

**Specification for radio disturbance and immunity
measuring apparatus and methods –**

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

*This **English-language** version is derived from the original **bilingual** publication by leaving out all French-language pages. Missing page numbers correspond to the French-language pages.*



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

CISPR 16-1-2

First edition
2003-11

INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

Specification for radio disturbance and immunity measuring apparatus and methods –

Part 1-2:

Radio disturbance and immunity measuring apparatus – Ancillary equipment – Conducted disturbances

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INTERNATIONAL ELECTROTECHNICAL COMMISSION
INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

**SPECIFICATION FOR RADIO DISTURBANCE AND IMMUNITY
MEASURING APPARATUS AND METHODS –**

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

FOREWORD

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International Standard CISPR 16-1-2 has been prepared by CISPR subcommittee A: Radio interference measurements and statistical methods.

This first edition of CISPR 16-1-2, together with CISPR 16-1-1, CISPR 16-1-3, CISPR 16-1-4 and CISPR 16-1-5, cancels and replaces the second edition of CISPR 16-1, published in 1999, amendment 1 (2002) and amendment 2 (2003). It contains the relevant clauses of CISPR 16-1 without technical changes.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until 2004. At this date, the publication will be

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- withdrawn;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

Withdrawn

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

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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

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

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.

3.5

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

3.6

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

3.7

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⁾)

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

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.

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

4.1 Network impedance

The impedance of an artificial mains network is the magnitude of the impedance with respect to reference earth measured at an equipment terminal when the corresponding disturbance output terminal is terminated with $50\ \Omega$.

The impedance at the equipment 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 $50\ \Omega$.

The impedance of each of the mains conductors of the network 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 or the RF filter described in 4.7, 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.

4.2 $50\ \Omega/50\ \mu\text{H} + 5\ \Omega$ artificial mains V-network (for use in the frequency range 9 kHz to 150 kHz)

The network shall have the impedance versus frequency characteristic shown in figure 1a in the relevant frequency range. A tolerance of $\pm 20\%$ is permitted.

NOTE This network may be constructed such that it can meet the combined impedance requirements of this subclause and 4.3.

4.3 $50\ \Omega/50\ \mu\text{H}$ artificial mains V-network (for use in the frequency range 0,15 MHz to 30 MHz)

The network shall have the impedance versus frequency characteristic shown in figure 1b in the relevant frequency range. A tolerance of $\pm 20\%$ is permitted.

NOTE The $50\ \Omega/50\ \mu\text{H} + 5\ \Omega$ artificial mains V-network of 4.2 may also meet the impedance requirement of this subclause.

4.4 $50\ \Omega/5\ \mu\text{H} + 1\ \Omega$ artificial mains V-network (for use in the frequency range 150 kHz to 100 MHz)

The network shall have the impedance versus frequency characteristic shown in figure 2. A tolerance of $\pm 20\%$ is permitted.

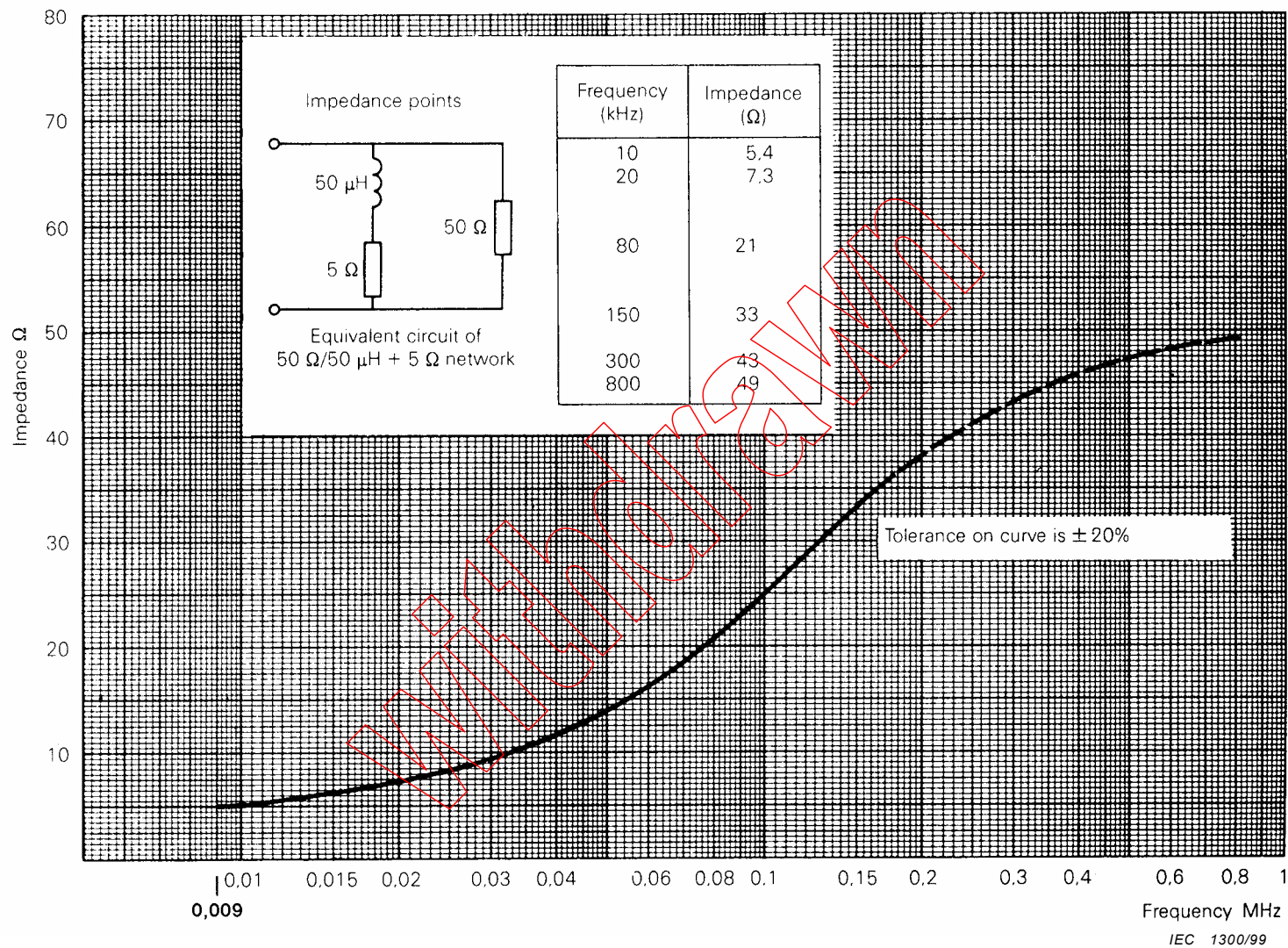


Figure 1a – Impedance of artificial mains network for band A (see 4.2)

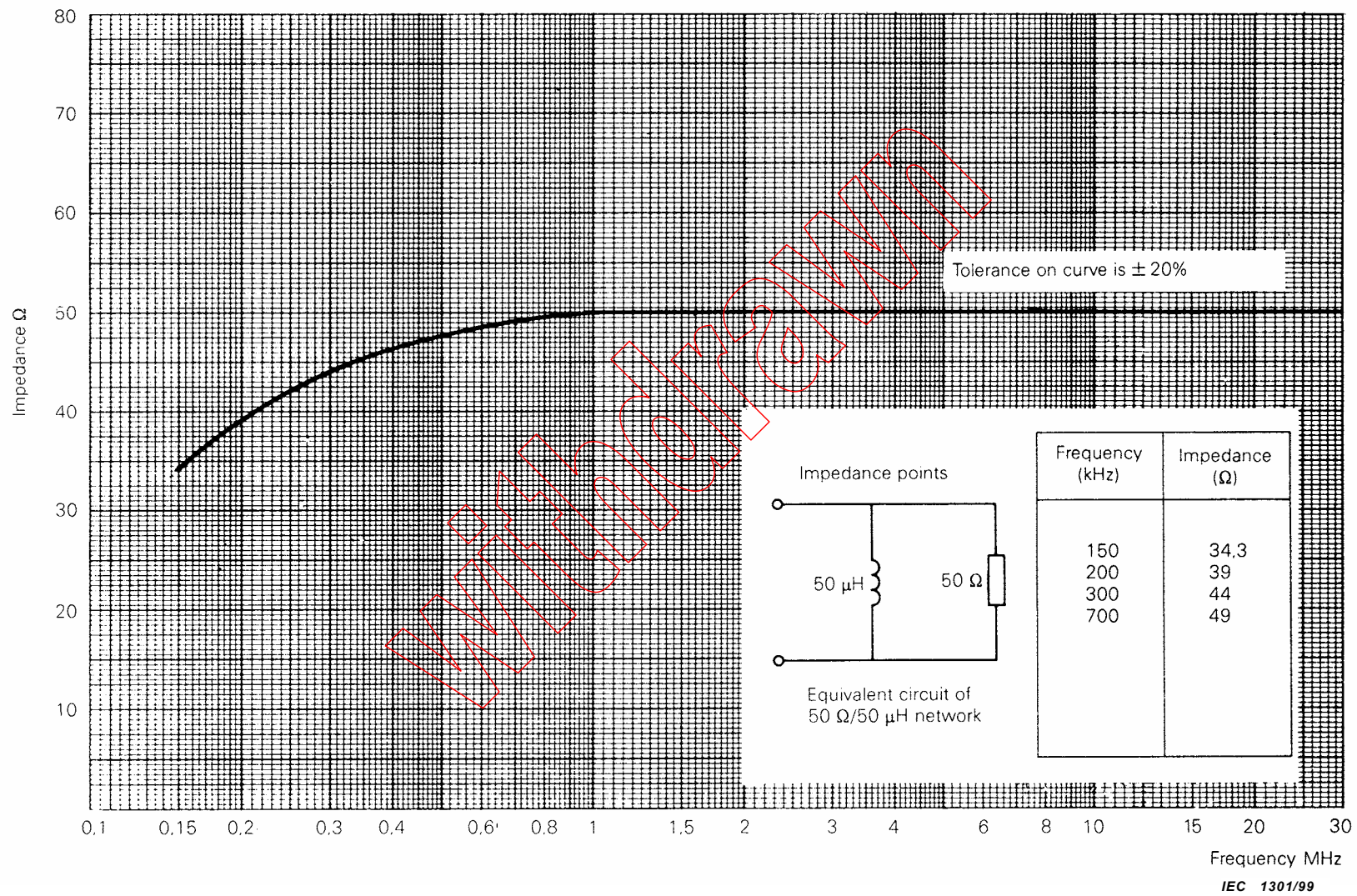


Figure 1b – Impedance of artificial mains network for band B (see 4.3)

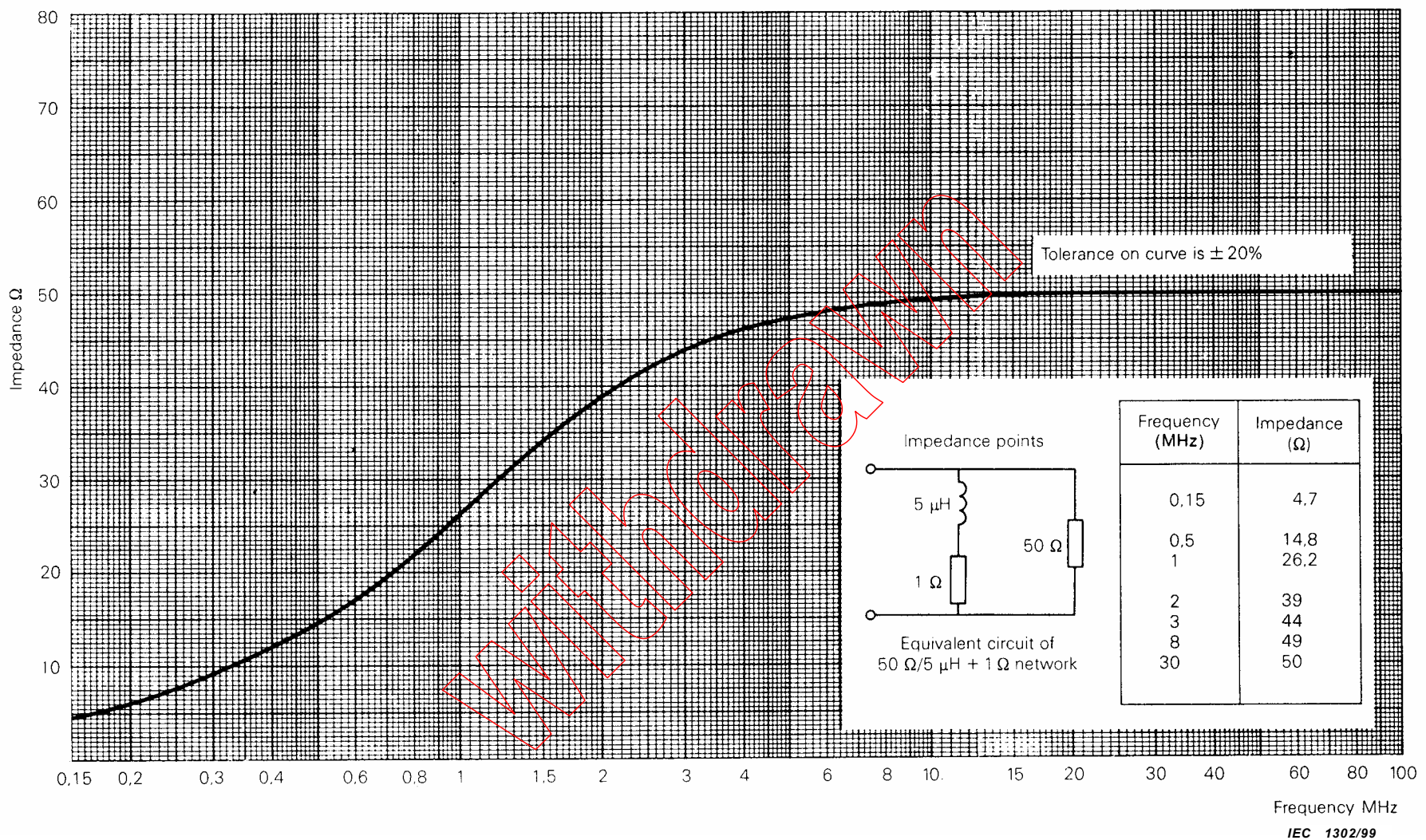


Figure 2 – Impedance of artificial mains network for band B, 0,15 MHz to 30 MHz or band C, 30 MHz to 100 MHz (see 4.4)

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° .

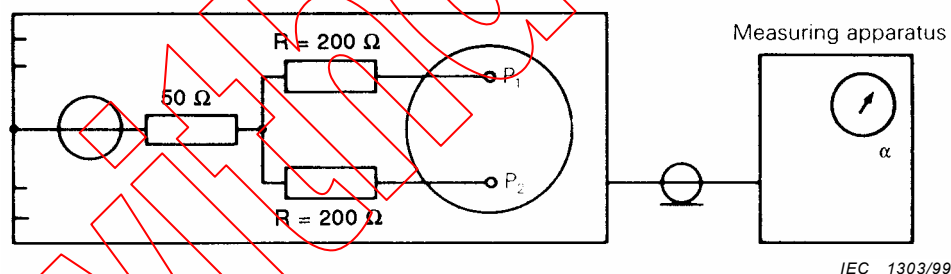
4.6 150 Ω artificial mains delta-network (for use in the frequency range 150 kHz to 30 MHz)

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 $1\,000 \Omega$ 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 200Ω equal to each other within 1 %
 P_1, P_2 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 50Ω , 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

To ensure that at any test frequency unwanted signals existing on the supply mains do not affect the measurement, an additional RF low-pass filter may be required, inserted between the artificial mains network and the supply mains. With this filter inserted, the impedance requirements given in 4.2, 4.3, 4.4, 4.5, and 4.6 shall be met. The components forming this filter shall be enclosed in a metallic screen directly connected to the reference earth of the measuring system.

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 Ω resistor mentioned in 4.2 should be omitted.

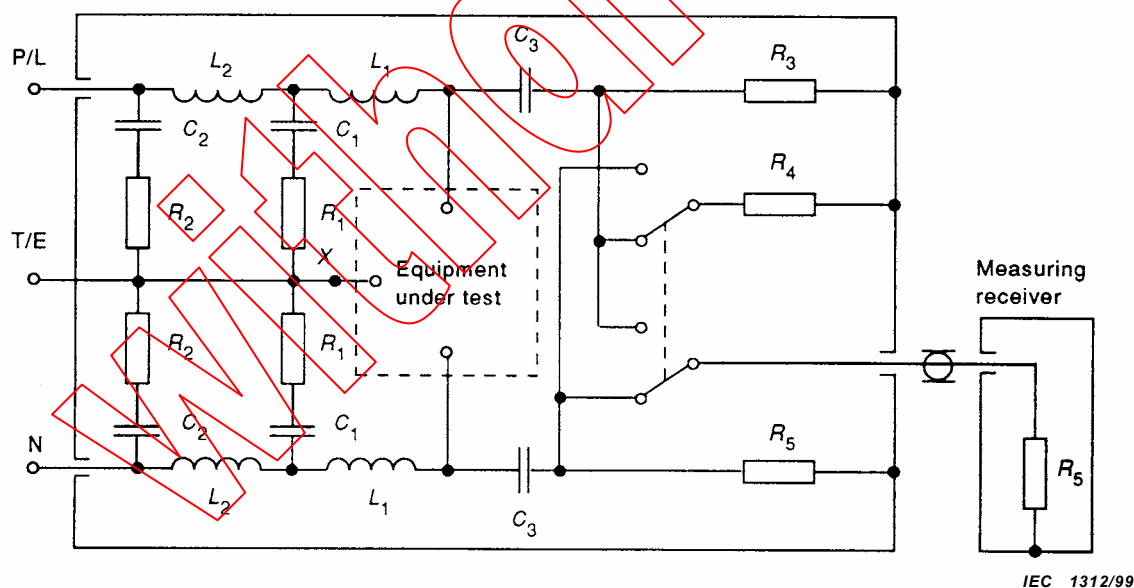


Figure 4 – Example of artificial mains 50 Ω /50 μ H + 5 Ω V-network
(see 4.2 and clause A.2)

IEC 1312/99

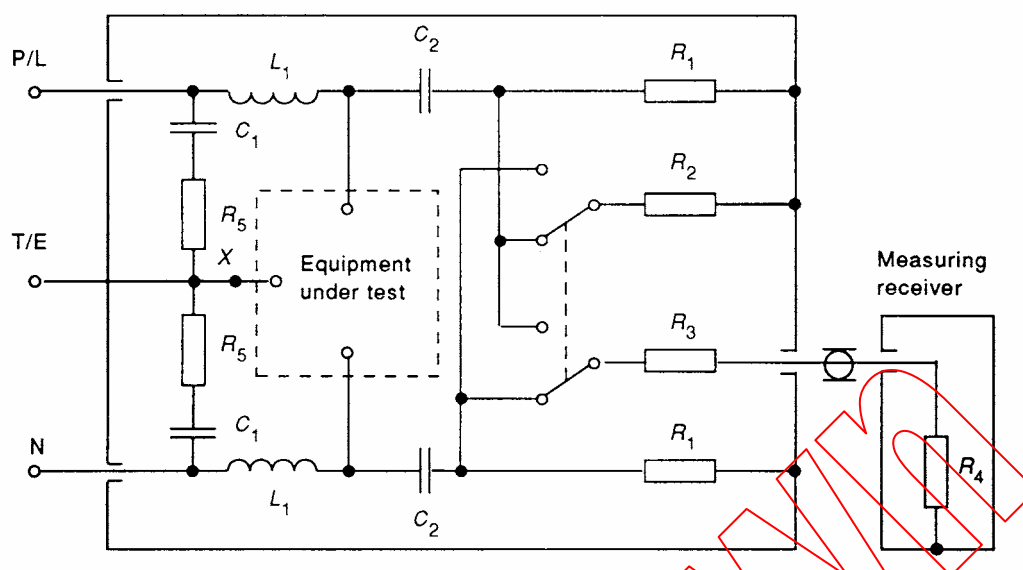


Figure 5 – Example of artificial mains V-networks, 50 Ω /50 μ H, 50 Ω /5 μ H + 1 Ω or 150 Ω (see 4.3, 4.4, 4.5 and clauses A.3, A.4 and A.5, respectively)

4.10 Calibration of the voltage division factor of artificial mains V-networks

The voltage division factor between the EUT port of the V-network and the RF output port shall be measured and taken into consideration during the measurement of the disturbance voltage. A procedure to measure the voltage division factor is contained in clause A.8.

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.

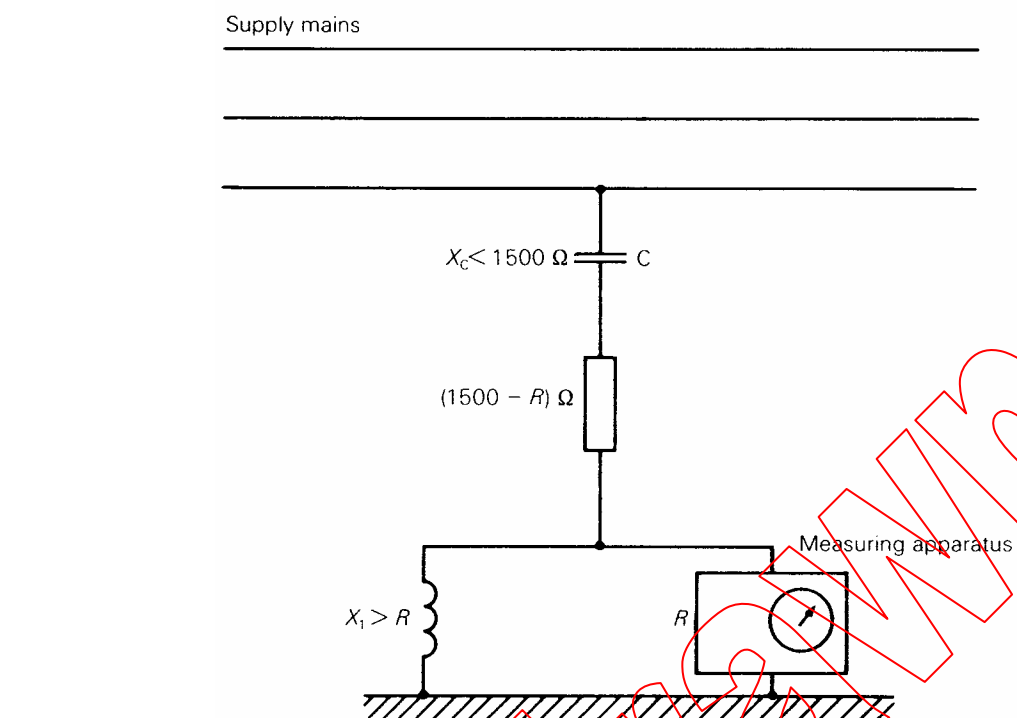
5.1.2 Characteristics

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
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

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 Ω . 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.

* 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.



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

where

V is the disturbing voltage

U is the voltage at the input of the measuring apparatus

Figure 6 – Circuit for RF voltage measurement on supply mains

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.

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.

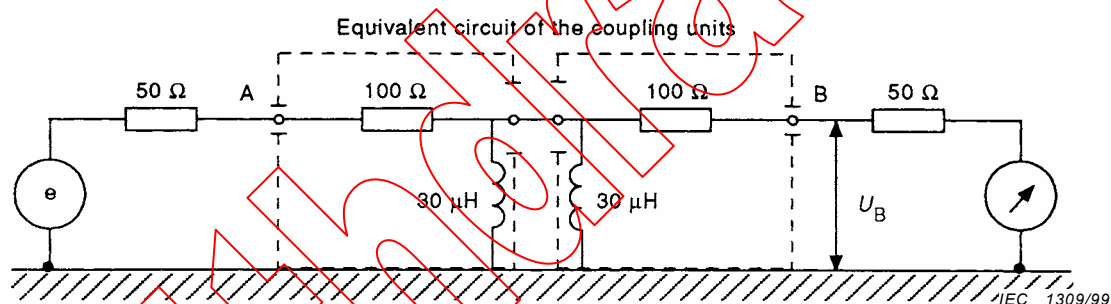
6.1.1 Impedance

In the frequency range 0,15 MHz to 30 MHz, the total asymmetric impedance (RF choke coil in parallel with the $150\ \Omega$ 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 $150\ \Omega$ 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.

6.1.2 Insertion loss

In the frequency range 30 MHz to 150 MHz the insertion loss of two identical coupling units in tandem shall be within the range 9,6 dB to 12,6 dB, measured as shown in figure 7.



The insertion loss, U_G/U_B of two identical coupling units measured according to this figure should be within 9,6 dB and 12,6 dB in the frequency range 30 MHz to 150 MHz. U_G is the reading of the receiver when the generator and receiver are directly connected together.

NOTE The two units shall be connected together with very short wires (≤ 1 cm).

Figure 7 – Measuring set-up to check the insertion loss of the coupling units in the frequency range 30 MHz to 150 MHz

7 Coupling devices for measuring signal lines

The interference potential (and immunity) of signal lines may be assessed by measurement (or injection) of the conducted disturbance voltage or current. For this purpose coupling devices are needed to measure the disturbance component while rejecting the intentional signal on the line. The devices included are to measure the electromagnetic emission and immunity (common and differential mode, current and voltage). Typical devices for these kinds of measurements are current probes and asymmetric artificial networks (AANs or Y-networks).

NOTE 1 Requirements for AANs for conducted immunity tests on signal lines may be found in IEC 61000-4-6²⁾ (AANs are special versions of “coupling and decoupling devices” [so called coupling/decoupling networks (CDNs)]). An AAN which meets the requirement for emission measurements may also meet the requirements for immunity testing.

NOTE 2 Signal lines include telecommunication lines and terminals of equipment intended to be connected to these lines.

NOTE 3 The terms “asymmetric voltage” and “common mode voltage” as well as “symmetric voltage” and “differential mode voltage” are synonyms, as defined in Clause 3.

NOTE 4 The term “asymmetric artificial network (AAN)” is used as synonym for “Y-network”, which is in contrast to V-networks and Δ -networks. The T-network is a special version of the Y-network.

When a current probe is used and the limit value is specified in volts, the voltage value must be divided by the impedance of the signal line or termination impedance as specified by the detailed measurement procedure, to obtain the limit value for the current. This impedance may be common mode as required by the detailed measurement procedure.

Subclause 7.1 states the specification for asymmetric (common mode) artificial networks (AANs). The differential mode to common mode rejection (V_{dm}/V_{cm}) is crucial to the useability of the AAN. This parameter is related to the longitudinal conversion loss (LCL). An example of asymmetric artificial networks and the required test and calibration procedures are given in Annex E.

7.1 Requirements for asymmetric artificial networks (AANs or Y-networks)

Asymmetric artificial networks (AANs) are 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 In CISPR 22 this type of network is called impedance stabilization network (ISN).

Figure 8a shows the general circuit diagram of an asymmetric artificial network.

²⁾ IEC 61000-4-6, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*