Ford Motor Company

Component and Subsystem Electromagnetic Compatibility
零部件和子系统
电磁兼容性

Worldwide Requirements and Test Procedures

ES-XW7T-1A278-AC

Date Issued: October 10 2003

Forward

This engineering specification addresses electromagnetic compatibility (EMC) requirements for electrical and/or electronic (E/E) components and subsystems for Ford Motor Company (FMC), which includes all of its associated vehicle brands. This specification is the direct link from ARL-09-0466. These requirements have been developed to assure compliance with present and anticipated domestic and foreign regulations in addition to customer satisfaction regarding the EMC of vehicle E/E systems. This specification replaces ES-XW7T-1A278-AB. Information regarding differences between these specifications may be found at http://www.fordemc.com. This specification is applicable to all E/E component/subsystems whose commercial agreements are signed after the October 10, 2003. These requirements, all or in part may also be adopted for current components and subsystems, but with written approval from the FMC EMC department.

Questions concerning this specification should be directed to: spec_questions@fordemc.com

Release Date: 10/10/2003
Printed copies are uncontrolled

Table of Contents:

1.0 Scope 6
1.1 Purpose of the Specification 6
1.2 Use of this Specification 6
1.3 Additional Information 7
2.0 References 7
2.1 International Documents 7
2.2 Military Standards 7
2.3 Other Documents 8
3.0 Abbreviations, Acronyms, Definitions, & Symbols 8
4.0 Common Test Requirements 10
4.1 Test Fixture 10
4.2 Artificial Networks 11
4.3 Interconnections 11
4.4 Test Conditions 11
5.0 Additional Requirements 12
5.1 Functional Importance Classification/ Performance Requirements 12
5.2 EMC test plans 12
5.3 Sample Size 13
5.4 Sequence of Testing 13
5.5 Revalidation 13
5.6 Test Laboratory Requirements 13
5.7 Data Reporting 13
6.0 Requirement Applicability 14
7.0 Radiated RF Emissions: RE 310 15
8.0 Conducted RF Emissions: CE420 21
9.0 Conducted Transient Emissions: CE 410 24
10.0 RF Immunity: RI 112, RI 114 26
11.0 Magnetic Field Immunity: RI 140 34
12.0 Coupled Immunity: RI 130, RI 150 38
13.0 Immunity from Continuous Disturbances: CI 210 42
14.0 Immunity from Transient Disturbances: CI 220 44
15.0 Immunity to Power Cycling: CI 230 50
16.0 Immunity to Voltage Offset: CI 250 53
17.0 Immunity to Voltage Dropout: CI 260 55
18.0 Immunity to Voltage Overstress: CI 270 62
19.0 Electro Static Discharge: CI 280 63
Annex A (normative): Component EMC Test Plan 68
Annex B (Normative): Process for Repeat EMC Testing 70
Annex C (informative): RF Service Bands 72
Annex D (normative): Field Calibration for ALSE Method above 1000 MHz 73
Annex E (normative): Mode Tuning Chamber Calibration 74
Annex F (Informative): Transient Waveform Description (A, B, C) 81
Annex G (Normative): Transient Test Circuit 86
Annex H (informative): P&B Relay Specifications 88

List of Tables:

Table 1- 1: Vehicle Level EMC Requirements 6
Table 4- 1: Permissible Tolerances 12
Table 4- 2: Environmental Test Conditions 12
Table 6- 1: Requirement Selection Matrix 14
Table 7-1: Level 1 Requirements 15
Table 7- 2: Level 2 Requirements 16
Table 7- 3: Measurement Instrumentation Set-up Requirements (Bands EU1, G1) 19
Table 7- 4: Measurement Instrumentation Set-up Requirements (All Bands except EU1, G1) 19
Table 8- 1: Conducted Emissions Requirements 21
Table 8- 2: Measurement Instrumentation Set-up Requirements (Bands EU1, G1) 22
Table 8- 3: Measurement Instrumentation Set-up Requirements (Band JA1, G3) 22
Table 10- 1: RF Immunity Acceptance Criteria 26
Table 10- 2: Test Frequency Steps 26
Table 10- 3: Requirements 400 – 3100 MHz 30
Table 11- 1: Magnetic Field Immunity Requirements 34
Table 11- 2: Test Frequency Requirements 34
Table 12- 1: Coupled Immunity Requirements 38
Table 13- 1: Test Frequency Requirements 43
Table 14- 1: Supply Voltage Transients - Immunity Requirements 44
Table 15- 1: Power Cycling Requirements 50
Table 16 1: Ground Voltage Offset Requirements 53
Table 16 2: Test Frequency Requirements 54
Table 17- 1: Voltage Dropout Requirements 55
Table 18- 1: Requirements for Voltage Overstress 62
Table 19- 1: ESD Requirements: Handling (unpowered) 63
Table 19- 2: ESD Requirements: Powered 64
Table B- 1: Electrical interconnect changes on Printed Circuit Boards, ... 70
Table B- 2: Software Changes 70
Table B- 3: E/E Component changes on PCBs, hybrid boards, or flat wire interconnects. 71
Table B- 4: Packaging or Mechanical changes 71
Table B- 5: Loading changes 71
Table C- 1: Typical RF Service Bands 72
Table E- 1: Independent samples and frequencies 79
Table H- 1: P&B Relay Specifications 88

List of Figures:

Figure 4- 1: Standard Configuration using Test Fixture 11
Figure 7- 1: Test Harness Bend Radius Requirements 17
Figure 7- 2: Test Configuration for Testing above 1000 MHz 18
Figure 9- 1: Transient Emissions Test Set-up 24
Figure 10- 1: Requirements using Bulk Current Injection (BCI) 27
Figure 10- 2: BCI Test Harness Configuration 29
Figure 10- 3: ALSE Test Set-up (1000 – 2000 MHz) 33
Figure 11- 1: Magnetic Immunity Test Set-up: Radiating Loop 35
Figure 11- 2: Magnetic Immunity Test Set-ups for Helmholtz Coil 36
Figure 12- 1: Test Set-up for Immunity from Inductive Transients 39
Figure 12- 2: Test Set-up for Immunity from Charging System Noise 40
Figure 12- 3: Test Set-up Requirements for use of Shielded/Twisted Wiring 41
Figure 13- 1: Requirements Continuous Disturbances 42
Figure 13- 2: Test Set-up for Continuous Disturbances 43
Figure 14- 1: Waveform for Test Pulse D 45
Figure 14- 2: Test Pulse E 45
Figure 14- 3: Test Pulse F 46
Figure 14- 4: Test Pulse G 46
Figure 14- 5: Test Set-up for Devices with a Single Power Supply Circuit 47
Figure 14- 6: Test Set-up for Devices with Two Power Supply Connections 48
Figure 14- 7: Test Set-up for Devices with Control Circuits 48
Figure 14- 8: Test Set-up Detail for Control Circuits using Pull-Up Resistors 49
Figure 14- 9: Test Set-up Modification for Application of Pulse 5 49
Figure 15- 1: Power Cycling Waveforms and Timing Sequence 51
Figure 15- 2: Power Cycling Test Set-up 52
Figure 16- 1: Test Set-up for Ground Offset of DUT 54
Figure 16- 2: Test Set-up for Ground Offset of DUT 54
Figure 17- 1: Waveform A (Voltage Dropout: High) 56
Figure 17- 2: Waveform B (Voltage Dropout: Low) 56
Figure 17- 3: Waveform C (Single Voltage Dropout) 56
Figure 17- 4: Waveform D (Voltage Dip) 57
Figure 17- 5: Waveform E (Battery Recovery) 57
Figure 17- 6: Waveform F (Random Bounce) 58
Figure 17- 7: Waveform F (Expanded) 58
Figure 17- 8: Test Set-up Detail for Waveforms A , B and C 59
Figure 17- 9: Test Set-up Detail for Waveforms D and E 59
Figure 17- 10: Test Set-up for Waveform F 60
Figure 19- 1: ESD Handling Test Set-up 65
Figure 19- 2: ESD Powered Test Set-up 66
Figure A- 1: EMC test plan Outline 68
Figure A- 2: Component / Subsystem EMC Test Plan Title Page 69

Figure D- 1: Calibration for 1000 to 2000 MHz 73

Figure E- 1: Reverberation Test Configuration (Mode Tuning) 80

Figure F- 1: Pulse A1 Composite Waveform (Mode 1) 82
Figure F- 2: Pulse A1 Short Duration Pulse Component (Mode 1) 83
Figure F- 3: Pulse A2 83
Figure F- 4: Pulse A2 (Detail) 84
Figure F- 5: Test Pulse B1 84
Figure F- 6: Typical Waveform for Test Pulse C 85
Figure F- 7: Typical Waveform for Test Pulse C 85

Figure G- 1: Transient Generator Circuit for Pulses A1, A2 and C 86
Figure G- 2: Transient Generator Circuit for Pulses B1, B2 86
Figure G- 3: Detail for Relay Circuit used for Mode 1 Transients 87
Figure G- 4: Detail for Relay Circuit used for Mode 2 Transients 87

1.0 Scope

This engineering specification defines the electromagnetic compatibility (EMC) requirements, test methods and test procedures for E/E components and subsystems used by Ford Motor Company (FMC) including associated vehicle brands. 范围：工程规范明确了电磁兼容性的要求，测试方法和E/E零部件的测试步骤以及福特汽车公司包括相关汽车品牌使用的子系统

1.1 Purpose of the Specification

1.1 规格的用途：此工程规格的用途在于确保汽车内和汽车之间以及汽车电磁环境的电磁兼容性。规格规定了电磁兼容性的要求和测试方法，测试方法是为E/E零部件和汽车的独立子系统研发的。规格包含的要求，其偏差只有在以下情况中容许出现：一是在供应商和具体汽车生产线之间明确同意，二是在适用零部件或子系统的工程规格中有记录。这些行动应EMC和供应商之间的合同协议完成前发生

The purpose of this engineering specification is to ensure electromagnetic compatibility (EMC) within the vehicle and between the vehicle and its electromagnetic environment. This specification presents EMC requirements and test methods that have been developed for E/E components and subsystems independent of the vehicle. Deviations from the requirements contained in this specification are only allowed if agreed explicitly between the supplier and the specific vehicle line and documented in the applicable component or subsystem engineering specification. These actions shall occur before completion of the contractual agreements (i.e. Targeting Agreements, Statement of Work) between FMC and the supplier.

The purpose of component and subsystem testing is the pre-qualification of EMC at a time when representative vehicles are not yet available. In addition to meeting the requirements specified herein, E/E components and subsystems, shall also comply with one or more of the following FMC vehicle EMC requirements when installed in the vehicle:

零部件和子系统测试的目的在于对当代表汽车不可用时电磁兼容性的资格预审。不仅要符合这里指定的要求，E/E零部件和子系统在安装于汽车时还要符合FMC汽车电磁兼容性要求中的一个或多个。

Table 1- 1: Vehicle Level EMC Requirements 汽车水平电磁兼容性要求

ARL 09-0411	ARL 09-0422	ARL 09-0433
ARL 09-0419	ARL 09-0425	ARL 09-0467
ARL 09-0418	ARL 09-0426	ARL 09-0468

The supplier may contact the FMC EMC department for details concerning these requirements. Verification testing to these requirements is performed by FMC. Note that additional component, subsystem, and vehicle level EMC requirements may be imposed by individual vehicle brands reflecting special conditions in their target markets. The component or subsystem supplier should verify that any additional requirements, or modifications to the requirements delineated herein shall be included in the supplier's statement of work and the component/subsystem's engineering specification.

关于这些要求的细节，供应商应和FMC电磁兼容性部门取得联系。这些要求的验证试验要由FMC进行。值得注意的是附加零部件，子系统以及汽车水平电磁兼容性要求应由单独的汽车品牌来规定，这些要求反映了其目标市场的特殊要求。零部件或子系统供应商核实所有附加要求或在此规定的要求的改动应包括在供应商工作声明和零部件/子系统的工程规格中。

1.2 Use of this Specification

1.2 规范的使用：此工程规格中的要求和测试方法都尽可能以国际标准为基础来规定。如果没有国际标准，可以使用军事和企业内部标准。

The requirements and test methods in this engineering specification are based on international standards wherever possible. If international standards do not exist, military, and internal corporate standards are used. Note that under some circumstances, unique requirements and test methods are presented that experience has shown to better represent the vehicle electromagnetic environment. Refer to the definitions in section 3.0 for clarification of terms. Should a conflict exist between this specification and any of the referenced documents, the requirements of this specification shall prevail, except for regulatory requirements. This specification applies to all components and subsystems that reference EMC in their engineering specification. Components may be referred to in this specification as a component, device, module, motor, product or DUT (device under test).

值得注意的是，在一些情况下，特殊的要求和测试方法表明了更好地代表车辆电磁环境的经验。此规范和所有参考文件之间可能存在冲突，规范的要求应占主导，除了管理机构要求

本规范适用于所有零部件和子系统，参考他们的工程规范的EMC。此规范里的零部件指的是组件，装置，模块，发动机，产品或受试设备。

The following steps shall be taken by the FMC Design and Release (D&R) group and their supplier for assuring EMC compliance of their component or subsystem:

FMC设计和发行组应采取以下步骤，他们的供应商要确定电磁兼容性和他们组件或子系统的一致性。

1. Provide the supplemental information needed to classify the E/E component/subsystem functional importance classification (see section 5.1) 1.提供E/E组件/子系统功能重要性分类所需的补充信息（参见5.1）
2. Identify which tests are applicable (refer to section 6). 2.确定适用的测试（参考6）
3. Identify acceptance criteria specific to the component or subsystem. 3.确定特别针对组件或子系统的验收准则
4. Develop an EMC test plan (see section 5.2 and Annex A) 4.开发一个电磁兼容性测试计划（参见5.2和附录A）
5. Assure that the test results are forwarded to the FMC EMC department 5.确保测试结果发送至FMC电磁兼容性部门

It's important to emphasis that the FMC D&R group and their supplier (not the FMC EMC department) are responsible for determining the acceptance criteria for their component or subsystem (step 3).

强调FMC研发组和他们的供应商（不是FMC电磁兼容性部门）负责决定他们组件或子系统（步骤3）的验收准则

These acceptance criteria shall be documented in the component/subsystem's engineering specification. The FMC D&R group is also responsible for verifying that the requirements delineated in this specification are met. The supplier is responsible for performing the verification testing per the requirements of this specification.
这些验收准则应录入组件/子系统的工程规范。FMC研发组也负责审核测试和规范中规定的要求的一致。供应商负责进行关于此规范中要求的验证测试
The FMC EMC department reserves the right to perform audit testing or witness supplier design verification (DV) on sample parts in order to verify compliance with this specification.
FMC电磁兼容性部门保留进行审计测试或者监督供应商对样本部件的设计验证的权力这样做是为了验证其和该标准的一致性
1.3 附加信息：对此规范所需的E/E组件或子系统测试表明了组件/子系统性能的经验风险分析和对已知的环境威胁和客户满意度要求的衍生近似值的比较

1.3 Additional Information

此规范的发展在广泛经验的基础上进行，广泛经验是指在达成和期望汽车高水平可预测性性能的相关性方面。但是，电磁兼容性测试，就其本质来说，受制于机械测试时的相似变化。

E/E component or subsystem testing to the requirements of this specification represents an empirical risk analysis of component/subsystem performance versus derived approximations to known environmental threats and customer satisfaction requirements. The development of this specification is based on extensive experience in achieving correlation to expected vehicle performance with a high level of predictability. However, EMC testing, by its nature, is subject to similar variation as mechanical testing. Because of coupling variability and measurement uncertainty, correlation between component/subsystem level performance and final performance in the complete vehicle cannot be exact. In order to maintain a competitive and quality product, vehicle EMC testing will be performed to evaluate overall integrated system performance. However, vehicle level analysis and testing is not a substitute for component/subsystem conformance to this specification.
由于耦合可变性和测量的不确定性，组件/子系统水平性能和在完整汽车里的最终性能的相关性不能精确。
为了维持具有竞争性和好质量的产品，需要进行汽车电磁兼容性测试来评估整体集成系统的性能。但是，汽车水平分析和测试不能替代符合规范的组件/子系统
This specification does not include any information regarding component/subsystem design required to meet the requirements presented herein. Information on this subject may be found in ES3U5T-1B257-AA *"EMC Design Guide for Printed Circuit Boards"*, which is available for download from http://www.fordemc.com. Additional information may be found from a number of technical journals and textbooks.
本规范不包括任何有关必须符合这里提出的要求的组件/子系统的设计。关于这一点在ES…“印刷电路板的EMC设计指导”里有规定，
这个规定可以从http…这个网站下载使用。附加信息可以从许多技术期刊和课本里找到。

2.0 References

2.1 International Documents

CISPR 16-1 1999-10 Specification for radio disturbance and immunity measuring apparatus and methods - Part 1: Radio disturbance and immunity measuring apparatus

CISPR 25 Edition 2 Limits and methods of measurement of radio disturbance characteristics for the protection of receivers used on board vehicles.

IEC 61000-4-21 Electromagnetic compatibility (EMC) - Part 4-21: Testing and measurement techniques - Reverberation chamber test methods

ISO 10605 2001-12 Road vehicles - Test methods for electrical disturbances from electrostatic discharge

ISO 7637-1 2002-03 Road vehicles, Electrical disturbance by conduction and coupling Part 1 – Definitions and general considerations.

ISO 7637-2 2nd DIS 2002-07 Road vehicles, Electrical disturbance by conduction and coupling Part 2 - Vehicles with nominal 12 V or 24 V supply voltage - Electrical transient transmission by capacitive and inductive coupling via supply lines

ISO 10605 2001-12 Road vehicles – Test methods for electrical disturbances from electrostatic discharge

ISO 11452-1 2001-04 Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 1: General and definitions

ISO 11452-2 1995-12 Road vehicles, Electrical disturbances by narrowband radiated electromagnetic energy - Component test methods Part 2 - Absorber-lined shielded enclosure

ISO 11452-4 2001-02 Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 4: Bulk current injection (BCI)

ISO/IEC 17025 1999-12 General requirements for the competence of testing and calibration laboratories

2.2 Military Standards

MIL-STD-461E United States Department of Defense Interface Standard, Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment

2.3 Other Documents

ES3U5T-1B257-AA EMC Design Guide for Printed Circuit Boards. Available at http://www.fordemc.com/

3.0 Abbreviations, Acronyms, Definitions, & Symbols

缩写词，缩略词，定义和符号

Acceptance Criteria. Defines the limits of variance in function performance of the device during exposure to an electromagnetic disturbance. 验收准则：定义了在设备暴露于电磁干扰期间设备功能性能的变化范围

Active Electronic Module. Electronic modules that function via use of digital or analog circuitry including microprocessors, operational amplifiers, and memory devices.

有源电子模块：电气模块通过使用数字或模拟电路包括微处理器，运算放大器和存储设备来运行

AEMCLRP. Automotive EMC Laboratory Recognition Program.

AEMCLRP:汽车电磁兼容性实验室识别程序

ALSE. Absorber-lined shielded enclosure. Also used in this document together with ISO or SAE to designate the test itself with reference to the method described in ISO 11452-1 or SAE J1113-21. ALSE：吸收器内衬屏蔽壳体。

Annex. Supplementary material attached to the end of a specification, usually used to supply general information and not requirements. 附录：附加到规范结尾的补充材料，通常用来提供一般的信息不是要求

Artificial Network (AN). A device used to present a known impedance to the powerline of the DUT.

人工网络（模拟网络）：用来显示被测设备电源线的已知阻抗

BCI. Bulk Current Injection. Method for coupling common mode RF current into a harness

BCI：大电流注入。耦合共模射频电流到线束的方法

CBCI. Common Mode BCI. CBCI：共模大电流注入

CE. Conducted Emissions CE:传导发射

CI. Conducted Immunity CI：抗传导干扰性

CISPR. An acronym for “Comité International Spécial des Perturbations Radioeléctriques” (Special International Committee on Radio Interference). CISPR：无线电干扰国际特别委员会

CLD. Centralized Load Dump CLD：集中负载突降

Component. Reference for active electronic modules, electric motors, passive and inductive devices

组件：供有源电子模块，电动机，被动/电感元件

Control Circuits. I/O circuits that are connected to the vehicle battery via switches, relays or resistive/inductive loads, where that load is fed by a direct or switched battery connection.

控制电路：I/O电路通过开关，继电器或者电阻/电感负荷连接到汽车电池，这里的负荷通过直接或者开关蓄电池连接输入。

Component, subsystem Engineering Specification. Engineering specification for the component or subsystem documenting all performance requirements (mechanical, thermal, EMC, etc)

组件，子系统工程规范：组件或子系统的工程规范载入了所有性能要求（机械，热量的，电磁兼容性等）

CP. Confirmation Prototype. CP is development milestone of FPDS

CP：确认原型。

D&R. Design and Release D&R：设计和发行

dBpT. dB picotesla (160 dBpT or 10^{-4} tesla = 1 Gauss).

Disturbance. Any electrical transient or electromagnetic phenomenon that may affect the proper operation of an electrical or electronic device (see stimulus). 干扰：任何电气暂态或电磁现象都可能影响电气或者电子设备的正确操作

DBCI. Differential Mode Bulk Current Injection DBCI：差模大电流注入

DUT. Device(s) Under Test. Any electrical or electronic component, module, motor, filter, etc being tested.

DUT:被测设备。所有电气或电子组件，模块，发动机，滤波器等被测的设备

DV. Design Verification (components not constructed from production tooling). DV：设计验证

E/E. Electrical and/or Electronic. E/E：电气和/或电子

EMC. Electromagnetic Compatibility EMC：电磁兼容性

EMI. Electromagnetic Interference EMI：电磁干扰

Effect. A detectable change in DUT performance due to an applied stimulus. 影响：由于应用刺激物被测设备性能产生的可察觉的变化

EM. Electronically Controlled Motor. EM：电控发动机

ESD. Electrostatic discharge. ESD：静电放电

ESD - Air Discharge. Test method whereby the electrode of the test generator is brought near the DUT and discharge is accomplished through an arc to the DUT.

ESD-空气放电：此测试通过测试发生器的电极靠近被测设备，然后通过被测设备的电弧完成放电

ESD - Contact Discharge. Test method whereby the electrode of the test generator is brought into contact with the DUT and the discharge is triggered by the discharge switch located on the generator.

ESD-接触放电：此测试通过测试发生器的电极和被测设备接触，然后通过安装在发生器上的放电开关引发放电

Fail-Safe Mode. A predictable operating mode intended to minimize adverse effects by restricting or shutting down operation when a significant stimulus has made operation unreliable. Operation shall recover after the stimulus is removed without permanent loss of function or corruption of stored data or diagnostic information.

故障安全模式：当有明显的刺激使操作变得不可靠时，可预测的操作模式旨在通过限制和关闭操作来减小不利影响

操作在刺激移除后恢复，刺激的移除不能造成功能的永久丧失，存储信息或诊断信息的损坏

FMC. Ford Motor Company FMC：福特汽车公司

FMC D&R Group. The FMC engineering activity responsible for design or the component or subsystem FMC D&R Group：福特汽车公司工程活动负责设计组件或子系统的设计

FMC EMC Department. The Ford Motor Company EMC department associated with a specific brand. FMC EMC部门：福特汽车公司电磁兼容性部门和特殊品牌有关联

FPDS. Ford Product Development System FPDS：福特产品开发系统

Function. The intended operation of an electrical or electronic module for a specific purpose. The module can provide many different functions, which are, defined (functional group and acceptable performance) by the module specification. 功能：有特殊目的的电气或电子模块的意向操作。模块可以提供许多不同的功能，这些功能通过模块规范明确（功能组合和可接受性能）

Functional Importance Classifications: Defines the importance of E/E component/subsystem functions with respect to safe vehicle operation. 功能重要性分类：明确关于安全汽车操作的E/E组件/子系统功能的重要性

- **Class A:** Any function that provides a convenience. 等级A：所有功能操作便利
- **Class B:** Any function that enhances, but is not essential to the operation and/or control of the vehicle. 等级B：所有功能加强，但是对汽车的操作和/或控制不必要
- **Class C:** Any function that controls or affects the essential operation of the vehicle or could confuse other road users. Note that certain Class C functions which may experience an unintentional change that may surprise the vehicle operator and which cannot be remedied safely and immediately (e.g., air bag deployment, base steering loss, base braking loss, engine stalls or surges) may be subject to more stringent requirements. 等级C：所有功能控制或影响汽车的基本操作或者会扰乱其他的道路使用者。值得注意的是，某些等级C的功能可能受制于更严厉的要求 这些功能可能遭受非故意的变化，这种变化可能惊吓到汽车操作者并且不能立即安全修补（如安全气囊部署，丧失基本转向和刹车功能，发动机失速或者喘振）

Function Performance Status. The performance of DUT functions, when subjected to a disturbance, is described by three performance status levels: 功能性能状态：受制于干扰时，被测设备功能的性能被分为以下三种性能状态水平：

- **Status I:** The function shall operate as designed (or meet specified limits) during and after exposure to a disturbance. 状态1：在设备暴露于干扰之中和之后，功能应按设计操作
- **Status II:** The function may deviate from designed performance, to a specified level, during exposure to a disturbance or revert to a fail-safe mode of operation, but shall return to normal immediately following removal of the disturbance. No effect on permanent or temporary memory is allowed (see fail-safe mode). 状态2：在设备暴露于干扰之中或转向操纵的自动防故障模式时，功能可能偏离了设计的性能要求，但是干扰移除后功能应恢复正常。不会造成对永久或暂时存储的影响
- **Status III:** The function may deviate from designed performance during exposure to a disturbance but shall not affect safe operation of the vehicle or safety of its occupants. Operator action may be required to return the function to normal after the disturbance is removed (e.g. cycle ignition key, replace fuse). No effect on permanent type memory is allowed. 状态3：设备暴露于干扰之间时功能可能偏离设计的性能要求，但是不会影响汽车的安全操作或车内人员安全。移除干扰后可能需要操作员操作返回正常功能（如循环点火钥匙，更换保险丝）。对永久型存储没有影响
- **Status IV:** The device shall not sustain damage, changes in I/O parametric values (resistance, capacitance, leakage current etc.) or a permanent reduction in functionality 状态4：设备不应遭受损害，不能有参数值（电阻，电容，泄漏电流等）的变化或功能的永久减弱

Inductive Device. An electromechanical device that stores energy in a magnetic field. Examples include, but not limited to solenoids, relays, buzzers, and electromechanical horns. 电感元件：在磁场储存能量的机电装置。例子包括但不局限于螺线管，继电器，蜂鸣器和机电号角

Informative. Additional (not normative) information intended to assist the understanding or use of the specification. Informative：旨在协助规范的理解或使用的附加（不是标准）信息

I/O. Input and output. Also used in this document to designate the transient pulse testing on I/O-lines. I/O：输入和输出。也使用在文件中指定I/O线上的瞬时脉冲测试

Memory (temporary or permanent). Computer memory used for, but not limited to storage of software code, engine calibration data, drive personalization, radio presets. Hardware for this includes ROM, RAM and FLASH memory devices. 存储（暂时或永久）：电脑储存器用来存储发动机校准资料，驱动个性化和电台预设，但是不局限于软件代码的存储。存储的硬件包括ROM,RAM和闪速存储器

N/A. Not Applicable N/A：不可用

NIST. An acronym for National Institute of Science and Technology. NIST：国家科学与技术学院

Normative. Provisions that are necessary (not informative) to meet requirements. Normative：需要(不是informative)符合要求的条款

PCB. Printed Circuit Board. PCB：印刷电路板

PRR. Pulse Repetition Rate PRR：脉冲重复率

PV. Production Verification (component constructed from production tooling) PV：产品验证

PWM. Pulse Width Modulated or Modulation. PWM：调谐脉冲宽度或脉冲宽度调制

RE. Radiated emission RE：辐射发射

RI. Radiated Immunity RI：辐射抗扰度

Recognized Laboratory. An EMC laboratory that meets the requirements for acceptance by Ford Motor Company through in part, accreditation via AEMCLRP requirements. Refer to http://www.fordemc.com for more details on this program. 认可的实验室：EMC实验室要符合福特汽车公司接受的要求

RF Boundary. An element of an EMC test set-up that determines what part of the harness and/or peripherals is included in the RF environment and what is excluded. It may consist of, for example, ANs, filter feed-through pins, fiber optics, RF absorber coated wire and/or RF shielding.

射频边界：EMC测试装置的元件决定线束和/或外围设备的什么部分包括在射频环境中或什么部件不包括子里面。它包括，比如，接入网，滤波器输入针，现为光学，射频吸收器涂丝和/或射频防护

Shall. Denotes a requirement.

Shall：代表要求

Single Shot. Refers to the capture mode of a digitizing oscilloscope. A single shot represents a single capture of the voltage or current waveform over a defined sweep time setting

单拍：指的是数字化示波器的拍照方式。单拍表示电压或者电流波经过一个指定的扫频时间设置的单拍

Should. Denotes a recommendation.

should：代表推荐

Substitution Method. The substitution method is a technique for mapping out the power required to produce a target RF field, Magnetic field, or current in absence of the DUT at a designated reference position. When the test object is introduced into the test chamber, this previously determined reference power is then used to produce the exposure field.

代替法：代替法是用来安排所需功率的一项技术，这个功率用来在指定的没有被测设备的参考位置产生目标射频场，电磁场或者电流。当测试目标被引入实验室时，这个之前决定的参考功率这时使用来产生辐射场

Switched Power Circuits. Any circuit that is connected to the vehicle battery through a switch or relay.

开关电源电路：任何通过开关或继电器连接到汽车电池的电路

4.0 普通测试要求

4.0 Common Test Requirements

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

所有使用来测量的测试设备应按照ISO 17025(或者由制造商推荐的文件)的标准进行校准，可追溯至NIST或其他等效的国家标准实验室。

- 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.

应注意射频边界对放射和抗扰性试验的控制，这样是为了减少被测设备，测试装备和电磁环境之间的不受期望的相互作用

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

测试设备，测试装置和测试步骤应该载入测试实验室步骤中作为其中的一个部分。福特汽车公司保有检查实验程序的权利

- Although testing generally involves only one physical component, subsystem testing involving multiple components (e.g. distributed audio components) is permissible.

虽然测试一般只包括一个物理组件，但是准许子系统测试包括了多个组件（比如分布式音频组件）

- Information regarding typical test equipment used for testing may be found at http://www.fordemc.com

关于用来进行测试的典型测试设备的信息请登录http//...

- All DV testing requires a EMC test plan in accordance with the requirements of Annex A. See section 5.2 for additional details.

所有DV测试都需要一个EMC测试计划，这个计划要符合附录A的要求，参见5.2的附加详情

4.1 测试装备

4.1 Test Fixture

被试设备的操作应该通过使用测试装备来协助，构件测试装备是用来模拟汽车系统（即负荷模拟器）。测试装备，如Fig.4-1所示，是一个屏蔽室，其包括了所有外部电气界面（传感器，负荷等），这些界面通常被当做被测设备

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 4-1, is a shielded enclosure that contains all external electrical interfaces (sensors, loads etc.) normally seen by the DUT.

只要有可能，生产意图组件应使用到负荷。这一点对调制电感和脉冲宽电路特别重要。如果实际负荷不可用，那模拟负荷应准确表示电阻，电容和生产汽车中期望的电感，不应该使用简单电阻负载，除非证明其存在于实际汽车安装中

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.

如果被测设备由来自另一个电子模块（如传感器）的能力驱动，那模块能量供应的电流限制应得到准确的反映。

有源设备可以包含在测试装置内，但是应该采取合适的步骤来防止在抗干扰测试期间对支撑设备的潜在影响以及对辐射放射的测试结果的影响。通常，任何连接到车身的电气负荷都应参考测试装置事例（参见4-1）

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 (see Figure 4-1)

测试装置应同时作为被测设备和界面的射频边界用来进行支撑设备的测试，支撑设备用来协助被测设备的操作和抗干扰测试期间被测设备重要功能的监测。

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 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 (see Figure 4-1). Exceptions to this requirement include conditions where packaging requirements dictate local grounding of the DUT.

在一般情况下，所有的输入和输出应参照建立在测试装置内一个点的电源地，并连接到测试装置的外壳下（参见Fig.4-1）。

这项要求的例外情况包括包装要求决定被测设备的当地接地的条件

Fiber optic media should be used wherever possible to connect DUT inputs and outputs to remotely located test support instrumentation (see Figure 4-1). 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

尽可能的使用光纤媒体来连接被测设备输入和输出到远处的测试支撑仪器（参见Fig.4-1）。

应该选择光纤媒体的频宽来避免无意的信号耦合，这种信号可能影响测试支持仪器仪表。虽然不推荐屏蔽线，但其可以代替光纤媒体使用，在测试装备和试验室之间的长度尽可能的短。

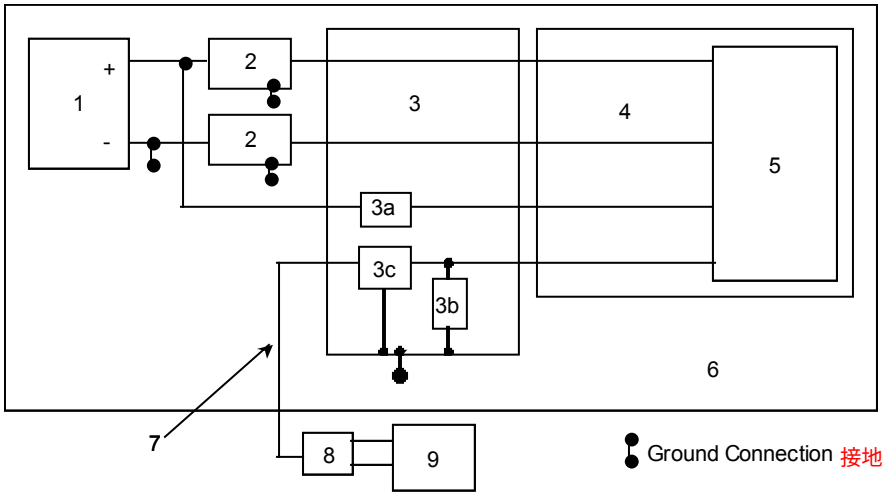
值得注意的是要确保这些电缆不会影响测试结果。这些电缆的结构图（即路由选择，屏蔽接地等）应载入EMC测试计划中
sure these cables do not influence the test results. Configuration of these cables (i.e. routing, shield grounding etc.) shall be documented in the EMC test plan.

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.
射频滤波应该使用来防止射频能量偏移而造成监测/支持仪器的故障。如果使用了射频滤波，射频滤波就应该被选择，这样它才不会影响组件的操作和/或影响EMC测试过程中的组件性能。射频滤波电容不应超过组件通常的电容。射频滤波器电容应载入EMC测试计划中

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 4-1. Artificial Network design and performance characteristics shall conform to CISPR 25, Edition 2.
4.2 人工网络：此规范中几个测试需要使用到人工网络。除非另有声明，否则此规范中人工网络的使用和连接应符合fig.4-1所示的装置。人工网络设计和性能特征应符合CISPR25，第二版

Figure 4- 1: Standard Configuration using Test Fixture



Key:

1 Power Supply 电源
2 Artificial Network 人工网络
3 Test Fixture 测试装置
3a DUT Load (referenced to power supply) 被测设备负荷（和电源一致）
3b DUT Load (referenced to Text Fixture case) 被测设备负荷（和测试装备外壳一致）
3c Fiber Optic Interface (optional, may be located outside of Test Fixture) 光纤界面（选择性的，可以安装在测试装备外面）
4 Insulated support ($\varepsilon_r \leq 1.4$) 绝缘支撑
5 DUT 被测设备
6 Ground Plane 接地
7 Fiber Optic 光纤
8 Fiber Optic Interface 光纤界面
9 Support/Monitoring Equipment 支撑/监测设备

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 mm +300/- 0 mm unless otherwise stated within this specification. The harness shall contain wiring that represents what is use in the actual vehicle installation.
4.3 相互连接：被测设备和测试装备之间的电气互联应该通过使用标准测试线束变得便利。该线束的长度应为1700㎜+300/-0㎜，除非另有规定，否者要符合此规定。线束应包含使用在实际汽车安装中的线路

4.4 Test Conditions 4.4 测试条件

4.4.1 Dimensions

All dimensions in this document are in millimeters unless otherwise specified.
4.4.1 尺寸：此文件中的所有尺寸都以号码为准，除非另有规定

4.4.2 Tolerances.

公差：除非另有规定，公差一律按照表4.1指定的为准

Unless indicated otherwise, the tolerances specified in Table 4.1 are permissible.

Table 4- 1: Permissible Tolerances 容许公差

Supply voltage and current 电源电压和电流	± 5 %
Time interval, length 时间间隔，长度	± 10 %
Resistance, capacitance, inductance, impedance 电阻，电容，电感，阻抗	± 10 %
Test parameters for RF field strength, Electrical or magnetic field strength, injected current, power, energy, transient voltage amplitude (if adjustable)	+10% - 0%

射频场强度的测试参数，电气或磁场强度，注入的电流，功率，能量，瞬时电压振幅（如果可以调整）

4.4.3 Environmental Test Conditions 环境测试条件

Unless indicated otherwise, the climatic test conditions are defined in Table 4-2.

除非另有规定，气候测试条件一律要符合表4-2的规定

Table 4- 2: Environmental Test Conditions

Temperature 温度	23 ± 5.0 degrees C
Humidity 湿度	20 to 80% relative humidity (RH) 相对湿度

4.4.4 Power Supply

The power supply voltage shall be between 13 (+ 0.5/-1.0) volts unless otherwise stated within this specification. For some tests, only an automotive battery may be used. Under those conditions, the battery voltage shall not fall below 12 volts 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 that 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.

电源：电源电压应在13V（+0.5/-1.0）之间，除非另有规定，否则按照此规范进行。对于一些实验，只能使用汽车电池。在那些条件下，电池电压在测试期间不能下降到低于12V。测试之中电池可以充电，但是只能用线性电源。对于一些测试（比如辐射放射测试，抗干扰测试），需要把线性电源安装到屏蔽室的外面。可以使用隔板射频示波器来防止偏离射频信号进出屏蔽室。

5.0 Additional Requirements 附加要求

5.1 Functional Importance Classification/ Performance Requirements 功能重要性分类/性能要求

此规范需要所有组件和子系统功能根据它们在汽车全部操作中重要性来分类（即功能重要性分类）。所有组件功能的分类应在项目批准之前进行。在很多情况下，普通功能在之前进行分类。但是，针对特别的汽车品牌这些规范可能会有所不同。联系福特汽车公司EMC部门进行这些现存分类的澄清。如果引入了新的功能，福特汽车公司设计和发行组合和福特汽车公司EMC部门合作开发以达成合适的分类。

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. However, for a specific vehicle brand these classifications may be different. Contact the FMC EMC department for clarification of these existing classifications. If new functions are introduced, the FMC D&R group shall work with the FMC EMC department 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 FMC D&R group and their supplier(s) shall be responsible for developing these performance requirements.

一旦这些功能分类建立，关联性能要求应建立起来然后载入组件或子系统的工程分类中。这些性能要求看做是EMC测试中使用的组件/子系统验收标准的基础。福特汽车公司设计和发行组及他们的供应商应负责开发这些性能要求

5.2 EMC test plans

A EMC test plan shall be prepared and submitted to the FMC EMC department 20 days prior to commencement of EMC testing unless otherwise specified in EMC SDS requirements associated with the specific vehicle brand. The purpose of this test plan is to develop and document well though out procedures to verify that the component is robust to the anticipated electromagnetic environment that it must operate within.

EMC测试计划：EMC测试计划应准备好然后在EMC测试进行之前的20天提交到福特汽车公司EMC部门，除非EMC SDS要求另有规定。

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.EMC测试计划也提供了一个机制来不断增强和改善装置，这样就更好地与车辆水平测试相互关联。

The EMC test plan shall be prepared in accordance with the outline shown in Annex A. FMC 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 FMC 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 FMC EMC department to correct any deficiency and repeat testing if required by FMC.
EMC测试计划的准备要符合附录A所示的略图。福特汽车公司有保留检查和挑战EMC测试计划详细规格的权利，详细规格包括了抗干扰测试的具体验收标准。如果在之后检查显示在测试设置和/或验收标准中有缺陷，福特汽车公司对EMC测试计划的接受不能让供应商放弃其职责。供应商应和福特汽车公司EMC部门一起商讨来更正缺陷，如果福特汽车公司要求还有重复测试。

5.3 Sample Size

A minimum of two samples shall be tested. All applicable tests are performed on each of the samples.
样本尺寸：两个最小的样本应进行测试。所有适用的测试都要在每个样本上进行

5.4 Sequence of Testing

ESD handling tests (see section 19.2.1) 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 FMC EMC department shall be contacted immediately in the event that ESD issues are encountered.
测试顺序：ESD的操纵测试（参见19.2.1）应在其他所有测试之前进行。所有其他测试可以不按顺序进行。值得注意的是要以防推荐的额外测试样本由于ESD造成的损坏。但是，需要用来减缓ESD问题的所有纠正设计行为都需要重新测试。如果遇到ESD问题要立刻和福特汽车公司EMC部门取得联系

5.5 Revalidation

重新确认：为了确保测试继续符合EMC要求，如果有任何电路或PCB设计变化（比如微缩制程，新的PCB布局），就
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. die shrinks, new PCB layout). The criteria presented in Annex B shall be used to determine what additional testing will be required. The FMC EMC department and the FMC D&R group shall be notified if any of the design changes outlined in Annex B are planned. The FMC EMC department shall concur on any proposal to reduce the extent of repeat testing as outlined in Annex B.
需要附加EMC测试。这个标准在附录B中有明确规定，并将用来决定需要什么附加测试。如果附录B中的略图出现设计变化要通知福特汽车公司的EMC部门和福特汽车公司设计和发行组。福特汽车公司EMC部门应达成一致意见来减小附录B中描述的重复测试的程度

5.6 Test Laboratory Requirements

测试实验室要求：所有测试应在经过验证的EMC测试设备上进行，不论设备是否属于组件供应商或者是独立测试服务的一部分。福特汽车公司通过汽车EMC实验室认知计划来进行实验室寻求认知。这个计划的详情和实验室认知步骤可以在http，找到
All testing shall be performed in a recognized EMC test facility regardless whether it is owned by the component supplier or is part of an independent testing service. Laboratories seeking recognition by FMC shall do so via the Automotive EMC Laboratory Recognition Program (AEMCLRP). Details on this program and steps for laboratory recognition may be found at http://www.fordemc.com.

Note that FMC reserves the right to arrange for follow-up correlation tests and/or on site visits to evaluate the test methods presented herein. A laboratory which refuses such follow-up activities, or for which significant discrepancies are found is subject to having its recognition withdrawn.
值得注意的是福特汽车公司保留准备后续测试和/或现场参观的权利以便评估这里指定的测试方法。如果实验室不能做这类后续测试或者发现相差很大就要撤销认知测试

5.7 Data Reporting

资料报告：DV EMC测试结果的概括应有E/E组件或子系统供应商在测试完成后5个工作日内直接报告到福特汽车公司EMC部门。供应商应该在测试后30个工作日内传送一份详细的测试报告复印件到福特汽车公司EMC部门。所有测试报告应包括参考测试计划跟踪号（参见附录A）和实验室验证测试结果的结束。
A summary of the DV EMC test results shall be reported by the E/E component or subsystem supplier directly to the FMC EMC department within 5 business days following completion of testing. The supplier shall also forward a copy of the detailed test report to the FMC EMC department within 30 business days following testing. All test reports shall include the reference test plan tracking number (See Annex A) 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 MS Word or Adobe PDF formats. These reporting requirements do not apply to developmental test data.
每个要求的明确报告要求在此做出了规定。报告应用MS word 或者pdf格式制作。这些报告要求不用于发展测试自理哦

For vehicle brands being designed under FPDS, DV EMC test data shall be reported to the FMC EMC department no later than 30 days before the CP milestone.
汽车品牌按照FPDS,DV EMS测试资料设计应在CP里程碑之前不晚于30天的时间内上报都FMC EMC部门

6.0 Requirement Applicability

Table 6-1 lists all of the EMC requirements delineated in this specification along with their applicability to E/E components. Note that although test ID references have been carried over from the previous version of this specification (ES-XW7T-1A278-AB), requirements and verification methods are not necessarily the same.
要求适用性：表6-1列举了此规范中明确的EMC的所有要求，以及这些要求对E/E组件的适用性。值得注意的是虽然测试ID参考值沿袭了规范的前一个版本的至，但是要求和验证方法不必要一致。

Table 6- 1: Requirement Selection Matrix
要求选择矩阵

	Requirement Type	Test ID [1]	Component Category 组件种类								
			Passive [2] Modules 被动模块	Inductive Devices 电感设备	Electric Motors 电动机		Active Electronic Modules 有源电子模块				
			P	R	BM	EM	A	AS	AM	AX	AY
Requirement Applies (✓)	Emissions 发射										
	Radiated RF 辐射射频	RE 310			✓	✓	✓	✓	✓	✓	✓
	Conducted RF	CE 420			✓	✓	✓	✓	✓	✓	✓
	Conducted Transient 传导瞬变 传导射频	CE 410		✓	✓	✓				✓	✓
	Radiated Immunity 抗辐射干扰度										
	RF Immunity 抗射频干扰	RI 112 RI 114				✓	✓	✓	✓	✓	✓
	Magnetic Field 磁场	RI 140							✓		
	Coupled Transients 耦合瞬态										
	Inductive 电感式	RI 130				✓	✓	✓	✓	✓	✓
	Charging System 充电系统	RI 150				✓	✓	✓	✓	✓	✓
	Conducted Immunity 抗传导干扰性										
	Continuous 持续式	CI 210				✓	✓		✓	✓	✓
	Transient 瞬态	CI 220	✓			✓	✓		✓	✓	✓
	Power Cycle 动力循环	CI 230				✓	✓		✓	✓	✓
	Ground Offset 地面偏移	CI 250				✓	✓		✓	✓	✓
	Voltage Dropout 电压下降	CI 260				✓	✓	✓	✓	✓	✓
	Voltage Overstress 电压过压	CI 270	✓	✓		✓	✓		✓	✓	✓
	ESD	CI 280	✓			✓	✓	✓	✓	✓	✓

[1] Requirements and tests delineated in this specification are not necessarily identical to former versions referenced in ES-XW7T-1A278-AB 此规范里规定的要求和测试无必要和之前版本的相同，之前的版本参考ES...

[2] Applies only to devices connected to the vehicle power supply (direct or switched connections)
只能应用于连接到汽车电源的（直接或交换连接）设备

Passive Modules: 无源模块：

P: A passive electrical module consisting of only passive components. Examples: resistor, capacitor, inductor, blocking or clamping diode, Light Emitting Diode (LED), thermistor
P：无源电气模块只包括无源组件。比如，电阻器，电容器，感应器，阻流或钳位二极管，发光二极管，热敏电阻

Inductive Devices: 电感元件：

R: Relays, solenoids and horns R：继电器，螺线管和喇叭

Electric Motors: 电动机：

BM: A brush commutated dc electric motor. BM：电刷整流直流电动机

EM: An electronically controlled electric motor. EM：电子控制电动机

Active Electronic Modules: 有源电子模块：

A: A component that contains active electronic devices. Examples include analog op amp circuits, switching power supplies, microprocessor based controllers and displays.
A：包含有源电子元件的组件。比如包括模拟运算放大器电路，开关式电源，基于控制器和显示器的微处理器

AS: 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.
AS：用来自位于另一个模块的稳定电源操作电子组件或模块。这通常是传感器向控制器提供输入

AM: An electronic component or module that contains magnetically sensitive elements or is connected to an external magnetically sensitive element. AM：包含有磁感元件的电子组件或模块或者电子组件或模块连接到外部磁感元件

AX: 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).
AX：在有源电子模块内包含有电气或电子控制的发动机或者电子模块控制外部电感元件包括电气或电子控制发动机

AY: An electronic module that contains a magnetically controlled relay within its package.
AY：在有源电子模块内包含有电磁控制继电器的电子模块

7.0 Radiated RF Emissions: RE 310 辐射射频发射：RE 310

These requirements, delineated in Table 7-1 and 7-2 are applicable to the following component categories:
表7-1,7-2规定的这些要求应用到以下种类的组件：

Electronic Modules: A, AS, AM 电子模块：A,AS,AM
Shall meet Limit B for bands EU1 and G1. For the remaining bands, these devices shall meet Limit A.
应符合品牌EU1和G1的限制条件B。对于其余频段，这些设备应满足限制条件A

Electronic Modules: AX, AY, EM 电子模块：AX,AY,EM
Shall meet Limit A and Limit B. 应符合限制条件A和B

Electric Motors: BM 电动机：BM
Shall meet Limit B. These requirements do not apply to devices that operate with intermittent duration AND with direct operator control (both conditions must apply).
应满足限制条件B。这些要求不能应用到那些用间歇时间和直接操作控制（必须应用两个条件）操作的设备

7.1 Requirement 要求

- Radiated emissions requirements cover the frequency range from 0.15 to 2500 MHz. Requirements are linked directly to specific RF service bands, which are segregated into Level 1 and Level 2 requirements. Level 1 requirements are applicable for all FMC vehicle brands and markets worldwide.
辐射发射要求涵盖的频率范围为0.15到2500MHz。直接和特定射频服务频段相关联的要求分为水平1和水平2。水平1要求应用于所有福特汽车公司汽车品牌和全世界的市场
- Level 2 requirements are based on specific brand or market demands. Level 2 requirements are applicable to all vehicle programs unless specific exclusions are granted in writing by the vehicle program chief engineer or their designate prior to program approval. These exclusions shall be documented in the component or subsystem's engineering specification.
水平2要求基于特定的品牌或者市场需求。水平2要求应用于所有汽车计划，除非同意录入汽车计划总工程师或者在计划批准之前他们的设计这种特殊例外情况。这些例外应载入组件或子系统工程规范
- Note that for some vehicle applications, additional radiated emissions requirements may be imposed by a specific vehicle brand (*see Annex C*). These requirements shall be identified and signed off by the program's chief engineer prior to program approval to be applicable.
值得注意的是对于一些汽车的应用，附加辐射发射要求可以友一个特定的汽车品牌来规定（参见附录C）。这些要求应由计划的总工程师在计划批准投入应用之前确认和签发和保证
- Level 1 and Level 2 requirements are delineated in Tables 7-1 and 7-2. Note that for each level, the applicability of the limits (i.e. Limit A, Limit B) is based on the component being tested (see section 7.0). Also note that the limits are dependent on the measurement system bandwidth and detection scheme as delineated in section 7.2.2.
水平1和水平2要求在表7-1和7-2中有规定。要注意的是，对于每个水平，限制条件（A和B）的适用性基于被测的组件（参见7.0）。而且依赖于测量系统带宽和检测方案的限制条件在7.2.2做出了规定

Table 7-1: Level 1 Requirements

(Mandatory requirements for all FMC brands worldwide)
全世界福特汽车公司品牌需要遵循的强制性要求

Band #	Frequency Range (MHz)	Limit A Peak (dBuV/m) (1)	Limit B Quasi Peak (dBuV/m) (1)
M1	30 - 75	52 - 25.13*Log(f /30)	62 - 25.13*Log(f /30)
M2	75 – 400	42 + 15.13*Log(*f* /75)	52 + 15.13*Log(*f* /75)
M3	400 - 1000	53	63

1 f = Measurement Frequency (MHz)
测量频率

Table 7- 2: Level 2 Requirements

(see paragraph 7.1 for description of these requirements) 这些要求的详情参见7.1

Band #	Region	RF Service (User Band in MHz)	Frequency Range (MHz)	Limit A (2) Peak (dBuV/m)	Limit B Quasi Peak (dBuV/m) 准峰值
EU1	Europe	Long Wave 长波	0.15 - 0.28	n/a	41
G1	Global	Medium Wave (AM) 中波	0.53 - 1.7	n/a	30
NA1	North America	DOT 1 (45.68 - 47.34)	45.2 – 47.8 (1)	12	24
G2	Global	4 Meter (66 – 87.2)	65.2 – 88.1 (1)	12	24
JA1	Japan	FM 1 (76 – 90)	75.2 – 90.9 (1)	12	24
G3	Global 全球	FM 2 (87.5 – 108)	86.6 – 109.1 (1)	12	24
G4	Global	2 Meter (142 – 175)	140.6 – 176.3 (1)	12	24
EU2	Europe	TV, DAB 1 (174.1 – 240)	172.4 – 242.4 (1)	12	24
G5	Global	RKE, TPMS 1	310 - 320	20	30
G6	Global	RKE , TPMS 2	429 -439	25	30
G7	Global	TV	470 - 890	24	32
G8	Global	GPS	1567 - 1574	50 - 20664*log(*f* /1567) (3,4)	n/a
			1574 - 1576	10 (3,4)	n/a
			1576 - 1583	10 + 20782*log(*f* /1576) (3,4)	n/a
NA2	North America	SDARS	2320 - 2345	25	n/a
G9	Global	Bluetooth	2400 - 2500	25	n/a

1 User Band with 1% guard band. Applicable only for bands NA1, G2, JA1, G3, G4, EU2 用户频带带有1%的防护频带。只能应用于频带NA1，G2，JA1，G3，G4，EU2

2 Values listed for Limit A (except band G8) are based on use of peak detection. However, for electronic module categories AX, AY, and EM, average detection may be used. If average detection is used, the values for Limit A are reduced by 6 db. *Example: Band NA1, Limit A= 12 dbuV/m. If average detection is used, Limit A is reduced to 6 dbuV/m).* 限制条件A所列的值（除了频带G8）基于峰值检测的使用。但是，对于电子模块种类AX,AY和EM来说，可以使用平均检测。如果使用平均检测，限制条件A的值减小到6db.例如NA1，限制条件A=12dbu V/m。如果使用平均检测，限制条件A减小到6dbuV/m

3 f = Measurement Frequency (MHz) f=测量频率（MHz）

4 Values listed for Limit A, band G8 are based on use of averaged detection. 限制条件A所列的值，频带G8基于平均检测的使用

7.2 测试验证和测试装置：CISPR 25版本2的要求，ALSE法应使用来进行被测设备性能的验证，此规范中规定的除外。测试期间的组件操作应载入EMC测试计划，该计划是由组件/子系统供应商和EMC测试实验室准备的（参见5.2）

7.2 Test Verification and Test Set-up

The requirements of CISPR 25 Edition2, 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 EMC test laboratory (see section 5.2).

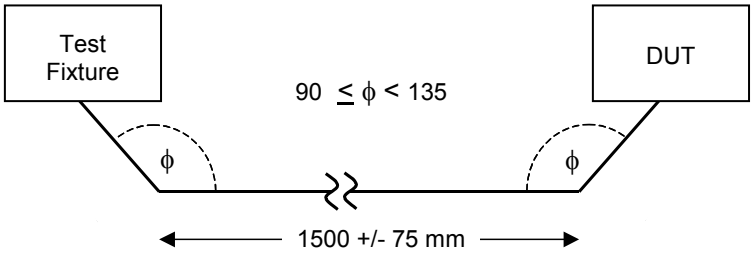
- The DUT and any electronic hardware in the Test Fixture shall be powered from an automotive battery (see paragraph 4.4.4 for requirements). The battery negative terminal shall be connected to the ground plane bench. The battery may be located on, or under the test bench. The standard test set-up shown in Figure 4-1 shall be used for the Test Fixture, battery and Artificial Networks. 测试装备上的被测设备和所有电子硬件应该由汽车电池供电（参见4.4.4的要求）。电磁负极应连接到地平面试验台。电池可以安装在试验台上面或下面。标准测试装置如fig.4-1所示应使用到测试装备，电池和人工网络
- The total harness length shall be 1700 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 7-1. The harness shall lie on an insulated support 50 mm above the ground plane. 总的线束长度为1700mm（+300/-0mm）。被测设备和测试装备的位置需要线束的弯曲。线束弯曲半径应在90°到135°之间，如fig.7-1所示。线束应位于绝缘支撑位上，支撑物位于地平面50mm之上

- 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 uncertainly 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.

如果被测设备的外壳是金属的，并且安装在车上时可以接地，那么被测设备应在测试期间安装且电气连接到地平面。如果被测设备外壳没有在汽车中接地，被测设备应安装在位于地平面之上50mm的绝缘板上。如果不能确定这一点，被测设备应在两个结构中进行测试。被测设备位置/方向应载入EMC测试计划和测试报告中

Figure 7- 1: Test Harness Bend Radius Requirements

测试线束弯曲半径要求



7.2.1 Test Set-up for Measurements above 1000 MHz

1000MHz以上测量的测试装置：进行1000MHz以上测试时，接收天线应重新安装以便其中心和被测设备的中心遗址，如fig.7-2所示。测试设置的剩余部分保持不变

When tests are performed above 1000 MHz, the receiving antenna shall be relocated such that its center is aligned with the center of the DUT as illustrated in Figure 7-2. The rest of the test set-up will remain unchanged.

7.2.2 Measurement System Requirements

Tables 7-3 and 7-4 list the measurement system requirements when using either a swept (i.e. spectrum analyzer) or stepped EMI receiver. Limit A requirements are based on use of peak detection using a 9 - 10 kHz measurement bandwidth. For electronic module categories AX, AY, and EM, average detection may be used as an alternative for all bands except EU1 and G1. If average detection is used, the values for Limit A are reduced by 6 db. Example: Band NA1, Limit A= 12 dbuV/m. If average detection is used, Limit A is reduced to 6 dbuV/m). Limit B requirements are based on quasi-peak detection using a 9-10kHz or 120kHz measurement bandwidth (frequency dependent).

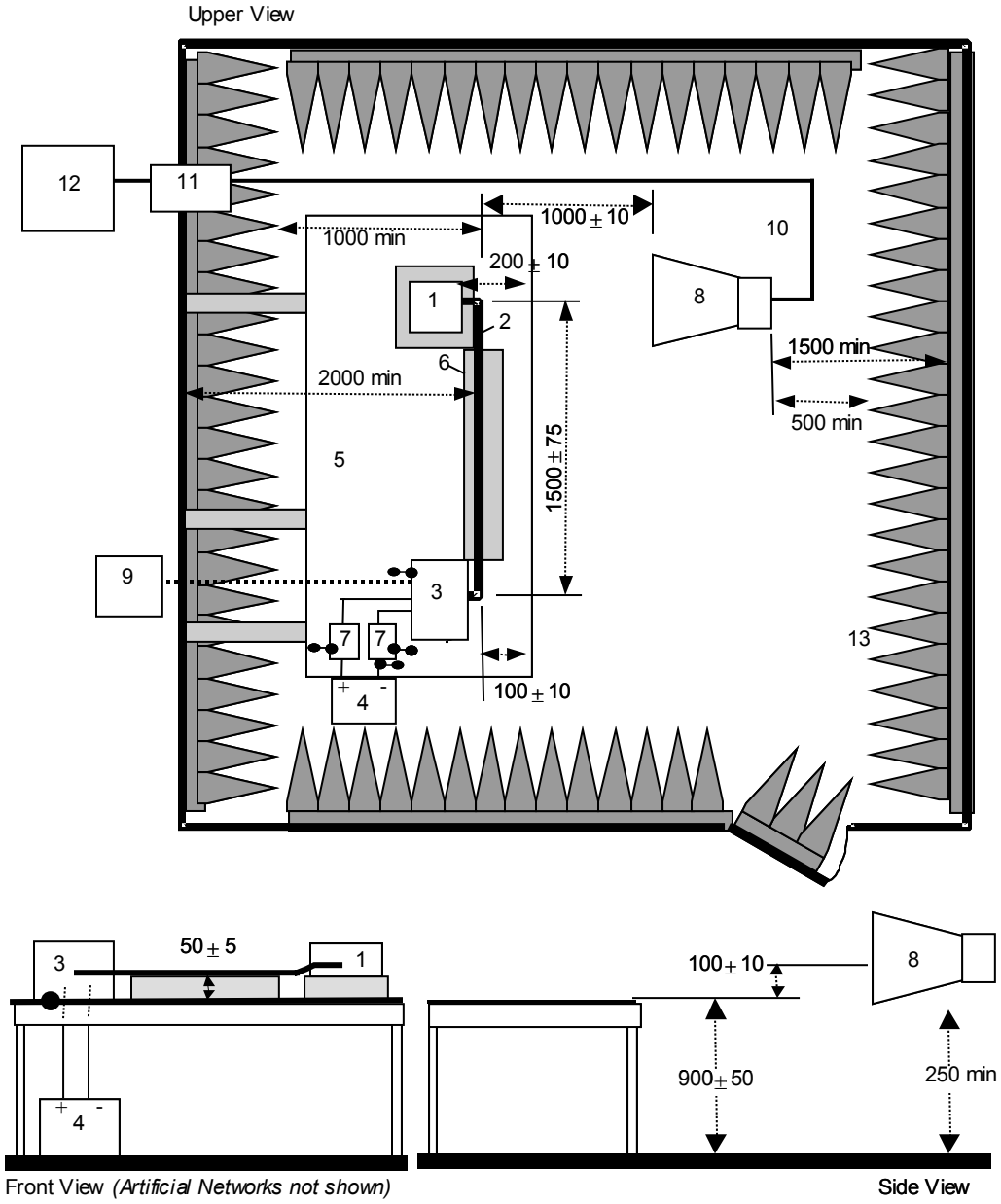
Measurement times listed in Tables 7-3 and 7-4 may be increased depending on DUT operation. This is particularly critical for low repetition rate signals. For Bands EU1 and G1, it is recommended that the measurement time (stepped receivers) be equal to $1/f$, where f *is* the signal repletion rate. Swept receivers need to be adjusted accordingly. Measurement times used shall be documented in the EMC test plan.

7.2.2 测量系统要求

表7-3,7-4列明了使用扫频或步进EMI接收器时的测量系统要求。限制条件A要求基于峰值检测的使用，使用9-10kHz测量带宽。对于电子模块种类AX,AY和EM，平均检测可以当做所有频带除了EU1和G1的一个选择。如果使用平均检测，限制条件A减小到6dbu V/m.限制条件B要求基于准峰值检测，使用9-10kHz或者120kHz的测量带宽（独立频率）

表7-3，7-4列明的测量次数取决于被测设备操作可以增加。这对低重复率信号非常重要。对于频带EU1和G1，推荐测量时间（步进接收器）等同于1/f，f是信号饱和率。扫频接收器需要相应进行调整。使用的测量次数应载入EMC测试计划

Figure 7- 2: Test Configuration for Testing above 1000 MHz



Key:

1 DUT
2 Test harness 测试线束
3 Test Fixture 测试装备
4 Automotive Battery 汽车电池
5 Ground plane (bonded to shielded enclosure) 地平面（和屏蔽室绑定）
6 Insulated support ($\varepsilon_r \leq 1.4$) 绝缘支撑物
7 Artificial Network (AN) 人工网络
8 Receiving Antenna 接收天线
9 Support Equipment 支撑设备
10 High quality double-shielded coaxial cable (e.g. RG 223) 高质量双重屏蔽同轴电缆
11 Bulkhead connector 穿板式连接器
12 Measuring instrument 测量仪器
13 RF absorber material 射频吸收器材料

Table 7- 3: Measurement Instrumentation Set-up Requirements (Bands EU1, G1)
测量仪器装备要求（频带EU1，G1）

	Swept Receivers 扫频接收器	Stepped Receiver 步进接收器
Detection Method 检测方法	Quasi Peak准峰值	Quasi Peak
Measurement Bandwidth (MBW) [1] 测量带宽	9 – 10 kHz	9 – 10 kHz
Video bandwidth 视频带宽	100 kHz	
Maximum sweep rate [2] 最大扫频率	20 sec / MHz	
Maximum Frequency Step Size 最大频率步长		50 kHz
Minimum Measurement Time per Frequency Step [2] 每个频率步进的最小测量时间		1 sec

1 To allow for the use of various receiver types, any bandwidth in this range may be used.
2 Sweep rate and measurement time may be increased for low repetition rate signals. See section 7.2.2 for details.
容许使用各种类型的接收器，可以使用这个范围内的带宽
扫频率和测量时间的低重复率信号可以提高。参见7.2.2

Table 7- 4: Measurement Instrumentation Set-up Requirements (All Bands except EU1, G1)
测量仪器设置要求（除了EU1和G1的所有频段）

	Swept Receivers		Stepped Receivers	
	Limit A	**Limit B**	**Limit A**	**Limit B**
Detection Method	Peak	Quasi-Peak	Peak	Quasi-Peak
Measurement Bandwidth (MBW) [1]	9 – 10kHz	120 kHz	9 – 10kHz	120 kHz
Video bandwidth	100 kHz	1 MHz		
Frequency sweep rate	1 sec / MHz	1 sec / MHz		
Maximum Frequency Step Size			0.5*MBW	1 MHz
Minimum Measurement Time per Frequency Step			5 msec	1 sec

1 For peak detection, any bandwidth in the range may be used. 对于峰值检测，可以使用范围内的所有频段

7.3 Test Procedure 测试程序

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 7-1 and 7-2. If this requirement is not met, testing shall not proceed until the associated test set-up issues are resolved.

Note that some laboratories use low noise preamplifiers to meet the ambient requirements. This approach is not recommended because of the potential of overload. If a preamplifier is used, its gain shall be no greater than 30 db. The laboratory shall also take steps to verify that the measurements system is not subject to overload at the measurement frequencies where the preamplifier is used.

测量被测设备辐射发射之前，测试装置环境水平（即所有设备通电，除了被测设备）应验证为6db或者更大，如7-1,7-2所列的特定要求下面的规定。如果不符合要求，测试要直到相关测试设置问题解决才能进行

值得注意的是一些实验室使用低噪音前置放大器来满足环境要求。这个方法这里不推荐，因为有过压的趋向。如果使用前置放大器，噪音的增加不会大于30db。实验室还应该采取措施来验证测量系统不会受制于前置放大器使用地点的测量频率的过压

b) Measurement of DUT radiated emissions shall be performed over all frequency bands listed in Tables 7-1 and 7-2. At measurement frequencies ≥ 30 MHz, measurements shall be performed in both vertical and horizontal antenna polarizations 被测设备辐射发射的测量应覆盖所有表7-1,7-2所列的频段。测量频率≥30MHz，测量应在天线极化的垂直和水平两个方向进行。

c) Tests shall be repeated for all DUT operating mode(s) delineated in the component EMC test plan. 测试应重复组件EMC测试计划中规定的所有被测设备操作模式

d) When assessing DUT performance to Limit B, the use of peak detection with the same measurement bandwidth is permitted as a quick pre-scan in all applicable bands to increase testing efficiency. If the peak emissions are below Limit B, the test data may be submitted as the final result. If the peak emissions are above any of the individual band requirements, it will be necessary to re-sweep individual frequency points which exceeded the limit for the band of interest using Quasi-peak detection. Peak and quasi-peak data shall be submitted in the test report. 被测设备性能的评估遵照限制条件B，容许使用带有相同测量带宽的峰值检测作为所有应用频带中的快速预扫描以便提高测试效率。如果峰值发射超过了所有独立频带要求，有必要重新对独立频率点进行扫频，独立频率点超过了频带的限制，频带有意使用准峰值检测的频带。峰值和准峰值信息应提交到测试报告

7.4 Data Reporting 信息报告

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: 每个被测设备操作模式和天线极化的测试信息应概括到一张纸上。信息单应包括以下内容：

- DUT operating mode 被测设备操作模式
- Limit reference (i.e. Limit A, Limit B) 限制条件参考（限制条件A和B）
- Antenna polarization 天线极化
- Measurement system bandwidth (MBW) 测量系统带宽
- Detection scheme (i.e. Peak, Quasi Peak, Average) 检测方案（即峰值，准峰值，平均峰值）
- Plotted emissions data over each frequency band. 涵盖每个频带的绘制发射
- Tabularized summary for DUT emissions in each frequency band. The table shall include the band #, maximum DUT emission level measured for the band, and associated band limit. Non-compliance to any band requirement shall be clearly noted. 列表概括每个频带的被测设备发射情况。该表应包括频带#，测量频带的被测设备的最大发射水平，以及相关频带限制。不符合所有频带要求的应注明清楚

Additional information required includes:

- Plots of the test set-up ambient data associated with each band 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.

所需附加信息包括：

和每个频带限制和计划相关的测试设置环境信息的平面图。这些平面图应包括使用的测量带宽和检测方案

所有偏离测试程序的都应注明，如EMC测试计划所示那样

8.0 Conducted RF Emissions: CE420 传导射频发射：CE420

These requirements are applicable to the following component categories: 这些要求应用于以下类型的组件：

Electronic Modules: A, AS, AM, AX, AY 电子模块：A,AS,AM,AX,AY

Electric Motors: BM, EM 电动机：BM,EM

For electric motors that operate with intermittent duration AND with direct operator control, this requirement may be relaxed or waived with written approval from the vehicle program chief engineer or their designate prior to program approval.
对于用间隔时间和直接操作控制进行操作的电动机来说，可以不受此要求的约束或者可以连同出自汽车计划总工程师的书面批准或他们在计划批准之前的设计一起舍弃

8.1 Requirement

8.1 要求：组件电源和电源回路上的传导射频电压发射不应超过表8-1所列的要求。对长波，中波(即调幅)以及调频广播服务的限制要求。

Conducted RF voltage emissions on the component power and power return circuits shall not exceed the requirements listed in Table 8-1. Requirements are limited to Long Wave (LW), Medium Wave (i.e. AM) and FM broadcast services. These requirements are applicable to all vehicle programs unless specific exclusions are granted in writing by the vehicle program chief engineer or their designate prior to program approval. These exclusions shall be documented in the component engineering specification.
这些要求应用于所有汽车计划中，除非同意录入汽车计划总工程师或者在计划批准之前他们的设计这种特殊例外情况。这些例外应载入组件工程规范

Note that for some vehicle applications, additional conducted emissions requirements may be imposed by a specific vehicle brand (*see Annex C*). These requirements shall be identified and signed off by the program's chief engineer or their designate prior to program approval to be applicable.
值得注意的是对于一些汽车的应用，附加传导发射要求可以由一个特定的汽车品牌来规定（参见附录C）。这些要求应由计划的总工程师在计划批准投入应用之前确认和签发和保证

Table 8- 1: Conducted Emissions Requirements 传导发射要求

Band #	RF Service	Frequency Range (MHz)	Limit Quasi-Peak (dbuV)
EU1	Long Wave (LW)	0.15 - 0.28	80
G1	Medium Wave (AM)	0.53 - 1.7	66
JA1	FM 1	76 -90	36
G3	FM 2	87.5 - 108	36

8.2 Test Verification and Test Set-up 测试验证和测试设置

- The requirements of CISPR 25 (Edition 2), voltage method shall be used for verification of the component performance except where noted in this specification.
CISPR 25（版本2）中的要求，电压方法应使用来进行组件性能的验证，此规范里规定的除外
- 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.
测试装备上的被测设备和所有电子硬件应由汽车电池供源（参见4.4.4）。电池的负极应连接到地平面
- The power/power return wiring between the DUT and the Artificial Network shall be 200 +/-50 mm in length.
被测设备和人工网络之间的电源/电源回路长度为200+/-50mm
- 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 uncertainly about this, the DUT shall be tested in both configurations.
如果被测设备的外壳是金属的并且安装在汽车时可以接地，被测设备应在测试期间安装和电气连接到地平面。如果在汽车中，被测设备的外壳没有接地，被测设备应放置在地平面50mm之上的绝缘支撑设备上。如果对此不确定，被测设备应在两个结构中都进行测试
- 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.
如果被测设备的回路在汽车内局部接地，那回路应直接连接到地平面。在这些条件下，可能忽略人工网络连接到被测设备的回路

8.2.1 Measurement System Requirements 8.2.1 测量系统要求

表8-2,8-3列明了使用扫频（波谱分析仪）或步进EMI接收器时的测量系统要求。

Tables 8-2 and 8-3 list the measurement system requirements when using either a swept (i.e. spectrum analyzer) or stepped EMI receiver. Note that RF FFT analyzers may be used as an alternative with approval from the FMC EMC department. For Bands EU1 and G1, it is recommended that the measurement time (stepped receivers) be equal to $1/f$, where f *is* the signal repletion rate. Swept receivers need to be adjusted accordingly. Measurement times used shall be documented in the EMC test plan.
值得注意的是射频频谱分析仪可以使用来作为福特汽车公司EMC部门赞同的一个选择。对于频带EU1和G1，推荐的测量时间（步进接收器）等同于1/f,f是信号饱和率。扫频接收器需要相应的进行调整。使用的测量次数应载入EMC测试计划

Table 8- 2: Measurement Instrumentation Set-up Requirements (Bands EU1, G1)
测量仪器装置要求（频带EU1，G1）

	Swept Receivers	Stepped Receiver
Detection Method 检测方法	Quasi-Peak	Quasi-Peak
Measurement Bandwidth (MBW)[1] 测量带宽	9 – 10 kHz	9 – 10 kHz
Video bandwidth 视频带宽	100 kHz	
Maximum sweep rate 最大扫频率	20 sec / MHz	
Maximum Frequency Step Size 最大频率步长		50 kHz
Minimum Measurement Time per Frequency Step 每个频率步进的最小测量时间		1 sec

1 To allow for the use of various receiver types, any bandwidth in this range may be used.
容许使用多种类型的接收器，可以使用此范围内的所有带宽

Table 8- 3: Measurement Instrumentation Set-up Requirements (Band JA1, G3)

	Swept Receivers	Stepped Receivers
Detection Method	Quasi-Peak	Quasi-Peak
Measurement Bandwidth (MBW)	120 kHz	120 kHz
Video bandwidth	1 MHz	
Frequency sweep rate	1 sec / MHz	
Maximum Frequency Step Size		1 MHz
Minimum Measurement Time per Frequency Step		1 sec

8.3 Test 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 8-1. 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测量被测设备传导发射之前，测试装置环境水平（即所有设备通电，除了被测设备）应验证为6db或者更大，如8-1所列的特定要求下面的规定。如果在指定限制条件下面的环境水平小于6db，测试直到解决了和测试设置相关的问题后才能进行

b) Measurement of DUT conducted emissions shall be performed over each frequency band listed in Table 8-1. 被测设备传导发射的测量的进行应覆盖表8-1所列的每个频带

c) Tests shall be repeated for all DUT operating mode(s) delineated in the component EMC test plan.
应重复组件EMC测试计划中规定的所有被测设备操作模式的测试

d) When assessing DUT performance the use of peak detection with the same measurement bandwidth is permitted as a quick pre-screen to increase testing efficiency. If the peak emissions are below the limit, the test data may be submitted as the final result. If the peak emissions exceed the band requirements, it will be necessary to re-sweep individual frequencies where the limit was exceeded using Quasi-peak detection. Peak and quasi-peak data shall be submitted in the test report.
评估被测设备性能时，容许使用带相同测量带宽的峰值检测作为快速预检来提高测试效率。如果峰值发射低于限制条件，测试信息可以作为最终结果提交。如果峰值发射超过频带要求，有必要重新对独立频率进行扫频，使用准峰值检测时独立频率超过了限制条件。峰值和准峰值信息应提交到测试报告中

8.4 Data Reporting

- 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.

测试信息应概括到单页纸中，显示测量过的被测设备发射的平面图，带有一个应用限制条件的平面图。报告的格式应和辐射发射使用的格式相似。不符合所有频带要求应注明清楚。测试报告还应包括一个测试设置环境资料的平面图

所有偏离测试程序的都应注明，如EMC测试计划所示那样

9.0 Conducted Transient Emissions: CE 410

传导瞬态发射

These requirements are applicable to the following component categories: 这些要求应用于以下类型的组件

Electronic Modules: AX, AY 电子模块：AX,AY

Electric Motors and Inductive Devices: BM, EM, R 电动机和电感元件：BM,EM,R

9.1 Requirement

The component shall not produce positive transient voltages exceeding +100 volts or negative transient voltages exceeding –150 volts on its power supply circuits.

要求：组件在其电源电路上产生的正极瞬时电压不应超过+100V或者负极瞬时电压不超过-150V

9.2 Test Verification and Test Set-up

测试验证和测试设置

The DUT shall be tested in accordance with ISO 7637-2, except where noted in this specification, using the test set-up illustrated in Figure 9-1. 被测设备的测试要符合ISO 7637-2的规定，此规范规定的地方除外，使用fig.9-1所示的测试设置

- 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:
  被测设备电源电路直接通过机械开关或者带有一组独立触点的电机械学开关连接到人工网络。开关具有以下特征：
  - contact rating: $I \geq 30$ A, continuous, resistive load ;
    触电容量 持续，电阻负载
  - high purity silver contact material ;高纯度银触点材料
  - no suppression across relay contact;穿过继电器触点没有抑制
  - single/double position contact electrically insulated from the coil circuit ; 单/双位置触点电气绝缘线圈电路
  - coil with transient suppression. 带瞬态抑制的线圈

  The actual switch used for testing shall be specified in the EMC test report.
  实际使用来进行测试的开关在EMC测试报告中做出了明确规定
- The wiring between the DUT and the Artificial Network shall be 200 +/-50 mm in length. No other connections shall be made between the switch and the DUT.
  被测设备和人工网络之间的线路长度为200+/-50mm。开关和被测设备之间没有其他连接
- An automotive battery shall be used as the power source (see paragraph 4.4.4 for requirements). The battery negative terminal shall be connected to the ground plane.
  使用汽车电池作为电源（参见4.4.4）。电池的负极应连接到地平面
- A digital sampling scope shall be used for the voltage measurements using a capable sampling rate of 1 Giga-samples per second (single shot capability) 数字采样范围应当用于电压测量，使用每秒1千兆样本采样率（单拍能力）
- 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 uncertainly about this, the DUT shall be tested in both configurations.
  如果被测设备的外壳是金属的且安装到汽车时可以接地，被测设备在测试期间可以安装和电气连接到地平面。如果被测设备壳体在汽车中没有接地，被测设备应放置在离地平面之上50mm的绝缘支撑物上。如果不能确定这一点，被测设备就在两个结构中都进行测试
- If the DUT is an electric motor or actuator, it shall be mechanically loaded to simulate 80% 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.
  如果被测设备时电动机或驱动器，那应机械负载被测设备以便模拟其80%的指定最大负载。发动机和驱动器可能在正常操作过程中停运，正常操作应在“停止”状态下进行；但是，停运的持续时间不能长于1秒。这是为了防止内保护设备的驱动，这里的内保护设备可能会限制或打断到被测设备的电流。

9.3 Test Procedures

测试程序

a) Close the external switch contacts (see Figure 9-1) and power up the DUT. Verify the DUT is functioning properly. 关闭外部开关触点（参见9-1）并通电至被测设备。确认被测设备功能正常

b) Set the trigger level of the digital sampling scope to +80 volts 数字取样范围的触发电平设子到+80V

c) Set the time base to 1 msec/div. 扫描基线设置到1msec/div

d) Adjust the oscilloscope sampling rate to the highest level available for the time base selected.
调整示波器取样率到最高水平以供扫描基线的选择

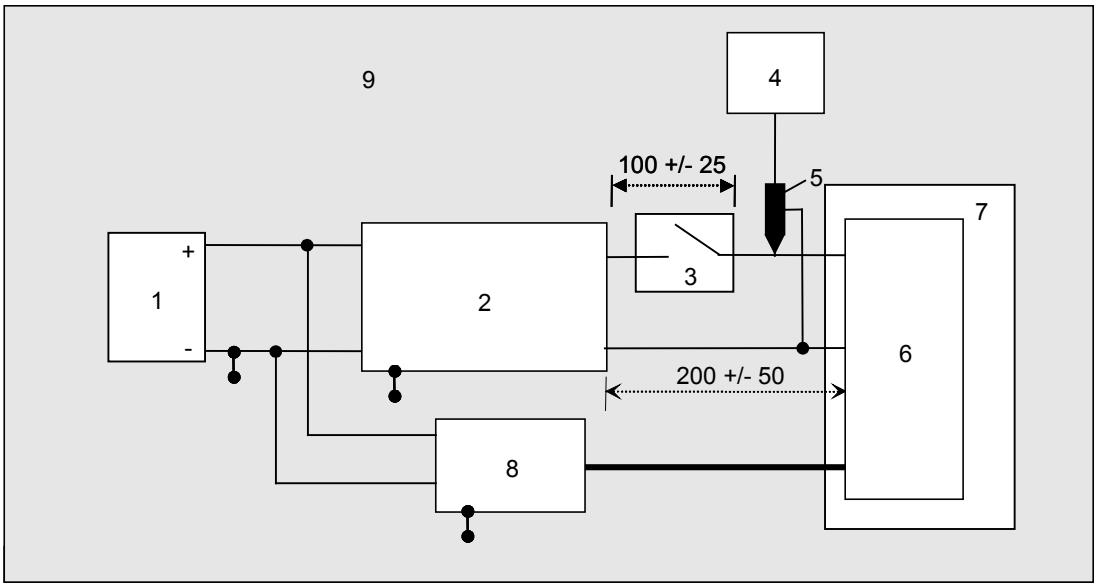
e) If the DUT is of component categories AX, AY, measure and record the peak transient voltages while exercising the DUT functions in operating modes identified in the EMC test plan. *Note that this step may be omitted for component categories BM and R.*
如果被测设备用于组件类型AX,AY，行驶被测设备功能时测量和记录下峰值瞬态电压，功能的行驶用的是操作模式，EMC测试计划中有规定。值得注意的是这个步骤可能会忽视组件类型BM和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 9-1. 对于所有带有开关电源电路的组件类型，通过外部开关开关被测设备10次（每种条件10次）时测量和记录下峰值瞬态电压，如fig.9-1所示

e) Repeat step d) through f) for each of the following time base values: 以下每个时基值通过步骤f)重复步骤d)实现
   - 100 usec/div;
   - 1 usec/div
   - 0.5 usec/div

f) Re-adjust the trigger level of the digital sampling scope to -120 volts. Repeat steps c) through e) except record the peak negative transient voltages. 重新调整数字取样范围的触发电平到-120V。通过e)重复步骤c)，记录峰值负瞬态电压除外

Figure 9- 1: Transient Emissions Test Set-up
瞬态发射测试设置



All Dimensions in mm

Key:

1	Automotive Battery 汽车电池	6	DUT 被测设备
2	Artificial Network (AN) 人工网络	7	Insulated support ($\varepsilon_r \leq 1.4$) 绝缘支撑物
3	Mechanical /Electromechanical Switch机械/机电开关	8	Test Fixture 测试装备
4	Digitizing Oscilloscope 数字化示波器	9	Ground Plane 地平面
5	High Impedance Probe (>1 Meg ohm, C < 4 pf)高阻抗探针		

9.4 Data Reporting

Report the peak positive and negative transient voltages exceeding the trigger level for each time base.
记录下每个时基超过触发电平的峰值正负瞬态电压

10.0 RF Immunity: RI 112, RI 114

抗射频干扰性要求涵盖了从1-3100MHz的频率范围。这些要求基于期望的“关闭汽车”射频电磁源，“打开汽车”射频源（比如业余无线电，移动电话）除外。

Radiated immunity requirements cover the frequency range from 1 to 3100 MHz. Requirements are based on anticipated “off-vehicle” RF electromagnetic sources in addition to “on-vehicle” RF sources (e.g. amateur radio, cellular phones). These requirements are applicable to the following component categories:

这些要求应用于以下类型的组件

电子模块 Electronic Modules: A, AS, AM, AX, AY

电动机 Electronic Motors: EM

10.1 Generic Requirements

一般要求：组件功能性能应符合表10-1所示的验收标准。由于频率范围宽广，需要多样的测试方法进行性能验证。

Component functional performance shall meet the acceptance criteria delineated in Table 10-1. Due to the wide frequency coverage, multiple test methods are needed for performance verification. Level 1 and Level 2 requirements are dependent on those test methods. Note that for some vehicle applications, more stringent RF immunity requirements may be imposed by a specific vehicle brand (*see Appendix C*). However, these requirements shall be identified and signed off by the program's chief engineer or their designate prior to program approval to be applicable.

水平1和2的要求基于这些测试方法。值得注意的是，对于一些汽车应用，特定的汽车品牌（参见附录C）可能会指定更严格的抗射频干扰性要求
但是，这些要求应由计划的总工程师或者他们在批准计划投入使用之前的设计来确认和保证

Table 10- 1: RF Immunity Acceptance Criteria

抗射频干扰性验收准则

Requirement Level	Functional Performance Status 功能性能状态		
	Class A	Class B	Class C
1	I (1)	I	I
2	II (1,2)	II	I

1 For audio, video and RF functions, some degradation in performance (e.g. distortion) is permitted, but shall be defined and quantified in the component/subsystem's engineering specification.

对于音频，录像和射频功能来说，容许一些性能的降级（比如失真），但是应在组件/子系统的工程规格里做出明确规定并定量

2 For audio components, volume level (measured at speaker terminals) shall not increase by more than 50%. 对于响度，音量控制（在扩声器末端测量）强度增加不超过50%

10.2 Generic Test Procedures 一般测试程序

- RF Immunity testing shall be performed with linear frequency step sizes no greater than those listed in Table 10-2. 抗射频干扰性测试应用线性频率来进行，线性频率的步长不能大于表10-2的要求
- CW and modulation (AM & Pulsed) dwell times shall be a minimum of 2 second. Note that longer dwell times may be necessary if DUT function response times are expected to be longer. This information shall be documented in the EMC test plan. 连续波和调制(调幅和脉冲的)保压时间最小应为2s。值得注意的是，如果期望被测设备功能反映时间更长，就需要更长的保压时间 此信息应载入EMC测试计划中
- The AM modulation frequency shall be 1 kHz at a level of 80%. 调幅调制频率在80%水平处应为1kHz

Table 10- 2: Test Frequency Steps 测试频率步骤

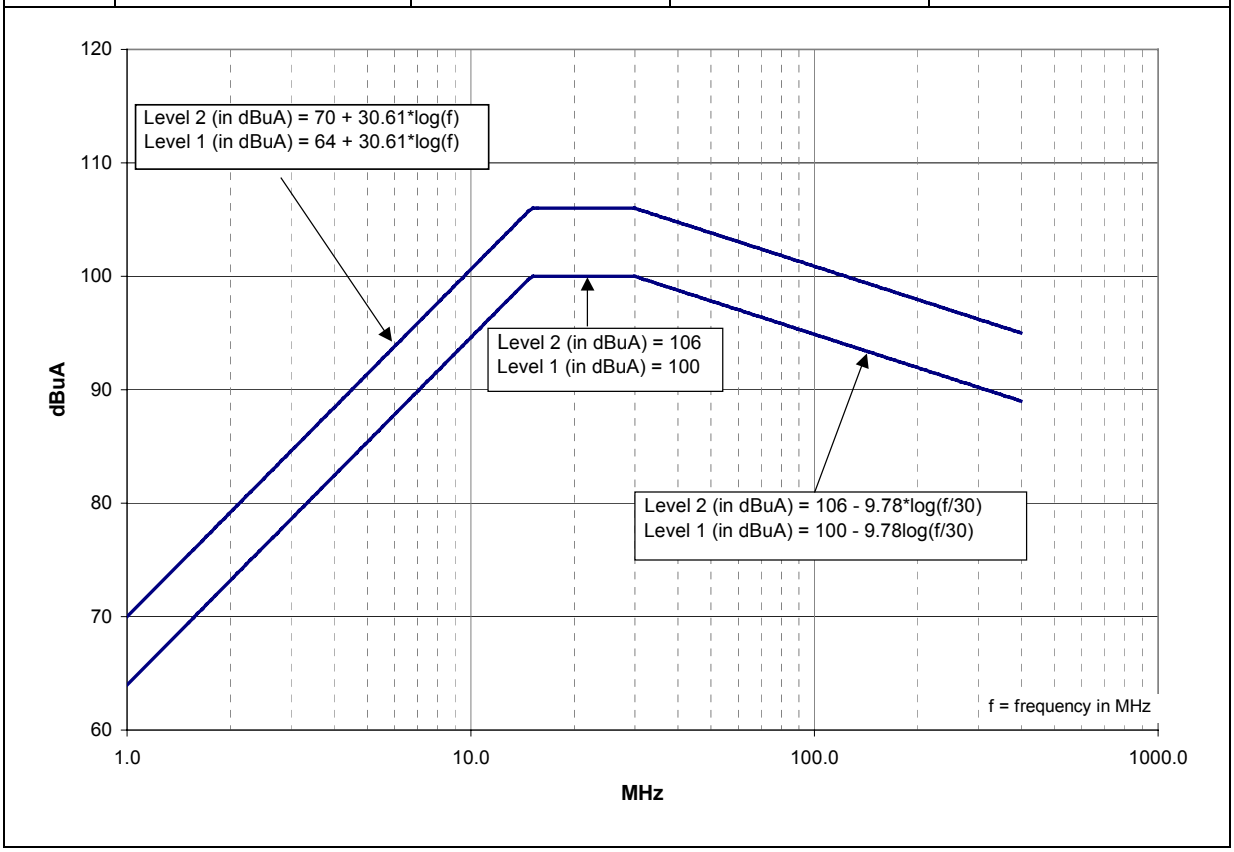
Frequency Range (MHz) 频率范围	Minimum Frequency Step Size (MHz) 最小频率步长
1 - 30	0.5
30 - 200	2
200 - 400	5
400 - 1000	10
1000 - 2000	20
2700 - 3100	40

10.3 Requirements 1 – 400 MHz: RI 112 1-400MHz的要求

The device shall operate as required when exposed to the RF current levels and modulation listed and illustrated in Figure 10-1. The currents are produced using the BCI test method.
当设备暴露于fig10-1所示的射频电流水平和调制时，设备要按要求进行操作。使用BCI测试方法产生电流

Figure 10- 1: Requirements using Bulk Current Injection (BCI)

Band	Frequency Range (MHz)	Level 1 (dBuA)	Level 2 (dBuA)	Modulation
1	1 - 15	64 - 100	70 - 106	CW, AM 80%
2	15 - 30	100	106	CW, AM 80%
3	30 - 400	100 - 89	106 - 95	CW, AM 80%



10.3.1 Test Verification and Test Set-up

测试验证和测试设置：组件性能的验证要符合BCI方法的规定，在此规范中有规定的地方除外

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 4-1 shall be used for the Test Fixture, battery and Artificial Networks.

被测设备应由汽车电池供源（参见4.4.4）。电池的负极应和地平面相接。电池应安装在测试台上面或下面。fig.4-1所示的标准测试设置应使用于测试装备，电池和人工网络

- The test harness shall be 1700 mm (+ 300/- 0 mm) long and routed 50 mm above the ground plane on an insulated support ($\varepsilon_r \leq 1.4$) over the entire length between the DUT and the Test Fixture. *Note that this harness can also be used for CISPR 25 Radiated Emission testing.*

测试线束应长1700mm（+300/-0mm），在位于地平面50mm以上的绝缘支撑物上回路，绝缘支撑物的长度超过被测设备和测试装备之间的总长度。值得注意的是，这个线束可以用于CISPR 25的辐射发射测试

- 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.

测试台应包括一个足够大的地平面，以便平面延伸超过测试设置所有边缘至少100mm

- 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 ≥ 500 mm.

测试设置和所有传导结构（比如屏蔽室的墙）的距离除开地平面应≥500m

- 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 uncertainly about this, the DUT shall be tested in both configurations

如果被测设备的外壳是金属的，安装在汽车上时可以接地，被测设备在台架测试期间应安装和电气连接到地平面。如果被测设备壳体没在汽车上接地，那么被测设备应放置在地平面50mm以上的绝缘支撑物上。如果这点不确定，被测设备应在两个结构中进行测试

- In the frequency range from 1 MHz - 30 MHz all power return (i.e. ground) wires of the DUT wiring harness shall be routed outside of the injection probe (DBCI) as illustrated in Figure 10-2a. Note that if the DUT is a sensor with dedicated power returns to another module, all of its associated wiring shall be routed inside the injection probe.

在1-30MHz频率范围里，被测设备线束的所有电源返回线都应在注入探针外部回路，如fig.10-2a所示。注意如果被测设备是一个传感器而且它的专用电源会返回到另一个模块，那和它相关联的所有线路都应在注射探针内回路

- In the frequency range 30 MHz.- 400 MHz all wires of the DUT wiring harness shall be routed inside of the injection probe (CBCI) as illustrated in Figure 10-2b.

在30-400MHz的频率范围内，所有被测设备线束的线路都应在注入探针内部回路，如fig.10-2b所示

- The injection probe shall be insulated from the ground plane.

注入探针应和地平面绝缘

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

一个合适的电流检测探针（不会影响偏差剖面）应放置在离被测设备（选择性的）50mm的地方

10.3.2 Test Procedure

测试程序

参照ISO 11452-4的规定使用校准注入探针法（替代法）

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

a) Forward power shall be used as reference parameter for calibration and during the actual test of the DUT.

正向功率应作为校准的参考参数使用，应在被测设备的实际测试期间使用

b) Use step frequencies listed in Table 10-2 and the modulation as specified in Figure 10-2.

步进频率按照表10-2的规定和fig.10-2指定的调制使用

c) In the frequency range from 1 to 30 MHz, testing shall be performed at two fixed injection probe positions (**150 mm, 450 mm**)

在1-30MHz的频率范围里，测试应在两个固定注入探针的位置（150mm,450mm）进行

d) In the frequency range from 30 MHz to 400 MHz, testing shall be performed at two fixed injection probe positions (**450 mm, 750 mm**)

在30-400MHz的频率范围里，测试应在两个固定注入探针的位置（450mm,750mm）进行

e) 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.

如果观察到偏离，感应电流应减小直到被测设备功能恢复正常。然后感应电流应增加直到发生偏离。这个水平要记录为偏差阈值

f) The DUT operating mode(s) exercised during testing shall conform to that delineated in the EMC test plan.

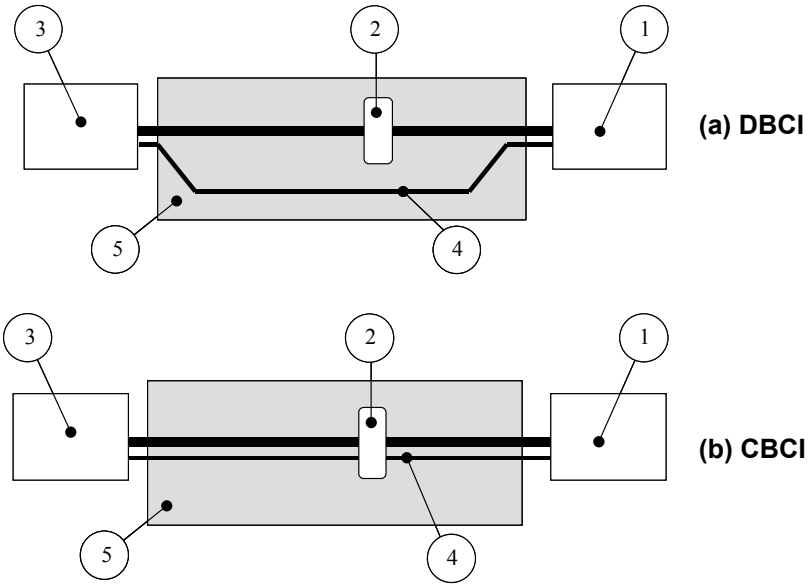
被测设备操作模式在测试期间的执行应符合EMC测试计划中的规定

g) If a monitor probe is sued it may not be used to adjust the RF current delineated in Table 10-1. The measured values are used for information only and may be included in the test report.

如果检测探针提出请求，可以不用它对表10-1指定的射频电流进行调整。测量得到的值只适用于测试计划中的信息和可能包含的信息

Figure 10- 2: BCI Test Harness Configuration

BCI测试线束结构图



Key:

1 DUT 被测设备
2 Injection Probe 注入探针
3 Test Fixture 测试设备
4 DUT Ground Wire 被测设备接地线
5 Insulating Support 绝缘支撑物

10.3.3 Data Reporting

以下信息要包括进测试报告中：

The following elements shall be included in the test report:

- Tabular data and plots from the two probe positions.
  来自探针位置的数据列表和平面图
- 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.
  把数据列表和平面图相结合以形成针对观察到的每个偏离的单独最快情况数据集。注意在每个频率处，为结合的数据集选择带有最低偏离阀值的的探针位置。每个偏离需要分离平面图
- Immunity threshold plot (calculated current in dBuA vs. frequency)
  抗干扰阀值平面图（计算dBμA对频率的电流）
- Measured currents from current monitor probe if used (optional). See section 10.3.1 and 10.3.2 for details.
  如果使用（选择性的），测量来自电流检测探针的电流。参见10.3.1和10.3.2

10.4 Requirements: 400 – 3100 MHz: RI 114

The device shall operate as required when exposed to RF electromagnetic fields as delineated in Table 10-3.
当设备暴露于射频电磁场时，按照表10-3的规定进行测试

Table 10- 3: Requirements 400 – 3100 MHz

Band	Frequency Range (MHz)	Level 1 (V/m)	Level 2 (V/m)	Modulation
4	400 - 800	50	100	CW, AM 80%
5	800 - 2000	50	70	CW, Pulsed PRR= 217 Hz, PD=0.57 msec
6	1200 - 1400	n/a	600	Pulsed PRR= 300 Hz, PD = 3 usec, with only 50 pulses output every 1 sec. (1,2)
7	2700 – 3100	n/a	600	

脉冲的脉波重复率=300Hz,电位差=3 usec,只带有每秒50脉冲的输出

1 PD shall be extended to 6 usec when testing using the reverberation (mode tuned) method. See 10.4.2.2 for additional detail. PD应在测试使用混响法时延展到6usec。参见10.4.2.2的附加信息

2 Pulsed field strength requirements are peak V/m (maximum RMS) levels.
脉冲场强要求为峰值V/m（最大输出功率）水平

10.4.1 Test Verification and Test Set-up

Verification of device performance shall be in accordance with either the following methods:
测试验证和测试设置：设备性能的验证应符合以下方法中的任意一个：

1. ALSE Method (ISO 11452-2) except where noted in this specification. Note the that test set-up is similar to that used for radiated emissions testing (see section 7.2).
除了在此规范中注明的地方外使用ALSE方法。注意测试设置和用来进行辐射发射测试的方法相似（参见7.2）
2. Reverberation, (Mode Tunned) Method (IEC 61000-4-21) except where noted in this specification.
除了在此规范中注明的地方外使用混响法

10.4.1.1 ALSE Method

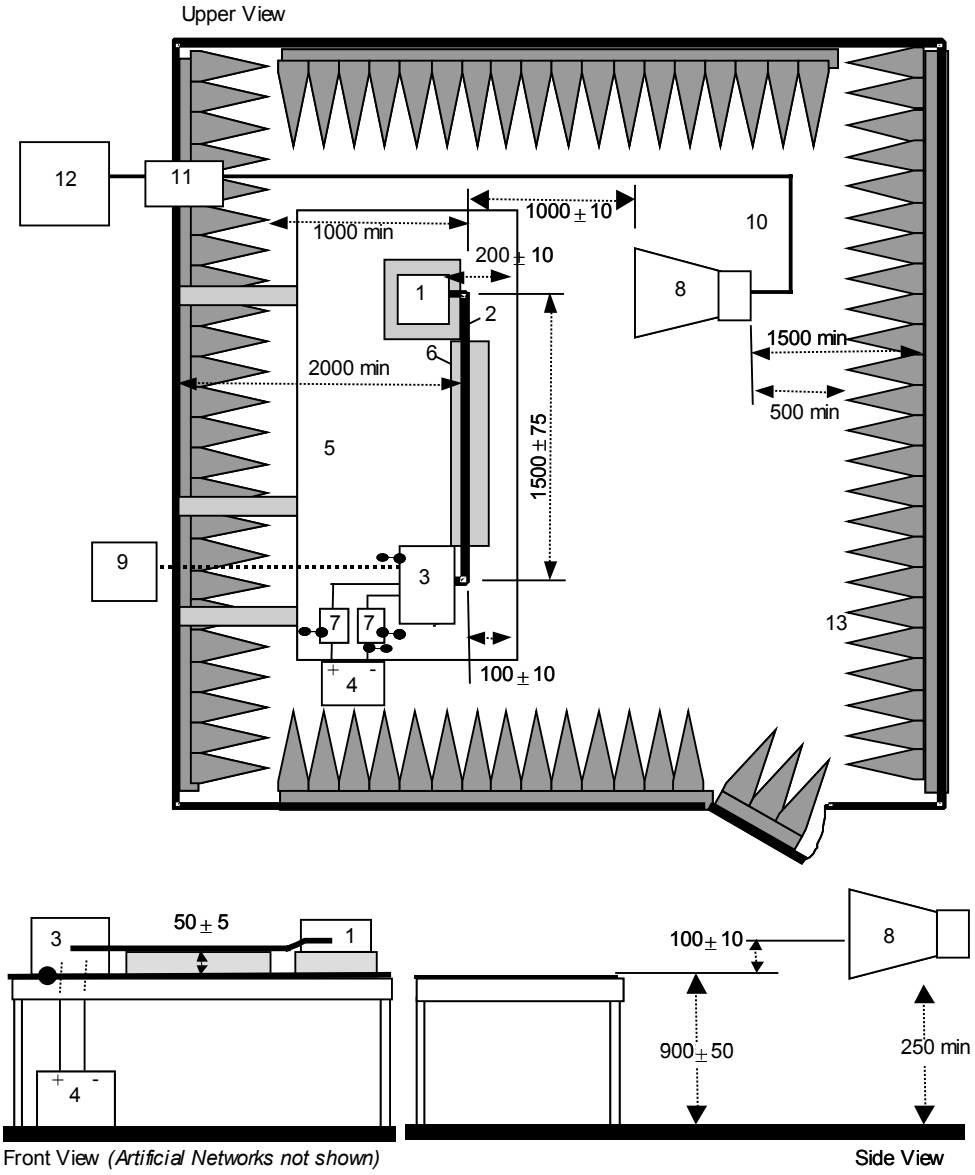
测试设备中的被测设备和所有的电子硬件应由汽车电池供源（参见4.4.4）。电池负极应连接到地平面试验台。电池应安装在试验台上面或下面。

- 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 Figure 4-1 shall be used for the Test Fixture, battery and Artificial Networks.
标准测试设备如fig.4-1所示应使用到测试设备，电池和人工网络
- For frequencies ≤ 1000 MHz, the field-generating antenna shall be positioned in front of the middle of the harness (refer to ISO 11452-2). For frequencies above 1000 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 10-3). Refer to Annex D for the test calibration procedures.
对于≤1000MHz的频率，场产生天线应安装在线束中央的前面（参考ISO 11452-2）。对于1000MHz以上的频率，天线应移动750mm和被测设备地平面的前边缘平行。天线的中央直指被测设备而不是线束的中央（参见fig.10-3）。参考附录D，测试校准程序
- The total harness length shall be 1700 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 7-1. 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 uncertainly 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.

线束总长应为1700mm（+300/-0mm）。被测设备和测试设备的安装需要弯曲线束。线束弯曲半径应在90到135°之间，如fig.7-1所示。线束应放置在地平面50mm以上的绝缘支撑物上

如果被测设备的外壳为金属并且安装在汽车上时可以接地，被测设备应在台架测试期间安装和电气连接到地平面。
如果被测设备外壳在汽车中不接地，被测设备应放置在地平面50mm以上的绝缘支撑物上。如果对此不确定，被测设备应在两个结构中进行测试。被测设备位置/方向应载入EMC测试计划和测试报告中

Figure 10- 3: ALSE Test Set-up (1000 – 3100 MHz)



The figure is adapted from ISO/CD 11452-2. Note: Horn antenna has been moved to sight on the DUT.
数字改变自ISO/CD 11452-2.注意：号角天线移动到被测设备上可以看到的地方

Key:

1 DUT 被测设备
2 Test harness 测试线束
3 Test Fixture 测试装备
4 Automotive Battery 汽车电池
5 Ground plane (bonded to shielded enclosure) 地平面（绑定到屏蔽室）
6 Insulated support ($\varepsilon_r \leq 1.4$) 绝缘支撑物
7 Artificial Network 人工网络
8 Transmitting Antenna 发射天线
9 Support /Monitoring Equipment 支撑/检测设备
10 High quality double-shielded coaxial cable (50Ω) 高质量双同轴电缆
11 Bulkhead connector 穿板式连接器
12 RF Generation Equipment 射频发电设备
13 RF absorber material 射频吸收器材料

10.4.1.2 Reverberation Method 混响法

- The test set-up is illustrated in Figure E-1 of Annex E 测试设置如fig.E-1的附录E所示
- The reverberation chamber shall be sized large enough to test a DUT within the chamber's working volume. 混响室的尺寸应大到足够在室内的工作空间之内测试被测设备
- Ground plane shall not be used for this test. 地平面不应使用到此测试
- The mechanical tuner shall be as large as possible with respect to overall chamber size (at least three-quarters of the smallest chamber dimension) and working volume considerations. Each tuner should be shaped such that a non-repetitive field pattern is obtained over one revolution of the tuner. 机械调谐器室内的总尺寸（至少是最小室内尺寸的3/4）和工作空间的考虑应尽可能大。每个调协器应成形以便通过调谐室的一次循环获取非重复场图
- The electric field probes shall be capable of reading and reporting three orthogonal axes. 电场探针应具有阅读和记录三个正六方轴线的功能
- The RF signal generator shall be capable of covering the frequency bands and modulations specified. 射频信号发生器应具有涵盖指定的频带和调制的功能
- The transmit antenna shall be linearly polarized and capable of satisfying the frequency coverage requirements. The transmit antenna shall not directly illuminate the test volume. 传输天线应线性极化并且具有满足频率范围的要求。传输天线不能直接显示检测体积
- The receive antenna shall be linearly polarized and capable of satisfying the frequency coverage requirements. The receive antenna shall not be directed into the test volume. 接收天线应线性极化并且具有满足频率范围的要求。接收天线不能指向测试体积
- The power amplifiers shall be capable of amplifying the RF signal to produce the required field strengths. 功率放大器应具有放大射频信号的功能以便产生所需的场强
- Associated equipment shall be present to record the power levels necessary for the required field strength. 应用相关联的设备来记录所需场强需要的功率水平
- The DUT shall be at least 250 mm from the chamber walls, tuner, transmit antenna, and receive antenna. 被测设备离试验室的墙，调谐器，传输天线和接收天线至少250mm
- The total harness length shall be 1700 mm (+300 /-0 mm). The harness, along with the DUT and Test Fixture shall lie on an insulated support within the middle of the test volume. The dielectric constant of the insulated support shall be less than 1.4. 线束总长为1700mm。线束连同被测设备和测试设备应放置在测试容积中央的绝缘支撑物上。绝缘支撑物的介质常数应小于1.4
- Artificial Networks shall not be used. 不应使用人工网络
- The power returns from the DUT shall be connected directly to the battery negative terminal 被测设备返回的电源应直接连接到电池负极
- If the outer case of the DUT is metal and shall be grounded when installed in the vehicle, a braided copper ground strap shall be used to connect the DUT case to the battery negative terminal. The strap shall be 1700 mm (+300/- 0 mm) with a width no greater than 13 mm. This method shall also be used if the DUT power returns are locally grounded. 如果被测设备的外壳是金属并且安装在汽车上时应接地，编制铜接地套带应使用来连接被测设备外壳到电池负极。套带长1700mm，宽度不大于13mm。如果被测设备电源返回局部接地就应使用此方法

10.4.2 Test Procedures 测试程序

测试期间被测设备操作模式的执行应符合EMC测试计划的规定

The DUT operating mode(s) exercised during testing shall conform to that delineated in the EMC test plan.

10.4.2.1 ALSE Method ALSE方法

a) Testing shall be performed using the substitution method. Refer to ISO 11452-2 for calibration procedures for testing below 1000 MHz. Refer to Annex D for calibration procedures above 1000 MHz. 应使用替代法进行测试。参考ISO...针对1000MHz以下测试的校准程序。参考附录D1000MHz以上的校准程序
b) Forward power shall be used as reference parameter for field characterization and the actual test of the DUT. 正向功率应使用来作为场特性和被测设备实际测试的参考参数
c) Use the step frequencies listed in Table 10-2. Use the modulation as specified in Table 10-3. 使用步进频率，如表10-2所示。使用表10-3指定的调制
d) All modulation dwell time (i.e., time that RF is applied for per modulation type) shall be at least 2 sec. 所有调制的停留时间（即应用于每个调制类型的射频的时间）至少为2秒
e) The test shall be performed using both horizontal and vertical antenna polarization. 使用水平和垂直天线极化进行测试
f) At test frequencies ≥ 1000 MHz, the DUT shall be tested in a minimum of three (3) orthogonal orientations. 在测试频率≥1000MHz处，被测设备至少应在3个正交方向进行
g) 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 threshold. 如果观察到偏离，场应减小直到被测设备功能恢复正常。此时场应增强直到偏流发生。这个水平应以偏离阀值记录

10.4.2.2 Reverberation Method 混响法

a) Use test frequencies according to Table 10-2. Use the modulation specified in Table 10-3 except for bands 6 and 7. For bands 6 and 7, increase the pulse duration (PD) to 6 usec. 按照表10-2的要求使用测试频率。按表10-3的要求使用调制，除了频带6和7.对于频带6和7，增加脉冲持续时间到6usec。
b) All modulation dwell time (i.e., time that RF is applied for per modulation type) shall be at least 2 s. 所有调制停留时间（即应用于每个调制类型的射频的时间）应至少为2秒
c) Electric field probes shall not be used during the test. 电场探针在测试期间不应使用

d) The test chamber shall be calibrated according to Annex E, section E.1.1 (Field Uniformity Validation).
试验室要根据附录E的E.1.1进行校准

e) Prior to collecting data, the procedures of Annex E, section E.2 (Calibration and DUT loading check) shall be performed. 搜集信息之前，应执行附录E的E.2的程序

f) The transmit antenna shall be in the same location as used for calibration according to Annex E.
传输天线应该和校准使用的位置相同，参见附录E

g) The DUT shall be exposed to each field level and frequency at each mode tuner position.
被测设备应暴露于每个场水平和每个模式调谐器位置的频率

h) The chamber input power for the electric field levels is determined via the equation:
试验室针对电场水平的输入功率通过以下方程式决定：

$$Test\_Input\_Power = \left[\frac{E_{test}}{\left\langle \vec{E} \right\rangle_{24or9} \cdot \sqrt{CLF(f)}} \right]$$

where:

E_{test} = Required field strength in V/m (see Table 8.3) 在V/m所需的场强

CLF(f) = Chamber loading factor from Annex E, section E.2, step7. 附录A，E.2步骤7中的试验室负载系数

$\left\langle \vec{E} \right\rangle_{24or9}$ = Normalized electric field from the empty chamber calibration from Annex E, section E.1. It may be necessary to linearly interpolate (*CLF* and normalized electric field values) between the calibration frequency points.
附录A,E.1空试验室校准的标准化电场.它在校准频率点之间需要进行线性插入（CLF和标准化电场值）

i) 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.
如果观察到偏离，场应减小直到被测设备功能恢复正常。燃火场应增强直到偏离发生。这个水平应报告为偏离阀值

10.4.3 Data Reporting

The following elements shall be included in the test report: 以下信息应包含在测试报告中：

- Description of the functions monitored. 检测到的功能描述
- Modulation status 调制状态
- Any performance deviations. 所有性能偏离
- Monitoring instrumentation and technique 检测仪器和技术
- Minimum RF field strength at each frequency where deviations occur. Include modulation and polarization (ALSE Method only) 发生偏离的每个频率处的最小射频场强。包括调制和极化（只能用ALSE方法）
- Photos of the three DUT positions (ALSE Method Only) 三个被测设备位置的照片（只能用ALSE方法）
- Number of tuner steps at each frequency (Reverberation Method only). 每个频率处调谐器步骤的数量（只能用混响法）

11.0 Magnetic Field Immunity: RI 140 抗磁场干扰：RI140

Magnetic field immunity requirements cover the frequency range from 50 to 10,000 Hz. Requirements are based on anticipated "off-vehicle" electromagnetic sources (e.g. AC power lines) in addition to "on-vehicle" sources (e.g. charging system, PWM sources). These requirements are applicable to the following component categories:
抗磁场干扰要求的频率范围为50-10000Hz。这些要求基于期望的"关闭汽车"电磁源（如AC电源线），"打开汽车"源（如充电系统，脉宽调制源）除外。重要应用于以下组件种类：

Electronic Modules: AM
电子模块

11.1 Requirements

The component including any attached magnetic sensors (if applicable) shall operated without deviation when exposed to the magnetic field levels delineated in Table 11-1
当暴露于表11-1所示的磁场水平时，组件包括所有附着磁传感器（如果适用）操作不能有偏离

Table 11- 1: Magnetic Field Immunity Requirements
抗磁场干扰的要求

Requirement		Functional Performance Status 功能性能状态		
Frequency (Hz)	**Level (dBpT RMS)**	**Class A**	**Class B**	**Class C**
50 – 340	L = 163 – 39.64*log(*f*/50) (1)	I	I	I
340 – 10,000	L = 130 + 20.43*log(*f*/50) (1)	I	I	I
600 – 10,000	122 (2)	I	-	-

1 f = frequency in Hz
2 Requirement applicable only to audible distortion from multimedia subsystem
要求只适用于来自多媒体子系统的音频失真

11.2 Test Verification and Test Set-up 测试验证和测试设置

- Verification of component performance shall be verified using the test method delineated in MIL-STD-461E, RS101 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 11-1 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 or a Helmholtz coil. These test set-up configurations are illustrated in Figure 11-1 and 11-2. Testing shall be performed a the frequencies listed in Table 11-2
组件性能的验证应在使用MIL...，RS101规定的测试方法时进行，此规范注明的地方除外。测试设置的安装使被测设备直接暴露于表11-1所示的场更容易，磁场暴露于所有可以连接到被测设备的磁传感器除外。这个测试可以使用120mm直径的磁辐射圈或者亥姆霍兹线圈完成。这些测试设置结构图如fig 11-1和11-2所示，应测试表11-2所列的频率

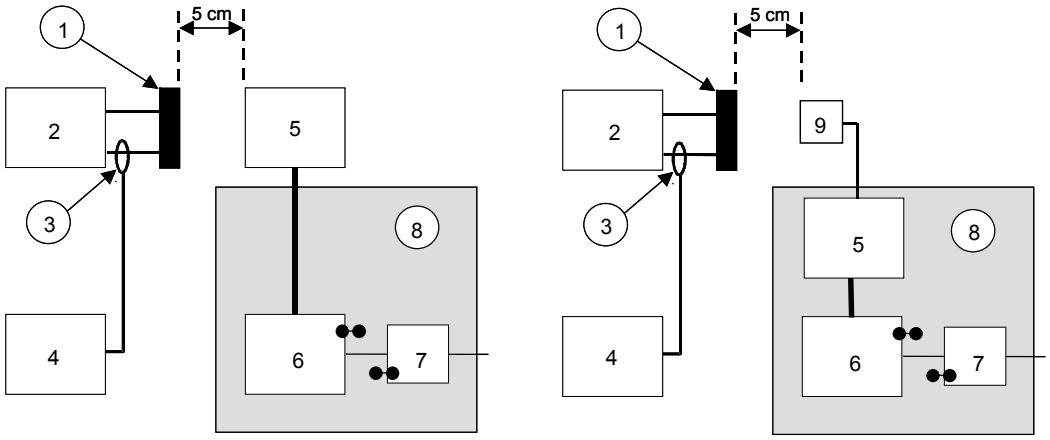
Table 11- 2: Test Frequency Requirements
测试频率要求

Test Frequency Range (Hz) 测试频率范围	Frequency Step (Hz) 频率步进
50 - 100	10
100 – 1,000	20
1000 – 10,000	500

- 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 radiating loop or Helmholtz coils.
- 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. The battery/power supply shall be placed on the floor below or adjacent to the test bench.
试验两个测试方法时，被测设备应放置于木桌或者绝缘桌上。测试装备和其他支撑设备应安装到地平面上，但是测试装备或者地平面里辐射圈或亥姆霍兹线圈不能小于200mm。

测试装备上的被测设备和所有电子硬件由汽车电池或者线性电源供源（参见4.4.4）。电池或电源负极应和地平面试验台连接。电池/电源应放置在挨着试验台或试验台下面的地板上

Figure 11- 1: Magnetic Immunity Test Set-up: Radiating Loop
抗磁干扰测试设置：辐射圈



Configuration for Testing DUT only
仅供被测设备测试的结构图

Configuration for Testing DUT with attached Magnetic Sensors
带附着磁感应器的被测设备测试结构图

Key:

1 Radiating Loop 辐射圈
2 Signal Source 信号源
3 Current Probe 电流探针
4 Measurement Receiver 测量接收器
5 DUT 被测设备
6 Test Fixture 测试设备
7 Artificial Network 人工网络
8 Ground Plane 地平面
9 Magnetic Sensor 磁感应器

11.3 Test Procedures

The DUT operating mode(s) exercised during testing shall conform to that delineated in the EMC test plan.
测试程序：被测设备操作模式在测试期间执行，执行应符合EMC测试计划的规定

11.3.1 Radiating Loop Method 辐射环法

a) Prior to performing testing of the DUT, calibrate the radiation loop using procedures delineated in *MIL-STD-461E, RS101*
在进行被测设备测试之前，使用MIL...规定的程序进行辐射环的校验

b) Partition each face of the DUT into 100 x 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 x 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.
把被测设备每个面划分为100×100平方毫米的区域，然后把辐射环面向这些区域每个面的中心。如果被测设备的表面小于100×100mm，那把辐射环放置在被测设备面的中心，辐射环和被测设备的面之间的间隔为50mm.环形传感器的平面安装要和被测设备的面平行也要和所有接插件的轴平行

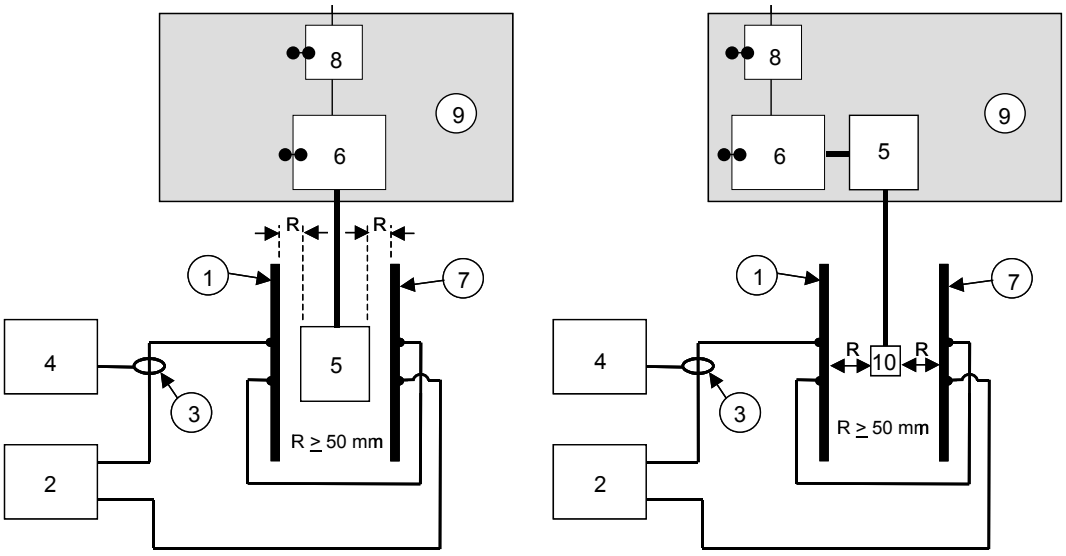
c) At each position, supply the loop with sufficient current to produce the corresponding magnetic field levels delineated in Table 11-1 at each test frequency step listed in Table 11-2.
在每个位置向回路提供充足的电流以便产生如表11-2所列的每个测试频率步进在11-1规定的相应的磁场水平

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.
停留时间至少应为2s。注意如果被测设备功能反映次数比预期更长就需要更长的停留时间。此信息应记录在EMC测试计划中

e) 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.
如果观察到偏离，场应降低强度知道被测设备功能恢复正常。此时场应增强直到偏离发生未知。这个水平应记录为偏离阀值

f) 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 (see Figure 11-1).
如果被测设备附有一个磁传感器，当验证被测设备正确操作时（参见11-1），分别进行的测试只暴露传感器

Figure 11- 2: Magnetic Immunity Test Set-ups for Helmholtz Coil
亥姆霍兹线圈抗磁干扰测试设置



Configuration for Testing DUT only
仅供被测设备测试的结构图

Configuration for Testing DUT with attached Magnetic Sensors
附着有磁传感器的被测设备的测试结构图

Key:

1 Radiating Loop A辐射环A
2 Signal Source 信号源
3 Current Probe电流探针
4 Measurement Receiver 测量接收器
5 DUT 被测设备
6 Test Fixture 测试夹具
7 Radiating Loop B辐射环B
8 Artificial Network 人工网络
9 Ground Plane 地平面
10 Magnetic Sensor 磁传感器

11.3.2 Helmholtz Coil Method
亥姆霍兹线圈法

a) Prior to performing testing of the DUT, characterize the Helmholtz Coil using procedures delineated in *MIL-STD-461E, RS101*. Select coil spacing based on the physical dimensions of the DUT.
在进行被测设备测试之前，使用MIL...规定的程序确定亥姆霍兹线圈的特点。以被测设备的实际尺寸为基础选择线圈间距
- 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.
对于尺寸小于一个线圈半径的被测设备而言，线圈应由一个线圈半径分隔开。被测设备的每个面和每个线圈之间的间隔至少应为50mm
- 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.
对于尺寸大于一个线圈半径的被测设备而言，线圈应被分隔以便被测设备表面的平面离每个线圈平面至少50mm，两个线圈之间的间隔不超过1.5半径

b) Supply the Helmholtz Coil with sufficient current to produce the corresponding magnetic field levels delineated in Table 11-1 at each test frequency listed in Table 11-2.
向亥姆霍兹线圈提供充足的电流以便产生表11-2所列的每个测试频率在表11-1所示的相应的磁场水平

c) 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.
停留时间至少为2s。注意如果期望的被测设备功能反应时间更长就可能需要更长的停留时间。此信息应记录到EMC测试计划中

d) Reposition the DUT or Helmholtz coils successively such that the two coils are parallel to each face of the DUT and parallel to the axis of any connector.
相继重新安装被测设备或亥姆霍兹线圈以便两个线圈和被测设备的每个面以及所有接插件的轴平行

e) 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.
如果观察到偏离，场应减小强度直到被测设备功能恢复正常。然后场应增加强度直到偏离出现。这个水平应记录为偏离阀值

f) 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 (see Figure 11-2).
如果被测设备有附着有磁传感器，那当验证被测设备的正确操作时分别进行测试，测试只暴露传感器

11.4 Data Reporting

The following elements shall be included in the test report: 以下信息应包括进测试报告中：

- Details of the test set-up including locations/orientations tested and Helmholtz coil separation. 测试设置的详情包括测试过的位置/方向和亥姆霍兹线圈分离
- Description of the functions monitored. 检测到的功能的描述
- Any performance deviations. 所有性能偏离
- Maximum exposure field at each frequency where deviations occur. 发生偏离位置每个频率的最大暴露场
- Tabular data showing verification of the calibration of the radiating loop 列表数据显示的是辐射环的校验验证

12.0 Coupled Immunity: RI 130, RI 150 抗耦合干扰性：RI 130，RI 150

These requirements are related to component immunity from parasitic coupling of unintended continuous and transient disturbances. These disturbances originate from the vehicle's charging and ignition system in addition to switching of inductive loads including solenoids and motors. These requirements are applicable to the following component categories: 这些要求是关于来自非计划中连续和瞬时干扰的寄生耦合的。这些干扰源自汽车充电和点火系统，包括螺线管和发动机的电感负载的开关。这些要求适用于以下组件种类：

电子模块 Electronic Modules: A, AS, AM, AX, AY

Electric Motors: EM
电动机

12.1 Requirements

The device shall operate without deviation when exposed to electromagnetic disturbances delineated in Table 12-1. 要求：当按照表12-1的规定暴露电磁干扰时，设备操作没有偏离

Table 12- 1: Coupled Immunity Requirements
抗耦合干扰要求

Requirement	Frequency (Hz)	Level	Functional Performance Status 功能性能状态		
			Class A	Class B	Class C
Immunity from Inductive Transients RI 130 抗电感瞬变的干扰	n/a	+100 / -280 V (1)	I	I	I
Immunity from Charging System RI 150 抗充电系统的干扰	600 – 10,000 (sinewave)	0.5 Amperes (p-p)	I	I	I

1 Values listed are approximate values and are based on the test set-up. Actual measured values may be 20 –50% higher. 所列的值为近似值，都是以测试设置为基础获得的。实际测量值可能会高20~50%

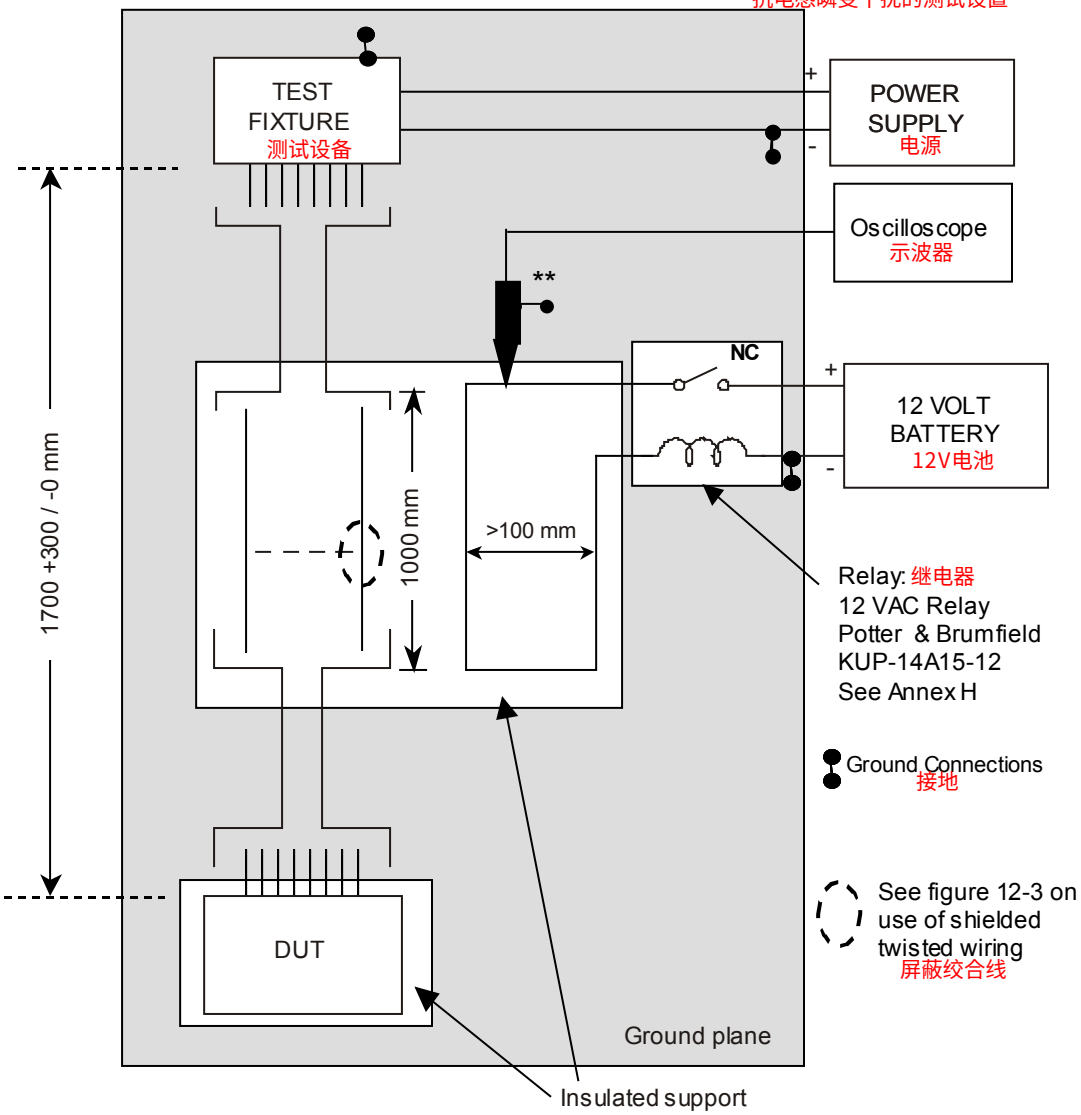
12.2 Test Verification and Test Set-up
测试验证和测试设置

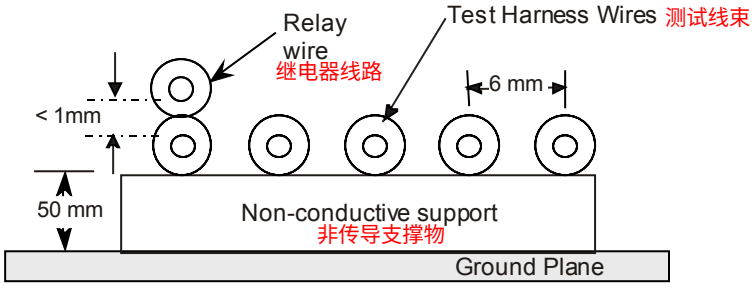
使用fig.12-1和12-2所示的测试设置进行验证

Verification shall be performed using the test set-ups shown in Figures 12-1 and 12-2.

- For RI 130, see Annex H for specifications of the relay used. 对于RI130，参见附录H使用的继电器规格
- Position the DUT, harness, Test Fixture, and transient generation hardware on the ground plane as shown in Figures 12-1 and 12-2. The test harness is supported by a insulated support ($\varepsilon_r \leq 1.4$) 50 mm above the ground plane. If the DUT normally includes shielded and/or twisted wiring, this shall be included as part of the test harness. However, if this wiring is used, a section shall be included in the middle of the test harness where the shielding is removed and the wiring is untwisted. This is illustrated in Figure 12-3. *Note that inclusion of this section represents typical vehicle applications where an in-line connector is used.*
  按照fig.12-1和12-2所示把被测设备，线束，测试夹具以及瞬时产生硬件安装到地平面。测试线束由绝缘支撑物支撑，绝缘物处于地平面50mm以上。如果被测设备通常包括屏蔽和/或绞合线，那屏蔽和/或绞合线要作为测试线束的一部分。但是，如果使用了此线路，那移除屏蔽和拆开绞合线的部分应包括在测试线束的中央。如fig.12-3所示。注意包含的这部分体现了同轴接插件使用处的典型汽车应用
- 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 testing. 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 uncertainly about this, the DUT shall be tested in both configurations.
  如果被测设备的外壳是金属并且安装在汽车上时可以接地，那在测试期间被测设备应安装和电气连接到地平面。如果被测设备壳体在汽车中没有接地，那被测设备应放置到离地平面50mm以上的绝缘支撑物上。如果这一点不确定，被测设备应在两个结构中进行测试
- The DUT and any electronic hardware in the Test Fixture shall be powered from a vehicle 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. The battery/power supply shall be placed on the floor below or adjacent to the test bench.
  测试装备中的被测设备和所有电子硬件应由汽车电池或者线性电源供源（参见4.4.4）。电池或电源负极应连接到地平面试验台。电池/电源应放置在试验台下面或靠近试验台的地板上
- The DUT and all parts of the test set-up shall be a minimum of 100 mm from the edge of the ground plane.
  被测设备和所有测试设置的部件最小应离地平面的边缘100mm
- A digital sampling scope shall be used for test voltage verification using a capable sampling rate of 1 Giga-samples per second (single shot capability). Physical connection of the oscilloscope to the test fixture shall be facilitated with a high impedance probe. The probe capacitance shall be less than 4 pico-farads.
  使用每秒可以采集1千兆样本的样本采样率进行测试电压的验证，这个验证应使用数字采样范围。示波器实体连接到测试装备，使用高阻抗探针会使其更便利。探针电容容量不小于4pico-farads

Figure 12- 1: Test Set-up for Immunity from Inductive Transients
抗电感瞬变干扰的测试设置

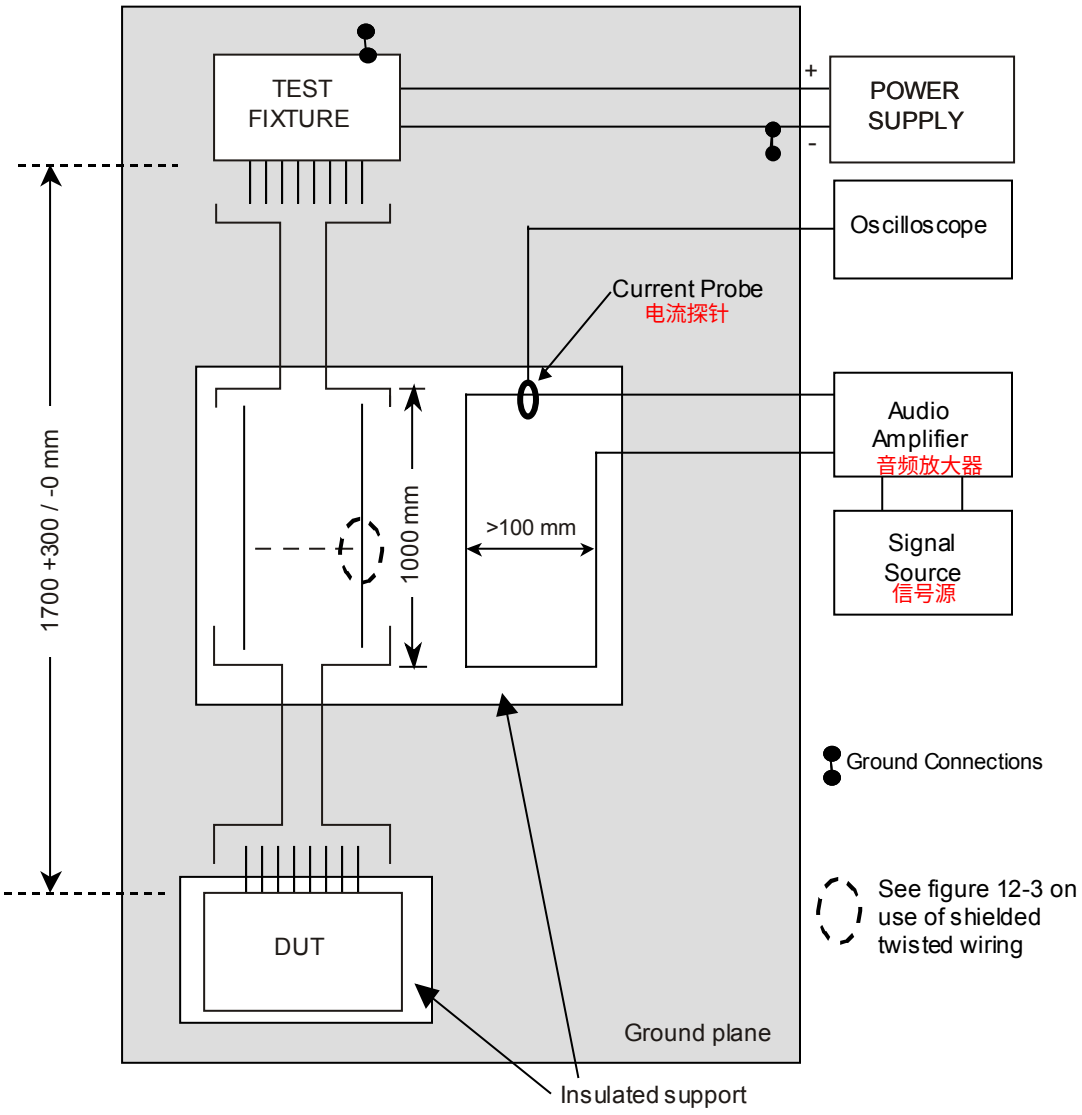




* Note that relay should be replace after 100 hours of usage 注意继电器使用100小时后要重新安装

** Use 10X high impedance probe (1 M ohm, C < 4pf)
使用100×高阻抗探针

Figure 12- 2: Test Set-up for Immunity from Charging System Noise
抗充电系统噪音干扰的测试设置



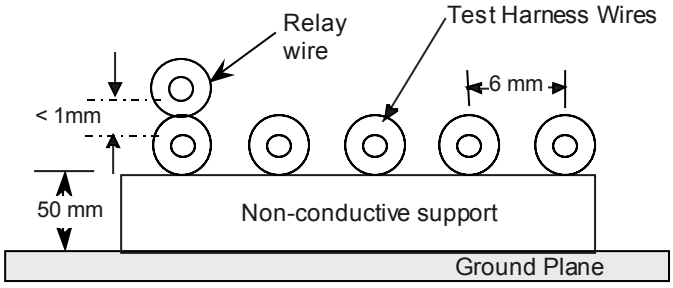
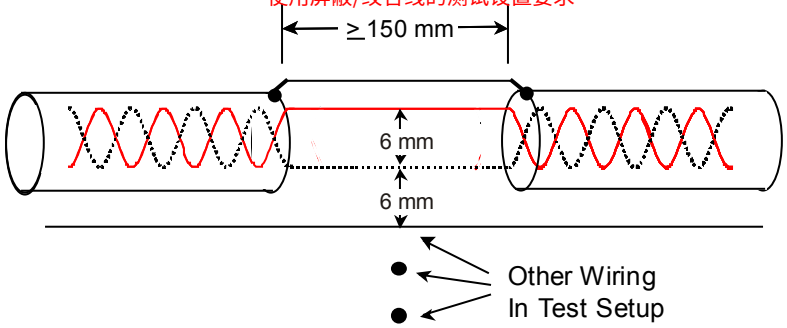


Figure 12- 3: Test Set-up Requirements for use of Shielded/Twisted Wiring
使用屏蔽/绞合线的测试设置要求



12.3 Test Procedures

Testing shall be repeated for all DUT operating modes listed in the EMC test plan.
测试程序：EMC测试计划中所列的所有被测设备操作模式都要重复测试

12.3.1 Immunity from Inductive Transients 抗电感瞬态干扰

a) Verify voltage measured at the test point (see Figure 12-1) is greater than +100 / -280 volts (negative pulse/positive pulse) 验证在测试点测量到的电压，电压要大于+100/-280V（负脉冲/正脉冲）
b) Activate the DUT and verify that it is functioning correctly. 激活被测设备并且验证其正确运行
c) Expose each DUT wire for minimum of 5 sec. 暴露每个被测设备线路最少5s

12.3.2 Immunity from Charging System
抗充电系统干扰

a) Activate the DUT and verify that it is functioning correctly.
激活被测设备并且验证其正确运行
b) Adjust the signal source to 600 Hz and the signal level to attain peak-peak current listed in Table 12-1.
调整信号源到600Hz并且调整信号水平以便获得表12-1所列的峰-峰电流
c) While maintaining this level, expose each DUT wire to the disturbance for a minimum of 2 seconds.
维持这个水平时，把每个被测设备线路至少暴露到干扰中2s
d) Repeat a) through c) over the frequency range listed in Table 12-1 using a maximum frequency step of 500 Hz. 按照表12-1所示的频率范围，使用500Hz最大频率步进，通过c步骤重复a步骤

12.4 Data Reporting

The following elements shall be included in the test report: 以下信息应包括进测试报告中：

- Description of the functions monitored. 检测到的功能描述
- Any observed performance deviations. 所有观察到的性能偏离

13.0 Immunity from Continuous Disturbances: CI 210

抗连续干扰：CI 210

These requirements are applicable to the following component categories: 这些要求适用于以下组件类型：

Electronic Modules: A, AM, AX, AY
电子模块
Electric Motors: EM
电动机

13.1 Requirements

The device shall be immune to continuous disturbances on its power and control circuits produced by vehicle's charging system. The device's functional performance shall meet the acceptance criteria delineated in Figure 13-1. 要求：设备应抗由汽车充电系统产生的在设备的电源和控制电路上的连续干扰。设备的功能性能应符合fig.13-1规定的验收准则

13.2 Test Verification and Test Set-up

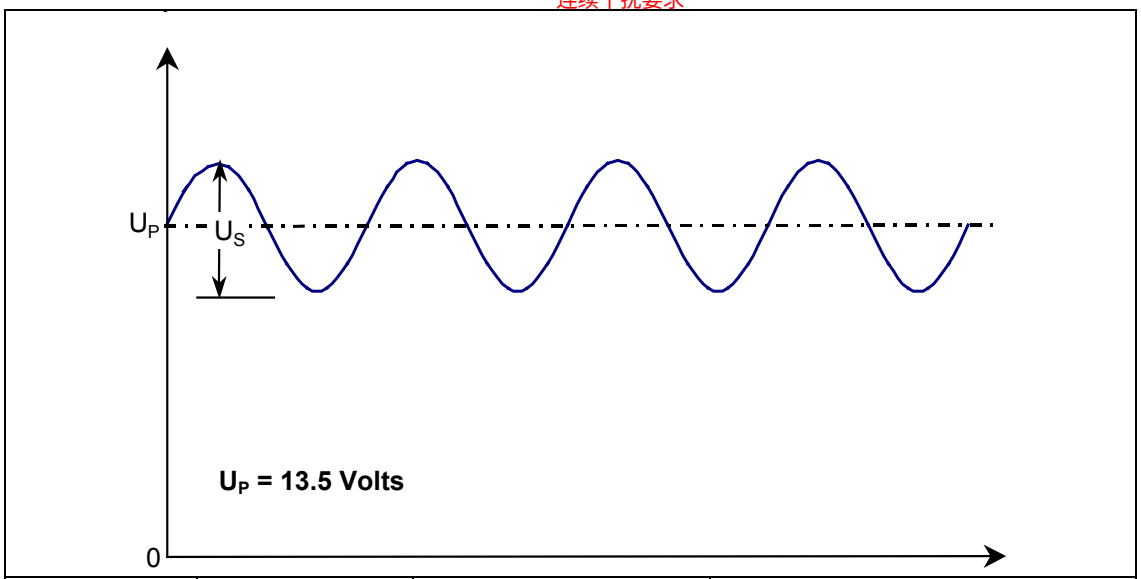
测试验证和测试设置

Testing shall be performed using the test set-up shown in Figure 13-2. 使用fig.31-2所示的测试设置进行测试

- The test harness connecting the DUT to the Test Fixture and transient pulse generator shall be ≤ 2000 mm in length. 把测试设备连接到测试设备和瞬时脉冲发生器的测试线束长度应≤2000mm
- 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.
被测设备和线束应放置在地平面50mm以上的绝缘支撑物上。如果被测设备的外壳是金属并且安装在汽车上时可以接地，被测设备应安装和电气连接到地平面

Figure 13- 1: Requirements Continuous Disturbances

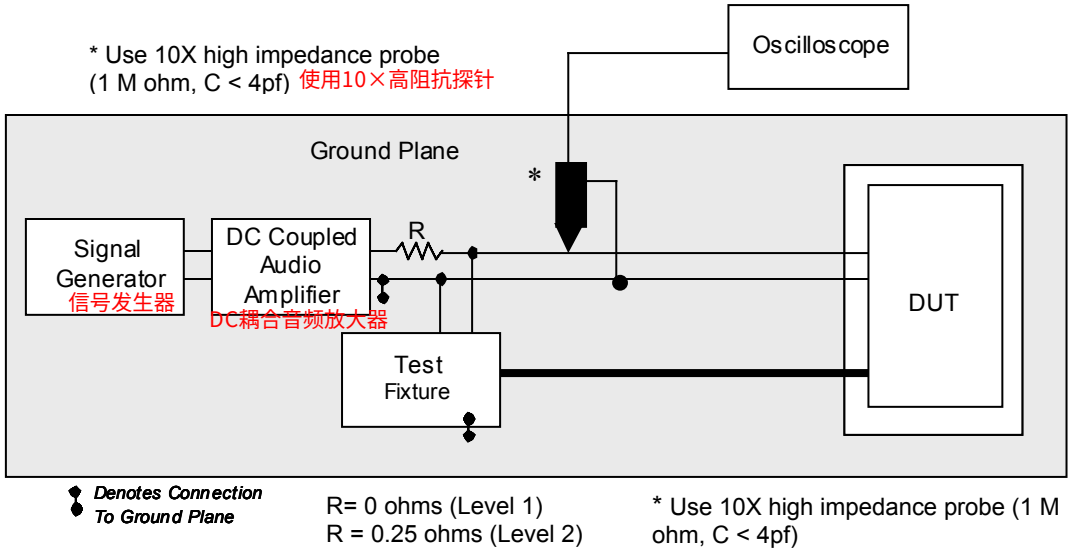
连续干扰要求



Requirement Level	Frequency Range (Hz)	U_S (Vp-p)	Functional Performance Status		
			Class A	Class B	Class C
1	50 – 600 Hz	0.2	I	I	I
	600 – 10,000	0.2 + 1.47*log(*f* /600)	I	I	I
2	50 – 600	2	III	II	II
	600 – 3,000	2 + 14.31*log(*f* /600)	III	II	II
	3000 – 10,000	12	III	II	II

f = frequency in Hz

Figure 13- 2: Test Set-up for Continuous Disturbances
连续干扰测试设置



13.3 Test Procedures

a) Adjust DC offset of the signal generator/audio amplifier to 13.5 volts with the DUT disconnected (open circuit) 调整信号发生器/音频放大器的DC支线到13.5V，调整时要断开被测设备（开路）

b) At each test frequency set and record the signal generator output to the specified voltage level with the DUT disconnected (open circuit). Use the frequency steps listed in Table 13-1.
在每个测试频率处设置和记录信号发生器输出到指定的电压水平，调整时要断开被测设备（开路）。使用表13-1所列的频率步进

c) Without the test signal present, connect the DUT and verify that it is functioning correctly.
没有测试信号的状态下，连接被测设备并且验证其的正确执行

d) Apply the test signal to the DUT and the Test Fixture such that all power and control circuits are exposed to the disturbance. All power and control circuits are tested simultaneously.
应用测试信号到被测设备和测试装备以便所有电源和控制电路暴露于干扰中。所有电源和控制电路要同时测试

e) Repeat testing for all DUT operating modes listed in the EMC test plan.
EMC测试计划中所列的所有被测设备操作模式都要重复测试

Table 13- 1: Test Frequency Requirements

Test Frequency Range	Frequency Step (Hz)
50 - 100	10
100 - 1000	20
1000 – 10000	500

13.4 Data Reporting

- Description of the functions monitored. 检测到的功能描述
- Any performance deviations. 所有性能偏离

14.0 Immunity from Transient Disturbances: CI 220 抗瞬态干扰：CI 220

These requirements are related to immunity from conducted transients on power and control circuits connected to the switched and direct connections to vehicle battery. These requirements are applicable to the following component categories:这些是抗来自电源和控制电路的传导瞬态的要求，控制电路连接到汽车电池的开关和直接连接。这些要求适用于以下组件种类：

Electronic Modules: A, AM, AX, AY 电子模块

Electric Motors: EM 电动机

Passive Devices: P
被动元件

14.1 Requirements

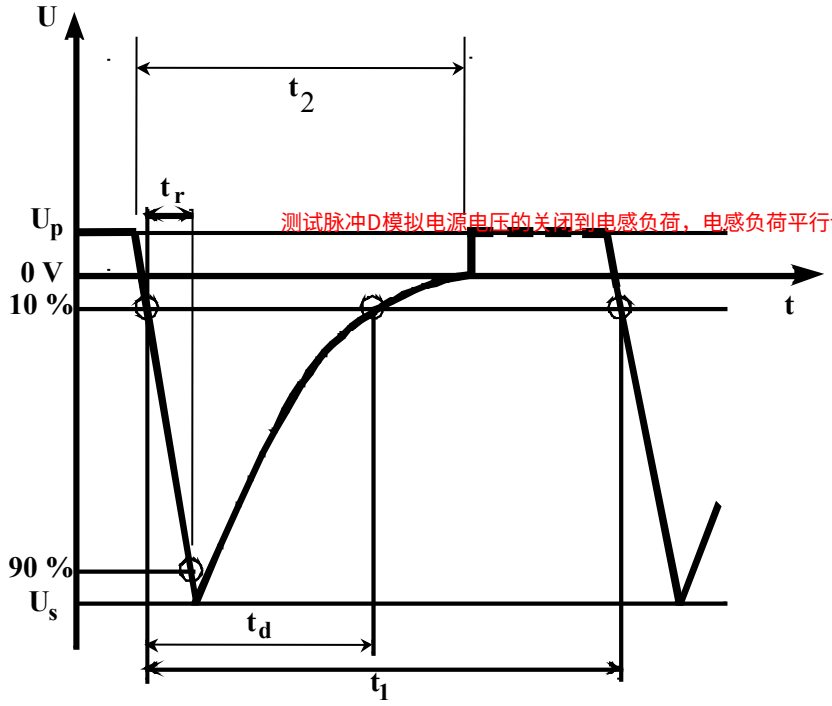
The component shall be immune to voltage transients present on its power supply and control circuits (i.e. I/O circuits that are connected directly or indirectly via electrical loads to switched power). Specific applicability of these transients and component performance requirements are listed in Table 14-1.
要求：组件可以抗其电源和控制电路上的电压瞬态干扰（即I/O电路直接或间接通过电气负荷连接到开关电源）。这些瞬态和组件性能要求的具体适用性如表14-1所示

Table 14- 1: Supply Voltage Transients - Immunity Requirements

Transient Pulse 瞬时脉冲	Application	Transient Characteristics 瞬态特征	Duration 持续时间	Functional Performance Status 功能性能状态		
				Class A	Class B	Class C
Pulse A1	Switched power circuits 开关电源电路 Control circuits 控制电路	Mode 1 (1, 2) PRR= 0.2 Hz, 10% duty cycle	120 sec	II (3)	II (3)	II (3)
Pulse A2	Switched power circuits Control circuits		120 sec	II (3)	II (3)	II (3)
Pulse B1	Control Circuits	Mode 1 (1, 2) PRR= 0.2 Hz, 10% duty cycle	120 sec	I	I	I
Pulse B2	Control Circuits		120 sec	I	I	I
Pulse C	Switched power circuits Power / control circuits with direct battery connections 带有直接电池连接的电源/控制电路	Mode 2 (1, 2) Random	30 sec	I	I	I
Pulse D	Switched power circuits Control circuits	See Figure 14-1	120 pulses	II (3)	II (3)	II (3)
Pulse E	Switched power circuits Control circuits	See Figure 14-2	24 pulses	II (3)	II (3)	II (3)
Pulse F	Switched power circuits Power / control circuits with direct battery connection.	See Figure 14-3	120 pulses	II (3)	II (3)	II (3)
Pulse G (Load Dump)	Power /control circuits with switched or direct connection to battery.	See Figure 14-4	3 pulses	III	III	II

1 See Annex F for description of Transient Pulses A, B and C 参见附录F，瞬时脉冲A,B,C的描述
2 See Annex G for description of test circuit and mode description. 参见附录G，测试电路描述和模式描述
3 Control Circuits are Status I. For power supply inputs, the DUT may reset, but shall recover normal operation at the end of the test. 控制电路是状态1.对于电源输入，被测设备可以重新设置，但是会在测试结尾的时候恢复正常操纵

Figure 14- 1: Waveform for Test Pulse D
测试脉冲D的波形



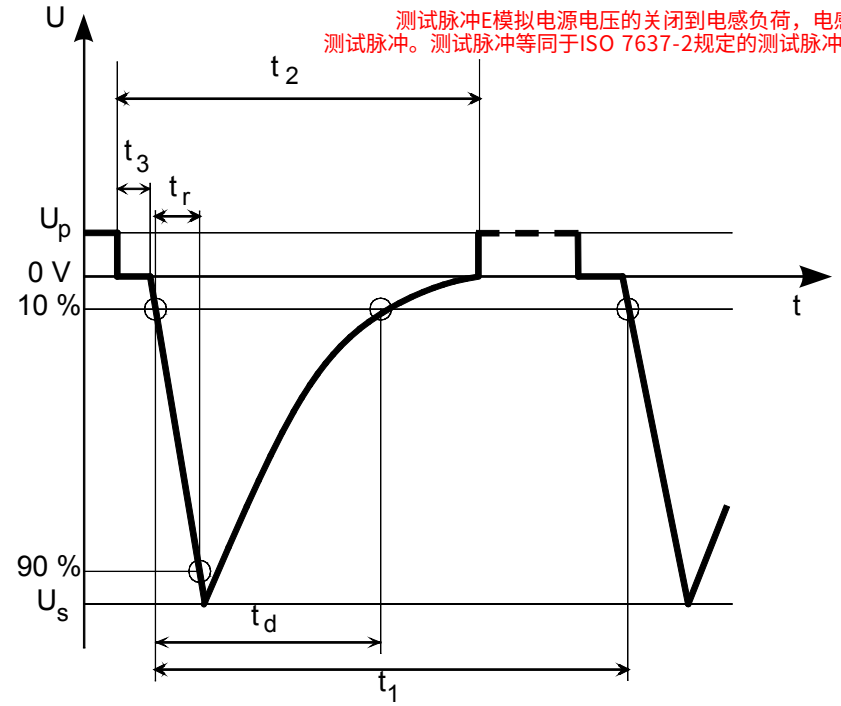
Test Pulse D simulates the switch-off of a supply voltage to an inductive load switched parallel to the DUT. Only switched power supply and control circuits shall be exposed to this test pulse.
测试脉冲D模拟电源电压的关闭到电感负荷，电感负荷平行切换到被测设备。只用开关电源和控制电路应暴露到此测试脉冲中

Test Pulse D - Parameters 测试脉冲D-参数

U_p	13.5 V
U_s	-300 V
t_r	1 us
t_d	50 us
t_1	5 sec
t_2	200 –500 ms
R_i	4 ohms

Waveform voltage begins and ends at Up
波形电压在上升时开始和结束

Figure 14- 2: Test Pulse E
测试脉冲E



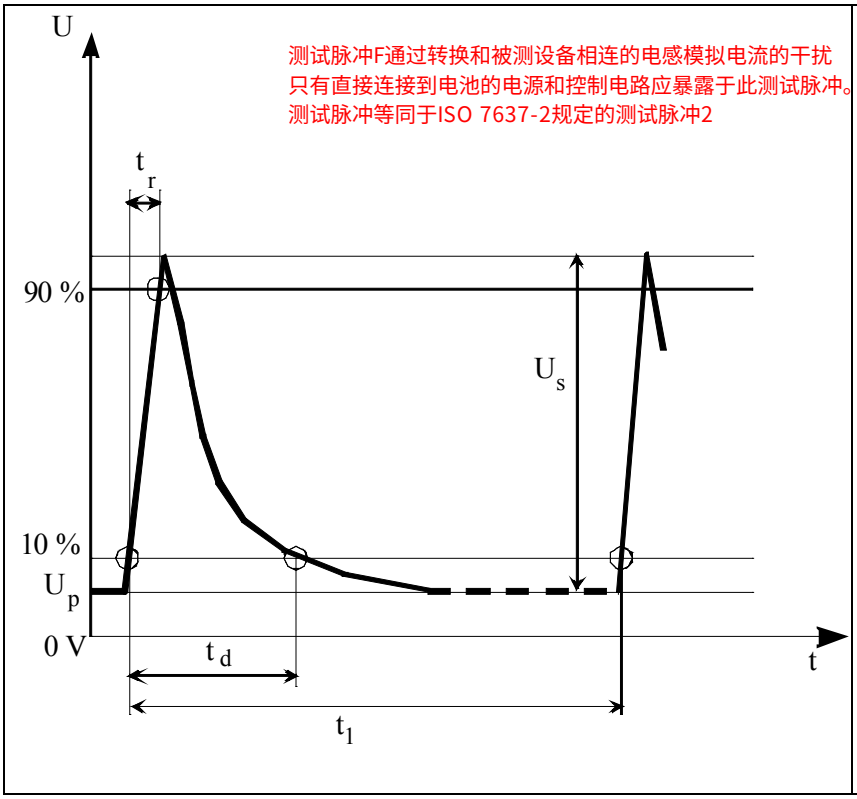
测试脉冲E模拟电源电压的关闭到电感负荷，电感负荷平行转换到被测设备。只有开关电源和控制电路应暴露于此测试脉冲。测试脉冲等同于ISO 7637-2规定的测试脉冲1Test pulse E simulates the switch-off of a supply voltage to an inductive load switched parallel to the DUT. Only switched power supply and control circuits shall be exposed to this test pulse. The test pulse is equivalent to Test Pulse 1 delineated in ISO 7637-2.

Test Pulse 1 - Parameters

U_p	13.5 V
U_s	-100 V
t_r	1 us
t_d	2 ms
t_1	5 s
t_2	200 ms
t_3	≤ 100 us
R_i	10 ohms

Waveform voltage begins and ends at **Up**

Figure 14- 3: Test Pulse F



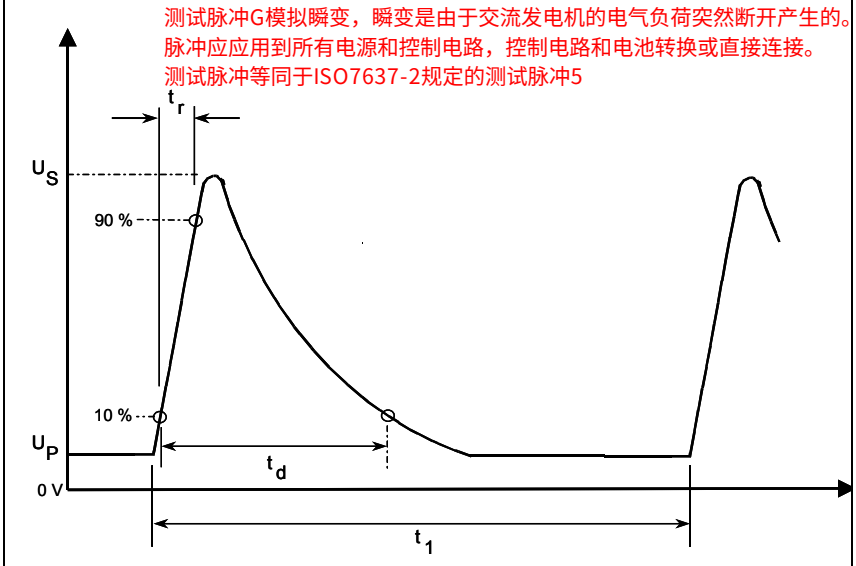
Test pulse F simulates the interruption of a current through an inductance switched in series with the DUT. Only power supply and control circuits with direct connection to battery shall be exposed to this test pulse. The test pulse is equivalent to Test Pulse 2 delineated in ISO 7637-2.

Test pulse 2 - Parameters

U_p	13.5 V
U_s	150 V
t_r	1 us
t_d	50 us
t_1	200 –500 ms
R_i	4 ohms

Waveform voltage begins and ends at **Up**

Figure 14- 4: Test Pulse G



Test pulse G simulates the transient produced due to sudden disconnection of the electrical load from the alternator. The pulse shall be applied to all power supply and control circuits with switched or direct connection to battery. The test pulse is equivalent to Test Pulse 5 delineated in ISO 7637-2.

Test pulse 5 - Parameters

U_p	13.5 V
U_s	60 V
t_r	1 – 10 ms
t_d	150 ms –0/+20%
t_1	30 s
R_i	0.5

Waveform voltage begins and ends at **Up**

14.2 Test Verification and Test Set-up

Verification of component performance shall be in accordance with ISO 7637-2 except where noted in this specification. 测试验证和测试设置：组件性能的验证要符合ISO…的要求，此规范中注明的地方除外

- Test pulses D, E, F, and G shall be generated using any standard transient generator capable of producing standard test pulses per ISO 7637-2. 测试脉冲D,E,F和G通过使用任何具有产生ISO..规定的标准测试脉冲的标准瞬时发生器产生
- Test pulses A, B, and C shall be generated using the test circuit shown in Annex G. 测试脉冲A,B和C通过使用附录G所示的测试电路产生
- The DUT and any electronic hardware in the Test Fixture shall be powered from a vehicle battery (see paragraph 4.4.4 for requirements). 测试准备上的被测设备和所有电子硬件应由汽车电池供源（参见4.4.4）
- The test harness connecting the DUT to the Test Fixture and transient pulse generator shall be ≤ 2000 mm in length. Note that the individual ground circuits may be part of the cable harness or split out as illustrated in the figure. If the DUT has mulitple power and control circuits, they shall be test separatedly 测试线束连接被测设备到测试设备，瞬时脉冲发生器长度≤2000mm。注意独立接地电路可以是如图所示电缆线束的部件或者可以分离。如果被测设备有多功率和控制电路，那就分别对他们进行测试
- The DUT and test harness shall be placed on an insulated support 50 mm above the ground plane. If in the DUT has a local ground (wire length < 200 mm) the DUT ground shall be connected directly to the ground plane at the DUT location. 被测设备和线束应放置在地平面50mm以上的绝缘支撑物上。如果被测设备有本地接地线（长度＜200mm）,那么被测设备的接地线应直接连接到被测设备位置的地平面
- A device powered from an external supply located in another module (Category AS) shall be tested as a system with the sourcing module or an equivalent power supply. Details of this set-up shall be documented in the EMC test plan. 设备由安装在另一个模块（类型AS）的外部电源供源，设备应作为一个带有供源模块或等同的电源的系统被测试。此设置的详情应记录到EMC测试计划中

Figure 14-5 illustrates the generic test set-up for testing of a single DUT power supply circuit with a remote ground connection. 图14-5所示的是对带有远程接地连接的独立被测设备电源电路测试的一般测试设置

Figure 14- 5: Test Set-up for Devices with a Single Power Supply Circuit 带有单个电源电路的设备的测试设置

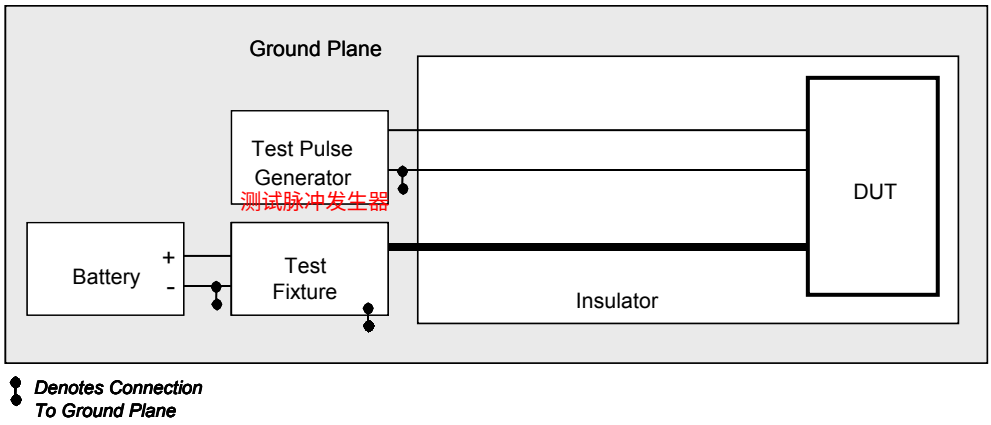


Figure 14-6 illustrates the test set-up for devices with two supply circuits. In this configuration, the untested power supply circuit (U_1) is connected directly to the battery. If the device has additional power supply circuits operating at the same voltage, those circuits should also be connected directly to the battery.
图14-6所示的是带有两个供电电路的设备的测试设置。在这个结构图中，未经测试的电源电路直接连接到电池。
如果有附加电源电路的设备在相同电压处操作，那那些电路应直接连接到电池

Figure 14- 6: Test Set-up for Devices with Two Power Supply Connections
带有两个电源连接的设备的测试设置

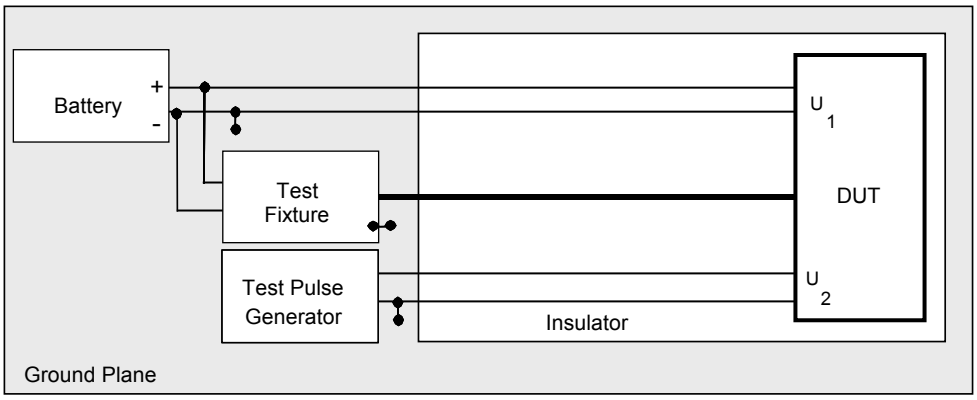
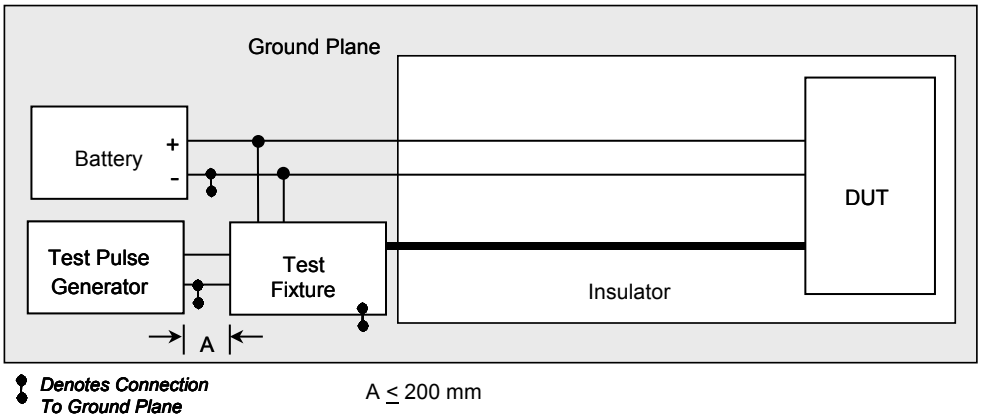


Figure 14-7 illustrates the set-up used for testing of control circuits. Note that control circuits may be directly or indirectly connected to battery. Figure 14-8 illustrates the special case where the control circuit is connected to the battery indirectly using a pull-up resistor.
图14-7所示的是控制电路测试使用的设置。注意控制电路可以直接或间接连接到电池。图14-8所示的是特殊例子，控制电路连接到电池间接使用了上拉电阻

Figure 14- 7: Test Set-up for Devices with Control Circuits 带有控制电路的设备的测试设置



When applying Pulse 5, the test set-ups show above shall be modified to include a 0.7 ohm resistor connected across the Test Pulse Generator unless otherwise specified in EMC SDS requirements associated with a specific vehicle brand. This modification is shown in Figure 14-9.
应用脉冲5时，上面所示的测试设置应修改为包括一个0.7ohm电阻，这个电阻跨接测试脉冲发生器，除非EMS SDS指定的关于特定汽车品牌的要求另有说明
Note that for some vehicle applications that make use of Central Load Dump (CLD) protection, a zener diode shall also be connected across the Test Pulse Generator. Details specifications for this diode may be found in SDS requirements for the affected vehicle applications. The supplier shall contact the FMC EMC department for clarification on use of the zener diode before commencement of testing.
注意对一些使用中央负载转储保护的汽车应用而言，稳压二极管应跨接测试脉冲发生器。此二极管的详细规范可以再SDS要求中找到，这些要求是针对受影响的汽车应用。供应商应联系福特汽车公司EMC部门在测试前进行稳压二极管使用进行阐述

Figure 14- 8: Test Set-up Detail for Control Circuits using Pull-Up Resistors

使用上拉电阻器的控制电路的测试设置详情

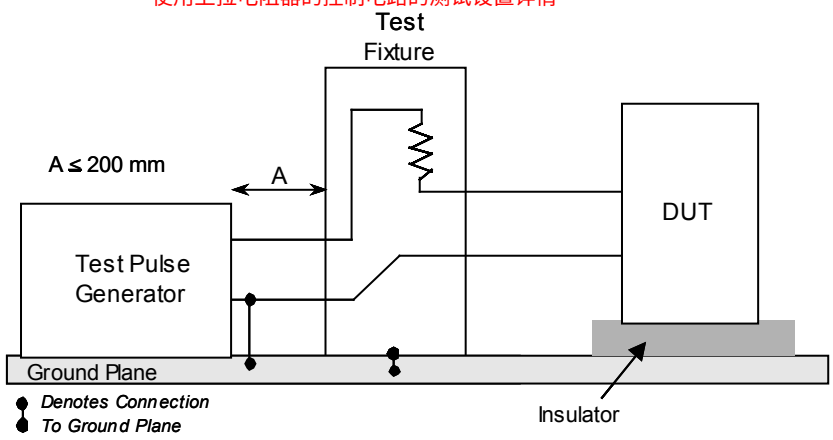
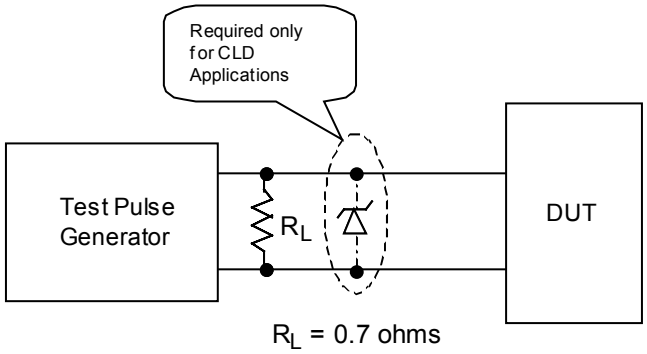


Figure 14- 9: Test Set-up Modification for Application of Pulse 5

脉冲5应用的测试设置修改



14.3 Test Procedures

a) Prior to testing: 测试前
- For Pulses D, E, F and G adjust the transient generator to voltage levels listed in Figures 14-1 through 14-4 with the DUT disconnected (open circuit condition).
- For Pulses A, B, C, and D verify that the output of the transient test circuit (open circuit conditions) produces waveforms typical of those illustrated in Annex F.

对于脉冲D,E,F和G而言，调整瞬变发生器到图14-1所示的电压水平，被测设备断开电源（开路条件）

对于脉冲A,B,C和D而言，验证瞬态测试电路的输入（开路条件）产生的波形如附录F所示那种类型

b) Connect and activate the DUT. Verify that it is functioning correctly. 连接，激活被测设备。验证其功能正确

c) Except for Pulse 5, apply each test pulse listed in Table 14-1 to each DUT power and control circuit one at a time unless analysis demonstrates that testing each circuit individually is unnecessary. The analysis shall be documented in the EMC test plan and approved by the FMC EMC deparment prior to commencement of testing. 除了脉冲5，应用表14-1所示的每个测试脉冲到每个被测设备电源和控制电路，一次一个，除非分析显示有必要每个电路单独测试。分析应记录在EMC测试计划中并在测试进行之前由福特汽车公司EMC部门批准

d) Prior to application of Pulse 5, connect the 0.7ohm resistor across the Transient Pulse Generator as illustrated in Figure 14-9. Connect the optional diode for CLD applications only (the default condition excludes the diode). Pulse 5 shall be applied simultaneously to all power and control circuits.

应用脉冲5之前，跨接0.7ohm电阻器到瞬态脉冲发生器，如fig.14-9所示。连接可选二极管只是为了CLD应用（默认条件不包括二极管）。脉冲5应同时应用到所有电源和控制电路

e) Monitor DUT functions before, during, and after application of each series of test pulses for the time stated in Table 14-1. 按照表14-1所示的时间在应用每种测试脉冲前，中，后检测被测设备功能

14.4 Data Reporting

- Description of the functions monitored. 检测到的功能描述
- Any performance deviations. 所有性能偏离

15.0 Immunity to Power Cycling: CI 230
抗电源循环干扰：CI 230

These requirements are applicable to the following component categories: 这些要求适用于以下组件种类

Electronic Modules: A, AM, AX, AY 电子模块

Electric Motors: EM 电动机

15.1 Requirements

The component shall be immune to voltage fluctuations, which occur when the vehicle's engine is started. The voltage waveforms representing these fluctuations are illustrated in Figure 15-1. Specific application of these waveforms is dependent on the method used to connect the component's power supply and control circuits. Application requirements for each waveform are listed in Table 15-1 along with the performance requirements for the component.要求：组件应抗电压波动干扰，波动发生在汽车发动机启动之时。电压波形显示了这些波动，如图15-1所示。这些波形的特殊应用依靠使用来连接组件电源和控制电路的方法。每个波形的应用要求，如表15-1所示，带有组件的性能要求

Table 15- 1: Power Cycling Requirements

Waveform (1)	Application	Duration	Functional Performance Status (2)		
			Class A	Class B	Class C
A	Power & control circuits connected to battery via the IGN 1 (RUN) contact of the ignition switch. (i.e. circuits active in RUN but not START). 电源和控制电路通过点火开关的IGN1(运行)触点连接到电池（即电路运行时有源，但启动时没有）	2圈间隔30分钟 2 cycles separated by 30 min	II	II	II
B	Power & control circuits connected to battery via the IGN 2 (RUN/START) contact of the ignition switch (i.e. circuits active during RUN and START). Also includes connections to battery through a relay switch. 电源和控制电路通过点火开关的IGN2(运行/启动)触点连接到电池（即电路在运行和启动期间有源）。也通过继电器开关连接到电池		II	II	II (3)
C	Power & control circuits connected to battery via the START contact of the ignition switch. (i.e. circuits active only during engine START). 电源和控制电路通过点火开关的启动触点连接到电池（即电路只有在发动机启动期间有源）		II	II	II
D	Power & control circuits connected directly to Battery 电源和控制电路直接连接到电池		II	II	II

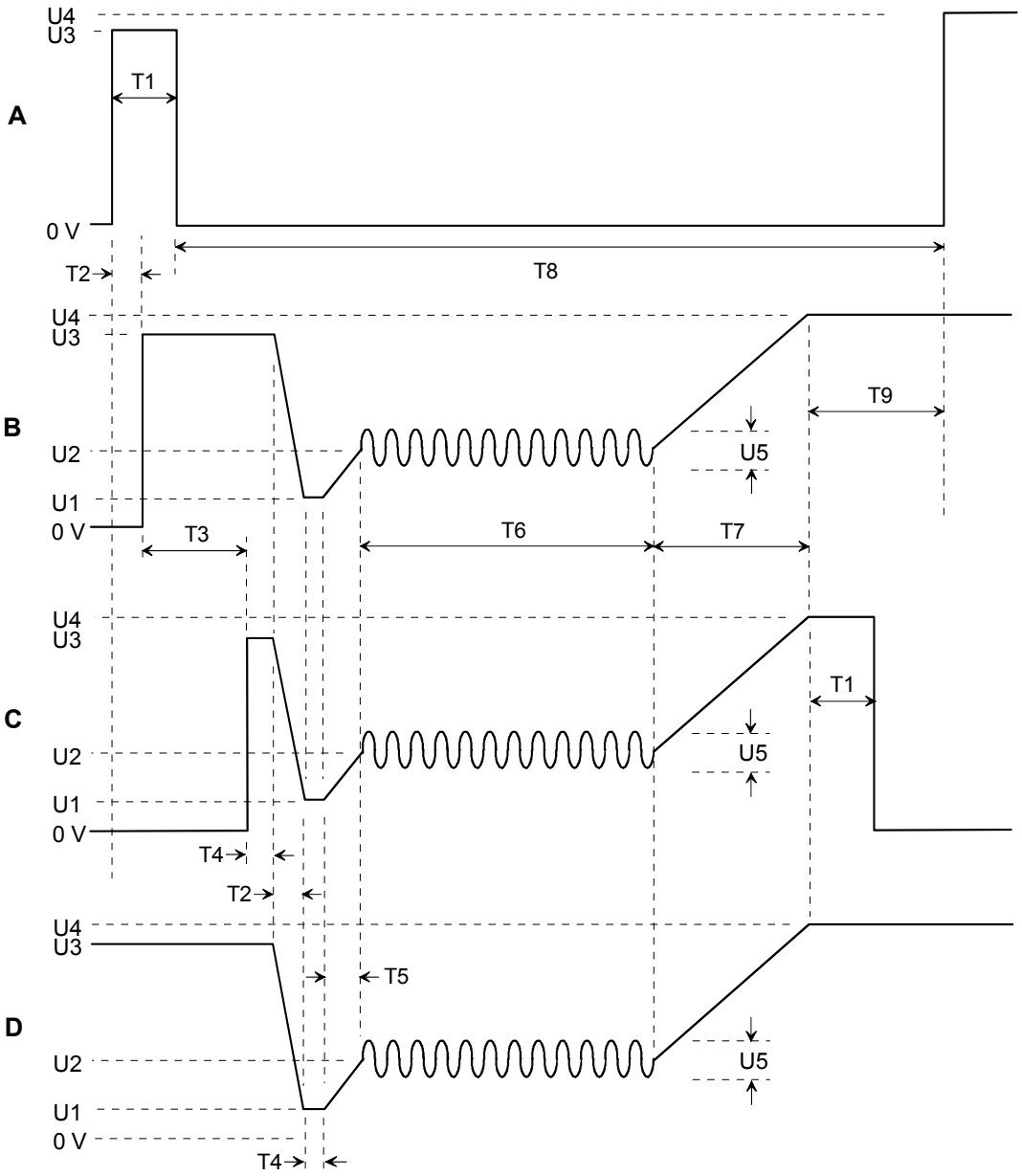
1 Waveforms applied simultaneously to all power supply and control circuits. 波形同时应用到所有电源和控制电路
2 Any degradation in performance shall not inhibit the ability of the vehicle to start 所有性能的下降不会阻碍汽车启动的能力
3 Class C functions required for starting the engine are Status I 需要等级C的功能来启动发动机，这是状态1

15.2 Test Verification and Test Set-up 测试验证和测试设置

Testing shall be performed using the test set-up shown in Figure 15-2. 使用图15-2所示的测试设置进行测试

- The test harness connecting the DUT to the Test Fixture and transient pulse generator shall be < 2000 mm in length. 测试线束连接被测设备到测试设备和瞬态脉冲发生器，长度应＜2000mm
- Testing shall be performed at -40 +0 / - 5 degrees C or the coldest temperature specified in component's engineering specification. The temperature shall be documented in the EMC test plan. 测试应在-40 +0/-5°C或组件工程准则中指定的最冷温度中进行测试。温度应记录在EMC测试计划中
- The DUT shall be placed on a dielectric support 50 mm above the metal floor of the thermal chamber. 被测设备应放置在热处理室的金属地板50mm以上的非传导支撑物上

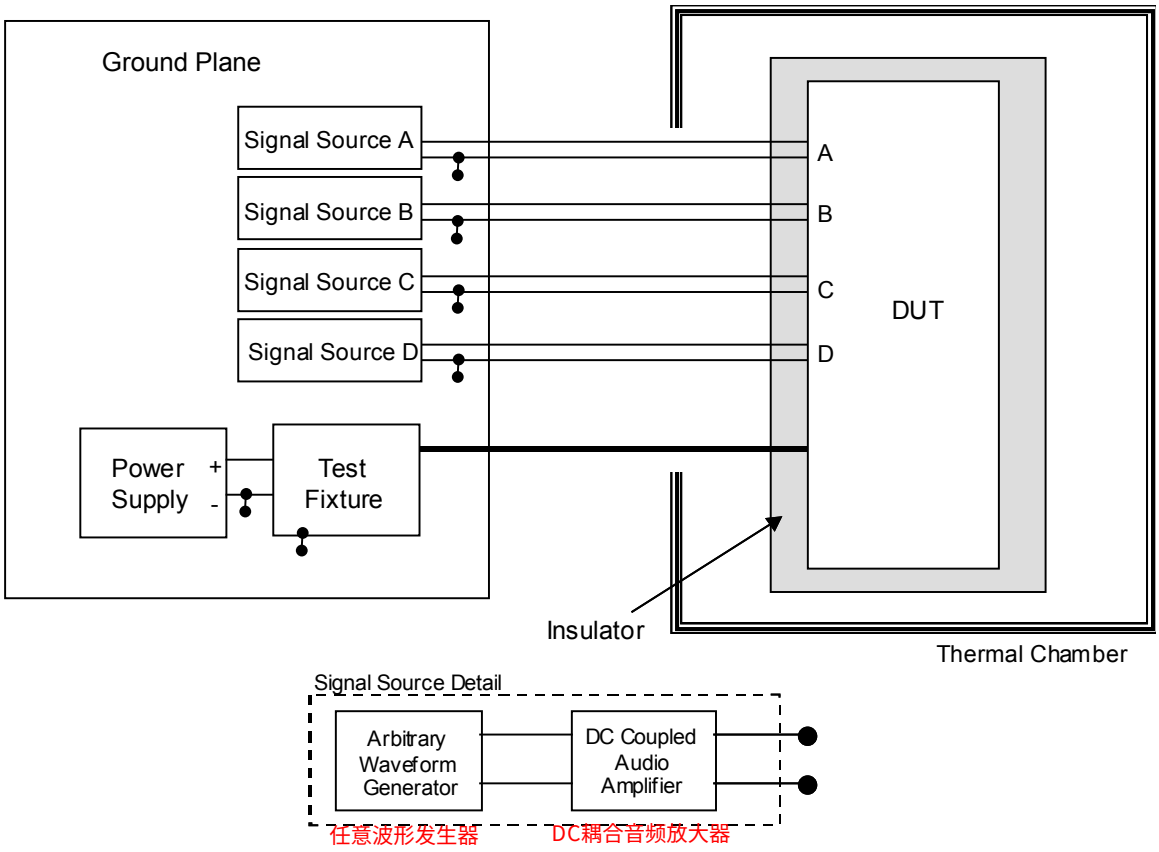
Figure 15- 1: Power Cycling Waveforms and Timing Sequence
电源循环波形和时序



Key

T1 = 100 msec	T8 = 11 sec
T2 = 5 msec	T9 = 325 msec
T3 = 185 msec	U1 = 5 V
T4 =15 msec	U2 = 9 V
T5 = 50 msec	U3 = 12.5 V
T6 = 10 sec	U4 = 13.5 V
T7 = 500 msec	U5 = 2 Vp-p @ 4 Hz

Figure 15- 2: Power Cycling Test Set-up
电源循环测试设置



15.3 Test Procedures

All waveforms shall be applied simultaneously to all power supply and control circuits per the timing sequence shown in Figure 15-1. Verify waveforms prior to application to the DUT.
测试程序：所有波形应同时使用到所有电源和控制电路，如图15-1所示的时序。应用到被测设备之前验证波形

a) Verify the waveforms prior to application to the DUT 应用到被测设备之前验证波形

b) Soak the DUT (unpowered) at the coldest operating temperature specified in component's engineering specification or at -40 +0 / - 5 degrees C for one hour prior to testing unless otherwise stated in the EMC test plan. See section 15.2 for details.
测试前把被测设备（未供源）放入组件工程规范中指定的最冷操作温度中或者放入-40/-5°C的环境中一个小时，除非EMC测试计划另有说明。详见15.2

c) Apply the test sequence illustrated in Figure 15-1. Monitor DUT functions before, during and after the test.
应用15-1所示的测试顺序。在测试前，中，后检测被测设备功能

Note that while it is recommended to apply the test sequence with the DUT located in the thermal chamber (see Figure 15-2) the test may be performed with the DUT located outside of the thermal chamber provided that the test sequence is applied within ten (10) minutes of the DUT being removed from the thermal chamber following the hour long soak period (step b). If this approach is taken, the soak temperature shall be lowered an additional 10 degrees C. Deviations to this approach are only permissible if agreed to in writing by the FMC EMC department.
值得注意的是当推荐应用测试顺序时，被测设备安装在热处理室内（参见15-2），如果测试顺序在被测设备移出热处理室10分钟以内使用，那可以进行测试，被测设备安装在热处理室外面。如果采用这种方法，那浸入温度应降低10°C。只有在福特汽车公司EMC部门同意把此方法录入规范时才允许转向此方法

d) Soak the DUT at the same temperature from step b) for 30 minutes and repeat c). Note that if the DUT was tested outside of the thermal chamber, it shall be returned to that chamber within 10 minutes.
把被测设备浸入和步骤b中温度相同的温度中30分钟然后重复c。注意如果被测设备在热处理室外面进行测试，那在10分钟内设备要返回处理室中

15.4 Data Reporting

- Description of the DUT functions monitored. 检测到的被测设备的功能描述
- Any performance deviations. 所有性能偏离

16.0 Immunity to Voltage Offset: CI 250

抗电压偏离干扰

These requirements are applicable to the following component categories: 这些要求应用于以下组件种类：

Electronic Modules: A, AM, AX, AY 电子模块

Electronic Controlled Electric Motors: EM

电子控制电动机

This requirement is not applicable to components with a dedicated power return back to another module (e.g. sensors). 此要求不适用于那种专用电源会返回到另一个模块的组件（比如传感器）

16.1 Requirements

The component shall be immune to AC ground voltage offset. Circuits affected include all power and signal returns that may be spliced to other subsystem components. Requirements are delineated in Table 16-1.

要求：组件可以抗AC接地电压偏离干扰。电路影响包括所有的电源和信号返回，这些电源和信号返回可以接合到其他子系统组件。要求如表16-1所示

Table 16 1: Ground Voltage Offset Requirements 接地电压偏离要求

Waveform 波形	Frequency 频率	Amplitude 幅	Duration 持续时间	Functional Performance Status 功能性能状态		
				Class A	Class B	Class C
Sinewave	50 – 1000 Hz	200 mV_{P-P}	60 sec at each frequency 每个频率60s	I	I	I

16.2 Test Verification and Test Set-up

Testing shall be performed using the standard test set-up shown in Figure 16-1. Figure 16-2 illustrates the test set-up to be used if the DUT is connected to another module, sensor or electrical load that has a separate ground connection to the vehicle. Application of the offset waveforms is not required only if the module or sensor has a dedicated return back to the DUT. 使用图16-1所示的标准测试设置进行测试。如果被测设备连接到另一个模块，传感器或电气负荷时使用图16-2所示的测试设置，电气负荷有一个分离式接地连接到汽车。偏离波形的应用只有在模块或传感器有专用返回线返回被测设备时才需要

- The test harness connection between the DUT to the Test Fixture shall be ≤ 2000 mm. Note that the individual ground circuits may be part of the cable harness or split out as illustrated in the figure. If the DUT has mulitple ground circuits, they shall be test separately. 测试线束在被测设备和测试装备之间的长度≤2000mm。注意单独接地电线可以是电缆线束的部件或者如图中所示进行分离。如果被测设备有多种接地电路，那它们应该分别进行测试
- Ground circuits not being testing shall be connected directly to the ground plane. 没测试的接地电路应直接连接到地平面
- The DUT and any electronic hardware in the Test Fixture shall be powered from an automotive battery or linear DC power supply (see paragraph 4.4.4 for requirements). Power circuits to the DUT shall be connected to the power supply. The power supply negative terminal shall be connected to the ground plane. 测试设备中的被测设备和所有电子硬件应由汽车电池或者线性DC电源（参见4.4.4）供源。到被测设备的电源电路应连接到电源。电源的负极应连接到地平面
- The DUT and wire harness shall be placed on an insulated support 50 mm above the ground plane. 被车设备和线束应放置在地平面50mm以上的绝缘支撑物上

16.3 Test Procedures

The waveform shall be applied to one ground circuit at a time unless analysis demonstrates that testing each circuit individually is unnecessary. The analysis shall be documented in the EMC test plan and approved by the FMC EMC department prior to commencement of testing. 波形一次应用到一根接地线路，除非分析显示有必要单独测试每个电路。分析应录入EMC测试计划然后在测试进行之前由福特汽车公司EMC部门批准

a) At each test frequency set and record the signal generator output to the specified voltage level with the DUT disconnected (open circuit). Use the frequency steps listed in Table 16-2. 在每个测试频率处，设置和记录信号发生器输出到指定的电压水平，被测设备断开连接（开路）使用表16-2所列的频率步进

b) Connect the DUT and verify that it is functioning correctly. 连接被测设备然后验证设备的功能正确性

c) Apply the waveform to each ground circuit separately. Monitor DUT functions before, during, and after application of waveform for the time stated in Table 16-1. 分别把波形应用到每个接地线路。被测设备功能的检测在表16-1指定的时间应用波形前，中，后进行

d) Repeat testing for all DUT operating modes listed in the EMC test plan. 重复EMC测试计划中所有被测设备操作模式的测试

Figure 16- 1: Test Set-up for Ground Offset of DUT 被测设备接地偏离的测试设置

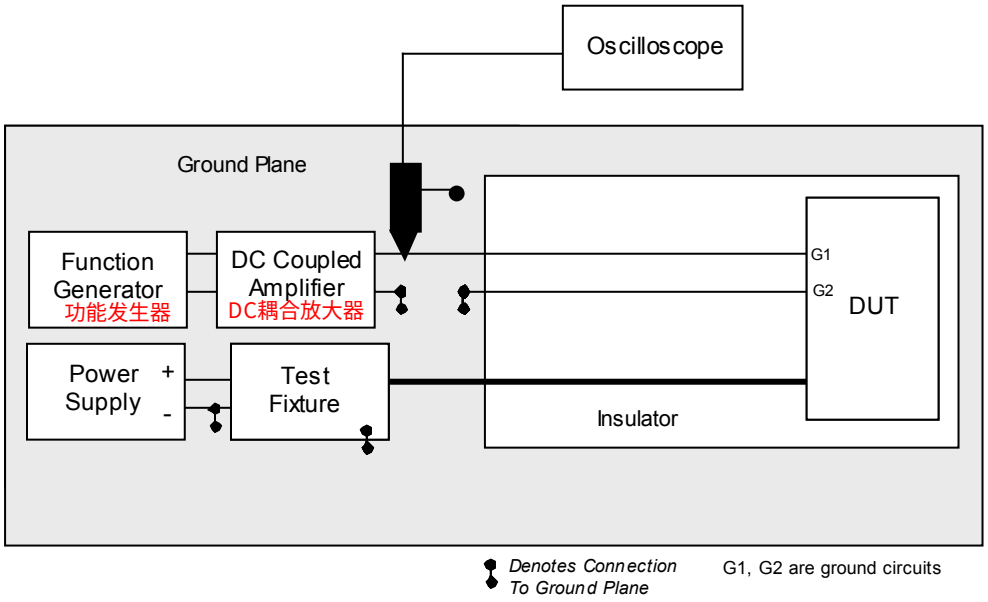


Figure 16- 2: Test Set-up for Ground Offset of DUT

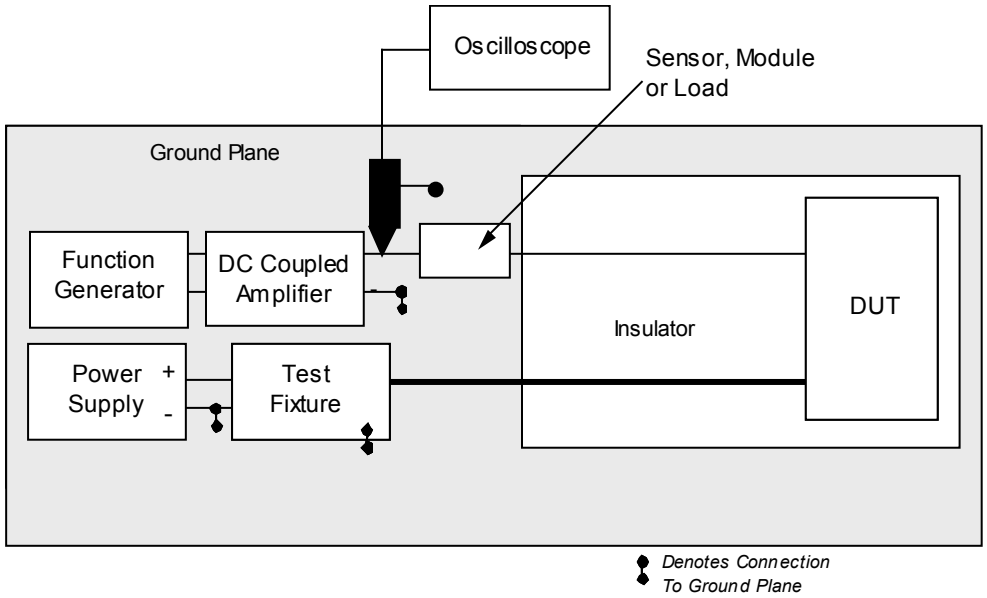


Table 16 2: Test Frequency Requirements

Test Frequency Range (Hz)	Frequency Step (Hz)
50 - 100	10
100 - 1000	300

16.4 Data Reporting

- Description of the functions monitored. 检测到的功能描述
- Any performance deviations. 所有性能偏离

17.0 Immunity to Voltage Dropout: CI 260抗电压跌落干扰：CI 260

These requirements are applicable to the following component categories:这些要求应用于以下组件种类

Electronic Modules: A, AS, AM, AX, AY电子模块

Electronic Controlled Electric Motors: EM电子控制电动机

17.1 Requirements

要求：组件应抗暂时电压降落干扰，干扰在汽车使用寿命期间都可能发生。

The component shall be immune to momentary voltage dropouts, which may occur over the life of the vehicle. Circuits affected include all power supply and control circuits. These requirements also apply to components that are connected to a regulated power provided by another module (e.g. sensors). Requirements are listed in Table 17-1. The purpose of this test is the verification of controlled recovery of hardware and software from power interruptions.电路影响包括所有电源和控制电路。这些要求也应用在连接到由另一个模块提供的稳定电源的组件（比如传感器）。如表17-1所示。此测试的目的是验证来自电源干扰的软件和硬件的受控恢复

Table 17- 1: Voltage Dropout Requirements电压降落要求

Waveform	Application	Level	Duration	Functional Performance Status (2)		
				Class A	Class B	Class C
A Voltage Dropout: High	All Power Supply and Control Circuits所有电源和控制电路	See Figure 17-1	3 cycles separated by 20 s	II	II	II
B Voltage Dropout: Low	All Power Supply and Control Circuits	See Figure 17-2	3 cycles separated by 20 s	II	II	II
C Single Voltage Dropout	All Power Supply and Control Circuits	See Figure 17-3	3 cycles separated by 20 s	I	I	I
D Voltage Dip	All Power Supply and Control Circuits	See Figure 17-4	10 cycles separated by 20 s	II	II	II
E (1) Battery Recovery电池回收	Limited to Power Supply Circuits with direct connection to battery.限于带有直接连接到电池的电源电路	See Figure 17-5	2 cycles separated by 20 s	II	II	II
F Random Bounce随机反弹	All Power Supply and Control Circuits	See Figures 17-6, 17-7	60 s	II	II	II

1 Applicable only to direct battery connections只应用于直接电池连接

2 Performance Status checked after each waveform cycle性能状态在每个波形循环之后检测

17.2 Test Verification and Test Set-up

Testing shall be performed using the test set-ups shown in Figure 17-8 through 17-10. The test harness connecting the DUT to the Test Fixture and transient pulse generator shall be ≤ 2000 mm in length.
应通过图17-10使用图17-8所示的测试设置进行测试。测试线束连接被测设备到测试装备和瞬态脉冲发生器，长度≤2000mm

Figure 17- 1: Waveform A (Voltage Dropout: High)

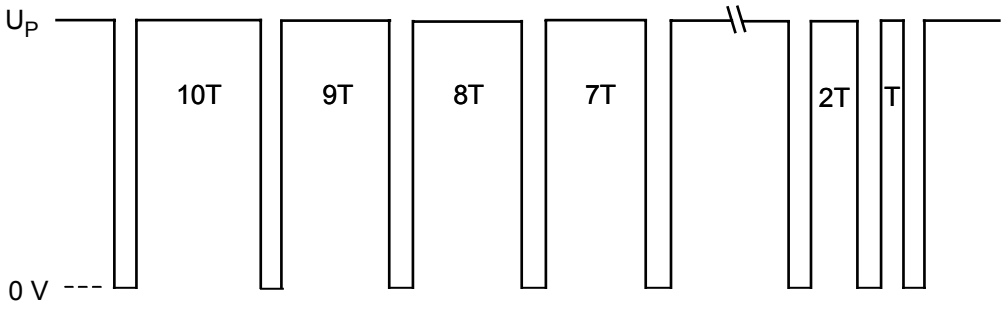
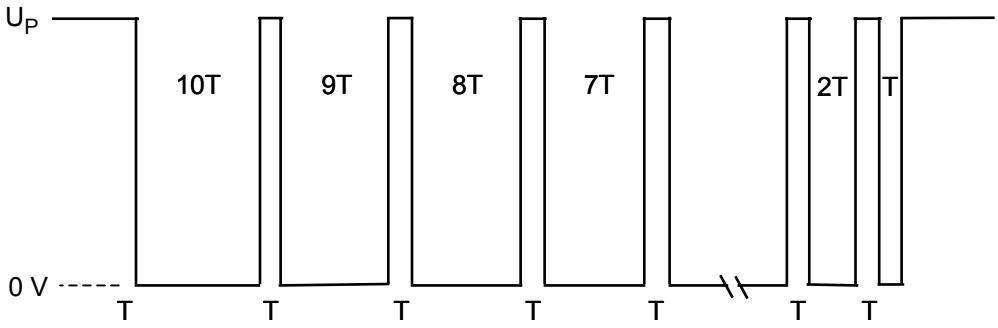


Figure 17- 2: Waveform B (Voltage Dropout: Low)

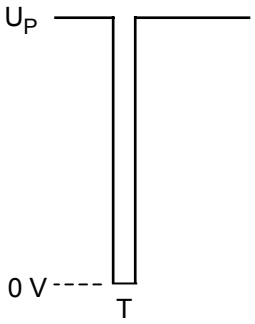


Key:

	Power from Vehicle Battery 汽车电池电源					Regulated Power from another Module 来自另一个模块的稳定电源				
U_P	13.5 VDC					Nominal Supply Voltage (e.g. 5 Vdc, 3 Vdc)				
T	100us	300 us	500us	1ms	3ms	100us	300 us	500us	1ms	3ms
	5 ms	10 ms	30 ms	50 ms		5 ms	10 ms	30 ms	50 ms	

Waveform transition times are approximately 10 us

Figure 17- 3: Waveform C (Single Voltage Dropout)

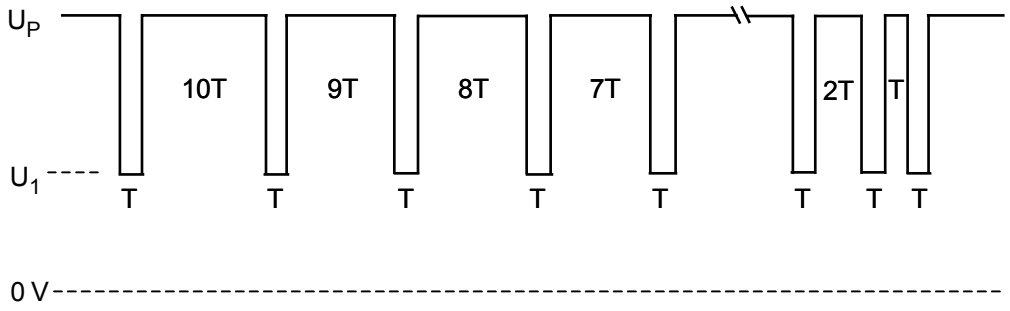


Key:

	Power from Vehicle Battery			Regulated Power from another Module 来自另一个模块的额定电源		
U_P	13.5 VDC			Nominal Supply Voltage (e.g. 5 VDC, 3 VDC)		
T	100us	200 us	400us	100us	200 us	400us

Waveform transition times are approximately 10 us
波形转换的次数大概为10us

Figure 17- 4: Waveform D (Voltage Dip)

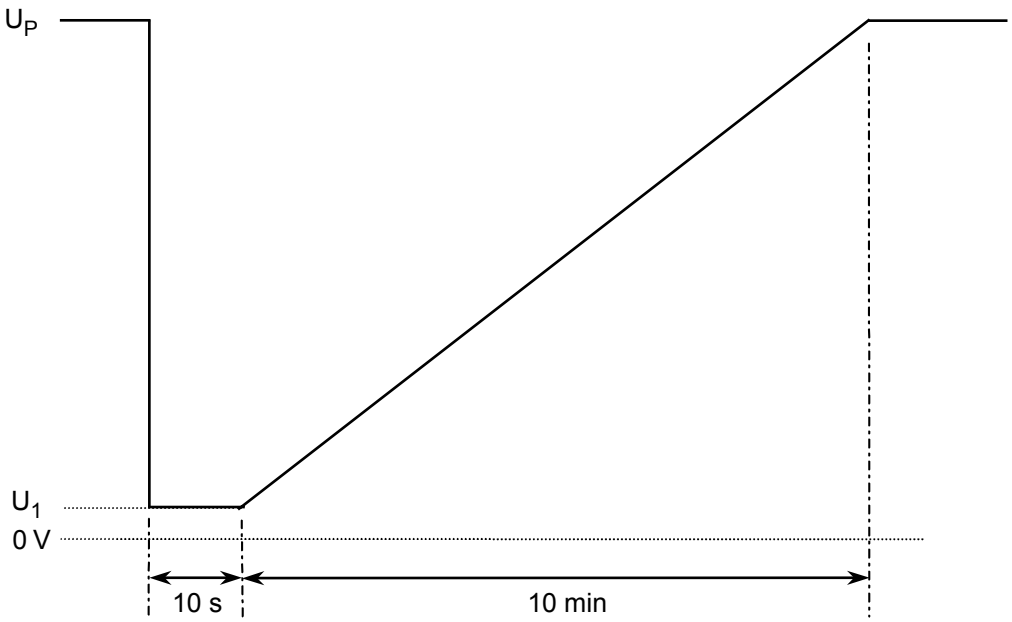


Key:

	Power from Vehicle Battery					Regulated Power from another Module				
U_P	13.5 VDC					Nominal Supply Voltage (e.g. 5 V, 3 V)				
U_1	5 V					80% of Nominal Supply Voltage				
T	100us	300 us	500us	1ms	3ms	100us	300 us	500us	1ms	3ms
	5 ms	10 ms	30 ms	50 ms		5 ms	10 ms	30 ms	50 ms	

Waveform transition times are approximately 10 us

Figure 17- 5: Waveform E (Battery Recovery)



Key:

U_P	12.5 V DC
U_1	5 V

Figure 17- 6: Waveform F (Random Bounce)

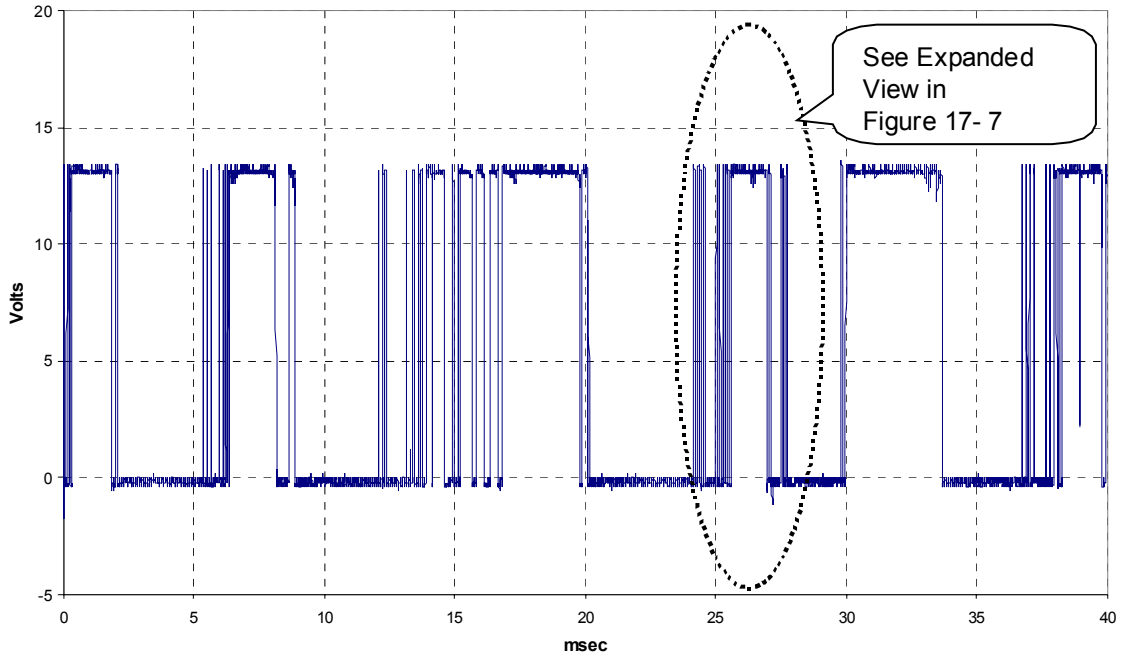


Figure 17- 7: Waveform F (Expanded)

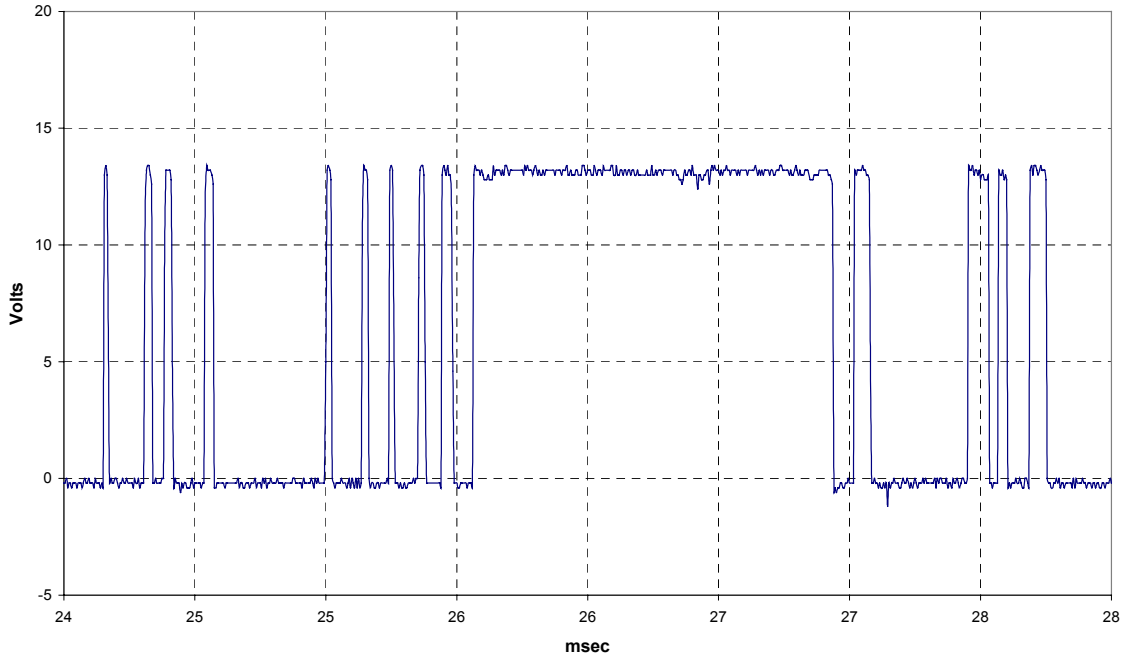


Figure 17- 8: Test Set-up Detail for Waveforms A , B and C

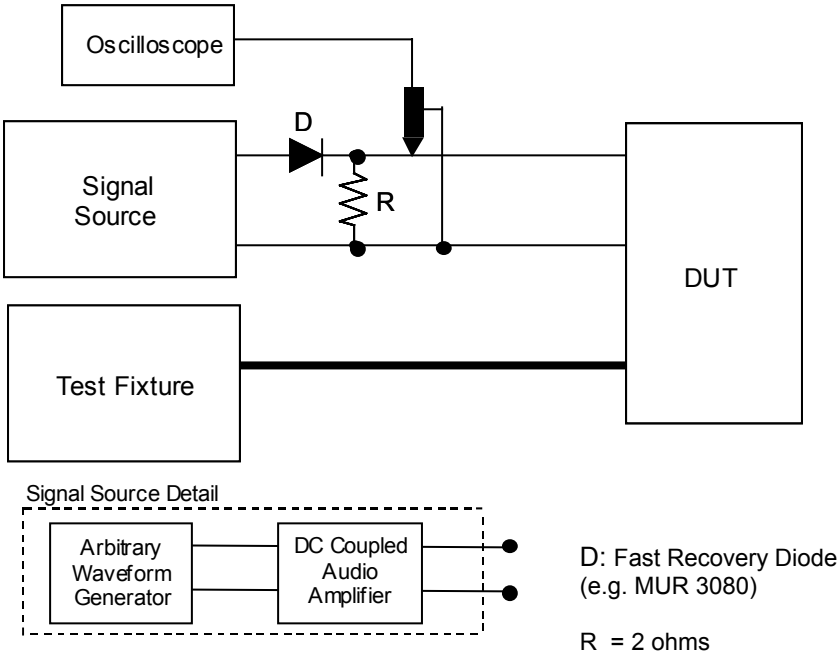


Figure 17- 9: Test Set-up Detail for Waveforms D and E

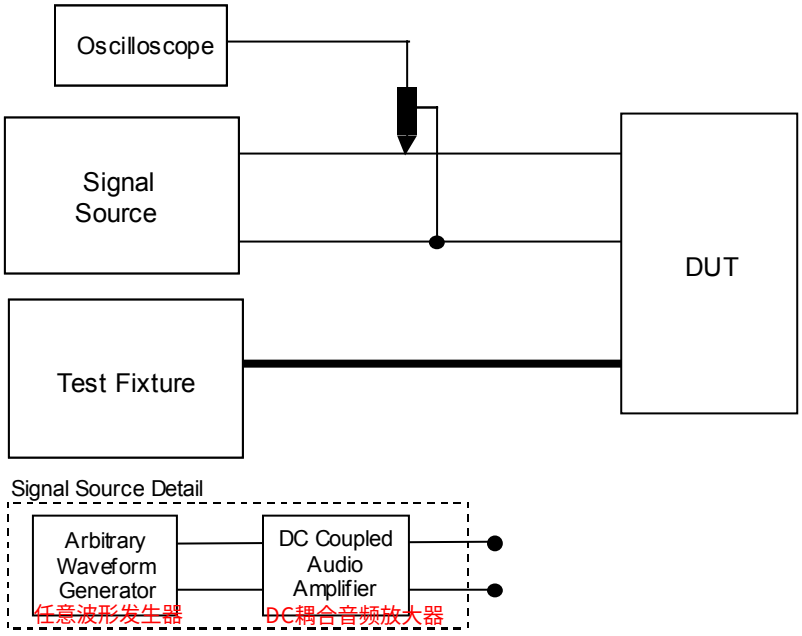
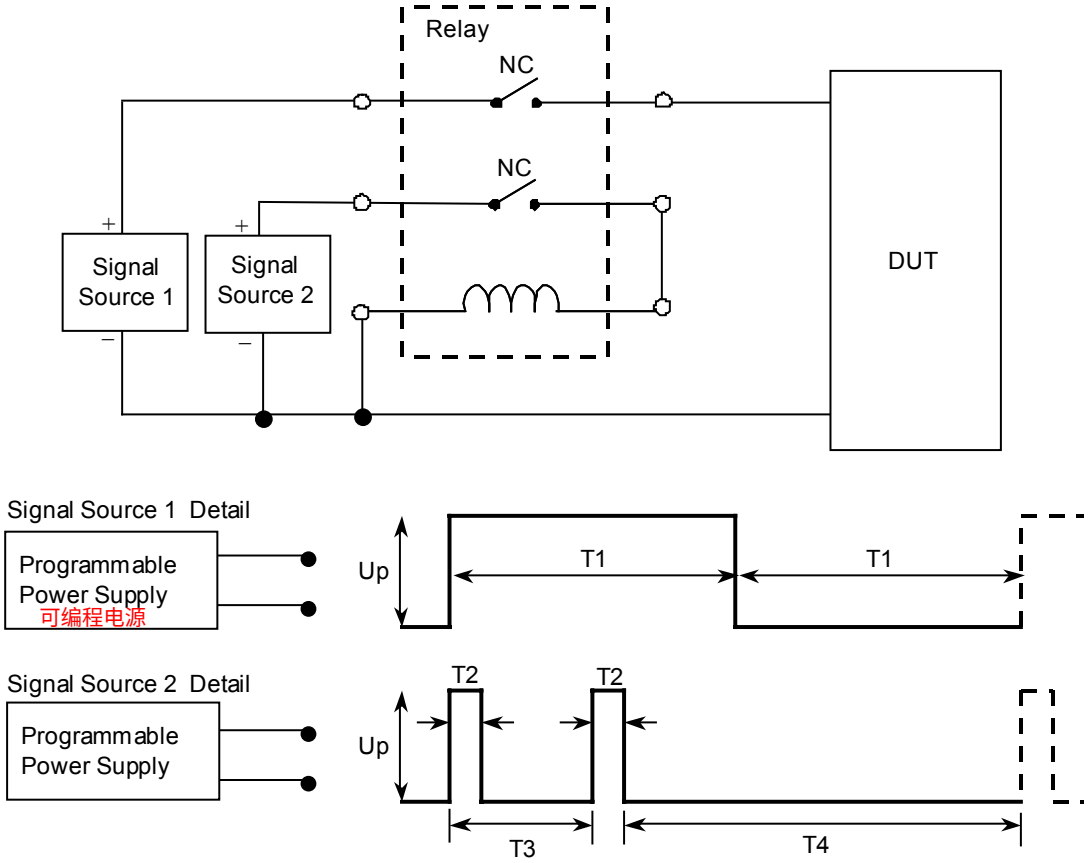


Figure 17- 10: Test Set-up for Waveform F



Key:

Up = 13.5 volts	Relay*: 12 volt AC relay: Potter & Brumfield KUP-14A15-12. No substitutions permitted without written authorization from the FMC EMC department. See Annex H for relay specifications. 没有福特汽车公司EMC部门通的书面授权不容许代替 参见附录H，继电器的规格
T1 = 5 sec	
T2 = 100 msec	
T3 = 2.5 sec	
T4 = 7.4 sec	

* Note that the P&B relay contacts are limted to 10 amperes. When testing requires higher operating currents, alternative relays may be used with written approval from the FMC EMC department.

注意P&B继电器触点要限制在10安培。测试需要更高的操作电流时，可以使用交流继电器，但要有福特汽车公司EMC部门的书面许可

17.3 Test Procedures

a) Adjust DC offset of the signal generator/audio amplifier to 13.5 volts with the DUT disconnected (open circuit) 调整信号发生器/音频放大器的DC支线到13.5V，被测设备断开连接（开路）

b) Prior to testing, measure and verify that the test waveforms A , B, C, D and E match those waveforms illustrated in section 17.2. For waveform F, measure and verify that the test waveform voltages are similar to that illustrated in Figure 17-6 and 17-7. All measurements shall be made with the DUT disconnected from the waveform generator. 测试之前，测量和验证测试波形A,B,C,D和E负荷17.2规定的那些波形。对于波形F，测量和验证测试波形电压和图17-6,17-7所示的波形相似。所有测量进行时被测设备要断开和波形发生器的连接

c) Connect and activate the DUT. Verify that it is functioning correctly. 连接和激活被测设备。验证功能的正确性

d) Except for waveform E, apply each waveform into each power supply and control circuit separately. Apply waveform E simultaneously to all power circuits with direct battery connections. 除了波形E，分别把每个波形应用到每个电源和控制电路中。同时应用波形E到所有带直接电池连接的电源电路

e) Application of the waveforms shall be in accordance with the requirements delineated in Table 17-1. Monitor DUT functions before, during, and after application of each test waveform. 波形的应用应符合表17-1所示的要求。应用每个测试波形前，中，后检测被测设备功能

f) Repeat testing for all DUT operating modes listed in the test. 对所列的所有被测设备操作模式的进行重复测试

17.4 Data Reporting

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

18.0 Immunity to Voltage Overstress: CI 270 抗过压干扰：CI 270

These requirements are applicable to the following component categories: 这些要求应用于以下组件种类：

Electronic Modules: A, AS, AM, AX, AY 电子模式

Electronic Controlled Electric Motors: EM 电子受控电动机

Passive Modules and Inductive Devices: P, R 被动模块和电感元件

18.1 Requirements

组件应抗潜在过压干扰。此要求应用于所有电源或控制电路，任意一个转换到货直接连接到电池。要求也可以应用来控制路直接连接到开关电池连接的电路或者通过一个外部上上拉电阻器控制电路。参见18-1所示的要求。

注意如果分析表明部件符合表18-1所示的要求那可能放弃此要求。但是，福特汽车公司EMC部门会评审和赞同此分析以避免测试

The component shall be immune to potential voltage overstress. This requirement is applicable to all power supply or control circuits, either switched to, or directly connected to battery. The requirement is also applicable to control circuits directly connected to switched battery connections or through an external pull-up resistor. Requirements are delineated in Table 18-1. Note that this requirement may be waived if analysis shows that the component will meet the requirements in Table 18-1. However, the FMC EMC department shall review and concur on this analysis to avoid this testing.

Table 18- 1: Requirements for Voltage Overstress

Requirement		Functional Performance Status	
Amplitude	**Duration**	**Class A**	**Class B and C**
-14 V	60 sec	III	III
19 V	60 min	III	II
24 V	60 sec*	III	II

* Applicable to devices connected directly to battery or via the ignition switch. For devices connected only to the start circuit, the duration time may be reduced to 15 sec.

应用于直接连接或通过点火开关连接的设备。对于只连接到启动电路的设备，持续时间可以减少到15s。

18.2 Test Set-up and Verification

The DUT and any electronic hardware in the Test Fixture shall be powered from a linear DC power supply (see paragraph 4.4.4 for requirements). Note that for these tests, the power supply shall have minimum short circuit capacity of 200 amperes.

测试装备上的被测设备和所有电子硬件由线性DC电源供源（参见4.4.4）。注意对于这些测试，电源应有200安培的最小短路容量

A device that is reverse battery protected via use of a fused power circuit and a reverse biased diode in parallel with the device shall be tested in a configuration representative of the vehicle. Example: If a vehicle fuse is used to protect the device, testing shall be performed using the same type (i.e. style and fuse rating) as used in the vehicle. The fuse type shall be documented in the component engineering specification and the EMC test plan

一个反向电池的装置通过使用装有保险丝的电源电路和一个反向偏压二极管得到保护，反向偏压二极管要和在汽车代表结构中进行测试的设备平行。比如：如果使用汽车保险丝保护设备，应该使用汽车中使用的相同类型的保险丝进行测试。保险丝的类型应记录在组件工程规范和EMC测试计划中

18.3 Test Procedures

a) Apply –14 volts only to power circuits with direct battery connections. After 60 seconds, the same potential shall then be applied to the remaining switched power and control circuits for 60 seconds while maintaining the same potential on the direct battery connections. After completion of this test, apply normal +13.5 volts and verify that the DUT powers up and functions properly.

只能使用-14V的电压到带有直接电池连接的电源电路。60s过后，当在直接电池连接上维持相同电势时，相同的电势在这时应使用到剩下的开关电源和控制电路中60s。完成测试以后，应用额定电压+13.5V并验证被测设备的通电和正常运行

b) Repeat step a) with 24 volts.

用24V电压重复步骤a

c) Apply +19 volts to all power and control circuits. All circuits shall be tested simultaneously. Verify functionality per Table 18-1.

应用+19V电压到所有电源和控制电路。所有电路同时测试。按照表18-1的规定验证功能

18.4 Data Reporting

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

19.0 Electro Static Discharge: CI 280 静电放电：CI280

The component shall be immune to overstress due to Electrostatic Discharge (ESD). These requirements are applicable to the following component categories: 组件应抗由于静电放电产生的过压。这些要求应用于以下组件种类

Electronic Modules: A, AS, AM, AX, AY
电子模块
Electric Motors: Categories EM
电动机
Passive Modules: P
被动模块

19.1 Requirements

- The component shall be immune to ESD events that occur during normal handling and assembly. These requirements are listed in Table 19-1. 组件应抗在正常处理和组装期间产生的抗静电放电干扰。这些要求参见19-1
- The component shall be immune to ESD events that can occur during normal operation (i.e. powered). These requirements are listed in Table 19-2. This includes components with direct access from within the passenger compartment, or by direct access through an open window from a person outside the vehicle (e.g. door locks, turn signal stalk). 组件应抗在正常操作（即供源）期间产生的静电放电干扰。这些规范参见19-2.包括从客舱里面直接接入的组件，或者通过车外的人直接连接的组件（比如，车锁，方向灯杆）
- After exposure to ESD events listed in Tables 19-1 and 19-2, component I/O parametric values (e.g., resistance, capacitance, leakage current, etc.) shall remain within their specified tolerances.
暴露于表19-1和19-2规定的静电放电干扰后，组件I/O参数（比如，电阻，电容，泄漏电流等）应保持在他们指定的公差内

19.2 Test Verification and Test Set-up

Testing shall be performed in accordance with ISO 10605 except were noted in this specification. The test facility shall be maintained at an ambient temperature at (23 ±3) °C and a relative humidity from 20 % to 40 % (20 °C and 30 % relative humidity preferred).
测试要符合ISO...的规定，此规范中指明的除外。实验设备应维持在23±3°C的环境温度中，相对湿度从20%到40%（最好是20%和30%的相对湿度）
The ESD simulator waveform verification shall comply with ISO 10605 with the following exceptions:
静电放电模拟器波形验证应符合ISO...的规定，以下情况除外：

- Contact discharge rise time ≤ 1 ns 触点放电上升时间≤1ns
- Air discharge rise time ≤ 20 ns 空气放电上升时间≤20ns

The RC time constant shall be verified by calculation using the exponentially decaying portion of the waveform after the leading edge and/or ringing. RC时间常数应通过计算验证，计算使用的是波形的指数衰减部分

Table 19- 1: ESD Requirements: Handling (unpowered)

Type of Discharge	Test Voltage Level	Minimum Number of Discharges at each polarity 两极最小放电次数	Functional Performance Status		
			Class A	Class B	Class C
Contact discharge 触点放电 C = 150 pF, R = 2kΩ	± 4 kV	3	IV*		
Contact discharge C = 150 pF, R = 2kΩ	± 6 kV	3			
Air discharge 空气放电 C = 150 pF, R = 2kΩ	± 8 kV	3			

* The component's parametric values (e.g., resistance, capacitance, leakage current, etc.) shall be within their specified limits. 组件的参数（比如电阻，电容，泄漏电流等）应在它们指定的限制范围内

Table 19- 2: ESD Requirements: Powered

Discharge Sequence	Type of Discharge	Test Voltage Level	Minimum Number of Discharges at each polarity	Functional Performance Status		
				Class A	Class B	Class C
1	Air discharge C = 330 pF, R = 2kΩ	± 4 kV	3	I		
2	Contact discharge C = 330 pF, R = 2kΩ	± 4 kV	3			
3	Air discharge C = 330 pF, R = 2kΩ	± 6 kV	3			
4	Contact discharge C = 330 pF, R = 2kΩ	± 6 kV	3	II		
5	Air discharge C = 330 pF, R = 2kΩ	± 8 kV	3			
6	Contact discharge C = 330 pF, R = 2kΩ	± 8 kV	3			
7	Air discharge C = 330 pF, R = 2kΩ	± 15 kV	3			
8[1]	Air discharge C = 150 pF, R = 2kΩ	± 25 kV[1]	3			

1 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 switch, cluster)
设备从汽车外直接连接到客舱，不触碰汽车的任何部分（比如车锁开关，照明灯开关，群），这是对此设备的限制要求

19.2.1 Handling Tests

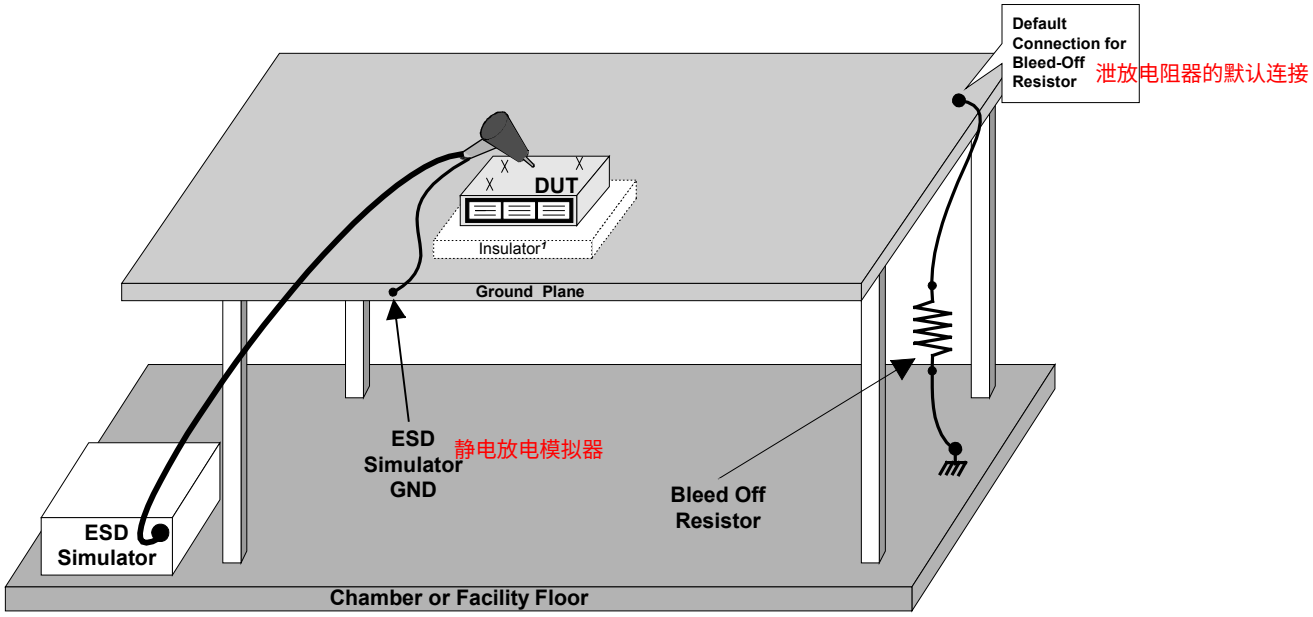
操纵测试：静电放电操纵测试应在其他所有EMC测试之前进行。参见5.4

ESD handling tests shall be performed before any other EMC testing. See section 5.4 for details.

The standard test set-up for handling tests is illustrated in Figure 19-1. The DUT, which is unpowered with all leads disconnected, shall be placed on a clean, non-hygroscopic insulator that is 50 mm thick. The insulator lies directly on the ground plane. The ground plane shall be attached to the facility ground.

操纵测试的标准测试设置如图19-1所示。被测设备不供源，所有导线断开，应放置在50mm厚的干净不易潮湿的绝缘体上。绝缘体直接放置到地平面上。地平面附着在设施地面

Figure 19- 1: ESD Handling Test Set-up
静电放电操纵测试设置



Bleed Off resistor used to bleed charge from discharge points
使用泄放电阻器对放电点进行放电

19.2.2 Powered Tests 供电测试

图19-2所示的是在被测设备通电和执行时的标准设置。测试装备上的被测设备和电子硬件应由汽车电池（参见4.4.4）供源

Figure 19-2 illustrates the standard set-up used when the DUT is powered and functioning. The DUT and any electronic hardware in the Test Fixture shall be powered from an automotive battery (see paragraph 4.4.4 for requirements).

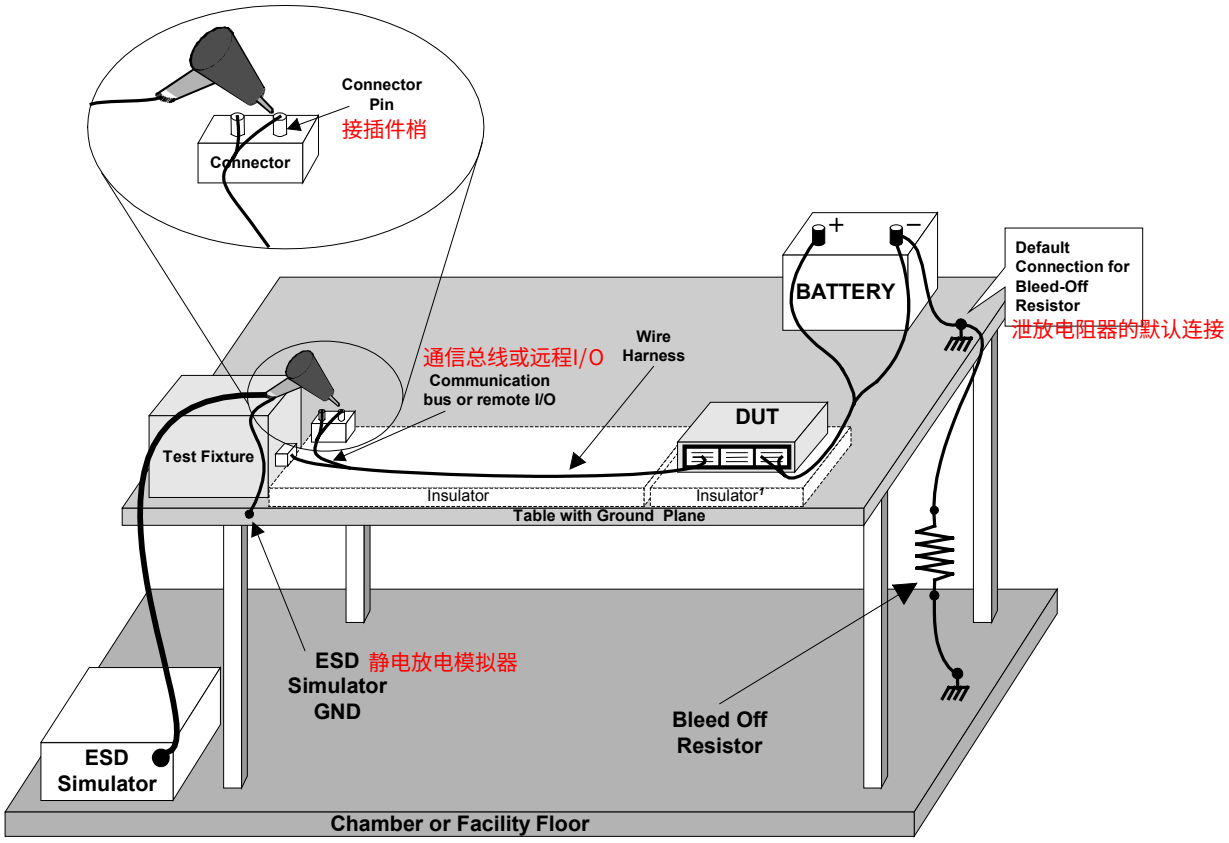
被测设备和其附着的线束应放置在50mm厚的干净不易潮湿的绝缘支撑物上。绝缘物直接放置在地平面上。测试线束连接被测设备和测试装备，其长度为1700mm（+300/-0mm）。测试装备应直接连接到地平面。如果被测设备的外壳是金属且安装在汽车时可以接地，那被测设备应直接放置在地平面上。如果对怎样把被测设备安装到汽车不确定，那被测设备应在两个结构中测试。地平面应附着在电池的负极和测试设备地面。注意作为选择，电池可以放置在设备的地板上

The DUT and its attached test harness shall be placed on a clean, non-hygroscopic insulating support that is 50mm thick. The insulator lies directly on the ground plan. The test harness connecting the DUT and Test Fixture shall be 1700 mm (+300/-0 mm) in length. The Test Fixture shall be connected directly to the ground plan. If the outer case of the DUT is metal and can be grounded when installed in the vehicle, the DUT it shall be placed directly on the ground plane. If there is uncertainly about how the DUT is installed in the vehicle, the DUT shall be tested in both configurations. The ground plane shall be attached to the negative terminal of the battery and to test facility ground. *Note that as an alternative, the battery may be place on the floor of the facility.*

If the DUT has remote inputs that are accessible by the operator (e.g. switches, communications bus circuits accessible via diagnostic connectors) the associated wiring shall be split out of the main harness and attached to conductive pins (See Figure 19-2). These pins will facilitate direct discharge from the ESD gun. Note that for remote inputs that normally connect to a customer accessible switch, a representative switch may be use, but shall be approved by the FMC EMC department in writing prior to commencement of testing. If approved, details of this switch shall be included in the EMC test plan.

如果被测设备有操作者可接近的远程输入（如通过诊断接插件可接近的开关，通信总线电路），那相关联的线路应从主线束中分离出来然后附着到传导梢（参见19-2）。这些梢使静电放电枪的直接放到更便利。注意，对于通常连接到客户可接近开关的远程输入，可以使用代表开关，但是在测试前要经福特汽车公司的批准。如果得到了批准，此开关的详情应包括进EMC测试计划中

Figure 19- 2: ESD Powered Test Set-up



Bleed Off resistor used to bleed charge from discharge points

19.3 Test Procedures

Testing shall be performed sequentially starting with handling tests followed by powered and direct access tests (Discharges 1 – 7).按顺序进行测试，开始进行操作测试接下来进行通电和直接接入测试

- Between individual discharges, the remaining charge shall be bled off using the bleed-off resistor (approximately 1M ohm resistance) by touching the discharge point and the ground plane.
  在个别放电之间，使用泄放电阻器（大概1ohm的电阻）通过接触放电点和地平面泄放剩余的电荷
- Charge dissipation between discharges of some modules (instrument panels, large plastic modules etc.) may require use of an ionizer. If used, the air ionizer shall be turned off and removed before each discharge is applied. 一些模块（仪表板，大塑料模块等）放电之间的电荷消散可能需要使用电子发生器。如果使用了电子发生器，空气电子发生器应关闭并且在使用每个放电之前移除

19.3.1 Handling (Unpowered) Tests操纵（不供源）测试

Before testing commences, the discharge voltage of the ESD simulator shall be verified at the levels listed in Table 19-1.在测试开始之前，静电放电模拟器的放电电压应在表19-1所列的水平处验证

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. 在所有被测设备表面（排除接插件梢）±8KV处进行空气放电测试，用户可以在包装，安装或解除期间接触被测设备表面。所有放电表面应在EMC测试计划中做出说明

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.
如果在测试中观察到一个或多个放电，重复2个附加放电到那些表面，一共3个放电

If the connector body is metallic with recessed connector pins, the remainder of the steps listed below shall be omitted. 如果接插件身含有金属并且带有凹口接插件梢，以下所示的步进剩余物应省略

c) Repeat step a) at all DUT connectors. Attempt discharge to one or more DUT pins.
在所有被测设备接插件重复步骤a。尝试放电到一个或多个被测设备梢

d) If one or more discharges are observed, perform three +/-4 KV contact discharges at each connector pin (three of each polarity). If connector body is non-metallic and the connector pins are recessed, an extension contact (< 25 mm) shall be installed to facilitate testing.
如果观察到一个或多个放电，在每个接插件梢（每个极3个）进行三个+/-4KV的触点放电。如果接插件身不含金属，并且接插件梢带有凹口，就安装一个延伸触点以方便测试

e) Repeat step d) using three +/- 6 KV contact discharges (three of each polarity)
使用3个+/-6KV的触点放电（每个极三个）重复步骤d

f) After all discharges have been carried out, a functional performance and parametric tests shall be performed to verify that the DUT meets the requirements delineated in Table 19-1.
在所有放电执行以后，进行功能性能和参数测试来验证被测设备满足了表19-1所示的要求

19.3.2 Powered Tests

19.3.2 通电测试：当使用表19-2所示的电压水平和静电放电网络值操作被测设备时，要进行所有的测试。在测试开始之前，进行静电放电模拟器的放电电压的验证。测试应限制到一个被测设备操作模式。那个操作模式应在EMC测试计划中指明。测量仪器可以附着到被测设备，可能受测试干扰或在测试中被损坏。因此在测试中不推荐使用这 类附件

All tests shall be performed while the DUT is in operation using the voltage levels and ESD network values listed in Table 19-2. Before testing commences, the discharge voltage of the ESD simulator shall be verified. Testing shall be limited to one DUT operating mode. That operating mode shall be specified in the EMC test plan. Measuring instruments, which may be attached to the DUT, can interfere with the test and/or be damaged during testing. As a result the use of such attachments is not recommended during testing.

验证被测设备的彻底运行。如果被测设备包含网络功能（比如J1850…），应模拟正常网络流量在汽车应用中显示该功能

a) Verify that the DUT is fully operational. If the DUT contains network functions (e.g. J1850, CAN, LIN), normal network traffic shall be simulated to represent that typical in the vehicle application.

b) Perform contact and air discharge tests on all DUT surfaces including shaft, actuator linkages, and wiring in addition to surfaces that are directly accessible by the vehicle occupant (e.g. remote switch inputs, displays, clocks, radio presets etc). If the DUT has remote inputs that are accessible by the operator (e.g. switch inputs, communications bus circuits accessible via diagnostic connectors), apply contact and air discharges directly to the connector pins as illustrated in Table 19-2. For remote inputs that normally connect to a customer accessible switch, a representative switch may be use, but shall be approved by the EMC EMC department in writing prior to commencement of testing.
在所有被测设备包括轴，驱动器联动装置和线路上进行触点和空气放电测试，除了汽车占有者（比如远程开关输入，显示，时钟，音频重置等）可以直接连接到表面。如果被测设备有操作者（开关输入，通过诊断接插件连接的通信总线电路）可以连接的远程输入，那把触点和空气放电直接连接到接插件梢，如表19-2所示。对于通常连接到客户可连接的开关的远程输入而言，可以使用代表开关，但是要在测试之前得到福特汽车公司EMC部门的书面批准

c) For each of the required discharge voltages, 3 discharges of positive and 3 discharges of negative polarity shall be applied at each of the specified discharge points. Discharges shall be applied according to the discharge sequence shown in Table 19-2. The individual discharge points shall be specified in the EMC test plan. Testing using ± 25 KV shall be limited only to:
对于所需的每个放电电压而言，正极的3个放电和负极的3个放电应使用到指定的每个放电点。放电要根据放电时序进行应用，参见19-2.单个放电点应在EMC测试计划中指明。测试使用的±25KV电压仅限于以下条件使用：

- Components packaged in the passenger compartment and that are directly accessible from outside the vehicle (e.g. turn signal stalk switch) 包装到客舱里的组件并且可以直接从车外连接（比如，方向灯杆开关）
- Components directly or remotely accessible from the outside of the vehicle (e.g. keyless entry) 部件从汽车外面（比如无钥匙进入）直接或远程连接

Testing using ± 25 KV shall not be applied to remote circuits accessible at diagnostic connectors.
测试使用的±25KV不能应用到在诊断接插件连接的远程电路

g) After all discharges have been carried out, a functional performance and parametric tests shall be performed to verify that the DUT meets the requirements delineated in section 13.1.
所有放电执行了以后，应进行功能性能和参数测试以便验证被测设备符合13.1规定的要求

19.4 Data Reporting

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

组件EMC测试计划

Annex A (normative): Component EMC Test Plan

应准备EMC测试计划并在EMC测试开始之前20天提交到EMC部门。此测试计划的目的在于开发和记录周详的程序以便验证组件可以强硬到抵抗期望的电磁环境，组件必须在此环境中进行。EMC测试计划还提供机械装置以继续增强和提高测试设置，这样能更好的和汽车水平测试相关联

The EMC Test Plan shall be prepared and submitted to the vehicle line EMC department 20 days prior to commencement of EMC testing. The purpose for this test plan is to develop and document a well thought out procedure to verify that the component is robust to the anticipated electromagnetic environment that it must operate within. The EMC test plan also provides a mechanism for ongoing enhancements and improvements to the test set-up, which better correlates with vehicle level testing.

组件EMC测试计划的准备要符合图A-1的要求。测试计划需要供应商和EMC测试组织之间的合作。福特汽车公司EMC部门对EMC测试计划的接受要在供应商，FMC D&R小组和测试实验室批准之前。这些签字要出现在测试计划主题页面。

The component EMC test plan shall be prepared in accordance to the outline shown in Figure A-1. The test plan requires collaborations between the supplier and the EMC testing organization. Acceptance of the EMC test plan by the FMC EMC department requires prior sign-off by the supplier, the FMC D&R group, and the test laboratory. These signatures shall appear on the test plan title page. A copy of the title page is shown in Figure A-2. This title page shall be used for all EMC test plans.主题页面的复印件在图A-2做出了规定。此主题页面应使用到所有EMC测试计划中

When the EMC test plan is completed with the required signatures, it shall be submitted to the FMC EMC department for assignment of a test plan tracking number. This tracking number shall be stamped on all test data when submitted to FMC. Note that the FMC EMC department reserves the right to review and challenge specific details of the plan, which may require modification by the supplier prior to test. Also note that for some vehicle brands, the FMC EMC department may require pre-approval of the EMC test plan before testing may commence.

当EMC测试计划完成了所需签字后提交到FMC EMC部门以获取测试计划跟踪号的任务。提交到FMC时，跟踪号应印刷到所有测试资料上。注意FMC EMC部门保有评审和挑战计划特殊细节的权利，这需要在测试之前由供应商进行修改。还要注意对于一些汽车品牌而言，FMC EMC部门需要在测试进行之前EMC测试计划的提前批准

Figure A- 1: EMC test plan OutlineEMC测试计划概要

Title Page (see Figure A-2)

1.0 Introduction
- 1.1 Product Description
- 1.2 Theory of Operation
- 1.3 Physical Construction
- 1.4 EMC Specification Release
- 1.5 Approved Test Facility
- 1.6 Component Part Number(s)
- 1.7 Component Manufacturer(s)
- 1.8 Component Usage

2.0 EMC Requirements Analysis
- 2.1 Critical Interface Signals
- 2.2 Potential Sources of Emissions
- 2.3 Component Surrogate selection

3.0 Test Design and Requirements
- 3.1 Component Operating Modes/Functional Classifications
- 3.2 Test Requirements
- 3.3 Input Requirements
- 3.4 Output Requirements
- 3.5 Load Box/Test Support Requirements

4.0 Test Set-up

5.0 Test Report Requirements

Figure A- 2: Component / Subsystem EMC Test Plan Title Page 组件/子系统EMC测试计划主题页面

Product Name:	
Product Supplier Name: Product Design Engineer:	Ford Recognized EMC Test Facility(s) used: *Include Lab Manager Name(s)*
Product Manager: Product Part Number(s): *List all product part numbers that this test plan is applicable to. (May be listed on separate page)*	Vehicles & Model Year using this product: If multiple part numbers, identify which vehicles part numbers are used. *(May be listed on separate page with part numbers)*
Product Manufacturing Location(s) Where with this product be produced?	EMC Specification Used: *Identify specification and revision number being used*

I certify that the information contained in this test plan is factual including description of the product operation, correct functional classifications, and acceptance criteria. I understand and agree that any subsequent changes to this test plan prior to design verification testing shall be communicated to the FMC EMC department. Any changes or revisions to this test plan after test completion shall require written technical justification and approval by the same EMC department. I understand that failure to follow this process may result in non-acceptance of the product's EMC test data by the FMC EMC department. I also understand and acknowledge that requirements validated via this test plan are relevant only to the specific vehicles that the product is to be fitted to. Use of the product on other vehicle platforms may require additional EMC performance requirements, which will necessitate additional verification testing of the product. I certify that the product samples submitted for EMC testing are of a production representative design. I agree to submit a summary report directly to the FMC EMC department no later than five (5) business days following completion of testing. I also agree to forward a copy of the test laboratory's detailed test report directly to the FMC EMC department within thirty (30) business days following completion of testing.

Supplier Product Design Engineer:

_____

Sign and Date

Supplier Product Manager Concurrence*:*

_____

Sign and Date

Ford Design & Release Engineer Concurrence:

_____

Sign and Date

For Internal EMC Department Use (Do not Mark)						
Received by FMC EMC Department						
☐ *Aston Martin*	☐ *FOA*	☐ FOE	☐ Jaguar	☐ Land Rover	☐ Mazda	☐ Volvo
Date Received/ FMC EMC Engineer			Test Plan Tracking Number			

Annex B (Normative): Process for Repeat EMC Testing

Changes to the component's original production design may often impact its EMC characteristics. Often some additional EMC testing needs to be repeated to verify there is no negative impact. Information provided in this annex presents a process for assessing what EMC testing shall be required when specific component design changes are being considered.重复EMC测试的过程：组件原件设计的改变可能会经常影响EMC的特征。经常性的，需要重复一些附加EMC测试以便验证没有负面影响。此附录提供的信息显示了当考虑特定组件设计变化时所需EMC测试的评估过程。

Information provided in Tables B1 through B5 shall be used by the supplier to determine what EMC tests shall be required to validate the design changes. The supplier shall notify the FMC D&R group for the component and the FMC EMC department prior to commencement of testing. The component's original EMC test plan shall be used to facilitate the testing. Deviations from this process shall be pre-approved by the FMC EMC department.

通过B5在表B1提供的信息由供应商使用来决定需要什么EMC测试来验证设计的变化。供应商在测试开始之前通知FMC的组件D&R小组和FMC EMC部门。组件的原始EMC测试计划应使用来使测试更加便利。此过程的偏离要经过FMC EMC部门的提前批准

Table B- 1: Electrical interconnect changes on Printed Circuit Boards, hybrid boards, or flat wire interconnects.印刷电路板上的电气相互连接变化混合电路板或者扁线相互连接

Interconnect	Planned Changes	Required Test(s)	Section
I/O to external connectors I/O到外部接插件	Location change ≥ 0.152 mm 位置变化 Width ≥ 0.152 mm	RE RI ESD	7.0 10.0 19.0
Mux Lines (e.g. SCP, CAN)	Location change ≥ 0.152 mm Length ≥ 0.152 mm	RE	7.0
Reset Lines 重设电线	Location change ≥ 0.152 mm Length ≥ 0.152 mm	RI Coupled Immunity 抗耦合干扰	10.0 12.0
Low Level Analog低水平模拟	Location change ≥ 0.152 mm Length ≥ 0.152 mm	RI Coupled Immunity	10.0 12.0
Ground Plane	Any Change	RE RI Coupled Immunity ESD	7.0 10.0 12.0 19.0
General	Location change ≥ 0.152 mm Thickness/width change ≥ 0.152 mm	RE	7.0
Supply Lines/ High Current 供源线/高电流	Location change ≥ 0.152 mm Width ≥ 0.152 mm 厚度/宽度变化	RE RI	7.0 10.0

Table B- 2: Software Changes

Attribute	Change	Required Test(s)	Section
PLL	Frequency	RE RI	7.0 10.0
O/P Slew Rate 转换速率	Increase or Decrease	RE CE	7.0 8.0
Watchdog, Reset, Interrupt 电子狗，重设，中断	Any	RI Power Dropout	10.0 17
General	Any	RE	7.0

Table B- 3: E/E Component changes on PCBs, hybrid boards, or flat wire interconnects.

Component	Change	Required Test(s)	Section
I/O Capacitor	Value Change (10X)	RE RI ESD	7.0 10.0 19.0
Regulator Capacitor (I/P)	Value Change (10X)	RE RI Continuous Disturbances Transient Disturbances Power Cycle	7.0 10.0 13.0 14.0 15.0
IC Decoupling Capacitor	Value Change (10X)	RE	7.0
Slew Rate Capacitors	Value Change (10X)	RE RI	7.0 10.0
Op Amp Input Capacitors	Value Change (>10%)	RI	10.0
I/O Series Resistor	Value Change (>10%)	RE RI ESD	7.0 10.0 19.0
Slew Rate Resistors	Value Change (>5%)	RE RI	7.0 10.0
Zener or MOV on Battery	Voltage rating	Transients Disturbances Voltage Overstress	14.0 18.0
Microprocessor	OTP to ROM	RE RI	7.0 10.0
Oscillator	Frequency	RE Power Dropout	7.0 17.0
PWM Controller	Slew Rate or Current	RE CE (RF)	7.0 8.0

Table B- 4: Packaging or Mechanical changes

Attribute	Change	Required Test(s)	Section
Packaging material	Conductivity	RE RI ESD	7.0 10.0 19.0
Grounding	Impedance or location	RE RI ESD	7.0 10.0 19.0
Heatsink	Size, location, Grounding	RE (grounding only) ESD	7.0 19.0
Apertures	Size or Location	ESD	19.0

Table B- 5: Loading changes

Attribute	Change	Required Test(s)	Section
Solenoids, motors, Relays	Impedance	CE (Transient)	7.0
Active Sensors	Sensor Impedance	RI Voltage Offset	10.0 17.0

附录C：射频服务频带：射频发射和抗干扰要求基于无线电娱乐（如MW,FM）使用的频率波普，普通移动通信应用使

Annex C (informative): RF Service Bands

用的波普除外。注意当这些要求适用于大多数预期应用时，也应考虑在组件设计期间的其他频带。表C-1列举了几

RF emissions and immunity requirements are based on frequency spectrum used for radio entertainment (e.g. MW, FM) in addition to spectrum used for common mobile communication applications. Note that while these requirements cover the majority of anticipated applications, other frequency bands should also be considered during the component design. Table C-1 lists several of these RF services. Note that while this EMC specification does not impose component requirements for all of these RF service bands, specific brand applications may impose addition requirements that may include these and other RF service bands.

个这种射频服务。注意当此EMC规范不在所有这些射频服务频带的组件要求中使用时，特殊品牌应用的要求可以使

用到附加要求中，附加要求可以包括这些以及其他射频服务频带的要求

Table C- 1: Typical RF Service Bands 典型的射频服务频带

1.7 - 10 MHz 业余 Amateur (1.8 - 2.0, 160 meters) Amateur (3.5 - 4.0, 75/80 meters) Amateur (7.0 - 7.3, 40 meters) **10 - 30 MHz** Amateur (10.10 - 10.15, 30 meters) Amateur (14.00 - 14.35, 20 meters) Amateur (18.068 - 18.168, 17 meters) Amateur (21.00 - 21.45, 15 meters) Amateur (24.89 - 24.99, 12 meters) Citizens Band {CB} (26.965 - 27.405) CB (26.965 - 27.405) Amateur (28.0 - 29.7, 10 meters) Amateur (28.0 - 29.7, 10 meters)	**30 - 55 MHz** Amateur (51 - 54, 6 meters) Domestic Public Land Mobile Business 国内公共陆地移动业务 Petroleum 石油 Power 电力 Local Government 当地政府 Police 警察 Special Industrial 特殊行业 Special Emergency 特殊紧急事件 Fire 火灾 Highway Maintainance 高速公路维护 Forestry Conservation 林地保护 **143 - 177 MHz** Amateur (144 - 148, 2 meters) Business Petroleum Power Local Government Police Special Industrial Special Emergency	**218 - 228 MHz** Amateur (222 - 225) Business Petroleum Power Local Government **428 - 515 MHz** Amateur (440 - 450) **1.7 - 2.0 GHz** GSM 1800 [1710-1785; 1805-1880] PCS; GSM 1900 [1850-1910; 1930 -1990]

Annex D (normative): Field Calibration for ALSE Method above 1000 MHz

附录D：1000MHz以上电波暗室法的磁场校准

在被测设备进行实际测试之前，需要用来产生特定磁场强度（用磁场探针测量）的正向功率都要确定用于各个测试频率

Prior to the actual testing of the DUT, the forward power required to produce the specific field strength (measured with a field probe) shall be determined for each test frequency.

此校准应用一个未调制的测试信号进行

a) This calibration shall be performed with an unmodulated test signal.

校准应该在1000到2000MHz和2700到3100MHz的测试频率范围内进行。磁场探针的安装要使相位中心处于终点位置，

b) Calibration shall be performed over the test frequency range from 1000 to 2000 MHz and 2700 to 3100 MHz. The field probe shall be positioned so that its phase center is at the end point of where the 1500 mm part of the test harness would be located and 200 (+/- 10) mm from the front edge of the ground plane. This is where the forward edge of the DUT would be located. The field probe shall be positioned 150 (+/- 10) mm above the ground plane. Figure D-1 illustrates the location of the field probe

测试线束1500mm的部分要安装在此终点并且此终点离地平面的前缘200（+/-10）mm远。这就是被测设备的前沿的位置。此磁场探针应安装在地平面上150（+/-10）mm处。表D-1显示了磁场探针的位置

对场强的垂直和水平极化进行校准

c) The field strength shall be calibrated for vertical and horizontal polarizations.

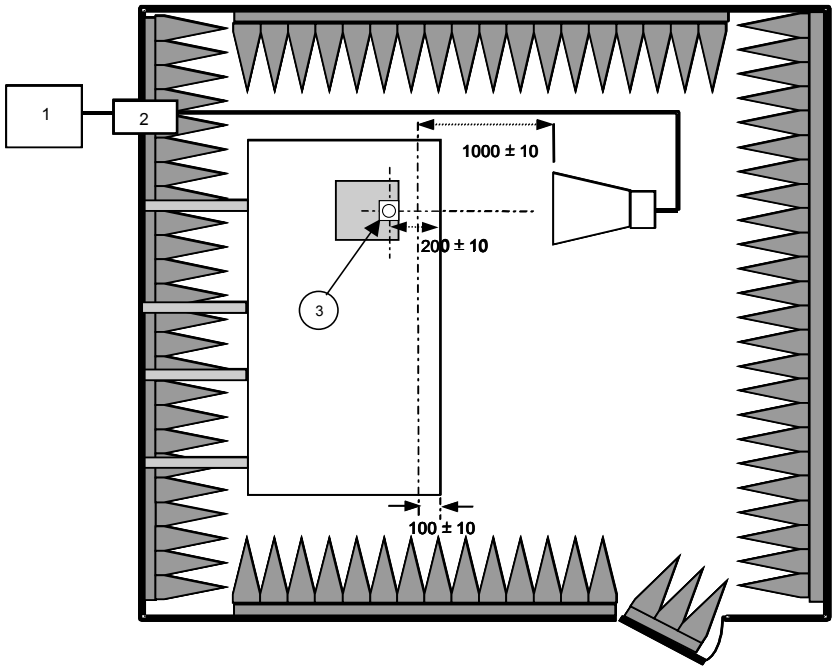
校准要以正向功率为基础

d) Calibration is based on forward power.

测量到的正向功率值应记录在校准文件中。如果EMC测试计划有需要，校准文件资料和磁场探针相关联位置的精确描述应包括在测试报告中

e) Measured values of forward power shall be recorded in the calibration file. The calibration file data and a precise description of the associated position of the field probe shall be included in the test report if required in the EMC test plan.

Figure D- 1: Calibration for 1000 to 3100 MHz



Key 射频放大器系统

1. RF Amplifier System
2. Bulk Head Connector
3. Field Probe 磁场探针

Annex E (normative): Mode Tuning Chamber Calibration 附录E：模式调整室校准

(Based on Draft 61000–4–21 IEC 2000)

试验室校准和负载验证：空试验室校准要在用此附录程序在试验室进行测试之前进行各个被测设备测试之前，根据E.2的程序进行负载验证

E.1 Chamber Calibration and Loading Validation.

The empty chamber calibration shall be performed prior to the use of the chamber for testing using the procedures of this Appendix. Prior to each DUT test, a loading validation shall be performed according to the procedures of section E.2.

所有校准特别针对天线进行。在测试之前对天线的改变需要一个新的校准。带有多种样本的测试开始时的负载验证充足
如果正被测试的被测设备没有进行显著的修改以影响设备的尺寸和形状（即电路板改变），那就不需要在测试之间进行多种负载验证

All calibrations are antenna specific. Changing antennas prior to a test shall require a new calibration. One loading validation (outlined in section E.2) is sufficient at the start of a test with multiple samples. Multiple loading validations are not required in between tests if the DUT being tested has not been significantly modified to affect its size and shape (i.e. circuit board alterations).

E.1.1 Field Uniformity Validation. 磁场均匀性验证

1) Remove all non-essential equipment from the test chamber including DUTs, simulators, cameras, etc.
从测试室移除所有不重要的设备，包括被测设备，模拟器，摄影机等

2) Place the transmitting antenna as indicated in the notes of Figure E.1 directing it into a corner. The transmitting antenna shall not be moved during the field uniformity validation. The transmit antenna shall be linearly polarized and rated for the frequencies being tested. The transmit antenna shall remain in a fixed location for all calibrations and testing. 把发射天线放置在图E.1所示的位置，把其朝向角落。发射天线在磁场均匀性验证期间不能移除。
发射天线要进行线性极化并且额定被测的频率。发射天线应保持在一个固定的位置以便进行所有校验和测试

3) Place the receive antenna within the working volume of the chamber defined in the notes of Figure E.1. The receive antenna, probe, or chamber working volume shall not be in the direct path of the transmit antenna. The receive antenna shall be linearly polarized and rated for the frequencies being tested. The receive antenna shall also be cross polarized with respect to the transmit antenna.
把接收天线放置在试验室的工作容积内，如图E.1备注的规定。接收天线，探针或者试验室工作容积不应在发射天线的直接通路上。
接收天线应进行线性极化并额定正被测试的频率。接收天线还应进行关于发射天线的横向极化

4) Place an electric field probe (capable of reading three orthogonal axes) on the perimeter of the chamber working volume as shown in Figure E.1. 把一个电场探针（能阅读三个正六方轴线）安装在试验室工作容积的周边，如图E.1所示

5) At the lowest test frequency (f_S = 400 MHz), inject an appropriate amount of RF power, into the transmit antenna. RF power shall be applied for an adequate dwell time to ensure that the amplitude measuring device and the electric field probes have time to respond properly. Harmonics of the RF input to the chamber shall be at least 15 dB below the carrier frequency.
在测试频率的最低点，把一个适量的射频功率注入发射天线。射频功率应用时长为充足的保压时间以确保振幅测量
设备和电场探针有时间进行合适的反映。输入到试验室的射频泛音至少应该在载波频率以下的15dB

6) Step the tuner through 360° in discrete steps (mode-tuning) so that the amplitude measuring device connected to the receive antenna (e.g., spectrum analyzer, power meter, etc.) and electric field probes captures the minimum number of samples required as indicated in Table E.1.
加强调谐器在离散的步骤，通过360°C（模式调整），振幅测量设备连接到接收天线（如频谱分析仪，功率计，等）和电场探针捕获所需的最低样本数。
注意：合适的输入功率量取决于试验室的尺寸和材料也取决于电场探头的本底噪声和振幅测量设备。

Note: An appropriate amount of input power is dependent on the size and material of the test chamber as well as the noise floor of the electric field probe and amplitude measuring equipment.

对于每个调谐器位置，记录接收到的功率，电场探头的每个轴的场强。用这些数值计算接收到的最大功率，接收到
的平均功率，电场探头每个轴的最大场强以及一个调谐器旋转的平均输入功率。所有计算出来的数值应为线性单位

7) For each tuner position, record the received power, the field strength for each axis of the electric field probe, and the input power. From these values compute the maximum received power (P_{maxRec}), average received power (P_{AveRec}), the maximum field strength for each axis of the electric field probe ($E_{Max\ x}$, $E_{Max\ y}$, $E_{Max\ z}$), and the average input power (P_{Input}) over one tuner rotation. All calculated values shall be in linear units (i.e. Watts, not dBm and V/m, not dBV/m). Ensure that the power measurement instruments have an equipment noise floor at least 20 dB below the maximum received power (P_{MaxRec}) for proper average data collection.
（即瓦特，而不是dBm和V/m,dBV/m）.确保功率测量仪器有设备本底噪声，至少为最大接收功率以下的20dB，接收功率针对的是合适平均资料搜集的

Note: P_{Input} is the forward power averaged over one tuner rotation. The number of samples used to determine P_{Input} should be at least the same number of samples used for chamber calibration. All power measurements are relative to the antenna terminals (both forward and received).
注意：P...是正向功率，由一次调谐器旋转平均得到的。使用来决定P...的样本数量应至少和使用来进行试验室验
校验的样本数量相同。所有的功率测量都和天线端子（向前的和接收到的）相关

8) Repeat steps 5) through 7) in log spaced frequency steps as indicated in Table E.1 until the frequency is at least 4000 MHz (10 f_S). 通过7）重复步骤5）按照记录的间隔频率步骤进行，如表E.1所示，直到频率为至少4000兆赫为止

9) Repeat steps 5) through 7) for each of the eight probe locations shown in Figure E.1 and for eight antenna locations until 4000 MHz (10 fs). If the receive antenna will be in a specific position during routine testing, the antenna shall be in one of these positions during the eight runs.
通过7重复5，进行8个探针位置和8个天线位置的每个探针的测试，如图E.1所示，直到测试到4000MHz为止。如果接收天线在常规测试期间处于特定的位置，那么天线在8个探针运行期间应处于其中的一个位置。

Note: The order of steps 6) and 8) may be interchanged, i.e. step through all the frequencies at each step of the tuner. 步骤6和8的顺序要调换，即单步调试调谐器每个步进的所有频率

10) Above 4000 MHz (10·fs), only three antenna locations and electric field probe positions shall be evaluated. Repeat steps 5) through 8) for the remainder of the calibration frequencies as indicated in Table E.1. One of the probe locations shall be the center of the working volume and one of the antenna positions shall be the typical receive antenna position as described in step ix.
在4000MHz以上，只有3个天线位置和电场探针位置要评估。通过8重复5，进行校准频率剩余部分的测试，如表E.1所示。其中的一个探针位置应为工作容积的中心，其中的一个天线位置应为4描述的典型接收天线位置

Note: The receive antenna shall be moved to a new location within the working volume of the chamber for each change in probe location. The receive antenna shall be oriented in a different direction for each position (a change in angle of 20° or greater is recommended). The electric field probes do not have to be oriented along the chamber axis during calibration as long as the electric field probe axes remain consistent with each probe position. A proper separation distance shall be maintained between the antenna and probe at each probe location. It is recommended that each probe location be at least 1 m (minimum distance 0.25 m) from any previous location.由于探针位置的每个变化，接收天线应移动到试验室工作容积内的新位置。接收天线的每个位置（推荐20°或更大角的变化）都应定位于不同的方向。电场探针在校验期间不必沿着试验室的轴定位，只要电场探针轴和每个探针位置保持一致。在每个探针位置的天线和探针之间维持适当的分离距离。

11) Normalize each of the maximum electric field probe measurements (each of the 24 rectangular components below 10 fs, and 9 rectangular components above 10 fs) to the square-root of the average input power using the data from step vii.:
使用步骤7的信息把最大电场测量（低于10fs的24个矩形组件的每一个，9个高于10fs的矩形组件）标准化为平均输入功率的平方根

$$\ddot{E}_x = \frac{E_{Max_x}}{\sqrt{P_{Input}}}$$

$$\ddot{E}_y = \frac{E_{Max_y}}{\sqrt{P_{Input}}}$$

$$\ddot{E}_z = \frac{E_{Max_z}}{\sqrt{P_{Input}}}$$

where

$E_{Max_{x,y,z}}$ = maximum measurement from each probe axis (24 or 9 measurements) 每个探针轴的最大测量（24或9次）

$\ddot{E}_{x,y,z}$ = normalized maximum measurement from each probe axis 来自每个探针轴的标准化最大测量

P_{input} = average input power to transmit antenna during the tuner rotation at which $E_{Max\ x,y,z}$ was recorded
在调谐器旋转期间发射天线的平均输入功率，旋转期间记录下E...

12) For each calibration frequency below 10 fs (4000 MHz), calculate the average of the normalized maximum of each probe axis of the electric field probe measurements:
对于每一个低于10fs(4000MHz)的校准频率而言，要计算出每个电场探针测量的探针轴处平均的标准化最大值

$$\left\langle \ddot{E}_x \right\rangle = \left(\sum \ddot{E}_x\right) / 8$$

$$\left\langle \ddot{E}_y \right\rangle = \left(\sum \ddot{E}_y\right) / 8$$

$$\left\langle \ddot{E}_z \right\rangle = \left(\sum \ddot{E}_z\right) / 8$$

13) For each calibration frequency below 10 fs (4000 MHz), calculate the average of the normalized maximum of all the electric field probe measurements:
对于每一个10fs(4000MHz)以下的校准频率，要计算所有电场探针测量的平均标准化最大值：

$$\left\langle \ddot{E} \right\rangle_{24} = \sum \left(\ddot{E}_{ix} + \ddot{E}_{iy} + \ddot{E}_{iz}\right) / 24$$

探针位置数量

i = 1,2, ... 8 (number of probe locations)

Note: < > indicates arithmetic mean, i.e.,
< >指的是等差中项

$$\left\langle \vec{E} \right\rangle_{24} = \sum \left(\vec{E}_{ix} + \vec{E}_{iy} + \vec{E}_{iz} \right) / 24$$

represents the sum of the 24 rectangular electric field normalized maximums divided by the number of measurements. 这个公式指的是24个矩形电场的标准化最大值的总和除以测量的数量

14) Repeat step 12) for each frequency above 10 fs (4000 MHz), replacing 8 with 3.
10fs(4000MHz)以上的每个频率都要重复步骤12，用3代替8

15) Repeat step 13) for each frequency above 10 fs (4000 MHz), replacing 24 with 9.
10fs(4000MHz)以上的每个频率都要重复步骤12，用24代替9

16) For each frequency below 10 fs, verify that the chamber meets the field uniformity requirements by the following procedure: 对于10fs以下的每个频率，验证试验室通过以下程序符合磁场统一要求

a) Field uniformity is indicated by the standard deviation from the mean value of the maximum electric field values obtained at each of the probe location during one complete rotation of the tuner. This standard deviation is calculated from data for each probe axis independently and the total data collected. 在调谐器的一个完整旋转期间，每个探针位置获得的最大电场值的平均值，其标准偏差表面了磁场统一性。此标准偏差由每个探针轴的独立信息和搜集到的所有信息计算而来。
The standard deviation is the following:
标准偏差如下所示：

$$\sigma = \alpha * \sqrt{\frac{\sum \left(\vec{E}_i - \left\langle \vec{E} \right\rangle \right)^2}{n-1}}$$

where
i = 1,2, ... 8 (number of probe locations)探针位置的编号
n = number of measurements
测量编号
$\vec{E}_i$ = maximum normalized electric field probe measurement
最大标准化电场探针测量
$\left\langle \vec{E} \right\rangle$ = arithmetic mean of the normalized electric field measurements
标准化电场测量的等差中项
α = 1.06 for n ≤ 20 and 1 for n > 20
σ = standard deviation for a given axis (x, y, or z)
给定轴的标准偏差

Example for the x-axis x轴的例子

$$\sigma_x = 1.06 * \sqrt{\frac{\sum \left(\vec{E}_{ix} - \left\langle \vec{E}_x \right\rangle \right)^2}{8-1}}$$

where
i = 1,2, ... 8
$\vec{E}_{ix}$ = maximum normalized electric field probe measurement of x axis
x轴的最大标准化电场探针测量
$\left\langle \vec{E}_x \right\rangle$ = arithmetic mean of normalized axes from all eight measurement locations
所有8个测量位置的标准化轴的等差中项
Example for all axes:

$$\sigma_{24} = 1 * \sqrt{\frac{\sum \left(\vec{E}_{ix,y,z} - \left\langle \vec{E} \right\rangle_{24} \right)^2}{24-1}}$$

where i = 1,2, ... 8
$\vec{E}_{ix,y,z}$ = maximum normalized electric field probe measurements of all axes (x, y, and z)
所有轴的最大标准化电场探针测量
$\left\langle \vec{E} \right\rangle_{24}$ = arithmetic mean of normalized Emax x,y,z axes from all 24 measurements
所有24个测量的标准化E...轴的等差中项
σ_{24} = standard deviation of all axes (x, y, and z)所有轴的标准偏差
The standard deviation is expressed in terms of dB relative to the mean:
标准偏差用和中位数相关的dB表示

$$\sigma(dB) = 20 * log \frac{\sigma + \left\langle \vec{E}_{x,y,z} \right\rangle}{\left\langle \vec{E}_{x,y,z} \right\rangle}$$

b) The chamber meets the field uniformity requirements if the standard deviation from the individual axes (x, y, and z), and the total data set (all axes) are less than 3 dB (a maximum of three frequencies per octave may exceed the allowed standard deviation by no greater than 1dB).
如果单个轴（X,Y和Z）和总的数据集（所有轴）的标准偏差小于3dB（每8个测量中3个频率最大值可能超过的标准偏差不大于1dB），那试验室要符合磁场统一要求。

E.1.2 Receive antenna calibration. 接收天线校准

The receive antenna calibration factor (ACF) for an empty chamber is established to provide a comparison with a loaded chamber. The ACF for each frequency is:
建立空试验室的接收天线校准因子，用来提供和负载试验室进行比较的频率。每个频率的天线校准因子为：

$$ACF = \left\langle \frac{P_{AveRec}}{P_{Input}} \right\rangle_{8\ for \le 10\ f_S, 3\ for \ge 10\ f_S}$$

where
P_{Input} is the average input power from E.1.1, step 7) for the location at which the average received power P_{AveRec} from E.1.1, step 7) was measured. 对（E1.1步骤7）接收到的平均功率P...的（E1.1步骤7的）平均输入功率P...进行测量

E.1.3 Chamber Insertion Loss.

The chamber insertion loss (IL) for the chamber is given by the following:
给出的试验室插入损耗如下所示

$$IL = \left\langle \frac{P_{MaxRec}}{P_{Input}} \right\rangle_{8\ for \le 10\ f_S, 3\ for \ge 10\ f_S}$$

where
P_{Input} is the average input power from E.1.1, step 7) for the location at which the maximum received power P_{MaxRec} from E.1.1.vii. was measured. 最大试验室负载验证

E.1.4 Maximum Chamber Loading Verification.

The following procedure is used to determine if the chamber is affected by a DUT which loads (absorbs a significant amount of energy) the chamber. This procedure should be performed once in the life of the chamber or whenever the chamber has undergone major structural modifications. Prior to each test, a chamber calibration shall be performed according to section E.2.
以下的程序使用来决定试验室是否受负载（吸收了大量能量）在试验室的被测设备的影响。此程序在试验室使用寿命期间或者在试验室经历重大结构改变时进行一次。每次测试之前，要根据E.2的规定进行试验室校准

1) Install a significant amount of absorbing material (e.g., foam absorber) in the chamber to load the chamber to the amount expected during normal testing (a factor of sixteen or 12dB is typical).
在试验室里安装大量的吸收材料（如泡沫吸收器）以便常规测试期间在试验室里把能量负载到期望的量（通常是16倍或12dB）

2) Repeat the calibration procedure from section E.1.1 using eight or three locations of the field probes according to the frequency (eight < 10 fs, three > 10 fs). The electric field probes and receive antenna should be a minimum of 0.25 m away from any absorbing material. Determine the chamber loading by comparing the ACF of an unloaded chamber with the ACF of a loading chamber as follows:
根据频率（8<10fs,3>10fs）使用场探针的8个或3个位置重复E.1.1的校准程序。电场探针和接收天线离所有吸收材料的最小距离为0.25m远。通过把为负载试验室ACF和负载试验室的ACF进行比较来决定试验室负载，如下所示：

$$Loading = \frac{ACF_{Empty\ Chamber}}{ACF_{Loaded\ Chamber}}$$

3) Repeat the field uniformity calculations as described in section E.1.1, step 16).
如E.1.1步骤16所示，重复场统一计算。

4) If either the field uniformity of the individual rectangular components or the field uniformity for all axes (x, y, and z) is greater than the allowed standard deviation indicated in section E.1.1, step 4, then the chamber has been loaded to the point where field uniformity is unacceptable. Reduce the amount of loading and repeat the loading effects evaluation.
如果单个矩形组件的场均匀性或者所有轴的场均匀性比E.1.1步骤4所示的容许标准偏差大，那试验室要负载到场均匀性不可接受的点。减少负载量，重复负载效果评价

E.2 Calibration and DUT Loading Check. 校准和被测设备负载检查

The following procedure shall be performed prior to each test of the DUT. The DUT and any necessary supporting equipment shall be installed into the chamber. 被测设备的每个测试进行之前执行以下程序。被测设备和所有必要的支撑设备应安装进试验室内。

1) Place the receive antenna within the working volume (see E.1.1.x.) at least 0.25 m from the DUT and supporting equipment.
把接收天线放置在工作容量内，离被测设备和支撑设备至少0.25m
2) At the lowest test frequency (f_S = 400 MHz), inject an appropriate amount of RF power, into the transmit antenna. Harmonics of the RF input to the chamber shall be at least 15 dB below the carrier frequency.
在最低测试频率（fs=400MHz）处，把适量的发射功率注入发射天线。输入试验室的射频泛音至少应为波载频率以下15dB.
3) Operate the chamber and the tuner for the desired number of steps as indicated in Table E.1 (alternatively, mode stirring is allowed with a maximum stir speed of 16.5 seconds per tuner revolution). RF power shall be applied for an appropriate amount of dwell time to ensure that the amplitude-measuring device has time to respond properly.
按照表E.1所示的步骤操作试验室和调谐器（或者，模式搅拌容许每个调谐器循环圈有16.5s的最大搅拌速度）。射频功率应使用适当的量的保压时间以确保振幅测量设备有时间做出合适的反映。
4) Calculate the maximum received power, average received power (P_{MaxRec}, P_{AveRec}), and the average input power (P_{Input}) over one tuner rotation. All calculated values shall be in linear units (i.e. W, not dBm; V/m, not dBV/m). Ensure that the power measurement instruments have an equipment noise floor at least 20 dB below the maximum received power (P_{MaxRec}) for proper average data collection.
计算出最大的接收功率，平均接收功率，以及一个调谐器旋转圈的平均输入功率。所有计算得到的值为线性单位（即W,不是dBm;是V/m,不是dBV/m）.确保功率测量仪器有一个设备噪底，至少在合适平均信息搜集的最大接收功率以下20dB.
5) Repeat step 4) for each frequency defined in Table 8-2.
如表8-2步骤4重复每个频率的测试
6) The chamber calibration factor (CCF) for each frequency is as follows:
每个频率的试验室校准系数如下所示

$$CCF = \left\langle \frac{P_{Ave\,Rec}}{P_{Input}} \right\rangle_n$$

where

CCF = the normalized average received power over one tuner rotation with the DUT and support equipment in the chamber 一个调谐器旋转圈的标准化平均接收功率，被测设备和支撑设备要处于试验室中

P_{AveRec}= average received power over one tuner rotation from step 7). 步骤7一个调谐器旋转圈的平均接收功率

P_{Input}= forward power averaged over one tuner rotation from step 7). 步骤7一个调谐器旋转圈的平均向前功率

n = number of antenna locations the CCF is evaluated over. Only one is required, however multiple antenna positions may be used and the CCF averaged over the number of locations.
CCF评估的天线位置数量，只需要1个，但是可能使用到多个天线位置，通过位置的数量平均CCF

7) Determine the chamber loading factor (CLF) for each frequency as follows:
确定每个频率的实验室负载系数，如下所示：

$$CLF = \frac{CCF}{ACF}$$

where 通过步骤6获取的输入功率的平均接收功率的比率

- CCF = the ratio of the average received power to the input power obtained from step 6).
- ACF = the ratio of the average received power to input power obtained in the antenna calibration of section E.1.2. Use linear interpolation to obtain the ACF.

通过E.1.2中天线校准获取的输入功率的平均接收功率的比率。使用线性插值以获取ACF

If the magnitude of the chamber-loading factor is larger than that measured in section E.1.4 for more than 10 % of the frequencies, the chamber is loaded and the field uniformity is affected. If this happens, the field uniformity measurements of section E.1.1 shall be repeated with the DUT in the test chamber.
如果实验室负载系数比通过E1.4测量到的频率大10%，那么试验室负载并且场均匀性受影响。如果发生这种情况，按照E.1.1进行的场均匀性测试应在试验室带有被测设备的情况下进行重复

Note: If the P_{AveRec} measured in E.2, step 4) is within (i.e., not greater than or less than) the values recorded for all eight locations in section E.1.1 step 7), the CLF calculation is not necessary and the value of CLF is one (1).

注意：如果如果按照E.2步骤4测量到的P...值在按照E.1.1步骤7测量到的所有8个位置的值以内，那么CLF计算就没必要并且CLF的值是1（1）

E.3 Q and Time Constant Calibration.

These measurements are conducted to ensure that the chamber can support the pulse waveforms outlined in Section 8.4, Table 8-3. Q和时间常数校准：这些测量的进行时为了确保试验室可以支持8.4表8-3所示的脉冲波形

1) Calculate the quality factor, Q, of the chamber using the CCF of section E.2, step 6), for each frequency:
使用E.2步骤6为每个频率计算试验室的质量系数，Q值

$$Q = \left(\frac{16\pi^2 V}{\eta_{Tx}\eta_{Rx}\lambda^3} \right)(CCF)$$

where 发射和接收天线的天线效率因素，这个因素针对对数周期天线可以假定为0.75，号角天线为0.9

- ηTx, ηRx = the antenna efficiency factors for the transmit and receive antenna which can be assumed to be 0.75 for a log periodic antenna and 0.9 for a horn antenna.
- V = the chamber volume (m^3) 试验室容积
- λ = wavelength at the specific frequency 特定频率的波长
- CCF = chamber calibration factor 试验室校准因子

Note: If the CLF was assumed to be one (1) from step E.2, step 7), the ACF from section E.1.2 shall be used in place of the CCF when computing chamber Q.
注意：如果CLF假定为E.2步骤7的1（1），则计算试验室Q值时，E1.2的ACF应代替CCF投入使用

2) Determine the chamber time constant, t, for every frequency using the following:
对于每个评论要确定试验室时间常数，t,如下所示

$$\tau = \frac{Q}{2\pi f}$$

where

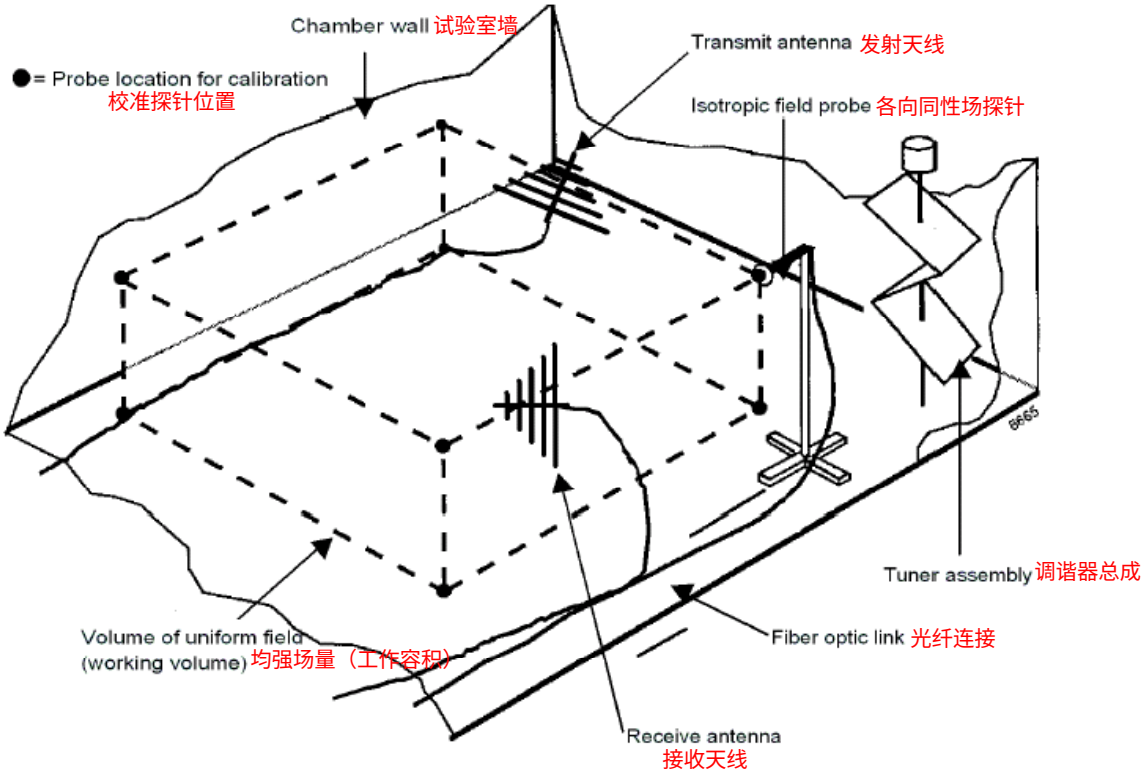
- Q = the value calculated in step i, above 根据以上步骤i计算得到的值
- f = the test frequency (Hz) 测试频率

iIf τ > 0.4 * PD *(pulse duration)* given in Section 8.4, Table 8-3 for more than 10 % of the test frequencies, absorber material shall be added and the Q measurement shall be repeated. The CLF calculations shall be repeated if absorber material is to be added.
如果8.4，表8-3指定的t＞0.4PD（脉冲持续时间）比测试频率大10%，则应增加吸收器材料并且重复Q测量。如果吸收器材料增加了，则应重复CLF计算

Table E- 1: Independent samples and frequencies 独立样本和频率

Frequency range (MHz) 频率范围	Number of samples (i.e. independent tuner positions or intervals) recommended for calibration and test 推荐进行校准和测试的样本数量（即独立调谐器位置或间隔时间）	Number of frequencies (logarithmically spaced) required for calibration 校验所需的频率数量（对数性间隔）
400 ... 1000	12	20
1000 ... 4000	6	15
> 4000	6	20 / decade

Figure E- 1: Reverberation Test Configuration (Mode Tuning)
混响测试结构（模态调谐）



Notes:

a. Calibration shall consist of eight probe locations below 10 fs (4000 MHz) and three locations above 10 fs (4000 MHz).校准应包括8个10fs以下的探针位置和3个10fs以上的位置

b. The locations selected shall enclose the "working volume" as shown above. The working volume should be located at least 1 meter from the chamber walls, mode-tuning device, and transmitting antenna.
如上图所示，选择的地点应附上“工作容积”。工作容积应放置在离试验室墙，模式微调装置，发射天线至少1米的位置

c. The receive antenna shall be located in the working volume for calibration purposes as described in E.1.1, step 3). The transmit antenna shall be pointed into a corner at least 0.25 m away from the chamber surface. The transmit antenna shall remain in a fixed location for all calibrations and testing.
接收天线应安装在用于验证的工作容积内，如E.1.1步骤3所示。发射天线应指向角落，离试验室表面0.25m远。所有校准和测试，发射天线都应保持在固定的位置

d. The working volume may be sized to suit the size of the DUT's to be tested.工作容积可以调整尺寸以便设备被测设备被测的尺寸

e. The minimum separation distance may be reduced less than 1 m provided that the separation distance is always at least 0.25 m.
最小间隔可以减小到少于1m，假设间隔总是至少在0.25m

附录F：瞬态波形描述

Annex F (Informative): Transient Waveform Description (A, B, C)

抗传导瞬时干扰测试包括ISO...规定的两个标准脉冲，由转换电感负荷产生的脉冲除外。采用接下来的方法产生脉

Conducted transient immunity testing consists of both standard pulses as delineated in ISO 7637-2 in addition to pulses produced by switching an inductive load. This later approach is taken to produce pulse waveforms that more accurately simulate actual voltage transients produced on the vehicle's electrical system. Note that switching an inductive load using a mechanical switch results in contact arcing, which contributes toward the generation of the transient waveforms depicted below. Transients produced in this manner are not necessarily repeatable as compared to standard ISO test pulses. However, experience has shown that this approach can produce anomalies that are often missed when using only the standard ISO pulses. The waveforms depicted represent typical transients produced by the transient generator circuit illustrated in Annex G. Note that the actual waveforms will vary from pulse to pulse because of the mechanical switching. The waveforms shown serve as guidance of what to expect from the transient generator. Note that all waveforms shown are measured under open circuit conditions.

冲波形以便可以更准确的模拟由汽车电气系统产生的实际电压瞬态。注意使用机械开关转换电感负荷造成触点电弧，这导致了以下描述的瞬态波形的产生。

用这种方式产生的瞬态和标准ISO测试脉冲比较没有必要重复。但是，经验显示当只使用标准ISO脉冲时，这种方法会产生经常漏掉的异常情况。所示的波形显示了由附录G中瞬态产生器电路产生的典型瞬态。注意实际波形会随着脉冲的变化而变化，这是由于机械转换所致。所示的波形作为指南可以从瞬态发生器获得。注意所示的所有波形在开路条件下进行测试

Test Pulse A1

Test pulse A1 simulates the voltage transient produced during switch-off of the power supply voltage to a high current (> 1 ampere) inductive load connected in parallel to the DUT. The circuit illustrated in Annex G is used to generate this pulse. This pulse is applied to the following circuits:

测试脉冲A1模拟在电源电压关闭到平行于被测设备的高电流（>1安培）电感负荷期间产生的电压瞬态。附录G所示的电路使用离产生此种脉冲。脉冲应用到以下电路：

1. Component power supply circuits that are connected to the vehicle battery via mechanical switches (e.g. ignition switch) and electromagnetic or solid state relays.
2. Control circuits that are connected directly or indirectly (e.g. pull-up resistor) to the vehicle battery via mechanical switches (e.g. ignition switch) and electromagnetic or solid state relays.

组件电源电路通过机械开关（如点火开关）和电池或固态继电器连接到汽车电池

控制电路通过机械开关（如点火开关）和电池或固态继电器直接或间接（如上拉电阻器）连接到汽车电池

Pulse A1 is composed of two basic components. The first is the long duration portion of the pulse as noted in Figure F-1. This is produced by the initial arc discharge across the switch contacts. The pulse duration may vary between 4 to 5 msec. The second component is a much shorter duration pulse (20 – 50 usec), which is due to the inductive fly back due to the remaining store energy in the inductor. The pulse component, illustrated in Figure F-2, may have peak voltage levels between –280 to –500 volts.

脉冲A1有两个基本组件构成。第一个是图F-1所示的脉冲长持续时间部分。这是有初始电弧通过开关触点放电产生的。脉冲持续时间可以在4到5msec之间变化。第二组件是一个持续时间段很多的脉冲（20到50usec），是由于电感回扫到电感器内剩余的储存能量产生的。脉冲组件，如图F-2所示，可以再-280到-500V之间有峰值电压水平

The waveforms shown in Figures F-1 and F-2 are produced from the test circuit, presented in Annex G, using a pulse repetition rate of 0.2 Hz, 10 % duty cycle (Mode 1).

图F-1和F-2所示的波形产生自测试电路，显示在附录G中，使用的脉冲重复率为0.2Hz，10%的工作周期（模式1）

Test Pulse A2

测试脉冲A2模拟在电源电压关闭到平行于被测设备的高电流（<0.4安培）电感负荷期间产生的电压瞬态。附录G所示的电路使用离产生此种脉冲。脉冲应用到以下电路：

Test pulse A2 simulates the voltage transient produced during switch-off of a supply voltage to a low current (< 0.4 amperes) inductive load switched in parallel to the DUT. The circuit illustrated in Annex G is used to generate this pulse. This pulse is applied to the following circuits:

1. Component power supply circuits that are connected to the vehicle battery via mechanical switches (e.g. ignition switch) and electromagnetic relays.
2. Control circuits that are connected directly or indirectly (e.g. pull-up resistor) to the vehicle battery via mechanical switches (e.g. ignition switch) and electromagnetic relays.

组件电源电路通过机械开关（如点火开关）和电池继电器连接到汽车电池

控制电路通过机械开关（如点火开关）和电池直接或间接（如上拉电阻器）连接到汽车电池

Pulse A2, illustrated in Figure F-3 is produced by a secondary arc ("showing arc") discharge across the switch contacts. The total disturbance time may vary significantly from 20 to 400 usec. Duration of individual pulses (see Figure F-4) may vary between 100 nsec to 10 usec. Peak positive voltages levels for this pulse may be between +100 to +200 volts. Peak negative voltage levels are between –280 to –500 volts.

The waveforms shown in Figures F-3 and F-4 are produced from the test circuit, presented in Annex G, using a pulse repetition rate of 0.2 Hz, 10 % duty cycle (Mode 1).

脉冲A2，如图F-3所示，由次生弧通过开关触点放电产生。总的干扰事件可能在20-400usec范围内发生重大变化。独立脉冲的持续时间在100nsec-10usec之间可能发生变化。此脉冲的峰值正电压水平可以在+100-+200V之间。峰值负电压水平在-280--500V之间

图F-3和F-4所示的波形由测试电路产生，显示在附录G中，使用的脉冲重复率为0.2Hz，10%的工作周期

Test Pulse B1 测试脉冲B1：测试脉冲B1模拟由低侧高电流电感负荷的关闭引起的电压瞬态。此脉冲只应用来控制电路，电路通过机械开关（如点火开关）和电磁继电器直接或间接地连接到汽车电池。脉冲B1，如图F-5所示，除了相反极性外和脉冲A1有相似的特征

Test pulse B1 simulates the voltage transient produced due to low-side switch-off of a high current (> 1 ampere) inductive load. This pulse is applied only to control circuits that are connected directly or indirectly (e.g. pull-up resistor) to the vehicle battery via mechanical switches (e.g. ignition switch) and electromagnetic relays. Pulse B1, shown in Figure F-5 is has similar characteristics as Pulse A1 except with opposite polarity.

Pulse B1 is produced from the test circuit, presented in Annex G, using a pulse repetition rate of 0.2 Hz, 10 % duty cycle (Mode 1). 脉冲B1由测试电路产生，如附录G所示，使用的脉冲重复率为0.2Hz，10%的工作周期（模式1）

Test Pulse B2 测试脉冲B1：测试脉冲B1模拟由低侧高电流（<0.4安培）电感负荷的关闭引起的电压瞬态。此脉冲只暴露于此测试脉冲脉冲B2，除了相反极性外和脉冲A3有相似的特征

Test pulse B1 simulates the voltage transient produced due to low-side switch-off of a high current (< 0.4 ampere) inductive load. Only control circuits are exposed to this test pulse. Pulse B2, has similar characteristics as Pulse A2 except with opposite polarity.

Pulse B2 is produced from the test circuit, presented in Annex G, using a pulse repetition rate of 0.2 Hz, 10 % duty cycle (Mode 1). 脉冲B2由测试电路产生，如附录G所示，使用的脉冲重复率为0.2Hz，10%的工作周期（模式1）

Test Pulse C 测试脉冲C模拟在低电流电感负载期间产生的电压瞬变，低电流电感负载和被测设备共享共同的汽车电池。电路如附录G所示，应使用来产生此脉冲。此测试脉冲应用到以下电路：

Test pulse C simulates the voltage transient produced during switching of low current (< 0.4 amperes) inductive loads that share a common vehicle battery connection as the DUT. The circuit illustrated in Annex G shall be used to generate this pulse. This test pulse is applied to the following circuits:

1. Component power supply circuits that are directly connected to the vehicle battery (i.e. no switches) 组件电源电路直接连接到汽车电池（即没有开关）
2. Component power supply circuits when connected to the vehicle battery via mechanical switches (e.g. ignition switch) and electromagnetic relays. 组件电源电路通过机械开关（如点火开关）和电磁继电器连接到汽车电池
3. Control circuits when connected directly or indirectly (e.g. pull-up resistor) to the vehicle battery via mechanical switches (e.g. ignition switch) and electromagnetic relays. 控制电路通过机械开关（如点火开关）和电磁继电器直接或间接（如上拉电阻器）连接到汽车电池

Typical waveforms for Pulse C are depicted in Figures F-6 and F-7. Note that the waveforms may change significantly at each application to the DUT. Pulse C is produced from the test circuit, presented in Annex G using pseudo-random pulses (Mode 2). 脉冲C的典型波形如图F-6和F-7所示。注意波形在被测设备的每个应用处可能发生大的改变。脉冲C由测试电路产生，如附录G所示，使用假随机脉冲（模式2）

Figure F- 1: Pulse A1 Composite Waveform (Mode 1) 脉冲A1复合波形

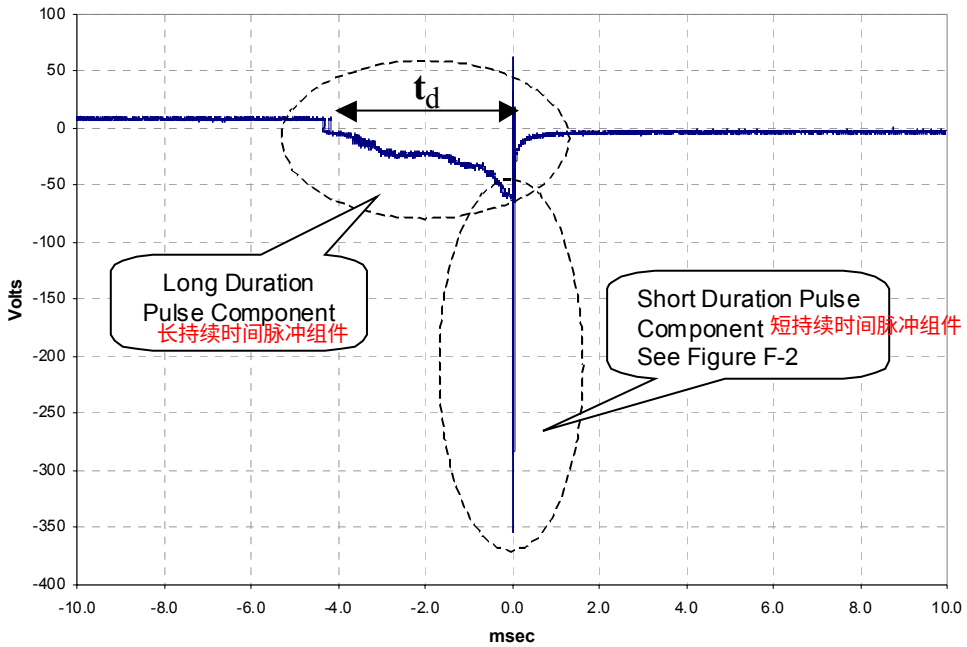


Figure F- 2: Pulse A1 Short Duration Pulse Component (Mode 1)

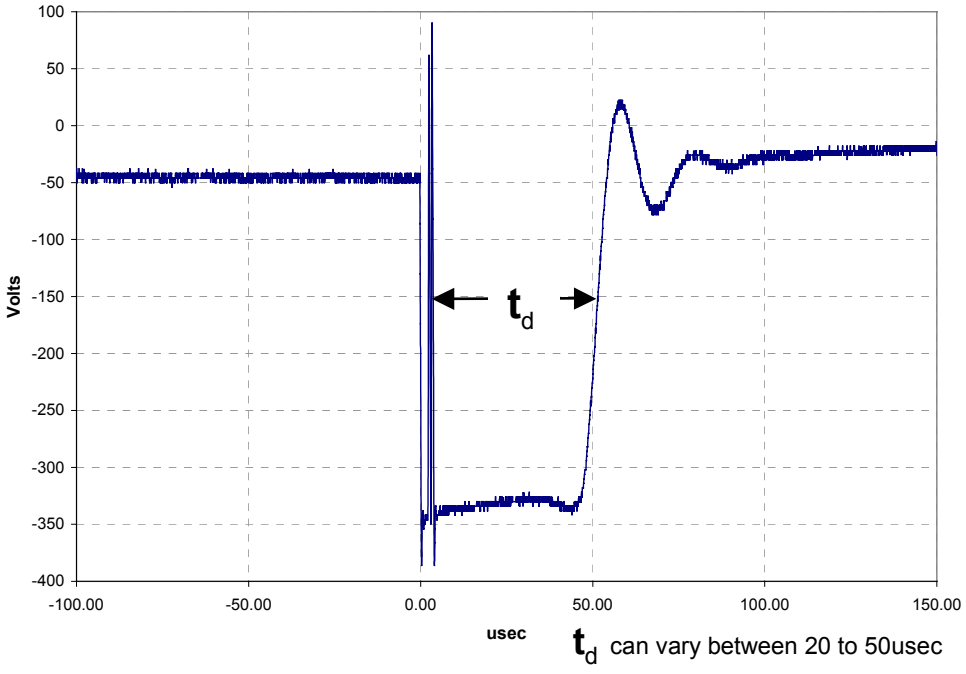


Figure F- 3: Pulse A2

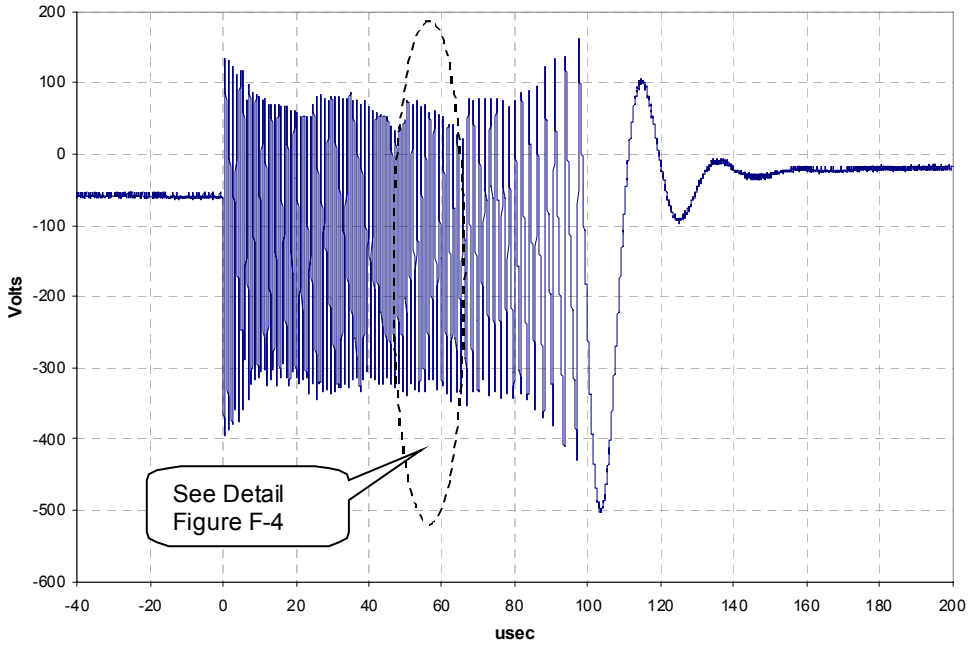


Figure F- 4: Pulse A2 (Detail)

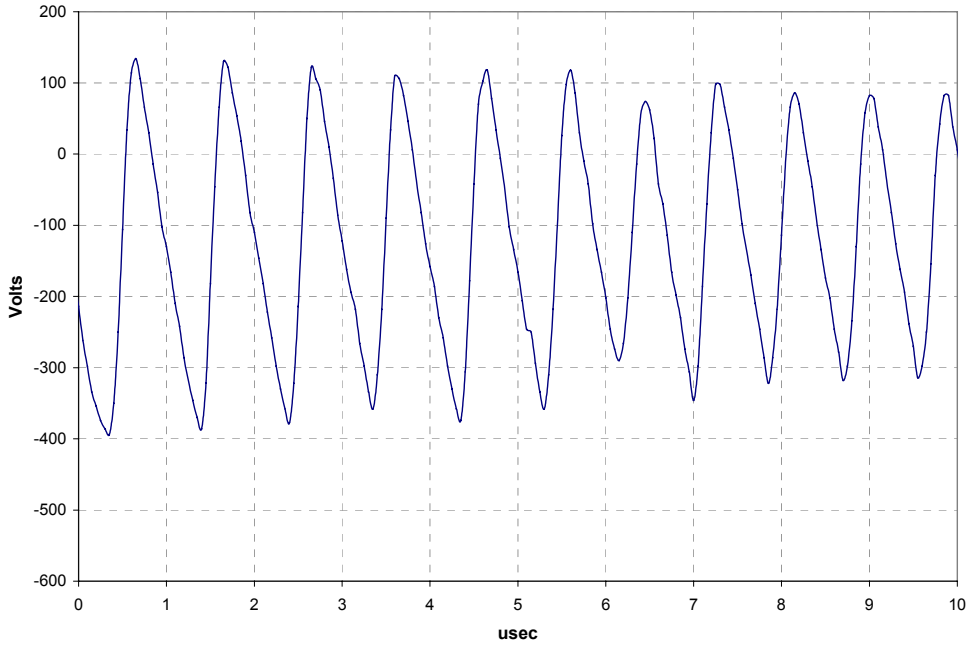


Figure F- 5: Test Pulse B1

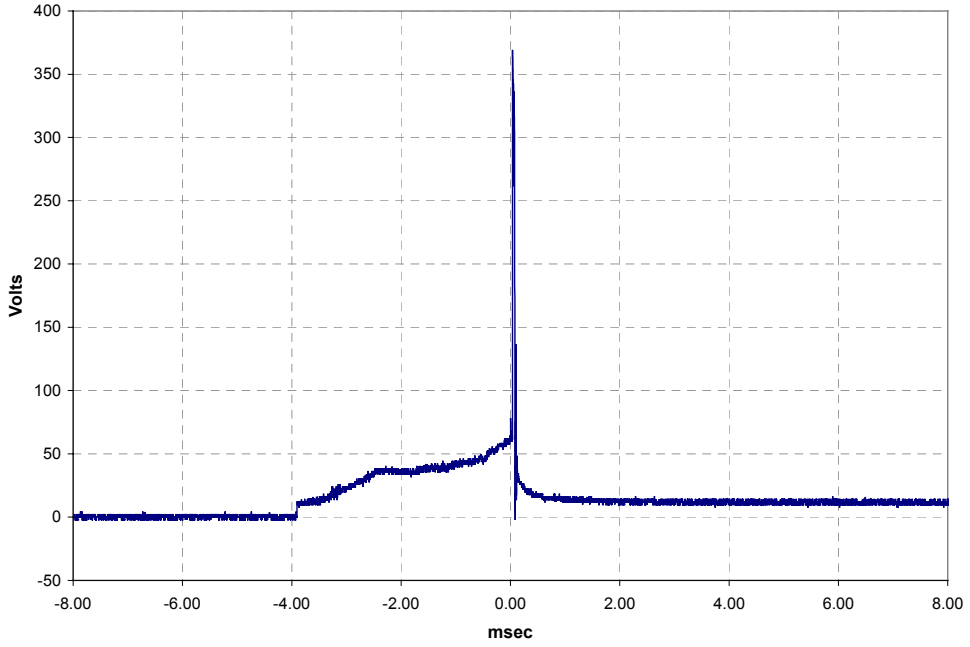


Figure F- 6: Typical Waveform for Test Pulse C

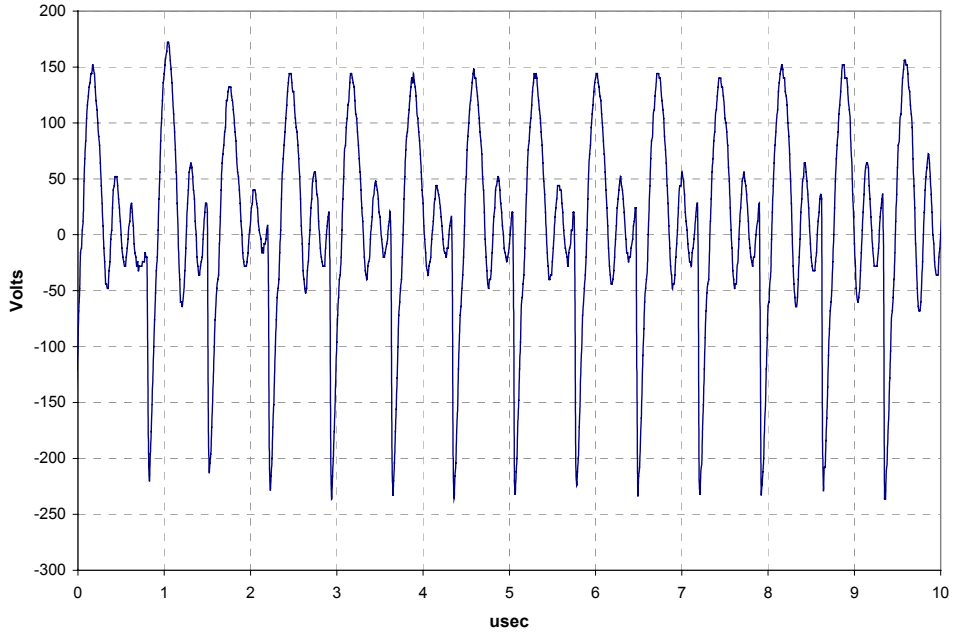
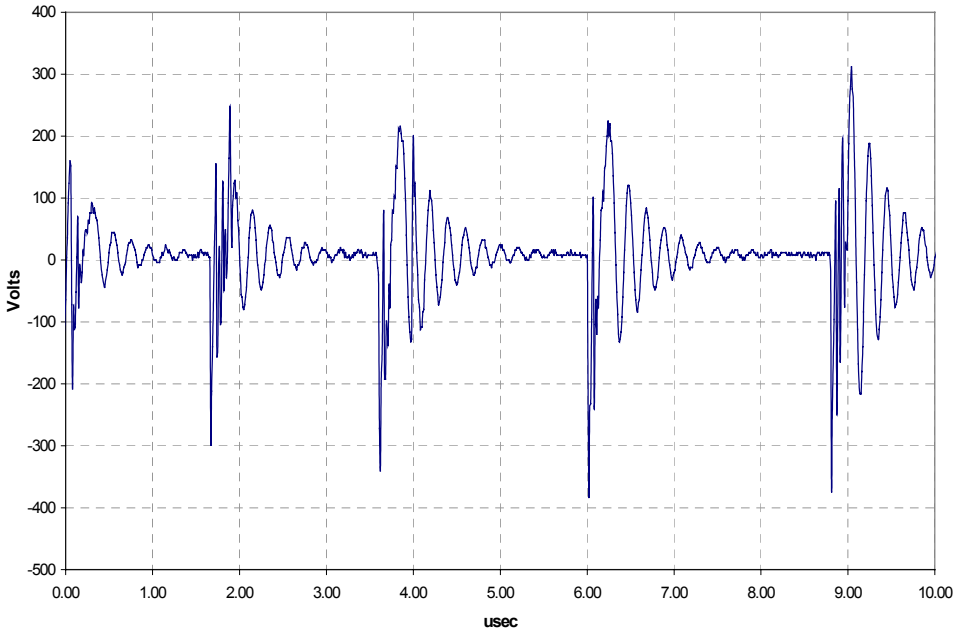


Figure F- 7: Typical Waveform for Test Pulse C



附录G：瞬态测试电路：瞬态脉冲A,B和C（参见14和附录F）通过使用测试电路产生的，如图G-1到G-4所示。电路包含几个关键组件，如果没有福特汽车公司EMC部门的允许不能代替。这些组件在图中做出了强调。关于这些测试电路的具体详情包括关键组件的触点位置，可以在网站http...找到

Annex G (Normative): Transient Test Circuit

Transient pulses A, B, and C (see section 14 and Annex F) shall be generated using the test circuit illustrated in Figures G-1 through G-4. The circuits contain a few critical components that may not be substituted without permission from the FMC EMC department. These components are highlighted in the figures. Specific details about these test circuits including contact locations for critical components may be found at http://fordemc.com.

The circuit facilitates generation of Mode 1 and Mode 2 transients. Mode 1 consists of repetitive pulses with a PRR at either 0.1 Hz, 10% duty cycle. The sub-circuit illustrated in G3 facilitates Mode 1 pulses. Mode 2 consists of pseudo-random pulses that are generated by the sub-circuit illustrated in G4.

电路给模式1和模式2瞬态的产生提供了便利。模式1包括重复脉冲，脉冲带有一个PRR 0.1Hz，10%的工作周期。G3中的子电路便于产生模式1脉冲。脉冲2包括假随机脉冲，此脉冲是由G4所示的子电路产生的。

Figure G- 1: Transient Generator Circuit for Pulses A1, A2 and C

脉冲A1，A2和C的瞬时发生器电路

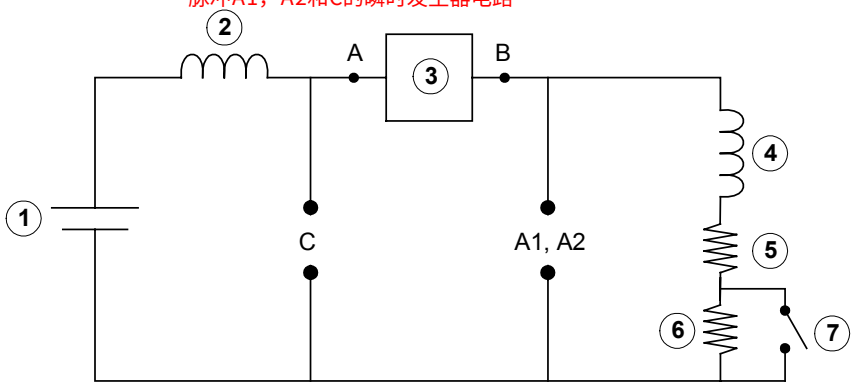
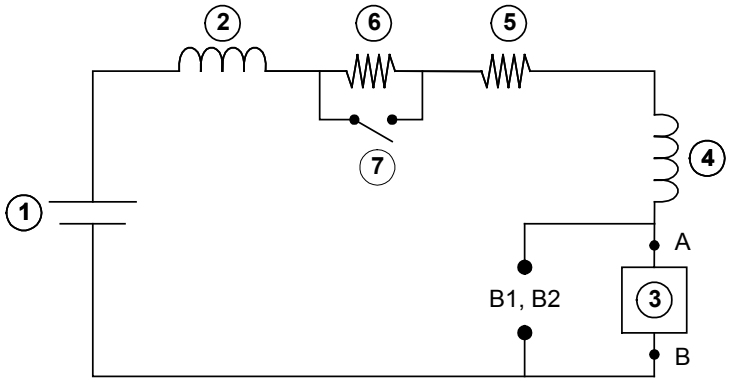


Figure G- 2: Transient Generator Circuit for Pulses B1, B2 脉冲B1，B2的瞬时发生器电路

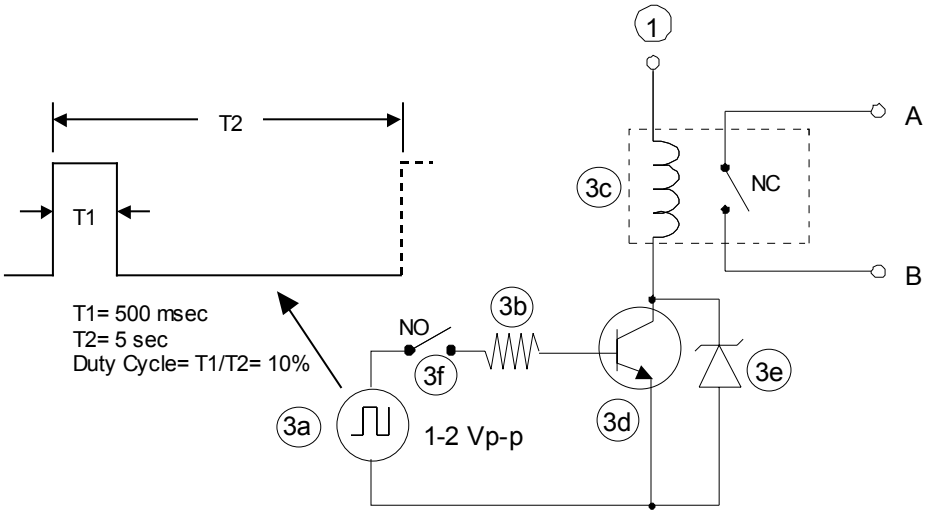


Key (Figures G-1, G-2)

1	Vehicle Battery (12 VDC)	5	Resistor: 6 ohms +/- 5 %
2	5 uH Inductor (50 amp)* 感应器 *(Osborn Transformer Part Number 8745)*	6	Resistor: 100 ohms +/- 5%
3	Relay Sub-circuit (see Figure G3 for detail) 继电器子电路	7	Switch: SPST (1 amp). Switch closed for Pulses A1 and C. 脉冲A1和C需要关闭开关
4.	Inductor: 100 mH @ 1amp* *(Osborn Transformer Part Number 32416)*		

* *Critical Component, no substitutions permitted without written authorization from the FMC EMC department.* 关键组件，没有福特汽车公司EMC部门的书面授权不得替代

Figure G- 3: Detail for Relay Circuit used for Mode 1 Transients
模式1瞬时使用的继电器电路详情

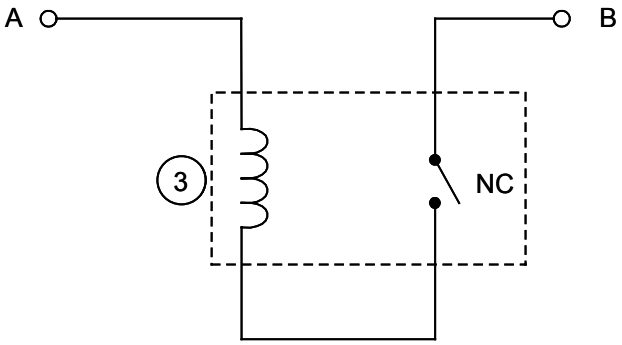


Key:

1	Vehicle Battery Connection 汽车电池连接	
3a	Function Generator (0.1 & 20 Hz square wave)	功能发生器
3b	Resistor: 51 ohms .25 watt	平方波
3c	12 volt AC Relay: Potter & Brumfield KUP-14A15-12 (1)	12V AC继电器
3e	NPN Transistor: TIP 41	
3e	Zener Diode: 39V, 5W (1N5366A)	稳压二极管
3f	Test Switch: SPST Switch	测试开关

1 Critical Component: No substitutions permitted without written authorization from the FMC EMC department. See Annex H. Relay should be replace after 100 hours of usage 参见附录H，继电器使用100小时后应替换

Figure G- 4: Detail for Relay Circuit used for Mode 2 Transients



附录H：P&B继电器规范 此规范中的几个测试使用P&B继电器。当继电器准备在美国使用时，在世界其他地方就难以定位了。此继电器的规格如下面表H-1所示。经验显示大多说12 AC继电器按照此规范可以进行性能测试。使用替代继电器之前，应电压测

Annex H (informative): P&B Relay Specifications

试并和附录D所示的那些波形进行比较。这些测量的结果应在使用这些继电器之前由福特汽车公司EMC部门进行评审和批准

Several tests in this specification make use of a Potter and Brumfield (P&B) relay. While the relay is readily available in North America, it may be difficult to locate in other parts of the world. Specifications for this relay are listed in Table H-1 below. Experience shows that most any 12 AC relay can be used for this performing testing per this specification. Before using alternative relays, voltage measurements shall be performed and compared to those waveforms illustrated in Annex D. The results of these measurements shall be reviewed and approved by the FMC EMC department prior to using these alternative relays.

Note that when using these relays for the purposes delineated in this specification, it is recommended that the relay be replace after 100 hours of usage.注意当使用此规范中指定的继电器达到试验目的之时，建议在继电器使用100小时后替换

Table H- 1: P&B Relay Specifications

Contact Arrangement:	3 Form C, 3PDT, 3 C/O 触点形式
Contact Current Rating (Amps.):	10 触点额定电流
Coil Magnetic System:	Monostable 线圈磁场系统
Coil Selection Criteria:	Nominal Voltage 线圈选择标准
Actuating System:	AC
Input Voltage (VAC):	12
Coil Suppression Diode:	Without
Coil Resistance (Ω):	18
Coil Power, Nominal (VA):	2.70
Mounting Options:	Plain Case
Termination Type:	.187 x .020 Quick Connect Terminals
Enclosure:	Enclosed
Contact Material:	Silver Cadmium Oxide
Approved Standards:	UL Recognized, CSA Certified