

American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

C63[®]

Accredited Standards Committee C63[®] — Electromagnetic Compatibility

Accredited by the
American National Standards Institute



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American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

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

Secretariat

Institute of Electrical and Electronics Engineers, Inc.

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C63®

Abstract: The procedures for testing the compliance of a wide variety of unlicensed wireless transmitters (also called intentional radiators and license-exempt transmitters) including, but not limited to, remote control and security unlicensed wireless devices, frequency hopping and direct sequence spread spectrum devices, antipilferage devices, cordless telephones, medical unlicensed wireless devices, Unlicensed National Information Infrastructure (U-NII) devices, intrusion detectors, unlicensed wireless devices operating on frequencies below 30 MHz, automatic vehicle identification systems, and other unlicensed wireless devices authorized by a radio regulatory authority are covered in this standard. Excluded by this standard are test procedures for unlicensed wireless devices already covered in other published standards (e.g., Unlicensed Personal Communication Services (UPCS) devices).

Keywords: ANSI C63.10, compliance testing, intentional radiators, license-exempt transmitters, spread spectrum devices, test procedures, Unlicensed National Information Infrastructure (U-NII), unlicensed wireless devices

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Introduction

This introduction is not part of ANSI 63.10-2013, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices.

This standard provides procedures for testing the compliance of a wide variety of unlicensed wireless devices (transmitters) including but not limited to the following: remote control and security unlicensed wireless devices, frequency hopping and direct sequence spread spectrum devices, antipilferage devices, cordless telephones, wireless medical unlicensed wireless devices, Unlicensed National Information Infrastructure devices, intrusion detectors, unlicensed wireless devices operating on frequencies below 30 MHz, automatic vehicle identification systems, and other unlicensed wireless devices authorized for operation by a radio regulatory authority. Procedures for testing of some of these devices were previously provided in ANSI C63.4-2009,^a but they will be removed in a future revision of that standard. The intention is to include all procedures in this standard for testing unlicensed wireless devices, except any devices excluded from the scope; for example, test procedures for Unlicensed Personal Communication Systems devices are addressed by ANSI C63.17-2006 [B3].^b

^a Information on references can be found in Clause 2.

^b The numbers in brackets correspond to those of the bibliography in Annex L.

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American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

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1. Overview

1.1 Scope

This standard specifies U.S. consensus standard ~~specifies methods,~~ and instrumentation, and test facilities requirements for measurement of radio frequency (RF) signals and ~~RF~~ noise emitted from unlicensed wireless devices (also called unlicensed transmitters, intentional radiators, and license-exempt transmitters) operating in the frequency range 9 kHz to 231 GHz. It does not include generic ~~nor~~ product-specific emission limits. ~~Measurement methods are provided for radiated and conducted emissions that can be generated by a variety of devices, as described below. This standard does not consider test methods for unlicensed wireless devices already covered in other published standards, such as Unlicensed Personal Communication Services (UPCS) devices, which~~

~~are covered in ANSI C63.17 [B1].¹ In addition, many types of wireless devices are also subject to regulatory requirements concerning human exposure to RF energy; RF exposure conformity assessment methods are not considered in this standard, but are the subject of other standards, e.g., IEEE Std 1528T-2003 [B22].~~It also does not cover measurement of radio emissions from unintentional radiators, as mentioned in 1.2. Where possible, the specifications herein are harmonized with other national and international standards used for similar purposes.

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

¹ The numbers in brackets correspond to those of the bibliography in Annex ~~F~~.

Measurement methods are provided for radiated and 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. 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 should be used in conjunction with this standard. The main text is augmented by a series of annexes that provide details for certain measurement methods and facilities.

1.2 Purpose and applications

Various unlicensed wireless devices (also known as unlicensed transmitters, intentional radiators, and license-exempt transmitters) are subject to certain regulatory requirements. The primary way to show compliance in meeting regulatory requirements is by testing such devices in a repeatable and reproducible manner. This standard presents the methods of measurement to show compliance with the technical specifications for the majority of current wireless devices in wide use. It represents a consolidation and elucidation of procedures that were heretofore dispersed throughout many documents. It is not expected that all unlicensed wireless devices on the market will in fact be covered by this standard.

This standard does not consider test methods for unlicensed wireless devices already covered in other published standards, such as Unlicensed Personal Communication Services devices, which are covered in ANSI C63.17-2006 [B3].¹ Procedures for evaluating dynamic frequency selection (DFS) functionality (i.e., required for U-NII devices in the United States) and for television-band unlicensed wireless devices² are not addressed in this standard. This standard also does not cover measurement of emissions from radio receivers, the receiver portion of a transceiver, and other types of unintentional radiators, which are covered by other standards (e.g., ANSI C63.4).³ This standard does not cover other types of unintentional radiators (e.g., industrial, scientific, and medical (ISM) equipment). In addition, many types of unlicensed wireless devices are also subject to regulatory requirements concerning human exposure to RF energy; RF exposure conformity assessment methods are not considered in this standard but are the subject of other standards (e.g., IEEE Std 1528TM-2003 [B37]).

This document provides standard test methods for determining compliance with regulatory requirements for many types of unlicensed wireless devices. These unlicensed wireless devices include, but are not limited to, the following:

- Remote control and security unlicensed wireless devices
- Frequency hopping and direct sequence spread spectrum devices
- Digital transmission system devices

¹ The numbers in brackets correspond to those of the bibliography in Annex L.

² Television-band unlicensed wireless devices are covered in 47 CFR part 15 subpart H.

³ Information on references can be found in Clause 2.

- Anti-pilferage devices
- Cordless telephones
- Radio frequency identification (RFID) tag readers
- Unlicensed National Information Infrastructure devices
- Intrusion detectors
- Unlicensed wireless devices operating below 30 MHz
- Wireless (garage) door openers
- Ultra-wideband (UWB) devices
- Automatic vehicle identification systems
- ~~Other~~Inductive devices, ~~e.g., with operations authorized under Part 15 of the FCC Rules and Regulations (47 CFR Part 15).~~²

~~2 Information on references can be found in Clause 2.~~

Clause 2 and Clause 3 contain the normative references and definitions used in this standard, respectively. Clause 4 provides the specifications for the necessary test instrumentation needed for performing compliance testing. Clause 5 provides the general requirements for all standard test methods. Clause 6 provides standard test methods required for most unlicensed wireless devices. ~~Clause 7 identifies additional tests or requirements for specific unlicensed wireless devices. Clause 8~~ [Clause 7, Clause 8 \(FM band devices\), Clause 9 \(millimeter-wave devices\), Clause 10 \(ultra-wideband devices\), Clause 11 \(DTS devices\), Clause 12 \(U-NII devices\), Clause 13 \(devices using antenna arrays\), and Clause 14 \(devices with multiple outputs\) identify additional tests or requirements for specific types of unlicensed wireless devices. Clause 15 specifies requirements for reporting test results, ~~with special emphasis on the use of guidance from ISO/IEC 17025:2005.~~](#)

Annex A is an informative listing of the tests required to ~~show~~ [determine](#) compliance of a specific unlicensed wireless device [and gives examples of regulatory band-edge requirements for various unlicensed wireless devices](#). Because Annex A describes regulatory requirements for testing of unlicensed wireless devices, it serves as a key to use of this standard. Annex B is an informative example of the information to be included in a test report. Annex C is an informative discussion on instrumentation pulse desensitization considerations. Annex D provides information about detector types and functions used in EMC testing. Annex E ~~and~~ [provides information about measurements above 1 GHz from an instrumentation perspective](#). Annex F [is an informative discussion on broadband measurements](#). Annex G provides guidelines for effective radiated power (ERP) and equivalent isotropically radiated power (EIRP) measurements. Annex H discusses the rationale for making radiated emission measurements using two different methods. Annex I discusses site considerations for measuring inductive-loop devices below 1 MHz. Annex J provides details of an alternative procedure for determining compliance of unlicensed FM transmitters. Finally, Annex K [and Annex L](#) provide an informative glossary and ~~related reading (a bibliography)~~, respectively.

Use of the annexes and clauses applicable to ~~a~~[an unlicensed](#) wireless device under test allows users of this standard to determine compliance of a device ~~to national~~[with](#) regulatory requirements. However, any test procedure identified for use by the national regulatory authority that differs from the provisions of this standard shall take precedence.

Numbered cross-references used throughout this standard refer to either a specific clause or subclause of this standard; ~~e.g.~~[for example](#), 6 refers to Clause 6, 6.2 refers to subclause 6.2, and A.2 refers to subclause A.2 of Annex A.

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 can be applied to all devices within its scope and to supplement these methods with particular requirements for some types of devices. Device-specific requirements take precedence over general requirements. See Annex A for guidance in applying this standard to specific types of devices.

This document covers measurement methodologies but is not intended to describe regulatory limits.

1.2 Purpose

~~A wide variety of unlicensed wireless devices (also known as intentional radiators) are subject to certain regulatory requirements. The primary way to show compliance in meeting regulatory requirements is by testing such devices in a repeatable and reproducible manner. This standard presents the methods of measurement to show compliance with the technical specifications for the majority of present wireless devices in wide use. It represents a consolidation and elucidation of procedures that were heretofore dispersed throughout a number of documents, which caused confusion regarding where to find the appropriate test method. It is not expected that all of the wireless devices on the market will in fact be covered by this standard. For example, this standard excludes test procedures for unlicensed wireless devices already covered in other published standards; e.g., Unlicensed Personal Communication Services devices. Also, as [As](#) new measurement methods mature, this standard will be amended or a follow-up standard [will be](#)~~

developed to present the new method^s. It is also expected that the ASC C63[®] Committee that developed this standard will provide a forum for test laboratories, manufacturers, and government agencies to determine the need for additions and amendments of this standard to accommodate new wireless devices in the future.

1.3 Measurement uncertainty

The results of measurements of emissions from an unlicensed wireless device shall include measurement instrumentation uncertainty considerations contained in ETSI TR 100 028-2001. Determining compliance shall be based on the results of the compliance measurement, not taking into account measurement instrumentation uncertainty. However, the measurement uncertainty of the measurement instrumentation and its associated connections between the various instruments in the measurement chain shall be calculated, and both the measurement results and the calculated measurement uncertainty shall appear in the test report.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

ANSI C63.2, American National Standard for Electromagnetic Noise and Field Strength Instrumentation, 10 Hz to 40 GHz—Specifications.³⁴

ANSI 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.

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

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

ANSI C63.14, American National Standard Dictionary ~~for Technologies~~ of Electromagnetic Compatibility (EMC) including Electromagnetic ~~Pulse (EMP), and Electrostatic Discharge (ESD)~~ ~~(Dictionary of EMC/EMP/ESD Terms and Definitions)~~ Environmental Effects (E3).

CISPR 16-1-1:~~2006~~2010, Specification for Radio Disturbance and Immunity Measuring Apparatus and Methods—Part 1-1: Radio Disturbance and Immunity Measuring Apparatus—Measuring Apparatus.⁵

~~3 C63® publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, Piscataway, NJ 08854, USA, or from the Sales Department, American National Standards Institute, 11 W. 42nd St., New York, NY 10036, USA (<http://standards.ieee.org/>).~~

⁴ ANSI publications are available from the American National Standards Institute (<http://www.ansi.org/>).

⁵ CISPR documents are available from the International Electrotechnical Commission (<http://www.iec.ch/>). They are also available in the United States from the American National Standards Institute (<http://www.ansi.org/>).

~~IEEE Std 139TM-1988, IEEE recommended practice for the measurement of radio frequency emission from industrial, scientific, and medical (ISM) equipment installed on user's premises.^{4,5}~~

[CISPR 16-1-4:2010, Specification for Radio Disturbance and Immunity Measuring Apparatus and Methods—Part 1-4: Radio Disturbance and Immunity Measuring Apparatus—Ancillary Equipment— Radiated Disturbances.](#)

[ETSI TR 100 028 V1.3.1 \(2001-03\), Electromagnetic Compatibility and Radio Spectrum Matters \(ERM\); Uncertainties in the Measurement of Mobile Radio Equipment Characteristics—Part 1 and Part 2.⁶](#)

[IEEE Std 1309TM-2005, IEEE Standard for Calibration of Electromagnetic Field Sensors and Probes, Excluding Antennas, from 9 kHz to 40 GHz.^{7, 8}](#)

ISO 10012-1:2003, Quality Assurance Requirements for Measuring Equipment, Part 1: Metrological Confirmation System for Measuring Equipment.^{6,9}

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

⁵ ~~The IEEE standards or products referred to in this clause are trademarks of the Institute of Electrical and Electronics Engineers, Inc.~~

⁶ [ETSI publications are available from the European Telecommunications Standards Institute \(http://www.etsi.org/\).](http://www.etsi.org/)

^{4,7} ~~IEEE publications are available from The Institute of Electrical and Electronics Engineers Inc., 445 Hoes Lane, Piscataway, NJ 08854, USA~~ (<http://standards.ieee.org/>).

⁸ [The IEEE standards or products referred to in this clause are trademarks of The Institute of Electrical and Electronics Engineers, Inc.](#)

^{6,9} ~~ISO publications are available from the ISO Central Secretariat, Secretariat, Case Postale 56, 1 ch. De la Voie Creuse, CH 1211, Genève 20, Switzerland/Suisse~~ (<http://www.iso.org/>). ISO publications are also available in the United States from the American National Standards Institute (<http://www.ansi.org/>).

[RSS-210, Licence-exempt Radio Apparatus \(All Frequency Bands\): Category I Equipment, Industry Canada.](#)¹⁰

~~U.S. Code of Federal Regulations Title 47 Telecommunication, Chapter I Federal Communications Commission, Part 2 Frequency Allocations and Radio Treaty Matters; General Rules and Regulations (47 CFR Part 2).~~⁷

[RSS-220, Devices Using Ultra-Wideband \(UWB\) Technology, Industry Canada.](#)

~~U.S. Code of Federal Regulations Title 47 Telecommunication, Chapter I Federal Communications Commission, Part 15 Radio Frequency Devices (47 CFR Part 15).~~

[RSS-310, Licence-exempt Radio Apparatus All Frequency Bands\): Category II Equipment, Industry Canada.](#)

[RSS-Gen, General Requirements for Compliance of Radio Apparatus—Limits and Methods of Measurement.](#)

[U.S. Code of Federal Regulations Title 47—Telecommunication, Chapter I—Federal Communications Commission, Part 15—Radio Frequency Devices \(47 CFR Part 15\).](#)¹¹

¹⁰ RSS publications are available from Industry Canada (<http://www.ic.gc.ca>).

¹¹ ~~U.S. CFR publications are available from the Superintendent of Documents, U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20013-7082, USA.~~ (<http://www.access.gpo.gov/>).

3. Definitions and acronyms

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. ~~The ANSI C63.14 and the IEEE Standards Dictionary: Glossary of Terms & Definitions and ANSI C63.14, Online~~ should be referenced for terms not defined in this clause.⁸¹² Definitions in wireless device product standards or regulations shall take precedence where applicable. See also the Glossary provided in Annex ~~E~~K, which includes various terms relevant for wireless devices compiled from [the](#) FCC, ITU, and other documents.

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

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

continuous transmit mode: A mode in which the unlicensed wireless device is continuously transmitting at a 100-% duty cycle.

emission bandwidth (EBW): An unlicensed wireless device parameter determined by measuring the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, which are 26 dB down relative to the maximum level of the modulated carrier based on the use of measurement instrumentation employing a peak detector function with an instrument resolution bandwidth approximately equal to 1.0% of the emission bandwidth of the device under measurement. [47 CFR §§ 15.303(c), 15.403(i) - MOD]

NOTE—See also the similar but distinct terms and concepts *authorized bandwidth, necessary bandwidth, and occupied bandwidth* in Annex K.

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

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).

inductive-loop device: A low-frequency unlicensed wireless device used for low-frequency radio frequency identification (RFID) devices, access control card readers, electronic article surveillance, and so on, consisting of a simple inductive single-loop coil or co-planar phase aiding loops for generating a magnetic field.

intentional radiator: A device that intentionally generates and emits radio frequency energy by radiation or induction and ~~may~~can be operated without an individual license. *Syn:* **unlicensed wireless device;** license-exempt transmitter.

license-exempt transmitter: A device that intentionally generates and emits radio frequency energy by radiation or induction and can be operated without an individual license. *Syn:* **unlicensed wireless device; intentional radiator.**

~~⁸ The IEEE Standards Dictionary: Glossary of Terms & Definitions is available at <http://shop.ieee.org/>.~~

¹²The IEEE Standards Dictionary Online subscription is available at http://www.ieee.org/portal/innovate/products/standard/standards_dictionary.html.

line impedance stabilization network (LISN): A network inserted in the power supply lead of [equipment under test \(EUT\)](#) 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—A LISN unit may contain one or more individual LISN circuits.⁹¹³

peak power: Power measured with the peak detector using a filter with [adequate band](#)width and shape ~~of which is sufficient~~ to accept the signal bandwidth.

restricted bands: Frequency bands in which [fundamental emissions of an](#) intentional radiator~~s~~ are not permitted ~~to operate~~.^{10.14} *Syn:* [exclusion bands](#).

symbol rate: [The rate at which the waveform changes per second using a digitally modulated signal. It is measured in baud or symbols per second for a modulated signal. Each symbol can represent or convey one or several bits of data. The reciprocal of the symbol rate is called the symbol period.](#)

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

⁹⁻¹³Notes in text, tables, and figures [of a standard](#) are given for information only and do not contain requirements needed to implement this standard

¹⁰¹⁴See 47 CFR 15.205.

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

test equipment: Equipment that is intended primarily for [the](#) purposes of performing measurements or scientific investigations. Such equipment includes, but is not limited to, [field strength meters](#), [spectrum analyzers](#), and modulation monitors.¹¹¹⁵

NOTE—Test equipment products that also contain unlicensed wireless device component(s) and/or function(s) are generally subject to applicable radio regulatory requirements.

unintentional radiator: A device that intentionally generates radio frequency ([RF](#)) energy for use within the device, or that sends radio frequency signals by conduction to associated equipment via connecting wiring, but ~~which~~ [that](#) is not intended to emit ~~RF~~ [radio frequency](#) energy by radiation or induction.¹²¹⁶

Unlicensed National Information Infrastructure (U-NII) device: Intentional radiator operating in the frequency bands 5.15 GHz to 5.25 GHz, 5.25 GHz to 5.35 GHz, 5.470 GHz to 5.725 GHz, and 5.725 GHz to 5.825 GHz that use wideband digital modulation techniques and provide a wide array of high-data-rate mobile and fixed communications for individuals, businesses, and institutions.

NOTE—[A](#) high data rate is defined as [a](#) bit rate of 1 Mbps or more.

¹⁵ ~~47~~ CFR 15.3(dd).

¹⁶ ~~47~~ CFR 15.3(z)

unlicensed wireless device: (A) A low-power communication device that intentionally generates and emits radio frequency energy by radiation or induction. These devices or systems typically can be operated without an individual license in some countries, provided they comply with certain technical and administrative requirements. **(B)** Device that is permitted to emit radio frequency (RF) energy⁷ but requires no specific device licensing or user authorization.¹³ ¹⁷Syn:
intentional radiator; license-exempt transmitter.

NOTE—This term also is essentially the same as ~~“intentional radiator” or~~ “short range device” used by various regulatory authorities.

3.2 Acronyms

~~ANSI~~ ~~————~~ ~~American National Standards Institute~~

~~ASC~~ ~~————~~ ~~Accredited Standards Committee~~

~~BB~~ ~~————~~ ~~broadband~~

~~CFR~~ ~~————~~ ~~U.S. Code of Federal Regulations~~

~~CISPR~~ ~~————~~ ~~International Special Committee on Radio Interference (IEC)~~

~~CW~~ ~~————~~ ~~continuous wave~~

¹³ ~~—~~ ¹⁷FCC/DA-03-1758 ~~[B44]~~ [B19].

DFS dynamic frequency selection

~~DSSS direct sequence spread spectrum~~

DTS digital transmission system

EBW emission bandwidth

EIRP equivalent ~~isotropic~~isotropically radiated power

EMC electromagnetic compatibility

EMI electromagnetic interference

ERP equivalent radiated power

EUT equipment under test

~~FCC Federal Communications Commission FHSS~~

FHSS frequency hopping spread spectrum

GPR ground-penetrating radar

~~IEC International Electrotechnical Commission~~

~~IEEE Institute of Electrical and Electronic Engineers~~

IF intermediate frequency

~~KDB Knowledge Database (FCC/OET)~~

LISN line impedance stabilization network

~~LO local oscillator~~

~~NB narrowband~~

~~NIST National Institute of Standards and Technology~~

LPDA log periodic dipole array

MIMO multiple-input multiple-output

NSA normalized site attenuation

OATS open-area test site

OBW occupied bandwidth

OET Office of Engineering and Technology (FCC)

PDA personal digital assistant

PRF pulse repetition frequency

PDCF pulse desensitization correction factor

PPSD peak power spectral density

PSD power spectral density

~~PWB~~ ~~printed wiring board~~

QP quasi-peak

RBW resolution bandwidth

RF radio frequency

RFID radio frequency identification

SPL sound pressure level

~~TCB~~ ~~Telecommunication Certification Body (FCC)~~

~~TPC~~ ~~transmitter power control~~

U-NII Unlicensed National Information Infrastructure

~~UPCS~~ ~~Unlicensed Personal Communications Service~~

UWB ultra-wideband

VBW video bandwidth

~~VCO~~ ~~voltage-controlled oscillator~~

WIR wall-imaging radar

4. Measurement instrumentation

4.1 [Emission measuring instrumentation](#)

[4.1.1](#) General considerations

Use of proper measurement instrumentation is critical to obtaining accurate, reproducible results. Various [measuring equipment](#) accessories ~~that may and settings can~~ be needed ~~depend~~[depending](#) on the particular measurements to be performed, as described in ~~the following subclauses~~. [4.1.2 through 4.1.6](#).

~~4.2 Emission measuring instrumentation~~

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

- ANSI C63.2~~, or~~
- CISPR 16-1-1:~~2006~~[2010](#)

A spectrum analyzer typically will not meet all [the](#) requirements stated in ANSI C63.2 or CISPR 16-1-1:~~2006~~[2010](#) without additional accessories. Appropriate accessories, such as pre-selection, quasi-peak detection, and specific [intermediate frequency \(IF\)](#) filters ~~may~~, [can](#) be used with a spectrum analyzer; this combination ~~may~~[can](#) be equivalent to a receiver, meeting the requirements in either specification. ~~This standard recognizes that a spectrum analyzer may be used for making measurements.~~

~~4.1.2.1~~ Receiver

The specifications of ~~a~~ an EMI receiver for measurements of radiated and ac power-line conducted radio noise ~~is~~ are contained in ANSI C63.2 or CISPR 16-1-1:~~2006-~~2010.

Other instruments not conforming to ANSI C63.2 or CISPR 16-1-1:2010 may be used for certain restricted and specialized measurements. ~~when data are measured using an instrument conforming to ANSI C63.2 or CISPR 16-1-1:2006. Automatic scanning.~~ Scanning receivers may be used, but the maximum ~~scan speed rate~~ 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~~ selected such that emissions are properly intercepted so that the amplitude of each emission is measured correctly, ~~i.e., in accordance with a measurement with a non-scanning receiver. Bandwidth and scan rates.~~ Bandwidths shall be chosen that are appropriate for the frequencies being ~~scanned~~ investigated. Guidance for selecting measurement bandwidths is given in 4.1.4.

If the output of the quasi-peak or average detector is indicated in decibels (dB) or other logarithmic units, then the logarithms shall be taken after the signal is detected and the detector function is fully realized. Otherwise, instruments that use logarithmic detectors, pre-detection 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 4.2.3.~~

NOTE—Users should be aware that the EMI receiver specifications in CISPR 16-1-1:~~2006~~2010 and ANSI C63.2 contain several differences. For example, for measurements above 1 GHz, the bandwidth definitions for measurements are different. These differences in bandwidth specification ~~may~~ might result in different measured values for broadband signals.

4.2.2.1.3 Spectrum analyzer

The use of spectrum analyzers for radiated and ac power-line conducted radio noise compliance measurements is permissible, although spectrum analyzers without further accessories will not meet all the specifications called out in the standards mentioned in 4.21.1 and 4.1.2.4.

To meet the requirements in 4.21.1, spectrum analyzers shall be equipped with proper quasi-peak detection as the reference detector for measurements up to 1 GHz. However, measurements with the peak detector of the instrument are permissible to demonstrate compliance of ~~a~~ equipment under test (EUT) because peak detection will yield amplitudes equal to or greater than amplitudes measured with the quasi-peak detector. ~~Data~~ Thus, the data measured using the peak detector of a spectrum analyzer or EMI receiver will represent the worst-case results.

~~Minimum~~ Nominal values for the resolution bandwidth are specified in 4.2.3.1.4. It should be noted that most spectrum analyzers incorporate a 3 dB resolution bandwidth specification, which is acceptable because larger bandwidths for measurements are permissible. The resolution bandwidths, cited in the standards listed in 4.1.2.4 for the frequency range ~~up to 1 GHz~~, do not have a Gaussian shape but are specified individually ~~specified~~ by their frequency response ("masks"). When using larger bandwidths than those specified or when using filters with different transfer functions, different measurement results for broadband signals ~~must~~ can be expected.

~~In order for~~ For a spectrum analyzer to meet the specifications of either of the two standards listed in 4.1.1, it ~~must be equipped with proper filtering at the input, which can~~ shall provide adequate overload protection and system dynamic range ~~of the system to~~, achieve ~~the~~ proper weighting of pulses, when using quasi-peak detection, and ~~the~~ have the bandwidths specified ~~bandwidths~~ in either ANSI C63.4.2.3. In this case, the spectrum analyzer performs as a scanning EMI receiver, meeting the specifications for the resolution bandwidth, pulse weighting, and quasi peak detection or CISPR 16-1-1:2010. If a spectrum analyzer is to be used to make quasi-peak measurements of low-repetition-rate signals (i.e., pulse repetition rate of 20 Hz or less), then the use of a preselector is

required to provide an adequate dynamic range of the instrument.

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

- a) Overload—Most spectrum analyzers have no RF pre-selection in the frequency range up to 2 GHz; that is, the input signal is fed directly ~~fed~~ to a broadband mixer. To avoid overload, to prevent damage, and to operate a spectrum analyzer linearly, the signal amplitude at the mixer shall be less than 150 mV peak or be limited to the manufacturer's maximum input level specification. RF attenuation or additional RF pre-selection ~~may~~might be required to reduce the input signal to this level.
- b) Linearity test—Linearity can be verified by measuring the level of the specific signal under investigation and repeating this measurement after a 6 dB or less external attenuator has been inserted at the input of the measuring ~~set~~instrument or, if used, the preamplifier. The new reading of the measuring set display ~~should~~shall differ from the first reading by the amount of inserted attenuation ~~by not more than~~ ± 0.5 dB ~~from the first reading~~ when the measuring system is linear. In the case of broadband time-variant signals and spread-spectrum signals, the linearity test ~~may~~can be performed by setting the analyzer max hold with peak detector function.

- c) Normal response to pulses—The response of a spectrum analyzer ~~set~~ with quasi-peak detection shall be verified with the ~~calibration~~reference test pulses specified in CISPR 16-1-1:~~2006~~2010. The large peak voltage of the ~~calibration~~reference test pulses typically requires an insertion of RF attenuation of 40 dB or more to satisfy the linearity requirements. This decreases the instrumentation sensitivity and makes the measurement of low-repetition-rate and isolated ~~calibration~~ test pulses impossible for CISPR bands B, C, and D.¹⁴¹⁸ If a pre-selecting filter is used ~~ahead of the measuring set~~at the input of the spectrum analyzer, then the RF attenuation can be decreased. The filter limits the spectrum width of the calibration test pulse as seen by the mixer.
- d) Signal interception—The spectrum of time-varying emissions ~~may~~can be captured with peak detection and digital display storage ~~if provided~~(max hold function). Multiple, fast frequency scans reduce the time to intercept an emission compared to a single, slow frequency scan. The starting time of the scans shall be varied to avoid any synchronism with the emission~~and~~, thereby ~~hiding~~masking it. The total observation time for a given frequency range shall be longer than the time between the emissions. Depending ~~upon~~ the type of disturbance being measured, the peak detection measurements can replace all or part of the measurements needed using quasi-peak detection. Re-tests using a quasi-peak detector shall then be made at frequencies where emission maxima have been found.

¹⁴¹⁸ CISPR 16-1-1:~~2006~~2010 band B is 0.15 MHz to 30 MHz, and bands C and D are 30 MHz to 1000 MHz.

- e) ~~Average~~ Voltage average detection—~~Average~~ For spectrum analyzers not equipped with a linear average detector as specified in 4.1.4.1, an alternative method of linear average detection for measurements with a spectrum analyzer is can be obtained by setting the detector mode to peak and reducing the video bandwidth until no further smoothing of the displayed signal is observed. The sweep time must be increased with reductions in video bandwidth to maintain amplitude calibration. For measurements in accordance with CISPR 16-1 1:2006 the video bandwidth shall be set to a 10 Hz value to ensure that the proper integration time is realized. For such measurements, the instrument shall be used in the linear mode of the detector. After linear detection is made, the signal may be processed logarithmically for display, in which case the value is corrected even though it is the logarithm of the linearly detected signal. A logarithmic amplitude display mode may be used, for example, to distinguish more easily between narrowband and broadband signals. The displayed value is the average of the logarithmically distorted IF signal envelope. It results in a larger attenuation of broadband signals than in the linear detection mode without affecting the display of narrowband signals. Video filtering in log mode is, therefore, especially useful for estimating the narrowband component in a spectrum containing both; see 4.1.4.2.3 for a basic measurement procedure.
- f) ~~Selection of display mode—For EMC measurements the positive peak detector should be selected to ensure that the highest emission amplitudes are displayed. Scanning the frequency range of interest in multiple frequency segments can reduce the introduced frequency error. This will improve frequency accuracy but will increase the overall test time~~

NOTE—Notwithstanding the video bandwidth requirements of 6.5.4 of CISPR 16-1-1:2010 measurement instrumentation standard, the measurement procedure standards CISPR 16-2-1:2010 [B4] (i.e., Annex D therein) and CISPR 16-2-3:2010 [B5] (i.e., Annex C therein) allow the use of higher video bandwidths, at least for prescan measurements, when measuring slowly intermittent, unsteady, or drifting narrowband disturbance signals that have pulse repetition frequencies or modulation frequencies greater than

5 Hz. Also, because the measurand in 6.5.4 of CISPR 16-1-1:2010 is specified to be the peak reading, the larger amplitude fluctuations that occur with the use of a higher-than-specified video bandwidth will provide a conservative measurement result (i.e., higher emission level).

f) Selection of display mode—the display mode shall be set to the appropriate detector(s) for the measurement being made (e.g., “positive peak” or “sample” detection mode).

g) When using sample or average detectors, the spectrum analyzer’s bin size shall be no larger than half the measurement (resolution) bandwidth.

4.2.3-1.4 Detector functions and selection of bandwidth

4.2.31.4.1 General considerations

Unless otherwise specified, EMI receivers and spectrum analyzers shall have the reference detector functions and bandwidths specified in ANSI C63.2 or CISPR 16-1-1:~~2006 for frequencies up to and including 40 GHz~~2010. Peak-detector measured data may be substituted for the ~~appropriate~~reference detector data to show compliance, if the peak level obtained does not exceed the limit. The bandwidths used shall be equal to or greater than that specified in ANSI C63.2. ~~Use~~The use of bandwidths greater than those specified ~~may~~can produce higher readings for certain types of emissions, and ~~should~~such use shall be recorded in the test report. More than one instrument ~~may~~might be needed to ~~perform all of these functions~~cover the complete frequency range of interest.¹⁹

¹⁹ For measurements above 40 GHz, see Clause 9.

The measuring instrument shall satisfy the following ~~conditions~~provisions:

- ~~— The measuring instrumentation with the quasi-peak or or~~ The average detector shall have a linear response and shall meet the linear average specifications in ANSI C63.2 or CISPR 16-1-1:2010. This is a voltage average detector. The use of log-average or CISPR rms detectors for average measurements is not permitted.
- The quasi-peak 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~~be adequate to yield correct results.

When using a spectrum analyzer or an other instrument providing a ~~spectral display the~~ video bandwidth function for peak measurements, 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 unwanted amplitude smoothing.

NOTE—For the purposes of this document, the terms ~~intermediate frequency (IF)~~ *bandwidth* and *resolution bandwidth* are synonymous.

4.1.4.2.3.2 Specific detector functions and bandwidths for unlicensed wireless device measurements

Measurement of conducted and radiated emissions from unlicensed wireless devices is based on the following considerations, unless otherwise specified elsewhere in this standard.

~~4.1.4.2.3.2.1~~ Frequencies less than or equal to 1000 MHz

~~On~~At any frequency or frequencies less than or equal to 1000 MHz, measurements shall be made ~~employing a~~ with the CISPR quasi-peak detector ~~function~~ and related measurement bandwidths, unless otherwise specified ~~for a specific EUT~~. The specifications for the measuring instrument using the CISPR quasi-peak detector are given in CISPR 16-1-1:~~2006~~, 2010. Where average limits are specified, an average detector shall be used. Where peak limits are also specified, the peak emission shall also be measured with instrumentation properly adjusted for factors, such as pulse desensitization.²⁰ As an alternative to CISPR quasi-peak measurements or average measurements, a test laboratory may demonstrate compliance with the emission limits using measuring equipment employing a peak detector function, as long as the ~~same~~ equivalent or greater bandwidths as indicated for CISPR quasi-peak measurements or average measurements, as applicable, are employed.¹⁵

~~For pulse~~Pulse-modulated devices with a pulse repetition frequency of 20 Hz or less ~~and for which CISPR quasi-peak measurements are specified, measurements shall be made using measuring equipment employing a peak detector function, using the same measurement bandwidths that are indicated for CISPR quasi-peak measurements.~~ have additional requirements.²¹

²⁰ See 47 CFR 15.35(b).

¹⁵ If an average limit is specified for the EUT, the peak emission shall also be measured with instrumentation properly adjusted for factors, such as pulse desensitization, to ensure that the peak emission is less than 20 dB above the average limit per U.S./FCC regulations. [See 47 CFR 15.35(b).]

²¹ The FCC requires that for pulse-modulated devices with a pulse repetition frequency of 20 Hz or less and for which CISPR quasi-peak measurements are specified, measurements shall be made using measuring equipment employing a peak detector function, using the equivalent or greater measurement bandwidths that are indicated for CISPR quasi-peak measurements. See 47 CFR 15.35(a) and RSS-Gen 7.2.3.

4.1.4.2.3.2 Frequencies above 1000 MHz

Unless otherwise stated, on any frequency or frequencies above 1000 MHz, measurements shall be made with measurement instrumentation employing an average detector function²². ~~When an average limit is specified for the EUT, the peak emission must also be measured to ensure that the emission is less than 20 dB above the average limit or below the peak limit specified for the EUT.~~ Unless otherwise specified, measurements above 1000 MHz shall be performed using a minimum resolution bandwidth of 1 MHz. ~~This peak limit applies~~ Peak measurements can apply to the total peak emission level radiated by the device, (i.e., the total peak power level) depending on the applicable regulatory requirement. Note that the use of a pulse desensitization correction factor ~~may~~might be needed to determine the total peak emission level. ~~The instruction manual or application note for the measurement instrument should be consulted~~ See 4.1.4.2.6 and Annex C for more information and methods for determining pulse desensitization factors, ~~as necessary. (See also 4.2.3.2.6).~~

4.1.4.2.3.2.3 Average voltage measurements using spectrum analyzer reduced video bandwidth

~~Some regulatory bodies allow the use of spectrum analyzers to make average measurements by reduction of video bandwidth, in which case the following procedure shall be used~~ When the spectrum analyzer is not equipped with an average detector (4.1.4.1), the following alternative method may be used for average voltage measurements:

²² If an average limit is specified for the EUT, then the peak emission shall also be measured with instrumentation properly adjusted for factors, such as pulse desensitization, to ensure that the peak emission is less than 20 dB above the average limit per U.S./FCC regulations. [See 47 CFR 15.35(b).]

- a) Tune the instrument to the signal of interest by setting ~~the~~its center frequency to the signal frequency. The resolution bandwidth shall be set according to the frequency of measurement.
 - b) ~~Reduce~~ Set the spectrum analyzer frequency span to ~~a value of zero. The~~capture fully the emission that is to be measured while keeping the peak value of the measured signal ~~shall be kept~~ in the center of the display ~~during the reduction of the span.~~
 - c) ~~Select spectrum analyzer linear~~ The display mode shall be set to a positive peak detector and the sweep time shall be auto-coupled.
 - d) ~~Set spectrum analyzer reference level such that the measured signal is positioned as close as possible the top line of the display graticule.~~
 - e) ~~Reduce video bandwidth to at least 100 times less than the resolution bandwidth, but no less than 10 Hz.~~
 - f) ~~After items a) through e) are completed, measure the maximum average signal on the display.~~
-
- d) Set the instrument to perform video filtering in a linear (voltage) mode. For many instruments, this will require setting the vertical scale to linear and amplitude units to voltage (V or dB V). If the analyzer can set the video filter averaging type independently of the display settings, the average type shall be voltage average.²³
 - e) Set the reference level of the instrument, as required, preventing the signal from exceeding the maximum spectrum analyzer input mixer level for linear operation. In general, the peak of the spectral envelope shall be at least $[10 \log (OBW/RBW)]$ below the reference level (OBW is occupied bandwidth and RBW is resolution bandwidth). Specific guidance is given in 4.1.5.2.

f) Reduce the video bandwidth until no significant variations in the displayed signal are observed in subsequent traces, provided the video bandwidth is no less than 1 Hz. For regulatory requirements that specify averaging only over the transmit duration (e.g., digital transmission system [DTS] and Unlicensed National Information Infrastructure [U-NII]), the video bandwidth shall be greater than $[1 / (\text{minimum transmitter on time})]$ and no less than 1 Hz.

g) Set the trace display for maximum hold until it is stabilized, then record the highest level.

²³ If unsure of the analyzer capabilities, then a check that the correct averaging is being performed using the reduced video filtering method can be made by measuring the peak and average values of a pulse-modulated carrier set for a 50% duty cycle, a period of approximately 2 ms, and an amplitude at least 40 dB above the instrument noise floor. Both peak and average measurements are made using a 1 MHz resolution bandwidth and a peak detector. The average measurement shall be performed using a video bandwidth of 1 Hz. The peak measurement shall be performed using a video bandwidth of at least 3 MHz. The difference between peak and average values of the signal should be ~6 dB if a linear voltage average is being performed. The difference will be 20 dB or more between peak and log-average measurement results. The verification should be performed using the same measurement control software used for subsequent EUT measurements.

Additional details about use of spectrum analyzers for average measurements are given for example in Linkwitz ~~[B29]~~, [B47].

NOTE—A logarithmic amplitude display mode may be useful, for example, to distinguish more easily between narrowband and broadband signals. A logarithmic amplitude display mode results in a larger attenuation of broadband signals than in the linear display mode without affecting the display of narrowband signals (assuming a 100% duty cycle). Therefore, video filtering in the log display mode is especially useful for determining the narrowband component in a spectrum containing both broadband and narrowband signals.

4.2.3.1.4.2.4 Average value of pulsed emissions

Unless otherwise specified, when the radiated emission limits are expressed in terms of the average value of the emission, and pulsed operation is employed, the average measurement shall be determined from the peak field strength shall be determined from the peak field strength after correcting for the worst-case duty cycle as described in 7.5. ~~by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 s. As an alternative (provided the unlicensed wireless device operates for longer than 0.1 s) or in cases where the pulse train exceeds 0.1 s, the measured field strength shall be determined from the average absolute voltage during a 0.1 second interval while the field strength is at its maximum value.~~ The exact method of calculating the average field strength shall be included in the test report.

4.1 4.2.3.2.2.5- Measurement of power average (rms) emissions

For testing ultra-wideband systems and other systems that require average readings based on a an power average (rms) value, a spectrum analyzer with a an rms power average detector ~~function~~ shall be used. The analyzer shall provide a means to record, store, and display the rms values across the desired band of operation. The analyzer bin size shall not exceed the measurement bandwidth.

4.14.2.3.2.6 Pulse desensitization

Some unlicensed wireless devices generate wideband emissions using extremely narrow pulses. Compliance measurements are typically performed with a receiver or spectrum analyzer. Depending on various factors (resolution bandwidth, pulse width, etc.), the spectrum analyzer ~~may~~ might not display the true peak value of the measured emission. This effect, called “pulse desensitization,” relates to the capabilities of the measuring instrument and to the characteristics of the emission. For the measurement and reporting of the true peak of pulsed emissions, it ~~may~~ can be necessary to apply a pulse desensitization correction factor (PDCF) to the measured value. In other words, the test report ~~must~~ shall include the true peak level of the emission when the limit is specified in terms of a peak emission, which ~~may~~ can necessitate the use of a PDCF. See also Annex C concerning other pulse desensitization considerations.

NOTE 1—PDCF typically applies only to peak emission measurements. As an example, where a requirement specifies that a minimum 1 MHz resolution bandwidth is employed for emission measurements above 1000 MHz, when pulse widths are narrower than the inverse of the resolution bandwidth employed by a spectrum analyzer, the PDCF is applied to the peak level measured on the spectrum analyzer to compensate for the inability of the analyzer to respond fast enough to reflect the true peak power (i.e., the spectrum analyzer does not have sufficient bandwidth to measure all of the energy in the pulsed signal).

NOTE 2—PDCF typically is not applicable for ultra-wideband (UWB) device measurements; regulatory authorities ~~may~~ might specify other measurement procedures for determining compliance with UWB regulations.

4.2.4 Signal monitoring

~~EMI measurements should be monitored (audio and/or visual) by the test operator using a headset, a loudspeaker, a spectrum display, or any combination thereof as an aid to detecting ambient signals~~

~~and selecting the emissions that have the highest amplitude relative to the limit. Precautions shall be taken to ascertain that the use of a headset or speaker does not affect the measuring instrument indication during measurements.~~

4.1.5 Reference level, attenuation, and headroom

4.1.5.1 General considerations

For measurements where the bandwidth of the emission is greater than the resolution bandwidth of the measuring instrument, care must be taken to ensure that the input mixer of the instrument is operating in its linear region and is not saturating or clipping the signal.

For measurements where the bandwidth of the emission is less than or equal to the resolution bandwidth of the measuring instrument, it is generally sufficient that the peak of the displayed signal be less than the reference level, as long as the instrument attenuation is set to AUTO.

4.1.5.2 Setting the proper reference level and input attenuation

- a) Set attenuation to auto. (If finer control of attenuation is required to achieve a sufficiently low noise floor for out-of-band measurements, then manual setting of attenuation is permitted provided that the power level corresponding to the reference level setting specified below falls within the mixer level range recommended by the instrument manufacturer.)
- b) Set the reference level based on power measurements of the signal or by ensuring that the “head room” between the maximum spectrum level and the reference level is at least $[10 \log (99\% \text{ occupied bandwidth I RBW})]$. The nominal channel bandwidth or the emission bandwidth may be substituted for 99% occupied bandwidth in this formula, if a measurement of occupied bandwidth is not available.