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Di-electric Pyramidal Horn Antenna on the Basis of Geometrical Theory of Diffraction

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Abstract: The transmission of speech, music, pictures and other information by means of electrical signals is known as electrical communication. Across short distance speech and music are transmitted directly from there source to the listeners by mean of acoustic wave, similarly a picture is transmitted directly by light wave across short distance. Over large distances, wire communication and radio communications are used to transmit such signals, in the latter case it is the antenna system which plays the vital role in the process by coupling the source of power to free space and then directing this energy in some preferred direction. This paper introduce microwave and has briefly presented the history of antenna developments. Middle portion of the paper gives acquaintance with the work done on dielectric antennas. In the last the author has attempted to justify the reason for taking of the problem and has also briefly mentioned the aspects to be dealt with, also discussed the Geometrical theory of Diffraction.

Keywords: Electrical Communication, Acoustic Wave, Wire Communication, Radio Communications, Antenna, Microwave

I. INTRODUCTION

In almost any electrical communication system is necessary to transfer electromagnetic energy in some form, from one place to another. The process of transferring this energy is usually referred to as the transmission and can take place either through a material medium or through the free space. In the latter case it is the antenna system which plays the vital role in the process by coupling the source of power to free space and then directing this energy in some preferred direction. An antenna which radiates in all directions equally is called an isotropic or source. There is no such antenna because every antenna exhibits some directive properties was released by hertz, who first successfully demonstrated radiation of electromagnetic waves. The present-day position is that many types of microwave antennas are in use, of which the important ones are: (i) Aperture antenna consisting of horns, slot and open-ended waveguides, (ii) Dielectric and surface wave antennas comprising of the dielectric road, tube and horn antenna and (iii) Secondary antenna which can be subdivided into two classes (a) Reflectors and (b) Lenses.

II. BRIEF HISTORY OF ANTENNA

Firstly, Issac Newton formulated law of Universal Gravitation and he was reluctant to announce because his law violated the principle that the action at a distance is impossible. But Edmud Hally persuaded Newton to present the law before Royal Society in 1685 after discovering Comet. After that in 1839 Mickel Faraday presented the results of his “Experimental Researches” with curved line of force extended through empty space Joseph Henry in 1842 invented wire antennas for telegraphy by throwing a spark to a circuit of wire from his laboratory to parallel wire to 20 ft away. In 1875 Edison discovered that key clicks radiated to a distance and 1885 he patented a communication system using vertical top-loaded grounded antennas. In late nineteenth century microwave antenna which Marconi had added Lodge’s tuning advances to his vertical grounded antenna. The period 1910-1919 said the construction of many large low frequency high power antennas. In 1911 construction started of “Radio Virginia” at to Arlington. In 1913 the station was commissioned with 100 kw spark transmitter and a 35 kv arc transmitter. After centimeter wave antenna VHF and microwave antenna entered into the applications of radio electronics in the late of 1940’s. In this connection brief history of antenna is the history of spectrum utilization. As different regions of the spectrum are opened up at different epochs in time antenna evaluation always taken place sometime minor often major. Basically, spectral expansion is dominated by human motivation and the current level of technical feasibility.

A. Work Done on Dielectric Antenna

The need to concentrate the radiated power in some preferred direction was realized almost simultaneously with the successful demonstration of the radiation of electromagnetic waves by Hertz[1] in the year 1888. Bose, Marconi, Righi,

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Lodge and several other workers were also engaged independently in similar experiments generally in microwave region. In United States of America Southworth [2]in 1941 took out a patent which was based on his intensive research on the radiation from dielectric rods. At Bell Telephone Laboratories, Mueller and Tyrell commenced an exclusive study on the subject in 1941. They give a method for deriving an expression for the radiation pattern of a dielectric rods exited at one end. Covering the practical expect of the problem, they have described the designing details and have shown that for microwave antennas involving gains of 15-20 dB, payloads display high efficiency and are epically suitable for a broad-side array arrangement. In 1942 Van Atta [3] discussed the limitations of the size and shape of a parabodial reflector and its effect on radiation pattern for a given field distribution over the aperture plane. He conducted experiments on a number of such reflectors maintaining the f/D ratio constant and using the same feed as primary source. He concluded that with D increasing the beam width angle of the main lob decreases and the side lobes move closer towards the axles. In 1975 Jha [4] reported a comparative study of dielectric and metallic pyramidal horns of four different flare angles and axial lengths. In the same year an experimental study of dielectric pyramidal horn is reported by Mishrataking forty fiveantennas of five different flare angles, such as 5^0, 10^0, 20^0, 30^0& 45^0 and nine different axial lengths, such as 0.5 λ, 1.0 λ, 2.0 λ,..., 8.0 λ in each flare angle.Choudhary and Jhain 1986 proposed empirical solutions to power distributions in the far field due to a radiating system consisting of a rectangular waveguide terminated by a dialectical pyramidal horn. In 1992 radiation patters of E-plane sectoral solid dielectric horn excited by a rectangular metallic waveguide were predicated and compared with pattern measured at 9.37 GHz by Anil K. Singh, R Chaudhari, B. Jha and R.K. Jha. Far-field radiation patterns of dielectric pyramidal horn on the basis of near field observations were determined by Dr. A. Jha and Prof. L. Jha in 1993.

B. Geometrical Theory of Diffraction

Diffraction is the process where light propagation differs from the predictions of geometrical optics. Geometrical optics, the oldest and most widely used theory of light propagation, fails to account for certain optical phenomena called diffraction.One of the first exact solutions for the scattering of an electromagnetic wave by a perfectly conducting circular cylinder. It was obtained by separations of variables, and was an infinite series of products of trigonometric functions of the angular co-ordinate. Corresponding results were obtained for the sphere by Mic (1908), for the parabolic cylinder by Epstein (1914), for the strip or complementary slit by Morse and Rubenstein (1938), for the circular disc or complementary hole by Moglich (1927), BouWkamp (1941, 1946) and Meixner and Andrejewski (1950), and for the semi-infinite circular cone by Carslaw (1914) and by Hansen and Schiff (1948).

C. Diffraction like reflection and transmission

It is localized phenomenon at high frequencies i.e. it depends only on the nature of the boundary surface and the incident field in the immediate neighborhood of the point of diffraction. It is therefore possible to introduce a diffraction coefficient for each type of diffracted ray in the same sense as a reflection coefficient in GO, which allow to relate the magnitude of the diffracted field associated with each point on the diffracted ray to that of the incident ray which generates it. Like the reflection coefficients, the diffraction coefficient will depends only on the local geometry within a small region about the point of diffraction and so may be derived by extracting them from the asymptotic solution for a body which approximates the geometry of the actual surface over the region of interest. Those problems for which exact asymptotic solutions have been obtained are referred to as canonical problems. For example, in the case of diffraction by the edge of a thin screen, the canonical problem is that of a plane wave diffracted by a thin screen, occupying the half plane and thus having the straight edge. This problem is solved by Sommerfield in 1986 for a scalar field satisfying the wave equation and vanishing on the screen or having a vanishing normal derivative on the screen by expending this solution asymptotically for large K and comparing the result with that of geometrical theory, the diffraction coefficient d for these two cases can be determined. The normal laws of geometrical optics apply in detail the diffracted wave propagates along its ray so that

(a) Power is conserved in a tube or a strip of ray.
(b) The phase delay along the ray path equals the product of the wave number of the medium and the distance. Thus if the phase is known at one point of the ray, it can be found at all other points on the ray. Moreover at the point of diffraction, the phase is continuous, i.e. the phase of the incident ray equals that of the diffracted ray.

III. PROPOSED METHODOLOGY

Cylindrical wave Incidence on a wedge

Diffraction of a plane wave by a perfectly conducting wedge has been discussed in the preceding section. However, the more general situation of cylindrical wave diffraction by a wedge is of particular importance in the analysis of the horn antenna. The solution for these fields can also be obtained in the familiar formulation of plane wave diffraction theory. It is convenient to maintain the definitions of $\psi_o$equals the incident angle and ψ equals the diffraction angle in the direction of the desired field u_a.Because of the cylindrical nature of the incident field, the plane wave diffraction theory discussed cannot be directly applied to obtain u_a. However, the solution is obtained from the reciprocal example with the point of observation and source interchanged the total field's u_a and u_b are equivalent by the reciprocity principle.

The field u_b is now obtained for a plane wave incident on the wedge at an angle ψ

$$u_b = v = (x_o, \psi_o - \psi) \pm v(x_o, \psi_0 + \psi) \quad (1.1)$$

Using the property that

$$V(r, \emptyset) = v(r - \emptyset) \quad (1.2)$$

the solution for $u_a$becomes

$$u_a = v(x_o, \psi - \psi_o) \pm v(x_o, \psi + \psi_o) \quad (1.3)$$

This is the solution for diffraction of a cylindrical wave by a wedge, which may be viewed as being directly obtained from (1.1) by substituting the radial distance x_o to the line source for r of the observation point.
Equation (1.3) represents the field at an infinite distance from the edge but it gives a good angular representation of the field for moderate distance from the edge. The phase reference for (1.3) is at the edge, the superposition of diffraction from several edges requires the use of a common phase reference.
Plane wave diffraction is now a special case of (1.3). It is seen that when the line source recedes to infinity (1.3) must be evaluated by the form of v_B..Moreover the approximation of large a k r, may be valid for cylindrical wave diffraction. That is the diffraction for cylindrical wave incidence is the sameas that for plane wave incidence in regions sufficiently removed from any shadow boundary; the region about a shadow boundary in which the two are significantly different depends on the radial distance x_o to the line sourced.
The field u at point P is a solution to the scalar wave equation subject to the appropriate boundary conditions; the solution may be formulated as

$$u(r, \psi) = v(r, \psi + \psi_o) \pm v(r, \psi - \psi_o) \quad (1.4)$$

Polarization determines the choice of sign such that, with the electric vector perpendicular (parallel) to the edge, the positive (negative) sign is chosen. It is convenient to represent the incident or reflected field in the form

$$v(r, \phi) = v(r, \psi \pm \psi_o) \quad (1.5)$$

such that the (-) sign yields the incident fields and the (+) sign yields the reflected fields. The component field is given by

$$^{V}(r, \emptyset) = v^* + V_B \quad (1.6)$$

Where v* is the geometrical optics field given by

$$v^* = \begin{cases} e^{jp\cos(\phi+2} & -\pi < \phi + 2\pi nN < \pi \\ & N = 0, \ \pm 1, \ \pm 2, \ldots \\ 0 & otherwise \end{cases} \quad (1.7)$$

andv_B is the diffracted field given by

$$v_B = \frac{1}{2\pi n} \int - \frac{e^{j\rho\cos B}}{C\, 1 - e^{-j(B+\phi)/n}} dB \quad (1.8)$$

Where $\rho = kr$
Here C is the appropriate path in the plane of the complex variable.
An asymptotic expression for (1.5), obtained by sommerfield, is of the form

$$v_B(r, \phi) \approx (2\pi\rho)^{\frac{1}{2}} e^{-j}(\rho + \frac{\pi}{4})^{n-1} \frac{\sin\pi/n}{\frac{\cos\pi}{n} - \frac{\cos\phi}{n}} \quad (1.9)$$

This form yields infinite fields in the vicinity of the shadow boundary and is valid only if

$$\rho\left(\cos\frac{\pi}{n} - \cos\frac{\phi}{n}\right)^2 \gg 1 \quad (1.10)$$

However, for the special case of n = 2, the diffracted field expression was obtained by Sommerfield in terms of the Fresnel integral as

$$v_B(r, \phi) = -e^j(\pi/4)\left(\frac{2}{\pi a}\right)^{1/2} e^{j\rho\cos\phi} \left|\cos\frac{\phi}{2}\right| \cdot \int_{(a\rho)^{1/2}}^{\infty} e^{-jr^2} dT \quad (1.11)$$

Where

$$a = 1 + \cos\phi \quad (1.12)$$

it should be noted that the positive square root of ($a\rho$) should always be taken. The sum $V^* + V_B$ can also be represented more compactly by

$$V_{(r,\phi)} = \frac{e^{j(\frac{\pi}{4})}}{\sqrt{\pi}} e^{j\rho\cos\phi} \int_{-\infty}^{(2\rho)^{\frac{1}{2}}\cos\phi/2} e^{-jr^2} dT \quad (1.13)$$

It is seen that no discontinuities exist for $\phi = \pi$

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By making a transformation of variables and choosing an appropriate contour, Pauli [5] obtain an expression for Sommerfied's solution (1.5) which is expressed in series form as

$$V_{B(r,\phi)} = \frac{2e^{j(\pi/4)} \sin\frac{\pi}{n} |cos\frac{\phi}{2}|}{n\sqrt{\pi}\ \ cos\frac{\pi}{n} - cos\frac{\phi}{n}}$$

$$e^{jkr} - \cos\phi \int_{(a\rho)^{1/2}}^{\infty} e^{-jr^2} \mathrm{dr}+... \qquad (1.14)$$

Where the higher order terms may be neglected for large Kr. In the case of the thin half plane (n-2) the higher order terms are incidentally zero and (1.14) reduce to (1.11) if the higher order term may be neglected, the value of V_B converges to one-half the incident field at the shadow boundary or at $\phi = \pi$.
If the assumptions that (aρ) is large is valid, the asymptotic form of (1.12) which is given in (1.9) may be used to advantage as

$$V_{B(r,\phi)} = \frac{V_\phi\, e^{-j(\rho+\pi/4)}}{\sqrt{2\pi\rho}} \qquad (1.15a)$$

Where,

$$V_\phi = \frac{\frac{1}{n}sin\frac{\pi}{n}}{cos\frac{\pi}{n} - cos\frac{\phi}{n}} \qquad (1.15b)$$

IV. STUDY OF RADIATION PATTERN OF DIELECTRIC PYRAMIDAL HORN ANTENNA ON GEOMETRICAL THEORY OF DIFFRACTION

The design of pyramidal electromagnetic horn must take into consideration the fact that only the required mode of oscillation is excited in the horn and all other modes must be suppressed. In addition obtaining the desired gain and beam with of main lobe is also equally important.
The pyramidal shape is preferable because of the convenience of controlling beam within the E- and H-plane independently. Also, it is possible to produce linearly polarized waves. The pyramidal horn will have a rectangular apex and hence has to be fed by a rectangular waveguide which is designed to as to carry the $TE_{0,\,1}$ mode which is transferred to the radiating horn. However, this $TE_{0,\,1}$ mode is modified by the process and encounter to major changes. First the magnitude of the radial component of the electric and magnetic field vectors diminishes to a negligibly small value of large distance from the apex. Further these vector components are oriented tangential to the wave front surface, which in the case of acute pyramidal horn is a circle with its center at the apex of the horn and a slightly distorted spherical shape in the case of a wedge shape horn.
The computation of radiation characteristic of a metallic pyramidal horn necessitates the evaluation of electric and magnetic field vector in the aperture plane and then treating the aperture of the horn as equivalent to an opening of same dimension in a conducting metallic sheet of infinite size, to which diffraction can be applied as suggested by Fradin [6]. The field in the aperture plane is computed assuming that the horn is infinitely long, its wall is perfectly conducting and that flare is smooth and small.
The application of vector Kirchoff's formula to the fields in the aperture planes yields the following values of the radiation field components in the H- and E-plane as derived by Fradin.

$$E_H = J\,\frac{\exp(-jkr)}{r}.E_o cos^2\left(\frac{\theta}{2}\right)\int_{-D\frac{2}{2}}^{D\frac{i}{2}} exp\left(-j\,\frac{\pi ys^2}{R_2}\right)dy_s$$

$$\int_{D^{1/2}}^{D^{1/2}} cos\,\frac{\pi xs}{D_1}\exp(-j\frac{\pi}{\lambda}\frac{x_s{}^2}{R_1})\ \exp(jkx_s sin\theta)dx_2 \qquad (1.16)$$

And

$$E_E = J\,\frac{\exp(-jkr)}{r}\,E_o\cos^2\left(\frac{\theta}{2}\right)\int_{-D\frac{2}{2}}^{D\frac{2}{2}} \exp\left(-j\,\frac{\pi ys^2}{R_2}\right).$$

$$\exp(jky_s\sin\theta)dy_s \int_{-D^{1/2}}^{D^{1/2}} cos\,\frac{\pi x_s}{D_1}\ \exp(-j\frac{\pi xs^2}{R_1})dy_s \qquad (1.17)$$

It can be shown that the first integral of equation (1.16) and the second integral of (4.17) on solution yield values independent of θ. On the contrary the other two integrals in the above pair of equations reduce to expressions which contain some functions of θ, and hence these dictate directional pattern in the two principle planes respectively. In this chapter the radiation pattern of dielectric pyramidal horn has been studied on Geometrical Theory of diffraction. The theoretical radiation pattern calculated on GTD has been compared with the experimental observations studied by Jha and Mishra [7]. The theoretical finding follows the experimental observations within the limits of experimental errors.

V. RESULTS AND DISCUSSION

Gain of Microwave antenna

The gain of an antenna is almost always expressed with respect to an isotropic radiator. The latter is a very convenient mathematical reference but is hardly of practical value since it does not exist, atleast for a fixed state of polarization. The elementary half-wave dipole is sometimes an acceptable substitute, since its gain is accurately known, but its radiation pattern is bidirectional and its gain is inconveniently low. The horn has become the universally slandered against to measure the gain of other antennas.

The gain G of an antenna is defined as,

$$G = \frac{\text{Maximum rsdiation intensity}}{\text{Maximum radiation intensity from a reference antenna with same power input}} \quad (1.6.1)$$

Any type of antenna may be taken as the references but often a linear ½ wavelength antenna is taken as reference one. Gain includes the effect of losses in the antenna under consideration and in the reference antenna.

It will be convenient to assume that the reference antenna is an isotropic source of 100 percent efficiency. So the gain so defined for the subject antenna is called the gain G_0 with respect to an isotropic source.

Thus,

$$G_0 = \frac{\text{Maximum radiation intensity from subject antenna}}{\text{Radiation intensity from isotropic source with the same power input}} \quad (1.6.2)$$

Let the maximum radiation intensity from the subject antenna be U'_m and let this be related to the value of the maximum radiation intensity U_m for a 100 percent efficient subject antenna by a radiation efficiency factor K. Hence,

$$U'_m = K\,U_m \quad (1.6.3)$$

Where, $0 \leq K \leq 1$

Therefore, equation (5.2) may be written as

$$G_0 = U'_m / U_0 = KU_m / U_0 \quad (1.6.4)$$

Where U_0 is the radiation intensity from the lossless isotropic source with the same power input, U_0 = w/4. But the ratio U_m / U_0 is the directivity D so the equation becomes

$$G_0 = KD \quad (1.6.5)$$

Thus, the gain of an antenna over a lossless isotropic source equals to the directivity of the antenna is 100 percent efficient (K = 1) but is less than the directivity if any losses are present in the antenna (K < 1).

The directivity D and G_0 implies the maximum values for an antenna. The directivity or gain in the direction for which the radiation intensity U is not maximum may be designed by specifying the angle Ø at which it is measured or, in general, by symbol D (θ, Ø) or G_0 (θ, Ø) that is

$$D(\theta, \emptyset) = \frac{U}{Um} D \quad (1.6.6)$$

$$G_0(\theta, \emptyset) = \frac{U}{Um} G_0 \quad (1.6.7)$$

Where, U = radiation intensity in the direction (θ, Ø).

U_m = maximum radiation intensity

Both directivity and gain may be expressed as a decibel ratio by taking 10 times the algorithm to the base 10, that is,

$$\text{Dbdirectivity} = 10 \log_{10} D \quad (1.6.8)$$

$$\text{Db gain} = 10 \log_{10} G \quad (1.6.9)$$

Since the power gain G is equal to the square of the gain in the field intensity G_f, we also have

$$\text{Db gain} = 20 \log_{10} Gf \quad (1.6.10)$$

Thus the Db is the same, whether based on the power gain or gain in field intensity.

Jakes [30] described an experimental investigation of the gain of pyramidal electromagnetic horn. When computing the gain of pyramidal electromagnetic horns, it is permissible to use their actual physical dimensions and Schelkunoff's curves. The error due to the edge effect is less then 0,1db for optimum horns, with aperture dimensions greater than 4λ. If it is desired to compute the transmitted power between two identical horns, the familiar transmission formula

$$P_R = \left(\frac{G\lambda}{4\pi r}\right)^2 P_T \quad (1.6.11)$$

Where,

P_R = Power received

P_T = Power transmitted

G = Gain of each individual horn

Is valid in the transmission zone between the Fraunhofer and Fresnel regions, provided r is replaced by r_0+2D, where r_0 is separation between the apertures and D is the distance from the horn aperture back to the reference point. For an optimum horn D is equal to the axial height, but for horns shorter or longer than optimum, D is greater or less than the axial height and must be determined by the experiment.

For the horn tested it was found that (1) the edge effects are less than 0.2db so that the gain of the horn may be computed to that accuracy from their physical dimensions and Schelkunoff'scurves; and (2) for the transmission of

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power between two horns the ordinary transmission formula is valid, provided that the separation distance between the horn is measured between the proper reference points on the horns, rather than between their apertures.
Recent experimental evidence [8] indicates that the measured gain of pyramidal electromagnetic horn may be considerably in error if the measurement is carried out at short distance, and the aperture to aperture separation between horns is used in the gain formula.

$$G= 4\pi R/\lambda \sqrt{PR/PT} \qquad (1.6.12)$$

Further experimental verification of this effect has been obtained and a theory developed which is good quantitative, agreement which present experimental data and demonstrate the physical reason why the previous "far field" criterion of $2D^2 / \lambda$ is invalid. Curves are presented from which the error in gain measured at any distance may be obtained and applied as a correlation. The minimum aperture separation for which zero correction is required makes the beginning of the true Fraunhofer region. Keeping in view an idea recently suggested by Jakes and Braun the later presented a table from which the gain of all

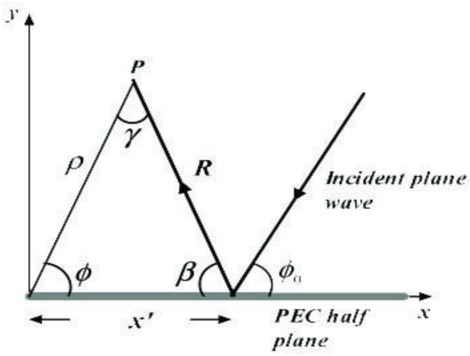

Fig.1(a)

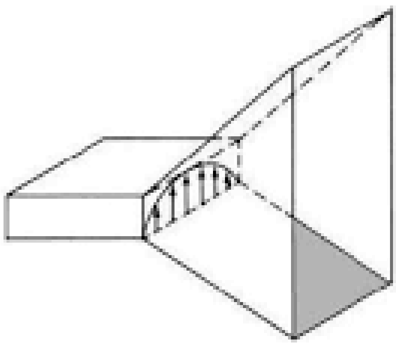

Fig.1(b)

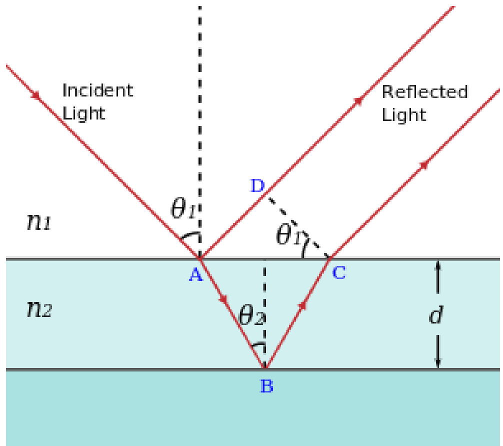

Fig. 1(c)

1(a). Co-ordinates for magnetic line source near a conducting half-plane
1(b). Two-dimensional E-plane sectorialhorns formed by conducting sector with magnetic line at apex. Ray path of an-axis geometric optics and non-interaction aperture diffracted fields are shown.
1(c). Ray path of upper edge diffracted fields reflected in forward directions from horn interior.
Electromagnetic horns may be calculated with substantially the same accuracy obtainable using the gain formula. The exact parameters of an optimum horn are given, and a simple procedure for the design of the optimum horns with a specified gain and other desirable properties is described.

Expression of far-field: By using the exact solution for the far field of a magnetic line source near a conducting, half plane, singularities on shadow boundary occurring in a direct application of a geometrical theory of diffraction are avoided. In Fig. 1(a) the far field at r, θ of the source at $r'^{o,}\theta_o$ in solution is

$$H_X \ in \ c(r,\theta) = (\tfrac{\pi}{2})^2 \exp(-j\tfrac{\pi}{4}) H_o(2)(K1) \simeq \frac{exp-jk[r-r_o(\theta-\theta_0)]}{(Kr)^{1/2}}, KP \gg 1. \qquad (1.6.2.1)$$

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Where K $=\frac{2\pi}{\lambda}$ is the free space propagation constant. If this source is parallel to the edge of a consulting half plane, there is a reflected far-field in $0 < \theta < \pi - \theta_o$ given by (4.6.2.1) with $\theta + \theta_o$replacing $\theta - \theta_0$ and in $0 < \theta < 2\pi$ a diffracted far-field

$$H_X\, diff(r, \theta) = \frac{\exp(-jkr)}{(kr)^{1/2}}\, f(r_o, \theta,\ \theta_o) \qquad (1.6.2.2)$$

Where,

$$F(r_o, \theta, \theta_o) = v(r_o, \theta\text{-}\theta_o) + v(r_o, \theta + \theta_o) \qquad (1.6.2.3)$$

With,

$$V(r_o, \alpha) = -\frac{\exp(jkr_o cos\alpha + J\frac{\pi}{4})}{\sqrt{\pi}} \cdot \int_{(2kr_o)^{\frac{1}{2}} cos\alpha/2}^{\alpha} exp\,(-jT^2)dT$$

$$= -\frac{\exp(jkr_o cos\alpha)}{2}\{1 - (1+j).[c((\frac{4kr_0}{\pi})^{\frac{1}{2}} cos\frac{\alpha}{2}) - js((\frac{4kr_o}{\pi})^{\frac{1}{2}} cos\frac{\alpha}{2})]\} \qquad (1.6.2.4)$$

and

$$C(u) - js(u) = \int_0^u \exp(-j\frac{\pi}{2}t^2)\, dt \qquad (1.6.2.5)$$

When this line source is on the conducting half plane at $r_o = 1$ from the edge, the source field

$$H_X\, i\,(r, \theta) = \frac{\exp[-jk(r - lcos\theta)]}{(Kr)^{1/2}} \qquad (1.6.2.6)$$

Produces a diffracted field

$$H_X d(r, \theta) = \frac{\exp(-jkr)}{(kr)^{1/2}}\, V(1, \theta) \qquad (1.6.2.7)$$

Study of Gain of Dielectric Pyramidal Horn on Geometrical Theory of Diffraction Empirical formula for the far field

The equality of the radiation pattern in the far field due to a dielectric horn is controlled by the wavelength of the propagating wave, the dielectric property and the thickness of the wall of the horn in addition to its various other parameters viz. Length and flare angle. While in the metallic case the amplitude at the center of the horn is constant, in dielectric case it varies with the wavelength of the radiation excited from the wave guide and the dielectric properties of the material of the horn. Further the phase velocity inside the horn varies with the distance between the walls parallel to the dielectric field vectors. The wave propagating through the antennas are more or less cylindrical.

No attempt has been taken on our part to make predictions for the expressions of the field components in the aperture plane of the antennas. Instead a strong conjecture for the formula of electric vectors in the H- and E-planes in the far field has been made. The component functions are symmetrical in the radiating angle θ, the axes of the horn being assumed to be θ = 0 line. The thickness of the side walls of the horn has been assumed to be negligible for all practical purposes. Hence this parameter does not enter into the expression for the electric vector. Introduction of an error of one percent due to this account is only expected in the final results. We write the expression for electric component vectors in the H- and E-planes in the far field due to TE_{01} mode propagating through dielectric horn as

$$E = E_0 cos\theta\, \{\frac{-1}{-cos\theta}\}.\frac{sin\beta}{sin\beta}cos\psi \qquad (1.7.1)$$

Where θ = diffracted angle

$$\beta = \frac{\pi L}{\lambda}(\quad -cos\theta), \qquad (1.7.2)$$

$$\beta_0 = \frac{\pi L}{\lambda}(\quad - 1),$$

$$\Psi = \frac{\pi D}{\lambda} \sin\theta$$

$$= \sqrt{1 - \left(\frac{\lambda}{2D}\right) \in 0/\in}$$

L = Axial length of the horn.
λ = Free space wavelength.
∈= Dielectric constant of the material used in the construction of the horn.
∈ 0 = Dielectric constant of the air.
D = Dimensions of the aperture in the H- or E- plane concerned.

V. CONCLUSION

From inspection of the current trends it is not difficult to determine a number of aspects of antenna technology which will require substantial research development and design effort over the next decade. The following list is far from complete but it does provide some indications of the range of topics which must be addressed.

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1. Antenna provides improved and 'affordable' electronically controllable radiation characteristics. This category includes steerable beam, multiple beam and adaptive antennas from LF and EHF.
2. Technologies such as microstrip, for antennas and microwave components, hybrid microwave integrated circuits and monolithic microwave and millimeter-wave integrated circuits; new transmission-line technologies for the millimeter-wave bands.
3. Hybrid lens and reflector antennas with 'smart' array feeds, which offer a mean of acquiring many of the desirable features of the electronic control at an acceptable cost.
4. Integration and optimization of antenna in their working environments, including computer aided design methods dealing with antenna and its environment, improved random design, planar, conformal and wrap-around antennas; in conspicuous antenna; and multiband and multifunction antenna concepts to reduce the number of antenna system for any given application.
5. Very slow side-lobe antennas (of all types) and the associated high performance RF components which can operate over band-widths of 15% or more, in multiple bands.
6. Dule-polarised antenna system for communications and radar, which can maintain their characteristics over wide band-widths and/or in multiple bands.
7. Materials research for improved antennas and radomes and the effects of the use of new materials on antenna performance (e.g. the use of carbon fibre in aircraft and other vehicles).
8. The development of the theoretical and, analytical and computer-aided techniques which improves fundamental understanding or provide an enhance design capability for antennas or components of all types.
9. Further progress in the electromagnetic measurements methods and provision of traceable standards and celebration for radiation field.
10. Finally, the means, both the technological and 'political' to introduce electromagnetic design concepts into an earlier stage in the design of system, vehicles and installations in general.

REFERENCES

[1]. Ted Simpson, "On hertz and the speed of light", 2017 IEEE International Symposium on Antennas and Propagation & USNC/URSI National Radio Science Meeting, IEEE Xplore: 19 October 2017.

[2]. Nancy Ghattas, Atef M. Ghuniem, Sherif M. Abuelenin, "Optimization of Dielectric Rod Antenna Design in Millimeter Wave Band for Wireless Communications", ResearchGate, July, 2017.

[3]. Michael J. Coleman, Frank Baginski, Robert R. Romanofsky, "The Effect of Boundary Support and Reflector Dimensions on Inflatable Parabolic Antenna Performance", NASA/TM—2011-217110.

[4]. Chintan A Patel, Shobhit K Patel, "Pyramidal horn antenna design loaded by metamaterial for performance enhancement", Conference: 2015 IEEE MTT-S International Conference on Numerical Electromagnetic and Multiphysics Modeling and Optimization (NEMO), At Ottawa, ON, Canada, August 2015.

[5]. Di Wu; ZhengheFeng; Wei Liu "A novel conical horn antenna loaded with ball cone dielectric", Proceedings of 2014 3rd Asia-Pacific Conference on Antennas and Propagation INSPEC Accession Number: 14824453,Date Added to IEEE Xplore: 22 December 2014.

[6]. Ramesh Chandra Gupta, Surya Pal Singh, "Analysis of radiation patterns of compound box-horn antenna", Progress In Electromagnetics Research 76:31-44, January 2007.

[7]. KamillKlem-Musatov, Henning C. Hoeber, Tijmen Jan Moser, Michael A. Pelissier "Classical and Modern Diffraction Theory", SEG Geophysics reprint series no 29, 2016.

[8]. E. H. Braun, "Gain of Electromagnetic Horns", Proceedings of the IRE 41(1):109 - 115 · February 1953.

[9]. MohitAnand, "Applications of Metamaterial in Antenna Engineering", International Journal of Technical Research and Applications, Volume 2, Issue 1 (jan-feb 2014).

[10]. A.P. Gregory , R.N. Clarke, "A review of RF and microwave techniques for dielectric measurements on polar liquidsSign In or Purchase", IEEE Transactions on Dielectrics and Electrical Insulation, Issue 4, Aug. 2006.

[11]. Kexin Liu, "Theoretical Investigation on Propagation and Coupling of Nonreciprocal Electromagnetic Surface Waves", KTH School of Electrical Engineering, Osquldasväg 6,SE-100 44 Stockholm,Sweden, September 2016.

[12]. Peter Bienstman, Solomon Assefa, Steven G. Johnson and John D. Joannopoulos, Gale S. Petrich and Leslie A. Kolodziejski, "Taper structures for coupling into photonic crystal slab waveguides", Vol. 20, No. 9/September 2003/J. Opt. Soc. Am. B.

[13]. Prabhakar.Telagarapua, A.LakshmiPrasanthib, G.VijayaSanthic, B. Ravi Kirand, "Design and Analysis of Parabolic Reflector with High Gain Pencil Beam and Low side lobes by Varying feed", Int. J. Advanced Networking and Applications 1105 Volume: 03, Issue: 02, Pages: 1105-1115 (2011).