Test Report issued under the responsibility of:

TEST REPORT
STANDARD FOR SAFETY
ANSI/CAN/UL-2272:2016, Electrical Systems for Personal E-Mobility Devices

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Tested by(+signature).....:	Sunny
Approved by(+signature).....:	Barry
Date of issue.....:	2021-10-20
Total number of pages.....:	54 pages
Testing Laboratory .....:	**Shenzhen STL Testing Technology Co., Ltd.**
Testing location .....:	Unit C, 4F, Building A, ShengHengji Industrial Park, No. 137 FuYuan 1 Road, Heping Community, Fuyong Street, Baoan District, Shenzhen, China
Applicant's name.....:	**Jinhua Smart Electric Technology Co.,Ltd**
Address.....:	No.1067, Jinde Road,Jiangling Gaoxin Zhizhao District, Jiangdong Town,Jindong District,Jinhua City,Zhejiang Province
Manufacturer's name.....:	**Jinhua Smart Electric Technology Co.,Ltd**
Address.....:	No.1067, Jinde Road,Jiangling Gaoxin Zhizhao District, Jiangdong Town,Jindong District,Jinhua City,Zhejiang Province
Test specification:	
Standard.....:	ANSI/CAN/UL-2272:2016, Electrical Systems for Personal E-Mobility Devices
Test procedure.....:	UL 2272
Non-standard test method.....:	N/A
Test Report Form No.....:	TR_UL2272
Test Report Form(s) Originator.....:	UL
Master TRF.....:	Dated 2016-10
Test item	
Description .....:	Self Balancing Scooter
Trade Mark .....:	N/A
Model/Type reference .....:	EV2、EV4、EV6、E1、SMART-S、Z+、JD、JD1、JD5、JD6、JD7、JD8、XP7、XP8、XP9、XP10、WJ1、WJ2、Z5、Z29、Z35、C1++、Z1++、ER6， HY-A02， HY-A03， HY-A04
Model differences.....:	All models are identical except for model No and enclosure Colour . After comparison, tests carried out on model EV2 were considered
Ratings .....:	For Power supply:100-240Vac, 50/60Hz, 1A Max. Output: 29.4Vdc, 1A For Self Balancing Scooter 29.4Vdc, 1A or 25.2Vdc, 4Ah, 100.8Wh, IPX4

Possible test case verdicts:

- test case does not apply to the test object..... : N/A
- test object does meet the requirement..... : P (Pass)
- test object does not meet the requirement.....: F (Fail)

Testing..... :

Date of receipt of test item.....: 2021-10-12

Date (s) of performance of tests..... : 2021-10-12 to 2021-10-20

General remarks:

The test results presented in this report relate only to the object tested.
This report shall not be reproduced, except in full, without the written approval of the Issuing testing laboratory.
"(see Enclosure #)" refers to additional information appended to the report.
"(see appended table)" refers to a table appended to the report.
Throughout this report a comma (point) is used as the decimal separator.

Copy of Marking plate ***(marking will be the one finally provided on product for selling)***

Self Balancing Scooter
Model: EV2
Rating: 29.4V⎓1A or 25.2Vdc, 4Ah, 100.8Wh, IPX4
Jinhua Smart Electric Technology Co.,Ltd
No.1067, Jinde Road,Jiangling Gaoxin Zhizhao District,
Jiangdong Town,Jindong District,Jinhua City,
Zhejiang Province
DD/MM/YYYY S/N:xxxxx
Made in China

Remarks

The use of certification marks on a product must be authorized by the respective certification bodies that own these marks.

UL 2272			
Clause	Requirement + Test	Result - Remark	Verdict
INTRODUCTION			
1	**Scope**		**-**
1.1	These requirements cover the electrical drive train system including the battery system, other circuitry and electrical components for electric powered scooters and other devices to be referred to as personal e-mobility devices as defined in this standard.		P
1.2	This standard is intended for evaluation of the safety of the electrical drive train system and battery and charger combination for energy and electrical shock hazards and does not evaluate the performance or reliability of these devices. In addition, it does not evaluate the physical hazards that may be associated with the use of personal e-mobility devices.		P
2	Components		P
2.1	A component of a product covered by this standard shall comply with the requirements for that component. See Appendix A for a list of standards covering components generally used in the products covered by this standard.		P
3	Units of Measurement		P
3.1	Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.		P
4	Undated References		-
4.1	Any undated reference to a code or standard appearing in the requirements of this standard shall be interpreted as referring to the latest edition of that code or standard.		P
5	Normative References		-
5.1	Products covered by this standard shall comply with the reference standards noted in this section as appropriate for the country where the product is to be used. When the product is intended for use in more than one country, the product shall comply with the standards for all countries where it is intended to be used.		P
5.2	The following standards are referenced in this standard, and portions of these referenced standards as identified in this standard may be essential for compliance.		P
6	Glossary		-
6.1	BATTERY – A generic term for one or more cells electrically connected in series and/or parallel with or without monitoring and protection circuitry for charging and discharging.		-

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6.2	BATTERY PACK – Batteries that are ready for use in a personal e-mobility device, contained in a protective enclosure, with protective devices, with a battery management system, and monitoring circuitry and that may be removable by the user for charging separately from the device.		-
6.3	BATTERY SYSTEM – Battery system includes the battery, charger and monitoring and protection circuit for charging and discharging of the battery.		-
6.4	CAPACITY, RATED – The total number of ampere-hours that can be withdrawn from a fully charged battery at a specific discharge rate to a specific end-of-discharge voltage (EODV) at a specified temperature as declared by the manufacturer.		-
6.5	CASING – The container that directly encloses and confines the electrolyte, and electrodes of a cell.		-
6.6	CELL – The basic functional electrochemical unit (sometimes referred to as a battery) containing an electrode assembly, electrolyte, separators, casing, and terminals. It is a source of electrical energy by direct conversion of chemical energy.		-
6.7	CHARGING – The application of electric current to battery terminals, which results in a Faradic reaction that takes place within the battery that leads to stored electro-chemical energy. For personal e-mobility devices, charging of the battery can occur through one or more of the following methods: a) Regenerative charging which utilizes energy from regeneration through braking or acceleration (i.e. when going down a hill). b) Off board charging which utilizes an ac to dc charger, a dc charger, or an inductive charger external to the device. c) On board charging which utilizes a charger on the personal e-mobility device to convert the ac mains supply to dc for charging.		-
6.8	CHARGING, CONSTANT CURRENT (CC) – Charging mode where current is held constant while charging voltage is allowed to vary.		-
6.9	DUT – Device under test.		-
6.10	ELECTRIC SHOCK HAZARD – A potential for exposure of persons to hazardous voltage circuits through direct contact from openings in protective enclosures and/or insufficient insulation between hazardous voltage circuits and accessible parts.		-
6.11	ELECTRICAL DRIVE TRAIN SYSTEM – The electrical components that power the personal e-mobility device’s motion and would include the battery system; the electric motor(s); the protection, balance and control systems; and the circuitry and wiring to connect them together.		-

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6.12	ELECTRICAL SYSTEM – All of the electrical components and circuits that are provided with the personal e-mobility device and would include the electrical drive train system, the internal or external charger used to recharge the battery and auxiliary electrical systems such as lighting, communications and audio that may be provided on the device.		-
6.13	ELECTROLYTE LEAKAGE – A condition where liquid electrolyte escapes through an opening in a designed vent as well as through a rupture or crack or other unintended opening in the casing or enclosure of a cell or capacitor and is visible external to the DUT.		-
6.14	ENCLOSURE – The outer cover of a device that provides protection to its contents to prevent a potential hazard, and may have one or more specific levels of protection as noted below: a) ELECTRICAL ENCLOSURE – Provides protection from access to hazardous voltage circuits and may serve as part of the electrical insulation. b) FIRE ENCLOSURE – Provides protection from the spread of fire from components within. c) MECHANICAL ENCLOSURE – Provides physical protection from damage to components and parts contained within and/or prevents access to hazardous moving parts. d) ENVIRONMENTAL ENCLOSURE – Provides protection from ingress of materials from the environment such as water that could damage internal components or introduce hazards. A rating such as the IP code provides the level of protection given by the enclosure		-
6.15	END-OF-DISCHARGE VOLTAGE (EODV) – The voltage, under load, of the cell or battery at the end of discharge. The EODV may be specified, as in the case of a voltage terminated discharge, or simply measured in the case of a time-controlled discharge.		-
6.16	EXPLOSION – A violent release of energy that produces projectiles or an energy wave from the DUT and results in the DUT’s contents being forcibly expelled through a rupture in the enclosure or casing.		-
6.17	FIRE – The sustained combustion of the DUT’s contents as evidenced by flame, heat and charring or other damage of materials.		-
6.18	FULLY CHARGED – A battery which has been charged per the manufacturer’s specifications to its full state of charge (SOC).		-
6.19	FULLY DISCHARGED – A battery, which has been discharged, according to the manufacturer’s specifications, to its specified end of discharge voltage (EODV).		-

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6.20	HAZARDOUS VOLTAGE – Voltage exceeding 30 Vrms/42.4 Vac peak or 60 Vdc		-
6.21	INSULATION LEVELS – The following are levels of electrical insulation: a) BASIC – A single level of insulation that provides protection against electric shock. Basic insulation alone may not provide protection from electric shock in the event of a failure of the insulation. b) DOUBLE INSULATION – Insulation comprising both basic insulation and supplementary insulation. c) FUNCTIONAL INSULATION – Insulation that is necessary only for the correct functioning of the equipment. Functional insulation by definition does not protect against electric shock. It may, however, reduce the likelihood of ignition and fire. d) REINFORCED INSULATION – Single insulation system that provides a degree of protection against electric shock equivalent to double insulation under the conditions specified in this standard. The term ″ insulation system″ does not imply that the insulation has to be in one homogeneous piece. It may comprise several layers that cannot be tested as basic insulation and supplementary insulation. e) SUPPLEMENTARY INSULATION – Independent insulation applied in addition to basic insulation in order to reduce the risk of electric shock in the event of a failure of the basic insulation.		-
6.22	PERSONAL E-MOBILITY DEVICE – A consumer mobility device intended for a single rider with a rechargeable electric drive train that balances and propels the rider, and which may be provided with a handle for grasping while riding. This device may or may not be self-balancing.		-
6.23	ROOM AMBIENT – Considered to be a temperature in the range of 25 ±5° C (77 ±9° F).		-
6.24	RUPTURE – A mechanical failure of the DUT’s enclosure/casing from either internal or external causes, that results in spillage and/or exposure of internal contents of the DUT, but does not result in projectiles and violent energy release such as occurs during an explosion.		-
6.25	SAFETY CRITICAL CIRCUITS/COMPONENTS – Those circuits or discrete components that are relied upon for safety as identified in the safety analysis of 16.2.		-

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6.26	SPECIFIED OPERATING REGION – That region of voltage, current and temperature within which a cell can be safely charged and discharged repetitively throughout its anticipated life. The manufacturer specified these values, which are then used in the safety evaluation of the device and may vary as the device ages. The specified operating region may include transient values for voltage, current and temperature that are allowed under limited conditions specified by the cell manufacturer. The specified operating regions will include the following parameters for charging and discharging as specified by the manufacturer: a) CHARGING TEMPERATURE LIMITS – The upper and lower limits of temperature, specified by the manufacturer for charging of the cell. This temperature is measured on the casing. b) DISCHARGE TEMPERATURE LIMITS – The upper and lower limits of temperature, specified by the manufacturer for discharging the cell. This temperature is measured on the casing. c) END OF DISCHARGE VOLTAGE – Refer to 6.13. Also, see Figure 3.1 of the Standard for Lithium Batteries, UL 1642. d) MAXIMUM DISCHARGING CURRENT – The maximum discharging current rate, which is specified by the cell manufacturer. e) MAXIMUM CHARGING CURRENT – The maximum charging current in the specified operating region, which is specified by the cell manufacturer. This value may vary with temperature		-
6.27	STATE OF CHARGE (SOC) – The available capacity in a pack, module or cell expressed as a percentage of rated capacity.		-
CONSTRUCTION			
7	Non-Metallic Materials		P
7.1	The materials employed for enclosures relied upon for safety per 6.14 shall comply with the applicable enclosure requirements outlined in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, Path III of the Enclosure Requirements in Table 4.1 or the Standard for Evaluation of Properties of Polymeric Materials, CAN/CSA-C22.2 No. 0.17, except as modified by this standard.		P

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7.2	Polymeric materials employed for fire enclosures shall have a minimum flame rating of 94V-1 in accordance with the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94, or the Standard for Evaluation of Properties of Polymeric Materials, CAN/CSA-C22.2 No. 0.17. Exception: The enclosure may alternatively be evaluated to the 20 mm end product flame test in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, or the Standard for Evaluation of Properties of Polymeric Materials, CAN/CSA-C22.2 No. 0.17.		P
7.3	The following factors in (a) – (e) are taken into consideration when an enclosure employing nonmetallic materials is being judged. For a nonmetallic enclosure all of these factors are to be considered with respect to thermal aging. Dimensional stability of a polymeric enclosure is addressed by compliance to the mold stress relief test. Suitability to factors (a) – (e) below may be determined by the tests of this standard. a) Resistance to impact; b) Crush resistance; c) Abnormal operations; d) Severe conditions; and e) Mold-Stress Relief Distortion.		P
7.4	The polymeric materials employed for enclosures and insulation shall be suitable for anticipated temperatures encountered in the intended application. Enclosures shall have a Relative Thermal Index (RTI) with impact suitable for temperatures encountered in the application but no less than 80° C (176° F), as determined in accordance with the Standard for Polymeric Materials – Long Term Property Evaluations, UL 746B, or the Standard for Evaluation of Properties of Polymeric Materials, CAN/CSA-C22.2 No. 0.17.		P
7.5	The enclosure materials intended to be directly exposed to sunlight and rain in the end use application shall comply with the UV Resistance and the Water Exposure and Immersion tests in accordance with the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C, or the Standard for Evaluation of Properties of Polymeric Materials, CAN/CSA-C22.2 No. 0.17. This requirement may be waived if the personal e-mobility device is marked that it be stored indoors and user instructions also indicate that it not be left outdoors to be exposed to UV or rain. See 45.11 and Section 46.		P

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7.6	Materials employed as electrical insulation in the assembly shall be resistant to deterioration that would result in an electrical shock, fire or other safety hazard. Compliance is determined by the tests of this standard. Materials employed for direct support of live parts at hazardous voltage, shall additionally meet the direct support insulation criteria outlined in the Material Property Considerations, Table 6.1, in the Standard for Polymeric Materials – Use in Electrical Equipment Evaluations, UL 746C or the Standard for Evaluation of Properties of Polymeric Materials, CAN/CSA-C22.2 No. 0.17, unless employed as part of a component that has been evaluated to a suitable component standard. Insulated wiring is subjected to the requirements outlined in Section 10, Wiring and Terminals.		P
7.7	Gaskets and seals relied upon for safety, shall be determined suitable for the environmental conditions and chemical substances they are anticipated to be exposed to in their end use.		P
8	Metallic Parts Resistance to Corrosion		N/A
8.1	Metal enclosures shall be corrosion resistant. A suitable plating or coating process can achieve corrosion resistance. Additional guidance on methods to achieve corrosion protection can be found in the Standard for Enclosures for Electrical Equipment, Environmental Considerations, UL 50E or in CSA-C22.2 No. 94.2.	No Metal enclosures	N/A
8.2	Metal enclosures may be provided with an insulating liner to prevent shorting of live parts to the enclosure. If using an insulating liner for this purpose, the insulating liner shall consist of non-moisture absorbent materials that have a temperature rating suitable for temperatures during operation including charging.	No Metal enclosures	N/A
8.3	Conductive parts in contact at terminals and connections shall not be subject to corrosion due to electrochemical action.		P
9	Enclosures		P
9.1	General		P
9.1.1	The enclosure relied upon for safety per 6.14 shall have the strength and rigidity required to resist the possible physical abuses that it will be exposed to during its intended use, in order to reduce the risk of fire or injury to persons as determined by the requirements contained in this standard.		P
9.1.2	A tool providing the mechanical advantage of a pliers, screwdriver, hacksaw, or similar tool, shall be the minimum mechanical capability required to open the enclosure.		N/A

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9.1.3	Openings in the enclosure relied upon for safety per 6.14 shall be designed to prevent inadvertent access to hazards such as hazardous voltages, hazardous moving parts or hot surfaces that could result in burns. Parts that can be removed without the use of a tool, are to be removed to determine compliance. Compliance is determined by Clause 12, Tests for Protection Against Access to Hazardous Parts Indicated by the First Characteristic Numeral, of the Standard for Degrees of Protection Provided by Enclosures (IP Code), IEC 60529, or the Standard for Degrees of Protection Provided by Enclosures (IP Code), CAN/CSA-C22.2 No. 60529, for a minimum IP rating of IP3X. Evaluation per the Standard for Degrees of Protection Provided by Enclosures (IP Code), IEC 60529 or CAN/CSA-C22.2 No. 60529, Clause 12, consists of the use of the Test Rod 2.5 mm, 100 mm long, shown in Figure 1 of the Standard for Batteries for Use In Light Electric Vehicle (LEV) Applications, UL 2271, or CAN/ULC-S2271, applied with a force of 10 N ± 10%.		N/A
9.1.4	Openings in the environmental enclosure per 6.14 shall be designed to prevent ingress of water as installed in the personal e-mobility device in accordance with intended use and IP rating in accordance with the Standard for Degrees of Protection Provided by Enclosures (IP Code), IEC 60529, or CAN/CSA-C22.2 No. 60529 with a minimum rating of IPX4 and resistant to hazards associated with partial immersion. Compliance is determined by the Water Exposure Tests in Section 42.	IPX4	P
9.2	Battery compartments		P
9.2.1	Cell vents shall not be obstructed in such a way as to defeat their operation if venting is relied upon for compliance with this standard. Compliance is checked by inspection.		P
9.2.2	Battery compartments within enclosures shall secure the battery in place sufficiently to prevent excessive movement and stress on the battery and cells that could result in a hazard. Compliance is checked by inspection and the mechanical tests of this standard.		P
10	Wiring and Terminals		P
10.1	Wiring shall be insulated and acceptable for the purpose, when considered with respect to temperature, voltage, and the conditions of service to which the wiring is likely to be subjected within the equipment.		P

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10.2	Internal wiring shall be routed, supported, clamped or secured in a manner that reduces the likelihood of excessive strain on wire and on terminal connections; loosening of terminal connections; and damage of conductor insulation. In safety critical circuits, for soldered terminations, the conductor shall be positioned or fixed so that reliance is not placed upon the soldering alone to maintain the conductor in position. Wire routing shall not result in undue stress on battery cells in fully assembled products.		P
10.3	An external terminal shall be designed to prevent an inadvertent shorting and misalignment and a reverse polarity connection when connections are made. For battery packs that are intended for removal from the personal e-mobility device for external charging or replacement with a charged battery pack, the external terminal for discharging shall be designed to prevent inadvertent shorting, a reverse polarity connection and a misalignment.		P
10.4	For battery packs that are intended for removal from the personal e-mobility device for external charging or replacement with a charged battery pack by the user, the external terminal for discharging and any other external terminals with hazardous voltage shall be designed to prevent access by the user. Compliance is determined by use of the articulate test finger shown in Figure 10.1.		P
10.5	The external terminals of a battery pack with hazardous voltage circuits that is intended for removal from the personal e-mobility device for charging, shall be evaluated to either the no load endurance test or endurance with load test as applicable to the end use application in accordance with the Standard for Plugs, Receptacles, and Couplers for Electric Vehicles, UL 2251, or the Standard for Plugs, Receptacles, and Couplers for Electric Vehicles, CAN/CSA C22.2 No. 282, without being subjected to the exposure to contaminants.		N/A
10.6	A hole by which insulated wires pass through a metal wall shall be provided with a smoothly rounded bushing or shall have smooth surfaces, free of burrs, fins, sharp edges, and the like, upon which the wires may bear, to prevent abrasion of the insulation.		N/A
10.7	Wiring for hazardous voltage shall be enclosed in an electrical enclosure with hazardous voltage warning labels such as ISO 7010, No. W012 (i.e. lightning bolt within triangle).		N/A
11	Chargers		P

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11.1	Power supplies intended for charging the personal e-mobility device shall be evaluated for intrinsic safety in accordance with the Standard for Class 2 Power Units, UL 1310, or the Standard for Power Supplies with Extra-Low-Voltage Class 2 Outputs, CSA-C22.2 No. 223, the Standard for Power Units other than Class 2, UL 1012, or the Standard for General Use Power Supplies, CSA-C22.2 No. 107.1, the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1, or CAN/CSA-C22.2 No. 60950-1, or the Standard for Audio/Video, Information and Communication Technology Equipment – Part 1: Safety Requirements, UL 62368-1, or CAN/CSA-C22.2 No. 62368-1, and shall be determined compatible with the device's battery system. Compliance is determined by a review of data on the battery system and charger and the tests of this standard. The charger shall be provided with a means for connection to a standard outlet if intended for connection to a mains source of electrical supply in accordance with the standards noted above.	Approved power supply	P
11.2	The connector provided with the charger for connecting to the personal e-mobility device/battery terminal for charging, shall be designed to prevent misalignment and reverse polarity.		P
12	Fuses		P
12.1	Fuses shall be acceptable for the current and voltage of the circuit they are protecting.		P
12.2	For user replaceable fuses, a fuse replacement marking shall be located adjacent to each fuse or fuse holder, or on the fuse holder, or in another location provided that it is obvious to which fuse the marking applies, and giving the fuse ratings. Where user replaceable fuses with special fusing characteristics such as time delay or breaking capacity are necessary, the type shall also be indicated. Information on proper fuse replacement of user replaceable fuses shall also be included in the instructions.		P
13	Lighting		P
13.1	An integral lamp shall be rated for the application. If provided with user replaceable bulbs, replacement shall not impair the safety of the personal e-mobility device and there shall be no risk of electric shock. Instructions provided with the personal e-mobility device shall include information on the type and ratings of user replaceable bulbs.		P
14	Electrical Spacings and Separation of Circuits	Approved power supply	N/A

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14.1	Electrical circuits within the personal e-mobility device at opposite polarity shall be provided with reliable physical spacing to prevent inadvertent short circuits (i.e. electrical spacings on printed wiring boards, physical securing of uninsulated leads and parts, etc.). Insulation suitable for the anticipated temperatures and voltages shall be used where spacings cannot be controlled by reliable physical separation.		N/A
14.2	Electrical spacings in circuits shall have the following minimum over surface and through air spacings as outlined in Table 14.1 or the spacings requirements outlined in the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1, or CAN/CSA-C22.2 No. 60950-1, Clause 2.10, Clearances, Creepage Distances and Distances Through Insulation. Unless provided with instructions regarding limiting the personal e-mobility device use to elevation levels to 2000 m above sea level or below per 42.3, multiplications factors per 2.10.3.1 of UL 60950-1 or CAN/CSA-C22.2 No. 60950-1 shall be applied to the electrical spacings.		N/A
14.3	There are no minimum spacings applicable to parts where insulating compound completely fills the casing of a component or subassembly if the distance through the insulation, at voltages above 60 Vdc or above 30 Vrms is a minimum of 0.4-mm (0.02-in) thick for supplementary or reinforced insulation, and passes the Dielectric Voltage Withstand Test, Section 29, and the Isolation Resistance Test, Section 30. There is no minimum insulation thickness requirement for insulation of circuits at or below 60 Vdc or for basic or functional insulation. Some examples include potting, encapsulation, and vacuum impregnation.		N/A
14.4	Conductors of circuits operating at different voltages shall be reliably separated from each other through the use of mechanical securements such as barriers or wire ties to maintain spacing requirements unless they are each provided with insulation acceptable for the highest voltage involved. An insulated conductor shall be reliably retained so that it cannot contact an uninsulated live part of a circuit operating at a different voltage.		N/A
15	Insulation Levels and Protective Grounding		N/A

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15.1	Hazardous voltage circuits shall be insulated from accessible conductive parts and safety extra low voltage (SELV) circuits as outlined in 15.2 through the following: a) Basic insulation and provided with a protective grounding system for protection in the event of a fault of the basic insulation; or b) A system of double or reinforced insulation; or c) A combination of (a) and (b).		N/A
15.2	Safety extra low voltage (SELV) circuits (i.e. circuits at or below 60 Vdc or 48 Vrms under normal and single fault conditions) that are insulated from accessible conductive parts through functional insulation only are considered accessible.		N/A
15.3	If relying upon a protective grounding system (i.e. grounding of an accessible metal enclosure), it shall comply with 15.4 – 15.6.		N/A
15.4	Parts of a protective grounding system shall be reliably secured in accordance with 10.2 and provided with good metal-to-metal contact of the grounded parts of the personal e-mobility device. The impedance from the various bonding conductors and connections to the main ground terminal shall have a maximum resistance of 0.1 Ω . Compliance can be determined by measurement using an ohmmeter.		N/A
15.5	The main ground terminal of the protective earthing ground system shall be identified by one of the following: a) A green-colored, not readily removable terminal screw with a hexagonal head; b) A green-colored, hexagonal, not readily removable terminal nut; c) A green colored pressure wire connector; or d) The word ″ Ground″ or the letters ″ G″ or ″ GR″ or the grounding symbol (IEC 60417, No. 5019 – upside down ″ tree″ in circle) or otherwise identified by a distinctive green color. For Canada only use the grounding symbol rather than the words “Ground”, or “G” or “GR”		N/A
15.6	Conductors, relied upon for the protective grounding and bonding system, shall be sized to handle intended fault current. If insulated, the insulation shall be green or green and yellow striped in color.		N/A
16	Protective Circuits and Safety Analysis		N/A

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16.1	The personal e-mobility device’s protective circuitry shall maintain the cells within their specified operating region for charging and discharging through the life of the device. If cell specified operating limits are exceeded, the protective circuitry shall limit or shut down the charging or discharging to mitigate excursions beyond specified operating limits. Compliance is determined through a review of the cell specified cations and safety analysis of 16.2 and through the testing of this standard. If applicable to the personal e-mobility device design, the analysis and testing needs to evaluate the overcharge protection control’s ability to mitigate overcharge due to regenerative charging during use.		N/A
16.2	An analysis of potential electrical and energy hazards (including an FMEA) shall be conducted on the personal e-mobility device’s electrical system to determine that events that could lead to a hazardous condition have been identified and addressed through design or other means. Documents that can be used as guidance for the safety analysis include: a) The Standard for Analysis Techniques for System Reliability – Procedure for Failure Mode and Effects Analysis (FMEA), IEC 60812; b) The Standard for Fault Tree Analysis (FTA), IEC 61025; c) The Potential Failure Mode and Effects Analysis in Design (Design FMEA), Potential Failure Mode and Effects Analysis in Manufacturing and Assembly Processes (Process FMEA), SAE J1739; or d) The Procedures for Performing a Failure Mode, Effects, and Criticality Analysis, MIL-STD-1629A.		N/A
16.3	The analysis in 16.2 is utilized to identify anticipated faults in the system which could lead to a hazardous condition and the types and levels of protection provided to mitigate the anticipated faults. The analysis shall consider single fault conditions in the protection circuit/scheme as part of the anticipated faults.		N/A
16.4	When conducting the analysis of 16.2, active devices shall not be relied upon for critical safety unless: a) They are provided with a redundant passive protection device; or b) They are provided with redundant active protection that remains functional and energized upon loss of power/failure of the first level active protection; or c) They are determined to fail safe upon loss of power to/failure of the active circuit.		

UL 2272			
Clause	Requirement + Test	Result - Remark	Verdict
16.5	Devices relied upon for critical safety as noted in 16.4(a) – (b) shall minimally comply with the applicable Environmental Stress tests described in Sections 9 – 22 of the Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991, or fully comply with appropriate functional safety requirements below. Devices solely relied upon for critical safety as noted in 16.4 (c) shall fully comply with appropriate functional safety requirements in one of the following standards as appropriate to the design of the electronic and software protection scheme: a) The Standard for Tests for Safety-Related Controls Employing Solid-State Devices, UL 991, or the Standard for Safety Functions Incorporating Electronic Technology, CSA-C22.2 No. 0.8, and the Standard for Software in Programmable Components, UL 1998; b) The Standard for Automatic Electrical Controls for Household and Similar Use – Part 1: General Requirements, UL 60730-1 or CAN/CSA-E60730-1; and c) The Standard for Functional Safety of Electrical/Electronic/Programmable Electronic Safety- Related Systems – Part 1: General Requirements, IEC 61508-1, and all parts.		N/A
16.6	A personal e-mobility device containing hazardous voltage shall have a manual disconnect to prevent inadvertent access to hazardous voltage parts during servicing. The manual disconnect shall: a) Disconnect both poles of the hazardous voltage circuit; b) Require manual action to break the electrical connection; c) Ensure disconnection is physically verifiable and can include actual removal of the battery system from the personal e-mobility device or unplugging the battery system connector/plug; and d) When engaged (i.e. under disconnection), it does not create exposed conductors capable of becoming energized and is insulated to prevent a shock hazard during actuation.		N/A

UL 2272			
Clause	Requirement + Test	Result - Remark	Verdict
16.7	If a hazardous voltage automatic disconnect device is provided to isolate accessible conductive parts from the hazardous voltage circuit of the battery system, it shall: a) Not be able to be reset automatically although it may be able to be reset deliberately upon clearing of the fault; b) Disconnect both poles of the hazardous voltage circuit; c) Be capable of handling full load disconnects of the hazardous voltage circuit that it is isolating; and d) Not result in a hazardous condition upon automatic actuation.		N/A
16.8	The personal e-mobility device shall have charger connect-interlock so that the unit cannot be activated when the charger is plugged in.		N/A
17	Cells		P
17.1	Cells shall be designed to safely withstand anticipated abuse conditions for personal e-mobility devices. Compliance is determined by the requirements in 17.2 – 17.6 and by the tests of this standard.		P
17.2	Lithium ion and other lithium based cells shall comply with the requirements for secondary lithium cells in the Standard for Batteries for Use in Electric Vehicles, UL 2580 or CAN/ULC-S2580 or the Standard for Batteries for Use in Light Electric Vehicle (LEV) Applications, UL 2271, or CAN/ULC-S2271.		P
17.3	The temperature limits need to consider the cell manufacturer’s specified temperatures limits on the cell casing surface during charging and discharging. When evaluating the cell and battery control combination, consideration must be given to tolerances in the control circuitry for charging. If the control circuitry settings with tolerances exceed the cell charge specifications for voltage, testing of the cell needs to be repeated with the cell charged to these higher voltage values.		P
17.4	Nickel metal hydride cells and other nickel based cells shall comply with the nickel cell requirements in the Standard for Batteries for Use in Electric Vehicles, UL 2580 or CAN/ULC-S2580 or the Standard for Batteries for Use in Light Electric Vehicle (LEV) Applications, UL 2271, or CAN/ULC-S2271.		P
17.5	Valve regulated lead acid batteries shall comply with the pressure release test of the Standard for Standby Batteries, UL 1989.		P
17.6	Electrochemical capacitors shall comply with the capacitor requirements in the Standard for Electrochemical Capacitors, UL 810A.		P
18	Motors		P

UL 2272			
Clause	Requirement + Test	Result - Remark	Verdict
18.1	A traction motor used in a personal e-mobility device shall not be hazardous under locked rotor and overload conditions. Compliance is determined by the tests of this standard unless previously evaluated as part of a motor and motor protector combination evaluation		P
18.2	Motors shall be capable of carrying the maximum normal anticipated load without exceeding temperatures on insulation and windings as determined during the temperature test.		P
18.3	Motors located in hazardous voltage circuits shall comply with the requirements of the Standard for Rotating Electrical Machines – General Requirements, UL 1004-1 or the Standard for Motors and Generators, CSA-C22.2 No. 100. Motors located in low voltage circuits shall comply with either UL 1004-1 or CSA-C22.2 No. 100 or the requirements of this standard.		P
19	Manufacturing and Production Line Testing		P
19.1	Personal e-mobility devices shall be subjected to 100% production screening as described in 19.2 and 19.6 to determine the acceptability of spacing, insulation and grounding system in production.		P
19.2	A dielectric withstand test shall be conducted on 100% production of personal e-mobility devices with working voltage exceeding 60 Vdc or 30 Vrms/42.4 Vpeak ac. There shall be no evidence of breakdown as a result of the dielectric voltage withstand test.		P
19.3	Personal e-mobility devices with hazardous voltage circuits electrically isolated from ac mains supplied circuits shall be subjected to a production dielectric withstand voltage consisting of an dc or ac potential of twice the rated voltage. For those personal e-mobility devices with hazardous voltage circuits intended for connection to an ac mains supply or not electrically isolated from ac mains circuits, the test voltage shall be an essentially ac potential of frequency 60 Hz at 1,000 V plus twice the rated voltage. If using a dc potential to test the non-isolated circuit, the test voltage shall be 1.414 times the ac test potential value of 1,000 V plus twice the rated voltage.		N/A

UL 2272			
Clause	Requirement + Test	Result - Remark	Verdict
19.4	The test voltages shall be applied for a minimum of 1 minute with the cells/modules disconnected in a manner to prevent inadvertent charging during application of the voltage. Exception No. 1: The time for the production Dielectric Withstand Test can be reduced to 1 s. If the value of the voltage noted above is increased as follows: a) 2.4 times the circuit voltage for those circuits isolated from the ac mains supply; and b) 1200 plus 2.4 times the circuit voltage for those circuits not isolated from the ac mains supply.	Approved power supply	N/A
19.5	The test equipment shall consist of a 500 VA or larger capacity transformer, the output voltage, which is variable and which is essentially sinusoidal if using an ac test method and dc output if using a dc test method. There is no trip current setting for the test equipment since the test is checking for insulation breakdown, which results in a large increase of current.		p
19.6	A continuity check of the grounding conductors using a mega ohmmeter or other method shall be conducted on 100% production employing protective grounding. The continuity check shall determine that the resistance of the protective grounding system does not exceed 0.1 Ω .		N/A
19.7	The manufacturer is required to have documented production process controls in place that continually monitor the following key elements of the manufacturing process that can affect safety: (a) supply chain control and (b) assembly processes, and it shall include corrective/preventative action to address defects found affecting the key elements.		P
PERFORMANCE			
20	General		P
20.1	Unless indicated otherwise, personal e-mobility device batteries shall be fully charged in accordance with the manufacturer’ s specifications for conducting the tests in this standard. After charging and prior to testing, the batteries shall be allowed to rest for a maximum period of 8 h at room ambient.		P
20.2	Unless otherwise indicated, fresh samples representative of production are to be used for the tests described in this standard. The test program and number of samples to be used in each test is shown in Table 20.1.		P
20.3	All tests, unless noted otherwise, are conducted in a room ambient 25 ±5° C (77 ±9° F).		P

UL 2272			
Clause	Requirement + Test	Result - Remark	Verdict
20.4	Temperature shall be measured using thermocouples consisting of wires not larger than 0.21 mm 2 (24 AWG) and not smaller than 0.05 mm 2 (30 AWG) connected to a potentiometer-type instrument. Temperature measurements are to be made with the measuring junction of the thermocouple held tightly against the component/location being measured. For those tests that require the sample to reach thermal equilibrium (also referred to as steady state conditions), thermal equilibrium is considered to be achieved if after three consecutive temperature measurements taken at intervals of 10% of the previously elapsed duration of the test but not less than 15 min, indicate no change in temperature greater than ±2° C (±3.6° F).		P
20.5	Where there is a specific reference to a single fault condition in the individual test methods, the single fault is to consist of a single failure (i.e. open, short or other failure means) of any component in the personal e-mobility devices that could occur and affect the results of the test. Faulting over two redundant components that have not been determined to be independent of each other is considered a single fault condition. This fault is implemented in conjunction with the test being conducted (i.e. overcharge, short circuit, etc.) or may be conducted as part of a verification of a protective circuit. A protective device determined to be reliable may remain in the circuit without being faulted. See Appendix A and 2.1. A protective device determined to be reliable is one that has been shown to comply with an appropriate component safety standard and is used within its ratings.		N/A
20.6	The tests contained in this standard may result in explosions, fire and emissions of flammable and/or toxic fumes as well as electric shock. It is important that personnel use extreme caution and follow local and regional worker safety regulations when conducting any of these tests and that they be protected from flying fragments, explosive force, and sudden release of heat and noise that could result from testing. The test area is to be well ventilated to protect personnel from possible harmful fumes or gases. As an additional precaution, the temperatures on surface of at least one cell/module within the DUT are to be monitored during the test for safety and information purposes. All personnel involved in the testing are to be instructed to never approach the DUT until temperatures are falling and have returned to within ambient temperatures.		P

UL 2272			
Clause	Requirement + Test	Result - Remark	Verdict
20.7	Unless noted otherwise in the individual test methods, the tests shall be followed by a minimum 1-h observation time prior to concluding the test and temperatures are to be monitored in accordance with 20.6.		P
20.8	Some testing may be waived for battery systems previously evaluated to the Standard for Batteries for Use in Light Electric Vehicle (LEV) Applications, UL 2271, if determined equivalent to the testing of UL 2272 in the personal e-mobility device system. These tests would include the following: Overcharge, Short Circuit, Overdischarge, and Imbalanced Charging. However, it must be determined through analysis that the tests conducted on the battery pack in accordance with UL 2271 are representative of testing with the system in accordance with UL 2272.		P
21	Tolerances		-
21.1	Unless noted otherwise in the test methods, the overall accuracy of measured values of test specifications or results when conducting testing in accordance with this standard, shall be within the following values of the measurement range. a) ±1% for voltage; b) ±1% for current; c) ±2° C (±3.6° F) for temperature at or below 200° C (392° F) and ±3% for temperatures above 200° C (392° F); d) ±0.1% for time; and e) ±1% for dimension.		P
22	Post Test Cycle		P
22.1	Personal e-mobility devices that are operational after the following tests shall be subjected to a minimum of one cycle of charging and discharging or if not operational, subjected to an attempt to charge only in accordance with the manufacturer’s specifications to determine that there is no non-compliant results as outlined in Table 22.1 for that test: a) Electrical Tests – Overcharge, short circuit, overdischarge protection, imbalanced charging; b) Mechanical Tests – Vibration, shock, drop, crush; and c) Environmental Tests – Water exposure, and thermal cycling.		P
22.2	The method of discharging the batteries may vary according to the personal e-mobility device design and should be a method agreed upon by the manufacturer and organization testing the personal e-mobility device.		P
23	Results Criteria		P

UL 2272			
Clause	Requirement + Test	Result - Remark	Verdict
23.1	See Table 22.1 for results criteria for tests outlined in this standard and Glossary, Section 6 for definitions of the non-compliance results terms. See also individual tests methods for any additional details.		P
ELECTRICAL TESTS			
24	Overcharge Test		P
24.1	This test is intended to evaluate a DUT’s ability to withstand an overcharge condition under non-faulted and under a single fault in the charging control circuitry that could result in an overcharge condition.		P
24.2	A fully charged sample is to be discharged at a 0.2 C constant discharge rate or a higher discharge rate permitted by the cell manufacturer to the manufacturer’s specified EODV. The DUT is then subjected to a constant current charging at the cell manufacturer’s maximum specified charging rate and under a single fault condition in the charging protection circuitry that could lead to an overcharge condition. Protective devices that have been determined reliable may remain in the circuit as noted in 20.5. For information purposes, temperatures are to be monitored on the cell/module where temperatures may be highest. The output control circuitry of external chargers with standardized output connectors (e.g. USB connectors) that may result in the use of unspecified chargers shall not be considered as a reliable control to prevent an overcharging condition.		P
24.3	The test is to be continued until the voltage has reached 110% of the specified upper limit charging voltage or the maximum obtainable charging voltage (if the 110% of specified upper limit charging voltage cannot be reached due to remaining protection circuitry), and monitored temperatures return to ambient or steady state conditions and an additional 2 h has elapsed, or explosion/fire occur. If the DUT is operational after the test, it shall be subjected to a minimum of one charge/discharge cycle at the cell manufacturer’s maximum specified values per Section 22, Post Test Cycle. The test shall be followed by an observation period per 20.7.		P
24.4	At the conclusion of the observation period, the samples with hazardous voltage circuits shall be subjected to a Dielectric Voltage Withstand Test, Section 29, or Isolation Resistance Test, Section 30, (without humidity conditioning).		P
24.5	If a protective device in the circuit operates, the test is repeated at 90% of the trip point of the protection device or at some percentage of the trip point that allows charging for at least 10 min. Temperatures shall be measured on the DUT for monitoring purposes.		P

UL 2272			
Clause	Requirement + Test	Result - Remark	Verdict
24.6	As a result of the overcharge test, any of the following results in (a) – (e) below are considered a non-compliant result. See also Table 22.1 and Section 23, Results Criteria. a) E – Explosion; b) F – Fire; c) R – Rupture (enclosure); d) L – Electrolyte Leakage (external to enclosure); and e) S – Electric shock hazard (resistance below isolation resistance limits or dielectric breakdown).The voltage limits on the cells are not to exceed the specified upper limit charging voltage.		P
25	Short Circuit Test		P
25.1	This test evaluates a DUT’s ability to withstand a short circuit condition.		P
25.2	A fully charged sample of the battery system is to be short-circuited by connecting the positive and negative terminals of the sample with a circuit load having a total resistance of less than or equal to 20 mΩ .		P
25.3	Samples are to be subjected to a single fault across any protective device in the load circuit. Protective devices that have been determined reliable may remain in the circuit as noted in 20.5.		P
25.4	The sample shall be discharged until the sample has returned to ambient temperature or fire or explosion occurs. Temperatures shall be measured on the DUT for monitoring purposes.		P
25.5	If the DUT is operational after the test, it shall be subjected to a minimum of one charge/discharge cycle at the manufacturer’s maximum specified values per Section 22, Post Test Cycle. The test shall be followed by an observation period per 20.7.		P
25.6	If a protective device in the circuit operates, the test is repeated at 90% of the trip point of the protection device or at some percentage of the trip point that allows discharging for at least 10 min.		P
25.7	At the conclusion of the test and after cooling to near ambient, the samples that contain hazardous voltage circuits shall be subjected to a Dielectric Voltage Withstand Test, Section 29, or Isolation Resistance Test, Section 30, (without humidity conditioning).		P

UL 2272			
Clause	Requirement + Test	Result - Remark	Verdict
25.8	As a result of the short circuit test, any of the following results in (a) – (e) below are considered a non-compliant result. See also Table 22.1 and Section 23, Results Criteria. a) E – Explosion; b) F – Fire; c) R – Rupture (enclosure); d) L – Electrolyte Leakage (external to enclosure); and e) S – Electric shock hazard (resistance below isolation resistance limits or dielectric breakdown).		P
26	Overdischarge Test		P
26.1	This test is intended to evaluate a DUT’s ability to withstand an overdischarge under protection circuitry fault condition.		P
26.2	The fully charged sample is to be subjected to a constant discharging current at the maximum discharging current specified by the manufacturer under a single fault condition in the discharging circuit of the DUT that could lead to an overdischarge condition. Protective devices that have been determined reliable may remain in the circuit as noted in 20.5. Temperatures shall be measured on a cell/module for monitoring purposes.		P
26.3	The test is to be continued until the sample is fully discharged to a near zero state or protective devices remaining in the circuit operate, and the monitored temperatures return to ambient or steady state, or explosion and/or fire occurs. If the DUT is operational after the test, it shall be subjected to a minimum of one charge/discharge cycle at the manufacturer’s maximum specified values per Section 22, Post Test Cycle. The test shall be followed by an observation period per 20.7.		P
26.4	At the conclusion of the observation period, the samples with hazardous voltage circuits shall be subjected to an Isolation Resistance Test, Section 30, (without humidity conditioning) or a Dielectric Voltage Withstand Test, Section 29.		P
26.5	As a result of the overdischarge test, any of the following results in (a) – (e) below are considered a non-compliant result. See also Table 22.1 and Section 23, Results Criteria. a) E – Explosion; b) F – Fire; c) R – Rupture (enclosure); d) L – Electrolyte Leakage (external to enclosure); and e) S – Electric shock hazard (resistance below isolation resistance limits or dielectric breakdown). Voltages on the cells are not to exceed the specified end of discharge voltage limits.		P

UL 2272			
Clause	Requirement + Test	Result - Remark	Verdict
27	Temperature Test		P
27.1	This test is conducted to determine whether or not the component cells are being maintained within their specified operating limits during maximum charge and discharge conditions of the personal e-mobility device. During this test, it shall also be determined as to whether or not temperature sensitive safety critical components and temperature sensitive materials in the personal e-mobility device are being maintained within their temperature ratings based upon the maximum operating temperature limits of the personal e-mobility device. Temperatures on accessible surfaces, which may be contacted by the user, are also monitored.		P
27.2	A fully discharged DUT (i.e. discharged to EODV) is to be conditioned within a chamber set to the upper limit charging temperature specifications of the personal e-mobility device manufacturer. After thermal stabilization in the chamber, the DUT is to be connected to a charging circuit input representative of anticipated maximum charging parameters provided by the specified charger. The DUT shall then be subjected to the maximum specified charging rate while monitoring voltages and currents on cells until it reaches the manufacturer’ s specified fully charged condition. Temperatures shall be monitored on temperature sensitive components including cells, motors, etc. and on any user accessible surfaces.		P

UL 2272			
Clause	Requirement + Test	Result - Remark	Verdict
27.3	While still in the conditioning chamber, and after allowing temperatures to stabilize, the fully charged DUT shall then be discharged in accordance with the manufacturer’ s specifications representative of the maximum continuous electrical load representative of the maximum operating load conditions while monitoring voltage and current on cells until the DUT reaches its specified EODV. The method of simulating the maximum continuous electrical load for discharging the batteries may vary according to the personal e-mobility device design and should be a method agreed upon by the manufacturer and organization testing the personal e-mobility device. The methods to simulate this loading can include the use of a dynamometer or other mechanical loading means, or manipulation of the electrical and electronic control circuit(s) to simulate loading on the motor. Factors to be considered when determining the maximum continuous electrical load during discharge include maximum weight of rider, maximum speed of movement, angle of movement and loads from auxiliary devices such as lights, audio, etc. that may be operating when the personal e-mobility device is moving. If there is a need to consider the surface impact to loading, concrete is to be used to represent typical outdoor operating surfaces. Temperatures shall be monitored on temperature sensitive safety critical components including cells, motors, etc. and on any user accessible surfaces.		P
27.4	The manufacturer’ s specified limits (voltage, current and temperatures measured) shall not be exceeded during the charging and discharging cycles. Temperatures measured on components shall not exceed their specifications. See Tables 27.1 and 27.2 for surface and component temperature limits.		P
27.5	At the conclusion of the observation period, the samples with hazardous voltage circuits shall be subjected to an Isolation Resistance Test, Section 30, (without humidity conditioning) or a Dielectric Voltage Withstand Test, Section 29.		P
27.6	As a result of the temperature test, any of the following results in (a) – (e) below are also considered a non-compliant result. See also Table 22.1 and Section 23, Results Criteria. a) E – Explosion; b) F – Fire; c) R – Rupture (enclosure); d) L – Electrolyte Leakage (external to enclosure); and e) S – Electric shock hazard (resistance below isolation resistance limits or dielectric breakdown).		P

UL 2272			
Clause	Requirement + Test	Result - Remark	Verdict
28	Imbalanced Charging Test		P
28.1	This test is to determine whether or not a DUT with series connected cells can maintain the cells within their specified operating parameters if it becomes imbalanced.		P
28.2	A fully charged DUT shall have all of its cells with the exception of one cell/cell block discharged to its specified fully discharged condition. The undischarged cells shall be discharged to approximately 50% of its specified state of charge (SOC) to create an imbalanced condition prior to charging.		P
28.3	The DUT shall then be charged in accordance with the manufacturer’s specifications using the specified charger and under a single fault condition in the charging protection circuitry. Protective devices that have been determined reliable may remain in the circuit as noted in 20.5. The voltage of the partially charged cells shall be monitored during the charging to determine if its voltage limits are exceeded. If the DUT is operational after the test, it shall be subjected to a minimum of one charge/discharge cycle at the manufacturer’s maximum specified values per Section 22, Post Test Cycle.		P
28.4	At the conclusion of the observation period, the samples with hazardous voltage circuits shall be subjected to an Isolation Resistance Test, Section 30, (without humidity conditioning) or a Dielectric Voltage Withstand Test, Section 29.		P
28.5	The maximum voltage limit of the cells shall not exceed the manufacturer’s specifications. In addition, any of the following results in (a) – (e) below are considered a non-compliant result. See also Table 22.1 and Section 23, Results Criteria. a) E – Explosion; b) F – Fire; c) R – Rupture (enclosure); d) L – Electrolyte Leakage (external to enclosure); and e) S – Electric shock hazard (resistance below isolation resistance limits or dielectric breakdown).		P
29	Dielectric Voltage Withstand Test		N/A
29.1	This test is an evaluation of the electrical spacings and insulation at hazardous voltage circuits within the DUT.		N/A
29.2	Circuits at 60 Vdc or 30 Vrms or higher and electrically isolated from ac mains supplied circuits shall be subjected to a dielectric withstand voltage consisting of a dc potential of twice the rated voltage.	29.4Vdc< 60Vdc	N/A

UL 2272			
Clause	Requirement + Test	Result - Remark	Verdict
29.3	For those circuits connected to an ac mains supply or not electrically isolated from ac mains circuits, the test voltage shall be an essentially ac potential of a frequency of 60 Hz at 1,000 V plus twice the rated voltage. If using a dc potential, the test voltage shall be 1.414 times the ac test potential value of 1,000 V plus twice the rated voltage.		N/A
29.4	The test voltage is to be applied between the hazardous voltage circuits of the DUT and non-current carrying conductive parts that may be accessible.		N/A
29.5	The test voltage is also to be applied between the hazardous voltage charging circuit and the enclosure/accessible non-current carrying conductive parts of the DUT.		N/A
29.6	If the accessible parts of the DUT are covered with insulating material that may become live in the event of an insulation fault, then the test voltages are applied between each of the live parts and metal foil in contact with the accessible parts. The metal foil shall be wrapped tightly around and in intimate contact with the accessible part. The foil is to be drawn tightly across any opening in the enclosure or other accessible parts to form a fiat plane across such opening. See Figure 29.1.		N/A
29.7	The test voltages shall be applied for a minimum of 1 minute with the cells/modules disconnected in a manner to prevent charging during application of the voltage.		N/A
29.8	The test equipment shall consist of a 500 VA or larger capacity transformer, the output voltage, which is variable and which is essentially sinusoidal if using an ac test method and dc output if using a dc test method. There is no trip current setting for the test equipment since the test is checking for insulation breakdown, which results in a large increase of current. Setting a trip current may result in a false failure of this test, as it may not be indicative of insulation breakdown.		N/A
29.9	There shall be no evidence of a dielectric breakdown (breakdown of insulation resulting in a short through insulation/arcing over electrical spacings) as evidenced by an appropriate signal from the dielectric withstand test equipment as a result of the applied test voltage. Corona discharge or a single momentary discharge is not regarded as a dielectric breakdown (i.e. insulation breakdown)		N/A
30	Isolation Resistance Test		N/A
30.1	This test is intended to determine that insulation of the DUT provides adequate isolation of hazardous voltage circuits from accessible conductive parts of the DUT and that the insulation is non-hygroscopic.		N/A

UL 2272			
Clause	Requirement + Test	Result - Remark	Verdict
30.2	A DUT with accessible parts shall be subjected to an insulation resistance test between the positive terminal and accessible dead metal parts of a DUT. If the accessible parts of the DUT are covered with insulating material that may become live in the event of an insulation fault, then the test voltages are applied between each of the live parts and metal foil in contact with the accessible parts as shown in 29.6 and Figure 29.1.		N/A
30.3	The insulation resistance shall be measured after a 60-s application with a high resistance voltmeter using a 500 Vdc potential applied for at least 1 min to the locations under test.		N/A
30.4	The test shall be repeated on a sample subjected to humidity conditioning in accordance with the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, UL 60950-1, or the Standard for Information Technology Equipment – Safety – Part 1: General Requirements, CAN/CSA-C22.2 No. 60950-1, Clause 2.9.2. Measurements shall be made with the sample still in the chamber.		N/A
30.5	The measured insulation resistance between the positive terminals and accessible parts of the DUT shall be at least 50,000 Ω .		N/A
31	Leakage Current Test		N/A
31.1	This test is intended to evaluate a personal e-mobility device containing hazardous AC voltage circuits that can connect to mains AC during charging, for hazardous levels of leakage current.		N/A
31.2	The leakage current of a DUT when tested in accordance with 31.3 to 31.5 shall not be more than 0.5 milliampere.		N/A
31.3	All exposed conductive surfaces shall be tested for leakage currents. The leakage currents from these surfaces are to be measured to the grounded supply conductor individually as well as collectively if simultaneously accessible, and from one surface to another if simultaneously accessible. Surfaces are considered to be simultaneously accessible if they can be readily contacted by one or both hands of a person at the same time. If all accessible surfaces are bonded together and connected to the grounding conductor of the power supply cord, the leakage current may be measured between the grounding conductor and the grounded supply conductor.		N/A

UL 2272			
Clause	Requirement + Test	Result - Remark	Verdict
31.4	If a conductive surface other than metal is used for the enclosure or a part of the enclosure, the leakage current is to be measured using a metal foil with an area of 10 by 20 centimeters (3.9 by 7.9 inches) in contact with the surface as shown in Figure 29.1. If the surface is less than 10 by 20 centimeters, the metal foil is to be the same size as the surface.		N/A
31.5	The circuit for the leakage current measurement is to be as illustrated in Figure 31.1. The meter that is actually used for a measurement need only indicate the same numerical value for a particular measurement as would the defined instrument. The meter used need not have all the attributes of the defined instrument. The measurement instrument is to comply with the following: a) The meter is to have an input impedance of 1500 ohms resistive shunted by a capacitance of 0.15 microfarad. b) The meter is to indicate 1.11 times the average of the full-wave rectified composite waveform of voltage across the resistor or current through the resistor. c) Over a frequency range of 0 – 100 kilohertz, the measurement circuit is to have a frequency response – ratio of indicated to actual value of current – that is equal to the ratio of the impedance of a 1500-ohm resistor shunted by a 0.15-microfarad capacitor to 1500 ohms. At an indication of 0.5 or 0.75 milli-ampere, the measurement is not to have an error of more than 5 percent at 60 hertz.		N/A
32	Grounding Continuity Test		N/A
32.1	Personal e-mobility devices with grounding and bonding systems shall be tested to determine that the resistance of that grounding/bonding circuit does not exceed the 0.1 Ohm limit per 15.4.		N/A
32.2	The resistance of the grounding/bonding circuit can be measured between two points on the bonding connections of the grounding circuit using a milli-ohmmeter.		N/A
32.3	The measured resistance between any two bonding connections shall be less than or equal to 0.1 Ohm.		N/A
MECHANICAL TESTS			
33	Vibration Test		P

UL 2272			
Clause	Requirement + Test	Result - Remark	Verdict
33.1	This test evaluates the DUT’s ability to withstand vibration that may occur during its anticipated use. The test shall be performed in accordance with the Standard for Electrically Propelled Road Vehicles – Test Specification for Lithium-Ion Traction Battery Packs and Systems – Part 1: High-Power Applications, ISO 12405-1, without temperature conditioning, (which references the Standard for Environmental Testing – Part 2-64: Tests – Test Fh: Vibration, Broadband Random and Guidance, IEC 60068-2-64) per Table 6 of the Standard for Batteries for Use in Light Electric Vehicle (LEV) Applications, UL 2271, or CAN/ULC-S2271, or to a test profile determined by the customer and verified to the personal e-mobility device application.		P
33.2	The DUT is to be securely mounted to a vibration test platform in a manner similar to how it is oriented during use located within a chamber or test room, where the temperature during testing can be varied. The DUT is to be subjected to a random vibration along three perpendicular axes in space in a sequence starting with the vertical axes (Z) and ending with the longitudinal axis (X).		P
33.3	The DUT shall be subjected to the vibration in each axis for 21 h if testing one sample, 15 h if testing two samples or 12 h if testing 3 samples. For each axis the frequency shall be varied from 5 Hz to 200 Hz with power spectral density (PSD) for the vertical (Z) axis, the longitudinal (X) axis, and the transverse (Y) axis as outlined in the Standard for Electrically Propelled Road Vehicles – Test Specification for Lithium-Ion Traction Battery Packs and Systems – Part 1: High-Power Applications, ISO 12405-1.		P
33.4	If the DUT is operational after the test, it shall be subjected to a minimum of one charge/discharge cycle at the manufacturer’s maximum specified values per Section 22, Post Test Cycle. The test shall be followed by an observation period per 20.7.		P
33.5	At the conclusion of the observation period, the samples with hazardous voltage circuits shall be subjected to a Dielectric Voltage Withstand Test, Section 29, or Isolation Resistance Test, Section 30, (without humidity conditioning). The sample shall be examined with the probe of 9.1.3 to determine if it is possible to access hazardous parts if applicable.		P

UL 2272			
Clause	Requirement + Test	Result - Remark	Verdict
33.6	As a result of the vibration test, any of the following results in (a) – (e) below are considered a non-compliant result. See also Table 22.1 and Section 23, Results Criteria. a) E – Explosion; b) F – Fire; c) R – Rupture (enclosure); d) L – Electrolyte Leakage (external to enclosure); and e) S – Electric shock hazard (resistance below isolation resistance limits or dielectric breakdown).		P
34	Shock Test		P
34.1	This test is intended to determine whether or not the DUT can withstand a mechanical shock that may occur when in use.		P
34.2	The fully charged sample of the personal e-mobility device is to be secured to the testing machine by means of a rigid mount, which supports all mounting surfaces of the sample. Temperatures on the center cell are monitored for information purposes.		P
34.3	The sample is to be subjected to mechanical shock testing with parameters as shown in Table 34.1 or according to a test profile determined by the customer and verified to the personal e-mobility device application. When considering the level of shock, the weight of the DUT and maximum specified weight of the rider need to be considered. The battery can be tested first separately from the personal e-mobility device and the higher shock levels for lighter devices prior to testing the complete assembly. The shocks are to be applied in all 6 spatial directions.		P
34.4	If the DUT is operational after the test, it shall be subjected to a minimum of one charge/discharge cycle at the manufacturer’ s maximum specified values per Section 22, Post Test Cycle. The test shall be followed by an observation period per 20.7.		P
34.5	At the conclusion of the observation period, the samples with hazardous voltage circuits shall be subjected to a Dielectric Voltage Withstand Test, Section 29, or Isolation Resistance Test, Section 30, (without humidity conditioning). The sample shall be examined with the probe of 9.1.3 to determine if it is possible to access hazardous parts if applicable.		P

UL 2272			
Clause	Requirement + Test	Result - Remark	Verdict
34.6	As a result of the shock test, any of the following results in (a) – (e) below are considered a non-compliant result. See also Table 22.1 and Section 23, Results Criteria. a) E – Explosion; b) F – Fire; c) R – Rupture (enclosure); d) L – Electrolyte Leakage (external to enclosure); and e) S – Electric shock hazard (resistance below isolation resistance limits or dielectric breakdown).		P
35	Crush Test		P
35.1	This test is conducted to determine the DUT’s ability to withstand a crush that could occur during use.		P
35.2	This test is conducted on a fully charged DUT.		P
35.3	One sample of the personal e-mobility device is to be supported on a fixed rigid supporting surface, in the position and orientation that is representative of operation of the personal e-mobility device. A crushing force is to be applied to the personal e-mobility device foot support surface by two flat applicator lates each sized 102 by 254 mm (4 by 10 inches). A force of 2 times the maximum specified rider weight is to be evenly distributed between the two applicator plates to the personal e-mobility device foot support surface. The total weight of the force applied to the personal e-mobility device foot support surfaces is to include the weight of the fiat applicators.		P
35.4	The test force is to be held in place for a minimum of one minute. The sample shall be only subjected to one crush. If the DUT is operational after the test, it shall be subjected to a minimum of one charge/discharge cycle at the manufacturer’s maximum specified values per Section 22, Post Test Cycle. The test shall be followed by an observation period per 20.7.		P
35.5	At the conclusion of the observation period, samples with hazardous voltage circuits shall be subjected to a Dielectric Voltage Withstand Test, Section 29, or Isolation Resistance Test, Section 30, (without humidity conditioning). The sample shall be examined with the probe of 9.1.3 to determine if it is possible to access hazardous parts if applicable.		P

UL 2272			
Clause	Requirement + Test	Result - Remark	Verdict
35.6	As a result of the crush test, any of the following results in (a) and (c) below are considered non-compliant results. See also Table 22.1 and Section 23, Results Criteria. a) E – Explosion; b) F – Fire; c) R – Rupture (enclosure); d) L – Electrolyte Leakage (external to enclosure); and e) S – Electric shock hazard (resistance below isolation resistance limits or dielectric breakdown).		P
36	Drop Test		P
36.1	This test is intended to evaluate whether a hazard exists when an DUT is subjected to an inadvertent drop during lifting or handling by the user when charging or replacement, etc.		P
36.2	A fully charged DUT is to be dropped three times from a height of 1.0 ±0.01 m (39.4 ±0.4 in) to strike a concrete surface in a manner most representative of what would occur during lifting or handling of the DUT by the user. The concrete surface shall be at least 76-mm (3-in) thick and shall be large enough in area to cover the DUT. If the DUT is operational after the drop, it is to be subject to a minimum of one normal charge/discharge cycle in accordance with the manufacturer’s specifications.		P
36.3	DUTs shall be conditioned for a minimum of 3 h at 0° C (32° F) (or temperature specified if lower than 0° C (32° F)) prior to conducting the drop test, which shall be conducted immediately after removing the samples from the cold conditioning.		P
36.4	If the DUT is operational after the test, it shall be subjected to a minimum of one charge/discharge cycle at the manufacturer’s maximum specified values. The test shall be followed by an observation period per 20.7 and then examined.		P
36.5	After the examination, the DUTs shall be subjected to a Dielectric Voltage Withstand Test, Section 29, or Isolation Resistance Test, Section 30, (without humidity conditioning) if applicable.		P
36.6	There shall be no damage of the enclosure that would allow hazardous voltage parts to be accessed by use of the test rod 2.5 mm diameter, 100 mm long, shown in Figure 1 of the Standard for Batteries for Use in Light Electric Vehicle (LEV) Applications, UL 2271, or CAN/ULC-S2271, and the probe noted in 9.1.3.		P

UL 2272			
Clause	Requirement + Test	Result - Remark	Verdict
36.7	As a result of the drop test, any of the following results in (a) – (e) below are considered non-compliant. See also Table 22.1 and Section 23, Results Criteria. a) E – Explosion; b) F – Fire; c) R – Rupture (enclosure); d) L – Electrolyte Leakage (external to enclosure); and e) S – Electric shock hazard (resistance below isolation resistance limits or dielectric breakdown).		P
37	Mold Stress Relief Test		N/A
37.1	This test is intended to evaluate whether any shrinkage or distortion exists on a molded or formed thermoplastic enclosure due to release of internal stresses caused by the molding or forming operation and result in the exposure of hazardous parts or reduction of electrical spacings.		N/A
37.2	The sample is to be placed in a full-draft circulating-air oven maintained at a uniform temperature of 70° C (158° F). The samples are to remain in the oven for 7 h.		N/A
37.3	To prevent hazards from overheating energized cells, samples shall be fully discharged prior to conditioning.		N/A
37.4	After careful removal from the oven, the sample shall be allowed to cool to room temperature and then examined. After the examination, the samples shall be subjected to a Dielectric Voltage Withstand Test, Section 29, or Isolation Resistance Test, Section 30, (without humidity conditioning).		N/A
37.5	There shall be no insulation breakdown during the Dielectric Voltage Withstand Test, Section 29, or the isolation resistance shall not be below the levels outlined in the Isolation Resistance Test, Section 30.		N/A
37.6	There shall be no damage of the DUT enclosure that would allow hazardous voltage parts to be accessed by use of the test rod 2.5 mm diameter, 100 mm long, shown in Figure 1 of the Standard for Batteries for Use in Light Electric Vehicle (LEV) Applications, UL 2271, or CAN/ULC-S2271, and the probe in 9.1.3.		N/A
38	Handle Loading Test		N/A
38.1	This test is intended to evaluate the strength of the handle(s) on a personal e-mobility device that may be used to lift the personal e-mobility device.		N/A
38.2	A force is to be applied on the handle in the intended carrying direction uniformly over a 75-mm (2.95-in) length at the center of the handle. The applied force shall be gradually increased from zero to four times the weight of the DUT in 5 – 10 s and then maintained at the level for 1 min.		N/A

UL 2272			
Clause	Requirement + Test	Result - Remark	Verdict
38.5	If more than one handle is provided, the test force shall be determined by the percentage of the DUT weight sustained by each handle with the DUT in the intended carrying position. If a DUT weighing less than 25 kg (55.1 lbs) is provided with more than one handle and can be carried by only one handle, each handle shall be capable of withstanding a force based on the total weight of the DUT.		N/A
38.4	There shall be no breakage of the handle, its securing means, or that part of the DUT to which the handle is attached.		N/A
39	Motor Overload Test		N/A
39.1	This test is intended to evaluate a motor’ s ability to safely withstand an overload condition, which may occur in the end use application. This test is waived if the motor and its overload protection has already been evaluated as part of a motor and motor protector combination evaluation per the Standard for Rotating Electrical Machines – Thermally Protected Motors, UL 1004-3, or the Standard for Rotating Electrical Machines – Electronically Protected Motors, UL 1004-7, as applicable to the method of thermal protection		N/A
39.2	The motor is to be tested while in the personal e-mobility device and temperatures on windings are to be monitored. As an alternative, the motor can be tested outside the personal e-mobility device.		N/A
39.3	The motor is first operated under maximum normal load conditions. The load is then increased so that the current is increased in appropriate gradual steps with the motor supply voltage being maintained at its original value. When steady state temperature conditions are established the load is again increased. The load is thus progressively increased in appropriate steps until either the overload protection device operates or the motor winding becomes an open circuit.		N/A
39.4	The motor winding temperatures are determined during each steady period and the maximum temperature recorded shall not exceed the value in Table 39.1.		N/A
39.5	If the design or size of the motor prevents the measuring of temperature windings, the test may be conducted with the motor removed from the personal e-mobility device and instead of monitoring temperatures, the DUT is to be supported on a surface covered with a single layer of tissue paper with the DUT covered with a single layer of cheesecloth.		N/A
39.6	If the DUT contains a hazardous voltage circuit, the DUT shall be subjected to a Dielectric Voltage Withstand Test, Section 29, or Isolation Resistance Test, Section 30, (without humidity conditioning).		N/A

UL 2272			
Clause	Requirement + Test	Result - Remark	Verdict
39.7	There shall be no insulation breakdown during the Dielectric Voltage Withstand Test, Section 29, or the isolation resistance shall not be below the levels outlined in the Isolation Resistance Test, Section 30.		N/A
39.8	If monitoring temperatures on windings during the overload test, the temperatures on the windings shall not exceed the values noted in Table 39.1. If not monitoring temperatures on windings during the test, there shall be no sign of ignition of the tissue or cheesecloth at the conclusion of the test.		N/A
40	Motor Locked Rotor		P
40.1	This test is intended to evaluate a motor’ s ability to safely withstand a locked rotor condition, which may occur in the end use application. This test is waived if the motor and its locked rotor protection has already been evaluated as part of a motor and motor protector combination evaluation, per the Standard for Rotating Electrical Machines – Thermally Protected Motors, UL 1004-3, or the Standard for Rotating Electrical Machines – Electronically Protected Motors, UL 1004-7, or if relying on impedance protection per the Standard for Rotating Electrical Machines – Impedance Protected Motors, UL 1004-2, as applicable.		P
40.2	The motor is operated at the voltage used in its personal e-mobility device application and with its rotor locked for 7 h or until steady conditions are established. The motor is to be tested while in the personal e-mobility device and temperatures on windings are to be monitored. As an alternative, the motor can be tested outside the personal e-mobility device.		P
40.3	If the design or size of the motor prevents the measuring of temperature windings, the test may be conducted with the motor removed from the personal e-mobility device and instead of monitoring temperatures, the DUT is to be supported on a surface covered with a single layer of tissue paper with the DUT covered with a single layer of cheesecloth.		P
40.4	If the DUT contains a hazardous voltage circuit, the DUT shall be subjected to a Dielectric Voltage Withstand Test, Section 29, or Isolation Resistance Test, Section 30, (without humidity conditioning).		P
40.5	There shall be no insulation breakdown during the Dielectric Voltage Withstand Test, Section 29, or the isolation resistance shall not be below the levels outlined in the Isolation Resistance Test, Section 30.		P

UL 2272			
Clause	Requirement + Test	Result - Remark	Verdict
40.6	If monitoring temperatures on windings during the locked rotor test, the temperatures on the windings shall not exceed the values noted in Table 40.1. If not monitoring temperatures on windings during the test, there shall be no sign of ignition of the tissue or cheesecloth at the conclusion of the test.		P
41	Strain Relief Tests (Cord Anchorages)		N/A
41.1	General		N/A
41.1	The strain relief tests are conducted on those personal e-mobility devices that have exposed non-detachable cords or cables that may be subjected to pull in the end use personal e-mobility device.		N/A
41.2	Strain relief pull test		N/A
41.2.1	The purpose of this test is to determine if the strain relief means for a non-detachable accessible cord prevents damage or displacement upon being pulled.		N/A
41.2.2	One sample of the personal e-mobility device or accessory provided with a strain relief shall withstand without damage to the cord or conductors and without displacement, a direct pull of 2 times the weight of the DUT but no greater than 156 N (35 lbf), applied to the cord for 1 min. Supply connections within the equipment are to be disconnected from terminals or splices during the test when applicable.		N/A
41.2.3	If the cord anchorage is mounted in polymeric enclosure material, the test is to be conducted after the mold stress test and after the sample has cooled to room temperature.		N/A
41.2.4	As a result of the pull force, there was no damage or displacement of internal connectors. Inner conductors may not elongate more than 2 mm (0.08 in) from the pre-test position.		N/A
41.3	Push-back test		N/A
41.3.1	The purpose of this test is to determine if the strain relief of a non-detachable accessible cord provides adequate protection to connections and prevents hazardous displacement of internal wiring and connections as a result of push back.		N/A
41.3.2	The DUT is to be tested in accordance with 41.3.3 and 41.3.4 without occurrence of any of the following conditions: a) Subjecting the supply cord to mechanical damage; b) Exposing the supply cord to a temperature higher than that for which it is rated; c) Reducing spacings (such as to a metal strain-relief clamp) below the minimum required values; or d) Damaging internal connections or components.		N/A

UL 2272			
Clause	Requirement + Test	Result - Remark	Verdict
41.3.3	The non-detachable cord is to be held 25.4 mm (1 in) from the point where it emerges from the DUT and is then to be pushed back into the DUT. When a removable bushing, which extends further than 25.4 mm (1 in) is present it is to be removed prior to the test.		N/A
41.3.4	When the bushing is an integral part of the cord, then the test is to be carried out by holding the bushing. The cord is to be pushed back into the product in 25.4-mm (1-in) increments until the cord buckles or the force to push the cord into the product exceeds 26.7 N (6 lbf).		N/A
ENVIRONMENTAL TESTS			
42	Water Exposure Tests		P
42.1	IPX4 Code rating		P
42.1.1	This test is intended to evaluate the personal e-mobility device’s ability to withstand potential water exposure in its intended use and is conducted in accordance with the test method outlined in 42.1.2.		P
42.1.2	A fully charged DUT shall be subjected to a water exposure test in accordance with the Standard for Degrees of Protection Provided by Enclosures (IP Code), IEC 60529 or CAN/CSA-C22.2 No. 60529, Tests for Protection Against Water Indicated by the Second Characteristic Numeral 4 (IPX4) unless the personal e-mobility device is provided with a higher IP Code rating, in which case the DUT shall be tested in accordance with its rating.		P
42.1.3	If the DUT is operational after the test, it shall be subjected to a minimum of one charge/discharge cycle at the manufacturer’s maximum specified values per Section 22, Post Test Cycle. The test shall be followed by an observation period per 20.7 except that the observation period will be for a minimum of 48 hours.		P
42.1.4	At the conclusion of the observation period, the samples with hazardous voltage circuits shall be subjected to a Dielectric Voltage Withstand Test, Section 29, or Isolation Resistance Test, Section 30, (without humidity conditioning).		P
42.1.5	As a result of the IPX4 Code rating test, any of the following results in (a) – (e) below are considered a non-compliant result. See also Table 22.1 and Results Criteria, Section 23. a) E – Explosion; b) F – Fire; c) R – Rupture (enclosure); d) L – Electrolyte Leakage (external to enclosure); and e) S – Electric shock hazard (resistance below isolation resistance limits or dielectric breakdown).		P

UL 2272			
Clause	Requirement + Test	Result - Remark	Verdict
42.2	Partial immersion		N/A
42.2.1	The DUT is subjected to a partial immersion test representative of a personal e-mobility device exposure to puddles during operation as noted in 42.2.2.		N/A
42.2.2	The DUT is subjected to immersion in salt water (5% by weight NaCl in H 2 O) at a height sufficient to reach the personal e-mobility device foot support surface. The personal e-mobility device is partially immersed for 5 minutes.		N/A
42.2.3	If the DUT is operational after the test, it shall be subjected to a minimum of one charge/discharge cycle at the manufacturer’ s maximum specified values per Section 22, Post Test Cycle. If the DUT is non-operational, it shall be connected to a charger and determined that no hazard exists. The test shall be followed by an observation period per 20.7.		N/A
42.2.4	At the conclusion of the observation period, the samples with hazardous voltage circuits shall be subjected to a Dielectric Voltage Withstand Test, Section 29, or Isolation Resistance Test, Section 30, (without humidity conditioning).		N/A
42.2.5	As a result of the partial immersion test, any of the following results in (a) – (e) below are considered a non-compliant result. See also Table 22.1 and Section 23, Results Criteria. a) E – Explosion; b) F – Fire; c) R – Rupture (enclosure); d) L – Electrolyte Leakage (external to enclosure); and e) S – Electric shock hazard (resistance below isolation resistance limits or dielectric breakdown).		N/A
43	Thermal Cycling Test		P
43.1	This test determines the personal e-mobility device’ s ability to withstand exposure to rapidly changing environments such as when the personal e-mobility device is entering or exiting a heated garage after being in a cold environment, or during transport etc. without evidence of damage that could lead to a hazardous event.		P
43.2	A fully charged DUT shall be subjected to the thermal cycling in accordance with 43.3.		P

UL 2272			
Clause	Requirement + Test	Result - Remark	Verdict
43.3	For the test, the DUT shall be placed in a chamber with ambient air cycling at the temperature extremes of either 60 ±2° C (140 ±3.6° F) or -20 ±2° C (-4 ±3.6° F). The transition period between exposure temperatures is to be 15 min or less. This swing of temperature variations may be performed either through the use of a fast-response chamber, or by moving the DUT between two chambers at the two test temperatures. The DUT shall remain at each temperature extreme for as long as required for the DUT to reach a uniform temperature (±5° C) of the chamber temperature but no less than 6 h. A total of five cycles (at the high and low temperature extremes) are to be performed.		P
43.4	If the DUT is operational after the test, it shall be allowed to return to room ambient and then subjected to a minimum of one charge/discharge cycle at the manufacturer’ s maximum specified values per Section 22, Post Test Cycle. The test shall be followed by an observation period per 20.7.		P
43.5	At the conclusion of the observation period, the samples with hazardous voltage circuits shall be subjected to a Dielectric Voltage Withstand Test, Section 29, or Isolation Resistance Test, Section 30, (without humidity conditioning).		P
43.6	As a result of the thermal cycling test, any of the following results in (a) – (e) below considered a non-compliant result. See also Table 22.1 and Section 23, Results Criteria. a) E – Explosion; b) F – Fire; c) R – Rupture (enclosure); d) L – Electrolyte Leakage (external to enclosure); and e) S – Electric shock hazard (resistance below isolation resistance limits or dielectric breakdown).		P
44	Label Permanence Test		P
44.1	The purpose of this test is to evaluate the permanence of an adhesive label that has not been subjected to a previous evaluation program.		P
44.2	An adhesive label secured to a surface representative of the end use application and is subjected to the following conditioning: a) The label sample is rubbed by hand for 15 s with a piece of cloth soaked with water; and b) The sample is again rubbed for 15 s with a piece of cloth soaked with petroleum spirit.		P

UL 2272			
Clause	Requirement + Test	Result - Remark	Verdict
44.3	The petroleum spirit to be used for the test is an aliphatic solvent hexane having: a) A maximum aromatics content of 0.1% by volume; b) A kauributenol value of 29; c) An initial boiling point of approximately 65° C (149° F); d) A dry point of approximately 69° C (156.2° F); and e) A mass per unit volume of approximately 0.7 kg/l.		P
44.4	After the conditioning outlined in 45.2, the sample is to be examined for signs of damage including curing and to determine if the marking is still legible. The sample is also examined to determine if it can be removed easily by hand from the adhered surface.		P
44.5	As a result of the conditioning, the sample label shall remain legible, show no evidence of damage including curling and shall not be able to be easily removed by hand from the adhered surface.		P
MARKINGS			
45	General		P
45.1	The markings required for compliance shall be legible and permanent such as etched, adhesive labels, etc. An adhesive-backed label shall comply with the requirements in the Standard for Marking and Labeling Systems, UL 969, or the Standard for Adhesive Labels, CSA-C22.2 No. 0.15, for the intended		P
45.2	Personal e-mobility devices are to be marked with the manufacturer’ s name, trade name, trademark or other descriptive marking which may identify the organization responsible for the product, part number or model number, and electrical ratings in volts dc and Ah or Wh. The personal e-mobility device is to also be marked with the maximum weight in lbs or kg and speed in mph or km/h.		P
45.3	Personal e-mobility devices shall also be marked with the date of manufacture, which may be in the form of a code that does not repeat within 10 years.		P
45.4	Personal e-mobility devices shall be marked with charging instructions. An example of such markings would be the following or equivalent ″ Use Only (__) Charger″ .	HLT-118A-4200400U	P
45.5	All external terminals and connections shall be provided with identification and if applicable, polarity markings.		P

UL 2272			
Clause	Requirement + Test	Result - Remark	Verdict
45.6	Personal e-mobility devices with separable battery packs that are intended to be user removable are to include markings indicating the correct battery pack to use with the personal e-mobility device, such as “Use only (__) battery pack with this personal e-mobility device”. The separable battery pack shall be marked “Use only with (__) personal e-mobility device”. The information to be filled in shall minimally be the manufacturer’s name and the model number of the part for correlation.		N/A
45.7	The point of connection to the charger earth grounding system shall be identified by the word ″Ground″ or the letters ″G″ or ″GR″ (except in Canada) or the grounding symbol IEC 60427, No. 5019 (upside down tree within a circle) or otherwise identified by a distinctive green color. Any other grounding terminals shall also be identified in a manner that is distinctive from the main earth ground terminal for the charger system.		N/A
45.8	Personal e-mobility devices that contain hazardous voltage circuits shall be marked ″Warning: Hazardous Voltage Circuits″ or be marked with the electric shock hazard symbol ISO 3864, No. 5036 (lightning bolt within a triangle).		N/A
45.9	Personal e-mobility devices shall be marked as follows: ″WARNING – To reduce the risk of injury, user must read instruction manual″ or shall be marked with the sign M002 of the Standard for Graphical Symbols Safety Colours and Safety Signs, Safety Signs Used in Workplaces and Public Area, ISO 7010, and ISO 7010, No. W001 (i.e. exclamation point in triangle).		P
45.10	A personal e-mobility device may or may not be marked with the minimum required IPX4 rating. Personal e-mobility devices marked with a higher IP rating than the minimally required rating of IPX4, shall comply with the requirements for that higher rating in accordance with 42.1.		P
45.11	Personal e-mobility devices employing plastic enclosure materials not evaluated for exposure to UV rays and rain per 7.5 shall be marked with the following or equivalent: “Store Indoors When Not in Use”. See also 46.4.		P
INSTRUCTIONS			
46	General		P

UL 2272			
Clause	Requirement + Test	Result - Remark	Verdict
46.1	A personal e-mobility device shall be provided with instructions for the proper use including charging and operating, storage and disposal. These instructions shall include temperature limits, appropriate charger and weight limits (maximum and minimum). The personal e-mobility device instructions shall also include the maximum speed obtainable by the personal e-mobility device. The instructions shall also provide information on water and other environmental exposures as well as recommendations on surfaces for travel, use on gradients, etc. as applicable to the personal e-mobility device design. Instructions for replacement of user replaceable fuses and light bulbs shall also be provided.		P
46.2	A user removable battery pack intended for removal and charging outside of the personal e-mobility device shall be provided with instructions for the safe handling including removal and insertion into the personal e-mobility device and during charging and instructions for storage outside of the personal e-mobility device.		P
46.3	The following or equivalent marking shall be provided in the instructions: ″ WARNING – Risk of Fire and Electric Shock – No User Serviceable Parts″ . Contact information for servicing the personal e-mobility device shall be provided.		P
46.4	Personal e-mobility devices not intended for use in high altitude locations, which may require increased electrical spacings in electrical circuits, shall indicate that they are not intended for use at elevations greater than 2000 m above sea level. See 14.2.		P
46.5	Personal e-mobility devices intended to be stored indoors to protect against prolonged exposure to UV rays or the elements that may damage enclosure materials per 7.5, shall have the following or equivalent included in the instruction manual: “Prolonged Exposure to UV Rays, Rain and the Elements May Damage the Enclosure Materials, Store Indoors When Not in Use”.		P

24	Table: Input Test					P
U (V)	**I (A)**	**Irated (A)**	**P (W)**	**Fuse #**	**Ifuse (A)**	**Condition/status**
29.4VDC	0.98	1	28.8	--	--	
Supplementary information:						

27	TABLE: Temperature Test		P
Maximum measured temperature T of part/at::	**Measured temperature rise (K)**		**Limit (K)**
Enclosure of power supply	55.6	--	90
DC connector	34.3	--	Ref.
E-cap	37.8	--	130
PCB near main IC	52.3	--	130
Battery surface	34.6	--	60
Motor wingding	45.8	--	110
Plastic enclosure inside	35.6	--	60
Plastic enclosure outside	31.2	--	Ref.
Ambient	25.0	--	--
supplementary information:			

	TABLE: Dielectric strength Test			
Test voltage applied between:	Test voltage (V)	Breakdown Yes / No	Insulation resistance (Ω)	
Supplementary information:				

	TABLE: Abnormal Operation Test					P
Component No.	Fault	Supply voltage (V)	Test time	Fuse #	Fuse current (A)	Observation
C5	SC	25.2	10	--	--	Normal working
D3	SC	25.2	10	--	--	Unit shut down, no damage, no hazard
U5 pin 2-5	SC	25.2	10	--	--	Unit shut down, no damage, no hazard
Supplementary information:						

Appendix: Photos

Fig.1

Fig.2

Fig.3

Fig.4

Fig.5

Fig.6

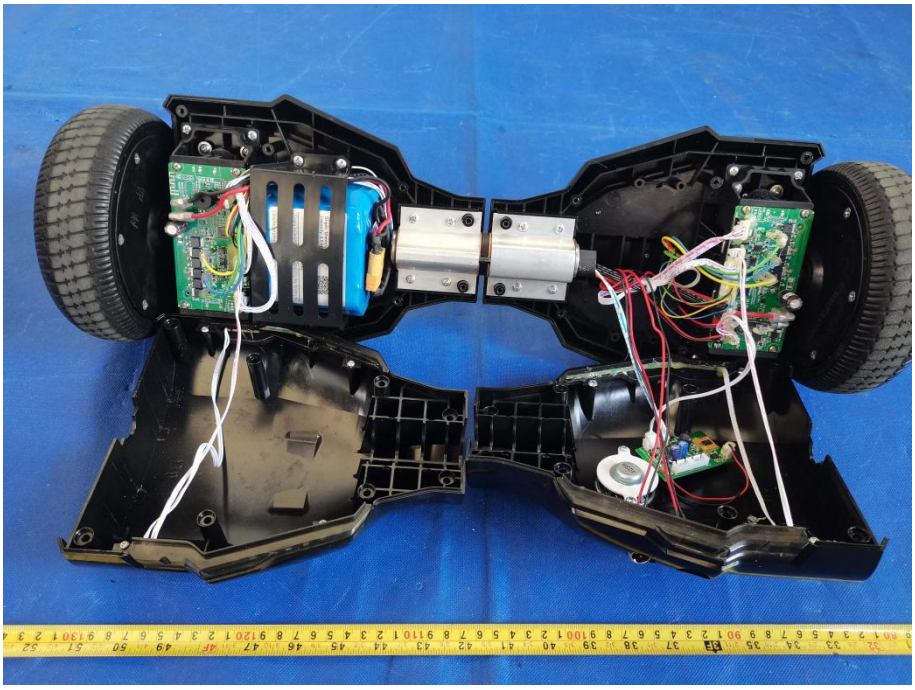

Fig.7


KAI RI-Power
Lithium ion Power Battery
Name: KR20-7S2P
Origin: Shenzhen
Capacity: 4.0AH
Charge limit voltage: 29.4V
Voltage: 25.2V
Power: 100.8Wh
UN38.3
MSDS
WARNING
1.Charging must be done between 0~40 C°conditions to keep the battery dry.
2.Avoid violently impact,crush or dismantle the battery.
3.Only charge using the charger stated in user manual.
4.Do not put the battery into fire or close to the heat source.
5.During transportation and use,prevent short circuit of positive and negative.
6.Unauthorized prohibition of any form of split battery.

Fig.8

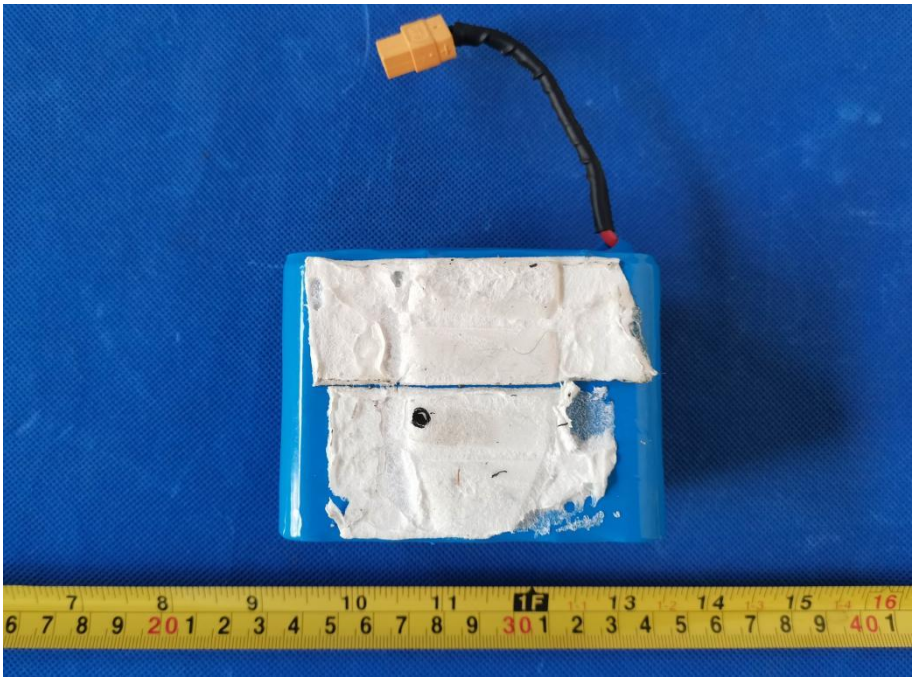

Fig.9

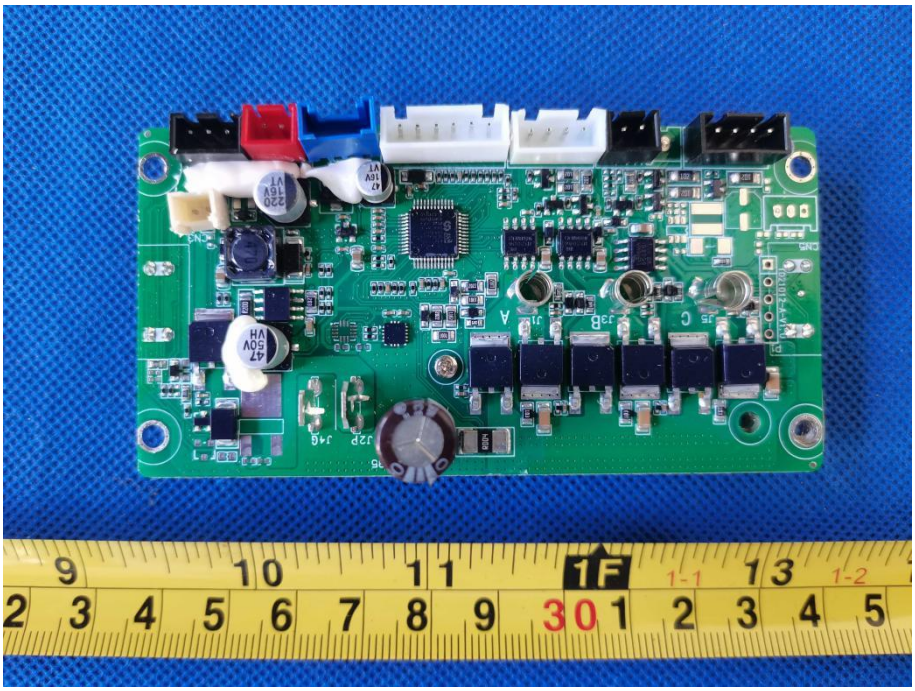

Fig.10

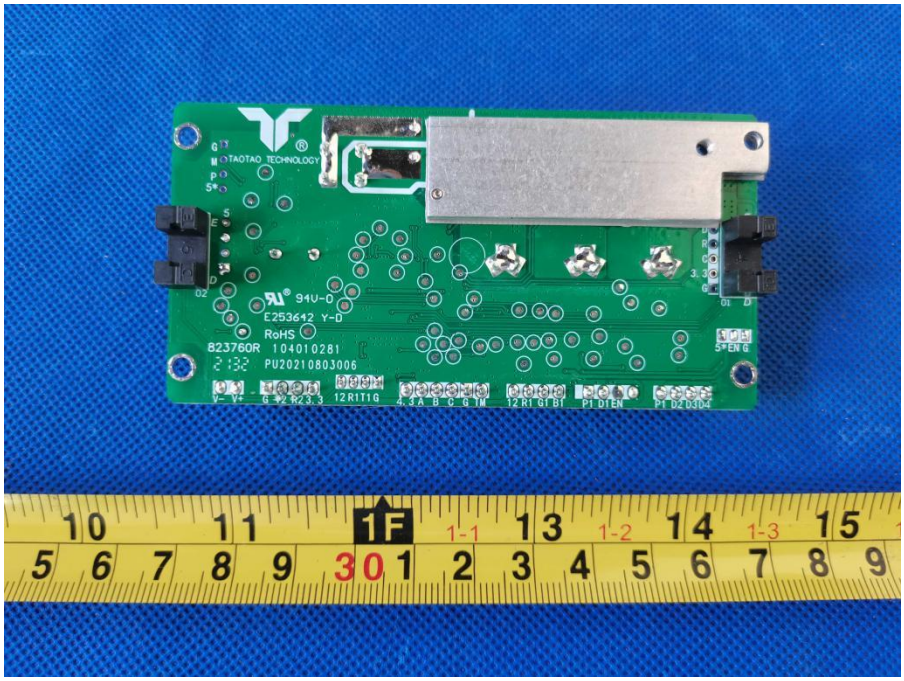
TAOTAO TECHNOLOGY
94V-0
E253642 Y-D
RoHS
823760R 104010281
PU20210803006
1F

Fig.11

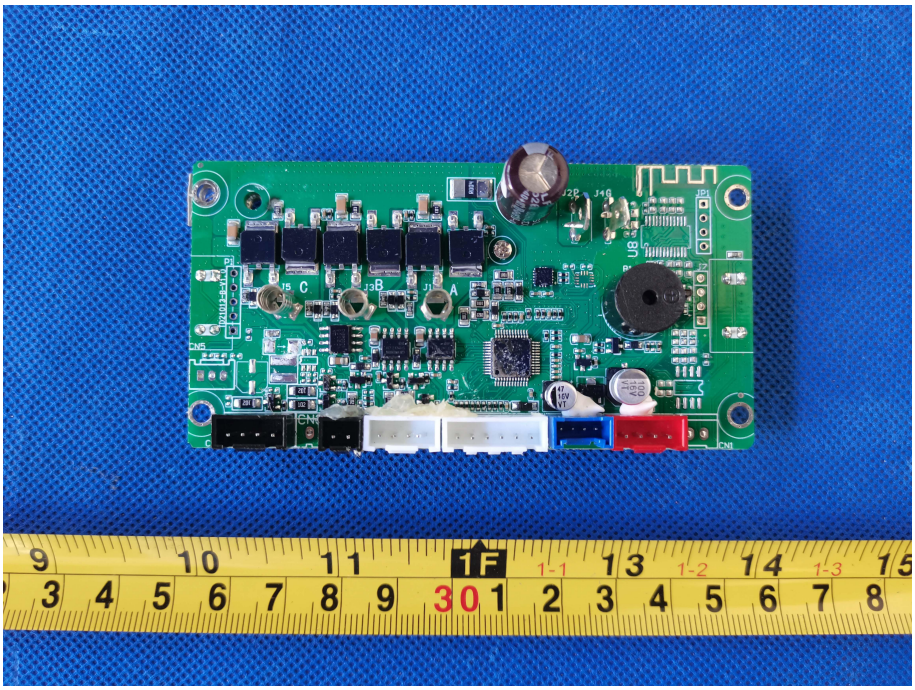
1F

Fig.12

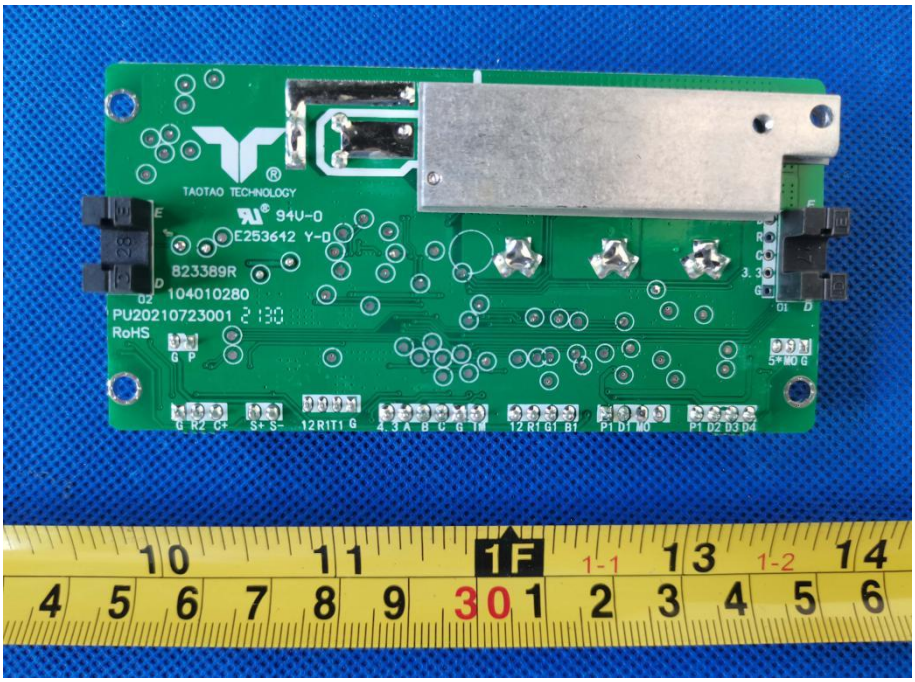
TAOTAO TECHNOLOGY
94V-0
E253642 Y-D
823389R
104010280
PU20210723001
RoHS

Fig.13

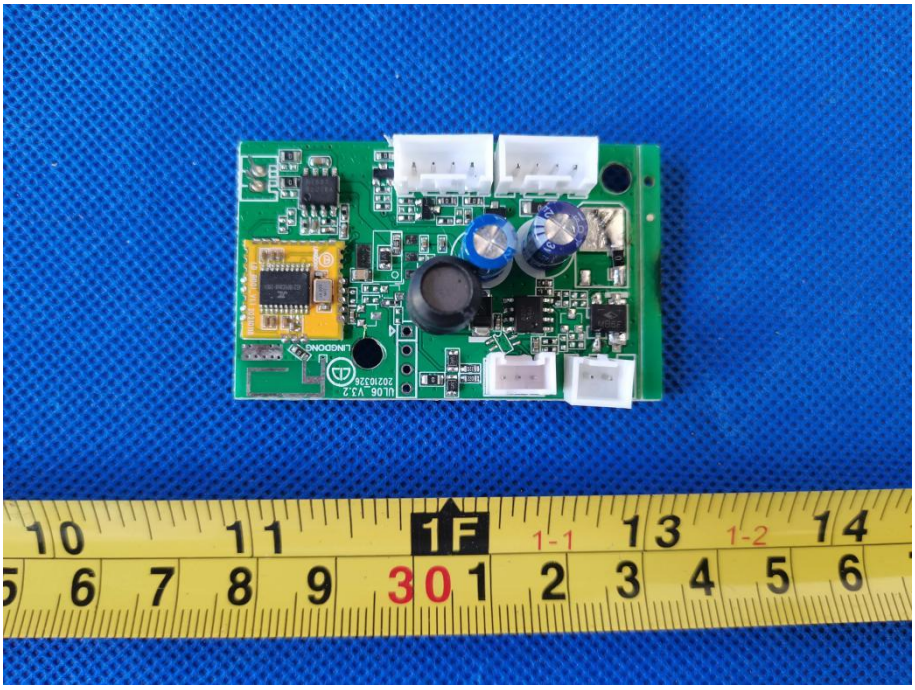

Fig.14

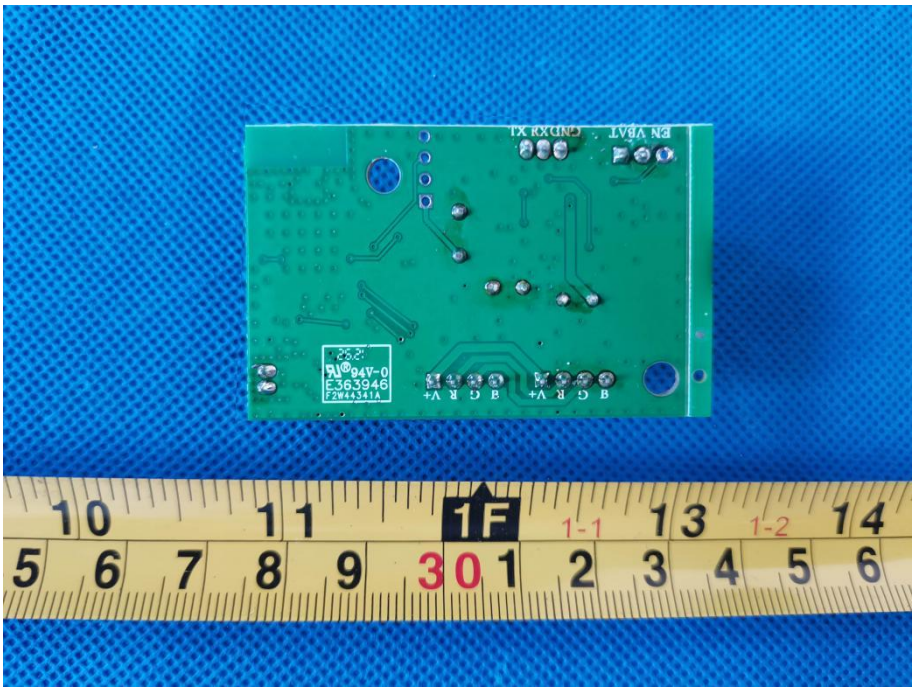

Fig.15

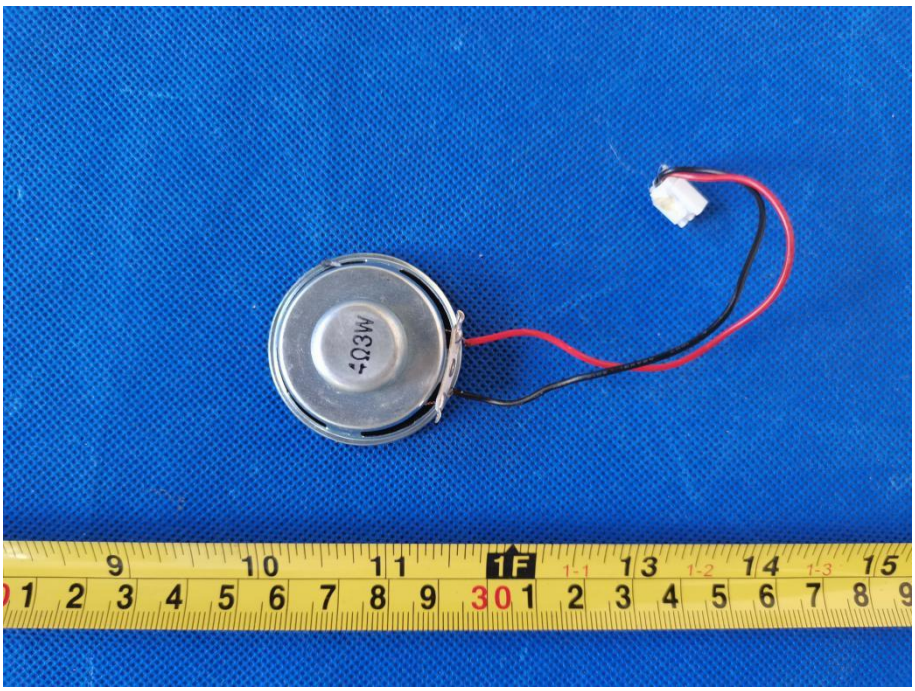

Fig.16

Fig.17

---End of report---