



上汽股份有限公司技术中心企业技术标准 Enterprise Technical Standard of SAIC Motor Technical Center

SMTc 3 800 006—2011 (V1)

电子电器零件/系统电磁兼容测试规范

General specification for electrical/electronic components and
subsystems, electromagnetic compatibility

2011-01-13 发布/Issue

2011-01-14 实施/Implementation

上汽股份技术中心技术标准化委员会 发 布
Technical Standardization Committee of SAIC Motor Technical Center Issue

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前 言

为规范 SMTC 零件的电磁兼容要求，特制订本标准。

本标准是对 MGR ES 62.21.627 《车辆电磁兼容》的修订，本标准实施之日起代替 MGR ES 62.21.627。当中英文产生疑义时，以中文为主。

当中英文产生疑义时，以中文为准。

本标准由整车试验分标委、电子电器分标委提出。

本标准由 SMTC 技术标准化委员会批准。

本标准由标准化工作组归口管理。

本标准起草部门：试验认证部、电子电器部。

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本标准于 2011 年 1 月 13 日首次批准发布，2011 年 1 月 14 日实施。

Foreword

This standard is established for the premise to specify the EMC requirement of electrical / electronic components.

This standard is a revision of MGR ES 62.21.627 Automotive Electromagnetic Compatibility, and replace MGR ES 62.21.627 since the date this standard is implemented.

In the event of a conflict between Chinese and English, Chinese shall take precedence.

This standard was proposed by vehicle test sub-committee and Electronic & Electric sub-committee.

This standard was approved by the SMTC Technical Standardization Committee.

This standard is under the management of Standardization working team..

The drafting departments of this standard are: Test & Validation Dept and Electronic & Electric Dept..

The main drafters of this standard are: Ma Fangchi, Gao Jing, Wang Wei, Gong Hongbing, Hao Fei.

This standard was first published on Jan.13, 2011 and implemented on Jan.14, 2011.

电子电器零件/系统电磁兼容 测试规范

1 范围

本标准规定了SMTC研发生产的车载电子、电器零件、系统的电磁兼容（EMC）要求、测试方法及测试顺序。

本标准适用于汽车电器/电子装置、总成、组件及零件。

本标准为基础技术标准，供应商所开发的产品需符合本标准的要求。

任何与本标准要求不一致的更改都必须获得SMTC的认可。

2 规范性引用文件

下列文件中的条款通过本标准的引用而成为本标准的条款。凡是注日期的引用文件，其随后所有的修改单（不包括勘误的内容）或修订版均不适用于本标准，凡是不注日期的引用文件，其最新版本适用于本标准。

ISO 7637-1-2002 道路车辆—由传导和耦合引起的电骚扰 第1部分：定义和一般要求

ISO 7637-2-2008 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 7637-3-2007 道路车辆—由传导和耦合引起的电骚扰 第3部分：

ISO 10605-2008 道路车辆—静电放电测试方法

ISO 11452-1-2005 道路车辆—电子器件抗窄带辐射骚扰测试方法 第一部分：一般定义及术语

ISO 11452-2-2004 道路车辆—电子器件抗窄带辐射骚扰测试方法 第二部分：自由场法

General specification for electrical/electronic compo nents and subsystems, ele ctromagnetic compatibility

1 Scope

This standard provides SMTC R & D car electronics, electrical components, the system electromagnetic compatibility (EMC) requirements, test methods and test sequence.

The standard applies to electrical and electronic devices, assemblies, modules and components.

The standard basis for the development of technical standards, vendors have developed products subject to the requirements of this standard.

Any inconsistencies with this standard changes that must be SMTC recognition.

2 Normative references

The following normative documents contain provision which, through reference in this text, constitute provisions of this standard. For dated reference, subsequent amendments to, or revisions of, any of these publications do not apply (exclude the correction), but parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards. For undated references, the latest edition of the normative document referred to applies.

ISO 7637-1-2002 Radio vehicles Electrical disturbances from conduction and coupling Part 1: Definitions and general considerations

ISO 7637-2-2008 Radio vehicles Electrical disturbances from conduction and coupling Part 2: Electrical transient conduction along supply lines only

ISO 7637-3-2007 Radio vehicles Electrical disturbances from conduction and coupling Part 3: Electrical transient transmission by capacitive and inductive coupling via lines other than supply lines

ISO 10605-2008 Road vehicles-Test methods for electrical disturbances from electrostatic discharge

ISO 11452-1-2005 Road vehicles - Component test methods for electrical disturbances from narrowband radiated electromagnetic energy Part 1: General principles and terminology

ISO 11452-2-2004 Road vehicles - Component test methods for electrical disturbances from narrowband radiated electromagnetic

ISO 11452-4-2005 道路车辆—电子器件抗窄带辐射骚扰测试方法 第四部分：大电流注入法

ISO 11452-8-2007 道路车辆—电子器件抗窄带辐射骚扰测试方法 第八部分：抗电磁场干扰

ISO/IEC 17025 检测和校准实验室能力认可准则

CISPR 25-2008 用于保护车载接收机的无线电骚扰特性的限值和测量方法

3 术语及定义

下列术语及定义适用于本标准。

3.1 半电波暗室

除地板以外，其余内表面均装有吸波材料的屏蔽室。

3.2 天线因子

用于将测量接收机输入端获得的电压，转换为天线处测得的场强值。天线校正因子由天线系数和电缆系数组成。

3.3 天线匹配单元

在天线测量频率范围内，用于与 50 Ω 测量接收机达成阻抗匹配的天线阻抗匹配单元。

3.4 性能等级

由买卖双方同意，并记录在试验计划总的执行限值。

3.5 接收机终端电压（天线电压）

由无线电骚扰源产生的电压，由符合 CISPR 16 规定的无线电骚扰测量仪器测量，以 dB μ V 表示。

3.6 人工电源网络（AN）/线性阻抗稳定网络（LISN）

串接在被试设备电源进线处的网络。它在给定频率范围内，为骚扰电压的测量提供规定的负载阻抗，并使被试设备与电源相互隔离。

3.7 检波器

探测器的输出电压，这是一个适用于信号包

energy Part 2: Absorber-lined chamber

ISO 11452-4-2005 Road vehicles - Component test methods for electrical disturbances from narrowband radiated electromagnetic energy Part 4: Bulk current injection(BCI)

ISO 11452-8-2007 Road vehicles - Component test methods for electrical disturbances from narrowband radiated electromagnetic energy Part 8: Immunity to magnetic fields

ISO/IEC 17025 Accreditation Criteria for the Competence of Testing and Calibration Laboratories

CISPR 25-2008 Radio disturbance characteristics for the protection of receivers used on board vehicles, boats, and on devices -Limits and methods of measurement

3 Term and definition

For the purposes of this document, the following terms and definitions apply.

3.1 Absorber lined shielded enclosure (ALSE)

Shielded enclosure/screened room with radio frequency-absorbing material on its internal ceiling and walls.

3.2 Antenna factor

The factor which is applied to the voltage measured at the input connector of the measuring instrument to give the field strength at the antenna.

3.3 Antenna matching unit

A unit for matching the impedance of an antenna to that of the 50 Ω measuring instrument over the antenna measuring frequency range.

3.4 Class

A performance level agreed upon by the purchaser and the supplier and documented in the test plan.

3.5 Receiver terminal voltage (antenna voltage)

The voltage generated by a source of radio disturbance and measured in dB μ V by a radio disturbance measuring instrument conforming to the requirements of CISPR 16.

3.6 Artificial network (AN) ; line impedance stabilization network (LISN)

A network inserted in the supply lead or signal/load lead of apparatus to be tested which provides, in a given frequency range, a specified load impedance for the measurement of disturbance voltages and which may isolate the apparatus from the supply or signal sources/loads in that frequency range.

3.7 Average detector

A detector, the output voltage of which is

络的平均值。

3.8 带宽

3.8.1 带宽（测试设备）

设备或传输通道的给定特性偏离其参考值，但不超过某一规定值或比率时的频带宽度。

3.8.2 （发射或信号）带宽

任一带外频谱分量的电平都不超过参考电平中的某一规定百分比的频带宽度。

3.9 宽带发射

带宽大于某一特定的测量设备或接收机带宽的发射。

3.10 骚扰抑制

减弱或消除电磁骚扰的措施。

3.11 骚扰电压

在规定条件下测得的两分离导体上两点间由电磁骚扰引起的电压。

3.12 电磁环境

存在于给定场所的所有电磁现象的总和。

3.13 接地参考平面（接地平板）

一块导电平面，其电位用作公共参考电位。

3.14 窄带发射

带宽小于特定测量设备或接收机的带宽的发射。

3.15 峰值检波器

输出电压力所施加信号峰值的检波器。

3.16 准峰值检波器

具有规定的电气时间常数的检波器，当施加规则重复等幅脉冲时，其输出电压是脉冲峰值的分数，并且此分数随脉冲重复率增加。

3.17 屏蔽室

专门为隔离室内和室外的电磁环境而设计的屏栅或整体金属封闭室。其目的是阻止室外的电磁场干扰室内的环境，并阻止对室外各种电磁活动产生干扰发射。

3.18 耦合

电路间的互感作用，能量从一个规定位置传输到另一个规定位置。

3.18.1 耦合网络

the average value of the envelope of an applied signal.

3.8 Bandwidth

3.8.1 Bandwidth (of an equipment)

The width of a frequency band over which a given characteristic of an equipment or transmission channel does not differ from its reference value by more than a specified amount or ratio.

3.8.2 Bandwidth (of an emission or signal)

The width of the frequency band outside which the level of any spectral component does not exceed a specified percentage of a reference level.

3.9 Broadband emission

An emission which has a bandwidth greater than that of a particular measuring apparatus or receiver.

3.10 Disturbance suppression

Action which reduces or eliminates electromagnetic disturbance.

3.11 Disturbance voltage; interference voltage (deprecated in this sense)

Voltage produced between two points on two separate conductors by an electromagnetic disturbance, measured under specified conditions.

3.12 Electromagnetic environment

The totality of electromagnetic phenomena existing at a given location.

3.13 Ground (reference) plane

A flat conductive surface whose potential is used as a common reference.

3.14 Narrowband emission

An emission which has a bandwidth less than that of a particular measuring apparatus or receiver.

3.15 Peak detector

A detector, the output voltage of which is the peak value of an applied signal.

3.16 Quasi-peak detector

A detector having specified electrical time constants which, when regularly repeated identical pulses are applied to it, delivers an output voltage which is a fraction of the peak value of the pulses, the fraction increasing towards unity as the pulse repetition rate is increased.

3.17 Shielded enclosure; screened room

A mesh or sheet metallic housing designed expressly for the purpose of separating electromagnetically the internal and the external environment.

3.18 Coupling

Interaction between circuits, transferring energy from one circuit to another.

3.18.1 Coupling network

Electrical circuit for the purpose of trans-

为传输电路能量从一个到另一个为目的的电路。

3.18.2 去耦合网络

为减弱或消除电路能量由一个电路转移到另一个电路的电路。

3.19 大电流注入

大电流注入。对于线束进行射频耦合的方式。

3.20 电流注入探头

不通过切断导线而向导线中注入电流的设备，也不会向该电路引入阻抗。

3.21 前向功率

由放大器活信号发生器提供的输出功率。

3.22 静电放电

具有不同静电电位的物体相互靠近或直接接触引起的电荷转移。

3.23 产品功能重要性划分

Region I: 任何为驾驶员及成员提供便利的功能，但失效后不会影响车辆的行驶安全；

Region II: 提高车辆的操作/控制的功能，但对于车辆的操作/控制功能不具决定性作用并且失效后不会影响车辆的行驶安全；

Region III: 对于车辆的操作和控制起决定性作用并且对车辆或行人造成安全影响的功能。

3.24 性能等级划分

Class A: 被测件或系统的所有功能在干扰之时和干扰之后正常运转，符合设计要求；

Class B: 在受干扰时，被测件或系统的所有功能正常运转。但是，一项或多项功能运转会偏离指定误差。所有功能在干扰撤离后能自动恢复至正常状况，但记忆功能应为 Class A；

Class C: 被测件或系统的一项或多项功能在受干扰时不能正常运转，但在干扰撤离后能自动恢复至正常状况，但记忆功能不能受到影响；

Class D: 在受干扰之时和受干扰之后，设备和系统的功能不能正常运转，但在去除干扰并通过操作者/用户复位启动后，还可以正常运转，但记忆功能不能受到影响；

Class E: 在受干扰之时和受干扰之后，设备和系统的功能不能正常运转，并且如果不对设备或系统进行维修或替换，则功能不能恢复至正常状况。

ferring energy from one circuit to another.

3.18.2 De-coupling network

Electrical circuit for the purpose of reducing or eliminating disturbances coupled from one circuit to another.

3.19 Bulk current inject

Total amount of common mode current in a harness.

3.20 Current injection probe

Device for injecting current in a conductor without interrupting the conductor and without introducing significant impedance into the associated circuits.

3.21 Forward power

Power supplied by the output of an amplifier or generator.

3.22 ESD

The Phenomenon that the objects with different electrostatic potentials near or direct contact with each other due to charge transfer.

3.23 Functional Importance Classifications

Region I: Any function that provides a convenience.

Region II: Any function that enhances, but is not essential to the operation and/or control of the vehicle.

Region III: Any function that controls or affects the essential operation of the vehicle or could confuse other road users.

3.24 Function performance class

Class A: The function shall operate as designed (or meet specified limits) during and after exposure to a disturbance.

Class B: All functions of a device or system perform as designed during exposure; however, one or more of them may go beyond the specified tolerance. All functions return automatically to within normal limits after exposure is removed. Memory functions shall remain class A.

Class C: One or more functions of a device or system do not perform as designed during exposure but return automatically to normal operation after exposure is removed.

Class D: One or more functions of a device or system do not perform as designed during exposure and do not return to normal operation until exposure is removed and the device or system is reset by a simple "operator/use" action.

Class E: One or more functions of a device or system do not perform as designed during and after exposure and cannot be returned to proper operation without repairing or replacing the device or system.

4 一般测试要求

所有运用于测试的系统及设备必须经过 ISO/IEC 17025 (或 SMTC 指定) 的计量审核或具有相应认证资格的国家实验室进行测试, 必须具有可追溯性。

应注意控制辐射和抗干扰能力测试中的射频范围, 以减少试验件、试验台和电磁环境之间产生不利的相互作用。

应将测试设备、测试装置和测试程序作为测试实验室的程序的一部分记录到文件中。SMTC 保留检查实验室程序的权力。

然而, 测试针对一个零件、一个包含多个零件的子系统 (例如音视频零件) 都是允许的但需经过 SMTC 的批准。

要求所有 EMC 测试都应有符合 SMTC 要求格式的 EMC 测试计划。测试要求参见第 6 章节中的细节要求。

4.1 测试夹具

通过建立模拟车辆系统 (即负载模拟器) 的测试以便为被测样件提供便利的试验测试条件。图 1 所示的测试夹具带有屏蔽外壳, 外壳包含所有试验样件常配装置的外部电气接口 (传感器、负载等)。

尽可能地使用那些将用于生产的部件作为负载。这对于电感和脉冲宽度调制 (PWM) 电路尤为重要。如果无法使用实际负载, 模拟的负载应精确代表产品车中实际的电阻、电容和电感。不可使用简单的电阻负载, 除非可以证明它确实存在于实际的车辆设备中。

如果被测样件的电源来自其他电子模块 (如传感器), 应能准确反映模块电源的电流极限。测试夹具中如包含有源装置, 但应采取适当措施, 防止在抗干扰测试中对辅助设备造成潜在影响, 或影响辐射发射的测试结果。任何正常连接到车身的电气负载应参考试验设备外壳的情况 (图 1)。试验设备在抗扰测试中既是测试样件

4 Common Test Requirements

All test equipment used for measurement shall be calibrated in accordance with ISO 17025 (or as recommended by SMTC) traceable to NIST or other equivalent national standard laboratory.

Attention shall be directed to control of the RF boundary in both emission and immunity tests to reduce undesired interaction between the DUT, the Test Fixture and the electromagnetic environment.

The test equipment, test set-ups and test procedures shall be documented as part of the test laboratory's procedures. SMTC reserves the right to inspect the lab procedures.

Although testing generally involves only one physical component, subsystem testing involving multiple components (e.g. distributed audio components) is permissible, but need approved by SMTC.

All EMC testing requires an EMC test plan in accordance with the requirements of SMTC's format. See chapter 6 for additional details.

4.1 Test Fixture

DUT operation shall be facilitated by use of a Test Fixture that is constructed to simulate the vehicle system (i.e. load simulator). The Test Fixture, illustrated in Figure 1, is a shielded enclosure that contains all external electrical interfaces (sensors, loads etc.) normally seen by the DUT.

Production intent components should be used for the loads wherever possible. This is particularly critical for inductive and pulse width modulated (PWM) circuits. If actual loads are not available, simulated loads shall accurately represent the resistance, capacitance and inductance that is expected in a production vehicle. Simple resistive loads shall not be used unless proven to exist in the actual vehicle installation.

If the DUT is powered from another electronic module (e.g. sensors), the current limitation of the module's power supply shall be accurately reflected. Active devices may be contained within the Test Fixture, but appropriate steps shall be taken to prevent potential influences on the support equipment during immunity testing and influence on test results for radiated emissions. Any electrical loads that are normally connected to the vehicle body shall be referenced to the Test Fixture case (Figure 1). The Test Fixture also serves both as an RF Boundary for the DUT and an interface to test support equipment required to facilitate operation of the DUT and monitoring

的测试负载，同时也是便利试验件操作、监控试验件关键功能所需的测试辅助设备的接口。一般而言，所有的输入输出应参考位于试验台上的已有电源接地，并连接到试验台外壳(图 1)。当包装规定要求试验件的局部接地时，可以例外不遵守这个规定。

应尽可能使用光学纤维连接被测样件的输入/输出信号和远程测试辅助设备(图 1)。

合理的选择光纤的频率带宽以避免耦合无用信号，以及对测试辅助设备造成的潜在影响。在确保不影响试验结果的前提下，也可以使用屏蔽电缆代替光纤，但是测试夹具和测试实验室墙壁之间的距离要尽可能的短。应密切注意并确认这些电缆不会影响测试结果。应在 EMC 测试计划中记录这些电缆的配置(即路线、屏蔽接地等)。

应使用射频滤波器以防止射频能量杂散造成监控/辅助设备故障。如果使用射频滤波器，应当选择不影响元件操作，并且在 EMC 测试中不影响元件性能的射频滤波器。应在 EMC 测试计划中记录射频滤波器的电容。

of its critical functions during immunity testing. In general, all inputs and outputs shall be referenced to power ground established at one point within the Test Fixture and connected to the Test Fixture case (Figure 1). Exceptions to this requirement include conditions where packaging requirements dictate local grounding of the DUT.

Fiber optic media should be used wherever possible to connect DUT inputs and outputs to remotely located test support instrumentation (see Figure 1). The frequency bandwidth of the fiber optic media shall be selected to avoid unintentional signals from coupling to, and potentially affecting the test support instrumentation. Shielded cables, although not recommended, may also be used in lieu of fiber optic media but should be as short as possible between the Test Fixture and the wall of the test chamber. Note that great care should be given to make sure these cables do not influence the test results. Configuration of these cables (i.e. routing, shield grounding etc.) shall be documented in the EMC test plan.

RF filtering should be used to prevent stray RF energy from causing monitoring/support instrumentation to malfunction. If RF filtering is used it shall be selected so that it does not affect the operation of the component and/or influence the component's performance during EMC testing. RF filter capacitance shall not exceed what is normally seen by the component. RF filter capacitance shall be documented in the EMC Test Plan.

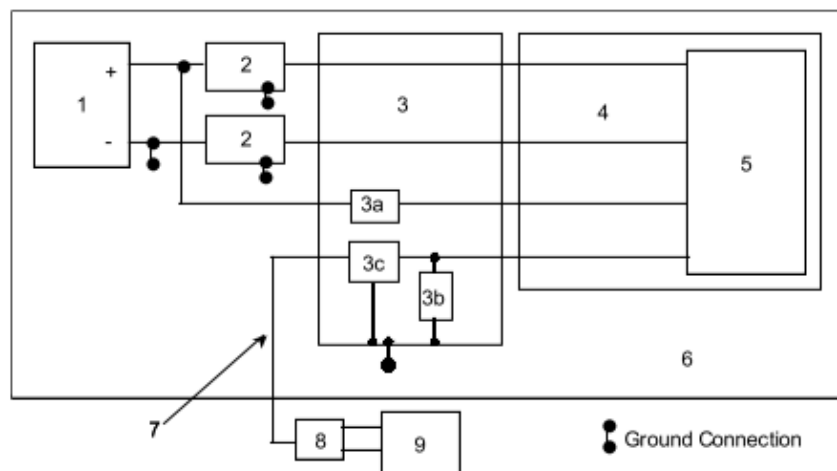


图 1 测试夹具

Figure 1 Test Fixture

说明 description:

1——电源 Power Supply

2——人工网络 Artificial Network

3——测试台 Test Fixture

3a——测试样件负载(参考电源) DUT Load(referenced

4——绝缘支架 ($\epsilon \leq 1.4$) Insulated support

5——测试样件 DUT

6——接地平板 Ground Plane

7——光纤 Fiber optic

to power supply)

3b——测试样件负载（参考测试台外壳）DUT Load(referenced to Test Fixture case)

3c——光纤接口（可选，可设置于测试台外）Fiber Optic Interface(optional, may be located outside of Test Fixture)

8—— 光纤接口 Fiber Optic Interface

9—— 辅助/监控设备 Support/Monitoring Equipment

4.2 人工网络

本标准中有数个测试要求使用人工网络。除非本标准另有说明，否则人工网络的使用与连接应依照图 1 所示设定进行。人工网络的设计和性能特征应符合 CISPR（国际无线电干扰特别委员会）25(版本 3)。

4.2 Artificial Networks

Several tests in this specification require the use of Artificial Networks. Unless otherwise stated in this specification the use and connection of Artificial Networks shall be in accordance to the set-up shown in Figure 1. Artificial Network design and performance characteristics shall conform to CISPR 25, Edition 3.

4.3 连接要求

应使用标准测试线缆，方便被测样件和测试辅助设备的相互电气连接。除非本标准另有说明，否则该线缆的长度应 $1700\text{ mm}+300/-0\text{ mm}$ 。线缆应能代表实车使用的线束。

4.3 Interconnections

The electrical interconnections between the DUT and Test Fixture shall be facilitated using a standard test harness. The length of this harness shall be $1700\text{ mm}+300/-0\text{ mm}$ unless otherwise stated within this specification. The harness shall contain wiring that represents what is use in the actual vehicle installation.

4.4 测试条件

4.4.1 尺寸要求

除非另有规定，否则本标准中的所有尺寸单位为 mm。

4.4 Test Condition

4.4.1 Dimensions

All dimensions in this document are in millimeters unless otherwise specified.

4.4.2 公差

除非另有说明，允许存在表 1 中所述的公差。

4.4.2 Tolerance

Unless indicated otherwise, the tolerances specified in Table 1 are permissible.

表 1 允许公差

Table 1 Permissible Tolerances

电压、电流 Supply voltage and current	$\pm 5\%$
时间、长度 Time interval, length	$\pm 10\%$
电阻、电容、电感、阻抗 Resistance, capacitance, inductance, impedance	$\pm 10\%$
射频场强度、电场或磁场强度、注入电流、电源、能量、瞬态电压压振幅（若可调）的测试参数 Test parameters for RF field strength, Electrical or magnetic field strength, injected current, power, energy, transient voltage amplitude (if adjustable)	$+10\% \sim 0\%$

4.4.3 测试环境条件

除非另有说明，表 2 中规定了测试的气候条件。

4.4.3 Environment Test Condition

Unless indicated otherwise, the climatic test conditions are defined in Table 2.

表 2 测试环境条件

Table 2 Environment Test Condition

温度 Temperature	$(23 \pm 5)^\circ\text{C}$
湿度 Humidity (静电放电测试 ESD test)	20 %~80 %相对湿度 (30 %~60 %)

4.4.4 电源

除非本标准另有规定，否则电源电压应为 $13.5\text{ V} (+0.5\text{ V} / -1.0\text{ V})$ 之间。电源电压测量

4.4.4 Power supply

The power supply voltage shall be between $13.5\text{ V} (+0.5\text{ V} / -1.0\text{ V})$ unless otherwise stated within this specification. The power

位置为人工网络输出端。有些测试仅能使用一个车载电池作为供电电源。在这样的条件下，测试中的电池电压不得低于 12 V。测试中可对电池充电，但仅能使用线性电源进行充电。对于某些测试（例如辐射发射测试、抗扰测试），这样做的同时要求线性电源位于屏蔽室之外。同时还需要使用人工电源网络做隔离，以防止寄生射频信号进入或泄漏出屏蔽室。

4.5 测试负载

如无特殊说明，被测样件在抗扰测试中需使用实际的电器负载进行测试，在骚扰测试中需使用等效的模拟负载进行测试。电机类产品测试应在最大负载条件下测试，且确保负载本身不会影响测试结果。

应在测试计划中详细描述负载的相关信息。

4.6 测试线束

如无特殊说明，测试用线束规格（包括线径、材质等）均需与实车使用线束一致，线束长度应符合本标准中各测试项目的要求。

应在测试计划中详细描述测试线束的相关信息。

5 补充要求

5.1 功能重要性分类/性能要求

本标准要求所有的零件和子系统功能依照其在车辆整车操作中的重要性进行分类（即功能重要性分类）。在测试批准之前，应完成所有部件功能的分类。在许多情况下，常规功能已经预先分类完毕。如果引入了新的功能，供应商应协同 SMTC 的 PDT（产品设计开发）小组协商制定适当的分类。

功能分类确定后，应开发相关的性能要求并将其记录在部件或子系统的工程规格说明书中。在 EMC 测试中，部件/子系统的验收标准便是基于这些性能要求。SMTC 的 PDT 小组及其供应商应负责改进这些性能要求。

supply test point is the AN output. For some tests, only an automotive battery may be used. Under those conditions, the battery voltage shall not fall below 12 V during testing. The battery may be charged during testing, but only with a linear power supply is used. For some testing (e.g. radiated emissions, immunity) this may require that the linear power supply be located outside of the shielded enclosure. A bulkhead RF filter may be used to prevent stray RF signals from entering or leaving the shielded enclosure.

4.5 Load

The actual load should be used during the immunity test and the simulated load should be used in the emission test unless otherwise stated within this specification. The test sample according to the motor category should be tested in the max. load which should not be interfered the test results.

It is very important to describe the load information in the test plan.

4.6 Test harness

The actual wiring harness(include the radius material etc.) which used in the vehicle should be used in the test unless otherwise stated within this specification, and the length of test harness should be according to this specification.

It is very important to describe the test harness information in the test plan.

5 Additional Requirements

5.1 Functional importance classification/Performance Requirement

This specification requires that all component and subsystem functions be classified according to their criticality in the overall operation of the vehicle (i.e. Functional Importance Classification). Classification of all component functions shall occur prior to program approval. In many cases common functions have been previously classified. If new functions are introduced, the supplier(s) shall work with the SMTC PDT (product design team) to develop and agree to the appropriate classifications.

Once these functional classifications are established, the associated performance requirements shall be developed and documented in the component or subsystem's engineering specification. These performance requirements serve as the basis for the component/subsystem acceptance criteria used during EMC testing. The SMTC PDT and their supplier(s) shall be responsible for developing these performance requirements.

5.2 EMC 测试计划

详细的 EMC 测试计划应在测试开始前至少 30 天提交给 SMTC 产品开发小组进行审核。

EMC 测试计划也提供了一个不断改进和完善的测试平台,以便更好地与整车级的测试关联起来。

EMC 测试计划应按照 SMTC 的格式进行编制, SMTC 保留审查和更改 EMC 测试计划的权力,包括详细的抗扰性测试接受标准。上汽集团接受 EMC 测试计划并没有剥夺供应商的责任,如果后面的审查发现,在测试设置和/或接受标准方面存在缺陷。供应商应与 SMTC 的产品开发小组联系并纠正缺陷,如果 SMTC 有要求,应对产品进行复测。

5.3 样件数量

每个测试项目的测试样件最少不得低于 2 个,且每个产品都需通过测试计划中要求的所有项目的测试并符合要求。

5.4 测试顺序

非工作模式(不上电模式)和工作模式(上电)的静电放电测试(如章节 7.4.5 所示)推荐在其它测试项目开始之前进行测试。确保进行其他项目测试的样件都是经过 ESD 测试的,其余所有的测试项目可以按照任意顺序进行。注意,由于静电放电测试可能引起的损害,我们推荐准备备用的测试样品。但是,所有因为静电放电而进行的纠正性措施都需要重新测试。在任何测试项目一旦出现问题时,应立即联系 SMTC PDT 小组。

5.5 复测

为确保不断地符合 EMC 要求,当任何电路或 PCB 设计变动(如新的 PCB 布局等)都需要增加相应的 EMC 测试来进行验证。对零件的任何更改都须提供详细的书面的整改报告给 SMTC 的 PDT 小组。最终由 SMTC PDT 小组将根据实际情况同意或减少重复测试的程度。

5.6 测试实验室要求

所有测试都应在 SMTC 认可的 EMC 测试试验室中进行,无论它是属于部件供应商,还是属于独立测试服务机构的一部分。

注: SMTC 保留安排后续相关测试和/或实地访问,以评估本文试验方法的权利。

5.7 测试报告

5.2 EMC Test Plan

An EMC test plan shall be prepared and submitted to the SMTC PDT 30 days prior to commencement of EMC testing.

The EMC test plan also provides a mechanism for ongoing enhancements and improvement to the test set-up, which better correlates with vehicle level testing.

The EMC test plan shall be prepared in accordance with the format of SMTC's requirement.

SMTC reserves the right to review and challenge specific detail of the EMC test plan, including specific acceptance criteria for immunity testing. Acceptance of the EMC test plan by SMTC does not relinquish the supplier from responsibility if latter review shows deficiencies in the test set-up and/or the acceptance criteria. The supplier shall work with the SMTC PDT to correct any deficiency and repeat testing if required by SMTC.

5.3 Sample Size

A minimum of two samples shall be tested. All applicable tests are performed on each of the samples.

5.4 Sequence of Testing

ESD handling tests (see section 7.4.5) shall be performed prior to any other testing. All other tests may be performed in any order. Note that extra test samples are recommended in the event of damage due to ESD. However, any corrective design actions required to mitigate ESD issues will require retesting. The SMTC PDT shall be contacted immediately in the event that any issues are encountered.

5.5 Re-validation

To assure that EMC requirements are continually met, additional EMC testing shall be required if there are any circuit or PCB design changes (e.g. new PCB layout). Any changes to the components required to provide a detailed written report to the SMTC of the rectification of the PDT. And ultimately by the SMTC PDT will be based on actual consent, or reduce the extent of repeat tests.

5.6 Test Laboratory Requirements

All tests should be done in SMTC approved EMC tests laboratory, regardless of it whether to belong to the part supplier or belong to an independent test service part.

Note: The SMTC retention the right to arrange following dependence test and/or the field visits, appraise this specification testing method.

5.7 Test Report

A summary of the EMC test results shall

电子电器零件或集成系统供应商应在测试完成后 5 个工作日内向 SMTC 产品开发小组提交一份汇总的测试报告。供应商应同样应在测试完成后 15 个工作日内向 SMTC 产品开发小组提交一份详细的测试报告。所有的测试报告应包含用于追述测试计划的编号及测试试验室的签发文件。对于每个测试详细的要求也应记录在测试报告中。测试报告应以 PDF 格式提交。开发性质的测试数据不适用此要求。

6 应用要求

表 3 列出本标准所述的所有电磁兼容性要求以及电气/电子部件的适用范围。表 3 为推荐测试要求，最终以 SMTC 工程师签署的测试计划为准。

be reported by the E/E component or subsystem supplier directly to the SMTC PDT within 5 business days following completion of testing. The supplier shall also forward a copy of the detailed test report to the SMTC PDT within 15 business days following testing. All test reports shall include the reference test plan tracking number and sign-off by the laboratory verifying the test results. Specific reporting requirements for each requirement delineated herein. The report shall be presented using either Adobe PDF formats. These reporting requirements do not apply to developmental test data.

6 Application requirement

Table 3 lists all of the specifications described in the electromagnetic compatibility requirements as well as electrical / electronic components of the application in this specification. The recommend test requirement are list in table 3, but the final test requirement should according to the test plan which have been signed off by SMTC engineer.

表 3 测试要求矩阵图
Table 3 Test Requirement Matrix

章节号 Section No.	零件种类 Component Category 测试项目 Test Requirement	零件种类/Component Category								
		无源 ^a 器件 Pas- sive Mod- ules	电感 ^b 装置 Induc- tive De- vices	电机 ^c Electric Mo- tors		有源电子模块 ^d Active Electronic Modules				
		P ^e	R	BM	EM	A	AS	AM	AX	AY
辐射 Emission										
7.1.1	射频辐射发射 Radiated Emission	——	——	√	√	√	√	√	√	√
7.1.2	传导发射 Conducted Emission	——	——	√	√	√	√	√	√	√
7.1.3	瞬态传导发射 Conducted Transient Emission	——	√	√	√	——	——	——	√	√
辐射抗干扰 Radiated Immunity										
7.2.1	射频抗扰-自由场法 RF Immunity-Anechoic Chamber	——	——	——	√	√	√	√	√	√
7.2.2	射频抗扰-大电流注入法 RF Immunity-BCI	——	——	——	√	√	√	√	√	√
7.2.3	磁场抗扰 Magnetic Field Immunity	——	——	——	√ ^f	——	——	√	——	——
瞬态抗干扰 Transient Immunity										
7.3.1	耦合抗干扰 Couple/inductive Tran- sient Immunity	——	——	——	√	√	√	√	√	√
7.3.2	瞬态传导抗干扰 Conducted Transient Immunity	√	——	——	√	√	√	√	√	√

表 3 测试要求矩阵图 (续)

Table 3 Test Requirement Matrix (continuous)

章节号 Section No.	零件种类 Component Category 测试项目 Test Requirement	零件种类/Component Category								
		无源 ^a 器件 Pas- sive Mod- ules	电感 ^b 装置 Induc- tive De- vices	电机 ^c Electric Mo- tors		有源电子模块 ^d Active Electronic Modules				
P ^e	R	BM	EM	A	AS	AM	AX	AY		
传导抗干扰 Conducted Immunity										
7.4.1	连续抗干扰 Continuous Immunity	—	—	—	√	√	—	√	√	√
7.4.2	起动抗干扰 Starting Immunity	√	—	—	√	√	—	√	√	√
7.4.3	参考地和电源偏移 Ground and supply offset	—	—	—	√	√	—	√	√	√
7.4.4	电压跌落 Voltage drop	—	—	—	√	√	√	√	√	√
7.4.5	静电放电 ESD	√	—	—	√	√	√	√	√	√
<p>a 无源器件 P:仅由无源元器件组成的电子模块。如: 电阻、电容、电感、二极管、LED 等/ A passive electrical module consisting of only passive components. Examples: resistor, capacitor, inductor, blocking or clamping diode, Light Emitting Diode (LED), thermistor</p> <p>b 电感装置 R: 继电器、螺线管、喇叭/Relays, solenoids and horns</p> <p>c 电机 Motor:</p> <p>有刷电机 BM: 由电刷驱动的电机电机。/A brush commutated dc electric motor.</p> <p>无刷电机 EM: 由电子器件控制的电机。/ An electronically controlled electric motor.</p> <p>d 有源电子模块 Active Electronic Modules:</p> <p>A: 包括有源电子元器件的零件, 如: 模拟放大电路, 开关电源, 基于微处理器的控制器及显示器。/A component that contains active electronic devices. Examples include analog op amp circuits, switching power supplies, microprocessor based controllers and displays.</p> <p>AS: 由另外一个调制电源提供电源的模块, 通常为给控制器提供信号的传感器。/An electronic component or module operated from a regulated power supplier located in another module. This is usually a sensor providing input to a controller.</p> <p>AM: 自身包含磁性灵敏元件或连接到外部磁性灵敏元件的零件或模块。/An electronic component or module that contains magnetically sensitive elements or is connected to an external magnetically sensitive element.</p> <p>AX: 自身包装内包含一电气或电子控制的电机, 或控制外部电感应装置 (包括电子或电气控制的电机)。/An electronic module that contains an electric or electronically controlled motor within its package or controls an external inductive device including electric or electronically controlled motor(s).</p> <p>AY: 自身包含磁性继电器的电子模块。/An electronic module that contains a magnetically controlled relay within its package.</p> <p>e 该类测试仅适用于直接连接到蓄电池上产品 (包括直接连接或通过开关连接)。/Applies only to devices connected to the vehicle power supply (direct or switched connections).</p> <p>f 该测试仅适用于内置霍尔元件的电机。/Applies only to motors with integral Hall Effect sensors.</p>										

7 零件、系统要求

7.1 干扰

7.1.1 辐射发射

7.1.1.1 设备

测试设备应符合 CISPR 25-2008 的要求。

前置放大器/预选器: 由于需要预先确认外界低功率的微信号, 在接收机前需要加装前置放

7 System/Component Test Requirement

7.1 Interference

7.1.1 Radiated RF Emission

7.1.1.1 Equipment

The test equipment shall comply with the requirements of CISPR 25-2008.

Preamplifier/Pre-selector: Due to the extremely low level signals that must be observed, a

大器(或预选器)以提高、改进测试系统的灵敏度。(可选)

测试接收机或频谱仪参数设置应符合 CISPR 25-2008 的要求。

测试天线:

- a) 0.15 MHz~30 MHz 1 m 单极垂直天线;
- b) 30 MHz~200 MHz 双锥天线;
- c) 200 MHz~1 000 MHz 对数周期天线;
- d) 1 000 MHz~2 500 MHz 喇叭天线或对数周期天线。

7.1.1.2 校验和测试布置

除非另有说明,应使用 CISPR 25-2008 (第三版)中半电波暗室法的要求来验证被测样件的性能。零件在测试期间的工作模式需要在 EMC 测试计划中详细定义下来,该测试计划需要获得零件供应商及零件/系统工程师及 SMTC PDT 工程师的确认。

被测样件及测试辅助设备中的电子硬件的供电需使用车载蓄电池(参见 4.4.4 节的要求)。蓄电池的负极端须与接地平板连接到一起。蓄电池可以置于接地平板上或者置于测试台下方。标准的测试布置图(测试工装、蓄电池、人工网络)参见图 1 要求。

测试用线束的总长度应为 1 700 mm (+300 mm/-0 mm)。线束与被测样件的位置应被固定,且线束弯曲的半径角度应在 90° 到 135° 之间,如图 2 所示。线束应置于接地平板上 50 mm 厚的绝缘垫之上。

如被测样件的外壳为金属材料且在整车上的安装位置为外壳接地,则该样件在测试时应直接将其与接地平板连接到一起。如被测样件的外壳在整车上不是直接连到车身上,被测样件需要放置在接地平板上 50 mm 厚的绝缘垫上。如果对以上两种情况均不明确,则被测样件需要按上述两种要求进行测试。被测样件的放置位置及放置方向应在 EMC 的测试计划和测试报告中详细说明。

preamplifier (or pre-selector) may be required ahead of the receiver to improve the system sensitivity. (option)

The test equipment parameter shall comply with the requirements of CISPR 25-2008.

Test antenna:

- a) 0.15 MHz to 30 MHz 1 m vertical monopole;
- b) 30 MHz to 200 MHz a biconical antenna;
- c) 200 MHz to 1 000 MHz a log-periodic antenna;
- d) 1 000 MHz to 2 500 MHz a horn or log-periodic antenna.

7.1.1.2 Test Verification and Test Set-up

The requirements of CISPR 25-2008 (Edition 3), ALSE method shall be used for verification of the DUT performance except where noted in this specification. Component operation during testing shall be documented in an EMC test plan prepared by the component/subsystem supplier and SMTC PDT engineers.

The DUT and any electronic hardware in the Test Fixture shall be powered from an automotive battery (see paragraph 4.4.4 for requirements). The battery negative terminal shall be connected to the ground plane bench. The battery may be located on, or under the test bench. The standard test set-up shown in Figure 1 shall be used for the Test Fixture, battery and Artificial Networks.

The total harness length shall be 1 700 mm (+300 mm /-0 mm). Location of the DUT and Test Fixture requires that the harness be bent. The harness bend radius shall be between 90° and 135° as illustrated in Figure 2. The harness shall lie on an insulated support 50 mm above the ground plane.

If the outer case of the DUT is metal and can be grounded when installed in the vehicle, the DUT shall be mounted and electrically connected to the ground plane during the test. If the DUT case is not grounded in the vehicle, the DUT shall be placed on an insulated support 50 mm above the ground plane. If there is uncertainty about this, the DUT shall be tested in both configurations. The DUT position/orientation shall be documented in the EMC test plan and test report.

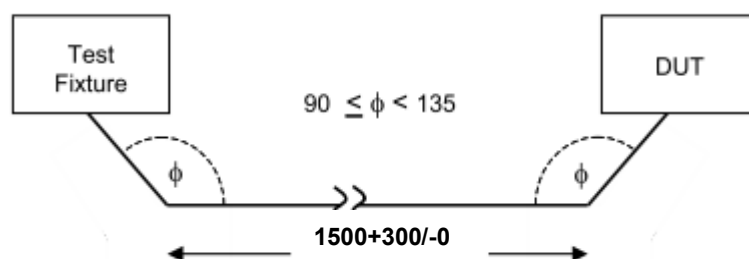


图 2 测试线束弯曲半径要求
Figure 2 Test Harness Bend Radius Requirements

7.1.1.3 程序

- a) 在测试被测样件的辐射骚扰值之前应确认整个测试布置（包括所有设备，被测样件除外）的背景噪声至少比表 5 中规定的限值低 6 dB 以上。如果整个背景噪声达不到这个限值要求，不建议执行该测试除非该问题已得到解决；
- b) 被测试样件应按照图 3 所示流程进行测试；
- c) 被测样件辐射骚扰限值的测试应覆盖表 5 中所列出的各频段。当测试频率 ≥ 30 MHz 时，需要分别测试在水平极化和垂直极化两个方向的值；
- d) EMC 测试计划中所定义被测样件工作模式都应进行测试。

7.1.1.3 Procedure

- a) Prior to measurement of DUT radiated emissions, test set-up ambient levels (i.e. all equipment energized except DUT) shall be verified to be 6 db or more below the specified requirements listed in Tables 5. If this requirement is not met, testing shall not proceed until the associated test set-up issues are resolved;
- b) The DUT should be tested following the test flow according to figure 3;
- c) Measurement of DUT radiated emissions shall be performed over all frequency range listed in Tables 5. At measurement frequencies ≥ 30 MHz, measurements shall be performed in both vertical and horizontal antenna polarizations;
- d) Tests shall be repeated for all DUT operating mode(s) delineated in the component EMC test plan.

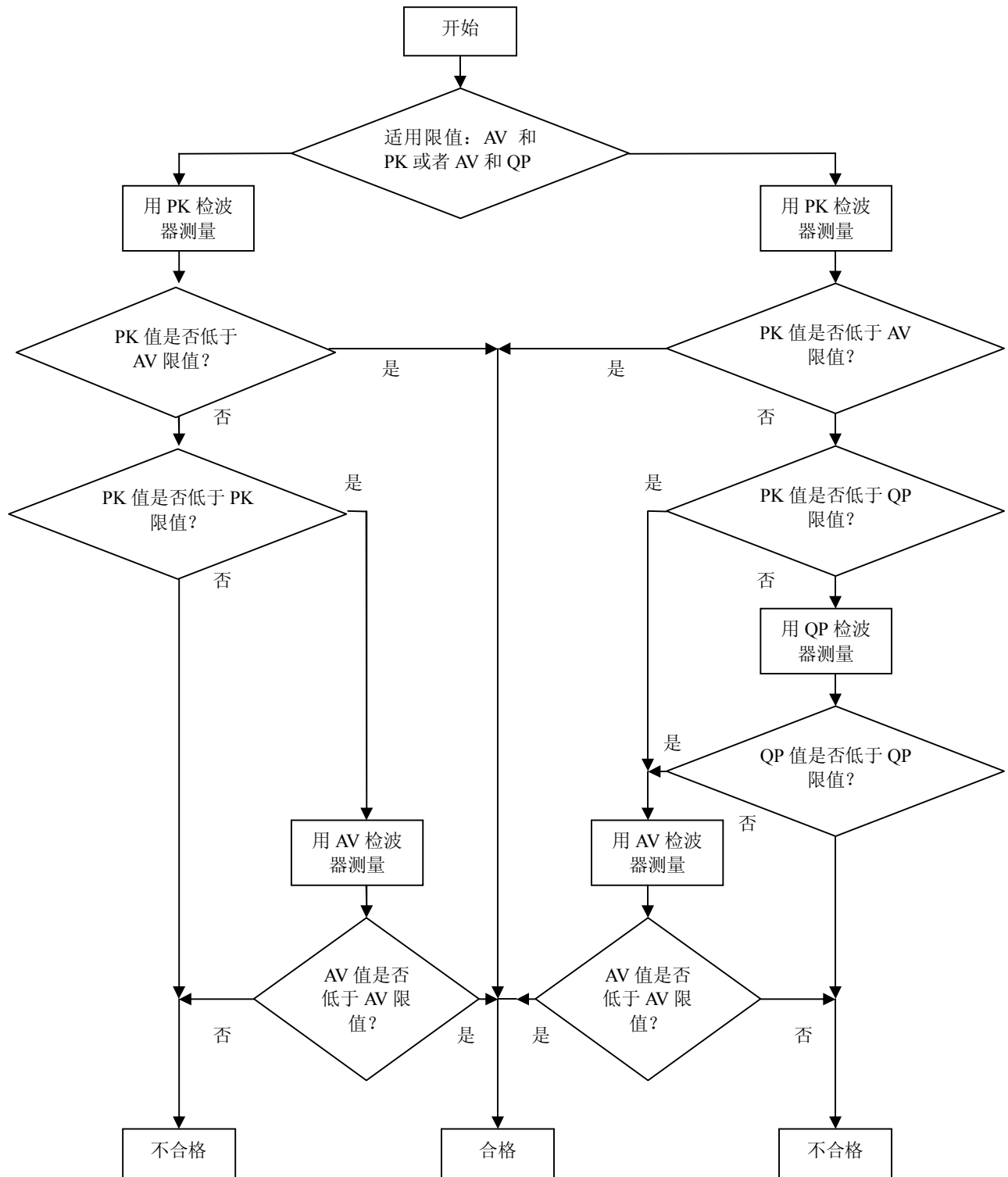


图 3 测试流程

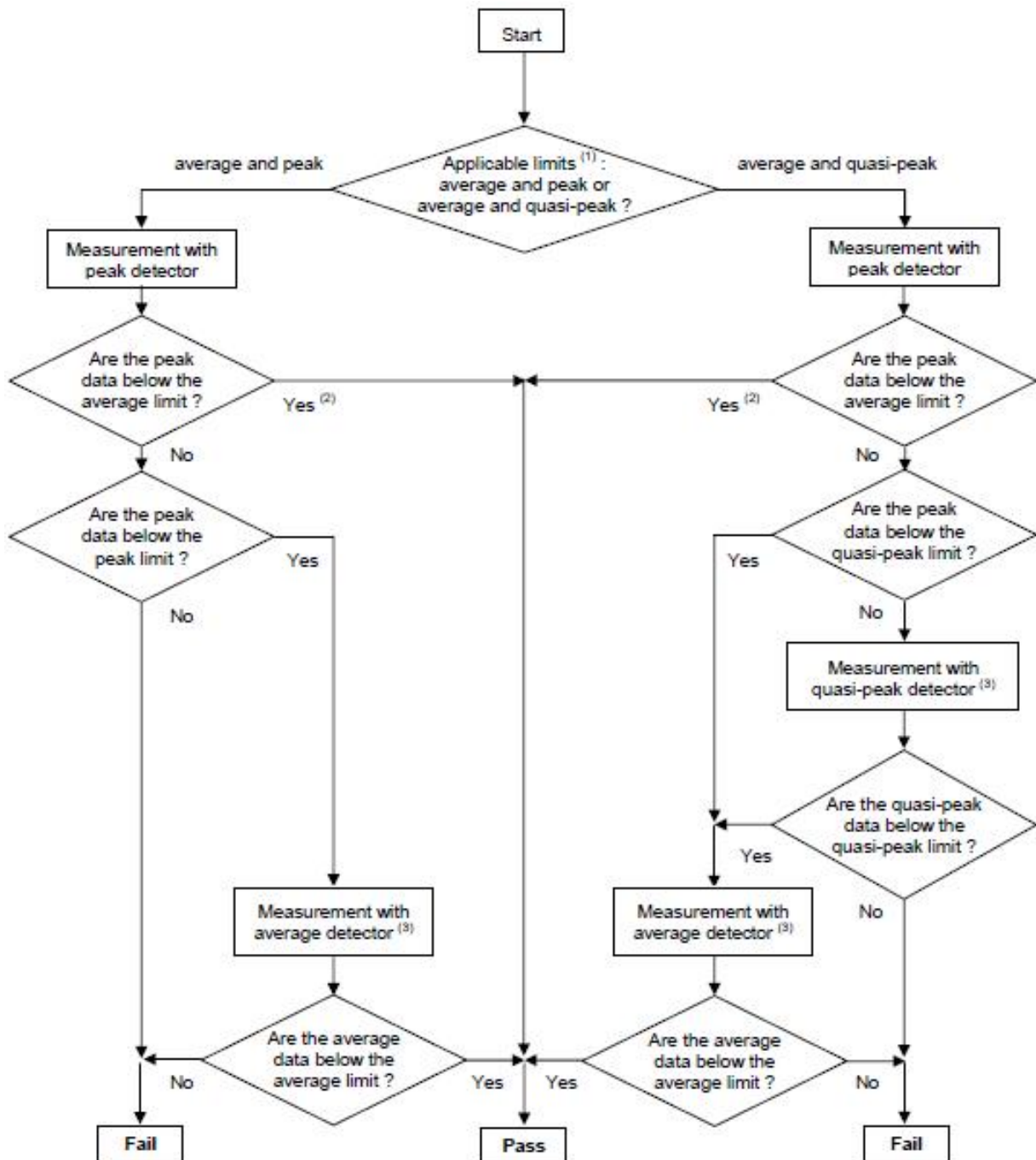


Figure 3 flow chart

7.1.1.4 要求

被测试样件辐射骚扰测试要求覆盖 0.15 MHz~2 500 MHz 频段。各频段的限值见表 5 中要求。

被测试样件的辐射骚扰限值还需符合表 4 中各频段的要求。

限值要求分别见图 4 和图 5。

7.1.1.4 Requirements

The DUT radiated emissions requirements cover the frequency range from 0.15 MHz~2 500 MHz. And the emission limits are listed in table 5.

And the DUT radiated emission should also be satisfied the limits are listed in table 4.

The radiated emission limits are painted in figure 4 and figure 5.

表 4 连续限值要求

Table4 Continuous limits values for components

频段 Frequency	频段范围 (MHz)	限值A 准峰值QP (dBuV/m) ^a	限值B 平均值AV (dBuV/m) ^b
M1	30~75	$62-25.13*\text{Log}(f/30)$	$52-25.13*\text{Log}(f/30)$
M2	75~400	$52+15.13*\text{Log}(f/75)$	$42+15.13*\text{Log}(f/75)$
M3	400~1 000	63	53

a f 为测量频率(MHz) 。/f test frequency.

b 全频段需同时符合限值A,和限值B要求, BM类部件, 只需符合限值B要求。/All frequency shall meet Limit A and Limit B,BM parts shall meet Limit B.

c 120kHz带宽检波器 (准峰值和平均值)。/120 kHz band with detector (QP and AV)

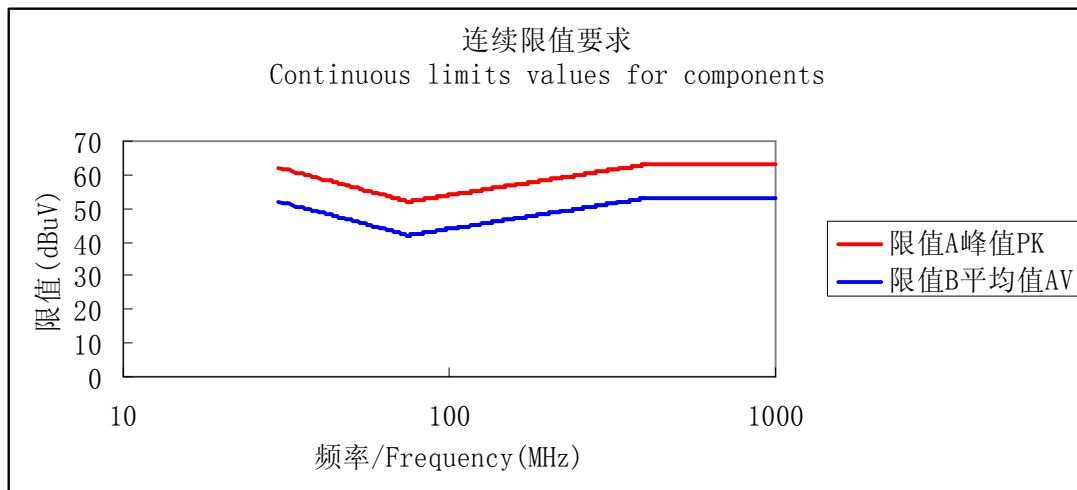


图 4 连续限值要求

Figure 4 Continuous limits values for components

表 5 零件辐射发射限值

Table 5 Limits values for interferences radiated by components

—	限值要求 Levels in dB(μV/m)		
频率 Frequency(MHz)	峰值 Peak	准峰值 Quasi-Peak	平均值 AVG
0.15~0.3 (LW)	56	43	36
0.53~1.8(MW)	40	27	20
5.9~6.2(SW)	46	33	26
26~41	46	33	26
41~68	34	—	24
76~108(VHF)	38	25	18
142~170	41	28	21
170~245	32	—	22
300~330	38	—	24
380~470	44	31	24
470~770	51	—	41
820~960	50	37	30
1 447~1 494	34	—	24
1 567~1 574	—	—	$50-20\ 664*\text{log}(f/1567)$
1 574~1 576	—	—	10
1 576~1 583	—	—	$10+20\ 782*\text{log}(f/1576)$
1 803~2 172	50	—	30
2 320~2 345	46	—	36
2 400~2 500	56	—	36

注 1: LW,MW,SW 和 VHF 频段, 需同时满足 PK,QP,和 AV 限值要求。
Note1: In the LW,MW,SW and VHF frequency ranges, the limit values for average, peak and quasi-peak must be complied.

注 2: 对于短时型骚扰源 (如后视镜调节电机), 在获得 SMTC 工程部门同意的情况下限值可以增加 10dB。
Note2: For short-term interference(e.g. rearview mirror actuator motors),limits may be increased by 10dB by only agreement with the SMTC engineering department.

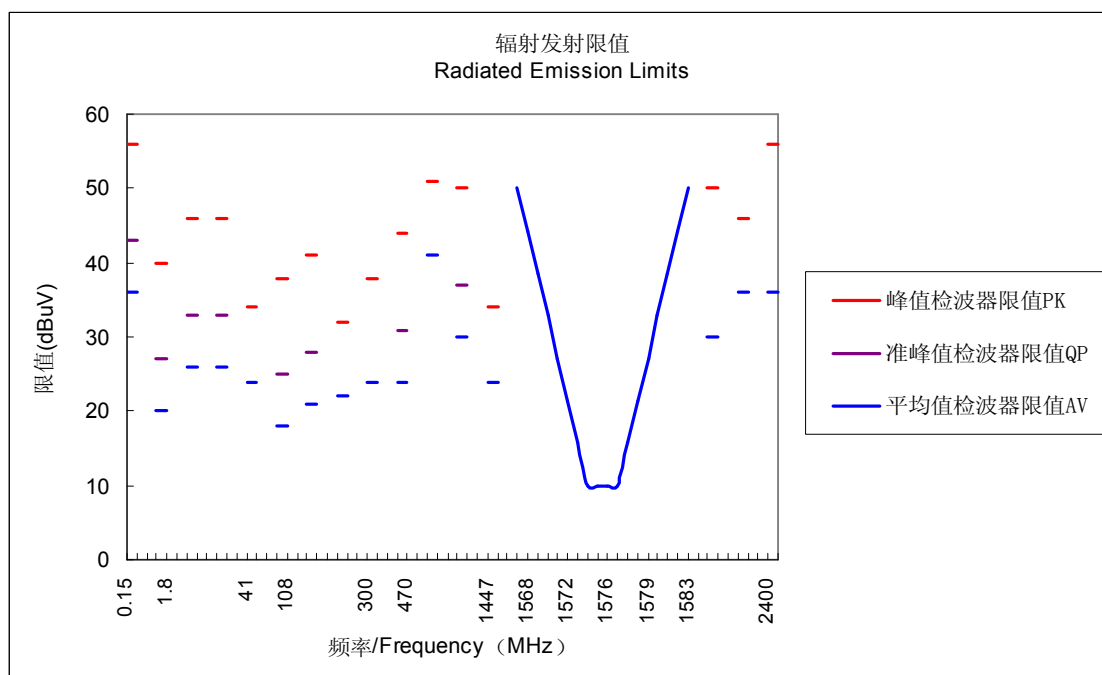


图5 辐射发射限值

Figure 5 Limits values for interferences radiated by components

7.1.1.5 报告

所有工作模式和极化方向的测试数据应总结在单页报告中。数据应包含下列信息：

- 被测样件的工作模式；
- 参考限值；
- 天线极化方向；
- 测量系统的带宽；
- 检波器的类型（如：峰值检波器、准峰值检波器、平均值检波器）；
- 被测样件在每个频段辐射限值的描点图；
- 应列出被测样件在每个频段的概要表，该表应包括测试频段、在这个频段内被测样件最大的辐射骚扰值。不满足该频段辐射限值的地方需要明确的标注出来。

增加的信息包括：

- 每个频段及不同极化下测试系统的背景噪声及限值图应附在数据中，这些图中应标明测量系统带宽及所使用检波器的类型；
- 所有与测试计划中规定不符的偏差都应记录在测试数据中。

7.1.2 传导发射

7.1.2.1 传导发射-电压法

7.1.1.5 Test Report

The test data shall be summarized in single page for each DUT operating mode and antenna polarization. The data sheet shall include the following information:

- DUT operating mode;
- Limit reference;
- Antenna polarization;
- Measurement system bandwidth (MBW);
- Detection scheme (i.e. Peak, Quasi Peak, Average);
- Plotted emissions data over each frequency band.
- Tabularized summary for DUT emissions in each frequency band. The table shall include the frequency range, maximum DUT emission level measured for the frequency range, and associated limit. Non-compliance to any frequency range requirement shall be clearly noted.

Additional information required includes:

- Plots of the test set-up ambient data associated with each limit and polarization. These plots shall also include the MBW and the detection scheme used;
- Any deviations in the test procedure, as delineated in the EMC test plan, shall be noted.

7.1.2 Conducted Emission

7.1.2.1 Conducted Emission-Voltage Me-

7.1.2.1.1 设备

测试设备应符合 CISPR 25 的要求。

7.1.2.1.2 校验和测试布置

除非另有说明, 应使用 CISPR 25-2008 (第三版) 中电压法的要求来验证被测样件的性能。

被测样件及测试辅助设备中的电子硬件的供电需使用车载蓄电池(参见 4.4.4 节的要求)。蓄电池的负极端须与接地平板连接到一起。

被测样件与人工网络之间电源/电源回路线束的长度应为 200 mm (+50 mm /-0 mm)。

如被测样件的外壳为金属材料且在整车上的安装位置为外壳接地, 则该样件在测试时应直接将其与接地平板连接到一起。如被测样件的外壳在整车上不是直接连到车身上, 被测样件需要放置在接地平板上 50 mm 厚的绝缘垫上。如果对上述两种情况不明确, 则被测样件需要按上述两种要求进行测试。

如果被测样件的接地线为直接接到车身上(线长<200 mm), 则接地线应直接连接到接地平板上。在这个条件下接地线端的人工网络可以忽略不使用。

7.1.2.1.3 程序

- a) 在测试被测样件的传导骚扰值之前应确认整个测试布置(包括所有设备, 被测样件除外)的背景噪声至少比表 6 中规定的限值低 6 dB 以上。如果整个背景噪声达不到这个限值要求, 不建议执行该测试除非该问题已得到解决。
- b) 被测样件的传导骚扰值应按表 6 中各频段的要求进行测试;
- c) 测试应覆盖测试计划中队被测样件定义的所有工作模式。

7.1.2.1.4 要求

所有被测样件的电源线正极及开关正极都应分开单独连接到人工网络的输出端。

传导发射的电压限值应满足表 6 中的要求, 该值不包含人工网络的修正因子。

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7.1.2.1.1 Equipment

The test equipment shall comply with the requirements of CISPR 25.

7.1.2.1.2 Test Verification and Test Set-up

The requirements of CISPR 25-2008 (Edition 3), voltage method shall be used for verification of the component performance except where noted in this specification.

The DUT and any electronic hardware in the Test Fixture shall be powered from an automotive battery (see paragraph 4.4.4 for requirements).

The battery negative terminal shall be connected to the ground plane.

The power/power return wiring between the DUT and the Artificial Network shall be 200 mm (+50 mm /-0 mm) in length.

If the outer case of the DUT is metal and can be grounded when installed in the vehicle, the DUT shall be mounted and electrically connected to the ground plane during the test. If the DUT case is not grounded in the vehicle, the DUT shall be placed on an insulated support 50mm above the ground plane. If there is uncertainty about this, the DUT shall be tested in both configurations.

If the DUT's power return is locally grounded in the vehicle (< 200 mm), the power return shall be connected directly to the ground plane. Under these conditions, the Artificial Network connected to the DUT's power return may be omitted.

7.1.2.1.3 Procedure

- a) Prior to measurement of DUT conducted emissions, test set-up ambient levels (i.e. all equipment energized except DUT) shall be verified to be 6 db or more below the specified requirements listed in Table 6. If ambient levels are less than 6 db below the specified limits, testing shall not proceed until the associated test set-up issues are resolved;
- b) Measurement of DUT conducted emissions shall be performed over each frequency range listed in Table 6;
- c) Tests shall be repeated for all DUT operating mode(s) delineated in the component EMC test plan.

7.1.2.1.4 Requirement

All DUT B+ and switched B+ shall be single connected to the output of the artificial network.

The voltage level of the conducted emissions shall not exceed the levels of Tables 6. The limits apply for artificial networks without

限值要求见图 6。

correction factors applied.

The emission limits are painted in figure 6.

表 6 传导发射限值—电压法
Table 6 Conducted Emission Limit-Voltage method

频率 Frequency(MHz)	限值要求 Levels in dB(μV)		
	峰值 Peak	准峰值 Quasi-Peak	平均值 AVG
0.15~0.3	80	67	60
0.53~1.8	54	41	34
5.9~6.2	59	46	39
26~41	50	37	30
41~68	40	—	30
68~108	38	25	18

注/Note: 对于短时型骚扰源(如后视镜调节电机), 在获得 SMTC 工程部门同意的情况下限值可以增加 10 dB。
For short-term interference(e.g. rearview mirror actuator motors), limits may be increased by 10dB by only agreement with the SMTC engineering department.

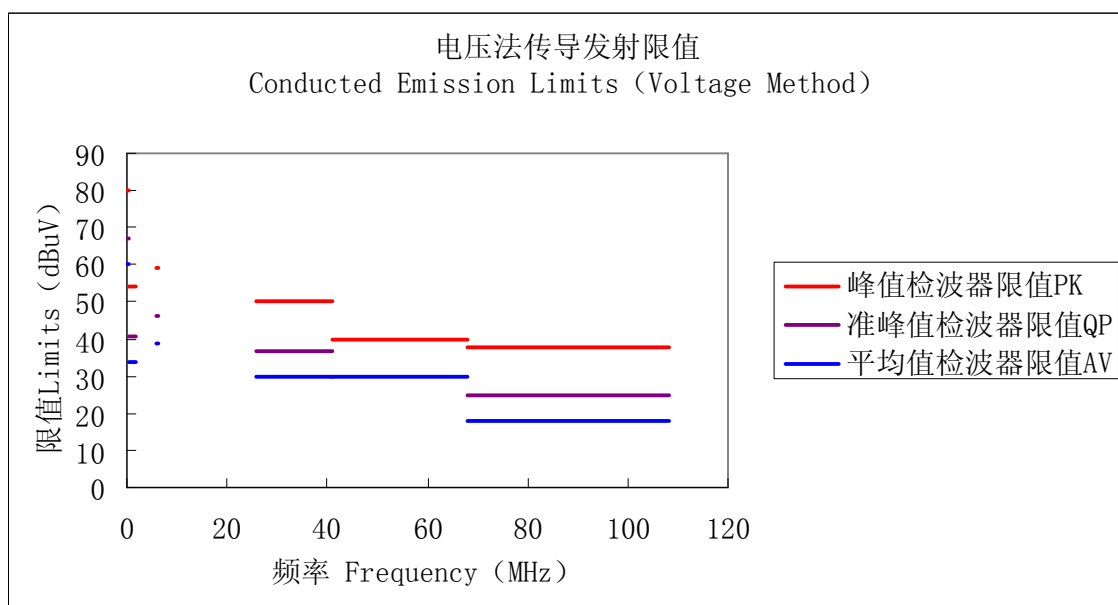


图 6 传导发射限值-电压法
Figure 6 Conducted Emission Limit-Voltage method

7.1.2.1.5 报告

所有被测样件的辐射测试数据的描点图及其限值描点图都应汇总在单页纸报告中。该报告的格式与辐射发射的要求类似。所有不满足测试要求的数据都应清楚地标注出来。测试报告中应包含测试装置的背景噪声数据。

所有与测试计划中不符的测试操作过程都应在测试报告中标注清楚。

7.1.2.2 传导发射-电流法

7.1.2.2.1 设备

测试设备应符合 CISPR 25 的要求。

7.1.2.2.2 校验和测试布置

除非另有说明, 应使用 CISPR 25-2008 (第

7.1.2.1.5 Report

The test data shall be summarized in single page showing a plot of the measured DUT emissions with a plot of the applicable limits. The format for this shall be similar to that use for radiated emissions. Non-compliance to any frequency range requirement shall be clearly noted. The test report shall also include a plot of the test set-up ambient data.

Any deviations in the test procedure, as delineated in the EMC test plan, shall also be noted.

7.1.2.2 Conducted Emission-Current Method

7.1.2.2.1 Equipment

The test equipment shall comply with the requirements of CISPR 25.

7.1.2.2.2 Test Verification and Test Set-up

The requirements of CISPR 25 -2008(Edition 3), current method shall be used

三版) 中电流法的要求来验证被测样件的性能。

被测样件及测试辅助设备中的电子硬件的供电需使用车载蓄电池(参见 4.4.4 节的要求)。蓄电池的负极端需要与接地平板连接到一起。

被测样件与模拟负载之间的线束长度应为 1 700 mm (+300 mm/0 mm)。

如被测样件的外壳为金属材料且在整车上安装位置为外壳接地, 则该样件在测试时应直接将其与接地平板连接到一起。如被测样件的外壳在整车上不是直接连到车身上, 被测样件需要放置在接地平板上 50 mm 厚的绝缘垫上。如果对以上两种情况不明确, 则被测样件需要按上述两种要求进行测试。

7.1.2.2.3 程序

所有的线束(除电源线及地线)都应放到测试探头(参见 CISPR16-1-2)中。

在距离被测样件线束长度为 50 mm、750 mm 的位置测试辐射值。

在一般情况下, 最大辐射位置点在离被测样件的接插件尽可能近的地方。如果是与被测金属外壳连接器装备, 探测器应夹紧到电缆紧邻连接器外壳, 但不包括连接器外壳本身。被测样件及测试夹具应至少距离测试平板边缘 100 mm。

7.1.2.2.4 要求

所有的信号线及控制线都应进行测试。

传导辐射的限值应符合表 7 中的要求。

限值要求见图 7。

for verification of the component performance except where noted in this specification.

The DUT and any electronic hardware in the Test Fixture shall be powered from an automotive battery (see paragraph 4.4.4 for requirements). The battery negative terminal shall be connected to the ground plane.

The power/power return wiring between the DUT and the Load Simulator shall be 1 700 mm (+300 mm /0 mm) in length.

If the outer case of the DUT is metal and can be grounded when installed in the vehicle, the DUT shall be mounted and electrically connected to the ground plane during the test. If the DUT case is not grounded in the vehicle, the DUT shall be placed on an insulated support 50mm above the ground plane. If there is uncertainty about this, the DUT shall be tested in both configurations.

7.1.2.2.3 Procedure

The probe (see CISPR 16-1-2) shall be mounted around the complete harness (including all wires except power & power return line).

Measure the emissions with the probe positioned 50 mm and 750 mm from the DUT.

In most cases, the position of maximum emission will be as close to the DUT connector as possible. Where the DUT is equipped with a metal shell connector, the probe shall be clamped to the cable immediately adjacent to the connector shell, but not around the connector shell itself. The DUT and all parts of the test set-up shall be a minimum of 100 mm from the edge of the ground plane.

7.1.2.2.4 Requirement

All DUT signal and control lines shall be Tested.

The voltage level of the conducted emissions shall not exceed the levels of Tables 7.

The emission limits are painted in figure 7.

表 7 传导发射限值—电流法
Table 7 Conducted Emission Limit-Current Probe method

频率 Frequency(MHz)	限值要求 Levels in dB(μA)		
	峰值 Peak	准峰值 Quasi-Peak	平均值 AVG
0.15~0.3	60	47	40
0.53~1.8	26	13	6
5.9~6.2	25	12	5
26~41	16	3	-4
41~68	6	—	-4
68~108	4	-9	-16

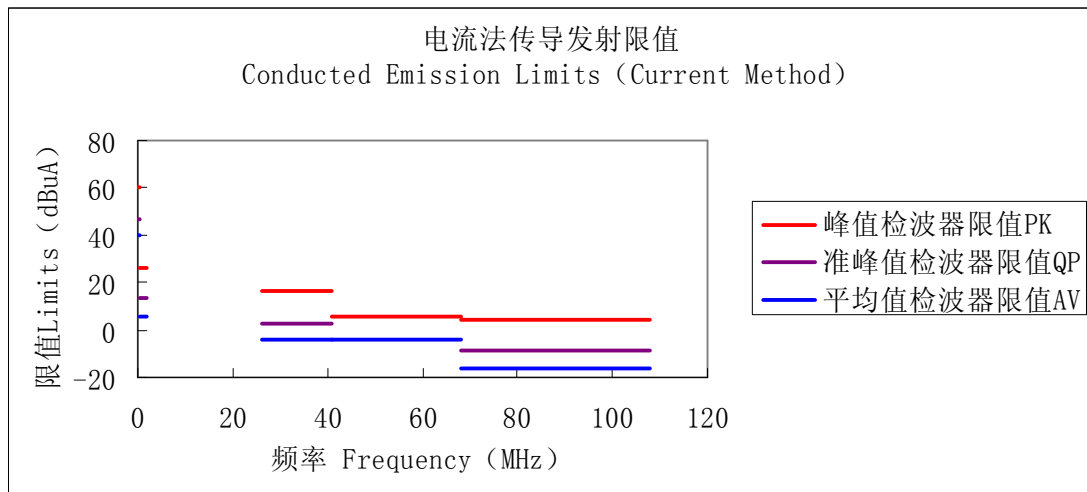


图 7 传导发射限值—电流法

Figure 7 Conducted Emission Limit-Current Probe method

7.1.2.2.5 报告

所有被测样件的辐射测试数据的描点图及其限值描点图都应汇总在单页纸报告中。该报告的格式与辐射发射的要求类似。所有不满足测试要求的数据都应清楚地标注出来。测试报告中应包含测试装置的背景噪声数据。

所有与测试计划中不符的测试操作过程都应在测试报告中标注清楚。

7.1.3 瞬态传导发射

7.1.3.1 设备

测试用设备应符合 ISO 7637-1 和 ISO 7637-2 中的相关要求。

7.1.3.2 校验和测试布置

被测样件的电源线应直接通过单触点机械或电子机械开关连接到人工网络上。该类型开关应符合下列要求：

- 触点容量： $I \geq 30$ A，连续，低阻抗；
- 高纯度镀银触点材料；
- 无抑制作用继电器触点；
- 单/双触点与线圈电路电器绝缘；
- 瞬态抑制作用绕组；

如使用的是实际连接的开关进行测试，则应在测试报告中注明。

被测样件与人工网络之间的线束长度应为 200 mm (+50 mm /-0 mm)。其间不应包含任何的连接器。

车载蓄电池应作为电源给被测样件进行供电。蓄电池的负极端应与接地平板连接到一起。

测试用示波器的采样率应在每秒 1 GHz 以上。

7.1.2.2.5 Report

The test data shall be summarized in single page showing a plot of the measured DUT emissions with a plot of the applicable limits. The format for this shall be similar to that use for radiated emissions. Non-compliance to any band requirement shall be clearly noted. The test report shall also include a plot of the test set-up ambient data.

Any deviations in the test procedure, as delineated in the EMC test plan, shall also be noted.

7.1.3 Conducted Transient Emission

7.1.3.1 Equipment

The test equipment shall comply with ISO 7637-1 and ISO 7637-2.

7.1.3.2 Test Verification and Test Set-up

The DUT power circuit(s) connects directly to the Artificial Network through either mechanical or electromechanical switch with a single set of contacts. The switch shall have the following characteristics:

- contact rating: $I \geq 30$ A, continuous, resistive load ;
- high purity silver contact material ;
- no suppression across relay contact;
- single/double position contact electrically insulated from the coil circuit ;

Coil with transient suppression.

The actual switch used for testing shall be specified in the EMC test report.

The wiring between the DUT and the Artificial Network shall be 200 mm (+50 mm /-0 mm) in length. No other connections shall be made between the switch and the DUT.

An automotive battery shall be used as the power source. The battery negative terminal shall be connected to the ground plane.

A digital sampling scope shall be used for the voltage measurements using a capable

如被测样件的外壳为金属材料且在整车上的安装位置为外壳接地,则该样件在测试时应直接将其与接地平板连接到一起。如被测样件的外壳在整车上不是直接连到车身上,被测样件需要放置在接地平板上 50 mm 厚的绝缘垫上。如果对以上两种情况不明确,则被测样件需要按上述两种要求进行测试。

如果被测样件为电机或执行器,则其在测试中应加载其定义的最大模拟负载。如该电机或执行器在实际的使用过程中可能出现堵转的情况,则应进行堵转情况下的测试,堵转的时间不应超过 1 s。这是为了防止激活被测样件中的保护电路从而限制或中断被测样件电路,达不到相应的测试目的。

7.1.3.3 程序

- a) 闭合外部接触开关同时给被测样件上电,确保被测样件功能正常;
- b) 设置触发电平的限值为+70 V;
- c) 设置时间轴为 1 ms/div;
- d) 将示波器的采样率调整到该时间轴的最大值;
- e) 如果被测样件属于 AX, AY, 那么在 EMC 测试计划中规定的操作模式下使被测样件执行功能时测量并记录瞬间电压的峰值。注意,对于元件种类 BM 和 R,该步骤可以省略;
- f) 对所有由开关控制的零件,必须测量并记录被测样件由非上电模式切换成上电模式的传导峰值电压(对每种工况需进行 10 次测试),控制开关见图 8;
- g) 按如下时间设置重复步骤 d) 到 f):
100 μ s/div
1 μ s/div
0.5 μ s/div
- h) 重新设置触发电平的限值为-80 V,重复步骤 c) 到步骤 e),并记录最小的传导峰值电压。

sampling rate of 1 Giga-samples per second (single shot capability).

If the outer case of the DUT is metal and can be grounded when installed in the vehicle, the DUT shall be mounted and electrically connected to the ground plane during the test. If the DUT case is not grounded in the vehicle, the DUT shall be placed on an insulated support 50 mm above the ground plane. If there is uncertainty about this, the DUT shall be tested in both configurations.

If the DUT is an electric motor or actuator, it shall be mechanically loaded to simulate 100% of its specified maximum loading. Motors and actuators that may stall during normal operation shall be tested in the “stall” condition; however, the stall should not be held longer than one second. This is to prevent activation of in-line protection devices that would limit or interrupt current to the DUT.

7.1.3.3 Procedure

- a) Close the external switch contacts (see Figure 3) and power up the DUT. Verify the DUT is functioning properly;
- b) Set the trigger level of the digital sampling scope to +70 V;
- c) Set the time base to 1 ms/div.;
- d) Adjust the oscilloscope sampling rate to the highest level available for the time base selected;
- e) If the DUT is of component categories AX, AY, measure and record the peak transient voltages while exercising the DUT functions in operating modes identified in the EMC test plan. Note that this step may be omitted for component categories BM and R;
- f) For all component categories with switched power circuits, measure and record peak transient voltages while by turning the DUT off and on ten times (10 measurements for each condition) via the external switch shown in Figure 8;
- g) Repeat step d) through f) for each of the following time base values:
100 μ s/div;
1 μ s/div
0.5 μ s/div
- h) Re-adjust the trigger level of the digital sampling scope to -80 V. Repeat steps c) through e) except record the peak negative transient voltages.

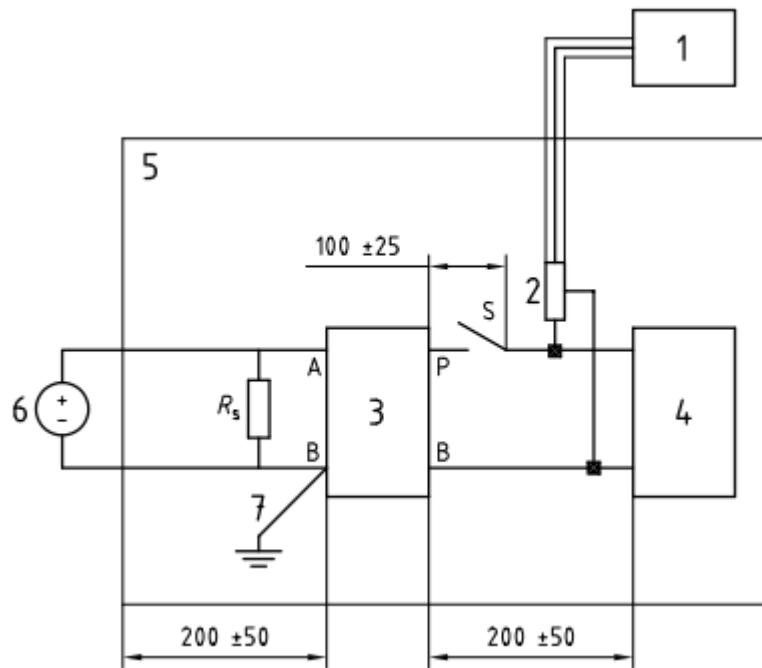


图 8 传导发射测试布置图
Figure 8 Transient Emission Set-up

注：所有尺寸单位为 mm。Note: All dimensions in mm.

说明 description :

1——数字示波器 Digitizing Oscilloscope

2——电压探头 Voltage probe

3——人工网络 Artificial Network (AN)机械/电磁开关 Mechanical /Electromechanical Switch

4——测试样件 DUT

5——接地平板 Ground Plane

6——蓄电池 Battery

7——地线，长度 < 100 mm Ground connection; length < 100 mm

7.1.3.4 要求

被测样件的正极瞬态电压不应超过+75 V，
负极瞬态电压不应超过-100 V。

7.1.3.4 Requirement

The component shall not produce positive transient voltages exceeding +75 volts or negative transient voltages exceeding -100 volts on its power supply circuits.

7.1.3.5 报告

测试报告应包括以下内容：

测试脉冲的描点图。

被测样件的情况描述。

对于脉冲的描点图应添加适当的说明。

7.1.3.5 Report

The following elements shall be included in the test report:

Plots of measured pulses.

Description of DUT conditions.

Appropriate requirement shall be displayed on plot of pulses.

7.2 抗干扰测试

7.2.1 射频抗干扰测试-半电波暗室法

7.2.1.1 设备

测试设备应满足 ISO 11452-1 和 ISO 11452-2 中的要求。

7.2.1.2 校验和测试布置

测试使用替代法进行。

被测样件及测试辅助设备中的电子硬件的供电需使用车载蓄电池（参见 4.4.4 节的要求）。

蓄电池的负极端需要与接地平板连接到一起。蓄电池可以置于接地平板上或者置于测试台下方。标准的测试布置图（测试工装、蓄电池、

7.2 Immunity Test

7.2.1 RF Immunity-ALSE

7.2.1.1 Equipment

The test equipment shall comply with ISO 11452-1 and ISO 11452-2.

7.2.1.2 Test Verification and Test Set-up

The substitution method shall be used.

The DUT and any electronic hardware in the Test Fixture shall be powered from a automotive battery (see paragraph 4.4.4 for requirements).

The battery negative terminal shall be connected to the ground plane bench. The battery may be located on, or under the test bench. The standard test set-up shown in Fig-

人工网络) 参见图 1 要求。

对于频率 $\leq 1\,000\text{ MHz}$ 的测试, 发射天线应置于被测样件线束的中心位置正前方(参照 ISO 11452-2)。对于频率 $\geq 1\,000\text{ MHz}$ 的测试, 天线应沿接地平板前沿平移 750 mm, 正对被测样件。天线的中心应正对被测样件, 不再正对测试线束中心(见图 9)。

线束长度应为 1 700 mm (+300/-0 mm)。被测样件和测试辅助设备线束呈弯曲放置。线束弯曲的角度应在 90° 至 135° 之间, 如图 2 所示。测试线束应置于接地平板 50 mm 厚的绝缘垫上。

如被测样件的外壳为金属材料且在整车上的安装位置为外壳接地, 则该样件在测试时应直接将其与接地平板连接到一起。如被测样件的外壳在整车上不是直接连到车身上, 被测样件需要放置在接地平板上 50 mm 厚的绝缘垫上。如果对以上两种情况不明确, 则被测样件需要按上述两种要求进行测试。被测样件的放置位置及放置方向应在 EMC 的测试计划和测试报告中详细说明。

被测样件需要至少进行三个放置方向上进行测试。

在校准和实际的测试中, 前向功率需要记录作为参考参数。

7.2.1.3 程序

- 测试采用替代法进行, 参照 ISO 11452-2 的要求进行校准和测试;
- 前向功率将作为电磁场的特征参数, 并且需将其运用于实际的测试中;
- 频率步进要求需满足表 8 中的要求, 调制方式需满足表 9 中的要求;
- 所有调制方式的驻留时间(驻留时间: 用于每种射频调制的时间)不应小于 2s;
- 测试极化方式应包括水平极化和垂直极化两种方式;
- 在测试频率范围 $\geq 1\,000\text{ MHz}$ 时, 被测样件应在三个轴向分别进行测试;
- 如在测试中发现测试样件功能出现背离现象, 则测试场强应逐步降低, 直到被测样件功能恢复正常; 此时, 场强应逐步增加, 直到被测样件功能再次发生背离现象。此时, 这个场强值应作为阈值

ure 1 shall be used for the Test Fixture, battery and Artificial Networks.

For frequencies $\leq 1\,000\text{ MHz}$, the field-generating antenna shall be positioned in front of the middle of the harness (refer to ISO 11452-2). For frequencies above $1\,000\text{ MHz}$, the antenna shall be moved 750 mm parallel to the front edge of the ground plane towards the DUT. The center of the antenna shall be pointed directly at the DUT instead of the center of the wiring harness (See Figure 9).

The total harness length shall be 1 700 mm (+300 /-0 mm). Location of the DUT and Test Fixture requires that the harness be bent. The harness bend radius shall be between 90° and 135° degrees as illustrated in Figure 2. The harness shall lie on an insulated support 50 mm above the ground plane.

If the outer case of the DUT is metal and can be grounded when installed in the vehicle, the DUT shall be mounted and electrically connected to the ground plane during the bench test. If the DUT case is not grounded in the vehicle, the DUT shall be placed on an insulated support 50 mm above the ground plane. If there is uncertainty about this, the DUT shall be tested in both configurations. The DUT position/orientation shall be documented in the EMC test plan and test report.

The DUT shall be tested in a minimum of three orientations.

For calibration and during the actual test of a DUT, forward power shall be used as reference parameter.

7.2.1.3 Procedure

- Testing shall be performed using the substitution method. Refer to ISO 11452-2 for calibration and testing;
- Forward power shall be used as reference parameter for field characterization and the actual test of the DUT;
- Use the step frequencies listed in Table 8. Use the modulation as specified in Table 9;
- All modulation dwell time (i.e., time that RF is applied for per modulation type) shall be at least 2 sec;
- The test shall be performed using both horizontal and vertical antenna polarization;
- At test frequencies $\geq 1\,000\text{ MHz}$, the DUT shall be tested in a minimum of three (3) orthogonal orientations;
- If deviations are observed, the field shall be reduced until the DUT functions normally. The field shall then be increased until the deviation occurs. This level shall be reported as deviation

记录在测试报告中。

tion threshold.

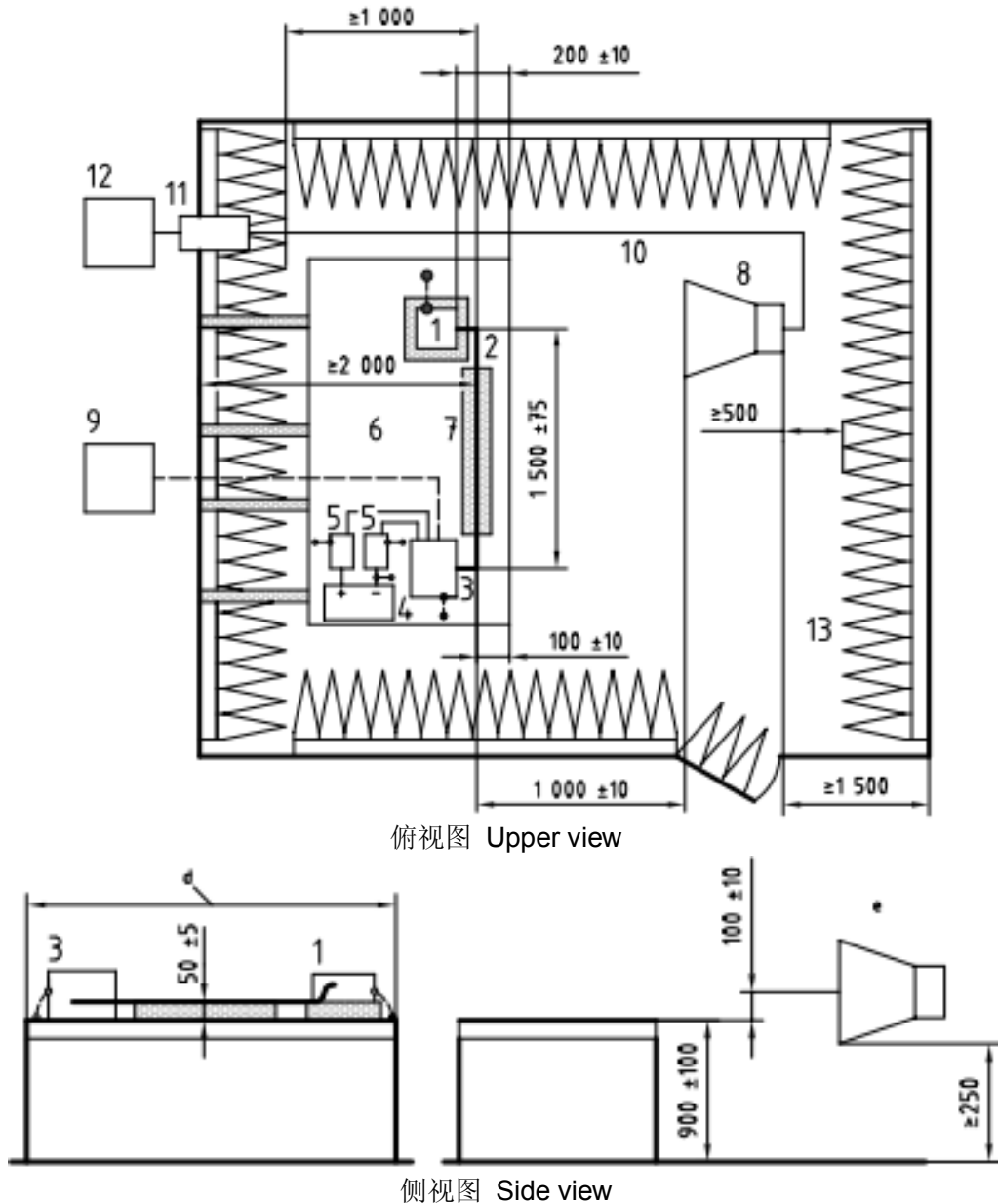


图 9 半电波暗室法测试布置
Figure 9 ALSE Test Set-up (1 000 ~3 000 MHz)

说明 description:

1——被测样件 DUT

2——测试线束 Test harness

3——模拟负载 Load simulator

4——车用蓄电池 Automotive Battery

5——人工网络 Artificial Network

6——接地平板（连接到屏蔽室墙壁）ground plane (bonded to shielded enclosure)

8——喇叭天线 Horn Antenna

9——模拟及监控设备 Stimulation and monitoring system

10——高质量双层屏蔽同轴电缆 High quality double-shielded coaxial cable (50 Ω)

11——隔板连接器 Bulkhead connector

12——射频发生器 RF Generation Equipment

表 8 最大步进频率
Table 8 Max. frequency steps

频率范围 Frequency Range (MHz)	最大步进范围 Max Step Size(MHz)
200~1 000	5
1 000~2 000	10
2 000~3 000	20

表 9 自由场抗射频干扰测试要求

Table 9 Requirement level for the immunity to electromagnetic field for components and subsystems measured in the Anechoic chamber

频率 Frequency(MHz)	Level 1 (V/m)	Level 2 (V/m)	调制方式 Modulation
200~800 ^a	50	100	CW, AM80 %
800~1 000	50	100	CW, AM80 %
800~1 000	50	100	Pulse, ton = 577 μs, T = 4.6 ms
1 000~2 000	50	100	CW, Pulse, ton = 577 μs, T = 4.6 ms
2 000~3 000	50	100	CW, Pulse, ton = 577 μs, T = 4.6 ms
1 200~1 400	300	600	Radar pulse packets PRR=300 Hz, PD=3 μs(+3/-0 μs),with only 50 pulses output every 1 s ^b
2 700~3 100	300	600	
a 其中 200 MHz~400 MHz 只需天线垂直极化, 其余频段需天线垂直极化和水平极化。/The frequency range of 200 MHz~400 MHz just need vertical polarization, other frequency need both vertical and horizontal polarization.			
b 脉冲场强度为最大有效值 (V/m)。/Pulsed field strength requirements are peak V/m (maximum RMS) levels.			

7.2.1.4 要求

被测样件的功能只能在场强值大于表 9 中的要求时才能背离设计要求。

7.2.1.5 报告

以下要素应记录在测试报告中:
详细叙述功能的检测方式
测试所用调制方式
任何出现背离设计要求的现象
检测设备及相应的检测技术
出现背离设计要求时每个频率点的最小场强值

应包含相应的调制方式和计划方式
被测样件三个轴向的测试照片

7.2.2 射频抗干扰测试-大电流注入法

7.2.2.1 设备

测试设备应符合 ISO 11452-1 和 ISO 11452-4 要求。

7.2.2.2 校验和测试布置

ISO 11452-4 中的 BCI 方法将用于验证零件性能, 本标准中注明不做要求的部分除外。

被测样件及测试辅助设备中电子硬件的供电需使用车载蓄电池 (参见 4.4.4 节的要求)。

蓄电池的负极端需要与接地平板连接到一起。蓄电池可以置于接地平板上或者置于测试台下方。标准的测试布置图 (测试辅助设备、蓄电池、人工网络) 参见图 1 要求。

被测样件和测试辅助设备之间的线束长度应为 1 000 mm (+100/-100 mm), 并应放置于接地平板 50 mm 厚的绝缘垫 ($\epsilon_r \leq 1.4$) 上。

测试台架应包含足够大的接地平板, 测试平板的边缘在各个方向都要超出测试装置至少 100 mm。

测试装置与除了接地平板以外的其他所有

7.2.1.4 Requirement

DUT functions may only deviate above the levels according to Table 9.

7.2.1.5 Report

The following elements shall be included in the test report:

Description of the functions monitored.

Modulation status.

Any performance deviations.

Monitoring instrumentation and technique.

Minimum RF field strength at each frequency where deviations occur.

Include modulation and polarization.

Photos of the three DUT positions.

7.2.2 RF Immunity-BCI

7.2.2.1 Equipment

The test equipment shall comply with ISO 11452-1 and ISO 11452-4.

7.2.2.2 Test Verification and Test Set-up

Verification of component performance shall be in accordance with the BCI method (ISO 11452-4) except where delineated in this specification.

The DUT shall be powered from an automotive battery (see paragraph 4.4.4 for requirements).

The battery negative terminal shall be connected to the ground plane. The battery may be located on, or under the test bench. The standard test set-up shown in Figure 1 shall be used for the Test Fixture, battery and Artificial Networks.

The test harness shall be 1 000 mm (+100/-100 mm) long and routed 50 mm above the ground plane on an insulated support ($\epsilon_r \leq 1.4$) over the entire length between the DUT and the Test Fixture.

The test bench shall include a sufficiently large ground plane, such that the plane extends beyond the test set-up by at least 100 mm on all sides.

导电结构的距离应该保证 $\geq 100\text{ mm}$ 。

如被测样件的外壳为金属材料且在整车上的安装位置为外壳接地,则该样件在测试时应直接将外壳与接地平板连接到一起。如被测样件的外壳在整车上不是直接连到车身上,被测样件需要放置在接地平板上 50 mm 厚的绝缘垫上。如果对以上两种情况不明确,则被测样件需要按上述两种要求进行测试。

在测试频率范围内,被测样件的所有线束都应置于注入钳之内。

注入钳应与接地平板绝缘。

在距离被测样件 50 mm 的地方应选择性地放置一个合适的监测电流钳,该电流钳不应影响测试结果(可选)。

7.2.2.3 程序

应使用符合 ISO11452-4 要求的校准注入钳法(替代法)进行测试。

- 前向功率将作为电磁场的特征参数,并且需将其运用于实际的测试中;
- 频率步进要求需满足表 10 中的要求,调制方式需满足表 10 中的要求;
- 在频率范围 1 MHz 到 400 MHz 内,注入钳应分别置于距被测样件(150 mm, 450 mm, 750 mm)的位置进行测试;
- 如在测试中发现测试样件功能出现背离现象,则注入电流应逐步降低,直到被测样件功能恢复正常;然后注入电流应逐步增加,直到被测样件功能再次发生背离现象。此时,这个注入电流值应作为阈值记录在测试报告中;
- 在测试期间被测样件的工作模式应符合测试计划中的要求;
- 如果在测试中使用电流钳检测电流,则该电流钳不应用来调节表 11 中的射频电流值。监测值应作为参考信息记录到测试报告中。

The distance between the test set-up and all other conductive structures (such as the walls of the shielded enclosure) with the exception of the ground plane shall be $\geq 100\text{ mm}$.

If the outer case of the DUT is metal and can be grounded when installed in the vehicle, the DUT shall be mounted and electrically connected to the ground plane during the bench test. If the DUT case is not grounded in the vehicle, the DUT shall be placed on an insulated support 50 mm above the ground plane. If there is uncertainty about this, the DUT shall be tested in both configurations.

In the test frequency range all wires of the DUT wiring harness shall be routed inside of the injection probe.

The injection probe shall be insulated from the ground plane.

An appropriate current monitoring probe, which does not affect the deviation profile, may be placed 50 mm from the DUT (optional).

7.2.2.3 Procedure

Use the calibrated injection probe method (substitution method) according to ISO 11452-4.

- Forward power shall be used as reference parameter for calibration and during the actual test of the DUT;
- Use step frequencies listed in Table 10 and the modulation as specified in Figure 10;
- In the frequency range from 1 to 400 MHz, testing shall be performed at two fixed injection probe positions (150 mm, 450 mm, 750 mm);
- If deviations are observed, the induced current shall be reduced until the DUT functions normally. Then the induced current shall be increased until the deviation occurs. This level shall be reported as the deviation threshold;
- The DUT operating mode(s) exercised during testing shall conform to that delineated in the EMC test plan;
- If a monitor probe is used it may not be used to adjust the RF current delineated in Table 11. The measured values are used for information only and may be included in the test report.

表 10 最大步进频率

Table 10 Max. frequency steps

频率范围 Frequency Range (MHz)	最大步进范围 Max Step Size(MHz)
1~200	1
200~400	2

7.2.2.4 要求

被测样件的功能只能在注入电流值大于表 11 和图 10 中的要求时才能背离设计要求。

7.2.2.4 Requirement

DUT functions may only deviate above the levels according to Table 11 and Figure 10.

表 11 大电流注入法抗干扰测试要求

Table 11 Requirement level for the immunity to electromagnetic fields for components and subsystems measured using BCI method

频率 Frequency(MHz)	Level 1 (mA)	Level 2 (mA)	方法 Method	调制方式 Modulation
1~400	100	200	BCI	CW, AM80 %

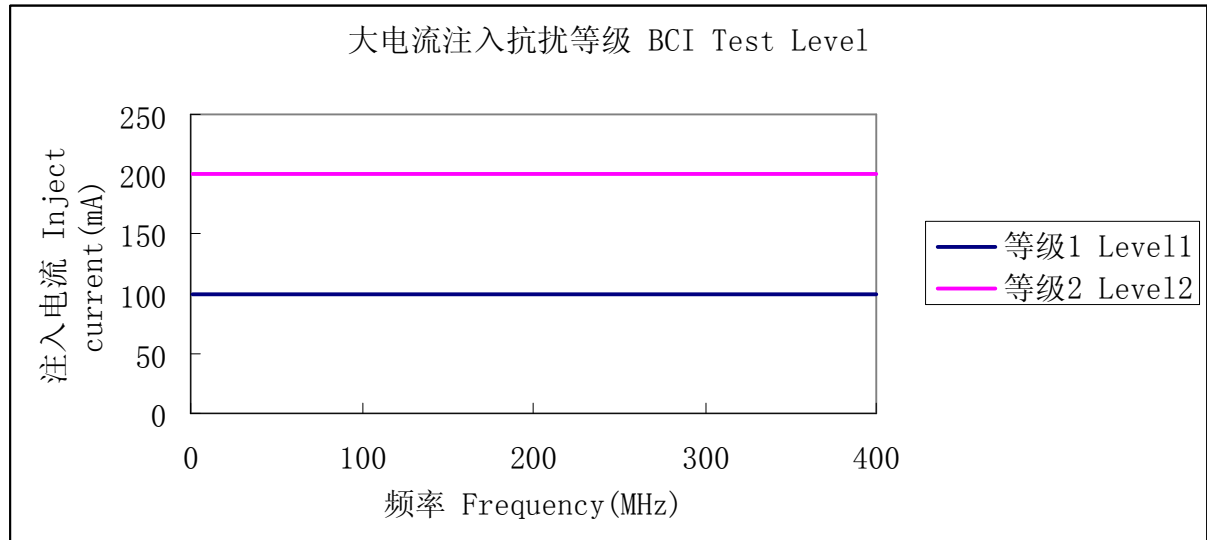


图 10 大电流注入法抗干扰测试要求

Figure 10 Requirement level for the immunity to electromagnetic fields for components and subsystems measured using BCI method

7.2.2.5 报告

测试报告中需要包括以下内容：

表格数据和描点图的两个探头位置。

结合表格数据和描点图，形成一个单一的最好的情况下每个偏差设置观测资料。请注意，在每一个频率，最低的偏差阈探测器的立场是合并后的数据集选择。每个偏差都需要单独表明相应的点图。免疫阈值图（计算与频率 dB μ A 电流）。

从电流钳中测量测试电流（如果选择使用电流探头）。

7.2.2.5 Report

The following elements shall be included in the test report:

Tabular data and plots from the two probe positions.

Combined tabular data and plots to form a single worst-case data set for each deviation observed. Note that at each frequency, the probe position with the lowest deviation threshold is chosen for the combined data set. Separate plots are required for each deviation. Immunity threshold plot (calculated current in dB μ A vs. frequency)

Measured currents from current monitor probe if used (optional).

7.2.3 Magnetic Field Immunity

7.2.3.1 Helmholtz coil method

7.2.3.1.1 Equipment

The test equipment shall comply with ISO 11452-1 and ISO 11452-8.

7.2.3.1.2 Test Verification and Test Set-up

Verification of component performance shall be verified using the test method delineated in ISO 11452-8 except where noted in this

7.2.3 磁场抗干扰

7.2.3.1 赫尔姆霍茨线圈法

7.2.3.1.1 设备

测试设备必须满足 ISO 11452-1 和 11452-8 标准中的要求。

7.2.3.1.2 校验和测试布置

ISO 11452-8 中的方法将用于验证零件性能，本标准中注明不做要求的部分除外。测试设

置应以方便配置被测样件直接暴露于表 12 中所列出的磁场区域,任何可能被连接到被测样件的磁性传感器都应置于磁场领域中。推荐使用直径为 120 mm 赫尔姆霍兹线圈进行测试。这些测试设置配置如图 11 所示。测试应覆盖表 12 列出的频率。

在测试中被测样件应放在一个木制平板或绝缘平板上。测试辅助设备和其他支持设备应安装在地平面,但测试辅助设备及接地平板与赫尔姆霍兹线圈的距离不应小于 200 mm。

被测样件及测试辅助设备中的电子硬件的供电需使用车载蓄电池(参见 4.4.4 节的要求)。该电池或电源的负极,应连接到地平面平板上。

7.2.3.1.3 程序

- a) 在对被测样件进行测试之前,应按照 ISO 11452-8 中规定的程序对赫尔姆霍兹线圈特性进行校准。应根据被测样件的物理尺寸选择合适的测试线圈。
对于被测样件尺寸小于一个线圈半径的样件,线圈应该离开一个半径的距离。被测样件各表面距离相邻线圈应至少为 50 mm。
对于被测样件尺寸大于一个线圈半径的样件,线圈的距离应该使得 DUT 面所在平面与两线圈中任一线圈所在平面至少 50 mm,两线圈之间的距离不超过 1.5 倍半径。
- b) 频率步进要求需满足表 12 中的要求;
- c) 给赫尔姆霍兹线圈提供足够的电流以产生表 13 中各频率点相应的磁场强度;
- d) 驻留时间应至少为 2 s。请注意,如果被测样件的功能响应时间很长,则延长驻留时间可能是必要的。这种信息应记录在 EMC 测试计划;
- e) 重新定位被测件或赫尔姆霍兹线圈,先两个线圈与被测样件的每个面平行并

specification. The test set-up shall be configured to facilitate direct exposure of the DUT to the fields listed in Table 12 in addition to magnetic field exposure to any magnetic sensors that may be connected to the DUT. This may be accomplished using either a 120 mm diameter magnetic a Helmholtz coil. These test set-up configurations are illustrated in Figure 11. Testing shall be performed all the frequencies listed in Table 12.

The DUT shall be placed on a wooden table or insulated table for either test method. The Test Fixture and other support equipment shall be mounted to a ground plane, however no portion of the Test Fixture or ground plan shall be closer than 200 mm to the Helmholtz coils.

The DUT and any electronic hardware in the Test Fixture shall be powered from an automotive battery or a linear power supply (see paragraph 4.4.4 for requirements). The battery or power supply negative terminal shall be connected to the ground plane bench.

7.2.3.1.3 Procedure

- a) Prior to performing testing of the DUT, characterize the Helmholtz Coil using procedures delineated in ISO 11452-8. Select coil spacing based on the physical dimensions of the DUT.
For a DUT with dimensions less than one coil radius, the coils shall be separated by one coil radius. Separation between each surface of the DUT and either coil shall be at least 50 mm.
For a DUT with dimensions greater than one coil radius, the coils shall be separated such that the plane of the DUT face is at least 50 mm from the plane of either coil and the separation between the two coils does not exceed 1.5 radii.
- b) Use step frequencies listed in Table 12;
- c) Supply the Helmholtz Coil with sufficient current to produce the corresponding magnetic field levels delineated in Table 13 at each test frequency listed in Table 13;
- d) Dwell time shall be at least 2 seconds. Note that a longer dwell time may be necessary if DUT function response times are expected to be longer. This information shall be documented in the EMC test plan;
- e) Reposition the DUT or Helmholtz coils successively such that the two coils are parallel to each face of the DUT

- 平行任何连接器的轴面；
- f) 如果发现有背离，应减小测试磁场强度直到被测样件的功能正常。然后，应增加测试磁场强度，直至被测样件出现偏差。这时的磁场强度应作为阈值记录在测试报告中；
- g) 如果被测件有附加的磁传感器，应对传感器进行单独的测试以验证被测样件能够正常工作。

and parallel to the axis of any connector;

- f) If deviations are observed, the field shall be reduced until the DUT functions normally. Then the field shall be increased until the deviation occurs. This level shall be reported as deviation threshold;
- g) If the DUT has magnetic sensors attached to it, separate tests shall be performed exposing only the sensor while verifying correct operation of the DUT.

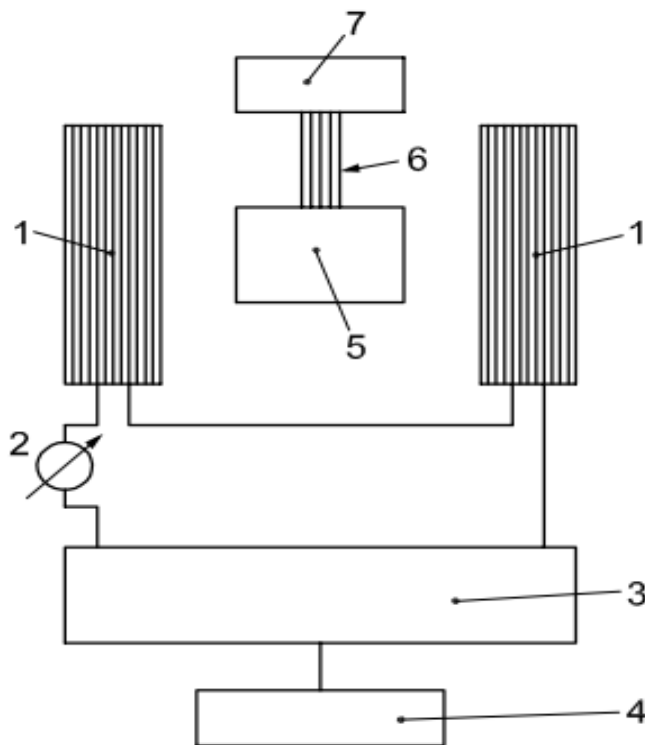


图 11 赫尔姆霍茨线圈法测试布置图
Figure 11 Set-up of Helmholtz coil method

说明 description:

- 1——线圈 Coil (s)
2——电流表 Current monitor
3——低频信号放大器 LF amplifier
4——低频信号源 LF generator
5——被测样件或磁场计（特征值或校准值） DUT or magnetic field meter (for characterization or verification)
6——线束 Wiring harness

表 12 最大步进频率
Table 12 Maximum frequency steps sizes

频率范围 Frequency rang (kHz)	最大线性步进 Linear Steps (kHz)
0.015~0.1	0.01
0.1~1	0.1
1~10	1
10~150	10

7.2.3.1.4 要求

被测样件的性能只有在测试等级超出表 13

7.2.3.1.4 Requirement

DUT functions may only deviate from the

中的要求时才允许偏离设计要求。

designed performance above the test levels in table 13.

表 13 赫尔姆霍茨线圈法测试要求

Table 13 Helmholtz coil method test requirement

频段 Frequency Band (Hz)	测试等级 1 Test Level 1 (A/m)	测试等级 2 Test Level 2 (A/m)
15~1 000	300	1 000
1 000~10 000	$300/(f/1\,000)^2$	$1\,000/(f/1\,000)^2$
10 000~150 000	3	10

7.2.3.1.5 报告

以下内容应包括在测试报告:

该测试装置的细节, 包括地点设立/方向测试和赫尔姆霍茨线圈分离。

功能监测的详细说明。

任何性能偏差。

每个频率最高的曝光场下发生偏差。

显示的辐射回路校准核查表格数据。

7.2.3.2 辐射线圈法

7.2.3.2.1 设备

测试设备应符合 ISO11452-1 和 11452-8 中的要求。

7.2.3.2.2 校验和测试布置

在测试零件的性能之前, 应使用 ISO 11452-8 中所述的测试方法进行测试, 除非本标准种另有说明。测试设置应以方便配置 DUT 直接暴露于表 13 中列出的磁场中, 任何可能被连接到 DUT 的磁性传感器都应置于测试场强中。这可以使用 120 mm 直径的磁辐射线圈来实现。这些测试设置配置如图 12 和图 13 所示。

被测样件应放在一个木制平板或绝缘垫上。测试夹具和其他辅助设备应安装在接地平板上, 但测试夹具和接地平板部分与辐射环的距离应不小于 200 mm。

被测样件及测试辅助设备中的电子硬件的供电需使用车载蓄电池 (参见 4.4.4 节的要求)。该电池或电源的负极, 应连接到接地平板上。

7.2.3.1.5 Report

The following elements shall be included in the test report:

Details of the test set-up including locations/orientations tested and Helmholtz coil separation.

Description of the functions monitored.

Any performance deviations.

Maximum exposure field at each frequency where deviations occur.

Tabular data showing verification of the calibration of the radiating loop.

7.2.3.2 Radiated Loop Method

7.2.3.2.1 Equipment

The test equipment shall comply with ISO 11452-1 and ISO 11452-8.

7.2.3.2.2 Test Verification and Test Set-up

Verification of component performance shall be verified using the test method delineated in ISO 11452-8 except where noted in this specification. The test set-up shall be configured to facilitate direct exposure of the DUT to the fields listed in Table 13 in addition to magnetic field exposure to any magnetic sensors that may be connected to the DUT. This may be accomplished using either a 120 mm diameter magnetic radiating loop. These test set-up configurations are illustrated in Figure 12 and 13.

The DUT shall be placed on a wooden table or insulated table for either test method. The Test Fixture and other support equipment shall be mounted to a ground plane, however no portion of the Test Fixture or ground plane shall be closer than 200 mm to the radiating loop.

The DUT and any electronic hardware in the Test Fixture shall be powered from a automotive battery or a linear power supply (see paragraph 4.4.4 for requirements). The battery or power supply negative terminal shall be connected to the ground plane bench.

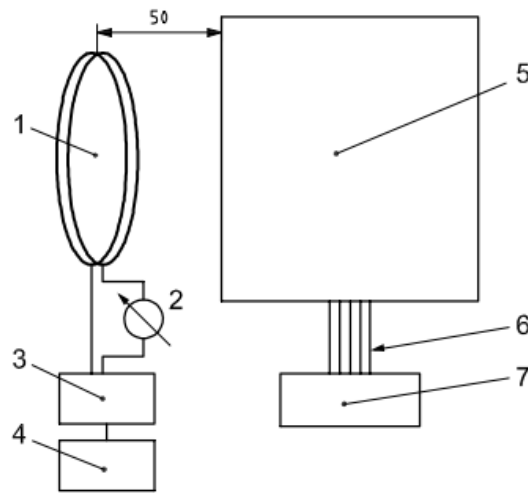


图 12 辐射线圈法

Figure 12 Radiating loop configuration

说明 description:

- 1——辐射线圈 Radiating Loop
- 2——电流表 Current monitor
- 3——射频放大器 LF amplifier
- 4——射频发生器 LF generator

- 5——被测样件 DUT
- 6——线束 Wiring harness
- 7——外围设备 Peripheral

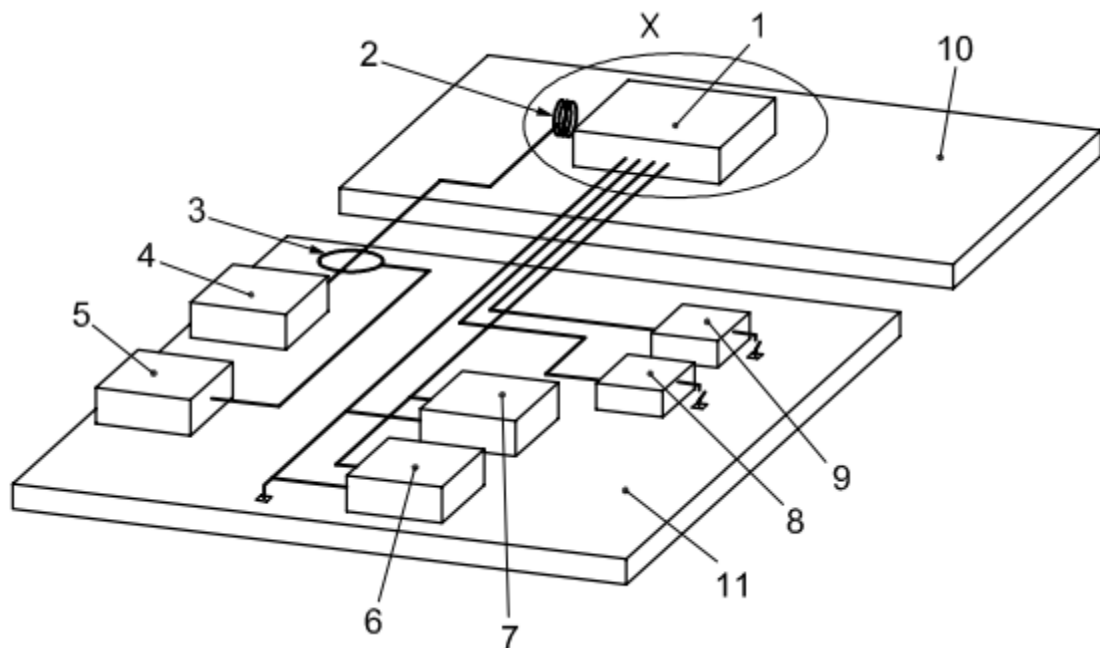


图 13 辐射线圈法测试布置图

Figure 13 Radiating loop test set-up

说明 description:

- 1——被测样件 DUT
- 2——辐射线圈 Radiating loop
- 3——电流探头 Current probe
- 4——信号源和放大器 Generator and amplifier
- 5——示波器 Oscilloscope
- 6——电源 Power supply

- 7——蓄电池 Battery
- 8——传感器 Sensors
- 9——执行机构 Actuators
- 10——绝缘垫 Insulating support
- 11——接地平板 Ground plan

7.2.3.2.3 程序

- a) 在对被测样件进行测试前须按照 ISO 11452-8 中所述的方法对辐射线圈进行校准;

7.2.3.2.3 Procedure

- a) Prior to performing testing of the DUT, calibrate the radiation loop using procedures delineated in ISO 11452-8;
- b) Use step frequencies listed in Table 12;

- b) 频率步进要求需满足表 12 中的要求;
- c) 将被测样件的表面分为 100×100 mm 的区域并将辐射线圈面向被测样件置于上述各区域的中心。如果被测样件的表面小于 100×100 mm, 则将被辐射线圈置于被测样件表面的中心。辐射环的表面到被测样件表面的距离应为 50 mm。传感器应平行被测样件的表面且平行任何连接器的轴心;
- d) 在每个位置, 给辐射线圈提供足够的电流已产生满足表 13 所定义的场强, 并按表 12 中列出的各频率步进要求进行测试;
- e) 驻留时间应至少为 2 s。请注意, 如果 DUT 的功能响应时间较长, 则停留时间较长是必要的。这种信息应在 EMC 测试计划中说明;
- f) 如果有偏差现象发生, 则应减少测试场强直到被测样件的功能恢复正常。然后, 再增加测试场强直至被测样件出现偏差。这场强值应作为阈值记录在测试报告中;
- g) 如果被测件有附加的磁传感器, 则应单独对该传感器进行测试, 以便验证被测样件能够正确操作。
- c) Partition each face of the DUT into 100×100 mm square areas and position the radiating loop face to the center of each of these areas. If the DUT face is less than 100×100 mm, place the radiating loop in the center of the DUT face. Separation between the face of the radiating loop and DUT surface shall be 50 mm. Orient the plane of the loop sensor parallel to the DUT faces and parallel to the axis of any connector;
- d) At each position, supply the loop with sufficient current to produce the corresponding magnetic field levels delineated in Table 13 at each test frequency step listed in Table 12;
- e) Dwell time shall be at least 2 seconds. Note that a longer dwell time may be necessary if DUT function response times are expected to be longer. This information shall be documented in the EMC test plan;
- f) If deviations are observed, the field shall be reduced until the DUT functions normally. Then the field shall be increased until the deviation occurs. This level shall be reported as deviation threshold;
- g) If the DUT has magnetic sensors attached to it, separate tests shall be performed exposing only the sensor while verifying correct operation of the DUT.

7.2.3.2.4 要求

被测样件只有在测试等级超出表 13 中的要求才允许发生功能偏离。

7.2.3.2.5 报告

以下内容应包括在测试报告:

该测试装置的细节, 包括地点设立/方向测试和赫尔姆霍兹线圈距离。

职能说明监测。

任何性能偏差。

每个频率最高的曝光场下发生偏差。

显示的辐射回路校准核查表格数据。

7.2.3.2.4 Requirement

DUT functions may only deviate from the designed performance above the test levels in table 13.

7.2.3.2.5 Report

The following elements shall be included in the test report:

Details of the test set-up including locations/orientations tested and Helmholtz coil separation.

Description of the functions monitored.

Any performance deviations.

Maximum exposure field at each frequency where deviations occur.

Tabular data showing verification of the calibration of the radiating loop.

7.3 瞬态抗干扰

7.3.1 耦合/感应传导抗干扰

7.3.1.1 设备

测试设备应符合 ISO 7637-1 和 ISO 7637-3 中的要求。

7.3.1.2 校验和设备布置

7.3 Transient Immunity

7.3.1 Couple/Inductive Transient Immunity

7.3.1.1 Equipment

The test equipment shall comply with ISO 7637-1 and ISO 7637-3.

7.3.1.2 Test verification and Test set-up

在测试前应对脉冲发生器进行校准。脉冲幅值应用 $50\ \Omega$ 的示波器进行校准，该示波器应连接到配有为 $50\ \Omega$ 的衰减器的耦合钳（探头）上。在耦合钳内不允许包含其余的线束。

电压测量通过 $50\ \Omega$ 同轴电缆连接到 $50\ \Omega$ 衰减器和示波器上。衰减器是用来代替 CCC 终端电阻。

DUT 应按其相关的要求进行连接。被测件应连接到真实的操作装置（负载，传感器等）上，连接线束应为相应的测试线束或实际产品线束，该方式符合车辆制造商和供应商所达成的要求。

如果不能提供被测件的实际工作信号，则应用相应的模拟信号来代替。

如被测样件的外壳为金属材料且在整车上的安装位置为外壳接地，则该样件在测试时应直接将其与接地平板连接到一起。如被测样件的外壳在整车上不是直接连到车身上，被测样件需要放置在接地平板上 $50\ \text{mm}$ 厚的绝缘垫上。如果对以上两种情况不明确，则被测样件需要按上述两种要求进行测试。

如有可能，所有的负载，传感器等用最短的线连接到接地平板上。

The test pulse generator shall be calibrated prior to performance of the test (see Figure 9). The pulse amplitude is calibrated with an oscilloscope connected to the coupling clamp which is terminated in a $50\ \Omega$ attenuator and $50\ \Omega$ oscilloscope. No lines are permitted to route through the coupling clamp during calibration.

The voltage measurement is made by a $50\ \Omega$ oscilloscope connected to a $50\ \Omega$ attenuator by a $50\ \Omega$ coaxial cable. The attenuator is used instead of the CCC termination resistor.

The DUT is arranged and connected according to its requirements. The DUT should be connected to the original operating devices (loads, sensors, etc.) using a test harness or the production wiring harness, as agreed upon between the vehicle manufacturer and the supplier.

If the actual DUT operating signal sources are not available they may be simulated.

If the outer case of the DUT is metal and can be grounded when installed in the vehicle, the DUT shall be mounted and electrically connected to the ground plane during the bench test. If the DUT case is not grounded in the vehicle, the DUT shall be placed on an insulated support $50\ \text{mm}$ above the ground plane. If there is uncertainty about this, the DUT shall be tested in both configurations.

Where possible, all loads, sensors, etc. are connected to the ground plane using the shortest possible lead length.

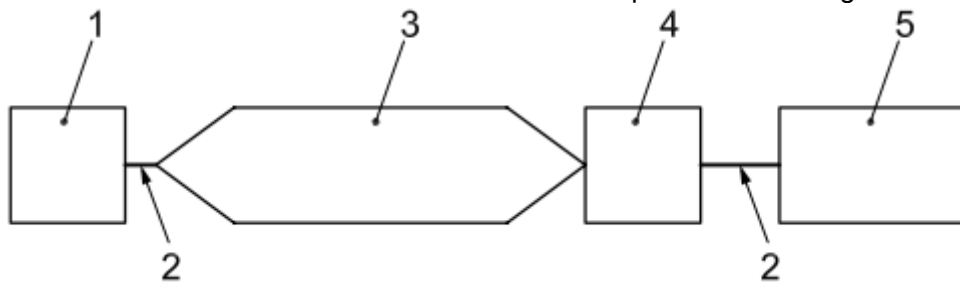


图 14 电容耦合钳法校准布置图

Figure 14 Set-up for calibration of the test pulse amplitude-CCC method

说明 description:

- 1——测试脉冲发生器 Test pulse generator
2—— $50\ \Omega$ 同轴电缆 $50\ \Omega$ Coaxial cable
3——电容耦合钳 CCC

- 4—— $50\ \Omega$ 衰减器 $50\ \Omega$ Attenuator
5——示波器 Oscilloscope

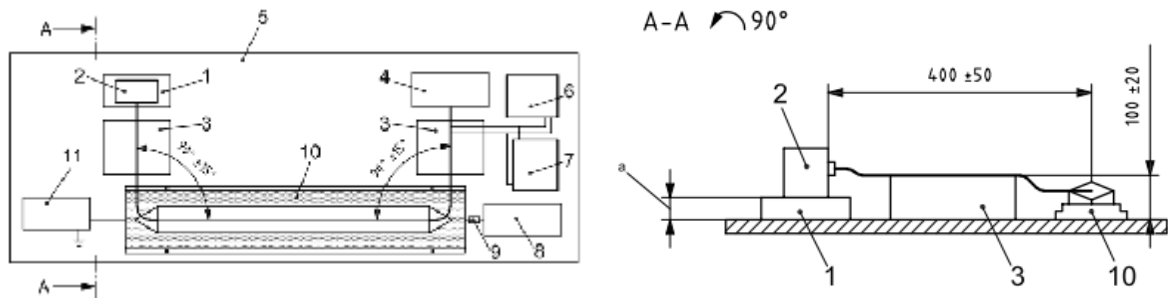


图 15 电容耦合钳法测试布置图
Figure 15 Test set-up for CCC method

说明 description:

- 1——绝缘垫 Insulation support (If DUT is not to be connected to the ground in the vehicle)
2——被测样件 DUT
3——测试线束绝缘垫 Insulating supports for test harness
4——外围设备 Peripheral (e.g. sensors, load, accessories), mounted as in the vehicle
5——接地平板 Ground plane
6——电源 Power supply
7——蓄电池 Battery
8——示波器 Oscilloscope
9——50 Ω 衰减器 50 Ω Attenuator
10——电容耦合钳 CCC
11——测试脉冲发生器 Test pulse generator

7.3.1.4 要求

用表 14 中的脉冲 A 和脉冲 B 进行测试，被测样件的功能应符合设计要求 Class A。

7.3.1.4 Requirement

Use only test pulse A and B in table 14, and the function performance class should be class A.

表 14 耦合抗干扰测试要求
Table 14 Test requirement for CCC method

测试脉冲 Test Pulse	测试等级 Test level Us	最短测试时间 Minimum test time	脉冲周期 Burst cycle time	
			最小 Min.	最大 Max.
3a	-60 V	1 h	90 ms	110 ms
3b	+40 V	1 h	90 ms	110 ms

7.3.1.5 报告

测试报告中应包括以下内容：
测试脉冲数；
对于每个传导脉冲在测试中被测试样件的功能情况。

7.3.1.5 Report

The following elements shall be included in the test report:

Test pulse being applied (by number).

Performance of the functions monitored during and following application of each transient.

7.3.2 Conducted transient Immunity

7.3.2 瞬态传导抗干扰

7.3.2.1 设备

测试设备需满足 ISO 7637-1 和 ISO 7637-2 中的相关要求。

7.3.2.1 Equipment

The test equipment shall comply with ISO 7637-1 and ISO 7637-2.

7.3.2.2 校验和设备布置

应按照 ISO 7637-2 中的要求对测试用设备进行校准，除非本标准中另有说明。

7.3.2.2 Test verification and Test set-up

Verification of component performance shall be in accordance with ISO 7637-2 except where noted in this specification.

7.3.2.3 程序

如无特殊规定，本测试适用于所有电源线 (B+) 及通过开关控制直接连接到蓄电池上的线束。该测试同样也适用于连接到由蓄电池提供电源的感性负载输入/输出端口。测试脉冲应施加所有与 B+ 相关的引脚和由 B+ 提供电源的 I/O 口。

7.3.2.3 Procedure

If not otherwise stated, this test procedure applies to battery+ (B+) and switched battery lines (e.g. Ignition, Accessory). It also applies to I/O lines that are connected to an inductive load, where that load is fed by B+ or switched battery. The test pulses shall be applied to B+, each switched battery line and I/O lines fed by either B+ or switched battery separately.

The test method should according to ISO

测试应符合 ISO 7637-2 中的要求。

7.3.2.4 要求

被测样件只有在测试等级超出表 15 中的要求才允许发生功能偏离。

7637-2.

7.3.2.4 Requirement

DUT functions may only deviate from the designed performance above the levels according to Tables 15.

表 15 电源线瞬态传导抗干扰要求

Table 15 Requirements Levels for the Immunity to Transients on Power Lines

脉冲序号 Pulse No.	脉冲参数 Parameter	测试脉冲要求 Test requirement	功能状态 Functional Status
1	$U_s = -100\text{ V}$	5 000 pulse	功能状态应满足 Class C 要求, 记忆功能应满足 Class A 要求。 Class C; Class A for memory functions
2a	$U_s = +75\text{ V}$	5 000 pulse	Class A
2b	$U_s = +10\text{ V}$	10 pulse	功能状态应满足 Class C 要求, 记忆功能应满足 Class A 要求。 Class C; Class A for memory functions
3a	$U_s = -150\text{ V}$	1 h	Class A
3b	$U_s = +100\text{ V}$	1 h	Class A
5b	+34 V, $t_d(5a)=400\text{ ms}$, $R_i=2\ \Omega$	10 pulses at 1 minute intervals	Class B
注: 未说明的测试参数按 ISO 7637-2 中要求规定执行。 Note: The test parameter which is not defined must according to ISO 7637-2.			

7.3.2.5 报告

以下内容应包括在测试报告:
所实施的测试脉冲波形 (脉冲编号)
每个测试脉冲实施重复测试的数量;
脉冲周期;
脉冲注入点;
在每个测试脉冲测试期间被测样件的功能。

7.3.2.5 Report

The following elements shall be included in the test report:

Test pulse being applied (by number).
Number of repetitions of the pulse applied.
Pulse cycle time (interval between pulses).
Injection points (pin number, letter, or name).

Performance of the functions monitored during and following application of each transient.

7.4 传导抗干扰

7.4.1 连续抗干扰

7.4.1.1 设备

测试设备应符合 ISO 7637-1 和 ISO 7637-2 的要求, 或使用满足要求的可编程电源。

7.4.1.2 校验和设备布置

应使用图 16 中所示的布置方式进行测试。

被测样件及线束应置于接地平板 50 mm 厚的绝缘垫上。如果被测样件的外壳为金属材料且在实车上为接地安装, 则被测样件应直接连接到接地平板之上。

7.4.1.3 程序

按图 16 示方式连接被测样件。将满足下列条件的测试波形注入到被测样件的电源正极线上。

测试电压 U_s max (见图 17): 16 V;
交流电压 (正弦): $U_{pp}=4\text{ V}$;
电源内阻: 50 m Ω ~100 m Ω ;
频率范围 (见图 17): 50 Hz~20 KHz;

7.4 Conducted Immunity

7.4.1 Continuous Immunity

7.4.1.1 Equipment

The test equipment shall comply with ISO 7637-1 and ISO 7637-2 or Programmable Power supply.

7.4.1.2 Test verification and Test set-up

Testing shall be performed using the test set-up shown in Figure 16.

The DUT and wire harness shall be placed on an insulated support 50 mm above the ground plane. If the outer case of the DUT is metal and can be grounded when installed in the vehicle, the DUT shall be mounted and electrically connected to the ground plane.

7.4.1.3 Procedure

Connect the DUT as shown in Figure 16. Apply the following test simultaneously to all applicable inputs (connections) of the DUT.

Test voltage U_s max (see Figure 17): 16 V ;

AC voltage (sinusoidal): $U_{pp} = 4\text{ V}$;

Internal resistance of the power supply: 50 m Ω to 100 m Ω ;

Frequency range (see Figure 17): 50 Hz to 20 kHz;

频率扫描类型：对数型；
扫描周期：120 s；
扫描次数：5 次（连续）

Type of frequency sweep: Triangular, logarithmic;
Sweep duration (see Figure 3): 120 s;
Number of sweeps: 5 (continuously).

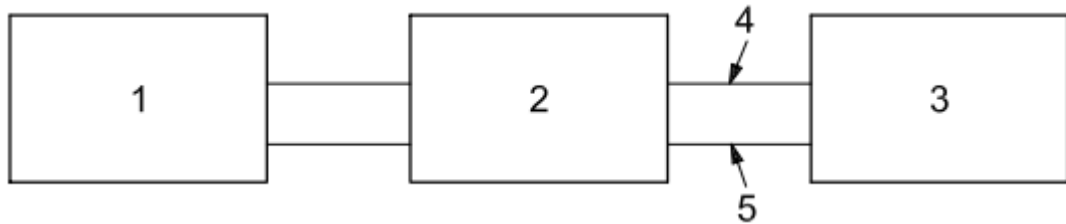


图 16 连续抗干扰测试布置图
Figure 16 Set-up of Continuous immunity

说明 description:

1——扫描发生器 Sweep generator

2——可调制电源 power supply unit capable of being modulated

3——被测样件 DUT

4——电源正极 Positive

5——电源负极 Negative

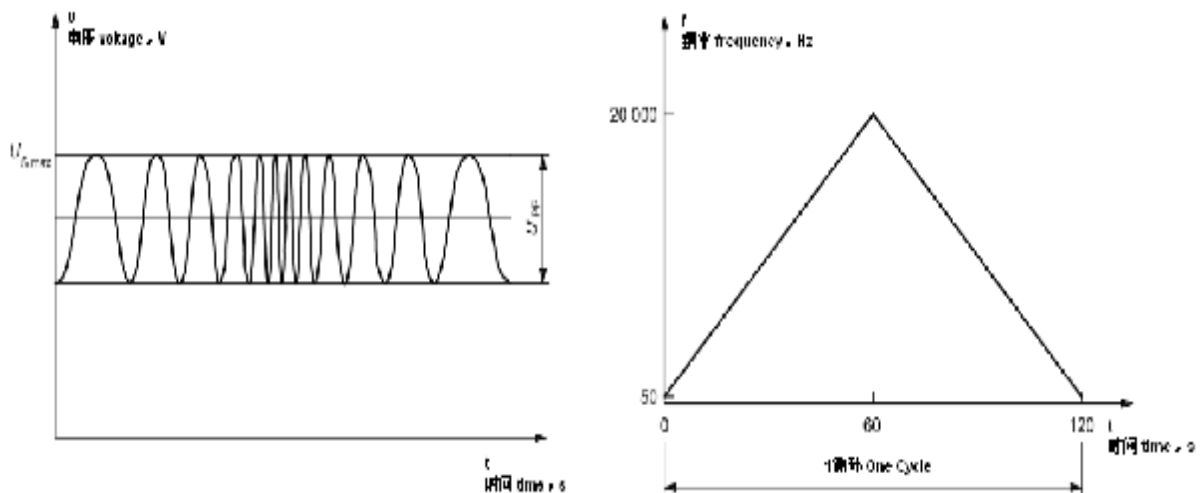


图 17 连续抗干扰测试要求
Figure 17 Test requirement of continuous immunity

7.4.1.4 要求

被测样件只有在测试等级超出表中的要求才允许发生功能偏离。

7.4.1.5 报告

以下内容应包括在测试报告：
详细的功能描述。
任何与设计值之间出现的偏差。

7.4.2 起动抗干扰

7.4.2.1 设备

测试设备应符合 ISO 7637-1 和 ISO 7637-2 的要求，或使用满足要求的可编程电源。

7.4.2.2 校验和测试布置

应使用图 16 中所示的布置方式进行测试。

被测样件及线束应置于接地平板 50 mm 厚的绝缘垫上。如果被测样件的外壳为金属材料且在实车上为接地安装，则被测样件应直接连接到接

7.4.1.4 Requirement

DUT functions may only deviate from the designed performance above the levels.

7.4.1.5 Report

The following elements shall be included in the test report:

Description of the functions monitored.
Any performance deviations.

7.4.2 Starting Immunity

7.4.2.1 Equipment

The test equipment shall comply with ISO 7637-1 and ISO 7637-2 or Programmable Power supply.

7.4.2.2 Test verification and Test set-up

Testing shall be performed using the test set-up shown in Figure 16.

The DUT and wire harness shall be placed on an insulated support 50 mm above the ground plane. If the outer case of the DUT is metal and can be grounded when installed in

地平板之上。

7.4.2.3 程序

按图 16 种的方式连接好被测样件。同时将测试波形注入到被测样件的电源线上。

the vehicle, the DUT shall be mounted and electrically connected to the ground plane.

7.4.2.3 Procedure

Connect the DUT as shown in Figure 16. Apply the following test simultaneously to all applicable inputs (connections) of the DUT.

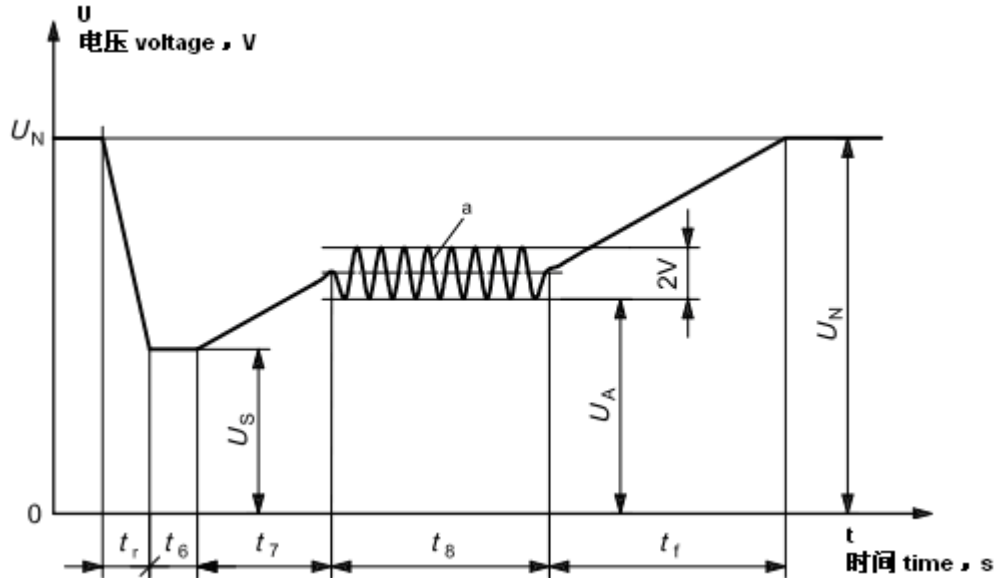


图 18 起动波形图

Figure 18 Starting profile

表 16 起动抗干扰测试要求

Table 16 Test requirement of starting immunity

供电电压 Supply Voltage	起动抗干扰测试等级/电源 Levels/voltages/duration of starting profile		
$U_N=12.5\text{ V}$	测试等级 1 Test Level 1	测试等级 2 Test Level 2	容差 Tolerances
	$U_S=8\text{ V}$	$U_S=4.5\text{ V}$	$\pm 0.2\text{ V}$
	$U_A=9.5\text{ V}$	$U_A=6.5\text{ V}$	
	$t_r=5\text{ ms}$		$\pm 10\%$
	$t_6=15\text{ ms}$		
	$t_7=50\text{ ms}$		
	$t_8=1\text{ s}$	$t_8=10\text{ s}$	
	$t_f=40\text{ ms}$	$t_f=100\text{ ms}$	
	功能状态 Functional status		——
	B	C	——

7.4.2.5 要求

与车辆起动相关的功能产品必须符合功能状态 Class A 的要求，其余产品功能需符合表 16 中的要求。

7.4.2.5 Requirement

Functions of the DUT that are relevant to vehicle operation during cranking shall be class A, all other functions of the DUT shall be according to Table 16.

7.4.2.6 报告

以下内容应包括在测试报告：
详细的功能描述。
任何与设计值之间出现的偏差。

7.4.2.6 Report

The following elements shall be included in the test report:

Description of the functions monitored.
Any performance deviations.

7.4.3 参考地和电源偏移

7.4.3 Ground and supply Offset

7.4.3.1 设备

7.4.3.1 Equipment

线性电源。

Linear power supply.

7.4.3.2 校验和测试布置

7.4.3.2 Test verification and Test set-up

Testing shall be performed using the test

应使用图 16 中所示的布置方式进行测试。

被测样件及线束应置于接地平板 50 mm 厚的绝缘垫上。如果被测样件的外壳为金属材料且在实车上为接地安装, 则被测样件应直接连接到接地平板之上。

7.4.3.3 程序

被测样件所有的输入输出端都必须连接整车上的实际负载或等效模拟负载。

参考地/电源偏移测试应对电源线及地线进行测试。偏移量应按一定的顺序分别作用于每个电源线和地线上。

对于所有的被测样件, 偏移电压为 1.0 V。

- a) 给被测样件提供电压 $U_A=14.0$ V;
- b) 分别将偏移电压作用于地线和电源线上;
- c) 在偏移条件下进行一次全功能检测;
- d) 对其余地线和电源线按 c 步骤重复进行测试。

用相反的偏移电压重复上述步骤进行测试。

7.4.3.4 要求

被测样件只有在偏移电压超过 1 V 时才允许发生功能偏离。

7.4.3.5 报告

以下内容应包括在测试报告:
详细的功能描述。
任何与设计值之间出现的偏差。

7.4.4 电压跌落

7.4.4.1 设备

测试设备应符合 ISO 7637-1 和 ISO 7637-2 的要求, 或使用满足要求的可编程电源。

7.4.4.2 校验和测试布置

应使用图 16 中所示的布置方式进行测试。

被测样件及线束应置于接地平板 50 mm 厚的绝缘垫上。如果被测样件的外壳为金属材料且在实车上为接地安装, 则被测样件应直接连接到接地平板之上。

7.4.4.3 程序

将图 20 中的测试波形作用于相应的输入端, 同时检测 DUT 的重置行为。

按 5 % 幅度递减供电电压, 供电电压从 U_s 减少至 $0.95 U_s$, 维持这个供电电压 5 s 下, 然后再将供电电压增加至 U_s , 在 U_s 电压下维持至少 10 s 并进行一次相应的功能检测, 然后再将供电电压减少至 $0.9 U_s$, 如此继续。

set-up shown in Figure 16

The DUT and wire harness shall be placed on an insulated support 50 mm above the ground plane. If the outer case of the DUT is metal and can be grounded when installed in the vehicle, the DUT shall be mounted and electrically connected to the ground plane.

7.4.3.3 Procedure

All inputs and outputs shall be connected to representative loads or networks to simulate the in-vehicle configuration.

The ground/supply offset test applies to ground/supply lines. The offset shall be applied to each ground/supply line and between each ground/supply line separately in sequence.

For all DUT, the offset voltage shall be 1.0 V.

- a) Apply $U_A=14.0$ V to the DUT;
- b) Subject ground/supply line to the offset voltage relative to the DUT ground/supply line;
- c) Perform a functional test under this condition;
- d) Repeat No. 3 for each next ground/supply line combination.

Repeat the test with reverse offset voltage.

7.4.3.4 Requirement

DUT functions may only deviate from the designed performance above 1 V offset.

7.4.3.5 Report

The following elements shall be included in the test report:

Description of the functions monitored.
Any performance deviations.

7.4.4 Voltage Drop

7.4.4.1 Equipment

The test equipment shall comply with ISO 7637-1 and ISO 7637-2 or Programmable Power supply.

7.4.4.2 Test verification and Test set-up

Testing shall be performed using the test set-up shown in Figure 16.

The DUT and wire harness shall be placed on an insulated support 50 mm above the ground plane. If the outer case of the DUT is metal and can be grounded when installed in the vehicle, the DUT shall be mounted and electrically connected to the ground plane.

7.4.4.3 Procedure

Apply the test pulse simultaneously in Figure 20 to all relevant inputs (connections) and check the reset function of the DUT.

Decrease the supply voltage by 5 % from U_s min to $0.95 U_s$ min. Hold this voltage for 5 s. Raise the voltage to U_s min. Hold U_s min for at least 10 s and perform a functional test. Then decrease the voltage to $0.9 U_s$ min, etc.

按 5 % 的幅度递减供电电压 (如图 15 所示), 直到供电电压最低值到达 0 V 为止, 然后再将供电电压恢复至 U_s 。

7.4.4.4 要求

被测样件的功能状态应符合 Class C 的要求。

Continue with steps of 5 % of U_s min, as shown in Figure 15, until the lower value has reached 0 V. Then raise the voltage to U_s min again.

7.4.4.4 Requirement

The DUT functional status shall be class C.

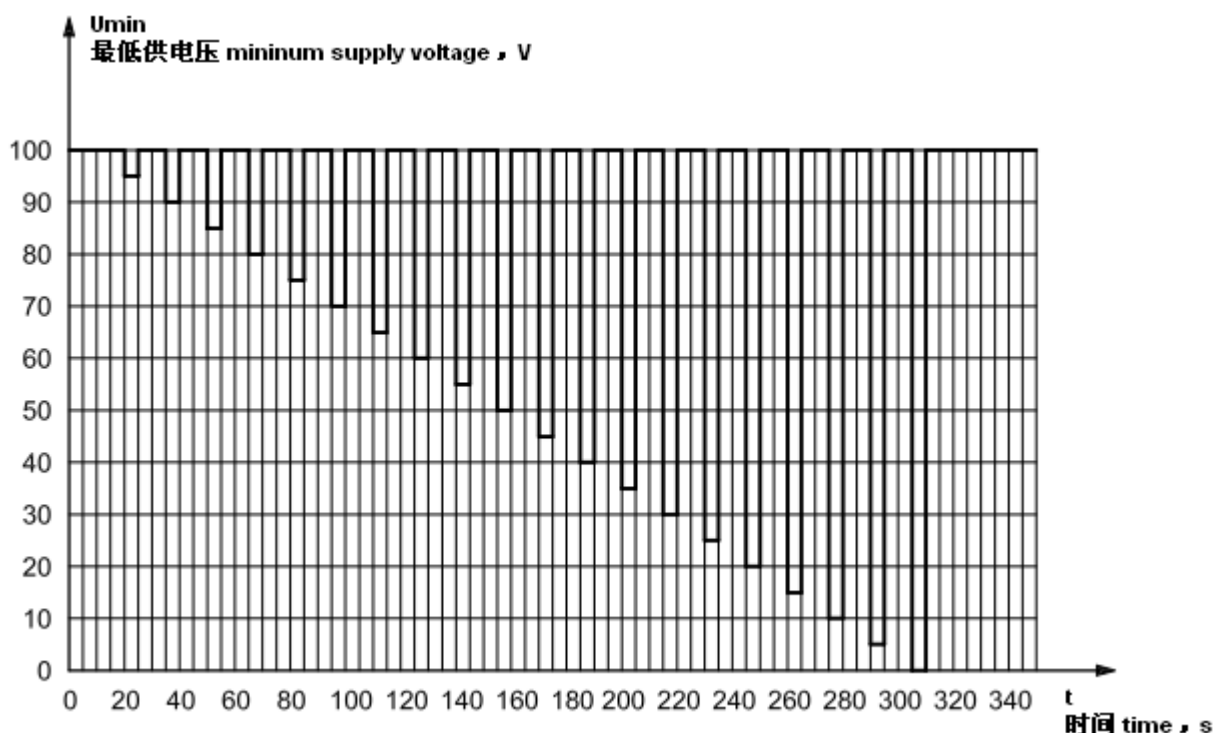


图 19 电压跌落波形
Figure 19 Voltage drop

7.4.4.5 报告

以下内容应包括在测试报告:
详细的功能描述。
任何与设计值之间出现的偏差。

7.4.4.5 Report

The following elements shall be included in the test report:
Description of the functions monitored.
Any performance deviations.

7.4.5 静电放电

7.4.5.1 设备

测试设备应符合 ISO 10605 中的要求。

7.4.5 ESD

7.4.5.1 Equipment

The test equipment shall comply with ISO 10605.

7.4.5.2 校验和测试布置

测试应符合 ISO 10605 中的要求, 除非本标准中另有说明。试验设施应置于温度为 $(23 \pm 3)^\circ\text{C}$ 和相对湿度为 20 %~40 % (20°C 和 30 % 相对湿度的首选) 的环境中。

7.4.5.2 Test verification and Test set-up

Testing shall be performed in accordance with ISO 10605 except where noted in this specification. The test facility shall be maintained at an ambient temperature at $(23 \pm 3)^\circ\text{C}$ and a relative humidity from 20 % to 40 % (20°C and 30 % relative humidity preferred).

静电放电模拟器的波形校验应符合 ISO 10605 的要求, 但下列情况除外:

The ESD simulator waveform verification shall comply with ISO 10605 with the following exceptions:

接触放电的上升时间 $\leq 1\text{ ns}$

Contact discharge rise time $\leq 1\text{ ns}$

空气放电的上升时间 $\leq 20\text{ ns}$

Air discharge rise time $\leq 20\text{ ns}$

RC 时间常数应该通过用引导边和/或阻尼振

The RC time constant shall be verified by calculation using the exponentially decaying portion of the waveform after the leading edge

荡之后波形指数衰减部分的计算进行验证。

7.4.5.3 程序

对于手持（不上电）模式测试

测试开始前，应按照表格 17 所列出的电压等级对 ESD 模拟器的放电电压进行校验。

- a) 在所有的包装，安装或拆卸期间由用户可以接触到的被测样件（除接插件引脚）在 ± 8 kV 上进行空气放电测试。应该在 EMC 测试计划中规定所有的放电表面；
- b) 如果在此测试期间观察到一个或更多的放电，给这些表面重复 2 个附加的放电（2 个极性），总共是 3 次。。

7.4.5.4 要求

被测样件的性能只有在测试等级超出表 17 和表 18 中的要求时才能与设计相背离。

and/or ringing.

7.4.5.3 Procedure

For handling (Un powered) Test

Before testing commences, the discharge voltage of the ESD simulator shall be verified at the levels listed in Table 17.

- a) Perform air discharge tests at ± 8 kV on all DUT surfaces (excluding the connector pins) that can be touched by the user during packaging, installation or dismantling. All discharge surfaces shall be specified in the EMC test plan;
- b) If one or more discharges are observed during this testing, repeat two (2) additional discharges (both polarities) to those surfaces, for a total of three (3) discharges.

7.4.5.4 Requirement

DUT functions may only deviate from the designed performance above the test levels in table 17 and table 18.

表 17 手持静电放电参数（非工作模式）
Table17 Discharge parameters for handling (unpowered test)

放电类型 Type of discharge	测试等级 Test Level	人体模型 Human body model	放电点放电次数及恢复时间 No. of discharges per test point and recovery time	放电点 Discharge points	功能要求 Functional status for all systems
接触放电 Direct discharge	± 8 kV	2 k Ω /150 pF	3+&3-;5 s	接插件的每个 Pin 脚及暴露在表面的零部件 Each connector pin, each separate exposed surface, seam and component	功能状态应满足 Class C 要求，记忆功能应满足 Class A 要求。
空气放电 Air discharge	± 8 kV	2 k Ω /150 pF	3+&3-;5 s	同上 As above	Class C; memory functions must remain Class A

表 18 工作静电放电参数 (工作模式)
Table18 Discharge parameters for operation (powered test)

放电类型 Type of discharge	测试等级 Test Level	人体模型 Human body model	放电点放电次数及恢复时间 No. of discharges per test point and recovery time	放电点 Discharge points	功能要求 Functional status for all systems	
					一般要求 Systems with normal requirements	提高要求 Systems with increased requirements
接触放电 Direct discharge	±6 kV	2 kΩ/330 pF	10+&10-;5s	所有的操作把手、按键、开关以及所有能够接触到的表面，通信总线 (±8kV) 在 1m 线束的终端进行测试 All shafts, buttons, switches and surfaces accessible to vehicle occupants plus CAN terminations with 1m of harness	Class A	Class A
接触放电 Direct discharge	±8 kV	2 kΩ/330 pF	10+&10-;5s		Class C	Class A
空气放电 Air discharge	±8 kV	2 kΩ/330 pF	10+&10-;5s		Class A	Class A
空气放电 Air discharge	±15 kV	2 kΩ/330 pF	10+&10-;5s		Class C	Class A
空气放电 ^a Air discharge	±25 kV	2 kΩ/150 pF	3+&3-;5s	车外可接近 Which can touch outside the vehicle	Class C	Class A
a 仅限于可以直接从汽车的外边接近而不触摸汽车的任何部分(例如, 门锁开关, 头灯开关, 仪表)的装置的要求/Requirement limited to devices in the passenger compartment that are directly accessible from outside the vehicle without touching any portion of the vehicle(e.g. door lock switches, head lamp switches, cluster).						

7.4.5.5 报告

测试报告中应包含以下要素:

- 功能检测说明;
- 任何放电事宜;
- 任何的性能偏差。

8 测试文件

与试验相关的文件格式须符合《WD-7.3-TCTV-032 供应商设计及产品验证工作指导书》的要求。

7.4.5.5 Report

The following elements shall be included in the test report:

- Description of the functions monitored.
- Any discharge events
- Any performance deviations.

8 Test document

The documents format should according to the requirement of <WD-7.3-TCTV-032 Supplier Design and product validation procedure>.