

C63.4

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

Accredited by the American National Standards Institute

Sponsored by the
Accredited Standards Committee on Electromagnetic Compatibility, C63



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Secretariat

Institute of Electrical and Electronics Engineers, Inc.

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American National Standards Institute

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

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

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Introduction

(This introduction is not a part of ANSI C63.4-2003, American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.)

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

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

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

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

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

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

- Control of site reference groundplane conductivity, flatness, site enclosures, effects of surrounding objects, and certain other site construction features.
- Accounting for antenna factors, associated cabling, and balun and device under test characteristics.
- Consideration of mutual coupling effects between the device under test and the receiving antenna and their images in the reference groundplane.

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

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

Work on a further revision began during 1991 to provide for the testing of intentional as well as unintentional radiators. The 1992 document included these changes. In 1994, work began on harmonizing the document with emerging international standards, clarifying several issues with respect to ac powerline conducted emission measurements and turntable usage, and standardizing terminology. The use of transverse electromagnetic (TEM) devices for measuring emissions, extension from 10 kHz down to 9 kHz, and revisions to the clause on the Artificial Hand were also added. Minor changes have been made to the normalized site attenuation tables to correct rounding errors. That work culminated in the 2001 issue.

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

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

1. Overview

1.1 Scope

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

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

NOTE—Annex A through Annex K, Annex M, and Annex N are informative.

1.2 Applications

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

This standard may be applied to emission measurement of a variety of electrical/electronic devices regardless of size and character. The devices may be single, stand-alone units, or multiple, interconnected units. Examples of devices to which these measurement procedures may be applied include small hand-held electronic devices such as portable digital “assistants” and garage door openers, as well as large devices such as electronically controlled gas station pumps and systems of computers used in banking and insurance centers.

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

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

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

Use of the word *shall* in this standard implies that the associated requirement must be met to satisfy this standard. The word *should* implies that the associated requirement is recommended but not mandatory. Tolerances on dimensions and distances are based on good engineering practice where not specified. The word *may* implies that the recommendation is at the discretion of the user.

In this standard the text takes precedent over the figures. The text is complete and the figures are illustrative of a typical application of the text. However, the text is more complete and therefore takes precedent.

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 powerline conducted and radiated emission measurements
- b) Measurement antenna distances for radiated emission measurements
- c) Identification of any uncommon requirements such as the following:
 - 1) Radiated magnetic field strength measurements below 30 MHz (see 8.2.1)
 - 2) Radiated electric field strength measurements below 30 MHz (see 8.2.2)
 - 3) Use of the absorbing clamp for radiated emission measurements (see Clause 9)

- 4) Use of current probes for ac powerline conducted measurements (see 4.1.4)
- 5) Relaxation of the limits for clicks (transients) (see Clause 14)
- 6) Use of the artificial hand for measurement of portable, hand-held devices (see 5.7)
- 7) Any requirements that differ from the requirements contained herein
- 8) Any requirement concerning statements of uncertainty of the measurement results (see ISO/IEC 17025-1999¹).

NOTE—Methods for calculating measurement instrumentation uncertainty are under development.

2. References

This standard shall be used in conjunction with the following publications. When following specifications are superseded by an approved revision, the revision shall apply.

ANSI C63.2-1996, American National Standard for Electromagnetic Noise and Field Strength Instrumentation, 10 Hz to 40 GHz—Specifications.²

ANSI C63.5-1988, American National Standard for Electromagnetic Compatibility of Antennas Used for Radiated Emissions Measurements in Electromagnetic Interference (EMI) Control—Calibration of Antennas.

ANSI C63.5-1998, American National Standard for Calibration of Antennas Used for Radiated Emissions Measurements in Electromagnetic Interference (EMI) Control.

ANSI C63.6-1996, American National Standard Guide for the Computation of Errors in Open-Area Test Site Measurements.

ANSI C63.7-1992, American National Standard for Construction of Open-Area Test Sites for Performing Radiated Emission Measurements.

ANSI C63.14-1998, American National Standard Dictionary for Technologies of Electromagnetic Compatibility (EMC), Electromagnetic Pulse (EMP), and Electrostatic Discharge (ESD) (Dictionary of EMC/EMP/ESD Terms and Definitions).

ANSI C63.22, Draft Guide for Automated EMI Measurements.³

ANSI/NCSL Z540-1-1994, American National Standard for Calibration—Calibration Laboratories and Measuring Test Equipment—General Requirements.⁴

CISPR 14-1 (2002-10), Ed. 4.2 Consolidated Edition, Electromagnetic compatibility—Requirements for household appliances, electric tools and similar apparatus—Part 1: Emission.⁵

¹Information on references may be found in Clause 2.

²C63 publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA, or from the Sales Department, American National Standards Institute, 11 West 42nd St., New York, NY 10036, USA. (<http://standards.ieee.org/>).

³This ANSI standards project was not approved by ANSI at the time this publication went to press. For information about obtaining a draft, contact ANSI.

⁴NCSL publication are available from National Conference of Standards Laboratories, 1800 30th St., Suite 305B, CO 80301, USA.

⁵CISPR publications are available from the International Electrotechnical Commission, 3 rue de Varembe, Case Postale 131, CH-1211, Genève 20, Switzerland/Suisse. In the United States, CISPR publications are available from the Sales Department, American National Standards Institute.

CISPR 16-1-1 (2003-11), Specification for radio disturbance and immunity measuring apparatus and methods—Part 1-1: Radio disturbance and immunity measuring apparatus—Measuring apparatus.

CISPR 22 (2003-04), Information technology equipment—Radio disturbance characteristics—Limits and methods of measurement. (See also CENELEC EN 55022-1998 [B8].)⁶

EIA-378 (Aug., 1970), Measurement of Spurious Radiation from FM and TV Broadcast Receivers in the Frequency Range of 100 to 1000 MHz—Using the EIA Laurel Broadband Antenna.⁷

FCC 47 CFR Part 15, Radio Frequency Devices.⁸

IEEE Std 139™ -1988 (Reaff 1999), IEEE Recommended Practice for the Measurement of Radio Frequency Emission from Industrial, Scientific, and Medical (ISM) Equipment Installed on User's Premises.^{9, 10}

IEEE Std 149™ -1979 (Reaff 1990), IEEE Standard Test Procedures for Antennas.

IEEE Std 187™ -1990 (Reaff 1995) IEEE Standard on Radio Receivers: Open Field Method of Measurement of Spurious Radiation from FM and Television Broadcast Receivers.

IEEE Std 475™ -2000, IEEE Standard Measurement Procedure for Field Disturbance Sensors (RF Intrusion Alarms).

IEEE Std 1394™ -1995, IEEE Standard for a High Performance Serial Bus.

ISO/IEC 17025-1999, General Requirements for the Competence of testing and calibration laboratories, First edition.¹¹

ISO 10012:2003, Quality Assurance Requirements for Measuring Equipment, Part 1: Meteorological Confirmation System for Measuring Equipment.

Universal Serial Bus (USB) Specification Revision 2.0.¹²

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

⁷EIA publications are available from Global Engineering, 1990 M Street NW, Washington, DC 20036, USA. (<http://global.ihs.com/>).

⁸For information on how to purchase FCC publications, contact the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, USA.

⁹IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA. (<http://standards.ieee.org/>).

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

¹²For more information, please visit the following URL: <http://www.usb.org/developers/docs/>.

3. Definitions and acronyms

3.1 Definitions (see L.2 in Annex L for definitions on testing in TEM waveguides)

The definitions in ANSI C63.14-1998, unless noted below, apply throughout this standard. Otherwise, use IEEE Std 100 [B18]. Definitions in particular product standards or in applicable regulations take precedence.

3.1.1 ambient level: The value of unwanted radiated and conducted emissions existing at a specific test location and time when the test sample is not activated.

3.1.2 antenna factor: A factor that when multiplied with the linear voltage reading of the measuring instrument yields the electric field strength in volts/meter or the magnetic field strength in amperes per meter.

NOTES

1—The factor includes the effects of antenna effective length and mismatch, and it may include transmission line losses.

2—The factor for electric field strength is not necessarily the same as the factor for the magnetic field strength.

3—The antenna factor, as determined in ANSI C63.5-1998, is very nearly equal to the free-space antenna factor.

3.1.3 broadband interference: A disturbance that has a spectral energy distribution sufficiently broad, so that the response of the measuring receiver in use does not vary significantly when tuned over a specified number of receiver bandwidths.

3.1.4 click: A disturbance which exceeds the limit of continuous disturbance not longer than 200 ms and which is separated from a subsequent disturbance by at least 200 ms. Both intervals are related to the level of the limit of continuous disturbance. A click may contain a number of impulses; in which case the relevant time is that from the beginning of the first to the end of the last impulse.

NOTE—For the specified values and conditions, guidance may be found in CISPR 14-1 (2002-10) and CISPR 16-1-1 (2003-11).

3.1.5 digital device: An unintentional radiator (device or system) that uses digital techniques and generates and uses timing signals or pulses at a rate in excess of 9000 pulses (cycles) per second; inclusive of telephone equipment that uses digital techniques or any device or system that generates and uses RF energy for the purpose of performing data processing functions, such as electronic computations, operations, transformations, recording, filing, sorting, storage, retrieval, or transfer. (FCC 47CFR Part 15).

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

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

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

3.1.7 (electromagnetic) emission: The phenomenon by which electromagnetic energy emanates from a source.

3.1.8 equipment arrangement: An equipment configuration specially arranged with cables at the test site to form an equipment under test (EUT) (also known as “test setup”).

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

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

3.1.11 field disturbance sensor: A device that establishes a radio frequency (RF) field in its vicinity and detects changes in that field from the movement of persons or objects within its range. (FCC 47 CFR Part 15).

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

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

3.1.14 incidental radiator: A device that produces RF energy during the course of its operation, although the device is not intentionally designed to generate or emit RF energy. Examples of incidental radiators are dc motors, mechanical light switches, and so on.

3.1.15 information technology equipment (ITE): Any equipment

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

It includes, for example, data processing equipment, office machines, electronic business equipment, predominantly digital audio and video equipment, and telecommunications equipment which contains digital circuits.

3.1.16 intentional radiator: A device that intentionally generates and emits RF energy by radiation or induction. (FCC 47 CFR Part 15).

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

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

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

3.1.19 narrow-band interference: For purposes of measurement, a disturbance of spectral energy lying within the bandpass of the measuring receiver in use.

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

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

3.1.22 personal computer: An electronic computer that is marketed for use in the home, notwithstanding business applications. Such computers are considered Class B digital devices. Computers which use a standard TV receiver as a display device or meet all of the following conditions are considered examples of personal computers:

- 1) Marketed through a retail outlet or direct mail order catalog.
- 2) Notices of sale or advertisements are distributed or directed to the general public or hobbyist users rather than restricted to commercial users.
- 3) Operates on a battery or 120 volt electrical supply.

If the responsible party can demonstrate that because of price or performance the computer is not suitable for residential or hobbyist use, it may request that the computer be considered to fall outside of the scope of this definition for personal computers.

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

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

3.1.24 restricted bands: Bands of frequencies in which intentional radiators are not permitted to operate. (FCC 47 CFR Part 15).

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

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

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

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

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

3.1.29 unintentional radiator: A device that generates RF energy for use within the device, or that sends RF signals by conduction to associated equipment via connecting wiring, but which is not intended to emit RF energy by radiation or induction. (FCC 47 CFR Part 15).

3.2 Acronyms

CISPR	International Special Committee on Radio Interference
CSTD	cable system terminal device
CW	continuous wave
EIA	Electronic Industries Alliance
EUT	equipment under test

FCC	Federal Communications Commission
IF	Intermediate Frequency
ISM	industrial, scientific, and medical
ISN	impedance stabilization network [CISPR 16-1-1 (2003-11)]
ITE	information technology equipment
LISN	line impedance stabilization network
NIST	National Institute of Standards and Technology
NSA	normalized site attenuation
NTSC	National Television Systems Committee
OATS	open area test site
RC	resistor-capacitor
RF	radio frequency
TEM	transverse electromagnetic
VCR	videocassette recorder
VDU	video display unit
VITS	vertical interval test signal
VSWR	voltage standing-wave ratio

4. Measurement instrumentation

4.1 General

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

4.1.1 Receiver standards

Measurement instrumentations used for making radiated and ac powerline conducted radio noise measurements include those which conform to the specifications contained in either:

- a) ANSI C63.2-1996, or
- b) CISPR 16-1-1 (2003-11).

A spectrum analyzer may be used for making these measurements, but it typically does not meet either of these specifications without additional accessories. If appropriate accessories like preselection, quasi-peak detection and specific IF filters are used with a spectrum analyzer, this combination can be equivalent to a receiver meeting the specifications in either item a) or item b) above.

This standard recognizes that any of the above measurement instrumentation may be used for making measurements. However, in case of a dispute, radiated and ac powerline test results taken with a receiver meeting the specification in 4.1.1.1 shall take precedence

4.1.1.1 Reference receiver

The reference receiver for measurements of radiated and ac powerline conducted radio noise is an instrument conforming to ANSI C63.2-1996 or CISPR 16-1-1 (2003-11). Other instruments may be used for certain restricted and specialized measurements when data so measured are correlated to a device

conforming to ANSI C63.2-1996 or CISPR 16-1-1 (2003-11). Automatic scan receivers may be used, but the maximum scan speed shall be limited by the response time of the measuring system and the repetition rate of the radio noise to be measured to ensure that the level of each emission is measured correctly, i.e., in accordance with a measurement with a nonscanning receiver. Bandwidth and scan rates shall be chosen that are appropriate for the frequencies being scanned. In case of dispute, one of the reference receivers shall take precedence.

NOTES

1—If the output of the quasi-peak or average detector is indicated in decibels (dB) or other logarithmic units, the logarithms shall be taken after the signal is detected and the detector function is fully realized. Otherwise, instruments that use logarithmic detectors, predetection logarithmic circuits, or both shall include corrective circuits so that the output indication is the logarithm of the true average or quasi-peak value of the signal or noise. Bandwidths are given in 4.2.

2—The user should be aware that the EMI receiver specifications in CISPR 16-1-1 (2003-11) and ANSI C63.2-1996 contain some differences. For measurements below 1 GHz, the specifications in CISPR 16-1-1 (2003-11) are essentially the same as the specifications for an EMI receiver in ANSI C63.2-1996, except for screening effectiveness. For measurements above 1 GHz the bandwidth definition for measurements are different. These differences in bandwidth specification may result in different measured values.

4.1.1.2 Spectrum analyzer

The use of spectrum analyzers for radiated and ac powerline conducted radio noise compliance measurements is permissible, although spectrum analyzers without further accessories will not meet all specifications called out in the standards mentioned in 4.1.1 and 4.1.1.1.

In order to meet the requirements in 4.2, spectrum analyzers shall be equipped with proper quasi-peak detection for measurements below 1 GHz as the reference detector. However, measurements with the instrument's peak detector are permissible to demonstrate compliance of an EUT since peak detection will yield amplitudes equal to or greater than amplitudes measured with the quasi-peak detector. The spectrum analyzer's peak detector measurement data will represent the worst case results.

Minimum values for the resolution bandwidth are specified in 4.2. It should be noted that most spectrum analyzers incorporate a 3 dB resolution bandwidth specification, which is acceptable since larger bandwidths are permissible. The resolution bandwidths, cited in the standards listed in 4.1.1.1 for the frequency range up to 1 GHz do not have a Gaussian shape but are individually specified by their frequency response ("masks"). When using larger bandwidths than the ones specified or filters with different transfer functions, different measurement results for broadband signals must be expected. In case of dispute, the test results measured with one of the reference receivers, as defined in 4.1.1.1 will take precedence.

In order for a spectrum analyzers to meet the specifications of one the two reference receivers, it must be equipped with proper filtering at their input, which can provide adequate overload protection and dynamic range of the system to achieve the proper weighting of pulses, using quasi-peak detection and the specified bandwidths in 4.2. In this case, the spectrum analyzer functions as a scanning EMI receiver, meeting the specifications for the resolution bandwidth, pulse weighting and quasi-peak detection.

4.1.2 LISN

A LISN having an impedance characteristic within the limits shown in Figure 1 is required for ac conducted emission measurements. When the "measuring instrument" ports are terminated in 50 Ω , the characteristic impedance in Figure 1 shall be present at the EUT ports of the LISN. Figure 2 and Figure 3 show two circuits that when carefully constructed can provide the impedance characteristics of Figure 1 (for use with connecting cable, see also 5.2.3.1).

Where specific equipment requirements specify another LISN, the specified LISN shall be used.

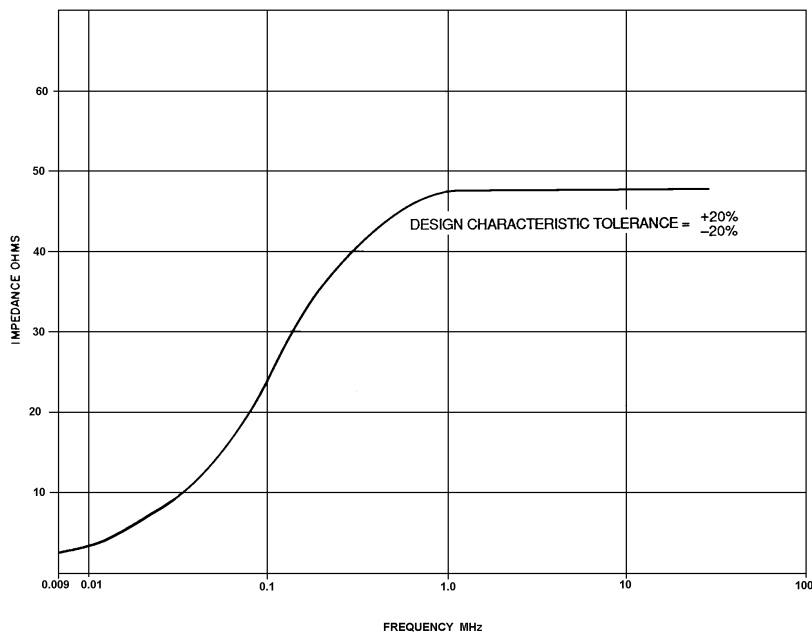
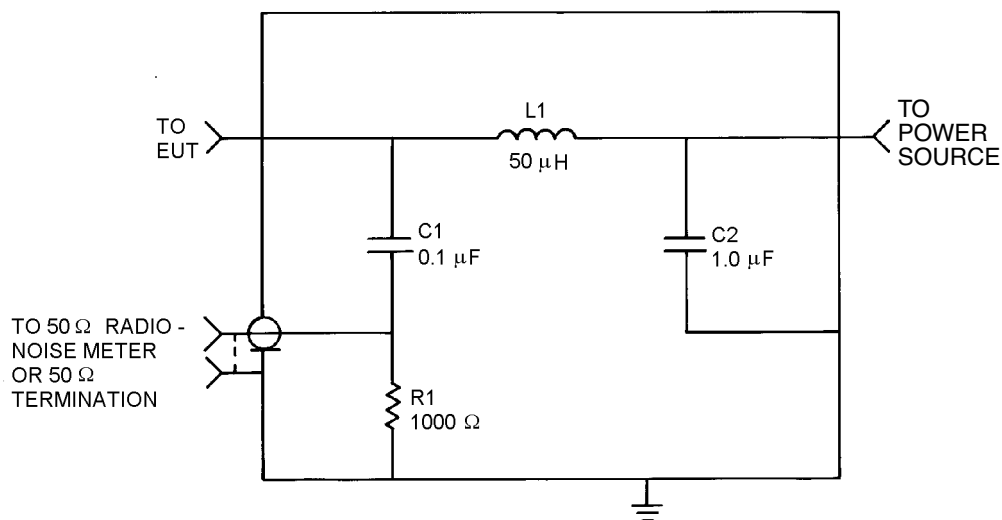
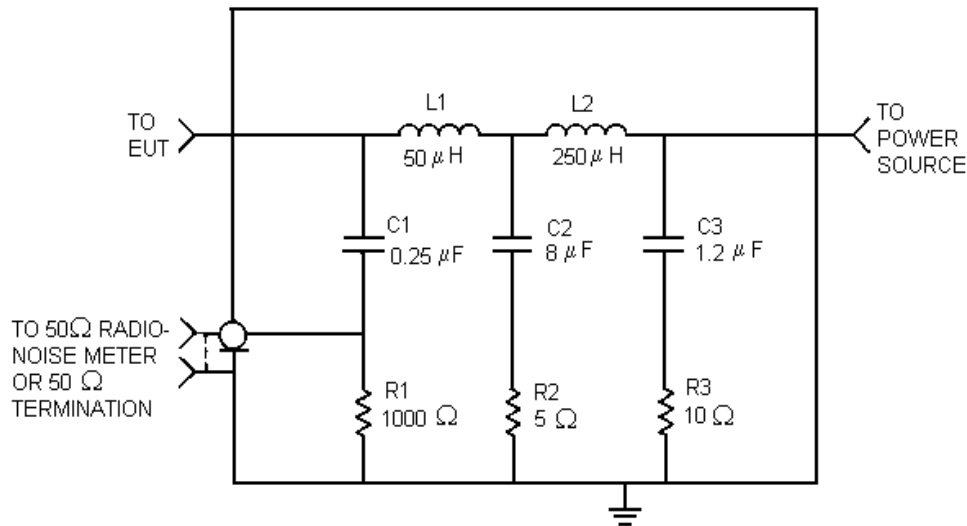


Figure 1—Impedance characteristic of LISN port 9 kHz to 30 MHz



*IN SOME LISNs, A SERIES RESISTANCE IS INCLUDED IN SERIES WITH CAPACITOR C2, E.G., CISPR PUBLICATION 16 - 1999

Figure 2—Circuit diagram of LISN to provide impedance of Figure 1 for the 0.15 MHz to 30 MHz frequency range



* IF CAREFULLY CONSTRUCTED, THIS NETWORK CAN BE USED ABOVE 150kHz TO AS HIGH AS 30 MHz.

Figure 3—Circuit diagram of LISN to provide impedance of Figure 1 for the 9 kHz to 150 kHz (30 MHz) frequency range

4.1.3 Voltage probes

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

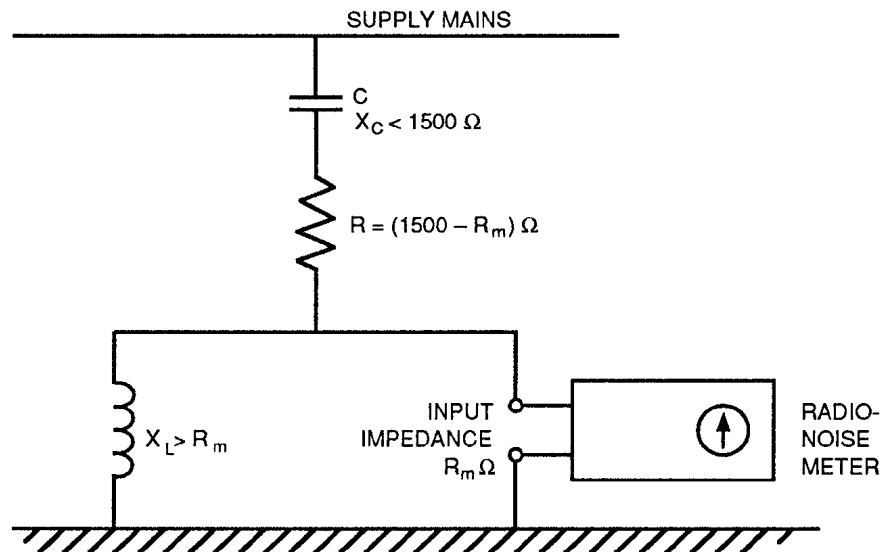


Figure 4— Voltage probe for measurements at user's installation

4.1.4 Current probe

A current probe that fits around each current-carrying conductor under measurement may be used, when permitted, to measure radio-noise currents (in lieu of radio-noise voltages) generated by the EUT. The probe shall be immune to external fields, calibrated, and used with the proper terminating impedance. An LISN in accordance with 4.1.2 shall be inserted between the EUT conductors and the power receptacle. The probe is placed between the EUT and the LISN as near to the LISN as possible. An appropriate adapter may be fitted between the EUT and the LISN to allow the current probe to be clamped on individual current-carrying conductors. If an appropriate LISN satisfying the current requirements of the EUT is not commercially available, the LISN may be eliminated and the current probe placed between the EUT and the power receptacle.

4.1.5 Antennas

The use of specific antennas depends on the frequency range and field (electric or magnetic) being measured in performing radiated emissions measurements, as indicated in 4.1.5.1, 4.1.5.2, 4.1.5.3, and 4.1.5.4. For the present, both ANSI C63.5-1988 and ANSI C63.5-1998 are referenced for use in calibrating antennas for both radiated electronic field emission measurements and site attenuation measurements. Both versions are retained so that test sites qualified using either standard are acceptable. Antenna calibrations for making radiated emission measurements can use either version of the standard in that the differences are not considered significant for this purpose. A revision to ANSI C63.5 is in preparation that will replace both of the earlier documents and will have a single approach for antenna calibration for radiated electric field measurements using the Standard Site Method.

4.1.5.1 Magnetic field measurements (9 kHz to 30 MHz)

Calibrated loop antennas as specified in ANSI C63.2-1996 shall be used to measure magnetic fields in the frequency range of 9 kHz to 30 MHz.

4.1.5.2 Electric field measurements (9 kHz to 30 MHz)

Calibrated monopole (rod) antennas as specified in ANSI C63.2-1996, ANSI C63.5-1988, and ANSI C63.5-1998 shall be used to measure electric fields in the frequency range of 9 kHz to 30 MHz. Generally, a 1.04 m (approximately 41 in) vertical monopole antenna is used with or without a counterpoise, as specified by the manufacturer.

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

4.1.5.3 Electric field measurements (30 MHz to 1000 MHz)

Calibrated, linearly polarized antennas as specified in ANSI C63.2-1996 shall be used to measure electric fields in the frequency range of 30 MHz to 1000 MHz. Tunable dipoles should be used. Alternatively, a linearly polarized broadband antenna or a dipole tuned only above 80 MHz, and set to the 80 MHz tuned length when used between 30 and 80 MHz, may be used in lieu of a tuned dipole, provided that the measurement can be correlated with that made with a tuned dipole with an acceptable degree of accuracy. In case of dispute, data taken with a reference antenna or a tuned dipole calibrated in accordance with ANSI C63.5-1988 or ANSI C63.5-1998 shall take precedence.

4.1.5.4 Electric field measurements (1 to 40 GHz)

Calibrated, linearly polarized antennas as specified in ANSI C63.2-1996 shall be used. These include double-ridged guide horns, rectangular waveguide horns, pyramidal horns, optimum gain horns, and standard gain horns. The “beam,” or main lobe of the pattern, of any antenna used, shall be large enough to encompass the EUT, or system arrangement, when located at the measuring distance. Otherwise, provisions shall be made for “scanning” the EUT or system arrangement to locate the direction or source of its radiated emissions. The aperture dimensions of these horn antennas shall be small enough so that the measurement distance in meters is equal to or greater than the Rayleigh distance, i.e., $R_m = 2D^2 / (\lambda)$, where D is the largest dimension of the antenna aperture in meters, and λ is the free-space wavelength in meters at the frequency of measurement. In case of dispute, measurements made with the standard gain horn antenna shall take precedence.

NOTE—Any calibrated, linearly polarized antenna, e.g., a log-periodic dipole array, may be used to make these measurements. The gain of many antennas, other than horn antennas, in this frequency range may be inadequate if the antennas are used with spectrum analyzers or older radio-noise meters. The tester shall ensure that the overall measurement sensitivity is at least 6 dB below the applicable limit at the measurement distance in use, and that any means used to improve sensitivity, e.g., a preamplifier, does not cause distortion, spurious signals, or other overload problems. Because a log-periodic dipole array has a much wider beam width than a horn antenna, reflections from the reference groundplane may cause significant error in measurements that are made with a log-periodic dipole array. The tester shall ensure that these reflections do not adversely affect the measured value.

4.1.6 Absorbing clamp

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

NOTE—Some regulatory and purchasing agencies do not allow the use of the absorbing clamp for measurement of radio-noise power.

4.2 Detector function/selection of bandwidth

Unless otherwise specified, radio-noise meters or spectrum analyzers shall have as the reference detector function the quasi-peak detector specified in ANSI C63.2-1996 or CISPR 16-1-1 (2003-11) for frequencies up to and including 1 GHz. For measurements above 1 GHz, if peak or average detectors are specified, use the requirements in ANSI C63.2-1996 or CISPR 16-1-1 (2003-11). Peak detector measured data may be substituted for the appropriate detector data to show compliance if the peak level obtained does not exceed the limit. The bandwidth used shall be equal to or greater than that specified in ANSI C63.2-1996. The bandwidth used shall be equal to or greater than 100 Hz from 9 kHz to 150 kHz, 9 kHz from 150 kHz to 30 MHz, 100 kHz from 30 MHz to 1000 MHz, and 1 MHz from 1 GHz to 40 GHz. However, the bandwidth used should be in accordance with the bandwidth specifications in ANSI C63.2-1996 or CISPR 16-1-1 (2003-11). More than one instrument may be needed to perform all of these functions. Use of bandwidths greater than those specified may produce higher readings for certain types of emissions and should be recorded in the test report. In case of dispute, the reference receiver shall take precedence.

The measuring instrument shall satisfy the following conditions:

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

When using a spectrum analyzer or other instrument providing a spectral display the video bandwidth shall be set to a value at least three times greater than the Intermediate Frequency (IF) bandwidth of the measuring instrument to avoid the introduction of amplitude smoothing.

NOTE—For the purposes of this document the term *Intermediate Frequency (IF) Bandwidth* and *Resolution Bandwidth* are synonymous.

4.3 Receiver monitoring

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

4.4 Calibration of measuring equipment

All instruments that can have a significant effect on the accuracy or validity of measurements made as specified in this standard shall be calibrated in accordance with the manufacturers recommendations and the instrument requirements of ANSI C63.2-1996. The instruments shall be calibrated in accordance with the manufacturer's recommendations. A calibration system shall be maintained, as part of a quality system, which monitors the calibration status of the test equipment and ensures the traceability to national standards.

4.4.1 Confirmation interval

Calibration of all instruments shall be confirmed in the first year. Subsequent confirmation intervals may be longer (up to two years) or shorter based on review of calibration data relative to the instrument manufacturers recommendations, and the required measurement accuracy. All instruments should 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.

4.4.2 Antenna calibration

All antennas shall be individually calibrated to a reference antenna or by other methods, using instruments traceable to the NIST or equivalent standards organization. Antennas shall be calibrated when damage or deterioration is suspected and at regular intervals, as described in 4.4.1.

Reference antennas that are used only for calibration purposes shall be constructed as specified and should be checked at least every three years in accordance with ANSI C63.5-1988 or ANSI C63.5-1998.

Antennas for use below 30 MHz shall be calibrated using one of the methods in ANSI C63.5-1988 and ANSI C63.5-1998.

Antennas for use from 30 to 1000 MHz shall be calibrated in accordance with the methods specified in ANSI C63.5-1988 and ANSI C63.5-1998. Adjustable (tunable) dipole antennas used below 80 MHz while fixed-tuned at 80 MHz resonant length shall also be calibrated at that fixed length for the range of frequencies of use. Antennas for use at or above 1 GHz shall be calibrated in accordance with one of the methods in ANSI C63.5-1998 or IEEE Std 149-1979.

All antennas shall be calibrated per ANSI C63.5-1998.

Note that for the present, antennas calibrated using ANSI C63.5-1988 and ANSI C63.5-1998 shall be used for performing NSA measurements for alternative test site validation (see 5.4.2).

NOTES

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

2—Gain standard horn antennas (sometimes called standard gain horn antennas) need not be calibrated beyond that which is provided by the manufacturer unless they are damaged or deterioration is suspected, or they are used at a distance closer than $2 \times a^2 / \lambda$. Gain standard horn antennas have gains that are fixed by their dimensions and dimensional tolerances.

4.4.3 LISN impedance and insertion loss measurements

The impedance and insertion loss of each LISN used in testing emissions shall be measured over the frequency range of use. The LISN shall be measured as it is used for testing a product. An acceptable procedure for performing these measurements is given in Annex E. See 5.2.3.1 for testing a permanently installed LISN. The LISN should be checked routinely to ensure acceptable performance. See 4.4.1.

4.4.4 Characterization of absorbing cable clamp

Absorbing clamps used to measure RF energy radiated from cables, should be characterized in accordance with Annex G of CISPR 16-1-1 (2003-11), which is summarized in Annex F.

4.4.5 Cable insertion loss

The insertion loss of cables used for connection of antennas or transducers to measuring instruments (radio-noise meters, spectrum analyzers, etc.) shall be characterized and checked frequently for deterioration caused by use and environmental exposure (e.g., variation due to change in temperature, damage).

5. Test facilities

Radiated and ac powerline conducted emission measurements shall be made in an environment that ensures valid, repeatable measurement results as described in 5.2 (ac powerline conducted emission test sites) or 5.3, 5.4, and 5.5 (radiated emission test sites). Where appropriate, tests may be made at the manufacturer's location or the user's installation (5.6). In any case, the requirements of 5.1 shall be observed.

5.1 General requirements

5.1.1 Power source

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

5.1.2 Ambient radio noise and signals

AC powerline conducted and radiated ambient signal levels, measured at the test site with the EUT de-energized should be at least 6 dB below the allowable limit of the applicable specification or standard. In the event that the measured levels of ambient plus EUT radio noise are not above the applicable limit, the EUT shall be considered to be in accordance with the limit.

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

- a) In the case of radiated emission measurements, perform measurements at the closest distance permitted by 5.4.1 and extrapolate results to the specified limit distance. The method of extrapolation shall be justified and described in the test report.
- b) Perform radiated emission measurements of critical frequency bands during hours when broadcast stations are off the air and at times when ambients from industrial equipment are reduced to less than the 6 dB level.
- c) Perform measurements in an absorber-lined shielded room (see 5.4.2 for conditions of use).
- d) Make ac powerline conducted emission measurements in a shielded enclosure. However, this method is recommended only at frequencies below the resonant frequencies of the enclosure, usually under 30 MHz.
- e) For ac powerline conducted emission measurements, insert suitable powerline filters between the power source and the LISN.
- f) Orient the radiated emission test site to discriminate against such ambient signals insofar as possible.
- g) If the signal being measured is either a CW signal or only one single spectral component of the signal to be measured is within the passband of the IF filter at any time, and the ambient electric field is broad band, reduce the resolution bandwidth if using a spectrum analyzer or the bandwidth if using an EMI receiver.
- h) Rotate the EUT on a turntable while observing possible correlation between radiated emission amplitude and EUT azimuth.
- i) Monitor the radio-noise meter audio with a loudspeaker or headphones and its video with a time-based oscilloscope display to discriminate between ambient noise and signals and EUT emissions.

5.2 AC powerline conducted emission test requirements

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

5.2.1 Reference groundplane

The reference groundplane for measuring ac powerline conducted emissions is to consist of a floor earth-grounded conducting surface, which may be the metal floor of a shielded test chamber. The reference groundplane is to be at least 2 m by 2 m in size, and shall extend at least 0.5 m beyond the vertical projection (footprint) of the EUT or EUT arrangement. If the EUT normally does not make electrical contact with a groundplane, the reference groundplane shall be covered by insulating materials up to 12 mm thick.

5.2.2 Vertical conducting plane

For measurements of ac powerline conducted emissions on a tabletop device, a vertical conducting plane or screen of at least 2 m by 2 m in size, shall be, if required, located 40 cm to the rear of the EUT. The vertical conducting plane or screen shall be electrically connected to the reference groundplane at intervals not greater than 1 m along its entire length through low impedance connections, e.g., 3 cm-wide metal straps. The metal wall of a screen room will normally satisfy this requirement.

A tabletop device may be measured for ac powerline conducted emissions without a vertical conducting plane while maintaining the 80 cm EUT elevation specified in 6.2.1. However, in case of a dispute, ac powerline conducted emission measurements made on a tabletop device with a vertical, conducting plane in place shall take precedence.

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

5.2.3 LISN installation

LISNs may be required for ac powerline conducted emission measurements and may be used for radiated emission measurements. For exceptions, see 5.6.

5.2.3.1 LISN connected to the reference groundplane

Where use of a LISN is required (see Clause 7), it shall be placed on and electrically bonded to the top surface of, or immediately beneath, the reference groundplane and bonded to the groundplane. If LISNs are kept on the test site for radiated emission measurements, it is preferred that they be installed under the reference groundplane with the ac power receptacle flush with the reference groundplane. Otherwise, NSA requirements may not be able to be met.

The impedance at the receptacle end of any cable connected to the EUT end of the LISN (as contrasted to the impedance at the LISN terminals given in Figure 1), with the measuring instrument port of the LISN terminated in 50 Ω , shall be within +30% and -20% of the nominal LISN impedance shown in Figure 1 over the frequency range of the network to be used. See 4.1.2. If the attenuation (insertion loss) between the EUT receptacle and the measuring instrument port on the LISN is more than 0.5 dB, (see Annex E as an example of a method of measurement) it shall be taken into account when calculating the EUT emission levels. The site reference groundplane is the ground reference for the LISN.

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

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

5.2.4 Voltage probe

If use of an LISN is impossible because of high current requirements of the EUT, or if a reference groundplane is not available, ac powerline conducted emission measurements shall be performed using the voltage probe, as discussed in 4.1.3. See also 5.6.

5.3 Radiated emission tests (below 30 MHz)

For magnetic field strength measurements (see 8.2.1), a site similar to that of Figure 5 should be used, except that a reference groundplane is not required. If a reference groundplane is present, the measured level of emissions may be higher than if measurements were made without a groundplane. Magnetic field strength measurements made at a site with no reference groundplane shall take precedence. If permitted by the procuring or regulatory agency, measurements may also be made in a shielded enclosure at frequencies below its resonant frequency, or in a TEM device (see Annex L).

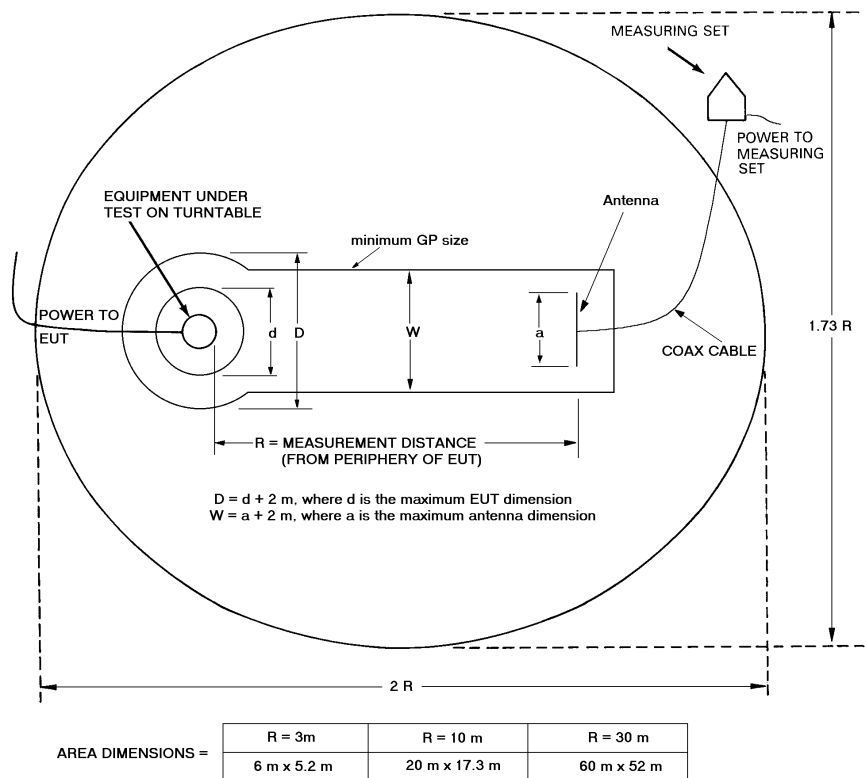


Figure 5—Radiated emissions measurements obstruction-free area and minimum size of groundplane for test site with a turnable

5.4 Radiated emission tests (30 MHz to 1 GHz)

The requirements for facilities used to make radiated emission measurements between 30 MHz and 1 GHz are as listed in the following subclauses.

5.4.1 Standard test site

The standard test site shall be an open, flat, level area that is clear of overhead wires and reflecting structures, and sufficiently large to permit measuring antenna placement at the specified distance. Adequate spacing shall also be provided between the site, including the EUT and the measuring antenna, and any adjacent, large reflecting structures. Reflecting structures are defined as objects or housings that are conductive or become conductive over time; e.g., structures may absorb conductive airborne contaminants when in use. Test personnel shall not be permitted within the perimeter of the area during testing. The floor of the site shall be covered by a conductive metal groundplane as described in 5.4.3. ANSI C63.7-1992 provides additional important guidance on the desired characteristics, construction, and deterioration possibilities of standard sites. A suggested layout for the standard site is diagrammed in Figure 5, where the recommended EUT-to-antenna distances R are 3, 10, and 30 m (by measurement along the main EUT to measurement antenna axis). A standard test site shall comply with the NSA requirements of 5.4.6. In case of disagreement, measurements made at a standard test site take precedence.

5.4.2 Alternative test sites

Measurements may be made at facilities that differ from the standard test site. Alternative test sites include RF absorber-lined, metal test chambers, office or factory buildings, and weather-protected OATS with covering structures that are or become significantly reflective with weather. Such alternative sites shall comply with the volumetric NSA requirements of 5.4.6.5 over the volume occupied by the EUT, or the EUT arrangement. Metal shield enclosures and other sites that do not comply with the volumetric NSA requirements may be used only for exploratory radiated emission measurements unless it can be demonstrated that the results achieved are equivalent to those obtained at a standard or alternative site that complies with the appropriate NSA requirement. Measurements may also be made in a TEM device under certain conditions (see Annex L).

5.4.3 Reflecting groundplane

A reflecting groundplane shall be installed on the floor of the radiated electric field emission test site to provide a uniform, predictable reflection of radiated emissions measured at the site. The groundplane shall be constructed of metallic material with limited discontinuities and sufficiently high conductivity and surface smoothness to ensure compliance with the NSA requirements. The surface smoothness of the groundplane shall comply with the maximum values for terrain roughness defined by the Rayleigh criterion, as shown in ANSI C63.7-1992. Groundplanes with discontinuities (including connection point separation between adjacent metallic material) larger than 3.0 cm or overall size less than the minimum configuration shown in Figure 5, are not recommended. See ANSI C63.7-1992 for guidance.

5.4.4 EUT turntable

A continuously rotatable, remotely controlled turntable shall be used for installation at the test site to support the EUT and facilitate determination of the direction of maximum radiation at each EUT emission frequency. For floor-standing EUTs, the turntable shall be metal covered and flush with the groundplane. For tabletop EUTs, the turntable may be nonmetallic and located on top of the reference groundplane. Turntable design and operation should be based on the radiated emission measurement requirements specified in 8.1 and adhere to the reflecting structure and groundplane limitations that ensure compliance with the NSA requirements. See ANSI C63.7-1992 for additional specific guidance on turntable installations.

5.4.5 Antenna positioner

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

5.4.6 Site quality validation

The quality of radiated emission sites shall be confirmed by measurement of the attenuation of signals propagated over the site and compared with theoretical attenuation of signals propagated over an ideal site. Horizontally and vertically polarized attenuation measurements shall be made over the frequency range 30 MHz to 1 GHz. These measurements shall be made in accordance with the procedures of 5.4.6.4 and 5.4.6.5 and the results normalized for comparison to the theoretical values.

NOTE—During site attenuation measurements, the receiving antenna positioner normally used and raised turntable, if used, shall be in place.

5.4.6.1 Acceptability criterion

The measured NSA for a radiated emissions test site shall be within ± 4 dB of the theoretical NSA for an ideal test site. A discussion of site errors can be found in ANSI C63.6-1996, and in its Annex C possible corrective actions are suggested.

5.4.6.2 Validation interval

Validation of the acceptability criterion shall be confirmed in the first year. Subsequent validation intervals may be longer (up to three years) or shorter based on review of NSA data relative to the extent and severity of use of the site, weather effects on the site, drifting of reflective characteristics of covering structures of weather-protected OATS, and physical modifications made to the site or adjacent areas. The objective is to optimize the balance of risks and costs consistent with the required accuracy. See Annex A of ISO 10012:2003 for guidance.

5.4.6.3 Theoretical NSA

The theoretical NSAs for the most used measurement separations and antennas are shown in Table 1, Table 2, and Table 3 for an ideal site.

The theoretical NSA is developed and calculated in Smith, German, and Pate [B30]. Table 1, Table 2, and Table 3 are from [B12], Heirman [B16], Pate [B28], [B11], [B10], and [B29]. The mutual impedance correction factors for tuned dipole antennas were developed in [B29], have subsequently been revised in [B12] and [B28] and are shown in Table 4. The symbols for these tables are defined as follows:

- R = Horizontal separation between the projection of the transmit and receive antennas on the reference groundplane (meters),
- h_1 = Height of the center of the transmitting antenna above the reference groundplane (meters),
- h_2 = Height of the center of the receiving antenna above the reference groundplane (meters).

NOTE—In the measurement procedure, h_2 is varied and the maximum received signal in the height scan range is used in the NSA measurements. f_M = frequency in megahertz, A_N = NSA. See Equation (1).

Table 1 is used for broadband antennas such as biconical and log periodic arrays. Table 2 is for tunable dipoles (and broadband antennas for alternative test site qualification) aligned horizontally with respect to the reference groundplane. Finally, Table 3 is for tunable dipoles, vertically aligned with respect to the

reference groundplane. Note that in Table 3, there are restrictions in the scan height h_2 . This takes into account the fact that the lowest tip of the receive dipole is kept 25 cm or more from the reference groundplane.

NSA for frequencies other than for those shown in the tables may be found using linear interpolation between the tabulated values.

NOTE—The spacing R between log-periodic array antennas is measured from the projection onto the reference groundplane of the midpoint of the longitudinal axis of each antenna.

5.4.6.4 NSA measurement: basic procedures

Two antennas are set up on the test site in an appropriate geometry as shown in Figure 6 and Figure 7. The NSA procedure requires two different measurements of the voltage received, V_R . The first reading of V_R is with the two coaxial cables disconnected from the two antennas and connected to each other via an adapter. The second reading of V_R is taken with the coaxial cables reconnected to their respective antennas and the maximum signal measured with the receive antenna scanned in height (Heirman [B17]). For both of these measurements, the signal source V_I is kept constant. The first reading of V_R is called V_{Direct} , and the second is V_{Site} . These are used in the following Equation (1) for the measured NSA, A_N :

$$A_N = V_{\text{Direct}} - V_{\text{Site}} - AF_T - AF_R - \Delta AF_{TOT} \quad (1)$$

where

AF_T = Antenna factor of transmitting antenna (dB/m),

AF_R = Antenna factor of receiving antenna (dB/m),

AF_{TOT} = Mutual impedance correction factor (dB).

NOTE—The first two terms represent the actual measurement of site attenuations; i.e., $V_{\text{Direct}} - V_{\text{Site}}$ is equal to the classic site attenuation and

$$V_{\text{Direct}} = V_I - C_T - C_R \quad (2)$$

where C_T and C_R are the cable losses that do not need to be measured separately.

**Table 1— Theoretical normalized site attenuation for ideal site
(recommended geometries for broadband antennas) ^a**

Polarization <i>R</i> meters <i>h</i>₁ meters <i>h</i>₂ meters <i>f</i>_M (MHz)	Horizontal 3 1 1–4	Horizontal 10 1 1–4	Horizontal 30 1 1–4	Vertical 3 1 1–4	Vertical 3 1.5 1–4 <i>A</i>_N (dB)	Vertical 10 1 1–4	Vertical 10 1.5 1–4	Vertical 30 1 1–4	Vertical 30 1.5 1–4
30	15.8	29.8	47.7	8.2	9.3	16.7	16.9	26.0	26.0
35	13.4	27.1	45.0	6.9	8.0	15.4	15.5	24.7	24.7
40	11.3	24.9	42.7	5.8	7.0	14.2	14.4	23.5	23.5
45	9.4	22.9	40.7	4.9	6.1	13.2	13.4	22.5	22.5
50	7.8	21.1	38.8	4.0	5.4	12.3	12.5	21.6	21.6
60	5.0	18.0	35.7	2.6	4.1	10.7	11.0	20.0	20.0
70	2.8	15.5	33.0	1.5	3.2	9.4	9.7	18.7	18.7
80	0.9	13.3	30.7	0.6	2.6	8.3	8.6	17.5	17.5
90	–0.7	11.4	28.7	–0.1	2.1	7.3	7.6	16.5	16.5
100	–2.0	9.7	26.9	–0.7	1.9	6.4	6.8	15.6	15.6
120	–4.2	7.0	23.8	–1.5	1.3	4.9	5.4	14.0	14.0
140	–6.0	4.8	21.1	–1.8	–1.5	3.7	4.3	12.7	12.7
160	–7.4	3.0	18.9	–1.7	–3.7	2.6	3.4	11.5	11.6
180	–8.6	1.7	16.9	–1.3	–5.3	1.7	2.7	10.5	10.6
200	–9.6	0.6	15.2	–3.6	–6.7	1.0	2.1	9.6	9.7
250	–11.7	–1.6	11.6	–7.7	–9.1	–0.5	0.3	7.7	7.9
300	–12.8	–3.3	8.7	–10.5	–10.9	–1.5	–1.9	6.2	6.5
400	–14.8	–5.9	4.5	–14.0	–12.6	–4.1	–5.0	3.9	4.3
500	–17.3	–7.9	1.8	–16.4	–15.1	–6.7	–7.2	2.1	2.8
600	–19.1	–9.5	0.0	–16.3	–16.9	–8.7	–9.0	0.8	1.8
700	–20.6	–10.8	–1.3	–18.4	–18.4	–10.2	–10.4	–0.3	–0.9
800	–21.3	–12.0	–2.5	–20.0	–19.3	–11.5	–11.6	–1.1	–2.3
900	–22.5	–12.8	–3.5	–21.3	–20.4	–12.6	–12.7	–1.7	–3.4
1000	–23.5	–13.8	–4.5	–22.4	–21.4	–13.6	–13.6	–3.6	–4.3

^a These data apply to antennas that have at least 25 cm of ground plane clearance when the center of the antenna is 1 m above the groundplane in vertical polarization.

**Table 2—Theoretical normalized site attenuation for ideal site
(recommended geometries for tunable dipoles and broadband
antennas on alternative test sites, horizontal polarization)**

Polarization R, meters h_1, meters h_2, meters f_M (MHz)	Horizontal 3^a 2 1–4 A_N (dB)	Horizontal 10 2 1–4 A_N (dB)	Horizontal 30 2 1–4 A_N (dB)
30	11.0	24.1	41.7
35	8.8	21.6	39.1
40	7.0	19.4	36.8
45	5.5	17.5	34.7
50	4.2	15.9	32.9
60	2.2	13.1	29.8
70	0.6	10.9	27.2
80	–0.7	9.2	24.9
90	–1.8	7.8	23.0
100	–2.8	6.7	21.2
120	–4.4	5.0	18.2
140	–5.8	3.5	15.8
160	–6.7	2.3	13.8
180	–7.2	1.2	12.0
200	–8.4	0.3	10.6
250	–10.6	–1.7	7.8
300	–12.3	–3.3	6.1
400	–14.9	–5.8	3.5
500	–16.7	–7.6	1.6
600	–18.4	–9.3	0.0
700	–19.7	–10.7	–1.4
800	–20.9	–11.8	–2.5
900	–21.9	–12.9	–3.5
1000	–22.8	–13.8	–4.5
^a The mutual impedance correction factors in Table 4 for horizontally polarized tunable dipoles spaced 3 m apart should be inserted in Equation (1) in 5.4.6.4 in determining the measured NSA data for comparison with the theoretical normalized site attenuation values for an ideal site given in this table.			

**Table 3— Theoretical normalized site attenuation for ideal site
(recommended geometries for tunable dipoles, vertical polarization)**

f_M MHz	$R = 3 \text{ m}^a$ $h_1 = 2.75 \text{ m}^a$		$R = 10 \text{ m}$ $h_1 = 2.75 \text{ m}$		$R = 30 \text{ m}$ $h_1 = 2.75 \text{ m}$	
	$h_2(\text{m})$	$A_N(\text{dB})$	$h_2(\text{m})$	$A_N(\text{dB})$	$h_2(\text{m})$	$A_N(\text{dB})$
30	2.75–4	12.4	2.75–4	18.6	2.75–4	26.3
35	2.39–4	11.3	2.39–4	17.4	2.39–4	24.9
40	2.13–4	10.4	2.13–4	16.2	2.13–4	23.8
45	1.92–4	9.5	1.92–4	15.1	1.92–4	22.7
50	1.75–4	8.4	1.75–4	14.2	1.75–4	21.8
60	1.50–4	6.3	1.50–4	12.6	1.50–4	20.2
70	1.32–4	4.4	1.32–4	11.3	1.32–4	18.9
80	1.19–4	2.8	1.19–4	10.2	1.19–4	17.7
90	1.08–4	1.6	1.08–4	9.2	1.08–4	16.7
100	1–4	0.6	1–4	8.4	1–4	15.8
120	1–4	–0.7	1–4	7.5	1–4	14.3
140	1–4	–1.5	1–4	5.5	1–4	13.0
160	1–4	–3.0	1–4	3.9	1–4	12.0
180	1–4	–4.5	1–4	2.7	1–4	11.1
200	1–4	–5.4	1–4	1.6	1–4	10.3
250	1–4	–7.0	1–4	–0.6	1–4	8.7
300	1–4	–8.9	1–4	–2.3	1–4	7.6
400	1–4	–11.4	1–4	–5.0	1–4	3.9
500	1–4	–13.4	1–4	–6.9	1–4	1.8
600	1–4	–14.9	1–4	–8.4	1–4	0.2
700	1–4	–16.3	1–4	–9.8	1–4	–1.2
800	1–4	–17.4	1–4	–11.0	1–4	–2.4
900	1–4	–18.5	1–4	–12.0	1–4	–3.4
1000	1–4	–19.4	1–4	–13.0	1–4	–4.3
^a The mutual impedance correction factors in Table 4 for vertically polarized tunable dipoles spaced 3 m apart should be inserted in Equation (1) of 5.4.6.4 in determining the measured NSA data for comparison with theoretical NSA values or an ideal site given in this table.						

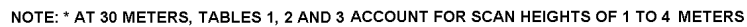


Figure 6—Site attenuation measurement horizontal polarization, broadband, and tuned dipoles

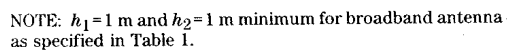


Figure 7—Site attenuation measurement vertical polarization using tuned dipole antennas

AF_T and AF_R are determined as specified in ANSI C63.5-1988 and ANSI C63.5-1998. The mutual impedance correction factor in Table 4 applies only to the recommended site geometry of 3 m separation, both horizontal and vertical polarization, with the use of resonant tuned dipoles. $AF_{TOT} = 0$ for all other geometries and for broadband antennas in which mutual coupling effects are minimal.

Accurate antenna factors are necessary in determining the measured NSA. In general, antenna factors provided with the antenna are inadequate unless they were specifically or individually measured and the calibration is traceable to a national standard. Linearly polarized antennas are required. ANSI C63.5-1988 and ANSI C63.5-1998 contain a design of a reference antenna and methods for calibrating antennas. The reference dipole antenna (4.1.5.3) should be spot-checked against a known calibrated antenna. Antenna factors usually account for losses from the balun. If a separate balun or any integrally associated cables are used, their effects shall be accounted for.

Two procedures may be employed to determine the measured NSA: a discrete frequency method and a swept frequency method. The swept method may be used only with broadband antennas. Figure 6 shows the horizontal polarization geometry. In Figure 7, the recommended vertical polarization geometries for using tunable, resonant half-wave dipoles are shown. This assumes that the dipoles are tuned down to 30 MHz. The limiting factor of maintaining at least a 25 cm clearance between the lower tip of the receive and transmit antennas is covered by fixing the transmit height at 2.75 m and restricting the downward travel of the receive antenna. These restrictions are stated explicitly in Table 3. For vertical NSA measurements with broadband antennas, no such scan height restrictions are usually required because of the much smaller fixed dimensions of a broadband antenna compared with a tuned dipole, especially between 30 and 80 MHz. Using linearly polarized broadband antennas also usually allows a transmit antenna height of 1 m.

NOTES

1—For both methods, an impedance mismatch at the output of the signal source or at the input of the radio-noise meter or spectrum analyzer may result in cable reflections that could cause errors exceeding the NSA tolerance. This can be avoided by use of padding attenuators of 10 dB; one at the output end of each transmitting and receiving cable. These attenuators shall remain in the signal path for both V_{Direct} and V_{Site} measurements. Attenuator values of 6 dB are often adequate, and values as low as 3 dB can sometimes be used.

2—For vertically polarized antennas, it is especially important to keep the cables, leaving the antennas in the same horizontal plane as the center of the antenna, directly behind the antenna for a minimum distance of 1 m. Use of ferrite beads on both the transmit and receive antenna cables close to the antennas can help to eliminate common-mode signals that cause measurement errors.

For the discrete frequency method, specific frequencies given in Table 1, Table 2, and Table 3 are measured in turn. At each frequency the receive antenna is moved over the height range given in the appropriate table to maximize the received signal. These measured parameter values are inserted in Equation (1) to obtain the measured NSA. Annex A contains a suggested procedure involving a worksheet approach to record the data, calculate the measured NSA, and then compare it with the theoretical NSA.

For the swept frequency method, measurements using broadband antennas may be made using automatic measuring equipment having a peak hold (maximum hold) storage capability and a tracking generator. In this method, both antenna height and frequency are scanned or swept over the required ranges. The frequency sweep speed shall be much greater than the antenna height scan rate. Otherwise, the procedure is the same as in the previous paragraph. A detailed procedure is given in Annex B.

5.4.6.5 NSA for alternative test sites

For an alternative test site (see 5.4.2) a single-point NSA measurement is insufficient to pick up possible reflections from the construction or RF-absorbing materials comprising the walls and ceiling of the test site. For these sites, a “test volume” is defined as that volume traced out by the largest equipment or system to be tested as it is rotated about its center location through 360°, such as by a turntable. In evaluating the site, the transmit antenna shall be placed at various points within the test volume with both horizontal and vertical

polarization, such as illustrated in Figure 8a and Figure 8b (German [B15]). This may require a maximum of 20 separate site attenuation measurements, i.e., five positions in the horizontal plane (center, left, right, front, and rear, measured with respect to the center and a line drawn from the center to the position of the measuring antenna), for two polarizations (horizontal and vertical), and for two heights (1 and 2 m, horizontal) (1 and 1.5 m, vertical). The maximum height of the EUTs to be measured, above the reference groundplane, shall not exceed the height at which the volumetric measurements were performed. The maximum volumetric measurement height is to the top tip of the antenna used in the vertical orientation or horizontal orientation when performing NSA.

Table 4—Mutual impedance correction factors (ΔAF_{TOT}) for geometry using two resonant tunable Roberts dipoles spaced 3 m apart

f_M MHz	Horizontal Pol $R = 3$ m $h_1 = 2$ m $h_2 = 1$ to 4 m scan	Vertical Pol $R = 3$ m $h_1 = 2.75$ m $h_2 =$ (see Table 3)
	ΔAF_{TOT}	
30	3.1	2.9
35	4.0	2.6
40	4.1	2.1
45	3.3	1.6
50	2.8	1.5
60	1.0	2.0
70	-0.4	1.5
80	-1.0	0.9
90	-1.0	0.7
100	-1.2	0.1
120	-0.4	-0.2
140	-0.1	0.2
160	-1.5	0.5
180	-1.0	-0.4

NOTE—Calculated for resonant dipoles with reference antenna baluns using Method of Moments. Theoretical free-space antenna factors are for ideal resonant dipoles with an assumed 0.5 dB balun loss (each antenna). If the actual balun loss is known, it should be used to provide an appropriate modification to each antenna factor used in arriving at the correction factors in this table. See Reference Antenna in ANSI C63.5-1988 or ANSI C63.5-1998. These correction factors do not completely describe antenna factors measured above a ground plane, e.g., at heights of 3 or 4 m, because these antenna factors differ from free-space antenna factors at the lower frequencies. However, within the error, and for baluns with substantially different loss than 0.5 dB, bounds described in ANSI C63.6-1996, the values are adequate to indicate site anomalies.

User is cautioned when using half-wavelength dipoles or antennas with other than reference antenna baluns. These may exhibit characteristics different than the reference antenna.

Mutual coupling correction factors for 10 and 30 m are under consideration. As an interim procedure, site adequacy can be assessed by considering these correction factors to be equal to zero for such geometries and for all measurements using a broadband antenna.

These measurements are carried out with broadband antennas. Separation distances R , are measured with respect to the center of the transmit and receive antennas. The separation distance R shall be maintained for all measurements. This requires that the receive antenna be moved along the line in the directions shown in Figure 8a through Figure 8d to maintain the separation distance R constant for all transmit antenna positions.

Also, the transmit and receive antennas shall be aligned with the antenna elements parallel to each other and orthogonal to the measurement axis. This requires that for all transmit antenna positions off the centerline, for horizontal polarization, both antennas be rotated about a vertical axis so that the antenna elements remain parallel to each other while maintaining the correct polarization.

For vertical polarization, the off-center positions, of the transmit antenna are at the periphery of the test volume. Furthermore, the lower tip of the antenna shall be greater than 25 cm from the floor, which may require the center of the antenna to be slightly higher than 1 m for the lowest height measurement.

For horizontal polarization measurements in the left and right positions, if the distance between the construction or absorbing material on the side walls and the EUT periphery is at least 1 m, the center of the antenna may be moved toward the center position so that the extreme outside tip of the antenna is either at the test volume periphery or at a distance inward from the periphery by not more than 10% of the test volume diameter. The front and rear positions are at the periphery of the test volume.

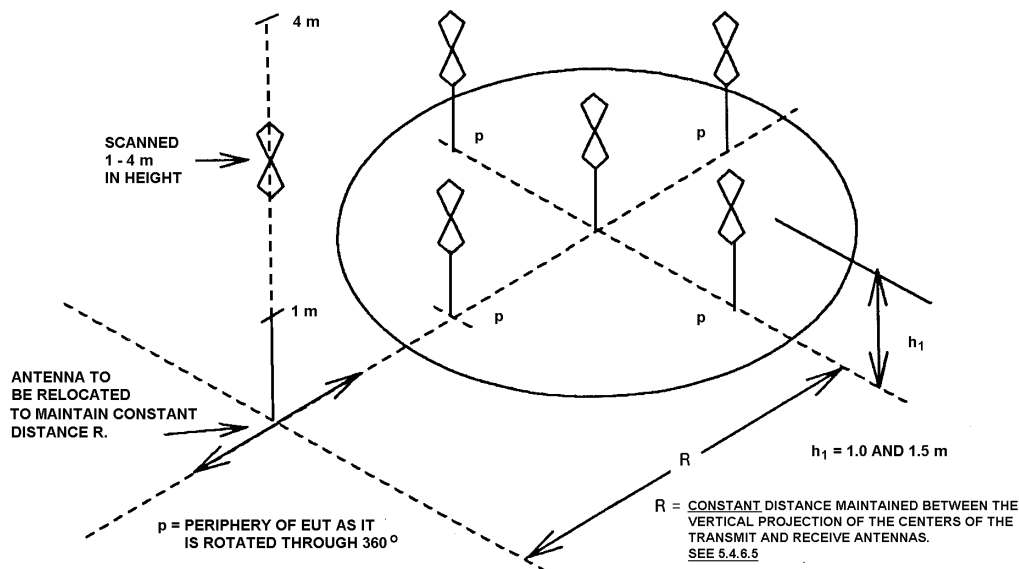


**Figure 8a—Typical antenna positions for alternative test sites:
Vertical polarization NSA measurements (antenna orientation adjusted as
described in 5.4.6.5)**

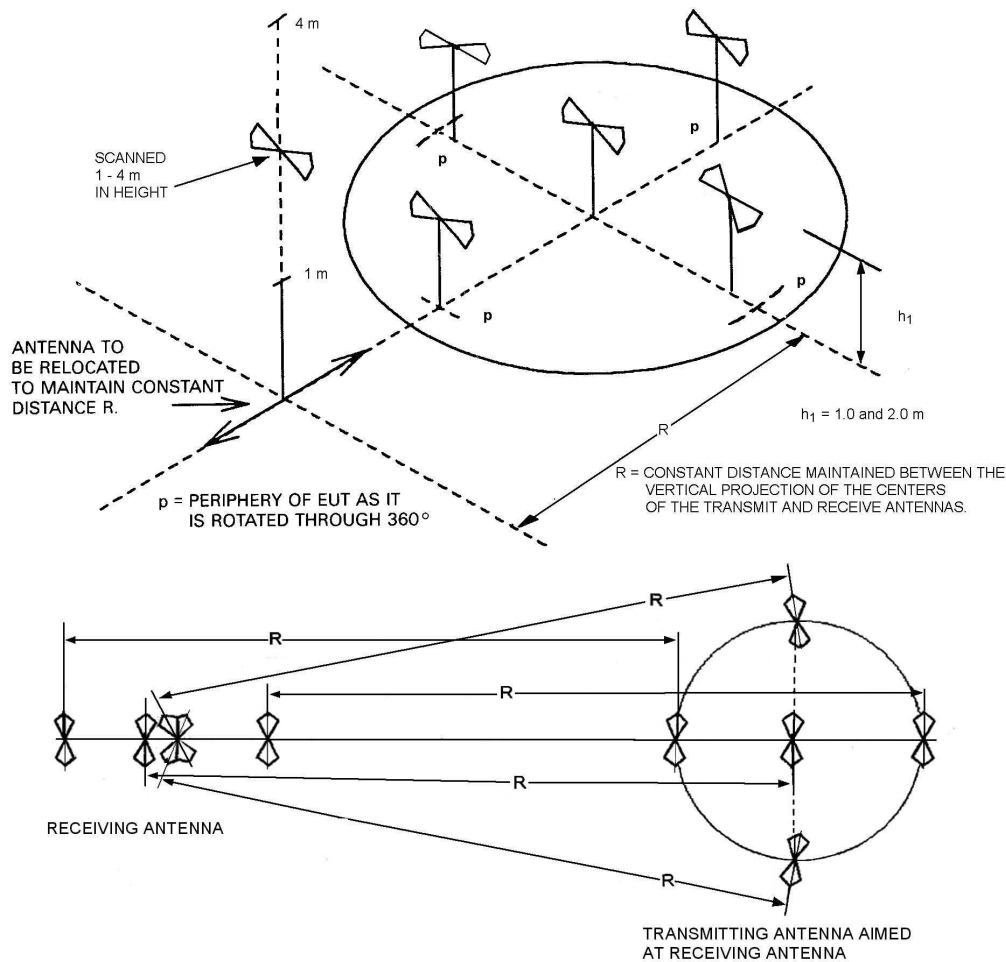


**Figure 8b—Typical antenna positions for alternative test sites:
Horizontal polarization NSA measurements**

The number of required measurements can be reduced under the following circumstances:

- The vertical and horizontal polarization measurements in the rear position may be omitted if the closest point of the construction or absorbing material is at a distance of greater than 1 m from the rear boundary of the test volume (see NOTE 1 below).
- The total number of horizontal polarization measurements along the test volume diameter joining the left and right positions may be reduced to the minimum number necessary for the antenna footprints to cover 90% of that diameter.
- The vertical polarization measurements at the 1.5 m height may be omitted if the top of the EUT, including any table mounting, is less than 1.5 m in height.
- If the test volume is no larger than 1 m in depth, by 1.5 m in width, by 1.5 m in height, including table, if used, horizontal polarization measurements need to be made at only the center, front, and rear positions but at both the 1 m and 2 m heights. If a) applies, the rear position may be omitted. This will require a minimum of eight measurements: four positions vertical polarization (left, center, right, and front) for one height, and four positions horizontal polarization (center and front) for two heights; see Figure 8c and Figure 8d.

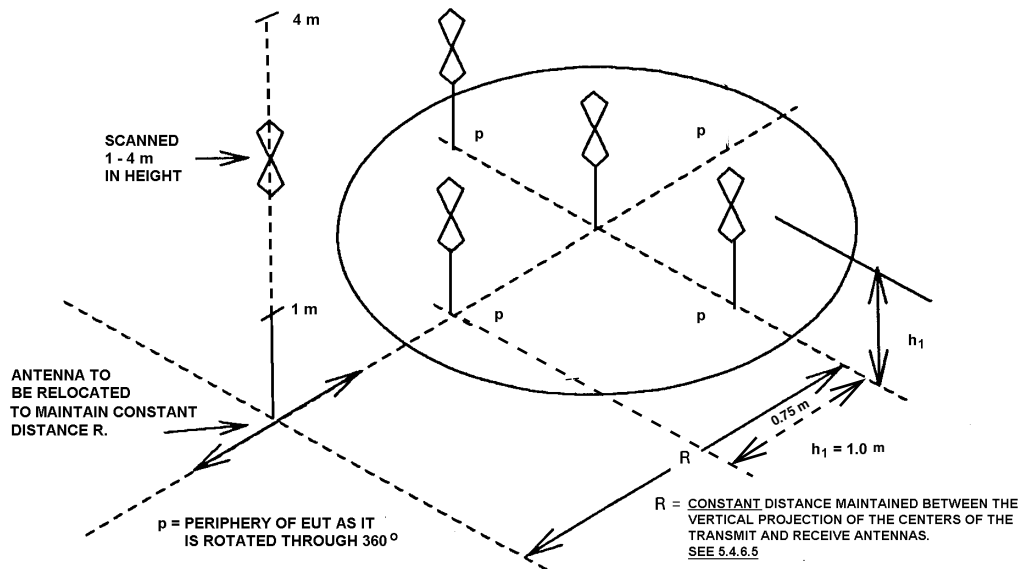


**Figure 8c—Typical antenna positions for alternative test sites:
Vertical polarization NSA measurements for an EUT that does not exceed a volume of
1.0 m depth, 1.5 m width, and 1.5 m height, with the periphery greater than 1.0 m
from the closest material that may cause undesirable reflections**

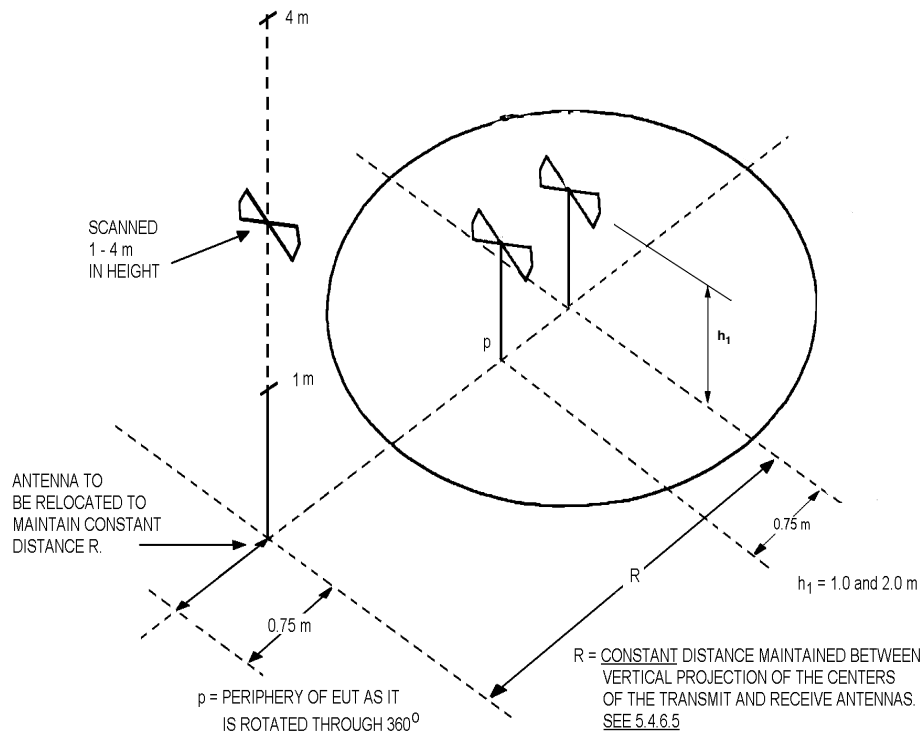


**Figure 8d—Typical antenna positions for alternative test sites:
Horizontal polarization NSA measurements for an ETU that does not exceed a
volume of 1.0 m depth, 1.5 m width, and 1.5 m height, with the periphery greater
than 1.0 m from the closest material that may cause undesirable reflections**

NSA measurements shall be performed with the transmit and receive antenna separation held constant according to Table 1, Table 2, and Table 3. The receive antenna shall be moved along a line toward the turntable center to maintain the appropriate separation; see Figure 8a through Figure 8d. The alternative test site is considered suitable for performing radiated emissions testing if all NSA measurements prescribed above meet the requirements of 5.4.6.1 and the reference groundplane requirements of 5.4.3 (see NOTE 2).

NOTES

1—Radiated emissions sources located near dielectric interfaces such as absorbing pyramids or ferrite tiles have been shown to have variations in current distribution that can affect the radiation properties of the source at that location (Pate [B28]). When the EUT can be located near these interfaces, additional site attenuation measurements are required.

2—Studies are underway to determine if any further measurements are required to show alternative test site suitability.

5.5 Radiated emission test site requirements above 1 GHz

There are currently no test site validation requirements above 1 GHz. However, facilities suitable for measurements in the frequency range 30 MHz to 1000 MHz are considered suitable for the frequency range 1 GHz to 40 GHz, including the presence of the reference groundplane (see ANSI C63.7-1992).

NOTE—Additional site validation requirements above 1 GHz are currently under study.

5.6 Testing at manufacturer's location or user's installation

Testing is permitted at the end user's or manufacturer's premises, if the equipment cannot be set up on an OATS or alternative test site (see 8.3.2). In this case, both the equipment and its location are considered the EUT. The radiated emission test results are unique to the installation site because site containment properties affect the measurements. The ac powerline conducted emission test results also may be unique to the installation. However, where testing of a given system has been accomplished at three or more representative locations, the results may be considered representative of all sites with similar EUTs for the purposes of determining compliance with emission requirements (if allowed in the procuring or requirements standard). The voltage probe (see 4.1.3) shall be used for ac powerline conducted emission measurements. (See IEEE Std 139-1988 for additional information.)

Neither a reference groundplane nor an LISN shall be installed for user's installation testing unless one or both are to be a permanent part of the installation.

5.7 Artificial hand [CISPR 16-1-1 (2003-11), Clause 21]

If the EUT is normally operated while held in the hand, when required by the procuring organization, measurements shall be made using an artificial hand to simulate the effects of the user's hand. If the EUT can be operated either held in the hand or not, it shall be tested in both ways.

The following clauses contain information on detailed application of the artificial hand. See Annex J for details on the construction and use of the artificial hand.

5.7.1 Application of the artificial hand

When the case of the EUT is entirely of metal, no metal foil is needed, but the terminal M of the RC element shall be connected directly to the body of the EUT.

When the case of the EUT is of insulating material, metal foil shall be wrapped around the handle B (see Figure 9b and also around the second handle D, if present). Metal foil 60 mm wide shall also be wrapped

around the body C at the point where the iron core of the motor stator is located or around the gear box if this gives a higher interference level. All of the pieces of metal foil and the metal ring or bushing A, if present, shall be connected together and to terminal M of the RC element.

When the case of the EUT is partly metal and partly insulating material, and has insulating handles, metal foil shall be wrapped around the handles B and D (Figure 9b). If the case is nonmetallic at the location of the motor, a metal foil 60 mm wide shall be wrapped around the body C at the point where the iron core of the motor stator is located, or alternatively around the gear box, if this is of insulating material and a higher interference level is obtained. The metal part of the body, the point A, the metal foil around the handles B and D, and the metal foil on the body C shall be connected together and to the terminal M of the RC element.

When a Class II EUT (without a ground wire) has two handles of insulating material, A and B, and a case of metal C, for example, an electric saw (Figure 9c), metal foil shall be wrapped around the handles A and B. The metal foil at A and B and the metal body C shall be connected together and to terminal M of the RC element.

NOTE—An artificial hand shall not be used when testing ITE.

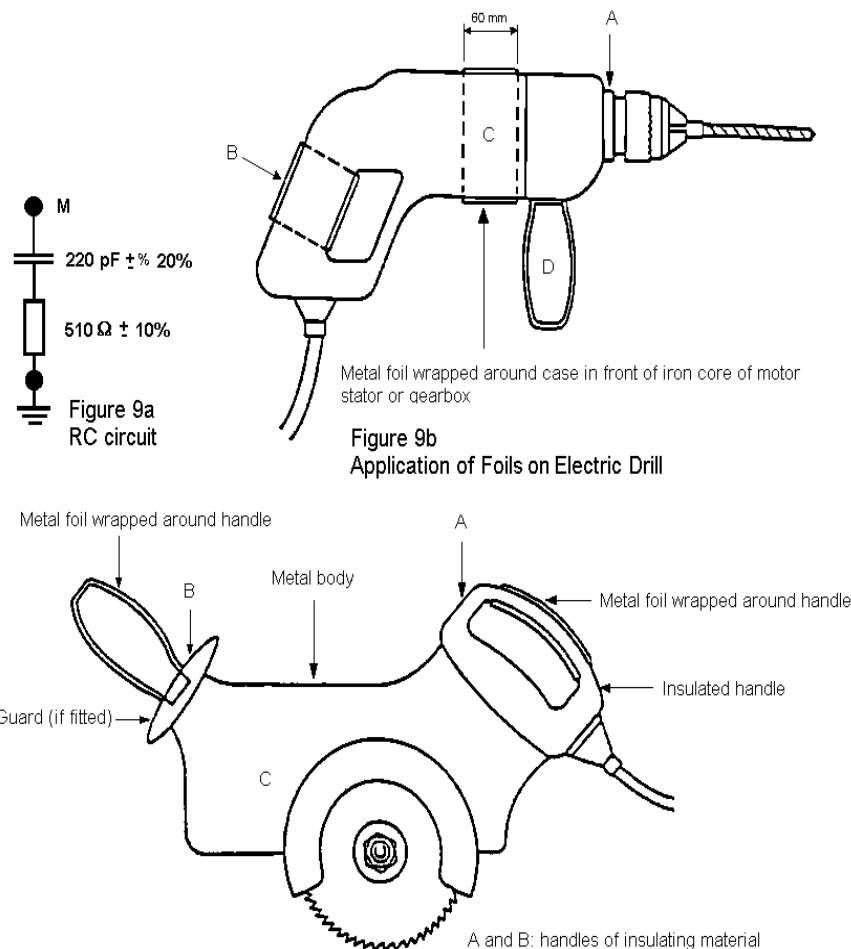


Figure 9c Application of Foils on Electric Saw

Figure 9—Application of foils on hand tools

6. General requirements for EUT equipment arrangements and operation

This clause specifies general requirements that are applicable to all EUTs covered under the scope of this standard. Additional and more detailed requirements on specific types of EUTs are given in Clause 11, Clause 12, and Clause 13.

6.1 Operating conditions

The EUT and accessories shall be operated at the rated (nominal) operating voltage and typical load conditions—mechanical, electrical, or both—for which they are designed. Loads may be actual or simulated as described in the individual equipment requirements. For some EUTs, it may be necessary to develop a set of explicit requirements specifying the test conditions, EUT operation, and so on, to be used in testing a specific EUT or class of EUTs for radio-noise emissions. Such requirements shall be documented in the report of measurements for the EUT and may be used in determining compliance with the limits.

The EUT shall be operated to ensure that all of the functions are exercised (software, etc.). For example, see 11.1 on ITE.

6.1.1 EUT

The EUT and accessories shall be placed in a typical arrangement as defined in 6.2.

6.1.2 Accessory equipment

Accessory equipment shall be placed in a typical arrangement as defined in 6.2.

6.1.2.1 Remotely located devices

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

6.1.2.2 Distributed networks

Distributed networks, e.g., a local area network, may be simulated on the test site by a cable at least 1 m in length and an actual peripheral or a remote network communications simulator. The network simulator shall be located at a distance sufficient to ensure that it does not contribute to the measured level. Signals on the network by the EUT should be typical of normal operation. See 6.1.7 for use of simulators.

6.1.3 EUT ports (or terminals)

Interconnect cabling or wiring shall be connected to one of each type of functional port of the EUT, and each cable or wire shall be terminated in a device typical of actual usage. Where there are multiple ports all of the same type, additional connecting cables or wires shall be added to the EUT to determine the effect these cables or wires have on both radiated and conducted emissions from the EUT. The number of additional cables or wires should be limited to the condition where the addition of another cable or wire does not significantly affect the emission level, i.e., varies less than 2 dB, provided, of course, that the EUT remains compliant. These additional cables or wires need not be terminated.

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

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

The rationale for the selection of the equipment configuration and loading of ports shall be included in the test report. Additional ports on support or interfacing units or simulators, other than those associated with the EUT or the minimum system required by 11.2 for ITE, need not be cabled or used during testing.

6.1.4 Interconnect and power cabling (or wiring)

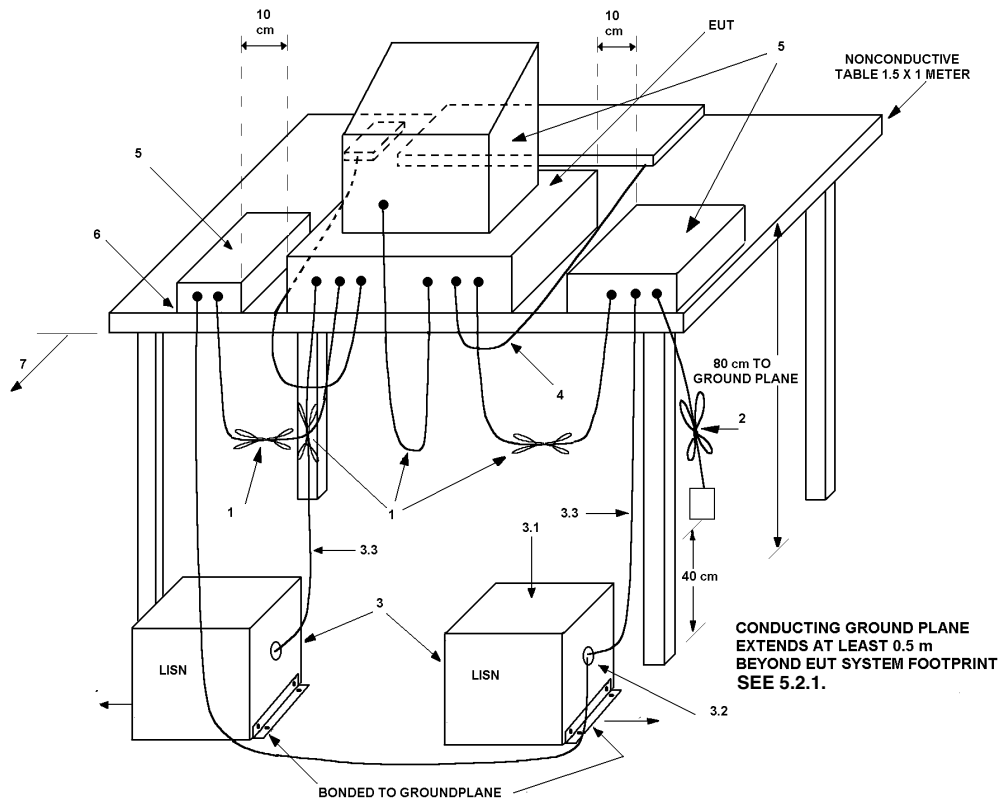
All interconnecting cable lengths should be typical of normal usage. The interconnect cabling used during testing shall be the specific cabling marketed with the EUT in practical applications. Where cables of variable length are used with the EUT, the cables most typical of all applications shall be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

For equipment tested on a tabletop, excess cable length shall be draped over the back edge of the tabletop. If any draped cable extends closer than 40 cm to the reference groundplane, the excess shall be bundled in the center in a serpentine fashion using 30 to 40 cm lengths in the center to maintain the 40 cm height. If the cables cannot be bundled because of bulk, length, or stiffness, they shall be draped over the back edge of the tabletop unbundled, but in such a way that all portions of the interface cable remain at least 40 cm from the horizontal reference groundplane. Interconnecting cables that are connected only between the EUT and the peripheral shall be bundled in the center to maintain the 40 cm height above the reference groundplane. The end of the cable may be terminated, if required, using the correct terminating impedance. The overall length of the bundled cable shall not exceed 1 m. See Figure 10a and Figure 11a. (For installations using overhead cables, see 6.1.4.1.)

For ac powerline conducted emission measurements, power cords of equipment other than the EUT do not require bundling. Drape the power cords of non-EUT equipment over the rear edge of the table, and route them down onto the floor of the conducted emission test site to the second LISN. These power cords of non-EUT equipment should not be draped over the top of an LISN. See Figure 10a.

For radiated emission measurements, all power cords drape to the floor and are routed over to the ac power receptacles (on the LISNs if used) (See Figure 11a).

For floor-standing equipment, excess interconnecting cable lengths shall be folded back and forth in the center to form a bundle between 30 and 40 cm in length. If the cables cannot be folded because of bulk, stiffness, or length, they shall be arranged in a serpentine fashion. Interconnecting cables that are not connected to a peripheral may be terminated, if required, using the correct terminating impedance. Cables that are normally grounded shall be grounded to the reference groundplane for all tests. Cables that are normally insulated from the ground shall be insulated from the reference groundplane by up to 12 mm of insulating material. For combined floor-standing and tabletop equipment, the interconnecting cable to the floor-standing unit, drapes to the reference groundplane with the excess bundled. Cables not reaching the reference groundplane are draped to the height of the connector or 40 cm, whichever is lower (see Figure 14, Note 6).



LEGEND:

- 1) Interconnecting cables that hang closer than 40 cm to the groundplane shall be folded back and forth in the center forming a bundle 30 to 40 cm long (see 6.1.4 and 11.2.4).
- 2) I/O cables that are not connected to a peripheral shall be bundled in the center. The end of the cable may be terminated, if required, using the correct terminating impedance. The overall length shall not exceed 1 m (see 6.1.4).
- 3) EUT connected to one LISN. Unused LISN measuring port connectors shall be terminated in 50 Ω . LISN can be placed on top of, or immediately beneath, reference groundplane (see 5.2.3 and 7.2.1).
 - 3.1) All other equipment powered from additional LISN(s).
 - 3.2) Multiple outlet strip can be used for multiple power cords of non-EUT equipment.
 - 3.3) LISN at least 80 cm from nearest part of EUT chassis.
- 4) Cables of hand-operated devices, such as keyboards, mice, etc., shall be placed as for normal use (See 6.2.1.3 and 11.2.4).
- 5) Non-EUT components of EUT system being tested (see also Figure 13).
- 6) Rear of EUT, including peripherals, shall all be aligned and flush with rear of tabletop (see 6.2.1.1 and 6.2.1.2).
- 7) Rear of tabletop shall be 40 cm removed from a vertical conducting plane that is bonded to the groundplane (see 5.2.2 for options).

Figure 10a—Test arrangement for conducted emissions