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Using Lens at Aperture of Antenna for NFF and FFS

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***Abstract:** Antenna technology is developing in today's world where data transmission is main. In such environment number of different antennas is developed for near field and far field focusing. In this paper a linear feed antenna array is presented which is a sectoral horn H-plane antenna having dielectric lens of biconvex shape are placed in the aperture. Only in h-plane our antenna focuses its beam for providing high aperture and small width of linear array illumination. For the array length illumination in the other plane the field distribution is found on the array having nice agreement of 10 GHz frequency prototype. In this paper we use CST tool for simulation.*

***Key Words:** CST, prototype, H-plane, far field, biconvex, aperture.*

I. INTRODUCTION

Most of the research are now began in near field operation field where need is more with demand. In today's world well developing technique have number of applications such as material characterization, biomedical, imagery sensing etc. Based on phase adjustment in the near field antenna focusing design in antenna aperture for obtaining Wave front which is locally plane at a focal point. As we consider that Gaussian beam is generated by the field antenna which makes possible for focus beam width evaluation which is considered as waist of beam. There is beam focus enabled in the regions of near field. By using an patch array of planar type we can obtain focus of beam, having dielectric lens, slotted waveguide of rectangular type, lens of horn antenna with plates of metal and with lens of metal. It's better to place a horn antenna aperture with a lens. A 2-d spot is generated by this antennas focused at near field, here we use a sectoral antenna which is having lens of dielectric in its aperture which is only to adjust far field properties of beam. Anyhow antenna which is focusing the near field having focusing beam at single plane and broad beam at plane of orthogonal may be having few interesting applications Such as long material testing optic having width very less or as a feed system to microwave Application in linear array of linear antenna. A dielectric lens horn antenna with sectoral H-plane is loaded by the dedicated dielectric lens of horn antenna having dimensions of 280mm length and 49mm width presented in this paper.

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Which is placed in the field of near field feed region. For array width illumination in one single plane the E- field structure is focused and along the orthogonal plane a long beam is generated of the array and for array of length illumination. For illuminating the array length a broad beam at once of orthogonal plane id used. At 8GHz frequency our antenna is measured and mutated on this antenna which is developed as part of radar which is innovated for navigation. In this paper we follow the theory part first and then results are presented in next section which is in CST tool support at last comparison between practical and theoretical results.

II. LENS OPERATION

As shown in figure.1 below the length L is considered and A as aperture of antenna which is having near field focusing theory. We have linearly polarized electric field where x and z are the aperture coordinates.

$$\vec{E}_{AP}(x,z) = E_0(x,z)\cdot e^{-j\varphi(x,z)}\vec{x} \quad \ldots\ldots\ldots\ldots\ldots (1)$$

Following is the distribution expressed as radiation of electric field:

$$\vec{E}(P) = \frac{1}{4\pi}\iint_{(A)} \vec{E}_{AP}(M)\cdot\frac{e^{-jkr}}{r}\cdot\left[\left(jk+\frac{1}{r}\right)\vec{i}\cdot\vec{r}+jk\vec{i}\cdot\vec{s}\right]dxdz \quad \ldots\ldots (2)$$

P is a point of observation,
M is a point source on aperture location A.
R is considered as source to observation point distance.

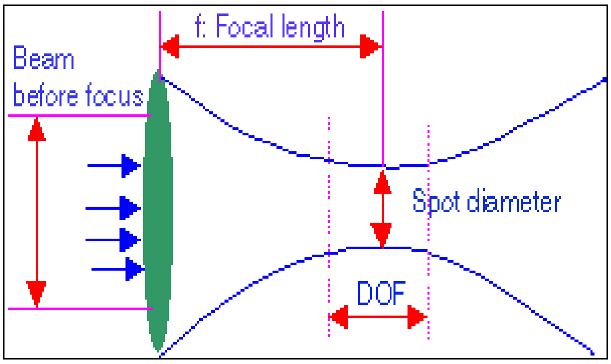

Figure.1: NFF Apertures

P : r = $\|\vec{r}\| = \|\overrightarrow{MP}\|$,
k is the free space constant,
$k = 2\pi/\lambda_0$,
i Bar is vector unit in direction y,
s Bar is vector unit in the direction y,
'β' is angle among the y axis and radiated beam of each source.

when

$$r \gg \lambda,\ \vec{i} \cdot \vec{r} = \cos\theta \text{ and } \vec{i} \cdot \vec{s} = 1,$$

Then equation 2 as given above is considered as

$$\vec{E}(P) = \iint_{(A)} K \cdot \vec{E}_{AP}(M) . \frac{e^{-jkr}}{r} dxdz \quad \text{...... (3)}$$

Where K is considered as equation of constant

$$K = \frac{jk(\cos\beta + 1)}{4\pi}$$

At the point of focus F (0; d_f ; 0), the each field generated phase is given as

$$\varphi = \varphi(\beta) + kr = \varphi(\beta) + k \cdot \frac{d_f}{\cos(\beta)} \sqrt{\left(1 + \frac{x^2 \cos^2(\beta)}{d_f^2}\right)} \quad \text{................(4)}$$

As we have x<< d_f then

$$\varphi \approx \varphi(\beta) + k \cdot \frac{d_f}{\cos(\beta)}$$

The phase of the field at the point of focus of radiation by location of each source must constant on the aperture.

$$\varphi(\beta) + k \cdot \frac{d_f}{\cos(\beta)} = C$$

Here constant is denoted as C. and if we consider the reference as a field phase radiation from the location of source where z = L/2, we obtain

$$C = \frac{d_f}{\cos\left(\beta_{\max}\right)}$$

That's why for focal distance focusing of beam at d_f , aperture of phase of variation must be considered as,

$$\varphi(\beta) = k \cdot d_f \left(\frac{1}{\cos(\beta_{\max})} - \frac{1}{\cos(\beta)}\right) \quad \text{.......... (5)}$$

By combining the dielectric lens and horn antenna we can synthesize the phase differences of for obtaining the required thickness and the character of lens permittivity we adjust the phase of the equation.5 which is given above. Based on total problem of optical analogy the antenna lens is dependent as described below.

- The lenses field which is depicted in horn antenna having lens in side facing is considered by source S point.
- On both the sides of lens we consider the propagation model of free space.
- On the lens surfaces there is no refraction and reflection occurs. It's common that at geometry of lens we determine the error due to such problem of simplification is included.

Our proposed antennas are having length of 100mm. whereas sectoral horn antenna aperture is equal to 300mm in the plane of H and in the plane of E it is 50mm.

As shown in figure.3 below the topology of lens is reported on which the lens shapes calculation is dependent. At the horn antennas excitation point we place a source point S. L is considered as length of horn antenna where is the required point of focus is considered as F. here lens is having 2 divisional parts of calculation.

- On the plane of horn antenna aperture the corresponding design of convex part which is first is designed.
- For focusing the beam at distance of desire we distribute the phase appropriately which is provided by second convex lens part.

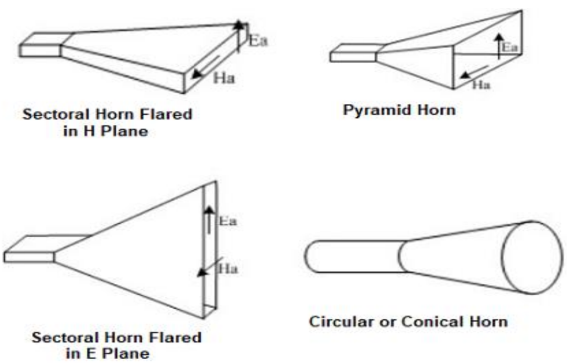

Figure.2: sector horn antenna.

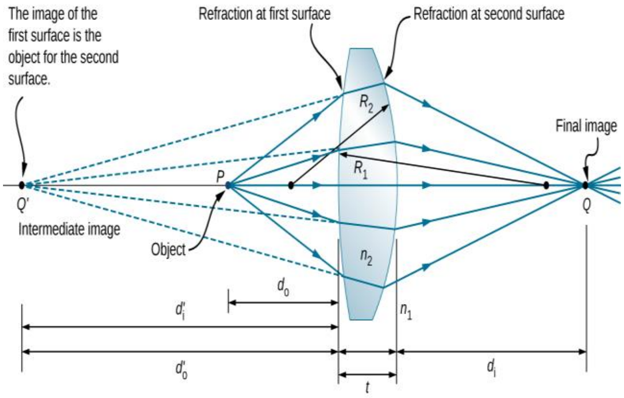

Figure.3: Lens parameters

The first part of lens convex are is given as beta versus thickness as given in equation below.

$$T_{lens1}(\alpha) = \frac{d_s \cdot \cos(\alpha)}{\sqrt{\varepsilon_r} - 1} \left(\frac{1}{\cos(\alpha_{\max})} - \frac{1}{\cos(\alpha)}\right)$$

For the second lens of convex part the beta versus thickness is given in equation below and as indicated in figure.3.

$$T_{lens2}(\beta) = \frac{d_f \cdot \cos(\beta)}{\sqrt{\varepsilon_r} - 1} \left(\frac{1}{\cos(\beta_{\max})} - \frac{1}{\cos(\beta)}\right)$$

The lens focal distance is determined by its shape of about d_f = 350 mm. d_s is denoted as horn antennas length which is equal to 250 mm with L = 325 mm which is an aperture.

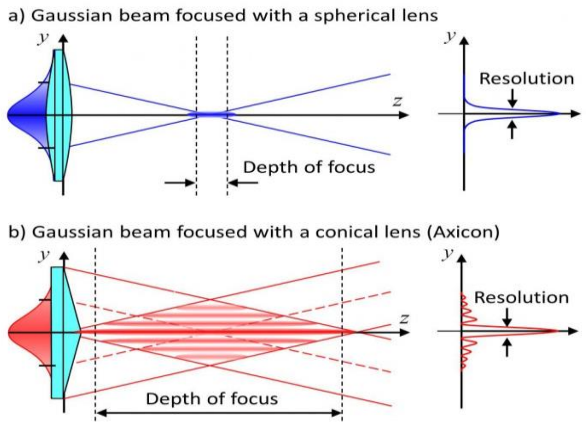

Figure.4: Gaussian beam.

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The parameters of our antenna lens is relative permittivity as 4 where thickness of first convex lens is given as beta is equal to 0 and $T_{lens1}(0)$ = 43:6 mm. whereas The second convex lens has a thickness for beta is equal to 0 which is equals to $T_{lens2}(0)$ = 35:9 mm.

2.2. Focal width estimation

If the beam distribution at the lens focal field which is getting distributed is considered as close to Gaussian beam at the output field, at the focal point the width is determined as the lens reflection ratio. We call this width as "waist" which is representing to the beam width at $20.\log_{10}(1/e) = -7.5$ dB. As corresponding to the plane wave front the beam width is minimal as corresponding to it as explained initially in introduction and is shown in figure.4 above.

We can calculate the width as shown below:

$$d_0 \approx \frac{2 d_f \lambda}{L}$$

The focal width in our case is equal to focal distance which os of 300mm and is equal to d_0=68.7 mm.

III. RESULTS

We maximize the dimensions of lens which we discussed in previous section that is done by using CST tool. This main agenda is to optimize the distance of focusing beam which is constrained from the aperture of horn antenna.

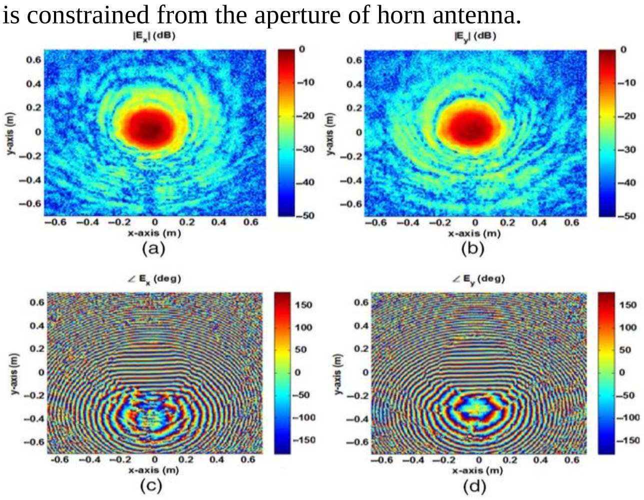

Figure.5: E_x & E_y planes.

For the first lens of convex shape the thickness is optimized and we obtained $T_{lens1}(0)$ = 30 mm and where as for the second lens the thickness size is $T_{lens\ 2}(0)$ = 35 mm. then we take reflection and diffraction of signals into account the horn antenna aperture where the lens are placed in the simulation part. Here it's clear there is lots of difference in theoretical and simulation results of thickness of lens. In the figure.5 as above we can see that a both electric and magnetic field plane gives E_x-field in both magnitude and phase at 8 GHz frequency. Form which we identified that field is not focused in E- plane due to fact that on the behavior of phase propagation the lens has no impact. So, its quite opposite as expected in H- plane here the field is much focused with point of focus located in the horn antenna aperture at distance with 300 mm size. Anyhow the wave front is plane locally in the point of focus. For the calculation we use the simulation and theoretical models result which are compliant for validating the process of design.

IV. METHODOLOGY

The methodology we used in our paper is to have lenses near the aperture on antenna which we use and we simulate it with using CST Microwave tool. We designed an antique prototype which is as shown in figure.6 below with its manufacturing of this antenna type. We measure this antenna at 8GHz frequency range and we evaluate the E-field at 300 mm from antennas horn and the mapping of E_x-fleld of our antenna in simulation process which is

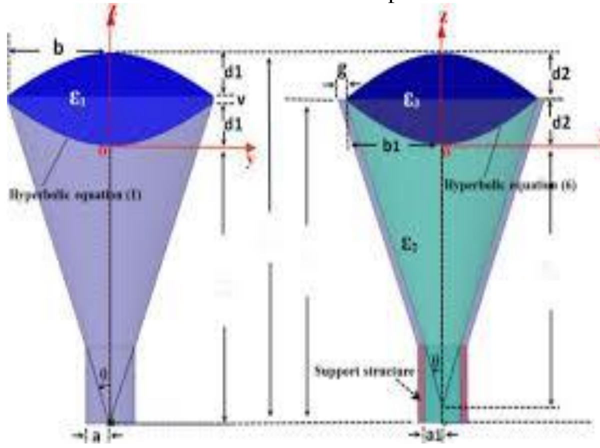

Figure.6: lens content antenna aperture

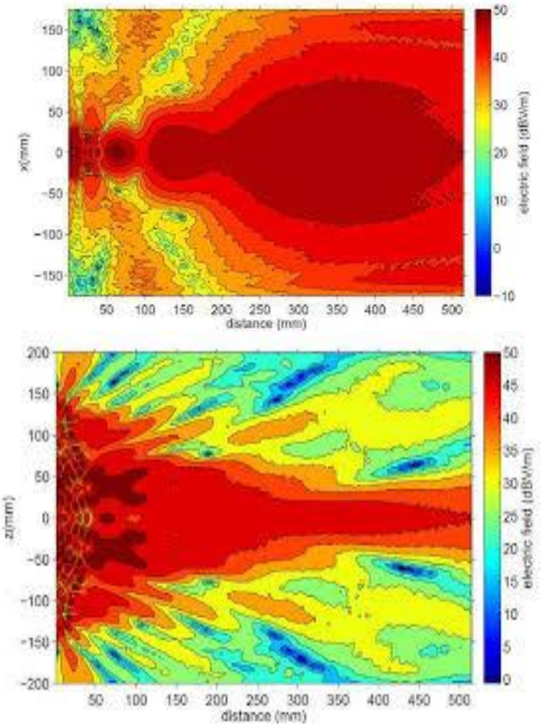

Figure.7: electric field operation of both practical and theoretical

The desired contour is measured with the color change operation with the area of 8dB in the ending side of simulation result. The E_x-fleld is obtained in both theoretical and practical simulation which is slightly different.

The field of magnitude at the edge of contour is considered and equal to 7dB in the magnetic plane. For measuring these values we have different ranges of 4 dB in magnetic and 7dB in electric plane. So, we can see the differences between these 2 which is due to small tilt in the beams which is totally of 4 mm and 3mm in both electric and magnetic fields that can be explained by measurement setups small difference of tilt. We can make equal the magnitude of field at the edge to 5dB in magnetic and 7dB in electric planes.

Table.1: simulation measurement of waist value

	Theory	Simulation	Measurement
Value of the waist	60 mm	50 mm	60 mm

We have a good agreement of results which we can say by seeing the tabular form where the theoretical, practical and simulated result gives the exact understanding of waist value.

V. CONCLUSION

We have investigated the 1-D focused antenna which is better operating in near fields which is theoretically can be expressed easy so, practical approach is considered with lens shape at an aperture of horn antenna for focusing the beam. A biconvex sectoral horn antenna structure is final in both the planes E and H plane by using CST tools for simulation.

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AUTHOR PROFILE

Mohammed Nayeemuddin, has completed his technical education in Gudlavalleru Engineering College. presently an research scholar in SSSUTMS University with area of interest in antennas domain. Has published 12 international and 5 scopus journals and having membership in IAENG, ISRD, IJCRT and JARTMS.

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