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EMC SYSTEM AND COMPONENT REQUIREMENTS
Electromagnetic Compatibility Specification

EMC SYSTEM AND COMPONENT REQUIREMENTS
Electromagnetic Compatibility Specification

This engineering specification addresses Electromagnetic Compatibility (EMC) requirements at component level. These requirements have been developed to assure compliance with present and anticipated regulations in addition to customer satisfaction regarding EMC.

This engineering specification defines the Electromagnetic Compatibility (EMC) requirements, test methods and test procedures for components used by Volvo Car Group (VCC). The purpose of this specification is to secure vehicle level Electromagnetic Compatibility.

Electro explosive devices (e.g. inflator/initiator/squib) are exempt from the EMC requirements as detailed in this specification; they are covered by USCAR-28.

Note: In the event of a conflict between the text of this specification and the documents cited herein, the text of this specification takes precedence. However, nothing in the specification supersedes applicable laws and regulations unless a specific exemption has been obtained.

Contents

1. Scope

This specification presents EMC requirements and test methods that have been developed for components independent of the vehicle. This requirement is designed to reduce the number of interference issues during vehicle integration and to secure VP builds.

The purpose of component testing is the qualification of EMC, in order for the component to be allowed into a test vehicle for final verification. However, vehicle level analysis and testing is not a substitute for component/subsystem conformance to this specification. The test results will also be used during virtual verification.

The EMC part of vehicle homologation is based on the availability of EMC Component test reports.

2. Use of this Specification

The requirements and test methods in this specification are based on international standards wherever possible. If international standards do not exist, military, and corporate standards are used.
The following steps shall be taken by the VCC Design engineer and the supplier for assuring EMC compliance of their component:

1. Identify which EMC tests are applicable.
2. Develop an EMC test plan based on the VCC template and obtain VCC EMC Department approval.
3. Perform testing at an accredited test facility, see section 5.1.
4. EMC DV Testing shall be completed and the test report approved by VCC no later than the FDJ milestone.
5. Compliance to the EMC requirements shall be determined by the VCC EMC department and the Design engineer after review of the test results submitted by the test laboratory.
6. EMC PV testing is only required if the design tested during DV have been changed, the timing shall support the PPAP process.

The VCC EMC department reserves the right to perform audit testing or witness supplier design verification (DV) on sample parts in order to verify compliance with this specification.

2.1 Test facility Requirements

For a test facility to be accepted by VCC it shall fulfil the following requirements:

- Proof of accreditation to ISO 17025 and to the International Standards referenced in the test report by an ILAC MRA signatory body.
- Name, telephone number and email of the person responsible for maintaining the accreditation in the organization.

VCC reserves the right to arrange for follow-up correlation tests and/or on site visits to evaluate the test methods presented herein. A laboratory which refuses such follow-up activities, or for which significant discrepancies are found is subject to having all of its reports disqualified.

2.2 Sample Size

A minimum of two samples of each part number shall be tested against each requirement. Both samples must pass the test. A reduction of the number of samples must be accompanied with an analysis showing the rationale for accepting the sample reduction.

2.3 Sequence of Testing

ESD tests shall be performed on separate samples. These samples shall then be subjected to an ISO 16750-4 5.3.2, Rapid change of temperature with specified transition duration, 200 cycles with a dwell time of at least 1h. Following this the I/O parametric values shall be revalidated.

Perform the remaining EMC tests on non ESD tested samples in any order. This is to prevent the EMC validation to be performed on possibly degraded samples.

2.4 Revalidation

To assure that EMC requirements are continually met, validation according to this specification is required when any circuit or PCB design change occur (e.g. component replacement, die shrinks, new PCB layout). This shall be documented in the MOC.

2.5 Data Reporting & Data Review

All test data shall be reviewed by the VCC EMC department. All Test reports shall contain the approved test plan reference number. The test report shall be released by the supplier according to the requirements in ISO 17025.

3. Immunity Pass/Fail criteria

The purpose of the EMC immunity test is to verify that the DUT can perform its intended function in the vehicle electrical environment.
All of the DUT I/O and/or designed functions must be stimulated and monitored during the immunity tests. Each function is assigned a Functional importance classification; each I/O will inherit the classification from the functions it realizes. This and the Function performance class (based on I/O accuracy) are used during the EMC immunity test to determine Pass/Fail.

3.1 Functional Importance Classification

All functions in the vehicle shall be classified according to importance during normal operation.

Affected factors for the classification are:

VCC internal requirements
Legal requirements
Authority expectations

Inputs and outputs used by any FIC C classified function shall comply with the Immunity limits given for FIC C.

FIC C is defined as:

Functional Importance Class C - Any function that may be essential to the safe operation and control of the vehicle.

3.2 Function Performance Status Classification

During Immunity testing all inputs and outputs, both electrical and non-electrical shall be monitored and recorded. The ISO FPSC Status I and Status II definitions given in **ISO 11452-1:2005/ Amd.1:2009** shall be interpreted as given below.

Status I
The input or output under test performs as designed during and after exposure to disturbance. The pass/fail criteria is based on the hardware design, see 1 below, or a vehicle based criteria can be used, see 2 below.

1. An input or output is considered to have passed the test if its value remains within the designed tolerance during and after the test. Communication interfaces are not allowed to generate communication errors or transmit false messages.
2. Actual tolerance requirement can be determined from system/function simulations where the function with the most stringent tolerance requirement sets the pass/fail criteria for each I/O. This shall be defined in the TR/DPR.

During Conducted Immunity transient and ESD testing, the value may deviate, but must return to its designed value immediately after the transient. Resets are not allowed. One communication error or data message corruption is allowed for each transient occurrence or transient burst (ISO 7637, pulse 3a and 3b).

Status II
The input or output under test does not fulfil Status I pass/fail criteria (as given above) during exposure but returns automatically to normal operation after exposure is removed.

Status III
This status is not used.

Status IV
DUT shall return to Status I on the first power up cycle after each test sequence. Removing and reattaching the connection to kl30 is not allowed in the power up cycle.

4. Model and HW/SW deliverables

The supplier shall deliver the models required for virtual validation of EMC performance when integrated in the vehicle.

The supplier shall deliver the hardware and software required to perform the physical EMC integration, including all variants if applicable.

5. Vehicle Level Requirements

In addition to meeting the requirements specified herein, components shall comply with the vehicle EMC requirements when installed in the vehicle. Vehicle verification testing is performed by VCC. Failure to meet the requirements may result in redesign and revalidation with full support from the supplier. Additional component and vehicle level EMC requirements may be imposed reflecting conditions in specific markets.

6. Applicable tests

Based on the used technologies in the component the following matrix identifies the applicable tests, more than one column may apply to the DUT.

Applicable tests

Requirement		Used technologies					
		Passive (Resistors and capacitors)	Diodes and thermistors	Solenoids, relays and Electromechanical horns	Electric motor	Transistor IC:s and uC	RF Receiver or Transmitter
RE01	RF Emission Magnetic near field				X	X	
RE02	RF Emission Magnetic and Electric far field				X	X	
RE03	RF Emission Electric field, ALSE				X	X	
RE04	RF Emission Conducted Current				X	X	
RI01	RF Immunity Magnetic field		X			X	
RI02	RF Immunity Harness Excitation (BCI)		X			X	
RI03	RF Immunity ALSE		X			X	
RI04	RF Immunity, Portable transmitter						X
RI05	RF Immunity, Wireless receiving devices						X
CE01	Transient Emission			X	X	X	
CI01	Transient Immunity Power lines					X	
CI02	Transient Immunity Signal lines					X	
ESD01	Electrostatic Discharge (Un-Powered / Handling)	X	X			X	
ESD02	Electrostatic Discharge (Powered)	X	X			X	

On board battery chargers and other mains connected devices shall fulfil the requirements given in paragraph 13.

7. References

7.1 International documents

Only the specified version of the standard is applicable.

ISO/IEC 17025 General requirements for the competence of testing and calibration laboratories
ISO 11452-1:2005/Amd.1:2009 Road vehicles — Component test methods for electrical disturbances from narrowband radiated electromagnetic energy — Part 1: General principles and terminology
CISPR 25 3rd Ed Limits and methods of measurement of radio disturbance characteristics for the protection of receivers used on board vehicles

SAE J551-5 Rev JAN2004 Performance Levels and Methods of Measurements of Magnetic and Electric Field Strength from Electric Vehicles, Broadband, 9 kHz To 30 MHz.
SAE J551-5 Rev MAY2012 Performance Levels and Methods of Measurements of Magnetic and Electric Field Strength from Electric Vehicles, Broadband, 150 kHz To 30 MHz.
MIL-STD-461F United States Department of Defense Interface Standard, Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
ECE Reg 10-04

ISO 11452-1-2005 and Amd 1:2008 Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 1: General principles and terminology

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

ISO 11452-4-2011 Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 4: Harness excitation methods

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

ISO 11452-9-2012 Road vehicles -- Component test methods for electrical disturbances from narrowband radiated electromagnetic energy -- Part 9: Portable transmitters

ISO 7637-1-2002 and Amd 1:2008 Road vehicles, Electrical disturbance by conduction and coupling Part 1 – Definitions and general considerations.

ISO 7637-2-2011 Road vehicles, Electrical disturbance by conduction and coupling Part 2: Electrical transient conduction along supply lines only.

ISO 7637-3-2007 Road vehicles, Electrical disturbance by conduction and coupling Part 3: Electrical transient transmission by capacitive and inductive coupling

ISO 10605-2008 and Cor 1:2010 Road vehicles - Test methods for electrical disturbances from electrostatic discharge

ISO 16750-4-2010 Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 4: Climatic loads

7.2 Abbreviations, Acronyms, Definitions, & Symbols

Acceptance Criteria. Defines the limits of variance in function performance of the device during exposure to an electromagnetic disturbance.

ALSE. Absorber-lined shielded enclosure.

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

Average Detection (AVG). A detection method that produces an output voltage of which is the average value of the envelope of an applied signal. The average value must be taken over a specified time interval.

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

CE. Conducted Emissions

CI. Conducted Immunity

CISPR. Comité International Spécial des Perturbations Radioeléctriques (Special International Committee on Radio Interference).

Disturbance. Any phenomenon that may affect the proper operation.

DUT. Device(s) Under Test.

DV. Design Verification (Components intended for production but not necessarily built with production tooling).

E/E. Electrical and/or Electronic.

EMC. Electromagnetic Compatibility

EMI. Electromagnetic Interference

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

ESA. Electronic Sub-Assembly

ESD. Electrostatic discharge.

FIC. Functional Importance Classification as defined by VCC.

FPSC. Function performance status classification as defined by ISO 11452-1:2005/Amd.1:2009.

Inductive Device. An electromechanical device that stores energy in a magnetic field.

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

IC, Integrated Circuit

I/O. Input and output including power and ground connections.

MBW. Measurement System Bandwidth

MOC. Management of change document detailing changes and required EMC tests

N/A. Not Applicable

Normative. Provisions that are necessary (not informative) to meet requirements.

OBDII. On-Board Diagnostics II

PCB. Printed Circuit Board.

Peak Detection (PK). A detection method that produces an output voltage of which is the peak value of an applied signal.

PRR. Pulse Repetition Rate

PV. Production Verification (Component constructed from production tooling)

PWM. Pulse Width Modulated or Modulation.

QP. Quasi-Peak Detection, a detection method with peak detection and post detection time constant.

RE. Radiated Emission

RI. Radiated Immunity

Regulated Power Supply. Regulated power is derived using active electronic devices including linear and switch-mode power supplies.

Shall. Denotes a requirement.

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

Should. Denotes a recommendation.

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

Switched Power Circuits. Any circuit that is connected to the vehicle battery through a switch or relay.
uC, Microcomputer
VCC. Volvo Car Corporation

VCC EMC Department. The Volvo Car Corporation EMC department

Wireless receiving devices A component receiving or amplifying a wireless electromagnetic signal i.e. Radio/TV receiver, antenna amplifier, WIFI device, Keyless entry receiver …

8. Test environment

8.1 Load Simulator

DUT operation shall be facilitated by use of a Load Simulator that is constructed to simulate the vehicle environment as seen by the DUT in its installation. The Load Simulator, is an enclosure that contains all external electrical interfaces (sensors, loads, etc.) normally seen by the DUT. All Electrical interfaces shall be fitted with ESD capacitors, typical 10 nF. Data bus links shall be realized with a fiber optic link in the load box, the electrical interface shall follow the relevant VCC specification for each data bus interface. The Load Simulator serves as an interface to support and monitoring equipment required during testing.
DUT power supply is not allowed to be routed through the load simulator.

8.2 Artificial Networks

Artificial Network design and performance characteristics shall conform to CISPR 25, Edition 3, or ISO 7637-2 where applicable. For tests that do not specify the use of artificial networks, the power supply return shall be connected directly to the ground plane, Load simulator and DUT.

8.3 Interconnections

The electrical interconnections between the DUT and Load Simulator shall be facilitated using a standard test harness. The length of this harness shall be 1700 mm +300/- 0 mm unless otherwise stated in this specification. The harness shall contain wiring types (e.g. twisted wire pairs) that are used in the actual vehicle installation. The use of shielded cables is not allowed unless specifically called out in the drawings and documented in the EMC test plan and report. Selected tests may require shorter power/power return wiring between the DUT and measurement system.

8.4 Bonding of DUT, Load Simulator and Artificial Network to Ground Plane

The Load Simulator and Artificial Networks shall be directly bonded to the ground plane used in the test setup. Bonding shall be facilitated via screws directly into the ground plane. The bond impedance shall be verified to be less than 2.5 mΩ. Use of conductive tapes for bonding is prohibited.

The DUT shall be placed on an insulated support 50 mm above the ground plane. However, if the DUT is designed for a direct ground connection to the vehicle's sheet metal, the DUT shall be mounted and connected to the ground plane in a manner representative of the vehicle installation. *This configuration shall be documented on the drawings and in the product engineering specification.* The DUT grounding configuration shall be documented in the EMC test plan and report. If the DUT can be installed both connected and isolated both setups shall be tested.

8.5 Environmental Test Conditions

Unless indicated otherwise, the climatic test conditions are defined in Table 5-1.

Environmental Test Conditions

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

8.6 Power Supply

Power shall be supplied by batteries and/or a linear power supply. The requirements regarding ambient noise level shall always be fulfilled.

9. RF Emissions

Radiated emissions requirements cover the frequency range from 1 Hz to 6 GHz. The requirements cover both magnetic and electric field radiation. Part of the test is linked to legal demands in ECE R10, GB/T18387-2008 and part to customer satisfaction.
The intention of this requirement is to protect the wireless functions (Radio/TV/Phones/Keyless/Connectivity ….) that VCC provides to customers, and devices customers use in the vehicle. The legal demands are aimed at protecting the general public.

9.1 Test setup

- Co-location of multiple receiving antennas in the same test is not permitted.
- The harness shall be placed on an insulated support 50 mm above the ground plane.
- The DUT shall be placed on an insulated support 50 mm above the ground plane. However, if the DUT is designed for a direct ground connection to the vehicle's sheet metal, the DUT shall be mounted and connected to the ground plane in a manner representative of the vehicle installation. This configuration shall be documented on the drawings and in the product engineering specification. The DUT grounding configuration shall be documented in the test plan and test report. If the DUT can be installed both connected and isolated both setups shall be tested.

9.2 Test Procedure

Prior to measurement of DUT radiated emissions, test setup ambient levels (i.e. all equipment energized except DUT) shall be verified to be 6 dB or more below the specified limit. If this requirement is not met, testing shall not proceed until the associated test setup issues are resolved. Average measurements may use a smaller RBW than stated in CISPR25; this shall be stated in the test report together with the selected measurement time.

- Plots of the test setup ambient shall be included in the test report.
- Tests shall be repeated for all DUT operating modes.

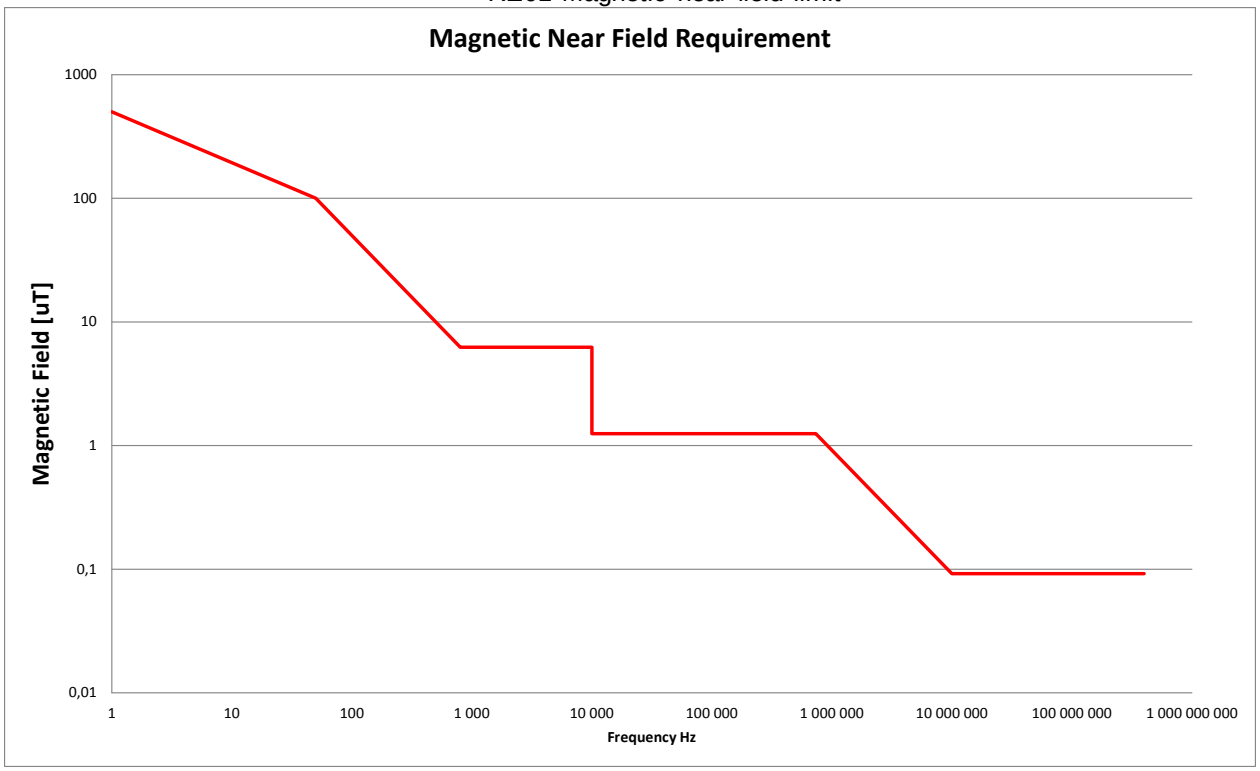
9.3 Requirement

The DUT shall conform to the requirements in its defined operating voltage range (i.e. 9 – 16 Volts for a 12 Volt component). This is shown by testing at the extreme voltages as well as the nominal voltage or by selection of the worst case operating voltage for each requirement.

9.3.1 RE01 Magnetic near field requirement

The MIL-STD-461F RE101 test method shall be used with the requirement level below. The RE101 loop sensor shall be replaced with a single turn sensor of similar size when measuring frequencies above 50 kHz.

RE01 Magnetic near field limit



Frequency [Hz]	B [uT]
1	500
50	100
800	6.25
10 k	6.25
10 k	1.25
735 k	1.25
10 M	0.092
400 M	0.092

Frequency	Bandwith	Detector
1 – 100 Hz	1 Hz	RMS
100 – 3000 Hz	30 Hz	RMS
3 – 150 kHz	300 Hz	RMS
150 kHz – 30 MHz	3 kHz	RMS
30 MHz – 400 MHz	10 kHz	RMS

9.3.2 RE02 Magnetic and Electric far field requirement

To ensure compliance with the current China legal requirement for hybrid vehicles, SAE J551-5 Rev JAN2004 test method shall be used. The requirement level is given below.

RE02 Magnetic and Electric far field limit
SAE J551-5 Rev JAN2004

Electric field limit

Frequency	Level [dBuV/m/kHz]
9 kHz to 4.77 MHz	99.9 – 20log10(Freq(MHz)/.009)
4.77 MHz to 15.92 MHz	154.4 – 40log10(Freq(MHz)/.009)
15.92 MHz to 20 MHz	89.4 – 20log10(Freq(MHz)/.009)
20 MHz to 30 MHz	22.5

Magnetic field limit

Frequency	Level [dBuA/m/kHz]
9 kHz to 4.77 MHz	48.4 – 20log10(Freq(MHz)/.009)
4.77 MHz to 15.92 MHz	102.9 – 40log10(Freq(MHz)/.009)
15.92 MHz to 20 MHz	37.9 – 20log10Freq(MHz)/.009)
20 MHz to 30 MHz	-29.0

To ensure compliance with the proposed China legal requirement for hybrid vehicles, SAE J551-5 Rev MAY2012 test method shall be used. The requirement level is given below.

RE02 Magnetic and Electric far field limit
SAE J551-5 Rev MAY2012

Peak electric field emission limits

Frequency f [MHz]	Level dB[µV/m]
0.15 to 4.77	88.89 – 20log10(f)
4.77 to 15.92	116.05 – 60log10(f)
15.92 to 20	67.98 – 20log10(f)
20 to 30	41.96

Peak magnetic field emission limits

Frequency f [MHz]	Level dB[µA/m]
0.15 to 4.77	37.36 – 20log10(f)
4.77 to 15.92	64.52 – 60log10(f)
15.92 to 20	16.45 – 20log10(f)
20 to 30	-9.57

Average electric field emission limits

Frequency f [MHz]	Level dB[µV/m]
0.15 to 0.8	59.37 – 20log10(f)
0.8 to 4.77	61.37
4.77 to 15.92	88.53 – 40log10(f)
15.92 to 30	40.46

9.3.3 RE03 Electric field requirement, ALSE

The requirements of CISPR 25 Edition 3, ALSE method, shall be used for verification.
The settings for GPS L1 shall be used for all GNSS bands.
Settings and test method used for 1000 – 2500 MHz shall be used for all other bands above 2500 MHz.
The DUT shall conform to each defined requirement i.e. at frequencies where more than one detector is specified, all requirements apply simultaneously.
The DUT shall be orientated in three (3) orthogonal directions.
To decrease the test time required, the QP limits may be validated with a Peak detector. If the QP limit is exceeded with the Peak detector a retest with the QP detector is required.

Legal limits

Frequency Range [MHz]	Limits [dBuV/m]	
	AVG	QP
30 - 75	52- 25.13*Log(f /30)	62 - 25.13*Log(f /30)
75 - 400	42 + 15.13*Log(f /75)	52 + 15.13*Log(f /75)
400 - 1000	53	63

Customer satisfaction limits

RF Service [User Band in MHz]	Requirement Frequency Range [MHz]	Limits [dBuV/m]			
		Peak	Average	Quasi-Peak	IMOD Quasi-Peak
RKE	.1 - .2	65	NA	NA	NA
Medium Wave (AM)	0.5 - 1.8	NA	12	30	36
4 Meter, FM	68 - 108	NA	12	24	36
2 meter	140 - 174	NA	12	24	36
DAB 1	174 - 245	18	12	NA	NA
RKE, TPMS 1	310 - 320	20	14	NA	NA
Tetra	380 - 422	24	12	NA	NA
RKE , TPMS 2	425 - 439	24	18	NA	NA
Police	440 - 470	NA	18	30	NA
TV, IMT, GSM, RKE, DAB, SDARS, BT, WLAN	470 - 3000	25	18	NA	NA
GNSS	1164 - 1300	NA	10	NA	NA
GNSS	1540 - 1610	NA	10	NA	NA
GNSS	5010 - 5030	NA	10	NA	NA
WLAN	5000 - 6000	35	25	NA	NA

IMOD = Intermittently Manually Operated Devices (electric motors /actuators) that are controlled by a user activated switch.

9.3.3.1 Measurement System Requirements

Measurement dwell/scan times listed in CISPR 25 Tables 1 and 2 shall be increased if the DUT operates with intermittent duration to capture the maximum level of emissions.

9.3.4 RE04 Conducted Current requirement

The requirements of CISPR 25 Edition 3, Conducted emissions from components/modules – current probe method, shall be used for verification.
On DUT:s with one or more connector, the harness attached to each connector shall be tested separately, in addition to this the power supply and power return wires shall be measured separately and individually.
The DUT shall conform to each defined requirement i.e. at frequencies where more than one detector is specified, all requirements apply simultaneously.

Customer satisfaction limit

Requirement Frequency Range [MHz]	Limits [dBuA]		
	Peak	Average	Quasi-Peak
0.5 - 1.8	NA	22	29
1.8 - 65	NA	11	18
65 - 176	NA	-4	3
176 - 320	16	-4	NA

9.3.4.1 Measurement System Requirements

Measurement dwell/scan times listed in CISPR 25 Tables 1 and 2 shall be increased if the DUT operates with intermittent duration to capture the maximum level of emissions.

9.4 Test report

DUT radiated emissions shall be plotted over each frequency band. The plots shall be clearly annotated with the following information:
- DUT operating mode
- DUT identification (e.g. serial number)
- Measurement system bandwidth (MBW)
- Limit line
- Antenna polarization/position
- Detection scheme (i.e. Peak, Quasi Peak, Average)
- Measurement dwell time or sweep rate
- Date of measurement

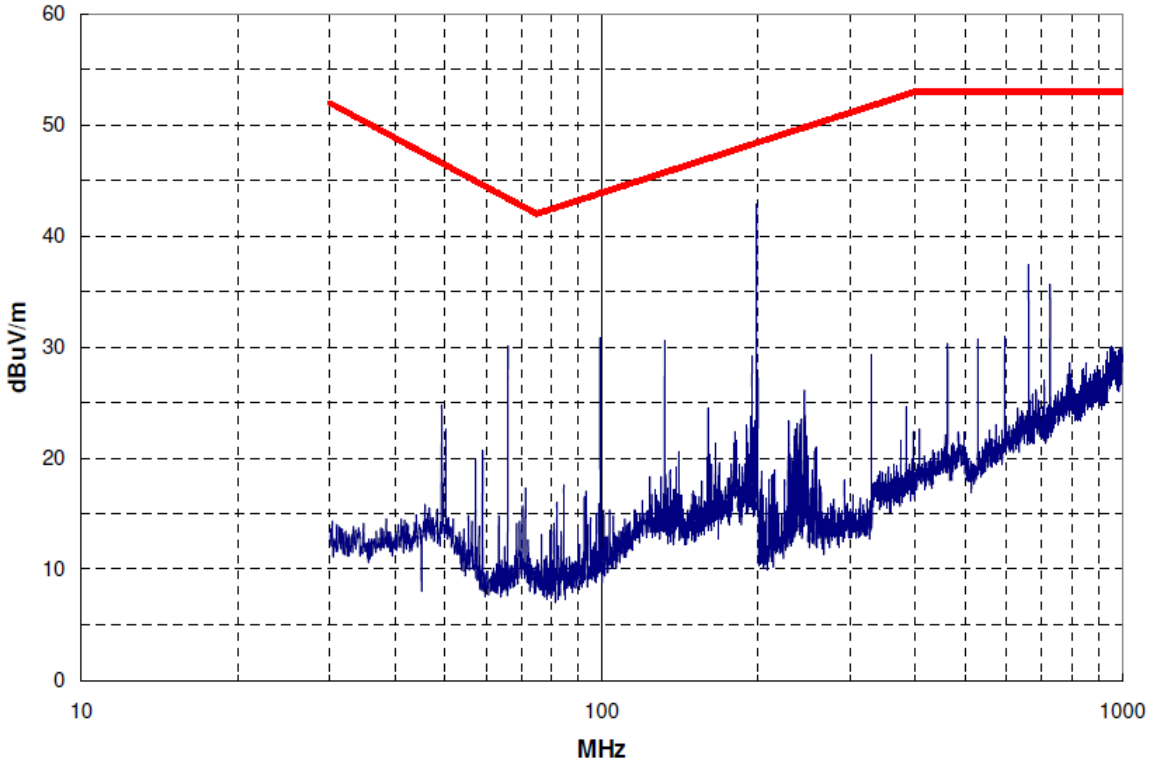
In addition to the plotted data, a tabularized summary for DUT emissions shall be provided for each frequency band. The table shall include the band frequency boundary, maximum DUT emission level measured for the

band, and the associated band limit. Noncompliance to any band requirement shall be clearly noted. The data may be present on a separate sheet or combined with the plotted data.
• **CSV or ODF files with the measured frequencies and amplitudes shall be provided**.

Additional information required includes:
• Plots of the test Setup ambient data.
• Photographs of the test setup

Example RE Plot

Test ID : ALSE		**Requirement :** Legal requirements	
DUT Description: Engine Controller		Approved Test Plan #: VCC 1234567890	
DUT Operating Mode: Engine Idle		Date Tested: 10/1/2009	
Antenna Polarization: **Vertical**		Bandwidth / Detector: 120 kHz / Average	
Frequency Range MHz	**DUT Maximum Emission dBuV/m**	**Limit dBuV/m**	**Pass / Fail**
30 - 75	30.1	52 - 42	Pass
75 – 400	42.8	42 – 53	Pass
400 – 1000	37.4	53	Pass



10. Radiated Immunity

Radiated immunity requirements cover the frequency range from 0 to 6 GHz. The requirements cover both magnetic and electric field radiation. Part of the test is linked to legal demands and part to customer satisfaction. Requirements are based on anticipated “off-board” and “on-board” sources such as:

- Power lines
- Electrical motors
- Charging system
- PWM sources
- Low power RF devices
- Electronic devices
- Broadcast radio and TV
- Cellular phones
- Amateur radio
- Communication radio
- Radar

The requirements and information in REQ-043878 is an integral part of this requirement and shall be applied.

10.1 Test Setup and Test Procedures

- The test harness shall be routed in a straight line.
- Each connector of the DUT shall have a separate cable harness and the harnesses separated by 50 mm when placed on the test bench. Actual test setup shall be documented in the test plan and report.
- The distance between the test Setup and all other conductive structures (such as the walls of the shielded enclosure) with the exception of the ground plane shall be $\geq$ 500 mm.
- Co-location of multiple transmitting antennas in the same test is not permitted.
- The DUT shall be placed on an insulated support 50 mm above the ground plane. However, if the DUT is designed for a direct ground connection to the vehicle's sheet metal, the DUT shall be mounted and connected to the ground plane in a manner representative of the vehicle installation. *This configuration shall be documented on the drawings and in the product engineering specification.* The DUT grounding configuration shall be documented in the EMC test plan and report. If the DUT can be installed both connected and isolated both setups shall be tested.
- Immunity testing shall be performed with frequency step sizes no greater than those listed in Table 1-1 below.
- At each tested frequency all inputs and outputs shall be monitored and the values/status recorded.
- Peak conservation shall be used per ISO 11452-1. CW and modulation (AM & Pulsed) dwell times shall be a minimum of 2 second. Longer dwell times may be necessary if DUT function response times are expected to be longer. This information shall be documented in the EMC test plan and report.
- When using pulse modulations, either peak envelope power (PEP) sensors or a spectrum analyzer are required to measure forward power.
- The AM modulation frequency shall be 1 kHz at a level of 80%.
- Testing shall initially be performed using the most severe requirements at each test frequency. If any DUT I/O is outside its specified tolerance this is to be deemed as a deviation and the stress level shall be

reduced until all DUT I/O:s are within specified tolerances. The stress level shall then be increased until the deviation occurs. This stress level shall be reported as the deviation threshold at this test frequency.

RF Immunity Test Frequency Steps

Frequency Range [MHz]	Frequency Step Size [MHz]
1 Hz – 1 MHz	10%
1 – 30	0.5
30 – 200	2
200 – 400	5
400 – 1000	10
1000 – 3100	20
3100 - 6000	40

10.2 Wireless receiving devices

Wireless receiving devices shall be tested with attached antennas or inputs. The Wireless signal may only be blocked at test frequencies within the operating frequency band. All other functionality of the Wireless receiving device shall continue to operate as designed. In addition to this two in band immunity requirements are given. The unintentional antenna port tests shall be performed with a termination at the antenna end of the antenna cable. This test is to verify that only the antenna port/ input connector is sensitive to in band electromagnetic energy.

The antenna port test is to verify that the antenna ports have sufficient interference immunity to function in the presence of vehicle generated noise.

Each band shall be tested at 3 frequencies, start, stop and center frequency. The Pass/Fail criteria shall be noise level / sensitivity remaining within the designed tolerances at room temperature.

10.3 Requirements

Component functional performance shall meet the requirements given in the frequency range 0 Hz (DC) – 6 GHz. Due to the wide frequency coverage, multiple test methods are needed for performance verification.

Inputs and outputs used by any FIC C classified function shall fulfil FPSC Status I at the Immunity limits given for FIC C.

Inputs and outputs used by any Non FIC C classified function shall fulfil FPSC Status I at the Immunity limits given for Non FIC C and FPSC Status II at the Immunity limits given for FIC C.

The test methods are in order of frequency:
ISO 11452-8 Immunity to magnetic fields
ISO 11452-4 Harness Excitation (BCI)
ISO 11452-2 Absorber-lined shielded enclosure.

An alternative to test method ISO 11452-4 must be used for components without connectors. Test method, correlation values and rationale shall be documented in the test plan and report.

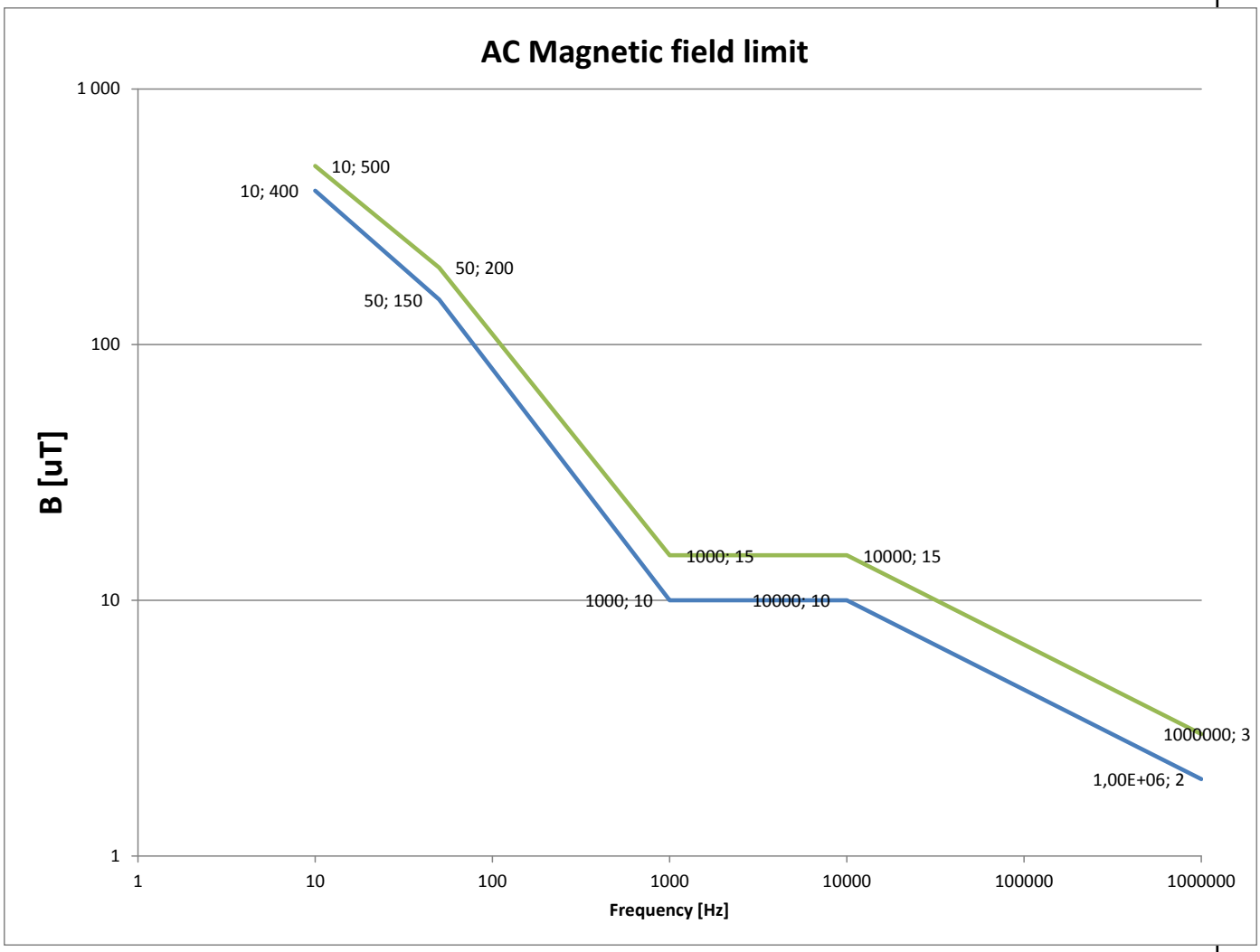
In addition to this all components located in the passenger compartment or trunk shall be tested according to ISO 11452-9 Portable transmitters

10.3.1 RI01 Magnetic Field Immunity

Verification of component performance shall be in accordance with the Immunity to magnetic field method ISO 11452-8.

RI01 Magnetic Field Immunity limit

The DUT and all I/O shall withstand **3 mT at DC** and the AC magnetic field given below.



Magnetic field limit

Frequency [Hz]	Non FIC C Limit B[uT]	FIC C limit B[uT]	Modulation
DC	3000	3000	CW
10	400	500	CW
50	150	200	CW
1000	10	15	CW
10000	10	15	CW
1 MHz	2	3	CW

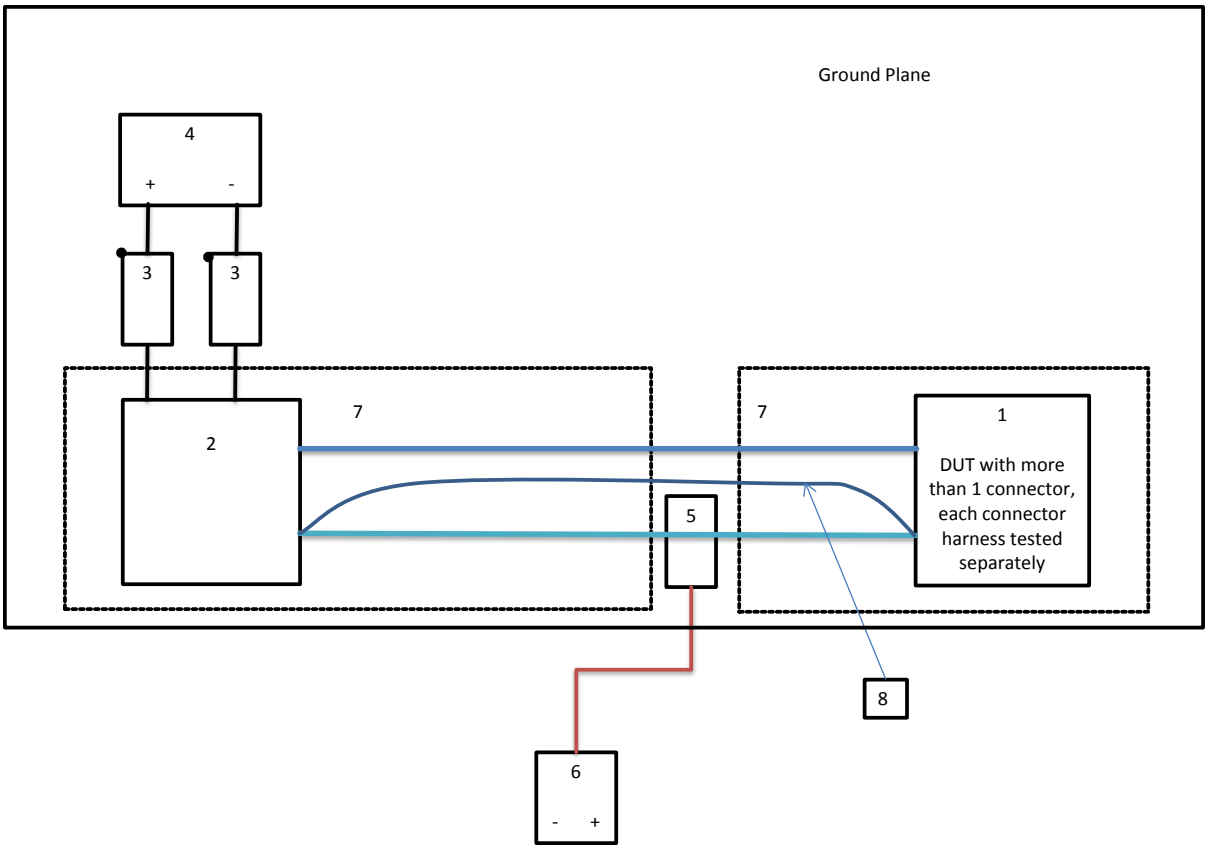
10.3.2 RI02 Harness Excitation (BCI) Requirements

Test Verification and Test Setup

Verification of component performance shall be in accordance with the BCI, substitution method, per ISO 11452-4 with the following additions and deviations.

- **Each connector on the DUT shall be tested individually with the injection probe placed around the harness associated with the connector. I/O:s contained in each connector shall be documented in the EMC test report and test plan.**
- **Power return wires shall be tested separately as if they were located in a dedicated connector.**
- BCI testing shall be performed at two fixed injection probe positions (150 mm, 450 mm).
- The injection probe shall be insulated from the ground plane.

BCI Test Setup



1. DUT
2. Load Simulator
3. Artificial Network
4. Automotive Battery
5. Injection Probe
6. RF Generation Equipment
7. Insulated Support
8. DUT Power Return wires removed from harness and tested separately.

RI02 Harness Excitation (BCI) limits

BCI Requirements 100 kHz – 400 MHz

Band	Frequency Range [MHz]	Non FIC C Limit [dBuA]	FIC C Limit [dBuA]	Modulation
1	0.1 - 1	84 – 64	90 – 70	CW, AM 80%
2	1 - 15	64 – 100	70 – 106	CW, AM 80%
3	15 - 30	100	106	CW, AM 80%
4	30 – 400	100 - 92	106 - 96	CW, AM 80%

10.3.3 RI03 ALSE Requirements

Test Verification and Test Setup

Testing shall be performed using the substitution method according to ISO 11452-2 with the following additions and deviations.

- Field characterization shall be performed at the highest field strengths given in the requirement. Field characterization at lower field strengths with subsequent power scaling for higher field strengths is not permitted.
- The test shall be performed using both horizontal and vertical antenna polarization.
- The DUT shall be tested in the most susceptible orientation; this may be demonstrated by testing in a minimum of three (3) orthogonal orientations.

Requirements 200 – 6000 MHz

Band	Frequency Range [MHz]	Non FIC C Limit [V/m]	FIC C Limit [V/m]	Modulation
5	200 - 800	70	100	CW, AM 80% Pulsed PRR = 18 Hz, PD = 28 msec
6	800 - 6000	50	70	CW, Pulsed PRR = 217 Hz, PD = 0.57 msec
7	1200 - 1400	300	600	Pulsed PRR= 300 Hz, PD = 3 usec, gated by a pulse PRR=1 Hz, PD=200 msec
8	2700 – 3100	300	600	

10.3.4 RI04 Portable transmitters Requirements

Test Verification and Test Setup

Testing shall be performed using the substitution method according to ISO 11452-9 with the following additions and deviations.

- Requirements are given in Net power at the input port of the antenna.
- This test procedure makes use of a small broadband antenna positioned above the DUT and it's wiring harness to simulate electromagnetic fields generated by hand portable transmitters operating in close proximity. The result of near field immunity tests is strongly influenced by the antenna type used and for this reason only Schwarzbeck antenna SBA9113 with elements 420NJ shall be used for this test.
- The separation between the test antenna and the DUT surfaces and harnesses shall be either 5 mm or 50 mm depending on expected proximity to intentional storage locations and product type as detailed in table 2-1 below. The test antenna is positioned in step sizes specified in table 3 to ensure all DUT surfaces and harnesses are thoroughly exposed.
- The test antenna shall be mounted above the DUT and parallel to the ground plane. The DUT shall be positioned to ensure that the surface under test is facing the antenna.
- Each antenna position shall be tested with the antenna parallel to the DUT harness and rotated 90 degrees.
- The DUT shall be rotated to facilitate testing of all surfaces.

Separation Distances and Antenna Positioning

DUT Surface or Harness description	Antenna Distance from DUT	Antenna Positioning Steps
DUT surfaces and first 300mm of their harnesses (measured from DUT connector) which are likely to be packaged between 50 to 200 mm of **intentional** and/or **unintentional** locations where a hand portable transmitter may be located.	50 mm	100 mm
DUT surfaces and first 300mm of their harnesses (measured from DUT connector) which are likely to be packaged less than 50 mm from **intentional** storage locations.	5 mm	50 mm
Keys and similar devices which may come in direct contact with hand portable transmitters.	5 mm	50 mm

RI04 Portable transmitter limits

Frequency Band [MHz]	Non FIC C and FIC C limit [W]	Modulation type
140 - 176	25	CW, AM 1 kHz 80%
220 - 225	10	CW, AM 1 kHz 80%
360 - 486	10	PM, 18 Hz, 50%, PM, 217 Hz, 12.5%
698 - 798	6	PM, 18 Hz, 50%, PM, 217 Hz, 12.5%
800 - 1000	14	PM, 217 Hz, 12.5%
1200 – 1463	2	CW, PM, 1600 Hz, 50%
1710 - 1950	3	PM, 217 Hz, 12.5%
1950 - 2200	1.5	PM, 217 Hz, 12.5%
2400 - 2500	0.2	PM, 1600 Hz, 50%
2500 - 2700	0.5	PM, 217 Hz, 12.5%

10.3.5 RI05 Wireless receiving devices

10.3.5.1 Ports unintentionally acting as antennas

Test Verification and Test Setup

Verification of component performance shall be in accordance with the BCI test method as defined in paragraph 10.3.2 of this document, with the following additions and deviations.

The upper frequency limit of the BCI test shall be extended to 1000 MHz for this test.

Each of the DUT possible receiving bands shall be tested at 3 frequencies: start, stop and center frequency.

The wanted test signal, at the set frequency of the receiver, with normal test modulation, at the level given in the limit, shall be applied to the receiver input connector.

The interference test signal, at the set frequency of the receiver + 200 Hz, with modulation and level as given in the limit shall be applied to the BCI probe.

The requirement is given in the limit associated with this requirement under the heading:
RI05 Wireless receiving devices, Ports unintentionally acting as antennas.

RI05 Wireless receiving devices limit

Ports unintentionally acting as antennas

Frequency [MHz]	Wanted signal level [dBuV]	Interference level [dBuA]	Modulation of Interference signal	Pass/Fail Criteria
.5 – 1.8	30	52	PM, 217 Hz, 12.5%	S/N >= 25 dB
65 - 174	20	26	PM, 217 Hz, 12.5%	S/N >= 25 dB
174 - 242	25	26	PM, 217 Hz, 12.5%	S/N >= 25 dB
310 - 1000	30	26	PM, 217 Hz, 12.5%	S/N >= 25 dB

10.3.5.2 Antenna ports

Test Verification and Test Setup

Each of the DUT possible receiving bands shall be tested at 3 frequencies: start, stop and center frequency.
The two input signals shall be connected to the receiver via a combining network.

The wanted test signal, at the set frequency of the receiver, with normal test modulation, at the level given in the limit, shall be applied to the receiver input connector via one input of the combining network.

The interference test signal, at the set frequency of the receiver + 200 Hz, with modulation and level as given in the limit shall be applied to the receiver input connector via the second input of the combining network.

The requirement is given in the limit associated with this requirement under the heading:
RI05 Wireless receiving devices, Antenna ports.

RF service	Frequency [MHz]	Wanted signal level [dBuV]	Interference level [dBuV]	Modulation of Interference signal	Pass/Fail Criteria
Medium Wave (AM)	0.5 - 1.8	30	0	PM, 217 Hz, 12.5%	S/N >= 25 dB
4 Meter, FM, 2 meter	65 – 174	20	0	PM, 217 Hz, 12.5%	S/N >= 25 dB
DAB 1	174 – 242	25	0	PM, 217 Hz, 12.5%	S/N >= 25 dB
RKE, TPMS 1	310 – 320	30	10	PM, 217 Hz, 12.5%	S/N >= 25 dB
Tetra	380 – 422	6	-4	PM, 217 Hz, 12.5%	S/N >= 25 dB
RKE , TPMS 2	425 -439	30	10	PM, 217 Hz, 12.5%	S/N >= 25 dB
Police	440 – 470	6	-4	PM, 217 Hz, 12.5%	S/N >= 25 dB
TV, IMT, GSM, RKE	470 – 6000	30	10	PM, 217 Hz, 12.5%	S/N >= 25 dB
GNSS		-30	0	PM, 217 Hz, 12.5%	S/N >= 25 dB

10.4 Test report

DUT radiated immunity shall be plotted over each frequency band. The plots shall be clearly annotated with the following information:

- DUT operating mode
- DUT identification (e.g. serial number)
- Performed test
- Limit line
- Antenna polarization
- Acceptance criteria
- Measurement dwell time or sweep rate
- Date of measurement
- Photographs of the test setup

In addition to the plotted data, a tabularized summary for DUT immunity performance shall be provided for each frequency band. Noncompliance to any requirement shall be clearly noted. The data shall be presented on a separate sheet or combined with the plotted data.

11. Transient Emission and Immunity Requirement

Transient emission requirements cover fast transients on system power supply lines and signal lines resulting from electromechanical switches. This requirement applies to all system voltages irrespective of operating voltage.

During transient immunity testing each DUT I/O, whose immunity may vary according to its internal timing or processing should be considered. The time allowed between the pulses, the number of pulses and the pulse levels applied should maximize the probability that a test pulse is applied during times of highest DUT susceptibility. In addition to these requirements, the component shall not be affected by transients generated as a result of its own operation, including switching of inductive loads either internal or external to the device.

11.1 Test setup

The test setup shall comply with ISO 7637 unless otherwise noted in this specification.

11.2 Requirement

11.2.1 CE01 Transient Emission

The maximum allowed levels are +50, -75 Volts peak.

11.2.1.1 Procedure

Use test methods in accordance with ISO 7637-2 fast pulses with the following specifications:

- The shunt resistor R_s as shown in figure 1b of ISO 7637-2 shall not be installed.
- Ensure that the 50 ohm termination is installed on the RF sampling port of the AN

Motors and actuators that can stall during normal operation shall, in addition to the off-to-on and on-to-off modes, be tested in a “stall” condition. The stall should not be held longer than one second. This is to prevent activation of in-line protection devices (such as Positive-Temperature Coefficient [PTC] resistors) that would interrupt the current to the DUT.

11.2.1.2 Report

The following elements shall be included in the test report:

- Plots of measured pulses.
- Description of DUT conditions.
- Appropriate requirement shall be displayed on plot of pulses.

Note: Consistent with ISO 7637-2, ten (10) waveform acquisitions are required for each mode of operation (e.g. ON-to-OFF, OFF-to-ON, etc). Only those waveforms with the highest positive and negative amplitudes shall be reported in tabular listings.

11.2.2 CI01 Transient immunity on Power Lines

Pulses 1, 2a, 2b, 3a and 3b defined in ISO 7637-2 shall be tested with the parameters given below.

Pulses 2a, 2b, 3a and 3b shall be tested with monitoring and recording of all inputs and outputs. If any DUT I/O (including software and memory content) is outside its specified tolerance this is to be deemed as a deviation and the stress level shall be reduced until all DUT I/O:s are within specified tolerances. The stress level shall then be increased until the deviation occurs. This stress level shall be reported as the deviation threshold at this pulse.

At Pulse 1 testing the DUT shall be monitored after the pulse sequence. If any DUT I/O is outside its specified tolerance this is deemed to be a failure and shall be reported.

CI01 Transient immunity limits on Power Lines

Test pulse	Requirement Level [V]	Number of pulses or test time	Pass/Fail criteria	Comment
1	-100	5000 pulses	Status IV	Pulse not applicable for operating voltages above 60 V
2a	+50	5000 pulses	Status I	
2b	+10	10 pulses	Status IV	
3a	-150	1 h	Status I	Amplitude calibrated in 50 ohm load
3b	+100	1 h	Status I	Amplitude calibrated in 50 ohm load

11.2.2.1 Procedure

If not otherwise stated the procedure in ISO 7637-2 shall be used. This test procedure applies to battery+ (B+) and switched battery lines (e.g. Ignition, Accessory). It also applies to I/O lines that are connected to an inductive load, where that load is fed by B+ or switched battery. The test pulses shall be applied to B+, each switched battery line and I/O lines fed by either B+ or switched battery separately. In addition, B+ and switched battery lines and I/O lines fed by either B+ or switched battery shall be tested simultaneously.

The waveform amplitude for pulse 3a and pulse 3b is determined from the average of the waveform peak voltages. For this specification, the injection levels shall be established across a 50 ohm load instead of the open-circuit condition per ISO 7637-2.

When the power supply is isolated from the ground plane, pulse 3a and 3b shall be injected between + and –, between + and GND and between – and GND.

11.2.2.2 Report

The following elements shall be included in the test report:

- Test pulse being applied (by number).
- Pulse amplitude
- Number of repetitions of the pulse applied.
- Pulse cycle time (interval between pulses).
- Injection points (pin number, letter, or name).
- Performance of the monitored I/O during and after application of each transient.

11.2.3 CI02 Transient immunity on Signal Lines

The component shall be immune (i.e. no change of I/O parametric values, software or memory content) to conducted transients coupled to inputs and outputs (I/O), other than battery, ignition or accessory inputs.

Pulses 3a and 3b defined in ISO 7637-2 shall be tested with the parameters given below.

Test pulse	Requirement Level [V]	Minimum test time	Pass/Fail criteria	Comment
3a	-150	1 min	Status I	Amplitude calibrated in 50 ohm load
3b	+100	1 min	Status I	Amplitude calibrated in 50 ohm load

11.2.3.1 Procedure

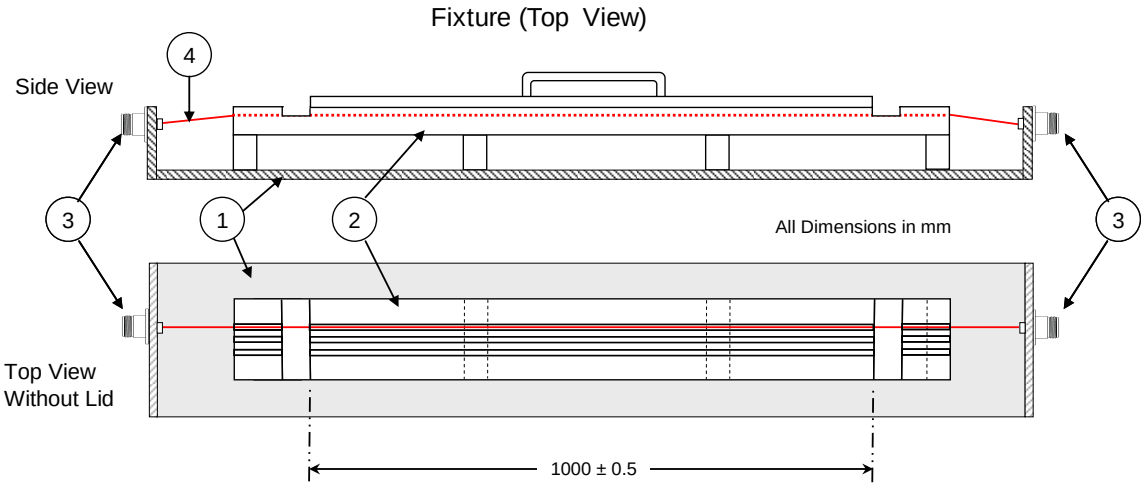
Use test methods according to the relevant sections of ISO 7637-3 with the following specification:

- Use only test pulse 3a and 3b.
- The coupling clamp in ISO 7637-2 shall be replaced by the Coupling Fixture, RSA TS-RI130-Fix from Rohde & Schwarz, or TF 130-150 from Schwarzbeck (or similar device).

The test shall be performed with monitoring and recording of all inputs and outputs. If any DUT I/O is outside its specified tolerance this is to be deemed as a deviation and the stress level shall be reduced until all DUT I/O:s are within specified tolerances. The stress level shall then be increased until the deviation occurs. This stress level shall be reported as the deviation threshold at this pulse.

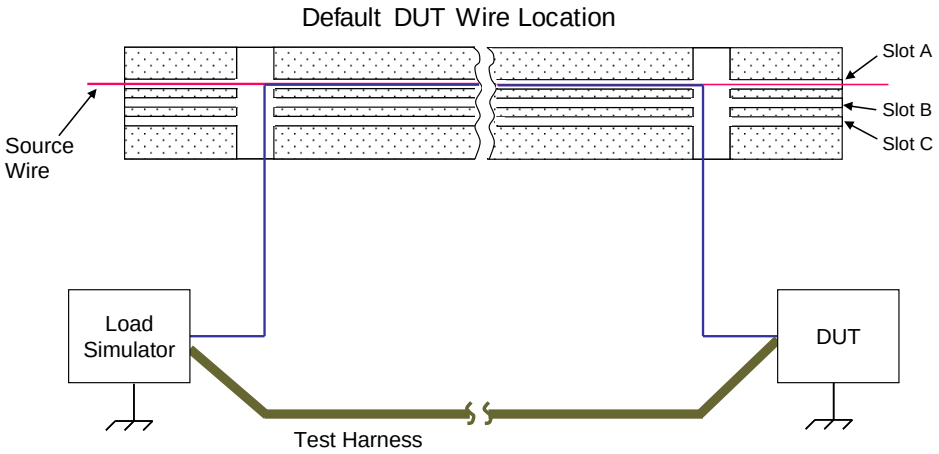
11.2.3.2 Test Fixture and Application

The test fixture is illustrated below. The fixture consists of a wire support mounted on an aluminium plate. .

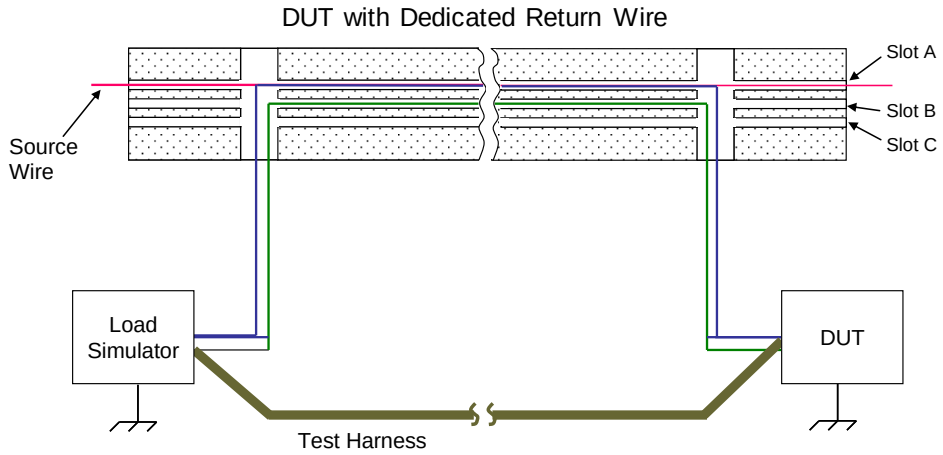


1. Aluminium plate
2. Wire support
3. Type N Connector, one connected to the transient generator and one to a 50 ohm termination
4. Source wire

The fixture contains a single copper wire ("source wire") that is connected to the signal source that generates the disturbances. The DUT is tested by placing individual wires in the same slot as the source wire directly on top of it (Slot A). This is illustrated below.

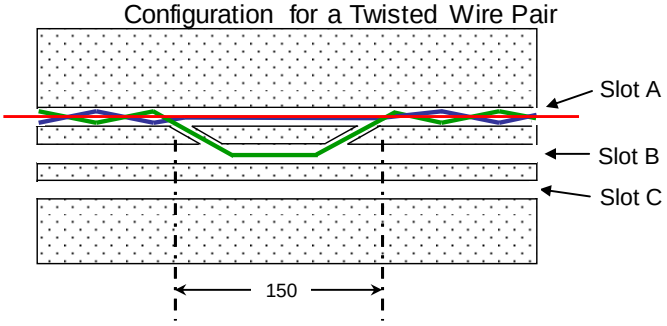


If the wire under test is connected to an I/O that have a dedicated signal return back to the DUT (*a signal return not shared by any other I/O)*, each wire connected to this I/O shall be placed in separate slots (Slots A and B) located in the test fixture as illustrated below. Dedicated signal returns shall always be located in Slot B unless specified in the EMC test plan. Each slot is 6 mm wide with a wall thickness of 6 mm.



If the I/O is specified to use a twisted pair, the twisted wire pair shall be placed in Slot A as illustrated below. However, it is required that the wire pair is untwisted for 150 mm, one wire in slot A and the other in slot B. This is facilitated via the section located in the center of the test fixture. *The inclusion of this untwisted and unshielded section simulates the device connector or use of an in-line connector.*

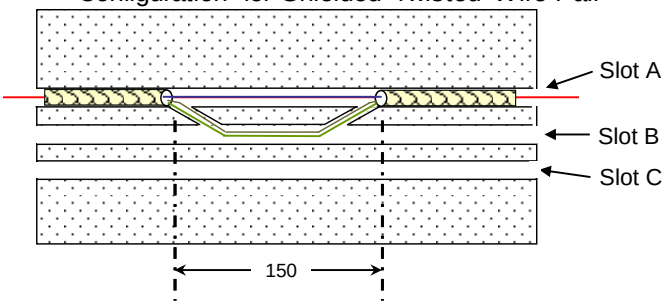
Configuration for a Twisted Wire Pair



If the I/O is specified to use shielded wires (excludes shielded wires with shielded connectors), each shielded wire shall be placed in Slot A. However it is required that the circuits are unshielded for 150 mm. This is facilitated via the section located in the center of the test fixture. The setup is similar to that used for a twisted wire pair.

Shielded cables with shielded connectors shall be tested with an inline connector located in slot B and the shield intact.

Configuration for Shielded Twisted Wire Pair



11.2.3.3 Report

The following elements shall be included in the test report:

- Test pulse being applied (by number).
- Pulse amplitude
- Tested wire
- Performance of the monitored I/O during and after application of each transient.

Document Type: NOTE-SPEC
Reference No:

Document Name:
EMC SYSTEM AND COMPONENT REQUIREMENTS
Electromagnetic Compatibility Specification

Part must comply with VCC Restricted Substance Management Standard (RSMS) VCS 5036,5

12. Electrostatic Discharge

The component shall be immune to overstress due to Electrostatic Discharge (ESD). This requirement covers manufacturing (Rh < 10 % during wintertime), service, and customer use of the vehicle.

This requirement covers components that are directly accessible and also those that are not directly accessible. The requirement levels are tailored based on location and accessibility.

ESD Testing shall be performed on separate samples!

12.1 Test Verification and Test Setup

The following test sequence shall be used.

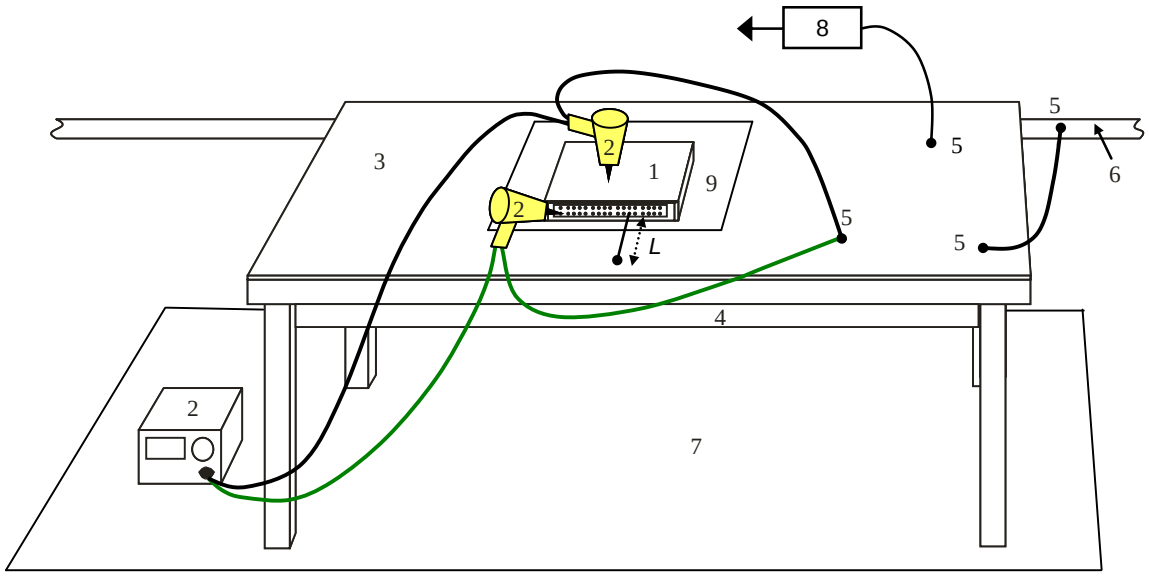
1. Validate the component I/O parametric values (e.g., resistance, capacitance, leakage current, etc.).
2. Perform the required ESD Testing in accordance with ISO 10605 except where noted in this requirement.
3. Subject the samples to ISO 16750-4 5.3.2, Rapid change of temperature with specified transition duration, 200 cycles with a dwell time of at least 1h.
4. Validate the component I/O parametric values (e.g., resistance, capacitance, leakage current, etc.). All parameters shall retain the values measured in step 1, including their specified tolerances.

12.2 ESD01 Handling Tests

The DUT shall be placed unpowered directly on a dissipative mat. When applying discharges to the DUT connector pins, All DUT power return terminals shall be connected to the ground plane via a grounding strap or wire with a maximum length of 200 mm. If there is multiple power return terminals which are not internally connected within the DUT, the logic return ground shall be connected to the ground plane and the remaining power return terminals shall be subjected to ESD pulses similar to all other I/O pins.

For devices that do not have a ground terminal (i.e. switches with internal LED's that are low-side sensed and/or latched by a controller, etc.), attach the low-side output (that would normally be connected to a controller I/O) to the ground plane.

12.2.1 ESD Handling Test Setup



L ≤ 200 mm

Key

1. DUT
2. ESD Simulator
3. Ground Plane
4. Wooden Table

L: Ground Wire Length ≤ 200 mm
Only used during application of ESD to connector pins

5. Ground Plane Connection
6. Test Facility Ground connection
7. Floor of Test Facility
8. ~ 1 Meg ohm bleed-off Resistor
9. Dissipative Mat

12.2.2 Handling (unpowered) ESD Requirements

The component shall be immune (i.e. no change of I/O parametric values, software or memory content) to ESD events that occur during normal handling, assembly and maintenance.

ESD01 Handling (unpowered) ESD limits

Discharge Sequence	Type of Discharge	Test Voltage Level	Pass/Fail Criteria	Minimum Number of Discharges at each polarity
1	Contact discharge C = 150 pF, R = 2kΩ	± 4 kV	Status IV	3
2	Contact discharge C = 150 pF, R = 2kΩ	± 6 kV	Status IV	3
3	Air discharge C = 150 pF, R = 2kΩ	± 8 kV	Status IV	3

Apply contact and air discharges according to the sequence above on all connector pins, exposed shafts, buttons, switches, and/or surfaces (including along all air gaps that exist between buttons, faceplates, etc.) that are a result of the design of the product.

If the connector pins are recessed, an extension contact (< 25 mm) shall be installed to facilitate testing of the individual pins.

All discharge points shall be specified in the EMC test plan and report.

12.3 ESD02 Powered Tests

The DUT and any electronic hardware in the Load Simulator shall be powered and functioning.

- The DUT and its attached test harness shall be placed on a clean, dielectric support ($\varepsilon_r \leq 1.4$) that is 50mm thick. The insulator lies directly on the ground plane. **The DUT shall be tested both placed on the dielectric support and placed directly on the ground plane.**
- The Load Simulator shall be connected directly to the ground plane.
- The ground plane shall be attached to the negative terminal of the power supply and to the test facility ground.
- Selection of discharge points is to be defined by analysis and documented in the test plan and report.
- If the DUT has remote I/O that are connected to components accessible by the operator (e.g. switches, LIN) or communications bus circuits accessible via diagnostic connectors, the associated circuit wires shall be split out of the harness at the DUT connector and subjected to ESD. A wire no longer than 1700 mm may be added if required in the test setup. Details of these remote connections shall be documented in the EMC test plan and report.
- Connectors and harnesses shall be subjected to ESD discharges.

12.3.1 Powered ESD Requirements

The component shall be immune to ESD events that can occur during normal operation (i.e. powered). These requirements are given below.

For each of the required discharge voltages, the specified number of positive and negative polarity discharges shall be applied at each of the discharge points.

A. Perform sequence 1 through 3 to each exposed shaft, button, switch and/or surface of the DUT including air gaps that exist between buttons, faceplates, etc. that are a result of the design of the product.

B. If the DUT has surfaces located in the passenger compartment or trunk that may be touched, repeat step A with discharge sequence 4.

C. Perform sequence 1 through 4 for DUT inputs and outputs that are accessible by the operator (e.g. switches, LEDs, USB, LIN nodes).

D. Perform sequence 1 through 3 for DUT communications bus circuits accessible via diagnostic connectors. Apply contact and air discharges directly to the connector pins.

E. Perform sequence 5 to DUT surfaces that are:
   - Located in the passenger compartment and directly accessible from outside the vehicle (e.g. stalk switches, steering wheel, seats, window switches, trunk switches).
   - Directly accessible from the outside of the vehicle (e.g. keyless entry keypad, lights, handles, locks, trailer connector)

F. Perform sequence 1 to 4 using the Indirect discharge setup

G. Perform sequence 5 using the indirect discharge setup on DUTs that are directly accessible from the outside the vehicle.

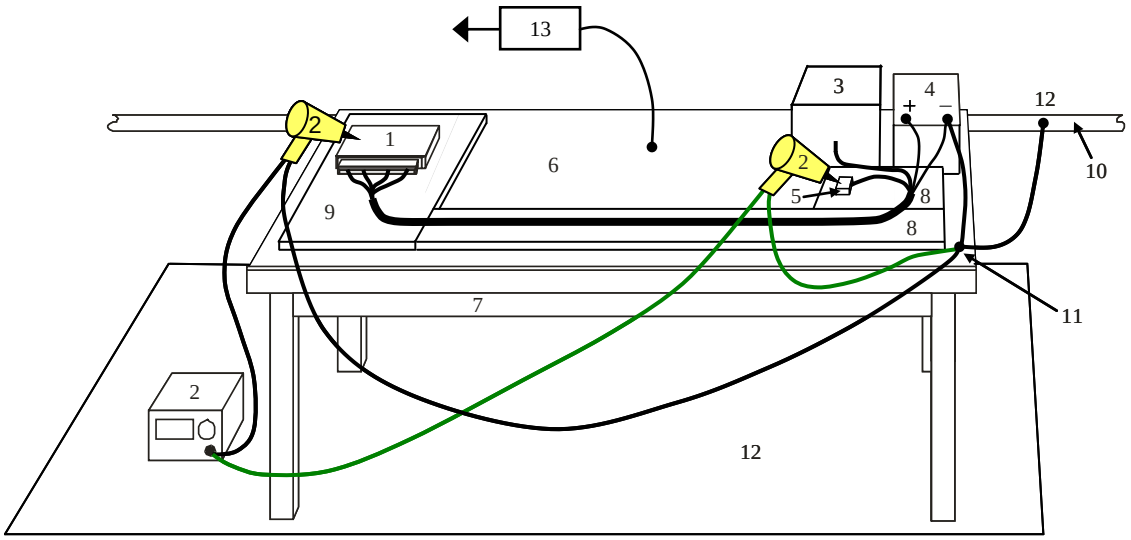
All discharge points shall be documented in the EMC test plan and report.

Discharge Sequence	Type of Discharge	Test Voltage Level	Non FIC C Pass/Fail Criteria	FIC C Pass/Fail Criteria	Minimum Number of Discharges at each polarity
1	Contact discharge C = 330 pF, R = 330Ω	± 4 kV	Status I	Status I	5
2	Contact discharge C = 330 pF, R = 330Ω	± 6 kV	Status I	Status I	5
3	Contact discharge C = 330 pF, R = 330Ω	± 8 kV	Status I	Status I	5
4	Air discharge C = 330 pF, R = 330Ω	± 15 kV	Status I	Status I	5
5	Air discharge C = 150 pF, R = 330Ω	± 25 kV	Status II	Status I	5

12.3.2 Test setup

The test shall be performed with monitoring and recording of all inputs and outputs. If any DUT I/O is outside its specified tolerance as stated in the DPR/TR, this is to be deemed as a failure and shall be reported.

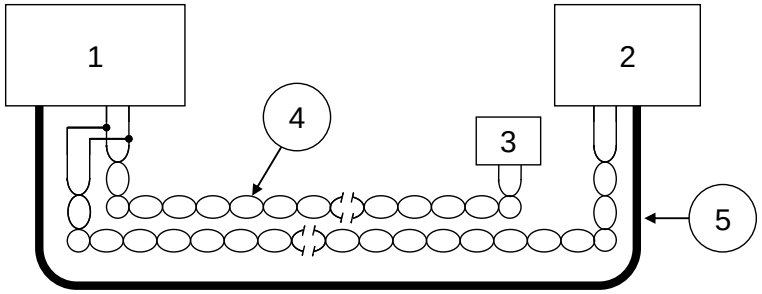
ESD Powered Test Setup



Key

1. DUT
2. ESD Simulator
3. Load Simulator
4. Battery
5. Remote I/O discharge connection
6. Ground Plane
7. Wooden Bench
8. Harness Insulator Support
9. DUT Insulator Support, as needed
10. Test Facility Ground
11. Ground Plane Reference Termination
12. Ground Plane Connection
13. ~ 1 Meg ohm bleed-off Resistor

ESD Remote I/O



Key

1. DUT
2. Load Simulator
3. Remote I/O discharge connection
4. Remote I/O Wire, Twisted pair shown but this also applies to single wire I/O (e.g.switches and LIN).
5. Other DUT circuits

12.3.3 Indirect discharge

For the Indirect discharge test one of two alternative HCP test setups shall be used.

- External lights shall use an aluminium foil wrapped over the lens as a coupling plane. The ESD discharges shall be applied to the edge of the aluminium foil.
- All other DUTs shall use the test setup defined in Annex F of ISO 10605.

12.4 Test report

The following elements shall be included in the test report:

- Component I/O parametric values before and after the handling test sequence
- Performance of the monitored I/O during and after application of each transient.
- DUT operating mode
- DUT identification (e.g. serial number)
- Performed test
- Acceptance criteria
- Date of measurement
- A tabularized summary for DUT immunity performance shall be provided for each test. Noncompliance to any requirement shall be clearly noted.
- Photographs of the test setup

13. Mains connected devices

All Mains Connected devices must comply with ECE R10.04.

13.1 Requirement:

Components and complete vehicles shall meet the requirements given in ECE R10.04 chapter 7.

Test details shall be included in the Component EMC Test plan.