



IEEE Standard Definitions of Terms Relating to Corona and Field Effects of Overhead Power Lines

IEEE Power and Energy Society

Developed by the
Transmission and Distribution Committee

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STANDARDS

IEEE Standard Definitions of Terms Relating to Corona and Field Effects of Overhead Power Lines

Developed by the

Transmission and Distribution Committee
of the
IEEE Power and Energy Society

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IEEE SA Standards Board

Abstract: Definitions and usage of terms used in the measurement and analysis of corona and field effects of overhead power lines are presented in this standard. Correlation between measurements from equipment to standard terms is defined. Weather conditions such as rain, snow, and fog are defined and their measurement standards discussed. The intent is to assist in correlating standard terms found in literature and requirements to standard engineering practice.

Keywords: audible noise, corona, coupled voltage, electric field, electric field meter, fair weather, field effects, foul weather, freezing rain, ion, IEEE 539™, magnetic field, perturbed field, radio noise, rain, snow, Trichel streamers, uniform field, wet snow

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Introduction

This introduction is not part of IEEE Std 539-2020, IEEE Standard Definitions of Terms Relating to Corona and Field Effects of Overhead Power Lines.

The purpose of this standard is to achieve uniformity in the use of terms relating to the areas of corona and the electromagnetic environment of power lines. Its scope is to define the most widely used terms specific to or associated with overhead power-line corona and field effects.

The original IEEE Std 539 and its 1979 and 1990 revisions were limited to terms relating to overhead power-line corona and radio noise. Since that time, the areas of interest have broadened to include audible noise, electric and magnetic fields, and space charge. The 2005 revision was broadened to include all aspects of power-line corona and electromagnetic fields. The 2005 revision marks the departure from the traditional method of specifying levels as they relate to sound pressure levels, exceedance levels, rain levels, etc. It adopted the method specified in the National Institute of Standards and Technology, Special Publication 811, Guide for the Use of the International System of Units (SI), 1995 Edition.

The 2020 revision is similar in content to the 2005 revision, but the format of the 2020 revision was significantly changed to correspond to the new IEEE standard formatting. The 2020 revision also sought to include definitions from recently accepted standards within the Corona and Field Effects Working Group and unify the language of those definitions herein.

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IEEE Standard Definitions of Terms Relating to Corona and Field Effects of Overhead Power Lines

1. Overview

1.1 Scope

The scope of this standard is to define the most widely used terms specific to or associated with overhead power-line corona and field effects.

1.2 Purpose

The purpose of this standard is to achieve uniformity in the use of terms relating to the areas of corona and the electromagnetic environment of power lines.

1.3 Word usage

The word *shall* indicates mandatory requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted (*shall* equals *is required to*).^{1, 2}

The word *should* indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required (*should* equals *is recommended that*).

The word *may* is used to indicate a course of action permissible within the limits of the standard (*may* equals *is permitted to*).

The word *can* is used for statements of possibility and capability, whether material, physical, or causal (*can* equals *is able to*).

2. Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause.³

¹The use of the word *must* is deprecated and cannot be used when stating mandatory requirements; *must* is used only to describe unavoidable situations.

²The use of *will* is deprecated and cannot be used when stating mandatory requirements; *will* is only used in statements of fact.

³*IEEE Standards Dictionary Online* is available at: <http://dictionary.ieee.org>. An IEEE Account is required for access to the dictionary,

acoustic noise: *See:* **audible noise.**

ambient noise: The all-encompassing noise associated with a given environment, usually a composite of contributions from many sources near and far.

audible noise (AN): Any undesired sound. *Syn:* **acoustic noise.**

background noise: The total of all sources of interference in a system used for the production, detection, measurement, or recording of a signal, independent of the presence of the signal.

NOTE—Ambient noise detected, measured, or recorded with the signal becomes part of the background noise.⁴

conducted radio noise: Radio noise that is propagated by conduction from a source through electrical connections.

decibel (dB): One-tenth of a bel, the number of decibels denoting the ratio of two amounts of power being 10 times the common logarithm of this ratio.

NOTE—The abbreviation dB is commonly used for the term decibel. With P_1 and P_2 designating two amounts of power, and the number of decibels denoting their ratio.

$$n = 10 \log \left(\frac{P_1}{P_2} \right) \text{ dB} \quad (1)$$

When the conditions are such that ratios of currents or ratios of voltages (or analogous quantities in other disciplines) are the square roots of the corresponding power ratios, the number of decibels by which the corresponding powers differ is expressed by the following equations:

$$n = 20 \log \left(\frac{I_1}{I_2} \right) \text{ dB} \quad (2)$$

$$n = 20 \log \left(\frac{V_1}{V_2} \right) \text{ dB} \quad (3)$$

where

$\frac{I_1}{I_2}$ is the given current ratio
 $\frac{V_1}{V_2}$ is the given voltage ratio

By extension, these relations between numbers of decibels and ratios of currents or voltages are sometimes applied where these ratios are not the square roots of the corresponding power ratios; to avoid confusion, such usage should be accompanied by a specific statement of the application in question.

electromagnetic noise: A time-varying electromagnetic phenomenon that apparently does not convey information and that may be superimposed on or combined with a wanted signal.

fluctuation noise: *See:* **random noise.**

frequency spectrum: The distribution of the amplitude (and sometimes the phase) of the frequency components of a signal, as a function of frequency.

and one can be created at no charge on the dictionary sign-in page.

⁴Notes in text, tables, and figures are given for information only, and do not contain requirements needed to implement the standard.

frequency: The number of complete cycles of sinusoidal variation per unit time.

NOTE 1—Electric and magnetic field components have a fundamental frequency equal to that of the power line voltages and currents.

NOTE 2—For ac power lines, the most widely used frequencies are 60 Hz and 50 Hz.

harmonic content: Distortion of a sinusoidal waveform characterized by the magnitude and the order of the Fourier series terms that describe the wave.

NOTE—For power lines, the harmonic content is typically small and of little concern for the purpose of field measurements, except at points near large industrial loads (saturated power transformers, rectifiers, aluminum and chlorine plants, etc.), where certain harmonics may reach 10% of the line voltage. Power equipment such as dc-to-ac and ac-to-dc converters also may produce harmonics. Laboratory installations may also have voltage or current sources with significant harmonic content.

impulse noise: Noise characterized by transient disturbances separated in time by quiescent intervals.

NOTE 1—The frequency spectrum of these disturbances is substantially uniform over the useful passband of the transmission system.

NOTE 2—The same source may produce impulse noise in one system and random noise in a different system.

lateral profile: The profile of a parameter, usually near ground level, plotted as a function of the horizontal distance from and at a right angle to the line conductors. For example, a lateral profile of the vertical component of the electric field strength, of the radio noise field strength, etc.

level: Magnitude, especially when considered in relation to an arbitrary reference value. Level may be stated in the units in which the quantity itself is measured (e.g., volts and ohms) or in the units (e.g., decibels) expressing the ratio to a reference value.

NOTE 1—Examples of the kinds of levels in common use are electric power level, sound pressure level, and voltage level.

NOTE 2—In symbols

$$L = k \log_r \left(\frac{q}{q_o} \right) \quad (4)$$

where

- L is the level determined by the kind of quantity under consideration
- r is the base of the logarithm of the reference ratio
- q is the quantity under consideration
- q_o is the reference quantity of the same kind
- k is a multiplier that depends upon the base of the logarithm and the nature of the reference quantity

NOTE 3—The level as defined here is measured in two common units: decibels when the logarithmic base is 10 or nepers when the logarithmic base is e . The decibel requires that k be 10 for ratios of power or 20 for quantities proportional to the square root of power. The neper is used to represent ratios of voltage, current, sound pressure, and particle velocity. The neper requires that k be 1.

longitudinal profile: The profile of a parameter, usually near ground level, measured at a constant lateral distance from the power line and plotted as a function of distance along the line. For example, a longitudinal profile of the vertical component of the electric field strength, of the radio noise field strength, etc.

noise: An undesired disturbance within the useful frequency band.

profile: A diagram showing the variation of a quantity or parameter with location.

radiated noise: Radio noise energy in the form of an electromagnetic field including both the radiation and induction components of the field.

radio noise (RN): Any unwanted disturbance within the radio frequency band, such as undesired electromagnetic waves in any transmission channel or device.

random noise: Noise that comprises transient disturbances occurring at random. *Syn:* **fluctuation noise.**

NOTE 1—Random noise is the part of noise that is unpredictable except in a statistical sense. The term is most frequently applied to limiting cases where 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.

NOTE 2—A random noise whose instantaneous magnitudes occur according to the Gaussian distribution is called *Gaussian random noise*.

NOTE 3—In power-line noise, random noise is a component of the total noise caused by discharges.

signal: The intelligence, message, or effect conveyed over a communication system.

signal-to-noise ratio (S/N): The ratio of the value of the signal to that of the noise.

NOTE 1—This ratio is usually in terms of measured peak values in the case of impulse noise and in terms of the root-mean-square (rms) values in the case of random noise.

NOTE 2—Where there is a possibility of ambiguity, suitable definitions of the signal and noise should be associated with this term; as, for example, peak signal to peak noise ratio, rms signal to rms noise ratio, peak-to-peak signal to peak-to-peak noise ratio, etc. In measurements of transmission line noise in the AM frequency range, the ratio of average station signal level to quasi-peak line noise level is generally used.

NOTE 3—This ratio often may be expressed in decibels (dB).

NOTE 4—This ratio may be a function of the bandwidth of the transmission or measuring system.

unwanted signal: A signal that may impair the measurement or reception of a wanted signal.

wanted signal: A signal that constitutes the object of the particular measurement or reception.

wave: A disturbance propagated in a medium.

NOTE—*Disturbance* in this definition is used as a generic term indicating not only mechanical displacement but also voltage, current, electric field strength, temperature, etc. Any physical quantity that has the same relationship to some independent variable (usually time) as a propagated disturbance, (at a particular instance) with respect to space, may be called a wave.

wavelength: The distance between points of the corresponding phase of two consecutive cycles of a sinusoidal wave. The wavelength, λ , is related to the phase velocity, v , and the frequency, f , by $\lambda = v/f$.

white noise: Noise, either random or impulsive, that has a flat frequency spectrum in the frequency range of interest.

3. Statistical terms

The levels defining corona and field effects on transmission lines are variable in time and cannot, without qualification, be adequately characterized by a single value. Many statistical terms are applied to levels defining corona and field effects. The following definitions apply to more commonly used terms (*See also A Dictionary of Statistical Terms*, 4th edition, and *Mathematics Dictionary*, 4th edition).

all weather distribution: A distribution of corona-effect data collected under all weather conditions. Such data are usually obtained from long-term recording stations.

NOTE—Weather classifications are defined in [Clause 4](#).

arithmetic mean: The numerical result obtained by dividing the sum of two or more quantities by the number of quantities. *Syn:* **average**.

NOTE 1—Strictly speaking, arithmetic means of corona-effect data expressed in decibels cannot be taken unless the sound pressure values are converted back to field quantity values, expressed in units such as microvolts per meter ($\mu\text{V}/\text{m}$) or micropascals (μPa).

NOTE 2—An arithmetic mean that is commonly used in audible noise investigations is the energy average of the quantities [see **energy-equivalent sound level** ($L_{A,eq}$)]. The units in decibels above 20 μPa are converted to energy units such as microwatts (μW), which are then averaged.

average: *See:* **arithmetic mean**.

exceedance level: A statistical descriptor that is often used in expressing levels of quantities. For example, in acoustics, the $L_{A,10\%}$ is the A-weighted sound level exceeded for 10% of the time over a specified time period (and for corona noise and a specified weather condition). For the other 90% of the time, the sound level is less than the $L_{A,10\%}$. Similarly, the $L_{A,50\%}$ is the sound level exceeded 50% of the time; the $L_{A,90\%}$ is the sound level exceeded 90% of the time, etc.

The concept of exceedance levels can also be used as a statistical term for other corona effects such as radio noise, corona loss, and dc fields and ions. Any exceedance level can be easily obtained from distributions that have been plotted on probability paper. *Syn:* **L-level**.

NOTE—When using this format for specifying levels for quantities such as rain, the form would be $L_{\text{rain},10\%}$, which would indicate the level of rain that would be exceeded 10% of the time over a specified time period.

fair weather distribution: A frequency or probability distribution of corona-effect data collected under fair weather conditions.

foul weather distribution: A frequency or probability distribution of corona-effect data collected under foul weather conditions. Other distributions can also be defined for more specific foul weather conditions such as rain, snow, fog, sleet, frost, etc.

frequency of occurrence: If a process is repeated n times, during which an event occurs m times, the frequency of occurrence of the event, h , is defined as $h = m/n$. For large values of n , the frequency approaches the asymptotic value, called *probability of occurrence*.

general statistical terms: Terms applied to the procedures of data collection, classification, and presentation.

geometric mean: The numerical result obtained by taking the n th root of the product of n quantities, n being equal to or greater than two.

NOTE—In radio noise measurements, geometric means have been used to determine the long-line frequency spectrum from the short-line frequency spectrum by taking the geometric mean of the maximum and minimum values in microvolts per meter across the spectrum (or the arithmetic mean of values in decibels).

L-level: *See:* **exceedance level.**

median ($L_{50\%}$): The level exceeded 50% of the time over a specified time period with a specified weather condition.

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

NOTE—An expression giving the probability of a discrete random variable x as a function of x or, for continuous random variables, the probability in an elemental range dx . The total probability is unity or 100%, so that the probability density function represents the proportion of probabilities for particular values of x .

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

NOTE 1—The distribution function $P(x)$ for a random variable x is the total frequency of occurrence of members with particular random-variable values less than or equal to x . The total frequency of occurrence of all values of x is unity or 100%, so that the distribution function is the proportion of members bearing values less than or equal to x . Similarly, for n , particular values of the random variable, $x_1, x_2, \dots, x_n$, the distribution function $P(x_1, x_2, \dots, x_n)$ is the frequency of values less than or equal to x_1 , for the first values, x_2 for the second, and so on.

NOTE 2—The terms *cumulative probability distribution* and, very often, simply *distribution* are used to denote the probability distribution function.

probability of occurrence: The asymptotic value of the frequency of occurrence of the event.

probability paper: A graph paper with the grid along the ordinate specially ruled so that the distribution function of a specified distribution can be plotted as a straight line against the variable on the abscissa. These specially ruled grids are available for the normal, binomial, Poisson, log-normal, and Weibull distributions, respectively.

statistical terms related to corona effects: Terms applied to the procedures of data collection, classification, and presentation relating to corona effects.

4. Weather classifications

Corona phenomena are drastically affected by the weather. Foul weather conditions have the greatest effect on corona generation, and it is important to have a common understanding of the weather terms that are used (see *American Meteorology Society Glossary of Meteorology*).⁵

crystalline frost: *See:* **hoarfrost.**

fair weather: The weather condition when the precipitation intensity is zero and the transmission line conductors are dry.

NOTE—This should not be confused with the general connotation of fair weather as descriptive of pleasant weather conditions. Common usage is subject to misinterpretation, for it is a purely subjective description. Technically, when this term is used in weather forecasts, it is meant to imply no precipitation, less than 40% sky cover of low clouds, and no other extreme conditions of cloudiness, visibility, or wind.

⁵This publication is available at https://glossary.ametsoc.org/wiki/Main_Page.

fog: Visible aggregate of minute water droplets suspended in the atmosphere near the earth's surface. According to international definition, fog reduces visibility below 1 km. Fog differs from clouds only in that the base of fog is at the earth's surface while clouds are above its surface. When composed of ice crystals, it is termed *ice fog*.

Fog is easily distinguished from haze by its appreciable dampness and gray color. Mist may be considered as intermediate between fog and haze. Mist particles are microscopic in size. Mist is less damp than fog and does not restrict visibility to the same extent. There is no distinct division, however, between any of these categories. Near industrial and heavy traffic areas, fog often is mixed with smoke and vehicle exhaust, and this combination is known as *smog*.

NOTE—Under fog or other dew formation conditions, conductors can become wet or dry depending upon the level of the load current in the conductors. Medium to high load currents produce enough heat through I^2R (resistance) losses to discourage dew formation. Load current also speeds up the drying process after rain, fog, wet snow, etc.

foul weather: The weather condition when there is precipitation or that can cause the transmission line conductors to be wet. Fog is not a form of precipitation, but it causes conductors to be wet. Dry snow is a form of precipitation, but it may not cause the conductors to be wet.

freezing fog: A fog whose droplets freeze upon contact with exposed objects and form a coating of hoarfrost and/or glaze.

freezing rain: Rain that falls in liquid form but freezes on impact to form a coating of glaze upon the ground and on exposed objects.

frost: *See:* **hoarfrost**.

hoar: *See:* **hoarfrost**.

hoarfrost: A deposit of interlocking ice crystals (hoar crystals) formed by direct sublimation on objects, usually those of small diameter, freely exposed to the air, such as tree branches, plant stems and leaf edges, wires, poles, etc.

The deposition of hoarfrost on an object is similar to the process by which dew is formed, except that the temperature of the object is below freezing. It forms when air with a dew point below freezing is brought to saturation by cooling. *Syn:* **crystalline frost; frost; hoar; white frost**.

intensity of precipitation: *See:* **precipitation intensity**.

mixed rain and snow: Precipitation consisting of a mixture of rain and wet snow. It usually occurs when the temperature of the air layer near the ground is slightly above freezing.

precipitation intensity: The rate of precipitation, usually expressed in millimeters per hour (mm/h). Since precipitation intensity in general is not constant, an average over some time period shorter than 1 h is most useful, unless instantaneous intensity is measured. *Syn:* **intensity of precipitation**.

NOTE—Rain gauge measurements can provide an indication of intensity except for light rain, where the quantization error is large.

rain: Precipitation in the form of liquid water drops with diameters greater than 0.5 mm or, if widely scattered, smaller diameters.

For observation purposes, the intensity of rainfall at any given time and place may be classified as follows: