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IEEE Standard for Definitions of Terms for Antennas

IEEE Antennas and Propagation Society

Sponsored by the

Antennas Committee

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USA

IEEE Std 145™-2013
(Revision of
IEEE Std 145-1993)

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Approved 11 December 2013

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

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When the IEEE-SA Standards Board approved this standard on 11 December 2013, it had the following membership:

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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IEEE Standard for Definitions of Terms for 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

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 are interrelated, and hence require some elaboration.

The viewpoints taken for polarization are that the term can be used in three related meanings and can apply:

a) To a field vector at some point in space

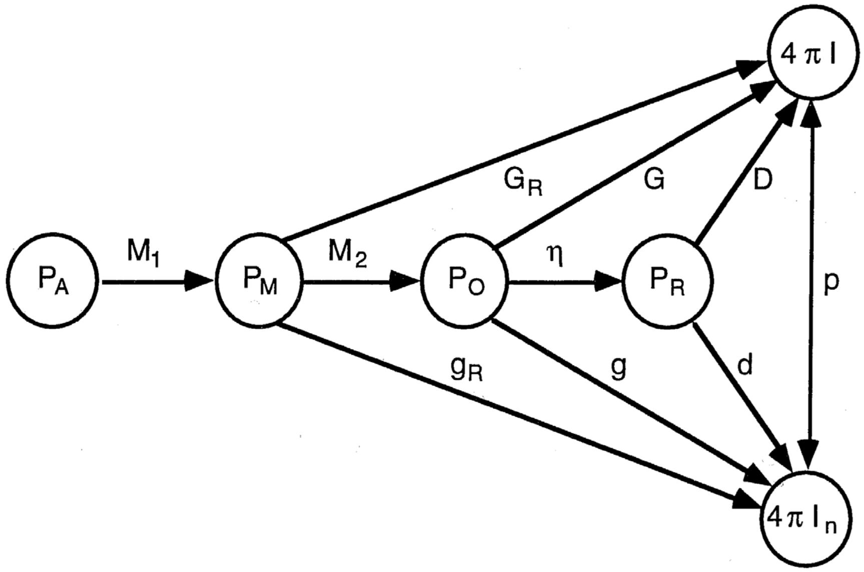
b) To a plane wave

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 to be the polarization of the plane wave. 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 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 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 is oriented in opposite directions (see Clause 11 of IEEE Std 149™-1979). 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 flowchart can be constructed for a receiving antenna.



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. 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

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 149™-1979, IEEE Standard Test Procedures for Antennas.[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)**.

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.

[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 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**.

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 radiating elements the inputs (or outputs) of which are combined. *Syn:* **antenna array**.

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

NOTE 2—For cases where the elements are not identical or not arranged in a regular fashion, qualifiers can be added. 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, 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 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 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 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 where the direction of maximum radiation is perpendicular to the line or to the plane of the array, respectively.

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 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.

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

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

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

NOTE 2—There are other alternate forms that are referred to as Cassegrainean. Examples include the form in which the sub-reflector is surrounded by a reflecting skirt and the form that utilizes a concave hyperboloidal reflector. When referring to these alternate forms, the term should be modified in order to differentiate them from the antenna described in the definition.

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**.

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

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

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

circular grid array: An array of elements the corresponding points of which lie on coplanar concentric circles.

circular multiflare horn antenna: *See:* **compound circular horn antenna**.

circularly polarized field vector: At a point in space, a field vector the extremity of which 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.

circularly polarized plane wave: A plane wave the electric field vector of which is circularly polarized.

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.

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

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**.

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

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.

complex dielectric constant: The complex permittivity of a physical medium as a ratio to the permittivity of free space.

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.

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.

compound circular horn antenna: A horn antenna of circular cross section with two or more abrupt changes of flare angle or diameter. *Syn:* **circular multiflare horn antenna**.

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

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

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. *Syn:* **rectangular multiflare horn antenna**.

conformal antenna [conformal array]: An antenna [an array] that conforms to a surface the shape of which is determined by considerations other than electromagnetic: for example, aerodynamic or hydrodynamic.

conformal array: *See:* **conformal antenna**.

conical array: A two-dimensional array of elements the corresponding points of which lie on a conical surface.

conical horn: A horn with a circular mouth and fed by a circular waveguide at the throat. Sometimes the horn interior wall is corrugated for pattern control.

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

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

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)**.

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

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

co-polar sidelobe level, relative: The maximum relative partial directivity (corresponding to the copolarization) of a sidelobe with respect to the maximum partial directivity (corresponding to the co-polarization) of the antenna.

NOTE—Unless otherwise specified, the co-polar sidelobe level is taken to be that of the highest sidelobe of the co-polar radiation pattern.

corner reflector: A reflecting object consisting of two or three mutually intersecting conducting flat surfaces.

NOTE—Dihedral forms of corner reflectors are frequently used in antennas; trihedral forms with mutually perpendicular surfaces are more often used as radar targets.

corner reflector antenna: An antenna consisting of a feed and a corner reflector.

corrugated horn (antenna): A hybrid-mode horn antenna produced by cutting narrow transverse grooves of specified depth in the interior walls of the horn. *See:* **hybrid-mode horn**.

cosecant-squared beam antenna: A shaped-beam antenna the pattern of which in one principal plane consists of a main beam with well-defined sidelobes on one side, but with the absence of nulls over an extended angular region adjacent to the peak of the main beam on the other side, with the radiation intensity in this region designed to vary as the cosecant-squared of the angle variable.

NOTE—The most common applications of this antenna are for use in ground-mapping radars and target-acquisition radars, since the cosecant-squared coverage provides constant signal return for targets with the same radar cross section at different ranges but a common height.

counterpoise: A system of conductors, elevated above and insulated from the ground, forming a lower system of conductors of an antenna.

NOTE—The purpose of a counterpoise is to provide a relatively high capacitance and thus a relatively low impedance path to Earth. The counterpoise is sometimes used in medium- and low-frequency applications where it would be more difficult to provide an effective ground connection.

cross-polarization: In a specified plane containing the reference polarization ellipse, the polarization orthogonal to a specified reference polarization.

NOTE—The reference polarization is usually the co-polarization.

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

cross-polar sidelobe level, relative: The maximum relative partial directivity (corresponding to the **cross polarization**) of a sidelobe with respect to the maximum partial directivity (corresponding to the **copolarization**) of the antenna.

NOTE—Unless otherwise specified, the cross-polar sidelobe level is be taken to be that of the highest sidelobe of the cross-polar radiation pattern.

cross section: *See:* **bistatic cross section; monostatic cross section; radar cross section; scattering cross section**.

cylindrical antenna: [Deprecated.] *See:* **cylindrical array; cylindrical dipole**.

cylindrical array: A two-dimensional array of elements the corresponding points of which lie on a cylindrical surface.

cylindrical dipole (antenna): A dipole, all of the transverse cross sections of which are the same, with the shape of a cross section of a cylinder being circular.

cylindrical reflector: A reflector that is a portion of a cylindrical surface.

NOTE—The cylindrical surface is usually parabolic, although other shapes may be employed.

density-tapered array antenna: *See:* **space-tapered array antenna**.

depolarization: The conversion of power from a reference polarization into the cross polarization.

despun antenna: On a rotating vehicle, an antenna the beam of which is scanned such that with respect to fixed reference axes, the beam is stationary.

dielectric constant: The real part of the complex dielectric constant.

dielectric resonator antenna: An antenna where the radiation pattern is controlled by electromagnetic resonances in a dielectric material excited by a probe or by a slot in a ground screen placed under it.

dielectric rod antenna: An antenna that employs a dielectric rod as the electrically significant part of a radiating element.

NOTE—The polyrod rod antenna is a notable example of the dielectric rod antenna when constructed of polystyrene.

difference pattern: A radiation pattern characterized by a pair of main lobes of opposite phase, separated by a single null, plus a family of sidelobes, the latter usually desired to be at a low level. *Contrast with:* **sum pattern**.

NOTE—Antennas used in many radar applications are capable of producing a sum pattern and two orthogonal difference patterns. The difference patterns can be employed to determine the position of a target in a right/left and up/down sense by antenna-pattern pointing, which places the target in the null between the twin lobes of each difference pattern.

digital beam forming array: An antenna array where beam forming is performed by software rather than hardware.

dipole: *See:* **dipole antenna; electrically short dipole; folded dipole (antenna); half-wave dipole; Hertzian electric dipole; Hertzian magnetic dipole; microstrip dipole; sleeve dipole antenna**.

dipole antenna: Any one of a class of antennas producing a radiation pattern approximating that of an elementary electric dipole. *Syn:* **doublet antenna**.

NOTE—Common usage considers the dipole antenna to be a metal radiating structure that supports a line current distribution similar to that of a thin straight wire so energized that the current has a node only at each end.

directional antenna: An antenna having the property of radiating or receiving electromagnetic waves more effectively in some direction[s] than others.

NOTE—This term is usually applied to an antenna the maximum directivity of which is significantly greater than that of a half-wave dipole.

directional-null: A sharp minimum in a radiation pattern that has been produced for the purpose of direction-finding or the suppression of unwanted radiation in a specified direction.

directional-null antenna: An antenna the radiation pattern of which contains one or more directional nulls. *See:* **null-steering antenna system.**

directive gain: [Deprecated.] *See:* **directivity**.

directivity (of an antenna) (in a given direction): The ratio of the radiation intensity in a given directionfrom the antenna to the radiation intensity averaged over all directions.

NOTE 1—The average radiation intensity is equal to the total power radiated by the antenna divided by 4π.

NOTE 2—If the direction is not specified, the direction of maximum radiation intensity is implied.

directivity, partial (of an antenna for a given polarization): In a given direction, that part of the radiation intensity corresponding to a given polarization divided by the total radiation intensity averaged over all directions.

NOTE—The (total) directivity of an antenna in a specified direction is the sum of the partial directivities for any two orthogonal polarizations.

director element: A parasitic element located forward of the driven element of an antenna, intended to increase the directivity of the antenna in the forward direction.

discone antenna: A biconical antenna with one cone being flat, having a vertex angle of 180°. *See:* **biconical antenna**.

Dolph-Chebyshev distribution: A set of excitation coefficients for an equi-spaced linear array antenna such that the array factor can be expressed as a Chebyshev polynomial. The sidelobes are of equal level.

doublet antenna: *See:* **dipole antenna**.

driven element: A radiating element coupled directly to the feed line of an antenna.

effective area (of an antenna) (in a given direction): In a given direction, the ratio of the available power at the terminals of a receiving antenna to the power flux density of a plane wave incident on the antenna from that direction, the wave being polarization matched to the antenna. *See:* **polarization match**.

NOTE 1—If the direction is not specified, the direction of maximum radiation intensity is implied.

NOTE 2—The effective area of an antenna in a given direction is equal to the square of the operating wavelength times its gain in that direction divided by 4π.

NOTE 3—For an active receiving antenna, available power is the active antenna available power. *See:* **active antenna available power.**

effective area, partial (of an antenna for a given polarization and direction): In a given direction, the ratio of the available power at the terminals of a receiving antenna to the power flux density of a plane wave incident on the antenna from that direction and with a specified polarization differing from the receiving polarization of the antenna.

effective height of an antenna (high-frequency usage): The height of the antenna's center of radiation above the ground level.

NOTE—For an antenna with a symmetrical current distribution, the center of radiation is the center of the distribution. For an antenna with an asymmetrical current distribution, the center of radiation is the center of the current moments when viewed from directions near the direction of maximum radiation.

effective isotropically radiated power: *See:* **equivalent isotropically radiated power**.

effective length of a linearly polarized antenna: For a linearly polarized antenna receiving a plane wave from a given direction, the ratio of the magnitude of the open-circuit voltage developed at the terminals of the antenna to the magnitude of the electric-field strength in the direction of the antenna's polarization.

NOTE 1—Alternatively, the effective length is the length of a thin straight conductor oriented perpendicularly to the given direction and parallel to the antenna's polarization, having a uniform current equal to that at the antenna's terminals and producing the same far-field strength as the antenna in that direction.

NOTE 2—In low-frequency usage, the effective length of a vertically polarized ground-based antenna is frequently referred to as effective height. Such usage should not be confused with **effective height of an antenna (high-frequency usage).**

effective radiated power (ERP): In a given direction, the relative gain of a transmitting antenna with respect to the maximum directivity of a half-wave dipole multiplied by the net power accepted by the antenna from the connected transmitter. *Contrast with:* **equivalent isotropically radiated power.** *Syn:* **equivalent radiated power**.

electrical boresight: The tracking axis as determined by an electrical indication, such as the null direction of a conical-scanning or monopulse antenna system, or the beam-maximum direction of a highly directive antenna. *See:* **reference boresight**.

NOTE—For electronically steerable-beam-antenna systems, the electrical boresight direction changes to follow the major lobe and/or the monopulse null direction while the reference boresight remains fixed.

electrically short dipole: A dipole the total length of which is small compared to the wavelength.

NOTE—For the common case that the two arms are collinear, the radiation pattern approximates that of a Hertzian dipole.

electrically small antenna: An antenna the dimensions of which are such that it can be contained within a sphere the diameter of which is small compared to a wavelength at the frequency of operation.

electric dipole: *See:* **Hertzian electric dipole**.

electromagnetic lens: *See:* **lens, electromagnetic**.

electromagnetic radiation: *See:* **radiation, electromagnetic**.

electronic scanning: Scanning an antenna beam by electronic or electric means without moving parts.
Syn: **inertialess scanning**.

element: *See:* **array element; director element; driven element; linear electric current element; linear magnetic current element; multi-wire element; parasitic element; radiating element; reflector element**.

element cell (of an array antenna): In an array having a regular arrangement of elements that can be made congruent by translation, an element and a region surrounding it that when repeated by translation, covers the entire array without gaps or overlay between cells.

NOTE—There are many possible choices for such a cell. Some may be more convenient than others for analytic purposes.

elliptically polarized field vector: At a point in space, a field vector the extremity of which describes an ellipse as a function of time.

NOTE—Any single-frequency field vector is elliptically polarized if “elliptical” is understood in the wide sense as including circular and linear. However, the expression is often used in the strict sense, meaning noncircular and nonlinear.

elliptically polarized plane wave: A plane wave the electric-field vector of which is elliptically polarized.

embedded element pattern: The radiation pattern of an element excited in an array with all other elements terminated.

NOTE 1—The embedded element pattern depends on the terminations of the other elements.

NOTE 2—Commonly, all terminations are identical.

end capacitor: A conducting element or group of conducting elements, connected at the end of a radiating element of an antenna, to modify the current distribution on the antenna, thus changing its input impedance.

end-fire array antenna: A linear array antenna the direction of maximum radiation of which lies along the line of the array.

E-plane, principal: For a linearly polarized antenna, the plane containing the electric-field vector and the direction of maximum radiation.

equivalent flat plate area of a scattering object: For a given scattering object, an area equal to the wavelength times the square root of the ratio of the monostatic cross section to 4π.

NOTE—A perfectly reflecting plate parallel to the incident wavefront and having this area, if it is large compared to the wavelength, will have approximately the same monostatic cross section as the object.

equivalent isotropically radiated power (EIRP): In a given direction, the gain of a transmitting antenna multiplied by the net power accepted by the antenna from the connected transmitter. *Syn:* **effective isotropically radiated power**.

equivalent radiated power: *See:* **effective radiated power**.

equivalent sources: *See:* **Huygens' sources**.

excitation (of an array antenna): For an array of radiating elements, the specification in amplitude and phase of either the voltage applied to each element or the input current to each element.

excitation coefficients: The relative values in amplitude and phase of the excitation currents or voltages of the radiating elements of an array antenna. *Syn:* **feeding coefficients**.

fan-beam antenna: An antenna producing a major lobe the transverse cross section of which has a large ratio of major to minor dimensions.

far-field (radiation) pattern: Any radiation pattern obtained in the far field of an antenna.

NOTE—Far-field patterns are usually taken over paths on a spherical surface. *See:* **radiation pattern cut; radiation sphere**.

far-field region: That region of the field of an antenna where the angular field distribution is essentially independent of the distance from a specified point in the antenna's region.

NOTE 1—In free space, if the antenna has a maximum overall dimension, D, which is large compared to the wavelength, the far-field region is commonly taken to exist at distances greater than $2D^2/\lambda$ from the antenna, with λ being the wavelength. The far-field patterns of certain antennas – such as multi-beam reflector antennas – are sensitive to variations in phase over their apertures. For these antennas, $2D^2/\lambda$ may be inadequate.

NOTE 2—In physical media, if the antenna has a maximum overall dimension, D, that is large compared to $\pi/|\gamma|$, the far-field region can be taken to begin approximately at a distance equal to $|\gamma|D^2/\pi$ from the antenna, with γ being the propagation constant in the medium.

far-field region in physical media: *See:* **far-field region,** NOTE 2.

feed of an antenna: (A) For continuous-aperture antennas, the feed is the primary radiator: for example, a horn feeding a reflector. (B) For array antennas, that portion of the antenna system that functions to produce the excitation coefficients.

feeding coefficients: *See:* **excitation coefficients**.

feed line: A transmission line interconnecting an antenna and a transmitter or receiver, or both.

ferrite core loop antenna: A loop antenna containing a high-permeability core.

field pattern: *See:* **radiation pattern**.

figure of merit (of an antenna) (G/T): The ratio of the gain to the noise temperature of an antenna.

NOTE 1—Usually the antenna-receiver system figure of merit is specified. For this case, the figure of merit is the gain of the antenna divided by the system noise temperature referred to the antenna's terminals.

NOTE 2—The system figure of merit at any reference plane in the RF system is the same as that taken at the antenna's terminals, since both the gain and system noise temperature are referred to the same reference plane.

fishbone antenna: An end-fire, traveling-wave antenna consisting of a balanced transmission line to which is coupled – usually through lumped circuit elements – an array of closely spaced, coplanar dipoles.

flat-top antenna: A short vertical monopole antenna with an end capacitor the elements of which are all in the same horizontal plane. *See:* **end capacitor; top-loaded vertical antenna**.

flush-mounted antenna: An antenna constructed into the surface of a mechanism, or of a vehicle, without affecting the shape of that surface. *Contrast with:* **conformal antenna**.

folded dipole (antenna): An antenna composed of two or more parallel, closely-spaced dipole antennas connected together at their ends, with one of the dipole antennas fed at its center and the others short-circuited at their centers.

folded monopole (antenna): A monopole antenna formed from half of a folded dipole with the unfed element(s) directly connected to the imaging plane.

footprint (of an antenna beam on a specified surface): An area bounded by a contour on a specified surface formed by the intersection of the surface and that portion of the beam of an antenna above a specified minimum gain level, the orientation of the beam with respect to the surface being specified.

fractal antenna: A multiband antenna having a self-similar shape at several different scales.

Fraunhofer pattern: A radiation pattern obtained in the Fraunhofer region of an antenna.

NOTE—For an antenna focused at infinity, a Fraunhofer pattern is a far-field pattern.

Fraunhofer region: The region in which the field of an antenna is focused.

NOTE 1—In the Fraunhofer region of an antenna focused at infinity, the values of the fields when calculated from knowledge of the source distribution of an antenna are sufficiently accurate when the quadratic phase terms (and higher-order terms) are neglected.

NOTE 2—*See:* NOTE 2 of **far-field region** for a more-restricted usage.

free-space loss: The loss between two isotropic radiators in free space, expressed as a power ratio.

NOTE—The free-space loss is not due to dissipation, but rather due to the fact that the power flux density decreases with the square of the separation distance and the effective area of the receiving isotropic antenna increases with the square of the wavelength. The free-loss space is usually expressed in decibels and is given by the formula 20log $(4\pi r/\lambda)$, where R is the separation of the two antennas and λ is the wavelength.

frequency selective surface: A distribution of elements (usually metallic) on a surface that reflects or transmits waves at certain frequencies.

Fresnel contour: The locus of points on a surface for which the sum of the distances to a source point and an observation point is a constant, differing by a multiple of a half-wavelength from the minimum value of the sum of the distances.

NOTE—This definition applies to media that are isotropic and homogeneous. For the general case, the distances along optical paths are employed.

Fresnel lens antenna: An antenna consisting of a feed and a lens (usually planar) that transmits the radiated power from the feed through the central zone and alternate Fresnel zones of the illuminating field on the lens. *Syn:* **zone-plate lens antenna**.

Fresnel pattern: A radiation pattern obtained in the Fresnel region.

Fresnel region: The region (or regions) adjacent to the region in which the field of an antenna is focused (that is, just outside the Fraunhofer region).

NOTE 1—In the Fresnel region in space, the values of the fields when calculated from knowledge of the source distribution of an antenna are insufficiently accurate unless the quadratic phase terms are taken into account, but are sufficiently accurate if the quadratic phase terms are included.

NOTE 2—*See:* NOTE 2 of **near-field region, radiating** for a more-restricted usage.

Fresnel zone: The region on a surface between successive Fresnel contours.

NOTE—Fresnel zones are usually numbered consecutively, with the first zone containing the minimum path length.

front-to-back ratio: The ratio of the maximum directivity of an antenna to its directivity in a specified rearward direction.

NOTE 1—This definition is usually applied to beam-type patterns.

NOTE 2—If the rearward direction is not specified, it is taken to be that of the maximum directivity in the rearward hemisphere relative to the antenna's orientation.

gain: *See:* **gain, partial (of an antenna for a given polarization); realized gain; realized gain, partial (of an antenna for a given polarization)**.

gain (in a given direction): The ratio of the radiation intensity in a given direction to the radiation intensity that would be produced if the power accepted by the antenna were isotropically radiated. *Syn:* **absolute gain (of an antenna)**.

NOTE 1—Gain does not include losses arising from impedance and polarization mismatches and does not depend on the system to which the antenna is connected.

NOTE 2—The radiation intensity corresponding to the isotropically radiated power is equal to the power accepted by the antenna divided by 4π.

NOTE 3—If an antenna is without dissipative loss, then in any given direction its gain is equal to its directivity.

NOTE 4—If the direction is not specified, the direction of maximum radiation intensity is implied.

NOTE 5—The term **absolute gain** is used in those instances where added emphasis is required to distinguish gain from relative gain: for example, absolute gain measurements.

gain, partial (of an antenna for a given polarization): In a given direction, that part of the radiation intensity corresponding to a given polarization divided by the radiation intensity that would be obtained if the power accepted by the antenna were isotropically radiated.

NOTE—The (total) gain of an antenna in a specified direction is the sum of the partial gains for any two orthogonal polarizations.

geodesic lens antenna: A lens antenna having a two-dimensional lens with uniform index of refraction, disposed on a surface such that the rays in the lens follow geodesic (minimal) paths of the surface.

grating lobe: A lobe other than the main lobe, produced by an array antenna when the inter-element spacing is sufficiently large to permit the in-phase addition of radiated fields in more than one direction.

Gregorian reflector antenna: A paraboloidal reflector antenna with a concave sub-reflector, usually ellipsoidal in shape, located at a distance from the vertex of the main reflector that is greater than the prime focal length of the main reflector.

NOTE—To improve the aperture efficiency of the antenna, the shapes of the main reflector and sub-reflector are sometimes modified.

ground plane: A conducting or reflecting plane functioning to image a radiating structure. *Syn:* **imaging plane**.

ground rod: A conducting rod serving as an electrical connection with the ground.

ground system: That portion of an antenna consisting of a system of conductors or a conducting surface in or on the ground.

half-power beamwidth: In a radiation-pattern cut containing the direction of the maximum of a lobe, the angle between the two directions in which the radiation intensity is one-half the maximum value. *See:* **principal half-power beamwidths**.

half-wave dipole: A wire antenna consisting of two straight collinear conductors of equal length, separated by a small feeding gap, with each conductor approximately a quarter-wavelength long.

NOTE—This antenna gets its name from the fact that its overall length is approximately a half-wavelength. In practice, the length is usually slightly smaller than a half-wavelength: enough to cause the input impedance to be pure real (jX=0).

helical antenna: An antenna the configuration of which is that of a helix.

NOTE—The diameter, pitch, and number of turns in relation to the wavelength provide control of the polarization state and directivity of helical antennas.

Hertzian electric dipole: An elementary source consisting of a time-harmonic electric current element of specified direction and infinitesimal length. *Syn:* **linear [lineal] electric current element**.

NOTE 1—The continuity equation relating current to charge requires that opposite ends of the current element be terminated by equal and opposite amounts of electric charge, these amounts also varying harmonically with time.

NOTE 2—As its length approaches zero, the current must approach infinity in such a manner that the product of current and length remains finite.

Hertzian magnetic dipole: A fictitious elementary source consisting of a time-harmonic magnetic current element of specified direction and infinitesimal length. *Syn:* **linear [lineal] magnetic current element**.

NOTE 1—The continuity equation relating current to charge requires that opposite ends of the current element be terminated by equal and opposite amounts of magnetic charge, these amounts also varying harmonically with time.

NOTE 2—As its length approaches zero, the current approaches infinity in such a manner that the product of current and length remains finite.

NOTE 3—A magnetic dipole has the same radiation pattern as an infinitesimally small electric current loop.

hoghorn antenna: *See:* **horn reflector antenna**.

horizontally polarized field vector: A linearly polarized field vector the direction of which is horizontal.

horizontally polarized plane wave: A plane wave the electric-field vector of which is horizontally polarized.

horn (antenna): An antenna consisting of a waveguide section in which the cross-sectional area increases towards an open end that is the aperture.

horn reflector antenna: An antenna consisting of a portion of a paraboloidal reflector fed with an offset horn that physically intersects the reflector, part of the wall of the horn being removed to form the antenna's aperture.

NOTE—The horn is usually either pyramidal or conical, with an axis perpendicular to that of the paraboloid.

H-plane, principal: For a linearly polarized antenna, the plane containing the magnetic-field vector and the direction of maximum radiation.

Huygens' source radiator: An elementary radiator having the radiation properties of an infinitesimal area of a propagating electromagnetic wavefront.

Huygens' sources: Electric and magnetic sources that if properly distributed on a closed surface, *S*, in substitution for the actual sources inside *S* will help ensure the result that the electromagnetic field at all points outside *S* is unchanged. *Syn:* **equivalent sources**.

hybrid-mode horn (antenna): A horn antenna excited by one or more hybrid waveguide modes in order to produce a specified aperture illumination.

imaging plane: *See:* **ground plane**.

Impedance: *See:* **active impedance (of an array element); impedance mismatch factor; input impedance (of an antenna); intrinsic impedance; isolated impedance (of an array element); mutual coupling effect (on input impedance of an array element); mutual impedance; self-impedance of an array element**.

impedance mismatch factor: The ratio of the power accepted by an antenna to the power incident at the antenna's terminals from the transmitter.

NOTE—The impedance mismatch factor is equal to one minus the magnitude squared of the input reflection coefficient of the antenna.

inertialess scanning: *See:* **electronic scanning**.

input impedance (of an antenna): The impedance presented by an antenna at its terminals.

integrated antenna system: A radiator with an active or nonlinear circuit element or network incorporated physically within the structure of the radiator.

intercardinal plane: Any plane that contains the intersection of two successive cardinal planes and is at an intermediate angular position.

NOTE—In practice, the intercardinal planes are located by dividing the angle between successive cardinal planes into equal parts. Often, it is sufficient to bisect the angle so that there is only one intercardinal plane between successive cardinal planes.

interferometer antenna: An array antenna in which the inter-element spacings are large compared to wavelength and element size so as to produce grating lobes.

intrinsic impedance: [Deprecated] *See:* **input impedance (of an antenna)**.

invisible range: *See:* **visible range**.

isolated impedance (of an array element): The input impedance of a radiating element of an array antenna with all other elements of the array absent.

isolation between antennas: A measure of power transfer from one antenna to another.

NOTE—The isolation between antennas is the ratio of the power input to one antenna to the power received by the other, usually expressed in decibels.

isotropic noise response: For a receiving active-array antenna, the noise power at the output of a formed beam with a noiseless receiver when in an environment with a brightness temperature distribution that is independent of direction and in thermal equilibrium with the antenna.

isotropic radiator: A hypothetical, lossless antenna having equal radiation intensity in all directions.

NOTE—An isotropic radiator represents a convenient reference for expressing the directive properties of actual antennas.

leaky-wave antenna: An antenna that couples power in small increments per unit length, either continuously or discretely, from a travelling-wave structure to free space.

left-hand polarization of a field vector: *See:* **sense of polarization**.

left-hand polarization of a plane wave: *See:* **sense of polarization**.

lens antenna: An antenna consisting of an electromagnetic lens and a feed that illuminates it.

lens, electromagnetic: A three-dimensional structure through which electromagnetic waves can pass, possessing an index of refraction that may be a function of position, and a shape that is chosen so as to control the exiting aperture illumination.

lineal electric current element: *See:* **Hertzian electric dipole**.

lineal magnetic current element: *See:* **Hertzian magnetic dipole**.

linear antenna: An antenna consisting of one or more segments of straight conducting cylinders.

NOTE 1—This term has restricted usage, and applies to straight cylindrical wire antennas. This term should not be confused with the conventional usage of "linear" in circuit theory.

NOTE 2—*Contrast with:* **linear array antenna**.

linear array antenna: A one-dimensional array of elements the corresponding points of which lie along a straight line.

linear Bayliss distribution: *See:* **Bayliss distribution, linear**.

linear electric current element: *See:* **Hertzian electric dipole**.

linear magnetic current element: *See:* **Hertzian magnetic dipole**.

linear Taylor distribution: *See:* **Taylor distribution, linear**.

linearly polarized field vector: At a point in space, a field vector the extremity of which describes a straight line segment as a function of time.

NOTE—Linear polarization may be viewed as a special case of elliptical polarization where the axial ratio has become infinite.

linearly polarized plane wave: A plane wave the electric-field vector of which is linearly polarized.

line source: A continuous distribution of sources of electromagnetic radiation, lying along a line segment.

NOTE—Most often in practice the line segment is straight.

line source corrector: A linear array antenna feed with radiating element locations and excitations chosen to correct for aberrations present in the focal-region fields of a reflector.

loaded linear antenna: *See:* **sectionalized linear antenna**.

loading: The modification of a basic antenna, such as a dipole or monopole, caused by the addition of conductors or circuit elements that change the input impedance or current distribution or both.

lobe: *See:* **back lobe; beam of an antenna; major lobe; minor lobe; sidelobe; shoulder lobe; vestigial lobe**.

lobe switching: A form of scanning in which the direction of maximum radiation is discretely changed by switching. *See:* **sequential lobing**.

log periodic antenna: Any one of a class of antennas having a structural geometry such that its impedance and radiation characteristics repeat periodically as the logarithm of frequency.

long-wire antenna: A wire antenna that by virtue of its considerable length in comparison with the operating wavelength, provides a directional radiation pattern.

loop antenna: An antenna the configuration of which is that of a loop.

NOTE—If the electric current in the loop, or in multiple parallel turns of the loop, is essentially uniform and the loop circumference is small compared with the wavelength, the radiated pattern approximates that of a Hertzian magnetic dipole.

loop stick antenna: A loop receiving antenna with a ferrite-rod core used for increasing its radiation efficiency.

Luneburg lens antenna: A lens antenna with a circular cross section having an index of refraction varying only in the radial direction such that a feed located on or near a surface or edge of the lens produces a major lobe diametrically opposite the feed.

magnetic dipole: *See:* **Hertzian magnetic dipole**.

main lobe: *See:* **major lobe**.

main reflector: The largest reflector of a multiple reflector antenna.

major lobe: The radiation lobe containing the direction of maximum radiation. *Syn:* **main lobe**.

NOTE—In certain antennas, such as multilobed or split-beam antennas, there may exist more than one major lobe.

maximum relative sidelobe level: *See:* **sidelobe level, maximum relative**.

mean sidelobe level: The average value of the relative power pattern of an antenna taken over a specified angular region that excludes the main beam, the power pattern being relative to the peak of the main beam.

metamaterial: An arrangement of sub-wavelength material structures that results in bulk electromagnetic material properties not found in nature or difficult to obtain naturally. *See:* **artificial dielectric**.

microstrip antenna: An antenna that consists of a thin metallic conductor bonded to a thin grounded dielectric substrate.

NOTE—The metallic conductor typically has some regular shape: for example, rectangular, circular, or elliptical. Feeding is often by means of a coaxial probe or a microstrip transmission line.

microstrip array: An array of microstrip antennas.

microstrip dipole: A microstrip antenna of rectangular shape with its width much smaller than its length.

Mills cross antenna system: A multiplicative array antenna system consisting of two linear receiving arrays positioned at right angles to one another and connected together by a phase modulator or switch, such that the effective angular response of the output is related to the product of the radiation patterns of the two arrays.

minor lobe: Any radiation lobe except a major lobe. *See:* **back lobe; sidelobe**.

monopole: An antenna constructed above an imaging plane that produces a radiation pattern approximating that of an electric dipole in the half-space above the imaging plane.

monopulse: Simultaneous lobing whereby direction-finding information is obtainable from a single pulse.

monostatic cross section: The scattering cross section in the direction toward the source. *Contrast with:* **bistatic cross section**: *Syn:* **back-scattering cross section**.

multi-band antenna: An antenna designed to operate in several distinct frequency bands.

NOTE—Multiband antennas typically include: a) Antennas with one port for all bands. b) Antennas with separate ports for different bands or groups of bands.

multi-beam antenna: An antenna capable of creating a family of major lobes from a single non-moving aperture through the use of a multiport feed, with one-to-one correspondence between input ports and major lobes, the latter characterized by having unique main-beam pointing directions.

NOTE—Often, the multiple main-beam angular positions are arranged to provide complete coverage of a solid angle region of space.

multiplicative array antenna system: A signal-processing antenna system consisting of two or more receiving antennas and circuitry in which the effective angular response of the output of the system is related to the product of the radiation patterns of the separate antennas.

multi-wire element: A radiating element composed of several wires connected in parallel, the assemblage being the electrical equivalent of a single conductor larger than any one of the individual wires.

mutual coupling: Interactions of an antenna with one or more other antennas.

mutual coupling effects: The changes in the radiation pattern and impedance of an antenna due to mutual coupling.

mutual impedance: The mutual impedance between any two terminal pairs in a multi-element array antenna is equal to the open-circuit voltage produced at the first terminal pair divided by the current supplied to the second when all other terminal pairs are open-circuited.

near-field (radiation) pattern: Any radiation pattern obtained in the near field of an antenna. *See:* **Fresnel pattern**.

NOTE—Near-field patterns are usually taken over paths on planar, cylindrical, or spherical surfaces. *See:* **radiation pattern cut.**

near-field region: That part of space between the antenna and the far-field region.

NOTE—In lossless media, the near field may be further subdivided into reactive and radiating near-field regions.

near-field region, radiating: That portion of the near-field region of an antenna between the far field and the reactive portion of the near-field region, wherein the angular field distribution is dependent upon the distance from the antenna.

NOTE 1—If the antenna has a maximum overall dimension that is not large compared to the wavelength, this field region may not exist.

NOTE 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.

near-field region, reactive: That portion of the near-field region immediately surrounding the antenna wherein the reactive field predominates.

NOTE—For a very short dipole or equivalent radiator, the outer boundary is commonly taken to exist at a distance $\lambda/2\pi$ from the antenna's surface, where λ is the wavelength.

noise matching efficiency: For a receiving active array antenna, the ratio of the noise power contributed by receiver electronics at the output of a formed beam, with the receivers impedance matched to the array elements for minimum receiver noise temperature, to the actual receiver electronics noise power at the formed beam output, per unit bandwidth and at a specified frequency.

noise temperature of an antenna: The temperature of a resistor having an available thermal noise power per unit bandwidth equal to that at the antenna's output at a specified frequency.

NOTE 1—The noise temperature of an antenna depends on its coupling to all noise sources in its environment, as well as noise generated within the antenna.

NOTE 2—For an active antenna, the temperature of an isotropic thermal noise environment such that the isotropic noise response is equal to the noise power at the antenna's output per unit bandwidth at a specified frequency. *See:* **isotropic noise response**.

normalized directivity: *See:* **antenna [aperture] illumination efficiency**.

null steering: To control, usually electronically, the direction at which a directional null appears in the radiation pattern of an operational antenna.

null-steering antenna system: An antenna having in its radiation pattern one or more directional nulls that can be steered, usually electronically.

offset paraboloidal reflector: *See:* **paraboloidal reflector**.

offset paraboloidal reflector antenna: A reflector antenna the main reflector of which is a portion of a paraboloid that is not symmetrical with respect to its focal axis, and that does not include the vertex so that aperture blockage by the feed is reduced or eliminated.

omnidirectional antenna: An antenna having an essentially non-directional pattern in a given plane of the antenna and a directional pattern in any orthogonal plane. *Contrast with:* **isotropic antenna**.

NOTE—For ground-based antennas, the omnidirectional plane is usually horizontal.

orthogonal polarization (with respect to a specified polarization): In a common plane of polarization, the polarization for which the inner product of the corresponding polarization vector and that of the specified polarization is equal to zero. *See:* **polarization vector, NOTE 2** for a definition of the inner product.

NOTE 1—The two orthogonal polarizations can be represented as two diametrical points on the Poincaré sphere.

NOTE 2—Two elliptically polarized fields having the same plane of polarization have orthogonal polarizations if their polarization ellipses have the same axial ratio, major axes at right angles, and opposite senses of polarization.

parabolic torus reflector: A toroidal reflector formed by rotating a segment of a parabola about a nonintersecting co-planar line.

paraboloidal reflector: An axially symmetric reflector that is a portion of a paraboloid.

NOTE—This term may be applied to any reflector that is a portion of a paraboloid, provided the term is appropriately qualified. For example, if the reflector is a portion of a paraboloid but does not include its vertex, then it may be called an **offset paraboloidal reflector.**

parallel [perpendicular] polarization: A linear polarization for which the field vector is parallel [perpendicular] to some reference plane.

NOTE—These terms are applied mainly to uniform plane waves incident upon a plane of discontinuity (surface of the Earth, surface of a dielectric or a conductor). The convention is then to take as the reference the plane of incidence: that is, the plane containing the direction of propagation and the normal to the surface of the discontinuity. If these two directions coincide, the reference plane is specified by some other convention.

parasitic element: A radiating element that is not connected to the feed lines of an antenna and that materially affects the radiation pattern or impedance of an antenna, or both. *Contrast with:* **driven element**.

partial directivity (of an antenna, for a given polarization): *See:* **directivity, partial (of an antenna, for a given polarization)**.

partial effective area (of an antenna, for a given polarization and direction): *See:* **effective area, partial (of an antenna for a given polarization and direction)**.

partial gain (of an antenna for a given polarization): *See:* **gain, partial (of an antenna for a given polarization)**.

partial realized gain (of an antenna for a given polarization: *See:* **realized gain, partial (of an antenna for a given polarization)**.

passive antenna: An antenna that does not have an integral active device within its structure.

patch antenna: A planar antenna, typically printed and of circular or rectangular shape, located above a ground plane and parallel to it.

pencil-beam antenna: An antenna the radiation pattern of which consists of a single main lobe with narrow principal half-power beamwidths and sidelobes having relatively low levels.

NOTE—The main lobe usually has approximately elliptical contours of equal radiation intensity in the angular region around the peak of the main lobe. This type of pattern is diffraction-limited in practice. It is often called a sum pattern in radar applications.

periscope antenna: An antenna consisting of a very directive feed located close to ground level and oriented so that its beam illuminates an elevated reflector that is oriented so as to produce a horizontal beam.

perpendicular polarization: *See:* **parallel polarization**.

phase center: The location of a point associated with an antenna such that if it is taken as the center of a sphere the radius of which extends into the far field, the phase of a given field component over the surface of the radiation sphere is essentially constant, at least over that portion of the surface where the radiation is significant.

NOTE—Some antennas do not have a unique phase center.

phase of a circularly polarized field vector: In the plane of polarization, the angle that the field vector makes at a time taken as the origin with a reference direction and with the angle counted as positive if it is in the same direction as the sense of polarization, and negative if it is in the opposite direction to the sense of polarization.

phase pattern (of an antenna): The spatial distribution of the relative phase of a field vector excited by an antenna.

NOTE 1—The phase may be referred to any arbitrary reference.

NOTE 2—The distribution of phase over any path, surface, or radiation-pattern cut is also called a phase pattern.

phase, relative, of an elliptically polarized field vector: The phase angle of the unitary factor by which the polarization-phase vector for the given field vector differs from that of a reference field vector with the same polarization.

NOTE 1—The relative phase of an elliptically polarized field $\bar{E}_1$ can be defined with respect to that of another field $\bar{E}_0$ having the same polarization. In that case, the polarization vectors ê1 and $\hat{e}_0$ have the same direction and, being of unit magnitudes, they differ only by a unitary factor $\hat{e}_1 = e^{j\alpha}\, \hat{e}_0$. The angle α is the phase difference between $\bar{E}_1$ and $\bar{E}_0$.

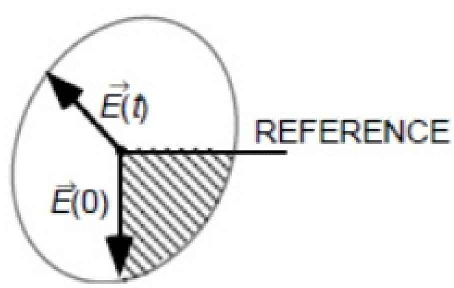

Figure 2—Elliptically polarized field

NOTE 2— The field vectors $\bar{E}_1$ (t) = Re $\bar{E}_1\, e^{j\omega t}$ and $\bar{E}_0$ (t) = Re $\bar{E}_0\, e^{j\omega t}$ describe similar ellipses as *t* varies. The angle α is 2π times the area of the sector shown on the figure divided by the area of the ellipse described by the extremity of $\bar{E}_0$ (t).

For circular polarization, α is the angle between $\bar{E}_0$ and $\bar{E}_1$ at any instant in time.

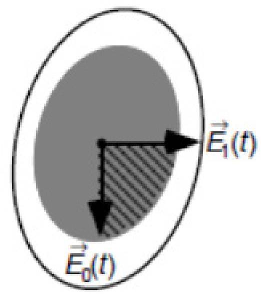

Figure 3—Circularly polarized field

NOTE 3— The phase of an elliptically polarized field vector can be expressed relative to a spatial direction in its plane of polarization. For example, the phase angle is given by 2π times the area of the sector shown in the figure, which is bounded by $\bar{E}(0)$ and the reference, divided by the area of the ellipse described by $\bar{E}(t)$. The angle is positive if it is in the same direction as the sense of polarization and negative if it is in the direction opposite to the sense of polarization.

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

planar array: A two-dimensional array of elements the corresponding points of which lie in a plane.

Planar Inverted F Antenna (PIFA): Is a compact antenna with a shorting pin at one corner and a feed pin located along its length. These are often used in handheld devices.

plane of polarization: A plane containing the polarization ellipse.

NOTE 1—When the ellipse degenerates into a line segment, the plane of polarization is not uniquely defined. In general, any plane containing the segment is acceptable; however, for a plane wave in an isotropic medium, the plane of polarization is taken to be normal to the direction of propagation.

NOTE 2—In optics, the expression *plane of polarization* is associated with a linearly polarized plane wave (sometimes called a *plane polarized wave*) and is defined as a plane containing the field vector of interest and the direction of propagation. This usage would contradict the above usage and is deprecated.

plane polarized wave: *See:* **plane of polarization**.

plane wave: A wave in which the only spatial dependence of the field vectors is through a common exponential factor the exponent of which is a linear function of position.

NOTE 1—In a linear, homogeneous, and isotropic space the electric-field vector, magnetic-field vector and the propagation vector are mutually perpendicular. The ratio of the magnitude of the electric-field vector to the magnitude of the magnetic-field vector is equal to the intrinsic impedance of the medium; for free space, the intrinsic impedance is equal to 376.730 Ω or approximately 120π Ω.

NOTE 2—A plane wave can be resolved into two component waves corresponding to two orthogonal polarizations. The total power flux density of the plane wave at a given point in space is equal to the sum of the power flux densities in the orthogonal component waves.

Poincaré sphere: A sphere the points of which are associated in a one-to-one fashion with all possible polarization states of a plane wave [field vector] according to the following rules: The longitude equals twice the tilt angle, and the latitude is twice the angle the cotangent of which is the negative of the axial ratio of the polarization ellipse.

NOTE 1—For this definition, the axial ratio carries a sign. *See:* **axial ratio (of a polarization ellipse), NOTE**.

NOTE 2—The points of the northern hemisphere of the Poincaré sphere represent polarizations with a left-hand sense and those of the southern hemisphere represent polarization with a right-hand sense. The north pole represents left-hand circular polarization and the south pole represents right-hand circular polarization. The points of the equator represent all possible linear polarizations.

polarization (of an antenna): In a given direction from the antenna, the polarization of the wave transmitted by the antenna. *See:* **polarization of a wave radiated by an antenna**.

NOTE—When the direction is not stated, the polarization is taken to be the polarization in the direction of maximum gain.

polarization [of a wave (radiated by an antenna in a specified direction)]: In a specified direction from an antenna and at a point in its far field, the polarization of the (locally) plane wave that is used to represent the radiated wave at that point.

NOTE—At any point in the far field of an antenna, the radiated wave can be represented by a plane wave the electric-field strength of which is the same as that of the wave and the direction of propagation of which is in the radial direction from the antenna. As the radial distance approaches infinity, the radius of curvature of the radiated wave's phase front also approaches infinity, and thus in any specified direction, the wave appears locally as a plane wave.

polarization efficiency: The ratio of the power received by an antenna from a given plane wave of arbitrary polarization to the power that would be received by the same antenna from a plane wave of the same power flux density and direction of propagation, the state of polarization of which has been adjusted for a maximum received power. *Syn:* **polarization mismatch factor**.

NOTE 1—The polarization efficiency is equal to the square of the magnitude of the inner product of the polarization vector describing the receiving polarization of the antenna and the polarization vector of the plane wave incident at the antenna. *See:* **polarization vector, NOTE 2** for definition of the inner product.

NOTE 2—If the receiving polarization of an antenna and the polarization of an incident plane wave are properly located as points on the Poincaré sphere, then the polarization efficiency is given by the square of the cosine of one-half the angular separation of the two points.

polarization match: The condition that exists when a plane wave, incident upon an antenna from a given direction, has a polarization that is the same as the receiving polarization of the antenna in that direction. *See:* **receiving polarization (of an antenna)**.

polarization mismatch factor: *See:* **polarization efficiency**.

polarization mismatch loss: The magnitude, expressed in decibels, of the polarization efficiency.

polarization pattern (of an antenna): (A) The spatial distribution of the polarizations of a field vector excited by an antenna taken over its radiation sphere. **(B)** The response of a given antenna to a linearly polarized plane wave incident from a given direction, the direction of polarization of which is rotating about an axis parallel to its propagation vector, the response being plotted as a function of the angle that the direction of polarization makes with a given reference direction.

NOTE 1—When describing the polarizations over the radiation sphere [definition **(A)**] or a portion of it, reference lines is specified over the sphere in order to measure the tilt angles of the polarization ellipses [*see:* **tilt angle** (of a polarization ellipse)] and the direction of polarization for linear polarizations. An obvious choice, though by no means the only one, is a family of lines tangent at each point on the sphere to either the θ or ϕ coordinate line associated with a spherical coordinate system of the radiation sphere.

NOTE 2—At each point on the radiation sphere, the polarization is usually resolved into a pair of orthogonal polarizations, the co-polarization and the cross polarization (*See:* **co-polarization; cross polarization**). To accomplish this, the co-polarization is specified at each point on the radiation sphere. For certain linearly polarized antennas, it is common practice to define the co-polarization in the following manner. First, the orientation of the co-polar electric-field vector at a pole of the radiation sphere is specified. Then, for all other directions of interest (points on the radiation sphere), it is required that the angle that the co-polar electric-field vector makes with each great-circle line through the pole remain constant over that circle, the angle being that at the pole. In practice, the axis of the antenna's main beam should be directed along the polar axis of the radiation sphere. The antenna is then appropriately oriented about this axis to align the direction of its polarization with that of the defined co-polarization at the pole. This manner of defining co-polarization can be extended to the case of elliptical polarization by defining the constant angles using the major axes of the polarization ellipses rather than the co-polar electric-field vector. The sense of polarization is also specified.

NOTE 3—The polarization pattern [definition **(B)**] generally has the shape of a dumbbell. The polarization ellipse of the antenna in the given direction is similar to one that can be inscribed in the dumbbell shape with points of tangency at the maxima and minima points: the axial ratio and tilt angle can thus be obtained from the polarization pattern.

polarization-phase vector (for a field vector): The polarization vector among all of those that define the same polarization that carries the phase information of the field vector the polarization of which it represents. *See:* **polarization vector (for a field vector)**.

NOTE—The polarization-phase vector of the field vector $\bar{E}$ is given by $\bar{e} \equiv \bar{E}E$, where E is the magnitude of $\bar{E}$, that is, the positive square root of $\bar{E}^{*} \cdot \bar{E}$.

polarization ratio: The magnitude of a complex polarization ratio.

polarization, receiving (of an antenna): The polarization of a plane wave incident from a given direction and having a given power flux density that results in maximum available power at the antenna's terminals.

NOTE 1—The receiving polarization of an antenna is related to the antenna's polarization on transmitting (see definition above) in the following way: In the same plane of polarization, the polarization ellipses have the same axial ratio, the same sense of polarization, and the same spatial orientation. Since their senses of polarization and spatial orientation are specified by viewing their polarization ellipses in the respective directions into which they are propagating, one should note that (a) although their senses of polarization are the same, they would appear to be opposite if both waves were viewed in the same direction; and (b) their tilt angles are such that they are the negative of one another with respect to a common reference.

NOTE 2—The receiving polarization may be used to specify the polarization characteristic of a non-reciprocal antenna that may transmit and receive arbitrarily different polarizations.

polarization state (of a plane wave [field vector]): *See:* **state of polarization (of a plane wave [field vector])**.

polarization vector (for a field vector): A unitary vector that describes the state of polarization of a field vector at a given point in space.

NOTE 1—Polarization vectors differing only by a unitary factor ($e^{j\alpha}$, where α is real) correspond to the same polarization state.

NOTE 2—The appropriate inner product, $<\hat{e}_1, \hat{e}_2>$, for two polarization vectors in the same planes of polarization is given by $<\hat{e}_1, \hat{e}_2> = \hat{e}_1^{*} \cdot \hat{e}_2$, where $\hat{e}_1$ and $\hat{e}_2$ represent the polarization vectors corresponding to polarizations 1 and 2.

NOTE 3—The magnitude of the inner product of polarization vectors representing the same polarization is equal to unity. The inner product of two polarization vectors representing orthogonal polarizations is zero.

NOTE 4—The inner product of a polarization vector corresponding to a specified polarization, $\hat{e}_1$, and a complex electric-field vector, $\bar{E}$, at a point in space will yield the component of the electric-field vector corresponding to the specified polarization, $\bar{E}_1$, that is $\bar{E}_1 = (\hat{e}_1^{*} \cdot \bar{E})\, \hat{e}_1$.

NOTE 5—The basis vectors for the components of the polarization vector may correspond to any two orthogonal polarizations, the most common being two orthogonal linear polarizations or right-hand and left-hand circular polarizations.

NOTE 6—*Contrast with:* **polarization-phase vector (for a field vector)**.

Potter horn: A circular horn with one or more abrupt changes in diameter that excites two or more waveguide modes in order to produce a specified aperture illumination.

power gain: [Deprecated.] *See:* **gain, partial (of an antenna)**.

power pattern: *See:* **radiation pattern**.

power reflectance of a radome: At a given point on a radome, the ratio of the power flux density that is internally reflected from the radome to that incident on the radome from an internal radiating source.

power transmittance of a radome: In a given direction, the ratio of the power flux density emerging from a radome with an internal source to the power flux density that would be obtained if the radome were removed.

primary radiator: The radiating element of a reflector or lens antenna that is directly coupled to the transmitter or receiver, or through a feed line.

NOTE—For some applications, an array of radiating elements is employed.

principal E-plane: *See:* **E-plane, principal**.

principal half-power beamwidths: For a pattern the major lobe of which has a half-power contour that is essentially elliptical, the half-power beamwidths in the two pattern cuts that respectively contain the major and minor axes of the ellipse.

principal H-plane: *See:* **H-plane, principal**.

printed circuit antenna: An antenna of some desired shape bonded onto a dielectric substrate.

NOTE—The microstrip antenna is a notable example. *See:* **microstrip antenna**.

proximity-coupled dipole array antenna: An array antenna consisting of a series of coplanar dipoles, loosely coupled to the electromagnetic field of a balanced transmission line, the coupling being a function of the proximity and orientation of the dipole with respect to the transmission line.

pyramidal horn antenna: A horn antenna-with flat sides and a rectangular aperture, fed by a rectangular waveguide.

NOTE 1—When the horn flare is only in the direction of the electric field, it is called an E-plane horn antenna.

NOTE 2—When the horn flare is only in the direction of the magnetic field, it is called an H-plane horn antenna.

***Q* of a resonant antenna:** The ratio of 2π times the energy stored in the fields excited by the antenna to the energy radiated and dissipated per cycle.

NOTE—For an electrically small antenna, the ***Q*** is numerically equal to one-half the magnitude of the ratio of the incremental change in impedance to the corresponding incremental change in frequency at resonance, divided by the ratio of the antenna's resistance to the resonant frequency.

quantization lobes: For an array antenna, significant sidelobes resulting from quantizing the amplitude and/or phase of the signals at the elements or subarrays.

radar cross section: For a given scattering object upon which a plane wave is incident, that portion of the scattering cross section corresponding to a specified polarization component of the scattered wave. *See:* **scattering cross section**.

radiating element: A basic subdivision of an antenna that in itself is capable of radiating or receiving radio waves.

NOTE—Typical examples of a radiating element are a slot, horn, or dipole antenna.

radiating near-field region: *See:* **near-field region, radiating**.

radiation efficiency: The ratio of the total power radiated by an antenna to the net power accepted by the antenna from the connected transmitter.

radiation, electromagnetic: The emission of electromagnetic energy from a finite region in the form of unguided waves.

radiation intensity: In a given direction, the power radiated from an antenna per unit solid angle.

radiation pattern: The spatial distribution of a quantity that characterizes the electromagnetic field generated by an antenna. *Syn:* **antenna pattern**.

NOTE 1—The distribution can be expressed as a mathematical function or as a graphical representation.

NOTE 2—The quantities that are most often used to characterize the radiation from an antenna are proportional to or equal to power flux density, radiation intensity, directivity, phase, polarization, and field strength.

NOTE 3—The spatial distribution over any surface or path is also an antenna pattern.

NOTE 4—When the amplitude or relative amplitude of a specified component of the electric-field vector is plotted graphically, it is called an **amplitude pattern, field pattern,** or **voltage pattern.** When the square of the amplitude or relative amplitude is plotted, it is called a **power pattern.**

NOTE 5—When the quantity is not specified, an amplitude or power pattern is implied.

radiation pattern cut: Any path on a surface over which a radiation pattern is obtained.

NOTE—For far-field patterns, the surface is that of the radiation sphere. For this case, the path formed by the locus of points for which θ is a specified constant and ϕ is a variable is called a "conical cut." The path formed by the locus of points for which ϕ is a specified constant and θ is a variable is called a "great circle cut." The conical cut with θ equal to 90° is also a great circle cut. A spiral path that begins at the north pole ($\theta = 0°$) and ends at the south pole ($\theta = 180°$) is called a "spiral cut."

radiation resistance. The ratio of the power radiated by an antenna to the square of the rms antenna current referred to a specified point.

NOTE 1—The total power radiated is equal to the power accepted by the antenna minus the power dissipated in the antenna.

NOTE 2—This term is of limited utility for antennas in lossy media.

radiation sphere (for a given antenna): A large sphere the center of which lies within the volume of the antenna and the surface of which lies in the far field of the antenna, over which quantities characterizing the radiation from the antenna are determined.

NOTE 1—The location of points on the sphere are given in terms of the θ and ϕ coordinates of a standard spherical coordinate system the origin of which coincides with the center of the radiation sphere.

NOTE 2—If the antenna has a spherical coordinate system associated with it, then it is desirable that its coordinate system coincide with that of the radiation sphere.

radiator: Any antenna or radiating element that is a discrete physical and functional entity.

radome: A cover usually intended for protecting an antenna from the effects of its physical environment without degrading its electrical performance.

random array antenna: *See:* **array antenna**.

reactive field (of an antenna): Electric and magnetic fields surrounding an antenna and resulting in the storage of electromagnetic energy rather than in the radiation of electromagnetic energy.

reactive near-field region: *See:* **near-field region, reactive**.

reactive reflector antenna: *See:* **reflect~~ive~~array antenna**.

reactively controlled directive array: An analog adaptive antenna where adaptive beamforming is achieved by adaptively adjusting the load reactance of parasitic elements.

NOTE—Sometimes also called an ESPAR (Electronically Steerable Parasitic Array Radiator).

realized gain: The gain of an antenna reduced by its impedance mismatch factor.

NOTE—The realized gain depends on the system to which the antenna is connected. It does not include losses due to polarization mismatch between two antennas.

realized gain, partial (of an antenna for a given polarization): The partial gain of an antenna for a given polarization reduced by its impedance mismatch factor.

realized radiation efficiency: The radiation efficiency of an antenna reduced by its impedance mismatch factor. *Syn:* **total radiation efficiency**.

receiving efficiency: The ratio of the isotropic noise response with a noiseless antenna to the isotropic noise response. *See:* **isotropic noise response**.

NOTE—Equivalent to radiation efficiency for a passive, reciprocal antenna.

receiving polarization (of an antenna): *See:* **polarization, receiving (of an antenna)**.

reconfigurable antenna: An antenna capable of changing its performance characteristics (resonant frequency, radiation pattern, polarization, etc.) by mechanically or electrically changing its architecture.

rectangular grid array: A regular arrangement of array elements in a plane such that lines connecting corresponding points of adjacent elements form rectangles.

rectangular multiflare horn antenna: *See:* **compound rectangular horn antenna**.

reference boresight: A direction established as a reference for the alignment of an antenna. *See:* **electrical boresight**.

NOTE—The direction can be established by optical, electrical, or mechanical means.

reference directivity: *See:* **standard directivity**.

reflectarray antenna: An antenna consisting of a feed and an array of reflecting elements arranged on a surface and adjusted so that the reflected waves from the individual elements combine to produce a prescribed secondary radiation pattern. *Syn:* **reflective array antenna, reactive reflector antenna**.

NOTE—The reflecting elements are usually waveguides containing electrical phase shifters and terminated by short circuits or printed elements providing fixed or adjustable phase-shifts.

reflective array antenna: *See:* **reflectarray antenna**.

reflector: *See:* **Cassegrain reflector antenna; corner reflector; cylindrical reflector; Gregorian reflector antenna; horn reflector antenna; main reflector; offset paraboloidal reflector antenna; parabolic torus antenna; paraboloidal reflector; reflector antenna; reflector element; spherical reflector; sub-reflector; toroidal reflector; umbrella reflector antenna**.

reflector antenna: An antenna consisting of one or more reflecting surfaces and a radiating [receiving] feed system.

NOTE—Specific reflector antennas often carry the name of the reflector used as part of the term used to specify it: for example, paraboloidal reflector antenna.

reflector element: A parasitic element located in a direction other than forward of the driven element of an antenna, intended to increase the directivity of the antenna in the forward direction.

relative co-polar sidelobe level: *See:* **co-polar sidelobe, relative**.

relative cross-polar sidelobe level: *See:* **cross-polar sidelobe level, relative**.

relative gain (of an antenna). The ratio of the gain of an antenna in a given direction to the gain of a reference antenna.

NOTE—Unless otherwise specified, the maximum gains of the antennas are implied.

relative partial gain (of an antenna with respect to a reference antenna of a given polarization): In a given direction, the ratio of the partial gain of an antenna, corresponding to the polarization of the reference antenna, to the maximum gain of the reference antenna.

relative phase of an elliptically polarized field vector: *See:* **phase, relative, of an elliptically polarized field vector.**

relative sidelobe level: *See:* **sidelobe level, relative**.

resistance: *See:* **antenna resistance; radiation resistance**.

resonant antenna: An antenna which can operate efficiently over a narrow band ~~of~~ around its resonant frequency. *See*: **resonant frequency (of an antenna)**.

resonant frequency (of an antenna): A frequency at which the input impedance of an antenna is nonreactive.

retrodirective antenna: An antenna which when illuminated by a distant source preferentially returns power in the direction of the source.

rhombic antenna: An antenna composed of long wire radiators arranged in such a manner that they form the sides of a rhombus.

NOTE—The antenna usually is terminated in a resistance. The length of the sides of the rhombus, the angle between the sides, the elevation above ground, and the value of the termination resistance are proportioned to give the desired radiation properties.

ridged horn (antenna): A horn antenna in which the waveguide section is ridged.

right-hand polarization of a field vector: *See:* **sense of polarization**.

right-hand polarization of a plane wave: *See:* **sense of polarization**.

ring array: *See:* **circular array**.

scan angle: The angle between the direction of the maximum of the major lobe or a directional null and a reference direction. *Syn:* **beam angle**.

NOTE 1—The term *beam angle* applies to the case of a pencil-beam antenna.

NOTE 2—The reference boresight is usually chosen as the reference direction.

scanning (of an antenna beam): A repetitive motion given to the major lobe of an antenna.

scan sector: The angular interval over which the major lobe of an antenna is scanned.

scattering cross section: For a scattering object and an incident plane wave of a given frequency, polarization, and direction, an area that when multiplied by the power flux density of the incident wave would yield sufficient power that could produce, by isotropic radiation, the same radiation intensity as that in a given direction from the scattering object. *See:* **bistatic cross section; monostatic cross section; radar cross section**.

NOTE—The scattering cross section is equal to 4π times the ratio of the radiation intensity of the scattered wave in a specified direction to the power flux density of the incident plane wave.

secondary radiator: That portion of an antenna having the largest radiating aperture, consisting of a reflecting surface or a lens, as distinguished from its feed.

sectionalized [loaded] linear antenna: A linear antenna in which reactances are inserted at one or more points along the length of the antenna.

sector scanning: A modification of circular scanning in which the direction of the antenna beam generates a portion of a cone or a plane.

self-complementary antenna: An antenna the conducting and non-conducting areas of which are congruent.

self-impedance (of an array element): The input impedance of a radiating element of an array antenna with all other elements in the array open-circuited.

self-phasing array antenna system: A receiving antenna system that introduces a phase distribution among the array elements so as to maximize the received signal, regardless of the direction of incidence. *Contrast with:* **retrodirective antenna**.

sense of polarization: For an elliptical or circularly polarized field vector, the sense of rotation of the extremity of the field vector when its origin is fixed.

NOTE—When the plane of polarization is viewed from a specified side, if the extremity of the field vector rotates clockwise [counterclockwise] the sense is right-handed [left-handed]. For a plane wave, the plane of polarization is viewed looking in the direction of propagation.

sequential lobing: A direction-determining technique utilizing the signals of partially overlapping lobes occurring in sequence.

series-fed vertical antenna: A vertical antenna that is insulated from ground and the feed line of which connects between ground and the lower end of the antenna.

shaped-beam antenna: An antenna that is designed to have a prescribed pattern shape.

shielded-loop antenna [probe]: An electrically small antenna consisting of a tubular electrostatic shield formed into a loop with a small gap, and containing one or more wire turns.

shielded-loop probe: *See:* **shielded-loop antenna**.

shoulder lobe: A radiation lobe that has merged with the major lobe, thus causing the major lobe to have a distortion that is shoulder-like in appearance when displayed graphically. *Syn:* **vestigial lobe**.

shunt-fed vertical antenna: A vertical antenna that is connected directly to ground at its base and the feed line of which connects to the antenna between ground and a point suitably positioned above the base. *See:* **sidelobe**.

sidelobe: A radiation lobe in any direction other than that of the major lobe. See: **back lobe; co-polar sidelobe level, relative; cross-polar sidelobe level, relative; mean sidelobe level; minor lobe; sidelobe level, maximum relative; sidelobe level, relative.** *Syn:* **side lobe**.

sidelobe level, maximum relative: The maximum relative directivity of the highest sidelobe with respect to the maximum directivity of the antenna.

sidelobe level, relative: The maximum relative directivity of a sidelobe with respect to the maximum directivity of an antenna, usually expressed in decibels.

sidelobe suppression: Any process, action, or adjustment to reduce the level of the sidelobes or to reduce the degradation of the intended antenna system's performance resulting from the presence of sidelobes.

signal processing antenna system: An antenna system having circuit elements associated with its radiating element(s) that perform functions such as multiplication, storage, correlation, and time modulation of the input signals.

simultaneous lobing: A direction-determining technique utilizing the signals of overlapping lobes existing at the same time.

sinuous antenna: A broadband antenna in which the arms change direction back and forth from the center feed to the edge. It provides both circular polarizations, and requires at least two feed ports. It has the ability for very wideband performance.

sleeve-dipole antenna: A dipole antenna surrounded in its central portion by a coaxial conducting sleeve.

sleeve-monopole antenna: An antenna consisting of half of a sleeve-dipole antenna projecting from a ground plane.

slot antenna: A radiating element formed by a slot in a conducting surface.

smart antenna: An antenna – typically, an array – the characteristics of which are dynamically controlled using signal processing. *See:* **adaptive antenna system**.

solid-beam efficiency: The ratio of the power received over a specified solid angle when an antenna is isotropically illuminated by uncorrelated and unpolarized waves to the total power received by the antenna.

NOTE—This term is sometimes used to mean the ratio of the power received corresponding to a particular polarization over the solid angle to the total power received. Equivalently, the term is used to mean the ratio of the power radiated over a specified solid angle by the antenna corresponding to a particular polarization to the total power radiated.

space-tapered array antenna: An array antenna the radiation pattern of which is shaped by varying the density of driven radiating elements over the array surface. *Syn:* **density-tapered array antenna**.

sparse array antenna: An array antenna that contains substantially fewer driven radiating elements than a conventional uniformly spaced array with the same beamwidth having identical elements. Interelement spacings in the sparse array can be chosen such that no large grating lobes are formed and sidelobes are reduced. *See:* **space- and density-tapered array antenna and thinned array antenna**.

spherical array: A two-dimensional array of elements the corresponding points of which lie on a spherical surface.

spherical reflector: A reflector that is a portion of a spherical surface.

spillover: In the transmitting mode of a reflector antenna, the power from the feed that is not intercepted by the reflecting elements.

spiral antenna: An antenna consisting of one or more conducting wires or tapes arranged as a spiral.

NOTE—Spiral antennas are usually classified according to the shape of the surface to which they conform (for example, conical or planar spirals), and according to the mathematical form (for example, equiangular or archimedean).

squint: A condition in which a specified axis of an antenna – such as the direction of maximum directivity or of a directional null—departs slightly from a specified reference axis.

NOTE 1—Squint is often the undesired result of a defect in the antenna; however, in certain cases, squint is intentionally designed in in order to satisfy an operational requirement.

NOTE 2—The reference axis is often taken to be the mechanically defined axis of the antenna: for example, the axis of a paraboloidal reflector.

squint angle: The angle between a specified axis of an antenna, such as the direction of maximum directivity or a directional null, and the corresponding reference axis.

standard [reference] directivity: The maximum directivity from a planar aperture of area A, or from a line source of length L, when excited with a uniform-amplitude, equiphase distribution.

NOTE 1—For planar apertures in which $A >> \lambda^2$, the value of the standard directivity is $4\pi A/\lambda^2$, with λ the wavelength and with radiation confined to a half space.

NOTE 2—For line sources with $L >> \lambda$, the value of the standard directivity is $2L/\lambda$.

standing-wave antenna: An antenna the excitation of which is essentially equiphase, as the result of two feeding waves that traverse its length from opposite directions, their combined effect being that of a standing wave.

state of polarization (of a plane wave [field vector]): At a given point in space, the condition of the polarization of a plane wave [field vector] as described by the axial ratio, tilt angle, and sense of polarization. *Syn:* **polarization state (of a plane wave [field vector])**.

steerable-beam antenna system: An antenna with a non-moving aperture for which the direction of the major lobe can be changed by electronically altering the aperture excitation or by mechanically moving a feed of the antenna.

stepped antenna: *See:* **zoned antenna**.

stub antenna: A short, thick monopole.

subarray: A subset of elements in an array that are connected together to a single port.

subreflector: A reflector other than the main reflector of a multiple-reflector antenna.

sum pattern: A radiation pattern characterized by a single main lobe the cross section of which is essentially elliptical, and a family of sidelobes, the latter usually at a relatively low level.

NOTE—Antennas that produce sum patterns are often designed to produce a difference pattern and have application in acquisition and tracking radar systems. *Contrast with:* **difference pattern**.

superconducting antenna: An antenna where one or more parts is constructed from superconducting materials such as YBCO.

Superdirectivity: The condition that occurs when the antenna directivity is significantly higher than that with the array or aperture uniformly excited.

NOTE—Superdirectivity is only obtained at the cost of a large increase in the ratio of average stored energy to energy radiated per cycle.

surface wave antenna: An antenna that radiates power from discontinuities in the structure that interrupt a bound wave on the antenna's surface.

switched parasitic antenna: An antenna in which the beam is controlled by varying the loading on one or more closely coupled parasitic element(s).

switched parasitic array antenna: *See:* **switched parasitic antenna**.

tapered slot antenna. *See:* **TEM horn [antenna]**.

Taylor distribution, circular: A continuous distribution of a circular planar aperture that is equiphase, with the amplitude distribution dependent only on distance from the center of the aperture and such as to produce a pattern with a main beam plus sidelobes. The sidelobe structure is rotationally symmetric, with a specified number of inner sidelobes at a quasi-uniform height, the remainder of the sidelobes decaying in height with their angular separation from the main beam.

NOTE—Taylor distributions are often sampled to obtain the excitation for a planar array.

Taylor distribution, linear: A continuous distribution of a line source that is symmetric in amplitude, has a uniform progressive phase, and yields a pattern with a main beam plus sidelobes. The sidelobe structure is symmetrical, with a specified number of inner sidelobes at a quasi-uniform height, the remainder of the sidelobes decaying in height with their angular separation from the main beam.

NOTE—Taylor distributions are often sampled to obtain the excitation for a linear array.

TEM horn [antenna]: A horn antenna with two mirror-symmetric conductors that guide a transverse electromagnetic wave. The three-dimensional version has two flat or curved triangular sides that form a rectangular aperture. Planar versions with straight or curved sides are called tapered slot antennas, tapered slots with exponentially curved sides are called Vivaldi antennas.

thinned array antenna: A sparse array antenna obtained by terminating or removing a substantial number of elements from a conventional uniformly spaced array.

NOTE 1—This is often used to reduce the sidelobe level of the full array, and to maintain a narrow beamwidth with a reduced number of element chains driven with equal amplitudes. *See:* **space- and density-tapered array antenna**.

NOTE 2—Grating lobes, if any, are in the same directions and at the same relative levels as those of the fully driven uniformly spaced "parent" array. *See:* **sparse array antenna**.

tilt angle (of a polarization ellipse): When the plane of polarization is viewed from a specified side, the angle measured clockwise from a reference line to the major axis of the ellipse.

NOTE 1—For a plane wave, the plane of polarization is viewed looking in the direction of propagation.

NOTE 2—The tilt angle is only defined up to a multiple of π radians and is usually taken in the range $(-\pi/2, +\pi/2)$ or $(0, \pi)$.

top-loaded vertical antenna: A vertical monopole with an additional metallic structure at the top intended to increase the effective height of the antenna and to change its input impedance.

toroidal reflector: A reflector formed by rotating a segment of a plane curve about a nonintersecting coplanar line.

NOTE—The plane curve segment is called the torus cross section and the co-planar line is called the toroidal axis.
total radiation efficiency. *See:* **realized radiation efficiency**.

tracking: A motion given to the major lobe of an antenna with the intent that a selected moving target be contained within the major lobe. *Syn:* **angle tracking**.

traveling-wave antenna: An antenna the excitation of which has a quasi-uniform progressive phase, as the result of a single feeding wave traversing its length only in one direction.

triangular grid array: A regular arrangement of array elements in a plane, such that lines connecting corresponding points of adjacent elements form triangles, usually equilateral.

turnstile antenna: An antenna composed of two dipole antennas, perpendicular to each other, with their axes intersecting at their midpoints. Usually, the currents on the two dipole antennas are equal and in phase quadrature.

two-dimensional scanning: Scanning the beam of a directive antenna using two degrees of freedom to provide solid-angle coverage.

umbrella reflector antenna: An antenna constructed in a form similar to an umbrella that can be folded for storage, or transported and unfolded to form a large reflector antenna for use.

uniform linear array: A linear array of identically oriented and equally spaced radiating elements having equal current amplitudes and equal phase increments between excitation currents.

V antenna: A V-shaped arrangement of two wire conductors, balanced-fed at the apex, with included angle, length, and apex height above the Earth chosen so as to give the desired directive properties to the radiation pattern.

vertex plate (of a reflector antenna): A small auxiliary reflector placed in front of the main reflector near its vertex for the purpose of reducing the standing waves in the feed due to reflected waves from the main reflector.

vertically polarized field vector: A linearly polarized field vector the direction of which is vertical.

vertically polarized plane wave: A plane wave the electric-field vector of which is vertically polarized.

vestigial lobe: *See:* **shoulder lobe**.

visible range: For the case in which the field pattern of a continuous line source $L\lambda$ wavelengths long is expressed as a function of ψ ($\psi = L\lambda \cos\theta$, the angle θ is measured from an axis coincident with the line source), that part of the infinite range of ψ that corresponds to a variation in the directional angle θ from π to 0 radians, that is, $-L\lambda < \psi < L\lambda$.

NOTE 1—All values of ψ outside the visible range are said to be in the invisible range.

NOTE 2—The formulation of the field pattern as a function of ψ is useful because the sidelobes in the invisible range are a measure of the Q of the antenna.

NOTE 3—This concept of a visible range can be extended to other antenna types.

Vivaldi antenna: Tapered TEM or quasi-TEM slot antenna with exponential tapered sides and broadband characteristics.

voltage pattern: *See:* **radiation pattern**.

wave antenna: *See:* **Beverage antenna**.

waveguide lens: A lens that is comprised of an array of waveguides and is space fed by an appropriate feed.

whip antenna: A thin, flexible, monopole antenna.

wideband antenna. *See:* **broadband antenna**.

wire antenna: An antenna composed of one or more conductors, each of which is long compared to the transverse dimensions, and with transverse dimensions of each conductor so small compared to a wavelength that for the purpose of computation the current can be assumed to flow entirely longitudinally and to have negligible circumferential variation.

wire-grid lens antenna: A lens antenna constructed of wire grids in which the effective index of refraction (and thus the path delay) is locally controlled by the dimensions and the spacings of the wire grid. *Contrast with:* **geodesic lens antenna; Luneberg lens antenna**.

Wullenweber antenna: An antenna consisting of a circular array of radiating elements, each has its maximum directivity along the outward radial, and a feed system that provides a steerable beam that is narrow in the azimuth plane.

Yagi antenna: [Deprecated.] *See:* **Yagi-Uda antenna.**

Yagi-Uda antenna: A linear end-fire wire antenna array consisting of a driven element, a reflector element, and one or more director elements.

zoned antenna: A lens or reflector antenna having various portions (called zones or steps) that form a discontinuous surface such that a desired phase distribution of the aperture illumination is achieved. *Syn:* **stepped antenna**.

zone-plate lens antenna: *See:* **Fresnel lens antenna**.