

Specification for radio disturbance and immunity measuring apparatus and methods —

**Part 1-2: Radio disturbance and
immunity measuring apparatus —
Ancillary equipment — Conducted
disturbances**

ICS 33.100.10; 33.100.20

National foreword

This British Standard is the UK implementation of EN 55016-1-2:2004+A2:2006. It is identical with CISPR 16-1-2:2003, incorporating amendments 1:2005 and 2:2006 and corrigendum January 2009. It supersedes BS EN 55016-1-2:2004 which is withdrawn. Together with BS EN 55016-1-1:2004, BS EN 55016-1-3:2004, BS EN 55016-1-4:2004 and BS EN 55016-1-5:2004 it supersedes BS CISPR 16-1:1999 which is withdrawn.

The standards in the new BS EN 55016 series referred to above have been produced following the publication by CISPR of a new multi-part edition of CISPR 16 and constitute an editorial reorganization of CISPR 16 without technical changes. This has resulted in the BS CISPR 16 series being replaced as follows:

BS CISPR 16-1:1999 replaced by BS EN 55016-1-1:2004,
BS EN 55016-1-2:2004, BS EN 55016-1-3:2004, BS EN 55016-1-4:2004 and
BS EN 55016-1-5:2004.

BS CISPR 16-2:1996 replaced by BS EN 55016-2-1:2004,
BS EN 55016-2-2:2004, BS EN 55016-2-3:2004 and BS EN 55016-2-4:2004.

BS CISPR 16-3:2000 replaced by PD CISPR/TR 16-3:2003,
PD CISPR/TR 16-4-1:2003, PD CISPR/TR 16-4-3:2003 and
PD CISPR/TR 16-4-4:2003.

BS CISPR 16-4:2002 replaced by BS EN 55016-4-2:2004.

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**Specification for radio disturbance and immunity
measuring apparatus and methods
Part 1-2: Radio disturbance and immunity measuring apparatus –
Ancillary equipment –
Conducted disturbances**

Spécifications des méthodes et des appareils
de mesure des perturbations radioélectriques
et de l'immunité aux perturbations
radioélectriques
Partie 1-2: Appareils de mesure
des perturbations radioélectriques
et de l'immunité aux perturbations
radioélectriques –
Matériels auxiliaires –
Perturbations conduites

Anforderungen an Geräte und Einrichtungen
sowie Festlegung der Verfahren zur Messung
der hochfrequenten Störaussendung
(Funkstörungen) und Störfestigkeit Teil 1-2:
Geräte und Einrichtungen zur Messung der
hochfrequenten Störaussendung
(Funkstörungen) und Störfestigkeit –
Zusatz-/Hilfseinrichtungen –
Leitungsgeführte Störaussendung

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CENELEC

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

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Foreword

The text of the International Standard CISPR 16-1-2:2003, prepared by CISPR SCA, Radiointerference measurements and statistical methods, was submitted to the formal vote and was approved by CENELEC as EN 55016-1-2 on 2004-09-01 without any modification.

The following dates were fixed:

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- latest date by which the national standards conflicting
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Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard CISPR 16-1-2:2003 was approved by CENELEC as a European Standard without any modification.

Foreword to amendment A1

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with the amendment have to be withdrawn (dow) 2008-02-01

Endorsement notice

The text of amendment 1:2004 to the International Standard CISPR 16-1-2:2003 was approved by CENELEC as an amendment to the European Standard without any modification.

Foreword to amendment A2

The text of document CISPR/A/654/FDIS, future amendment 2 to CISPR 16-1-2:2003, prepared by CISPR SC A, Radio-interference measurements and statistical methods, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as amendment A2 to EN 55016-1-2:2004 on 2006-11-01.

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Endorsement notice

The text of amendment 2:2006 to the International Standard CISPR 16-1-2:2003 was approved by CENELEC as an amendment to the European Standard without any modification.

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INTRODUCTION

CISPR 16-1, CISPR 16-2, CISPR 16-3 and CISPR 16-4 have been reorganised into 14 parts, to accommodate growth and easier maintenance. The new parts have also been renumbered. See the list given below.

Old CISPR 16 publications		New CISPR 16 publications	
CISPR 16-1	Radio disturbance and immunity measuring apparatus	CISPR 16-1-1	Measuring apparatus
		CISPR 16-1-2	Ancillary equipment – Conducted disturbances
		CISPR 16-1-3	Ancillary equipment – Disturbance power
		CISPR 16-1-4	Ancillary equipment – Radiated disturbances
		CISPR 16-1-5	Antenna calibration test sites for 30 MHz to 1 000 MHz
CISPR 16-2	Methods of measurement of disturbances and immunity	CISPR 16-2-1	Conducted disturbance measurements
		CISPR 16-2-2	Measurement of disturbance power
		CISPR 16-2-3	Radiated disturbance measurements
		CISPR 16-2-4	Immunity measurements
CISPR 16-3	Reports and recommendations of CISPR	CISPR 16-3	CISPR technical reports
		CISPR 16-4-1	Uncertainties in standardised EMC tests
		CISPR 16-4-2	Measurement instrumentation uncertainty
		CISPR 16-4-3	Statistical considerations in the determination of EMC compliance of mass-produced products
CISPR 16-4	Uncertainty in EMC measurements	CISPR 16-4-4	Statistics of complaints and a model for the calculation of limits

More specific information on the relation between the 'old' CISPR 16-1 and the present 'new' CISPR 16-1-2 is given in the table after this introduction (TABLE RECAPITULATING CROSS REFERENCES).

Measurement instrumentation specifications are given in five new parts of CISPR 16-1, while the methods of measurement are covered now in four new parts of CISPR 16-2. Various reports with further information and background on CISPR and radio disturbances in general are given in CISPR 16-3. CISPR 16-4 contains information related to uncertainties, statistics and limit modelling.

CISPR 16-1 consists of the following parts, under the general title *Specification for radio disturbance and immunity measuring apparatus and methods – Radio disturbance and immunity measuring apparatus*:

- Part 1-1: Measuring apparatus,
- Part 1-2: Ancillary equipment – Conducted disturbances,
- Part 1-3: Ancillary equipment – Disturbance power,
- Part 1-4: Ancillary equipment – Radiated disturbances,
- Part 1-5: Antenna calibration test sites for 30 MHz to 1 000 MHz.

TABLE RECAPITULATING CROSS-REFERENCES

Second edition of CISPR 16-1

Clauses, subclauses

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 3.8, ..., 3.10
 3.20, .., 3.23

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 6, 7, 8, 9, 10
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 A.6
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 C.1, ..., C.5
 D.1, D.2
 E.1, ..., E.6

SPECIFICATION FOR RADIO DISTURBANCE AND IMMUNITY MEASURING APPARATUS AND METHODS –

Part 1-2: Radio disturbance and immunity measuring apparatus – Ancillary equipment – Conducted disturbances

1 Scope

This part of CISPR 16 is designated a basic standard, which specifies the characteristics and performance of equipment for the measurement of radio disturbance voltages and currents in the frequency range 9 kHz to 1 GHz.

Specifications for ancillary apparatus are included for: artificial mains networks, current and voltage probes and coupling units for current injection on cables.

The requirements of this publication shall be complied with at all frequencies and for all levels of radio disturbance voltages and currents within the CISPR indicating range of the measuring equipment.

Methods of measurement are covered in Part 2, and further information on radio disturbance is given in Part 3 of CISPR 16.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

CISPR 14-1:2000, *Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus – Part 1: Emission*

CISPR 16-1-1:2003, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-1: Radio disturbance and immunity measuring apparatus – Measuring apparatus*

CISPR 16-2-1:2003, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-1: Methods of measurement of immunity and disturbance – Conducted disturbance measurements*

CISPR 16-3:2003, *Specification for radio disturbance and Immunity measuring apparatus and methods – Part 3: CISPR Technical reports*

CISPR 16-4-1:2003, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-1: Uncertainties, statistics and limit modelling – Uncertainties in standardized EMC tests*

CISPR 16-4-2:2003, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-2: Uncertainties, statistics and limit modelling – Measurement instrumentation uncertainties*

IEC 60050(161):1990, *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic compatibility*

International Vocabulary of Basic and General Terms in Metrology, International Organization for Standardization, Geneva, 2nd edition, 1993

3 Definitions

For the purpose of this part of CISPR 16, the following definitions apply. Also see IEC 60050(161).

3.1

symmetric voltage

in a two-wire circuit, such as a single-phase mains supply, the symmetric voltage is the radio-frequency disturbance voltage appearing between the two wires. This is sometimes called the differential mode voltage. If V_a is the vector voltage between one of the mains terminals and earth and V_b is the vector voltage between the other mains terminal and earth, the symmetric voltage is the vector difference ($V_a - V_b$)

3.2

asymmetric voltage

the asymmetric voltage is the radio-frequency disturbance voltage appearing between the electrical mid-point of the mains terminals and earth. It is sometimes called the common mode voltage and is half the vector sum of V_a and V_b , i.e., $(V_a + V_b)/2$

3.3

unsymmetric voltage

the amplitude of the vector voltage, V_a or V_b defined in 3.1 and 3.2. This is the voltage measured by the use of an artificial mains V-network

3.4

artificial mains network

AMN

provides a defined impedance to the EUT at radio frequencies, couples the disturbance voltage to the measuring receiver and decouples the test circuit from the supply mains. There are two basic types of AMN, the V-network (V-AMN) which couples the unsymmetrical voltages, and the delta-network which couples the symmetric and the asymmetric voltages separately. The terms line impedance stabilization network (LISN) and V-AMN are used interchangeably

3.5

asymmetric artificial network (AAN)

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

NOTE The term "Y-network" is a synonym for AAN.

3.6

impedance stabilization network (ISN)

generally an artificial network that provides a stabilized impedance to the EUT; often (e.g. in CISPR 22) used as a synonym for AAN

3.7

coupling/decoupling network (CDN)

artificial network for the measurement or injection of signals on one circuit while preventing signals from being measured or injected on another circuit 

A₂ 3.8 A₂**longitudinal conversion loss (LCL)**

in a one- or two-port network, a measure (a ratio expressed in dB) of the degree of unwanted transverse (symmetric mode) signal produced at the terminals of the network due to the presence of a longitudinal (asymmetric mode) signal on the connecting leads (definition from ITU-T Recommendation O.9¹⁾)

4 Artificial mains networks

An artificial mains network is required to provide a defined impedance at radio frequencies at the terminals of the equipment under test, to isolate the test circuit from unwanted radio-frequency signals on the supply mains, and to couple the disturbance voltage to the measuring receiver.

There are two basic types of artificial mains networks, the V-network which couples the unsymmetric voltages, and the delta-network which couples the symmetric and the asymmetric voltages separately.

For each mains conductor, there are three terminals: the mains terminal for connection to the supply mains, the equipment terminal for connection to the equipment under test, and the disturbance output terminal for connection to the measuring equipment.

A₂ NOTE 1 Examples of circuits of artificial mains networks are given in annex A.

NOTE 2 This clause specifies impedance and isolation requirements for the AMN including the corresponding measurement methods. Some background and rationale on the AMN related uncertainties is given in 6.2.3 of CISPR 16-4-1 and in CISPR 16-4-2.

4.1 AMN impedance

The specification of the impedance of an artificial mains network includes magnitude and phase of the impedance measured at an EUT terminal with respect to reference earth, when the receiver port is terminated with 50 Ω .

The impedance at the EUT terminals of the artificial mains network defines the termination impedance presented to the equipment under test. For this reason, when a disturbance output terminal is not connected to the measuring receiver, it shall be terminated by 50 Ω . In order to assure accurate termination into 50 Ω of the receiver port, a 10-dB attenuator shall be used either inside or external to the network, the VSWR of which (seen from either side) shall be less than or equal to 1,2 to 1. The attenuation shall be included in the measurement of the voltage division factor (see 4.10).

The impedance between each conductor (except PE) of the EUT terminal and reference earth shall comply with 4.2, 4.3, 4.4, 4.5 or 4.6 as appropriate for any value of external impedance, including a short circuit connected between the corresponding mains terminal and reference earth. This requirement shall be met at all temperatures which the network may reach under normal conditions for continuous currents up to the specified maximum. The requirement shall also be met for peak currents up to the specified maximum. **A₂**

1) ITU-T Recommendation O.9, *Measuring arrangements to assess the degree of unbalance about earth*.

A₂ Where the phase requirement cannot be met, the measured phase angles may be taken into account in the uncertainty budget according to CISPR 16-4-2. Annex I gives guidelines for the calculation of the uncertainty contribution of the phase if the tolerance is exceeded.

NOTE Since EUT connectors are not optimized for radio frequencies up to 30 MHz, the measurement of the network impedance must be carried out with special measurement adaptors to enable short connections. The NWA's OSM (open/short/matched) calibration is used to characterize the adaptors, taking the insertion loss and the conductor lengths of the adaptors into account. **A₂**

4.2 50 Ω /50 μ H + 5 Ω artificial mains V-network (for use in the frequency range 9 kHz to 150 kHz)

A₂ The AMN shall have the impedance (magnitude and phase) versus frequency characteristic shown in Table 3 and Figure 1a in the relevant frequency range. Tolerances of ± 20 % for the magnitude and of $\pm 11,5^\circ$ for the phase are permitted.

Table 3 – Magnitudes and phase angles of the V-network (see Figure 1a)

Frequency MHz	Impedance magnitude Ω	Phase angle Degree
0,009	5,22	26,55
0,015	6,22	38,41
0,020	7,25	44,97
0,025	8,38	49,39
0,030	9,56	52,33
0,040	11,99	55,43
0,050	14,41	56,40
0,060	16,77	56,23
0,070	19,04	55,40
0,080	21,19	54,19
0,090	23,22	52,77
0,100	25,11	51,22
0,150	32,72	43,35

NOTE If this AMN meets the combined impedance requirements of this subclause and 4.3., it can be used in the frequency range 150 kHz to 30 MHz as well. **A₂**

4.3 50 Ω /50 μ H artificial mains V-network (for use in the frequency range 0,15 MHz to 30 MHz)

 The AMN shall have the impedance (magnitude and phase) versus frequency characteristic shown in Table 4 and Figure 1b in the relevant frequency range. Tolerances of ± 20 % for the magnitude and of $\pm 11,5^\circ$ for the phase are permitted.

Table 4 – Magnitudes and phase angles of the V-Network (see Figure 1b)

Frequency MHz	Impedance magnitude Ω	Phase angle Degree
0,15	34,29	46,70
0,17	36,50	43,11
0,20	39,12	38,51
0,25	42,18	32,48
0,30	44,17	27,95
0,35	45,52	24,45
0,40	46,46	21,70
0,50	47,65	17,66
0,60	48,33	14,86
0,70	48,76	12,81
0,80	49,04	11,25
0,90	49,24	10,03
1,00	49,38	9,04
1,20	49,57	7,56
1,50	49,72	6,06
2,00	49,84	4,55
2,50	49,90	3,64
3,00	49,93	3,04
4,00	49,96	2,28
5,00	49,98	1,82
7,00	49,99	1,30
10,00	49,99	0,91
15,00	50,00	0,61
20,00	50,00	0,46
30,00	50,00	0,30



BS EN 55016-1-2:2004+A2:2006
EN 55016-1-2:2004+A2:2006 (E)

4.4 50 Ω /5 μ H + 1 Ω artificial mains V-network (for use in the frequency range 150 kHz to 100 MHz)

A₂ The AMN shall have the impedance (magnitude and phase) versus frequency characteristic shown in Table 5 and Figure 2. Tolerances of $\pm 20\%$ for the magnitude and of $\pm 11,5^\circ$ for the phase are permitted.

Table 5 – Magnitudes and phase angles of the V-Network (see Figure 2)

Frequency MHz	Impedance magnitude Ω	Phase angle Degree
0,15	4,70	72,74
0,20	6,19	73,93
0,30	9,14	73,47
0,40	12,00	71,61
0,50	14,75	69,24
0,70	19,82	64,07
1,00	26,24	56,54
1,50	33,94	46,05
2,00	38,83	38,15
2,50	41,94	32,27
3,00	43,98	27,81
4,00	46,33	21,63
5,00	47,56	17,62
7,00	48,71	12,80
10,00	49,35	9,04
15,00	49,71	6,06
20,00	49,84	4,55
30,00	49,93	3,04
50,00	49,97	1,82
100,00	49,99	0,91
108,00	49,99	0,84

A₂

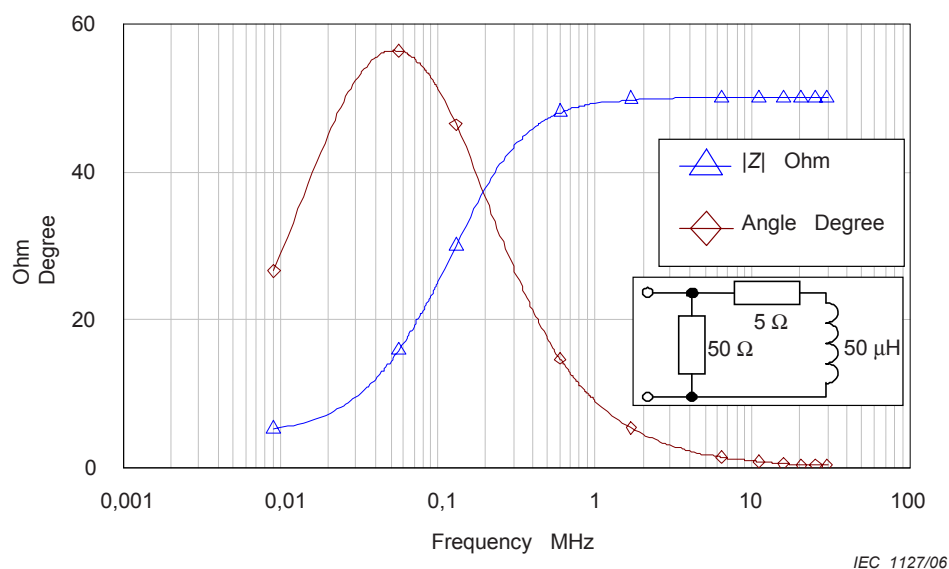
A₂

Figure 1a – Impedance (magnitude and phase) of the V-network for band A
(see 4.2, the relevant frequency range is from 9 kHz to 150 kHz)

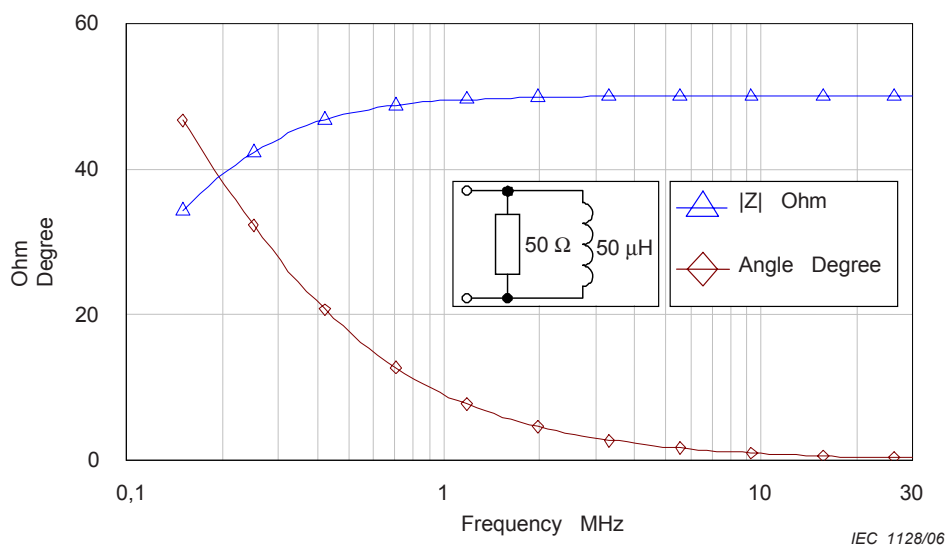


Figure 1b – Impedance (magnitude and phase) of the V-network for band B
(see 4.3)

A₂

A2

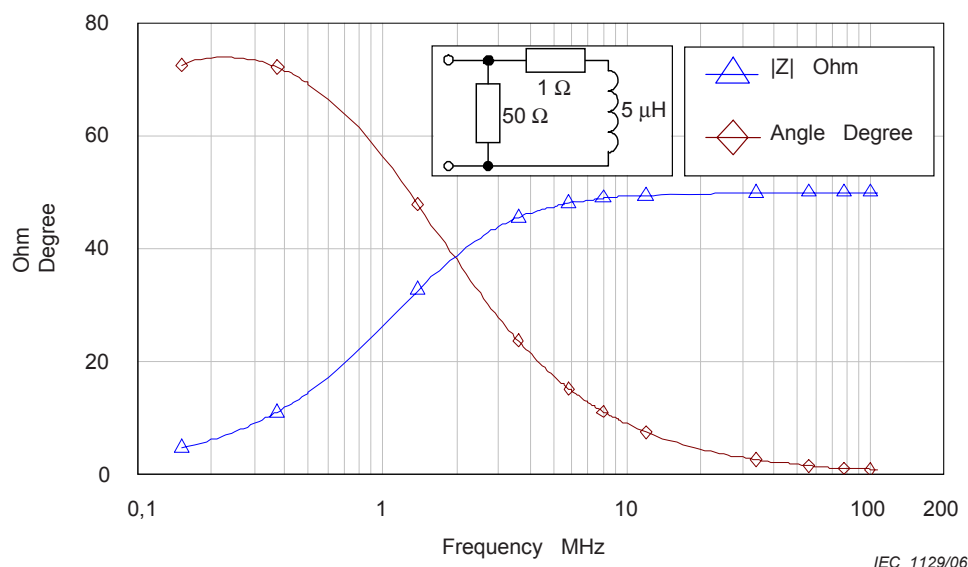


Figure 2 – Impedance (magnitude and phase) of the V-network for bands B and C (from 0,15 MHz to 108 MHz; see 4.4)

A2

4.5 150 Ω artificial mains V-network (for use in the frequency range 150 kHz to 30 MHz)

The network shall have an impedance of magnitude $150 \pm 20 \Omega$ with a phase angle not exceeding 20° .

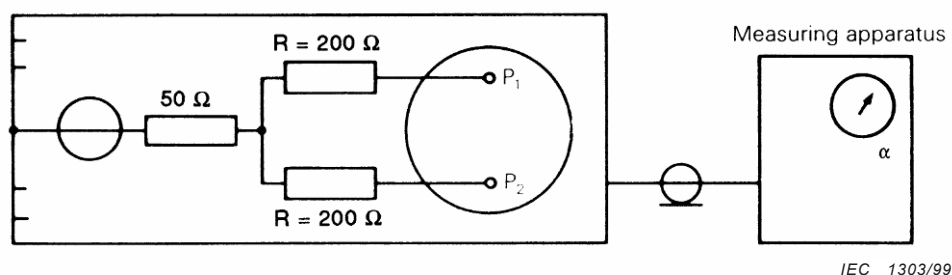
4.6 150 Ω artificial mains delta-network (for use in the frequency range 150 kHz to 30 MHz)

The network shall have an impedance of magnitude $150 \pm 20 \Omega$ with a phase angle not exceeding 20° , both between the equipment terminals and between the two equipment terminals joined together and reference earth.

For the measurement of the symmetric voltage, a screened and balanced transformer is required. To avoid appreciable modification of the impedance of the network, the input impedance of the transformer shall be not less than 1 000 Ω at all frequencies concerned. The voltage measured by the measuring receiver depends on the network component values and the transformer ratio. The network shall be calibrated.

4.6.1 Balance of the 150 Ω artificial mains delta-network

The balance of the system comprising the network and the measuring receiver connected thereto via the transformer shall be such that the measurement of symmetric voltage shall be substantially unaffected by the presence of an asymmetric voltage. The balance shall be measured using the circuit shown in figure 3.



R are the resistors of 200 Ω equal to each other within 1 %

P₁ P₂ are the terminals of network for connection of device

Figure 3 – Method for checking the balance of the arrangement for the measurement of symmetrical voltages

A voltage U_a is injected from a generator having an internal impedance of 50 Ω , between reference earth and the common point of two resistors each 200 $\Omega \pm 1$ %. The other end of these resistors is connected to the equipment terminals of the artificial mains network.

A voltage U_s is measured in the position for symmetric voltage measurement. The ratio U_a/U_s shall be greater than 20:1 (26 dB).

4.7 Isolation

A₂ 4.7.1 Requirement

To ensure that at any test frequency, unwanted signals existing on the mains side and the unknown impedance of the supply mains do not affect the measurement, a minimum isolation (decoupling factor) between each mains terminal and the receiver port for a given termination of the relevant terminal of the EUT port shall be met. The requirement applies to the V-AMN itself excluding additional external cables and filters.

Table 6 – Values of minimum isolation for V-Networks

Clause	Type of V-network	Frequency range MHz	Minimum isolation dB
4.2	50 Ω/50μH + 5 Ω	0,009 – 0,05	0 – 40*)
		0,05 – 30	40
4.3	50 Ω/50 μH	0,15 – 30	40
4.4	50 Ω/5 μH + 1 Ω	0, 15 – 3	0 – 40*)
		3 – 108	40
NOTE The values marked with an asterisk mean: minimum isolation rises linearly with the logarithm of frequency			

NOTE Additional filtering external to the AMN may be required for the suppression of disturbance on the mains port (see CISPR 16-2-1 for practical requirements). **A₂**

A2 4.7.2 Measurement procedure

The test setup is shown in Figure H.1. For the measurement, first a signal U_1 is measured across a load impedance of $50\ \Omega$ with a source impedance of $50\ \Omega$. Then this signal source shall be connected between the relevant mains terminal and reference ground, the relevant EUT terminals shall be terminated with $50\ \Omega$ and the output voltage U_2 shall be measured at the receiver port (terminated with an impedance of $50\ \Omega$). The attenuation of the 10-dB attenuator described in 4.1 shall be added to the isolation requirement. The isolation requirement shall be met for all mains and EUT terminals. If the termination of the other mains terminals influences the measurement result, then the requirement shall be met with the other mains terminals open and shorted.

The following equation shall be met:

$$U_1 - U_2 \geq F_D + A$$

where

- U_1 is the reference voltage at the mains terminals in dB(μ V);
- U_2 is the output voltage at the receiver port in dB(μ V);
- F_D is the minimum isolation (decoupling factor) requirement in dB;
- A is the attenuation of the built-in attenuator in dB.

NOTE Since EUT connectors are not optimized for radio frequencies up to 30 MHz, the measurement of the network isolation must be carried out with special measurement adaptors to enable short connections. The measurement of U_1 must be made with the adaptor connected to the source. **A2**

4.8 Current carrying capacity and series voltage drop

The maximum continuous currents and the maximum peak current shall be specified. The voltage applied to the equipment under test when passing continuous currents up to the maximum shall be not less than 95 % of the mains voltage at the mains terminals of the artificial mains network.

4.9 Modified reference earth connection

The measurement of some types of equipment may require the insertion of an impedance in the reference earth conductor in the artificial mains networks in 4.2 and 4.3 following the requirements of the related product publications. This is inserted at point X marked in the reference earth lead in figures 4 and 5, respectively. The impedance to be inserted is either a 1,6 mH inductor or an impedance conforming to the impedance requirement of 4.2 or 4.3, as appropriate for the frequency range.

NOTE For safety reasons, the $5\ \Omega$ resistor mentioned in 4.2 should be omitted.



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5 Current and voltage probes

5.1 Current probes

The asymmetrical disturbance currents of cables can be measured, without making direct conductive contact with the source conductor and without modification of its circuit, by use of specially developed clamp-on current transformers. The utility of this method is self-evident; complex wiring systems, electronic circuits, etc., may be measured without interruption of the normal operation or configuration. The current probe is constructed so that it may be conveniently clamped around the conductor to be measured. The conductor represents a one-turn primary winding. The secondary winding is contained within the current probe.

Current probes can be constructed for measurements in the frequency range 30 Hz to 1 000 MHz, although the primary measurement range is 30 Hz to 100 MHz. Beyond 100 MHz the standing currents in conventional power systems require that the current probe location be optimized for detection of the maximum current.

Current probes are designed to provide a flat frequency response over a passband. At frequencies below this flat passband accurate measurements can still be made but with decreased sensitivity due to reduced transfer impedances. At frequencies above the flat passband measurements are not accurate due to resonances in the current probe.

With an additional shielding structure, a current probe may be used to measure either the asymmetrical (common mode) or symmetrical (differential mode) current. Clause B.5 of annex B contains some construction details.

5.1.1 Construction

The current probe shall be constructed so as to enable the measurement of the current without disconnecting the lead under measurement.

Annex B contains some typical constructions of current probes.

5.1.2 Characteristics

Insertion impedance	1 Ω impedance maximum
Transfer impedance*	0,1 to 5 Ω in the flat linear range; 0,001 to 0,1 Ω below the flat linear range (current probe terminated into 50 Ω)
Added shunt capacitance	Less than 25 pF between the current probe housing and measured conductor
Frequency response	Transfer impedance is calibrated over a specified frequency range; the range of individual probes is typically 100 kHz to 100 MHz, 100 MHz to 300 MHz, and 200 MHz to 1 000 MHz
Pulse response	Under consideration
Magnetic saturation	The maximum d.c. or a.c. mains current in the primary lead for a measurement error less than 1 dB shall be specified

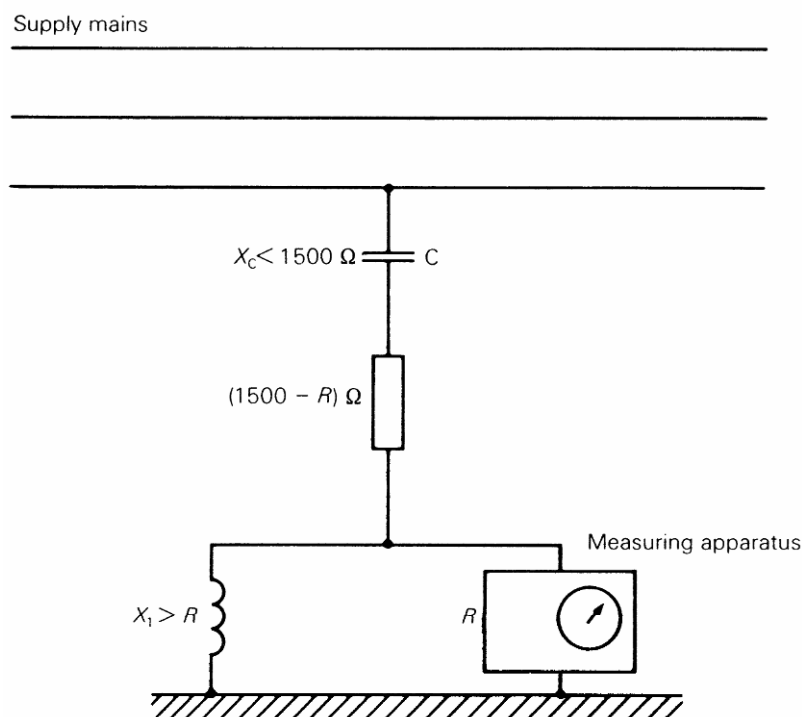
* The reciprocal transfer admittance, (in dB(S)), may be used instead. When expressed in decibels, the admittance is added to the reading of the measuring receiver. For the calibration of the transfer impedance or admittance, it may be necessary to use a jig designed for the purpose. See annex B.

Transfer impedance tolerance	Under consideration
Influence of external magnetic fields	40 dB reduction in indication when a current carrying conductor is removed from the current probe opening to a position adjacent to the probe
Influence of electric fields	Not susceptible to fields <10 V/m
Influence of orientation	Less than 1 dB up to 30 MHz and 2,5 dB from 30 MHz to 1 000 MHz, when used on a conductor of any size placed anywhere inside the aperture
Current probe opening	At least 15 mm

5.2 Voltage probe

A1 5.2.1 High impedance voltage probe

Figure 6 shows a circuit which is used to make voltage measurements between a mains conductor and reference ground. The probe consists of a blocking capacitor C and a resistor such that the total resistance between line and earth is $1\,500\ \Omega$. The probe may also be used to make measurements on other lines and for certain applications its impedance may need to be increased to avoid excessive loading of high impedance circuits. An inductor may have to be connected across the input of the measuring apparatus, for safety reasons; its inductive reactive, X_L , to be much greater than R . **A1**



NOTE $V = \frac{1\,500}{R} U$

where

V is the disturbing voltage

U is the voltage at the input of the measuring apparatus

A1 Figure 6 – Circuit for RF voltage measurement on supply mains (see 5.2.1) **A1**

The insertion loss of voltage probes shall be calibrated in a 50 Ω system over the frequency range of 9 kHz to 30 MHz. The effect on the accuracy of measurement of any device which may be used for protection should either be less than 1 dB or be allowed for in calibration. Care shall be taken to ensure that the level of disturbance is accurately measured in the presence of the ambient noise to make the measurement meaningful.

The loop formed by the lead connected to the probe, the mains conductor tested and reference ground should be minimized to reduce the effects of any strong magnetic fields.

A1 5.2.2 Capacitive voltage probe

The asymmetrical disturbance voltages of cables can be measured without making direct conductive contact with the source conductor and without modification of its circuit by the use of a clamp-on capacitive coupling device. The usefulness of this method is self-evident; complex wiring systems, electronic circuits, etc. may be measured without interruption of the normal operation or configuration of the EUT or the need to cut the cable to insert a measuring device. The capacitive voltage probe is constructed so that it may be conveniently clamped around the conductor to be measured.

The capacitive voltage probe is used for measurements of conducted disturbances in the frequency range 150 kHz to 30 MHz with an almost flat frequency response in the frequency range of interest. The voltage division factor, which is defined as the ratio of the disturbance voltage on the cable to the input voltage at the measuring receiver, depends on the type of cable. This parameter should be calibrated over a specified frequency range for each cable type, using the method described in Annex G.

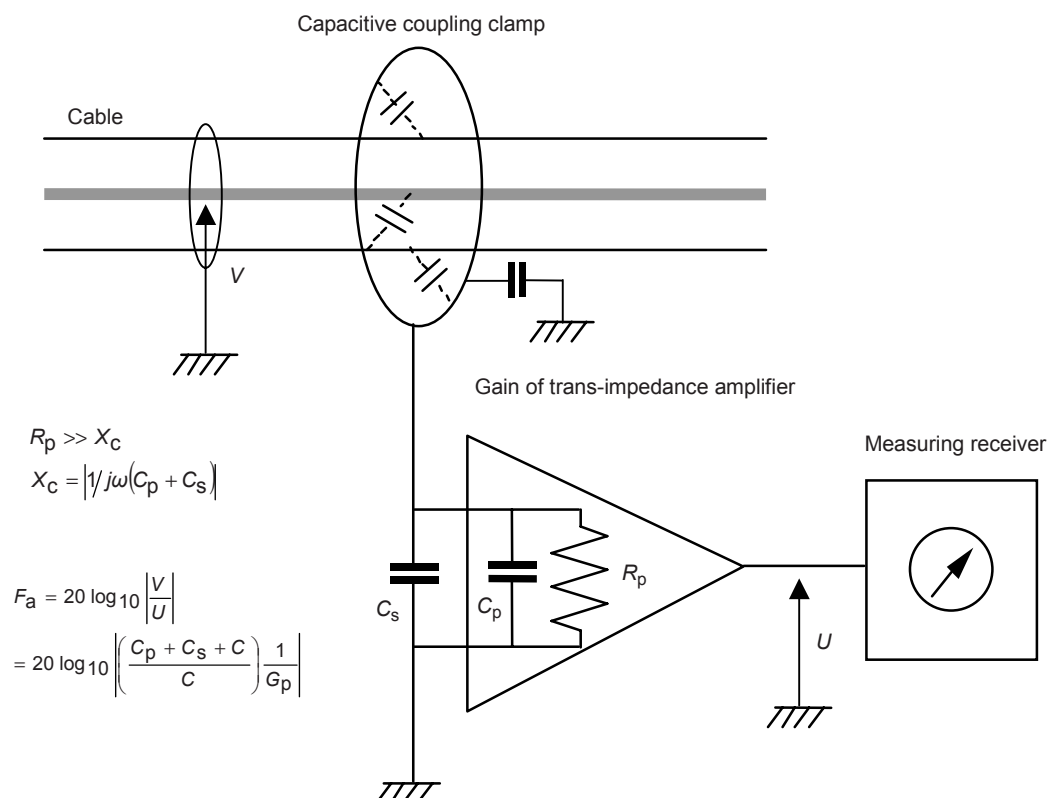
The capacitive voltage probe may need additional shielding to provide sufficient isolation from the asymmetrical (common mode) signal around the cable (see "Influence of electric field" in 5.2.2.2). Annex G contains an example of the construction and a method of measurement for the isolation.

This capacitive voltage probe can be used to measure the disturbances at telecommunication ports. The minimum measurable level is typically up to 44 dB(μ V).

5.2.2.1 Construction

The capacitive voltage probe shall be constructed so as to enable the measurement of the voltage without disconnecting the cable under measurement. Figure 11 shows a circuit that is used to make voltage measurements between a cable and a reference ground. The probe consists of a capacitive coupling clamp which is connected to a trans-impedance amplifier. The input resistance R_p of this amplifier shall be large enough compared to the reactance X_c to obtain a flat frequency response. **A1**

A1



IEC 437/04

Figure 11 – Circuit used to make voltage measurement between a cable and a reference ground

Annex G provides instructions for the typical construction and verification of the capacitive voltage probe. A1

5.2.2.2 Requirements

Added shunt capacitance:	Less than 10 pF between the grounding terminal of capacitive voltage probe and the cable under test.
Frequency response:	Voltage division factor, $F_a = 20 \log_{10} V/U $ in dB (see Figure 11), is calibrated over a specified frequency range.
Pulse response:	Maintain linearity for the pulse determined by the method in Annexes B and C of CISPR 16-1-1 for band B.
Influence of electric field: (influence caused by electrostatic coupling with other cables near the probe)	The voltage indication is reduced by more than 20 dB when a cable is removed from the capacitive voltage probe. The measurement method is described in Annex G.
Capacitive voltage probe aperture or opening: (aperture when the two coaxial electrodes open at the slot (see Figure G.1))	At least 30 mm

6 Coupling units for conducted current immunity measurement

The coupling units are designed to inject the disturbance current on to the leads under test and to isolate the other leads and any apparatus which is connected to the equipment under test from the effects of these currents. With a 150 Ω source impedance, there is a useful correlation between the RF disturbance field strength acting on a real installation and the e.m.f. that must be applied in the current injection method to produce the same degree of impairment, at least for frequencies up to 30 MHz. The immunity of an apparatus is expressed by this e.m.f. value. Annexes C and D give the principle of operation and examples of types of units and their construction.

6.1 Characteristics

The performance checks of the coupling units are done on the impedance in the frequency range 0,15 MHz to 30 MHz and on insertion loss in the frequency range 30 MHz to 150 MHz.

6.1.1 Impedance

In the frequency range 0,15 MHz to 30 MHz, the total asymmetric impedance (RF choke coil in parallel with the 150 Ω resistive disturbance source impedance) measured between the point of injection of the disturbance signal to the equipment under test and the ground of the unit shall have a modulus of 150 $\Omega \pm 20 \Omega$ and a phase angle less than $\pm 20^\circ$ (this impedance is the same as the CISPR 150 Ω artificial mains V-network, see 4.4).

For example, for coupling units type A and S, the point of injection is the shield of the output connector; for types M and L, the point of injection is the joint output terminals.