China Euro Vehicle Technology	Document Release Status **Released**	
	Release Date **2018-03-22**	Version
	Document No **8888621495**	Issue **002**
	Volume No	Page No **1 (50)**
Document Type **NOTE-TREG**	Reference No	
Document Name **ELECTROMAGNETC COMPATIBILITY SPECIFICATION**		

Electromagnetic Compatibility Specification

SYSTEM & COMPONENT REQUIREMENTS

Contents

1. Introduction

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 CEVT. 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 this specification supersedes applicable laws and/or regulations unless a specific exemption has been obtained**.**

1.1 Scope

This specification presents EMC requirements and test methods that have been developed for components independent of 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 the component, with regards to 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 showing that the component fulfils the EMC requirements.

1.2 Revision History

Revision	Date	Description
1	2016-10-13	Initial release
2	2018-03-21	Major rework of both structure and requirement limits.

1.3 Requisite documents

1.3.1 International documents

Only the specified version of the standard is applicable. If the version is not specified the latest version available is applicable.

Name	Description
ISO/IEC 17025	General requirements for the competence of testing and calibration laboratories.
CISPR 16-1-1:2015	Specification for radio disturbance and immunity measuring apparatus and methods - Part 1-1: Radio disturbance and immunity measuring apparatus - Measuring apparatus.
CISPR 16-2-2:2010	Specification for radio disturbance and immunity measuring apparatus and methods - Part 2-2: Methods of measurement of disturbances and immunity - Measurement of disturbance power.
CISPR 25:2016	Limits and methods of measurement of radio disturbance characteristics for the protection of receivers used on board vehicles.
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-461G	United States Department of Defence Interface Standard, Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment.
“ECE Regulation 10.05” E/ECE/324/Add.9/Rev.5 Regulation No. 10	Uniform provisions concerning the approval of vehicles with regard to electromagnetic Compatibility.
GB/T 18387-2017	National standard of the People’s Republic of China, Limits and test method of magnetic and electric field strength from electric vehicles.
ISO 11452-1:2015	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 11452-8:2015	Road vehicles - Component test methods for electrical disturbances from narrowband radiated electromagnetic energy - Part 8: Immunity to magnetic fields.

Name	Description
ISO 11452-9:2012	Road vehicles - Component test methods for electrical disturbances from narrowband radiated electromagnetic energy - Part 9: Portable transmitters.
ISO 7637-1:2015	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 7637-3:2016	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 and Amd.1:2014	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.

1.4 Abbreviations, Acronyms, Definitions & Symbols

Name	Description
Acceptance Criteria	Defines the limits of acceptable variance in function performance of the DUT during exposure to an electromagnetic disturbance.
ALSE	Absorber-Lined Shielded Enclosure.
AM	Amplitude modulation.
AN	Artificial Network - A device used to present a known impedance to the power line of the DUT.
AVG	Average Detection - 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 Emission.
CEVT	China Euro Vehicle Technology.
CI	Conducted Immunity.
CISPR	Comité International Spécial des Perturbations Radioélectriques (Special International Committee on Radio Interference).
CSV	Comma Separated Values (Output file format for measurement data).
CW	Continuos Wave.
Disturbance	Any phenomenon that may affect the proper operation of the DUT or test itself.

Name	Description
DUT	Device Under Test.
DV	Design Verification (Testing of component design/concept intended for production but not necessarily built with production tooling. Even Engineering samples may do if agreed to with CEVT EMC department).
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 CEVT.
FPSC	Function Performance Status Classification, as defined by ISO 11452-1
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.
ILAC	International Laboratory Accreditation Cooperation
IMOD	Intermittently Manually Operated Devices - Short duration devices with an activation time of no more than 20 seconds. This is typically components such as window and seat motors, washer pumps or certain actuators. **Note:** Not all of these are necessarily IMOD, this depends on their design, use and implementation in the vehicle, e.g. LIN controlled motors.
I/O	Input and Output including power and ground connections.
MBW	Measurement System Bandwidth.
MOC	Management of Change – Document/process describing changes and detailing required EMC revalidation for a changed component.
N/A	Not Applicable.
Normative	Provisions that are necessary (not informative) to meet requirements.
OBDII	On-Board Diagnostics II.
ODF	Open Document format. File format for transferring files/data between platforms.
PCB	Printed Circuit Board.
PD	Pulse Duration.

Name	Description
PK	Peak Detection - A detection method that produces an output voltage of which is the peak value of an applied signal.
PM	Pulse Modulation.
PRR	Pulse Repetition Rate.
PV	Product Verification (Testing of component manufactured with production tooling).
PWM	Pulse Width Modulated or Modulation.
QP	Quasi-Peak Detection - A detection method with peak detection and post detection time constant.
Regulated power supply	Regulated power is derived using active electronic devices including linear and switch-mode power supplies.
RE	Radiated Emission.
RI	Radiated Immunity.
Shall	Denotes a requirement
Should	Denotes a recommendation
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.
Step size	The step size of measurements defined in this document are all maximum step sizes. Smaller step sizes may always be utilized if deemed necessary.
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.
µC	Microcomputer.
Validation	The assurance that a component, function, or system meets the needs of the customer and/or other identified stakeholders. It often involves acceptance and suitability with external customers. Contrast with *verification.*
Verification	The evaluation of whether or not a component, function, or system complies with a, requirement or specification. Contrast with *validation.*
Wireless receiving device	A component receiving or amplifying a wireless electromagnetic signal i.e. Radio/TV receiver, antenna amplifier, WIFI device, Keyless entry receiver, etc.

2. General requirements

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 CEVT Design engineer and the supplier for assuring EMC compliance of their component with regards to: 1.) Legal requirements or regulations. 2.) CEVT Requirements. 3.) Other EMC requirements agreed to together with EMC Department.

1. Identify which EMC tests are applicable.
2. Develop an EMC test plan based on the CEVT template and obtain CEVT EMC Department approval.
3. Perform testing at an accredited test facility, see section 2.3.
4. EMC DV Testing shall be completed and the test report shall be submitted to CEVT EMC Department for review and approval, no later than at the FDJ milestone.
5. Compliance with the EMC requirements shall be determined by the CEVT EMC department and the Design engineer after review of the test results submitted by the test laboratory.
6. If component design remains unchanged between PV and successful DV testing, EMC PV testing may be reduced if agreed by CEVT EMC department.

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

2.1 Test Plan

An EMC test plan shall be prepared and agreed prior to commencement of any EMC testing. The purpose of the test plan is to develop and document well thought out procedures to verify that parts covered by this specification are robust to the anticipated electromagnetic environment it will operate within.

The EMC test plan shall be prepared in accordance with the outline given in the supplied template. CEVT reserves the right to challenge specific details in the plan, including acceptance criteria and monitoring methods of interfaces and level of granularity of supervision.

When the test plan is accepted by CEVT, a unique test plan number will be obtained, which will serve as a reference number for the subsequent test results.

Failure to obtain this test plan number, or failure to reference this in reports, may render test results invalid.

Acceptance of the EMC test plan does not relinquish the supplier from responsibility if further reviews shows deficiencies in the test setup or the acceptance criteria. The supplier is obliged to work with the CEVT EMC department, or resource appointed by CEVT EMC department, to correct any deficiency and repeat testing if required.

2.2 Vehicle Level Requirements

In addition to meeting the requirements specified herein, components shall comply with the vehicle EMC requirements when installed in the vehicle. Complete vehicle verification testing is performed by vehicle manufacturer. Failure to meet the vehicle level 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.

2.3 Test facility

For a test facility to be accepted by CEVT 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.
- The test facility shall have the knowledge and equipment to test all applicable CEVT requirements, using the methods and limits given in the CEVT requirements.
- Name, telephone number and email of the person responsible for maintaining the accreditation in the organization.

CEVT 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.

2.4 Number of test samples

For any electrical component, a minimum of two samples of each selected variant shall be tested against each EMC requirement.

For components to be subject to ESD tests, two additional sample of each variant is needed, specifically for those ESD tests.

Selection of variants shall be made on the analysis of possibilities of impacting the results of conformance to the EMC requirements. Both samples must pass the test.

Agreement on number of variants to be tested will be reviewed and approved by CEVT during Test plan review.

2.5 Sequence of Testing

For all tests, functional tests shall be performed before, between and after each test sequence.

ESD tests shall be performed on separate samples.

The ESD samples shall then be subjected to an ISO 16750 – 4, section 5.3.2, Rapid change of temperature test with specified transition duration, 200 cycles with a dwell time of 1 h.

Shorter times may be used if it can be shown that thermal mass of DUT gives that cycle temperature has been reached, with a safety margin of 10 minutes, i.e. No soaking time can be shorter than 10 minutes.

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.

2.6 Revalidation

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

2.7 Data Reporting & Data Review

All test data shall be reviewed by the CEVT 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.

All test data including emission data and communication logs (e.g. CAN, FlexRay, LIN, LVDS etc.) shall be recorded and stored by the supplier. CEVT reserves the right to request and review test data.

2.8 Immunity

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.

All communication (e.g. CAN, LIN, FlexRay, LVDS, etc.) shall be monitored during immunity tests, for instance to ensure that sensor signals are sending live data not just latest saved values.

2.8.1 Functional Importance Classification

All functions in the vehicle shall be classified according to importance during normal operation. Factors affecting the classification are:

- CEVT internal requirements.
- Legal requirements.
- Authority expectations.

Inputs and outputs used by any FIC C classified function shall comply with the Immunity requirements given for FIC C. All other functions shall comply with Non-FIC C requirements.

FIC C is defined as:

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

2.8.2 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 definitions given in **ISO 11452-1** shall be interpreted as given below.

2.8.2.1 Status I

The input or output under test performs as designed during and after exposure to disturbance. The pass/fail criteria are 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 Test plan.

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).

2.8.2.2 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.

2.8.2.3 Status III

N/A (This status is not used).

2.8.2.4 Status IV

The input or output does not perform as designed during the test and does not return to normal operation. DUT shall return to Status I on the first power up cycle after each test sequence. Removing and reattaching the connection to power is not allowed in the power up cycle. The DUT shall not have sustained any permanent damage as a result of the testing.

2.9 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.

3. Applicable tests

Based on the technologies used in the component, the following matrix identifies the applicable tests.

Note: Mains connected devices, such as On-board battery chargers, shall fulfil the requirements given in paragraph 9 (Mains connected devices).

More than one column may be applicable to the DUT.

Requirement		Used technologies				
		Passive (Resistors & capacitors)	Diodes and thermistors	Solenoids, relays and Electro-mechanical horns	Electric motors	Transistors ICs and µCs
RE01 [1)]	RF Emission. Magnetic near field				X	X
RE02 [1)]	RF Emission. Magnetic and Electric far field				X	X
RE03	RF Emission. Electric field, ALSE		X [4.)]	X	X	X
RI01	RF Immunity. Magnetic field		X			X
RI02	RF Immunity. Harness Excitation (BCI)		X			X
RI03	RF Immunity. ALSE		X			X
RI04 [2.)]	RF Immunity. Portable transmitter		X			X
CE01	Transient Emission			X	X	X
CE02	RF Emission. Conducted Current			X	X	X
CI01	Transient Immunity. Power lines					X
CI02	Transient Immunity. Signal lines					X
ESD01	Electrostatic Discharge (Un-Powered / Handling)	X	X	X [3.)]	X [3.)]	X
ESD02	Electrostatic Discharge. (Powered)	X	X	X [3.)]	X [3.)]	X

[1.)] RE01 and RE02 tests are not mandatory for components with a peak current consumption less than 200 mA.

[2.)] Requirement of RI04 is applicable only for components in passenger compartment or the trunk.

[3.)] Requirement is applicable if transient, or ESD, protection circuitry exists on design.

[4.)] Applicable only for PWM fed LEDs.

4. Test environment

4.1 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 via fibre optic links in the load box, the electrical interface shall follow the relevant 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.

4.2 Artificial Networks

Artificial Network design and performance characteristics shall conform to CISPR 25, 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.

The GND wire shall not use a LISN unless the vehicle installation uses more than 4 meters of GND wire.

4.3 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 1 700 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.

4.4 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 information can be found 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.

4.5 Environmental Test Conditions

Unless indicated otherwise, the climatic test conditions are defined in Table 4.5-1.

Table 4.5-1 Environmental Test Conditions

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

4.6 Power Supply

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

5. 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/T 18387-2017 and part to customer satisfaction.

The intention of this requirement is to protect the wireless functions (Radio/TV/Phones/Keyless/Connectivity) that CEVT provides to customers, and devices customers use in the vehicle. The legal demands are aimed at protecting the general public.

5.1 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 information can be found 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.

5.2 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.

Prior to any test, a Measurement chain test shall be performed. This shall be done by transmitting a known signal, but may also be done using a comb generator. The result shall be included in the part of the report where ambient emissions are reported.

If the 6 dB requirement to noise ratio is not met, testing shall not proceed until the associated test setup issues are resolved.

- Measurements with FFT receiver(s) shall conform to CISPR 16 requirements. (refer to scan times vs pulse repetition rates). Scan times shall be recorded. (if emission spectrum is not specified in the test plan, a pre-scan as per CISPR 16 2-2 may have to be performed for calculation of measurement time).
- Plots of the test setup ambient measurements shall be included in the test report.
- Tests shall be repeated for all DUT operating modes.

5.3 Requirement

The DUT shall conform to the requirements in its defined operating voltage range.

Nominal voltage to be used during testing is 13.5V +/-0.5V for designs not including DC/DC converters. Designs including DC/DC converters needs to be evaluated at 9V, 13.5V and 16V to capture voltage dependent effects.

Rationale for Requirement: *LED drivers (current regulators) have proven to generate high frequency emissions when the operating voltage increases, and shunting of the power reaches higher levels.*

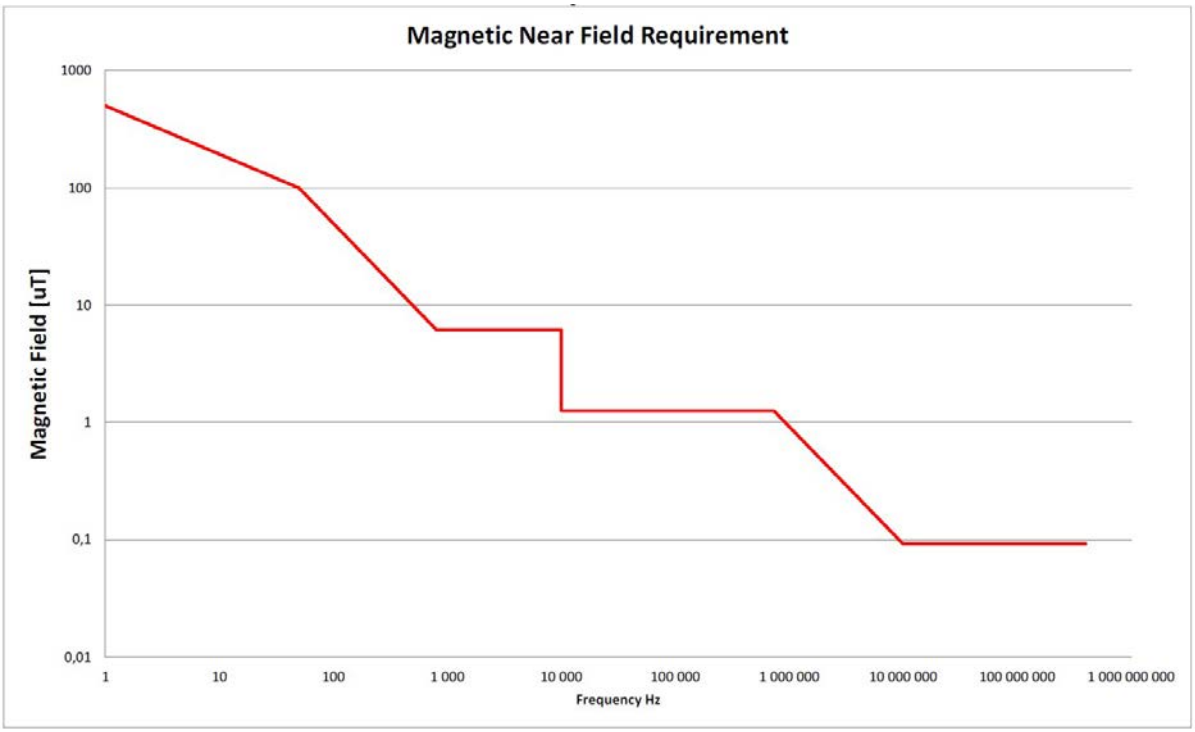
5.3.1 RE01 Magnetic near field requirement

The MIL-STD-461G RE101 test method shall be used with the requirement level below.

The high frequency end (above 50 kHz) of the requirement can be measured with a Schwarzbeck HRRAE 5163 or equivalent antennas.

The low frequency part (less than 10 kHz) of RE01 may be measured with an oscilloscope with FFT capability, a low frequency spectrum analyser or an Audio analyser, connected to the RE101 loop sensor specified in MIL-STD-461G.

Chart 5.3.1-1 RE01 Magnetic near field limit



Frequency [Hz]	B [µT]]
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 [Hz]	Resolution Bandwidth	Detector
1 - 100	1 Hz	RMS
100 - 3000	30 Hz	RMS
3 – 150 k	300 Hz	RMS
150 k – 30 M	3 kHz	RMS
30 M – 400 M	10 kHz	RMS

5.3.2 RE02 Magnetic and Electric far field requirement

Note: *This requirement is not applicable for IMOD.*

To ensure compliance with the current 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:

Table 5.3.2-1 Peak electric field emission limit

Frequency [MHz]	Level dB[µV/m]
0.15 to 4.77	98.89 – 20log10(f)
4.77 to 15.92	126.05 – 60log10(f)
15.92 to 20	77.98 – 20log10(f)
20 to 30	51.96

Table 5.3.2-2 Peak magnetic field emission limit

Frequency [MHz]	Level dB[µA/m]
0.15 to 4.77	47.36 – 20log10(f)
4.77 to 15.92	74.52 – 60log10(f)
15.92 to 20	26.45 – 20log10(f)
20 to 30	0.43

5.3.2.1 Test setup

The referenced standard is a vehicle level test.

For the Electrical field part of the test: A standard CISPR25 ALSE test method setup shall be used, with 1 m test distance. Part of the test can be included in the RE03 test, since the setups are identical.

For the Magnetic field part of the test: A modified CISPR25 ALSE test method setup shall be used, with 1 m test distance and 1 m antenna height, but with an appropriate magnetic field antenna.

5.3.3 RE03 Electric field requirement, ALSE

- The requirements of CISPR 25, 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 1 000 – 2 500 MHz shall be used for all other bands above 2 500 MHz. The DUT shall conform to each defined requirement i.e. at frequencies where more than one detector is specified, all requirements apply simultaneously.
- For frequencies above 470 MHz, the DUT shall be orientated in three (3) orthogonal directions. The rationale for three directions is to gather data for complete vehicle simulations. If only one direction is measured the quality of simulation will deteriorate and the number of test vehicles will increase.
- For frequencies below 470 MHz, the DUT may be tested in one direction (worst case).
- To decrease the test time required, the Average and QP limits may be validated with a Peak detector. If the Average or QP limit is exceeded with the Peak detector a retest with the corresponding detector is required.

Table 5.3.3-1 Legal limits

Frequency [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

Table 5.3.3-2 RE03 limits

RF Service [User band in MHz]	Frequency [MHz]	RBW (kHz)	Limits [dBuV/m]		
			Peak	Average	Quasi- Peak
RKE	0.10 – 0.20	9/10	56	N/A	N/A
Medium Wave (AM)	0.50 – 1.80	9/10	N/A	18 [28]	25 [35]
RE02 1.)	0.15 – 4.77	9/10	98.89 – 20 log (f)	N/A	N/A
	4.77 – 15.92	9/10	126.05 – 60 log (f)	N/A	N/A
	15.92 – 20	9/10	77.98 – 20 log (f)	N/A	N/A
	20 - 26	9/10	51.96	N/A	N/A
CB	26 - 30	9/10	48	28	N/A
VHF, TV Band I	41 - 76	100/120	34	24	N/A
4 Meter, FM	76 – 108	100/120	32	12	19 [32]
2 Meter	140 – 171	100/120	35	15	22
DAB 1	171 – 245	100/120	18 [36]	12	N/A
RKE, TPMS 1	310 – 320	100/120	20	14	N/A
Tetra	380 – 420	100/120	38	18	N/A
RKE, TPMS 2	420 – 450	100/120	32	18	N/A
Police, UHF	450 – 512	100/120	38	18	N/A
TV	512 - 944	100/120	41	24	N/A
TV, GSM	944 - 960	100/120	44	24	N/A
GNSS	1164 – 1300	9/10	N/A	10	N/A
DAB L-Band	1447 - 1494	100/120	28	18	N/A
GNSS	1540 – 1617	9/10	N/A	10	N/A
GSM, 3G, IMT	1803 - 2025	120	44	24	N/A
3G, IMT	2172 - 2180	120	44	24	N/A
SDARS	2320 – 2345	120	34	24	N/A
Bluetooth	2400 - 2500	120	44	24	N/A
5G	3000 - 5000	≥1000	64	44	N/A
GNSS	5010 – 5030	9/10	N/A	10	N/A
WLAN	5000 - 6000	≥1000	68	48	N/A

Notes:

- [1.)] If test method, RE02, has been performed, these bands may be omitted.
- **IMOD:** Only values in square brackets [ ] apply to IMOD.
- **Wide resolution bandwidths:** The use of wide resolution bandwidths (1 MHz or more) is permitted (and recommended) in the bands 470 – 3 000 MHz and 5 000 – 6 000 MHz.
- **Noise floor and RBW, average tests:** If the required Noise to Limit ratio (6dB) cannot be reached with the specified resolution bandwidth, average tests may be performed using a narrower bandwidth (e.g. 120 / 9 kHz). If a reduced RBW is used, the frequency step size must of course also be adjusted accordingly. However narrower RBW than stated in the table above is not permitted for Peak and Quasi-Peak measurements. If reduced RBW is used, measurements with RBW stated in this requirement shall also be recorded and included in the test report.
- Both Peak and Average detectors shall be used for the complete frequency band.

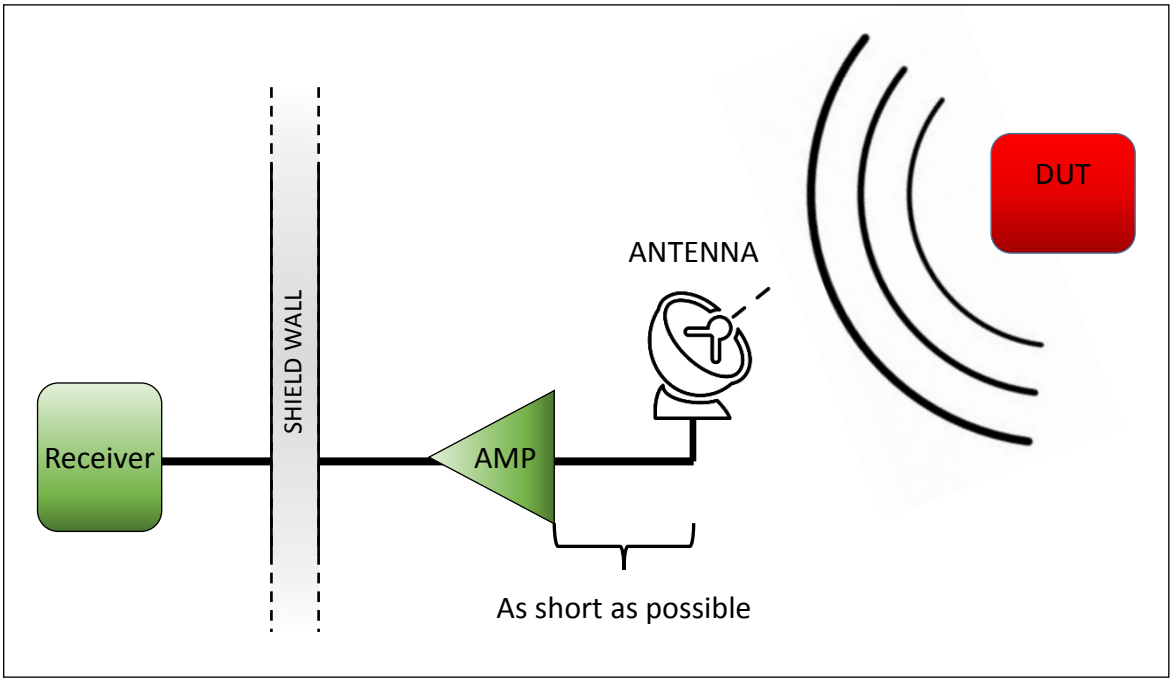
5.3.3.1 Measurement System Requirements

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.

Measurement set-up information:

The following setup is an example of how to maximize the S/N ratio of the test system. The cable between antenna and low noise amplifier shall be extremely short, preferably not used. A high gain antenna is allowed and shall, if used, also be used in the 470 – 1 000 MHz range, and be located in front of the DUT.

Picture 5.3.3.1-1 Amplifier location illustration



5.3.4 CE02 Conducted Current requirement

The requirements of “CISPR 25, Conducted emissions from components/modules – current probe method”, shall be used for verification.

On DUTs 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.

Table 5.3.4-1 Customer satisfaction limits:

Requirement Frequency Range [MHz]	Limits [dBµA]		
	Peak	Average	Quasi- Peak
0.5 – 1.8	N/A	22	29
1.8 – 65	N/A	11	18
65 – 174	N/A	- 4	3
174 – 320	16	- 4	N/A

Table 5.3.4-2 Customer satisfaction limits for short duration devices (IMOD):

Requirement Frequency Range [MHz]	Limits [dBµA]		
	Peak	Average	Quasi- Peak
0.5 – 1.8	N/A	22	29
76 - 108	N/A	-4	3
174 – 245	16	0	N/A

5.3.4.1 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.

5.4 Test report

Test report shall include:

- Plots of the test Setup ambient and system-check measurements.
- Photographs of the test setup.

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).
- Resolution Band Width (RBW).
- Limit line.
- Antenna polarization/position.
- Detection scheme (i.e. Peak, Quasi Peak, Average).
- Measurement dwell time or sweep rate.
- Date of measurement.

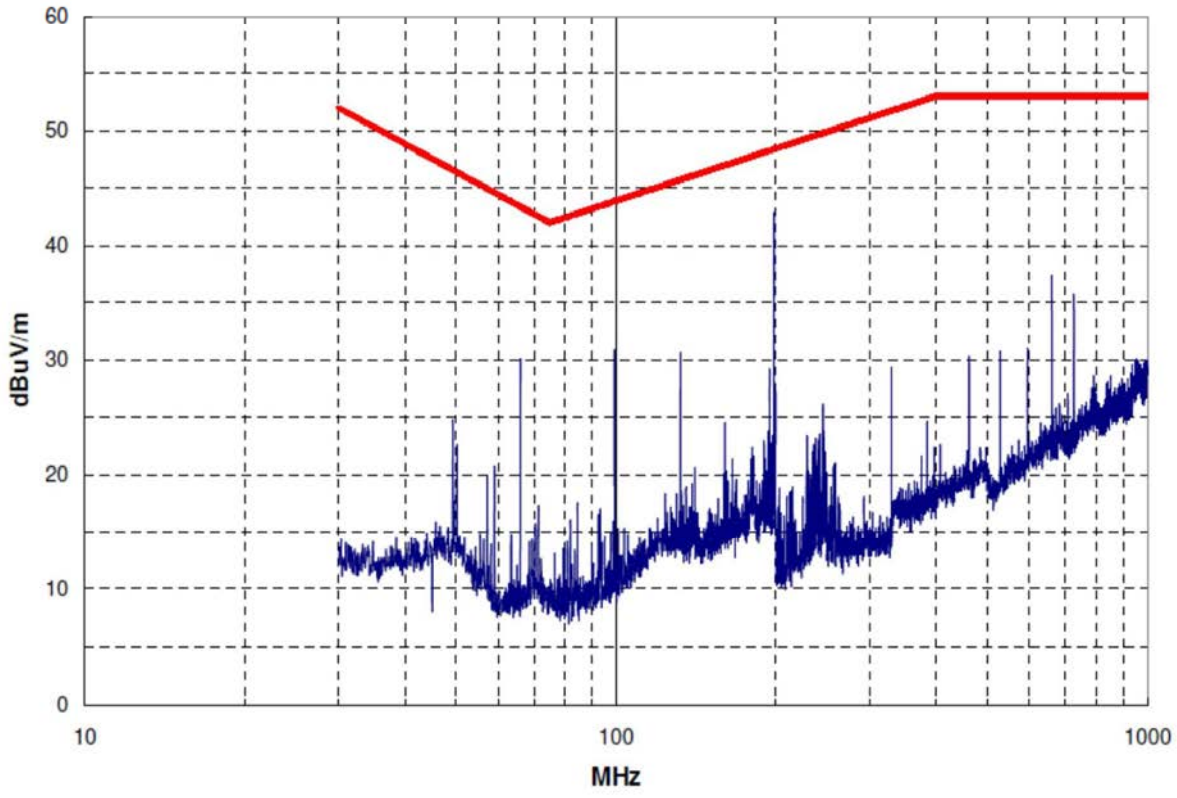
In addition to the plotted data, a tabularized summary for DUT emissions shall be provided for each frequency band. The table shall include the band frequency boundary, maximum DUT emission level measured for the band, and the associated band limit. Noncompliance to any band requirement shall be clearly noted.

The data may be presented on a separate sheet or combined with the plotted data.

CSV or ODF files with the measured frequencies and amplitudes shall be provided

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



6. 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.

6.1 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 > 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 information can be found 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 6.1-1 below.
- At each tested frequency, all inputs and outputs shall be monitored and the corresponding values/statuses shall be recorded.
- Peak conservation shall be used per ISO 11452-1. CW and modulation (AM & Pulsed) dwell times shall be double the expected DUT response time, and never less than a minimum of 2 seconds. Dwell times used shall be documented in the EMC test plan and report.
- When using pulse modulations, either peak envelope power (PEP) sensors or a spectrum analyser are required to measure forward power.
- The AM modulation frequency shall be 1 kHz at a level of 80 %. Additional modulations may be applied if the DUT is expected to be susceptible to these. Peak measurement shall in such cases be measured during the CW phase before the modulation is applied.
- 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.

Table 6.1-1 Maximum frequency step sizes

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

6.2 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 Immunity test level B.

Inputs and outputs used by any Non-FIC C classified function shall fulfil FPSC Status I at Immunity test level A and FPSC Status II at Immunity test level B.

The test methods are in order of frequency:

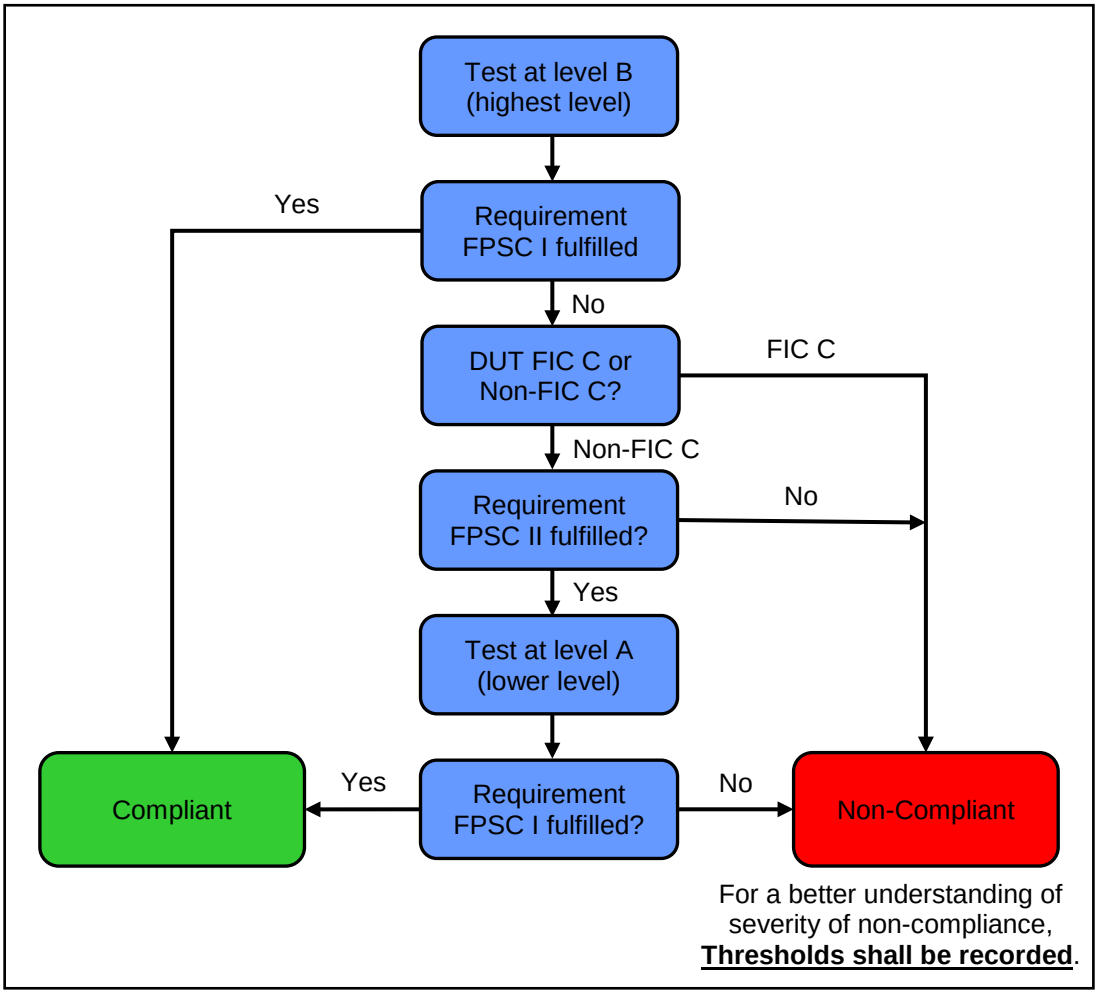
1. ISO 11452-8 Immunity to magnetic fields.
2. ISO 11452-4 Harness Excitation (BCI).
3. ISO 11452-2 Absorber-lined shielded enclosure.

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.

Chart 6.2-1 Test sequence flow chart

The Purpose of the chart is to make sure that all DUTs are tested at highest test level regardless of FIC.



6.2.1 RI01 Magnetic Field Immunity

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

This test requires other antennas than the ones stated in ISO 11452-8. A large loop antenna or Helmholtz coil may be used. The properties of the used antenna shall be documented in the test plan.

Components not mounted on a ground plane in complete vehicle shall be tested using a low permittivity table (plastic, wooden or similar).

Components mounted on a ground plane in complete vehicle shall be tested using test bench with ground plane.

Chart 6.2.1-1 RI01 Magnetic Field Immunity limit 5

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

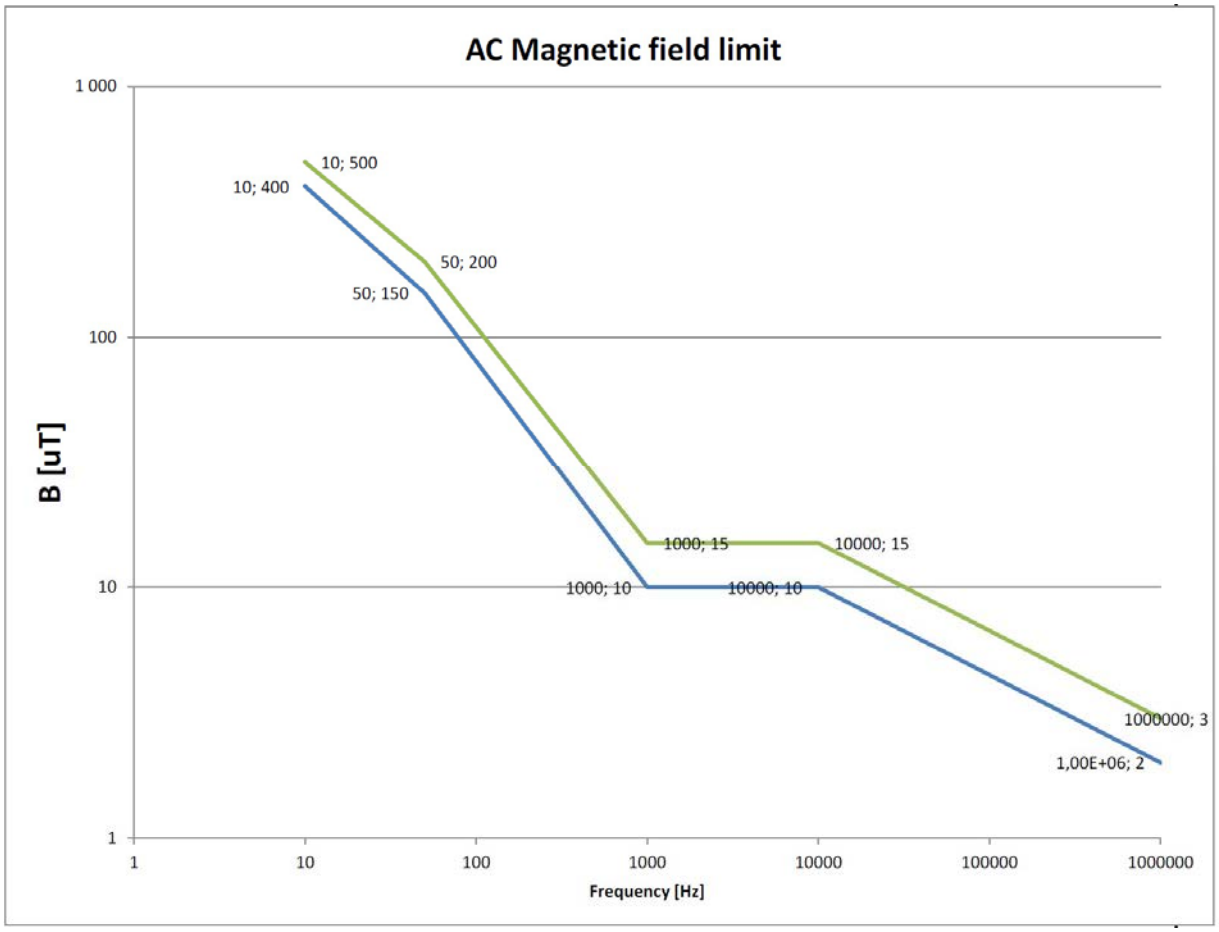


Table 6.2.1-1 Non-FIC C requirements.

Frequency [Hz]	Level A [µT]	FPSC	Level B [µT]	FPSC
DC	3000	Status I	3000	Status I
10	400	Status I	500	Status II
50	150	Status I	200	Status II
1000	10	Status I	15	Status II
10000	10	Status I	15	Status II
1 MHz	2	Status I	3	Status II

Table 6.2.1-2 FIC C requirements.

Frequency [Hz]	Level B [µT]	FPSC
DC	3000	Status I
10	500	Status I
50	200	Status I
1000	15	Status I
10000	15	Status I
1 MHz	3	Status I

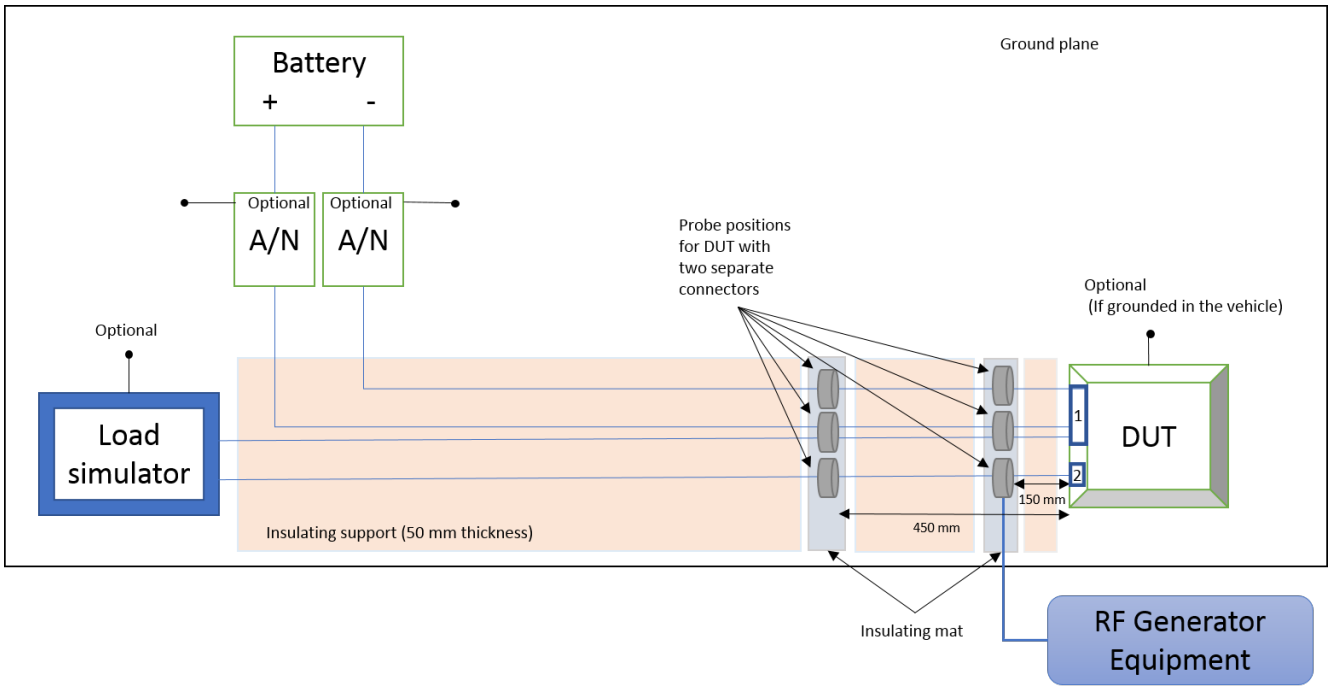
6.2.2 RI02 Harness Excitation (BCI) Requirements

6.2.2.1 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.

Pic 6.2.2.1-1 BCI Test Setup



No.	Comment
1	Connector 1

No.	Comment
2	Connector 2

6.2.2.2 RI02 Harness excitation (BCI) limits - 100 kHz – 400 MHz

Table 6.2.2.2-1 Non-FIC C requirements:

Band	Frequency [MHz]	Modulation	Level A [dBµA]	FPSC	Level B [dBµA]	FPSC
1	0.1 – 1	CW, AM (1)	84 – 64	Status I	90 – 70	Status II
2	1 – 15	CW, AM (1)	64 - 100	Status I	70 – 106	Status II
3	15 – 30	CW, AM (1)	100	Status I	106	Status II
4	30 - 400	CW, AM (1)	100 - 92	Status I	106 - 96	Status II

Table 6.2.2.2-2 FIC C requirements

Band	Frequency [MHz]	Modulation	Level B [dBµA]	FPSC
1	0.1 – 1	CW, AM (1)	90 – 70	Status I
2	1 – 15	CW, AM (1)	70 – 106	Status I
3	15 – 30	CW, AM (1)	106	Status I
4	30 - 400	CW, AM (1)	106 - 96	Status I

(1) AM: 1kHz, 80 %.

6.2.3 RI03 ALSE Requirements

6.2.3.1 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.
- For frequencies below 470 MHz, the DUT may be tested in one direction (worst case).
- The test distance in the Radar bands may be reduced to 60 cm provided that the DUT remains in the far field and remains covered by the antenna lobe, and that a proper calibration exists for the distance used.
- Components not mounted near a ground plane in complete vehicle may be tested using a low permittivity table (plastic or similar) instead of the regular CISRP25 setup wooden table with ground plane. This increases the field strength at the DUT for a given amplifier power.
- Band 9 and 10 can be tested using a low permittivity table in order to increase the field strength for a given amplifier power.

Table 6.2.3.1-1 Non-FIC C requirements

Band	Frequency [MHz]	Modulation	Level A [V/m]	FPSC	Level B [V/m]	FPSC
5*	80 – 200	CW, AM (1)	70	Status I	100	Status II
6	200 - 800	CW, AM (1)	70	Status I	100	Status II
7	800 – 3400	CW, PM1 (2)	70	Status I	100	Status II
8	3400 – 6000	CW, PM1 (2)	50	Status I	70	Status II
9	1200 – 1400	PM2 (3)	300	Status I	600	Status II
10	2700 – 3100	PM2 (3)	300	Status I	600	Status II

Table 6.2.3.1-2 FIC C requirements

Band	Frequency [MHz]	Modulation	Level B [V/m]	FPSC
5*	80 – 200	CW, AM (1)	100	Status I
6	200 - 800	CW, AM (1)	100	Status I
7	800 – 3400	CW, PM1 (2)	100	Status I
8	3400 – 6000	CW, PM1 (2)	70	Status I
9	1200 – 1400	PM2 (3)	600	Status I
10	2700 – 3100	PM2 (3)	600	Status I

* Applicate only for DUT larger than 35 cm in any direction.

(1) AM: 1kHz, 80 %.

(2) PM1: Pulsed PRR = 217 Hz, PD = 0.57 msec.

(3) PM2: Pulsed PRR = 300 Hz, PD = 3 µsec, gated by a pulse PRR = 1 Hz, PD = 200 msec.

6.2.4 RI04 - Portable Transmitter Requirements

6.2.4.1 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 its 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 frequencies between 360 MHz and 2700 MHz and Schwarzbeck antenna SBA9119 for frequencies above 3000 MHz. Using alternative antenna for frequencies below 360 MHz is permitted (end feed sleeve antenna or similar). In case of using Schwarzbeck antenna SBA9113 for frequencies below 360 MHz, the input power can be reduced to 10 Watt. In both cases the test set-up and used antennas shall be clearly denoted in the test report.
- 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 6.2.4.1-1 below. The test antenna shall be positioned in step sizes specified in table 6.2.4.1-1 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.

Table 6.2.4.1-1 Separation Distances and Antenna Positioning

DUT Surface or Harness description	Antenna Distance from DUT	Antenna Positioning Steps
DUT surfaces and first 300 mm 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 300 mm 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

Table 6.2.4.1-2 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%
3000 - 5000	1	PM, 217 Hz, 12.5%

7. Transient Emission and Immunity Requirements

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.

7.1 Test setup

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

7.2 Requirement

7.2.1 CE01 Transient Emission

Note: *48V requirements are intentionally not included in this specification.*

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

7.2.1.1 Procedure

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

- The shunt resistor R 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.

7.2.1.2 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.

7.2.2 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. The pulse repetition time shall be chosen such that the DUT has enough time to initialize correctly, but never shorter than 0.5s.

Table 7.2.2-1 CI01 Transient Immunity limits on Power lines.

Test pulse	Requirement level [V]	No. of pulses or test time	Pass/Fail criteria	Comment
1	-112	500 pulses	Status II	Pulse not applicable for operating voltages above 60V
2a	+55	500 pulses	Status I	
2b	+10	10 pulses	Status II	
3a	-165	1 h	Status I	Amplitude calibrated in 50 Ω load
3b	+112	1 h	Status I	Amplitude calibrated in 50 Ω load

7.2.2.1 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.

7.2.2.2 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.

7.2.3 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.

Table 7.2.3-1 Pulses 3a and 3b defined in ISO 7637-3 shall be tested with the parameters given below.

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

7.2.3.1 Procedure

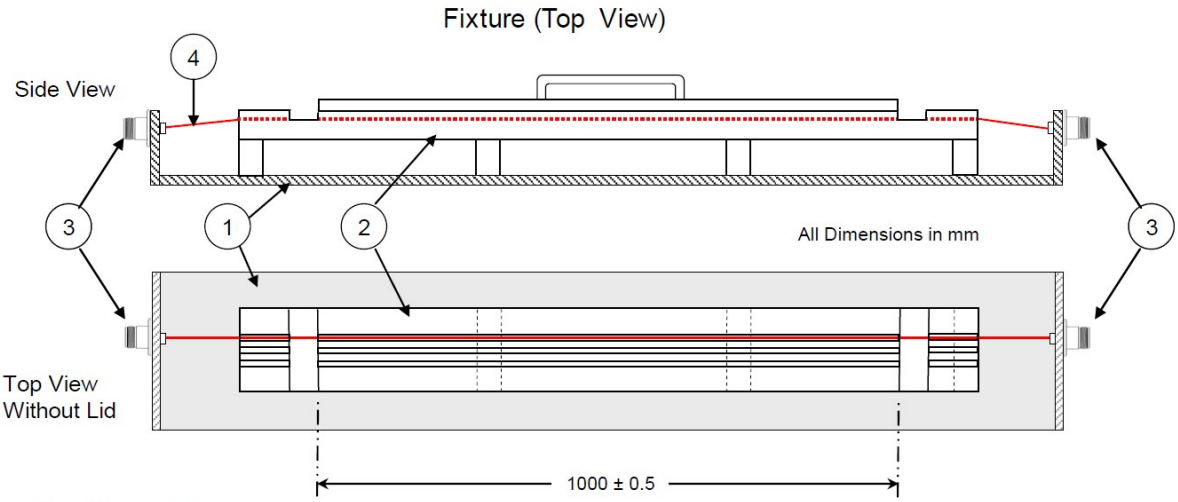
Use test methods according to the relevant sections of ISO 7637-3 with the following specification:

- Use only test pulse 3a and 3b.
- The coupling clamp in ISO 7637-3 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.

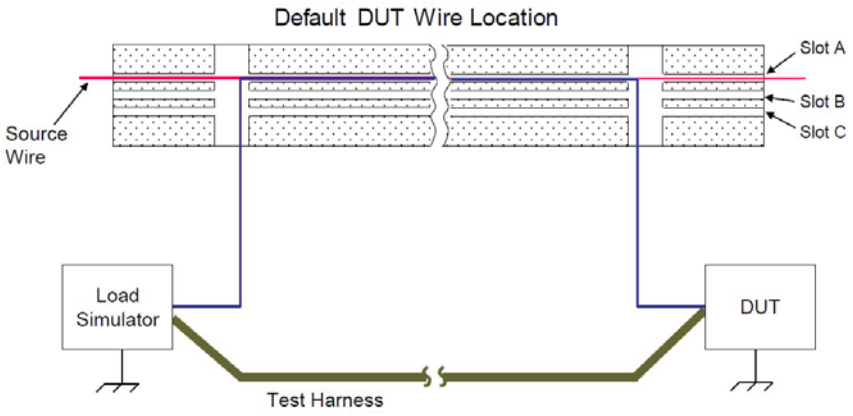
7.2.3.2 Test Fixture and Application

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

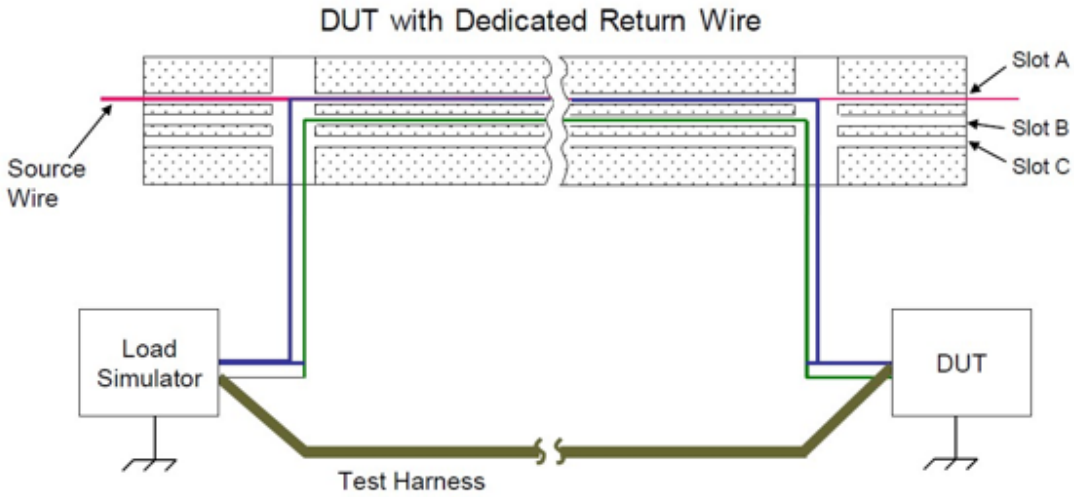


1. Aluminium plate
2. Wire support
3. Type N Connector, one connected to the transient generator and one to a 50 ohm termination
4. Source wire

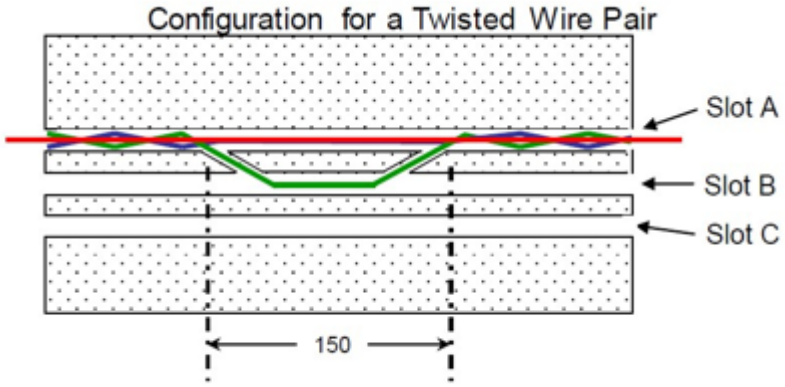
The fixture contains a single copper wire ("source wire") that is connected to the signal source that generates the disturbances. The DUT is tested by placing individual wires in the same slot as the source wire directly on top of it (Slot A). This is illustrated below.



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.

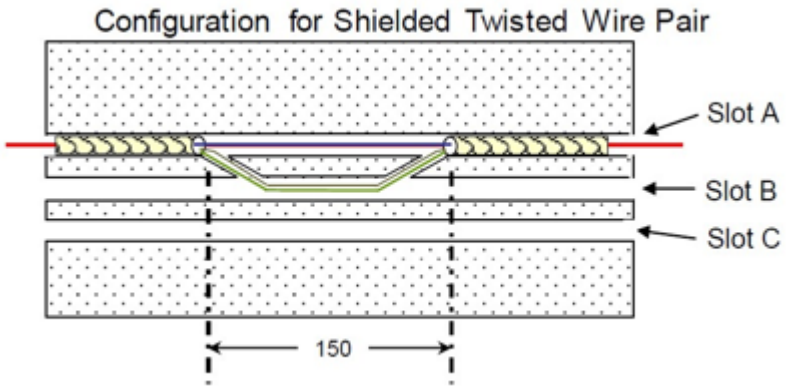


If the I/O is specified to use a twisted pair, the twisted pair shall be placed in Slot A as illustrated below. However, it is required that the wire pair is untwisted for 150 mm, one wire in slot A and the other in slot B. This is facilitated via the section located in the center of the test fixture.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



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.



7.2.3.3 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.

8. Electrostatic Discharge

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

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

Table 8-1 Environmental Test Conditions

Temperature	23 ± 5.0 degrees C
Humidity	20 to 40% relative humidity (RH)

ESD Testing shall be performed on separate samples!

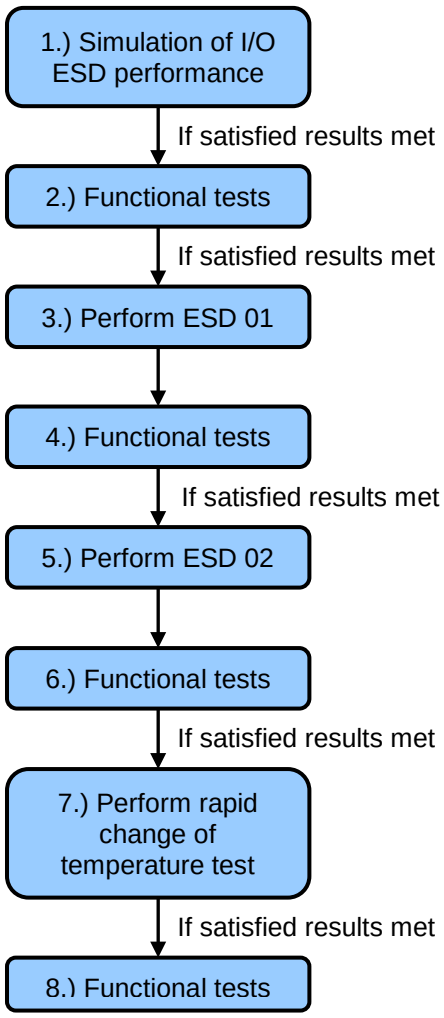
8.1 Test Verification and Test Setup

The Supplier has the option to use one of two different options for component ESD test (see below). Which option will be used shall be documented in the EMC Test plan.

- Option 1 – I/O Design simulation and test, or
- Option 2 – I/O Parameter verification.

8.1.1 Option 1 – I/O Design Simulation and ESD test

The following test sequence shall be used.



A. **Step 1 -** Validate the component I/O performance regarding ESD discharges through simulations. [Ref to ESD simulation appendix].

B. **Step 2, 4, 6 and 8** – Perform functional test to assure that all DUTs functions work as intended.

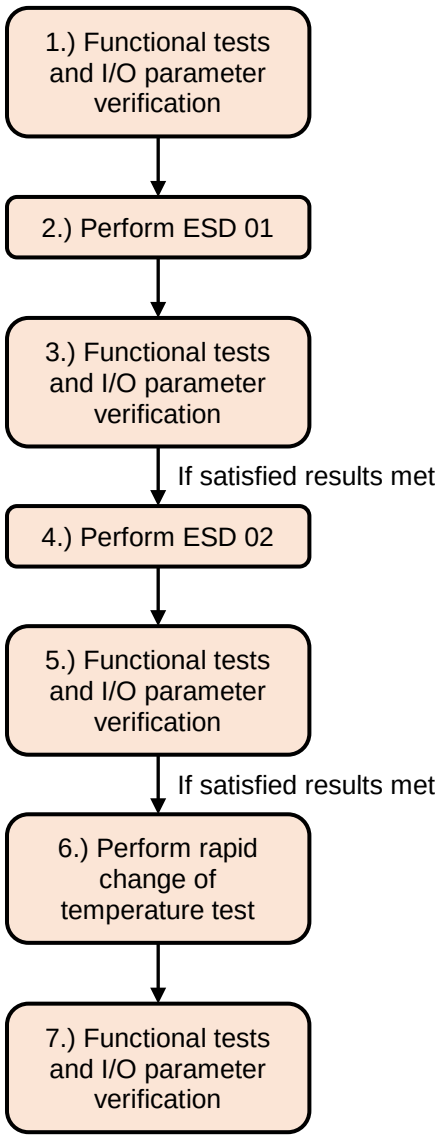
C. **Step 3 and 5** - Perform the required ESD Testing according to stated requirement.

D. **Step 7** - Subject the samples to ISO 16750-4 5.3.2, Rapid change of temperature with specified transition duration, 200 cycles with dwell time according to section 2.5. This test can be conducted together with other components.

If anywhere in the test flow, satisfied results are not met, the test is considered a fail and should be aborted.

8.1.2 Option 2 – I/O Parameter verification and ESD test

The following test sequence shall be used.



A. **Step 1 -** Verify the component I/O parametric values (e.g., resistance, capacitance, leakage current, etc.).

B. **Step 2 and 4** - Perform the required ESD Testing according to stated requirement.

C. **Step 6** - Subject the samples to ISO 16750-4 5.3.2, Rapid change of temperature with specified transition duration, 200 cycles with dwell time according to section 2.5. This test can be conducted together with other components.

D. **Step 3, 5 and 7** - Verify 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.

If anywhere in the test flow, satisfied results are not met, the test is considered a fail and should be aborted.

8.2 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.

8.2.1 ESD Handling Test Setup

Picture 8.2.1-1 ESD Handling Test Setup

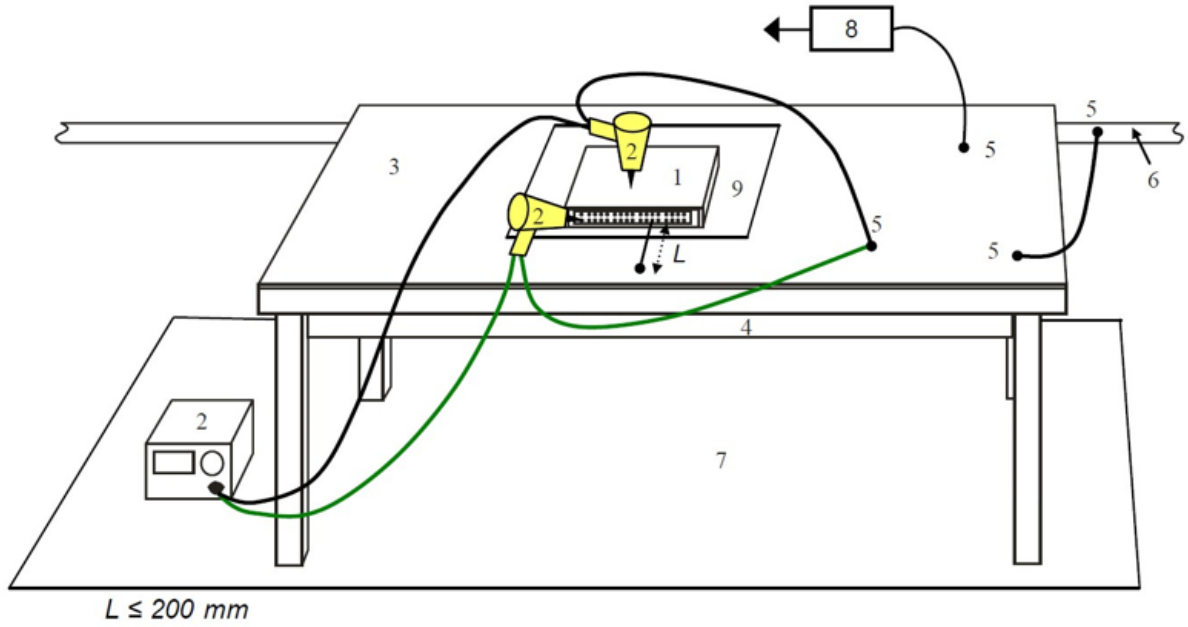


Table 8.2.1-1 ESD Handling Test Setup - Key:

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 M ohm bleed-off resistor
9	Dissipative mat

8.2.2 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.

Table 8.2.2-1 ESD01 Handling (unpowered) ESD limits – Discharge sequence

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 = 2 kΩ	± 4 kV	Status IV	3
2	Contact discharge C = 150 pF, R = 2 kΩ	± 6 kV	Status IV	3
3	Air discharge C = 150 pF, R = 2 kΩ	± 8 kV	Status IV	3

Apply contact and air discharges according to the sequence above on all DUT surfaces, 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. Connector pins excluded.

Apply contact discharges according to sequences 1 and 2 on all connector pins.

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.

8.3 ESD02 Powered Tests

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

- Chassis-mounted DUTs shall be placed on the conductive ground plane. DUTs isolated from chassis ground in normal installation shall be placed on a clean, dielectric support ($\varepsilon_r \leq 1.4$) that is 50 mm thick. The insulator lies directly on the ground plane. (see ISO 10605-section 8.3)
- 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.

8.3.1 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.

Table 8.3.1-1 Discharge sequence

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 = 150 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

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

8.3.2 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.

Picture 8.3.2-1 ESD Powered Test Setup

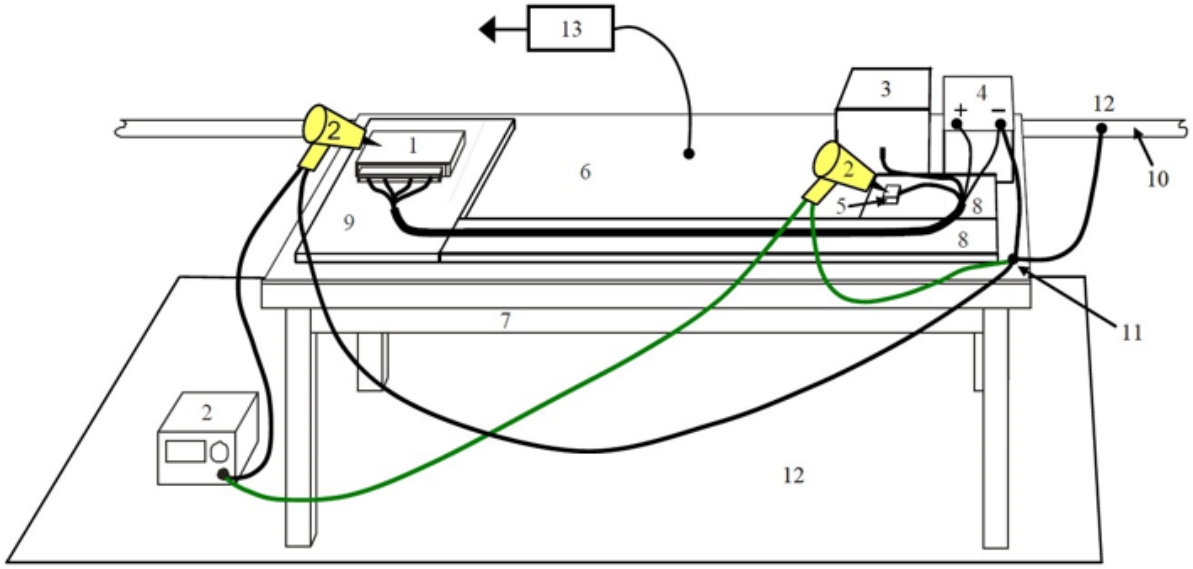


Table 8.3.2-1 ESD Powered Test Setup - Key:

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 M ohm bleed-off resistor

Picture 8.3.2-2 ESD Remote I/O

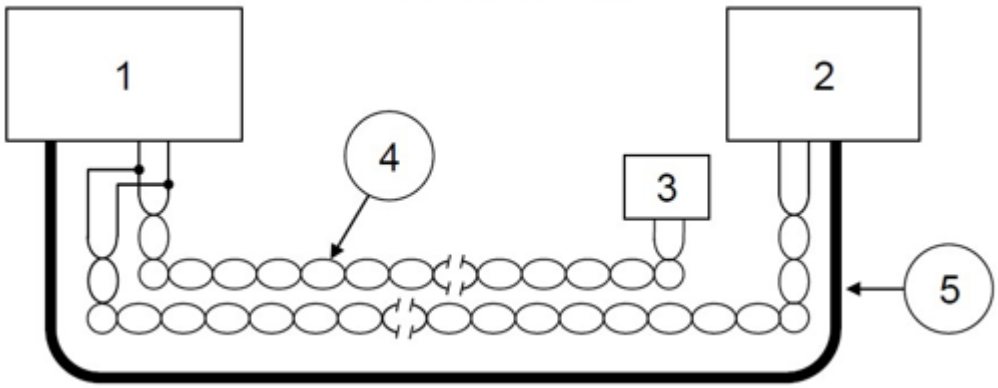


Table 8.3.2-2 ESD Remote I/O - Key:

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.

8.3.3 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.

8.4 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.

9. Mains connected devices

All Mains Connected devices must comply with ECE R10.05.

9.1 Requirement

Components and complete vehicles shall meet the requirements given in ECE R10.05 chapter 7.

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

Appendices

Appendices are not included in this document but available as separate documents. If not originally supplied, they can be requested by the supplier.

A. 8889109897-NOTE-DPR-Appendix A-ESD Simulation-Appendix to 8888621495.
B. 8889109898-NOTE-DPR-Appendix B-EMC Packaging Guideline-Appendix to 8888621495