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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) and Mitsubishi Motors (MMC) vehicles that reference this standard. **This standard shall be used in combination with DC-10613, EMC Performance Requirements – Vehicle 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

Three asterisks (***) indicate significant technical changes. See Annex F for a list of changes in the revisions to this standard.

NOTE: The English and German versions of this jointly developed engineering standard are equivalent. For all other translations, no guarantee can be made as to the accuracy of the technical information.

Chrysler Group Engineering Standard CS-9800 contains general application and subscription information for documents distributed via ADRESS (Automated Document Retrieval & Engineering Standards System). For subscription of documents via SIS (Standards Information System) check with your contact at DaimlerChrysler.

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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 (EMC) 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. 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).

The purpose of component testing is the pre-qualification of components from the supplier at a time when representative vehicles are not yet available. 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-10613, EMC Performance Requirements - Vehicle when installed in a representative vehicle. DaimlerChrysler may change the specific requirements for a given component or module, as a result of testing to DC-10613. Vehicle testing is authoritative for EMC approval. The supplier shall comply with this standard and ensure that the current edition is used.

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. The default tolerances are as stated in ISO 11452-1. 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).

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

- Reference this joint engineering standard in the component product specification(s)
- Provide the supplemental information needed to classify the component or system functions,
- Identify any exceptions,
- Develop an EMC test plan,
- Confirm that required testing is completed at a DC approved EMC laboratory and that the specified requirements for the DUT are met.

The supplier is responsible for assuring that the tests are performed to meet the requirements as specified in the releasing document, which references this standard. It is the responsibility of DaimlerChrysler Procurement and Supply and the product engineer to verify that the supplier performs these tests and that the requirements are met. DaimlerChrysler reserves the right to perform audit testing on sample parts to verify compliance with this standard.

This standard is supported by lab procedures, where referenced, that document how the tests are implemented at Chrysler Group (CG). They provide additional detail on test equipment, set up and procedures and are an example of the information lab procedures should contain. These CG lab procedures are subject to periodic updates. It is the responsibility of the supplier to maintain current lab procedures as required for their testing.

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 platform 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 platform 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 Appendix 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: Starter motors, snow plow motors and similar high current motors are not covered by this standard unless they incorporate integral electronics. These devices are subject to evaluation at the vehicle level. 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	X	Y	BCM	ECM	R	IP
EMISSIONS													
PCE or CISPR 25 CE (V & I)		X		I						V	X		V
CISPR 25 RE		X		X							X		
Magnetic RE								X		X	X		
Transient CE								X	X	X	X	X	X
IMMUNITY													
DRFI or BCI		X		BCI							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		
I/O: fast transients (a+b)		X									X		
I/O: slow transients (± #2)						X							
ESD	X	X	X	X							X		

Note: **X** – requirement, **V** – PCE or CISPR Voltage emission test only, **I** – CISPR current emission test only, 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 2003-11 Radio disturbances and immunity measuring apparatus – Measuring apparatus

CISPR 25 2002-08 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 & Amendment 2 1998 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/IEC Guide 58 1993 Calibration and testing laboratory accreditation systems - General requirements for operation and recognition (will be replaced by ISO/IEC 17011)

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

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

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

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

ISO 11452-7 2003-11 Road vehicles, Electrical disturbances by narrowband radiated electromagnetic energy - Component test methods Part 7 - Direct RF Power Injection

ISO/IEC 17025 1999-12 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-10613, EMC Performance Requirements – Vehicle

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

DS-108, Vehicle Grounding Requirements for Electrical and Electronic Systems

DS-150, Electronic Module Design Guidelines for Designers to meet EMC Requirements

DS-151, Electronic Module Design Guidelines for Engineers to meet EMC Requirements

PF-9607, Airbag Initiator Assembly

2.6 Chrysler Group Laboratory Procedures

LP-388C-30, Conducted Transient Emissions Test

LP-388C-32, Conducted Immunity - Direct RF Power Injection Test

LP-388C-34, Radiated Immunity - Transverse Electromagnetic Mode (TEM) Cell Test

LP-388C-35, Radiated Immunity Test - Anechoic Chamber

LP-388C-39, Electrical Disturbances from Conduction and Coupling (Voltage Spikes) - Immunity Tests

LP-388C-41, Pin Conducted RF Emissions (PCE) Test

LP-388C-42, Electrostatic Discharge Tests

LP-388C-58, Magnetic Field Immunity Test

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

LP-388C-71, Magnetic Field Emissions Test

LP-388C-72, Conducted Immunity - Bulk Current Injection (BCI)

LP-388C-73, Conducted and Radiated Emissions Test - CISPR 25

2.7 Other Documents

USCAR Initiator Technical Requirements and Validation Standard

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

3 Abbreviations, Acronyms, Definitions, & Symbols ***

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 or SAE, to designate the test itself with reference to the method described in ISO 11452-1 or SAE J1113-21.

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

Annex. Supplementary material attached to the end of a standard, usually used to supply general information and not requirements.

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 Guide 58. 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 platform team at Mercedes Car Group.

BAN. Broadband Artificial Network (refer to Annex C).

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 are in addition to the basic category designation if they apply.

- **C:** An electronic component that is subject to direct radiated coupling to 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).
- **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.
- **X:** An electronic module that contains an electric or electronically controlled motor within its package.
- **Y:** An electronic module that contains a magnetically operated relay within its package.

Electric motor categories:

- **BCM:** A 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).

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.

Direct RF Power Injection. A conducted RF immunity test technique that involves isolating the DUT so that the RF coupling path is controlled. This test is also referred to as single line injection (**SLI**) or Direct Radio Frequency Injection (**DRFI**).

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

DRFI. See Direct RF Power Injection.

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 electroexplosive 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).
- **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 ε_r < 2.5 and a relative permeability μ_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.

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, and as recommended by the manufacturer, traceable to NIST, PTB or other equivalent national standard laboratory. Attention shall be directed to control of the RF boundary in both emission and immunity tests to reduce undesired interaction between the 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. For production tooled parts (PV), a minimum of one sample shall be tested. For design verification (DV) level parts, a minimum of two samples shall 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.

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 between the DUT and the support equipment. These inline filters shall be in a shielded box with a shielded cable from this box to the enclosure wall.

Additional information, particularly for CG testing, is available in Annex E.

5.2 Test Conditions

5.2.1 Dimensions

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

5.2.2 Tolerances

Unless indicated otherwise, the tolerances specified in Table 2 are permissible:

Table 2: Permissible Tolerances

Voltage, current	± 5 %
Time interval, length, energy, power, field strength	± 10 %
Resistance, capacitance, inductance, impedance	± 10 %

5.2.3 Climatic test conditions

Unless indicated otherwise, the climatic test conditions are defined in Table 3.

Table 3: Climatic Test Conditions

Temperature	23 ± 5.0 degrees C (73.4 ± 9 degrees F)
Humidity	20 to 80% relative humidity (RH)

5.2.4 Test voltages

The permissible test voltages are indicated in Table 4.

Table 4: Permissible Test Voltages

Nominal System Voltage (V)	**Acceptable Range (V)**
12	12 – 14
24	24 – 28
42	36 – 42

5.3 Test Plan

Prior to testing at an approved lab, an approved test plan, signed by the appropriate DC product team EMC engineer, is required.

Test plan templates are available to facilitate test plan development. 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
- the precise test setup (measuring equipment involved, cabling including lengths, etc
- failure criteria (to determine functional status and monitoring)

- 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.

5.5 Test Report and Statement

On completion of the test, the results shall be submitted to the responsible development departments within DaimlerChrysler in the form of a test report with reference to the test plan (electronic data submission is preferred). The test setup shall be documented using photographs. A statement certifying the execution of the tests in accordance with this standard and compliance with its requirements shall be included in the test report.

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). 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, either Pin Conducted Emissions (PCE) testing shall be performed or both 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, 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 1 GHz.

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 Annex E.

Brush commutated electric motors (category BCM) and pulsed inductive devices (category IP) shall be tested for RF broadband emissions (no narrowband) over the frequency range from 150 kHz to 200 MHz using either Pin Conducted Emissions (PCE) or the CISPR 25 voltage method.

Passive devices (category P) are not tested for RF emissions. See Figure 1.

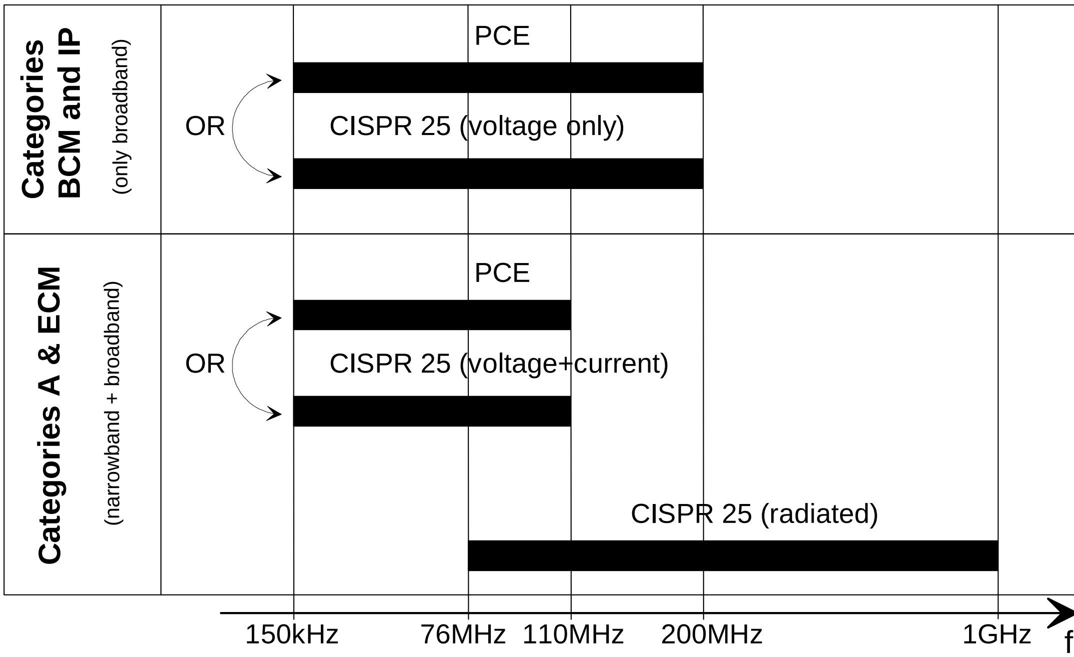


Figure 1: Test Methods versus Frequency

For narrowband emissions both peak (P) and average (AV) detectors are allowed, unless specified otherwise. For broadband emissions both peak and quasi-peak (QP) detectors are allowed to 200 MHz and only peak above 200 MHz, unless specified otherwise. 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. As described in CISPR25, narrowband testing may use a P detector with follow up testing using an AV detector if sufficient compliance margin is not available; broadband testing may use a P detector with follow up testing using a QP detector if sufficient compliance margin is not available. Alternatively, AV and P could be measured in one run (if the receiver allows that) followed by measuring BB emissions using QP, if necessary. Another option is measuring only AV and QP. 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.

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 or slower for 9/10 kHz RWB and 10 kHz or slower for 100/120 kHz RWB.

Minimum receiver measurement times are in Table 5.

Table 5: Minimum Receiver Measurement Time

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

Fast emission measurement methods incorporating FFT (fast Fourier transform) may be used to reduce the test time in cases where several sweeps are required, e.g. horizontal / vertical or several DUTs. Then a verification using a measuring receiver or spectrum analyzer is required only for the worst case FFT measurement. 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.

Limits are given for the continuous frequency ranges (150 kHz to 110/200 MHz and 76 MHz to 1 GHz) and for the specified frequency ranges where protection for onboard receivers is required. At transition frequencies where the limit changes, the lower level will apply. Consideration will be given to emissions at frequencies between 5% below the lower frequency and 5% above the upper frequency for each onboard receiver band.

E/E components and devices that represent a potential threat to other devices due to their emission of magnetic fields (e.g. motors or other inductive devices) shall be tested for their magnetic emissions in the frequency range from 15Hz to 30 kHz. Refer to paragraph 6.6.

E/E components and systems shall fulfill the requirements for transient emissions as specified in paragraph 6.7 unless otherwise specified in the product specification(s).

6.2 Pin Conducted RF Emissions (PCE)

The Pin Conducted RF Emissions limit levels are defined in Tables 6, 7, and 8. Table 6 contains the base limits for the continuous frequency range. For the defined frequency ranges where protection for onboard receivers is required, the limit values for narrowband (NB) disturbances are in Table 7 and those for broadband (BB) disturbances are in Table 8.

Use a receiver or spectrum analyzer bandwidth of 9 or 10 kHz. Refer to Annex D for special adaptations for CAN bus testing.

6.2.1 Requirements

For category A and ECM DUTs, the measured conducted RF narrowband emissions shall not exceed the NB limits in Tables 6 and 7 and the measured conducted RF broadband emissions shall not exceed the BB limits in Tables 6 and 8.

For CAN lines emissions up to 85 dBμV, from 500 kHz to 6.3 MHz and the NB values in Table 6 from 6.3 MHz to 110/200 MHz, are allowed subject to verification that vehicle emission level requirements are met. Also, there shall be no interference with the vehicle receiver attributed to CAN bus emissions at this higher level.

Dedicated signal and/or load lines from the DUT that use shielded wire for attenuation of coupled noise and short duration motors are allowed 10 dB above the limit that would otherwise apply.

Table 6: Pin Conducted RF Emissions Basic Limit Levels

Frequency Range	NB Limit (dBμV) P or AV	BB Limit (dBμV) P or QP
150 to 500 kHz	104 to 70	114 to 80
500 kHz to 6.3 MHz	70	80
6.3 to 30 MHz	60	70

Frequency Range	NB Limit (dBμV) P or AV	BB Limit (dBμV) P or QP
30 to 110/200 MHz	50	60

Note: Levels decrease linearly at the rate of 65 dB per decade of frequency increase in the range of 150 to 500 kHz. These basic limit levels apply outside the frequency ranges listed in Tables 7 and 8 and are 10 dB higher.

Table 7: PCE Measurement Settings and Narrowband Limit Levels for Specified Frequency Bands****

Test No.	Usage	Frequency Range (MHz)	Limit Value (dBμV) P or AV
Global Requirements			
G1	**LW AM (EU)**	**0.15 – 0.28**	**94-76**
G2	**MW AM**	**0.53 – 1.7**	**60**
G3	**SW AM (EU)**	**5.8 – 6.3**	**50**
G4	**Communications (NA)**	**30 – 54**	**40**
G5	**Communications /TV (EU)**	**65 – 87.5**	**40**
G6	**VHF**	**87.5 – 108**	**40**
Optional Requirements for Europe			
OEU1	Fleet	7.1 – 7.6 9.3 – 10.0 11.5 – 12.1 13.6 – 13.8 15.0 – 15.7	40
OEU2	Communications	25 – 30	40
OEU3	TV I	41 – 65	40
OEU4	Fleet	84.015 – 87.255	30
Optional Requirements for North America			
ONA1	Fleet	30 – 54	33

Table 8: PCE Measurement Settings and Broadband Limit Levels for Specified Frequency Bands****

Test No.	Usage	Frequency Range (MHz)	Limit Value (dBμV) P or QP
Global Requirements			
G1	**LW AM (EU)**	**0.15 – 0.28**	**104-86**
G2	**MW AM**	**0.53 – 1.7**	**70**
G3	**SW AM (EU)**	**5.8 – 6.3**	**60**
G4	**Communications (NA)**	**30 – 54**	**50**
G5	**Communications /TV (EU)**	**65 – 87.5**	**50**
G6	**VHF**	**87.5 – 108**	**50**
G7	**Communications**	**140 – 180**	**50**

Test No.	Usage	Frequency Range (MHz)	Limit Value (dBμV) P or QP
Optional Requirements for Europe			
OEU1	SW AM Fleet	7.1 – 7.6 9.3 – 10.0 11.5 – 12.1 13.6 – 13.8 15.0 – 15.7	60
OEU2	Communications	25 – 30	50
OEU3	TV I TV III	41 – 65 180 – 200	50

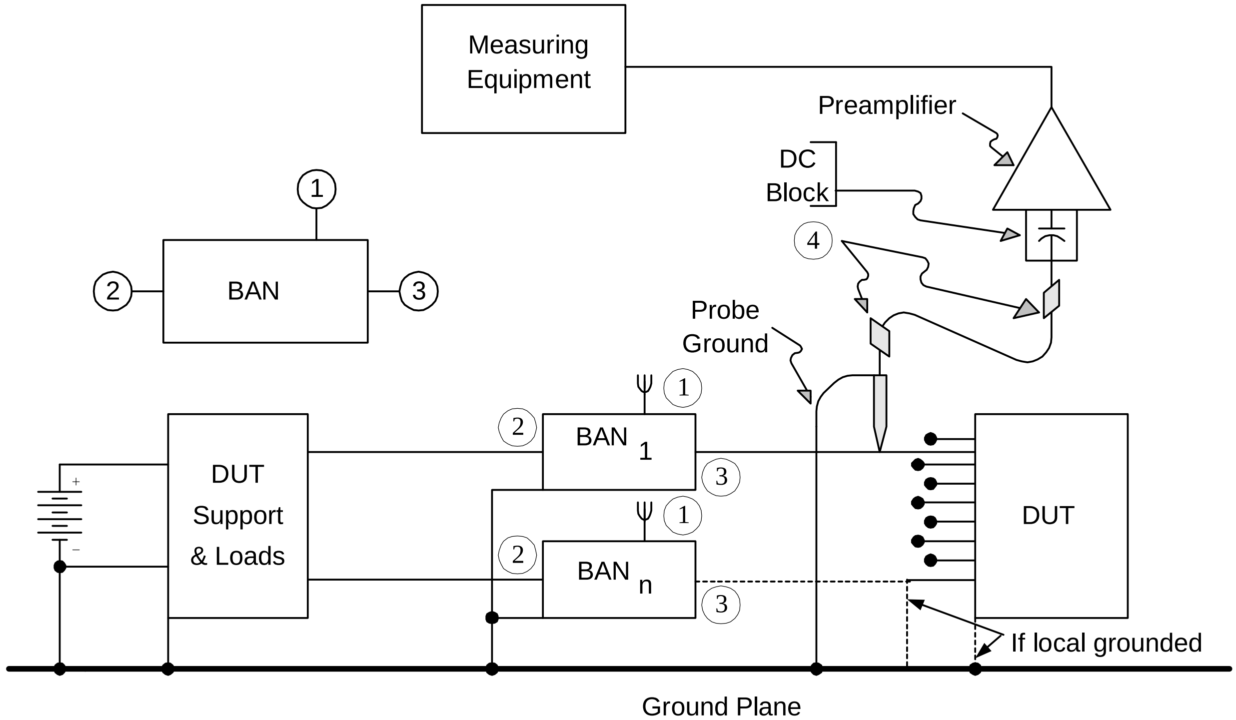
6.2.2 Test

The DUT shall be powered from a dc supply or storage battery. The voltage shall be within the acceptable range of Table 4. If a power supply is used, it shall have low conducted RF emissions that will not affect the test results. If a storage battery is used, its terminal voltage, under load, must not be below 12.0 V dc (or 24.0 V or 36.0 V depending on system voltage). Preferably, the DUT shall be operated with the minimal input and output connections consistent with 'essentially normal' oscillator frequency and logic activity. Necessary inputs and outputs shall be connected to their terminations through appropriate broadband artificial networks (BANs), except where special situations apply. An alternative is to use the full BAN isolated test setup from the DRFI test. For outputs that drive PWM or inductive loads, a representative load shall be connected to the line under test if the typically broadband RF output due to the switching activity is to be evaluated. This loaded characteristic is only to be evaluated if called out in the DUT PF or test plan. The measurement is limited by the dynamic range of the preamplifier. The measurement shall be made using a 500 to 1000 ohm nominal input impedance (10X to 20X) probe (50 ohm output impedance) connected through a blocking capacitor to a preamplifier (if used) and a spectrum analyzer or measuring receiver. A preamplifier may be used for NB measurements from 2 to 110/200 MHz, if needed for measurement to the specified levels. Do not use a preamplifier for BB measurements or below 2 MHz. If a preamplifier is used, assure that the preamplifier is not being overloaded by the DUT signal voltage by switching in 10 dB of attenuation between the probe and the preamplifier and verifying that the signal voltage from the preamplifier to the analyzer is attenuated by 10 dB at 2 MHz. A shielded room is required to provide an ambient level low enough for measurement to the levels specified. For CG test procedure, refer to LP-388C-41.

6.2.3 Test Setup

- Measurements shall be made over the following frequency ranges: 150 kHz to 2 MHz and 2 MHz to 110/200 MHz
- The maximum allowable length of the wiring from the DUT to point 3 on the BAN shall be 150 mm.

For the Pin Conducted Emissions Test setup, refer to Figure 2.



Key:

1. Low capacitance BNC or similar RF connector (Example: Amphenol 31.10)
2. Connection to the DUT supply/load circuitry
3. Connection to the DUT
4. Ferrite Clamps at each end of cable

Figure 2: Pin Conducted Emissions Test Setup

6.3 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 allowing the decoupling of the disturbance voltage. Artificial network(s) in accordance with CISPR 25 or 50 ohm BANs shall be used. The test setups for devices under test with several supply voltage connections shall be implemented using the appropriate number of ANs. Supplemental information for CG testing is provided in LP-388C-73.

6.3.1 Requirement

The measurements shall be made in the frequency range from 150 kHz to 30 MHz with a measuring bandwidth of 9 or 10 kHz. The measurements shall be made in the frequency range from 30 MHz to 110/200 MHz with a measurement bandwidth of 100 or 120 kHz except where additional narrowband measurements with 9/10 kHz bandwidth are specified. The measured values shall be below the limit values indicated in Tables 9, 10 and 11.

Table 9: CISPR 25 Conducted RF Emissions Basic Limit Levels on Power Lines

Frequency Range	NB Limit (dBμV) P or AV	BB Limit (dBμV) P or QP
150 to 500 kHz	94 to 70	104 to 80
500 kHz to 6.3 MHz	70	80
6.3 to 30 MHz	60	70
30 to 110/200 MHz	50	60

Table 10: CISPR 25 Measurement Settings and Narrowband CE Limit Levels on Power Lines for Specified Frequency Bands

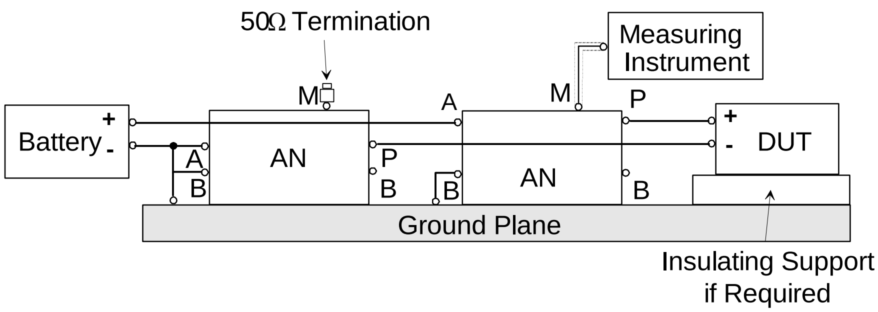
Test No.	Usage	Frequency Range (MHz)	Measuring Instrument Bandwidth (kHz)	Limit Value (dBμV) P or AV
Global Requirements				
G1	**LW AM (EU)**	**0.15 – 0.28**	**9/10**	**50**
G2	**MW AM**	**0.53 – 1.7**	**9/10**	**34**
G3	**SW AM (EU)**	**5.8 – 6.3**	**9/10**	**33**
G4	**Communications (NA)**	**30 – 54**	**9/10**	**24**
G5	**Communications/TV (EU)**	**65 – 87.5**	**100/120**	**24**
G6	**VHF**	**87.5 – 108**	**100/120**	**24**
Optional Requirements for Europe				
OEU1	Fleet	7.1 – 7.6 9.3 – 10.0 11.5 – 12.1 13.6 – 13.8 15.0 – 15.7	9/10	33
OEU2	Communications	25 – 30	9/10	24
OEU3	TV I	41 – 65	100/120	24
OEU4	Fleet	84.015 – 87.255	9/10	12
Optional Requirements for North America				
ONA1	Fleet	30 – 54	9/10	12

Table 11: CISPR 25 Measurement Settings and Broadband CE Limit Levels on Power Lines for Specified Frequency Bands

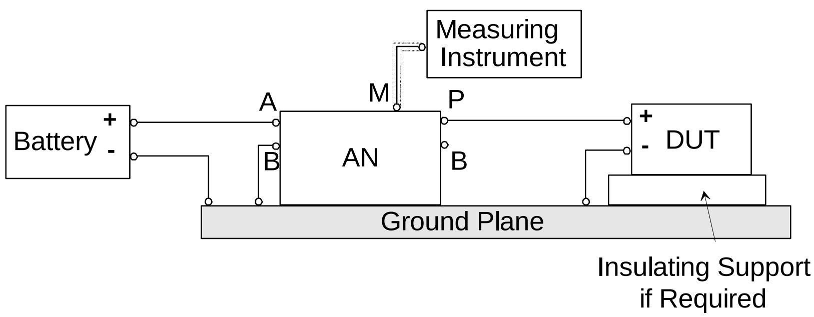
Test No.	Usage	Frequency Range (MHz)	Limit Value (dBμV) P or QP
Global Requirements			
G1	**LW AM (EU)**	**0.15 – 0.28**	**60**
G2	**MW AM**	**0.53 – 1.7**	**50**
G3	**SW AM (EU)**	**5.8 – 6.3**	**40**
G4	**Communications (NA)**	**30 – 54**	**24**
G5	**Communications/TV (EU)**	**65 – 87.5**	**24**
G6	**VHF**	**87.5 – 108**	**24**
G7	**Communications**	**140 – 180**	**24**
Optional Requirements for Europe			
OEU1	SW AM Fleet	7.1 – 7.6 9.3 – 10.0 11.5 – 12.1 13.6 – 13.8 15.0 – 15.7	40
OEU2	Communications	25 – 30	24
OEU3	TV I TV III	41 – 65 180 – 200	24

6.3.2 Test setup

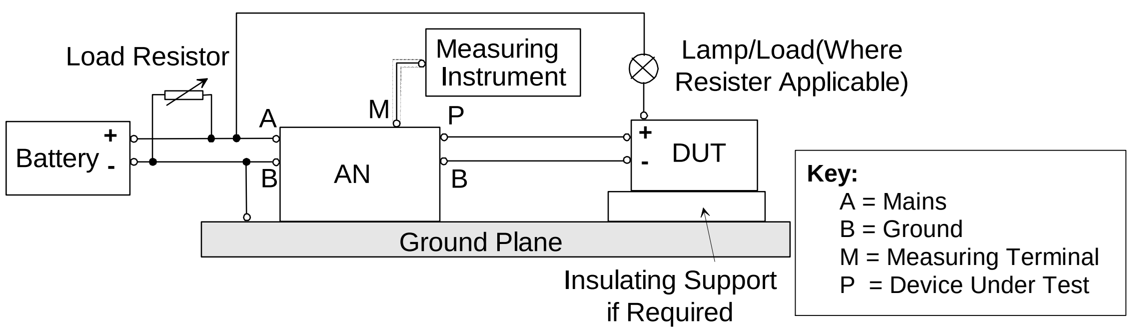
Test setup is described in detail in CISPR 25 and illustrated in Figure 3. Deviating from CISPR 25, either ANs or 50 ohm BANs are allowed. The test setup for devices under test with several supply voltage connections shall be implemented accordingly. Action shall be taken to ensure that the DUT emits its maximum disturbance power (occurring during normal operation) during the measurement.



a) Device Under Test with Long Ground Line



b) Device Under Test with Short Ground Line



c) Alternators and Generators.

Figure 3: Test setup of CISPR 25, voltage method

6.4 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 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 (50 ohm BANs are accepted as a substitute for ANs). Supplemental information for CG testing is provided in LP-388C-73.

6.4.1 Requirements

The measurements shall be made in the frequency range from 150 kHz to 30 MHz with a measuring bandwidth of 9 or 10 kHz. The measurements shall be made in the frequency range from 30 MHz to 110/200 MHz with a measurement bandwidth of 100 or 120 kHz except where additional narrowband measurements with 9/10 kHz bandwidth are specified. All measured values shall be below the limit values in Tables 12, 13 and 14.

Table 12: CISPR 25 Conducted RF Emissions Basic Limit Levels on All Lines

Frequency Range	NB Limit (dBμA) P or AV	BB Limit (dBμA) P or QP
150 to 500 kHz	68 to 44	78 to 54
500 kHz to 6.3 MHz	38	48
6.3 to 30 MHz	26	36
30 to 110/200 MHz	16	26

Table 13: CISPR 25 Measurement Settings and Narrowband CE Limit Levels on All Lines for Specified Frequency Bands

Test No.	Usage	Frequency Range (MHz)	Measuring Instrument Bandwidth (kHz)	Limit Value (dBμA) P or AV
Global Requirements				
G1	**LW AM (EU)**	**0.15 – 0.28**	**9/10**	**30**
G2	**MW AM**	**0.53 – 1.7**	**9/10**	**6**
G3	**SW AM (EU)**	**5.8 – 6.3**	**9/10**	**-1**
G4	**Communications (NA)**	**30 – 54**	**9/10**	**-6**
G5	**Communications/TV (EU)**	**65 – 87.5**	**100/120**	**-10**
G6	**VHF**	**87.5 – 108**	**100/120**	**-10**
Optional Requirements for Europe				
OEU1	Fleet	7.1 – 7.6 9.3 – 10.0 11.5 – 12.1 13.6 – 13.8 15.0 – 15.7	9/10	-1
OEU2	Communications	25 – 30	9/10	-6
OEU3	TV I	41 – 65	100/120	-10
OEU4	Fleet	84.015 – 87.255	9/10	-16

Table 14: CISPR 25 Measurement Settings and Broadband CE Limit Levels on All Lines for Specified Frequency Bands

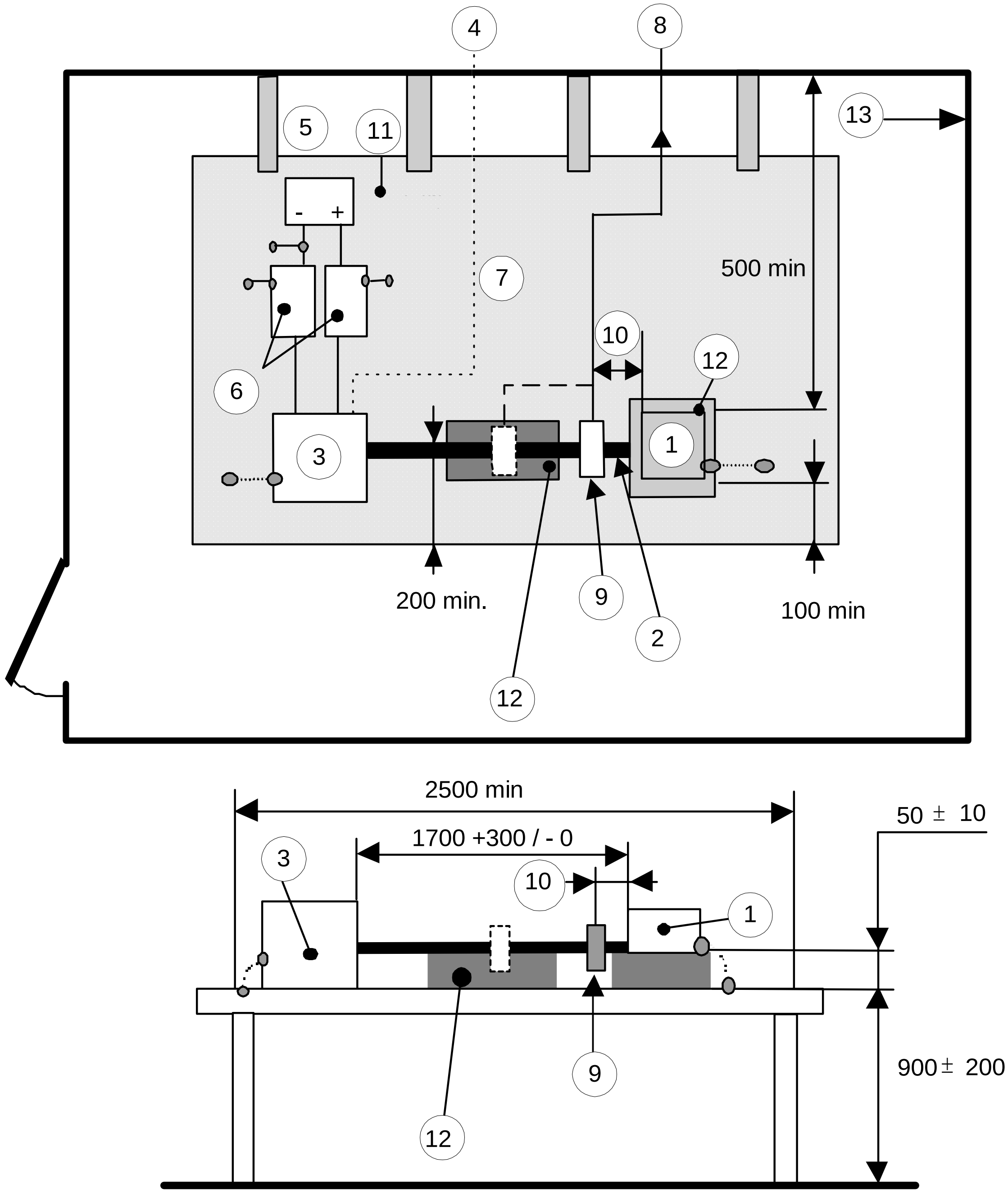
Test No.	Usage	Frequency Range (MHz)	Limit Value (dBµA) P or QP
Global Requirements			
G1	**LW AM**	**0.15 – 0.28**	**40**
G2	**MW AM**	**0.53 – 1.7**	**22**
G3	**SW AM**	**5.8 – 6.3**	**6**
G4	**Communications (NA)**	**30 – 54**	**6**
G5	**Communications/TV (EU)**	**65 – 87.5**	**-10**
G6	**VHF**	**87.5 – 108**	**-10**
G7	**Communications**	**140 – 180**	**-10**
Optional Requirements for Europe			
OEU1	SW AM Fleet	7.1 – 7.6 9.3 – 10.0 11.5 – 12.1 13.6 – 13.8 15.0 – 15.7	6
OEU2	Communications	25 – 30	6
OEU3	TV I TV III	41 – 65 180 – 200	-10

6.4.2 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 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 4.



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 or 50 ohm BAN
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

This figure is adapted from ISO WD 11452-4.

Figure 4: Measurement of Radio Disturbance Currents Conducted along the Wiring Harness

6.5 CISPR 25 Radiated Emissions

The emission of components shall be measured in accordance with CISPR 25 in an absorber-lined shielded enclosure with an antenna or antennas in the frequency range of 76 MHz to 1000 MHz (unless otherwise specified in the product specification). Supplemental information for CG testing is provided in LP-388C-73.

6.5.1 Requirements

The measurements shall be made in the frequency range from 76 to 1000 MHz with a measurement bandwidth of 100 or 120 kHz except where additional narrowband measurements with 9/10 kHz bandwidth are specified. The measured values shall be below the limit values in Tables 15, 16 and 17.

Table 15: CISPR 25 Radiated Emissions Basic Limit

Frequency Range	NB Limit (dBμV/m) P or AV	BB Limit (dBμV/m) P or QP(1)
76 to 200 MHz	40	50
200 to 400 MHz	45	55
400 to 1000 MHz	50	60

Note 1: up to 200 MHz

Table 16: CISPR 25 Radiated Measurement Settings and Narrowband Limit Levels for Specified Frequency Bands

Test No.	Usage	Frequency Range (MHz)	Measuring Instrument Bandwidth (kHz)	Limit Value (dBμV/m) P or AV
Global Requirements				
G6	**VHF**	**76 – 108**	**100/120**	**12**
G7	**Communications**	**140 – 180**	**9/10**	**12**
G8	**TETRA/Trunking**	**380 – 430**	**9/10**	**12**
G9	**Remote Keyless Entry (Immobilizer)**	**430 – 433 433 – 435 435 – 438**	**9/10**	**8 6 8**
G10	**Communications**	**420 – 520**	**9/10**	**18**
G11	**Cell Phone**	**869 – 894**	**9/10**	**18**
G12	**GSM 30 cm**	**925 – 960**	**9/10**	**18**
Optional Requirements for Europe				
OEU3	TV III TV IV/V	174 – 230 470 – 862	100/120	18 24
OEU4	Fleet	147 – 164	9/10	0
OEU5	Fleet	84.015 – 87.255 167.56 – 169.38 172.16 – 173.98	9/10	0
Optional Requirements for North America				
ONA2	Fleet	140 – 180	9/10	0
ONA3	Remote Keyless Entry	310 – 314 314 – 316 316 – 320	9/10	8 6 8

Test No.	Usage	Frequency Range (MHz)	Measuring Instrument Bandwidth (kHz)	Limit Value (dBμV/m) P or AV
ONA4	Fleet	420 – 520	9/10	12
ONA5	Fleet	869 – 894	9/10	14
ONA6	Fleet	925 – 960	9/10	14
Optional Requirements for Japan				
OJP1	Remote Keyless Entry	311 – 317	9/10	4
OJP2	TV IV/V	470 – 770	100/120	24
OJP3	Cell phone	810 – 885	9/10	18

Table 17: CISPR 25 Radiated Measurement Settings and Broadband Limit Levels for Specified Frequency Bands ***

Test No.	Usage	Frequency Range (MHz)	Limit Value (dBμV/m) P or QP(1)
Global Requirements			
G6	**VHF**	**76 – 108**	**12**
G7	**Communications**	**140 – 180**	**12**
G8	**TETRA 70 cm**	**380 – 430**	**24**
G9	**Remote Keyless Entry**	**430 – 438**	**30**
G10	**Communications**	**420 – 520**	**32**
G11	**Cell Phone**	**869 – 894**	**36**
G12	**GSM 30 cm**	**925 – 960**	**36**
Optional Requirements for Europe			
OEU3	TV III TV IV/V	174 – 230 470 – 700 700 – 862	18 32 36
Optional Requirements for North America			
ONA2	Remote Keyless Entry	310 – 320	30
Optional Requirements for Japan			
OJP1	TV II TV IV/V	90 – 108 470 – 700 700 – 770	12 32 36
OJP2	Remote Keyless Entry	311 – 317	30
OJP3	Cell phone	810 – 885	36

Note 1: up to 200 MHz

6.5.2 Test setup

The test setup is given in detail in CISPR 25 and illustrated in Figure 5. Deviating from CISPR 25, the use of 50 ohm BANs as a substitute for the ANs is acceptable. The outer surface of the DUT with the greatest disturbance emission, if known, shall be facing the antenna.

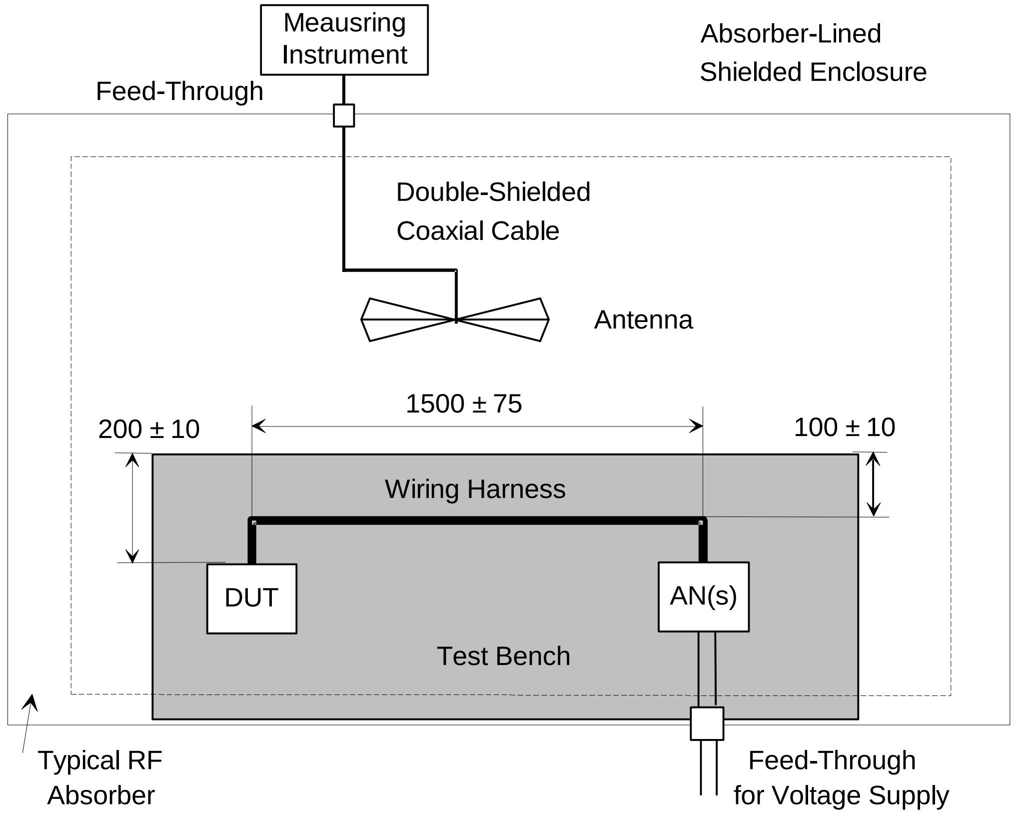


Figure 5: Test setup CISPR 25, radiated RF emissions

6.6 Magnetic Field Emissions

Electrical and electronic motors and components generate a magnetic field proportional to current that falls off with distance. This magnetic field emissions requirement is based on a minimum separation of 250 mm between the DUT and a magnetically sensitive module (e.g. blower motor to radio/cassette unit). Small motors (current draw less than 0.5 A) or motors that are an integral part of a module with magnetically sensitive components (e.g. drive motors contained in radio/cassette unit) are expected to be compatible with the overall function of the module and are not evaluated for this requirement. Supplemental information for CG testing is provided in LP-388C-71.

6.6.1 Requirement

The magnetic flux density measured at a distance of 250 mm from the periphery of the DUT shall not exceed 160 + 20 log(D/250) dBpT (dB picotesla) from 15 Hz to 60 Hz and above 60 Hz this shall decrease at a rate of 12 dB per octave to 52 + 20 log(D/250) dBpT at 30 kHz where ‘D’ represents the distance in millimeters from the periphery of the DUT to the nearest magnetically sensitive module. The measurements shall be performed at all six sides of the DUT to detect the position with the highest emission levels.

6.6.2 Test

The magnetic field emissions from the DUT shall be measured with the DUT configured so that it is drawing its rated operating current. If this is not practical, the actual current is to be measured and the magnetic emissions scaled at 6 dB increase for each doubling of DUT current to reach rated current. The test setup is shown in Figure 6. Refer to LP-388C-71 for test procedure.

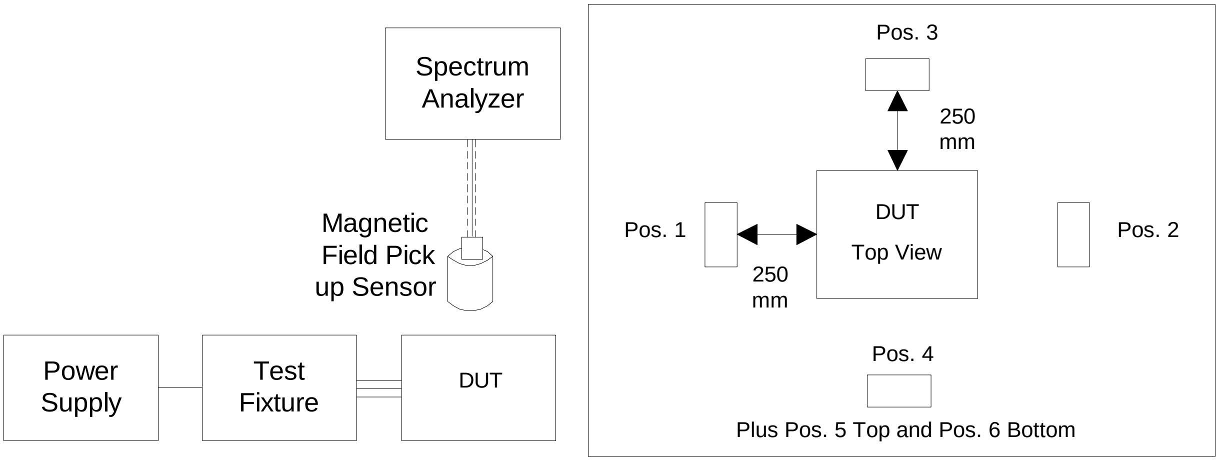


Figure 6: Magnetic Emissions Test Setup

6.7 Conducted Transient Emissions

The DUT shall conform to the following restrictions on switching transients. 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.

6.7.1 Requirement

The DUT shall be tested with the fast transient setup from ISO 7637-2. The transients for 12 and 42 V systems are limited to ± 80 volts regardless of their wave shape. The transients for 24 V systems are limited to +80 volts and –150 volts.

6.7.2 Test

For details on the test setup, refer to ISO 7637-2 fast transient setup. The setup for the measurements is shown in Figure 7.

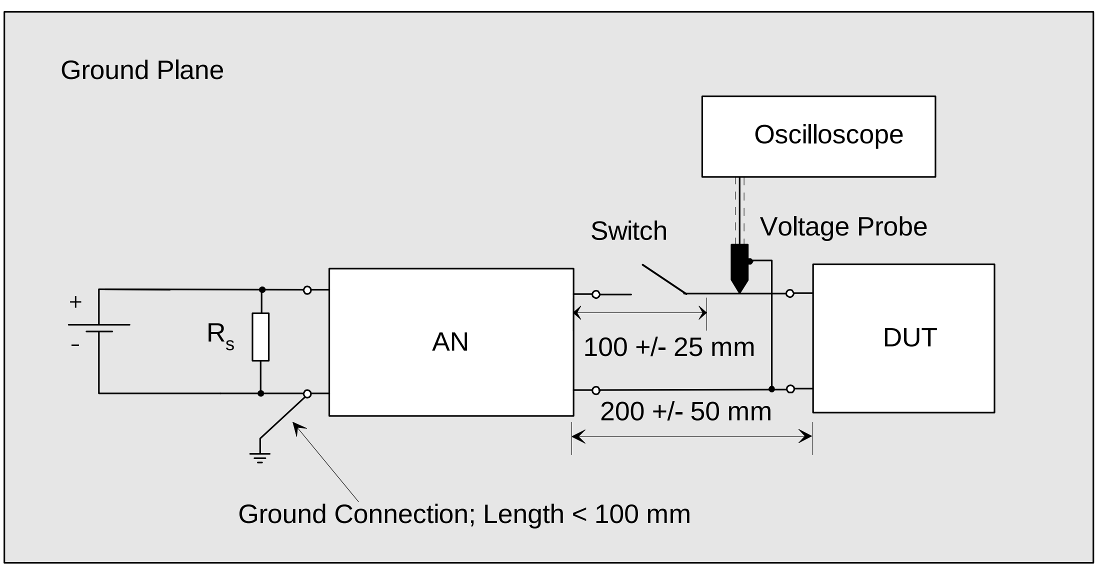


Figure 7: Transient Emissions Test Setup

Representative loading shall be used for the DUT whenever possible. 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 side of the AN. The rise time, peak voltage and pulse width shall be captured and recorded. Supplemental information for CG testing is provided in LP-388C-30.

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. As required in Table 1:

- 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.
- Select either DRFI (refer to 7.2) or BCI (refer to 7.3) for conducted immunity testing from 1 MHz to 400 MHz. For high voltage (HV) electric vehicle (EV) or hybrid electric vehicle (HEV) components, BCI shall be used.
- Select either ALSE with a ground plane (refer to 7.4) or without ground plane (refer to 7.5) for radiated immunity testing from 200 MHz to 3.2 GHz.
- Determine if TEM cell testing (refer to 7.6) is also required (subcategory C only).

Deviating from the requirements in this section, in very special cases, such as when a module is already specified and used in a vehicle application but needs additional validation for an application in a vehicle like a bus with many variants (i.e. testing in all variants is not practical), the method defined in Annex F for testing, especially in the frequency bands of handheld transmitters, may be used as a substitute above 1 GHz. However, this shall be explicitly agreed to between the supplier and the responsible EMC engineering department within DaimlerChrysler.

Figure 8 gives an overview of the test methods.

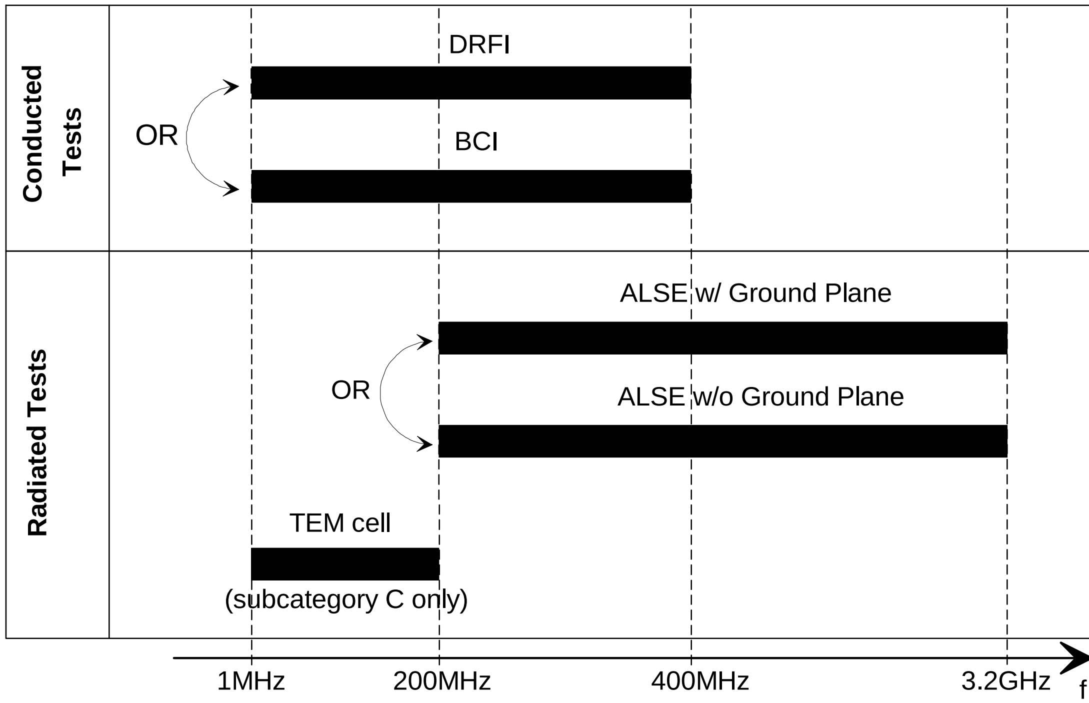


Figure 8: RF Immunity Testing

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. 800, 400, 200, 100 mW). 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.

Refer to Annex D for CAN bus testing adaptations. 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 frequency, refer to Annex E.

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 (default) and/or pulse modulation (when defined in the product specification) is applicable from 400 MHz to 3.2 GHz. The default pulse modulation is rectangular at 217 Hz (± 10%) PRF with 12% duty cycle. For testing to meet regulatory requirements, these frequency ranges and modulation types are modified. Refer to Tables 18 and 19.

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.

Table 18: Default Modulation for RF Immunity Testing ***

Frequency Range	**1 to 30 MHz**	**30 to 400 MHz**	**above 400 MHz**

Frequency Range	1 to 30 MHz	30 to 400 MHz	above 400 MHz
Modulation	**CW and AM** (1kHz, 80%, constant peak)	CW	**CW or Pulse** (default 217 Hz 12% duty cycle or t on 577 µs, period 4600 µs)

Table 19: Modulation for Regulatory RF Immunity Testing *

Frequency Range	20 to 800 MHz	800 to 2000 MHz
Modulation	**AM** (1kHz, 80%, constant peak)	**Pulse** (t on 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.

The minimum number of test frequencies per decade (logarithmically distributed) for Immunity Tests is defined in Table 20 and is based on assumed maximum Q factors for the DUT inputs and outputs. If the DUT is known to have higher than normal Q factors on some of its inputs and outputs, this information shall be incorporated into the product specification and/or test plan to increase the number of test frequencies per decade. The harmonics of the immunity test signal shall be at least - 12 dBc with a target of - 20 dBc. Care shall be taken to avoid equipment switching transients.

Table 20: RF Immunity Test Frequency Resolution

Frequency Range	1 to 10 MHz	10 to 100 MHz	0.1 to 1 GHz	1 to 3.2 GHz
Expected Max. Q	23	44	88	176
Min. Freq. Resolution Points per Decade	50	100	200	400

The severe environment frequency ranges for HIRF testing are defined in Table 21.

Table 21: Severe Environment Simulation – Frequency Ranges where HIRF Test Level Applies

Frequency Range (MHz)	Usage
1 – 30	MW & SW
30 – 54	Communications in North America
65 – 88	Communications in Europe
140 – 180	Communications
380 – 520	Communications
1 200 - 1 400	Radar
2 700 - 3 200	Radar

Refer to Figure 8 for appropriate test methods.

7.2 Direct RF Power Injection (DRFI) Test

This test is described in ISO 11452-7. Supplemental information for CG testing is provided in LP-388C-32. The DUT shall be subjected to direct RF power injection, line by line, on all input and output lines specified in the test plan, including unused connector pins. This test applies in the frequency range from 1 to 400 MHz. This test uses a 50 ohm, 10 dB attenuator in the injection network and a broadband isolator (BAN - see Annex C) between each DUT line and its termination, except that low impedance (less than 50 ohm) dedicated sensor or load lines shall be injected at the DUT without using an isolator. As this is a pin by pin test, exercise care to minimize cross coupling from the line under test to adjacent lines. The 10 dB attenuator limits the power at the DUT line under test to one tenth, or less, of the input power and minimizes the effect of reflections caused by the impedance discontinuity at the injection point. Balanced lines shall be injected with a common mode signal. Some lines may be considered balanced over part, but not all, of the frequency range. DUT with multiple grounds are subject to injection on one ground relative to another.

If the series inductance of the BAN inhibits data transfer on signal or bus lines, a reduced inductance (increased bandwidth) BAN is available for testing these lines with corresponding modifications to required test frequency ranges. Check in Annex C and with the E/E Systems Compatibility Department (5140) of Chrysler Group Scientific Laboratories or the EMC platform team at Mercedes Car Group for details. The test levels in Tables 22 and 23 are given as power measured into a 50 ohm load at the output of the 10 dB attenuator.

7.2.1 DRFI Test Requirements

The immunity performance requirements are specified in Tables 22 and 23 and the Test Levels in Figure 9.

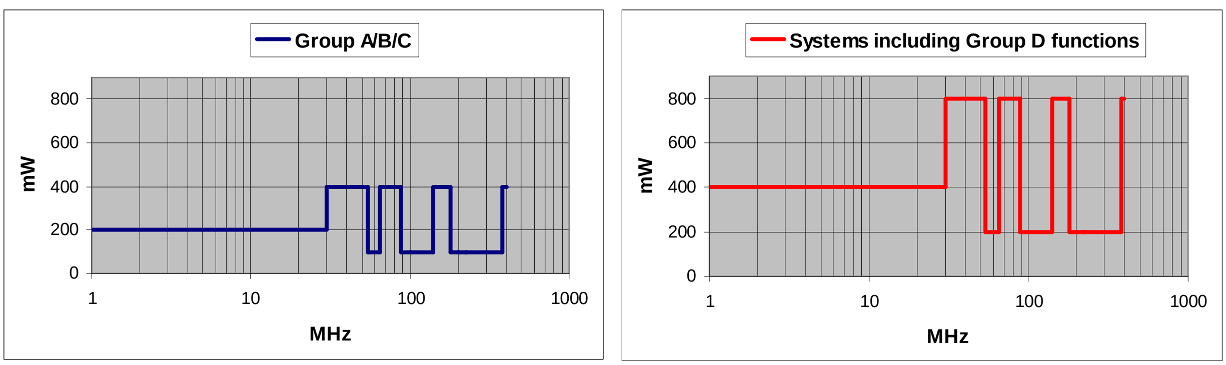


Figure 9: Test Levels for DRFI Testing, Group A, B, C and Systems including Group D functions***

The top level of Tables 22 and 23, shaded gray, is only evaluated if the DUT has a Group D function.

Table 22: DRFI Immunity Performance Requirements, 1 to 30 MHz for Group A, B, C & D ***

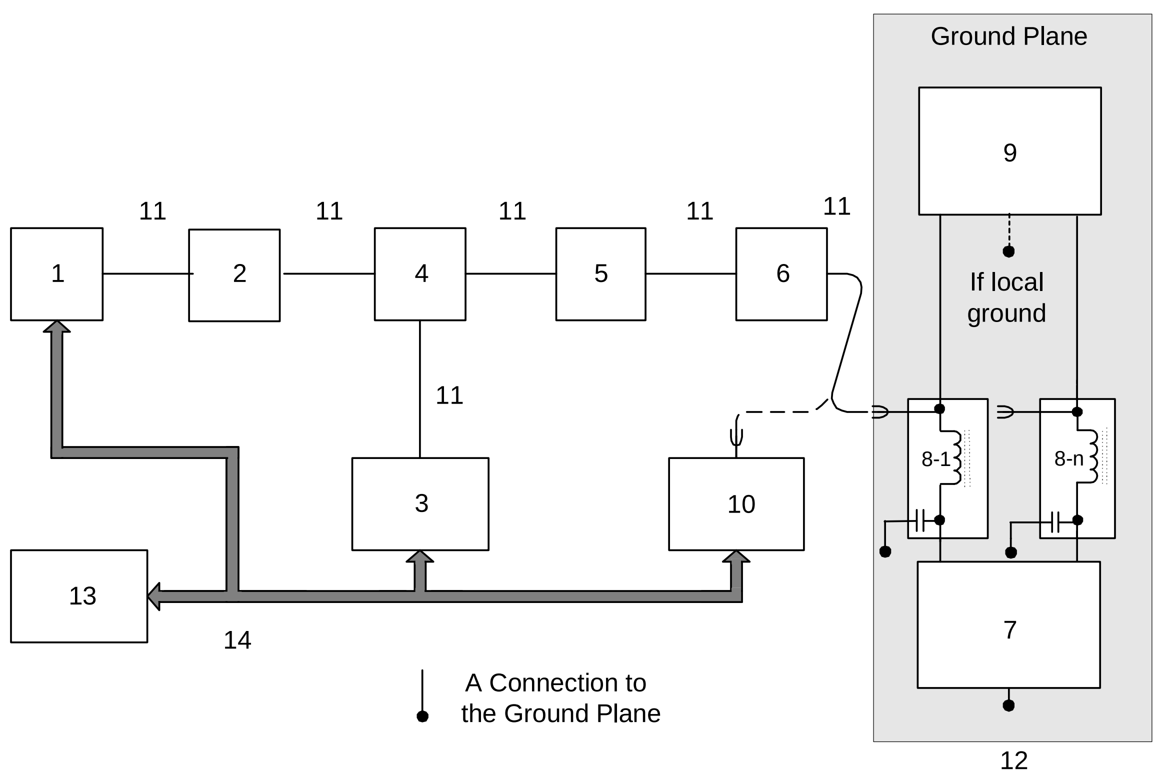
<table>
<tr><th>Test Level mW</th><th>Group A Status</th><th>Group B Status</th><th>Group C Status</th><th>Group D Status</th></tr>
<tr><td>> 200 to ≤ 400</td><td>IV</td><td>IV</td><td>III</td><td>II</td></tr>
<tr><td>> 100 to ≤ 200</td><td>III</td><td>III</td><td>II</td><td rowspan="4">I</td></tr>
<tr><td>> 50 to ≤ 100</td><td rowspan="2">II</td><td>II</td><td rowspan="3">I</td></tr>
<tr><td>> 25 to ≤ 50</td><td rowspan="2">I</td></tr>
<tr><td>≤ 25</td><td>I</td></tr>
</table>

Table 23: DRFI Immunity Performance Requirements, 30 to 400 MHz for Group A, B, C & D ***

<table>
<tr><th>Test Level mW</th><th>Group A Status</th><th>Group B Status</th><th>Group C Status</th><th>Group D Status</th></tr>
<tr><td>> 400 to ≤ 800</td><td>IV</td><td>IV</td><td>III</td><td>II</td></tr>
<tr><td>> 200 to ≤ 400</td><td>III</td><td>III</td><td>II</td><td rowspan="4">I</td></tr>
<tr><td>> 100 to ≤ 200</td><td rowspan="2">II</td><td>II</td><td rowspan="3">I</td></tr>
<tr><td>> 50 to ≤ 100</td><td rowspan="2">I</td></tr>
<tr><td>≤ 50</td><td>I</td></tr>
</table>

7.2.2 Test Setup

The maximum allowable length of the wiring from the DUT to the BAN shall be 150 mm. Refer to ISO 11452-7 and Figure 10 for test setup.



Key:

1. RF signal generator
2. RF amplifier(s) (10 to 25 W, typical)
3. Spectrum analyzer or RF power meter
4. RF sampling device (sampling T connector or directional coupler), 50 ohm, 25 W rating, 30 dB isolation
5. Attenuator (Pad) 50 ohm, 10 dB, 10 W
6. DC blocking capacitor
7. Peripherals
8. BANs, one in series with each lead except RF reference ground
9. Device under test
10. RF power meter (for test stand reference level determination)
11. Coaxial transmission line (double shielded or equivalent)
12. Ground Plane
13. Programmable controller and data acquisition equipment
14. Instrumentation data bus

Figure 10: DRFI Immunity Test Setup

7.3 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. Supplemental information for CG testing is provided in LP-388C-72.

7.3.1 Requirement

The immunity requirements are based on environmental data and are adapted to BCI through correlation with vehicle data. The immunity performance requirements are specified in Tables 24 to 27 and the Test Levels in Figure 11.

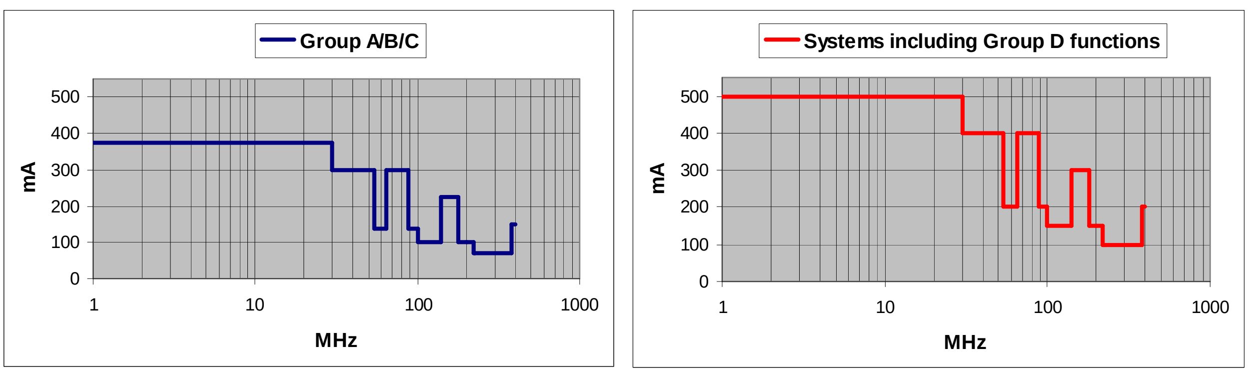


Figure 11: Test Levels for BCI Testing, Group A, B, C and Systems including Group D functions***

The top level of Tables 24, 25, 26 and 27, shaded gray, is only evaluated if the DUT has a Group D function.

Table 24: BCI Immunity Performance Requirements, 1 to 30 MHz for Group A, B, C and D ***

<table>
<tr><th>Test Level mA</th><th>Group A Status</th><th>Group B Status</th><th>Group C Status</th><th>Group D Status</th></tr>
<tr><td>> 375 to ≤ 500</td><td>IV</td><td>IV</td><td>III</td><td>II</td></tr>
<tr><td>> 250 to ≤ 375</td><td>III</td><td>III</td><td>II</td><td rowspan="4">I</td></tr>
<tr><td>> 180 to ≤ 250</td><td rowspan="2">II</td><td>II</td><td rowspan="3">I</td></tr>
<tr><td>> 90 to ≤ 180</td><td rowspan="2">I</td></tr>
<tr><td>≤ 90</td><td>I</td></tr>
</table>

Table 25: BCI Immunity Performance Requirements, 30 to 100 MHz for Group A, B, C and D ***

<table>
<tr><th>Test Level mA</th><th>Group A Status</th><th>Group B Status</th><th>Group C Status</th><th>Group D Status</th></tr>
<tr><td>> 300 to ≤ 400</td><td>IV</td><td>IV</td><td>III</td><td>II</td></tr>
<tr><td>> 200 to ≤ 300</td><td>III</td><td>III</td><td>II</td><td rowspan="4">I</td></tr>
<tr><td>> 140 to ≤ 200</td><td rowspan="2">II</td><td>II</td><td rowspan="3">I</td></tr>
<tr><td>> 70 to ≤ 140</td><td rowspan="2">I</td></tr>
<tr><td>≤ 70</td><td>I</td></tr>
</table>

Table 26: BCI Immunity Performance Requirements, 100 to 220 MHz for Group A, B, C and D ***

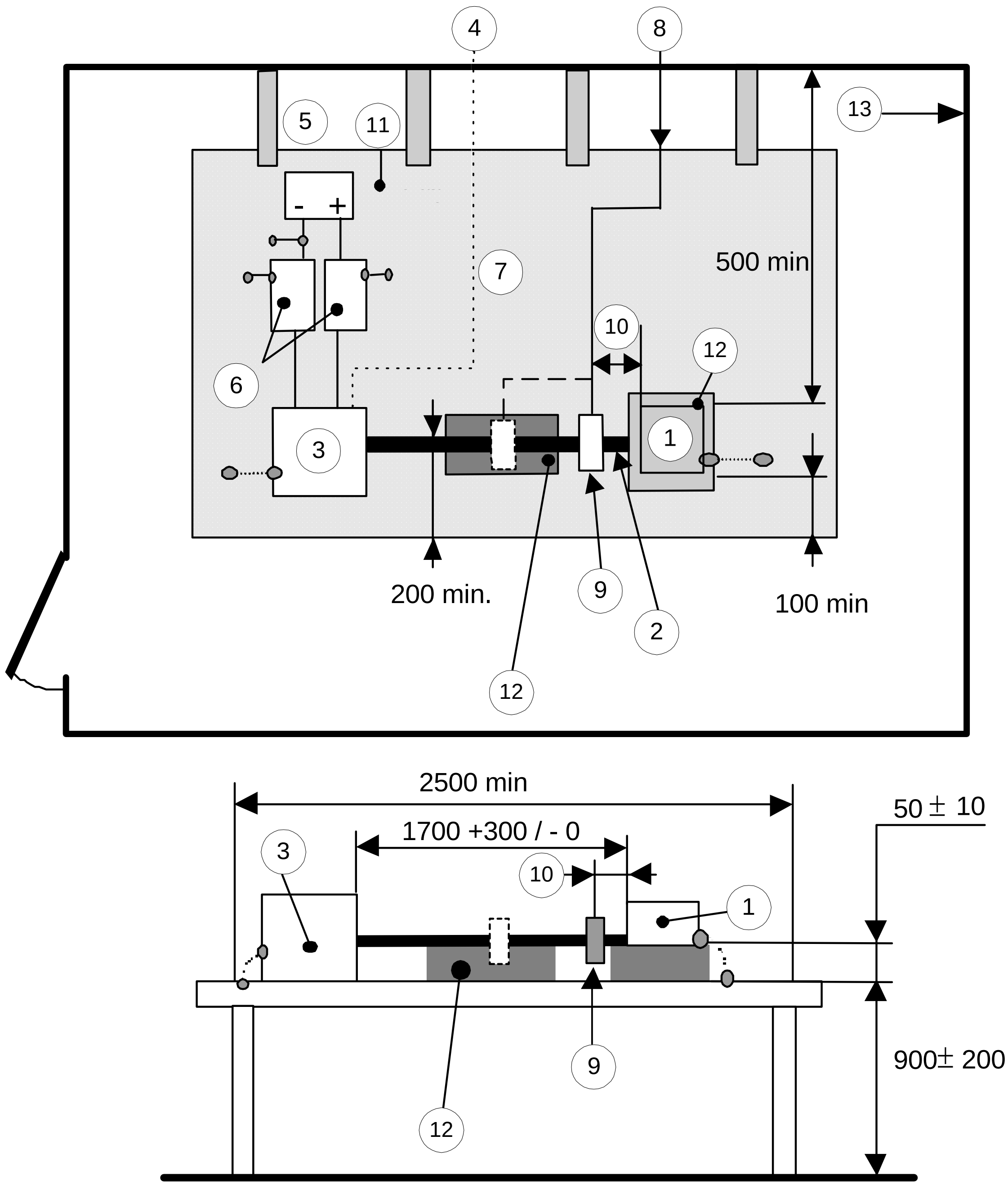
<table>
<tr><th>Test Level mA</th><th>Group A Status</th><th>Group B Status</th><th>Group C Status</th><th>Group D Status</th></tr>
<tr><td>> 225 to ≤ 300</td><td>IV</td><td>IV</td><td>III</td><td>II</td></tr>
<tr><td>> 150 to ≤ 225</td><td>III</td><td>III</td><td>II</td><td rowspan="4">I</td></tr>
<tr><td>> 100 to ≤ 150</td><td rowspan="2">II</td><td>II</td><td rowspan="3">I</td></tr>
<tr><td>> 50 to ≤ 100</td><td rowspan="2">I</td></tr>
<tr><td>≤ 50</td><td>I</td></tr>
</table>

Table 27: BCI Immunity Performance Requirements, 220 to 400 MHz for Group A, B, C and D ***

<table>
<tr><th>Test Level mA</th><th>Group A Status</th><th>Group B Status</th><th>Group C Status</th><th>Group D Status</th></tr>
<tr><td>> 150 to ≤ 200</td><td>IV</td><td>IV</td><td>III</td><td>II</td></tr>
<tr><td>> 100 to ≤ 150</td><td>III</td><td>III</td><td>II</td><td rowspan="4">I</td></tr>
<tr><td>> 70 to ≤ 100</td><td rowspan="2">II</td><td>II</td><td rowspan="3">I</td></tr>
<tr><td>> 35 to ≤ 70</td><td rowspan="2">I</td></tr>
<tr><td>≤ 35</td><td>I</td></tr>
</table>

7.3.2 Test Setup

Due to changes with respect to ISO 11452-4, refer to Figure 12 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 or 50 ohm BAN
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

This figure is adapted from ISO WD 11452-4.

Figure 12: 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 Emission 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.
- The voltage supply and the periphery shall be filtered and shielded (alternative: outside the shielded enclosure); exception: peripherals which are not susceptible to radiated disturbances (such as mechanical switches).
- Wherever possible, production intent vehicle switching devices and sensors shall be used.

7.4 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 (with ground plane) with changes as defined in this document.

7.4.1 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 28 and the Test Levels in Figure 13.

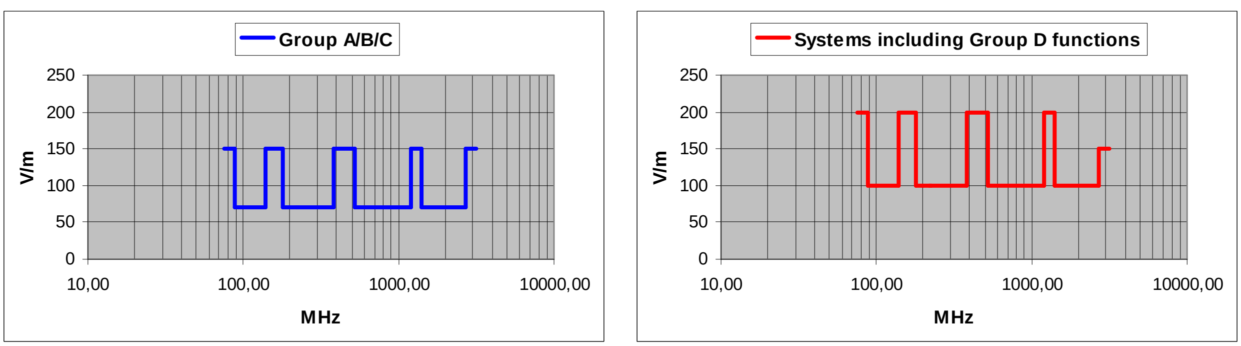


Figure 13: Test Levels for ALSE Testing, Group A, B, C and Systems including Group D functions***

The top level of Table 28, shaded gray, is only evaluated if the DUT has a Group D function.

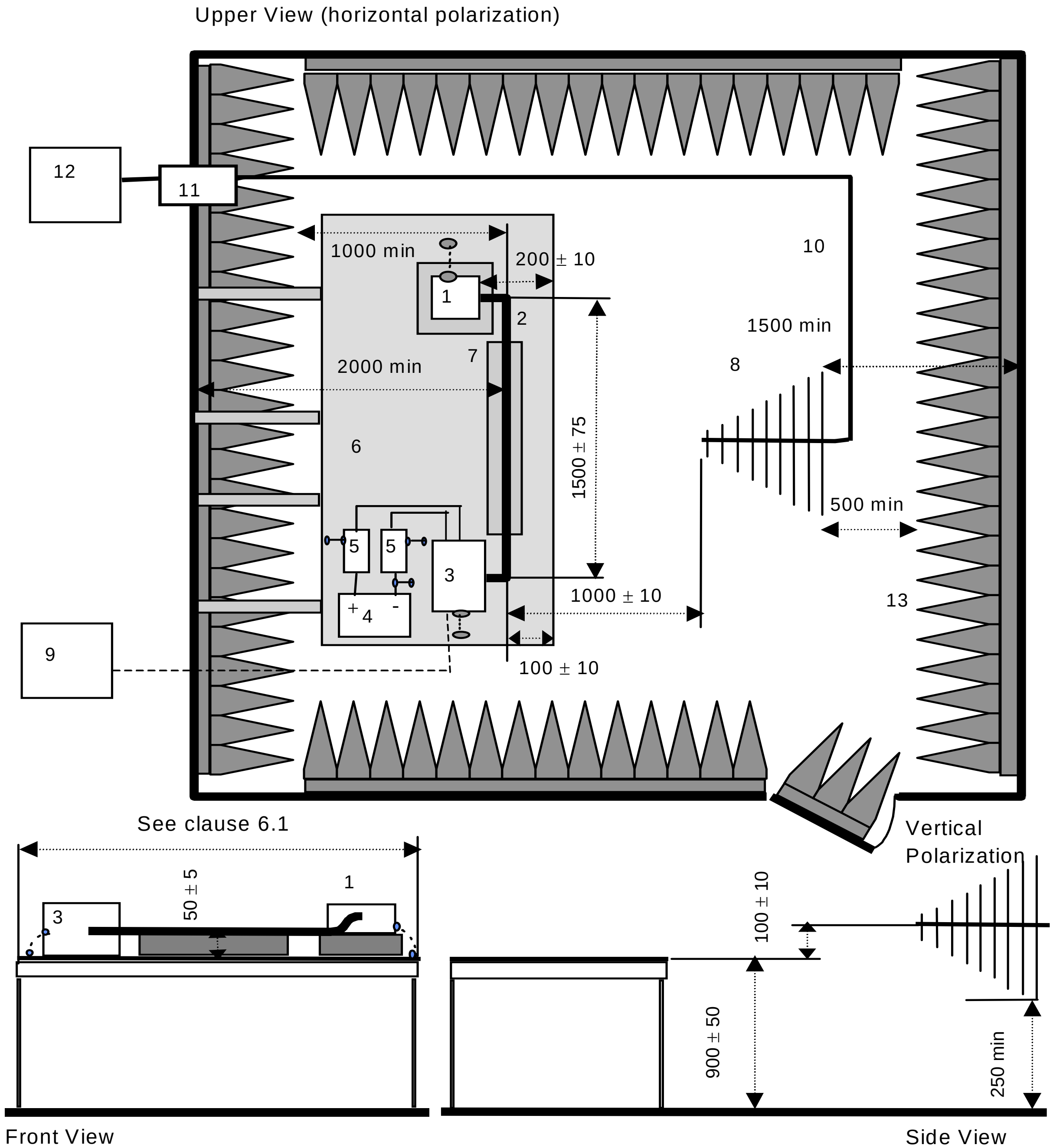
Table 28: Performance Requirements for ALSE Testing, Group A, B, C and D ***

<table>
<tr><th>Test Level V/m</th><th>Group A Status</th><th>Group B Status</th><th>Group C Status</th><th>Group D Status</th></tr>
<tr><td>> 150 to ≤ 200</td><td>IV</td><td>IV</td><td>III</td><td>II</td></tr>
<tr><td>> 100 to ≤ 150</td><td>III</td><td>III</td><td>II</td><td rowspan="4">I</td></tr>
<tr><td>> 70 to ≤ 100</td><td rowspan="2">II</td><td>II</td><td rowspan="3">I</td></tr>
<tr><td>> 35 to ≤ 70</td><td rowspan="2">I</td></tr>
<tr><td>≤ 35</td><td>I</td></tr>
</table>

7.4.2 Test setup

Refer to Figures 14 and 15 for schematic diagrams of the test setups. The following deviations from and additions to ISO 11452-2 apply:

- Use substitution method with forward power.
- For frequencies ≤ 1 GHz, the antenna shall be positioned in front of the middle of the harness (refer to Figure 14). For frequencies above 1 GHz, the antenna shall be sighted on the DUT (refer to Figure 15).
- For modules in a metal case, the DUT connector(s) should be oriented toward the antenna.
- Wiring harness length and routing shall be controlled and documented.
- Production intent vehicle sensors and loads shall be used as peripheral devices wherever possible.
- The test shall be carried out with vertical antenna polarization only up to 400 MHz and with vertical and horizontal antenna polarization above 400 MHz.

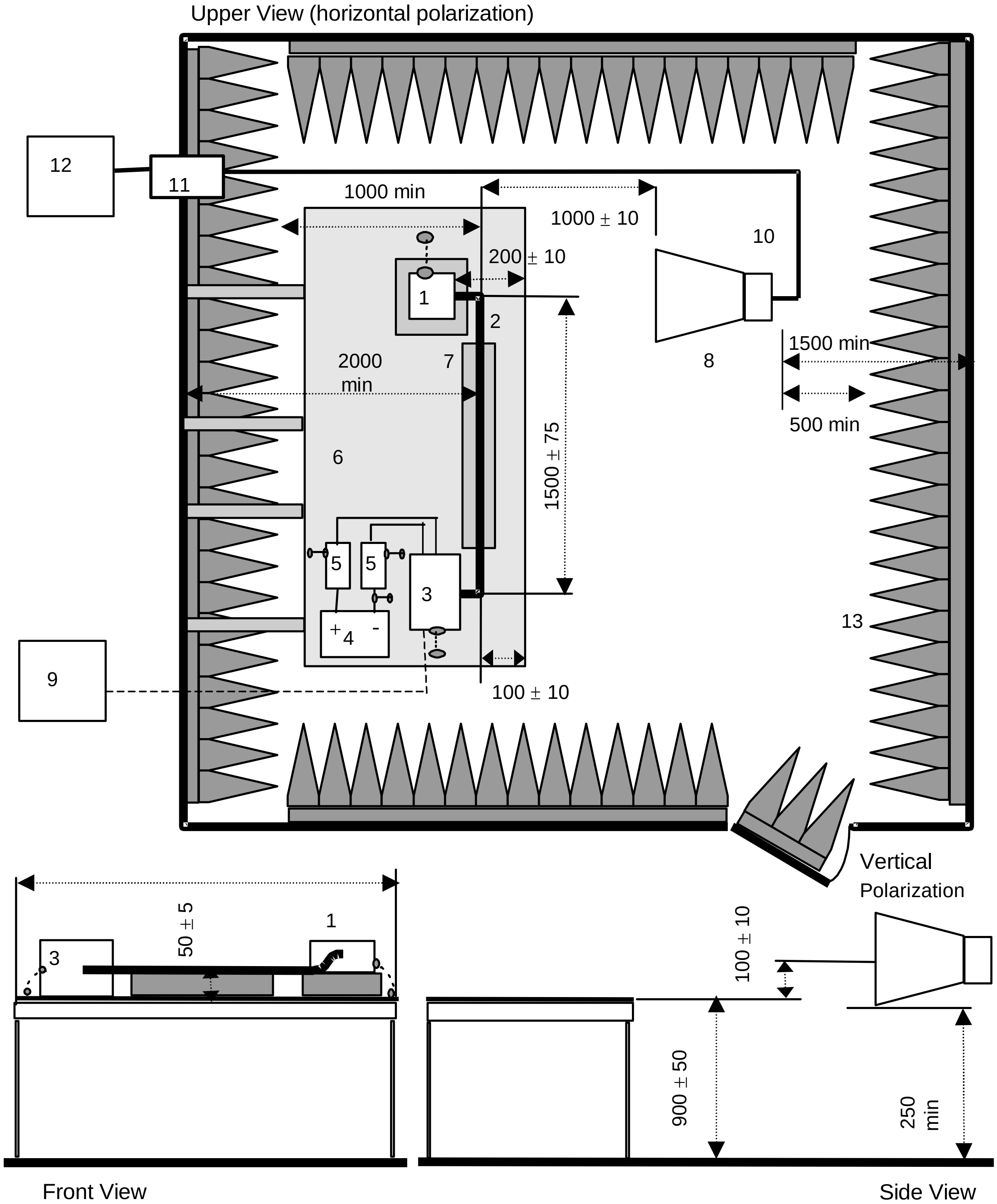


Key:

1 DUT (grounded locally if required in test plan)
2 Test harness
3 Load simulator (placement and ground connection according to ISO 11452-2)
4 Power supply (location optional)
5 Artificial network (AN) or 50 ohm BAN
6 Ground plane (bonded to shielded enclosure)
7 Low relative permittivity support ($\varepsilon_r \leq 1.4$)
8 Log-periodic antenna
9 Monitoring device
10 Double-shielded coaxial cable (50 ohm)
11 Bulkhead connector
12 RF Amplifier System
13 RF absorber material

The figure is adapted from ISO/CD 11452-2.

Figure 14: Radiated Immunity Test in an ALSE with a Ground Plane (≤1 000 MHz)



Key:

1 DUT (grounded locally if required in test plan)
2 Test harness
3 Load simulator (placement and ground connection according to ISO 11452-2)
4 Power supply (location optional)
5 Artificial network (AN) or 50 ohm BAN
6 Ground plane (bonded to shielded enclosure)
7 Low relative permittivity support ($\varepsilon_r \leq 1.4$)
8 Horn antenna
9 Monitoring device
10 Double-shielded coaxial cable (50 ohm)
11 Bulkhead connector
12 RF Amplifier System
13 RF absorber material

The figure is adapted from ISO/CD 11452-2. Note: Horn antenna has been moved to sight on the DUT.

Figure 15: Radiated Immunity Test in an ALSE with a Ground Plane (>1 000 MHz)

7.5 ALSE without a Ground Plane

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 details, refer to LP-388C-35.

7.5.1 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 Figure 13 and Table 28.

7.5.2 Test setup

Refer to LP-388C-35 for test procedure. For a schematic diagram of the test setup refer to Figure 16.

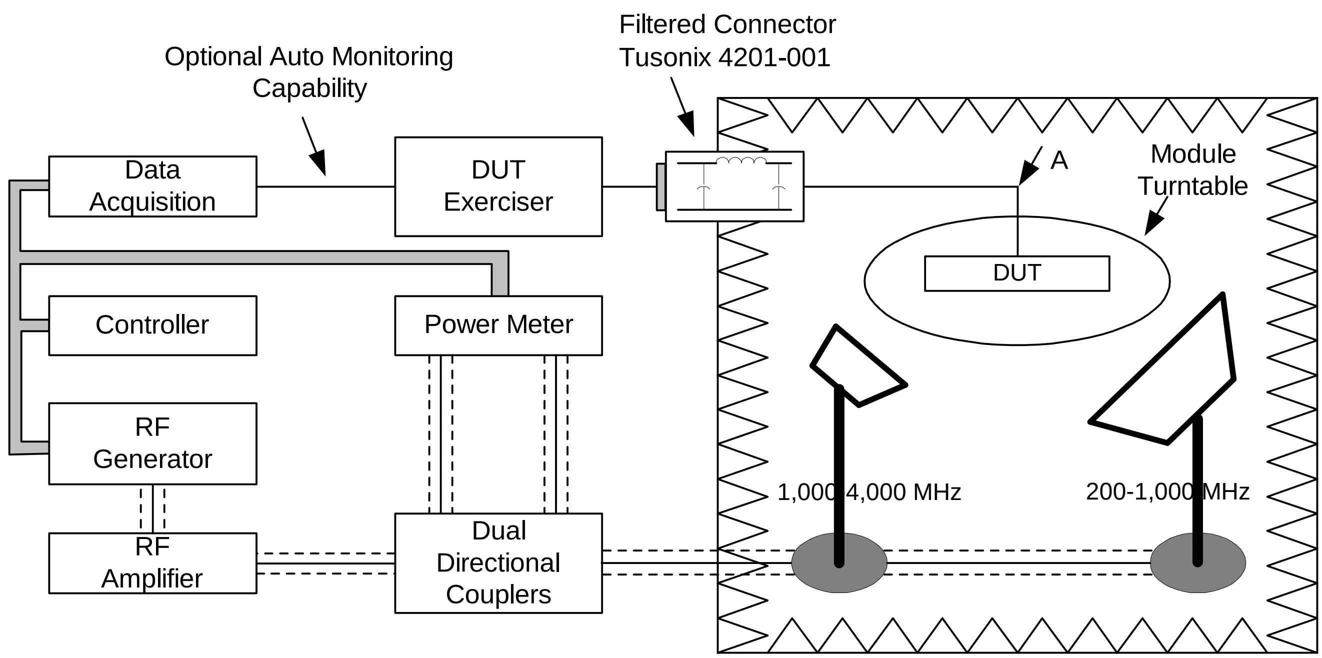


Figure 16: Radiated Immunity Test in an ALSE without a Ground Plane

- 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.
- Wiring harness routing shall be controlled and documented.

7.6 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. Supplemental information for CG testing is provided in LP-388C-34.

7.6.1 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 29 and the test levels in Figure 17.

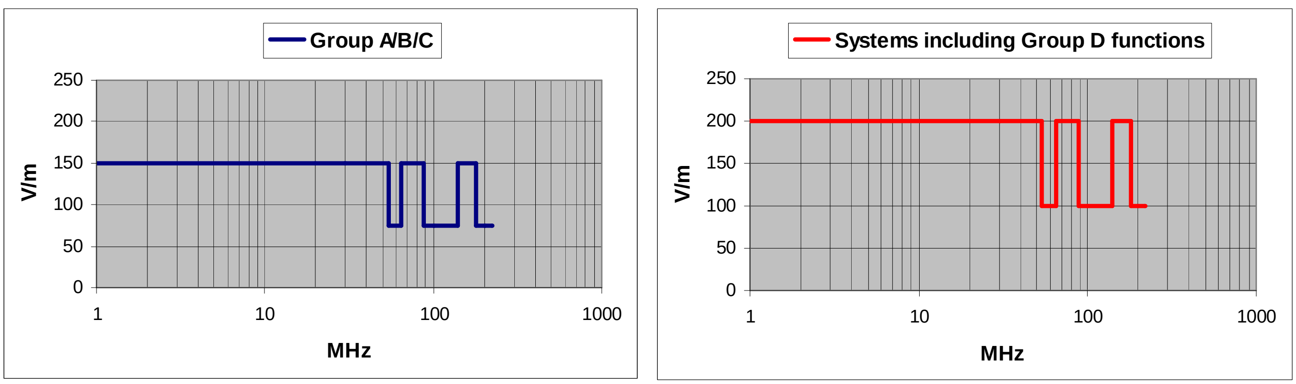


Figure 17 Test Levels for TEM Testing, Group A, B, C and systems including Group D functions***

The top level of Table 29, shaded gray, is only evaluated if the DUT has a Group D function.

Table 29: TEM Cell Immunity Performance Requirements, 1 to 200 MHz, Group A, B, C and D ***

<table>
<tr><th>Test Level V/m</th><th>Group A Status</th><th>Group B Status</th><th>Group C Status</th><th>Group D Status</th></tr>
<tr><td>> 150 to ≤ 200</td><td>IV</td><td>IV</td><td>III</td><td>II</td></tr>
<tr><td>> 100 to ≤ 150</td><td>III</td><td>III</td><td>II</td><td rowspan="4">I</td></tr>
<tr><td>> 70 to ≤ 100</td><td rowspan="2">II</td><td>II</td><td rowspan="3">I</td></tr>
<tr><td>> 35 to ≤ 70</td><td rowspan="2">I</td></tr>
<tr><td>≤ 35</td><td>I</td></tr>
</table>

7.6.2 Test setup

Details on the test setup are given in ISO 11452-3 and in Figure 18. Supplementary information for CG testing is provided in LP-388C-34.

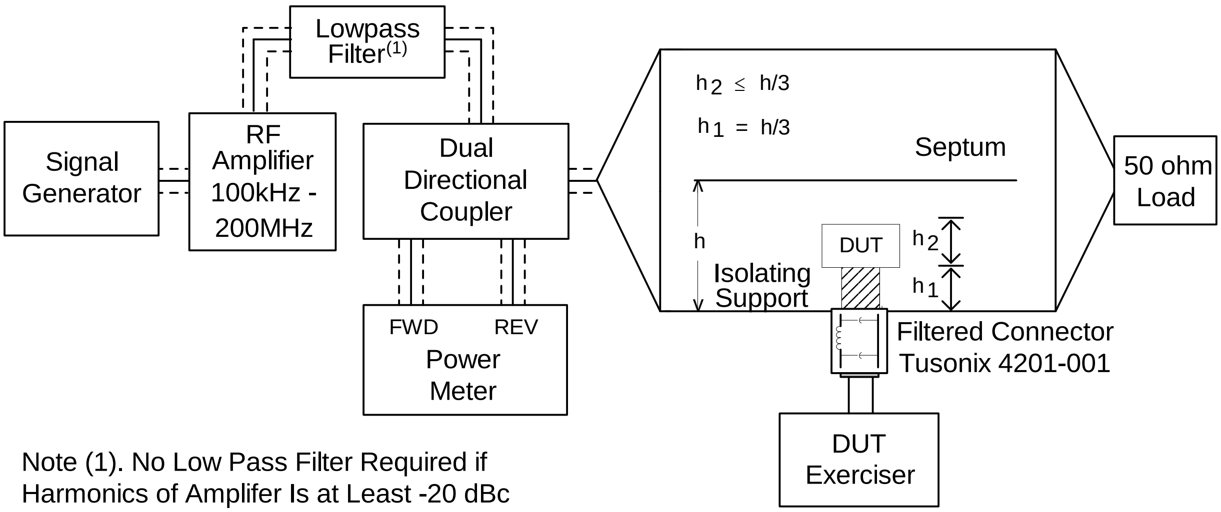


Figure 18: TEM Immunity Test Setup

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 not optional but required.
- 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. Subcategory MS DUTs in severe magnetic environments (e.g. located within 0.5 meter 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. Supplemental information for CG testing is provided in LP-388C-58.

8.2 Test

- Test frequency steps shall be at least 10 per decade (corresponding to a maximum expected Q of 4).
- 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 19.

8.2.1 Test Setup

Refer to Figure 19 for test setup.

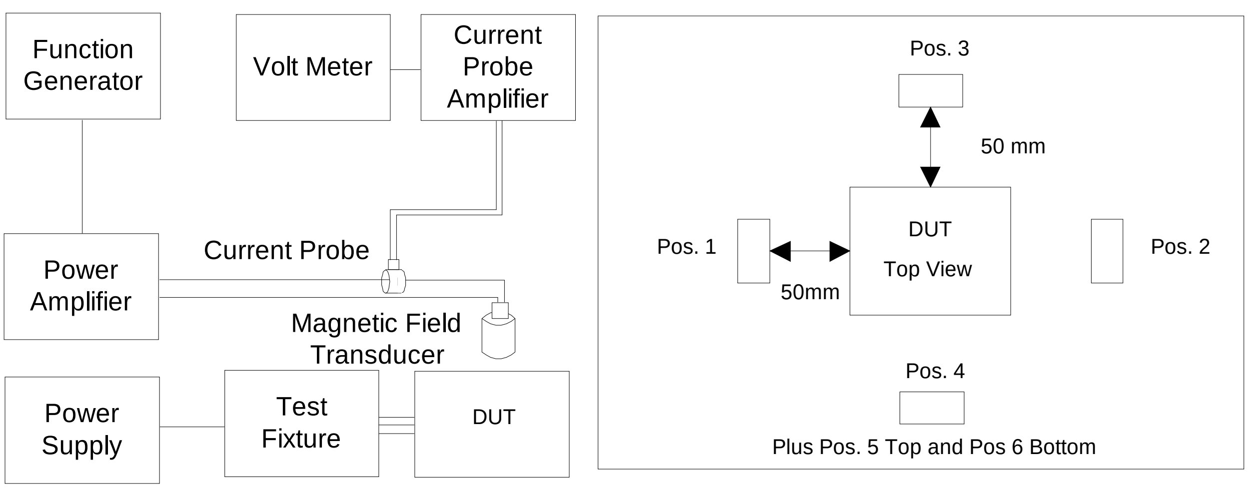


Figure 19: Magnetic Immunity Test Setup

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 32, 33, 34 and 35. 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 30.

Table 30: Supply Voltage Transients - Immunity Requirements

Transient Pulse	Performance Status Group A	Performance Status Groups B, C and D
Pulse #1	II	II
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).

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 6.7.1.

9.1.2 Test Conditions

Pulses #1 and #2 shall be applied for 1 hour each, pulses #3a and #3b shall be applied for one half hour each. This results in approximately 720 applications of pulse #1, 7 200 of pulse #2 and 1 800 000 each of pulses #3a and #3b. Supplemental information for CG testing is provided in LP-388C-39.

9.1.3 Test Setup

For devices with one supply voltage connection, refer to ISO 7637-2 for the test setup. Figure 20 illustrates the test setup for devices with 2 supply voltage connections, e.g. DC/DC converters.

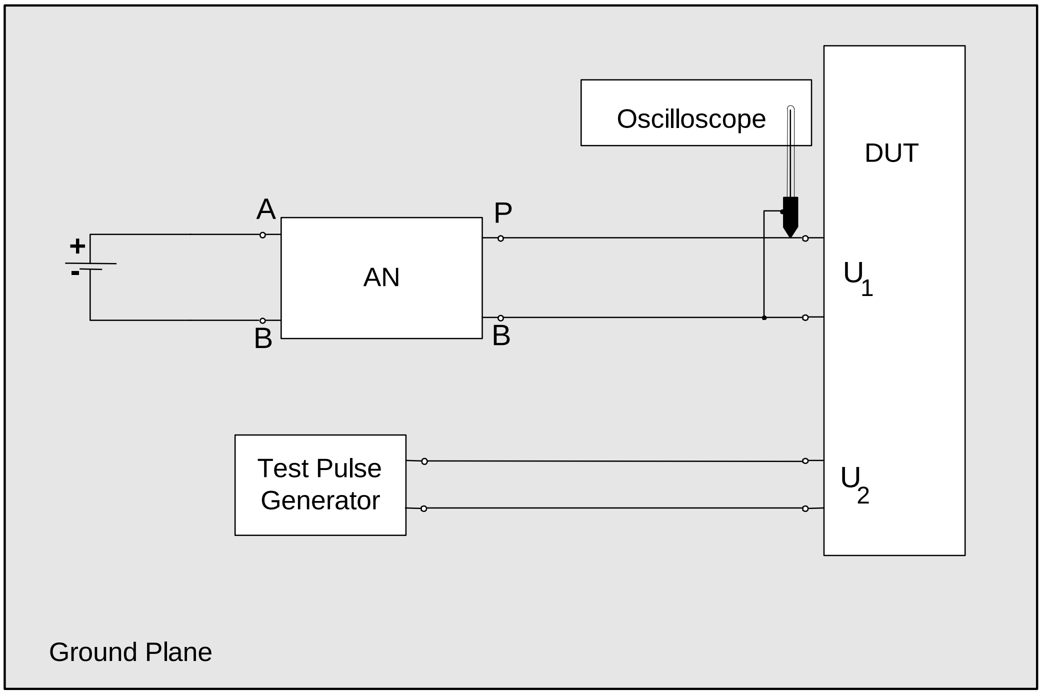
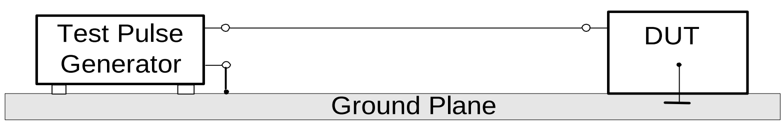
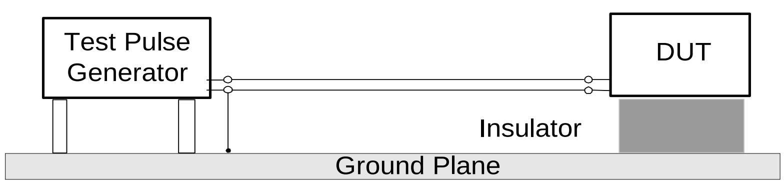


Figure 20: Test Setup for Devices with Two Voltage Supply Connections

Electrically asymmetrical and electrically symmetrical devices under test shall be connected as illustrated in Figure 21. (The oscilloscope, probe and switch or relay are not illustrated.)



a) DUT with Asymmetrical Connection



b) DUT with Symmetrical Connection

Figure 21: 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 21, 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 21, 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. Only switched supply lines shall be exposed to this test pulse. It is defined by Figure 22 and Table 31.

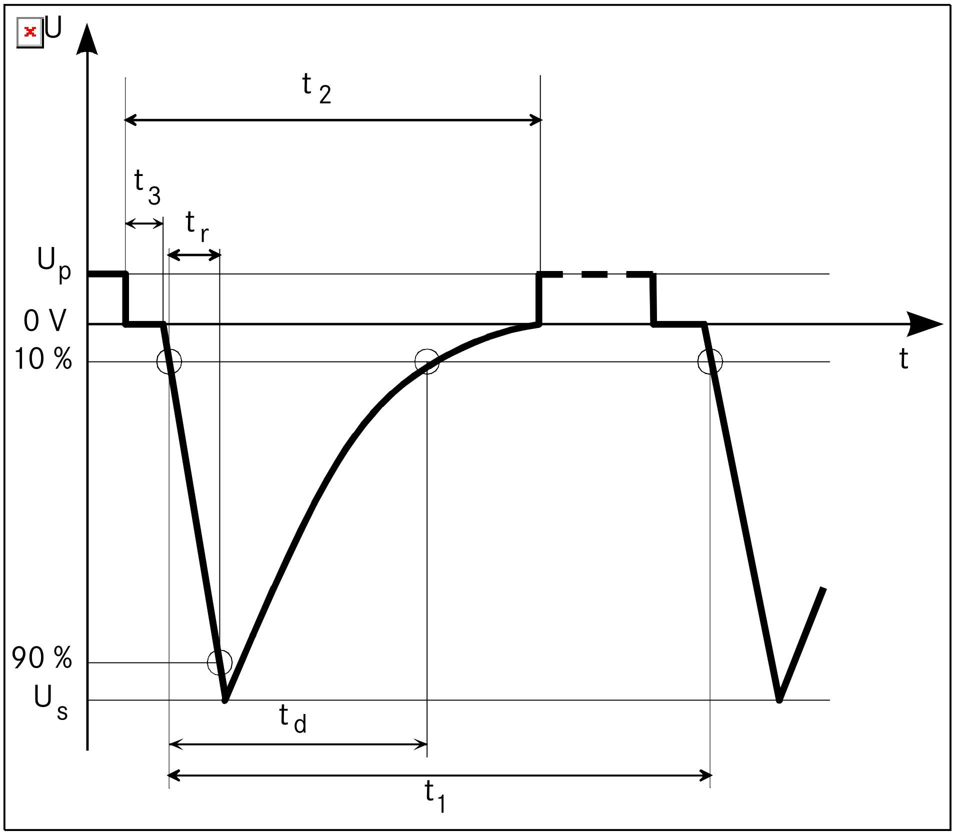


Figure 22: Test Pulse 1

Table 31: Test Pulse 1 - Parameters

Parameters	12 V System	24 V System	42 V System
U_p in V	13.5	27	42
U_s in V	-100	-300	-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	10	10
Test duration in h	1	1	1

9.1.4.2 Test pulse 2

Test pulse 2 simulates the interruption of a current through an inductance switched in series with the DUT. Only switched supply lines shall be exposed to this test pulse. It is defined by Figure 23 and Table 32 (deviating from its definition in ISO 7637-2).

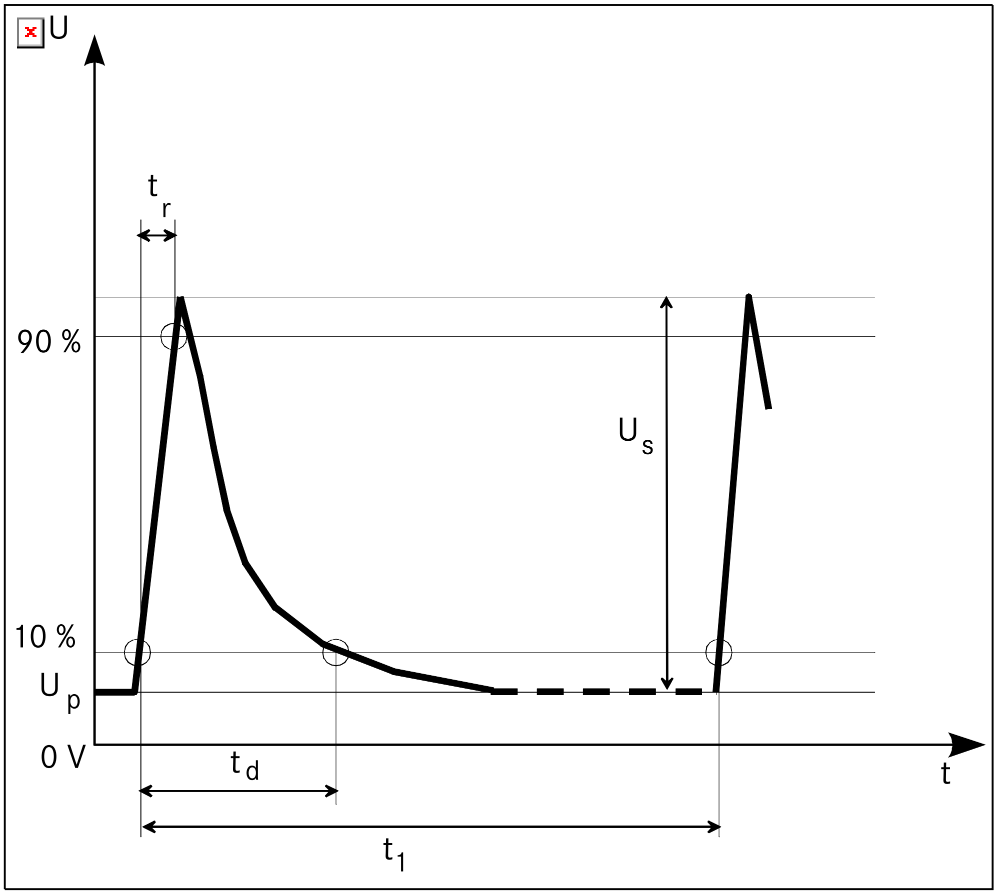


Figure 23: Test Pulse 2

Table 32: Test pulse 2 – Parameters

Parameters	12 V System	24 V System	42 V System
U_p 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	10	10	10
Test duration in h	1	1	1

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 33.

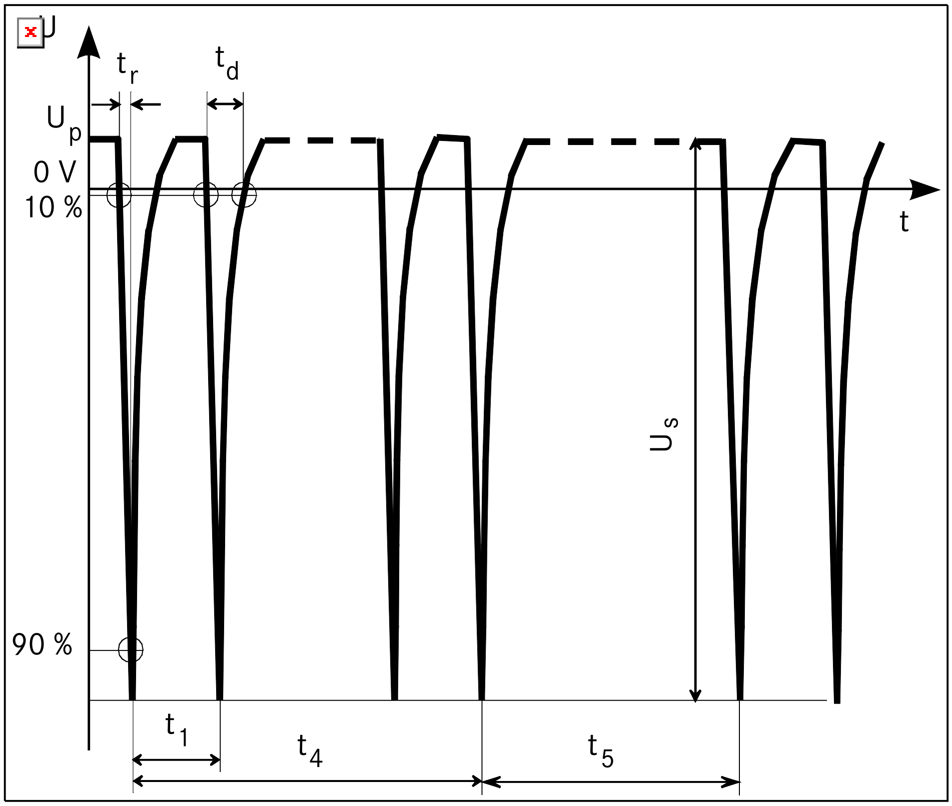


Figure 24: Test Pulse 3a

Table 33: Test Pulse 3a - Parameters

Parameters	12 V System	24 V System	42 V System
U_p 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 h	0.5	0.5	0.5

- **Test Pulse 3b**

Test pulse 3b simulates the positive pulses. It is defined by Figure 25 and Table 34.

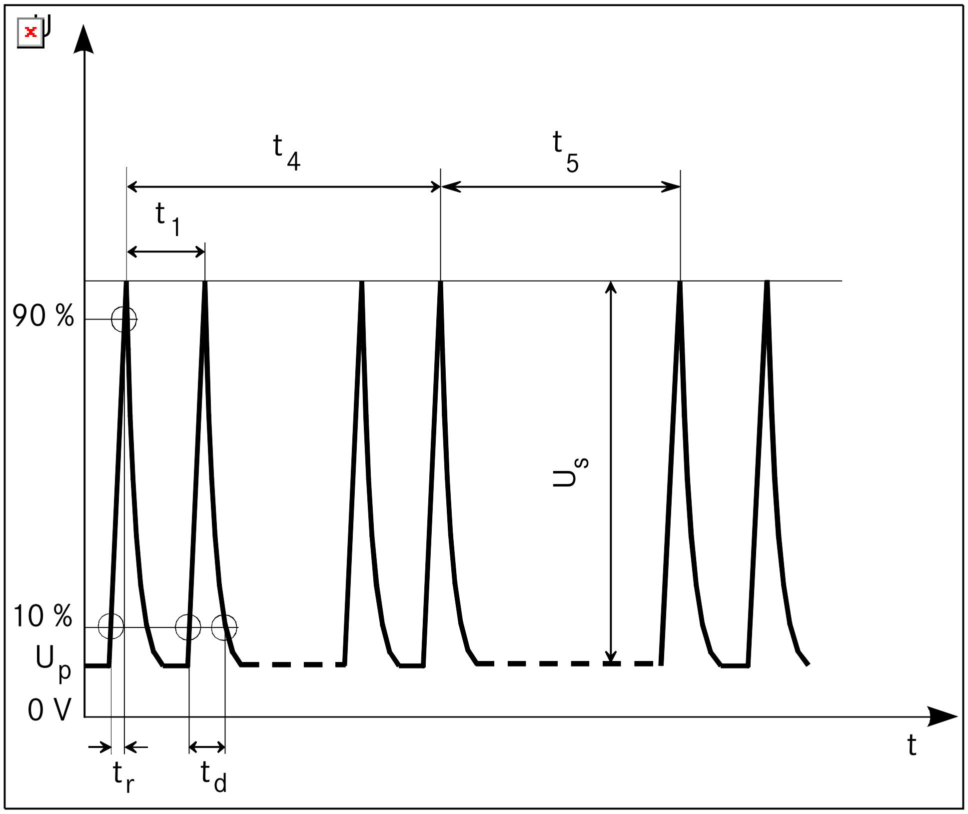


Figure 25: Test Pulse 3b

Table 34: Test Pulse 3b - Parameters

Parameters	12 V System	24 V System	42 V System
U_p 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 h	0.5	0.5	0.5

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 modules, testing with Pulse #2 using both positive and negative polarity and direct capacitive coupling is also required. 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 35.

Table 35: 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, 28, 29 and 30 and Tables 36, 37, 38 and 39. 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 and LP-388C-39 for test procedure.

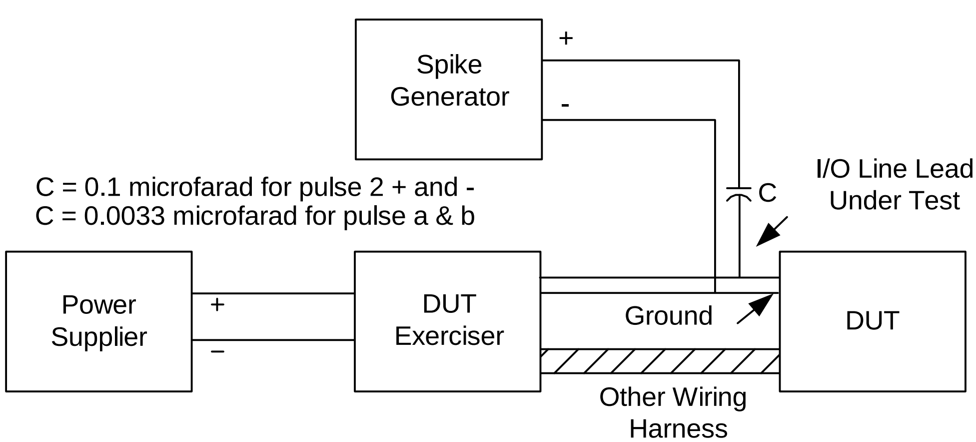


Figure 26: Direct Capacitor Coupling Test Setup

9.2.5 Test Pulses

Test Pulse 2, Positive and Negative Polarity in Figures 27 and 28 and in Tables 36 and 37.

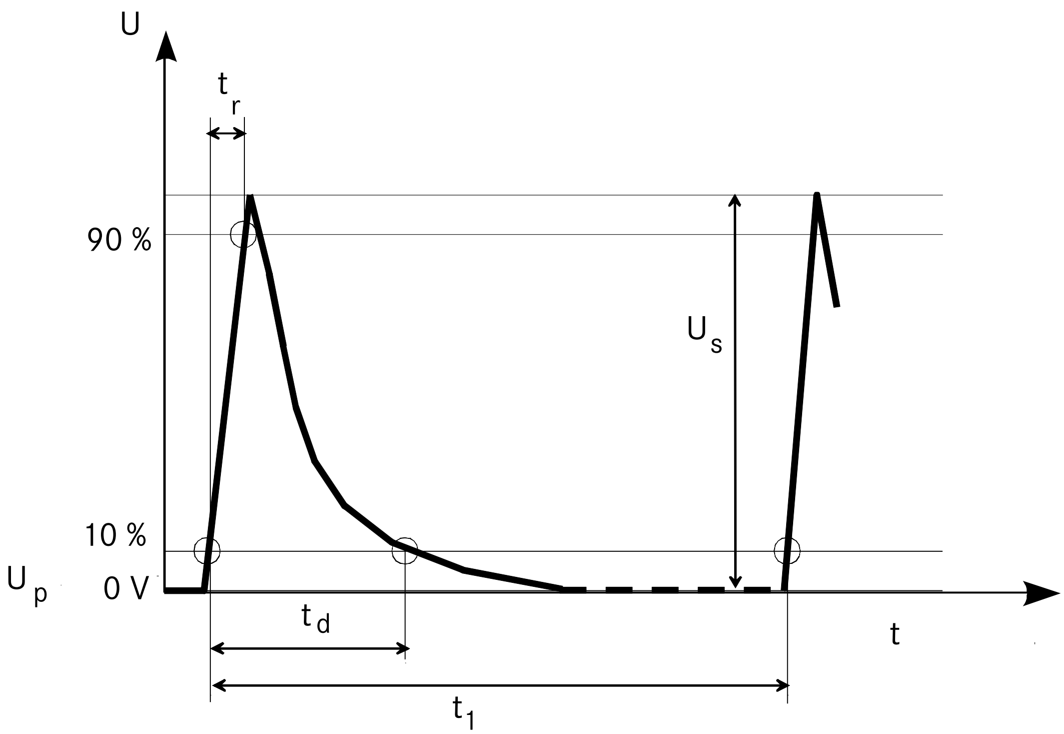


Figure 27: Positive Pulse 2 for I/O Coupling Test

Table 36: Positive Pulse 2 - I/O Coupling Parameters

Parameters	12 V System	24 V System	42 V System
U_p in V	0	0	0
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 minutes	5	5	5

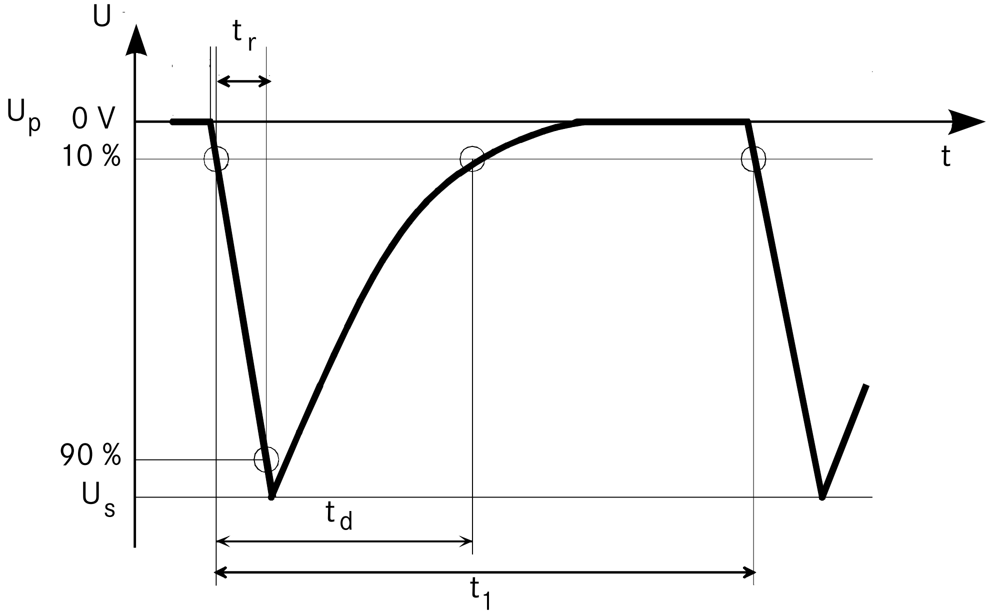


Figure 28: Negative Pulse 2 for I/O Coupling Test

Table 37: Negative Pulse 2 - I/O Coupling Parameters

Parameters	12 V System	24 V System	42 V System
U_p in V	0	0	0
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 minutes	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 38.

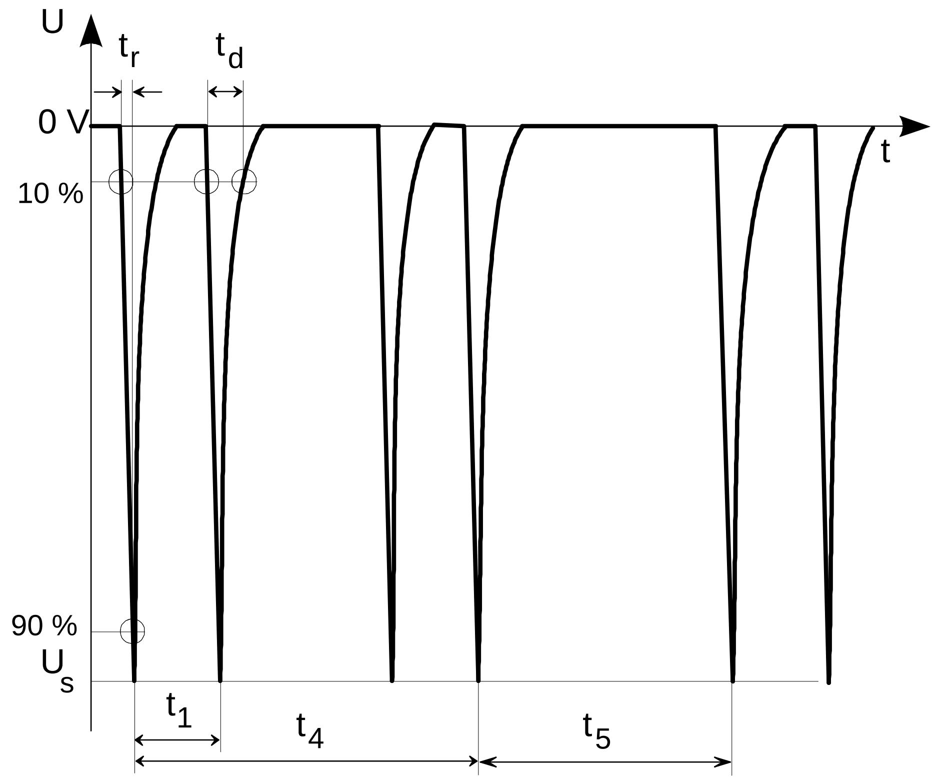


Figure 29: Test Pulse a

Table 38: Test Pulse a - 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 minutes	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 39.

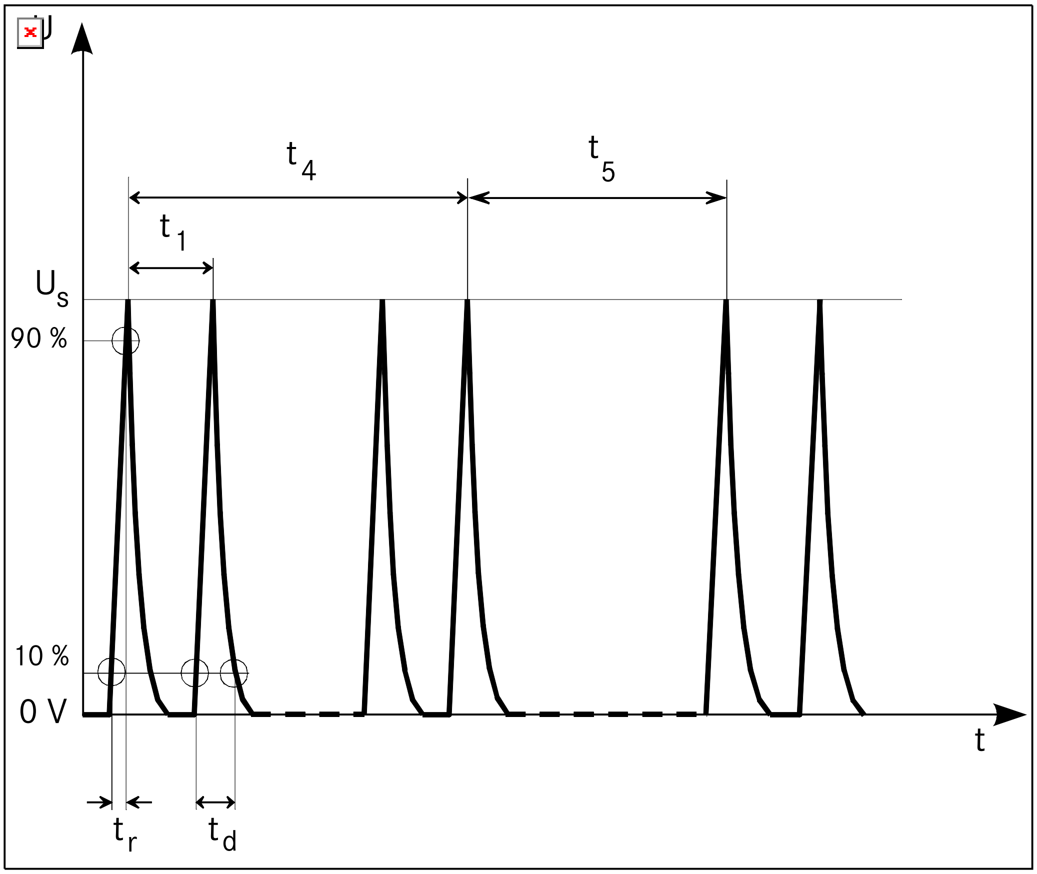


Figure 30: Test Pulse b

Table 39: Test Pulse b - Parameters

Parameters	12 V System	24 V System	42 V System
U_s in V	45	80	45
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 minutes	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 accessible to the occupants in a vehicle, or in readily accessible underhood or trunk locations, shall also be subjected to the direct discharge operating test in 10.2. 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 of 20% to 60% RH (below 40% preferred). 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, 1GHz analog bandwidth) which shall be shielded from the coaxial target and ground plane assembly. Direct contact characterization shall be used. Supplemental information for CG testing is provided in LP-388C-42.

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. This is a direct contact discharge test. Refer to Table 40 for the requirements.

Table 40: ESD Immunity Requirements – Handling Test

Test Voltage – Case	Test Voltage – Pins	Group A, B, C and D Status
± 8 kV	± 4 kV	IV
	± 3 kV	

10.1.2 ESD Handling test setup ***

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

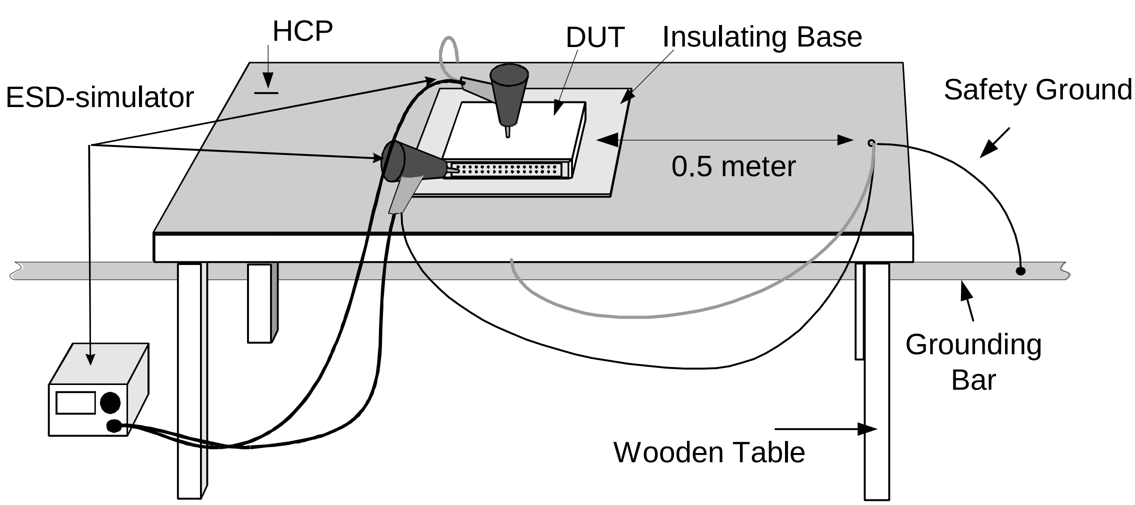


Figure 31: ESD Handling Test Setup *

- An ESD simulator and contact discharge electrode according to IEC 61000-4-2 shall be used with a discharge network of 150 pF and 330 ohms. 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 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 (copper or brass is preferred). 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 DUT, with all leads disconnected, shall be centered on the HCP. The case, if conductive and case grounded in the vehicle application, shall be case grounded to the HCP, otherwise an insulating spacer per ISO 10605 shall be used.

10.1.3 ESD Handling test conditions

- Before testing commences, the discharge voltage of the ESD simulator shall be verified.
- Discharge points: 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.
- 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.
- 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 and the housing. 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. 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 ***

This test applies to all components and their periphery. 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, otherwise use a discharge network of 150 pF and 330 ohms. The discharge network shall be specified in the test plan. The ESD simulator shall be capable of generating contact discharges from ±3 to ±20 kV.

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 41 and the ESD Immunity Requirements are in Table 42.

Supplemental information for CG testing is provided in LP-388C-42.

Table 41: ESD Operating Test Levels *

Requirement	Air (Conductive and non-conductive points)	Contact (Conductive points only)	Field Coupled (Contact discharge to test islands)
Systems without Group D functions	±4, ±8, ±15, ±20 kV	±3, ±4, ±8 kV	±8, ±15, ±20 kV
Systems including Group D functions	±4, ±8, ±15, ±20, ±25 kV	±3, ±4, ±8 kV	±8, ±15, ±20 kV

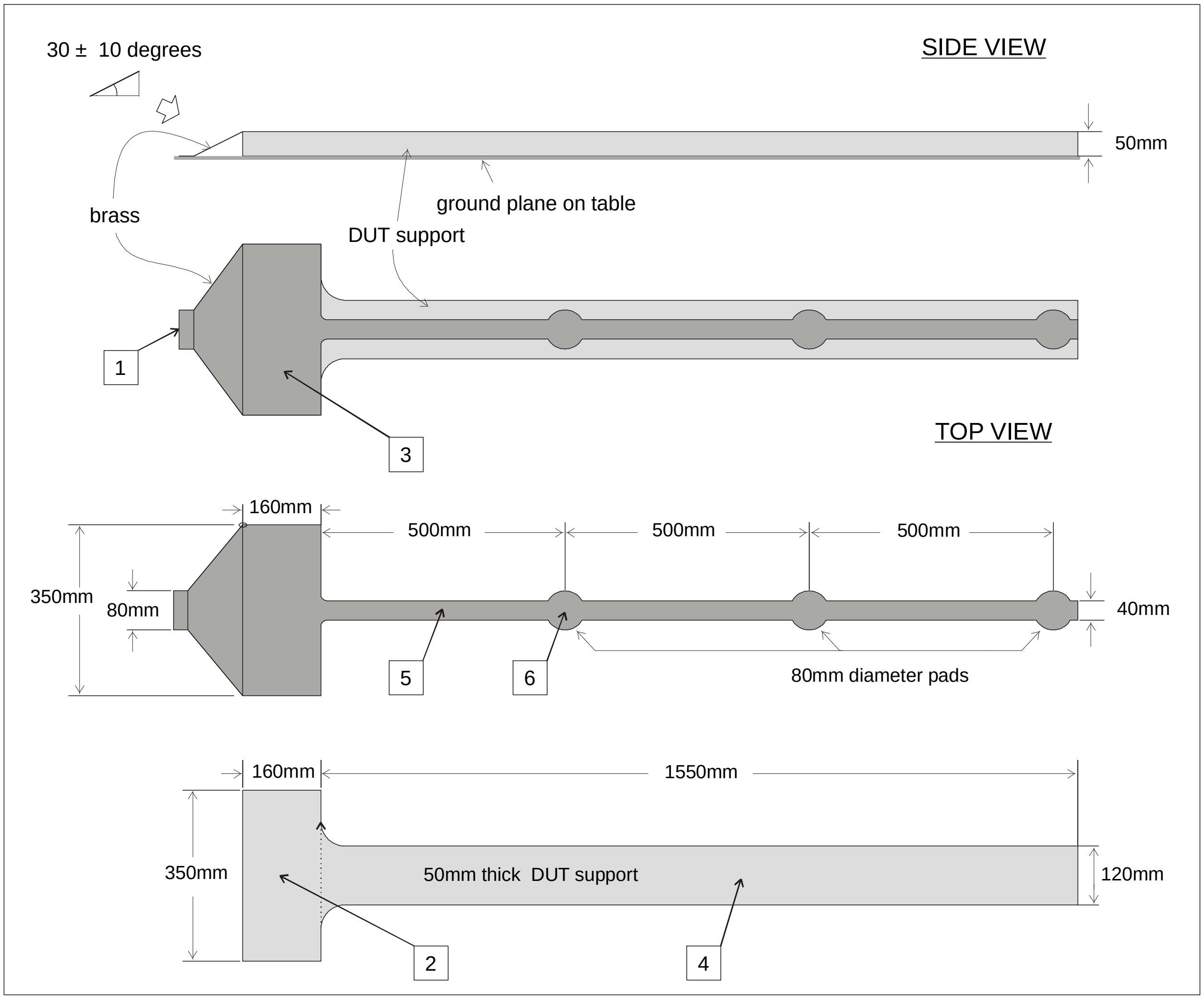
The top level of Table 42, shaded gray, is only evaluated if the DUT has a Group D function.

Table 42: ESD Operating Immunity Requirements ***

Test Voltage	Group A Status	Group B Status	Group C Status	Group D Status
± 25 kV	IV	IV	III	I
± 20 kV	III	II	II	I
± 15 kV	II	II	I	I
± 8 kV	II	I	I	I
± 4 kV	II	I	I	I
± 3 kV	II	I	I	I

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

For schematic diagrams of the test bench setup 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.

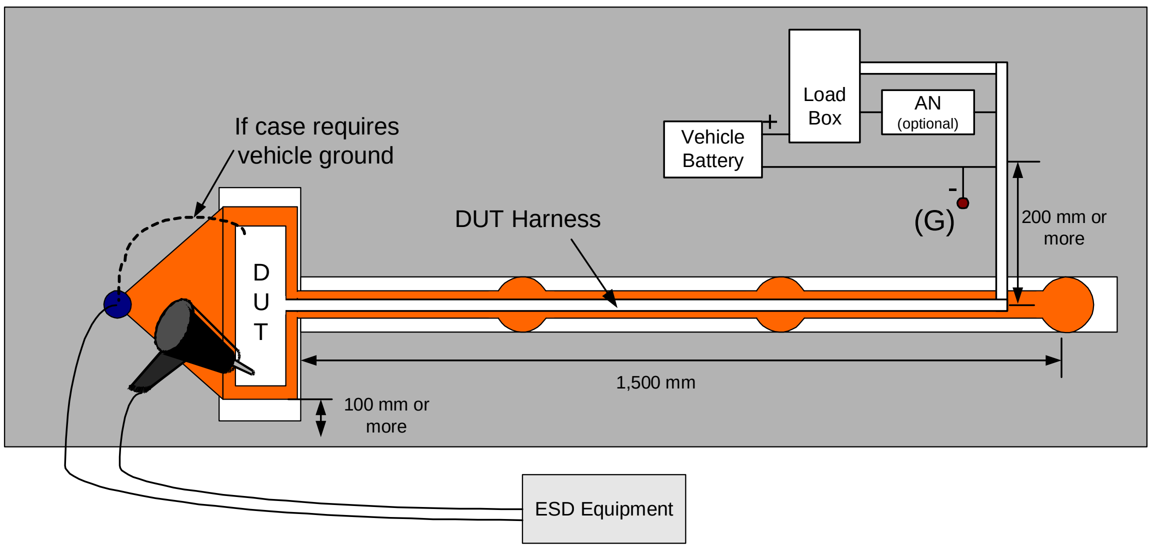


Key:

1. Ground reference point for the ESD simulator and the DUT ESD field coupling plane, the ESD simulator ground cable length shall allow discharges at the three discharge islands

2. DUT support – made of nonconductive material, $\varepsilon_r < 2.5$, e.g. foamed polypropylene or Styrofoam
3. DUT ESD field coupling plane, copper or brass, 0.5 to 2 mm thick, at least 10 mm larger than the DUT on all sides, 160 by 350 mm minimum dimensions – not including the ground taper section
4. Wiring harness support – made of nonconductive material, $\varepsilon_r < 2.5$, 50 mm high
5. ESD field coupling strip – copper or brass, 0.5 to 2 mm thick
6. ESD discharge islands – conductively coupled to the field coupling strip, copper or brass, 80 mm in diameter, 0.5 to 2 mm thick
7. All dimensions are ± 5%

Figure 32: ESD Operating Test Bench Setup***



Key: G is the ground reference point for the DUT.

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

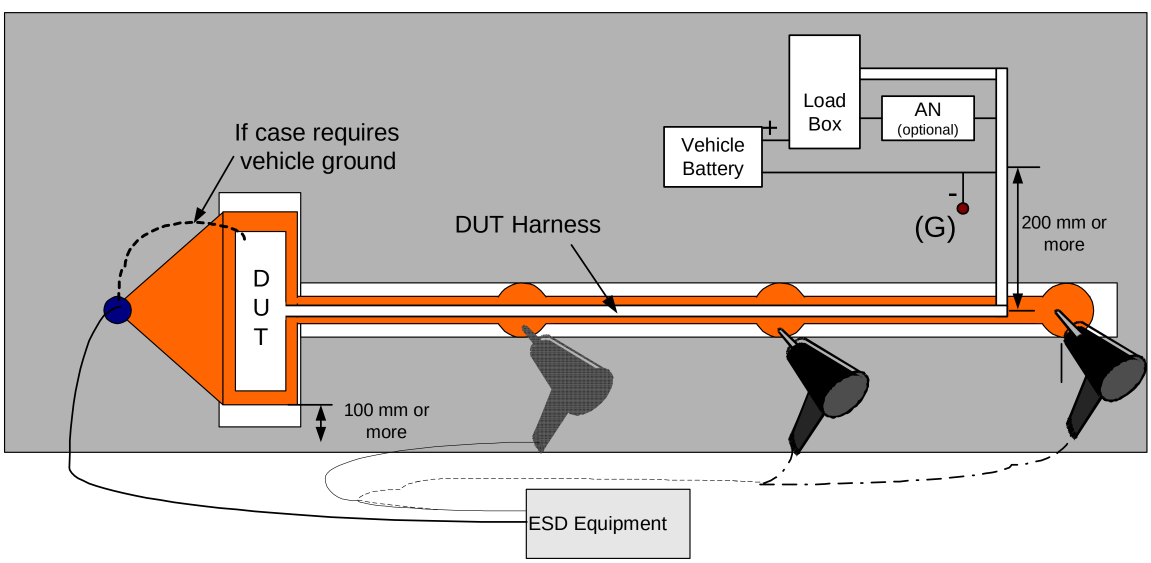


Figure 34: ESD Field Coupled Operating Test Setup ***

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

- An ESD simulator and discharge electrode according to IEC 61000-4-2 shall be used.

- Before testing commences, the discharge voltage of the ESD simulator shall be verified.
- The ESD simulator shall have its ground referenced as shown in Figures 33 and 34.
- The DUT shall be positioned on the ESD field coupling plane (#3 in Figure 32) and a 1700 (-0, +300) mm wiring harness shall be run from the DUT to its power supply and exerciser along the conductive trace on top of the ESD field coupling strip (# 5 on #4 in Figure 32). 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 is at point G. Refer to Figures 33 and 34 for illustration of setup.
- The DUT coupling plane shall be large enough so as to extend beyond the DUT on all sides by at least 10 mm.
- The ground connection (wiring) of the DUT shall be connected as intended in the vehicle - directly via the vehicle body (i.e. the HCP) or via the wiring harness.
- The case of the DUT, if conductive and case grounded in the vehicle application, shall be case grounded to the DUT ESD field coupling plane (refer to Figures 33 or 34).
- The battery ground shall be electrically connected to the HCP (refer to Figure 33 or 34)
- 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 ESD Test Setup by at least 200 mm (refer to Figure 33 or 34).

10.2.4 ESD Operating Test Conditions – Direct Coupled ***

- 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 discharge occurs.
- 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 and the housing. Alternatively, at least 1 s can be allowed to pass between two discharges.

10.2.5 ESD Operating Test Conditions – Field Coupled ***

- Use an ESD simulator with a discharge network of 330 pF and 330 ohms.
- For each polarity and voltage, 10 contact discharges shall be carried out in the center of the free area not covered by the wiring harness at each of the three specified discharge islands. Refer to Figure 32 (#6) or Figure 34 for these discharge islands.
- During this test, the DUT shall be monitored for effects. The default interval between discharges is 2 seconds. This interval may be reduced if the number of discharges is increased so that the total test time for each polarity and discharge island is constant (e.g. at 10 Hz, 200 discharges in total).
- Notes: 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:

- adaptive speed control (Distronic) operation
- antenna module operation
- auxiliary car heater operation
- chime operation (nonregulated function)
- climate control display
- electronic compass operation
- entertainment systems operation (radio, navigation, video, voice recognition system, CD, phone)
- front park and marker lamp operation (nonregulated)
- headlamp cleaning operation
- illuminated entry operation
- informational diagnostic capability (nonregulated)
- instrument cluster nonregulated functions & convenience indicators
- intermittent windshield wiper operation
- navigational display operation
- parking aid system (Parctronic) operation
- rain sensor operation
- rear wiper operation ability
- remote keyless entry operation
- seat and steering wheel heating operation
- solar roof operation (solar-cell-powered motor)
- time or information display
- trip odometer operation

Group B Functions:

- antilock brake system operation (with fail-safe default)
- chime operation (regulated function)
- electronic climate control functions that do not compromise windshield defrost system operation
- engine rpm stability (e.g. ± 200 rpm)
- headlight dimming/optical horn operation
- instrument cluster enhancement functions (fuel gauge, indicators)
- interior illumination stability
- license plate lamp operation and daytime running lights (DRL) (regulated function)
- motor cooling fan operation
- power door lock, trunk/hatch and trailer hitch release stability
- remote keyless entry stability
- tire pressure monitoring
- vehicle anti-theft system operation
- vehicle electrical charging system (alternator) operation
- vehicle immobilizer operation (at minimum range)
- vehicle speed control stability (e.g. ± 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
- data bus system operation (CAN-B, C, D, LIN-Bus, other serial bus systems, MOST /optical, D2B /optical)
- diagnostic memory stability and Group C functional inhibit capability
- dynamic vehicle control system (ESP) stability including steering angle sensor stability
- electronic transmission control
- emergency calling system (Teleaid) operation
- engine acceleration control
- engine malfunction indicator lamp (MIL) operation (regulated function)
- engine stall control
- entertainment system volume stability
- fog lamp/high beam interlock operation (regulated function)
- headlamp and tail lamp operation
- headlamp leveling operation
- horn operation (regulated function)
- inflatable restraints operation (nonelectronic control)
- instrument cluster (malfunction information, odometer, speedometer operation, regulated warnings)
- mirror stability (rearview and outside)
- neutral start function (regulated function)
- park and marker lamp operation (regulated function)
- park brake indicator lamp operation (regulated function)
- photochromatic mirror operation
- power door stability
- power folding mirror stability
- power seat position stability
- power supply control unit operation (power management for brake control and safety systems)
- power window stability and window express up/down function stability
- transmission gear indicator (regulated function)
- seat belt operation
- seat memory stability
- 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
- 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).

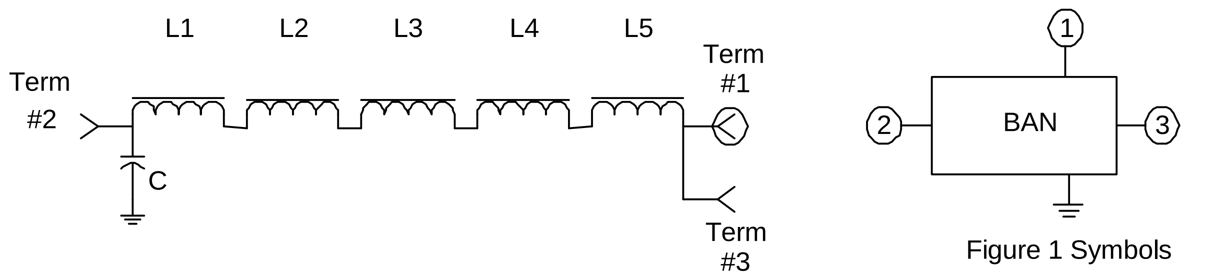
End of Annex A

# # # # #

Annex B (informative)

BROADBAND ARTIFICIAL NETWORK (BAN) DESIGN REQUIREMENTS

NOTE: DaimlerChrysler holds patents (#4,763,062 and #5,541,521) on an RF isolator or BAN design. This BAN is commercially available. Other designs may be used if they meet the design intent.



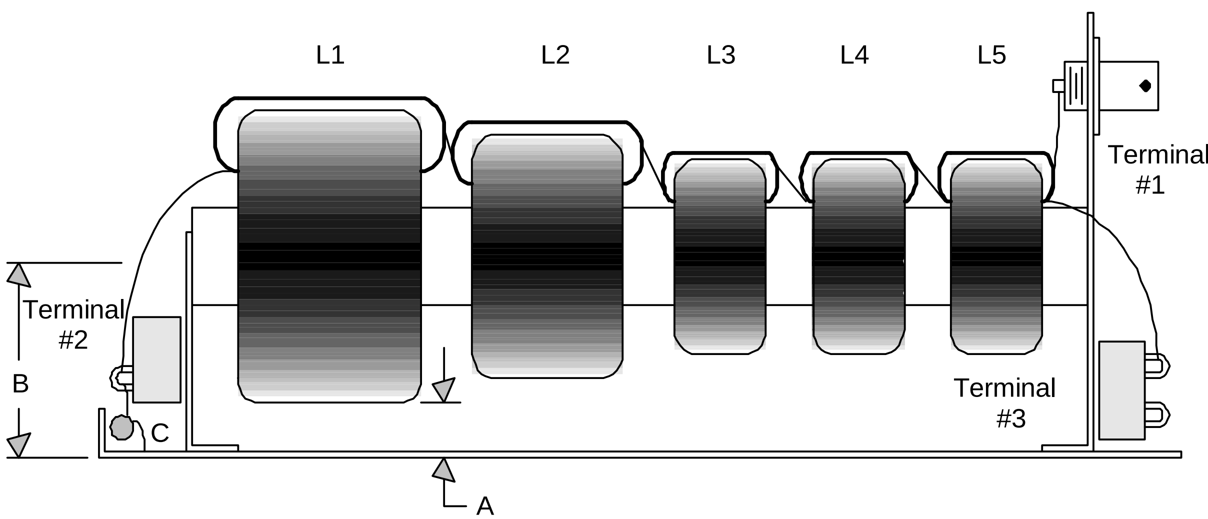


Figure B-1: Example Schematic and Assembly Drawing of a BAN (Side View)

The BAN is assembled from the appropriate wound toroid cores listed in Tables B-3 through B-7 on a nonconductive and nonmagnetic rod supported over a copper ground plane. In order for this isolator to function as designed up to 400 MHz, care must be taken to minimize and control parasitic capacitance, especially on the DUT (terminal #1) end of the BAN. To this end, the ground plane shall not extend out past L5 farther than necessary and any conductive support structure on the DUT end of the BAN shall be minimized.

- A is the separation between the L1 core and the ground plane surface.
- B is the distance from the axis of the cores to the ground plane surface and is the minimum separation between adjacent L1 of additional BAN when assembled into a multi line unit.
- Terminal #1: RF input, low capacitance BNC or similar RF connector (Example: Amphenol 31-10), for CAN BAN, this BNC shall be 30 mm min above the ground plane
- Terminal #2: Connection to the DUT supply and/or load support circuitry
- Terminal #3: Connection to the DUT input or output lead

  Note: Terminal #1 and #3 are connected together in the BAN.

BAN bypassing - The supply/load/support circuitry end of the BAN shall be bypassed to ground. This requires the optimum value of capacitor to provide sufficiently low impedance across the frequency range of interest for the test. Minimum lead length is to be used. Suggested optimum bypass capacitor C is a 0.047 uF ceramic monolithic capacitor for normal BANs, 0.01 uF for high speed BANs and 470 pF for CAN BANs.

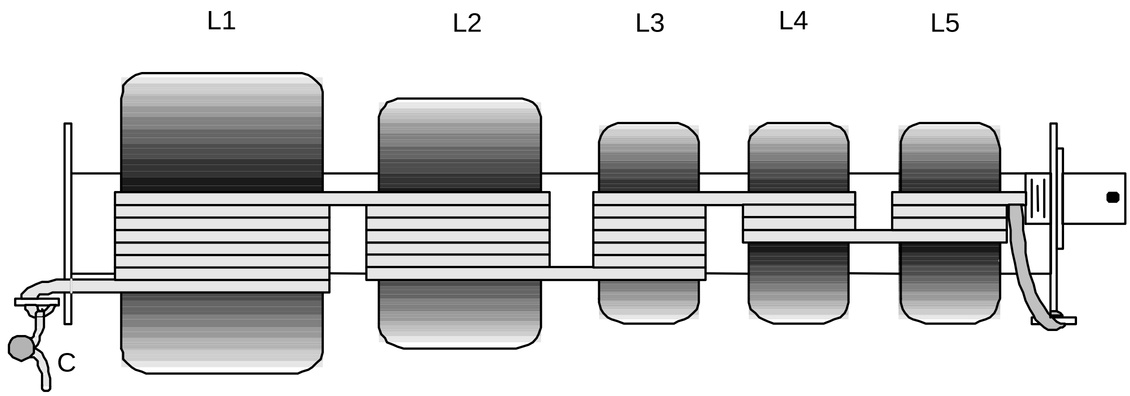


Figure B-2: Typical Wiring Arrangement (Top View)

BAN winding - The recommended technique for winding the assembly utilizes one continuous piece of wire. Leave sufficient wire for the termination on the capacitor end of L1 and wind the turns close-spaced on the toroid for L1. At this point, hold the toroid for L2 approximately 6 mm from L1 and wind the turns for L2 close-spaced in the opposite direction so that the windings are parallel to those of L1. Continue in this manner with L3 through L5 with the windings zigzagging from L1 to L5. Figure B-2 shows this arrangement. The remaining wire should be cut off allowing enough to connect L5 to its terminal lug. Install the assembly on the dowel, and then assemble the dowel to the support lugs (with the close-spaced windings away from the ground plane) with nonmetallic screws. Use minimum lead length for all connections. It is very important to control the geometry of the BAN assembly to minimize the parasitic capacitance at the terminal #1 end of the BAN, as this is critical to meeting the impedance requirements specified in Tables B-1 and B-2. Through loss is measured from terminals 1 and 3 to terminal 2.

Table B-1: Impedance and Through Loss Requirements - BANs up to 8 A Capacity

Frequency Range	Min. Impedance (ohms)			Min. Through Loss (dB)		
	Standard	High Speed	CAN	Standard	High Speed	CAN
1 MHz to 20 MHz	500	N/A	500	35	N/A	20
20 MHz to 250 MHz	500	500	200	35	35	20
250 MHz to 400 MHz	200	200	N/A	35	35	N/A

Table B-2: Impedance and Through Loss Requirements - BANs Over 8 A Capacity

Frequency Range	Min. Impedance (ohms)	Min. Through Loss (dB)
1 MHz to 2 MHz	200	20
2 MHz to 150 MHz	400	20
150 MHz to 400 MHz	100	20

Current Capacity - Current handling capacity shall be included in the parameters of the BAN design. The saturation characteristics of ferrite or powdered iron cores are a significant factor in the current handling capacity of a BAN.

Table B-3: Coil Winding Information – 0.5 A BAN

Coil	Core Type	Number of Turns	Inductance (μH)
L1	FT82-77	12	180
L2	FT50-61	4	1
L3	FT50-67	4	0.6
L4	FT50-68	4	0.2
L5	FT50-68	4	0.2

A = 4 mm, B is equal to or greater than 15 mm.
Wire is approximately 0.40 mm diameter (#26 AWG or #26 B&S) and approximately 1 m in length.
Core material - Ferrite (Amidon part numbers shown, equivalent parts are acceptable).
Inductance is measured at 10 kHz for L1, calculated for L2-L5.

Table B-4: Coil Winding Information – 0.5 A High Speed BAN

Coil	Core Type	Number of Turns	Inductance (μH)
L2	FT50-61	4	1
L3	FT50-67	4	0.6
L4	FT50-68	4	0.2
L5	FT50-68	4	0.2

A = 4 mm, B is equal to or greater than 15 mm. Inductance is calculated for L2-L5.
Wire is approximately 0.40 mm diameter (#26 AWG or #26 B&S). Bypass capacitor is 0.01 μF.
Core material - Ferrite (Amidon part numbers shown, equivalent parts are acceptable).

NOTE: The high data rate BAN is available for testing high-speed, single line, signal or bus lines. To fabricate a high data rate BAN, remove L1 (the 12-turn toroid) from a 0.5 A isolator and replace the 0.047 μF bypass capacitor with 0.01 μF. This lowers the inductance of the isolator to approximately 2 microhenries and raises the resonant frequency allowing 125 k baud data transmission bandwidth. When this isolator is required, the frequency range for Direct RF Injection is modified to 20 MHz to 400 MHz. Check with the E/E Systems Compatibility Department of DaimlerChrysler Corporation Scientific Laboratories for additional details.

NOTE: The CAN BAN has been developed for immunity and emissions testing of CAN bus lines. It is constructed with two lines bifilar wound (ten turns per inch) on six cores with two bypass caps on each line (terminal #2) and two capacitor feeds from the two lines to a common BNC connector (terminal #1) for common mode testing. Check with the E/E Systems Compatibility Department of DaimlerChrysler Corporation Scientific Laboratories for additional details and current information as this design is evolving.

Table B-5: Coil Winding Information – 0.5 A CAN BAN

Coil	Core Type	Number of Turns (2 lines - bifilar wound, 4 turns/cm or 10 turns/in)
L1	FT82-77	12
L2	FT50-61	4
L3	FT50-67	4
L4	FT50-68	7
L5	FT50-68	5
L6	FT50-68	5

Coil	Core Type	Number of Turns (2 lines - bifilar wound, 4 turns/cm or 10 turns/in)
A = 4 mm, B is equal to or greater than 15 mm. BNC connector is Amphenol 31-10 minimum 30 mm above the ground plane. Wire is approximately 0.40 mm diameter (#26 AWG or #26 B&S) and approximately 1 m in length. Core material - Ferrite (Amidon part numbers shown, equivalent parts are acceptable). 1) For PCE and DRFI tests, the bypass capacitor is 470 pF, split feed capacitors are 470 pF. This BAN with the split feed capacitor is called Common Mode CAN BAN with Single Point Injection. 2) For BCI and TEM Immunity Tests, the split feed capacitors shall be removed. The bypass capacitors shall be changed to 1500 pF. This BAN without the split feed capacitor is called Common Mode CAN BAN without Single Point Injection. The tolerance on the capacitors is ± 2%.		

Table B-6: Coil Winding Information - 2 A BAN

Coil	Core Type	Number of Turns	Inductance (μH)
L1	FT114A-77	8	180
L2	FT82-43	6	20
L3	FT50-67	6	1
L4	FT50-68	4	0.2
L5	FT50-68	4	0.2
A = 7 mm, B is equal to or greater than 17 mm Wire is approximately 0.64 mm diameter (#22 AWG or #22 B&S) and approximately 1.3 m long. Core material - Ferrite (Amidon part numbers shown, equivalent parts are acceptable). Inductance is measured at 10 kHz for L1 and L2, calculated for L3-L5.			

Table B-7: Coil Winding Information - 30 A BAN

Coil	Core Type	Number of Turns	Inductance (μH)
L1	T184-26	15	38
L2	T157-26	12	15
L3	T130-26	5	2.4
A = 12 mm, B is equal to or greater than 30 mm, Inductance is measured at 10 kHz Wire is approximately 1.61 mm diameter (#14 AWG or #14 B&S) and approximately 1.5 m long. Core material - Powdered Iron (Amidon part numbers shown, equivalent parts are acceptable).			

End of Annex B

# # # # #

Annex C (informative)

EMC Testing Information for Module / System with CAN Bus ***

The default CAN Data Bus Functional Classification requirements are:

CAN B:

Bus system communications (vehicle bus disabled due to latching or streaming):	Group C
Fault indicator lamp on, no diagnostic trouble code recorded:	Group C
DUT CAN communication faults (DUT not communicating correctly):	Group C

CAN C:

Bus communications (vehicle bus is disabled due to latching or streaming):	Group C
Fault indicator lamp on, no diagnostic trouble code recorded:	Group C
DUT CAN communication faults (DUT not communicating correctly):	Group C

The above functional classification information is offered as a guideline to be referred to when writing the DUT test plan. The actual CAN bus functional classification requirements depend on the criticality of the message content carried on the bus that the DUT is connected to. For example, if the CAN B bus is used for vehicle immobilizer to allow the vehicle to start, the CAN B bus would be considered Group C for Bus communications (vehicle bus is disabled due to latching or streaming).

For CAN applications, a PC based CANoe (CAN open environment) simulation program, along with the vehicle message matrix (VMM) are required to provide the correct CAN bus traffic. The hardware interface between the PC and the DUT is comprised of a CANcardX (PCMCIA card) and either a CANcab 1054 (CAN B node and cable connecting the CANcardX to the DUT CAN B transceiver) or a CANcab 251 (CAN C node and cable connecting the CANcardX to the DUT CAN C transceiver). The CAN bus shall be monitored for stability via the CANoe tool error frame rate indicator and VMM mismatch indicator.

Note: If a CAN BAN is used to test CAN C lines, the termination requirements of the bus shall be met. (See Annex B for information on BANs.)

Bulk Current Injection (BCI): Either Fiber Optical CAN interface or a Common Mode CAN BAN without Single Point Injection is used, refer to Annex B. This BAN allows the test to be performed from 1 MHz to 250 MHz.

Direct RF Injection: A Common Mode CAN BAN with Single Point Injection is used, refer to Annex B. This BAN allows the test to be performed from 1 MHz to 250 MHz. A 470 pf DC block shall be used to perform the test.

Pin Conducted Emission (PCE): A Common Mode CAN BAN with Single Point Injection is used, refer to Appendix C. This BAN allows the test to be performed from 1 MHz to 250 MHz. The CAN bus may be classified as a broadband source below 2.0 MHz; refer to LP-388C-41 for signal source classification. A 470 pf DC block shall be used to perform the test.

Radiated Immunity (TEM CELL): Either Fiber Optical CAN interface a Common Mode CAN BAN without Single Point Injection is used, refer to Annex B. The CAN wiring harness shall be as described in Section 7.6.2.

Radiated Immunity (ALSE - Anechoic Chamber): CAN shall be optically coupled for the test. For testing with a ground plane, the CAN wiring harness shall be as described in Figures 14 and 15. For testing without a ground plane, the CAN wiring harness shall be as described in Section 7.5.2.

Supplementary information on CAN bus loading for CG testing is provided in LP-388C-65.

End of Annex C

# # # # #

Annex D (informative)

ADDITIONAL INFORMATION

D.1 Relationship to Other Standards

This standard is a part of a series of standards intended to assure electromagnetic compatibility in vehicle electrical and electronic systems. During the module design process, reference should be made to DaimlerChrysler CG design standards DS-150 and DS-151 for information on PC board layout and the SAE J1752 or IEC 61967 series of standards for techniques to evaluate the RF emissions potential of integrated circuits. The vehicle electrical system design should follow the grounding guidelines in CG DS-108. See references.

D.2 Number of Available Test Samples

Additional test samples should be available to the EMC test lab in addition to those required for testing. For production tooled parts (PV), a minimum of two samples should be provided to the test lab. For design verification (DV) level parts, a minimum of three samples should be provided to the test lab.

D.3 Component Location in the Vehicle

Emissions

For most module locations in a metallic vehicle, the vehicle body provides some shielding. However, the risk of interference increases for modules in exposed or unshielded locations that have enhanced visibility to the vehicle antenna(s). For front mounted vehicle antennas, these exposed locations are the high instrument panel area (instrument cluster) and the overhead console. For vehicles with rear-mounted antennas or nonmetallic body panels, other locations may have enhanced visibility to the vehicle antenna(s).

Immunity

A wide range of factors including location, wiring interconnects and the shielding effectiveness of the vehicle affects the actual EMC performance of a system as installed in a vehicle. Some level of shielding may be provided by the vehicle body. Instrument clusters and overhead consoles are in locations where shielding effectiveness cannot be assumed and therefore they may be at increased risk of RF exposure. Other modules in exposed or unshielded locations, or any electronics in a nonmetallic vehicle, may also require special considerations in order to maintain the required vehicle immunity levels in DC-10613. This should be considered in the product specification and EMC test plan.

D.4 Pin Conducted RF Emissions (PCE)

This test evaluates the radiated RF emissions potential that the DUT will present when installed in a vehicle. A measurement of open circuit or simulated open circuit RF voltage, referenced to ground, is made at all DUT input and output terminals, including unused connector pins. This test evaluates the RF characteristics of a printed circuit board (PCB), including the ground plane and bypassing effectiveness. It is at the prototype PCB level where the diagnostic capabilities of this test facilitate cost-effective improvements in the RF emissions performance of the component.

D.5 DRFI

The Direct RF Power Injection (DRFI) test in paragraph 7.2, a pin-by-pin test, is particularly effective when used as part of the engineering development of the electronic component as it provides circuit board level diagnostic information to facilitate corrective action.

D.6 RF Immunity of RF Link Systems

Vehicle systems that use a low power RF link (i.e., RF remote keyless entry), require a low RF environment near their operating frequency to realize their normal operating range. In the presence of RF sources within this "window of vulnerability", devices such as RF RKE will exhibit reduced range or inhibited remote operation. This immunity window can be reduced by improved filtering in the receive module and should not exceed ± 5% of the system operating frequency. The product specification should define the acceptable performance limits for the system in the vicinity of its operating frequency range and the EMC test plan should take this into account.

D.7 RF Emissions of RF Link Systems

RF link systems will necessarily have emissions at their operating frequency and these emissions may exceed the emission limits specified for that band. Typically, these emission requirements are to control the emissions from unintended radiators in order to protect the operation of RF link devices and are not intended to inhibit the range or operation of these RF link systems themselves. The EMC test plan should take this into account.

End of Annex D

# # # # #

Annex E (informative)

IMMUNITY TO HANDHELD TRANSMITTERS

E.1 General

In a few cases, from an economical point of view, component tests instead of a lot of vehicle tests might be more efficient. This is especially true, when the component is already used in other vehicles, and a quick reliable test method is needed just to check for compliance in the new intended vehicle platform. This is even more the case, when the intended vehicle platform has a lot of variants which is common for buses and other commercial vehicles.

Recent publications and testing have shown that the tube coupler method can be used for immunity testing even above 1 GHz. It was especially designed for testing immunity of components to handheld transmitters.

This test applies for testing immunity to handheld transmitters operating in the bands GSM 900 and GSM 1800/1900. It applies only if explicitly agreed to between supplier and the responsible DaimlerChrysler EMC engineering department.

E.2 Requirements

The immunity requirements are based on environmental data and are adapted to the tube coupler test method through correlation with vehicle data. The immunity performance requirements are specified in Table E.1.

Table E.1: Simulated Handheld Transmitter Immunity Performance Requirements

GSM Band	Test Level[1]	Performance Status Group A	Performance Status Groups B, C and D
900	200 mW	II	I
1800/1900	100 mW	II	I

[1] Peak power level, note that the power meter in Figure E.2 will read the average value and for a 12% duty cycle rectangular pulse this will be approximately 12% of the peak value

The power levels given in Table E.1 are the forward power levels into the tube coupler reduced by the insertion loss (L_i) of the tube coupler and measured in dB using the procedure in E.5:

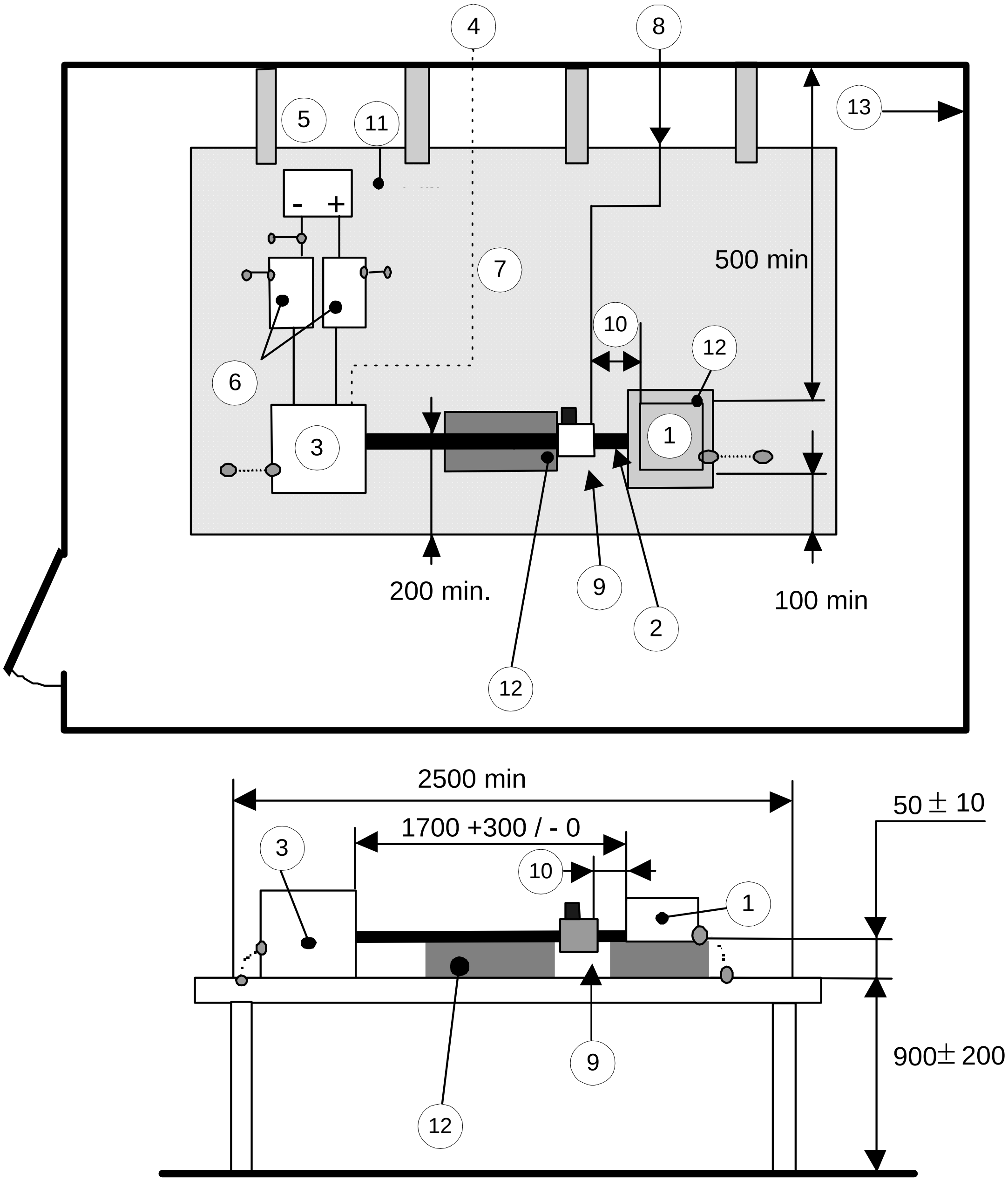
$$P_{test}\Big|_{dBm} = P_{forward}\Big|_{dBm} - L_i\Big|_{dB}$$

or in a linear scale using a transfer factor:

$$P_{test} = P_{forward} \cdot S_{21}$$

E.3 Test Setup

The test setup is essentially the same as for BCI testing (see 7.4). However, a tube coupler is used instead of a BCI injection probe; refer to Figure E.1 for a schematic diagram of the test setup.



Key:

1	Device under test (connected to ground if specified in the test plan)	7	Optical fibers
2	Wiring harness	8	High frequency equipment
3	Load simulator (placement and ground connection according to ISO 11452-4)	9	Tube coupler (2nd port loaded with 50 ohms)
4	Stimulation and monitoring system	10	The distance from the DUT to the tube coupler position
5	Power supply	11	Ground plane (connected to the shielded room)
6	AN or 50 ohm BAN	12	Insulating support
		13	Shielded room

This figure is adapted from ISO WD 11452-4.

Figure E.1: Immunity Test Using the Tube Coupler Method - Test Setup

- A tube coupler shall be used.
- The second input of the tube coupler shall be loaded with 50 ohms.
- 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.
- 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 emission testing).
- The tube coupler shall be located on the test harness 100 mm from the DUT. Where the harness has a number of branches, the test shall be repeated, so that the tube coupler shall be attached around each branch in turn.
- The voltage supply and the periphery shall be filtered and shielded or located outside the shielded enclosure; an exception is peripherals which are not susceptible to radiated disturbances (such as mechanical switches).
- Wherever possible, production intent vehicle switching devices and sensors shall be used.

E.4 Tube Coupler

A tube coupler is a coaxial system having two input ports that can be clamped around the wiring harness similar to a current probe. It consists of two tubes having the same axis. They form an outer coaxial system having 50 ohms impedance, and the inner tube together with the wiring harness forms an inner coaxial system. Both systems are coupled at the ends of the tubes.

E.5 Calibration

Calibration is done in a method similar to ISO 11452-4 deviating in that the calibration jig shall be designed to form a 150-ohm system together with the tube coupler in the jig. Both ends of the jig shall be loaded by 150 ohms. The calibration setup is shown in figure E.2.

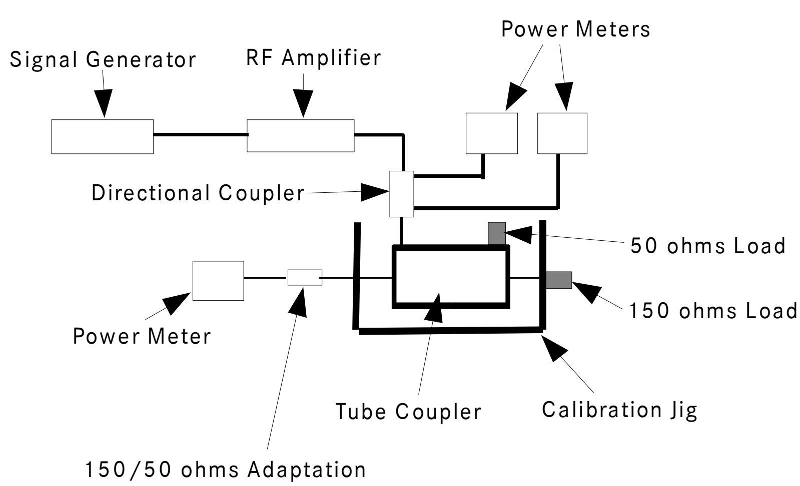


Figure E.2: Immunity Test Using the Tube Coupler Method - Calibration Setup

Calibration involves measuring the transfer factor from port 1 to port 2, i.e. the S-parameter S_{21}. RF power is injected into the system at port 1 using a signal generator and possibly an amplifier if needed (both with 50 ohm output impedance). At port 2, the transferred power through the tube coupler is measured using a power meter or equivalent (with 50 ohms input impedance). Care shall be taken to include the effects of the 150 ohms / 50 ohms matching network. Alternatively, a network analyzer can be used. The insertion loss L_i is given by the negative of the absolute value of S_{21} in dB.

End of Annex E

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Annex F (informative)

List of Changes in Rev. B ***

- Updated References and Abbreviations, Acronyms, Definitions & Symbols
- Frequency step size increased for QP detector and/or emission testing of inherently broadband components (Section 6.1)
- Spectrum analyzer scan rate dependent on repetition rate of DUT parameters (Section 6.1)
- FFT may be used for Emission measurements (Section 6.1)
- Updated Tables 7 (G5, G6 separated), 8 (G5, G6 separated), 13 (OEU4 instead of OEU5), 17 (G9 added)
- Added Figure 3 to Sections 6.3.2 and Figure 5 to Section 6.5.2 (from old Annex B)
- Ground lines <1 m are not included in CISPR 25 current measurement (Section 6.4)
- 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 (Section 7.1, Table 19)
- Test level profiles are added as figures for DRFI (Section 7.2.1), BCI (Section 7.3.1), ALSE (Section 7.4.1) and TEM Cell testing (Section 7.6.1)
- Tables for DRFI (Section 7.2.1), BCI (Section 7.3.1), ALSE (Section 7.4.1) and TEM Cell testing (Section 7.6.1) are updated
- VSWR requirement clarified for TEM Cell Test (Section 7.6.2)
- Transient pulses are applied individually to each supply voltage line
- Application of pulses 3a and 3b is reduced to one half hour each (Section 9.1.1 and 9.1.2, Tables 33 and 34)
- Corrected length of supply leads for transient testing to 500 mm (Section 9.1.3)
- ESD Handling Test setup: modified ground reference (Section 10.1.2, Figure 31)
- ESD Test Levels and Requirements specified in updated Tables 41 and 42
- ESD Operating test contact discharge for conductive points only, added 20 kV test for Group A and B (Section 10.2, Tables 41 and 42)
- Common test setup for both direct coupled and field coupled ESD operating tests (Section 10.2.3)
- Field coupled ESD test replaces indirect discharge test to HCP and VCP (Section 10.2, Tables 41 and 42, Figures 32, 33, 34, Sections 10.2.4 and 10.2.6)
- Annex B deleted, Annex C, D, E, F and G are renamed to Annex B, C, D, E and F
- Updated Annex C to define the DC block values for DRFI and PCE and CAN wiring harness information
- Updated Annex F with List of Changes in Rev. B

List of Changes in Rev. A

- Updated Table 1: EMC Test Selection Matrix
- Updated references
- ISO 17025 with automotive EMC scope allowed as an alternative to AEMCLRP
- Added categories B and HV
- Changed definition of subcategory C to one 200 mm dimension
- Updated terms in definitions including MCG and the term HIRF instead of high state level
- Electronic data submission preferred but not required
- Clarified emission requirements for electric vehicle components and for RF link systems
- Radiated emission measurements start at 76 MHz to cover all FM ranges
- Clarified use of P, AV or QP detectors for emission measurements
- Higher emission level for CAN added to PCE
- Some adjustment of frequency ranges for emission measurements
- Clarified immunity requirements for electric vehicle components and for RF link systems
- Added requirement to evaluate systems for IOD due to RF or magnetic induced wake up

- Modified pulse modulation to simulate digital phone (Table 19)
- Increased frequency resolution above 1 GHz (Table 20)
- Some adjustment of frequency ranges for HIRF (Table 21)
- Changed frequency resolution for magnetic immunity to 10 per decade
- Corrected magnetic immunity roll-off and high frequency limit
- Allow Helmholtz coil as an option for magnetic immunity testing
- Duration between repetition of pulse 2 decreased to 0.5 s
- Clarified ESD requirements for difficult to access pins
- Typos and spelling corrected
- Some clarifications to Annex A Functional Status Classification and Annex C for BANs
- Updates to Annex C and Annex E
- Added Annex F for Evaluation of Immunity to Handheld Transmitters
- Added Annex G with List of Changes

End of Annex F

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