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# Research on Electrostatic Discharge detection method of new energy high-voltage battery system

Shiwei Sha [a], Tiecheng Guo [b], Xiaoyong Yang [c], Boxu Zhang [d]

CATARC Automotive Test Center (Changzhou) Co., Ltd. Changzhou, China

[a]shashiwei@catarc.ac.cn, [b]1120816601@qq.com, cyangxiaoyong233@163.com, [d]zhangboxu@catarc.ac.cn

## Abstract

**This dissertation introduces what is used in the electrostatic discharge test of high-voltage battery system of new energy vehicles, test equipment, methods and problems. With the continuous research and development of new energy vehicles, the importance of automotive electromagnetic safety is increasing with each passing day. These problems are really related to the driving safety and property safety of users, therefore, the reliability of automotive electronic products is much higher than that of ordinary industrial products. As the energy source of new energy vehicles, the electromagnetic safety of the battery system is a top priority. Electrostatic discharge (ESD) test is one of the most important steps in vehicle Electromagnetic compatibility (EMC) test. This research verifies the electrostatic anti-interference ability of new energy battery system products by simulating the electrostatic discharge interference of new energy battery system in the natural environment. This paper analyzes the principle of electrostatic discharge, the composition of electrostatic discharge equipment, electrostatic discharge tests and cases.**

## Keywords

**New Energy; Electromagnetic Compatibility; Electrostatic Discharge; Digital bridge.**

## 1. Principle and Harmfulness of Electrostatic Discharge

The most common reason for electrostatic discharge is the contact and separation of two materials, they have different electrostatic potentials, when they are close to each other or in direct contact with each other, the charges between them will transfer due to the high or low potential, causing discharge. The most common electrostatic electrification phenomenon is the friction electrification between solids. Electrostatic electrification discharge of objects generally has the characteristics of high potential, strong electric field and broadband electromagnetic interference.

With the continuous development of new energy vehicles, there are more and more electronic circuits inside the vehicle body, Transient electromagnetic field and discharge current generated by spark discharge induced by electronic circuits direct or coupled access to internal circuits, all may lead to electrostatic discharge, thus affecting the operation of electronic equipment and causing damage to components. Electrostatic discharge does more harm to electronic equipment than the immediately observed performance degradation or damage, It will also cause hidden damage to the equipment. Although the performance of some equipment has not changed significantly after being impacted by electrostatic discharge for many times, the interior has been damaged. When it works in some boundary conditions or harsh environments, Failure may occur. For automobiles, once the auto spare parts fail, it is easy to cause serious consequences such as safety accidents.

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## 2. Electrostatic Discharge detection method and equipment

### 2.1. Test equipment

The equipment used for electrostatic discharge is generally composed of ESD generator, discharge electrode (discharge gun head) and resistance capacitance discharge network module.

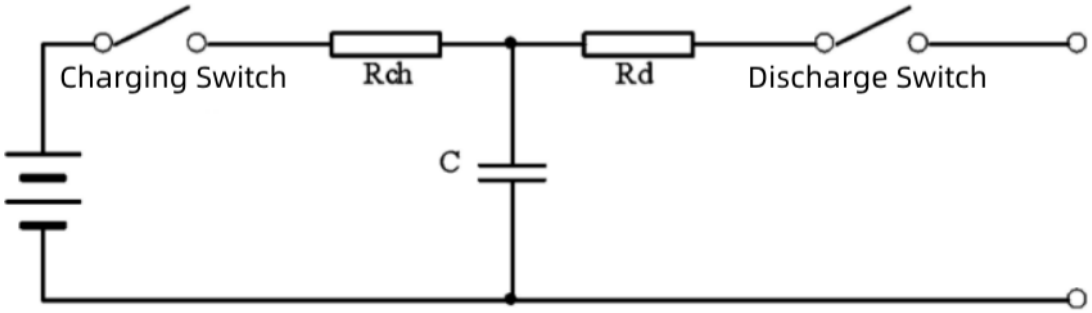


**Fig.1** Equivalent Circuit

Vehicle electrostatic discharge test requires 150pF/330Ω;330pF/330Ω; 150pF/2000Ω;330pF/2000Ω these four kinds of resistance capacitance discharge networks. The cases described in this paper use these two types according to the requirements of the tested piece: 150pF /2000Ω;330p

F/2000Ω.And only 150pF/2000Ω resistance capacitance discharge network is used in the non powered mode. Figure 2 illustrates the current characteristics of these two types of resistance capacitance discharge networks(150pF/2000Ω;330pF/2000Ω)at 5kV.

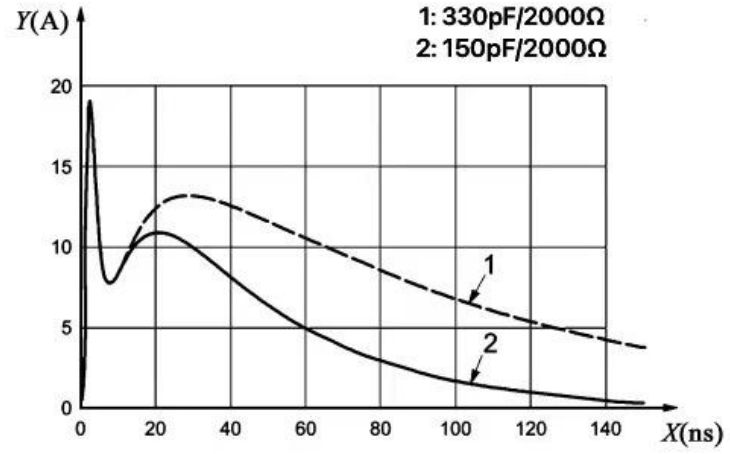


**Fig. 2** Current characteristics of resistance capacitance discharge network

The discharge electrode is generally made of stainless steel, it is divided into contact discharge electrode and air discharge electrode according to the way of use. The discharge terminal of the contact discharge electrode is sharp, and the discharge terminal of the air discharge electrode is arc shaped. See Figure 3 for the specific shapes of both.

### 2.2. Ambient Temperature and Humidity

The influence of environmental humidity on the electrostatic discharge intensity cannot be ignored. It can be clearly seen from Table 1 that the peak value of discharge current decreases significantly with the increase of humidity. If the environmental humidity is left unchecked, It is bound to fail to reach the level of severity it should have, thus affecting the authenticity of the test data. Therefore, the ambient humidity should be controlled between 20% to 60% as required.

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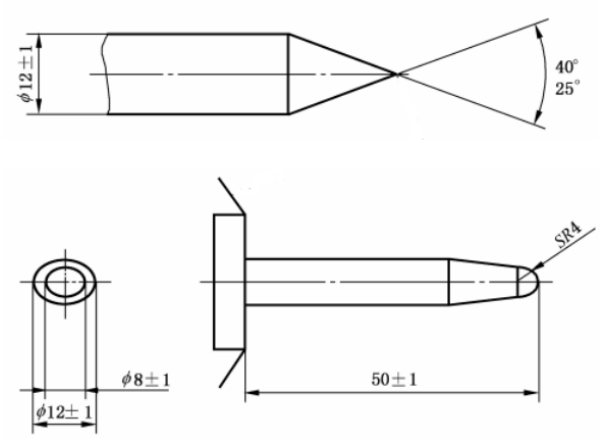
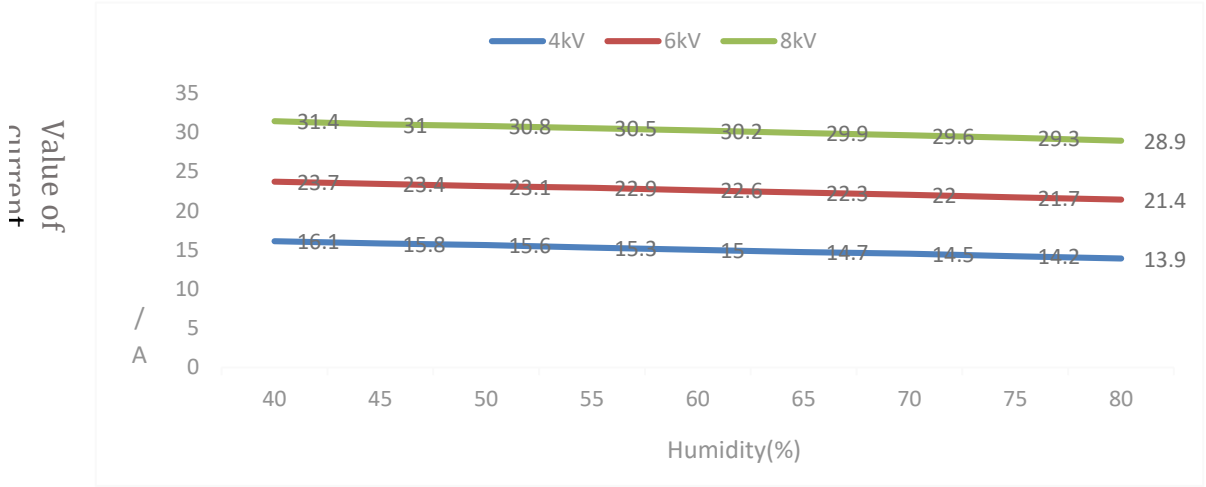



**Fig. 3** Discharge electrode

**Table.1** Change of discharge current (the first peak current) under different humidity




The ambient temperature has no obvious influence on electrostatic discharge. According to GB/T 19951, the test ambient temperature is controlled between 15-35 ℃.

## 2.3. Test layout

Figure 4 shows the site layout of a battery system of a certain brand when conducting electrostatic discharge test in the laboratory. It is necessary to ensure that the reference plane is well grounding. The EUT is placed on the insulating material. During the power on mode test, according to the specific situation of the sample, to use some equivalent loads and auxiliary equipment to simulate the electrical characteristics and data communication on the actual vehicle, These simulators and the tested parts are placed on the test bench together.

**Fig.4** Test layout

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# 3. Problems and solutions

## 3.1. LCR record

LCR record means to use digital bridge instrument to measure the equivalent value of inductance, capacitance and resistance between the test point and the grounding point. For the off power mode test, because of the tested part is in non working state, when conducting the electrostatic discharge test, it is impossible to directly see whether the tested part is affected by static electricity and fails from the working state of the tested part. Therefore, in order to understand the internal electronic circuit of the tested piece in the non working state from the side, Generally, will recording the LCR value of each pin of the tested part before and after the test. If the deviation of LCR value of one of the pins before and after the test exceeds the specified value, it is deemed that the tested part has failed after being subjected to electrostatic discharge.

## 3.2. Problem Cases

As shown in Figure 5, the battery system shall be subject to the electrostatic discharge off power mode test according to the standards and product requirements. As shown in Figure 5, the battery system is subject to the electrostatic discharge off power mode test according to the standards and product requirements. The selection of test discharge points under the silent state of the battery system shall cover the positions of all discharge points that may be touched by the human body during handling, assembly, use and maintenance, the preciseness of the test is ensured by the universality of point selection.

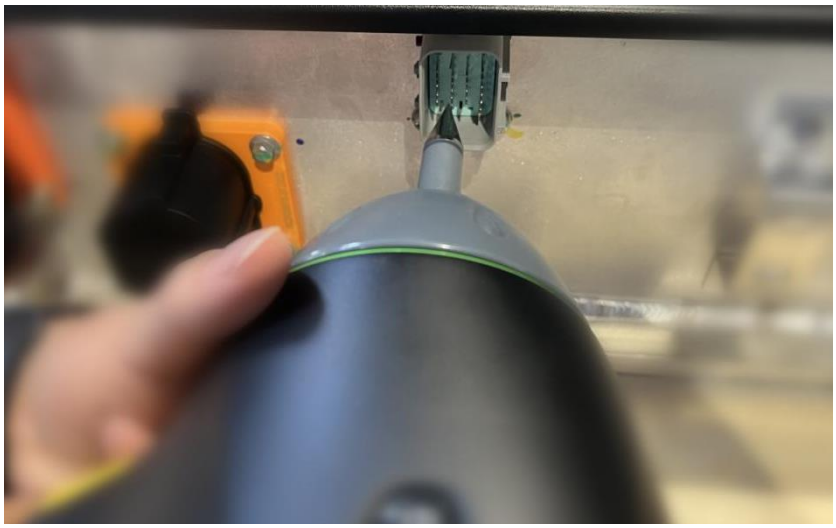

**Fig.5** Electrostatic Discharge Test Operation

In this case, according to the product requirements, the pins in the low-voltage connector port need to be discharged in turn during the power off test. The LCR values of each pin before and after the discharge test are recorded as follows.

**Table.2** Record of LCR Values before and after the Test

| | before discharge | | | after discharge | | |
|---|---|---|---|---|---|---|
| Pin | L(H) | C(F) | R(Ω) | L(H) | C(F) | R(Ω) |
| 1 | -2.381 | 10.637n | 338.69 | -2.361 | 10.73 | 353 |
| 2 | -5.334m | 4.751μ | 1.68k | -5.1m | 4.966μ | 1.759k |
| 3 | -244.69m | 103.67μ | 4.29k | -413m | 61.7μ | 35.2k |
| 4 | -149.31m | 171.31n | 20.115k | -596.2m | 43.05n | 41.35k |
| 5 | 3.7μ | -6.793m | 0.111 | 3.7μ | -6.679m | 0.114 |

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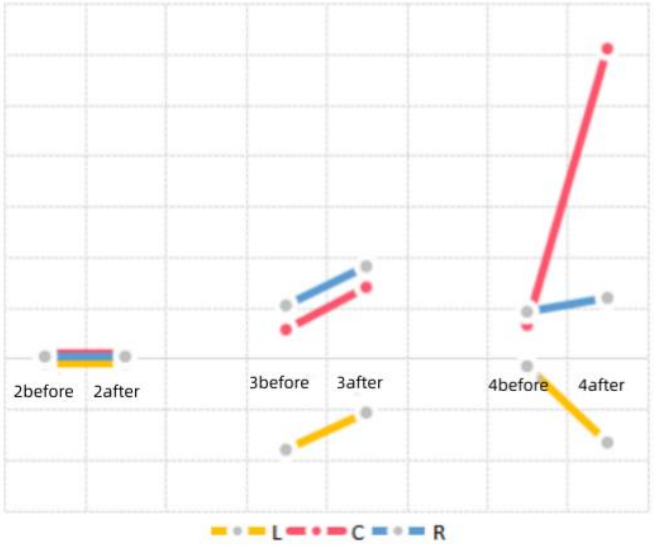
| | | | | | | |
|---|---|---|---|---|---|---|
| 6 | -2.58m | 98.06n | 2.097k | -2.58m | 96.54n | 2.097k |
| 7 | -2.707m | 93.4n | 2.07k | -2.715m | 93.3n | 2.07k |
| 8 | -234.6m | 1.08n | 1.998k | -234.6m | 1.08n | 1.998k |
| 9 | -35.5m | 7.1n | 33k | -35.5m | 7.2n | 33k |
| 10 | -35.5m | 7.12n | 33k | -35.5m | 7.12n | 33k |
| 11 | -37.26m | 6.8n | 33.1k | -39.81m | 6.69n | 33.9k |
| 12 | -37.26m | 6.79n | 33k | -35.57m | 6.74n | 33.2k |

It can be clearly seen from the data recorded in Table 2 above that the LCR value of pins 3 and 4 has obvious deviation, and it is preliminarily determined that there is a problem in the internal logic circuit of pins 3 and 4.To ensure the reliability of the experiment and eliminate data errors caused by random conditions, so test again for pins 3 and 4 and the selected other stable pin. The following table shows the LCR data recorded during the retest.

**Table.3** LCR records before and after retest

| | before discharge | | | after discharge | | |
|---|---|---|---|---|---|---|
| Pin | L(H) | C(F) | R(Ω) | L(H) | C(F) | R(Ω) |
| 2 | -5.028m | 5.039μ | 1.759k | -5.002m | 5.046μ | 1.76k |
| 3 | -901m | 28.2n | 52.08k | -535.26m | 70.12n | 90.62k |
| 4 | -776.1m | 32.54n | 45.84k | -830m | 305.15n | 59.58k |

**Table.4** LCR records before and after retest




It can be seen from the data in the table that the LCR value of pin 2 before and after the test is in a stable and reasonable range, with smooth fluctuations and no obvious deviation. In contrast, the data of pins 3 and 4 fluctuate violently and have serious deviation. It can be concluded that the internal logic circuit of pins 3 and 4 fails due to electrostatic discharge. Then connect 12V voltage to the low-voltage port of the tested part, and connect the upper computer system to monitor the internal parameters of the battery system, through parameter comparison, verify the problem and troubleshoot the cause. Then, as shown in Figure 6, the communication connection of the upper computer system fails.

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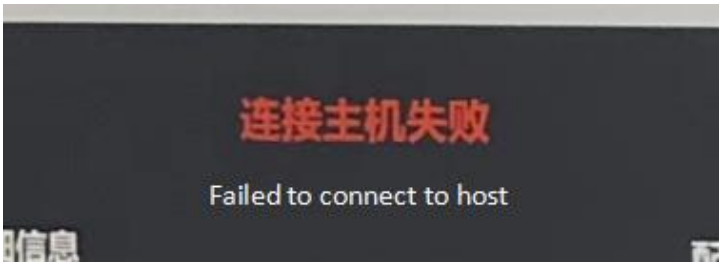


**Fig. 6** Connection failure of upper computer

Since the failure of the communication terminal makes it impossible to verify the cause of the problem from the side, so can only let the manufacturer open the battery system shell and directly check the hardware system of the internal logic circuit module corresponding to pins 3 and 4 to confirm the failure point. In the subsequent analysis and rectification by the manufacturer, it was found that the reason for the problem was that the signal chip was short circuited due to its inability to withstand the electrostatic discharge peak current, resulting in the failure of the entire logic circuit block to operate normally. After replacing the corresponding circuit board assembly, conduct the electrostatic discharge test again, and record the LCR value before and after the test as shown in the table below. It can be seen from the data in the table that the deviation of LCR values of pins 3 and 4 is obviously reduced, and the communication connection of the upper computer is normal within the required range. It can be determined that the problem is solved.

**Table.5** Record of LCR value of retest after rectification

| | before discharge | | | after discharge | | |
|---|---|---|---|---|---|---|
| Pin | L(H) | C(F) | R(Ω) | L(H) | C(F) | R(Ω) |
| 3 | -902.7mH | 280.37pF | 34.77kΩ | -859.1mH | 296.52pF | 42.07kΩ |
| 4 | -910.4mH | 278.8pF | 35.58kΩ | -8532mH | 300.4pF | 42.42kΩ |

### 3.3. Power on mode test

After that, the battery system is tested for electrostatic discharge under power on mode. This link aims to simulate and test the electrostatic discharge resistance of the battery system during daily operation. The host computer communication system monitors the internal parameters of the battery system in real time to determine whether the internal circuit of the battery system is affected by electrostatic discharge. The test results are all normal. The battery system passes the test and the test results are judged as qualified.

## 4. Summary

No matter in which field, electrostatic discharge has attracted much attention. To solve the electrostatic discharge problem of new energy battery system, the following points should be achieved. Fully understand and pay attention to various hazards caused by electrostatic discharge;

Take effective electrostatic protection measures; Verify whether the electrostatic protection effect is effective by testing. This paper analyzes the principle of electrostatic discharge, the composition of electrostatic discharge equipment, electrostatic discharge tests and specific cases, I hope it can provide some reference and help for the product R&D, testing and quality management personnel.

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