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INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

AMENDMENT 2
AMENDEMENT 2

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 16-2-1:2008/A2:2013

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FOREWORD

This amendment has been prepared by subcommittee 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:

FDIS	Report on voting
CISPR/A/1023/FDIS	CISPR/A/1029/RVD

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 publication will remain unchanged until the stability date indicated on the IEC web site 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- withdrawn,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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2 Normative references

Replace the existing reference to CISPR 16-1-2 by the following new reference:

CISPR 16-1-2:2003, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-2: Radio disturbance and immunity measuring apparatus – Ancillary equipment – Conducted disturbances*
Amendment 1:2004
Amendment 2:2006

3 Definitions

Add, after definition 3.34 added by Amendment 1, the new terms and definitions 3.35 and 3.36 as follows:

3.35
total common mode impedance
TCM impedance
impedance between the cable attached to the EUT port under test and the reference ground plane

NOTE The complete cable is seen as one wire of the circuit and the ground plane as the other wire of the circuit. The TCM wave is the transmission mode of electrical energy, which can lead to radiation of electrical energy if the cable is exposed in the real application. Vice versa, this is also the dominant mode, which results from exposure of the cable to external electromagnetic fields.

3.36
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 An AAN is an AN (artifical network) that provides a simulation of the asymmetric load realized by the telecommunication network.

NOTE 2 The term “Y-network” is a synonym for AAN.

NOTE 3 The AAN can also be used for immunity testing, where the receiver measurement port becomes the disturbance injection port.

6.4 Operating conditions of the EUT

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

6.4 EUT arrangement and measurement conditions

6.4.1 General

Replace the existing title and text of this subclause as follows:

6.4.1 EUT arrangement

6.4.1.1 General

Where not specified in the product standard, the EUT shall be configured as described in the following paragraphs.

The EUT shall be installed, arranged and operated in a manner consistent with typical applications. Where the manufacturer has specified or recommended an installation practice, such practice shall be used in the test arrangement, where possible. This arrangement shall be typical of the normal installation practice. Interface cables, loads and devices shall be connected to at least one of each type of interface port of the EUT, and where practical, each cable shall be terminated in a device typical of actual usage.

Where there are multiple interface ports of the same type, additional interconnecting cables, loads and devices may need to be added to the EUT depending upon the results of preliminary tests. The number of additional cables or wires of the same type should be limited to the condition where the addition of another cable or wire does not significantly affect the emission level, i.e. varies by less than 2 dB, provided that the EUT remains compliant. The rationale for the selection of the configuration and loading of ports shall be included in the test report.

Interconnecting cables should be of the type and length specified in the individual equipment requirements. If the length can be varied, the length shall be selected to produce maximum disturbance.

If shielded or special cables are used during the tests to achieve compliance, a note shall be included in the instruction manual advising of the need to use such cables.

Excess lengths of cables shall be bundled at the approximate centre of the cable with the bundles 30 cm to 40 cm in length. If it is impractical to do so because of cable bulk or stiffness, the disposition of the excess cable shall be precisely noted in the test report.

Where there are multiple interface ports all of the same type, connecting a cable to just one of that type of port is sufficient, provided it can be shown that the additional cables would not significantly affect the results.

Any set of results shall be accompanied by a complete description of the cable and equipment orientation so that results can be repeated. If specific conditions of use are required to meet the limits, those conditions shall be specified and documented, for example cable length, cable type, shielding and grounding. These conditions shall be included in the instructions to the user.

Equipment that is populated with multiple modules (such as drawers and plug-in cards) shall be tested with a mix and number representative of that used in a typical installation. The number of additional boards or plug-in cards of the same type should be limited to the condition where the addition of another board or plug-in card does not significantly affect the emission level, i.e. varies by less than 2 dB, provided that the EUT remains compliant. The rationale used for selecting the number and type of modules should be stated in the test report.

A system that consists of a number of separate units shall be configured to form a minimum representative configuration. The number and mix of units included in the test configuration shall normally be representative of that used in a typical installation. The rationale used for selecting units should be stated in the test report.

One module of each type shall be operational in each equipment evaluated in an EUT. For an EUT comprising a system, one of each type of equipment that can be included in the possible system configuration shall be included in the EUT.

The results of an evaluation of EUTs having one of each type of module can be applied to configurations having more than one of each of those modules.

NOTE It has been found that disturbances from identical modules are generally not additive in practice.

The EUT position relative to the reference ground plane shall be equivalent to that occurring in use. Therefore, floor-standing equipment is placed on, but insulated from, a reference ground plane, and tabletop equipment is placed on a non-conductive table.

Equipment designed for wall-mounted operation shall be tested as tabletop EUT. The orientation of the equipment shall be consistent with normal installation practice.

Combinations of the equipment types identified above shall also be arranged in a manner consistent with normal installation practice. Equipment designed for both tabletop and floor standing operation shall be tested as tabletop equipment unless the usual installation is floor standing, then that arrangement shall be used.

The ends of signal cables attached to the EUT that are not connected to another unit or auxiliary equipment (AuxEq) shall be terminated using the correct terminating impedance defined in the product standard. If no product standard can be applied to the particular configuration, the termination shall be defined by the EUT manufacturer and noted in the test report.

Cables or other connections to auxiliary equipment located outside the test site shall drape to the floor, and then be routed to the place where they leave the test site.

Installation of AuxEq shall be in accordance with normal installation practice. Where this means that the AuxEq is located on the test site, it shall be arranged using the same conditions applicable for the EUT (for example, distance from the ground plane and insulation from the ground plane if floor standing, layout of cabling).

6.4.1.2 Arrangement of tabletop equipment

Equipment intended for tabletop use shall be placed on a non-conductive table. The size of the table will nominally be 1,5 m by 1,0 m but may ultimately be dependent on the horizontal dimensions of EUT.

Intra-unit cables shall be draped over the back of the table. If a cable hangs closer than 0,4 m from the horizontal ground plane (or floor), the excess shall be folded at the cable centre into a bundle no longer than 0,4 m, such that the part of the bundle closest to the horizontal reference ground plane is at least 0,4 m above the plane.

Cables shall be positioned as for normal usage.

If the mains port input cable is less than 0,8 m long (including power supplies integrated in the mains plug), an extension cable shall be used such that the external power supply unit is placed on the tabletop. The extension cable shall have similar characteristics to the mains cable (including the number of conductors and the presence of a ground connection). The extension cable shall be treated as part of the mains cable.

In the above arrangements, the cable between the EUT and the power accessory shall be arranged on the tabletop in the same manner as other cables connecting components of the EUT.

6.4.1.3 Arrangement of floor-standing equipment

The EUT shall be placed on the horizontal reference ground plane, orientated for normal use, but separated from metallic contact with the reference ground plane by up to 15 cm of insulation.

The cables shall be insulated (by up to 15 cm) from the horizontal reference ground plane. If the equipment requires a dedicated ground connection, then this shall be provided and bonded to the horizontal reference ground plane.

Intra-unit cables (between units forming the EUT or between the EUT and any auxiliary equipment) shall drape to, but remain insulated from, the horizontal reference ground plane. Any excess cable shall either be folded at the cable centre into a bundle no longer than 0,4 m or arranged in a serpentine fashion. If an intra-unit cable length is not long enough to drape to the horizontal reference ground plane but drapes closer than 0,4 m, then the excess shall be folded at the cable centre into a bundle no longer than 0,4 m. The bundle shall be positioned such that it is either 0,4 m above the horizontal reference ground plane or at the height of the cable entry or connection point if this is within 0,4 m of the horizontal reference ground plane.

For equipment with a vertical cable riser, the number of risers shall be typical of installation practice. Where the riser is made of non-conductive material, a minimum spacing of at least 0,2 m shall be maintained between the closest part of the equipment and the nearest vertical cable. Where the riser structure is conductive, the minimum spacing of 0,2 m shall be between the closest parts of the equipment and riser structure.

6.4.1.4 Arrangement for combinations of tabletop and floor-standing equipment

Intra-unit cables between a tabletop unit and a floor-standing unit shall have the excess cable folded into a bundle no longer than 0,4 m. The bundle shall be positioned such that it is either 0,4 m above the horizontal reference ground plane or at the height of the cable entry or connection point if this is within 0,4 m of the horizontal reference ground plane.

Add, after the existing Subclause 6.4.6, the new subclauses:

6.4.7 Operation of multifunction equipment

Multifunction equipment that is subjected simultaneously to different clauses of a product standard and/or different standards shall be tested with each function operated in isolation, if this can be achieved without modifying the equipment internally. The equipment thus tested shall be deemed to have complied with the requirements of all clauses/standards when each function has satisfied the requirements of the relevant clause/standard.

For equipment that it is not practical to test with each function operated in isolation, or where the isolation of a particular function would result in the equipment being unable to fulfil its primary function, or where the simultaneous operation of several functions would result in saving measurement time, the equipment shall be deemed to have complied if it meets the provisions of the relevant clause/standard with the necessary functions operated.

6.4.8 Determination of EUT arrangement(s) that maximizes emissions

Initial testing shall identify the frequency that has the highest disturbance relative to the limit. This identification shall be performed whilst operating the EUT in typical modes of operation and with cable positions in a test arrangement that is representative of typical installation practice.

The frequency of highest disturbance with respect to the limit shall be found by investigating disturbances at a number of significant frequencies. This provides confidence that the probable frequency of maximum disturbance has been found and that the associated cable, EUT arrangement and mode of operation has been identified.

For initial testing, the EUT should be arranged in accordance with the product standards as appropriate.

6.4.9 Recording of measurement results

Of those disturbances above (L – 20 dB), where L is the limit level in dB(μV) or dB(μA), the disturbance levels and the frequencies of at least the six disturbances having the smallest margin to the limit L shall be recorded.

In addition, the test report shall include the value of the measurement instrumentation uncertainty corresponding to the used test setup, calculated as per the requirements of CISPR 16-4-2.

7.3.1 General

Replace the existing Note by the following new Note:

NOTE Some standards use the terms impedance stabilization network (ISN) for ANs for emission measurements on telecommunication ports (i.e. AANs or Y-networks).

7.3.3 Voltage probes

Replace the existing first paragraph of this subclause by the following new paragraph:

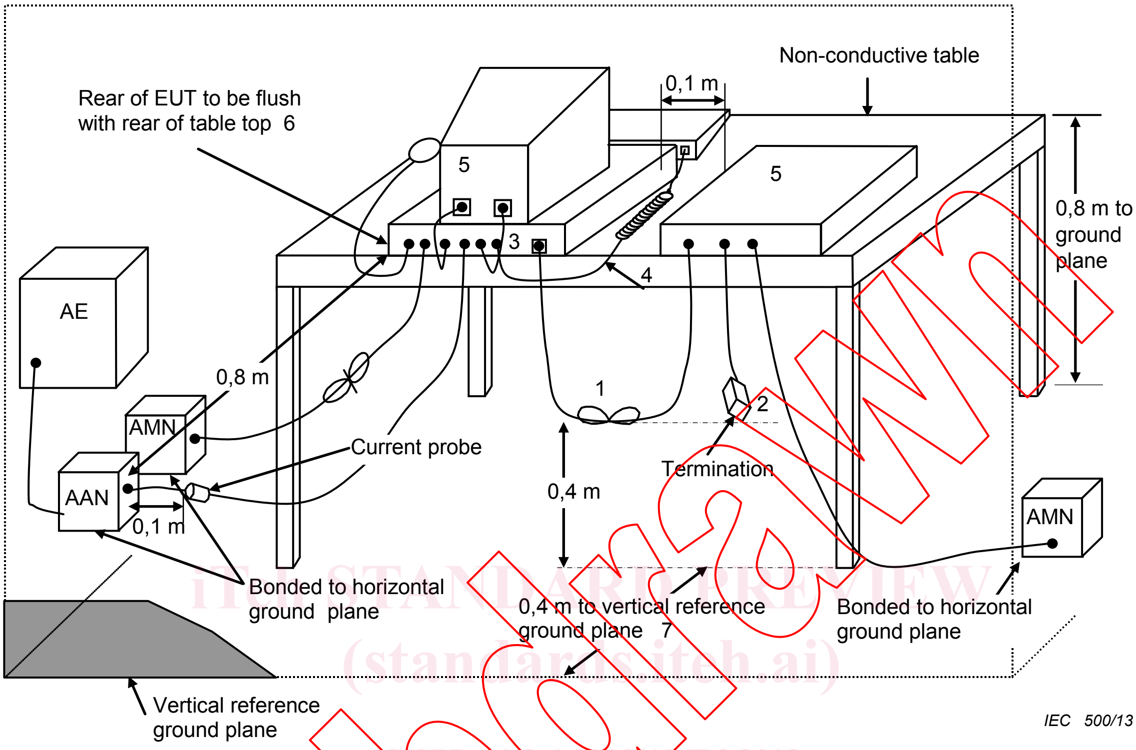
For specifications of voltage probes, see CISPR 16-1-2.

7.4.1 Arrangement of the EUT and its connection to the AN

*Replace, in the fifth dashed item of the list of this subclause, the abbreviation “*ISNs*” by the new abbreviation “*AANs.*”*

Figure 6 – Test configuration: table-top equipment for conducted disturbance measurements on power mains

Replace the existing figure and notes, modified by Amendment 1, by the following:



1 Interconnecting cables that hang closer than 40 cm to the ground plane shall be folded back and forth forming a bundle 40 cm long or less, hanging approximately in the middle between the ground plane and the table. The minimum bend radius of the cable shall not be exceeded. If the bend radius causes the bundle length to exceed 40 cm, the bend radius shall determine the bundle length.

2 I/O cables that are connected to a peripheral shall be bundled in the centre. The end of the cable may be terminated if required using correct terminating impedance. The total length shall not exceed 1 m – if possible.

3 EUT is connected to one AMN. Measurement terminals of AMNs and AANs must be terminated with 50 Ω if not connected to the measuring receiver. AMNs are placed directly on the horizontal ground plane 0,8 m from the EUT and 40 cm from vertical ground plane if the vertical ground plane is the reference ground plane (see also Figure 7 a)). Alternatively (as shown in Figure 7 b)), AMNs are placed on the vertical ground plane 0,8 m from the EUT, if the horizontal ground plane is the reference ground plane, which is 40 cm below the EUT. To reach the 0,8 m distance, the AMNs may have to be moved to the side. All associated equipment is connected to a second AMN if this second AMN is capable of supplying the necessary power. In cases where a single AMN is not capable of supplying the necessary power, several AMNs may be used to supply the associated equipment.

4 Cables of hand-operated devices, such as keyboards, mouses, etc., shall be placed as close as possible to the host.

5 Non-EUT components being tested.

6 Rear of EUT, including peripherals, shall all be aligned and flush with rear of table-top.

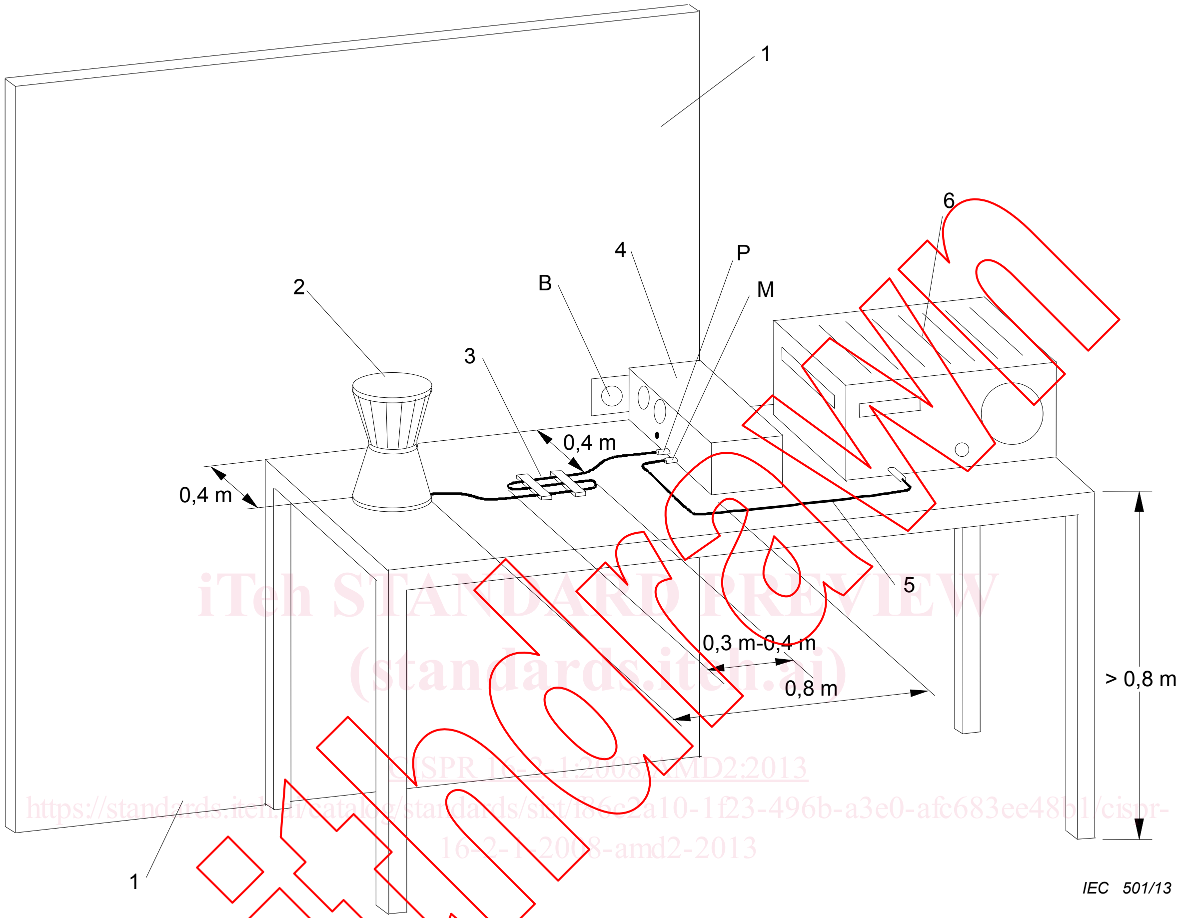
7 Rear of table-top shall be at a distance of 40 cm from a vertical conducting plane that is bonded to the floor ground plane.

Tolerances of cable lengths and distances are as practical as possible.

Figure 6 – Test configuration: table-top equipment for conducted disturbance measurements on power mains

Figure 8 – Optional example test configuration for an EUT with only a power cord attached

Replace the existing figure and notes by the following:



1 Metallic wall 2 m × 2 m

2 EUT

3 Excess power cord (e.g., 0,02 m × 0,3 m forming a meander)

4 AMN

5 Coaxial cable

6 Measuring receiver

B Reference ground connection

M Measuring receiver input

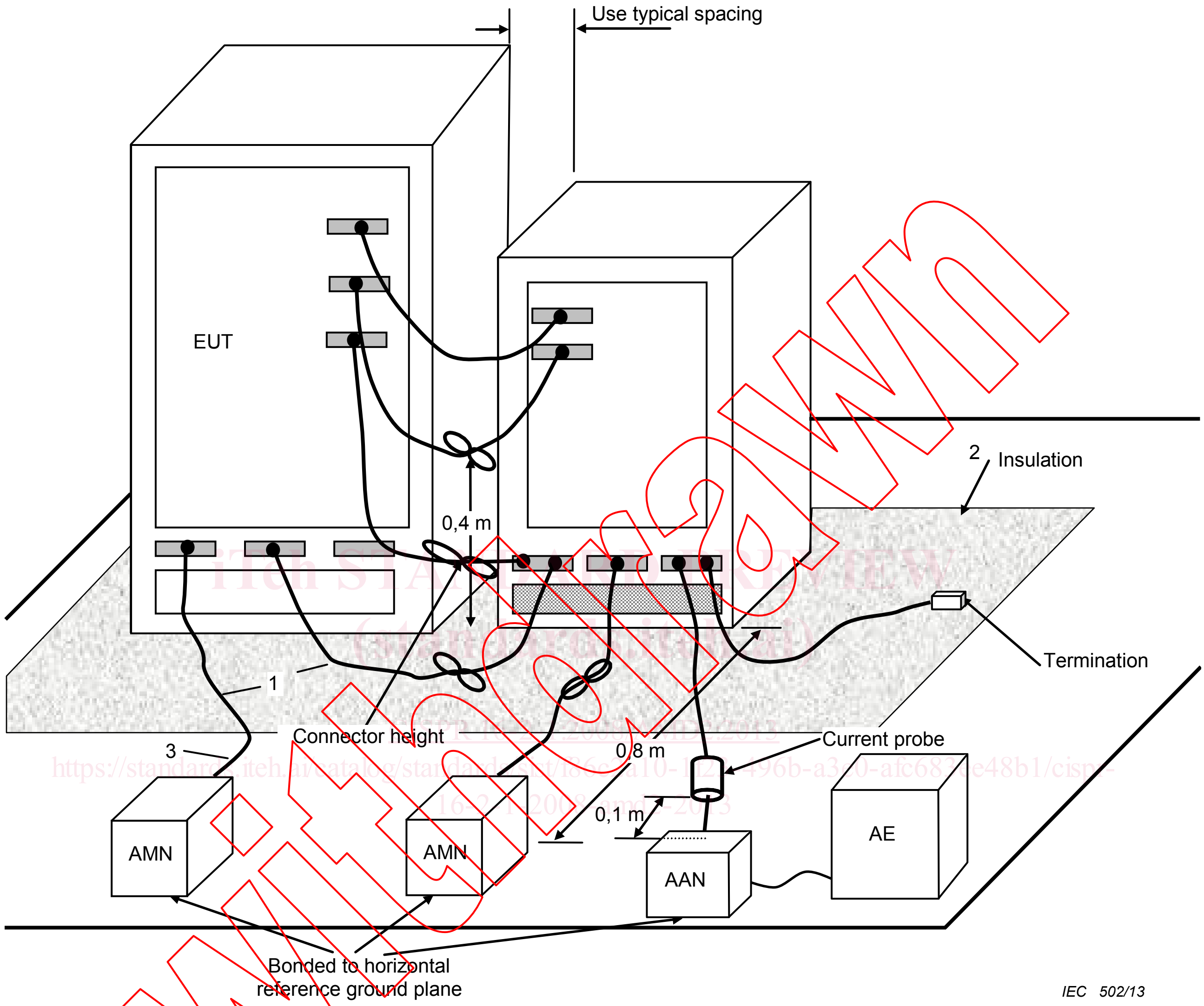
P Power to EUT

Tolerances of cable lengths and distances are as practical as possible.

Figure 8 – Optional example test configuration for an EUT with only a power cord attached

Figure 9 – Test configuration: floor-standing equipment (see 7.4.1 and 7.5.2.2)

Replace the existing figure and notes by the following:



1 Excess cables shall be bundled in the centre or shortened to appropriate length.

2 The EUT and cables shall be insulated (up to 15 cm) from the ground plane.

3 The EUT is connected to one AMN. The AMN can be placed on top of or immediately beneath the ground plane.
All other equipment is powered from the second AMN.

Tolerances of cable lengths and distances are as practical as possible.

Figure 9 – Test configuration: floor-standing equipment (see 7.4.1 and 7.5.2.2)

Add, after the existing Annex F added by Amendment 1, the following new Annexes G, H and I as follows:

Annex G
(informative)

Guidance for measurements on telecommunications ports

G.1 Limits

The disturbance voltage (or current) limit is defined for a TCM load impedance of 150 Ω (as seen by the EUT at the AE port during the measurement). This standardisation is necessary in order to obtain reproducible measurement results, independent of the indeterminate TCM impedance at the AE and the EUT.

NOTE 1 The common mode disturbances created from the wanted signal can be controlled at the design stage of the interface technology by giving proper consideration to the factors explained in CISPR/TR 16-3.

In general, the TCM impedance seen by the EUT at the AE port is not defined unless an AAN/CDN is used. If the AE is located outside the shielded room, the TCM impedance seen by the EUT at the AE port can be determined by the TCM impedance of the feed-through filter between the measurement set-up and the outside world. A Π-type filter has a low TCM impedance, whilst a T-type filter has a high TCM impedance.

NOTE 2 CDNs are described in IEC 61000-4-6.

AAN/CDNs do not exist for all types of cables used by EUTs. Therefore it is also necessary to define alternative test methods that do not use AAN/CDNs (i.e. "non-invasive" test methods).

Only the cable attached to the EUT port under test is shown in the figures of Annex H. Normally, there are several other cables (or ports) present at the EUT. At least the connection to the mains terminal is represented in most cases. The TCM impedance of these other connections (including a possible ground connection), and the presence or absence of these connections during the test, can influence the measurement result significantly, in particular for small EUTs. Therefore, the TCM impedance of the non-measured connections should be specified for the test of small EUTs. In addition to the port under test, it is sufficient to have at least two additional ports connected to a TCM impedance of 150 Ω (normally by using an AAN or CDN, with the RF measurement port terminated with 50 Ω load) to reduce this influence effect to a negligible amount.

Coupling devices for unshielded balanced pairs should also simulate the typical LCL (longitudinal conversion loss) of the lowest cabling category (worst LCL) specified for the telecom port under test. The intent of this requirement is to account for the transformation of the symmetrical signal into a CM (common mode) signal, which might contribute to the radiation when the EUT is in the end-use application. Asymmetry is built-in to an AAN to yield the specified LCL; this asymmetry may enhance or cancel the asymmetry of the EUT. To establish the worst case emissions and optimize test repeatability, consideration should therefore be given to repeating the testing with the LCL imbalance on each wire of a balanced pair when using the appropriate AAN.

Because imbalance on each balanced pair may contribute to the total common mode conducted emission, all combinations of imbalance on all balanced pairs should be considered. For a single balanced pair, this is a relatively minor impact on test effort – i.e. the two wires are reversed. However, for two balanced pairs, the number of LCL loading combinations is four (i.e. test configurations). For four balanced pairs, the number of loading combinations grows to sixteen. Such numbers will have a significant impact on test time and test documentation. Such testing should be undertaken with care, and properly documented if implemented.

The RF measurement port of an AAN/CDN not connected to the measuring receiver shall be terminated in a 50 Ω load.

Table G.1 summarizes the advantages and disadvantages of the methods described in Annex H.

Table G.1 – Summary of advantages and disadvantages of the methods described in the specific subclauses of Annex H

	Subclause H.5.2 (AAN)	Subclause H.5.3 (150 Ω load and cable shield)	Subclause H.5.4 (current probe and CVP)
Advantages	Smallest measurement uncertainty (Possible only if AAN/CDNs with appropriate transmission properties are available) LCL shall be known and shall be taken into account	– Non-invasive (except for the removal of the insulation of the shielded cable) – Always applicable for shielded cables – Small measurement uncertainty for higher frequencies	Non-invasive
Disadvantages	– Not applicable in all cases (needs appropriate AAN/CDNs) – Invasive (needs appropriate cable connections) – Needs an individual AAN/CDN for each cable type (results in a high number of different AAN/CDNs) – No isolation to symmetric signals from the AE is provided by an AAN	– Increased measurement uncertainty for very low frequencies (< 1 MHz) – Destruction of the cable insulation is necessary – Reduced isolation against disturbances from the AE side (compared to H.5.2) – Does not assess the interference potential that arises from the conversion of the symmetric signal into a common mode signal due to the limited LCL of the cable network to which the EUT port will be connected	– No isolation against disturbances from the AE side (compared to H.5.2) – Does not assess the interference potential that arises from the conversion of the symmetric signal into a common mode signal due to the limited LCL of the cable network to which the EUT port will be connected

G.2 Combination of current probe and capacitive voltage probe (CVP)

The method described in H.5.4 has the advantage of being applicable in a non-invasive way to all types of cables. However, unless the TCM impedance seen by the EUT at the AE connection is 150 Ω, the method of H.5.4 in general will show a result which is too high, but never too low (i.e. worst case estimation of the emission).

G.3 Basic ideas of the capacitive voltage probe

The set-up of Figure H.3 uses a capacitive voltage probe to measure the CM voltage. There are two approaches to the construction of a capacitive voltage probe. For either approach, if a TCM impedance of 150 Ω is present, the capacitance of the capacitive voltage probe to the cable attached to the EUT port under test will appear as a load in parallel with the 150 Ω TCM impedance.

NOTE 1 A CVP does not simulate the differential to common mode conversion that takes place in telecommunication networks (but which an AAN does), and therefore a CVP cannot be used to measure the converted common mode voltage. For the same reason, a combination of a CVP and a current probe cannot replace the AAN.

The TCM impedance tolerance is ± 20 Ω over the frequency range of 0,15 MHz to 30 MHz. If the capacitive voltage probe loading acts to reduce the 150 Ω TCM impedance at most down to 130 Ω, the capacitance of the capacitive voltage probe to the cable attached to the EUT port under test should be < 5 pF at 30 MHz (the worst case frequency). At 30 MHz, 5 pF is an impedance of approximately $-j1\ 061$ Ω, which in parallel with 150 Ω yields a combined TCM of approximately 148 Ω. Refer to Figure G.2 of CISPR 16-1-2:2003, Amendment 1 (2004) for further background information.

The first approach to construction of a capacitive voltage probe is to have the probe be a single device that relies on physical distance from the cable attached to the EUT port under test to achieve the < 5 pF loading. This style of capacitive voltage probe is described in 5.2.2 of CISPR 16-1-2:2003, Amendment 1 (2004).

The second approach to construction of a CVP uses a capacitive coupling device in close proximity to the cable attached to the EUT port under test (the device is actually in physical contact with the insulation of the cable attached to the EUT port under test). A standard oscilloscope-type voltage probe having an impedance > 10 MΩ, with a probe capacitance < 5 pF, is placed in series with the capacitive coupling device. The theory is that the probe capacitance in series with the capacitance of the capacitive coupling device will present only the probe capacitance to the cable attached to the EUT port under test. In practice, given the physical size of the capacitive coupling device, it is possible to have a large stray capacitance in parallel with the probe capacitance. If this occurs, the total capacitive loading will be greater than that of the probe itself, and the requirement to have loading < 5 pF may be violated. If this technique is employed, the capacitive loading should be verified by measurement, i.e. not rely only on theory.

This capacitance measurement can be made with any capacitance meter that can operate over the 150 kHz to 30 MHz frequency range. The capacitance is measured between the cable attached to the EUT port under test (all wires in the cable are connected together at the connection point to the meter) and the reference ground plane. The same type of cable used in the conducted disturbance measurement should be used for this capacitance measurement.

NOTE 2 The uncertainty of this method is lowest if the length of cable between the EUT and AE is less than 1,25 m. Significantly longer cables are subject to standing waves, which can adversely affect voltage and current measurements.

G.4 Combination of current limit and voltage limit

If the TCM impedance is not 150 Ω, the measurement of the voltage or the current alone is not acceptable, because of a very high measurement uncertainty due to the undefined and unknown TCM impedances. However, if both voltage and current are measured with limits on current and voltage applied simultaneously, the result is a worst case estimation of the disturbance, as explained below.

The basic circuit for which the limits are defined is shown in Figure G.1. This circuit is the reference for which the limits expressed in terms of current and voltage are derived; any other measurement should be compared to this basic circuit. In Figure G.1, Z_1 is an unknown parameter of the EUT; Z_2 is 150 Ω in the reference measurement.

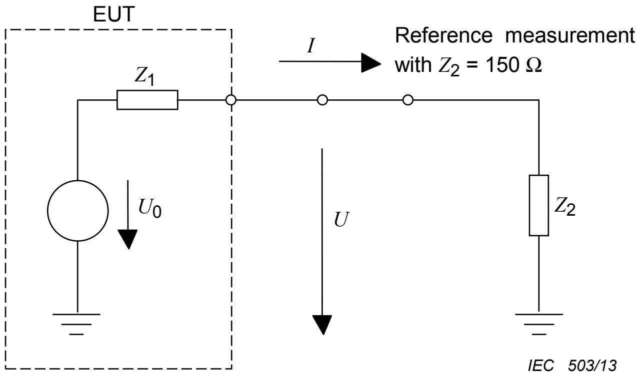


Figure G.1 – Basic circuit for considering the limits with a defined TCM impedance of 150 Ω

If the measurement is performed without specifying the TCM impedance seen by the EUT, the simplified circuit is as shown in Figure G.2, where the TCM impedance Z_2 seen by the EUT is defined by the AE, and can have any value. Therefore, Z_1 as well as Z_2 are unknown parameters of the measurement.

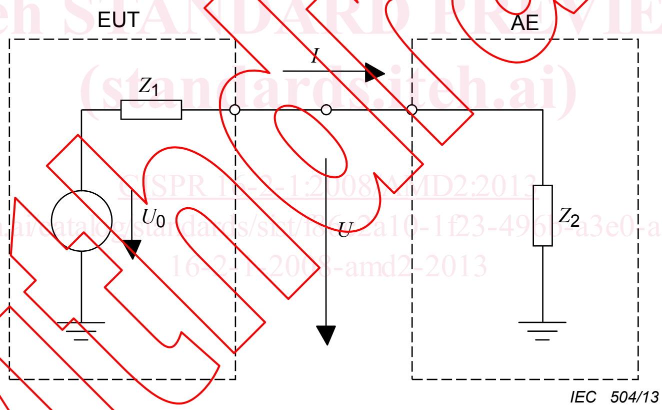


Figure G.2 – Basic circuit for the measurement with unknown TCM impedance

If the measurement is performed using the circuit of Figure G.1, the current limit and the voltage limit are equivalent. The relation between current and voltage will always be 150 Ω, and either can be used to determine compliance. However, this is not the case if Z_2 is not 150 Ω (i.e. see Figure G.2).

It is important to note that compliance with the limit is not solely determined by the source voltage U_0. The interference voltage measured should use a standardized Z_2 of 150 Ω, and depends on Z_1, Z_2 and U_0 together. For example, with the set-up from Figure G.1, the voltage limit value can be reached with an EUT containing a high impedance Z_1 and a high source voltage U_0, or with a lower U_0 combined with a lower impedance Z_1.

In the more general case of Figure G.2, where Z_2 is not defined, it is not possible to measure the exact value of the interference voltage. Because Z_1 and U_0 are not known, it is not possible to derive the interference voltage, even if the value of Z_2 is known (or is measured or calculated from I and U). For example, if an EUT with disturbance above the limit is evaluated only by measuring the voltage in a test set-up with low Z_2 (Z_2 < 150 Ω) at the AE side, the EUT might still seem to comply with the limits. In contrast, if the same EUT is measured only