



American National Standard for Methods of Measurement of Radio-Frequency Emissions from Lighting Devices

C63[®]

USEMCSC C63[®] Committee on Electromagnetic Compatibility –
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ANSI/USEMCSC C63.29-2022

STANDARDS

American National Standard for Methods of Measurement of Radio-Frequency Emissions from Lighting Devices

USEMCSC C63® Committee on Electromagnetic Compatibility

Accredited by the

American National Standards Institute

Secretariat

Institute of Electrical and Electronics Engineers, Inc.

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C63®

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

Keywords: ANSI C63.29, conducted emission testing, conducting ground plane, electric field measurement, intentional radiators, lighting devices, lighting equipment, line impedance stabilization network, magnetic field measurement, radiated emission testing, unintentional radiators

United States EMC Standards Corporation
5702 368th Avenue, PO Box 598, Burlington, WI 53105, USA

The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA

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Jennifer Santulli, Secretariat

<i>Organization Represented</i>	<i>Name of Representative</i>
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.....	Rob Miller (<i>Alt.</i>)
American Council of Independent Laboratories (ACIL)	Javier Cardenas
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Cisco Systems	Andy Griffin
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.....	Henry Benitez (<i>Alt.</i>)
Information Technology Industry Council (ITIC)	John Hirvela
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Intertek.....	Nicholas Abbondante
ISED Canada	Jason Nixon
.....	Horia Popovici (<i>Alt.</i>)
Keysight Technologies.....	Nate Potts
Motorola Solutions	Deanna Zakharia
.....	Sze Khian Ho (<i>Alt.</i>)
National Institute of Standards and Technology (NIST).....	Jason Coder
Qualcomm Technologies, Inc.	John Forrester
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Rohde & Schwarz	Jeremy Cline
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Telecommunication Certification Body (TCB) Council	Chris Harvey
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UL LLC	Bob DeLisi
.....	Michael Antola (<i>Alt.</i>)
U.S. Department of Defense—Joint Spectrum Center	Marcus Shellman
.....	Michael Duncanson (<i>Alt.</i>)
Individual Members.....	H. Stephen Berger
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.....	Daniel Hoolihan
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Introduction

This introduction is not part of ANSI/USEMCSC C63.29-2022, American National Standard for Methods of Measurement of Radio-Frequency Emissions from Lighting Devices.

This standard specifies procedures for verifying the electromagnetic (EMC) compliance of lighting equipment of various categories including, but not limited to: self-ballasted lamps, luminaires (light fixtures), dimmers, etc. and of various technologies, such as fluorescent, gas-discharge, light emitting diode (LED), etc.

This first edition includes measurement procedures applicable to lighting equipment of types and technologies that are or are soon to be introduced on the market at the time of publication of this standard. As new designs and technologies mature, they can be addressed in future revisions of this standard.

Lighting devices have been transforming from passive devices operating mostly at 60 Hz into electronic devices. Some of the earliest electronic lighting appliances were compact fluorescent lamp ballasts, which initially operated at frequencies of 25 kHz and later at frequencies of 45 kHz; regardless, this technology brought lighting devices into the scope of regulatory requirements applicable to unintentional radiators. Electronic ballasts were considered to be evaluated under FCC part 18 [B11] and to be measured using the MP-5 [B12]⁶ test methods since then. Two electronic compact fluorescent ballasts were introduced: one, an integral unit with the fluorescent lamp (called self-ballasted lamp), and another presented as an “adaptor,” which provided high-frequency power to a “plugged-in” fluorescent lamp to operate. Both, the self-ballasted lamp and the adaptor, included a lamp base similar to the incandescent lamp intending to retrofit incandescent lamps into existing consumer lamps. Consideration for high-frequency emissions were typically addressed at the self-ballasted lamp level and usually at the adaptor level.

Other types of fluorescent ballasts followed, including dimming ballasts, which expanded the frequency of operation above 100 kHz. Later, induction lamp drivers and high-frequency electronic ballasts were introduced, pushing the lamp current frequency into the MHz band. The Federal Communications Commission (FCC) introduced an amendment to FCC part 18 to accommodate these technologies. Electronic fluorescent ballasts were massively retrofitted in commercial and industrial luminaires in the late 1980s and 1990s. These luminaires were originally powered with magnetic ballasts. Similarly, high-frequency emissions were addressed at the fluorescent ballast level because they were meant to replace magnetic ballasts already being used in luminaires. No amendments were introduced to FCC part 18 or MP-5 [B12] at that time.

The United States supply chain evolved to operate as follows: luminaire manufacturers produced the mechanical enclosure, with the optics control, and purchased the light source and the electronics from a third party. Manufacturers of ballasts and self-ballasted lamps conducted the necessary high-frequency emission testing and kept records.

Currently, three new technology innovations are transforming the emission frequencies and levels from lighting devices: 1) the use of microprocessors, 2) the massive adoption of LED light sources, and 3) connected lighting systems. The first two changed the emissions nature and the last one brought intentional radiators into consideration. The FCC clarified that LED RF devices are to be evaluated under FCC part 15. There is a massive penetration of LED self-ballasted lamps with a newcomer, the tubular LED (TLED) lamp. These light sources evolved in three major ways: powered from the mains (similar to a self-ballasted lamp), powered from the existing ballast, and powered from a dedicated LED driver. Self-ballasted lamps have been tested similarly to fluorescent self-ballasted lamps: the TLEDs that are mains-connected are tested while mounted in a luminaire. The TLEDs operated from a ballast are supported in the initial ballast verification.

⁶ The numbers in brackets correspond to those of the bibliography in Annex J.

This ANSI C63.29 standard aims to replace MP-5 [B12] to modernize lighting device testing by using the methods specified in ANSI C63.4⁷ and CISPR 15 [B5].

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American National Standard for Methods of Measurement of Radio-Frequency Emissions from Lighting Devices

1. Overview

1.1 Scope

This standard includes procedures for evaluating the compliance of lighting devices with applicable electromagnetic compatibility (EMC) requirements. Test procedures for radiated field strength and conducted disturbance measurements are included, with reference to established standards, where applicable. This standard covers measurement methodologies, but is not intended to describe regulatory limits.

Some regulatory agencies classify lighting devices either as Industrial, Scientific and Medical (ISM) equipment or as digital equipment, depending on its technology. However, if the lighting device includes any wireless modules (intentional radiator, e.g., IEEE 802.11), that portion of the lighting device is usually classified as radio apparatus. This standard includes methods for evaluating the compliance of the lighting device, excluding its radio apparatus portion (if any), with the applicable EMC limits, as specified by the purchasing agency or regulatory authority. Compliance evaluation procedures for radio apparatus are usually subject to other testing procedures; e.g., ANSI C63.10 [B1],⁹ ANSI C63.26 [B2], and/or additional or other applicable requirements, as specified by the purchasing agency or regulatory authority. This standard does not cover the testing of other types of ISM equipment, incidental or un-intentional radiators.

This standard is also not intended to specify measurement techniques or limits for radio frequency (RF) exposure, electric shock, or electrostimulation due to electromagnetic fields generated by lighting devices.

Measurement methods are included for radiated and alternating current (ac) mains power-line conducted emissions that can be generated by a variety of lighting devices, as described in 1.2. For correctly measuring such emissions, this standard prescribes a sequence of three procedures: frequency identification [for determining the equipment under test (EUT) emission frequencies], exploratory measurements (for determining the set of conditions under which the EUT generates the highest emission relative to the applicable limit), and maximization (manipulation and operation of test instrumentation for determining the level of the highest emission from the EUT). These three processes are defined in 3.1.

⁹ The numbers in brackets correspond to those of the bibliography in Annex J.

Definitions are provided for terms and phrases contained in the text, in which the words do not represent obvious or common usage. 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 also included. The main text is augmented by a series of annexes that provide other useful information or normative requirements.

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

The methods in this standard are intended for measuring emissions from the equipment under test in the 9 kHz to 40 GHz frequency range.

1.2 Purpose and applications

1.2.1 General

This standard specifies the methods of measurement to be used for evaluating compliance with the applicable radiated and ac mains power-line conducted emissions requirements for lighting devices in wide use (such as luminaires, self-ballasted lamps, dimmers, etc.).

Emission limit requirements shall be obtained from the applicable voluntary or regulatory sources.

Not all clauses in this standard are applicable to all devices that are subject to this standard. The nature of this standard is to specify general methods that shall be applied to all devices in its scope and to supplement these methods with particular requirements for some specific categories of lighting devices. Device-particular requirements take precedence over general requirements.

This edition of ANSI C63.29 applies to the following general categories of lighting devices:

- a) Active luminaires (i.e., active light fixtures; see 3.1)
- b) The lighting components of multi-function equipment if one of the primary functions of this equipment is illumination
- c) Ultraviolet (UV) and infrared (IR) radiation equipment
- d) Active components (example: ballast, drivers, dimmers, lamps and other; see 3.1) intended exclusively for use with lighting devices or in lighting installations and which are marketed independently
- e) Simple advertising signs, i.e., advertising signs other than those in 1.2.2e)4)
EXAMPLE—Neon tube signs, emergency exit signs.
- f) Decorative and entertainment lighting

As new lighting technologies mature, this standard might need to be revised or a follow-up amendment might need to be developed to include them.

1.2.2 Exclusions

This edition of ANSI C63.29 does not apply to the following categories of lighting devices:

- a) Passive lighting devices, such as passive luminaires

NOTE 1—Passive lighting devices, i.e., that do not include any active/switching electronic components nor any gas-discharge lighting devices or associated components, are usually considered to be compliant with the applicable limits without testing.¹⁰

EXAMPLE—Luminaires with no electronics (e.g., consisting only of the chassis and power cable).

- b) Subassemblies or components intended to be built into lighting devices and that are not user-replaceable
- c) Lighting devices used inside aircraft
- d) Installations
- e) Equipment that includes lighting sub-components, but that does not have illumination as one of its primary functions. Some examples are:

- 1) Equipment with built-in lighting devices for display back-lighting or signaling

NOTE 2—Such equipment is in principle subject to ANSI C63.4, since it includes digital circuits.

- 2) Range hoods, refrigerators
- 3) Photocopiers, projectors (see NOTE 2 above)
- 4) Large advertising signs that include many individual lamps and are capable of displaying complex images or moving pictures (see NOTE 2 above)
- 5) Lighting devices used in motorized vehicles or boats for purposes exclusively related to traffic signaling and safe operation of the vehicle/boat, such as headlights or turn/stop signals, and which is factory-installed by the manufacturer of the vehicle / boat

NOTE 3—Lighting devices used in recreational vehicles (RVs), for purposes other than traffic signaling (i.e., headlights and/or turn/stop signals), is not covered by the above exclusion. Such lighting devices are operated when the RV is used as a residential dwelling and, as such, they are in the scope of ANSI C63.29.

NOTE 4—Lighting devices not factory-installed in the vehicle/boat, such as floodlights for after-market installation on top of the cabin of a truck, are components that are marketed independently and, as such, are in the scope of ANSI C63.29.

1.2.3 Additional information for the application of ANSI C63.29

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 mains power-line conducted and radiated emission measurements, together with detector function to be used for each limit (e.g., positive peak, quasi-peak, or linear average)
- b) What lighting device categories are considered residential or otherwise subject to Class B limits, if applicable
- c) Resolution bandwidth setting to be used on the measuring instrument for each test case, limit, and frequency range, if different from the bandwidth settings set out in this standard

¹⁰ Notes in text, tables, and figures are given for information only and do not contain requirements needed to implement the standard.

- d) Measurement antenna distance for radiated emission measurements for each applicable frequency range and for each applicable limit
- e) Extrapolation factor to be used when the limit is specified at a distance that is not practical for measurement, if different from the requirements in 9.2
- f) Identification of any uncommon requirements or of any requirements that differ from those specified herein
- g) Any requirement concerning statements of uncertainty of the measurement results (see ISO/IEC 17025:2017¹¹), if different from those in 1.6 (see also 10.3.7.2)

1.3 Word usage

For clarity in what is meant by the use of certain verbs in this standard, the following defines what each verb shown means:

- The word *shall* indicates a mandatory requirement strictly to be followed in order to conform to the standard and from which no deviation is permitted (*shall* equals *is required to*).^{12, 13}
- The word *should* indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required (*should* equals *is recommended that*).
- The word *may* is used to indicate a course of action permissible within the limits of the standard (*may* equals *is permitted to*).
- The word *can* is used for statements of possibility and capability, whether material, physical, or causal (*can* equals *is able to*).

NOTE—Use of these verbs follows the requirements in the 2021 IEEE SA Standards Style Manual.¹⁴

1.4 Additional word usage conventions

The word *shall* used in an informative annex indicates a mandatory requirement for the use of that annex (i.e., while the annex is not normative, if the user chooses to use it, then the mandatory requirements stated therein using the word *shall* indicate requirements that have to be met to satisfy this standard). The use of that annex makes all *shall* statements therein conditionally normative, i.e., if the annex is selected for use, then each *shall* statement in that annex becomes normative for the application of this standard.

The word *might* is used to express a chance or possibility that something will happen or exist in the future.

In addition, notes in this document are informative and are not part of the requirements. 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 as an aid applicable to the use of the standard, but mandatory requirements are not included in text footnotes.

¹¹ Information on references can be found in Clause 2.

¹² The use of the word *must* is deprecated and cannot be used when stating mandatory requirements; *must* is used only to describe unavoidable situations.

¹³ The use of the word *will* is deprecated and cannot be used when stating mandatory requirements; *will* is only used in statements of fact.

¹⁴ Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement this standard.

In this standard, figures are normative only if identified by inclusion of the word “normative” in the figure caption. In general, 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 to tables and figures are informative; however, footnotes (i.e., superscript notation) to tables and figures are normative, as are numbered paragraphs between a figure and its caption (e.g., the list paragraphs in Figure 3 through Figure 12).

1.5 Dimensional tolerances

Tolerances for spatial dimensional requirements specified in this standard are given in the tables of the normative Annex A and shall be used to provide the required tolerance.

Wherever non-spatial parameters are stated in this standard (e.g., a “50 Ω ” system), they are not normally accompanied by a normative tolerance requirement.

To aid in knowing when tolerances are to be used, a parenthetical statement follows those dimensions in the text. The wording simply says, e.g., “(see row #3 of Table A.1)” to lead the user to the applicable tolerance.

NOTE—Nominal dimensions are those dimensions that are stated without a specified tolerance. By definition, nominal dimensions should have tolerances that are consistent with good engineering practice. In particular, tolerances selected by users should be at least an order of magnitude less than the dimensional requirements themselves.

1.6 Measurement uncertainty

The reporting of measurement results of emissions from lighting devices shall be accompanied by corresponding measurement instrumentation uncertainty estimation (see 10.3.7.2). Determining compliance shall be based on the results of the compliance measurements, not taking into account the measurement instrumentation uncertainty. However, the measurement instrumentation uncertainty shall be calculated for each test case performed, as per the requirements below, and both the measurement results and the calculated measurement uncertainty shall appear in the test report.

Measurement instrumentation uncertainty shall be calculated as per the guidelines in ANSI C63.23 and the actual calculation method shall be available for inspection by any interested third party, but shall be based on the actual instrumentation and test site used by the specific test lab. Measurement instrumentation uncertainty need not be calculated and reported for test cases that are not covered in ANSI C63.23.

NOTE—CISPR 16-4-2 [B9] is normatively referenced in ANSI C63.23.

2. Normative references

The following referenced documents are indispensable for the application of this standard (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained).

Where a dated reference to a specific clause, subclause, table, figure, or annex of another document is made in this standard, it is acceptable to use a more recent edition of the referenced document, or an older one, provided identical text exists in both editions of that document for the referenced clause, subclause, table, figure, or annex.

ANSI C63.2-2016, American National Standard for Specifications of Electromagnetic Interference and Field Strength Measuring Instrumentation in the Frequency Range 9 kHz to 40 GHz.¹⁵

ANSI C63.4-2014 (amended per ANSI C63.4a-2017), 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.

ANSI C63.5-2017/Cor 1-2019, American National Standard for Electromagnetic Compatibility—Radiated Emission Measurements in Electromagnetic Interference (EMI) Control—Calibration and Qualification of Antennas (9 kHz to 40 GHz)—Corrigendum 1.

ANSI C63.7-2015, American National Standard Guide for Construction of Test Sites for Performing Radiated Emission Measurements.

ANSI C63.14-2014, American National Standard Dictionary of Electromagnetic Compatibility (EMC) including Electromagnetic Environmental Effects (E3).

ANSI C63.23-2012, American National Standard Guide for Electromagnetic Compatibility—Computations and Treatment of Measurement Uncertainty.

ANSI C63.25.1-2018, American National Standard Validation Methods for Radiated Emission Test Sites, 1 GHz to 18 GHz.

CISPR 16-1-1:2019-05, Specification for radio disturbance and immunity measuring apparatus and methods—Part 1-1: Radio disturbance and immunity measuring apparatus—Measuring apparatus, Ed. 5.0.¹⁶

CISPR 16-1-2:2017-11, Specification for radio disturbance and immunity measuring apparatus and methods—Part 1-2: Radio disturbance and immunity measuring apparatus—Coupling devices for conducted disturbance measurements, Ed. 2.1.

CISPR 16-1-4:2020-06, Specification for radio disturbance and immunity measuring apparatus and methods—Part 1-4: Radio disturbance and immunity measuring apparatus—Antennas and test sites for radiated disturbance measurements, Ed. 4.1.

CISPR 16-1-6:2017-01, Specification for radio disturbance and immunity measuring apparatus and methods—Part 1-6: Radio disturbance and immunity measuring apparatus—EMC antenna calibration, Ed. 1.1.

CISPR 16-2-3:2019-06, Specification for radio disturbance and immunity measuring apparatus and methods—Part 2-3: Methods of measurement of disturbances and immunity—Radiated disturbance measurements, Ed. 4.1.

ISO/IEC 17025:2017, General requirements for the competence of testing and calibration laboratories.¹⁷

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

¹⁵ ANSI C63® publications are available from The Institute of Electrical and Electronics Engineers (<http://standards.ieee.org/>) or from the American National Standards Institute (www.ansi.org/).

¹⁶ CISPR documents are available from the International Electrotechnical Commission (www.iec.ch/) and the American National Standards Institute (www.ansi.org/).

¹⁷ ISO publications are available from the ISO Central Secretariat (www.iso.ch/) and the American National Standards Institute (www.ansi.org/).

3. Definitions, acronyms, and abbreviations

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online*¹⁸ and ANSI C63.14 should be consulted for terms not defined in this subclause.¹⁹

NOTE—All the definitions in this subclause are written such that they can replace the corresponding term in its context within this standard. Therefore, the text of a definition does not start with an article (e.g., “the,” or “a”) nor end with a period.

active antenna: Antenna system with integral amplifiers, preamplifiers, and/or other nonlinear active devices that amplify the signal and/or shape the frequency response. (adapted from CISPR 16-1-4:2020-06, A.4.2.4) *Contrast:* **passive antenna.**

NOTE 1—Examples of active antennas used for electromagnetic compatibility (EMC) measurements include active loop antennas and active double-ridge guide horn antennas.

NOTE 2—In contrast, the text in A.4.2.4 of CISPR 16-1-4:2020-06 is: “A broadband antenna is considered an active antenna if it contains amplifiers, preamplifiers, and other non-linear active devices that amplify the signal or shape the frequency response or both.”²⁰

ambient level: Values of radiated and conducted signal and noise existing at a specified test location and time when the test sample (i.e., the EUT) is not activated.

ancillary equipment: Transducer or other equipment connected to the measurement instrument and used in the disturbance signal transfer between the EUT and the measurement instrument. (adapted from CISPR 16-1-2:2017-11)

NOTE 1—Examples of ancillary equipment: line impedance stabilization network (LISN), voltage probe, antenna, cable, preamplifier, attenuator, filter.

NOTE 2—In contrast, the definition in 3.1.1 of CISPR 16-1-2:2017-11 is: “transducers connected to a measuring receiver or (test) signal generator and used in the disturbance signal transfer between the EUT and the measuring or test equipment.”²¹

antenna factor: Ratio of the electric (or magnetic) field strength E (or H) in the polarization direction (or orientation) of the antenna to the voltage induced across the load connected to the antenna terminals V_o and expressed in decibel form $[20 \log (E/V_o)$ or $20 \log (H/V_o)]$. (adapted from ANSI C63.5-2017)

NOTE 1—The electrical antenna factor has a logarithmic unit of dB(1/m) and a linear unit of 1/m. The magnetic antenna factor has a logarithmic unit of dB(S/m) and a linear unit of S/m.

NOTE 2—In contrast, the text in 3.1 of ANSI C63.5-2017 is: “Ratio of the electric field strength (E) in the polarization direction of the antenna to the voltage (V_o) induced across the load connected to the antenna and expressed in decibel form $[20 \log (E/V_o)]$. The AF has units of dB(1/m) in logarithmic units and 1/m in linear units.”

¹⁸*IEEE Standards Dictionary Online* is available at: <http://dictionary.ieee.org>. An IEEE Account is required for access to the dictionary, and one can be created at no charge on the dictionary sign-in page.

¹⁹ References to standards enclosed in square brackets in the definition clause (3.1) are for information only.

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²¹ Copyright © 2017 IEC Geneva, Switzerland, www.iec.ch.

auxiliary equipment (AE): Peripheral equipment that is part of the EUT and is marketed together with the EUT as a package.

NOTE 1—Examples of AE: keyboard, mouse, and monitor marketed together with a desktop personal computer (PC); ac mains power adapter marketed together with a laptop PC. AE is included in the EUT arrangement and tested together with the EUT (as illustrated, for example, in Figure 4 and Figure 8).

NOTE 2—Examples of equipment that is not AE: keyboard, mouse, or monitor, not marketed together with a desktop PC (these are support equipment, in this case). Such equipment is not usually included in the EUT arrangement (as illustrated, for example, in Figure 8).

bin size: Frequency span divided by the number of trace points minus one, on an instrument display.

NOTE—The concept of “bin” is described in detail in the *Spectrum Analysis Basics* application note 150 [B16], wherein the term “bucket” is used rather than “bin.”

calibration: Operation establishing the relation between quantity values provided by measurement standards and the corresponding indications of a measuring system, carried out under specified conditions and including evaluation of measurement uncertainty. (ANSI C63.10-2013)

combination equipment under test (combination EUT): EUT comprised of tabletop and floor-standing units.

component: Device used to electrically drive or control a light source directly or indirectly, which can also include the light source itself.

EXAMPLES—Self-ballasted lamp, ballast, remote control, dimmer, control unit, light emitting diode (LED) module, ac mains power adapter, LED driver, electronic transformer.

(electromagnetic) disturbance: Electromagnetic phenomenon that can degrade the performance of a device, piece of equipment, or system, or adversely affect living or inert matter.

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

electronic ballast: Control circuit independent of the lamp, which controls the starting and operating currents.

electronic transformer (converter): AC driven device, converting the standard ac voltages (e.g., 120 V) to a lower ac voltage (e.g., 12 V or 24 V) required by the lamp or lighting system

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

NOTE—A specific emission source in an EUT can generate emissions at multiple frequencies (such as a clock oscillator generating emissions at the fundamental and at harmonics of the fundamental). The term *emission* is used in this document to refer to an emission at a specific frequency, or rather in a band equal to the RBW centered at that frequency, even though that emission might be related to other emissions, at other frequencies. The term is also used to refer to the ensemble of all EUT emissions, at all frequencies where these occur. However, the term is not to be understood as referring to a specific emission source in the EUT and, correspondingly, to the ensemble of emission frequencies generated by that specific source.

entertainment lighting: Luminaire, utilizing electric light source(s), that is intended to be used in stage, studio, television, and film studio applications.

NOTE 1—Stage entertainment lighting includes those intended for installation in bars, restaurants, museums, etc.

NOTE 2—This type of lighting is not usually intended for general illumination.

equipment under test (EUT): Device or system, which can consist of one unit or a combination of multiple units and interconnecting cables, including the AE and locally-placed support equipment (SE), that is representative of a product to be marketed and is being evaluated for compliance.

NOTE 1—The AE, if any, is part of the system under test, together with the EUT. Any SE that is not remotely located, while not part of the system under test, is nonetheless arranged in the same manner as the system under test (EUT and AE), in accordance with Clause 6.

NOTE 2—The terms “AE” and “SE” are added only where necessary, such as when different provisions apply to the EUT versus AE and/or versus locally-placed SE.

EUT arrangement: Physical layout and orientation of all the parts of the EUT, auxiliary equipment, support equipment (if included in the EUT arrangement, instead of being remotely located), and any corresponding cabling located within the test volume. (adapted from CISPR 32:2015-03)

NOTE—In contrast, the definition in 3.1.4 of CISPR 32:2015-03 is: “physical layout and orientation of all the parts of the EUT, AE and any associated cabling located within the area.”²² The abbreviation “AE” is used in CISPR 32 for the term “associated equipment,” which is equivalent to the term “support equipment” used in ANSI C63.29, and not for “auxiliary equipment,” as in this document (CISPR 32:2015-03 does not use the term “auxiliary equipment”).

EUT boundary: Smallest circle enclosing the EUT arrangement’s footprint on the floor of the radiated emission test site.

EUT configuration: Combination of equipment units constituting the EUT and the associated interconnections between them.

EUT operation: Manner in which the EUT is operated during the test, including placing it in its typical functional operation mode and exercising all its ports.

EUT setup: Manner in which the EUT is configured, arranged, and operated for testing.

NOTE—The EUT setup includes the EUT configuration, the EUT arrangement, and the EUT operation mode used during the test.

EUT volume: Vertically-oriented cylinder with smallest height and smallest diameter such that it encompasses the entire EUT arrangement.

exercise (a port): Process of passing signals or data into or out of the port at the applicable voltage, current, or rate for that port.

exploratory measurements: Process consisting of variation of the EUT’s position, orientation, configuration, cables’ positions, arrangement, and mode of operation for finding the specific set of conditions under which the highest emission relative to the limit is obtained.

NOTE—Guidelines on how to perform exploratory radiated emission measurements are included in Annex E. This is a compliance type test because its result determines the set of EUT conditions to be used for the final measurements.

extension cord: Electric cord having a standard plug at one end and a standard electric receptacle at the other.

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.

²² Copyright © 2015 IEC Geneva, Switzerland, www.iec.ch.

frequency identification: Process carried out for identifying EUT emission frequencies, in typical operation modes.

NOTE—This process is mostly used as an initial test prior to final compliance measurements on an OATS. It is usually performed in a shielded room and it is not a compliance-type measurement. The scope is not to find which EUT emission is highest relative to the limit.

gas-discharge lamp: Lighting device using a ballast to generate an electrical discharge to ionize an inert gas.

hybrid antenna: Antenna that is constructed such that it includes a combination of both broadband dipole (e.g., biconical, bow-tie) elements and log-periodic dipole array (LPDA) elements.

in situ testing: Process of performing electromagnetic interference (EMI) testing in an area where the equipment to be evaluated is normally installed and operated. (adapted from ANSI C63.14-2014,) *Contrast: test site testing.*

NOTE 1—This type of testing necessarily includes the effects of the environment as well as electromagnetic wave reflections due to structures and other objects.

NOTE 2—In contrast, the definition in 4.276 of ANSI C63.14-2014 includes the text in the preceding NOTE 1 as a second phrase within the definition text itself.

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.

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

lamp: *See: light source.*

LED driver: Device composed of a power source and LED control circuitry designed to operate an LED package (component), an LED array (module), or an LED lamp.²³ (ANSI/IES LS-1-20:2020 [B4])

LED light source: Device containing an LED or collection of LEDs used for the purpose of illumination.²⁴ (CISPR 15:2018-05 [B5])

light regulation (dimming): Operation consisting in controlling (varying) the light intensity generated by a lamp or luminaire.

light source: Generic term for a man-made device that produces optical radiation using electrical energy.

NOTE 1—The term is also used to denote sources that radiate energy in regions of the spectrum adjacent to the visible light spectrum, i.e., IR and UV.

NOTE 2—A light source is sometimes called a lamp, bulb, or tube.

lighting device: Independent unit which can be used to illuminate a scene, objects, or their surroundings so that they can be seen, including devices designed to be used with such independent units and any separable components assembled to form the independent unit. (adapted from CISPR 15:2018-05 [B5])

NOTE 1—Examples: luminaire, self-ballasted lamp, dimmer, remote control, ballast, LED driver.

²³ 6.8.4.1 of ANSI/IES LS-1-20:2020 [B4]. Copyright © 2020 Illuminating Engineering Society.

²⁴ 3.3.14 of CISPR 15:2018-05 [B7]. Copyright © 2018 IEC Geneva, Switzerland, www.iec.ch.

NOTE 2—In contrast, the definition in 3.3.16 of CISPR 15:2018-05 [B5] is: “device which can be used as an independent unit to illuminate a scene, objects or their surroundings so that they can be seen, and modules designed to be used in or with such device or assembly of devices.”²⁵ CISPR 15:2018-05 [B5] uses the term “lighting equipment,” which is equivalent to the term “lighting device” in ANSI C63.29.

line frequency: Frequency, measured while the EUT is operating in its normal state, at the point where the ac power is physically connected to the ac mains input power port of the EUT.

NOTE—This point can be a terminal block within the EUT, the input of the EUT’s power entry module, or the receptacle at the end of the EUT’s power cable, as applicable.

line impedance stabilization network (LISN): Network inserted in the power supply conductor of an EUT that provides, in a given frequency range, a specified load impedance for each current-carrying conductor for the measurement of conducted emission voltages.

NOTE 1—A LISN is used to isolate the EUT from the supply mains in that frequency range and couples the EUT emissions to the measuring instrument.

NOTE 2—A LISN unit can contain one or more individual LISN circuits.

NOTE 3—In IEC CISPR standards, LISNs are called artificial mains networks (AMNs).

line voltage: Voltage, measured while the EUT is operating in its normal state, at the point where the ac power is physically connected to the ac mains input power port of the EUT.

NOTE—This point can be a terminal block within the EUT, the input of the EUT’s power entry module, or the receptacle at the end of the EUT’s power cable, as applicable.

luminaire (light fixture): Complete lighting unit consisting of lamp(s), ballast(s), driver(s) (where applicable), and any other necessary components, together with the parts designed to distribute the light, position and protect the lamps, and to connect the lamp(s) to the power supply. (adapted from ANSI/IES LS-1-20:2020 [B4])

NOTE—In contrast, the definition in 10.3.1 of ANSI/IES LS-1-20:2020 [B4] is: “a complete lighting unit consisting of a light source(s) and ballast(s) or driver(s) (when applicable), together with the parts designed to distribute the light, to position and protect the light source(s), and to connect the light source(s) to the power supply; also known as a light fixture.”²⁶

maximization: Process consisting of variation of specific parameters related to the test equipment, as prescribed by the corresponding test method specified in this document, for the purpose of finding the set of conditions resulting in the highest level at the input of the measuring instrument.

NOTE—This process is a compliance-type measurement and is used for two cases:

- Maximization of a specific EUT emission, which involves variation of parameters such as turntable azimuth, antenna polarization, and antenna height; e.g., see 9.3.3.3.
- Maximization of the received signal during site validation measurements, which involves variation of the receive antenna height for a given set of conditions (i.e., for a given transmit antenna height, a given set of transmit antenna and receive antenna positions, and a specific polarization of both antennas); e.g., see ANSI C63.4-2014 amended per ANSI C63.4a-2017.

measurement antenna: Receive antenna used to measure the radiated emissions during field strength testing.

²⁵ Copyright © 2018 IEC Geneva, Switzerland, www.iec.ch.

²⁶ Copyright © 2020 Illuminating Engineering Society.

measurement instrumentation uncertainty: Parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand, induced by all relevant input quantities that are related to the measurement instrumentation.²⁷ (adapted from CISPR 16-4-2:2018-08 [B9])

NOTE 1—For a list of the relevant input quantities that need to be included in the calculation of the measurement instrumentation uncertainty, see ANSI C63.23.

NOTE 2—In contrast, the definition in 3.1.1 of CISPR 16-4-2:2018-08 [B9] does not include any note.

mode of operation: Manner in which the EUT is performing its intended (primary) function, as specified by the manufacturer, during its normal use. *See also:* **EUT operation, primary function.**

NOTE 1—An EUT can have multiple modes of operation, i.e., multiple primary functions.

NOTE 2—An EUT can also have secondary functions, such as a service or maintenance mode of operation. Such modes of operation are deemed to be irrelevant for EMI testing and, as such, are not included in the definition of this term, as used throughout ANSI C63.29.

nominal: Conventionally stated value of a quantity or dimension, but which does not necessarily correspond exactly to the actual value.

NOTE—The allowable tolerances for values above and below the nominal value need not be symmetric (see Annex A).

EXAMPLES—The nominal height of an EUT support table is 80 cm (see, e.g., 5.1.5). The nominal lowest and highest measurement antenna heights are 1 m and 4 m, respectively (see, e.g., 0).

nominal line frequency: Conventionally stated value of the line frequency, which, subject to allowable tolerances, is required to be supplied to the EUT during testing.

NOTE—See 5.1.2.

nominal line voltage: Conventionally stated value of the line voltage, which, subject to allowable tolerances, is required to be supplied to the EUT during testing.

NOTE—See 5.1.2 and Table 9.

nominally identical: Devices that are identical within the variation that can be expected to arise as a result of quantity production techniques. (47 CFR Part 2, §2.908 [April 24, 1981])

NOTE—The phrase “nominally identical” is often applied specifically to the parameters that describe the key properties of devices. For example, two standard-gain horn antennas can differ in the types of metals used in manufacturing, but if they have nominally identical key dimensions, nominally identical mainbeam gains, and nominally identical antenna patterns, they are considered to be “nominally identical” antennas.

normalized site attenuation (NSA): Site attenuation divided by the free-space antenna factors (all in linear units) of the transmit antenna and the receive antenna, and corrected by the geometry-specific correction factors, if available.²⁸ (adapted from ANSI C63.5-2017) *See also:* **site attenuation.**

NOTE 1—NSA values are usually stated in decibel units.

NOTE 2—In contrast, the definition in Clause 3 of ANSI C63.5-2017 is: “Site attenuation (SA) divided by the free-space antenna factors (all in linear units) of the transmit antenna and the receive antenna, and corrected by the geometry-specific correction factors (GSCF) if available. Results can be stated in decibel units.”

²⁷ Copyright © 2018 IEC Geneva, Switzerland, www.iec.ch.

²⁸ See ANSI C63.5 for details about applicable antenna factors and other parameters.

open area test site (OATS): Open, flat, level area where the ground is covered with conductive material and that is clear of overhead wires and reflecting structures.

outlet: Female connector used for ac mains power, e.g., a wall ac power outlet or the output port of a LISN.
Syn: **receptacle.**

passive antenna: Antenna that functions without any source of energy other than input signals. (adapted from IEC 702-09-07)²⁹ *Contrast:* **active antenna.**

NOTE 1—Examples of passive antennas used for electromagnetic compatibility (EMC) measurements include tuned dipoles, biconical dipoles, log-periodic dipole array (LPDA) antennas, hybrid antennas, and many types of horn antennas.

NOTE 2—In contrast, the definition IEC 702-09-07 is for the term “passive” and it is: “pertaining to an electrical network or device which functions without any source of energy other than the input signals.”³⁰

passive luminaire: Incandescent, LED, or discharge light luminaire other than active luminaires.

NOTE—A passive luminaire does not contain active switching electronic components and thus is not likely to produce any electromagnetic disturbances. For example, a mains rectifying diode is considered a passive component.

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

NOTE—A peripheral device can be either support equipment or auxiliary equipment, for the purpose of testing as per this standard.

plug-in portable dimmer: Dimmer that plugs into a receptacle outlet either directly or via a cord-connection and incorporates a means to connect a luminaire.

populate (a port): Attach a cable (to the port).

port: Cabled interface of an EUT or of an EUT’s module / plug-in card.

power line dimmer: Electronic device, internal or external to a lamp, luminaire, ballast, or LED driver, but connected to the latter by a wired connection, which directly controls the input power to the lamp, luminaire, ballast, or LED driver.

primary function: Function of an equipment which is defined as such by the manufacturer.³¹ (CISPR 15:2018-05 [B5])

(radio) receiver: Device for detecting radio-frequency emissions.

NOTE—See Clause 4.

reference ground plane: Conducting (metallic) flat surface or plate that is used as a common reference point for circuit returns and electric or signal potentials.

representative test fixture: Luminaire used for testing components, which is representative of the type of luminaires used with the component that is the EUT.

NOTE—The requirements applicable to the representative test fixture are specified in 7.3.2.

²⁹ IEC Online, IEC 60050, International Electrotechnical Vocabulary, International Electrotechnical Commission, Geneva, CH, (<http://www.electropedia.org/>).

³⁰ Copyright © 1992 IEC Geneva, Switzerland, www.iec.ch.

³¹ 3.2.6 of CISPR 15:2018-05 [B7]. Copyright © 2018 IEC Geneva, Switzerland, www.iec.ch.

remote-control devices: Devices that control a load either by a dedicated control line, powerline carrier signals over the ac mains, or via wireless means.

secondary function: Function of an equipment not being essential for fulfilling the primary function.

self-ballasted lamp: Lamp with a built-in circuit that controls both starting and operating currents.

NOTE 1—These devices typically consist of an integrated power supply/ballast and light producing element.

NOTE 2—This term denotes any type of lamp that can be directly connected to its source of power (e.g., ac mains) and does not need additional components to operate. This includes lamps other than fluorescent / gas-discharge, such as LED lamps, even though these do not require a “ballast” to operate.

semi-luminaire: Device (sometimes called adapter) equipped, on the one side, with any IEC-standardized lamp cap system to allow mounting in a standard lamp holder and, on the other side, with a lamp holder to allow the insertion of a replaceable light source with a cap.³² (CISPR 15:2018-05 [B5])

site attenuation: Minimum relative insertion loss measured between two polarization-matched antennas located on a test site when one antenna is moved vertically over a specified height range. (ANSI C63.5-2017) *See also:* **normalized site attenuation (NSA)**.

site voltage standing wave ratio (S_{VSWR}): Ratio of maximum received signal to minimum received signal, caused by interference between direct (intended) and reflected signals.³³ (CISPR 16-1-4:2020-06)

small loop antenna: Radiated emissions magnetic field strength transducer that is compliant with 4.3 and 4.4 of CISPR 16-1-4:2020-06.

spectral plot: Graphical representation of the emissions in the frequency domain, showing the full spectrum measured over a specific frequency range.

street light: Complete lighting device intended for street illumination consisting of a light source together with its direct appurtenances such as globe, reflector, refractor, housing, and such support as is integral with the housing, but not including the pole, post, or bracket. (adapted from IEEE 100, *The Authoritative Dictionary of IEEE Standards Terms*)

NOTE—In contrast, the definition in IEEE 100 is “Complete lighting device consisting of a light source together with its direct appurtenances such as globe, reflector, refractor, housing, and such support as is integral with the housing. The pole, post, or bracket is not considered part of the luminaire.”

support equipment (SE): Equipment that is required for exercising or monitoring the EUT, but which is not part of the EUT.

NOTE 1—In contrast, CISPR documents, such as CISPR 32, use the term “associated equipment” for this type of equipment.

NOTE 2—SE is not usually included in the EUT arrangement (as illustrated, for example, in Figure 8).

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

NOTE—There are two exceptions to the above definition. These are: “*calibration records system*” and “*laboratory quality system*” in 4.6.1.

³² 3.3.22 of CISPR 15:2018-05 [B7]. Copyright © 2018 IEC Geneva, Switzerland, www.iec.ch.

³³ 7.3.1 of CISPR 16-1-4:2020-06. Copyright © 2020 IEC Geneva, Switzerland, www.iec.ch.

tabletop device: Device designed to be placed and normally operated on the raised surface of a table or other surfaces of similar height.

terminate (a cable connected to a port): Fit the end of the cable (that has its other end connected to the port) with a load whose characteristic impedance is equal to that of the port.

terminate (a port): Directly connect (to the port) a load whose characteristic impedance is equal to that of the port.

test case: Single, continuous, measurement that completely determines the compliance of the specific EUT setup with the limits applicable to that single, continuous, measurement.

NOTE 1—A test case is performed on a specific combination of EUT setup and measurement setup, including test site and test equipment.

NOTE 2—Examples of single, continuous, measurements include ac mains conducted emissions on all current carrying conductors of all EUT's ac mains power cables, magnetic field strength radiated emissions within 9 kHz to 30 MHz, or electric field strength radiated emissions from 30 MHz to 1 GHz. However, if the test lab uses, for example, two antennas from 30 MHz to 1 GHz (e.g., biconical and LPDA), splitting this frequency range in two (30 MHz to 200 MHz and 200 MHz to 1 GHz), unless the measurement is performed over the entire frequency range before altering the EUT setup, each one of these two ranges represents a separate test case.

NOTE 3—A test case might have to be repeated a number of times, for determining which EUT setup results in the highest emission relative to the limit applicable to that specific single, continuous, measurement (e.g., by varying the EUT cables' positions).

test equipment: Equipment that is intended primarily for purposes of performing measurements or scientific investigations.

NOTE—Such equipment includes, but is not limited to, field strength meters, spectrum analyzers, and modulation monitors.

test report: Document that includes a summary of measurement results (and can also include engineering analyses) related to a specific EUT sample or samples (specific brand, model, and serial number or numbers) and which complies with the requirements of this standard.

NOTE 1—See Clause 10.

NOTE 2—The test report usually includes a statement upfront that the measurement results therein only apply to the unit or units tested (specific serial number or numbers).

test site: Location meeting appropriate validation criteria, if identified, to perform EMC measurements on the EUT. *Contrast:* **in situ**.

transducer: Device that receives energy from one system and supplies energy, of either the same or of a different kind, to another system, in such a manner that the desired characteristics of the energy input appear at the output.

NOTE—Examples of transducers: line impedance stabilization network (LISN), voltage probe, antenna.

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

voltage probe: Conducted emissions transducer, for measuring the voltage between an EUT mains conductor and the reference ground, which provides a nominal 1500 Ω resistance between the measured line and ground.

NOTE—Some measurement method documents refer to a voltage probe as a line probe [e.g., FCC/OET MP-5 [B12] (47 CFR § 18.311)].

wall-wart: Informal term denoting an ac power adapter that does not have any ac mains cable and plugs directly into an ac mains receptacle, the formal equivalent of which is “wall-mounted power adapter.”

3.2 Acronyms and abbreviations

AC, ac	alternating current
AE	auxiliary equipment
ANSI	American National Standards Institute
ASC	Accredited Standards Committee
AUT	antenna under test
CFR	U.S. Code of Federal Regulations
CISPR	International Special Committee on Radio Interference
CW	continuous wave
DC, dc	direct current
EMC	electromagnetic compatibility
EMI	electromagnetic interference
EUT	equipment under test
FCC	Federal Communications Commission
FFT	fast Fourier transform
GP	ground plane
HAIMP	hybrid antenna impedance matching pad
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IF	intermediate frequency
ISED	Innovation, Science and Economic Development Canada
ISM	industrial, scientific, and medical
ISO	International Organization for Standardization
KDB	Knowledge Database (FCC/OET)
LED	light-emitting diode
LISN	line impedance stabilization network
LLA	large loop antenna
LLAS	large loop antenna system
LPDA	log-periodic dipole array
NSA	normalized site attenuation

OATS	open-area test site
RBW	resolution bandwidth
RF	radio frequency
RGP	reference ground plane
RMS, rms	root mean square
RV	recreational vehicle
Rx	receive or receiver
S_{VSWR}	site voltage standing wave ratio
SAC	semi-anechoic chamber
SE	support equipment
SNA	scalar network analyzer
TD S_{VSWR}	time domain site-voltage standing wave ratio
TLED	tubular light emitting diode (LED)
Tx	transmit or transmitter
VNA	vector network analyzer
VSWR	voltage standing wave ratio

4. Measurement instrumentation

4.1 General

The use of proper measurement instrumentation is critical to obtaining accurate, reproducible results. Various measuring accessories that might be needed depend on the particular measurements to be performed, as described in 4.2 through 4.7.

The sensitivity of the entire measurement system, including the measurement instrument (i.e., receiver or spectrum analyzer) and all ancillary equipment between the measurement instrument and the EUT (e.g., attenuators, cables, transducers such as the antenna or the LISN), shall be sufficient for distinguishing EUT emissions from the system noise floor. This requirement is only satisfied if an EUT emission at a level corresponding to the applicable limit level results in a signal at the measurement instrument's input that is 6 dB or higher above the measurement instrument's noise floor at each frequency of measurement, in the specified limit detector.

NOTE—One practical way to verify compliance with this requirement would be, for example, to insert all factors in the measurement instrument or measurement software (such as antenna factor and cable loss) and plot the limit together with the instrument's noise floor, with the instrument configured as per the corresponding requirements for that frequency range.

4.2 Emission measuring instrumentation

4.2.1 General considerations

This standard recognizes that both spectrum analyzers (see 4.2.3) and electromagnetic interference (EMI) receivers (see 4.2.2) may be used for making emission measurements. Measurement instrumentation used for making radiated and alternating current (ac) power-line conducted emission measurements include

those that conform to the specifications contained in either or both of the following standards as appropriate to the frequency of measurement:

- a) ANSI C63.2 (for measurements up to and including 40 GHz)
- b) CISPR 16-1-1:2019-05 (for measurements up to and including 18 GHz)

NOTE—ANSI C63.2 normatively references CISPR 16-1-1 for frequencies up to 18 GHz.

A spectrum analyzer typically does not meet all of the requirements stated in ANSI C63.2 or CISPR 16-1-1:2019-05 without additional accessories. Appropriate accessories, such as preselection, quasi-peak detection, and specific intermediate frequency (IF) filters, may be used with a spectrum analyzer. By meeting the requirements in 4.2.1a) or 4.2.1b), this combination is equivalent to a receiver.

4.2.2 Reference measurement instrument

The reference measurement instrument for performing measurements of radiated and ac power-line conducted emissions is an instrument conforming to 4.2.1.

Scanning receivers may be used, but the maximum scan rate shall be limited by the response time of the measuring system and selected such that emissions are properly intercepted (e.g., based on the pulse repetition frequencies) so that the amplitude of each emission is measured correctly (e.g., based on the IF bandwidth selection). Bandwidths shall be chosen that are appropriate for the frequencies being investigated. Requirements for selecting measurement bandwidths are given in 4.2.5.

If the output of the quasi-peak or linear average detector is indicated in logarithmic units, then the logarithms shall be taken in the measuring instrument after the signal is detected and the detector function is fully realized. It shall be confirmed that the output indication represents the logarithm of the true quasi-peak or linear average value of the signal measured.

4.2.3 Spectrum analyzer

The use of spectrum analyzers for radiated and ac power-line conducted emission compliance measurements is permissible only if they meet all the requirements of the standards listed in 4.2.1.

To meet the requirements in 4.2.5, spectrum analyzers shall be equipped with quasi-peak and linear average detection that is compliant with the relevant standards listed in 4.2.1. However, measurements with the positive peak detector of the instrument may be used for demonstrating compliance of the EUT, as long as the required resolution bandwidth is used.

NOTE 1—This is due to the fact that positive peak detection yields amplitudes equal to or greater than amplitudes measured with the quasi-peak or linear average detector. Thus, the data measured using the positive peak detector of a spectrum analyzer represents the worst-case results.

Nominal values for the resolution bandwidth shall be as specified in 4.2.5. Most spectrum analyzers use Gaussian-shaped intermediate frequency (IF) filters with resolution bandwidths specified at -3 dB, which are acceptable for measurements made in accordance with this standard because larger bandwidths are permissible. The resolution bandwidths cited in the standards listed in 4.2.1 do not have a Gaussian shape but are instead specified individually by their frequency response (i.e., “masks”). When using larger bandwidths than those specified, or when using filters with different transfer functions, different measurement results for broadband signals can be expected. In case of dispute, the test results measured with the reference receiver specified in 4.2.2 shall take precedence.

For a spectrum analyzer to meet the specifications of either of the two standards listed in 4.2.1, it shall provide adequate overload protection and system dynamic range, achieve proper weighting of pulses when using quasi-peak detection, and have the resolution bandwidths specified in either ANSI C63.2 or

CISPR 16-1-1:2019-05. If a spectrum analyzer is to be used to perform quasi-peak measurements of low-repetition-rate signals (i.e., pulse repetition rate of 20 Hz or less), then the use of a preselector is required to provide an adequate dynamic range of the instrument.

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

- a) *Overload*—Most spectrum analyzers have no radio frequency (RF) preselection in their lowest frequency band. In this band, the input signal is fed directly to the broadband input mixer. To help avoid overload, to help prevent damage, and to operate the spectrum analyzer linearly, the signal amplitude at the mixer shall be less than the manufacturer's stated specification for the maximum input level for linear operation.³⁴ RF attenuation and/or additional RF preselection might be required to reduce the input signal to this level.
- b) *Linearity test*—When saturation or gain compression condition is suspected to exist, the linearity can be verified by measuring the level of the specific signal under investigation and repeating this measurement after a 6 dB or greater external attenuator has been inserted at the input of the measuring instrument or, if used, of the preamplifier. The new reading of the measuring instrument display, plus the inserted attenuation, shall differ by no more than ± 0.5 dB from the first reading for deeming the measuring system linear; see G.4 for details. Observe the resulting signal to noise ratio (with added attenuation) to verify that the added attenuation is not contributing to any measurement difference. In the case of broadband time-variant signals and spread-spectrum signals, the linearity test may be performed by setting the analyzer in maximum hold with positive peak detector function, separately, for each one of the two measurements.

NOTE 2—Some common examples of situations where saturation or gain compression condition exists are as follows (not an exhaustive list):

- There is an indicator on the measurement instrument signaling that such a condition exists.
 - Emission level is high compared to the limit.
 - High ambient signals are present, such as a Wi-Fi signal or other intentional transmission.
 - The EUT generates high level emissions just outside of the measured frequency range (e.g., just below 150 kHz).
- c) *Signal interception*—The spectrum of intermittent and/or time-varying emissions can be captured with positive peak detection and digital display storage (i.e., “max hold” function). Multiple, fast frequency scans reduce the time to intercept an emission compared to a single, slow frequency scan. The starting time of the scans shall be varied to help avoid any synchronism with the emission and thereby masking it. The total observation time for a given frequency range shall be longer than the time between the emissions. Depending on the type of emission being measured, the positive peak detection measurements can replace all or part of the measurements needed using quasi-peak or linear average detection. Retests using a quasi-peak or linear average detector shall then be made at frequencies where emission maxima have been found.
 - d) *Linear average detection*—For spectrum analyzers not equipped with a linear average detector as specified in 4.2.5.1, an alternate method of linear average detection with a spectrum analyzer can be obtained by setting the detector mode to positive peak and reducing the video bandwidth until no significant variations in the displayed signal are observed from trace to trace; see 4.2.5.2 for a basic measurement procedure.
 - e) *Selection of display mode*—For measurements with peak detector (e.g., where the limit is specified for peak detection), the positive peak detector shall be selected, so that the highest emission amplitudes are displayed.

³⁴ The typical maximum input level for the linear operation of a spectrum analyzer is 150 mV peak; regardless, users should be aware of the actual maximum input level for linear operation of their particular spectrum analyzer.

NOTE 3—The positive peak detector may also be used in other cases (i.e., where the limit is specified for other type of detector) for speeding up the measurement; see 4.2.3c) above. The use of any other common detector, such as quasi-peak, average, etc. generally results in a lower amplitude of the signal being measured. Scanning the frequency range of interest in multiple frequency segments can reduce the introduced frequency error. This improves frequency accuracy but increases the overall test time.

- f) *Bin size*—When using a spectrum analyzer in average detection mode, its bin size shall be no larger than half the measurement (resolution) bandwidth.

NOTE 4—Bin size is specific to instruments having a digital display and describes the frequency resolution (horizontal resolution) of that instrument's display. The instrument determines the level to be displayed at each "trace point" by applying the selected detector function to all input signal samples in the "bin" corresponding to that "trace point." For example, positive peak detector function selects the input signal sample having the highest amplitude for display and discards all the other samples in that bin. As such, greater accuracy is achieved by decreasing the span because the "bin" then includes a larger number of samples.

NOTE 5—When measuring impulsive signals, bin size smaller or equal to half the measurement bandwidth might also be required for peak or quasi-peak detection modes.

See also Annex G for more details on and precautions concerning the use of spectrum analyzers.

4.2.4 FFT-based measurement instrument

Spectrum analyzers or EMI receivers equipped with fast Fourier transform (FFT) capabilities may be used as long as they are compliant with the requirements stated in 4.2.1.

4.2.5 Detector functions and selection of bandwidth

4.2.5.1 General considerations

Unless otherwise specified, EMI receivers and spectrum analyzers shall have the detector functions and bandwidths specified in either ANSI C63.2 or CISPR 16-1-1:2019-05 for frequencies up to and including 18 GHz; above 18 GHz, the detector functions and bandwidths specified in ANSI C63.2 shall be used.

In the frequency range from 1 GHz to 18 GHz, the IF filter used in an EMI receiver or in a spectrum analyzer shall satisfy any one of the following requirements:

- The IF filter shall comply with the selectivity criterion called out in Figure 4 of CISPR 16-1-1:2019-05.
- The IF filter shall have a 1 MHz impulse bandwidth.
- If the 1 MHz measurement bandwidth of the IF filter is not calibrated as the impulse bandwidth, a correction factor for broadband signal amplitudes shall be applied.

For EMI receivers or spectrum analyzers subject to the preceding condition 4.2.5.1c), the necessary correction factor shall be determined as follows:

- The impulse bandwidth, B_{imp} , of the 1 MHz IF filter shall be determined by measurements made in accordance with the method stated in E.7 of CISPR 16-1-1:2019-05.
- A bandwidth correction factor shall be applied ONLY when broadband signal amplitudes are measured. The broadband correction factor (in decibels) shall be calculated using $C_{BB} = 20 \log (B_{imp} / B_{meas})$, where B_{meas} equals the measurement bandwidth (i.e., 1 MHz). This correction factor is to be added algebraically to the broadband signal level measured using the available 1 MHz IF bandwidth.

In the frequency range from 18 GHz to 40 GHz, the IF filter used in an EMI receiver or in a spectrum analyzer shall satisfy the requirements stated under either the preceding 4.2.5.1b) or 4.2.5.1c).

Positive peak detector measured data may be substituted for the reference detector data to show compliance, as long as the required resolution bandwidth is maintained or exceeded, if the peak level obtained does not exceed the limit. The bandwidth used shall be equal to or greater than that specified in ANSI C63.2 or CISPR 16-1-1:2019-05. The use of bandwidths greater than those specified can produce higher readings for certain types of emissions. If bandwidths greater than those specified are used, the actual bandwidths used shall be recorded in the test report. In case of dispute, the reference receiver shall take precedence. More than one instrument might be needed to perform all of these functions and/or to cover the complete frequency range of interest.

The measuring instrument shall satisfy the following provisions:

- 1) The quasi-peak detector shall have a linear response.
- 2) The average detector shall have a linear response and shall meet the linear average specifications in ANSI C63.2 or CISPR 16-1-1:2019-05. This is a voltage average detector. A logarithmic average detector shall not be used for performing measurements in accordance with ANSI C63.29. A CISPR RMS detector (or power average detector) may be used because it results in a measured level that is greater than or equal to the level measured with a voltage average detector.
- 3) When measuring an emission with a low duty cycle, the dynamic range of the measuring instrument shall be adequate to yield correct and traceable results.
- 4) When using a spectrum analyzer or other instrument providing access to the video bandwidth function for peak measurements, the video bandwidth shall be set to a value at least three times greater than the IF bandwidth of the measuring instrument, to help avoid the introduction of unwanted amplitude smoothing.

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

4.2.5.2 Average measurements using spectrum analyzer with reduced video bandwidth

For a spectrum analyzer not having a dedicated average detector function in accordance with 4.2.5.1, the following procedure shall be used to perform average measurements by reduction of video bandwidth:

- a) Tune the instrument to the signal of interest by setting its center frequency to the signal frequency and setting its resolution bandwidth to the required resolution bandwidth.
- b) Select the spectrum analyzer linear display mode.
- c) Set the spectrum analyzer reference level such that the measured signal is positioned as close as possible to the top line of the display graticule (this step is optional for digital spectrum analyzers).
- d) Reduce the video bandwidth to a value that does not result in any further reduction in the displayed signal amplitude, but not less than 1 Hz (see also NOTE 2 below).
- e) After items 4.2.5.2a) through 4.2.5.2d) are completed, measure the maximum average signal on the display. Maximum-hold processing of traces should be employed to achieve the maximum reading.

This method yields the linear average value of signals at the input of a spectrum analyzer measured with a specified resolution bandwidth.

The sweep time shall be increased with reductions in video bandwidth to maintain amplitude calibration. For such measurements, the instrument shall be used in the linear mode of the detector, and maximum-hold processing of traces should be employed to achieve the maximum reading. 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.

NOTE 1—A logarithmic amplitude display mode may be used for investigative or exploratory purposes only; 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. Therefore, video filtering in the log display mode is especially useful for estimating the narrowband component in a spectrum containing both broadband and narrowband signals. *This technique is useful for troubleshooting but is not applicable for compliance measurements.*

When performing final compliance measurements, the video bandwidth shall be set to a value lower than the lowest pulse repetition frequency of the measured signal, but not lower than 1 Hz, in accordance with CISPR 16-1-1:2019-05, so that the proper integration time is realized; G.7 provides other details.

NOTE 2—Notwithstanding the video bandwidth requirements of 7.3.3 of CISPR 16-1-1:2019-05, the associated measurement procedure standards CISPR 16-2-1:2017-06 [B8] (i.e., Annex D therein) and CISPR 16-2-3:2019-06 (i.e., Annex C therein) allow the use of higher video bandwidths, at least for pre-scan measurements, when measuring slowly intermittent, unsteady, or drifting narrowband disturbance signals that have pulse repetition frequencies or modulation frequencies greater than 5 Hz. Also, because the measurand in 7.3.3 of CISPR 16-1-1:2019-05 is specified to be the peak reading, the larger amplitude fluctuations that occur with the use of a higher-than-specified video bandwidth provides a conservative measurement result (i.e., higher emission level).

4.2.6 Using an external preamplifier with a spectrum analyzer or EMI receiver

Spectrum analyzers or EMI receivers can lack the appropriate sensitivity to perform EMI measurements, because of a higher instrument noise figure. Adding an external preamplifier to the measuring instrument serves as a method to improve the measurement system sensitivity. However, the dynamic range of the measurement system is affected, as well as the amplitude accuracy. In addition, overload requirements for the measuring instrument shall be accounted for, to help avoid possible erroneous measurement results. Clause J.2 in Annex J of CISPR 16-1-1:2019-05 describes detailed considerations for the best design of an emission test system that includes a measuring instrument and an external preamplifier.

The performance of the system, i.e., system noise level and overload capability, depends on the characteristics of both the preamplifier and the measuring receiver; therefore, it is necessary to properly understand the linearity specifications of both the measuring instrument and the preamplifier. Clause J.3 in Annex J of CISPR 16-1-1:2019-05 details the procedure to be used for determining if the system (measurement instrument with preamplifier) is linear. Proper precautions to help avoid overload or saturation conditions during the measurement shall be taken, i.e., in the form of linearity checks of the system, as specified in Clause J.3 of CISPR 16-1-1:2019-05. If a measuring instrument with FFT technology is used, specific requirements for overload detection shall be accounted for, as documented in Clause J.4 of Annex J of CISPR 16-1-1:2019-05.

4.3 Line impedance stabilization network (LISN)

A LISN having the impedance magnitude and phase angle listed in Table C.1 and Table C.2 (see C.5.1) and illustrated in Figure C.1 and Figure C.2 (see C.5.2) shall be used for ac power-line conducted emission measurements, in order to provide a standard impedance to the equipment under test (EUT) and help prevent external electromagnetic noise to enter the EUT setup through the ac mains cable, except for in situ measurements (see 4.4 and 5.6). When the measuring instrument (receiver or spectrum analyzer) ports of the LISN are each terminated into an impedance of 50 Ω , the characteristic impedance in Table C.1 or Table C.2 or both (based on the measurement frequency range of conducted emissions from the EUT) shall be present at the EUT ports of the LISN.

The required nominal impedance values (magnitude and phase) were derived from idealized LISN circuits: 50 Ω in parallel with a series combination of 5 Ω and 50 μH , for the 9 kHz to 150 kHz frequency range, and 50 Ω in parallel with 50 μH , for the 150 kHz to 30 MHz frequency range. Figure C.3 and Figure C.4 (see C.5.2) illustrate two circuits that, when carefully constructed, can provide the impedance characteristics of Figure C.1 and Figure C.2.

The LISN impedance shall not deviate from the nominal values listed in Table C.1 or Table C.2 or both (and plotted in Figure C.1 and Figure C.2), as applicable, by more than $\pm 20\%$ for the LISN impedance magnitude and $\pm 11.5^\circ$ for the LISN impedance phase, at the LISN's EUT terminals.

The insertion loss of the LISN (from its EUT port to the coaxial measurement port), taken from the most recent calibration data of the LISN, shall be used for correcting the measurement result before comparing with the applicable limit at each frequency of measurement.

4.4 Voltage probe

Voltage probes (see definition in 3.1) shall be calibrated for use. For measurements with a voltage probe, the method shown in Figure 1 (see 4.7) should 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 conducted measurements on the EUT mains power supply.

The measurements are dependent on the impedance presented by the power supply and can vary with time and location because of variations in the power supply. It might be necessary to perform repeated measurements over a suitable period of time to determine the variation in measured values. In this case, 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 the test 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 1, such that the total resistance between line and ground is $1500\ \Omega$. If the voltage probe includes an inductor placed parallel to the input of the measurement instrument (see Figure 1), for safety reasons, its reactance, X_L should be much greater than the instrument's input impedance, R_m . Because the voltage probe attenuates the emission voltage, appropriate calibration factors shall be added to the measured values. For reducing measurement errors that can be caused by strong ambient magnetic field strength, the measurement arrangement should be such that the area of the loop formed by the line under test, the voltage probe, and the reference ground is as small as possible.

4.5 Antennas

4.5.1 Antenna types

4.5.1.1 General considerations

The use of specific antennas depends on the frequency range and the type of field strength (electric or magnetic) being measured when performing radiated emissions measurements, as indicated in 4.5.2 through 4.5.4. Antennas used for radiated emission measurements shall be calibrated in accordance with ANSI C63.5, or as per the requirements in this standard, as applicable.

The antenna, together with any preamplifier, if used, shall have sufficient sensitivity to measure EUT emissions, at the chosen measurement distance; see 4.1.

4.5.1.2 Frequency identification and relative-comparison evaluation measurements

Table 1, Table 2, and Table 3 provide a summary listing of types of antennas that may be used in performing *frequency identification* radiated emission measurements and/or for performing *relative-comparison evaluation* measurements (e.g., A/B comparisons). Hence, any type of antenna listed in the table for a given frequency band may be used for performing such measurements in that band. Table 1, Table 2, and Table 3 identify the typical frequency ranges over which these antennas operate and provide normative footnotes regarding special considerations in their use.

Antenna types other than those specifically listed in Table 1, Table 2, and Table 3 may also be employed for performing frequency identification radiated emissions measurements and/or relative-comparison evaluation measurements, but users are cautioned to carefully consider the performance characteristics of those antennas as well as the applicable calibration procedures for those antennas prior to their use.

Table 1—Radiated emission antennas for purposes of frequency identification and/or relative-comparison evaluation (9 kHz to 30 MHz)

#	Antenna types	Footnotes
1	Passive small loop	
2	Active small loop	a
3	Large loop antenna system (LLAS), 2 m diameter	b

^a When an active antenna is used for frequency identification or relative-comparison measurements, users are cautioned to verify whether the ambient and/or measured signals are causing the preamplifier portion of the active antenna to saturate (thus yielding unacceptable, erroneous measurements) and, if they are, to take corrective action (e.g., use of a notch filter, reorientation of the measurement axis) to eliminate the saturation condition. It is further recommended that only active antennas equipped with an operating saturation indicator are used, and the saturation indicator is monitored during the course of the testing to help ensure it does not indicate saturation.

^b The LLAS shall not be used when the largest dimension of the EUT arrangement is greater than 1.6 m.

Table 2—Radiated emission antennas for purposes of frequency identification and/or relative-comparison evaluation (30 MHz to 1000 MHz)

#	Antenna types	Footnotes
1	Resonant tuned dipole (passive)	
2	Biconical dipole (50 Ω or 200 Ω balun)	
3	Log-periodic dipole array (LPDA)	
4	Hybrid (bicon/log)	
5	Double-ridge guide horn (passive)	a, b

^a In general, tuned dipole, biconical dipole, and LPDA antennas operate within the 30 MHz to 1000 MHz frequency range, and waveguide/DRG horn antennas operate over portions of the 1 GHz to 40 GHz band. However, some designs of tuned dipole, biconical dipole, and LPDA antennas also operate within portions of the 1 GHz to 40 GHz range, and some designs of DRG horns operate at frequencies as low as 170 MHz.

^b The largest aperture dimension, D , of these horn antennas (i.e., length or width; in meters) should be small enough so that the measurement distance (in meters) is equal to or greater than the Rayleigh distance (i.e., $R_m = D^2 / 2\lambda$), where λ is the free-space wavelength (in meters) at the frequency of measurement.

Table 3—Radiated emission antennas for purposes of frequency identification and/or relative-comparison evaluation (1 GHz to 40 GHz)

#	Antenna types	Footnotes
1	Resonant tuned dipole (passive)	a, b
2	Biconical dipole (50 Ω or 200 Ω balun)	a, b
3	Precision broadband omnidirectional biconical dipole	
4	Log-periodic dipole array (LPDA)	a, b
5	Hybrid (bicon/log)	
6	Waveguide horn	c
7	Double-ridge guide horn (passive)	a, c
8	Double-ridge guide horn (active)	a, c, d

- ^a In general, tuned dipole, biconical dipole, and LPDA antennas operate within the 30 MHz to 1000 MHz frequency range, and waveguide/DRG horn antennas operate over portions of the 1 GHz to 40 GHz band. However, some designs of tuned dipole, biconical dipole, and LPDA antennas also operate within portions of the 1 GHz to 40 GHz range, and some designs of DRG horns operate at frequencies as low as 170 MHz.
- ^b Users of biconical antennas, with 50 Ω or 200 Ω baluns, and LPDA antennas are cautioned that the required calibration methods for these antennas at frequencies up to and including 1 GHz are completely different from those required to be used at frequencies above 1 GHz. For further details, see the ANSI C63.5.
- ^c The largest aperture dimension, D , of these horn antennas (i.e., length or width; in meters) should be small enough so that the measurement distance (in meters) is equal to or greater than the Rayleigh distance (i.e., $R_m = D^2 / 2\lambda$), where λ is the free-space wavelength (in meters) at the frequency of measurement.
- ^d When an active antenna is used for frequency identification or relative-comparison measurements, users are cautioned to verify whether the ambient and/or measured signals are causing the preamplifier portion of the active antenna to saturate (thus yielding unacceptable, erroneous measurements) and, if they are, to take corrective action (e.g., use of a notch filter, reorientation of the measurement axis) to eliminate the saturation condition. It is further recommended that only active antennas equipped with an operating saturation indicator are used, and the saturation indicator is monitored during the course of the testing to verify it does not indicate saturation.

4.5.1.3 Final compliance measurements

Table 4, Table 5, and Table 6 contain the complete list of antenna types that are permitted to be used for performing *final compliance measurements* (including *exploratory measurements* – see Annex E) for this standard and identify the frequency ranges over which those antennas are permitted to operate when performing final compliance or exploratory measurements.

Only the antenna types specifically listed in Table 4, Table 5, and Table 6, and used in the frequency ranges listed for their operation in Table 4, Table 5, and Table 6 (and used in a manner consistent with the normative footnotes in Table 4, Table 5, and Table 6) shall be used for performing exploratory and final compliance measurements.

Table 4—Radiated emission antennas for use in performing exploratory and final compliance measurements (9 kHz to 30 MHz)

#	Antenna types ^a (see NOTE)	Footnotes
1	Passive small loop	
2	Active small loop	b
3	Large loop antenna system (LLAS), 2 m diameter	c

NOTE—The regulatory authority or purchasing agency might require accreditation of antenna calibration laboratories.

- ^a To be acceptable for use in performing final compliance measurements on devices, each antenna used shall have a current, valid calibration that was performed in accordance with ANSI C63.5 (small loop antenna) and according with this standard (LLAS; see D.2) and is evidenced by a calibration certificate/report that, among other things, states the specific calibration method or methods used, the factors determined for that specific antenna, and the associated calibration measurement uncertainty. To be acceptable, a calibration certificate/report shall have been issued by a calibration laboratory having demonstrated competence in performing the specific calibration method or methods and to cover the required frequency range (e.g., this competence may be demonstrated through accreditation: see NOTE above). For further details, see 4.6.3.
- ^b The use of an active loop antenna is permitted for final compliance measurements on devices ONLY if the active loop antenna is equipped with an operating saturation indicator and ONLY if the saturation indicator is monitored during the course of the testing and the monitor does not indicate saturation.
- ^c The LLAS shall not be used when the largest dimension of the EUT arrangement is greater than 1.6 m. The user shall verify if the use of the LLAS is permitted by the regulatory authority or purchasing agency for final compliance measurements.

Table 5—Radiated emission antennas for use in performing exploratory and final compliance measurements (30 MHz to 1 GHz)

#	Antenna types ^a (see NOTE 1)	Footnotes
1	Resonant tuned dipole (passive)	
2	Biconical dipole (50 Ω or 200 Ω Balun)	See NOTE 2
3	Log-periodic dipole array (LPDA)	
4	Hybrid (bicon/log)	b, c

NOTE 1—The regulatory authority or purchasing agency might require accreditation of antenna calibration laboratories.

NOTE 2—The use of biconical antennas is limited to a maximum frequency of 200 MHz for NSA site validation measurements, in accordance with ANSI C63.4. However, this limitation does not exist for the use of biconical antennas for exploratory and final compliance measurements on devices. For exploratory measurements and for final compliance measurements, the biconical antenna can be used up to a maximum frequency of 300 MHz, or to its highest calibrated frequency, whichever is lower.

- ^a To be acceptable for use in performing final compliance measurements on devices, each antenna used shall have a current, valid calibration that was performed in accordance with ANSI C63.5 and is evidenced by a calibration certificate/report that, among other things, states the specific antenna calibration method or methods used, the antenna factors determined for that specific antenna, and the associated calibration measurement uncertainty. To be acceptable, an antenna calibration certificate/report shall have been issued by an antenna calibration laboratory having demonstrated competence in performing the specific antenna calibration method or methods and to cover the required frequency range (e.g., this competence may be demonstrated through accreditation: see NOTE 1 and NOTE 2). For further details, see 4.6.3.
- ^b See Annex I for the site-specific hybrid antenna qualifications that shall be met for a specific hybrid antenna to be used at a specific test site over the frequency range of 30 MHz to 1 GHz.
- ^c If a hybrid antenna impedance matching pad (HAIMP) attenuator was used during the site-specific hybrid antenna qualification procedure detailed in Annex I, then either the exact same HAIMP (i.e., same serial number) or an attenuator of the same make, model number, insertion loss value, and the same frequency range of operation shall be used during all final compliance measurements performed with that specific hybrid antenna on that specific test site.

Table 6—Radiated emission antennas for use in performing exploratory and final compliance measurements (1 GHz to 40 GHz)³⁵

#	Antenna types ^a (see NOTE)	Footnotes
1	Precision broadband omnidirectional biconical dipole	b
2	Log-periodic dipole array (LPDA)	c
3	Hybrid (bicon/log)	c, d, e
4	Waveguide horn	f
5	Double-ridge guide horn (passive)	f
6	Double-ridge guide horn (active)	f, g

NOTE—The regulatory authority or purchasing agency might require accreditation of antenna calibration laboratories.

^a To be acceptable for use in performing final compliance measurements on devices, each antenna used shall have a current, valid calibration that was performed in accordance with ANSI C63.5 and is evidenced by a calibration certificate/report that, among other things, states the specific antenna calibration method or methods used, the antenna factors determined for that specific antenna, and the associated calibration measurement uncertainty. To be acceptable, an antenna calibration certificate/report shall have been issued by an antenna calibration laboratory having demonstrated competence in performing the specific antenna calibration method or methods and to cover the required frequency range (e.g., this competence may be demonstrated through accreditation: see NOTE above). For further details, see 4.6.3.

^b The use of precision broadband omnidirectional (biconical) antennas is permitted for final compliance measurements ONLY if complying with the constructional and pattern requirements specified in 7.4 of CISPR 16-1-4:2020-06. No other types of biconical antennas shall be used above 1 GHz for final compliance measurements.

^c Users of LPDA and hybrid antennas are cautioned that the required calibration methods for these antennas at frequencies up to and including 1 GHz are completely different from those required to be used at frequencies above 1 GHz. Users are further cautioned that an LPDA or hybrid antenna whose operating frequency range extends above 1 GHz shall be acceptable for final compliance measurements on devices ONLY if the calibration certificate/report for that antenna explicitly states the differences between the calibration methods used below 1 GHz and the calibration method used above 1 GHz and separately lists the antenna factors below and above 1 GHz.

^d See Annex I for the site-specific hybrid antenna qualifications that shall be met for a specific hybrid antenna to be used at a specific test site over the frequency range of 30 MHz to 1 GHz. A specific hybrid antenna that has been determined to be suitable for use on a specific test site from 30 MHz to 1 GHz by means of the procedures detailed in Annex I is deemed to be suitable for use on that same test site from 1 GHz upwards to its highest frequency of operation.

^e If a hybrid antenna impedance matching pad (HAIMP) attenuator was used during the site-specific hybrid antenna qualification procedure detailed in Annex I, then either the exact same HAIMP (i.e., same serial number) or an attenuator of the same make, model number, insertion loss value, and the same frequency range of operation shall be used during all final compliance measurements performed with that specific hybrid antenna on that specific test site.

^f The largest aperture dimension, D , of these horn antennas (i.e., length or width; in meters) shall be small enough so that the measurement distance (in meters) is equal to or greater than the Rayleigh distance (i.e., $R_m = D^2 / 2\lambda$), where λ is the free-space wavelength (in meters) at the frequency of measurement.

^g The use of an active horn antenna is permitted for final compliance measurements on devices; however, users shall verify whether the ambient and/or EUT signals are causing the preamplifier portion of the active horn antenna to saturate (thus yielding unacceptable, erroneous measurements) and, if they are, corrective action shall be taken (e.g., use of a notch filter, reorientation of the measurement axis) to eliminate the saturation condition.

³⁵ The shading on table footnotes is used only to enhance readability; all footnotes have equal importance.

4.5.1.4 Test site validation measurements

Table 7 and Table 8 contain the complete list of antennas that are permitted to be used for performing *test site validation measurements* and identify the frequency ranges over which those antennas are permitted to operate when performing test site validation measurements.

Only antenna types specifically listed in Table 7 and Table 8, when used over the frequency ranges listed for their operation in Table 7 and Table 8 (and used in a manner consistent with the normative footnotes in Table 7 and Table 8) shall be used for performing test site validation measurements.

**Table 7—Radiated emission antennas for use in performing
test site validation measurements (NSA 30 MHz to 1000 MHz)**

#	Antenna types ^a (see NOTE)	Frequency range (MHz)	Footnotes
1	Resonant tuned dipole (passive)	30–1000	
2	Biconical dipole	30–200	^b
3	Log-periodic dipole array (LPDA)	200–1000	

NOTE—The regulatory authority or purchasing agency might require accreditation of antenna calibration laboratories.

^a To be acceptable for use in performing test site validation measurements, each antenna used shall have a current, valid calibration that was performed in accordance with ANSI C63.5 and is evidenced by a calibration certificate/report that, among other things, states the specific antenna calibration method or methods used, the antenna factors determined for that specific antenna, and the associated calibration measurement uncertainty. To be acceptable, an antenna calibration certificate/report shall have been issued by an antenna calibration laboratory having demonstrated competence in performing the specific antenna calibration method or methods and to cover the required frequency range (e.g., this competence may be demonstrated through accreditation: see NOTE above). For further details, see 4.6.3.

^b When performing NSA measurements, users are cautioned that the geometry-specific correction factors (GSCFs) required for biconical dipole antennas with 50 Ω baluns are significantly different from those applicable to biconical dipole antennas with 200 Ω baluns. Additionally, users are cautioned that the GSCFs for all biconical dipole antennas vary with measurement distance and frequency. ANSI C63.5 provides specific instructions and appropriate tables for the use of these antennas with the different balun designs and at different measurement distances as a function of frequency when performing NSA measurements. For further details, see ANSI C63.4a-2017 and ANSI C63.5.

Table 8—Radiated emission antennas for use in performing test site validation measurements (S_{VSWR} or TD S_{VSWR} 1 GHz to 18 GHz)³⁶

#	Antenna types ^a (see NOTE)	Footnotes
1	Precision biconical dipole	b, c
2	Log-periodic dipole array (LPDA)	c, d
3	Waveguide horn	c, e
4	Double-ridge guide horn (passive)	c, e
5	Double-ridge guide horn (active)	c, e, f

NOTE—The regulatory authority or purchasing agency might require accreditation of antenna calibration laboratories.

^a To be acceptable for use in performing test site validation measurements, each antenna used shall have a current, valid calibration that was performed in accordance with ANSI C63.5 and is evidenced by a calibration certificate/report that, among other things, states the specific antenna calibration method or methods used, the antenna factors determined for that specific antenna, and the associated calibration measurement uncertainty. To be acceptable, an antenna calibration certificate/report shall have been issued by an antenna calibration laboratory having demonstrated competence in performing the specific antenna calibration method or methods and to cover the required frequency range (e.g., this competence may be demonstrated through accreditation: see NOTE above). For further details, see 4.6.3.

^b The use of precision broadband omnidirectional (biconical) antennas is permitted when performing test site validation measurements using the S_{VSWR} or TD S_{VSWR} *Method* ONLY if they comply with the constructional and pattern requirements specified in 7.4 of CISPR 16-1-4:2020-06. No other types of biconical antennas shall be used for test site validation above 1 GHz.

^c When performing test site validation by means of the S_{VSWR} or TD S_{VSWR} *Method*, the receive antenna(s) used for performing test site validation measurements above 1 GHz shall comply with 4.6 of CISPR 16-1-4:2020-06.

^d Users of LPDA antennas are cautioned that the required calibration methods for these antennas at frequencies up to and including 1 GHz are completely different from those required to be used at frequencies above 1 GHz. Users are further cautioned that an LPDA antenna whose operating frequency range extends above 1 GHz shall be acceptable for use in performing test site validation measurements ONLY if the calibration certificate/report for that antenna explicitly states the differences between the calibration methods used below 1 GHz and the calibration method used above 1 GHz and separately lists the antenna factors below and above 1 GHz.

^e The largest aperture dimension, D , of these horn antennas (i.e., length or width; in meters) shall be small enough so that the measurement distance (in meters) is equal to or greater than the Rayleigh distance (i.e., $R_m = D^2 / 2\lambda$), where λ is the free-space wavelength (in meters) at the frequency of measurement.

^f The use of an active horn antenna is permitted when S_{VSWR} or TD S_{VSWR} *Method* test site validation measurements are made in a shielded enclosure (e.g., RF anechoic chamber). The use of an active horn antenna is permitted when S_{VSWR} or TD S_{VSWR} *Method* test site validation measurements are made in a non-shielded environment (e.g., an OATS); however, users shall verify whether the ambient signals are causing the preamplifier portion of the active horn antenna to saturate (thus yielding unacceptable, erroneous measurements) and, if they are, corrective action shall be taken (e.g., use of a notch filter, reorientation of the measurement axis) to eliminate the saturation condition.

³⁶ The shading on table footnotes is used only to enhance readability; all footnotes have equal importance.

4.5.2 Magnetic field measurements (9 kHz to 30 MHz)

4.5.2.1 General

EUTs with largest dimension greater than 1.6 m (see row #1 of Table A.4) shall be measured for radiated emissions at frequencies within 9 kHz to 30 MHz in terms of magnetic field strength using the small loop antenna, compliant with the requirements in 4.5.2.2.

Unless otherwise specified by the regulatory authority or purchasing agency, EUTs with largest dimension of up to 1.6 m (see row #1 of Table A.4) shall be measured for radiated emissions at frequencies within 9 kHz to 30 MHz either using the small loop antenna specified in 4.5.2.2 (in terms of magnetic field strength) or using the large loop antenna system (LLAS) specified in 4.5.2.3 (in terms of induced current in the three large loops of the LLAS).

The determination of the largest dimension of the EUT shall include the entire EUT arrangement (i.e., including all EUT components and auxiliary equipment, as well as the length of each cable that is required to be exposed during measurements, as per the requirements specified in this standard).

4.5.2.2 Shielded, balanced loop antenna

Either a passive small loop antenna or an active small loop antenna compliant with CISPR 16-1-4:2020-06 shall be used to measure radiated emissions in terms of magnetic field strength in the frequency range of 9 kHz to 30 MHz. A ferrite-rod antenna (as specified in CISPR 16-1-4:2020-06) shall not be used for ANSI C63.29 measurements. See Table 1 and Table 4 for the applicable conditions of use of small loop antennas.

NOTE—The loop antenna used to perform magnetic field strength measurements for the purpose of ANSI C63.29 is traditionally referred to as the “60 cm” loop antenna. However, its diameter (for circular loop antennas) or largest side (for rectangular loop antennas) can be any smaller value and can never be exactly 60 cm, due to the requirement specified in CISPR 16-1-4:2020-06 that the loop antenna has to fit in a square of 60 cm on a side. In practice, loop antennas with a diameter (circular loop antenna) or side (rectangular loop antenna) of at least 50 cm are typically used to help minimize the antenna factor values as a function of frequency and improve the measurement system sensitivity (see 4.1).

4.5.2.3 Large loop antenna system (LLAS)

Provided the regulatory authority or purchasing agency allows it, EUTs with largest dimension of up to 1.6 m (see row #1 of Table A.4) may alternatively be measured using the LLAS.

The LLAS holds several advantages over the small loop antenna. These include:

- The LLAS is largely insensitive to external ambient signals, allowing it to be used at any location.
- The LLAS includes three orthogonally-placed large loop antennas, completely surrounding the EUT. As such, efficiency of measurement can be realized, with no need to change the orientation of the EUT (in case of hand-held, wall-mount or ceiling-mount equipment) or rotate the EUT through 360°.
- The LLAS is more sensitive to EUT emissions (because it is located so close to the EUT), allowing detection of significantly more EUT emissions than the small loop.
- The LLAS measures all EUT emissions, in all directions in 3D space around the EUT.

The large loop antenna system (LLAS) consists of three loops of 2 m diameter positioned orthogonally to one another and supported by a non-metallic base. The three orthogonal loops allow the measurement of the magnetic field strength emitted by the EUT in all possible polarizations/orientations without requiring the rotation or reorientation of the EUT. This is performed by measuring the current induced in each one of

the three loops and converting this current to an equivalent magnetic field strength value at a set distance from the EUT by means of applying a set conversion factor, at each frequency of measurement.

The LLAS shall comply with the construction, electrical, calibration, and validation requirements set out in CISPR 16-1-4:2020-06 amended and complemented in accordance with Annex D.

4.5.3 Electric field measurements (30 MHz to 1000 MHz)

Linearly polarized antennas, as specified in ANSI C63.5, shall be used to measure electric fields in the frequency range of 30 MHz to 1000 MHz (see also CISPR 16-1-4:2020-06). Specifically, tuned dipole antennas, biconical dipole antennas, LPDA antennas, and hybrid antennas may be used. However, hybrid antennas shall be used only if the requirements specified in Annex I are satisfied. Antennas shall comply with Clause 4 of CISPR 16-1-4:2020-06. See Table 2 and Table 5 for the applicable conditions of use for tuned dipole antennas, biconical dipole antennas, LPDA antennas, and hybrid antennas.³⁷

4.5.4 Electric field measurements (1 GHz to 40 GHz)

Linearly polarized antennas as specified in Table 3 and Table 6, as applicable, and calibrated in accordance with ANSI C63.5, shall be used (see also CISPR 16-1-4:2020-06). These antennas include hybrid antennas, LPDAs, double-ridge guide horns,³⁸ quadruple-ridge 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 for measurements within 1 GHz to 18 GHz, which shall be taken as the half-power (3 dB) beamwidth of the antenna (see Figure 24), shall be large enough to encompass the physical size of the EUT or system arrangement, in both width and height but excluding EUT cables that connect to the outside environment (i.e., power or remotely located SE) and portions of any rack in which the EUT is installed if these do not include any EUT units, when located at the measuring distance, in each antenna polarization used for measurements, when the antenna is placed at its lowest height of 1 m (see row #7 of Table A.4) and aligned with the mid-width of the EUT arrangement (as illustrated in Figure 25 and Figure 26). The same is recommended for measurements within 18 GHz to 40 GHz. See also 9.3.4.2.

NOTE 1—Double-ridge guide horn antennas are sometimes referred to using the deprecated descriptive “double-ridged guide horn antenna.”

The aperture dimensions of the horn antenna shall be small enough so that the measurement distance is equal to or greater than the Rayleigh distance (i.e., $R_m = D^2 / 2\lambda$, where D is the largest dimension of the antenna aperture and λ is the free-space wavelength at the frequency of measurement). The same requirement applies for the other types of antennas mentioned in this subclause, but in that case D is the largest dimension of the antenna elements active at the frequency of measurement. In case of dispute, measurements made with a standard-gain horn antenna shall take precedence.

The antenna used for performing final compliance measurements on EUTs and that used for test site validation shall both comply with 4.6 of CISPR 16-1-4:2020-06.

NOTE 2—It is recommended that the antenna used for site validation measurements should be of same type, production series, and model number as the antenna used for final compliance measurements on EUTs at that site.

³⁷ Some regulatory authorities and/or purchasing agencies might require the use of a reference antenna (i.e., tuned dipole as described in 6.3, Annex C, and Annex D of ANSI C63.5-2017) for measurements of radiated emissions.

³⁸ Users should exercise caution when using “conventional” double-ridge guide horn antennas at frequencies above approximately 12 GHz, because such antennas suffer lobe splitting and rotation of the split lobes out of the principal planes of polarization. This can result in a significant reduction in the gain of the antenna in the direction of the mechanical boresight.

4.6 Calibration of measuring equipment

4.6.1 General requirements

All measurement equipment, instruments, and corresponding ancillary equipment (e.g., cables), including all ancillary equipment in the signal path used for measurements as specified in this standard shall be calibrated. A calibration records system shall be maintained, as part of a laboratory quality system, which monitors the calibration status of the test equipment and facilitates the traceability to national standards.

4.6.2 Confirmation interval

The calibration of all instruments, measurement equipment, and ancillary equipment shall be confirmed in the first year of deployment. The 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. Other requirements can also apply, such as CISPR 16-1-1:2019-05 or ANSI C63.2 for the measurement instrument. All instruments, measurement equipment, and ancillary equipment in the measurement path 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.

4.6.3 Antenna calibration

For the LLAS, see Annex D.

All antennas, other than the LLAS, shall be calibrated in accordance with ANSI C63.5 and this subclause, including antennas used for performing NSA measurements for standard test site validation and alternative test site validation (see 5.4.1 and 5.4.2) and antennas used for performing S_{VSWR} [or time domain (TD) S_{VSWR} , if allowed by the regulatory authority or purchasing agency] measurements for test site validation above 1 GHz (see 5.5).

Antennas shall be calibrated at regular intervals (i.e., periodically calibrated) as described in 4.6.2 and calibrated after repair or when damage or deterioration is suspected or known to have occurred. Notwithstanding the provisions of the preceding sentence, precision broadband omnidirectional (biconical) antennas used for S_{VSWR} (or TD S_{VSWR} , if allowed by the regulatory authority or purchasing agency) site validation testing (see also 5.5.1) and complying with the constructional and pattern requirements specified in 7.4 of CISPR 16-1-4:2020-06 need not be periodically calibrated, unless damage or deterioration is suspected or known to have occurred.

The quantities that shall be calibrated as a function of frequency, over the entire frequency range over which the antenna is used, depend on the antenna type, as follows:

- a) Antenna factor (all antenna types)
- b) Return loss at the antenna coaxial port (only for antennas used in the 30 MHz to 1 GHz frequency range)
- c) Antenna symmetry (hybrid and biconical antennas)

The return loss and the antenna symmetry need not be periodically calibrated unless damage or deterioration is suspected or known to have occurred.

The return loss at the antenna's coaxial port shall be measured in accordance with A.8.7 of CISPR 16-1-6:2017-01. The return loss within 30 MHz to 1 GHz shall be greater than or equal to 7.36 dB [i.e., voltage standing wave ratio (VSWR) smaller than or equal to 2.5:1].

NOTE 1—If the antenna has a small return loss (i.e., large VSWR), this can be corrected by adding an attenuator on the antenna coaxial output port.

To be acceptable, an antenna calibration certificate/report for the antenna factor, i.e., 4.6.3a), shall have been issued by an antenna calibration laboratory having demonstrated competence in performing the specific antenna calibration method or methods, over the required frequency range, and the calibration certificate/report shall include the calibration measurement uncertainty.

NOTE 2—Antenna calibration in accordance with ANSI C63.5-2017 is a challenging process with additional site performance requirements as defined in Annex J of ANSI C63.5-2017 and other aspects that can cause problems. The process can only be performed using proper equipment, relevant procedures, and experienced staff. The regulatory authority, accreditation body, or purchasing agency might require accreditation of antenna calibration laboratories.

Small loop antennas shall be calibrated in accordance with Annex N of ANSI C63.5-2017.

NOTE 3—Annex N of ANSI C63.5-2017 is informative. However, that annex is made normative for calibrating the small loop antenna for use in measurements according to ANSI C63.29, by the use of “shall” in the above paragraph.

4.6.4 LISN impedance and insertion loss

The attenuation (insertion loss) between the EUT receptacle and the measuring instrument port on the LISN (see Annex C for an example method of measurement) shall be accounted for when calculating the EUT emission levels, at each frequency of measurement. The impedance and insertion loss of each LISN used in conducted emissions testing shall be measured over the frequency range of use. The LISN shall be measured in the configuration for which it is used for testing a product. Acceptable procedures for performing these measurements are given in Annex C, which also includes the requirements the LISN impedance shall comply with (nominal impedance magnitude and phase values and maximum tolerances). The LISN shall be checked routinely to confirm acceptable performance; see 4.6.2.

NOTE—It is suggested that the insertion loss measurement be carried out after the completion of the impedance measurements.

4.6.5 Insertion loss of passive devices and preamplifier gain

The insertion loss of passives included in the measurement path (such as cables, attenuators, directional couplers, and filters), as well as the gain of preamplifiers used for connection of antennas or other transducers to measuring instruments (e.g., EMI receivers, spectrum analyzers) shall be characterized over the used frequency range and the calibrated loss or gain factor shall be applied for correcting the measurement result before comparing with the applicable limit, at each frequency of measurement.

Cables shall be checked frequently for deterioration caused by use and environmental exposure (e.g., variation due to change in temperature and damage). Published data³⁹ 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. This should also be applied for the other passive components used during measurements (such as attenuators, filters, couplers, adapters).

³⁹ For example, see http://www.gore.com/en_xx/products/cables/microwave/changes_insertion_loss_phase.html.

4.7 Figures for Clause 4

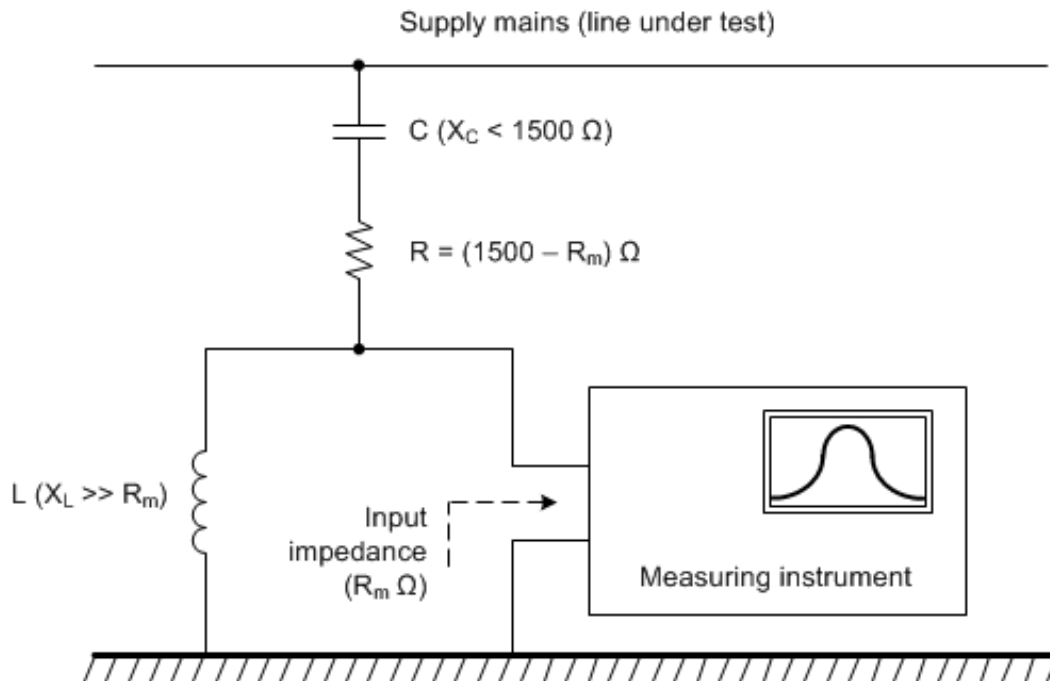


Figure 1—Example use of a voltage probe for measurements at a user's installation

5. Test facilities

5.1 General requirements

5.1.1 General considerations

Radiated and ac power-line conducted emission measurements shall be made in an environment that provides valid, repeatable measurement results (i.e., as described in 5.2 for ac power-line conducted emission test sites or 5.3 through 5.5 for 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 (5.1) shall be observed.

5.1.2 Power source

5.1.2.1 Direct current (dc) network powered EUT

This subclause does not apply to EUT powered from ac mains through an external power adapter or another device.

For EUT powered from a dc network, the voltage supplied to the EUT power input port, while the EUT is in its normal operating mode, shall be within $\pm 10\%$ of the voltage specified for the EUT.

5.1.2.2 AC mains powered EUT

Sufficient ac power shall be available to operate the EUT at its rated voltage, current, power, and frequency. The line voltage supplied to the EUT shall comply with Table 9, as applicable.

When power is provided to the EUT from a local power supply, instead of from 60 Hz public utility lines, the line frequency supplied to the EUT shall be 60.00 Hz $\pm$ 0.10 Hz. Testing according to this standard shall not be carried out using ac power with a nominal line frequency of 50 Hz. In exceptional cases, the use of other line frequencies is permitted if these are used in North America and the EUT is designed to be powered from an ac power source of such nominal line frequency (e.g., 16.66 Hz).

The voltage level and the frequency of the ac mains power supplied to the EUT shall be verified to be within the tolerances specified in this subclause at the ac mains power input of the EUT, for each test configuration, with the EUT operational.

Table 9—Nominal line voltages and allowable voltage tolerances ^a

Nominal wye line-to-neutral voltage (Vrms)	Nominal wye or delta line-to-line voltage (Vrms)	Allowable voltage tolerance (from nominal)	Allowable voltage tolerance range (Vrms)
120 (single-phase)	N/A	$\pm 5\%$	114.0–126.0 (L-N)
120	240 (split-phase)	$\pm 5\%$	114.0–126.0 (L-N) 228.0–252.0 (L-L)
120	208	$\pm 5\%$	114.0–126.0 (L-N) 197.6–218.4 (L-L)
N/A	208	$\pm 5\%$	197.6–218.4 (L-L)
277	480	$\pm 5\%$	263.2–290.9 (L-N) 456.0–504.0 (L-L)
N/A	480	$\pm 5\%$	456.0–504.0 (L-L)
347	600	$\pm 5\%$	329.6–364.4 (L-N) 570.0–630.0 (L-L)
N/A	600	$\pm 5\%$	570.0–630.0 (L-L)

NOTE 1—All values listed in this table assume that the line frequency is 60.00 Hz $\pm$ 0.10 Hz.
NOTE 2—Where line-to-neutral voltages are stated as N/A, the circuit is assumed to have no neutral conductor.

^a If an electronic power supply or a locally-operated rotating machine is used to provide the voltage for testing, it is required to verify that both the line frequency and the line voltage are within the tolerances stated in this table and in this subclause while the EUT is operating in its normal state, under its maximum or typical load conditions, as applicable.

5.1.3 Ambient disturbances and signals

AC power-line conducted and radiated ambient signal levels, measured at the test site with the EUT de-energized, shall be:

- At least 6 dB below the allowable limit of the applicable specification or standard when measured in peak detection mode (preliminary scans); or
- If the measured levels of ambient plus EUT emission are not above the applicable limit, when measured with peak detector or with the detector for which the limit is specified, then 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 9.3.2.2, 9.3.3.2, or 9.3.4.3, as applicable, and extrapolate results to the specified limit distance in accordance with 9.2. The measurement distance and the method of extrapolation shall be 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 the level of 6 dB below the limit or lower.
- c) Perform measurements in an absorber-lined shielded room (see 5.4.2 for conditions of use, in case of radiated emissions).
- d) Orient the radiated emission test site to discriminate against such ambient signals insofar as possible.
- e) If the signal being measured is a continuous wave (CW) signal or consists of only one single spectral component of a specific EUT emission, and if the ambient field is broadband, then reduce the resolution bandwidth if using a spectrum analyzer or reduce the bandwidth if using an EMI receiver while keeping the signal being measured within the pass band of the IF filter at all times.
- 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 / 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 input of the LISN.

5.1.4 EUT turntable

5.1.4.1 General

For radiated emissions (except for measurements with the LLAS), a remotely controlled turntable shall be installed at the test site to support the EUT arrangement. This turntable shall be capable of continuous rotation through 360° of azimuth (e.g., $\pm 180^\circ$, or 0° through 360°). This requirement is waived only for excessively large EUTs, where a suitable turntable is not available, in which case the requirements for measurement at a specified minimum number of azimuth angles shall apply, as per 9.3.2.2, 9.3.3.3, and 9.3.4.4.

5.1.4.2 Turntable for radiated emissions measurements at and below 1 GHz

If the turntable is flush mounted (ignoring any annular ring around the turntable periphery), with its top surface at the level of the ground plane, it shall be metallic or metal covered.

A non-metallic turntable may only be used provided the following conditions are satisfied:

- a) The non-metallic turntable is located above the metallic ground plane. The metallic ground plane shall be continuous below the entire surface of the non-metallic turntable, with the exception of any openings in the turntable for passing EUT cables outside the test site, as long as the test site validation requirements are met.
- b) The top surface of the non-metallic turntable shall be such that the lowest surface of the EUT is at a height above the metallic ground plane that complies with the requirements in 6.3.2.1 (for tabletop EUT), in 6.3.3.1 (for floor-standing EUT), and in 6.3.4.1 (for combination EUT).
- c) A non-metallic turntable shall not be used for floor-standing equipment that is normally installed in direct contact with a metallic floor (see 5.2.2 and 6.3.3.1).

NOTE—Lifting the floor-standing EUT above the metallic ground plane can increase the level of some of its emissions, as compared with the situation where the EUT is in direct contact with the metallic ground plane.