

American National Standard for Electromagnetic Compatibility Limits— Recommended Practice

Accredited Standards Committee On Electromagnetic Compatibility, C63

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Foreword

(This Foreword is not part of ANSI C63.12-1987.)

The problem of electromagnetic compatibility has existed from the early days of radio when spark gaps were used for transmitting and receivers picked up many signals unintentionally. Radio transmission has evolved from those early days into a highly sophisticated science. However, the need for compatibility is even greater today than it was in earlier times since modern society has come to depend on radio waves in all facets of life from garage door openers and licensed broadcasting to sophisticated airplane and missile guidance systems. The proliferation of unintentional radiators such as personal computers and video games has increased the need for electromagnetic compatibility.

The need for an electromagnetic compatibility document was recognized by the American National Standards Committee C63, and a draft standard of this document was approved by C63 on August 5, 1977. The first official issue of the standard was approved December 2, 1983, and published by the IEEE in 1984. Changes in national and international standards since that time prompted Committee C63 to request that Subcommittee No 1 undertake revision of C63.12. The present document is the result of that undertaking.

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1. Scope

Over the years many electromagnetic compatibility measurement and control standards have been developed. Many of these are of concern to particular classes of devices such as receivers, transmitters, incidental radiation devices, etc. In establishing limits, it is necessary to relate the measurement technique used to determine compliance with a given limit to the field conditions under which the device being controlled will actually operate. The purpose of this standard is to set forth, at least for reference purposes, a suggested set of limits which may find general application. This document does not set specific limits. It presents a rationale for developing limits and recommends a set of limits that are representative of current practice. In practice these limits¹ may be adjusted in particular applications as circumstances dictate. This document does not consider limits for industrial, scientific, and medical (ISM) equipment which specifically uses radio frequencies as a major part of its operation.

As part of the development of limits, the following parameters should be considered:

- 1) The general properties of both man-made and natural environmental noise
- 2) An understanding of the devices commonly used for measurement of radio noise and their properties, which will assist the practitioner in selecting such equipment and associated measurement techniques for the particular application
- 3) The rationale that can be used in selecting a consistent set of limits for emission and immunity, (susceptibility) subject to various environmental constraints (good engineering practice)

These practices are intended to be applicable to individual equipment as well as systems of various sizes and, if properly applied, will provide guidance for obtaining both intrasystem and intersystem compatibility.

This standard is organized as follows: Section 2 references instrumentation and measurements methods, Section 3 contains a list of definitions, Section 4 describes environmental radio noise, and Section 5 describes the selection of measurement parameters. Section 6 discusses limit setting, and Section 7 is a list of references.

¹It should be noted that the limits and measurement techniques described herein are proposed for general use to the extent that they are not covered in regulations of Federal Government agencies. Clearly, in circumstances where such regulations apply and could be considered to be in conflict with these practices, the government regulations take precedence.

Appendixes A, B, and C discuss the measurement of amplitude distribution, the measurement set envelope amplitude distribution, and the amplitude probability distribution, respectively.

2. Instrumentation and Measurement Methods References

Instrumentation and measurement methods used for determining electromagnetic compatibility (EMC) are described in more detail in IEEE Std C63.2-1987 [1]²ANSI C63.4-1981 [2], and in forthcoming immunity documents to be added to them. These documents should be reviewed before proceeding to make measurements. A forthcoming ANSI document (see 7.2, footnote 9), Guide to Electromagnetic Compatibility Standards and Procedures (PC63.8), contains information on various EMC standards in current use in the United States. When American National Standards referred to in this standard are superseded by a revision approved by the American National Standards Institute, the revision shall apply.

3. Definitions

amplitude probability distribution (APD): The fraction of the total time interval for which the envelope of a function is above a given level x .

atmospheric radio noise: Noise having its source in a natural atmospheric phenomenon.

average crossing rate: The average rate at which a specified level (zero if not specified) is crossed in the positive-going direction.

distribution function [$P(x)$]: The probability that a parameter is less than a given value x .

electromagnetic compatibility (EMC): The ability of a device, equipment, or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment.

envelope amplitude distribution (EAD): A cumulative distribution of the impulse response positive crossing rates of a bandpass filter at different spectrum amplitudes.

environmental radio noise: The total electromagnetic disturbance complex in which an equipment subsystem or system may be immersed, exclusive of its own electromagnetic contribution.

immunity (to a disturbance): The ability of a device, equipment, or system to perform without degradation in the presence of an electromagnetic disturbance.

impulsive noise: Electromagnetic noise that, when incident on a particular device or equipment, manifests itself as a succession of distinct pulses or transients.

NOTES:

1 — The frequency spectrum of these disturbances must be substantially uniform over the useful pass band of the transmission system.

2 — The same source may produce an output characteristic of impulsive noise in one system and of random noise in a different system.

intersystem electromagnetic compatibility: The condition that enables a system to function without perceptible degradation due to electromagnetic sources in another system.

intrasystem electromagnetic compatibility: The condition that enables the various portions of a system to function without perceptible degradation due to electromagnetic sources in other portions of the same system.

² Numbers in brackets correspond to those of the references listed in Section 7

noise amplitude distribution (NAD): A distribution showing the pulse amplitude that is equalled or exceeded as a function of pulse repetition rate.

power density: Emitted power per unit cross-sectional area normal to the direction of propagation.

probability density function [p(x)]: The derivative of the distribution function $P(x)$.

pulse count: The number of pulses in some specified time interval.

random noise: Electromagnetic noise the values of which at given instants are not predictable.

NOTE — The part of the noise that is unpredictable except in a statistical sense. The term is most frequently applied to the limiting case in which the number of transient disturbances per unit time is large so that the spectral characteristics are the same as those of thermal noise. Thermal noise and shot noise are special cases of random noise.

4. Description of Environmental Radio Noise

The minimum level required for satisfactory reception of desired radio or control signals is determined by the level of environmental radio noise or undesired signals with which the desired signal must compete. Several types of radio noise may influence reception; however, with a particular system and environment one type will generally predominate at a given time, especially if a receiver is located physically near a specific source.

All sources of radio noise can be divided into two general groups, wide bandwidth and narrowbandwidth noise, in which the distinction is usually based on comparison with the bandwidth of a typical receiver. Wide bandwidth noise is frequently impulsive and can be divided further into two groups, natural and man made. Narrow bandwidth noise is usually generated by a variety of restricted radiation devices—industrial, scientific, medical (ISM) equipment, licensed radio transmitters, and incidental radiating devices operating with fast rise time oscillations or microprocessors or both. These devices generally radiate radio frequency energy over a limited portion of the spectrum clustered around discrete frequencies. Licensed radio transmitters also radiate a broad noise spectrum near their carrier frequency.

To the extent that radio noise varies, a time-domain statistical description is necessary to characterize it. Just how much detail is needed in the description depends upon the desired accuracy of predicting degradation and the information bandwidth of the system with which it may interfere. In general, the noise variations take place in spectrum amplitude, which may be associated with a change in impulse rate and may occur in periods of time ranging from fractions of a second to periods of a year or more as in the case of atmospherics.

In determining how to conduct measurements of radio noise sources, the following criteria should be kept in mind [3]:

- 1) Since many measurements are usually required in many areas, parameters should be simple and economical to measure and analyze
- 2) Parameters should be such that the interference effect of the noise on the various types of receiving systems likely to be affected can be accurately judged
- 3) Parameters should be such that they can be related to such predictors as, for example, population and vehicle density.
- 4) Parameters should be useful in identifying the source of the measured noise

The amplitude probability distribution (APD) and the noise amplitude distribution (NAD) are time-domain statistical distributions that have been measured frequently. They give detailed information about the noise, and they can be used to evaluate the effects of a given type of noise on a given communication system with varying degrees of accuracy. They are briefly described in Section 5 Other distributions have been measured.

For stationary distributions, relatively simple real-time logic functions can be utilized in a measurement system to obtain the required data, generally presented graphically. Another approach is to measure certain statistics of the distribution, such as the average, peak, rms, quasi-peak, and average logarithm, rather than the distribution itself [8],