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0.0 DEFINITIONS

These definitions are mostly derived from the individual standards describing the tests. As far as possible; they have been harmonized with the definitions contained in IEC 60050-161. In case of doubt, the more easily understood definition has been adopted.

1. **Onboard system nominal voltage**

The nominal voltage of the onboard power system, is 12 Volts DC or 24 Volts DC.

2. **Absorber-lined chamber**
Shielded room with absorbing material on its internal reflective surfaces (the floor may optionally be exempted).

3. **Amplitude modulation (AM)**
Process by which the amplitude of a carrier wave is varied following a specified law, and resulting in an AM signal.

4. **Antenna matching unit**
A device for matching the impedance of an antenna to the impedance of a 50 Ω measuring receiver over the frequency range of the antenna.

5. **Bandwidth**

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

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

6. **Ground reference plane**
Flat conductive surface, whose electric potential is used as a common reference.

7. **Artificial network; line impedance stabilization network (LISN)**

   - An electrical network inserted into the power supply line of a device under test generating a impedance in a specified frequency range for measuring disturbance voltages and which allows the device to be regarded in this frequency range as if it was isolated from the power supply network.

   - The LISN will be according to CISPR25 for RF tests and ISO 7637-2 for transient tests.

   - The artificial network is a measuring aid simulating the average impedance of the lines of the vehicle supply network (according to DIN 40839-1).

8. **Broadband emission**
Emission which has a bandwidth greater than that of a particular measuring apparatus or receiver.

9. **Bulk Current**
Total amount of common-mode current in a harness.

10. **Direct discharge**
    A discharge that is applied directly to the device under test.

11. **Intrinsic disturbance suppression**
    Reduction of the radio disturbance voltage of electrical vehicle equipment coupled via the vehicle onboard system to the receiving antenna mounted on the vehicle.

12. **Equipment**
    Equipment is the generic term for apparatus and system / device and system.

13. **ESA**
    Electrical/electronic subassembly' (ESA) means an electrical and/or electronic device or set(s) of devices intended to be part of a vehicle, together with any associated electrical connections and wiring, which performs one or more specialized functions.

14. **Electromagnetic compatibility (EMC)**
    The ability of an equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment.

15. **Electromagnetic disturbance**
    Any electromagnetic phenomenon which may degrade the performance of a device, equipment or system; or adversely affect living or inert matter.

16. **Electromagnetic interference (EMI)**
    Degradation of equipment, transmission channel or system caused by an electromagnetic disturbance.

17. **Electromagnetic environment**
    The totality of electromagnetic phenomenon existing at a given location.

18. **Receiver input voltage (antenna voltage)**
    Voltage generated by a radio frequency emitter of electromagnetic disturbance and measured by a radio disturbance measuring apparatus (according to CISPR 16-1 in dB(μV))

19. **Electrostatic discharge (ESD)**
    A transfer of electric charge between bodies of different electrostatic potential in proximity or through direct contact.

20. **Disturbance suppression**
    Action which reduces or eliminates electromagnetic disturbance.

21. **Malfunction**
    Malfunction is the unacceptable degradation of the performance of a device.

22. **Failure**
    Failure is the unacceptable degradation of the performance of a device and whereby performance can only be restored by means of technical measures.

23. **Degradation (of performance)**
    Degradation (of performance) is a decrease of the performance of a device which, although not negligible, is accepted as permissible.

24. **Disturbances of the function**
Disturbances of the function are the undesired degradation of the performance of a device.

25. **Function performance status**
See specific test section.

26. **HCP**
Horizontal coupling plane (See “coupling plane”).

27. **Indirect discharge**
The discharge is made to a coupling plane in the vicinity of the device under test simulating a human discharge to objects arranged in the vicinity of the device under test.

28. **I/O ports**
I/O ports are input and output connections or leads for signals, data, and control.

29. **Compression point**
Value of the input signal at which the gain of the measuring system becomes non-linear so that the output value displayed deviates from the output value of an ideal linear system by the specified value in dB.

30. **Contact discharge**
Test method whereby the electrode of the test generator is brought into physical contact with the device under test and the discharge is triggered by the discharge switch located on the generator.

31. **Continuous conducted disturbances of a component.**
Continuous disturbance voltages/currents along supply and other lines of a component/module which may disturb reception of an on-board vehicle receiver.

32. **Coupling**
Means or device for transferring power between systems.

33. **Coupling plane**
A metal panel or plate on which discharges are made in order to simulate discharges of static electricity to objects in the vicinity of the device under test.

34. **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 metallic electrical connection to it.

35. **Antenna cable Open-circuit voltage**
Voltage at the radio end of the antenna cable, when no load is connected to it.

36. **Power supply Open-circuit voltage**
Voltage on the power supply terminals, when no load is connected to it.

37. **Load Dump**
An electrical transient caused by disconnection of a cable from the battery, while the generator is supplying charging current.

38. **Air discharge**
Test methods, whereby the electrode of the test generator is brought near the device under test and discharge is accomplished through an arc to the device under test.

39. **Average detector**
A measuring instrument circuit that produces an output voltage, that is the average value of the envelope of an applied signal.

40. **Net power**
It is difference between Forward power and reflected power.

41. **Parallel plate antenna**
An antenna with an arrangement of parallel arms generating an electrical field.

42. **Polarization (of a wave or a field vector)**
Property of a sinusoidal electromagnetic wave or of a field vector, defined at a fixed point in space by the direction of the electrical field strength vector or of any specified field vector; when this direction varies with time, the property may be characterized by the locus described by the extremity of the considered field vector.

43. **Test pulses**
Pulses simulating impulsive disturbances occurring in the vehicle onboard system with regard to their effect.

44. **Pulse sequence**
A pulse sequence is a repetition of pulses during a given time interval.

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

46. **Reference field method**
The reference field method is a field strength irradiation measurement method whereby, before the actual irradiation measurement, the output power of the amplifier which provides the required field strength is determined without test set up for each measuring frequency. The device under test is then placed at its given location and the actual measurement is carried out after the power values determined beforehand have been set.

47. **Reflected power**
Power reflected by the load due to impedance mismatch between the transmission line and the load.

48. **Directional coupler**
A four-port device consisting of two transmission lines coupled together in such a manner that a single traveling wave in any one transmission line will induce a single traveling wave in the other, the direction of propagation of the latter wave being dependent upon that of the former.

49. **Shielded enclosure**
Mesh or sheet metal housing designed expressly for the purpose of separating electromagnetically, the internal and external environment.

50. **Narrow band emission**
Emission which has a bandwidth less than that of a particular measuring apparatus or receiver.

51. **Peak detector**
A measuring instrument circuit that produces an output voltage, which is the peak value of an applied signal.

52. **Standing wave ratio (SWR); voltage standing wave ratio (VSWR)**
Ratio of a maximum to an adjacent minimum magnitude of a particular field component of a standing wave, along a transmission line.

53. **Disturbance emission**
The emission of a disturbance generated by a noise source.

54. **(Electromagnetic) susceptibility**
The inability of a device, equipment or system; to perform without malfunction in the presence of an electromagnetic disturbance.

55. **Immunity (to a disturbance)**
The ability of a device, equipment, or system; to perform without malfunction in the presence of an electromagnetic disturbance.

56. **Immunity level**
The maximum level of a given electromagnetic disturbance incident on a particular device, equipment or system; for which it remains capable of operating at a required degree of performance.

57. **Emitter**
An emitter is an origin of disturbances.

58. **Limit of disturbance**
The maximum permissible electromagnetic disturbance level, as measured in a specified way.

59. **Susceptible device**
Electrical equipment whose performance is degraded by a defined electromagnetic disturbance.

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

61. (**Electromagnetic) radiation**
   A. The phenomenon by which energy in the form of electromagnetic waves emanates from a source into space.
   B. Energy transferred through space in the form of electromagnetic waves.

62. **Disturbing line**
A disturbing line is the line from which electromagnetic disturbances emanate.

63. **Strip-line**
A terminated transmission line consisting of two parallel plates between which a wave is propagated in the transverse electromagnetic mode to produce a specified field for testing purposes.

64. **Bulk current injection (BCI)**
Supply of common-mode current into a harness.

65. **Current probe**
Device for measuring the current in a conductor without interrupting the conductor and without introducing significant impedance into the associated circuits.

66. **TEM**
Abbreviation for “transverse electromagnetic“. Used to characterize electromagnetic fields.

67. **TEM mode**
A state where the longitudinal component of both the electrical as well as of the magnetic field strength vector is zero at all places.

68. **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.

69. **Transmission Line System (TLS)**
A strip-line, parallel plate, TEM cell, or similar device used to generate an electromagnetic field in a shielded enclosure.

70. **VCP**
Vertical coupling plane (also see coupling plane).

71. **Forward power**
The incident power supplied by the output of an amplifier (or generator).

72. **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.

73. **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.

74. **GLOSSARY:**

DUT – Device Under Test (Electric/electronic component or ESA)
ERC – Engineering Research Center.
IEC – International Electro technical Commission.
TS, T. Spec – TATA Specification.
JIS – Japan industrial standards.
ISO- International Organization for Standardization
CISPR- International Special Committee on Radio Interference, IEC
V – Voltage.
RH – Relative Humidity.
RPM – Revolution Per Minute.
Ω – Ohms.
M – Mega.
k – Kilo.
N – Newton.
Nm – Newton meter.
°C – Degree Celsius.
mA- milli ampere
s – Seconds.
min – Minute
h, hrs – Hours.
NaCl – Sodium chloride.
Li – Lithium.
ml – mile litre.
Hz – Hertz
m/s – Meter/second.
RMS – Root mean square.
DC – Direct Current.
IOD- Ignition off Draw
E/E-Electrical and/or Electronic
TML- TATA Motors Ltd.

1.0 GENERAL

1.1 Purpose.

This document specifies the electromagnetic compatibility required for electrical and electronic equipment, with a nominal power supply of 12 V / 24 V, applicable on TATA Motors vehicles. Herein, the device or component under test shall be referred to as the Device Under Test (DUT). For applicability of tests see section 2.9.

Deviations from the requirements of standard are allowed only, if agreed and documented between the supplier and TATA Motors, ERC.

Final EMC approval would be granted based on satisfactory vehicle compliance to EMI/EMC.

1.1.1 SUPPLIER'S RESPONSIBILITY

The approved supplier is responsible for ensuring that the requirements of this specification are met. All applicable test data (procedures, reports, etc.) are to be provided to TATA Motors ERC. ERC personnel shall have the rights of observing any or all of the tests performed by or for the supplier.

Since additional electromagnetic compatibility tests may prove necessary according to application; TATA Motors, reserves the right to specify additional details or revise this document during product development.

The test plan definition is responsibility of the approved supplier in agreement with TATA Motors. The test plan shall have at least the request information listed in the section 1.7 of this document.

The approved supplier and TATA Motors are responsible to work in the resolution of the any failure of the equipment during the test vehicle.

The approved supplier is responsible to provide the test report including the information listed in the section 1.8 and the specific information listed in each test of this standard to TATA Motors.

The approved supplier is responsible to provide all the information about of any change in the equipment in order to met the requirements of this standard to TATA motors.

1.1.2 REQUIRED INFORMATION FROM SUPPLIER

The following information is to be indicated on the drawings and in the product specification (if one exists) particular to each item covered:

Operating Voltage range
Functional group
Functional region of performance as specified in section 2.4 of this document.

Any deviations from this document must be indicated on the drawings and in the product specification.

1.2 Scope.

This standard applies to electrical and/or electronic components or subassemblies for their EMC requirements. When referring to this standard in component-specific Technical Supply Specifications, drawings and Performance Specifications shall apply and be supplemented with the appropriate specifications in consultation with the TML,ERC.

1.3 Normative references

Standard	Version	Title
2004/104/EC	**2004**	COMMISSION DIRECTIVE 2004/104/EC of 14 October 2004 adapting to technical progress Council Directive 72/245/EEC relating to the radio interference (electromagnetic compatibility) of vehicles and amending Directive 70/156/EEC on the approximation of the laws of the Member States relating to the type-approval of motor vehicles and their trailers
CISPR16-1	**2003-11**	Specification for radio disturbances and immunity measuring apparatus and methods Part 1 : Radio disturbances and immunity measuring apparatus
CISPR25	**2008-03**	Radio disturbance characteristics for the protection of receivers used on boards vehicles, boats and on devices. Limits and methods of measurement
ISO 7637-1	**2002-03**	Road vehicles, Electrical disturbance by conduction and coupling Part 1 Definitions and general consideration
ISO 7637-2	**2004-09 (Amendment 1 2008)**	Road vehicles, Electrical disturbance by conduction and coupling Part 2 Electrical transient conduction along supply lines only.
ISO 7637-3	**2007-07**	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 16750-1:	**2006-08**	Road vehicles - Environmental conditions and testing for electrical and electronic equipment Part 1 - General.
ISO 16750-2:	**2006-08**	Road vehicles - Environmental conditions and testing for electrical and electronic equipment Part 2 - Electrical loads.
ISO 10605	**2001-12**	Road vehicle – Electrical disturbances from electrostatic discharges
ISO 11452-1:	**2005-02 (Amendment 1 2008-01)**	Road vehicles, Electrical disturbances by narrowband radiated electromagnetic energy - Component test methods Part 1 - General and definitions.
ISO 11452-2:	**2004-11**	Road vehicles, Electrical disturbances by narrowband radiated electromagnetic energy - Component test methods Part 2 - Absorber- lined chamber.
SAE J1113-2	**2004-07**	EMC measurement procedures and limits for vehicle components - Conducted Immunity
ISO 11452-4:	**2005-04**	Road vehicles, Electrical disturbances by narrowband radiated electromagnetic energy - Component test methods Part 4 - Bulk current injection (BCI).

1.4. Regulation and certification

The provisions relative to regulation and certification such as, AIS-004, 72/245/EEC amended by 2006/96/EEC, ECE R10.02 etc. will be given in specific test plan.

1.5 Test Conditions

1.5.1 CLIMATIC TEST CONDITIONS

Unless indicated otherwise in the specific test plan, the climatic conditions are defined in Table 1.

Room Temperature ≈	23 ± 5.0 degrees Celsius (73.4 ± 9 degrees Fahrenheit)
Humidity	20 to 80 % relative humidity (RH)

Table 1 : Climatic test conditions

1.5.2 TEST VOLTAGE

Unless indicated otherwise in the specific test plan or in a specific test of this document, the test voltage are defined in Table 2.

Nominal System Voltage (V)	12 V system	24 V system
	13.5 ± 0.5 Volt	27± 1 Volt

Table 2 : Test voltage

1.5.3 TOLERANCES

Unless indicated otherwise in the specific test plan, the tolerances are defined in Table 13.

Voltage, Current	± 5 %
Time Interval	± 10 %
Length	± 10 %
Power , Energy	± 10 %
Field Strength	± 10 %
Resistance, Capacitance, Inductance	± 10 %
Impedance	± 10 %

Table 3 : Tolerances

1.6 EMC Test plan content

Prior to testing, an approved test plan shall be signed by the appropriate supplier EMC engineer and TATA Motors, ERC. This document typically includes:

1. The DUT information (Model, Serial number, hardware and software version…)
2. Number of samples to be tested.
3. Pin out and short systems information.
4. Test to be performed with the specific options and test levels.
5. Precise test setup including load box definitions.
6. Failure criteria (to determine functional status and monitoring)
7. Critical timing and/or operating parameters that may affect the testing of the DUT.

1.7. Test Report Format

On completion of the test, an EMC test report conforming to the requirements of this specification shall be prepared and submitted for review and approval at the completion of EMC testing. The test report shall include at least the following information:

- **Location of Test Services:** Provide detail of the geographic location of the test facility.
- **Description of Test Equipment:** List of test equipment used to perform the tests including auxiliary equipments. Calibration details of equipments along with Serial Number, Name of manufacturer, Date of calibration, due date of calibration etc.
- **Description of the DUT and Reference Number:** Description of the DUT, and reference number, Hardware and software version.
- **Generic Test Setup Description:** Provide a description of the test setup used for performing each test. The description shall include the following:
    - Block Diagrams of the test setup including list of actual equipment used (include manufacture's name, model number etc.)
    - Dimensioned diagrams and/or photos to illustrate the general test setup and critical aspects of each test including power supply and grounding locations, and load box details.
    - Diagrams and/or photos illustrating how control and monitor signals are brought in and out of the test chamber to support a typical component test.
    - For immunity testing, provide measurements of actual test signals.
    - EMC test data (which documents test results and any deviations from the approved EMC test plan).
    - More specific data to include in the test report are specified for every test in the present standard.
    - Measurement uncertainty of the EMC tests.
    - EMC test plan reference number and version.
- **Test Results Declaration:** The results shall be declared along with the following documents
    - Output Waveforms:
        - Before the commencement of test
        - During the course of test
        - After the completion of test
    - Diagnostic functions:
        - Before the commencement of test
        - During the course of test
        - After the completion of test
    - Load Box Indications (in a table / truth table)
        - Before the commencement of test
        - During the course of test
        - After the completion of test
    - Region of performance
    - Mode of failure
    - Photographs, charts, waveforms showing failure, if any.

2.0 TEST DESIGN AND REQUIREMENTS

2.1 Operating Mode:

For EMC testing, at least three modes can be considered:

1. **NOT OPERATING:** complete with connectors but not powered.
2. **KEY ON –** Engine stand still: The DUT is powered with all ports connected to their respective loads. In this mode, minimum loads are actuated and this is used to identify mostly narrowband noise from the DUT. For clarity throughout the document, this shall be known as “KEY ON”.
3. **RUN MODE** - Engine running in a standard driving condition represented by an engine speed of 2500 RPM. For clarity throughout the document, this shall be known as “RUN MODE”.

2.2 Functional classification/ performance requirements:

This specification requires all component and subsystem functions to be classified according to their criticality in the overall operation of the vehicle (i.e. Functional Classification). Classification of all component functions shall occur prior to program approval. Contact the TML, ERC personals for clarification of these existing classifications. If new functions are introduced, the TML, ERC to develop and agree to the appropriate classifications.

The performance requirements serve as the basis for the component/subsystem acceptance criteria used during EMC testing. The TML, ERC and their supplier(s) shall be responsible for developing these performance requirements.

2.3 Functional Group Classification:

Component or module functions are divided into four classes based on criticality of function. Refer to Annexure I for Functional Group examples. This element classifies the operational group of the function for an electrical/electronic device within the vehicle as define below.

Group A	Any function that provides a convenience (e.g., entertainment, comfort) and is not included in Group C.
Group B	Any function that enhances and is not included in Group C (e.g., electrical power window, etc).
Group C	Any function that is essential to the operation or control of the vehicle or can confuse other users of the road (e.g., braking, engine management, exterior lights, etc) or functions which, when disturbed, affect vehicle statutory data (e.g. tachograph, odometer).
Group D	Any function that electronically controls the deployment of an electro-explosive device (EED) actuated passive restraint system with the potential for inadvertent deployment.

Table 4: Functional group classification

2.4 Region of performance:

When a DUT is subjected to a stimulus, the required operation of a specific function(s) is determined by the criticality of that function.

Functional Performance Region for Electrical and electronic Systems is hierarchical.

- ❖ Region I is the highest and Region V is the minimum.
    - i. e if the response required is in Region II, then Region I is also acceptable due to the hierarchy.
    - Similarly, if the response required is Region IV then Region I, Region II or Region III is also acceptable.

This element describes the region of performance of the DUT during and after the test.
The minimum functional status shall be given in each test. An additional test requirement may be agreed between supplier and vehicle manufacturer.

Region	Description
Region I	All functions of a device/system perform as designed during and after exposure to disturbance.
Region II	All functions of a device/system perform as designed during exposure. However, one or more of them can go beyond specified tolerance. All functions return automatically to within normal limits after exposure is removed. Memory functions related to the vehicle statutory data shall remain in region I.
Region III	One or more functions do not perform as designed during exposure but returns automatically to normal operation after exposure is removed. NVS Memory functions shall remain in region I (DUT-CPU can be reset but the memory maintenance function should have no abnormality. Current application data can be lost but is reloaded from last valid shutdown, ie, no data corruption allowed). Malfunctioning is not permissible.
Region IV	One or more functions of a device/system do not perform as designed during exposure and does not return to normal operation until exposure is removed and the device system is reset by simple “operator/use” action.
Region V	One or more functions of a device/system do not perform as designed during and after exposure and cannot be returned to proper operation without repairing or replacing the device/system.

Table 5: Region of performance

2.5 Test Signal Level:

This element defines the specification of test signal level and essential parameters. The test signal severity level is the stress level (voltage, volts per meter, etc.) applied to the DUT and shall be described for each test.

2.6 Test samples:

A minimum of 2 DUTs shall be used for each testing. In case of wide variation of the performance between the 2 DUTs, a third one shall be used to confirm the results.

2.7 Testing sequence:

ESD tests shall be performed prior to any other testing. Note that extra test samples are recommended in the event of damage due to destructive tests. However, any corrective design actions required to mitigate ESD issues will require retesting. The TML, ERC shall be contacted immediately in the event that ESD issues are encountered.

2.8 Revalidation:

To assure that EMC requirements are continually met, some aspects of EMC testing shall be required if there are any circuit or PCB design changes (e.g. die shrinks, new PCB layout). This is to be discussed with TATA Motors, ERC personnel.

2.9 Requirement Applicability

TEST TYPE	COMPONENT CATEGORY *Note1							
	Passive modules	Active modules	Inductive devices	Motors		Electronic modules with EM or Magnetic relays	Electronic modules with RPS	Electronic modules with magnetic sensitive elements
				BM	EM			
Conducted Emissions								
Conducted Transient emissions along supply lines		√	√	√	√	√		
Radio disturbance along supply lines		√		√	√	√	√	√
Radio disturbance along control/ signal lines		√			√	√	√	√
Conducted Immunity								
Transient disturbance along supply lines	√	√	√ *Note7	√ *Note4	√	√		√
Transient disturbance along control/ signal lines	√	√			√	√		√
Supply voltage ripple		√			√	√		√
Power supply voltage range		√			√	√		√
Momentary interruption of power		√			√	√		√
Reset behavior at voltage drop		√			√	√		√
Source voltage fluctuations		√			√	√		√
Over voltage test	√	√	√	√ *Note4	√	√		√
Reverse polarity	√	√		√ *Note5	√	√		√
Supply voltage offset		√			√	√		√
Open Circuit tests. Single and multiple lines disconnection		√			√	√		√
Supply voltage slow ramp up		√			√	√		√
High voltage flash test	√ *Note6	√			√	√	√	√
Short circuit (ground & battery)	√	√			√	√	√	√
Insulation resistance test	√*Note6	√			√	√	√	√
Ignition High voltage ***Note2**		√			√	√	√	√
Radiated Emissions								
EMI measured with antenna		√		√	√	√	√	√
Radiated Immunity								
Bulk current injection		√			√	√	√	√
Absorber lined chamber with ground plane		√			√	√	√	√
Immunity to radiated magnetic fields						√		√
Onboard Transmitters simulation *Note3		√			√	√	√	√
Electrostatic Discharge								
Powered ESD	√	√			√	√	√	√
Un powered ESD (handling & packaging)	√	√			√	√	√	√

Table 6: Test selection matrix

***Note1:** For those equipments which are a combination of the previous categories or for equipments. Categories not included above, the applicable tests shall be specified by mutual agreement between TML and the supplier.

***Note2:** Only applicable to equipments and its harness installed in the engine compartment with spark ignition system vehicles.

***Note3:** Only applicable to equipments susceptible of being radiated by onboard transmitters when placed in the passenger compartment.

***Note4:** Only applicable to BM with transient suppressors or filters implemented.

***Note5:** Only applicable to BM with transient suppressors implemented.

***Note6:** Only applicable to equipments with electrical insulated circuits from the enclosure

***Note7:** Only applicable to equipments with transient suppressors implemented.

Passive modules: A module that contains only passive electrical components. Examples: resistor, capacitor, blocking or clamping Diode, LED, etc.

Active modules: A component or module that contains active electronic devices. Examples: an analog op amp circuit, switching power supply, microcontroller or microprocessor controller.

Inductive devices: Relays, Solenoids, horns, etc.

BM: A brush commutated DC electric motor.

EM: Electronically controlled electric motor.

RPS: Regulated Power Source (from another module). Usually a sensor gets Input from Control unit.

3.0 TEST REQUIREMENTS

3.1. CONDUCTED TRANSIENT EMISSIONS

3.1.1 CONDUCTED TRANSIENT EMISSION ALONG SUPPLY LINES

Reference document: ISO 7637-2

NOTE: The requirements of the Directive 2004/104/EC, annex X shall be fulfilled.

Purpose of the test:

The purpose of the test is to evaluate the electrical / electronic components by considering the DUT as a potential source of conducted disturbances, for conducted emissions of transients along the battery-fed or switched supply lines.

Test Conditions:

According to ISO 7637-2.

The disturbance voltage emission conducted along the supply lines of the DUT is measured, whereby the device is operated as intended.
In the case of availability of a standard production switch which is to be used in the vehicle with the DUT, it shall be used to perform the test. Otherwise an electronic switch following the characteristics as per ISO 7637-2**,** shall be used.

Minimum measurement equipment requirements:

- An oscilloscope of a minimum analog bandwidth of 500 MHz and a minimum sampling rate of 1 GHz shall be used.
- High impedance voltage probe with bandwidth greater than or equal to 500 MHz.
- LISN in compliance with the ISO 7637-2.

DUT operating modes:

- Switch ON operation: During this action the DUT is not supplied (NOT OPERATING MODE) and remains off until the external switch is closed.
- Switch OFF operation: During this action the DUT is supplied and shall remain in a representative operation mode (RUN MODE) until the external switch is opened. For a BM and EM motors and during the RUN MODE, the DUT shall be at all the different speed configurations until the external switch is opened.
- Continuous operation: During this action the DUT is supplied and shall remain in a representative operation mode (RUN MODE). For a BM and EM motors and during the RUN MODE, the DUT shall be at all the different speed configurations during the test measurements. For a Inductive devices and Electronic modules with EM or Magnetic relays and during the RUN MODE, the DUT shall be exercised as designed (relays or magnetic relays opened and closed).

Test fixture/load box requirements:

The test fixture and the load box shall provide all the load conditions needed by the DUT during the operation modes defined before.

Test Procedure:

Calibration:

A special calibration is not required to perform this test. All the instrumentation used to perform the test shall be within its calibration state.

Test setup:

Dimensions in millimeters – not to scale

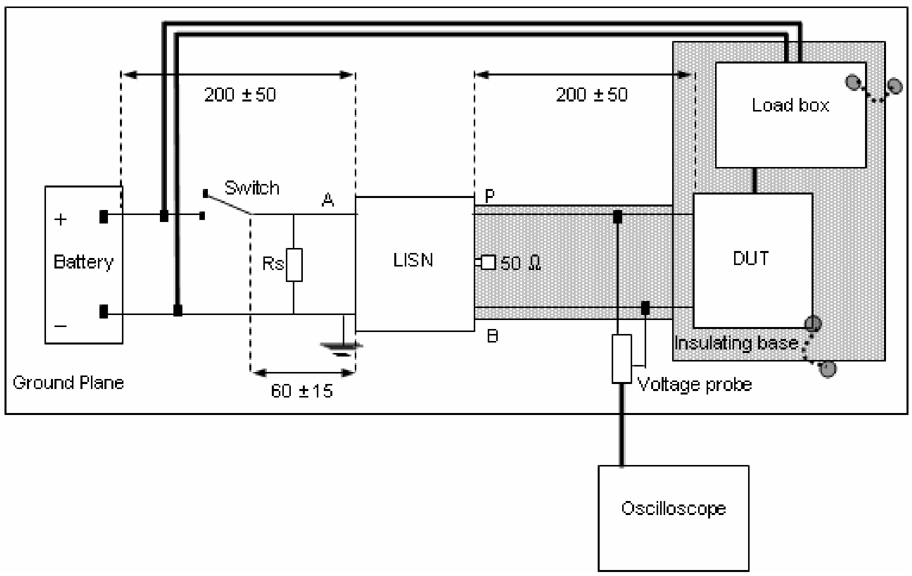


Figure 1. Slow pulses (Top view)

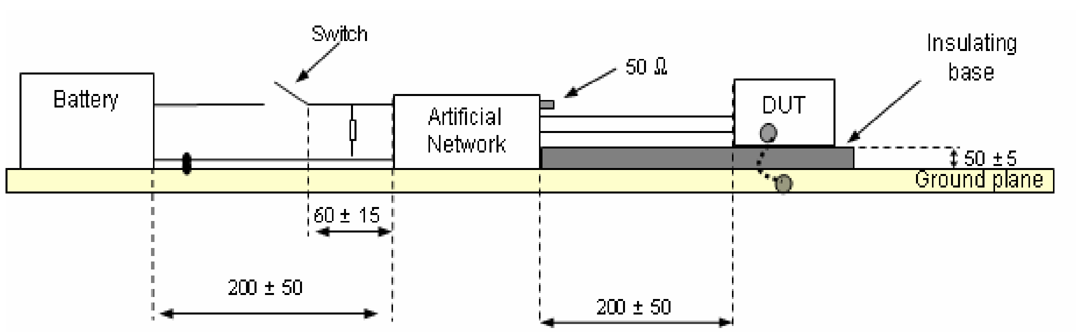


Figure 2. Slow pulses (Lateral view)

Dimensions in millimeters – not to scale

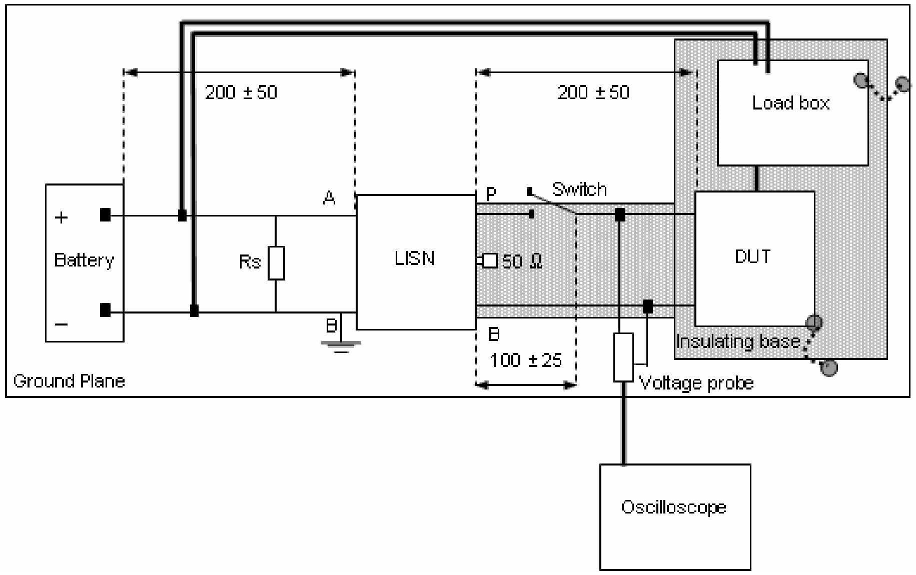


Figure 3. Fast pulses (Top view)

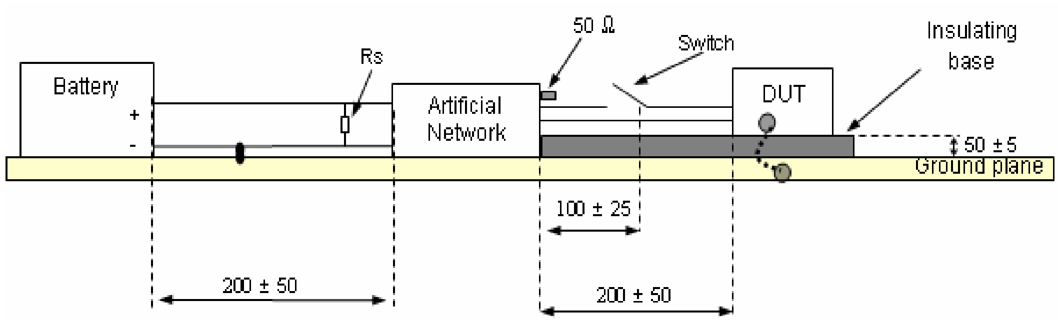


Figure 4. Fast pulses (Lateral view)

Test:

The test shall be performed in switch ON, switch OFF and continuous operation, as detailed below:

The time between measurements (switch ON, switch OFF operations) shall be higher than the minimum required for the DUT stabilization.

Prior to start of measurement, run the DUT minimum for 10 minutes in normal operation.

1. In order to assure the correct test-setup to be used (Slow or Fast pulses test setup), a first measurement shall be made (during the switch on, switch off and continuous operation) following the test-setup shown in the Figure 3 and 4 (Test setup, fast pulses), adjusting the scan time to measure the overall emissions coming from the DUT with the purpose of identifying all the voltage transients produced by the DUT.
If all the voltage transient emissions have a duration equal or greater than 1ms, then made the measurements following the test setup shown in the Figures 1 and 2 (Test setup slow pulses).
If any voltage transient emissions have a duration less than 1ms (microsecond to nanosecond range), then made the measurements following the test setup shown in the Figures 3 and 4.

2. **Switch ON operation:**
With the external switch open (DUT in NOT OPERATING MODE) set the trigger level of the oscilloscope at + 75V (+ 150V for a 24V systems) and configure the time base in order to measure the entire transient emission coming from the DUT. Adjust the oscilloscope sampling rate in order to obtain the maximum resolution for the time base selected and close the external switch.
If any transient emission appears, then decrease the trigger level of the oscilloscope until the transient emission appears.
Identify the voltage transient emission and then decrease the oscilloscope time base and increase the sampling rate in order to obtain a zoom of the voltage transient with the maximum resolution.
Measure and record the maximum voltage, rise time, width and fall time of the voltage transient emission.

Set the trigger level of the oscilloscope at – 75 V(- 150 V for a 24 V systems) in order to measure the negative voltage transient emissions and repeat the previous procedure.
Measure and record the maximum voltage, rise time, width and fall time of the voltage transient emission.

A minimum of 10 measurements shall be made for every oscilloscope configuration (scan time/sampling rate) in order to obtain the maximum level of emissions.

3. **Switch OFF operation:**
With the external switch closed (DUT in RUN MODE) set the trigger level of the oscilloscope at + 75 V (+ 150 V for 24 V systems) and configure the time base in order to measure the entire transient emission coming from the DUT. Adjust the oscilloscope sampling rate in order to obtain the maximum resolution for the time base selected and open the external switch.
If any transient emission appears, then decrease the trigger level of the oscilloscope until the transient emission appears.
Identify the voltage transient emission and then decrease the oscilloscope time base and increase the sampling rate in order to obtain a zoom of the voltage transient with the maximum resolution.
Measure and record the maximum voltage, rise time, width and fall time of the voltage transient emission.

Set the trigger level of the oscilloscope at - 75V (- 150 V for a 24 V systems) in order to measure the negative voltage transient emissions and repeat the previous procedure.
Measure and record the maximum voltage, rise time, width and fall time of the voltage transient emission.

A minimum of 10 measurements shall be made for every oscilloscope configuration (scan time/sampling rate) in order to obtain the maximum level of emissions

Repeat the Switch OFF operation measurements for each DUT work condition (i.e. different speed configurations for a BM and EM motors)

4. **Continuous operation.**
With the external switch closed (DUT in RUN MODE), set the trigger level of the oscilloscope around of the DUT voltage supply value (above and below of this value) and measure the entire transient emission coming from the DUT while exercising the DUT in all of its work conditions (i.e. different speed configurations for a BM and EM motors).
Adjust the oscilloscope sampling rate in order to obtain the maximum resolution for the time base selected.
If any transient emission appears, then decrease the trigger level of the oscilloscope until the transient emission appears.
Identify the voltage transient emission and then decrease the oscilloscope time base and increase the sampling rate in order to obtain a zoom of the voltage transient with the maximum resolution.
Measure and record the maximum voltage, rise time, width and fall time of the voltage transient emission.

A minimum of 10 measurements shall be made for every oscilloscope configuration (scan time/sampling rate) in order to obtain the maximum level of emissions.

Acceptance criteria:

The measured interference voltages during the switch ON, switch OFF and continuous operation must not exceed the maximum voltage value of V_s = + 75 V as positive transients and - 75 V as negative transients on its power supply circuits for a 12 V systems or V_s = + 150 V as positive transients and - 150 V as negative transients on its power supply circuits for 24V systems.

Polarity of pulse amplitude	12 V systems	24 V systems
Positive	+ 75V	+ 150V
Negative	- 75V	- 150V

Table 7: Conducted transient emission along supply lines limits

Test report requirements

In addition of the test report requirements specified in section 1.8 of this specification, the following information shall be reported:

- Test setup used during the test (Slow pulses or Fast pulses test setup).
- Photos of the test setup
- Grounding locations (DUT, Load box and LISN)

- Data table with the maximum voltage, rise time, width and fall time of the voltage transient emission measured specifying the condition at which it has been tested (switch ON, switch OFF and continuous operation).
- Screen shot or screen captures of the oscilloscope for all the maximum measured transients (with the specific parameters).
  - Screen shot of the entire transient emission coming from the DUT.
  - Screen shot zoom for each transient emission coming from the DUT.
- Load box conditions during the voltage transient measurements.

3.1.2 RADIO FREQUENCY CONDUCTED EMISSION ALONG SUPPLY LINES

Reference documents: CISPR25:2008

Purpose of the test:

The purpose of the test is to measure the conducted EMI as the Radio frequency noise voltage injected back into the main supply.

Test Conditions:

The generic test conditions are described in the CISPR 25:2008 document in operating condition (Run) mode.

LIMITS AND SPECTRUM ANALYSER PARAMETERS.
PEAK AND QUASI-PEAK DETECTORS

Service/Band	Frequency Range MHz	Peak detector		Quasi Peak detector		Peak detector Limit dB (µV)	Quasi-peak detector Limit dB (µV)
		RBW at - 3 dB	Scan time	RBW at - 6 dB	Scan time		
BROADCAST							
LW	0.15 ... 0.3	9/10 kHz	10 s/MHz	9 kHz	200 s/MHz	70	57
MW	0.53 ... 1.8					54	41
SW	5.9 ... 6.2					53	40
TV BAND I	41 … 88	100/120 kHz	100 ms/MHz	120 kHz	20 s/MHz	34	-
FM	76 … 108					38	25
MOBILE SERVICES							
CB	26 … 28	9/10 kHz	10 s/MHz	9 kHz	200 s/MHz	44	31
VHF	30 … 54	100/120 kHz	100 ms/MHz	120 kHz	20 s/MHz	44	31
VHF	68 … 87					38	25

Table 8: Limits and Spectrum analyzer parameters for a Peak and Quasi-peak detectors.

LIMITS AND SPECTRUM ANALYSER PARAMETERS. AVERAGE DETECTOR				
Service/Band	Frequency Range MHz	Average detector		Average detector Limit dB (µV)
		RBW at - 3 dB	Scan time	
BROADCAST				
LW	0.15 ... 0.3	9/10 kHz	10 s/MHz	50
MW	0.53 ... 1.8			34
SW	5.9 ... 6.2			33
TV BAND I	41 … 88	100/120 kHz	100 ms/MHz	24
FM	76 … 108			18
MOBILE SERVICES				
CB	26 … 28	9/10 kHz	10 s/MHz	24
VHF	30 … 54	100/120 kHz	100 ms/MHz	24
VHF	68 … 87			18

Table 9: Limits and Spectrum analyzer parameters for Average detector.

Note1: By default, quasi-peak detector and quasi-peak limit shall be used for BB measurements. In the case of using peak detector and peak limit it shall be agreed with TML.

Note2: When a spectrum analyzer is used, the video bandwidth shall be at least tree times the resolution bandwidth (RBW).

Note 3: The scan time listed in Table 8 is the minimum allowed. This value can be modified depending of the DUT emissions repetition rate. For BM motors the scan time shall be increased in order to avoid errors in the measurement due to the low repetition rate of the emissions.

LIMITS AND SCANNING RECEIVER PARAMETERS. PEAK AND QUASI-PEAK DETECTORS									
Service/Band	Frequency Range MHz	Peak detector			Quasi Peak detector			Peak detector Limit dB (µV)	Quasi-peak detector Limit dB (µV)
		RBW at - 6 dB	Step size	Dwell time	RBW at - 6 dB	Step size	Dwell time		
BROADCAST									
LW	0.15 ... 0.3	9 kHz	5 kHz	50 ms	9 kHz	5 kHz	1s	70	57
MW	0.53 ... 1.8							54	41
SW	5.9 ... 6.2							53	40
TV BAND I	41 … 88	120 kHz	50 kHz	5 ms	120 kHz	50 kHz	1s	34	-
FM	76 … 108							38	25
MOBILE SERVICES									
CB	26 … 28	9 kHz	5 kHz	50 ms	9 kHz	5 kHz	1s	44	31
VHF	30 … 54	120 kHz	50 kHz	5 ms	120 kHz	50 kHz	1s	44	31
VHF	68 … 87							38	25

Table 10: Limits and Scanning receiver parameters for a Peak and Quasi-peak detectors.

LIMITS AND SCANNING RECEIVER PARAMETERS. AVERAGE DETECTOR					
Service/Band	Frequency Range MHz	Average detector			Average detector Limit dB(μV)
		RBW at - 6 dB	Step size	Dwell time	
BROADCAST					
LW	0.15 ... 0.3	9 kHz	5 kHz	50 ms	50
MW	0.53 ... 1.8				34
SW	5.9 ... 6.2				33
TV BAND I	41 … 88	120 kHz	50 kHz	5 ms	24
FM	76 … 108				18
MOBILE SERVICES					
CB	26 … 28	9 kHz	5 kHz	50 ms	24
VHF	30 … 54	120 kHz	50 kHz	5 ms	24
VHF	68 … 87				18

Table 11: Limits and Scanning receiver parameters for Average detector

Note1: By default, quasi-peak detector and quasi-peak limit shall be used for BB measurements. In the case of using peak detector and peak limit it shall be agreed with TML.
Note 2: The step size listed in Table 10 is the maximum allowed and the dwell time is the minimum allowed. These values can be modified depending of the DUT emissions repetition rate. For BM motors, the step size shall be increased up to 5 times the RBW.

DUT operating modes:

- Electronic modules and active modules shall be tested at least in two modes: DUT normal operation (DUT in RUN MODE) and Standby or Sleep mode (DUT in KEY ON MODE)
- EM and BM shall be tested in RUN MODE in all the different speed configurations, otherwise specified in the test plan. The EM shall be tested also in KEY ON MODE.

Test fixture/load box requirements:

The load box shall provide the correct load conditions to the DUT during all the operating modes tested. To assure that the emissions are coming only from the DUT and the load box have not influence in the measurements, filters or LISN may be used between the load box and the DUT. These filters shall have a minimum attenuation of 40 dB from 10MHz up to 400 MHz.

Test procedure:

Calibration:

A special calibration is not required to perform this test. All the instrumentation used to perform the test shall be within its calibration period.

Test setup:

Dimensions in millimeters – not to scale

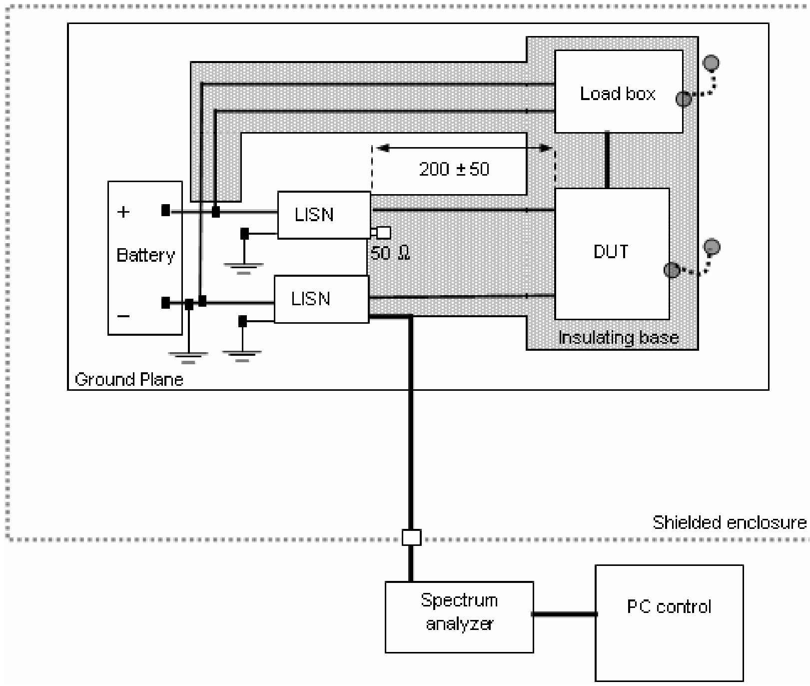


Figure 5. DUT with power return line remotely grounded (Top view)

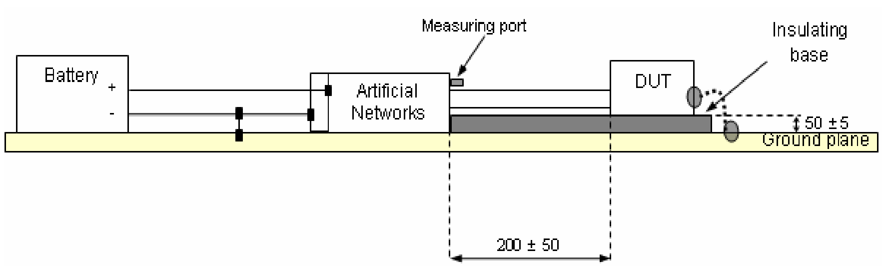


Figure 6. DUT with power return line remotely grounded (Lateral view).

Dimensions in millimeters – not to scale

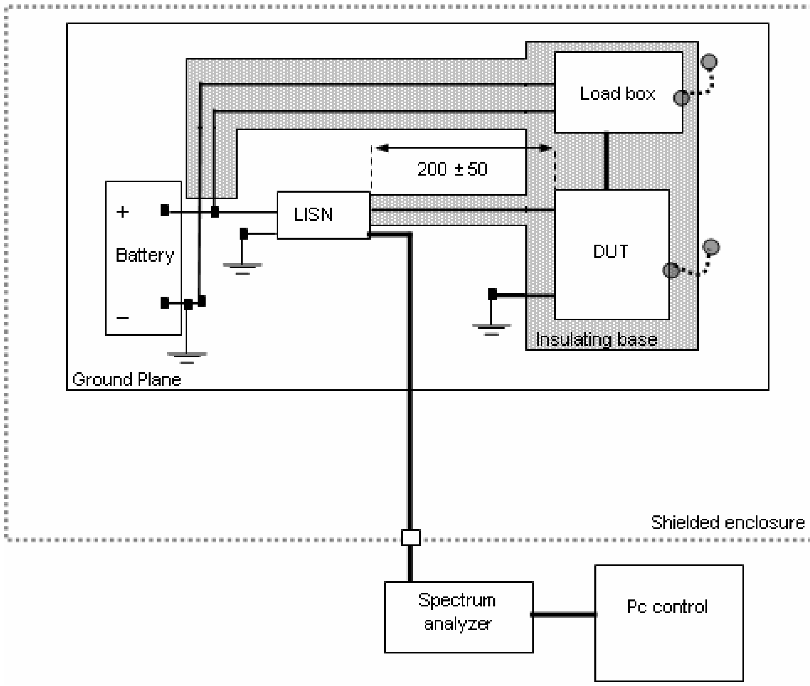


Figure 7. DUT with power return line locally grounded (Top view)

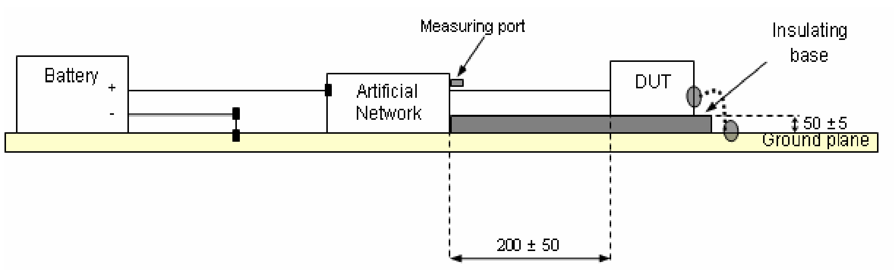


Figure 8. DUT with power return line locally grounded (Lateral view).

Test:

- Depending on the DUT to be tested and its grounding conditions, the measurements shall be done following the correct test setup as shown in Figures 5 to 8.
- Prior testing the DUT, depending on the DUT, the ambient noise measurement shall be done.
- Connect the DUT to the LISN and run a minimum of 10 minutes in normal operation (RUN MODE).
- Connect the measurement cable to the measuring port of the LISN to the positive line and make the measurement following the method of determination of conformance of CISPR25 shown in Figure 9.
- Connect the measurement cable to the measuring port of the LISN to the negative line and make the measurement following the method of determination of conformance of CISPR25 shown in Figure 9.
- Repeat all the measurements for KEY ON mode, if it applies.

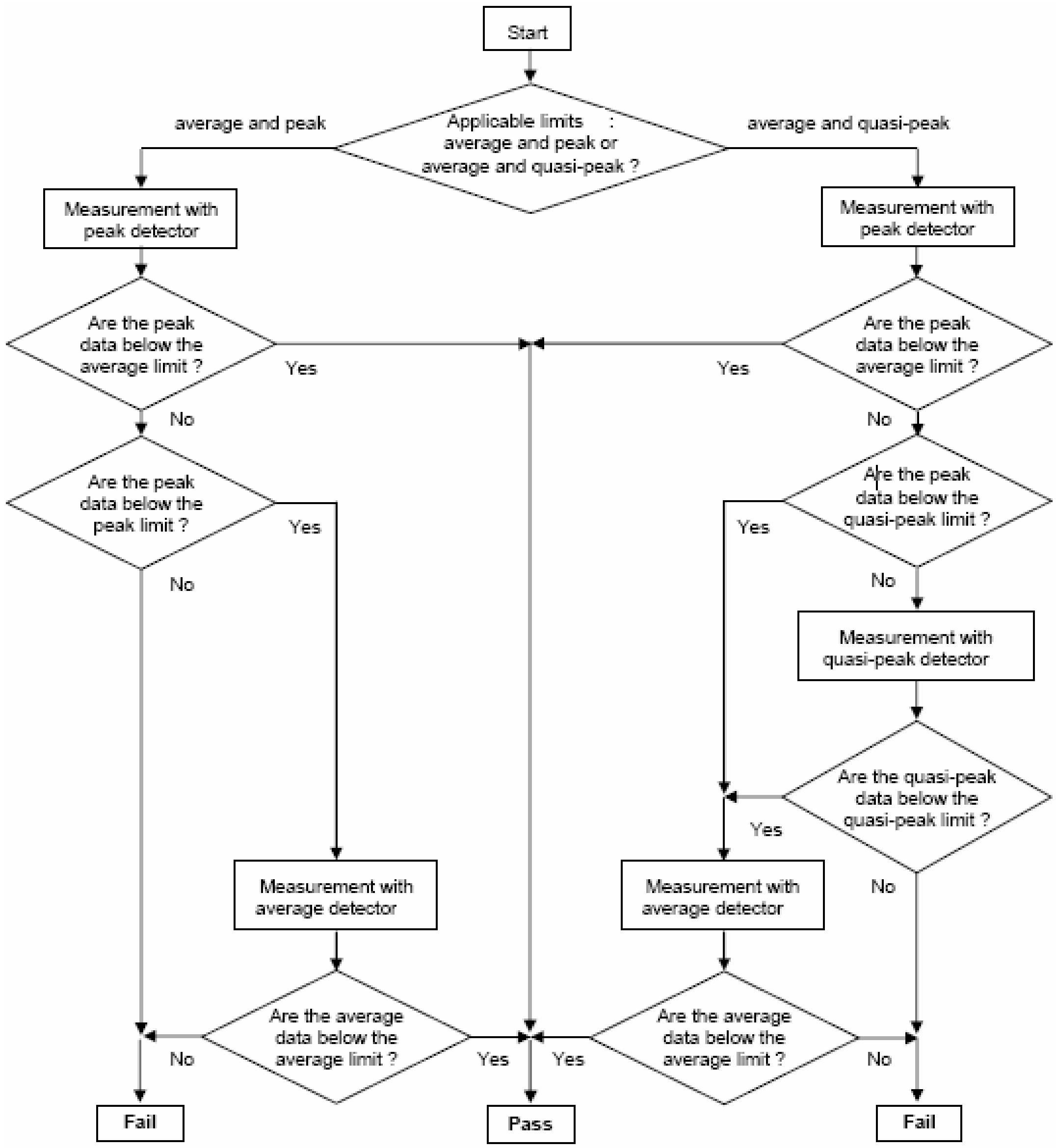


Figure 9. Method of determination of conformance for all frequency bands

Acceptance criteria:

- In all the cases (broadband or narrowband sources) the DUT shall comply with the average limit following the CISPR 25:2008 requirements
- In the frequency bands where peak and quasi peak limits are defined, the DUT shall comply with the quasi-peak limit, otherwise specified in the test plan and agreed with TML
- In the frequency bands where only the peak limit is defined, the DUT shall comply with peak limit.

Test report requirements:

- List of equipment used during the test. Specify if spectrum analyzer or scanning receivers are used.
- RBW (resolution bandwidth at -3dB or -6dB), VBW (video bandwidth), Scan time, Step size and Dwell time used during the measurements.
- Test setup and grounding conditions used (remotely or locally ground connection and ground case conditions for the DUT and load box).
- Limit lines to meet by the DUT. Average detector limit line (for any DUT) and Quasi-peak or Peak detector limit lines.
- Photos of the test setup.
- DUT operation mode during all the measurements.
- Load box conditions during all the measurements (data table with all the associated loads activated).
- Parameters monitored during the test.
- Plot of the ambient noise for all the frequency bands specifying frequency and level measured in dB (μV).
- Plot of the test measurements for all the frequency bands and for all the lines to be tested specifying frequency and level measured in dB (μV). Numeric results shall be submitted in the case of failure.
- Table with all the frequency bands and the result of the DUT evaluated separately (per every frequency band).
- Measurement uncertainties.

3.1.3 RADIO FRECUENCY CONDUCTED EMISSION ALONG CONTROL/SIGNAL LINES

Reference documents: CISPR25:2008

Purpose of the test:

This test is to measure the conducted EMI, as the Radio frequency noise voltage injected back into the signal lines.

Test Conditions:

The generic test methods are described in the CISPR 25:2008 document.

LIMITS AND SPECTRUM ANALYSER PARAMETERS. PEAK AND QUASI-PEAK DETECTORS							
Service/Band	Frequency Range MHz	Peak detector		Quasi Peak detector		Peak detector Limit dB (µA)	Quasi-peak detector Limit dB (µA)
		RBW at -3 dB	Scan time	RBW at -6 dB	Scan time		
BROADCAST							
LW	0.15 ... 0.3	9/10 kHz	10 s/MHz	9 kHz	200 s/MHz	50	37
MW	0.53 ... 1.8					26	13
SW	5.9 ... 6.2					19	6
TV BAND I	41 … 88	100/120 kHz	100 ms/MHz	120 kHz	20 s/MHz	0	-
FM	76 … 108					4	-9
MOBILE SERVICES							
CB	26 … 28	9/10 kHz	10 s/MHz	9 kHz	200 s/MHz	10	-3
VHF	30 … 54	100/120 kHz	100 ms/MHz	120 kHz	20 s/MHz	10	-3
VHF	68 … 87					4	-9

Table 12: Limits and Spectrum analyzer parameters for a Peak and Quasi-peak detectors.

LIMITS AND SPECTRUM ANALYSER PARAMETERS. AVERAGE DETECTOR				
Service/Band	Frequency Range MHz	Average detector		Average detector Limit dB (µA)
		RBW at -3 dB	Scan time	
BROADCAST				
LW	0.15 ... 0.3	9/10 kHz	10 s/MHz	30
MW	0.53 ... 1.8			6
SW	5.9 ... 6.2			-1
TV BAND I	41 … 88	100/120 kHz	100 ms/MHz	-10
FM	76 … 108			-16
MOBILE SERVICES				
CB	26 … 28	9/10 kHz	10 s/MHz	-10
VHF	30 … 54	100/120 kHz	100 ms/MHz	-10
VHF	68 … 87			-16

Table 13: Limits and Spectrum analyzer parameters for Average detector.

Note 1: By default, quasi-peak detector and quasi-peak limit shall be used for BB measurements. In the case of using peak detector and peak limit, it shall be agreed with TML.
Note 2: When a spectrum analyzer is used, the video bandwidth shall be at least tree times the resolution bandwidth (RBW).
Note 3: The scan time listed in Table 12 and 13 are the minimum allowed. This value can be modified depending of the DUT emissions frequency repeatability. For BM motors the scan time shall be increased in order to be adapted to the repetition rate of the emissions.

LIMITS AND SCANNING RECEIVER PARAMETERS. PEAK AND QUASI-PEAK DETECTORS									
Service/Band	Frequency Range MHz	Peak detector			Quasi Peak detector			Peak detector Limit dB (µA)	Quasi-peak detector Limit dB (µA)
		RBW at -6 dB	Step size	Dwell time	RBW at -6 dB	Step size	Dwell time		
BROADCAST									
LW	0.15 ... 0.3	9 kHz	5 kHz	50 ms	9 kHz	5 kHz	1s	50	37
MW	0.53 ... 1.8							26	13
SW	5.9 ... 6.2							19	6
TV BAND I	41 … 88	120 kHz	50 kHz	5 ms	120 kHz	50 kHz	1s	0	-
FM	76 … 108							4	-9
MOBILE SERVICES									
CB	26 … 28	9 kHz	5 kHz	50 ms	9 kHz	5 kHz	1s	10	-3
VHF	30 … 54	120 kHz	50 kHz	5 ms	120 kHz	50 kHz	1s	10	-3
VHF	68 … 87							4	-9

Table 14: Limits and Scanning receiver parameters for a Peak and Quasi-peak detectors.

LIMITS AND SCANNING RECEIVER PARAMETERS. AVERAGE DETECTOR					
Service/Band	Frequency Range MHz	Average detector			Average detector Limit dB (µA)
		RBW at -6 dB	Step size	Dwell time	
BROADCAST					
LW	0.15 ... 0.3	9 kHz	5 kHz	50 ms	30
MW	0.53 ... 1.8				6
SW	5.9 ... 6.2				-1
TV BAND I	41 … 88	120 kHz	50 kHz	5 ms	-10
FM	76 … 108				-16
MOBILE SERVICES					
CB	26 … 28	9 kHz	5 kHz	50 ms	-10
VHF	30 … 54	120 kHz	50 kHz	5 ms	-10
VHF	68 … 87				-16

Table 15: Limits and Scanning receiver parameters for Average detector

Note1: By default, quasi-peak detector and quasi-peak limit shall be used for BB measurements. In the case of using peak detector and peak limit, it shall be agreed with TML.

Note 2: The step size listed in Table 14 and 15 is the maximum allowed and the dwell time is the minimum allowed. These values can be modified depending of the DUT emissions repetition rate. For a BM motors the step size shall be decreased up to 5 times the RBW.

DUT Operating modes:

- Electronic modules and active modules shall be tested at least in two modes: DUT normal operation (DUT in RUN MODE) and Standby or Sleep mode (DUT in KEY ON MODE)
- EM and BM shall be tested in RUN MODE in all the different speed configurations, otherwise specified in the test plan. The EM shall be tested also in KEY ON MODE.

Test fixture/load box requirements:

The load box shall provide the correct load conditions to the DUT during all the operating modes tested. To assure that the emissions are coming only from the DUT and the load box not have influence in the measurements, filters or LISN may be used between the load box and the DUT. These filters shall have a minimum attenuation of 40dB from 10 MHz up to 400 MHz.

Test procedure:

Calibration:

A special calibration is not required to perform this test. All the instrumentation used to perform the test shall be within its calibration period.

Test setup:

Dimensions in millimeters – not to scale

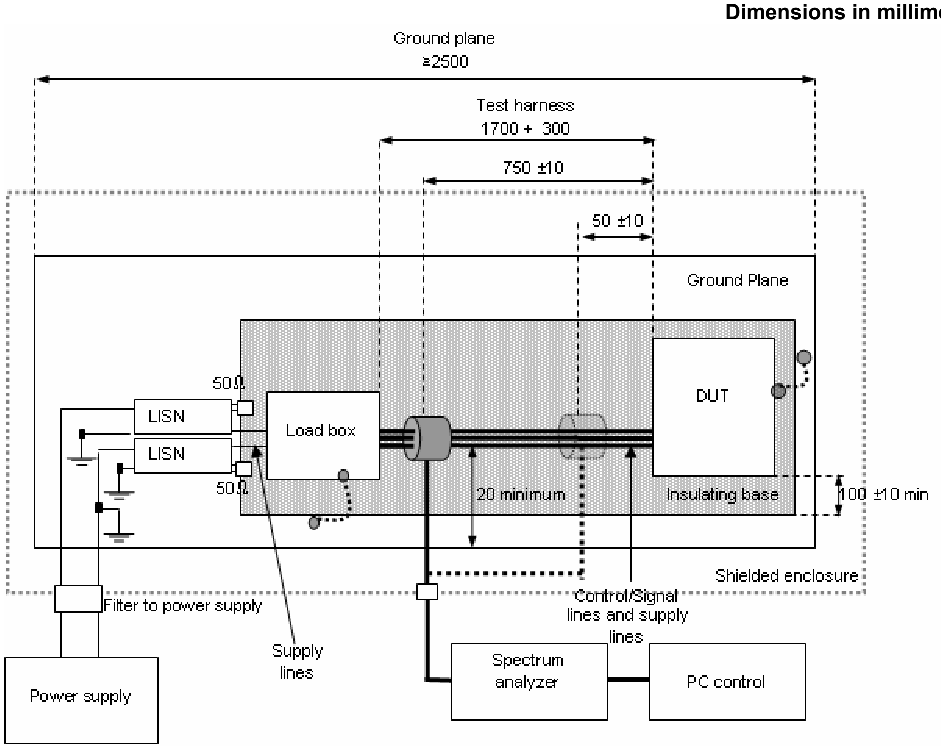


Figure 10. Test setup (top view)

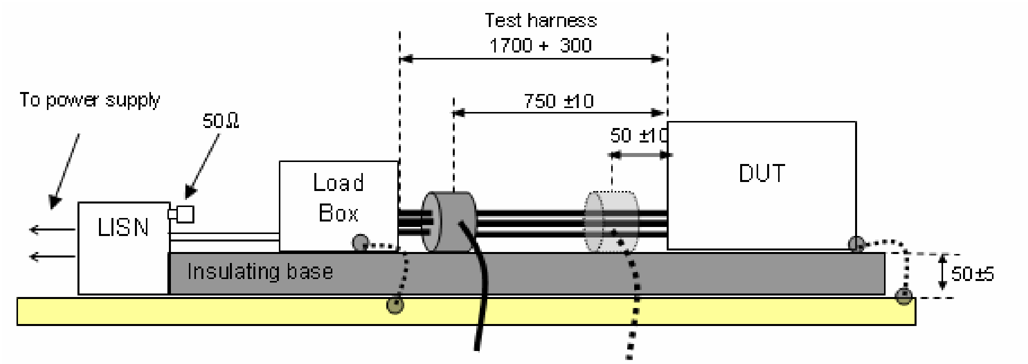


Figure 11. Test setup (lateral view)

Test:

- Set the DUT to be tested with the test setup shown in Figures 10 and 11.
- An ambient noise measurement shall be made in each line to be tested in order to know the noise floor of the test bench and to meet the requirements in the CISPR25:2008.
- Connect the DUT to the Load box and run a minimum of 10 minutes in normal operation (RUN MODE).
- Set the current probe at 750 mm from the DUT and make the measurement following the method of determination of conformance of CISPR25:2008 shown in Figure 12.
- Set the current probe 50mm from the DUT connector and make the measurement following the method of determination of conformance of CISPR25:2008 shown in Figure 12.
- In some cases additional measurements may be done with only the positive supply line inside the current probe and/or the negative line only inside the current probe. For these cases, the limits to be applied and the test conditions shall be defined in the test plan before hand.

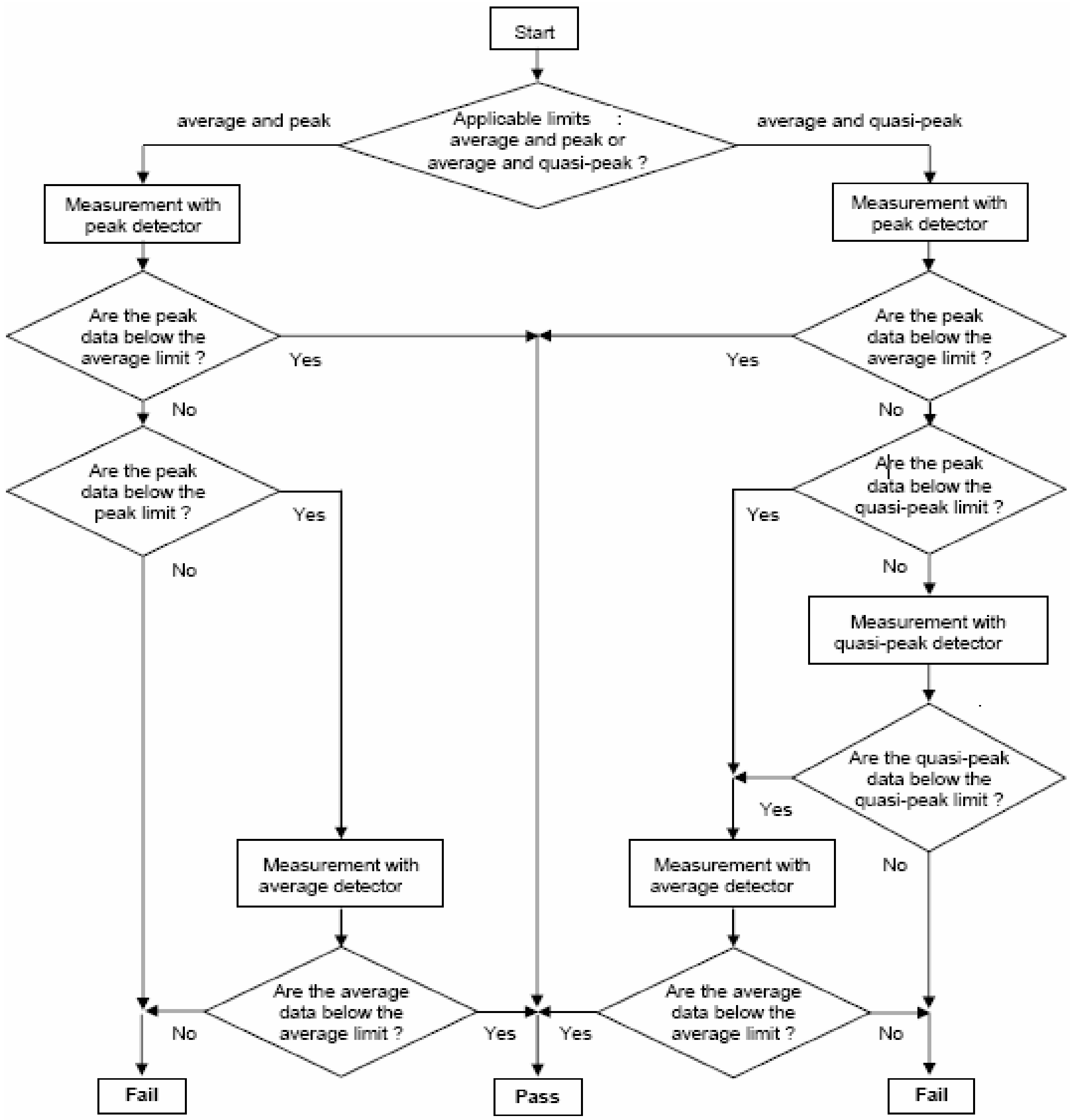


Figure 12. Method of determination of conformance for all frequency bands

Acceptance criteria:

- In all the cases (broadband or narrowband sources) the DUT shall comply with the average limit following the CISPR 25:2008 requirements
- In the frequency bands where peak and quasi peak limits are defined, the DUT shall comply with the quasi-peak limit, otherwise specified in the test plan and agreed with TML.
- In the frequency bands where only the peak limit is defined, the DUT shall comply with peak limit.

Test report requirements:

- List of equipment used during the test. Specified if spectrum analyzer or scanning receivers are used.
- RBW (resolution bandwidth at -3 dB or -6 dB), VBW (video bandwidth), Scan time, Step size and Dwell time used during the measurements.
- Test setup and grounding conditions used (remotely or locally ground connection and ground case conditions for the DUT and load box).
- Limit lines to meet by the DUT. Average detector limit line (for any DUT) and Quasi-peak or Peak detector limit lines.
- Photos of the test setup.
- DUT operation mode during all the measurements.
- Load box conditions during all the measurements (data table with all the associated loads activated).
- Parameters monitored during the test.
- Plot of the ambient noise for all the frequency bands specifying frequency and level measured in dB (μA).
- Plot of the test measurements for all the frequency bands and for all the lines to be tested specifying frequency and level measured in dB (μA). Numeric results shall be submitted in the case of failure.
- Table with all the frequency bands and the result of the DUT evaluated separately (band to band).
- Measurement uncertainties.

3.2. CONDUCTED IMMUNITY

3.2.0 TRANSIENT DISTURBANCES ALONG SUPPLY LINES

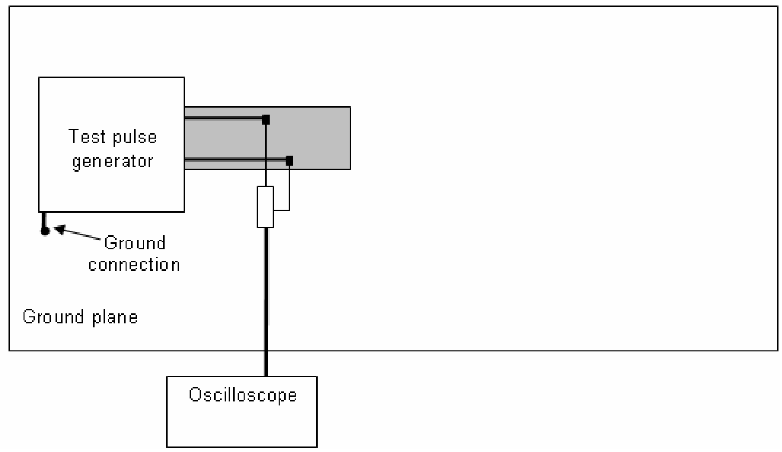
Reference documents: ISO 7637-2

Generic test requirements and conditions:

The purpose of the test is to evaluate DUT against transients conducted along the supply lines, using different test pulses.
Conducted Immunity on Power Lines shall be conducted in accordance with the methods and procedures outlined in **ISO 7637-2** with the following addendums outlined below.

NOTE: The requirements of the Directive 2004/104/EC, annex X shall be additionally fulfilled.

Generic calibration test setup:



Dimensions in millimeters – not to scale

Figure 13. Calibration setup in open circuit

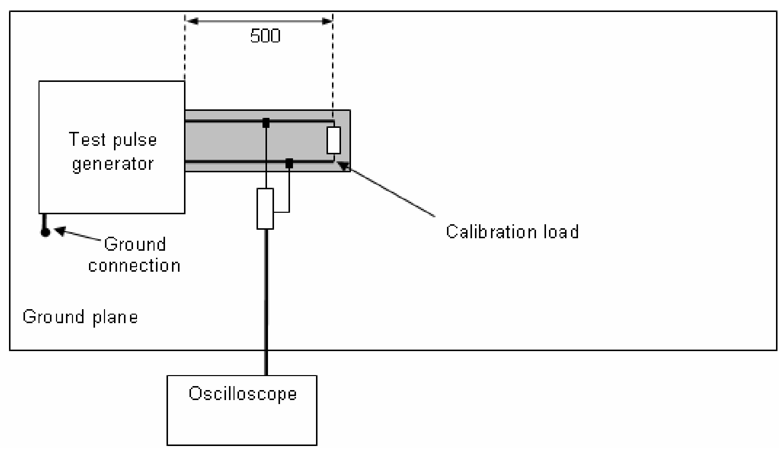


Figure 14. Calibration setup in matching conditions

Generic test setup:

Dimensions in millimeters – not to scale

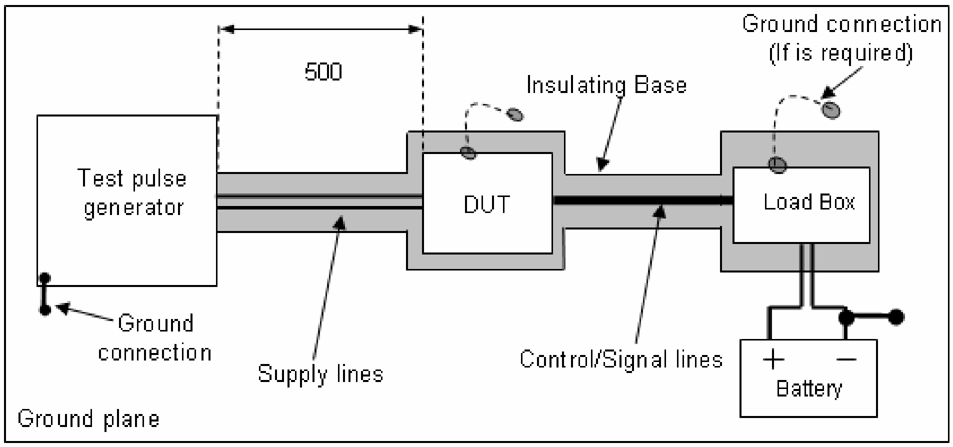


Figure 15. Test setup (top view)

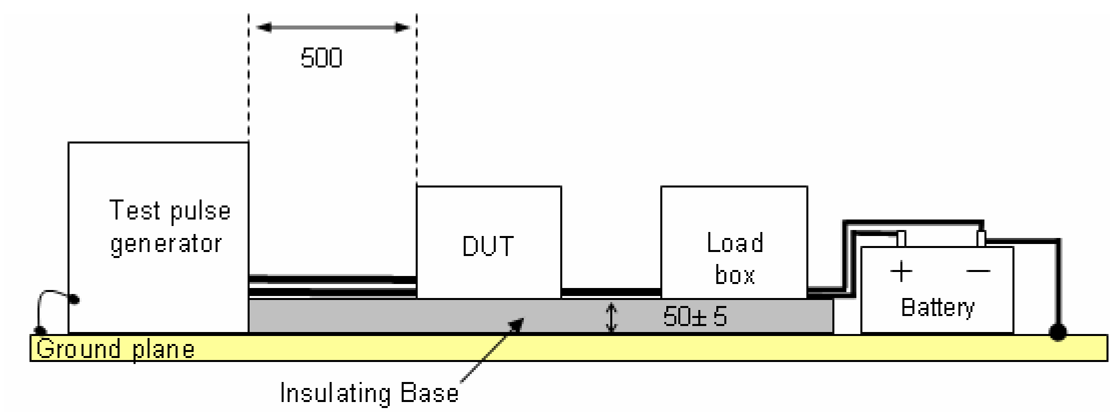


Figure 16. Test setup (lateral view)

3.2.1. Pulse 1

Purpose of the test:

This pulse is a simulation of transients due to supply disconnection from inductive loads. It is applicable to DUT's, which are connected directly parallel with an inductive load.

Test condition:

Lines to be tested: DUT Ignition lines and DUT power supply lines connected directly to the power supply system of the vehicle. Power Lines coming from voltage regulators shall not be tested.

Conducted Immunity on Power Lines: Parameters test Pulse 1		
Pulse parameters	**12 V systems**	**24 V systems**
U_A	13.5 V	27 V
Us	- 100 V	- 600 V
t_d	2 ms	1 ms
t_r	1 µs	3 µs
t_2	200 ms	200 ms
t_1	0.5 s	0.5 s
t_3	≤ 100 us	≤ 100 us
Ri	10 Ohm	50 Ohm
No of pulses	5000	5000

Table 16. Pulse 1 test parameters

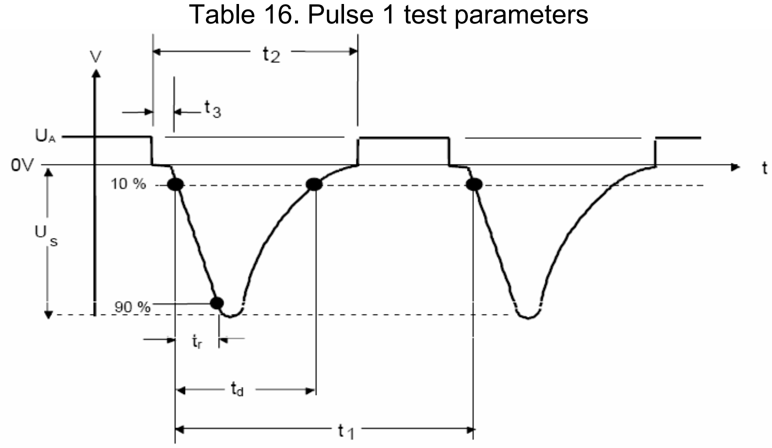


Figure 17. Pulse 1. Waveform and parameters

DUT Operating modes:

Passive modules, inductive devices, electronic modules, active modules, EM and BM shall be tested in nominal conditions. The speed configuration for EM and BM during the test shall be noted in the test report.

Test fixture/load box requirements:

The load box shall provide the correct load conditions to the DUT during all the operating modes tested. In order to assure a correct performance of the load box during the test (free of the transient disturbances), an independent power supply or battery can be used to supply the load box if specified in the test plan.

Test procedure:

Calibration:

- Connect the oscilloscope (high impedance input) to the generator output (in open circuit) and set the generator to obtain the specified pulse shown in the Figure 17 and Table 16.
- In order to verify the test pulse generator, the transient disturbance shall be calibrated in two load conditions following the ISO 7637-2 requirements and the parameters showing in the Table 17.

Power supply systems	Calibration conditions	Us	t_r	t_d
12 V	**Open circuit (no load)**	- 100 V ± 10 V	1µs	2000 µs ± 400 µs
	10 Ω load	- 50 V ± 10 V	1µs	1500 µs ± 300 µs
24 V	**Open circuit (no load)**	- 600 V ± 60 V	3µs	1000 µs ± 200 µs
	50 Ω load	- 300 V ± 30 V	3µs	1000 µs ± 200 µs

Table 17. Calibration parameters Pulse 1

Test:

- Set the DUT to be tested and following the test setup as shown in the Figures 15 and 16.
- Connect the voltage probe and the oscilloscope to the power supply lines in order to monitoring the disturbance applied during the test. Also, monitoring all the parameters or associated loads in the load box.
- Apply the disturbance to the ignition power line and others power supply lines connected directly to the power supply system of the vehicle following the pulse parameters specified in the Table 16.
- Evaluate the DUT performance and the associated loads during and after the test and note all the deviations.
- Perform a full functional test upon completion of test.

Acceptance criteria:

- In order to meet the acceptance criteria shown in the Table 18, the performance or function of the DUT shall be evaluated during and after the test.

Test Pulse	Region of performance (See paragraph 2.4)
Pulse 1	Region III, Memory function region I

Table 18. Pulse 1 Acceptance criteria

Test report requirements:

- Screen shot or screen captures of the oscilloscope for the calibration procedure in open circuit and matching conditions (with the specific parameters).
- Photos of the test setup
- Grounding locations (DUT, Load box and LISN)
- DUT operation mode during the test.
- Description of the power supply lines tested (ignition lines and others power supply lines)
- Load box conditions during the test and description of the associated loads to evaluate the DUT performance.
- Data table with the parameters of the pulse applied.
- Screen shot or screen captures of the oscilloscope for the transients applied to the power supply lines (with the specific parameters) and Screen shot of the associated loads performance.
- A description of the failure (if any) and the region of performance (according to the paragraph 2.4 of this document).

3.2.2. Pulse 2

Purpose of the test:

This pulse simulates transients due to sudden interruption of currents in a device connected in parallel with the DUT, due to the inductance of the wiring harness.

Test condition:

- Lines to be tested: DUT Ignition lines and DUT power supply lines connected directly to the power supply system of the vehicle. Power supply lines coming from voltage regulators shall not be tested.

Conducted Immunity on Power Lines: Parameters test Pulse 2		
Pulse parameters	**12 V systems**	**24 V systems**
U_A	13.5 V	27 V
Us	100 V	100 V
t_d	50 µs	50 µs
t_r	≤ 1 µs	≤ 1 µs
t_1	0.5 s	0.5 s
Ri	2 Ohm	2 Ohm
No of pulses	5000	5000

Table 19. Pulse 2 test parameters

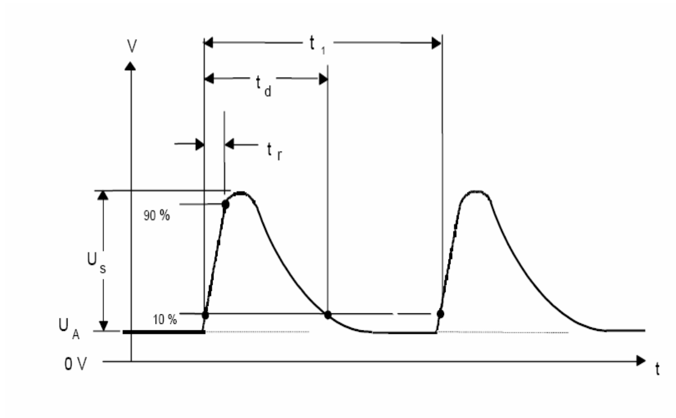


Figure 18. Pulse 2. Waveform and parameters

DUT Operating modes:

Passive modules, inductive devices, electronic modules, active modules, EM and BM shall be tested in nominal conditions. The speed configuration for EM and BM during the test shall be noted in the test report.

Test fixture/load box requirements:

- The load box shall provide the correct load conditions to the DUT during all the operating modes tested. In order to assure a correct performance of the load box during the test (free of the transient disturbances), an independent power supply or battery can be used to supply the load box, if specified in the test plan.

Test procedure:

Calibration:

- Connect the oscilloscope (high impedance input) to the generator output (in open circuit) and set the generator to obtain the specified pulse shown in the Figure 18 and Table 19.

- In order to verify the test pulse generator, the transient disturbance shall be calibrated in two load conditions following the ISO 7637-2:2004 requirements and the parameters showing in the Table 20.

Power supply systems	Calibration conditions	Us	t_r	t_d
12 V	**Open circuit (no load)**	100 V ± 10 V	1 µs	50 µs ± 10 µs
	2 Ω load	50 V ± 10 V	1 µs	12 µs ± 2,4 µs
24 V	**Open circuit (no load)**	100 V ± 10 V	1 µs	50 µs ± 10 µs
	2 Ω load	50 V ± 10 V	1 µs	12 µs ± 2,4 µs

Table 20. Calibration parameters Pulse 2

Test:

- Set the DUT to be tested and following the test setup showing in the Figures 15 and 16
- Connect the voltage probe and the oscilloscope to the power supply lines in order to monitoring the disturbance applied during the test. Also, monitoring all the parameters or associated loads in the load box.
- Apply the disturbance to the ignition power line and others power supply lines connected directly to the power supply system of the vehicle following the pulse parameters specified in the Table 19.
- Evaluate the DUT performance and the associated loads during and after the test and note all the deviations.
- Perform a full functional test upon completion of test.

Acceptance criteria:

In order to meet the acceptance criteria shown in the Table 21, the performance or function of the DUT shall be evaluated during and after the test.

Test Pulse	Region of performance (See paragraph 2.4)
Pulse 2	Region I

Table 21. Pulse 2 Acceptance criteria

Test report requirements:

- Screen shot or screen captures of the oscilloscope for the calibration procedure in open circuit and matching conditions (with the specific parameters).
- Photos of the test setup.
- Grounding locations (DUT, Load box and LISN)
- DUT operation mode during the test.
- Description of the power supply lines tested (ignition lines and others power supply lines)
- Load box conditions during the test and description of the associated loads to evaluate the DUT performance.
- Data table with the parameters of the pulse applied.
- Screen shot or screen captures of the oscilloscope for the transients applied to the power supply lines (with the specific parameters) and Screen shot of the associated loads performance.
- A description of the failure (if any) and the region of performance (according to the paragraph 2.4 of this document).

3.2.3. Pulse 3a

Purpose of the test:

The test pulse is a simulation of transient which occur as a result of the switching processes. This transient is influenced by distributed capacitance and inductance of the wiring harness

Test condition:

Lines to be tested: DUT Ignition lines and DUT power supply lines connected directly to the power supply system of the vehicle. Power supply lines coming from voltage regulators shall not be tested.

Conducted Immunity on Power Lines: Parameters test Pulse 3a		
Pulse parameters	12 V systems	24 V systems
U_A	13.5 V	27 V
Us	-150 V	-200 V
t_d	0,1 µs	0,1 µs
t_r	5 ns	5 ns
t_1	100 µs	100 µs
t_4	10 ms	10 ms
t_5	90 ms	90 ms
Ri	50 Ohm	50 Ohm
Test duration	1 hour	1 hour

Table 22. Pulse 3a test parameters

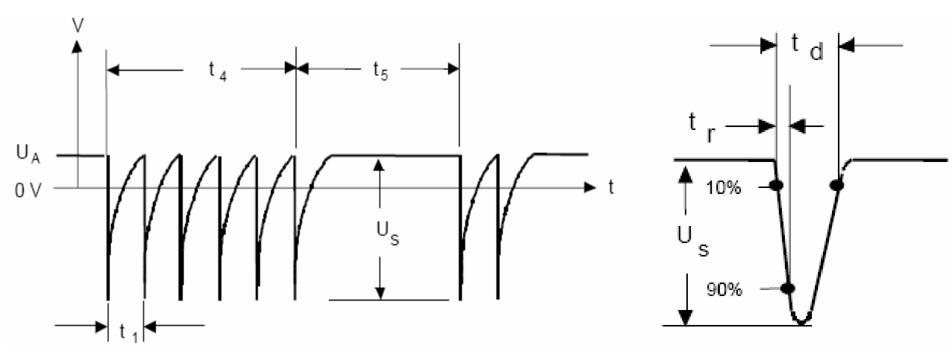


Figure 19. Pulse 3a. Waveform and parameters

DUT Operating modes:

Passive modules, inductive devices, electronic modules, active modules, EM and BM shall be tested in nominal conditions. The speed configuration for EM and BM during the test shall be noted in the test report.

Test fixture/load box requirements:

The load box shall provide the correct load conditions to the DUT during all the operating modes tested. In order to assure a correct performance of the load box during the test (free of the transient disturbances), an independent power supply or battery can be used to supply the load box if specified in the test plan.

Test procedure:

Calibration:

- Connect the oscilloscope (50 ohms input) to the generator 50 ohm output (in open circuit) and set the generator to obtain the specified pulse as shown in the Figure 19 and Table 22.

- In order to verify the test pulse generator, the transient disturbance shall be calibrated in two load conditions following the ISO 7637-2:2004 requirements and the parameters shown in the Table23.

Power supply systems	Calibration conditions	Us	t_r	t_d
12 V	**Open circuit (no load)**	-200 V ± 20 V	5ns ± 1,5ns	150 ns ± 45 ns
	50Ω load	-100 V ± 20 V	5ns ± 1,5ns	150 ns ± 45 ns
24 V	**Open circuit (no load)**	-200 V ± 20 V	5ns ± 1,5ns	150 ns ± 45 ns
	50Ω load	-100 V ± 20 V	5ns ± 1,5ns	150 ns ± 45 ns

Table 23. Calibration parameters Pulse 3a

Test:

- Set the DUT to be tested and following the test setups shown in the Figures 15 and 16.
- Connect the voltage probe and the oscilloscope to the power supply lines in order to monitoring the disturbance applied during the test. Also, monitoring all the parameters or associated loads in the load box.
- Apply the disturbance to the ignition power line and others power supply lines connected directly to the power supply system of the vehicle following the pulse parameters specified in the Table 22.
- Evaluate the DUT performance and the associated loads during and after the test and note all the deviations.
- Perform a full functional test upon completion of test.

Acceptance criteria:

In order to meet the acceptance criteria shown in the Table 24, the performance or function of the DUT shall be evaluated during and after the test.

Test Pulse	Region of performance (See paragraph 2.4)
Pulse 3a	Region I

Table 24. Pulse 3a Acceptance criteria

Test report requirements:

- Screen shot or screen captures of the oscilloscope for the calibration procedure in open circuit and matching conditions (with the specific parameters).
- Photos of the test setup
- Grounding locations (DUT, Load box and LISN)
- DUT operation mode during the test.
- Description of the power supply lines tested (ignition lines and others power supply lines)
- Load box conditions during the test and description of the associated loads to evaluate the DUT performance.
- Data table with the parameters of the pulse applied.
- Screen shot or screen captures of the oscilloscope for the transients applied to the power supply lines (with the specific parameters) and Screen shot of the associated loads performance.
- A description of the failure (if any) and the region of performance (according to the paragraph 2.4of this document).

3.2.4. Pulse 3b

Purpose of the test:

The test pulse is a simulation of transient which occur as a result of the switching processes. This transient is influenced by distributed capacitance and inductance of the wiring harness

Test condition:

Lines to be tested: DUT Ignition lines and DUT power supply lines connected directly to the power supply system of the vehicle. Power supply lines coming from voltage regulators shall not be tested.

Conducted Immunity on Power Lines. Parameters test Pulse 3b		
Pulse parameters	**12 V systems**	**24 V systems**
U_A	13.5 V	27 V
Us	100 V	200 V
t_d	0,1 µs	0,1 µs
t_r	5 ns	5 ns
t_1	100 µs	100 µs
t_4	10 ms	10 ms
t_5	90 ms	90 ms
Ri	50 Ohm	50 Ohm
Pulse duration	1 hour	1 hour

Table 25. Pulse 3b test parameters

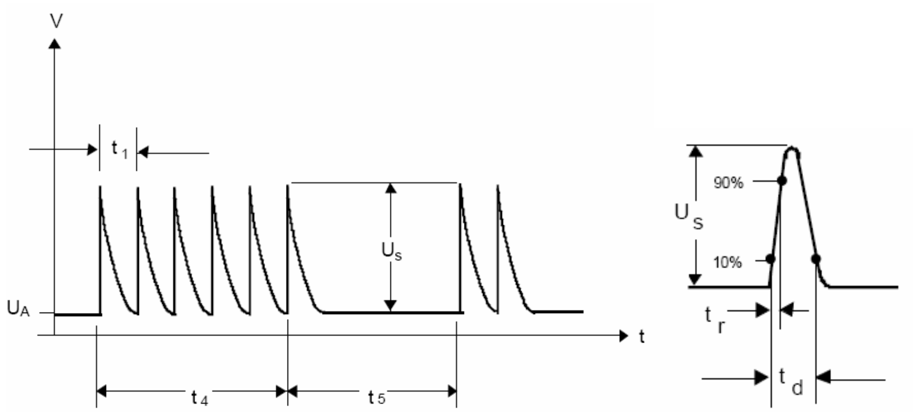


Figure 20. Pulse 3b. Waveform and parameters

DUT Operating modes:

Passive modules, inductive devices, electronic modules, active modules, EM and BM shall be tested in nominal conditions.. The speed configuration for EM and BM during the test shall be noted in the test report.

Test fixture/load box requirements:

The load box shall provide the correct load conditions to the DUT during all the operating modes tested. In order to assure a correct performance of the load box during the test (free of the transient disturbances), an independent power supply or battery can be used to supply the load box if specified in the test plan.

Test procedure:

Calibration:

- Connect the oscilloscope (50 ohms impedance input) to the generator 50 ohm test output (in open circuit) and set the generator to obtain the specified pulse shown in the Figure 20 and Table 25.
- In order to verify the test pulse generator, the transient disturbance shall be calibrated in two load conditions following the ISO 7637-2:2004 requirements and the parameters shown in the Table26.

Power supply systems	Calibration conditions	Us	t_r	t_d
12 V	**Open circuit (no load)**	200 V ± 20 V	5ns ± 1,5ns	150 ns ± 45 ns
	50 Ω load	100 V ± 20 V	5ns ± 1,5ns	150 ns ± 45 ns
24 V	**Open circuit (no load)**	200 V ± 20 V	5ns ± 1,5ns	150 ns ± 45 ns
	50 Ω load	100 V ± 20 V	5ns ± 1,5ns	150 ns ± 45 ns

Table 26. Calibration parameters Pulse 3

Test:

- Set the DUT to be tested and following the test setup shown in the Figures 15 and 16.
- Connect the voltage probe and the oscilloscope to the power supply lines in order to monitoring the disturbance applied during the test. Also, monitoring all the parameters or associated loads in the load box.
- Apply the disturbance to the ignition power line and others power supply lines connected directly to the power supply system of the vehicle following the pulse parameters specified in the Table 25.
- Evaluate the DUT performance and the associated loads during and after the test and note all the deviations.
- Perform a full functional test upon completion of test.

Acceptance criteria:

In order to meet the acceptance criteria shown in the Table 27, the performance or function of the DUT shall be evaluated during and after the test.

Test Pulse	Region of performance (See paragraph 2.4)
Pulse 3b	Region I

Table 27. Pulse 3b Acceptance criteria

Test report requirements:

- Screen shot or screen captures of the oscilloscope for the calibration procedure in open circuit and matching conditions (with the specific parameters).
- Photos of the test setup.
- Grounding locations (DUT, Load box and LISN)
- DUT operation mode during the test.
- Description of the power supply lines tested (ignition lines and others power supply lines)
- Load box conditions during the test and description of the associated loads to evaluate the DUT performance.
- Data table with the parameters of the pulse applied.
- Screen shot or screen captures of the oscilloscope for the transients applied to the power supply lines (with the specific parameters) and Screen shot of the associated loads performance.
- A description of the failure (if any) and the region of performance (according to the paragraph 2.4 of this document).

3.2.5. Pulse 4

Purpose of the test:

This pulse simulates the supply voltage reduction caused by energizing the starter motor circuits of internal combustion engines, excluding spikes associated with starting

Test condition:

Lines to be tested: DUT Ignition lines and DUT power supply lines connected directly to the power supply system of the vehicle. Power supply lines coming from voltage regulators shall not be tested.

Conducted Immunity on Power Lines: Parameters test Pulse 4		
Pulse parameters	**12 V systems**	**24 V systems**
U_B	12 V	24 V
U_{min}	4,5 V	9 V
U_{start}	6,5 V	13 V
t_R	5 ms	10 ms
t_6	40 ms	40 ms
t_7	50 ms	100 ms
t_F	50 ms	100 ms
t_8	10 s	10 s
Ri	0,01 Ohm	0,01 Ohm
Test pulses	10 pulses	10 pulses

Table 28. Pulse 4 test parameters

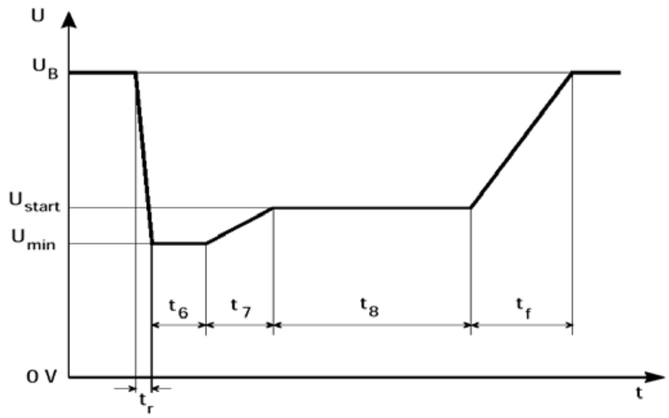


Figure 21. Pulse 4. Waveform and parameters

DUT Operating modes:

Passive modules, inductive devices, electronic modules, active modules, EM and BM shall be tested in nominal conditions.. The speed configuration for EM and BM during the test shall be noted in the test report.

Test fixture/load box requirements:

The load box shall provide the correct load conditions to the DUT during all the operating modes tested. In order to assure a correct performance of the load box during the test (free of the transient disturbances), an independent power supply or battery can be used to supply the load box if specified in the test plan.

Test procedure:

Calibration:

- Connect the oscilloscope (high impedance input) to the generator output (in open circuit) and set the generator to obtain the specified pulse shown in the Figure 21 and Table 28.

- A special test pulse generator verification procedure is not needed in this section.

Test:

- Set the DUT to be tested and following the test setup shown in the Figures 15 and 16.
- Connect the voltage probe and the oscilloscope to the power supply lines in order to monitoring the disturbance applied during the test. Also, monitoring all the parameters or associated loads in the load box.
- Apply the disturbance to the ignition power line and others power supply lines connected directly to the power supply system of the vehicle following the pulse parameters specified in the Table 28.
- Evaluate the DUT performance and the associated loads during and after the test and note all the deviations.
- Perform a full functional test upon completion of test.

Acceptance criteria:

In order to meet the acceptance criteria shown in the Table 29, the performance or function of the DUT shall be evaluated during and after the test.

Test Pulse	Region of performance (See paragraph 2.4)
Pulse 4	Region II, Memory function region I

Table 29. Pulse 4 Acceptance criteria

Note: Functions of the DUT that are relevant to vehicle operation during cranking shall be Region I, all other functions shall be Region II. Memory function should operate in region I (the status of the memory shall not be altered during the test and after).

Test report requirements:

- Photos of the test setup
- Grounding locations (DUT, Load box and LISN)
- DUT operation mode during the test.
- Description of the power supply lines tested (ignition lines and others power supply lines)
- Load box conditions during the test and description of the associated loads to evaluated the DUT performance
- Data table with the parameters of the pulse applied.
- Screen shot or screen captures of the oscilloscope for the transients applied to the power supply lines (with the specific parameters) and Screen shot of the associated loads performance.
- A description of the failure (if apply) and the region of performance (according to the paragraph 2.4 of this document).

3.2.6. Pulse 4b

Purpose of the test:

As per section 3.2.5 Pulse 4 of this document.

Test condition:

As per section 3.2.5 Pulse 4 of this document with the specific parameters shown in the following Table:

Conducted Immunity on Power Lines. Parameters test Pulse 4b		
Pulse parameters	**12 V systems**	**24 V systems**
U_B	12 V	24 V
U_{min}	4,5 V	9 V
U_{start}	6,5 V	13 V
t_R	5 ms	10 ms
t_6	40 ms	40 ms
t_7	50 ms	100 ms
t_F	50 ms	100 ms
t_8	10 s	10 s
Ri	0,01 Ohm	0,01 Ohm
F (sinusoidal)	2 Hz	2 Hz
Test pulses	10 pulses	10 pulses

Table 30. Pulse 4b test parameters

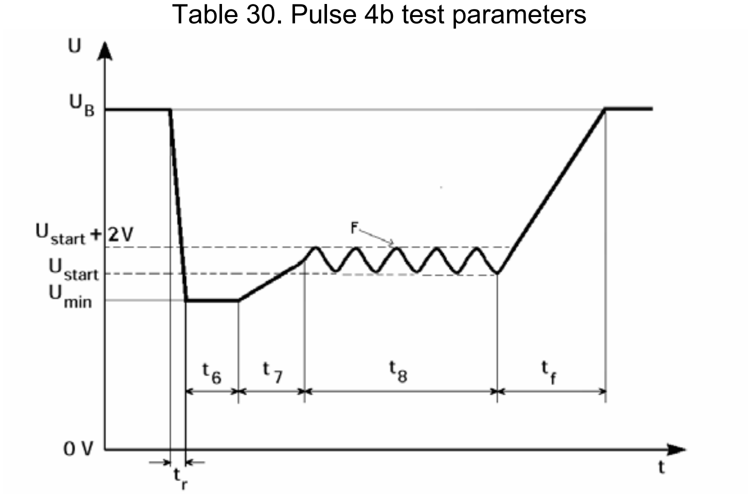


Figure 22. Pulse 4b. Waveform and parameters

DUT Operating modes:

As per section 3.2.5 Pulse 4 of this document.

Test fixture/load box requirements:

As per section 3.2.5 Pulse 4 of this document.

Test procedure:

Calibration:

A special calibration is not required to perform this test.

Test:

As per section 3.2.5 Pulse 4 of this document.

Acceptance criteria:
As per section 3.2.5 Pulse 4 of this document.

Test report requirements:

As per section 3.2.5 Pulse 4 of this document.

3.2.7. Pulse 5

Purpose of the test:

This pulse is a simulation of load dump transient, occurring in the event of a discharged battery being disconnected while alternator is generating current and other loads are remaining in the alternator circuit

Test condition:

- Lines to be tested: DUT Ignition lines and DUT power supply lines connected directly to the power supply system of the vehicle. Power supply lines coming from voltage regulators shall not be tested.

- For the signal lines which are getting supply voltage trough switches, Load dump test to be followed.

Conducted Immunity on Power Lines. Parameters test Pulse 5		
Pulse parameters	**12 V systems**	**24 V systems**
U_A	13.5 V	27 V
Us	87 V	174 V
t_d	400 ms	350 ms
t_r	10 ms	10 ms
Delay between pulses	45 s	45 s
Ri	0,5 Ohm	1 Ohm
Test pulses	10 pulses	10 pulses

Table 31. Pulse 5 test parameters

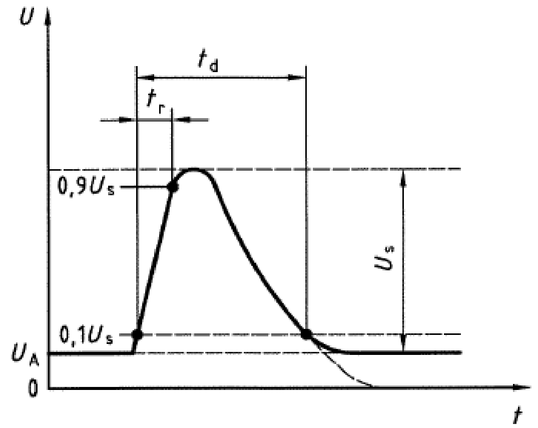


Figure 23. Pulse 5 Waveform and parameters

DUT Operating modes:

Passive modules, inductive devices, electronic modules, active modules, EM and BM shall be tested in nominal conditions. The speed configuration for EM and BM during the test shall be noted in the test report.

Test fixture/load box requirements:

The load box shall provide the correct load conditions to the DUT during all the operating modes tested. In order to assure a correct performance of the load box during the test (free of the transient disturbances), an independent power supply or battery can be used to supply the load box if specified in the test plan.

Test procedure:

Calibration:

- Connect the oscilloscope (high impedance input) to the generator output (in open circuit) and set the generator to obtain the specified pulse shown in the Figure 23 and Table 31**.**

- In order to verify the test pulse generator, the transient disturbance shall be calibrated in two load conditions following the ISO 7637-2 requirements and the parameters shown in the Table32.

Power supply systems	Calibration conditions	Us	t_r	t_d
12 V	**Open circuit (no load)**	100 V ± 10 V	10ms	400 ms ± 80 ms
	2 Ω load	50 V ± 10 V	-	200 ms ± 40 ms
24 V	**Open circuit (no load)**	200 V ± 20 V	10ms	350 ms ± 70 ms
	2 Ω load	100 V ± 20 V	-	175 ms ± 35 ms

Table 32. Calibration parameters Pulse 5

Test:

- Set the DUT to be tested and following the test setup shown in the Figures 15 and 16.
- Connect the voltage probe and the oscilloscope to the power supply lines in order to monitoring the disturbance applied during the test. Also, monitoring all the parameters or associated loads in the load box.
- Apply the disturbance to the ignition power line and others power supply lines connected directly to the power supply system of the vehicle following the pulse parameters specified in the Table 31.
- Evaluate the DUT performance and the associated loads during and after the test and note all the deviations.
- Perform a full functional test upon completion of test.

Acceptance criteria:

In order to meet the acceptance criteria shown in the Table 33, the performance or function of the DUT shall be evaluated during and after the test.

Test Pulse	Region of performance (See paragraph 2.4)
Pulse 5	Region I

Table 33. Pulse 5 Acceptance criteria

Test report requirements:

- Screen shot or screen captures of the oscilloscope for the calibration procedure in open circuit and matching conditions (with the specific parameters).
- Photos of the test setup.
- Grounding locations (DUT, Load box and LISN).
- DUT operation mode during the test.
- Description of the power supply lines tested (ignition lines and others power supply lines)
- Load box conditions during the test and description of the associated loads to evaluate the DUT performance.
- Data table with the parameters of the pulse applied.
- Screen shot or screen captures of the oscilloscope for the transients applied to the power supply lines (with the specific parameters) and Screen shot of the associated loads performance.
- A description of the failure (if any) and the region of performance (according to the paragraph 2.4 of this document).

3.2.8. TRANSIENT DISTURBANCES FROM CONDUCTION AND COUPLING ALONG SIGNAL LINES.

Reference document: ISO 7637-3

Purpose of the test:

The purpose of the test is to check the operation of concerned device, when subjected to injection of high-frequency and low-frequency transient's noises. These are due to switching inductive loads or disconnection from the supply line, and relay contact bounce and to be applied by means of a capacitive, direct and inductive coupling via lines other than supply lines.

- This test establishes 3 evaluation methods in order to simulate fast and slow transient disturbances:

1. Capacitive coupling clamp method (CCC). This method is suitable for coupling fast transient test pulses due to the switching processes.

2. Direct capacitive coupling method (DCC). This method is suitable for coupling fast transient test pulses (due to the switching process) and slow transient test pulses (due to the disconnection of the inductive loads).

3. Inductive coupling clamp method (ICC). This method is suitable for coupling slow transient test pulses due to the disconnection of the inductive loads.

Transient	CCC method	DCC method	ICC method
Slow pulses	Not applicable	Applicable	Applicable
Fast pulses	Applicable	Applicable	Not applicable

Table 34. Test method applicability

Note: Only one test method need be selected for each slow transients and fast transients.

Test condition:

Test equipment: The capacitive coupling clamp, injection probe, oscilloscope, voltage probe, power supply and test pulse generator used to perform the test shall be according to the ISO 7637-3:2007 standard. The capacitor's values recommended for the DCC method are shown in the Table s 39 and 42 of this section.

- <u>Capacitive coupling clamp method (CCC)</u>

- This method can be used for testing all the harnesses simultaneously (power supply lines and signal lines routed inside of the clamp as per the test setup shown in the Figure 40) or only the lines other than supply lines (power supply lines routed outside of the clamp as per the test setup shown in the Figure 41).

  - The transients shall be applied in negative polarity (Fast transient pulse A) and positive polarity (Fast transient pulse B).

  - Test pulse parameters for Fast transient pulses A and B:

Transient disturbances from conduction and coupling along signal lines. Parameters Fast Pulses A		
Pulse parameters	**12 V systems**	**24 V systems**
Us	- 150 V	- 200 V
t_d	0,1 µs	0,1 µs
t_r	5 ns	5 ns
t_1	100 µs	100 µs
t_4	10 ms	10 ms
t_5	90 ms	90 ms
Ri	50 Ohm	50 Ohm
Test duration	1 hour	1 hour

Table 35. Fast transient test pulse A. Parameters for CCC method

Note: The parameters shown in the Table 35 are measured or calibrated previously with an oscilloscope connected to the coupling clamp which is terminated in 50 Ω attenuator and an input impedance of 50 Ω.

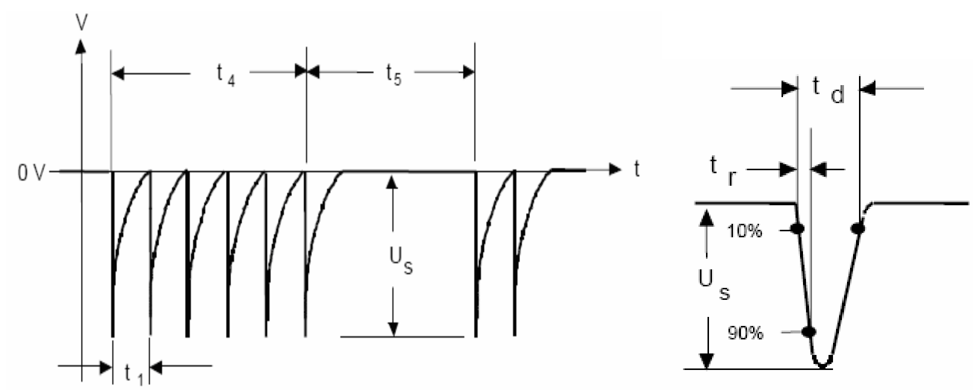


Figure 24. Fast transient test pulse A. Waveform and parameters for CCC method

Transient disturbances from conduction and coupling along signal lines. Parameters Fast Pulses B		
Pulse parameters	**12 V systems**	**24 V systems**
Us	100 V	200 V
t_d	0,1 µs	0,1 µs
t_r	5 ns	5 ns
t_1	100 µs	100 µs
t_4	10 ms	10 ms
t_5	90 ms	90 ms
Ri	50 Ohm	50 Ohm
Test duration	1 hour	1 hour

Table 36. Fast transient test pulse B. Parameters for CCC method

Note: The parameters shown in Table 36 are measured or calibrated previously with an oscilloscope connected to the coupling clamp which is terminated in 50 Ω attenuator and an input impedance of 50 Ω.

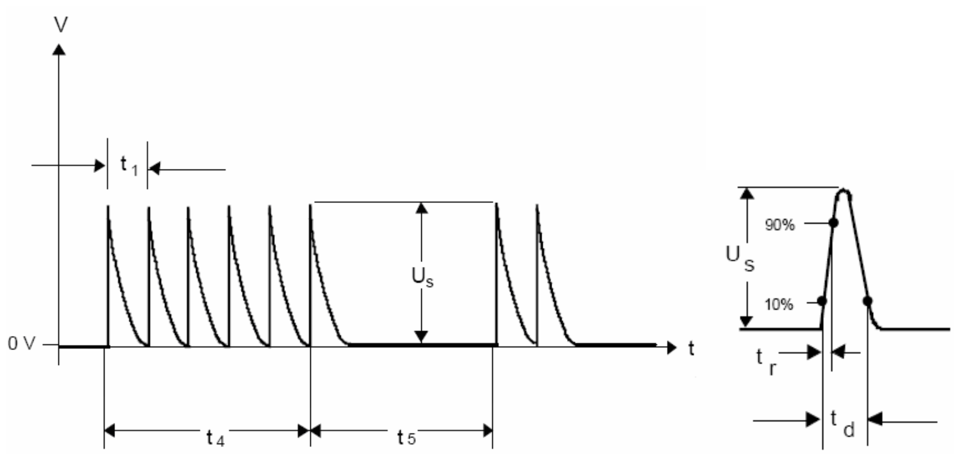


Figure 25. Fast transient test pulse B: Waveform and parameters for CCC method

- **Direct capacitive coupling method (DCC)**

- Only signal lines (other than the supply lines except Can bus lines) shall be tested as per the test setup shown in the Figure 43 and only the CAN bus lines shall be tested as per the test setup shown in the Figure 44 (excite all CAN bus lines identically at the same time).

- This method can be used for testing fast transient pulses and slow transient pulses:

  - Fast transient pulses: The transients shall be applied in negative polarity (Fast transient pulse A) and positive polarity (Fast transient pulse B).

  - Slow transient pulses: The transients shall be applied in negative polarity (Negative Slow transient) and positive polarity (Positive Slow transient).

- Test pulse parameters: Fast transient pulses A and B:

Transient disturbances from conduction and coupling along signal lines. Parameters Fast Pulses A		
Pulse parameters	**12 V systems**	**24 V systems**
Us	-150 V	-200 V
t_d	0,1 µs	0,1 µs
t_r	5 ns	5 ns
t_1	100 µs	100 µs
t_4	10 ms	10 ms
t_5	90 ms	90 ms
Ri	50 Ohm	50 Ohm
Test duration	30 minutes	30 minutes

Table 37. Fast transient test pulse A: Parameters for DCC method

Note: The parameters shown in Table 37are measured in open circuit (generator output connected in series through the coupling capacitor) and in appropriated impedance matching conditions following the ISO 7637-2 specifications.

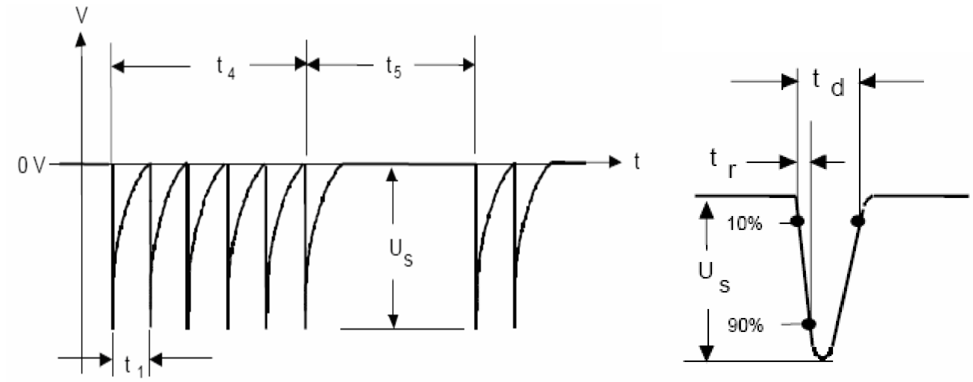


Figure 26. Fast transient test pulse A. Waveform and parameters for DCC method

Transient disturbances from conduction and coupling along signal lines: Parameters Fast Pulses B		
Pulse parameters	**12 V systems**	**24 V systems**
Us	100 V	150 V
t_d	0,1 µs	0,1 µs
t_r	5 ns	5 ns
t_1	100 µs	100 µs
t_4	10 ms	10 ms
t_5	90 ms	90 ms
Ri	50 Ohm	50 Ohm
Test duration	1 minutes	30 minutes

Table 38. Fast transient test pulse B: Parameters for DCC method

Note: The parameters shown in the Table 38 are measured in open circuit (generator output connected in series through the coupling capacitor) and in appropriated impedance matching conditions following the ISO 7637-2 specifications.

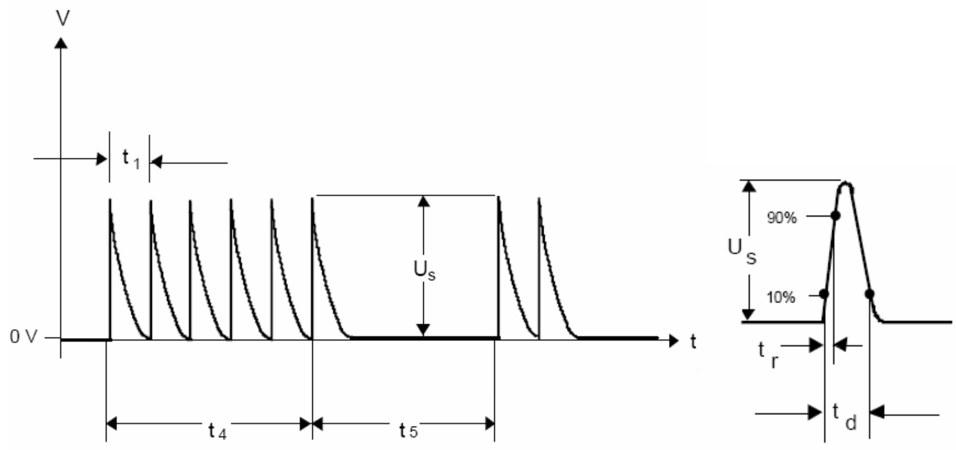


Figure 27. Fast transient test pulse B. Waveform and parameters for DCC method

Lines under test	Test pulse	Capacitor value
Signal lines only (other than the power supply lines)	Fast transient test pulses A and B	100 pF, 200 V minimum
Can bus lines only		

Table 39. Capacitor values recommended for fast transient test pulses A and B. DCC method

Test pulse parameters.
Slow transient negative polarity and positive polarity:

Transient disturbances from conduction and coupling along signal lines. Parameters Slow transient test Pulses (negative polarity)		
Pulse parameters	**12 V systems**	**24 V systems**
Us	-150 V	-200 V
t_d	50 µs	50 µs
t_r	≤ 1 µs	≤ 1 µs
t_1	1 s	1 s
Ri	2 Ohm	2 Ohm
Test duration	30 minutes	30 minutes

Table 40. Slow transient test pulse (negative polarity): Parameters for DCC method

Note: The parameters shown in Table 40 are measured in open circuit (generator output connected in series through the coupling capacitor) and in appropriated impedance matching conditions following the ISO 7637-2:2004 specifications.

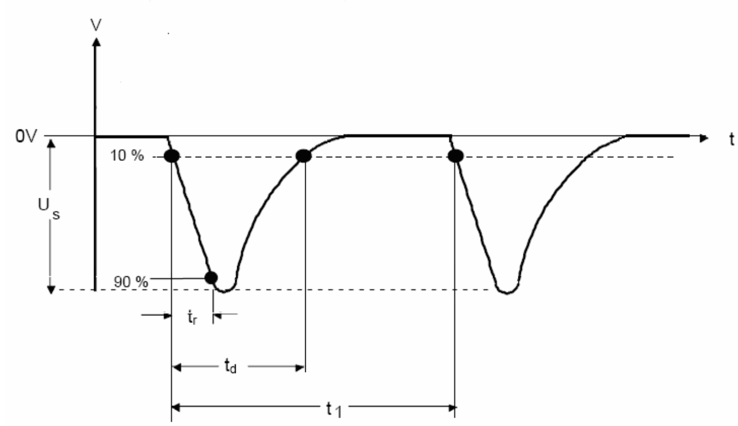


Figure 28. Slow transient test pulse (negative polarity). Waveform and parameters for DCC method

Transient disturbances from conduction and coupling along signal lines. Parameters Slow transient test Pulses (positive polarity)		
Pulse parameters	**12 V systems**	**24 V systems**
Us	150 V	200 V
t_d	50 µs	50 µs
t_r	≤ 1 µs	≤ 1 µs
t_1	1 s	1 s
Ri	2 Ohm	2 Ohm
Test duration	30 minutes	30 minutes

Table 41. Slow transient test pulse (positive polarity): Parameters for DCC method

Note: The parameters shown in Table 41 are measured in open circuit (generator output connected in series through the coupling capacitor) and in appropriated impedance matching conditions, following the ISO 7637-2:2004 specifications.

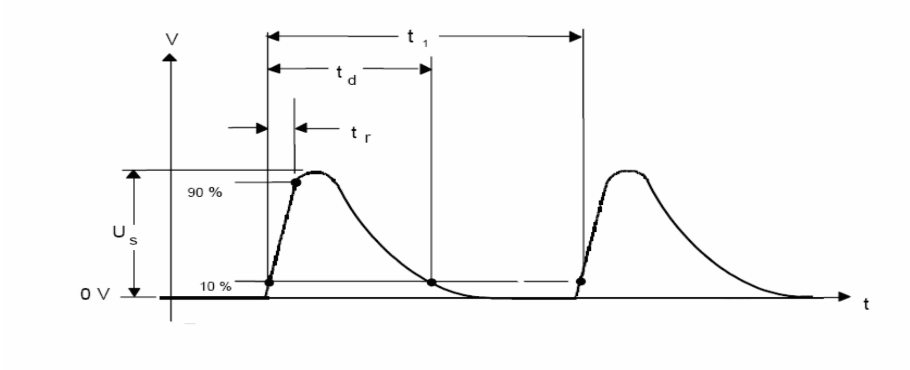


Figure 29. Slow transient test pulse (positive polarity) :Waveform and parameters for DCC method

Lines under test	Test pulse	Capacitor value
Signal lines only (other than the power supply lines)	Slow transient test pulses (negative and positive polarity)	100 nF 200 V minimum
Can bus lines only		470 pF 200 V minimum

Table 42. Capacitor values recommended for SLOW transient test pulses A and B: DCC method

- <u>Inductive coupling clamp method (ICC)</u>

- When this method is used the lines to be tested are only the lines other than supply lines (power supply lines routed outside of the injection probe) and as per the test setup shown in Figure 45.
- The Slow transient test pulses shall be applied in negative and positive polarity.
- Test pulse parameters. Slow transient negative polarity and positive polarity:

Transient disturbances from conduction and coupling along signal lines. Parameters Slow transient test Pulses (negative polarity)		
Pulse parameters	**12 V systems**	**24 V systems**
Us	- 30 V	- 40 V
t_d	3,5 µs	3,5 µs
t_r	≤ 1,2 µs	≤ 1,2 µs
t_1	1 s	1 s
Ri	2 Ohm	2 Ohm
Test duration	30 minutes	30 minutes

Table 43. Slow transient test pulse (negative polarity) :Parameters for ICC method

Note: The parameters shown in Table 43 are measured as per the specifications of the Figure 39.

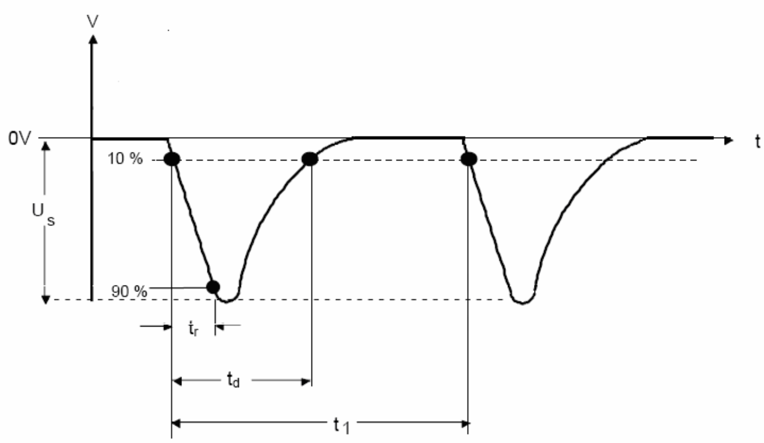


Figure 30. Slow transient test pulse (negative polarity). Waveform and parameters for ICC method

Transient disturbances from conduction and coupling along signal lines. Parameters Slow transient test Pulses (positive polarity)		
Pulse parameters	**12 V systems**	**24 V systems**
Us	30 V	40 V
t_d	50 µs	50 µs
t_r	≤ 1 µs	≤ 1 µs
t_1	1 s	1 s
Ri	2 Ohm	2 Ohm
Test duration	30 minutes	30 minutes

Table 44. Slow transient test pulse (positive polarity): Parameters for ICC method

Note: The parameters shown in Table 44 are measured as per the specifications of the Figure 39.

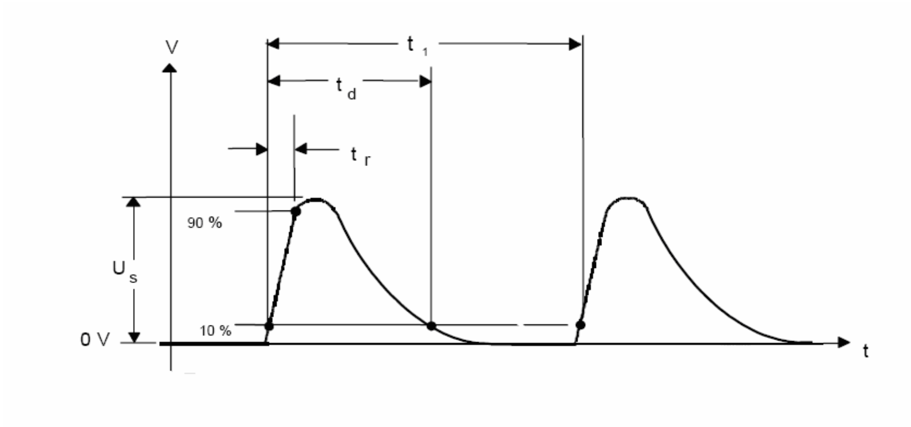


Figure 31. Slow transient test pulse (positive polarity): Waveform and parameters for ICC method

DUT Operating modes:

Passive modules, electronic modules, active modules and EM shall be tested in RUN MODE. The speed configuration for EM during the test shall be noted in the test report.

Test fixture/load box requirements:

The load box shall provide the correct load conditions to the DUT during all the operating modes tested. In order to assure a correct performance of the load box during the test (free of the transient disturbances), an independent power supply or battery can be used to supply the load box if specified in the test plan.

Test procedure:

Calibration:

1. Calibration procedure for a CCC method:

The parameters shown in the Table 35 and Table 36 are measured or calibrated previously with an oscilloscope connected to the coupling clamp which is terminated in 50 Ω attenuator and an input impedance of 50 Ω as shown in the Figure 32.

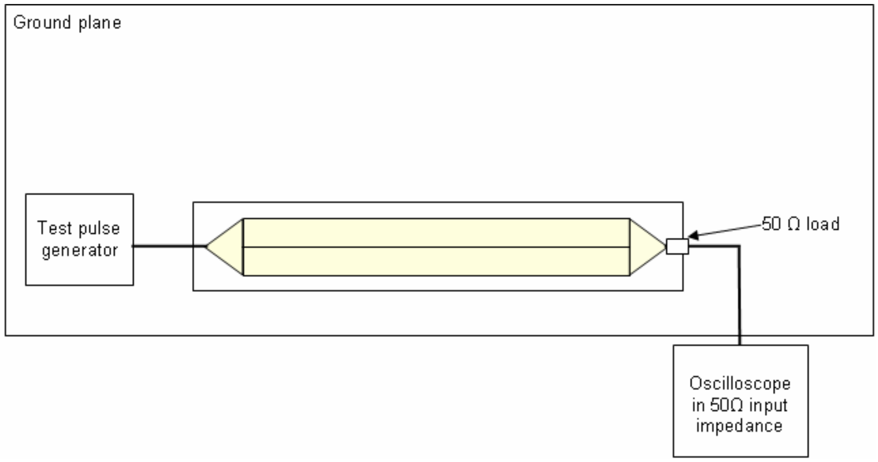


Figure 32. Calibration setup CCC method

2. Calibration procedure for a DCC method.

The pulse parameters shown in the Table 37, Table 38, Table 40 and Table 41; are measured in open circuit as shown in the Figure 33 and Figure 36 (generator output connected in series through the coupling capacitor) and in appropriated impedance matching conditions (depending of the transient pulse applied) as shown in the Figure 34, Figure 35, Figure 37 and Figure 38.

- **CAN lines:**

The calibration shall be performed in open circuit (for a Fast and Slow transient pulses as shown the Figure 33). In order to perform a verification of the test pulse generator, a calibration in matching conditions shall be performed for a Fast and Slow transient pulses as shown the Figure 34 and Figure 35.

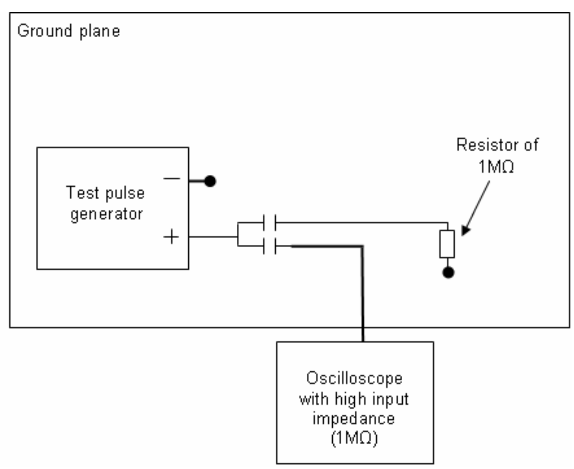


Figure 33. Calibration setup DCC method in open circuit: CAN lines Fast and Slow transient pulses

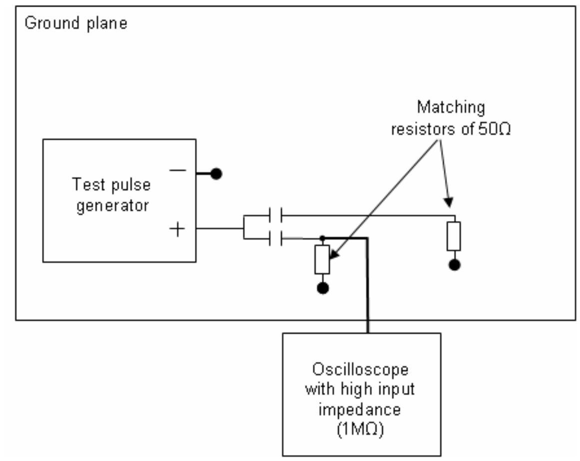


Figure 34. Calibration setup DCC method in matching conditions: CAN lines Fast transient pulses

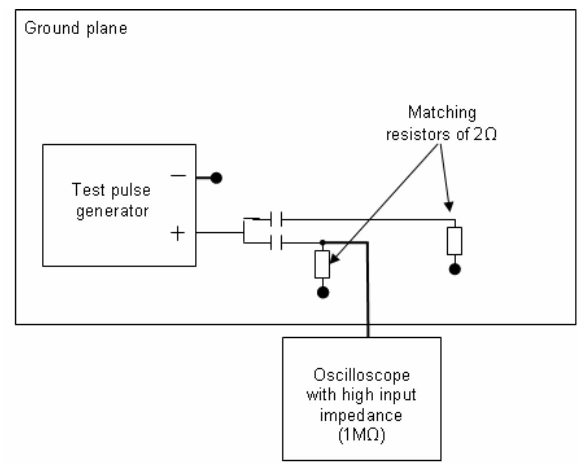


Figure 35. Calibration setup DCC method in matching conditions: CAN lines Slow transient pulses

- Signal lines: The calibration shall be performed in open circuit (for a Fast and Slow transient pulses as shown the Figure 36). In order to perform a verification of the test pulse generator, a calibration in matching conditions shall be performed for a Fast and Slow transient pulses as shown in Figure 37 and Figure 38.

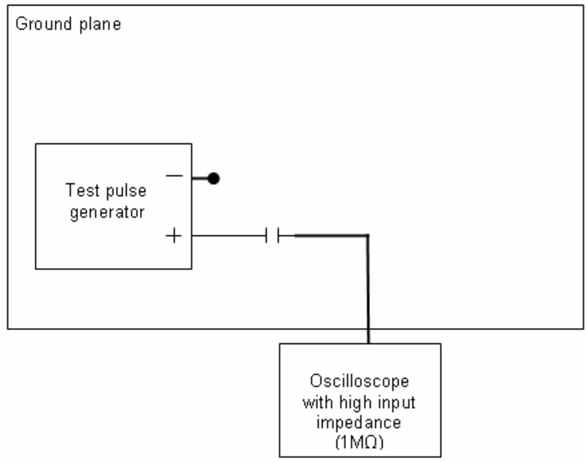


Figure 36. Calibration setup DCC method in open circuit: Signal lines Fast and Slow transient pulses

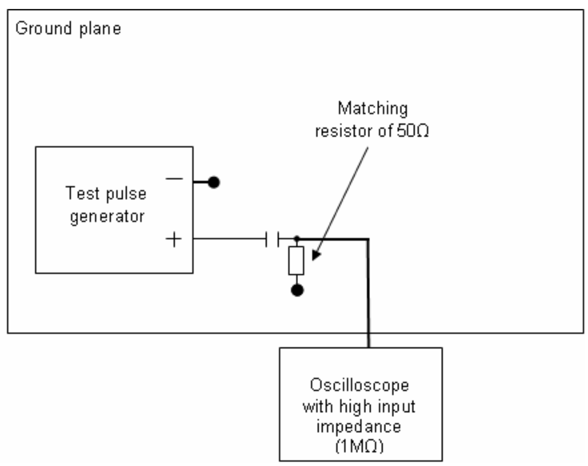


Figure 37. Calibration setup DCC method in matching conditions: Signal lines Fast transient pulses

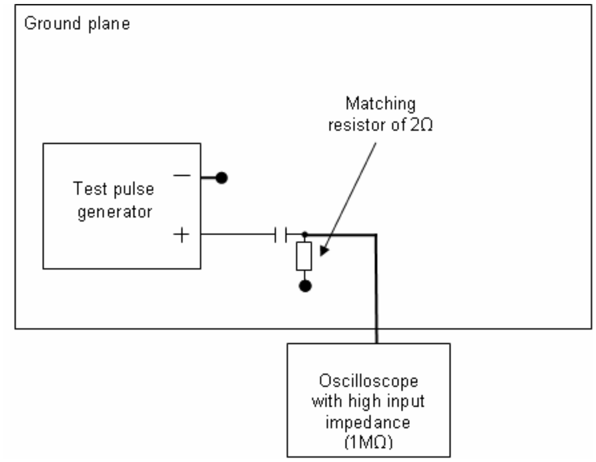


Figure 38. Calibration setup DCC method in matching conditions: Signal lines Slow transient pulses

Calibration procedure for a ICC method.

- The parameters shown in the Table 43 and Table 44 are measured as per the specifications in Figure 39.

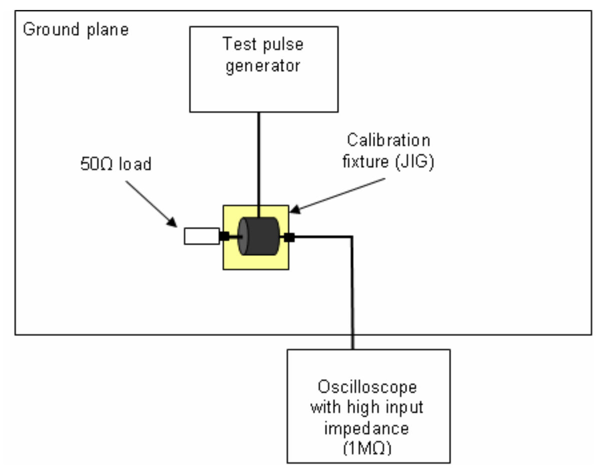


Figure 39. Calibration setup ICC method

Test setup:

Dimensions in millimeters – not to scale

A. Test setup CCC method (Coupling clamp)

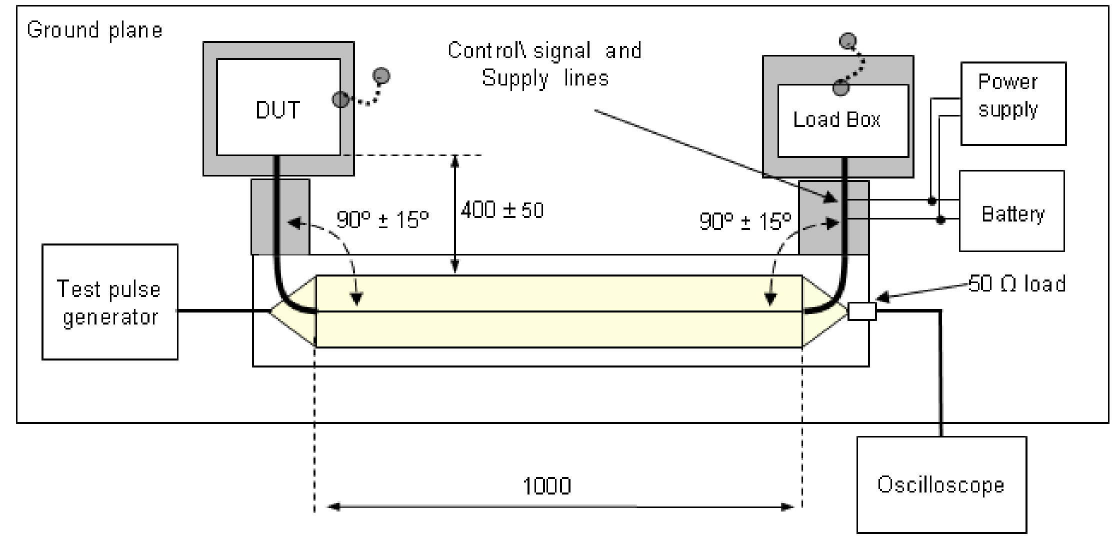


Figure 40. Test setup CCC: Supply lines inside Coupling clamp

Dimensions in millimeters – not to scale

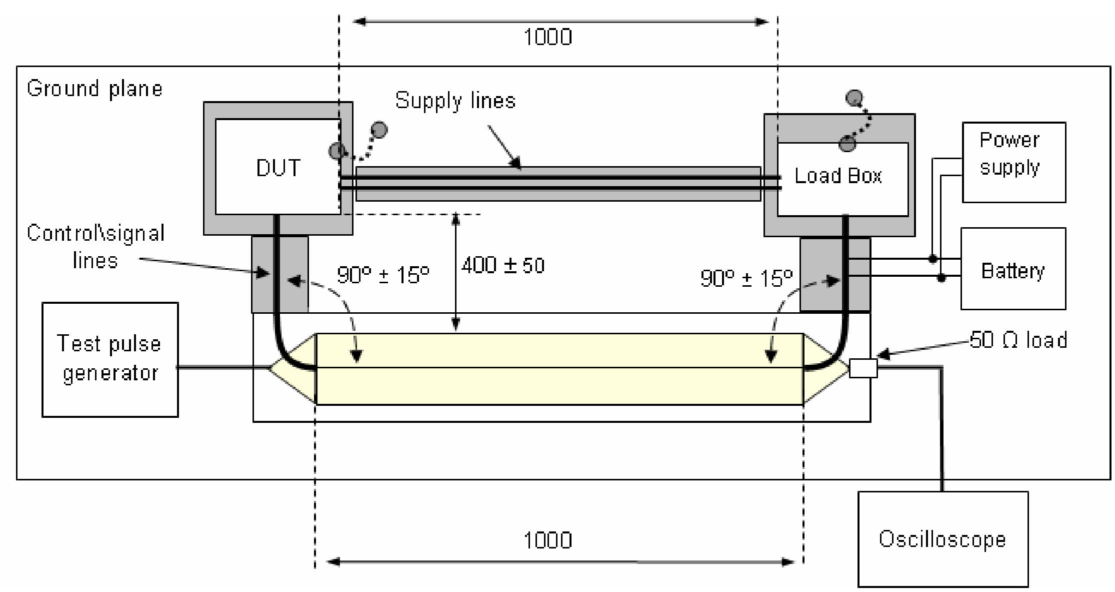


Figure 41. Test setup CCC: Supply lines outside Coupling clamp

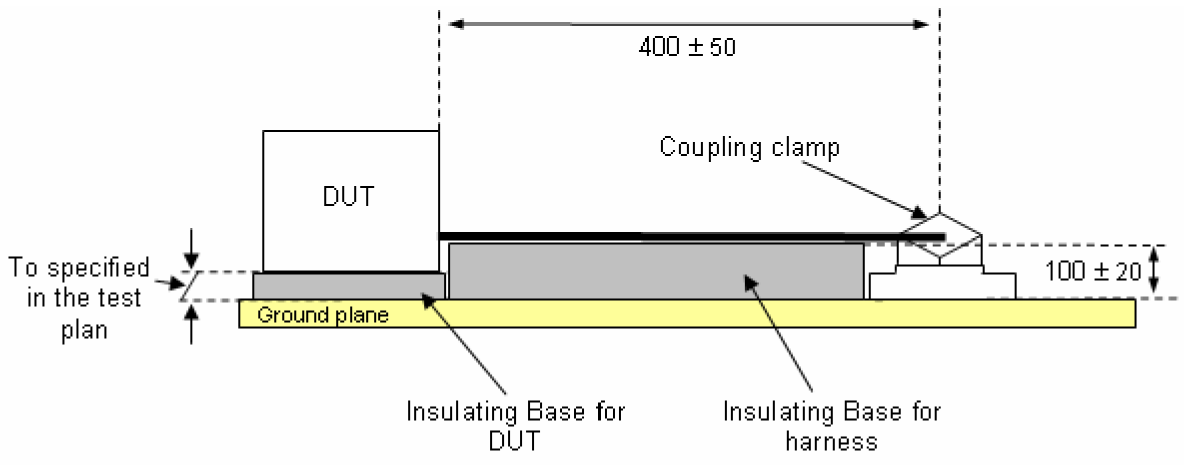


Figure 42. Test setup CCC (Lateral view)

C. Test setup DCC method (Direct Capacitor Coupling)

Dimensions in millimeters – not to scale

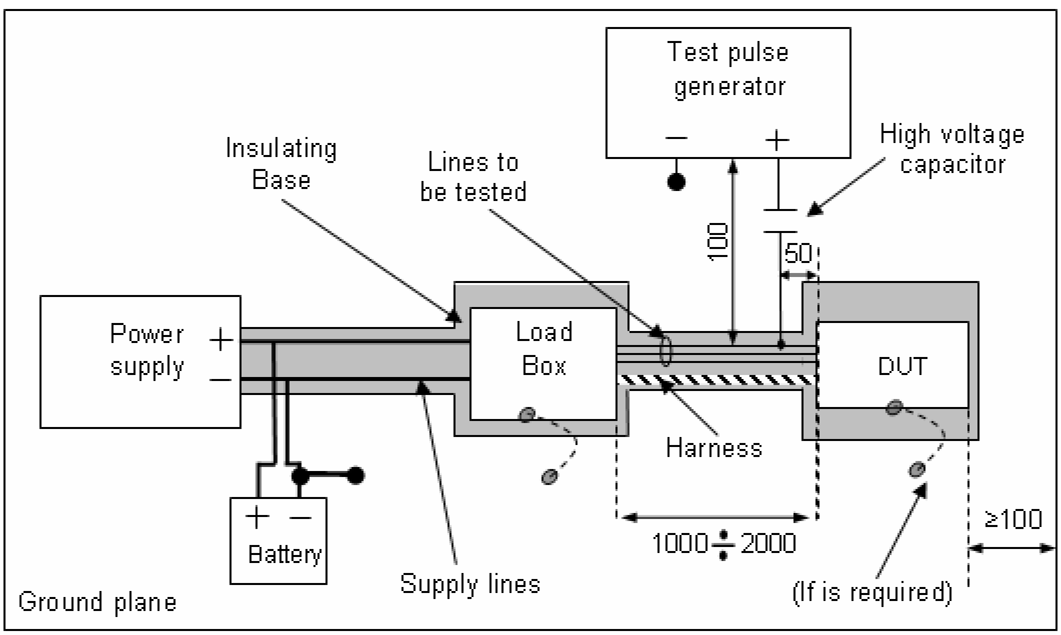


Figure 43. Test setup DCC for signal lines

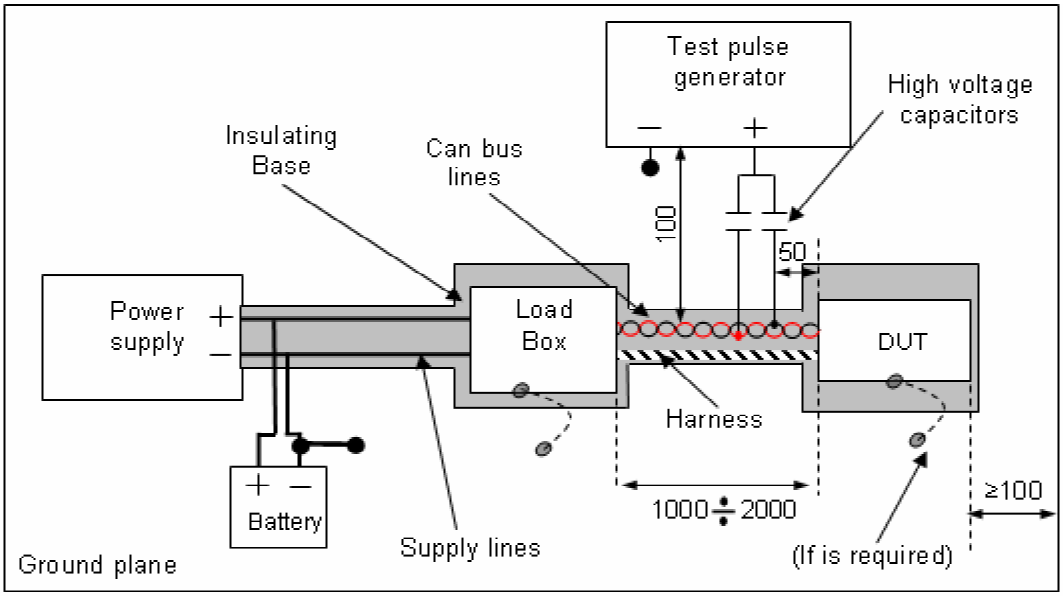


Figure 44. Test setup DCC for CAN bus

D. Test setup ICC method (Inductive Coupling clamp)

Dimensions in millimeters – not to scale

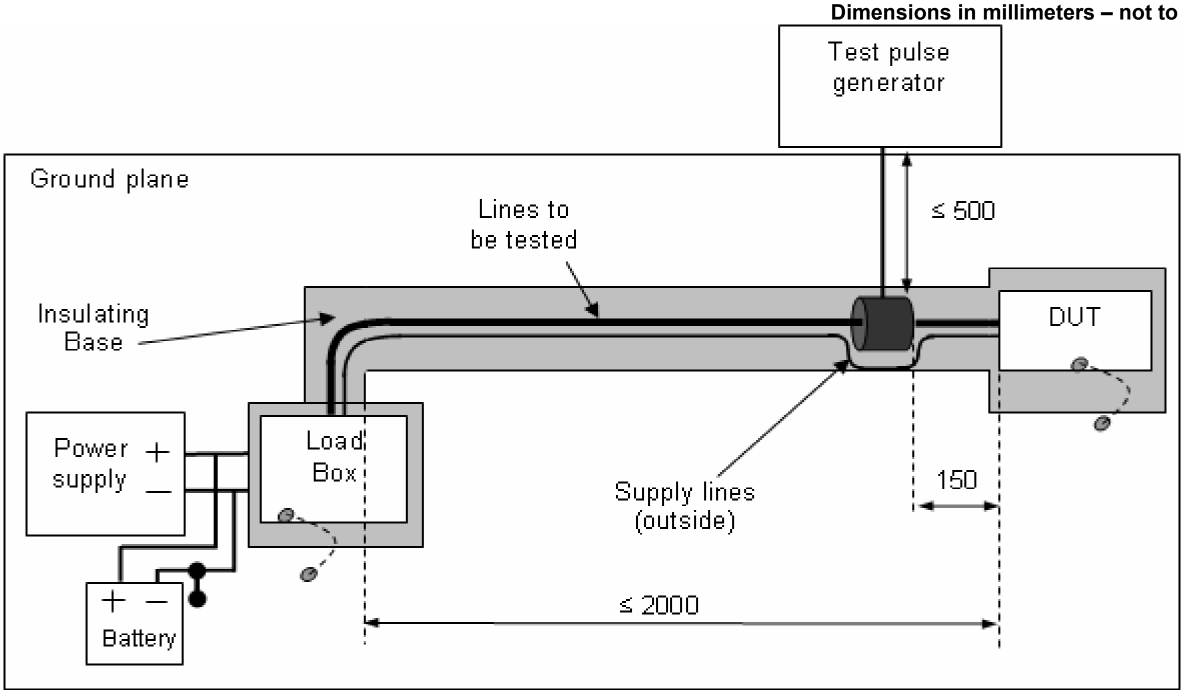


Figure 45. Test setup ICC

Test:

- Prior any measurement, the test method to be applied (CCC, DCC or ICC method) shall be defined in the test plan. Only one method shall be selected for a Fast transient pulses (CCC or DCC method) and only one method shall be selected for a Slow transient pulses (DCC or ICC method).
- Set the DUT to be tested and as per the test setup shown in the Figures 40 to Figure 45 depending of the test method to be performed.
- Depending of the test method to be perform, connect the voltage probe and the oscilloscope in an appropriated measurement point in order to monitoring the disturbance applied during the test. Also, monitoring all the parameters or associated loads in the load box.
- Configure the test pulse generator in order to apply the transient disturbance calibrated previously
- Evaluate the DUT performance and the associated loads during and after the test and note all the deviations.
- Perform a full functional test upon completion of test.

Acceptance criteria:

Test method	Region of performance (See paragraph 2.4)
CCC method	Region I, Memory function region I
DCC method	
ICC method	

Table 45. Acceptance criteria: Transient disturbances from conduction and coupling along signal lines.

Test report requirements:

- Test method used for a Fast transient pulses (CCC or DCC method) and for a Slow transient pulses (DCC or ICC method).
- Screen shot or screen captures of the oscilloscope for the calibration procedure in open circuit and matching conditions (with the specific parameters).
- Photos of the test setup.
- Grounding locations (DUT, Load box and LISN)
- DUT operation mode during the test.
- Description of the signal lines, Can lines or power supply lines tested.
- Load box conditions during the test and description of the associated loads to evaluated the DUT performance
- Data table with the parameters of the pulse applied.
- Screen shot or screen captures of the oscilloscope for the transients applied (with the specific parameters) and Screen shot of the associated loads performance.
- A description of the failure (if apply) and the region of performance (according to the paragraph 2.4 of this document).

3.2.9 IMMUNITY TO SUPPLY VOLTAGE RIPPLE

Reference documents: SAE J1113-2

Purpose of the test:

- The purpose of the test is to ensure immunity to supply voltage variations generated by the alternator.

Test conditions:

General test conditions as per SAE J1113-2 specification. Test equipment shall be according to the SAE J1113-2 standard requirements.

- Step size:

Frequency range (Hz)	Step size (linear)
15 ~150	10 Hz
150 ~1500	50 Hz
1500 ~ 30000	≤ 500 Hz

Table 46. Step size

Note: It shall be accepted to perform the sweep increase in a continuous way instead of using frequency steps. In this case it shall be specified in the test report.

- Voltage ripple shall be superimposed on normal test voltage.

- Power supply or test voltage: 13.5 ± 0.2 Volt for 12 V systems and 27 ± 1 V for 24 V systems

- The test shall be performed following the test parameters shown in the Table 47 and Table 48 (or Table 47and Table 49 for a 24 V power supply systems)

Power supply system	Frequency sweep	Dwell time (minimum)	Continuous sweep time (minimum) *Note1
12V and 24V	15 Hz ⇒ 1500 Hz	3 s per frequency	8 minutes
	1500 Hz ⇒ 30 kHz		4 minutes
	30 kHz ⇒ 1500 Hz		4 minutes
	1500 Hz ⇒ 15 Hz		8 minutes

Table 47. Test parameters

Note1: This is the minimum sweep time required in order to perform all the frequency sweep taking into account a dwell time of 3 seconds per frequency step.

- **Severity level**

12 V system	
Frequency range (Hz)	Voltage level (Vpp)
15 ~1500	4.24 (1.5 V rms)
1500 ~ 30000	linearly decreasing from 4.24 Vpp (1.5 V AC rms) to 0.212 Vpp (75 mV AC rms)

Table 48. Severity level 12 V power supply systems.

24 V system	
Frequency range (Hz)	Voltage level (Vpp)
15 ~ 1500	8.48 (3 V rms)
1500 ~ 30000	linearly decreasing from 8.48 Vpp (3 V AC rms) to 0.424 Vpp (150 mV AC rms)

Table 49. Severity level 24 V power supply systems.

- **Test method**: Close feedback loop method on Voltage level

- Modulation: CW sinusoidal for the whole frequency range.

- Lines to be tested: All the power supply lines of the DUT simultaneously.

DUT Operating modes:

- Electronic modules and active modules shall be tested at least in two modes: DUT normal operation (DUT in RUN MODE) and Standby or Sleep mode (DUT in KEY ON MODE)
- EM shall be tested in RUN MODE in all the different speed configurations, otherwise specified in the test plan. The EM shall be tested also in KEY ON MODE.

Test fixture/load box requirements:

- The load box shall provide the correct load conditions to the DUT during all the operating modes tested.
- All the parameters related to the DUT performance shall be monitored during the test. The monitoring system of the Load box and the DUT parameters shall be described previously in the test plan and noted in the test report.

Test procedure:

Calibration:

A special calibration is not required to perform this test. All the instrumentation used to perform the test shall be within its calibration period.

Test setup:

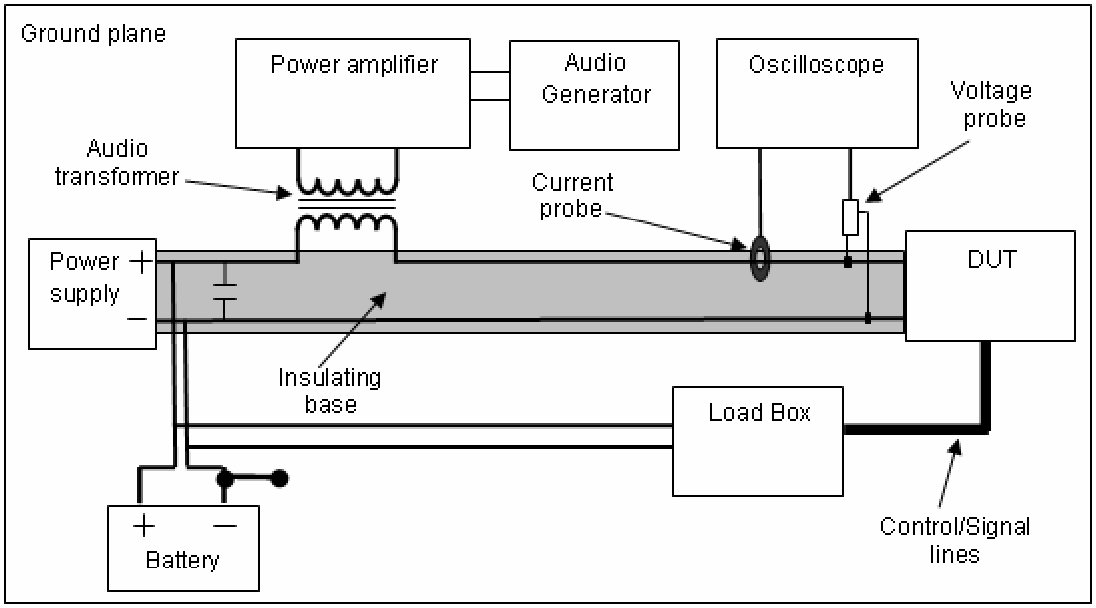


Figure 46. Test setup for Immunity to supply voltage ripple test.

Test:

- Set the DUT as per the test setup shown in the Figure 46
- Increase the signal generator level progressively up to the required level measured in the DUT terminals by the voltage probe following the conditions shown in the Table 47 (Table 49 for 24V power supply system).
- Measure the DUT current consumption and ensure that not exceed of $1A_{RMS}$.
- If the DUT causes distortion in the signal applied then replace the DUT by a 4 Ω non inductive resistor and calibrate the test level. Do not change the signal generator value and replace the resistor by the DUT.
- Check the DUT performance and all the associated loads. If a DUT failure is detected during the test procedure shown above, then the DUT susceptibility threshold shall be determinate.
- Decrease the signal generator level progressively until the failure disappears. Increase the signal generator slowly until the failure appears, then record the Voltage level of failure (V_{FAULT}), and the current applied (I_{FAULT}). These values shall be note in the test report.

Reduce the signal generator level before change to the next frequency in order to avoid DUT failures in the frequency transitions. Change to the next frequency and repeat all the steps shown above for entire frequency range.

Acceptance criteria:

- There should not be any malfunction during the test.
- Region of Performance I, for all Functional Groups.
- Any other particular acceptance criteria can be agreed between TML and the supplier.

Test report requirements:

- Screen shot or screen captures of the oscilloscope for the calibration procedure in open circuit and matching conditions (with the specific parameters).
- Photos of the test setup.
- Grounding locations (DUT, Load box and LISN)
- DUT operation mode during the test.
- Description of the power supply lines tested (ignition lines and others power supply lines)
- Load box conditions during the test and description of the associated loads to evaluate the DUT performance.
- Data table with the parameters of the pulse applied.
- Screen shot or screen captures of the oscilloscope for the transients applied to the power supply lines (with the specific parameters) and Screen shot of the associated loads performance.
- A description of the failure (if any) and the region of performance (according to the paragraph 2.4 of this document).

3.2.10. POWER SUPPLY VOLTAGE RANGE

Reference documents: ISO 16750-2.

Purpose of the test:

The purpose of the test is to verify the correct performance of the DUT at the minimum and maximum power supply voltage range defined in the vehicle power supply network.

Test conditions:

- The DUT shall be grounded as in the vehicle.
- Lines to be tested: Test voltage shall be applied to all the DUT supply voltage lines simultaneously
- Dwell time: The test duration shall be sufficient to verify the specified DUT functions at each voltage level.
- The following voltage levels shall be tested depending on the Functional Group shown in the Table 50 and Table 51. The test shall be performed at three different temperatures: T_{min}, T_{nom}, T_{max} (e.g. – 40°C, 23°C and 85 °C).

12 V system		
Functional group	Minimum voltage	Maximum voltage
Functional Group A	9	16
Functional Group B	8	16
Functional Group C (if operation required during engine cranking)	6	16
Functional Group C (if operation not required during engine cranking)	8	16
Functional Group D	6	18

Table 50. Voltage range depending of the functional groups: 12 V power supply systems

24 V system		
Functional group	Minimum voltage	Maximum voltage
Functional Group A	22	32
Functional Group B	16	32
Functional Group C (if operation required during engine cranking)	10	36
Functional Group C (if operation not required during engine cranking)	8	16
Functional Group D	10	36

Table 51. Voltage range depending of the functional groups: 24 V power supply systems

DUT Operating modes:

- Electronic modules, active modules and EM shall be tested in RUN MODE. The speed configuration for EM during the test shall be noted in the test report.
- BM motors shall be tested in Run mode. The speed configuration for EM during the test shall be noted in the test report.

Test fixture/load box requirements:

The load box shall provide the correct load conditions to the DUT during all the operating modes tested.

Test procedure:

Calibration:

A special calibration is not required to perform this test. All the instrumentation used to perform the test shall be within its calibration period.

Test setup:

Dimensions in millimeters – not to scale

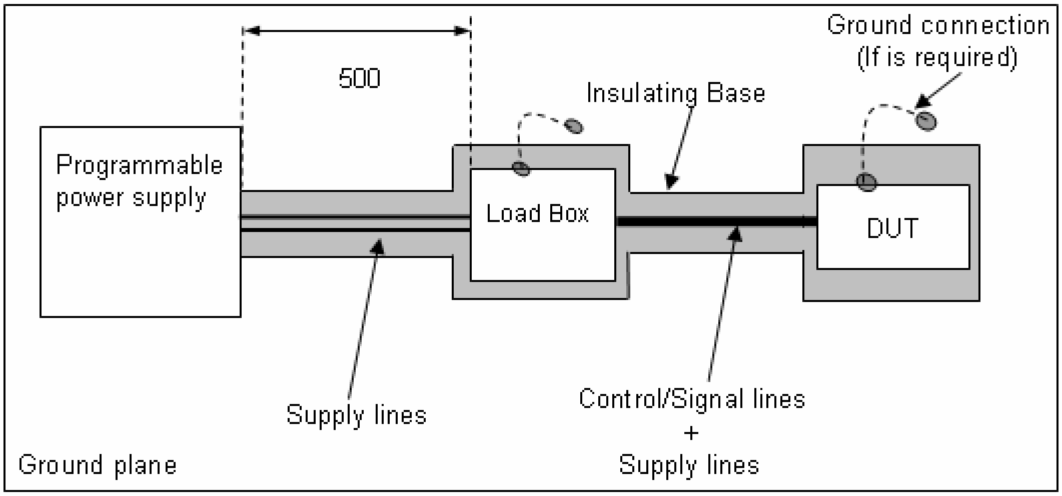


Figure 47. Test setup for a Power supply voltage range tests

Test:

- Set the DUT following the test setup shown in the Figure 47.
- Set the programmable power supply in order to apply the minimum voltage range (depending of the DUT functional group) defined in Table 50 or Table 51.
- Monitor all the DUT parameters and the associated loads during the test.
- If any failure appears during the test, the minimum power supply voltage shall be increased in order to obtain the voltage value needed to recover the correct performance of the DUT.
- Set the programmable power supply in order to apply the maximum voltage range (depending of the DUT functional group) defined in Table 50 or Table 51.
- Monitoring all the DUT parameters and the associated loads during the test.
- If any failure appears during the test, the maximum power supply voltage shall be decreased in order to obtain the voltage value needed to recover the correct performance of the DUT.

Acceptance criteria:

Power supply system	Region of performance (See paragraph 2.4)
12V	Region I, Memory function region I for all the functional groups
24V	

Table 52. Acceptance criteria

Test report requirements:

- Screen shot or screen captures of the oscilloscope for the calibration procedure in open circuit and matching conditions (with the specific parameters).
- Photos of the test setup
- Grounding locations (DUT, Load box and LISN).
- DUT operation mode during the test.

- Description of the power supply lines tested (ignition lines and others power supply lines)
- Load box conditions during the test and description of the associated loads to evaluate the DUT performance.
- Data table with the parameters of the pulse applied.
- Screen shot or screen captures of the oscilloscope for voltages applied to the power supply lines (with the specific parameters) and Screen shot of the associated loads performance.
- A description of the failure (if any) and the region of performance (according to the paragraph 2.4 of this document).

3.2.11. IMMUNITY TO MOMENTARY INTERRUPTION OF POWER

Reference documents: ISO 16750-2.

Purpose of the test:

- This test simulates the effect when conventional fuse element melts in another circuit.

Test conditions:

- Power supply: 12 Volts for 12 V systems and 24 V for 24 V systems
- The DUT shall be subjected to the following supply voltage conditions:

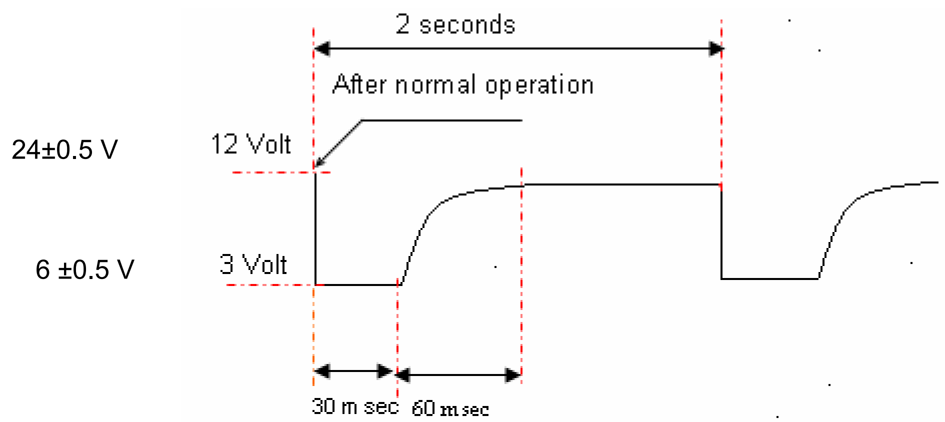


Figure 48. Momentary Interruption of power for 12 V systems.

- Period: 2 seconds
- Number of cycles: 100
- Lines to be tested: Test voltage shall be applied to all the DUT supply voltage lines

DUT Operating modes:

Electronic modules, active modules and EM shall be tested in RUN MODE. The speed configuration for EM during the test shall be noted in the test report.

Test fixture/load box requirements:

- The load box shall provide the correct load conditions to the DUT during all the operating modes tested

Test procedure:

Calibration:

- A special calibration is not required to perform this test. All the instrumentation used to perform the test shall be within its calibration period.

Test setup:

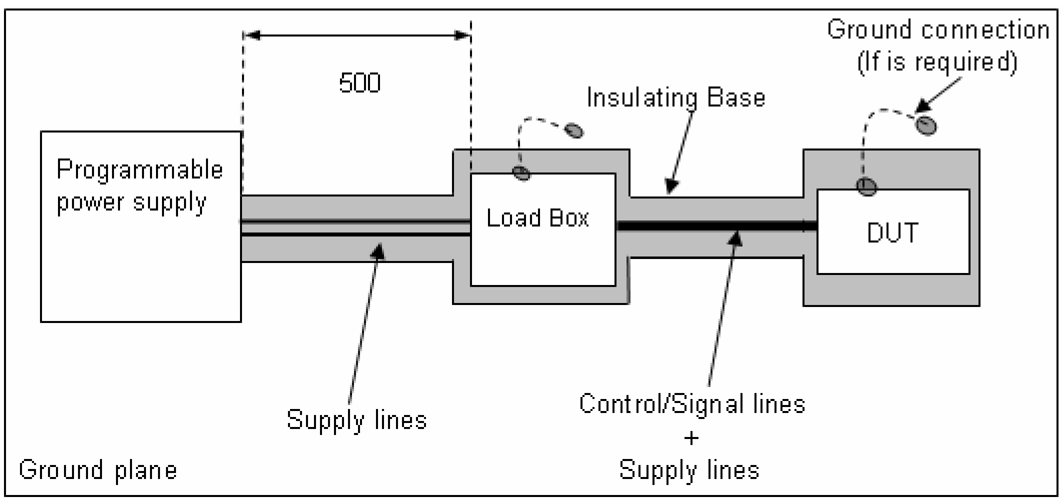


Figure 49. Test setup for a Momentary interruption of power test

Test:

- Set the DUT following the test setup shown in Figure 49.
- Set the programmable power supply in order to obtain the signal and parameters defined in the Figure 48.
- Apply 100 cycles of the disturbance signal to the DUT power supply lines.
- Monitoring all the DUT parameters and the associated loads during the test.

Acceptance criteria:

Power supply system	Region of performance (See paragraph 2.4)
12 V	Region II, Memory function region I There should not be malfunction during the test
24 V	

Table 53. Acceptance criteria

Test report requirements:

- Photos of the test setup.
- Grounding locations (DUT, Load box and LISN).
- DUT operation mode during the test.
- Data table with the following parameters measured during the test: Power supply voltage applied during the test and DUT performance (according to the paragraph 2.4 of this document).
- A description of the failure (if any) specifying the DUT performance during the test and the performance of the associated loads and the region of performance (according to the paragraph 2.4 of this document).

3.2.12 RESET BEHAVIOR AT VOLTAGE DROP

Reference documents: ISO 16750- 2:2006

Purpose of the test:

- This test verifies the reset behavior of the DUT at different voltage drops. This test is applicable to equipment with reset function (e.g. equipment containing microcontrollers).

Test conditions:

- As per ISO 16750- 2 clause 4.5.2.
- Decrease the supply voltage by 5% from V_{min} to 0.95 V_{min}. Hold this for 5seconds. Raise the voltage to V_{min}. Hold for 10seconds and perform a functional test. Then decrease the voltage to 0.9 V_{min}. Continue with steps of 5% of V_{min}, until the lower value is reached 0V. Then rise to V_{min} again. The waveform to be applied is shown in Figure 50.

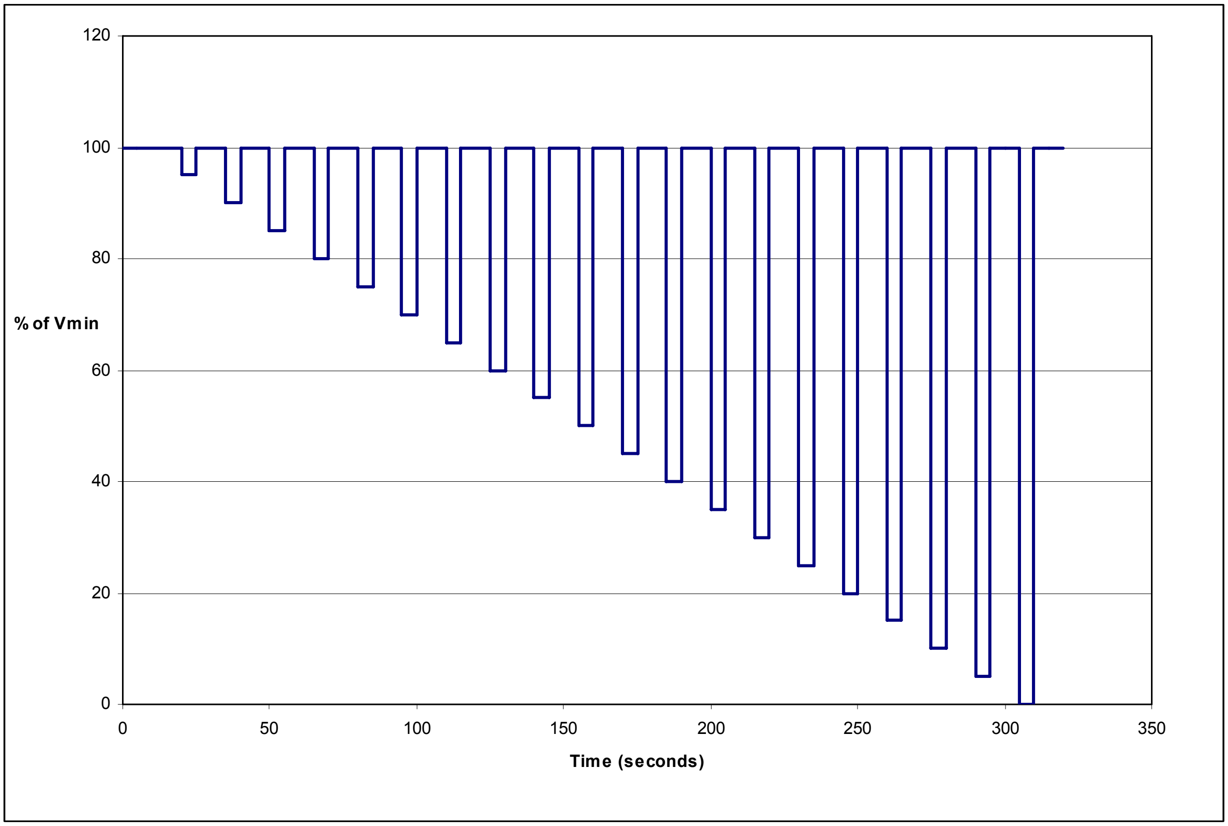


Figure 50. Reset behavior at voltage drop

DUT Operating modes:

Electronic modules, active modules and EM shall be tested in RUN MODE. The speed configuration for EM during the test shall be noted in the test report.

Test fixture/load box requirements:

The load box shall provide the correct load conditions to the DUT during all the operating modes tested.

Test procedure:

Calibration:

A special calibration is not required to perform this test. All the instrumentation used to perform the test shall be within its calibration period.

Test setup:

Dimensions in millimeters – not to scale

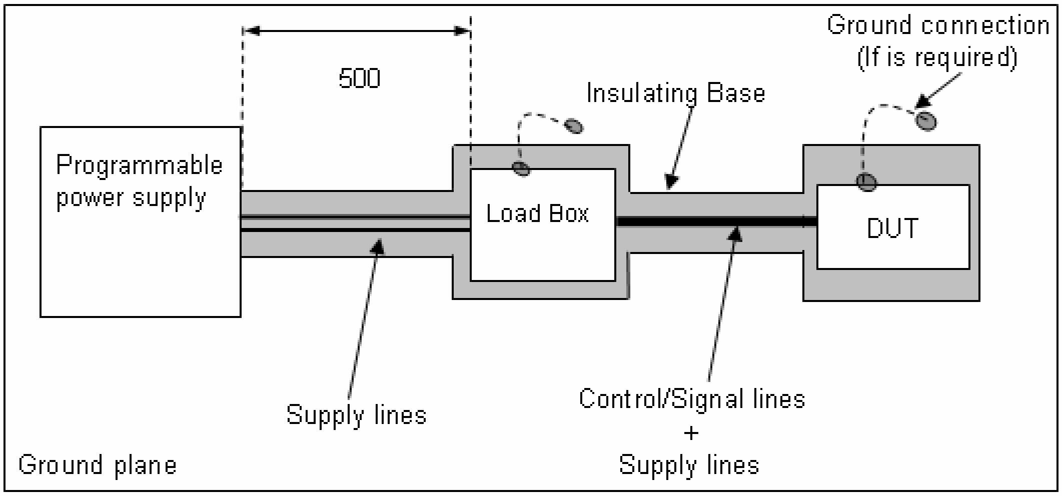


Figure 51. Test setup for a Reset behavior at voltage drop test.

Test:

- Set the DUT as per the test setup shown in the Figure 51.
- Set the programmable power supply in order to obtain the signal and parameters required.
- Apply the signal to the DUT power supply lines.
- Monitoring all the DUT parameters and the associated loads during the test.

Acceptance criteria:

Power supply system	Region of performance (See paragraph 2.4)
12 V	Region II, Memory function region I There should not be malfunction during the test
24 V	

Table 54. Acceptance criteria: Reset behavior at voltage drop test

Test report requirements:

- Photos of the test setup
- Grounding locations (DUT, Load box and LISN).
- DUT operation mode during the test.
- Data table with the following parameters measured during the test: Power supply voltage applied during the test and DUT performance (according to the paragraph 2.4 of this document).
- A description of the failure (if apply) specifying the DUT performance during the test and the performance of the associated loads and the region of performance (according to the paragraph 2.4 of this document).

3.213. IMMUNITY TO SOURCE VOLTAGE FLUCTUATION

Reference documents: ISO 16750-2.

Purpose of the test:

- This test verifies the behavior of the DUT for voltage fluctuations.

Test conditions:

- The sample shall be subjected to the following conditions to see the effect of source voltage fluctuation for 12 V supply system. The disturbance signal is shown in Figure 52.

- Set the programmable power supply following the next parameters:

  - From 5.5 ± 0.2 V to 13 ± 0.2 Volts for 0.2 seconds.
  - Maintain 13 ± 0.2 Volts for 1 second.
  - From 13 ± 0.2 V to 5.5 ± 0.2 Volts for 10 ± 2 millisecond
  - At 5.5 ± 0.2 Volts for 0.79 seconds (1 cycle)

- No. of Cycles: 5

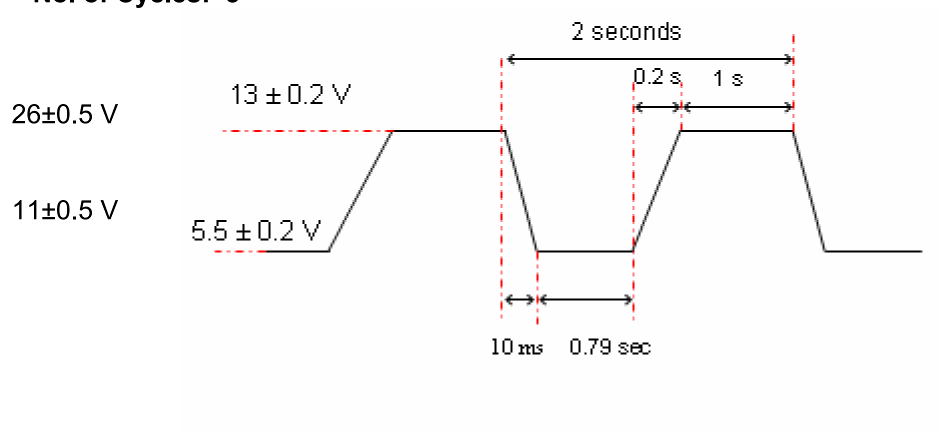


Figure 52. Source voltage fluctuation

DUT Operating modes:

- Electronic modules and active modules shall be tested at least in two modes: DUT normal operation (DUT in RUN MODE) and Standby or Sleep mode (DUT in KEY ON MODE).
- EM shall be tested in RUN MODE in all the different speed configurations, otherwise specified in the test plan. The EM shall be tested also in KEY ON MODE.

Test fixture/load box requirements:

The load box shall provide the correct load conditions to the DUT during all the operating modes tested.

Test procedure:

Calibration:

A special calibration is not required to perform this test. All the instrumentation used to perform the test shall be within its calibration period.

Test setup:

Dimensions in millimeters – not to scale

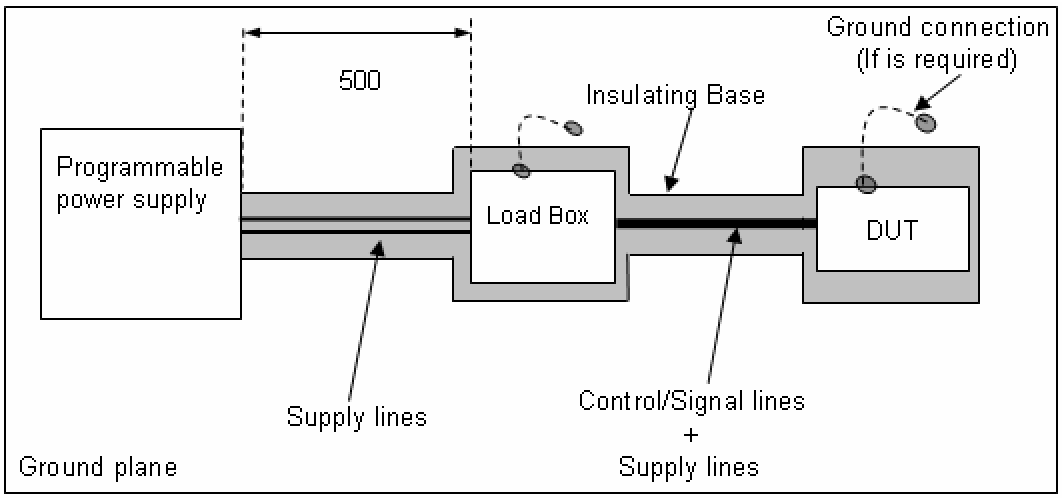


Figure 53. Test setup for a Source voltage fluctuation tests

Test:

- Set the DUT as per the test setup shown in Figure 53.
- Set the programmable power supply in order to obtain the signal and parameters defined in Figure 52.
- Apply the signal to the DUT power supply lines.
- Monitoring all the DUT parameters and the associated loads during the test.

Acceptance criteria:

Power supply system	Region of performance (See paragraph 2.4)
12 V	Region II, Memory function region I There should not be malfunction during the test. DUT CPU can be reset but the memory maintenance function should have no abnormality.
24 V	

Table 55. Acceptance criteria: Source voltage fluctuation test

Test report requirements:

- Photos of the test setup.
- Grounding locations (DUT, Load box and LISN).
- DUT operation mode during the test.
- Data table with the following parameters measured during the test: Power supply voltage applied during the test and DUT performance (according to the paragraph 2.4 of this document).
- A description of the failure (if apply) specifying the DUT performance during the test and the performance of the associated loads and the region of performance (according to the paragraph 2.4 of this document).

3.2.14. IMMUNITY TO OVER VOLTAGE

Reference documents: ISO 16750-2

Purpose of the test:

- The purpose of the test is to verify DUT immunity to higher than normal operations and surges that may occur during over voltage.
- This test simulates two over voltage conditions produced by:

1. Fails of generator regulator
2. Jump start

Test conditions:

- As specified in ISO 16750-2:2003 section 4.2.
- The test conditions shall be applied to all the relevant inputs of the DUT simultaneously.

- Fail of generator regulator:

- The test shall be done at T=(T_{MAX} – 20ºC).
- The voltage shall be applied to all relevant inputs of the DUT following the conditions shown in Table 56.

Power supply systems	Test temperature	Voltage applied	Test time
12V	T= (T_{MAX} – 20 ºC)	20V	1 hour
24V		36V	1 hour

Table 56. Test conditions Over voltage test (generator regulator fails)

- Jump start:

- The test shall be done with a stabilized temperature of the DUT (at room temperature).
- The voltage shall be applied to all relevant inputs of the DUT as per the conditions shown in the Table 57.

Power supply systems	Test temperature	Voltage applied	Test time
12 V	T = 23 ºC)	27 V	60 seconds
24 V		54 V	60 seconds

Table 57. Test conditions: Over voltage test (Jump start)

DUT Operating modes:

- Electronic modules and active modules shall be tested at least in two modes: DUT normal operation (DUT in RUN MODE) and Standby or Sleep mode (DUT in KEY ON MODE)
- EM shall be tested in RUN MODE in all the different speed configurations, otherwise specified in the test plan. The EM shall be tested also in KEY ON MODE.

Test fixture/load box requirements:

The load box shall provide the correct load conditions to the DUT, during all operating modes under test.

Test procedure:

Calibration:

A special calibration is not required to perform this test. All the instrumentation used to perform the test shall be within its calibration period.

Test setup:

Dimensions in millimeters – not to scale

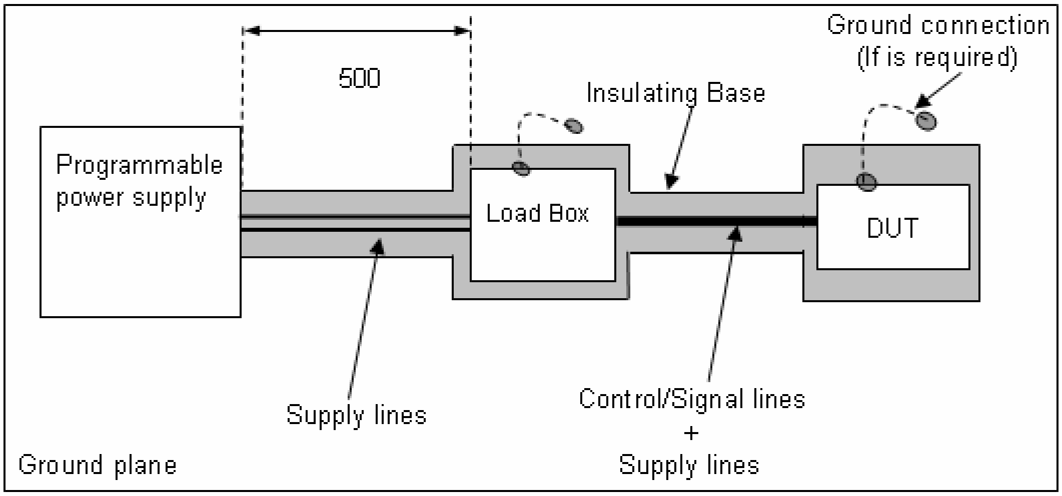


Figure 54. Test setup for a Over voltage test

Test:

- As specified in ISO 16750-2.
- Set the DUT following the test setup shown in the Figure 54

Over voltage test (generator regulator fails)

- Set the DUT in a room temperature at T= (T_{MAX} – 20 ºC).
- Set the programmable power supply in order to obtain the voltage level shown in the Table56 depending of the DUT power supply system (12 V or 24 V).
- Apply the voltage to all the DUT power supply lines during 1 hour.
- Monitoring all the DUT parameters and the associated loads during the test.

Over voltage test (jump start)

- Stabilized the DUT temperature at 23 ºC (in a room temperature).
- Set the programmable power supply in order to obtain the voltage level shown in the Table57 depending of the DUT power supply system (12 V or 24 V).
- Apply the voltage to all the DUT power supply lines during 60 seconds.
- Monitoring all the DUT parameters and the associated loads during the test.

Acceptance criteria:

Power supply system	Region of performance (See paragraph 2.4)
12 V	Region II, Memory function region I There should not be malfunction during the test. DUT CPU can be reset but the memory maintenance function should have no abnormality.
24 V	

Table 58. Acceptance criteria Over voltage test

Test report requirements:

- Photos of the test setup
- DUT operation mode during the test.
- Description of the DUT inputs lines under test.
- Data table with the following parameters measured during the test: Power supply voltage applied during the test, input lines of the DUT tested, test time, test temperature and DUT performance (according to the paragraph 2.4 of this document).
- A description of the failure (if apply) specifying the DUT performance during the test, test temperature, input voltage applied and the performance of the associated loads and the region of performance (according to the paragraph 2.4 of this document).

3.2.15. IMMUNITY TO REVERSE POLARITY

Reference documents: ISO 16750-2

Purpose of the test:

This test checks the resistance of a device against the connection of reversed battery in case of using auxiliary starting device.

Test conditions:

- This test is not applicable to generators or relays with clamping diodes without external reverse polarity protection device.
- The sample shall be subjected to the conditions as per ISO 16750-2 and following the specific test conditions shown in the Table59.

Power supply systems	Reverse voltage applied	Test time
12V	16 V	60 seconds
24V	27 V	60 seconds

Table 59. Test conditions reverse polarity test

- The reverse voltage shall be applied to all the relevant inputs of the DUT simultaneously.

DUT Operating modes:

- All the DUTS shall be configure d in OFF mode before the test (DUT not supplied)

Test fixture/load box requirements:

A load box is not required for this test. Connect the load box to the DUT in order to verify the DUT performance after the test. The load box shall provide the correct load conditions to the DUT

Test procedure:

Calibration:

A special calibration is not required to perform this test. All the instrumentation used to perform the test shall be within its calibration period.

Test setup:

Dimensions in millimeters – not to scale

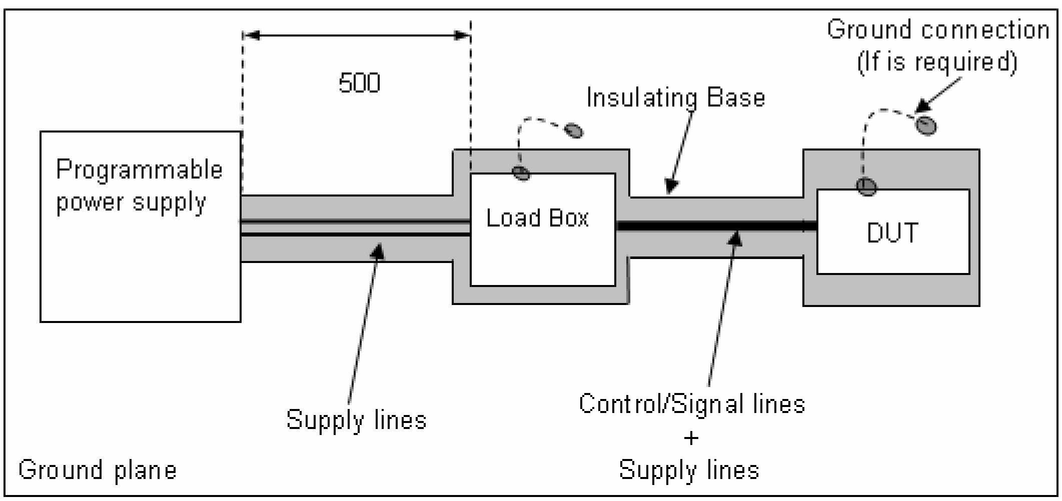


Figure 55. Test setup for a Reverse polarity test

Test:

- As specified in ISO 16750-2:2003 section 4.2.
- Set the DUT following the test setup shown in the Figure 55.
- Set the programmable power supply in order to obtain the voltage defined in the Table 59.
- Apply the reverse voltage to all the relevant inputs of the DUT simultaneously.
- After the test, monitoring the DUT performance, DUT parameters and the associated loads.

Acceptance criteria:

Power supply system	Region of performance (See paragraph 2.4)
12 V	Region **III**, Memory function region **I** There should not be malfunction during the test.
24 V	

Table 60. Acceptance criteria: Reverse polarity test

Test report requirements:

- Photos of the test setup
- Grounding locations (DUT, Load box and LISN).
- Data table with the following parameters measured during the test: Power supply voltage applied during the test and test time
- A description of the DUT performance after the test, the performance of the associated loads and the region of performance (according to the paragraph 2.4 of this document).

3.2.16. IMMUNITY TO SUPPLY VOLTAGE OFFSET

Reference documents: ISO 16750-2

Purpose of the test:

This test is applicable only if compatibility with various electrical potentials at the power-supply input terminals for two (2) or more inputs in the normal run condition are being supplied by different circuits, is to be evaluated. For example, after “ignition on” and for “stand by / quiescent current supply” in an E/E component. The second purpose is to verify interference-free data communications among E/E components (Potential offsetting currents in data lines must be eliminated).

Test conditions:

- Establish a voltage difference equal to ± 1.5 V ground offset (Maximum 1.5 Volts ground to ground offset).
- The Voltage shall be measured at the device under test.
- The test is as long as it takes to confirm normal operation.
- Repeat for each ground path and combinations of ground paths until all combinations are tested.
- A power supply with a floating output is needed in order to supply the DUT.
- An extra power supply is needed in order to generate the required offset ground.
- The test shall be applied at all the DUT inputs simultaneously.

Power supply system	Ground offset
12 V	± 1.5 V
24 V	± 2 V

Table 61. Ground offset level

DUT operating modes:

- Electronic modules and active modules shall be tested at least in two modes: DUT normal operation (DUT in RUN MODE) and Standby or Sleep mode (DUT in KEY ON MODE)
- EM shall be tested in RUN MODE in all the different speed configurations, otherwise specified in the test plan. The EM shall be tested also in KEY ON MODE.

Test fixture/load box requirements:

- The load box shall provide the correct load conditions to the DUT during all the operating modes tested.

Test procedure:

Calibration:

- A special calibration is not required to perform this test. All the instrumentation used to perform the test shall be within its calibration period.

Test setup:

- The DUT power supply shall have a floating output.
- An extra power supply is needed in order to generate the ground offset.

Dimensions in millimeters – not to scale

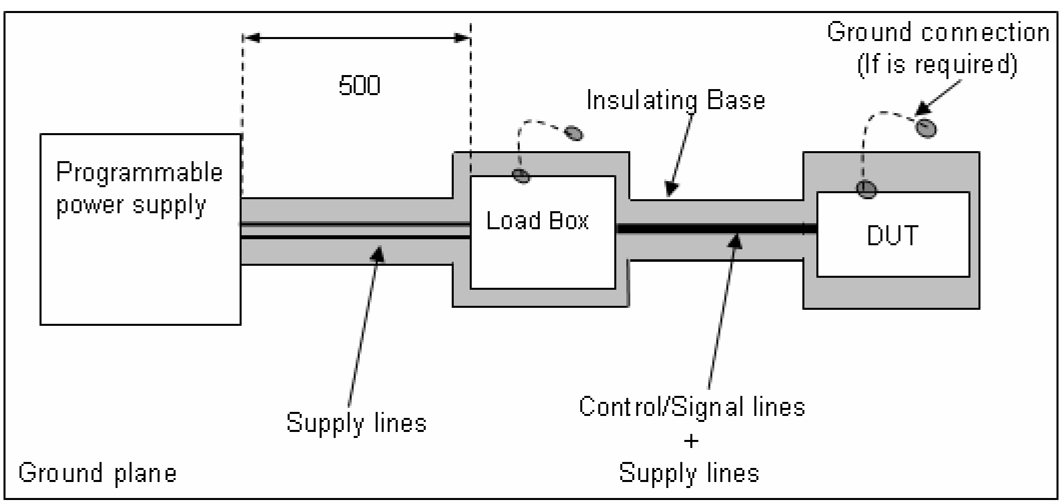


Figure 56. Test setup for a Supply voltage offset test

Test:

- Set the DUT supplied with a floating output power supply as per the test setup shown in Figure 56
- Configure the output voltage of the extra power supply in order to obtain the ground offset as defined in the Table 61.

- Supply the DUT and connect the positive line of the extra power supply to the ground line of the DUT.
- The Voltage shall be measured at the device under test.
- Monitoring all the DUT parameters and the associated loads during the test.
- The test is as long as it takes to confirm normal operation.
- Repeat for each ground path and combinations of ground paths until all combinations are tested.

Acceptance criteria:

Power supply system	Region of performance (See paragraph 2.4)
12 V	Region I for all functional groups. There should be no undesirable response
24 V	

Table 62. Acceptance criteria

Test report requirements:

- Photos of the test setup
- Grounding locations of the DUT and power supply.
- DUT operation mode during the test.
- Data table with the following parameters measured during the test: Power supply voltage applied during the test, ground offset, lines tested and DUT performance (according to the paragraph 2.4 of this document).
- A description of the failure (if apply) specifying the DUT performance during the test and the performance of the associated loads and the region of performance (according to the paragraph 2.4 of this document).

3.2.17. OPEN CIRCUIT TESTS. SINGLE AND MULTIPLE LINES DISCONNECTION

Reference documents: ISO16750-2

Purpose of the test:

- The purpose of this test is to verify the performance of the DUT against an open contact in two conditions:

  - Single line interruption: Open contact of one circuit or line of the DUT/System interface.
  - Multiple line interruption: Open contact of connector or connectors of the DUT.

Test conditions:

- The interruption time (contact open time) shall be 10 seconds.
- The open circuit resistance shall be ≥ 100 MΩ.
- In order to open the DUT single line or DUT connector under test an external switch shall be used to switch this line or connectors at 100 MΩ resistor as per the test setup shown in the Figure 57.

- The test shall be carry out in each DUT line separately for a Single line interruption test.
- The test shall be carry out in each DUT connector separately for a Multiple line interruption test.

DUT Operating modes:

- Electronic modules and active modules shall be tested at least in two modes: DUT normal operation (DUT in RUN MODE) and Standby or Sleep mode (DUT in KEY ON MODE)
- EM shall be tested in RUN MODE in all the different speed configurations, otherwise specified in the test plan. The EM shall be tested also in KEY ON MODE.

Test fixture/load box requirements:

The load box shall provide the correct load conditions to the DUT during all operating modes under test.

Test procedure:

Calibration:

A special calibration is not required to perform this test. All the instrumentation used to perform the test shall be within its calibration period.

Test setup:

Dimensions in millimeters – not to scale

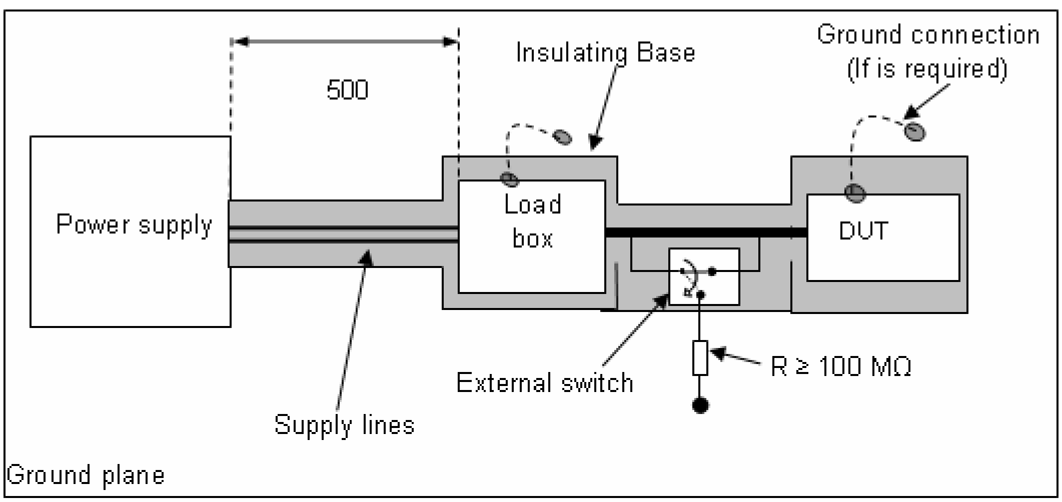


Figure 57. Test setup open circuit test

Test:

- Set the DUT as per the test setup shown in Figure 57.

Single line interruption test:

- Configure the external switch in order to connect the DUT line under test to the load box.
- Supply the DUT during 10 minutes in normal work conditions.
- Change the contact of the external switch to the resistor of 100MΩ during 10 seconds. Monitoring the DUT performance during and after the interruption and note any deviation of performance.
- Repeat the test for all the DUT lines separately.

Multiple line interruption test:

- For the multiple line interruption test the external switch used shall be capable of switching all the DUT connector lines at the same time (simultaneously).
- Configure the external switch in order to connect all the DUT connector lines under test to the load box.
- Supply the DUT during 10 minutes in normal work conditions.
- Change the contacts of the external switch to the resistor of 100 MΩ during 10 seconds. Monitoring the DUT performance during and after the interruption and note any deviation of performance.
- Repeat the test for all the DUT connectors separately.

Acceptance criteria:

Power supply system	Region of performance (See paragraph 2.4)
12 V	- During the interruption time Region III, Memory function region I for all the groups - After the interruption time Region I, Memory function region I for all the groups
24 V	

Table 63. Acceptance criteria

Test report requirements:

- Photos of the test setup.
- Grounding locations of the DUT and power supply.
- DUT operation mode during the test.
- A description of the following parameters monitoring during the test: line tested or connector tested and DUT performance during and after of the interruption time (according to the paragraph 2.4 of this document).
- Screen shot or screen captures of the oscilloscope (with the specific parameters) of the DUT performance and associated loads performance during and after the interruption time.

3.2.18. SLOW INCREASE AND DECREASE OF THE SUPPLY VOLTAGE

Reference documents: ISO 16750-2

Purpose of the test:

The purpose of this test is to verify the performance of the DUT against slow increase and decrease of the power supply due to the gradual discharge and recharge of the battery

Test conditions:

- The sample shall be subjected to the ISO 16750-2:2003 section 4.4 conditions.
- The test shall be applied at all the DUT inputs simultaneously.
- The voltage applied to the DUT is shown in the Figure 58 and Figure 59.

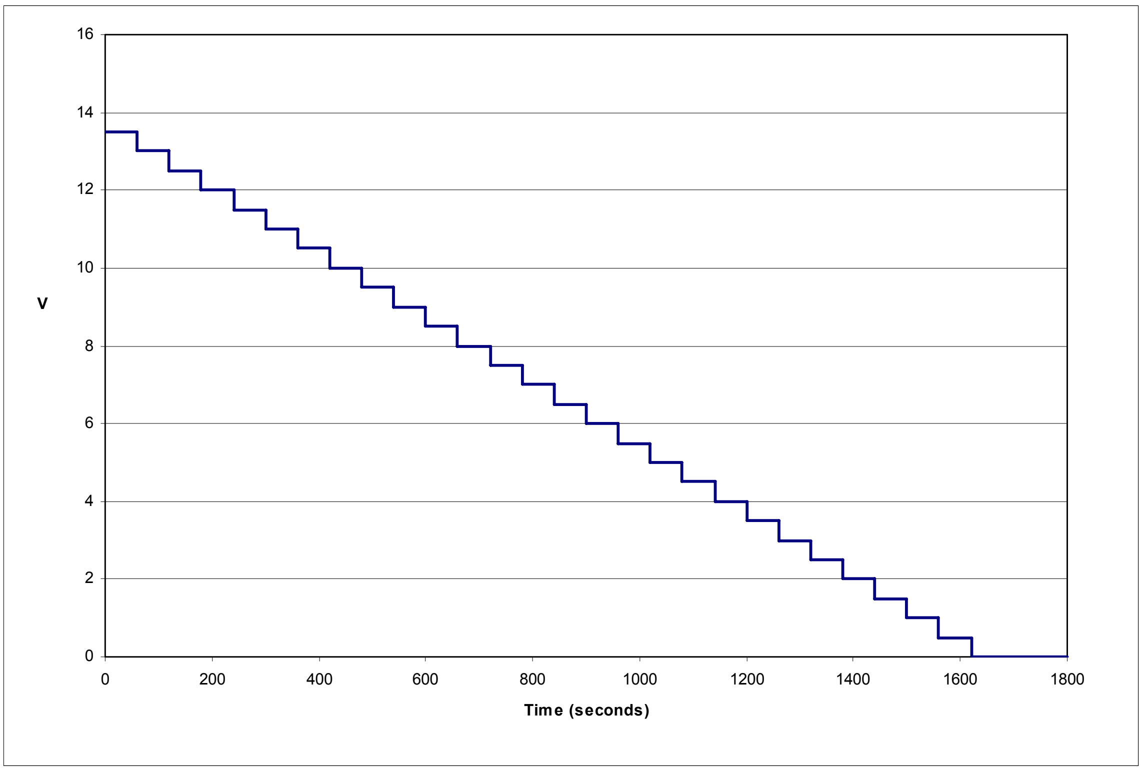


Figure 58. Input voltage: Slow decrease of the power supply test.

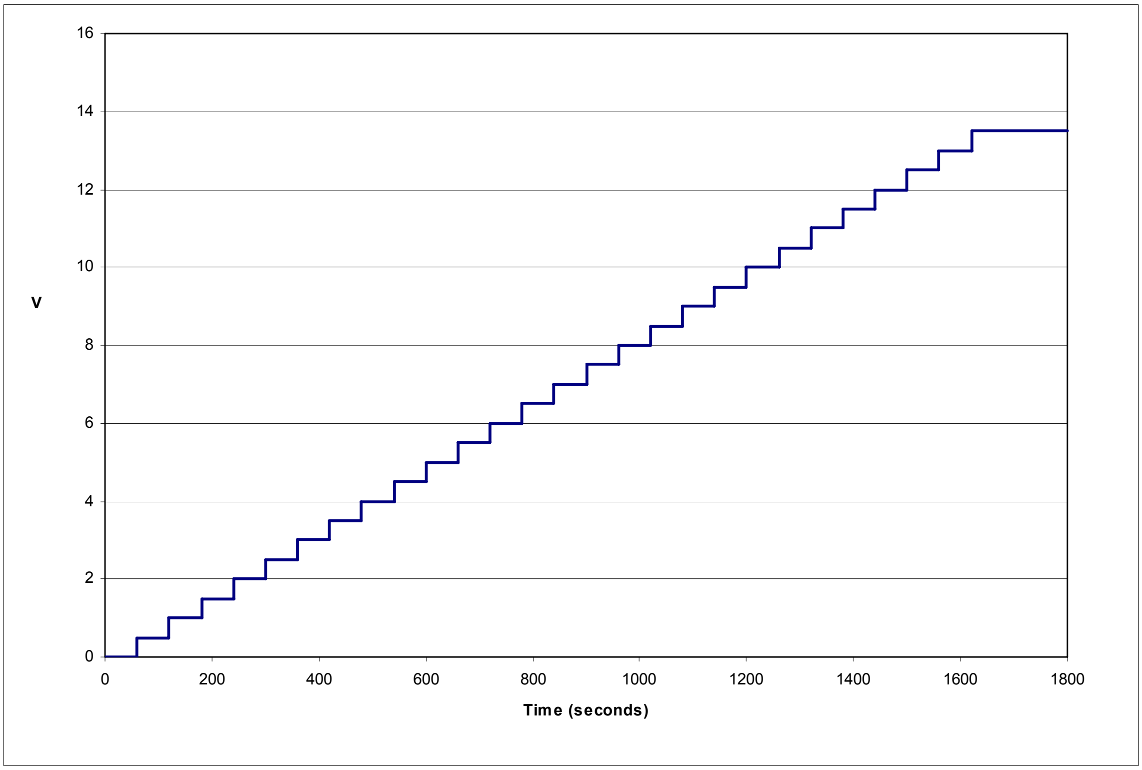


Figure 59. Input voltage: Slow increase of the power supply test.

The change rate applied shall be 0,5V/min for both test conditions (slow increase and decrease) and for both power supply systems (12V and 24V).

DUT Operating modes:

- Electronic modules and active modules shall be tested at least in two modes: DUT normal operation (DUT in RUN MODE) and Standby or Sleep mode (DUT in KEY ON MODE)
- EM shall be tested in RUN MODE in all the different speed configurations, otherwise specified in the test plan. The EM shall be tested also in KEY ON MODE.

Test fixture/load box requirements:

The load box shall provide the correct load conditions to the DUT during all the operating modes tested.

Test procedure:

Calibration:

A special calibration is not required to perform this test. All the instrumentation used to perform the test shall be within its calibrated state.

Test setup:

Dimensions in millimeters – not to scale

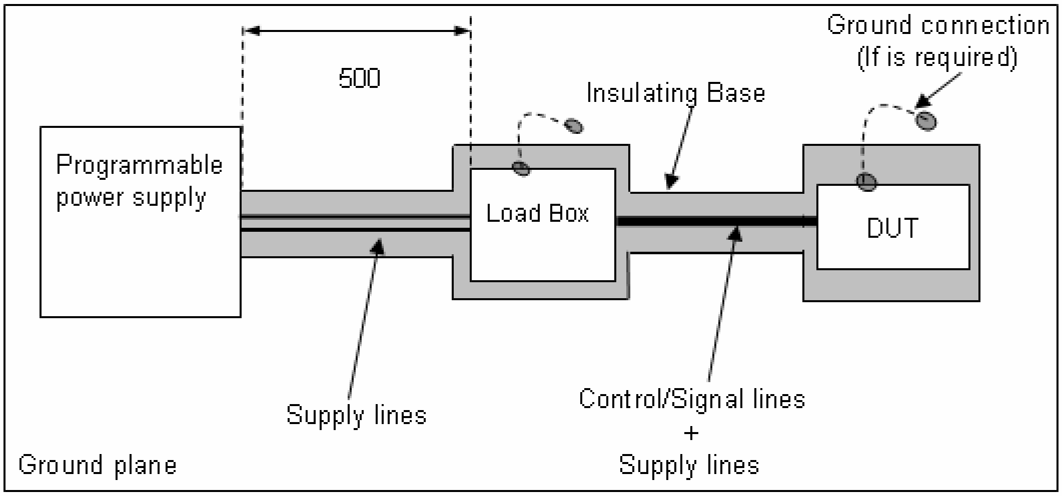


Figure 60. Test setup for Slow increase and decrease of the power supply test

Test:

- As specified in ISO 16750-2:2003, section 4.4.
- Set the DUT as per the test setup shown in Figure 60
- Power up the DUT to the nominal voltage until it reaches its normal performance perform a functional verification
- Set the programmable power supply in order to obtain the voltage defined in Figure 58
- Apply the voltage to all the relevant inputs of the DUT simultaneously.
- Monitor the performance of the DUT and the associated loads and write down any abnormal behavior at every voltage level.
- Power up the DUT to the nominal voltage until it reaches its normal performance perform a functional verification.
- Set the programmable power supply in order to obtain the voltage defined in Figure 59
- Apply the voltage to all the relevant inputs of the DUT simultaneously.
- Monitor the performance of the DUT and the associated loads and write down any abnormal behavior at every voltage level.

Acceptance criteria:

Power supply system	Region of performance (See paragraph 2.4)
12 V	The performance region inside the supply voltage range shall be as region **I**. Outside that range, it shall be minimum as region **III**.
24 V	

Table 64. Acceptance criteria

Test report requirements:

- Photos of the test setup.
- Grounding locations of the DUT and power supply.
- DUT operation mode during the test.
- Data table with the following parameters measured during the test: Power supply voltage applied during the test, lines tested and DUT performance at every voltage level.
- Description of the performance of the DUT and any abnormal behavior at every voltage level.

3.2.19. DIELECTRIC STRENGTH TEST

Reference documents: ISO 16750-2.

Purpose of the test:

- The purpose of this test is to ensure the dielectric withstand voltage capability of circuits with galvanic isolation. This test is required only for DUTs which contain inductive elements (relays, motors, coils) or connected to the circuit with inductive loads.
- This test stresses the insulation system and checks the ability of the dielectric materials to withstand the higher voltage caused by switching of inductive loads.

Test conditions:

- The DUT shall be tested at a severity level of - 500 Volts AC, 40 to 60 Hz, to 12 V and 24 V devices.
- Before start the test, perform a “Test 1:damp heat cyclic” test in accordance with ISO 16750-4:2006.
- The DUT shall remain 0.5 hour at room temperature after the damp heat test.
- The test shall be performed over a non conductive surface.

DUT Operating modes:

This test shall be carry out in OFF mode (DUT not supplied and not connected to the harness)

Test fixture/load box requirements:

A load box is not required to perform the test.

Test procedure:

Calibration:

A special calibration is not required to perform this test. All the instrumentation used to perform the test shall be within its calibrated state.

Test:

- Apply the disturbance during 60 seconds:

- between terminals without galvanic connection
- between terminals and housing having an electrically conductive surface without galvanic connection
- between terminals and an electrode wrapped around the housing (e.g. metal foil, sphere bath) in the case of a housing made of plastic material.
- Power up the DUT to the nominal voltage until it reaches its normal performance and perform a functional verification.

Acceptance criteria:

- No arcing or puncturing of insulation is allowed.
- To satisfy functional performance after the test.
- Region of performance III.

Test report requirements:

- Photos of the test setup.
- Data table with a description of the terminals or lines tested in each case and the leakage current value between the terminals.
- Any abnormal behavior of the DUT after the test shall be reported.

3.2.20. INSULATION RESISTANCE TEST

Reference documents: ISO 16750-2

Purpose of the test:

This test ensures a minimum value of ohmic resistance required to avoid current flow between galvanically isolated circuits and conductive parts of the DUT. The test gives an indication of the relative quality of the insulation system and material.

Test conditions:

- The DUT shall be tested at a severity level of 500 Volts DC, for 12 V and 24 V devices.
- Before start the test, perform a “Test 1:damp heat cyclic” test in accordance with ISO 16750-4:2006.
- The DUT shall remain 0.5 hour at room temperature after the damp heat test.
- The test shall be performed over a non conductive surface.

DUT Operating modes:

This test shall be carry out in OFF mode (DUT not supplied and not connected to the harness)

Test fixture/load box requirements:

A load box is not required to perform the test.

Test procedure:

Calibration:

A special calibration is not required to perform this test. All the instrumentation used to perform the test shall be within its calibrated state.

Test:

- Apply the the voltage to the DUT for 1 minute, or during the time needed to obtain a stable measurement, as follows:

  - between terminals with galvanic isolation
  - between terminals and housing with electrically conductive surface with galvanic isolation
  - between terminals and an electrode wrapped around the housing (e.g. metal foil) in the case of made of plastic material.

Acceptance criteria:

- The insulation resistance shall be greater than 10 MΩ.

Test report requirements:

- Photos of the test setup.
- Data table with a description of the terminals or lines tested in each case and the insulation resistance value measured.

3.2.21. IMMUNITY TO SHORT CIRCUITS (TO GROUND & BATTERY)

Reference documents: ISO 16750-2

Purpose of the test:

This test simulates short circuit to the inputs and outputs of a device.

Test conditions:

- All outputs and inputs short-circuit proof against supply positive and ground with each of the following conditions, at the maximum operating temperature:
    - outputs activated
    - outputs not activated
    - voltage supply absent
    - grounding absent
- Test voltage: (14 ± 0.2) V
- Test time: 60seconds
- Repeat fuse blowing Minimum 5 times with 30 second apart for all Load circuits
- Operating temperature: + 85 °C

DUT Operating modes:

- Electronic modules, active modules shall be tested at least in two modes: DUT normal operation (DUT in RUN MODE) and Standby or Sleep mode (DUT in KEY ON MODE)
- EM and BM shall be tested in RUN MODE in all the different speed configurations, otherwise specified in the test plan. The EM shall be tested also in KEY ON MODE.
- Inductive and passive devices shall be tested in normal conditions.

Test fixture/load box requirements:

The load box shall provide the correct load conditions to the DUT during all the operating modes tested.

Test procedure:

Calibration:

A special calibration is not required to perform this test. All the instrumentation used to perform the test shall be within its calibration period.

Test setup:

-A external power supply is needed in order to connect the DUT lines to the 13.5 V DC or 0.0 VDC

Dimensions in millimeters – not to scale

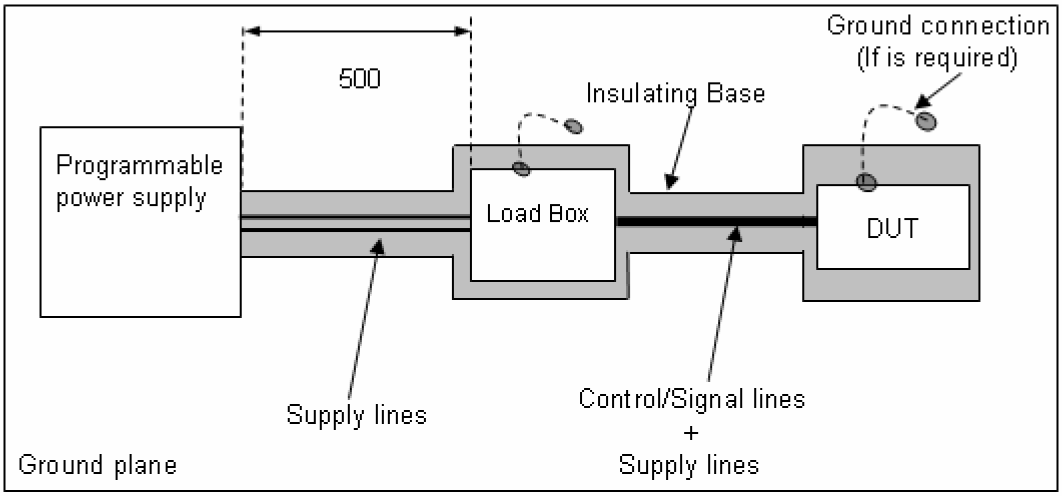


Figure 61. Test setup for Immunity to short circuits test

Test:

- As specified in ISO 16750-2.
- The DUT shall remain during the test at room temperature at + 85 °C.
- Set the DUT as per the test setup shown in Figure 61.
- Power up the DUT to the nominal voltage until it reaches its normal performance perform a functional verification.
- Connect all the relevant inputs and outputs of the DUT in sequence to 13.5 V and to 0.0 V during 60 seconds, in each case. The test shall be done for following test conditions in each line tested (All the others inputs and outputs shall remain in open circuit or as stated in the following test conditions):
    - outputs activated
    - outputs not activated
    - positive voltage supply absent
    - grounding absent
- Repeat fuse blowing minimum 5 times with 30 second apart for all Load circuits

Acceptance criteria:

- The fuse should blow upon short circuit.
- Alternately the output should shut off under short circuit condition and reset whenever the load is disconnected or power switch off & on.
- There should not be any physical damage and DUT should function satisfactorily.

Test report requirements:

- Photos of the test setup.
- Grounding locations of the DUT and power supply.
- DUT operation mode during the test.
- DUT lines tested (and connection conditions for the others DUT lines) for a 13.5 V connection.
- DUT lines tested (and connection conditions for the others DUT lines) for a 0.0 V connection.
- Description of the DUT performance during the test.

3.2.22. IMMUNITY TO POWER SUPPLY MICRO-INTERRUPTION

Reference documents: No reference documents

Purpose of the test:

This test simulates the voltage dropouts occurs in the vehicle power supply system due to imperfect contacts of components fitted in the vehicle.

Test conditions:

The DUT shall be tested following the test conditions shown in Table 65 and Figure 62.

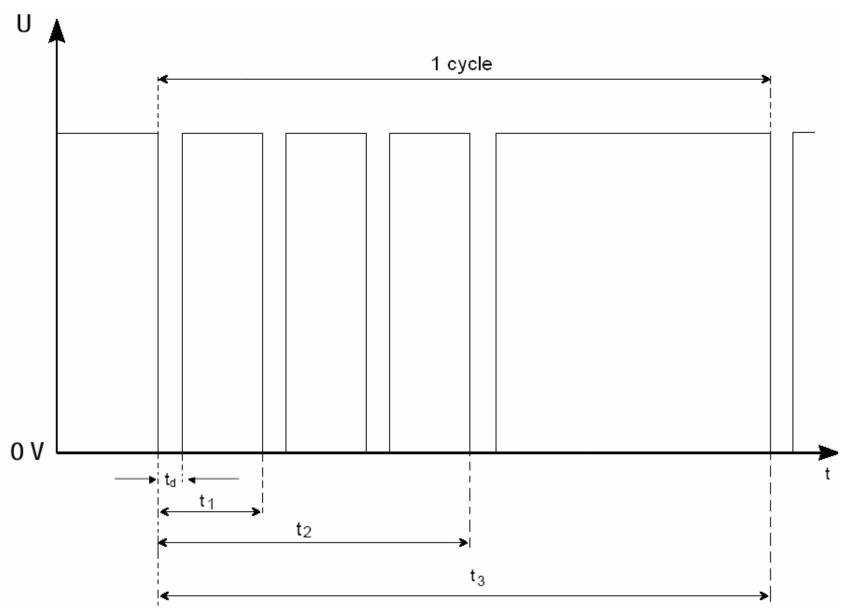


Figure 62. Micro-interruption waveform

Micro-interruption duration (t_d)	t_1	t_2	t_3	t_f	t_r	Number of cycles
1 µs	1 ms	1 s	10 s	≤1 µs	≤1 µs	3
100µs	1 ms	1 s	10 s	≤1 µs	≤1 µs	3
5 ms	10 ms	1 s	10 s	≤1 µs	≤1 µs	3
200 ms	500 ms	5 s	10 s	≤1 µs	≤1 µs	3

Table 65. Test conditions for Micro-interruption test

- The test shall be done in all the DUT power supply lines separately and together.
- A programmable power supply or electronic switch shall be use in order to generate the micro-interruption required.

- The programmable power supply or electronic switch shall remain in open circuit conditions during the micro-interruption duration t_d.

DUT operating modes:

- Electronic modules and active modules shall be tested at least in two modes: DUT normal operation (DUT in RUN MODE) and Standby or Sleep mode (DUT in KEY ON MODE)
- EM shall be tested in RUN MODE in all the different speed configurations, otherwise specified in the test plan. The EM shall be tested also in KEY ON MODE.

Test fixture/load box requirements:

The load box shall provide the correct load conditions to the DUT during all the operating modes under test.

Test procedure:

Calibration:

A special calibration is not required to perform this test. All the instrumentation used to perform the test shall be within its calibrated state.

Test setup:

Dimensions in millimeters – not to scale

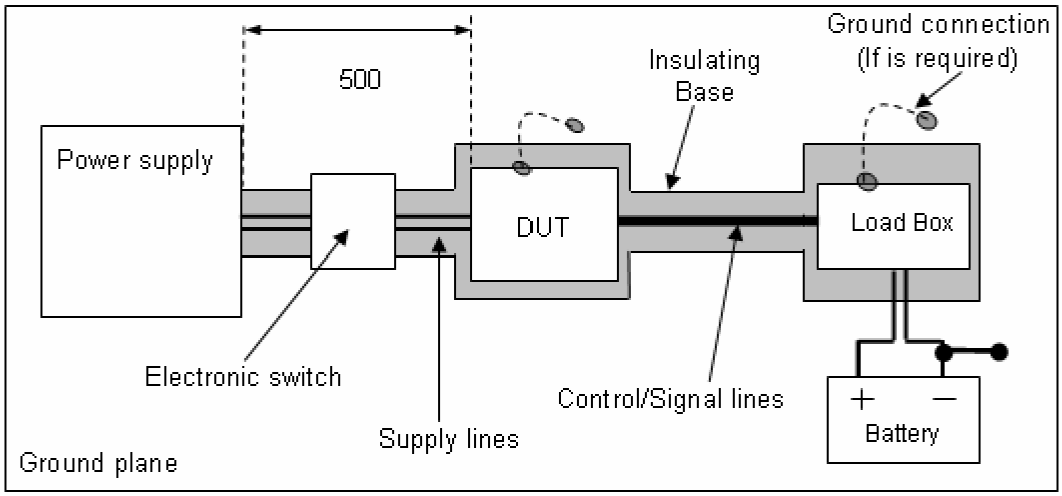


Figure 63. Test setup for Power supply Micro-interruption test

Test:

- Set the DUT as per the test setup shown in Figure 63.
- Supply the all the power supply lines of the DUT with the power supply or battery except the line under test.
- Supply the line under test with a programmable power supply or electronic switch capable to do the micro-interruptions defined in Table 65 and Figure 62.
- Apply 3 cycles of the 1µs micro-interruption disturbance to the DUT line under test.
- Monitoring all the DUT parameters and the associated loads during the test and note any deviation of the DUT performance.
- Apply 3 cycles of the 100 µs micro-interruption disturbance to the DUT line under test.
- Monitoring all the DUT parameters and the associated loads during the test and note any deviation of the DUT performance.
- Apply 3 cycles of the 5ms micro-interruption disturbance to the DUT line under test.
- Monitoring all the DUT parameters and the associated loads during the test and note any deviation of the DUT performance.
- Apply 3 cycles of the 200 ms micro-interruption disturbance to the DUT line under test.
- Monitoring all the DUT parameters and the associated loads during the test and note any deviation of the DUT performance.
- Repeat the test for all the power supply lines of the DUT separately.
- Repeat the test for all the power supply lines of the DUT together.

Acceptance criteria:

Micro-interruption	Region of performance (See paragraph 2.4)
1 µs	Region I for all the groups
100 µs	Region I for all the groups
5 ms	Region II groups A and B , Memory function region I Region I groups C and D, Memory function region I
200 ms	Region III groups A and B, Memory function region I Region I groups C and D, Memory function region I

Table 66. Acceptance criteria Micro-interruption test

Test report requirements:

- Photos of the test setup.
- Grounding locations of the DUT and power supply.
- DUT operation mode during the test.
- Load box conditions during the test and description of the associated loads to evaluate the DUT performance.
- Data table with the following parameters measured during the test: Power supply voltage during the test, micro-interruption applied, description of the lines tested and DUT performance (according to the paragraph 2.4 of this document).
- A description of the failure (if apply) specifying the DUT performance during the test, the micro-interruption applied, line tested and the performance of the associated loads and the region of performance (according to the paragraph 2.4 of this document).
- Screen shot or screen captures of the oscilloscope (or monitoring tools) of the associated load performance's or DUT parameters when a failure appears.

3.2.23. IMMUNITY TO IGNITION VOLTAGE

Reference documents: No reference document is used.

Purpose of the test:

The purpose of this test is to verify the immunity of the DUT against disturbances coming from spark ignition systems. This test applies to the Electric/Electronic equipments and their wires placed in the engine compartment.

Test conditions:

- All the DUT I/Os shall be operating in a representative mode.
- The DUT shall be grounded as in the vehicle.
- The ignition coil used to perform the test shall be of the same type than used in the vehicle, in agreement with TML.
- If the original or equivalent equipments are not available (Ignition coil and transistor), the test can be performed with an alternative method replacing the vehicle ignition system by a High voltage generator. Also, the spark plug can be replaced by two electrodes connected in series with a

15kΩ resistor. The GAP between the electrodes shall be 5 mm. The alternative method is shown in the Figure 71.

- The parameters and waveform of the interference signal for a LOW voltage interference test is shown in Figure 64 and Table 67.

Interference signal parameters	
U_S	≥ 400 V
t_R	≤ 2 μs
t_1	≥ 5 ms

Table 67. Interference signal parameters: Low voltage

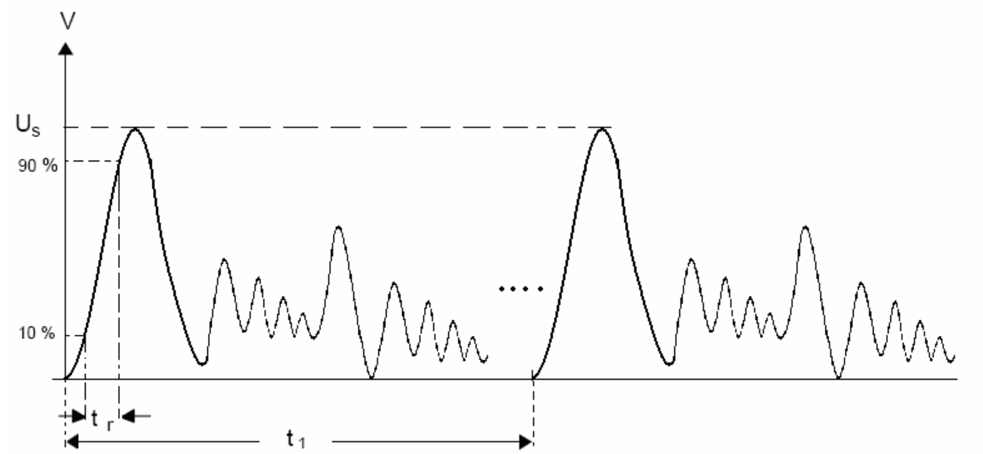


Figure 64. Interference signal: LOW voltage interference test. Waveform and parameters

- The parameters and waveform of the interference signal for a HIGH voltage interference test is shown in the Figure 65 and Table 68.

Interference signal parameters	
U_S	≥ 15 kV
t_D	≤ 5 μs
t_1	≥ 5 ms

Table 68. Interference signal parameters. High voltage

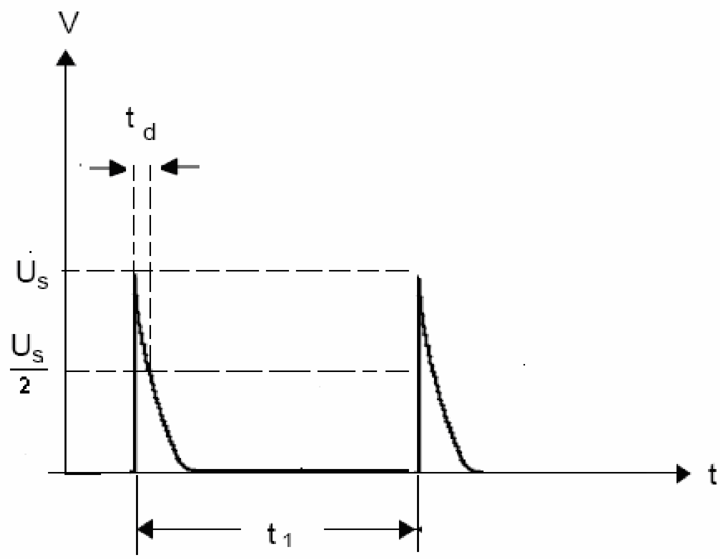


Figure 65. Interference signal: HIGH voltage interference test. Waveform and parameters

Note: The frequency of the interference signal equates to 7500 engine rpm, approximately.

DUT Operating modes:

Electronic modules, active modules and EM shall be tested in RUN MODE. The speed configuration for EM during the test shall be noted in the test report.

Test fixture/load box requirements:

The load box shall provide the correct load conditions to the DUT during all the operating modes tested

Test procedure:

Calibration:

- Set the setup shown in Figure 66.
- Set the signal generator to drive the transistor, in order to obtain the required transient specified in Table 67.
- Record the signal generator level and frequency.
- Set the setup as shown in the Figure 67.
- Set the signal generator to drive the transistor, in order to obtain the required transient specified in Table 68.

- Record the signal generator level and frequency.

Calibration setup:

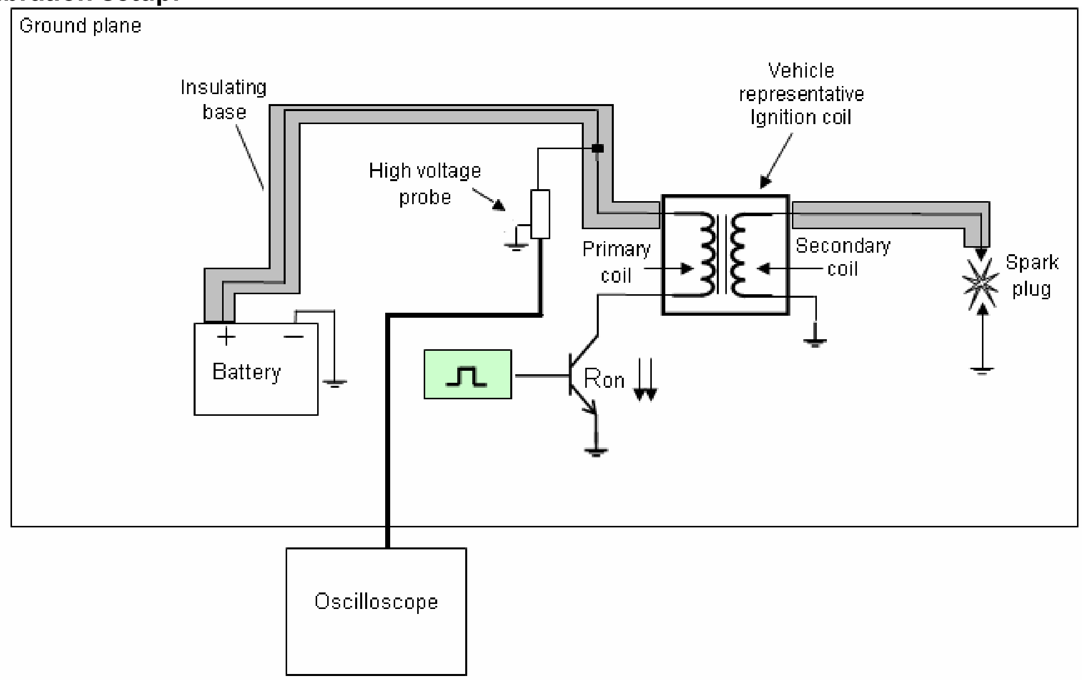


Figure 66. Calibration of Low voltage interferences

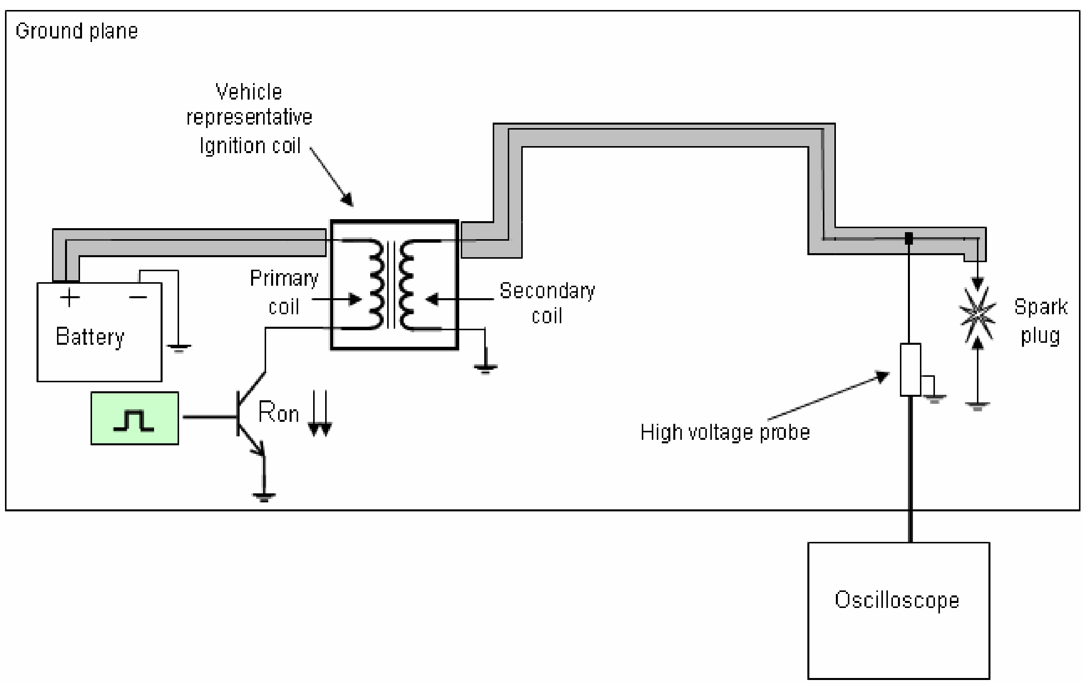


Figure 67. Calibration of High voltage interferences

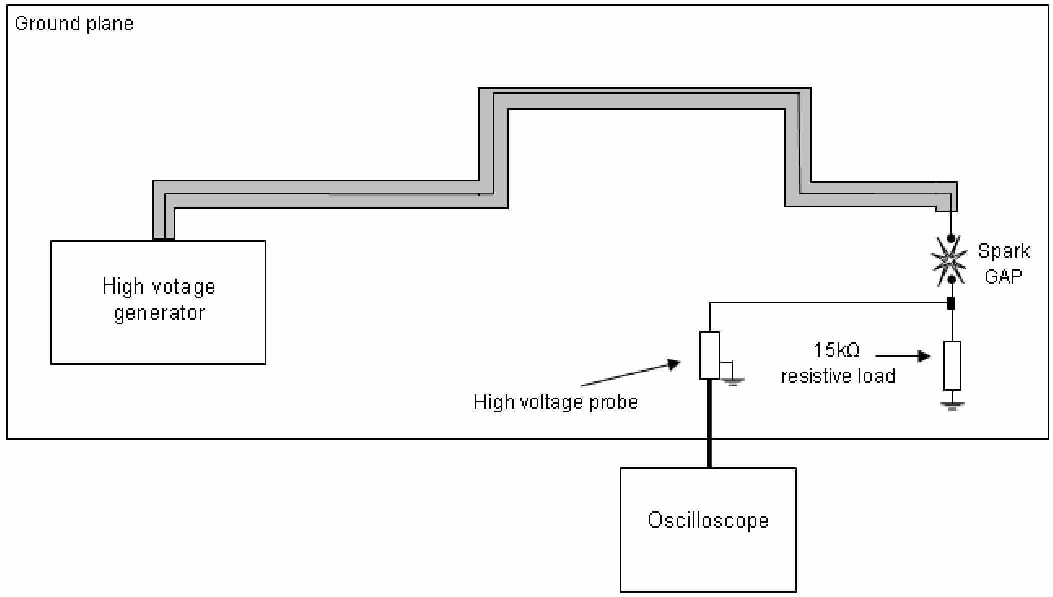


Figure 68. Calibration of High and Low voltage interferences (Alternative method)

Test setup:

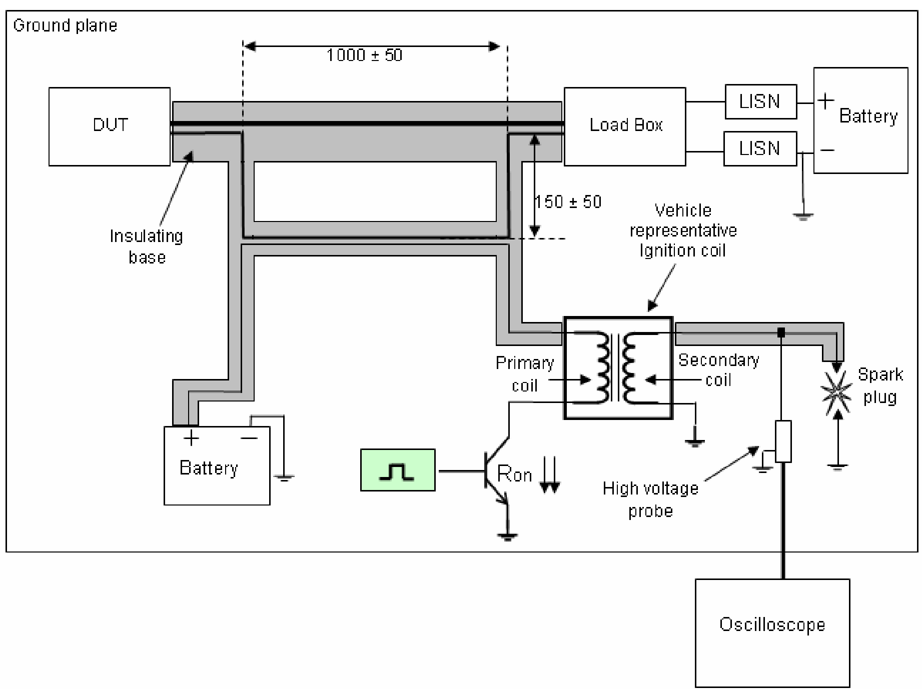


Figure 69. Test setup Low voltage interferences (Top view).

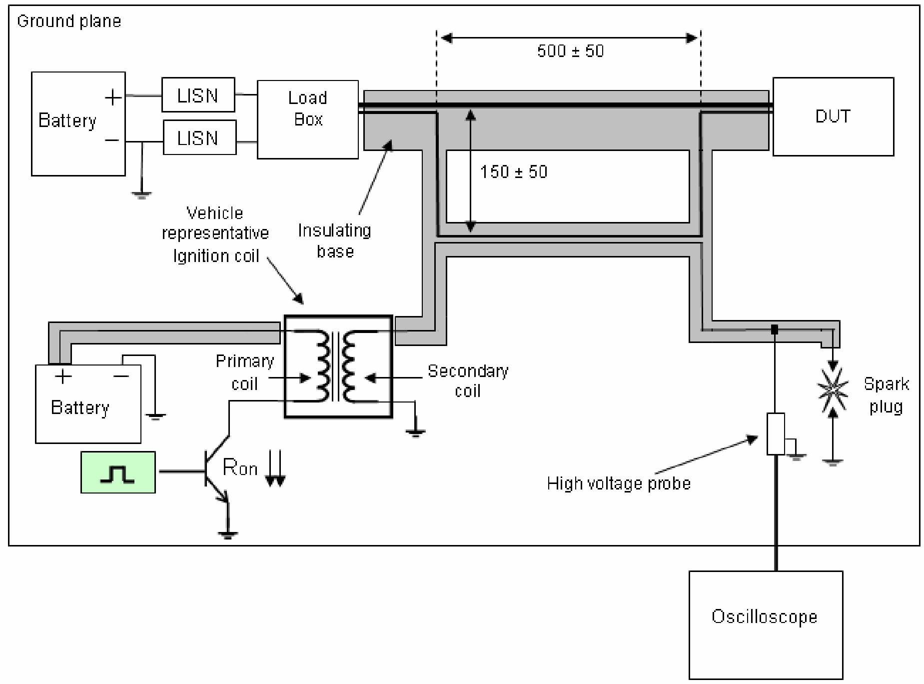


Figure 70. Test setup High voltage interferences (Top view)

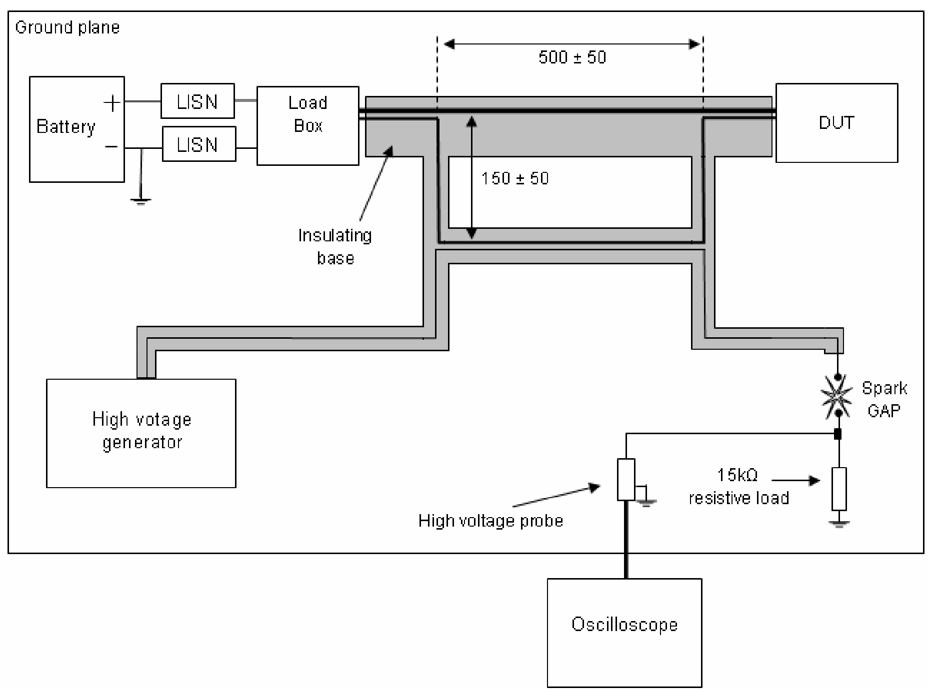


Figure 71. Test setup High and Low voltage interferences (Alternative method).

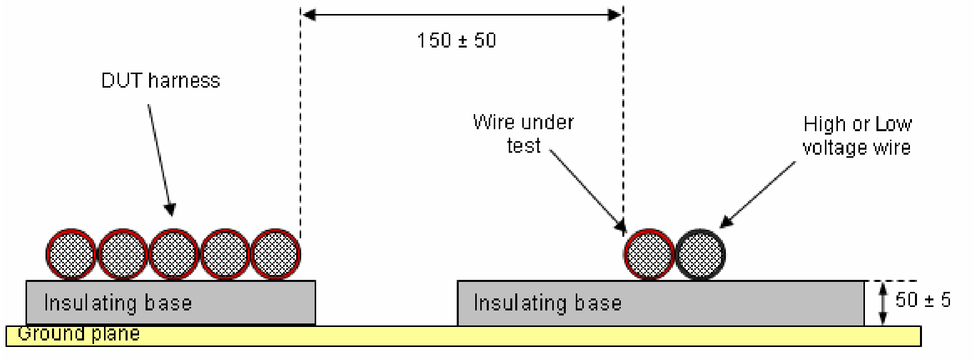


Figure 72. Test setup (lateral view).

Test :

1. Low Voltage:
- Set the DUT as per the test setup shown in Figure 69.
- Set the signal generator level and frequency obtained during the calibration procedure, in order to obtain the interference voltage required.
- Mate all the DUT cables or lines (one by one) with the low interference cable (primary coil cable of the ignition coil) as shown Figure 72. The test shall be a duration of 5 minutes (otherwise specified in test plan) by DUT cable or line.
- If a failure occurs during the test, then increase the gap between the interference cable and the actual DUT line tested until the failure disappears. Note the resulting GAP.
- Monitor the DUT performance during the test and all their associated loads.
- Repeat all the test for all the DUT lines

2. High Voltage:
- Set the DUT as per the test setup shown in Figure 70.
- Set the signal generator level and frequency obtained during the calibration procedure in order to obtain the interference voltage required.
- Mate all the DUT cables or lines (one by one) with the High interference cable (secondary coil cable of the ignition coil) as shown Figure 72. The test shall have a duration of 5 minutes (otherwise specified in test plan) by DUT cable or line.
- If a failure occurs during the test, then increase the gap between the interference cable and the actual DUT line tested until the failure disappears. Note the resulting GAP.
- Monitor the DUT performance during the test and all their associated loads.
- Repeat all the test for all the DUT lines.

Acceptance criteria:

Immunity to ignition voltage test	Region of performance (See paragraph 2.4)
Low voltage interference	Region I, Memory function region I
High voltage interference	

Table 69. Acceptance criteria

Test report requirements:

- Photos of the test setup.
- Grounding locations (DUT, Load box and LISN).
- DUT operation mode during the test.
- Description of the DUT cables or lines tested.
- Load box conditions during the test and description of the associated loads to evaluated the DUT performance.
- DUT monitoring tools used.
- Screen shot or screen captures of the oscilloscope with both interference signals calibrated specifying all the parameters.
- Data table with the following parameters: Line tested, DUT performance during the test in all the interferences conditions (LOW and HIGH voltage interferences).
- A description of the failure (if any) specifying the interference applied (LOW or HIGH interference voltage), DUT line of failure, and the immunity GAP threshold.
- Screen shot or screen captures of the oscilloscope (or monitoring tools) of the associated load performance's or DUT parameters when a failure appears.
- Description of the test equipments used.

3.3. RADIATED EMISSIONS

3.3.1 ELECTROMAGNETIC INTERFERENCE

Reference documents: CISPR25:2008

Purpose of the test:

The purpose of this test is to verify that the DUT's unintended emissions do not exceed a level that will interfere with the operation of other electrical/electronics devices.

Test conditions:

The generic test conditions are described in the CISPR 25:2008 document in operating condition (Run mode).

LIMITS AND SPECTRUM ANALYSER PARAMETERS. PEAK AND QUASI-PEAK DETECTORS							
Service/Band	Frequency Range MHz	Peak detector		Quasi Peak detector		Peak detector Limit dB (µV/m)	Quasi-peak detector Limit dB (µV/m)
		RBW at -3 dB	Scan time	RBW at -6 dB	Scan time		
BROADCAST							
LW	0.15 ... 0.3	9/10 kHz	10 s/MHz	9 kHz	200 s/MHz	46	33
MW	0.53 ... 1.8					40	27
SW	5.9 ... 6.2					40	27
TV BAND I	41 … 88	100/120 kHz	100 ms/MHz	120 kHz	20 s/MHz	28	-
FM	76 … 108					38	25
TV BAND III	174 … 230			DOES NOT APPLY		32	-
DAB III	171 … 245					26	-
TV BAND IV/	468 … 944					41	-
DTTV	470 … 770					45	-
DAB L BAND	1447 … 1494					28	-
SDARS	2320 … 2345					34	-
MOBILE SERVICES							
CB	26 … 28	9/10 kHz	10 s/MHz	9 kHz	200 s/MHz	40	27
VHF	30 … 54	100/120 kHz	100 ms/MHz	120 kHz	20 s/MHz	40	27
VHF	68 … 87					35	22
VHF	142 … 175					35	22
Analogue VHF	380 … 512					38	25
RKE	300 … 330					32	-
RKE	420 ... 450					32	-
Analogue VHF	820 … 960					44	31
GSM 800	860 … 895					44	-
EGSM/GSM 900	925 … 960					44	-
GPS L1 CIVIL	1567 … 1583	DOES NOT APPLY		DOES NOT APPLY		-	-
GSM 1800 (PCN)	1803 … 1882	100/120 kHz	100 ms/MHz	DOES NOT APPLY		44	-
GSM 1900	1850 … 1990					44	-
3G / IMT 200	1900 … 1992					44	-
3G / IMT 200	2010 … 2025					44	-
3G / IMT 200	2108 … 2172					44	-
Bluetooth/802.11	2400 … 2500					44	-

Table 70: Limits and Spectrum analyzer parameters for a Peak and Quasi-peak detectors.

LIMITS AND SPECTRUM ANALYSER PARAMETERS. AVERAGE DETECTOR				
Service/Band	Frequency Range MHz	Average detector		Average detector Limit dB (µV/m))
		RBW at - 3 dB	Scan time	
BROADCAST				
LW	0.15 ... 0.3	9/10 kHz	10 s/MHz	26
MW	0.53 ... 1.8			20
SW	5.9 ... 6.2			20
TV BAND I	41 … 88	100/120 kHz	100 ms/MHz	18
FM	76 … 108			18
TV BAND III	174 … 230			22
DAB III	171 … 245			16
TV BAND IV/	468 … 944			31
DTTV	470 … 770			35
DAB L BAND	1447 … 1494			18
SDARS	2320 … 2345			24
MOBILE SERVICES				
CB	26 … 28	9/10 kHz	10 s/MHz	20
VHF	30 … 54	100/120 kHz	100 ms/MHz	20
VHF	68 … 87			15
VHF	142 … 175			15
Analogue VHF	380 … 512			18
RKE	300 … 330			18
RKE	420 ... 450			18
Analogue VHF	820 … 960			24
GSM 800	860 … 895			24
EGSM/GSM 900	925 … 960			24
GPS L1 CIVIL	1567 … 1583	9/10 kHz	1 s/MHz	10
GSM 1800 (PCN)	1803 … 1882	100/120 kHz	100 ms/MHz	24
GSM 1900	1850 … 1990			24
3G / IMT 200	1900 … 1992			24
3G / IMT 200	2010 … 2025			24
3G / IMT 200	2108 … 2172			24
Bluetooth/802.11	2400 … 2500			24

Table 71:Limits and Spectrum analyzer parameters for Average detector.

Note 1: By default, quasi-peak detector and quasi-peak limit shall be used for BB measurements. In the case of using peak detector and peak limit, it shall be agreed with TML.

Note 2: When a spectrum analyzer is used, the video bandwidth shall be at least tree times the resolution bandwidth (RBW)

Note 3: The scan time listed in Table 70 and Table 71 is the minimum allowed time. This value can be modified depending of the DUT emissions repetition rate. For BM motors the scan time shall be increased to the level of the repetition rate of the emissions.

LIMITS AND SCANNING RECEIVER PARAMETERS.
PEAK AND QUASI-PEAK DETECTORS

Service/Band	Frequency Range MHz	Peak detector			Quasi Peak detector			Peak detector Limit dB (µV/m)	Quasi-peak detector Limit dB (µV/m)
		RBW at - 6 dB	Step size	Dwell time	RBW at - 6 dB	Step size	Dwell time		
BROADCAST									
LW	0.15 ... 0.3	9 kHz	5 kHz	50 ms	9 kHz	5 kHz	1 s	46	33
MW	0.53 ... 1.8							40	27
SW	5.9 ... 6.2							40	27
TV BAND I	41 … 88	120 kHz	50 kHz	5 ms	120 kHz	50 kHz	1 s	28	-
FM	76 … 108							38	25
TV BAND III	174 … 230				DOES NOT APPLY			32	-
DAB III	171 … 245							26	-
TV BAND IV/	468 … 944							41	-
DTTV	470 … 770							45	-
DAB L BAND	1447 … 1494							28	-
SDARS	2320 … 2345							34	-
MOBILE SERVICES									
CB	26 … 28	9 kHz	5 kHz	50 ms	9 kHz	5kHz	1 s	40	27
VHF	30 … 54	120 kHz	50 kHz	5 ms	120 kHz	50kHz	1 s	40	27
VHF	68 … 87							35	22
VHF	142 … 175							35	22
Analogue VHF	380 … 512							38	25
RKE	300 … 330							32	-
RKE	420 ... 450							32	-
Analogue VHF	820 … 960							44	31
GSM 800	860 … 895							44	-
EGSM/GSM 900	925 … 960							44	-
GPS L1 CIVIL	1567 … 1583	DOES NOT APPLY			DOES NOT APPLY			-	-
GSM 1800 (PCN)	1803 … 1882	120 kHz	50 kHz	5 ms	DOES NOT APPLY			44	-
GSM 1900	1850 … 1990							44	-
3G / IMT 200	1900 … 1992							44	-
3G / IMT 200	2010 … 2025							44	-
3G / IMT 200	2108 … 2172							44	-
Bluetooth/802.11	2400 … 2500							44	-

Table 72: Limits and Scanning Receivers parameters for a Peak and Quasi-peak detectors.

LIMITS AND SCANNING RECEIVER PARAMETERS. AVERAGE DETECTOR					
Service/Band	Frequency Range MHz	Average detector			Average detector Limit dB (µV/m)
		RBW at - 6 dB	Step size	Dwell time	
BROADCAST					
LW	0.15 ... 0.3	9 kHz	5 kHz	50 ms	26
MW	0.53 ... 1.8				20
SW	5.9 ... 6.2				20
TV BAND I	41 … 88	120 kHz	50 kHz	5 ms	18
FM	76 … 108				18
TV BAND III	174 … 230				22
DAB III	171 … 245				16
TV BAND IV/	468 … 944				31
DTTV	470 … 770				35
DAB L BAND	1447 … 1494				18
SDARS	2320 … 2345				24
MOBILE SERVICES					
CB	26 … 28	9 kHz	5 kHz	50 ms	20
VHF	30 … 54	120 kHz	50 kHz	5 ms	20
VHF	68 … 87				15
VHF	142 … 175				15
Analogue VHF	380 … 512				18
RKE	300 … 330				18
RKE	420 ... 450				18
Analogue VHF	820 … 960				24
GSM 800	860 … 895				24
EGSM/GSM 900	925 … 960				24
GPS L1 CIVIL	1567 … 1583	9 kHz	5 kHz	5 ms	10
GSM 1800 (PCN)	1803 … 1882	120 kHz	50 kHz	5 ms	24
GSM 1900	1850 … 1990				24
3G / IMT 200	1900 … 1992				24
3G / IMT 200	2010 … 2025				24
3G / IMT 200	2108 … 2172				24
Bluetooth/802.11	2400 … 2500				24

Table 73:Limits and Scanning receiver parameters for Average detector.

Note1: By default, quasi-peak detector and quasi-peak limit shall be used for BB measurements. In case of using peak detector and peak limit, it shall be agreed with TML.
Note 2: The step size listed in Table 72 and Table 73 is the maximum allowed and the dwell time is the minimum allowed. These values can be modified depending of the DUT emissions repetition rate. For a BM motors the step size shall be decreased up to 5 times the RBW.

-The limits of EU directive 2004/104/EC limits have been added in the frequency bands not covered by CISPR25:2008

Limit E dB (μV) /m) at frequency F (MHz) under 2004/104/EC requirements		
Quasi-peak detector (RBW=120 kHz)		
30~75 MHz	75~400 MHz	400~1000 MHz
E = 62 – 25.13 log (F/30)	E = 52 + 15.13 log (F/75)	E = 63

Table 74. Directive 2004/104/EC limits for a Broad band emissions.

Limit E (dBμV/m) at frequency F (MHz) under 2004/104/EC requirements		
Average detector (RBW=120 kHz)		
30~75 MHz	75~-400 MHz	400~1000 MHz
E = 52 – 25.13 log (F/30)	E = 42 + 15.13 log (F/75)	E = 53

Table 75. Directive 2004/104/EC limits for a Narrow band emissions

- The measurements shall be performed with the antennae and polarizations as shown in Table 76

Frequency range (MHz)	Antenna	Polarization
0,150 kHz ~ 30 MHz	Rod antenna (1 m length)	-
30 MHz ~ 200 MHz	Bi-conical	Horizontal and vertical
200 MHz ~ 1GHz	Log periodic	
1GHz ~ 2.5GHz	Horn	

Table 76: Test antennas

DUT Operating modes:

- Electronic modules and active modules shall be tested at least in two modes: DUT normal operation (DUT in RUN MODE) and Standby or Sleep mode (DUT in KEY ON MODE)
- EM and BM shall be tested in RUN MODE in all the different speed configurations, otherwise specified in the test plan. The EM shall be tested also in KEY ON MODE.

Test fixture/load box requirements:

- The load box shall provide the correct load conditions to the DUT during all the operating modes tested.

Test procedure:

Calibration:

A special calibration is not required to perform this test.

Test setup:

A. Test setup Rod antenna (150 kHz ~ 30 MHz):

Dimensions in millimeters – not to scale

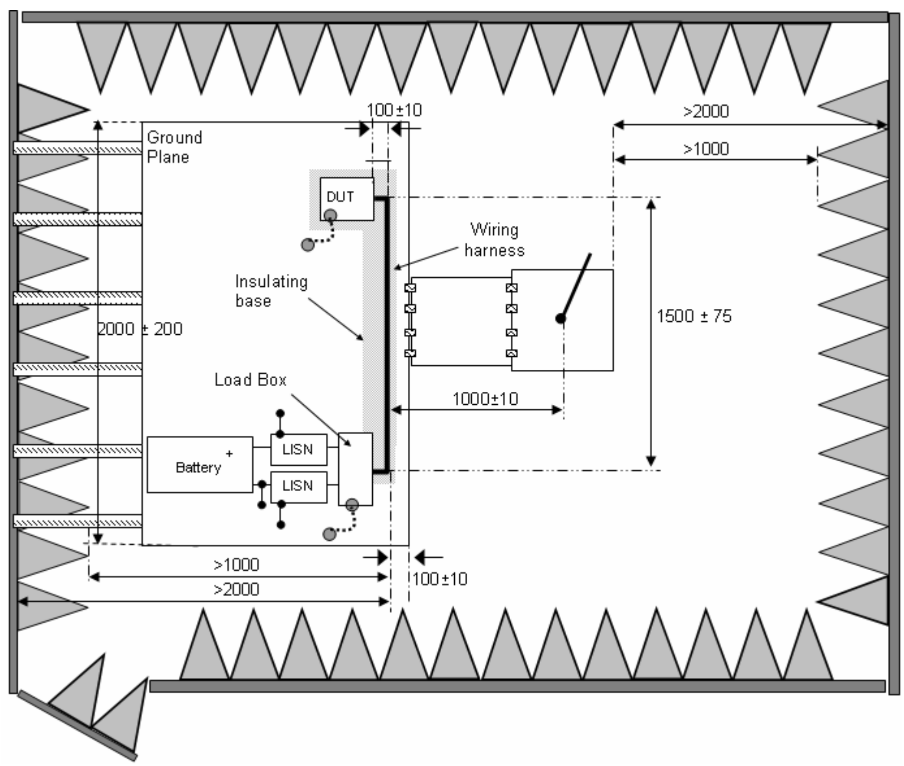


Figure 73. Test setup 150 kHz ~ 30 MHz.(Top view).

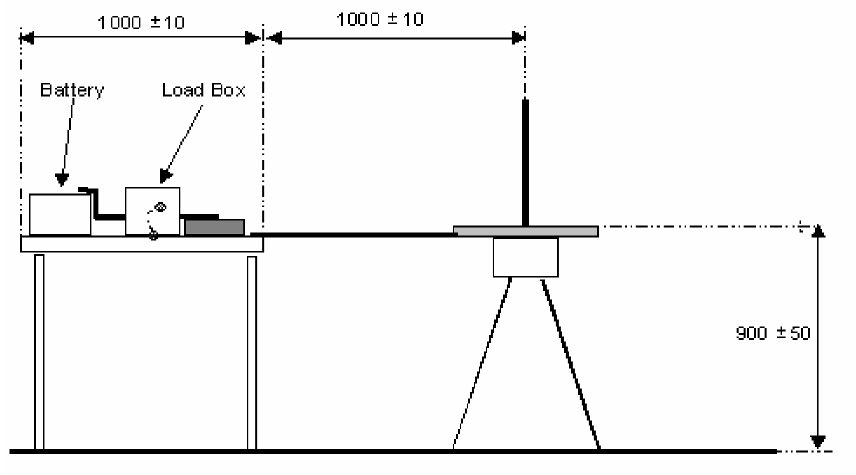


Figure 74. Test setup 150 kHz ~ 30 MHz (Lateral view).

B. Test setup Biconical antenna (30 MHz ~ 200 MHz):

Dimensions in millimeters – not to scale

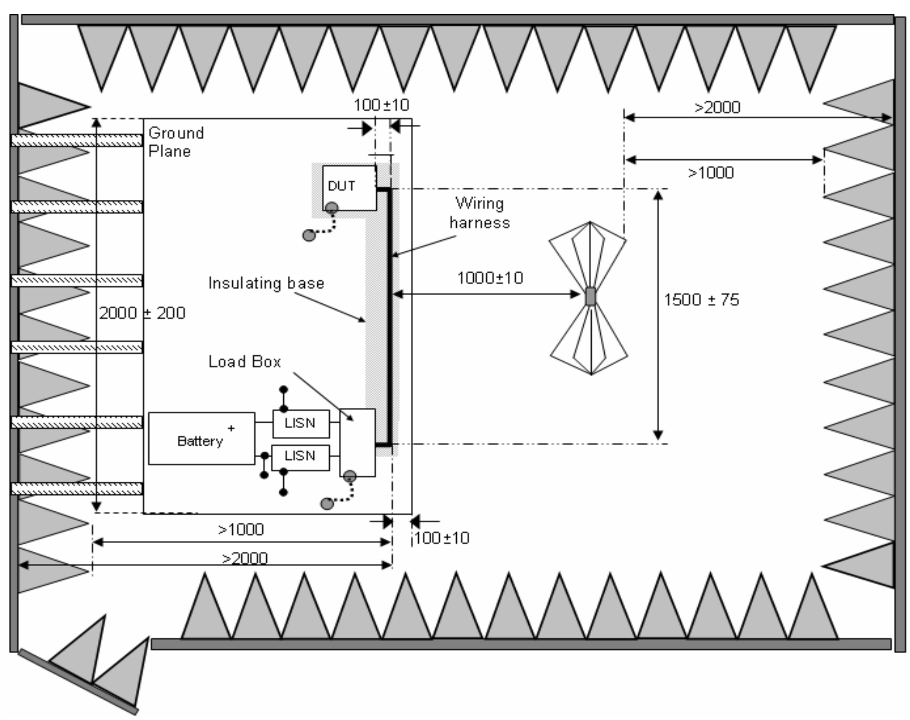


Figure 75. Test setup 30MHz ~ 200MHz (Top view).

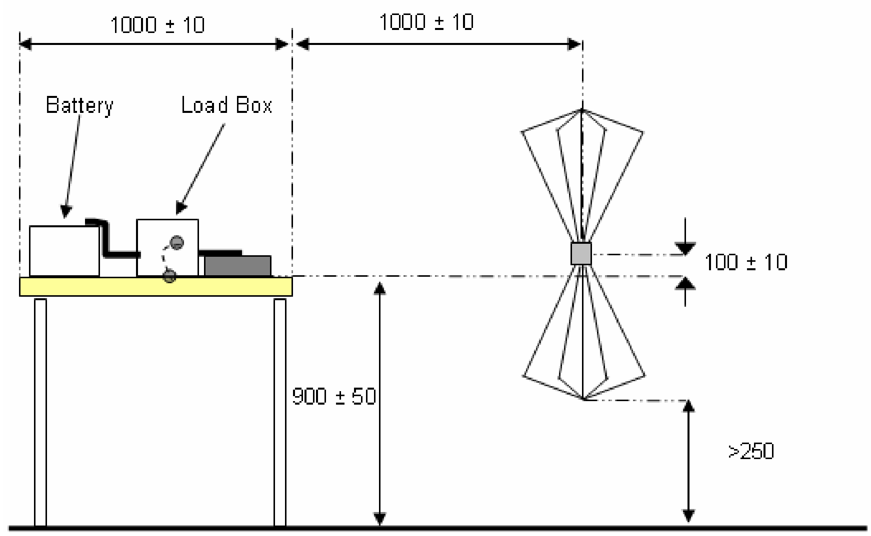


Figure 76. Test setup 30 MHz ~ 200 MHz (Lateral view).

C. Test setup Log periodic antenna :

Dimensions in millimeters – not to scale

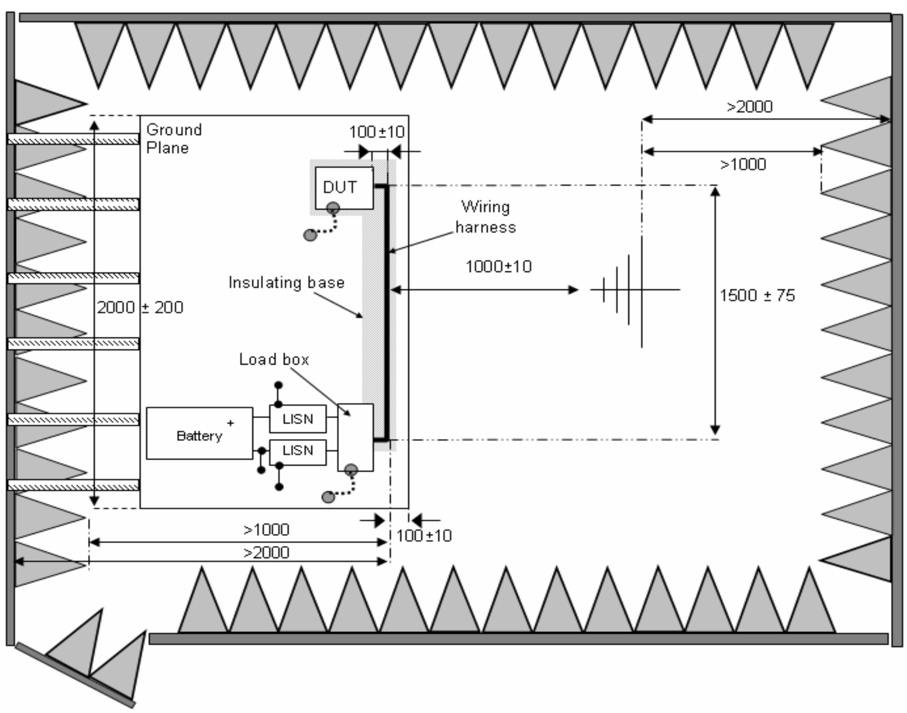


Figure 77. Test setup 200 MHz ~ 800 MHz (Top view).

Dimensions in millimeters – not to scale

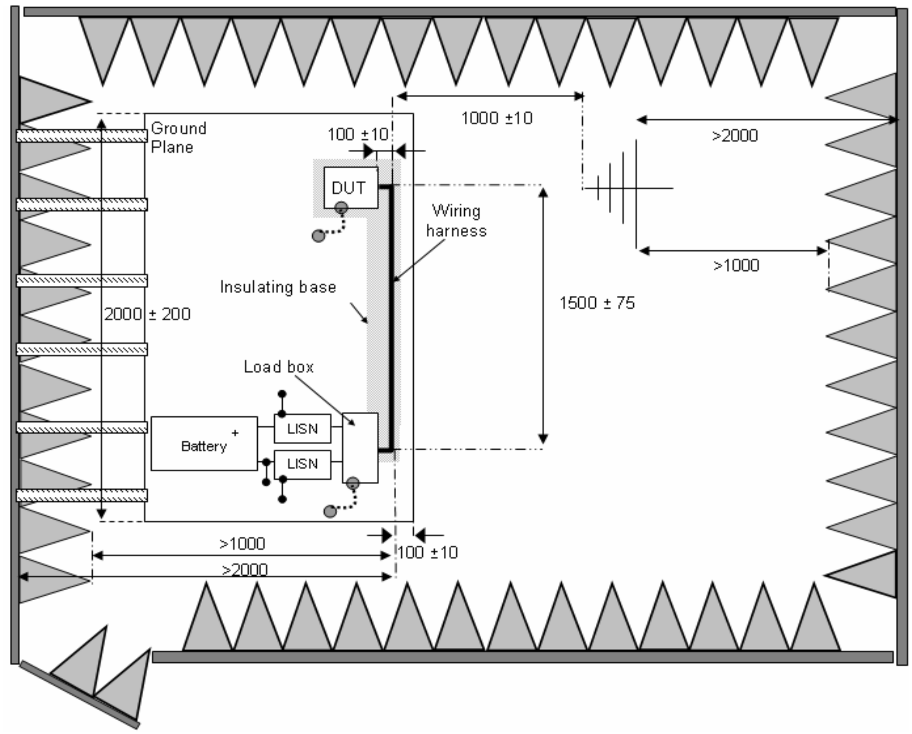


Figure 78. Test setup 800 MHz ~ 1GHz (Top view).

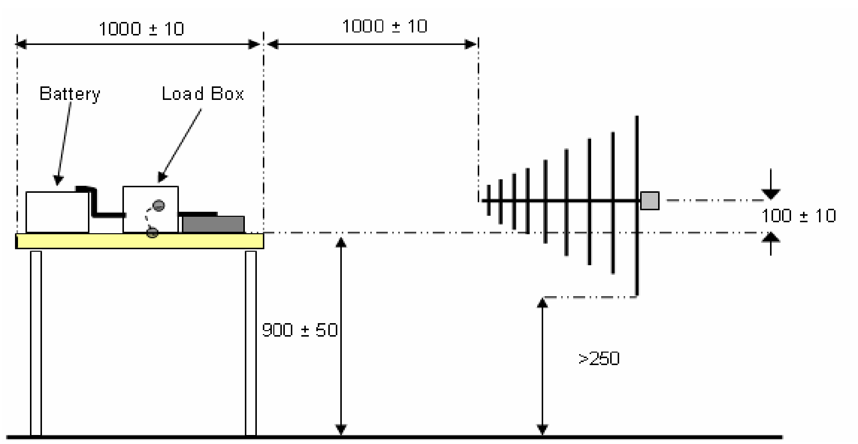


Figure 79. Test setup 200 MHz ~ 1GHz (Lateral view).

E. Test setup Horn antenna (1 GHz ~ 2.5 GHz):

Dimensions in millimeters – not to scale

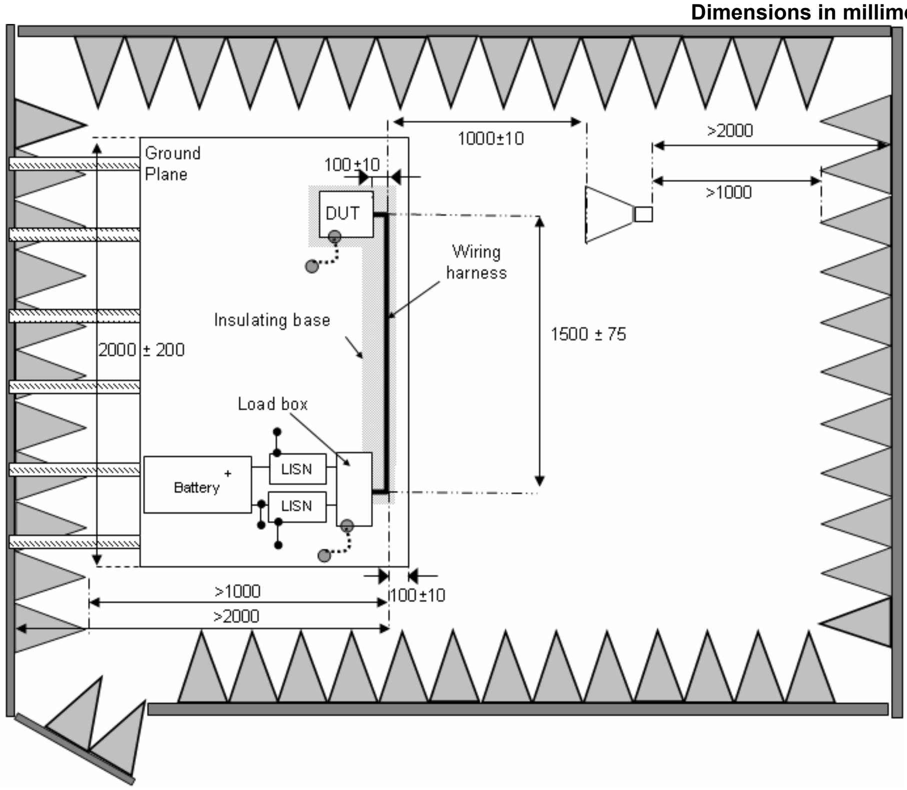


Figure 80. Test setup 1GHz ~ 2.5 GHz (Top view)

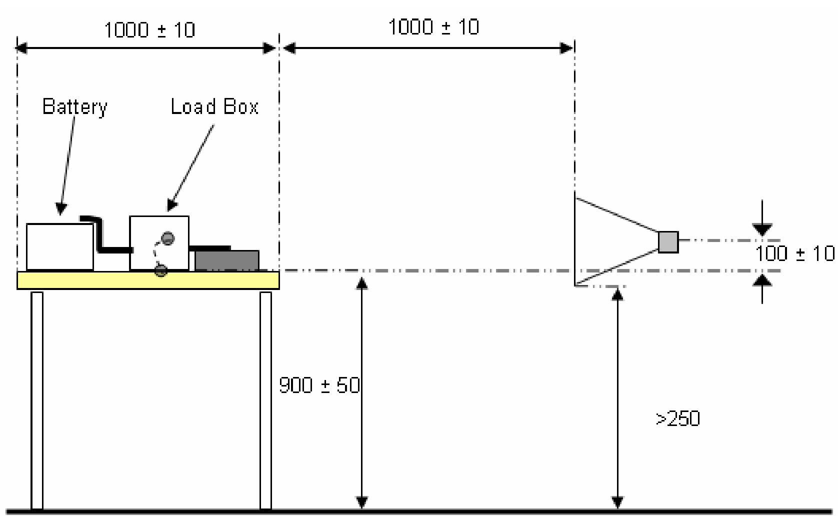


Figure 81.Test setup 1GHz ~2.5 GHz (Lateral view).

F. Test setup Front view:

Dimensions in millimeters – not to scale

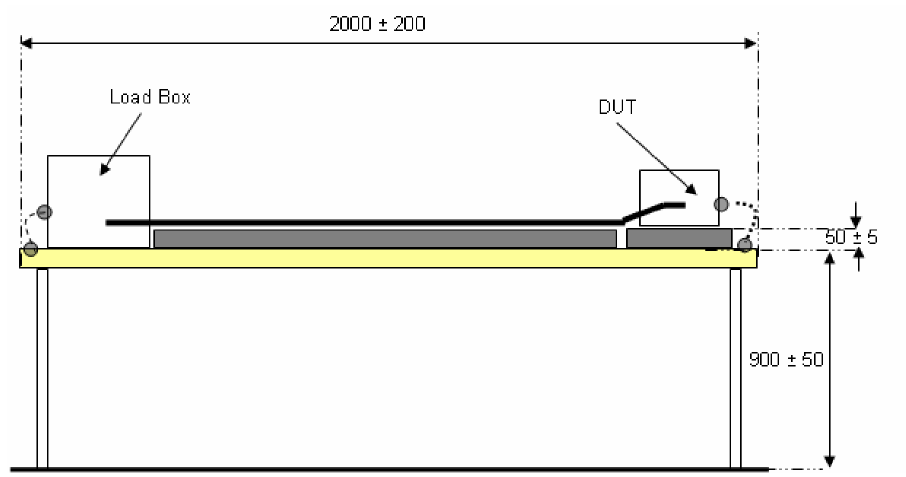


Figure 82. Test setup (front view).

Test:

- -Set the DUT to be tested as per the correct test setup shown in the Figures 73 through Figure 82.
- An ambient noise measurement shall be done with each antenna and each polarization in order to know the noise floor of the test bench and to meet the requirements in the CISPR25:2008.
- Connect the DUT to the LISN and run a minimum of 10 minutes in normal operation (RUN MODE).
- Configure the measurement equipment as shown in Table 70 through Table 73 and perform the measurement in horizontal and vertical polarization as per the method of determination of conformance of CISPR25:2008 showing in Figure 83.

- Repeat all the measurements for KEY ON mode, if apply.

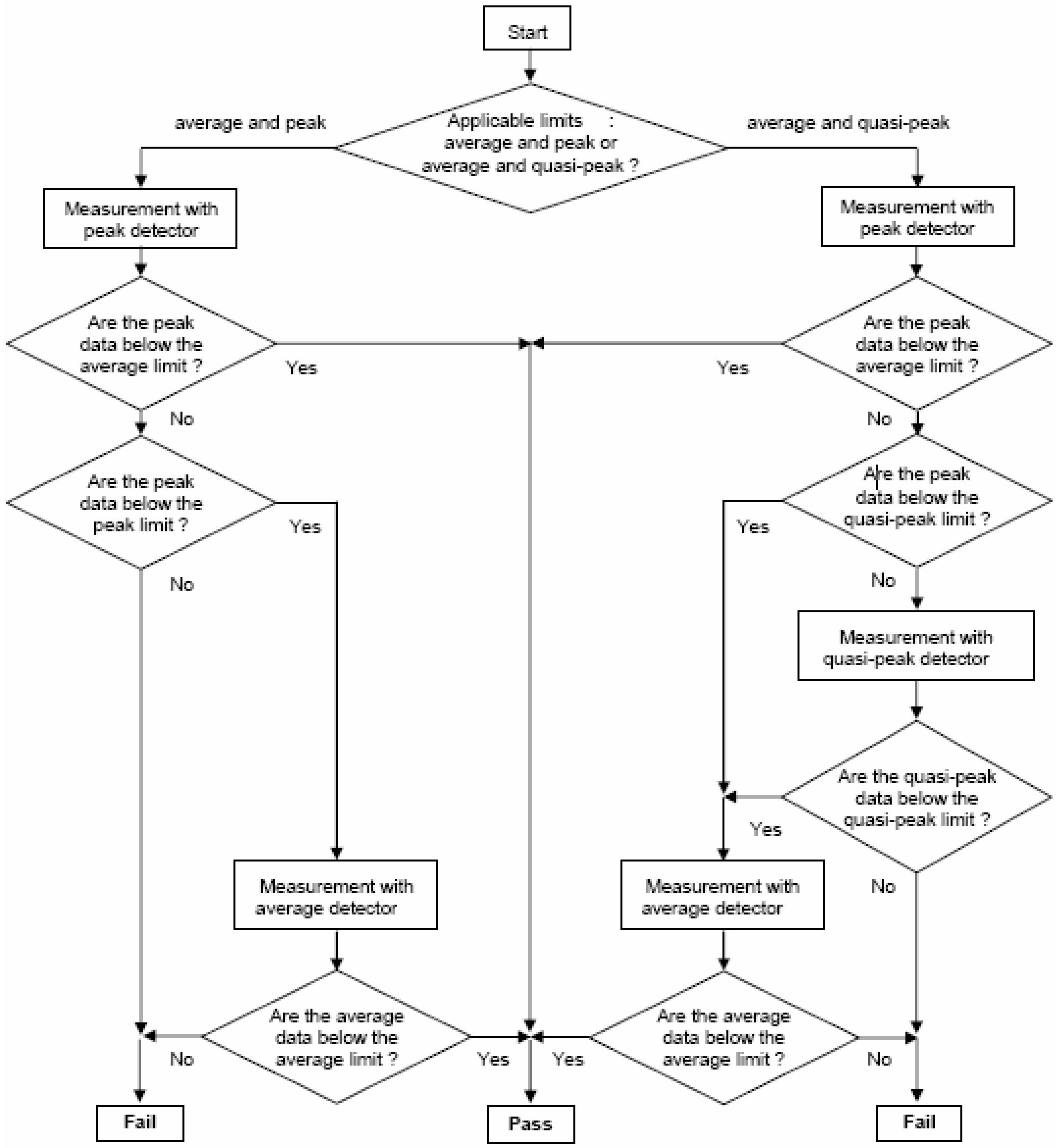


Figure 83. Method of determination of conformance for all frequency bands

Acceptance criteria:

- In all the cases (broadband or narrowband sources) the DUT shall comply with the average limit following the CISPR 25:2008 requirements.
- In the frequency bands where peak and quasi peak limits are defined, the DUT shall comply with the quasi-peak limit, otherwise specified in the test plan and agreed with TML.
- In the frequency bands where only the peak limit is defined, the DUT shall comply with peak limit.

Test report requirements:

- List of equipment used during the test to be specified if spectrum analyzer or scanning receivers are used.
- RBW (resolution bandwidth at -3 dB or -6 dB), VBW (video bandwidth), Scan time, Step size and Dwell time used during the measurements.
- Test setup and grounding conditions used (remotely or locally ground connection and ground case conditions for the DUT and load box).
- Limit lines to meet by the DUT. Average detector limit line (for any DUT) and Quasi-peak or Peak detector limit lines.
- Photos of the test setup.
- DUT operation mode during all the measurements.
- Load box conditions during all the measurements (data table with all the associated loads activated).
- Parameters monitored during the test.
- Plot of the ambient noise for all the frequency bands specifying frequency and level measured in dB μV/m.
- Plot of the test measurements for all the frequency bands and for all the lines to be tested specifying frequency and level measured in dB μV. Numeric results shall be submitted in the case of failure.
- Table with all the frequency bands and the result of the DUT evaluated separately (band to band).
- Measurement uncertainties.

3.4 RADIATED IMMUNITY

3.4.1 BULK CURRENT INJECTION (BCI)

Reference documents: ISO 11452-4:2005

Purpose of the test:

The purpose of this test is to verify the immunity of the DUT against electromagnetic fields.
The bulk current injection is a method for carrying out tests by inducing disturbance signals directly into the wiring harness by means of a current injection probe.

Test conditions:

General test conditions as per ISO 11452-4 specification. Test equipment shall be according to the ISO 11452-4 requirements.

- Power supply: Standard 12 V/24 V automotive battery with LISN.

- Frequency range and severity level:

Frequency range (MHz)	Severity level	Functional groups
1 ~ 400	300 mA	DUTs included in functional groups C and D ***Note1**
	200 mA	DUTs included in all functional groups
	100 mA	DUTs included in all functional groups

Table 77. Severity levels

***Note1**: This level shall be performed, only when agreed between TML and the supplier and shall be specified in the test plan.

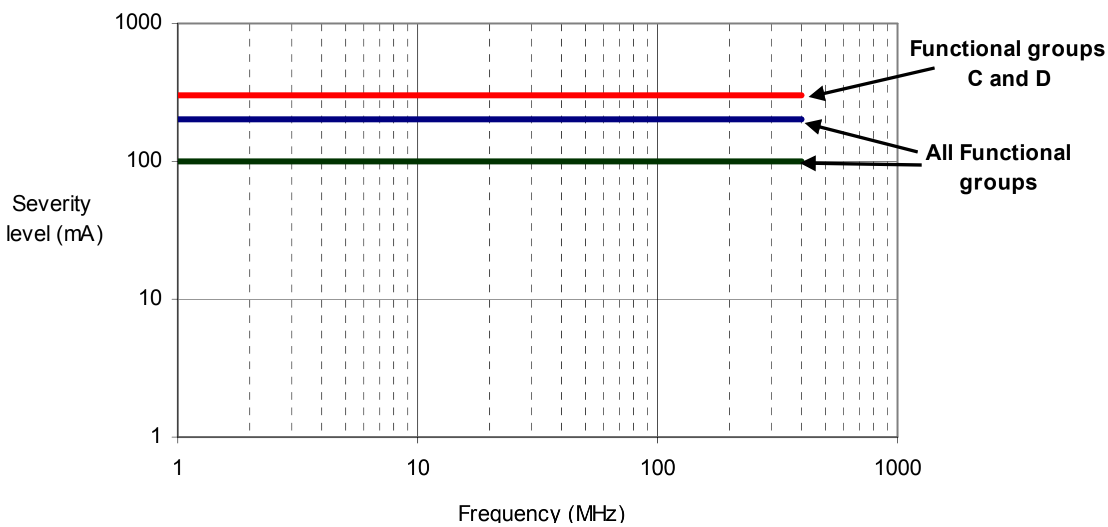


Figure 84. Severity levels and functional groups

The severity levels per functional group shown above shall be specified in the test plan and in agreement between TML and the supplier.

- Step size:

Frequency range (MHz)	Step size (linear)
1 ~ 10	1 MHz
10 ~ 200	2 MHz
200 ~ 400	5 MHz

Table 78. Step size

- Dwell time: Shall be 3 sec minimum. This time shall be increased if necessary to monitor a complete functional cycle of the DUT. In between frequencies the power level shall be reduced by 10 dB during the leveling phase, in order to avoid DUT failures in the frequency transitions.

- Modulation: CW and AM modulation with conservation of peak (1 kHz sinusoidal, 80% depth) for the whole frequency range.

- Test method: Closed Loop method with an increase of the power up to 4 times the calibrated power, as per ISO 11452-4.

- Lines to be tested: All the harness simultaneously. When a harness contains several branches is used, the test shall be repeated with the injection probe clamped around each branch.

DUT Operating modes:

- Electronic modules and active modules shall be tested at least in two modes: DUT normal operation (DUT in RUN MODE) and Standby or Sleep mode (DUT in KEY ON MODE).
- EM and BM shall be tested in RUN MODE in all the different speed configurations, otherwise specified in the test plan. The EM shall be tested also in KEY ON MODE.

Test fixture/load box requirements:

- The load box shall provide the correct load conditions to the DUT during all the operating modes under test. All the parameters related to the DUT performance shall be monitored during the test. The monitoring system of the Load box and the DUT parameters shall be described previously in the test plan and noted in the test report.

Test procedure:

Calibration:

Prior to the test, the specific severity level to be applied shall be calibrated following the ISO 11452-4: 2005 standard requirements.

Set the injection probe around of the 50 Ω calibration fixture (JIG). Connect a 50 Ω load at one end of the JIG and connect a power meter to the other end (protected with a 50Ω attenuator, if needed).

The calibration shall be performed with an unmodulated sinusoidal wave.

Increase the forward power applied to the injection probe until the required current severity level is reached. When the severity level is achieved, record the forward and the reverse power needed for the current frequency and reduce the forward power by 10 dB before the next frequency step. Repeat this step for each frequency.

The forward power and reverse power needed to establish the required severity level on a 50 Ω calibration JIG shall be recorded for each frequency.

Test setup:

Dimensions in millimeters – not to scale

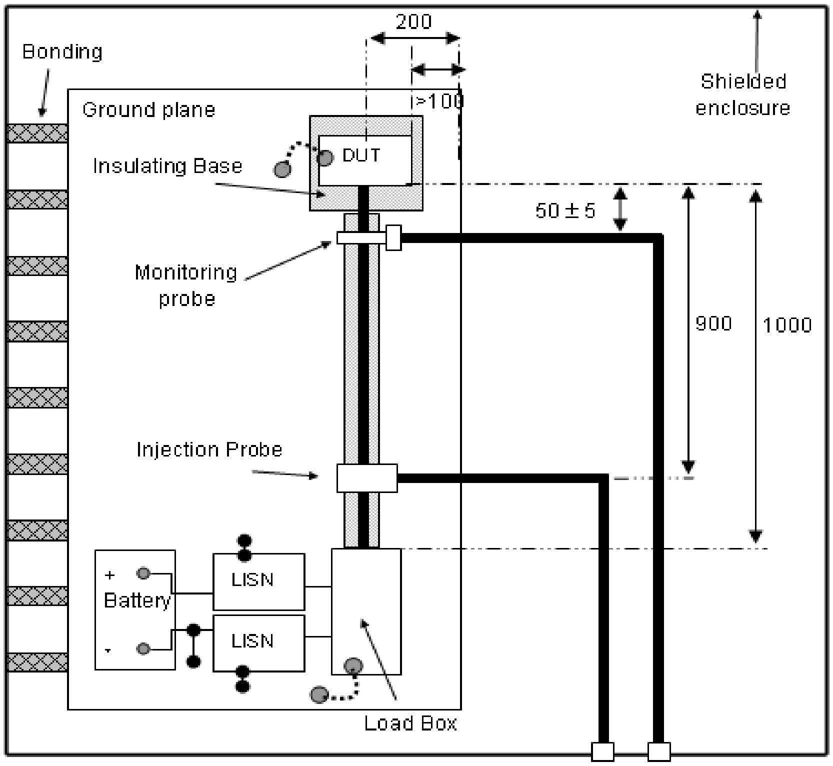


Figure 85. Test setup BCI (Top view)

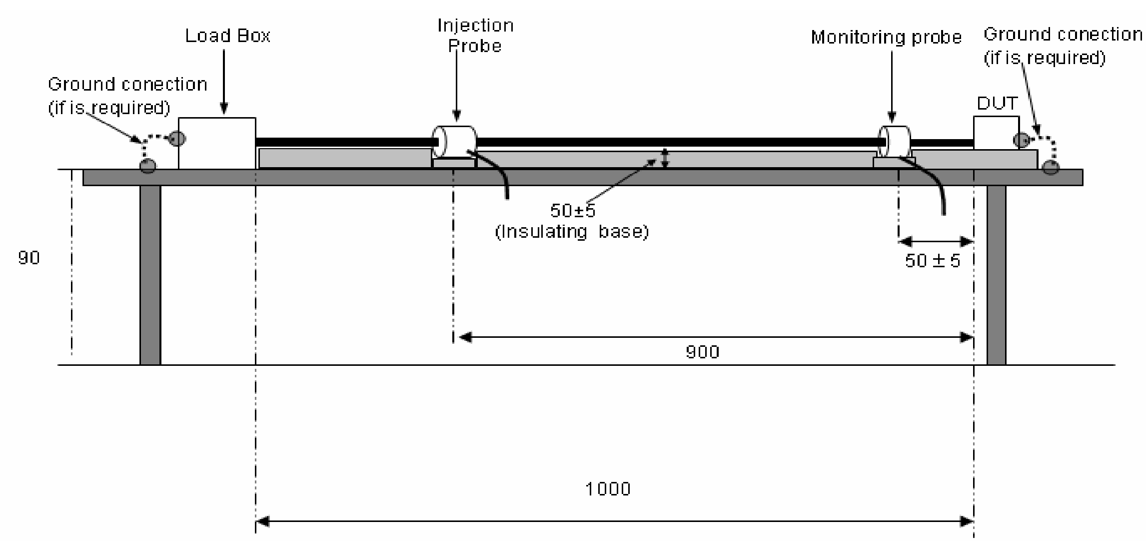


Figure 86. Test setup BCI. (Lateral view).

Test:

The test shall be performed in Close loop method with power limitation.
Set the DUT as per the test setup shown in Figure 85 and Figure 86.

Increase the forward power applied P_{TEST} to the injection probe in steps of 3 dB and measure the injected current I_{TEST} to the DUT harness until the measured current reaches the specific severity level or the forward power applied reaches the forward power limit $P_{POWER\ LIMIT}$ (4 times the forward power recorded during the calibration).
Record the achieved current I_{REF} (injected current measured and coupled to the DUT harness) and the forward power applied P_{TEST}. Apply the corresponding modulation.

Check the DUT performance and all the associated loads. If a DUT failure is detected during the test procedure shown above, then the DUT susceptibility threshold shall be determined.
Decrease the forward power until the failure disappears. Increase the forward power slowly until the failure appears and then record the current of failure (I_{FAULT}), and the power applied (P_{FAULT}). These values shall be noted in the test report.

Reduce the forward power by 10 dB before change to the next frequency in order to avoid DUT failures in the frequency transitions. Change to the next frequency and repeat all the steps showing above for all the frequency range.

Acceptance criteria:

Severity Level	Functional Groups	Region of performance
300 mA	C, D	II *Note2
200 mA	A	III
	B	II
	C,D	I
100 mA	A	II
	B	I

Table 79: Acceptance criteria

*Note2: This severity level and the region of performance shall be agreed between TML and the supplier and shall be specified in the test plan.

Test report requirements:

- Photos of the test setup.
- Grounding locations (DUT, Load box and LISN).
- DUT operation mode during the test.
- Description of the harness or branch groups tested (lines by line).
- Load box conditions during the test and description of the associated loads to evaluated the DUT performance.
- DUT monitoring tools used.

- Calibration graphs and calibration data tables (Calibration current vs Frequency and Calibration Forward power Vs Frequency).
- Test graphs and test data tables with the following parameters: Frequency range, I_{TEST}, P_{TEST}, I_{FAULT}, and P_{FAULT} for each test (CW and AM modulations)
- A description of the failure (if any) specifying the frequency of failure, I_{FAULT}, P_{FAULT}, modulation, performance of the associated loads and the region of performance (according to the paragraph 2.4 of this document).
- Screen shot or screen captures of the oscilloscope (or monitoring tools) of the associated load performance's or DUT parameters when a failure appears.
- Graphs and data tables for a Test harness transfer function (Z_{TRANS} transfer impedance) defined by:

$$Z_{TRANSFER}(\Omega) = 100 \cdot \frac{I_{CALIBRATION}}{I_{TEST}} \cdot \sqrt{\frac{P_{TEST}}{P_{CALIBRATION}}}$$

3.4.2 RADIATED IMMUNITY (ABSORBER LINED CHAMBER METHOD)

Reference documents: ISO 11452-2:2004

Purpose of the test:

The purpose of this test is to verify that immunity of the DUT against electromagnetic fields. Radiated electromagnetic fields are generated using antennae with a radio frequency (RF) energy source capable of producing the desired field strengths.

Test conditions:

General test conditions as per ISO 11452-2 specification. Test equipment shall be according to the ISO 11452-2:2004 standard requirements.

- Power supply: Standard 12 V/24 V Automotive battery with LISN

- Frequency range and severity level:

Frequency range (MHz)	Severity level	Functional groups
200 ~ 3100	200 V/m	DUTs included in functional groups C and D
	150 V/m	DUTs included in functional groups B and C
	100 V/m	DUTs included in functional groups A and B

Table 80. Severity levels

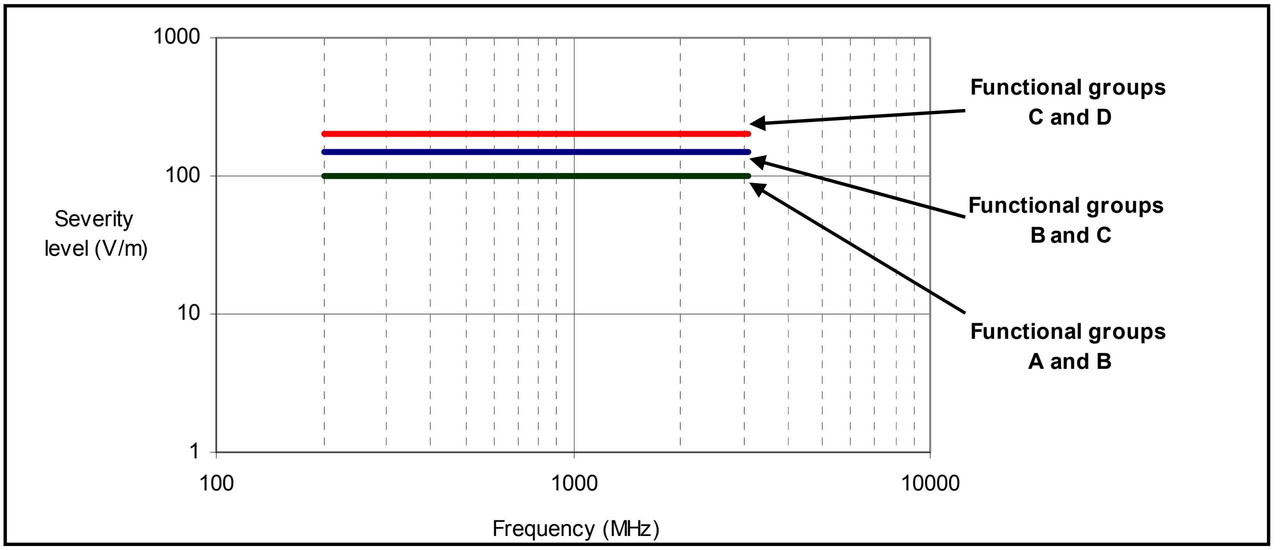


Figure 87. Severity levels and functional groups

- Step size:

Frequency range (MHz)	Step size (linear)
200 ~ 400	10 MHz
400 ~ 1000	20 MHz
1000 ~ 3100	40 MHz

Table 81. Step size

- Dwell time: Shall be 3 sec minimum. This time shall be increased, if necessary to monitor a complete functional cycle of the DUT. Between frequencies the power level shall be reduced by 10 dB during the leveling phase in order to avoid DUT failures in the frequency transitions

- Modulation:

Frequency range (MHz)	Modulation
200 - 800	CW and AM (1 kHz sinusoidal, 80% Modulation Index)
800 - 3100	CW and PM (Ton= 577 µs, Period = 4600 µs)

Table 82. Modulations

- Test method: Substitution Method with forward power.

- Antenna position and polarization:

From 200~ 800 MHz pointing to the half of the exposure cable.
From 800 MHz to 3.1 GHz the antenna shall be placed in front of the DUT.
Vertical and Horizontal polarization shall be used for all the frequency range.

DUT Operating modes:

- Electronic modules and active modules shall be tested at least in two modes: DUT normal operation (DUT in RUN MODE) and Standby or Sleep mode (DUT in KEY ON MODE)
- EM and BM shall be tested in RUN MODE in all the different speed configurations, otherwise specified in the test plan. The EM shall be tested also in KEY ON MODE.

Test fixture/load box requirements:

- The load box shall provide the correct load conditions to the DUT during all the operating modes tested.
- All the parameters related to the DUT performance shall be monitored during the test. The monitoring system of the Load box and the DUT parameters shall be described before in the test plan and noted in the test report.

Test procedure:

Calibration:

Previously the actual test, the specific severity level to be applied shall be calibrated following the ISO 11452-2:2004 standard requirements.

Without the DUT, wiring harness and Peripheral devices in the test bench, place the electrical phase centre of the field probe (150 ± 10) mm above the ground plane and at a distance of (100 ± 10) mm from the front edge of the ground plane.

For frequencies of from 200 MHz to 1000 MHz, the phase centre of the field probe shall be in line with the centre of the longitudinal part of the wiring harness position.

For frequencies above 1000 MHz, the phase centre of the field probe shall be in line with the DUT position.

Place the field-generating device (antenna) at a distance of (1000 ± 10) mm from the electrical phase centre of the field probe.

Calibrate the field strength for vertical and horizontal polarizations.

The calibration shall be performed with an unmodulated sinusoidal wave.

Increase the forward power applied to the field-generating device until reaches the required field strength. When the field strength is achieved, record the forward and the reverse power needed for the actual frequency and reduce by 10 dB the forward power before the next frequency in order to avoid failures in the readings.
Repeat this step for each frequency.

The forward power and reverse power needed to establish the field strength shall be recorded for each frequency.

Test setup:

C. Test setup Biconical antenna:

Dimensions in millimeters – not to scale

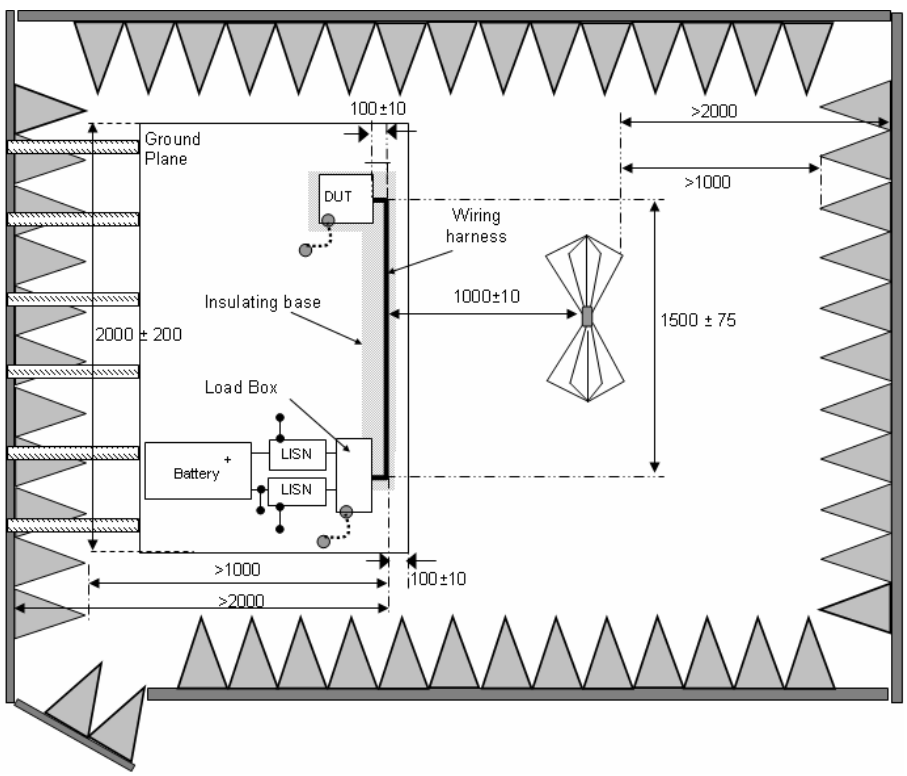


Figure 88. Test setup biconical antenna (Top view).

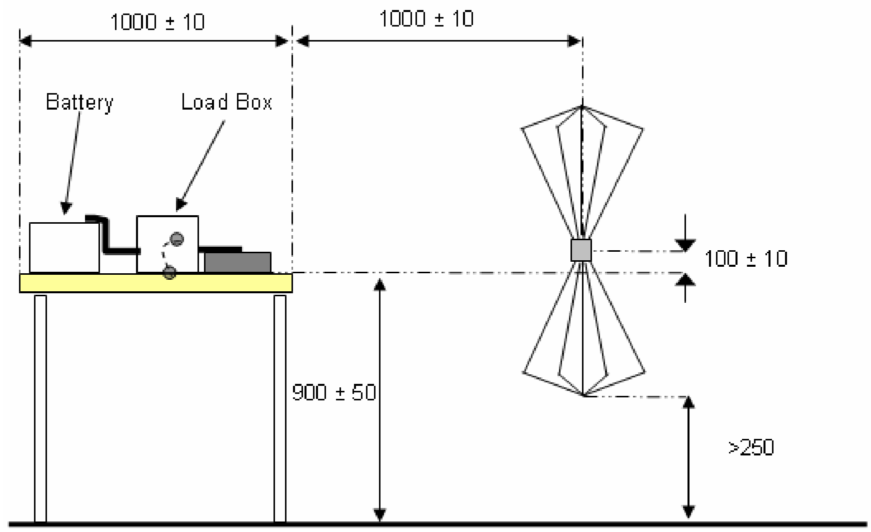


Figure 89. Test setup biconical antenna (Lateral view)

B. Test setup Log periodic antenna:

Dimensions in millimeters – not to scale

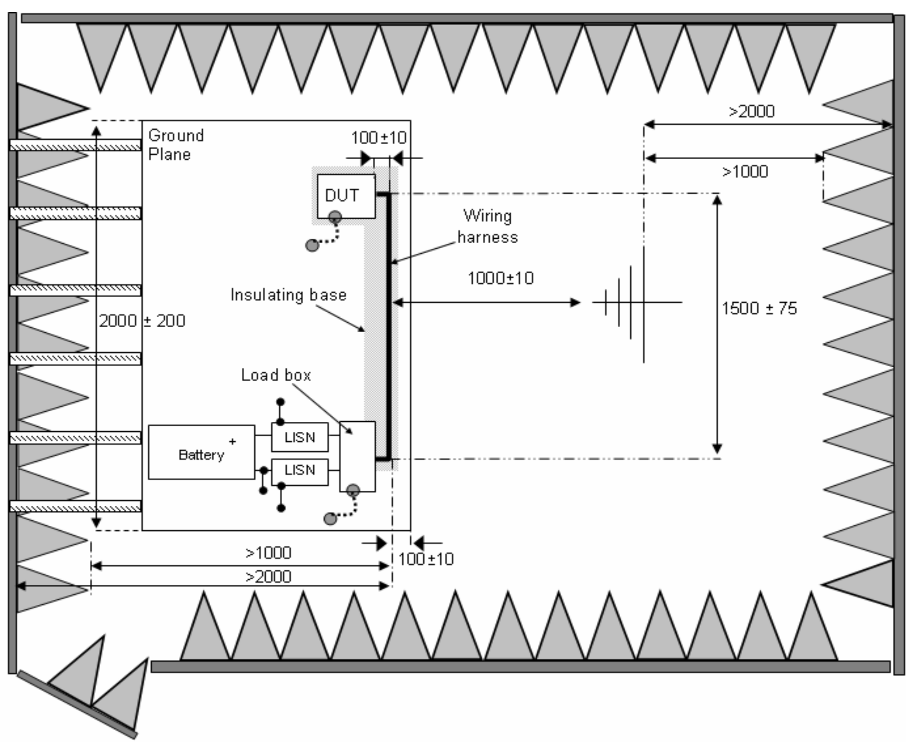


Figure 90. Test setup Log periodic antenna (Top view)

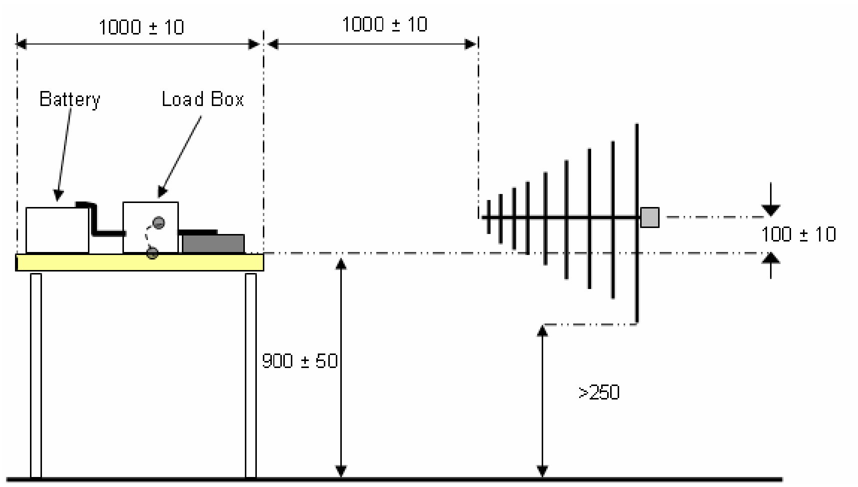


Figure 91. Test setup Log periodic antenna (Lateral view).

2. Test setup Horn antenna:

Dimensions in millimeters – not to scale

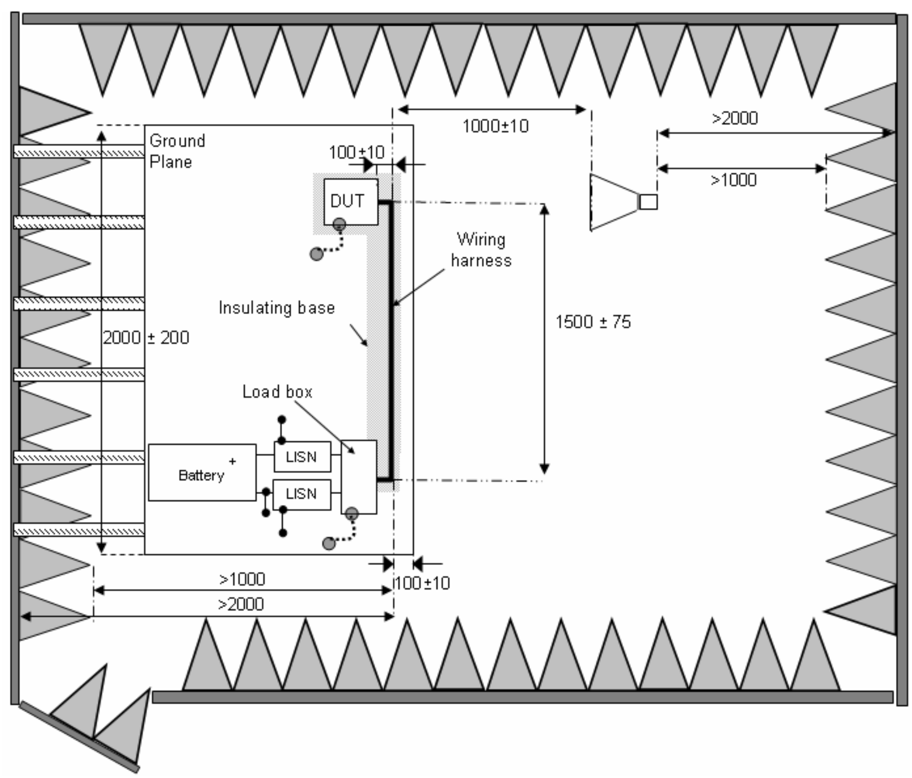


Figure 92. Test setup Horn antenna (Top view).

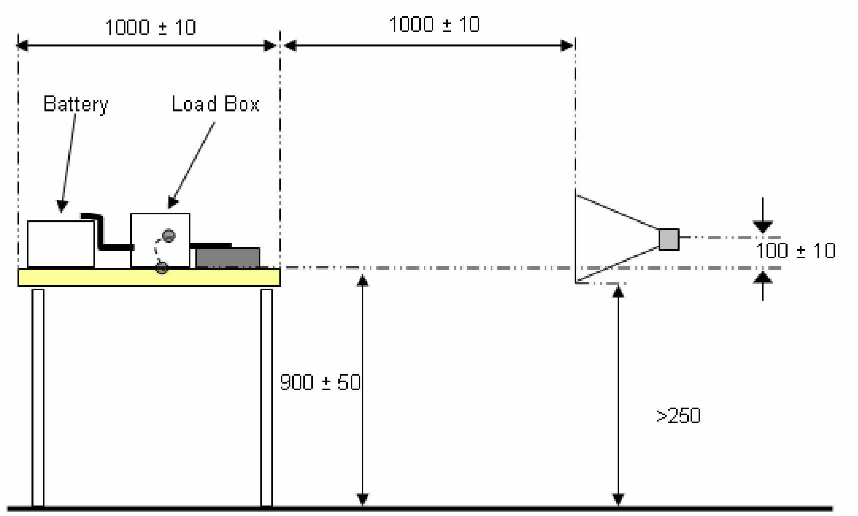


Figure 93. Test setup Horn antenna (Lateral view).

G. Test setup Front view:

Dimensions in millimeters – not to scale

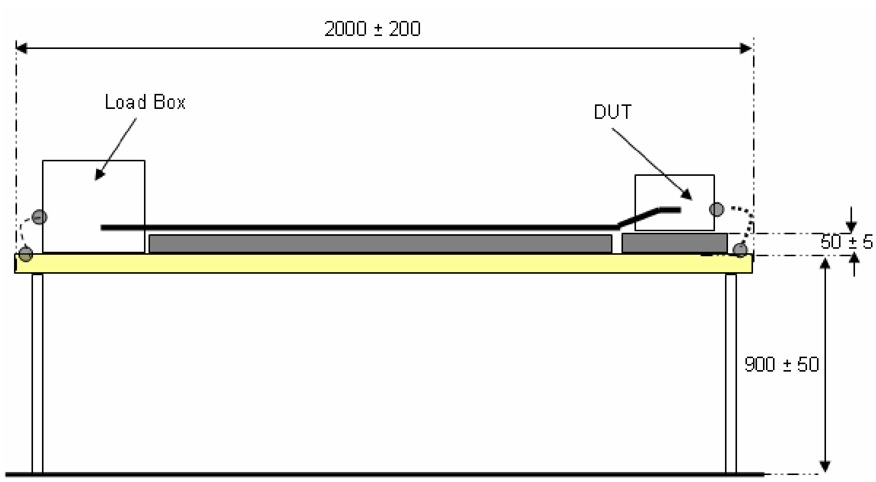


Figure 94. Test setup (front view).

Test:

- The test shall be performed in Substitution method with Forward power.
- Set the DUT following the test setup across the Figure 88 Figure 94 (depending of the frequency range to be test).

- Increase the forward power applied to the field-generating device in steps of 3 dB and measure the forward power until reaches the forward power applied during the calibration procedure. Apply the corresponding modulation.

- Record the field strength measured and the forward power applied.

- Check the DUT performance and all the associated loads. If a DUT failure is detected during the test procedure shown above, then the DUT susceptibility threshold shall be determinate.
- Decrease the forward power until the failure disappears. Increase the forward power slowly until the failure appears and then record field strength (E_{FAULT}), and the power applied (P_{FAULT}). These values shall be note in the test report.

- Reduce the forward power by 10 dB before change to the next frequency in order to avoid DUT failures in the frequency transitions. Change to the next frequency and repeat all the steps showing above for all the frequency range.

Acceptance criteria:

Severity Level	Functional Groups	Region of performance
200 V/m	D	I
	C	II
150 V/m	C	I
	B	II
100 V/m	B	I
	A	II

Table 83: Acceptance criteria

Test report requirements:

- Photos of the test setup.
- Grounding locations (DUT, Load box and LISN).
- DUT operation mode during the test.
- Description of the DUT position during the test (specifying the DUT side put in front of the field-generating device).
- Load box conditions during the test and description of the associated loads to evaluated the DUT performance.
- DUT monitoring tools used.
- Test graphs and test data tables with the following parameters: Frequency range, $E_{CALIBRATION}$ (V/m), $P_{CALIBRATION}$, E_{FAULT} (V/m), and P_{FAULT} for each test (CW, AM and PM modulations)
- A description of the failure (if any) specifying the frequency of failure, E_{FAULT}, P_{FAULT}, modulation, performance of the associated loads and the region of performance (according to the paragraph 2.4 of this document).
- Screen shot or screen captures of the oscilloscope (or monitoring tools) of the associated load performance's or DUT parameters when a failure appears.

3.4.3 IMMUNITY TO RADIATED MAGNETIC FIELDS

Reference documents: SAE J1113-22

Purpose of the test:

This test aims at checking operation of system under test when subjected to high intensity and low frequency magnetic fields (15 Hz to 30 kHz), such as those generated by power lines or transformer rooms nearby.

Test conditions:

General test conditions as described in SAE J1113-22.

-DUT 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 SAE J1113-22.

- Frequency range and severity level:

Magnetic field spectrum envelope (dB(µA) / m)		
Frequency band(Hz)	Engine compartment	Passenger compartment area
15 ~ 1000	170	150
1000 ~10000	170 - 40 x log (F/1000)	150 - 40 x log (F/1000)
10000 ~ 150000	130	110

Table 84. Severity levels

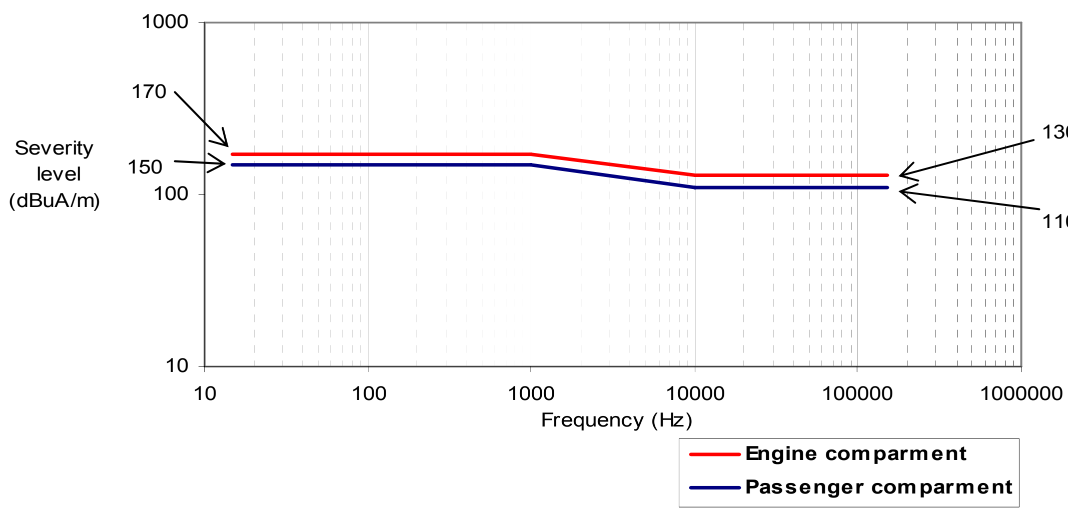


Figure 95. Severity levels and functional groups

- Step size:

Frequency range (Hz)	Step size (log)
15 ~100000	10 %
100000 ~ 150000	5 %

Table 85. Step size

- Dwell time: Shall be 3 sec minimum. This time shall be increased if necessary to monitor a complete functional cycle of the DUT. Between frequencies the current applied to the Helmholtz coils shall be reduced in order to avoid DUT failures in the frequency transitions

- Modulation:

Frequency range (Hz)	Modulation
15 ~ 150000	CW (sinusoidal)

Table 86. Modulations

- Test method: Substitution Method

- DUT position and orientation:

The test shall be performed in 3 DUT orientations or axis, as shown in Figure 96.

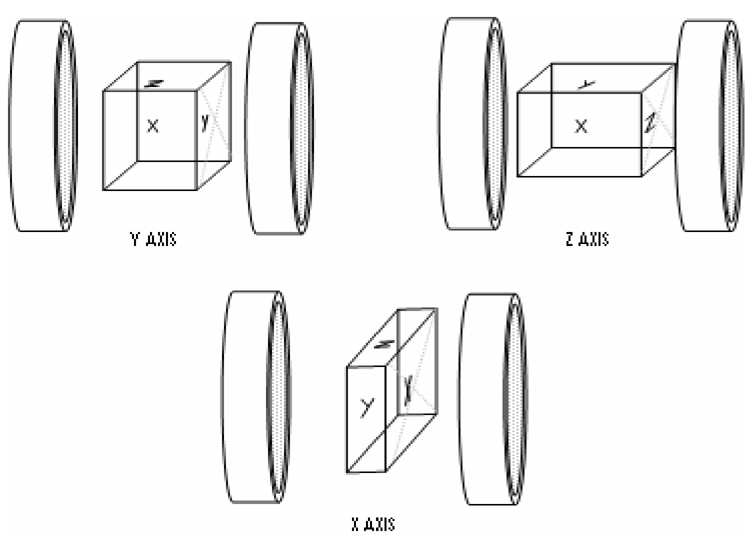


Figure 96. DUT orientations

DUT Operating modes:

Electronic modules at least in two modes: DUT normal operation (DUT in RUN MODE) and Standby or Sleep mode (DUT in KEY ON MODE).

Test fixture/load box requirements:

- The load box shall provide the correct load conditions to the DUT during all the operating modes under test.
- All the parameters related to the DUT performance shall be monitored during the test. The monitoring system of the Load box and the DUT parameters shall be described beforehand in the test plan and noted in the test report.

Test procedure:

Calibration:

As per SAE J1113-22 standard

- -Prior to start the test and with the Helmholtz coils empty, set the signal generator at 15 Hz and adjust the output current to generate the magnetic field shown in Figure 95 and Table 84

- -Record the current value and the signal generator level needed to obtain the magnetic field required.

- -Increase the frequency and repeat the previous procedure until the last frequency.

Test setup:

Dimensions in millimeters – not to scale

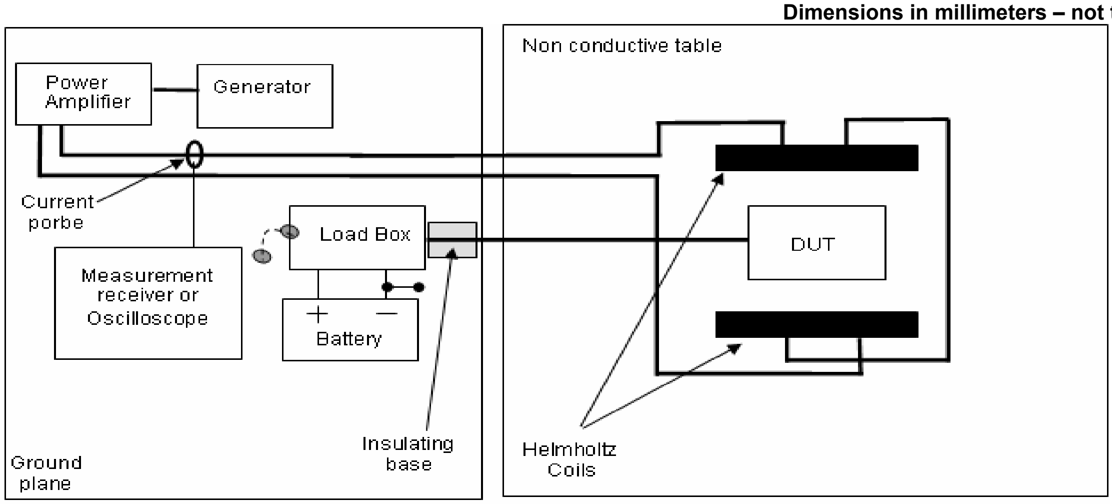


Figure 97. Test setup (Top view).

Dimensions in millimeters – not to scale

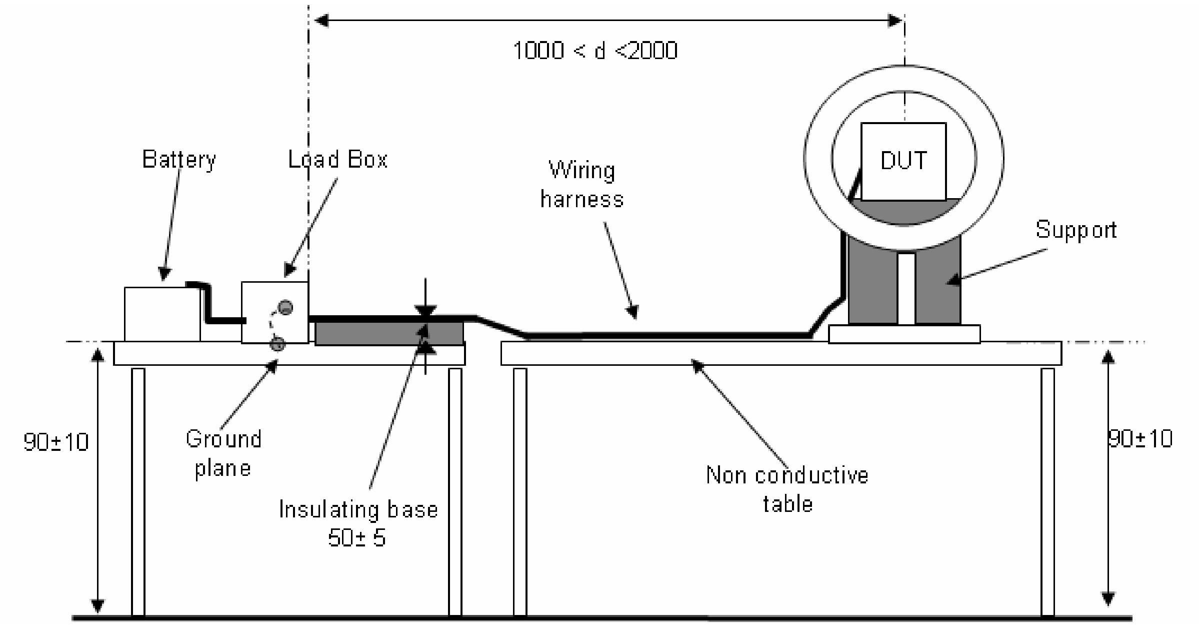


Figure 98. Test setup (Lateral view)

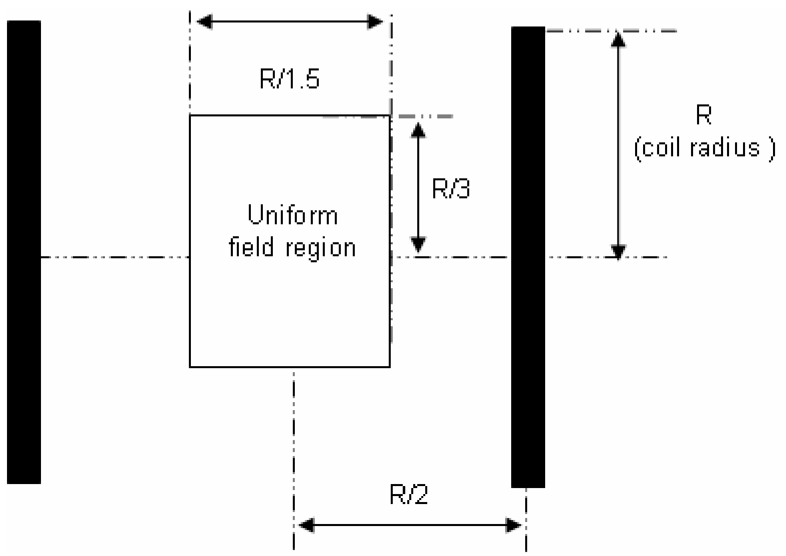


Figure 99. Test setup (Top view)

Test:

- The test shall be performed in Substitution method.
- Set the DUT in X axis as per the test setup across the Figure 96 (DUT orientations) Figure 97 and Figure 98.

- Set the signal generator at 15 Hz and increase the current applied to the Helmholtz coils slowly up to the current calibration value, obtained during the calibration procedure.

- Check the DUT performance and all the associated loads. If a DUT failure is detected during the test procedure shown above, then the DUT susceptibility threshold shall be determined.
- Decrease the current applied to the coils until the failure disappears. Increase the current coils slowly until the failure appears and then record the current level measured and calculate the magnetic field associated. These values shall be note in the test report.

- Reduce the current applied to the coils before change to the next frequency in order to avoid DUT failures in the frequency transitions. Change to the next frequency and repeat all the steps showing above for all the frequency range.

- Repeat all the test procedure for Y and Z DUT axis.

Acceptance criteria:

- There should not be malfunction during the test.
- Functional Performance region I, for all Functional Groups.

Test report requirements:

- Photos of the test setup.
- Grounding locations (DUT, Load box and LISN).
- DUT operation mode during the test.
- Description of the DUT position during the tests (X, Y or Z axis).
- Load box conditions during the test and description of the associated loads to evaluated the DUT performance.
- DUT monitoring tools used.
- A description of the failure (if apply) specifying the frequency of failure, magnetic field Immunity threshold, current coils measured, performance of the associated loads and the region of performance (according to the paragraph 2.4 of this document).
- Screen shot or screen captures of the oscilloscope (or monitoring tools) of the associated load performance's or DUT parameters when a failure appears.

3.4.4. IMMUNITY TO ONBOARD TRANSMITERS

Reference documents: No reference document is used.

Purpose of the test:

The purpose of this test is to verify the immunity of the DUT against radiated disturbances created by handheld transmitters, when used inside the passenger compartment of a vehicle. This test applies only to ESA's fitted in the passenger compartment.

Test conditions:

- The DUT shall be grounded as in the vehicle.

- **Power supply:** Standard 12 V/24 V Automotive battery with LISN.

- **Severity levels:** The test shall be performed in the frequencies, power conditions shown in the Table below:

MODULATION		FREQUENCY (MHz)	NET POWER (W)
CW		144	5.5
CW		159	5.5
CW		174	5.5
CW		410	7.5
CW		440	7.5
CW		470	7.5
TETRA	PM18Hz 50%	380	10
TETRA	PM18Hz 50%	390	10
TETRA	PM18Hz 50%	400	10
TETRA	PM18Hz 50%	410	10
TETRA	PM18Hz 50%	420	10
TETRA	PM18Hz 50%	450	10
TETRA	PM18Hz 50%	455	10
TETRA	PM18Hz 50%	460	10
TETRA	PM18Hz 50%	470	10
GSM850	PM 217 Hz 12.5%	824	10
GSM850	PM 217 Hz 12.5%	836	10
GSM850	PM 217 Hz 12.5%	849	10
TETRA	PM18Hz 50%	868	10
TETRA	PM18Hz 50%	878	10
TETRA	PM18Hz 50%	888	10
TETRA	PM18Hz 50%	915	10
TETRA	PM18Hz 50%	924	10
TETRA	PM18Hz 50%	933	10

MODULATION		FREQUENCY (MHz)	NET POWER (W)
GSM900	PM 217 Hz 12.5%	876	8
GSM900	PM 217 Hz 12.5%	896	8
GSM900	PM 217 Hz 12.5%	915	8
PDC	PM 50 Hz 50%	940	7.5
PDC	PM 50 Hz 50%	948	7.5
PDC	PM 50 Hz 50%	956	7.5
GSM1800/1900	PM 217 Hz 12.5%	1710	4
GSM1800/1900	PM 217 Hz 12.5%	1748	4
GSM1800/1900	PM 217 Hz 12.5%	1785	4
GSM1800/1900	PM 217 Hz 12.5%	1850	4
GSM1800/1900	PM 217 Hz 12.5%	1880	4
GSM1800/1900	PM 217 Hz 12.5%	1910	4
IMT-2000	PM-1600Hz 50%	1885	4.5
IMT-2000	PM-1600Hz 50%	1995	4.5
IMT-2000	PM-1600Hz 50%	2025	4.5
BLUETOOTH	PM-1600Hz 50%	2400	1
BLUETOOTH	PM-1600Hz 50%	2450	1
BLUETOOTH	PM-1600Hz 50%	2500	1

Table 87. Frequency range and severity levels

Note: The VSWR shall be less than 3:1

Test antennae:

- Rod or dipole antennae shall be used to perform the test up to 1 GHz
- Quarter wave tuned antennas or path antennae shall be used from 1 GHz.
- The test shall be performed in the frequencies and power shown in table 3.4.4.2.

Antenna location:
The handheld transmitters shall be placed in different positions around the DUT and its wiring harness following the Figure 103, Figure 104, Figure 105 and Figure 106 of this section.

Harness configuration:
The original DUT cables shall be used, if available. Otherwise, 1 m length cable exposure shall be used.

Dwell time:
Shall be 3 sec minimum. This time shall be increased if necessary, to monitor a complete functional cycle of the DUT. Between frequencies the power applied to the transmitter shall be reduced in order to avoid DUT failures in the frequency transitions.

Modulation: As per Table 87.

Test method: Close feedback loop method on NET power.

DUT Operating modes:

- Electronic modules and active modules shall be tested at least in two modes: DUT normal operation (DUT in RUN MODE) and Standby or Sleep mode (DUT in KEY ON MODE)
- EM shall be tested in RUN MODE in all the different speed configurations, otherwise specified in the test plan. The EM shall be tested also in KEY ON MODE.

Test fixture/load box requirements:

- The load box shall provide the correct load conditions to the DUT during all the operating modes tested.
- All the parameters related to the DUT performance shall be monitored during the test. The monitoring system of the Load box and the DUT parameters shall be described beforehand in the test plan and noted in the test report.

- **Test procedure:**

Calibration setup:

Dimensions in millimeters – not to scale

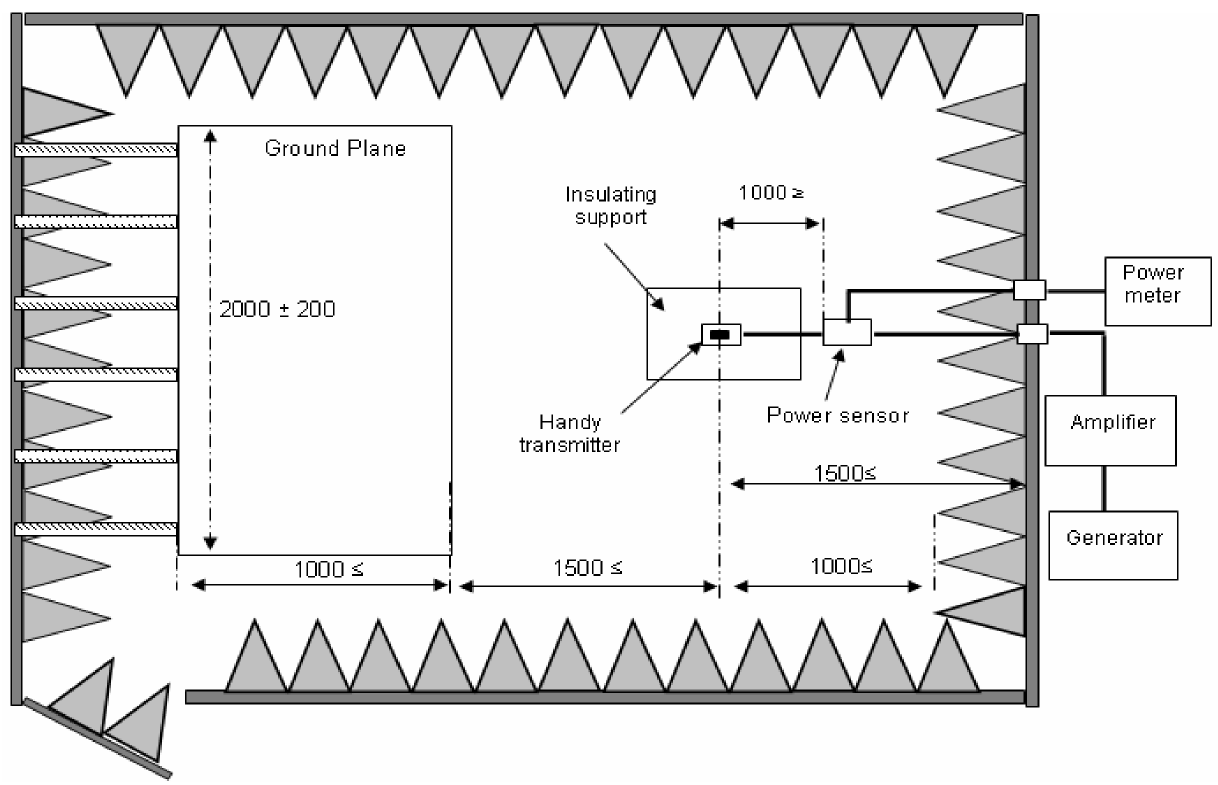


Figure 100. Calibration setup (Top view).

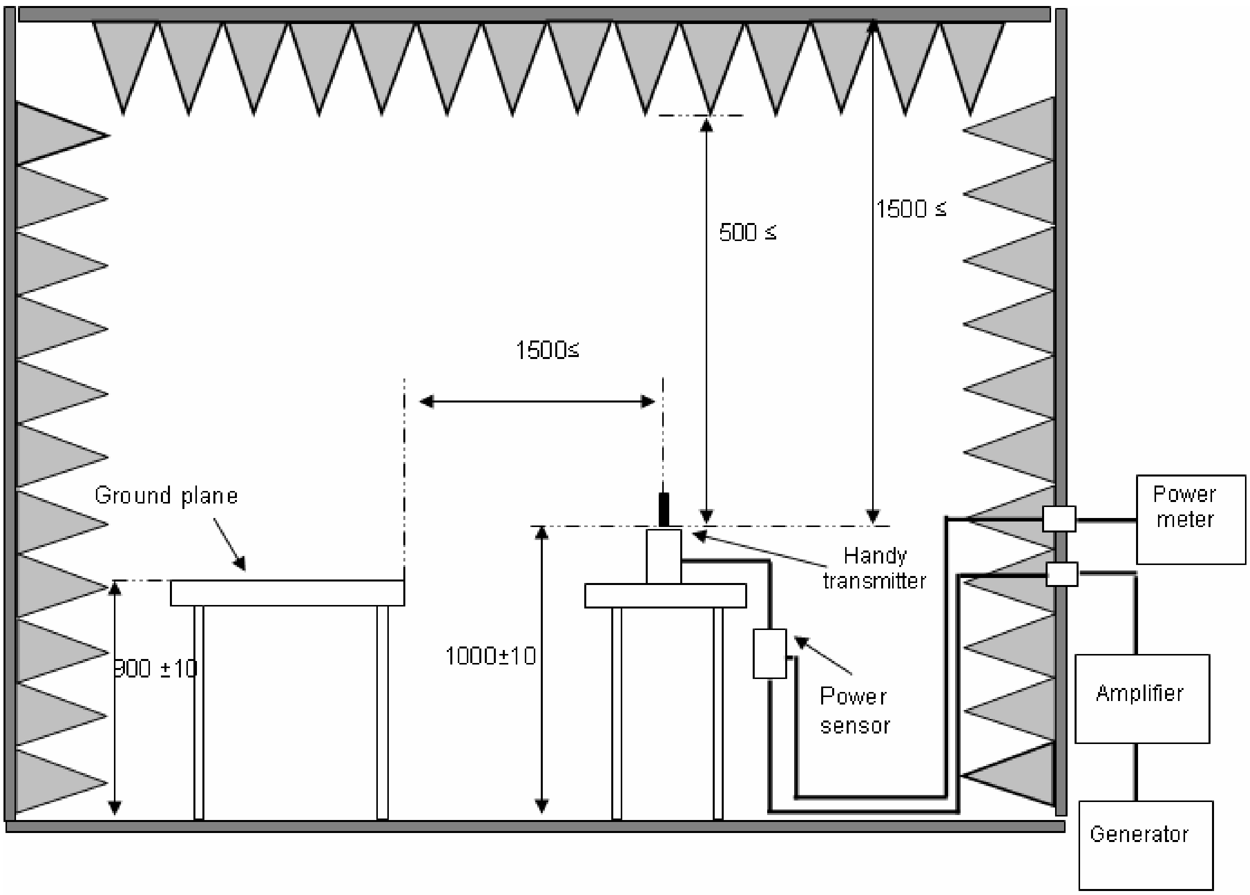


Figure 101. Calibration setup (Front view).

Calibration method:

- In order to obtain the measure of the Net power, a power meter with at least 2 channels shall be used to read the forward and reverse power (Net power = Forward power – Reverse power).
- Set the test setup as shown in Figure 100 and Figure 101.
- Increase the power applied to the handheld transmitter to obtain the Net Power shown in Table 87 for the actual frequency. Special care shall be taken to compliance the VSWR condition.
- -Record the forward power needed to obtain the Net power required.
- Repeat all the procedure shown above for each frequency and condition listed in the Table 87.

Test setup:

Dimensions in millimeters – not to scale

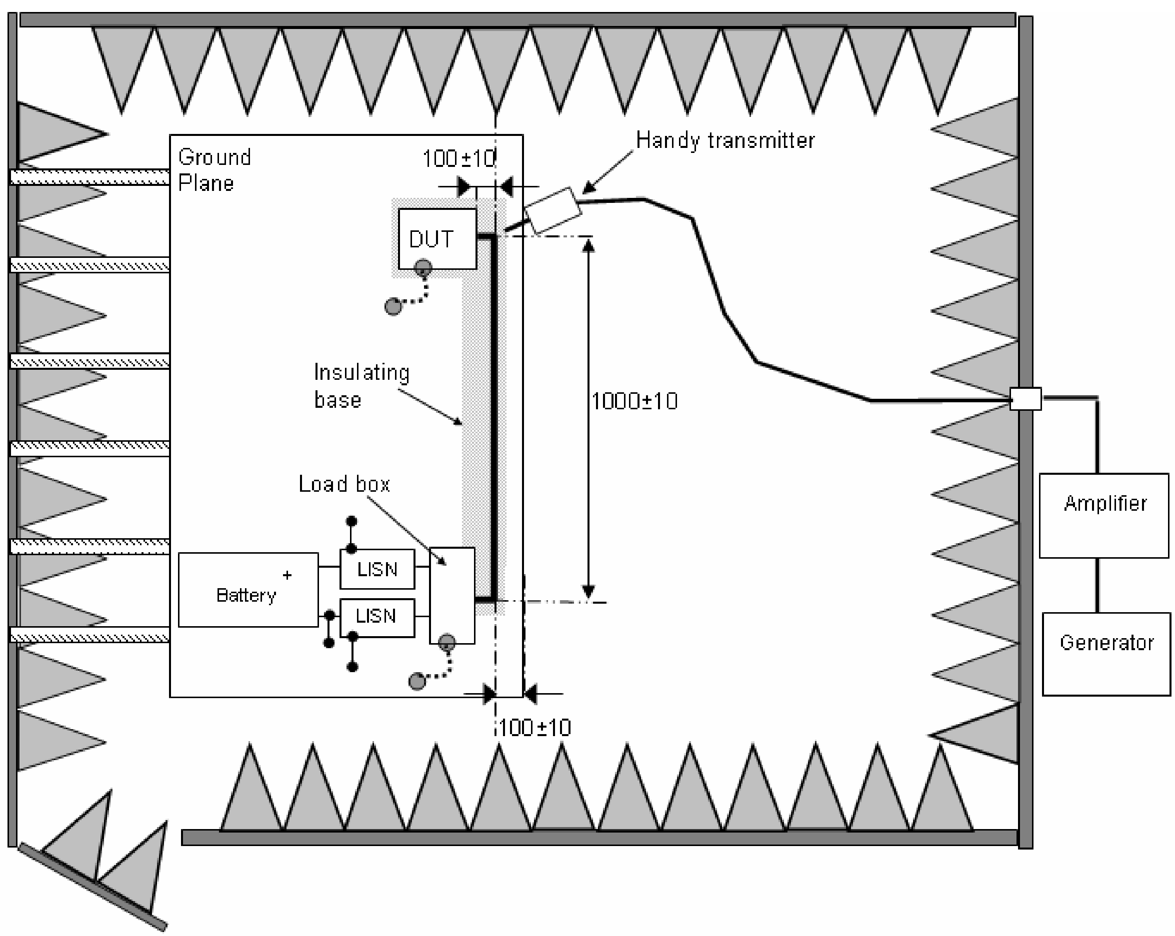


Figure 102. Test setup (Top view).

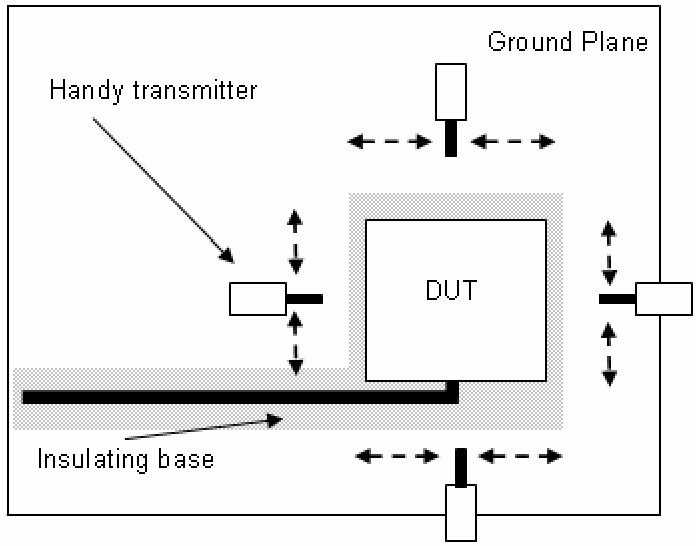


Figure 103. Handy transmitter positions in lateral faces of the DUT (Top view).

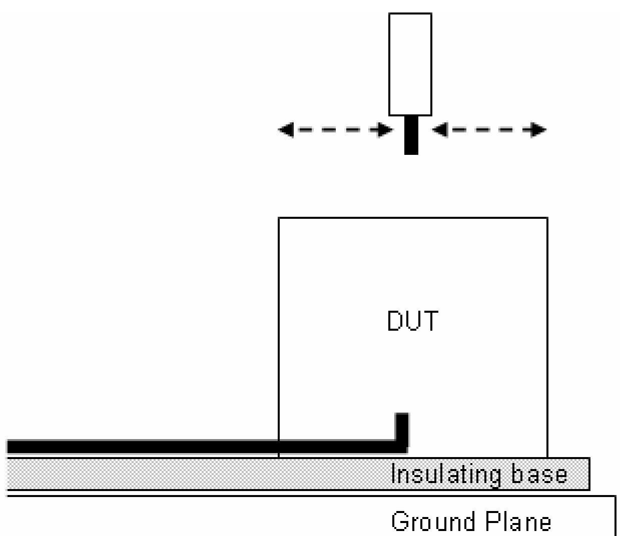


Figure 104. Handy transmitter positions in up faces of the DUT (Front view).

Dimensions in millimeters – not to scale

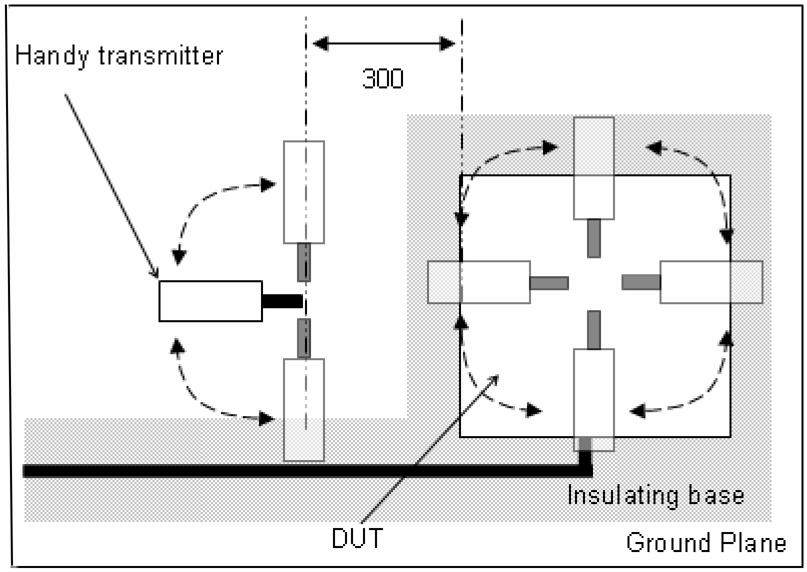


Figure 105. Angle positions in up and lateral faces of the DUT (Top view).

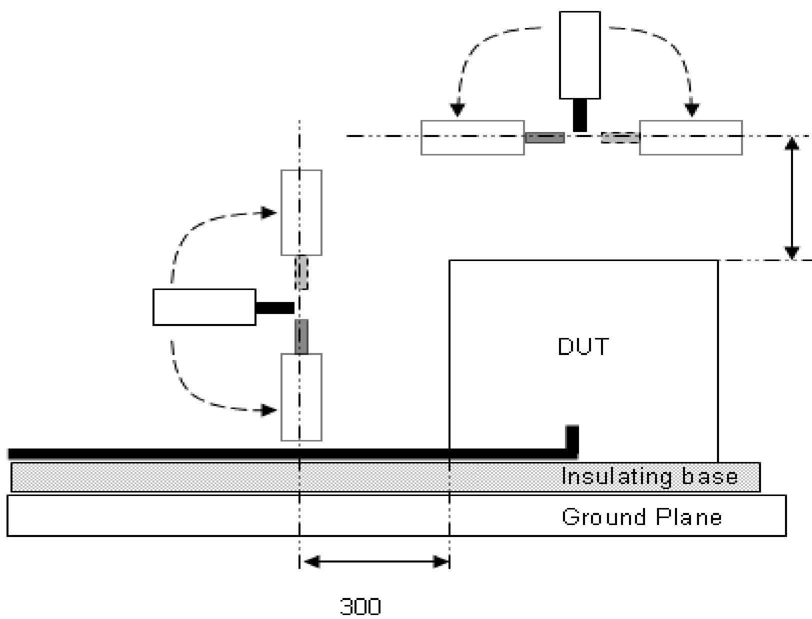


Figure 106. Angle positions in up and lateral faces of the DUT (Front view).

Test:

- Set the DUT as per the test setup shown in Figure 102.
- Apply the forward power level of the calibration procedure to the handheld transmitter simulator.
- Place the handheld transmitter in front of every face of the DUT from a distance of 30 cm and turn the angle of it in respect to the DUT case in azimuth and elevation as shown across the Figure 103 through Figure 106.
- If no failure appears, decrease the distance to the DUT surface until the DUT fails or until the distance between the handheld transmitter and the DUT case is 0 mm, by turning the handheld transmitter angle as specified in the previous point.
- Repeat previous points in front of every face of the DUT and in parallel to the wiring harness exposure.

Acceptance criteria:

Distance test antenna - DUT	Functional Groups	Region of performance
0 mm	C and D	I
	A and B	III
10 mm ≤ d ≤ 30 mm	C and D	I
	A and B	II
30 mm ≤ d ≤ 50 mm	B, C and D	I
	A	II
d > 50 mm	A, B, C and D	I

Table 88 Acceptance criteria onboard transmitter test

Test report requirements:

- Photos of the test setup.
- Grounding locations (DUT, Load box and LISN).
- DUT operation mode during the test.
- Description of the handheld transmitter positions during the test and DUT sides or faces tested.
- Load box conditions during the test and description of the associated loads to evaluated the DUT performance.
- DUT monitoring tools used.
- Data table with the following parameters measured during the calibration: Frequency, Forward power, Reverse power, Net power and VSWR.
- Data table with the following parameters measured during the test: Frequency, Forward power, Reverse power and VSWR.
- A description of the failure (if apply) specifying the frequency of failure, handheld transmitter position, DUT side, distance between handheld transmitter antenna and DUT, performance of the associated loads and the region of performance (according to the paragraph 2.4 of this document).

3.5 ELECTROSTATIC DISCHARGE

Reference document: ISO 10605

Purpose of the test:

The purpose of the test is to check the correct performance of the electric/electronic equipments of the vehicle against electrostatic discharges, in accordance with ISO10605.

3.5.1 POWERED ESD

Test condition: General test conditions as per ISO 10605.

- As described in the ISO 10605 specification.
- The test shall start with the minimum severity level and shall be increased up to the maximum level.
- Discharge points: Potentially all points which can be touched by the user during packaging, installation or dismantling when the DUT is powered.
- The ESD simulator with a discharge network of C = 330 pF and R = 2 kΩ shall be used. When the DUT is placed in the passenger compartment and is directly accessible from outside the vehicle a C = 150 pF shall be used.
- Relative humidity should be 20% ... 60% (under 30%, preferred).
- The voltage values indicated in Table 89 shall be used for testing.

Type of discharge	Severity Level	Human body model	No. Of discharges per test point and recovery time	Discharge points	Functional status for all system
Direct discharge	± 6 kV	2 kΩ /330 pF	10+ and 10-; 5 s	All shafts, buttons, switches and surfaces accessible to vehicle occupants plus CAN terminations with 1 m of harness.	**Region I**
Direct discharge	± 8 kV	2 kΩ /330 pF	10+ and 10-; 5 s	As above	**Region I**
Air discharge	± 8 kV	2 kΩ /330 pF	10+ and 10-; 5 s	As above	**Region I**
Air discharge	± 15 kV	2 kΩ /330 pF	10+ and 10-; 5s	As above	**Region I**
Air discharge	± 25 KV	2 kΩ /150 pF	10+ and 10-; 5s	Devices in the passenger compartment that are directly accessible from outside the vehicle (e.g. Door lock switch, Instrument cluster)	**Region II**

Table 89: ESD component test (powered mode) requirements

DUT Operating modes:

- Electronic modules and active modules shall be tested at least in two modes: DUT normal operation (DUT in RUN MODE) and Standby or Sleep mode (DUT in KEY ON MODE).
- Passive modules shall be tested at normal operation (DUT in RUN mode).
- EM shall be tested in RUN MODE in all the different speed configurations, otherwise specified in the test plan. The EM shall be tested also in KEY ON MODE.

Test fixture/load box requirements:

- The load box shall provide the correct load conditions to the DUT during all the operating modes under test.
- All the parameters related to the DUT performance shall be monitored during the test. The monitoring system of the Load box and the DUT parameters shall be described beforehand in the test plan and noted in the test report.

Test procedure:

Calibration:

The ESD simulation shall be calibrated as per ISO 10605.

Test setup:

Dimensions in millimeters – not to scale

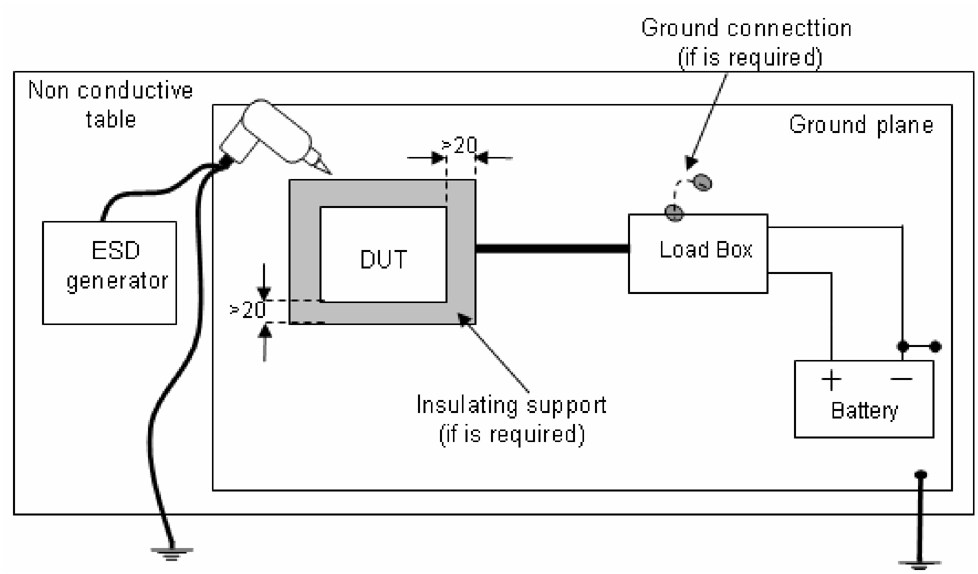


Figure 107. Test setup Powered ESD (Top view).

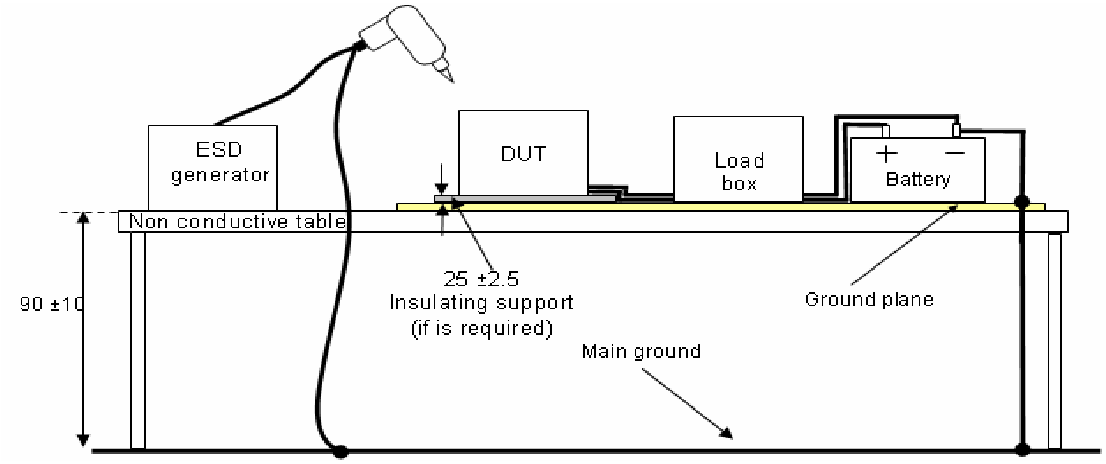


Figure 108. Test setup Powered ESD (Front view).

Test:

- Set the DUT as per the test setup shown in Figure 107 and 108.
- Set the DUT during 10 minutes in RUN mode.

Direct discharges:

- Configure the ESD simulator with the 2 kΩ /330 pF discharge network and -6 kV of severity level. Place the ESD simulator in contact with the discharge points shown in Table 89 and perform 10 discharges spaced out by 5 s. Check the correct operation of the DUT and all the associated loads after the discharges.
- Configure the ESD simulator with the 2 kΩ /330 pF discharge network and +6 kV of severity level. Place the ESD simulator in contact with the discharge points shown in the Table 89 and perform 10 discharges spaced out by 5 s. Check the correct operation of the DUT and all the associated loads after the discharges.

- Repeat the test for a severity level of ± 8 kV.

Air discharges:

- Configure the ESD simulator with the 2 kΩ /330 pF discharge network and – 8 kV of severity level. Place the ESD simulator perpendicular to the discharge point shown in the Table 89 and move it slowly towards the DUT until a single discharge is obtained. If the discharge is not obtained move the ESD simulator around the discharge point and reduce the GAP until place the ESD simulator in contact with the discharge point. Perform 10 discharges spaced out by 5 s. Check the correct operation of the DUT and all the associated loads after the discharges.

- Configure the ESD simulator with the 2 kΩ /330 pF discharge network and + 8 kV of severity level. Place the ESD simulator perpendicular to the discharge point shown in the Table 89 and move it slowly towards the DUT until a single discharge is obtained. If not obtain the discharge, move the ESD simulator around the discharge point and reduce the GAP until place the ESD simulator in contact with the discharge point. Perform 10 discharges spaced out by 5 s. Check the correct operation of the DUT and all the associated loads after the discharges.

- Repeat the test for a severity level of ± 15 kV and after for ± 25 kV.

Acceptance criteria:

- No damage to the device shall occur.
- No degradation is permissible during the function testing, after exposure.
- To meet region of performance as specified in table: 89.

Test Report requirements:

- List of equipment used during the test.
- Test setup and grounding conditions used (remotely or locally ground connection and ground case conditions for the DUT and load box).
- Climatic conditions during the test. Temperature and humidity.
- Photos of the test setup.
- DUT operation mode during all the measurements.
- Load box conditions during all the measurements (data table with all the associated loads activated).
- Parameters monitored during the test.
- Description and pictures of the DUT discharge points (direct and air discharge points)
- Table with the severity level tested, test conditions and DUT result evaluated following the acceptance criteria shown in the Table 89.

3.5.2 UNPOWERED ESD (PACKAGING AND HANDLING)

Test condition: General test conditions as per ISO 10605.

- As described in the ISO 10605 specification.
- Discharge points: Potentially all points which can be touched by the user during packaging, installation or dismantling.
- The ESD simulator with a discharge network of C = 150 pF and R = 2 kΩ shall be used.
- Relative humidity should be 20% ... 60% (under 30%, preferred).
- The voltage values indicated in Table 90 shall be used for testing.

Type of discharge	Test Level	Human Body model	No. Of discharges per test point and recovery time	Discharge points	Functional status for all systems
Direct discharge	± 6 kV	2 kΩ /150 pF	10+ and 10-; 5 s	Each connector, each separate exposed surface, seam and components	DUT shall operate in region I before and after the test.*
Direct discharge	± 8 kV	2 kΩ /150 pF	10+ and 10-; 5 s	Each connector, each separate exposed surface, seam and components	
Air discharge	± 8 kV	2kΩ /150 pF	10+ and 10-; 5 s	Each connector, each separate exposed surface, seam and components	
Air discharge	± 15 kV	2 kΩ /150 pF	10+ and 10-; 5 s	ECU case Only	
Air discharge	± 25 kV	2 kΩ /150 pF	10+ and 10-; 5 s	ECU case Only	

Table 90: ESD component test (packaging and handling) requirements

*: The component parameter values (e. g. resistance, capacitance, leakage current etc.) shall be within the specified limits.

DUT operating modes:

- All the DUT are tested in NOT OPERATING mode.

Test fixture/load box requirements:

- The load box is not required to perform the test

Test procedure:

Calibration:

The ESD simulation shall be calibrated as per ISO 10605.

Test setup:

Dimensions in millimeters – not to scale

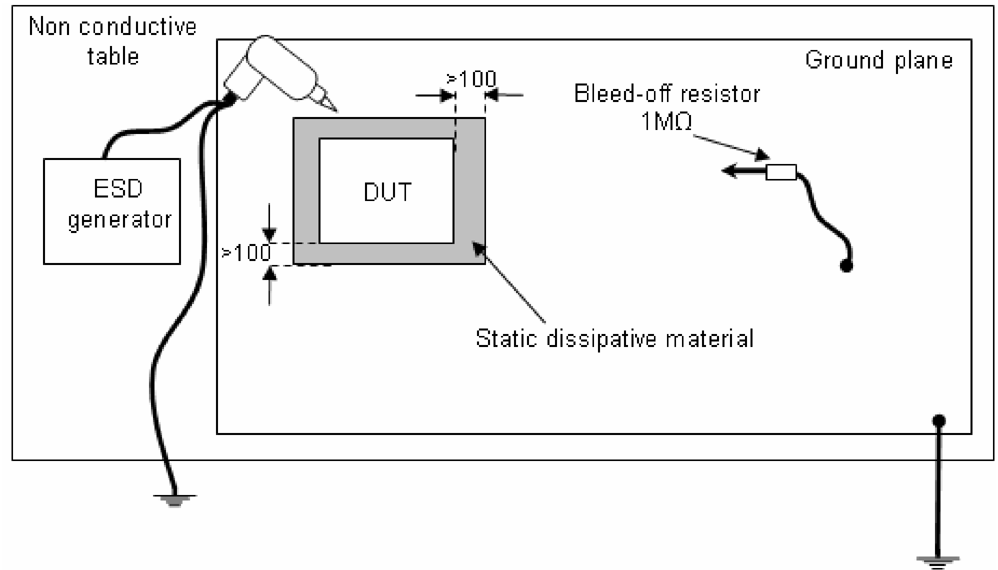


Figure 109. Test setup Unpowered ESD (Top view).

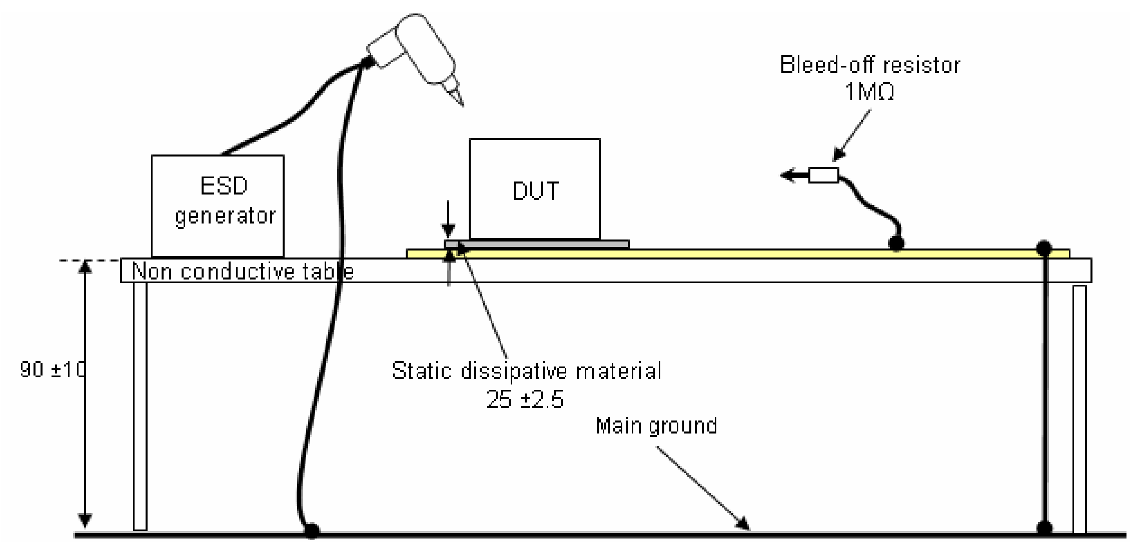


Figure 110. Test setup Powered ESD (Front view)

Test:

- Set the DUT as per the test setup shown in Figure 109 and 110.
- Direct discharges: Configure the ESD simulator with the 2 kΩ /150 pF discharge network and – 6 kV of severity level. Place the ESD simulator in contact with the discharge points shown in the Table 90 and perform 10 discharges spaced out by 5 s. Connect the DUT to the power supply and check the correct operation of the DUT and all the associated loads after the discharges.
- Configure the ESD simulator with the 2 kΩ /150 pF discharge network and + 6 kV of severity level. Place the ESD simulator in contact with the discharge points shown in Table 90 and perform 10 discharges spaced out by 5 s. Connect the DUT to the power supply and check the correct operation of the DUT and all the associated loads after the discharges.
- Repeat the test for a severity level of ± 8 kV.
- Air discharges: Configure the ESD simulator with the 2 kΩ /150 pF discharge network and - 8 kV of severity level. Place the ESD simulator perpendicular to the discharge point shown in the Table 90 and move it slowly towards the DUT until a single discharge is obtained. If not obtain the discharge, move the ESD simulator around the discharge point and reduce the GAP until place the ESD simulator in contact with the discharge point. Perform 10 discharges spaced out by 5 s. Connect the DUT to the power supply and check the correct operation of the DUT and all the associated loads after the discharges.
- Configure the ESD simulator with the 2 kΩ /150 pF discharge network and + 8 kV of severity level. Place the ESD simulator perpendicular to the discharge point shown in the Table 90 and move it slowly towards the DUT until a single discharge is obtained. If not obtain the discharge, move the ESD simulator around the discharge point and reduce the GAP until place the ESD simulator in contact with the discharge point. Perform 10 discharges spaced out by 5 s. Connect the DUT to the power supply and check the correct operation of the DUT and all the associated loads after the discharges.
- Repeat the test for a severity level of ± 15 kV and after for ± 25 kV.

Acceptance criteria:

- No damage to the device shall occur.
- No degradation is permissible during the function testing, after exposure.
- To meet region of performance as specified in table: 17.

Test Report requirements:

- List of equipment used during the test.
- Test setup used.
- Climatic conditions during the test. Temperature and humidity.
- Photos of the test setup.
- Description and pictures of the DUT discharge points (direct and air discharge points)
- Table with the severity level tested, test conditions and DUT result evaluated following the acceptance criteria shown in Table 90

4.0 ANNEXURES

ANNEXURE I: FUNCTIONAL GROUP EXAMPLES

Group A Functions:

- antenna module operation
- auxiliary car heater operation
- chime operation (non-regulatory function)
- climate control display
- electronic compass operation
- Entertainment systems operation (radio, navigation, video, voice recognition system, CD, phone) if due to any EMC disturbance the noise of the speakers is increased and can exalt the vehicle driver then this function shall be transferred to Group C.
- front park and marker lamp operation (non-regulatory)
- headlamp cleaning operation when non xenon lamps are used. If Xenon lamps are used, this function shall be transferred to Group C.
- illuminated entry operation
- informational diagnostic capability (non-regulatory)
- instrument cluster non-regulatory functions & convenience indicators
- rain sensor operation
- 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:

- chime operation (regulatory function)
- electronic climate control functions that do not compromise windshield defrost system operation
- engine RPM stability (e.g. ± 200 RPM)
- instrument cluster enhancement functions (fuel gauge indicators, temperature indicator, etc)
- interior illumination stability
- license plate lamp operation and daytime running lights (regulatory function)
- motor cooling fan operation
- power door lock, trunk/hatch and trailer hitch release stability
- operating range stability of the remote keyless entry
- tire pressure monitoring
- vehicle electrical charging system (alternator)
- vehicle immobilizer operation (at minimum range)

Group C Functions:

- anti-lock brake system operation
- intermittent windshield wiper operation
- mirror stability (rearview and outside)
- vehicle anti-theft system operation
- vehicle speed control stability (e.g. ± 5 km/h)
- headlight dimming/optical warning
- rear wiper operation ability
- automatic headlamp operation

- back-up lamp operation (regulatory function)
- brake lamp and center high mounted brake light operation (regulatory function)
- brake system malfunction indicator lamp (MIL)
- child occupancy detection operation
- data bus system (CAN-B, LIN-Bus, etc)
- diagnostic memory stability
- Electronic stability program (ESP) stability including steering angle sensor stability
- electronic transmission control
- engine acceleration control
- engine stall control
- fog lamp/high beam interlock operation (regulatory function)
- headlamp and tail lamp operation
- headlamp leveling operation
- horn operation (regulatory function)
- inflatable restraints operation (non electronic control)
- instrument cluster (malfunction information, odometer, speedometer operation, regulated warnings)
- malfunction indicator lamp (MIL) (regulatory function)
- neutral start function (regulatory function)
- park and marker lamp operation (regulatory function)
- park brake indicator lamp operation (regulatory function)
- photo-chromatic mirror operation
- power door 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 (regulatory function)
- seat belt operation
- start ability or Key in/Cranking
- steering wheel positioning stability
- suspension system stability (air leveling system, active body control)
- turn signal and indicator operation (regulatory function)
- vehicle braking ability
- vehicle immobilizer stability
- vehicle steering ability
- windshield defrost system operation
- windshield washer
- windshield wiper operation ability

Group D Functions:
Any function that has the potential to inadvertently deploy a passive restraint system, actuated by an electro explosive device (EED).

Note: This list is not necessarily all-inclusive functions in a vehicle. In the case of an E/E equipment or ESA with a functionality not included in the previous list, it shall be classified as agreement between TATA MOTORS, ERC department and the supplier.

ANNEXURE II. LIST OF TABLES

ANNEXURE III. LIST OF FIGURES