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Road vehicles — Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy —

Part 1: General principles and terminology

Véhicules routiers — Méthodes d'essai d'un véhicule soumis à des perturbations électriques par rayonnement d'énergie électromagnétique en bande étroite — ~~Partie 1: Principes généraux et terminologie~~

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FDIS stage

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: + 41 22 749 01 11
~~Email~~E-mail: copyright@iso.org
Website: www.iso.org

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Foreword

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This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 32, *Electrical and electronic components and general system aspects*.

This fifth edition cancels and replaces the fourth edition (ISO 11451-1:2015), which has been technically revised.

The main changes are as follows:

— ~~—~~update in Table 1~~Table 1~~;;

— ~~—~~update on modulations (type and frequency range);

— ~~—~~technical revision of Annex B~~Annex B~~;;

— ~~—~~new Annex D~~Annex D~~ on broadband test signal generation;

— ~~—~~new Annex E~~Annex E~~ on evaluation of test instrumentation uncertainties.

A list of all parts in the ISO 11451 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

In recent years, an increasing number of electronic devices for controlling, monitoring~~,~~ and displaying a variety of functions have been introduced into vehicle designs. It is necessary to consider the electrical and electromagnetic environment in which these devices operate.

Electrical and radio-frequency disturbances occur during the normal operation of many items of motor vehicle equipment. They are generated over a wide frequency range with various electrical characteristics and can be distributed to on-board electronic devices and systems by conduction, radiation~~,~~ or both. Narrowband signals generated from sources on or off the vehicle can also be coupled into the electrical and electronic system, affecting the normal performance of electronic devices. Such sources of narrowband electromagnetic disturbances include mobile radios and broadcast transmitters.

The characteristics of the immunity of a vehicle to radiated disturbances ~~have to~~should be established. The ISO 11451 series provides various test methods for the evaluation of vehicle immunity characteristics (not all methods need be used to test a vehicle).

The ISO 11451 series is not intended as a product specification and cannot function as one (see A.1~~A.1).~~. Therefore, no specific values for the test severity level are given.

~~Protection~~It is important to consider protection from potential disturbances ~~needs to be considered~~ in a total system validation, and this can be achieved using the various parts of the ISO 11451 series.

NOTE Immunity measurements of complete vehicles are generally able to be carried out only by the vehicle manufacturer, owing to, for example, high costs of absorber-lined shielded enclosures, the desire to preserve the secrecy of prototypes or a large number of different vehicle models. The ISO 11452 series specifies test methods for the analysis of component immunity, which are better suited for supplier use.

Road vehicles — Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy —

Part 1:
General principles and terminology

1 Scope

This document specifies general conditions, defines terms, gives practical guidelines and establishes the basic principles of the vehicle tests used in the ISO 11451 series, for determining the immunity of passenger cars and commercial vehicles to electrical disturbances from narrowband radiated electromagnetic energy, regardless of the vehicle propulsion system (e.g. spark-ignition engine, diesel engine, electric motor).

The electromagnetic disturbances considered are limited to continuous narrowband electromagnetic fields. A wide frequency range (0,01 MHz to 18 000 MHz) is allowed for the immunity testing in the ISO 11451 series.

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.

CISPR 16-1-2:2014~~+AMD1:2017~~, *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*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

— ~~—~~ISO Online browsing platform: available at https://www.iso.org/obp

— ~~—~~IEC Electropedia: available at https://www.electropedia.org/

3.1 ~~**3.1**~~
1 dB compression point
input signal level at which a system becomes non-linear, when the output value will deviate by 1 dB of the value given by an ideal linear system

3.2 ~~**3.2**~~
absorber-lined shielded enclosure
ALSE
shielded enclosure {3.34~~(3.34)~~} with radio frequency absorbing material on its internal ceiling and walls

Note 1 to entry: The common practice is for the room to have a metallic floor, but absorbing material can also be used on the floor.

3.3 ~~3.3~~
amplitude modulation
AM
process by which the amplitude of a carrier wave is varied following a specified law, resulting in an AM signal

3.4 ~~3.4~~
artificial mains network
AMN
network that provides a defined impedance to the vehicle under test at radio frequencies, couples the disturbance voltage to the measuring receiver, and decouples the test circuit from the supply mains

Note 1 to entry: There are two basic types of AMN, the V-network (V-AMN) which couples the unsymmetrical voltages and the delta-network which couples the symmetric and the asymmetric voltages separately. The terms line impedance stabilization network (LISN) and V-AMN are used.

Note 2 to entry: This network is inserted in the power mains of the vehicle in charging mode and provides, in a given frequency range, a specified load impedance and which isolates the vehicle from the power mains in that frequency range.

3.5 ~~3.5~~
artificial network
AN
network inserted in the supply lead or signal/load lead of apparatus to be tested which provides, in a given frequency range, a specified load impedance for the measurement of disturbance voltages and which can isolate the apparatus from the supply or signal sources/loads in that frequency range

Note 1 to entry: This network is inserted in the DC power lines of the vehicle in charging mode and provides, in a given frequency range, a specified load impedance and which isolates the vehicle from the DC power supply in that frequency range.

3.6 ~~3.6~~
asymmetric artificial network
AAN
network used to measure (or inject) asymmetric (common mode) voltages on unshielded symmetric signal (e.g. telecommunication) lines while rejecting the symmetric (differential mode) signal

Note 1 to entry: This network is inserted in the communication/signal lines of the vehicle in charging mode to provide a specific load impedance and/or a decoupling (e.g. between communication/signal lines and power mains).

3.7 ~~3.7~~
auxiliary equipment
AE
equipment needed to exercise, monitor or both exercise and monitor the operation of the vehicle

EXAMPLE Load simulator, charging cables, monitoring equipment, fibre optic interface modules, TV camera.

3.8 ~~3.8~~
bonded
<ground connection and DC resistance> grounding connection with a DC resistance not exceeding 2,5 mΩ and that provides the lowest possible impedance (resistance and inductance) connection between two metallic parts

Note 1 to entry: See CISPR 16-2-1:2014/AMD1:2017, 5.3.

Note 2 to entry: A low current (≤100 mA) 4-wire milliohm meter is recommended for this measurement.

3.9 ~~**3.9**~~
broadband signal
~~a~~ signal where the power is distributed over several megahertz, either by a broadband nature of the signal itself or by a collection of subcarriers

3.10 ~~**3.10**~~
bulk current
total amount of common mode current in a harness

3.11 ~~**3.11**~~
charging mode
mode of operation intended for charging the storage system that provides electric energy for electric propulsion

3.11.1 ~~**3.11.1**~~
charging mode 1
charging mode where the vehicle is connected to a standard socket-outlet of an AC supply network, utilizing a cable and plug, both of which are not fitted with any supplementary pilot or auxiliary contacts

Note 1 to entry: In some countries, mode 1 charging can be prohibited or requires special precautions.

Note 2 to entry: Charging mode 1 is defined in IEC 61851-1:2017,6.2.1.

3.11.2 ~~**3.11.2**~~
charging mode 2
charging mode where the vehicle is connected to AC mains using a charging cable, which has an *electric vehicle supply equipment (EVSE)* (3.18~~*EVSE* (3.18)~~) box in-line (e.g. in-cable control box / in-cable control and protection device), providing control pilot signalling between the vehicle and the EVSE box and personal protection against electric shock

Note 1 to entry: In some countries, special restrictions have to be applied for mode 2 charging.

Note 2 to entry: There is no communication with the vehicle.

Note 3 to entry: Charging mode 2 is defined in IEC 61851-1:2017,6.2.2.

3.11.3 ~~**3.11.3**~~
charging mode 3
charging mode where the vehicle is connected to a fixed installation [*electric vehicle supply equipment (EVSE)* (3.18~~*EVSE* (3.18),~~), e.g. AC charging station, AC wallbox) providing AC power to the vehicle, with communication between the vehicle and the EVSE (through signal/control lines and/or through wired network lines)

Note 1 to entry: Charging mode 3 is defined in IEC 61851-1:2017,6.2.3.

3.11.4 ~~**3.11.4**~~
charging mode 4
charging mode where the vehicle is connected to a fixed installation [*electric vehicle supply equipment (EVSE)* (3.18~~*EVSE* (3.18),~~), e.g. DC charging station), providing DC power to the vehicle (with an off-board charger), with communication between the vehicle and the EVSE (through signal/control lines and/or through wired network lines)

Note 1 to entry: Charging mode 4 is defined in IEC 61851-1:2017,6.2.4.

3.12 ~~3.12~~
coupling
means or device for transferring power between systems

3.13 ~~3.13~~
current injection probe
device for injecting current in a conductor without interrupting the conductor and without introducing significant impedance into the associated circuits

3.14 ~~3.14~~
current measuring probe
device for measuring the current in a conductor without interrupting the conductor and without introducing significant impedance into the associated circuits

3.15 ~~3.15~~
degradation of performance
undesired departure in the operational performance of any device, equipment, or system from its intended performance

Note 1 to entry: The term "degradation" can apply to temporary or permanent failure.

3.16 ~~3.16~~
direct current charging artificial network
DC-charging-AN
network inserted in the high voltage DC lead of vehicle in charging mode which provides, in a given frequency range, a specified load impedance and which can isolate the vehicle from the HV DC charging station in that frequency range

3.17 ~~3.17~~
dual directional coupler
four-port device consisting of two transmission lines coupled together in such a manner that a single travelling wave in any one transmission line will induce a single travelling wave in the other, the direction of propagation of the latter wave being dependent upon that of the former

3.18 ~~3.18~~
electric vehicle supply equipment
EVSE
equipment or a combination of equipment, providing dedicated functions to supply electric energy from a fixed electrical installation or supply network to an electric vehicle for the purpose of charging

3.19 ~~3.19~~
electromagnetic compatibility
EMC
ability of equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable *electromagnetic disturbance* [3.20(~~3.20~~)] to anything in that environment

3.20 ~~3.20~~
electromagnetic disturbance
any electromagnetic phenomenon which can degrade the performance of a device, equipment, or system or adversely affect living or inert matter

EXAMPLE An electromagnetic disturbance can be an electromagnetic noise, an unwanted signal, or a change in the propagation medium itself.

3.21 ~~3.21~~
electromagnetic interference
EMI
degradation of the performance of equipment, transmission channel, or system caused by *electromagnetic disturbance* [3.20(~~3.20~~)]

Note 1 to entry: The English words "interference" and "disturbance" are often used indiscriminately.

3.22 ~~3.22~~
electromagnetic radiation
phenomenon by which energy in the form of electromagnetic waves emanates from a source into space; energy transferred through space in the form of electromagnetic waves

Note 1 to entry: By extension, the term "electromagnetic radiation" sometimes also covers induction phenomena.

3.23 ~~3.23~~
forward power
power supplied by the output of an amplifier or generator

3.24 ~~3.24~~
ground reference plane
flat conductive surface whose potential is used as a common reference

3.25 ~~3.25~~
immunity to a disturbance
ability of a device, equipment, or system to perform without degradation in the presence of an *electromagnetic disturbance* [3.20(~~3.20~~)]

3.26 ~~3.26~~
lowest usable frequency
LUF
lowest frequency for which the field uniformity requirements are met for the reverberation chamber method and at least 12 independent stirring configurations can be achieved

3.27 ~~3.27~~
net power
forward power [3.23(~~3.23~~)] minus *reflected power* [3.32(~~3.32~~)]

3.28 ~~3.28~~
polarization
property of sinusoidal electromagnetic wave or field vector defined at a fixed point in space by the direction of the electric field strength vector or of any specified field vector, when this direction varies with time

Note 1 to entry: The property can be characterized by the locus described by the extremity of the considered field vector.

3.29 ~~3.29~~
portable transmitter
hand-held radio frequency communication device

3.30 ~~3.30~~
power mains
general purpose alternating current (a.c.) or direct current (d.c.) electric power supply

3.31 ~~3.31~~
pulse modulation
PM
process by which the amplitude of a carrier wave is varied following a specified law, resulting in a PM signal

3.32 ~~3.32~~
reflected power
reverse power
power reflected by the load due to impedance mismatch between RF-source and load

3.33 ~~3.33~~
reverberation chamber
high Q shielded room (cavity) whose boundary conditions are changed via one or several rotating tuners or moving walls (including Vibrating Intrinsic Reverberation Chambers (VIRC) with or without conductive contact to the floor) or repositioning of the transmitting antenna(s)

Note 1 to entry: This results in a statistically uniform electromagnetic field.

Note 2 ~~to entry:~~ VIRC is defined in ISO 11451-5.

3.34 ~~3.34~~
shielded enclosure
mesh or sheet metallic housing designed expressly for the purpose of separating electromagnetically the internal and external environment

3.35 ~~3.35~~
susceptibility
inability of a device, equipment or system to perform without degradation in the presence of an *electromagnetic disturbance* [3.20~~(3.20)~~]

Note 1 to entry: Susceptibility is the lack of immunity.

3.36 ~~3.36~~
susceptibility threshold
minimum level of a given *electromagnetic disturbance* [3.20~~(3.20)~~] incident on a particular device, equipment or system for which it does not operate at a required degree of functional performance

3.37 ~~3.37~~
test generator
~~Generator~~generator capable of generating the required test signal

Note 1 to entry: The test generator can, e.g. include a vector signal generator, modulation sources, attenuators, broadband power amplifiers and filters~~, etc~~.

3.38 ~~3.38~~
transmission line system
TLS
field-generating device that works in a similar way to a TEM (transverse electromagnetic) wave generator

EXAMPLE Stripline, TEM cell, parallel plate.

3.39 ~~3.39~~
tubular wave coupler
TWC
device to couple RF power to a harness or a conductor without interrupting the conductor and without introducing significant impedance into the associated circuits

3.40 ~~3.40~~
voltage standing wave ratio
VSWR
ratio, along a transmission line, of a maximum to an adjacent minimum magnitude of a particular field component of a standing wave

Note 1 to entry: This ratio is equal to: $(1+|\Gamma|)/(1-|\Gamma|)$ where $|\Gamma|$ is the magnitude of the complex reflection factor Γ.

3.41 ~~3.41~~
white noise
flat random noise
random noise which has a continuous spectrum and a constant power spectral density in the frequency band considered

4 General aim and practical use

The test methods, procedures, test instrumentation, and levels specified in the ISO 11451 series are intended to facilitate vehicle specification for electrical disturbances by narrowband radiated electromagnetic energy. A basis is provided for mutual agreement between vehicle manufacturers and component suppliers intended to assist rather than restrict.

Certain devices are particularly susceptible to some characteristics of electromagnetic disturbance, such as frequency, severity level, modulation or type of coupling.

Electronic devices are sometimes more susceptible to modulated, as opposed to unmodulated, ~~radiofrequency~~radio frequency (RF) signals. The reason is that high-frequency disturbances can be demodulated by semiconductors. In the case of unmodulated signals, this leads to a continuous shift of, for example, a voltage; in the case of amplitude-modulated signals, the resulting low-frequency fluctuations can be interpreted as intentional signals (e.g. speed information) and therefore, disturb the function of the vehicle under test more severely.

A single standard test might not reveal all the needed information about the vehicle under test. It is thus necessary for users of the ISO 11451 series to anticipate the appropriate test conditions, select applicable parts of the ISO 11451 series, and define function performance objectives. The main characteristics of each test method in ISO 11451-~~–~~2 to ISO 11451-~~–~~5 are presented in Table 1~~Table 1~~.

Table 1 — Main characteristics of test methods in the ISO 11451 series

Part of the ISO 11451 series	Applicable frequency range	Coupling to	Test severity parameter and unit	Provisions
ISO 11451-~~–~~2 Off-vehicle radiation sources	10 kHz to 18 GHz	Components and wiring harness	Electric field (V/m)	ALSE required

Part of the ISO 11451 series	Applicable frequency range	Coupling to	Test severity parameter and unit	Provisions
ISO 11451-3 On-board transmitter simulation	1,8 MHz to 6 GHz	Components and wiring harness	Power (W)	ALSE recommended
ISO 11451-4 Harness excitation methods	100 kHz to 3 GHz	Wiring harness	Current (mA) or Power (dBm)	Shielded enclosure recommended
ISO 11451-5 Reverberation chamber	10 kHz or LUF to 18 GHz	Components and wiring harness	Electric field (V/m)	Reverberation chamber required

5 General test conditions

5.1 General

Unless otherwise specified, the following test conditions are common to all parts of the ISO 11451 series:

— test temperature;

— supply voltage;

— modulation;

— dwell time;

— frequency step sizes;

— definition of test severity level;

— test signal quality.

NOTE 1 The use of the same parameters as those used for the vehicle test methods given in the corresponding parts of the ISO 11451 series will achieve better correlation.

Unless otherwise specified, the variables used shall have the following tolerances:

— ±10 % for durations and distances;

— ±10 % for resistances and impedances;

and the following magnitude accuracy:

— ±1 dB for power meter including power sensor;

— ±3 dB for field probe.

NOTE 2 When estimating the instruments uncertainty, the calibration results and the uncertainties of the calibration laboratory ~~may~~can be used.