

Information technology equipment — Radio disturbance characteristics — Limits and methods of measurement

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British Standard

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National foreword

This British Standard is the English language version of EN 55022:1998. It was derived by CENELEC from CISPR 22:1997. It supersedes BS EN 55022:1995.

NOTE BS EN 55022:1995 may continue to be used until it is withdrawn on 31 July 2001 (see the Foreword to EN 55022:1998).

The CENELEC common modifications have been implemented at the appropriate places in the text and are indicated by a sideline in the margin.

The UK participation in its preparation was entrusted by Technical Committee GEL/210, Electromagnetic compatibility, to Subcommittee GEL/210/7, Interference characteristics of ITE, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

Cross-references

Attention is drawn to the fact that CEN and CENELEC Standards normally include an annex which lists normative references to international publications with their corresponding European publications. The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled "International Standards Correspondence Index", or by using the "Find" facility of the BSI Standards Electronic Catalogue.

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Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 55 and a back cover.

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Amendments issued since publication

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Descriptors: Radio interference, information technology equipment, methods of measurement, characteristic

English version

**Information technology equipment - Radio disturbance characteristics
Limits and methods of measurement
(CISPR 22:1997, modified)**

Appareils de traitement de l'information
Caractéristiques des perturbations
radioélectriques
Limites et méthodes de mesure
(CISPR 22:1997, modifiée)

Einrichtungen der Informationstechnik
Funkstörungen
Grenzwerte und Meßverfahren
(CISPR 22:1997, modifiziert)

This European Standard was approved by CENELEC on 1998-08-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Foreword

The text of document CISPR/G/112/FDIS, future edition 3 of CISPR 22, prepared by CISPR SC G, Interference relating to information technology equipment, was submitted to the IEC-CENELEC parallel vote.

The text of document CISPR/G/121/FDIS, a further part of CISPR 22, which failed to pass the IEC-CENELEC parallel vote within CENELEC, together with the common modifications prepared by SC 210A, EMC Products, of Technical Committee CENELEC TC 210, EMC, was submitted to the Unique Acceptance Procedure.

The combined text of edition 3 of CISPR 22, the common modifications in amendment A2:1997 to EN 55022:1994 and those for CISPR/G/121/FDIS were approved by CENELEC as EN 55022 on 1998-08-01.

This European Standard supersedes EN 55022:1994 + corrigendum August 1997 + A1:1995 + corrigendum August 1997 + A2:1997.

The following dates were fixed:

- latest date by which the EN has to be implemented
at national level by publication of an identical
national standard or by endorsement (dop) 1999-02-01

- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2001-08-01

Annexes designated "normative" are part of the body of the standard.

Annexes designated "informative" are given for information only.

In this standard, annexes A, B, C et ZA are normative and annexes D and E are informative.

Annex ZA has been added by CENELEC.

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INTRODUCTION

The scope is extended to the whole radio-frequency range from 9 kHz to 400 GHz, but limits are formulated only in restricted frequency bands, which is considered sufficient to reach adequate emission levels to protect radio broadcast and telecommunication services, and to allow other apparatus to operate as intended at reasonable distance.

INFORMATION TECHNOLOGY EQUIPMENT – RADIO DISTURBANCE CHARACTERISTICS – LIMITS AND METHODS OF MEASUREMENT

1 Scope and object

This publication applies to ITE as defined in 3.1.

Procedures are given for the measurement of the levels of spurious signals generated by the ITE and limits are specified for the frequency range 9 kHz to 400 GHz for both class A and class B equipment. No measurements need be performed at frequencies where no limits are specified.

The intention of this publication is to establish uniform requirements for the radio disturbance level of the equipment contained in the scope, to fix limits of disturbance, to describe methods of measurement and to standardize operating conditions and interpretation of results.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this publication. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this publication are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60083:1997, *Plugs and socket-outlets for domestic and similar general use standardized in member countries of IEC*

IEC 61000-4-6:1996, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 6: Immunity to conducted disturbances, induced by radio-frequency fields*

CISPR 11:1990, *Limits and methods of measurement of electromagnetic disturbance characteristics of industrial, scientific, and medical (ISM) radio-frequency equipment*

CISPR 16-1:1993, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1: Radio disturbance and immunity measuring apparatus*

CISPR 16-2:1996, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2: Methods of measurement of disturbances and immunity*

ISO/IEC 11801:1995, *Information technology – Generic cabling for customer premises*

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3 Definitions

For the purpose of this publication the following definitions apply:

3.1 information technology equipment (ITE)

Any equipment:

- a) which has a primary function of either (or a combination of) entry, storage, display, retrieval, transmission, processing, switching, or control, of data and of telecommunication messages and which may be equipped with one or more terminal ports typically operated for information transfer;
- b) with a rated supply voltage not exceeding 600 V.

It includes, for example, data processing equipment, office machines, electronic business equipment and telecommunication equipment.

Any equipment (or part of the ITE equipment) which has a primary function of radio transmission and/or reception according to the ITU Radio Regulations are excluded from the scope of this publication.

NOTE – Any equipment which has a function of radio transmission and/or reception according to the definitions of the ITU Radio Regulations should fulfil the national radio regulations, whether or not this publication is also valid.

Equipment, for which all disturbance requirements in the frequency range are explicitly formulated in other IEC or CISPR publications, are excluded from the scope of this publication.

3.2 equipment under test (EUT)

A representative ITE or functionally interactive group of ITE (system) which includes one or more host unit(s) and is used for evaluation purposes.

3.3 host unit

Part of an ITE system or unit that provides the mechanical housing for modules, which may contain radio-frequency sources, and may provide power distribution to other ITE. Power distribution may be a.c., d.c., or both between the host unit(s) and modules or other ITE.

3.4 module

Part of an ITE which provides a function and may contain radio-frequency sources.

3.5 identical modules and ITE

Modules and ITE produced in quantity and within normal manufacturing tolerances to a given manufacturing specification.

3.6 telecommunication ports

Ports which are intended to be connected to telecommunication networks (e.g. public switched telecommunication networks, integrated services digital networks), local area networks (e.g. Ethernet, Token Ring) and similar networks.

4 Classification of ITE

ITE is subdivided into two categories denoted class A ITE and class B ITE.

4.1 Class B ITE

Class B ITE is a category of apparatus which satisfies the class B ITE disturbance limits.

Class B ITE is intended primarily for use in the domestic environment and may include:

- equipment with no fixed place of use; for example, portable equipment powered by built-in batteries;
- telecommunication terminal equipment powered by a telecommunication network;
- personal computers and auxiliary connected equipment.

NOTE - The domestic environment is an environment where the use of broadcast radio and television receivers may be expected within a distance of 10 m of the apparatus concerned.

4.2 Class A ITE

Class A ITE is a category of all other ITE which satisfies the class A ITE limits but not the class B ITE limits. Such equipment should not be restricted in its sale but the following warning shall be included in the instructions for use:

Warning

This is a class A product. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

5 Limits for conducted disturbance at mains terminals and telecommunication ports

The equipment under test (EUT) shall meet the limits in tables 1 and 3 or 2 and 4, as applicable, including the average limit and the quasi-peak limit when using, respectively, an average detector receiver and quasi-peak detector receiver and measured in accordance with the methods described in clause 9. Either the voltage limits or the current limits in table 3 or 4, as applicable, shall be met except for the measurement method of C.1.3 where both limits shall be met. If the average limit is met when using a quasi-peak detector receiver, the EUT shall be deemed to meet both limits and measurement with the average detector receiver is unnecessary.

If the reading of the measuring receiver shows fluctuations close to the limit, the reading shall be observed for at least 15 s at each measurement frequency; the higher reading shall be recorded with the exception of any brief isolated high reading which shall be ignored.

5.1 Limits of mains terminal disturbance voltage

Table 1 – Limits for conducted disturbance at the mains ports of class A ITE

Frequency range MHz	Limits dB(μV)	
	Quasi-peak	Average
0,15 to 0,50	79	66
0,50 to 30	73	60

NOTE – The lower limit shall apply at the transition frequency.

Table 2 – Limits for conducted disturbance at the mains ports of class B ITE

Frequency range MHz	Limits dB(μV)	
	Quasi-peak	Average
0,15 to 0,50	66 to 56	56 to 46
0,50 to 5	56	46
5 to 30	60	50

NOTE 1 – The lower limit shall apply at the transition frequencies.
NOTE 2 – The limit decreases linearly with the logarithm of the frequency in the range 0,15 MHz to 0,50 MHz.

5.2 Limits of conducted common mode (asymmetric mode) disturbance at telecommunication ports 1)

Table 3 – Limits of conducted common mode (asymmetric mode) disturbance at telecommunication ports in the frequency range 0,15 MHz to 30 MHz for class A equipment

Frequency range MHz	Voltage limits dB (μV)		Current limits dB (μA)	
	Quasi-peak	Average	Quasi-peak	Average
0,15 to 0,5	97 to 87	84 to 74	53 to 43	40 to 30
0,5 to 30	87	74	43	30

NOTE 1 – The limits decrease linearly with the logarithm of the frequency in the range 0,15 MHz to 0,5 MHz.
NOTE 2 – The current and voltage disturbance limits are derived for use with an impedance stabilization network (ISN) which presents a common mode (asymmetric mode) impedance of 150 Ω to the telecommunication port under test (conversion factor is $20 \log_{10} 150 / 1 = 44$ dB).

1) See 3.6.

Table 4 – Limits of conducted common mode (asymmetric mode) disturbance at telecommunication ports in the frequency range 0,15 MHz to 30 MHz for class B equipment

Frequency range MHz	Voltage limits dB (µV)		Current limits dB (µA)	
	Quasi-peak	Average	Quasi-peak	Average
0,15 to 0,5	84 to 74	74 to 64	40 to 30	30 to 20
0,5 to 30	74	64	30	20

NOTE 1 – The limits decrease linearly with the logarithm of the frequency in the range 0,15 MHz to 0,5 MHz.

NOTE 2 – The current and voltage disturbance limits are derived for use with an impedance stabilization network (ISN) which presents a common mode (asymmetric mode) impedance of 150 Ω to the telecommunication port under test (conversion factor is $20 \log_{10} 150 / 1 = 44$ dB).

NOTE 3 – Provisionally, a relaxation of 10 dB over the frequency range of 6 MHz to 30 MHz is allowed for high-speed services having significant spectral density in this band. However, this relaxation is restricted to the common mode disturbance converted by the cable from the wanted signal. The provisional relaxation of 10 dB will be reviewed no later than three years after the date of withdrawal based on the results and interference cases seen in this period. Wherever possible it is recommended to comply with the limits without the provisional relaxation.

6 Limits for radiated disturbance

The EUT shall meet the limits of tables 5 or 6 when measured at the measuring distance *R* in accordance with the methods described in clause 10. If the reading on the measuring receiver shows fluctuations close to the limit, the reading shall be observed for at least 15 s at each measurement frequency; the highest reading shall be recorded, with the exception of any brief isolated high reading, which shall be ignored.

Table 5 – Limits for radiated disturbance of class A ITE at a measuring distance of 10 m

Frequency range MHz	Quasi-peak limits dB(µV/m)
30 to 230	40
> 230 to 1 000	47

NOTE 1 – The lower limit shall apply at the transition frequency.

NOTE 2 – Additional provisions may be required for cases where interference occurs.

Table 6 – Limits for radiated disturbance of class B ITE at a measuring distance of 10 m

Frequency range MHz	Quasi-peak limits dB(µV/m)
30 to 230	30
230 to 1 000	37

NOTE 1 – The lower limit shall apply at the transition frequency.

NOTE 2 – Additional provisions may be required for cases where interference occurs.

7 Interpretation of CISPR radio disturbance limit

7.1 Significance of a CISPR limit

7.1.1 A CISPR limit is a limit which is recommended to national authorities for incorporation in national publications, relevant legal regulations and official specifications. It is also recommended that international organizations use these limits.

7.1.2 The significance of the limits for equipment shall be that, on a statistical basis, at least 80 % of the mass-produced equipment complies with the limits with at least 80 % confidence.

7.2 Application of limits in tests for conformity of equipment in series production

7.2.1 Tests shall be made:

7.2.1.1 Either on a sample of equipment of the type using the statistical method of evaluation set out in 7.2.3.

7.2.1.2 Or, for simplicity's sake, on one equipment only.

7.2.2 Subsequent tests are necessary from time to time on equipment taken at random from production, especially in the case referred to in 7.2.1.2.

7.2.3 Statistically assessed compliance with limits shall be made as follows:

This test shall be performed on a sample of not less than five and not more than 12 items of the type. If, in exceptional circumstances, five items are not available, a sample of four or three shall be used. Compliance is judged from the following relationship:

$$\bar{x} + kS_n \leq L$$

where

\bar{x} is the arithmetic mean of the measured value of n items in the sample

$$S_n^2 = \frac{1}{n-1} \sum (x_n - \bar{x})^2$$

x_n is the value of the individual item

L is the appropriate limit

k is the factor derived from tables of the non-central t -distribution which assures with 80 % confidence that 80 % of the type is below the limit; the value of k depends on the sample size n and is stated below.

The quantities x_n , \bar{x} , S_n and L are expressed logarithmically: dB(μ V), dB(μ V/m) or dB(pW).

n	3	4	5	6	7	8	9	10	11	12
k	2,04	1,69	1,52	1,42	1,35	1,30	1,27	1,24	1,21	1,20

NOTE - For general information, see CISPR 16, Section Nine.

7.2.4 The banning of sales, or the withdrawal of a type approval, as a result of a dispute shall be considered only after tests have been carried out using the statistical method of evaluation in accordance with 7.2.1.1.

8 General measurement conditions

A test site shall permit disturbances from the EUT to be distinguished from ambient noise. The suitability of the site in this respect can be determined by measuring the ambient noise levels with the EUT inoperative and ensuring that the noise level is at least 6 dB below the limits specified in clauses 5 and 6.

If at certain frequency bands the ambient noise is not 6 dB below the specified limit, the methods shown in 10.4 may be used to show compliance of the EUT to the specified limits.

It is not necessary that the ambient noise level be 6 dB below the specified limit where both ambient noise and source disturbance combined do not exceed the specified limit. In this case the source emanation is considered to satisfy the specified limit. Where the combined ambient noise and source disturbance exceed the specified limit, the EUT shall not be judged to fail the specified limit unless it is demonstrated that, at any measurement frequency for which the limit is exceeded, two conditions are met:

- a) the ambient noise level is at least 6 dB below the source disturbance plus ambient noise level;
- b) the ambient noise level is at least 4,8 dB below the specified limit.

8.1 EUT configuration

Where not specified herein, the EUT shall be configured, installed, arranged and operated in a manner consistent with typical applications. Interface cables/loads/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/devices may have to be added to the EUT depending upon the results of preliminary tests. 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, then 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, or because the testing is being done at a user installation, 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 which is populated with multiple modules (drawer, plug-in card, board, etc.) shall be tested with a mix and number representative of that used in a typical installation. 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.

Examples of a minimum representative configuration follow.

For a personal computer or a personal computer peripheral, the minimum configuration consists of the following device grouped and tested together:

- a) personal computer;
- b) keyboard;
- c) visual display unit;
- d) external peripheral for each of two different types of available I/O protocols, such as serial, parallel, etc.;
- e) if the EUT has a dedicated port for a special-purpose device such as a mouse or joystick, that device shall be part of the minimum configuration.

NOTE - Items a), b) and/or c) may, in some systems, be assembled in the same chassis. In no instance may items a), b), c) mouse or joystick controls, be used as a replacement for item d).

For a point of sale terminal, the minimum system consists of the following devices (to the extent applicable) grouped and tested together:

- a) active processor (till);
- b) cash drawer;
- c) keyboard(s);
- d) display units (operator and customer);
- e) typical peripheral (bar code scanner);
- f) handheld device (bar code scanner).

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

A unit of equipment which forms part of a system distributed over a wide area (such as data processing terminals or workstations, or private branch telecommunication exchanges, etc.), and which in itself may be a subsystem, may be tested independently of the host unit or system. Distributed networks, for example a local area network, may be simulated on the test site by lengths of cable and actual peripherals or remote network communications simulators located at a distance sufficient to ensure that they do not contribute to the measured level.

The results of an evaluation of EUTs having one of each type of module or ITE can be applied to configurations having more than one of each of those modules or ITE. This is permissible because it has been found that disturbances from identical modules or ITE (see 3.5) are generally not additive in practice.

In the case of EUTs which functionally interact with other ITE, including any ITE that is dependent on a host unit for its power interface, either the actual interfacing ITE or simulators may be used to provide representative operating conditions, provided the effects of the simulator can be isolated or identified. If an ITE is designed to be a host unit to other ITE, such ITE may have to be connected in order that the host unit shall operate under normal conditions.

It is important that any simulator used instead of an actual interfacing ITE properly represents the electrical and, in some cases, the mechanical characteristics of the interfacing ITE, especially RF signals and impedances. Following this procedure will permit the results of measurements of individual ITE to remain valid for system application and integration of the ITE with other similarly tested ITE, including ITE produced and tested by different manufacturers.

In the case of printed wiring board assemblies (PWBA), separately marketed for the enhancement of diverse host units, the PWBA (such as ISDN interface, CPU, adaptor cards, etc.) shall be tested in at least one appropriate representative host unit of the PWBA manufacturer's choice so as to ensure compliance of the PWBA with the entire population of hosts in which it is intended to be installed.

The host shall be a typical compliant production sample.

PWBA intended to be class B shall not be tested in hosts which are class A.

The accompanying documentation of the PWBA shall include information regarding the host units in which the PWBA was tested and verified, and information enabling the user to identify host units in which the PWBA will achieve compliance with the classification (A or B).

8.1.1 Determination of maximum emission configuration(s)

Initial testing shall identify the frequency that has the highest disturbance relative to the limit while operating the EUT in typical modes of operation and cable positions in a test set-up which is representative of typical system configurations. The identification of the frequency of highest disturbance with respect to the limit shall be found by investigating disturbances at a number of significant frequencies, to give confidence that the probable frequency of maximum disturbance has been found and that the associated cable, EUT configurations and mode of operation has been identified.

For initial testing, the EUT shall be set up in accordance with figures 4 through 14. The distances between the EUT and peripherals are set according to the figures.

Final measurements shall be conducted as in clauses 9 and 10 for terminal disturbance voltage and disturbance field strength measurements, respectively.

8.1.2 EUT configuration with ground plane

The EUT situation relative to the ground plane shall be equivalent to that occurring in use, that is floor-standing equipment is placed on a ground plane or on an isolating floor (for example wood) close to a ground plane, and portable equipment is placed on a non-metallic table. The

power and signal cables shall be oriented with respect to the ground plane in a manner equivalent to actual use. The ground plane may be of metal.

NOTE - Specific ground plane requirements are given in 9.3 for conducted disturbance measurements and in 10.3.4 for radiated disturbance measurements, and in figures 4 through 14 as they may relate to particular test set-ups.

8.2 Operation of the EUT

The operational conditions of the EUT shall be determined by the manufacturer according to the typical use of the EUT with respect to the expected highest level of emission. The determined operational mode and the rationale for the conditions shall be stated in the test report.

The EUT shall be operated within the rated (nominal) operating voltage range and typical load conditions (mechanical or electrical) for which it is designed. Actual loads should be used whenever possible. If a simulator is used, it shall represent the actual load with respect to its radio frequency and functional characteristics.

The test programmes or other means of exercising the equipment should ensure that various parts of a system are exercised in a manner that permits detection of all system disturbances. For example, in a computer system, tape and disk drives should be put through a read-write-erase sequence; and various portions of memories should be addressed. Any mechanical activities should be performed and visual display units should be operated as in 8.2.1.

9 Method of measurement of conducted disturbance at mains terminals and telecommunication ports

Measurements shall be carried out using quasi-peak and average detector receivers as described in 9.1. Both detectors may be incorporated in a single receiver, and measurements may be carried out by using alternatively the quasi-peak detector and the average detector.

NOTE – It is recommended that the measurement of conducted disturbances be performed in a screened enclosure.

To reduce testing time, a peak detector receiver may be used instead of a quasi-peak or an average detector receiver. In case of dispute, measurement with a quasi-peak detector receiver will take precedence when measuring to the quasi-peak limits, and measurement with an average detector receiver will take precedence when measuring to the average limits (see annex B).

9.1 Measuring receivers

The quasi-peak measuring receiver shall be in accordance with clause 2 of CISPR 16-1. Receivers with average detectors shall be in accordance with clause 4 of CISPR 16-1, and shall have a 6 dB bandwidth in accordance with clause 2 of CISPR 16-1. Receivers with peak detectors shall be in accordance with clause 3 of CISPR 16-1, and shall have a 6 dB bandwidth in accordance with clause 2 of CISPR 16-1.

9.2 Artificial mains network (AMN)

An AMN is required to provide a defined impedance at high frequencies across the power feed at the point of measurement of terminal voltage, and also to provide isolation of the circuit under test from the ambient noise on the power lines.

A network with a nominal impedance ($50 \Omega/50 \mu\text{H}$) as defined in CISPR 16-1, clause 11.3, shall be utilized.

Connection of the EUT to the AMN is required. The EUT is located so that the distance between the boundary of the EUT and the closest surface of the AMN is 0,8 m.

Where a mains flexible cord is provided by the manufacturer this shall be 1 m long, or if in excess of 1 m, the excess cable is folded back and forth as far as possible so as to form a bundle not exceeding 0,4 m in length.

Where a mains cable is specified in the manufacturer's installation instructions, a 1 m length of the type specified shall be connected between the EUT and the AMN.

Conducted disturbance is measured between the phase lead and the reference ground, and between the neutral lead and the reference ground. Both measured values shall be within the appropriate limits.

Ground connections, where required for safety purposes, shall be connected to the reference ground point of the network and, where not otherwise provided or specified by the manufacturer, shall be 1 m long and run parallel to the mains connection at a distance of not more than 0,1 m.

Other ground connections (for example for EMC purposes), either specified or supplied by the manufacturer for connection to the same ultimate terminal as the safety ground connection, shall also be connected to the reference ground of the network.

It may not be possible to measure at some frequencies because of conducted ambient noise caused by couples from local broadcast service fields. A suitable additional radio-frequency filter may be inserted between the AMN and the mains supply, or measurements may be performed in a shielded enclosure. The components forming the additional radio-frequency filter should be enclosed in a metallic screen directly connected to the reference ground of the measuring system. The requirements for the impedance of the AMN should be satisfied at the frequency of the measurement, with the additional radio-frequency filter connected.

Where the EUT is a collection of ITE with one or more host units and ITE each having its own power cord, the point of connection for the AMN is determined by the following rules:

- a) Each power cord which is terminated in a power supply plug of a standard design (IEC 60083 for example) shall be tested separately.
- b) Power cords or terminals which are not specified by the manufacturer to be connected via a host unit shall be tested separately.
- c) Power cords or field wiring terminals which are specified by the manufacturer to be connected via a host unit or other power-supplying equipment shall be connected to that host unit or other power-supplying equipment, and the terminals or cords of that host unit or other power-supplying equipment are those considered for connection to the AMN and tested.
- d) Where a special connection is specified, the necessary hardware to effect the connection shall be supplied by the manufacturer for the purpose of this test.
- e) When testing equipment with multiple mains cords, those mains cords not under test may be connected to a multiple outlet, which in turn shall be connected to an artificial mains network (AMN) different than the AMN used for the mains cord under test.

9.3 Ground plane

The EUT, when intended for table-top use, shall be placed 0,4 m from a vertical metal reference plane of at least 2 m by 2 m, and shall be kept at least 0,8 m from any other metal surface or other ground plane not being part of the EUT. If the measurement is made in a screened enclosure, the distance of 0,4 m may be referred to one of the walls of the enclosure. If the measurement is made in an open area test site or in a screened enclosure, the distance of 0,4 m may be referred to the horizontal metal ground plane.

Floor-standing EUTs shall be placed on a horizontal metal ground plane, the point(s) of contact being consistent with normal use, but not in metallic contact with the ground plane. A metal floor may replace the reference ground plane. The reference ground plane shall extend at least 0,5 m beyond the boundaries of the EUT, and have minimum dimensions of 2 m by 2 m.

The reference ground point of the AMN and the impedance stabilization network (ISN) shall be connected to the reference ground plane with a conductor that is as short as possible.

9.4 Equipment set-up

The EUT shall be configured and operated in accordance with the requirements of clause 8 and set up in accordance with figures 4 to 9 for table-top equipment, floor-standing equipment, and combined floor-standing and table-top equipment. Figures 13 and 14 display the set-up for floor-standing equipment using overhead cables.

Table-top EUTs shall be placed upon a non-metallic table 0,8 m above the horizontal metal reference plane (see 9.3). The table-top EUT shall be placed 40 cm from a vertical ground plane which is connected to the horizontal metal ground plane (see figures 4 to 6), or alternatively, shall be placed 40 cm above the horizontal metal ground plane (see figure 7). Where an alternative set-up is used (40 cm above the horizontal ground plane), this fact should be recorded in the test report.

In case of dispute tests shall be carried out as originally performed.

Equipment designed for both table-top and floor-standing operation shall be tested only in the table-top configuration, unless the typical installation is floor-standing, when that configuration is used.

Equipment designed for wall-mounted operation shall be tested as for table-top. The orientation of the equipment shall be consistent with that of normal operation (positioned as normally installed).

A mains port is connected, via its mains cord, to an AMN.

A telecommunication port is connected by its signal cable to an impedance stabilization network (ISN).

9.5 Measurement of disturbances at telecommunication ports

The purpose of these tests is to measure the common mode disturbance emitted at the telecommunication ports of an EUT. The wanted signal may contribute to those common mode disturbances. 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 discussed in annex E.

9.5.1 Methods of conformance testing

9.5.1.1 Alternative 1

Measurement is made at telecommunication ports using an ISN with a longitudinal conversion loss (LCL) as defined in c) 1) of 9.5.2.

The manufacturer shall demonstrate that the equipment does not exceed the limits of tables 3 or 4 as applicable when connected to such cables as are specified in the equipment documentation provided to the user.

In cases of dispute the method of conformance in 9.5.1.2 takes precedence for ports intended to be connected to category 3 and category 5 cables (see ISO/IEC 11801).

9.5.1.2 Alternative 2

For ports intended to be connected to category 3 cables the measurement is made using an ISN with a LCL as defined in c) 2) of 9.5.2.

For ports intended to be connected to category 5 cables the measurement is made using an ISN with a LCL as defined in c) 3) of 9.5.2.

9.5.2 Impedance stabilization network (ISN)

The mains voltage shall be supplied to the EUT via the AMN used when measuring the mains terminal disturbance voltages according to 9.2.

Assessment of common mode (asymmetric mode) current or voltage disturbances at telecommunication ports for attachment of unscreened balanced pairs shall be performed with the telecommunication port connected by a cable to an ISN; thus the ISN shall define the common mode termination impedance seen by the telecommunication port during the disturbance measurements. The ISN shall allow normal operation of the EUT, and to this end shall be interposed in the signal cable between the EUT and any auxiliary/associated equipment (AE) or load required to exercise the EUT.

It has not been possible to specify a generally applicable ISN, because the construction depends on the configuration of the telecommunication port under test. Until a suitable ISN is specified for screened and unbalanced cables, it is permitted to connect such cables to an AE or a simulator instead of an ISN. The actual load shall be reported and the common mode impedance shall be measured and stated in the test report. In any case the EUT shall meet the limits in tables 3 or 4 as applicable.

Where a current probe is used it should be possible to attach it to the cable to be measured without disconnecting the cable from its connections. The current probe must have a uniform frequency response without resonances, and must be capable of operating without saturation effects caused by the operating currents in the primary winding.

The current probe, if used, shall be mounted on the cable within 0,1 m distance of the ISN. The insertion impedance of the current probe must be 1Ω maximum, see CISPR 16-1, subclause 12.1.

The ISN shall have the following properties:

- a) The common mode termination impedance in the frequency range 0,15 MHz to 30 MHz shall be $150 \Omega \pm 20 \Omega$, phase angle $0^\circ \pm 20^\circ$.
- b) The ISN shall provide sufficient isolation against disturbances from an AE or load connected to the telecommunication port under test. The attenuation of the ISN, for common mode current or voltage disturbances originating from the AE, shall be such that the measured level of these disturbances at the measuring receiver input shall be at least 10 dB below the relevant disturbance limit.

The preferred isolation is:

- 150 kHz to 1,5 MHz > 35 dB to 55 dB, increasing linearly with the logarithm of the frequency
- 1,5 MHz to 30 MHz > 55 dB.

NOTE - Isolation is the decoupling of common mode disturbance originating in an AE and subsequently appearing at the EUT port of the ISN.

- c) 1) ISN for method of conformance alternative 1

The longitudinal conversion loss (LCL) shall be:

- 150 kHz to 1,5 MHz: $80 \text{ dB} \pm 3 \text{ dB}$;
- 1,5 MHz to 30 MHz: $(80 \text{ dB to } 55 \text{ dB}) \pm 3 \text{ dB}$, decreasing linearly with the logarithm of the frequency.

- c) 2) ISN for method of conformance alternative 2, ports for category 3 cables

The longitudinal conversion loss (LCL) shall be:

- 150 kHz to 1,5 MHz: $50 \text{ dB} \pm 3 \text{ dB}$;
- 1,5 MHz to 30 MHz: $(50 \text{ dB to } 25 \text{ dB}) \pm 3 \text{ dB}$, decreasing linearly with the logarithm of the frequency.

c) 3) ISN for method of conformance alternative 2, ports for category 5 cables

The longitudinal conversion loss (LCL) shall be:

- 150 kHz to 1,5 MHz: 60 dB \pm 3 dB
- 1,5 MHz to 30 MHz: (60 dB to 35 dB) \pm 3 dB, decreasing linearly with the logarithm of the frequency.

NOTE 1 – The above specifications of LCL versus the frequency (c) 2) and c) 3)) are an approximate representation of the LCL of typical telecommunication networks as installed in representative environments. Such specifications are under continuing study and open to future modification.

NOTE 2 – The LCL is defined in accordance with the ITU-T Recommendation G.117 (see E.3, [1]).

d) The attenuation distortion or other deterioration of the signal quality in the wanted signal frequency band caused by the presence of the ISN shall not significantly affect the normal operation of the EUT.

e) If a voltage port on the ISN is available then the accuracy of the voltage division factor shall be within $\pm 1,0$ dB. The voltage division factor is the difference between the voltage appearing across the common mode impedance presented to the EUT by the ISN and the resulting voltage appearing across a receiver input attached to the measuring port of the ISN, expressed in decibels. For example, for a 150 Ω common mode impedance and a 50 Ω receiver input, the voltage division factor is given by $20 \log_{10} (50/150) = -9,5$ dB.

9.5.3 Measurement at telecommunication ports

The EUT shall be set up in accordance with figures 4 through 9 for tabletop equipment, floor-standing equipment, and combined floor-standing equipment and tabletop equipment.

In order to make reliable emission measurements representative of high LAN utilization it is only necessary to create a condition of LAN utilization in excess of 10 % and sustain that level for a minimum of 250 ms. The content of the test traffic should consist of both periodic and pseudo-random messages in order to emulate realistic types of data transmission (e.g. random: files compressed or encrypted; periodic: uncompressed graphic files, memory dumps, screen updates, disk images). If the LAN maintains transmission during idle periods measurements shall also be made during idle periods (see clause E.3, [7]).

9.5.3.1 Voltage measurement at balanced telecommunication ports intended for connection to unscreened balanced pairs

When disturbance voltage measurements are performed, an ISN providing a voltage measuring port suitable for connection to a measuring receiver while satisfying the telecommunication port common mode termination impedance requirements shall be used.

When disturbance voltage measurements are performed on a single unscreened balanced pair, an adequate ISN for two wires shall be used; when performed on unscreened cables containing two balanced pairs, an adequate ISN for four wires shall be used (see annex D).

The measurement method of C.1.1 shall be used.

For cables containing more than two balanced pairs, see 9.5.3.5.

Where normal functioning cannot be achieved because of the impact of the ISN on the EUT, the measurement shall be carried out using the method given in 9.5.3.5.

9.5.3.2 Current measurements at balanced telecommunication ports intended for connection to unshielded balanced pairs

When disturbance current measurements are performed on an unshielded cable containing a single balanced pair or two balanced pairs, the cable should be terminated as for disturbance voltage measurements.

The measurement method of C.1.1 shall be used.

For cables containing more than two balanced pairs, see 9.5.3.5.

9.5.3.3 Voltage measurements at telecommunication ports intended for connection to shielded cables or to coaxial cables

The measurement method of C.1.2 shall be used.

9.5.3.4 Current measurements at telecommunication ports intended for connection to shielded cables or to coaxial cables

The measurement method of C.1.2 shall be used

9.5.3.5 Measurements at telecommunications ports intended for connection to cables containing more than two balanced pairs or to unbalanced cables

The measurement method of C.1.3 or C.1.4 shall be used. At each frequency, the requirements shall be met either by using the method of C.1.3 or by using the method of C.1.4.

NOTE – It is allowed to measure with method C.1.3 and then to measure with method C.1.4 only at frequencies for which the limit is exceeded when using method C.1.3.

9.6 Recording of measurements

Of those disturbances above ($L - 20$ dB), where L is the limit level in logarithmic units, record at least the disturbance levels and the frequencies of the six highest disturbances from each mains port and each telecommunication port which comprise the EUT. For the mains port, the current-carrying conductor for each disturbance shall be identified.

10 Method of measurement of radiated disturbance

Measurements shall be made with a quasi-peak measuring receiver in the frequency range 30 MHz to 1 000 MHz.

To reduce the testing time, a peak measuring receiver may be used instead of a quasi-peak measuring receiver. In case of dispute, measurement with a quasi-peak measuring receiver will take precedence.

10.1 Measuring receivers

The quasi-peak measuring receiver shall be in accordance with clause 2 of CISPR 16-1. Receivers with peak detectors shall be in accordance with clause 3 of CISPR 16-1, and shall have a 6 dB bandwidth in accordance with clause 2 of CISPR 16-1.

10.2 Antenna

The antenna shall be a balanced dipole. For frequencies of 80 MHz or above, the antenna shall be resonant in length, and for frequencies below 80 MHz it shall have a length equal to the 80 MHz resonant length. Further detailed information is given in clause 15 of CISPR 16-1.

NOTE – Other antennas may be used, provided the results can be correlated with the balanced dipole antenna with an acceptable degree of accuracy.

10.2.1 Antenna-to-EUT distance

Measurements of the radiated field shall be made with the antenna located at the horizontal distance from the boundary of the EUT as specified in clause 6. The boundary of the EUT is defined by an imaginary straight-line periphery describing a simple geometric configuration encompassing the EUT. All ITE intersystem cables and connecting ITE shall be included within this boundary (see also figure 2).

NOTE – If the field-strength measurement at 10 m cannot be made because of high ambient noise levels, or for other reasons, measurement of class B EUTs may be made at a closer distance, for example 3 m. An inverse proportionality factor of 20 dB per decade should be used to normalize the measured data to the specified distance for determining compliance. Care should be taken in the measurement of large EUTs at 3 m at frequencies near 30 MHz, due to near field effects.

10.2.2 Antenna-to-ground distance

The antenna shall be adjusted between 1 m and 4 m in height above the ground plane for maximum meter reading at each test frequency.

10.2.3 Antenna-to-EUT azimuth

Antenna-to-EUT azimuth shall also be varied during the measurements to find the maximum field-strength readings. For measurement purposes, it may be possible to rotate the EUT. When this is not practicable the EUT remains in a fixed position, and measurements are made around the EUT.

10.2.4 Antenna-to-EUT polarization

Antenna-to-EUT polarization (horizontal and vertical) shall be varied during the measurements to find the maximum field-strength readings.

10.3 Measurement site

10.3.1 General

Test sites shall be validated by making site attenuation measurements for both horizontal and vertical polarization fields in the frequency range of 30 MHz to 1 000 MHz.

The distance between the transmitting and receiving antennas shall be the same as the distance used for the radiated disturbance tests of the EUT.

10.3.2 Site attenuation measurements

A measurement site shall be considered acceptable if the horizontal and vertical site attenuation measurements are within ± 4 dB of the theoretical site attenuation of an ideal site (see also CISPR 16-1).

10.3.3 Open-area test site

The test site shall be flat, free of overhead wires and nearby reflecting structures, sufficiently large to permit antenna placing at the specified distance, and provide adequate separation between antenna, EUT and reflecting structures. Reflecting structures are defined as those in which construction material is primarily conductive. The test site shall be provided with a horizontal metal ground plane described in 10.3.4. Two such test sites are depicted in figures 1 and 2.

The test site shall satisfy the site attenuation requirements of CISPR 16-1 for open-area test sites.

10.3.4 Conducting ground plane

A conducting ground plane shall extend at least 1 m beyond the periphery of the EUT and the largest measuring antenna, and cover the entire area between the EUT and the antenna. It should be of metal with no holes or gaps having dimensions larger than one-tenth of a wavelength at the highest frequency of measurement. A larger size conducting ground plane may be required if the site attenuation requirements of the test site are not satisfied.

10.3.5 Alternative test sites

Tests may be conducted on other test sites which do not have the physical characteristics described in 10.3.3 and 10.3.4. Evidence shall be obtained to show that such alternative sites will yield valid results. Such alternative sites are suitable for performing disturbance tests if the site attenuation measurements described in annex A meet the site attenuation requirements of 10.3.2.

One example of an alternative site is an absorber lined shielded room.

NOTE – Annex A will be replaced by the corresponding procedure when specified in CISPR 16-1.

10.4 Equipment set-up

The EUT shall be configured and operated in accordance with the requirements of clause 8, and set up in accordance with figures 10, 11 and 12 for table-top equipment, floor-standing equipment, and combined floor-standing and table-top equipment. Figures 13 and 14 display the set-up for floor-standing equipment using overhead cables.

Table-top EUTs shall be placed upon a non-metallic table 0,8 m above the horizontal metal ground plane (see 10.3.4) of the radiated field strength test site. Floor-standing EUTs shall be placed directly on the horizontal metal ground plane, the point(s) of contact being consistent with normal use, but separated from metallic contact with the ground plane by up to 15 cm of insulation.

Equipment designed for both table-top and floor-standing operation shall be tested only in the table-top configuration unless the typical installation is floor-standing, when that configuration is used.

Equipment designed for wall-mounted operation shall be tested as table-top EUT. The orientation of the equipment shall be consistent with that of normal operation.

10.5 Recording of measurements

Of those disturbances above ($L - 20$ dB), where L is the limit level in logarithmic units, record at least the disturbance levels and the frequencies of the six highest disturbances. Record the antenna polarization for each reported disturbance.

10.6 Measurement in the presence of high ambient signals

In general, the ambient signals should not exceed the limit. Radiated emanations from the EUT at the point of measurement may, however, be impossible to measure at some frequencies due to ambient noise fields generated by local broadcast services, other man-made devices, and natural sources.

If the ambient signal field strength is high (see clause 8) at the specified distance, the following methods may be used to show compliance of the EUT.

- a) Perform measurements at close-in distances and determine the limit L_2 corresponding to the close-in distance d_2 by applying the following relation:

$$L_2 = L_1 (d_1/d_2)$$

where L_1 is the specified limit in microvolts per metre ($\mu\text{V/m}$) at the distance d_1 .

Determine the possible environmental and compliance test conditions stipulated in clause 8 using L_2 as the new limit for distance d_2 .

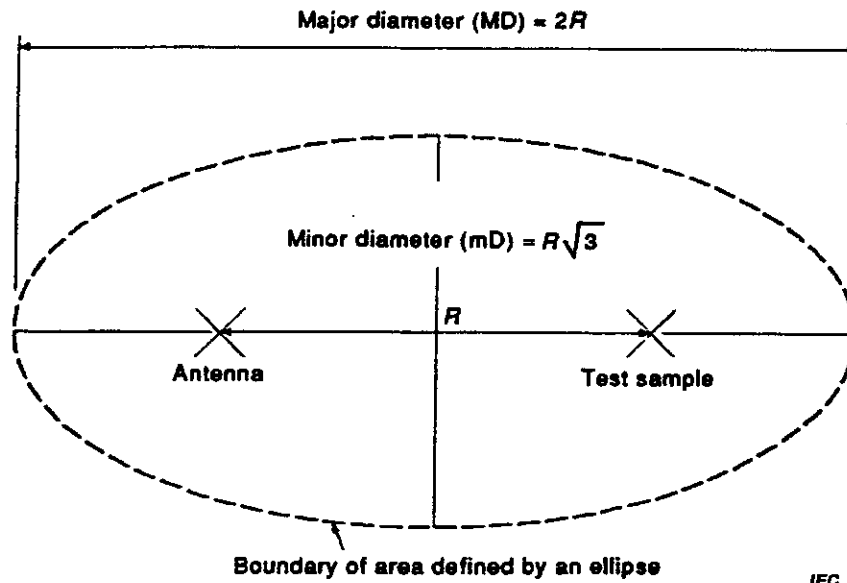
- b) In the frequency bands where the ambient noise values of clause 8 are exceeded (measured values higher than 6 dB below the limit), the disturbance values of the EUT may be interpolated from the adjacent disturbance values. The interpolated value shall lie on the curve describing a continuous function of the disturbance values adjacent to the ambient noise.
- c) Another possibility is to use the method described in annex C of CISPR 11.

10.7 User installation testing

In some cases, measurements of class A ITE at the user's installation might be necessary. These measurements shall be made preferably at the boundary of the user's premises; if such boundary is less than 10 m from the EUT, the measurements shall be made at a distance of 10 m from the EUT.

This form of compliance verification is specific to the installation site, since the site characteristics affect the measurement. Additional type-tested and compliant ITE may be added to the installed system without invalidating the compliance status of the site.

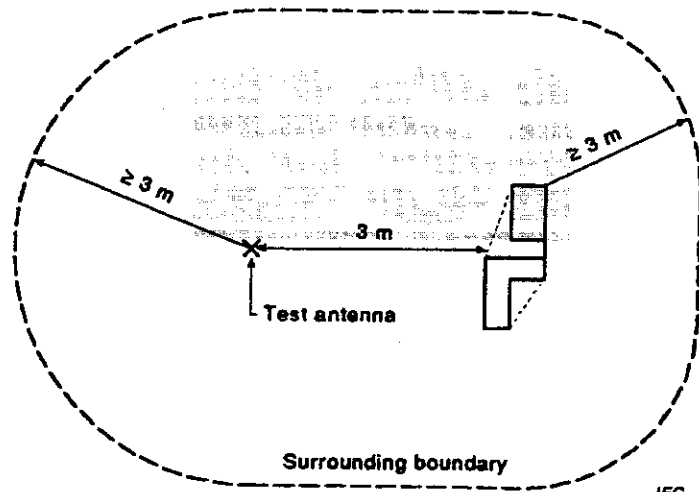
This method of measurement may not be applicable for compliance verification of physically very large ITE (such as some telecommunication centre equipment). For such equipment, methods of measurement and limits are under consideration.



Volume above earth to be free of reflecting objects.

NOTE – Characteristics of test site described further in 10.3. See also clause 6 for the value of R .

Figure 1 – Test site

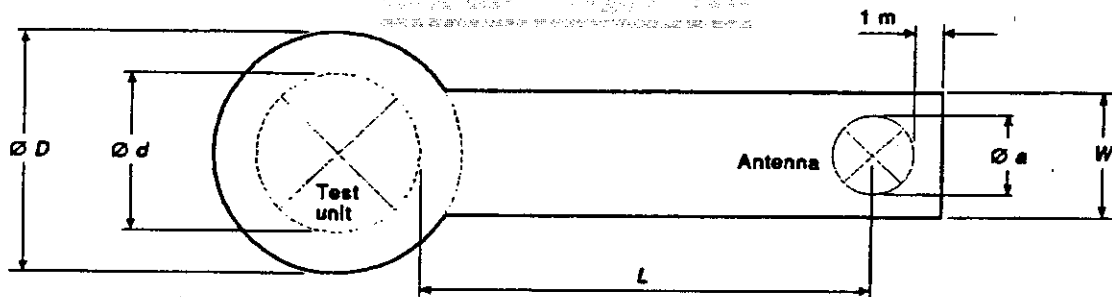


IEC 1263/97

There shall be no reflecting object inside the volume defined on the ground by the line corresponding to this figure and defined in height by a horizontal plane ≥ 3 m above the highest element of either aerial or equipment under test.

NOTE - See 10.3.3 for applicability of the alternate test site. Also, the peripheral string method is described in 10.2.1.

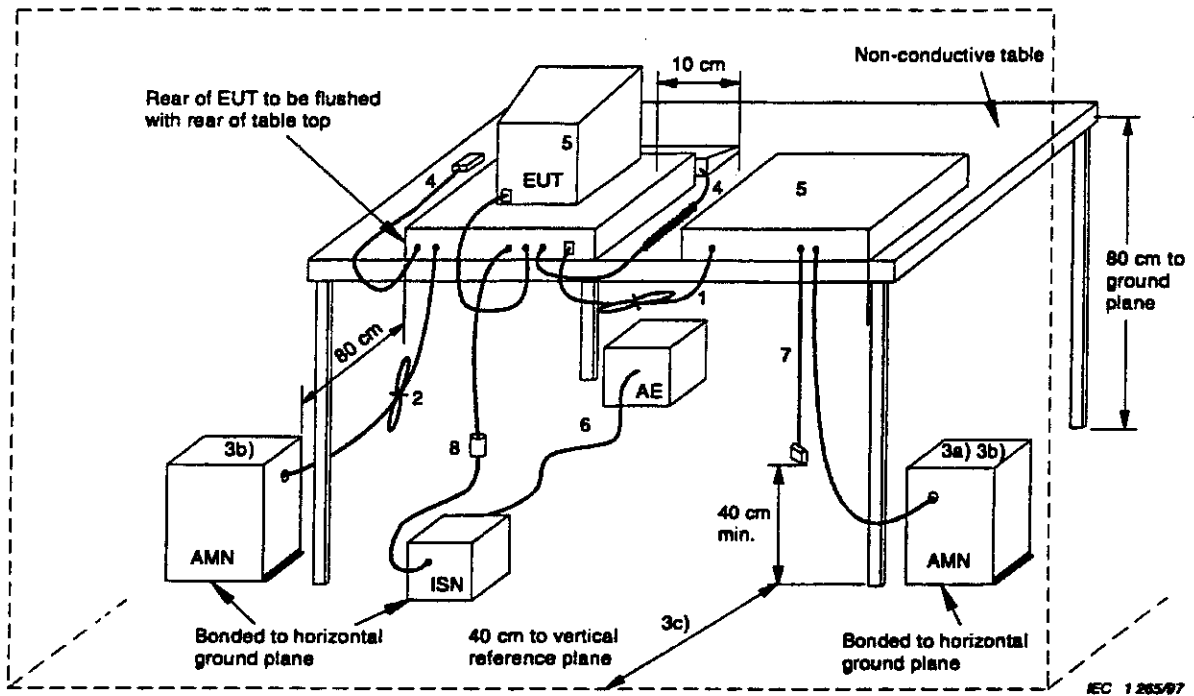
Figure 2 - Minimum alternative measurement site



IEC 1264/97

$D = d + 2$ m, where d is the maximum test unit dimension
 $W = a + 2$ m, where a is the maximum antenna dimension
 $L = 3$ m or 10 m

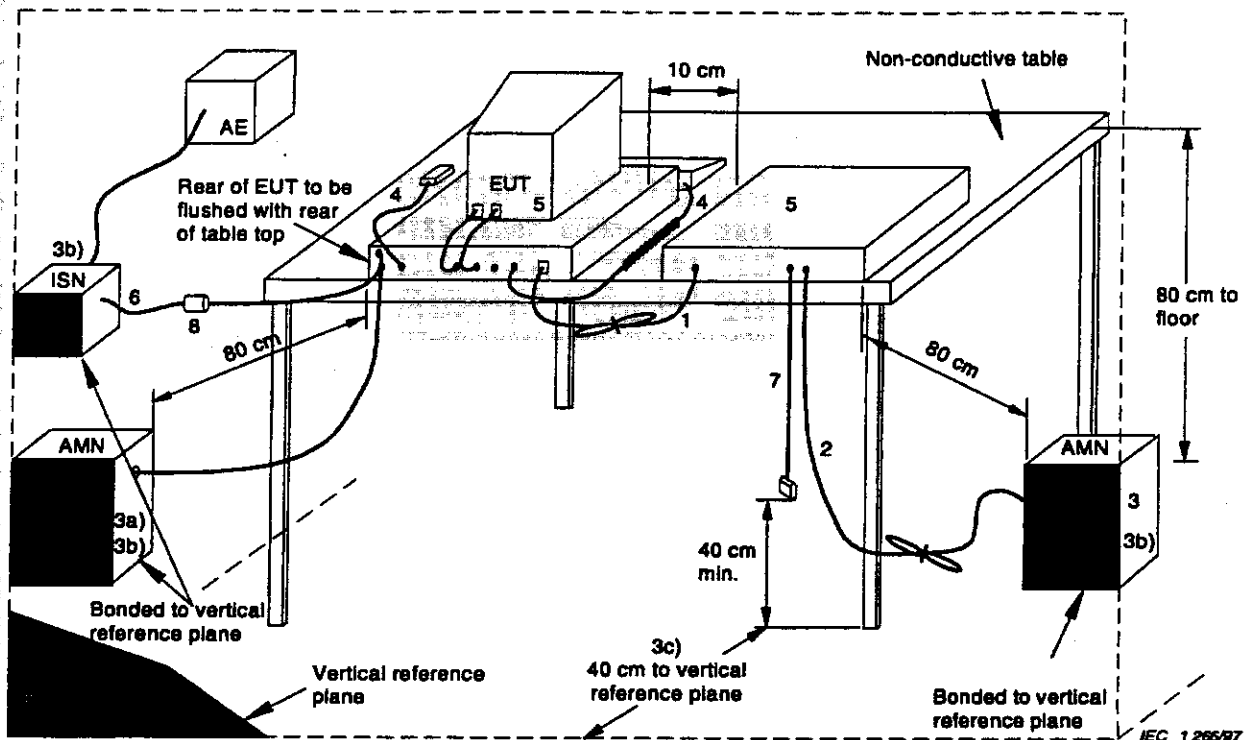
Figure 3 - Minimum size of metal ground plane



AMN = Artificial mains network
 AE = Associated equipment
 EUT = Equipment under test
 ISN = Impedance stabilization network

- 1) If cables, which hang closer than 40 cm to the horizontal metal groundplane, cannot be shortened to appropriate length, the excess shall be folded back and forth forming a bundle 30 cm to 40 cm long.
- 2) Excess mains cord shall be bundled in the centre or shortened to appropriate length.
- 3) EUT is connected to one artificial mains network (AMN). All AMNs and ISNs may alternatively be connected to a vertical reference plane or metal wall (see figures 5 and 6).
 - a) All other units of a system are powered from a second AMN. A multiple outlet strip can be used for multiple mains cords.
 - b) AMN and ISN are 80 cm from the EUT and at least 80 cm from other units and other metal planes.
 - c) Mains cords and signal cables shall be positioned for their entire lengths, as far as possible, at 40 cm from the vertical reference plane.
- 4) Cables of hand operated devices, such as keyboards, mouses, etc. shall be placed as for normal usage.
- 5) Peripherals shall be placed at a distance of 10 cm from each other and from the controller, except for the monitor which, if this is an acceptable installation practice, shall be placed directly on the top of the controller.
- 6) I/O signal cable intended for external connection.
- 7) The end of the I/O signal cables which are not connected to an AE may be terminated, if required, using correct terminating impedance.
- 8) If used, the current probe shall be placed at 0,1 m from the ISN.

Figure 4 – Test configuration: tabletop equipment (conducted measurement)



AMN = Artificial mains network
 AE = Associated equipment
 EUT = Equipment under test
 ISN = Impedance stabilization network

- 1) If cables, which hang closer than 40 cm to the horizontal metal groundplane, cannot be shortened to appropriate length, the excess shall be folded back and forth forming a bundle 30 cm to 40 cm long.
- 2) Excess mains cord shall be bundled in the centre or shortened to appropriate length.
- 3) EUT is connected to one AMN. All AMNs and ISNs may alternatively be connected to the horizontal metal groundplane (see figures 4 and 7).
 - a) All other units of a system are powered from a second AMN. A multiple outlet strip can be used for multiple mains cords.
 - b) AMN and ISN (or representative termination) are 80 cm from the EUT and at least 80 cm from other units and other metal planes.
 - c) Mains cords and signal cables shall be positioned for their entire lengths, as far as possible, at 40 cm from the vertical reference plane.
- 4) Cables of hand-operated devices, such as keyboards, mice, etc. shall be placed as for normal usage.
- 5) Peripherals shall be placed at a distance of 10 cm from each other and from the controller, except for the monitor which, if this is an acceptable installation practice, shall be placed directly on the top of the controller.
- 6) I/O signal cable intended for external connection.
- 7) The end of the I/O signal cables which are not connected to an AE may be terminated, if required, using correct terminating impedance.
- 8) If used, the current probe shall be placed at 0,1 m from the ISN.

Figure 5 – Alternative test configuration: tabletop equipment (conducted measurement)

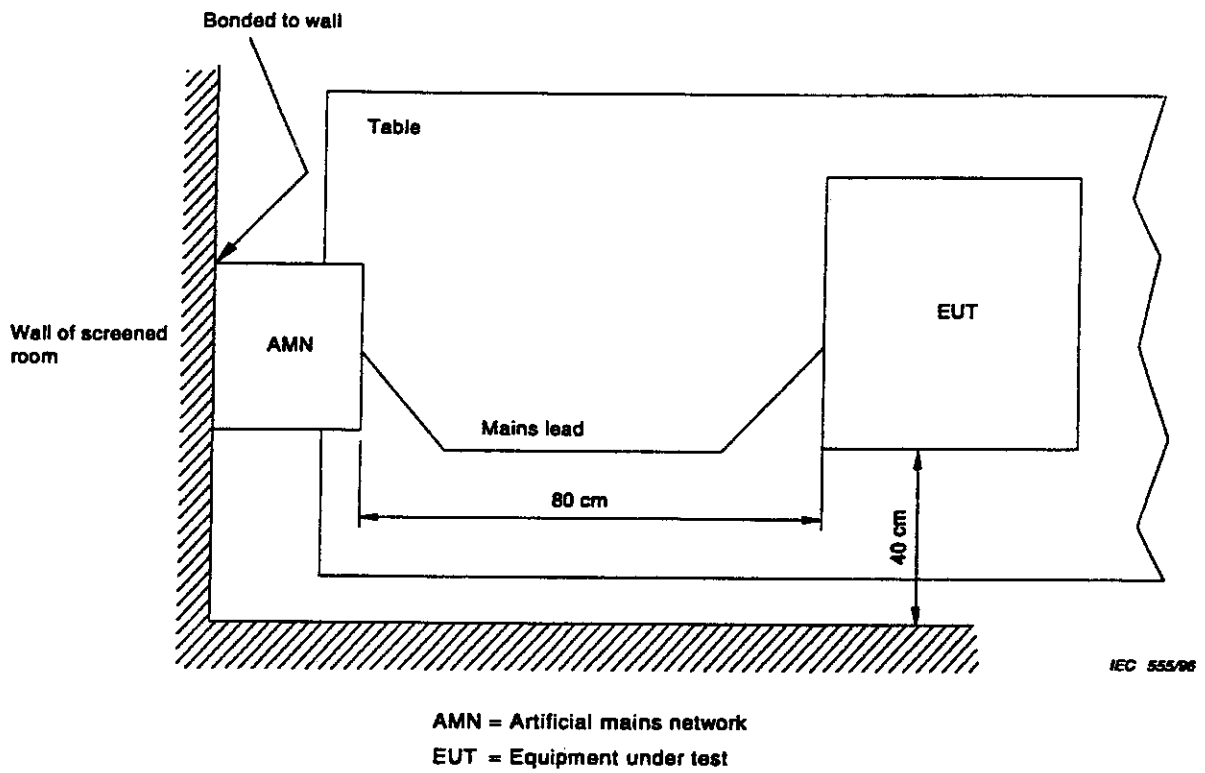
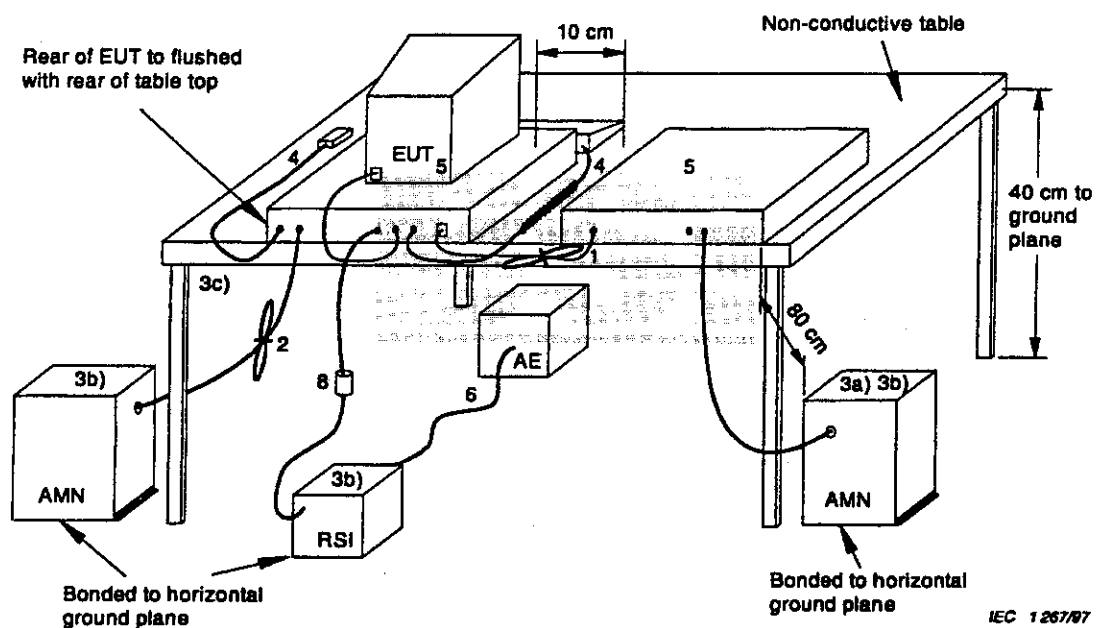


Figure 6 – Alternative test configuration: tabletop equipment (conducted measurement) – Plan view

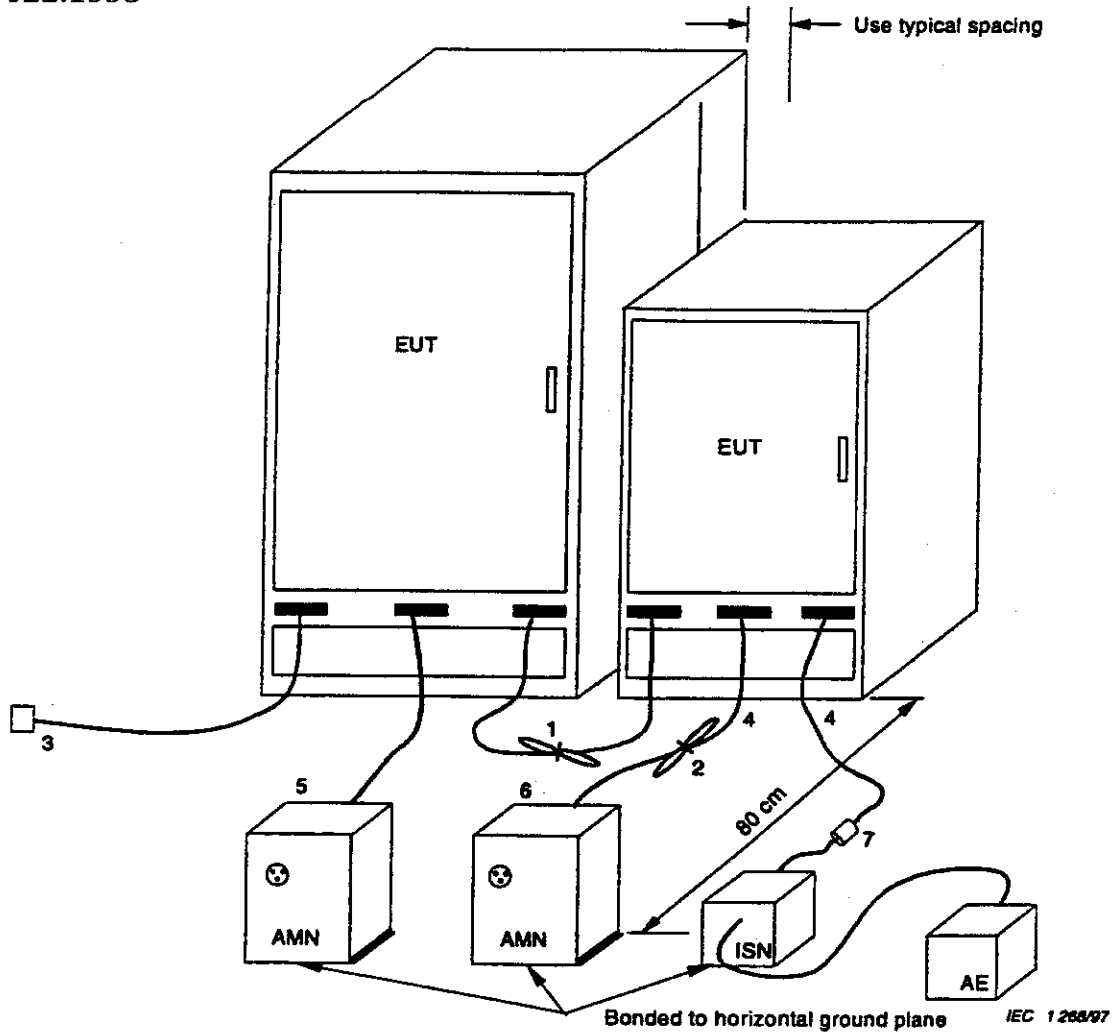


IEC 1267/87

AMN = Artificial mains network
 AE = Associated equipment
 EUT = Equipment under test
 ISN = Impedance stabilization network

- 1) If cables, which hang closer than 40 cm to the horizontal metal groundplane, cannot be shortened to appropriate length, the excess shall be folded back and forth forming a bundle 30 cm to 40 cm long.
- 2) Excess mains cord shall be bundled in the centre or shortened to appropriate length.
- 3) EUT is connected to one AMN. All AMNs and ISNs may alternatively be connected to the horizontal metal groundplane (see figures 4 and 7).
 - a) All other units of a system are powered from a second AMN. A multiple outlet strip can be used for multiple mains cords.
 - b) AMN and ISN (or representative termination) are 80 cm from the EUT and at least 80 cm from other units and other metal planes.
 - c) Mains cords and signal cables shall be positioned for their entire lengths, as far as possible, at 40 cm from the horizontal reference plane.
- 4) Cables of hand-operated devices, such as keyboards, mouses, etc. shall be placed as for normal usage.
- 5) Peripherals shall be placed at a distance of 10 cm from each other and from the controller, except for the monitor which, if this is an acceptable installation practice, shall be placed directly on the top of the controller.
- 6) I/O signal cable intended for external connection.
- 7) The end of the I/O signal cables which are not connected to an AE may be terminated, if required, using correct terminating impedance.
- 8) If used, the current probe shall be placed at 0,1 m from the ISN.

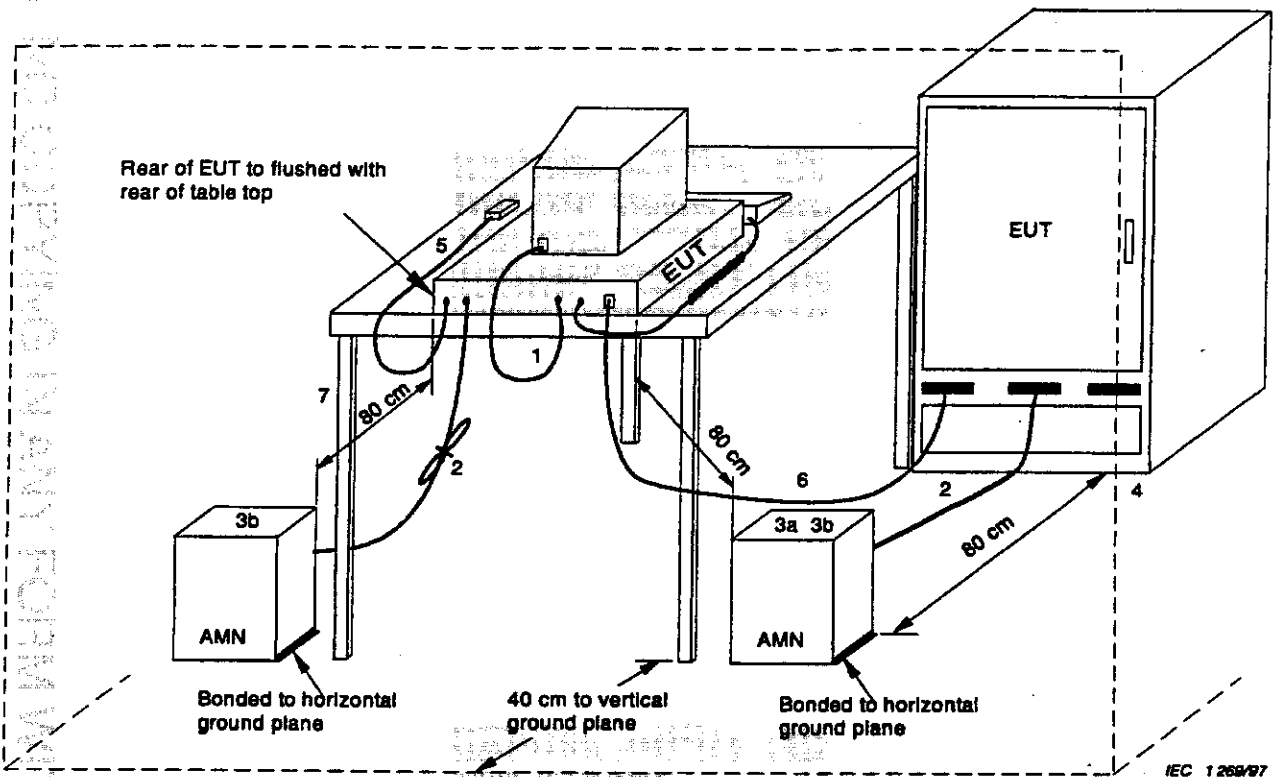
**Figure 7 - Test configuration: tabletop equipment
 (conducted measurement on a radiated test site)**



AMN = Artificial mains network
AE = Associated equipment
EUT = Equipment under test
ISN = Impedance stabilization network

- 1) If cables cannot be shortened to appropriate length, the excess shall be folded back and forth forming a bundle 30 cm 40 cm long. If bundling is not possible, the cables shall be arranged in a serpentine fashion.
- 2) Excess mains cord shall be bundled in the centre or shortened to appropriate length.
- 3) The end of the I/O signal cables which are not connected to a peripheral may be terminated if required for proper operation using correct terminating impedance.
- 4) EUT and cables shall be insulated (up to 15 cm) from the horizontal metal groundplane.
- 5) EUT is connected to one AMN. AMN can be placed on top of, or immediately beneath, the horizontal metal groundplane.
- 6) All other equipment is powered from a second AMN or additional AMNs.
- 7) If used, the current probe shall be placed at 0,1 m from the ISN (or representative termination).

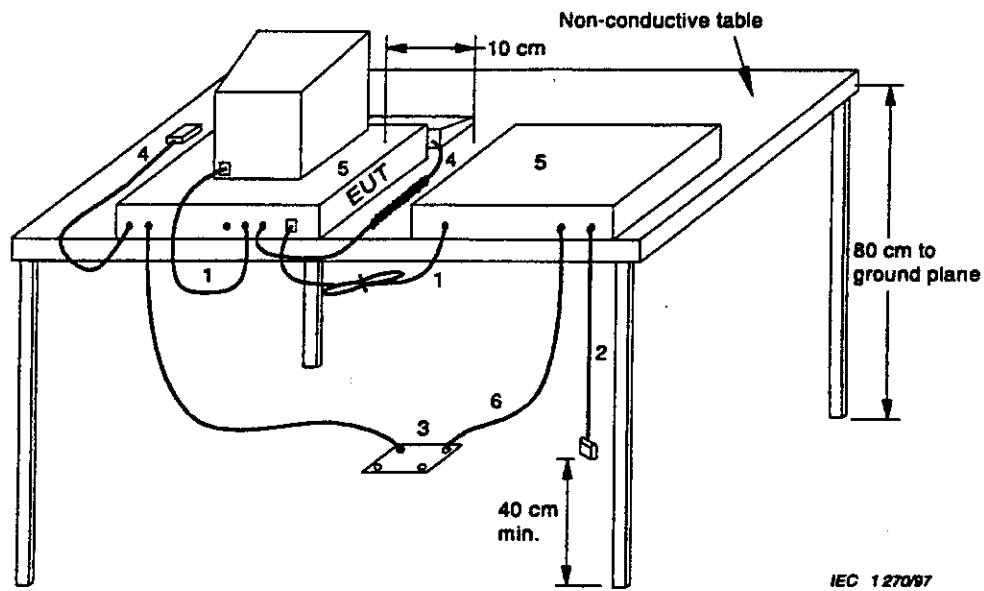
Figure 8 – Test configuration: floor-standing equipment (conducted measurement)



AMN = artificial mains network
EUT = equipment under test

- 1) If cables which hang closer than 40 cm to the horizontal metal ground plane cannot be shortened to appropriate length, the excess shall be folded back and forth forming a bundle 30 cm to 40 cm long.
- 2) Excess mains cord shall be bundled in the centre or shortened to appropriate length.
- 3) EUT connected to one AMN. The AMN may be connected alternatively to the vertical reference plane.
 - 3a) All other equipment powered from one or more additional AMNs.
 - 3b) AMN 80 cm from EUT and at least 80 cm from other units and other metal planes.
- 4) EUT and cables shall be insulated from horizontal metal ground plane.
- 5) Cables of hand operated devices, such as keyboards, mice, etc. shall be placed as for normal use.
- 6) I/O cable to floor-standing unit drapes to ground plane and excess is bundled. Cables not reaching ground plane are dropped to height of connector or 40 cm, whichever is lower.
- 7) For table-top equipment, either test configuration, figure 5 or figure 7, may be used.

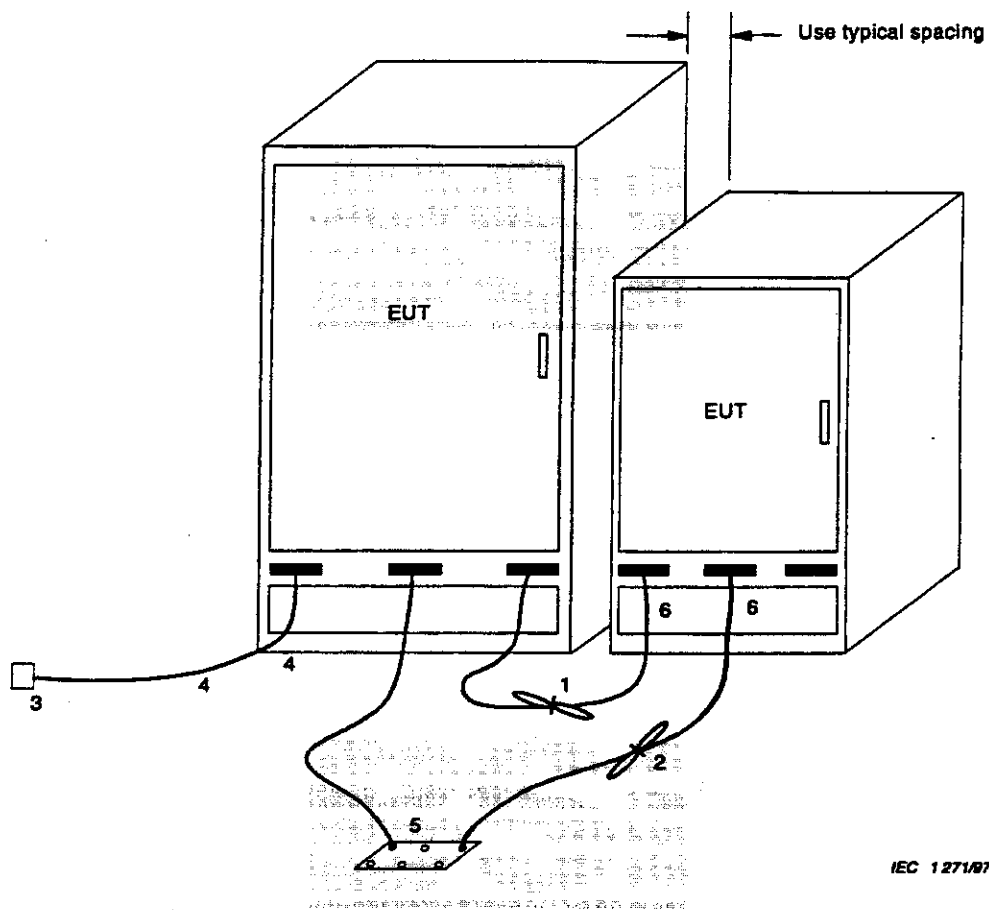
**Figure 9 – Test configuration: floor-standing and table-top equipment
(conducted measurement)**



EUT = equipment under test

- 1) If cables which hang closer than 40 cm to the horizontal metal ground plane cannot be shortened to appropriate length, the excess shall be folded back and forth forming a bundle 30 cm to 40 cm long.
- 2) The end of the I/O signal cables which are not connected to a peripheral may be terminated if required for proper operation using correct terminating impedance.
- 3) Mains junction box(s) shall be flush with, and bonded directly to, the metal ground plane.
NOTE - If used, the AMN shall be installed under the horizontal metal ground plane.
- 4) Cables of hand operated devices, such as keyboards, mouses, etc. shall be placed as for normal usage.
- 5) Peripherals shall be placed at a distance of 10 cm from each other and from the controller, except for the monitor which, if for an acceptable installation practice, shall be placed directly on the top of the controller.
- 6) Mains cables shall drape to the floor and then be routed to receptacle. No extension cords shall be used to mains receptacle.

Figure 10 - Test configuration: table-top equipment (radiated measurement)

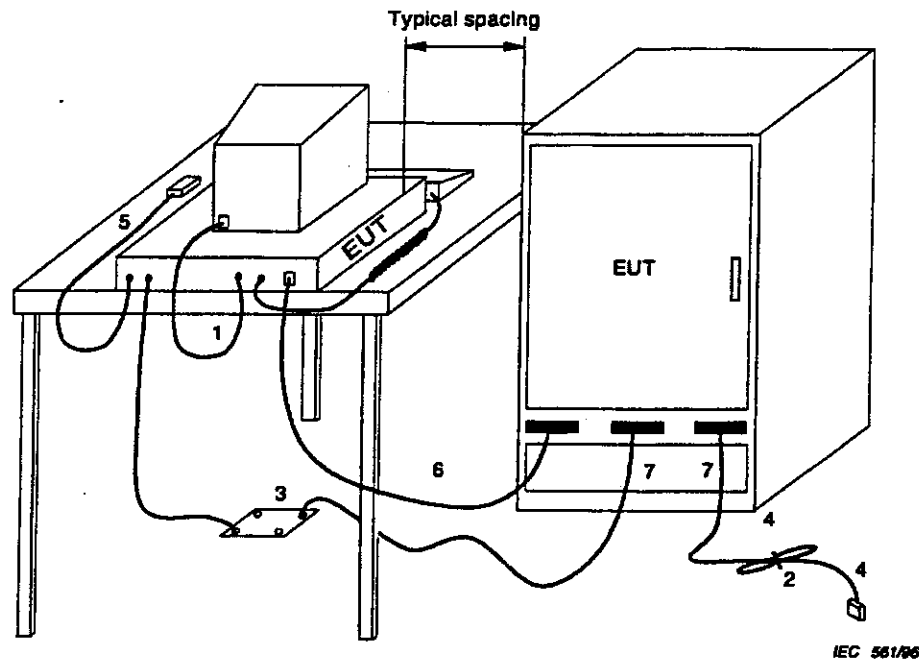


EUT = equipment under test

- 1) If cables cannot be shortened to appropriate length, the excess shall be folded back and forth forming a bundle 30 cm to 40 cm long. If bundling is not possible, the cables shall be arranged in a serpentine fashion.
- 2) Excess mains cords shall be bundled in the centre or shortened to appropriate length.
- 3) The end of the I/O signal cables which are not connected to a peripheral may be terminated if required for proper operation using correct terminating impedance.
- 4) EUT and cables shall be insulated from the horizontal metal ground plane.
- 5) Mains junction box(s) shall be flush with, and bonded directly to, the horizontal metal ground plane.
NOTE – If used, the AMN should be installed under the horizontal metal ground plane.
- 6) Mains and signal cables shall drape to the floor. No extension cords shall be used to mains receptacle.

Figure 11 – Test configuration: floor-standing equipment (radiated measurement)

IEC 1271/87

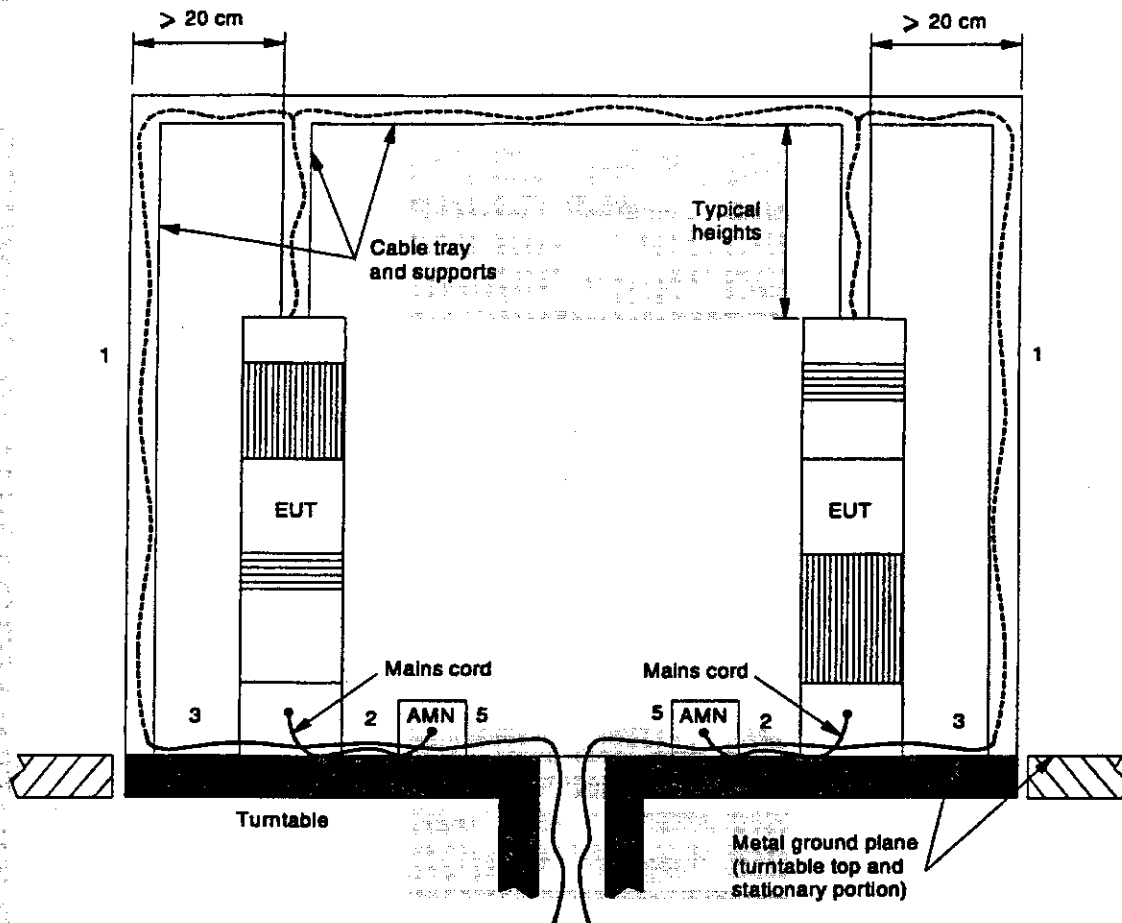


IEC 551/96

EUT = equipment under test

- 1) If cables which hang closer than 40 cm to the horizontal metal ground plane cannot be shortened to appropriate length, the excess shall be folded back and forth forming a bundle 30 cm to 40 cm long.
- 2) I/O cables which are not connected to a peripheral, if bundled, shall be bundled in centre. The end of the cable may be terminated if required for proper operation using correct terminating impedance.
- 3) Mains junction box(s) shall be flush with, and connected directly to, the horizontal metal ground plane.
NOTE – If used, the AMN shall be installed under the horizontal metal ground plane.
- 4) EUT and cables shall be insulated from the horizontal metal ground plane.
- 5) Cables of hand operated devices, such as keyboards, mouses, for example, shall be placed as for normal use.
- 6) I/O cable to floor-standing unit drapes to the metal ground plane and shortened or excess be bundled. Cables not reaching the metal ground plane are draped to the height of the connector or 40 cm, whichever is lower.
- 7) Mains and signal cables shall drape to the floor. No extension cords shall be used to the mains receptacle.

**Figure 12 – Test configuration: floor-standing and table-top equipment
(radiated measurement)**



I/O cables to remote peripherals and/or auxiliary equipment.
These cables may be terminated, if required, with correct impedance

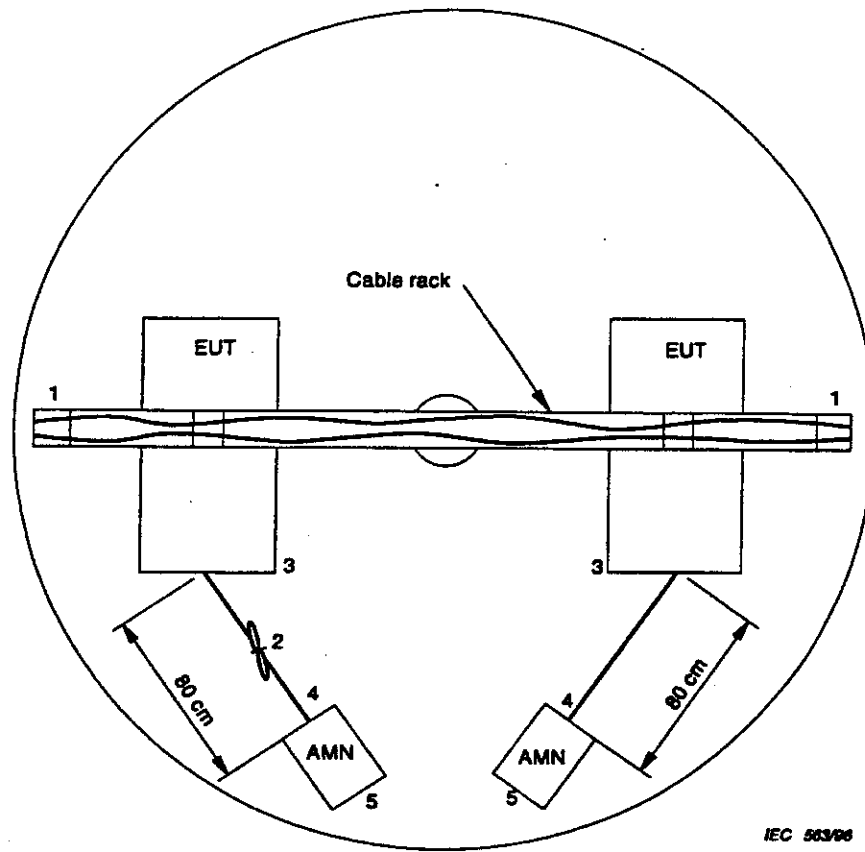
IEC 1272/87

AMN = artificial mains network

EUT = equipment under test

- 1) Only one vertical riser may be used where typical of system under test.
- 2) Excess mains cord shall be bundled in the centre or shortened to appropriate length.
- 3) EUT and cables shall be insulated from ground plane. Where the manual has specified, or there exists a code of practice for installation of the EUT, the test configuration shall allow the use of this practice for the tests.
- 4) Mains cord being measured connected to one AMN. All other system mains cords powered through other AMN(s). A multiple outlet strip may be used for other mains cords.
- 5) For *conducted* tests, the AMNs may be placed on top, or immediately beneath, and bonded directly to the ground plane.
For *radiated* tests, the AMN(s), if used, should be installed under, with the receptacle flush with the ground plane.
- 6) Installation practice, where specific, shall be used in the test configuration.

Figure 13 – Test configuration: floor-standing equipment
(overhead cables, side view)



AMN = artificial mains network
EUT = equipment under test

- 1) Only one vertical riser may be used when this configuration is typical of the system under test.
- 2) Excess mains cord shall be bundled in the centre or shortened to appropriate length.
- 3) EUT and cables shall be insulated from ground plane. Where the manual has specified, or there exists a code of practice for installation of the EUT, the test configuration shall allow the use of this practice for the tests.
- 4) Mains cord being measured connected to one AMN. All other system mains cords powered through other AMN(s). A multiple outlet strip may be used for other mains cords.
- 5) For *conducted* tests, AMNs may be placed on top, or immediately beneath, and bonded directly to the ground plane.
For *radiated* tests, the AMN(s), if used, should be installed under, with the receptacle flush with the ground plane.
- 6) Installation practice, where specific, shall be used in the test configuration.

Figure 14 – Test configuration: floor-standing equipment
(overhead cables, plan view)

Annex A
(normative)

**Site attenuation measurements
of alternative test sites**

A.1 Method of measurement of site attenuation

The transmit antenna shall be moved within a volume in both horizontal and vertical polarizations (see clause A.2, reference [2]) as shown in figure A.1. The recommended minimum volume includes lateral positions defined by a 1 m x 1,5 m test-table surface when rotated about its centre, and vertical extremities defined by typical EUT heights of both floor-standing and table-top equipment of 1,5 m or less as shown in figure A.2. Some test sites may require volumes larger than the recommended minimum depending upon the size of the typical equipment to be measured.

For these measurements, broadband antennas shall be used, and measurement distances shall be referenced between the centres of the antennas. The transmit and receive antennas shall be aligned with the antenna elements oriented orthogonal to the measurement axis so that the antenna elements are always parallel.

A.1.1 Vertical polarization

In the vertical polarization the height of the transmit antenna shall be 1 m to the centre of the antenna (a minimum clearance of 25 cm between the tip of the antenna and the ground plane shall be maintained).

Measurements shall also be performed with the transmit height at 1,5 m under either of the following conditions:

- a) the expected EUT height is greater than 1,5 m and less than 2 m;
- b) the tip of the transmit antenna does not extend to within 90 % of the top of the expected EUT height when at the 1 m height.

The transmit antenna shall be located in the following four positions at the appropriate heights for the vertical polarization:

- 1) the exact centre of the turntable (see note 1);
- 2) a position 0,75 m forward of the turntable centre and towards the receiving antenna (lying on a line, that is the measurement axis, drawn between the turntable centre and the receive antenna);
- 3) a position 0,75 m behind the turntable centre and away from the receiving antenna, unless this position is more than 1 m from the nearest vertical dielectric interface (see note 2);
- 4) the two positions 0,75 m on each side of centre (lying on a line drawn through the centre and normal to a line between the turntable centre and the receive antenna).

Normalized site attenuation (NSA) vertical polarization measurements shall be performed with the transmit and receive antenna separation held constant, using table A.1. The receive antenna shall be moved to the nearest location maintaining the appropriate distance, and along a line towards the turntable centre.

Assuming a maximum EUT height of 1,5 m, a minimum of four vertically polarized measurements are required (four positions in a horizontal plane at one height) (see figure A.2 a)).

A.1.2 Horizontal polarization

For NSA horizontal polarization measurements, two transmit heights shall be investigated. The lower height of the antenna shall be 1 m to the centre of the antenna, and the upper height shall be 2 m to the centre of the antenna (see table A.1). The following positions shall be measured at both antenna heights:

- 1) the exact centre of the turntable;
- 2) a position 0,75 m forward of the turntable centre and towards the receiving antenna;
- 3) a position 0,75 m behind the turntable centre and away from the receiving antenna unless this position is more than 1 m from the nearest vertical dielectric interface (see note 2);
- 4) two positions on either side of the turntable centre so that the tip of the antenna will circumscribe a volume 0,75 m from the centre. These two positions are not required if the tip of the antenna extends to within 90 % of the total volume width when the antenna is positioned at the turntable centre. If the antenna elements overlap the centre at these two positions due to the length of the antenna, then the exact centre (position 1) need not be measured.

The antenna heights are based upon a maximum product height of approximately 2 m, and the use of a typical broadband antenna. Testing EUTs greater than 2 m in height or occupying areas greater than that circumscribed by the rotated 1 m x 1,5 m table may require higher transmit heights and larger antenna displacements from the centre of the turntable. NSA values other than those provided in this publication may be needed for some geometries (see clause A.2, reference [1]).

Assuming that the maximum horizontal extension of the EUT is 1,5 m, the minimum required number of horizontally polarized antenna measurements is four (two positions in the horizontal plane at two heights) (see figure A.2 b)).

NOTE 1 – For sites without turntables, all references to the "centre" refer to the centre of the 1 m by 1,5 m test-table surface.

NOTE 2 – Sources located near dielectric interfaces have been shown to have variations in current distribution which can affect the radiation properties of the source at that location (see clause A.2, reference [3]). When located near these interfaces, an additional site attenuation measurement is required.

Table A.1 – Normalized site attenuation (A_N (dB)) for recommended geometries with broadband antennas

Polarization	Horizontal						Vertical				
	3	3	10	10	30	30	3	3	10	10	30
R (m)	3	3	10	10	30	30	3	3	10	10	30
h_1 (m)	1	2	1	2	1	2	1	1,5	1	1,5	1
h_2 (m)	1 to 4	1 to 4	1 to 4	1 to 4	1 to 4	1 to 4	1 to 4	1 to 4	1 to 4	1 to 4	1 to 4
f (MHz)	A_N (dB)										
30	15,8	11,0	29,8	24,1	47,7	41,7	8,2	9,3	16,7	16,9	26,0
35	13,4	8,8	27,1	21,6	45,0	39,1	6,9	8,0	15,4	15,6	24,7
40	11,3	7,0	24,9	19,4	42,7	36,8	5,8	7,0	14,2	14,4	23,5
45	9,4	5,5	22,9	17,5	40,7	34,7	4,9	6,1	13,2	13,4	22,5
50	7,8	4,2	21,1	15,9	38,8	32,9	4,0	5,4	12,3	12,5	21,6
60	5,0	2,2	18,0	13,1	35,7	29,8	2,6	4,1	10,7	11,0	20,0
70	2,8	0,6	15,5	10,9	33,0	27,2	1,5	3,2	9,4	9,7	18,7
80	0,9	-0,7	13,3	9,2	30,7	24,9	0,6	2,6	8,3	8,8	17,5
90	-0,7	-1,8	11,4	7,8	28,7	23,0	-0,1	2,1	7,3	7,6	16,5
100	-2,0	-2,8	9,7	6,7	26,9	21,2	-0,7	1,9	6,4	6,8	15,6
120	-4,2	-4,4	7,0	5,0	23,8	18,2	-1,5	1,3	4,9	5,4	14,0
125	-4,7	-4,7	6,4	4,6	23,1	17,6	-1,6	0,5	4,6	5,1	13,6
140	-6,0	-5,8	4,8	3,5	21,1	15,8	-1,8	-1,5	3,7	4,3	12,7
150	-6,7	-6,3	3,9	2,9	20,0	14,7	-1,8	-2,6	3,1	3,8	12,1
160	-7,4	-6,7	3,1	2,3	18,9	13,8	-1,7	-3,7	2,6	3,4	11,5
175	-8,3	-6,9	2,0	1,5	17,4	12,4	-1,4	-4,9	2,0	2,9	10,8
180	-8,6	-7,2	1,7	1,2	16,9	12,0	-1,3	-5,3	1,8	2,7	10,5
200	-9,6	-8,4	0,6	0,3	15,2	10,6	-3,6	-6,7	1,0	2,1	9,6
250	-11,7	-10,6	-1,6	-1,7	11,6	7,8	-7,7	-9,1	-0,5	0,3	7,7
300	-12,8	-12,3	-3,3	-3,3	8,7	6,1	-10,5	-10,9	-1,5	-1,9	6,2
400	-14,8	-14,9	-5,9	-5,8	4,5	3,5	-14,0	-12,6	-4,1	-5,0	3,9
500	-17,3	-16,7	-7,9	-7,6	1,8	1,6	-16,4	-15,1	-6,7	-7,2	2,1
600	-19,1	-18,3	-9,5	-9,3	0,0	0,0	-16,3	-16,9	-8,7	-9,0	0,8
700	-20,6	-19,7	-10,8	-10,6	-1,3	-1,4	-18,4	-18,4	-10,2	-10,4	-0,3
800	-21,3	-20,8	-12,0	-11,8	-2,5	-2,5	-20,0	-19,3	-11,5	-11,6	-1,1
900	-22,5	-21,8	-12,8	-12,9	-3,5	-3,5	-21,3	-20,4	-12,6	-12,7	-1,7
1 000	-23,5	-22,7	-13,8	-13,8	-4,5	-4,5	-22,4	-21,4	-13,6	-13,6	-3,6

NOTE – These data apply to antennas that have at least 250 mm of groundplane clearance when the centre of the antenna is 1 m above the ground plane in vertical polarization.

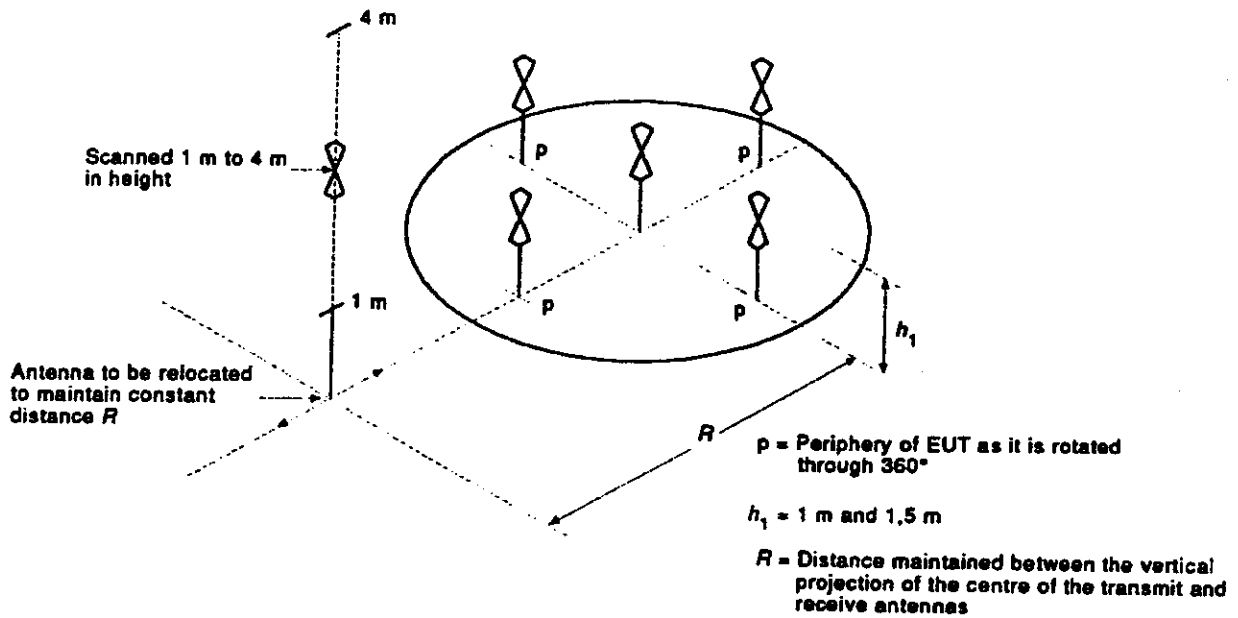


Figure A.1 a) – Typical antenna positions for alternate site NSA measurements in the vertical polarization

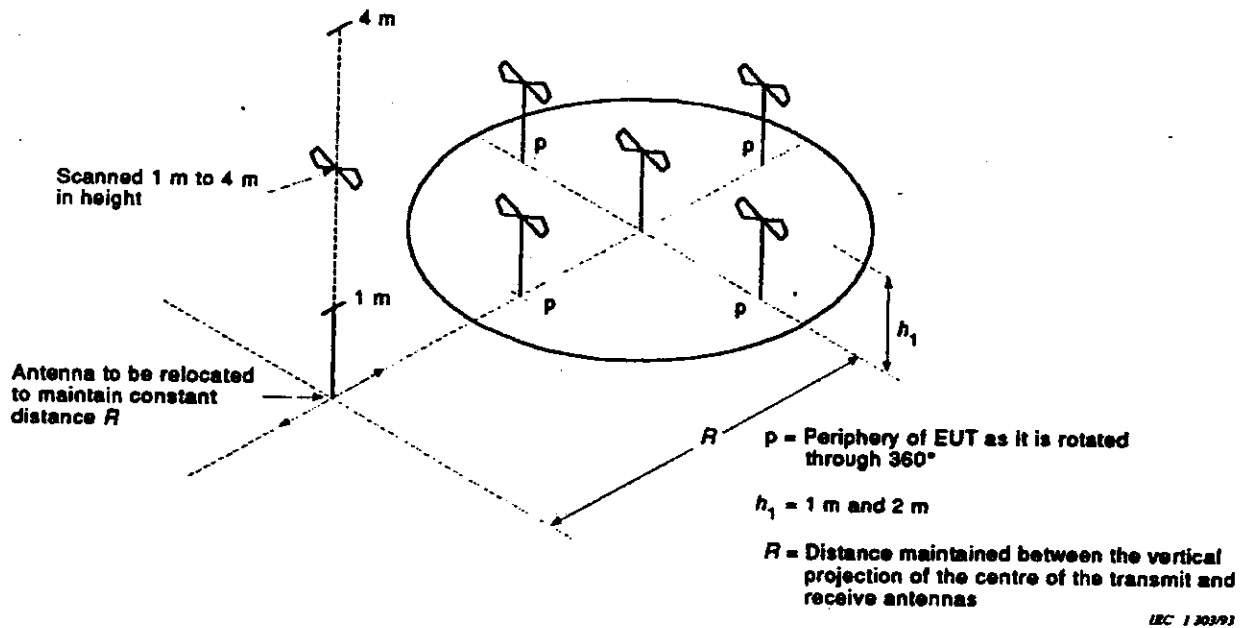


Figure A.1 b) – Typical antenna positions for alternate site NSA measurements in the horizontal polarization

Figure A.1 – Typical antenna positions for alternate site NSA measurements

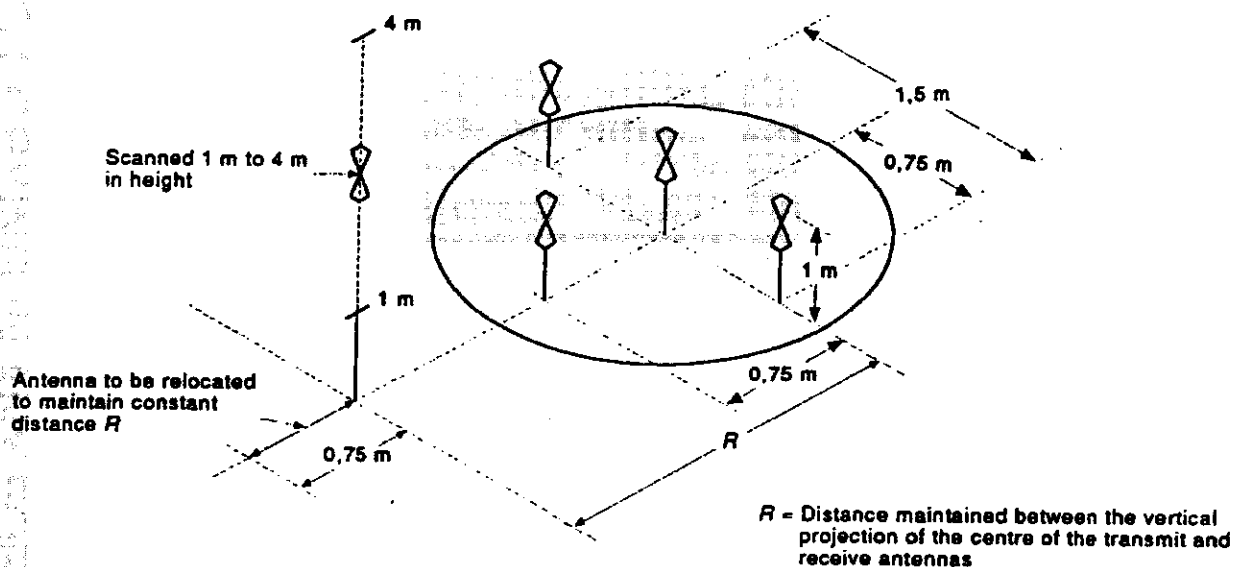


Figure A.2 a) – Typical antenna positions for alternate site NSA measurements in the vertical polarization for a volume not to exceed 1 m depth, 1,5 m width and 1,5 m height and rear boundary of the volume greater than 1 m from the closest material that may cause undesirable reflections

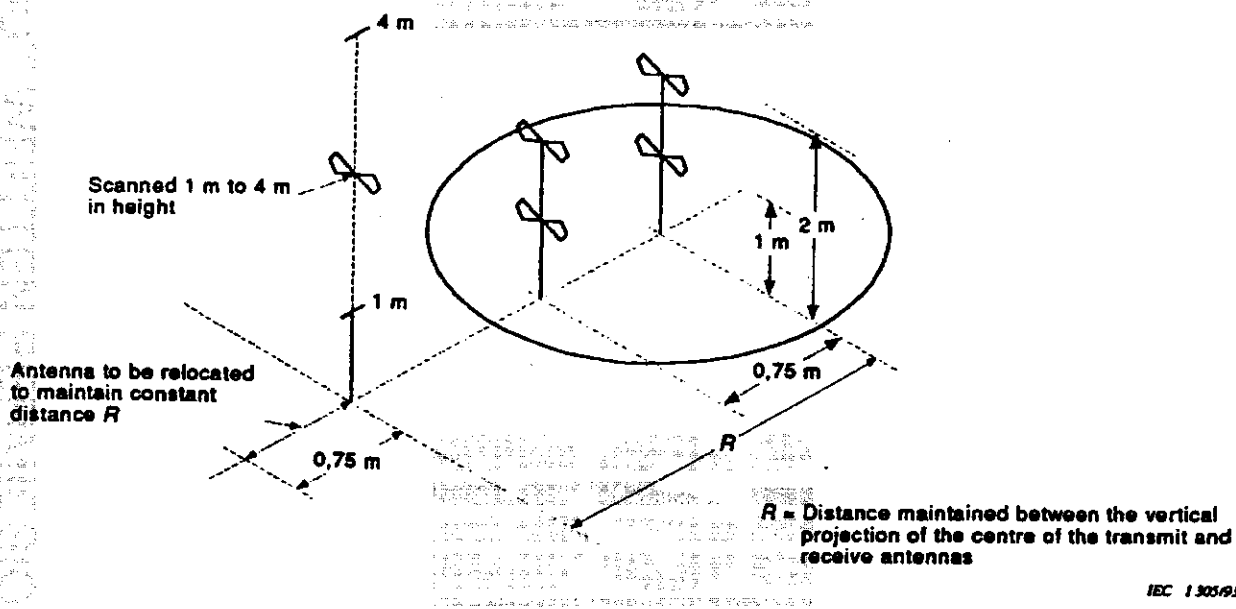


Figure A.2 b) – Typical antenna positions for alternate site NSA measurements in the vertical polarization for a volume not to exceed 1 m depth, 1,5 m width and 1,5 m height and rear boundary of the volume greater than 1 m from the closest material that may cause undesirable reflections

Figure A.2 – Antenna positions for alternate site measurements for minimum recommended volume

A.2 References

- [1] SMITH, A. A., GERMAN, R. F., PATE, J. B., "Calculation of site attenuation from antenna factors", IEEE Transactions on EMC, Vol EMC-24, 1982.
- [2] GERMAN, R. F., "Comparison of semi-anechoic chamber and open-field site attenuation measurements", 1982 IEEE International Symposium Record on Electromagnetic Compatibility, pp 260-265.
- [3] PATE, J. B., "Potential measurement errors due to mutual coupling between dipole antennas and radio frequency absorbing material in close proximity", 1984 IEEE National Symposium Record on Electromagnetic Compatibility.

Annex B
(normative)

Decision tree for peak detector measurements

If using a peak measuring receiver to reduce the testing time when performing conducted disturbance measurements at the mains or the telecommunication ports in the frequency range 150 kHz to 30 MHz, the following decision tree is used to determine a final pass/fail judgement.

Spectrum analyzers or receivers provided with RF preselectors which automatically follow the frequency being scanned by the spectrum analyzer or receiver should have a sufficiently long dwell time on each frequency to avoid amplitude errors in the measured values.

In addition, in order not to influence the measurement results, the video bandwidth of the spectrum analyzer shall be equal to, or greater than, the resolution bandwidth.

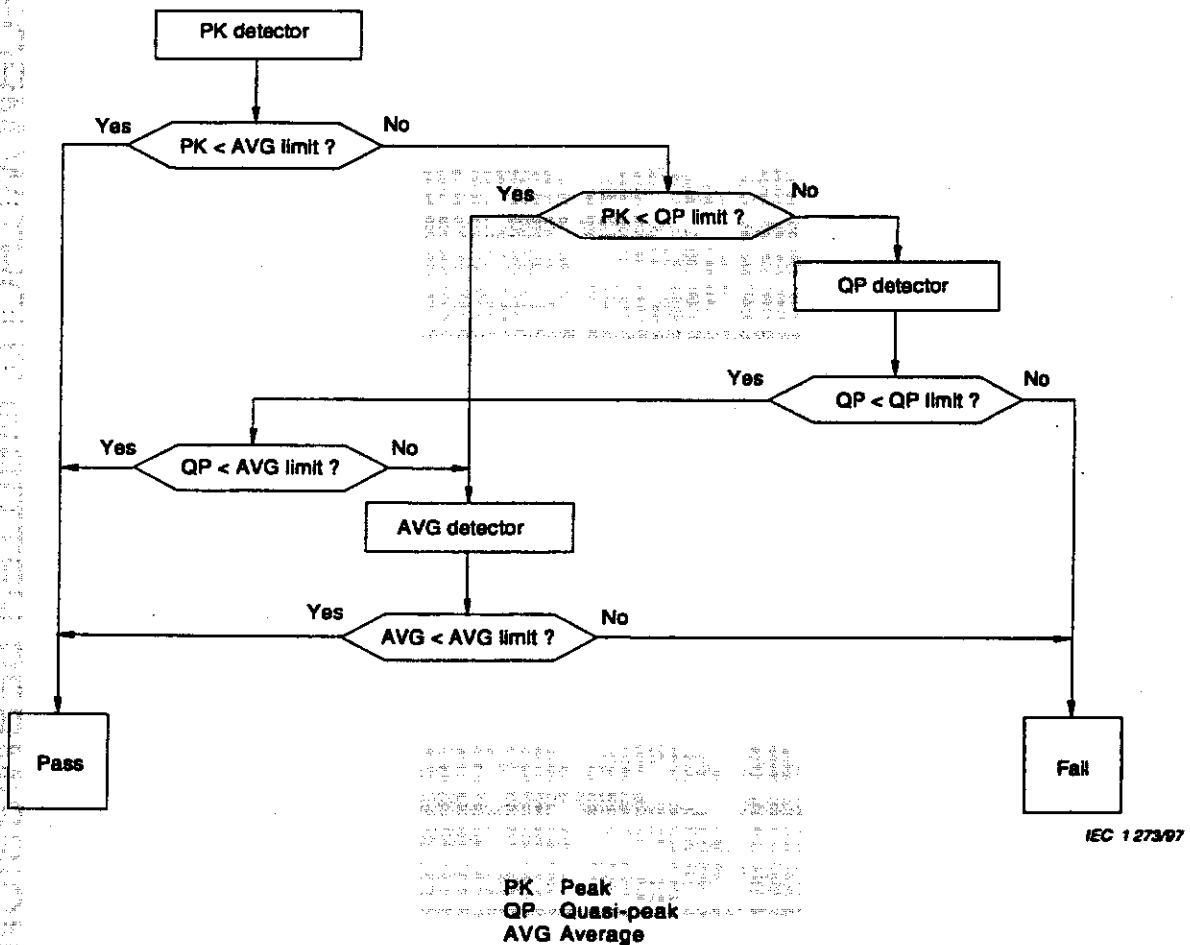


Figure B.1 – Decision tree for peak detector measurements

Annex C (normative)

Possible test set-ups for common mode measurements

C.1 Test set-ups for common mode measurements

These test methods and test set-ups are used where ISNs specified in 9.5.2 are not applicable.

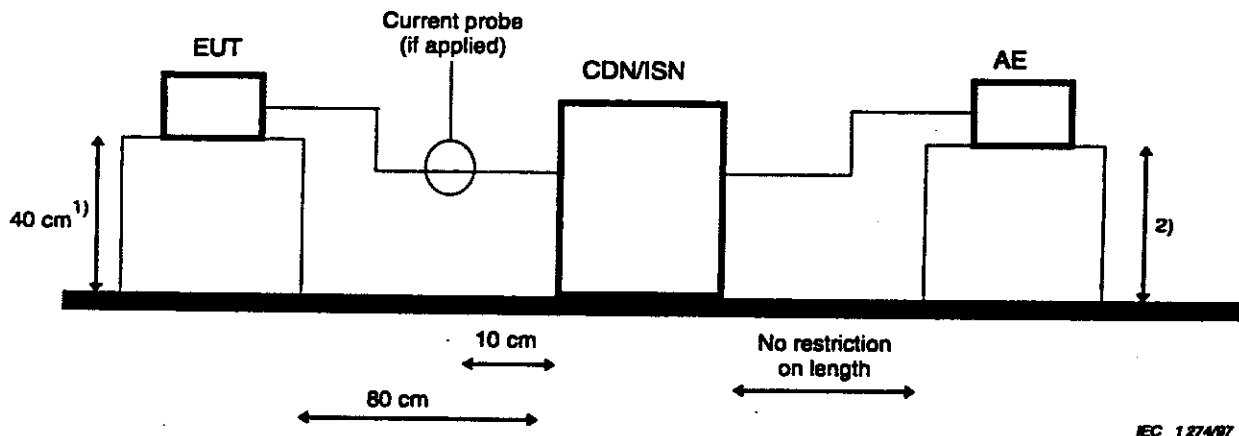
C.1.1 can be applied if appropriate coupling/decoupling networks CDN/ISNs are available.

C.1.2 can be applied to all types of shielded cables.

C.1.3 or C.1.4 shall be applied if other methods are not possible (i.e. unshielded cables containing more than two balanced pairs).

C.1.1 Using CDNs described in IEC 61000-4-6 as CDN/ISNs*)

- Connect CDN/ISN directly to reference groundplane.
- If voltage measurement is used, measure voltage at the measurement port of the CDN/ISN, correct the reading by adding the voltage division factor of the CDN/ISN, and compare to the voltage limit.
- If current measurement is used, measure current with the current probe and compare to the current limit.
- It is not necessary to apply the voltage and the current limit if a CDN/ISN is used. A 50 Ω load has to be connected to the measurement port of the CDN/ISN during the current measurement.



AE = Associated equipment
EUT = Equipment under test

1) Distance to the reference groundplane (vertical or horizontal).

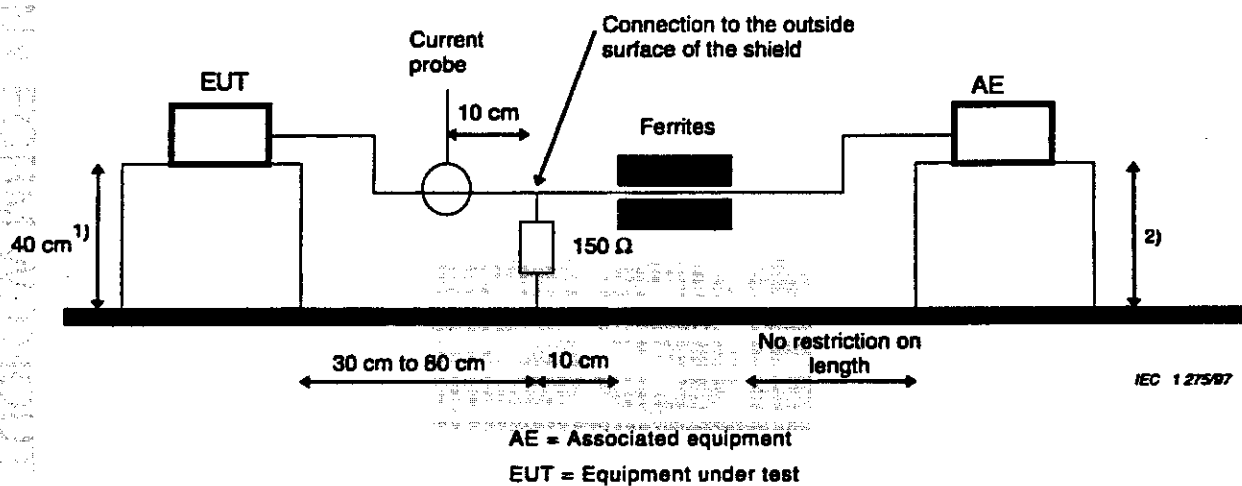
2) Distance to the reference groundplane is not critical.

Figure C.1

*) ISN is different from that described in annex D.

C.1.2 Using a 150 Ω load to the outside surface of the shield ("In situ CDN/ISN")

- Break the insulation and connect a 150 Ω resistor from the outside surface of the shield to ground.
- Apply a ferrite tube or clamp between 150 Ω connection and AE.
- Measure current with a current probe and compare to the current limit. The common mode impedance towards the right of the 150 Ω resistor shall be sufficiently large as not to affect the measurement. Use clause C.2 to measure this impedance which should be much greater than 150 Ω so as not to affect the measurement for frequencies emitted by the EUT.
- Voltage measurement is also possible either in parallel with the 150 Ω resistor with a high impedance probe, or by using a "50 Ω to 150 Ω adaptor" described in IEC 61000-4-6 as 150 Ω load, and applying the appropriate correction factor (9,6 dB in case of the "50 Ω to 150 Ω adaptor").

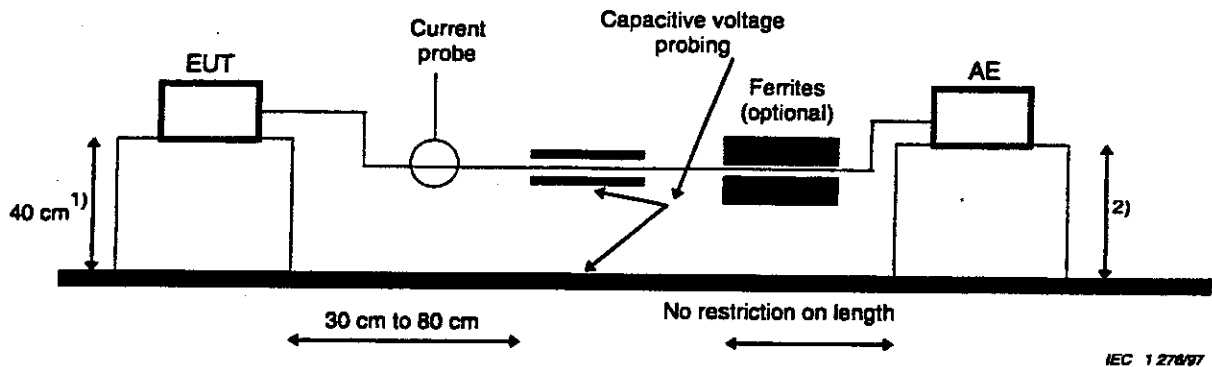


- 1) Distance to the reference groundplane (vertical or horizontal).
- 2) Distance to the reference groundplane is not critical.

Figure C.2

C.1.3 Using a combination of current probe and capacitive voltage probe

- Measure current with a current probe.
- Measure voltage with a capacitive probe (size of the capacitive clamp > 50 cm in length, impedance of the voltage probe > 1 MΩ in parallel with a capacitance <5 pF).
- Compare the measured voltage with the voltage limit.
- Compare the measured current with the current limit.
- The EUT shall meet both the voltage and current limits.



AE = Associated equipment
EUT = Equipment under test

- 1) Distance to the reference groundplane (vertical or horizontal).
- 2) Distance to the reference groundplane is not critical.

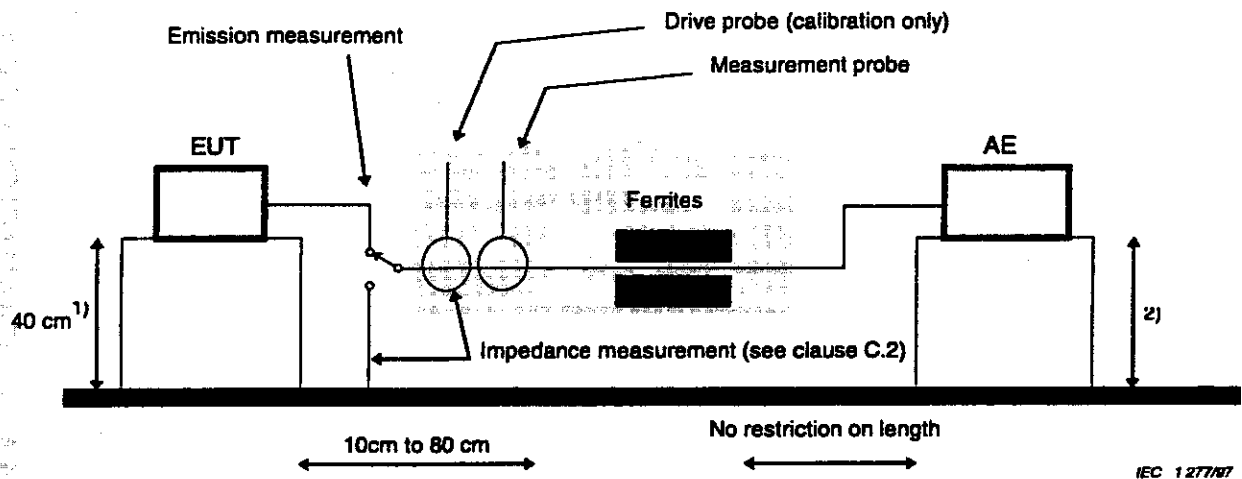
Figure C.3

C.1.4 Using no shield connection to ground and no ISN

- Apply ferrite material.
- By preliminary measurement, determine the frequencies emitted by the EUT.
- Record common mode impedance of cable, ferrite and AE by using the procedure shown in clause C.2 at frequencies emitted by the EUT. The position of the ferrite shall be adjusted until the common mode impedance is $150 \Omega \pm 20 \Omega$, this position shall be recorded. The ferrite shall be placed in this position during the measurement of the common mode current.

NOTE – Different types of ferrite may be required for different frequencies to achieve $150 \Omega \pm 20 \Omega$.

- Measure current with the current probe. The second probe in the figure is the "drive" probe used in the calibration procedure used in clause C.2. This probe shall not be used during compliance measurement but is used to verify the common mode impedance.
- Compare the measured current to the current limit.



AE = Associated equipment
EUT = Equipment under test

1) Distance to the reference groundplane (vertical or horizontal).

2) Distance to the reference groundplane is not critical.

Figure C.4

C.2 Measurement of cable, ferrite and AE common mode impedance

- Calibrate the "drive" and measurement probe 50 Ω system (see figure C.5). Insert a drive voltage (V_1) from a signal generator into the "drive" probe and record the resulting current (I_1) in the measurement probe.
- Remove the cable from the EUT and short it to ground at the EUT end (see figure C.5).
- Apply the same drive voltage (V_1) to the cable with the same "drive" probe.
- Measure the current with the same measurement probe and calculate the common mode impedance of the cable, ferrite and AE combination by comparing the current (I_2) read by the measurement probe with that in the first step (common mode impedance = $50 \times I_1 / I_2$). For example, if I_2 is half I_1 , then the common mode impedance is 100 Ω .

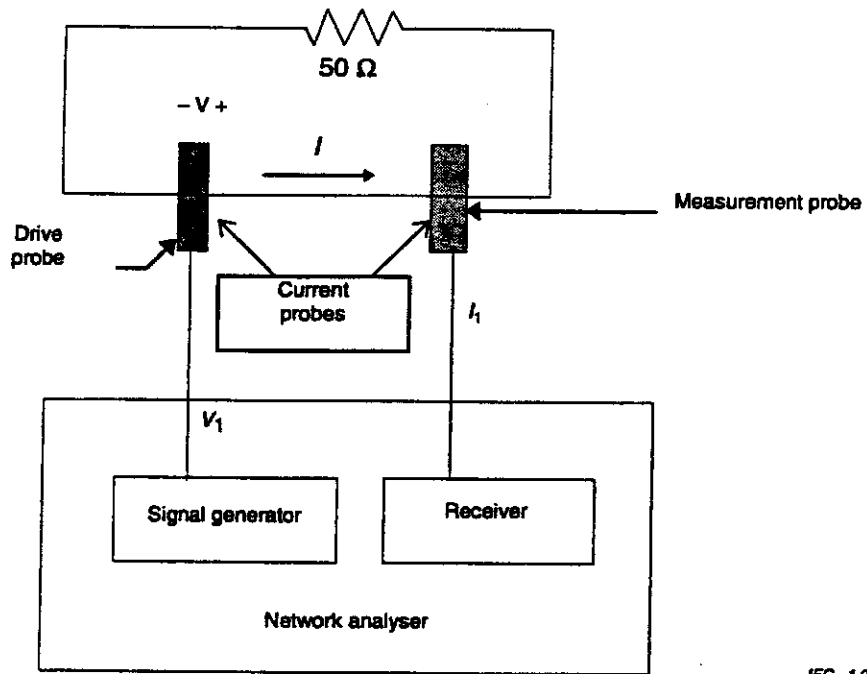
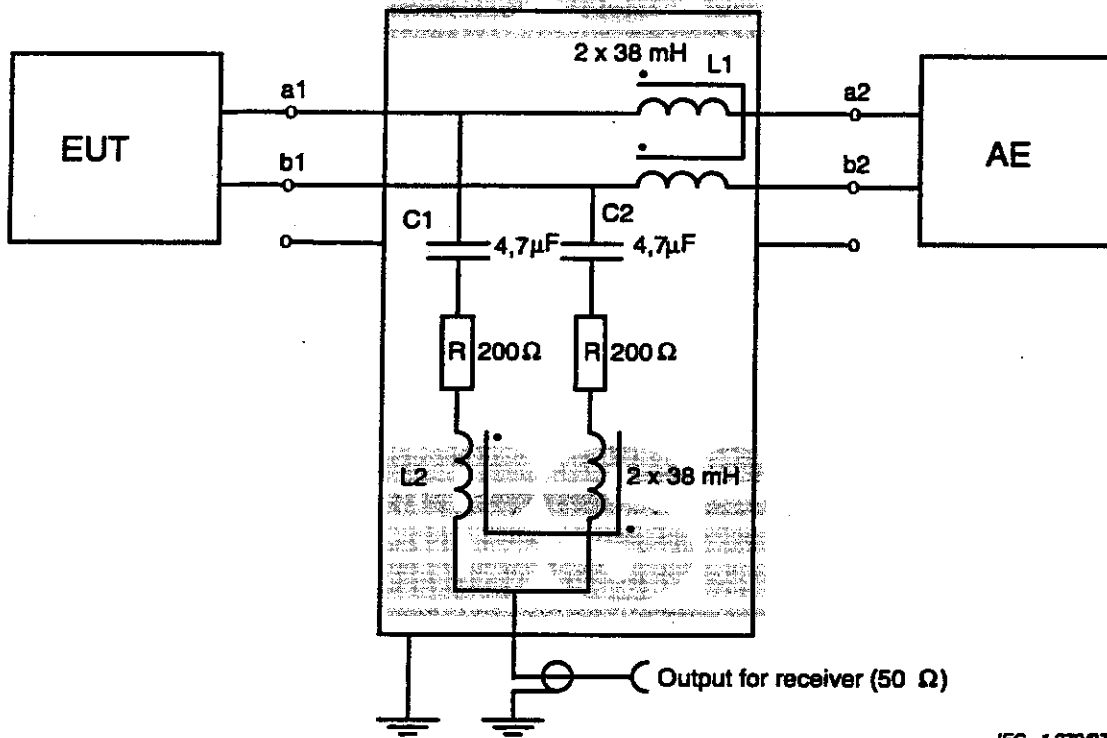


Figure C.5 – Calibration fixture

Annex D
(informative)

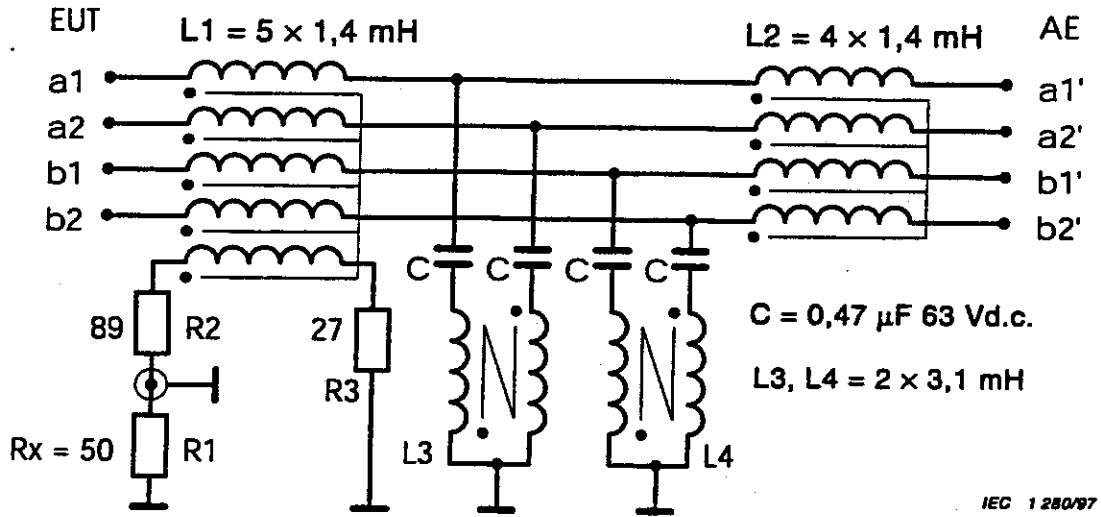
Schematic diagrams of impedance
stabilization networks (ISN)



IEC 1279/97

AE = Associated equipment
EUT = Equipment under test

Figure D.1 – ISN for use with unscreened single balanced pairs



AE = Associated equipment
EUT = Equipment under test

Figure D.2 – ISN with high longitudinal conversion loss for use with two unscreened single balanced pairs

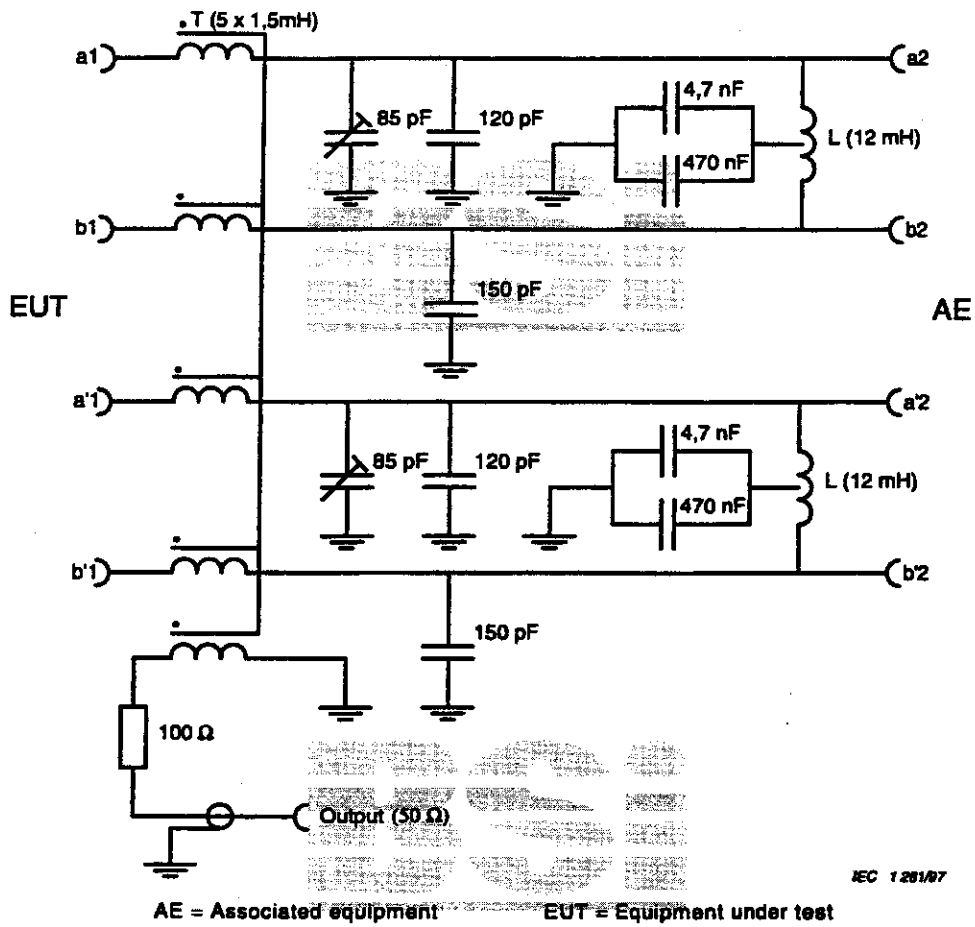


Figure D.3 – ISN for use with two unscreened single balanced pairs

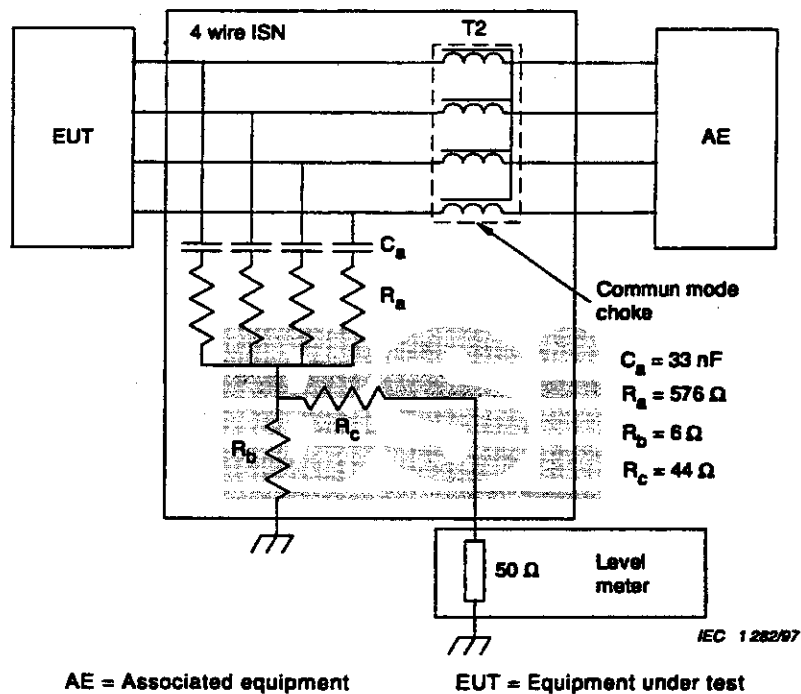


Figure D.4 – ISN for use with two unscreened single balanced pairs

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Annex E (informative)

Parameters of signals at telecommunication ports

E.1 General

No limits are defined for differential current or voltage signal levels in this standard.

However, the maximum signal levels that can be present at telecommunication ports in differential mode are dependent upon, and are limited by, the electrical balance or longitudinal conversion loss (LCL) [1] [2] of the telecommunication ports and the cables or networks to which they are intended to be connected, if the wanted signals are not to appear as unacceptable disturbances across the common mode impedance to ground.

The LCL of a signal port, cable, or network causes a portion of any differential signals on that port, cable, or network to be converted to common mode disturbances for which this standard has defined limits [3] [4] [5]. Common mode disturbances (also called antenna mode disturbances because they are a source of radiated disturbances in the environment) must be limited if interference with the reception of radio signals of all kinds is to be minimized. Common mode disturbances created at a nominally balanced signal port or transmission medium, for example a twisted copper pair, must be controlled and limited whether or not the port or medium is provided with an overall shield. If a shielded medium is used, deficiencies in the shield itself as well as in the shield connectors – leading perhaps to significant electrical discontinuities – will allow a portion of the common mode disturbances created within the shield environment to appear outside the shield.

The worst-case values for balance and LCL quoted in many network specifications are based upon the desired signal transmission and crosstalk performance of the networks and do not necessarily have regard for the control of the common mode disturbances considered in this standard.

To ensure that the physical layer specifications for telecommunication networks do not inadvertently lead to the generation of unacceptable electromagnetic disturbances, it is essential that the electromagnetic compatibility (EMC) implications of the specifications for some critical parameters be considered early in the development of the network standards.

To achieve EMC of telecommunication networks employing twisted pair media, the most important parameters to consider are:

- the levels specified for the wanted transverse or differential mode electrical signals;
- the spectral characteristics of the line codes specified for the wanted differential signals;
- the design of the protocol of the wanted differential signals;
- the expected electrical balance or LCL of the physical copper media, *in situ*, on which the wanted electrical signals will be conveyed;
- the electrical balance or LCL of the telecommunication signal ports of the medium attachment units which will be connected to the physical media;
- the differential mode and the common mode impedances expected of the physical media on which the wanted differential signals will be conveyed;

- the differential mode and the common mode impedances specified at the telecommunication signal ports of the medium attachment units on which the wanted differential signals will appear;
- the shielding effectiveness expected of connectors and shields if shielded media are to be used.

The influence of the absolute levels of the wanted differential signals on the resultant common mode disturbance levels needs little elaboration. In the absence of non-linearities, the levels of the common mode disturbances resulting from differential mode to common mode conversion by electrical unbalance of the telecommunication ports or the physical media will be directly proportional to the levels of the wanted differential signals.

The spectral characteristics and the protocols specified for the wanted differential signals will also have a major influence on the levels of the common mode disturbances appearing on the physical media.

For a given data rate, a differential signal employing line coding designed to spread the signal power across a wide range of frequencies is less likely to create unacceptable common mode disturbances than is a differential signal line code that concentrates the power into a narrow spectral band or bands.

Selection of the signal protocols can significantly influence the spectral characteristics of the differential signals. The formats of Start and End Delimiters, Framing and Synchronization bit patterns, the bit patterns of Tokens, and ultimately the design of the Access Control protocols, have a major influence on how much concentration of differential signal power into narrow spectral bands takes place during the various operating states (high traffic periods, low traffic periods, idle periods) of telecommunication networks. The creation of highly periodic waveforms which persist for lengthy periods of time should be avoided, if the levels of common mode disturbances, created from the differential signals on the network, are to be minimized.

E.2 Estimation of common mode disturbance levels

Estimations can be made of the levels of common mode disturbances that will be created by differential mode to common mode conversion of the wanted differential signals if the relationships between the important electrical and spectral parameters are known. In particular, estimations can be made of the maximum allowed levels for differential signals, if the common mode disturbances created from them are not to exceed the common mode disturbance limits.

Consider two items connected together in a LAN, for example a nominally balanced telecommunication signal port connected to a nominally balanced unshielded twisted pair terminated in its characteristic impedance. Assume that the electrical unbalance of the combination of these two items is dominated by the electrical unbalance of the item which exhibits the worst (lowest) LCL. The strength of the common mode disturbances produced by differential mode to common mode conversion through the LCL of that item can be estimated approximately from

$$I_{cm} \text{ (dB}\mu\text{A)} = U_T \text{ (dB}\mu\text{V)} - \text{LCL (dB)} - 20 \log_{10} \left| 2Z_0 \frac{Z_{cm} + Z_{ct}}{Z_0 + 4Z_{cm}} \right| \quad (\text{E.1})$$

when estimating the common mode current I_{cm} caused by the differential signal voltage, and

$$U_{cm} \text{ (dB}\mu\text{V)} \approx U_T \text{ (dB}\mu\text{V)} - \text{LCL (dB)} - 20 \log_{10} \left| \frac{2 Z_0}{Z_{cm}} \cdot \frac{Z_{cm} + Z_{ct}}{Z_0 + 4 Z_{cm}} \right| \quad (\text{E.2})$$

when estimating the common mode voltage U_{cm} caused by the differential signal voltage U_T ,

where

Z_{cm} is the common mode impedance presented by the item having the worst (lowest) LCL;

Z_{ct} is the common mode impedance presented by the item with the higher LCL;

Z_0 is the transverse or differential mode impedance at the telecommunication signal port.

The above expressions, which have been derived from relationships developed in [6], implicitly assume that both of the items in the combination present a transverse or differential impedance of Z_0 .

By setting the common mode disturbance levels in the equations equal to the common mode disturbance limits, the maximum allowable transverse or differential signal levels can be estimated.

When making use of the above equations it should be recalled that a common mode disturbance limit is a quantity that is specified for comparison with disturbances measured in a defined bandwidth (for example, 9 kHz) using a specified detector function (quasi-peak or average). Therefore, for the given LCL the maximum allowed differential signal levels estimated using the above expressions are those which are allowed to appear in the same bandwidth when measured differentially with the same detector functions.

E.3 Reference documents

- [1] ITU-T Recommendation G.117: 1996, Transmission aspects of unbalance about earth
- [2] ITU-T Recommendation O.9: 1988, Measuring arrangements to assess the degree of unbalance about earth
- [3] Daneffel, H.R. and Ryser, H., *Problem on the ISDN subscriber S and U interface*, ISSLS 86, pp. 145-149, 1986
- [4] Davies, W.S., Macfarlane, I.P. and Ben-Meir, D., "Potential EMI from ISDN basic access systems," *Electronic Letters*, Vol. 24, No. 9, pp. 533-534, April 1988
- [5] Kuwabara, N., Amemiya, F. and Ideguchi, T., "Interference field emission due to unbalance in telecommunication lines," *IEEE Int. Symp. on EMC, Nagoya*, pp. 487-492, Sept. 1989
- [6] van Maurik, R.M., "Potential Common Mode Currents On The ISDN S And T-Interface Caused By Cable Unbalance", *IEEE Eighth International Conference on Electromagnetic Compatibility, Edinburgh, 21-24 September, 1992*, IEE Conference Publication No. 362, pp. 202-206.
- [7] Haas, Lee & Christensen, Ken, *LAN Traffic Conditions for EMI Compliance Testing*, IBM Corporation, Research Triangle Park, NC.

Annex ZA (normative)

**Normative references to international publications
with their corresponding European publications**

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

NOTE: When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60083	1997	Plugs and socket-outlets for domestic and similar general use standardized in member countries of IEC	-	-
IEC 61000-4-6	1996	Electromagnetic compatibility (EMC) Part 4: Testing and measurement techniques -- Section 6: Immunity to conducted disturbances, induced by radio-frequency fields	EN 61000-4-6	1996
CISPR 11 (mod)	1990	Limits and methods of measurement of radio disturbance characteristics of industrial, scientific and medical (ISM) radio-frequency equipment	EN 55011 ¹⁾	1991
CISPR 16-1	1993	Specification for radio disturbance and immunity measuring apparatus and methods Part 1: Radio disturbance and immunity measuring apparatus	-	-
CISPR 16-2	1996	Part 2: Methods of measurement of disturbances and immunity	-	-
ISO/IEC 11801	1995	Information technology - Generic cabling for customer premises	-	-

1) EN 55011 is superseded by EN 55011:1998, which is based on CISPR 11:1997 (mod).

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