

IEEE Standard Definitions of Terms for Antennas

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Abstract: Definitions of terms in the field of antennas are provided.
Keywords: antennas, definitions, propagation, terminology

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Introduction

(This introduction is not a part of IEEE Std 145-1993, IEEE Standard Definitions of Terms for Antennas.)

This document is a revision of IEEE Std 145-1983, IEEE Standard Definitions of Terms for Antennas, and corrects minor errors that appeared in that printing. The original standard was issued in 1969.

The following persons were on the working group that developed this document:

Donald G. Bodnar, *Chair*

Charles C. Allen
A. David Bresler
Richard H. Bryan
Robert B. Dybdal
William J. English
E. S. Gillespie
Edward Hart
Doren Hess

Edward Joy
Walter K. Kahn
Flemming H. Larsen
Richard B. Mack
Allen C. Newell
H. George Oltman
A. David Olver
Harold R. Raemer

Antoine G. Roederer
Allen C. Schell
Alan J. Simmons
G. P. Tricoles
Michael T. Tuley
Edward A. Urbanik
A. T. Villeneuve
Jonathan D. Young

The following persons were on the balloting committee that approved this document for submission to the IEEE Standards Board:

Charles C. Allen
Donald G. Bodnar
A. David Bresler
Richard H. Bryan
Robert B. Dybdal
William J. English
E. S. Gillespie
Edward Hart

Doren Hess
Edward Joy
Walter K. Kahn
Flemming H. Larsen
Richard B. Mack
Allen C. Newell
H. George Oltman
A. David Olver
Harold R. Raemer

Antoine G. Roederer
Allen C. Schell
Alan J. Simmons
G. P. Tricoles
Michael T. Tuley
Edward A. Urbanik
A. T. Villeneuve
Jonathan D. Young

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IEEE Standard Definitions of Terms for Antennas

1. Overview

1.1 Scope

It is assumed in this standard that an antenna is a passive linear reciprocal device. Thus, where a definition implies the use of an antenna in a transmitting situation, its use in a receiving situation is also implicit, unless specifically stated otherwise.

When an antenna or group of antennas is combined with circuit elements that are active, nonlinear, or nonreciprocal, the combination is regarded as a system that includes an antenna. Examples of such cases are an adaptive antenna system and a signal-processing antenna system; the complete conical-scanning, monopulse, and compound interferometer systems also fall in this category.

For terms that are quantitative, it is understood that frequency must be specified. For those in which phase or polarization is a significant part of the definition, a coherent source of power is implied. Whenever a term is commonly used in other fields but has specialized significance in the field of antennas, this is noted in the title.

When applying terms pertaining to radiation characteristics, such as gain, polarization, beamwidth, etc., to multiple-beam antennas, each port shall be considered to be that of a separate antenna with a single main beam. For polarization diversity systems that may include active devices, these terms apply to each polarization state for which the antenna is adjusted.

Throughout this standard, where phasors are used, or are implied, the time convention shall be taken to be $\exp(j\omega t)$.

1.2 Background

The definitions of terms contained herein, for the most part, stand alone and are easily understood out of context. The terms pertaining to gain, directivity and polarization, however, are interrelated and hence require some elaboration.

The viewpoint taken for polarization is that this term can be used in three related meanings. It can apply

- a) To a field vector at some point in space
- b) To a plane wave
- c) To an antenna

The *polarization of a field vector* specifies the shape, orientation, and sense of the ellipse that the extremity of the field vector describes as a function of time. This applies to any field vector: electric field, magnetic field, velocity field in a plasma, displacement field in a solid, etc. In a single-frequency plane wave, a specified field vector has the same polarization at every point in space. This is taken as the *polarization of the plane wave*. Conventionally, in electromagnetics, the electric field is considered rather than the magnetic field. However, in a nonisotropic medium, the polarization state of the plane wave requires consideration of all its vector components. The third application of the term *polarization* is to antennas. The *polarization of*

an antenna in a given direction is that of the plane wave it radiates at large distances in that direction. By reciprocity, a plane wave coming from that direction whose polarization ellipse has the same axial ratio, orientation, and sense will yield the maximum response for a given power flux density. For best understanding, the three related definitions of polarization should be read in the above order.

One departure from previous usage should be noted. The definition of the tilt angle of the polarization ellipse now requires that it be measured according to the right-hand rule with the thumb pointing in a reference direction. For a plane wave, the reference direction is the direction of propagation. This is advantageous, since it removes any ambiguity about the specification of the orientation of the polarization ellipse. It should be noted, however, that the polarization of the antenna is defined as that of the wave it radiates, whether it is used for transmitting or receiving. This means that for the receive case, the coordinate system used to describe the polarization of the antenna and the incoming wave are oriented in opposite directions. (See IEEE Std 149-1979, IEEE Standard Test Procedures for Antennas, clause 11, Polarization.¹) There are two ways to handle this situation. One is to transform the polarization of the wave into the antenna's coordinate system; the second is to define a *receiving polarization* for the antenna, which is that of the wave to which the antenna is polarization matched. The latter was chosen both here and in IEEE Std 149-1979. This should not be taken to mean that one cannot use the antenna's coordinate system, but rather that if it is done, it should be clearly specified as the polarization of the incoming wave referred to the antenna's (transmitting) polarization. The term *receiving polarization* can also be applied to a nonreciprocal antenna that may receive only.

The interdependence of gain, polarization, and impedance has led to the inclusion of several terms, including *partial gain*, *partial directivity*, and *partial realized gain*. The interrelationships of these terms and the basic terms *gain*, *directivity* and *realized gain* are best visualized by referring to the flow chart shown in figure 1. A similar flow chart can be constructed for a receiving antenna.

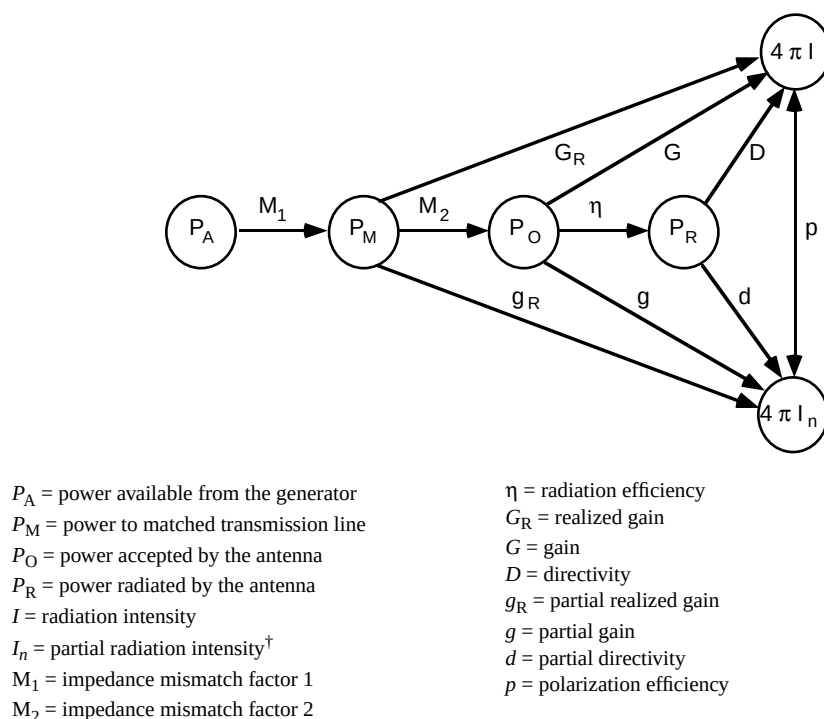


Figure 1—Gain and directivity flow chart

¹Information on the reference can be found in 1.3.

1.3 Reference

This standard shall be used in conjunction with the following publication:

IEEE Std 149-1979 (Reaff 1990), IEEE Standard Test Procedures for Antennas (ANSI).²

1.4 Definition structure

In these definitions, words or phrases in parentheses that are part of the term can be omitted when the term is used, provided they are understood from context. Those words or phrases in brackets can replace the words or phrases that immediately precede them. If bracketed words or phrases appear in several places in the definition, then all bracketed words or phrases must be used together in the definitions. For those cases where two or more terms are synonyms, the preferred term will be defined; the other terms will refer to the preferred term and be listed after the definition. Abbreviations appear after the term and are enclosed in parentheses. Terms that are no longer recommended for use are indicated as being deprecated. Synonyms for a term are listed at the end of the definition.

2. Definitions

2.1 absolute gain (of an antenna). *See: gain (in a given direction).*

2.2 active array antenna system. An array in which all or part of the elements are equipped with their own transmitter or receiver, or both.

NOTES

1—Ideally, for the transmitting case, amplitudes and phases of the output signals of the various transmitters are controllable and can be coordinated in order to provide the desired aperture distribution.

2—Often it is only a stage of amplification or frequency conversion that is actually located at the array elements, with the other stages of the receiver or transmitter remotely located.

2.3 active impedance (of an array element). The ratio of the voltage across the terminals of an array element to the current flowing at those terminals when all array elements are in place and excited.

2.4 active reflection coefficient (of an array element). The reflection coefficient at the terminals of an array element when all array elements are in place and excited.

2.5 adaptive antenna system. An antenna system having circuit elements associated with its radiating elements such that one or more of the antenna properties are controlled by the received signal.

2.6 Adcock antenna. A pair of vertical antennas separated by a distance of one-half wavelength or less, and connected in phase opposition to produce a radiation pattern having the shape of the figure eight in all planes containing the centers of the two antennas.

2.7 aerial. [Deprecated.]

2.8 Alford loop antenna. A multi-element antenna having approximately equal amplitude currents that are in phase and uniformly distributed along each of its peripheral elements and producing a substantially circular radiation pattern in its principal E-plane.

²IEEE publications are available from the Institute of Electrical and Electronics Engineers, Service Center, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA.

NOTE—This antenna was originally developed as a four-element, horizontally polarized, UHF loop antenna.

2.9 amplitude pattern. *See: radiation pattern.*

2.10 angle tracking. *See: tracking.*

2.11 annular slot antenna. A slot antenna with the radiating slot having the shape of an annulus.

2.12 antenna. That part of a transmitting or receiving system that is designed to radiate or to receive electromagnetic waves.

2.13 antenna array. *See: array antenna.*

2.14 antenna effect. [Deprecated.]

2.15 antenna efficiency of an aperture-type antenna. For an antenna with a specified planar aperture, the ratio of the maximum effective area of the antenna to the aperture area.

2.16 antenna [aperture] illumination efficiency. The ratio, usually expressed in percent, of the maximum directivity of an antenna [aperture] to its standard directivity. *Syn: normalized directivity. See: standard [reference] directivity.*

NOTE—For planar apertures, the standard directivity is calculated by using the projected area of the actual antenna in a plane transverse to the direction of its maximum radiation intensity.

2.17 antenna pattern. *See: radiation pattern.*

2.18 antenna resistance. The real part of the input impedance of an antenna.

2.19 aperiodic antenna. An antenna that, over an extended frequency range, does not exhibit a cyclic behavior with frequency of either its input impedance or its pattern.

NOTE—This term is often applied to an electrically small monopole or loop, containing an active element as an integral component, with impedance and pattern characteristics varying but slowly over the extended frequency range.

2.20 aperture (of an antenna). A surface, near or on an antenna, on which it is convenient to make assumptions regarding the field values for the purpose of computing fields at external points.

NOTE—The aperture is often taken as that portion of a plane surface near the antenna, perpendicular to the direction of maximum radiation, through which the major part of the radiation passes.

2.21 aperture blockage. A condition resulting from objects lying in the path of rays arriving at or departing from the aperture of an antenna.

NOTE—For example, the feed, subreflector, or support structure produce aperture blockage for a symmetric reflector antenna.

2.22 aperture distribution. The field over the aperture as described by amplitude, phase, and polarization distributions. *Syn: aperture illumination.*

2.23 aperture illumination. *See: aperture distribution.*

2.24 aperture illumination efficiency. *See: antenna illumination efficiency.*

2.25 area. *See: effective area (of an antenna); equivalent flat plate area of a scattering object; partial effective area (of an antenna, for a given polarization and direction).*

2.26 areal beamwidth. For pencil-beam antennas the product of the two principal half-power beamwidths. *See: principal half-power beamwidths.*

2.27 array antenna. An antenna comprised of a number of identical radiating elements in a regular arrangement and excited to obtain a prescribed radiation pattern. *Syn: antenna array.*

NOTES

1—The regular arrangements possible include ones in which the elements can be made congruent by simple translation or rotation.

2—This term is sometimes applied to cases where the elements are not identical or arranged in a regular fashion. For those cases qualifiers shall be added to distinguish from the usage implied in this definition. For example, if the elements are randomly located, one may use the term **random array antenna**.

2.28 array element. In an array antenna, a single radiating element or a convenient grouping of radiating elements that have fixed relative excitations.

2.29 array factor. The radiation pattern of an array antenna when each array element is considered to radiate isotropically.

NOTE—When the radiation patterns of individual array elements are identical, and the array elements are congruent under translation, then the product of the array factor and the element radiation pattern gives the radiation pattern of the entire array.

2.30 artificial dielectric. A medium containing a distribution of scatterers, usually metallic, that react as a dielectric to radio waves.

NOTES

1—The scatterers are usually small compared to a wavelength and embedded in a dielectric material whose effective permittivity and density are intrinsically low.

2—The scatterers may be in either a regular arrangement or a random distribution.

2.31 axial ratio (of a polarization ellipse). The ratio of the major to minor axes of a polarization ellipse.

NOTE—The axial ratio sometimes carries a sign that is taken as plus if the sense of polarization is right-handed and minus if it is left-handed. *See: sense of polarization.*

2.32 axial ratio pattern. A graphical representation of the axial ratio of a wave radiated by an antenna over a radiation pattern cut.

2.33 backfire antenna. An antenna consisting of a radiating feed, a reflector element, and a reflecting surface such that the antenna functions as an open resonator, with radiation from the open end of the resonator.

2.34 back lobe. A radiation lobe whose axis makes an angle of approximately 180 degrees with respect to the beam axis of an antenna.

NOTE—By extension, a radiation lobe in the half-space opposed to the direction of peak directivity.

2.35 back-scattering cross section. *See: monostatic cross section.*

2.36 bandwidth of an antenna. The range of frequencies within which the performance of the antenna, with respect to some characteristic, conforms to a specified standard.

2.37 Bayliss distribution, circular. A continuous distribution over a circular planar aperture that yields a difference pattern with a sidelobe structure similar to that of a sum pattern produced by a Taylor circular distribution.

2.38 Bayliss distribution, linear. A continuous distribution of a line source that yields a difference pattern with a side-lobe structure similar to that of a sum pattern produced by a Taylor linear distribution.

2.39 beam (of an antenna). The major lobe of the radiation pattern of an antenna.

2.40 beam angle. *See:* **scan angle.**

2.41 beam axis (of a pencil-beam antenna). The direction, within the major lobe of a pencil-beam antenna, for which the radiation intensity is a maximum.

2.42 beam coverage solid angle (of an antenna over a specified surface). The solid angle, measured in steradians, subtended at the antenna by the footprint of the antenna beam on a specified surface. *See:* **footprint (of an antenna beam on a specified surface).** *Contrast with:* **beam solid angle.**

2.43 beam solid angle. The solid angle through which all the radiated power would stream if the power per unit solid angle were constant throughout this solid angle and at the maximum value of the radiation intensity.

2.44 beam steering. Changing the direction of the major lobe of a radiation pattern.

2.45 beamwidth. *See:* **half-power beamwidth.**

2.46 Beverage antenna. A directional antenna composed of a system of parallel horizontal conductors from one-half to several wavelengths long, terminated to ground at the far end in its characteristic impedance. *Syn:* **wave antenna.**

2.47 biconical antenna. An antenna consisting of two conical conductors having a common axis and vertex.

2.48 bistatic cross section. The scattering cross section in any specified direction other than back toward the source. *Contrast with:* **monostatic cross section.**

2.49 blade antenna. A form of monopole antenna that is blade-shaped for strength and low aerodynamic drag.

2.50 boresight. *See:* **electrical boresight; reference boresight.**

2.51 boresight error. The angular deviation of the electrical boresight of an antenna from its reference boresight.

2.52 broadside array antenna. A linear or planar array antenna whose direction of maximum radiation is perpendicular to the line or plane, respectively, of the array.

2.53 cage antenna. A multi-wire element whose wires are so disposed as to resemble a cylinder, in general of circular cross section; for example, an elongated cage.

2.54 cardinal plane. For an infinite planar array whose elements are arranged in a regular lattice, any plane of symmetry normal to the planar array and parallel to an edge of a lattice cell.

NOTES

1—This term can be applied to a finite array, usually one containing a large number of elements, by the assumption that it is a subset of an infinite array with the same lattice arrangement.

2—This term is used to relate the regular geometrical arrangement of the array elements to the radiation pattern of the antenna.

2.55 Cassegrain reflector antenna. A paraboloidal reflector antenna with a convex subreflector, usually hyperboloidal in shape, located between the vertex and the prime focus of the main reflector.

NOTES

1—To improve the aperture efficiency of the antenna, the shapes of the main reflector and the subreflector are sometimes modified.

2—There are other alternate forms that are referred to as Cassegrainian. Examples include the following: one in which the subreflector is surrounded by a reflecting skirt and one that utilizes a concave hyperboloidal reflector. When referring to these alternate forms the term shall be modified in order to differentiate them from the antenna described in the definition.

2.56 cheese antenna. A reflector antenna having a cylindrical reflector enclosed by two parallel conducting plates perpendicular to the cylinder, spaced more than one wavelength apart. *Contrast with:* **pillbox antenna.**

2.57 circular array. An array of elements whose corresponding points lie on a circle. *Syn:* **ring array.**

NOTE—Practical circular arrays may include arrangements of elements that are congruent under translation or rotation.

2.58 circular Bayliss distribution. *See:* **Bayliss distribution, circular.**

2.59 circular grid array. An array of elements whose corresponding points lie on coplanar concentric circles.

2.60 circularly polarized field vector. At a point in space, a field vector whose extremity describes a circle as a function of time.

NOTE—Circular polarization may be viewed as a special case of elliptical polarization where the axial ratio has become equal to one.

2.61 circularly polarized plane wave. A plane wave whose electric field vector is circularly polarized.

2.62 circular scanning. Scanning where the beam axis of the antenna generates a conical surface.

NOTE—This can include the special case where the cone degenerates to a plane.

2.63 circular Taylor distribution. *See:* **Taylor distribution, circular.**

2.64 coaxial antenna. An antenna comprised of an extension to the inner conductor of a coaxial line and a radiating sleeve that in effect is formed by folding back the outer conductor of the coaxial line. *Contrast with:* **sleeve-dipole antenna.**

2.65 collinear array antenna. A linear array of radiating elements, usually dipoles, with their axes lying in a straight line.

2.66 complex conductivity. For isotropic media, at a particular point, and for a particular frequency, the ratio of the complex amplitude of the total electric current density to the complex amplitude of the electric field strength.

NOTE—The electric field strength and total current density are both expressed as phasors, with the latter composed of the conduction current density plus the displacement current density.

2.67 complex dielectric constant. The complex permittivity of a physical medium in ratio to the permittivity of free space.

2.68 complex permittivity. For isotropic media, the ratio of the complex amplitude of the electric displacement density to the complex amplitude of the electric field strength.

2.69 complex polarization ratio. For a given field vector at a point in space, the ratio of the complex amplitudes of two specified orthogonally polarized field vectors into which the given field vector has been resolved. *See: plane wave, NOTE 2.*

NOTE—For these amplitudes to define definite phase angles, particular unitary vectors (basis vectors) must be chosen for each of the orthogonal polarizations. *See: polarization vector, especially NOTE 1.*

2.70 compound circular horn antenna. A horn antenna of circular cross section with two or more abrupt changes of flare angle or diameter.

2.71 compound horn antenna. *See: compound circular horn antenna; compound rectangular horn antenna.*

2.72 compound interferometer system. An antenna system consisting of two or more interferometer antennas whose outputs are combined using nonlinear circuit elements such that grating lobe effects are reduced.

2.73 compound rectangular horn antenna. A horn antenna of rectangular cross section in which at least one pair of opposing sides has two or more abrupt changes of flare angle or spacing.

2.74 conformal antenna [conformal array]. An antenna [an array] that conforms to a surface whose shape is determined by considerations other than electromagnetic; for example, aerodynamic or hydrodynamic.

2.75 conformal array. *See: conformal antenna.*

2.76 conical array. A two-dimensional array of elements whose corresponding points lie on a conical surface.

2.77 conical scanning. A form of sequential lobing in which the direction of maximum radiation generates a cone whose vertex angle is of the order of the antenna half-power beamwidth.

NOTE—Such scanning may be either rotating or nutating according to whether the direction of polarization rotates or remains unchanged.

2.78 contoured beam antenna. A shaped-beam antenna designed in such a way that when its beam intersects a given surface, the lines of equal power flux density incident upon the surface form specified contours. *See: footprint (of an antenna beam on a specified surface).*

2.79 co-polarization. That polarization that the antenna is intended to radiate [receive]. *See: polarization pattern, NOTES 1 and 2.*

2.80 co-polar (radiation) pattern. A radiation pattern corresponding to the co-polarization. *See: co-polarization.*