



American National Standard Recommended Practice for the Immunity Measurement of Electrical and Electronic Equipment

C63[®]

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

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American National Standard Recommended Practice for the Immunity Measurement of Electrical and Electronic Equipment

Accredited Standards Committee C63®—Electromagnetic Compatibility

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Secretariat

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Abstract: This immunity measurement and measurement instrumentation specification document complements the recommended procedures for making emission measurements as specified in ANSI C63.4. The immunity methods are alternative methods that might be of use to manufacturers who want to ensure a reliable product and reduce customer complaints by adding some additional immunity into their products beyond that required by law or by correcting problems experienced in the field not related to regulatory requirements. This document generally covers the frequency range of 30 Hz to 10 GHz.

Keywords: electromagnetic compatibility, EMC, immunity, RF immunity

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Current interpretations can be accessed at the following URLs http://www.c63.org/explanations_interpretations_request.htm.

For more information about the committee that produced and maintains this standard, visit the ANSI Accredited Standards Committee C63[®] web site at <http://www.c63.org>.

Introduction

This introduction is not part of ANSI C63.15-2010, American National Standard Recommended Practice for the Immunity Measurement of Electrical and Electronic Equipment.

In the early 1980s, televisions received their signals only over the air because cable and satellite reception was not available. The tuners had only limited shielding, if any. RF signals from a variety of sources outside the TV bands interfered with TV reception. In 1982, legislation passed by the U.S. Congress and President Reagan (Public Law 97-259) giving the FCC the authority to require that home electronics equipment would have to meet RFI susceptibility standards. This stemmed from the work at the time of Senator Barry Goldwater and House Representative Charles Vanik. Senator Goldwater was himself an amateur radio operator and certainly aware of the need for immunity of home electronics especially to licensed broadcasters using frequencies outside of the TV bands.

At the time, ASC C63[®] was asked by the FCC to work with the Electronics Industry Association (EIA) to see if there was a way to add immunity to TVs by the manufacturer so as not to require FCC regulations. A task force in ASC C63[®] Subcommittee 1 was set up to address this matter. After extensive discussions, the TV industry came up with designs that significantly increased the immunity of TVs to out of band signals. This was one of the first times that the voluntary standards community helped to solve a problem without the need for regulations.

The above background served to set the stage for the interest in ASC C63[®] to consider preparing immunity standard test methods. As such the project was approved in Subcommittee 1 in the 1980s, for an addition to ANSI C63.4 for measurement methods, and an addition to ANSI C63.2 for measurement instrumentation. Don Heirman was named as the chairman of the WG on Immunity with the assistance of Ray Magnuson. A ballot was then taken of the work in 1983. The ballot had many comments but more importantly eight negative votes. Work then proceeded to resolve the comments. Bill Hayes took over the measurement instrumentation portion of the task at that time. In parallel there was also major activity in immunity measurement methods starting in the IEC arena. This required decisions on how to proceed with the work of ASC C63[®]. The outcome was that the ASC C63[®] work on immunity was stalled for several years. However the WG did contribute in this time frame to the military work on commercial off the shelf (COTS) procurements, as well as immunity text for ANSI C63.12 in the mid-1990s. Further revisions were made to the C63[®] draft during this time, headed by Steve Bloom, but at a slow rate because the work in the IEC was gaining speed. In early 2000, another draft was ready for ballot. The ballot was taken and the document still failed to get sufficient approval votes. At that time, Herb Mertel assumed the WG chairmanship working to prepare another draft taking into account the comments that would require extensive changes to the draft standard. The Subcommittee 1 projects were called project 1-1.1 (Immunity measurement methods) and project 1-1.3 (Immunity instrumentation) for development of the overall standard C63.15. By 2003, the projects were combined into one document and given the number C63.15 as early as 1999. It was identified as a recommended practice. In 2004, Mike Windler took over the task of editing the document. The ballot again failed in 2005 with substantial negative comments. At that time the project was shifted to Subcommittee 5 because that subcommittee deals with immunity standards. In 2006, the last ballot was taken and this time it passed in the parent committee. The final editing was completed in Fall of 2008, with ANSI and IEEE processing completed for publication in 2010.

The above scenario has been compiled from a variety of documents and sources. It is considered as a reasonable trail of the activity to publish with this document.

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1. Scope

The conducted immunity (CI) and radiated immunity (RI) test methods in this recommended practice do not universally apply to every product. Applicable test methods should be selected. A qualified EMC engineer should document test planning and the rationale for using particular immunity tests. This document is intended to

- a) Identify preferred or optional immunity test methods.
- b) Describe specific measurement techniques.
- c) Suggest product performance degradation criteria as applicable to general and specific products.
- d) Identify test instrumentation specifications.

Wherever possible, existing voluntary standards are utilized and summarized. It should be noted that the techniques listed herein should in no way limit the user to a particular method to increase product immunity. The immunity levels in this document are recommended. Should product classifications and type have other immunity levels that apply, they shall take precedence. Equipment developed for military applications should use MIL-STD-461E¹ or later editions for test procedures and limits.

¹ Information on references can be found in Clause 2.

2. Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

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

ANSI C63.12, American National Standard, Recommended Practice for Electromagnetic Compatibility Limits.

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

ANSI/EIA-544, Immunity of TV and VCR Tuners to Internally Generated Harmonic Interference from Signals in the Band 535 kHz to 30 MHz.³

ANSI/TIA-470A, Telephone Instruments with Loop Signaling.

ANSI/TIA-579, Acoustic-To-Digital and Digital-To-Acoustic Transmission Requirements for ISDN Terminals.

ANSI/TIA/EIA-631, Telecommunications Telephone Terminal Equipment Radio Frequency Immunity Requirements for Equipment Having an Acoustic Output.

CEA-31, Design Guideline—Rejection of Educational Interference to Ch 6 Television Reception.⁴

EIA Interim Standard No. 16, Immunity of TV Receivers and Video Cassette Recorders (VCRs) to Direct Radiation from Radio Transmissions, 0.5 to 30 MHz.⁵

EIA/CEMA/TV/VCR SET, TV/VCR Receiver Immunity Set.

IEC 61000-4-3:2006, Testing and measurement techniques—Section 3: Radiated, radio-frequency electromagnetic field immunity test.⁶

IEC 61000-4-4:2006, Testing and measurement techniques—Section 4: Electrical fast transient/burst immunity test.

IEC 61000-4-5:2005, Testing and measurement techniques—Section 5: Surge immunity test.

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⁴ CEA publications are available from Global Engineering Documents, 15 Inverness Way East, Englewood, CO 80112, USA (<http://global.ihs.com/>).

⁵ EIA publications are available from Global Engineering Documents, 15 Inverness Way East, Englewood, CO 80112, USA (<http://global.ihs.com/>).

⁶ IEC publications are available from the Sales Department of the International Electrotechnical Commission, Case Postale 131, 3, rue de Varembe, CH-1211, Genève 20, Switzerland/Suisse (<http://www.iec.ch/>). IEC publications are also available in the United States from the Sales Department, American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA (<http://www.ansi.org/>).

IEC 61000-4-6:2001, Testing and measurement techniques—Section 6: Immunity to conducted disturbances, induced by radio-frequency fields.

IEC 61000-6-1, Electromagnetic Compatibility (EMC)—Part 6: Generic Standards—Section 1: Immunity for Residential, Commercial and Light-Industrial Environments.

IEC 61000-6-2, Electromagnetic compatibility (EMC) Part 6-2: Generic standards Immunity for industrial environments.

IEEE Std 299TM, IEEE Standard Method for Measuring the Effectiveness of Electromagnetic Shielding Enclosures.^{7, 8}

IEEE Std C95.1TM, IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz.

ISO/IEC 17025, General Requirements for the Competence of Calibration and Testing Laboratories.⁹

MDS-201-0004, Electromagnetic Compatibility Standard for Medical Devices
(<http://www.fda.gov/cdrh/ode/638.pdf>).

MIL-HDBK-454A, Department of Defense Handbook, General Guidelines for Electronic Equipment.¹⁰

MIL-STD-461E, Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment (<http://www.jsc.mil/jsce3/emcslsa/stdlib/LibDisplay.asp?folder=ms>).

MIL-STD-462, Department of Defense Test Method Standard for Measurement of Electromagnetic Interference Characteristics.

NBS TN-1013, July 1981: Using a TEM Cell for EMC Measurements of Electronic Equipment, Crawford, M. L.; Workman, J. L.¹¹

RCTA DO-160E, Radio Technical Committee for Aircraft, Environmental Conditions and Test Procedures for Airborne Equipment (<http://www.rtca.org/>).

3. Definitions

The definitions in ANSI C63.14 apply. Definitions in particular product standards or in applicable regulations take precedence.

dBrnC: Noise power above a reference noise measured by a set with C-message weighting.

dBSPL: Sound pressure level relative to a particular noise as a reference source.

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¹⁰ MIL publications are available from Customer Service, Defense Printing Service, 700 Robbins Ave., Bldg. 4D, Philadelphia, PA 19111-5094.

¹¹ This NBS publication is no longer in publication. However, a copy of this standard is available at some university libraries as well as from the IEEE-SA.

4. General requirements

4.1 Safety precautions

WARNING

Electric Shock Hazard: Precautions against electric shock hazard should be taken when ac-operated test instrumentation is used and when test instrumentation is connected to power circuits. There are numerous requirements for leakage currents and the precautions given in manufacturers' manuals and local codes need to be considered. The following are two examples:

In MIL-HDBK-454A, it is specified that in normal use if the open circuit potential to ground is more than 25 V (ac) and the current with a 1500 Ω load is more than 4 mA (dc) and 1 mA (ac) a shock hazard exists.

In Europe this amplitude is 0.75 mA for handheld equipment and 3.5 mA for floor standing equipment.

WARNING

Nonionizing Radiation Exposure Hazard: IEEE Std C95.1 specifies safety levels and guidelines with respect to human exposure to radio frequency electromagnetic fields. Fields that exceed these safety levels are possible when using the test instrumentation in this recommended practice, particularly when the test instrumentation is used to perform radiated immunity testing. Precautions against exposing personnel to these electromagnetic fields should be taken.

4.2 Input power requirements

If the test instrument requires ac power, it should operate on a supply that meets its specifications for voltage and frequency. The test instrumentation should have adequate power-line filtering to prevent erroneous or undesirable operation due to power-line interference.

4.3 Measurement tolerances

The general tolerances are derived from MIL-STD-461E. Unless otherwise stated for a particular measurement, the tolerance of the value stated shall be as follows:

- a) Distance: $\pm 5\%$
- b) Frequency: $\pm 2\%$
- c) Amplitude, measurement receiver: ± 2 dB
- d) Amplitude, measurement system (includes measurement receivers, transducers, cables, etc.): ± 3 dB
- e) Time (waveforms): $\pm 5\%$
- f) Resistance: $\pm 5\%$
- g) Capacitance: $\pm 20\%$

4.4 Annexes

The annexes provide a tutorial on immunity, a view of performance degradation criteria and the recommended test equipment (Annex B) for test methods that were obtained from the obsolete and detailed reference documents.

4.5 Test reports

The test report shall provide the following:

- a) Graphical or tabular data showing the frequencies and amplitudes at which the test was performed
- b) Data on any immunity threshold and the associated frequencies that were determined for each immunity test
- c) Indication of compliance for each test in a summary table
- d) Measurement uncertainty if applicable (see ISO/IEC 17025 for guidance)

5. Conducted immunity

Conducted interference may degrade electronic product operation as it enters the product via ac power, dc power, signal, communication, telemetry lines, and receiver antenna input. Hence, these lines must be immune to common conducted interfering signals comprised of steady-state, transient, and other signal types typically found in radio frequency (RF) ambient and product locations.

5.1 CI-1: Power-line immunity, 30 Hz to 150 kHz

5.1.1 General considerations

This test method is used to verify the ability of the equipment under test (EUT) to withstand ripple voltages present on power leads. Since the applied voltage is coupled in series using a transformer, Kirchhoff's voltage law requires that the voltage appearing across the transformer output terminals must drop around the circuit loop formed by the EUT input and the power source impedance. The voltage specified by the product specification is measured across the EUT input because part of the transformer voltage can be expected to drop across the source impedance.

5.1.2 Measurement procedure

Use the measurement procedure given in Method CS101, MIL-STD-461E.

5.1.3 Performance degradation

Performance criterion should be established using the guidelines described in Annex A.

5.1.4 Suggested immunity levels

The suggested immunity level is shown in Figure CS 101-1 of MIL-STD-461E, Curve 1.

This limit is 136 dB μ V (6 V) from 30 Hz to 5 kHz on lines greater than 28 V and decreases as a log function (linear on a log scale) to 106.5 dB μ V (0.21 V) at 150 kHz.

NOTE—Test voltages are in terms of the rms value of a sine wave.

5.2 CI-2: Power-line and signal-line immunity, bulk current injection, 10 kHz to 200 MHz

5.2.1 General considerations

This test method is used to verify the ability of the EUT to withstand RF signals present on interconnecting cables, including power leads. This type of test is often considered a bulk current test because current is the parameter measured. However, it is important to note that the test signal is inductively coupled and that Faraday's law predicts an induced voltage in a circuit loop with the resultant current flow and voltage distribution dependent on the various impedances present.

This method induces levels on all wires at a connector interface simultaneously (common mode) which simulates actual use.

Testing is required on both entire power cables and power cables with the neutral or grounded conductors removed to evaluate common-mode coupling to configurations that may be present in different installations.

In some installations, the neutral or grounded wire is routed with the line conductor. In other installations, neutrals or grounded conductors are tied to the grounded system structure near the utilization equipment.

The entire grounded system structure is being used as the power return path.

5.2.2 Measurement procedure

Use the measurement procedure given in Method CS114, MIL-STD-461E to 200 MHz.

Optionally, IEC 61000-4-6 may be used over the frequency range of 150 kHz to 230 MHz.

5.2.3 Suggested immunity level

The suggested immunity level is shown in Curve 3 of Figure CS 114-1 of MIL-STD-461E.

It is 49 dB μ A (282 μ A) at 10 kHz increasing to 89 dB μ A (28 mA) at 1 MHz to 30 MHz and it is decreasing to 77 dB μ A (7 mA) at 400 MHz.

5.3 CI-3: Communications receiver antenna input immunity (receivers other than broadcast), 30 Hz to 10 GHz

5.3.1 General considerations

This test method is applicable for determining the immunity or front-end rejection of receivers operating in the frequency range of 30 Hz to 10 GHz. This test method is derived from an earlier version of MIL-STD-462 that is no longer available.