International Journal of Engineering Research & Management Technology

ISSN: 2348-4039

March-2018 Volume 5, Issue-2

Email: editor@ijermt.org www.ijermt.org

STUDY OF DI-ELECTRIC PYRAMIDAL HORN AERIAL ON THE BASIS OF GEOMETRICAL THEORY OF DIFFRACTION

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ABSTRACT

Radio communication requires the transfer the energy between the transmitter and receiver. During this transmission, an important step is the release of radio frequency energy into space for the communication of intelligence. For this energy release, transmission line is terminating by a radiating element, transferred r.f. energy affected by the intelligence, is applied to this radiator, which setup high frequency currents along its length. The electromagnetic waves are produced into the space due to the escape of electrical energy from this radiating element, which then travel with the velocity of light. This radiating element is usually known as “AERIAL”.

KEY WORDS: Frequency, Gain, Radiation Pattern, Di-electric, Horn

INTRODUCTION

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 almost any electrical communication system is necessary to transfer electromagnetic energy in some form, from one place to another. The process of transferring these 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 aerial 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. Thus the function of a transmitting aerial is to receive electrical energy, transform it into the electromagnetic form, which consequently transmitted into space in a direction determined by the aerial itself.

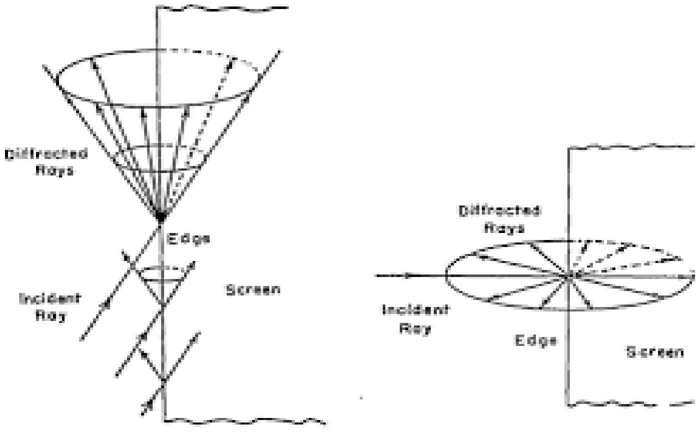
Similarly a receiving aerial captures electromagnetic radiation from the space converts it into corresponding electrical energy which in turn is fed to proper circuits for directions. Since an aerial and the associated propagation medium generally constitute a passive linear network, it follows from the reciprocity theorem that the radiation pattern and the impedance are the same whether the aerial be used for transmission or reception. This property is readily utilised in radar system, where the aerial is used for both transmission and reception.

An aerial which radiates in all directions equally is called an isotropic or source. There is no such aerial because every aerial exhibits some directive properties was released by hertz, who first successfully demonstrated radiation of electromagnetic waves.

However, the very thought of utilizing the microwave frequency region for obtaining directional patterns remained obscure for decades. This was mainly due to lack of adequate experimental facilities for high frequencies. Ultimately the World War II caused a breakthrough in the direction because of the widespread requirement of radar and other communication systems and thus a new era of development of microwave aerials began. The development of high power generators of centimetre and shorter wavelength was an important landmark in the direction as with it a series of microwave aerials completely unknown to the long wave region followed. The present day position is that many types of microwave aerials are in use, of which the important ones are: (i) Aperture aerial consisting of horns, slot and open-ended waveguides, (ii) Dielectric and surface wave aerials comprising of the dielectric road, tube and horn aerial and (iii) Secondary aerial which can be subdivided into two classes (a) Reflectors and (b) Lenses.

The main difference between these aerials and those employed at lower frequencies lies in the fact that in these microwave aerials are required shaping of the beam of radiation is achieved not by individually feeding discrete radiating element but by techniques akin to those used in optics. As the dimensions of the aerials are generally large compared with the wavelength optical design principles are both preferable and practicable.

Diffracted rays are produced by incident rays which hit edges, corners or vertices of boundary surfaces or which graze such surfaces just as there are laws of reflection and refractions which governs the behaviour of incident reflected and refracted rays. Keller proposed adding several new laws



(a) (b)

Our attention will be restricted to isotropic homogeneous media. In such a media Maxwell equation for a harmonic field are equivalent to:

$$\nabla^2\vec{E} + K^2\vec{E} = 0 \qquad (1)$$

$$\nabla.\vec{E} = 0 \qquad (2)$$

$$\overrightarrow{H} = \frac{1}{iK\eta}\nabla\, X\, \vec{E} \qquad (3)$$

Where the time dependence e^{-iwt} hasbeen chosen and suppressed and where η is the characteristic impedance of the media given by $\eta = \sqrt{\frac{u}{\epsilon}}$. In order to introduce the technique which may be used to construct asymptotic solutions verifying the vector Helmholtz equations (1) subject to the condition (2) called Gaussian law, we first consider a scalar field U in which case, the equations (2) – 4) reduce to the scalar Helmholtz equations:

$$\nabla\, U + k^2U = 0 \qquad (4)$$

When k -- >∝we know that (2.4) is verified by the GO field. Thus we seek for solutions of the form:

$$U\,(\vec{r}) = A(\vec{r})e^{iks\,(\overrightarrow{r})} \qquad (5)$$

Where A is a slowly varying function of position and k is large. Substituting (5) into (4) we get:

$$1 - (\nabla s)^2 + \frac{1}{k}[\nabla s + \frac{\nabla A}{A}\,.\,\vec{\nabla} s] + \frac{1}{k2}.\frac{\nabla A}{A}=0 \qquad (6)$$

Since k is supposed large but arbitrary equation (7) is verified if:

$$(\nabla s)^2 = 1 \qquad (7)$$

$$\nabla s + \frac{\vec{\nabla} A}{A}.\vec{\nabla}\, s = 0 \qquad (8)$$

$$\frac{\nabla A}{A} = 0 \qquad (9)$$

We recognize in (7) and (8) the eikonal and transport equations of Go.

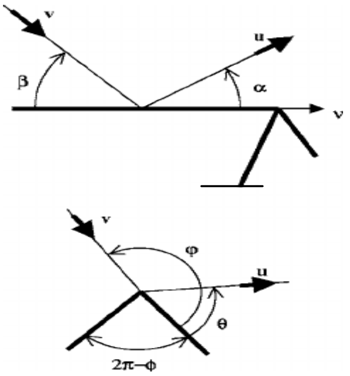


Fig 1 Diffraction of plane wave by wedge

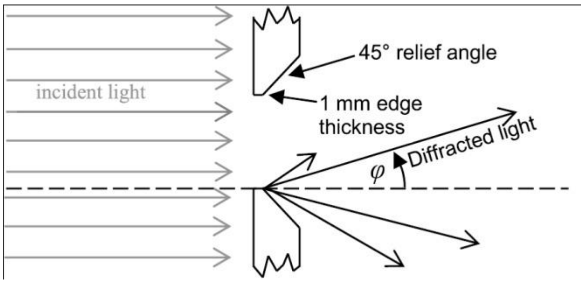


Fig 2 Construction of diffracted fields by a thick edge.

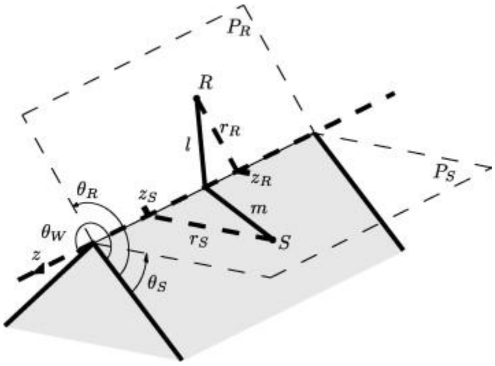


Fig 3 Co-ordinate systems for cylindrical wave diffracted by a thick edge

In this conventional metallic horn aerial the expression for radiation field is derived by first evaluating the electric and magnetic field vector in the aperture plane and then applying the vector Kirchoff's formula to them. However, such is not the case with dielectric horn aerial. Deriving analogy from the uniform cylindrical dielectric rod aerial, here again the resultant radiation pattern can safely be assumed to be due to the combined effect of :

(1) The radiation from the waveguide mouth,
(2) The radiation from the side walls of the dielectric horn, and
(3) The radiation due to the field in the aperture plane

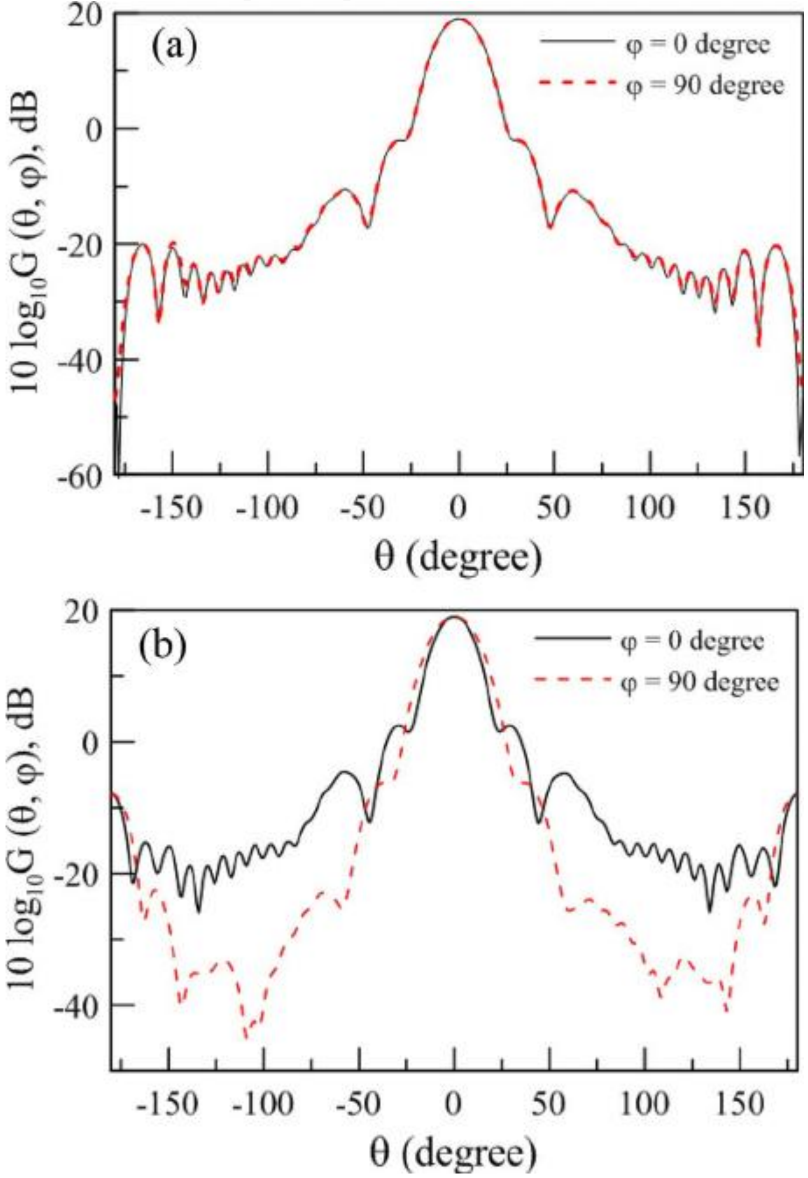


Fig.4

radiators will not be in the same phase due to the varying distance of these radiators from the point P. This phase difference between rays from two adjacent points is given by Fig. 4

$$\delta = \frac{2\pi}{\lambda} X \sin\theta \qquad (10)$$

Where θ is the angle which the point P makes with the surface of the dielectric horn. This expression where substituted into equation (4.5) yields,

Also let VE be the field at P due to anyone of the radiators along the line PS and E the field if all the radiators along this line were in phase and located at the middle point of PS. The resultant field intensity at P due to combined effect of radiators along PS can then be written as :

$$E_p\,(d_1) = \Delta E[1 + \exp(j\delta) + \exp(ij\delta) + \cdots \exp\{(n-1)j\delta\}]$$

$$= \Delta E[\frac{1-\exp(-jn\delta)}{1-\exp(j\delta)}]$$

$$= \Delta E\left[\frac{\sin\frac{n\delta}{2}}{\sin\delta\,/2}\right] \qquad (11)$$

Where exp (jδ) denotes the phase change factor of the wave.

The gain G of an aerial is defined as,

$$G = \frac{\text{Maximum rsdiation intensity}}{\text{Maximum radiation intensity from a reference aerial with same power input}} \qquad (12)$$

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

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

Thus,

$$G_0 = \frac{\text{Maximum radiation intensity from subject aerial}}{\text{Radiation intensity from isotropic source with the same power input}} \qquad (13)$$

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

$$U'_m = K\,U_m \qquad (14)$$

Where, $0 \leq K \leq 1$

Therefore, equation (5.2) may be written as

$$G_0 = U'_m / U_0 = KU_m / U_0 \qquad (15)$$

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 (15) becomes

$$G_0 = KD \qquad (16)$$

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

CONCLUSION

One of the important function of radar is to find the rang of target at as much distance as possible. Further to resolve the more accurately is equally important function of it. One of the way of increasing the radar range to enhance the transmitting power, while for greater resolution it is necessary to concentrate the transmitted power in a narrow region in space. The latter technique is much more useful in the sense that for the fixed radar transmitted power, the resolution as well as the range of radar is increased. Also by this technique the communication likes may be operated with a relatively a low power of the transmitter. Thus it is most essential to devise a radiating system which concentrates the power within the smallest possible half power beam width is necessary to surmount the a foreside problems. The existing state of art does solve the problem but the cost is high.

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