Draft American National Standard

Publication of this draft standard for trial use and comment has been approved by the Institute of Electrical and Electronics Engineers. Distribution of this draft standard for comment shall not continue beyond thirty-six months from the date of publication. It is expected that following this thirty-six-month period, this draft standard, revised as necessary, shall be submitted to the American National Standards Institute for approval as an American National Standard. Suggestions for revision should be directed to the Secretary, IEEE Standards Board, 345 East 47th Street, New York, NY 10017.

withstand capability of relay systems to radiated electromagnetic interference from transceivers

ANSI/IEEE C37.90.2

american national standards institute, inc.

December 14, 1987

SH11775

ANSI/IEEE C37.90.2
(Issued for Trial Use December 1987)

Draft American National Standard

IEEE Trial-Use Standard Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers

Sponsor

Power System Relaying Committee
of the
IEEE Power Engineering Society

Draft American National Standard

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Foreword

(This Foreword is not a part of ANSI/IEEE C37.90.2, IEEE Trial-Use Standard Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers.)

The use of hand-held transceivers (walkie-talkies) has increased dramatically over the past few years. When operated in close proximity to a static protective relay, these transceivers will produce local, high field strength, electromagnetic radiation that may affect relay performance. The need for a standard on radiated interference withstand capability for static protective relays is therefore apparent.

The Working Group on Effects of High Frequency Radiation on Control and Protective Devices of the Power System Relaying Committee has been working on this document since 1976, and has now reached a point where further refinement of the document is not possible without feedback from those parties within the electric power industry who will be testing static protective relays per this standard. The Working Group hopes that the release of this document for trial use will provide the feedback needed to complete its task.

The following is a list of topics for comments of particular interest to the Working Group, although comments in other areas are welcome:

(1) Is the test relatively straightforward to perform? Describe the problem(s) encountered.

(2) Were the test procedures and test results easy to interpret?

(3) Are the test results repeatable?

(4) Does amplitude modulation or the keying test produce malfunctions not detected by the continuous wave test?

Comments are welcome and should be directed to:

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We would also encourage response in the form of technical papers which would permit formal discussion and closure.

The Working Group on High-Frequency Radiation Effects on Static Control and Protection Devices, of the Relay Electrical Environment Subcommittee, had the following membership at the time this standard was developed:

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Contents

Draft American National Standard

IEEE Trial-Use Standard Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers

1. Scope and References

1.1 Scope. The purpose of this standard is to establish a common reference and test procedure for evaluating the performance of static protective and control relays used in electric power facilities. It establishes a test method to evaluate the susceptibility of the relays to single frequency electromagnetic fields in the radio frequency domain, such as those generated by portable or mobile radio transceivers.

1.2 References. The following publications shall be used in conjunction with this standard.

[1] ANSI/IEEE Std 100-1984, IEEE Standard Dictionary of Electrical and Electronics Terms.[1]

[2] FCC Rules and Regulations (contained within CFR [Code of Federal Regulations]), Part 15: Radio Frequency Devices, US Government Printing Office.[2]

[1] This publication is available from the Institute of Electrical and Electronics Engineers Service Center, 445 Hoes Lane, PO Box 1331, Piscataway, NJ 08855-1331. Copies may also be obtained from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018.

[2] This publication is available from the Superintendent of Documents, US Government Printing Office, PO Box 37082, Washington, DC 20013-7082.

2. Definitions

susceptibility (electromagnetic). The characteristic of any equipment that results in an undesired response to an electromagnetic field.

transmitter (radio). A device or circuit that generates high-frequency electric energy, controlled or modulated, which can be radiated by an antenna.

Terms other than those defined here have standard definitions as listed in ANSI/IEEE Std 100-1984, IEEE Standard Dictionary of Electrical and Electronics Terms [1].[3]

3. Single-Frequency Test Parameters

The most common source of single-frequency interference to static protective and control relays is provided by portable radio transmitters when they are used in close proximity to the relays. Those frequencies in general use in electric power systems are given in Appendix A.

[3] The numbers in square brackets correspond to those of the references listed in 1.2 of this standard; when preceded by B, they correspond to publications listed in Section 7, Bibliography.

The portable transceivers normally used in power system communications have output power less than 10 W measured at the base of the antenna. There are other factors, besides power level, that may affect the susceptibility of the relay equipment to these devices, such as the frequency and modulation level. In deciding on a meaningful test level, it is important to know what field strengths are produced by commercial portable transceivers since these are the dominant interfering sources. Data by European researchers on the field strength produced by six portable VHF and UHF transceivers supports the following empirical equation for field strength, E. (See [B8].)

$$E = (1.6\sqrt{P})/d \quad \text{(V/m)}$$

where

d = distance, in meters
P = manufacturer's advertised rating of the transceiver, in watts

For a 10 W rated transceiver at a distance of 1 m, this gives a value for E of 5 V/m. These data reveal the practical effects of transmitter and antenna efficiencies when compared to the theoretical equation for the field produced by half wave dipole radiator:

$$E = (7.02\sqrt{P})/d \quad \text{(V/m)}$$

For the same 10 W transceiver, this gives about 22 V/m. See [B8] for a discussion of antenna efficiency, which points out that, for antennas used with portable transceivers, efficiency is not likely to exceed 50% and may be much less. On this basis it seems that a field strength of 10 V/m is a realistic value that represents, with some margin, the field that can be reasonably expected due to a portable transceiver 1 m distant. Reliable operation of protective and control relays used in an electric utility system requires that they must be designed to withstand this type of interference. To assure that this is done, a field strength withstand capability level of between 10 V/m and 20 V/m shall be used over the frequency range of 25 MHz to 1000 MHz. This will be measured at the relay location. This measurement is defined as a value that would exist at that point prior to placing the equipment in the radiated field.

4. Test Conditions

4.1 Selection and Preparation of Samples

4.1.1 Relay Systems. Static protective or auxiliary relays, when supplied as an integrated relay system with an enclosure, shall be tested in the enclosure. All components should be mounted and interconnected. Where system components are unavailable at time of test, dummy modules may be used, and these modules shall, insofar as possible, duplicate the shielding to be realized from the actual components.

4.1.2 Individual Relays. Individual relays shall be tested separately without regard to their ultimate relationship to other circuit components after the relays are finally installed in a system. The responsibility for testing a complete system that is assembled by the user shall rest with the user.

4.1.3 Selection of Test Sample. This test is a *design test* and shall, therefore, be applied to a randomly selected relay or relay system of each type. The test shall be repeated for each modification to the physical arrangement or selection of components contained in the relay or system, unless documentation is available to indicate tests are not needed.

4.2 External Wiring. External wiring shall be shielded or otherwise treated to eliminate antenna-like pickup of the test signal and subsequent conduction into the test specimen. Immunity to conducted interference should be tested separately in accordance with the appropriate standards.

4.3 Grounding. All equipment used in the tests, such as relays, relay panels, relay enclosures, and cable shields, shall be properly grounded. Cable trays, conduit, or external cables shall also be grounded.

5. Test Methods

5.1 Introduction. The purpose of this section is to establish a method of determining the susceptibility of static protective and control relays to single-frequency sources of radio frequency interference. A method of developing electromagnetic fields in the vicinity of a protective relay is described. To generate fields that are useful for simulation of field conditions may require significant antenna drive power to achieve high field strength levels.

CAUTION

The requirements of the Federal Communications Commission Rules and Regulations or any other regulating agency must be considered before testing in accordance with this procedure. Refer to [2] for further information.

5.2 General Description. A protective relay must be secure from incorrect operations due to the presence of electromagnetic interference. It is the intent of this test to duplicate, as nearly as possible, in-service conditions with normal input and output from the relay in its normal nontransitional state. The settings shall be those that are typical of the application for which the equipment is intended. Input voltage to power supply circuits shall be within specified limits.

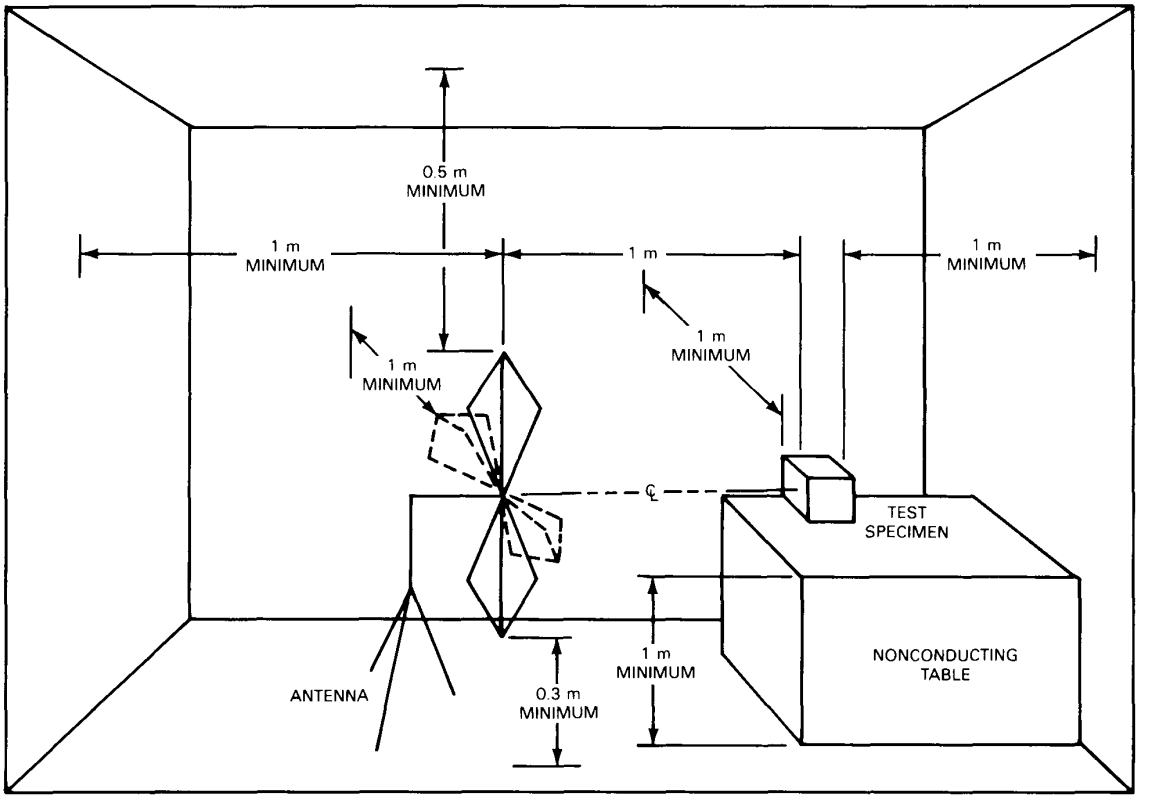
5.3 Environment. A shielded enclosure is recommended for testing in accordance with this specification. Dimensions for such an enclosure along with the location of the radiating element and the test specimen are shown in Fig 1. Use of an anechoic enclosure is recommended to minimize the effect of reflection within the enclosure. Temperature, atmospheric pressure, and relative humidity are not recognized as influential factors for this testing. When a means is required to support the test sample, it should be constructed of nonmetallic material.

5.4 Test Equipment. The following test equipment is recommended. The use of other means of establishing and controlling the field is not ruled out and is acceptable providing the required conditions can be verified.

(1) Shielded enclosure—Size adequate to maintain distances shown by Fig 1.

(2) Signal generator(s) capable of covering frequency range with capability of amplitude modulation (if automatic sweep, sweep rate should be capable of achieving 0.005 octave/second).

Fig 1
Test Setup for Radiated Susceptibility



(3) Power amplifier—To amplify signal and provide antenna drive if signal generator is inadequate.

(4) Antennas—Signal source capable of covering frequency range such as

(a) biconical

(b) conical logarithmic spiral

(5) Field strength monitor antennas with EMI meter.

(6) Associated equipment to monitor output of test sample to establish operating performance and signals for test sample during test.

5.5 Test Procedure

5.5.1 The test procedure assumes the use of biconical and conical logarithmic antennas. Other methods of establishing the fields are acceptable providing the proper fields can be generated.

5.5.2 Basic Radiation Susceptibility Test

(1) Set up the test sample and the transmitting antenna per the distance restrictions of Fig 1. For the biconical transmitting antenna, adjust it so that the electromagnetic field is polarized vertically.

(2) Establish the field strength by placing the field strength receiving antenna or antennas in place of the test samples. Sweep a continuous wave signal to the applicable antenna over a frequency range of 25-1000 MHz. Monitor the field strength via a remote field strength indicator outside the test chamber. During this determination, the transmitter power shall be adjusted so that the monitored field strength stays between 10 and 20 V/m.

(3) Replace the receiving antenna with the test sample and repeat the frequency sweep using the same source power setting(s) used in step (2). Document the response of the test sample. Automatic sweep rate should be at 0.005 octaves/second or less. If manual sweep is utilized, the sweep rate should approximate 0.005 octave/second or less. For frequencies below 50 MHz, amplitude modulate at 90% with a 1000 Hz sine wave. (See 5.5.3 for digital equipment.)

(4) Step (3) shall be repeated to expose the test sample in other planes as follows:

(a) Floor mounted equipment—four sides of the equipment shall be exposed to the test source.

(b) Other than floor mounted equipment—six sides of the equipment shall be exposed to the test source.

(5) When using the biconical antenna, change electromagnetic wave polarization to horizontal and repeat steps (2) and (3), exposing only the front and back of the sample.

5.5.3 Digital Equipment Modulation Test. All digital equipment using clocked logic circuits shall also be subjected to electromagnetic radiation that is amplitude (pulse or square wave) modulated at a frequency close to 10 kHz, but not in synchronism with the digital clock frequency. The 1000 Hz sine wave modulation listed in step (3) of 5.5.2 may be omitted when the 10 kHz modulation test is performed.

5.5.4 Keying Test. Some equipment is susceptible to repeated operation of a transmitter. This test shall be performed to evaluate the test specimen in this mode. To simulate keying of a transceiver, the signal source shall be 100% pulse or square wave modulated. The modulating signal shall have an on and off duration of at least 1 s each. The pulse or square wave shall have a rise and fall time of no greater than 50 μs. There shall be at least three keying cycles per frequency octave. Exposure need be to the front of the test specimen only.

6. Acceptance Criteria

A test is successful when no erroneous output is present, no component failure occurs, and there is no change in calibration exceeding normal tolerance. An erroneous output is one that presents false information, such as target lights, trip pulses, missing bits, unwanted bits, and synchronization errors.

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[B8] IEC Technical Committee 65 Working Group 4. Radiated Electromagnetic Field Requirements Test Method, proposed draft, July 1981.

[B9] SAMA, Electromagnetic Susceptibility of Process Control Instrumentation, Standard PMC 33.1, 1978.

Appendix

(This Appendix is not a part of ANSI/IEEE C37.90.2, IEEE Trial-Use Standard Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers.)

Appendix A

Radio Frequencies in General Use in Electric Power Operations in United States

Private Electric Utilities Radio Frequency Bands	Government Electrical Power Facilities Radio Frequency Bands
37 MHz	27.54 - 28 MHz
47 - 48 MHz	40.39 - 42 MHz
72 - 76 MHz	45 - 46 MHz
153 - 154 MHz	162.0125 - 173.2 MHz
169 - 172 MHz	406.1 - 420 MHz*
173 MHz	453 MHz
451 MHz	458 MHz
456 MHz	902.0 - 928 MHz
462 MHz	1710 - 1850 MHz*
467 MHz	7125 - 7900 MHz*
470 - 512 MHz	8025 - 8400 MHz*
806 - 821 MHz	14 400 - 15 350 MHz
851 - 866 MHz	36 000 - 38 600 MHz
2450 - 2500 MHz	FCC Frequency Bands
8400 - 8500 MHz	
10 550 - 10 680 MHz	*Used for Protective Relaying