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INTERNATIONAL STANDARD

colour inside

Electric vehicle conductive charging system –
Part 21-1: Electric vehicle on-board charger EMC requirements for conductive connection to an AC/DC supply

IEC 61851-21-1:2017-06(en)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FOREWORD

International Standard IEC 61851-21-1 has been prepared by subcommittee 69: Electric road vehicles and electric industrial trucks.

This first edition, together with IEC 61851-21-2, cancels and replaces IEC 61851-21:2001. It constitutes a technical revision.

This edition includes the following significant technical changes with respect to IEC 61851-21:2001:

a) this document addresses now only EMC tests instead of other electrical tests;

b) test setups are defined more precisely;

c) Annex A "Artificial networks, asymmetric artificial networks and integration of charging stations into the test setup" was added.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
69/507/FDIS	69/516/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 61851 series, under the general title: *Electric vehicle conductive charging system,* can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

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ELECTRIC VEHICLE CONDUCTIVE CHARGING SYSTEM –

Part 21-1: Electric vehicle on-board charger EMC requirements for conductive connection to an AC/DC supply

1 Scope

This part of IEC 61851, together with IEC 61851-1:2010, gives requirements for conductive connection of an electric vehicle (EV) to an AC or DC supply. It applies only to on-board charging units either tested on the complete vehicle or tested on the charging system component level (ESA – electronic sub assembly).

This document covers the electromagnetic compatibility (EMC) requirements for electrically propelled vehicles in any charging mode while connected to the mains supply.

This document is not applicable to trolley buses, rail vehicles, industrial trucks and vehicles designed primarily to be used off-road, such as forestry and construction machines.

NOTE 1 Specific safety requirements that apply to equipment on the vehicle during charging are treated in separate documents as indicated in the corresponding clauses of this document.

NOTE 2 Electric vehicle (EV) includes pure electric vehicles as well as plug-in hybrid electric vehicles with additional combustion engine.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60038:2009, *IEC standard voltages*

IEC 61000-3-2:2014, *Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)*

IEC 61000-3-3:2013, *Electromagnetic compatibility (EMC) – Part 3-3: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤ 16 A per phase and not subject to conditional connection*

IEC 61000-3-11:2000, *Electromagnetic compatibility (EMC) – Part 3-11 – Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems – Equipment with rated current ≤ 75 A and subject to conditional connection*

IEC 61000-3-12:2011, *Electromagnetic compatibility (EMC) – Part 3-12 – Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current > 16 A and ≤ 75 A per phase*

IEC 61000-4-4:2012, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-5:2014, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61000-6-3:2006, *Electromagnetic compatibility (EMC) – Part 6-3: Generic standards – Emission standard for residential, commercial and light-industrial environments*
IEC 61000-6-3:2006/AMD1:2010

IEC 61851-1:2010, *Electric vehicle conductive charging system – Part 1: General requirements*

CISPR 12:2007, *Vehicles, boats and internal combustion engines – Radio disturbance characteristics – Limits and methods of measurement for the protection of off-board receivers*
CISPR 12:2007/AMD1:2009

CISPR 16-1-2:2014, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-2: Radio disturbance and immunity measuring apparatus – Coupling devices for conducted disturbance measurements*

CISPR 16-2-1:2014, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-1: Methods of measurement of disturbances and immunity – Conducted disturbance measurements*

CISPR 22:2008, *Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement*

CISPR 25:2016, *Vehicles, boats and internal combustion engines – Radio disturbance characteristics – Limits and methods of measurement for the protection of on-board receivers*

ISO/TR 8713:2012, *Electrically propelled road vehicles – Vocabulary*

ISO 7637-2:2011, *Road vehicles – Electrical disturbances from conduction and coupling -- Part 2: Electrical transient conduction along supply lines only*

ISO 11451-1:2015, *Road vehicles – Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 1: General principles and terminology*

ISO 11451-2:2015, *Road vehicles – Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 2: Off-vehicle radiation sources*

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 – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – 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*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61851-1:2010 and ISO/TR 8713:2012, as well as the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
REESS
rechargeable energy storage system that provides electric energy for electric propulsion of the vehicle

3.2
on-board EV charging system
all equipment in the charge power supply chain inside the vehicle

Note 1 to entry: It includes the plug and cable if physically connected to the vehicle (cable cannot be removed without any tool, i.e. case A as defined in IEC 61851-1:2010).

3.3
electrical/electronic sub-assembly
ESA
electrical and/or electronic device or set(s) of devices intended to be part of a vehicle, together with any associated electrical connections and wiring, which performs one or more specialized functions

3.4
low voltage
LV
operating DC voltage below 60 V

EXAMPLE Nominal voltages of 12 V, 24 V, 48 V.

3.5
LV harness
low voltage harness with operating voltages below 60 V

3.6
high voltage
HV
operating voltages of 60 V to 1000 V

Note 1 to entry: HV+ and HV- are abbreviations for the positive and negative terminal line, respectively.

Note 2 to entry: HV definition is in accordance to CISPR 25, ISO 11451-1 and ISO 11452-1.

3.7
electric vehicle
EV
pure electric vehicles as well as plug-in hybrid electric vehicles with additional combustion engine

4 General test conditions

The vehicle systems shall operate correctly within +10 % to –15 % of the standard nominal supply voltage. This takes into account variations that are induced by the installation as defined in Annex A of IEC 60038:2009. The rated value of the frequency is 50 Hz ± 1 % or 60 Hz ± 1 %.

NOTE IEC 60038:2009 specifies the voltage at the delivery point. Annex A proposes to specify wider values to allow for further voltage variations due to installations.

Test methods concern only the electric vehicle charging system with "REESS in charging mode coupled to the power grid". Tests shall be performed either on separate samples or on the whole vehicle at the vehicle manufacturer’s request as defined in the test plan.

The vehicle shall be in an unladen condition except for necessary test equipment.

The vehicle shall be immobilized, engine OFF, and in charging mode.

All other equipment which can be switched on permanently by the driver or passenger shall be OFF.

The tests shall be carried out with the equipment under test (EUT) or any movable part of it placed in the most unfavourable position as defined in the test plan.

Unless otherwise specified, the tests shall be carried out in a draught-free location and at an ambient temperature of 23 °C ± 5 °C according to ISO 11451-1:2015 and ISO 11452-1:2015.

5 Test methods and requirements

5.1 General

5.1.1 Overview

All tests shall be carried out using the charging cable specified or provided by the electric vehicle supply equipment (EVSE) manufacturer or the electric vehicle manufacturer as described in further detail in the test plan, for example cable lengths.

If the charging cable is provided by the vehicle manufacturer the extraneous length shall be z-folded in 0,5 m width.

The artificial (mains) networks (AN/AMN) for power supply and asymmetric artificial networks (AAN) for charging communications to be used for these tests are described in Annex A.

For electrical/electronic sub-assembly (ESA) separated on-board charger tests an appropriate load shall be used to simulate the vehicle HV-systems terminations, for example HV battery. If specific load boxes are used, these shall also be described in the test plan.

5.1.2 Exceptions

Vehicles and/or ESA which are intended to be used in "REESS charging mode coupled to the power grid" in the configuration connected to a DC-charging station with a length of a DC network cable shorter than 30 m do not have to fulfil the requirements of conducted emissions, surge and fast transients (burst) neither on vehicle nor ESA level.

In this case, the manufacturer shall provide a statement that the vehicle and/or ESA can be used in "REESS charging mode coupled to the power grid" only with cables shorter than 30 m. This information shall be made publicly available following the type approval.

Vehicles and/or ESA which are intended to be used in "REESS charging mode coupled to the power grid" in the configuration connected to a local/private DC-charging station without additional participants do not have to fulfil requirements of conducted emissions, surge and fast transients (burst) neither on vehicle nor ESA level.

In this case, the manufacturer shall provide a statement that the vehicle and/or ESA can be used in "REESS charging mode coupled to the power grid" only with a local/private DC charging station without additional participants. This information shall be made publicly available following the type approval.

5.2 Immunity

5.2.1 General

The tests shall be carried out individually as single tests in sequence. The tests may be performed in any order.

In general, the EUT shall be tested in configuration "REESS in charging mode coupled to the power grid".

If the current consumption can be adjusted, the current shall be set to at least 20 % of its nominal value.

If the current consumption cannot be adjusted, the REESS state of charge (SOC) shall be kept between 20 % and 80 % of the maximum SOC during the whole time duration of the measurement

NOTE This may lead to split the measurement in different time slots/sub-bands with the need to discharge the vehicle's traction battery before starting the next time slot/ sub-band.

The EUT shall be switched on and shall operate as defined in the test plan.

The description of the test, relevant generator, appropriate methods, and the setup to be used are given in the basic standards, which are referred to in Table 1.

The contents of these basic standards are not repeated here, however modifications or additional information needed for the practical application of the tests are given in this document.

Only non-disturbing equipment shall be used while monitoring the vehicle or ESA. The vehicle exterior and the passenger compartment/ESA shall be monitored to determine whether the requirements are met (e.g. for vehicle test by using (a) video camera(s), a microphone, etc.).

The electric vehicle shall not become dangerous or unsafe as a result of the application of the tests defined in this document.

5.2.2 Function performance criteria

Subclause 5.2.2 defines the expected performance objectives for the function of the vehicle subjected to the test conditions. The performance criteria of the function (expected behaviour of the function observed during test) are listed below.

NOTE This element is applicable to every single individual function of an equipment under test and describes the operational status of the defined function during and after a test.

Performance criterion A: The vehicle shall not be set in motion. The charging function shall continue to operate as intended during and after the test. No degradation of performance or loss of function is allowed.

Performance criterion B: The vehicle shall not be set in motion. The charging function shall continue to operate as intended after the test. No degradation of performance or loss of function is allowed after the test. During the test temporary loss of charging function is allowed provided the charging function is restored automatically without user interaction.

Performance criterion C: The vehicle shall not be set in motion. Temporary loss of function is allowed, provided the function can be restored by simple operations of the controls and without the use of tools, by the user of the equipment or operator from remote position.

5.2.3 Test severity level

This defines the specification of test severity level of essential signal parameters. The test severity level is the stress level applied to the equipment under test for any given test method. The test severity levels depend on the required operational characteristics of the function. Test severity levels are given in Table 1.

5.2.4 Immunity of vehicles to electrical fast transient/burst disturbances conducted along AC and DC power lines

5.2.4.1 General

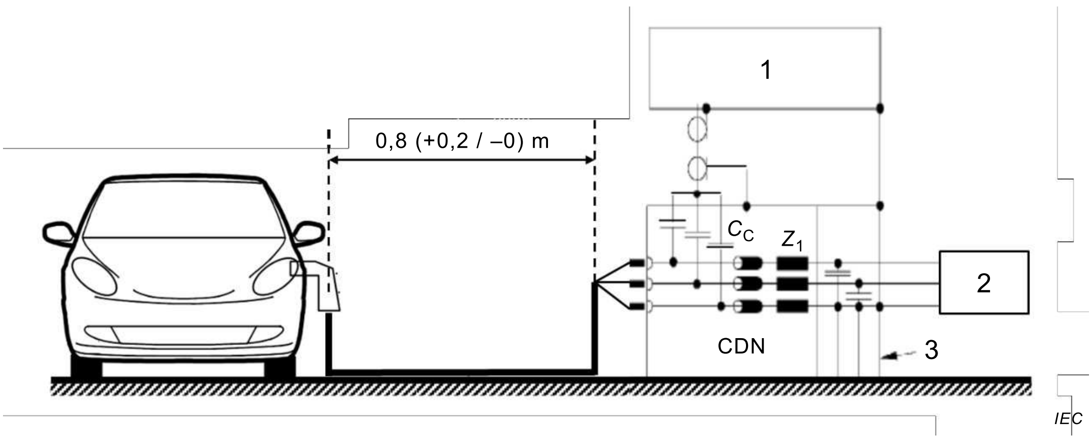
EV charging equipment directly powered by the AC power lines and DC power lines shall withstand common mode conducted disturbances to levels given in Table 1, generally caused by the switching of small inductive loads, relay contacts bouncing, or switching of high-voltage switchgear.

5.2.4.2 Electric vehicle charging equipment test

This test is intended to demonstrate the immunity of the vehicle electronic systems network according to IEC 61000-4-4:2012. The electric vehicle charging equipment shall be subject to electrical fast transient/burst disturbances conducted along AC and DC power lines of the vehicle as described in 5.2.5.2. The vehicle shall be monitored during the tests.

The test setup is depicted in Figure 1.

The vehicle shall be placed directly on the ground plane. The cable shall be z-folded in less than 0,5 m width if longer than 1 m, placed 0,1 (± 0,025) m above the ground plane and at least 0,1 m away from the car body.



Key

1 EFT/burst-generator

2 AC/DC/mains

3 filter

Figure 1 – Electrical fast transient/burst test vehicle setup

5.2.4.3 ESA, separated on-board charger test

The test procedure according to IEC 61000-4-4:2012 shall be applied to separated on-board charger tests.

The enclosure of ESA need not be bonded to ground plane directly.

5.2.5 Immunity of vehicles to surges conducted along AC and DC power lines

5.2.5.1 General

On-board EV charging equipment directly powered by the AC power mains shall withstand the voltage surges, generally caused by switching phenomena in the power grid, faults or lightning strokes (indirect strokes) as described in Table 1.

The test equipment is composed of a reference ground plane (a shielded room is not required), a surge generator and a coupling/decoupling network (CDN).

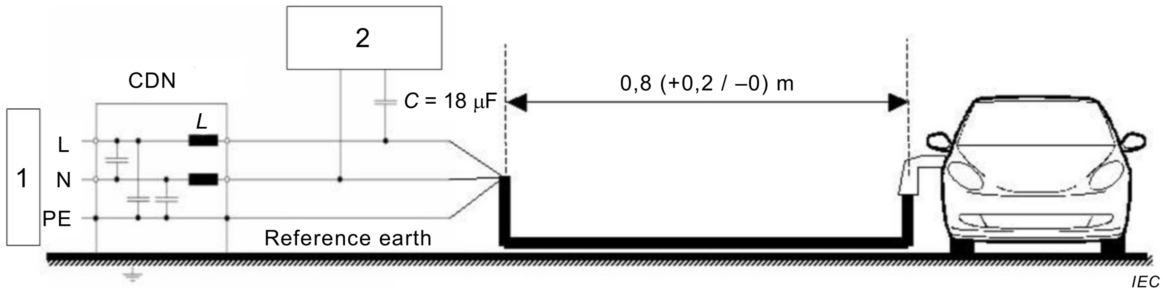
5.2.5.2 Electric vehicle charging system test

This test is intended to demonstrate the immunity of the vehicle electronic systems according to IEC 61000-4-5:2014. The vehicle shall be subject to surges conducted along AC and DC power lines of the vehicle. The vehicle shall be monitored during the tests.

NOTE If transmitters being part of authorization and payment process might not be switched off during charging, then transmitter-specific standard applies (e.g. 3G, 4G, RFID).

The vehicle shall be positioned on the ground plane. The electrical surge shall be applied on the vehicle on the AC and DC power lines between each line and earth and between lines by using CDN as described in Figures 2 to 5.

The cable shall be z-folded in less than 0,5 m width if longer than 1 m, placed 0,1 (± 0,025) m above the ground plane and at least 0,1 m away from the car body.



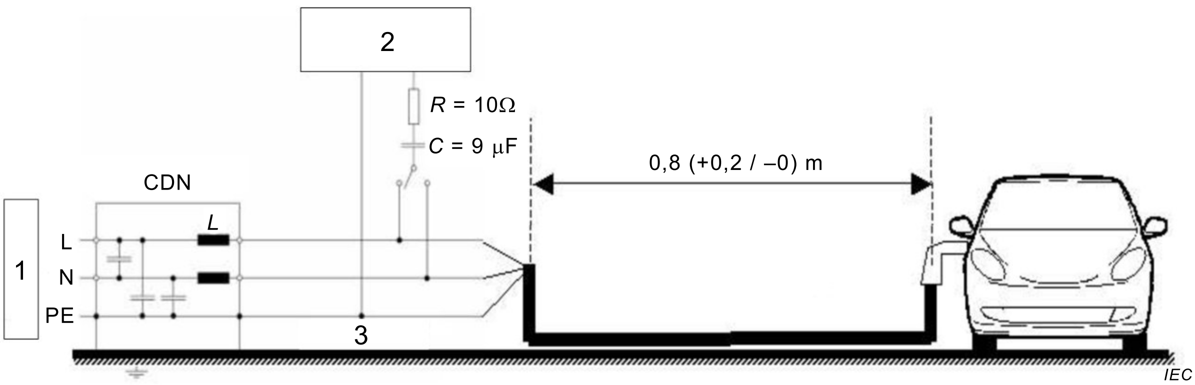
Key

1 surge-generator

2 AC/DC/mains

3 filter

Figure 2 – Vehicle in configuration "REESS charging mode coupled to the power grid" – coupling between lines for AC (single phase) and DC power lines



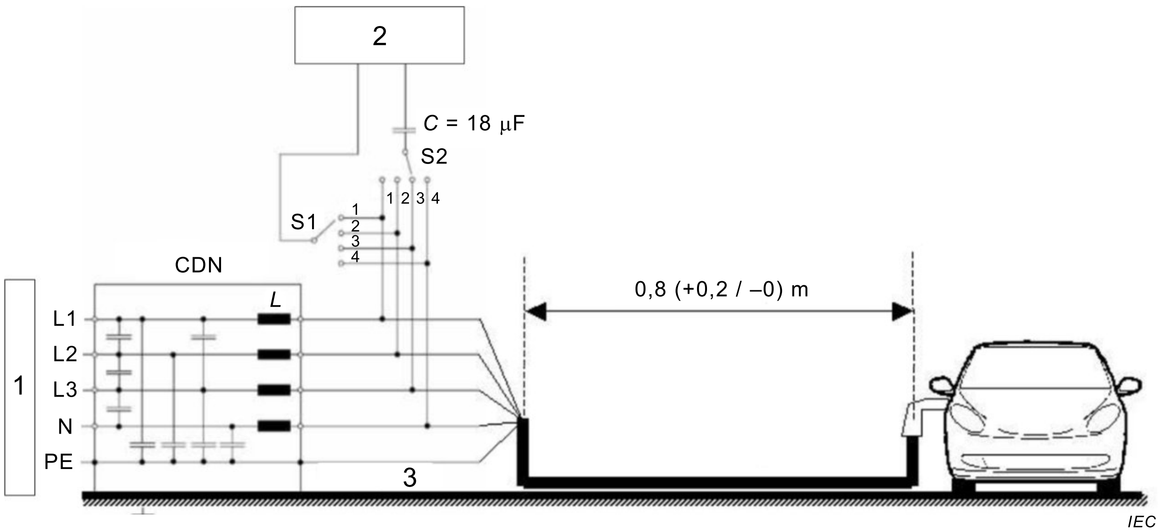
Key

1 surge-generator

2 AC/DC/mains

3 filter

Figure 3 – Vehicle in configuration "REESS charging mode coupled to the power grid" – coupling between each line and earth for AC (single phase) and DC power lines



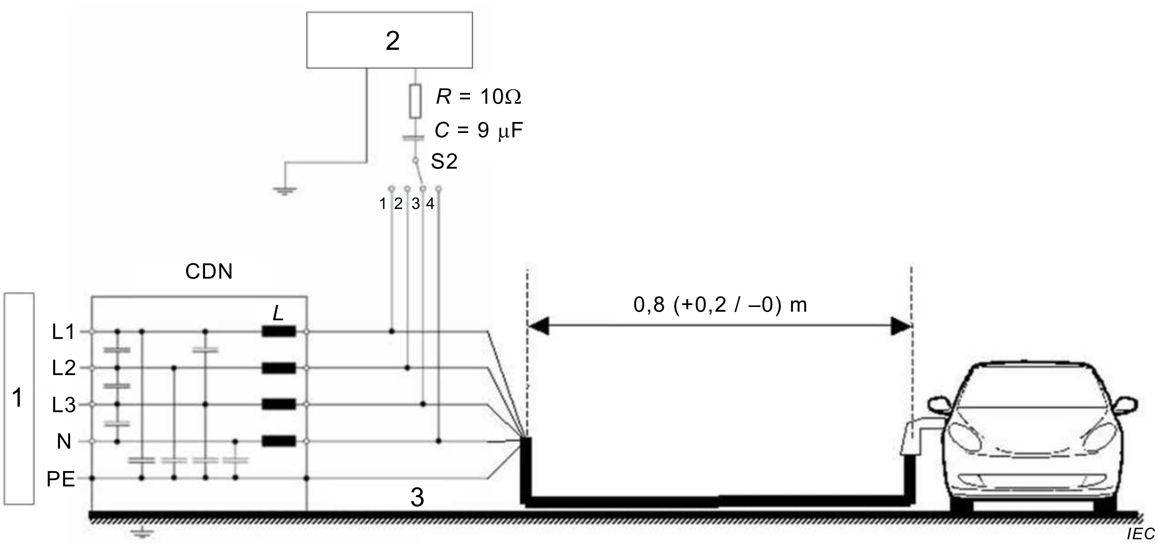
Key

1 surge-generator

2 AC/mains

3 filter

Figure 4 – Vehicle in configuration "REESS charging mode coupled to the power grid" – coupling between lines for AC (three phases) power lines



Key

1 surge-generator

2 AC/mains

3 filter

Figure 5 – Vehicle in configuration "REESS charging mode coupled to the power grid" – coupling between each line and earth for AC (three phases) power lines

5.2.5.3 ESA, separated on-board charger test

The test procedure according to IEC 61000-4-5:2014 shall be applied to separated on-board charger tests. The enclosure of ESA need not be bonded to ground plane directly.

5.2.6 Immunity to electromagnetic radiated RF-fields

5.2.6.1 General

The EV charging system shall withstand radiated electromagnetic disturbances according to ISO 11451-2:2015.

5.2.6.2 Electric vehicle charging system test

The reference point is the middle of the vehicle (from front view), 0,2 m behind the front wheel axle.

For charging cables supplied by the vehicle manufacturer, extraneous length shall be z-folded in less than 0,5 m width. The cable shall be z-folded in less than 0,5 m width if longer than 1 m, placed 0,1 (± 0,025) m above the ground plane and at least 0,1 m away from the car body.

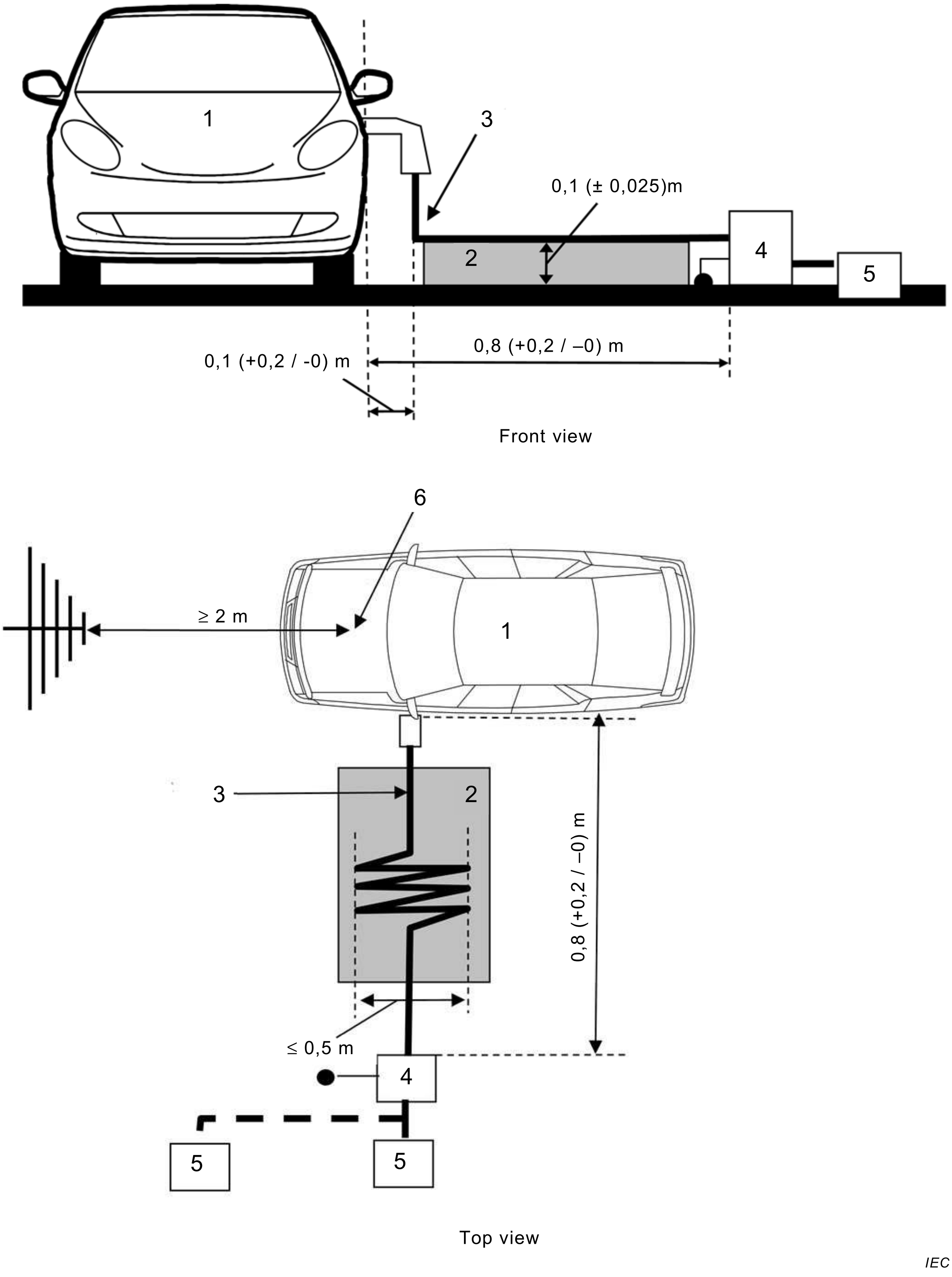
The EV in configuration "REESS charging mode coupled to the power grid" shall comply with the requirements of the semi-anechoic chamber test according ISO 11451-2:2015 at the manufacturer's discretion. Measurements shall be made in the 20 MHz to 2 000 MHz frequency range with frequency steps according to ISO 11451-1:2015.

The EV in configuration "REESS charging mode coupled to the power grid" shall be exposed to electromagnetic radiation as defined in 1.2 to 1.3 of Table 1.

For vehicles with the power charging plug located at the side of the vehicle, the AMN/AN shall be placed aligned with the vehicle power charging plug and the vehicle charging cable.

For vehicles with plug located front/rear or the power charging plug located at the front/rear of the vehicle, the AMN/AN shall be placed perpendicular to the vehicle power charging plug and shall be aligned with the vehicle charging cable.

Figure 6 to Figure 9 depict vehicle configurations in charging mode with and without communications applied.



Key

1 vehicle under test

2 insulating support

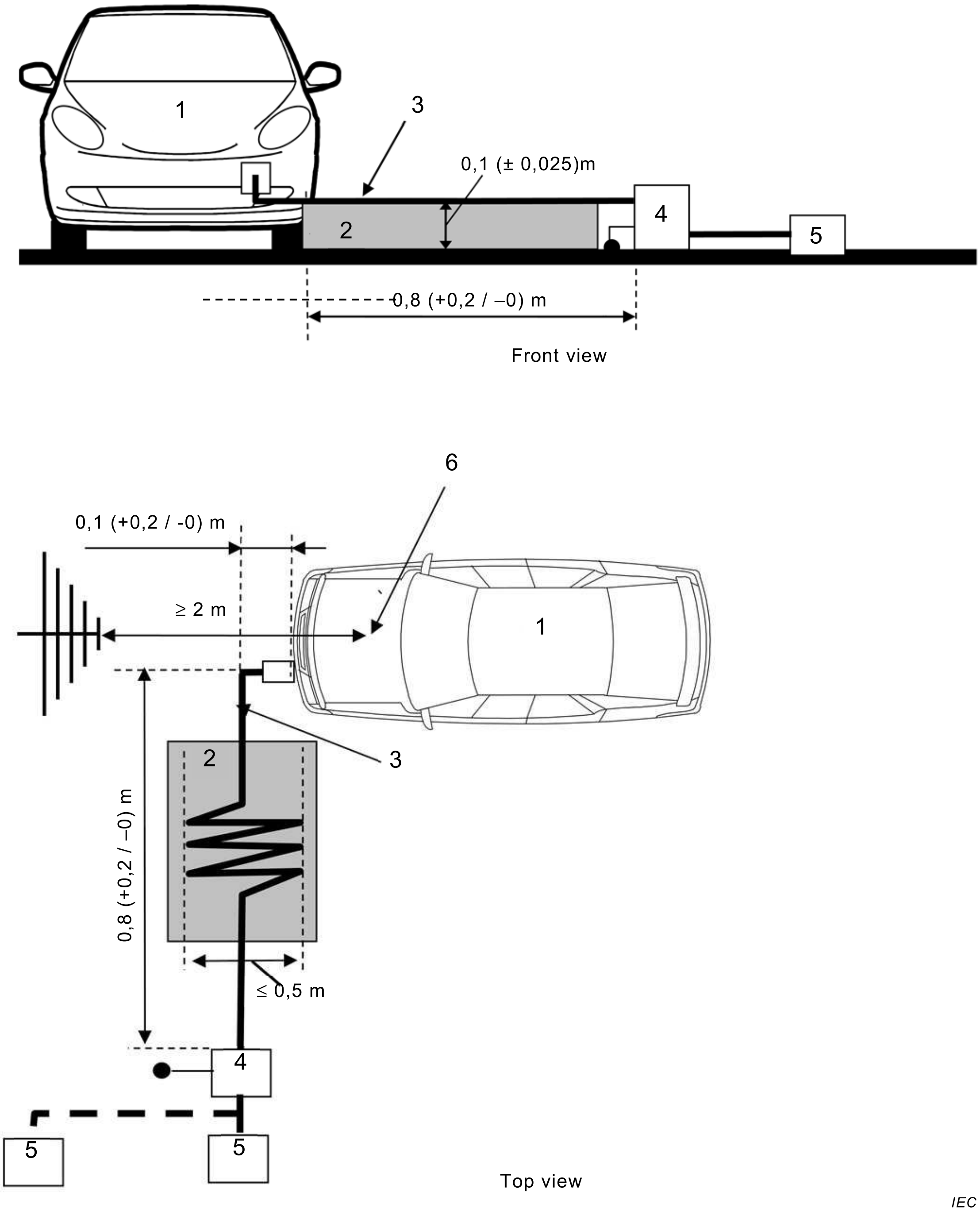
3 charging cable (extraneous length z-folded)

4 artificial (mains) network(s) grounded

5 AC power mains socket or AC/DC charging station (dotted line: arbitrary position)

6 reference point

Figure 6 – Example of test setup for vehicle with inlet located on the vehicle side (AC/DC power charging without communication)



Key

1 vehicle under test

2 insulating support

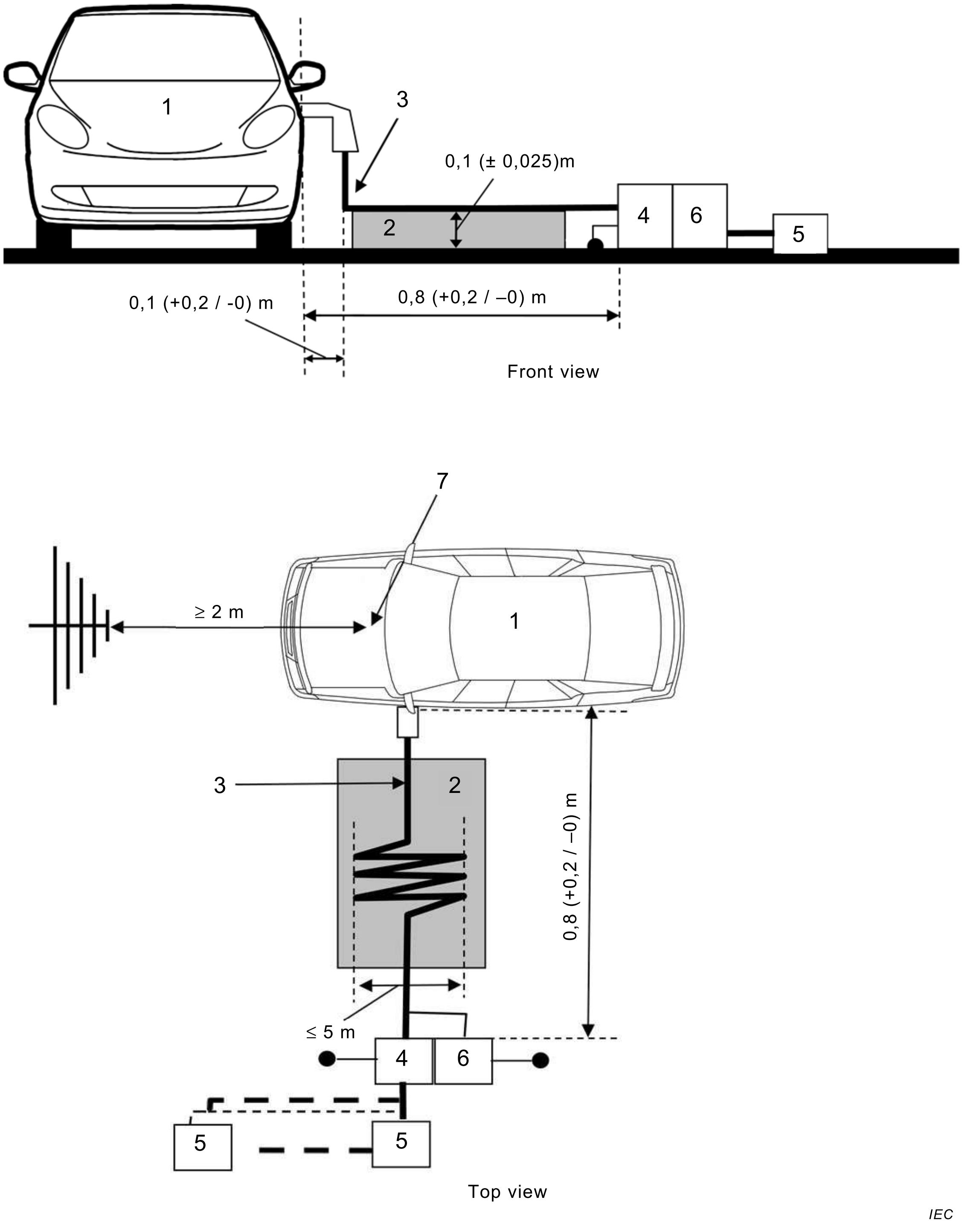
3 charging cable (extraneous length z-folded)

4 artificial (mains) network(s) grounded

5 AC power mains socket or AC/DC charging station (dotted line: arbitrary position)

6 reference point

Figure 7 – Example of test setup for vehicle with inlet located at the front/rear of the vehicle (AC/DC power charging without communication)



Key

1 vehicle under test

2 insulating support

3 charging cable (extraneous length z-folded)

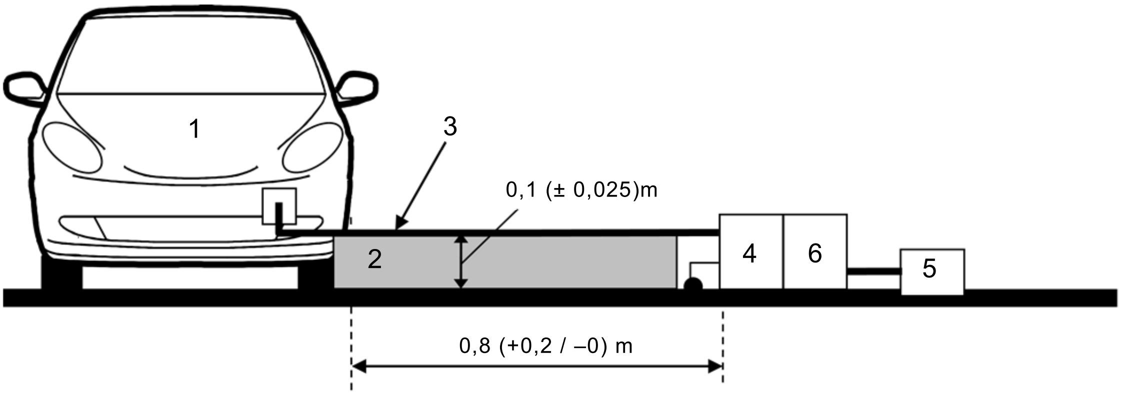
4 artificial (mains) network(s) grounded

5 AC power mains socket or AC/DC charging station (dotted line: arbitrary position)

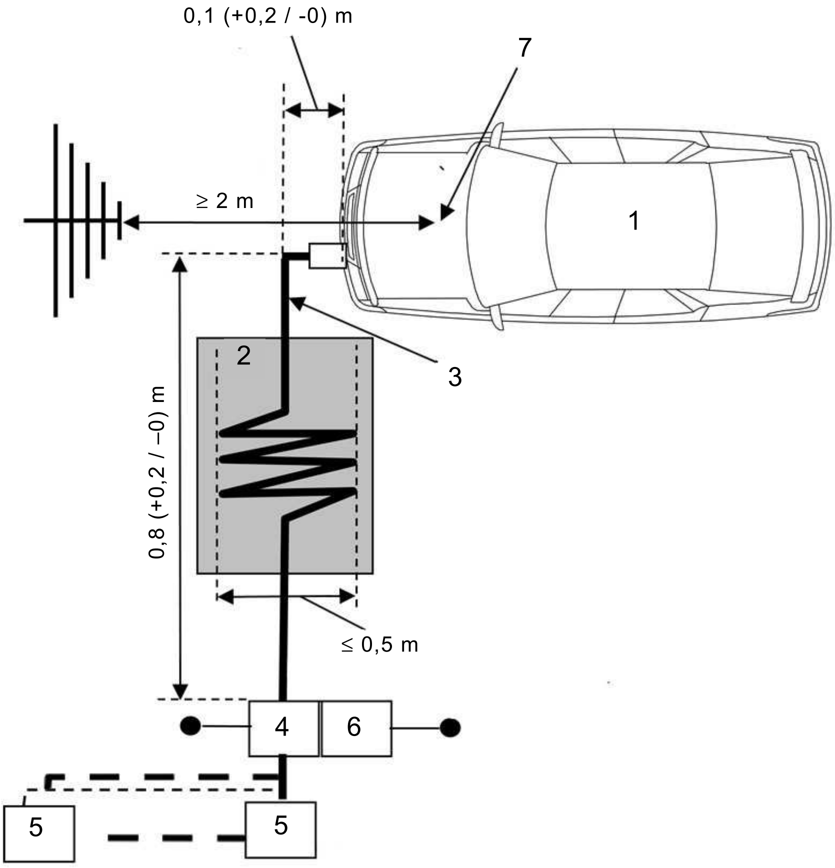
6 impedance stabilisation network(s) grounded

7 reference point

Figure 8 – Example of test setup for vehicle with inlet located on vehicle side (AC or DC power charging with communication)



Front view



Top view

IEC

Key

1 vehicle under test

2 insulating support

3 charging cable (extraneous length z-folded)

4 artificial (mains) network(s) grounded

5 AC power mains socket or AC/DC charging station (dotted line: arbitrary position)

6 asymmetric artificial network(s) grounded

7 reference point

Figure 9 – Example of test setup for vehicle with inlet located at the front/rear of the vehicle (AC or DC power charging with communication)

5.2.6.3 ESA, separated on-board charger test

ESAs in configuration "REESS charging mode coupled to the power grid" shall comply with the requirements of the combination of the semi-anechoic chamber test according ISO 11452-2:2004 and bulk current injection testing according ISO 11452-4:2011 at the manufacturer's discretion. Measurements shall be made in the 20 MHz to 2 000 MHz frequency range with frequency steps according to ISO 11452-1:2015.

The enclosure of ESA need not be bonded to ground plane directly.

ESAs in configuration "REESS charging mode coupled to the power grid" shall be exposed to electromagnetic radiation as defined in 1.9 of Table 1.

5.2.7 Immunity to pulses on supply lines

The immunity of the ESA representative of its type shall be tested by the method(s) according to ISO 7637-2:2011 on supply lines as well as to other connections of ESAs which may be operationally connected to supply lines.

The enclosure of ESA need not be bonded to ground plane directly.

The test levels and test pulse types are given in 1.9 of Table 1.

5.2.8 Immunity test and severity level overview

Table 1 summarizes the immunity test requirements.

Table 1 – Immunity tests

	Environmental phenomena	Test severity level	Units	Basic standards	Remarks	Performance criterion [f]
1.1	Radio-frequency electromagnetic field. Amplitude modulated	20 to 800 [g] 30 80	MHz V/m (RMS) % AM (1 kHz)	ISO 11451-2:2015	Vehicle test Vertical polarization of the E field [a b d]	B
1.2	Radio-frequency electromagnetic field. Pulse modulated	800 to 2 000 30 t_{ON}: 577 T: 4 600	MHz V/m (RMS) µs µs	ISO 11451-2:2015	Vehicle test Vertical polarization of the E field [a b]	B
1.3	Fast transients (AC and DC power lines)	± 2 5/50 5	kV (open circuit test voltage) T_r/T_h ns Repetition frequency kHz	IEC 61000-4-4:2012	Vehicle or ESA test Private I/O lines like pilot lines are covered by the charging cable internal capacitive coupling [c]	B
1.4	Surges (AC power lines) line-to-earth line-to-line	1,2/50 (8/20) ± 2 ± 1	T_r/T_h µs kV (open circuit test voltage) kV (open circuit test voltage)	IEC 61000-4-5:2014	Vehicle or ESA test Each surge shall be applied 5 times at 1 min (or less, minimum 10 s) intervals for each of the following angles: 0°, 90°, 180° and 270°	B[g]
1.5	Surges (DC power lines) line-to-earth line-to-line	1,2/50 (8/20) ± 0,5 ± 0,5	T_r/T_h µs kV (open circuit test voltage) kV (open circuit test voltage)	IEC 61000-4-5:2014	Vehicle or ESA test Each surge shall be applied 5 times at 1 min (or less, minimum 10 s) intervals [e f]	B[g]
1.6	Bulk current injection (BCI) Amplitude modulated	20 to 200 60 80	MHz mA (RMS) % AM (1 kHz)	ISO 11452-4:2011	ESA [b d]	B
1.7	Radio-frequency electromagnetic field. Amplitude modulated	200 to 800 30 80	MHz V/m (RMS) % AM (1 kHz)	ISO 11452-2:2004	ESA Vertical polarization of the E field [a b d]	B

	Environmental phenomena	Test severity level	Units	Basic standards	Remarks	Performance criterion [f]
1.8	Radio-frequency electromagnetic field. Pulse modulated	800 to 2 000 30 t_{ON}: 577 T: 4 600	MHz V/m (RMS) µs µs	ISO 11452-2:2004	ESA Vertical polarization of the E field [a b]	B
1.9	Immunity to pulses on supply lines	III	Pulse number 1 and 2b	ISO 7637-2: 2011	ESA	C
		III	Pulse number 2a and 4			B
		III	Pulse number 3a/3b			A

[a] The field strength shall be 30 V/m RMS in over 90 % of the 20 MHz to 2 000 MHz frequency range and a minimum of 25 V/m over the whole 20 MHz to 2 000 MHz frequency range.

[b] The artificial mains network to be used for this test on vehicle is defined in Annex A.

[c] When the coupling/decoupling network cannot be used on AC power lines, the capacitive coupling clamp defined in 6.3 of IEC 61000-4-4:2012 may be used.

[d] AM is peak conservation according to ISO 11451-1:2015 or ISO 11452-1:2015.

[e] Vehicles and/or ESA which are intended to be used in "REESS charging mode coupled to the power grid" in the configuration connected to a DC-charging station with a length of a DC network cable shorter than 30 m need not fulfil these requirements.

[f] Vehicles and/or ESA which are intended to be used in "REESS charging mode coupled to the power grid" in the configuration connected to a local/private DC-charging station without additional participants need not fulfil these requirements.

[g] If protective devices and/or safety functions are implemented in the EUT, the performance criterion could be lowered to C.

5.3 Emissions

5.3.1 Test conditions

5.3.1.1 General

If the current consumption cannot be adjusted, the state of charge (SOC) of the traction battery shall be kept between 20 % and 80 % of the maximum SOC during the whole time duration of the measurement (this may lead to splitting the measurement in different time slots/sub-bands with the need to discharge the vehicle’s traction battery before starting the next time slot/sub-band). If the current consumption can be adjusted, then the current shall be set to at least 80 % of its nominal value.

5.3.1.2 Telecommunication lines exceptions

When there is no direct connection to the public telecommunication network which includes telecommunication service additional to the charging communication service, methods of testing for emission of RF conducted disturbances on network and telecommunication access from vehicle and ESA (both according to CISPR 22:2008) shall not be applied.

When network and telecommunication access of the vehicle uses power line transmission (PLT) on AC and DC power lines, methods of testing for emission of RF conducted disturbances on network and telecommunication access from vehicle shall not be applied.

NOTE 1 The pilot line is not a telecommunication line according to CISPR 22:2008.

NOTE 2 In Europe (CENELEC members), standard EN 50561-1 gives the limits for PLT systems intentionally coupled to the grid for communication purposes.

5.3.2 Emissions of harmonics on AC power lines

5.3.2.1 General

The measurements of even and odd current harmonics shall be performed up to the fortieth harmonic (see Table 2).

The observation time to be used for the measurements shall be as for quasi-stationary equipment as defined in IEC 61000-3-2:2014, Table 4.

The harmonic limits for the AC input current of electric vehicle charging systems (for rated current less than 16 A per phase) are covered by IEC 61000-3-2:2014 with general test conditions. In this case, compliance is checked according to IEC 61000-3-2:2014, Table 2.

Table 2 – Maximum allowed harmonics (input current ≤ 16 A per phase)

Harmonic number N	Maximum authorized harmonic current A
Odd harmonics	
3	2,3
5	1,14
7	0,77
9	0,40
11	0,33
13	0,21
$15 \leq n \leq 39$	$0{,}15 \times 15/n$
Even harmonics	
2	1,08
4	0,43
6	0,30
$8 \leq n \leq 40$	$0{,}23 \times 8/n$

The harmonic limits for the AC input current (I_i) of electric vehicle charging systems (for rated current more than 16 A, and less than 75 A per phase) are covered by IEC 61000-3-12:2011 with general test conditions. In this case, compliance is checked according to IEC 61000-3-12:2011 with R_{sce} of 33 (see Table 3).

Table 3 – Acceptable harmonics for R_{sce} = 33 (16 A < I_i ≤ 75 A)

Acceptable individual harmonic current I_n/I_1 %						Maximum current harmonic ratio %	
I_3	I_5	I_7	I_9	I_{11}	I_{13}	THD	PWHD
21,6	10,7	7,2	3,8	3,1	2	23	23

Relative values of even harmonics lower than or equal to 12 shall be lower than $16/n$ %. Even harmonics greater than 12 are taken into account in the total harmonic distortion (THD) and partial weighted harmonic distortion (PWHD) the same way as odd harmonics.

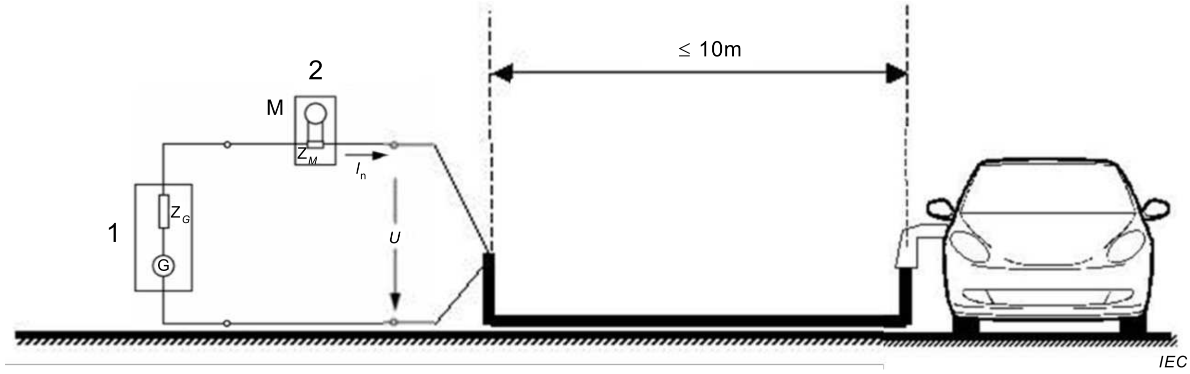
Equipment that can operate over a power range that is covered by both IEC 61000-3-2:2014 and IEC 61000-3-12:2011 shall conform to each of these standards in the corresponding current range.

Equipment with a rated current ≤ 16 A shall be tested according to IEC 61000-3-2:2014. Equipment with a rated current of, for example, 20 A shall be tested according to IEC 61000-3-12:2011 and IEC 61000-3-2:2014 with a current limited to 16 A.

5.3.2.2 Electric vehicle charging system test

The test setup for single-phase vehicle in configuration "REESS charging mode coupled to the power grid" is shown in Figure 10.

For charging cables supplied by the vehicle manufacturer, extraneous length shall be z-folded in less than 0,5 m width, if the cable length exceeds 1 m. The cable shall be placed 0,1 (± 0,025) mm above the ground plane and at least 100 mm away from the car body.



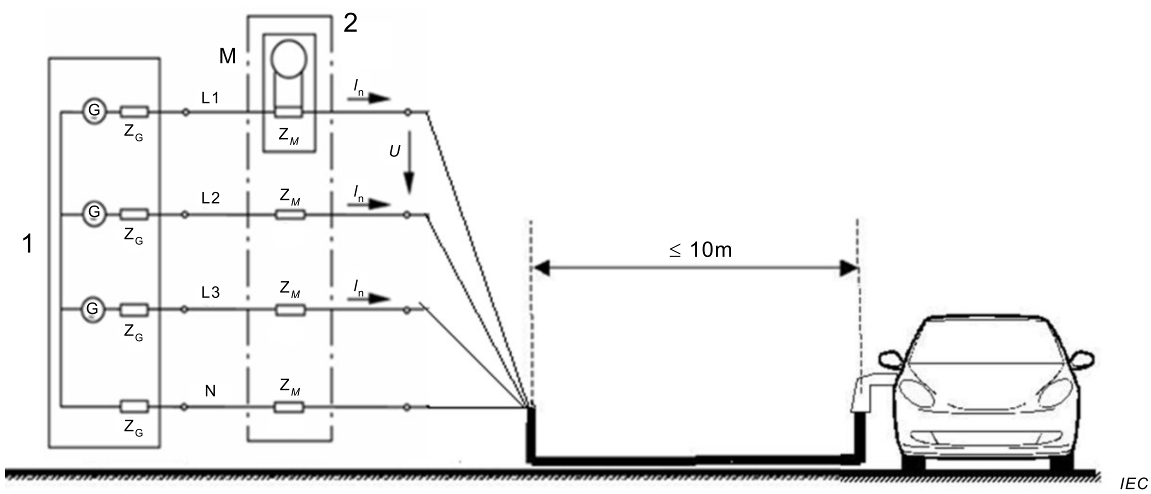
Key

1 power supply of internal impedance Z_G and open circuit voltage G

2 measurement device with input impedance Z_M

Figure 10 – Vehicle in configuration "REESS charging mode coupled to the power grid" – Single-phase charger test setup

The test setup for three-phase charger in configuration "REESS charging mode coupled to the power grid" is shown in Figure 11. The cable shall be z-folded in less than 0,5 m width if longer than 1 m, placed 0,1 (± 0,025) m above the ground plane and at least 0,1 m away from the car body.



Key

1 power supply of internal impedance Z_G and open circuit voltage G

2 measurement device with input impedance Z_M

Figure 11 – Vehicle in configuration "REESS charging mode coupled to the power grid" – Three-phase charger test setup

5.3.2.3 ESA, separated on-board charger test

The test procedure according to IEC 61000-3-2:2014 with general test conditions shall be applied to separated on-board charger tests (for rated current less than 16 A per phase).

The test procedure according to IEC 61000-3-12:2011 with general test conditions shall be applied to separated on-board charger tests (for rated current more than 16 A and less than 75 A per phase).

5.3.3 Emission of voltage changes, voltage fluctuations and flicker on AC power lines

5.3.3.1 General

The limits for rated current (for rated current less than 16 A per phase) and not subjected to conditional connection are those defined in Clause 5 of IEC 61000-3-3:2013.

The limits for rated current (for rated current more than 16 A and less than 75 A per phase) and subjected to conditional connection are those defined in Clause 5 of IEC 61000-3-11:2000.

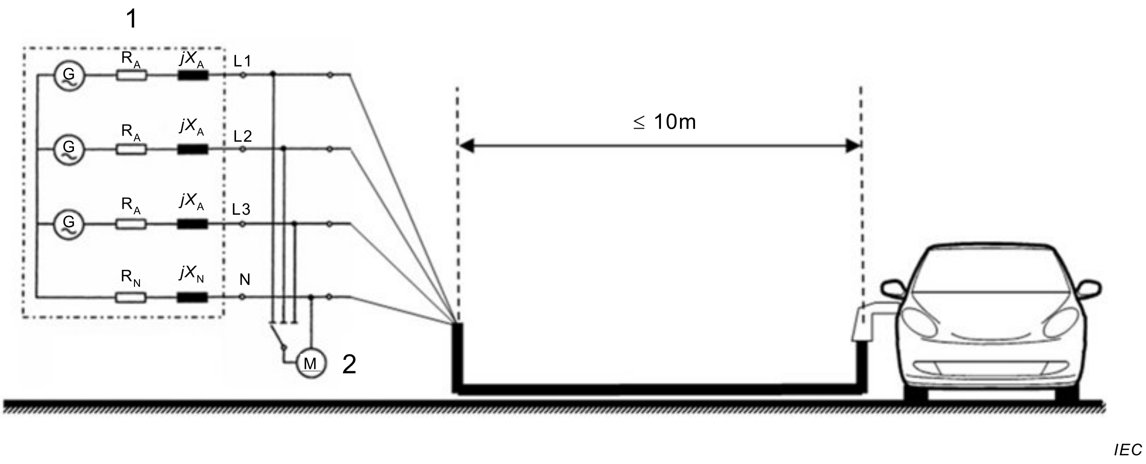
Equipment that can operate over a power range that is covered by both IEC 61000-3-3:2013 and IEC 61000-3-11:2000 shall conform to each of these standards in the corresponding current range.

Equipment with a rated current ≤ 16 A shall be tested according to IEC 61000-3-3:2013. Equipment with a rated current of, for example, 20 A shall be tested according to IEC 61000-3-11:2000 and IEC 61000-3-3:2013 with a current limited to 16 A.

The parameters to be determined in the time-domain are "short duration flicker value", "long duration flicker value" and "voltage relative variation".

5.3.3.2 Electric vehicle charging equipment test

The test setup for vehicle in configuration "REESS charging mode coupled to the power grid" is shown in Figure 12. The cable shall be z-folded in less than 0,5 m width if longer than 1 m, placed 0,1 (± 0,025) m above the ground plane and at least 0,1 m away from the car body.



Key

1 power supply with open circuit voltage G and (RP + jXP) impedance

2 measurement device

Figure 12 – Vehicle in configuration "REESS charging mode coupled to the power grid"

5.3.3.3 ESA, separated on-board charger test

The test procedure on low frequency harmonics according to IEC 61000-3-3:2013 with general test conditions shall be applied to separated on-board charger tests (for rated current less than 16 A).

The test procedure according to IEC 61000-3-11:2000 with general test conditions shall be applied to separated on-board charger tests (for rated current more than 16 A and less than 75 A).

5.3.4 High-frequency conducted disturbances on AC or DC power lines

5.3.4.1 General

This test is intended to measure the level of radio frequency conducted disturbances generated by the vehicle/ESA in configuration "REESS charging mode coupled to the power grid" through its AC or DC power lines in order to ensure it is compatible with residential, commercial and light industrial environments.

The artificial (mains) networks for power supply and asymmetric artificial networks (AAN) for charging communications to be used for this test are described in Annex A of this document.

The measurements shall be performed with a spectrum analyser or a scanning receiver. The parameters to be used are respectively defined in CISPR 25:2016, 4.4.1 (Table 1) and 4.4.2 (Table 2).

Measurements shall be performed with average and either quasi-peak or peak detectors. If peak detectors are used, a correction factor as defined in CISPR 12:2007/CISPR 12:2007/AMD1:2009 shall be applied.

The limits on AC power lines are those defined in IEC 61000-6-3:2006/IEC 61000-6-3:2006/AMD1:2010 and given in Table 4.

Table 4 – Maximum allowed radiofrequency conducted disturbances on AC power lines

Frequency (MHz)	**Limits and detector**
0,15 to 0,5	66 dB(μV) to 56 dB(μV) (quasi-peak) 56 dB(μV) to 46 dB(μV) (average) (linearly decreasing with logarithm of frequency)
0,5 to 5	56 dB(μV) (quasi-peak) 46 dB(μV) (average)
5 to 30	60 dB(μV) (quasi-peak) 50 dB(μV) (average)

The limits on DC power lines are those defined in IEC 61000-6-3:2006/IEC 61000-6-3:2006/AMD1:2010 and given in Table 5.

Table 5 – Maximum allowed radiofrequency conducted disturbances on DC power lines

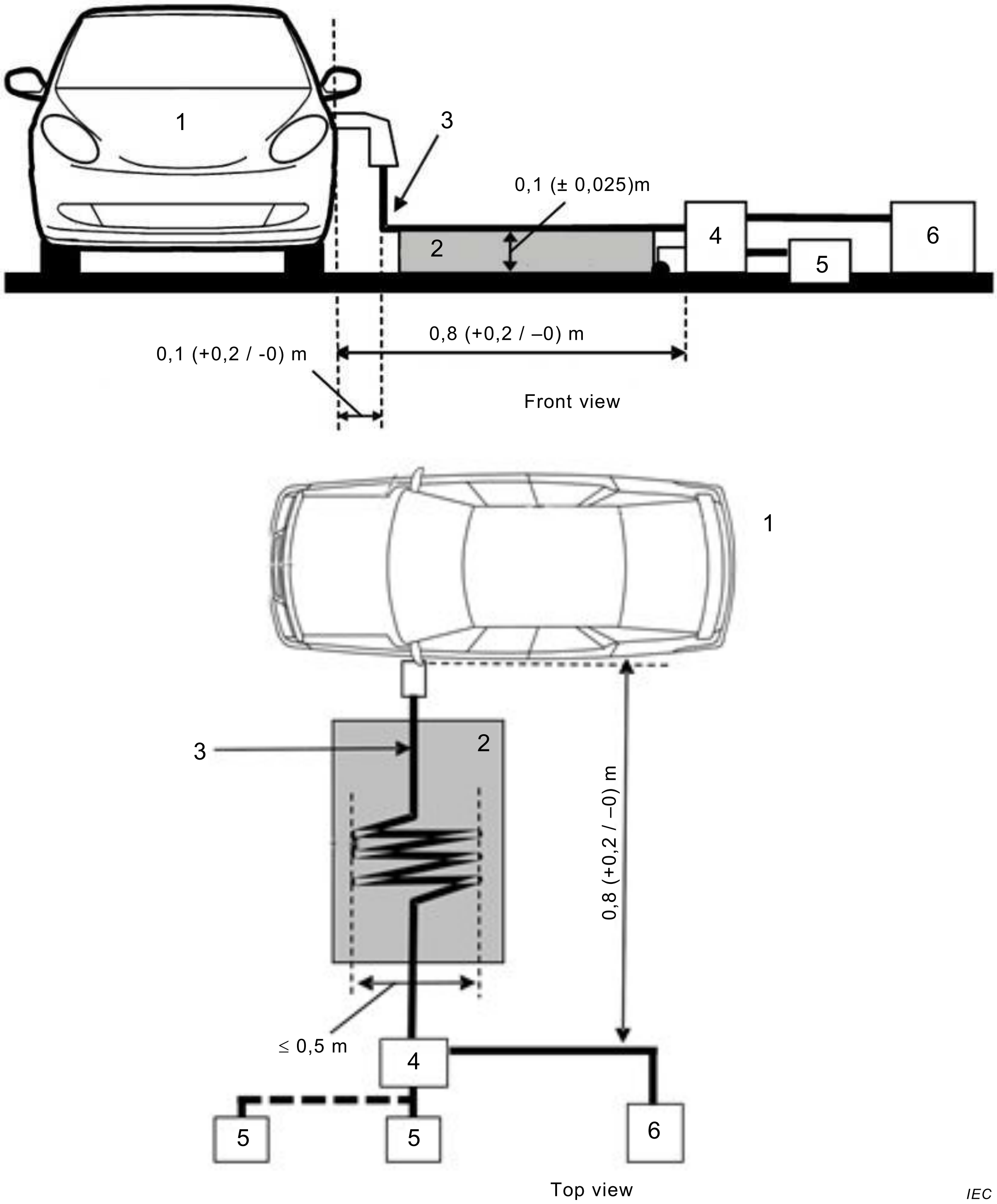
Frequency (MHz)	**Limits and detector disturbance voltage**
0,15 to 0,5	79 dB(µV) (quasi-peak) 66 dB(µV) (average)
0,5 to 30	73 dB(µV) (quasi-peak) 60 dB(µV) (average)

The limits apply throughout the frequency range 0,15 MHz to 30 MHz for measurements performed in a semi anechoic chamber or open area test site.

5.3.4.2 Electric vehicle charging equipment test

The test setup for the connection of the vehicle in configuration "REESS charging mode coupled to the power grid" is shown in Figure 13.

Cable configuration (communication lines separate or part of charging cable) shall be defined in the test plan. The cable shall be z-folded in less than 0,5 m width if longer than 1 m, placed 0,1 (± 0,025) m above the ground plane and at least 0,1 m away from the car body.



Key

1 vehicle under test

2 insulating support

3 charging cable

4 artificial (mains) network grounded

5 AC power mains socket or AC/DC charging system (dotted line: arbitrary position)

6 measuring receiver

Figure 13 – Vehicle in configuration "REESS charging mode coupled to the power grid"

5.3.4.3 ESA, separated on-board charger test

The test procedure according to 7.4.1 of CISPR 16-2-1:2014 with general test conditions shall be applied.

Electrical connection of the enclosure of ESA and artificial networks to ground plane should be made in line with vehicle test, and grounding configuration shall be defined in the test plan.

5.3.5 High-frequency conducted disturbances on network and telecommunication access

5.3.5.1 General

The test setup shall be performed according to CISPR 22:2008, Clause 5 for conducted emissions.

The measurements shall be performed with a spectrum analyser or a scanning receiver. The parameters to be used are respectively defined in CISPR 25:2016, 4.4.1 (Table 1) and 4.4.2 (Table 2).

Measurements shall be performed with average and either quasi-peak or peak detectors. If peak detectors are used, a correction factor as defined in CISPR 12:2007/CISPR 12:2007/AMD1:2009 shall be applied.

The limits on network and telecommunication access are those defined in IEC 61000-6-3:2006/IEC 61000-6-3: 2006/AMD1:2010 and given in Table 6.

Table 6 – Maximum allowed radiofrequency conducted disturbances on network and telecommunication access

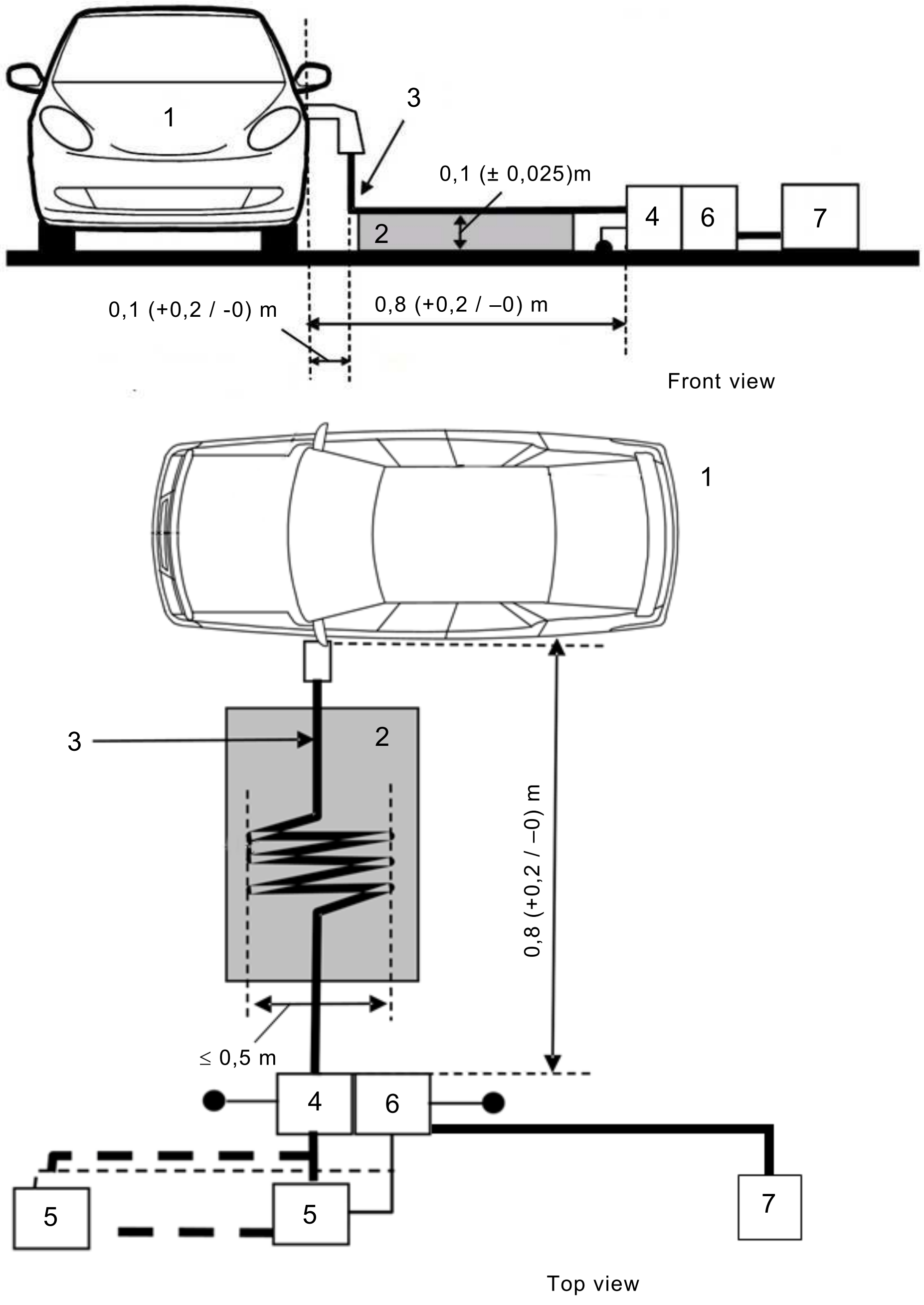
Frequency (MHz)	**Limits and detector**	
0,15 to 0,5	84 to 74 dB(μV) (quasi-peak) 74 to 64 dB(μV) (average) (linearly decreasing with logarithm of frequency)	40 to 30 dB(μA) (quasi-peak) 30 to 20 dB(μA) (average) (linearly decreasing with logarithm of frequency)
0,5 to 30	74 dB(μV) (quasi-peak) 64 dB(μV) (average)	30 dB(μA) (quasi-peak) 20 dB(μA) (average)

The limits apply throughout the frequency range 0,15 MHz to 30 MHz for measurements performed in a semi anechoic chamber or an open area test site.

5.3.5.2 Electric vehicle charging equipment test

The test setup for the connection of the vehicle in configuration "REESS charging mode coupled to the power grid" is shown in Figure 14.

Cable configuration (communication lines separate or part of charging cable) shall be defined in the test plan. The cable shall be z-folded in less than 0,5 m width if longer than 1 m, placed 0,1 (± 0,025) m above the ground plane and at least 0,1 m away from the car body.



Key

1 vehicle under test

2 insulating support

3 charging cable

4 artificial (mains) network(s) grounded

5 AC power mains socket or AC/DC charging station (dotted line: arbitrary position)

6 asymmetric artificial network(s) grounded

7 measuring receiver

Figure 14 – Vehicle in configuration "REESS charging mode coupled to the power grid"

5.3.5.3 ESA, separated on-board charger test

The test procedure according to CISPR 22:2008, Clause 5, with general test conditions shall be applied.

Electrical connection of the enclosure of ESA and artificial networks to ground plane should be made in line with vehicle test, and grounding configuration shall be defined in the test plan.

5.3.6 High-frequency radiated disturbances

5.3.6.1 Purpose

This test is intended to measure the level of radio frequency radiated disturbances generated by the vehicle in configuration "REESS charging mode coupled to the power grid" in order to ensure it is compatible with residential, commercial and light industrial environments.

The test setup shall be performed according to CISPR 12:2007/CISPR 12:2007/AMD1:2009.

5.3.6.2 General

For vehicles in configuration "REESS charging mode coupled to the power grid" the antenna position is towards the middle of the vehicle (Figure 15).

The artificial (mains) networks for power supply and asymmetric artificial networks (AAN) for charging communications to be used for this test are described in Annex A.

5.3.6.3 Electric vehicle charging equipment test

The measurements shall be performed with a spectrum analyser or a scanning receiver. The parameters to be used are respectively defined in CISPR 25:2016, 4.4.1 (Table 1) and 4.4.2 (Table 2).

Measurements shall be performed with either quasi-peak or peak detectors. If peak detectors are used a correction factor as defined in CISPR 12:2007/CISPR 12:2007/AMD1:2009 shall be applied.

The limits according to Table 7 apply throughout the frequency range 30 MHz to 1 000 MHz for measurements performed in a semi anechoic chamber or an outdoor test site.

Table 7 – Maximum allowed vehicle high-frequency radiated disturbances

Frequency (MHz)	**Limits and detector** vehicle-to-antenna spacing of 10,0 m ± 0,2 m	**Limits and detector** vehicle-to-antenna spacing 3,0 m ± 0,05 m
30 to 75	32 dB(μV/m) (quasi-peak)	42 dB(μV/m) (quasi-peak)
75 to 400	32 dB(μV/m) to 43 dB(μV/m) (quasi-peak) (linearly increasing with logarithm of frequency)	42 dB(μV/m) to 53 dB(μV/m) (quasi-peak) (linearly increasing with logarithm of frequency)
400 to 1 000	43 dB(μV/m) (quasi-peak)	53 dB(μV/m) (quasi-peak)

Enclosed test facilities may be used if correlation can be shown between the results obtained in the enclosed test facility and those obtained at an outdoor site. Enclosed test facilities do not need to meet the dimensional requirements of the outdoor test site other than the distances from the antenna to the vehicle and the height of the antenna.

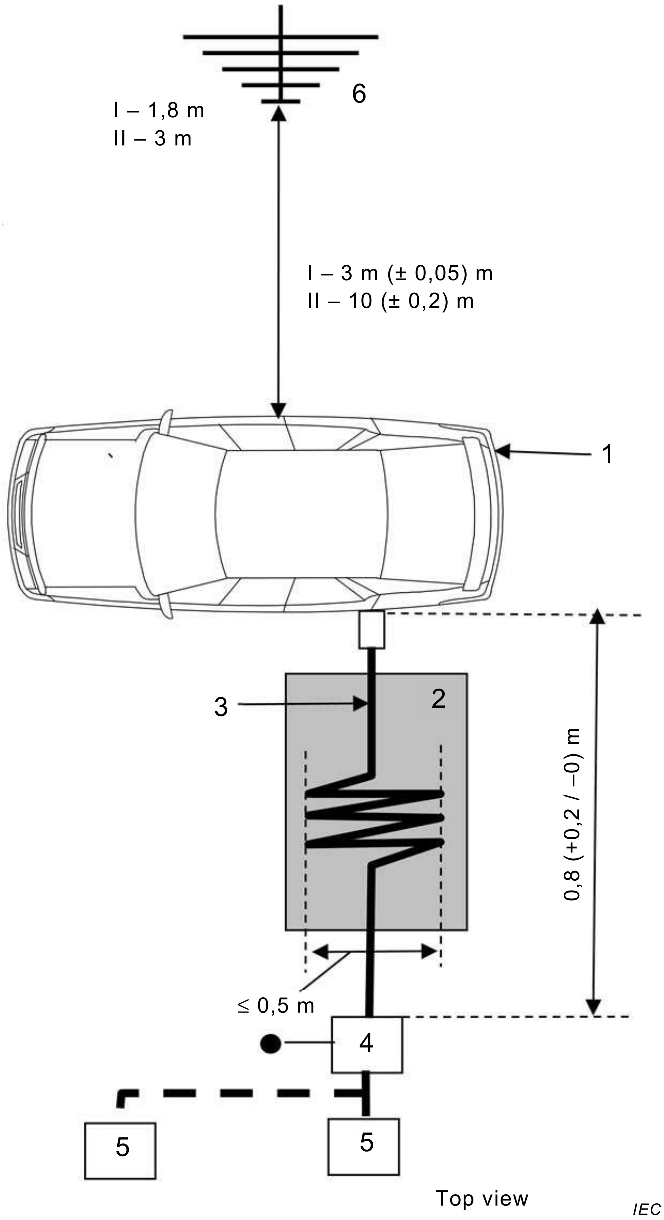
The maximum of the readings relative to the limit (horizontal and vertical polarization and antenna location on the left and right-hand sides of the vehicle) shall be taken as the characteristic reading at the frequency at which the measurements were made.

An example of the test setup for the connection of the vehicle in configuration "REESS charging mode coupled to the power grid" is shown in Figure 15. For further configurations with and without communications refer also to Figure 6 to Figure 9.

For charging cables supplied by the vehicle manufacturer, extraneous length shall be z-folded in less than 0,5 m width if longer than 1 m, placed 0,1 (± 0,025) m above the ground plane and at least 0,1 m away from the car body.

For vehicles with the power charging plug located at the side of the vehicle, the AMN/AN shall be placed aligned with the vehicle power charging plug and the vehicle charging cable.

For vehicles with the power charging plug located at the front/rear of the vehicle, the AMN/AN shall be placed perpendicular to the vehicle power charging plug and shall be aligned with the vehicle charging cable.



Key

1 vehicle under test

2 insulating support

3 charging cable

4 artificial (mains) network(s) grounded

5 AC power mains socket or AC/DC charging station (dotted line: arbitrary position)

6 antenna: 1,8 m high for 3,0 (± 0,05) m distance to reference point and 3,0 m high for 10 (± 0,05) m distance to reference point

Figure 15 – Example of vehicle in configuration "REESS charging mode coupled to the power grid"

5.3.6.4 ESA, separated on-board charger test

5.3.6.4.1 Test arrangement

For ESAs in configuration "REESS charging mode coupled to the power grid" the test arrangement shall be according to Figure 16.

Electrical connection of the enclosure of ESA and artificial networks to ground plane should be made in line with vehicle test, and grounding configuration shall be defined in the test plan.

The shielding configuration shall be according to the vehicle series configuration. Generally all shielded HV parts shall be properly connected with low impedance to ground (e.g. artificial network (AN), cables, connectors, etc.). ESAs and loads shall be connected to ground. The external high voltage (HV) power supply shall be connected via feed-through-filtering.

Unless otherwise specified the length of the low voltage (LV) harness and the HV harness shall be 1700^{+300}_{0} mm. The long segment of the HV lines test harness shall be located at 100^{+100}_{0} mm from the LV lines test harness (as shown in Figure 16). Unless otherwise specified in the test plan, the configuration with the long segment of HV lines test harness at a distance of (100 ± 10) mm from the edge and the LV lines test harness located at 100^{+100}_{0} mm from the HV lines shall also be tested.

All of the harnesses shall be placed on a non-conductive, low relative permittivity material ($\varepsilon_r \leq 1{,}4$), at (50 ± 5) mm above the ground plane.

Shielded supply lines for HV+ and HV- and three-phase lines may be coaxial cables or in a common shield depending on the high voltage connector used. The original HV harness from the vehicle may optionally be used.

Unless otherwise specified the ESA housing shall be connected to the ground plane either directly or via defined impedance.

For on-board chargers the AC/DC power lines shall be placed the furthest from the antenna (behind LV and HV harness). The distance between the AC/DC power lines and the closest harness (LV or HV) shall be 100^{+100}_{0} mm.

As an alternative to an absorber lined shielded enclosure (ALSE), an open area test site (OATS) which complies with the requirements of CISPR 16-1-4:2010 may be used.

5.3.6.4.2 Test requirements

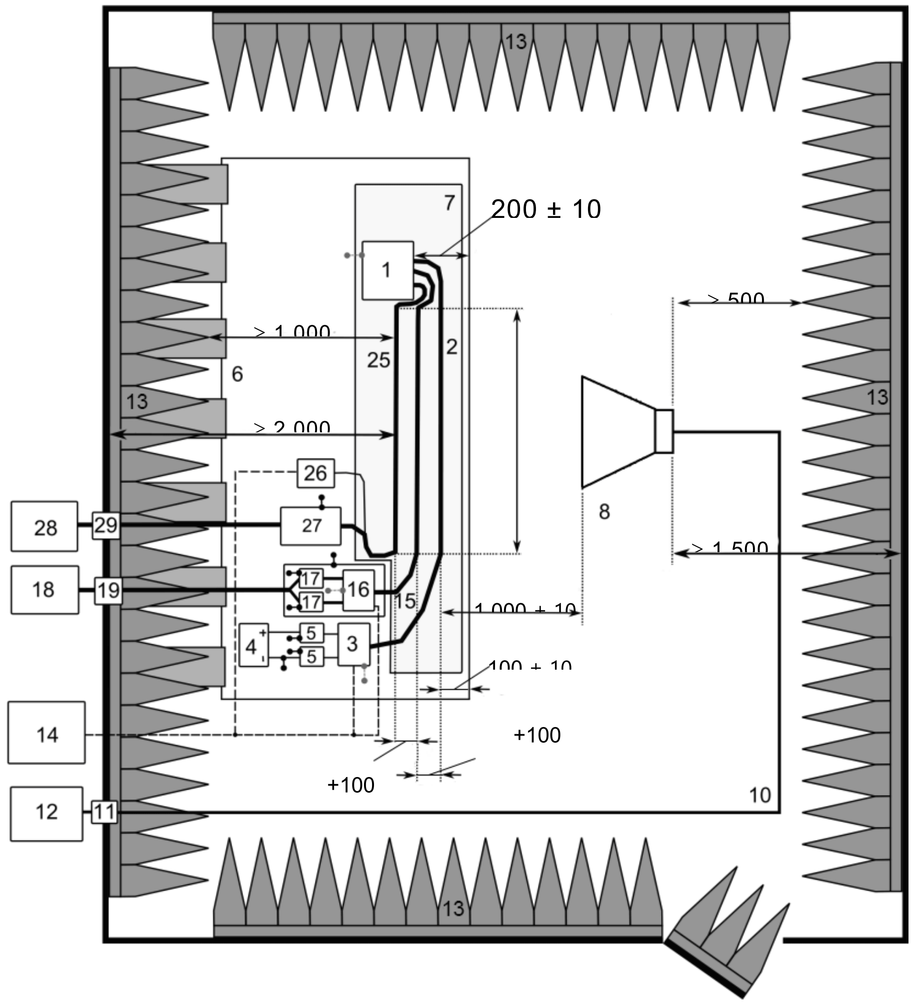
Measurements shall be performed with either quasi-peak or peak detectors. If peak detectors are used a correction factor as defined in CISPR 12:2007/CISPR 12:2007/AMD1:2009 shall be applied.

The limits according to Table 8 apply throughout the frequency range 30 MHz to 1 000 MHz for measurements performed in a semi anechoic chamber or an outdoor test site.

Table 8 – Maximum allowed ESA high-frequency radiated disturbances

Frequency (MHz)	**Limits and detector** ESA-to-antenna spacing 1 m
30 to 75	62 dB(μV/m) to 52 dB(μV/m) (quasi-peak) (linearly decreasing with logarithm of frequency)
75 to 400	52 dB(μV/m) to 63 dB(μV/m) (quasi-peak) (linearly increasing with logarithm of frequency)
400 to 1 000	63 dB(μV/m) (quasi-peak)

The phase centre of the antenna shall be in line with the centre of the longitudinal part of the wiring harnesses.



Top view (Vertical polarization)

Key

1 ESA
2 LV test harness
3 LV load simulator (placement and ground connection according to CISPR 25:2016, 6.4.2.5)
4 power supply (location optional)
5 LV artificial network
6 ground plane (bonded to the shielded enclosure)
7 low relative permittivity support
8 horn antenna
10 high-quality coaxial cable, for example double shielded
11 bulkhead connector
12 measurement instrument
13 RF absorber material
14 stimulation and monitoring system
15 HV harness
16 HV load simulator
17 HV artificial network
18 HV power supply
19 HV feed-through
25 AC/DC charger harness
26 AC/DC load simulator
27 50 mH AMN (AC) or HV artificial network (DC)
28 AC/DC power supply
29 c./DC feed-through

Figure 16 – Test configuration for ESAs involved in REESS charging mode coupled to the power grid (example for horn antenna)

5.3.7 Radiated disturbances on supply lines

The emission of the ESA representative of its type shall be tested by the method(s) according to ISO 7637-2:2011 on supply lines as well as to other connections of ESAs which may be operationally connected to supply lines.

The maximum allowed emission levels are given in the Table 9 below.

Table 9 – Maximum allowed ESA radiated disturbances on supply lines

Polarity of pulse amplitude	Vehicles with 12 V Systems	Vehicles with 24 V Systems
Positive	+75 V	+150 V
Negative	–100 V	–450 V

Annex A
(normative)

Artificial networks, asymmetric artificial networks and integration of charging stations into the test setup

A.1 Overview

Annex A describes artificial (mains) networks (AMN/AN) for termination of AC and DC power lines. It is necessary to use networks which provide specific load impedance and isolate the component from the power supply:

- artificial networks (AN) are used for DC power supplies;
- artificial mains networks (AMN) are used only for AC power mains.

This annex also provides asymmetric artificial networks (AAN) for the termination and coupling of charging communication for symmetric communication lines and asymmetric communication lines.

Furthermore it provides guidance on how to deal with power connections in the test setup.

A.2 Charging station and power mains connection

The charging station may be placed either on the test site or outside the test location.

In both cases the power mains sockets and communication sockets shall fulfil the following conditions.

- The sockets shall be placed directly on the ground plane.
- The length of the harness between the sockets and the corresponding artificial networks/asymmetric artificial networks shall be kept as short as possible.
- The harness between the sockets and the artificial networks/asymmetric artificial networks shall be placed directly on the ground plane.

If the charging station is located on the test site the cabling shall

- hang vertically at the side of the charging station to ground, and
- any extraneous length of the cable shall be placed directly on the ground plane (z-folded, if necessary).

If the charging station is located on the test site it shall not be placed in direct line-of-sight between the measurement antenna and the vehicle.

In case of a charging station located outside the test location the power mains sockets and communication line sockets should be filtered.

If the communication between the vehicle and the charging station can be simulated, this communication simulation and a direct supply from power mains may replace the charging station.

A.3 Artificial networks (AN)

A.3.1 General

Currently different types of power supplies and power supply cabling are used for a component powered by low voltage (LV) and/or high voltage (HV).

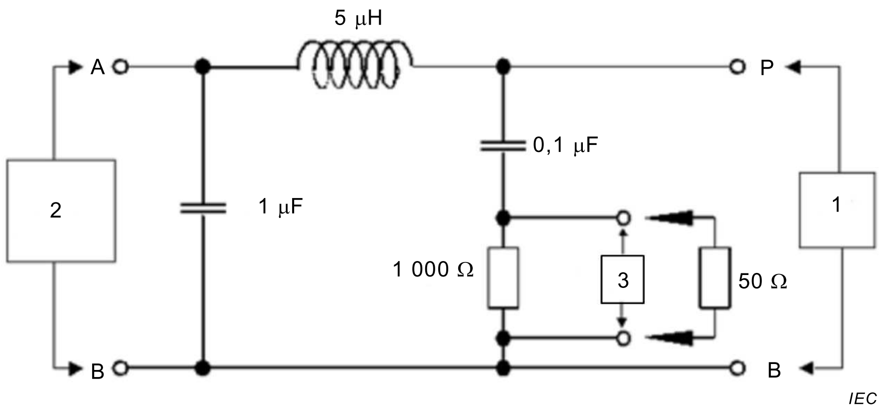
A.3.2 Low voltage (LV) powered component

For a component powered by LV, a 5 µH/50 Ω-AN as defined in CISPR 25:2016, Annex E, and shown in Figure A.1 shall be used.

The AN(s) shall be mounted directly on the ground plane. The case of the AN(s) shall be bonded to the ground plane. The DC resistance between the ground of the AN measurement port and the ground plane shall not exceed 2,5 mΩ.

Measurement ports of AN(s) shall be terminated with a 50 Ω load.

The AN magnitude impedance Z_{PB} (tolerance ± 20 %) in the measurement frequency range of 0,1 MHz to 100 MHz is shown in Figure A.2. It is measured between the terminals P and B (of Figure A.1) with a 50 Ω load on the measurement port with terminals A and B (of Figure A.1) short circuited.



Key

1 port for the EUT

2 power supply port

3 measurement port

Figure A.1 – Example of 5 µH AN schematic

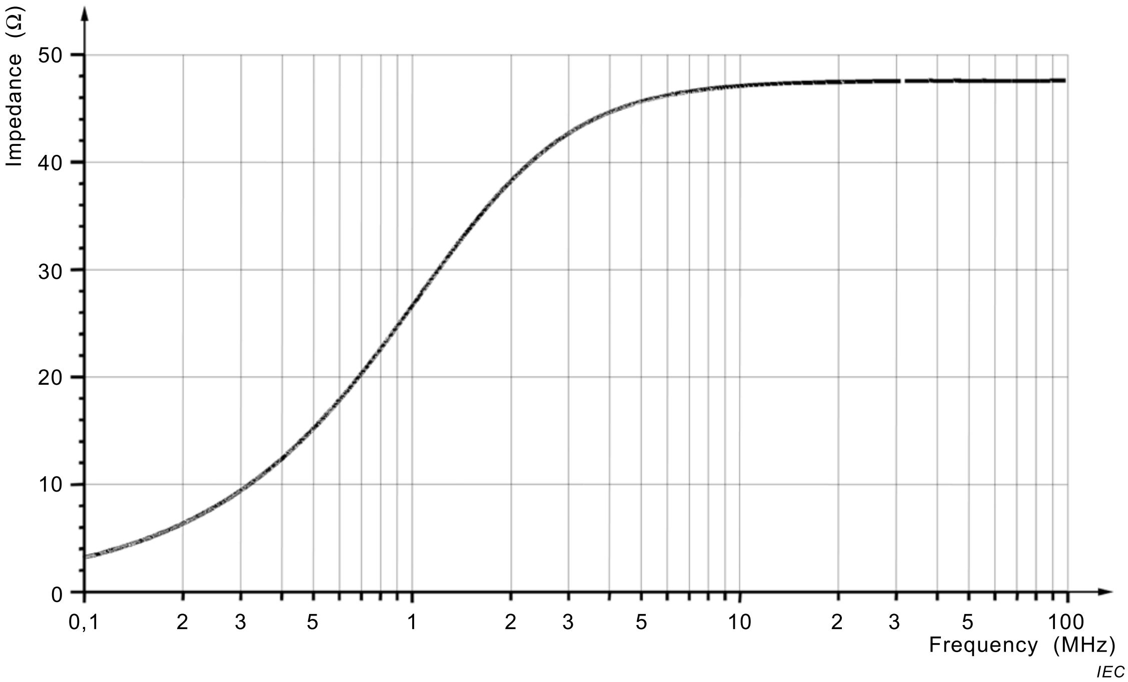


Figure A.2 – Characteristics of the AN impedance

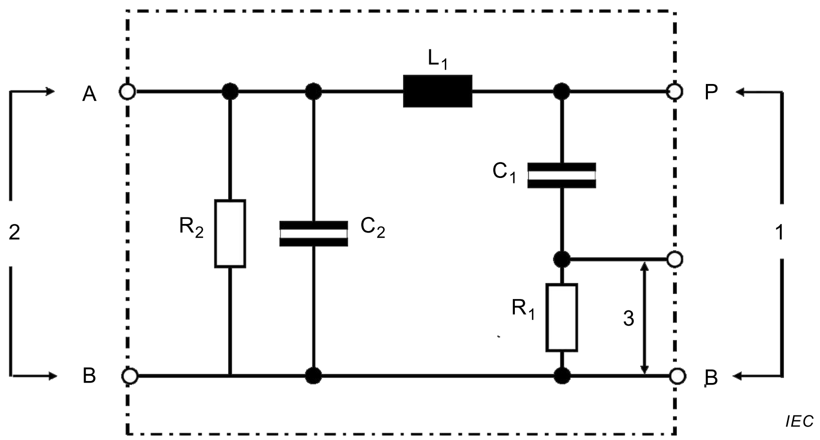
A.3.3 High voltage (HV) powered component

For a component powered by HV, a 5 µH/50 Ω HV-AN as defined in Figure A.3 shall be used.

The AN(s) shall be mounted directly on the ground plane. The case of the AN(s) shall be bonded to the ground plane. The DC resistance between the ground of the AN measurement port and the ground plane shall not exceed 2,5 mΩ.

Measurement ports of AN(s) shall be terminated with a 50 Ω load.

The AN magnitude impedance Z_{PB} (tolerance ± 20 %) in the measurement frequency range of 0,1 MHz to 100 MHz is shown in Figure A.4. It is measured between the terminals P and B (of Figure A.3) with a 50 Ω load on the measurement port with terminals A and B (of Figure A.3) short circuited.



Key

1	port for the EUT	C_1:	0,1 µF
2	power supply port	C_2:	0,1 µF
3	measurement port	R_1:	1 kΩ
L_1:	5 µH	R_2:	1 MΩ (discharging C_2 to < 50 V_{DC} within 60 s)

Figure A.3 – Example of 5 µH HV AN schematic

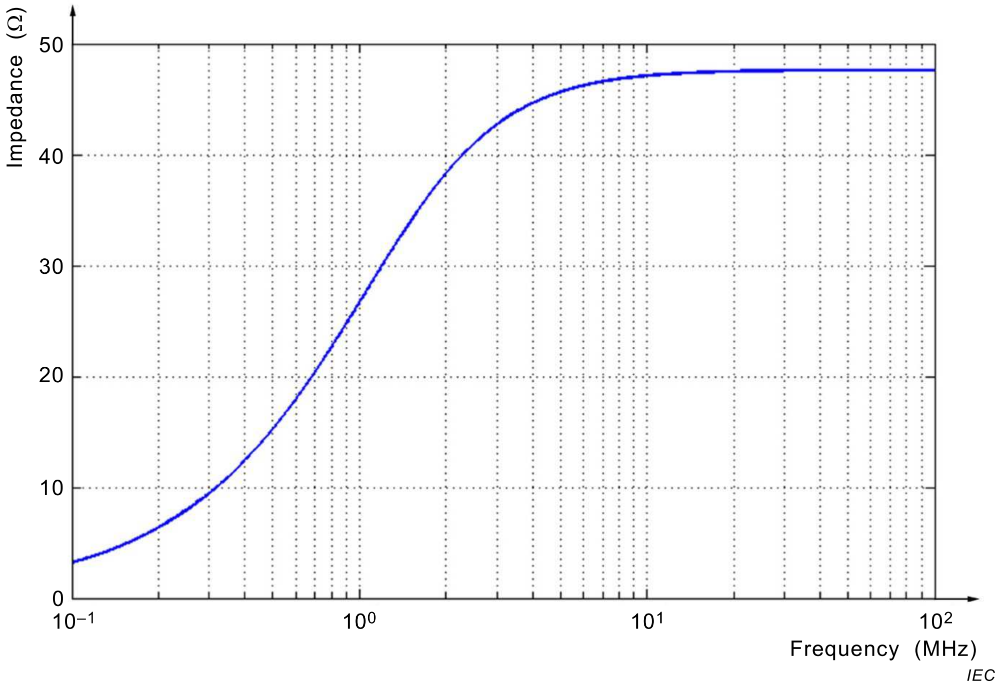


Figure A.4 – Characteristics of the HV AN impedance

If unshielded HV ANs are used in a single shielded box, then there shall be an inner shield between the HV ANs as described in Figure A.5.

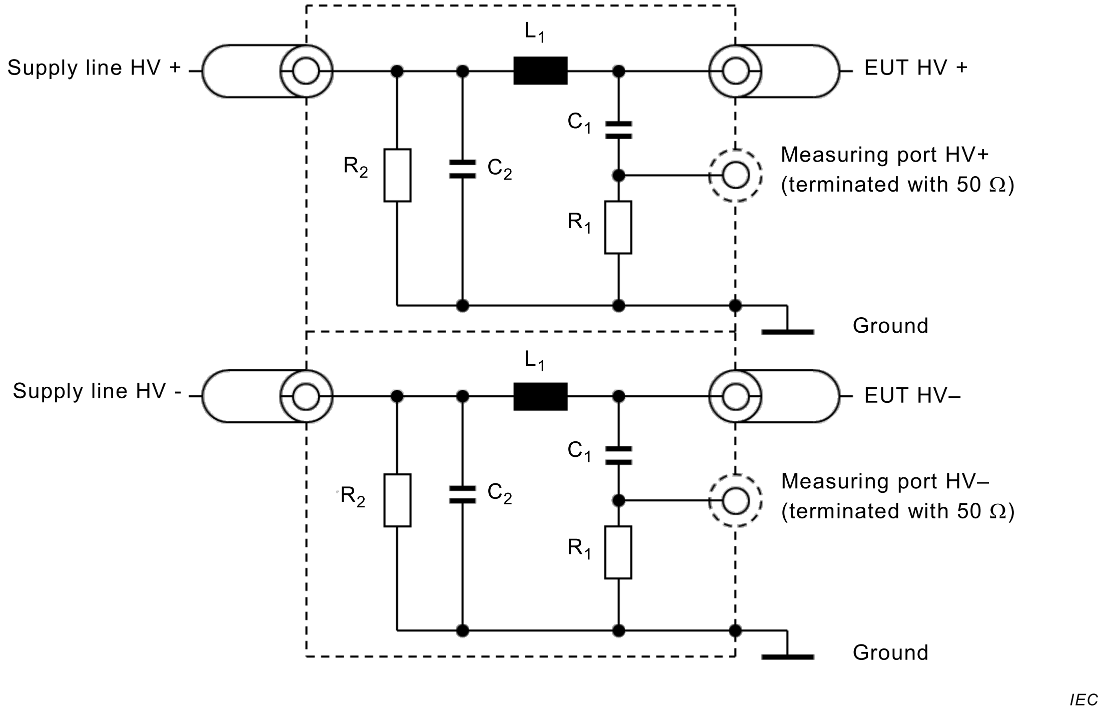


Figure A.5 – Example of 5 μH HV AN combination in a single shielded box

An optional impedance matching network may be used to simulate common mode/differential mode impedance seen by the device under test (EUT) plugged into an HV power supply (see Figure A.6). The parameters of this optional impedance matching network have to be defined in the test plan.

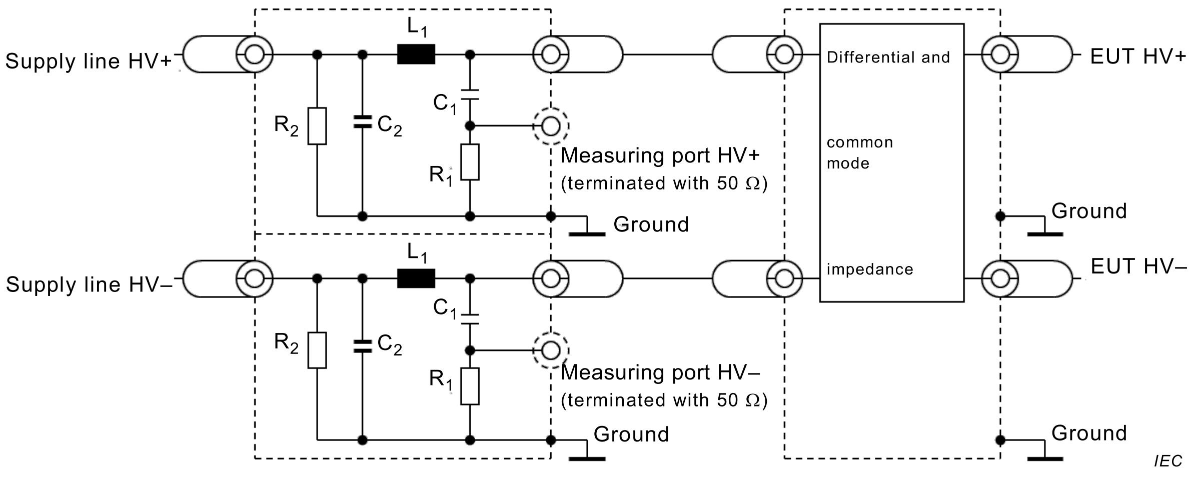


Figure A.6 – Impedance matching network attached between HV ANs and EUT

A.3.4 Components involved in charging mode connected to DC power supply

For a component involved in charging mode (e.g. charger) connected to a DC power supply, 5 μH/50 Ω-AN as defined in Clause A.3 shall be used.

A.4 Artificial mains networks (AMN)

For a components involved in charging mode (e.g. charger) connected to an AC power mains, 50 μH/50 Ω-AMN as defined in CISPR 16-1-2:2014, 4.3, shall be used.

The AMN(s) shall be mounted directly on the ground plane. The case of the AMN(s) shall be bonded to the ground plane. The DC resistance between the ground of the AMN measurement port and the ground plane shall not exceed 2,5 mΩ.

Measurement ports of AMN(s) shall be terminated with a 50 Ω load.

A.5 Asymmetric artificial networks (AAN)

A.5.1 General

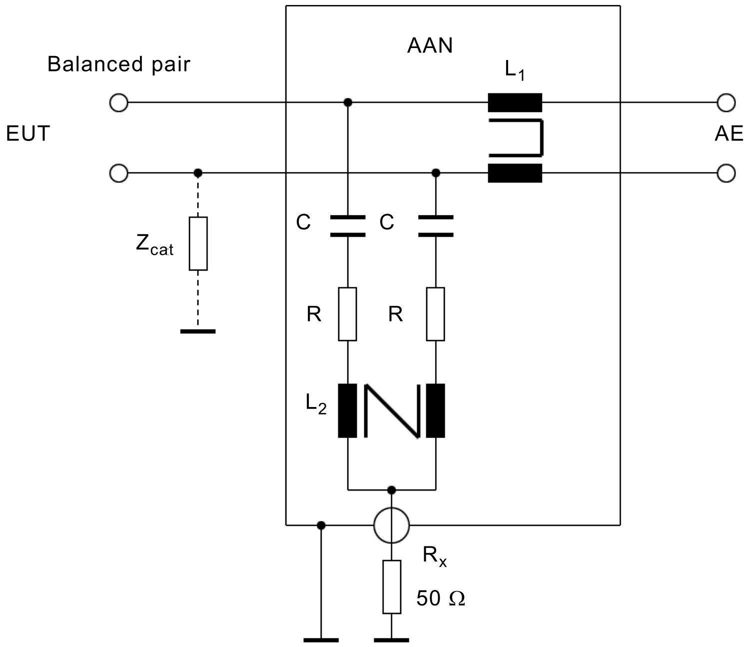
Currently different types of communication systems and communication cabling are used for the communication between charging station and vehicle. Therefore a distinction between some specific cabling/operation types is necessary.

The AAN(s) shall be mounted directly on the ground plane. The grounding connection of the AAN(s) shall be bonded to the ground plane with a low inductivity connection.

Unused measurement ports of AAN(s) shall be terminated with the corresponding load (50 Ω for the coaxial output of the IS in Figure A.7).

A.5.2 Symmetric communication lines (e.g. CAN)

An asymmetric artificial network (AAN) is to be connected between vehicle and charging station, respectively. Communication simulation is defined in CISPR 22:2008, 9.6.2 and Annex D, see example in Figure A.6. The IS has a common mode impedance of 150 Ω. The impedance Z_{cat} adjusts the symmetry of the cabling and attached periphery typically expressed as longitudinal conversion loss (LCL). The value of LCL should be predetermined by measurements or be defined by the manufacturer of the charging station/charging cable. The selected value for LCL and its origin shall be stated in the test report.



Key

C = 4,7 µF

R = 200 Ω

L1 = 2 × 38 mH

L1 = 2 × 38 mH

AE = Associated equipment

EUT = Equipment under test

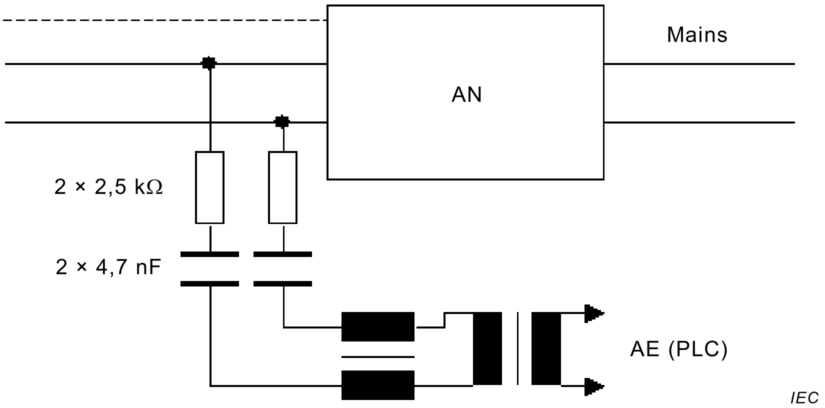
Source: CISPR 22:2008, Annex D

Figure A.7 – Example of an impedance stabilization network for symmetric communication lines

A.5.3 PLC on power lines

At present, there is no CISPR standard to cover the EMC of powerline communication (PLC) systems completely. The circuits shown in Figure A.8 and Figure A.9 allow at least emission measurements for out-of-band emissions and immunity tests. For in-band emission measurements a disturbance current (common mode) measurement (as defined in CISPR 16-2-1:2014) on the charging cable may be performed. In case of in-band emission measurements, the disturbance current should fulfil the requirements for conducted disturbance currents on network and telecommunication access.

The circuit in Figure A.8 provides a common mode termination by the AN. For emission testing only the emissions from the PLC modem of the EUT should be measured. In case the aux equipment signal levels cannot be set by software (in reference to ISO 15118-3), an attenuator is located between powerline and the PLC modem on the AE side in the circuit for emission tests. This attenuator consists of two resistors in combination with the input/output impedance of the PLC modem. The value of the resistors depends on the design impedance of the PLC modems and the allowed attenuation for the PLC system.



The value of the resistors depends on the allowed attenuation and the design impedance of the PLC modem (here: 40 dB attenuation, 100 Ω PLC design impedance).

Figure A.8 – Example of a circuit for emission tests of PLC on AC or DC powerlines

The attenuator between the two PLC modems will reduce the signal-to-noise ratio on the line, which would give unrealistic results during immunity testing. Therefore, immunity tests should be performed without the attenuator (see Figure A.9)

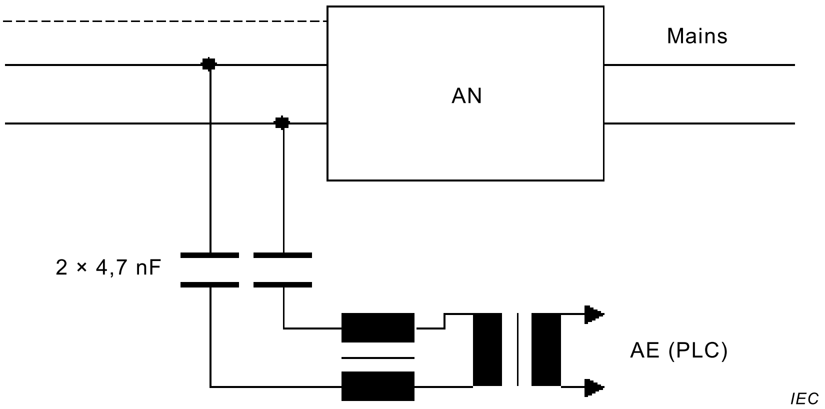
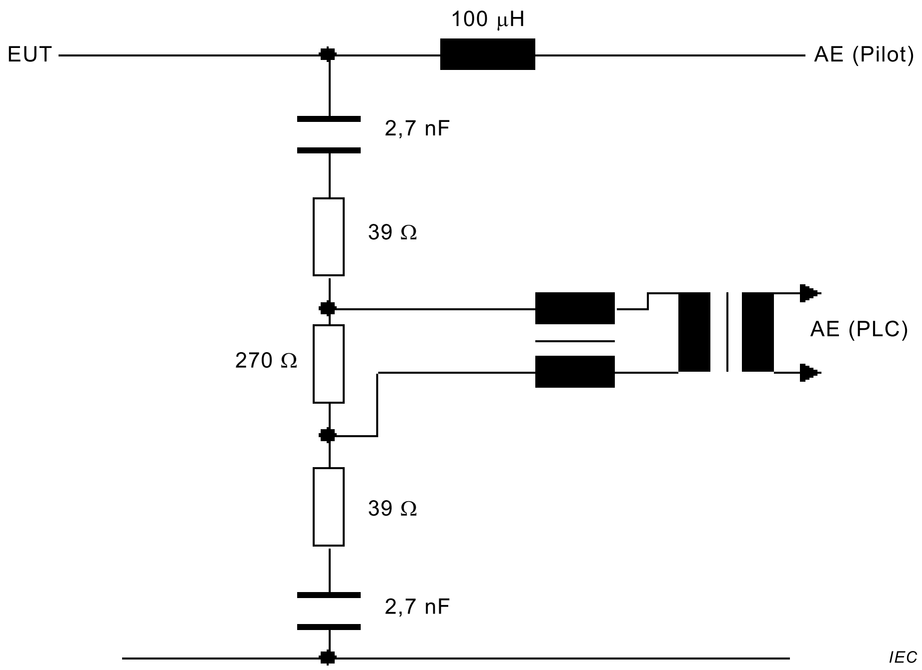


Figure A.9 – Example of a circuit for immunity tests of PLC on AC or DC powerlines

A.5.4 PLC (technology) on control pilot

Some communication systems make use of the control pilot line (versus PE) with a superimposed (high frequency) communication. Typically the technology developed for powerline communication (PLC) is used for that purpose. On one hand the communication lines are operated unsymmetrically, on the other hand two different communication systems operate on the same line. Therefore a special network shall be used. The network shown in Figure A.10 provides a common mode impedance of 150 Ω ± 20 Ω (150 kHz to 30 MHz) on the control pilot line (assuming a design impedance of the modem of 100 Ω). Both types of communications (control pilot, PLC) are separated by the network. Therefore, typically a communication simulation is used in combination with this network. The attenuator built by the resistors and the design impedance of the PLC modem makes sure that the signal on the charging cable is dominated by the EUT’s communication signals rather than the AE PLC modem.

Alternatively in order to assure that the signal is dominated by the EUT’s communication signal the transmission power of the AE PLC modem needs to be properly adjusted to be lower than EUT’s transmit power.



The values of the three resistors depend on the design impedance of the PLC modem connected on AE side. The values given in the schematic are valid for a design impedance of 100 Ω.

Figure A.10 – Example of a circuit for emission tests of PLC on control pilot line

The attenuator between the two PLC modems will reduce the signal-to-noise ratio on the line, which would give unrealistic results during immunity testing. Therefore, immunity tests should be performed without the attenuator (see Figure A.11).

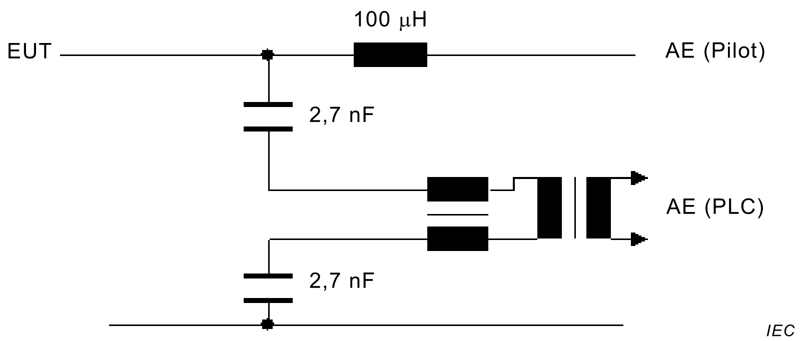


Figure A.11 – Example of a circuit for immunity tests of PLC on control pilot line

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