

IEEE Standard for Definitions of Terms for Antennas

IEEE Antennas and Propagation Society

Sponsored by the
Antennas Committee



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Antennas Committee
of the
IEEE Antennas and Propagation Society

Approved 11 December 2013

IEEE-SA Standards Board

Abstract: Definitions for antennas and for systems that incorporate an antenna as a component of the system are established in this standard.

Keywords: antennas, definitions, IEEE 145™, terms

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Introduction

This introduction is not part of IEEE Std 145™-2013, IEEE Standard for Definitions of Terms for Antennas.

This document is an updated release of standardized definitions for terms commonly used in the field of antennas. It is anticipated that future revisions to this standard will include additional terms, particularly in the field of active signal-processing antennas

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1. Overview

1.1 Scope

This standard establishes definitions for antennas and for systems that incorporate an antenna as a component of the system.

1.2 Purpose

Many individuals and organizations are involved in the design, manufacture, measurement and use of antennas for many different applications. This standard is intended to provide a set of standard definitions for the community so that when terminology is used all will understand its meaning.

1.3 Background

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

The viewpoints taken for polarization are that the ~~is that this~~ term can be used in three related meanings. ~~It~~ and can apply:

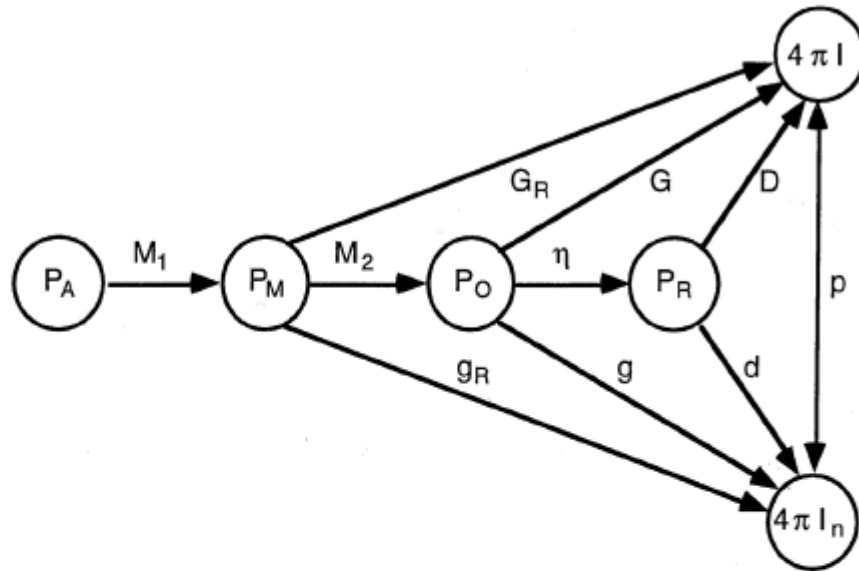
- a) To a field vector at some point in space
- b) To a plane wave
- c) To an antenna

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 to be~~ the polarization of the plane wave. ~~Conventionally,~~ In electromagnetics, conventionally the electric field is considered rather than the magnetic field. However, in a non-isotropic 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~~ with a polarization ellipse that 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. However, 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 receiving case, the coordinate system used to describe the polarization of the antenna and the incoming wave ~~are~~ is oriented in opposite directions (see Clause 11 of IEEE Std 149TM-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 only receive.

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 flowchart shown in Figure 1. A similar flow-chart can be constructed for a receiving antenna.

¹~~Information on the reference can be found in 1.3~~



P_A = power available from the generator
 P_M = power to matched transmission line
 P_O = power accepted by the antenna
 P_R = power radiated by the antenna
 I = radiation intensity
 I_n = partial radiation intensity[†]
 M_1 = impedance mismatch factor 1
 M_2 = impedance mismatch factor 2

η = radiation efficiency
 G_R = realized gain
 G = gain
 D = directivity
 g_R = partial realized gain
 g = partial gain
 d = partial directivity
 p = polarization efficiency

[†]All partial quantities correspond to a specified polarization, n .

Figure 1.— Gain and directivity flow chart

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 thus 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 into 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 $\exp(j\omega t)$.

2. Normative references

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

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

IEEE Std 149TM-1979-~~(Reaff 1990)~~, IEEE Standard Test Procedures for Antennas-~~(ANSI)~~-1, 2, 3

3. 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.

4. 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.⁴

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

¹ ~~IEEE Std 149-1979 was reaffirmed in 2008.~~

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⁴ IEEE Standards Dictionary Online subscription is available at:
http://www.ieee.org/portal/innovate/products/standard/standards_dictionary.html.

active antenna: An antenna packaged with an active device such as an amplifier or impedance-matching electronics.

active antenna available gain: For a receiving active array antenna, the ratio of the isotropic noise response to the available power at the terminals of any passive antenna over the same bandwidth and in the same isotropic noise environment. See: **isotropic noise response**.

active antenna available power: For a receiving active array antenna, the power at the output of a formed beam divided by the active antenna available gain. See: **active antenna available gain**.

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

NOTE 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.

NOTE 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.

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.

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.

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

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.

Aerial: [Deprecated] [See antenna.](#)

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.

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

amplitude pattern: *See:* radiation pattern.

angle tracking: *See:* tracking.

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

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

[NOTE—The term antenna is sometimes used for electromagnetic devices that couple over distances less than that associated with radiated fields.](#)

antenna array: *See:* array antenna.

2.14 antenna effect. [Deprecated.]

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

NOTE 1—Does not generally apply for steerable-beam antenna systems where the electrical boresight direction changes with respect to the reference boresight.

NOTE 2—For steerable-beam antenna systems, the boresight error is the difference in pointing direction between the actual boresight direction relative to the reference boresight and the commanded pointing direction relative to the reference boresight.

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.

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.

antenna pattern: *See:* **radiation pattern**.

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

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.

aperiodic array: An array with non-uniformly spaced elements.

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.

aperture antenna: An antenna with an electrically large physical aperture. See: **aperture (of an antenna).**

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, sub-reflector, or support structure produce aperture blockage for a symmetric reflector antenna.

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

aperture illumination: *See:* **aperture distribution.**

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

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).**

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

array antenna: An antenna comprised of a number of ~~identical~~ radiating elements ~~in a regular arrangement and excited to obtain a prescribed radiation pattern.~~ the inputs (or outputs) of which are combined. *Syn:* **antenna array**.

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

~~2—This term is sometimes applied to~~ NOTE 2—For cases where the elements are not identical or not arranged in a regular fashion. ~~For those cases,~~ qualifiers ~~shall~~ can 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**.

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

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.

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

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

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

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.*

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

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.

back lobe: A radiation lobe ~~whose~~the axis of which makes an angle of approximately 180 degrees with respect to the beam axis of an antenna lobe in the half-space opposed to the direction of peak directivity.

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

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

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.

Bayliss distribution, linear: A continuous distribution of a line source that yields a difference pattern with a sidelobe structure similar to that of a sum pattern produced by a Taylor linear distribution.

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

beam angle: *See: scan angle.*

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.

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.

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.

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

beam waveguide: A collection of reflecting mirrors or lenses that transports power.

Beamwidth: *See: half-power beamwidth.*

Beverage antenna: A directional wire 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.*

biconical antenna: An antenna consisting of two conical conductors ~~having a common~~ with the same axis facing in opposite directions and driven at their common vertex.

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

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

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

broadband antenna: An antenna the bandwidth of which is of the order of or greater than 2:1.
Syn: wideband antenna.

broadside array antenna: A linear or planar array antenna ~~whose~~ where the direction of maximum radiation is perpendicular to the line or to the plane of the array, 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~~

NOTE—In a linear or planar array antenna, the direction perpendicular to the line or plane of the array, respectively, is often referred to as the array's broadside direction.

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

NOTE 1—This term can be applied to 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.