The English language version is the original and the reference in case of dispute.

PARTS AND COMPONENTS

Electro-magnetic compatibility, EMC

Orientation

This issue differs from issue 4 in that:

- Some clarifications have been added and some corrections have been made.
- A conductive emission test case (test case 6), which is intended to evaluate “braked/disconnected” electrical motors, has been added.
- Parts of the requirements for test cases 1 to 5 of conductive emissions have been deleted.
- Regarding conducted susceptibility, test pulse 2b has been added, and test pulse 5b has been removed.
- Regarding conducted transient susceptibility on signal leads, “fast-transient test pulses a and b” has been renamed “fast-transient test pulses 3a and 3b”, and “slow-transient test pulses 1 and 2” has been renamed “slow-transient test pulses positive and negative 2a”. In addition, the test times for “fast-transient test pulses 3a and 3b” and “slow-transient test pulses positive and negative 2a”, have been clarified.
- The test methods for radiated emissions for complete vehicle are now in accordance with ECE R10 instead of Council Directive 72/245/EEC.
- Regarding radiated emissions measured in accordance with ECE R10, the requirement has been clarified for the case when antenna-vehicle separation is 10 meters.
- The frequency range where the radiated susceptibility requirements apply has been updated to 150 kHz – 3 GHz. More specifically, the frequency ranges where CW and AM apply have been changed. Additionally, two types of pulse modulations, “pulse-modulated 1 (PM1)” and “pulse-modulated 2 (PM2)”, together with their applied frequency ranges and pulse properties, have been clarified.
- For component radiated susceptibility far field and BCI tests, the lower frequency range limit has been changed from 90 kHz to 150 kHz.
- For component radiated susceptibility, a test case of simulated portable transmitter according to ISO 11452-9 has been added.

Contents

1 Scope and field of application

A component must function as intended when installed in a vehicle's electrical system. Furthermore, it shall not degrade the electrical environment in which it is installed.

To ensure this, the levels of radiated and conducted emissions must be controlled. This also applies to the susceptibility, radiated as well as conducted.

To be permitted to market our products, they must comply with relevant EC and other national regulations. Requirements on emission and susceptibility levels must be set and maintained in order to achieve the following targets:

- Make the complete product compliant with relevant EC and other national requirements.
- Maintain our product responsibility.

A device(component)/system may be approved by Volvo even if it does not comply with all of the requirements in this document. Such exemptions shall be decided by Volvo on a case-by-case basis.

All components shall fulfil both the component requirements and the complete vehicle requirements.

- Tests on vehicle are used to make a final validation.
- Tests on device(component)/system are the supplier's responsibility; tests on vehicle are the Volvo Group's responsibility.

1.1 Indications to be mentioned in the component TR or drawing

The following shall be indicated in the component TR or the drawing:

- Severity index (1, 2 or 3), see definition in 2.1.
- Quantification of allowed deviation during susceptibility test per Functional Status Classification (FSC).
- Specification of ISO 7637 pulse 4 application.
- Identification of all I/O lines designed for any connection to power supply, to enable correct testing scope for conducted transient susceptibility.

1.2 Changes of approved components

When a component or system has been approved, it may not be changed in any way which could change its EMC characteristics without permission from Volvo. This concerns, for example, changes to:

- Layout of PCB
- Component selection (type, value, casing and manufacturer)
- Case material (plastic or metal)
- Surface treatment on conductive surfaces.

2 Definitions

The following concepts are used to specify or describe the behaviour of the system (or a function of the system):

2.1 Severity index (SI)

The following indices shall be selected to describe the importance of the system/component/function to the vehicle. Components which handle different types of functions might need more than one SI. If more than one SI is needed, this shall be clearly communicated in the component TR.

SI 1: Malfunction affects safety-related functions, e.g. the brake function.

SI 2: Malfunction affects basic functions and basic performance of the vehicle, such as driveability. This class also includes other functions of the vehicle, such as driving and engine condition instruments, excluding comfort functions. Functions without important risk of damage to man and/or environment.

SI 3: Malfunction affects the comfort of the vehicle, e.g. air conditioning.

2.2 Functional status classification (FSC)

FSC is used to define the degree of function/malfunction during exposure to interference when performing an immunity test.

The tolerated degree of malfunction comes as a result of the SI classification and is stated for each kind of immunity test defined in this standard.

Unwanted operation of the device under test (DUT, referring to component/system) is not allowed in any of the following classes (A to E)

FSC A: All functions of a device/system perform as designed during and after exposure to interference.

FSC B: All functions of a device/system perform as designed during exposure; however, one or more of them can go beyond the specified tolerance. All functions return automatically to within normal limits after exposure is removed. Memory functions must remain class A.

FSC C: A function of a device/system does not perform as designed during exposure, but returns automatically to normal operation as soon as exposure is removed.

FSC D: A function of a device/system does not perform as designed during exposure and does not return to normal operation when exposure is removed. The device/system is reset by a simple "operator/use" action.

FSC E: One or more functions of a device/system do not perform as designed during and after exposure and cannot be returned to correct operation without repairing or replacing the device/system.

2.3 Test levels

Defines the level at which the test is realized, indicated with a Roman digit. The higher the number, the higher the level.

2.4 Terms and definitions

Terms and definitions given in ISO 7637-1, ISO 11451-1 and ISO 11452-1 apply.
Note: Transient voltage, Us

Positive or negative transient values are always superimposed on the power supply voltage Ua or Ub. (Ua or Ub +/- Us).

3 General test conditions

The device(component)/system shall be positioned in vehicle configuration and its attachment as per the drawing.

The test on device(component)/system shall be realized with an environment representative of the vehicle operating mode.

Unless otherwise specified, the environmental conditions shall be:

- Temperature: 23 ± 5 ºC
- Humidity: 25–75 % for all tests except ESD tests. For ESD tests, please refer to ISO 10605.
- Air pressure: 86–106 kPa

3.1 Test set-up

To improve repeatability and to enable tests to be performed at any location, each requirement shall be verified in its specified test set-up.

3.2 Power-supply voltages

Table 1

Nominal voltage	12 V system	24 V system
Test voltage Ua	14,2 V +/- 0,3	28,5 V +/- 0,3
Test voltage Ub	12,5 V +/- 0,5	25 V +/- 1

Ua: Vehicle power supply provided by battery and alternator with regulator.
Ub: Vehicle power supply provided by battery.

4 Conducted emissions

4.1 Conducted transient emissions

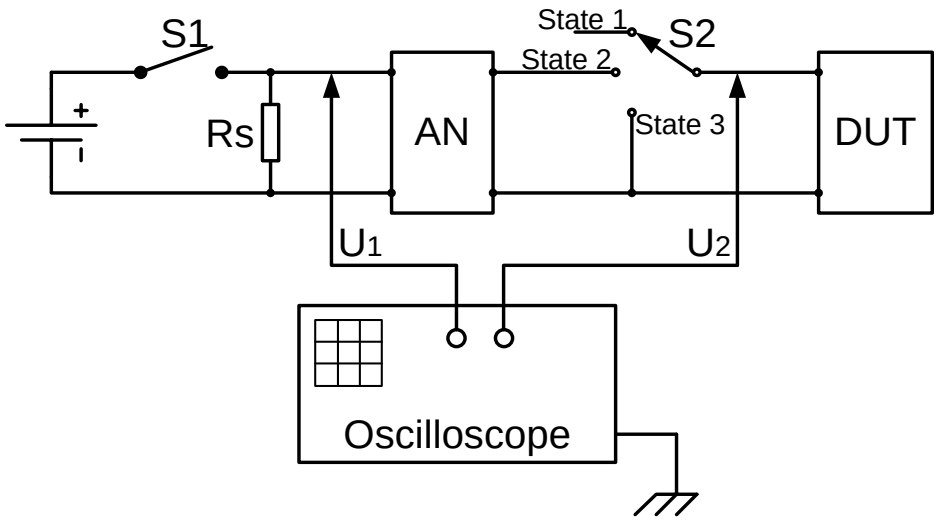


Fig. 1

This procedure conforms to ISO 7637-2.

This test is intended to evaluate permanent interference, as well as switch-off and switch-on transients sent from the DUT (Fig. 1). It is also intended to evaluate “braked/disconnected” electric motors (state 3).

Permanent interference shall be measured when switch S1 is closed and switch S2 is closed to state 2.

Transients are measured when opening or closing switch S1, and when switching S2 between its different states.

Exception: If a complete system is purchased from a supplier, the system might be regarded as a component, and the conducted emission requirement shall apply to the system and not to the specific components.

4.1.1 Test method

The test set-up shall be in accordance with ISO 7637-2, section 4.3.

Test cases 2, 3, 4, 5 and 6 shall be repeated 10 times.

Table 2

Test case	S1 state	S2 state	Test goal
Test case 1	Permanently closed	Permanently closed to state 2	Waveforms sent by DUT
Test case 2	Permanently closed	Switching from state 2 to state 1	Waveforms sent by DUT
Test case 3	Permanently closed	Switching from state 1 to state 2	Waveforms sent by DUT
Test case 4	Opening (from ON to OFF)	Permanently closed to state 2	Waveforms sent by DUT, AN and Rs
Test case 5	Closing (from OFF to ON)	Permanently closed to state 2	Waveforms sent by DUT, AN and Rs
Test case 6	Permanently closed	Switching from state 2 to state 3	Waveforms sent by DUT

4.1.2 Requirements

Requirements for test cases 1 to 6:

Table 3

Result	Requirements	
	24 V system	12 V system
U_2*	-75 V < U_2 < +50 V	-50 V < U_2 < +50 V

* U_2 = Ua + Us, where Ua is the supply voltage and Us is the disturbance voltage or superimposed transient voltage

For each test case, U1 and U2 waveform recordings shall be submitted to Volvo for analysis.

4.2 Conducted RF emission – Voltage method

Reference document

Components shall comply with the requirements defined in CISPR 25, Edition 04.

Field of application

This test is intended to evaluate the radio frequency-conducted disturbances generated by the DUT and its power supply wiring.

Principal characteristics

- Frequency band [0,15–108 MHz].
- Peak detector and average detectors shall always be used.
- Peak and average detection are used for compliance with both average and peak limits.

Frequency bands outside of CISPR 25 bands are also included, not shaded in the table.
In case of overlap between bands, the lower limit shall apply.

Reference levels

The device(component)/system shall comply with the requirements specified in Table 4 (similar to CISPR Class 5)

Table 4

Band	Frequency band (MHz)	Peak detector		Average detector	
		Limit value dB (µV)	BW (kHz)	Limit value dB (µV)	BW (kHz)
LW [1]	0,15–0,30	70	9/10	50	9
[2]	0,30–0,53	70	9/10	50	9/10
MW [1]	0,53–1,8	54	9/10	34	9/10
[2]	1,8–5,9	54	9/10	34	9/10
SW [1]	5,9–6,2	53	9/10	33	9/10
[2]	6,2–26	53	9/10	33	9/10
CB [3]	26–28	44	9/10	24	9/10
[2]	28–30	44	9/10	24	9/10
VHF [3]	30–54	44	100/120	24	100/120
TV band 1 [1]	41–88	34	100/120	24	100/120
VHF [3]	68–87	38	100/120	18	100/120
FM [1]	76–108	38	100/120	18	100/120

1) Broadcast
2) Free band
3) Mobile services band

5 Conducted susceptibility

5.1 Conducted transient susceptibility on power supply leads and I/Os connected to power supply

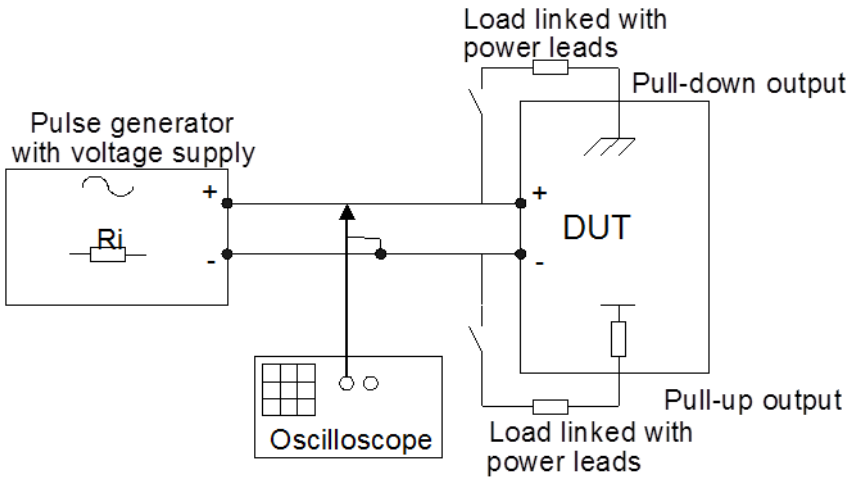


Fig. 2

This test is intended to check the immunity of the DUT to conducted electrical transients caused by electronic and electric components. These interferences affect power supply lines and signal or sensor input lines when these lines are directly or indirectly connected to the power supply lines.

Unless otherwise specified, the test shall be performed in accordance with ISO 7637-2 for pulses 1, 2, 3, and ISO 16750 for pulses 4, 5.

All pulses shall be superimposed on the lines of the device(component)/system connected to the power supply.

All test pulses shall be characterized under no-load conditions, i.e. voltages are open-loop voltages.

Table 5 FSC with respect to SI and pulse number
Choose the severity index (SI) and read the functional status classification (FSC) attached to the pulse.

Pulse number	1	2	3	4	5a [1)]	5c [2)]
SI 1	C	A	A	*)	A	A
SI 2	C	B	B	*)	B	B
SI 3	C	C	C	*)	C	C

1) This requirement is valid for 12 V systems only
2) This requirement is valid for 24 V systems only
*) This is decided on a case-by-case basis, depending on unit and application

5.1.1 Test pulse 1

Scope: This pulse originates from the switching off of an inductive load in parallel with the tested component/system, e.g. electric valves without clamp diodes.

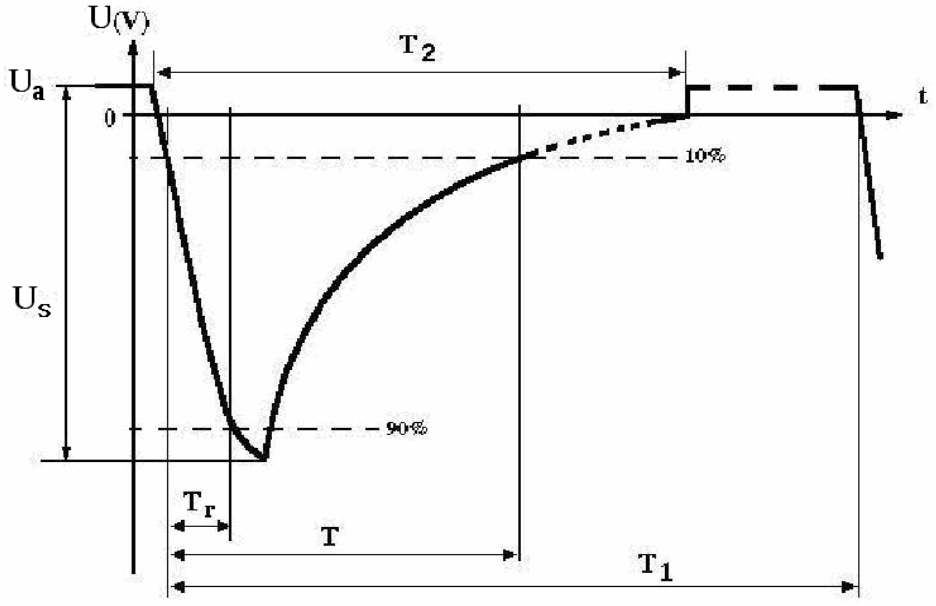


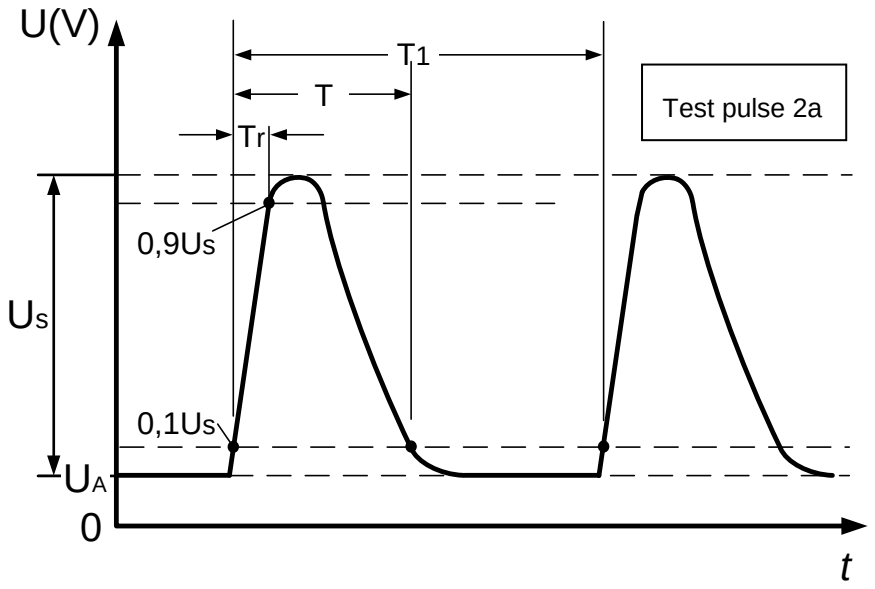
Fig. 3

Table 6 Parameters of test pulse 1

Parameter	12 V system	24 V system
U_S (V)	-600	-600
T_r (µs)	≤ 1	≤ 1
T (ms)	1	1
T_1 (s)	5	5
T_2 (ms)	200	200
R_i (Ω)	20	50
Number of pulses	1000	1000

5.1.2 Test pulse 2

Scope: Pulse 2a originates from the switching off of an inductive load that is in series with the tested component/system, e.g. a DC motor. Pulse 2b simulates transients from a DC motor acting as a generator after the ignition is switched off.



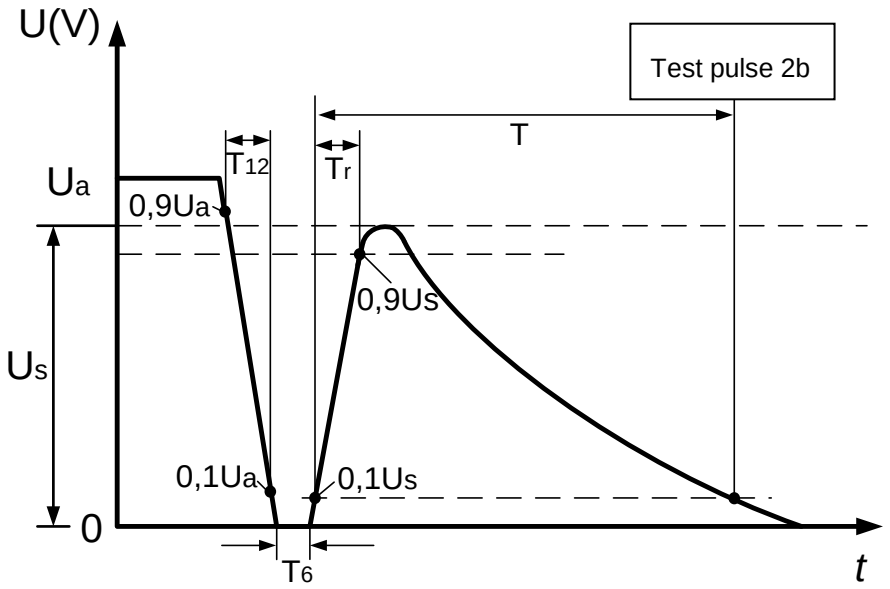


Fig. 4 Test pulse 2a and 2b

Table 7 Parameters of test pulse 2

Parameter	Test pulse 2a	Test pulse 2b	
		Nominal 12 V system	Nominal 24 V system
U_S (V)	+ 100	10	20
T_r	$\leq$ 1 µs	1 ms ± 0,5 ms	
T	0,05 ms	2 s	
T_1	5 s	N/A	
R_i (Ω)	10	0 Ω to 0,05 Ω	
Number of pulses	1000	100	
T_6	N/A	1 ms ± 0,5 ms	
T_{12}	N/A	1 ms ± 0,5 ms	

5.1.3 Test pulse 3

Scope: This pulse simulates transients that occur during bouncing of a relay contact.

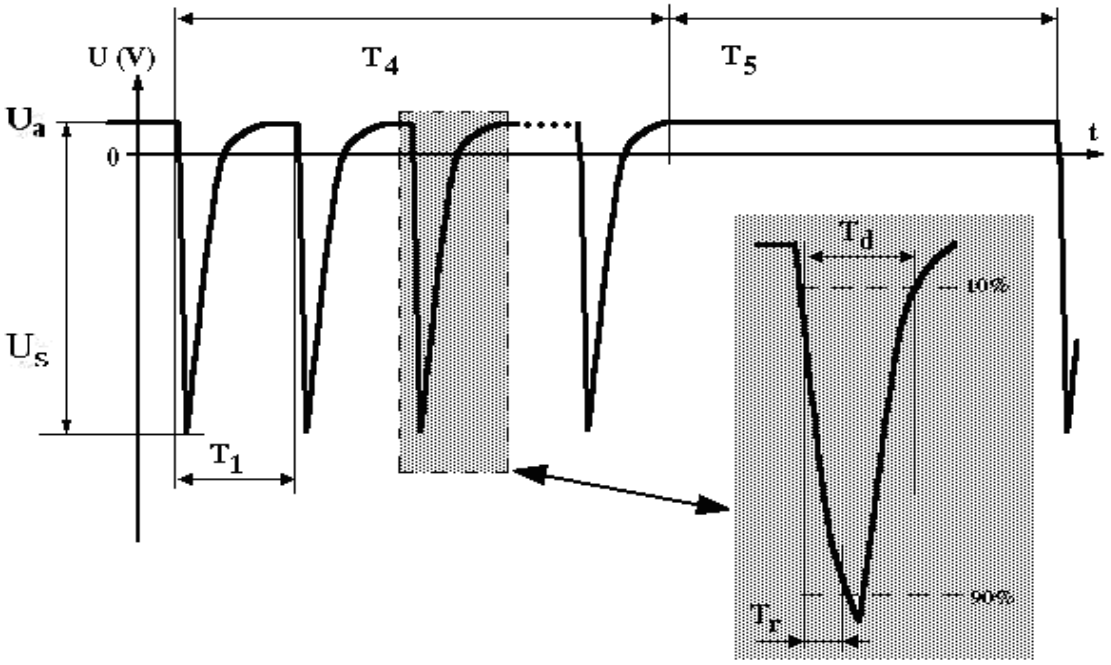


Fig. 5 Example for negative burst

Table 8 Parameters of test pulse 3

Parameter	Pulse 3a 12 V system	Pulse 3a 24 V system	Pulse 3b 12 V and 24 V system
U_S (V)	-150	-200	+ 200
T_r (ns)	$\leq$ 5	$\leq$ 5	$\leq$ 5
T_d (µs)	0,1	0,1	0,1
T1 (µs)	100	100	100
T4 (ms)	10	10	10
T5 (ms)	100	100	100
Ri (Ω)	50	50	50
Test duration	1 h	1 h	1 h

5.1.4 Test pulse 4

Scope: This pulse originates from a voltage drop in the main supply due to cranking.

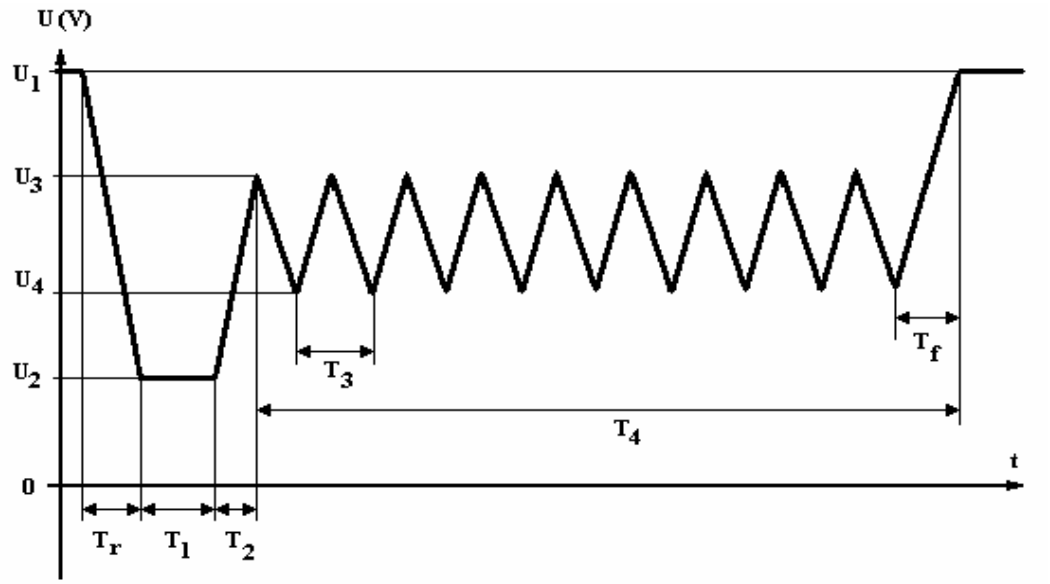


Fig. 6

Table 9 Parameters of test pulse 4

Parameter	12 V system	24 V system
U_{1*} (V)	12	24
U_2 (V)	5	8
U_3 (V)	10	18
U_4 (V)	6	12
T_r (ms)	5	10
T_f (ms)	10	10
T_1 (ms)	40	100
T_2 (ms)	2	2
T_3 (ms)	100	100
T_4 (s)	20	20

* U_1: Value corresponding to a battery charge state of 50 %

5.1.5 Test pulse 5

Scope: This pulse may be generated using a charging alternator connected to a battery with an appropriate load in parallel. The alternator speed and load should then be varied and the corresponding load dump pulse logged using an oscilloscope, the component/system not connected, to find the appropriate combination for producing the desired test pulse. The component can then be connected and the test performed.

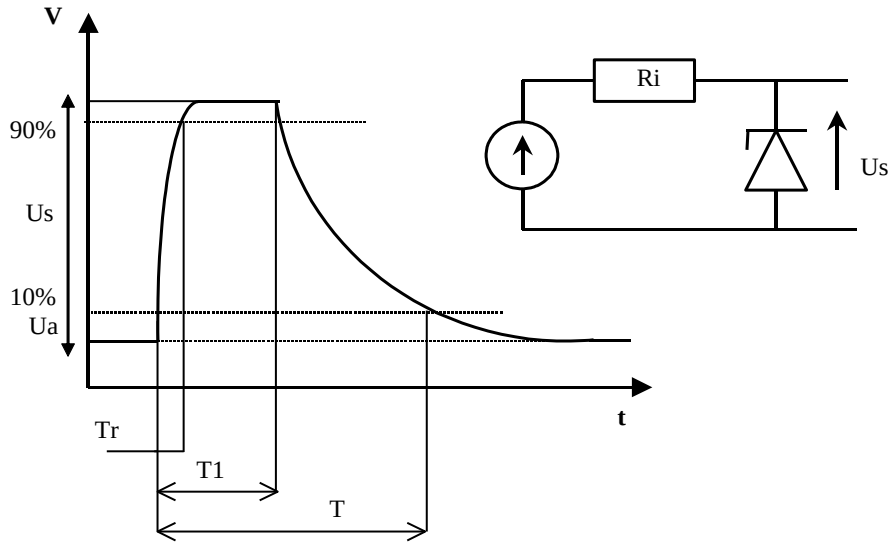


Fig. 7

A total of five pulses shall be applied for each pulse type (a and c) tested. A period of 60 seconds shall pass between the pulses. Ua is the supply voltage according to Section 3.1.

Table 10 Parameters of test pulse 5

Test pulse		Pulse 5a[1)]	Pulse 5c[1)]
Applicability		12 V system	24 V system
Para-meters	U_S (V)	25,8	29,5
	T_r (ms)	$\leq$ 5	$\leq$ 5
	T1 (ms)	160	160
	T (ms)	600	600
	R_i (Ω)	0,7	1,8

1) Alternator with internal zener diode

5.2 Conducted transient susceptibility on signal leads

Scope: This test is intended to ensure the immunity to transient transmission by inductive and capacitive coupling via vehicle signals or sensor cables.

A capacitive coupling clamp (CCC) is used to test capacitive coupling with fast pulses.

An inductive coupling clamp (ICC) is used to test inductive coupling with slow pulses.

The device/system shall withstand exposure to transients coupled to all signal lines. Test pulses and test methods are defined in ISO 7637-3.

Fast-transient test pulses 3a and 3b

Parameters are identical to section 5.1.3 of this document (pulse 3 applied on supply leads) with the exception of pulse amplitude and number of pulses, as follows:

Pulse 3a: Us = -200 V, test time 10 minutes

Pulse 3b: Us = +200 V, test time 10 minutes

Slow-transient test pulses positive and negative 2a

According to ISO 7637-3

Test level IV

Pulse positive 2a: Us = +10 V, test time 5 minutes

Pulse negative 2a: Us = -10 V, test time 5 minutes

Requirements: Irrespective of SI classification, FSC A is required for both pulses.

5.3 Power supply quality

5.3.1 Test method

A programmable power supply or a high-power operational amplifier and signal generator may be used to generate the “saw-tooth” supply voltage. It must be able to supply both the static and dynamic currents required by the tested component/system.

As an alternative, an alternator and a partly charged battery may be used to generate the test voltage specified in section 5.3.2. A high-power solid-state relay may be used to generate the cuts required in section 5.3.3.

An ordinary power supply can be used to generate the test voltage specified in section 5.3.4.

5.3.2 Power supply with and without battery

This test is intended to check the immunity of the device(component)/system to minimum and maximum voltages of the power system due to the regulation of the alternator.

The voltage is that encountered in a commercial vehicle, with the following characteristics:

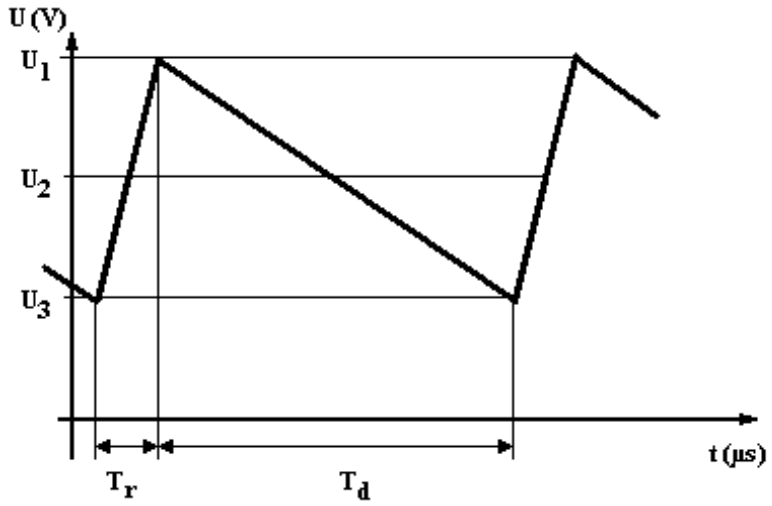


Fig. 8

Table 11 Parameters of test voltage, power supply quality

	With battery		Without battery	
Parameter	12 V	24 V	12 V	24 V
U1 [V]	16	31	18	30
U2 [V]	14,2	28,5	13	25
U3[V]	11	26	8	20
Tr [µs]	20	20	20	20
Td [µs]	160	160	160	160
Test duration	1 h	1 h	1 h	1 h

Requirements: Irrespective of SI classification, FSC A is required.

5.3.3 Immunity to micro power cuts

Scope: This test comes from problems with logic control circuits due to short-duration power cuts causing software-related problems.

The power supply of the tested component/system shall undergo micro power cuts as stipulated in the component TR. Unless otherwise specified, tests with a power cut duration ($t_{interrupt}$) of 100, 200 and 400 µs shall be applied 5 times, with a >1 s delay between each power cut. Waveform transition times shall be approximately 10 µs and the voltage drop shall be from nominal operating voltage, U_{nom} to 0 V. For illustration of the test pulse, see the figure below.

The test harness connecting the DUT to the test fixture and transient pulse generator shall be ≤ 2000 mm in length.

During the micro power cut, the supply line shall be in open circuit.

Requirement: A component/system shall be capable of uninterrupted operation when micro power cuts are applied (FSC A).

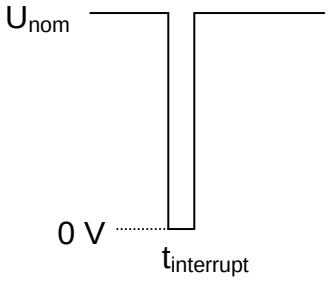


Fig. 9 Micro power cut

5.3.4 Immunity to high-voltage supply

Scope: This test comes from battery chargers/starters used in combination with batteries in poor condition. This will result in a rise of the supply voltage.

A component shall be immune to high voltage in the supply lines for a certain amount of time. This simulates a quick charger/starter.

Table 12 Requirements per electrical system and test

12 V systems			
Test name	U, supply	T, duration	Requirement
Charger/starter	24 V	5 min	FSC D
24 V systems			
Test name	U, supply	T, duration	Requirement
Charger/starter	48 V	2 min	FSC D

6 Radiated emissions

To protect on-board and off-board receivers, the following requirements shall apply.

6.1 Complete vehicle test

6.1.1 Radiated emissions measured at the foot of the antenna

Reference document

The components shall comply with the requirements defined in CISPR 25, Edition 04.

Field of application

This test is intended to evaluate the level of electromagnetic disturbance received by the vehicle's antennas.

Principal characteristics:

- Frequency band [150 kHz – 3,0 GHz]
- Peak and average detectors shall always be used.
- Peak and average detection are used to measure compliance with both average and peak limits.

Comments:

Frequency bands outside of CISPR 25 bands are also included, not shaded in the table.

In the 30–3000 MHz range with 100/120 kHz bandwidth, the measurements using average detector can be conducted with a bandwidth of 9/10 kHz if the ambient electromagnetic noise level measured at 100/120 kHz is not at least 6 dB lower than the applicable limit.

Unless otherwise defined in CISPR 25, edition 04, the measurement time (receiver) or sweep time (spectrum analyzer) shall be increased if low recursive frequency shall be measured.

Based on the type of possible receivers (depending on vehicle range and region), the tests can be carried out with the specific frequency bands specified by the EMC responsible at Volvo. This will be decided on a case-by-case basis.

In case of an overlap between bands, the lower limit shall apply.

Radiated levels

To protect on-board receivers, the disturbance voltage at the end of the antenna cable shall not exceed the values in table 13.

Table 13

Band		**Frequency band (MHz)**	**Peak detector**		**Average detector**	
			Limit value dB(µV)	BW (kHz)	Limit value dB(µV)	BW (kHz)
LW	1)	0,15–0,30	26	9/10	20	9/10
	2)	0,30–0,53	26	9/10	20	9/10
MW	1)	0,53–1,8	22	9/10	10	9/10
	2)	1,8–5,9	22	9/10	10	9/10
SW	1)	5,9–6,2	22	9/10	10	9/10
	2)	6,2–26	22	9/10	10	9/10
CB	3)	26–28	22	9/10	0	9/10
	2)	28–30	22	9/10	0	9/10
VHF	3)	30–54	20	100/120	0	100/120
TV Band 1	1)	41–88	16	100/120	6	100/120
VHF	3)	68–87	20	100/120	0	100/120
FM	1)	76–108	26	100/120	6	100/120
	2)	108–137	26	100/120	6	100/120
VHF	3)	137–175	20	100/120	0	100/120
TV Band 3	1)	174–230	16	100/120	6	100/120
DAB 3	1)	171–245	10	100/120	0	100/120
	2)	245–300	20	100/120	6	100/120
RKE	3)	300–330	20	100/120	6	100/120
	2)	330–380	20	100/120	6	100/120
RKE	3)	420–450	20	100/120	6	100/120
UHF	3)	380–512	20	100/120	0	100/120
DTTV	1)	470–770	20	100/120	10	100/120
TV Band 4/5	1)	468–944	16	100/120	6	100/120
UHF	3)	820–960	20	100/120	0	100/120

Band	Frequency band (MHz)	Peak detector		Average detector	
		Limit value dB(µV)	BW (kHz)	Limit value dB(µV)	BW (kHz)
GSM 800 3)	860–895	26	100/120	6	100/120
GSM 900 3)	925–960	26	100/120	6	100/120
2)	960–1447	26	100/120	6	100/120
DAB L BAND 1)	1447–1494	10	100/120	0	100/120
2)	1494–1567	20	100/120	0	100/120
GPS 3)	1567–1583	20	100/120	0	100/120
2)	1583–1803	26	100/120	6	100/120
GLONASS 3)	1591–1616	20	100/120	0	100/120
GSM 1800 3)	1803–1882	26	100/120	6	100/120
GSM 1900 3)	1850–1990	26	100/120	6	100/120
UMTS (3G) 3)	1900–2172	26	100/120	6	100/120
2)	2172–2320	26	100/120	6	100/120
SDARS 1)	2320–2345	16	100/120	6	100/120
2)	2345–2400	16	100/120	6	100/120
Bluetooth /WLAN 3)	2400–2500	26	100/120	6	100/120
2)	2500–3000	26	100/120	6	100/120

1) Broadcast
2) Free band
3) Mobile services band

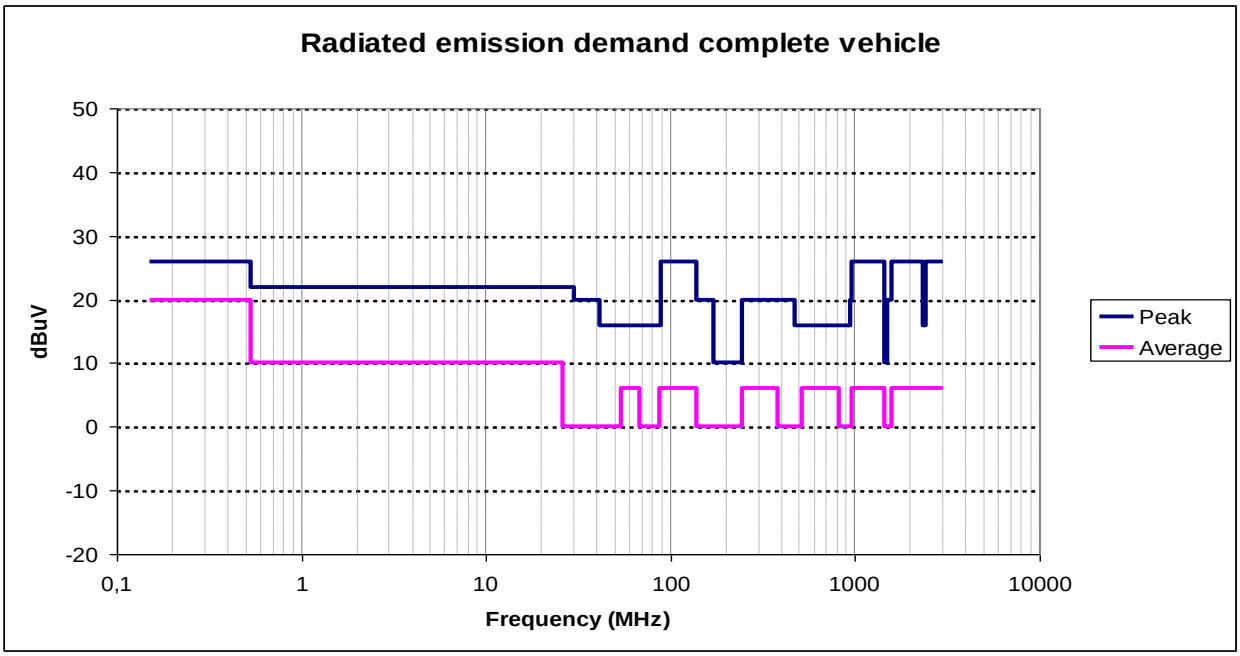


Fig. 10 Limit line showing emission requirement level of a complete vehicle test (peak and average limits)

6.1.2 Radiated emissions measured in accordance with ECE R10

The test methods are in accordance with ECE R10 with the following setup:

- Frequency band [30 MHz – 2 GHz]
- Horizontal and vertical polarization
- Limits according to table 14 and table 15

References levels

The vehicle shall comply with the requirements stated in table 14 and table 15.

Measurements at 3 metres or 10 metres:

Table 14 Peak and average when antenna-vehicle separation is 3 metres

Frequency (MHz)	Peak detector limit (dBµV/m)	Average detector limit (dBµV/m)
30–75	54	32
75–400	54 + 15,13·log (F/75)	32 + 15,13·log (F/75)
400–2000	65	43

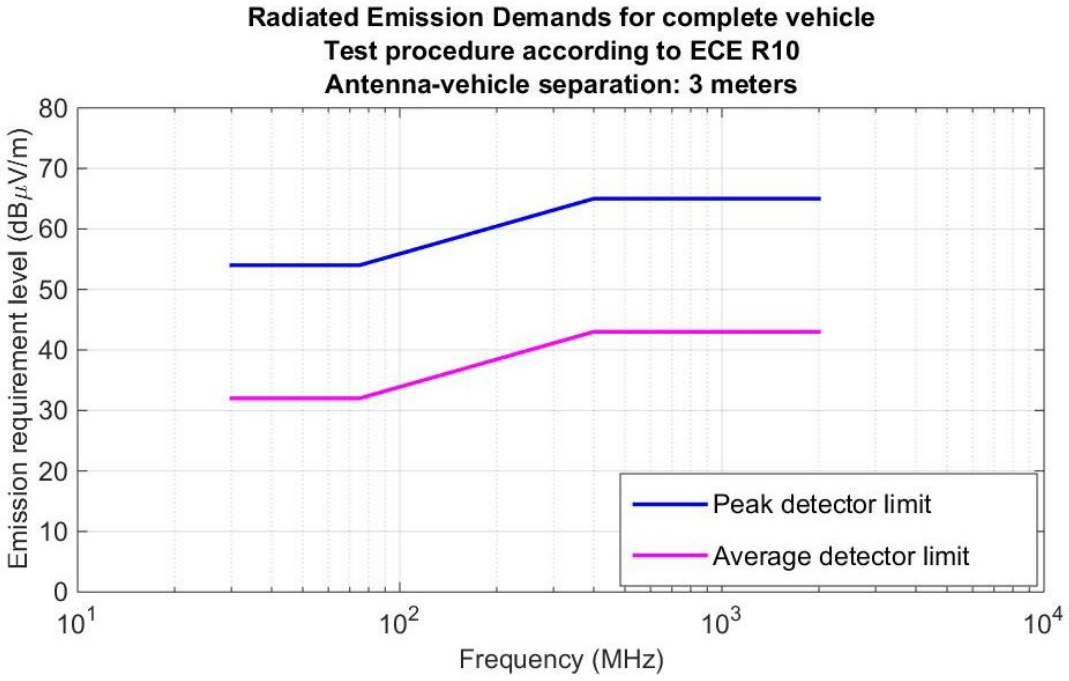


Fig. 11 Limit line showing emission requirement levels for a complete vehicle test, peak and average detector limits (antenna-vehicle separation is 3 metres)

Table 15 Peak and average when antenna-vehicle separation is 10 metres

Frequency (MHz)	Peak detector limit (dBµV/m)	Average detector limit (dBµV/m)
30–75	44	22
75–400	44 + 15,13·log (F/75)	22 + 15,13·log (F/75)
400–2000	55	33

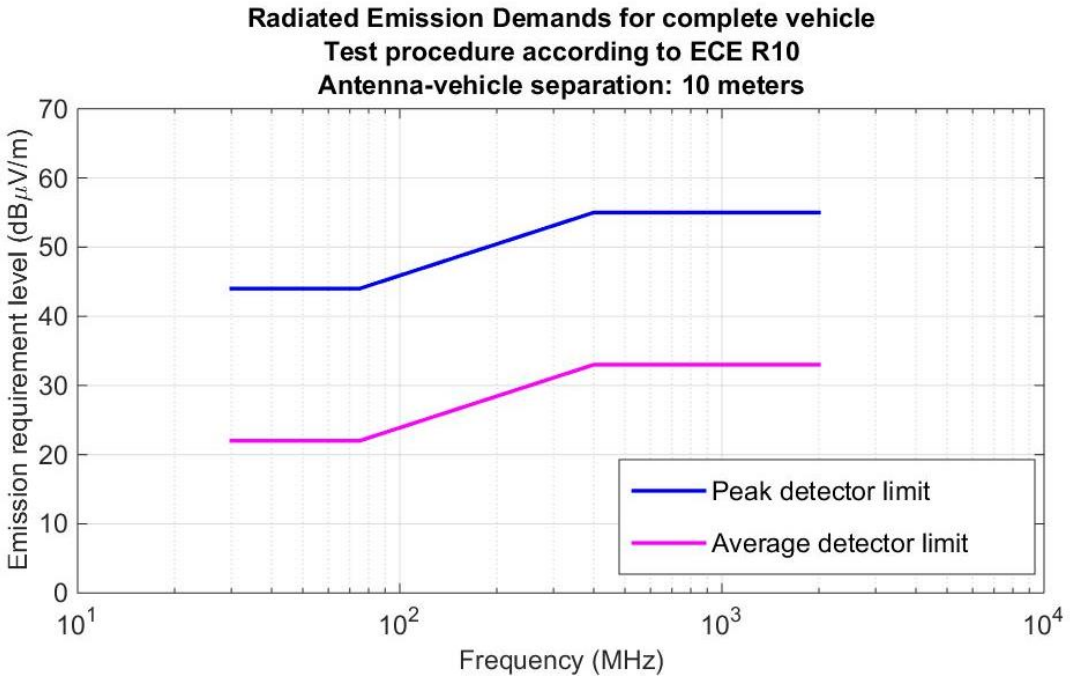


Fig. 12 Limit line showing emission requirement levels for a complete vehicle test, peak and average detector limits (antenna-vehicle separation is 10 metres)

6.2 Component test – ALSE method

Reference document

The components shall comply with the requirements defined in CISPR 25, Edition 04.

Field of application

This test is intended to evaluate radio frequency-emitted disturbances generated by the DUT and its wiring.

Principal characteristics:

- Frequency band [150 kHz – 3,0 GHz].

- Peak detector and average detector shall always be used. Peak and average detection are used to measure compliance with both average and peak limits.
- Frequency bands outside of CISPR 25 bands are included, not shaded in the table.
- In the range 30–3000 MHz with 100/120 kHz bandwidth, the measurements using average detector can be conducted with a bandwidth of 9/10 kHz if the ambient electromagnetic noise level measured at 100/120 kHz is not at least 6 dB lower than the applicable limit.
- Unless otherwise defined in CISPR 25, edition 04, the measurement time (receiver) or sweep time (spectrum analyzer) shall be increased if low recursive frequency shall be measured.
- In case of an overlap between bands, the lower limit shall apply.

In a component test, the actuator, sensors, switches, etc., connected to the tested component/system shall, as far as possible, be the same as those used in production.

In a component test, the component/system with its actuator, sensors, switches, etc., shall be connected to the ground plane in the same way as the vehicle installation.

References levels

The device(component)/system shall comply with the requirements in table 16.

Table 16

Band		Frequency band (MHz)	Peak detector		Average detector	
			Limit value dB(µV/m)	BW (kHz)	Limit value dB(µV/m)	BW (kHz)
LW1	1)	0,15–0,30	46	9/10	26	9/10
	2)	0,30–0,53	46	9/10	26	9/10
MW	1)	0,53–1,8	40	9/10	20	9/10
	2)	1,8–5,9	40	9/10	20	9/10
SW	1)	5,9–6,2	40	9/10	20	9/10
	2)	6,2–26	40	9/10	20	9/10
CB	3)	26–28	40	9/10	20	9/10
	2)	28–30	40	9/10	20	9/10
VHF	3)	30–54	40	100/120	20	100/120
TV Band 1	1)	41–88	28	100/120	18	100/120
VHF	3)	68–87	35	100/120	15	100/120
FM	1)	76–108	38	100/120	18	100/120
	2)	108–137	38	100/120	18	100/120
VHF	3)	137–175	35	100/120	15	100/120
TV Band 3	1)	174–230	32	100/120	22	100/120
DAB 3	1)	171–245	26	100/120	16	100/120
	2)	245–300	32	100/120	18	100/120

Band		Frequency band (MHz)	Peak detector		Average detector	
			Limit value dB(µV/m)	BW (kHz)	Limit value dB(µV/m)	BW (kHz)
RKE	3)	300–330	32	100/120	18	100/120
	2)	330–380	32	100/120	18	100/120
RKE	3)	420–450	32	100/120	18	100/120
UHF	3)	380–512	38	100/120	18	100/120
DTTV	1)	470–770	45	100/120	35	100/120
TV Band 4/5	1)	468–944	41	100/120	31	100/120
UHF	3)	820–960	44	100/120	24	100/120
GSM 800	3)	860–895	44	100/120	24	100/120
GSM 900	3)	925–960	44	100/120	24	100/120
	2)	960–1447	44	100/120	24	100/120
DAB L BAND	1)	1447–1494	28	100/120	18	100/120
	2)	1494–1567	44	100/120	18	100/120
GPS	3)	1567–1583	44	100/120	10	100/120
	2)	1583–1803	44	100/120	24	100/120
GLONASS	3)	1591–1616	44	100/120	10	100/120
GSM 1800	3)	1803–1882	44	100/120	24	100/120
GSM 1900	3)	1850–1990	44	100/120	24	100/120
UMTS (3G)	3)	1900–2172	44	100/120	24	100/120
	2)	2172–2320	44	100/120	24	100/120
SDARS	1)	2320–2345	34	100/120	24	100/120
	2)	2345–2400	44	100/120	24	100/120
Bluetooth /WLAN	3)	2400–2500	44	100/120	24	100/120
	2)	2500–3000	44	100/120	24	100/120

1) Broadcast
2) Free band
3) Mobile services band

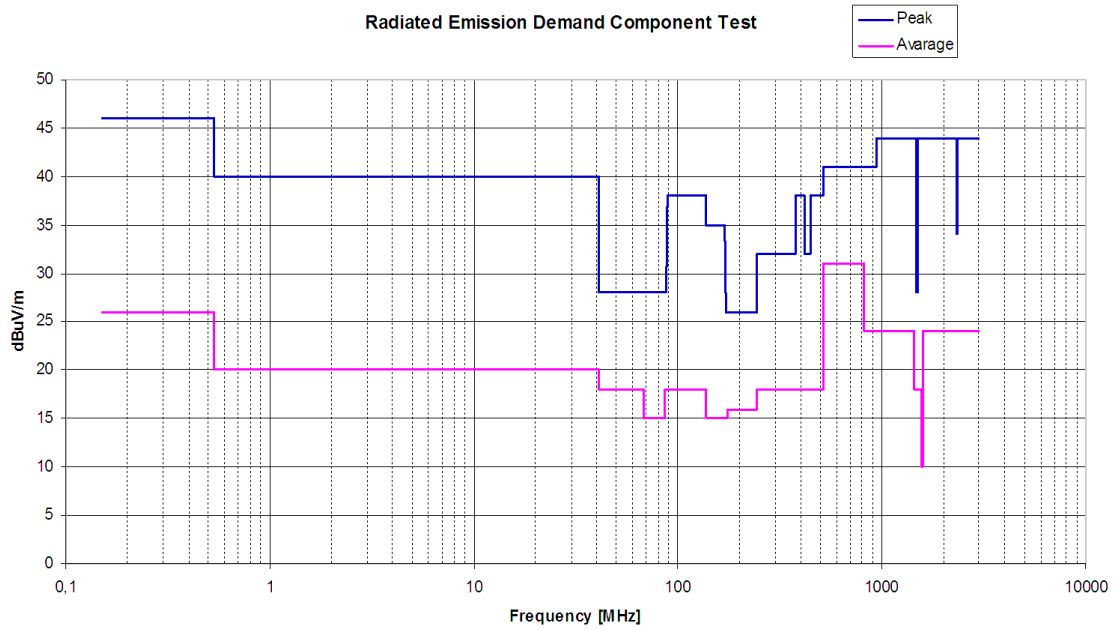


Fig. 13 Limit line showing emission requirement levels for a component test (peak and average limits)

7 Radiated susceptibility

7.1 General

The frequency range where the radiated susceptibility requirements apply is 150 kHz – 3 GHz, with the additional radar frequency bands up to 12,4 GHz.

- Substitution method with the conservation of peak level
- Semi-anechoic or anechoic chamber shall be used

Modulation vs frequency range:

- CW in the 150 kHz – 3 GHz range
- AM in the 150 kHz – 800 MHz range
- PM1 in the 800 MHz – 3 GHz range
- PM2 in the 1,15–1,45 GHz range, L-band
- PM2 in the 2,6–3,2 GHz range, S-band
- PM2 in the 5,2–5,9 GHz range, C-band
- PM2 in the 8,2–12,4 GHz range, X-band

According to ISO 11451-1 and ISO 11452-1

- Non-modulated signal: continuous wave (CW)
- Amplitude modulated (AM): 1 kHz 80 %

- Pulse-modulated 1 (PM1): Ton 577 µs, period 4600 µs
- Pulse-modulated 2 (PM2): Ton 3 µs, period 3333 µs

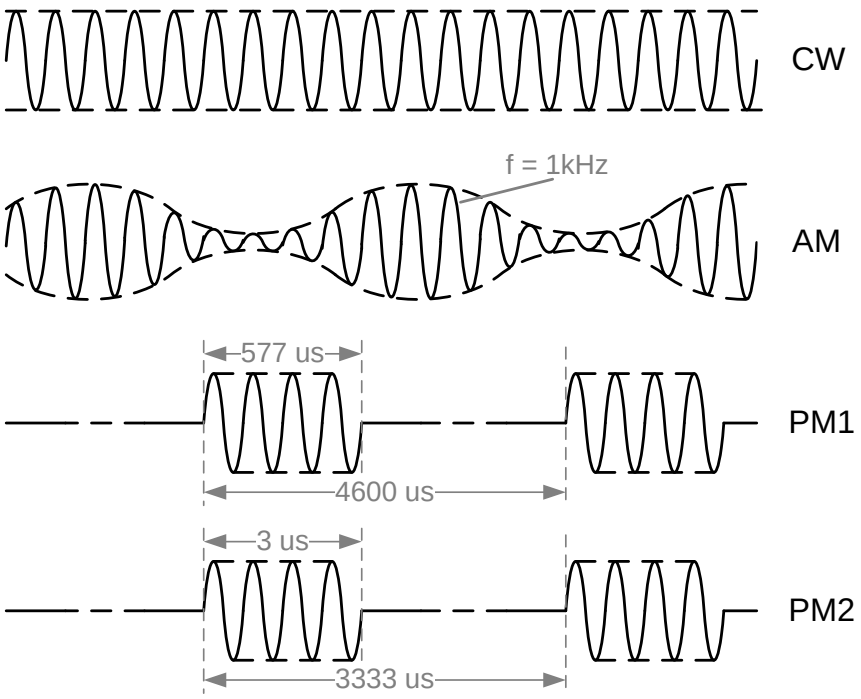


Fig. 14

To confirm that the vehicle/component meets the requirements in this section, the vehicle/component shall be tested with the following maximum frequency steps:

- From 150 kHz to 1 MHz: step 30/decade
- From 1 MHz to 20 MHz: step 0,5 MHz
- From 20 MHz to 220 MHz: step 1 MHz
- From 220 MHz to 500 MHz: step 2 MHz
- From 500 MHz to 1 GHz: step 5 MHz
- From 1 GHz to 3 GHz: step 20 MHz
- L-band, from 1,15–1,45 GHz: step 5 MHz
- S-band, from 2,6–3,2 GHz: step 5 MHz
- C-band, from 5,2–5,9 GHz: step 10 MHz
- X-band, from 8,2–12,4 GHz: step 20 MHz

At each frequency, the field amplitude shall be applied as follows:

- From 0 V/m to the maximum
- Constant during X seconds
- From maximum to 0 V/m.

The amplitude modulation is effective during the constant part of the cycle. Time X shall be sufficient to allow the device(component)/system under test to react to the interference and for any reaction to be recorded; X shall never be less than 2 seconds.

Vertical and horizontal polarization shall be used above 20 MHz.

Table 17 FSC requirements and test levels

Severity index		**SI 1**	**SI 2**	**SI 3**
Test level	**III**	A	B	D
	II	A	A	C
	I	A	A	A

Observe the defined severity index (SI) as defined in the component's technical regulation.

Observe the defined functional status classification (FSC) for each level.

Carry out the different test levels and check FSC compliance.

7.2 Complete vehicle test

A complete vehicle test shall conform to ISO 11451-2 and ISO 11451-3.

TABLE 18 TEST LEVELS WITH RESPECT TO TEST METHODS

Test method	**Applicable standard**	**Test level (V/m)**		
		Level I	**Level II**	**Level III**
Vehicle test, far field	ISO 11451-2	30	50	100
On-board transmitter simulation	ISO 11451-3	See tables A.1 and A.2 of ISO 11451-3		

7.3 Component test

7.3.1 Far field and BCI tests

The components shall comply with the following requirements.
The applicable frequency range for this test method is 150 kHz – 3000 MHz, and L-, S-, C-, X-bands. Testing over the full frequency range could require different field-generating devices, but this does not imply that testing of overlapping frequency ranges is required. Only the test methods described in table 19 are accepted.

Table 19 Test levels with respect to test methods

Test method	Applicable standard	Test level		
		Level I	Level II	Level III
Far field (V/m), 200–3000 MHz	ISO 11452-2	30	50	100
Far field (V/m), L-band	ISO 11452-2	200	600	N/A
Far field (V/m), S-band	ISO 11452-2	100	200	N/A
Far field (V/m), C-band	ISO 11452-2	100	200	N/A
Far field (V/m), X-band	ISO 11452-2	100	200	N/A
BCI test* (mA), 150 kHz – 400 MHz	ISO 11452-4	60	100	200

*) When using the closed-loop method with limitation of forward power, K = 4 shall be used. When using the substitution method, all 3 positions (150 mm, 450 mm, 750 mm) shall be used. If multiple harnesses or connectors are used, a test shall be performed for each harness/connector.

7.3.2 Simulated portable transmitter

This test is applicable for electrical and electronic components that can be located close to handheld transmitters (e.g. cellular phone). For each component, Volvo shall evaluate and determine if this test needs to be performed. This test should be performed according to ISO 11452-9, excluding the frequency ranges for “10 m”, “2 m” and “IEEE 802.11a”.

8 Immunity to electrostatic discharge

This test is intended to check the immunity of components to electrostatic discharges produced by:

- operators during storage, handling, assembly and maintenance. Unpowered test is required.
- occupants in or near the vehicle and customer service operation. Powered test is required.

The electrostatic discharge immunity test procedure shall be conducted using ISO 10605 with the following conditions and requirements.

Table 20

Tests	Direct contact Discharge sequence	Air contact Discharge sequence	Specifications
Component test: Unpowered tests (handling)	**± 4 / 8 KV** On each connector pin[3] and conductive surface of the device(component)/system	**± 4 / 8 / 15 / (30)[1] KV** On all accessible points and other surfaces of the device(component)/system	**Supplier test** Sequence with a series of 10 discharges for each negative and positive level (from the lowest level to the highest level) Intervals between each discharge: 5 s minimum Network: R = 330 Ω, C = 150 pF
	REQUIREMENTS: FSC A AFTER RECONNECTION		
Component test: Powered-up tests (live and loaded conditions)	**± 4 / 8 KV** (Device(component)/system and remote inputs/outputs)[2] On all points accessible by vehicle occupants during maintenance and operation (determined in the test plan)	**± 4 / 8 / 15 / (25)[1] KV** (Device(component)/ system and remote inputs/outputs)[2] On all points accessible by vehicle occupants during maintenance and operation (determined in the test plan)	**Supplier test** Sequence with a series of 10 discharges for each negative and positive level (from the lowest to the highest level) Intervals between each discharge: 5 s minimum Network: R = 330 Ω C = 330 pF (150 pF)[a]
	REQUIREMENTS: ± 4 / 8 KV: FSC A for severity indices 1 and 2, FSC B for severity index 3 ± 15 / (25)[1] KV: FSC B for severity indices 1 and 2, FSC C for severity index 3		
Vehicle test	**If needed** Test plan, specifications and requirements defined by the EMC engineering department Contact discharge: ± 4 / 8 KV Air discharge: ± 4 / 8 / 15 / (25) [1] KV		**Vehicle manufacturer test** Network: R = 330 Ω C = 150 / 330 pF [4]
	REQUIREMENTS: ± 4 / 8 KV: FSC A for severity indices 1 and 2, FSC B for severity index 3 ± 15 / (25)[1] KV: FSC B for severity indices 1 and 2, FSC C for severity index 3		

1) Only for pyrotechnic components.

2) For powered-up tests, the device(component)/system shall be connected to all inputs/outputs necessary for functional testing, as well as controls, actuators, sensors, etc.

All discharge sequences also apply to:

All devices(components)/systems directly connected to the unit and accessible by vehicle occupants during maintenance and operation, as well as remote control, switches, displays, harness, connectors, etc.

All inputs/outputs that are connected to communication buses and regarded as accessible points (e.g.: diagnostic plug, OBD plug). In that case C = 150 pF; note [a]

All devices(components)/systems directly connected to the unit may be subject to ESD indirectly by a charged source (e.g., wheel speed sensor, external temperature sensor, etc.)

In agreement with Volvo, if a periphery is not available for the test, the connecting lines shall be tested directly with discharges.

3) For testing pins in contact mode, an extension line for easy discharge can be used. The line shall be no longer than 25 mm.

4) C = 330 pF for areas that can only be touched from the inside of the vehicle.

C = 150 pF for areas that can only be touched from the outside of the vehicle.

9 Low-frequency magnetic fields

9.1 Immunity to low-frequency magnetic fields

Scope: This requirement serves to protect systems from interference from power lines, their harmonics and DC fields present at certain industrial plants. Conforms to ISO 11452-8.

The following requirements are applicable to magnetic fields of zero and low frequencies from 15 Hz up to 150 kHz.

Test levels:

DC field: 25 mT

AC field (15 Hz to 150 kHz): according to ISO 11452-8, test level IV (internal field)

The frequency steps shall be at least 10/decade, linear or logarithmic. If any resonance frequency of the system can be suspected, the number of steps shall be increased to at least 80 steps/decade, logarithmic steps, or 3 % step size.

Requirements:

- System with SI 1: FSC A must be maintained throughout the test.
- System with SI 2 or SI 3: At least FSC C must be maintained.

9.2 Emission of low-frequency magnetic fields

9.2.1 Test set-up, complete vehicle

The magnetic field shall be measured in accordance with the following test set-up.

The following conditions shall be fulfilled:

- Headlights on
- Radio turned on
- Fan on half speed
- Cab lights turned on.

The measurements shall be carried out both at idle and at 2000 rpm, driver and passenger side. The measurement points shall be in accordance with fig. 15.

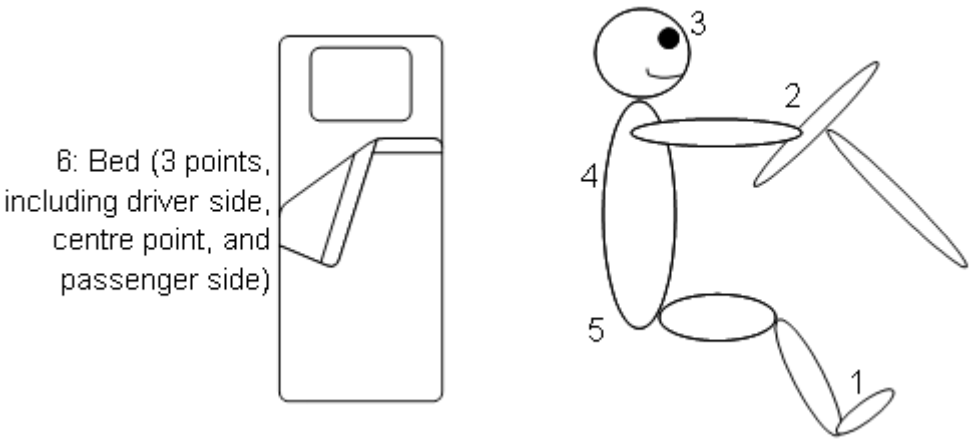


Fig. 15

Measurement shall also be carried out at measurement point 6 with the engine shut off.

9.2.2 Requirements

Frequency range	RMS value (must never be exceeded)
5 Hz – 2 kHz	2,0 µT
2 kHz – 400 kHz	0,25 µT

10 Relevant documents

Conducted susceptibility:

ISO 7637-1, 2015

ISO 7637-2, 2011

ISO 7637-3, 2007

ISO 16750-2, 2012

Radiated emissions:

CISPR 25, Edition 04

Radiated susceptibility, vehicle testing:

ISO 11451-1, 2015

ISO 11451-2, 2015

ISO 11451-3, 2015

Radiated susceptibility, component testing:

ISO 11452-1, 2015

ISO 11452-2, 2004

ISO 11452-4, 2012

ISO 11452-8, 2015

ISO 11452-9, 2012

Electrostatic discharge (ESD):

ISO 10605, 2008

11 Legislation

ECE-R10