN provides an elaborate monitoring network to sense the voltage, current, and temperature of each cell.

1.1.1 Features

- Hosts the L9963E AEC-Q100 qualified automotive multicell battery monitoring and balancing IC
- Voltage monitoring of every single cell and of the entire battery node
- Voltage, current, and temperature sensing of each cell
- 5 GPIOs to connect temperature sensors as NTCs
- An NTC hosted on the L9963E to sense the chip temperature
- Passive balancing
- Compact size: 100 mm x 76 mm
- Included in the AutoDevKit ecosystem

1.1.2 Main components

1. ISOH port to connect the board to another AEK-POW-BMS63EN in a daisy chain
2. ISOL port to connect the board to the AEK-COM-ISOSPI1
3. L9963E
4. GPIOs for external NTC connection
5. Hot plug protection
6. Balancing resistors
7. Connector for the battery pack

Figure 2. AEK-POW-BMS63EN main components (top view)

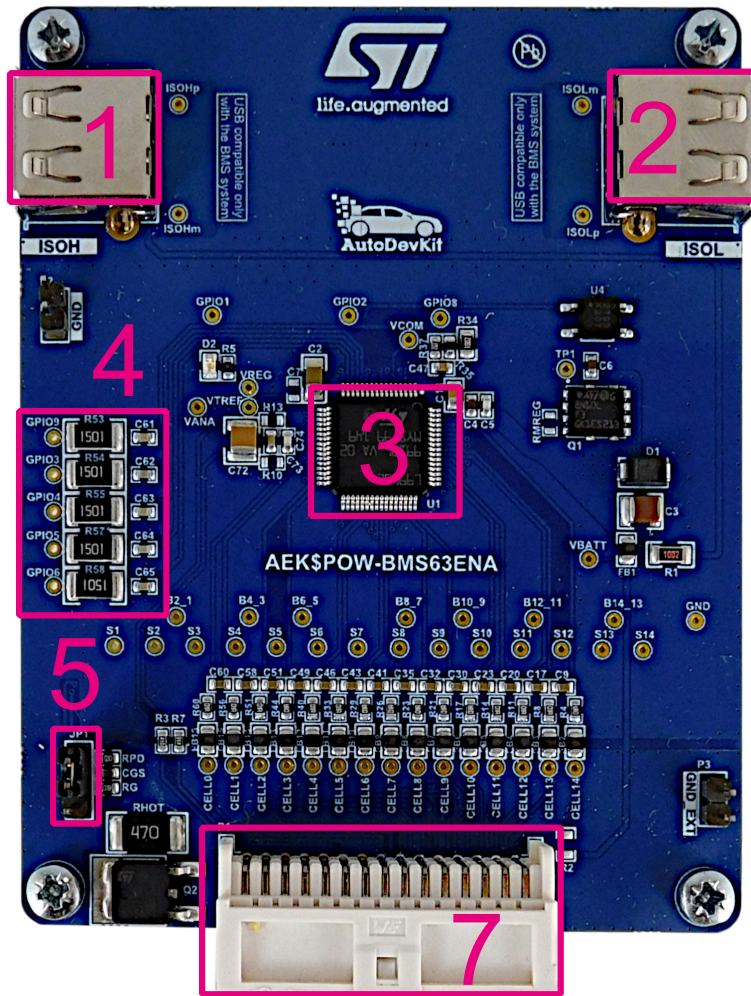
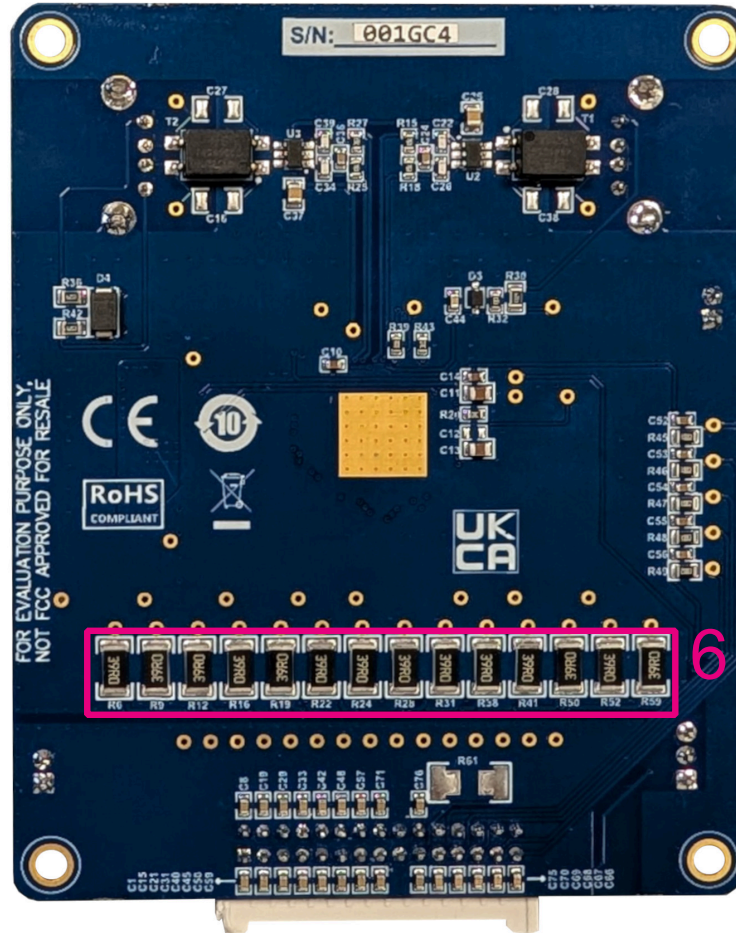


Figure 3. AEK-POW-BMS63EN main components (bottom view)


1.2 AEK-POW-BMSNOTX overview

Our offer for BMS evaluation boards also includes the [AEK-POW-BMSNOTX](#) that manages from 4 to 14 battery cells.

Like the AEK-POW-BMS63EN, this board is based on the L9963E.

This embedded L9963E device can act as a transceiver, directly communicating with an MCU via SPI.

The board is particularly fit for auxiliary battery systems to supply power for devices (such as audio system, window cleaning system, seat heating, light system, light signalization, climate control system) connected to your vehicle (even when the engine is not running), ensuring the main starting battery is reserved for engine cranking and vehicle electrical requirements.

1.2.1 Features

- The board hosts the [L9963E](#) AEC-Q100 qualified automotive multicell battery monitoring and balancing IC
- Voltage monitoring of every single cell and of the entire battery node
- Current sensing of the entire battery node
- 4 GPIOs to connect NTC sensors present on the battery pack connector
- 3 NTC sensors that can be connected to CN3, CN4 and CN5 connectors
- 1 NTC sensor to measure the board temperature
- CN1 connector to communicate with an MCU board via SPI
- CN2 connector for diagnostic functions
- CN6 connector for MCU ADCs dedicated to the NTC sensors reading
- Passive balancing available
- Compact size: 100 mm x 76 mm
- Included in the [AutoDevKit](#) ecosystem

1.2.2 Main components

1. ISOH port to connect the board to an AEK-POW-BMS63EN in a daisy chain
2. CN3, CN4 and CN5 connectors to connect three external NTC sensors
3. LM2902W Low power quad operational amplifier
4. CN6 connector for MCU ADCs dedicated to the NTC sensors reading
5. CN2 connector for diagnostic functions
6. CN1 connector to communicate with an MCU board via SPI
7. [L9963E](#) AEC-Q100 qualified automotive multicell battery monitoring and balancing IC
8. Balancing resistors
9. Connector for the battery pack
10. Hot plug protection
11. GPIOs for external NTC connection handled by [L9963E](#)

Figure 4. AEK-POW-BMSNOTX main components (top view)

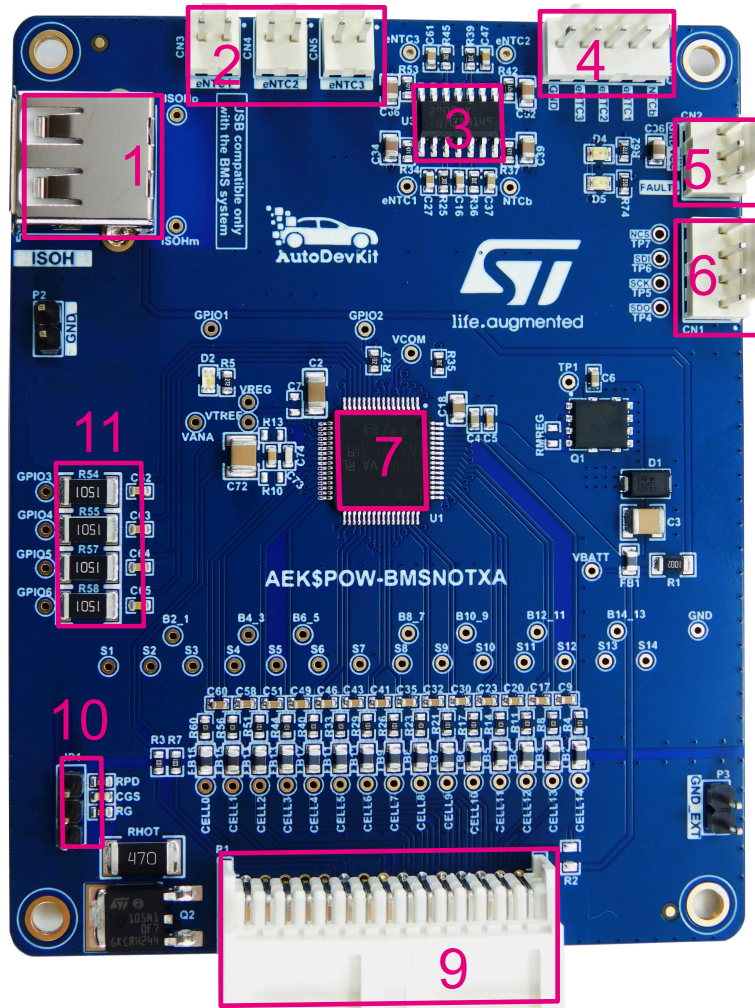
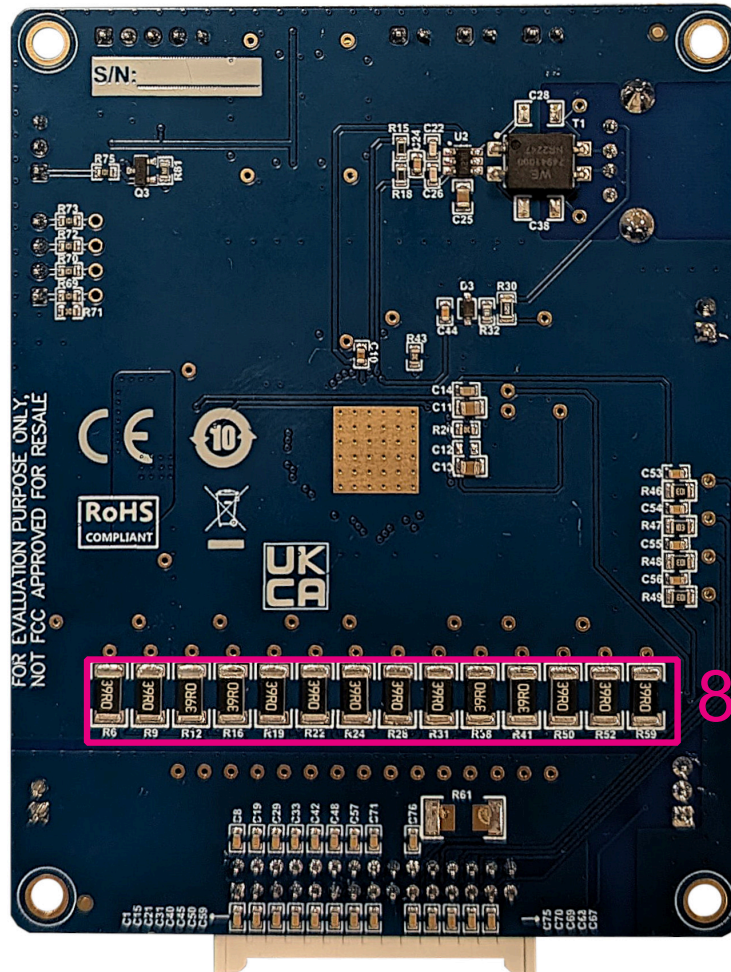


Figure 5. AEK-POW-BMSNOTX main components (bottom view)


1.3 AEK-POW-BMSWTX overview

The **AEK-POW-BMSWTX** 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 L9963E Li-ion battery monitoring and protection chip for high-reliability automotive applications and the L9963T general purpose SPI to isolated SPI bidirectional transceiver.

The main activity of the L9963E 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 periodically, with a programmable cycle interval.

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 L9963T general purpose SPI to isolated SPI bidirectional transceiver can transfer communication data incoming from a classical 4-wire based SPI interface to a 2-wire isolated interface (and vice versa). In our board, the transceiver is configured as a slave.

1.3.1 Features

- Hosts the L9963E AEC-Q100 qualified automotive multicell battery monitoring and balancing IC
- Hosts the L9963T AEC-Q100 qualified automotive 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 mm x 76 mm
- Included in the [AutoDevKit](#) ecosystem

1.3.2 Main components

1. ISOH port to connect the board to an AEK-POW-BMS63EN in a daisy chain
2. Connector for MCU ADCs dedicated to the NTC sensors reading
3. Automotive 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 L9963E
10. L9963E AEC-Q100 qualified automotive multicell battery monitoring and balancing IC

Figure 6. AEK-POW-BMSWTX main components (top view)

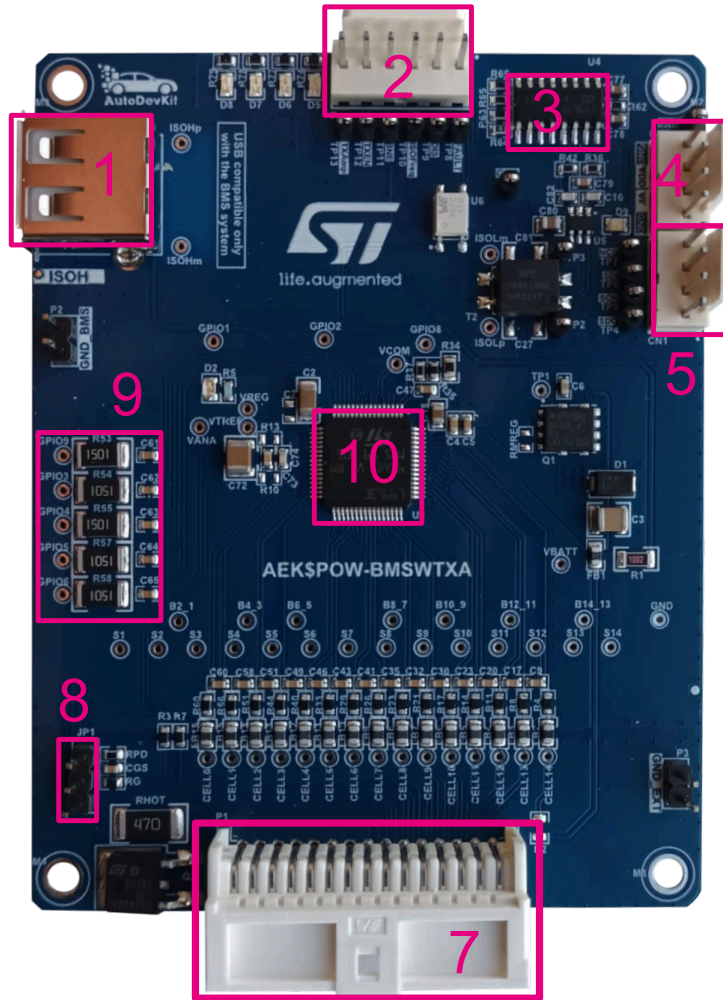
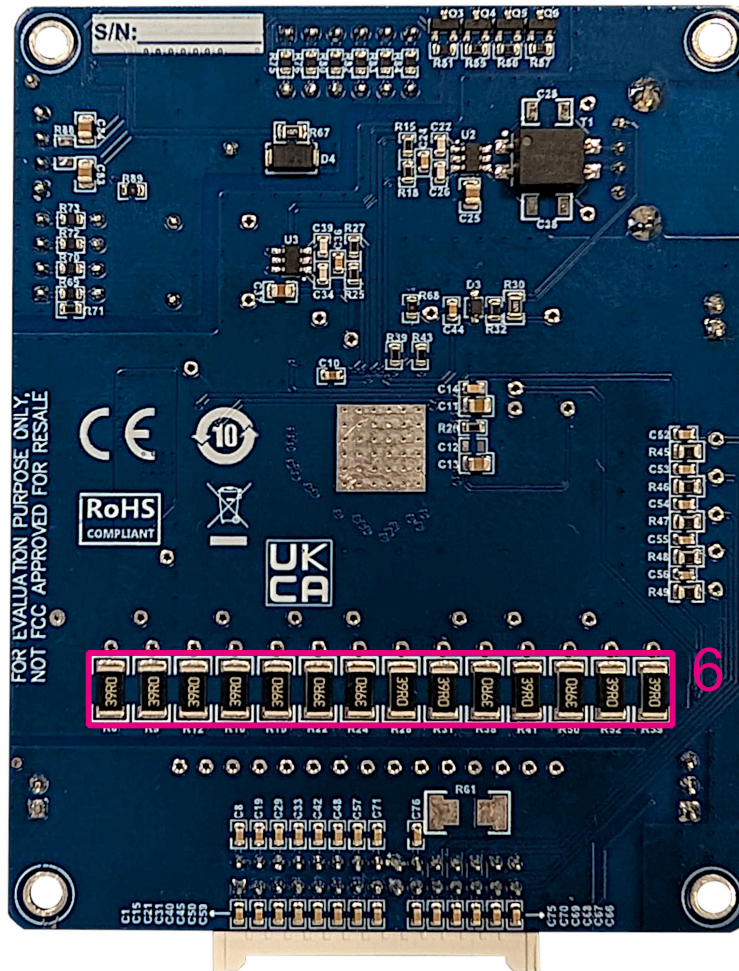


Figure 7. AEK-POW-BMSWTX main components (bottom view)


1.4 Compact BMS evaluation boards

Our BMS portfolio also includes two optimized form-factor and packaged battery management system modules for battery pack easy mounting: [AEK-POW-BMSSC](#) and [AEK-POW-BMCCTX](#).

The ability to easily integrate into a system, compact dimensions and a wide range of applications make these compact BMS systems ideal for any solution enhancing battery life, efficiency and cost effectiveness during use and operation.

The small size allows for greater flexibility in battery pack installation, addressing the challenges of using a BMS in confined spaces.

Their compact design allows them to fit easily, enabling more batteries to be installed within the same volume. This increases the overall battery storage, providing robust performance without adding unnecessary weight.

The following two subsections focus on each of this board specific features.

1.4.1 AEK-POW-BMCC overview

The [AEK-POW-BMSSC](#) is based on the [L9963E](#) Li-ion battery monitoring and protection chip for high-reliability automotive applications.

It can be used in a centralized daisy chain as an intermediate node, where the first node is an [AEK-POW-BMCCTX](#). As intermediate node, the [AEK-POW-BMSSC](#) can be part of a chain of up to 31 BMS nodes. Each battery node manages from 4 to 14 battery cells. The total voltage of the chain may range between 48 V and 800 V.

1.4.1.1 Main components

1. P1 connector for the battery pack with:
 - 14 x cell connection
 - 5 x L9963E dedicated ADC pins for NTC sensors reading
2. P4 connector to:
 - Communicate with the previous/next BMS node via ISOSPI
 - Receive and Redirect FAULT for diagnostic
3. L9963E AEC-Q100 qualified automotive multicell battery monitoring and balancing IC
4. Balancing resistors (Cell 1, Cell 2)
5. Balancing resistors (Cell 3 to Cell 14)
6. Voltage dividers for external NTC connection, handled by L9963E
7. D2: ON when L9963E is configured and working
8. D8: ON when TXEN is high (Transceiver ON)
9. D7: blinks when the SPI communication with the MCU is established
10. D6: ON when the transceiver is disabled
11. D5: ON when a FAULT occurs
12. D9: ON when VDD is high (MCU board ON)

Figure 8. AEK-POW-BMSCC main components (top view)

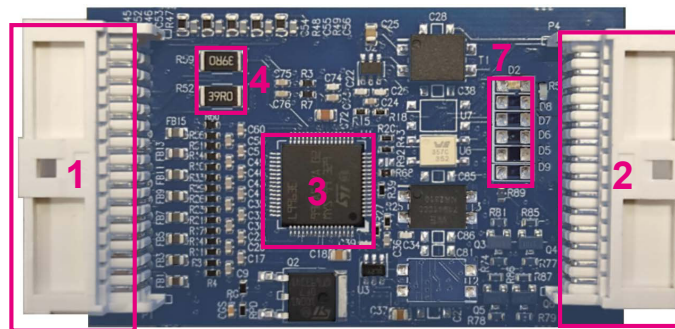
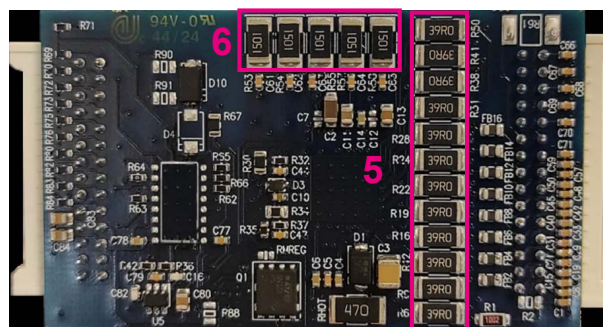


Figure 9. AEK-POW-BMSCC main components (bottom view)



1.4.2 AEK-POW-BMSCCCTX overview

The AEK-POW-BMSCCCTX can handle from 1 to 31 BMS nodes. Each battery node manages from 4 to 14 battery cells. The total voltage of the chain may range between 48 V and 800 V.

The board is based on the L9963E Li-ion battery monitoring and protection chip for high-reliability automotive applications and the L9963T general purpose SPI to isolated SPI bidirectional transceiver.

The main advantage of this evaluation board is ensuring isolated connection to an external MCU, thanks to the embedded transceiver.

The board can be used in a centralized daisy chain as the first node, while the other nodes will be AEK-POW-BMSCC evaluation boards.

1.4.2.1 Main components

1. P1 Connector for the battery pack with:
 - 14 x cell connection
 - 5 x L9963E dedicated ADC pins for NTC sensors reading
2. P4 connector to:
 - Communicate with an MCU board via SPI
 - Configure an AEK-POW-BMSCC node via ISO line in a daisy chain
 - Receive and Redirect FAULT for diagnostic
3. L9963E AEC-Q100 qualified automotive multicell battery monitoring and balancing IC
4. L9963T automotive general-purpose SPI to isolated SPI transceiver
5. Balancing resistors (Cell 1, Cell 2)
6. Balancing resistors (Cell 3 to Cell 14)
7. Voltage dividers for external NTC connection, handled by L9963E
8. LEDs used to display the operational status of the board. Each LED indicates different states and functions
 - D2: ON when L9963E is configured and working
 - D8: ON when TXEN is high (Transceiver ON)
 - D7: blinks when the SPI communication with the MCU is established
 - D6: ON when the transceiver is disabled
 - D5: ON when a FAULT occurs
 - D9: ON when VDD is high (MCU board ON)

Figure 10. AEK-POW-BMSCCTX main components (top view)

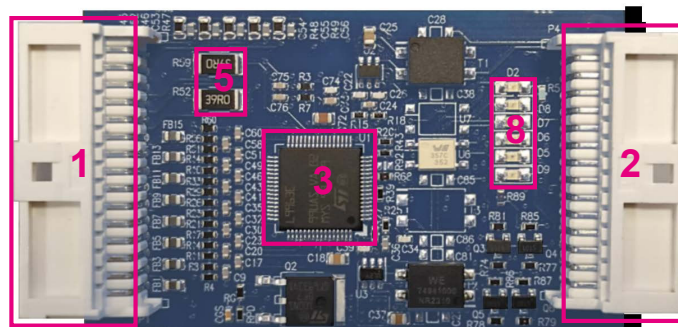
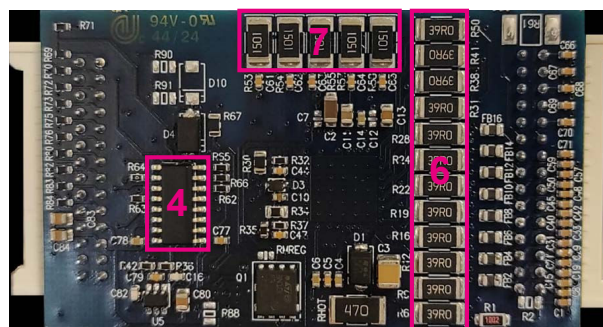


Figure 11. AEK-POW-BMSCCTX main components (bottom view)

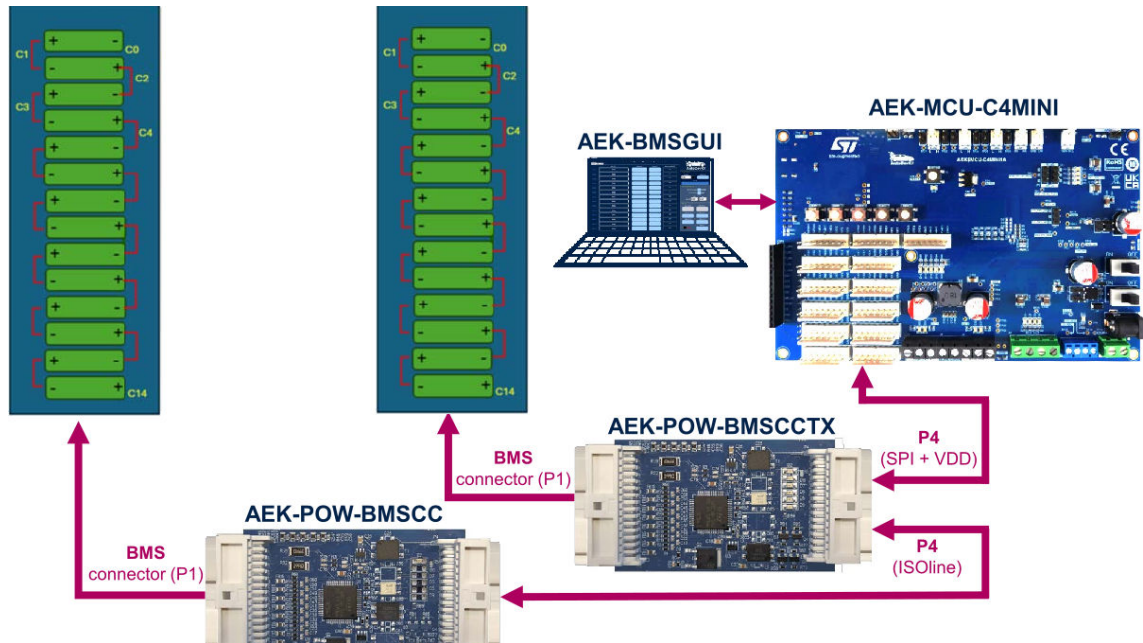


1.4.3 Additional information on daisy chain configuration for AEK-POW-BMCC and AEK-POW-BMSCCTX

To connect the two boards in a daisy chain configuration, using the AEK-MCU-C4MINI as MCU and two battery holders (for example, AEK-POW-BMSHOLD), refer to the image below.

To visualize data, use our GUI (see Figure 93. BMS GUI tabs).

Figure 12. Example of daisy chain using AEK-POW-BMCC and AEK-POW-BMSCCTX evaluation boards and AEK-BMSGUI

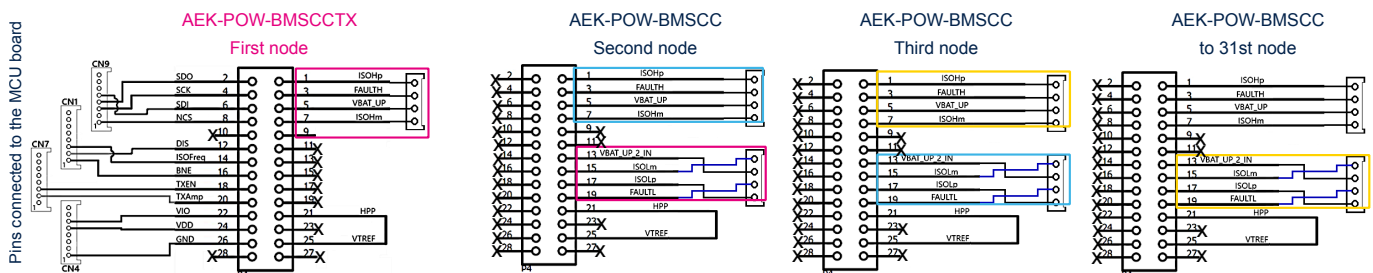


Refer to P4 board connector pinout shown below to link the chain nodes.

In detail, wire:

- ISOHp of a node with ISOLp of the following node
- FAULTH of a node with FAULTL of the following node
- VBAT_UP of a node with VBAT_UP_2_IN of the following node
- ISOHm of a node with ISOLm of the following node

Figure 13. Daisy chain node connections



1.5 AEK-POW-BMS63EM evaluation board

The **AEK-POW-BMS63EM** is a battery management system (BMS) evaluation board that can handle from 1 to 31 Li-ion battery nodes. Each battery node manages from 4 to 14 battery cells, for a voltage range between 48 V and 64 V.

Thanks to the two embedded transceivers, the board can be used as the first node in a BMS daisy chain, connected to a battery pack of 6, or 10 (in configuration A or B), or 14 cells, and in a dual access ring BMS chain.

The board monitors state of charge (SOC) and state of health (SOH) of each battery and manages battery balancing by passive discharge, thanks to the software already preloaded on the on-board **SPC58NN84E7** microcontroller.

The board is equipped with two CAN ports featuring the versatile CAN2.0 protocol that facilitates integration into several systems and efficient component communication.

It hosts the following devices: **SPC58NN84E7**, **L9963F**, **L9963T**, **SPSB100**, **LM2902W**, and **STGAP2GS**.

In our application, to connect different battery holders with a variable number of battery cells to the first node, we short-circuited the missing cells on the battery pack as well as the unused cells of the **L9963F** device, through MOSFETs driven by the **STGAP2GS** gate driver.

Moreover, the unused cells are disabled via software to avoid incorrect readings of the remaining cells and the related diagnostics, and to prevent potential failures (such as cell undervoltage).

Our board safety features include overload and overvoltage protection, against potential issues that could compromise battery integrity, alongside over-discharge protection to prevent excessive discharge and extend battery life.

The board core features ensure battery health and longevity. Continuous voltage monitoring provides real-time information about battery status, enabling quick detection of deviations from ideal voltage levels, ensuring reliability, and preventing potential issues.

1.5.1 Features

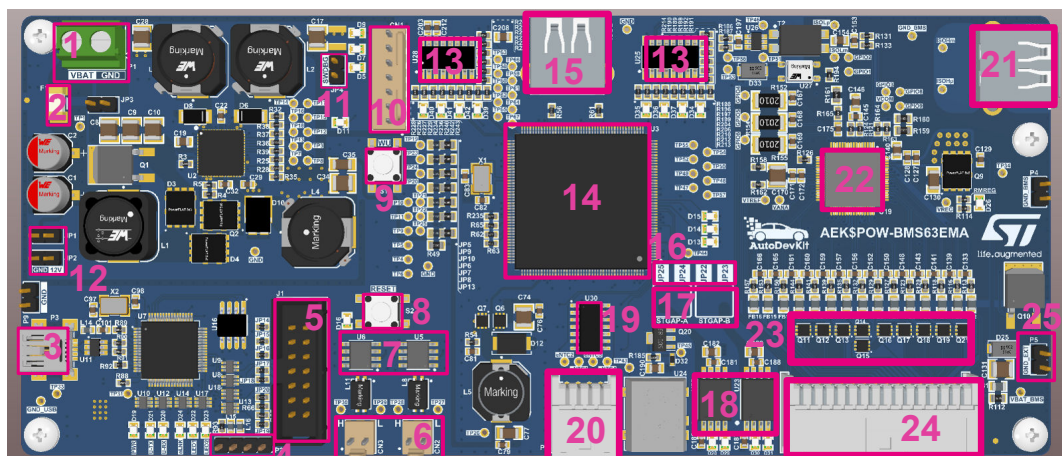
- Hosts:
 - **L9963F** AEC-Q100 qualified automotive multicell battery monitoring and balancing IC
 - Two **L9963T** AEC-Q100 qualified automotive general-purpose SPI to isolated SPI bidirectional transceivers
 - Two CAN-FD transceivers supporting high-speed applications up to 8Mbps
 - **SPC58NN84E7** ASIL-D MCU, featuring five cores and a hardware security module for system robustness, safety and integrity, to perform charge balancing and to compute the state of charge (SOC) and the state of health (SOH)
 - Two **STGAP2GS** isolated gate drivers to isolate the microcontroller from overvoltage or faults and to allow different battery pack connections by driving the MOSFETs that short-circuit unused cells
 - **LM2902W** low-power quad operational amplifier to sense the battery pack temperature
- Four battery pack connections are possible with 6, or 10 (in configuration A or B), or 14 cells, using the **AEK-POW-BMS63EM** as first node
- Voltage monitoring of up to 14 battery cells
- Current sensing of the entire battery node
- Thanks to the two embedded **L9963T** ISOSPI transceivers, the board allows configuring two different topologies: daisy chain and dual access ring
- 4 configurable GPIOs, pluggable with NTCs for temperature measurement through an external temperature sensor
- 3 embedded NTCs to sense the BMS node temperature
- 3 additional NTCs hosted on the battery holder connector
- SPI interface to communicate with the MCU
- Passive balancing
- JTAG module for board firmware debugging/programming
- Debug mode for board testing
- Compact size: 183 mm x 78 mm
- Included in the **AutoDevKit** ecosystem

1.5.2 Main components

The board top side components are listed below and shown in figure Figure 14:

1. 12 V DC power supply connector
2. Fuse
3. OpenOCD debugger/programmer connector
4. UART connector
5. JTAG connector
6. CAN Line
7. CAN transceiver
8. RESET button
9. WAKE-UP button
10. NVM connector
11. SWDBG jumper
12. External 12V to address the NVM procedure
13. L9963T automotive general-purpose SPI to isolated SPI transceiver
14. SPC58NN84E7RMHBR 32-bit Power Architecture MCU for Automotive ASIL-D applications
15. ISOL port to connect the board to an AEK-POW-BMS63EN in a dual ring configuration
16. User programmable LEDs
17. STGAP jumper
18. STGAP2GS galvanically isolated 3 A single gate driver for Enhancement mode GaN FETs
19. LM2902W low-power quad operational amplifier
20. External temperature sensor connector
21. ISOH port to connect the board to an AEK-POW-BMS63EN in a dual ring configuration
22. L9963F automotive Multicell battery monitoring and balancing IC
23. STL7N6F7 N-channel power MOSFET
24. Connector for the battery pack
25. Hot plug protection

Figure 14. AEK-POW-BMS63EM, main components (top view)

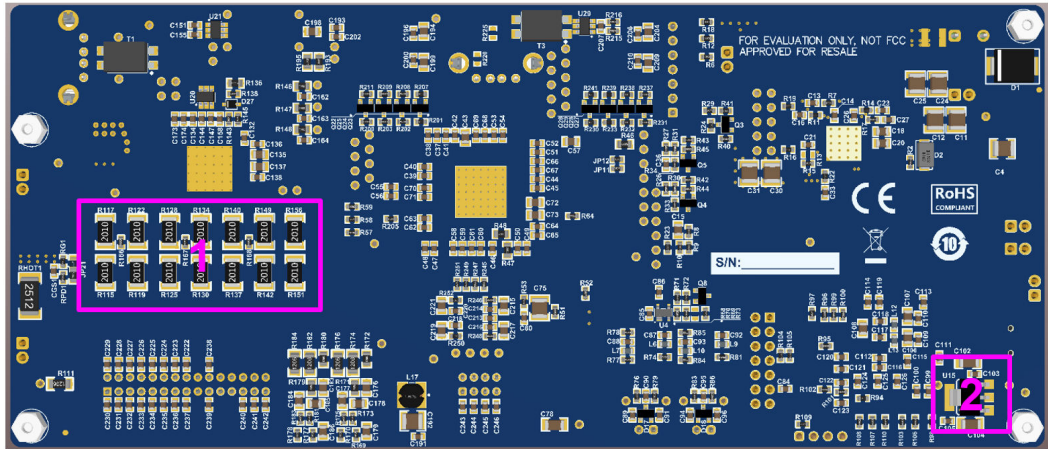


Note: Programming the microcontroller via the USB connector requires the FTDI (FT232HL) to be mounted on the PCB. Since the FTDI is not populated on the available board due to a component shortage, USB programming is not supported. However, the microcontroller can still be programmed via JTAG, by connecting the related connector (fno. 4 in Figure 14) to the debugging dongle serial connector.

The board bottom side components are listed below and shown in figure Figure 15:

1. Balancing resistors
2. LD1117S33 adjustable and fixed low drop positive voltage regulator

Figure 15. AEK-POW-BMS63EM, main components (bottom view)



1.5.3 SPSB100

Note: For any future development, it is recommended to use **SPSB100G** as alternative part number.

SPSB100 is used in fully integrated automotive power management systems, specifically designed for highly integrated application processors. It consists of four DC-DC converters and two linear voltage regulators (LDOs). The DC-DC converters include three step-down converters (BUCK1, BUCK2, and BUCK3) at 5 V, 3.3 V, and 0.97 V, respectively, and one step-up converter (BOOST) at 9.5 V. The two LDOs provide 5 V each.

The first two step-down converters (BUCK1 and BUCK2) can power the microcontroller and other peripherals with a current capacity of 3 A. BUCK3 (0.97 V), after reconfiguration of the non-volatile memory (NVM), can power the microcontroller VDD_LV with a maximum current capacity of 6 A.

In the current configuration, BUCK2 at 5 V powers the microcontroller and associated peripherals.

The first linear regulator (LDO1) powers the microcontroller ADC with a current capacity of 120 mA, whereas LDO2 is used as a tracker with a current capacity of 10 mA. The step-up converter is used when the 12 V input voltage drops below the critical value of 9.5 V, with a current capacity of 4.2 A.

Note: Non-volatile memory (NVM) can be used to reprogram voltages, maximum current capacity, and other device characteristics. Currently, the default ST values are present. To reprogram the device NVM, refer to the **SPSB100BR** datasheet and use JP2 to provide an external 12 V supply. Use CN1 and test points TP15, TP16, TP17, and TP18 to control the SPI and power supply.

Additional features of the SPSB100 are:

- **Fail-safe output:** with a dedicated LED indicator in case of error.
- **Wake-up input:** sensitive to any transition level (positive or negative) with static or cyclic detection. This input can be used through a test button or by the microcontroller through a dedicated line.
- **Ignition input:** sensitive to any transition level (positive or negative) with static or cyclic detection. This input can be used by the microcontroller through a dedicated line. In the automotive sector, this input acts as a wake-up for vehicle electronics, ensuring that some components or control units operate only when the engine is running or ready to start. This function prevents potential damage.
- **Interrupt output request:** used to signal errors or failures to the microcontroller.
- **NRST output:** used to reset the microcontroller. This feature is currently not used on the board.
- **FIN1 input:** used to monitor errors reported by the FCCU (fault collection and control unit) of the microcontroller. This hardware unit collects, monitors, and manages errors and faults detected in the system.
- **High side output:** used to drive resistive loads with open-load and overcurrent diagnosis. This feature is currently not used.

Protection and safety features:

- Detection and limitation of overcurrent for all BUCK converters.
- Integrated soft start.
- Temperature warning and protection beyond limits.
- Configurable watchdog.
- Low quiescent current.
- Low-power and deep-sleep states.
- Integrated control via STM SPI.
- NVM (Not-Volatile Memory). This feature is currently not used on the board.
- Static and dynamic error reporting.
- Software debug mode for software development and testing.

1.5.3.1 SW debug mode

To enter this mode, follow the steps below:

1. With the board powered off, insert the supplied jumper into header JP4 to short the SWDBG pin to VIO.
2. Turn on the board.
3. Within a time (t_{SWDBG_TO}) of 10 seconds, remove the jumper.
4. The debug mode is now active.

Figure 16. SWDBG pin schematic View

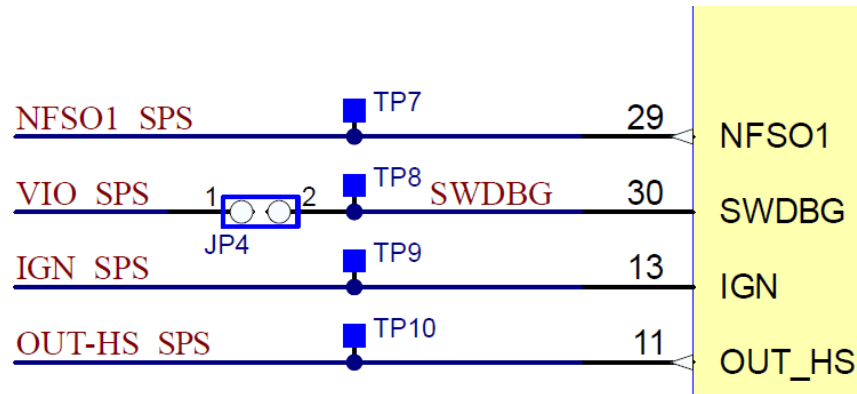
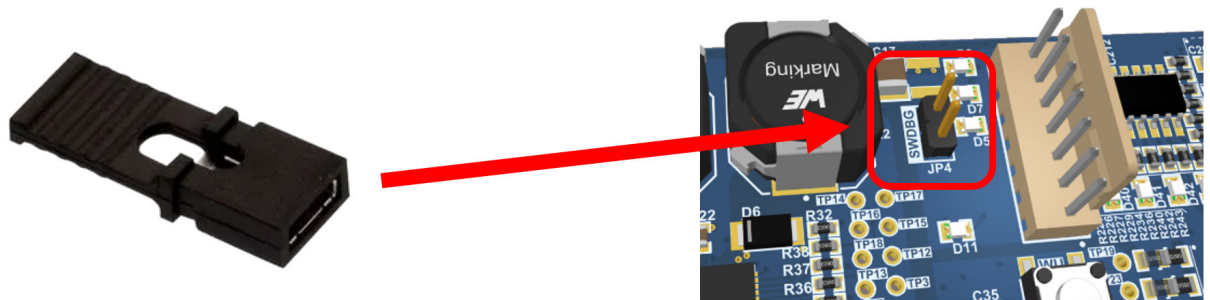


Figure 17. SWDBG pin 3D view



1.5.4 SPC58NN84E7RMHBR

The AEK-POW-BMS63EM core is the [SPC58NN84E7RMHBR](#) microcontroller. The SPC58NN series is a 32-bit automotive Power Architecture microcontroller that embeds five cores and a hardware security module. It is designed to meet requirements for automotive and transportation applications, as well as other applications that require automotive safety levels such as ASIL-D. ASIL-D represents the highest level of safety and risk, requiring the highest system integrity and robustness. This safety level allows use in numerous applications, including brake systems, advanced steering control systems, and battery management systems (BMS).

In this application, the microcontroller monitors the state of charge (SOC) and state of health (SOH) of the batteries managed by the onboard [L9963F](#). It enables passive cell balancing and manages parameters such as voltage and current.

The microcontroller also manages:

- Two CAN FD ports to facilitate integration of various automotive systems.
- Four external temperature sensors based on the [LM2092W](#) operational amplifier.
- Two isolated gate drivers ([STGAP2GS](#)) to allow use of four different battery packs.
- Control and management of the [SPSB100BR](#) using watchdog and SPI.
- Single access configuration with related parameters through the onboard [L9963F](#) and [L9963T](#).
- Dual ring configuration with related parameters through [L9963F](#) and two [L9963T](#).
- Firmware flashing on the board.

1.5.5 STGAP2GS

The **STGAP2GS** isolated gate driver ensures galvanic isolation between the control section (logic, microcontroller, field-programmable gate array (FPGA), and so on) and the power section.

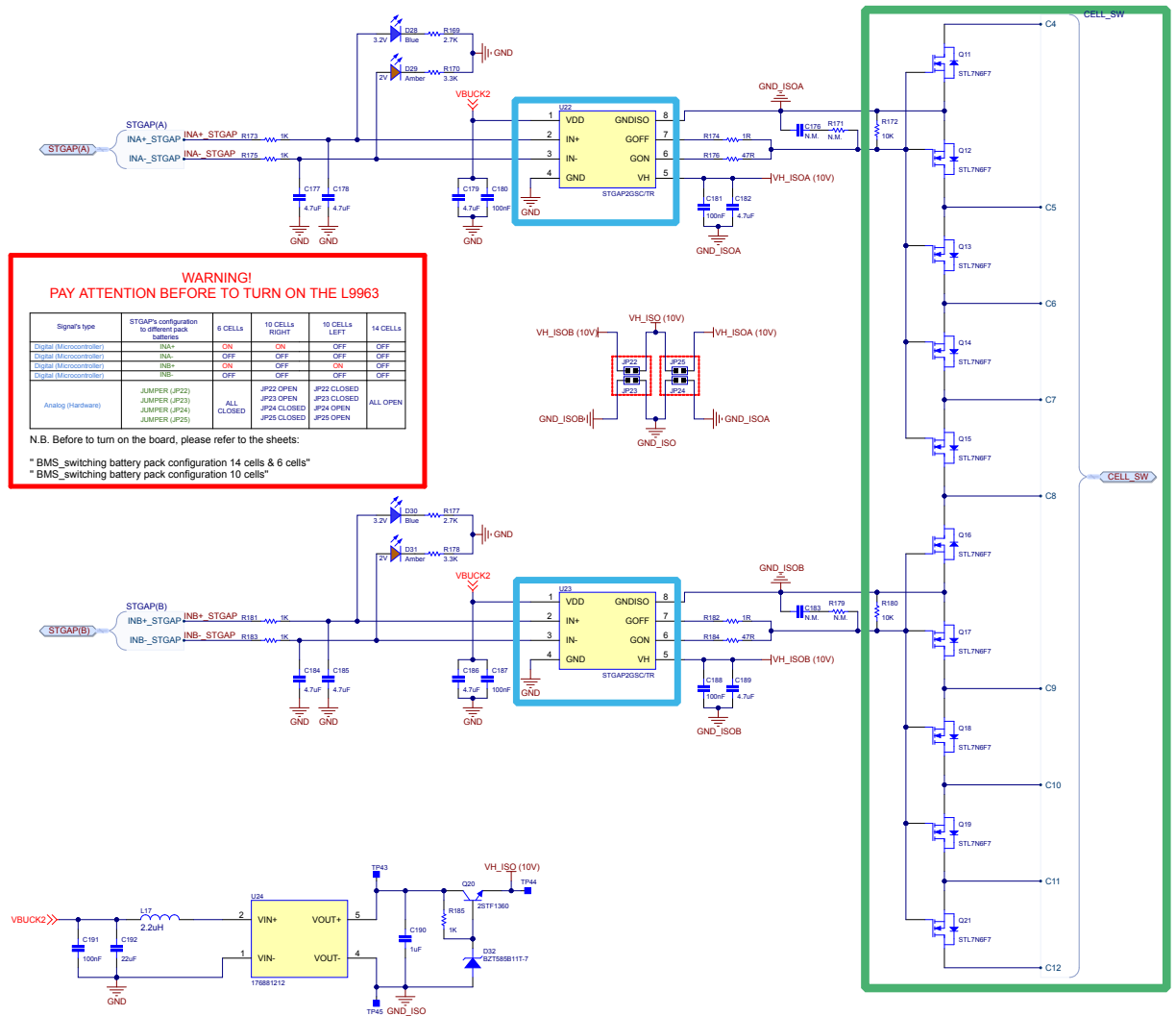
The isolation is necessary for:

- **Safety:** isolation protects the control section from overvoltages, disturbances, or faults that can occur in the power section.
- **Management of different ground references:** in many converters, such as half-bridge, full-bridge, or inverter topologies, the MOSFETs or IGBTs potentials can differ significantly from the control logic ground.
- **Noise reduction:** isolation helps prevent noise from the power section from transferring to the control section.

On the **AEK-POW-BMS63EM** board, two **STGAP2GS** single gate drivers provide galvanic isolation between the gate driver channel and the control circuit.

In the image below, the blue box highlights the two gate drivers on the **AEK-POW-BMS63EM** board, while the green box highlights the external MOSFETs driven by the two **STGAP2GS** devices connected in parallel to the **L9963F** cells. Gate drivers are also necessary to detect the voltage of the cells connected to the battery pack correctly, especially if there are fewer cells.

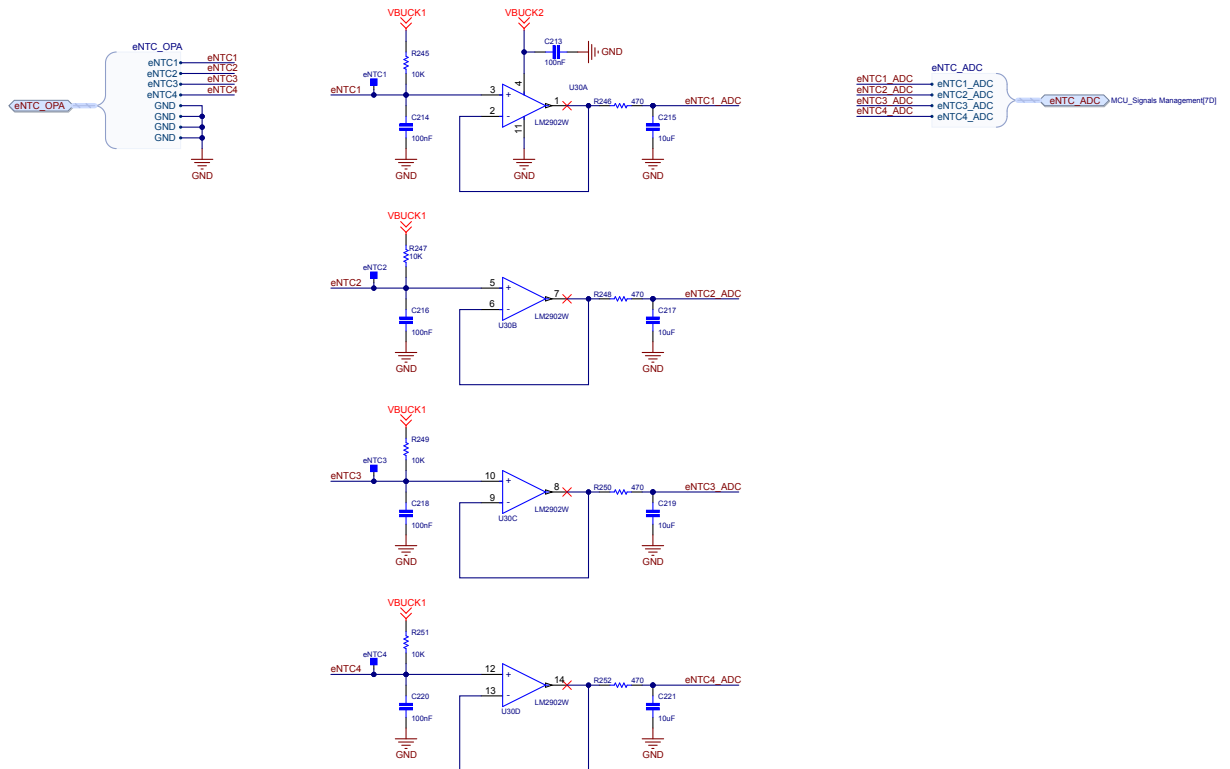
Figure 18. STGAP2GS control circuit - schematic view



1.5.6 LM2902W and external temperature sensors

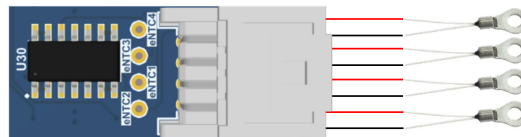
The AEK-POW-BMS63EM board hosts the LM2902W device, which contains four independent high-gain operational amplifiers designed for automotive and industrial control systems. The device operates in a single-supply configuration from 0 V to 3.3 V. Using four external temperature sensors, LM2902W detects temperature within the battery pack system.

Figure 19. LM2902W operational amplifiers - schematic view



To use these four sensors, connect them to P7 connector, as shown in the image below.

Figure 20. External temperature sensor connection to the AEK-POW-BMS63EM - 3D view



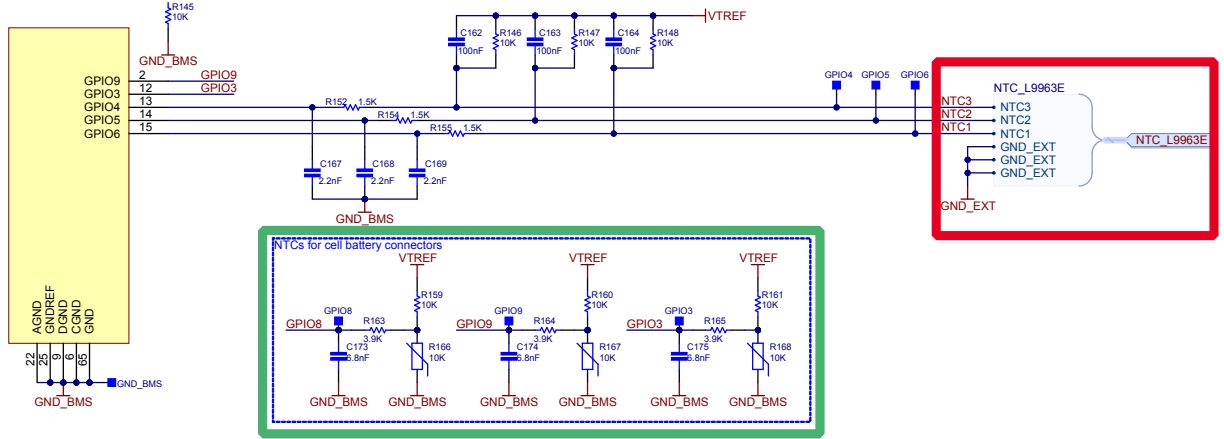
Note: *Temperature sensors shown above do not have polarity. For each sensor, connect one wire (shown in red) to eNTCx. Then, connect the other wire (shown in black) to GND.*

The four temperature sensors, combined with the six sensors managed directly by the L9963F, allow estimation of the battery pack, the cells, and the board temperatures.

1.5.7 Temperature sensors managed by L9963F

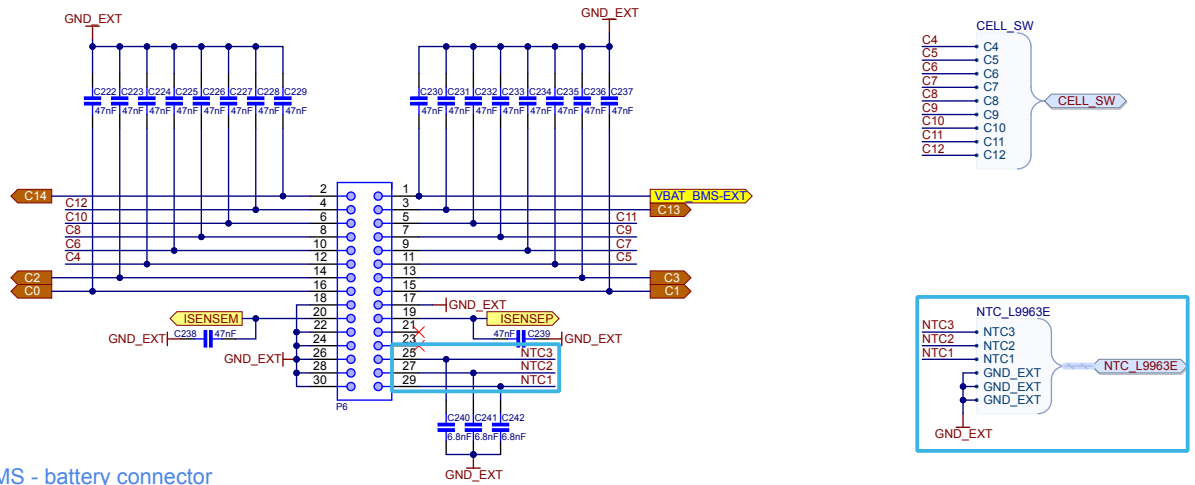
The **AEK-POW-BMS63EM** board manages six additional temperature sensors. These sensors are divided into external sensors, shown in red, and internal sensors, shown in green.

Figure 21. Temperature sensor managed by L9963F



The internal NTC thermistors can be used to detect the temperature on the board. The three external sensors, when connected to the battery pack, feed into the BMS connector, shown in the image below.

Figure 22. Schematic view of the BMS connector [P6]



BMS - battery connector

1.5.8 Other peripherals

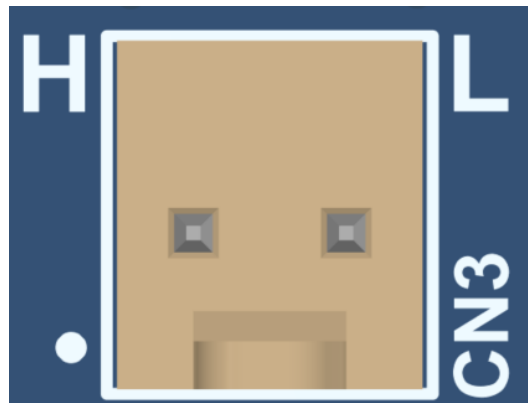
The **AEK-POW-BMS63EM** board includes other features such as two CAN lines, a JTAG module for firmware programming and debugging, and additional peripherals for software development.

1.5.8.1 CAN peripherals

Available on CAN connectors CN2 and CN3, the CAN protocol allows microcontrollers and devices to communicate with each other. All nodes connect through a two-wire bus. The wires are a twisted pair with a nominal characteristic impedance of 120 Ω . Each CAN line on the board includes a 120 Ω resistor.

The two onboard CAN lines support high-speed applications up to 8 Mbps by using two dedicated CAN-FD transceivers. These lines also support CAN 2.0 and meet automotive requirements for CAN-FD bit rates above 2 Mbps. They also feature low quiescent current and comply with electromagnetic compatibility (EMC) and electrostatic discharge (ESD) requirements.

Figure 23. CAN connector [CN3]

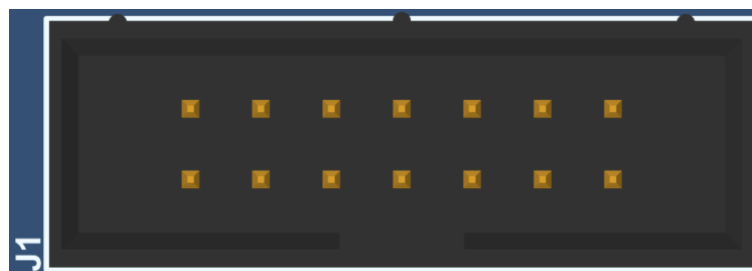


Note: The two CAN lines do not have external ESD protection, as it is embedded in the CAN transceiver and it covers up to ± 13 kV in compliance with IEC61000-4-2.

1.5.8.1.1 JTAG Interface

The JTAG interface is available on the JTAG connector to enable programming and debugging of applications. Connect the AEK-MCU-SPC5LNK board and use the OpenOCD driver within AutoDevKit.

Figure 24. JTAG connector [J1]

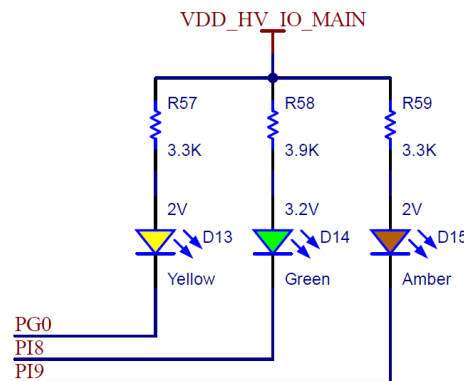


1.5.8.1.2 Additional peripherals

The microcontroller hosted on the [AEK-POW-BMS63EM](#) board connects to the following peripherals to facilitate programming and debugging:

- Three general-purpose LEDs: D13, D14, D15
- Reset button: S2
- Serial interface available on P2 connector

Note: The UART serial interface is available on P2 connector, shown in green. The RS232 interface is accessible through U7, shown in blue, and allows conversion to USB data. However, as mentioned in [Section 1.5.2: Main components](#), to exploit USB programming, you must mount the FTDI on the PCB.

Figure 27. LEDs - schematic view


1.5.9 Battery pack configurations

Our application features four configurations for the battery pack cell selection: 6 cells, 10 cells configuration A, 10 cells configuration B, 14 cells.

To use different battery packs with a variable number of cells (4, 10 configuration A, 10 configuration B, and 14), the unused individual cells associated with the L9963F have been short-circuited, using MOSFETs controlled by the gate driver.

Then, the same unused cells have been disabled by software to prevent incorrect readings of the remaining cells and related diagnostics. This procedure prevents potential malfunctions that can be latched in the registers (Example VCELL_UV (0x43)).

To configure the selected battery pack, on hardware and software levels, four available options are available, as described in the table below.

Table 1. STGAP2GS and battery pack configuration table

Signal type	STGAP2GS configuration	6-cell configuration	10-cell configuration A	10-cell configuration B	14-cell configuration
Digital (from microcontroller)	INA+	ON	ON	OFF	OFF
Digital (from microcontroller)	INA-	OFF	OFF	OFF	OFF
Digital (from microcontroller)	INB+	ON	OFF	ON	OFF
Digital (from microcontroller)	INB-	OFF	OFF	OFF	OFF
Analog (by hardware)	JP22 jumper JP23 jumper JP24 jumper JP25 jumper	All closed	JP22 open JP23 open JP24 closed JP25 closed	JP22 closed JP23 closed JP24 open JP25 open	All open

The table covers analog and digital signal types. The digital part follows the STGAP2S truth table (shown below).

To ensure safety, only one of the four available combinations can be used to activate the MOSFET gate. To control the two STGAP2S, it is necessary to use four GPIO pins of the microcontroller and send a high signal when the device is ON or a low signal when the device is OFF.

Table 2. STGAP2GS input and output pin configuration

Input pins		Output pins	
IN+	IN-	GON	GOFF
L	L	OFF	ON
H	L	ON	OFF
L	H	OFF	ON
H	H	OFF	ON

Regarding the analog side, by selecting the correct configuration from the four available jumpers [JP22, JP23, JP24, and JP25], it is possible to power the [STGAP2S](#) to prevent unintended activation of the MOSFETs.

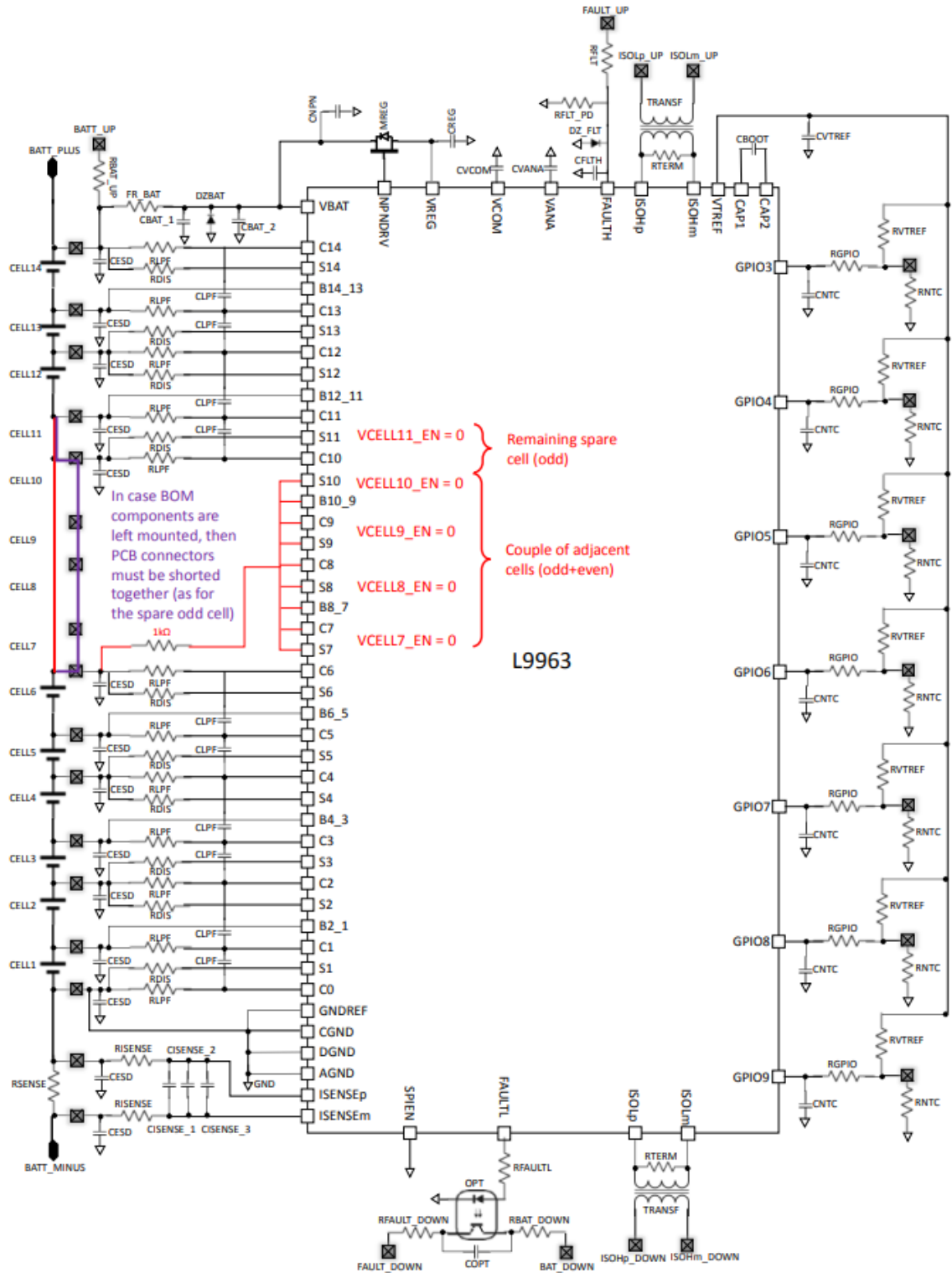
Regarding cell handling, the [L9963F](#) manages the cells connected to the battery pack and allows connection of four to fourteen cells.

The minimum configuration allowed by the device requires the use of CELL1, CELL2, CELL13 and CELL14.

If fewer than fourteen cells are installed, remove N/2 adjacent pairs and short-circuit the printed circuit board connectors of the unused cells (see [Figure 28](#)).

If a remaining spare cell is left uninstalled, it must be an odd-numbered cell, as shown in the figure below.

Figure 28. Guide for unmounted cells in the L9963F



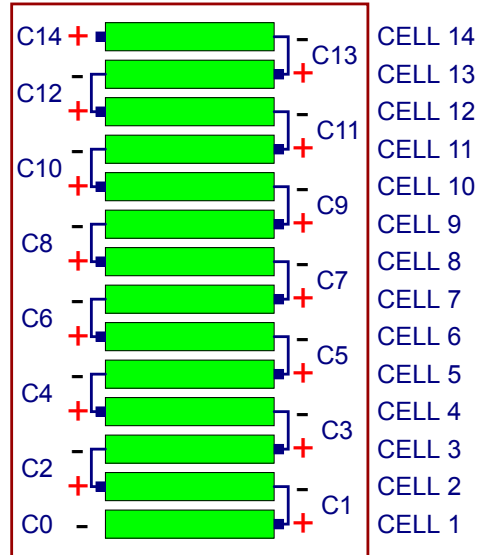
Additionally, the uninstalled cells must have the corresponding V_{CELLx_EN} bit set to 0 to disable the related diagnostics to prevent an error that can be latched in the registers (Example V_{CELL_UV} (0x43)).

The following images show the implementation of the four possible configurations, using the **AEK-POW-BMS63EM** with the **AEK-POW-BMSHOLD** battery holder.



If there are fewer than 14 cells, replace the unused cells with a short-circuit between the positive and negative terminals of the adjacent cells.

Figure 29. Battery pack with 14 cells

Pack battery with 14 cells in series



Color battery Legend

-  → Connected Cells
-  → No Cells connected. Substituted with a short (wire) from Positive to Negative.

Color connection Legend

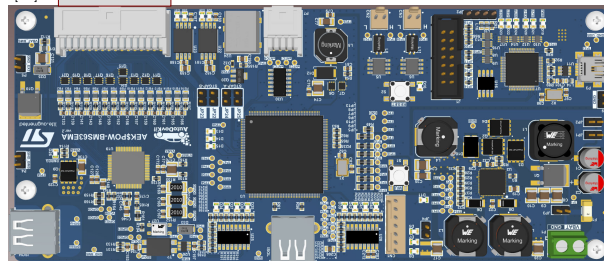


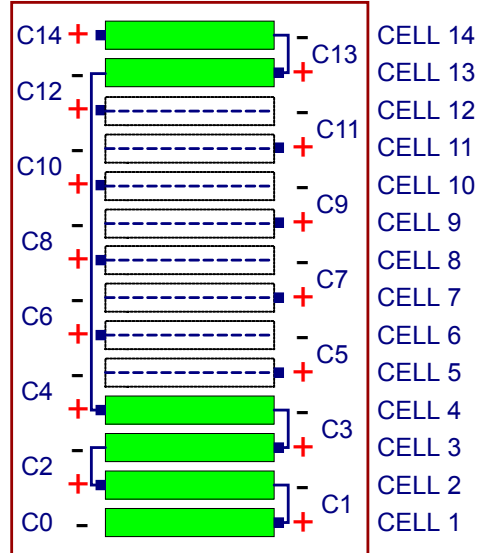


Figure 30. Battery pack with 6 cells

Pack battery with 6 cells in series

Color battery Legend

-  → Connected Cells
-  → No Cells connected. Substituted with a short (wire) from Positive to Negative.



Color connection Legend

Connector

-  C0, C14
-  VBAT-BMS
-  ISENSE (P-M)
-  NTC1-3
-  GND-EXT [1..7]

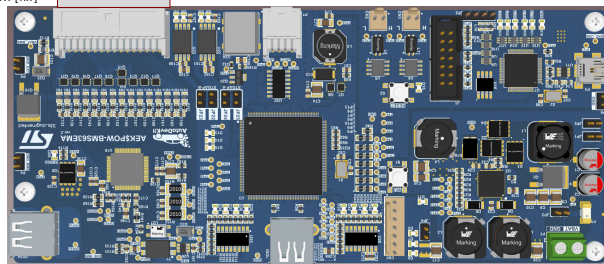
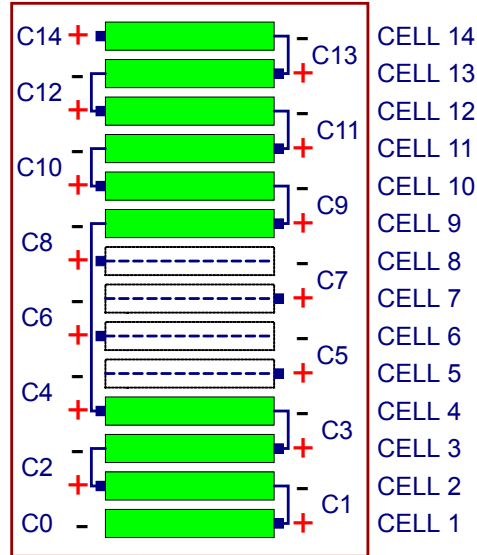


Figure 31. Battery pack with 10 cells configuration A

Pack battery with 10 cells in series
-Configuration A-



Color battery Legend

- → Connected Cells
- No Cells connected. Substituted with a short (wire) from Positive to Negative.

Color connection Legend

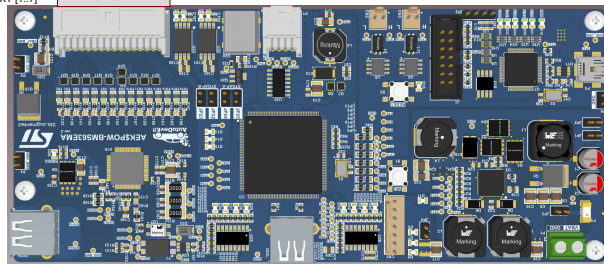
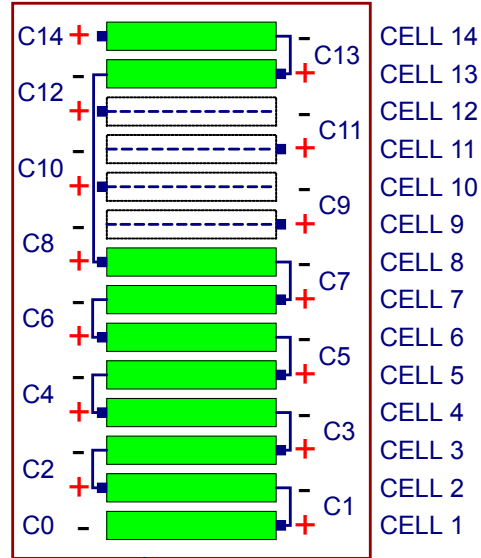




Figure 32. Battery pack with 10 cells configuration B

Pack battery with 10 cells in series
-Configuration B-

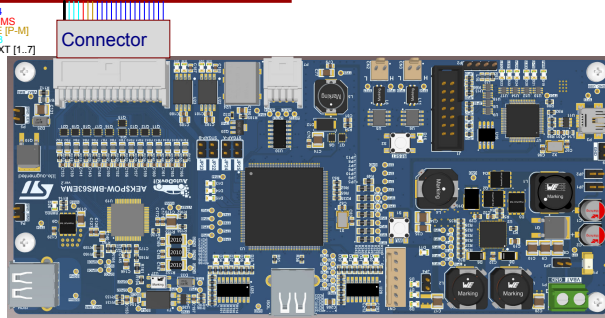


Color battery Legend

-  → Connected Cells
-  → No Cells connected. Substituted with a short (wire) from Positive to Negative.

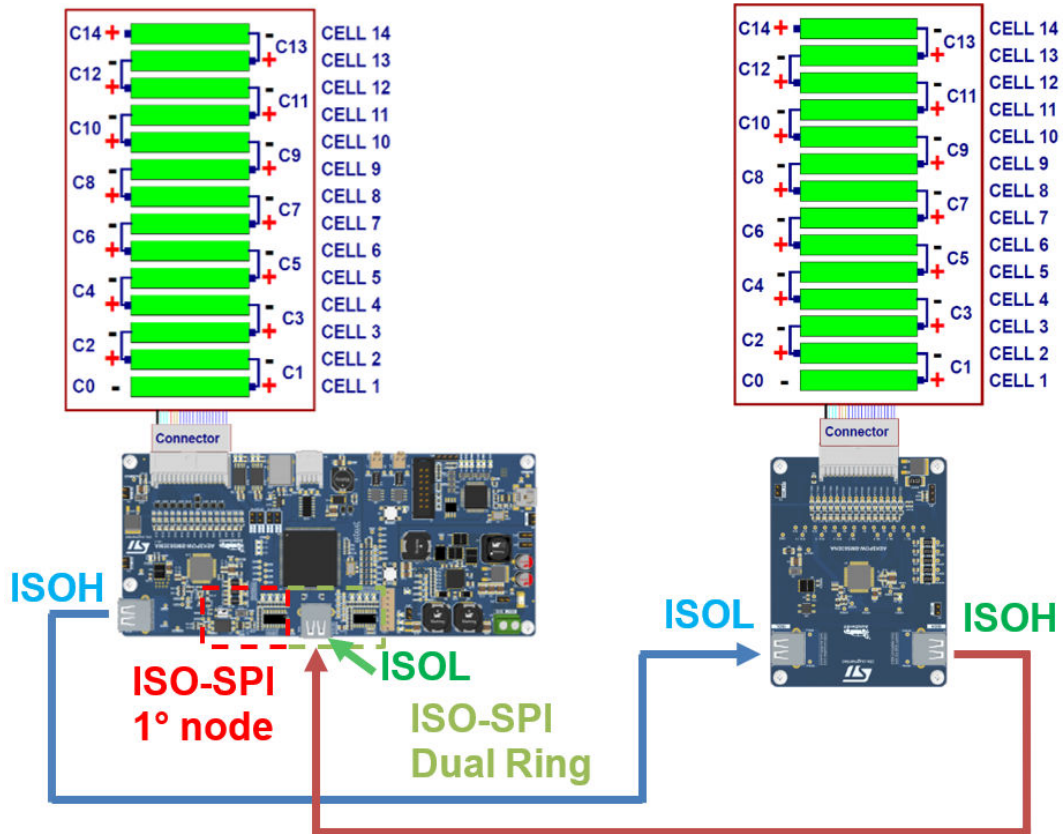
Color connection Legend

-  C0, C14
-  VBAT-BMS
-  ISENSE [P-M]
-  INTCP [1-5]
-  GND-EXT [1..7]



1.5.9.1 Dual ring configuration

The AEK-POW-BMS63EM embeds two L9963T transceivers that enable the implementation of the dual access ring configuration. In this configuration, the second transceiver (named ISO-SPI Dual Ring in the figure below) closes the ring and acts as a backup if the first node fails.

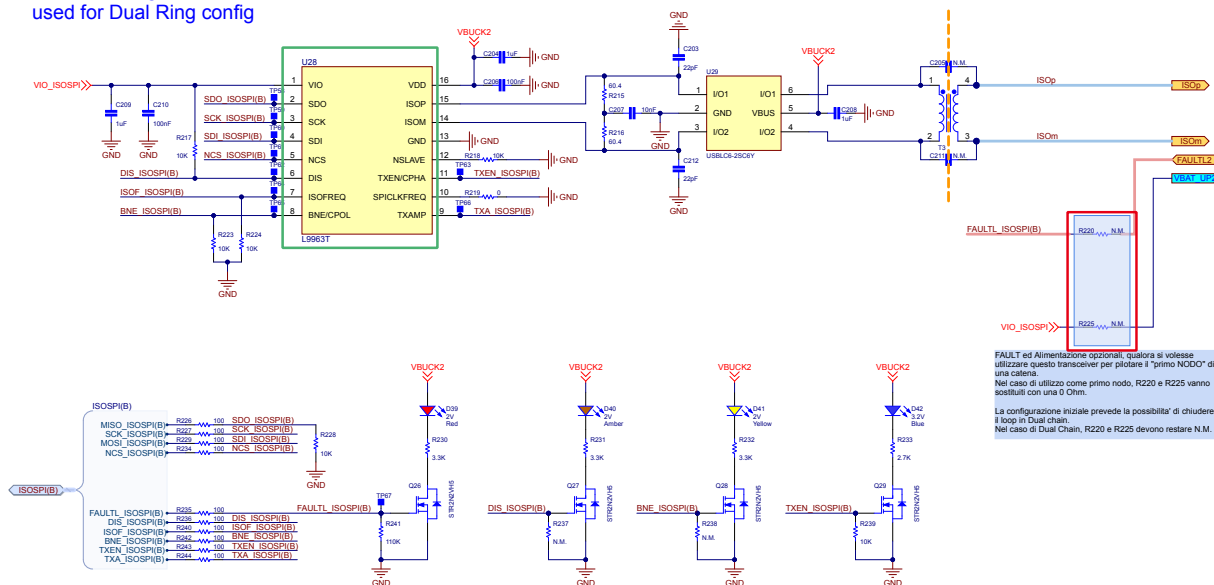
Figure 33. Dual ring configuration for the AEK-POW-BMS63EM


To recreate the setup shown above:

- – ◦ Connect a 14-cell battery holder to the AEK-POW-BMS63EM and another 14-cell battery holder to the AEK-POW-BMS63EN
- Connect the AEK-POW-BMS63EM ISOH port to the AEK-POW-BMS63EN ISOL port via a USB type A cable
- Connect the AEK-POW-BMS63EM ISOL port to the AEK-POW-BMS63EN ISOH port via a USB type A cable

Note: The L9963T transceiver (U28, highlighted in green in the image below) can be reconfigured to implement the single access configuration, acting as the first node of the chain. To use U28 in single access configuration, insert a 0 Ω resistor in R220 and R225 (highlighted in red in the image below).

Figure 34. Dual ring configuration – schematic view

 L9963T configured in SLAVE mode -
 used for Dual Ring config


1.6 Embedded devices

1.6.1 L9963E/L9963F

The L9963E/L9963F is intended for operation in both hybrid electric (HE) and full electric (FE) vehicles 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.

The L9963E/L9963F 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 L9963E/L9963F via SPI protocol. The physical layer can either be a classic 4-wire based SPI or 2-wire transformer/capacitive based isolated interface through a dedicated isolated transceiver device.

The L9963E/L9963F 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.

1.6.2 L9963T

L9963T is a general purpose SPI to isolated SPI transceiver intended to create a communication bridge between devices located into different voltage domains.

L9963T 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.

L9963T 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 L9963 isolated SPI, allowing its usage in the BMS applications.

L9963T is compatible with both 3.3 V and 5 V logics.

1.7 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.

1.7.1 Linear regulators

Our BMS boards feature several linear voltage regulators, which are switched on according to a specific sequence at power-up (see Figure 42. Finite state machine of the voltage conversion routine).

VREG

This linear regulator exploits an external MOS to decrease the power dissipation inside the L9963E [Section 1.6.1: L9963E/L9963F](#).

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 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 .

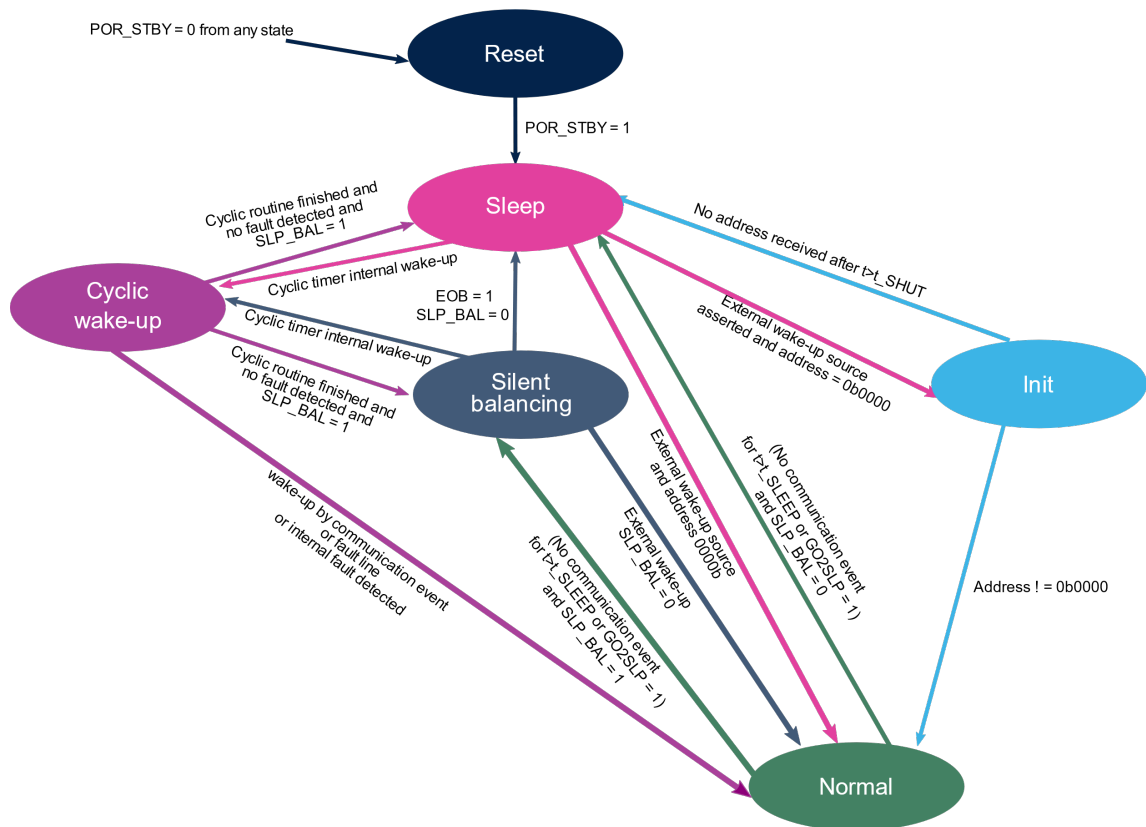
VTREF regulator is disabled by default. Its operation can be controlled via SPI.

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.

1.7.2 Simplified state machine

Figure 35. State machine



1.7.2.1 Reset and sleep states

When the standby logic is reset, all registers on the device are in the reset state. The battery voltage is still under threshold. No operation is possible during this state.

The sleep state is reached:

- From the reset state, when POR_STBY rises.
- From other states, if a GO2SLP command is sent or no communication is received for $t > t_{SLEEP}$.
- From the init state in case the device address is still 0b0000 after $t > t_{SHUT}$.
- From the cyclic wakeup state when the silent balancing is not resumed.

In the sleep state, the device is sensitive to external sources (such as ISO lines, fault line, SPI_CS (SPI_CLK) pins, and a GPIO pin for master units) to wake up the main logic. A slow oscillator works in this state to allow the device to wake up every $t = t_{CYCLIC_SLEEP} + t_{CYCLIC_WUP}$ and move to the cyclic wakeup state.

During the sleep state, the current consumption is significantly reduced to the I_{SLEEP} current value: only the communication wakeup source monitoring, low-speed oscillator for cyclic wakeup timer, and the corresponding reference and power supply are activated.

1.7.2.2 Init state

In the init state, after having been woken up, the device waits for the microcontroller to send the address assignment command (refer to [Section 1.7.2.2.1: Addressing procedure](#)). If the address command is received before the initialization timer expires (t_{SHUT}), the device address is stored into a standby logic register (chip_ID) and the device enters the normal state.

The chip_ID field is then locked and no longer editable. Two actions can correctly re-initialize the device (including the chip_ID):

- Hardware reset: (POR_STBY)
- Software reset: set SW_RST and GO2SLP in the same frame

Note: the software reset leaves the communication timeout (CommTimeout) unmodified, and clears the chip_ID.

If only SW_RST is sent, the device waits for CommTimeout and then moves to the sleep state.

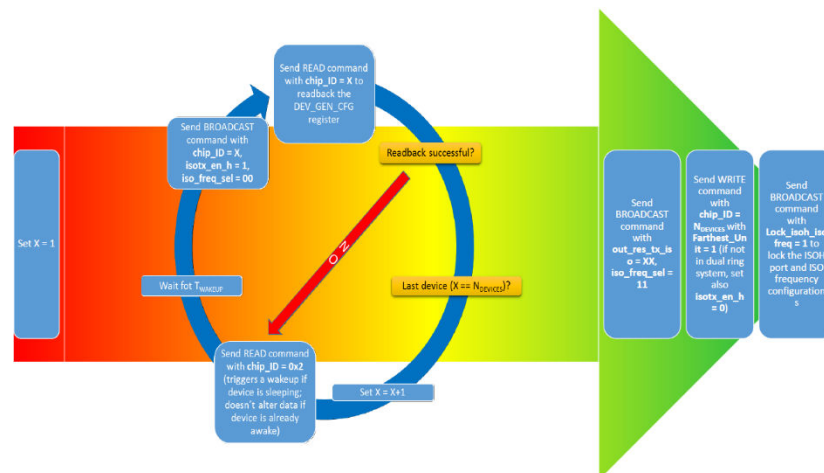
If the initialization timer (t_{SHUT}) expires before the command is received, the device goes back to the sleep state.

Any failure is masked until the device receives an address.

1.7.2.2.1 Addressing procedure

The following figure shows the daisy-chain addressing procedure for a stack of $N_{DEVICES}$.

Figure 36. Daisy chain addressing procedure

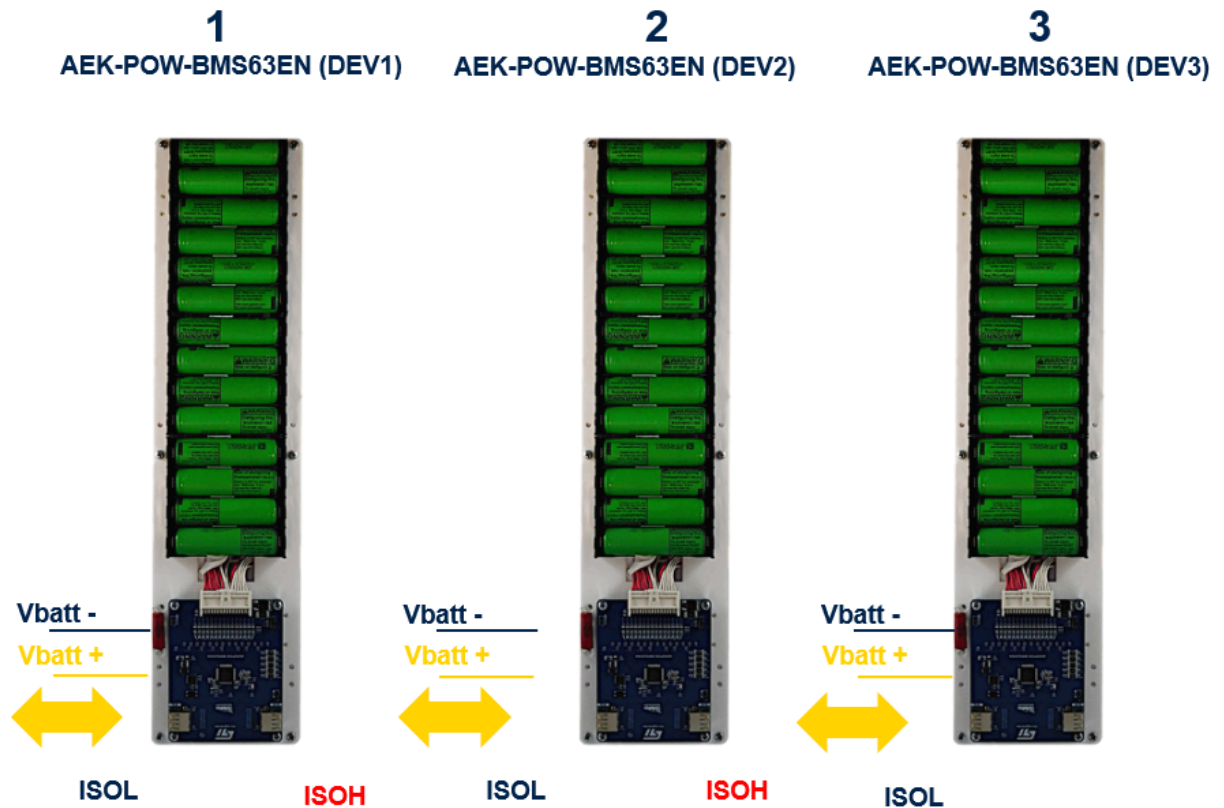


1.7.2.2.2 Addressing procedure

The addressing procedure assign a unique ID to each chain board.

IDs are sequentially assigned to all the BMS included in the system: ID no. 1 is assigned to the first BMS in the chain, ID no. 2 is assigned to the second, and so on.

Figure 37. Addressing procedure example for the AEK-POW-BMS63EN



To determine if the addressing procedure has been successful, check the D2 LED on the BMS. If it remains always on, it means that the procedure has been correctly executed and each BMS has its own ID. Only if you unplug the connector, the BMS loses their ID.

1.7.2.3 Normal state

In this state, all references are powered. ADCs and interfaces are ready for measurement and data transmission, respectively.

The commands sent by the microcontroller can be read from both ISO lines and SPI pins.

When receiving a valid command, the L9963E/L9963F executes the corresponding operations, such as voltage, current, and overtemperature measurements.

Some safety operations (OV, UV, OT, and VBAT monitoring) are automatically checked in background.

If the communication with the MCU is missing for $t > t_{SLEEP}$ (programmable via CommTimeout, maskable via comm_timeout_dis) or a GO2SLP command is received, the device moves either to the sleep state or to the silent balancing state, depending on the slp_bal_conf bit and balancing state.

1.7.2.4 Silent balancing state

In this state, one or more cells are balanced with a reduced current consumption with respect to the normal state. Active resources are the same as the ones of the sleep state plus the balance drivers and the necessary bias circuitry.

To enter the silent balancing state from the normal state, check the following conditions:

1. Cell balancing must be on.
2. The slp_bal_conf flag has to be set to 1.
3. Verify the "go to sleep" condition (an explicit GO2SLP command or communication timeout expiration).

If cell balancing is previously requested in the normal state and the slp_bal_conf flag is set to 1, when a condition to go to sleep (low consumption) occurs, the device enters the silent balancing state.

To exit from the silent balancing state, there are three possible events:

- A wakeup signal on communication or fault line can force the chip to stop balancing and then go back to the normal state.
- An external fault must bring the device to the normal state and stop the balancing.
- As soon as the required balancing target stops, the end of balancing (EOB) bit is set to 1 and the chip enters the sleep state.

If the Cyclic signal is raised, the device goes to the cyclic wakeup state, runs the diagnosis, and then resumes silent balancing (if slp_bal_conf flag = 1).

1.7.2.5

Cyclic wakeup state

From both sleep and silent balancing states, the device moves periodically (once every $t_{\text{CYCLIC_SLEEP}}$) to the cyclic wakeup state to monitor eventual faults.

The ADC must be on to check possible critical battery conditions. Any detected fault moves the device to the normal state.

An on-demand operation is possible only once the device has moved to the normal state in case of any detected fault.

Conditions to leave this state are:

- Any fault detected moves the device to the normal state.
- A wakeup from the fault line or communication line moves the device to the normal state if the defined monitoring tasks are finished; the device can move to the sleep or silent balancing states automatically based on the state before cyclic conversions (slp_bal_conf flag).

2 BMS topologies

Our BMS boards can work in two different daisy chain topologies: centralized and dual access ring.

Note: To quickly create a battery pack for our BMS solutions, the AutoDevKit ecosystem has been extended to include a specific cylindrical battery holder (AEK-POW-BMSHOLD).

Note: The daisy chain and dual access ring topologies are based on a chain of BMS evaluation boards. In both topologies, the chain first node can be an AEK-POW-BMS63EN plus AEK-COM-ISOSPI1, an AEK-POW-BMSWTX or an AEK-POW-BMSNOTX. The remaining nodes must be all AEK-POW-BMS63EN evaluation boards.

You can create a centralized daisy chain also using the AEK-POW-BMSCCTX as first node and the AEK-POW-BMSCC as subsequent nodes.

2.1 Centralized configuration

In a centralized daisy chain configuration, a series of BMS is connected to an MCU board (e.g., AEK-MCU-C4MLIT1) through a single transceiver connected to the AEK-POW-BMS63EN isolated ISOL port. The BMS are connected to each other through the isolated ISOH port.

The MCU communicates with the AEK-COM-ISOSPI1 hosted L9963T transceiver through the SPI protocol. The transceiver converts these signals into ISO SPI signals to communicate with the BMS.

Figure 38. Centralized BMS diagram

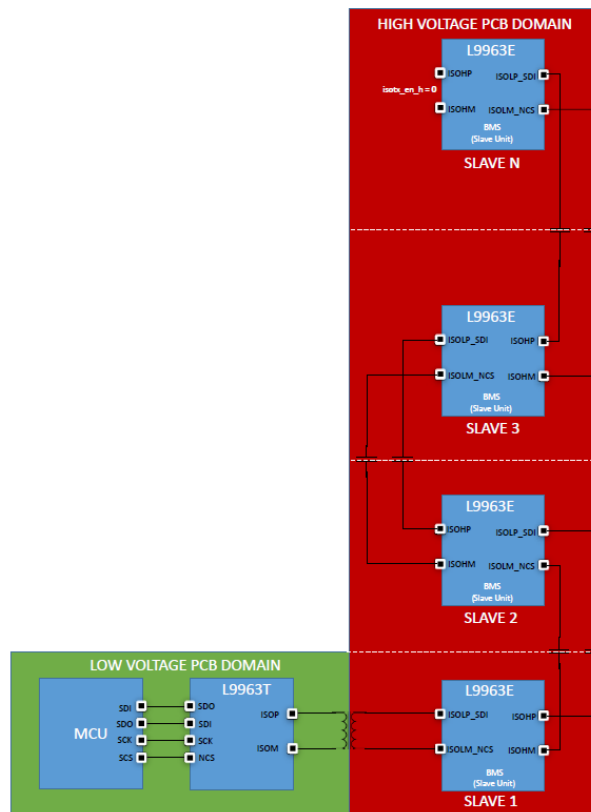
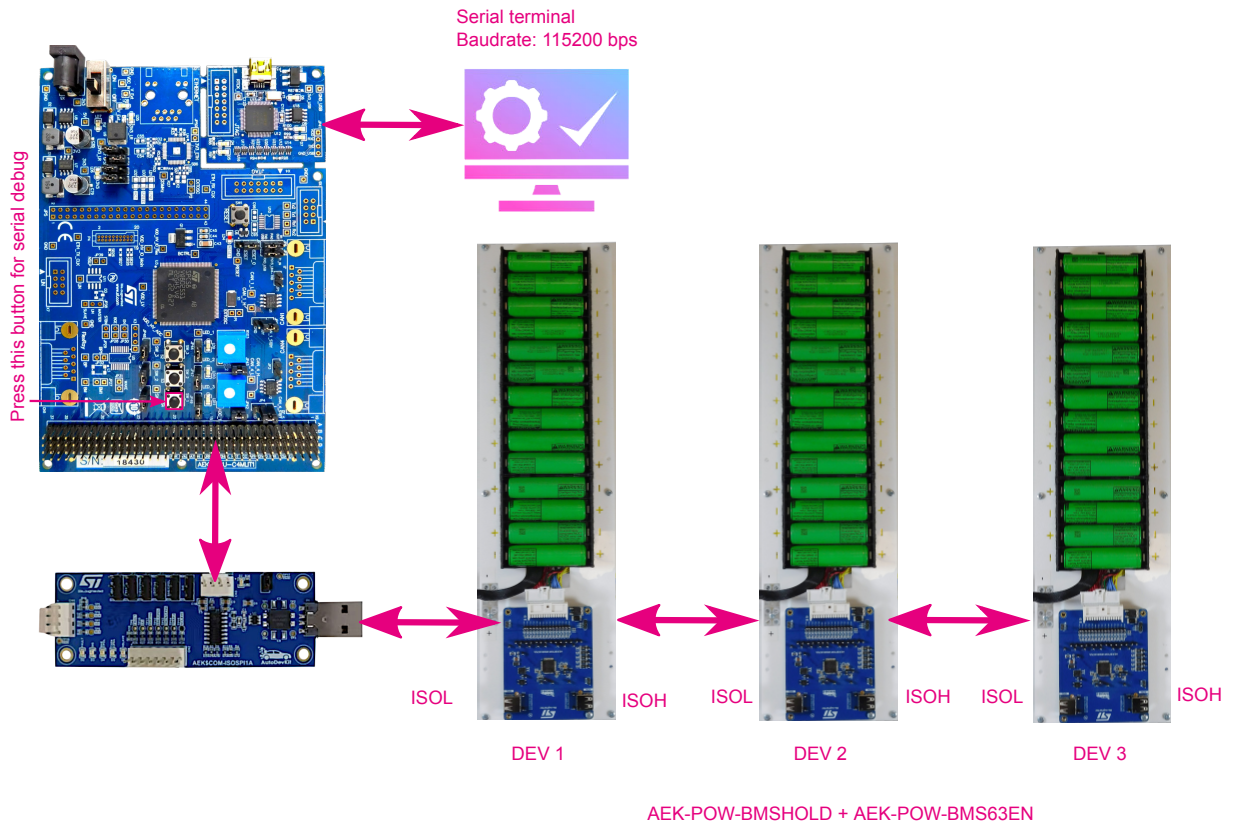


Figure 39. Example of centralized BMS chain using the AEK-POW-BMS63EN with the AEK-COM-ISOSPI1 and the AEK-MCU-C4MLIT1



2.2 Dual access ring configuration

A dual access ring configuration is realized by adding another transceiver that makes the communication bidirectional. The secondary ring is used as a backup in case the primary ring 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 40. Dual access ring BMS diagram

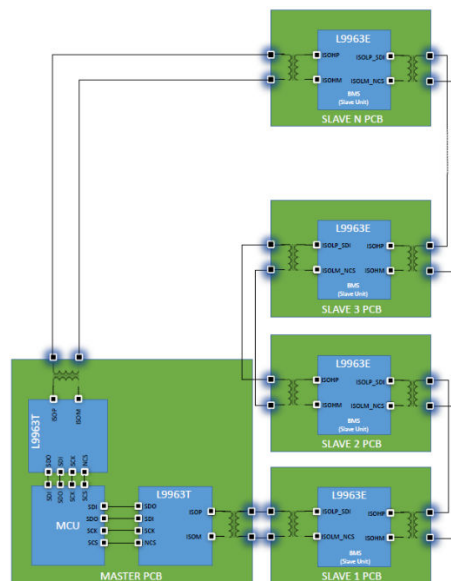
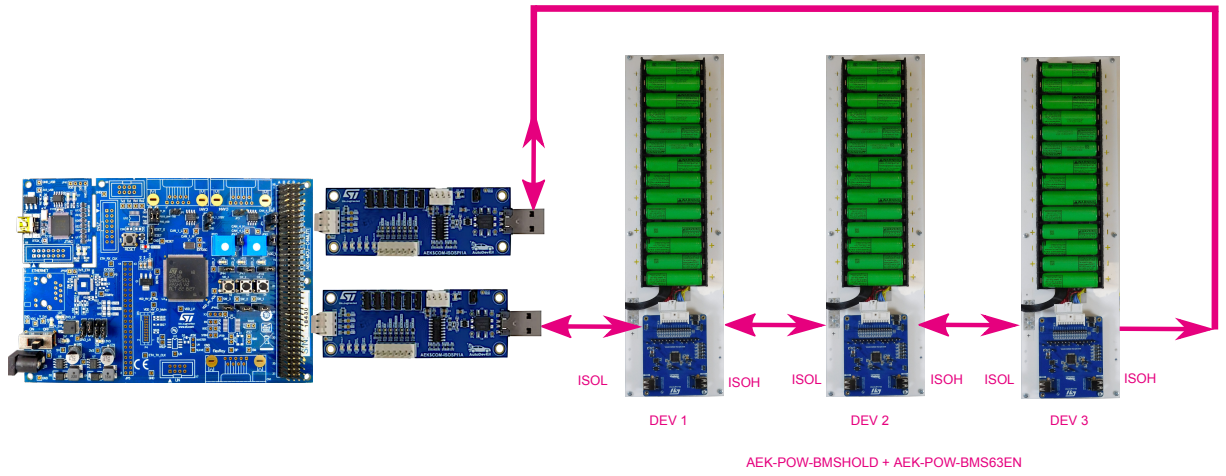


Figure 41. Dual ring configuration example for the AEK-POW-BMS63EN



3 Voltage conversion routine

L9963E/L9963F implements a flexible voltage conversion routine, whose main goals are:

- Providing on-demand information about the cell voltage, the stack voltage, and the cell temperature.
- Providing on-demand diagnostic information about device functionality.
- Periodically monitoring the cells and the stack status, along with the device functionality.
- Limit power consumption by activating only the necessary resources.
- Automatically validate any eventual failure detected during the routine execution.

Through the voltage conversion routine we can also read voltages from the GPIOs configured as analog inputs. Thus, connecting NTCs to GPIOs, we can measure the battery pack temperature.

The voltage conversion routine can be executed in three different ways according to the microcontroller commands. The different modes are mutually exclusive: only one routine at a given time is allowed and multiple threads are not supported.

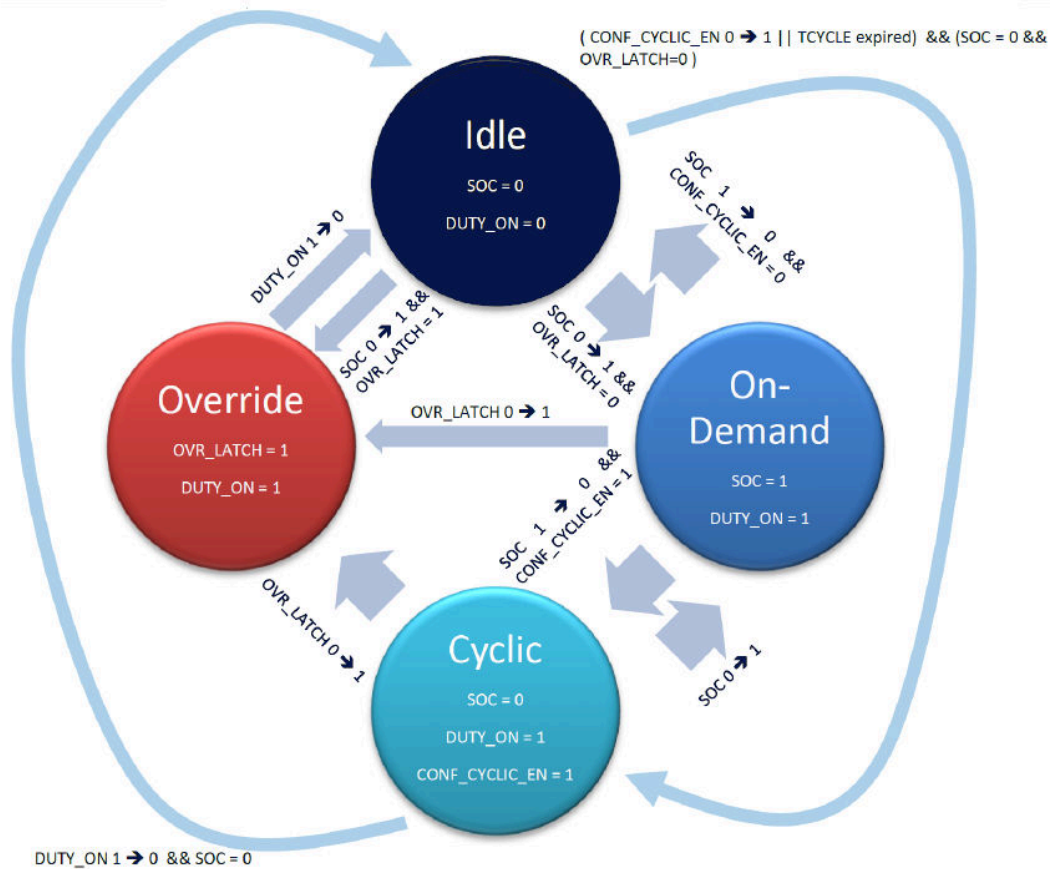
The execution modes have different priorities:

- Configuration override is high priority since its purpose is to perform diagnostics upon failure detection to validate the failure type. It can interrupt any ongoing activity and, once done, the voltage conversion routine is moved to the idle state, waiting for the microcontroller to interpret the diagnostic data.
- On-demand conversions are low priority. They are meant to allow the microcontroller to perform measurements or diagnostic at chosen time instants. They cannot co-exist with cyclic conversions: to run an on-demand conversion, cyclic conversions must be disabled and the MCU must wait for their termination (monitor the DUTY_ON flag). On the other hand, on-demand conversions cannot interrupt themselves or a configuration override.
- Cyclic conversions are low priority. Their main purpose is to monitor the battery pack and the L9963E/L9963F status. However, they can also be used to retrieve periodically measurement data. They can be interrupted by the configuration override. They cannot co-exist with on-demand conversions: before enabling cyclic conversions, the MCU must wait for any ongoing on-demand conversion to end first (monitor the DUTY_ON flag).

The following FSM describes the functionality and the transitions among the different operating modes of the voltage conversion routine.

Figure 42. Finite state machine of the voltage conversion routine

SOC = state of conversion



To start on-demand conversions, the user must set SOC = 1 in the ADCV_CONV register: in case the coulomb counting routine is enabled, 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 allows a perfect synchronization between voltage and current samples but might result in a maximum delay of $T_{CYCLEADC_CUR}$, which must be taken into account by user SW and added to the recommended T_{DATA_READY} as per the device datasheet.

To start cyclic conversions, the user must set CONF_CYCLIC_EN = 1 in the ADCV_CONV register. The ADC_FILTER_CYCLE determines the duration of the routine steps.

Cyclic conversions can be used for diagnostic and measurement purposes:

- In case the routine is only intended for diagnostic purposes, the user can set CYCLIC_UPDATE = 0. This setting causes any conversion result to be used only for internal comparisons. Data are subsequently discarded and registers containing measurement results are not updated.
- In case measurement results are used for diagnostics and SOC estimation, the user must set CYCLIC_UPDATE = 1, thus causing measurement register update upon each step completion, as for on-demand conversions. Note: results of a previous on-demand conversion might be overwritten by the ones of cyclic executions.

Two counters are implemented for driving the cyclic execution:

- TCYCLE, which is an SPI programmable timer accounting for cycle period.
- NCYCLE, which is an internal counter, incremented by 1 every time TCYCLE expires: it counts the number of cycles executed.

These counters are started/stopped upon FSM transitions.

4 Coulomb counting routine

The coulomb counting routine is performed to evaluate the charge injected/subtracted during vehicle operation. To enable it, the CoulombCounter_en bit must be set to 1.

Disabling the coulomb counter by setting CoulombCounter_en to 0 does not reset the accumulator (CoulombCounter_msb, CoulombCounter_lsb) and sample counter (CoulombCntTime) registers. The MCU is responsible for resetting the coulomb counter, clearing any data previously stored.

5 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, L9963E/L9963F also allows to synchronize the **Voltage Conversion Routine** and the **Coulomb Counting Routine** for a precise State Of Charge estimation. Everytime 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, that must be taken into account by user SW only in case current ADC is enabled

6 L9963E/L9963F safety and diagnostic features

The L9963E/L9963F provides an extended set of safety mechanisms to reach the required ASIL standard. It monitors potentially damaging conditions for the battery pack.

6.1 Cell UV/OV diagnostic

It is possible to select the value for the overvoltage threshold as well as for the undervoltage threshold of the cells. This diagnostic feature is completed by analyzing, inside the logic block, the digital information provided by the voltage measurement ADCs. Measurements are performed just on enabled cells.

In case of cell UV/OV (VCELL_OV/UV):

- The corresponding fault flag is set and latched in the VCELL_OV / VCELL_UV register.
- Fault is propagated through the FAULT line.
- Balancing is stopped in case of UV event:
 - A cell UV causes balancing to be stopped on the whole cell stack.
 - A cell balance UV causes balancing activity to be stopped only on the affected cell.
 - The conversion routine goes into configuration override.

6.2 Total battery VBAT diagnostic

The total stack voltage diagnostic is implemented through three different safety mechanisms:

- Arithmetic sum of the digital information of cell ADC (within the cell conversion step of the voltage conversion routine). Such a value is then compared to the digital thresholds (programmable via registers).
- Direct conversion of the voltage at VBAT pin through internal resistive divider. The result is compared to fixed thresholds. This diagnostic is mainly intended to protect the IC against absolute maximum rating (AMR) violation on the VBAT pin. It can also be used as a redundant coherency check with the arithmetic sum of cells.
- Continuous sense of the VBAT pin voltage with a VBAT_UV/OV comparator, featuring fixed thresholds. It is used as an overvoltage warning or an undervoltage warning. This diagnostic is intended to provide a fast reaction against transient overvoltage and undervoltage events.

This UV/OV comparator is always enabled to guarantee a continuous safety check on VBAT voltage.

6.3 VBAT overvoltage

The aim of this diagnostic is to detect a dangerous increase of battery voltage to protect the circuitry connected to VBAT.

If $VBAT > VBAT_OV_WARNING$ (COMP) (for a time longer than TVBAT_FILT) or $VBATT_SUM > VBAT_OV$ (SUM) or $VBATT_MONITOR > VBAT_CRITICAL_OV_TH$, the overvoltage fault is directly reported in registers and notified to the microcontroller with 3 dedicated flags, according to the Fault communication procedure.

6.4 VBAT undervoltage

The aim of this diagnostic is to detect a decrease of battery voltage to notify this fault that may cause system malfunctions.

6.5 Cell open wire diagnostic

The open cell detection can be performed through the voltage conversion routine. The diagnostic strategy depends on the ADC_CROSS_CHECK bit.

6.5.1 Cell open with ADC_CROSS_CHECK = 0

If the cell terminal diagnostics step of the voltage conversion routine is executed having programmed $ADC_CROSS_CHECK = 0$, then the diagnostic addresses the following failures:

- RLPF (low pass filter resistor) degradation: diagnostic has been implemented to guarantee that low pass filter resistor in series to the Cx pin is below the critical limit RLPF_OPEN:
 - On odd cells, RLPF degradation will cause the assertion of the corresponding CELLx_OPEN flag.
 - On even cells, flag assertion depends on the RLPF degradation:
 - Small degradation (RLPF < 24 kΩ typ. with 10 nF CLPF) only causes the assertion of the corresponding CELLx_OPEN flag.
 - Large degradation (RLPF > 24 kΩ typ. with 10 nF CLPF) causes the assertion of both the corresponding CELLx_OPEN flag and the lower odd cell CELLx-1_OPEN flag.
- L9963E/L9963F C1-C14 pin open.
- L9963E/L9963F C0 pin open or PCB connector open.

Diagnostic is present on enabled cells only (VCELLx_EN = 1).

6.5.2 Cell open with ADC_CROSS_CHECK = 1

ADC_CROSS_CHECK = 1, then the diagnostic addresses the following issues:

- Failure in the filtering capacitor CLPF (low pass filter capacitor) causing an excessive leakage from cell.
- ADC error due to bandgap shift or failure on the conversion path.

For each pair of consecutive cells, the two corresponding ADCs, each of whom is referenced to a different bandgap, are measuring the voltage drop on the external RLPF.

Since no pull-down current is applied while measurement is ongoing, the voltage drop on RLPF is expected to be null, and the two measurement results should match.

If one of the two ADCs is experiencing an issue, or an excessive leakage from the CLPF is causing a voltage drop on the RLPF, a mismatch in the results occurs. If such a mismatch is greater than VADC_CROSS_FAIL, failure is detected.

6.6 PCB open diagnostic

To detect loss of cell wire at PCB connector, follow the procedure described in the L9963E/L9963F datasheet.

Note: when performing PCB open diagnostic, other diagnostics such as Cell UV/OV diagnostic and balancing open load diagnostic might also be triggered. They must be then discarded by user software.

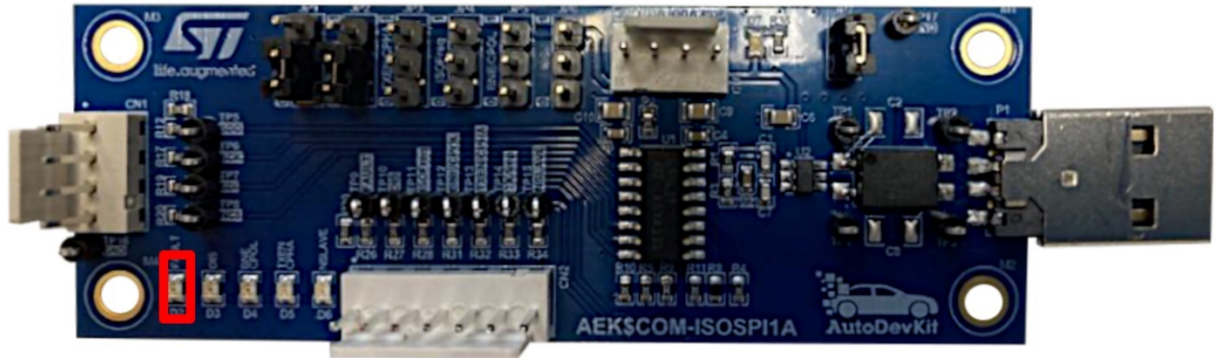
6.7 Die temperature diagnostic and overtemperature

An internal temperature sensor continuously monitors the temperature of the chip.

The chip prevents overheating through an overtemperature threshold TSD (which includes a hysteresis TSD_HY). Once the die temperature reaches TSD, a thermal shutdown circuit will force the chip to reduce the consumption by stopping balancing. A fault is reported to the microcontroller with a dedicated bit OTchip and propagated through the FAULT Line. When the temperature of the die returns to a normal level, L9963E/L9963F can resume the normal operation. Balancing is released after the microcontroller reads OTchip latch.

7 Fault condition in daisy chains

Figure 43. Fault LED on the AEK-COM-ISOSPI1



When using the AEK-POW-BMS63EN with the AEK-COM-ISOSPI1 transceiver board, you can detect a fault through the fault LED of the image above. It 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.

8 L9963E/L9963F cell balancing

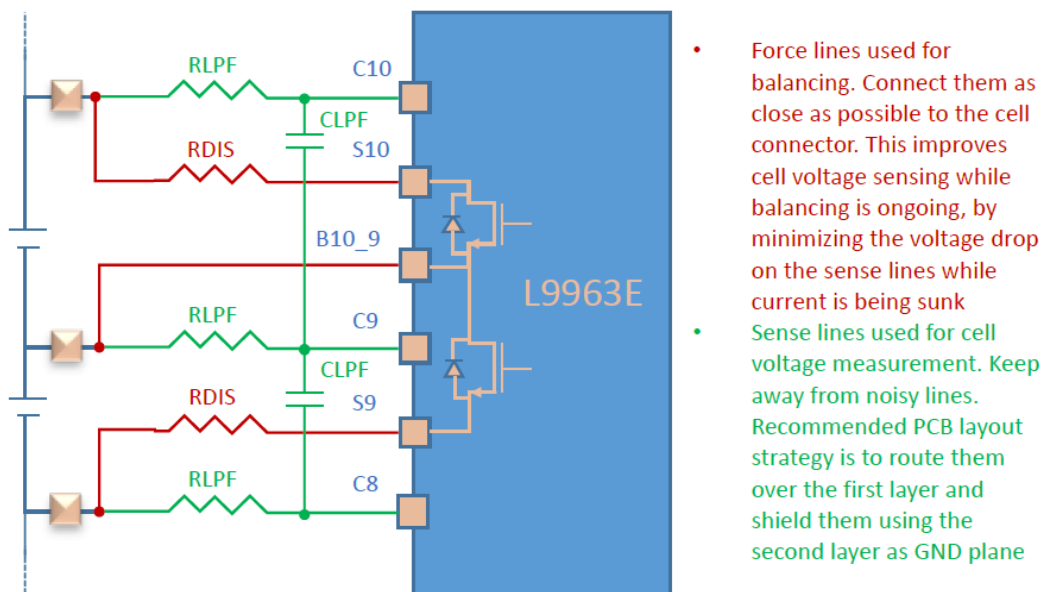
In the L9963E/L9963F, the Sx and Bx_x-1 pins are used to balance the charge of the cells by discharging the ones with a higher SOC. Balancing can be performed either with external resistors or internal MOSFETs.

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 $V_{CELL14} < V_{CELL14_BAL_MIN}$, the corresponding balancing circuitry does not operate properly, and false overcurrent detection may occur.

8.1 Passive cell balancing with internal MOSFETs

The board is designed using internal MOSFETs.

Figure 44. 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.

9 Methods for SOC estimation

The state of charge (SOC) of a cell indicates the energy stored by a cell, defined as the ratio of the charge quantity of a cell in a given moment and its total capacity.

The traditional calculation method is the coulomb counting.

According to this method, a charging/discharging current $I(t)$ is integrated in time to calculate the residual energy quantity of the cell itself.

SOC(t) in a specific instant is calculated as the sum of the SOC related to the previous instant SOC(t-1) and the quantity of energy removed/added to that specific instant, as shown in the following formula:

$$SOC_{(t)} = SOC_{(t-1)} + \int_{t-1}^t \frac{I_t \cdot \eta}{Q_n} \cdot dt$$

where:

- SOC(t) is the state of charge of the cell in the instant (t)
- SOC(t-1) is the state of charge of the cell in the previous instant (t-1)
- Q is the total capacity of the cell
- η is the cell efficiency

This method does not consider the speed, and hence the dynamics of the cell charge/discharge, temperature, hysteresis of charge/discharge and especially the cell age, which directly influences efficiency.

Moreover, this method is not accurate due to the error of integration and to the initial SOC estimation, and to the eventual inaccuracy of the cell current measurement.

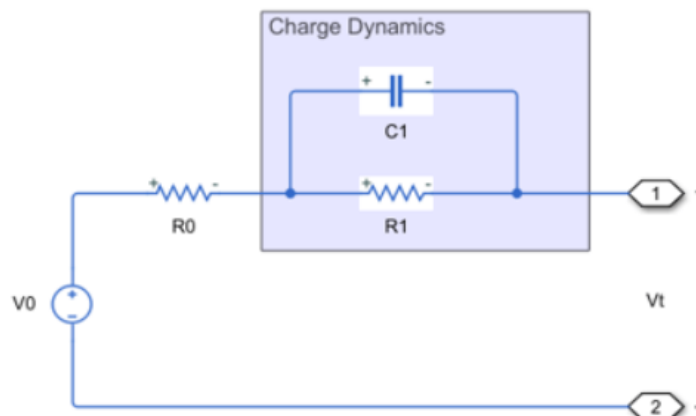
Other issues are related to the difficult estimation in case the cell undergoes an open circuit voltage variation (OCV with no load voltage) that is not significant in relation to the actual SOC (for example, in case LFP batteries are used).

The Kalman filter represents a promising alternative approach, which allows overcoming these obstacles through a higher effort in terms of computational resources.

This filter is based on a non-linear model of a cell through an equivalent circuit.

In our approach, we have used a first-grade equivalent circuit, as shown in the image below.

Figure 45. Equivalent circuit



In this circuit:

- V_0 is the no-load voltage
- V_t is the voltage at the battery poles
- R_0 represents the ohmic behavior of the cell
- R_1C_1 takes into account the dynamic behavior during charge and discharge

The equations that define the model are:

$$\frac{dSOC}{dt} = -\frac{i}{3600AH(T)}$$

$$\frac{dV_1}{dt} = \frac{i}{C_1(SOC, T)} - \frac{V_1}{R_1(SOC, T) \cdot C_1(SOC, T)}$$

$$V_t = V_0(SOC, T) - iR_0 - V_1$$

Where:

- SOC is the state of charge
- i is the current
- V_0 is the no-load voltage
- V_t is the terminal voltage
- AH is the ampere-hour rating
- R_1 is the first polarization resistance
- C_1 is the parallel RC capacitance
- T is the temperature

As opposed to the coulomb counting approach, this model considers the voltage at the battery poles and the cell capacity, as well as the temperatures and charge/discharge dynamics.

The equivalent circuit parameters used in the equations above must be estimated during the characterization phase.

Building the Kalman filter requires the definition of the state to estimate and the functions of process and observation, as shown below.

$$x = [SOC V_1]^T$$

$$f(x, i) = \begin{bmatrix} -\frac{i}{3600AH(T)} \\ -\frac{i}{C_1(SOC, T)} - \frac{V_1}{R_1(SOC, T) \cdot C_1(SOC, T)} \end{bmatrix}$$

$$h(x, i) = V_0(SOC, T) - iR_0 - V_1$$

The Kalman filter has been configured in Simulink according to the above functions.

The parameters (V_0 , R_0 , C_1 , and R_1) have been configured through lookup tables, after characterizing an INR 18650 MJ1 battery by LG.

The x status matrix (see above) estimated by the Kalman filter can define the SOC over time during the charge/discharge operations and at no load.

From the Kalman model in Simulink, we generated the C code through the embedded coder tool. Then, the code has been integrated into the L9963E/L9963F drivers to estimate the SOC in real-time. For further details, see the related [Mathworks page](#).

Another method to estimate the SOC is based on neural networks. This method requires a network training phase in all the operative conditions of the cell that belongs to the battery pack (during the charge/discharge operations and at no load).

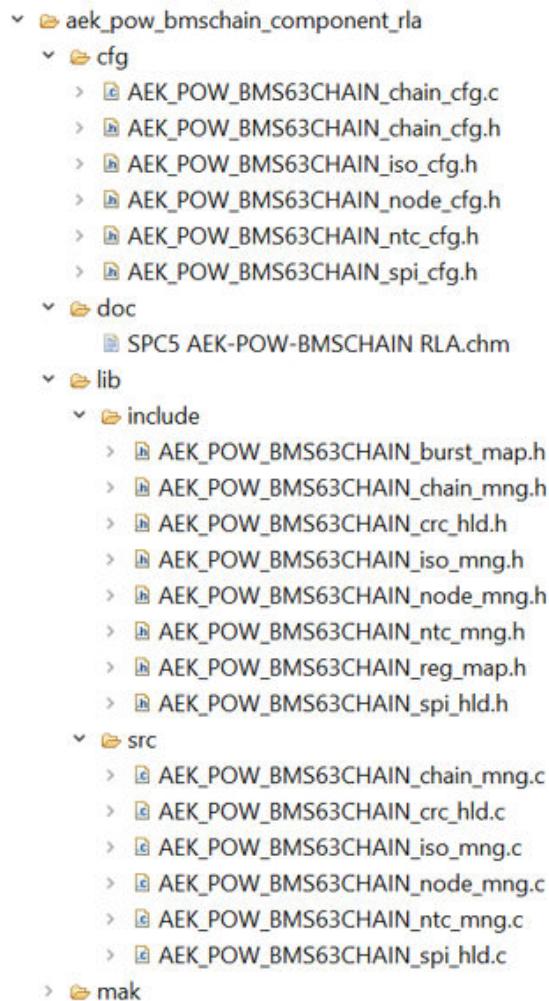
10 AutoDevKit ecosystem

The application development employing our BMS evaluation boards takes full advantage of the [AutoDevKit ecosystem](#), whose basic components are:

- AutoDevKit Studio IDE (STSW-AUTODEVKIT)
- OpenOCD programmer and debugger

10.1 AEK-POW-BMSCHAIN component folder structure

Figure 46. AEK-POW-BMSCHAIN component folder structure



The cfg folder contains all the configuration files.

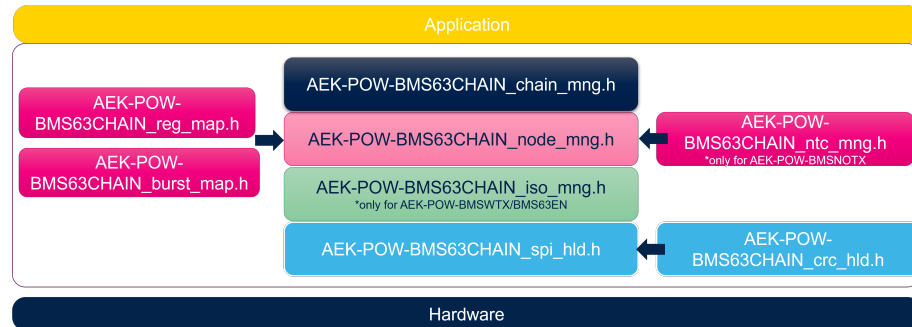
The doc folder contains the doxygen documentation.

The lib folder contains the component header and source files.

10.2 Software component architecture (AEK-POW-BMSCHAIN component RLA)

The following image shows the architecture of the software components created for our BMS boards, which consists of the layers shown in the image below:

Figure 47. Software architecture



SPI High Level Driver contains APIs that sends SPI message packets to the daisy chain. These functions implement SPI communication in Single Access and Broadcast Access to read and write L9963E/L9963F registers in each node.

CRC High Level Driver contains APIs that implement CRC calculation for packets sent via SPI.

ISOSPI manager contains APIs that handle the AEK-POW-ISOSPI1 transceiver in a daisy chain in Single or Dual Access Ring configurations. If the first chain node is an AEK-POW-BMSNOTX evaluation board, the ISOSPI manager is not used.

Node Manager contains APIs that use SPI High Level Driver to implement measure and diagnostic functions for the chain BMS nodes through L9963E/L9963F register reading and writing.

reg_map-h contains the map of L9963 registers for each chain node.

Burst_map contains the map of burst commands and replies from L9963 after SPI requests.

NTC Manager contains APIs to handle external NTCs for the AEK-POW-BMSNOTX evaluation board. This software manager is excluded from compiling in case there is no AEK-POW-BMSNOTX evaluation board in daisy chains.

Chain manager represents the driver entry level and implements APIs that handle one or more allocated BMS chains. These APIs include the function for addressing procedure and parameter setting defined in the component.

10.3 How to import the AEK-POW-BMSCHAIN component in AutoDevKit

This example is an application for a centralized daisy chain topology using the AEK-MCU-C4MINI1 as the microcontroller board. To recreate this scenario, follow the procedure below.

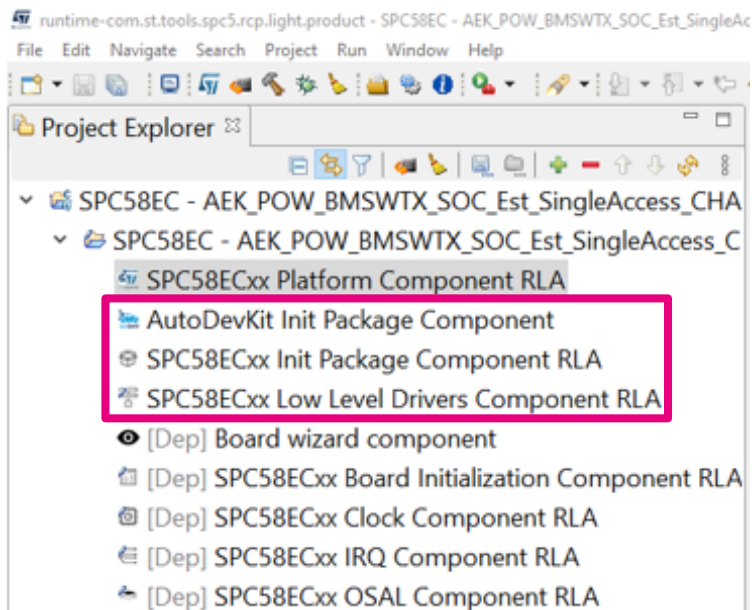
Step 1. Create a new SPC5-STUDIO application for the SPC58EC series microcontroller and add the following components:

- SPC58ECxx Init Package Component RLA
- SPC58ECxx Low Level Drivers Component RLA
- AutoDevKit Init Package Component

These components must be added immediately, or the other components will not be visible.

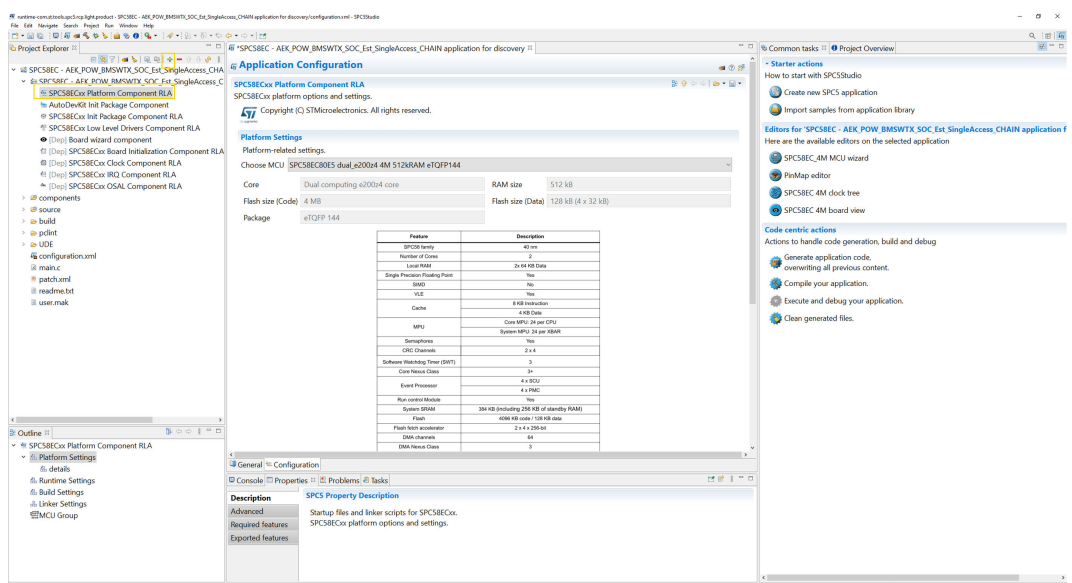
Note: If you are using an AEK-MCU-C4MINI1 for your project, you must add also the AEK-MCU-C4MINI1 Init Package component.

Figure 48. Adding components



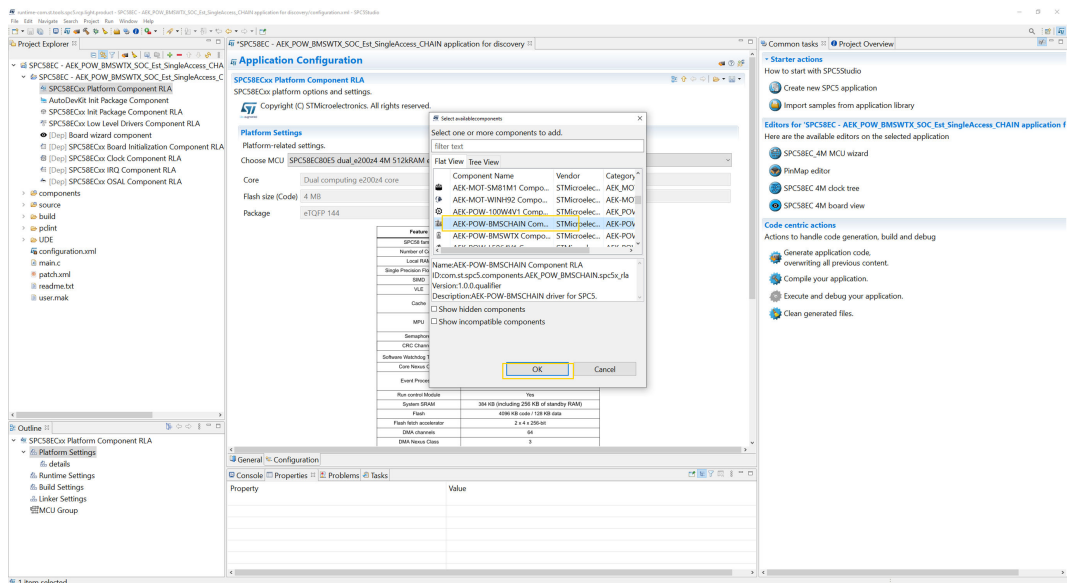
Step 2. Click on SPC58ECxx Platform Component RLA. Then, click on “+” to import the new component.

Figure 49. Adding SPC58ECxx Platform Component RLA



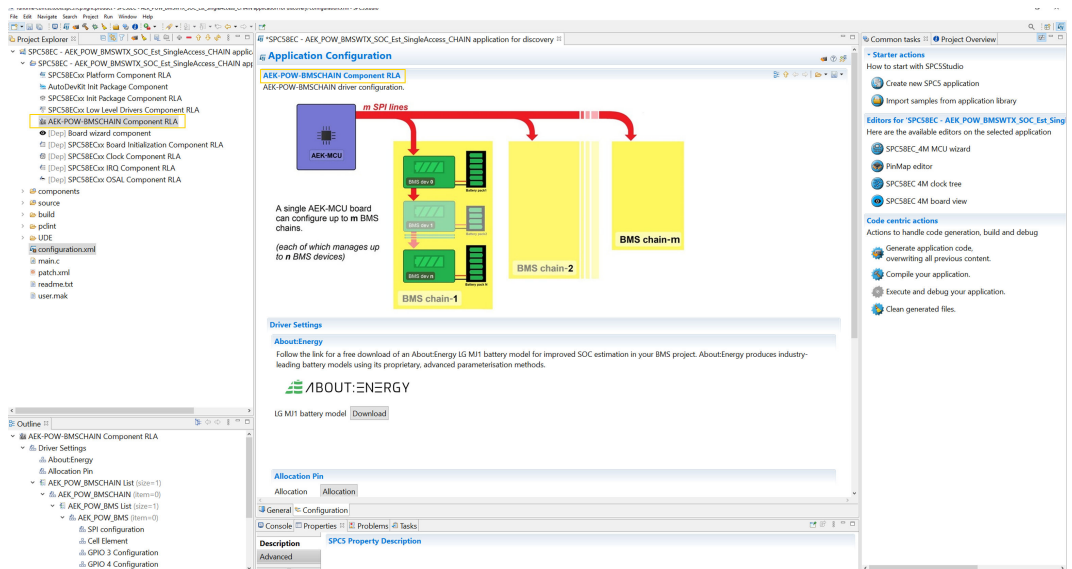
Step 3. Select “AEK-POW-BMSCHAIN”. Then, click on “OK”.

Figure 50. Selecting AEK-POW-BMSCHAIN Component



Step 4. If you have correctly imported the component, it is then visible in the Project explorer section, as highlighted below.

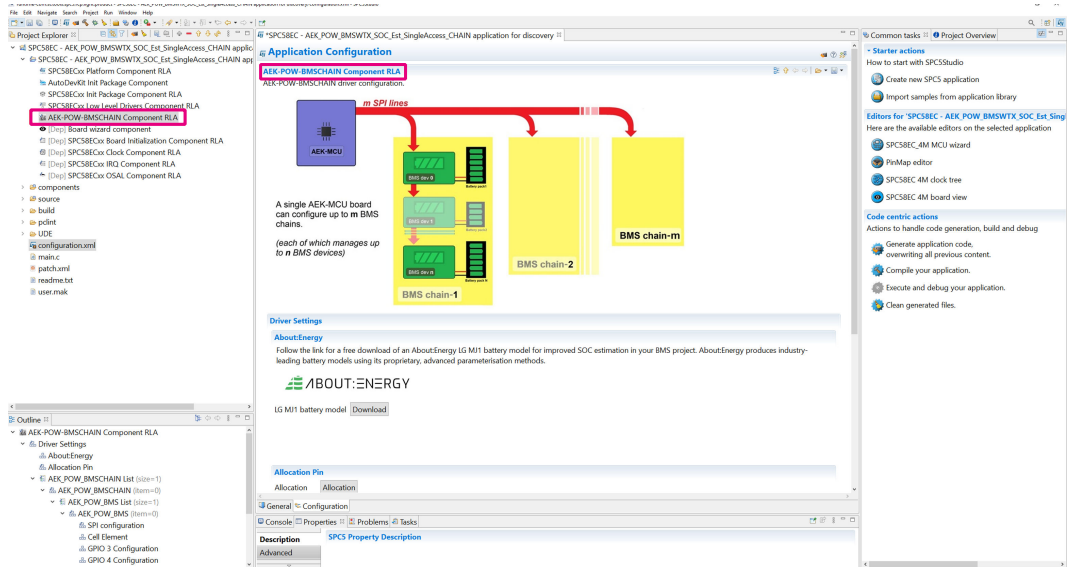
Figure 51. AEK-POW-BMSCHAIN component visualization in the Project explorer and application configuration windows



10.4 Chain allocation

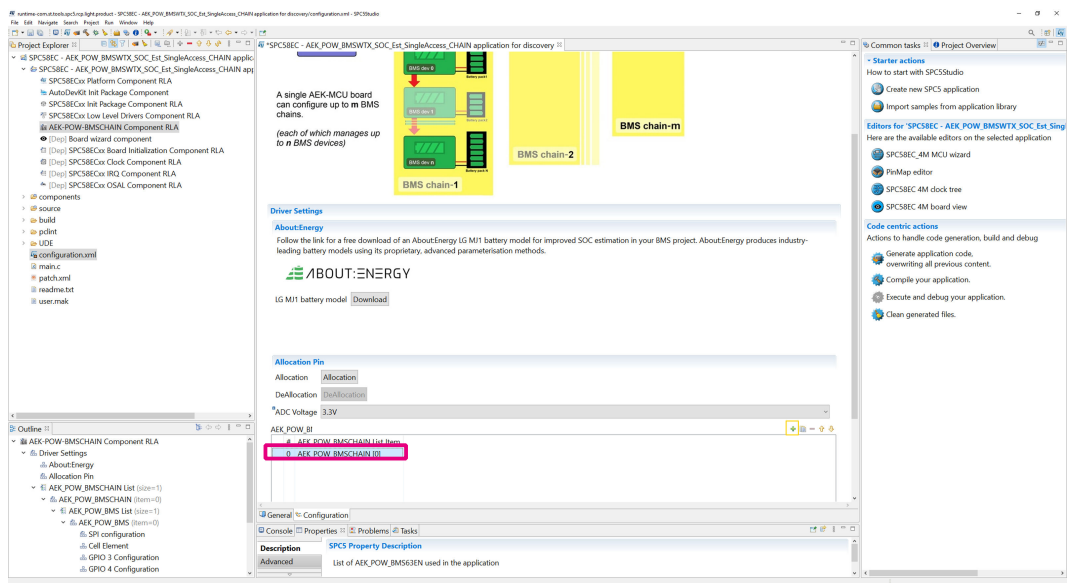
Step 1. Select the AEK-POW-BMSCHAIN component in the Project Explorer section.

Figure 52. AEK-POW-BMSCHAIN component selection



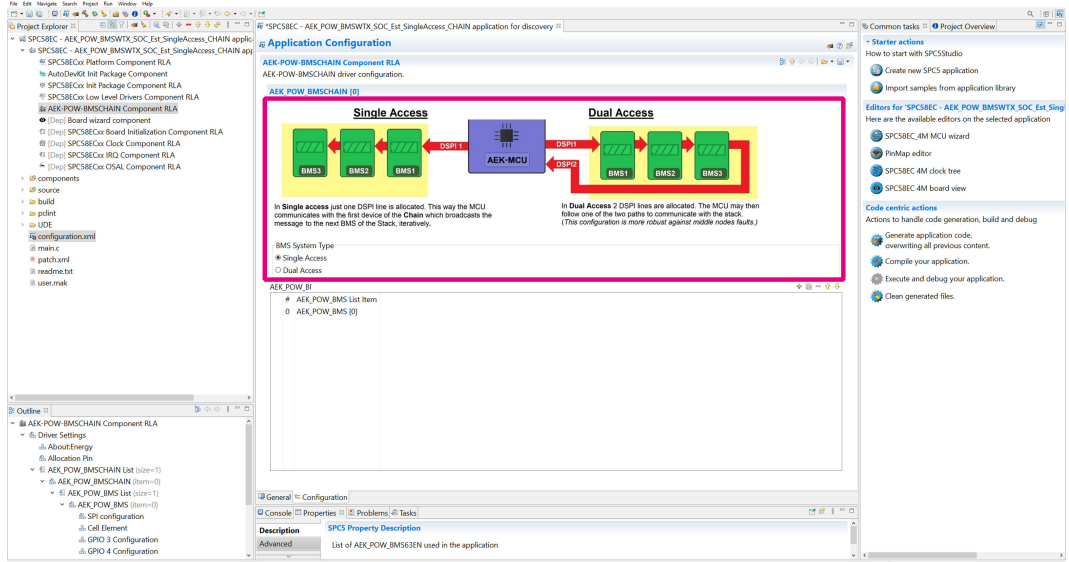
Step 2. Click on “+” to add a new chain to the allocation table. Then, click on the chain to customize it.

Figure 53. Chain customization



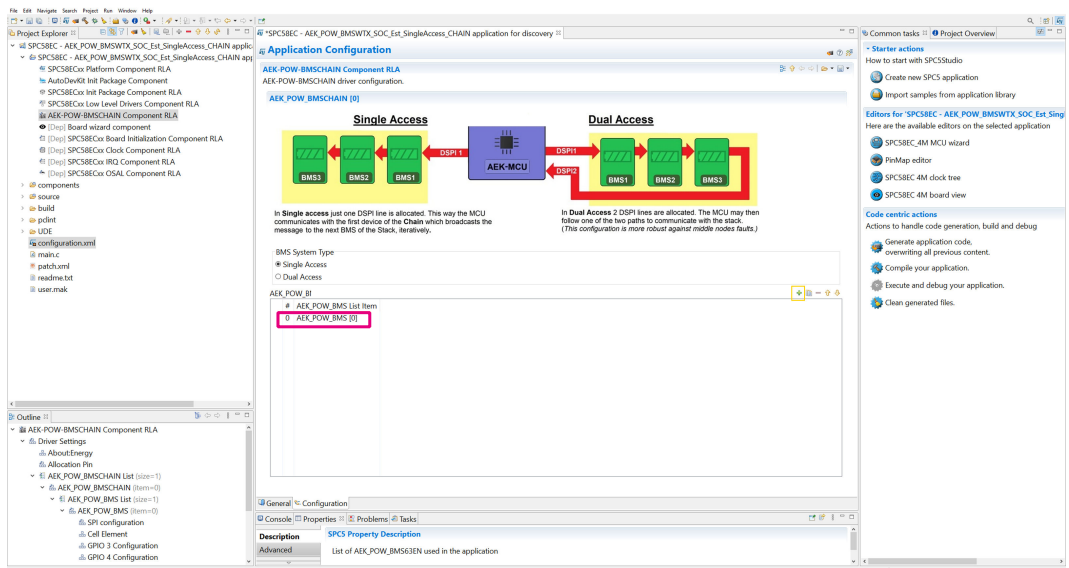
Step 3. Choose a chain topology: “Single Access” (Centralized) or “Dual Access”.

Figure 54. Chain topology selection



Step 4. Click on “+” to add a new node to your chain. Then, click on the newly added node to customize it.

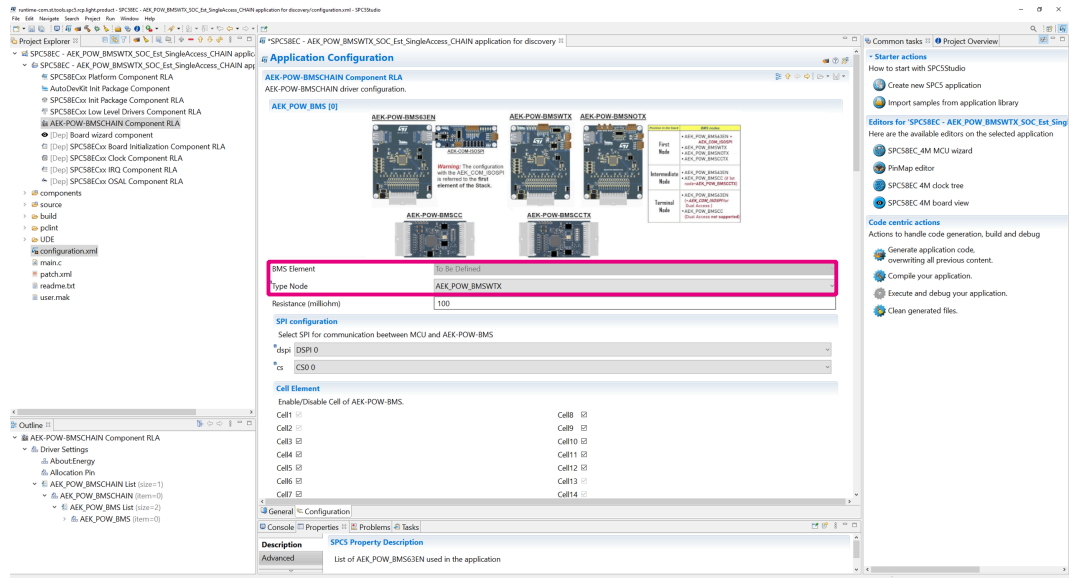
Figure 55. New node addition and customization



Step 5. Each node has its own dedicated configuration page, featuring several options that must be customized or left to their default value. The “BMS Element” field defines the topology of each chain node (First Element, Node or End Element).

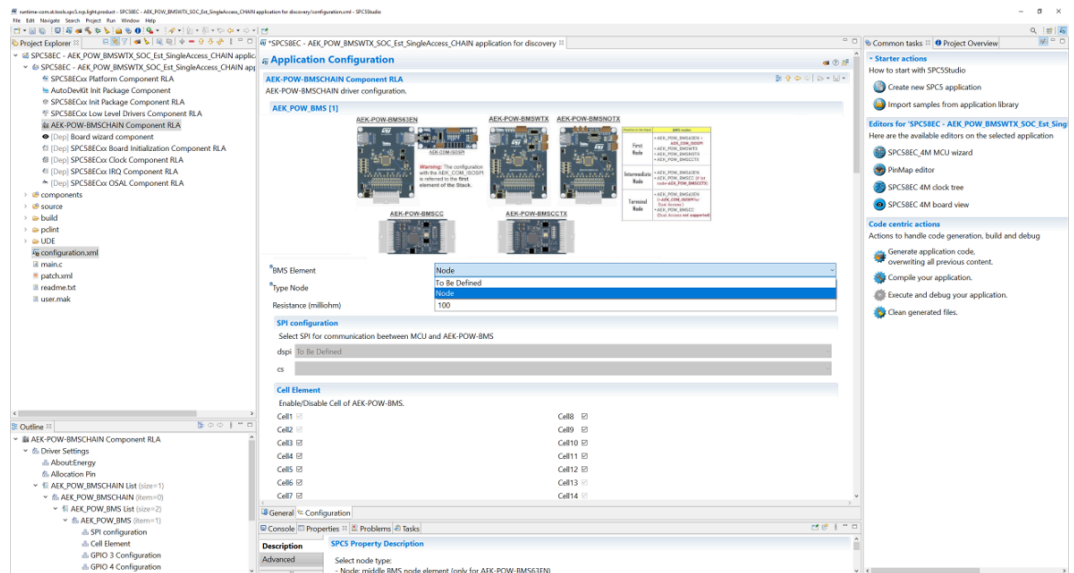
Note: *In both Single Access and Dual Access modes, the first chain node is defined as “First Element”. So, the “BMS Element” field is defined by default.*

Figure 56. BMS element field customization details



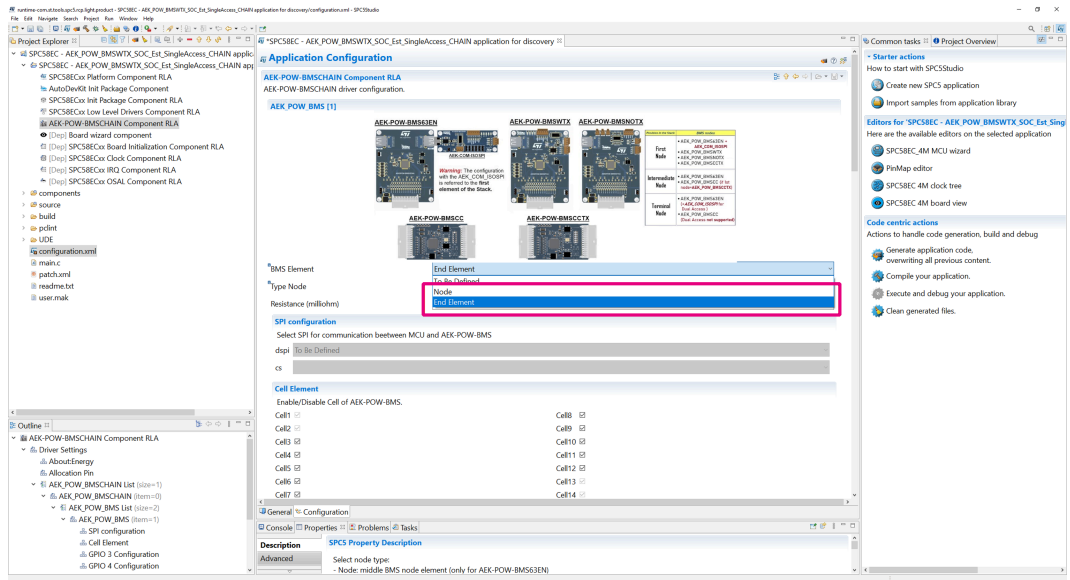
Step 6. If you choose “Single Access” mode chain, fill the “BMS Element” field with “Node” for each node of the chain, except the first (defined as “First Element”) and the last (defined as “End Element”) ones.

Figure 57. Single Access mode customization



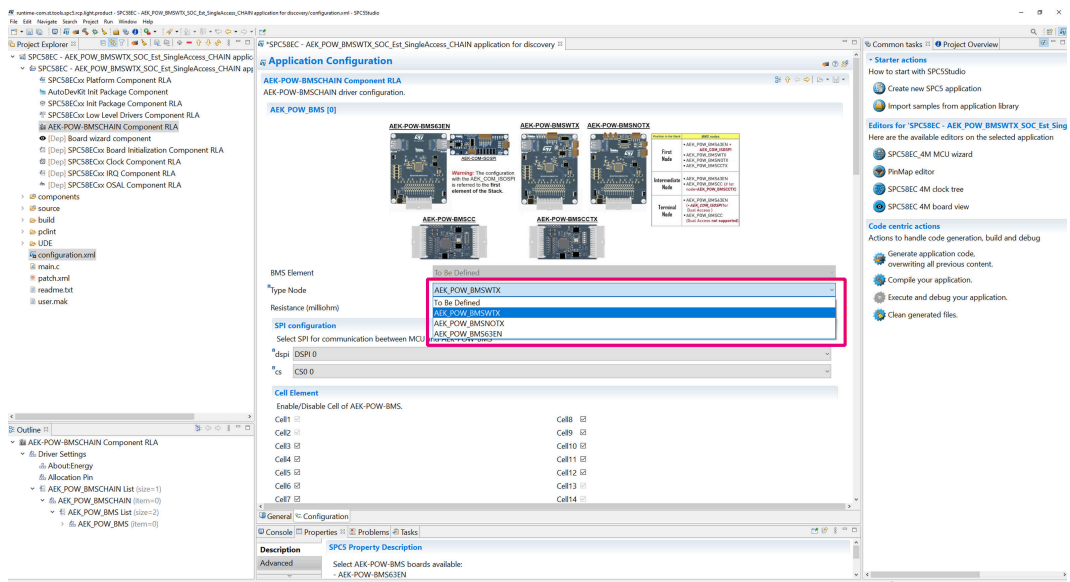
Step 7. If you choose “Dual Access” mode chain, fill the “BMS Element” according to the same rule defined in step 5.

Figure 58. Dual access mode customization



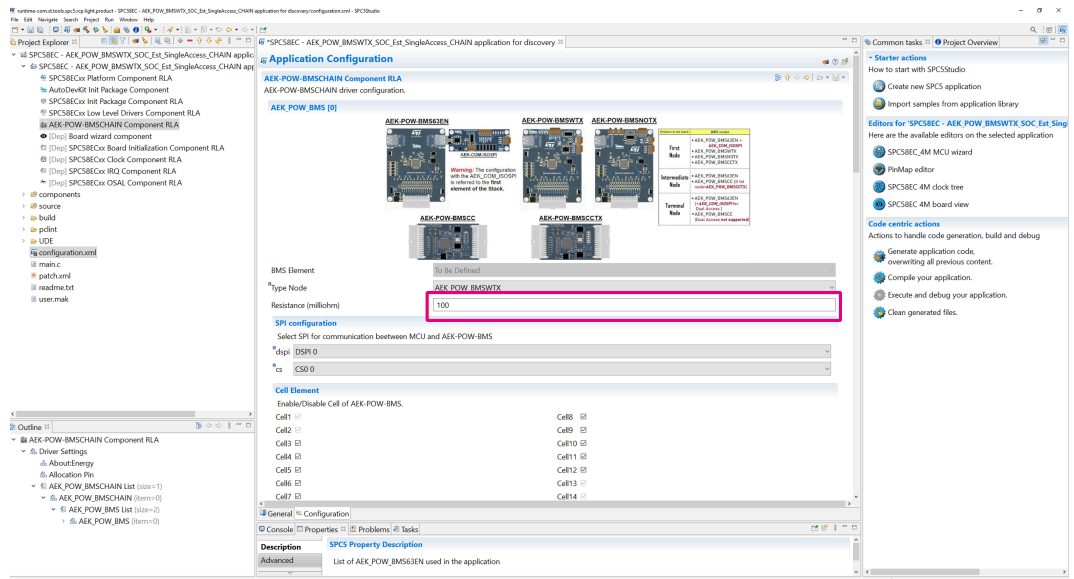
Step 8. Use one among AEK-POW-BMS63EN, AEK-POW-BMSWTX and AEK-POW-NOTX only for the first chain node, both for single access and dual access modes. All remaining nodes must be AEK-POW-BMS63EN to best exploit ISOSPI communication.

Figure 59. Example of chain configuration



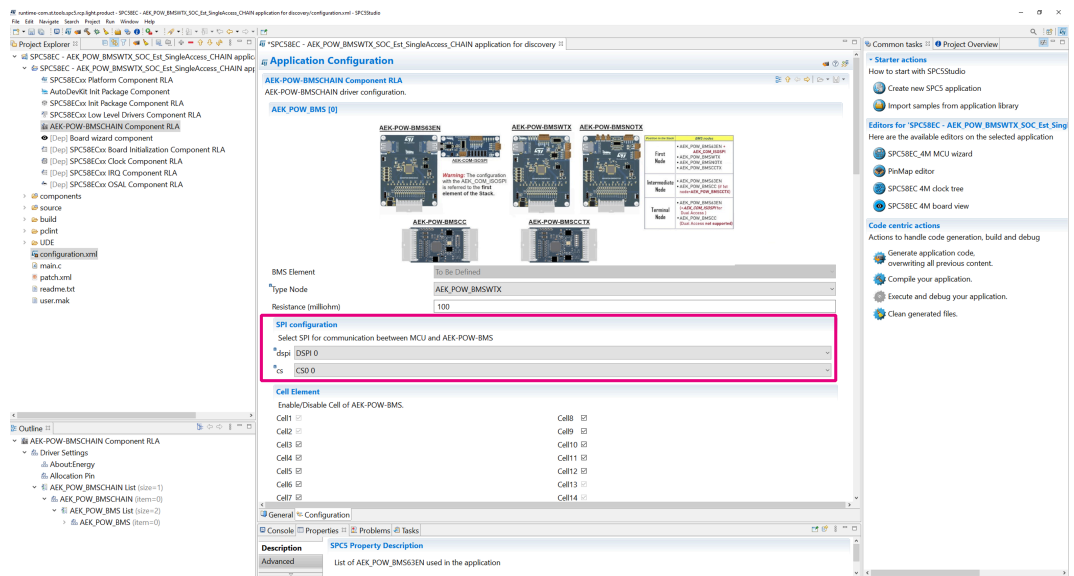
Step 9. Customize the sensing resistor for every single node. The default value is 100 mΩ.

Figure 60. Customizing the sensing resistor



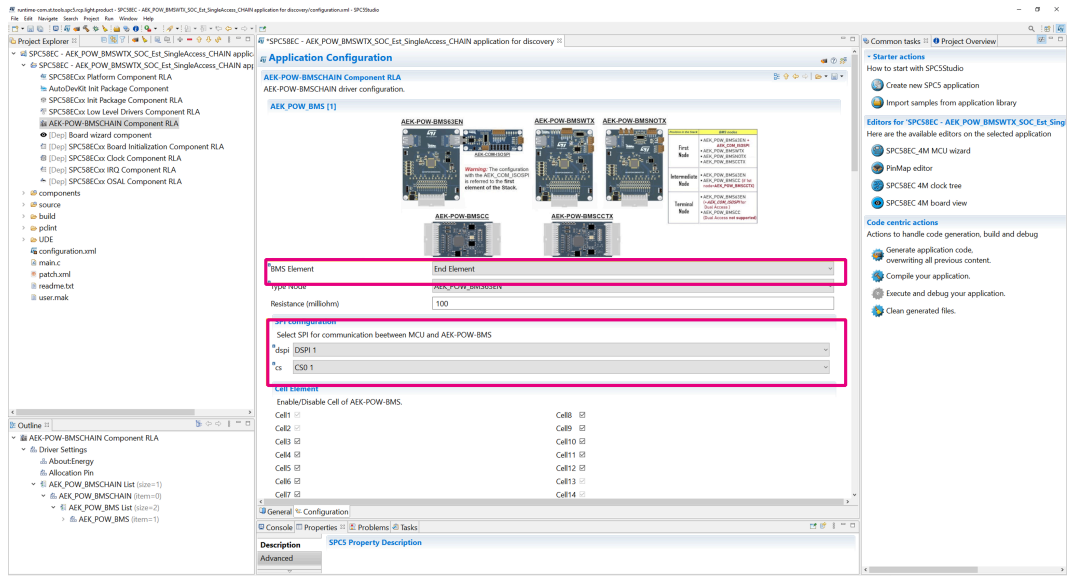
Step 10. In “Single Access” mode chain, define the SPI configuration for the first chain node. Choose the DSPL peripheral and Chip Select.

Figure 61. SPI configuration for single access mode



Step 11. In “Dual Access” mode chain, define the SPI configuration also for the last chain node (“End Element”). Choose the DSPI peripheral and Chip Select for this end node but not for the intermediate nodes.

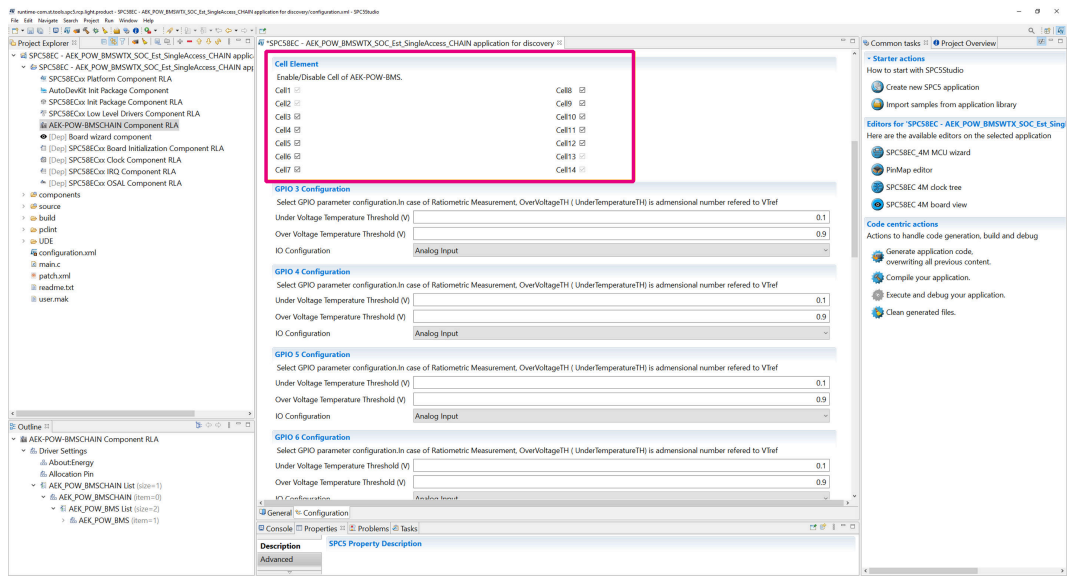
Figure 62. SPI configuration for dual access mode



Step 12. For each chain node, choose and configure the cells to be enabled.

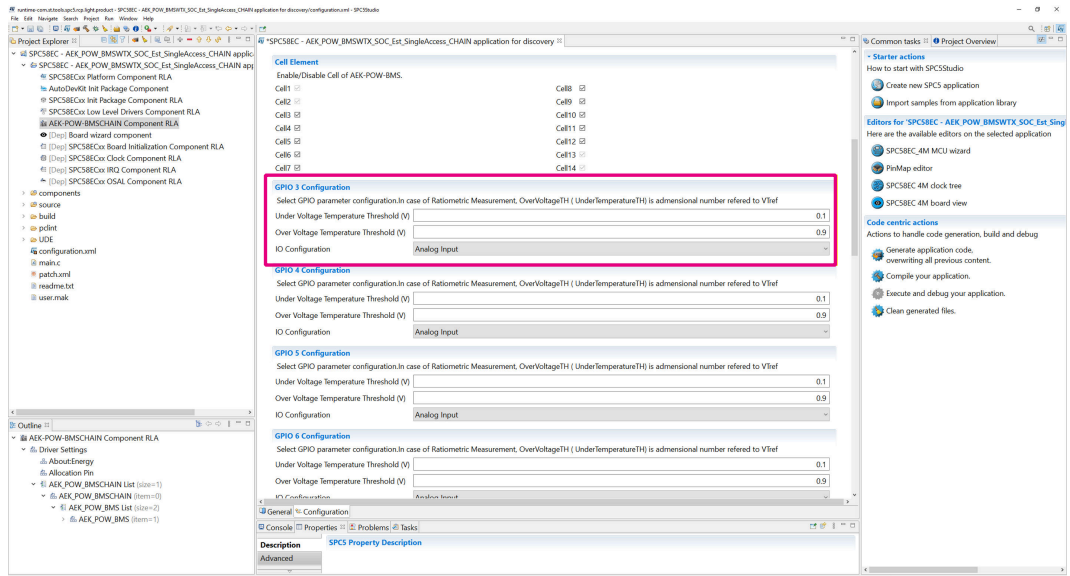
Note: Cell1, Cell2, Cell13, and Cell14 cannot be disabled.

Figure 63. Cell selection and configuration



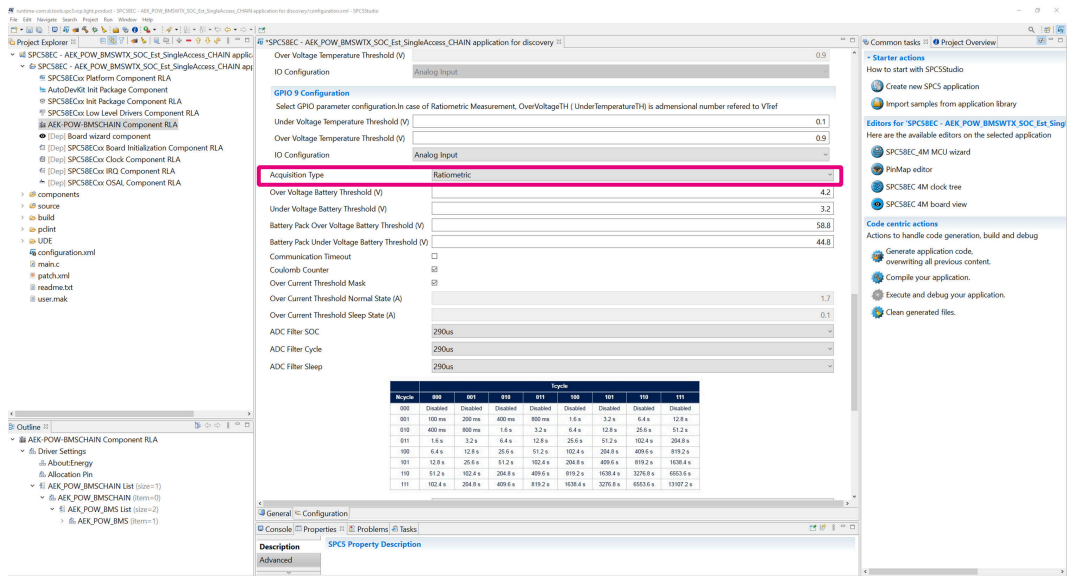
Step 13. Each GPIO handled by the L9963E/L9963F can be configured as Digital/Analog Input or Digital Output. You can associate temperature thresholds (in voltage) for fault management.

Figure 64. GPIO configuration



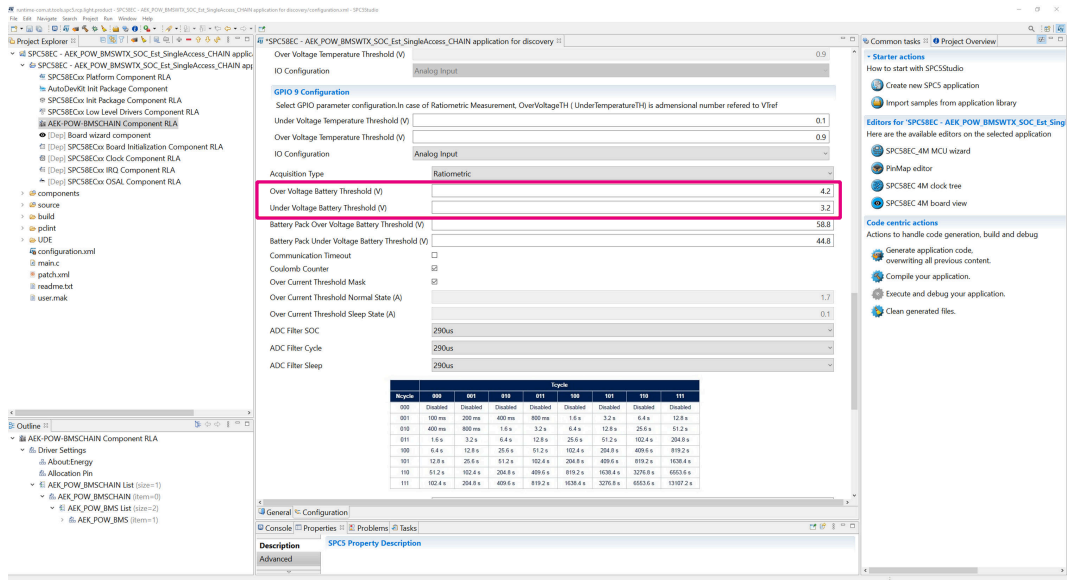
Step 14. For each chain node, configure the GPIO voltage acquisition mode. In Ratiometric mode, voltage is measured according to the L9963E/L9963F V_{tref} function. In Absolute mode, measured voltage is not acquired with reference to the V_{tref} generated by its regulator.

Figure 65. GPIO voltage acquisition mode configuration



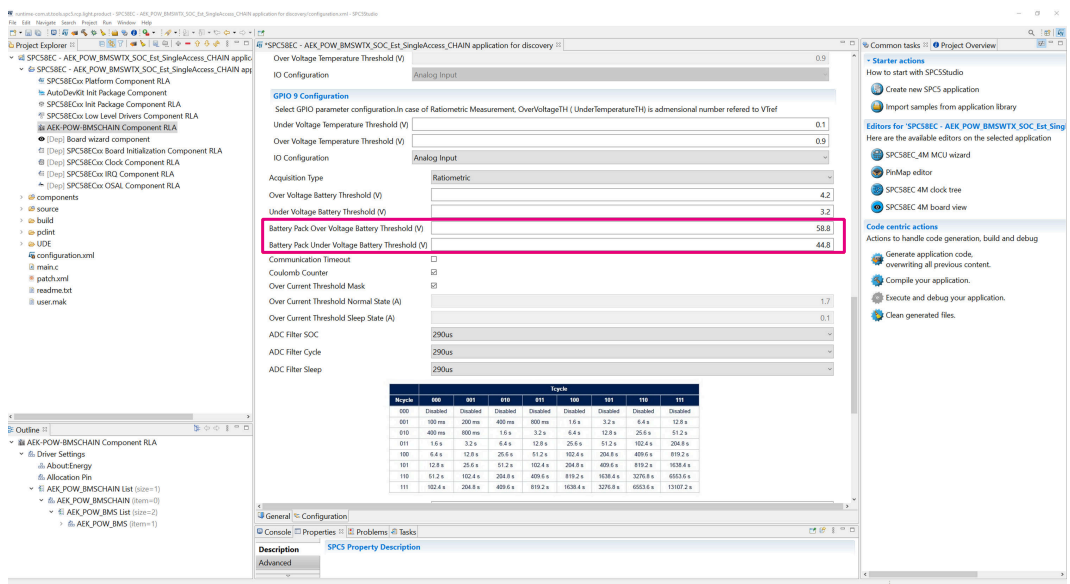
Step 15. Associate voltage thresholds (Under/Over voltage) to each enabled cell. When exceeding the threshold, a fault will be visible if it is not masked via software.

Figure 66. Voltage thresholds association for enabled cells



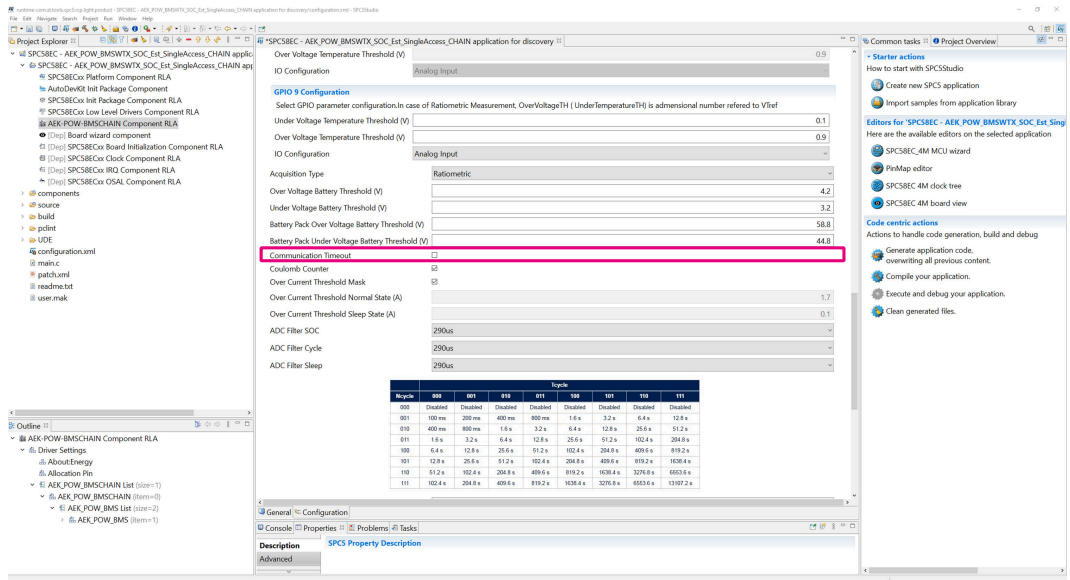
Step 16. You can also associate voltage thresholds (Under/Over voltage) to the entire battery pack managed by each single node. When exceeding the threshold, a fault occurs if it is no masked via software.

Figure 67. Voltage thresholds association for the entire battery pack



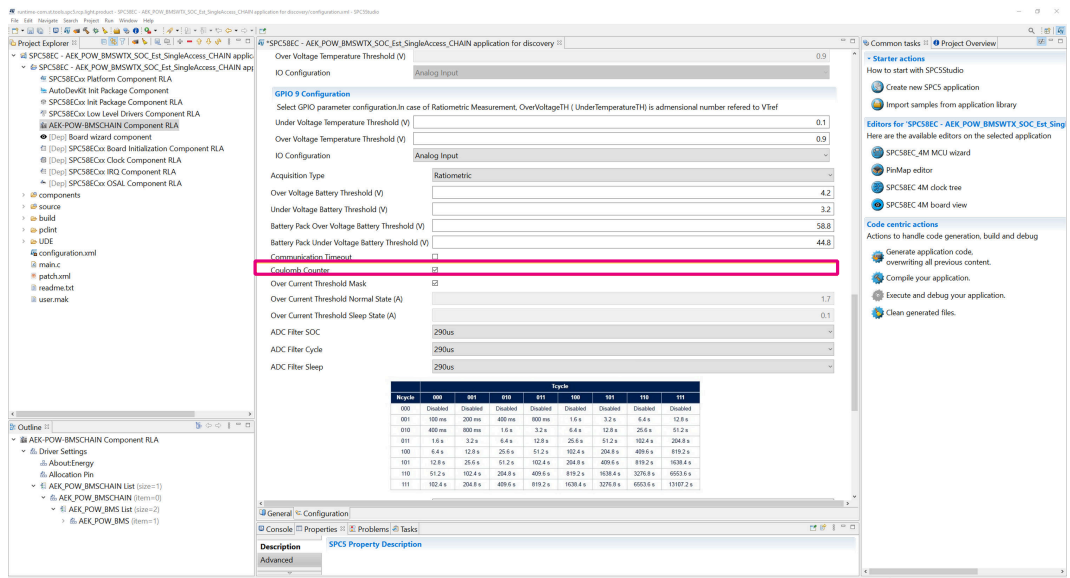
Step 17. When the “Communication timeout” field is enabled, if a chain node does not reply to an SPI command within the time defined in “Communication timeout” (configurable via SPI command), the node enters sleep mode. If the flag is disabled, the node remains in normal mode.

Figure 68. Communication timeout field enabling



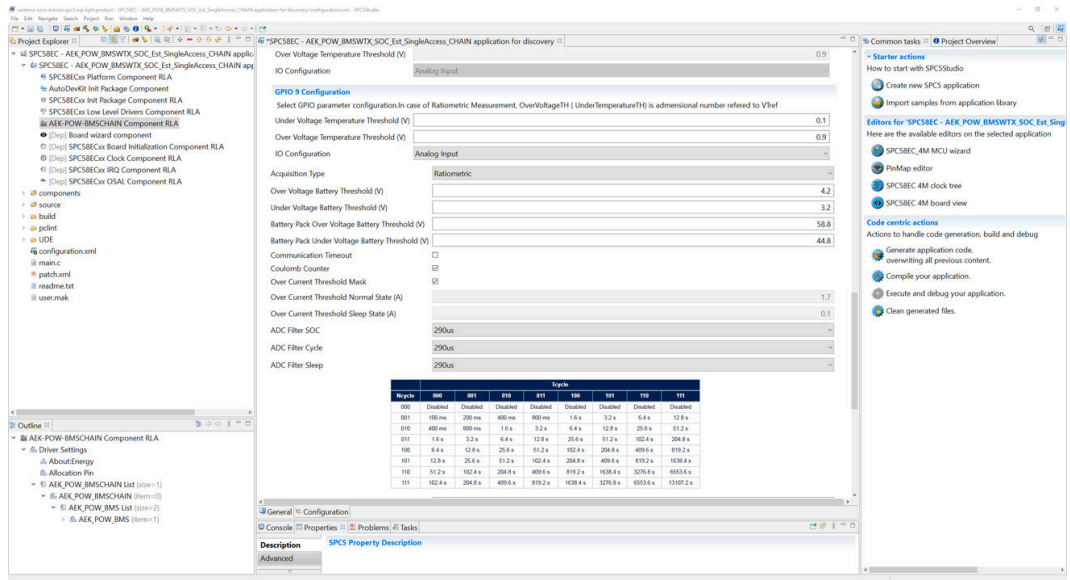
Step 18. If the “Coulomb Counter” field is enabled, values measured from enabled cells will be synchronized with the selected node voltage value.

Figure 69. Coulomb Counter field enabling



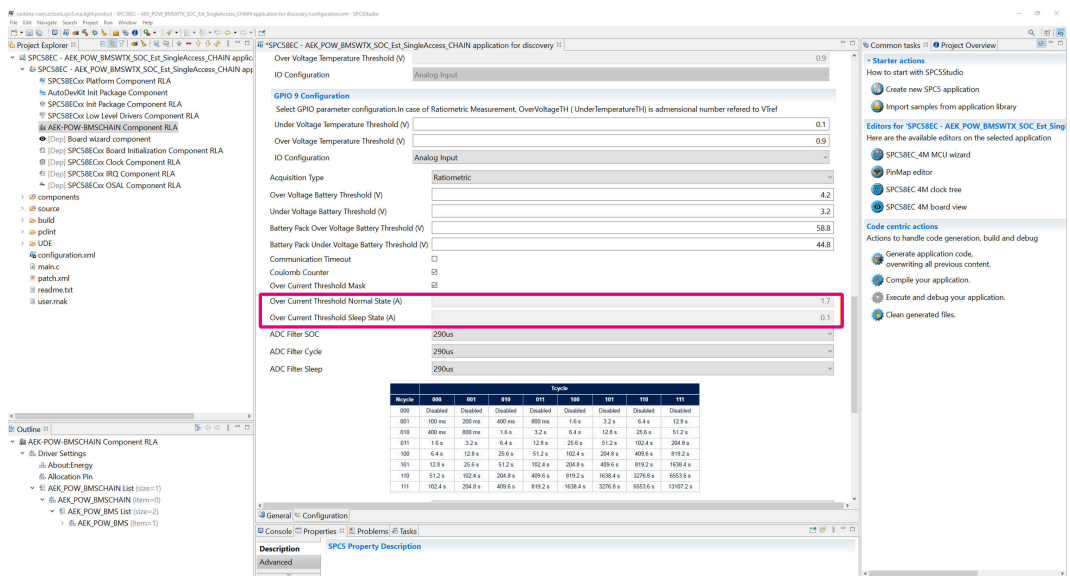
Step 19. If the “Over Current Threshold Mask” field is enabled, the driver masks faults that occur when exceeding the voltage threshold on Rsense, both in sleep and in normal modes.

Figure 70. Over Current Threshold Mask field enabling



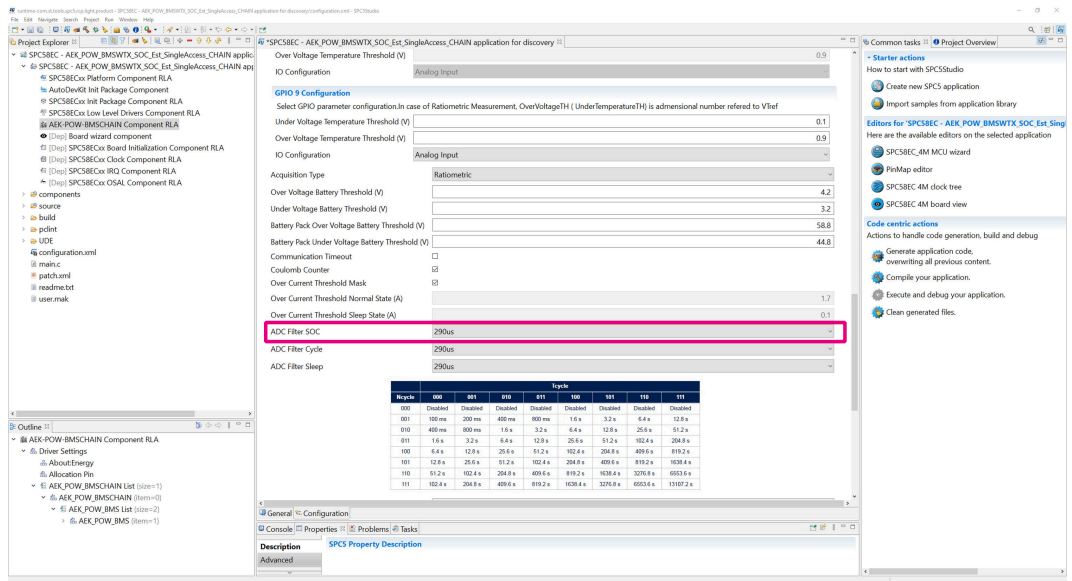
Step 20. Configure overcurrent thresholds in normal and sleep states.

Figure 71. Overcurrent threshold configuration



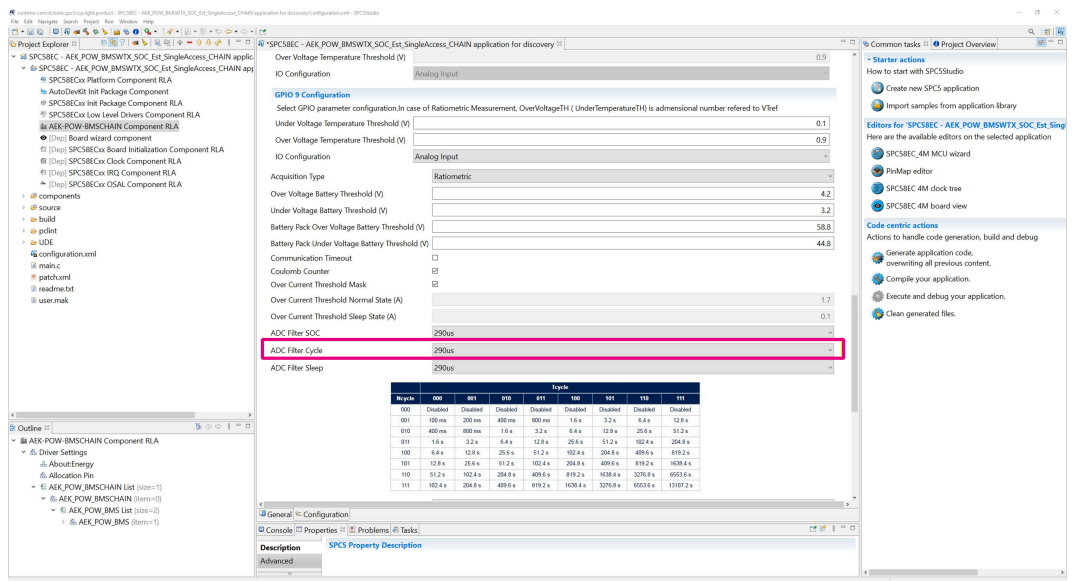
Step 21. Configure “ADC Filter SOC” field to enable on-demand conversion routine (manual request).

Figure 72. ADC Filter SOC field configuration



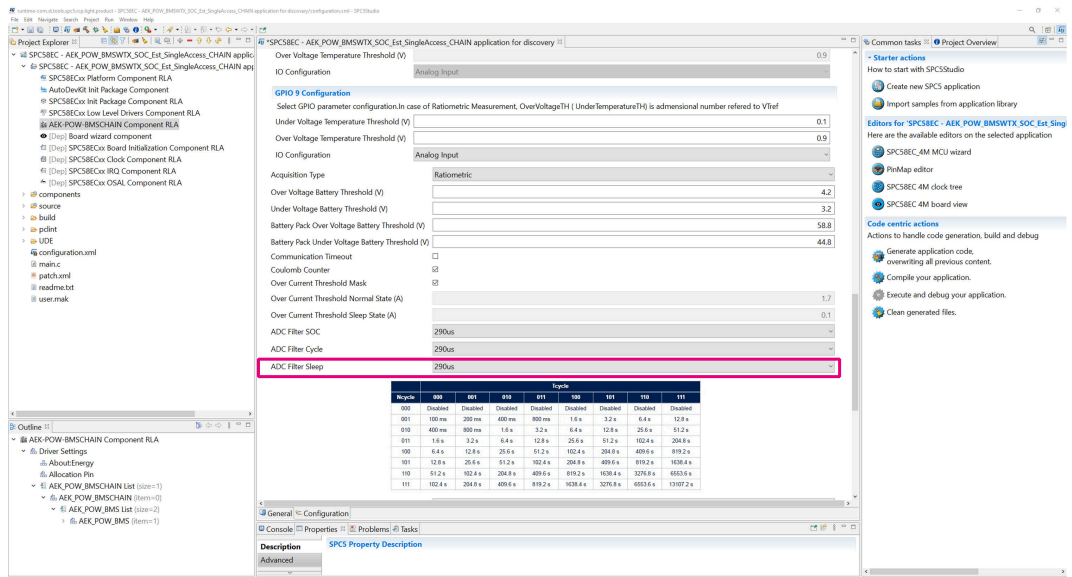
Step 22. Configure “ADC Filter Cycle” field to enable cycle conversion routine in normal state.

Figure 73. ADC Filter Cycle field configuration



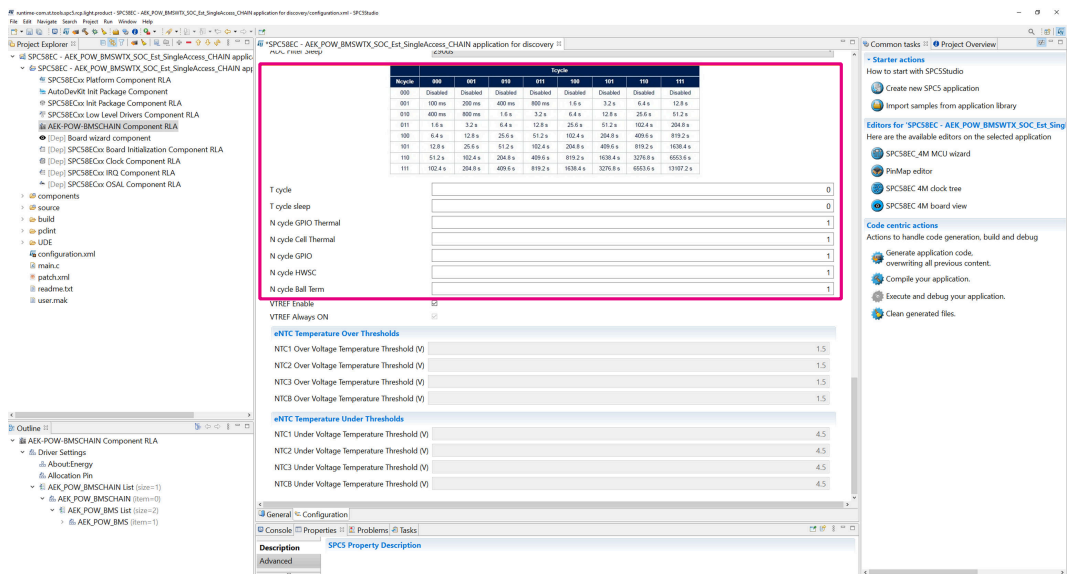
Step 23. Configure “ADC Filter Sleep” field to enable cycle conversion routine in sleep state.

Figure 74. ADC Filter Sleep field configuration



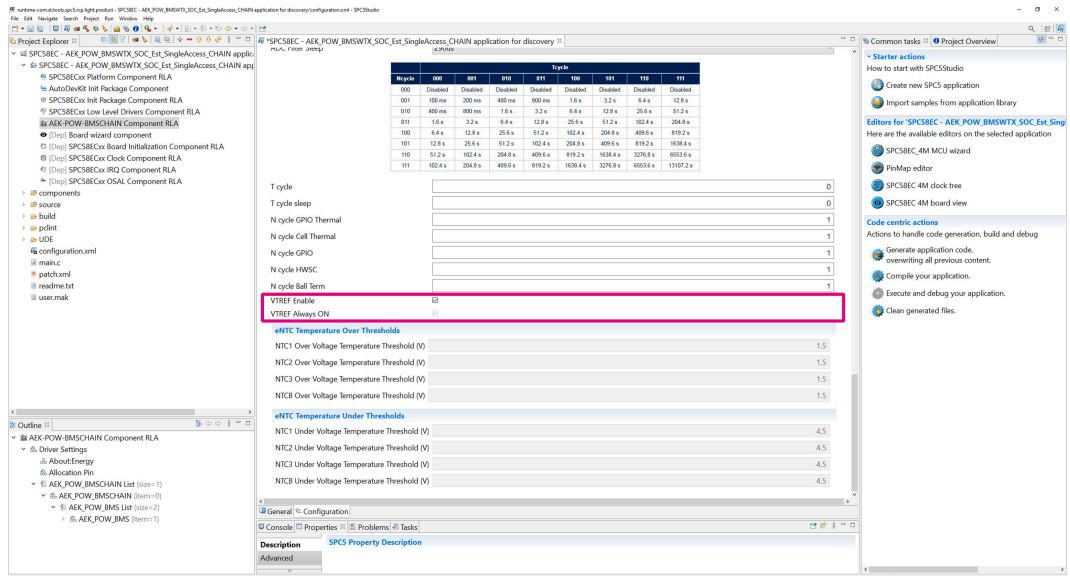
Step 24. Configure periodic acquisition. For example, if Tcycle = 001 and NcycleGPIO = 001, voltage values on GPIOs will be acquired every 200 ms.

Figure 75. Periodic acquisition configuration



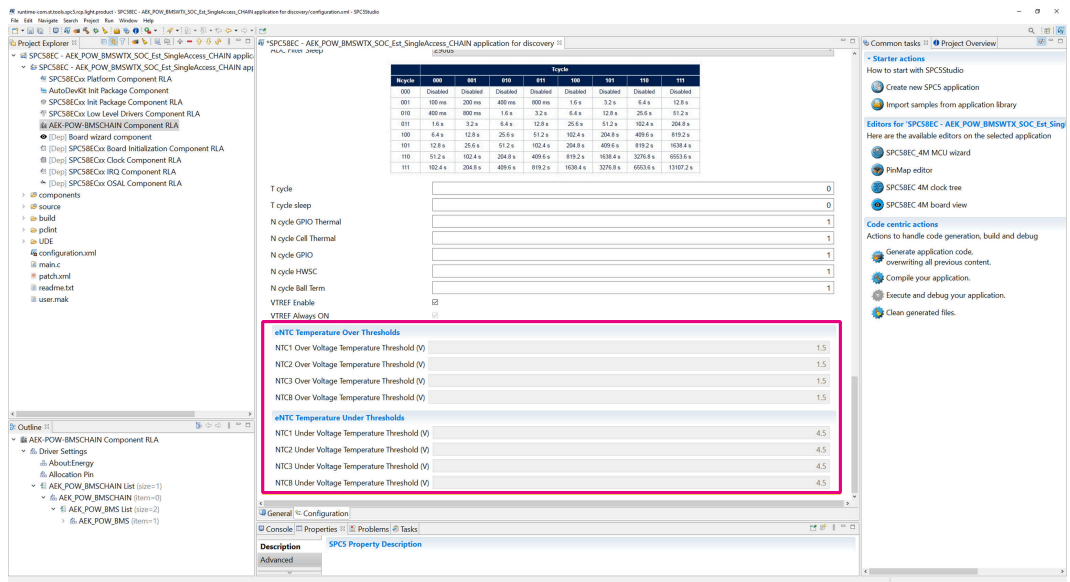
Step 25. Configure Vtref voltage regulator. If the “Vtref Enable” field is enabled, the voltage regulator will be active when required (for example, during voltage acquisition on GPIOs if the Ratiometric mode is enabled). If the “Vtref Always ON” field is enabled, the voltage regulator is always active.

Figure 76. Vtref voltage regulator configuration



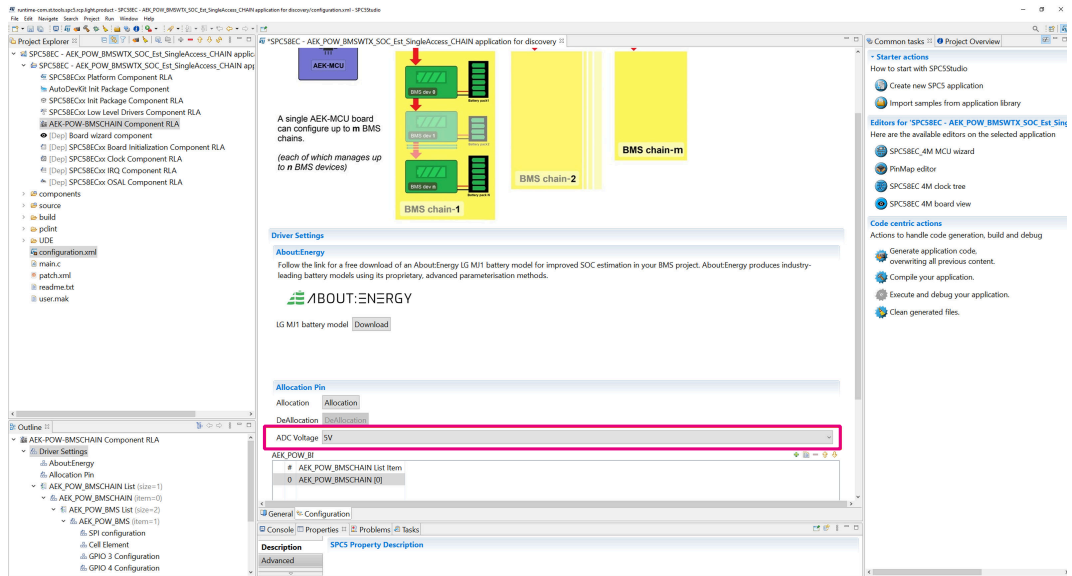
Step 26. Configure temperature thresholds (in voltage) if the first chain node is an AEK-POW-BMSNOTX evaluation board. If the first chain node is a different board, the thresholds are not customizable.

Figure 77. Temperature threshold configuration



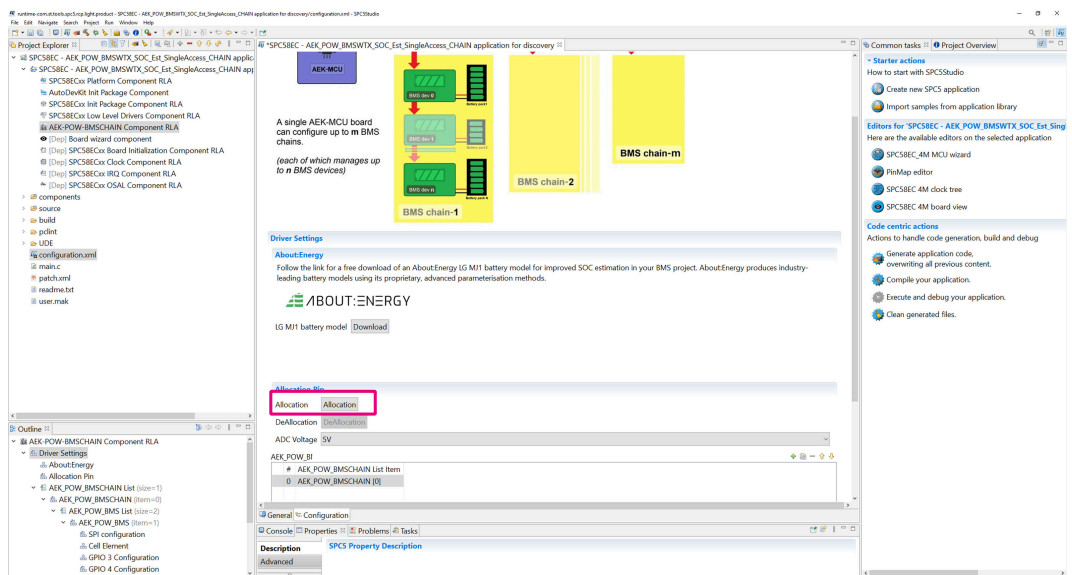
Step 27. In case an AEK-POW-BMSNOTX is included in a chain, you must configure the reference voltage of the MCU ADC (ADC Voltage field). This configuration does not replace the configuration of the MCU board jumpers.

Figure 78. MCU ADC voltage configuration when including an AEK-POW-BMSNOTX



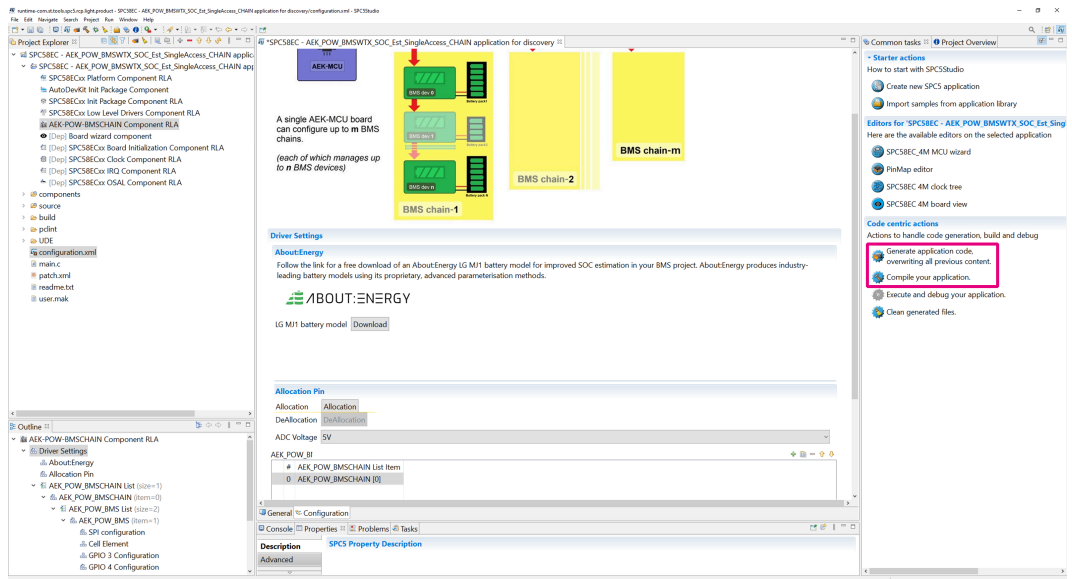
Step 28. After configuring all chain nodes, proceed with automatic allocation for all customized chains.

Figure 79. Automatic allocation for all customized chains



Step 29. Generate the AEK-POW-BMSCHAIN library C code and compile the project.

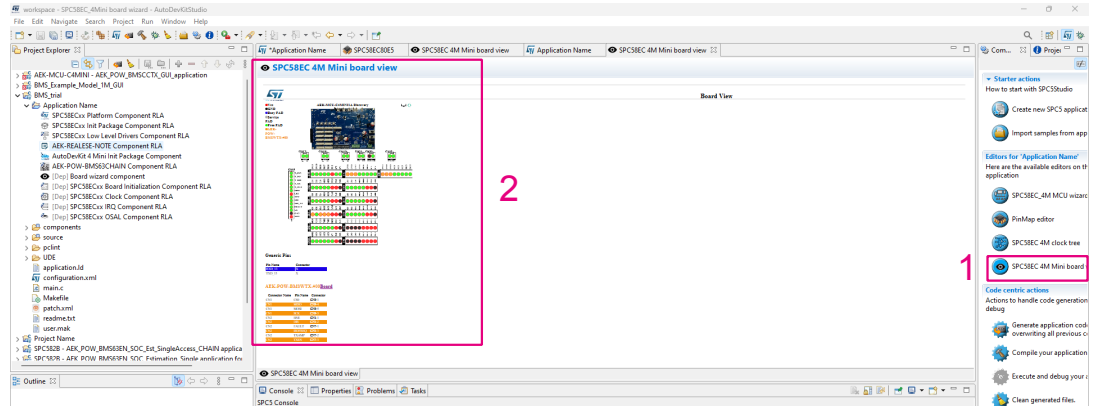
Figure 80. AEK-POW-BMSCHAIN library C code generation and compilation



Step 30. Include `AEK_POW_BMS63CHAIN_app_mng.h` in your main application and write your application code.

Step 31. Click on [Board View] to display the hardware connection between the AEK-MCU-C4MINI1 board and the BMS chain board.

Figure 81. Board View



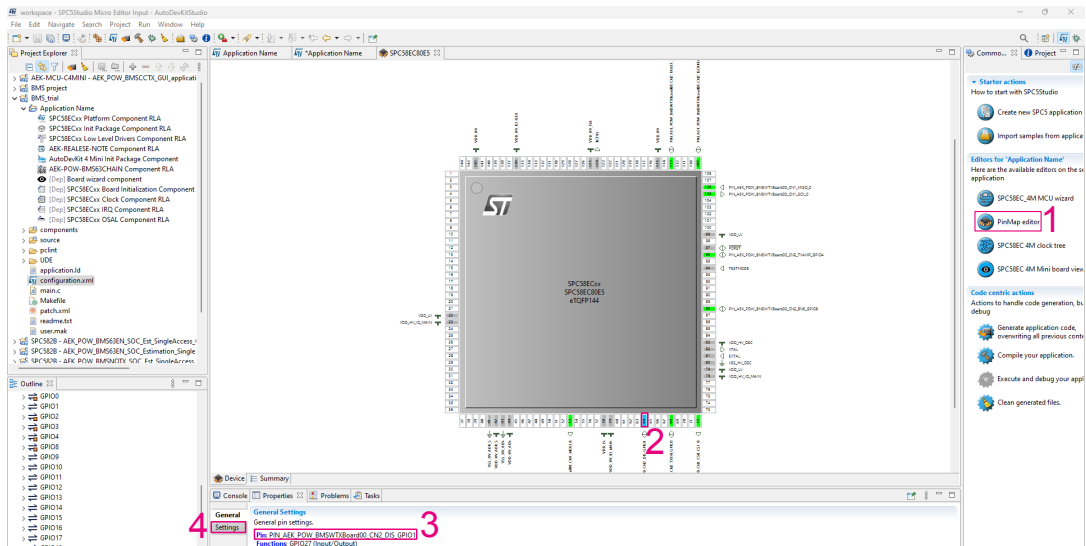
Note: If a pin is not physically wired, the connection table could include some Xs, as shown below.

Figure 82. Connection table example

Connector Name	Pin Name	Connector
CN1	CS0	CN14-1
CN1	MISO	CN12-4
CN1	MOSI	CN2-6
CN1	SCK	CN12-3
CN2	BNE	X
CN2	DIS	X
CN2	FAULT	X
CN2	ISOFREQ	X
CN2	TXAMP	CN7-2
CN2	TXEN	X

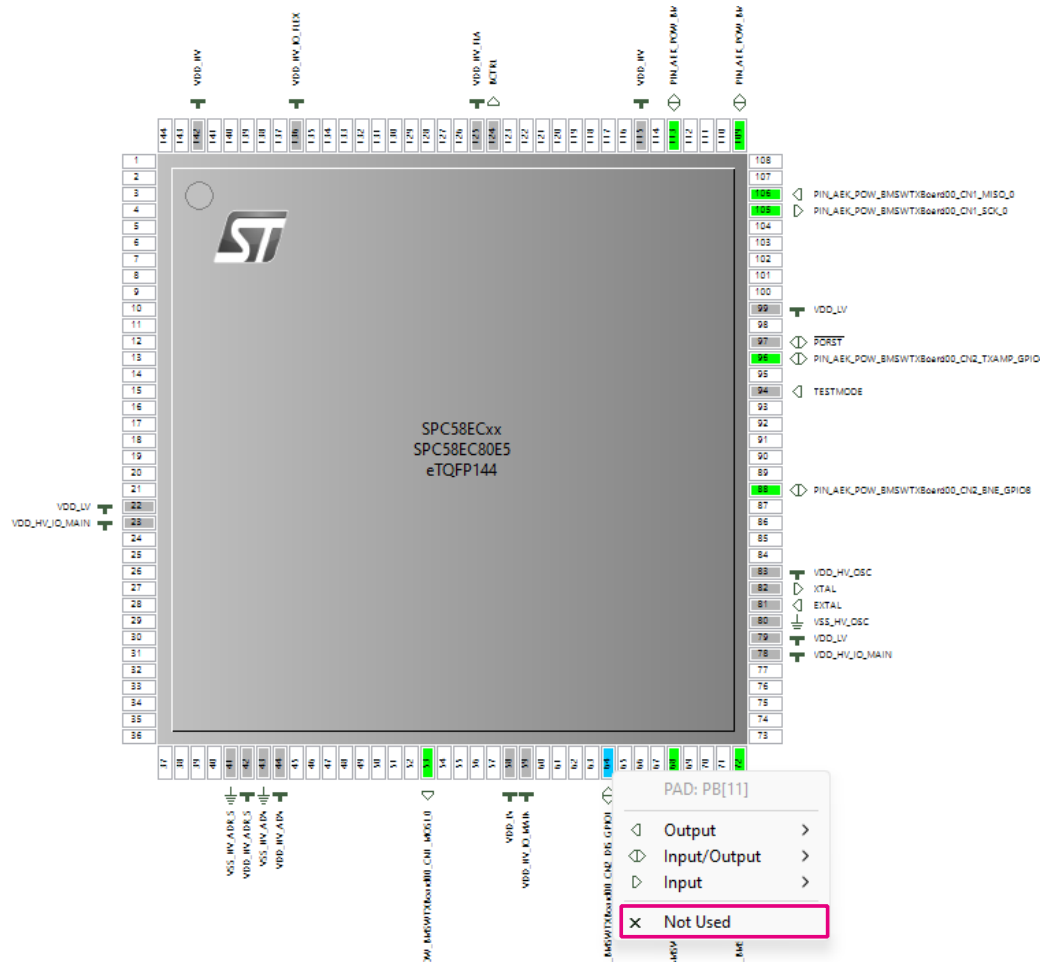
In this case, check table 1 in UM3350 and look for the pin number related to DIS, for example. Then, open Pin Map editor, look for the pin PAD name. Then, copy its label and the related settings.

Figure 83. Pin Map editor allocation



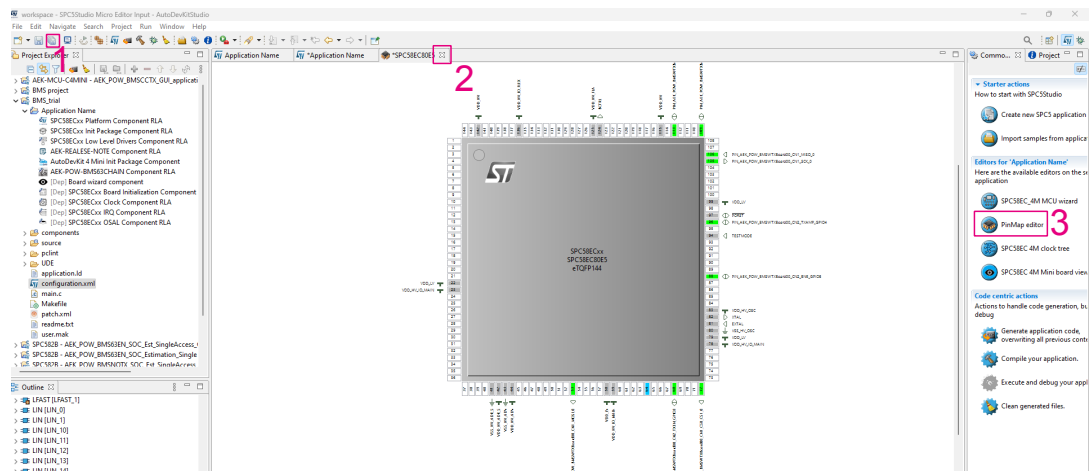
Right-click on the pin and select "not used".

Figure 84. Pin Map editor allocation

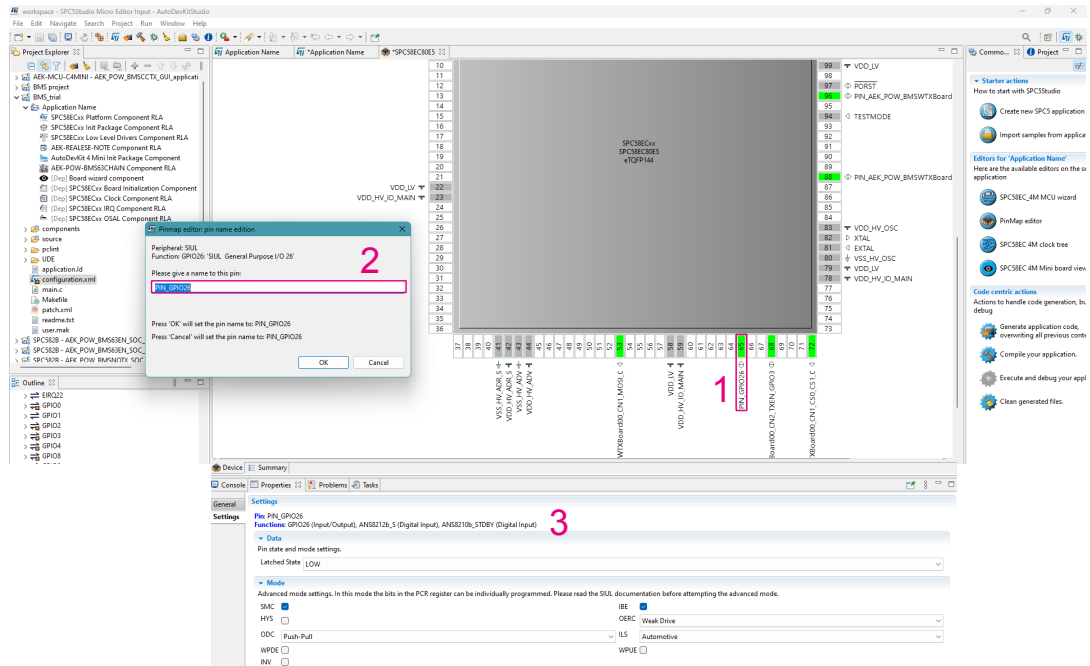


Important: Every time you change a pin allocation, you have to save the pin map editor and close it. Then, save the project and reopen the pin map editor.

Figure 85. Save all



Select the pin, right-click on it, choose the new configuration and put the same label and settings copied before.

Figure 86. New pin definition


Repeat this sequence to allocate all pins marked with an X in Figure 82. Connection table example.

10.5 Available demos

In the AutoDevKit starting from release 2.4.0, there are several available demos for our BMS boards:

Figure 87. Available demos

- SPC58EC - AEK_POW_BMSWTX_SOC_Estimation application for discovery
- SPC58EC - AEK_POW_BMSWTX_SOC_Est_SingleAccess_CHAIN_GUI application for discovery
- SPC58EC - AEK_POW_BMSWTX_SOC_Est_SingleAccess_CHAIN application for discovery
- SPC58EC - AEK_POW_BMSWTX_DualAccess_CHAIN application for discovery
- SPC58EC - AEK_POW_BMSNOTX_SOC_Est_SingleAccess_CHAIN_GUI application for discovery
- SPC58EC - AEK_POW_BMSNOTX_SOC_Est_SingleAccess_CHAIN application for discovery
- SPC58EC - AEK_POW_BMSLV application for discovery
- SPC58xN - AEK-POW-BMSEM_SingleAccess-6cell
- SPC58xN - AEK-POW-BMSEM_SingleAccess-10bcell
- SPC58xN - AEK-POW-BMSEM_SingleAccess-10acell
- SPC58xN - AEK-POW-BMSEM_DualAccess_CHAIN application for discovery
- SPC58EC - AEK_POW_BMS63EN_SOC_Estimation_Single application for discovery
- SPC58EC - AEK_POW_BMS63EN_SOC_Estimation_DualRing application for discovery
- SPC58EC - AEK_POW_BMS63EN_SOC_Estimation_Centralized application for discovery
- SPC58EC - AEK_POW_BMS63EN_SOC_Estimation_6Cells_GUI application for discovery
- SPC58EC - AEK_POW_BMS63EN_SOC_Estimation_14Cells_GUI application for discovery
- SPC58EC - AEK_POW_BMS63EN_SOC_Est_SingleAccess_CHAIN_GUI application for discovery
- SPC58EC - AEK_POW_BMS63EN_SOC_Est_SingleAccess_CHAIN application for discovery
- SPC58EC - AEK_POW_BMS63EN Single 6 Cells application for discovery
- AEK-MCU-C4MINI - AEK_POW_BMSCCTX_GUI application for discovery
- AEK-MCU-C4MINI - AEK_POW_BMSCCTX_2_nodes_chain_GUI application for discovery

All "SOC_Est_SingleAccess" demos can estimate SOC for a single node chain. (A demo has been created for each node topology).

The AEK_POW_BMSWTX_DualAccess_CHAIN shows how a chain with two nodes (AEK-POW-BMSWTX and AEK-POW-BMS63EN) works in dual access ring. This demo does not estimate the SOC.

Only demos for SPC58EC with SOC_Est_SingleAccess plot SOC, voltage and current via serial terminal.

10.5.1 Centralized application (SPC58EC - AEK_POW_BMSWTX_SOC_Est_SingleAccess_CHAIN application for discovery demo)

This application is based on the SPC58EC microcontroller and can estimate the SOC of 14 cells (in our case, the batteries used are INR 18650 MJ1 by LG) connected with the AEK-POW-BMSWTX evaluation board. The results of SOC estimation, cell voltage, NTC temperatures, and current are printed via a serial port with a speed rate of 115200 bps.

Below is the main code for the SPC58EC - AEK_POW_BMSWTX_SOC_Est_SingleAccess_CHAIN application for discovery demo:

Figure 88. SPC58EC - AEK_POW_BMSWTX_SOC_Est_SingleAccess_CHAIN code

```

/*****
 *
 * Copyright © 2015-2021 STMicroelectronics - All Rights Reserved
 *
 * This software is licensed under SLA0098 terms that can be found in the
 * DM00779817_1_0.pdf file in the licenses directory of this software product.
 *
 * THIS SOFTWARE IS DISTRIBUTED "AS IS," AND ALL WARRANTIES ARE DISCLAIMED,
 * INCLUDING MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.
 *
 *****/

/* Inclusion of the main header files of all the imported components in the
   order specified in the application wizard. The file is generated
   automatically.*/
#include "AEK_POW_BMS63CHAIN_app_mng.h"

#define AEK_POW_BMS63CHAIN_TIMESTEP 1000 //msec
#define AEK_POW_BMS63CHAIN_SERIAL_TIMESTEP 1000 //msec

void main_core0(void) {
    irqIsrEnable();
    AEK_POW_BMS63CHAIN_app_serialInit();
    for(;;){
        AEK_POW_BMS63CHAIN_app_serialStep(AEK_POW_BMS63CHAIN_SERIAL_TIMESTEP);
    }
}

int main(void) {
    componentsInit();
    irqIsrEnable();
    /* Application init */
    AEK_POW_BMS63CHAIN_app_init();
    runCore0();
    /* Application main loop.*/
    for ( ; ; ) {
        AEK_POW_BMS63CHAIN_app_step(AEK_POW_BMS63CHAIN_TIMESTEP);
    }
}

```

This application enables two cores:

- Core2 (main core) – Used to start the manager process (AEK_POW_BMS63CHAIN_app_step()).

This process is called every 1000ms.

Figure 89. Core 2 enablement

```
void AEK_POW_BMS63CHAIN_app_step(uint32_t AEK_POW_BMS63CHAIN_app_timestamp)
{
    uint8_t AEK_POW_BMS63CHAIN_chainidx = 0;
    uint8_t AEK_POW_BMS63CHAIN_devIdx = 0;
    uint8_t AEK_POW_BMS63CHAIN_cellIdx = 0;
    if((uint32_t)AEK_POW_BMS63CHAIN_app_timestamp == 0)
        pal_llt_toggle(PORT_F, debug);
    //Acquisition
    for(AEK_POW_BMS63CHAIN_chainidx = AEK_POW_BMS63CHAIN_CHAIN0; AEK_POW_BMS63CHAIN_chainidx < AEK_POW_BMS63CHAIN_CHAIN_GENUM(); AEK_POW_BMS63CHAIN_chainidx++){
        for(AEK_POW_BMS63CHAIN_devIdx = AEK_POW_BMS63CHAIN_NODE_DEV1; AEK_POW_BMS63CHAIN_devIdx < AEK_POW_BMS63CHAIN_CHAIN_GETDEVNUM(AEK_POW_BMS63CHAIN_chainidx); AEK_POW_BMS63CHAIN_devIdx++){
            AEK_POW_BMS63CHAIN_app_datachain[AEK_POW_BMS63CHAIN_chainidx][AEK_POW_BMS63CHAIN_FastMeas][AEK_POW_BMS63CHAIN_devIdx - 1] = AEK_POW_BMS63CHAIN_node_getFastMeas(AEK_POW_BMS63CHAIN_chainidx, AEK_POW_BMS63CHAIN_devIdx);
            AEK_POW_BMS63CHAIN_app_datachain[AEK_POW_BMS63CHAIN_chainidx][AEK_POW_BMS63CHAIN_FastIdag][AEK_POW_BMS63CHAIN_devIdx - 1] = AEK_POW_BMS63CHAIN_node_getFastIdag(AEK_POW_BMS63CHAIN_chainidx, AEK_POW_BMS63CHAIN_devIdx);
            AEK_POW_BMS63CHAIN_app_datachain[AEK_POW_BMS63CHAIN_chainidx][AEK_POW_BMS63CHAIN_FastIdag][AEK_POW_BMS63CHAIN_devIdx - 1] = AEK_POW_BMS63CHAIN_node_getFastIdag(AEK_POW_BMS63CHAIN_chainidx, AEK_POW_BMS63CHAIN_devIdx);
            AEK_POW_BMS63CHAIN_app_datachain[AEK_POW_BMS63CHAIN_chainidx][AEK_POW_BMS63CHAIN_ovrLatched][AEK_POW_BMS63CHAIN_devIdx - 1] = AEK_POW_BMS63CHAIN_node_ovrLatched(AEK_POW_BMS63CHAIN_chainidx, AEK_POW_BMS63CHAIN_devIdx);
        }
    }
    1) AEK_POW_BMS63CHAIN_curSenseOverTemp()
    if(AEK_POW_BMS63CHAIN_node_getVoltageConversionRouteIndex(AEK_POW_BMS63CHAIN_chainidx, AEK_POW_BMS63CHAIN_devIdx) == AEK_POW_BMS63CHAIN_NODE_ID0){
        AEK_POW_BMS63CHAIN_node_enableConversionRequest(AEK_POW_BMS63CHAIN_chainidx, AEK_POW_BMS63CHAIN_devIdx, AEK_POW_BMS63CHAIN_GPDCONV_ENABLE, AEK_POW_BMS63CHAIN_GPIOTERRCONV_ENABLE, AEK_POW_BMS63CHAIN_CELLTERRCONV_ENABLE, AEK_POW_BMS63CHAIN_BALTERRCONV_ENABLE,
        AEK_POW_BMS63CHAIN_node_cyclicMeasurementConversionRequest(AEK_POW_BMS63CHAIN_chainidx, AEK_POW_BMS63CHAIN_devIdx, AEK_POW_BMS63CHAIN_TCVCLE_TRIGGERED);
    }
    }
    //Parser Data
    AEK_POW_BMS63CHAIN_app_parserData();
    //Model execution
    AEK_POW_BMS63CHAIN_app_modelExec();
    //Balancing
    for(AEK_POW_BMS63CHAIN_chainidx = AEK_POW_BMS63CHAIN_CHAIN0; AEK_POW_BMS63CHAIN_chainidx < AEK_POW_BMS63CHAIN_CHAIN_GENUM(); AEK_POW_BMS63CHAIN_chainidx++){
        for(AEK_POW_BMS63CHAIN_devIdx = AEK_POW_BMS63CHAIN_NODE_DEV1; AEK_POW_BMS63CHAIN_devIdx < AEK_POW_BMS63CHAIN_CHAIN_GETDEVNUM(AEK_POW_BMS63CHAIN_chainidx); AEK_POW_BMS63CHAIN_devIdx++){
            //Balancing Enabled
            if(AEK_POW_BMS63CHAIN_app_datachain[AEK_POW_BMS63CHAIN_chainidx][AEK_POW_BMS63CHAIN_nodeData][AEK_POW_BMS63CHAIN_devIdx - 1].AEK_POW_BMS63CHAIN_Pack_Bal_en_sts){
                //Balancing enabling
                if(AEK_POW_BMS63CHAIN_app_datachain[AEK_POW_BMS63CHAIN_chainidx][AEK_POW_BMS63CHAIN_FastMeas][AEK_POW_BMS63CHAIN_devIdx - 1].AEK_POW_BMS63CHAIN_Pack_Bal_en_sts){
                    1) AEK_POW_BMS63CHAIN_cofbal()
                    //Balancing Command - Balancing Status for first cell found
                    for(AEK_POW_BMS63CHAIN_cellIdx = AEK_POW_BMS63CHAIN_CELL1; AEK_POW_BMS63CHAIN_cellIdx < AEK_POW_BMS63CHAIN_CELL14; AEK_POW_BMS63CHAIN_cellIdx++){
                        if(AEK_POW_BMS63CHAIN_app_datachain[AEK_POW_BMS63CHAIN_chainidx][AEK_POW_BMS63CHAIN_nodeData][AEK_POW_BMS63CHAIN_devIdx - 1].AEK_POW_BMS63CHAIN_Pack_Bal_cmd[AEK_POW_BMS63CHAIN_cellIdx - 1] == 1){
                            AEK_POW_BMS63CHAIN_app_datachain[AEK_POW_BMS63CHAIN_chainidx][AEK_POW_BMS63CHAIN_nodeData][AEK_POW_BMS63CHAIN_devIdx - 1].AEK_POW_BMS63CHAIN_Pack_Bal_sts[AEK_POW_BMS63CHAIN_cellIdx - 1] = 1;
                        }
                    }
                    //Stop Balancing
                    AEK_POW_BMS63CHAIN_node_setStopBal(AEK_POW_BMS63CHAIN_chainidx, AEK_POW_BMS63CHAIN_devIdx);
                    break;
                }
                else{
                    //Balancing not ongoing
                }
            }
            else{
                for(AEK_POW_BMS63CHAIN_cellIdx = AEK_POW_BMS63CHAIN_CELL1; AEK_POW_BMS63CHAIN_cellIdx < AEK_POW_BMS63CHAIN_CELL14; AEK_POW_BMS63CHAIN_cellIdx++){
                    //Balancing cmd active
                    if(AEK_POW_BMS63CHAIN_app_datachain[AEK_POW_BMS63CHAIN_chainidx][AEK_POW_BMS63CHAIN_nodeData][AEK_POW_BMS63CHAIN_devIdx - 1].AEK_POW_BMS63CHAIN_Pack_Bal_cmd[AEK_POW_BMS63CHAIN_cellIdx - 1] == 1){
                        AEK_POW_BMS63CHAIN_app_datachain[AEK_POW_BMS63CHAIN_chainidx][AEK_POW_BMS63CHAIN_nodeData][AEK_POW_BMS63CHAIN_devIdx - 1].AEK_POW_BMS63CHAIN_Pack_Bal_sts[AEK_POW_BMS63CHAIN_cellIdx - 1] = 1;
                    }
                }
                //Balancing cmd not active
                AEK_POW_BMS63CHAIN_node_disableBalCell(AEK_POW_BMS63CHAIN_chainidx, AEK_POW_BMS63CHAIN_devIdx, AEK_POW_BMS63CHAIN_cellIdx);
                AEK_POW_BMS63CHAIN_app_datachain[AEK_POW_BMS63CHAIN_chainidx][AEK_POW_BMS63CHAIN_nodeData][AEK_POW_BMS63CHAIN_devIdx - 1].AEK_POW_BMS63CHAIN_Pack_Bal_sts[AEK_POW_BMS63CHAIN_cellIdx - 1] = 0;
            }
        }
    }
    //Start Balancing
    AEK_POW_BMS63CHAIN_node_setStartBal(AEK_POW_BMS63CHAIN_chainidx, AEK_POW_BMS63CHAIN_devIdx);
    }
    else{
        //Balancing not enabled
    }
    //Balancing enabling
    if(AEK_POW_BMS63CHAIN_app_datachain[AEK_POW_BMS63CHAIN_chainidx][AEK_POW_BMS63CHAIN_nodeData][AEK_POW_BMS63CHAIN_devIdx - 1].AEK_POW_BMS63CHAIN_Pack_Bal_en_sts){
        1) AEK_POW_BMS63CHAIN_cofbal()
        //Balancing Command - Balancing Status
        if(AEK_POW_BMS63CHAIN_app_datachain[AEK_POW_BMS63CHAIN_chainidx][AEK_POW_BMS63CHAIN_nodeData][AEK_POW_BMS63CHAIN_devIdx - 1].AEK_POW_BMS63CHAIN_Pack_Bal_cmd != AEK_POW_BMS63CHAIN_app_datachain[AEK_POW_BMS63CHAIN_chainidx][AEK_POW_BMS63CHAIN_nodeData][AEK_POW_BMS63CHAIN_devIdx - 1]){
            //Stop Balancing
            AEK_POW_BMS63CHAIN_node_setStopBal(AEK_POW_BMS63CHAIN_chainidx, AEK_POW_BMS63CHAIN_devIdx);
        }
        else{
            //Balancing ongoing
        }
    }
    else{
        //Balancing not ongoing
    }
}
}
```

This process starts the cyclic conversion routine to measure cell voltage, cell current, and GPIO NTC temperature.

It also performs the state of charge estimation by using the C-code generated through a Simulink model and enables the manual balancing during the Normal state of the FSM.

In case of Fault condition activated, on-demand conversion routine will replace cyclic conversion routine.

- Core0 (auxiliary core) – Used to start a process to print via serial the following data (with a speed rate of 115200 bps):
 - State of charge percentage for each cell.
 - Cell voltage values.
 - Current value.
 - Balancing status.

This process is called every 1000 ms.

10.5.2 Dual ring application (SPC58EC - AEK_POW_BMSWTX_DualAccess_CHAIN application for the discovery demo)

This application is based on the SPC58EC microcontroller and can measure cell voltage, current and GPIO voltage for 2 AEK-POW-BMSWTX evaluation boards.

Find below the main code for the SPC58EC - AEK_POW_BMSWTX_DualAccess_CHAIN application for the discovery demo:

Figure 90. SPC58EC - AEK_POW_BMSWTX_DualAccess_CHAIN code

```

/*****
*
* Copyright © 2015-2021 STMicroelectronics - All Rights Reserved
*
* This software is licensed under SLA0098 terms that can be found in the
* DM00779817_1_0.pdf file in the licenses directory of this software product.
*
* THIS SOFTWARE IS DISTRIBUTED "AS IS," AND ALL WARRANTIES ARE DISCLAIMED,
* INCLUDING MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.
*
*****/

/* Inclusion of the main header files of all the imported components in the
order specified in the application wizard. The file is generated
automatically.*/
#include "AEK_POW_BMS63CHAIN_app_mng.h"

#define AEK_POW_BMS63CHAIN_TIMESTEP 200 //msec
#define AEK_POW_BMS63CHAIN_SERIAL_TIMESTEP 1000 //msec

void main_core0(void) {
  irqIsrEnable();
  AEK_POW_BMS63CHAIN_app_serialInit();
  for(;;){
    AEK_POW_BMS63CHAIN_app_serialStep(AEK_POW_BMS63CHAIN_SERIAL_TIMESTEP);
  }
}

int main(void) {
  componentsInit();
  irqIsrEnable();
  /* Application init */
  pal_lld_setpad(PORT_F, debug);
  AEK_POW_BMS63CHAIN_app_init();

  runCore0();
  /* Application main loop.*/
  for ( ; ; ) {
    AEK_POW_BMS63CHAIN_app_step(AEK_POW_BMS63CHAIN_TIMESTEP);
  }
}

```

This application is based on the SPC58EC microcontroller and can measure cell voltage, current and GPIO voltage for 2 AEK-POW-BMSWTX evaluation boards.

Find below the main code for the SPC58EC - AEK_POW_BMSWTX_DualAccess_CHAIN application for the discovery demo:

Figure 91. SPC58EC - AEK_POW_BMSWTX_DualAccess_CHAIN code

```

/*****
*
* Copyright © 2015-2021 STMicroelectronics - All Rights Reserved
*
* This software is licensed under SLA0098 terms that can be found in the
* DM00779817_1_0.pdf file in the licenses directory of this software product.
*
* THIS SOFTWARE IS DISTRIBUTED "AS IS," AND ALL WARRANTIES ARE DISCLAIMED,
* INCLUDING MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.
*
*****/

/* Inclusion of the main header files of all the imported components in the
order specified in the application wizard. The file is generated
automatically.*/
#include "AEK_POW_BMS63CHAIN_app_mng.h"

#define AEK_POW_BMS63CHAIN_TIMESTEP 200 //msec
#define AEK_POW_BMS63CHAIN_SERIAL_TIMESTEP 1000 //msec

void main_core0(void) {
  irqIsrEnable();
  AEK_POW_BMS63CHAIN_app_serialInit();
  for(;;){
    AEK_POW_BMS63CHAIN_app_serialStep(AEK_POW_BMS63CHAIN_SERIAL_TIMESTEP);
  }
}

int main(void) {
  componentsInit();
  irqIsrEnable();
  /* Application init */
  pal_llid_setpad(PORT_F, debug);
  AEK_POW_BMS63CHAIN_app_init();

  runCore0();
  /* Application main loop.*/
  for ( ; ; ) {
    AEK_POW_BMS63CHAIN_app_step(AEK_POW_BMS63CHAIN_TIMESTEP);
  }
}

```

10.5.3 Single centralized application (SPC58EC – AEK_POW_BMS63EN_SOC_Estimation_Single application for discovery demo)

This application is based on the SPC58EC microcontroller and can estimate the SOC of 14 cells in a single BMS node (in our case, the battery used are INR 18650 MJ1 by LG) connected with an AEK-POW-BMS63EN evaluation board.

The results of SOC estimation, cell voltage, NTC temperatures, and current are printed via serial port with a speed rate of 115200 bps.

Find below the main code for the SPC58EC – AEK_POW_BMS63EN_SOC_Estimation_Single application for discovery demo:

```

*
* Copyright © 2022 STMicroelectronics - All Rights Reserved
*
* License terms: STMicroelectronics Proprietary in accordance with licensing
* terms SLA0089 at www.st.com.
*
* THIS SOFTWARE IS DISTRIBUTED "AS IS," AND ALL WARRANTIES ARE DISCLAIMED,
* INCLUDING MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.
*
* EVALUATION ONLY "NOT FOR USE IN PRODUCTION"
*****/
/* Inclusion of the main header files of all the imported components in the
order specified in the application wizard. The file is generated
automatically.*/

```

```

#include "components.h"
#include "AEK_POW_BMS63EN_Appl.h"
#include "wkpu_lld_cfg.h"
#include "serial_lld_cfg.h"
#include <stdio.h>
#include <string.h>
volatile uint8_t i_device_disp=0;
void main_core0(void) {
    char message[11];
    AEK_POW_BMS63EN_module_t AEK_POW_BMS63EN_BatteryModule;
    uint8_t cell_idx = 0;
    /* Enable Interrupts */
    irqIsrEnable();
    sd_lld_start(&SD5,&serial_config_BMS_serial);
    /* Application main loop.*/
    for ( ; ; ) {
        if((osalThreadGetMilliseconds()%100)==0){
            AEK_POW_BMS63EN_BatteryModule = AEK_POW_BMS63EN_GetModule(i_device_disp);
            //SOC Elaboration Done
            sprintf(message, "DEV:%d      \n", (int)(i_device_disp+1));
            sd_lld_write(&SD5, (uint8_t *)message, (uint16_t)(sizeof(message)/sizeof(message[0]]));
            //Printing SOC
            for(cell_idx = AEK_POW_BMS63EN_CELL1; cell_idx <= AEK_POW_BMS63EN_CELL14; cell_idx++){
                sprintf(message, "S%.2d:%.3d      ", cell_idx+1, (int)((AEK_POW_BMS63EN_BatteryModule.AEK_POW_B
                MS63EN_Pack_SOC[cell_idx]) * 100));
                sd_lld_write(&SD5, (uint8_t *)message, (uint16_t)(sizeof(message)/sizeof(message[0]]));
            }
            sprintf(message, "      \n");
            sd_lld_write(&SD5, (uint8_t *)message, (uint16_t)(sizeof(message)/sizeof(message[0]]));
            //Printing Bal
            for(cell_idx = AEK_POW_BMS63EN_CELL1; cell_idx <= AEK_POW_BMS63EN_CELL14; cell_idx++){
                sprintf(message, "B%.2d:%.3d      ", cell_idx+1, AEK_POW_BMS63EN_BatteryModule.AEK_POW_BMS63EN_
                Pack_Bal_cmd[cell_idx]);
                sd_lld_write(&SD5, (uint8_t *)message, (uint16_t)(sizeof(message)/sizeof(message[0]]));
            }
            sprintf(message, "      \n");
            sd_lld_write(&SD5, (uint8_t *)message, (uint16_t)(sizeof(message)/sizeof(message[0]]));
            //Printing Voltage
            for(cell_idx = AEK_POW_BMS63EN_CELL1; cell_idx <= AEK_POW_BMS63EN_CELL14; cell_idx++){
                sprintf(message, "V%.2d:%.3f      ", cell_idx+1, AEK_POW_BMS63EN_BatteryModule.AEK_POW_BMS63EN_Pa
                ck_CellVoltage[cell_idx]);
                sd_lld_write(&SD5, (uint8_t *)message, (uint16_t)(sizeof(message)/sizeof(message[0]]));
            }
            sprintf(message, "      \n");
            sd_lld_write(&SD5, (uint8_t *)message, (uint16_t)(sizeof(message)/sizeof(message[0]]));
            //Printing Current
            sprintf(message, "C:%.4f      \n", AEK_POW_BMS63EN_BatteryModule.AEK_POW_BMS63EN_Pack_Current);
            sd_lld_write(&SD5, (uint8_t *)message, (uint16_t)(sizeof(message)/sizeof(message[0]]));
        }
    }
}
void *sbrk(size_t incr)
{
    extern uint8_t __heap_base__;
    extern uint8_t __heap_end__;
    static uint8_t *p=&__heap_base__;
    static uint8_t *newp;
    newp = p+ incr;
    if(newp> &__heap_end__)
    {
        return (void*)-1;
    }
    return p =newp;
}
int main(void) {
    componentsInit();
    irqIsrEnable();
    wkpu_lld_start(&WKPU1, &wkpu_config_wkpu_cfg);
    AEK_POW_BMS63EN_init();
    runCore0();
}

```

```
AEK_POW_BMS63EN_Start_Mgn_exec();
while (1) {
}
}
```

This application enables two cores:

- **Core2 (main core)**
 - Used to start the manager process (AEK_POW_BMS63EN_Mng_exec()) through a PIT (i.e., a 5 Hz programmable timer:)

```
void AEK_POW_BMS63EN_Mgn_exec(){
pal_lld_togglepad(PORT_F,LED3);
AEK_POW_BMS63EN_soc_elab_sts = AEK_POW_BMS63EN_SOC_ELABORATION_BUSY;
AEK_POW_BMS63EN_VA_Measurement();
AEK_POW_BMS63EN_TEMP_Measurement();
if(AEK_COM_ISOSPI_GetFault(ISOSPI_DEV0)){
AEK_POW_BMS63EN_DIAG_Measurement();
}
AEK_POW_BMS63EN_Model_exec();
AEK_POW_BMS63EN_Balancing();
AEK_POW_BMS63EN_soc_elab_sts = AEK_POW_BMS63EN_SOC_ELABORATION_DONE;
pal_lld_togglepad(PORT_F,LED3);
}
```

This process starts the manual conversion routine to measure the cell voltage, current, and GPIO NTC temperature.

Moreover, this process performs the SOC estimation by using the C-code generated through a Simulink model and enables the manual balancing during the Normal state of the FSM.

- **Core0 (auxiliary core)**
 - Used to start a process that can print via serial the following data (with a speed rate of 115200 bps):
 - State of charge percentage for each cell
 - Cell voltage values
 - Current value
 - Balancing status
 - This process is called every 100 ms.

11 Available APIs

Table 3. Chain management APIs

API name	Description
AEK_POWBMS63CHAIN_chain_init	Initializes the BMS chain
AEK_POWBMS63CHAIN_chain_wakeup	Init BMS chain wakeup
AEK_POW_BMS63CHAIN_chain_addressingProcedure	Init BMS chain addressing procedure
AEK_POW_BMS63CHAIN_chain_parSetting	Set BMS chain parameters
AEK_POW_BMS63CHAIN_chain_getDevNum	Get the Node number of the BMS chain
AEK_POW_BMS63CHAIN_chain_geNum	Ge the BMS chain number.

Table 4. CRC APIs

API name	Description
AEK_POW_BMS63CHAIN_crc_elab	Get the SPI frame with CRC.

Table 5. ISOSPI management APIs

API name	Description
AEK_POW_BMS63CHAIN_iso_init	Init ISOSPI for BMSCHAIN.
AEK_POW_BMS63CHAIN_iso_signalSetting	Init ISOSPI for BMSCHAIN.
AEK_POW_BMS63CHAIN_iso_setDis	Setting Disable Pin of ISOSPI.
AEK_POW_BMS63CHAIN_iso_setISOFreq	Setting ISOSPI Frequency.
AEK_POW_BMS63CHAIN_iso_setTXEn	Setting TXEn Pin of ISOFreq.
AEK_POW_BMS63CHAIN_iso_setTxAmp	Setting ISOSPI Trasmission Amplitude.

Table 6. Node management APIs

API name	Description
AEK_POW_BMS63CHAIN_node_getTwoComp	Get 2' Complement from spi data read.
AEK_POW_BMS63CHAIN_node_getInverseTwoComp	Get 2' Inverse Complement from spi data read.
AEK_POW_BMS63CHAIN_node_enableCell	Enable Cell of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_disableCell	Disable Cell of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getVoltageCell	Disable Cell of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getVoltagePackSum	Get Pack Sum Voltage value of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getVoltagePack	Get Pack Voltage value of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getVoltageTRef	Get Voltage Reference value of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getCalibCurrent	Get Calib Current value of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getInstCurrent	Get Inst Current value of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getChipTemperature	Get Chip Temperature value of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getOTChipTemperature	Get OverTemperature Chip flag of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getGPIOVoltage	Get GPIO Voltage value of Node of BMS Chain.

API name	Description
AEK_POW_BMS63CHAIN_node_setGPIOUTT	Set GPIO UnderTemperature Threshold of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setGPIOOTT	Set GPIO OverTemperature Threshold of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setGPORatioAbsMode	Set GPIO Measurement Mode of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setGPIOConf	Set GPIO Configuration of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setGPIOMsk	Set GPIO Fault Mask of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setOVCSleepMsk	Set OverCurrent Fault Mask Sleep status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setOVCSNormMsk	Set OverCurrent Fault Mask Normal status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setGPIO7WUEn	Enable Wakeup from GPIO7 of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setGPIO7WUDis	Disable Wakeup from GPIO7 of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setVCellOVT	Set Cell OverVoltage Cell Threshold of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setVCellUVT	Set Cell UnderVoltage Cell Threshold of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setVBattSumOVT	Set Battery Sum OverVoltage Cell Threshold of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setVBattSumUVT	Set Battery Sum UnderVoltage Cell Threshold of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setCSAThNorm	Set CSA Threshold Normal status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setCSAThSleep	Set CSA Threshold Sleep status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getVoltageConvRoutineSts	Get FSM of Voltage Conversion routine status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setSOC	Set Request SOC routine (on-demand Conversion) of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setCyclicConf	Set Request Cyclic Conversion routine of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setCyclicMode	Set Cyclic Mode of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_onDemandVoltageConversionRequest	Request OnDemand Conversion Routine of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_cyclicMeasurementConversionRequest	Request Cyclic Conversion Routine of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_cyclicDiagnosticConversionRequest	Request Cyclic Diagnostic Conversion Routine of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setGPIOConv	Set GPIO Conv flag of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setGPOTermConv	Set GPIO Term Conv flag of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setCellTermConv	Set Cell Term Conv flag of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setBalTermConv	Set Balancing Term Conv flag of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setHWSCConv	Set Hardware Self Check Conv flag of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setCoulombCounter	Set Coulomb Counter flag of Node of BMS Chain.

API name	Description
AEK_POW_BMS63CHAIN_node_setCommTimeout	Set Communication Timeout flag of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setCyclicUpdate	Set Cyclic Update flag of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setNcycleGPIOTerm	Set NCycle GPIO Term of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setNcycleCellTerm	Set NCycle Cell Term of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setNcycleBalTerm	Set NCycle Balancing Term of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setNcycleGPIO	Set NCycle GPIO of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setNcycleHWSC	Set NCycle Hardware Self Check of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setADCFilterCycle	Set ADC Filter Cycle of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setADCFilterSleep	Set ADC Filter Sleep of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setADCFilterSOC	Set ADC Filter SOC of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setTCycle	Set TCycle of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setTCycleSleep	Set TCycle Sleep of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setVTrefEnable	Set VTref Enable/Disable of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setVTrefAlwaysON	Set VTref Always ON Enable/Disable of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getFSMsts	Get Voltage Conversion Routine status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setSilentBalancingMode	Set Silent Balancing of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setSWReset	Request Software Reset of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_go2Sleep	Request Go To Sleep transition of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setISOTXH	Set ISOTX High of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_wakeup	Request Wakeup of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setISOFreqSel	Set ISOFreqSel of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setOutResTx	Set OUTResTX of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setChipID	Set CHIPID of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getChipID	Get CHIPID of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setFarthestUnit	Set FarthestUnit of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_lockISOHISOFreq	Set LockISOFreq of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_unlockISOHISOFreq	UnLock ISOFreq of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getSPIError	Get SPI Communication Error of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getFrameSPIError	Get Frame Error of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getLossAGnd	Get AGndLoss Error of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getLossDGnd	Get DGndLoss Error of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getLossCGnd	Get CGndLoss Error of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getLossGndRef	Get Ref Gnd Loss Error of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getTrimmCalOK	Get TrimCalOK of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getClockMonInitDone	Get Clock Monitor Init Done of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getOSCFail	Get Oscillator Error of Node of BMS Chain.

API name	Description
AEK_POW_BMS63CHAIN_node_getSenseMinusOpen	Get Sense Minus Open Error of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getSensePlusOpen	Get Sense Plus Open Error of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getCurrSenseOVcNorm	Get OverCurrent Sense Normal status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getCurrSenseOvcSleep	Get OverCurrent Sense Normal status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getFaultLineLSts	Get Fault L status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getFaultHLineFault	Get Fault H status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getCommTimeoutFlt	Get Communication Timeout Filter of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getEOFBal	Get End Of Balancing status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getBalON	Get Balancing ON status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getTimedBalAcc	Get Timed Balancing Acc status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getEoBTimeError	Get End Of Balancing Time error status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getHeartBeatEn	Get HeartBeat Enable status of Node of BMS Chain
AEK_POW_BMS63CHAIN_node_getHeartBeatFault	Get HeartBeat Fault status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getCoulombCounterEn	Get Coulomb Counter Enable status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getCoCouOvf	Get Coulomb Counter Overflow status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getOverLatch	Get Overlatch status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getDutyON	Get duty ON of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getConfCyclicEN	Get Cyclic EN status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getTCyclicOVF	Get Tcyclic Overflow status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getEEPROMDownloadDone	Get EEPROM Download Done status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getEEPROMCRCErrCalRam	Get EEPROM CRC Cal RAM status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getEEPROMCRCErrSect0	Get EEPROM CRC Error Sect0 status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getRAMCRCErr	Get RAM CRC Error status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getWUgpio7	Get Wakeup from GPIO7 status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getWUspi	Get Wakeup from SPI status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getWUISOLine	Get Wakeup from ISOLINE status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getWUFaultH	Get Wakeup from FaultH status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getWUCyc	Get Wakeup from Cyclic Mode status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getVoltageCellIOV	Get OverVoltage Cell status of Node of BMS Chain.

API name	Description
AEK_POW_BMS63CHAIN_node_getVoltageCellUV	Get UnderVoltage Cell status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getCellOpen	Get Open Cell status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getBalOpen	Get Balancing Open Cell status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getVoltagePackWarningUV	Get UnderVoltage Pack Warning status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getVoltagePackCritUV	Get UnderVoltage Pack Critical status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getVoltagePackCritOV	Get OverflowVoltage Pack Critical status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getVoltagePackSumUV	Get UnderVoltage Pack Sum status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getVoltagePackSumOV	Get OverVoltage Pack Sum status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getVoltageBalUV	Get UnderVoltage Balancing status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getVoltageBattCompBistFail	Get Voltage Battery Comp Bist Fail status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getMuxBistFail	Get Mux Bist Fail status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getOpenBistFail	Get Open Bist Fail status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getGPIOBistFail	Get GPIO Bist Fail status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getVTrefBistFail	Get VTref Bist Fail status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getVBattDivBistFail	Get VBattDiv Bist Fail status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getFastMeas	Get FastMeasure struct of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getFastDiag	Get FastDiag struct of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setBalMode	Set Balancing Mode of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setStartBal	Set Balancing Start of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setStopBal	Set Balancing Stop of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_enableBalCell	Enable Balancing Cell of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_disableBalCell	Disable Balancing Cell of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_getBalSts	Get Balancing Status of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setThrTimedBalCell	Set Threshold Timed Balancing Cell of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setSleepBalConf	Set Sleep Balancing Configuration of Node of BMS Chain.
AEK_POW_BMS63CHAIN_node_setTimedBalRes	Set Timed Balancing Res of Node of BMS Chain.

Table 7. NTC management APIs

API name	Description
AEK_POW_BMS63CHAIN_ntc_init	NTC init for BMS Chain.
AEK_POW_BMS63CHAIN_ntc_deinit	NTC deinit for BMS Chain.
AEK_POW_BMS63CHAIN_ntc_getNTC1VoltageMeas	Get NTC1 voltage measure for BMS Chain.
AEK_POW_BMS63CHAIN_ntc_getNTC2VoltageMeas	Get NTC2 voltage measure for BMS Chain.
AEK_POW_BMS63CHAIN_ntc_getNTC3VoltageMeas	Get NTC3 voltage measure for BMS Chain.

API name	Description
AEK_POW_BMS63CHAIN_ntc_getNTCbVoltageMeas	Get NTCb voltage measure for BMS Chain.
AEK_POW_BMS63CHAIN_ntc_getNTC1Meas	Get NTC1 resistor measure for BMS Chain.
AEK_POW_BMS63CHAIN_ntc_getNTC2Meas	Get NTC2 resistor measure for BMS Chain.
AEK_POW_BMS63CHAIN_ntc_getNTC3Meas	Get NTC3 resistor measure for BMS Chain.
AEK_POW_BMS63CHAIN_ntc_getNTCbMeas	Get NTCb resistor measure for BMS Chain.

Table 8. SPI handling APIs

API name	Description
AEK_POW_BMS63CHAIN_spi_init	SPI protocol Init for BMS Chain.
AEK_POW_BMS63CHAIN_spi_delnit	SPI protocol Deinit for BMS Chain.
AEK_POW_BMS63CHAIN_spi_readReg	Get register value for BMS Chain.
AEK_POW_BMS63CHAIN_spi_readRegBurst	Send SPI burst command for BMS Chain.
AEK_POW_BMS63CHAIN_spi_writeReg	Send SPI write command for BMS Chain.

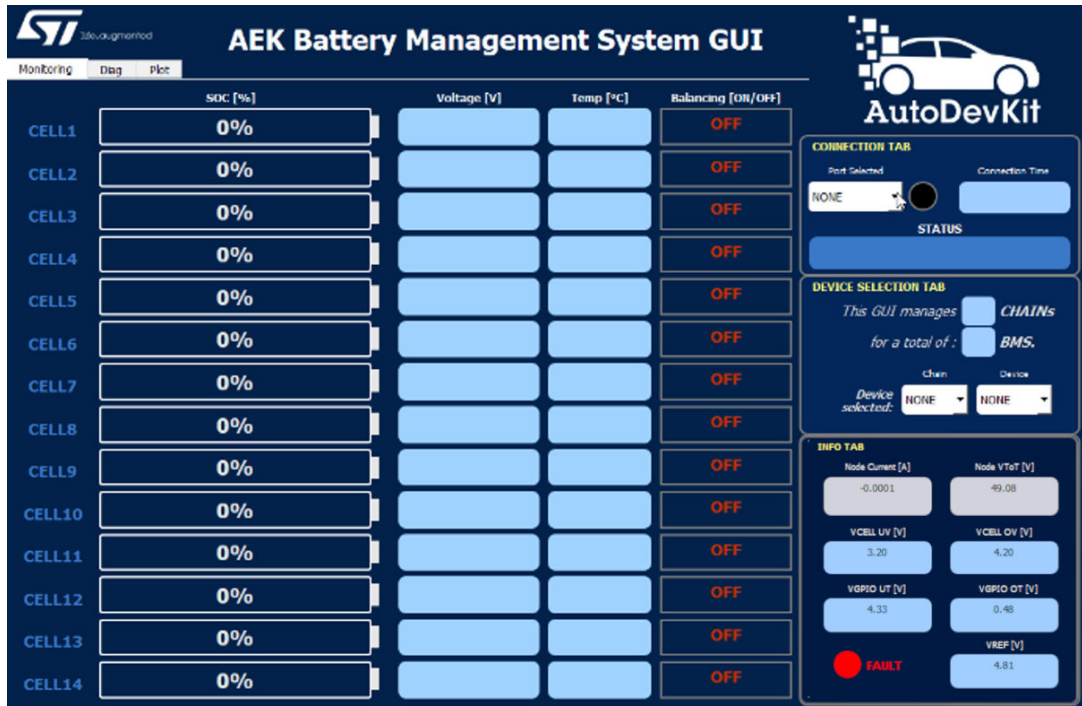
For further details on the APIs, refer to the doxygen documentation under the doc folder (see [AEK-POW-BMSCHAIN component folder structure](#)).

12 BMS GUI

The AutoDevKit Battery Management System GUI for our portfolio of BMS evaluation boards is simple and very user-friendly. It shows the state of charge, voltage, current, temperature, balancing status and faults of a selected chain and node.

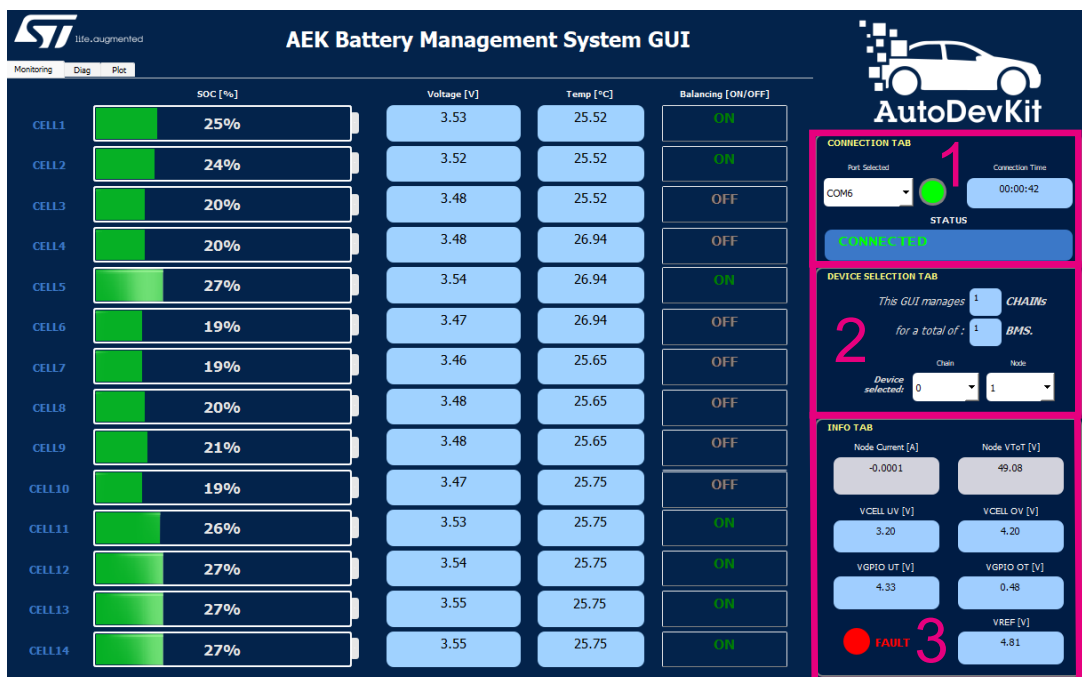
The GUI also plots total current and voltage over time.

Figure 92. BMS GUI main page



Various examples are importable from AutoDevKitStudio, depending on the selected BMS board.

Figure 93. BMS GUI tabs



The main page features three main sections, as shown in Figure 93:

1. Connection tab, which shows connection data:
 - Port Selected: to select the USB port
 - Connection Time: to show the connection time elapsed
 - STATUS: to show the GUI connection status
2. Device selection tab, to select which device of which chain you want to monitor data of
3. Info tab, which shows:
 - Node Current: indicates current drained by the load
 - Node VToT: shows cell total voltage
 - VcellUV/OV: shows under/over voltage thresholds
 - VGPIOUT/OT: shows under/over temperature thresholds
 - VREF: shows reference voltage
 - FAULT: this LED lights on to signal a fault. The Diag tab shows all faults and warnings occurred.

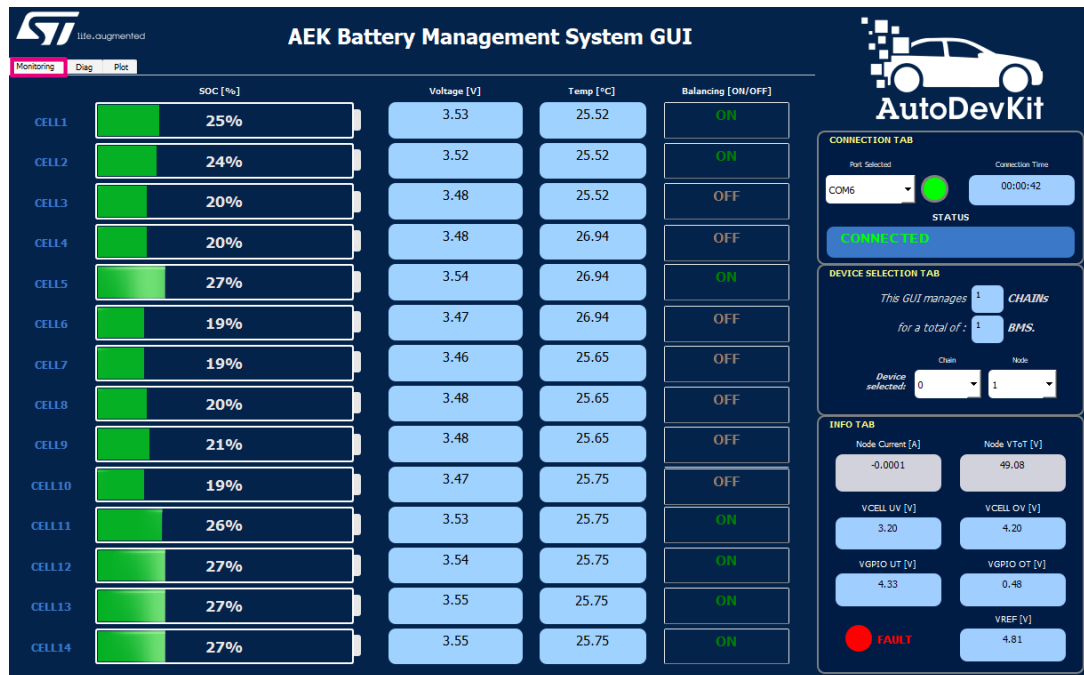
Note: VcellUV/OV, VGPIOUT/OT, VREF fields refer to the chain first node.

The GUI also features Monitoring, Diag, and Plot tabs.

Monitoring tab shows:

- SoC: every cell state of charge
- Voltage: cell instant voltage
- Temp: temperature measured by the NTC connected to a specific cell
- Balancing ON/OFF: cell passive balancing status (ON when passive balancing is running, OFF otherwise)

Figure 94. BMS GUI Monitoring tab



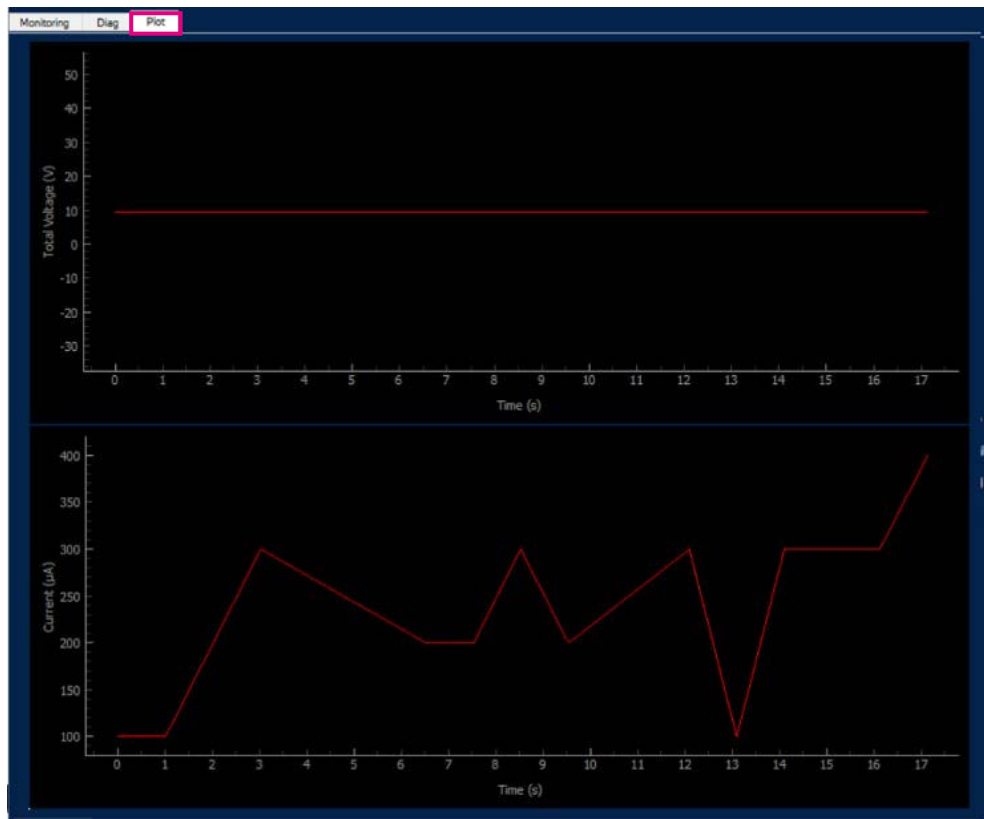
Diag tab shows a diagnostic LED matrix. Each LED lights up when a fault occurs (in red), a specific working stage (flashing, last wakeup typology balancing, etc.) has been completed or to signal a warning status (in orange).

Figure 95. BMS GUI Diag tab



Plot tab shows the graph of the total cell voltage and the total current of the selected node.

Figure 96. BMS GUI Plot tab



12.1 System setup

To make the GUI properly work, you need:

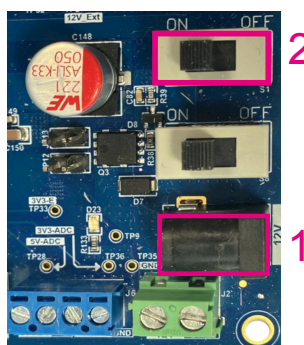
- 1 to 31 battery holders (e.g. AEK-POW-BMSHOLD)
- 1 to 31 BMS boards
- 14 x batteries per BMS node 18x65mm (LG INR 18650-MJ1 3500mAh -10A)
- 1 x MCU board (for example, AEK-MCU-C4MINI1)
- 1 x 12 V power supply with a coaxial cable
- 1 x USB/mini-USB cable
- AEK-POW-BMSCHAIN_GUI.exe, located under your BMS project source folder in AutoDevKit

12.1.1 Hardware setup and firmware flashing

After importing a specific project as defined in [Section 10.3: How to import the AEK-POW-BMSCHAIN component in AutoDevKit](#), follow the step-by-step procedure below for HW setup and firmware flashing before using the BMS GUI.

- Step 1.** Connect the 12 V cable to the AEK-MCU-C4MINI1 and switch it on.

Figure 97. Supplying the AEK-MCU-C4MINI1 (1) and switching it on (2)

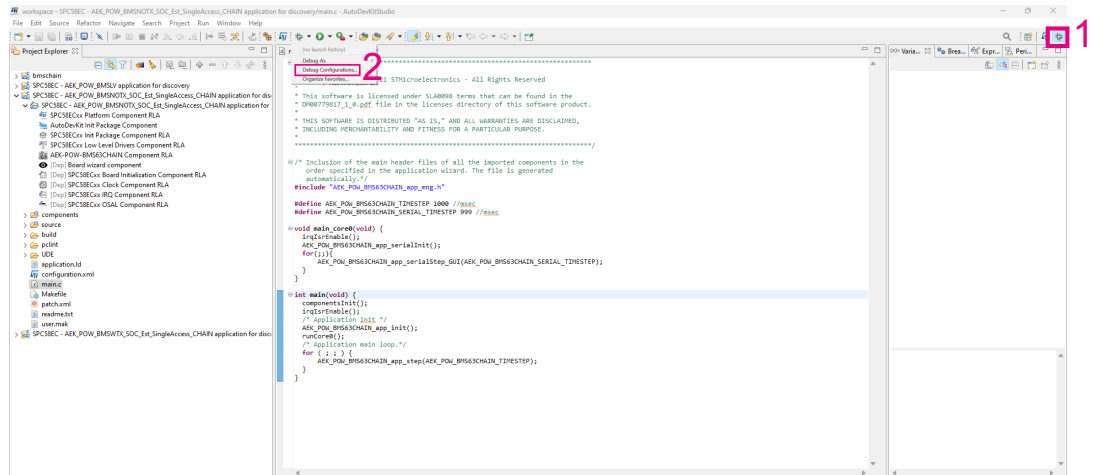


- Step 2.** Connect the USB/mini-USB cable between the AEK-MCU-C4MINI1 and your PC/laptop.

Step 3. Flash the out.elf file generated using OpenOCD programmer already present in AutoDevKit as described here below.

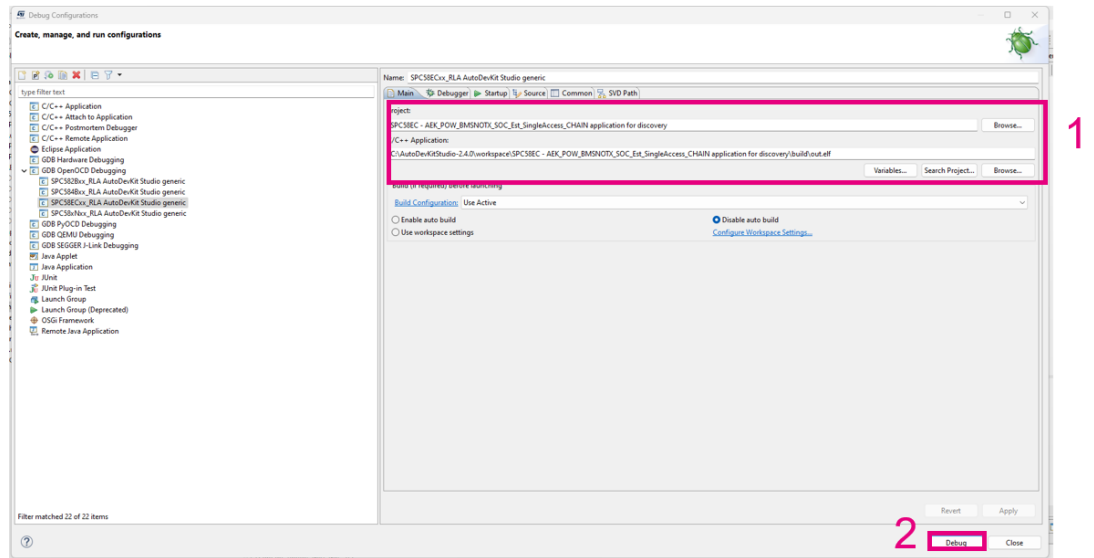
Step 3a. Switch to “Debug” by clicking on the green beetle icon and then select “Debug Configurations”.

Figure 98. Switching to debug (1) and selecting Debug Configurations (2)



Step 3b. Browse to your workspace and insert the path of the elf file in the project field. Click on Debug.

Figure 99. Inserting the path of your elf file (1) and debugging (2)



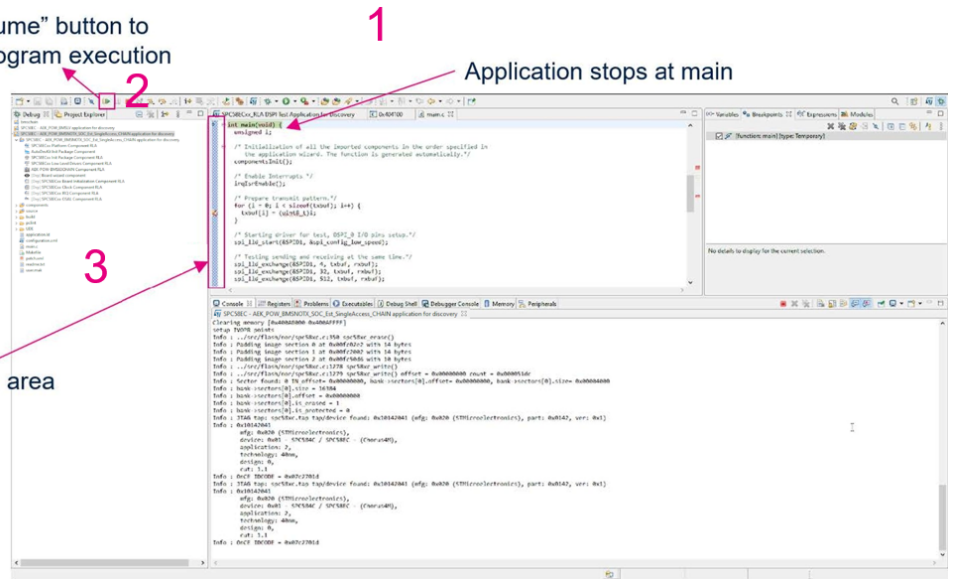
Step 3c. The console opens and shows your application generic code execution. The code execution stops at the main file. To continue executing the code, press resume. You can manually insert a breakpoint to stop code execution.

Figure 100. Code execution

Press "Resume" button to continue program execution

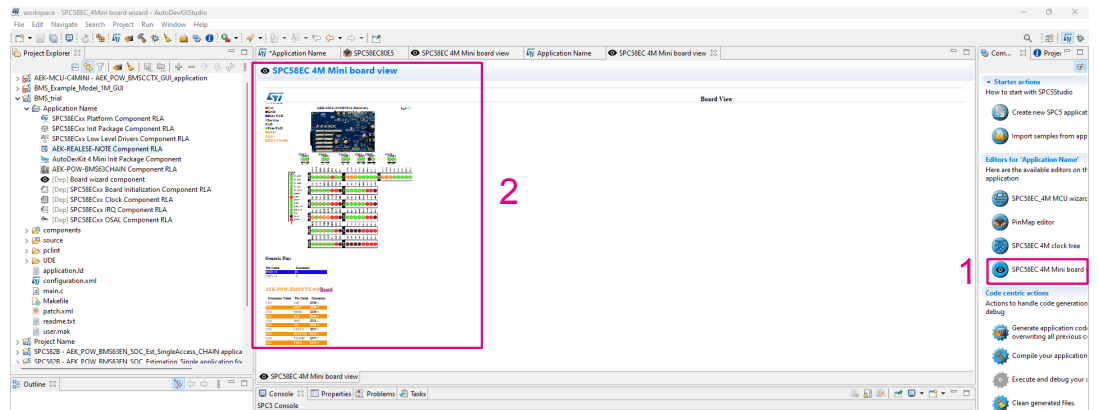
Application stops at main

Breakpoints area



- Step 4.** Switch off the MCU board.
- Step 5.** Mount the BMS on the battery holder (do not connect the battery pack connector in this phase).
- Step 6.** Click on the AEK-MCU-C4MINI1 board view. All pins will be automatically allocated.

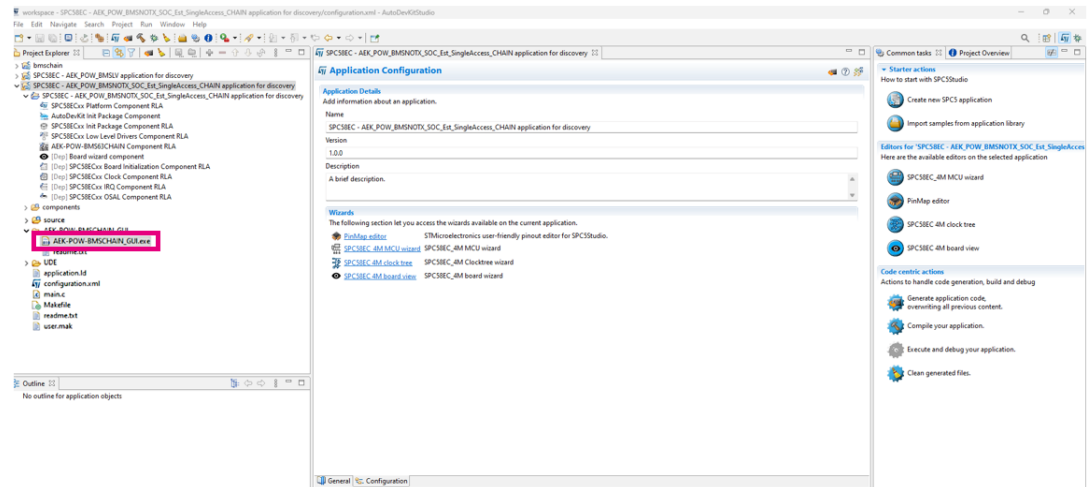
Figure 101. AutoDevKit board view



- Step 7.** Insert charged batteries into the battery holder slots (pay attention to battery poles).
- Step 8.** Connect the battery holder connector to the BMS female connector (BMS LED turns on).
- Step 9.** Switch the AEK-MCU-C4MINI1 on.

Step 10. Copy the **.exe** file from project folder onto your Desktop. Then, launch the GUI.

Figure 102. Launching the GUI

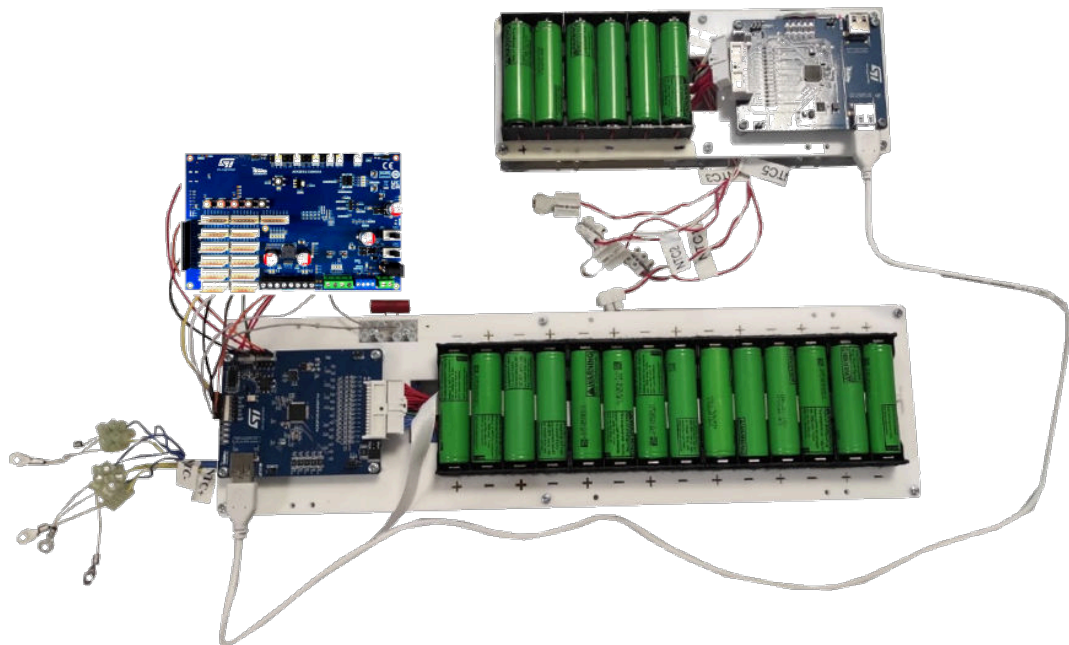


12.1.1.1 Using the GUI: an example

This example consists of monitoring two nodes in single access mode using the GUI. It is based on an AEK-POW-BMSCHAIN component project, using:

- A 14-cell battery holder mock-up, connected with the AEK-POW-BMSWTX
- A 6-cell battery holder mock-up, connected with the AEK-POW-BMS63EN
- An AEK-MCU-C4MINI1 MCU evaluation board

Figure 103. Hardware setup



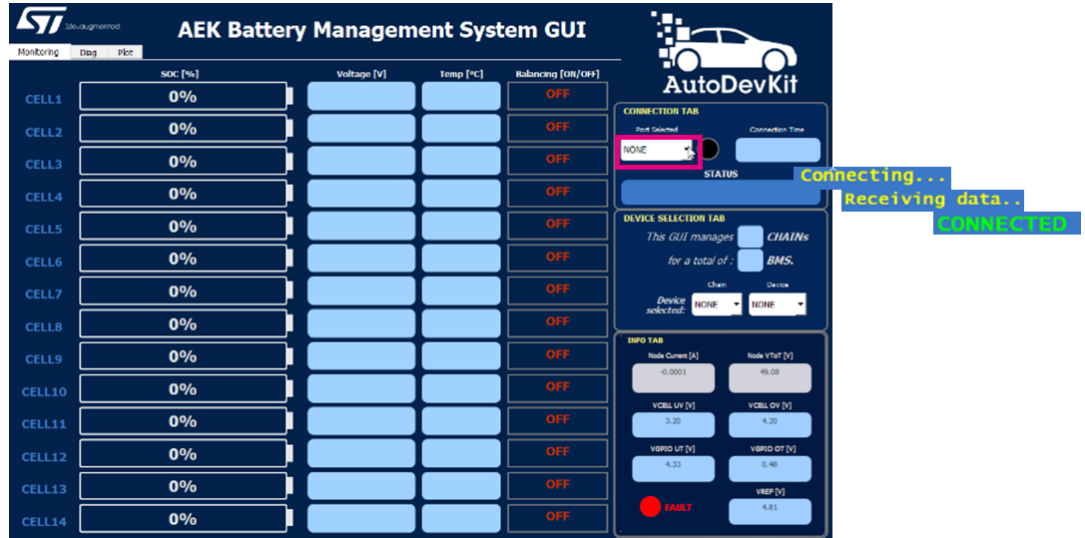
Step 1. Wire the BMS board to the AEK-MCU-C4MINI1 board according to the table below.

Figure 104. Wiring connections among the AEK-POW-BMSWTX and the AEK-MCU-C4MINI1

Connector Name	Pin Name	Connector
CN1	CS0	CN9-1
CN1	MISO	CN9-4
CN1	MOSI	CN9-5
CN1	SCK	CN9-3
CN2	BNE	CN1-1
CN2	DIS	CN1-2
CN2	FAULT	CN7-1
CN2	ISOFREQ	CN1-3
CN2	TXAMP	CN7-2
CN2	TXEN	CN7-3

- Step 2.** Click on the drop-down menu and select the COM port the AEK-MCU-C4MINI1 is connected with. When the serial data-stream is acknowledged the connection status change until connection is successful.

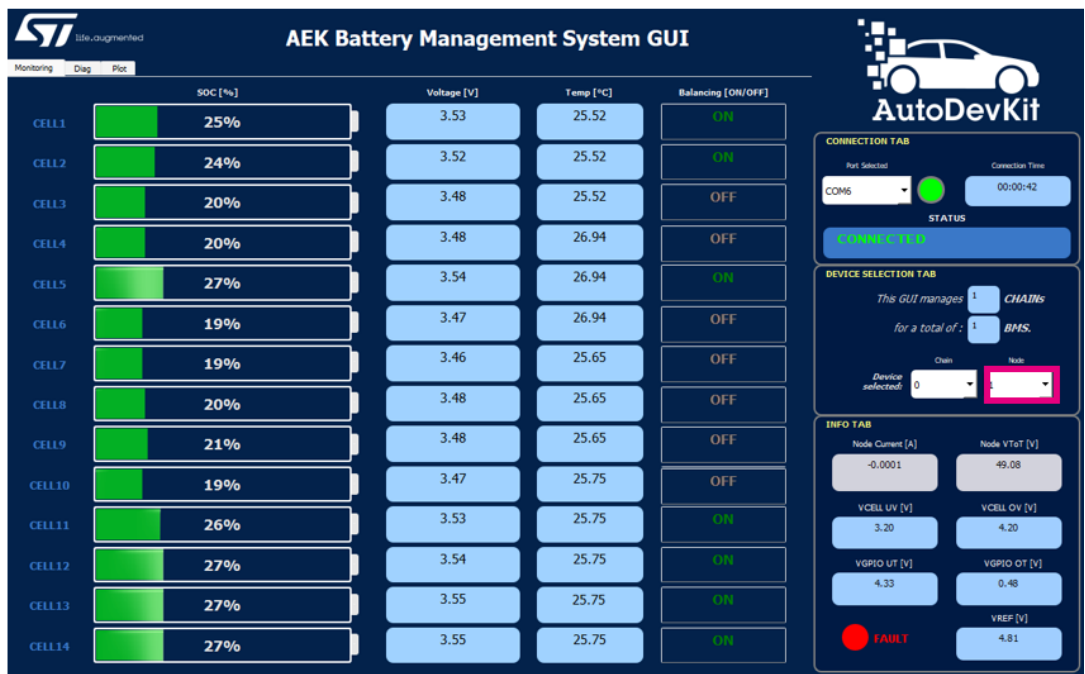
Figure 105. BMS GUI connection



Once CONNECTED, you can surf various windows and visualize data related to the selected node.

Note: The GUI automatically connects to node 1. You can display data related to node 2 by selecting it from the related drop-down menu.

Figure 106. BMS GUI node selection



Step 3. Click on the monitoring tab to visualize the cell state of charge (max 4.6 V min. 3.2 V for the cell type we used).

The monitoring tab also shows temperature and balancing status.

In our example, we tested the GUI using NTCALUG02A103F as NTC resistors. If you use another NTC typology, Temp field might show INVALID values. So, you might need another compatible version to visualize correct temperatures.

Figure 107. 14-cell battery holder mock-up

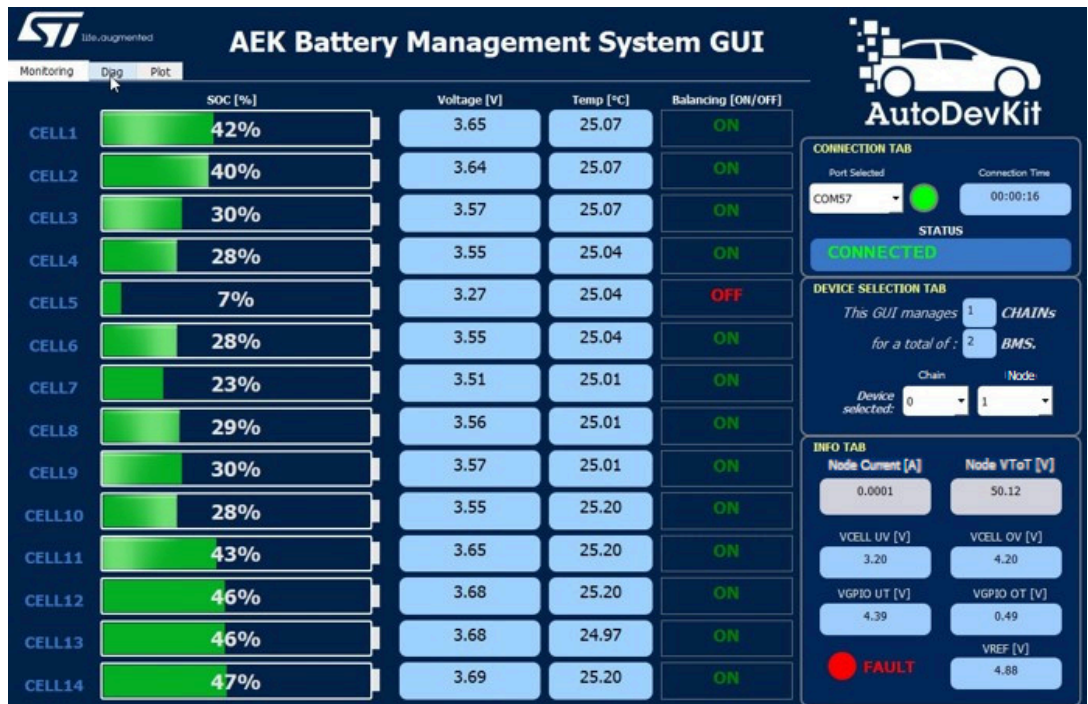
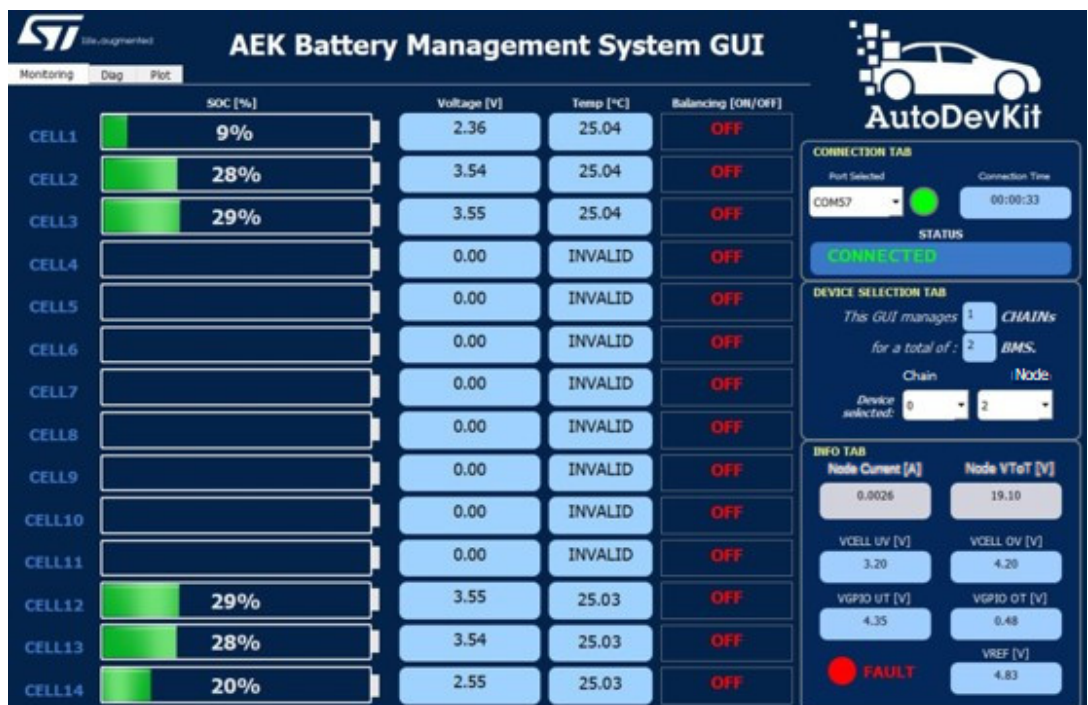


Figure 108. 6-cell battery holder mock-up



Step 4. Click on the Diag tab to visualize faults related to the two nodes, selecting one node per time.

Figure 109. 14-cell battery holder mock-up



Figure 110. 6-cell battery holder mock-up



Step 5. Click on the Plot tab to visualize voltage and current for the two nodes, selecting one node per time.

Figure 111. 14-cell battery holder mock-up

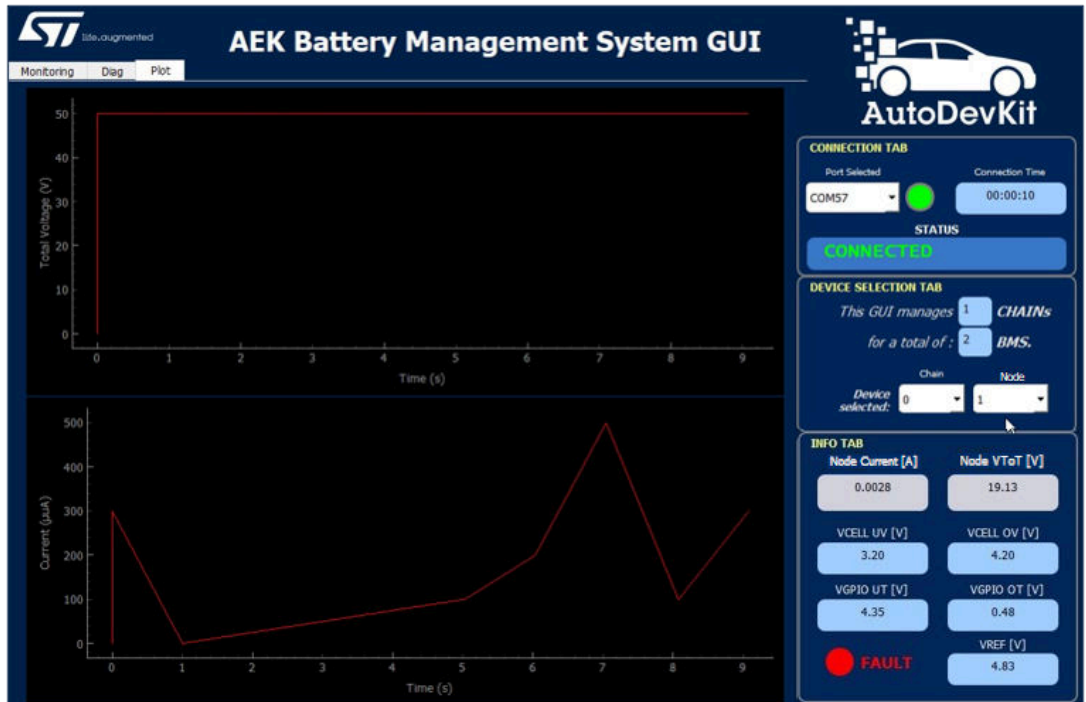
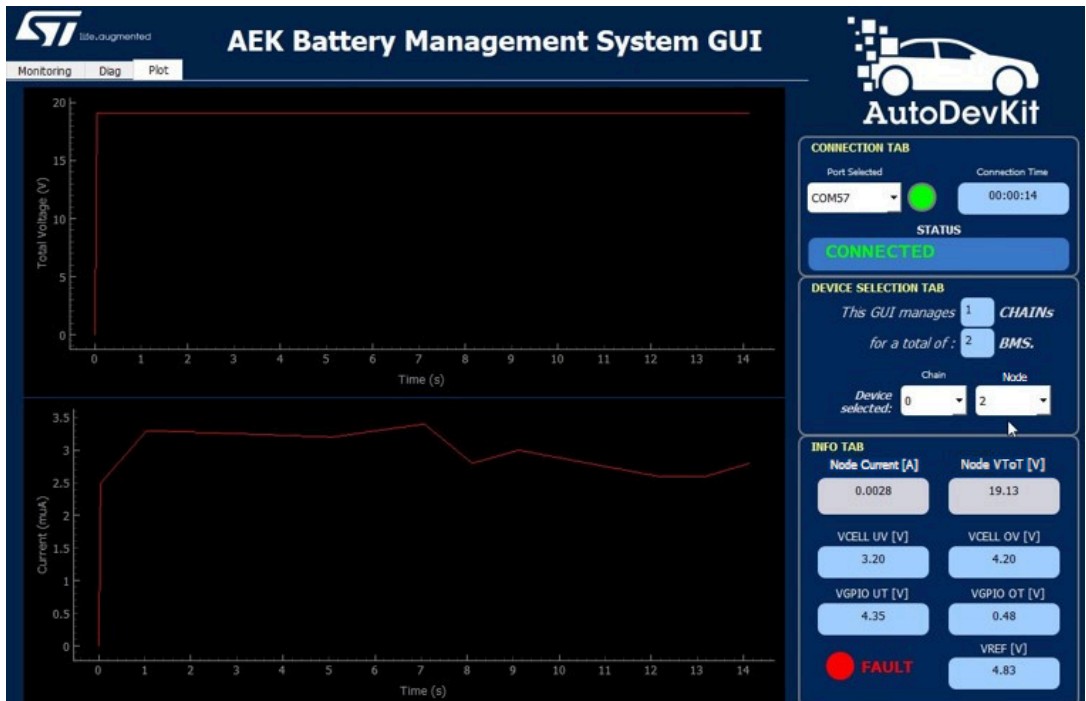


Figure 112. 6-cell battery holder mock-up

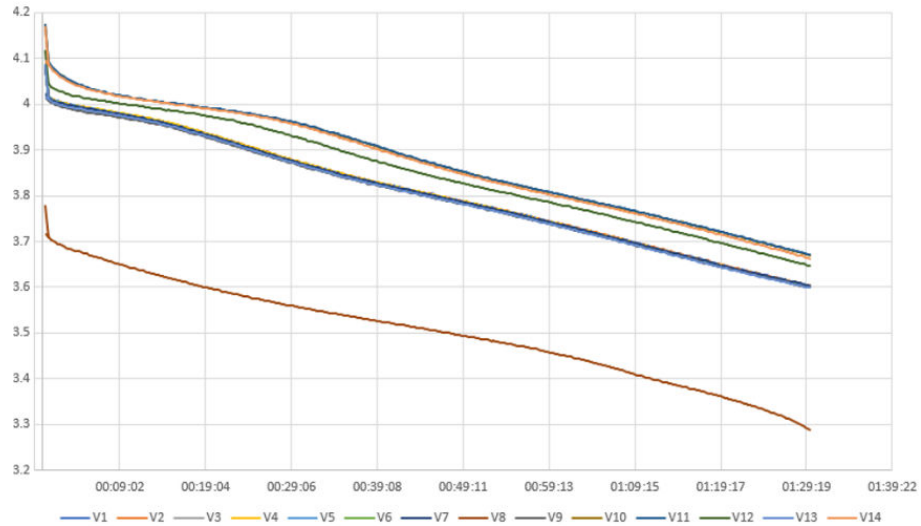


13 Waveforms

The following waveform shows the time trend of the voltages of the 14 cells connected to an AEK-POW-BMS63EN in a single centralized configuration, with an active load of 1 A and balancing activated by the cell 8 voltage value.

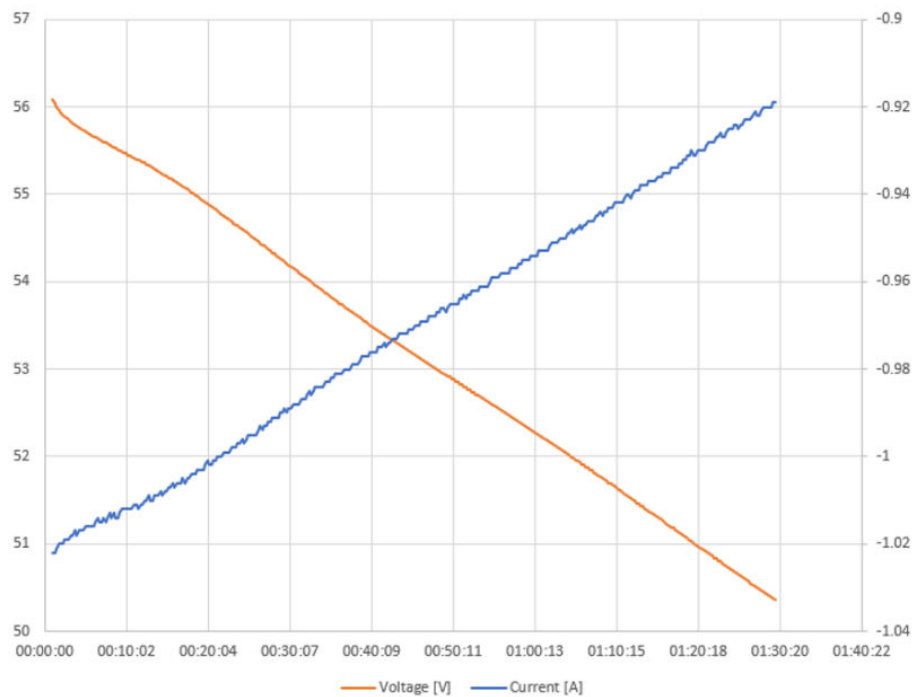
The x axis shows the time (in hours). The y axis shows the 14 cell voltages in Volts.

Figure 113. 14-cell voltage discharge with an active load of 1 A



The following waveform shows the time trend of the battery pack voltage (defined by 14 cells connected to an AEK-POW-BMS63EN in a single centralized configuration) with an active load of 1 A. The x axis shows the time (in hours). The y axis shows the battery pack voltage in Volts and the load current.

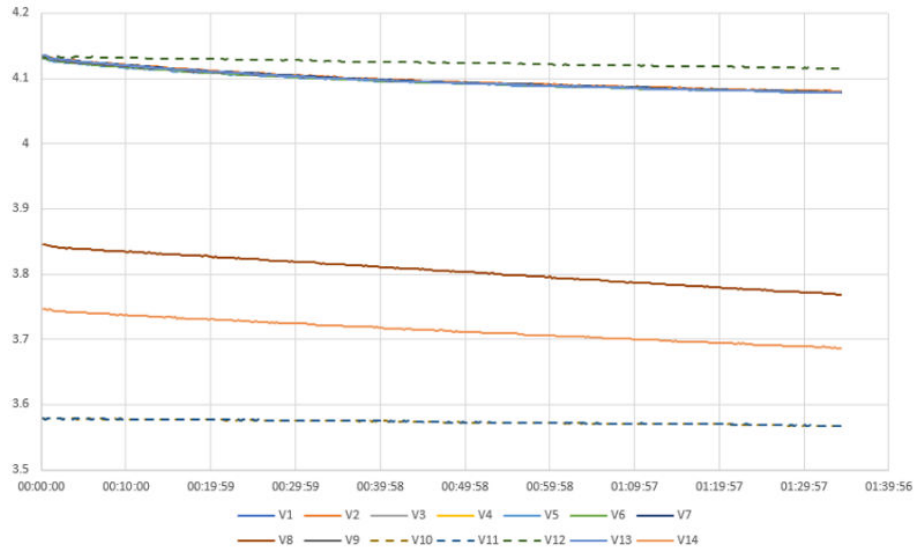
Figure 114. Battery pack voltage discharge with an active load of 1 A



The following waveform shows the time trend of the voltages of the 14 cells connected to an AEK-POW-BMS63EN in a single centralized configuration, when balancing is active.

The x axis shows the time (in hours). The y axis shows the voltages of the 14 cells in Volts.

Figure 115. 14 cell voltages during balancing



13.1 Process timing

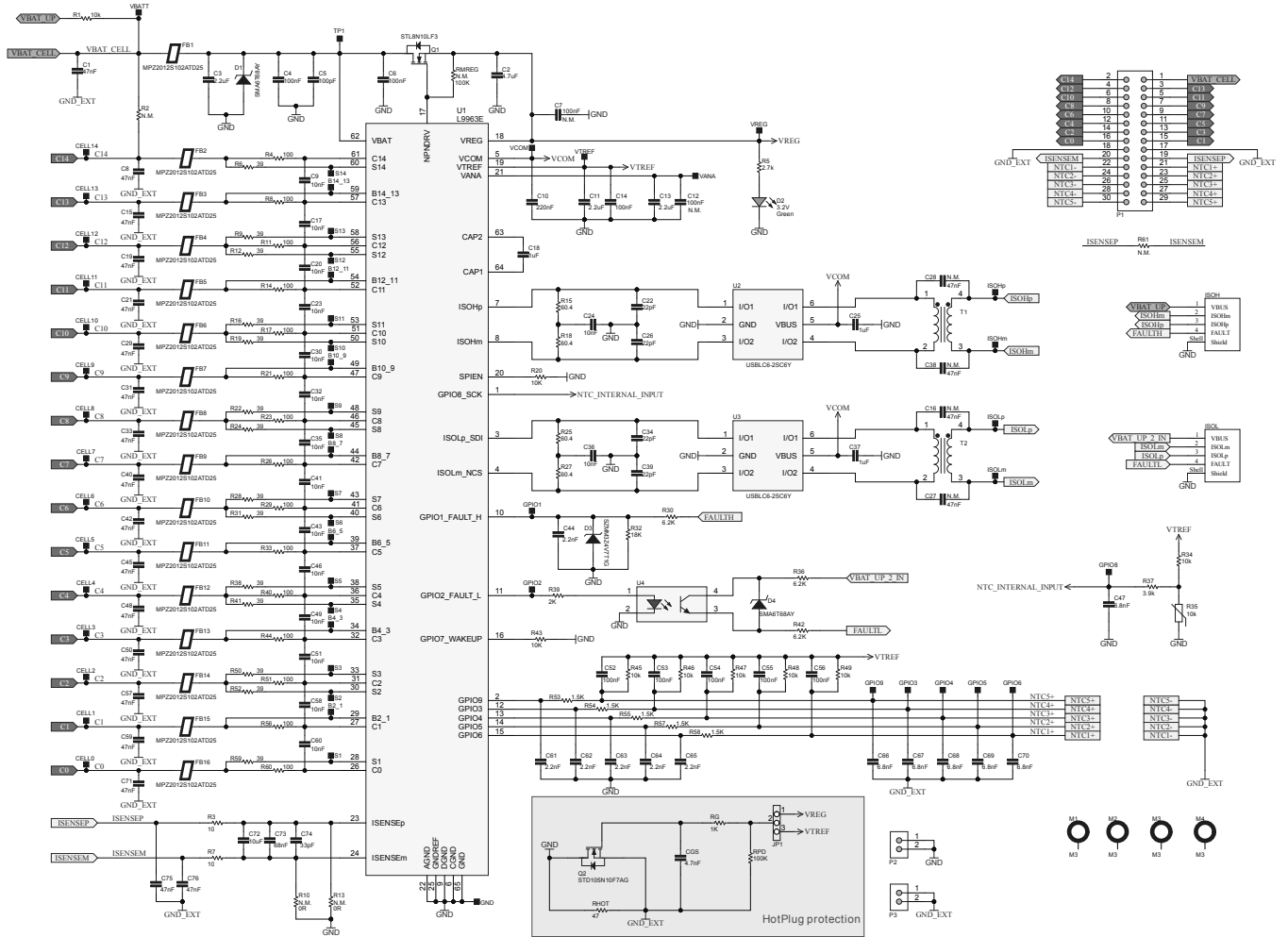
The following table defines the time length of the tasks defined in the SPC58EC - AEK_POW_BMSWTX_SOC_Est_SingleAccess_CHAIN application for discovery demo.

Table 9. Task process timing

Task	Timing
Voltage and current estimation	7 ms in cyclic conversion routine
SOC estimation	15.87 ms

14 AEK-POW-BMS63EN schematic diagrams

Figure 116. AEK-POW-BMS63EN schematic diagram



15 AEK-POW-BMS63EN bill of materials

Table 10. AEK-POW-BMS63EN 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 - 50V - X7R Class II	WE	885012206093
2	1	C2	4.7uF	1206 - 50V - 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.M.	N.M.
7	16	C9, C17, C20, C23, C24, C30, C32, C35, C36, C41, C43, C46, C49, C51, C58, C60	10nF	0603 - 50V - X7R Class II	WE	885012206089
8	1	C10	220nF	0603 - 50V - X7R Class II	WE	885012206125
9	2	C11, C13	2.2uF	0805 - 25V - X7R Class II	WE	885012207079
10	4	C16, C27, C28, C38	N.M.	1206	N.M.	N.M.
11	3	C18, C25, C37	1uF	0805 - 50V - X7R Class II	WE	885012207103
12	4	C22, C26, C34, C39	22pF	0603 - 50V - NP0 Class I	WE	885012006053
13	6	C44, C61, C62, C63, C64, C65	2.2nF	0603 - 50V - X7R Class II	WE	885012206085
14	6	C47, C66, C67, C68, C69, C70	6.8nF	0603 - 50V - X7R Class II	WE	885012206088
15	5	C52, C53, C54, C55, C56	100nF	0603 - 50V - X7R Class II	WE	885012206095
16	1	C72	10uF	1210 - 50V - X7R Class II	WE	885012209073
17	1	C73	68nF	0603 - 50V - X7R Class II	WE	885012206094
18	1	C74	33pF	0603 - 50V - NP0 Class I	WE	885012006054
19	1	CGS	4.7nF	0603 - 50V - X7R Class II	WE	885012206087
20	2	D1, D4	SMA6T68AY	Automotive 600 W, 68V TVS in SMA	STMicroelectronics	SMA6T68AY
21	1	D2	Green	0805 - Led Green - 3.2V	WE	150080GS75000
22	1	D3	SZMM3Z4V7T1G	4.7V Zener Voltage Regulators, 300mW	Onsemi	SZMM3Z4V7T1G

Item	Q.ty	Ref.	Part / Value	Description	Manufacturer	Order code
23	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 0.15Ohm DCR 0805	TDK	MPZ2012S102ATD25
24	2	ISOH, ISOL	61400416021	USB 2.0 Type A, Receptacle, Horizontal, THT	WE	61400416021
25	1	JP1		THT Vertical 3 pins Header, Pitch 2.54 mm, Single Row	WE	61300311121
26	1	P1		2.00mm - WR-WTB - Male Dual Row Horizontal Shrouded Header w. positive locking	WE	62403021722
27	2	P2, P3	61300211121	2.54mm - WR-PHD Pin Header, THT, pitch 2.54mm, Single Row, Vertical, 2p	WE	61300211121
28	1	Q1	STL8N10LF3, PowerFLAT 5x6 WF	Automotive-grade N-channel 100 V, 25 mΩ typ., 7.8 A STripFET™ F3 Power MOSFET in a PowerFLAT™ 5x6 package	STMicroelectronics	STL8N10LF3
29	1	Q2	STD105N10F7AG, DPAK	Automotive-grade N-channel 100 V, 6.8 mΩ typ., 80 A, STripFET™ F7 Power MOSFET in a DPAK package	STMicroelectronics	STD105N10F7AG
30	1	R1	10k	1206 - ±1% - 0.66W	Panasonic	ERJUP8F1002V
31	1	R2	N.M.	0805	N.M.	N.M.
32	2	R3, R7	10	0603 - ±1% - 0.25W	Panasonic	ERJPA3F10R0V
33	15	R4, R8, R11, R14, R17, R21, R23, R26, R29, R33, R40, R44, R51, R56, R60	100	0603 - ±1% - 0.25W	Panasonic	ERJPA3F1000V
34	1	R5	2.7k	0603 - ±1% - 0.125W	Vishay	MCT06030C2701FP500
35	14	R6, R9, R12, R16, R19, R22, R24, R28, R31, R38, R41, R50, R52, R59	39	2010 - ±1% - 1.25W	TE Connectivity	CRGP2010F39R
36	3	R10, R13, RMREG	N.M.	0603	N.M.	N.M.
37	4	R15, R18, R25, R27	60.4	0603 - ±1% - 0.1W	Panasonic	ERJ3EKF60R4V
38	2	R20, R43	10K	0603 - ±1% - 0.2W	Panasonic	ERJP03F1002V
39	3	R30, R36, R42	6.2K	0805 - ±1% - 0.5W	Panasonic	ERJP06F6201V
40	1	R32	18K	0603 - ±1% - 0.2W	Panasonic	ERJP03F1802V

Item	Q.ty	Ref.	Part / Value	Description	Manufacturer	Order code
41	6	R34, R45, R46, R47, R48, R49	10k	0805 - $\pm 1\%$ - 0.5W	Panasonic	ERJP6WF1002V
42	1	R35	10k	0603 - $\pm 1\%$ - 0.1W	TDK	NTCG163JH103HTDS
43	1	R37	3.9k	0603 - $\pm 1\%$ - 0.1W	Panasonic	ERJ3EKF3901V
44	1	R39	2K	0603 - $\pm 1\%$ - 0.2W	Panasonic	ERJP03F2001V
45	5	R53, R54, R55, R57, R58	1.5K	2010 - $\pm 1\%$ - 2W	TE Connectivity	35021K5FT
46	1	R61	N.M.	N.M.	N.M.	N.M.
47	1	RG	1K	0603 - $\pm 1\%$ - 0.25W	Panasonic	ERJPA3F1001V
48	1	RHOT	47	2512 - $\pm 5\%$ - 1W	TE Connectivity	352047RJT
49	1	RPD	100K	0603 - $\pm 1\%$ - 0.25W	Panasonic	ERJP03F1003V
50	2	T1, T2	125uH	Transformer for BMS	WE	74941000
51	1	U1	L9963E, TQFP 64 10x10x1.0	Automotive chip for battery management applications with daisy chain up to 31 devices	STMicroelectronics	L9963E
52	2	U2, U3	USBLC6-2SC6Y, SOT23-6L	Automotive ESD protection for high speed interfaces.	STMicroelectronics	USBLC6-2SC6Y
53	1	U4	PS2703-1-A	4-Pin Phototransistor Optocoupler	Renesas	PS2703-1-A
54	1	for blister	60900213421	WR-PHD 2.54 mm Multi-Jumper Jumper with Test Point	WE	60900213421
55	4	for blister	970080365	WA-SPAII Plastic Spacer Stud, metric, internal/ internal	WE	970080365
56	4	for blister	97790403111	WA-SCRW Pan Head Screw w. cross slot M3	WE	97790403111
57	1	for blister	624030213322	WR-WTB 2.00 mm Female Dual Row Terminal Housing w. positive locking	WE	624030213322
58	30	for blister	62400113722	WR-WTB 2.00 mm Female Dual Row Crimp Contact	WE	62400113722

16 AEK-POW-BMS63EN board versions

Table 11. AEK-POW-BMS63EN versions

Finished good	Schematic diagrams	Bill of materials
AEK\$POW-BMS63ENA ⁽¹⁾	AEK\$POW-BMS63ENA schematic diagrams	AEK\$POW-BMS63ENA bill of materials

1. This code identifies the AEK-POW-BMS63EN evaluation board first version. It is printed on the board PCB.

17 AEK-POW-BMS63EN 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.

À des fins d'évaluation uniquement. Ce kit génère, utilise et peut émettre de l'énergie radiofréquence et n'a pas été testé pour sa conformité aux limites des appareils informatiques conformément aux règles d'Industrie Canada (IC).

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 2015/863/EU (RoHS).

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).

18 AEK-POW-BMSNOTX schematic diagrams

Figure 117. AEK-POW-BMSNOTX circuit schematic (1 of 2)

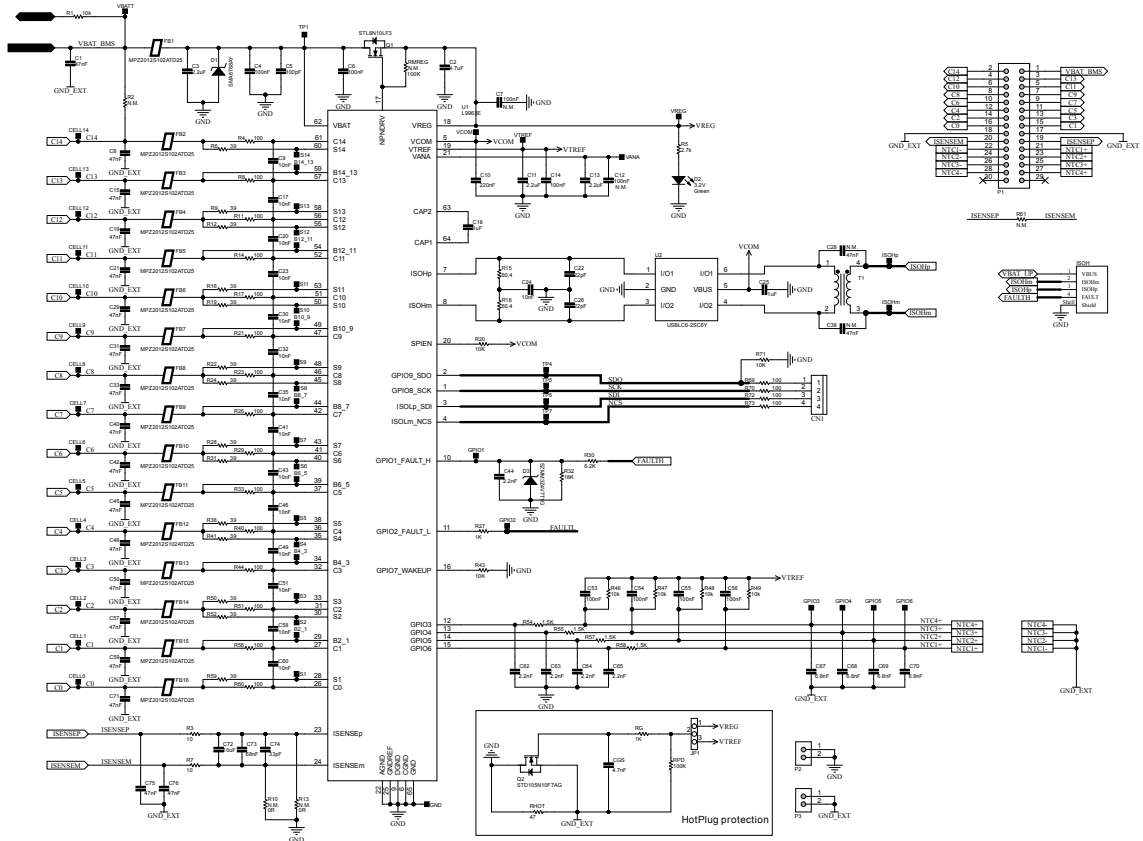
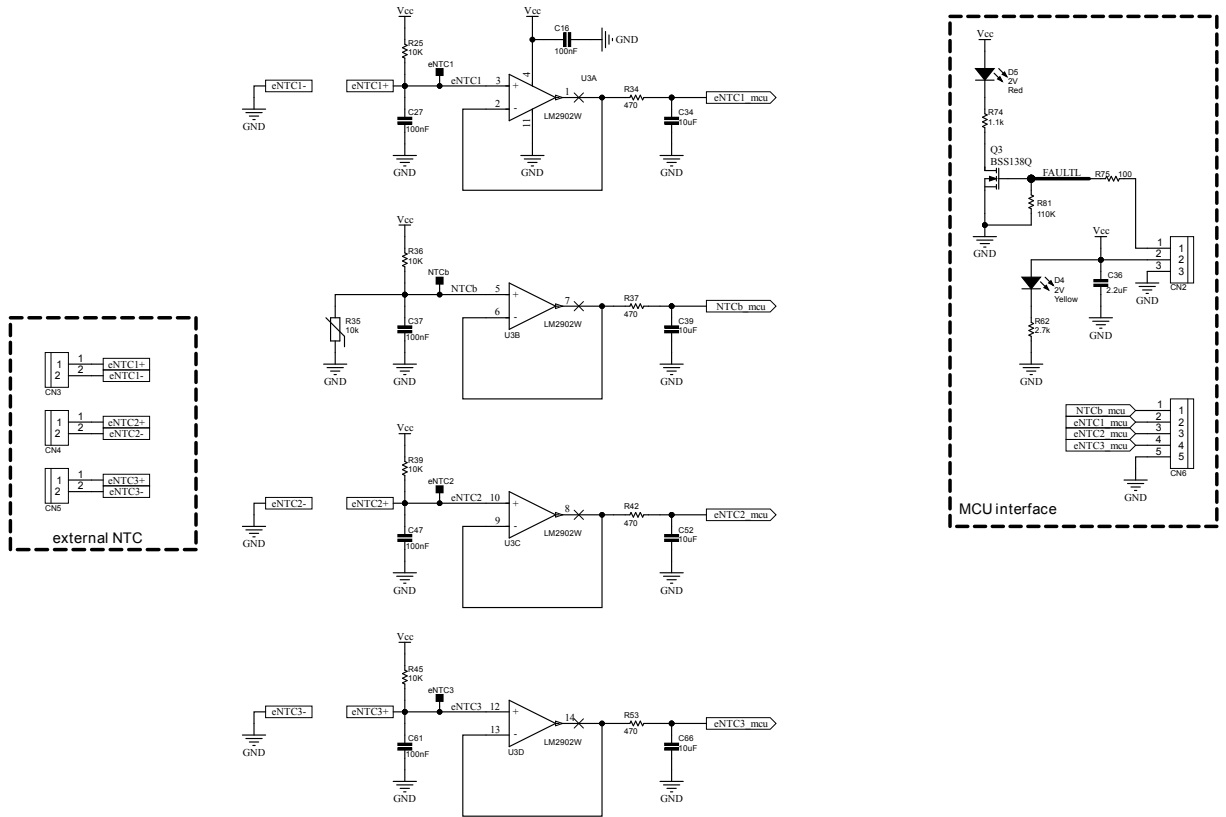


Figure 118. AEK-POW-BMSNOTX circuit schematic (2 of 2)



19 AEK-POW-BMSNOTX bill of materials

Table 12. AEK-POW-BMSNOTX 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 - 50V - X7R Class II	WE	885012206093
2	1	C2	4.7uF	1206 - 50V - 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	15	C9, C17, C20, C23, C24, C30, C32, C35, C41, C43, C46, C49, C51, C58, C60	10nF	0603 - 50V - X7R Class II	WE	885012206089
8	1	C10	220nF	0603 - 50V - X7R Class II	WE	885012206125
9	3	C11, C13, C36	2.2uF	0805 - 25V - X7R Class II	WE	885012207079
10	9	C16, C27, C37, C47, C53, C54, C55, C56, C61	100nF	0603 - 50V - X7R Class II	WE	885012206095
11	2	C18, C25	1uF	0805 - 50V - X7R Class II	WE	885012207103
12	2	C22, C26	22pF	0603 - 50V - NP0 Class I	WE	885012006053
13	2	C28, C38	N.M.	1206	N.A.	N.A.
14	4	C34, C39, C52, C66	10uF	0805 - 16V - X5R Class II	WE	885012107014
15	5	C44, C62, C63, C64, C65	2.2nF	0603 - 50V - X7R Class II	WE	885012206085
16	4	C67, C68, C69, C70	6.8nF	0603 - 50V - X7R Class II	WE	885012206088
17	1	C72	10uF	1210 - 50V - X7R Class II	WE	885012209073
18	1	C73	68nF	0603 - 50V - X7R Class II	WE	885012206094
19	1	C74	33pF	0603 - 50V - NP0 Class I	WE	885012006054
20	1	CGS	4.7nF	0603 - 50V - X7R Class II	WE	885012206087
21	1	CN1		2.54mm - 1 row - KK254 - Male	WE	61900411121
22	1	CN2		2.54mm - 1 row - KK254 - Male	WE	61900311121
23	3	CN3, CN4, CN5		2.54mm - 1 row - KK254 - Male	WE	61900211121
24	1	CN6		2.54mm - 1 row - KK254 - Male	WE	61900511121

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
25	1	D1	SMA6T68AY, SMA	Automotive 600 W, 68V TVS in SMA	ST	SMA6T68AY
26	1	D2	Green	0805 - Led Green - 3.2V	WE	150080GS75000
27	1	D3	SZMM3Z4V7T1G	4.7V Zener Voltage Regulators, 300mW	Onsemi	SZMM3Z4V7T1G
28	1	D4	Yellow	0805 - Led Yellow - 2V	WE	150080YS75000
29	1	D5	Red	0805 - Led Red - 2V	WE	150080RS75000
30	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 0.15Ohm DCR 0805	TDK	MPZ2012S102ATD25
31	1	ISOH	61400416021	USB 2.0 Type A, Receptacle, Horizontal, THT	WE	61400416021
32	1	JP1		THT Vertical 3 pins Header, Pitch 2.54 mm, Single Row	WE	61300311121
33	1	P1		2.00mm - WR-WTB - Male Dual Row Horizontal Shrouded Header w. positive locking	WE	62403021722
34	2	P2, P3	61300211121	2.54mm - WR-PHD Pin Header, THT, pitch 2.54mm, Single Row, Vertical, 2p	WE	61300211121
35	1	Q1	STL8N10LF3, PowerFLAT 5x6 WF	Automotive-grade N-channel 100 V, 25 mΩ typ., 7.8 A STripFET™ F3 Power MOSFET in a PowerFLAT™ 5x6 package	ST	STL8N10LF3
36	1	Q2	STD105N10F7AG, DPAK	Automotive-grade N-channel 100 V, 6.8 mΩ typ., 80 A, STripFET™ F7 Power MOSFET in a DPAK package	ST	STD105N10F7AG
37	1	Q3	BSS138Q	N-Channel Enhancement Mosfet	NEXPERIA	BSS138Q-7-F
38	1	R1	10k	1206 - ±1% - 0.66W	Panasonic	ERJUP8F1002V
39	1	R2	N.M.	0805	N.A.	N.A.
40	2	R3, R7	10	0603 - ±1% - 0.25W	Panasonic	ERJPA3F10R0V
41	20	R4, R8, R11, R14, R17, R21, R23, R26, R29, R33, R40, R44, R51, R56, R60, R69, R70, R72, R73, R75	100	0603 - ±1% - 0.25W	Panasonic	ERJPA3F1000V
42	2	R5, R62	2.7k	0603 - ±1% - 0.125W	Vishay	MCT06030C2701FP500
43	14	R6, R9, R12, R16, R19, R22, R24, R28, R31, R38, R41, R50, R52, R59	39	2010 - ±1% - 1.25W	TE Connectivity	CRGP2010F39R

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
44	3	R10, R13, RMREG	N.M.	0603	N.A.	N.A.
45	2	R15, R18	60.4	0603 - $\pm 1\%$ - 0.1W	Panasonic	ERJ3EKF60R4V
46	7	R20, R25, R36, R39, R43, R45, R71	10K	0603 - $\pm 1\%$ - 0.2W	Panasonic	ERJP03F1002V
47	2	R27, RG	1K	0603 - $\pm 1\%$ - 0.25W	Panasonic	ERJPA3F1001V
48	1	R30	6.2K	0805 - $\pm 1\%$ - 0.5W	Panasonic	ERJP06F6201V
49	1	R32	18K	0603 - $\pm 1\%$ - 0.2W	Panasonic	ERJP03F1802V
50	4	R34, R37, R42, R53	470	0603 - $\pm 1\%$ - 0.125W	Panasonic	ERJH3EF4700V
51	1	R35	10k	0603 - $\pm 1\%$ - 0.1W	TDK	NTCG163JH103HTDS
52	4	R46, R47, R48, R49	10k	0805 - $\pm 1\%$ - 0.5W	Panasonic	ERJP6WF1002V
53	4	R54, R55, R57, R58	1.5K	2010 - $\pm 1\%$ - 2W	TE Connectivity	35021K5FT
54	1	R61	N.M.	2512	N.A.	N.A.
55	1	R74	1.1k	0603 - $\pm 1\%$ - 0.25W	Panasonic	ERJPA3F1101V
56	1	R81	110K	0603 - $\pm 1\%$ - 0.25W	Panasonic	ERJPA3F1103V
57	1	RHOT	47	2512 - $\pm 5\%$ - 1W	TE Connectivity	352047RJT
58	1	RPD	100K	0603 - $\pm 1\%$ - 0.25W	Panasonic	ERJP03F1003V
59	1	T1	120uH	Pulse Transformers 120uH	WE	74941000
60	1	U1	L9963E, TQFP 64 10x10x1.0	Automotive chip for battery management applications with daisy chain up to 31 devices	ST	L9963E
61	1	U2	USBLC6-2SC6Y, SOT23-6L	Automotive ESD protection for high speed interfaces.	ST	USBLC6-2SC6Y
62	1	U3	LM2902WYDT, SO-14	Low-power quad operational amplifier	ST	LM2902WYDT
63	1	for blister	60900213421	WR-PHD 2.54 mm Multi-Jumper Jumper with Test Point	WE	60900213421
64	4	for blister	970080365	WA-SPAll Plastic Spacer Stud, metric, internal/ internal	WE	970080365
65	4	for blister	97790603211	WA-SCRW Pan Head Screw w. cross slot M3	WE	97790603211
66	1	for blister	624030213322	WR-WTB 2.00 mm Female Dual Row Terminal Housing w. positive locking	WE	624030213322
67	30	for blister	62400113722	WR-WTB 2.00 mm Female Dual Row Crimp Contact	WE	62400113722
68	1	for blister	61900411621	WR-WTB 2.54 mm Female Terminal Housing	WE	61900411621
69	1	for blister	61900311621	WR-WTB 2.54 mm Female Terminal Housing	WE	61900311621
70	1	for blister	61900511621	WR-WTB 2.54 mm Female Terminal Housing	WE	61900511621
71	3	for blister	61900211621	WR-WTB 2.54 mm Female Terminal Housing	WE	61900211621

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
72	18	for blister	61910113722	WR-WTB 2.54 mm Female Crimp Contact	WE	61910113722

20 AEK-POW-BMSNOTX board versions

Table 13. AEK-POW-BMSNOTX versions

Finished good	Schematic diagrams	Bill of materials
AEK\$POW-BMSNOTXA ⁽¹⁾	AEK\$POW-BMSNOTXA schematic diagrams	AEK\$POW-BMSNOTXA bill of materials

1. This code identifies the AEK-POW-BMSNOTX evaluation board first version. It is printed on the board PCB.

21 AEK-POW-BMSNOTX 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.

À des fins d'évaluation uniquement. Ce kit génère, utilise et peut émettre de l'énergie radiofréquence et n'a pas été testé pour sa conformité aux limites des appareils informatiques conformément aux règles d'Industrie Canada (IC).

Notice for the European Union

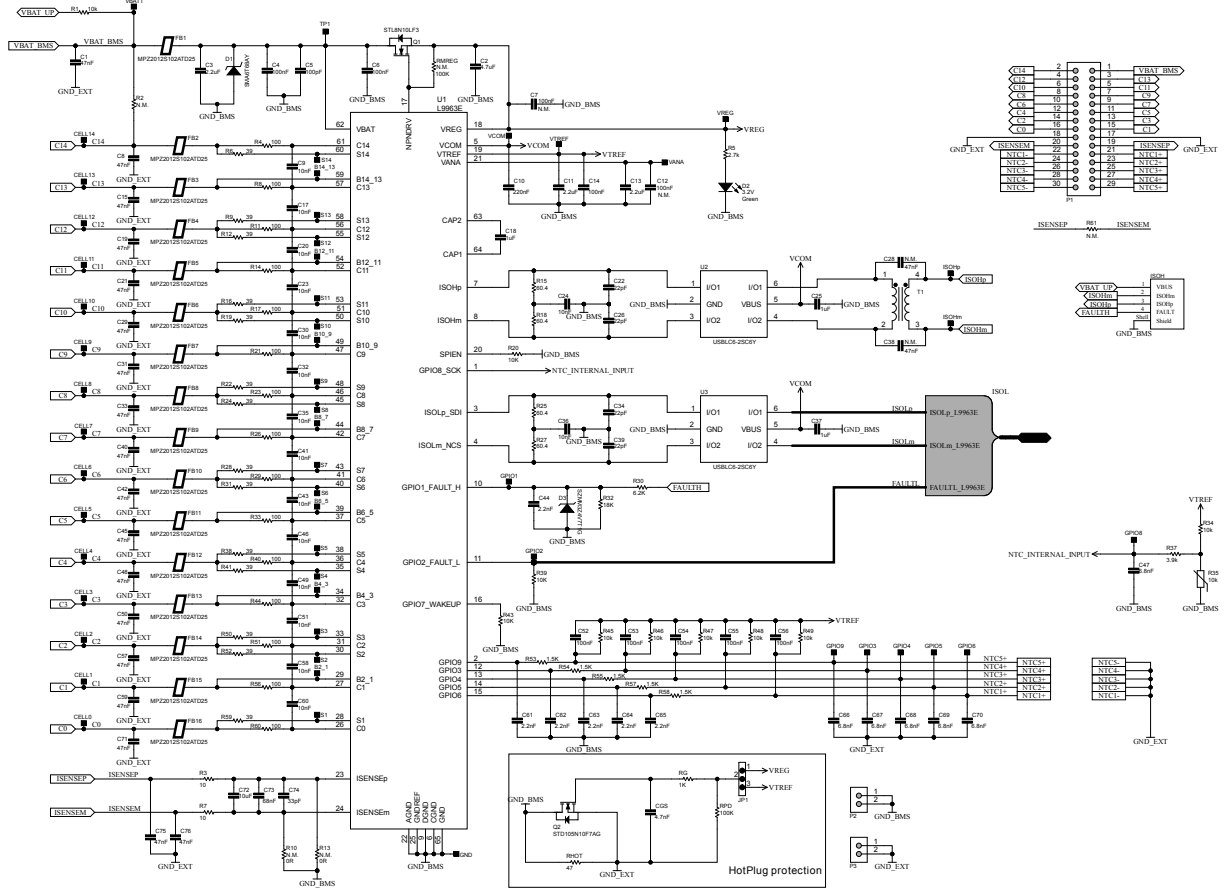
This device is in conformity with the essential requirements of the Directive 2014/30/EU (EMC) and of the Directive 2015/863/EU (RoHS).

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).

22 AEK-POW-BMSWTX schematic diagrams

Figure 119. AEK-POW-BMSWTX circuit schematic (1 of 2)



23 AEK-POW-BMSWTX bill of materials

Table 14. AEK-POW-BMSWTX 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 - 50V - X7R Class II	WE	885012206093
2	1	C2	4.7uF	1206 - 50V - 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 - 50V - X7R Class II	WE	885012206089
8	1	C10	220nF	0603 - 50V - X7R Class II	WE	885012206125
9	2	C11, C13	2.2uF	0805 - 25V - X7R Class II	WE	885012207079
10	6	C16, C22, C26, C34, C39, C82	22pF	0603 - 50V - NP0 Class I	WE	885012006053
11	6	C18, C25, C37, C80, C83, C84	1uF	0805 - 50V - 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 - 50V - X7R Class II	WE	885012206085
14	6	C47, C66, C67, C68, C69, C70	6.8nF	0603 - 50V - X7R Class II	WE	885012206088
15	7	C52, C53, C54, C55, C56, C77, C78	100nF	0603 - 50V - X7R Class II	WE	885012206095
16	1	C72	10uF	1210 - 50V - X7R Class II	WE	885012209073
17	1	C73	68nF	0603 - 50V - X7R Class II	WE	885012206094
18	1	C74	33pF	0603 - 50V - NP0 Class I	WE	885012006054
19	1	CGS	4.7nF	0603 - 50V - 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 0.15Ohm 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 5x6 WF	Automotive- grade N- channel 100 V, 25 mΩ typ., 7.8 A STripFET™ F3 Power MOSFET in a PowerFLAT™ 5x6 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	L9963E, TQFP 64 10x10x1.0	Automotive chip for battery management applications with daisy chain up to 31 devices	ST	L9963E
62	3	U2, U3, U5	USBLC6-2SC6 Y, SOT23-6L	Automotive ESD protection for high speed interfaces.	ST	USBLC6-2SC6Y
63	1	U4	L9963T, SO-16	Automotive general purpose SPI to isolated SPI transceiver	ST	L9963T
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-SPAll Plastic Spacer Stud, metric, internal/ internal	WE	970080365
67	4	for blister	97790603211	WA-SCRW Pan Head Screw w. cross slot M3	WE	97790603211

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
68	1	for blister	624030213322	WR-WTB 2.00 mm Female Dual Row Terminal Housing w. positive locking	WE	624030213322
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

24 AEK-POW-BMSWTX Board versions

Table 15. AEK-POW-BMSWTX versions

Finished good	Schematic diagrams	Bill of materials
AEK\$POW-BMSWTXA ⁽¹⁾	AEK\$POW-BMSWTXA schematic diagrams	AEK\$POW-BMSWTXA bill of materials

1. This code identifies the AEK-POW-BMSWTX evaluation board first version. It is printed on the board PCB.

25 AEK-POW-BMSWTX 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.

À des fins d'évaluation uniquement. Ce kit génère, utilise et peut émettre de l'énergie radiofréquence et n'a pas été testé pour sa conformité aux limites des appareils informatiques conformément aux règles d'Industrie Canada (IC).

Notice for the European Union

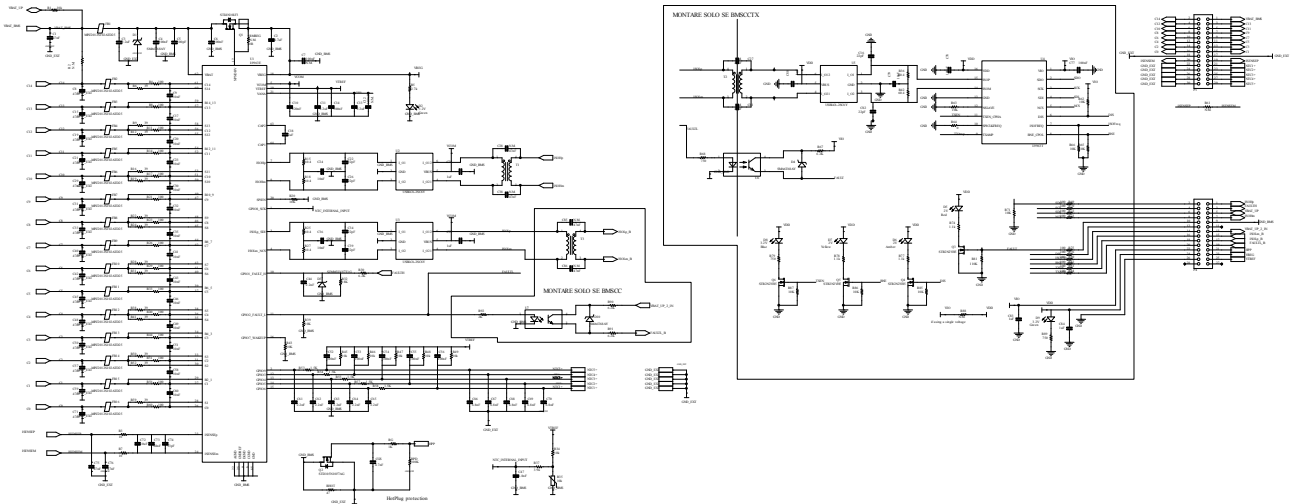
This device is in conformity with the essential requirements of the Directive 2014/30/EU (EMC) and of the Directive 2015/863/EU (RoHS). Compliance to EMC standards in Class A (industrial intended use).

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).

26 AEK-POW-BMSCC schematic diagrams

Figure 121. AEK-POW-BMSCC schematic diagram



27 Bill of materials
Table 16. AEK-POW-BMSSC 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 - 50V - X7R Class II	WE	885012206093
2	1	C10	220nF	0603 - 50V - X7R Class II	WE	885012206125
3	2	C11 C13	2.2uF	0805 - 25V - X7R Class II	WE	885012207079
4	4	C26 C34 C39 C22	22pF	0603 - 50V - NP0 Class I	WE	885012006053
5	3	C18 C25 C37	1uF	0805 - 50V - X7R Class II	WE	885012207103
6	1	C2	4.7uF	1206 - 50V - X7R Class II	WE	885012208094
7	1	C3	2.2uF	1210 - 100V - X7R Class II	WE	885012209071
8	8	C4 C6 C14 C52 C53 C54 C55 C56	100nF	0603 - 100V - X7R Class II	WE	885012206120
9	6	C44 C61 C62 C63 C64 C65	2.2nF	0603 - 50V - X7R Class II	WE	885012206085
10	6	C47 C66 C67 C68 C69 C70	6.8nF	0603 - 50V - X7R Class II	WE	885012206088
11	1	C5	100pF	0603 - 100V - X7R Class II	WE	885012206102
12	1	C72	10uF	0805 - 50V - X5R Class II	TDK	C2012X5R1H106K125AC
13	1	C73	68nF	0603 - 50V - X7R Class II	WE	885012206094
14	1	C74	33pF	0603 - 50V - NP0 Class I	WE	885012006054
15	17	C9 C17 C20 C23 C24 C30 C32 C35 C36 C41 C43 C46 C49 C51 C58 C60	10nF	0603 - 50V - X7R Class II	WE	885012206089
16	1	CGS	4.7nF	0603 - 50V - X7R Class II	WE	885012206087
17	1	D1	SMA6T68AY	Automotive 600 W, 68V TVS in SMA	ST	SMA6T68AY
18	1	D10	SMA6T68AY	Automotive 600 W, 68V TVS in SMA	ST	SMA6T68AY
19	1	D2	Green	LED_VERDE. SMA	WE	150120GS75000

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
20	1	D3	SZMM3Z4V7T1G	4.7V Zener Voltage Regulators, 300mW	Onsemi	SZMM3Z4V7T1G
21	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 0.15Ohm DCR 0805	TDK	MPZ2012S102ATD25
22	1	P1		2.00mm - WR-WTB - Male Dual Row Horizontal Shrouded Header w. positive locking	WE	62403021722
23	1	P4		2.00mm - WR-WTB - Male Dual Row Horizontal Shrouded Header w. positive locking	WE	62402821722
24	1	Q1	STL8N10LF3	Automotive-grade N-channel 100 V, 25 mΩ typ., 7.8 A STripFET™ F3 Power MOSFET in a PowerFLAT™ 5x6 package. TR	ST	STL8N10LF3
25	1	Q2	STD105N10F7AG	Automotive-grade N-channel 100 V, 6.8 mΩ typ., 80 A, STripFET™ F7 Power MOSFET in a DPAK package. DPAK	ST	STD105N10F7AG
26	1	R1	10k	1206 - ±1% - 0.66W	Panasonic	ERJUP8F1002V
27	4	R15 R18 R25 R27	60R4	0603 - ±1% - 0.1W	Panasonic	ERJ3EKF60R4V
28	3	R20 R39 R43	10K	0603 - ±1% - 0.2W	Panasonic	ERJP03F1002V
29	2	R3 R7	10R	0603 - ±1% - 0.25W	Panasonic	ERJPA3F10R0V
30	1	R30	6.2K	0805 - ±1% - 0.5W	Panasonic	ERJP06F6201V
31	2	R90 R91	6.2K	0805 - ±1% - 0.5W	Panasonic	ERJP06F6201V
32	1	R32	18K	0603 - ±1% - 0.2W	Panasonic	ERJP03F1802V

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
33	6	R34 R45 R46 R47 R48 R49	10k	0805 - ±1% - 0.5W	Panasonic	ERJP6WF1002V
34	1	R35	NTC 10k	0603 - ±1% - 0.1W	TDK	NTCG163JH103HTDS
35	1	R37	3.9k	0603 - ±1% - 0.1W	Panasonic	ERJ3EKF3901V
36	15	R4 R8 R11 R14 R17 R21 R23 R26 R29 R33 R40 R44 R51 R56 R60	100R	0603 - ±1% - 0.25W	Panasonic	ERJPA3F1000V
37	1	R5	2.7k	0603 - ±1% - 0.125W	Vishay	MCT06030C2701FP500
38	5	R53 R54 R55 R57 R58	1.5K	2010 - ±1% - 2W	TE Connectivity	35021K5FT
39	14	R6 R9 R12 R16 R19 R22 R24 R28 R31 R38 R41 R50 R52 R59	39R	2010 - ±1% - 1.25W	TE Connectivity	CRGP2010F39R
40	1	RG	1K	0603 - ±1% - 0.25W	Panasonic	ERJPA3F1001V
41	1	RHOT	47R	2512 - ±5% - 1W	TE Connectivity	352047RJT
42	1	RPD	100K	0603 - ±1% - 0.25W	Panasonic	ERJP03F1003V
43	1	R92	2k	0603 - ±1% - 0.1W	WE	560112116091
44	1	T1	125uH	Pulse Transformers 125uH	WE	74941000
45	1	T3	125uH	Pulse Transformers 125uH	WE	74941000
46	1	U1	L9963E	Automotive chip for battery management applications with daisy chain up to 31 deviceS. TQFP 64 10x10x1.0	ST	L9963E
47	2	U2 U3	USBLC6-2SC6 Y	Automotive ESD protection for high speed interfaces. SOT23-6L	ST	USBLC6-2SC6Y
48	1	U7	OPTO_PS2703- 1-A		Renesas	PS2703-1-A
49	1	box		MC-530000342- RB - Scatolino ST CT6118 BOTTOM	Electronica	EH04-0237-A
50	1	cover		MC-530000342- RB - Coperchio ST CT6118	Electronica	EH04-0238-A

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
51	1	for blister	624028213322	WR-WTB 2.00 mm Female Dual Row Terminal Housing w. positive locking	WE	624028213322
52	1	for blister	624030213322	WR-WTB 2.00 mm Female Dual Row Terminal Housing w. positive locking	WE	624030213322
53	58	for blister	62400113722	WR-WTB 2.00 mm Female Dual Row Crimp Contact	WE	62400113722

28 Board versions

Table 17. AEK-POW-BMSSC versions

PCB version	Schematic diagrams	Bill of materials
AEK\$POW-BMSSCA ⁽¹⁾	AEK\$POW-BMSSCA schematic diagrams	AEK\$POW-BMSSCA bill of materials

1. This code identifies the AEK-POW-BMSSC evaluation board first version. It is printed on the board PCB.

29 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.

À des fins d'évaluation uniquement. Ce kit génère, utilise et peut émettre de l'énergie radiofréquence et n'a pas été testé pour sa conformité aux limites des appareils informatiques conformément aux règles d'Industrie Canada (IC).

Notice for the European Union

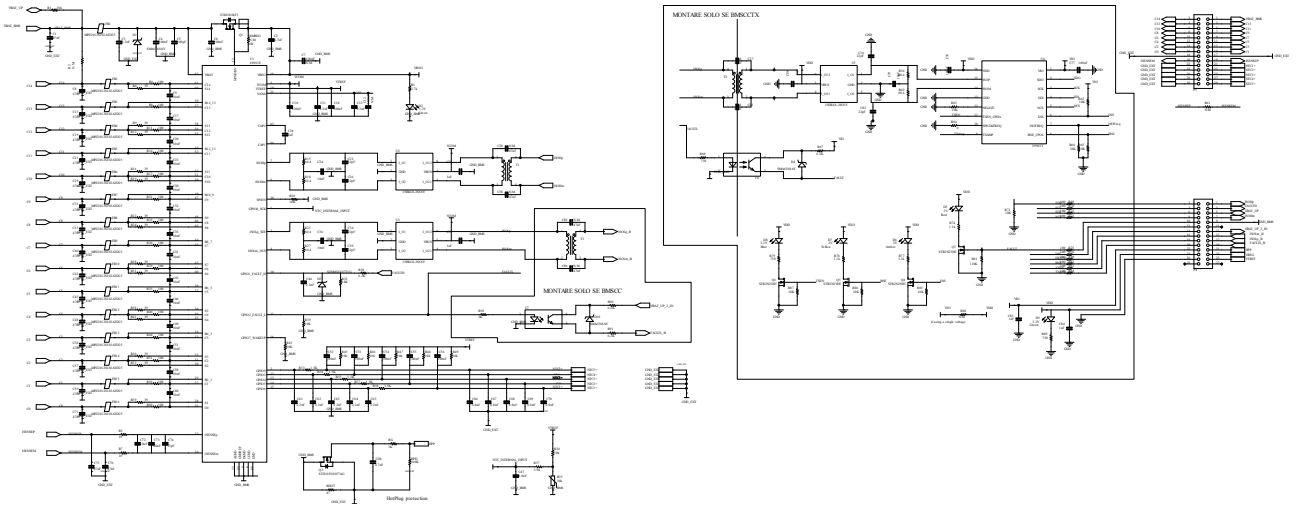
This device is in conformity with the essential requirements of the Directive 2014/30/EU (EMC) and of the Directive 2011/65/EU (RoHS II), including subsequent revisions and additions, as well as amended by the Delegated Directive 2015/863/EU (RoHS III). Compliance to EMC standards in Class A (industrial intended use).

Notice for the United Kingdom

This device is in 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).

30 AEK-POW-BMSCCTX schematic diagrams

Figure 122. AEK-POW-BMSCCTX schematic diagram



31 Bill of materials
Table 18. AEK-POW-BMSCCTX 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 - 50V - X7R Class II	WE	885012206093
2	1	C10	220nF	0603 - 50V - X7R Class II	WE	885012206125
3	2	C11 C13	2.2uF	0805 - 25V - X7R Class II	WE	885012207079
4	4	C26 C34 C39 C22	22pF	0603 - 50V - NP0 Class I	WE	885012006053
5	2	C16 C82	22pF	0603 - 50V - NP0 Class I	WE	885012006053
6	5	C18 C25 C37 C80	1uF	0805 - 50V - X7R Class II	WE	885012207103
7	2	C83 C84	1uF	0805 - 50V - X7R Class II	WE	885012207103
8	1	C2	4.7uF	1206 - 50V - X7R Class II	WE	885012208094
9	1	C3	2.2uF	1210 - 100V - X7R Class II	WE	885012209071
10	8	C4 C6 C14 C52 C53 C54 C55 C56	100nF	0603 - 100V - X7R Class II	WE	885012206120
11	2	C77 C78	100nF	0603 - 100V - X7R Class II	WE	885012206120
12	6	C44 C61 C62 C63 C64 C65	2.2nF	0603 - 50V - X7R Class II	WE	885012206085
13	6	C47 C66 C67 C68 C69 C70	6.8nF	0603 - 50V - X7R Class II	WE	885012206088
14	1	C5	100pF	0603 - 100V - X7R Class II	WE	885012206102
15	1	C72	10uF	0805 - 50V - X5R Class II	TDK	C2012X5R1H106K125AC
16	1	C73	68nF	0603 - 50V - X7R Class II	WE	885012206094
17	1	C74	33pF	0603 - 50V - NP0 Class I	WE	885012006054
18	17	C9 C17 C20 C23 C24 C30 C32 C35 C36 C41 C43 C46 C49 C51 C58 C60	10nF	0603 - 50V - X7R Class II	WE	885012206089
19	1	C79	10nF	0603 - 50V - X7R Class II	WE	885012206089
20	1	CGS	4.7nF	0603 - 50V - X7R Class II	WE	885012206087

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
21	1	D1	SMA6T68AY	Automotive 600 W, 68V TVS in SMA	ST	SMA6T68AY
22	1	D4	SMA6T68AY	Automotive 600 W, 68V TVS in SMA	ST	SMA6T68AY
23	1	D2	Green	LED_VERDE	WE	150120GS75000
24	1	D9	Green	LED_VERDE	WE	150120GS75000
25	1	D3	SZMM3Z4V7T1G	4.7V Zener Voltage Regulators, 300mW	Onsemi	SZMM3Z4V7T1G
26	1	D5	Red	LED_ROSSO	WE	150120RS75000
27	1	D6	Amber	LED_AMBRA	WE	150120AS75000
28	1	D7	Yellow	LED_GIALLO	WE	150120YS75000
29	1	D8	Blue	LED_BLU	WE	150120BS75000
30	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 0.15Ohm DCR 0805	TDK	MPZ2012S102ATD25
31	1	P1		2.00mm - WR-WTB - Male Dual Row Horizontal Shrouded Header w. positive locking	WE	62403021722
32	1	P4		2.00mm - WR-WTB - Male Dual Row Horizontal Shrouded Header w. positive locking	WE	62402821722
33	1	Q1	STL8N10LF3	Automotive-grade N-channel 100 V, 25 mΩ typ., 7.8 A STripFET™ F3 Power MOSFET in a PowerFLAT™ 5x6 package	ST	STL8N10LF3
34	1	Q2	STD105N10F7AG	Automotive-grade N-channel 100 V, 6.8 mΩ typ., 80 A, STripFET™ F7 Power MOSFET in a DPAK package	ST	STD105N10F7AG
35	4	Q3 Q4 Q5 Q6	BSS138Q	N-Channel Enhancement Mosfet	NEXPERIA	BSS138Q-7-F

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
36	1	R1	10k	1206 - ±1% - 0.66W	Panasonic	ERJUP8F1002V
37	4	R15 R18 R25 R27	60R4	0603 - ±1% - 0.1W	Panasonic	ERJ3EKF60R4V
38	2	R36 R42	60R4	0603 - ±1% - 0.1W	Panasonic	ERJ3EKF60R4V
39	3	R20 R39 R43	10K	0603 - ±1% - 0.2W	Panasonic	ERJP03F1002V
40	8	R63 R62 R65 R66 R85 R86 R87 R71	10K	0603 - ±1% - 0.2W	Panasonic	ERJP03F1002V
41	2	R3 R7	10R	0603 - ±1% - 0.25W	Panasonic	ERJPA3F10R0V
42	1	R30	6.2K	0805 - ±1% - 0.5W	Panasonic	ERJP06F6201V
43	1	R67	6.2K	0805 - ±1% - 0.5W	Panasonic	ERJP06F6201V
44	1	R32	18K	0603 - ±1% - 0.2W	Panasonic	ERJP03F1802V
45	6	R34 R45 R46 R47 R48 R49	10k	0805 - ±1% - 0.5W	Panasonic	ERJP6WF1002V
46	1	R35	NTC 10k	0603 - ±1% - 0.1W	TDK	NTCG163JH103HTDS
47	1	R37	3.9k	0603 - ±1% - 0.1W	Panasonic	ERJ3EKF3901V
48	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	100R	0603 - ±1% - 0.25W	Panasonic	ERJPA3F1000V
49	1	R5	2.7k	0603 - ±1% - 0.125W	Vishay	MCT06030C2701FP500
50	5	R53 R54 R55 R57 R58	1.5K	2010 - ±1% - 2W	TE Connectivity	35021K5FT
51	14	R6 R9 R12 R16 R19 R22 R24 R28 R31 R38 R41 R50 R52 R59	39R	2010 - ±1% - 1.25W	TE Connectivity	CRGP2010F39R
52	1	R64	0	0603 - ±1% - 0.1W	Panasonic	ERJ3GEY0R00V
53	1	R89	750R	0603 - ±0.5% - 0.25W, 0603 - ±1% - 0.25W	Panasonic	ERJUP3D7500V
54	1	R79	750R	0603 - ±0.5% - 0.25W, 0603 - ±1% - 0.25W	Panasonic	ERJUP3D7500V
55	1	R68	750R	0603 - ±0.5% - 0.25W, 0603 - ±1% - 0.25W	Panasonic	ERJUP3D7500V
56	3	R74 R77 R78	1.1k	0603 - ±1% - 0.25W	Panasonic	ERJPA3F1101V

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
57	1	R81	110K	0603 - ±1% - 0.25W	Panasonic	ERJPA3F1103V
58	1	RG	1K	0603 - ±1% - 0.25W	Panasonic	ERJPA3F1001V
59	1	RHOT	47R	2512 - ±5% - 1W	TE Connectivity	352047RJT
60	1	RPD	100K	0603 - ±1% - 0.25W	Panasonic	ERJP03F1003V
61	1	T1	125uH	Pulse Transformers 125uH	WE	74941000
62	1	T2	125uH	Pulse Transformers 125uH	WE	74941000
63	1	U1	L9963E	Automotive chip for battery management applications with daisy chain up to 31 devices. TQFP 64 10x10x1.0	ST	L9963E
64	2	U2 U3	USBLC6-2SC6Y	Automotive ESD protection for high speed interfaces. SOT23-6L	ST	USBLC6-2SC6Y
65	1	U5	USBLC6-2SC6Y	Automotive ESD protection for high speed interfaces. SOT23-6L	ST	USBLC6-2SC6Y
66	1	U4	L9963T	Automotive general purpose SPI to isolated SPI transceiver. SO-16	ST	L9963T
67	1	U6	140357145300	WL-OCPT Optocoupler Phototransistor, SOP4, 1 Channel, DC, 35V, 60mA	WE	140357145300
68	1	box		MC-530000342-RB - Scatolino ST CT6118 BOTTOM	Electronica	EH04-0237-A
69	1	cover		MC-530000342-RB - Coperchio ST CT6118	Electronica	EH04-0238-A
70	1	for blister	624028213322	WR-WTB 2.00 mm Female Dual Row Terminal Housing w. positive locking	WE	624028213322

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
71	1	for blister	624030213322	WR-WTB 2.00 mm Female Dual Row Terminal Housing w. positive locking	WE	624030213322
72	58	for blister	62400113722	WR-WTB 2.00 mm Female Dual Row Crimp Contact	WE	62400113722

32 Board versions

Table 19. AEK-POW-BMSCCTX versions

PCB version	Schematic diagrams	Bill of materials
AEK\$POW-BMSCCTXA ⁽¹⁾	AEK\$POW-BMSCCTXA schematic diagrams	AEK\$POW-BMSCCTXA bill of materials

1. This code identifies the AEK-POW-BMSCCTX evaluation board first version. It is printed on the board PCB.

33 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.

À des fins d'évaluation uniquement. Ce kit génère, utilise et peut émettre de l'énergie radiofréquence et n'a pas été testé pour sa conformité aux limites des appareils informatiques conformément aux règles d'Industrie Canada (IC).

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 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).

34 AEK-POW-BMS63EM schematic diagrams

Figure 123. AEK-POW-BMS63EM schematic diagrams (1 of 12)

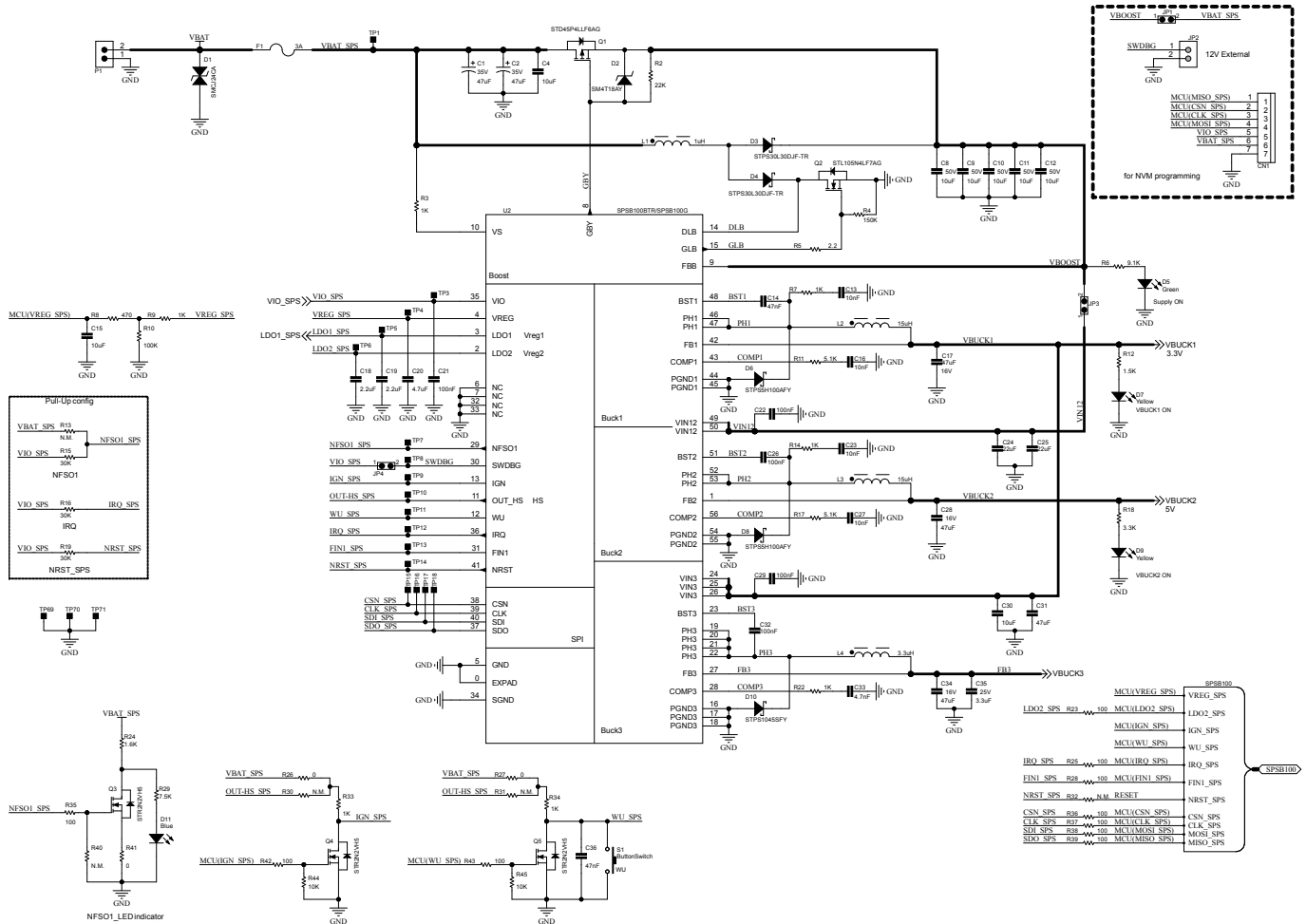


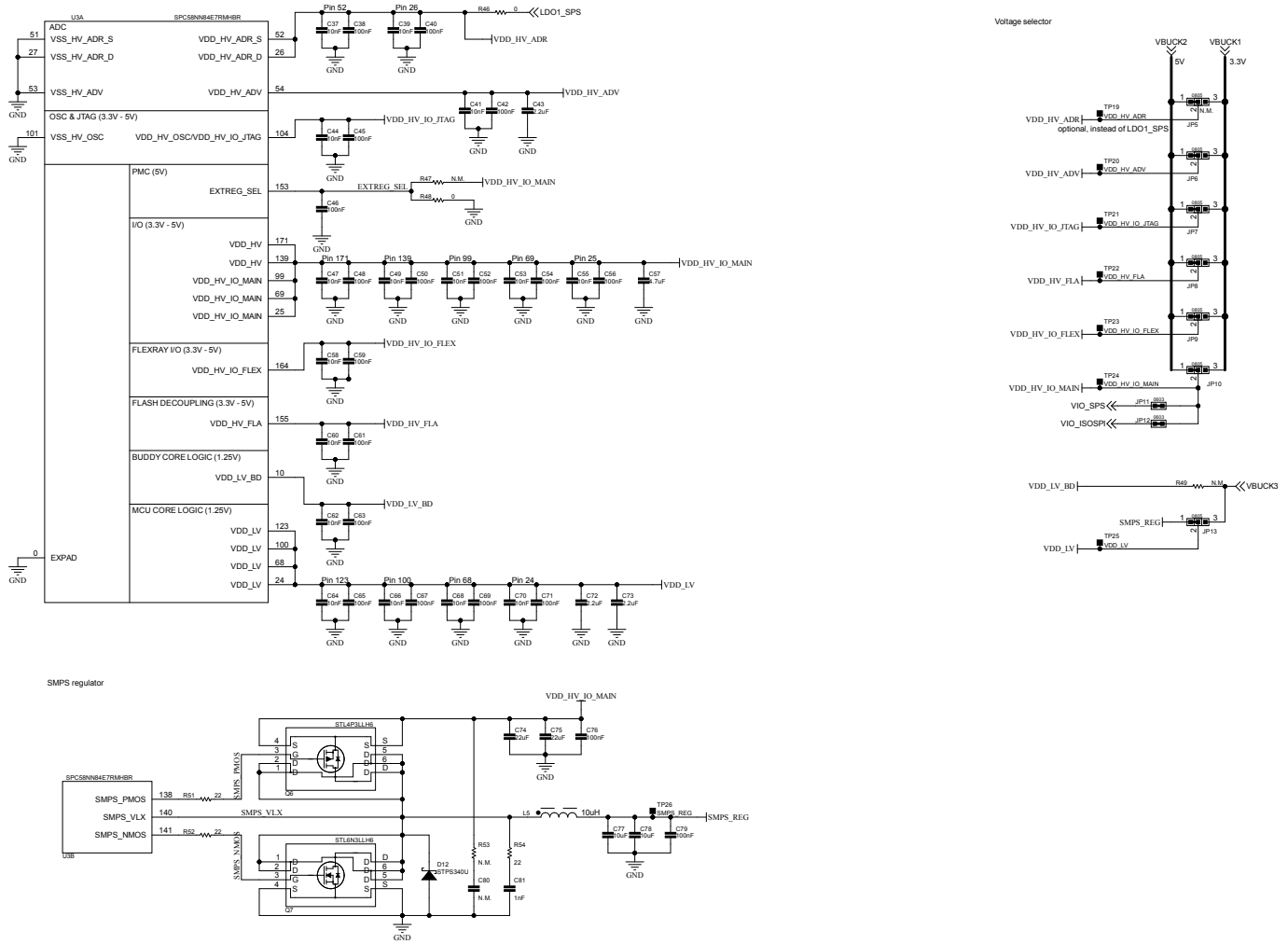
Figure 124. AEK-POW-BMS63EM schematic diagrams (2 of 12)


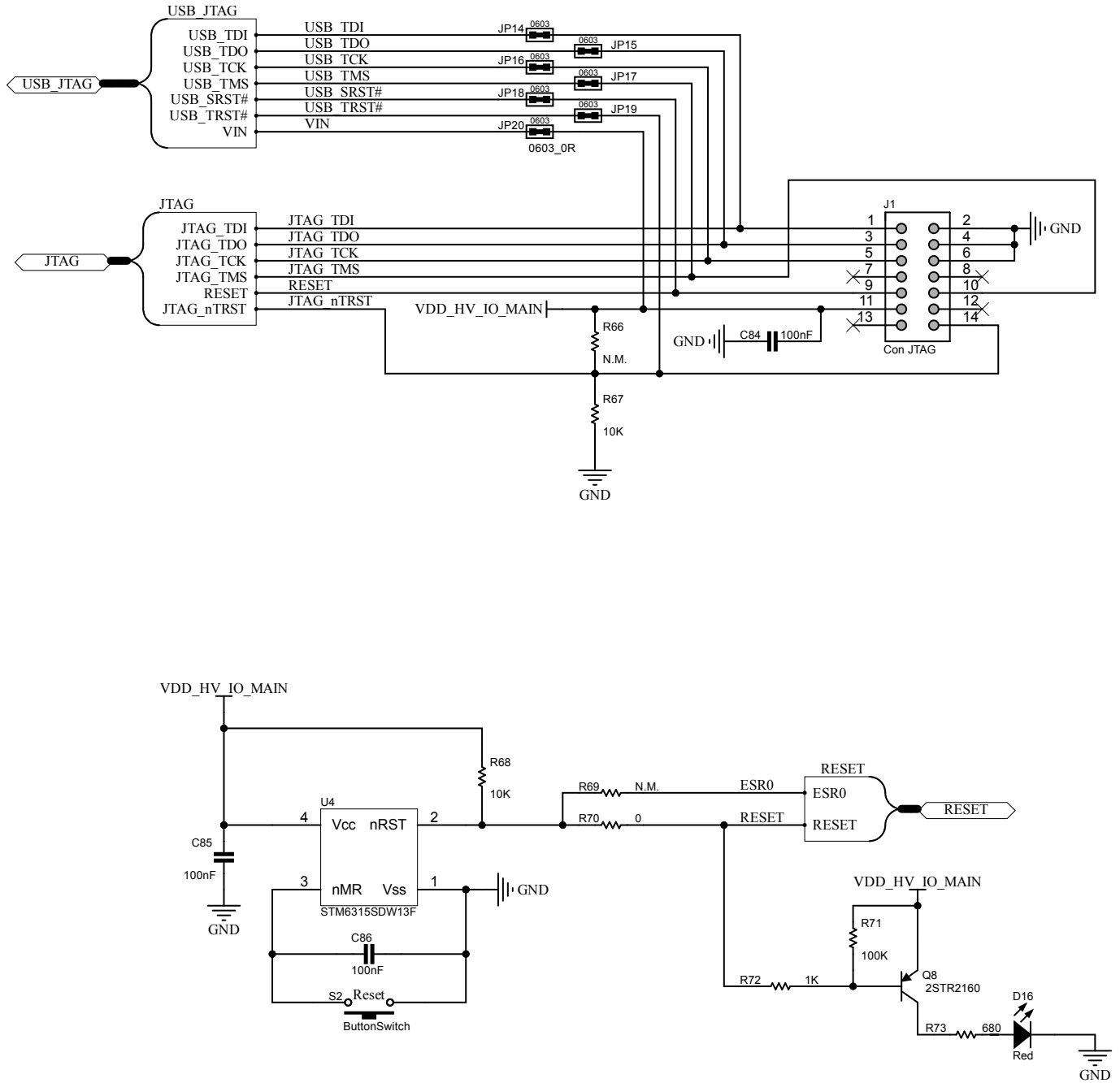
Figure 126. AEK-POW-BMS63EM schematic diagrams (4 of 12)


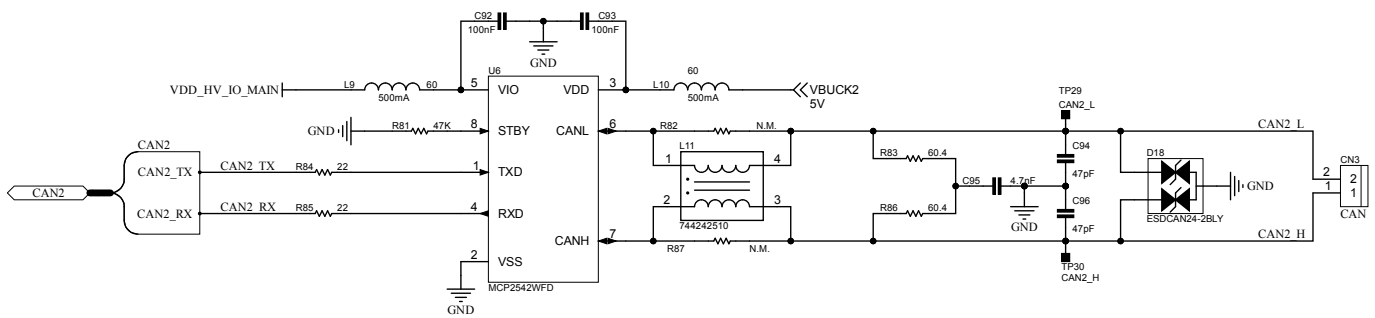
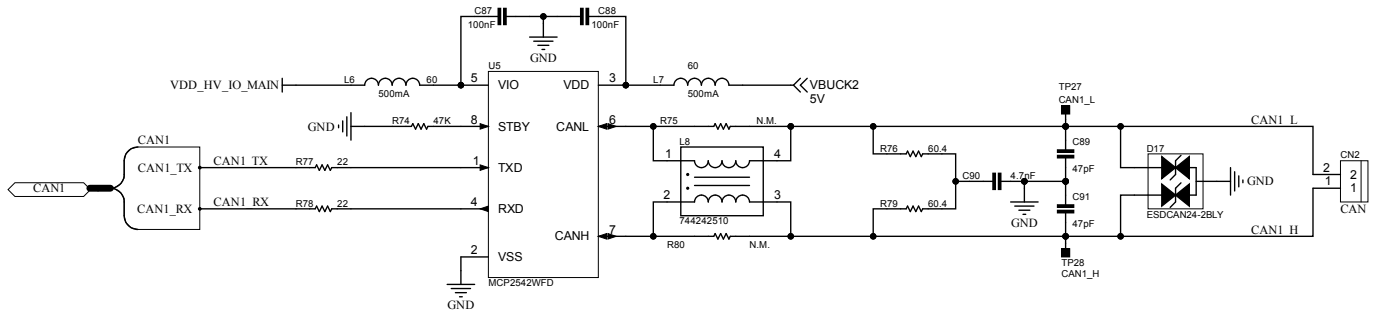
Figure 127. AEK-POW-BMS63EM schematic diagrams (5 of 12)


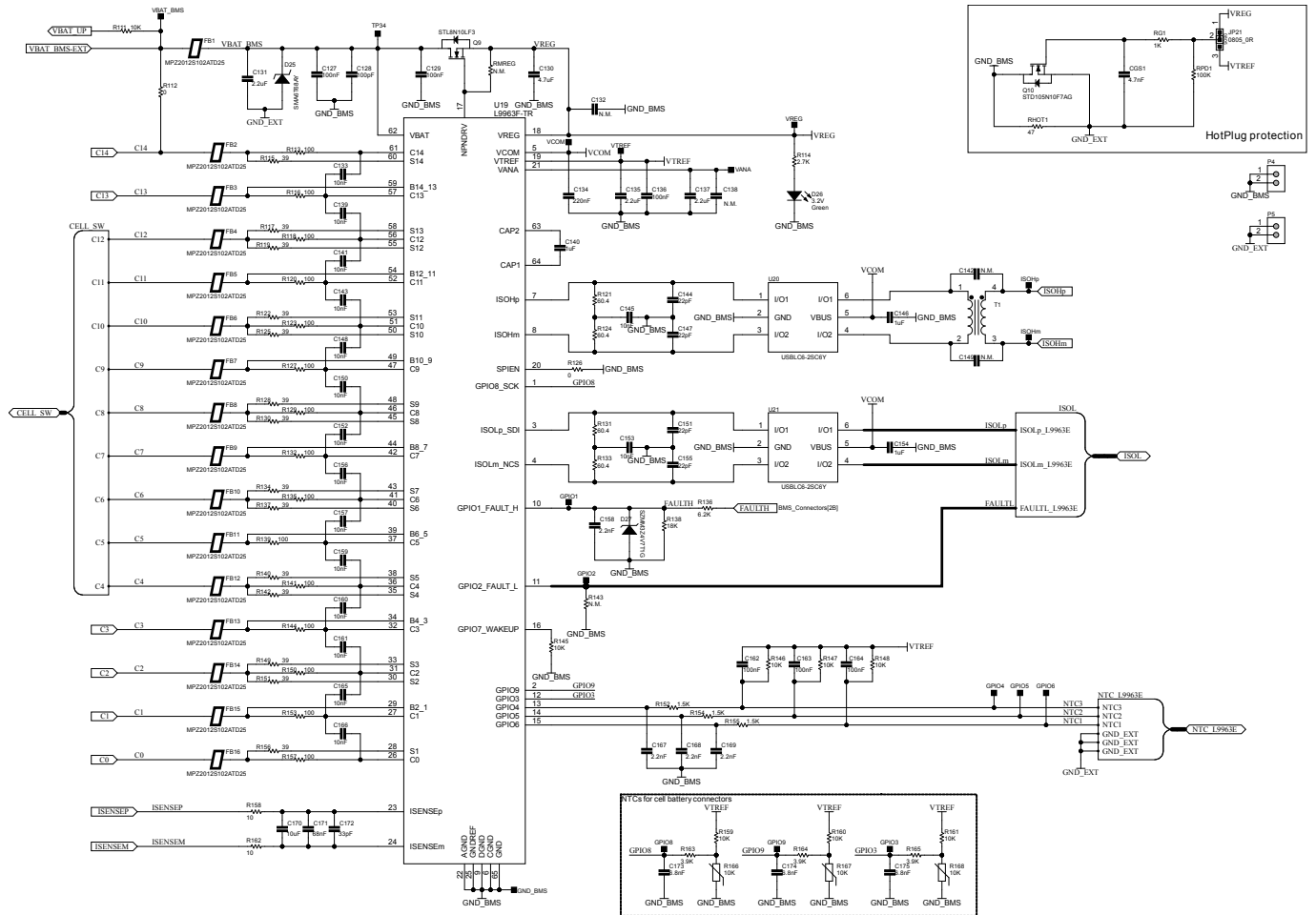
Figure 129. AEK-POW-BMS63EM schematic diagrams (7 of 12)


Figure 130. AEK-POW-BMS63EM schematic diagrams (8 of 12)

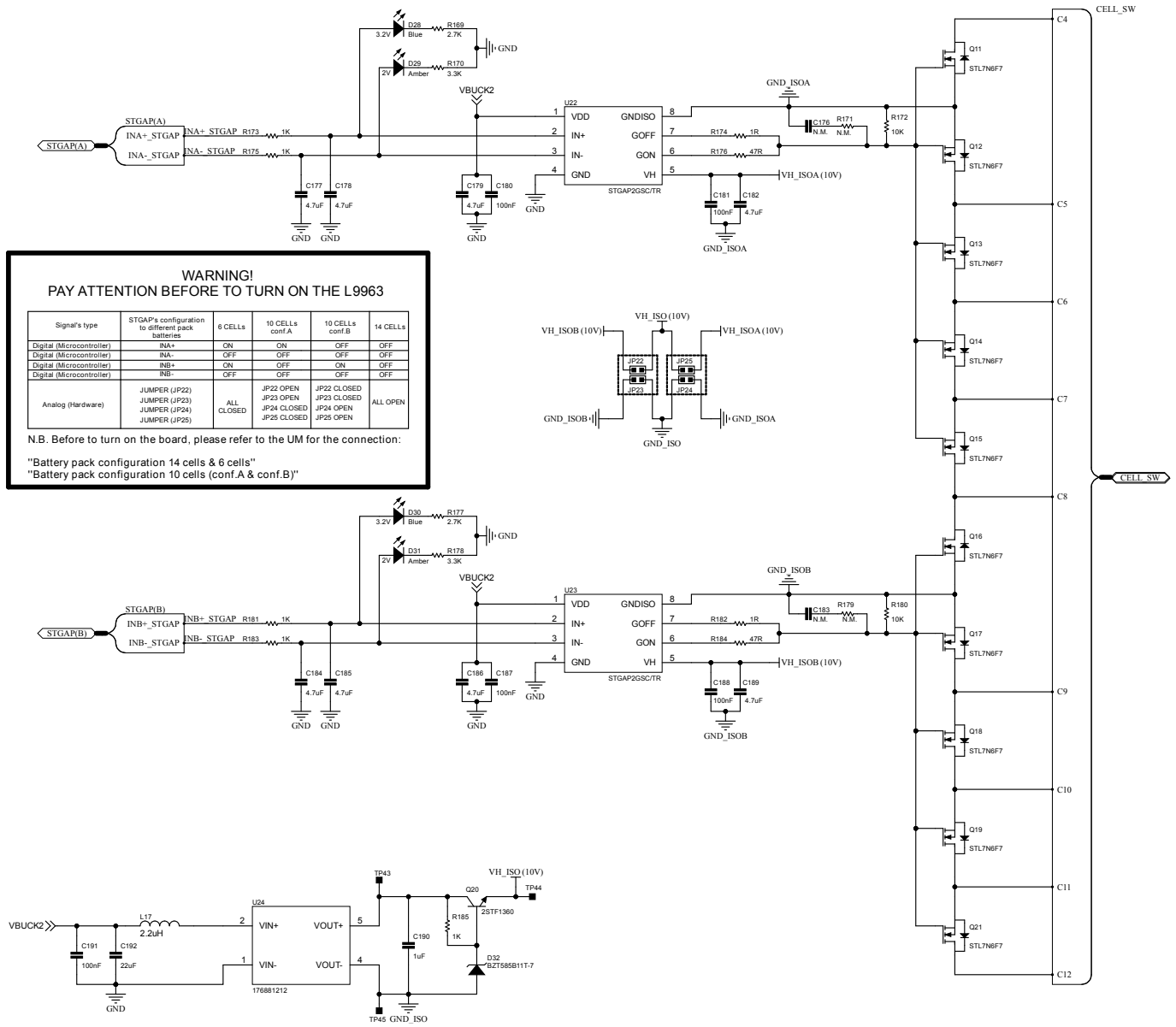


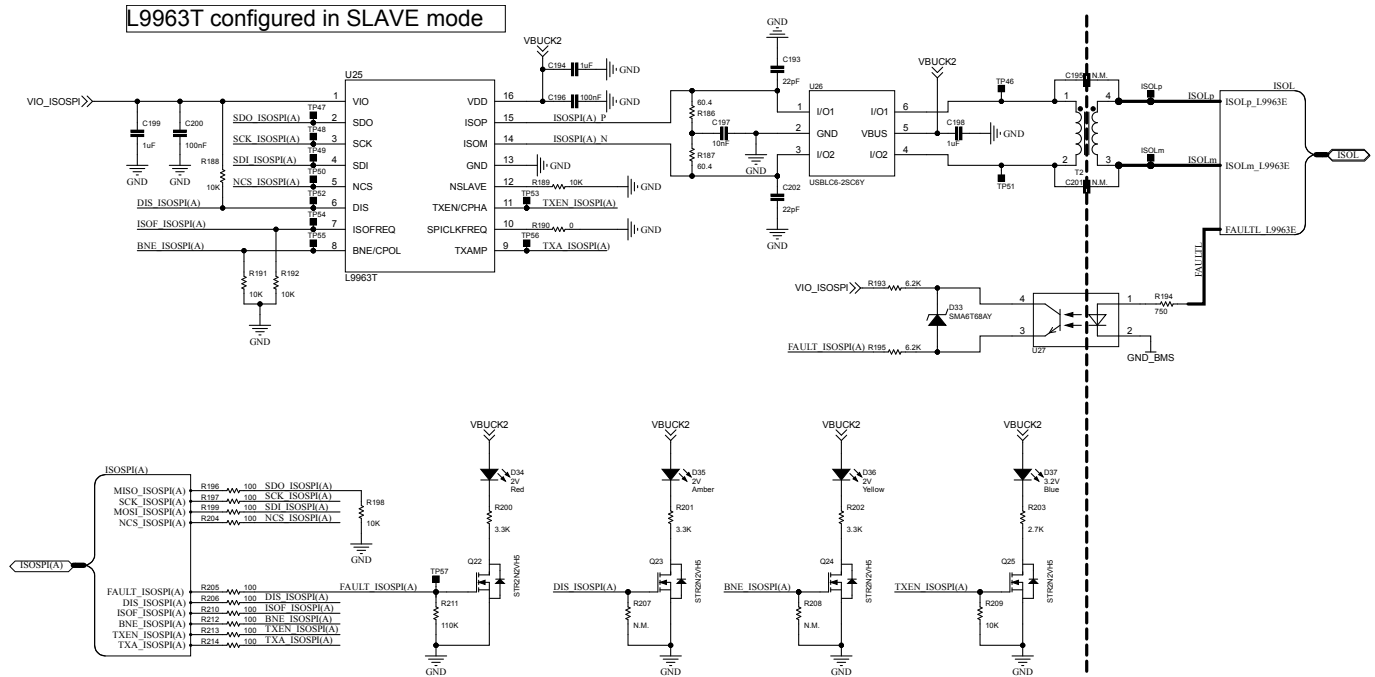
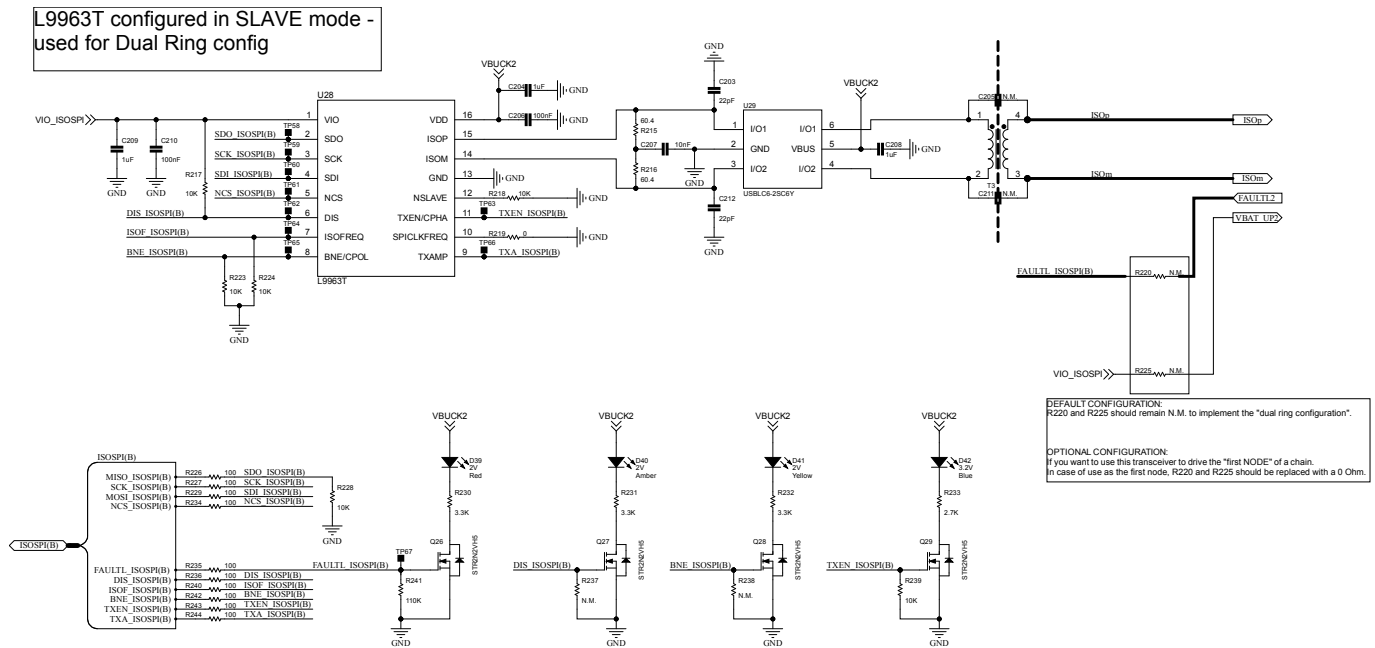
Figure 131. AEK-POW-BMS63EM schematic diagrams (9 of 12)

Figure 132. AEK-POW-BMS63EM schematic diagrams (10 of 12)


Figure 133. AEK-POW-BMS63EM schematic diagrams (11 of 12)

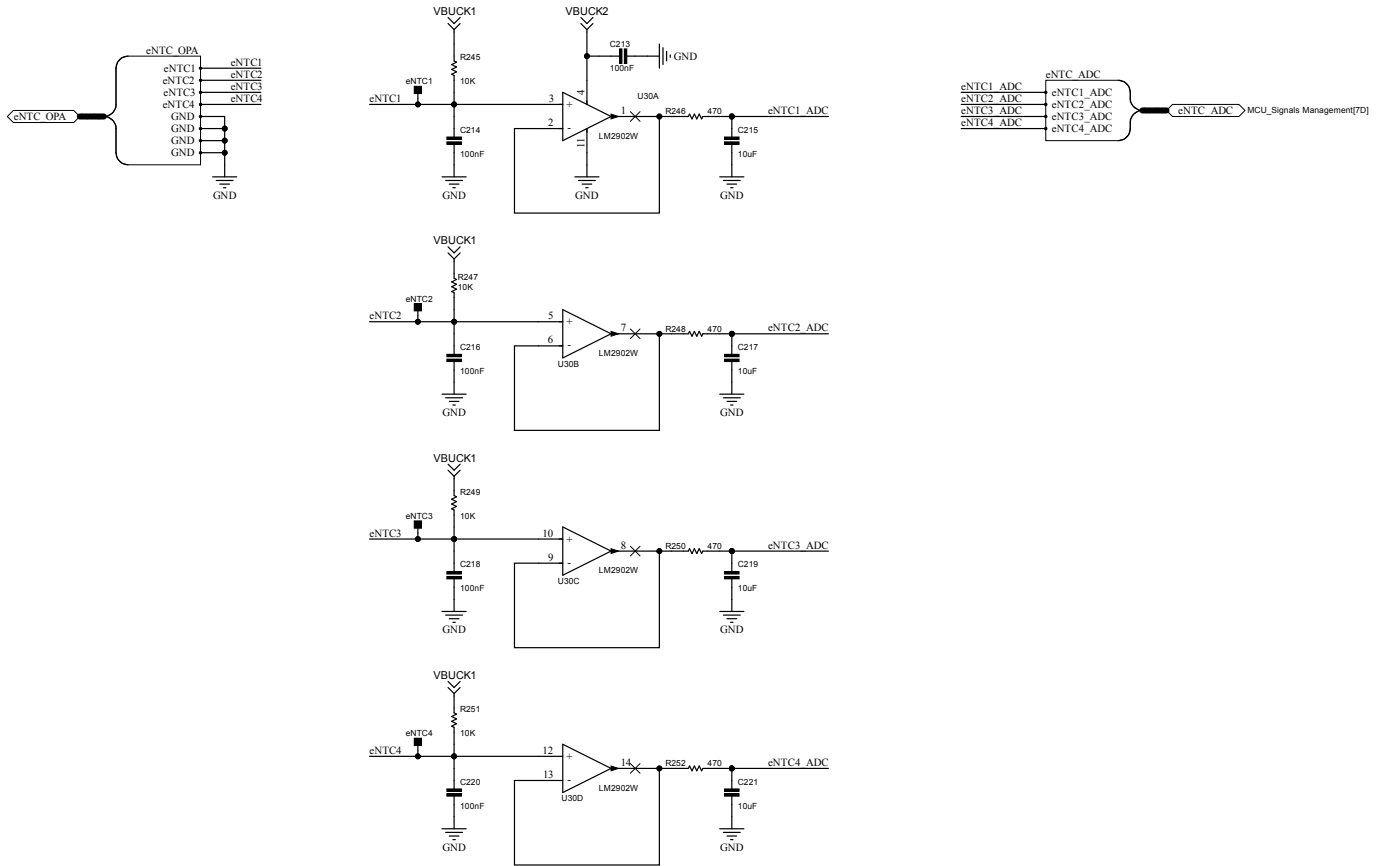
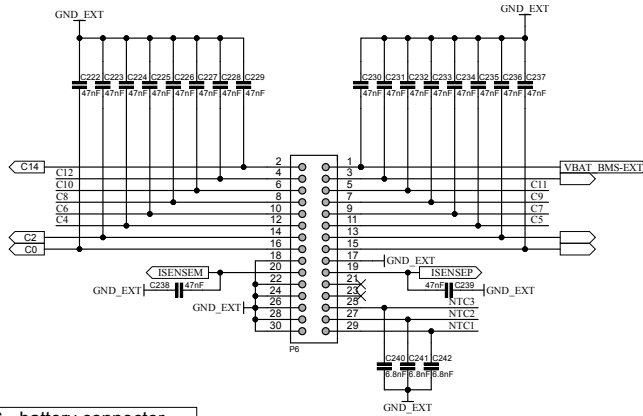
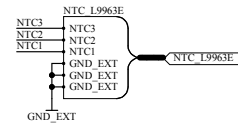
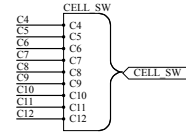


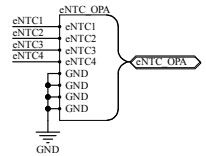
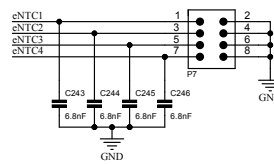
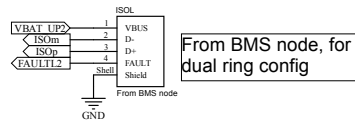
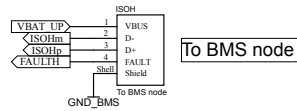
Figure 134. AEK-POW-BMS63EM schematic diagrams (12 of 12)



BMS - battery connector



External Temp sensor



35 Bill of materials
Table 20. AEK-POW-BM63EM bill of materials

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
1	2	C1, C2	47uF	WCAP-PSLP Aluminum Polymer Capacitor, V- Chip SMT, D6.3 x H7.7mm, 47µF, 35V	WE	875105645005
2	8	C4, C8, C9, C10, C11, C12, C30, C170	10uF	1210 - 50V - X7R Class II	WE	885012209073
3	38	C13, C16, C23, C27, C37, C39, C41, C44, C47, C49, C51, C53, C55, C58, C60, C62, C64, C66, C68, C70, C133, C139, C141, C143, C145, C148, C150, C152, C153, C156, C157, C159, C160, C161, C165, C166, C197, C207	10nF	0603 - 50V - X7R Class II	WE	885012206089
4	20	C14, C36, C222, C223, C224, C225, C226, C227, C228, C229, C230, C231, C232, C233, C234, C235, C236, C237, C238, C239	47nF	0603 - 50V - X7R Class II	WE	885012206093
5	5	C15, C215, C217, C219, C221	10uF	0805 - 25V	TAIYO YUDEN	TMK212BC6106MG-T
6	4	C17, C28, C31, C34	47uF	1210 - 16V - X5R Class II	WE	885012109011
7	7	C18, C19, C43, C72, C73, C135, C137	2.2uF	0805 - 25V - X7R Class II	WE	885012207079
8	12	C20, C57, C106, C107, C177, C178, C179, C182, C184, C185, C186, C189	4.7uF	0805 - 25V - X5R Class II	WE	885012107018

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
9	71	C21, C22, C26, C29, C32, C38, C40, C42, C45, C46, C48, C50, C52, C54, C56, C59, C61, C63, C65, C67, C69, C71, C76, C79, C84, C85, C86, C87, C88, C92, C93, C99, C100, C101, C103, C105, C109, C110, C111, C112, C113, C114, C115, C116, C117, C118, C119, C120, C121, C122, C123, C124, C125, C126, C162, C163, C164, C180, C181, C187, C188, C191, C196, C200, C206, C210, C213, C214, C216, C218, C220	100nF	0603 - 50V - X7R Class II	WE	885012206095
10	5	C24, C25, C74, C75, C192	22uF	1210 - 25V - X7R Class II	WE	885012209074
11	4	C33, C90, C95, CGS1	4.7nF	0603 - 50V - X7R Class II	WE	885012206087
12	1	C35	3.3uF	1206 - 25V - X7R Class II	WE	885012208067
13	4	C77, C78, C102, C104	10uF	1206 - 50V - X5R Class II	WE	885012108022
14	3	C80, C132, C138	N.M.	0603	N.A.	N.A.
15	1	C81	1nF	0603 - 50V - X7R Class II	WE	885012206083
16	12	C82, C83, C97, C98, C144, C147, C151, C155, C193, C202, C203, C212	22pF	0603 - 50V - NP0 Class I	WE	885012006053
17	4	C89, C91, C94, C96	47pF	0603 - 50V - NP0 Class I	WE	885012006055
18	1	C108	3.3uF	0805 - 25V - X5R Class II	WE	885012107017
19	3	C127, C129, C136	100nF	0603 - 100V - X7R Class II	WE	885012206120
20	1	C128	100pF	0603 - 100V - X7R Class II	WE	885012206102
21	1	C130	4.7uF	1206 - 50V - X7R Class II	WE	885012208094

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
22	1	C131	2.2uF	1210 - 100V - X7R Class II	WE	885012209071
23	1	C134	220nF	0603 - 50V - X7R Class II	WE	885012206125
24	10	C140, C146, C154, C190, C194, C198, C199, C204, C208, C209	1uF	0805 - 50V - X7R Class II	WE	885012207103
25	6	C142, C149, C195, C201, C205, C211	N.M.	1206	N.A.	N.A.
26	4	C158, C167, C168, C169	2.2nF	0603 - 50V - X7R Class II	WE	885012206085
27	1	C171	68nF	0603 - 50V - X7R Class II	WE	885012206094
28	1	C172	33pF	0603 - 50V - NP0 Class I	WE	885012006054
29	10	C173, C174, C175, C240, C241, C242, C243, C244, C245, C246	6.8nF	0603 - 50V - X7R Class II	WE	885012206088
30	2	C176, C183	N.M.	0805 - xxV - xxxx	N.A.	N.A.
31	1	CN1	Con 7P	2.54mm - 1 row - KK254 - Male	WE	61900711121
32	2	CN2, CN3	Con 2P	2.54mm - 1 row - KK254 - Male	WE	61900211121
33	1	D1	SMCJ24CA-TR, SMC - NP	SMC TVS - 24VDC - Bidirectional	ST	SMCJ24CA-TR
34	1	D2	SM4T18AY, SMA	SMA TVS - 15VDC - Unidirectional	ST	SM4T18AY
35	2	D3, D4	STPS30L30DJF -TR< PowerFLAT 5x6_WF type C	30 V, 30 A high efficiency PowerFLAT power Schottky diode	ST	STPS30L30DJF-TR
36	9	D5, D14, D19, D20, D21, D22, D23, D24, D26	Green	0805 - Led Green - 3.2V	WE	150080GS75000
37	2	D6, D8	STPS5H100AF Y, SOD-128 FLAT	Automotive 100V, 5A Power Schottky Rectifier	ST	STPS5H100AFY
38	5	D7, D9, D13, D36, D41	Yellow	0805 - Led Yellow - 2V	WE	150080YS75000
39	1	D10	STPS1045SFY, TO-277A	Automotive 45V, 10A Power Schottky Rectifier	ST	STPS1045SFY
40	5	D11, D28, D30, D37, D42	Blue	0805 - Led Blue - 3.2V	WE	150080BS75000

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
41	1	D12	STPS340U, SMB	SMB Power Schottky Rectifier - 40VDC - Unidirectional	ST	STPS340U
42	5	D15, D29, D31, D35, D40	Amber	0805 - Led Amber - 2V	WE	150080AS75000
43	3	D16, D34, D39	Red	0805 - Led Red - 2V	WE	150080RS75000
44	2	D17, D18	ESDCAN24-2B LY, SOT23	Automotive dual-line TVS in SOT23-3L for CAN bus	ST	ESDCAN24-2BLY
45	2	D25, D33	SMA6T68AY, SMA	SMA TVS - 68VDC - Unidirectional	ST	SMA6T68AY
46	1	D27	SZMM3Z4V7T1 G	4.7V Zener Voltage Regulators, 300mW	Onsemi	SZMM3Z4V7T1G
47	1	D32	BZT585B11T-7	11V Zener Voltage Regulators, 350mW	DIODES	BZT585B11T-7
48	1	F1	0451003.MRL	451/453 Series -Very Fast-Acting Fuse -3A	LittleFuse	0451003.MRL
49	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 0.15Ohm DCR 0805	TDK	MPZ2012S102ATD25
50	2	ISOH, ISOL	USB 2.0 Type A Receptacle	USB 2.0 Type A, Receptacle, Horizontal, THT	WE	61400416021
51	1	J1	Con JTAG	2.54mm - IDC, Male Box Header WR-BHD, THT, Vertical	WE	61201421621
52	10	JP2, JP3, JP4, JP22, JP23, JP24, JP25, P4, P5, P9	Header 2p 2.54, Jumper 2p	2.54mm - WR-PHD Pin Header, THT, pitch 2.54mm, Single Row, Vertical, 2p, THT Vertical 2 pins Header, Pitch 2.54 mm, Single Row, 2.54mm - Pin Header, THT, pitch 2.54mm, Single Row, Vertical, 2p	WE	61300211121
53	7	JP6, JP7, JP8, JP9, JP10, JP13, JP21	0	0805_Jumper 3p Closed SMD	Vishay	RCC08050000Z0EA

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
54	20	JP11, JP12, JP14, JP15, JP16, JP17, JP18, JP19, JP20, R26, R27, R65, R70, R100, R104, R105, R109, R126, R190, R219	0	0603_Jumper 2p Closed SMD, 0603 - ±1% - 0.1W	Panasonic	ERJ3GEY0R00V
55	1	L1	1uH	WE-LHMI SMT Power Inductor, size 7050, 1uH, 11.4A, 8.3mOhm	WE	74437346010
56	2	L2, L3	15uH	WE-LHMI SMT Power Inductor, size 7050, 15uH, 3.6A, 81mOhm	WE	74437349150
57	1	L4	3.3uH	WE-LHMI SMT Power Inductor, size 7050, 3.3uH, 7.5A, 19mOhm	WE	74437349033
58	1	L5	10uH	WE-LHMI SMT Power Inductor, size 7050, 10uH, 4.05A, 27mOhm	WE	74437349100
59	9	L6, L7, L9, L10, L12, L13, L14, L15, L16	60	WE-CBF SMT EMI Suppression Ferrite Bead. 60 Ohm, 500mA	WE	74279267
60	2	L8, L11	51uH	WE-SLM SMT Common Mode Line Filter - 51uH	WE	744242510
61	1	L17	2.2uH	WE-PD2A SMT Power Inductor, size 4352, 2.2uH, 2.5A, 34mOhm	WE	784773022
62	1	P1	Con 2p 5.08_green	5.08mm - WR- TBL Series 2135 - Horizontal Entry Modular	WE	691213510002
63	1	P2	Header 4p 2.54	2.54mm - WR- PHD Pin Header, THT, pitch 2.54mm, Single Row, Vertical, 4p	WE	61300411121
64	1	P3	65100516121	WR-COM Mini USB 2.0 Type B SMT Horizontal 5 Contacts	WE	65100516121

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
65	1	P6	Con 30p_2.00	2.00mm - WR-WTB - Male Dual Row Horizontal Shrouded Header w. positive locking	WE	62403021722
66	1	P7	Con 8p_2.00	2.00mm - WR-WTB THT Male Horizontal Shrouded Header with positive locking, Dual Row, pitch 2mm, 8pins	WE	62400821722
67	1	Q1	STD45P4LLF6A G, DPAK_TO-252	Automotive-grade P-channel -40 V, 12 mΩ typ., -50 A STRipFET™ F6 Power MOSFET in a DPAK package	ST	STD45P4LLF6AG
68	1	Q2	STL105N4LF7A G, PowerFLAT 5x6_WF type C	Automotive-grade N-channel 40 V, 3.0 mΩ typ., 105 A STRipFET™ F7 Power MOSFET in a PowerFLAT™ 5x6 package	ST	STL105N4LF7AG
69	11	Q3, Q4, Q5, Q22, Q23, Q24, Q25, Q26, Q27, Q28, Q29	STR2N2VH5, SOT23	N-channel 20 V, 0.025 Ω typ., 2.3 A STRipFET™ H5 Power MOSFET in a SOT-23 package	ST	STR2N2VH5
70	1	Q6	STL4P3LLH6, POWERFLAT_2 X2_STM	P-channel 30 V, 48 mΩ typ., 4 A, STRipFET H6 Power MOSFET in a PowerFLAT 2x2 package	ST	STL4P3LLH6
71	1	Q7	STL6N3LLH6, POWERFLAT_2 X2_STM	N-channel 30 V, 0.021 Ω typ., 6 A STRipFET™ H6 Power MOSFET in a PowerFLAT™ 2x2 package	ST	STL6N3LLH6
72	1	Q8	2STR2160, SOT23	PNP Low voltage fast-switching power transistor 60V 1A	ST	2STR2160

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
73	1	Q9	STL8N10LF3, PowerFLAT 5x6_WF type C	Automotive- grade N- channel 100 V, 25 mΩ typ., 7.8 A STripFET™ F3 Power MOSFET in a PowerFLAT™ 5x6 package	ST	STL8N10LF3
74	1	Q10	STD105N10F7 AG, DPAK_TO-252	Automotive- grade N- channel 100 V, 6.8 mΩ typ., 80 A, STripFET™ F7 Power MOSFET in a DPAK package	ST	STD105N10F7AG
75	10	Q11, Q12, Q13, Q14, Q15, Q16, Q17, Q18, Q19, Q21	STL7N6F7, POWERFLAT_2 X2_STM	N-channel 60 V, 21 mΩ typ., 7 A STripFET™ F7 Power MOSFET in a PowerFLAT™ 2x2 package	ST	STL7N6F7
76	1	Q20	2STF1360, SOT89	NPN Low voltage fast- switching power transistors	ST	2STF1360
77	1	R2	22K	0603 - ±1% - 0.25W	Panasonic	ERJ-UP3F2202V
78	15	R3, R7, R9, R14, R22, R33, R34, R72, R92, R173, R175, R181, R183, R185, RG1	1K	0603 - ±1% - 0.25W	Panasonic	ERJPA3F1001V
79	1	R4	150K	0603 - ±5% - 0.25W	Panasonic	ERJ-PA3J154V
80	1	R5	2.2	0603 - ±5% - 0.25W	Panasonic	ERJ-PA3J2R2V
81	1	R6	9.1K	0603 - ±1% - 0.25W	Panasonic	ERJ-PA3F9101V
82	5	R8, R246, R248, R250, R252	470	0603 - ±1% - 0.125W	Panasonic	ERJH3EF4700V
83	3	R10, R71, RPD1	100K	0603 - ±1% - 0.2W	Panasonic	ERJP03F1003V
84	2	R11, R17	5.1K	0603 - ±1% - 0.1W	Panasonic	ERJ-3EKF5101V
85	6	R12, R98, R103, R106, R107, R108	1.5K	0603 - ±1% - 0.25W	Panasonic	ERJ-PA3F1501V
86	5	R13, R32, R69, R220, R225	N.M.	0603	N.A.	N.A.
87	3	R15, R16, R19	30K	0603 - ±1% - 0.33W, 0603 - ±1% - 0.25W	Panasonic	ERJ-PA3F3002V

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
88	11	R18, R57, R59, R170, R178, R200, R201, R202, R230, R231, R232	3.3K	0603 - $\pm 1\%$ - 0.25W	Panasonic	ERJ-PA3F3301V
89	45	R23, R25, R28, R35, R36, R37, R38, R39, R42, R43, R113, R116, R118, R120, R123, R127, R129, R132, R135, R139, R141, R144, R150, R153, R157, R196, R197, R199, R204, R205, R206, R210, R212, R213, R214, R226, R227, R229, R234, R235, R236, R240, R242, R243, R244	100	0603 - $\pm 1\%$ - 0.125W	Panasonic	ERJH3EF1000V
90	1	R24	1.6K	0603 - $\pm 1\%$ - 0.25W	Panasonic	ERJ-UP3F1601V
91	1	R29	7.5K	0603 - $\pm 1\%$ - 0.25W	Panasonic	ERJ-UP3F7501V
92	20	R30, R31, R40, R53, R56, R61, R64, R66, R75, R80, R82, R87, R88, R93, R143, R207, R208, R237, R238, RMREG	N.M.	0603	N.A.	N.A.
93	1	R41	0	0603 - jumper - 1A	Panasonic	ERJH3G0R00V
94	22	R44, R45, R67, R68, R96, R145, R188, R189, R191, R192, R198, R209, R217, R218, R223, R224, R228, R239, R245, R247, R249, R251	10K	0603 - $\pm 1\%$ - 0.2W	Panasonic	ERJP03F1002V
95	3	R46, R48, R112	0	0805 - jumper - 0.25W	Vishay	RCC08050000Z0EA
96	4	R47, R49, R171, R179	N.M.	0805	N.A.	N.A.
97	7	R51, R52, R54, R77, R78, R84, R85	22	0603 - $\pm 1\%$ - 0.125W	Panasonic	ERJH3EF22R0V
98	5	R58, R110, R163, R164, R165	3.9K	0603 - $\pm 1\%$ - 0.1W	Panasonic	ERJ3EKF3901V

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
99	7	R62, R63, R94, R95, R97, R101, R102	4.7K	0603 - ±1% - 0.25W	Panasonic	ERJPA3F4701V
100	1	R73	680	0603 - ±1% - 0.25W	Panasonic	ERJPA3F6800V
101	2	R74, R81	47K	0603 - ±1% - 0.25W	Panasonic	ERJPA3F4702V
102	12	R76, R79, R83, R86, R121, R124, R131, R133, R186, R187, R215, R216	60.4	0603 - ±1% - 0.1W	Panasonic	ERJ3EKF60R4V
103	1	R89	12K	0603 - ±1% - 0.1W	Panasonic	ERJ-3EKF1202V
104	4	R90, R91, R158, R162	10	0603 - ±1% - 0.25W	Panasonic	ERJPA3F10R0V
105	1	R99	2.2K	0603 - ±1% - 0.1W	Panasonic	ERJ-3EKF2201V
106	1	R111	10K	1206 - ±1% - 0.66W	Panasonic	ERJUP8F1002V
107	5	R114, R169, R177, R203, R233	2.7K	0603 - ±1% - 0.1W	Vishay	MCT06030C2701FP500
108	14	R115, R117, R119, R122, R125, R128, R130, R134, R137, R140, R142, R149, R151, R156	39	2010 - ±1% - 1.25W	TE Connectivity	CRGP2010F39R
109	3	R136, R193, R195	6.2K	0805 - ±1% - 0.5W	Panasonic	ERJP06F6201V
110	1	R138	18K	0603 - ±1% - 0.2W	Panasonic	ERJP03F1802V
111	8	R146, R147, R148, R159, R160, R161, R172, R180	10K	0805 - ±1% - 0.5W	Panasonic	ERJP6WF1002V
112	3	R152, R154, R155	1.5K	2010 - ±1% - 2W	TE Connectivity	35021K5FT
113	3	R166, R167, R168	10K	0603 - ±1% - 0.1W	TDK	NTCG163JH103HTDS
114	2	R174, R182	1R	1206 - ±1% - 0.75W	Bourns	CHP1206QFW-1R00ELF
115	2	R176, R184	47R	1206 - ±1% - 0.75W	Bourns	CHP1206AFX-47R0ELF
116	1	R194	750	0603 - ±0.5% - 0.25W	Panasonic	ERJUP3D7500V
117	2	R211, R241	110K	0603 - ±1% - 0.25W	Panasonic	ERJPA3F1103V
118	1	RHOT1	47	2512 - ±5% - 1W	TE Connectivity	352047RJT
119	2	S1, S2	ButtonSwitch	Switch	WE	430152043826

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
120	3	T1, T2, T3	120uH	Pulse Transformers 120uH	Sumida America Inc.	ESMIT-4180/A
121	1	U2	SPSB100BTR, QFN56 8x8x1mm	Automotive Power management IC for highly integrated processors (1Boost+3Buck +2LDO)	ST	SPSB100BTR/SPSB100G
122	1	U3	SPC58NN84E7 RMHBR, LQFP176 24x24x1.4mm	32-bit Power Architecture microcontroller for automotive ASIL-D applications	ST	SPC58NN84E7RMHBR
123	1	U4	STM6315SDW1 3F, SOT143-4	STMICROELECTRONICS - STM6315SDW1 3F - Reset Circuit, Active-Low, Open-Drain, 1V to 5.5V, 2.93V Threshold, 1 Monitor	ST	STM6315SDW13F
124	2	U5, U6	MCP2542WFD	CAN FD Transceiver with Wake-up Pattern (WUP) Option	Microchip	MCP2542WFD
125	1 N.M.	U7	FT2232HL	USB Hi-Speed to Dual Channel Serial UART/ FIFO/ JTAG/SPI/I2C	FTDI Chip	FT2232HL NOT mounted
126	8	U8, U9, U10, U12, U13, U14, U17, U18	SN74LVC1T45 DCK	Single-Bit Dual-Supply Bus Transceiver With Configurable Voltage Translation and 3-State Outputs	Texas Instruments	SN74LVC1T45DCK
127	5	U11, U20, U21, U26, U29	USBLC6-2SC6 Y, SOT23-6L	Automotive ESD protection for high speed interfaces.	ST	USBLC6-2SC6Y
128	1	U15	LD1117S33TR, SOT-223	The LD1117330TR is a low drop voltage regulator able to provide up to 800 mA of output current. Vout is 3.3V.	ST	LD1117S33TR

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
129	1	U16	M93S46-WMN6TP, SO-8	1Kbit (64x16) Serial Microwire Bus EEPROM With Block Protection	ST	M93S46-WMN6TP
130	1	U19	L9963F-TR, TQFP64	Automotive chip for battery management applications with daisy chain up to 31 devices	ST	L9963F-TR
131	2	U22, U23	STGAP2GSC, SO-8W	Galvanically isolated 3 A single gate driver for Enhancement mode GaN FETs_Gate driving voltage up to 15 V	ST	STGAP2GSC
132	1	U24	176881212	MagI3C Power Module FISM – Fixed Isolated SMT Module, Vin 4.5V - 5.5V - Vout 12V - Iout 84mA	WE	176881212
133	2	U25, U28	L9963T, SO16N	Automotive general purpose SPI to isolated SPI transceiver	ST	L9963T
134	1	U27	140357145300	WL-OCPT Optocoupler Phototransistor, SOP4, 1 Channel, DC, 35V, 60mA	WE	140357145300
135	1	U30	LM2902WYDT, SO14	Low-power quad operational amplifier	ST	LM2902WYDT
136	1	X1	40Mhz	WE-XTAL Quartz Crystal, SMT, CFPX-104, 40MHz, +/-20ppm	WE	830059537
137	1	X2	12Mhz	WE-XTAL Quartz Crystal, SMT, CFPX-104, 12MHz, +/-30ppm	WE	830055999
138	8	for blister	609002115121	WR-PHD 2.54 mm Multi-Jumper Jumper with Test Point	WE	609002115121
139	4	for blister	970100365	WA-SPAll Plastic Spacer Stud, metric, internal/ internal	WE	970100365

Item	Q.ty	Ref.	Part/value	Description	Manufacturer	Order code
140	4	for blister	97790603211	WA-SCRW Pan Head Screw w. cross slot M3	WE	97790603211
141	1	for blister	624030213322	WR-WTB 2.00 mm Female Dual Row Terminal Housing w. positive locking	WE	624030213322
142	1	for blister	624008213322	WR-WTB 2.00 mm Female Dual Row Terminal Housing w. positive locking	WE	624008213322
143	1	for blister	62400113722D EC	WR-WTB 2.00 mm Female Dual Row Crimp Contact	WE	62400113722DEC
144	1	for blister	61900711621	WR-WTB 2.54 mm Female Terminal Housing	WE	61900711621
145	2	for blister	61900211621	WR-WTB 2.54 mm Female Terminal Housing	WE	61900211621
146	1	for blister	61900113722D EC	WR-WTB 2.54 mm Female Crimp Contact	WE	61900113722DEC

36 AEK-POW-BMS63EM board versions

Table 21. AEK-POW-BMS63EM versions

Finished good	Schematic diagrams	Bill of materials
AEK\$POW-BMS63EMA ⁽¹⁾	AEK\$POW-BMS63EMA schematic diagrams	AEK\$POW-BMS63EMA bill of materials

1. This code identifies the AEK-POW-BMS63EM evaluation board first version. It is printed on the board PCB.

37 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.

À des fins d'évaluation uniquement. Ce kit génère, utilise et peut émettre de l'énergie radiofréquence et n'a pas été testé pour sa conformité aux limites des appareils informatiques conformément aux règles d'Industrie Canada (IC).

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 conformity with the relevant provisions of the following EU legislation recognized by the United Kingdom:

- Electromagnetic Compatibility Regulations 2016 (S.I. 2016/1091) implementing Directive 2014/30/EU (EMC). Compliance to EMC standards in Class A (industrial intended use).
- The Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012 (RoHS) (S.I. 2012/3032) implementing Directive 2011/65/EU (RoHS II), including subsequent revisions and additions, as well as amended by the Delegated Directive 2015/863/EU (RoHS III).

Revision history

Table 22. Document revision history

Date	Version	Changes
16-May-2023	1	Initial release.
20-May-2024	2	Updated title in cover page. Added AEK-POW-BMSNOTX overview. Minor text changes.
08-Aug-2024	3	Updated Introduction, <i>Section 1.6.2.2.2: Addressing procedure</i> , BMS topologies, <i>Section 3: Voltage conversion routine</i> , <i>Section 7: Fault condition in daisy chains</i> , <i>Section 10: AutoDevKit ecosystem</i> , <i>Section 10.5: Available demos</i> , <i>Section 11: Available APIs and Section 14.1: Process timing</i> . Added <i>Section 1: BMS evaluation board overview</i> , <i>Section 1.5: Embedded devices</i> , <i>Section 5: Cell current measurement</i> , <i>Section 23: AEK-POW-BMSWTX schematic diagrams</i> , <i>Section 24: AEK-POWBMSWTX bill of materials</i> , <i>Section 25: AEK-POW-BMSWTX Board versions</i> and <i>Section 26: AEKPOW-BMSWTX regulatory compliance information</i> . Minor text changes.
21-May-2025	4	Updated Section Introduction, Section 1: BMS evaluation board overview, Section 2: BMS topologies and Section 10: AutoDevKit ecosystem . Added BMS GUI, Section 26: AEK-POW-BMSCC schematic diagrams, Section 27: Bill of materials, Section 28: Board versions, Section 29: Regulatory compliance information, Section 30: AEK-POWBMSCCTX schematic diagrams, Section 31: Bill of materials, Section 32: Board versions and Section 33: Regulatory compliance information.
06-Jun-2025	5	Updated Section 27: Bill of materials and Section 31: Bill of materials .
27-May-2026	6	Updated Section Introduction , Section 1.5: AEK-POW-BMS63EM evaluation board , Section 1.4.3: Additional information on daisy chain configuration for AEK-POW-BMCC and AEK-POW-BMSCCTX and Figure 87. Available demos . Added Section 1.5: AEK-POW-BMS63EM evaluation board , Figure 87. Available demos , Section 35: Bill of materials , Section 36: AEK-POW-BMS63EM board versions and Section 37: Regulatory compliance information . Minor text changes.

Contents

1	BMS evaluation board overview	3
1.1	AEK-POW-BMS63EN overview	3
1.1.1	Features	3
1.1.2	Main components	3
1.2	AEK-POW-BMSNOTX overview	5
1.2.1	Features	6
1.2.2	Main components	6
1.3	AEK-POW-BMSWTX overview	8
1.3.1	Features	9
1.3.2	Main components	9
1.4	Compact BMS evaluation boards	11
1.4.1	AEK-POW-BMCC overview	11
1.4.2	AEK-POW-BMSCCTX overview	12
1.4.3	Additional information on daisy chain configuration for AEK-POW-BMCC and AEK-POW-BMSCCTX	14
1.5	AEK-POW-BMS63EM evaluation board	15
1.5.1	Features	15
1.5.2	Main components	16
1.5.3	SPSB100	18
1.5.4	SPC58NN84E7RMHBR	19
1.5.5	STGAP2GS	20
1.5.6	LM2902W and external temperature sensors	21
1.5.7	Temperature sensors managed by L9963F	22
1.5.8	Other peripherals	22
1.5.9	Battery pack configurations	25
1.6	Embedded devices	34
1.6.1	L9963E/L9963F	34
1.6.2	L9963T	34
1.7	Voltage operating range	34
1.7.1	Linear regulators	35
1.7.2	Simplified state machine	35
2	BMS topologies	39
2.1	Centralized configuration	39
2.2	Dual access ring configuration	40
3	Voltage conversion routine	42
4	Coulomb counting routine	44

5	Cell current measurement	45
6	L9963E/L9963F safety and diagnostic features	46
6.1	Cell UV/OV diagnostic	46
6.2	Total battery VBAT diagnostic	46
6.3	VBAT overvoltage	46
6.4	VBAT undervoltage	46
6.5	Cell open wire diagnostic	46
6.5.1	Cell open with ADC_CROSS_CHECK = 0	46
6.5.2	Cell open with ADC_CROSS_CHECK = 1	47
6.6	PCB open diagnostic	47
6.7	Die temperature diagnostic and overtemperature	47
7	Fault condition in daisy chains	48
8	L9963E/L9963F cell balancing	49
8.1	Passive cell balancing with internal MOSFETs	49
9	Methods for SOC estimation	50
10	AutoDevKit ecosystem	52
10.1	AEK-POW-BMSCHAIN component folder structure	52
10.2	Software component architecture (AEK-POW-BMSCHAIN component RLA)	52
10.3	How to import the AEK-POW-BMSCHAIN component in AutoDevKit	53
10.4	Chain allocation	56
10.5	Available demos	73
10.5.1	Centralized application (SPC58EC - AEK_POW_BMSWTX_SOC_Est_SingleAccess_CHAIN application for discovery demo)	74
10.5.2	Dual ring application (SPC58EC - AEK_POW_BMSWTX_DualAccess_CHAIN application for the discovery demo)	76
10.5.3	Single centralized application (SPC58EC - AEK_POW_BMS63EN_SOC_Estimation_Single application for discovery demo)	77
11	Available APIs	80
12	BMS GUI	86
12.1	System setup	89
12.1.1	Hardware setup and firmware flashing	89
13	Waveforms	98
13.1	Process timing	99
14	AEK-POW-BMS63EN schematic diagrams	100
15	AEK-POW-BMS63EN bill of materials	101
16	AEK-POW-BMS63EN board versions	104

17	AEK-POW-BMS63EN regulatory compliance information	105
18	AEK-POW-BMSNOTX schematic diagrams	106
19	AEK-POW-BMSNOTX bill of materials	108
20	AEK-POW-BMSNOTX board versions	112
21	AEK-POW-BMSNOTX regulatory compliance information.....	113
22	AEK-POW-BMSWTX schematic diagrams	114
23	AEK-POW-BMSWTX bill of materials	116
24	AEK-POW-BMSWTX Board versions	121
25	AEK-POW-BMSWTX regulatory compliance information.....	122
26	AEK-POW-BMSCC schematic diagrams	123
27	Bill of materials.....	124
28	Board versions	128
29	Regulatory compliance information	129
30	AEK-POW-BMSCCTX schematic diagrams	130
31	Bill of materials.....	131
32	Board versions	136
33	Regulatory compliance information	137
34	AEK-POW-BMS63EM schematic diagrams	138
35	Bill of materials.....	149
36	AEK-POW-BMS63EM board versions.....	161
37	Regulatory compliance information	162
	Revision history	163

List of figures

Figure 1.	AutoDevKit BMS evaluation board range	2
Figure 2.	AEK-POW-BMS63EN main components (top view)	4
Figure 3.	AEK-POW-BMS63EN main components (bottom view)	5
Figure 4.	AEK-POW-BMSNOTX main components (top view)	7
Figure 5.	AEK-POW-BMSNOTX main components (bottom view)	8
Figure 6.	AEK-POW-BMSWTX main components (top view)	10
Figure 7.	AEK-POW-BMSWTX main components (bottom view)	11
Figure 8.	AEK-POW-BMSCC main components (top view)	12
Figure 9.	AEK-POW-BMSCC main components (bottom view)	12
Figure 10.	AEK-POW-BMSCCTX main components (top view)	13
Figure 11.	AEK-POW-BMSCCTX main components (bottom view)	13
Figure 12.	Example of daisy chain using AEK-POW-BMSCC and AEK-POW-BMSCCTX evaluation boards and AEK-BMSGUI	14
Figure 13.	Daisy chain node connections	14
Figure 14.	AEK-POW-BMS63EM, main components (top view)	16
Figure 15.	AEK-POW-BMS63EM, main components (bottom view)	17
Figure 16.	SWDBG pin schematic View.	19
Figure 17.	SWDBG pin 3D view	19
Figure 18.	STGAP2GS control circuit - schematic view	20
Figure 19.	LM2902W operational amplifiers - schematic view.	21
Figure 20.	External temperature sensor connection to the AEK-POW-BMS63EM - 3D view	21
Figure 21.	Temperature sensor managed by L9963F	22
Figure 22.	Schematic view of the BMS connector [P6].	22
Figure 23.	CAN connector [CN3]	23
Figure 24.	JTAG connector [J1]	23
Figure 25.	RESET button - schematic view	24
Figure 26.	Serial interface (in blue) - schematic view.	24
Figure 27.	LEDs - schematic view	25
Figure 28.	Guide for unmounted cells in the L9963F	27
Figure 29.	Battery pack with 14 cells.	28
Figure 30.	Battery pack with 6 cells	29
Figure 31.	Battery pack with 10 cells configuration A.	30
Figure 32.	Battery pack with 10 cells configuration B.	31
Figure 33.	Dual ring configuration for the AEK-POW-BMS63EM.	32
Figure 34.	Dual ring configuration – schematic view	33
Figure 35.	State machine	35
Figure 36.	Daisy chain addressing procedure	36
Figure 37.	Addressing procedure example for the AEK-POW-BMS63EN	37
Figure 38.	Centralized BMS diagram	39
Figure 39.	Example of centralized BMS chain using the AEK-POW-BMS63EN with the AEK-COM-ISOSPI1 and the AEK-MCU-C4MLIT1	40
Figure 40.	Dual access ring BMS diagram	40
Figure 41.	Dual ring configuration example for the AEK-POW-BMS63EN	41
Figure 42.	Finite state machine of the voltage conversion routine	43
Figure 43.	Fault LED on the AEK-COM-ISOSPI1	48
Figure 44.	Cell monitoring with internal balancing	49
Figure 45.	Equivalent circuit	50
Figure 46.	AEK-POW-BMSCHAIN component folder structure	52
Figure 47.	Software architecture.	53
Figure 48.	Adding components	54
Figure 49.	Adding SPC58ECxx Platform Component RLA	54
Figure 50.	Selecting AEK-POW-BMSCHAIN Component.	55
Figure 51.	AEK-POW-BMSCHAIN component visualization in the Project explorer and application configuration windows.	55

Figure 52.	AEK-POW-BMSCHAIN component selection	56
Figure 53.	Chain customization	56
Figure 54.	Chain topology selection	57
Figure 55.	New node addition and customization	57
Figure 56.	BMS element field customization details	58
Figure 57.	Single Access mode customization	58
Figure 58.	Dual access mode customization	59
Figure 59.	Example of chain configuration	59
Figure 60.	Customizing the sensing resistor.	60
Figure 61.	SPI configuration for single access mode	60
Figure 62.	SPI configuration for dual access mode	61
Figure 63.	Cell selection and configuration	61
Figure 64.	GPIO configuration	62
Figure 65.	GPIO voltage acquisition mode configuration	62
Figure 66.	Voltage thresholds association for enabled cells	63
Figure 67.	Voltage thresholds association for the entire battery pack.	63
Figure 68.	Communication timeout field enabling	64
Figure 69.	Coulomb Counter field enabling	64
Figure 70.	Over Current Threshold Mask field enabling	65
Figure 71.	Overcurrent threshold configuration	65
Figure 72.	ADC Filter SOC field configuration	66
Figure 73.	ADC Filter Cycle field configuration	66
Figure 74.	ADC Filter Sleep field configuration	67
Figure 75.	Periodic acquisition configuration	67
Figure 76.	Vtref voltage regulator configuration	68
Figure 77.	Temperature threshold configuration	68
Figure 78.	MCU ADC voltage configuration when including an AEK-POW-BMSNOTX.	69
Figure 79.	Automatic allocation for all customized chains	69
Figure 80.	AEK-POW-BMSCHAIN library C code generation and compilation	70
Figure 81.	Board View	71
Figure 82.	Connection table example	71
Figure 83.	Pin Map editor allocation	71
Figure 84.	Pin Map editor allocation	72
Figure 85.	Save all	72
Figure 86.	New pin definition	73
Figure 87.	Available demos	73
Figure 88.	SPC58EC - AEK_POW_BMSWTX_SOC_Est_SingleAccess_CHAIN code.	74
Figure 89.	Core 2 enablement	75
Figure 90.	SPC58EC - AEK_POW_BMSWTX_DualAccess_CHAIN code	76
Figure 91.	SPC58EC - AEK_POW_BMSWTX_DualAccess_CHAIN code	77
Figure 92.	BMS GUI main page	86
Figure 93.	BMS GUI tabs	86
Figure 94.	BMS GUI Monitoring tab	87
Figure 95.	BMS GUI Diag tab	88
Figure 96.	BMS GUI Plot tab	88
Figure 97.	Supplying the AEK-MCU-C4MINI1 (1) and switching it on (2)	89
Figure 98.	Switching to debug (1) and selecting Debug Configurations (2)	90
Figure 99.	Inserting the path of your elf file (1) and debugging (2).	90
Figure 100.	Code execution	91
Figure 101.	AutoDevKit board view	91
Figure 102.	Launching the GUI	92
Figure 103.	Hardware setup	92
Figure 104.	Wiring connections among the AEK-POW-BMSWTX and the AEK-MCU-C4MINI1	93
Figure 105.	BMS GUI connection.	94
Figure 106.	BMS GUI node selection	94

Figure 107.	14-cell battery holder mock-up	95
Figure 108.	6-cell battery holder mock-up	95
Figure 109.	14-cell battery holder mock-up	96
Figure 110.	6-cell battery holder mock-up	96
Figure 111.	14-cell battery holder mock-up	97
Figure 112.	6-cell battery holder mock-up	97
Figure 113.	14-cell voltage discharge with an active load of 1 A	98
Figure 114.	Battery pack voltage discharge with an active load of 1 A	98
Figure 115.	14 cell voltages during balancing	99
Figure 116.	AEK-POW-BMS63EN schematic diagram	100
Figure 117.	AEK-POW-BMSNOTX circuit schematic (1 of 2)	106
Figure 118.	AEK-POW-BMSNOTX circuit schematic (2 of 2)	107
Figure 119.	AEK-POW-BMSWTX circuit schematic (1 of 2)	114
Figure 120.	AEK-POW-BMSWTX circuit schematic (2 of 2)	115
Figure 121.	AEK-POW-BMSCC schematic diagram	123
Figure 122.	AEK-POW-BMSCCTX schematic diagram	130
Figure 123.	AEK-POW-BMS63EM schematic diagrams (1 of 12)	138
Figure 124.	AEK-POW-BMS63EM schematic diagrams (2 of 12)	139
Figure 125.	AEK-POW-BMS63EM schematic diagrams (3 of 12)	140
Figure 126.	AEK-POW-BMS63EM schematic diagrams (4 of 12)	141
Figure 127.	AEK-POW-BMS63EM schematic diagrams (5 of 12)	142
Figure 128.	AEK-POW-BMS63EM schematic diagrams (6 of 12)	143
Figure 129.	AEK-POW-BMS63EM schematic diagrams (7 of 12)	144
Figure 130.	AEK-POW-BMS63EM schematic diagrams (8 of 12)	145
Figure 131.	AEK-POW-BMS63EM schematic diagrams (9 of 12)	146
Figure 132.	AEK-POW-BMS63EM schematic diagrams (10 of 12)	146
Figure 133.	AEK-POW-BMS63EM schematic diagrams (11 of 12)	147
Figure 134.	AEK-POW-BMS63EM schematic diagrams (12 of 12)	148

List of tables

Table 1.	STGAP2GS and battery pack configuration table	25
Table 2.	STGAP2GS input and output pin configuration.	26
Table 3.	Chain management APIs	80
Table 4.	CRC APIs	80
Table 5.	ISOSPI management APIs	80
Table 6.	Node management APIs	80
Table 7.	NTC management APIs	84
Table 8.	SPI handling APIs	85
Table 9.	Task process timing	99
Table 10.	AEK-POW-BMS63EN bill of materials.	101
Table 11.	AEK-POW-BMS63EN versions	104
Table 12.	AEK-POW-BMSNOTX bill of materials	108
Table 13.	AEK-POW-BMSNOTX versions	112
Table 14.	AEK-POW-BMSWTX bill of materials	116
Table 15.	AEK-POW-BMSWTX versions	121
Table 16.	AEK-POW-BMSCC bill of materials	124
Table 17.	AEK-POW-BMSCC versions	128
Table 18.	AEK-POW-BMSCCTX bill of materials	131
Table 19.	AEK-POW-BMSCCTX versions	136
Table 20.	AEK-POW-BM63EM bill of materials	149
Table 21.	AEK-POW-BMS63EM versions	161
Table 22.	Document revision history	163

IMPORTANT NOTICE – READ CAREFULLY

STMicroelectronics NV and its subsidiaries (“ST”) reserve the right to make changes, corrections, enhancements, modifications, and improvements to ST products and/or to this document at any time without notice.

In the event of any conflict between the provisions of this document and the provisions of any contractual arrangement in force between the purchasers and ST, the provisions of such contractual arrangement shall prevail.

The purchasers should obtain the latest relevant information on ST products before placing orders. ST products are sold pursuant to ST’s terms and conditions of sale in place at the time of order acknowledgment.

The purchasers are solely responsible for the choice, selection, and use of ST products and ST assumes no liability for application assistance or the design of the purchasers’ products.

No license, express or implied, to any intellectual property right is granted by ST herein.

Resale of ST products with provisions different from the information set forth herein shall void any warranty granted by ST for such product.

If the purchasers identify an ST product that meets their functional and performance requirements but that is not designated for the purchasers’ market segment, the purchasers shall contact ST for more information.

ST and the ST logo are trademarks of ST. For additional information about ST trademarks, refer to www.st.com/trademarks. All other product or service names are the property of their respective owners.

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

© 2026 STMicroelectronics – All rights reserved