Certificate of Conformity

Certificate No.: ANT2412020006-010C

Applicant	:	**Shandong Dejin New Energy Science and Technology Co., Ltd.**
Address	:	**No.001, South First, Tonghai Road, Longkou High-tech Industrial Park Longkou City, Yantai City, Shandong Province**
Manufacturer	:	**Shandong Dejin New Energy Science and Technology Co., Ltd.**
Address	:	**No.001, South First, Tonghai Road, Longkou High-tech Industrial Park Longkou City, Yantai City, Shandong Province**
Product	:	**Rechargeable Lithium-ion Cell**
Trade Mark	:	**N/A**
Models	:	**CBA71173207EES-314Ah**
Test Standard(s)	:	**IEC 62321-3-1: 2013; IEC 62321-5: 2013; IEC 62321-4:2013+A1:2017; IEC 62321-6:2015; IEC 62321-7-1:2015; IEC 62321-7-2:2017; IEC 62321-8:2017**
Report No.	:	**ANT2412020006-010**

The submitted products have been tested by us with the listed standards and found in compliance with the following European Directives:

(EU) 2015/863 amending Annex II to RoHS Directive 2011/65/EU

The Restriction of The Use of Certain Hazardous Substances In Electrical and Electronic Equipment

The tests were performed in normal operation mode. The test results apply only to the particular sample tested and to the specific tests carried out. This certificate applies specifically to the sample investigated in our test reference number only.

The RoHS markings as shown below can be affixed on the product after preparation of necessary technical documentation.

Other relevant Directives have to be observed.

RoHS

SHENZHEN ALLIANCE TESTING TECHNOLOGY CO.,LTD
ANT LAB
Report Seal

.....
Manager

Date of Issue: December 24, 2024

Shenzhen Alliance Testing Technology Co., LTD.
202,building B, jinfengzhihuigu, No.45, Yonghe Road,Heping community, Fuhai street, Bao'an District,Shenzhen, Guangdong, China
Tel: 0755-23224560 E-mail: ant@ant-alliance.net www.ant-alliance.cn

Certificate

of Conformity

Registered No.:

COCPVP11047/24E-002

File reference	Test report No.	Date of issue
PVP11047/24E-002	TRPVP11047/24E/002	2025-01-20

On the basis of the tests undertaken, the samples of the below product(s) have been found to comply with the essential requirements of the referenced specifications at the time the tests were carried out:

Applicant:	**Shenzhen Enjoy Technology Co., Ltd.** (Settle-in Shenzhen Qianhai Commerce Secretariat Co., Ltd.) 201Room, Building A, Qianwan Road 1, Qianhai Shenzhen-Hong Kong Cooperation Zone, Shenzhen City, Guangdong Province, P.R. China
Manufacturer:	**Shenzhen Enjoy Technology Co., Ltd.** (Settle-in Shenzhen Qianhai Commerce Secretariat Co., Ltd.) 201Room, Building A, Qianwan Road 1, Qianhai Shenzhen-Hong Kong Cooperation Zone, Shenzhen City, Guangdong Province, P.R. China
Factory:	**Shenzhen Enjoy Technology Co., Ltd.** Building 5, TE Connectivity Technology Park, Shiyan Beihuan Road, Bao'an District, Shenzhen, China
Product:	Power Conversion System
Type designation:	EPCS30-AM, EPCS50-AM, EPCS63-AM, EPCS80-AM, EPCS105-AM, EPCS105-AM-F, EPCS125-AM, EPCS125-AM-F Software version: V200B000D000
Certification program:	BOS-P-01 Rev. 00
Certification fundamental(s):	IEC 61727:2004, IEC 62116:2014 See test report for detailed information.

This document is based on the evaluation of the samples of the above mentioned product(s). It does not imply an assessment of the mass-production of the product(s), and it does not permit the use of a TÜV NORD mark. The holder of this document may use it in connection with the related test report(s).

Renewable Energy

CNAS 中国认可 产品 PRODUCT CNAS C183-P

TÜV NORD (HANGZHOU) CO., LTD.
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P.R. China

C E R T I F I C A T E

of Conformity
Directive 2014/30/EU
Electromagnetic Compatibility

Registration No.:	AE 50665367 0001
Report No.:	CN25DXHP 001
Holder:	Shenzhen Enjoy Technology Co., Ltd. (Settle-in Shenzhen Qianhai Commerce Secretariat Co.,Ltd.) 201Room, Building A, Qianwan Road 1, Qianhai Shenzhen-Hong Kong Cooperation Zone, Shenzhen City, 518000 Guangdong P.R. China
Product:	Converter *(Power Conversion System)*

Type designation listed on the next page

This certificate of conformity is based on an evaluation of a sample of the above mentioned product. This is to certify that the tested sample is in conformity with all provisions of Annex I of Council Directive 2014/30/EU. This certificate does not imply assessment of the production of the product and does not permit the use of a TÜV Rheinland mark of conformity. The holder of the certificate is authorized to use this certificate in connection with the EC declaration of conformity according to the a.m. Directive.
This is not an EU-Type Examination Certificate.

Certification Body

TÜV Rheinland LGA Products GmbH TÜVRheinland Zertifizierungsstelle

Tongle Lee

Date: 2025-02-20

TÜV Rheinland LGA Products GmbH - Tillystraße 2 - 90431 Nürnberg

C E R T I F I C A T E

of Conformity
Directive 2014/30/EU
Electromagnetic Compatibility

Registration No.:	AE 50665367 0001
Product:	Converter *(Power Conversion System)*
Tested according to:	EN IEC 61000-6-2:2019 EN IEC 61000-6-4:2019
Identification:	Type Designation EPCS105-AM, EPCS105-AM-F, EPCS125-AM, EPCS125-AM-F Remark: Refer to the test report for details.

TÜV Rheinland LGA Products GmbH
TÜVRheinland
Zertifizierungsstelle

TÜV Rheinland LGA Products GmbH - Tillystraße 2 - 90431 Nürnberg

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C E R T I F I C A T E

of Conformity
Low Voltage Directive (EU) 2014/35

Registration No.:	AN 50663492 0001
Report No.:	CN25FXA8 001
Holder:	Shenzhen Enjoy Technology Co., Ltd. (Settle-in Shenzhen Qianhai Commerce Secretariat Co.,Ltd.) 201Room, Building A, Qianwan Road 1, Qianhai Shenzhen-Hong Kong Cooperation Zone, Shenzhen City, 518000 Guangdong P.R. China
Product:	Converter *(Power Conversion System)*

Type designation listed on the next page

This certificate of conformity is based on an evaluation of a sample of the above-mentioned product. Technical Report and documentation are at the License Holder's disposal. This is to certify that the tested sample is in conformity with Annex I of Council Directive (EU) 2014/35, referred to as the Low Voltage Directive. This certificate does not imply assessment of the series-production of the product and does not permit the use of a TÜV Rheinland mark of conformity. The holder of the certificate is authorized to use this certificate in connection with the EC declaration of conformity according to Annex IV of the Directive.

Certification Body

Date: 2025-03-14

A. Chen

TÜV Rheinland LGA Products GmbH
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Zertifizierungsstelle

TÜV Rheinland LGA Products GmbH - Tillystraße 2 - 90431 Nürnberg

The CE marking may be used if all relevant and effective EC Directives/Regulations are complied with.

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C E R T I F I C A T E

of Conformity
Low Voltage Directive (EU) 2014/35

Registration No.: AN 50663492 0001

Product: Converter
(Power Conversion System)

Identification: Type Designation
EPCS125-AM, EPCS125-AM-F, EPCS105-AM, EPCS105-AM-F

Remark: Refer to test report CN25FXA8 001 for details.

TÜV Rheinland LGA Products GmbH - Tillystraße 2 - 90431 Nürnberg

The CE marking may be used if all relevant and effective EC Directives/Regulations are complied with.

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CERTIFICATE OF COMPLIANCE

Certificate Number: **SGSNA/22/SH/00101**

Contract Number: 801741
Certificate Project Number: SH-CERT220200872

Certified Product: Electric Storage Battery Control Module
Trademarks:

Model(s): ESBCM-X133 (X=F, C, A)
Technical Data: Input: 9 V d.c. - 32 V d.c.; 0,92 A; 8,3 W;
Class III

Certificate Holder: Hangzhou Gold Electronic Equipment Inc.
Room 201, Building F, Haichuang Park, 198 Aicheng Street, Hangzhou, Zhejiang

This certificate supercedes previous certificates issued with the same certificate number. Certification is valid when products are indicated on the SGS directory of certified products at www.sgs.com or using the QR code below. The product is certified according to ISO/IEC Guide 17067, Conformity assessment - Fundamentals of product certification, System 3, and in accordance with:

UL 62368-1, Ed. 3 dated December 13, 2019
CAN/CSA C22.2 No. 62368-1-19

Authorized by:

Effective date: 13 May 2022

Mark Lohmann
Certifier

Certification Body

Consumer and Retail Services, a division of SGS North America Inc.
620 Old Peachtree Road, Ste. 100, Suwanee, GA 30024, USA
t +1 770 570 1800 f +1 770 277 1240 www.sgs.com

Ref. Certif. No.
BE-41356

IEC SYSTEM FOR MUTUAL RECOGNITION OF TEST CERTIFICATES FOR ELECTRICAL EQUIPMENT (IECEE) CB SCHEME

CB TEST CERTIFICATE

Product	Electric Storage Battery Control Module
Name and address of the applicant	Hangzhou Gold Electronic Equipment Inc. Room 201, Building F, Haichuang Park, 198 Aicheng Street, Hangzhou, 310012, Zhejiang, China
Name and address of the manufacturer	Hangzhou Gold Electronic Equipment Inc. Room 201, Building F, Haichuang Park, 198 Aicheng Street, Hangzhou, 310012, Zhejiang, China
Name and address of the factory	Hangzhou Gold Electronic Equipment Inc. Room 201, Building F, Haichuang Park, 198 Aicheng Street, Hangzhou, 310012, Zhejiang, China
Note: *When more than one factory, please report on page 2*	☐ Additional Information on page 2
Ratings and principal characteristics	9 V d.c. - 32 V d.c.; 0,92 A; 8,3 W; Class III
Trademark (if any)	GOLD
Customer's Testing Facility (CTF) Stage used	-
Model / Type Ref.	ESBCM-X133 (X=F, C, A)
Additional information (if necessary may also be reported on page 2)	- ☐ Additional Information on page 2
A sample of the product was tested and found to be in conformity with	IEC 60950-1:2005, IEC 60950-1:2005/AMD1:2009, IEC 60950-1:2005/AMD2:2013 National Differences: EU Group Differences, EU Special National Conditions
As shown in the Test Report Ref. No. which forms part of this Certificate	SHES210901901001

This CB Test Certificate is issued by the National Certification Body

SGS Belgium NV - Division SGS CEBEC
Riverside Business Park
Bld Internationalelaan 55, Building K
B-1070 Brussels, Belgium

Date: 2022-04-08

Signature: Mark Lohmann

Technical Report for Functional Safety

Report No.: SHFS220200006171

February. 25th, 2022

Client / Applicant:	Hangzhou Gold Electronic Equipment Inc. Room 201,Building F, Haichuang Park, 198 Aicheng Street, Hangzhou, Zhejiang, China.
Manufacturer:	Same as applicant.
Project Title:	Battery management system in lithium battery.
Module No.:	ESBCM: ESBCM-X133(X=F, C, A) ESBMM: ESBMM-2422 (Note: A=1000V, C=1200V, F=1500V)
Tested Standards:	UL 60730-1: 2016 Annex H
Conclusion	In this report, safety protection function of Battery Management System was assessed to achieved class B according to UL 60730-1:2016 Annex - H, detail of safety function items sees Table 1 Safety functions definition.

This evaluation report confirms the achievement of the requirements of functional safety based on the following proofs:

- Proof of systematic safety integrity for defined phases of the life cycle
- Proof of the techniques and measures according to UL 60730-1:2016 Annex H
- Proofs that process and methods are established at the manufacturer guaranteeing that unexceptionable processes.

In terms of risk analysis, design, production, validation, change management and quality management comply with the safety-related standard.

Independent organization for functional safety assessment	Assessor	Approver
SGS-CSTC Standards Technical Services (Shanghai) Co., Ltd.	Bob Jin	Jerry Zheng

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中国·上海·松江区金都西路 588 号 邮编: 201612 t (86-21) 61915666 f (86-21) 61915678 e sgs.china@sgs.com

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1. Summary of assessment

This technical report summarizes the safety performance evaluation results towards the software safety functions in Battery Management system [Model No.: **ESBCM: ESBCM-X133 ESBMM: ESBMM-2422**], provides by Gold Electronic Equipment Inc., Ltd.

No deviations were found during the assessment acc. To UL 60730-1:2020 Annex H for safety related software functions in BMS system in terms of systematic capacity.

The validation of functional safety is based on a basic examination regarding quality management system and the functional safety management as part of the software performance level. All project development engineers have completed relevant trainings in functional safety, and most of them previously participated in product development projects involving functional safety.

In this report, the below safety functions for Model No.: **ESBCM: ESBCM-X133 ESBMM: ESBMM-2422** Battery Management System have been assessed:

Identification	Safety Critical Function Items
SF01	Over/Deep under voltage protect for charge.
SF02	Under voltage protect for discharge.
SF03	Over current of battery protect for charge.
SF04	Over current of battery protect for discharge.
SF05	Short current of battery protection.
SF06	High/Low temperature protect for charge.
SF07	High/Low temperature protect for discharge.
SF08	Low insulation resistance protection for charge and discharge.

Table 1: Safety functions definition

Supplementary Information:

[1] UL60730-1:2016 Annex H as a guide
[2] The more detail information please refers to the following report.
[3] This assessment is based on the requirement stated in UL 60730-1:2016 Annex H towards software Class B

2. Assessment Period

Beginning of project: 2021-10-12
End of project: 2022-02-25

3. References

No.	Document Description

[D01]	Quality Management System Certificate
[D02]	SW Design Specification_GoldBMS
[D03]	Schematic of ESBCM-X133 HV4.0
[D04]	Schematic of EVBMM-2422 HV4.0
[D05]	PCB Bottom Layer of ESBCM-X133 HV4.0
[D06]	PCB Top Layer of ESBCM-X133 HV4.0
[D07]	PCB Layer of EVBMM-2422_HV4.0
[D08]	ESBCM-X133-HV4.0 Critical Component List
[D09]	EVBMM-2422 HV4.0 Critical Component List
[D10]	Gold Electronic General rules of software coding specification V1.2
[D11]	ESBCM X133-HV4.0 FMEDA template per UL60730_v20210825
[D12]	EVBMM-2422 HV4.0 FMEDA
[D13]	Software product development process
[D14]	Software project development process
[D15]	Project software change management process
[D16]	Change management procedure A2.0
[D17]	Product Version Coding Specification A1.0
[D18]	SVN Code Management Scheme_ V1.1
[D19]	BCM-X133 Code Review Record
[D20]	ESBMM-2422 Code Review Record
[D21]	ESBCM-X133 HV4.0 Code Static Test Report
[D22]	ESBMM2422 HV4.0.2 Code Static Test Report
[D23]	Derating design criteria for electronic components
[D24]	Component derating design data list
[D25]	ESBCM-X133 V4.0 MCU Pin Interface definition
[D26]	ESBMM-2422 V4.0 MCU Pin Interface definition
[D27]	ESBCM-X133 HV4.0 Intergration Test Report
[D28]	ESBMM-2422 HV4.0 Intergration Test Report
[D29]	EVBMS Debugging Software V2.2 user's manual
[D30]	ESBCM-X133 software architecture design
[D31]	ESBCM-X133 CAN communication detailed design
[D32]	EVBCM-X133 SW module interface description

[D33]	ESBMM-2422 SW detailed design for cell volgtage and cell temperature acquisition
[D34]	EVBCM-X133 SW detailed design for high voltage acquisition
[D35]	EVBCM-X133 SW detailed design for current acquisition.
[D36]	EVBCM-X133 HT7107 SW detailed design for insulation acquisition.
[D37]	SW based parameterization

Table 2: References and documents

4. Revision Logs

Version	Changes Description
V1.0	Initial Version

Table 3: Revision logs

5. Symbols and abbreviated terms

No.	Abbreviation	Description
1	HW	Hardware
2	SW	Software
3	SF	Safety Function
4	SRS	Safety Requirement Specification
5	CHG (MOS)	Charge MOS
6	DCHG (MOS)	Discharge MOS
7	MCU	Microcontroller Unit
8	ADC	Analog to Digital Converter
9	WDT	Watch Dog Timer
10	E-Cap	Electrolytic capacitor
11	Cap	Capacitance
12	ESBCM	Electric Storage Battery Control Model
13	ESBMM	Electric Storage Battery Monitor Model
14	SV	Software Version
15	C-Tm	Temperature of cell

Table 4: Glossary and Terms

6. Design and Development Tools

No.	Type of Tool	Vendor	Tool Name	Revision
1	Version Control	OpenSSL	TortoiseSVN	V1.7.2

2	Development Tool of ESBCM	Freescale	CodeWarrior IDE	V5.1
3	Development Tool of ESBMM	Freescale	IAR Embedded Workbench IDE	V7.40.5
4	Simulation of ESBCM	Freescale	USBDM	V4.12
5	Simulation of ESBMM	Freescale	J-link	V8.0
6	Schematic and PCB Design	Altium	Altium Designer	V14.3.16
7	Soft Development	Mathwork	MatLab	R2014

Table 5: Design tools

7. HW Design Description

No.	Parts	Type	Location	Rated value	Actual value	Road rate
ESBCM-X133						
1	Fuse	AF120610.0T	F1	10A	6.2A	62%
2	Power IC	MPQ9843GL	U1	3.5A	0.8A	23%
3	Bead	BLM21AG601SN1#	L15	700mA	0.25mA	0.036%
4	CAP	CC0805KKX7R0BB104	C196	100V	5V	5%
5	Resistance	RT0603BRC-0710KL	R247	3.5mA	0.25mA	7%
6	MOS	BTS724G	U51	7.3A	3A	41%
7	MOS	IPG20N06S4L-26	Q27	20A	1A	5%
8	Fuse	0437-005	F13	5A	1A	20%
9	Resistance	RC1206FR-0720KL	R269	3.5mA	1.2mA	34%
10	CAP	CC0805KKX7R0BB104	C216	100V	32V	32%
11	Resistance	RC0805FR-07510KL	R273	0.5mA	0.06mA	1%
12	Transistor	S-LBC847BLT1G	Q19	45V	5V	11%
13	PhotoMOS Relay	AQV258HAX	U36	1500V	860V	57%
14	Resistance	CSRV0207DTCT5103	R154	350V	108V	31%
15	Resistance	CSRV0204FTCV1004	R206	200V	125V	63%
ESBMM-2422						

1	Fuse	LP-SM300C	F25	3A	0.83A	28%
2	Power IC	LM2576HVS-5.0	U14	3A	0.2A	7%
3	Resistance	RC0805FR-07120RL	R310_1	32mA	1uA	0.0031%
4	CAP	CC0805KKX7R0BB104	C310_1	100V	5V	5%
5	Resistance	RC1206FR-071RL	R287_1	0.5A	0.01A	2%

Table 6: Derating Design Description of Critical Parts

I/O No.	I/O PIN Name	Direction: In/Out	Function Description
"ESBCM-X133 V4.0" MCU Interface allocation as below			
1	PK1 (Pin 7)	Output	Main Positive Relay Control
2	PK0 (Pin 8)	Output	Pre-Charge Relay Control
3	PT0 (Pin 9)	Output	Main Negative Relay Control
4	PT5 (Pin 16)	Input	Disconnector status feedback
5	PB2 (Pin 26)	Input	Main Positive Relay status feedback
"ESBMM-2422 V4.0" MCU Interface allocation as below			
1	PD1 (Pin 1)	Output	SPI Send Data (MOSI)
2	PDO (Pin 2)	Output	SPI Clock Signal
3	PTI4 (Pin 13)	Input	Fault feedback receiving pin of first GT3801
4	PTB0 (Pin 34)	Input	Balance the power supply and voltage detection of GT3801
5	PTA7 (Pin 37)	Input	Power supply sampling pin
Note: All IO ports of MCU are clearly assigned, for complete description of MCU pin interface refer to document [D25] and [D26].			

Table 7: MCU I/O assignment table

8. Assessment Item Information

Inspection item description ..... : Battery management system in lithium battery

Model of ESBCM ..... : ESBCM-X133(X=F, C, A)

ESBCM HW Version ..... : HV4.0

ESBCM SW Version ..... : SV:M-3-4.0.4

Model of ESBMM ..... : ESBMM-2422

ESBMM HW Version..... : HV4.0

ESBMM SW Version..... : SV:M-3-4.2.1

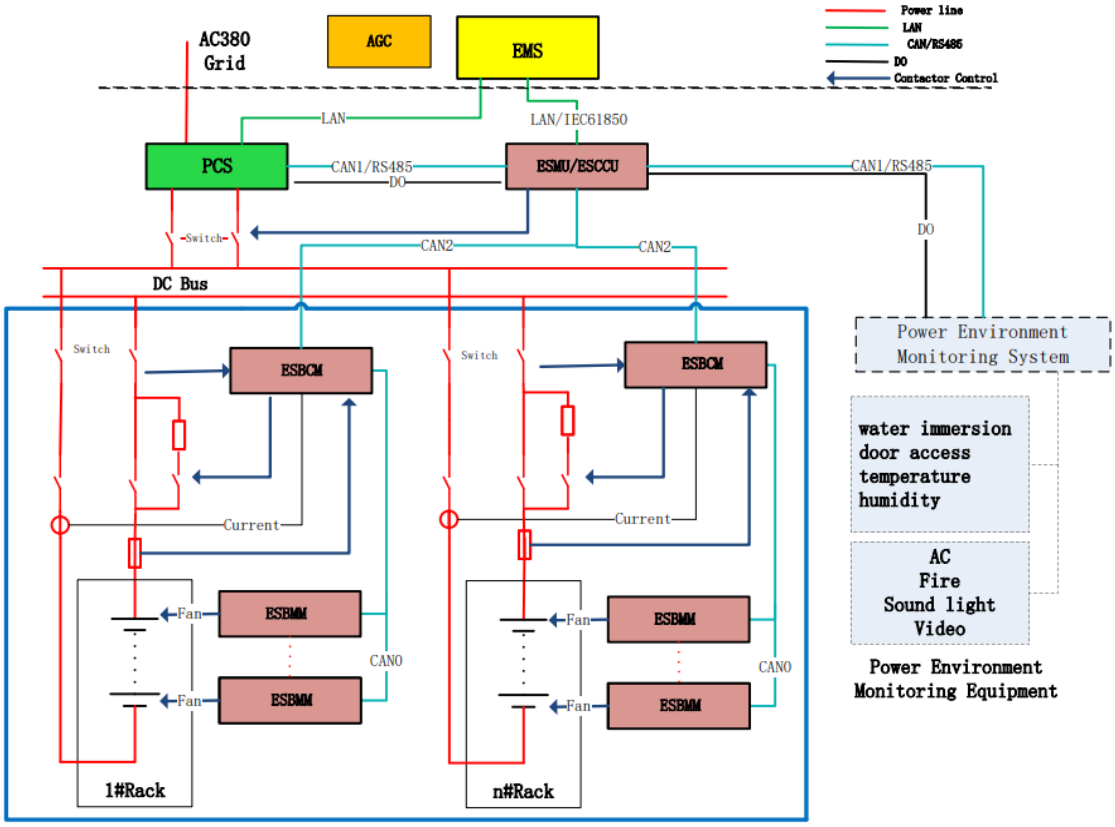


Figure 1 System Architecture of BMS

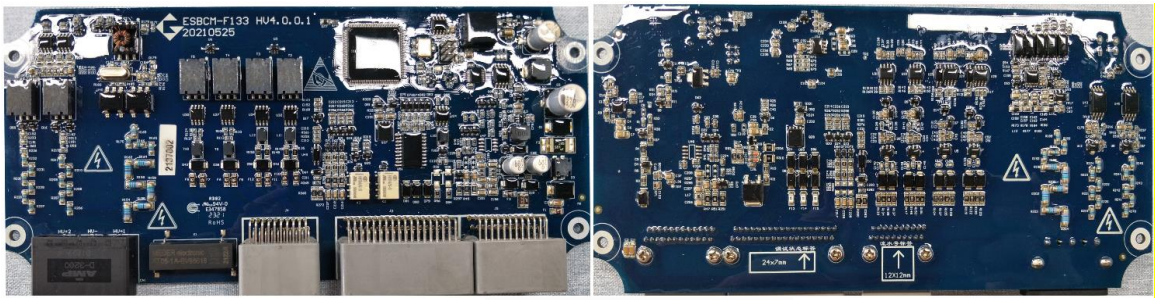


Figure 2 View of ESBCM PCBA

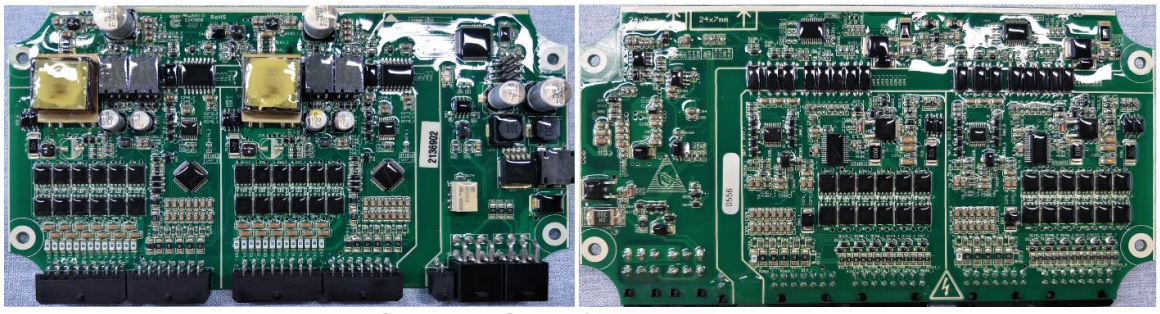


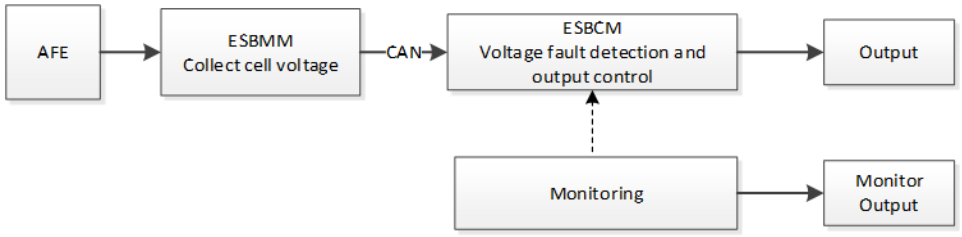
Figure 3 View of ESBMM PCBA

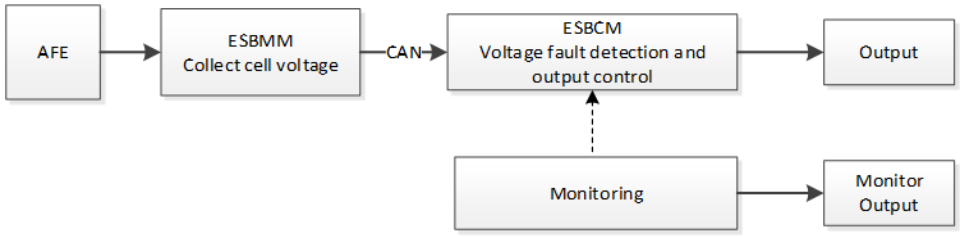
9. SW Safety Requirement Specification

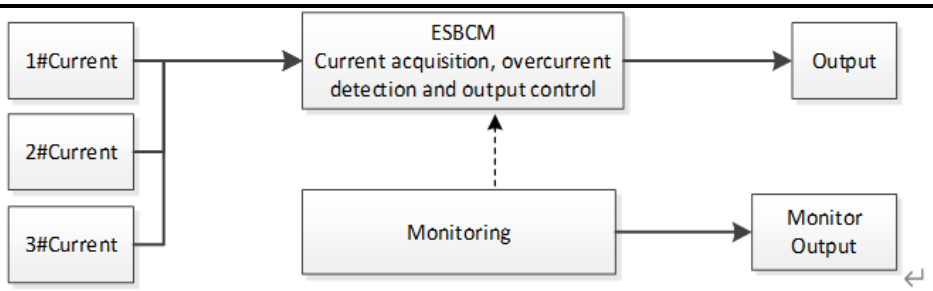
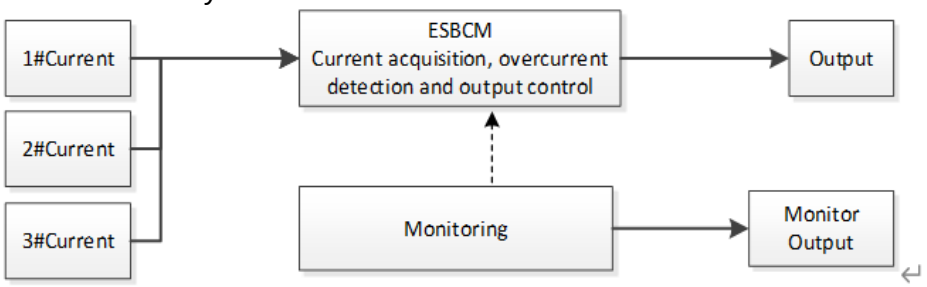
9.1. Safety Function Definition

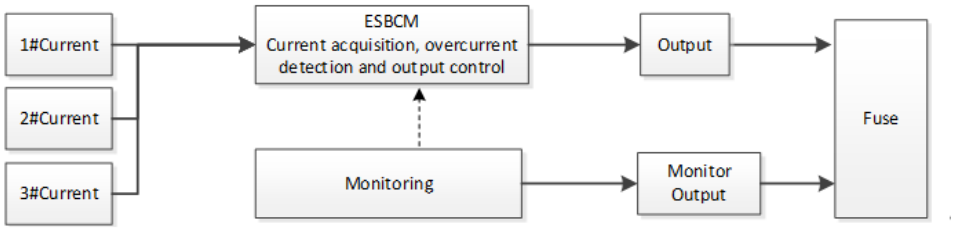
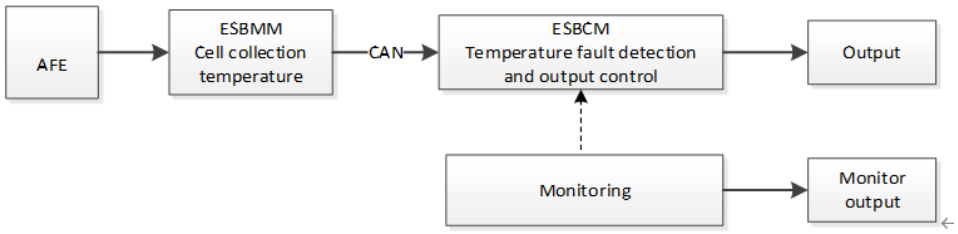
The below protection functions of BMS shall be defined as safety function, refers to **Table 1** safety function definition.

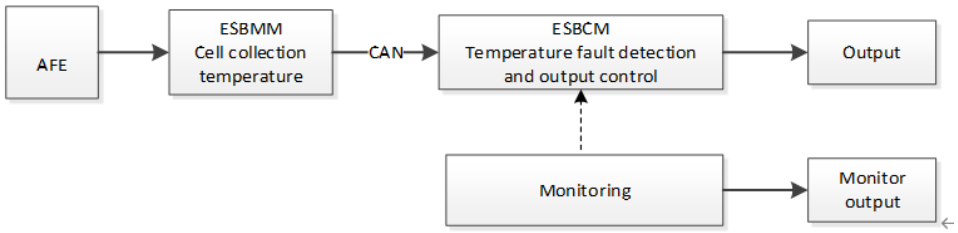
The details requirements for above safety functions specified as following tables:

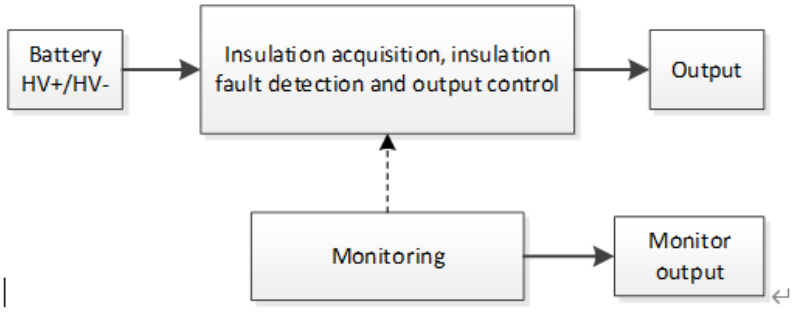
Ident.	
SRS01	Safety function: Over/Deep under voltage protect for charge
	1. Function Safety Circuit Structure  Input Circuit: AFE GT1812 IC and related circuit. Logic Circuit: S9KEAZ128AMLH\S912XEQ512AMAL and related circuit. Output Circuit: Relay and related circuit. TE Circuit: Co-processor of S912XEQ512AMAL IC and related circuit. OTE Circuit: Relay and related circuit. More information of details refers to [D02].
	2. Safety state description 2.1 Over voltage: **Detection:** Any cell voltage > X1 and durations 3s or Any cell voltage >= Y1 and durations 3s **Recovery:** cell voltage < (X1-Z1) and cell voltage < Y1. 2.2 Deep Under voltage: **Detection:** Any cell voltage < X2 and durations 3s and Any cell voltage <= Y2 and durations 3s **Recovery:** cell voltage > (X2+Z2) and cell voltage > Y2. 2.3 Enter the safety state: Cut off the Positive relay and Negative relay. Relay keep open even if fault recovery until manual maintain. Notes: a. X1/X2 and Z1/Z2 can be config through parameters. b. Y1 Curing in program: Lithium iron phosphate battery: 3.8v.

	Lithium titanate battery: 2.85v. Ternary lithium battery: 4.35v. c. Y2 Curing in program: Lithium iron phosphate battery: 2.5v. Lithium titanate battery: 4.1v. Ternary lithium battery: 2.5v.
	3. Fault tolerance time interval Time ≤ 8.0s
SRS02	Safety function: Under voltage protect for discharge
	1. Function Safety Circuit Structure  Input Circuit: AFE GT1812 IC and related circuit. Logic Circuit: S9KEAZ128AMLH\S912XEQ512AMAL and related circuit. Output Circuit: Relay and related circuit. TE Circuit: Co-processor of S912XEQ512AMAL and related circuit. OTE Circuit: Relay and related circuit. More information of details refers to [D02].
	2. Safety state description 2.1 Under voltage: **Detection:** Any cell voltage < X and durations 3s or Any cell voltage < Y and durations 3s **Recovery:** Any cell voltage > (X+Z) and Any cell voltage > Y. 2.2 Enter the safety state: Cut off the Positive relay and Negative relay. Relay keep open even if fault recovery until manual maintain. Notes: a. X and Z can be set th config rough parameters. b. Y Curing in program: Lithium iron phosphate battery: 2.5v. Lithium titanate battery: 1.4v. Ternary lithium battery: 2.5v.
	3. Fault tolerance time interval Time ≤ 8.0s
SRS03	Safety function: Over current of battery protect for charge
	1. Function Safety Circuit Structure

	 Input Circuit: A sampling circuit composed of r247, r251, r255 resistors. Logic Circuit: S912XEQ512AMAL IC and related circuit. Output Circuit: Relay and related circuit. TE Circuit: Co-processor of S912XEQ512AMAL IC and related circuit. OTE Circuit: Relay and related circuit. More information of details refers to [D02].
	2. Safety state description 2.1 Fault detection and recovery conditions： **Detection:** Charge current > XA and durations 3s **Recovery:** Charge current < (X-Y)A and durations 3s. 2.2 Enter the safety state： Cut off the Positive relay and Negative relay. Relay keep open even if fault recovery. Relay re-connect need manual operation. Note: X and Y can be config through parameters.
	3. Fault tolerance time interval Time ≤ 8.0s
SRS04	Safety function: Over current of battery protect for discharge
	1. Function Safety Circuit Structure  Input Circuit: A sampling circuit composed of r247, r251, r255 resistors. Logic Circuit: S912XEQ512AMAL IC and related circuit. Output Circuit: Relay and related circuit. TE Circuit: Co-processor of S912XEQ512AMAL IC and related circuit. OTE Circuit: Relay and related circuit. More information of details refers to [D02].
	2. Safety state description 2.1 Fault detection and recovery conditions：

	Detection: Discharge current > XA and durations 3s **Recovery:** Discharge current < (X-Y) A and durations 3s. 2.2 Enter the safety state： Cut off the Positive relay and Negative relay. Relay keep open even if fault recovery. Relay re-connect need manual operation. Note: X and Y can be config through parameters.
	3. Fault tolerance time interval Time ≤ 8.0s
SRS05	Safety function: Short current of battery protect
	1. Function Safety Circuit Structure  Input Circuit: A sampling circuit composed of r247, r251, r255 resistors. Logic Circuit: S912XEQ512AMAL IC and related circuit. Output Circuit: Relay and related circuit. TE Circuit: Co-processor of S912XEQ512AMAL IC and related circuit. OTE Circuit: Relay and related circuit. More information of details refers to [D02].
	2. Safety state description 2.1 Fault detection and recovery conditions： **Detection:** Discharge current or charge current > XA and durations 500ms **Recovery:** Discharge current or charge current < (X-Y)A and durations 500ms. 2.2 Enter the safety state： Cut off the Positive relay and Negative relay. Relay keep open even if fault recovery. Relay re-connect need manual operation. Note: X and Y can be config through parameters.
	3. Fault tolerance time interval Time ≤ 1.0s
SRS06	Safety function: High / Low temperature protect for charge
	1. Function Safety Circuit Structure 

	Input Circuit: A sampling temperature AFE IC and related circuit. Logic Circuit: S912XEQ512AMAL IC and related circuit. Output Circuit: Positive relay and related circuit. TE Circuit: Co-processor of S912XEQ512AMAL IC and related circuit. OTE Circuit: Negative relay and related circuit. More information of details refers to [D02].
	2. Safety state description 2.1 High temperature fault detection and recovery conditions： **Detection:** C-Tm > X1℃ and durations 3s or C-Tm > 75℃ and duration 3s. **Recovery:** C-Tm < (X1-Y1)℃ and durations 3s and Highest C-Tm < 75℃ and duration 3s. 2.2 Low temperature fault detection and recovery conditions： **Detection:** Lowest C-Tm < X2℃ and durations 3s. **Recovery:** Highest C-Tm > (X2+Y2)℃ and durations 3s. 2.3 Enter the safety state： Cut off the Positive relay and Negative relay. Relay keep open even if fault recovery. Relay re-connect need manual operation. Note: X1/X2 and Y1/Y2 can be config through parameters.
	3. Fault tolerance time interval Time ≤ 8.0s
SRS07	Safety function: High / Low temperature protect for discharge
	1. Function Safety Circuit Structure  Input Circuit: A sampling temperature AFE IC and related circuit. Logic Circuit: S912XEQ512AMAL IC and related circuit. Output Circuit: Positive relay and related circuit. TE Circuit: Co-processor of S912XEQ512AMAL IC and related circuit. OTE Circuit: Negative relay and related circuit. More information of details refers to [D02].
	2. Safety state description 2.1 High temperature fault detection and recovery conditions： **Detection:**

	C-Tm > X1℃ and durations 3s or C-Tm > 75℃ and duration 3s. **Recovery:** C-Tm < (X1-Y1)℃ and durations 3s and Highest C-Tm < 75℃ and duration 3s. 2.2 Low temperature fault detection and recovery conditions: **Detection:** Lowest C-Tm < X2℃ and durations 3s. **Recovery:** Highest C-Tm > (X2+Y2)℃ and durations 3s. 2.3 Enter the safety state: Cut off the Positive relay and Negative relay. Relay keep open even if fault recovery. Relay re-connect need manual operation. Note: X1/X2 and Y1/Y2 can be config through parameters.
	3. Fault tolerance time interval Time ≤ 8.0s
SRS08	Safety function: Low insulation resistance protection for charge and discharge
	1. Function Safety Circuit Structure  Input Circuit: A sampling port voltage AFE IC and related circuit. Logic Circuit: S912XEQ512AMAL IC and related circuit. Output Circuit: Positive relay and related circuit. TE Circuit: Co-processor of S912XEQ512AMAL IC and related circuit. OTE Circuit: Negative relay and related circuit. More information of details refers to [D02].
	2. Safety state description 2.1 Fault detection and recovery conditions: **Detection:** Insulation resistance < X and durations 60s. **Recovery:** Insulation resistance > (X+Y) and durations 60s. 2.2 Enter the safety state: Cut off the Positive relay and Negative relay. Relay keep open even if fault recovery. Relay re-connect need manual operation. Note: X and Y can be config through parameters.

	3. Fault tolerance time interval Time ≤ 120.0s

Table 8: Safety function definition

9.2. Safe State

Safety response time please refer to the definition of each safety function in the part of “protection working mode definition”.

9.3. Safety Response Time

Safety response time please refer to the definition of each safety function in the part of “protection working mode definition”.

10. Assessment based on UL 60730-1:2016 Annex H

The colour legend applicated for software assessment as below.

Colour	Meaning
Green	Requirements fulfilled
Yellow	Measures are acceptable, improvement recommended
Red	Requirement not assessed in this report
White	Requirement not applicable

Table 9: Colour of requirement

H.6	Classification, additions	
H.6.18	Class of control function (A, B, C)	Class B
H.7	Information in addition to Table 1 provided:	
	66 - Software sequence documentation; clause: H.11.12.2.9; method: X.....	Requirements fulfilled. The software is referenced to relevant parts of the operating sequence and the associated hardware functions, refer to “SW Design Specification GoldBMS[D02]”.
	67 - Program documentation; clause: H.11.12.2.9, H.11.12.2.12; method: X.....	Requirements fulfilled. All hardware related software interfaces and memory variables are initialized. See documented in “SW Design Specification GoldBMS[D02]”.

	68 - Software fault analysis; clause: H.11.12, H.27.1.1.4; method: X.....	Requirements fulfilled. See document [D11](ESBCM X133 HV4.0 FMEDA) and [D12](ESBMM 2422FMEDA) for relevant fault analysis.
	69 - Software class(es) and structure; clause: H.11.12.2, H.11.12.3, H.27.1.2.2.1, H.27.1.2.3.1; method: D.....	Requirements fulfilled. The software has taken sufficient measures to detect faults and avoid the architectural design of fault measures, refer to document [D02] (SW Design Specification GoldBMS).
	70 - Analytical measures and fault/error control techniques employed; clause: H.11.12.1.2, H.11.12.2.2, H.11.12.2.4; method: X..	Requirements fulfilled Analytical measures is FMEDA and fault/error control techniques are employed with "disconnect charge and discharge circuit". See document [D02] (SW Design Specification GoldBMS).
	71 - Software fault/error detection time(s) for controls with software Classes B or C; clause: H.2.17.10, H.11.12.2.6; method: X.....	Requirements fulfilled. Software fault/error detection time(s) for controls are defined in document [D02] (SW Design Specification GoldBMS).
	72 - Control response(s) in case of detected fault/error; clause: H.11.12.2.7; method: X.....	Requirements fulfilled. For controls with functions, detection of a fault/error is result in the response declared in document [D02].
	93 – Maximum number of reset actions within a time period; clause H.11.12.4.3.6, H.11.12.4.3.4; method: D	Requirement not applicable
	94 – Number of remote reset actions; clause H.17.1.4.3; method: X.....	Requirement not applicable

	m – Controls with software classes B or C had information provided for safety-related segments of the software. Information on the non-safety related segments was sufficient to establish that they did not influence safety-related segments	Requirements fulfilled. Safety-related segments of the software and non-safety related segments are designed in different modules and allocated to different storage spaces, refer to document [D30] (ESBCM-X133 software architecture design).
	n – Software sequence was documented and, together with the operating sequence, included a description of the control system philosophy, the control flow, data flow and the timings.....	Requirements fulfilled. This information is described in the software architecture design. You can view the architecture design document [D30](ESBCM-X133 software architecture design).
	o - Safety-related data and safety-related segments of the software sequence, the malfunction of which could result in non-compliance with the requirements of Clauses 17, 25, 26 and 27, are identified	Requirements fulfilled. Identify the safety related data in the software sequence and this part of the function of the safety related section, and do the function safety, data protection and memory detection, refer to document [D30] (ESBCM-X133 software architecture design).
	– Included the operating sequence	Requirements fulfilled. The operation sequence is monitored by the watchdog ic. For details, you can check the document [D30] (ESBCM-X133 software architecture design).
	– Software fault analysis was related to the hardware fault analysis in Clause H.27	Requirements fulfilled. The software fault analysis considers the corresponding hardware fault analysis results, refer to document [D11] and [D12].

	q - Programming documentation was supplied in a programming design language declared by the manufacturer.....	Requirements fulfilled. The actual programming language is consistent with the manufacturer's declaration, and C language is used.
	r – Different software classes applied to different control functions	Requirements fulfilled. The functional safety requirements and levels of the project are derived from the concept of functional safety. There is a traceability relationship. Each functional safety has its own safety level. See document [D02] for more details.
	s - Measures declared are chosen by manufacturer from the requirements of Clauses H.11.12.1.2 to H.11.12.2.4 inclusive	Requirements fulfilled. The product meets single channel with periodic self-test and monitoring. Measures are declared with software class C. See document [D02] for details.
H.11	Constructional requirements	
H.11.12	Controls using software	
	Controls using software were so constructed that the software did not impair control compliance with the requirements of this standard	Requirements fulfilled. It has been confirmed that software did not impair control compliance with the requirements of this standard. The remote-control module operates in configuration and debugging mode, and the module code is partitioned and isolated, refer to [D02].
H.11.12.1	Requirements for the architecture	

H.11.12.1.1	Control functions with software class B or C use measures to control and avoid software-related faults/errors in safety-related data and safety-related segments of the software, as detailed in H.11.12.1.2 to H.11.12.3 inclusive	Requirements fulfilled. The software uses watchdog, timing monitoring, time slot monitoring and other measures. See document [D30] for more information.
H.11.12.1.2	Control functions with software class C have one of the following structures:	
	– single channel with periodic self-Inspect and monitoring (H.2.16.7)	Requirements fulfilled. All safety functions are single channel with periodic self-inspect and monitoring, more detail information see [D02].
	– dual channel (homogenous) with comparison (H.2.16.3)	Requirement not applicable See description above.
	– dual channel (diverse) with comparison (H.2.16.2)	Requirement not applicable See description above.
	Control functions with software class B have one of the following structures:	
	– single channel with functional test (H.2.16.5)	Requirement not applicable All safety functions comply with H.2.16.7.
	– single channel with periodic self-test (H.2.16.6)	Requirement not applicable All safety functions comply with H.2.16.7.
	– dual channel without comparison (H.2.16.1)	Requirement not applicable All safety functions comply with H.2.16.7.
H.11.12.1.3	Other structure permitted with equivalent level of safety to those in H.11.12.1.2	Requirement not applicable All safety functions comply with H.2.16.7.
H.11.12.2	Measures to control faults/errors	

H.11.12.2.1	Redundant memory with comparison provided on two areas of the same component: data stored in different formats	Requirements fulfilled. All memory data are designed to be redundant and heterogeneous. Check document [D30](ESBCM-X133 software architecture design) for more information.
H.11.12.2.2	Software class C using dual channel structures with comparison: additional fault/error detection means	Requirement not applicable Safety functions use single channel with periodic self-Inspect and monitoring.
H.11.12.2.3	Software class B or C: means for recognition and control of errors in transmission to external safety-related data paths: Means took into account errors of data, addressing, transmission timing and sequence of protocol	Requirements fulfilled. It is taking into Errors of data, addressing, transmission timing and sequence of protocol, more information see document[D31](ESBCM-X133 CAN communication detailed design).
H.11.12.2.4	Software class B or C: within the control, measures are taken to address the fault/errors in safety-related segments and data indicated in Table H.1 and identified in Table 1 requirement 68.	Requirements fulfilled. The relevant assessment is shown in Table H.1 below.
H.11.12.2.5	Measures others than those specified in H.11.12.2.4 utilized to satisfy the requirements listed in Table H.1	Requirements fulfilled. All measures are applied according to Table H.1
H.11.12.2.6	Software fault/error detection:	
	– occur not later than declared time(s), Table 1, requirement 71	Requirements fulfilled. Software fault/error detection time(s) for controls are defined in [D02] (SW Design Specification GoldBMS).
	– acceptability of declared time(s): evaluated during fault analysis of the control	Requirements fulfilled. All software fault/errors are evaluated during fault analysis of the control.

H.11.12.2.7	For controls with functions, classified as Class B or C, detection of fault/error:	
	– results in the response declared in Table 1, requirement 72	Requirements fulfilled. The safety faults will alarm, and the dangerous faults will cut off the charge and discharge relay at the same time and enter the safe state. See document[D02], [D11]and [D12] for more information.
	– for Class C: independent means capable of performing this response provided	Requirements fulfilled. The coprocessor controls the drive to disconnect the main negative relay.
H.11.12.2.8	Class C, dual channel structure, loss of dual channel capability: deemed to be an error	Requirement not applicable Not dual channel structure.
H.11.12.2.9	Software referenced:	
	– to relevant parts of the operating sequence	Requirements fulfilled. The software operation sequence is monitored by the monitoring module and the module is protected, see document [D31](ESBCM-X133 software architecture design) for more information.
	– to the associated hardware functions	Requirements fulfilled. Hardware watchdog chip helps realize timing monitoring, see document [D03] and [D04] for more information.

H.11.12.2.10	Labels used for memory locations are unique	Requirements fulfilled. Labels used for storage locations are constants or uniquely expressed by variable names, see document [D31] [D32][D33][D34][D35][D36] (detail design).
H.11.12.2.11	Software protected from user alteration of safety-related segments and data	Requirements fulfilled. Users cannot modify the code segment, and the parameter configuration will not change the security architecture. They can only configure within a limited data range. And there are complete integrity inspection and monitoring modules to ensure data security.
H.11.12.2.12	Software and safety-related hardware under its control is initialized to and terminates at a declared state, Table 1, requirement 66	Requirements fulfilled. The start and end of the software will return to the safe state, that is, the charging and discharging relay is disconnected, see document [D27] and [D28](Test Report).
H.11.12.3	Measures to avoid errors	
H.11.12.3.1	For controls with software class B or C the measures shown in Figure H.1 to avoid systematic faults are applied	Requirements fulfilled. The fault avoidance measures in figure h.1 have been implemented and tested and verified. See relevant table h.1 evaluation items, see document [D02] for more information.

	Other methods utilized that incorporate disciplined and structured processes including design and Inspect phases	Requirements fulfilled. All functions are designed according to modular architecture, from concept to unit design, with complete technical traceability system, test plan, test report and safety confirmation, see document [D02] and [D30](ESBCM-X133 software architecture design).
H.11.12.3.2	Specification	
H.11.12.3.2.1	Software safety requirements	
H.11.12.3.2.1.1	The specification of the software safety requirements includes:	
	• A description of each safety related function to be implemented, including its response time(s): - functions related to the application including their related software classes - functions related to the detection, annunciation and management of software or hardware faults	Requirements fulfilled. All safety related functions, including detection functions, are gradually decomposed from architecture design to modules, and finally to unit design by technical traceability number and integrity inspection. See related document [D30](Architecture) and [D31]/ [D33]/[D34]/[D35]/[D36](detail design).
	• A description of interfaces between software and hardware	Requirements fulfilled. Interfaces between software and hardware is descripted, see related document [D32] for more information.
	• A description of interfaces between any safety and non-safety related functions	Requirements fulfilled. interfaces between any safety and non-safety related functions is described, see related document [D02] for more information.

H.11.12.3.2.2	Software architecture	
H.11.12.3.2.2.1	The description of software architecture includes the following aspects:	
	• Techniques and measures to control software faults/errors (refer to H.11.12.2)	Requirements fulfilled. The technologies and measures for controlling software faults / errors are fully applied, including the detection and FMEDA application related to Table H.1, as well as the verification of program code during power on.
	• Interactions between hardware and software	Requirements fulfilled. The interaction between software and hardware is fully defined in relevant documents. Later, the consistency and integrity are designed according to the interface definition in the architecture design, so that the hardware initialization and power down end state meet the hardware safety requirements, see document [D30] and [D32] for complete information.
	• Partitioning into modules and their allocation to the specified safety functions	Requirements fulfilled. All modules of architecture design are numbered and have a traceability relationship with functional safety, which comes from the software design specification, see document [D30] for more information.

	• Hierarchy and call structure of the modules (control flow)	Requirements fulfilled. The module architecture is divided into three layers: application layer, logic layer and driver layer. Each module has a flow chart to clearly show the relationship between modules. See document [D30] for more information.
	• Interrupt handling	Requirements fulfilled. Considering the mutual monitoring between interrupt nesting and interrupt itself, the function of monitoring program timing is designed by using interrupt. See document [D30] for complete information.
	• Data flow and restrictions on data access	Requirements fulfilled. The data flow has a special control flow chart, and the program is designed in strict accordance with the flow chart. Access is restricted by authentication code, access quantity and other measures. Refer to document [D02].
	• Architecture and storage of data	Requirements fulfilled. There is a data storage module in the architecture design. The data storage makes the technical design of heterogeneous dual storage in different data storage areas and has data verification. Complete information see document [D02] and [D30].

	• Time based dependencies of sequences and data	Requirements fulfilled. Sequence and data time monitoring has been designed in the architecture, and the interrupt program feeds the external watchdog regularly.
H.11.12.3.2.2.2	The architecture specification is verified against the specification of the software safety requirements by static analysis	Requirements fulfilled. Complete information see document [D21] and [D22].
H.11.12.3.2.3	Module design and coding	
H.11.12.3.2.3.1	Software is suitably refined into modules. Software module design and coding are implemented in a way that is traceable to the software architecture and requirements. The module design specified:	Requirements fulfilled. The software has architecture design and module design and has identification number and traceability, see document [D30] to [D36].
	– function(s)	Requirements fulfilled. In the architecture design document, modules are decomposed layer by layer from the top module to the unit module, see document [D30] to [D36].
	– interfaces to other modules	Requirements fulfilled. Each module description includes interface description and consistency check between interfaces.
	– data	Requirements fulfilled. The architecture design includes data flow control and data type description.

H.11.12.3.2.3.2	Software code is structured	Requirements fulfilled. The software is gradually decomposed into modules according to the architecture design, and the coding rules are written according to MISRA-C and the additional rules formulated by the company, see document [D10](software coding specification).
H.11.12.3.2.3.3	Coded software is verified against the module specification, and the module specification is verified against the architecture specification by static analysis	Requirements fulfilled. There are static analysis documents to verify the module code design.
H.11.12.3.2.4	Design and coding standards	Requirements fulfilled. There are design and coding standards, mainly based on MISRA C 2012, see document [D10](Gold Electronic General rules of software coding specification V1.2) for more information.
	Program design and coding standards is used during software design and maintenance	Requirements fulfilled.
	Coding standards	
	– specified programming practice	Requirements fulfilled. There are verification documents, see document [D21] and [D22].
	– proscribed unsafe language features	It proscribed unsafe language features, mainly based on MISRA C 2012, see document [D10](Gold Electronic General rules of software coding specification V1.2) for more information.

	– specify procedures for source code documentation	Requirements fulfilled. Source code development follows document [D13](Software product development process) and [D14](Software project development process).
	– specify data naming conventions	Requirements fulfilled. The coding specification has a data naming convention, and the design follows the coding specification, see document [D10](software coding specification) and review record [D19]/[D20].
H.11.12.3.3	Testing	
H.11.12.3.3.1	Module design (software system design, software module design and coding)	
H.11.12.3.3.1.1	A test concept with suitable test cases is defined based on the module design specification.	Requirements fulfilled. There are test concept documents to describe the test purpose, test standards, test specifications, etc.
H.11.12.3.3.1.2	Each software module is tested as specified within the test concept	Requirements fulfilled. See document [D21] and [D22] for more information.
H.11.12.3.3.1.3	test cases, test data and test results are documented	Requirements fulfilled. See document [D21] and [D22] for more information.
H.11.12.3.3.1.4	Code verification of a software module by static means includes such techniques as software inspections, walk-throughs, static analysis and formal proof	Requirements fulfilled. See document [D21] and [D22] for more information.
	Code verification of a software module by dynamic means includes functional testing, white-box Inspecting and statistical testing	Requirements fulfilled. See document [D21] and [D22] for more information.

H.11.12.3.3.2	Software integration testing	
H.11.12.3.3.2.1	A test concept with suitable test cases is defined based on the architecture design specification	Requirements fulfilled. There are test concept documents to describe the test purpose, test standards, test specifications, etc.
H.11.12.3.3.2.2	The software is tested as specified within the test concept	Requirements fulfilled. Tests that have been applied within test concept, see document [D27](ESBCM-X133 HV4.0.0 Intergration Test Report) and [D28](ESBMM-2422 HV4.0.0 Intergration Test Report) for more information.
H.11.12.3.3.2.3	Test cases, test data and test results are documented	Requirements fulfilled. For complete information, please check document [D27]and [D28].
H.11.12.3.3.3	Software validation	
H.11.12.3.3.3.1	A validation concept with suitable Inspect cases is defined based on the software safety requirements specification	Requirements not applicable.
H.11.12.3.3.3.2	The software is validated with reference to the requirements of the software safety requirements specification as specified within the validation concept	Requirements not applicable. The software is validated with reference to the requirements of the software safety requirements specification.
	The software is exercised by simulation or stimulation of:	
	• input signals present during normal operation	Requirements fulfilled. The software has been exercised by simulation refer to [D27] and [D28].

	• anticipated occurrences	Requirements fulfilled. See document [D27] and [D28] for more information.
	• undesired conditions requiring system action	Requirements fulfilled. Fault detection has been done for some abnormal signal inputs, see document [D27] and [D28] for more information.
H.11.12.3.3.3.4	Test cases, test data and test results are documented	Requirements fulfilled. See document [D27] and [D28] for more information.
H.11.12.3.4	Other Items	
H.11.12.3.4.1	Equipment used for software design, verification and maintenance was qualified appropriately and demonstrated to be suitable for purpose in manifold applications	The equipment has calibration records and has been verified to meet the requirements of testing, refer to document [D02].
H.11.12.3.4.2	Management of software versions: All versions are uniquely identified for traceability	Requirements fulfilled. There are special software version management specifications and management software SVN, see document [D17] and [D18].
H.11.12.3.4.3	Software modification	
H.11.12.3.4.3.1	Software modifications are based on a modification request which details the following:	
	• the hazards which may be affected	Requirements fulfilled. There is a special hazard analysis, see document [D15] and [D16].
	• the proposed change	Requirements fulfilled. There is a special hazard analysis, see document [D15] and [D16].

	• the reasons for change	Requirements fulfilled. There is a special hazard analysis, see document [D15] and [D16].
H.11.12.3.4.3.2	An analysis is carried out to determine the impact of the proposed modification on functional safety.	Requirements fulfilled. Impact analysis and risk assessment on the modified part.
H.11.12.3.4.3.3	A detailed specification for the modification is generated including the necessary activities for verification and validation, such as a definition of suitable Inspect cases	Requirements fulfilled. There are special modified detailed specifications, see document [D15] and [D16].
H.11.12.3.4.3.4	The modification is carried out as planned	Requirements fulfilled. All modifications are carried out in accordance with the process specification, refer to [D15].
H.11.12.3.4.3.5	The assessment of the modification is carried out based on the specified verification and validation activities.	Requirements fulfilled. Confirmation and evaluation are carried out in strict accordance with the process, see document [D16](Change management procedure A2.0).
H.11.12.3.4.3.6	All details of modification activities are documented	Requirements fulfilled. See description above.
H.11.12.3.5	For class C control functions: One of the combinations (a–p) of analytical measures given in the columns of table H.9 is used during hardware development	Requirement not applicable. The following test combinations were used: Inspection/Walk-through/Static analysis/FMEA/Operation test.
H.11.12.4	Remotely actuated control functions	

H.11.12.4.1.1	Data Exchange – General – Remotely actuated control functions are connected to separate, independent devices, which may themselves contain control functions or provide other information and any data exchange between these devices does not compromise the integrity of class B control function or class C control function.	Requirement not applicable. No such function.
H.11.12.4.1.2	Type of data - Message types for data exchange in a control function or functions are allocated to class A control function, class B control function or class C control function. The safety or protective relevance or influence, message types or data exchange are allocated only to class B control function or class C control functions, see Table H.10.	Requirements fulfilled. The product has the message of modifying and determining the parameters of relevant class B control functions and class C control functions, and both have qualified safety control measures.
H.11.12.4.1.3.1	Communication of Safety Related Data – Transmission – Safety relevant data is transmitted authentically concerning:	/
	– data corruption	Requirements fulfilled. The data has a verification and retransmission mechanism.
	– address corruption	Requirements fulfilled. The address data is also included in the CRC verification section and is identified by the address attribute.
	– wrong timing or sequence	Requirements fulfilled. There are special sequence monitoring procedures and timing monitoring procedures for timing and timeliness, which are responsible for functional safety.

	Data variation or corrupted data did not lead to an unsafe state	Requirements fulfilled. Judge the effective range of all safety related data and take safety protection measures in case of unexpected errors in the data, see document [D02].
	Before transmitted data was used it was ensured that data corruption, address corruption and wrong timing or sequence are addressed using the measures as given in Annex H.	Requirements fulfilled. See the document [D37] for relevant measures.
	The following failure modes are addressed	/
	– permanent “auto-sending” or repetition,	Requirement not applicable Not used.
	– interruption of data transfer	Requirements fulfilled. Data transmission is carried out by interrupt, and the data has sequence and timing detection, see document [D37].
H.11.12.4.1.3.2	Access to data exchange - All types of access to class B control function or class C control function related data exchange systems is clearly restricted	Requirements fulfilled The data exchange has clear timing control, is monitored by the monitoring program, and is point-to-point communication at the same time.
	Adequate hardware/software measures are taken to prevent unauthorized access to the control functions (class B and C; operating data, configuration parameters and/or software modules)	Requirements fulfilled. Access has authentication function to prevent unauthorized external devices from illegal communication.

	Access to data exchange of class B control function or class C control function related operating data through public networks, has appropriate cryptographical techniques implemented.	Requirement not applicable. No possibility of public network use.
H.11.12.4.1.3.3	For class B and class C software revisions the requirements of H.11.12.3 and hardware configuration management are applied, and the control maintains its protective functions	Requirements fulfilled Special software change management and configuration management is applied in software development life cycle.
H.11.12.4.1.4	Remotely actuated control function operation have the duration or limits set before switching on except when automatic switching off is realized at the end of a cycle or the system is designed for permanent operation.	Requirements fulfilled. The duration of remote drive control function operation is automatically closed at the end of the cycle and ends with the introduction of commissioning mode, see document [D37] for more information.
H.11.12.4.2	Priority of remotely actuated control functions over control functions does not lead to a hazardous condition.	Requirements fulfilled. It will not lead to dangerous situation, and the parameter range of all control functions is limited to the allowable range of battery safety parameters. Battery voltage, current and other safety related protection functions have the highest priority.
H.11.12.4.3.1	Remote reset action is manually initiated.	Requirement not applicable. No remote reset functions.
	Reset functionality initiated by a hand-held device required at least two manual actions to activate	Requirements fulfilled. Two operations are required to restart

H.11.12.4.3.2	Reset functions are capable of resetting the system as intended	Requirements fulfilled The reset function restores all variables, registers, peripherals, etc. to the initial state and is confirmed by test.
H.11.12.4.3.3	Unintended resets from safe state do not occur.	Requirements fulfilled Unintended resets from safe state do not occur.
H.11.12.4.3.4	Any fault of the reset function does not cause the control or controlled function to result in a hazardous condition, and was evaluated for its Class B classification	Requirements fulfilled The reset function is protected by the program and can be executed only after multiple conditions are met, see document [D30].
H.11.12.4.3.5	For reset functions initiated by manual action not in visible sight of the appliance, the following additional requirements apply:	Requirement not applicable. There is no such usage scenario.
	– the actual status and relevant information of the process under control is visible to the user before, during and after the reset action;	Requirement not applicable. There is no such usage scenario.
	– the maximum number of reset actions within a time period is declared. Following this, any further reset is denied unless the appliance is physically checked	Requirement not applicable. There is no such usage scenario.
H.11.12.4.3.6	The reset function is evaluated on the final application.	Requirements fulfilled. For complete information refer to document [D27] and [D28].
	Manual switching of a thermostat or device with similar function that activates a reset is declared by the manufacturer and is suitable in the final application.....	Requirement not applicable.
H.11.12.4.4	Software Download and Installation	

	Software updates provided by the manufacturer and transmitted to the control via remote communication were checked prior to its use:	/
	– against corruption through communication ensuring Hamming distance 3 for software class B, or Hamming distance 4 for software class C;	Requirement not applicable
	– that the software version is compatible with the hardware version of the control according to the version management documentation.	Requirements fulfilled. When updating the software, the hardware version will be checked first, see document [D17] and [D18].
	The software which performs the above mentioned checks had measures to control the fault/error conditions specified in H.11.12.2.	Requirements fulfilled. Memory and related registers will be checked before and during software update, see document [D02].
H.11.12.4.4.2	In case of software download via remote communication, the cryptographic techniques in H.11.12.4.5 were provided. In addition to the requirements in H.11.12.4.5, identification procedures were provided for the software packages.	Requirement not applicable
	The cryptographic techniques employed were part of the control, did not rely upon part of the router or similar data transmission device itself, and were performed prior to transmission.	Requirement not applicable

H.11.12.4.4.3	Each update of software had provisions for authorization by the user and a version ID number which were accessible.	Requirements fulfilled. Each software update is subject to the same management of the software version management specification and has a unique ID, see [D17](product Version Coding Specification A1.0) for more information.
H.11.12.4.4.4	The installation of class B software or class C software was permitted during and after which the software installation process the control remained in compliance with the requirements of this standard.	Requirements fulfilled. Download the software update specification without damaging the requirements of the original program. The program update design refers to various requirements of functional safety.
H.11.12.4.5	Cryptographical techniques	
	In cases where class B control function or class C control function related operating data, configuration parameters and/or software modules were transmitted over a public network, and/or where software updates were provided by the manufacturer via remote communication, cryptographic techniques were employed.	Requirements fulfilled. The human-computer interaction software of corresponding parameter configuration adopts cryptographic technology, and the key technology is used in the communication of BMS manager.
H.27.1.2	Protection against internal faults to ensure functional safety	
H.27.1.2.1	Design and construction requirements	
H.27.1.2.1.1	Fault avoidance and fault tolerance	
	Controls incorporating control functions of class B or C are designed according to H.27.1.2 taking into account the failure modes of Cl. H.11.12 for software	Requirements fulfilled. Controls with control functions are designed according to H.27.1.2 taking into account the failure modes of Cl. H.11.12 for software.

	Systematic errors are avoided	Requirements fulfilled. Systematic errors are avoided refer to document [D02].
	Random faults are dealt with by a proper system configuration	Requirements fulfilled. A special watchdog monitoring module is designed to monitor the random faults of the software, please see document [D30](software architecture design) for more information.
	Functional analysis of the application resulted in a structured design with:	/
	– Control flow	Requirements fulfilled. Control flow is described in document [D02].
	– Data flow	Requirements fulfilled. Data flow is described in document [D30](software architecture design).
	– Time related functions required by the application	Requirements fulfilled. In the design of software modules, there are descriptions of module time requirements, including cycle and other parameters, refer to document [D31] to [D36].
	For custom-chips special attention was made to minimize systematic errors	Requirements fulfilled. Some measures have been taken, such as using batch product error test and correction.
	System configuration was failsafe or:	Requirements fulfilled. The system configuration is carried out in safe mode.

	Incorporated components with direct safety-critical functions guarded by safeguards that cause a completely independent safety shut-down in accordance to H.11.12 software class B or C	/
	- safeguards are built into hardware and,	Requirements fulfilled. See document [D02] for more information.
	- safeguards are supplemented by software	Requirements fulfilled. Safeguards are supplemented by software Refer to [D02].
	Time slot monitoring is sensitive to both an upper and a lower limit of the time interval.	Requirements fulfilled. See document [D30](software architecture design) description.
	Faults resulting in a shift of the upper and/or lower limit are taken into account.	Requirements fulfilled. The influence of hardware parameter changes caused by temperature and other environments is considered.
	In a class C control function when a single fault in a primary safeguard can render the safeguard inoperative, a secondary safeguard is provided	Requirement not applicable. The product is Class B control SW.
	The reaction time of the secondary safeguard is in accordance with Clause H.27.1.2.3.	Requirement not applicable. The product is Class B control SW.
H.27.1.2.1.2	Documentation	
	The documentation was based on H.11.12.3.2	Requirements fulfilled.

	The functional analysis of the control and the safety related programs under its control are documented in a clear hierarchical way in accordance with the safety philosophy and the program requirements.	Requirements fulfilled. Relevant information is described in the security concept and architecture design, see document [D02] and [D30](SW architecture design).
	Documentation provided for assessment included:	
	• A description of the system philosophy, the control flow, data flow and timings.	Requirements fulfilled. Refer to document [D02]/[D30]etc.
	• A clear description of the safety philosophy of the system with all safeguards and safety functions clearly indicated. Sufficient design information is provided to enable the safety functions or safeguards to be assessed	Requirements fulfilled. A clear description of the safety philosophy of the system with all safeguards and safety functions clearly indicated, see document [D02].
	• Documentation for any software within the system	Requirements fulfilled.
	Programming documentation is supplied in a programming design language declared by the manufacturer.....	Requirements fulfilled. Programming Language: C The code development complies with MISRA-C code rule.
	Safety related data and safety related segments of the operating sequence are identified and classified according to H.11.12.3	Requirements fulfilled. There are relevant timing monitoring and module management in the software architecture design, see [D30].

	There is a clear relationship between the various parts of the documentation	Requirements fulfilled. The documents are generated according to the product concept to design, and the corresponding documents are generated according to the process of traceability and development.
H.27.1.2.2	Class B control function	
H.27.1.2.2.1	Design and construction requirements	
	Control function shall be designed such that under single fault conditions it remains in or proceeds to the defined state.	Requirements fulfilled. All-important single faults related to safety will be detected and identified and enter the safe state, refer to test report [D27] and [D28].
H.27.1.2.3	Class C control function	
H.27.1.2.3.1	Design and construction requirements	
	Control function shall be designed such that under first and second fault conditions it remains in or proceeds to the defined state.	It a class B software
H.27.1.2.5	Circuit and construction evaluation	
H.27.1.2.5.3	Assessment	

	Only the safety related software (software class B and C) as identified according to H.27.1.2.1.2 were subjected to further assessment	The following documents are provided: 1. A description of the system philosophy, the control flow, data flow and timings. 2. Description of system safety concept and relevant documents, including all safeguard measures and functions clearly indicated by safety measures. 3. Software architecture design, detailed design and other documents.

Table 10: Checklist of UL 60730-1:2016 Annex H

Component	Fault / Error	Measures description
1.1 CPU Registers	Stuck at DC Fault	Requirements fulfilled. First 1s cycle detection register value. ESBMM-X133: 1. Write 0x55 and 0XAA to registers a, B, X and y, and then read the comparison confirmation. 2. For the SP arithmetic unit, write 0x5556 and 0xaaab, and then read the comparison confirmation. 3. Reset program in case of master control failure. ESBMM: 1. R0-R12, LR: write 0xaaaaaaaa and 0x5555555 and read comparison. 2. APSR: write 0x50000000 and 0xa0000000 and read comparison. 3. SP: write 0x5555554 and 0xaaaaaaa8 and read comparison. Reset the slave control program while the slave control module failure.
1.3 CPU Program counter	Stuck at DC fault	Requirements fulfilled. 1. Use hardware watchdog while fault. 2. The following logic is executed in one second cycle: Call three functions through the pointer. The three functions return fixed values 0x55, 0XAA and 0x56 respectively. If the return value is correct, it is normal. Restart

		the program in case of abnormality. See document [D02] for more information.
2 Interrupt handling and execution	No interrupt or too frequent Interrupt No interrupt or too frequent interrupt related to different sources	Requirements fulfilled. 1. Hardware watchdog dog feeding program. 2. The main function accumulates the data value in the main cycle, and the 2ms timer is interrupted and cleared. If it is judged that the accumulated value exceeds 0xFFFF in the main cycle, it is considered that the interrupt program is abnormal, and the contactor is disconnected. The accumulated value in the 2ms timer is cleared in the main cycle. If the accumulated value in the 2ms timer exceeds 1s, it is considered that the program is abnormal, and the contactor is disconnected. 3. There is RTC clock in the ESBCM. The power on timing is 20s. The software timing of RTC clock and 2ms timer is compared. If the difference exceeds 1s, it is considered that the program is abnormal, and the contactor is disconnected. See document [D02] for more information.
3 Clock	Wrong frequency (for quartz synchronized clock: harmonics/ subharmonics only)	Requirements fulfilled. The ESBCM has RTC clock, power on timing for 20s, software timing comparison between RTC clock and 2ms timer of external crystal oscillator clock. If the difference exceeds 1s, it is considered that the program is abnormal, and the contactor is not allowed to be closed. See document [D02] for more information.
4.1 Memory Invariable memory	All single bit faults 99,6 % coverage of all information errors	Requirements fulfilled. During power on, the parameters of ESBMM and ESBCM are verified by CRC. If it is wrong, it is not allowed to close the contactor; In addition, march-c mode is adopted to detect the variable area. If it is wrong, it is not allowed to close the contactor.
4.2 Memory Variable	DC fault & DC fault and dynamic cross	Requirements fulfilled.

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memory	links	Same as above 4.1.
4.3 Memory Addressing (relevant to variable and invariable memory)	Stuck at & DC fault	Requirements fulfilled. 1. For the involatile storage unit, the CRC check is made for the whole stored data when the power is on, and the check result is stored at the end of the involatile storage unit. In the process of operation, CRC is checked at intervals and compared with the saved unit. 2. Volatile variable area, stack boundary detection and March C detection.
5.1 Internal data path Data	Stuck at & DC fault	Requirements fulfilled. Do March C test and double reverse storage test for key data. If the detection fails, transfer protection function.
5.2 Internal data path Addressing	Wrong address & Wrong address and multiple addressing	Requirements fulfilled. The program sets the stack boundary detection area, and sets 0x5a filling on both sides of the variable interval If the address is wrong, transfer protection function.
6.0-6.1 External communication Data	Hamming distance 3 & Hamming distance 4	Requirements fulfilled. The key signal adopts the design of Hamming distance 3, and all communications have done CRC check, the polynomial is X15 + X13 + 1. If the data is wrong, do the discard processing, multiple errors or loss, report the error processing
6.2 External communication Addressing	Wrong address & Wrong and multiple addressing	Requirements fulfilled. There will be multiple ESBMM under an ESBCM, and the address of each ESBMM is different. PS in canid is the message receiver and SA is the message sender. ESBMM and ESBCM identify and receive messages through PS and SA. ESBMM only receives messages sent by ESBCM. The ESBCM requests ESBMM data periodically, and only one ESBMM is requested at a time. After receiving the

		request, the ESBMM replies the voltage and temperature data to the ESBCM. If the ESBCM does not receive ESBMM data for 10 seconds, judge the fault and cut off the contactor. The voltage and temperature data replied by ESBMM are verified by checksum (refer to the communication protocol). Wrong and multiple addressing: ESBMM and ESBCM addresses are unique, and there is no device with the same address.
6.3 External communication Timing	Wrong point in time & Wrong sequence	Requirements fulfilled. CAN communication is used between ESBCM and ESBMM, and CAN messages are single frame messages. Message slot monitoring and sequence monitoring program.
7.1 Input/output periphery Digital I/O	Fault conditions specified in H.27	Requirements fulfilled. The I / O port input and output signals are detected when starting up. All ports can be set to self-test mode, and the external input is disconnected. Then the port register outputs the required high / low level and reads the level value from the port to compare and judge whether it is valid.
7.2.1 Input/output periphery Analog I/O A/D- and D/A-convertor	Fault conditions specified in H.27	Requirements fulfilled. Monomer voltage / temperature acquisition: through the acquisition temperature of temp1 and temp2, select 8-out-of-1 gating switch for temperature. There is verf-NTC1 in the circuit, which is about 4.5V test voltage. Judge whether the voltage and temperature acquisition circuit are normal by collecting verf-ntc1. The voltage and temperature acquisition are abnormal, and the system cuts off the contactor. Current acquisition: before the contactor is closed, it is normal if the detected current is less than 1a (zero drift). Total voltage acquisition: compare with the

		accumulated value of single battery. If the difference is less than 5V, it is normal. If the total voltage acquisition is abnormal, report an alarm and cut off the contactor.
7.2.2 Input/output periphery Analog I/O Analog multiplexer	Wrong addressing	Requirements fulfilled. Single cell voltage / temperature acquisition: single cell voltage and temperature acquisition through AFE, and SPI communication between AFE and MCU. Periodically collect the voltage of S1 ~ S12 and the temperature of x0 ~ X7. Through the acquisition temperature of temp1 and temp2, the temperature selects 8-out-of-1 gating switch. Verf-ntc1 in the circuit is about 4.5V. Judge whether the voltage and temperature acquisition circuit are normal by collecting verf-ntc1. The voltage and temperature acquisition are abnormal, and the system cuts off the contactor.
9. Custom chips e.g. ASIC, GAL, Gate array	Any output outside the static and dynamic functional specification	Requirements fulfilled. Voltage and temperature acquisition chip of ESBMM: The voltage and temperature of single battery are collected through AFE, and the communication between AFE and MCU is through SPI. Periodically collect the voltage of S1 ~ S12 and the temperature of x0 ~ X7. Through the acquisition temperature of temp1 and temp2, the temperature selects 8-out-of-1 gating switch. There is a test voltage of about 4.5V for verf-ntc1 in the circuit. Judge whether the voltage and temperature acquisition circuit are normal by collecting verf-ntc1. The voltage and temperature acquisition are abnormal, and the system cuts off the contactor.

Table 11: Checklist of Measures to address fault/errors

----------End of the report----------

LOW VOLTAGE DIRECTIVE, ELECTROMAGNETIC COMPATIBILITY DIRECTIVE ATTESTATION OF CONFORMITY

Technical file of the company mentioned below has been inspected and audit has been completed successfully.

2014/30/EU Electromagnetic Compatibility Directive and 2014/ 35/EU Low Voltage Directive has been taken as referances for these processes.

Company Name	: **CAMA (LUOYANG) ELECTROMECHANIC CO., LTD**
Company Address	: No. 77 Lichun West Road, Jianxi District, Luoyang Area, Pilot Free Trade Zone, Henan, China
Related Directives and Annex	: **2014/35/EU Low Voltage Directive /Annex III** **2014/30/EU Electromagnetic Compatibility Directive /Annex II**
Related Standards	: **EN IEC 60335-2-40:2023+A11:2023, EN 60335-1:2012+A15:2021** **EN 62233:2008, EN IEC 61000-6-2:2019, EN IEC 61000-6-4:2019** **EN IEC 61000-3-2:2019+A1:2021, EN 61000-3-3: 2013+A2:2021**
Product Name	: **Battery Thermal Management System**
Report No and Date	: C230526062, STT/23T1039-EMC, STT/23T1040-LVD
Product Brand/Model/Type	: BTMS050-ES, BTMS080-ES, BTMS100-ESH , BTMS050-ESH, BTMS200-ES, BTMS030-ES, BTMS450-ES, BTMS600-ES, BTMS050, BTMS080, BTMS100
Certificate Number	: **M.2023.206.C86443**
Initial Assessment Date	: 08.06.2023
Registration Date	: 09.06.2023
Reissue Date/No	: -
Expiry Date	: **08.06.2028**

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