



American National Standard for Methods of Measurement of Radio- Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz

C63[®]

Sponsored by the
Accredited Standards Committee C63[®] —Electromagnetic Compatibility

Accredited by the American National Standards Institute

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American National Standard for Methods of Measurement of Radio- Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz

Accredited Standards Committee C63®—Electromagnetic Compatibility
accredited by the
American National Standards Institute

Secretariat

Institute of Electrical and Electronic Engineers, Inc.

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Abstract: U.S. consensus standard methods, instrumentation, and facilities for measurement of radio-frequency (RF) signals and noise emitted from electrical and electronic devices in the frequency range 9 kHz to 40 GHz are specified. This standard does not include generic nor product-specific emission limits. Where possible, the specifications herein are harmonized with other national and international standards used for similar purposes.

Keywords: conducted emission testing, conducting ground plane, digital equipment, electric-field measurement, intentional radiators, line impedance stabilization network, low-voltage electrical equipment, low-voltage electronic equipment, magnetic field measurement, normalized site attenuation, radiated emission testing, radio-noise emissions, radio-noise power, site attenuation, unintentional radiators

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Introduction

This introduction is not a part of ANSI C63.4-2009, American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.

Almost from the beginning of radio broadcasting, the electric utility companies were faced with the problem of radio noise. In 1924, the National Electric Light Association appointed a committee to study the subject. The manufacturers of electric power equipment had encountered similar problems, and in 1930, a subcommittee of the NEMA Codes and Standards Committee was established.^a The following year, the EEI-NEMA-RMA Joint Coordination Committee on Radio Reception was organized.

The Joint Coordination Committee issued a number of reports, among which was Methods of Measuring Radio Noise, 1940. This report included specifications for a radio-noise and field-strength meter for the frequency band 0.15 MHz to 18 MHz. The report recommended procedures for measuring radio-noise voltage (conducted noise) from low- and high-voltage apparatus, making noise field-strength measurements near overhead power lines, determining broadcast field strengths, and collecting data on which to base tolerable limits for radio noise.

During World War II, the needs of the armed services for instruments and methods for radio-noise measurement, particularly at frequencies higher than the broadcast band, became pressing, and in 1944, work on developing suitable specifications was begun by a special subcommittee, called the ASA Sectional Committee C63, Radio-Electrical Coordination. This special subcommittee developed a wartime specification that became Army-Navy Specification JAN-I-225 issued in 1945 and later approved as C63.1-1946, American War Standard-Method of Measuring Radio Interference of Electrical Components and Completed Assemblies of Electrical Equipment for the Armed Forces from 150 kHz to 20 MHz.

In 1951, ASA Sectional Committee C63, through its Subcommittee No. 1 on Techniques and Developments, started work on improving and extending measurement methods, taking into account methods mentioned in the 1940 report and those in current military specifications. In the course of this work, Subcommittee No. 1 developed the standard C63.4-1963, Radio-Noise Voltage and Radio-Noise Field Strength, 0.015 to 25 MHz, Low-Voltage Electric Equipment and Non-Electric Equipment. Work continued within the subcommittee on developing methods of measurement above 25 MHz and the subsequent inclusion of these measurement methods in future revisions of C63.4-1963.

C63.4-1963 was reaffirmed in 1969, and work within the subcommittee was accelerated to produce a draft standard that would make use of the experience gained by several years use of the standard, extend its coverage to embrace a broader frequency range, and incorporate newer measurement techniques that had been developed within the United States and by the International Special Committee on Radio Interference (CISPR) as set forth in CISPR 14 and CISPR 16. The revised standard was published in 1981.

Although many improvements had been made in ANSI C63.4 in the several revisions, the reproducibility of measurements of radiated interference from one test site to another had not been completely satisfactory. In 1982, a concerted effort was organized in Subcommittee No. 1 of the American National Standards Committee C63 to determine how the technique could be improved. Evidence showed that the variability was caused, in part, by the following inadequate processes:

- Control of site reference ground plane conductivity, flatness, site enclosures, effects of surrounding objects, and certain other site construction features
- Accounting for antenna factors, associated cabling, and balun and device under test characteristics

^a Acronyms: ASA, American Standards Association; EEI, Edison Electric Institute; JAN, joint Army-Navy; NEMA, National Electrical Manufacturers Association; RMA, Radio Manufacturers Association.

- Consideration of mutual coupling effects between the device under test and the receiving antenna and their images in the reference ground plane

Accordingly, ANSI C63.4 was further revised in 1988, and the standards ANSI C63.5, ANSI C63.6, and ANSI C63.7 were prepared to provide additional information.

In late 1988 and in 1989, the importance of including additional details on test procedures to provide proper evaluation of complex systems, such as information technology equipment and systems, was recognized. Measurements on such systems can be sensitive to the exact arrangement of equipment units and interconnecting cables. The 1991 edition of ANSI C63.4 was the result of a major effort on the part of the members of the Committee and various other participating individuals.

Work on another revision began during 1991 to provide for the testing of intentional as well as unintentional radiators. The 1992 ANSI C63.4 document included these changes. In 1994, work began on harmonizing the document with emerging international standards, clarifying several issues with respect to ac power-line conducted emission measurements and turntable usage, and standardizing terminology. Also added were provisions for the use of transverse electromagnetic (TEM) wave devices for measuring emissions, extension of the lowest frequency from 10 kHz down to 9 kHz, and revisions to the clause on the artificial hand. Minor changes were made to the normalized site attenuation tables to correct rounding errors. That work culminated in the 2001 issue of ANSI C63.4.

When the 2001 issue of ANSI C63.4 was approved, several subject areas were identified that needed to be considered for the next edition. Those subjects included clarification of what is mandatory and that figures are examples while text takes precedence; allowing emission measurement instrumentation, such as a spectrum analyzer, which does not fully meet either CISPR 16 or ANSI C63.2, to be used, but in case of dispute allowing only instrumentation meeting either of these two standards to take precedence; clarification of instrumentation calibration interval requirements; identifying new test setups when power accessories (power packs) are either the equipment under test (EUT) or not; allowing use of “loop back” cable connections for large floor-standing equipment to accommodate the arrangement of cables connected to output ports to be connected to input ports under certain conditions; warning that test facilities not allowing full antenna height search may not yield sufficient data to predict radiated emissions at a site that meets normalized site attenuation; clarifying EUT setups and minimum ports that need to be populated during personal computer testing; clarifying test frequencies for intentional radiator measurements; and correcting errors on certain figures, tables, and appendices. The resolution of these subject areas as well as other clarifications appeared in the 2003 edition of ANSI C63.4.

As was the case for the 2003 edition of this standard, several topics continued to be identified for future editions of the standard. There were several areas of interest to be considered for this edition. Based on the maturity of the work on these areas, significant progress was achieved on the following items:

- a) Adding tables of LISN impedances (in addition to the plots in the 2003 edition) with and without the use of extension cords between the EUT power connection of the LISN and the end of the extension cord where the EUT connects its power plug
- b) Clarifying and expanding the information and criteria to be used for selecting what must appear on video displays during emission testing
- c) Updating of the signal levels used in receiver testing in Clause 12
- d) Clarifying in Annex B the LISN calibration process
- e) Accommodating the concern for the variation in antenna cable loss as a function of significant temperature variation at the test site

These areas are addressed in this edition as well as further edits in the text resulting from the process of review and entering the above changes. A significant addition was precautions that are needed in using spectrum analyzers, which appear in 4.2.2 and Annex H. The informative annexes for step-by-step testing procedures have been omitted, because those were mostly duplicative of the normative procedures in the

main text. Basic specifications for current probes have been omitted, because LISN and voltage probe measurements remain preferred. In several clauses, figures were placed at the end of the respective clause to avoid breaking the flow of the text itself.

Additionally, based on comments received during the initial ballot of this revision, other areas deserved due attention, which led to the following changes:

- Ensured that the standards not under the control of Accredited Standards Committee (ASC) C63[®] were dated to guarantee the acceptance of the versions that are referenced, whereas the ASC C63[®] standards were undated because ASC C63[®] would be voting their acceptance.
- Added information on the effects of materials used to construct EUT support tables and antenna masts.
- Condensed the information about absorbing clamp calibration and use, as well as the artificial hand, as these continue to be in limited use.
- Retained the Clause 13 requirements for emission measurements of intentional radiators.
- Introduced site validation specifications above 1 GHz from CISPR 16-1-4:2007, while still allowing use of absorber material on the ground plane for an open-area test site (OATS) and semi-anechoic chambers without any further site validation measurements.
- For measurement methods above 1 GHz, there remains international standards activity as to the final outcome about how such measurements are to be made; meanwhile, this edition of ANSI C63.4 retains provisions of ANSI C63.4-2003 with no change.

Other topics remain under consideration for the next edition of the standard to be prepared after this version. ASC C63[®] has started this further work to include, but is not limited to, site validation above 1 GHz, measurement methods above 1 GHz, and measurement uncertainty as well as the possibility of moving the information on antenna calibration into one document and in particular ANSI C63.5. These other areas will constitute the ASC C63[®] maintenance process.

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American National Standard for Methods of Measurement of Radio- Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz

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1. Overview

1.1 Scope

This standard specifies U.S. consensus standard methods, instrumentation, and facilities for measurement of radio-frequency (RF) signals and noise emitted from electrical and electronic devices in the frequency range 9 kHz to 40 GHz. It does not include generic nor product-specific emission limits. Where possible, the specifications herein are harmonized with other national and international standards used for similar purposes.

Uses of the word *shall* in this standard indicate a mandatory requirement that must be met to satisfy this standard. The word *should* is used to indicate that a requirement is recommended but not mandatory. Tolerances on dimensions and distances are based on good engineering practice where not specified. The word *may* is used to indicate a recommendation that is at the discretion of the user. In addition, notes in this document are informative and are not part of the requirements. In this standard, the text takes precedence over the figures because the text is complete and the figures are illustrative of a typical application of the text. Notes are used in the text for emphasis or to offer informative suggestions about the technical content of the standard, and these notes provide additional information to assist the reader with a particular passage but do not include mandatory requirements. Footnotes in text are included only for information,

clarification, and/or aid applicable to the use of the standard, but mandatory requirements are not included in text footnotes.

Measurement methods are included for radiated and line-conducted emissions that can be generated by a variety of devices, as described in 1.2. Definitions are provided for terms and phrases contained in the text, in which the words do not represent obvious or common usage. Measurement instrumentation, facilities, and test sites are specified and characterized, including open-area test sites (OATS) and RF absorber-lined, metal chambers used for radiated emission measurement. Transverse electromagnetic (TEM) wave devices used for radiated emission measurement are treated in normative Annex F. The requirements of Annex F, when such tests are performed, shall take precedence in this standard. In most cases, measurement instrumentation and calibration requirements are only generally characterized in deference to standards dedicated to these subjects, which should be used in conjunction with this standard. The requirements for operation of test samples during measurements are presented for devices in general, as well as for specific types of devices that are frequently measured. Specific requirements for emission test data recording and reporting are presented with reference to general requirements contained in documents dedicated to standard laboratory practices, which should be used in conjunction with this standard. The main text is augmented by a series of annexes that provide details for certain measurement methods and facilities. Annex A provides an index of main text clauses to be used when testing particular equipment under test (EUT) types.

1.2 Purpose and applications

This document is intended to standardize methods, instrumentation, and facilities used to characterize device emissions with respect to voluntary or regulatory compliance requirements designed to protect authorized communication services. The specified procedures are intended to be applied primarily in controlled laboratory environments, but they may be used for emission measurement of in situ devices where indicated.

This standard may be applied to emission measurement of a variety of electrical and electronic devices, regardless of size and characteristics. The devices may be single, stand-alone units, or multiple, interconnected units.

These methods may be applied to the measurement of certain devices that purposefully radiate energy, such as intentional emitters, but they might not be applicable to licensed transmitters in the United States and other countries. Similarly, these methods may not be adequate for measurement of emissions from avionics or industrial, scientific, and medical (ISM) equipment.¹

All limit specifications, relevant to a given emitting device, should be applied in their entirety to the characterization of the device over the specified frequency range in all propagation modes. Piecewise application is discouraged and runs the risk of incomplete characterization, which could fail to protect the authorized radio communications services in the manner intended. Emission limit requirements shall be obtained from other voluntary and regulatory sources, and certain other procedural documents shall be applied concurrently where specified herein. Still other procedural documents may be used as alternatives to this standard where equivalent results can be demonstrated. For regulatory applications invoking the methods in this standard, results obtained as prescribed herein shall take precedence over results obtained with alternative methods.

Not all clauses in this standard are applicable to all devices that can be measured with these methods. The nature of this standard is to specify general methods that may be applied to all devices within its scope and to supplement these methods with particular requirements for some types of devices. Device-particular

¹Various standards used in the United States require emission measurements below 9 kHz (e.g., MIL-STD-461F [B19], MDS-201-0004 [B18], and SAE ARP 1772:1986 [B21]). These have their own measurement procedures and thus require no reference to ANSI C63.4 emission measurement procedures. However, they may require reference to ANSI C63.2 and ANSI C63.4 for instrumentation specifications. Individual procurement requirements shall take precedence.

requirements take precedence over general requirements. See Annex A for guidance in applying this standard to specific types of devices.

A complete voluntary or regulatory requirement should specify the following information in conjunction with the application of this standard:

- a) Limits and frequency ranges for both ac power-line conducted and radiated emission measurements
- b) Measurement antenna distances for radiated emission measurements
- c) Identification of any uncommon requirements such as the following:
 - 1) Radiated magnetic field strength measurements below 30 MHz (see 8.2.1)
 - 2) Radiated electric field strength measurements below 30 MHz (see 8.2.2)
 - 3) Use of the absorbing clamp for radiated emission measurements (see Clause 9)
 - 4) Relaxation of the limits for clicks (transients) (see Clause 14)
 - 5) Use of the artificial hand for measurement of portable, hand-held devices (see 6.2.12)
 - 6) Any requirements that differ from the requirements contained herein
 - 7) Any requirement concerning statements of uncertainty of the measurement results (see ISO/IEC 17025:2005²).

2. Normative references

The following referenced documents are indispensable for the application of this standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies. Undated references are used only for ANSI C63[®] and IEEE standards; however, references to specific subclauses in other documents are usually dated.

Agilent Technologies, Inc., Agilent Spectrum Analyzer Series, Application Note 150-2, Spectrum Analysis...Pulsed RF, 2005.³

ANSI C63.2, American National Standard for Electromagnetic Noise and Field Strength Instrumentation, 10 Hz to 40 GHz—Specifications.⁴

ANSI C63.5, American National Standard for Electromagnetic Compatibility—Radiated Emission Measurements in Electromagnetic Interference (EMI) Control—Calibration of Antennas (9 kHz to 40 GHz).

ANSI C63.7, American National Standard for Construction of Open-Area Test Sites for Performing Radiated Emission Measurements.

ANSI C63.14, American National Standard Dictionary for Technologies of Electromagnetic Compatibility (EMC), Electromagnetic Pulse (EMP), and Electrostatic Discharge (ESD) (Dictionary of EMC/EMP/ESD Terms and Definitions).

²Information on references can be found in Clause 2.

³Agilent publications are available from Agilent Technologies, Inc. (<http://www.agilent.com/>).

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ANSI C63.22, American National Standard Guide for Automated Electromagnetic Interference Measurements.

CISPR 14-1:2005, Electromagnetic Compatibility—Requirements for Household Appliances, Electric Tools and Similar Apparatus—Part 1: Emission.⁵

CISPR 16-1-1:2007, Specification for Radio Disturbance and Immunity Measuring Apparatus and Methods—Part 1-1: Radio Disturbance and Immunity Measuring Apparatus—Measuring Apparatus.

CISPR 16-1-2:2006, Specification for Radio Disturbance and Immunity Measuring Apparatus and Methods—Part 1-3: Radio Disturbance and Immunity Measuring Apparatus—Ancillary Equipment—Conducted Disturbances.

CISPR 16-1-3:2004, Specification for Radio Disturbance and Immunity Measuring Apparatus and Methods—Part 1-3: Radio Disturbance and Immunity Measuring Apparatus—Disturbance Power.

CISPR 16-1-4:2007, Specification for Radio Disturbance and Immunity Measuring Apparatus and Methods—Part 1-4: Radio Disturbance and Immunity Measuring Apparatus—Ancillary Equipment—Radiated Disturbances.

Code of Federal Regulations, Title 47—Telecommunication, Chapter I—Federal Communications Commission, Part 15—Radio Frequency Devices (FCC 47 CFR Part 15).⁶

IEEE Std 139™, IEEE Recommended Practice for the Measurement of Radio Frequency Emission from Industrial, Scientific, and Medical (ISM) Equipment Installed on User's Premises.^{7,8}

IEEE Std 187™, IEEE Standard for Measurement Methods of Emissions from FM and Television Broadcast Receivers in the Frequency Range of 9 kHz to 40 GHz.

IEEE Std 475™, IEEE Standard Measurement Procedure for Field Disturbance Sensors (RF Intrusion Alarms).

ISO 10012:2003, Measurement management systems—Requirements for measurement processes and measuring equipment.⁹

ISO/IEC 17025:2005, General requirements for the competence of testing and calibration laboratories.

3. Definitions, acronyms, and abbreviations

For the purposes of this document, the following terms and definitions apply. *The IEEE Standards Dictionary: Glossary of Terms & Definitions*¹⁰ and ANSI C63.14 should be referenced for terms not defined in this clause. See F.3 for definitions specific to testing in TEM waveguides.

⁵CISPR documents are available from the International Electrotechnical Commission, 3, rue de Varembe, Case Postale 131, CH-1211, Genève 20, Switzerland/Suisse (<http://www.iec.ch/>). They are also available in the United States from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

⁶CFR publications are available from the Superintendent of Documents, U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20013-7082, USA (<http://www.gpoaccess.gov/>).

⁷IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, Piscataway, NJ 08854, USA (<http://standards.ieee.org/>).

⁸The IEEE standards or products referred to in this clause are trademarks of the Institute of Electrical and Electronics Engineers, Inc.

⁹ISO publications are available from the ISO Central Secretariat, Case Postale 56, 1 rue de Varembe, CH-1211, Genève 20, Switzerland/Suisse (<http://www.iso.ch/>). ISO publications are also available in the United States from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA (<http://www.ansi.org/>).

¹⁰ *The IEEE Standards Dictionary: Glossary of Terms & Definitions* is available at <http://shop.ieee.org/>.

3.1 Definitions

ambient level: The values of radiated and conducted signal and noise existing at a specified test location and time when the test sample is not activated.

antenna factor: Ratio of the electric field strength E in the polarization direction of the antenna to the voltage induced across the load connected to the antenna terminals V_o and expressed in decibel form $[20 \log (E/V_o)]$. [ANSI C63.5-2006, 3.2]

click: A disturbance that exceeds the limit of continuous disturbance not longer than 200 ms and that is separated from a subsequent disturbance by at least 200 ms.

NOTE—For the specified values and conditions, guidance may be found in CISPR 14-1:2005 and CISPR 16-1-1:2007.¹¹

counterpoise: A system of conductors designed to simulate actual ground that may be elevated above and insulated from the ground, forming a lower system of conductors of an antenna.

digital device: An unintentional radiator (device or system) that uses digital techniques and generates and uses timing signals or pulses at a rate in excess of 9000 pulses (cycles) per second, inclusive of telephone equipment that uses digital techniques or any device or system that generates and uses RF energy for the purpose of performing data processing functions, such as electronic computations, operations, transformations, recording, filing, sorting, storage, retrieval, or transfer.

NOTE—Computer terminals and peripherals that are intended to be connected to a computer are digital devices.

electromagnetic disturbance: Any electromagnetic phenomenon that may degrade the performance of a device, piece of equipment, or system, or adversely affect living or inert matter.

NOTE—An electromagnetic disturbance may be a noise, an unwanted signal, or a change in the propagation medium.

(electromagnetic) emission: (A) The phenomenon by which electromagnetic energy emanates from a source. (B) Electromagnetic energy propagated from a source by radiation or conduction.

equipment arrangement: An equipment configuration spatially arranged with cables at the test site to form an equipment under test (EUT). *Syn:* **test setup.**

equipment configuration: A combination of equipment units constituting the equipment under test (EUT).

equipment under test (EUT): A device or system being evaluated for compliance that is representative of a product to be marketed.

field disturbance sensor: A device that establishes a radio-frequency (RF) field in its vicinity and detects changes in that field from the movement of persons or objects within its range.

floor-standing equipment: Equipment designed to be used directly in contact with the floor or supported above the floor on a surface designed to support both the equipment and the operator (e.g., a raised computer floor).

host: A device to which other devices (peripherals) are connected and that generally controls those devices.

¹¹ Notes in text, tables, and figures are given for information only and do not contain requirements needed to implement the standard.

industrial, scientific, and medical (ISM) equipment: Equipment or appliances designed to generate and use locally RF energy for industrial, scientific, medical, domestic, or similar purposes, excluding applications in the field of telecommunication.

information technology equipment (ITE): Any equipment:

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

NOTE—Examples of ITE include data-processing equipment, office machines, electronic business equipment, predominantly digital audio and video equipment, and telecommunications equipment that contain digital circuits.

intentional radiator: A device that intentionally generates and emits RF energy by radiation or induction.

line impedance stabilization network (LISN): A network inserted in the power supply conductor of an apparatus to be tested that provides, in a given frequency range, a specified load impedance for each current-carrying conductor for the measurement of disturbance voltages. A LISN is used to isolate the apparatus from the supply mains in that frequency range and couples the EUT emissions to the measuring instrument.

NOTE—A LISN unit may contain one or more individual LISN circuits.

low-voltage electrical and electronic equipment: Electrical and electronic equipment with operating input voltages of up to 600 V dc or 600 V rms ac.

module: Any assembly of interconnected components that constitutes an identifiable device, instrument, or piece of equipment.

normalized site attenuation (NSA): Site attenuation divided by the antenna factors of the radiating and receiving antennas (all in linear units).¹² *See also:* **site attenuation.**

peripheral device: A digital accessory that feeds data into or receives data from another device (host) that, in turn, controls its operation.

personal computer: An electronic computer that is marketed for use in the home, notwithstanding business applications.

NOTE—Other definitions given in product standards or applicable regulations may take precedence.

reference ground plane: A conducting flat surface or plate that is used as a common reference point for circuit returns and electric or signal potentials and that reflects electromagnetic waves.

restricted bands: Bands of frequencies in which intentional radiators are not permitted to operate.

site attenuation: The ratio of the power input of a matched, balanced, lossless, tuned dipole radiator to that at the output of a similarly matched, balanced, lossless, tuned dipole receiving antenna for specified polarization, separation, and heights above a flat electromagnetically reflecting surface. It is a measure of the transmission path loss between two antennas. *See also:* **normalized site attenuation.**

¹²See ANSI C63.5 for details about applicable antenna factors and other parameters.

NOTE—The above is the classic definition of site attenuation. In this standard, it is extended to cover broadband antennas as well as tuned dipole antennas.

system: A configuration of interconnected devices, including accessories and peripherals, and their cables that is designed to perform a particular function or functions.

tabletop device: A device designed to be placed and normally operated on the raised surface of a table or other surfaces of similar height, e.g., most personal computers.

transfer switch: A device used to alternate between the reception of over-the-air radio frequency signals via connection to an antenna and the reception of radio frequency signals received by any other method, such as from a TV interface device.

TV interface device: An unintentional radiator that produces or translates in frequency a radio carrier modulated by a video signal derived from an external or internal signal source and that feeds the modulated RF energy by conduction to the antenna terminals or other nonbaseband input connections of a television broadcast receiver.

unintentional radiator: A device that generates RF energy for use within the device or that sends RF signals by conduction to associated equipment via connecting wiring, but that is not intended to emit RF energy by radiation or induction.

3.2 Acronyms

AC, ac	alternating current
ASC	Accredited Standards Committee
ATSC	Advanced Television Systems Committee
CSTD	cable system terminal device
CW	continuous wave
DC, dc	direct current
EMI	electromagnetic interference
EUT	equipment under test
FCC	Federal Communications Commission
IF	intermediate frequency
ISM	industrial, scientific, and medical
ITE	information technology equipment
LISN	line impedance stabilization network
NSA	normalized site attenuation
NTSC	National Television Systems Committee
OATS	open-area test site
PC	personal computer
RF	radio frequency
TEM	transverse electromagnetic
VCR	videocassette recorder
VDU	video display unit
VITS	vertical interval test signal

4. Measurement instrumentation

4.1 General

The use of proper measurement instrumentation is critical to obtaining accurate, reproducible results. Various measuring accessories that may be needed depend on the particular measurements to be performed, as described in the following subclauses.

4.2 Emission measuring instruments

This standard recognizes that both spectrum analyzers and electromagnetic interference (EMI) receivers may be used for making emission measurements. Measurement instrumentation used for making radiated and alternating current (ac) power-line conducted radio-noise measurements include those that conform to the specifications contained in either:

- a) ANSI C63.2
- b) CISPR 16-1-1:2007

A spectrum analyzer typically will not meet all requirements stated in ANSI C63.2 or CISPR 16-1-1:2007 without additional accessories. Appropriate accessories, such as preselection, quasi-peak detection, and specific intermediate frequency (IF) filters, may be used with a spectrum analyzer; this combination can be equivalent to a receiver, meeting the specifications in either item a) or item b).

4.2.1 Reference receiver

The receiver for measurements of radiated and ac power-line conducted radio noise is an instrument conforming to ANSI C63.2 or CISPR 16-1-1:2007. Other measuring instruments may be used for certain restricted and specialized measurements when these instruments conform to ANSI C63.2 or CISPR 16-1-1:2007. Automatic scanning receivers may be used, but the scan speed is to be selected such that calibrated measurements can be performed (based on the IF bandwidth selection) and the signals are properly intercepted (e.g., based on the pulse repetition frequencies). Guidance for selecting the proper bandwidth is given in 4.2.3.

If the output of the quasi-peak or average detector is presented in logarithmic units, the logarithms shall be taken in the measuring instrument after the signal is detected. It shall be ensured that the output indication represents the logarithm of the true quasi-peak or average value of the signal measured.

NOTE 1—Instruments that use logarithmic detectors, predetection logarithmic circuits, or both should include corrective circuits so that the output indication is the logarithm of the true average or quasi-peak value of the signal or noise.

NOTE 2—Users should be aware that the EMI receiver specifications in CISPR 16-1-1:2007 and ANSI C63.2 contain several differences. For example, for measurements above 1 GHz, the bandwidth definition for measurements are different. These differences in bandwidth specification may result in different measured values for broadband signals.

4.2.2 Spectrum analyzer

The use of spectrum analyzers for radiated and ac power-line conducted radio-noise compliance measurements is permissible, although spectrum analyzers without additional accessories will not meet all specifications called out in the standards listed in 4.2 and 4.2.1.

In order to meet the requirements in 4.2.3, spectrum analyzers shall be equipped with proper quasi-peak detection for measurements below 1 GHz as the reference detector. However, measurements with the peak detector of an instrument are permissible to demonstrate compliance of an EUT, because peak detection will yield amplitudes equal to or greater than amplitudes measured with the quasi-peak detector. The measurement data from a spectrum analyzer peak detector will represent the worst-case results.

Minimum values for the resolution bandwidth are specified in 4.2.3. It should be noted that most spectrum analyzers incorporate a 3 dB resolution-bandwidth specification, which is acceptable because larger bandwidths are permissible. The resolution bandwidths cited in the standards listed in 4.2.1 for the frequency range up to 1 GHz do not have a Gaussian shape but are individually specified by their frequency response (i.e., “masks”). When using larger bandwidths than the ones specified, or filters with different transfer functions, different measurement results for broadband signals must be expected. In case of dispute, the test results measured with one of the reference receivers defined in 4.2.1 will take precedence.

In order for a spectrum analyzer to meet the specifications of one of the two reference receivers, it must be equipped with proper filtering at the input. The input filtering must provide adequate overload protection and dynamic range of the system, to achieve the proper weighting of pulses using quasi-peak detection and the specified bandwidths in 4.2.3. In this case, the spectrum analyzer performs as a scanning EMI receiver, meeting the specifications for the resolution bandwidth, pulse weighting, and quasi-peak detection. The following items show additional considerations about the use of spectrum analyzers.

When using spectrum analyzers, the following characteristics shall be addressed:

- a) Overload—Most spectrum analyzers have no RF preselection in the frequency range up to 2 GHz; that is, the input signal is directly fed to a broadband mixer. To avoid overload, to prevent damage, and to operate a spectrum analyzer linearly, the signal amplitude at the mixer shall be less than 150 mV peak. RF attenuation or additional RF preselection may be required to reduce the input signal to this level.
- b) Linearity test—Linearity can be verified by measuring the level of the specific signal under investigation and repeating this measurement after a 6 dB or less attenuator has been inserted at the input of the measuring instrument or, if used, the preamplifier. The new reading of the measuring instrument display should differ by the inserted attenuation by not more than ± 0.5 dB from the first reading when the measuring system is linear—see H.3 for details. In case of broadband time-variant signals and spread-spectrum signals, the linearity test may be performed by setting the analyzer max hold with peak detector function.
- c) Normal response to pulses—The response of a spectrum analyzer with quasi-peak detection shall be verified with the calibration test pulses specified in CISPR 16-1-1:2007. The large peak voltage of the calibration test pulses typically requires an insertion of RF attenuation of 40 dB or more to satisfy the linearity requirements. This decreases the sensitivity and makes the measurement of low repetition rate and isolated calibration test pulses impossible for bands B, C, and D.¹³ If a preselecting filter is used ahead of the measuring instrument, then the RF attenuation can be decreased. The filter limits the spectrum width of the calibration test pulse as seen by the mixer.
- d) Signal interception—The spectrum of intermittent emissions may be captured with peak detection and digital display storage if provided. Multiple, fast frequency scans reduce the time

¹³CISPR 16-1-1:2007 band B is 0.15 MHz to 30 MHz, and bands C and D are 30 MHz to 1000 MHz.

to intercept an emission compared with a single, slow frequency scan. The starting time of the scans shall be varied to avoid any synchronism with the emission and thereby hiding it. The total observation time for a given frequency range shall be longer than the time between the emissions. Depending on the type of disturbance being measured, the peak detection measurements can replace all or part of the measurements needed using quasi-peak detection. Retests using a quasi-peak detector shall then be made at frequencies where emission maxima have been found.

- e) Average detection—Average detection with a spectrum analyzer can be obtained by reducing the video bandwidth until no further smoothing of the displayed signal is observed. The sweep time must be increased with reductions in video bandwidth to maintain amplitude calibration. For measurements in accordance with CISPR 16-1-1:2007, the video bandwidth shall be set to a 10 Hz value to ensure that the proper integration time is realized. For such measurements, the instrument shall be used in the linear mode of the detector. After linear detection is made, the signal may be processed logarithmically for display; in which case, the value is corrected even though it is the logarithm of the linearly detected signal. A logarithmic amplitude display mode may be used, for example, to distinguish more easily between narrowband and broadband signals. The displayed value is the average of the logarithmically distorted IF signal envelope. A logarithmic amplitude display mode results in a larger attenuation of broadband signals than in the linear detection mode without affecting the display of narrowband signals. Video filtering in log mode is, therefore, especially useful for estimating the narrowband component in a spectrum containing both.
- f) Selection of display mode—For EMC measurements, the positive peak detector should be selected to ensure that the highest emission amplitudes are displayed. Scanning the frequency range of interest in multiple frequency segments can reduce the introduced frequency error. This will improve frequency accuracy but will increase the overall test time.

See also Annex H for more details about precautions in the use of spectrum analyzers.

4.2.3 Detector functions and selection of bandwidth

Unless otherwise specified, EMI receivers or spectrum analyzers shall have the reference detector functions and bandwidths specified in ANSI C63.2 or CISPR 16-1-1:2007 for frequencies up to and including 40 GHz. Peak detector measured data may be substituted for the appropriate detector data to show compliance, if the peak level obtained does not exceed the limit. The bandwidths used shall be equal to or greater than that specified in ANSI C63.2. Use of bandwidths greater than those specified may produce higher readings for certain types of emissions and should be recorded in the test report. In case of dispute, the reference receiver shall take precedence. More than one instrument may be needed to perform all of these functions.

The measuring instrument shall satisfy the following conditions:

- The quasi-peak detector, or average detector if used, shall have a linear response.
- When measuring an emission with a low duty cycle, the dynamic range of the measuring instrument shall not be exceeded.

When using a spectrum analyzer or other instrument that allows access to the video bandwidth setting, this bandwidth shall be set to a value at least three times greater than the IF bandwidth of the measuring instrument to avoid the introduction of amplitude smoothing.

NOTE—For the purposes of this document, the terms *IF bandwidth* and *resolution bandwidth* are synonymous.

4.2.4 Signal monitoring

All radio-noise measurements should be monitored (audio and/or visual) by the test operator using a headset, a loudspeaker, a spectrum display, or any combination thereof as an aid to detecting ambient signals and selecting the emissions that have the highest amplitude relative to the limit. Precautions shall be taken to ascertain that the use of a headset or speaker does not affect the measuring instrument indication during measurements.

4.3 LISN

A LISN having the nominal impedance characteristic shown in Figure 1 (see figures in 4.8) is required for ac conducted emission measurements.¹⁴ When the measuring instrument (receiver or spectrum analyzer) ports are terminated into an impedance of 50 Ω , the characteristic impedance in Figure 1 shall be present at the EUT ports of the LISN. Figure 2 and Figure 3 (see 4.8) show two circuits that when carefully constructed can provide the impedance characteristics of Figure 1 (for use with connecting cable, see also 5.2.3). Table B.1 through Table B.4 show the $\pm 20\%$ limit values for the LISN impedance at the LISN terminals and the $+30\% / -20\%$ limit values for the LISN impedance when extension cords are used with the LISN, respectively. Where specific equipment requirements specify another LISN, the specified LISN shall be used.

NOTE—Care shall be taken to check for and ensure that no unusual resonances exist in situations where LISNs are used for making measurements below 9 kHz (see 1.2).

4.4 Voltage probe

A voltage probe may be used for radio-noise voltage measurements when measurements are made at a user's installation (see 5.6) or when the ac current level exceeds the current-carrying capability of commercially available LISNs.¹⁵ Voltage probes shall be calibrated for use. For such measurements, the method shown in Figure 4 (see 4.8) may be used. Special precautions shall be taken to establish a reference ground for the measurements. A LISN shall not be used in conjunction with a voltage probe for measurements at a user installation. The measurements are dependent on the impedance presented by the power supply and may vary with time and location because of variations in the power supply. (It may be necessary to perform repeated measurements over a suitable period of time to determine the variation in measured values. The time period shall be sufficient to cover all significant variations caused by operating conditions at the installation.) Such measurement results shall be regarded as unique to that EUT and installation environment. The measurements shall be made between each current-carrying conductor in the power supply and the ground conductor with a blocking capacitor (C) and a resistor (R), shown in Figure 4, such that the total resistance between line and ground is 1500 Ω . Because the voltage probe attenuates the radio-noise voltage, appropriate calibration factors shall be added to the measured values. Measurements made with LISNs shall take precedence over measurements made with voltage probes.

4.5 Antennas

The use of specific antennas depends on the frequency range and field type (electric or magnetic) being measured in performing radiated emissions measurements, as indicated in 4.5.1 through 4.5.4. Antennas

¹⁴In this document, associated figures are placed at the end of each clause.

¹⁵Some measurement method documents refer to a voltage probe as a line probe [e.g., FCC/OET MP-5 [B10] (FCC 47 CFR § 18.311)].

shall be calibrated in accordance with ANSI C63.5. Table 1 provides a summary listing of antennas and typical frequency ranges. See 4.7.2 for antenna calibration requirements.

Table 1—Antennas for selected frequency ranges

Antenna	10 Hz to 20 kHz	10 kHz to 150 kHz	0.15 MHz to 30 MHz	30 MHz to 1000 MHz	1 GHz to 40 GHz
Rod (passive)	Yes	Yes	Yes	No	No
Dipole (passive)	No	No	No	Yes	No
Biconical dipole	No	No	No	Yes	No
Log-periodic dipole array	No	No	No	Yes	No
Loop (passive)	Yes	Yes	Yes	No	No
Waveguide horn	No	No	No	No	Yes
Active monopole	Yes	Yes	Yes	No	No
Double-ridged guide horn	No	No	No	Yes	Yes

NOTE 1—This table is adapted from Table 6 of ANSI C63.2-1996.

NOTE 2—Frequency ranges (i.e., instrumentation tuning ranges) are as suggested in Clause 5 of ANSI C63.2-1996.

NOTE 3—Some designs of dipole, biconical, and log-periodic dipole array antennas operate within portions of the 1 GHz to 40 GHz range.

4.5.1 Magnetic field measurements (9 kHz to 30 MHz)

Loop antennas, as specified in ANSI C63.2, shall be used to measure magnetic fields in the frequency range of 9 kHz to 30 MHz (see also CISPR 16-1-4:2007).

4.5.2 Electric field measurements (9 kHz to 30 MHz)

Monopole (rod) antennas as specified in ANSI C63.2 and ANSI C63.5 shall be used to measure electric fields in the frequency range of 9 kHz to 30 MHz (see also CISPR 16-1-4:2007). Generally, a 1.04 m (approximately 41 in) vertical monopole antenna is used with or without a counterpoise, as specified by the manufacturer. The height of the base of the rod element shall be placed to be within 0 cm to 20 cm above the height of the base of the EUT.

NOTE—Some regulatory and purchasing agencies do not allow the use of a rod antenna for measurement of radiated emissions.

4.5.3 Electric field measurements (30 MHz to 1000 MHz)

Linearly polarized antennas as specified in ANSI C63.2 shall be used to measure electric fields in the frequency range of 30 MHz to 1000 MHz (see also CISPR 16-1-4:2007). Tunable dipoles should be used. Alternatively, a linearly polarized broadband antenna, or a dipole tuned only above 80 MHz and set to the 80 MHz tuned length when used between 30 MHz and 80 MHz, may be used in lieu of a tuned dipole, provided that the measurement can be correlated with that made with a tuned dipole with an acceptable degree of accuracy.

NOTE—Some regulatory and purchasing agencies may require the use of a reference antenna (see 6.2, Annex C, and Annex E of ANSI C63.5-2006) for measurements of radiated emissions.

4.5.4 Electric field measurements (1 GHz to 40 GHz)

Linearly polarized antennas as specified in Table 1 and calibrated in accordance with ANSI C63.5 shall be used. These antennas include double-ridged waveguide horns, rectangular waveguide horns, pyramidal horns, optimum-gain horns, octave-band horns, and standard-gain horns. The main “beam” or main lobe of the pattern for any antenna used shall be large enough to encompass the physical size of the EUT, or system arrangement, when located at the measuring distance. See 8.2.4 for details on techniques for encompassing products in the measurement process.

The aperture dimensions of these horn antennas shall be small enough so that the measurement distance in meters is equal to or greater than the Rayleigh (far-field) distance [i.e., $R_m = (2D^2)/\lambda$], where D is the largest dimension of the antenna aperture in meters and λ is the free-space wavelength in meters at the frequency of measurement. In case of dispute, measurements made with a standard-gain horn antenna shall take precedence.

4.6 Absorbing clamp

Measurements of radio-noise power, if required, are made with an absorbing clamp—see Clause 9.

4.7 Calibration of measuring equipment

All instruments that can have a significant effect on the accuracy or validity of measurements made as specified in this standard shall be calibrated in accordance with the manufacturer’s recommendations and the instrument requirements of ANSI C63.2. A calibration records system shall be maintained, as part of a laboratory quality system, which monitors the calibration status of the test equipment and ensures the traceability to national standards.

4.7.1 Confirmation interval

The calibration of all instruments shall be confirmed in the first year of deployment. Reference antennas that are used only for calibration or NSA measurement purposes shall be constructed as specified and should be checked using ANSI C63.5 methods at least every 3 years. For other instruments, subsequent recalibration intervals may be longer (up to 3 years) or shorter based on review of calibration data relative to the recommendations of the instrument manufacturer and the required measurement accuracy. All instruments shall be checked as frequently as necessary between calibration intervals to provide evidence that instrument accuracy and system measurement uncertainty is continuously maintained—see ISO 10012:2003.

4.7.2 Antenna calibration

All antennas shall be calibrated per ANSI C63.5, including antennas used for performing NSA measurements for standard test site validation as well as for alternative test site validation (see 5.4.2). Antennas shall be calibrated when damage or deterioration is suspected and at regular intervals, as described in 4.7.1.

Standard-gain horn antennas have gain characteristics that are established by the physical dimensions and dimensional tolerances. Consequently, standard-gain horn antennas need not be calibrated beyond the dimensional characteristics that are provided by the manufacturer, unless damaged or deterioration is suspected, or if used at distances closer than $(2D^2)/\lambda$.

NOTE—If the antenna is calibrated at a distance $R \geq (2D^2)/\lambda$ (where D is the maximum aperture dimension of the antenna—see Figure 5), it may be used to make measurements at any distance greater than $(2D^2)/\lambda$ with an error of less than 1 dB.

4.7.3 LISN impedance and insertion loss measurements

The impedance and insertion loss of each LISN used in testing emissions shall be measured over the frequency range of use. It is recommended that the insertion loss measurement be carried out after the completion of the impedance measurements. The LISN shall be measured in the configuration for which it is used for testing a product. An acceptable procedure for performing these measurements is given in Annex B. See 5.2.3.1 for verifying a permanently installed LISN. The LISN should be checked routinely to ensure acceptable performance—see 4.7.1.

4.7.4 Characterization of absorbing clamp

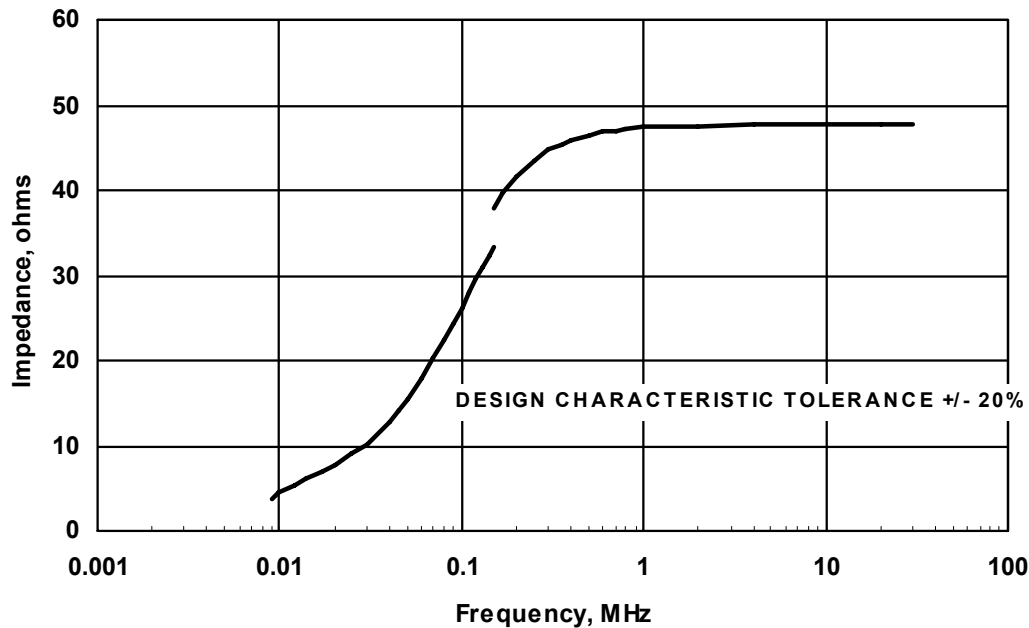
Absorbing clamps used to measure disturbance power on cables should be characterized in accordance with Annex B of CISPR 16-1-3:2004; see also Annex C herein.

4.7.5 Cable insertion loss

The insertion loss of cables used for connection of antennas or transducers to measuring instruments (EMI receivers, spectrum analyzers, etc.) shall be characterized or checked frequently for deterioration caused by use and environmental exposure (e.g., variation due to change in temperature and damage). Published data¹⁶ have shown that temperature variations of 15 °C or more result in 2% or greater change in cable losses. Consequently, the temperatures present during initial cable loss characterization and product testing shall be recorded. When the temperature change exceeds 15 °C, the cable characterization shall be repeated.

¹⁶For example, see http://www.gore.com/en_xx/products/cables/microwave/changes_insertion_loss_phase.html.

4.8 Figures for Clause 4



NOTE—The discontinuity in the curve is due to the impedance values being derived from the two different circuits for the 9 kHz to 150 kHz (Figure 2) and 150 kHz to 30 MHz (Figure 3) frequency ranges.

Figure 1—Nominal impedance characteristic of LISN port, 9 kHz to 30 MHz¹⁷

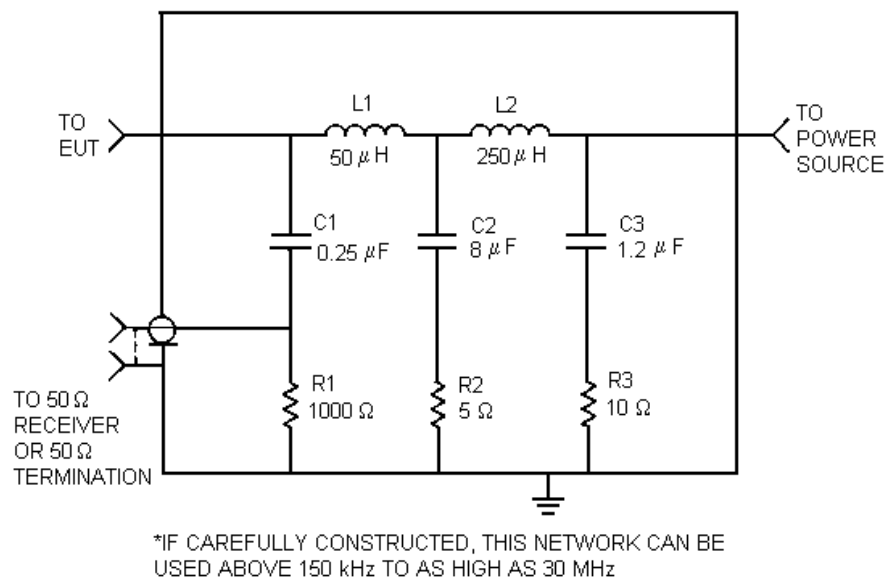
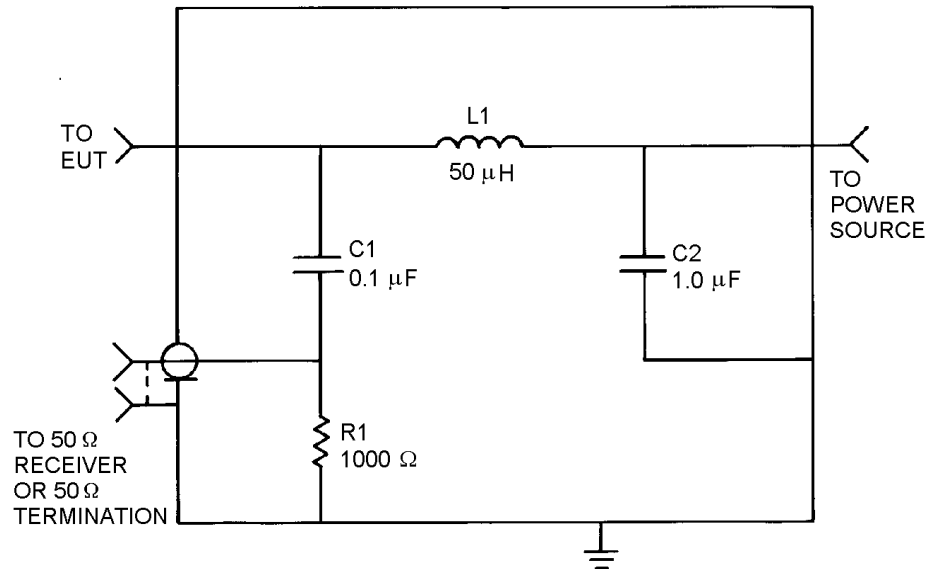


Figure 2—Circuit diagram of LISN to provide impedance of Figure 1 for the 9 kHz to 150 kHz (30 MHz¹⁸) frequency range

¹⁷Past editions of ANSI C63.4 contained an idealized continuous version of the LISN nominal impedance curve. Although the previous idealized curve was within the $\pm 20\%$ impedance tolerances corresponding to the piecewise curve of Figure 1, it did not reflect the actual calculated responses of the circuits of Figure 2 and Figure 3 at frequencies above and below the 150 kHz break point.



*IN SOME LISNs, A SERIES RESISTANCE IS INCLUDED IN SERIES WITH CAPACITOR C2

Figure 3—Circuit diagram of LISN to provide impedance of Figure 1 for the 0.15 MHz to 30 MHz frequency range

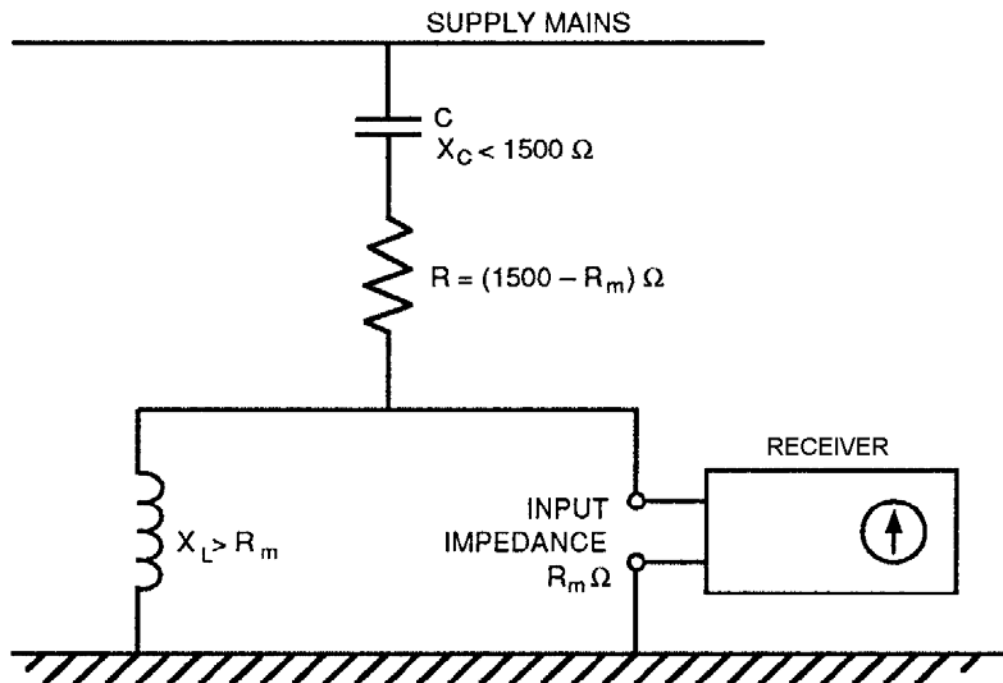


Figure 4—Voltage probe for measurements at a user's installation

¹⁸Some designs and implementations support use of the Figure 2 circuit up to 30 MHz without impedance resonances or anomalies.

5. Test facilities

5.1 General requirements

Radiated and ac power-line conducted emission measurements shall be made in an environment that ensures valid, repeatable measurement results [i.e., as described in 5.2 (ac power-line conducted emission test sites) or 5.3 through 5.5 (radiated emission test sites)]. Where appropriate, tests may be made at the manufacturer's location or the user's installation (see 5.6). In any case, the requirements of this subclause shall be observed.

5.1.1 Power source

Sufficient ac power shall be available to operate the EUT at its rated voltage, current, power, and frequency.

5.1.2 Ambient radio noise and signals

AC power-line conducted and radiated ambient signal levels, measured at the test site in peak detection mode (preliminary scans) with the EUT deenergized, shall be at least 6 dB below the allowable limit of the applicable specification or standard. In the event that the measured levels of ambient plus EUT radio noise are not above the applicable limit, the EUT shall be considered to be in accordance with the limit.

If the ambient field exceeds the applicable limit(s), the following alternatives may be used:

- a) In the case of radiated emission measurements, perform measurements at the closest distance permitted by 5.4.1 and extrapolate results to the specified limit distance. The method of extrapolation shall be justified and described in the test report.
- b) Perform radiated emission measurements of critical frequency bands during hours when broadcast stations are off the air and at times when ambient signals from industrial equipment are reduced to less than the 6 dB level.
- c) Perform measurements in an absorber-lined shielded room (see 5.4.2 for conditions of use).
- d) Orient the radiated emission test site to discriminate against such ambient signals insofar as possible.
- e) If the signal being measured is either a continuous wave (CW) signal, or only one single spectral component of the signal to be measured is within the pass-band of the IF filter at any time, and the ambient electric field is broadband, reduce the resolution bandwidth if using a spectrum analyzer or the bandwidth if using an EMI receiver.
- f) Rotate the EUT on a turntable while observing possible correlation between radiated emission amplitude and EUT azimuth.
- g) Monitor the audio output of the EMI receiver with a loudspeaker or headphones and its video output with a time-based oscilloscope display to discriminate between ambient noise and signals and EUT emissions.

If the power-line ambient level exceeds the applicable limit(s), the following alternatives may be used for ac power-line conducted emission testing:

- Perform measurements in a shielded enclosure. However, this method is recommended only at frequencies below the resonant frequencies of the enclosure, usually under 30 MHz.
- Insert suitable power-line filters between the power source and the LISN.

5.1.3 EUT turntable

A continuously rotating, remotely controlled turntable shall be used for installation at the test site to support the EUT and facilitate determination of the direction of maximum radiation for 360° azimuth rotation at each EUT emission frequency. For floor-standing EUTs, the turntable shall be metal covered and flush with the ground plane. For tabletop EUTs, the turntable may be nonmetallic and located on top of the reference ground plane. Turntable design and operation should be based on the radiated emission measurement requirements specified in 8.1 and adhere to the reflecting structure and ground plane limitations that ensure compliance with the NSA requirements. See ANSI C63.7 for additional specific guidance on turntable installations.

5.1.4 EUT support table

Tabletop devices shall be placed on a nonconducting platform, of nominal size 1 m by 1.5 m, raised 80 cm above the reference ground plane. A method for evaluating the effects of the table on EUT radiated emissions is given in subclause 5.9 of CISPR 16-1-4:2007 for frequencies up to 1 GHz.

5.1.5 Antenna positioner

A remote-controlled antenna positioner with continuously variable height is recommended for installation at the site to support the measuring antenna and facilitate determination of the height of maximum radiation at each EUT emission frequency, over a range of 1 m to 4 m above the reflecting plane. Antenna positioner design and operation should be based on the radiated emission measurement requirements specified in 8.1, and one must ensure compliance with the NSA requirements.

5.2 AC power-line conducted emission test requirements

AC power-line conducted emission measurements may be made at a facility that meets the requirements of this clause. This may include a shielded (screened) room or a radiated emission test site.

5.2.1 Reference ground plane

The reference ground plane for measuring ac power-line conducted emissions is to consist of a floor earth-grounded conducting surface, which may be the metal floor of a shielded test chamber. The reference ground plane shall be at least 2 m by 2 m in size, and it shall extend at least 0.5 m beyond the vertical projection of the horizontal perimeter (i.e., footprint) of the EUT or EUT arrangement. If the EUT normally does not make electrical contact with a ground plane, then insulating materials with thickness of up to 12 mm shall be used to cover the reference ground plane.

5.2.2 Vertical conducting plane

Optionally, for measurements of ac power-line conducted emissions for a tabletop device, a vertical conducting plane or screen, with a size of at least 2 m by 2 m, may be located 40 cm to the rear of the EUT. The vertical conducting plane or screen shall be electrically connected to the reference ground plane at intervals not greater than 1 m along its entire length through low impedance connections (e.g., 3-cm-wide metal straps). The metal wall of a screen room will normally satisfy this requirement. A tabletop device may be measured for ac power-line conducted emissions without a vertical conducting plane while maintaining the 80 cm EUT elevation specified in 6.3.1. In case of a dispute, ac power-line conducted emission measurements performed on a tabletop device with a vertical conducting plane in place shall take precedence.

A vertical conducting plane is not required for ac power-line conducted emissions measurements on a floor-standing device. A vertical conducting plane shall not be used for any radiated emission measurements.

5.2.3 LISN installation

Line impedance stabilization networks may be required for ac power-line conducted emission measurements and may be utilized for radiated emission measurements. For exceptions, see 5.6.

5.2.3.1 LISN connected to the reference ground plane

Where use of a LISN is required (see Clause 7), it shall be placed on and electrically bonded to the top surface of, or immediately beneath, the reference ground plane and shall be bonded to the ground plane. The site reference ground plane is the ground reference for the LISN. The bond used shall have a direct current (dc) resistance of less than or equal to 2.5 m Ω . If LISNs are kept on the test site for radiated emission measurements, it is preferred that they be installed under the reference ground plane with the ac power receptacle flush with the reference ground plane. Otherwise, the LISN(s) must be present during NSA measurements.

The impedance at the receptacle end of any cable connected to the EUT end of the LISN (as contrasted to the impedance at the LISN terminals given in Figure 1), with the measuring instrument port of the LISN terminated into a 50 Ω load, shall be within +30% and -20% of the nominal LISN impedance shown in Figure 1 over the frequency range of the network to be used; see 4.3. If the attenuation (insertion loss) between the EUT receptacle and the measuring instrument port on the LISN is more than 0.5 dB (see Annex B as an example of a method of measurement), it shall be accounted for when calculating the EUT emission levels.

5.2.3.2 Use of filters or isolation transformers

Ambient noise may be present on the ac power lines at some locations and at some frequencies within the frequency range of interest. If the levels are sufficient to cause interference with readings made using a LISN, filtering of the ac power may be required. The filter should be inserted between the ac power supply and the ac input connection to the LISN, preferably as close as possible to the LISN to reduce interference pickup by the leads between the filter and the LISN.

Where an isolation transformer is used between the ac power supply and the LISN, care shall be taken to ensure that the rating of this transformer is large enough to not affect the peak current drawn by the EUT. This may require up to 10 times the kilovolt-ampere rating of the EUT. If other than air-core inductors are used in the LISN, they shall be in a linear permeability range at the peak currents drawn by the EUT.

5.2.4 Voltage probe

If use of a LISN is impossible because of the high current requirements of the EUT, or if a reference ground plane is not available, ac power-line conducted emission measurements shall be performed using a voltage probe, as discussed in 4.4; see also 5.6.

5.3 Radiated emission test facilities (9 kHz to 30 MHz)

For magnetic field strength measurements (see 8.2.1), a site similar to that shown in Figure 5, should be used, except that a reference ground plane is not required. The site does not have to meet an NSA requirement at these frequencies because NSA is based on electric fields. If a reference ground plane is present, the measured level of emissions may be higher than if measurements were made without a ground plane. The magnetic field strength measurements made at a site with no reference ground plane shall take precedence. If permitted by the procuring or regulatory agency, measurements may also be made in a shielded enclosure at frequencies below its resonant frequency, or in a TEM device (see Annex F).

5.4 Radiated emission test facilities (30 MHz to 1 GHz)

5.4.1 Standard test sites

The standard test site shall be an open, flat, level area that is clear of overhead wires and reflecting structures and is sufficiently large to permit measuring antenna placement at the specified distance. This is commonly called an OATS when the ground is covered with conductive material. Adequate spacing shall also be provided between the site, including the EUT and the measuring antenna, and any adjacent, large reflecting structures. Reflecting structures are defined as objects or housings that are conductive or become conductive over time (e.g., structures may absorb conductive airborne contaminants when in use). Test personnel shall not be permitted within the perimeter of the area during testing. A conductive metal ground plane shall cover the floor of the site, as described in 5.4.3. ANSI C63.7 provides additional important guidance on the desired characteristics, construction, and deterioration possibilities of standard sites. A suggested layout for the standard site is diagrammed in Figure 5, where the recommended EUT-to-antenna distances R are 3 m, 10 m, and 30 m (measured along the main EUT-to-measurement-antenna axis). A standard test site shall comply with the NSA requirements of 5.4.4. In case of disagreement, measurements made at a standard test site take precedence.

5.4.2 Alternative test sites

Radiated emissions measurements may be made at certain types of alternative test sites. Alternative test sites include RF absorber-lined metal test chambers with only the floor composed of a conductive material, office or factory buildings large enough for reflections to not disrupt the field at the point of measurements, and weather-protected OATS because the potential effects of the cover material cannot be shown without volumetric NSA measurements. All such alternative sites shall comply with the volumetric NSA requirements of D.3 over the volume occupied by the EUT or the EUT arrangement in order to be acceptable as an alternative test site. Metal-shielded enclosures and other sites that do not comply with the volumetric NSA requirements may be used only for exploratory radiated emission measurements, unless it can be demonstrated that the results achieved are equivalent to those obtained at a standard or alternative site that complies with the appropriate NSA requirement. In addition, measurements may be made in a TEM device under certain conditions—see Annex F.

5.4.3 Reflecting ground plane

A reflecting ground plane shall be installed on the floor of the radiated electric field emission test site to provide a uniform, predictable reflection of radiated emissions measured at the site. The ground plane shall be constructed of metallic material with limited discontinuities and sufficiently high conductivity and surface smoothness to ensure compliance with the NSA requirements. The surface smoothness of the ground plane shall comply with the maximum values for terrain roughness defined by the Rayleigh criterion, as shown in ANSI C63.7. Ground planes with discontinuities (including connection point separation between adjacent metallic materials) larger than 3.0 cm, or with overall size less than the minimum configuration shown in Figure 5, are not recommended—see ANSI C63.7 for guidance about test sites in the frequency range 30 MHz to 1 GHz.

5.4.4 Site validation

Radiated emission test sites shall be validated by measurement of the attenuation of signals propagated over the site and compared with theoretical attenuation of signals propagated over an ideal site. Horizontally and vertically polarized attenuation measurements shall be made over the frequency range 30 MHz to 1 GHz. These measurements shall be made in accordance with the procedures of D.2 and/or D.3 as applicable of Annex D, and the results normalized for comparison with the theoretical attenuation values.

During site attenuation measurements, the receiving antenna positioner normally used, the raised turntable if used, and ground-plane-mounted LISNs (see 5.2.3.1) shall be in place at the site. If special antenna connecting cabling is required to meet the site validation requirements, the same or similarly treated cabling with the same RF characteristics shall also be used for radiated emissions testing.

5.4.4.1 Site acceptability criterion

The measured NSA for a radiated emissions test site shall be within ± 4 dB of the theoretical NSA for an ideal test site (see D.1).

5.4.4.2 Site validation interval

Validation of the acceptability criterion shall be confirmed in the first year for a new site or one that has undergone physical and electrical upgrades or changes. Subsequent validation intervals may be longer (up to 3 years) or shorter, based on a review of NSA data relative to the extent and severity of use of the site, weather effects on the site, drifting of reflective characteristics of covering structures of weather-protected OATS, and physical modifications made to the site or adjacent areas (see ANSI C63.7). It is recommended that periodic site-attenuation measurements be made in order to detect anomalies due to degradation of all-weather protection caused by weather conditions (moisture absorption, for example) or contamination of enclosure materials. A 12-month interval is generally adequate unless physical signs indicate material degradation sooner; that is, the weather-proofing material changes color due to airborne contaminants. In those cases, a 6-month interval is recommended. The objective is to optimize the balance of risks and costs consistent with the required accuracy—see also Annex A of ISO 10012:2003 for more guidance.

5.5 Radiated emission test facilities for frequencies above 1 GHz (1 GHz to 40 GHz)

Currently, test site reference validation requirements above 1 GHz have not been established. However, facilities suitable for measurements in the frequency range 30 MHz to 1000 MHz are considered suitable for the frequency range 1 GHz to 40 GHz with RF absorbing material covering the ground plane such that the site validation criterion called out in CISPR 16-1-4:2007 is met, or alternatively covering a minimum

area of 2.4 m by 2.4 m (for a 3 m test distance) between the antenna and the EUT using RF absorbing material with a minimum-rated attenuation of 20 dB (for normal incidence) up to 18 GHz. For separation distances greater than 3 m, a proportional increase in the area of suitable absorbing material is required.

During emission testing for floor-standing EUTs, floor absorbers used during the site validation measurements, when done in accordance with the procedure of CISPR 16-1-4:2007, may be removed in the immediate area of the EUT footprint, for up to 10 cm surrounding the EUT footprint. The RF absorbing material shall not exceed 30 cm in height above the conducting floor of the test facility.

5.6 Testing at manufacturer's location or user's installation (on-site/in situ testing)

Testing is permitted at the end user or manufacturer's premises, if the equipment cannot be set up on an OATS or alternative test site (see 8.3.3). In this case, both the equipment and its location are considered the EUT. The radiated emission test results are unique to the installation site because site containment properties affect the measurements. The ac power-line conducted emission test results also may be unique to the installation. However, where testing of a given system has been accomplished at three or more representative locations, the results may be considered representative of all sites with similar EUTs for the purposes of determining compliance with emission requirements (if allowed in the procuring or requirements standard). A voltage probe (see 4.4) shall be used for ac power-line conducted emission measurements (see IEEE Std 139™ for additional information). Neither a reference ground plane nor a LISN shall be installed for user's installation testing, unless one or both are to be a permanent part of the installation.

5.7 Figure for Clause 5

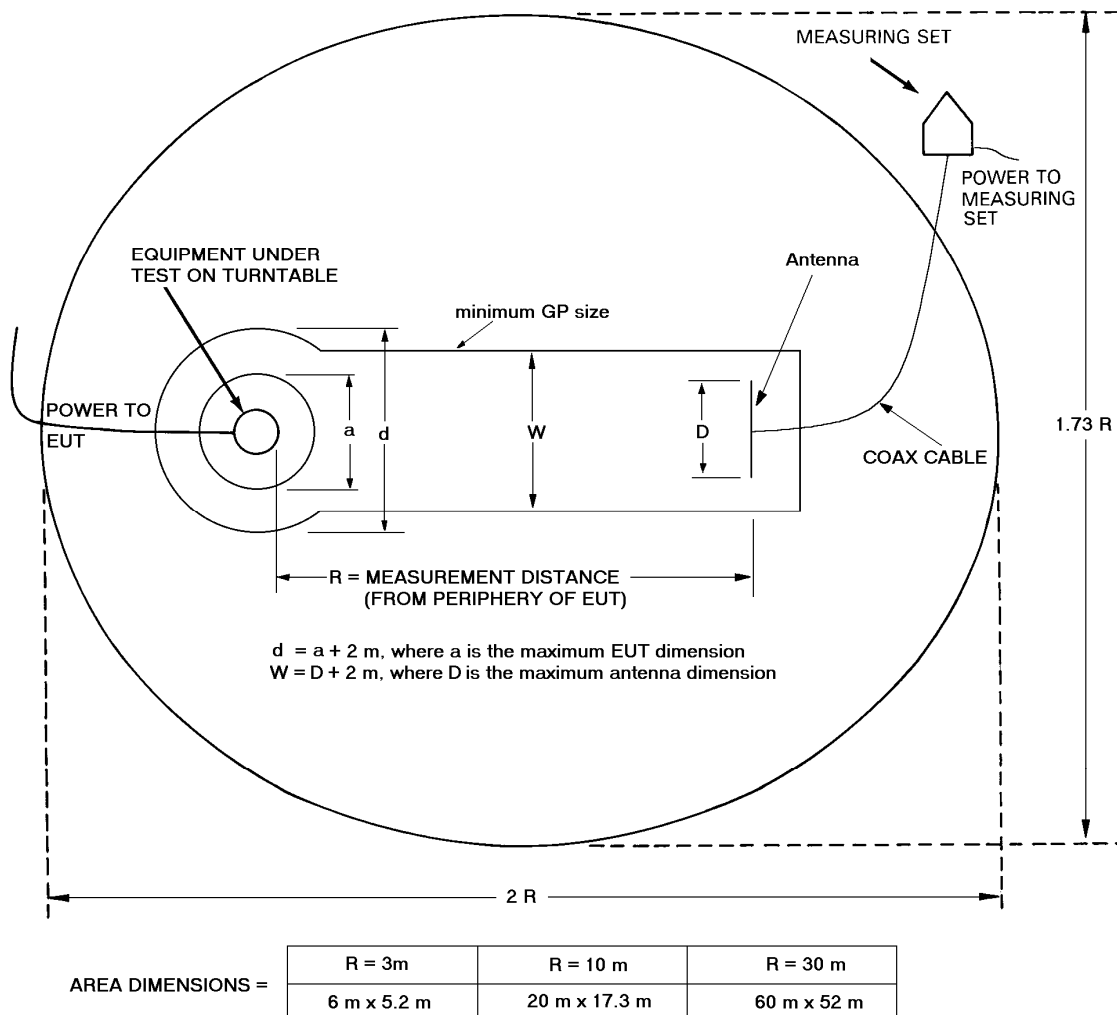


Figure 5—Radiated emissions measurement obstruction-free area and minimum size of ground plane for test site with a turntable

6. General requirements for EUT arrangements, configuration, and operation

6.1 General

This clause specifies general requirements that are applicable to all EUTs covered under the scope of this standard. Additional and more detailed requirements for specific types of EUTs are given in Clause 11 through Clause 13. Both sets of requirements shall be met [i.e., the applicable clause(s) for the specific type of EUT and the requirements of Clause 6 (see also Annex A)].

6.2 Operating conditions

The EUT and accessories shall be operated at the rated (nominal) operating voltage, operating temperature, and typical load conditions—mechanical, electrical, or both—for which they are designed. Loads may be actual or simulated as described in the individual equipment requirements. It may be necessary to develop a set of explicit requirements specifying the test conditions, EUT operation, and so on, to be used in testing a specific EUT or class of EUTs for radio-noise emissions. Such requirements shall be documented for the EUT and may be used in determining compliance with the limits. The EUT shall be operated to ensure that all the functions are exercised (software, etc.); for example, see 11.2 on information technology equipment (ITE). If software is used to exercise the EUT, then a description and all identifiers (e.g., model/issue name/number and revision number) of the specific operating software shall be included in the test report to ensure reproducible test results.

6.2.1 EUT

The EUT and accessories shall be placed in a typical arrangement as defined in 6.3.

6.2.2 Accessory equipment

Accessory equipment shall be placed in a typical arrangement as defined in 6.3.

6.2.2.1 Remotely located devices

In certain applications, a remotely located device may be connected to the EUT. In these cases, it is permissible for cabling from the remotely located device to the EUT or accessories to be placed directly on the reference ground plane or, if normally installed beneath the reference ground plane, beneath it. The remotely located device shall be located at a distance sufficient to ensure that it does not contribute to the measured radiated emission level. This procedure evaluates the interference potential of the EUT, its accessories, and interconnecting cables or wires standing apart from the remotely located device, which in turn shall be evaluated separately, if required.

6.2.2.2 Distributed networks

Distributed networks (e.g., a wired local area network) may be simulated on the test site using a cable of at least 1 m in length and an actual peripheral or a remote network communications simulator. The network simulator shall be located at a distance sufficient to ensure that it does not contribute to the measured

radiated emission level. Signals on the network from the EUT should be typical of normal operation. See 6.2.8 about use of simulators.

6.2.3 EUT ports (or terminals)

Interconnect cabling or wiring shall be connected to one of each type of functional port of the EUT, and each cable or wire shall be terminated in a device typical of actual usage. Where there are multiple ports all of the same type, additional connecting cables or wires shall be added to the EUT to determine the effect these cables or wires have on both radiated and conducted emissions from the EUT.

The number of additional cables to be added to identical ports may be limited using a process called the 2 dB rule. The 2 dB rule has two aspects: There must be an indication that the addition of cables changes the EUT emission amplitude closest to the limit by 2 dB or less, and that this emission amplitude does not continue to rise as additional cables are attached. If the amplitude of the emission continues to rise as cables are added, then additional cables shall be added even though the change in emission amplitude is less than 2 dB. The maximum signal must asymptotically rise to a level that is below the limit. Emission levels not close to the limit may vary much more than 2 dB, but the lower amplitude emission levels are not of concern because emissions closest to the limit are relevant for demonstrating compliance. The 2 dB rule also applies to the addition of identical modules to a EUT that accepts multiple modules (see 6.2.6).

NOTE—Typically, the loading of similar connectors, terminals, or ports is limited by the following:

- a) Availability of multiple loads (for large systems)
- b) Reasonableness of multiple loads representing a typical installation

The rationale for the selection of the equipment configuration and loading of ports shall be included in the test report. Additional ports on support or interfacing units or simulators, other than those associated with the EUT or the minimum system required by 11.5 for ITE, need not be cabled or used during testing.

6.2.4 Interconnect and power cabling (or wiring)

All interconnecting cable lengths should be typical of normal usage. The interconnect cabling used during testing shall be the specific cabling marketed with the EUT for use in practical applications. Where cables of variable length are used with the EUT, the cables most typical of all applications shall be used throughout the testing. When cable length is unknown, cables of 1 m nominal length shall be used. The same type of cable (i.e., unshielded, braided, foil shield, etc.) specified in the user manual should be used throughout the tests.

For equipment tested on a tabletop, excess cable length shall be draped over the back edge of the tabletop. If any draped cable extends closer than 40 cm to the reference ground plane, the excess shall be bundled in the center in a back and forth fashion using 30 cm to 40 cm lengths in the center to maintain the 40 cm height. If the cables cannot be bundled because of bulk, length, or stiffness, they shall be draped over the back edge of the tabletop unbundled, but in such a way that all portions of the interface cable remain at least 40 cm from the horizontal reference ground plane. Interconnecting cables that are connected only between the EUT and the peripheral shall be bundled in the center to maintain the 40 cm height above the reference ground plane. The end of the cable may be terminated, if required, using the correct terminating impedance. The overall length of the bundled cable shall not exceed 1 m. See Figure 7 and Figure 9 (for installations using overhead cables, see 6.2.5).

For ac power-line conducted emission measurements of tabletop equipment, power cords of equipment other than the EUT do not require bundling. Drape the power cords of non-EUT equipment over the rear edge of the table and route them down onto the floor of the conducted emission test site to the second LISN. These power cords of non-EUT equipment should not be draped over the top of a LISN. See Figure 7.

For radiated emission measurements of tabletop equipment, all power cords drape to the floor and are routed over to the ac power receptacles (on the LISNs if used) (see Figure 9).

For floor-standing equipment, excess interconnecting cable lengths shall be folded back and forth in the center to form a bundle between 30 cm and 40 cm in length. If the cables cannot be folded because of bulk, stiffness, or length, they shall be arranged in a serpentine fashion. Interconnecting cables that are not connected to a peripheral may be terminated, if required, using the correct terminating impedance. Cables that are normally grounded shall be grounded to the reference ground plane for all tests. Cables that are normally insulated from the ground shall be insulated from the reference ground plane by up to 12 mm of insulating material. For combined floor-standing and tabletop equipment, the interconnecting cable to the floor-standing unit drapes to the reference ground plane with the excess bundled. Cables not reaching the reference ground plane are draped to the height of the connector or 40 cm, whichever is lower (see NOTE 6 in Figure 13).

6.2.5 Overhead cable trays and suspended ceilings

Where overhead cable trays or suspended ceilings are used to support overhead cables, tests may be performed with overhead cable trays or suspended ceilings as shown in Figure 11 and Figure 12. The trays or ceilings should be representative of a typical installation. The precise cable layout shall be documented.

6.2.6 Modular equipment

Equipment that consists of an enclosure unit populated with multiple plug-in printed circuit boards, modules, enhancement cards, coprocessors, and so on, shall be tested with a mixture of plug-ins representative of that used in a typical installation. For installations with a large number of plug-ins (modules), a limited number of representative plug-ins may be used. The number of additional modules to be added may be limited using a process called the 2 dB rule. The 2 dB rule has two aspects: There must be an indication that the addition of modules changes the EUT emission amplitude closest to the limit by 2 dB or less, and that this emission amplitude does not continue to rise as additional modules are attached. If the amplitude of the emission continues to rise as modules are added, additional modules shall be added even though the change in emission amplitude is less than 2 dB. The maximum signal must asymptotically rise to a level that is below the limit. Emission levels not close to the limit may vary much more than 2 dB, but the lower amplitude emission levels are not of concern because emissions closest to the limit are relevant for demonstrating compliance. If applicable, each added plug-in shall have an interconnect cable or wire connected to it. These additional cables need not be terminated unless those boards are used in configuring a minimum system, such as defined in 11.5. The rationale used for selecting the number of plug-ins should be stated in the test report.

NOTE—Modular equipment here generally refers to modules as described in CISPR 22:2005, that is, part of an ITE which provides a function and may contain radio-frequency sources, but does not refer to intentional radiator modules [e.g., as described in Federal Communications Commission (FCC) 47 CFR 15.212].

6.2.7 Grounding

The EUT shall be grounded in accordance with the individual equipment requirements and conditions of intended use. When the EUT is furnished with a grounding terminal or internally grounded lead, and when this terminal or lead is used in actual installation conditions, the terminal or lead shall be connected to the reference ground plane or under the floor in a raised floor installation, simulating actual installation conditions. Any internally grounded lead included in the plug end of the ac power cord of the EUT shall be connected to the ground through the utility power service (see also 7.3).

6.2.8 Simulators

In case the EUT is required to interact functionally with other units, the actual interfacing units shall be used to provide representative operating conditions unless there is some justified reason for using a simulator. If a simulator is used, it shall represent the common-mode and differential-mode RF impedance of the interface unit, and the reasons for its use shall be documented. For communication networks simulation, see 6.2.2.2.

6.2.9 Shock and vibration isolators

The EUT shall be secured to mounting bases with shock or vibration isolators, if such mounting bases are used in the normal installation. Any bonding straps furnished with the mounting base shall be connected to the reference ground plane. When mounting bases do not have bonding straps, bonding straps shall not be used in the test arrangement.

6.2.10 Temperature and humidity

The ambient air temperature of the test site shall be within the range of 10 °C to 40 °C (50 °F to 104 °F), unless the EUT requirements specify testing over a different temperature range. The EUT and the measuring equipment shall be operated until temperature stabilizes before the testing proceeds. The warm-up time shall be included along with the measurement results if the ambient conditions are outside of the range stated above, and evidence shall be given that the measuring equipment is accurate at the temperatures used.

Humidity levels shall be in the range of 10% to 90% relative humidity unless the EUT operating requirements call for a different level. Unless specifically called out in the EUT requirements, there should be no condensation of moisture on the EUT. The ambient temperature and humidity levels shall be recorded and included in the test report if critical to the test results—see 10.2.8.

6.2.11 Special instrumentation connected to EUT

During the time radio-noise measurements are being made, external electrical meters or electrical indicating devices shall not be in the input or output circuits of the EUT, except those normally used with the measuring equipment.

6.2.12 Artificial hand

If the EUT is normally operated while held in the hand, when required by the procuring organization, measurements shall be made using an artificial hand (see Clause 8 of CISPR 16-1-2:2006) to simulate the effects of the user's hand. If the EUT can be operated either held in the hand or not, it shall be tested in both ways.

6.3 Arrangement of EUT

EUT arrangement is the manner in which the EUT and its associated equipment are laid out on the test table for tabletop equipment or on the floor for floor-standing equipment. The EUT shall be carefully arranged in a manner that is most representative of the equipment as typically used (i.e., as specified in the

EUT instruction manual) or as specified herein. Equipment that typically operates within a system made of multiple interconnected units should be tested as part of such a typical operational system.

The system that is tested shall be based on that typically marketed to the end user. If the marketing information is not available or it is not practical to assemble extraordinary amounts of equipment to replicate a complete marketed product installation, the test shall be performed using the best judgment of the test engineer in consultation with the design engineering staff. The results of any such discussion and decision process shall be reported in the test report. A photograph or detailed drawing shall be used to document the equipment arrangement and shall be part of the test report.

In order to replicate emission measurements, it is important to document the arrangement of the system components, cables, wires, and ac power cords. Three general equipment test arrangements are tabletop, floor standing, and a combination of tabletop and floor standing defined for testing all classes of devices as described below.

6.3.1 Tabletop equipment tests

Portable, small, lightweight, or modular devices that may be handheld, worn on the body, or placed on a table during operation shall be positioned on a nonconducting platform, the top of which is 80 cm above the reference ground plane. The preferred area occupied by the EUT arrangement is 1 m by 1.5 m, but it may be larger or smaller to accommodate various sized EUTs (see Figure 6, Figure 7, and Figure 9). For testing purposes, ceiling- and wall-mounted devices also shall be positioned on a tabletop (see also 6.3.4 and 6.3.5). In making any tests involving handheld, body-worn, or ceiling-mounted equipment, it is essential to recognize that the measured levels may be dependent on the orientation (attitude) of the three orthogonal axes of the EUT. Thus, exploratory tests as specified in 8.3.1 shall be carried out for various axes orientations to determine the attitude having maximum or near-maximum emission level.

6.3.1.1 Placement of tabletop EUTs

For tabletop systems, the EUT shall be centered laterally (left to right facing the tabletop) on the tabletop, and its rear shall be flush with the rear of the table. If the EUT is a stand-alone unit, its center shall be located over the center of the turntable.

6.3.1.2 Placement of tabletop accessories/peripherals

Accessories/peripherals that are part of a system tested on a tabletop shall be placed in a test arrangement on one or both sides of the host with a 10 cm separation between the nearest points of the cabinets (see Figure 6). The rear of the host and accessories should be flush with the back of the supporting tabletop unless that would not be typical of normal use. If more than two accessories are present, then an equipment test arrangement should be chosen that maintains a spacing of 10 cm between cabinets unless the equipment is normally located closer together.

Multiple peripherals/accessories (more than two) may be distributed around the table as shown in Figure 6. If the EUT peripherals are designed to be stacked in typical use, then they shall be stacked for emission testing, occupying positions of peripheral 1 or peripheral 2. See Figure 6.

When there is only one peripheral, place the peripheral as shown in Figure 6 for peripheral 1.

Accessories, such as ac power adapters providing dc power to the EUT, which are typically table mounted because of cable length, shall be mounted on the tabletop in a typical manner.

Accessories, which are typically floor mounted, shall occupy a floor position directly below the portion of the EUT to which they are typically connected.

NOTE—The keyboard and mouse cables from the back of a personal computer (PC) should be routed along the side of the central processing unit (CPU) to gain maximum coupling between the CPU and the cables.

Power accessories, such as ac power adapters that power other devices, shall be tested in the following manner:

- a) Power accessories that are not the EUT: If the power accessory connects to a tabletop EUT having a power cord to the power accessory less than 80 cm in length, the power accessory is placed on the tabletop. If the EUT power cord to the power accessory is 80 cm or greater in length, then the power accessory is placed on the floor immediately under the EUT.

If the power accessory plugs directly into the wall outlet, it shall be attached to the source of power on top of the ground plane and directly under the EUT with the EUT connected. If the EUT power cord is less than 80 cm, then a nonconductive support for raising the power accessory is needed along with a short extension cord from the source of power to the raised power accessory.

- b) Power accessories that are the EUT: If the input power cord of the power accessory has length 80 cm or greater, the power accessory shall be placed on the tabletop. If the power accessory has an input power cord that is less than 80 cm, the power accessory shall be placed at a height above the ground plane such that its input power cord is fully extended in the vertical direction.

If the power accessory plugs directly into the wall outlet, the power accessory shall be tested on the tabletop using an extension cord between the source of power and the accessory. The extension cord shall be connected in a manner such that it takes the most direct path to the power accessory.

6.3.1.3 Placement and manipulation of interconnect cabling (or wiring) of tabletop equipment

The system shall be arranged in one typical equipment arrangement for the test. In making any tests involving several tabletop equipment components interconnected by cables or wires, it is essential to recognize that the measured levels may be critically dependent on the exact placement of the cables or wires. Thus, exploratory tests as specified in 7.3.3 and 8.3.1 shall be carried out while varying cable positions within typical arrangements to determine the maximum or near-maximum emission level. During manipulation, cables shall not be placed under or on top of the system units unless such placement is required by the inherent equipment design or consistent with typical use.

6.3.2 Floor-standing equipment tests

Where a floor-standing EUT is typically installed with its base in direct electrical contact with, or connected to, a grounded metal floor or grid, the EUT shall be connected to, or placed directly on, the test site (or turntable) reference ground plane in a manner representative of this contact or connection.

Where floor-standing equipment is not typically installed with its base in direct electrical contact with, or connected to, a metal floor or grid, the EUT shall not be placed in direct electrical contact with the test site (or turntable) reference ground plane. If necessary to prevent direct metallic contact of the EUT and the reference ground plane, insulating material (up to 12 mm thick) shall be placed under the EUT.

In order to represent typical raised/false floor installation of EUTs more explicitly, the base of the EUT shall be raised but in no case can exceed 34 cm above the reference ground plane. If an EUT elevation that is not representative of a typical installation is used for testing, the reason for the variation shall be explained in the test report.

Floor-standing equipment (i.e., as defined in 3.1) can be interconnected with cabling lying on the floor, under the floor (to simulate a raised floor installation), or overhead, according to normal installation. The material used to raise the test item shall be nonconductive and shall not adversely affect the site validation criteria.

6.3.2.1 Placement of floor-standing EUTs

Test arrangements for floor-standing equipment are shown in Figure 8 and Figure 10 through Figure 12. Normally, tests shall be run with the equipment standing on the reference ground plane, with or without an insulating surface, as appropriate.

6.3.2.2 Placement of floor-standing accessories

Accessories that are part of a floor-standing system shall be placed in one typical arrangement with typical spacing between equipment cabinets or enclosures. If more or less than two accessories are present, a typical arrangement should be chosen that maintains typical spacing between all equipment cabinets or enclosures.

6.3.2.3 Placement and manipulation of interconnect cabling (or wiring) of floor-standing equipment

Interconnecting cables are not normally manipulated for floor-standing equipment in which the typical installation is known. Instead, the cables shall be laid out as shown in Figure 8 and Figure 10. If the configuration of a typical installation is not known or changes with each installation, cables of floor-standing equipment shall be manipulated to the extent possible to produce the maximum level of emissions, within the range of typical installations. For large equipment interfacing with other large equipment normally at a distance, cables may be attached to the EUT, extend away from the EUT in the horizontal direction for at least 1 m, and then return to another port of the EUT (which would normally receive the transmit signal from another equipment), but at an elevation sufficiently different than that of the outgoing direction so as not to cancel the emission potential of either cable in this loop back situation. Loop back for this purpose is then characterized by a single cable leaving a port of the EUT, extending a distance away, and then routed back to the EUT at another port.

6.3.3 Combination equipment tests

Equipment designed for both tabletop and floor operation shall be tested only in the tabletop arrangement. Equipment designed for floor operation shall be tested on the floor.

Equipment that is part of a combination of both tabletop and floor-standing equipment, which are typically used together, shall be tested as a combination in accordance with Figure 13.

6.3.3.1 Placement of combination equipment EUTs

Tabletop or floor-standing EUTs shall be positioned following 6.3.1.1 or 6.3.2.1, respectively, unless this produces an atypical arrangement. In such cases, position the EUT in a typical arrangement for testing and document the reason and differences in the test report.

6.3.3.2 Placement of combination equipment accessories

Tabletop or floor-standing accessories shall be positioned following 6.3.1.2 or 6.3.2.2, respectively, unless this produces an atypical arrangement. In such cases, position the accessory or accessories in a typical arrangement for testing and document the justification for the change and description of differences in the test report.

6.3.3.3 Placement and manipulation of interconnect cabling (or wiring) of combination equipment

Follow Figure 7 through Figure 10 and Figure 13, as well as 6.3.1.3, for placement and manipulation of cabling or wiring connecting two tabletop units or a tabletop unit and a floor-standing unit. Follow 6.3.2.3 for placement and manipulation of cabling connecting two floor-standing units.

6.3.4 Placement of wall-mounted equipment

Equipment designed for wall-mounted operation shall be tested as tabletop EUT. The orientation of the equipment shall be consistent with that of normal operation. Any special supporting structures shall simulate typical installations and shall put the base of the EUT at a height of 80 cm above the reference ground plane.

6.3.5 Placement of ceiling-mounted equipment

Equipment designed for ceiling-mounted operation shall be tested as tabletop EUT. Any special supporting structures shall simulate typical installations, except that the downward-facing direction of the EUT shall be oriented pointing upwards, and shall put the base of the EUT at a height of 80 cm above the reference ground plane. In addition to the upward-facing EUT orientation, one orthogonal axis position shall be tested with the downward-facing direction oriented horizontal (i.e., EUT downward-direction axis parallel to ground plane); see also 8.3.1.