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# EMC Performance Requirements --- Components

## Foreword

This joint engineering standard is an acceptance specification for the electromagnetic compatibility (EMC) requirements of electrical and electronic components and systems for DaimlerChrysler (DC) vehicles that reference this standard. **This standard shall be used in combination with DC-11223, EMC Performance Requirements – Vehicle, with DC-11225, EMC Supplemental Information and Alternative Component Requirements and with DC-10615, Electrical System Performance Requirements for Electrical and Electronic Components.** These requirements have been developed to assure compliance with present and anticipated domestic and foreign regulations and customer satisfaction regarding the EMC of vehicle E/E systems.

## Changes

Initial issue. See Annex B for a list of changes in this standard relative to DC-10614, which is the previous joint engineering standard for EMC Performance Requirements – Component.

**NOTE: The English version of this jointly developed engineering standard is the official document. The German version of this jointly developed engineering standard is the official translation of this document. The official German translation can be found on the DocMaster website. For all other translations, no guarantee can be made as to the accuracy of the technical information.**

## Contents

# 1 Scope

This joint engineering standard defines the electromagnetic compatibility requirements for components and subassemblies that contain electrical or electronic components for DaimlerChrysler vehicles and applies to all electrical and electronic components that reference this standard.

## 1.1 Purpose of the Standard

The purpose of this joint engineering standard is to ensure electromagnetic compatibility within the vehicle and between the vehicle and its electromagnetic environment. To support this, bench tests of the components not installed in a vehicle are described and the permissible emitted disturbances and the immunity requirements are defined in this standard.

The purpose of component testing is qualification of components from the supplier to meet vehicle requirements to the extent this is possible at a time when representative vehicles are not yet available.

## 1.2 Use of this Standard

The requirements and test methods in this joint engineering standard are based on the international standards referenced in paragraph 2.2, wherever possible. Refer to the definitions in this standard and in the references for clarification of terms.

Should a conflict exist between this standard and any of the referenced documents, the requirements of this standard shall prevail, except for regulatory requirements.

DaimlerChrysler may change the specific requirements for a given component or module, as a result of testing to this standard. This standard applies to electrical and/or electronic components or modules that reference this standard for their EMC requirements. These components are referred to in this standard as the component, module, motor or the generic term DUT (device(s) under test).

Deviations from the requirements contained in this standard are only allowed if agreed explicitly between the supplier and the appropriate vehicle line within DaimlerChrysler and documented in the applicable product specification(s).

In addition to meeting the requirements for a module or component as specified in this standard, the module or component must comply with DaimlerChrysler Standard DC-11223, EMC Performance Requirements - Vehicle when installed in a representative vehicle.

The recommended procedure for assuring EMC compliance for an electronic module, electrical component or motor is to:

- The DC EMC team develops the EMC requirements for the component product specification(s) (Lastenheft) based on this joint engineering standard and DC-11223 but adapted to the component and to the vehicles in which it will be used (including classification of the component or system functions).
- Deviations from the Lastenheft (e.g. DUT states for the tests, or classifications) need to be approved by the DC EMC team and documented as changes in the product specification(s) (Lastenheft).
- The supplier develops a test plan based on the product specification(s) and the DC EMC team approves this test plan.
- Confirm that required testing is completed according to the test plan at a DC approved EMC laboratory and that the specified requirements for the DUT are met.

Questions concerning this standard should be directed to the E/E Architecture & Standards Center of Competence, Department (6090) at Chrysler Group or to the EMC team at Mercedes Car Group (MCG). Questions concerning lab procedures and test methods should be directed to Scientific Laboratories, E/E Systems Compatibility Department (5140) at Chrysler Group or to the EMC team at Mercedes Car Group.

### 1.2.1 Additional Information

Component testing to the requirements of this standard represents an empirical risk analysis of

component performance versus derived approximations to known environmental threats and customer satisfaction requirements. The development of this standard 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 more variation than mechanical testing. Because of coupling variability and measurement uncertainty, correlation between component 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. Vehicle level analysis is not a substitute for component conformance to this standard.

## 1.3 Requirements for Applying this Generic Standard to a Specific Component

The releasing department, in cooperation with the appropriate product team EMC engineer, shall define the following information when referencing this EMC joint engineering standard in the product specification(s):

- Category (and subcategory, if applicable) of the electronic component or module (see definitions)
- DUT Functions and their Functional Group (affects test levels, see definitions and Annex A)
- Acceptable Performance Limits for these functions (to establish criteria for Function Performance)
- DUT Location, Internal Signals or Other Factors that may affect the appropriate requirements.

Note: Alternators, starters and certain other high current motors should have their own electrical requirements document. These devices should reference this standard for their EMC requirements as appropriate. Electroexplosive devices (EEDs) or initiators are not covered by this standard; refer to PF-9607 or the USCAR Initiator Technical Requirements and Validation Standard.

Not all tests are applicable to all electrical or electronic components; the applicable tests shall be specified in the DUT product specification. For default requirements refer to Table 1, EMC Test Selection Matrix.

**Table 1: EMC Test Selection Matrix**

| TEST | ELECTRONIC COMPONENTS | | | | | | | | MOTORS | | | Inductive Devices | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Category | | | | Subcategory (in addition to Category) | | | | Category | | | Category | |
| | P | A | B | HV | C | S | MS | Y | BCML | BCMS | ECM | R | IP |
| **EMISSIONS** | | | | | | | | | | | | | |
| CISPR 25 CE (V & I) | | X | | I | | | | | V | V* | X | | V |
| CISPR 25 RE (0.15 - 76 MHz) | | | | | X | | | | | | | | |
| CISPR 25 RE (76 – 2500 MHz) | | X | | X | | | | | | | X | | |
| Transient CE | | | | | | | | X | X | X | X | X | X |
| **IMMUNITY** | | | | | | | | | | | | | |
| BCI | | X | | X | | | | | | | X | | |
| TEM | | | | | X | | | | | | | | |
| ALSE: ISO or SAE (with or without Ground Plane) | | X | X | X | | | | | | | X | | |
| Magnetic Field | | | | | | | X | | | | | | |
| **TRANSIENTS** | | | | | | | | | | | | | |
| Power Lines | X | X | | | | | | | X | X | X | | |
| I/O: fast transients (a+b) | | X | | | | | | | | | X | | |
| I/O: slow transients (± #2) | | | | | | X | | | | | | | |
| ESD | X | X | X | X | | | | | | | X | | |

Note: **X** – requirement, **V** – CISPR Voltage emission test only, **I** – CISPR current emission test only, **V*** – short duration motors, if they are configured to accommodate a drop in part for RF suppression (i.e. no retooling) are only required to meet the RF emissions basic limits if agreed upon between DCX and the

supplier, otherwise the full CISPR 25 voltage testing is required, refer to Section 3 for definitions of the categories, sub-categories and abbreviations.

# 2 References

## 2.1 General

QS-9000, 3rd Edition Chrysler, Ford, and General Motors manual, “Quality System Requirements”

## 2.2 International Documents

**CISPR 16-1-1 2006-03 Specification for radio disturbance and immunity measuring apparatus and methods Part 1-1:** Radio disturbances and immunity measuring apparatus – Measuring apparatus

**CISPR 25 2002-08, Corrigendum 1 2004-03** Radio disturbance characteristics for the protection of receivers used on-board vehicles, boats and on devices – Limits and methods of measurement

**IEC 60050-161 1990-08, Amendment 1 1997-10, Amendment 2 1998-04** International electrotechnical vocabulary, Chapter 161: Electromagnetic compatibility

**IEC 61000-4-2 2001-04** Electromagnetic compatibility (EMC) - Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test (Edition 1.2)

**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 2004-06** 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 7637-3 1995-07, Technical Corrigendum 1 1995-11** Road vehicles, Electrical disturbance by conduction and coupling Part 3 - Vehicles with nominal 12 V or 24 V supply voltage - Electrical transient transmission by capacitive and inductive coupling via lines other than supply lines

**ISO 11452-1 2005-02** Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 1: General and definitions

**ISO 11452-2 2004-11** Road vehicles, Electrical disturbances by narrowband radiated electromagnetic energy - Component test methods Part 2 - Absorber-lined shielded enclosure

**ISO 11452-3 2001-03** Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 3: Transverse electromagnetic (TEM) cell

**ISO 11452-4 2005-04** Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 4: Bulk current injection (BCI)

**ISO/IEC 17011 2004-09** Conformity assessment – General requirements for accreditation bodies accrediting conformity assessment bodies

**ISO/IEC 17025 2005-5** General requirements for the competence of testing and calibration laboratories

## 2.3 SAE Documents

**SAE J1113-21, 1998-01** Electromagnetic Compatibility Measurement Procedure for Vehicle Components – Part 21: Immunity to Electromagnetic Fields, 10 kHz to 18 GHz, Absorber-Lined Shielded enclosure

## 2.4 Military Standards

**MIL-STD-1576 (USAF), 1992-09** Military Standard - Electroexplosive Subsystem Safety Requirements and Test Methods for Space Systems

**MIL-STD-461E, 1999-08 Department** of Defense Interface Standard, Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment

### 2.5 DaimlerChrysler Standards

DC-11223, EMC Performance Requirements – Vehicle

DC-11225, EMC Supplemental Information and Alternative Component Requirements

DC-10615, Electrical System Performance Requirements for Electrical and Electronic Components

PF-9607, Airbag Initiator Assembly

### 2.6 Chrysler Group Laboratory Procedures

LP-388C-65, E/E Systems Level Electrical and Electromagnetic Compatibility (EMC) Testing - General Information and requirements for DCTC, Supplier or Third Party EMC Laboratory

### 2.7 Other Documents

USCAR Initiator Technical Requirements and Validation Standard

EMC - Evaluation of CAN - Transceivers, FTZ Zwickau (FH) University of Applied Science

## 3 Terms and Definitions

Refer to IEC 60050-161, ISO 11452-1 and ISO 7637-1 for additional definitions.

**ADRESS.** An acronym for Automated Document Retrieval & Engineering Standards System.

**ALSE.** Absorber-lined shielded enclosure (also known as anechoic or semi-anechoic chamber). Used in this document, together with ISO, to designate the test itself with reference to the method described in ISO 11452-1.

**Anomaly.** An effect that represents a deviation from performance as specified in the DUT PF and described in the DUT test plan (see effect).

**Approved Laboratory.** An EMC laboratory that meets the requirements for acceptance by Mercedes Car Group and Chrysler Group through accreditation to ISO-17025. The basic test methods as defined in the international standards that are referenced in this standard, e.g. ISO 7637-2, -3, ISO 11452-2 and CISPR 25, shall be within the scope of the accreditation. This accreditation shall be performed by a nationally recognized accrediting body operating in accordance with ISO/IEC 17011. DC reserves the right to arrange for follow-up correlation tests and/or on site visits to evaluate the DC test methods not included in the ISO-17025 requirements and to further review and discuss the tests defined in the DC EMC Specification(s). A laboratory which refuses such follow-up activities or for which significant discrepancies are found is subject to having its approval/recognition withdrawn. Questions regarding this policy should be addressed to the E/E Systems Compatibility Department (5140) at Chrysler Group or to the EMC team at Mercedes Car Group.

**BAN.** Broadband Artificial Network (refer to DC-11225, Annex F).

**Bulk Current Injection (BCI).** Method for coupling common-mode RF current into a harness.

**Category and subcategory.** In this document, electronic modules, electric motors and inductive devices are classified into categories and subcategories, which determine the appropriate test requirements.

**Electronic module categories**:

- **P:** A passive electrical component or module. Examples: resistor, capacitor, blocking or clamping diode

- **A:** A component or module that contains active electronic devices. Examples: an analog op amp circuit, switching power supply or microprocessor controller.
- **B:** An electronic component that operates without a wiring connection to the vehicle (e.g. tire pressure monitor).
- **HV:** Components that operate at high voltage (greater than 60 V) for electric vehicle power systems.

**Electronic module subcategories**, if they apply, are in addition to the basic category designation.

- **C:** An electronic component that is subject to direct radiation to and from the circuit board below 200 MHz. This is usually an unshielded component that has at least one dimension greater than 200 mm (e.g. instrument cluster, displays utilizing HV technologies).
- **S:** An electronic component or module operated from a regulated power source in another module. This is usually a sensor providing input to a controller.
- **MS:** An electronic component or module that contains magnetically sensitive elements.
- **Y:** An electronic module that contains an electric or electronically controlled motor or a magnetically operated relay within its package.

**Electric motor categories**:

- **BCML:** A long operating duration or auto cycle brush commutated dc electric motor.
- **BCMS:** A short operating duration brush commutated dc electric motor.
- **ECM:** An electronically controlled or commutated dc electric motor.

**Inductive device categories**:

- **R:** Relays and solenoids
- **IP:** Inductive devices pulsed at a rate of 100 Hz or greater

**CE.** Conducted emission test.

**CG.** Chrysler Group (DaimlerChrysler Corp., DaimlerChrysler Canada, DaimlerChrysler de Mexico, etc.).

**CISPR.** An acronym for “Comité International Spécial des Perturbations Radioeléctriques” (Special International Committee on Radio Interference).

**Component.** Device that contains passive or active electrical or electronic elements, also referred to as a module.

**Controlled Manner.** Refers to the response of the DUT to an applied stimulus. A response is considered controlled when the operation of the DUT and its system returns to normal after the stimulus is removed (see function performance status, status II).

**Coupling Clamp.** A coupling clamp is a device with defined dimensions and characteristics for the common-mode coupling of a disturbance with a test circuit without electrical connection to it.

**Damage.** A DUT is considered damaged when it no longer performs as specified in the DUT product specification or shows visual evidence (such as discoloration) of electrical or electronic components that have exceeded their ratings.

**dBc.** The ratio of the amplitude of the harmonics of the RF carrier to the RF carrier fundamental frequency amplitude, in dB.

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

**DC.** DaimlerChrysler.

**Dedicated Lines.** Lines connecting the DUT to a sensor, load or similar input or output without a conductive path, other than ground, to any other module or the vehicle electrical power system.

**Diagnostic Indication.** An output from the DUT that indicates system status and predefined failure conditions. This output might be an indicator light or a data link to a diagnostic readout.

**Disturbance.** Any electrical transient or electromagnetic phenomenon that may affect the proper operation of an electrical or electronic device (see stimulus).

**DUT.** An acronym for Device(s) Under Test. Any electrical or electronic component, module, motor, filter, etc. Also referred to as EUT or equipment under test.

**DUT PF.** The DaimlerChrysler Corporation Performance Standard for the DUT (see product specification).

**DV.** Design Verification (parts not from production tooling, A or B samples for MCG).

**E/E.** Electrical and/or Electronic.

**Effect.** A detectable change in DUT performance due to an applied stimulus.

**Effect Threshold.** A repeatable transition of the DUT from normal to affected operation occurring at a value or over a range of values of an electrical test parameter.

**Electronically Controlled Motor.** A motor that has active electronic devices as part of the motor package.

**Engineering Standard.** An Engineering Standard contains information that would be too voluminous or repetitive to include in the CAD model or Engineering Graphic Overview. It is a written normative specification that describes material, process, performance, reliability, quality, and/or design requirements for a production part, family of parts, or system. Standards contain common requirements, procedures, processes, acceptance criteria, and/or guidelines. Standards are documented agreements containing technical specifications or other precise criteria to be used consistently as rules, requirements, procedures, processes or definitions of characteristics, to ensure that materials, products, processes, and services are fit for their purpose.

**ESD.** Electrostatic discharge.

**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 - 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 - Indirect Discharge (Field Coupled).** A discharge onto a coupling plane or strip in the vicinity of the DUT or its wiring harness simulating an ESD discharge to objects in the vicinity of the component as installed in the vehicle.

**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 be recoverable after the stimulus is removed without permanent loss of function or corruption of stored data or diagnostic information.

**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.

**Functional Group.** Component or module functions are divided into four groups based on criticality of function. Immunity requirements are appropriate for the functional group - refer to Annex A for functional group classification examples:

- **Group A:** Any function that provides a convenience.
- **Group B:** Any function that enhances, but is not essential to, the operation and/or control of the vehicle.
- **Group C:** Any function that controls or affects the essential operation of the vehicle.
- **Group D:** Any function that electronically controls the deployment of an electro explosive device (EED) actuated passive restraint system with the potential for inadvertent deployment. [Refer to definitions and background in MIL-STD-1576 (USAF)]

**Function Performance Status.** The performance of DUT functions, when subjected to a disturbance, is described by four performance status levels:

- **Status I:** The function operates as designed during and after exposure to a disturbance.
- **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 operation after the disturbance is removed (see fail-safe mode). Performance deviations from the DUT shall not inhibit other DUT or systems causing them to exhibit a Status III (e.g. through loss of critical communications).
- **Status III:** The function may deviate from designed performance during exposure to a disturbance. Driver action may be required to return the function to normal operation after the disturbance is removed (e.g. ignition off/on).
- **Status IV:** The device/function shall not sustain any permanent damage as a result of exposure to a disturbance. Dealer action may be required to return the function to normal operation after the disturbance is removed (e.g. battery reset).

**Function Status Classification.** The required operation of vehicle electronic systems, when subjected to a stimulus, defined in terms of functional group (criticality of function) and function performance status.

**HIRF.** High Intensity Radiated Field.

**Inductive Device.** An electromechanical device that stores energy in a magnetic field. Examples are solenoids, relays, buzzers and electromechanical horns.

**Informative.** Additional (not normative) information intended to assist the understanding or use of the standard.

**Insulating Spacer.** Non conductive material with a relative permittivity $\varepsilon_r < 2.5$ and a relative permeability $\mu_r < 2$.

**I/O.** Input and output. Also used in this document to designate the transient pulse testing on I/O-lines.

**MCG.** Mercedes Car Group.

**Motor - Auto Cycle.** A motor that cycles automatically, without direct operator input. These motors are considered to be the same as long operating duration motors for EMC performance. Examples are radiator fan or ABS pump motors.

**Motor - Long Operating Duration.** A motor that is expected to be in operation for extended periods of time. (Also applies for other broadband sources.) Examples are blower and wiper motors.

**Motor - Short Operating Duration.** A motor that operates for short periods of time under operator control. (Also applies for other broadband sources.) Examples are power window, seat or mirror motors.

**Motor - Very Short Cycle.** A motor that operates a single cycle of less than one second duration under operator control (e.g. a power door lock actuator).

**NIST.** An acronym for National Institute of Science and Technology.

**Normative**. Provisions that are necessary to meet requirements.

**PCB.** Printed Circuit Board.

**PCE.** Pin-conducted emission test.

**PF.** Performance Standard.

**Powered-down State.** A DUT connected in its operating configuration with battery power applied but ignition or switched power turned off and all active functions timed out.

**PRF.** Pulse repetition frequency.

**Product Specification.** A DaimlerChrysler Performance Standard (PF), Lastenheft (final specification), Pflichtenheft (performance specification), CATIA model or other document used to specify the EMC requirements for a vehicle component or system.

**PTB.** Physikalisch-Technische Bundesanstalt (German National Institute of Natural and Engineering Sciences)

**PV.** Production Validation (parts from production tooling, C and D samples for MCG).

**PWM.** Pulse Width Modulated or Modulation.

**RE.** Radiated emission test.

**RF Boundary.** An element of an EMC test setup 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, BANs, filter feed-through pins, RF absorber coated wire and/or RF shielding. Also: An RF-test-system implementation within which circulating RF currents are confined to the intended path between the DUT port under test and the RF-generator output port, in the case of immunity measurements, and to the intended path between the DUT port(s) under test and the measuring apparatus input port, in the case of emissions measurement, and outside of which stray RF fields are minimized. The boundary is maintained by insertion of BANs, shielded enclosures, and/or decoupling or filter circuits.

**Section.** Refers to a major subdivision of this standard or a Laboratory Procedure.

**Shall.** Denotes a requirement.

**Should.** Denotes a recommendation.

**SIS.** Standards Information System

**Stability.** The condition where the DUT maintains control, within defined limits, of a specific function in the presence of an applied stimulus.

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

**Substitution Method.** The substitution method is a technique for mapping out the power required to produce a target RF field intensity in an empty test chamber 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.

**Supply Voltage.** The voltage that will be available in the vehicle or as simulated on the bench to power the DUT. This voltage is applied to the battery and ignition lines and any DUT inputs or outputs sourced from battery or ignition voltage as configured in a DUT's complete system including circuit protection. This includes lines such as voltage sense, illumination and loads sourced from supply voltage and switched to ground in the DUT.

**System Nominal Voltage.** The nominal voltage of the onboard power system, which may be: 12, 24 or 42 V.

**TEM.** Transverse electromagnetic. Used in this document also as an abbreviation for “TEM cell test”.

**TEM Cell.** An enclosed system, often a rectangular coaxial line, in which a wave is propagated in the transverse electromagnetic mode to produce a specified field for testing purposes.

# 4 Regulated Substances and Recyclability

All materials, procedures, processes, components, or systems must conform to the current regulatory (governmental) requirements regarding regulated substances and recyclability.

# 5 Test Requirements and Functional Status Classification

## 5.1 General

All test equipment used for measurement shall be calibrated in accordance with ISO 17025. Attention shall be directed to control of the RF boundary in both emission and immunity tests to reduce undesired interaction between the device under test, the test apparatus and the electromagnetic environment. The test equipment, test setups and test procedures shall be documented in lab procedures. DaimlerChrysler reserves the right to inspect the lab procedures. The CG lab procedures (see References) are an example of the information that should be included. The DUT test plan shall specify the number of samples to be tested. A DUT is expected to pass all tests, regardless of the order of testing.

A test fixture, or DUT exerciser, provided by the supplier shall be used to electrically simulate the DUT vehicle system and to exercise all of the required functions of the DUT. This system exerciser shall operate during the DUT testing without adverse effect. The system exerciser shall be able to simulate the appropriate load characteristics, i.e., equivalent resistance, capacitance and inductance as expected in a production vehicle. Production intent components should be used for the loads where ever possible. This is particularly critical for inductive and pulse width modulated (PWM) circuits (e.g. motors). Refer to DC-11225, EMC Supplemental Information and Alternative Component Requirements, Annex D for termination information for CAN and LIN bus.

For emission and immunity tests that require a shielded enclosure, connections to the DUT support equipment shall not compromise the shielded enclosure. This may be accomplished by either having the DUT support equipment located in the shielded enclosure or, for remotely located support equipment, by using feedthrough filters inline or optical links between the DUT and the support equipment. The inline filters shall be in a shielded box with a shielded cable from this box to the enclosure wall. Take care that the emissions of optical links is at least 6 dB below the limits and that the immunity is higher than the required test level.

Additional information for CG testing is available in DC-11225, EMC Supplemental Information and Alternative Component Requirements, Annex E.

## 5.2 Test Conditions

All dimensions in this document are in millimeters unless otherwise specified. The default tolerances, test voltages are stated in ISO 11452-1 with the tolerance on ambient temperature understood to be a normal target range and not a controlled range.

## 5.3 Test Plan

The test plan shall provide any additional information that was not included in the product specification and that is needed for the proper testing of the component.

Any additions or deviations in the test plan from the product specification(s) (Lastenheft) shall be approved by the DC EMC team prior to testing.

The product specification and/or the test plan for the DUT shall include:

- the DUT identification (manufacturer, model, serial number, hardware and software version, etc.)
- the voltage, current and appropriate impedance information for each pin

- the number of samples to be tested
- the tests to be performed specifying any available options and including test levels (for alternative tests, if both are performed, a failure of either test is a failure of the overall requirement)
- the precise test setup (measuring equipment involved, cabling including lengths, etc
- failure criteria (to determine functional status and monitoring)
- Critical loading requirement (CAN or LIN bus, motor, etc.)
- critical timing or operating parameters that may affect the testing of the DUT

Supplementary and Test Plan Template information for CG is contained in LP-388C-65.

### 5.4 Function Performance Status Classification

For immunity testing, the required operation of vehicle electronic systems, when subjected to an electromagnetic stimulus, is described by criticality of function (group) and function performance status. Refer to definitions for function, functional group and function performance status and Annex A for examples.

### 5.5 Test Report and Statement

On completion of the test, the results shall be submitted to the responsible releasing engineer. In addition, a copy to the test report, test setup and all data results shall be supplied to the DC EMC team within DaimlerChrysler. Electronic data submission is preferred.

The test report shall include:

- A reference to the test plan and/or product specification of the component
- A statement certifying the execution of the tests in accordance with this standard and compliance with its requirements
- Documentation of the test setup and any loading used including photographs
- Equipment list
- Thresholding information for any immunity anomalies observed

Use the test report template provided by the DC EMC team or provide the same information contained or requested by the template.

## 6 Emissions (Emitted Disturbances)

### 6.1 General

Active devices and electronically controlled motors (categories A and ECM) shall be tested from 150 kHz to 1GHz unless otherwise specified in the product specification(s). In case frequency bands above 1 GHz are to be tested, the frequency range is extended to 2.5 GHz. Refer to Table 1 to determine which emissions tests are required for the category (and subcategory) that applies to the DUT.

For categories A and ECM CISPR 25 voltage on supply lines and CISPR 25 current measurement on all lines shall be performed in the frequency range from 150 kHz to 110 MHz. For high voltage (HV) electric vehicle (EV) or hybrid electric vehicle (HEV) components using shielded power supply lines, the CISPR 25 voltage measurement is not required. For components without a wiring harness, the CISPR 25 voltage and current measurements are not required. CISPR 25 radiated emissions shall be performed from 76 MHz to 2.5 GHz, as specified. For subcategory C modules the CISPR25 radiated emission test shall additionally be performed between 150 kHz and 76 MHz.

Components that use a low power RF link (e.g. RF remote keyless entry) require special considerations for emission testing at their operating frequency, refer to DC-11225, EMC Supplemental Information and Alternative Component Requirements, Annex E for explanation.

Long operating duration or auto cycle brush commutated electric motors (category BCM) and pulsed inductive devices (category IP) shall be tested for RF emissions over the frequency range from 150 kHz

to 200 MHz using the CISPR 25 voltage method. For categories BCM and IP the average measurement may be omitted since the emissions of these categories are purely broadband in nature. Short duration motors, if they are configured to accommodate a drop in part for RF suppression (i.e. no retooling) are only required to meet the RF emissions basic limits if agreed upon between DCX and the supplier, otherwise the full CISPR 25 voltage testing is required. Passive devices (category P) or very short cycle motors are not tested for RF emissions. See Figure 1.

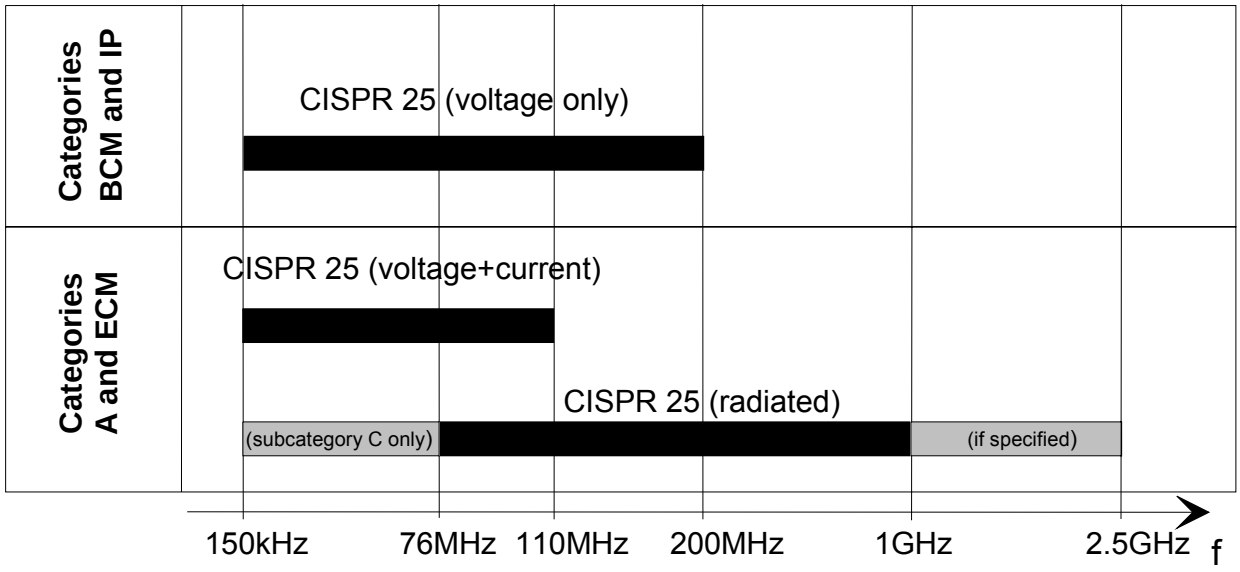



**Figure 1: Test Methods versus Frequency**

The limits are defined for average, peak and quasi-peak detectors. The limit tables of each method specify which detectors to use in which frequency band and give the measurement bandwidth of the receiver or spectrum analyzer.

Basic limits for the continuous frequency range 30 MHz to 1000 MHz are defined to meet the requirements of 2004/104/EC on the vehicle level (protection of off-board receivers). For the protection of on-board receivers limits are specified for the receiver bands. Both basic and on-board receiver limits need to be met.

E/E components and systems shall fulfill the requirements for transient emissions as specified in paragraph 6.5 unless otherwise specified in the product specification(s).

Action shall be taken to ensure that the DUT emits its maximum disturbance power (occurring during normal operation) during the measurement, e.g. proper mechanical loading of electric motors corresponding to their vehicle application or for PWM 50% duty cycle.

### 6.1.1 Measuring Instruments and Settings

For receivers, frequency step sizes shall be ≤ 50% of the measurement bandwidth for P and AV detectors unless otherwise specified in the product specification and/or test plan. When a QP detector is used, or for broadband emission testing of category BCM or IP components, the frequency step size shall be ≤ 5 times the measurement bandwidth.

Minimum receiver measurement times are in Table 2.

**Table 2: Minimum Receiver Measurement Time**

| Detector Type | Minimum Measurement Time [ms] |
|---|---|
| Peak (P) or Average (AV) | 50 |
| Quasi-peak (QP) | 1000 |

For measurements using a spectrum analyzer with peak detector, the sweep speed shall be set to reflect the modulation rate (if known) according to the following formula:

$$Vs \leq 2/3*RBW*fm$$

Where:
- Vs is the sweep speed in MHz per second
- RBW is the spectrum analyzer resolution bandwidth in MHz
- fm is the modulation frequency in Hz, defined as the lowest repetition rate of a software routine or other DUT operating parameter that may affect the measured RF emissions

The sweep speed used shall be selected such that a slower sweep speed will not result in a significant change in the measured emissions. In all cases, the spectrum analyzer must be operating in calibrated mode. A spectrum analyzer sweep rate of 1 MHz per second or slower for 9/10 kHz resolution bandwidth (RBW) and 10 MHz per second or slower for 100/120 kHz RBW, assumes a maximum fm of 150 Hz. For QP, equivalent sweep rates are 1 kHz per second or slower for 9/10 kHz RWB and 10 kHz per second or slower for 100/120 kHz RWB.

When a spectrum analyzer is used for peak or quasi-peak detector measurements, the video bandwidth shall be at least three times the resolution bandwidth.

Fast emission measurement methods incorporating FFT (fast Fourier transform) may be used to reduce test time. It shall be demonstrated that, for the software used, the detectors and resolution bandwidths implemented work correctly according to the CISPR 16-1-1 requirements. For the verification of the detector response to pulses with different repetition rates (e.g. section 4.4.2 in CISPR 16-1-1 for quasi-peak detector), higher detector readings for repetition rates of the test pulses below 20 Hz are allowed. If measurements using FFT methods exceed the specified emission limits and if these limits are required for compliance with regulatory requirements, then these measurements shall be verified using another CISPR 16-1-1 compliant measuring instrument.

## 6.2 CISPR 25 Conducted RF Emissions - (Voltage on Supply Lines)

Radio disturbance emissions conducted along supply lines shall be measured in accordance with CISPR 25 within the frequency range of 150 kHz to 110/200 MHz (see Figure 1) using one or several artificial networks (ANs) allowing the decoupling of the disturbance voltage. The test setups for devices under test with several supply voltages shall be implemented using the appropriate number of ANs.

The PCE method defined in DC-11225, Annex A may be used as substitute for this test, if explicitly agreed upon between the supplier and the responsible DaimlerChrysler EMC engineering department and stated in the product specification.

### 6.2.1 Requirement

The measurement settings and limit values are defined in Tables 3, 4, and 5. Table 3 contains the basic limits for the continuous frequency range. The required frequency bands from Table 5 by marketing region are given in Table 4 (on-board receiver bands). All bands from Table 3 and those from Table 5 called out in the DUT product specification shall be measured and the limits met.

**Table 3: Basic Limit Levels. CISPR 25 Voltage Method.**

| Test No. | Frequency Range (MHz) | Peak | | Quasi-Peak | | Average | |
|---|---|---|---|---|---|---|---|
| | | Level | BW | Level | BW | Level | BW |
| | | dB (µV) | kHz | dB (µV) | kHz | dB (µV) | kHz |
| CE V 1 [1)] | 0.15 – 0.5 | 104 – 80 | 9/10 | - | - | - | - |
| CE V 2 [1)] | 0.5 – 6.3 | 80 | 9/10 | - | - | - | - |
| CE V 3 [1)] | 6.3 – 30 | 70 | 9/10 | - | - | - | - |
| CE V 4 | 30 – 110 | 70 | 1000 [2)] | - | - | 60 | 1000 [3)] |
| CE V 5 | 110 – 200 | 70 | 1000 [2)] | - | - | 60 | 1000 [3)] |

Notes: [1)] applies only for BCMS
[2)] if using 100/120 kHz instead of 1000 kHz, lower limit level by 10dB
[3)] if using 100/120 kHz instead of 1000 kHz, lower limit level by 4dB

**Table 4: Required Emission Test Bands by Marketing Region**

| Markets | Required test bands for broadcast and mobile services – test numbers from Table 5 |
|---|---|
| ECE | All vehicles: 1, 2, 3, 13, (19)<br>Opt. 1 (if TV available for car line): 16, 17, (18)<br>Opt. 2 (fleet vehicles): 30, (31), 44, (46, 47, 48)<br>Opt. 3 (heavy trucks): 4 - 8, 24<br>Opt. 4 (add. SW broadcast): 4 -12 |
| NA | All vehicles: 2, 13, 25, 31<br>Opt. 1 (fleet vehicles): 43, (45)<br>Opt. 2 (if weather band avail.): (14) |
| JP | 2, 13, 17, (18) |
| RoW (Rest of World) | 2, 13, 31 |

**Table 5: On-board Receiver Limits. CISPR 25 Voltage Method.**

| Test No. | Service or Band | Frequency (MHz) | Peak | | Quasi-Peak | | Average | |
|---|---|---|---|---|---|---|---|---|
| | | | Level | BW | Level | BW | Level | BW |
| | | | dB (µV) | kHz | dB (µV) | kHz | dB (µV) | kHz |
| **Broadcast** | | | | | | | | |
| 1 | LW | 0.15 – 0.28 | - | - | **53** | 9/10 | **50** | 9/10 |
| 2 | MW (AM) | 0.52 – 1.73 | - | - | **40** | 9/10 | **34** | 9/10 |
| 3 | SW 49m | 5.8 – 6.3 | - | - | **39** | 9/10 | **33** | 9/10 |
| 4 | SW 41m | 7.1 – 7.6 | - | - | **39** | 9/10 | **33** | 9/10 |
| 5 | SW 31m | 9.3 – 10.0 | - | - | **39** | 9/10 | **33** | 9/10 |
| 6 | SW 25m | 11.5 – 12.1 | - | - | **39** | 9/10 | **33** | 9/10 |
| 7 | SW 21m | 13.6 – 13.8 | - | - | **39** | 9/10 | **33** | 9/10 |
| 8 | SW 19m | 15.0 – 15.7 | - | - | **39** | 9/10 | **33** | 9/10 |
| 9 | SW 17m | 17.4 – 17.9 | - | - | **39** | 9/10 | **33** | 9/10 |
| 10 | SW 16m | 18.9 – 19.1 | - | - | **39** | 9/10 | **33** | 9/10 |
| 11 | SW 14m | 21.4 – 21.9 | - | - | **39** | 9/10 | **33** | 9/10 |
| 12 | SW 12m | 25.6 – 26.1 | - | - | **39** | 9/10 | **33** | 9/10 |
| 13 | VHF (FM) | 76 – 108 | - | - | **30** | 100/120 | **24** | 100/120 |
| 14 | WB | 162.4 – | - | - | **30** | 100/120 | **24** | 100/120 |

| Test No. | Service or Band | Frequency (MHz) | Peak | | Quasi-Peak | | Average | |
|---|---|---|---|---|---|---|---|---|
| | | | Level | BW | Level | BW | Level | BW |
| | | | dB (µV) | kHz | dB (µV) | kHz | dB (µV) | kHz |
| | | 162.55 | | | | | | |
| 16 | TV I | 41 – 88 | **49** | 1000 [1)] | **-** | - | **34** | 1000 [2)] |
| 17 | TV II | 90 – 108 | **49** | 1000 [1)] | **-** | - | **34** | 1000 [2)] |
| 18 | TV III | 174 – 200 | **49** | 1000 [1)] | **-** | - | **34** | 1000 [2)] |
| 19 | DAB | 174 – 200 | **44** | 1000 [1)] | **-** | - | **34** | 1000 [2)] |
| **Mobile Services** | | | | | | | | |
| 24 | Communication | 26.5 – 29.7 | **47** [3)] | 9/10 | **34** [3)] | 9/10 | **28** | 9/10 |
| 25 | Communication | 30 – 54 | **47** | 100/120 | **-** | - | **25** | 9/10 |
| 30 | 4m | 65 – 88 | **43** [3)] | 100/120 | **30** [3)] | 100/120 | **24** | 100/120 |
| 31 | 2m | 140 – 180 | **43** [3)] | 100/120 | **30** [3)] | 100/120 | **24** | 100/120 |
| **Fleet Mobile Services** | | | | | | | | |
| 43 | Fleet (US) | 40 – 44 | **-** | - | **-** | - | **22** | 9/10 |
| 44 | Fleet (EU) | 84.015 – 87.255 | **-** | - | **-** | - | **14** | 9/10 |
| 45 | Fleet (US) | 140 – 180 | **-** | - | **-** | - | **18** | 9/10 |
| 46 | Fleet (EU) | 147 – 164 | **-** | - | **-** | - | **14** | 9/10 |
| 47 | Fleet (EU) | 167.56 – 169.38 | **-** | - | **-** | - | **14** | 9/10 |
| 48 | Fleet (EU) | 172.16 – 173.98 | **-** | - | **-** | - | **14** | 9/10 |

Notes: [1)] if using 100/120 kHz instead of 1000 kHz, lower limit level by 10dB
[2)] if using 100/120 kHz instead of 1000 kHz, lower limit level by 4dB
[3)] for test no. 24, 30 and 31 choose either Peak or QuasiPeak detector
Shaded frequency bands are the corresponding numbered bands in parentheses from Table 4

### 6.2.2 Test setup

Test setup is described in detail in CISPR 25. The test setup for devices under test with several supply voltage connections shall be implemented accordingly.

## 6.3 CISPR 25 Conducted RF Emissions - (Current on all Lines in Harness)

The emitted radio disturbance currents shall be measured on the wiring harness in accordance with CISPR 25 using a current probe within the frequency range of 150 kHz to 110/200 MHz including the power leads in the current probe. Ground leads that are shorter than 1m, or not included in the wiring harness, shall be taken out of the current probe. The power supply shall be connected via an artificial network (AN) in accordance with CISPR 25 .

The PCE method defined in DC-11225, Annex A may be used as substitute for this test, if explicitly agreed upon between the supplier and the responsible DaimlerChrysler EMC engineering department and stated in the product specification.

### 6.3.1 Requirements

The measurement settings and limit values are defined in Table 6, 7, and 8. Table 6 contains the basic limits for the continuous frequency range. The required frequency bands from Table 8 by marketing region are given in Table 7 (on-board receiver bands). All bands called out in the DUT product specification shall be measured and the limits met.

**Table 6: Basic Limit Levels. CISPR 25 Current Method.**

| Test No. | Frequency Range (MHz) | Peak | | Quasi-Peak | | Average | |
|---|---|---|---|---|---|---|---|
| | | Level | BW | Level | BW | Level | BW |
| | | dB (µA) | kHz | dB (µA) | kHz | dB (µA) | kHz |
| CE A 1 | 30 – 110 | 36 | 1000 [1)] | - | - | 26 | 1000 [2)] |
| CE A 2 | 110 – 200 | 36 | 1000 [1)] | - | - | 26 | 1000 [2)] |

Notes: [1)] if using 100/120 kHz instead of 1000 kHz, lower limit level by 10dB
[2)] if using 100/120 kHz instead of 1000 kHz, lower limit level by 4dB

**Table 7: Required Emission Test Bands by Marketing Region**

| Markets | Required test bands for broadcast and mobile services – test numbers from Table 8 |
|---|---|
| ECE | All vehicles: 1, 2, 3, 13, (19)<br>Opt. 1 (if TV available for car line): 16, 17, (18)<br>Opt. 2 (fleet vehicles): 30, (31), 44, (46, 47, 48)<br>Opt. 3 (heavy trucks): 4 - 8, 24<br>Opt. 4 (add. SW broadcast): 4 -12 |
| NA | All vehicles: 2, 13, 25, 31<br>Opt. 1 (fleet vehicles): 43, (45)<br>Opt. 2 (if weather band is avail.): (14) |
| JP | 2, 13, 17, (18) |
| RoW (Rest of World) | 2, 13, 31 |

**Table 8: On-board Receiver Limits. CISPR 25 Current Method.**

| Test No. | Service or Band | Frequency (MHz) | Peak | | Quasi-Peak | | Average | |
|---|---|---|---|---|---|---|---|---|
| | | | Level | BW | Level | BW | Level | BW |
| | | | dB (µA) | kHz | dB (µA) | kHz | dB (µA) | kHz |
| **Broadcast** | | | | | | | | |
| 1 | LW | 0.15 – 0.28 | - | - | **33** | 9/10 | **30** | 9/10 |
| 2 | MW (AM) | 0.52 – 1.73 | - | - | **12** | 9/10 | **6** | 9/10 |
| 3 | SW 49m | 5.8 – 6.3 | - | - | **5** | 9/10 | **-1** | 9/10 |
| 4 | SW 41m | 7.1 – 7.6 | - | - | **5** | 9/10 | **-1** | 9/10 |
| 5 | SW 31m | 9.3 – 10.0 | - | - | **5** | 9/10 | **-1** | 9/10 |
| 6 | SW 25m | 11.5 – 12.1 | - | - | **5** | 9/10 | **-1** | 9/10 |
| 7 | SW 21m | 13.6 – 13.8 | - | - | **5** | 9/10 | **-1** | 9/10 |
| 8 | SW 19m | 15.0 – 15.7 | - | - | **5** | 9/10 | **-1** | 9/10 |
| 9 | SW 17m | 17.4 – 17.9 | - | - | **5** | 9/10 | **-1** | 9/10 |
| 10 | SW 16m | 18.9 – 19.1 | - | - | **5** | 9/10 | **-1** | 9/10 |
| 11 | SW 14m | 21.4 – 21.9 | - | - | **5** | 9/10 | **-1** | 9/10 |
| 12 | SW 12m | 25.6 – 26.1 | - | - | **5** | 9/10 | **-1** | 9/10 |
| 13 | VHF (FM) | 76 – 108 | - | - | **-4** | 100/120 | **-10** | 100/120 |
| 14 | WB | 162.4 – 162.55 | - | - | **-4** | 100/120 | **-10** | 100/120 |
| 16 | TV I | 41 – 88 | **15** | 1000 [1)] | - | - | **0** | 1000 [2)] |
| 17 | TV II | 90 – 108 | **15** | 1000 [1)] | - | - | **0** | 1000 [2)] |
| 18 | TV III | 174 – 200 | **15** | 1000 [1)] | - | - | **0** | 1000 [2)] |
| 19 | DAB | 174 – 200 | **10** | 1000 [1)] | - | - | **0** | 1000 [2)] |

| Test No. | Service or Band | Frequency (MHz) | Peak | | Quasi-Peak | | Average | |
|---|---|---|---|---|---|---|---|---|
| | | | Level | BW | Level | BW | Level | BW |
| | | | dB (µA) | kHz | dB (µA) | kHz | dB (µA) | kHz |
| **Mobile Services** | | | | | | | | |
| 24 | Communication | 26.5 – 29.7 | **13** [3] | 9/10 | **0** [3] | 9/10 | **-6** | 9/10 |
| 25 | Communication | 30 – 54 | **13** | 100/120 | **-** | - | **-9** | 9/10 |
| 30 | 4m | 65 – 88 | **9** [3] | 100/120 | **-4** [3] | 100/120 | **-10** | 100/120 |
| 31 | 2m | 140 – 180 | **9** [3] | 100/120 | **-4** [3] | 100/120 | **-10** | 100/120 |
| **Fleet Mobile Services** | | | | | | | | |
| 43 | Fleet (US) | 40 – 44 | **-** | - | **-** | - | **-12** | 9/10 |
| 44 | Fleet (EU) | 84.015 – 87.255 | **-** | - | **-** | - | **-20** | 9/10 |
| 45 | Fleet (US) | 140 – 180 | **-** | - | **-** | - | **-16** | 9/10 |
| 46 | Fleet (EU) | 147 – 164 | **-** | - | **-** | - | **-20** | 9/10 |
| 47 | Fleet (EU) | 167.56 – 169.38 | **-** | - | **-** | - | **-20** | 9/10 |
| 48 | Fleet (EU) | 172.16 – 173.98 | **-** | - | **-** | - | **-20** | 9/10 |

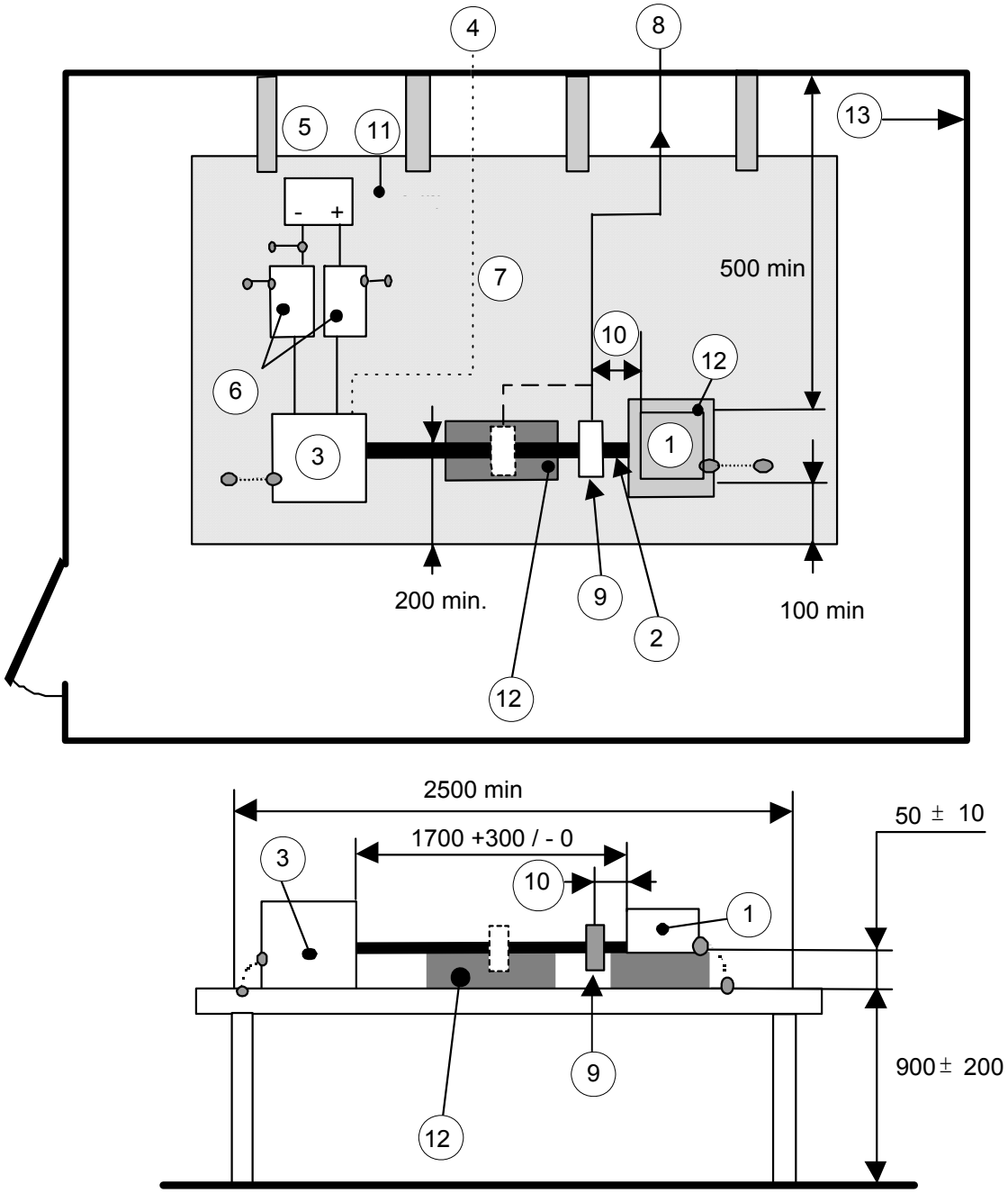
Notes: [1] if using 100/120 kHz instead of 1000 kHz, lower limit level by 10dB
[2] if using 100/120 kHz instead of 1000 kHz, lower limit level by 4dB
[3] for test no. 24, 30 and 31 choose either Peak or QuasiPeak detector
Shaded frequency bands are the corresponding numbered bands in parentheses from Table 7

### 6.3.2 Test setup

CISPR 25 applies with the following exceptions:

- The test harness shall be 1700 (+ 300, – 0) mm long and routed 50 mm above the ground plane (this harness can also be used for BCI or ALSE testing);
- Measurements shall be taken at the following one or two points;
  - at a distance of 50 ± 10 mm from the DUT connector or case over all frequencies;
  - at a distance of 750 ± 50 mm from the DUT connector or case for frequencies above 30 MHz;

For a schematic diagram of the measuring setup, refer to Figure 2.




**Key:**

1. Device under test (connected to ground if specified in the test plan)
2. Wiring harness
3. Load simulator (placement and ground connection according to ISO 11452-4)
4. Stimulation and monitoring system
5. Power supply
6. AN
7. Optical fibers
8. Measurement equipment
9. Current probe (represented at 2 positions)
10. The distance from the DUT to the closest probe position
11. Ground plane (connected to the shielded room)
12. Insulating support
13. Shielded room

**Figure 2: Measurement of Radio Disturbance Currents Conducted along the Wiring Harness**

## 6.4 CISPR 25 Radiated Emissions

The emission of components shall be measured in accordance with CISPR 25 in an absorber-lined shielded enclosure (ALSE) with an antenna or antennas in the frequency range of 75 MHz to 1000/2500 MHz as specified in the product specification. For subcategory C modules, the frequency range is extended down to 150 kHz.

### 6.4.1 Requirements

The measurement settings and limit values are defined in Tables 9, 10, and 11. Table 9 contains the basic limits for the continuous frequency range. The required frequency bands from Table 11 by marketing region are given in Table 10 (on-board receiver bands). All bands called out in the DUT product specification shall be measured and the limits met.

**Table 9: Basic Limit Levels. CISPR 25 ALSE Method.**

| Test No. | Frequency Range (MHz) | Peak | | Average | |
|---|---|---|---|---|---|
| | | Level | BW | Level | BW |
| | | dB (µV/m) | kHz | dB (µV/m) | kHz |
| CE R 1 [4)] | 30 – 75 | 68 - 25.13 lg(f/30) [1)] | 1000 [2)] | 58 - 25.13 lg(f/30) [1)] | 1000 [3)] |
| CE R 2 | 75 – 400 | 58 + 15.13 lg(f/75) [1)] | 1000 [2)] | 48 + 15.13 lg(f/75) [1)] | 1000 [3)] |
| CE R 3 | 400 - 1000 | 69 | 1000 [2)] | 59 | 1000 [3)] |

Notes: [1)] In the formulas, f is in MHz and lg denotes the logarithm to base 10
[2)] if using 100/120 kHz instead of 1000 kHz, lower limit level by 10dB
[3)] if using 100/120 kHz instead of 1000 kHz, lower limit level by 4dB.
[4)] required only for subcategory C components

**Table 10: Required Emission Test Bands by Marketing Region**

| Markets | Required test bands for broadcast and mobile services – test numbers from Table 11 |
|---|---|
| ECE | All vehicles: (1, 2, 3), 13, 15, 19, 22, 29, 35, 37, 39-42<br>Opt. 1 (if TV available for car line): (16), 18, 21<br>Opt. 2 (fleet vehicles): (30), 31, 32, 44, 46, 47, 48<br>Opt. 3 (heavy trucks): (4 - 8, 24)<br>Opt. 4 (add. SW broadcast): (4 -12) |
| NA | All vehicles: (2), 13, 15, 27, 29, 34, 38, 41<br>Opt. 1 (fleet vehicles): (25), 28, 31 and 43, 45, 49 if specified in test plan<br>Opt. 2 (if weather band available): (14)<br>Opt. 3 (If SDARS available): 23<br>Opt. 4 (if Bluetooth or WLAN available): 42 |
| JP | (2), 13, 15, (16), 17, 18, 20, 26, 33, 36, 42 |
| RoW (Rest of World) | (2), 13, 15, 35, 37 |

**Table 11: On-board Receiver Limits. CISPR 25 ALSE Method.**

| Test No. | Service or Band | Frequency (MHz) | Peak | | Quasi-Peak | | Average | |
|---|---|---|---|---|---|---|---|---|
| | | | Level | BW | Level | BW | Level | BW |
| | | | dB (µV/m) | kHz | dB (µV/m) | kHz | dB (µV/m) | kHz |
| **Broadcast** | | | | | | | | |
| 1 [4)] | LW | 0.15 – 0.28 | - | - | **27** | 100/120 | **24** | 9/10 |

| Test No. | Service or Band | Frequency (MHz) | Peak | | Quasi-Peak | | Average | |
|---|---|---|---|---|---|---|---|---|
| | | | Level | BW | Level | BW | Level | BW |
| | | | dB (µV/m) | kHz | dB (µV/m) | kHz | dB (µV/m) | kHz |
| 2 [4] | MW (AM) | 0.52 – 1.73 | - | - | **24** | 100/120 | **18** | 9/10 |
| 3 [4] | SW 49m | 5.8 – 6.3 | - | - | **24** | 9/10 | **18** | 9/10 |
| 4 [4] | SW 41m | 7.1 – 7.6 | - | - | **24** | 9/10 | **18** | 9/10 |
| 5 [4] | SW 31m | 9.3 – 10.0 | - | - | **24** | 9/10 | **18** | 9/10 |
| 6 [4] | SW 25m | 11.5 – 12.1 | - | - | **24** | 9/10 | **18** | 9/10 |
| 7 [4] | SW 21m | 13.6 – 13.8 | - | - | **24** | 9/10 | **18** | 9/10 |
| 8 [4] | SW 19m | 15.0 – 15.7 | - | - | **24** | 9/10 | **18** | 9/10 |
| 9 [4] | SW 17m | 17.4 – 17.9 | - | - | **24** | 9/10 | **18** | 9/10 |
| 10 [4] | SW 16m | 18.9 – 19.1 | - | - | **24** | 9/10 | **18** | 9/10 |
| 11 [4] | SW 14m | 21.4 – 21.9 | - | - | **24** | 9/10 | **18** | 9/10 |
| 12 [4] | SW 12m | 25.6 – 26.1 | - | - | **24** | 9/10 | **18** | 9/10 |
| 13 | VHF (FM) | 76 – 108 | - | - | **18** | 100/120 | **12** | 100/120 |
| 14 | WB | 162.4 – 162.55 | - | - | **18** | 100/120 | **12** | 100/120 |
| 15 | GPS | 1574 – 1577 | - | - | - | - | **25** | 100/120 |
| 16 [4] | TV I | 41 – 88 | **33** | 1000 [1] | - | - | **18** | 1000 [2] |
| 17 | TV II | 90 – 108 | **37** | 1000 [1] | - | - | **22** | 1000 [2] |
| 18 | TV III | 174 – 230 | **37** | 1000 [1] | - | - | **22** | 1000 [2] |
| 19 | DAB | 174 – 241 | **32** | 1000 [1] | - | - | **22** | 1000 [2] |
| 20 | TV IV/V (JP) | 470 – 770 | **44** | 1000 [1] | - | - | **29** | 1000 [2] |
| 21 | TV IV/V | 470 – 862 | **44** | 1000 [1] | - | - | **29** | 1000 [2] |
| 22 | DAB (L-Band) | 1452 – 1497 | **45** | 1000 [1] | - | - | **35** | 1000 [2] |
| 23 | SDARS | 2320 – 2345 | **56** | 1000 [1] | - | - | **46** | 1000 [2] |
| **Mobile Services** | | | | | | | | |
| 24 [4] | Communication | 26.5 – 29.7 | **34** [3] | 9/10 | **21** [3] | 9/10 | **15** | 9/10 |
| 25 [4] | Communication | 30 – 54 | **34** | 100/120 | - | - | **12** | 9/10 |
| 26 | Remote Keyless Entry (JP) (Immobilizer) | 311 – 317 | **38** | 100/120 | - | - | **4** | 9/10 |
| 27 | Remote Keyless Entry (US) (Immobilizer) | 310 – 314 | **38** | 100/120 | - | - | **16** | 9/10 |
| | | 314 – 316 | **19** | | | | **14** | 9/10 |
| | | 316 – 320 | **19** | | | | **16** | 9/10 |
| 28 | Communication | 420 – 520 | **38** | 100/120 | - | - | **16** | 9/10 |
| 29 | Remote Keyless Entry (Immobilizer) | 430 – 433 | **38** | 100/120 | - | - | **16** | 9/10 |
| | | 433 – 435 | **19** | | | | **14** | 9/10 |
| | | 435 – 438 | **19** | | | | **16** | 9/10 |
| 30 [4] | 4m | 65 – 88 | **31** [3] | 100/120 | **18** [3] | 100/120 | **12** | 100/120 |
| 31 | 2m | 140 – 180 | **31** [3] | 100/120 | **18** [3] | 100/120 | **12** | 100/120 |
| 32 | TETRA/Trunking | 380 – 430 | **38** | 100/120 | - | - | **19** | 100/120 |
| 33 | Cell Phone (PDC) | 860 – 885 | **44** | 100/120 | - | - | **25** | 100/120 |

| Test No. | Service or Band | Frequency (MHz) | Peak | | Quasi-Peak | | Average | |
|---|---|---|---|---|---|---|---|---|
| | | | Level | BW | Level | BW | Level | BW |
| | | | dB (µV/m) | kHz | dB (µV/m) | kHz | dB (µV/m) | kHz |
| 34 | Cell Phone (D-AMPS) | 869 – 894 | **44** | 100/120 | **-** | - | **25** | 100/120 |
| 35 | Cell Phone (GSM-900) | 925 – 960 | **44** | 100/120 | **-** | - | **25** | 100/120 |
| 36 | Cell Phone (PDC) | 1477 – 1501 | **44** | 100/120 | **-** | - | **25** | 100/120 |
| 37 | Cell Phone (GSM-1800) | 1805 – 1880 | **44** | 100/120 | **-** | - | **25** | 100/120 |
| 38 | Cell Phone (GSM-1900) | 1930 – 1990 | **44** | 100/120 | **-** | - | **25** | 100/120 |
| 39 | Cell Phone (UMTS) | 1900 – 1920 | **45** | 1000 [1)] | **-** | - | **35** | 1000 [2)] |
| 40 | Cell Phone (UMTS) | 2010 – 2025 | **45** | 1000 [1)] | **-** | - | **35** | 1000 [2)] |
| 41 | Cell Phone (UMTS, WCDMA) | 2110 – 2170 | **45** | 1000 [1)] | **-** | - | **35** | 1000 [2)] |
| 42 | Bluetooth, WLAN | 2402 – 2497 | **56** | 1000 [1)] | **-** | - | **46** | 1000 [2)] |
| **Fleet Mobile Services** | | | | | | | | |
| 43 [4)] | Fleet (US) | 40 – 44 | **-** | - | **-** | - | **6** | 9/10 |
| 44 | Fleet (EU) | 84.015 – 87.255 | **-** | - | **-** | - | **2** | 9/10 |
| 45 | Fleet (US) | 140 – 180 | **-** | - | **-** | - | **6** | 9/10 |
| 46 | Fleet (EU) | 147 – 164 | **-** | - | **-** | - | **2** | 9/10 |
| 47 | Fleet (EU) | 167.56 – 169.38 | **-** | - | **-** | - | **2** | 9/10 |
| 48 | Fleet (EU) | 172.16 – 173.98 | **-** | - | **-** | - | **2** | 9/10 |
| 49 | Fleet (US) | 420 – 520 | **-** | - | **-** | - | **9** | 9/10 |

Notes: [1)] if using 100/120 kHz instead of 1000 kHz, lower limit level by 10dB
[2)] if using 100/120 kHz instead of 1000 kHz, lower limit level by 4dB
[3)] for test no. 24, 30 and 31 choose either Peak or QuasiPeak detector
[4)] required only for subcategory C components
Shaded frequency bands are the corresponding numbered bands in parentheses from Table 10

### 6.4.2 Test setup

The test setup is given in detail in CISPR 25. The outer surface of the DUT with the greatest disturbance emission, if known, shall be facing the antenna. For frequencies above 1 GHz the phase center of the antenna should be in line with the DUT (i.e. in front of the DUT instead of in front of the middle of the harness).

## 6.5 Conducted Transient Emissions

Motors and inductive devices (Category R or IP) are to be tested with any intended parallel suppression in place. If this suppression is remotely located at a driver in a module, the inductive device must be tested as a system with the module or with the suppression simulated across the inductive device. Conducted transient emissions shall be measured in accordance with ISO 7637-2, fast transient setup.

### 6.5.1 Requirement

The DUT, when tested under operating load typical for its intended application, shall conform to the following restrictions on switching transients. The DUT shall be tested with the fast transient setup from ISO 7637-2. The measured transients are limited to +100/-150 volts when the pulse duration (measured at the 10%-amplitude) is smaller than 100 µs and ±80 volts if it is greater than or equal to 100 µs.

### 6.5.2 Test

For details on the test setup, refer to ISO 7637-2, fast transient setup.

Measure the transient voltages generated by the DUT (motor, inductive device or module) with a storage scope (sampling rate of 1 giga samples per second minimum) while exercising the DUT functions and while turning the DUT on and off ten times using the appropriate vehicle system switch or relay or a switch or relay specified in the test plan. Use an AN between the power supply and the DUT. The conducted transient is measured across the DUT with the power switched on the load (DUT) side of the AN. The rise time, peak voltage and pulse width shall be captured and recorded.

NOTE: Vehicle system switches and relays are subject to deterioration with accumulated operating time. This can result in the generation of transients with faster rise times or higher peak voltages. Therefore, the switch or relay used should represent ‘worst case’ to preclude later system problems.

# 7 RF Immunity

## 7.1 General

RF Immunity testing shall be performed over the frequency range of 1 MHz to 3.2 GHz. Refer to Table 1 to determine which immunity tests are required for the category (and subcategory) that applies to the DUT.

- RF immunity testing is performed from 1 to 400 MHz using a conducted test method and from 200 MHz to 3.2 GHz using a radiated test method.
- Use BCI (refer to 7.2) for conducted immunity testing from 1 MHz to 400 MHz.
- Select either ALSE with a ground plane (refer to 7.3) or without ground plane (refer 7.4) for radiated immunity testing from 200 MHz to 3.2 GHz.
- Determine if TEM cell testing (refer to 7.5) is also required (subcategory C only).

In special cases the tube coupler method defined in DC-11225, Annex C may be additionally required or used as a substitute above 800 MHz. However, this shall be explicitly agreed to between the supplier and the responsible EMC engineering department within DaimlerChrysler and stated in the product specification.

Figure 3 gives an overview of the standard test methods.

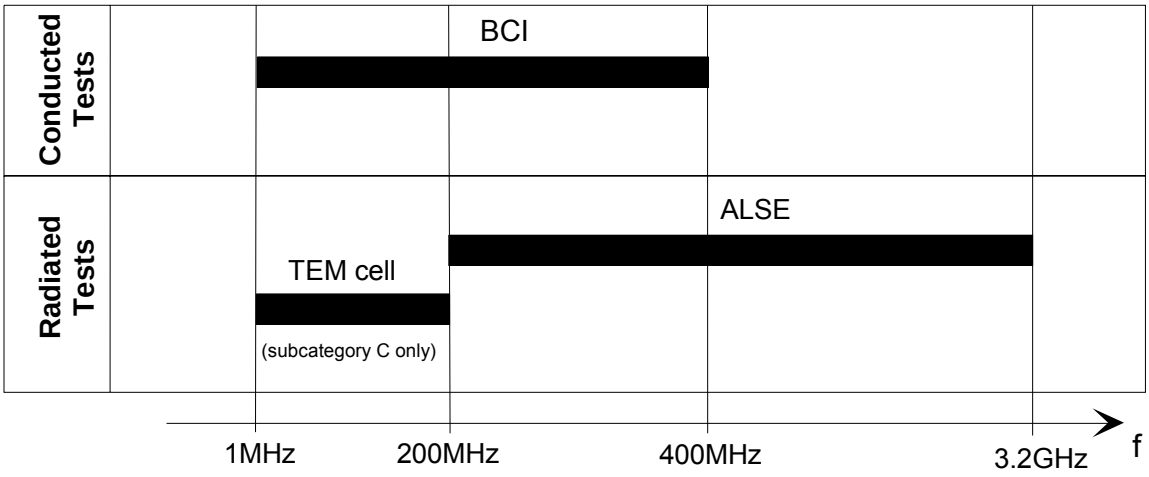



**Figure 3: RF Immunity Testing**

Normally, testing is done at the level of the highest immunity requirement for the most critical functional group for the DUT. A quick scan at the specified test level, noting the frequency range of any effects, followed by a thresholding scan over these identified effect frequency ranges is the preferred test procedure. Thresholding is done to determine the actual immunity level for other functional groups and status levels. For the thresholding scan, the test level is incremented up to the required level at each test frequency. As an alternative to thresholding, testing may be performed at several levels (e.g. 150, 100, 70, 35 V/m). For transition frequency points between basic and HIRF (High Intensity Radiated Field) test levels, the higher level shall be applied. The DUT shall be monitored for effects.

Bus modules and systems shall be evaluated for increased ignition off current draw (IOD) resulting from inadvertent wake up from standby or power-down modes during RF exposure.

Components that use a low power RF link (e.g. RF remote keyless entry) require special considerations for immunity testing near their operating frequencies, refer to DC-11225, Annex E for explanations.

CW and Amplitude modulation (AM, 1 kHz 80%) are required below 30 MHz. Amplitude modulation is constant peak relative to CW. The default modulation between 30 and 400 MHz is continuous wave (CW). CW and/or pulse modulation is applicable from 400 MHz to 3.2 GHz; pulse modulation is required in the cell phone and radar bands. The default pulse modulation is rectangular at 217 Hz (± 10%) PRF with 12% duty cycle (or duration 577 µs, period 4600 µs) for the cell phone bands, and 3 µs duration and 300 Hz PRF for the radar bands. For testing to meet regulatory requirements, these frequency ranges and modulation types are modified. Refer to Tables 12 and 13 and the regulation.

Other modulation techniques may be appropriate if the known DUT characteristics indicate a potential for reduced immunity to modulated signals. This information, if known, shall be incorporated in the product specification and/or test plan.

The harmonics of the immunity test signal shall be at least -12 dBc. Care shall be taken to avoid equipment switching transients.

**Table 12: Default Modulation for RF Immunity Testing**

| Frequency Range [MHz] | Modulation |
|---|---|
| **1 to 30** | **CW and AM**<br>(1kHz, 80%, constant peak) |

| Frequency Range [MHz] | Modulation |
|---|---|
| **30 to 400** | **CW** |
| **above 400** | **CW and/or Pulse – Pulse required in cell phone and radar bands**<br>Cell phone pulse: 217 Hz 12% duty cycle (or duration 577 µs, period 4600 µs)<br>Radar pulse: 300 Hz, 3 µs duration |

**Table 13: Typical Modulation for Regulatory RF Immunity Testing**

| Frequency Range [MHz] | Modulation |
|---|---|
| **20 to 800** | **AM** (1kHz, 80%, constant peak) |
| **800 to 2 000** | **Pulse** (duration 577 µs, period 4600 µs) |

The minimum dwell time for the immunity tests is 2 seconds. If the DUT or its software requires a longer dwell time for comprehensive testing, this shall be incorporated in the DUT EMC test plan. For all the immunity requirements, the components shall be evaluated for functional performance as specified in paragraph 5.4 and the referenced definitions.

All immunity tests shall be conducted with frequency steps not greater than the logarithmically distributed steps specified in Table 14. (Note: This specification now is in line with the definition of ISO 11452-1.

**Table 14: RF Immunity Test Frequency Resolution**

| Frequency Range [MHz] | Logarithmic Steps [%] |
|---|---|
| **1 to 10** | 4 |
| **10 to 100** | 2 |
| **100 to 1 000** | 1 |
| **1 000 to 3 200** | 0.5 |

The severe environment frequency ranges for HIRF testing are defined in Table 15.

**Table 15: Severe Environment Simulation – Frequency Ranges where HIRF Test Level Applies**

| Frequency Range [MHz] | Usage |
|---|---|
| 1 – 30 | AM Broadcast |
| 30 – 54 | Communications (North America) |
| 65 – 88 | Communications (Europe) |
| 140 – 180 | Communications |

| Frequency Range [MHz] | Usage |
|---|---|
| 380 – 520 | Communications |
| 824 – 915 | Cell phone |
| 1 200 – 1 400 | Radar |
| 1 710 – 1 980 | Cell phone |
| 2 700 – 3 200 | Radar |

## 7.2 Bulk Current Injection (BCI) Test

This test exposes the test harness to which the DUT is connected to radiation using the BCI method in accordance with ISO 11452-4 as modified below. This test applies in the frequency range from 1 to 400 MHz.

The DRFI method defined in DC-11225, Annex B may be used as substitute for this test, if explicitly agreed upon between the supplier and the responsible DaimlerChrysler EMC engineering department and stated in the product specification.

### 7.2.1 Requirement

The immunity requirements are based on environmental data and are adapted to BCI through correlation with vehicle data.

The basic shape of the needed currents in the calibration jig in dBµA is given by

$$I(f) = \begin{cases} I_1 - 20\lg\left(\frac{f_L}{f}\right) & for \quad 1MHz \le f < f_L \\ I_1 & for \quad f_L \le f \le 30MHz \\ I_1 - 10\lg\left(\frac{f}{f_U}\right) & for \quad 30MHz < f \le 400MHz \end{cases}$$

where $I_1$ is also given in dBµA and $f$, $f_L$ are given in MHz. Figure 4 illustrates this basic shape of the frequency-dependent behavior.

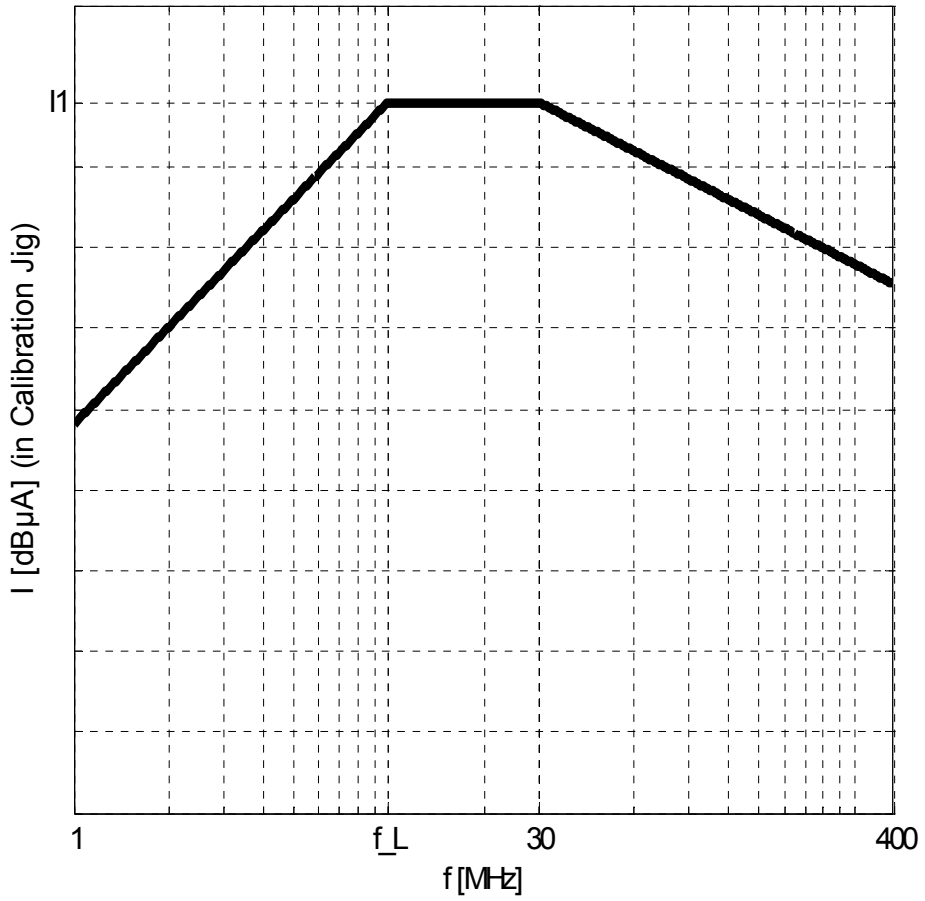



**Figure 4: Basic Shape of the Needed Current in the Calibration Jig**

In the following only the currents at the constant sections $I_1$ are specified, the frequency-dependent values can be calculated with the given formula.

For passenger cars, vans and light commercial vehicles, the lower corner frequency $f_L$ is 15 MHz and for large heavy trucks and buses the frequency $f_L$ is 5 MHz. The upper corner frequency is 30 MHz for all vehicles.

For Group A, B and C evaluation, the basic test level in the constant section is 105 dBµA (approx. 180 mA) and the HIRF test level in the constant section is 111 dBµA (approx. 360 mA). For Group D evaluation, the basic test level in the constant section is 108 dBµA (approx. 250 mA) and the HIRF test level in the constant section is 114 dBµA (approx. 500 mA). The immunity performance requirements are specified in Table 16.

Figures 5 and 6 for passenger cars, vans and light commercial vehicles and Figures 7 and 8 for large heavy trucks illustrate the test level over frequency and the thresholds between different functional statuses as given in Table 16.

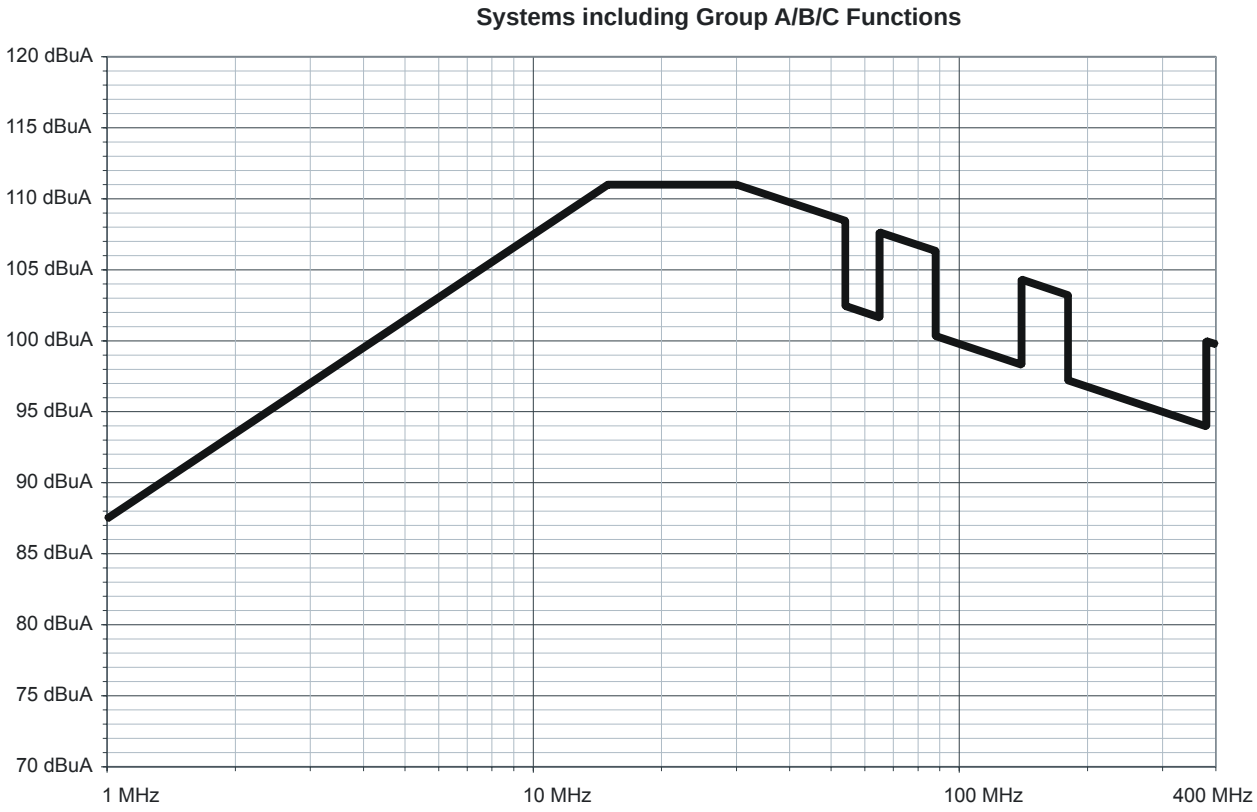



**Figure 5: Test Levels for BCI Testing, passenger cars, vans and light commercial vehicles, Group A, B and C**

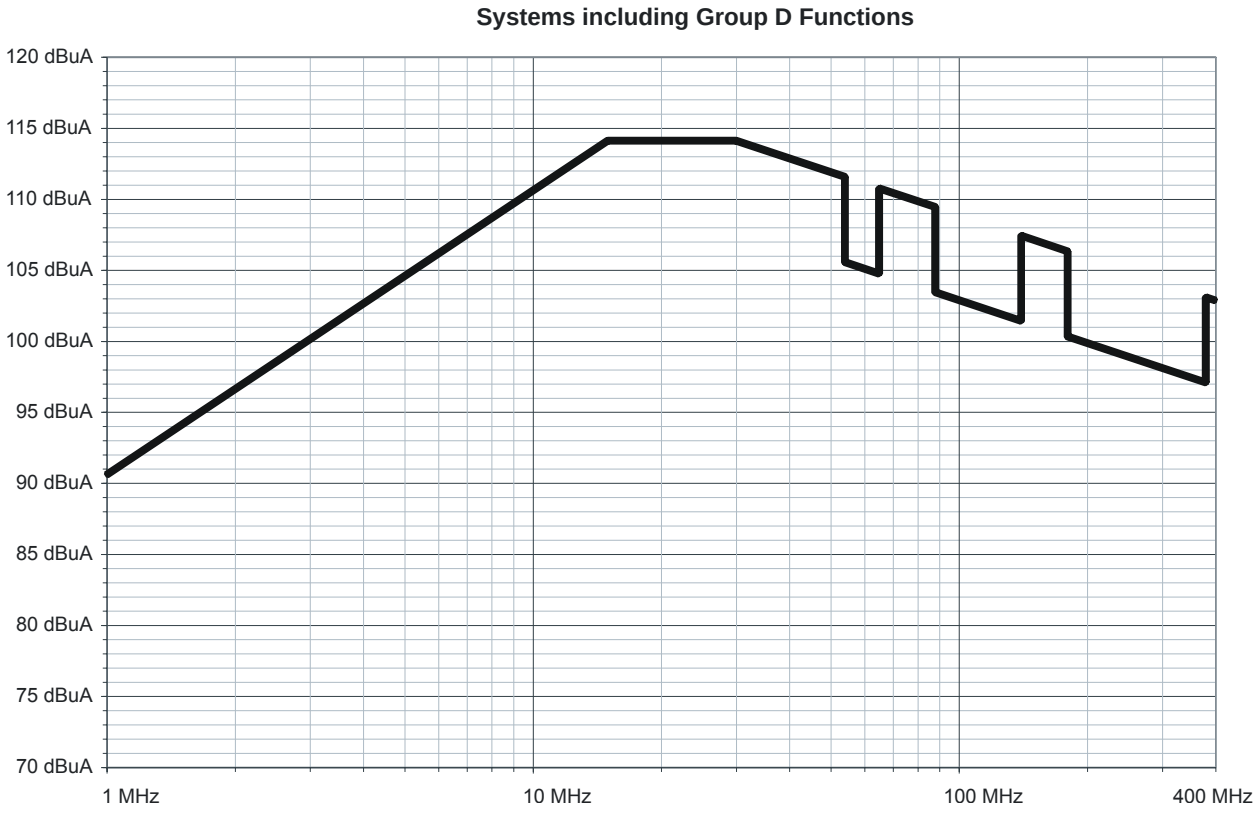



**Figure 6: Test Levels for BCI Testing, passenger cars, vans and light commercial vehicles, Systems including Group D functions**

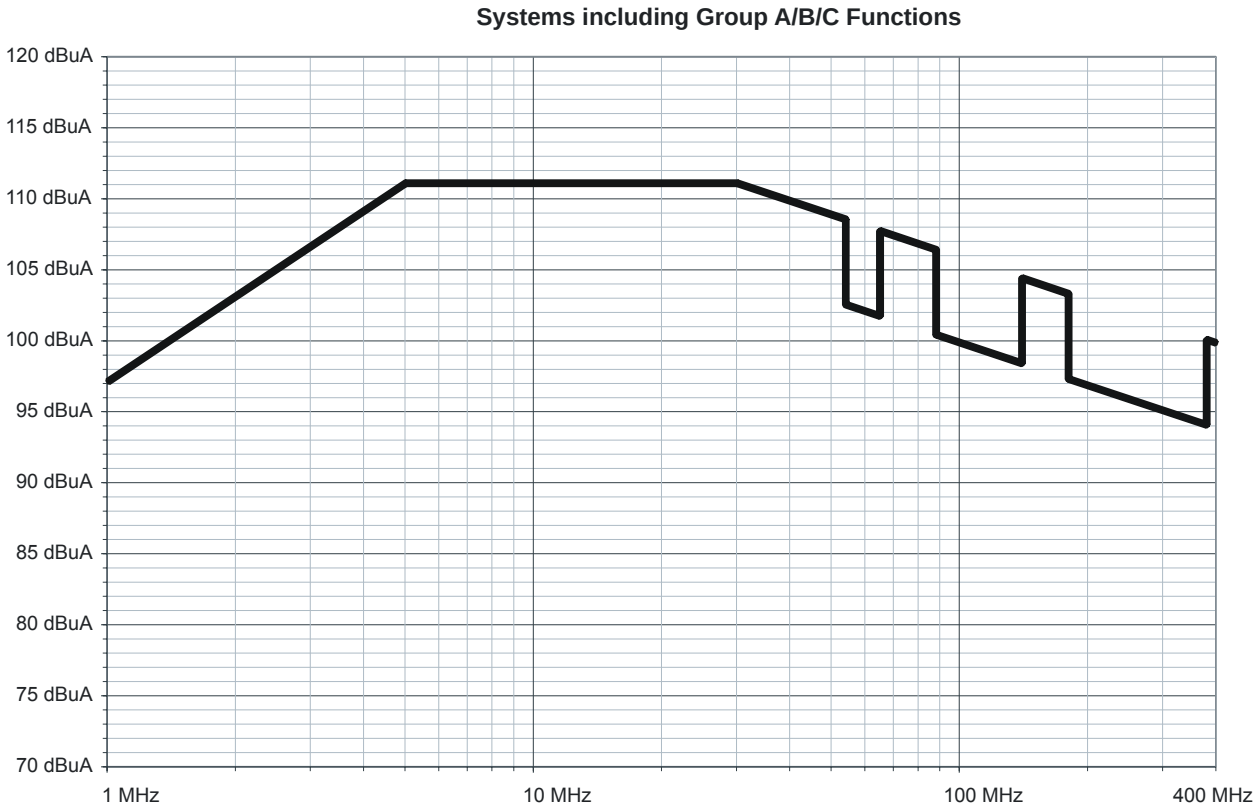



**Figure 7: Test Levels for BCI Testing, large heavy trucks and buses, Group A, B and C**

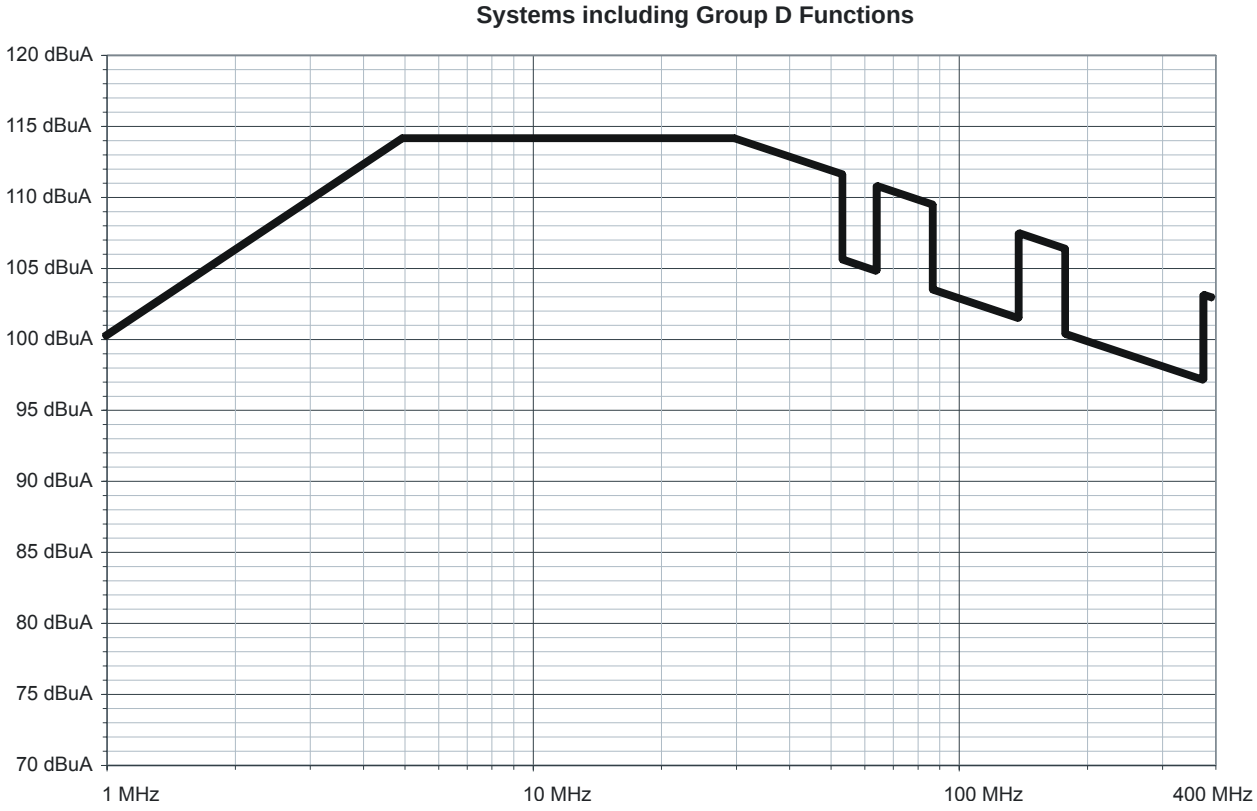



**Figure 8: Test Levels for BCI Testing, large heavy trucks and buses, Systems including Group D functions**

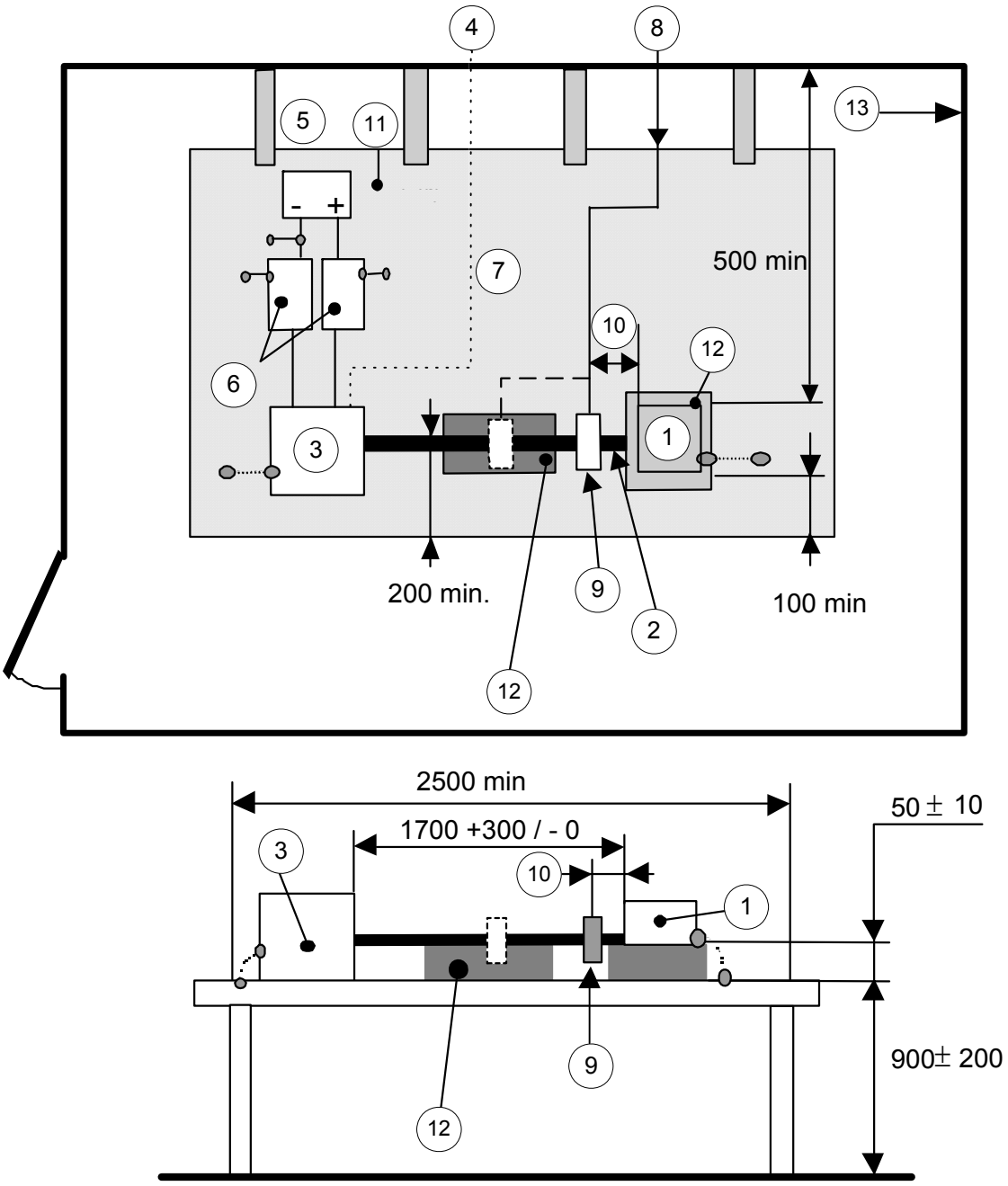
The top level of Table 16 shaded gray, is only evaluated if the DUT has a Group D function.

**Table 16: BCI Immunity Performance Requirements in the Constant Range (e.g. 20 MHz) for Group A, B, C and D**

| Test Level in the Constant Range [dB (µA)] | Approximate Test Level [mA] | Group A Status | Group B Status | Group C Status | Group D Status |
|---|---|---|---|---|---|
| **> 111 to ≤ 114** | **> 350 to ≤ 500** | IV | IV | III | II |
| **> 108 to ≤ 111** | **> 250 to ≤ 350** | III | III | II | I |
| **> 105 to ≤ 108** | **> 180 to ≤ 250** | II | II | I | |
| **> 99 to ≤ 105** | **> 90 to ≤ 180** | | I | | |
| **≤ 99** | **≤ 90** | I | | | |

### 7.2.2 Test Setup

Due to changes with respect to ISO 11452-4, refer to Figure 9 for a schematic diagram of the test setup.




**Key:**

1. Device under test (connected to ground if specified in the test plan)
2. Wiring harness
3. Load simulator (placement and ground connection according to ISO 11452-4)
4. Stimulation and monitoring system
5. Power supply
6. AN
7. Optical fibers
8. High frequency equipment
9. Injection probe (represented at 2 positions)
10. The distance from the DUT to the closest probe position
11. Ground plane (connected to the shielded room)
12. Insulating support
13. Shielded room

**Figure 9: Immunity Test Using the BCI Method - Schematic Diagram of the Test Setup**

- A current injection probe shall be used; a current monitoring probe is optional.
- Use substitution method with forward power.

- The test setup shall be on a sufficiently large ground plane, so that the plane shall extend beyond the test setup by at least 100 mm on all sides.
- The distance between the test setup and all other conductive structures (such as the walls of the shielded enclosure) with the exception of the ground plane shall be no less than 500 mm.
- Where part of the system to be tested is normally connected electrically with the vehicle body, this part shall be placed directly on the ground plane and connected with it.
- Deviating from ISO 11452-4, the test harness shall be 1700 (+ 300, – 0) mm long and routed 50 mm above the ground plane (this harness can also be used for CISPR 25 Radiated Emissions and Conducted Emissions Current Method testing).
- The current injection probe shall be located on the test harness at two points, a distance of 150 mm and at 750 mm from the DUT wiring connectors. Where the harness has a number of branches, the test shall be repeated, so that the current injection probe shall be attached around each branch.
- Wherever possible, production intent vehicle switching devices and sensors shall be used.

## 7.3 ALSE with a Ground Plane

The DUT shall be subjected to radiated immunity testing using an antenna for field generation in accordance with ISO 11452-2.

### 7.3.1 Requirement

For Group A, B and C evaluation, the basic test level is 70 V/m and the HIRF test level is 150 V/m from 200 MHz to 3.2 GHz. For Group D evaluation, the basic test level is 100 V/m and the HIRF test level is 200 V/m from 200 MHz to 1.4 GHz and 150 V/m from 1.4 to 3.2 GHz. The test levels and functional status requirements by frequency range and functional group are specified in Table 17 and the Test Levels in Figures 10 and 11.

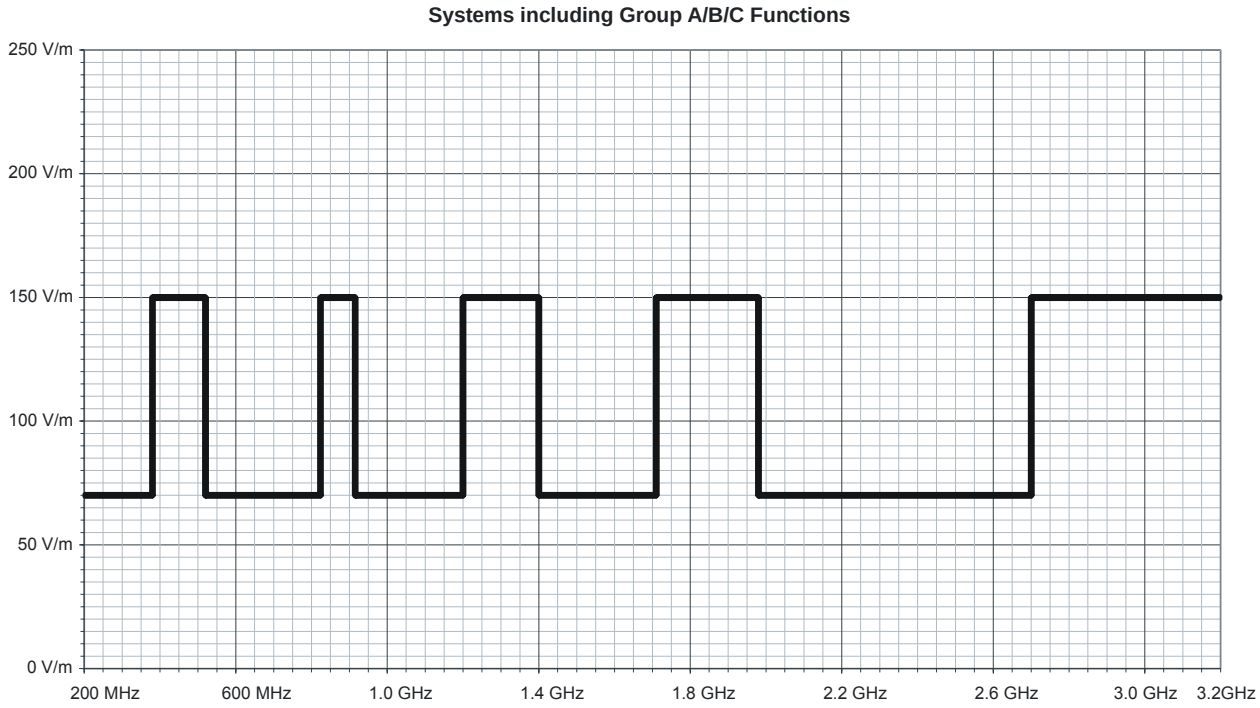



**Figure 10: Test Levels for ALSE Testing, Group A, B, C**

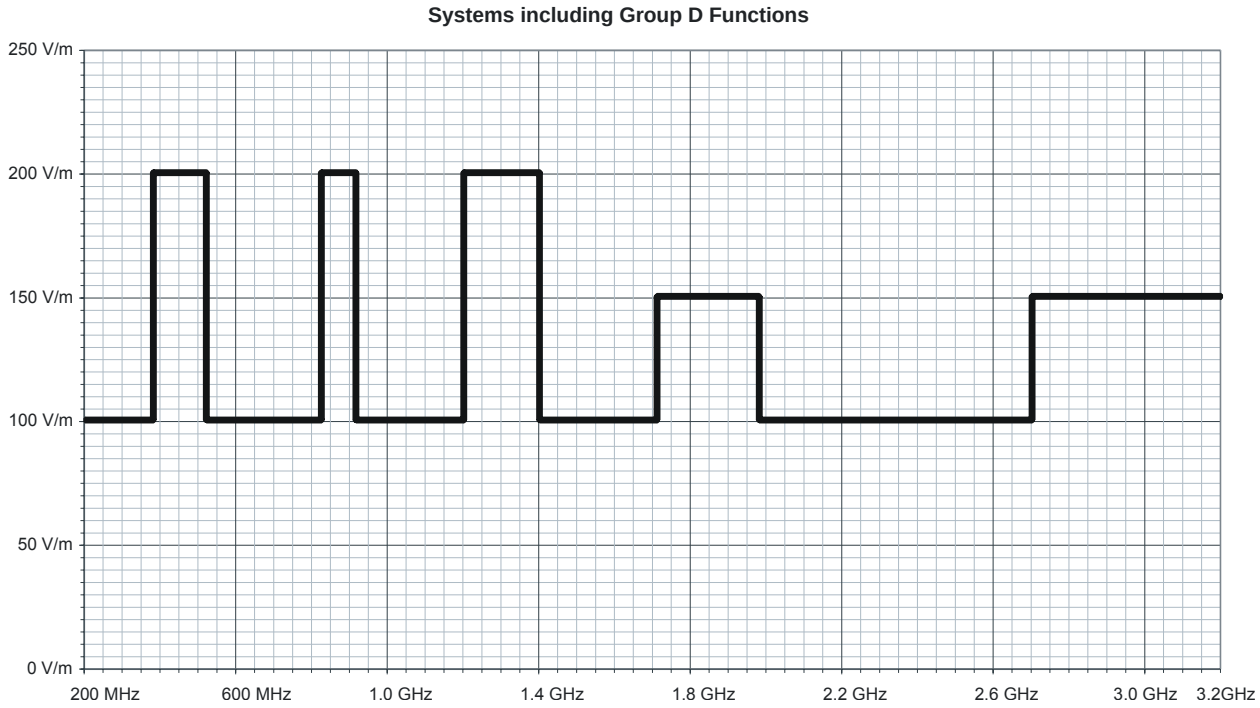



**Figure 11: Test Levels for ALSE Testing, Systems including Group D functions**

The top level of Table 17, shaded gray, is only evaluated if the DUT has a Group D function.

**Table 17: Performance Requirements for ALSE Testing, Group A, B, C and D**

| Test Level V/m | Group A Status | Group B Status | Group C Status | Group D Status |
|---|---|---|---|---|
| **> 150 to ≤ 200** | IV | IV | III | II |
| **> 100 to ≤ 150** | III | III | II | I |
| **> 70 to ≤ 100** | II | II | I | |
| **> 35 to ≤ 70** | | I | | |
| **≤ 35** | I | | | |

### 7.3.2 Test setup

Refer to ISO 11452-2.

## 7.4 ALSE without Ground Plane

### 7.4.1 General

The DUT shall be subjected to radiated immunity testing using an antenna for field generation in accordance with SAE J1113-21 (without ground plane). RF uniformity requirement: define a 0.5x1.0 meter rectangular vertical plane through the field reference location perpendicular to the line from the antenna to the DUT. Measure the uniformity at all the defined points for the lowest and highest frequency used for each antenna. The uniformity shall be less than or equal to 6 dB relative to the reference point. For system characterization, refer to DC-11225, Annex G.

### 7.4.2 Requirement

For Group A, B and C evaluation, the basic test level is 70 V/m and the HIRF test level is 150 V/m from 200 MHz to 3.2 GHz. For Group D evaluation, the basic test level is 100 V/m and the HIRF test level is 200 V/m from 200 MHz to 1.4 GHz and 150 V/m from 1.4 to 3.2 GHz. The test levels and functional status requirements by frequency range and functional group are specified in Figures 10 and 11 and Table 17.

### 7.4.3 Test setup

For a schematic diagram of the test setup refer to Figure 12.

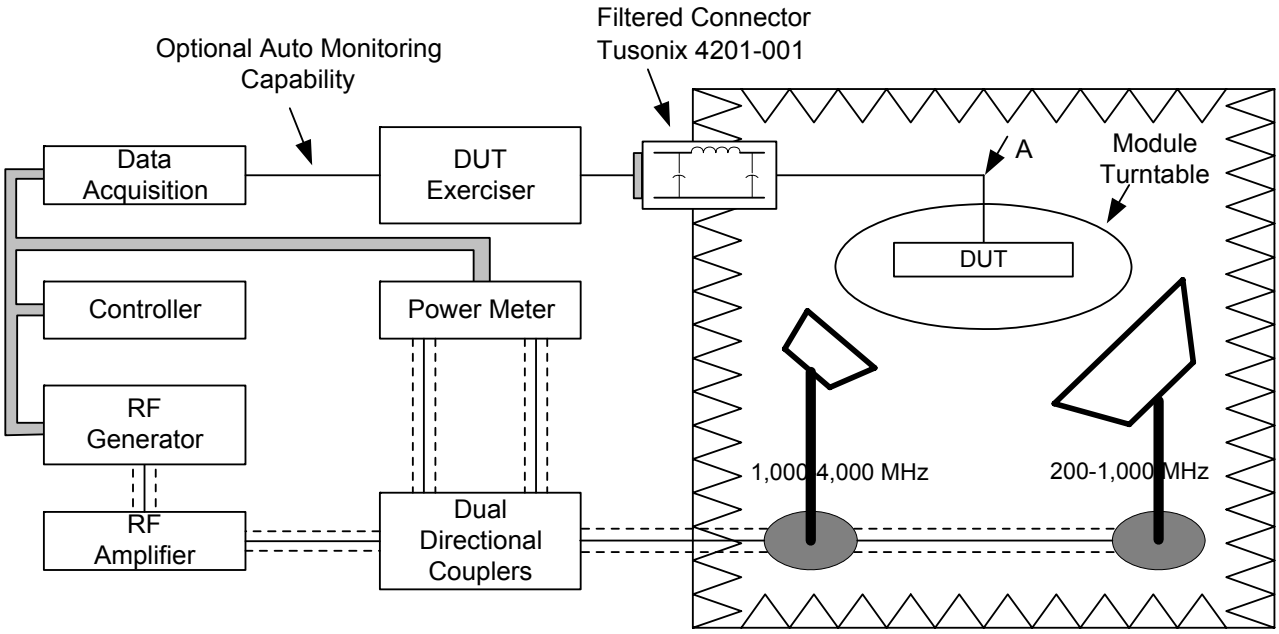



**Figure 12: Radiated Immunity Test in an ALSE without a Ground Plane**

- Use substitution method with forward power and specified uniformity.
- The antenna shall be sighted on the DUT.
- DUT to point “A” is an unshielded wiring harness of 600 ± 50 mm in length.
- From point “A”, the harness goes vertically 1 meter to the floor and along the floor to the wall bulkhead feedthrough filter.
- The DUT shall be 1 meter above the floor.
- The DUT shall be a minimum of 1 meter from the antenna and any other conductive surface and a minimum of 1 meter from any absorber.
- Vertical polarization shall be used.
- The DUT shall be tested in three mutually perpendicular orientations (principal planes): (i) with the main circuit board in the DUT parallel to the chamber floor (vehicle mounting surface down), (ii) with the main circuit board perpendicular to the chamber floor edge on to the antenna and (iii) with the main circuit board perpendicular to the chamber floor and broadside to the antenna. These three orientations shall be chosen from the six possible orthogonal orientations, to allow visibility of the DUT, if required, and to maintain a consistent and repeatable routing of the DUT harness and direct exposure of DUT apertures to the antenna.
- For modules in a metal case, the DUT connector(s) should be orientated upward or toward the antenna and only this one orientation is required.
- Wiring harness routing shall be controlled and documented.

## 7.5 TEM Cell Test

Subcategory C components shall be subjected to radiated immunity testing with reference to ISO 11452-3 over the frequency range of 1 to 200 MHz. The TEM cell used shall have a VSWR not to exceed 1.3:1 (empty cell) from 1 to 200 MHz. The TEM cell shall have a feedthrough filter assembly to provide RF isolated interfacing between the DUT and its system simulator outside the cell. A similar setup using a wideband TEM (GTEM) is acceptable for this frequency range. ALSE testing is another alternative. For additional information on setup and testing refer to DC-11225, Annex H.

### 7.5.1 Requirement

From 1 to 30 MHz, the basic test level is 150 V/m for Group A, B and C functions and 200 V/m for Group D functions. From 30 MHz to 200 MHz, the basic test level is 70 V/m and the HIRF test level is 150 V/m for Group A, B and C functions; the basic test level is 100 V/m and the HIRF level is 200 V/m for Group D functions. The immunity performance requirements are specified in Table 18 and the test levels in Figures 13 and 14.

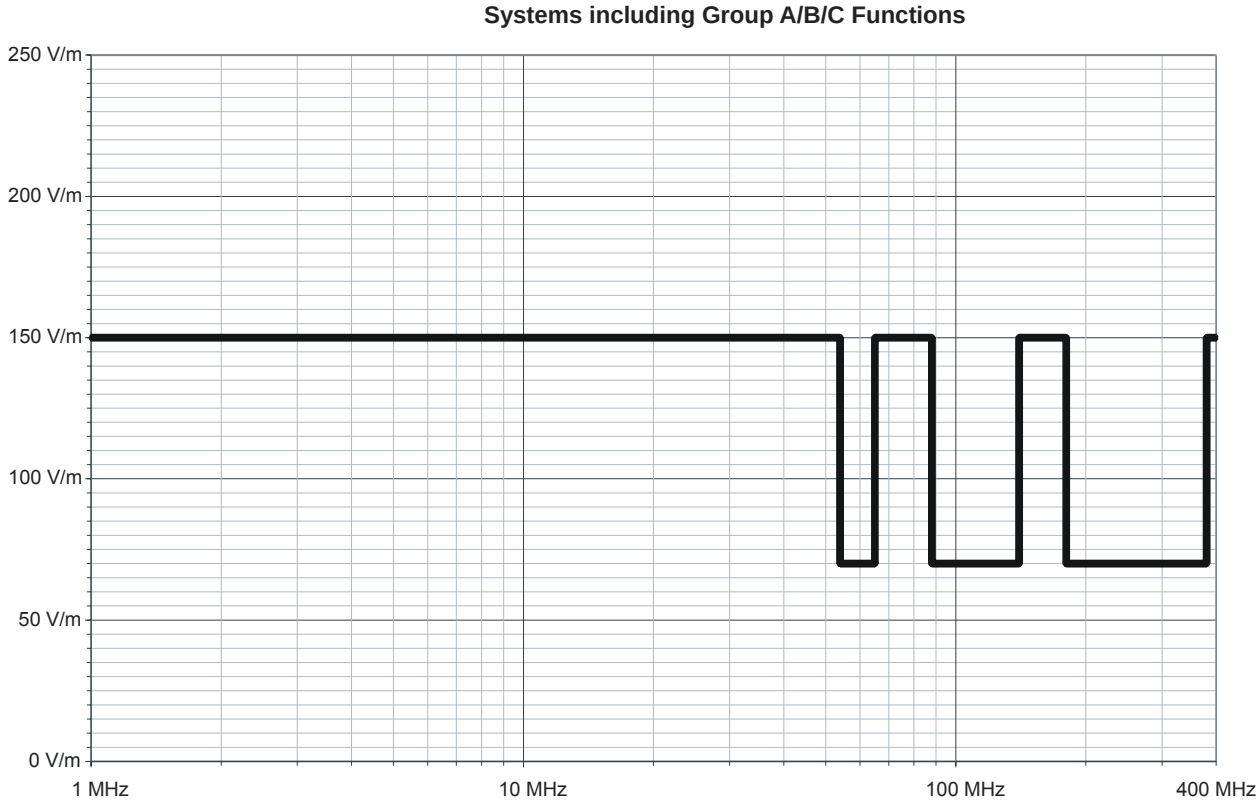



**Figure 13: Test Levels for TEM Testing, Group A, B, C**

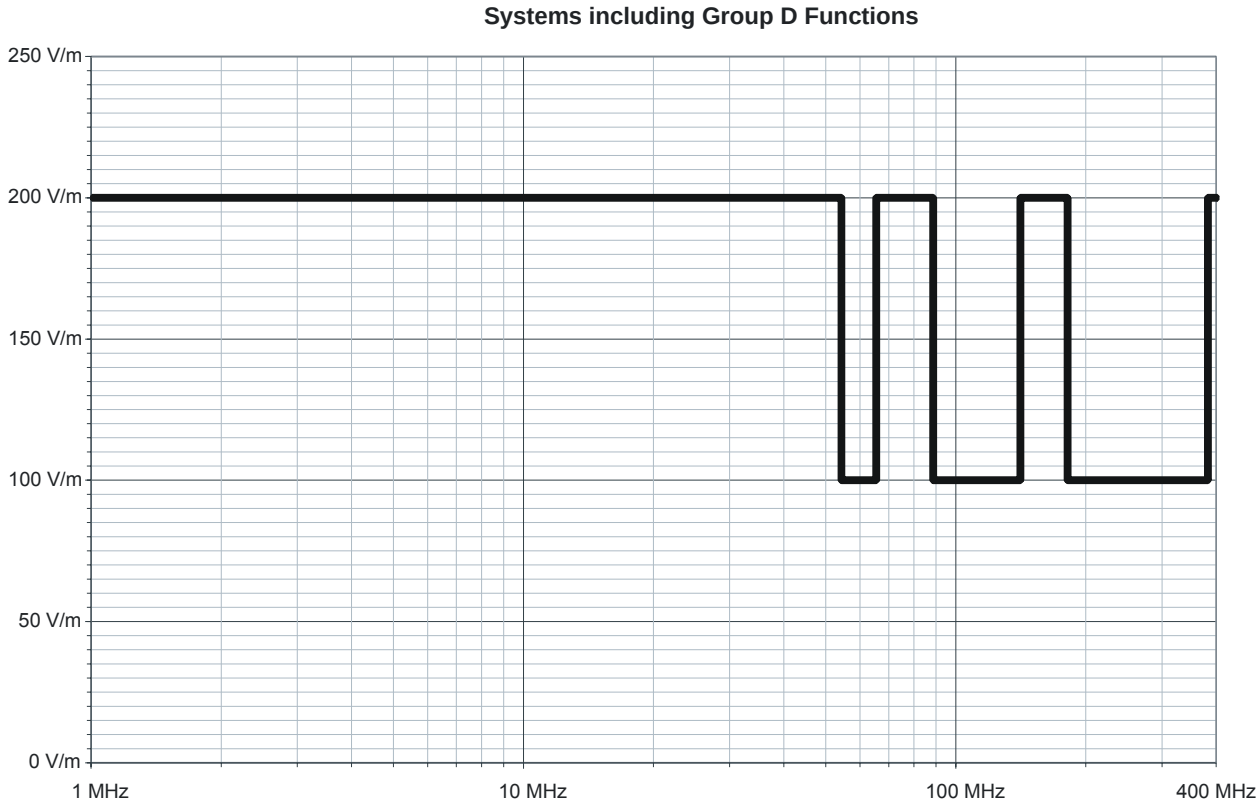



**Figure 14: Test Levels for TEM Testing, Systems including Group D functions**

The top level of Table 18, shaded gray, is only evaluated if the DUT has a Group D function.

**Table 18: TEM Cell Immunity Performance Requirements, 1 to 200 MHz, Group A, B, C and D**

| Test Level [V/m] | Group A Status | Group B Status | Group C Status | Group D Status |
|---|---|---|---|---|
| **> 150 to ≤ 200** | IV | IV | III | II |
| **> 100 to ≤ 150** | III | III | II | I |
| **> 70 to ≤ 100** | II | II | I | |
| **> 35 to ≤ 70** | | I | | |
| **≤ 35** | I | | | |

### 7.5.2 Test setup

Details on the test setup are given in ISO 11452-3 and in Figure 15.

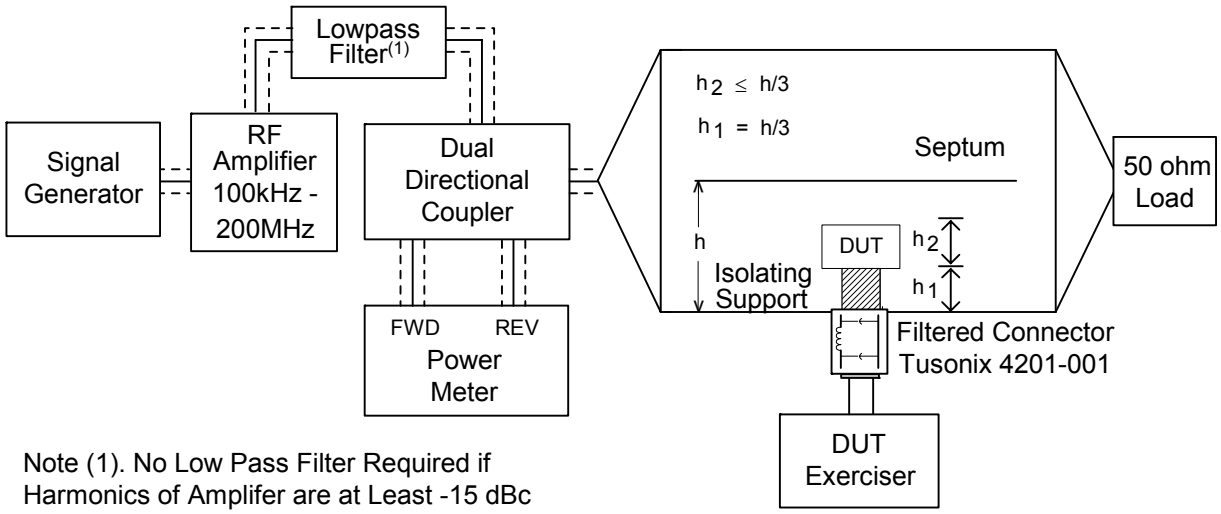



**Figure 15: TEM Immunity Test Setup**

Deviating from ISO 11452-3:

- The forward power required to achieve the specified field strengths shall be calculated with the formula in ISO 11452-3 using the actual impedance over frequency as measured for the TEM cell being used. To verify this calculation, the field strength achieved in an empty cell shall be measured using a field strength probe.
- The use of a feedthrough filter assembly is required, not optional.
- The DUT shall be connected to the filter assembly with an unshielded wiring harness of 600 ± 50 mm in length running diagonally from the DUT connector(s) to the TEM cell bulkhead connectors. The orientation of this harness in the TEM cell shall be controlled and documented. Any excess DUT harness shall be fastened with nonconductive tape to the TEM cell floor at the bulkhead connector end.
- The DUT shall be located in the approximate center of the TEM cell, midway between the septum and floor; it may be shifted off center to allow for a direct harness routing but it shall remain in the center two thirds volume of the cell. The position of the DUT shall be consistent and documented.
- DUT shall be tested in two orthogonal orientations: (i) with the main circuit board in the DUT parallel to the TEM cell floor (vehicle mounting surface down) and (ii) with the main circuit board perpendicular to the TEM cell floor or rotated 90 degrees about its vertical axis if perpendicular to the cell floor is not feasible due to exceeding the 1/3 floor to septum distance. These two orientations shall be chosen from the six possible orthogonal orientations, to allow visibility of the DUT, if required, and to maintain a consistent and repeatable routing of the DUT harness.
- The DUT connector(s) should be orientated toward the TEM cell door.
- The VSWR shall be monitored with the DUT under test. If this VSWR is greater than 1.5:1, the location of the DUT and / or routing of the wiring harness shall be adjusted to reduce the VSWR below 1.5:1 if possible, if not the data is indeterminate. The VSWR information shall be included in the test report.

## 8 Magnetic Field Immunity

For subcategory MS modules only: DUTs that incorporate components sensitive to magnetic fields (e.g. Hall effect sensors or magnetic pickups) shall be subjected to magnetic field immunity testing as described in MIL-STD-461E with the frequency range extended down to 15 Hz. For vehicle applications where the battery is located other than in the engine compartment, the routing of high current carrying conductors near vehicle electronics raises the magnetic environment.

## 8.1 Requirements

Subcategory MS DUTs shall not be affected by a magnetic flux density of 160 dBpT (dB picotesla) from 15 Hz to 60 Hz and above 60 Hz this flux density shall decrease at a rate of 6 dB per octave to 106 dBpT at 30 kHz (Fig. 16). Subcategory MS DUTs in severe magnetic environments (e.g. located within 0.5 m of a battery cable or other power feed carrying 50 A or more of current) shall not be affected by a flux density of 160 dBpT from 15 Hz to 30 kHz (Fig. 17).

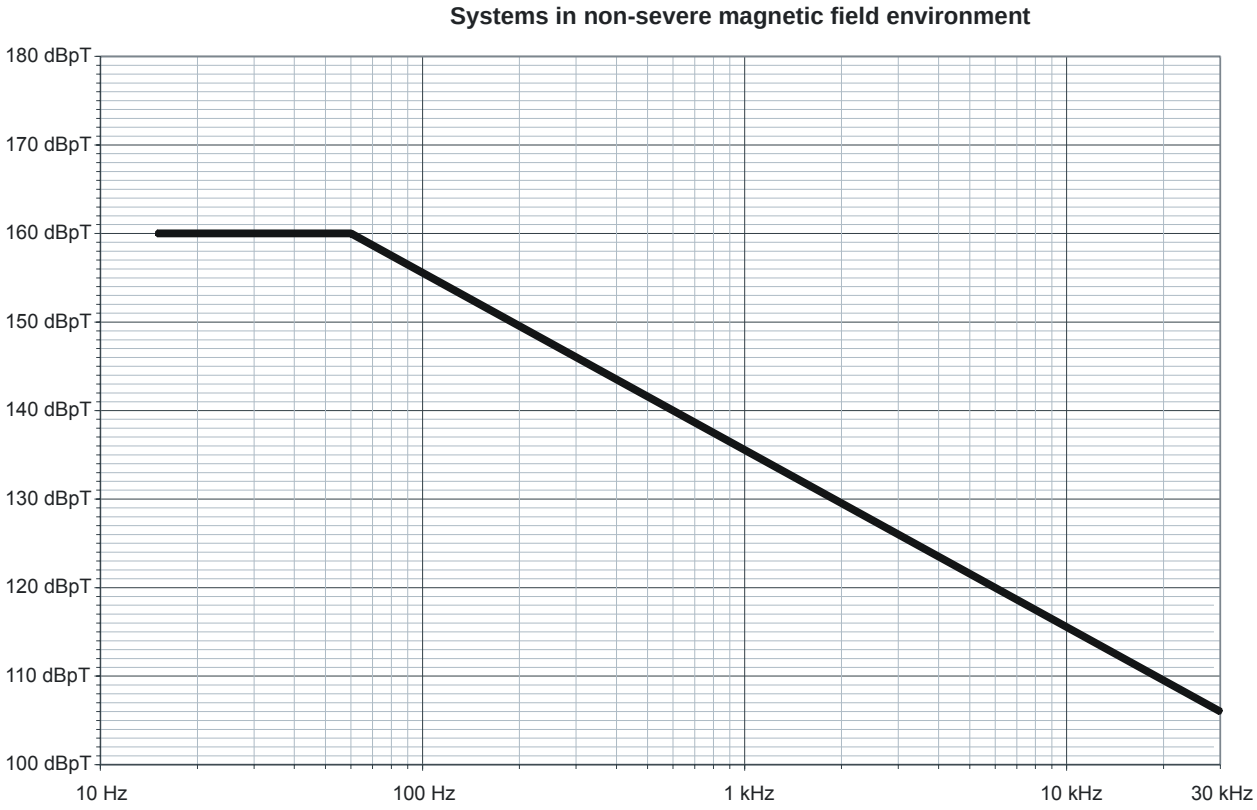



**Figure 16: Test Levels for DUTs in a non-severe magnetic field environment**

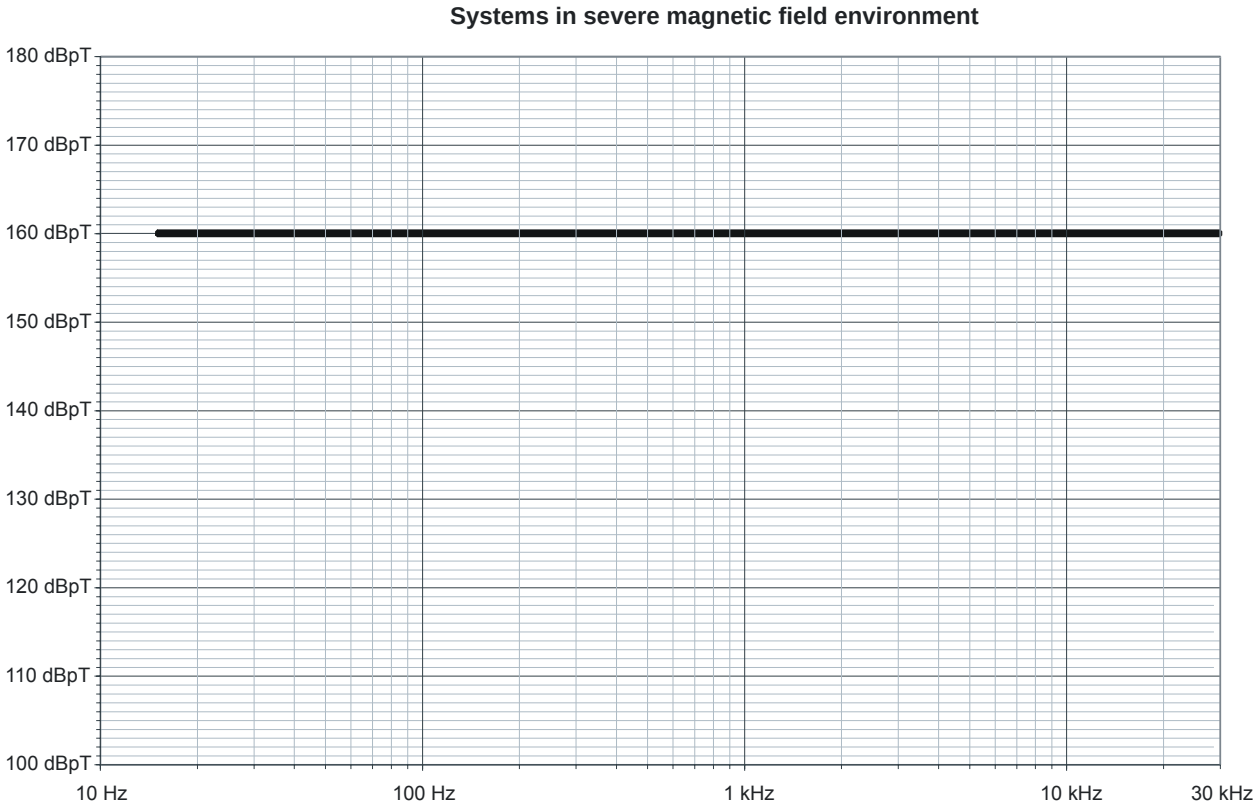



**Figure 17: Test Levels for DUTs in a severe magnetic field environment**

## 8.2 Test

- Test frequency steps shall be at least 10 per decade (equivalent to logarithmic steps of 23.28%).
- The DUT shall be exposed to a flux density of 160 dBpT from 15 Hz to 60 Hz using a sine wave test signal.
- For DUTs not in a severe magnetic field environment, the DUT shall be exposed to a 60 Hz square wave test signal that generates 160 dBpT amplitude of the 60 Hz component of the test signal.
- For DUTs not in a severe magnetic field environment, the sine wave scan using the 6 dB per octave decreasing limit shall be performed only if there are effects noted during the square wave test.
- DUTs in severe magnetic environments shall be tested at 160 dBpT over the full frequency range.
- Bus modules and systems shall be evaluated for increased ignition off current draw (IOD) resulting from inadvertent wake up from standby or power-down modes during magnetic exposure.
- A Helmholtz coil may be used with three mutually orthogonal orientations of the DUT instead of the six positions of the test coil shown in Figure 18.

### 8.2.1 Test Setup

Refer to Figure 18 for test setup.

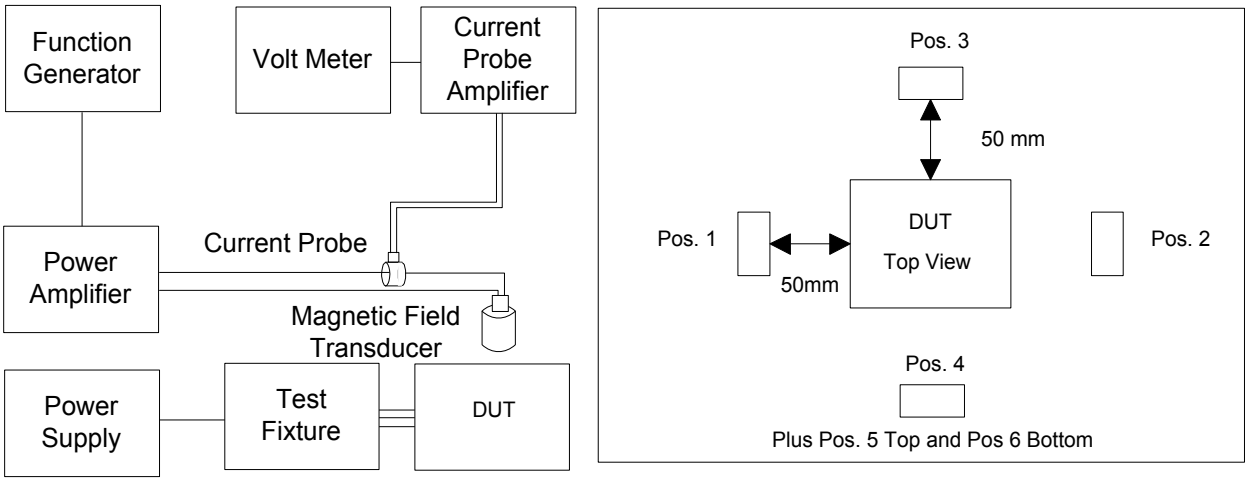



**Figure 18: Magnetic Immunity Test Setup**

# 9 Transient Immunity

## 9.1 Transient Disturbances Conducted along Supply Lines

### 9.1.1 Requirement

The DUT shall be subjected to repetitive voltage spikes with reference to ISO 7637-2. The DUT shall be monitored during operation while being subjected to the supply voltage transients as specified for the appropriate system voltage in Tables 20 to 24. These pulses are applied individually to each battery and ignition line and any inputs or outputs supplied from battery or ignition voltage as configured in a DUT's complete system. The DUT shall also be tested in a powered-down state, if appropriate, to check for inadvertent turn on (applies to modules that have logic power-up capability). For all the supply voltage transients, there shall be no damage to the DUT, no lockups of the DUT requiring power off reset and no effect on stored data or false diagnostic indication (Status II, except where specified otherwise). The DUT shall be tolerant of transient voltages generated by the operation of its own system (Status I). Refer to Table 19.

**Table 19: Supply Voltage Transients - Immunity Requirements**

| Transient Pulse | Performance Status Group A | Performance Status Groups B, C and D |
|---|---|---|
| **Pulse #1** | II | II |
| **Pulse #1b** | II | I |
| **Pulse #2** | II | I |
| **Pulse #3a** | II | I |
| **Pulse #3b** | II | I |

Note: Pulse # 1 includes a 200 ms dropout during which some DUT may reset. In this case, Status II applies for the specified test interval (the DUT shall recover normal operation at the end of the test). Pulse #1b is a positive transient and has no dropout.

DUT powered from regulated supplies in other modules (subcategory S) shall be tested as a system with the sourcing module or an equivalent power supply. This requirement is waived if the sourcing module product specification provides that, when subjected to the supply voltage transients, the output of the sourcing module's regulated supply meets the requirements of the supplied module.

For components with several supply voltage connections, the disturbance emission of the second connection shall be measured during immunity testing of the first, i.e. where the 42 V terminals of one DUT are exposed to test pulses the disturbance emission of the 12 V supply connections shall be measured and vice versa. In this process, the disturbance voltage emission shall not exceed the limit values specified in paragraph 6.5.1.

### 9.1.2 Test Conditions

All pulses shall be applied for 10 min each.

### 9.1.3 Test Setup

For devices with one supply voltage connection, refer to ISO 7637-2 for the test setup. Figure 19 illustrates the test setup for devices with 2 supply voltage connections, e.g. DC/DC converters.

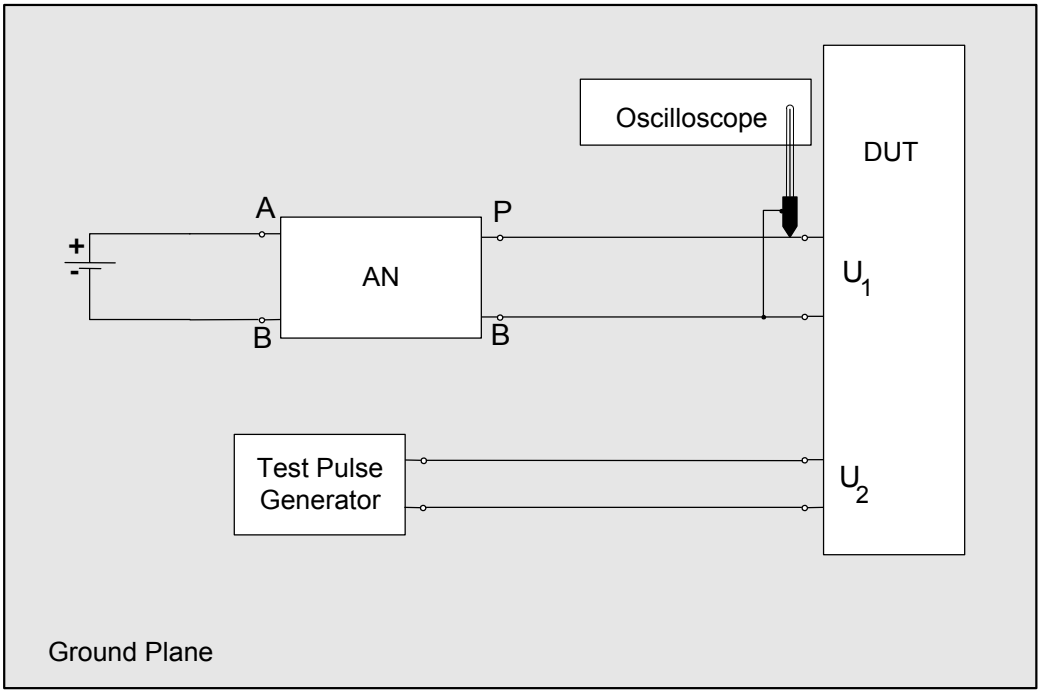
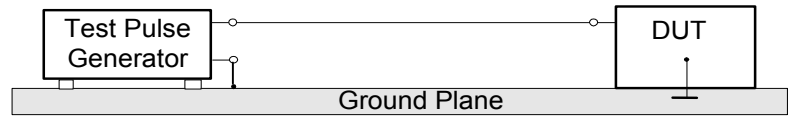
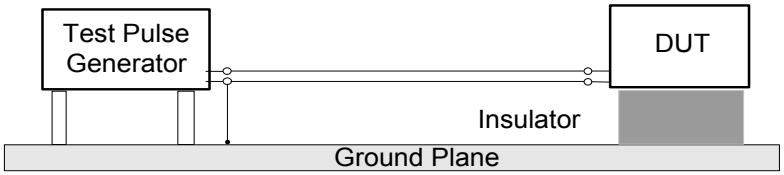



**Figure 19: Test Setup for Devices with Two Voltage Supply Connections**

Electrically asymmetrical and electrically symmetrical devices under test shall be connected as illustrated in Figure 20. (The oscilloscope, probe and switch or relay are not illustrated.)




a) DUT with Asymmetrical Connection




b) DUT with Symmetrical Connection

**Figure 20: Connection of the DUT**

- Devices under test where the ground connection in the vehicle is via the vehicle body shall be placed directly on the ground plane and connected with it. The ground plane serves as ground connection of the DUT with the test pulse generator, refer to Figure 20, example a).
- Devices under test where the ground connection in the vehicle is via dedicated cable shall be placed on a 50 mm high insulating base, refer to Figure 20, example b).
- Lines between the DUT and the test pulse generator shall be routed at a height of 50 mm above the ground plane and shall be 500 mm in length.

### 9.1.4 Test pulses

#### 9.1.4.1 Test pulse 1

Test pulse 1 simulates the switch-off of a supply voltage to an inductance switched parallel to the DUT. All supply lines shall be exposed to this test pulse. It is defined by Figure 21 and Table 20.

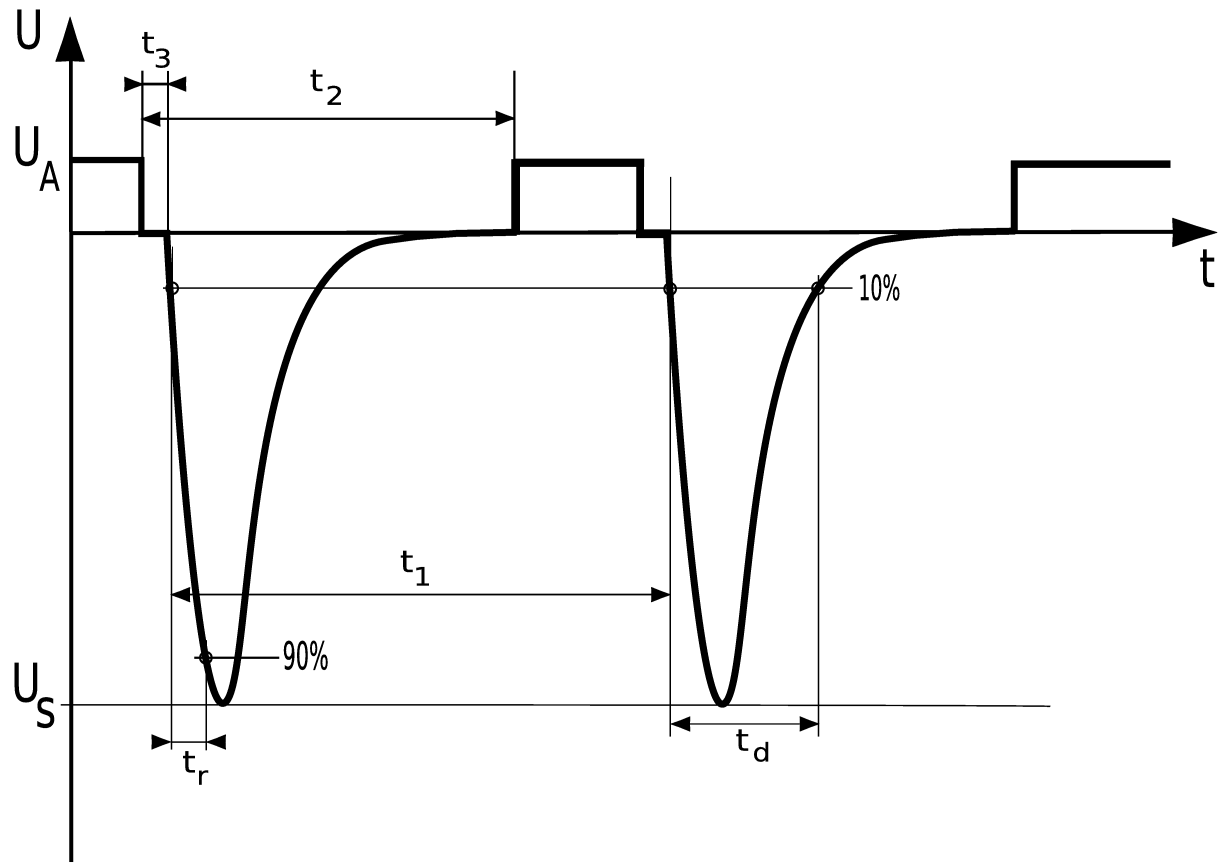



**Figure 21: Test Pulse 1**

**Table 20: Test Pulse 1 - Parameters**

| Parameters | 12 V System | 24 V System | 42 V System |
|---|---|---|---|
| $U_A$ in V | 13.5 | 27 | 42 |
| $U_s$ in V | -100 | -600 | -100 |
| $t_r$ in µs | 1 | 1 | 1 |
| $t_d$ in ms | 2 | 2 | 2 |
| $t_1$ in s | 5 | 5 | 5 |
| $t_2$ in ms | 200 | 200 | 200 |
| $t_3$ in µs | ≤ 100 | ≤ 100 | ≤ 100 |
| $R_i$ in ohms | 10 | 50 | 10 |
| Test duration in min | 10 | 10 | 10 |

#### 9.1.4.2 Test Pulse 1b

Pulse #1b simulates switched inductive operating loads. It is defined by Figure 22 and Table 21 and an inverted waveform of Pulse #1 with no supply voltage power off.

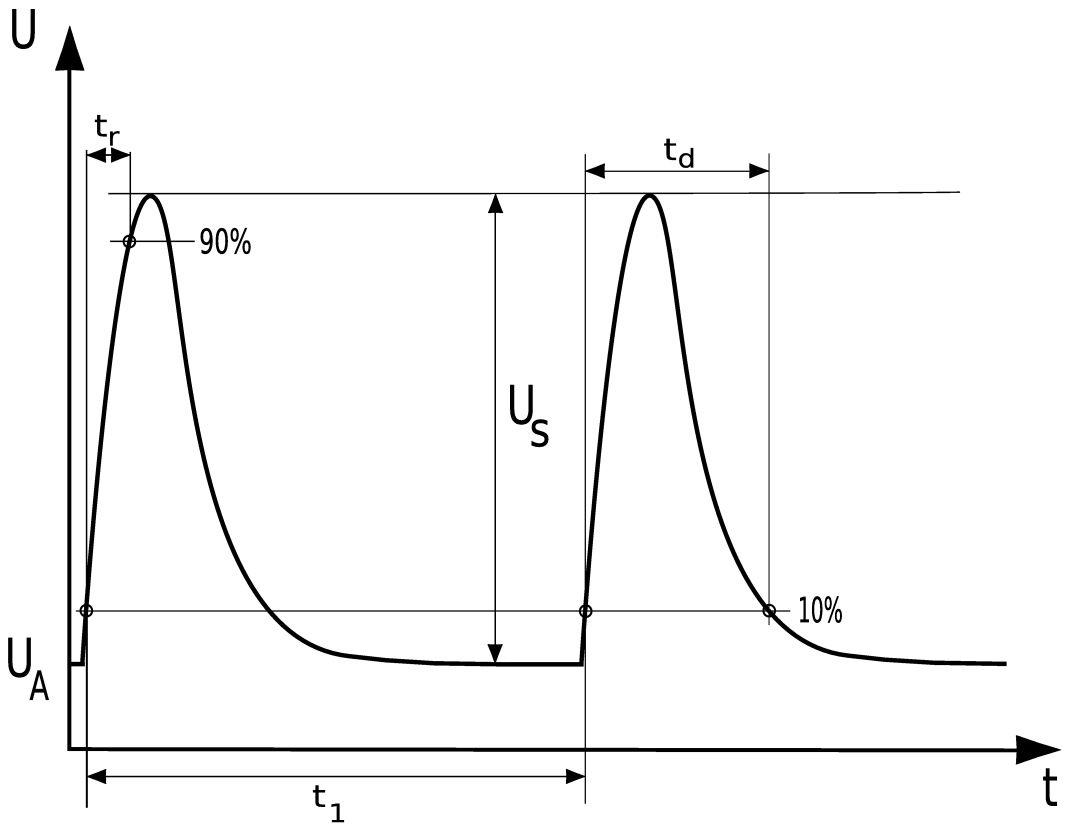



**Figure 22: Test Pulse 1b**

**Table 21: Pulse 1b - Parameters**

| Parameters | 12 V System | 24 V System | 42 V System |
|---|---|---|---|
| $U_A$ in V | 13.5 | 27 | 42 |
| $U_s$ in V | 40 | 50 | 40 |
| $t_r$ in µs | 1 | 1 | 1 |
| $t_d$ in ms | 1.5-2 | 1.5-2 | 1.5-2 |
| $t_1$ in s | 5 | 5 | 5 |
| $R_i$ in ohms | 10 | 10 | 10 |
| Test duration in min | 10 | 10 | 10 |

**Test pulse 2**

Test pulse 2 simulates the interruption of a current through an inductance switched in series with the DUT. All supply lines shall be exposed to this test pulse. It is defined by Figure 23 and Table 22.

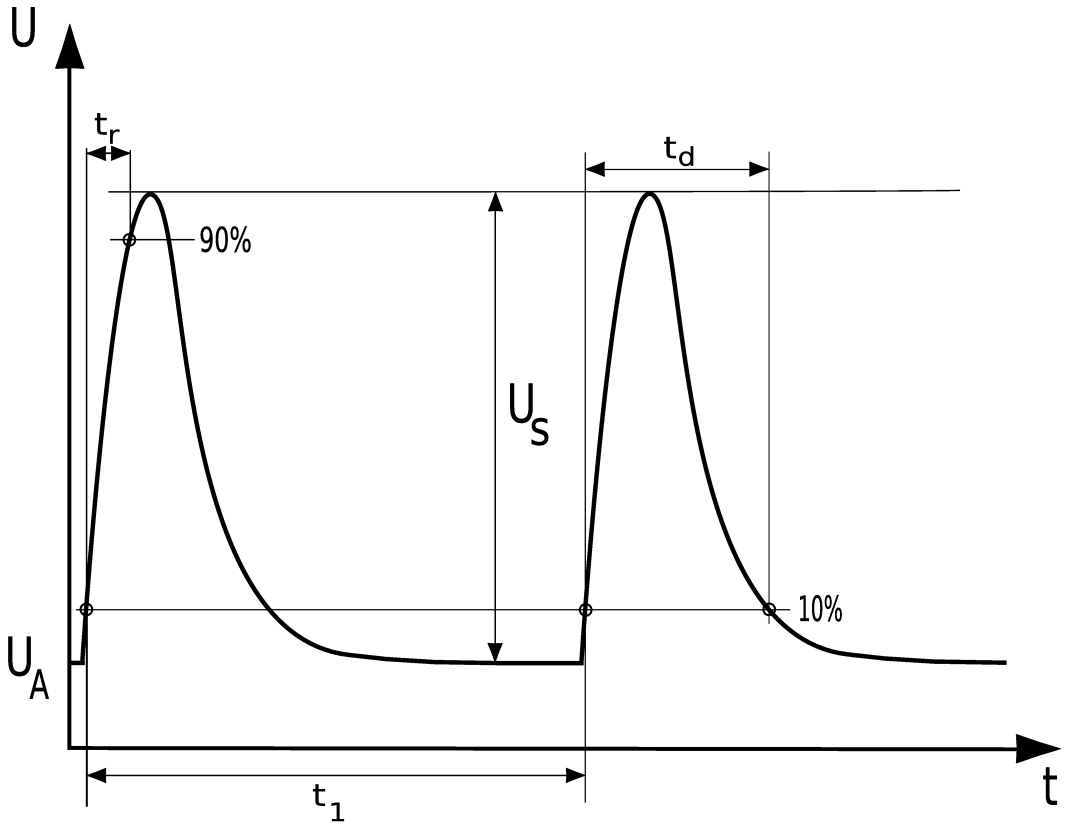



**Figure 23: Test Pulse 2**

**Table 22: Test pulse 2 – Parameters**

| Parameters | 12 V System | 24 V System | 42 V System |
|---|---|---|---|
| $U_A$ in V | 13.5 | 27 | 42 |
| $U_s$ in V | 100 | 150 | 100 |
| $t_r$ in µs | 1 | 1 | 1 |
| $t_d$ in µs | 50 | 50 | 50 |
| $t_1$ in s | 0.5 | 0.5 | 0.5 |
| $R_i$ in ohms | 2 | 2 | 2 |
| Test duration in min | 10 | 10 | 10 |

#### 9.1.4.3 Test Pulses 3a and 3b

Test pulses 3a and 3b simulate the pulse bursts generated during switching operations (e.g. in relays).

**Test Pulse 3a**

Test pulse 3a simulates the negative pulses. It is defined by Figure 24 and Table 23.

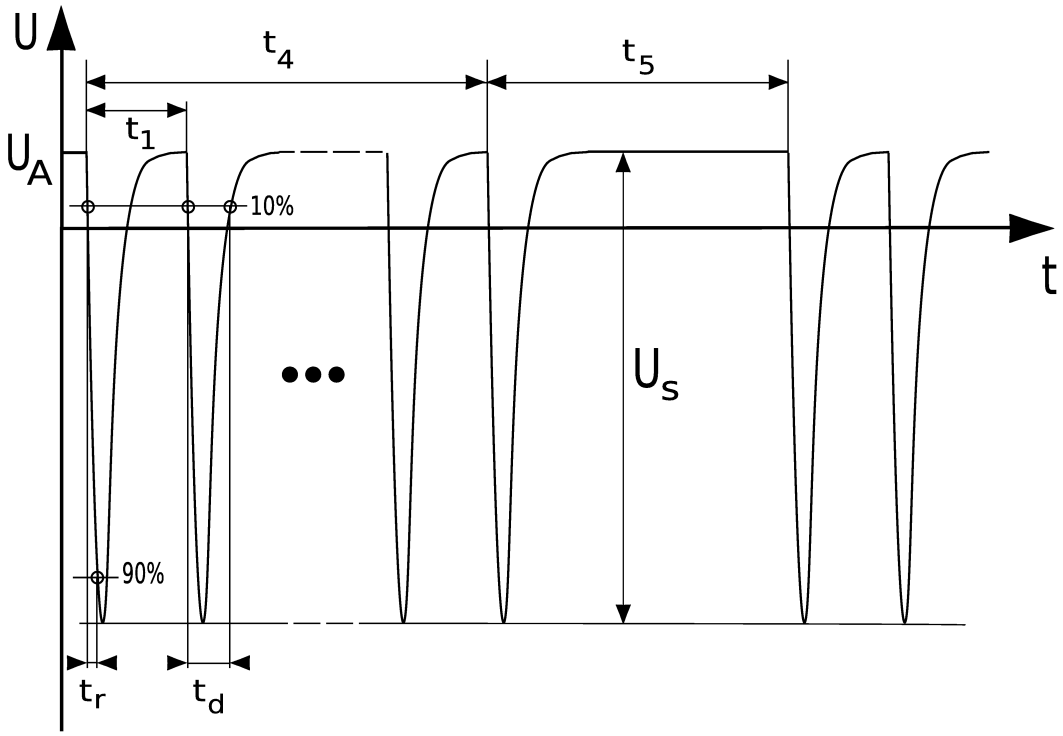



**Figure 24: Test Pulse 3a**

**Table 23: Test Pulse 3a - Parameters**

| Parameters | 12 V System | 24 V System | 42 V System |
|---|---|---|---|
| $U_A$ in V | 13.5 | 27 | 42 |
| $U_s$ in V | -150 | -200 | -150 |
| $t_r$ in ns | 5 | 5 | 5 |
| $t_d$ in µs | 0.1 | 0.1 | 0.1 |
| $t_1$ in µs | 100 | 100 | 100 |
| $t_4$ in ms | 10 | 10 | 10 |
| $t_5$ in ms | 90 | 90 | 90 |
| $R_i$ in ohms | 50 | 50 | 50 |
| Test duration in min | 10 | 10 | 10 |

- **Test Pulse 3b**

Test pulse 3b simulates the positive pulses. It is defined by Figure 25 and Table 24.

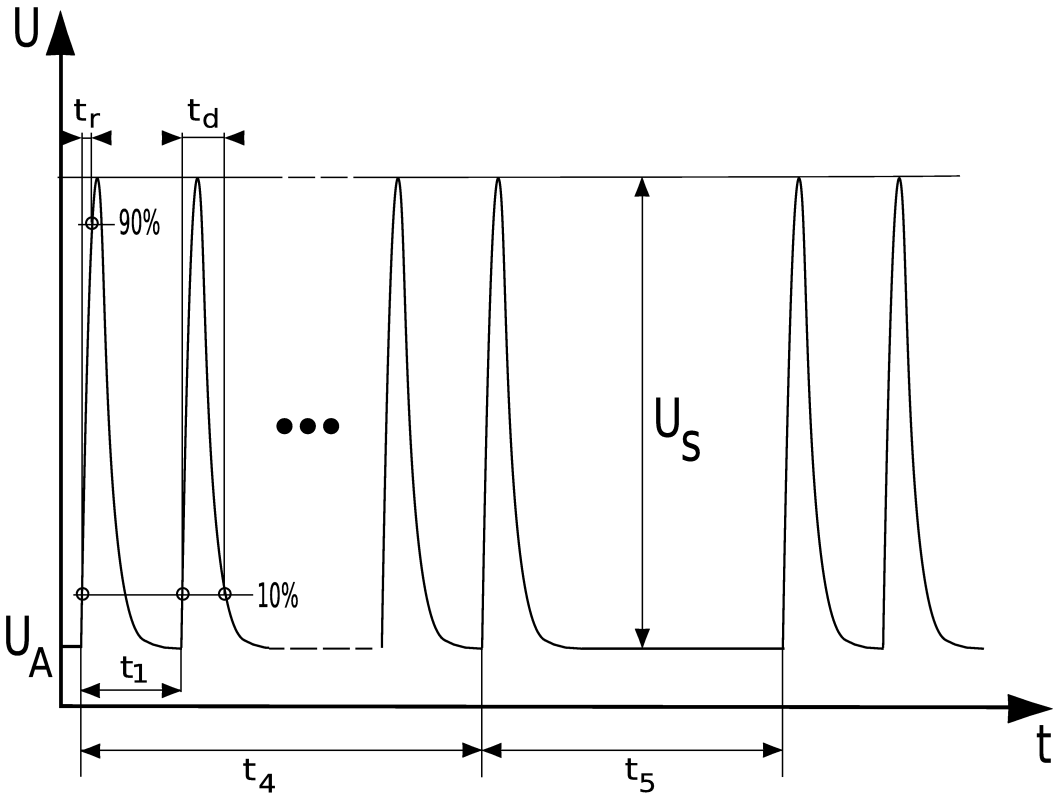



**Figure 25: Test Pulse 3b**

**Table 24: Test Pulse 3b - Parameters**

| Parameters | 12 V System | 24 V System | 42 V System |
|---|---|---|---|
| $U_A$ in V | 13.5 | 27 | 42 |
| $U_s$ in V | 100 | 200 | 100 |
| $t_r$ in ns | 5 | 5 | 5 |
| $t_d$ in µs | 0.1 | 0.1 | 0.1 |
| $t_1$ in µs | 100 | 100 | 100 |
| $t_4$ in ms | 10 | 10 | 10 |
| $t_5$ in ms | 90 | 90 | 90 |
| $R_i$ in ohms | 50 | 50 | 50 |
| Test duration in min | 10 | 10 | 10 |

## 9.2 Transient Disturbances Conducted along I/O or Sensor Lines

### 9.2.1 Requirement

The immunity testing of lines other than power supply lines shall be carried out in accordance with ISO 7637-3. For subcategory S components, testing with Pulse #2 using both positive and negative polarity and direct capacitive coupling is also required. For subcategory S, the regulated supply line (usually 5 V) is considered an I/O line and shall also be tested. Representative loading shall be used for subcategory S components in order to assure effective evaluation of possible system risks due to vehicle transients. Components shall be subjected to voltage transients on input and output lines while monitoring the DUT during operation. There shall be no damage to the DUT, no lockups of the DUT requiring power off reset and no effect on stored data or false diagnostic indication (Status II). Group B, C and D functions of the DUT shall not be affected by these voltage transients (Status I). Refer to Table 25.

**Table 25: Transients on I/O or Sensor Lines - Immunity Requirements**

| Transient Pulse | Performance Status Group A | Performance Status Groups B, C and D |
|---|---|---|
| **Pulse # 2 (+ and –) (Subcategory S only)** | II | I |
| **Pulse a** | II | I |
| **Pulse b** | II | I |

### 9.2.2 Test Conditions

Modules shall be subjected to repetitive voltage spikes that are capacitively coupled to the line(s) under test. This may be implemented by using a capacitive coupling clamp or by direct capacitive coupling for Pulses a and b, but direct capacitive coupling is required for Pulse 2 (+ and -). These voltage transients are the pulses illustrated in Figures 27 to 30 and Tables 26 to 29. These pulses shall be applied to all input and output lines; simultaneously (CCC) or line by line (DCC) for Pulses a and b and line by line (DCC) only for Pulse 2 (+ and -). The test pulse voltages are set open circuit and are referenced to module ground. They are applied for 5 minutes each.

### 9.2.3 Capacitive Coupling Clamp (CCC) Test Setup

For a schematic diagram of the capacitive coupling clamp test setup refer to ISO 7637-3. This method applies for Pulses a and b only. Supply voltage lines are not included in the clamp for this test.

### 9.2.4 Direct Capacitor Coupling (DCC) Test Setup

Direct capacitive coupling may be used replacing the capacitive coupling clamp for Pulses a and b, and is required to couple Pulse 2 (+and-) to the DUT. Refer to Figure 26 for the test setup.

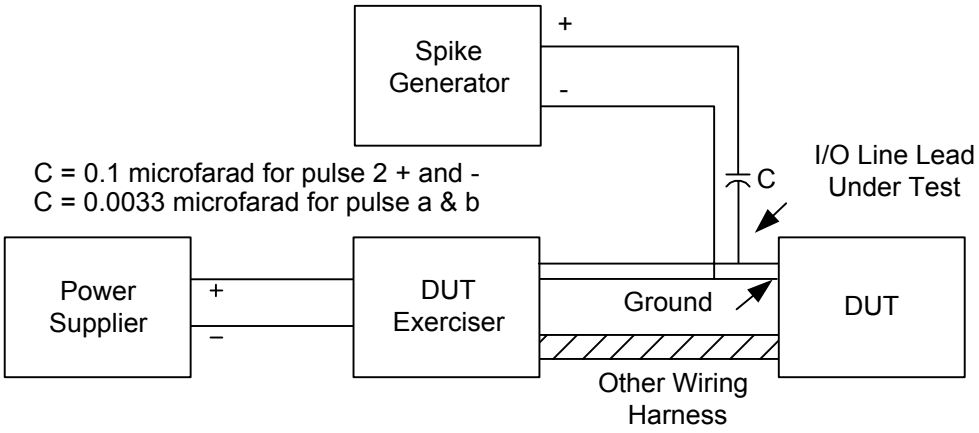



**Figure 26: Direct Capacitor Coupling Test Setup**

### 9.2.5 Test Pulses

Test Pulse 2, Positive and Negative Polarity in Figures 27 and 28 and in Tables 26 and 27.

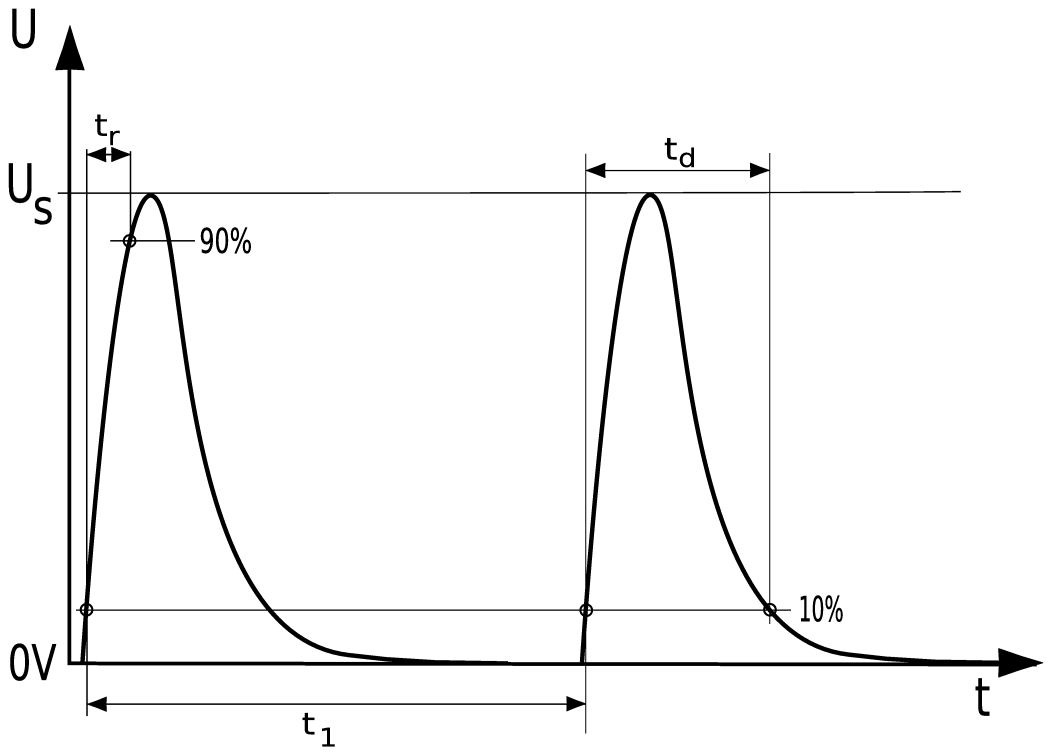



**Figure 27: Positive Pulse 2 for I/O Coupling Test**

**Table 26: Positive Pulse 2 - I/O Coupling Parameters**

| Parameters | 12 V System | 24 V System | 42 V System |
|---|---|---|---|
| $U_s$ in V | 30 | 45 | 30 |
| $t_r$ in µs | 1 | 1 | 1 |
| $t_d$ in µs | 50 | 50 | 50 |
| $t_1$ in s | 0.5 | 0.5 | 0.5 |
| $R_i$ in ohms | 10 | 10 | 10 |
| Test duration in min | 5 | 5 | 5 |

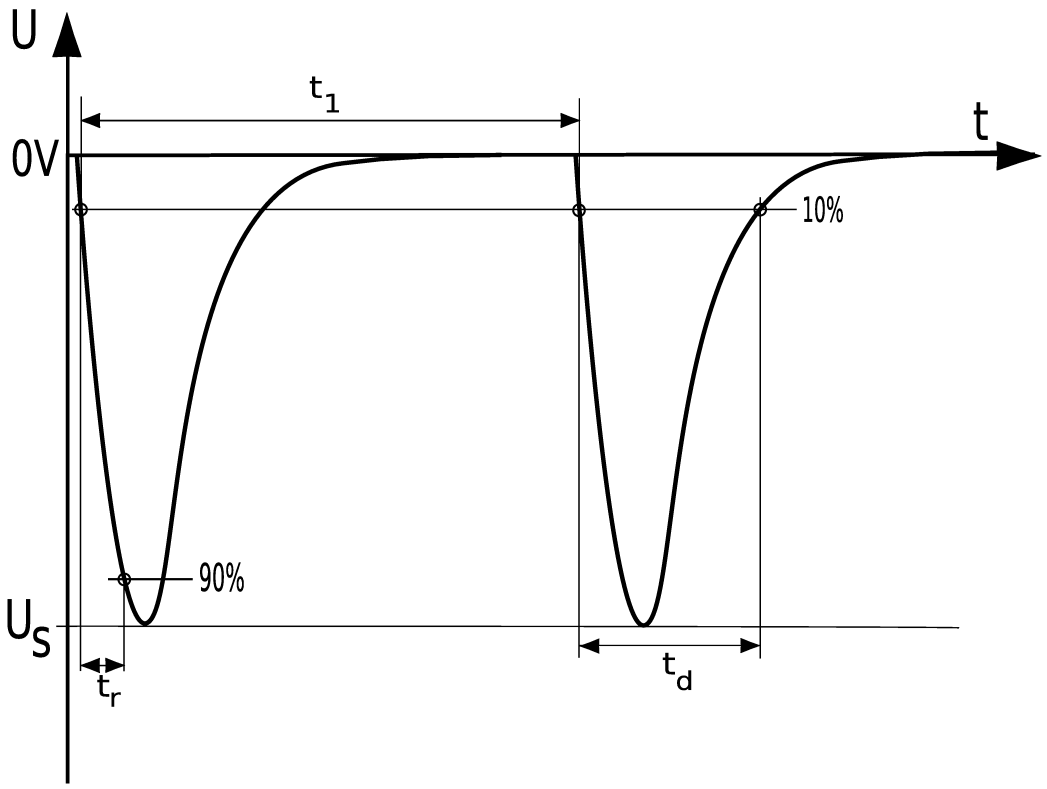



**Figure 28: Negative Pulse 2 for I/O Coupling Test**

**Table 27: Negative Pulse 2 - I/O Coupling Parameters**

| Parameters | 12 V System | 24 V System | 42 V System |
|---|---|---|---|
| $U_s$ in V | -30 | -45 | -30 |
| $t_r$ in µs | 1 | 1 | 1 |
| $t_d$ in µs | 50 | 50 | 50 |
| $t_1$ in s | 0.5 | 0.5 | 0.5 |
| $R_i$ in ohms | 10 | 10 | 10 |
| Test duration in min | 5 | 5 | 5 |

#### 9.2.5.1 Test Pulse a

This test pulse simulates the coupling of test pulse 3a onto control and signal lines. It is defined by Figure 29 and Table 28.

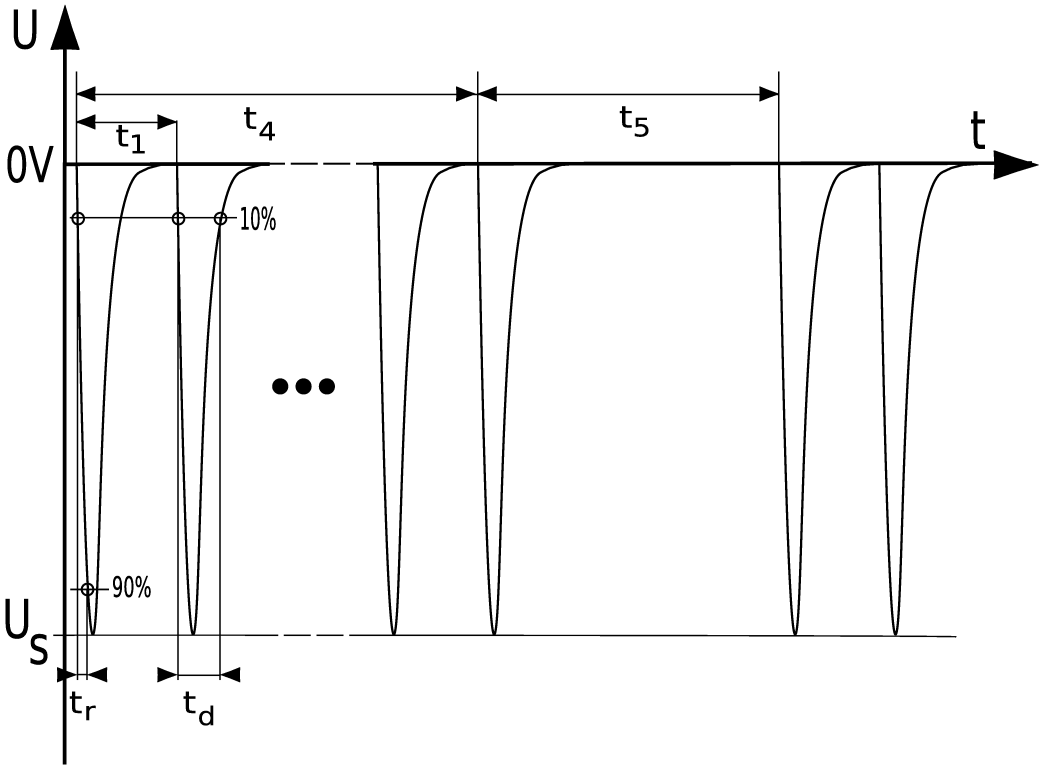



**Figure 29: Test Pulse a**

**Table 28: Test Pulse a - Parameters**

| Parameters | 12 V System | 24 V System | 42 V System |
|---|---|---|---|
| $U_s$ in V | -75 | -80 | -75 |
| $t_r$ in ns | 5 | 5 | 5 |
| $t_d$ in µs | 0.1 | 0.1 | 0.1 |
| $t_1$ in µs | 100 | 100 | 100 |
| $t_4$ in ms | 10 | 10 | 10 |
| $t_5$ in ms | 90 | 90 | 90 |
| $R_i$ in ohms | 50 | 50 | 50 |
| Test duration in min | 5 | 5 | 5 |

#### 9.2.5.2 Test pulse b

This test pulse simulates the coupling of test pulse 3b onto control and signal lines. It is defined by Figure 30 and Table 29.

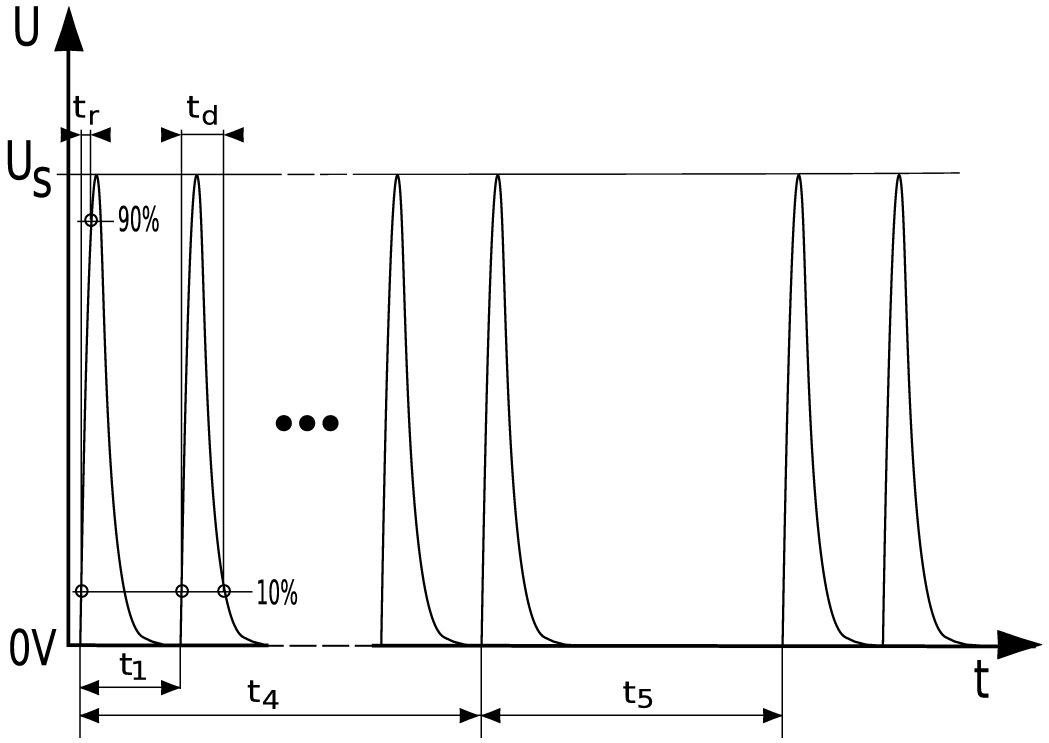



**Figure 30: Test Pulse b**

**Table 29: Test Pulse b - Parameters**

| Parameters | 12 V System | 24 V System | 42 V System |
|---|---|---|---|
| $U_s$ in V | 60 | 80 | 60 |
| $t_r$ in ns | 5 | 5 | 5 |
| $t_d$ in µs | 0.1 | 0.1 | 0.1 |
| $t_1$ in µs | 100 | 100 | 100 |
| $t_4$ in ms | 10 | 10 | 10 |
| $t_5$ in ms | 90 | 90 | 90 |
| $R_i$ in ohms | 50 | 50 | 50 |
| Test duration in min | 5 | 5 | 5 |

# 10 Electrostatic Discharge (ESD)

The immunity tests against electrostatic discharges shall be carried out in accordance with ISO 10605 and IEC 61000-4-2 with modifications as defined in this section. All DUT shall be subjected to the unpowered handling test in 10.1 and the field coupled operating test in 10.2. DUT that are readily accessible to the occupants in a vehicle, or in readily accessible under hood or trunk locations, shall also be subjected to the direct discharge operating test in 10.2. Readily accessible does not include disassembly except where required for customer serviceable items. For the operating tests, the DUT shall be put in operation with all its connected switches, displays, sensors, actuators etc. and configured as closely as possible to its intended vehicle application. Wherever possible, production intent parts shall be used. For these tests, the ambient humidity shall be monitored and maintained in the range below 60% RH. The pulse produced by the ESD simulator shall be characterized using a calibration target as described in IEC 61000-4-2. The pulse shall be measured with a storage scope (sampling rate of 2 giga samples per second minimum, 1 GHz analog bandwidth) which shall be shielded from the coaxial target and ground plane assembly. Direct contact characterization shall be used. The ESD simulator shall be capable of generating contact discharges from ±3 kV to ±25 kV.

## 10.1 ESD Handling Test

### 10.1.1 ESD Handling test requirements

For the handling (unpowered) test, there shall be no damage to the DUT and the DUT shall operate as specified, without effect on stored data, after the test. This is considered Status IV in this case as the DUT is not being monitored during the test and no judgment about effects can be made.

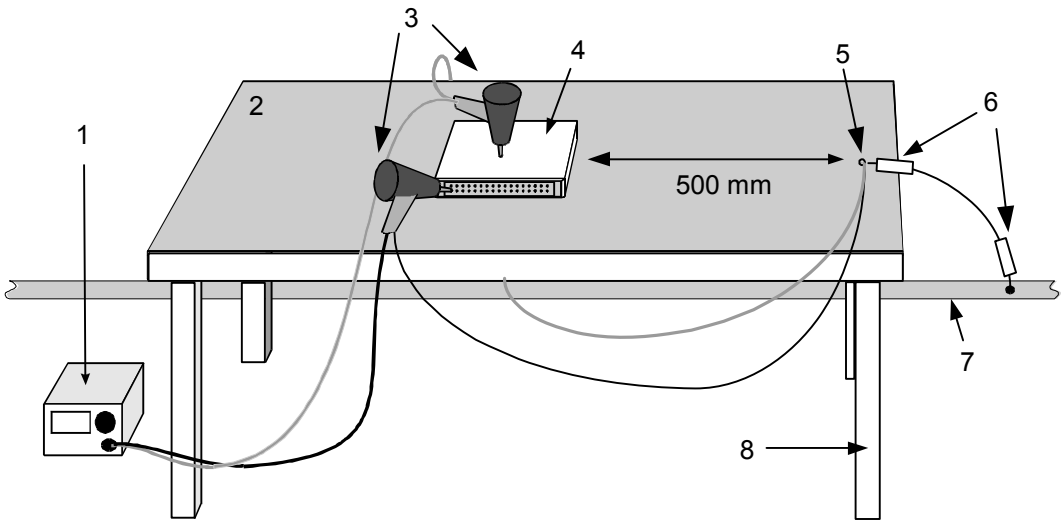
Refer to Table 30 for the requirements.

**Table 30: ESD Immunity Requirements – Handling Test**

| Non-conductive case<br>Air discharge<br>[kV] | Conductive case<br>Contact discharge<br>[kV] | Pins<br>Contact discharge<br>[kV] |
|---|---|---|
| ±8, ±15 | ±4, ±8 | ±3, ±4 |

### 10.1.2 ESD Handling test setup

For a diagram of the handling test setup, refer to Figure 31.




**Key**

1 ESD-generator main unit
2 HCP
3 ESD-generator
4 DUT
5 Ground point
6 2 x 470 k Ohm resistors to safety ground
7 Ground bar
8 Wooden table

**Figure 31: ESD Handling Test Setup**

- The HCP (horizontal coupling plane or ground plane) shall be placed on the test bench. The HCP shall be large enough so as to protrude beyond the DUT on all sides by at least 100 mm. The ESD simulator shall have its ground referenced to the HCP at a point 0.5 ± 0.1 m from the DUT as shown in Figure 31. The connection between safety ground and the HCP shall contain 2 x 470 kΩ, one at each end.
- An ESD simulator according to IEC 61000-4-2 shall be used with a discharge network of 150 pF and 330 ohms. For contact discharges the contact discharge electrode shall be used, for air discharges use the air discharge electrode. The ESD simulator power supply unit may be placed on the floor, a cart, or on a 50 mm insulating spacer on the HCP no closer than 200 mm to the DUT.
- The DUT, with all leads disconnected, shall be centered on the HCP and placed directly on the HCP.If the case is conductive, it shall be grounded to the HCP.

### 10.1.3 ESD Handling test conditions

- Before testing commences, the discharge voltage of the ESD simulator shall be verified.
- Discharge points on the DUT case: Potentially all points that can be touched by the user during packaging, installation or dismantling. The individual discharge points shall be specified in the test plan. For non-conductive cases, apply air discharges to the case, for conductive cases apply contact discharges to the case.
- Discharge points on the connector pins: In the case where the connector(s) on the DUT are configured so that individual pins are not readily accessible, or the pins are closely spaced such that discharge to individual pins is not practical, then an extender cable shall be used. This cable shall be

100 mm in length (solid wire recommended) and discharges shall be made to the fanned out leads at the end of this cable. Apply contact discharges to the pins.

- For each of the required discharge voltages, 3 discharges of positive and 3 discharges of negative polarity shall be performed at each of the specified discharge points.
- Between two individual discharges, the charge applied shall be removed via a grounded discharge resistor with approximately 1 megohm resistance (e.g. 2 × 470 kohm resistors in series) by touching the discharge point (DUT, case or pins). Alternatively, at least 5 s can be allowed to pass between two discharges.
- After all discharges have been carried out at each voltage level, a functional performance test shall be conducted. This includes the measurement of the ignition-off current draw. The results shall be documented in the test report.

### 10.2 ESD Operating Tests

There are two ESD Operating Tests, Direct Coupled and Field Coupled.

#### 10.2.1 ESD Operating Test Requirements

The DUT shall be monitored during operation. There shall be no lockups of the DUT requiring power off reset. The ESD Test Levels are in Table 31 and 33, the ESD Immunity Requirements are in Table 32 and 34.

**Table 31: ESD Operating Test Levels for Direct Discharges**

| Requirement | Direct coupled Air discharges [kV] (conductive and non-conductive points) | Direct coupled Contact discharges [kV] (conductive points only) |
|---|---|---|
| **Systems without Group C and D functions** | ±4, ±8, ±15 | ±3, ±4, ±8 |
| **Systems including Group C functions** | ±4, ±8, ±15, ±20 | ±3, ±4, ±8 |
| **Systems including Group D functions** | ±4, ±8, ±15, ±20, ±25 | ±3, ±4, ±8 |

**Table 32: ESD Operating Immunity Requirements for Direct Discharges**

| Test Voltage [kV] | Group A Status | Group B Status | Group C Status | Group D Status |
|---|---|---|---|---|
| **± 25** | Above Requirements | Above Requirements | Above Requirements | I |
| **± 20** | Above Requirements | Above Requirements | II | I |
| **± 15** | II | II | I | I |
| **± 8** | II | I | I | I |
| **± 4** | II | I | I | I |
| **± 3** | II | I | I | I |

The top level of Table 32, shaded gray, is only evaluated if the DUT has a Group D function.

**Table 33: ESD Operating Test Levels for Field Coupled Test**

| Requirement | Field Coupled<br>Contact discharges<br>[kV]<br><br>(contact discharge to test islands) |
|---|---|
| **Systems without Group D functions** | ±8, ±15, ±20 |
| **Systems including Group D functions** | ±8, ±15, ±20, ±25 |

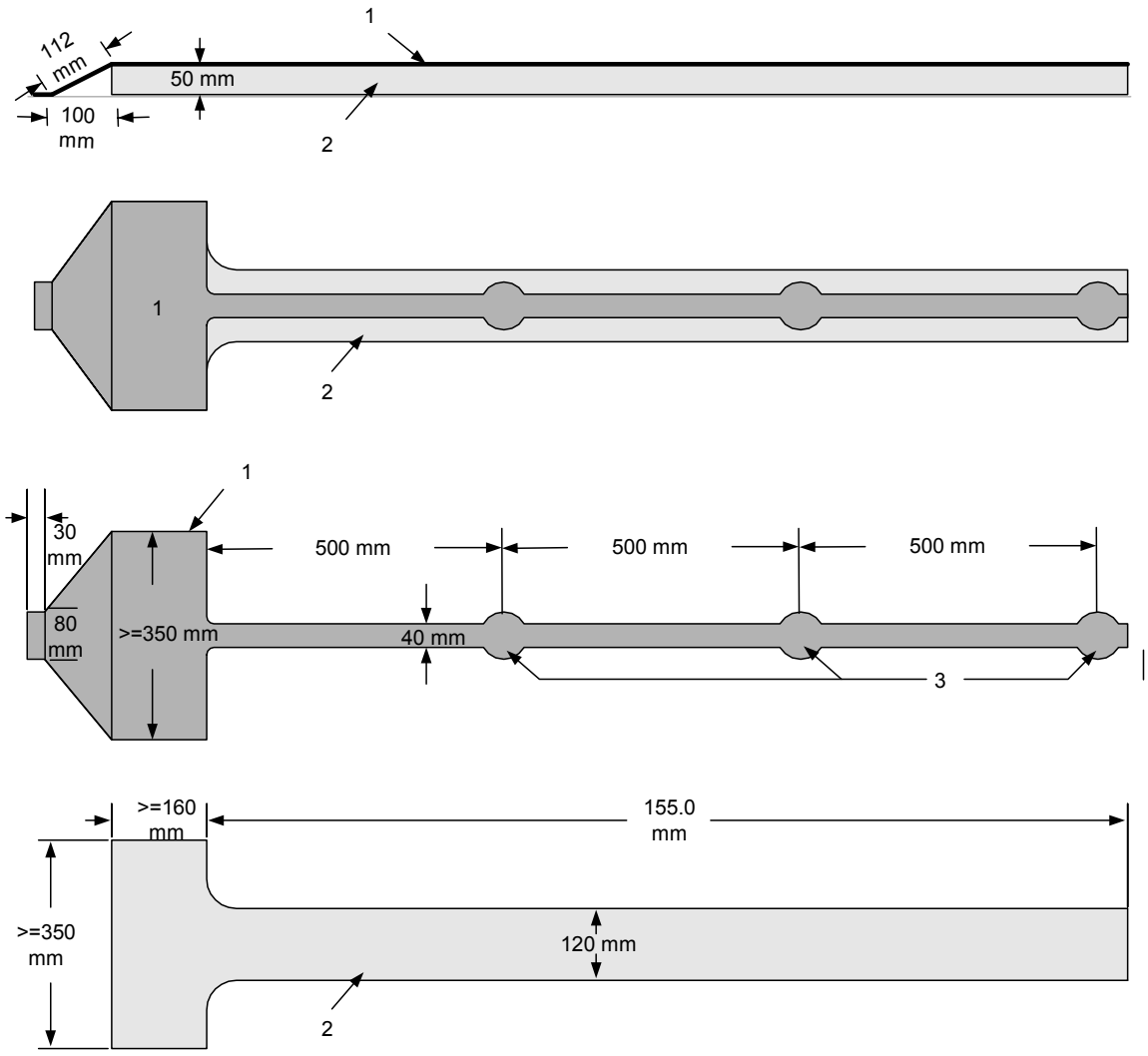
**Table 34: ESD Operating Immunity Requirements for Field Coupled Test**

| Test Voltage [kV] | Group A Status | Group B Status | Group C Status | Group D Status |
|---|---|---|---|---|
| **± 25** | Above Requirements | Above Requirements | Above Requirements | I |
| **± 20** | II | II | II | I |
| **± 15** | II | II | I | I |
| **± 8** | II | I | I | I |

The top level of Table 34, shaded gray, is only evaluated if the DUT has a Group D function.

### 10.2.2 ESD Operating Test Setup (Direct and Field Coupled)

For schematic diagrams of the test fixture for the ESD operating tests refer to Figure 32. For the Direct Discharge test setup refer to Figure 33 and for the Field Coupled test setup refer to Figure 34.




**Key**

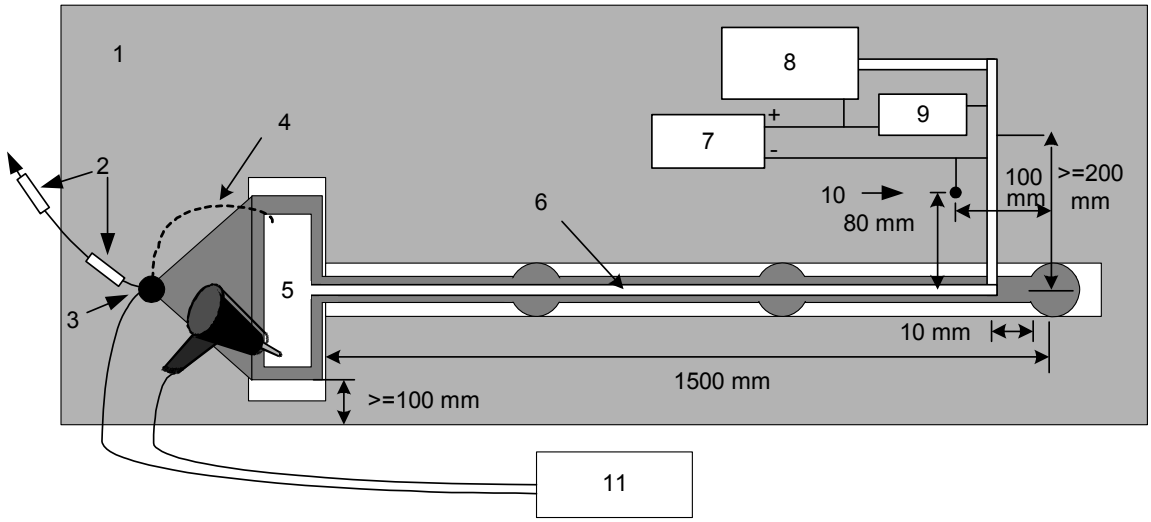
1 Field coupling strip: copper or brass, 0.5 to 2 mm thick. The area to support DUT shall be at least 10 mm larger than the DUT on all sides (160 by 350 mm are the minimum dimensions)

2 DUT and wiring harness isolation block – made of nonconductive material, $\varepsilon_r$ < 2.5, 50 mm high, e.g. foamed polypropylene or Styrofoam

3 ESD discharge islands: copper or brass, 0.5 to 2 mm thick, 80 mm in diameter, conductively bonded to or one piece with the field coupling strip

Note: Dimensions are in mm (with tolerance of ± 5%) – drawing not to scale

**Figure 32: ESD Operating Test Bench Setup**

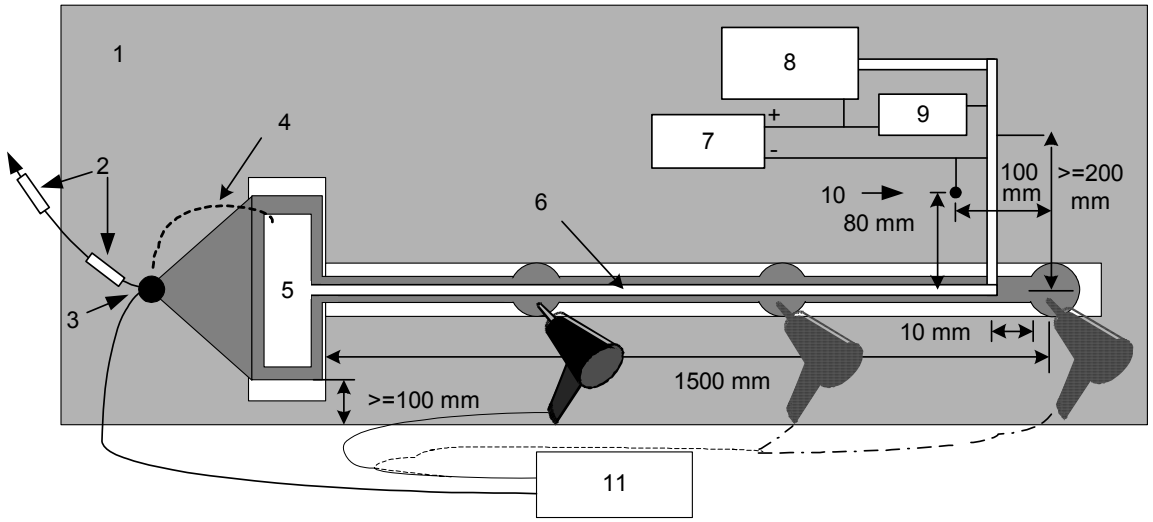



**Key**

1 HCP (ground plane)
2 2 x 470 k Ohm resistors to safety ground
3 Ground reference point for ESD coupling strip, ESD generator and safety ground connection
4 DUT local ground (if required)
5 DUT
6 DUT wiring harness
7 Battery
8 Peripheral or support equipment
9 AN (if used)
10 Ground reference point for battery and support equipment
11 ESD generator main unit

Note: Dimensions are in mm (with tolerance of ± 5%) – drawing not to scale

**Figure 33: ESD Operating Test Setup: Direct Coupled**




**Key**

1 HCP (ground plane)
2 2 x 470 k Ohm resistors to safety ground
3 Ground reference point for ESD coupling strip, ESD generator and safety ground connection
4 DUT local ground (if required)
5 DUT
6 DUT wiring harness
7 Battery
8 Peripheral or support equipment
9 AN (if used)
10 Ground reference point for battery and support equipment
11 ESD generator main unit

Note: Dimensions are in mm (with tolerance of ± 5%) – drawing not to scale

**Figure 34: ESD Operating Test Setup: Field Coupled**

### 10.2.3 ESD Operating Test Conditions – Direct and Field Coupled

- The ESD test bench ground plane shall be a minimum of 0.5 m from other conductive structures such as the surfaces of a shield room and shall be connected to safety ground with a connection that contains 2 x 470 kΩ (one at the ground plane end at point (3) and the other at the safety ground termination of the grounding conductor) .

- Before testing commences, the discharge voltage of the ESD simulator shall be verified.

- The ESD simulator shall have its ground referenced at point (3).

- The DUT coupling plane shall be large enough so as to extend beyond the DUT on all sides by at least 10 mm.

- The DUT shall be positioned on the ESD field coupling plane and a 1700 (-0, +300) mm wiring harness shall be run from the DUT to its power supply and support equipment along the conductive trace on top of the ESD field coupling strip. The harness shall exit the DUT harness support 10 mm from the edge of the discharge island most distant from the DUT.

- The ground reference for the DUT wiring harness and the load box is at point (10).

- The ground connection (wiring) of the DUT shall be connected as intended in the vehicle: for local ground, directly connect to the point (3) and for remote ground connect to the point (10) via the wiring harness.
- The case of the DUT, if conductive, shall be case grounded to the DUT ESD field coupling plane or at the point (3).
- The battery ground shall be electrically connected to the HCP at point (10).
- The DUT shall be put in operation with all its connected switches, displays, sensors, actuators etc. Wherever possible, production intent parts and wiring shall be used.
- Any peripheral support equipment shall be separated from the Field Coupling Strip by at least 200 mm.
- During this test, the DUT shall be monitored for effects. The default interval between discharges is 1 second.

#### 10.2.3.1 ESD Operating Test Conditions – Direct Coupled

- DUT that are accessible to occupants inside the vehicle shall be tested using an ESD simulator with a discharge network of 330 pF and 330 ohms. DUT that are accessible under hood or trunk locations shall use a discharge network of 150 pF and 330 ohms. DUT accessible location shall be specified in the test plan.
- Discharge points: Potentially all points which can be touched by the user after installation, including any DUT switches, displays, cables, plugs etc. The individual discharge points shall be specified in the test plan.
- For each polarity and voltage, 10 contact discharges to conductive points on the DUT only as defined in the test plan shall be carried out at each of the specified discharge points. In this process, the ESD simulator with the contact discharge electrode shall be positioned on the device and then discharged.
- For each polarity and voltage, 10 air discharges shall be carried out at each of the specified discharge points. In this process, the ESD simulator with the air discharge electrode shall be moved towards the discharge point as quickly as possible until either discharge occurs or the electrode touches the discharge point.
- Between two individual discharges, the charge applied shall be removed via a grounded discharge resistor with approximately 1 megohm resistance (e.g. 2 $\times$ 470 kohm resistors in series) by touching the discharge point and the housing. Alternatively, at least 1 s can be allowed to pass between two discharges.

#### 10.2.3.2 ESD Operating Test Conditions – Field Coupled

- Use an ESD simulator with the contact discharge electrode and a discharge network of 330 pF and 330 ohms.
- For each polarity and voltage, 10 contact discharges shall be carried out in the free area not covered by the wiring harness at each of the three specified discharge islands. Refer to Figure 34 for these discharge islands.
- Between two individual discharges wait for at least 1 s.
- For DUT with multiple harness branches (i.e. separate connectors) the branches shall be tested separately and as a combined bundle.
- Do not discharge directly to the harness. If there are more than 40 lines in the harness bundle, the harness bundle shall be flipped over (180 degrees) and the Field Coupled Test repeated.

**End of Main Document**

# # # # #

# Annex A (informative)

## FUNCTIONAL STATUS CLASSIFICATION EXAMPLES

Note: This list is not necessarily all-inclusive

**Group A Functions:**

- antenna module operation
- auxiliary car heater operation
- entertainment systems and display operation – DVD or other entertainment only displays
- front park and marker lamp operation (nonregulated)
- headlamp cleaning operation
- illuminated entry operation
- informational diagnostic capability (telltales & chimes – nonregulated functions)
- instrument cluster nonregulated functions & convenience indicators
- intermittent windshield wiper operation (with fail-safe default)
- inverters (110 Vac or other)
- parking aid system (Parctronic) operation
- photochromatic mirror operation (nonregulated functions)
- rain sensor operation
- rear wiper operation ability
- remote keyless entry operation (with operator key override)
- seat and steering wheel heating operation (except for fail w/ latch on)
- solar roof operation (solar-cell-powered motor)
- trip odometer operation

**Group B Functions:**

- adaptive cruise (speed) control (Distronic) operation (with operator override or fail-safe default)
- antilock brake system operation (with fail-safe default)
- chime operation (regulated function)
- data bus system operation (MOST /optical, D2B /optical)
- informational systems and display operation including instrument panel video – navigational, compass, climate control, time, general vehicle information – mileage, etc.
- electronic climate control functions that do not compromise windshield defrost system operation
- entertainment systems and display operation (radio, voice recognition system, CD, phone)
- final drive control – 2wd or 4wd (above 10 kph)
- headlight dimming/optical horn operation
- instrument cluster enhancement functions (fuel gauge, indicators)
- interior illumination stability (no perceptible variation)
- license plate lamp operation and daytime running lights (DRL) (regulated function)
- power door lock, trunk/hatch and trailer hitch release stability
- remote keyless entry start ability
- tire pressure monitoring
- vehicle anti-theft system operation
- vehicle electrical charging system (alternator) operation
- vehicle immobilizer operation (at minimum range)
- vehicle cruise (speed) control stability (e.g. $\pm$ 5 km/h)

**Group C Functions:**

- antilock brake system operation (without fail-safe default)
- automatic headlamp operation
- back up lamp operation (regulated function)
- brake lamp and center high mounted brake light (CHMSL) operation (regulated function)
- brake system malfunction indicator lamp (MIL) operation
- child occupancy detection operation
- convertible top stability (above 10 kph)
- data bus system operation (CAN-B, C, D, LIN-Bus, other serial bus systems)
- diagnostic memory stability and Group C functional inhibit capability
- dynamic vehicle control system (ESP) stability including steering angle sensor stability
- electronically controlled motor systems stability – motor cooling fan,seats with and without memory, windows with and without express up / down function, mirrors rearview and outside, headlamp leveling (no perceptible movement)
- electronic transmission control
- emergency calling system (Teleaid) operation
- engine acceleration control (not including speed control with operator override)
- engine malfunction indicator lamp (MIL) operation (regulated function)
- engine stall control
- engine rpm stability (e.g. $\pm$ 10%)
- entertainment system volume stability (e.g. ± 6 dB)
- fog lamp/high beam interlock operation (regulated function)
- headlamp and tail lamp operation
- horn operation (regulated function)
- instrument cluster (malfunction information, odometer, speedometer operation, regulated warnings)
- neutral start function (regulated function)
- park and marker lamp operation (regulated function)
- park brake indicator lamp operation (regulated function)
- passive restraint system operation
- photochromatic mirror reverse inhibit operation
- power door / hatch / liftgate stability (no inadvertent open or close)
- power supply control unit operation (power management for brake control and safety systems)
- transmission gear indicator (regulated function)
- seat and steering wheel heating stability (e.g. ± 5 degrees C)
- seat belt operation
- specialized functions for safety/fire/police or other emergency vehicles
- start ability
- steering wheel positioning stability
- suspension system stability (air leveling system, active body control)
- turn signal and indicator operation (regulated function)
- vehicle braking ability
- vehicle immobilizer stability (no inhibit of start)
- vehicle steering ability
- windshield defrost system operation
- windshield washer operation
- windshield wiper operation

**Group D Functions:**

- Any function that has the potential to inadvertently deploy a passive restraint system actuated by an electroexplosive device (EED).

**End of Annex A**

# # # # #

# Annex B (informative)

## LIST OF CHANGES FROM DC-10614 REV. A

- New standard number
- Updated References and Abbreviations, Acronyms, Definitions & Symbols
- Removed references to CG Lab Procedures except for LP-388C-65
- Modified Table 1 Test selection matrix
- Modified the definition of Status II to include system considerations
- Clarified that all DUT except for BCM and IP shall meet both narrowband and broadband requirements
- Short duration motors that can readily accommodate additional suppression are only required to meet the RF emissions basic limits if agreed upon between DCX and the supplier
- Very short cycle motors are not tested for RF emissions
- Frequency step size is increased for QP detector and/or emission testing of inherently broadband components
- Spectrum analyzer scan rate is dependent on repetition rate of DUT parameters
- FFT may be used for Emission measurements
- Emission tables are completely revised
- For emission measurements new services are included and the applicable frequency range is extended to 2.5 GHz
- Ground lines <1 m are not included in CISPR 25 current measurement
- Transient emission requirement for pulses shorter than 100µs are relaxed
- Immunity modulation for regulatory requirements (per CD 2004/104/EC) changed to AM up to 800 MHz and pulse from 800 MHz to 2 GHz
- Clarified that pulse modulation is required in cell phone and radar bands
- Changed frequency resolution definition to comply with ISO 11452-1
- Revised HIRF Frequency Ranges
- Moved DRFI and PCE to DC-11225
- Test level profiles are added as figures for immunity test requirements and the immunity requirements tables are updated
- VSWR requirement is clarified for TEM Cell Test
- Transient pulses are applied individually to each supply voltage line
- Adapted pulse 1 parameters for 24V to those of ISO 7637-2
- Added a Pulse 1b requirement
- Application of all transient pulses is set to 10 minutes
- Corrected length of supply leads for transient testing to 500 mm
- Increased the requirements for I/O pulses a and b
- ESD Handling Test setup: modified ground reference, clarified DUT placement and eliminated mat
- ESD Test Levels and Requirements are completely revised
- Common test setup specified for both direct coupled and field coupled ESD operating tests
- Field coupled ESD test replaces the ISO indirect discharge test to the HCP and VCP
- Material from informative annexes moved to DC-11225
- Updated Annex A with changes to some functional status group functions
- Updated Annex B with a List of Changes compared to DC-10614 revision A

**End of Annex B**

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