Test Report
EN ISO 13849-1:2015
BS EN 62061:2015

Responsibility

Tested by (printed name and signature) .....:	Charles Li	Charles Li
Approved by (printed name and signature) .....:	Jerry Zheng	Jerry Zheng
Date of issue .....:	2019-12-06	

Testing Laboratory Name .....:	SGS-CSTC Standards Technical Services (Shanghai) Co., Ltd.
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Applicant's Name .....:	PortaPower (China) Limited
Address .....:	Flat 1003, 10/F, Hopeful Factory, Centre 10-16 Wo Shing Street, Fotan, N.T., Hong Kong
Manufacturer's Name .....:	Same as applicant.
Address .....:	Same as applicant.

Test specification

Standard .....:	EN ISO 13849-1:2015 & BS EN 62061: 2015
Test procedure .....:	SGS-CSTC
Non-standard test method .....:	N/A
Test Report Form No.	BMS HFT=0_A
TRF originator.....:	SGS-CSTC
Master TRF .....:	Dated

Products may only be provided with an approval mark if the relevant conditions have been fulfilled.

Test Item Description .....:	BMS for EPAC battery package
Trademark .....:	N/A
Model and/or type reference .....:	Refer to page 4
HW Version .....:	KL96UF04A
Rating(s).....:	

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Over Charge Protection .....:	4.30±0.025V
2nd-level over Charge Protection ....:	4.45±0.025V
Under Discharge Protection .....:	2.50±0.025V
Over-current Protection .....:	40A±5A
Short-circuit Protection .....:	OUT+/OUT- Short Current
Over-Temp Protection for Charge ....:	>70°C: Can not Charge & Discharge
	<0°C or >50℃: Can not Charge

Test Case Verdicts

Test case does not check to the test object .....:	N/C
Test case does not apply to the test object .....:	N/A
Test item does meet the requirement .....:	P(ass)
Test item does not meet the requirement .....:	F(ail)

Testing

Date of receipt of test item .....:	2019-11-09
Date(s) of performance of test .....:	2019-11-09 to 2019-11-12

General Remarks

This report shall not be reproduced except in full without the written approval of the testing laboratory.
The test results presented in this report relate only to the item(s) tested.
" (see remark #)" refers to a remark appended to the report.
"(see Annex #)" refers to an annex appended to the report.
Throughout this report a comma is used as the decimal separator.

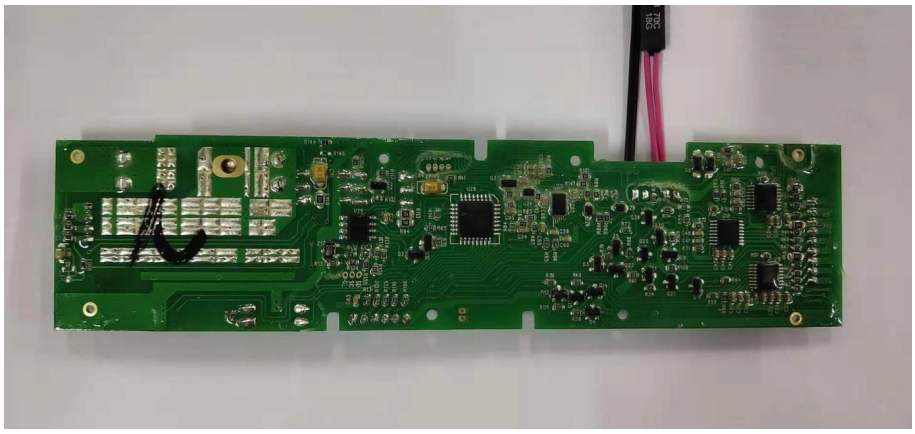
References

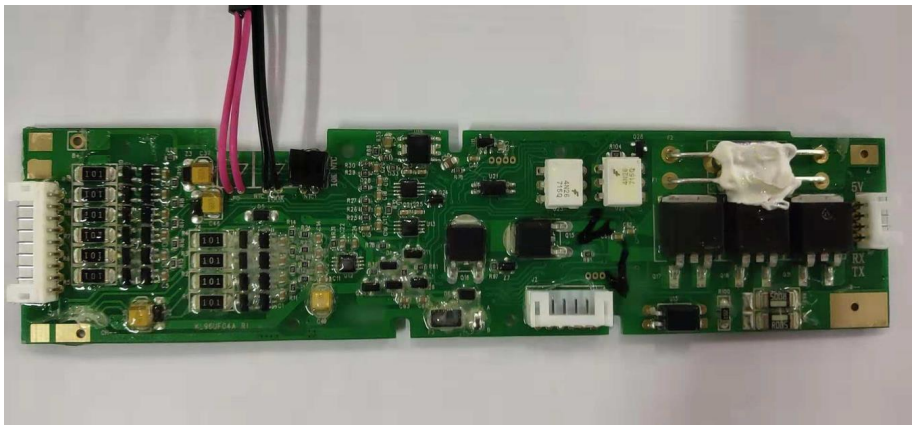
No.	Document Description
[1]	KL96UF04A _PCB Layout_v1.0
[2]	KL96UF04A_FMEDA_BMS_v1.0
[3]	KL96UF04A_Structure Block_v1.0

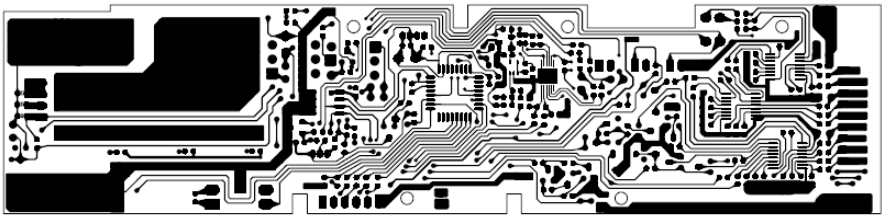
Revision Logs

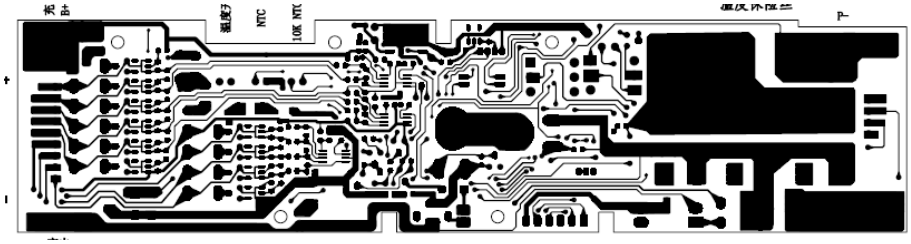
Version	Changes Description
v1.0	Initial Version

Nameplates and Photos









Summary of Assessment:

The safety protection functions of the KL96UF04A BMS meet the requirement of PL c / SIL 1 with HFT=0 architecture. The detail information please refer to the following report.

Models of battery pack listed below are evaluated with BMS board version **KL96UF04A.**

Name rule of battery packs specified by manufacture as below:

A1	A2	A3	A4	A5	A6	.	A7	A8

A1: Type of battery pack

Code	Description
KL	E-bike battery pack

A2: Special function/design to this E-bike battery pack, it may be as below

Code	Description
C	Customized the case design
U	USB
D	Handle Bar
O	Special charging Port

A3: rate voltage, it may be as below

Code	Description
21/22/23/24/25	24V
34/35/36/37/38/39	36V
42	42V
47/48/49	48V
other 2 digital number	Customer code like 99/96/77

A4: BMS function, it may be as below

Code	Description
P/PS/PH/PV	with sleep mode function
TP/TPH/TPV	with sleep mode function
H/HS/S	without sleep mode function
HU/HL/UL/UF/UY	UART communication protocol
CF/CB	CANBus communication protocol

A5. Serial No., it may be 00-99 or 001-999

Code	Description
xx	2 digital number
xxx	3 digital number

A6: Colour for battery cases, it may be as below

Code	Description
B	Black
S	Sliver
Y	Yellow
A	White
U	Blue
BW	Bright white

A7: Lithium battery cells type and manufactures, it may be as below

Cell Code	Model	Manufactory
082	UR18650AA	Panasonic
902	NCR18650ZM	Panasonic
089/809	NCR18650PF	Panasonic
804	NCR18650B	Panasonic
909	NCR18650BD	Panasonic
906	NCR18650GA	Panasonic
70G	NCR2170G	Panasonic
803	ICR18650-22P	Samsung
806	ICR18650-26J	Samsung
30Q	INR18650-30Q	Samsung
819	INR18650-29E	Samsung
916	INR18650-35E	Samsung
50E	INR21700-50E	Samsung
M26	INR18650M26	LG
M29	INR18650M29	LG
908	INR18650MH1	LG
907	INR18650MJ1	LG
M50	INR21700M50	LG
080	INR18650D205	YikLik/YLE
083	INR18650A220	YikLik/YLE
82V	INR18650D220	YikLik/YLE
826	INR18650D260	YikLik/YLE
89D	INR18650D290	YikLik/YLE
300	INR18650A300	YikLik/YLE
340	INR18650A340	YikLik/YLE

A8: BMS Version, it may be as below

Code	Description
E version	KL96UF04A

Example: KLC96UF04B.809E
KL: E-bike battery pack
C: Customized
96: Customer code & Rated voltage 36.0V
UF: UART communication protocol
04: serial number
B: Black case
809: Cell type NCR18650PF, manufactory: Panasonic
E: BMS of E version

1. Safety Function

Prevention of risk of fire in case of management system failure for batteries, following protection circuits have been defined as safety related function in BMS Part:
- Over/under voltage protection
- Over current (short) protection
- Over/under temperature protection

The behaviors of the safety function under fault condition were defined as switching off charging or discharging MOSFET within the specified response time.

Note:

The protection function of the BMS circuit included primary protection circuit, without secondary protection circuit, so the architecture of protection function could be considered as HFT =0 per BS EN 62061:2015.

Information on the recommended application of IEC 62061 and this part of ISO 13849

IEC 62061 and this part of ISO 13849 specify requirements for the design and implementation of safety-related control systems of machinery. The use of either of these International Standards, in accordance with their scopes, can be presumed to fulfil the relevant essential safety requirements. ISO/TR 23849 gives guidance on the application of this part of ISO 13849 and IEC 62061 in the design of safety-related control systems for machinery.

BS EN 62061 was referred to executed performance level assessment in this report.

2. Risk Assessment

Per the Figure A.1 of ISO 13849-1:2015

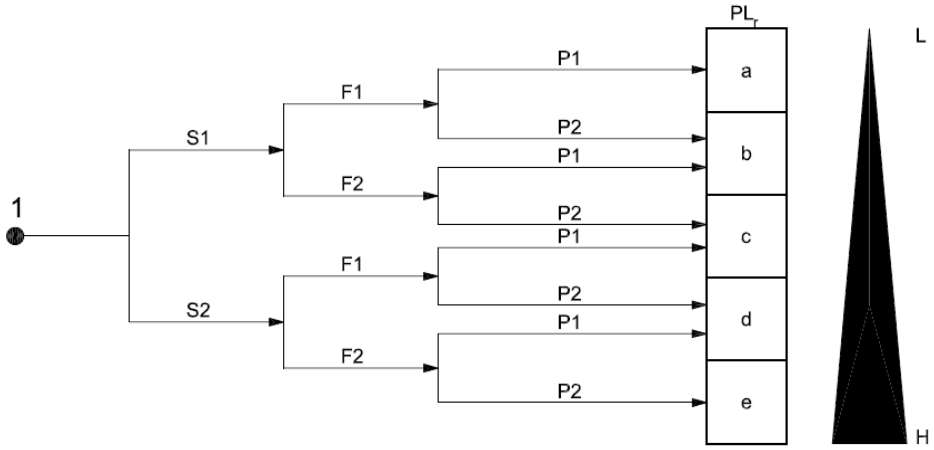


Figure 1 Risk Assessment

The required performance level as the following table.

Parameter		Result	Rationale	Required PLr
S	Severity of injury	S1	Only slight injuries	C

F	Frequency of exposure	F2	Frequently or continuously exposed to the hazard	
P	Probability of avoidance	P2	Scarcely possible to avoid a hazard	

Note: According to EN 15194:2017 Clause 4.3.22 (a type C standard), the Performance Level of Prevention of risk of fire in case of management system failure for batteries with capacity above 100Wh shall be PLr c.

3. Safety Block Diagram

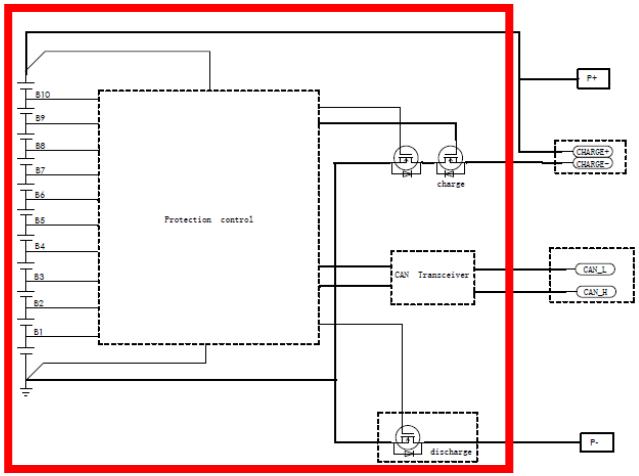


Figure 2 Safety Structure for BMS

Note:
Cells voltage acquisition module, Current acquisition module, temperature acquisition module, Protect IC, charging and discharging MOS circuit composed of safety related circuit in this BMS project.

Structure Analysis:
Category and circuit modules description as below table:

Category Modules	Circuit modules description
Input	Cells voltage acquisition module, Current acquisition module, temperature acquisition module
Logic	Protect IC
Output	charging and discharging MOS

Result:
According to above analysis and safety structure diagram, the protection function of the BMS circuit included primary protection circuit, without secondary protection circuit, so the architecture of protection function could be considered as HFT =0 per BS EN 62061:2015.

4. Calculate the MTTFd / PFH

Analysis:

The system MTTFd / PFH has been calculated based on schematic and BoM, the calculation report has been checked and confirmed, the total system MTTFd is 298.4 years, PFH is 3.83 * 10^{-7}.
Table 3 of BS EN 62061:2015 is used as the guideline to estimate the target failure values of the system, which in fact is noted as PFH_D.

Safety integrity level	Probability of a dangerous Failure per Hour (PFH_D)
3	>= 10^{-8} to < 10^{-7}
2	>= 10^{-7} to < 10^{-6}
1	>= 10^{-6} to < 10^{-5}

Result:

Per table 3 of BS EN 62061:2015., the calculated value for the system PFH_D = 3.83 * 10^{-7} results in a **SIL 2** level of target failure values.

5. Calculate the Safe Failure Fraction (SFF)

According to “KL96UF04A_FMEDA_BMS_v1.0”, SFF for this system is 67.42% (>= 60%).

6. Quantify SIL/PL Based On Input Parameters

The BMS protection circuit has been designed with the architecture of HFT = 0, SFF = 67.42% was evaluated. According to table 5 – architectural constraints on subsystems: maximum SIL that can be claimed for a SRCF using this subsystem, SIL1 could be claimed for this BMS protection circuit.

Safe Failure Fraction	Hardware Fault Tolerance		
	0	1	2
60% - < 90%	SIL1	SIL2	SIL3
90% - < 99%	SIL2	SIL3	SIL3
≥ 99%	SIL3	SIL3	SIL3

Result:
Above table is used to determine the SIL of the system, the system design (SFF and HFT) results in SIL 1.

7. Conclusions and Recommendations

The safety functions of the KL96UF04A BMS has been assessed to achieve SIL1 with HFT=0, according to the table 3 of EN ISO 13849-1:2015, it could be used in **PL c** application.

8. Systematic Failure

8.1 Introduction

When electrical systems are used in conjunction with other technologies, then relevant tables for basic safety and well–tried safety principles should also be taken into account.

8.2 List of basic safety principles

Table D.1 — Basic safety principles

Clause	Requirement + Test	Result - Remark	Verdict
	Use of suitable materials and adequate manufacturing Selection of material, manufacturing methods and treatment in relation to e. g. stress, durability, elasticity, friction, wear, corrosion, temperature, conductivity, dielectric rigidity.	Refer to the BMS BOM.	P
	Correct dimensioning and shaping Consider e. g. stress, strain, fatigue, surface roughness, tolerances, manufacturing.	Not assessed in project	N/C
	Proper selection, combination, arrangements, assembly and installation of components/system Apply manufacturer's application notes, e. g. catalogue sheets, installation instructions, specifications, and use of good engineering practice.	Work products in main phase are available. The battery user manual is available.	P
	Correct protective bonding One side of the control circuit, one terminal of the operating coil of each electromagnetic operated device or one terminal of other electrical device is connected to the protective bonding circuit [for full text see EN 60204-1:1997 (IEC 60204-1:1997), 9.1.4].	No such case	N/A
	Insulation monitoring Use of isolation monitoring device which either indicates an earth fault or interrupts the circuit automatically after an earth fault [see EN 60204- 1:1997 (IEC 60204-1:1997), 9.4.3.1].	No such case	N/A
	Use of de–energisation principle A safe state is obtained by de–energising all relevant devices, e. g. by using of normally closed (NC) contact for inputs (push–buttons and position switches) and normally open (NO) contact for relays [see also EN 292–2:1991 (ISO/TR 12100-2:1992), 3.7.1]. Exceptions may exist in some applications, e. g. where the loss of the electrical supply will create an additional hazard. Time delay functions may be necessary to achieve a system safe state [see EN 60204–1:1997 (IEC 60204-1:1997), 9.2.2].	Not this situation	N/A
	Transient suppression Use of a suppression device (RC, diode, varistor) parallel to the load, but not parallel to the contacts.	The general transient suppression was designed in BMS board according to the schematic.	P
	Reduction of response time Minimise delay in de–energising of switching components.	Manufacture has taken measures to minimise response time	P
	Compatibility Use components compatible with the voltages and currents used.	All components meet the requirements of volt and current rated value.	P

Clause	Requirement + Test	Result - Remark	Verdict
	Withstanding environmental conditions Design the equipment so that it is capable of working in all expected environments and in any foreseeable adverse conditions, e. g. temperature, humidity, vibration and electromagnetic interference (EMI)	The product has been executed EMC testing according to EN115194 requirement, all testing items passed, EMC testing report is available.	P
	Secure fixing of input devices Secure input devices, e. g. interlocking switches, position switches, limit switches, proximity switches, so that position, alignment and switching tolerance is maintained under all expected conditions, e. g. vibration, normal wear, ingress of foreign bodies, temperature. See EN 1088:1995 (ISO 14119:1998), clause 5.	No such case	N/A
	Protection against unexpected start–up Prevent unexpected start–up, e. g. after power supply restoration [see EN 292–2:1991 (ISO/TR 12100-2:1992), 3.7.2, EN 1037 (ISO 14118), EN 60204–1 (IEC 60204-1)].	No such case, this BMS always monitoring battery in its life cycling	N/A
	Protection of the control circuit The control circuit should be protected in accordance with EN 60204- 1:1997 (IEC 60204:-1:1997), 7.2 and 9.1.1.	Not assessed in project	N/C
	Sequential switching for circuit of serial contacts of redundant signals to avoid the common mode failure of the welding of both contacts, the switching on and off does not happen simultaneously, so that one contact always switches without current.	Sequential switching for non-concurrent design to avoid the common mode failure.	P

8.3 List of well–tried safety principles

Table D.2 — Well–tried safety principles

Clause	Requirement + Test	Result - Remark	Verdict
	Positive mechanically linked contacts Use of positively mechanically linked contacts for, e. g. monitoring function [see EN 292–2:1991 (ISO/TR 12100-2:1992), 3.5].	MOSFET used, no such case	N/A
	Fault avoidance in cables To avoid short circuit between two adjacent conductors: □ use cable with shield connected to the protective bonding circuit on each separate conductor, or □ in flat cables, use of one earthed conductor between each signal conductors.	PCBA board, no such case	N/A
	Separation distance Use of sufficient distance between position terminals, components and wiring to avoid unintended connections.	Not this situation	N/A
	Energy limitation Use of a capacitor for supplying a finite amount of energy, e. g. in timer application.	No such case	N/A
	Limitation of electrical parameters Limitation in voltage, current, energy or frequency resulting, e. g. in torque limitation, hold–to–run with displacement/time limited, reduced speed, to avoid leading to an unsafe state.	All main components were de-rating used.	P

Clause	Requirement + Test	Result - Remark	Verdict
	No undefined states Avoid undefined states in the control system. Design and construct the control system so that during normal operation and all expected operating conditions its state, e. g. its output(s) can be predicted.	All state is defined clearly, no undefined states.	P
	Positive mode actuation Direct action is transmitted by the shape (and not by the strength) with no elastic elements, e. g. spring between actuator and the contacts, [see EN 1088:1995 (ISO 14119:1998), 5.1].	No such case	N/A
	Failure mode orientation Wherever possible, the device/circuit should fail to the safe state or condition.	The diagnostic measures are designed, in case of any faults detected, the system will go into safe state.	P
	Oriented failure mode Oriented failure mode components or systems should be used wherever practicable [see EN 292–2:1991 (ISO/TR 12100-2:1992), 3.7.4].	No such case	N/A
	Over–dimensioning De-rate components when used in safety circuits, e. g. by: Current passed through switched contacts should be less than half their rated current, The switching frequency of components should be less than half their rated value, and Total number of expected switching operation shall be ten times less than the device's electrical durability.	The charging and discharging MOSFETs are chosen with de-rating use.	P
	Minimise possibility of faults Separate safety–related functions from the other functions.	Safety related circuit and non-safety related circuit are separated.	P
	Balance complexity/simplicity Balance should be made between complexity to reach a better control and simplify to have a better reliability.	The balance between complexity controllability and simple reliability are taken into consideration during product design and development life cycle.	P

--- **END OF THE REPORT** ---