

IEEE Recommended Practice for Measurement of Spurious Emission from Land-Mobile Communication Transmitters

Sponsor
**Standards Technical Committee
of the
IEEE Electromagnetic Compatibility Society**

Reaffirmed September 18, 1986
Reaffirmed September 26, 1991

IEEE Standards Board

Reaffirmed February 9, 1987
Reaffirmed May 6, 1992

American National Standards Institute

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Approved March 15, 1979

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Foreword

(This Foreword is not a part of IEEE Std 377-1980, IEEE Recommended Practice for Measurement of Spurious Emission from Land-Mobile Communication Transmitters.)

This standard was initiated as Project No 712-53, by the IEEE Electromagnetic Compatibility Group Committee 27.0. The project was approved by the IEEE Standards Committee on June 3, 1971. Subcommittee 27.7 was assigned the task. This subcommittee had recently completed a standard covering Measurement of Radio Noise Generated by Motor Vehicles. Continuing coordination with The IEEE Group on Vehicular Technology, the Electronics Industries Association and the International Electrotechnical Commission via common membership, was maintained.

The purpose of the measurement procedures is to enable design and system engineers engaged in a variety of development projects, to achieve uniform results, in recognizing sources and nature of radio frequency spurious emissions emanating from vehicular communications transmitters. The measurement procedure enables quantitative results, which determine the magnitude of undesired by-products of a transmitters RF carrier generation. The specific spurious emissions measured, are not readily recognized, except as they deprecate the performance of receivers associated with the transmitter or which are located in a moderately near field environment. In a modern vehicle employing a computerized fuel management system, the spurious emissions can be quite destructive.

A prime objective of the standard was to develop methods employing basically standard laboratory measuring equipment and produce useful planning or design data from which performance characteristics could be accurately derived.

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IEEE Recommended Practice for Measurement of Spurious Emission from Land-Mobile Communication Transmitters

1. Scope

This recommended practice covers definitions of terms, controlled test conditions, test apparatus, test methods and data presentation, all of which form the basis for establishing the energy levels of spurious emissions of mobile communication transmitters designed to generate frequency-modulated (FM) signals in the frequency range of 25 MHz to 1000 MHz. Procedures for measuring both broadband and narrowband spectra are provided for both conducted and radiated emissions. Specified limits are not included. However, reference values which are not limited by the state of the art are provided. Transmitter test conditions, apparatus and method are based on standard instrumentation and measuring techniques and do not require any special apparatus other than necessary terminal simulators. The procedures do not cover the associated antenna and transmission lines.

1.1 Subsystems

In those cases where transmitters are equipped with special function subsystems, such as selective calling, dialing supervision or other keying devices, said systems shall be disabled. An exception is continuous tone modulated equipment.

This recommended practice does not provide for testing of transmitters which include subsystems that cannot be disabled or bypassed.

1.2 Limitations

This recommended practice is limited to measurements of single channel voice modulated transmitters independent of their application to any specific communication system. Spurious energy levels contained within the transmitter's integral control system are not measured. Methods of testing or specific apparatus for use in testing of *personal* portable type transmitters employing integral antennas and audio input devices are not included.

1.3 Supplementary Testing

Special function subsystems which may require supplementary test methods are not covered by this recommended practice.

2. Definition of Terms

2.1 General

Definitions given are limited to those terms or expressions unique to the purpose of this recommended practice. Terms used in standard texts, related industry standards or recognized by common usage are not defined, except where the application within the context of this recommended practice requires specific limitation.

2.2 Standard Reference Terms

narrowband spurious emission: Any spurious output emitted from a radio transmitter, other than on its assigned frequency, which produces a disturbance of spectral energy lying within the bandpass of the measuring receiver in use.

near field region: The region of the field of an antenna between the reactive near field region and the far field region wherein radiation fields predominate and wherein the angular field distribution is dependent upon distance from the antenna.

NOTES:

- 1 — If the antenna has a maximum overall dimension which is not large compared to the wavelength, this field region may not exist.
- 2 — For an antenna focused at infinity, the radiating near field region is sometimes referred to as the Fresnel region on the basis of analogy to optical terminology.

far field region: The region of the field of an antenna where the angular field distribution is essentially independent of the distance from the antenna.

NOTES:

- 1 — If the antenna has a maximum overall dimension (D) that is large compared to the wavelength (λ), the far field region is commonly taken to exist at distances greater than $2D^2/\lambda$ from the antenna.
- 2 — For an antenna focused at infinity, the far field region is sometimes referred to as the Fraunhofer region on the basis of analogy to optical terminology.

spurious transmitter output, conducted: Any spurious output of a radio transmitter conducted over a tangible transmission path.

NOTE — Power lines, control leads, radio frequency transmission lines and waveguides are all considered as tangible paths in the foregoing definition. Radiation is not considered a tangible path in this definition.

broadband spurious emission: The term as used in this recommended practice is applicable to modulation products near the carrier frequency generated as a result of the normal modulation process of the transmitter and appearing in the spectrum outside the authorized bandwidth (FCC). The products may result from overdeviation or internal distortion and noise and may have a Gaussian distribution.

standard transmitter test modulation: The standard test modulation shall be 60% of the maximum rated deviation at 1 kHz.

spurious emission power: Any part of the radio frequency output that is not a component of the theoretical output, as determined by the type of modulation and specified bandwidth limitations.

conducted spurious emission power: Any part of the spurious emission power output conducted over a tangible transmission path. Radiation is not considered a tangible path.

radiated spurious emission power: Any part of the spurious emission power output radiated from the transmitter enclosure, independent of any associated transmission lines or antenna, in the form of an electromagnetic field composed of variations of the intensity of electric and magnetic fields.

spurious emission power radiation field: That portion of the spurious emission power which may be radiated from a transmitter enclosure and which can be measured in the near or far field regions.

near field region, radiating: (See **near field region**.) Measurement is limited to the region external to the induction field and extending to the outer boundary of the reactive field which is commonly taken to exist at a distance of $\lambda/2\pi$. Either the electric or magnetic component of the radiated energy may be used to determine the magnitude of power present.

far field region, radiating: (See **far field region**.) Measurement is performed at or beyond a distance of 3λ , but not less than 1 m.

antenna correction factor: A factor (usually supplied with the antenna) which, when properly applied to the meter reading of the measuring instrument, yields the electric field strength in V/m or the magnetic field strength in A/m.

NOTES:

- 1 — This factor includes the effects of antenna effective length and impedance mismatch plus transmission line losses.
- 2 — The factor for electric field strength is not necessarily the same as the factor for the magnetic field strength.

2.3 Performance Characteristics

spurious transmitter output, extraband: Spurious output of a transmitter outside of its specified band of transmission.

intermodulation spurious emission: External radio frequency (RF) emission of a transmitter which is a product of the nonlinear mixing process in the final stage of the transmitter which occurs when external RF power is coupled through the antenna output.

modulation sideband spectrum: The sideband energy produced at a discrete frequency separation from the carrier due to all sources of unwanted noise within the transmitter in a modulated condition.

SINAD: An acronym for *signal plus noise plus distortion to noise plus distortion ratio*, expressed in dB, where the *signal plus noise plus distortion* is the audio power recovered from a modulated radio frequency carrier, and the *noise plus distortion* is the residual audio power present after the audio signal is removed. This ratio is a measure of audio output signal quality for a given receiver audio power output level.

3. References

- [1] ANSI C63.2-1979, Specifications for Electromagnetic Noise and Field-Strength Instrumentation, 10 kHz to 1 GHz¹
- [2] ANSI C63.3-1964, Specifications for Radio-Noise and Field-Strength Meters, 20 to 100 Megacycles/Second
- [3] ANSI/IEEE Std 100-1977, Standard Dictionary of Electrical and Electronics Terms
- [4] IEEE Std ANSI/IEEE Std 152-1953 (Reaff 1971) Recommended Practice for Volume Measurements of Electrical Speech and Program Waves,

¹ANSI documents are available from the American National Standards Institute, 1430 Broadway, New York, N.Y. 10017.

- [5] ANSI/IEEE Std 184-1969, Test Procedure for Frequency-Modulated Mobile Communications Receivers
- [6] ANSI/IEEE Std 376-1975, Standard for the Measurement of Impulse Strength and Impulse Bandwidth
- [7] IEEE Std 151-1965 (Reaff 1971), Standard Definitions of Terms for Audio and Electroacoustics
- [8] IEEE Std 291-1969, Standards Report on Measuring Field Strength in Radio Wave Propagation
- [9] IEC Pub No 106-1974, Recommended Methods of Measurement of Radiated and Conducted Interference from Receivers for Amplitude Modulation, Frequency Modulation, and Television Broadcast Transmissions²

4. Test Conditions, Apparatus and Assembly

4.1 Test Conditions

In order to reproduce and verify the data resulting from the tests included in this test procedure, the temperature and humidity shall be specified in the data presentation. The test supply voltage shall be equivalent to the voltage which is normally applied to the input of the power cables supplied with the transmitter. The voltage shall be recorded with the data presentation. The following requirements provide measurements with reasonable accuracy and illustrate minimum test equipment configurations to support the method of measurement recommended.

4.1.1 Environmental

Case radiation of narrowband spurious and harmonic emissions are measured by the open field measurement technique. Figure 1 illustrates the configuration of the measurement system. The measuring equipment is located within a shielded enclosure, separate from the equipment to be tested. The equipment to be tested is mounted on a turntable in an open area. The ambient electromagnetic energy level within the shielded enclosure shall be at least 10 dB below the minimum level to be measured. The open area should provide unobstructed clearance in all directions from the antenna probe and the unit under test for a distance of at least 30 m to prevent multipath from reflecting or conducting objects (for example, large buildings, electric lines, buried pipes, metallic fences and trees).

The turntable shall have an effective ground plane defined by the following. The area shall not be less than 2.25 m². The thickness shall not be less than 0.25 mm for copper, 0.63 mm for brass. The smallest lineal dimension shall not be less than 76.0 cm. It shall be bonded by a single conduction point to a common earth reference point with a minimum bonding resistance of 2.5 m Ω . The equipment base plate shall be connected to this point by a minimum of four bonding straps. The bonding straps shall have a length not greater than 5 times the width, with a maximum thickness of 0.064 cm. Braid shall not be used. Preferred metals are copper or brass. Equipment mounting bases of dissimilar metals shall not be used unless they are close together in the electromotive series or suitably plated to minimize galvanic or electrolytic corrosion. The ground plane or its mounting structure shall not be used as a ground return for power. The case of the unit under test together with any test devices shall be electrically connected to the ground plane at one point only. This point on the ground plane shall be located so as to permit the shortest possible metallic path to each equipment's common ground return. The point on the ground plane shall be located as close as possible to its earth reference. Power input leads shall be shielded up to the point of attachment but without a shield to case electrical path. Water mains, grounded metal building frames or similar buried metallic structures 10 m or longer can be used for an earth reference. A line stabilization network shall be used in each power lead, with its case grounded by the shortest path to the earth reference point of the ground plane. The power line shields shall be connected to the line stabilization network case ground reference point for their shield return.

²International Electrotechnical Commission (IEC) documents are available from the American National Standards Institute, 1430 Broadway, New York, N.Y. 10017.

4.1.2 Standard Electrical Test Conditions

Direct current or alternating current voltages applied to the inputs of the equipment under test shall be regulated to the specified limits required by the manufacturer and shall be measured at the inputs of the power cable with a meter having an accuracy of $\pm 1.0\%$ full scale reading.

4.2 Test Apparatus

4.2.1 Frequency Selective Voltmeter

A frequency selective voltmeter or calibrated receiver which can tune over the full range of radiated or conducted frequencies of interest is required. Standard noise and field strength measuring sets which meet the requirements of ANSI C63.2-1979 [1]³ or ANSI C63.31964 [2] and include calibrated loops and dipole antennas will normally satisfy this requirement. The instrument's susceptibility to radiated energy should be well below the shielded enclosure's internal ambient RF field level as determined by its attenuation versus frequency characteristics (see 4.1.1). Any spurious responses should be clearly identified and recorded. Any harmonic responses should be clearly identified and recorded. Any harmonic responses not identified with the unit under test shall be isolated by use of high pass filters and included in the calibration record. The instrument's background noise spectrum shall be measured and recorded. This may be done by terminating the input with a resistive load ($50\ \Omega$) and adjusting the peak calibration control, that is, aural null slideback bias, to the threshold of audibility. Then replace the load with a calibrated impulse generator and adjust its output to match the background noise spectrum level. Record this value. A similar technique should be used to establish the test site ambient noise level. Replace the antenna or probe with the impulse generator. Means shall be provided to enable meter readings over the full range of the input attenuator, including frequencies below 20 MHz down to 0.15 MHz. The impulse bandwidth, if not specified, should be determined and recorded. See ANSI/IEEE Std 376-1975 [6].

4.2.1.1 Signal Detection

The average mode of signal detection is preferred for narrowband measurements since it is independent of carrier modulation within the modulation acceptance bandwidth of the receiver with less than 2.0 dB measurement error. In the substitution process, this error can be accounted for when the modulation characteristic is known when using a calibrated input source. The combined receiver and antenna sensitivity shall be adequate to permit measurement of -120 dBW/m^2 up to 300 MHz and -110 dBW/m^2 from 300 MHz to 1000 MHz after accounting for the insertion losses of all interconnecting cables, input couplers, filters, isolation networks or attenuators.

4.2.2 Modulation Sideband Receiver

A receiver having frequency selectivity characteristics which conform to those illustrated in Fig 2 is required to perform the tests described in 5.1.2.1 and 5.2.2. The operating frequency range of this receiver must be equivalent to that of the transmitter under test.

The receiver selectivity should be measured in accordance with ANSI/IEEE Std 184-1969 [5] and displayed on semilog graph paper as shown in Fig 2. Its 6 dB half bandwidth should be noted and recorded.

4.2.3 Modulation Monitor Receiver

The receiver shall be of the FM type and be such that the minimum intermediate frequency (IF) bandwidth is $\pm 75\text{ kHz}$ at the 6 dB points. The discriminator and audio circuit frequency response shall be flat to within $\pm 1\text{ dB}$ from 100 Hz to 10 kHz. The receiver shall be capable of being tuned over the frequency range of 25 to 1000 MHz. The residual hum and noise level shall be measured at the audio output terminals of the receiver when the output is terminated in a standard load and shall be expressed in dB below rated power output. A standard input signal source shall be connected

³The numbers in brackets correspond to those of the references in Section 3.