Q/SZ

上海思致汽车工程技术有限公司企业标准

Enterprise Standard of Shanghai Cotech Motor Corporation Co.Ltd.

Q/SZ N11-1-2018

代替 substitution Q/SZ N11-1-2015

低压电器部件电磁兼容测试规范

Specification for LV Electromagnetic Compatibility of Electrical Components

2018-06-01 发布 Issue　　2018-06-30 实施 Implementation

上海思致汽车工程技术有限公司　　发　布

Shanghai Cotech Motor Corporation Co. Ltd　　Issue

前　言

本标准按照GB/T 1.1—2009给出的规则起草。

本标准代替Q/SZ N11-1-2015 《电器部件电磁兼容测试规范》，与Q/SZ N11-1-2015相比，主要变化如下：

——增加了电器部件分类，人体防护的要求。

本标准由上海思致汽车工程技术有限公司提出。

本标准由上海思致汽车工程技术有限公司归口。

本标准起草部门：电子电器部

本标准主要起草人：覃宝山

本标准所替代标准的历次版本发布情况为：

——Q/SZ N11-1-2015。

Foreward

This standard is drafted according to the rules given by GB/T 1.1-2009.

This standard takes the place of the Q/SZ N11-1-2015.Compared with Q/SZ N11-1-2015, the main changes are as follows:

— — R Added electrical component classification, high-voltage device test items, human protection requirements.

This standard is put forward by Shanghai Cotech Motor Corporation Co.Ltd.

This standard belongs to Shanghai Cotech Motor Corporation Co.Ltd.

Draft Department: EE Division

Drafter: Baoshan.Qin

This Standard will replace the previous version:

——Q/SZ N11-1-2015.

低压电器部件电磁兼容测试规范

Specification for LV Electromagnetic Compatibility of Electrical Components

1 范围

本标准规定了上海思致汽车工程技术有限公司（简称：思致）关于低压12V系统电器部件电磁兼容的测试方法和限值要求。

本标准适用于上海思致汽车工程技术有限公司所有低压12系统的汽车电子电气部件和子系统的电磁兼容性。

1 Scope

This specification specifies the test methods and limits for LV 12V system electromagnetic compatibility of electrical components in Shanghai Cotech Automobile Engineering Technology Co., Ltd. (Abbreviation: Cotech).

This specification applies to the LV 12V system electromagnetic compatibility of all automotive electronics and electrical components and subsystems of Shanghai Cotech Automobile Engineering Technology Co., Ltd.

2 规范性引用文件

下列文件对于本标准的应用是必不可少的。凡是注日期的引用文件，仅注日期的版本适用于本标准。凡是不注日期的引用文件，其最新版本(包括所有的修改单)适用于本标准。

GB/T 18387 电动车辆的电磁场发射强度的限值和测量方法,宽带,9 kHz～30 MHz

CISPR 25 车辆、船舶和内燃机-无线电干扰特性-船载接收机保护用测量的限值和方法

2 Normative Reference Documents

The terms cited by this standard in the following documents become the terms of this standard. All subsequent revisions (excluding corrections) or revisions shall not apply to this reference document. The latest version of any non-dated reference document is applicable to this standard.

GB/T 18387 Limits and test method of magnetic and electric field strength from electric vehicles, broadband, 9kHz to 30MHz

CISPR 25 Radio disturbance characteristics for the protection of receivers used on-board vehicles, boats and on devices- Limits and methods of measurement

ISO 7637-2 道路车辆—由传导和耦合引起的电骚扰.第 2 部分: 沿电源线的电瞬态传导

ISO 7637-2 Road vehicles, Electrical disturbance by conduction and coupling Part 2-Vehicles with nominal 12V or 24V supply voltage-Electrical transient transmission by capacitive and inductive coupling via supply lines

ISO 11452-2 道路车辆窄带辐射的电磁能量产生的电干扰的部件试验方法.第 2 部分:吸波屏蔽外壳

ISO 11452-2 Road vehicles, Electrical disturbances by narrowband radiated electromagnetic energy- Component test methods Part 2- Absorber-lined shielded enclosure

ISO 11452-4 道路车辆窄带辐射电磁能量产生的电子干扰用部件试验方法.第 4 部分：大电流注入

ISO 11452-4 Road vehicles- Component test methods for electrical disturbances from narrowband radiated electromagnetic energy- Part 4: Bulk current injection

ISO/IEC 17025 检测和校准实验室能力的通用要求

ISO/IEC 17025General requirements for the competence of testing and calibration laboratories

ISO 10605 道路车辆.静电放电引起的电干扰的试验方法

ISO 10605Road vehicles - Test methods for electrical disturbances from ESD

3 术语和定义

3 Terminology

下列术语和定义适用于本文件。

This specification uses the following terms and definitions.

3.1

ALSE

带吸波材料的屏蔽室。

3.1

ALSE

Absorber-lined shielded enclosure

3.2

BB

宽带辐射

3.2

BB

Broad band emissions

3.3

BCI.

大电流注入

3.3

BCI.

Bulk Current Injection

3.4

CE.

传导发射测试

3.4

CE.

Conducted emission

3.5

3.5

CI.
传导抗扰度测试

3.6

DUT.
被测设备，可能是任何的电器部件

3.7

EMI.
电磁干扰

3.8

ESD.
静电放电

3.9

HF.
高频

3.10

I/O.
输入和输出

3.11

NB.
窄带辐射，带宽小于特定测量设备或接收机带宽的发射

3.12

PCB.
印刷电路板

3.13

RE.
辐射发射

3.14

RI.
辐射抗扰度

3.15

短时工作电机
需要人为控制，工作时间短的电机，如车窗电机、后视镜调节电机等。

CI.
Conducted immunity

3.6

DUT.
Devices under test

3.7

EMI.
Electro Magnetic Interference

3.8

ESD.
Electrical static discharge

3.9

HF.
High Frequency

3.10

I/O.
Input and Output

3.11

NB.
Narrow band emissions

3.12

PCB.
Printed Circuit Board

3.13

RE.
Radiated emission

3.14

RI.
Radiated immunity

3.15

Motor - Short-Operating Duration
A motor that operates for short periods of time under operator control.

Examples are power window or mirror motors

3.16

长时工作电机

工作时间长的电机，如雨刮电机、暖通电机。

3.16

Motor - Long-Operating Duration

A motor that is expected to be in operation for extended periods of time. Examples are blower and wiper motors

3.17

电磁环境

存在于给定场所的所有电磁现象的总和。

3.17

Electromagnetic Environment

The sum of all electromagnetic phenomena that is present at a given place.

3.18

断电状态

被测设备未与蓄电池连接，断开所有接头，所有可开启功能未开启。

3.18

Power-Down State

Device under test is not connected to the battery, the connectors are disconnected, and all openable functions are not turned on.

3.19

电控电机

内部包含有源器件的电机。

3.19

Electronically Controlled Motor

A motor that has active electronic devices as part of the motor package

3.20

峰值检波器

输出电压为所施加信号峰值的检波器。

3.20

Peak Detector

A detector that outputs voltage of the peak value of an applied signal

3.21

激励

被测设备电气环境的一种变化。这种变化可能是施加的电压、交流信号或无线电场。

3.21

Stimulus

A change induced in the electrical environment of the DUT. This change may be an applied voltage level, ac signal or RF field.

3.22

绝缘层

相对介电常数＜1.4，厚度为50 mm±5 mm的非传导材料。

3.22

Insulation Spacer

Non-conductive material with relative dielectric constant＜1.4 .

3.23

感性设备

将能量存储在磁场中的机电设备，如线圈、继电器。

3.24

屏蔽室

专门设计用来隔离内外电磁环境的网状或薄板金属壳体。

3.25

人工电源网络

串接在DUT电源线上的网络，它在给定频率范围内提供规定的负载阻抗，并使DUT与电网相互隔离。

3.26

失效

被测设备性能偏离设计要求或偏离测试计划中规定要求的现象。

3.27

代替法

一种确定在实验室内规定参考点产生需要的无线电场强所需要的能量的办法。被测设备放置到实验室后，使用先前确定的能量来产生需要的场强。

3.23

Inductive Device

An electromechanical device that stores energy in a magnetic field, such as a coil or a relay.

3.24

Shielded enclosure

Mesh or sheet metallic housing designed specifically for the purpose of separating the internal and the external electromagnetic environment.

3.25

Artificial Mains Network (LISN)

The network in series connection with DUT power line, provide a specified impedance in certain frequency range and isolate DUT and the electrical network. Also known as a Line Impedance Stabilization Network, LISN].

3.26

Failure

The performance of DUT deviates from the design requirements or its phenomenon deviates from the requirements specified in the test plan.

3.27

Substitution Method

A method for mapping out the power required to produce target RF field intensity in lab at a designated reference position. After placing the DUT into lab, RF field is generated using the power mapped out before the test.

4 测试要求

4 Testing Requirements

4.1 总则

4.1 General Provision

本规范中关于汽车电器部件电磁兼容的测试方法和限值要求以第 2 节中参考的标准为基础，若本规范与参考标准之间发生矛盾，以本规范规定为准。

The test methods and limits for the electromagnetic compatibility of automotive electrical components in this specification are based on the standards referenced in Section 2. If there is a conflict between this specification and the reference standard, this specification shall prevail

思致有权根据公司需求修改本规范，若该规范发生变更，由思致提前三个月通知供应商，三个月后开始执行修改后的规范要求。

Cotech has the right to modify the specification per the needs of the company. If the specification changes, Cotech informs the supplier three months in advance of the change, and the change becomes effective after three months of the revision of the specification.

思致电磁兼容小组负责对电器部件测试规范变更（如 DUT 测试状态的变化）的可行性进行验证，并记录到产品设计说明中。

Cotech EMC team is responsible for verifying the feasibility of changes to the specification of electrical components, such as changes in the DUT test status, and recorded into product design instructions.

供应商根据本规范制订测试计划，并提交给思致电磁兼容小组对测试计划进行审核。供应商需在思致认可的电磁兼容试验室完成测试计划中规定的所有测试内容，且测试结果满足要求。

The supplier shall develop a test plan in accordance with this specification and submit it to the EMC team for review prior to the test. The supplier shall complete all the test contents specified in the test plan at the approved electromagnetic compatibility laboratory and the test results shall meet the requirements.

满足本规范规定的要求后，供应商提供的电器部件在安装到汽车上后必须满足 GB 14023-2011 车辆、船和内燃机,无线电骚扰特性,用于保护车外接收机的限值和测量方法、GB/T 18387-2008 电动车辆的电磁场发射强度的限值和测量方法,宽带,9 kHz～30 MHz 的要求以及思致公司的整车标准测试要求。

After satisfying the requirements of this specification, electrical components provided by the supplier must meet the following specs after the installation to a vehicle: GB 14023-2011: Vehicles, boats and internal combustion engine - Radio disturbance characteristics - Limits and methods of measurement for the protection of off-board receivers, GB/T 18387-2008: Limits and test method of magnetic and electric field strength from electric vehicles, broadband, 9kHz to 30MHz and the vehicle EMC

思致公司保留为进一步确定电磁兼容问题而追加相关测试的权利，有权随时到测试现场对测试过程进行评估。

本规范最终解释权归思致电磁兼容小组。

思致认可的电磁兼容实验室所有测试设备必须根据 ISO/IEC 17025 进行标定。

所有电器部件在进行测试前，必须准备好经过思致电磁兼容小组认可签字的测试计划。

test specification of Cotech

Cotech reserves the right to add additional testing to further determine the issue of electromagnetic compatibility and is entitled to evaluate the testing process of the test site at any time

The final interpretation of this specification is done by Cotech’s EMC team.

Tests shall be conducted by EMC test laboratories approved by Cotech. All test equipment must be calibrated in accordance with ISO 17025.

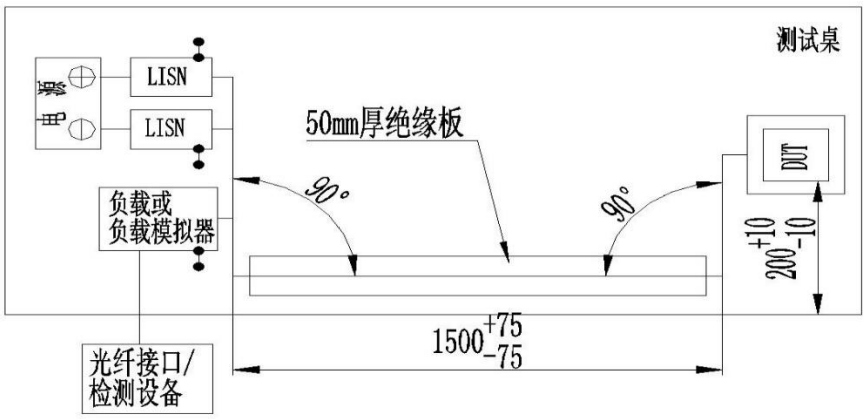
All electrical components must have their test plan approved by Cotech EMC team ready before the test.

4.2 负载模拟器

供应商负责提供模拟 DUT 在实车上工作时负载和环境的模拟器，它能够对 DUT 的功能进行检测。在对 DUT 进行测试时，负载或者负载模拟器不能造成负面影响。负载或者负载模拟器与 DUT 等之间的一般连接关系如图 1 所示。如有需要，负载或者负载模拟器可以放置在屏蔽盒内。

4.2 Load Simulator

The supplier is responsible for providing a simulator for simulating the load and environment of the DUT on actual vehicle, which can monitor the function of the DUT. The load simulator cannot be adversely affected when testing the DUT. The general connection between the load simulator and the DUT is shown in Figure 1. If necessarily, The load simulator should be placed in the shield room.



注 1：图中尺寸单位为 mm / The dimensions in figure is mm

注 2 ●—● 接地 / Grounding

图 1 负载模拟器与 DUT 的连接关系

Figure 1 Connection Relationship of Load Simulator with DUT

如果可以的话,建议使用汽车上的实际部件来模拟负载,尤其对于感性和脉宽调制电路。在实际负载难以实现的情况下,才选择负载模拟器。供应商提供的模拟器必须能够正确模拟 DUT 的负载特性,如等效的电阻、电容和电感。简单的电阻不能作为负载模拟器,除非能够说明实车条件下 DUT 的负载与之一致。

If possible, it is recommended to use the actual parts on the vehicle to simulate the load, especially for the inductive and pulse width modulation circuit. In the case that actual load is difficult to achieve, select to use the load simulator. The simulator provided by the supplier must be able to correctly simulate the load characteristics of the DUT, such as equivalent resistance, capacitance and inductance. A simple resistor cannot be used as a load simulator unless it can be described as equivalent to the load of DUT under an actual vehicle

如果 DUT(如传感器)由其它电器部件供电,那么负载模拟器可包含有源设备以给 DUT 供电,但要求能够正确模拟给该 DUT 供电的电器部件的电源特性。同时,要注意避免负载模拟器中的有源器件对辐射发射测试结果和测试设备造成影响。采用光纤通信时,必须保证光纤通信产生辐射骚扰要低于限值 6 dB。

If the DUT, such as sensor, is powered from other electrical components, the load simulator may contain an active device to supply the power to the DUT, but it is required to be able to correctly simulate the power characteristics of the electrical components connected to the DUT. At the same time, care should be taken to avoid the effects of active devices on the radiation emission test results and test equipment in the load simulator. When using optical fiber communication, it is necessary to ensure that the radiation interference of the optical fiber communication is lower than the limit value 6 dB.

4.3 功能划分和性能等级要求

4.3 Functional Class and Performance Level Requirements

4.3.1 功能划分

4.3.1 Functional Class

根据电器部件在汽车行驶过程中的重要性,本规范将电器部件的功能划分为以下 4 类:

In accordance with the importance of electrical components in the process of car driving, this specification divides the electrical components into the following four classes based on their functions:

A 类 ：提供操作方便性的功能

A-Class: The function of providing operational convenience

B 类 ：能够增强或帮助驾驶员驾驶或控制

B-Class:The function to enhance or assist

车辆,但并非驾驶员驾驶或控制车辆所必须的功能

the driver in driving or controlling the vehicle, but the function is not necessary for driver's driving or controlling of the vehicle

C 类：会影响驾驶员驾驶或控制车辆、影响驾驶员主观感受或者会影响道路其它使用者的功能以及驾驶员和乘客能主观感受的功能。

C-Class :The function will affect the driver driving or controlling the vehicle, affecting the subjective feeling of the driver or affecting other users on the road as well as the subjective feeling of the driver and passengers

D 类：电动助力转向系统、发动机转速稳定性、主动安全系统、被动安全系统、底盘稳定系统、刹车系统及其相关的功能。例如：安全气囊系统、自适应巡航控制(ACC)、车道保持辅助(LKA)、大灯随动转向控制(APS)、大灯自动高度调节(ALS)等;能够避免与缓解碰撞的低速/高速自动紧急刹车与行人保护(AEB)、主动安全带(ASB)、高速公路车队跟随系统等。

D-Class :This function can bring about an impediment or sever trouble to vehicle control, and or affect safety of passengers and/or of other road users. Electric power steering system, engine speed stability, active safety system, passive safety system, chassis stability system, brake system and related functions. Such as: airbag system, adaptive cruise control (ACC), lane keeping assist (LKA), headlight follow-up steering control (APS), headlamp automatic height adjustment (ALS), etc .; to avoid collisions with low speed / high speed Automatic emergency braking and pedestrian protection (AEB), active seat belt (ASB), freeway fleet follow-up system and more.

4.3.2 性能等级要求

4.3.2 Performance Level Requirement

将 DUT 置于一定外部干扰下，本规范将 DUT 功能的性能要求划分为 5 级：

Based on requirements for DUT to operate under certain stresses from external disturbance, this specification categorizes the electrical components into five levels of DUT functional performance requirements:

Ⅰ级：装置或系统在施加骚扰期间和之后，能执行其预先设计的所有功能。

Level I： The device or system can perform all of its designed functions during and after the application of disturbance.

Ⅱ级：装置或系统在施加骚扰期间，能执行其预先设计的所有功能；然而，可以有一项或多项指标超出规定的偏差。所有功能在停止施加骚扰之后，自动恢复到正常工作范围内。存储功能应维持Ⅰ级水平。

Level II :The device or system can perform all of its designed functions under the application of disturbance. However, there may be one or multiple parameters that may deviate from the specified range. All

functions are automatically restored to normal operating range after stopping the application of disturbance. The storage function should be maintained at Status I.

Level III : The device or system does not perform one or more of its designed functions during the application of disturbance, but automatically resume normal operation after removed disturbance.

Level IV : The device or system does not perform one or more of its designed functions during the application of disturbance and does not restore to normal operation until a simple "operation or use" reset action is performed.

Level V : The device or system does not perform one or more of its designed functions during and after the application of disturbance, and does not resume its normal operation unless the device or system is repaired or replaced.

Ⅲ级：装置或系统在施加骚扰期间，不执行其预先设计的一项或多项功能，但在停止施加骚扰之后能自动恢复到正常操作状态。

Ⅳ级：装置或系统在施加骚扰期间，不执行其预先设计的一项或多项功能，直到停止施加骚扰之后，并通过简单的“操作或使用”复位动作，才能自动恢复到正常操作状态。

Ⅴ级：装置或系统在施加骚扰期间和之后，不执行其预先设计的一项或多项功能，且如果不修理或不替换装置或系统，则不能恢复其正常操作。

4.3.3 DUT 布置

DUT 应放置在无导电性，低相对介电常数材料（介电常数＜1.4）上，距接地平面上方 50 mm ±5 mm 的位置。

DUT 的外壳不接地，除非用于模拟实际车辆结构。

进行辐射发射测试时，若已知 DUT 辐射最大的面，那么应该让该面朝向天线，若不能确定最大辐射面，按思致公司认可的测试计划进行测试，且要在测试报告中进行说明。

当电流回线超过 200 mm 时，采用远端接地方式；当电流回线小于 200 mm 时，采用近端接地方式。

4.3.3 DUT Layout

The DUT shall be placed on a non-conductive, low relative permittivity material(＜ 1.4), at(50 ± 5)mm above the reference ground plane.

The case of the DUT shall not be grounded to the reference ground plane unless it is intended to simulate the actual vehicle configuration.

In radiated emission test, if the surface of maximum radiation from DUT is known, it should be tested with that surface directed to the antenna. If the maximum radiating surface is not known, it shall be tested according to the test plan approved by Cotech and the test report shall include the description of the DUT orientations.

If the current return line exceeds 200 mm, use remote grounding. If the current return line is less than 200mm, use local

grounding, and the LISN for negative [power return] line should not be used.

4 4 测试过程

测试前应使用符合本规范 3.3 节中要求的负载模拟器来检查 DUT 的所有功能，只有所有功能满足技术开发要求的电器部件才允许继续测试。

测试过程中,需要确保 DUT 发射出正常工况下可能产生的最大的骚扰能量,根据 DUT 在汽车上的实际工作条件设置不小于额定负荷 80%的机械负载。为保证 DUT 在测试过程中正常工作，测试过程中 DUT 所有连接传感器、执行器等负载的接口需连接能够模拟整车负载条件的负载模拟器。

温湿度：室温(23±5)℃，相对湿度 20%～60%。

实验室背景噪声：测试之前，应检查背景噪声(即打开除 DUT 之外的所有设备，包括输入信号)至少应低于测试项目相应限值线 6dB，如果背景噪声不能满足上述要求,则在排除测试布置的问题之前不得进行测试。在某些输入脉冲或转速信号的测试中,可能需要在信号发生器输出端串联带通滤波器或衰减器以满足底噪要求。测试布置底噪的图表应包含在测试报告中。

4.5 测试计划和测试报告

4.4 Test Procedure

The load simulator that meets the requirements of Section 3.3 of this code should be used to check all functions of the DUT prior to testing. Only the electrical components that meet the technical development requirements should be allowed to continue the test.

During the test, it is necessary to ensure that the DUT emits the maximum level disturbance under normal operating conditions. According to the DUT's actual operating conditions on the vehicle, a mechanical load should not be less than 80% of the rated load. To ensure that the DUT is operating properly during the test, the DUT is connected to a load simulator capable of simulating vehicle load conditions and of monitoring the DUT status.

Temperature and Humidity: Room temperature (23 ± 5) ℃, Relative Humidity 20% to 60%.

Laboratory background noise: Prior to testing, background noise should be checked (ie, all devices except DUT, including the input signal) should be at least 6dB below the corresponding limit line of the test item. If the background noise does not meet the above requirements, Test Layouts should not be tested before. In some tests of input pulse or speed signals, it may be necessary to have a bandpass filter or attenuator in series at the signal generator output to meet noise floor requirements. Charts of test layout noise floor should be included in the test report.

4.5 Test Plan and Test Report

测试计划中的任何与本规范不一致的改动均要在测试前征得思致公司电磁兼容小组同意。测试计划至少需要包含以下信息：

a) 零部件信息，如制造商、样式、序列号、软硬件版本等；

b) 每个管脚的电压、电流和阻抗信息；

c) 测试样本数量；每个测试项目的测试样件最少不得低于 2 个，且每个产品都需要通过测试计划中要求的所有项目的测试并符合要求；

d) 需要进行的测试内容、功能等级和限值要求、工作状态；

e) 定义功能等级和失效的准则；

f) 重要的负载要求，如 CAN、LIN 总线，电机等；

g) 重要的可能会影响 DUT 测试的工作参数；

h) 负载模拟器信息；

i) 针对电磁兼容问题所采取措施的说明；

j) 其它对部件进行合理测试需要的信息。

在测试完成后 5 日内，供应商必须将测试结果提交给思致公司电磁兼容小组。在测试完成 30 日内，供应商必须将完整的测试报告提交给思致电磁兼容小组。

测试报告应包含以下内容：

a) 产品基本信息；

b) 保证整个试验过程均符合本规范的声

Any changes in the test plan that are inconsistent with this specification are subject to the consent of the EMC team prior to testing. The test plan must contain at least the following information:

a) Parts information, such as manufacturer, style, serial number, hardware and software version

b) The voltage, current and impedance information of each pin

c) The number of test samples. Each test item must have a minimum of 2 test samples and each product needs to pass the test of all the items required in the test plan and meet the requirements.

d) The required test content, performance level and limit requirements, operating status

e) Definition of the performance level and failure criteria

f) Important load requirements, such as CAN, LIN bus, a motor or the like

g) Important operating parameters that may affect the DUT

h) Load simulator information

i) Description of the measures taken for electromagnetic compatibility problems;

j) Other information that is reasonably required for component test

Within 5 days from the test completion, the supplier must submit the test results to the EMC team of Cortech. Within 30 days from the test completion, the supplier must submit a complete test report to the EMC team of Cortech.

The test report should contain the following:

a) Product basic informaton;

b) Statement that the entire test is

明；

c) 测试系统和测试过程中使用的所有负载详细文档信息和照片；

d) 测试过程中 DUT 工作状态的信息；

e) 设备型号列表；

f) 抗扰度测试时，产生异常动作的频带和异常动作的详细描述；

g) 所有测试数据、曲线和实验室背景噪声曲线。

performed in accordance with this specification;

c) Detailed description of the test system and load, with the photos of the test setup;

d) DUT’s operating state during the test

e) Test equipment model list;

f) For immunity tests, detailed description of the observed abnormal operation and frequency at which abnormal operation occurred;

g) All test data, test measurement plot. background noise measurement plot.

4.6 测试内容

并非所有电器部件要进行本规范中规定的所有测试。对于不同类型的电器部件需要进行的测试内容见表 1（打“√”表示需要进行该项测试）。

4.6 Test Content

Not all electrical parts are subject to all tests specified in this specification. Test content for different types of electrical components required in Table 1 (″√″mark indicates the need for this test)

表 1 电器部件 EMC 测试项选择表

Table 1 Electrical Component EMC Measurement Target Selection Table

测试内容 Test Item	ID	电器部件类型 Types of electrical devices								
		无源模块 Passive Module	感性设备 Sensor	电机 Motor		有源模块 Active Module				
		P	R	BM	EM	A	AS	AM	AX	AW
辐射发射 Radiated Emission	RE01	NA	NA	√	√	√	√	√	√	√
电源线传导发射 Power line conduction emission	CE01	NA	NA	√	√	√	√	√	√	NA
控制与信号线传导发射 Control and signal line conduction emission	CE02	NA	NA		√	√	√	√	√	NA

表 1（续）Table 1（continue）

测试内容 Test Item	ID	电器部件类型 Types of electrical devices								
		无源模块 Passive Module	感性设备 Sensor	电机 Motor		有源模块 Active Module				
		P	R	BM	EM	A	AS	AM	AX	AW
低频辐射发射 Low-Frequency radiated Emission[2]	RE02	NA	NA	√	√	√	√	√	√	√
磁场近场测试 magnetic near field test	MFI	NA	NA	√	√	√	√	√	√	√
瞬态传导发射 Transient Emission	CE10	NA	√	√	√	NA	NA	NA	√	NA
辐射抗扰度 Radiated Immunity	RI01	NA	NA	NA	√	√	√	√	√	√
大电流注入 Bulk Current Injection	RI02	NA	NA	NA	√	√	√	√	√	NA
发射器射频抗扰 Transmiter RF Immunity	RI03	NA	NA	NA	√	√	√	√	√	√
低频磁场抗扰度 Lowe Frequency Magnetic Field Immunity	RI04	NA	NA	NA	NA	AN	NA	√	NA	NA
电源线瞬态传导抗扰度 Power Line Transient Immunity	CI01	√	NA	NA	√	√	NA	√	√	NA
信号线瞬态传导抗扰度 Signal Line Transient Immunity	CI02	NA	NA	NA	√	√	√	√	√	NA
静电放电 Electrostatic Discharge	ESD	√	NA	NA	√	√	√	√	√	√

注 1 / Note 1： 无源模块 P 的瞬态传导抗扰度测试仅针对由蓄电池直接供电的设备 / The transient conduction immunity test of the passive module P is only for devices powered directly by the battery.

注 2/：Note 2： 可选择项目/this test is optional test.

电器部件分类如表 2 所示,该分类必须在测试计划中注明并由博郡确认

Functional classification of electrical components is shown in Table 2. The classification must be stated in the test plan

and confirmed by Bordrin.

表 2 电器部件分类表

Table 2 Functional Classification of Electrical Components

标识 mark	含义 mean
P	仅包含无源器件的电器部件或模块。Contains only electrical parts or modules of passive devices. 例如：电阻、电容、发光二极管、电感、防反/钳位二极管、发光二极管、热敏电阻。For Example: Resistors, capacitors, light-emitting diodes, inductors, anti-anti / anti-clamp diodes, light-emitting diodes, thermistors.
R	继电器与电磁阀和喇叭（内部含有有源器件的电喇叭属于 AX 类器件，机械喇叭归属于 R 类，但是该零部件需测试 RE01，CE01）。Relays with solenoid valves and speakers (The electric horn that contains the active device inside is AX type device, the Mechanical horn is R type device , but the RE01 test and CE01 test shall be required .)
BM	电刷整流电动机。Brush rectifier motor
EM	内部带有控制电路的电机。A motor with a control circuit inside
A	含有有源器件的电器模块。Electrical modules with active devices 例如：开关电源、微处理器控制器、模拟放大器和显示器。Example: Switching power supply, microprocessor controller, analog amplifier, and displays
AS	由其它模块中的调节电源供电的电器部件或模块。Electrical components or modules that is powered by a regulated power supply from other modules. 这类器件通常是向控制器提供信号输入的传感器。This type of device is usually a sensor that provides signal input to the controller.
AM	包含磁敏感元件的模块或者是外部连接有磁敏感元件的模块。A module containing a magnetosensitive element or a module externally connected with a magnetosensitive element.
AX	内部带有电机、继电器等感性设备的电器部件以及控制外部感性设备的电器部件。Internal electrical parts with electrical devices such as motors, relays, and electrical components that control external sensory devices.
AW	无外部线束的模块，例如遥控钥匙、TPMS 发射器。Modules without external wiring harness, such as remote control key, TPMS transmitter.

4.7 测试仪器

测量设备应符合 CISPR16-1-1，手动和自动频率扫描方式均可。扫描接收机驻留时间应设定用于 CISPR 频段和检波模式，测量仪器的本底噪声值至少比所选限值低 6 dB。要求的驻留时间、最大步长和带宽如表 3 所示。

4.7 Test Instruments

The measuring equipment shall comply with CISPR16-1-1, and manual and automatic frequency scanning methods can be used. The dwell time of the scanning receiver shall be adjusted for the CISPR frequency band and detection mode used. Minimum measurement time should meet the requirements of CISPR16-2-3. The noise floor of measuring instruments

should be lower than the applicable limit by at least 6dB. Required measurement time, maximum step size and bandwidth are shown in Table 3.

表 3 扫描接收机的参数设置

Table 3 Scan Receiver's Parameter Settings

频带（MHz）	峰值检波 / Peak Detection			准峰值检波 /Quasi-Peak Detection			均值检波 / Average Detection		
	BW	步长 / Step Size	驻留时间 / Measurement Time	BW	步长 / Step Size	驻留时间 / Measurement Time	BW	步长 / Step Size	驻留时间 / Measurement Time
0.15～30	9 KHz	5 KHz	50 ms	9 KHz	50 KHz	1000 ms	9 KHz	5 KHz	50 ms
＞30	120 KHz	50 KHz	5 ms	120 KHz	1 MHz	1000 ms	120 KHz	50 KHz	5 ms

5 辐射发射测试 RE01

5.1 辐射发射测试布置

电器部件辐射发射测试可参照 CISPR 25 标准中的 ALSE 方法进行。其一般布置如图 2 所示。

5 Radiated Emission Test RE01

5.1 Layout for Radiated Emission Test

Radiated emission test of electrical components can be carried out in accordance with CISPR 25 standard's "Radiated emissions from components/modules - ALSE method". General Layout is shown in Figure 2.

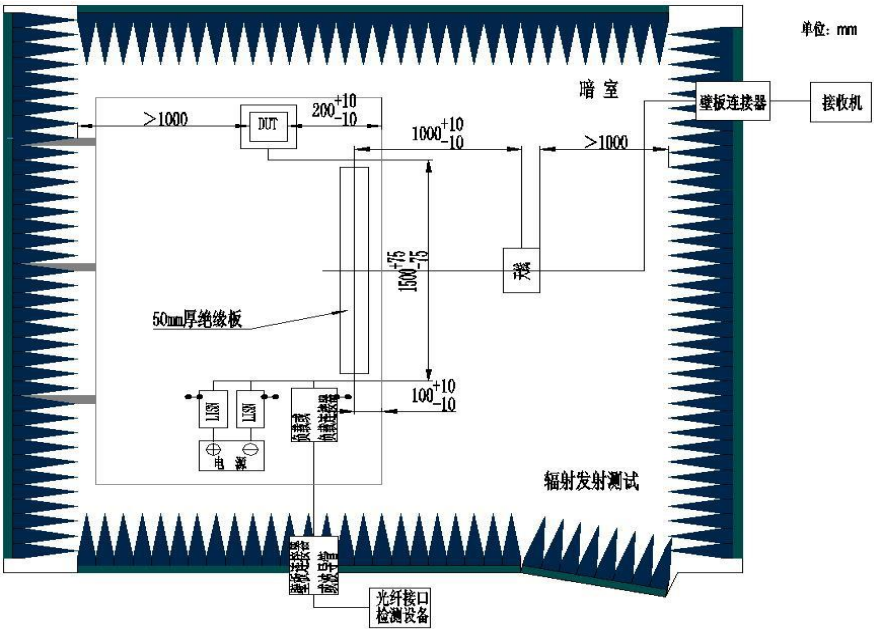


图 2 辐射发射的试验布置 Figure 2 Layout for Radiated Emission Test

5.2 辐射发射限值要求

若测试频率小于 30 MHz 时，采用垂直极化方式进行测试；若测试频率在 30 MHz～2.5 GHz 范围时,应该分别采用垂直和水平极化对 DUT 辐射发射进行测试；当测试频率大于 1 GHz，天线需正对 DUT 连接器。

所有类型的电器部件需要满足限值level 3 的要求。辐射发射需要在 0.15 MHz～2.5 GHz 的全频带范围内进行测试,辐射发射的限值等级要求见表 4、表 5。

5.2 Limits of Radiated Emission Test

If the test frequency is less than 30 MHz, the test should be done in vertical polarization. If the test frequency is in the range between 30 MHz and 2.5 GHz, the test should be done in both vertical and horizontal polarization. When the test frequency greater than 1 GHz, the antenna should point to DUT connector.

All types of electrical components need to meet the limit level 3 requirements. Radiation emissions need to be tested in the full frequency band of 0.15 MHz to 2.5 GHz. The radiation emission level requirements are shown in Table 4 and Table 5.

表 4 辐射骚扰准峰值或峰值限值—ALSE

Table 4 Quasi-peak and peak limits of Radiated Emission - ALSE method

业务/波段	频率/MHz	电平/dB(μV/m)									
		等级 1		等级 2		等级 3		等级 4		等级 5	
		峰值	准峰值	峰值	准峰值	峰值	准峰值	峰值	准峰值	峰值	准峰值
广播											
LW	0.15 ～ 0.30	86	73	76	63	66	53	56	43	46	33
MW	0.53 ～ 1.8	72	59	64	51	56	43	58	35	40	27
SW	5.9～6.2	64	51	58	45	52	39	46	33	40	27
FM	76～108	62	49	56	43	50	37	44	31	38	25
TV 频段 I	41～88	52	-	46	-	40	-	34		28	-
TV 频段 III	174～230	56	-	50	-	44	-	38		32	-
DAB Ⅲ	171～245	50	-	44	-	38	-	32		26	-
TV 频段 IV/V	468～944	65	-	59	-	53	-	47		41	-
DTTV	470～770	69	-	63	-	57	-	51		45	-
DAB L 频段	1447 ～ 1494	52	-	46	-	40	-	34		28	-
SDARS	2320 ～ 2345	58	-	52	-	46	-	40		34	-

表 5 辐射骚扰平均值限值—ALSE

Table 5 Average peak limits of Radiated Emission - ALSE method

业务/波段 Frequency band	频率/MHz Frequency/MHz	电平/Db(μV/m)				
		等级 1	等级 2	等级 3	等级 4	等级 5
		平均值	平均值	平均值	平均值	平均值
广播 broadcast						
LW	0.15～0.30	66	56	46	36	26
MW	0.53～1.8	52	44	36	28	20
SW	5.9～6.2	44	38	32	26	20
FM	76～108	42	36	30	24	18
TV 频段 Ⅰ	41～88	42	36	30	24	18
TV 频段 Ⅲ	174～230	46	40	34	28	22
DAB Ⅲ	171～245	40	34	28	22	16
TV 频段 Ⅳ/Ⅴ	468～944	55	49	43	37	31
DTTV	470～770	59	53	47	41	35
DAB L 频段	1447～1494	42	36	30	24	18
SDARS	2320～2345	48	42	36	30	24
移动业务 mobile service						
CB	26～28	44	38	32	26	20
VHF	30～54	44	38	32	26	20
VHF	68～87	39	33	27	21	15
VHF	142～175	39	33	27	21	15
模拟 UHF	380～512	42	36	30	24	18
RKE	300～330	42	36	30	24	18
RKE	420～450	42	36	30	24	18
模拟 UHF	820～960	48	42	36	30	24
GSM 800	860～895	48	42	36	30	24
EGSM/GSM 900	925～960	48	42	36	30	24
GPS L1 民用	1567～1583	34	38	22	16	10
GSM 1800(PCN)	1803～1882	48	42	36	30	24
GSM 1900	1850～1990	48	42	36	30	24
3G IMT 2000	1900～1992	48	42	36	30	24
3G IMT 2000	2010～2025	48	42	36	30	24
3G IMT 2000	2108～2172	48	42	36	30	24
蓝牙/802.11	2400～2500	48	42	36	30	24

注 1：本表中的多有数值相对于表 1 和表 2 中的带宽均有效。如果由于本底噪声的需求，一定要在不同于表 1 和表 2 中的带宽下测量，则需在试验计划中定义其适用的限值。Note 1: Many of the values in this table are valid relative to the bandwidths in Table 1 and Table 2. If it is necessary to measure at a bandwidth different from that in Table 1 and Table 2 due to noise floor requirements, the applicable limits shall be defined in the test plan.

注 2：在有多个频段使用相同限值时，用户应该选择适当的频段来覆盖这些频段进行测试。当试验计划出现频段交叠时，试验计划应明确所适用的限值。Note 2: When using the same limits for multiple bands, users should select the appropriate band to cover these bands for testing. When the test plan overlaps in frequency bands, the test plan shall specify the applicable limits.

对于 GPS 频段，推荐采用特别的限值特性，参考下图 3。

For the GPS band, a special limit feature is recommended, refer to Figure 3 below.

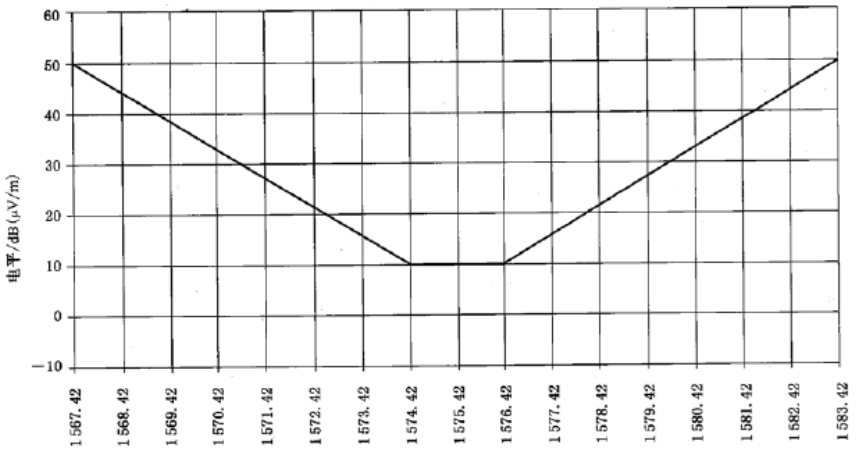


图 3　零部件在 GPS 波段 1567.42 MHz～1583.42 MHz 辐射骚扰平均值限值-等级 5

Figure 3　Components in the GPS band 1567.42 MHz～1583.42 MHz radiation harassment average limit - level 5

6　传导发射测试

6.1　电源线的传导发射 CE01

6.1.1　电源线传导发射的测试布置

电器部件电源线传导发射的测试可参照 CISPR 25 标准中关于车辆零部件和模块的电压测量方法进行。其一般布置如图 4 所示。

6　Conducted Emission Test

6.1　Conducted Emission Test: CE01

6.1.1　Layout for Conducted Emission Test on Power Lines

Conducted emission test on power lines can be carried out in accordance with CISPR25 standard’s “Conducted emissions from components/modules - Voltage method”. General Layout is shown in Figure 4.

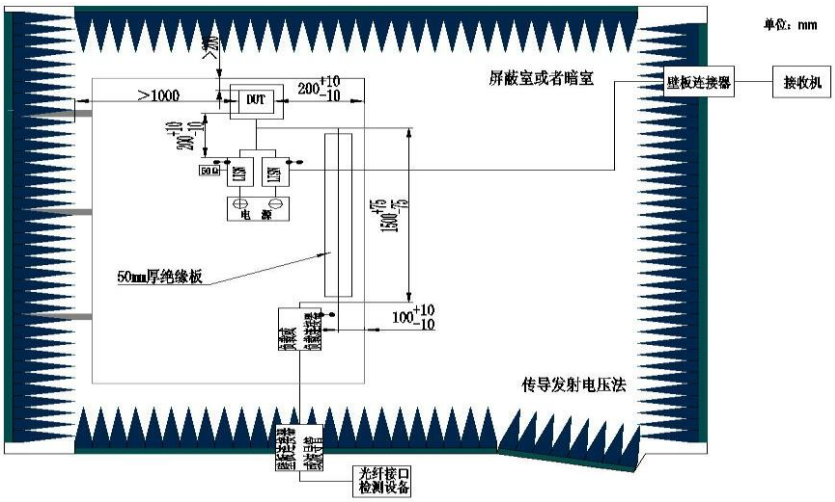


图 4　电源线传导发射的试验布置

Figure 4　Layout for Conducted Emission Test on Power Lines

6.1.2 电源线传导发射的限值要求

所有类型的电器部件需要满足限值 level3 的要求。电源线传导发射需要在 0.15 MHz～108 MHz 的全频带范围内进行测试，其限值要求见表 6、表 7。

6.1.2 Limits of Conducted Emission Test on Power Lines

All types of electrical components need to meet the limit level 3 requirements. Conducted emission power line needs to be tested in the full frequency range of 0.15 MHz～108 MHz, the limit requirements in Table 6, Table 7.

表 6 传导骚扰准峰值或峰值限值—电压法

Table 6 Quasi-peak and peak limits of Conducted Emission - Voltage method

业务/波段	频率/MHz	电平/dB（μV）									
		等级 1		等级 2		等级 3		等级 4		等级 5	
		峰值 PK	准峰值 QP	峰值 PK	准峰值 QP	峰值 PK	准峰值 QP	峰值 PK	准峰值 QP	峰值 PK	准峰值 QP
广播 BROADCAST											
LW	0.15～0.30	110	97	100	87	90	77	80	67	70	57
MW	0.53～1.8	86	73	78	65	70	57	62	49	54	41
SW	5.9～6.2	77	64	71	58	65	52	59	36	53	40
FM	76～108	62	69	56	43	50	37	44	31	38	25
TV 频段 I	41～88	58	-	52	-	46	-	40	-	34	-
移动业务 MOBILE SERVICES											
CB	26～28	68	55	62	49	56	43	50	37	44	31
VHF	30～54	68	55	62	49	56	43	50	37	44	31
VHF	68～87	62	49	56	43	50	37	44	31	38	25

注 1：本表中的多有数值相对于表 1 和表 2 中的带宽均有效。如果由于本底噪声的需求，一定要在不同于表 1 和表 2 中的带宽下测量，则需在试验计划中定义其适用的限值。

Note 1: Many of the values in this table are valid relative to the bandwidths in Table 1 and Table 2. If it is necessary to measure at a bandwidth different from that in Table 1 and Table 2 due to noise floor requirements, the applicable limits shall be defined in the test plan.

注 2：在有多个频段使用相同限值时，用户应该选择适当的频段来覆盖这些频段进行测试。当试验计划出现频段交叠时，试验计划应明确所适用的限值。

Note 2: When using the same limits for multiple bands, users should select the appropriate band to cover these bands for testing. When the test plan overlaps in frequency bands, the test plan shall specify the applicable limits.

表 7 传导骚扰平均值限值—电压法

Table 7 Average limits of Conducted Emission - Voltage method

业务/波段	频率/MHz	电平/dB（μV）				
		等级 1	等级 2	等级 3	等级 4	等级 5
		平均值 AV	平均值 AV	平均值 AV	平均值 AV	平均值 AV
广播						
LW	0.15～0.30	90	80	70	60	50
MW	0.53～1.8	66	58	50	42	34
SW	5.9～6.2	57	51	45	39	33
FM	76～108	42	36	30	24	18
TV 频段Ⅰ	41～88	48	42	36	30	24
移动业务						
CB	26～28	48	42	36	30	24
VHF	30～54	48	42	36	30	24
VHF	68～87	42	36	30	24	18

注 1：本表中的多有数值相对于表 1 和表 2 中的带宽均有效。如果由于本底噪声的需求，一定要在不同于表 1 和表 2 中的带宽下测量，则需在试验计划中定义其适用的限值。

Note 1: Many of the values in this table are valid relative to the bandwidths in Table 1 and Table 2. If it is necessary to measure at a bandwidth different from that in Table 1 and Table 2 due to noise floor requirements, the applicable limits shall be defined in the test plan.

注 2：在有多个频段使用相同限值时，用户应该选择适当的频段来覆盖这些频段进行测试。当试验计划出现频段交叠时，试验计划应明确所适用的限值。

Note 2: When using the same limits for multiple bands, users should select the appropriate band to cover these bands for testing. When the test plan overlaps in frequency bands, the test plan shall specify the applicable limits.

6.2 信号/控制线的传导发射 CE02

6.2.1 控制/信号线传导发射的测试布置

电器部件控制/信号线的传导发射的测试可参照 CISPR 25 标准中关于车辆零部件和模块的电流探头测量方法进行。

电流探头距 DUT 距离 50 mm 和 750 mm。其一般布置如图 5 所示。

6.2 Signal / Control Line Conducted Emission CE02

6.2.1 Layout for Conducted Emission Test on Control and Signal Lines

Conducted emission test on control and signal lines can be carried out in accordance with CISPR 25 standard’s “Conducted emissions from components/modules - Current probe method”.

Distance from the DUT to the current probe should be 50 mm and 750 mm. General Layout is shown in Figure 5.

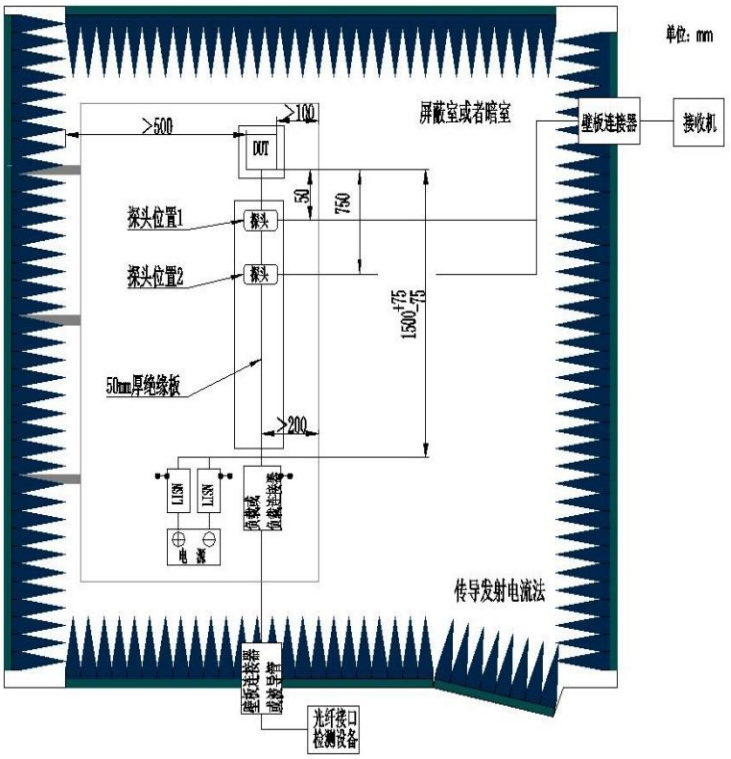


图 5　控制/信号线传导发射的试验布置

Figure 5　Layout for Conducted Emission Test on Control and Signal Lines

6.2.2　控制/信号线传导发射的限值要求

所有类型的电器部件需要满足限值level 3的要求。控制/信号线发射需要在0.15 MHz～108 MHz 的全频带范围内进行测试，其限值要求见表8、表9。

6.2.2　Limits of Conducted Emission Test on Control and Signal Lines

All types of electrical components need to meet the limit level 3 requirements. The measurement needs to be performed in the whole frequency range between 0.15 MHz and 108 MHz. Limit values are shown in Table 8 and Table 9.

表 8　传导骚扰准峰值和峰值限值--控制/信号线--电流探头法

Table 8　Peak limit and Quasi-Peak limit for Conducted Emission Test on Control and Signal Lines-current probe method

业务/波段 Frequency band	频率/MHz Frequency/ MHz	电平/dB（μA）									
		等级 1		等级 2		等级 3		等级 4		等级 5	
		峰值 PK	准峰值 QP	峰值 PK	准峰值 QP	峰值 PK	准峰值 QP	峰值 PK	准峰值 QP	峰值 PK	准峰值 QP
广播 BROADCAST											
LW	0.15～0.30	90	77	80	67	70	57	60	47	50	37
MW	0.53～1.8	58	45	50	37	42	29	34	21	26	13
SW	5.9～6.2	43	30	37	24	31	18	25	12	19	6
FM	76～108	28	15	22	9	16	3	10	--3	4	--9

表 8（续）Table 8（continue）

业务/波段 Frequency band	频率/MHz Frequency/MHz	电平/dB（μA）									
		等级 1		等级 2		等级 3		等级 4		等级 5	
		峰值 PK	准峰值 QP	峰值 PK	准峰值 QP	峰值 PK	准峰值 QP	峰值 PK	准峰值 QP	峰值 PK	准峰值 QP
TV 频段Ⅰ	41～88	24	-	18	-	12	-	6	-	0	-
移动业务 mobile service											
CB	26～28	34	21	28	15	22	9	16	3	10	--3
VHF	30～54	34	21	28	15	22	9	16	3	10	--3
VHF	68～87	28	15	22	9	16	3	10	--3	4	--9

注 1：本表中的多有数值相对于表 1 和表 2 中的带宽均有效。如果由于本底噪声的需求，一定要在不同于表 1 和表 2 中的带宽下测量，则需在试验计划中定义其适用的限值。Note 1: Many of the values in this table are valid relative to the bandwidths in Table 1 and Table 2. If it is necessary to measure at a bandwidth different from that in Table 1 and Table 2 due to noise floor requirements, the applicable limits shall be defined in the test plan.

注 2：在有多个频段使用相同限值时，用户应该选择适当的频段来覆盖这些频段进行测试。当试验计划出现频段交叠时，试验计划应明确所适用的限值。Note 2: When using the same limits for multiple bands, users should select the appropriate band to cover these bands for testing. When the test plan overlaps in frequency bands, the test plan shall specify the applicable limits.

表 9 传导骚扰平均值—控制/信号线—电流探头

Table 9 Average limit for Conducted Emission Test on Control and Signal Lines-current probe method.

业务/波段 Frequency band	频率/MHz Frequency/MHz	电平/dB（μV）				
		等级 1	等级 2	等级 3	等级 4	等级 5
		平均值 AV	平均值 AV	平均值 AV	平均值 AV	平均值 AV
广播 BROADCAST						
LW	0.15～0.30	70	60	50	40	30
MW	0.53～1.8	38	30	22	14	6
SW	5.9～6.2	23	17	11	5	--1
FM	76～108	8	2	--4	--10	--16
TV 频段Ⅰ	41～88	14	8	2	--4	--10
移动业务 mobile service						
CB	26～28	14	8	2	--4	--10
VHF	30～54	14	8	2	--4	--10
VHF	68～87	8	2	--4	--10	--16

注 1：本表中的多有数值相对于表 1 和表 2 中的带宽均有效。如果由于本底噪声的需求，一定要在不同于表 1 和表 2 中的带宽下测量，则需在试验计划中定义其适用的限值。Note 1: Many of the values in this table are valid relative to the bandwidths in Table 1 and Table 2. If it is necessary to measure at a bandwidth different from that in Table 1 and Table 2 due to noise floor requirements, the applicable limits shall be defined in the test plan.

注 2：在有多个频段使用相同限值时，用户应该选择适当的频段来覆盖这些频段进行测试。当试验计划出现频段交叠时，试验计划应明确所适用的限值。Note 2: When using the same limits for multiple bands, users should select the appropriate band to cover these bands for testing. When the test plan overlaps in frequency bands, the test plan shall specify the applicable limits.

7 低频辐射发射 RE02

7.1 测试布置

应对被测件进行电场和磁场的测试。电场采用符合 CISPR 25:2016 的棒状天线进行测量，见图 6；磁场采用符合 GB/T 6113.104 标准规定的环天线进行测量，见图 7。

电场测量时，杆天线距离线束中心 100 mm，且底板连接至测试桌的接地平板。

磁场测量时，要求环天线在两个位置变换三个极性进行测量。第一个位置是距离线束中心 1 m 处，第二个位置是正对被测件中心位置处。

7 Low-Frequency Radiated Emission RE02

7.1 Test Layout

The electric field test and magnetic field test should be measured by the DUT. The electric field test of electrical components can be carried out by rod antenna in accordance with CISPR 25:2016 standard. General Layout is shown in Figure 6. The magnetic field test of electric components can be carried out by loop antenna in accordance with GB/T6113.104. General Layout is shown in Figure 7.

For Electric field test, the distances from the center of the harness to the rod antenna should be 100 mm, grounding plate and bottom plate connected on the test table.

For magnetic field test, Loop antenna should be test in the center of the harness and the center of DUT, Loop antenna should test with three directions for each position.

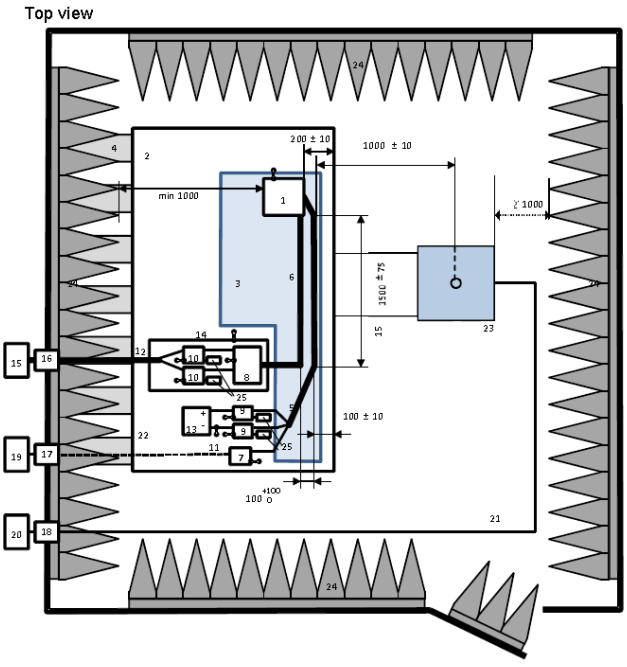


图 6 低频辐射发射棒状天线测试布置

Figure 6 Layout for Low-Frequency Radiated Emission with rod antenna

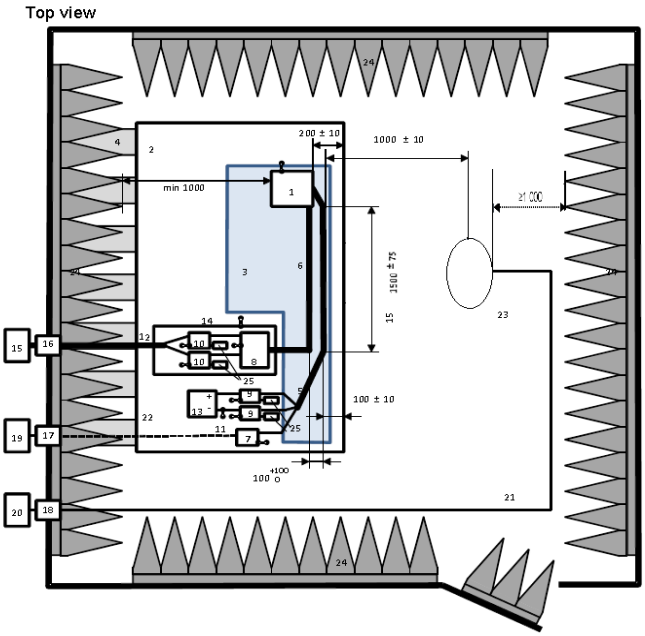


图 7　低频辐射发射环天线测试布置

Figure 7　Layout for Low-Frequency Radiated Emission with loop antenna

7.2　测试程序

接收机设置如下表 10 所示。

7.2　Measurement

Receiver Setting requirements in the table 10.

表 10　接收机设置

Table 10　Receiver Setting

频率（MHz）frequency	RBW	Step size	Time
0.009～0.15	200 Hz	≤100 Hz	≥5 ms
0.15～30	10 kHz	≤5 kHz	≥5 ms

7.3　测试结果评价

测试结果要求符合下表 11,表 12 中，电场和磁场的限值。

7.3　Evaluation of Test Results

Test results meet the following limits of electric field and magnetic field,　see the table 11 and table 12.

表 11　低频辐射发射电场限值

Table 11　limits of electric field

频率（MHz）	电场限值 limit of electric field limit（dBμV/m）
0.009～0.15	95.5-20log（f/0.009）
0.15～4.77	104-20log（f/0.15）
4.77～15.92	74-40log（f/4.77）
15.92～20	53.1-20log（f/15.92）
20～30	51.1
注：限值公式中 f 的单位是 MHz/ The unit of frequency in the formula is MHz.	

表 12 低频辐射发射磁场限值

Table 12 limit of magnetic field

频率（MHz）frequency	磁场限值 limits of magnetic field. （dBμA/m）
0.009～0.15	44-20log（f/0.009）
0.15～4.77	52.6-20log（f/0.15）
4.77～15.92	22.5-40log（f/4.77）
15.92～20	1.6-20log（f/15.92）
20～30	-0.4
注：公式中 f 的单位是 MHz/ The unit of frequency in the formula is MHz.	

8 磁场近场测试 MFI

8.1 磁场近场测试布置

该测试方法参照 MIL-STD-461F 中的 RE101 测试项目，见图 8。

如果条件允许，尽可能使用实际车辆上的线束。

实验前，EUT 必须开启至少 10 分钟，测试点要求覆盖产品表面和线束中心点上面，天线应摆放距离测试点 7cm 处进行测试，见图 9。

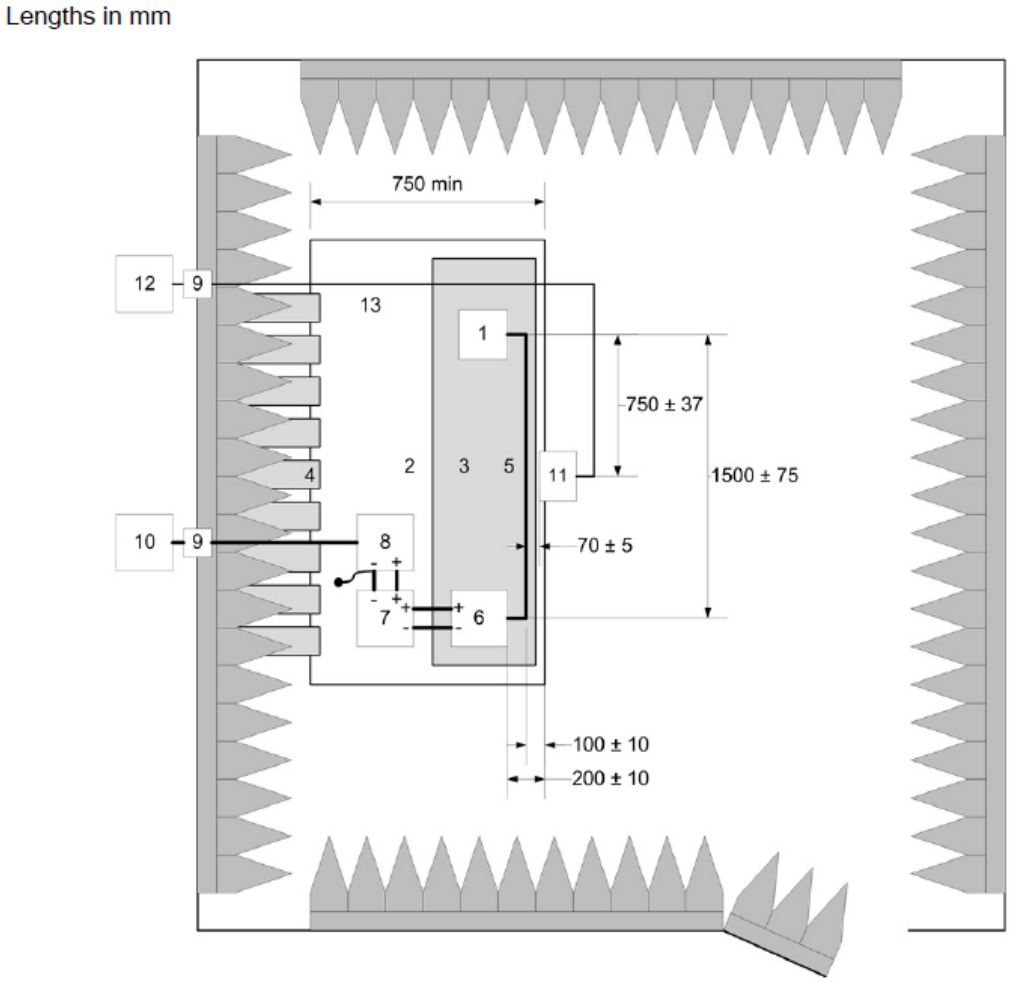
8 Magnetic near field test

8.1 Layout for magnetic near field Test

The MIL-STD-461F RE101 test method shall be used with the requirement level below, see the figure 8.

If possible, the original wiring harness can be used.

The DUT should be activated at least 10 minutes (warm-up time) before the measurement. The reference point of the loop antenna must be placed at a distance of 7 cm from the surface of the DUT or 7 cm above the wiring harness. During the measurement,see the figure 9.



注：note：

1 受试设备EUT

2 地平面Ground plane

3 支持低相对介电常数（εr≤1.4）Low relative permittivity support

4 接地平面接地 Electrical connection between ground plate and chamber wall

5 测试线束 Test wiring harness

6 模拟负载 Load simulation

7 人工电源网络 Artificial network

8 电池 battery

9 导通连接 Lead-through connection

10 供电电源 power supply

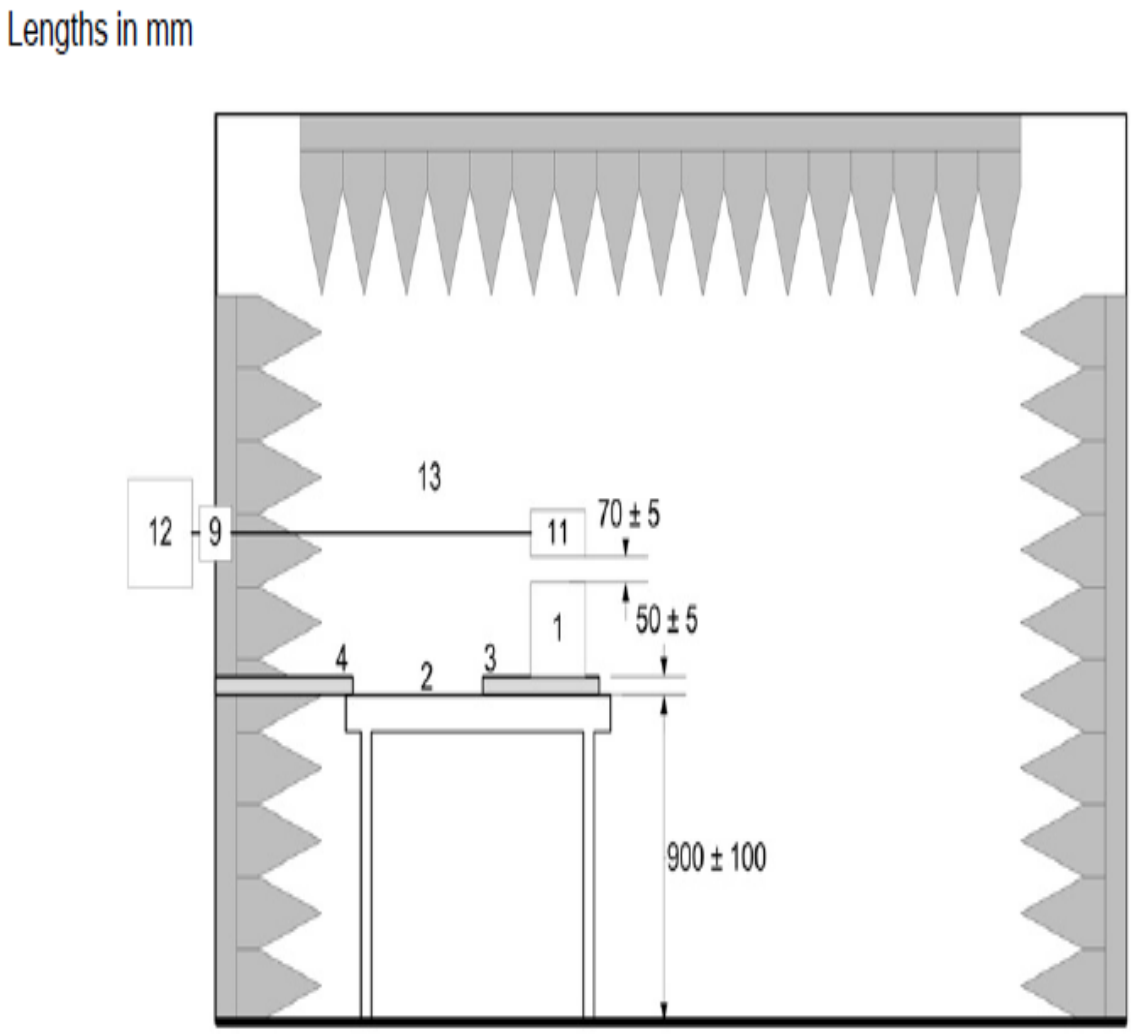
11 磁场探头Magnetic probe

12 测试接收机Measuring receiver

13 高频线缆 Coaxial cable

图 8 线束部分的磁场近场测试布置图

Figure 8 Setup with probe on the wiring harness



注：note:

1 受试设备EUT

2 地平面Ground plane

3 支持低相对介电常数（εr≤1.4）Low relative permittivity support

4 接地平面接地 Electrical connection between ground plate and chamber wall

9 导通连接 Lead-through connection

11 磁场探头Magnetic probe

12 测试接收机Measuring receiver

13 高频线缆 Coaxial cable

图 9 EUT端的磁场近场测试布置图

Figure 9 Setup with probe on the EUT

8.2 测试条件

测试探头选用 MIL-STD-461 标准中的探头，测试接受机测试频段为 20 Hz 到 150 KHz,采用峰值判定,见下表 13。

8.2 Test conditions

The magnetic probe as per MIL-STD-461 [3] must be used. Measuring receivers for the range 20 Hz to 150 kHz and peak detector, see the table 13.

表 13 测试条件 Table 13 test conditions

频率范围frequency band（KHz）	Bandwidth in kHz	Minimum dwell time in ms	Maximum increment
0.02 ≤ f ＜ 1	0.01	150	0.5*BW
1 ≤ f ＜ 10	0.1	150	0.5*BW
10 ≤ f ＜ 75	1	100	0.5*BW
75 ≤ f ＜ 150	9	100	0.5*BW

8.3 测试结果评价

测试结果需要满足表 14 要求。

8.3 Evaluation of Test Results

The measured values must not exceed the limits from table 14:

表 14 测试条件 Table 14 test conditions

频率范围frequency band （KHz）	Maximum emitted magnetic field in dB(μA/m)
0.02 to 0.06	160
0.06 to 6	160 - 20 × log(f/60)a)
6 to 150	120

9 瞬态传导发射 CE10

9.1 瞬态传导发射测试布置

电器部件电源线瞬态传导发射的测试可参照 ISO 7637-2 标准中的电压瞬态发射试验的快变脉冲测试方法。LISN 应符合 ISO7637-2 要求，测试布置距离测试桌边缘至少 200 mm。DUT 与人工网络之间的线缆长度为(200±50)mm。除开关外应没有其他装置连接在 DUT 与人工网络之间。开关与人工网络之间的线缆长度为(100±25)mm，探头与 DUT 之间的线缆长度为(50±10)mm。电器部件快变脉冲发射试验的一般布置如图 10 所示。

9 Transient Emission CE10

9.1 Layout for Conducted Transient Emission Test

Conducted transient emission test on the power lines is performed per the Fast Pulse test method of ISO 7637-2. The LISN shall comply with the requirements of ISO 7637-2 with a test layout of at least 200 mm from the edge of the test table. The cable length between the DUT and the artificial network is (200 ± 50) mm. There should be no other devices connected between the DUT and the artificial network. The cable length between the switch and the artificial network is (100 ± 25) mm, the cable length between the probe and the DUT is (50 ± 10) mm. General Layout for the fast pulse test is shown in Figure 10.

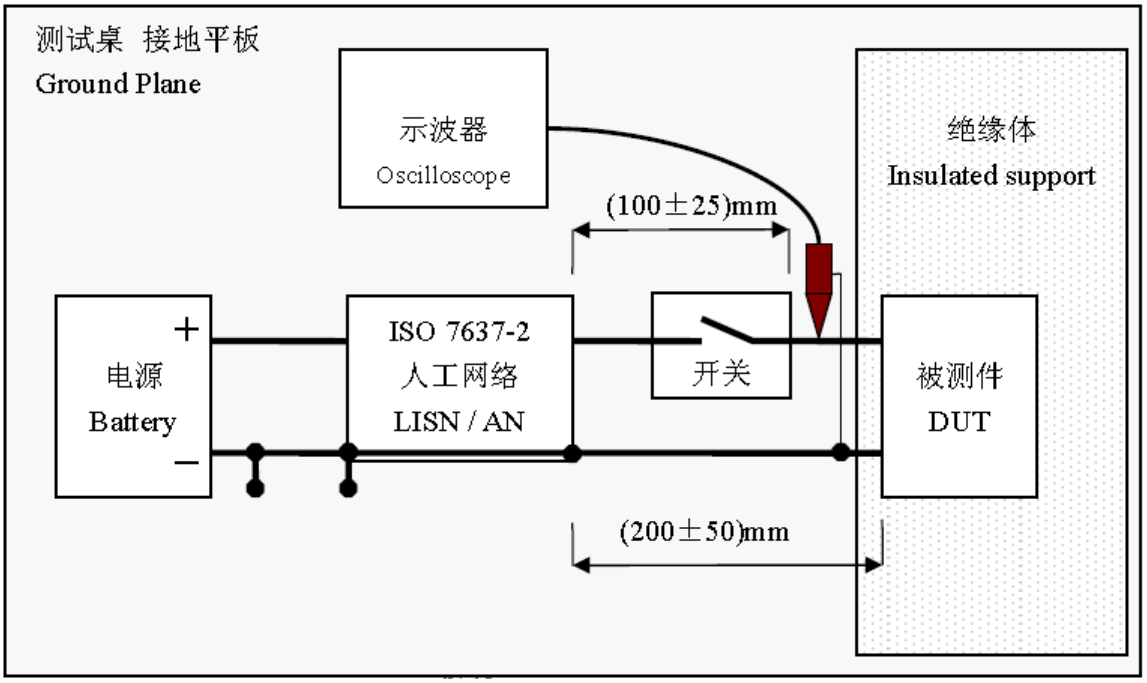


图 10 瞬态传导发射的试验布置图（快变脉冲）

Figure 10 Layout for Conducted Transient Emission Test (Fast Variable Pulse)

DUT 的电源应直接通过人工网络进行滤波处理。DUT 的电源正极线中应串联一个机械开关或电子开关。机械开关或电子开关的选择应在测试计划中说明。

DUT 与人工网络之间的线束长度 200 mm±50 mm，除开关外应没有其他装置连接在 DUT 与人工网络之间。开关距离人工网络 100 mm±25 mm。示波器探头距离 DUT 为 50 mm±10 mm。

DUT 应布置在离接地平板 50 mm 高的绝缘泡沫上。如 DUT 外壳为金属且在实车上直接安装在车身上，则应布置在接地平板上，且可靠接地。DUT 的接地方式应在测试计划及测试报告中描述。

如果 DUT 是电机或执行器，那么测试过程中需给 DUT 施加一定的机械负载，不小于 DUT 额定

The DUT power supply should be filtered directly through the artificial network. DUT positive power lines should be connected in series with a mechanical or electronic switch. The choice of mechanical switch or electronic switch should be stated in the test plan.

Length of the harness between the DUT and artificial network is 200 ±50mm. There should be no other devices connected between the DUT and the artificial network. The distance between artificial network and switch is 100 mm±25 mm. Oscilloscope probe is at 50 mm±10 mm away from the DUT.

DUT shall be placed on top of the insulation spacer, at 50mm high from the ground plane. If the DUT housing is metal and it is mounted directly on the vehicle body in actual vehicle, it should be arranged on the ground plane and should be grounded (locally). DUT's grounding should be described in the test plan and test report.

If the DUT is a motor or an actuator, the DUT shall be subjected to a certain mechanical

负载的 80%。

load during the test [documented in the approved Test Plan], not less than 80% of the DUT rated load.

9.2 测试过程

如下：

1) 闭合开关使 DUT 上电，确认 DUT 工作正常。

2) 设置示波器时基分辨率为 1 ms/div。

3) 设置示波器触发模式为单个触发，设置触发电压为＋10 V。

4) 不断地断开、闭合开关，直到电压脉冲能够触发示波器记录数据。

5) 将示波器触发电压修改为＋40 V。

6) 将时基分辨率改为 100 us/div、1 us/div，同时将示波器采样率调整到所选择时基能够实现的最高等级(至少 2 GSa/s)，重复步骤 4。实际的选择以能表现瞬态脉冲的整个。

7) 断开/闭合开关，测试记录最大峰值。进行 30 次测试。

8) 调整示波器的触发脉冲为-40 V，重复以上第 6～7 步。

9) 调整示波器的触发脉冲为-80 V、+60 V，重复以上第 6～7 步。

注 1：如触发电压设置为±40 V，电压脉冲不能触发示波器记录数据，则认为电器部件符合瞬态传导发射要求。但也需不断下调触发电平，在试验报告中记录其最大瞬态脉冲电压。电源线断开引起的瞬态电压，应在 DUT 稳定工作的状态下，断开开关 S 时刻开始测量。重

9.2 Test Procedure

See the next:

1) Close the switch to power up the DUT, and confirm that DUT is operating properly.

2) Set resolution of the oscilloscope to 1ms/div.

3) Set the trigger mode of the oscilloscope as a single trigger mode (single shot), the trigger voltage is set to + 10V.

4) Continuously open and close the switch until the voltage pulse can trigger the oscilloscope to record the data. Do not continue until triggering has been verified.

5) Change the oscilloscope trigger voltage to +40V.

6) Change the resolution of the time base to 100μs/div, 1μs/div, adjust the sample rate of the oscilloscope to the highest-level time base that can be achieved (at least 2GSa/s). Repeat step 4. The timebase is chosen to represent the entire transient pulse.

7) Continuously open and close the switch to measure any transient emissions present. Conduct 30 tests.

8) Adjust the oscilloscope trigger pulse at -40V, repeat the step 6 and 7.

9) Adjust the oscilloscope trigger pulse at -80V and +60V, repeat the step 6 and 7.

Note 1: If the trigger voltage is set to ± 40 V and the voltage pulse can not trigger the oscilloscope to record data, it is considered that the electrical components meet the requirements of transient conducted emission. But also need to constantly

复性的瞬态电压，应在开关 S 闭合的状态下进行。

reduce the trigger level, record the maximum transient pulse voltage in the test report. The transient voltage caused by the disconnection of the power line should be measured at the moment when the switch S is off while the DUT is operating stably. For repetitive transient voltage, the test should be carried out with switch S in closed state.

注 2：将含有最大正幅度和最大负幅度的瞬态电压波形及相关参数记录在试验报告中。

Note 2: The transient voltage waveform with the largest positive amplitude and the largest negative amplitude and the related parameters are recorded in the test report.

9.3 瞬态传导发射限值要求

电器部件在开关断开和闭合瞬间所产生的快变瞬态脉冲电压必须在-100 V～+75 V 之间。

根据测试数据统计，若出现的最大正幅度和最大负幅度的瞬态电压超出本规范 8.3 节规定的限值则测试结果不合格。若瞬态电压满足上述要求则合格。

9.3 Limit of Conducted Transient Emission Test

Transient voltages generated by the DUT through switch opening and closing must be within -100 and +75V.

According to the test data, if the maximum positive amplitude and the maximum negative amplitude of the transient voltage exceeds the limits specified in Section 8.3 of this specification, the test result is unqualified. If the transient voltages are within the the above requirement, the test result is qualified.

10 辐射抗扰度测试 RI01

10.1 辐射抗扰度测试布置

电器部件辐射抗扰度的测试可参照 ISO 11452-2 标准中的 ALSE 测试方法。电器部件辐射抗扰度试验的一般布置如图 11 所示。

10 Radiated Immunity Test RI01

10.1 Layout for Radiated Immunity Test

Refer to ISO 11452-2 standard’s ALSE method for test method. Test Layout is shown in Figure 11.

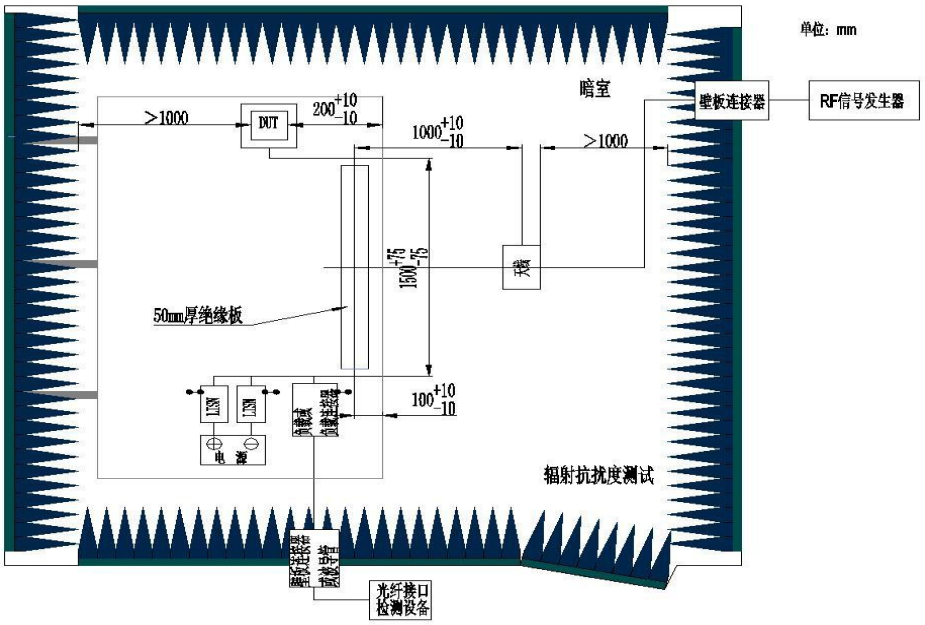


图 11　辐射抗扰度的试验布置

Figure 11　Layout for Radiated Immunity Test

10.2　辐射抗扰度限值要求

采用调幅方式（AM）时，调制频率为 1 kHz，调制等级 80%。采用脉冲调制方式（PM）时，方波重复频率为 217 Hz（±10%），高电平持续时间为 577 μs。每个频率点的停留时间不小于 2 s。干扰信号要求如表 15 所示。

10.2　Radiated Immunity Limit Requirements

For amplitude modulation (AM), modulation frequency is 1 kHz, and amplitude modulation is 80%. When using a pulse modulation (PM), the pulse repetition rate is 217 Hz (±10%), and the pulse duration is 577 μs. The dwell time at each frequency should be not less than 2 s. As required the interference signal shown in Table 15.

表 15　测试信号要求　Table 15　Test Signal Requirements

频带 Frequency（MHz）	步长 Step Size （MHz）	调制方式 Modulation Method	等级 1 Level 1（V/m）	等级 2 Level 2（V/m）
200～800	5	CW；AM 80%	60	100
800～2000	10	CW；Pulsed PRR= 217 Hz, PD=577 μs	60	100
1200～1400	10	Radar pulse packet（PRR=300Hz,PD=3 μs）,with only 50 pulses output every 1 s	NA	300
2700～3100	10	Radar pulse packet（PRR=300Hz,PD=3 μs）,with only 50 pulses output every 1 s	NA	300

辐射抗扰度的性能等级要求如表 16 所示。

The performance levels for radiated immunity are shown in Table 16.

表 16　辐射抗扰度功能等级要求

Table 16　Test Level and Performance Level Requirements for Radiated Immunity Test

干扰信号等级 Signal Level	功能等级要求 / Performance Level Requirement			
	A 类 Class A	B 类 Class B	C 类 Class C	D 类 Class D
等级 1 / Level 1	I	I	I	I
等级 2 / Level 2	II	II	I	I

11　大电流注入测试 RI02

11.1　大电流注入测试布置

电器部件大电流的测试可参照 ISO 11452-4 标准中的 BCI 测试方法中的替代法进行测试，注入钳应分别置于距 DUT（150 mm、450 mm、750 mm）的位置进行测试。应将除了同轴屏蔽电缆之外的所有线束夹在注入钳之内。电器部件大电流注入试验的一般布置如图 12 所示。

11　Bulk Current Injection Test RI02

11.1　Layout for bulk current injection

Bulk current injection test (BCI) should be performed in reference to the substitution method of ISO 11452-4. All harness wires other than coaxial shielded cables should be clamped within the injection probe. The location of the injection clamp shall be at 150 mm, 450 mm and 750 mm from the DUT. General Layout of electrical components is shown in Figure 12.

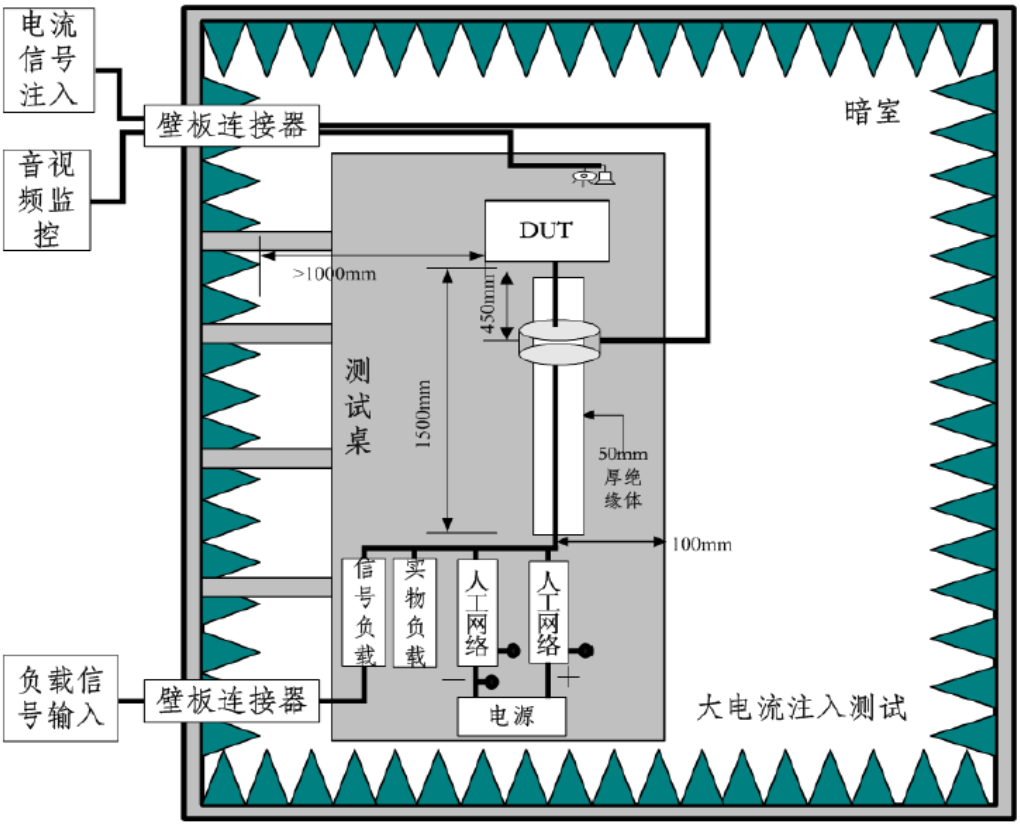


图 12　大电流注入的试验布置图

Figure 12　Layout for Bulk Current Injection Test

11.2 大电流注入限值要求

调幅方式调制频率为 1 kHz，调制深度 80%。每个频率点的驻留时间不小于 2 s。干扰信号要求如表 17 所示。

11.2 BCI Limit Requirements

The modulation frequency should be 1kHz, and modulation amplitude should be 80%. The dwell time at each frequency shall be no less than 2 s. The requirement of interference signal level is as shown in Table 17.

表 17 测试信号要求 Table 17 Test Signal Requirements

频带 Frequency（MHz）	步长 Step Size（MHz）	调制方式 Modulation Method	等级 1 Level 1（mA）	等级 2 Level 2（mA）
1～200	1	CW；AM 80%	100	200
200～400	2	CW；AM 80%	100	200

A、AS、AX、EM 类型的电器部件需要进行大电流注入的测试。功能为 A 类和 B 类电器部件处于 100 mA 的干扰电流下进行测试，C 类和 D 类电器部件应处于 200 mA 的干扰电流下进行测试，DUT 大电流注入的性能等级要求如表 18 所示。

A, AS, AX and EM types of electrical components require BCI test. Electrical components of Functional Class A and Class B shall be carried out with Level 1 current interference test current of 100 mA. Electrical components of Functional Class C and D should be carried out with Level 2 currentthe interference test current of 200 mA.The performance levels for BCI are shown in Table 18.

表 18 大电流注入功能等级要求

Table 18 Test Level and Performance Level Requirements for BCI

干扰信号等级 Signal Level	功能等级要求 / Performance Level Requirement			
	A 类 Class A	B 类 Class B	C 类 Class C	D 类 Class D
等级 1 / Level 1	I	I	I	I
等级 2 / Level 2	II	II	I	I

12 发射器射频抗扰度测试 RI03

12.1 发射器射频抗扰度测试布置

车载发射器射频抗扰度的测试可参照 ISO 11452-9 标准中的测试方法。对于没有线束的模块(如 PEPS 钥匙、RKE 钥匙)，图中涉及到的线束和 LISN 不适用。电器部件车载发射器射频抗扰度测试的一般布置如图 13、图 14 所示。

12 RF Transmitter Immunity Test RI03

12.1 Layout for RF Transmitter Immunity Test

Test method of RF Transmitter Immunity test can be referred to ISO 11452-9 standard. For modules without harness wiring (eg PEPS keys, RKE keys), the harnesses and LISNs involved in the figure do not apply.General Layout of the test is shown in Figure 13 and

Figure 14.

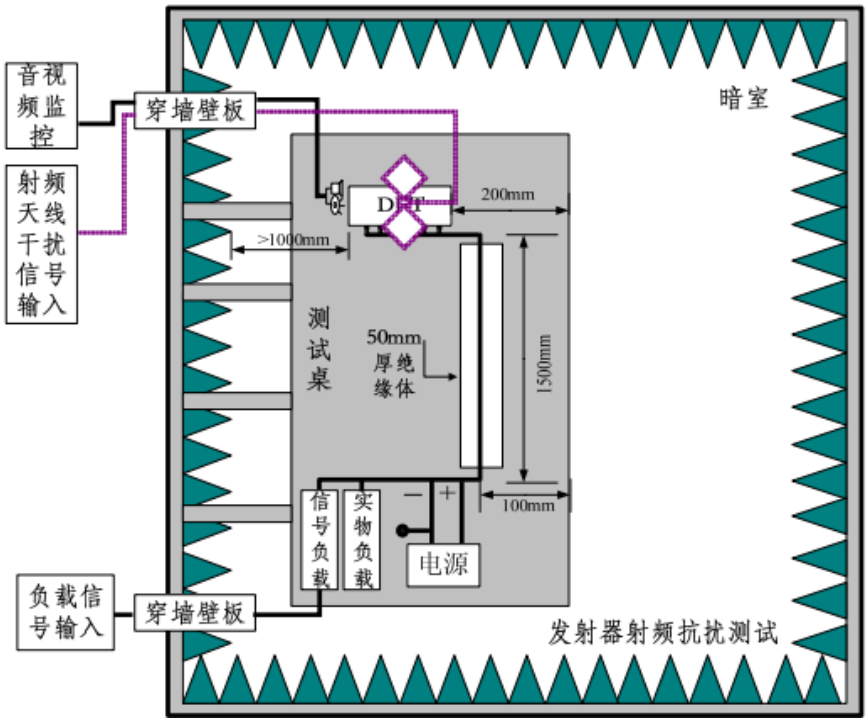


图 13　车载发射器射频抗扰度的试验布置图

Figure 13　Layout for RF Transmitter Immunity Test

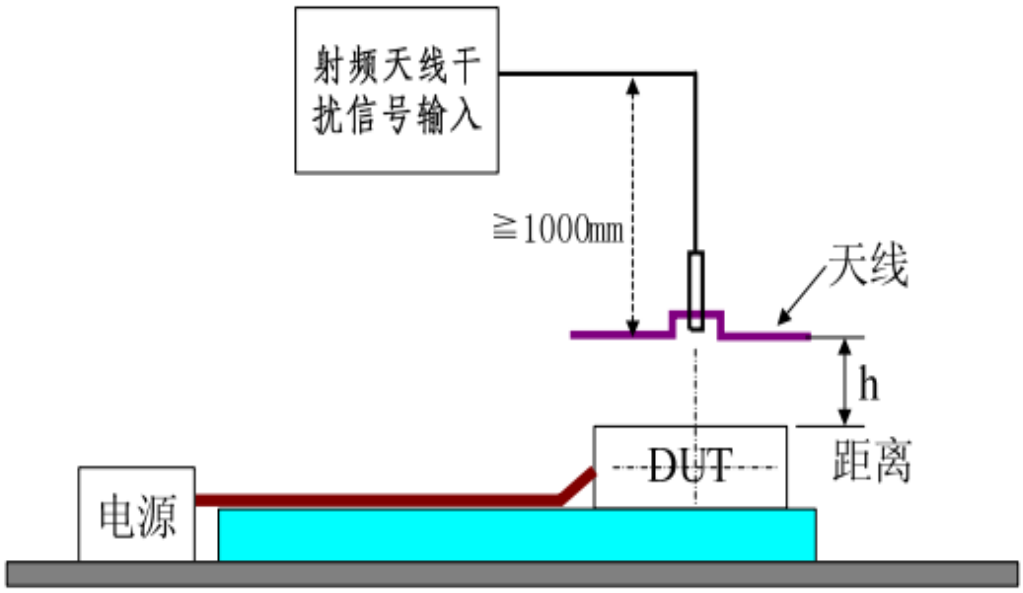


图 14　车载发射器射频天线距离 DUT 高度距离要求

Figure 14　Requirements of Antenna Height from DUT for RF Transmitter Immunity Test

高度要求见表 19。

Requirements of Antenna Height, see the table 19.

表 19 射频天线与 DUT 高度距离要求

Table 19 Requirement of RF Antenna and the Height from the DUT

DUT 外壳线束描述 DUT Housing Harness Description	射频天线与 DUT 距离要求, h Antenna Distance from DUT h, [mm]	射频天线位移步长 Antenna Poistioning Steps [mm]	备注 Remarks
DUT 距离车载发射器 50 mm 以上.DUT 50mm or more from the Vehicle-Mounted Transmitters	50 mm	100 mm	
DUT 距离车载发射器 50 mm 以下 DUT 50mm or less from the Vehicle-Mounted Transmitters	10 mm	30 mm	

12.2 发射器射频试验要求

对于安装在乘员舱或者行李舱内的零部件需要进行车载发射器射频抗扰度的测试。射频抗扰度强度要求和等级要求分别如表 20、表 21 所示

12.2 RF Transmitter Immunity Test Requirements

The components that installed in the crew compartment and the baggage hold need to carry out RF transmitter immunity test. Signal requirements and the performance requirements are shown in Tables 20 and Table 21 repectively.

表 20 射频抗扰强度要求

Table 20 RF Immunity Signal Requirements

序号 No	频段用途 frequency band service	测试频段 Test Frequency Range （MHz）	试验强度（单位：瓦） Test Strength (Unit: Watt)		调制方式 Modulation Method	步长 Step Size (MHz)
			等级 1 Level 1	等级 2 Level 2		
1	RKE 对讲机 (Walkie Talkie)	360～480	4.5	9.0	PM, 18Hz, 50%	10
2	GSM800/900	800～1000	7.0	14.0	PM, 217Hz, 12.5%	10
3	GSM1800/1900	1600～1950	1.5	3.0	PM, 217Hz, 12.5%	20
4	3G	1950～2200	0.75	1.5	PM, 217Hz, 12.5%	20
5	蓝牙 (Bluetooth)、WIFI	2400～2500	0.1	0.2	PM, 1600Hz, 50%	20
6		2500～2700	0.25	0.5	PM, 217Hz, 12.5%	20

表 21　射频抗扰结果等级要求

Table 21　Test Level and Performance Status Requirement for RF Transmitter Immunity

干扰等级 Interference Level	功能等级要求 / Performance Level Requirement			
	A 类 Class A	B 类 Class B	C 类 Class C	D 类 Class D
等级 1 / Level 1	I	I	I	I
等级 2 / Level 2	II	II	I	I

12.3　测试天线位置变化图

发射器射频抗干扰测试过程中，发射器天线应该按照要求在不同的位置进行变换测试，以测试各个方向的抗扰能力，测试过程记录测试现象。具体可参见下图 15。

12.3　Test Antenna Positio

During RF transmitter immunity test, the transmitter antenna should be located with different antenna placement configurations. Any DUT anomalies should be recorded. Figure 15 below shows the antenna locations.

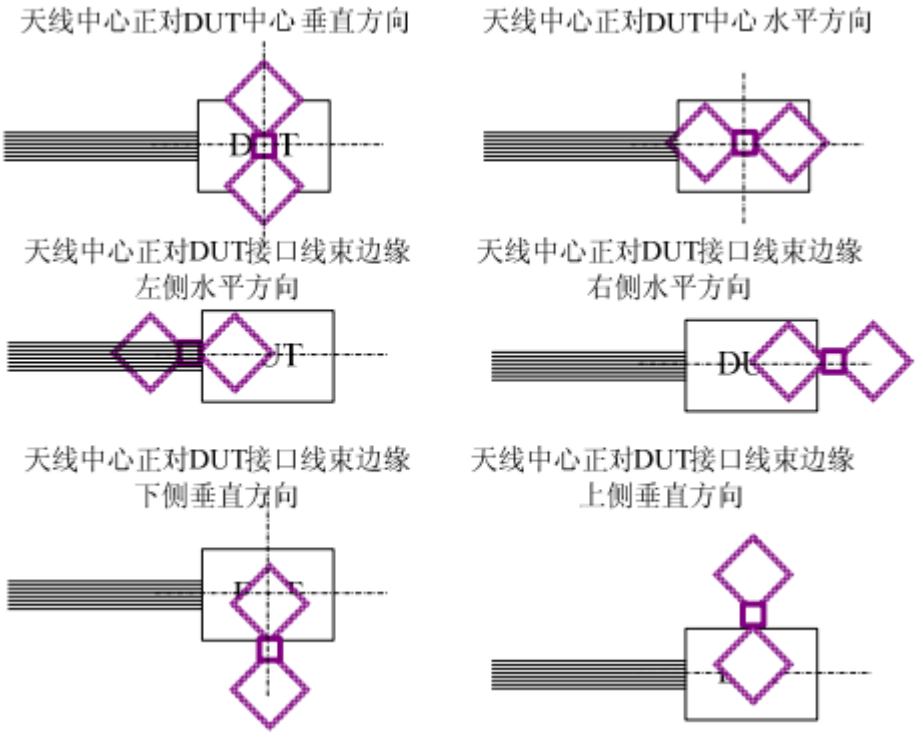


图 15　射频发射器天对 DUT 测试位置放置图

Figure 15　Position of Radio Transmitter above the DUT

13　低频磁场抗扰度测试 RI04

13.1　低频磁场抗扰度测试布置

低频磁场抗扰度测试使用固有共振频率高

13　Low Frequency Magnetic Field Immunity Test

13.1　Layout for Low Frequency Magnetic Field Immunity Test

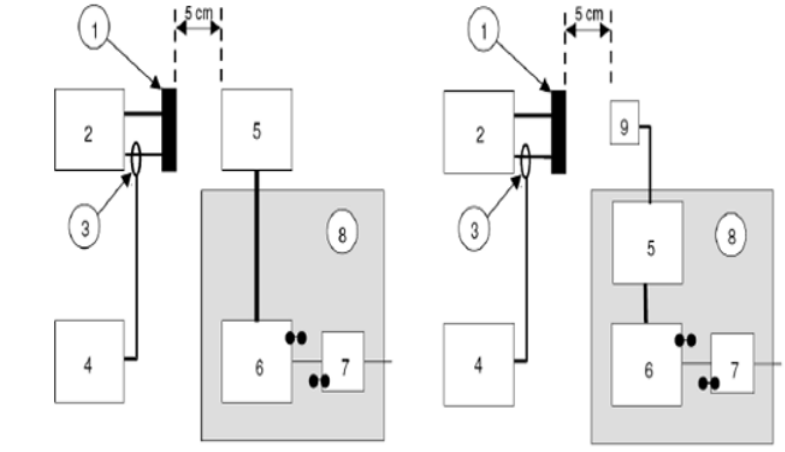
Low Frequency Magnetic Field Immunity Test

于 100 kHz、120 mm 直径的磁场辐射环。除将所有可能连接到 DUT 的电磁传感器暴露在规定的磁场中之外，测试布置应便于 DUT 直接接受磁场照射。各自测试布置如图 16 所示。仅允许使用带宽足够宽的电流探头监测回路电流(禁止使用分流器)。

uses a magnetic field radiation ring of 120mmm diameter with an inherent resonant frequency above 100 kHz. In addition to exposing all electromagnetic sensors that may be connected to the DUT to the specified magnetic field, the test arrangement should allow the DUT to receive direct magnetic field exposure. The respective test layout is shown in Figure 16. Only use current probes with a sufficiently wide bandwidth to monitor the loop current (shunting prohibited).

应使用汽车蓄电池为 DUT 以及所有负载模拟器中的电子器件供电。蓄电池或电源应置于测试桌下的地板上或测试桌附近，负极应与接地平板相连。应将 DUT 置于木桌或绝缘桌之上。负载模拟器及相关支持设备应安装在接地平板上，然而负载模拟器或接地平板的任意一部分都不应距离发射环小于 200 mm。

The car battery should be used to power the DUT and all the electronics in the load simulator. Battery or power supply should be placed under the test table floor or near the test table, the negative electrode should be connected to the ground plane. The DUT should be placed on a wooden table or insulated table. The load simulator and related supporting equipment should be mounted on the ground plane. However, no part of the load simulator or ground plane should be less than 200 mm from the transmitter.



DUT 测试布置　　DUT 及其磁传感器测试布置

1、发射环；　2、信号源；　3、电流探头；　4、测量接收机；　5、DUT

6、负载模拟器；　7、人工网络；　8、接地平板；　9、磁传感器

图 16　低频磁场抗扰度测试布置

Figure 16　Layout for Low Frequency Magnetic Field Immunity Test

13.2 测试步骤

如下：

1) 实施测试之前，先根据 ISO 11452-8 第 7.3.1 节所规定的步骤进行校准。

2) 将 DUT 的每个表面分为 100 mm×100 mm 的方格，将辐射环对准方格的中心。如果 DUT 表面小于 100 mm×100 mm，则将辐射环对准 DUT 表面的中心。辐射环与 DUT 表面的间距为 50 mm。环形传感器应与 DUT 表面平行且与所有接插件的轴向平行。

3) 对每一个测试位置，在表 15 规定的每一个频点向辐射环提供足够的电流以产生符合要求等级的磁场。

4) 驻留时间不少于 2 s。如果 DUT 响应时间长于 2 s，则应适当延长驻留时间。驻留时间应记录在测试计划中。

5) 若 DUT 有附属的电磁传感器，需要将传感器暴露在磁场中检验 DUT 能否正常工作。

6) 对测试计划中规定的每种测试状态分别测试，测试过程中记录出现异常现象的频及相应测试数据(CAN 通信监测数据、模拟信号测量值等)。

13.2 Test Procedure

See the next:

1) Before performing the test, perform the calibration according to the procedure specified in 7.3.1 of ISO 11452-8.

2) Divide each surface of the DUT into 100 x 100 mm squares and align the ring with the center of the square. If the DUT surface is less than 100 x 100 mm, align the ring with the center of the DUT surface. The spacing between radiation ring and the surface of the DUT spacing should be 50mm. The ring sensor should be parallel to the DUT surface and parallel to the axial direction of all connectors.

3) For each test location, provide sufficient current to the radiation ring at each frequency specified in Table 15 to produce a magnetic field of the desired level.

4) Residence time shall not be less than 2 s. If the DUT response time is longer than 2 s, the dwell time should be extended appropriately. The dwell time should be recorded in the test plan.

5) If the DUT has an attached electromagnetic sensor, the sensor needs to be exposed to a magnetic field to verify that the DUT is working properly.

6) Test and record the frequencies and corresponding test data when anomalies are found (CAN communication monitoring data, analog signal measurement value, etc.) for each test state specified in the test plan.

13.3 低频磁场抗扰度限值要求

这里的低频磁场抗扰度测试方法依据磁场辐射环法，磁场抗扰度测试频段为 50 Hz～100 kHz。测试基于可预见的车内电磁干扰源(如充电系统、无线充电器、PWM 源)和车外电磁干扰源(如交流电力线)。任何包含有关电磁传感器的零部件暴露在图 17 所规定的磁场等级条件下工作性能不应出现偏离，图 17 对应的等级如表 22。

13.3 Low Frequency Magnetic Field Immunity Limit Requirements

Low frequency magnetic field immunity test method here is based on the magnetic field radiation ring method, and the magnetic frequency immunity test frequency band is 50 Hz ~ 100 kHz. Tests are based on foreseeable sources of in-car sources of electromagnetic interference (such as charging systems, wireless chargers, PWM sources) and sources of external electromagnetic interference (such as AC power lines). Any component containing an electromagnetic sensor exposed to the magnetic field levels specified in Figure 17 shall not deviate from the operating performance, Figure 17 corresponds to the level in Table 22.

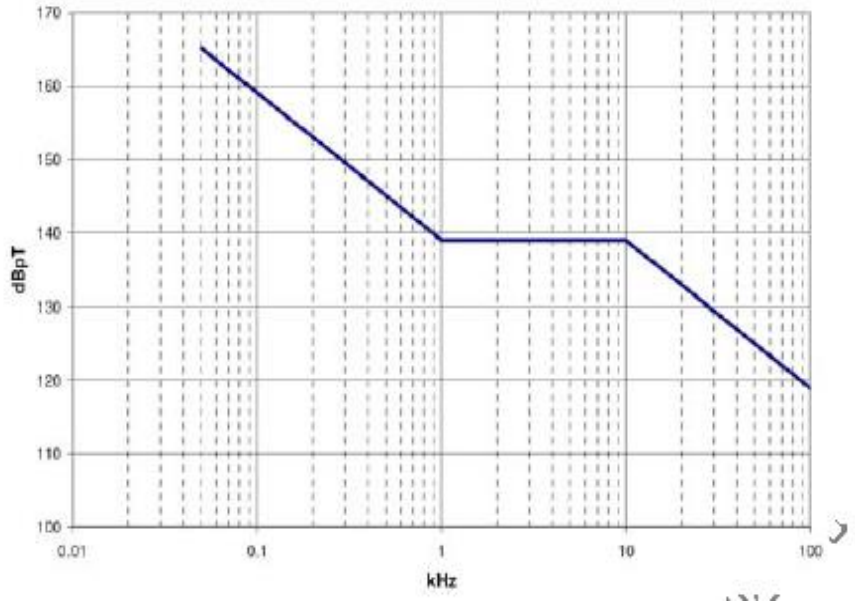


图 17 低频磁场抗扰度限值图

Figure 17 Low-frequency magnetic field immunity limit

13.4 测试结果评价

低频磁场抗扰度测试结果评价如下表 22。

13.4 Evaluation of test results

Low-frequency magnetic field immunity test result evaluation table is shown in Table 22 below.

表 22 低频磁场抗扰度测试等级及功能状态要求

Table 22 Low-frequency magnetic field immunity test level and Performance Level Requirements

频率 Frequency f（kHz）	步长 Step size （kHz）	磁场强度等级 Magnetid Field Level （dBpTrms）	功能状态要求 Performance Level Requirement			
			A类 Class A	B类 Class B	C类 Class C	D类 Class D
0.05～1	0.05	165-20log（f/0.05）	I	I	I	I
1～10	0.5	139	I	I	I	I
10～100	5	139-20log(f/10)	I	I	I	I

14 电源线瞬态传导抗扰度测试 CI01

14.1 电源线瞬态传导抗扰度测试布置

电器部件瞬态传导抗扰度的测试可参照 ISO 7637-2 标准中的测试方法。电器部件瞬态传导抗扰度试验的一般布置如图 18 所示。

14 Power Line Transient Immunity Test CI01

14.1 Layout for Power Line Transient Immunity Test

Electrical component conducted transient immunity test can be referred to ISO 7637-2. General Layout of Conducted Transient Immunity test is shown in Figure 18。

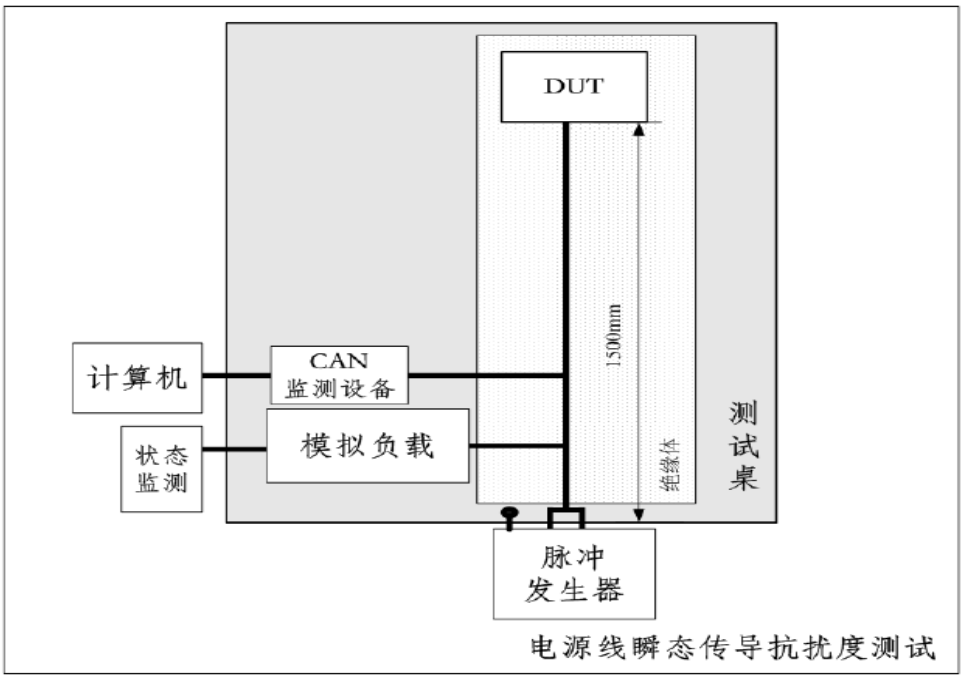


图 18 瞬态传导抗扰度的试验布置图

Figure 18 Layout for Transient Immunity Test

14.2 试验脉冲

14.2.1 测试脉冲 1

测试脉冲 1 模拟电源与感性负载断开连接时所产生的瞬态现象，适用于各种 DUT 在车辆上使用时与感性负载保持直接并联的情况。图 19 和表 23 对脉冲 1 进行了定义。

14.2 Test Pulses

14.2.1 Test Pulse 1

Test pulse 1 simulates the transient phenomenon that occurs when the power supply is disconnected from an inductive load, applicable to various DUTs that remain connected directly in parallel with an inductive load in the vehicle. Pulse 1 is defined in Figure 19 and Table 23.

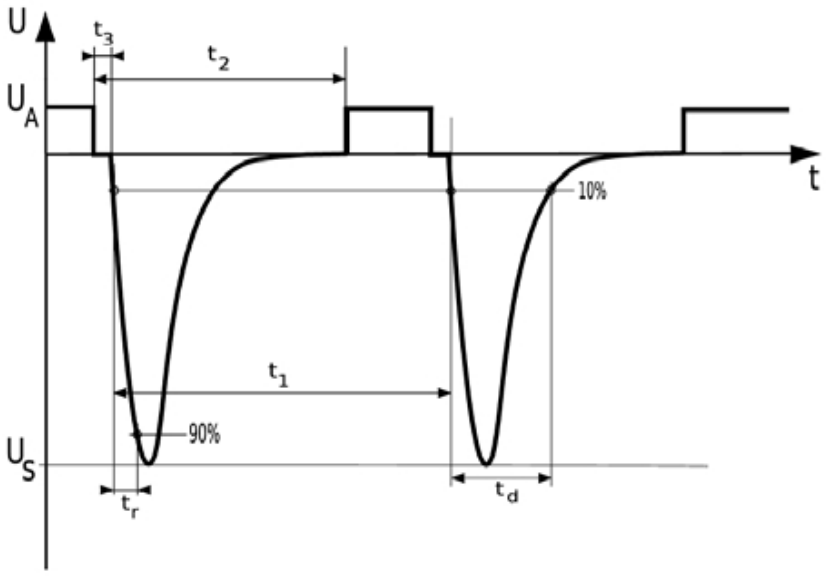


图 19 测试脉冲 1 波形

Figure 19 Waveform of Test Pulse 1

表 23 测试脉冲 1 参数 Table 23 Parameters of Test Pulse 1

参数 Parameter	12 V 系统 12 V System	24 V 系统 24 V System
U_A（V）	13.5	27
U_S（V）	-75	-450
t_r（us）	1	3
t_d（ms）	2	2
t_1（s）	5	5
t_2（ms）	200	200
t_3（us）	50	100
R_i（Ω）	10	50
脉冲数 / Number of Pulses	500	500

14.2.2 测试脉冲 2a

脉冲 2a 模拟由于线束电感使与 DUT 并联的装置内电流突然中断引起的瞬态现象。图 20 和表 24 对脉冲 2a 进行了定义。

14.2.2 Test Pulse 2a

Pulse 2a simulates the transient phenomenon caused by the abrupt interruption of the current in the device in parallel with the DUT due to the wiring harness inductance. Pulse 2a is defined in Figure 20 and Table 24.

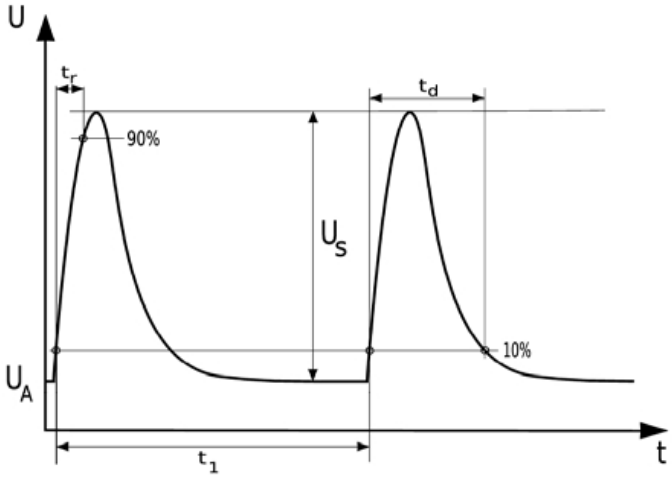


图 20 测试脉冲 2a 波形

Figure 20 Waveform of Test Pulse 2a

表 24 测试脉冲 2a 参数

Table 24 Parameters of Test Pulse 2a

参数 Parameter	12 V 系统 12 V System	24 V 系统 24V System
U_A（V）	13.5	27
U_S（V）	+37	50
t_r（us）	1	1
t_d（us）	50	50
T_1（s）	0.5	0.5
R_i（Ω）	2	2
脉冲数 / Number of Pulses	500	500

14.2.3 测试脉冲 2b

脉冲 2b 用于模拟点火开关断开后，直流电机成为发电机而产生的瞬态现象。图 21 和表 25 对脉冲 2b 进行了定义。

14.2.3 Test Pulse 2b

The pulse 2b is used to simulate the transient phenomenon from the DC motor acting as a generator after the ignition switch is turned off. Pulse 2b is defined in Figure 21 and Table 25.

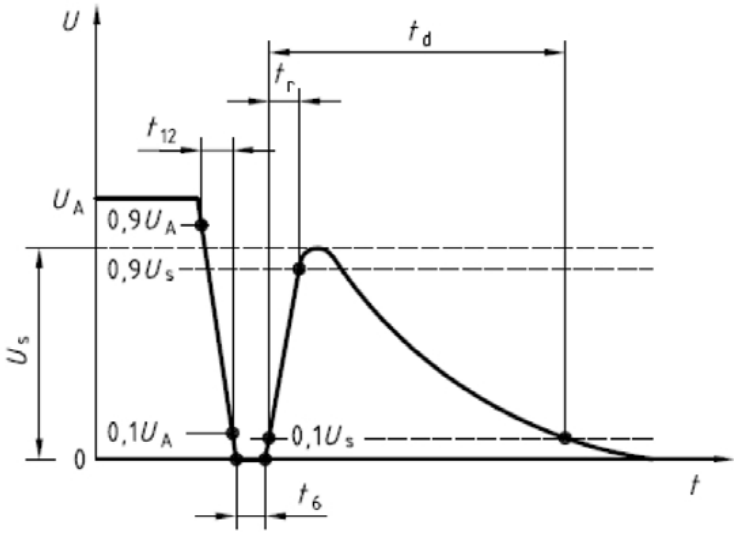


图 21　测试脉冲 2b 波形

Figure 21　Waveform of Test Pulse 2b

表 25　测试脉冲 2b 参数

Table 25　Parameters of Test Pulse 2b

参数 Parameter	12 V 系统 12 V System	24 V 系统 24 V System
U_A（V）	13.5	27
U_S（V）	10	20
t_r（ms）	1	1
t_d（s）	0.5	0.5
t_{12}（ms）	1	1
t_6（ms）	1	1
R_i（Ω）	0.05	0.05
脉冲数 / Number of Pulses	10	10

14.2.4　测试脉冲 3a 和 3b

脉冲 3a 和 3b 用于模拟开关过程产生的瞬态现象，这些瞬态干扰的特性受线束的分布电容和分布电感的影响。

脉冲 3a 是为了模拟开关过程形成的负脉

14.2.4　Test Pulse 3a and 3b

Pulses 3a and 3b are used to simulate the transient phenomena generated by the switching process. These transient disturbances are affected by the distributed capacitance and inductance of the wiring harness.

Pulse 3a simulates the negative pulses

冲。图 22 和表 26 对脉冲 3a 进行了定义。

formed by switching process. Pulse 3a is defined in Table 26 and Figure 22.

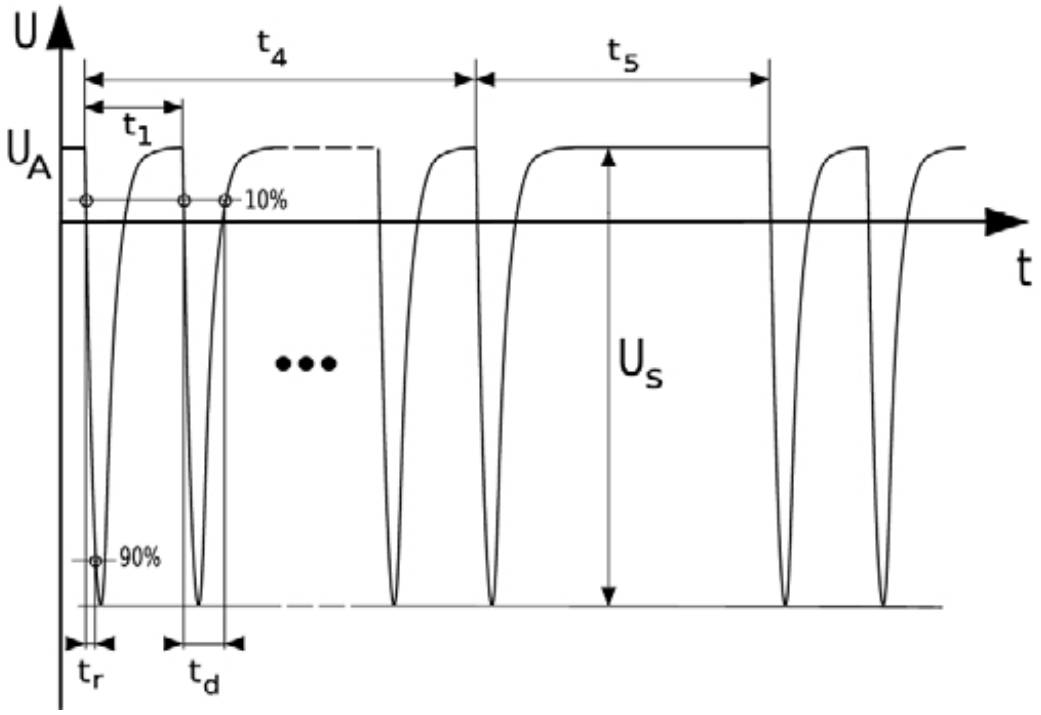


图 22 测试脉冲 3a 波形

Figure 22 Waveform of Test Pulse 3a

表 26 测试脉冲 3a 参数

Table 26 Parameters of Test Pulse 3a

参数 Parameter	12 V 系统 12 V System	24 V 系统 24 V System
U_A（V）	13.5	27
U_S（V）	-112V	-150
t_r（ns）	5	5
t_d（us）	0.1	0.1
t_1（us）	100	100
t_4（ms）	10	10
t_5（ms）	90	90
R_i（Ω）	50	50
脉冲时间（分钟） Test Duration (min)	60	60

14.2.5 测试脉冲 3b

测试脉冲 3b 模拟开关过程形成的正脉冲。图 23 和表 27 对测试脉冲 3b 进行了定义。

14.2.5 Pules 3b

Pulse 3b simulate the positive pulses formed by switching process. Pulse 3a is

defined in Table 27 and Figure 23.

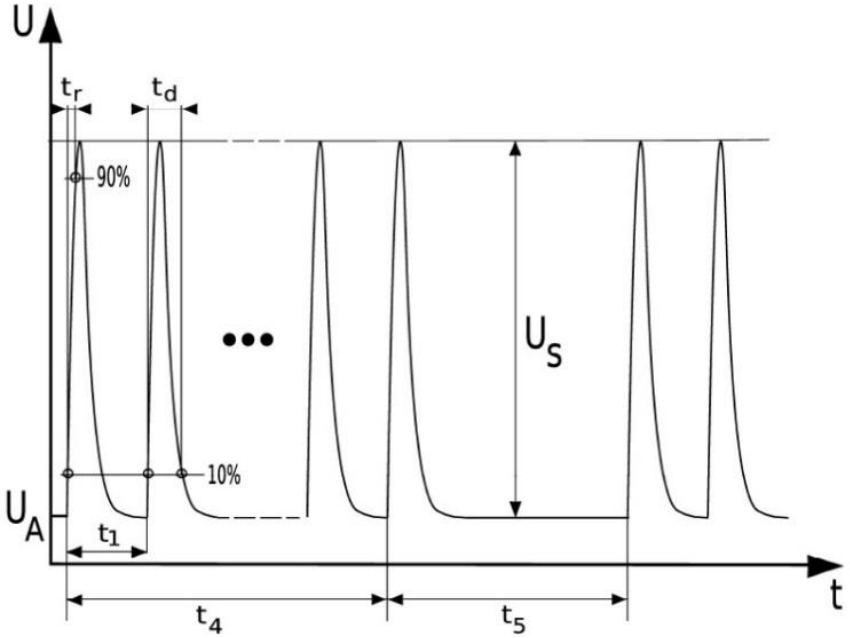


图 23 测试脉冲 3b 波形 Figure 23 Waveform of Test Pulse 3b

表 27 测试脉冲 3b 参数 Table 27 Parameters of Test Pulse 3b

参数 Parameter	12 V 系统 12 V System	24 V 系统 24 V System
U_A（V）	13.5	27
U_S（V）	+75	150
t_r（ns）	5	5
t_d（us）	0.1	0.1
t_1（us）	100	100
t_4（ms）	10	10
t_5（ms）	90	90
R_i（Ω）	50	50
脉冲时间（分钟） Test Duration (min)	60	60

14.2.6 脉冲 4

测试脉冲 4 模拟内电机的启动机电路通电时形成的电源电压的降低，不包括启动时的尖峰电压。图 24 和表 28 对脉冲 4 进行了定义。

14.2.6 Pulse 4

Pulse 4 simulates the reduction in the supply voltage formed when energizing the starter-motor circuits of internal combustion engines, excluding the peak voltage at start-up. Pulse 4 is defined in Figure 24 and Figure 28.

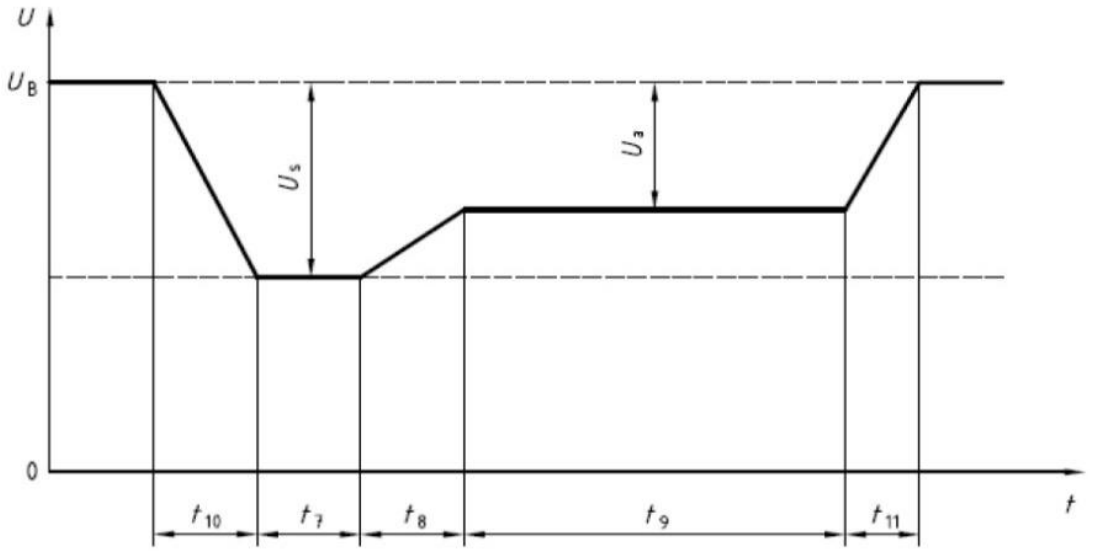


图 24　测试脉冲 4 波形　Figure 24　Waveform of Test Pulse 4

表 28　测试脉冲 4 参数　Table 28　Parameters of Test Pulse 4

参数 Parameter	12 V 系统 12V System	24 V 系统 24V System
U_A（V）	13.5	27
U_S（V）	-6	-12
U_a（V）	-2.5	-5
t_r（ns）	5	5
t_7（ms）	15	40
t_8（ms）	50	50
t_9（s）	10	10
t_{10}（ms）	5	10
t_{11}（ms）	100	100
R_i（Ω）	0.02	0.02
脉冲数 / Number of Pulses	1	1

14.3　瞬态传导抗扰度限值要求

瞬态传导抗扰度要求如表 29 所示。由其它模块中电源供电的 DUT ，必须将 DUT 与供电模块（或等效的电源）作为一个系统进行测试。

14.3　Performance Level Requirements of Conducted Transient Immunity Test

Requirement of conducted transient immunity test are shown in Table 29. If the DUT is powered by other power supply modules, DUT and its power module (or equivalent power) must be tested as a system.

表 29 瞬态传导抗扰度功能等级要求

Table 29 Performance Level Requirements of Conducted Transient Immunity Test

脉冲	功能等级要求 Performance Level Requirement			
	A 类 Class A	B 类 Class B	C 类 Class C	D 类 Class D
脉冲 1 Test Pulse 1	III	III	III	III
脉冲 2a Test Pulse 2a	I	I	I	I
脉冲 2b Test Pulse 2b	III	III	III	III
脉冲 3a Test Pulse 3a	I	I	I	I
脉冲 3b Test Pulse 3b	I	I	I	I
脉冲 4 Test Pulse 4	III	III	III	III

注：对于在高压电启动过程中需要正常工作的功能，在测试脉冲 4 时电器件功能必须满足功能等级 I 的要求。

Note: For functions that require normal operation under high supply voltage at start-up, the electrical device function must meet the requirements of performance level I when the Pulse 4 is tested.

15 信号线瞬态传导抗扰度测试 CI02

15.1 测试布置

本部分的试验方法，用以评价被测物（DUT）对耦合到非电源电路的电瞬态的抗扰度。试验脉冲模拟快速瞬态骚扰和慢速瞬态骚扰，例如电感负载转换、继电器触点跳起等引起的瞬态骚扰。

本部分有两种方法：电容耦合钳（CCC）法、电感耦合钳（ICC）法。它们的适用性如表 30 所示。

15 Signal Line Transient Conducted Immunity Test CI02

15.1 Test Layout

This section of the test method to evaluate the measured object (DUT) coupled to the non-power circuit transient immunity immunity. Test pulses simulate fast transient disturbances and slow transient disturbances, such as transient disturbances caused by inductive load transitions, relay contact jumps, and the like.

This section has two methods: Capacitive Coupling Clamp (CCC) method, Inductive Coupling Clamp (ICC) method. Their applicability is shown in Table 30.

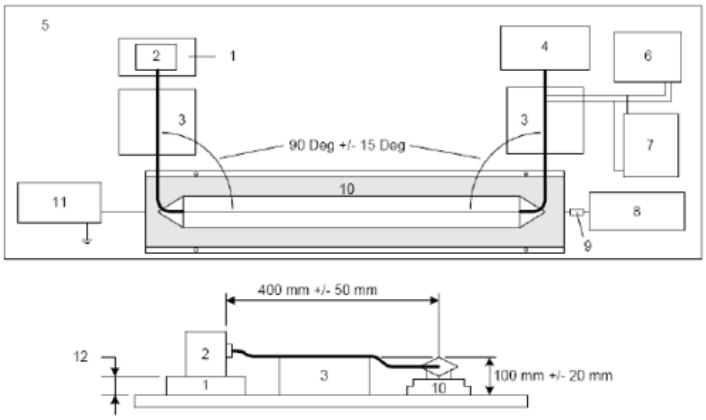
表 30　信号线瞬态抗扰度适用性

Table 30　Signal line transient immunity applicability

瞬时类型 Instantaneous Type	CCC 方法 / CCC Method	ICC 方法 / ICC Method
慢速脉冲 Slow Pulse	不适用 Not Applicable	适用 Applicable
快速脉冲 Fast pulse	适用 Applicable	不适用 Not Applicable

CCC 方法适用耦合快速瞬时试验脉冲，CCC 试验布置如图 25 所示。所有连接线束（包括电源线）穿过 CCC 耦合钳，测试线束长度 1 m。

The CCC method is suitable for coupling fast instantaneous test pulses and the CCC test setup is shown in Figure 25. All connecting harnesses (including the power cord) pass through the CCC coupling pliers and the test harness length is 1 m.



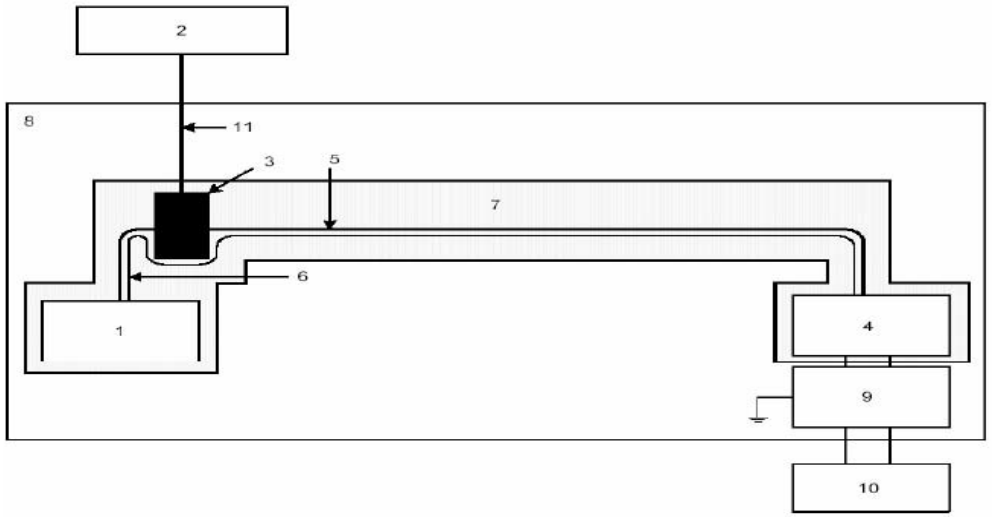
1、绝缘支架　2、被测物（DUT）　3、线束的绝缘支架　4、辅助设备（比如传感器，负载，配件）　5、地平面　6、电源　7、电池　8、示波器　9、50Ω衰减器　10、CCC 耦合板　11、测试脉冲发生器

图 25　CCC 方法试验布置图

Figure 25　CCC Method Test Layout

ICC 方法适用于耦合低速瞬态试验脉冲，ICC 试验方法如图 26 所示。DUT 所有的非地线束穿过 ICC 钳（如果 DUT 在车辆上使用时只有一条单独的接地线则应穿过 ICC 钳）

The ICC method is suitable for coupling low speed transient test pulses and the ICC test method is shown in Figure 26.All non-ground wire bundles of the DUT pass through the ICC clamp (if the DUT is used on a vehicle, it should pass through the ICC clamp with only a single ground wire)



注：note：

1、DUT 2、测试脉冲发生器 Pulse generator 3、注入钳 injector 4、负载设备 load

5、测试线束-1.5m harness-1.5m 6、接地线 Grounding wire 7、50mm厚绝缘体 Insulative material 8、接地平板 Grounding plate 9、电池 Battery 10、直流电源 DC power 11、50Ω同轴线缆 Coaxial cable

图 26 ICC 试验总体布置

Figure 26 ICC Method Test Layout

15 2 测试步骤

如下:

1) 将 DUT 和负载等连接，线束长度按照布置图要求执行。

2) 根据布置图，调节瞬态脉冲发生设备，产生规范要求的瞬态脉冲。

3) 将被测物（DUT）线束布置图要求穿过瞬态脉冲耦合钳，按照本规范要求的脉冲数量和脉冲特性依次对测试计划中规定的每种测试状态分别测试，测试过程中记录出现异常现象的频段及相应测试数据(CAN 通信监测数据、模拟信号测量值等)。

15.2 Test Procedure

See the next:

1) The DUT and load connections, wiring harness length should follow the layout requirements of the implementation;

2) According to the layout, adjust the transient pulse generating equipment to produce transient pulse as specified;

3) The DUT harness layout is required to pass through the transient pulse coupling clamp to test each of the test states specified in the test plan in sequence according to the number of pulses and pulse characteristics required by this specification. Test and record the frequencies and corresponding test data when anomalies are found (CAN communication monitoring data, analog signal measurement value, etc.) for

each test state specified in the test plan.

15.3 评价标准

信号线瞬态传导抗扰度限值要求。

1) 电容耦合钳（CCC）方法

CCC 法进行快速瞬态脉冲 a 和 b 两个脉冲试验，快速瞬态试验脉冲是模拟开关过程产生的电瞬态，脉冲形状和参数参见表 31 和表 32。

15.3 Evaluation Standard

Transient conducted signal line immunity limit requirements.

1) Capacitive coupling clamp (CCC) method

CCC method for fast transient pulse a and b two pulse test, fast transient test pulse is generated by the analog switch transient, pulse shape and parameters, see Table 31 and Table 32.

表 31 快速瞬时试验脉冲 a

Table 31 Fast Transient Test Pulse a

参数 Parameter	12 V 系统 12 V System
Up（V）	13.5
Us（V）	-40
Tr（ns）	5
td（μs）	0.1
t1(μs)	100
t4(ms)	10
t5(ms)	90
R1(ohms)	50
脉冲循环测试时间 Pulse Cycle Test Duration	10 min

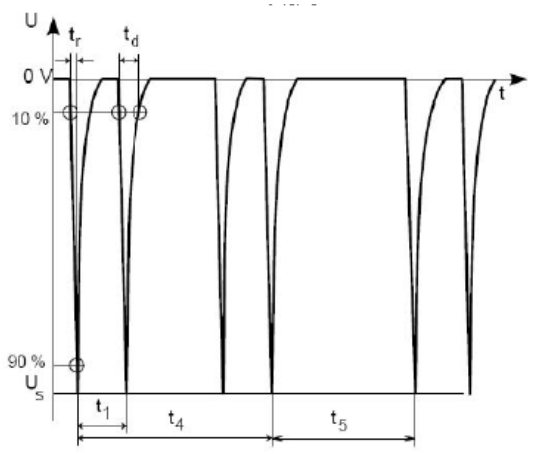
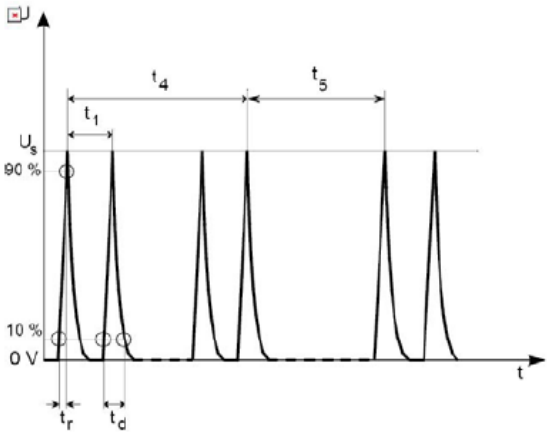


表 32 快速瞬时试验脉冲 b

Table 32 Fast Transient Test Pulse b

参数 Parameter	12 V 系统 12 V System
Up（V）	13.5
Us（V）	30
Tr（ns）	5
td（μs）	0.1
t1(μs)	100
t4(ms)	10
t5(ms)	90
R1(ohms)	50
脉冲循环测试时间 Pulse Cycle Test Duration	10 min



2) 电感耦合钳（ICC）方法

ICC 法低速瞬态试验脉冲模拟大电感负载电路中断出现的电瞬态，包含脉冲 c 和 d，比如散热风扇马达，空调压缩机离合器等为负载。脉冲形状和参数参见表 33 和表 34。

2) Inductive Coupling Clamp (ICC) Method

ICC method low-speed transient test pulse simulation of large inductive load circuit interrupt the occurrence of electrical transients, including pulses c and d, such as cooling fan motors, air conditioning compressor clutches and other loads. See Table 33 and Table 34 for pulse shape and parameters.

表 33 低速瞬时脉冲 c-正极

Table 33 Low-speed Instantaneous Pulse c - Positive

参数 Parameter	12 V 系统 12V System
Us（V）	5
Ri（ohms）	2
t1（s）	2.5
td（ms）	0.5
tr（μs）	1
脉冲循环测试数量 Pulse Cycle Test Number	20

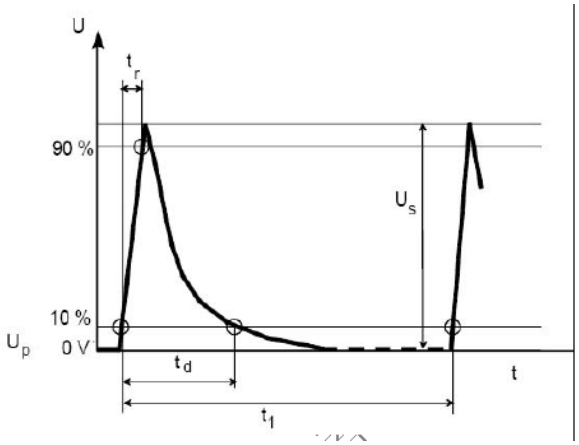
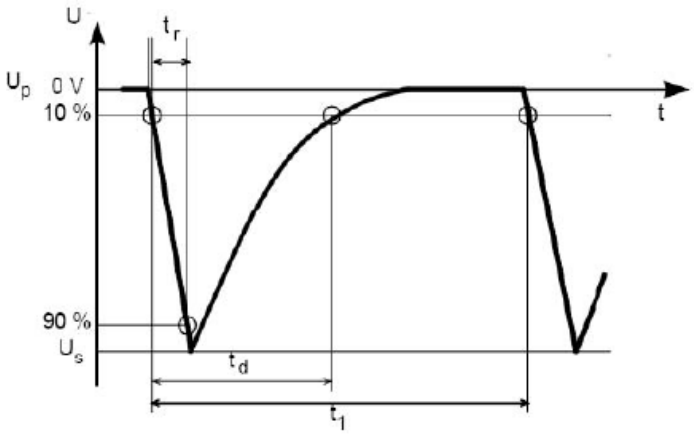


表 34 低速瞬时脉冲 d-负极

Table 34 Low-speed Instantaneous Pulse d - Negative

参数 Parameter	12 V 系统 12V System
Us（V）	-5
Ri（ohms）	2
t1（s）	2.5
td（ms）	0.5
tr（μs）	1
脉冲循环测试数量 Pulse Cycle Test Number	20



15.4 测试结果评价

15.4 Evaluation of Test Result

电源线瞬态抗扰度结果评价要求见表 35 所示。

Table 35 shows the requirements for evaluating the transient immunity of the power cord.

表 35 电源线瞬态传导抗扰度功能状态要求

Table 35 Power-line Transients Immunity Performance Level Requirements

测试脉冲 Test Pulse	功能状态要求 Performance Level Requirement			
	A 类 Class A	B 类 Class B	C 类 Class C	D 类 Class D
脉冲 a Pulse a	Ⅱ	Ⅱ	Ⅰ	Ⅰ
脉冲 b Pulse b	Ⅱ	Ⅱ	Ⅰ	Ⅰ
脉冲 c Pulse c	Ⅱ	Ⅱ	Ⅰ	Ⅰ
脉冲 d Pulse d	Ⅱ	Ⅱ	Ⅰ	Ⅰ

16 静电放电测试 ESD01

16 Electrostatic Discharge Test ESD01

16.1 试验布置

试验室仪器参照 ISO 10605 要求执行。

静电放电测试分为两部分：断电状态静电放电测试和通电状态静电放电测试，断电状态静电放电测试模拟零部件在正常装卸与装配过程中出现的静电放电现象。工作状态静电放电模拟用户正常使用、技术人员维修过程中出现的静电放电现象。

静电放电模拟器主机距离 DUT 的距离大于 200 mm，可放置在试验室地上。地平面要足够大，以保证 DUT 任何一个边缘距离地平面的边缘距离不小于 100 mm。放电电阻连接点距离 DUT 的距离不小于 500 mm。放电电阻为 1 MΩ 左右，可将两个 470 kΩ 电阻串联得到。

16.1 Test Layout

Ambient temperature and humidity test chamber should meet the requirements of ISO 10605.

Electrostatic discharge test is divided into two parts: Unpowered state ESD test and powered state ESD test. Unpowered state ESD test simulates electrostatic discharge phenomenon of components during normal handling and assembly process. Powered state ESD test simulates electrostatic discharge phenomenon of components during the normal use by users and technicians.

Electrostatic discharge simulator equipment should be separated from DUT by distance greater than 200 mm, and it can be placed on the laboratory floor. The ground plane should be large enough to ensure that any edge of the DUT is not less than 100 mm from the edge of the ground plane. Distance between discharge resistance connection point

a) 断电状态静电放电测试布置

参照ISO 10605 标准中的测试方法，按照图27的测试布置实施测试。 DUT 应放置在符合GB/T 19951 要求的静电消耗材料上。断电状态接触放电的放电网络为150 pF 和330 Ω。当实施引脚静电放电时，将 DUT 所有负极/地线通过接地母线或不长于200 mm的导线连接到接地平板。如果 DUT 有多个接地线并且在内部没有相互连接，则应将逻辑地线与接地平板相连接，剩下的地线应和其他引脚一样接受静电放电。对于没有接地线的零部件(例如：低端输出或者附加在控制器上的、内部有 LED 的开关等)，将低端输出(通常与控制器I/O 连接的)连接到接地平板。

and the DUT should not be less than 500 mm. Discharge resistance of about 1 MΩ can be obtained by two 470 kΩ resistors in series.

Powered State ESD Test:

a) Unpowered State ESD Test:

With reference to the test method in the ISO 10605 standard, the test is performed according to the test arrangement of Figure 27. DUT should be placed on top of anti-ESD material in accordance with the requirements of GB / T 19951. Discharge network for unpowered contact discharge test should be 150 pF and 330 Ω. When performing pin ESD test, connect all negative / ground of the DUT to the ground plane through the ground bus or wires longer than 200 mm. If the DUT has multiple ground lines and is not interconnected internally, the logic ground should be connected to the ground plane and the remaining ground should be subjected to the same ESD as any other pin. For components that do not have a ground wire (eg, low-side output or additional controller-attached LEDs with internal switches, etc.), connect the low-side output (typically the controller I / O connection) to the ground plane

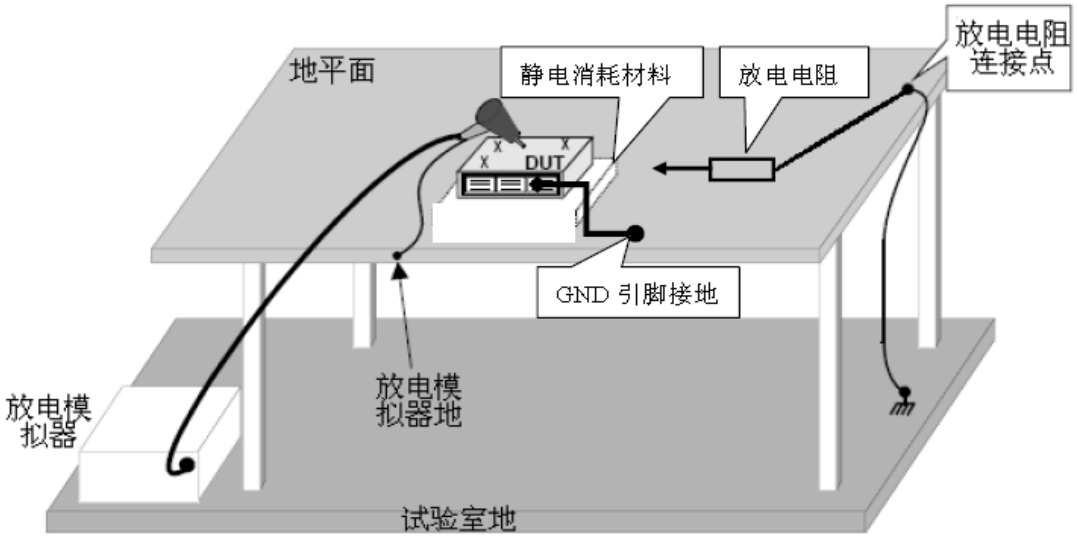


图 27 断电状态静电放电测试布置

Figure 27 Layout for Powered State ESD Test

b) 通电状态静电放电测试布置

参照ISO 10605标准中的测试方法，按照图28的测试布置实施测试。DUT 应放置在50 mm 厚的绝缘体上，若 DUT 外壳为金属外壳，且与车身地有直接电气连接，则应将DUT外壳与接地平板直接连接。测试线束应放置在50 mm厚的绝缘体上，连接 DUT 和负载模拟器的线束长度为1500 mm±75 mm。

b) Powered State ESD Test

Refering to the measurement method in ISO 10605 standard, the test is performed according to the test arrangement of Figure 28. The DUT should be placed on a 50mm thick insulator. If the DUT housing is a metal housing and has a direct electrical connection to the vehicle body, the DUT housing should be connected directly to the ground plane. The test harness should be placed on a 50 mm thick insulator with a harness length of 1500 ± 75 mm connecting the DUT to the load simulator.

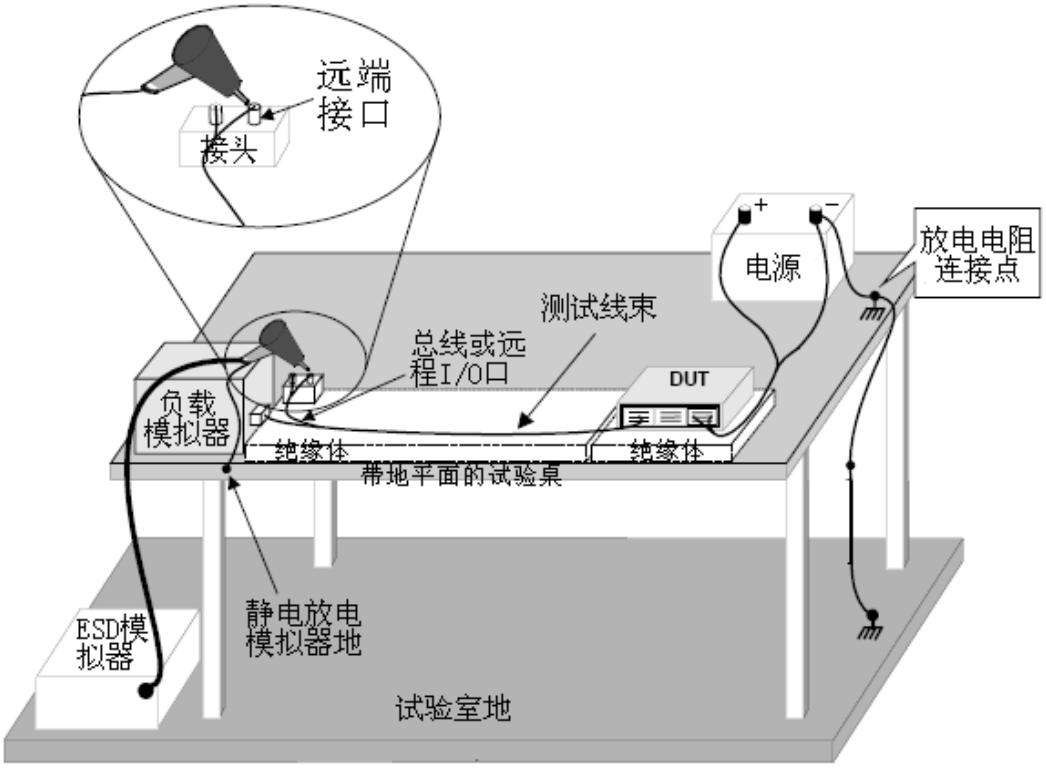


图 28 通电工作状态静电放电测试布置

Figure 28 Layout for Powered State ESD Test

16.2 测试步骤

静电放电应在其他 EMC 测试项目之前测试，以便于发现静电可能导致零部件内部电子元件的损害对其 EMC 性能的影响。

在测试计划中标明静电放电测试位置，对于

16.2 Test Procedur

Electrostatic discharges should be tested prior to other EMC test items in order to find out the effects of static electricity on their EMC performance that may result from the damage of electronic components inside the component.

Describe ESD discharge locations in the

以点标注的点实施放电，这些点通常标注在金属部件、孔；对线条标注的位置，在线条上间隔10 mm为一个放电测试点，这些线条通常标注在外壳缝隙；对于方框标注的表面，划分为长宽均为10 mm 的小方格，每一个方格的交叉点为放电位置，这些标注的表面通常是显示屏；对于按键或前面板，每一个按键的中心以及按键周围缝隙为放电位置。

test plan, and discharge points marked with dots, usually marked on metal parts, holes; mark the location of the line at intervals of 10 mm as a discharge test point, which are usually For the marked surface of the box, it is divided into small squares of 10 mm in length and width. The intersection of each square is the discharge position. The marked surface is usually the display screen. For the buttons or the front panel, the center of each button and the gap around the button for the discharge position.

a) 断电状态静电放电测试步骤

1) 在进行测试前，需要对静电放电发生器的放电电压进行检查，误差不大于0.1 KV。

2) 对 DUT 外壳进行放电：要对包装、安装、拆除过程中任何可能接触到的位置进行测试。

3) 对DUT引脚进行放电：测试之前确认电源负极已经按照6.12.11节的要求连接到接地平板。如果由于结构原因，很难直接对单个DUT引脚进行测试，可将长度小于25 mm的插针安装到单个引脚上以便于测试。对于一个系统由几个模块组成的，且模块之间通过线束接插件连接，则分别对各模块实施引脚静电放电，每个模块放电测试后立即检查此模块的功能状态是否满足技术要求。

a) Power-off status Electrostatic discharge test procedure

1) Before carrying out the test, it is necessary to check the discharge voltage of the electrostatic discharge generator with an error of not more than 0.1 KV.

2) Discharging the DUT Case: Test any locations that may come into contact with the package, during installation, or removal

3) Discharge the DUT pin: Verify that the negative supply has been connected to the ground plane as specified in Section 6.12.11 before testing. If, for structural reasons, it is difficult to test a single DUT pin directly, pins shorter than 25 mm in length can be mounted on a single pin for testing purposes. For a system consisting of several modules, and the modules are connected by harness connectors, the pins of each module are respectively electrostatically discharged. After each module discharge test, the performance level of the module is checked to meet the technical requirements

4) 在每个放电位置和每个放电电压至少进行3次放电，完成一次放电后，需要利用放电电阻接触放电位置泄放电荷或使用放电枪内置放电功能在放电0.2s后自动泄放电荷，两次放电之间的间隔不小于1 s。

4) Discharge at each discharge position and discharge voltage for at least 3 times to complete a discharge, the need to use the discharge resistor to contact the discharge position to discharge charge or use the discharge gun built-in discharge function discharge 0.2s after the automatic charge discharge, twice The interval between discharges is not less than 1 s.

5) 完成一个放电电压的所有放电测试后，需要对DUT功能进行检测，并将检查结果和现象记录在试验报告中。

5) After completing all discharges at each discharge voltage, the DUT function needs to be tested and the test results and phenomena need to be recorded in the test report

6) 实施断电状态静电放电测试之后，零部件的I/O 接口参数(例如：电阻、电容、漏电流等)应在技术要求的容差范围之内。应在ESD 测试完成之后或完成所有相关EMC 测试之后立即检查零部件的I/O 参数。

6) After performing unpowered state ESD test, the I / O interface parameters (eg resistance, capacitance, leakage current, etc.) of the component should be within the tolerances of the technical requirements. The I / O parameters of the part should be checked immediately after the ESD test is completed or after all relevant EMC tests have been completed

b) 通电状态静电放电测试步骤

b) Power-on state Electrostatic discharge test procedure

1) 在开始测试前，应对静电放电发生器的放电电压进行检查，误差不大于0.1 KV。

1) Before starting the test, the discharge voltage of the electrostatic discharge generator should be checked with an error of not more than 0.1 KV.

2) DUT任何可能被使用者接触到的位置均需要进行放电测试，包括DUT的开关、显示器、线束、接头等。

2) Any location that may be touched by the user needs to be tested for discharging, including the switch, display, wiring harness, connector, etc. of the DUT

3) 对于直接从车外能直接接触到以及安装在乘客舱内但能直接从车外接触到

3) ± 25KV electrostatic discharges, such as turn signal switch handle,

的DUT 表面实施±25 KV静电放电，例如转向灯开关手柄、车窗开关，无钥匙进入按键。

4) 测试过程中需要对 DUT 的功能状态进行监测。

5) 测试过程中应尽可能将 DUT 与实车状态下的负载进行连接。

6) 如果 DUT 存在远端的接头或通过开关控制的信号输入端，且该接头可能被驾驶员接触到(USB、CAN、AUX、车载逆变器输出端)，那么在测试过程中，需要对这些接触点进行放电测试。

7) 对于通过开关控制的 LED 灯具，在闭合、断开开关的状态下分别对LED 灯具接插件引脚实施空气放电测试。

8) 对于每个放电位置和放电电压，至少进行 3 次放电，完成一次放电后，需使用放电电阻接触放电位置以释放积累的电荷。两次放电之间的时间间隔最小为1 s。

window switch, keyless entry button, are provided for direct contact with the DUT directly in the passenger compartment and directly in the passenger compartment but accessible directly from the vehicle exterior.

4) During the test, the performance level of the DUT needs to be monitored.

5) The test process should be as much as possible to load the DUT and real car state connection.

6) If the DUT has a remote connector or a signal input that is controlled by a switch that may be touched by the driver (USB, CAN, AUX, car inverter output), these contacts are required during the test Point for discharge test.

7) For the LED lamps controlled by the switch, the LED lamp connector pins are respectively subjected to the air discharge test while the switch is closed and the switch is closed.

8) For each discharge location and discharge voltage, at least three discharges are performed, and after one discharge is completed, the discharge resistor is used to contact the discharge location to release the accumulated charge. The minimum time between discharges is 1 s.

16.3 评价标准

16.3.1 静电放电限值要求

对每个规定的放电点，按照要求的放电电压分别使用正、负极放电3次。静电放电测试限值要求如表36所示。

对于从车外能直接接触到的位置，例如门把手内部的天线或开关、后备箱裸露的的电器、发

16.3 Evaluation Standard

16.3.1 ESD Limit Requirement

For each specified discharge point, in accordance with the requirements of the discharge voltage were used positive and negative discharge three times. Electrostatic discharge test limits are given in Table 36.

For locations that are directly accessible from outside the vehicle, such as the inside

动机舱的电器部件、LED 灯具、方向盘上的功能按键、转向灯手柄、小灯开关等，才实施±25 KV 静电放电测试，放电网络使用150 pF 和2000 Ω。

of a door handle, an antenna or switch, an electrical appliance exposed within a trunk, electrical components of the engine compartment, LED lamps, function keys on the steering wheel, turn signal handle, small light switch, etc., ± 25 KV ESD test should be conducted and the discharge network to be used is 150 pF and 2000 Ω.

表 36 静电放电测试限值要求

Table 36 Electrostatic discharge test limits

工作状态 Operating Status	放电类型 Discharge Class	电压等级 Voltage Level	放电网络 Discharge Network	功能状态要求 Performance Level Requirement			
				A类 Class A	B类 Class B	C类 Class C	D类 Class D
断电 Unpowered	引脚接触放电 Pin Contact Discharge	±4 KV	C=150 Pf,R=330 Ω	I	I	I	I
	接触放电 Contact Discharge	±6 KV	C=150 Pf,R=330 Ω	I	I	I	I
	空气放电 Air Discharge	±8 KV	C=330 Pf,R=2 KΩ	I	I	I	I
通电 Powered	接触放电 Contact Discharge	±4 KV	C=150 Pf,R=330 Ω	I	I	I	I
		±6 KV	C=150 Pf,R=330 Ω	I	I	I	I
		±8 KV	C=150 Pf,R=330 Ω	I	I	I	I
	空气放电 Air Discharge	±6 KV	C=330 Pf,R=2 KΩ	I	I	I	I
		±8 KV	C=330 Pf,R=2 KΩ	I	I	I	I
		±15 KV	C=330 Pf,R=2 KΩ	II	II	II	II
		±25 KV	C=150 Pf,R=2 KΩ	III	III	III	III