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INTERNATIONAL STANDARD

NORME INTERNATIONALE

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INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE
COMITÉ INTERNATIONAL SPÉCIAL DES PERTURBATIONS RADIOÉLECTRIQUES

BASIC EMC PUBLICATION
PUBLICATION FONDAMENTALE EN CEM

AMENDMENT 1
AMENDEMENT 1

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

Spécifications des méthodes et des appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Partie 2-1: Méthodes de mesure des perturbations et de l'immunité – Mesures des perturbations conduites

CISPR 16-2-1:2014-02/AMD1:2017-06 (en-fr)

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FOREWORD

This amendment has been prepared by subcommittee CISPR A: Radio-interference measurements and statistical methods, of IEC technical committee CISPR: International special committee on radio interference.

The text of this amendment is based on the following documents:

CDV	Report on voting
CISPR/A/1168/CDV	CISPR/A/1201/RVC

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

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

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- withdrawn,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

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1 Scope

Replace the existing first paragraph by the following new paragraph:

This part of CISPR 16 is designated a basic standard that specifies the methods of measurement of disturbance phenomena in general in the frequency range 9 kHz to 18 GHz, and especially of conducted disturbance phenomena in the frequency range 9 kHz to 30 MHz. The CDNE extends the frequency range of conducted disturbance measurements to 300 MHz.

3.1 Terms and definitions

3.1.2
artificial network
AN

Replace the existing definition and note by the following new definition and new note:

network that provides a defined impedance to the EUT at radio frequencies, couples the disturbance voltage to the measuring receiver, and decouples the test circuit from the mains network or other power lines or from signal lines with associated equipment

Note 1 to entry: There are four basic types of this network: the V-network (V-AN), which couples the unsymmetric voltages; the delta-network (Δ-AN), which couples symmetric (DM) and asymmetric (CM) voltages separately; the Y-network (Y-AN); and the coaxial (screened cable) network, which couple asymmetric (CM) voltages.

3.1.3
artificial mains network
AMN

Replace the existing Note 1 to entry by the following new note:

Note 1 to entry: There are two basic types of this network: the V-network (V-AMN), which couples the unsymmetric voltages; and the delta-network (Δ-AMN), which couples symmetric (DM) and asymmetric (CM) voltages separately.

3.1.6
asymmetric voltage

Replace the existing definition and note by the following new definition and new note:

RF voltage appearing between the electrical mid-point of the individual terminals or leads in a two- or multi-wire circuit and reference ground, sometimes called the CM voltage

Note 1 to entry: If, in case of a LV AC mains power port, V_a is the vector voltage between one of the mains terminals and reference ground, and V_b is the vector voltage between the other mains terminal and reference ground, the asymmetric voltage is half the vector sum of V_a and V_b, i.e. $(V_a + V_b)/2$.

3.1.7
symmetric voltage

Replace the existing definition and note by the following new definition and new note:

RF voltage appearing between any pair of wires not comprising the wire at ground potential in a two- or multi-wire circuit, such as a single-phase mains supply or a bundle of twisted pairs in a communication cable, sometimes called the DM voltage

Note 1 to entry: In case of a LV AC mains power port, the symmetric voltage is the vector difference $(V_a - V_b)$.

3.1.8
unsymmetric mode voltage

Replace the existing term, definition and notes by the following new term, definition and note:

3.1.8
unsymmetric voltage
RF voltage appearing between an individual terminal or lead in a two- or multi-wire circuit and reference ground

Note 1 to entry: The unsymmetric voltage is the voltage measured by the use of an artificial mains V-network. It denotes the amplitude of the vector voltage, V_a or V_b (mentioned in the notes to entry in 3.1.6 and 3.1.7).

3.1.25
reference ground plane
RGP

Replace the existing definition and notes by the following new definition and new notes:

flat, conductive surface that is at the same electric potential as reference ground, which is used as a common reference, and which contributes to a reproducible parasitic capacitance with the surroundings of the EUT

Note 1 to entry: A reference ground plane is needed for the measurements of conducted disturbances, and serves as reference for the measurement of unsymmetric and asymmetric disturbance voltages.

Note 2 to entry: This note applies to the French language only.

Note 3 to entry: In some regions, the term ‘reference earth’ is used in place of ‘reference ground’.

3.2 Abbreviations

Add to the existing list the following new abbreviations:

DM	Differential mode
Δ-AN	Artificial Δ-network ('Δ' is pronounced 'delta')
GCPC	Grid connected power convertor
LV	Low voltage
RFI	Radio frequency interference
UM	Unsymmetric mode
V-AMN	Artificial mains V-network
V-AN	Artificial V-network
Y-AN	Artificial Y-network

5.3 Connections to RF reference ground

Delete, in the existing title, the abbreviated term "RF"*.*

Replace the second paragraph (the paragraph following NOTE 1) by the following new paragraphs:

The measurement of unsymmetric (UM) or terminal voltages and asymmetric (CM) voltages shall be referenced only to the reference ground. Ground loops (common impedance coupling) shall be avoided. Ground loops will negatively affect repeatability of measurement and can, e.g. be detected if grounded components of a test set-up are touch-sensitive. This should also be observed for measuring apparatus (e.g. measuring receivers and connected ancillary equipment, such as oscilloscopes, analyzers, recorders, etc.) fitted with a PE conductor of safety class I equipment.

NOTE 3 A detrimental ground loop can be detected when the components of a test set-up are touch-sensitive, i.e. the reading changes when the component is touched.

The measuring instrumentation shall be provided with RF isolation so that the AN has only one RF connection to reference ground. This can be accomplished by using RF chokes and isolation transformers, or by powering the measuring apparatus from batteries. Figure 1 shows an example of a recommended test set-up with three AMNs and PE chokes for the avoidance of ground loops. In this figure, also the receiver RF connecting cable to the AMN can act as a ground connection if the receiver is grounded. Therefore, either a PE choke is needed at the receiver power input, or, if the receiver is outside a shielded room, a sheath current suppressor is needed on the connecting cable. Each AMN is thus RF-grounded only once.

5.4 Connections between the EUT and the artificial mains network

Delete, in the existing title, the word "mains"*.*

Add, after the existing first sentence of this subclause, the following new sentence:

The same guidelines also apply for selection of connections of the EUT to other types of AN used for the termination of ports other than LV AC mains ports.

6.4.5 Supply

Replace the existing text of this subclause by the following new text:

The EUT shall be operated from a supply having the rated voltage of the EUT. EUTs with more than one rated voltage shall be tested at the rated voltage which causes maximum disturbance. Product standards may call for additional measurements at supply voltages within the rated supply voltage range, if, for example, the levels of disturbance vary considerably with the actual supply voltage used during the measurements.

7.1 General

Replace the existing item a), including the note, by the following new item:

a) *the types of disturbance:* there are two methods of measuring conducted disturbances, either as a voltage (prevailing method for CISPR measurements) or as a current. Both methods can be used to measure the three types of conducted disturbance, i.e.:
   - common mode (also called asymmetric mode, i.e. the vector sum of voltages/currents in a bundle or group of wires in relation to reference ground);
   - differential mode (also called symmetric mode);
   - unsymmetric mode (voltage between a terminal of the port under test and reference ground).

   NOTE The unsymmetric voltage is primarily measured at the LV AC mains power port. The CM voltage (or current) is measured primarily at telecommunication, signal and control ports.

7.3.2.1 General

Replace the existing text of this subclause by the following new text:

The CM, DM and UM impedances of actual networks, such as power mains and telecommunication networks, are location dependent and, in general, time varying. Therefore, type testing of disturbance requires standardized impedance simulation networks, referred to as artificial networks (ANs). The AN provides standardized RF load impedances to the EUT and simultaneously decouples the laboratory LV AC mains and/or DC power source or other type of peripheral and ancillary equipment, like a signal simulator, from the EUT. For this purpose, the AN is inserted between the terminals of the EUT and the actual network or signal simulator. In this way, the AN simulates extended networks (long lines) with defined impedances.

7.3.2.2 Types of artificial networks

Replace the existing text, including items a), b) and c), by the following new text:

The ANs specified in CISPR 16-1-2 shall be used, unless specific reasons call for another construction. In general, three types of AN can be distinguished:

a) *V-AN (typically used as V-AMN, or LISN):* in a defined frequency range, the RF impedances between each of the EUT terminals to be measured and the reference ground have a defined value, whereas no additional separate impedance component is connected directly between these terminals. The construction defines (indirectly) the measurement of the vector sum of both the symmetric (DM) and asymmetric (CM) voltages, i.e. of the composite unsymmetric (UM or terminal) disturbance voltage. In principle, there is no limit for the number of EUT terminals, i.e. for the number of lines to be measured by V-ANs;

b) *Δ-AN:* in a defined frequency range, the RF impedances between a pair of EUT terminals to be measured (and not comprising the grounding terminal) and between the electrical mid-point of these terminals and the reference ground have defined values. This construction defines directly both the symmetric (DM) and the asymmetric (CM) RF load impedances. Addition of a balance/unbalance transformer makes it possible to measure the symmetric (DM) and asymmetric (CM) disturbance voltages separately. Practical implementations of Δ-ANs are presently (2016) furnished only with connectors for a total of three individual EUT terminals, inclusive of common ground;

c) *Y-AN (also called the asymmetric artificial network, AAN, or ISN):* in a defined frequency range, the CM RF impedance between the electrical mid-point of a pair of EUT terminals

to be measured and the reference ground has a defined value. In general, no defined differential load impedance is included in a Y-AN as such. The defined DM impedance shall then be provided by the external circuit connected to the supply (line) terminals of the Y-AN. This type of AN is used to measure CM disturbance voltages only.

7.3.3 Current probes

Replace the existing first paragraph by the following new paragraph:

Current probes or current transformers allow the measurement of all three types of disturbance current (see 7.1 and CISPR 16-1-2) on mains and other power supply leads, signal lines, load lines, etc. A clip-on construction of the probe will facilitate its use.

7.4 Equipment under test configuration

Replace the existing title by the following new title:

7.4 Configuration of the EUT and method of measurement

7.4.1 Arrangement of the EUT and its connection to the AN

Replace the existing first paragraph by the following new paragraph:

For measurement of the disturbance voltage, the EUT is connected to the laboratory LV AC and/or DC power supply and any other extended network via one or more AN(s) in accordance with the following requirements. In general, the V-AMN is used for the LV AC mains power port (see Figure 9) in accordance with the following requirements. For termination of LV DC power ports under test, 150 Ω Δ-ANs per CISPR 16-1-2 can be used (see Figure 26). CISPR product publications supply additional test details relevant to particular EUTs.

Replace, in the second paragraph, the existing third dashed item by the following new item:

– the ANs are placed on the floor as shown in Figure 9 in such a way that one side of the AN housing is 40 cm from the vertical RGP and other metallic parts. V-AMNs and Y-ANs (AANs) are shown in Figures 9 and 10. If Δ-ANs are used, then they shall be placed on the floor in the same or similar way as the V-AMNs (see Figure 26).

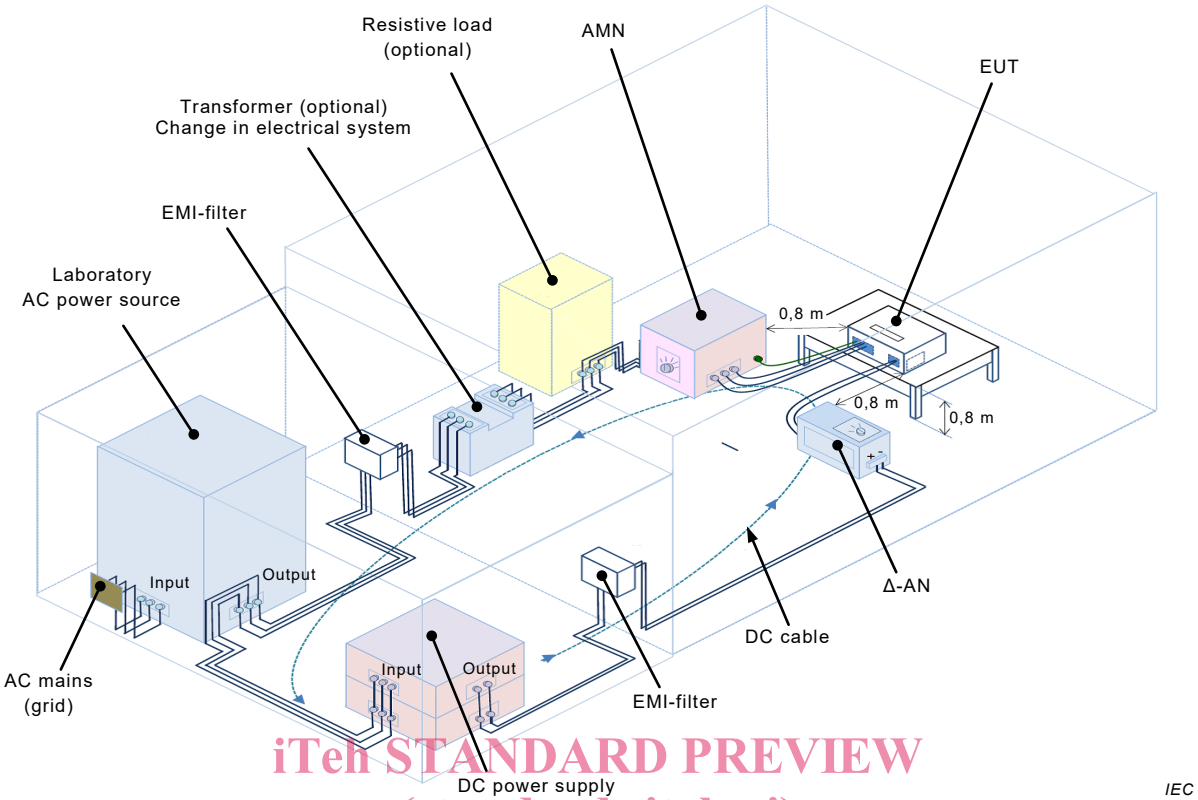
Replace, in the first sentence of the sixth paragraph the phrase "power mains leads"*, by the new phrase* "power leads."

Figure 9 – Test configuration: table-top equipment for conducted disturbance measurements on power mains

Replace the existing title of this figure by the following new title:

Figure 9 – Test configuration: table-top EUT for conducted disturbance measurements on LV AC mains power ports and on analogue/digital data ports

Add, below the existing Figure 11, the new Figure 26 as follows:



NOTE The Δ-AN is a 150 Ω Δ-AN as defined in CISPR 16-1-2.

Figure 26 – Test configuration: table-top EUT for conducted disturbance measurements on the LV AC mains and LV DC power port of a GCPC

7.4.2 Procedure for the measurement of unsymmetric disturbance voltages with V-networks (AMNs)

Replace the existing title by the new title:

7.4.2 Procedure for the measurement of disturbance voltages with ANs

7.4.2.1 General

Replace the existing text of this subclause by the following new text:

Generally, the measurement of disturbance voltages using ANs is the preferred CISPR measurement method. Only if, e.g. an AMN or other AN causes the EUT not to work, then measurements with current probes or voltage probes should be made.

The disturbance voltage at the LV AC or DC power port or any other port of an EUT can be measured using an AN suitable for the respective port. Disturbance voltages at the LV AC or DC power port can be measured either using a V-AN or a Δ-AN as appropriate and as further detailed in the product standard. By default, either type of AN specified in CISPR 16-1-2 for use with power ports can be specified in product standards.

Using the specific type of AN implies the following:

- where unsymmetric disturbance voltages are measured, compliance with the limits in the respective product standard is verified if the two (or more) unsymmetric disturbance voltage levels measured between each individual power terminal and reference ground meet the specified limits;

- where asymmetric (CM) and symmetric (DM) disturbance voltages are measured, compliance with the limits in the respective product standard is verified if the measured disturbance voltage levels of both modes, i.e. for the level of the asymmetric disturbance voltage as well as for the level of the symmetric disturbance voltage, meet the specified limits.

In any case, the assessment of the RFI potential of a given power port under test in the frequency range up to 30 MHz is only completed if measurement results were obtained and recorded either for the two (or more) composite unsymmetric disturbance components, or for both the asymmetric and the (one or more) symmetric disturbance components as well.

NOTE Proven by practical experience, it can be stated that the limits for LV AC mains power ports specified in CISPR product standards can be applied as reference for the assessment of unsymmetric, asymmetric or symmetric disturbance components, without further adjustment to the actual specific measurand used.

In principle, any type of AN specified in CISPR 16-1-2 can be used for termination of a given LV AC or DC power port under test with a defined RF load impedance. One should bear in mind however that application of a certain type of AN with measurements at a specific type of power port (AC power port or DC power port) may require the use of modified limits in order to get valid and fully comparable test results. This is due to the different RF load impedances provided by the different types of available ANs.

In case of doubt, one should therefore rely on the findings of the respective product committee for use of ANs according to CISPR 16-1-2 in type testing with EUTs of the product family concerned. This basic standard presently does not cover respective conversion factors. As a rule, the limits should be adjusted assuming the same permitted disturbance current level as can be calculated from the CM termination impedance of the type of AN for which the limits in the respective product standard were originally derived.

Disturbance voltages at an EUT having more than one type of power port, such as one having a LV AC power port and another LV DC power port, shall be measured with the respective ports connected to the respective power supply networks (or other appropriate load) via appropriate ANs.

7.4.2.2 Arrangement of equipment with ground connection

Replace the existing title by the following new title:

7.4.2.2 Set-up of EUTs with ground connection

Replace the existing first three paragraphs by the following new text:

For an EUT that is required to be grounded during its operation, or the conductive housing of which can come into contact with ground, the unsymmetric disturbance voltage of the individual LV AC mains or other kind of power lead is measured with reference to the RGP (general ground of the measuring equipment) to which the housing of the EUT is connected via its protective ground conductor and the ground connection of the AMN (see the equivalent circuit in Figure 15). Asymmetric disturbance voltages at all power leads in the respective cable to the power port under test are also measured with reference to reference ground. The symmetric disturbance voltage does not have relation to reference ground as it is the disturbance voltage measured between two individual leads or terminals of the power port under test not comprising the grounding terminal or PE wire.

The parameters determining the interference potential of grounded EUTs are discussed in Clause A.3.

For EUTs with two or more power and safety conductors or special ground connections, the measurement result depends much on the termination conditions of the mains and other power terminals and the grounding conditions (refer also to 7.5 on measurement in systems).

Figure 14 – Schematic of disturbance voltage measurement configuration (see also 7.5.2.3)

Add, between the end of the key and the title, the following new note:

NOTE A similar arrangement is used for defined termination of LV DC power ports under test.

Figure 15 – Equivalent circuit for measurement of unsymmetric disturbance voltage for safety-class I (grounded) EUT

Add, to the existing item 3 in the key, the phrase "(here, V-AMN)" *after the abbreviation* "AMN"*.*

7.4.2.3 Arrangement of equipment without ground connection

Replace the existing title by the following new title:

7.4.2.3 Set-up of EUTs without ground connection

Add, at the end of the existing first paragraph, the following new text:

Devices without ground connection comprise electrical devices with protective insulation (safety-class II) and devices which can be operated without ground or safety conductor (device of safety-class III) and also pluggable safety-class I devices connected via an isolating transformer. For these devices, the unsymmetric disturbance voltage of the individual conductors shall be measured with respect to the metal reference ground of the measurement arrangement as shown in the equivalent circuit of Figure 16. Asymmetric and symmetric disturbance voltages shall be measured with a Δ-AN replacing the V-AN shown at the right-hand side of Figure 16.

7.4.3.2 Measurement using the delta-type network

Replace the existing title by the following new title:

7.4.3.2 Measurement using the Δ-AN

Replace the existing text of this subclause by the following new text:

The asymmetric (CM) disturbance voltage at the terminals for symmetric (DM) signal lines of telecommunication, data processing and other equipment is measured with Δ-ANs in accordance with CISPR 16-1-2, in the frequency range 150 kHz to 30 MHz. The Δ-ANs specified in CISPR 16-1-2 could be constructed so as to allow signal and DC current paths needed for the proper functioning of the EUT, as long as the requirements for DM and CM termination impedances of CISPR 16-1-2 are met.

When using the Δ-AN for measurements on signal terminals, the differential mode rejection (DMR) or longitudinal conversion loss (LCL) of the Δ-AN shall be as high as needed so as not to give erroneous results when measuring an asymmetric disturbance voltage at the same frequency as the operational DM signal.

When the EUT is to be measured on its power supply terminals using a V-AMN, all voltage measurements shall be carried out with both networks connected simultaneously. The provisions prescribed in 7.4.1 and 7.4.2 shall be observed.

NOTE The measurement frequency range of the Δ-AN can be extended to 9 kHz using the same network impedance if decoupling of the connected signal line and coupling to the measuring receiver are designed accordingly.

7.4.4 Measurements using voltage probes

Replace the existing Subclauses 7.4.4.1, 7.4.4.2 and 7.4.4.3 by the following new Subclauses 7.4.4.1 through 7.4.4.4:

7.4.4.1 General

For measurements of conducted disturbance voltages, voltage probes can be used if the usual AN cannot be used for various reasons including, but not limited to, constraints in the rated throughput current.

In case of measurement of unsymmetric disturbance voltages, the probe is to be connected in succession between each individual line (or terminal) of the respective port under test and the chosen reference ground. Each individual unsymmetric disturbance voltage shall be measured.

Compliance with the limits of a given product standard can be shown in verifying that the limits of the disturbance voltage at the power ports specified in that product standard are met. In case of measurement of unsymmetric disturbance voltages, compliance with the limits needs to be demonstrated for each of the measured disturbance voltages.

With a Δ-AN used as voltage probe and with a capacitive voltage probe (CVP, see also 7.4.5), one can also measure asymmetric disturbance voltages at a pair or more of individual power or signal leads accommodated in the respective cable. In this case, compliance with the limits of a given product standard can be shown in verifying that the measured asymmetric disturbance voltage level meets the specified limits.

7.4.4.2 Voltage probe measurements with AMN

To test devices and systems with several connected or connectable lines, the disturbance voltage at the line connections that cannot be measured with an appropriate AN, such as a V-AMN (e.g. for connecting lines between parts of components which are separated from the mains), as well as at the connecting jacks for antennas, control and load lines, shall be measured with a voltage probe (see 7.3.3) with a high input impedance (1 500 Ω or more) to ensure that the lines are not loaded by the probe.

For these cases, however, the primary LV AC mains power input wires shall be isolated and RF terminated with the AMN. For the remaining lines, also those not to be measured with the probe, the corresponding conditions of 7.4.1 and the operating conditions laid down for the individual EUTs in the respective product standards (e.g. CISPR 11 [1] and CISPR 14-1) shall be observed regarding arrangement and length. The voltage probe is connected to the measuring receiver via a coaxial cable, the screen of which is connected to the reference ground and the case of the voltage probe. No connection shall be made directly from this case to live parts of the EUT.

7.4.4.3 Voltage probe measurements without an AMN

During testing of EUTs that cannot be measured with AMNs or other appropriate ANs, the disturbance voltage is measured across a defined simulation resistance (e.g. artificial fence simulation in CISPR 14-1 or under open-circuit conditions with an exactly defined arrangement and line layout taking into consideration the specifications of 7.4.1). The disturbance voltage is measured with a high-impedance voltage probe.

7.4.4.4 AMN or other appropriate AN used as a voltage probe

Where the current rating of an EUT exceeds the rating of available AMNs or other appropriate ANs, the AMN or AN can be used as a voltage probe. The EUT port of the AMN or AN used during the measurements is connected to each of the power lines of the EUT (i.e. to the AC single phase or three-phase leads, or to the DC plus and minus leads); see also Figure 27.