FRIWO

Motor-Control Experts

Manual

Battery Pack

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2 Copyright

3 Safety Information, Terms of Use and Liability Waiver

Warning!

Using the BMS referenced in this document can be dangerous. Please follow instructions it with extreme caution. Stop your application work if you encounter unexpected behaviour.

Terms of use

The use of this program, further called "Enable-Tool", can be very dangerous, that means it can cause damage to personal and property.

Use it with extreme care and make sure that you have received instructions for use of it by qualified personnel.

With this software, you are able to influence or control a connected electronic control system such as motor-controllers, battery-management-Systems or other general electronic control devices. Your actions may result in serious personal injury or property damage. Therefore, you should only be using this software if you understand the possible consequences of the actions with this software and if you have been specifically trained to handle this software! Enable-Tool is currently under development and functionality might be subject to change without prior notice or arrangement.

Liability waiver

This is a liability waiver (further called “waiver”) which is made between the parties FRIWO Gerätebau GmbH ("Manufacturer") Von-Liebig-Strasse 11, 48346 Ostbevern and the user of Enable-Tool ("User"). For purposes of this waiver, the definitions of the parties shall be deemed to include any parent, subsidiary, affiliate of, or entity under common control with any entity constituting the parties consisting of Manufacturer and User.

1. Purpose

User desires to get access to the online-network infrastructure of the Manufacturer to obtain a license to use Enable-Tool. User desires to use Enable-Tool to work with one or more electronic-control-units of Manufacturer. The parties acknowledge that advanced electronic-control-units are complex and proprietary devices that require special knowledge, skills and equipment to program and commission. User declares that he has all necessary special knowledge, skills and equipment to work with and apply to such devices.

2. No obligation

Neither party shall be legally obligated in any way as a result of this waiver. The execution of the waiver shall not prevent either party from continuing its independent, ongoing development of technologies, products and other business-related research and development.

3. General

This waiver shall inure to the benefit of and be binding upon the parties and their successors and assigns, provided that the receiving Party may not assign all or a part of this waiver without the prior written consent of the Disclosing Party. If any provision of the waiver is held invalid or unenforceable by a court of competent jurisdiction, such invalidity or unenforceability will not effect any other provision of the waiver, which shall remain in effect.

4. Governing Law

This waiver shall be construed, and the obligations, rights and remedies of the parties hereunder shall be governed by the laws of and subject to the jurisdiction of Kornwestheim, Germany.

5. Entire waiver

This waiver constitutes the entire waiver between the parties with respect to the subject matter herein, and supersedes all prior oral or written waivers, arrangements, and understandings related thereto. This waiver may not be modified or amended except in writing signed by an authorized representative of each Party. WHEREOF, in consideration for the mutual promises contained herein, the parties have caused this waiver to be executed by their authorized representatives. FRIWO Gerätebau GmbH assumes no liability for loss of data, personal injury or damage of property caused by misuse of the program or by use of improper settings. In particular, we expressly point out that Emerge Engineering GmbH under no circumstances warranty / liability for data loss, personal injury or property damage resulting from the direct use of this software takes over.

Disclaimer

1.)

FRIWO (hereinafter includes its parents, affiliates, subsidiaries, partners and suppliers) as a supplier of system components, such as motor controllers, BMS, display, etc. generally excludes any liability or recourse claims in connection with system integration.

2.)

The manufacturer of the end product, e.g. vehicle, machine, etc., hereinafter referred to as system integrator, is solely responsible for the correct system design and integration of the system components. This applies in particular to the mechanical and electrical design of the overall system and to the parameterization of the system components. Any liability for the overall system is excluded by FRIWO. Further, the system Integrator and/or end users shall indemnify FRIWO from any claims and damages resulting from the improper use of the components delivered by FRIWO.

3.)

The system integrator is solely responsible for the parameterization of the overall system, its validation, reliability and safety. FRIWO shall not be liable for any claims or damages which may arise in this connection.

4.)

The system integrator guarantees that the end product complies with the standards and guidelines applicable and/or required for the overall system before it is used on public roads. In case of a market launch or commercial sale to customers, the system integrator ensures that the overall system is certified and approved meeting all safety norms. Any liability for claims or damages on the part of FRIWO shall be excluded.

Examples for relevant standards and guidelines (no claim to completeness, to be checked by the system integrator):

UN 38.3 Recommendations on the Transport of Dangerous Goods

(IEC62281) Safety of primary and secondary lithium cells and batteries during transport (UN 38.3)

UL 62133-2 Secondary Cells and Batteries Containing Alkaline or Other Non-Acid Electrolytes - Safety Requirements for Portable Sealed Secondary Cells, and for Batteries Made From Them, for Use in Portable Applications

UL 2580 Standard for Batteries for Use In Electric Vehicles

UL 2271 Standard for Batteries for Use In Light Electric Vehicle (LEV) Applications

UL 1973 Standard for Batteries for use in Stationary, Vehicle Auxiliary Power, and Light Electric Rail (LER) Applications for data centres, IT equipment, and grid-tied energy storage

UL 2595 General Requirements for Battery-Powered Tools

UL 2054 Household and commercial batteries

5.)

If system components are explicitly provided / delivered to the system integrator without approvals, the system integrator is obliged to obtain the necessary approvals. FRIWO shall not be liable for any claims or damages arising directly or indirectly from breach of the above mentioned obligation by the system integrator.

6.)

If FRIWO supplies system components with the designation "Prototypes" or “Engineering Samples” to the system integrator in the course of the development process, the system integrator will ensure that these system components are only operated under supervision and exclusively for the verification of the use cases and are not placed on the market (end customer). These components may not be used in public areas. FRIWO shall not be liable for any claims or damages arising directly or indirectly from the operation of these components.

7.)

The system integrator ensures that the end product is safe for the end customer and that no danger emanates from it. FRIWO shall not be liable for any claims or damages for the safety of end product.

8.)

The system integrator shall be liable for any operating errors that may lead to personal injury, serious injury or death. The system integrator ensures that the integration and validation is carried out by personnel trained in the relevant technology areas (electrical, electronics, mechanical etc.).

4 General information

Note: Battery application should only be done by well-trained persons with deep knowledge of battery systems. Wrong handling of batteries could cause injuries and death. Under wrong handling Lithium-Ion batteries could cause fire. Changing parameters can have a negative effect on the behaviour of the BMS and could cause fatal errors.. Please observe the following notes when connecting a BMS or making adjustments. In case of questions contact the FRIWO Team.

Note: USB is not available in a fully assembled Battery Pack. For parametrization CAN Bus can be used.

Note: Do not open fully assembled Battery Pack. Opening a Battery Pack could cause injuries, fire and death.

In case of changes of the factory setup the warranty expires. If the parameterset is changed the costumer is responsible for all kind of errors or dangers that may result out of the change.

Note: Technical data and documentation subject to change without notice.

Note: The BMS is equipped with a precharge functionality to avoid hot plug events. It is recommended to use this function to power up external or connected systems. Hot plugging an external system could cause damages

4.1 Usage

Note: This document is not related to the end costumer!

This document describes the functionality and parametrazion of the FRIWO Gerätebau Battery Pack, equipped with BMS Mk2

To setup the BMS you need a Windows PC on which the FRIWO Enable Tool NG is installed in the latest Version.

Parameters on the BMS can be changed or measured during operation using the Enable-Tool software. A description of the Enable tool is provided separately.

4.2 Description of parameters and measured values

This document describes parameters and measured values that influence or make measurable the behaviour of the software at runtime and assumes that you understand the Parameter names according to the following nomenclature:

The formation of variable names follows the following principle:

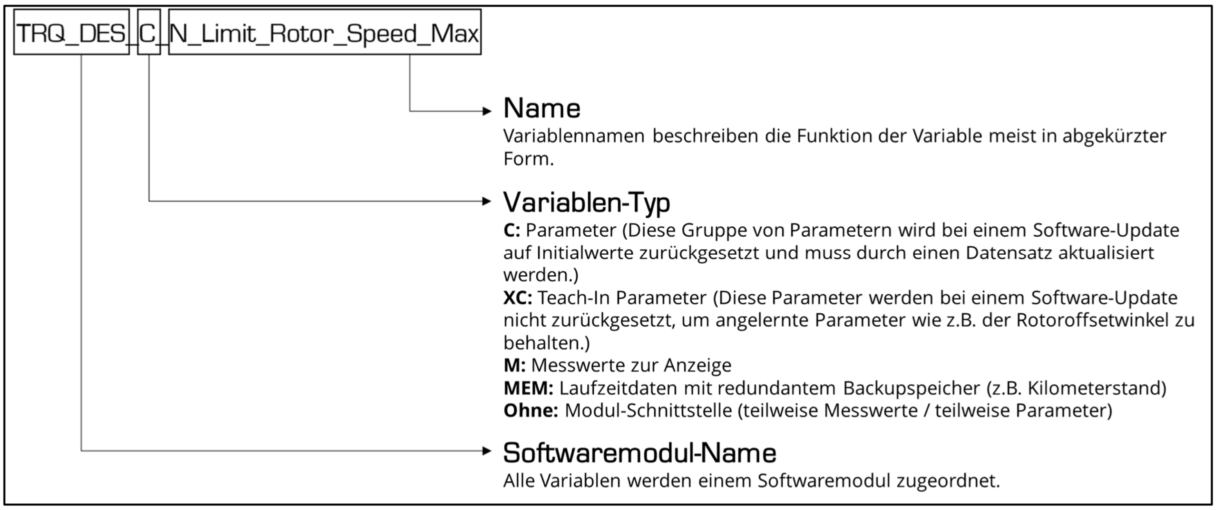


Figure 1: Variable education.

Variables can be adjusted or measured with the FRIWO Enable tool. Read the appropriate instructions before using the Enable tool. The view of the Enable tool is customer-specific configured and can vary depending on the application.

It is therefore possible that not all parameters and measured values described in this document are available to you.

4.3 Important notes on changing parameters

Note: Changing parameters can have a negative effect on the behaviour of the BMS. Please observe the following notes when making adjustments:

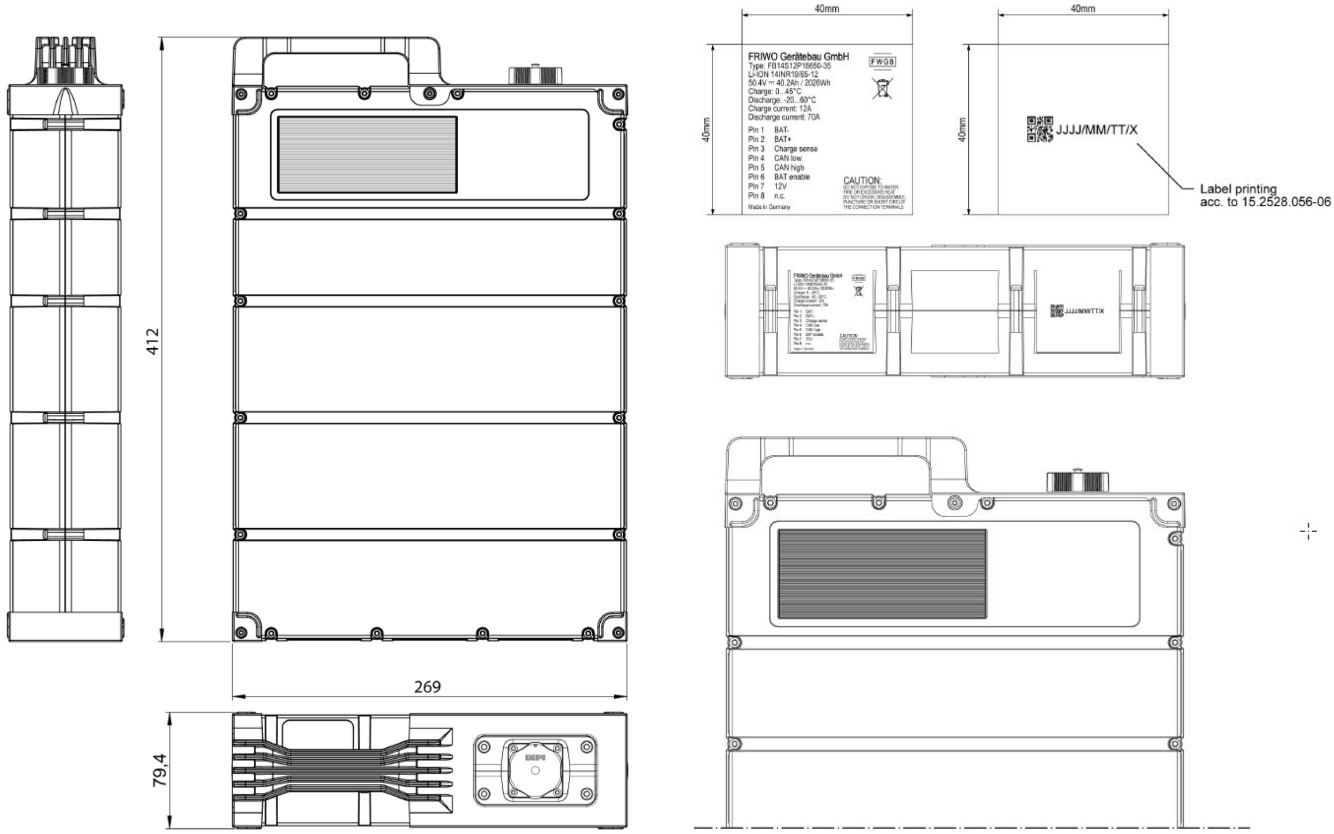
Note: Fully assembled Battery Packs are not intended to change any factory settings. With any change of parameters the warranty will expire .

Note: Changing parameters of a fully assembled Battery Packs could cause injuries, fire and death. Changing parameters can have a negative effect on the behaviour of the BMS and the Battery Pack and could cause fatal errors.

- Start your application work only after you have read this document completely and understood how the parameters work.
- Change parameters in the smallest possible steps.
- Great importance was attached to the safety during the development of the BMS software. Incorrect entries are usually intercepted and parameter changes are limited to safe values.
- However, a residual risk cannot be ruled out with certain changes. You should always use a USB isolator to protect your PC from possible overvoltages and to prevent ground loops in your laboratory or test bench.
- Some critical parameters are monitored by superimposed protective functions, so that only limited changes are possible during peration.
- Confirm the entry of the parameter values by pressing Enter. Save parameters by clicking on "Store Parameters". When restarting the BMS, the stored parameters are retained.

5 Technical Data

5.1 Housing/Dimensions



Weight: approx. 11.05kg

Volume: approx. 8.1l

5.2 Electrical Data Battery Pack

Configuration	14S12P
Cells	18650 Type (Samsung INR 18650-35E; BAK 18650-CP)
nominal voltage	50.4V
nominal capacity	40.2 Ah(0.2C, 2.5V discharge)
nominal energy	2026Wh
Charging voltage	58.8V
Charging method	CC-CV (constant voltage with current limit)
Max. charging current	20A
Recommended charging current	12A
Min. charging current	1A
Max. cont. discharge current	70A
Max. discharge current	Depending on temperature and cooling (see chapter 5.4)
Short circuit detection level	153A (<10µµsec)
Discharge cut off voltage	42V recommended, depending on the application and parametrization of the BMS , min. 37.1V not for cycle life
Operation temperature	Charge: 0 to 45°C Discharge: -10 to 60°C
Power Density	250Wh/l 183,41Wh/kg

5.3 BMS Mk2

Type:	1960815 or Variants
BMS cell configuration:	14S Li-Ion (HW Coded)
Max pack voltage:	60V
Max continuous Current:	70A (with Heatsink, 60A open Frame)
Peak current	150A (short Circuit protection @ 153A)
Idle power consumption:	20mA
Deep sleep consumption:	78µA
Max current 12V link:	2A

Note: BMS Mk2 is available in HW Coded to a cell configuration. Other variants from 10S up to 15S are available. Changing the HW code is not possible. Please contact the FRIWO Sales Team.

Note: Technical data and documentation subject to change without notice.

5.4 Runtime battery pack

The runtime of battery pack is dependent on mounting and cooling situation in application. The temperature of cells and BMS is continuously monitored and operation is limited to values mentioned in chapter 5.2.

Typical runtimes of battery pack starting at 20°C:

70A 20min (limited by cell temperature)

60A 30min (limited by cell temperature)

50A 45min (limited by capacity)

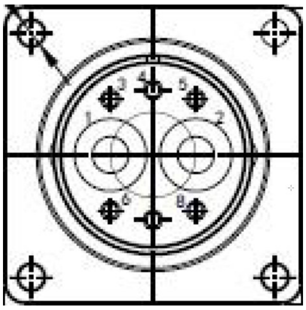
35A 60min (limited by capacity)

5.5 Power Connector

5.5.1 Connector Type

Type: WY28K8BZZ1

Rated current: 70A



5.5.2 Pin Assignment

PIN 1	BAT-
PIN 2	BAT+
PIN 3	Charge sense
PIN 4	CAN low
PIN 5	CAN high
PIN 6	BAT enable
PIN 7	12V
PIN 8	n.c.

5.6 Foil Display

Note: The functionality and the behaver of the Battery pack is depending on the software version and the parametrization. The described functionality may differ depending on the application!

5.6.1 Layout

Note: Example Layout of a Foil display. The Layout may differ. Main functionality will remain the same. Subject to change without notice.

5.6.2 State of charge (SoC) display

The current state of charge (SoC) is indicated by the LEDs as follows:

>80 to 100% -> 5 LED`s light up

>60 to 80% -> 4 LED`s light up

>40 to 60% -> 3 LED`s are on

>20 to 40% -> 2 LEDs are on

>5 to 20% -> 1 LED is on

0 to 5% -> No LED is lit

In addition, the LEDs generate different signals in the following applications:

When waking up the battery, the 5 LED`s generate a running light.

In case of error detection, all 5 LEDs flash several times simultaneously.

When switching to sleep mode (deepsleep), all 5 LEDs flash briefly, then generate a running light and go out.

6 Using the BMS/Battery Pack

Note: The functionality and the behaver of the Battery pack is depending on the software version and the parametrization. The described functionality may differ depending on the application!

6.1 Discharging the Battery

6.1.1 Switching ON/OFF pushbutton (Pushbutton Mode)

The pushbutton is used to switch the system on and off with the following realizations:

Short press (short press) t < 1s: wakes up the BMS and activates the communication on the CAN interface, this is indicated by a green backlit ring around the ON/OFF symbol. In addition, the 5 bars of the charge level indicator are backlit. The output voltage is not enabled.

Long press 1s< t < 5s: Activates the output voltage. This is indicated by the HV LED.

A long press in the activated state (HV switches the output voltage off again and the HV LED goes out.

Super long press (t= >5s): Deactivates the battery. The output voltage is switched off, if it was switched on, and the battery goes into sleep mode (Deepsleep). This is additionally indicated by a flashing of the SoC-LEDs and a running light from top to bottom, at the same time the HV-LED goes out, shortly afterwards also the backlit ring around the ON/OFF symbol.

6.1.2 Switching ON/OFF button (keylog mode)

In "Keylog Mode", the button is used only secondarily for switching the system on and off. In this mode, the system is primarily activated via the "Bat Enable" pin.

Pressing the button activates the battery analog to the "Bat Enable" pin (pulled to BAT-) and wakes up the BMS, activates the communication on the CAN interface and the 12V and HV output voltage. This is indicated by a green backlit ring around the ON/OFF symbol and the HV symbol.

When the button is released or the "Bat Enable" pin is opened, the communication on the CAN interface, the HV and 12V output voltage is deactivated again and the battery goes into sleep mode (Deepsleep).

6.2 Charging the Battery

6.2.1 Battery charging (Non Grid FW) (general)

To charge the battery the "Charge Sense" pin (Pin3) must be pulled to ground (GND or BAT-). The battery wakes up and the ring around the ON/OFF symbol is backlit.

The charging of the battery is signalised by a running light of the 5 LEDs.

To activate the HV, a reverse voltage (charging voltage) must be applied to the BAT+ and BAT- pins.

6.2.2 Battery charging (Non Grid FW) (FRIWO LEV500 variant)

To charge the battery the "Charge Sense" pin (Pin3) must be pulled to ground (GND or BAT-). The battery wakes up and the ring around the ON/OFF symbol is backlit. At the same time the HV is activated.

The charging of the battery is signalised by a running light of the 5 LED's.

6.2.3 Battery charging (Grid FW) (FRIWO LEV500 variant)

The battery must be brought into the "ready to charge" state for charging. To do this, the battery must be woken up with a long press (1s< t < 5s) without a plug in contact.

The readiness of the battery for charging is indicated by the LEDs.

LED 2 and 4 flash

LED 1, 3 and 5 are on

The ring around the ON/OFF symbol is backlit

Now the plug of the charger can be connected to the battery, the LEDs stop flashing, the BMS changes to charging mode and the HV switches on, provided there are no faults. Only now connect the charger to the 230V mains.

The charging of the battery is signalised by a running light of the 5 LEDs.

6.3 BMS Mk2 Protection and Safety features

6.3.1 Short-circuit Protection

- Charge sense, Push Button are protected against time limited overvoltage up to 60V
- The CAN BUS lines are protected against +/-60V, so failure connection is not critical.
- USB connection is only for analysis and is not isolated or protected against failure connections

Note: ▪ USB connection is only for analysis and is not isolated or protected against failure connections. USB connection is not available in fully assembled Battery Packs.

6.3.2 Protection on 12V output

- The 12V is protected against over current with electronic fuse. It trips at currents above 3.6A, depending also on temperature. When output voltage drops below 9V (Parameter) because of e-fuse trigger, output is switched off and alarm is shown.

Note: Please ensure safe operation with currents <2A for steady state operation.

6.3.3 Overcurrent Protection

µC controlled protection

- The MOSFET is controlled by main µC

HW Triggered Protection

- In short circuit events there is a hardware trigger, which turns MOSFETs off. The short circuit detection is independent of the microcontroller and can switch off the FETs directly

Melting Fuse

- The fuse is designed for 120A with slow characteristic. This charteristic is choosen to avoid trigger at high current peak in operation

6.3.4 Start-up safety check

- The output voltage of the current sensor must be at VCC/2 when the BMS is started. Checked by Microcontroller ADC
- Connection to Cell Monitor IC is checked via SPI

6.4 Precharge characteristics and limitations

Note: The BMS is equipped with a precharge functionality to avoid hot plug events. It is recommended to use this function to power up external or connected systems. Hot plugging an external system could cause damages

Note: Do not supply any additional DC/DC converter or reactive loads during precharge phase of the BMS. This may cause defects on the BMS!

Max precharge Current:	2A
Max precharge Time:	1sec (repetitive, depending on temperature)
Max capacitance to be precharged:	20mF
Max parallel current during precharge:	40mA
Reference temperature:	25°C

The precharge circuit of BMS Mk2 tries to load the DC link as high as possible. The precharge current is regulated to a maximum of 2A.

50ms after the start of precharging the output voltage is checked. If the voltage is still (or drops) below 2V, a short-circuit is assumed and the output is not enabled. The errorhandler will show a PreCharge error.

In all other cases, the main output is switched on as soon as one of the following conditions is met:

· Precharge components reach temperature limits

· Output voltage saturates (voltage rise is less than 0.1V in 50ms)

· Output voltage drops more than 0.5V in 10ms

· 1s is elapsed since start of precharging

If the inrush current after enabling the main output is still too high >150A (e.g. input capacitance is too big), the overcurrent protection will disable the output immediately and the errorhandler will show a AnalogOvercurrent error.

The maximum capacitance, which can be successfully precharged at 25 °C starting temperature is 20mF. If a constant load in parallel of more than 40mA is used, the maximum possible capacitance decreases.

Note: Subject to change without notice.

7 Advanced setup and Troubleshooting

Note: Battery application should only be done by well-trained persons with deep knowledge of battery systems. Wrong handling of batteries could cause injuries and death. Under wrong handling Lithium-Ion batteries could cause fire. Changing parameters can have a negative effect on the behaviour of the BMS and could cause fatal errors. Please observe the following notes when connecting a BMS or making adjustments. In case of questions contact the FRIWO Team.

In case of changes of the factory setup the warranty is lost! If the parameterset is changed the costumer is responsible for all kind of errors or dangers that result out of the change

Note: Always work under full ESD protection to avoid damages on the PCB. ESD loads could destroy the BMS!

Note: Always use an galvanic isolated USB Connection to parametrize the BMS

Note: USB connection is not available in a fully assembled Battery Pack

Note: CAN Bus can be used for parametrization

7.1 BMS Basic Setup

For basic setup the following parameters has to be set to the correct value.

Before starting the setup make sure that the parameter

SET_C_BMS_Setup_Valid is set to *"0"*

SET_C_Enable_2K_Powerstage is set to *"0"*

Set the following parameter according the design of your Core Pack. Please follow the parameter description in the Enable Tool NG

Note: BMS Mk2 is hardware coded to 14S

SET_C_CAN_Baudrate_Select

SET_C_Cell_Temp_Number_of_Sensors

SET_C_Cell_Design_Capacity

SET_C_Cell_Empty_Voltage

SET_C_Cell_FullCharge_Voltage

SET_C_Cell_Max_Voltage

SET_C_Cell_Deep_Sleep_Voltage

SET_C_Cell_Min_Voltage

SET_C_CHG_Voltage_Lim_Max

SET_C_Enable_2K_Powerstage

SET_C_Overtemp_Charge

SET_C_Overtemp_Discharge

SET_C_PACK_Charge_Current_Limit

SET_C_PACK_Discharge_Current_Limit

SET_C_Pack_Num_Parallel_Cells

SET_C_Pack_Num_Serial_Cells

SET_C_Undertemp_Charge

SET_C_Undertemp_Discharge

After setting up the basic parameters, save the configuration to the BMS. In some cases it might be helpful to store every single change to the BMS.

When the setup is completed set the parameter

SET_C_BMS_Setup_Valid to *"1"* so that the BMS will start working.

It might be necessary to setup further parameters to optimize the BMS configuration related to the application needs.

In case of questions or errors please contact the FRIWO support

7.2 Setup the charging behaviour of the Battery

7.2.1 Non Grid FW

The conditions for activating the battery charging are determined by the following parameter:

SM_C_s_Charge_Detection_Mode

If this parameter SM_C_s_Charge_Detection_Mode is set to "0", the output voltage (HV) of the battery is switched on as soon as the pin "Charge Sense" is pulled to ground AND a voltage is applied to the HV pins of the battery.

If the parameter SM_C_s_Charge_Detection_Mode is set to "1", the output voltage of the battery is switched on as soon as the pin "Charge Sense" is pulled to ground.

7.2.2 GridFW

To enable charging with Grid FW the battery has to be set to the "ready to charge" mode. The enable button has to be pressed for 1s < t <5s, with no connector connected. The battery will wake up in ready to charge mode This will be indicated by the LED´s

LED 2 and 4 are flashing

LED 1, 3 and 5 is enlightened

The ring around the ON/OFF sybol is enlightened

To enable the HV and charge the Battery the "Charge Sense" pin has to be pulled to ground. The flashing of the LED's will stop and the BMS will switch into charge-mode.

8 SOC/SOH module description

8.1 General Functions

The SOC module of the BMS firmware calculates the State of Charge and State of Health of the connected battery pack based on measured data and configured parameters. The module calculates the following values:

· SOC – State of Charge

· SOH – State of Health

· Number of charge cycles

· SOC Full charge capacity

· SOC remaining capacity

The battery management system uses a current integration method to calculate the SOC in active mode. In order to take measurement inaccuracies and other influences into account, the BMS has a voltage-dependent correction function that corrects the calculated SOC value based on the cell voltages in a load-free situation.

The State of Health is calculated over time by estimation of the maximum available capacity. The SOH value is corrected each time the BMS is charged from pack empty voltage to the configured full charge voltage.

8.2 SOC calculation - Current Integration

The SOC calculation in normal operation is done by integration of the measured current. This method, also known as "coulomb counting", calculates the SOC by measuring the battery current and integrating it in time. Since no measurement can be perfect, this method suffers from long-term drift and lack of a reference point: therefore, the SOC is re-calibrated on a regular basis, such as by resetting the SOC to 100% when the BMS determines that the battery is fully charged.

The SOC is corrected in the following scenarios:

8.2.1 Full charge correction

If the pack voltage exceeds a full charge limit during charging, the SOC is set to 100%. This is applied only if the pack current stays below a configured value.

Dependent variables:

· {1} SET_Pack_Full_Charge_Voltage

· {2} SOC_C_Reset_Voltage_Thresh_Upper

· {3} SOC_C_Reset_Current_Thresh

· {4} SOC_C_Reset_Current_ThreshL

The SOC is set to 100% if the measured Pack voltage exceeds {1}-{2} V while the absolute measured current stays below the limits configured in {3} and {4}.

8.2.2 Pack depletion detection

If the BMS detects a pack depletion state, the SOC is set to 0%.

Dependent variables:

· {1} SET_Pack_Discharge_Voltage

· {2} ERR_Pack_Discharge_Voltage_Limit

· {3} SOC (calculated)

· {4} SET_Cell_Empty_Voltage

· {5} SOC_C_Reset_Votlage_Thresh_Lower

· {6} SOC_C_DC_SOC

· {7} SOC_C_DC_Voltage

· {8} SOC_C_DC_Current

· {9} Lowest Cell Voltage

The SOC is set to 0% if the pack voltage drops below {1} – {5} while the CUV Error {2} is set. The Reset also occours if the SOC is below {6}% while the lowest cell voltage {9} drops below {4} + {7}.

8.2.3 SOC correction - Voltage measuring

This method converts a measurement of the battery voltage to SOC, using the known discharge curve (voltage vs. SOC) of the battery. However, the voltage is more significantly affected by the battery current (due to the battery's electrochemical kinetics) and temperature.

The voltage based correction of the calculated SOC can be activated with the parameter

SOC_CVC_C_s_Enable_CVC.

The voltage-dependent SOC value is continuously calculated and compared with the value of the Coulomb method. The voltage-based SOC is applied if the current SOC deviates over a certain value (The value is dependent on the BMS state). For the correction to be applied, the measured

current must stays below a state-dependent value for a configured timeout. If the correction event occurs, the voltage based SOC overwrites the current based SOC integration value.

The maximum allowed deviation is configured in the following variables:

· SOC_CVC_C_SOC_Diff_State_Idle

· SOC_CVC_C_SOC_Diff_State_Discharging

· SOC_CVC_C_SOC_Diff_State_Charging

· SOC_CVC_C_SOC_Diff_State_Other

The maximum allowed battery current for the correction event is configured with:

· SOC_CVC_C_Max_Current_State_Idle

· SOC_CVC_C_Max_Current_State_Discharging

· SOC_CVC_C_Max_Current_State_Charging

· SOC_CVC_C_Max_Current_State_Other

The configurable debounce time until the correction event is applied can be configured with:

· SOC_CVC_C_Debounce_Time_State_Idle

· SOC_CVC_C_Debounce_Time_State_Discharging

· SOC_CVC_C_Debounce_Time_State_Charging

· SOC_CVC_C_Debounce_Time_State_Other

The actual deviation between the two SOC measuring methods can be monitored with the parameter SOC_CVC_M_SOC_Diff.

8.2.4 SOC correction – manual preset

The SOC can be preset manually with the parameter SOC_C_SET_SOC_manual to the value configure in SOC_C_Cell_SOC_Preset. This also resets the State of Health to 100%.

8.3 SOH calculation

The State of Health (SOH) is a figure of merit of the condition of a battery compared to its ideal conditions. The units of SOH are percent points (100% = the battery's conditions match the battery's specifications). Typically, a battery's SOH will be 100% at the time of manufacture and will decrease over time and use.

The BMSv2 updates the SOH after a full charge cycle. This means that the battery must be drained to the empty voltage limit (see Pack depletion detection) and then charged to the full charge limit (see full charge correction). The measured full charge capacity in relation to the factory default capacity defines the State of Health value.

The newly calculated maximum battery capacity is only applied if the value deviates by a maximum of 5% from the last charging cycle. Similarly, only SOH values that deviate by a maximum of 30% from the specified nominal capacity are accepted.

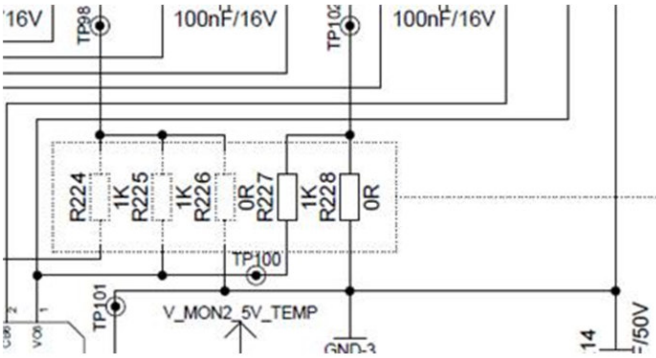
9 HW Code

9.1 BMS Mk2

Note: Do not change the HW Code of a BMS!

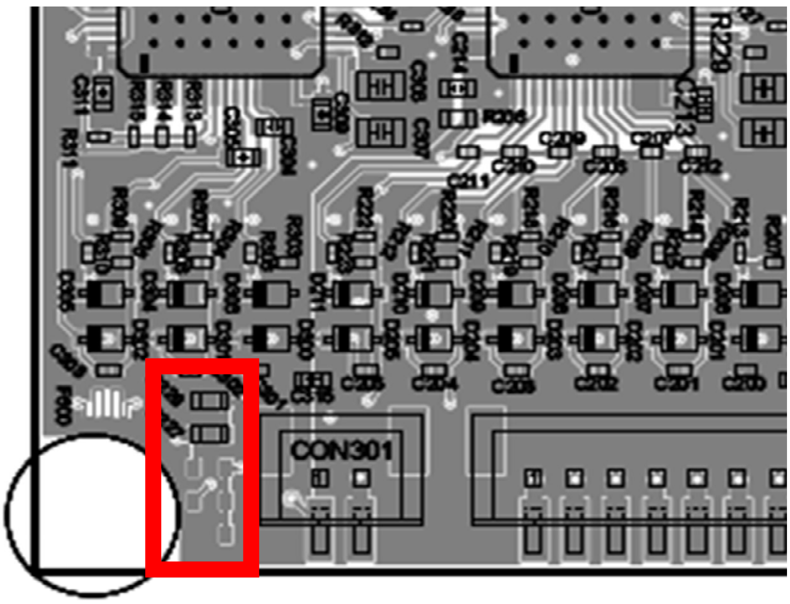
Only for information purpose!

The cell configuration setting of the BMS is HW Coded. The coding is defined by 0K and 1K resistors according the following matrix



BMS Cellconfiguration settings

Resistor / Cells	R224	R225	R226	R227	R228
10S/13S	1K	1K	0R	--	--
11S/14S	--	--	--	1K	0R
12S/15S	--	--	--	--	--



10 Using Battery Packs in parallel

Note: Do not connect two or more batteries in parallel without ensuring that the Grid FW is used! Using non Grid FW to connect batteries in parallel could cause fatal damages on the BMS and battery-pack!

Note: In Grid configuration an ICS Info Message with the actual drawn Grid Current and Grid Voltage required to startup the System!
In combination with an Emerge/FRIWO Motor Controller the MCU is sending the ICS Info Message.

10.1 Using "Grid" - General Information

With the Grid FW it is possible to use up to 12 (tested, depending on the Bus load even more) battery packs in parallel. The system automatically ensures that only batteries with the same charge status are activated, starting with the highest charge status. After reaching the nearest charge level, this battery is activated and so on.

In the "grid system" an active CAN- bus communication is necessary. The CAN-bus ID's of the connected bus participants are automatically negotiated by handshake. No addresses have to be assigned manually. So the system is "plug and play" with grid-compatible battery packs (same parameters and type required).

To activate the battery packs in the grid system or an individual battery packs it is necessary that an "ICS info message" with the total grid current is transferred to the bus and its participants. If this massage fails, the system automatically deactivates. If the total current deviates from that of the battery packs, these are automatically deactivated for safety reasons. In the recommended system shown in the circuit diagram the Emerge 6000 is determined to send the "ICS Info Message" to the CAN-bus. In charging state, this functionality is taken over by the charger.

To schwitch the system on, it exists 2 different solutions.

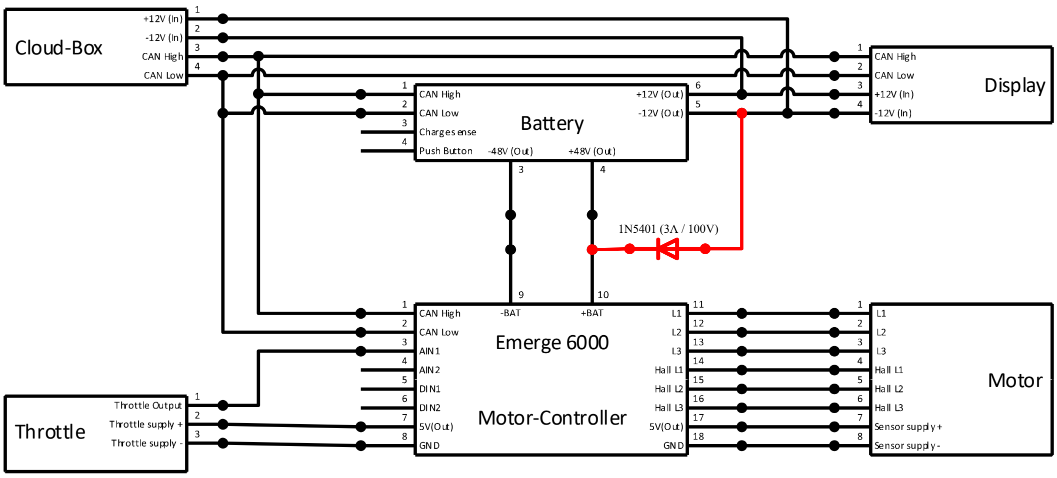
1. Use a key-switch to give a signal to an digital input
2. Use CAN Bus messages

10.2 References

- .dbc file which describes CAN bus message information

10.3 Wiring Diagram "Grid Connection"

In Grid Configuration CAN Bus is used to activate the system, the Motor Controller must have 12 V Power to drive the CAN Bus. For that, the 12 V Battery Power output has to connect over a diode to the 48 V input of the Motor Controller. Please see the picture below and the important diode in red.



The recommended wiring is shown in figure 1.

Note: ***The diode D1 must have a minimum reserve voltage of 100 volt and a minimum forward current of 3 amps.***

10.4 Activation Procedure using a "Key Switch"

To activate the battery pack / grid system, the enable PIN must be bridged to ground / GND.

The battery activates the 12 V output and CAN communication. The 12V output voltage supplies the motor controller via the diode (see circuit diagram) and the CAN communication between the CAN bus participants will be established. Then the battery packs are activated. The motor controller sends repetitive the "ICS info message", with the total gird current.

If the battery packs are used without a FRIWO motor controller, it is necessary to implement a CAN bus participant that provides and sends the "ICS Info Message" with the total grid current and voltages to the CAN bus network.

As reference a DBC file with the corresponding "ICS info message" can be provided on request.

10.5 Activation Procedure using a "CAN Bus message"

10.5.1 Settings in MC configuration to activate the solution CAN Bus messages

To choose the CAN Bus message start function, you have to set the following parameter in the Motor Controller with the configuration software Enable-Tool.

1. Parameter „APP_C_Activation_Mode" = 4
2. Parameter „SM_C_BMS_Control_Mode" = 3

10.5.2 Needed Messages

To start the system we use 2 different CAN messages.

1. Message 0x1B6: This messages will turn on the HV voltage of the Battery

Note: System can not drive while the immobilizer is activated.

2. Message 0x111: This messages will set the ignition on.

Note: System can drive while immobilizer is deactivated.

10.5.3 Procedure

The following steps in the right seqence are nessesary to start the system.

1. Push the button of the battery so that the Battery will support the system with power 12V

2. Receive and analyse the CAN message 0x1B5 coming from the Motor Controller. The first 4 bytes of the data in the message is the Challenge Code. See below.

CAN-ID	Lentgh	Data
1B5	8	22 00 3F 00 10 EC F9 40

3. Take the Challenge Code to an unsigned integer value (interpret as little endian)

4. Calculate the unlock code with adding one to the Challenge Code

   Unlock Code = Challenge Code + 1

5. Start sending every 100 ms the CAN message 0x1B6 with the calculated UnlockCode in the first 4 bytes of the data. This will activate the 48 V Power. But the Motor will not drive while the ignition is off.

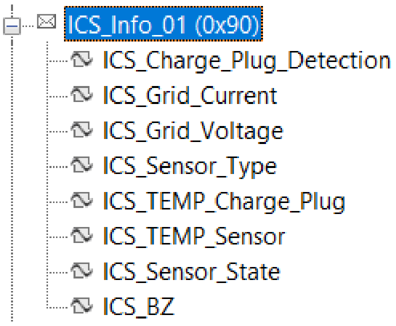
CAN-ID	Lentgh	Data
1B6	8	23 00 3F 00 00 00 00 00

10.6 ICS Info Message

Note: In Grid configuration an ICS Info Message with the actual drawn Grid Current and Grid Voltage required to startup the System!
In combination with an Emerge/FRIWO Motor Controller the MCU is sending the ICS Info Message.

If the BMS is equipped with Grid firmware and should be started up in this configuration it is required sending an ICS Info Message (0x90) with the actual Grid Current and Grid Voltage via CAN Bus. Otherwise the BMS will not activate the 48V bus.

In case that no Emerge/FRIWO MCU is used in the stem application the ICS Info Message has to be integrated externaly.



Name	Message	Multiplexing/Group	Star...	Len...	Byte Order	Value Type	Initial Value	Factor	Offset	Mini...	Max...	Unit	Value Table	Comment	NWM-Wa...	Gen...	GenSigSen...	Gen...
ICS_BZ	ICS_Info_01	-	0	8	Intel	Unsigned	0	1	0	0	255		<none>	Message counter ICS Sensor 0...255	<n.a.>*	0*	Cyclic*	0*
ICS_Grid_C...	ICS_Info_01	-	8	16	Intel	Signed	0	0.03125	0	-1000	1000	A	<none>	Actual Grid current measured	<n.a.>*	0*	Cyclic*	0*
ICS_Grid_V...	ICS_Info_01	-	24	14	Intel	Unsigned	0	0.015625	0	0	128		<none>	actual Voltage	<n.a.>*	0*	Cyclic*	0*
ICS_Charg...	ICS_Info_01	-	38	2	Intel	Unsigned	0	1	0	0	3		<none>	1=Plug detected	<n.a.>*	0*	Cyclic*	0*
ICS_Sensor...	ICS_Info_01	-	40	4	Intel	Signed	0	1	0	0	15		<none>	Indicates the status of the ICS...	<n.a.>*	0*	Cyclic*	0*
ICS_Sensor...	ICS_Info_01	-	44	4	Intel	Signed	0	1	0	0	15		<none>	Indicates the sensor type of the ICS...	<n.a.>*	0*	Cyclic*	0*
ICS_TEMP_...	ICS_Info_01	-	48	8	Intel	Unsigned	0	1	-30	-30	200	°C	<none>	Actual ICS Sensor temperature measured	<n.a.>*	0*	Cyclic*	30
ICS_TEMP_...	ICS_Info_01	-	56	8	Intel	Unsigned	0	1	-30	-30	200	°C	<none>	Actual Charge Plug temperature measured	<n.a.>*	0*	Cyclic*	30

11 Error Handler

The following reference describes all error states of the BMS, their causes and configuration parameters as well as the requirements for resetting the errors that have occurred.

11.1 References

- .dbc file which describes CAN bus message information

11.2 Overall Description

The firmware of the BMS contains an error handler, which detects errors and outputs them via a bit mask (error code). Depending on the configuration and the warnings and errors that occurred, the BMS changes to an error state. This leads to a shutdown of the FETs.

If an error is no longer actively present after the shutdown, it is possible to switch back to a charge or discharge state, depending on the error that occurred.

The following description lists all possible errors handled by the error handler and their dependent parameters.

11.3 Error Code Summary

Errorcode	Description
ERR_E_TEMP_Powerstage_1	FET Temperature sensor 1 value above the configured maximum
ERR_E_TEMP_Powerstage_2	FET Temperature sensor 2 value above the configured maximum
ERR_E_Charge_Current	Measured current in charge mode above the configured maximum
ERR_E_Discharge_Current	Measured current in discharge mode above the configured maximum
ERR_E_Pack_Voltage_Max	Pack voltage over configured maximum value
ERR_E_Analog_Overvoltage	Analog circuit detected critical overvoltage
ERR_E_Current_Sensor_Offset	Calculated current sensor offset value is out of valid range
ERR_E_EEPROM	Indicates errors in licensing, firmware/hardware mismatch, flash memory fault and parameter setup invalid
ERR_E_Cell_Monitor_CRC	Communication error with cell monitor IC
ERR_E_External_Enable	Configured external enable signal is missing
ERR_E_Cell_Monitor_Alert	Cell monitor IC reported cell alert state
ERR_E_Cell_Monitor_Fault	Cell monitor IC reported cell fault state
ERR_E_Powerstage	Deviation between pack voltage and output voltage in discharge mode out of valid range
ERR_E_PreCharge	Precharge circuit failed to raise output voltage to minimum desired value within configured time
ERR_E_Output_Voltage_High	Voltage on output too high to enable precharge circuit
ERR_E_Pack_Voltage_Min	Pack voltage lower than configured minimum value
ERR_E_Pack_Discharge_Voltage_Active_State	At least one cell dropped below configured empty voltage while in active state
ERR_E_Cell_Undervoltage	At least one cell dropped below configured minimum voltage
ERR_E_Cell_Overvoltage	At least one cell voltage is higher than the configured maximum value
ERR_E_Analog_Overcurrent	Analog circuit detected overcurrent >153A
ERR_E_Overtemp_Charge	Cell temperature above configured maximum while charging
ERR_E_Overtemp_Discharge	Cell temperature above configured maximum while discharging
ERR_E_Undertemp_Charge	Cell temperature below configured minimum while charging
ERR_E_Undertemp_Discharge	Cell temperature below configured minimum while discharging
ERR_E_Current_Flow_Passive_State	BMS detected unexpected current while in idle mode
ERR_E_CAN_Timeout	BMS did not receive expected CAN control frame within configured timeout
ERR_E_Cell_Connection	Faulty cell detected or number of detected cells deviate from configured number of serial cells
ERR_E_12V_AUX_Undervoltage	Measured 12V AUX output voltage below configured minimum

11.4 Errorcode behavior

Most blocks have two debouncing variables. With these values debounce times can be configured for the error conditions of the individual blocks. This helps to avoid unnecessary shutdowns due to short current peaks or measurement errors.

Each individual error has three different states:

Warning:

Most errors have an additional warning step. Usually is active as soon as the error condition is met, but before the debounce time is over. On some errors, the warning is set after the first debounce time is over. The warning is not latched and is inactive as soon as the error conditions are no longer met. The warning variables have the prefix *ERR_W_* instead of *ERR_E_*.

Active:

The error conditions are met and the debounce time is over. All errors in the error code are active errors. The active error is inactive as soon as the error conditions are no longer met. This also resets the debounce timeout values.

Latched:

Every active error is also latched. This saves the error state in the individual error variable of the block until the error block is reset. This is usually done automatically when the BMS shut off the powerstage and the error conditions are no longer met. Some errors however remain latched until the ECU is restarted.

11.5 Detailed Descriptions

11.5.1 ERR_E_TEMP_Powerstage_1

Dependent variables:

- {1} ERR_C_TEMP_Powerstage_1_MAX_Temp_FET1
- {2} ERR_C_TEMP_Powerstage_1_MAX_Temp_FET1_L2
- {3} ERR_C_TEMP_Powerstage_1_Debounce_L1
- {4} ERR_C_TEMP_Powerstage_1_Debounce_L2

Error latched if measured FET1 temperature exceeds {1} for longer than ({3}+{4})*100ms.

Error is also latched if measured FET1 temperature exceeds {2} for longer than {4}*100ms.

11.5.2 ERR_E_TEMP_Powerstage_2

Dependent variables:

- {1} ERR_C_TEMP_Powerstage_2_MAX_Temp_FET2
- {2} ERR_C_TEMP_Powerstage_2_MAX_Temp_FET2_L2

- {3} ERR_C_TEMP_Powerstage_2_Debounce_L1
- {4} ERR_C_TEMP_Powerstage_2_Debounce_L2

Error latched if measured FET2 temperature exceeds {1} for longer than ({3}+{4})*100ms.

Error is also latched if measured FET2 temperature exceeds {2} for longer than {4}*100ms.

11.5.3 ERR_E_Charge_Current

Dependent variables:

- {1} SET_C_PACK_Charge_Current_Limit
- {2} ERR_C_Charge_Current_Debounce_L1
- {3} ERR_C_Charge_Current_Debounce_L2

Error latched if measured charge current exceeds {1} for longer than ({2}+{3})*100ms.

Error is also latched if measured charge current exceeds ({1}*1.2) for longer than {3}*100ms.

11.5.4 ERR_E_Discharge_Current

Dependent variables:

- {1} SET_C_PACK_Discharge_Current_Limit
- {2} ERR_C_Discharge_Current_Debounce_L1
- {3} ERR_C_Discharge_Current_Debounce_L2

Error latched if measured charge current exceeds {1} for longer than ({2}+{3})*100ms.

Error is also latched if measured charge current exceeds ({1}*1.2) for longer than {3}*100ms.

11.5.5 ERR_E_Pack_Voltage_Max

Dependent variables:

- {1} SET_C_Pack_Num_Serial_Cells
- {2} SET_C_Cell_Max_Voltage
- {3} ERR_C_Voltage_Max_Debounce_L1
- {4} ERR_C_Voltage_Max_Debounce_L2

Error latched if measured pack voltage exceeds ({1}*{2}) for longer than ({3}+{4})*100ms.

11.5.6 ERR_E_Pack_Voltage_Min

Dependent variables:

- {1} SET_C_Pack_Num_Serial_Cells
- {2} SET_C_Cell_Min_Voltage
- {3} ERR_C_Voltage_Min_Debounce_L1
- {4} ERR_C_Voltage_Min_Debounce_L2

Error latched if measured pack voltage stays below ({1}*{2}) for longer than ({3}+{4})*100ms.

11.5.7 ERR_E_Analog_Overvoltage

Dependent variables:

- {1} ERR_C_Analog_Overvoltage_Debounce_L1
- {2} ERR_C_Analog_Overvoltage_Debounce_L2

Error latched if base firmware signals analog overcurrent detection for longer than ({1}+{2})*100ms.

Currently, there is no analog circuit present to raise this error. The base firmware also does not evaluate GPIOs for this purpose.

11.5.8 ERR_E_Current_Sensor_Offset

Dependent variables:

- {1} ERR_C_Current_Sensor_Offset_Debounce_L1
- {2} ERR_C_Current_Sensor_Offset_Debounce_L2
- {3} BSW_M_Bus_Current_Sensor_Offset
- {4} SET_C_Curr_Sense_Offset
- {5} BSW_C_Curr_Sense_Offset_Expected_Deviation

Error latched if base firmware signals an error while calibrating the current sensor offset for longer than ({1}+{2})*100ms.

This error can occur when the base firmware detects a sensor offset, which is greater than the maximum allowed deviation (Measured offset {3} is greater than ({4}+-{5}). On BMSv2, both current sensor inputs are evaluated.

11.5.9 ERR_E_EEPROM

Dependent variables:

- {1} SET_C_BMS_Setup_Valid
- {2} ERR_C_EEPROM_Debounce_L1
- {3} ERR_C_EEPROM_Debounce_L2

This is the only error which is held latched until an ECU reset. This error is latched if one of the following errors occurred:

- Flash memory fault detected
- Firmware license not found
- Hardware variant coding error (firmware license / hardware mismatch)
- Setup Valid variable {1} is not set to value '1'

11.5.10 ERR_E_Cell_Monitor_CRC

Dependent variables:

- {1} ERR_C_Cell_Monitor_CRC_Debounce_L1
- {2} ERR_C_Cell_Monitor_CRC_Debounce_L2

The error is latched if the cell monitor communication detected a CRC error. This can happen if the connection to the cell management ICs is interrupted or a bit error occurred. The error is latched after a timeout of ({1}+{2})*100ms.

11.5.11 ERR_E_External_Enable

Dependent variables:

- {1} ERR_C_External_Enable_Equipped
- {2} ERR_C_External_Enable_Debounce_L1
- {3} ERR_C_External_Enable_Debounce_L2

If variable {1} is set to '1', the error is latched if the external enable signal GPIO pin is logic low for longer than ({2}+{3})*100ms. If {1} is set to '0', the GPIO evaluation is inverse (error on logic high).

11.5.12 ERR_E_Cell_Monitor_Alert

Dependent variables:

- {1} ERR_C_Cell_Monitor_Alert_Debounce_L1
- {2} ERR_C_Cell_Monitor_Alert_Debounce_L2

This error is latched if the cell management alert signal is set in the base firmware for longer than ({1}+{2})*100ms.

Currently, this variable is not assigned in the firmware. The Cell_Management modul in the model however reads the status code from the cell management ICs and evaluates the cell alerts.

11.5.13 ERR_E_Cell_Monitor_Fault

Dependent variables:

- {1} ERR_C_Cell_Monitor_Fault_Debounce_L1
- {2} ERR_C_Cell_Monitor_Fault_Debounce_L2

This error is latched if the cell management fault signal is set in the base firmware for longer than ({1}+{2})*100ms.

Currently, this variable is not assigned in the firmware. The Cell_Management modul in the model however reads the status code from the cell management ICs and evaluates the cell faults.

11.5.14 ERR_E_Powerstage

Dependent variables:

- {1} ERR_C_Powerstage_Voltage_Diff
- {2} ERR_C_Cell_Monitor_Fault_Debounce_L1
- {3} ERR_C_Cell_Monitor_Fault_Debounce_L2

This error is latched if the difference between output voltage and pack voltage is greater than {1} for longer than ({2}+{3}*100ms.

The error can only be latched in active state.

This block can be configured to represent operating conditions with rapidly changing loads. The debounce blocks should allow a short deviation of the output voltage at changing loads. This is especially useful in automotive applications to avoid unnecessary shutdown (e.g. motor control).

11.5.15 ERR_E_PreCharge

Dependent variables:

- {1} OUTPUT_CTRL_C_PreCharge_Voltage
- {2} OUTPUT_CTRL_C_PreCharge_Time
- {3} OUTPUT_CTRL_C_PreCharge_Volt_Min
- {4} OUTPUT_CTRL_C_MOSFET_Ena_Curr_Max
- {5} ERR_C_PreCharge_Debounce_L1
- {6} ERR_C_PreCharge_Debounce_L2

This error can occur in the *Output_Control* module under the following conditions:

- The output voltage is below {1} after ({2}*10ms) of precharge in *Precharge* state
- The output voltage remains below {3} after 50ms of precharge in *Precharge* state
- The output current is greater than {4} in the first 150ms after enabling the highside driver in *Activate_Main_Output* state

The error signal of the *Output_Control* module is active for 2 seconds. The errorhandler displays the error after ({5}+{6})*100ms.

The debounce block delay located in the errorhandler (variables {5} and {6}) are unnecessary with the current module and should be set to '0'.

11.5.16 ERR_E_Output_Voltage_High

Dependent variables:

- {1} SET_C_CHG_Voltage_Lim_Max
- {2} ERR_C_Output_Voltage_High_Debounce_L1
- {3} ERR_C_Output_Voltage_High_Debounce_L2

This error can occur in the *Output_Control* module under the following conditions:

- The measured output voltage is higher than {1} in the *Check* state before the precharge

The error signal of the *Output_Control* module is active for 2 seconds. The errorhandler displays the error after ({2}+{3})*100ms.

The debounce block delay located in the errorhandler (variables {2} and {3}) are unnecessary with the current module.

11.5.17 ERR_E_Pack_Voltage_Min

Dependent variables:

- {1} SET_C_Cell_Min_Voltage
- {2} SET_C_Pack_Num_Serial_Cells
- {3} ERR_C_Pack_Voltage_Min_Debounce_L1
- {4} ERR_C_Pack_Voltage_Min_Debounce_L2

This error is latched if the pack voltage is lower than ({1}+{2}) for longer than ({3}+{4})*100ms.

11.5.18 ERR_E_Pack_Discharge_Voltage_Active_State

Dependent variables:

- {1} SET_C_Cell_Empty_Voltage
- {2} ERR_C_Pack_Discharge_Voltage_Active_State_Debounce_L1
- {3} ERR_C_Pack_Discharge_Voltage_Active_State_Debounce_L2

The error is latched if the voltage of at least one cell is below {1} for at least ({2}+{3})*100ms.

This block can be configured to represent operating conditions with rapidly changing loads. The debounce blocks should allow a short deviation of the minimum cell voltage at changing loads. This is especially useful in automotive applications to avoid unnecessary shutdown (e.g. motor control).

11.5.19 ERR_E_Cell_Undervoltage

Dependent variables:

- {1} SET_C_Cell_Min_Voltage
- {2} ERR_C_Cell_Undervoltage_Debounce_L1
- {3} ERR_C_Cell_Undervoltage_Debounce_L2

The error is latched if the lowest cell voltage is below {1} for at least ({2}+{3})*100ms.

The error is also latched if the cell management IC is reporting a cell undervoltage fault flag. This parameter is currently not configured in the EEPROM of the ICs and should therefore never appear.

11.5.20 ERR_E_Cell_Overvoltage

Dependent variables:

- {1} SET_C_Cell_Max_Voltage
- {2} ERR_C_Cell_Overvoltage_Debounce_L1

- {3} ERR_C_Cell_Overvoltage_Debounce_L2

The error is latched if the highest cell voltage is over {1} for at least ({2}+{3})*100ms.

The error is also latched if the cell management IC is reporting a cell overvoltage fault flag. This parameter is currently not configured in the EEPROM of the ICs and should therefore never appear.

11.5.21 ERR_E_Analog_Overcurrent

Dependent variables:

- {1} ERR_C_Analog_Overcurrent_Debounce_L1
- {2} ERR_C_Analog_Overcurrent_Debounce_L2
- {3} ERR_C_Analog_Overcurrent_Debounce_BSW

The error is latched if the overcurrent detection signal is active for at least ({2}+{3})*100ms.

BMSv2: The analog circuit is triggered by an overcurrent of +-153.4A. The circuit triggers a GPIO input of the MCU. The pin change interrupt evaluates the pin and raises the overcurrent detection signal if the signal on the pin stays high for the debounce value configured in {3}.

The debounce value {3} is handled in the base firmware within the GPIO interrupt. A while loop counts the debounce value up until it reaches the configured value in {3}. This means that the value in {3} does not relate to a certain amount in milliseconds.

11.5.22 ERR_E_Overtemp_Charge

Dependent variables:

- {1} SET_C_Overtemp_Charge
- {2} ERR_C_Overtemp_Charge_Hyst
- {3} ERR_C_Overtemp_Charge_Debounce_L1
- {4} ERR_C_Overtemp_Charge_Debounce_L2

The error is latched in charging mode if the highest measured cell temperature is larger than {1} with a hysteresis temperature configured in {2} for at least ({3}+{4})*100ms.

Hysteresis means that the error debounce starts running when the temperature gets higher than {1} and resets if the temperature drops below ({1} - {2}).

11.5.23 ERR_E_Overtemp_Discharge

Dependent variables:

- {1} SET_C_Overtemp_Discharge
- {2} ERR_C_Overtemp_Discharge_Hyst
- {3} ERR_C_Overtemp_Discharge_Debounce_L1
- {4} ERR_C_Overtemp_Discharge_Debounce_L2

The error is latched in discharge mode if the highest measured cell temperature is larger than {1} with a hysteresis temperature configured in {2} for at least ({3}+{4})*100ms.

Hysteresis means that the error debounce starts running when the temperature gets higher than {1} and resets if the temperature drops below ({1} - {2}).

11.5.24 ERR_E_Undertemp_Charge

Dependent variables:

- {1} SET_C_Undertemp_Charge
- {2} ERR_C_Undertemp_Charge_Debounce_L1
- {3} ERR_C_Undertemp_Charge_Debounce_L2

The error is latched in charging mode if the lowest measured cell temperature is lower than {1} for at least ({2}+{3})*100ms.

11.5.25 ERR_E_Undertemp_Discharge

Dependent variables:

- {1} SET_C_Undertemp_Discharge
- {2} ERR_C_Undertemp_Discharge_Debounce_L1
- {3} ERR_C_Undertemp_Discharge_Debounce_L2

The error is latched in discharge mode if the lowest measured cell temperature is lower than {1} for at least ({2}+{3})*100ms.

11.5.26 ERR_E_Current_Flow_Passive_State

Dependent variables:

- {1} ERR_C_Current_Flow_Passive_State_Current_Threshold
- {2} ERR_C_Current_Flow_Passive_State_Debounce_L1
- {3} ERR_C_Current_Flow_Passive_State_Debounce_L2

The error is latched only when not in charge or discharge mode and measured current is higher than {1} for at least ({2}+{3})*100ms.

11.5.27 ERR_E_CAN_Timeout

Dependent variables:

- {1} SET_C_CAN_Timeout_Monitoring
- {2} ERR_C_CAN_Allow_Charge_With_Timeout
- {3} CANIN_C_RX_Timeout_ID_160_Mode_Cyclic
- {4} ERR_C_Current_Flow_Passive_State_Debounce_L1
- {5} ERR_C_Current_Flow_Passive_State_Debounce_L2

This block can only latch an error if the variable {1} is set to '1'.

The error is latched if a CAN control frame timeout is detected by the base firmware. The CAN control frame is described in the *BMS .dbc* file. The timeout between two control frames can be set with the variable {3} in milliseconds. If the variable {2} is set to '1', it is possible to charge the BMS without control frame messages over CAN.

The error is latched after the debounce time ({4}+{5})*100ms.

11.5.28 ERR_E_Cell_Connection

Dependent variables:

- {1} SET_C_Pack_Num_Serial_Cells
- {2} ERR_C_Current_Flow_Passive_State_Debounce_L1
- {3} ERR_C_Current_Flow_Passive_State_Debounce_L2

The error is latched after the debounce time of ({2}+{3})*100ms if one of the following conditions is met:

- Number of detected serial cells differ from configured value in variable {1}
- Cell_Management module reported cell error (happens at cell connection check where each FET for the balance charging is triggered after each other and the voltage of a cell drops below a configured threshold)
- A cell overvoltage/undervoltage warning was detected during the ongoing cell connection check
- The cell monitoring ICs reported an alert or CRC error during the ongoing cell connection check

A cell connection error is only cleared after a restart of the ECU

11.5.29 ERR_E_12V_AUX_Undervoltage

Dependent variables:

- {1} ERR_C_12V_AUX_Voltage_Minimum
- {2} ERR_C_12V_AUX_Voltage_Debounce_L1
- {3} ERR_C_12V_AUX_Voltage_Debounce_L2

BMSv2 or newer:

The error is latched if the measured 12V AUX output voltage is lower than the configured minimum {1} for at least ({2}+{3})*100ms.

12 Versioning

Versioning of this document		
Version	**Date**	**Remarks**
V2 (EN)	20220915	BMS runtime information removed
V1.1 (EN)	20220223	Added hint to avoid hotplugging
V1 (EN)	20210921	First version

Table 1: Versioning of this document.