Development of Conical Horn Feed For Reflector Antenna

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***Abstract*—We have designed a antenna feed with prime concerned that with the growing conjunctions in the mobile networks, the parabolic antenna are evolving as an useful device for point to point communications where the need for high directivity and high power density is at the prime importance. With these needs we have designed the unusual type of feed antenna for parabolic dish that is used for both reception and transmission purpose. This different frequency band performance having horn feed, works for the parabolic reflector antenna. We have worked on frequency band between 4.8 GHz to 5.9 GHz for horn type of feed. Here function of the horn is to produce uniform phase front with a larger aperture than that of the waveguide and hence greater directivity. Parabolic dish antenna is the most commonly and widely used antenna in communication field mainly in satellite and radar communication.**

***Index Terms*—Horn Antenna, Parabolic Reflector, Return Loss, waveguide**

I. INTRODUCTION

Reflector antennas are widely used antenna in the communication world for numerous applications like radio astronomy, microwave communication, satellite tracking, and radar applications A feed is the main point of contact between the dish and the coaxial cable or a wave guide. In short, we can say that a feed is a medium of communication for the dish. It means that by means of the feed, we can communicate with the dish, of course the communication is bidirectional. i.e., we can transmit as well as receive waves with the help of the dish. Various types of feeds used for a parabolic dish are available. A horn antenna is a useful and simple radiator excited by a waveguide. Horn antenna is one of the most popular antennas used as a focal point feed in many reflector antennas. Generally the losses in the horn are negligible, and hence we can assume the gain of the horn to be the same as the directivity [1]. The function of the horn is to produce a uniform phase font with a larger aperture than that of the waveguide and hence greater directivity. Horn antenna was first constructed by well Known scientists Jagadis Chandra Bose, India 1897 and it was pyramidal horn [2] see in Fig.1-b.

The horn radiator is a tapered termination of a length of waveguide that provides the impedance transformation between the waveguide impedance and the free-space impedance. Horn radiators are used both as antennas in their own right, and as illuminators for reflector antennas. Horn antennas are not a perfect match to the waveguide, although standing wave ratios of 1.5:1 or less are achievable. The gain of a horn radiator is proportional to the area A of the flared open flange), and inversely proportional to the square of the wavelength [8].Following Fig.1 gives types of Horn radiators.

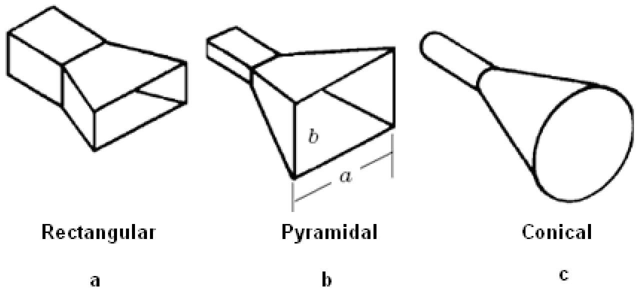

Fig.1 Horn Radiators

It is an example of circular horn. Fig 1 shows a conical type. When excited with a circular waveguide carrying TE_{11} mode wave, the electric field distribution at the aperture is as shown by arrows [2], a parabolic reflector can take two different forms. One configuration is that of the parabolic right cylinder shown in Fig 2 where dipole can be use as a feed. Whose energy is collimated at a line that is parallel to the axis of cylinder through the focal point of the reflector?

The most widely used for the type of a reflector is a liner dipole, a linear array or slotted Wave Guide (W/G) [3] This is formed by rotating the parabola around its axis and it is referred to as a parabololoid or parabola of revolution [4].A pyramidal or a conical horn has been widely utilized as a feed for this arrangement [5].

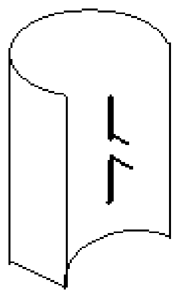

Fig.2 parabolic right cylinder where dipole can be use courtesy [3]

The parabolic reflector antenna is one of the most widespread of all the microwave antennas, and is the type

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that normally comes to mind when thinking of microwave systems. This type of antenna derives its operation from physics similar to optics, and is possible because microwaves are in a transition region between ordinary radio waves and infrared/visible light. At microwave frequencies, it becomes possible to use reflector antennas because of the short wavelengths involved.

Reflectors are theoretically possible at lower frequencies, but because of the longer wavelengths, the antennas would be so large that they become impractical [8]. Reflector antennas have existed since the days of Heinrich Hertz (who designed and built the first parabolic cylinder reflector in 1888) and are still one of the best solutions to requirements for cost effective, high gain, high performance antenna systems. Consequently, the majority of ground station antennas are reflector antennas of one type or another as are many spacecraft high gain antennas [9].Fig.3 is illustrates the conical horn with feed connector could be used as a feed for reflector antenna.

II. Design Consideration

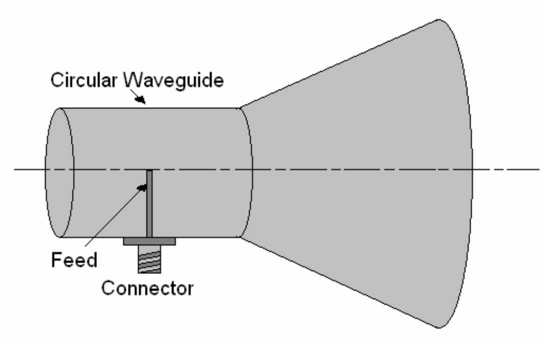

Fig. 3 conical Horn with Feed connector

For given Frequency of operation Parameters possible are 4.8 GHz to 5.9 GHz could be used in Wireless Local Area Network (WLAN).

So at this frequency let us a find a rest of parameters for designing an antenna.
4.8 GHz to 5.9 GHz, Diameter of the dish (D): 600mm, Focal Length (f): 270 mm, Depth of Dish (d): 83 mm, from the parameters given first calculate f/D ratio.

f/D = focal length/Diameter of dish = 0.445

Actual dish diameter is 600 mm but the diameter of the illuminated area is 432.66 mm (shown as shaded region) [6]. Horn designed on this basis will somehow reduce the power radiated outside the region of interest effectively which will cause improvement in gain of overall system [7].

Beam width is calculated by:
$70\ \lambda/Da = 7.291^0$

Lower cut off frequency f_c = 4.8 GHz

$$\therefore l_c = \frac{3\times10^8}{4.8\times10^9}$$

$$\therefore l_c = 62.5 \text{ mm}$$

Now, circular waveguide can operate in either TE (Transverse Electric) mode or TM (Transverse Magnetic) mode.

Physical Aperture Area of the Dish (A_a):

$$A_a = p\,r_a^2 \quad \therefore A_a = p\,(0.3)^2$$

$$A_e = p\,r_e^{\,2}, \text{ i.e. } A_e = 52\%\ (A_a)$$

$$\therefore p\,r_e^{\,2} = 0.52p\,r_a^{\,2} \;\therefore r_e = 0.7211\ r_a$$

$$\therefore r_e = 0.7211\ (0.3)$$
$$\therefore r_e = 0.21633 \text{ m}$$

$$BW = \frac{70\,l}{D_a}$$

$$\therefore BW = \frac{70\times0.0625}{0.6}$$

$$= 7.291^0$$

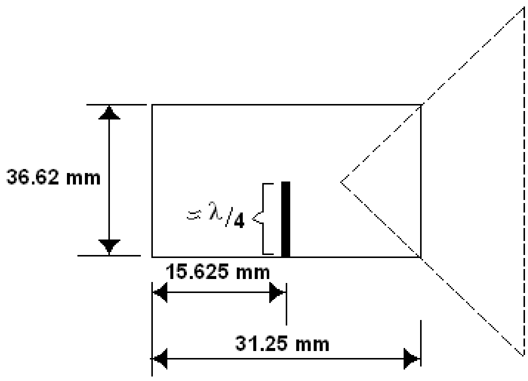

Fig.4 Waveguide dimension with feed

Let us choose length as λ/2.

i.e. l = 62.5/2 = 31.25 mm

Feed can be provided at λ/4 distance from closed wall (or closed end) of waveguide.

Feed length = λ / 4 = 15.625 mm

See in Fig.4 it is a W/G dimension with feed.

Horn feed designed for frequency range of (4.8 GHz to 5.9 GHz) is having maximum attainable gain of 16 dB (without reflector) and 32 (dB with reflector).

Even it's observed Received Gains for different feed lengths (Horn with Dish) & Received Gains for different feed lengths (With Horn only) Feed wire length 12mm and feed wire length arrangement and design of horn are very easy and accomplished at a very low cost. VSWR for the antenna is less than 2.5. We have dimensions are too small that blocking due to feed will be very low. Its mounting 13mm..

III. Results & Discussions

Fig.5 is a measurement set up for VSWR & Gain for horn antenna with the help of spectrum analyzer.

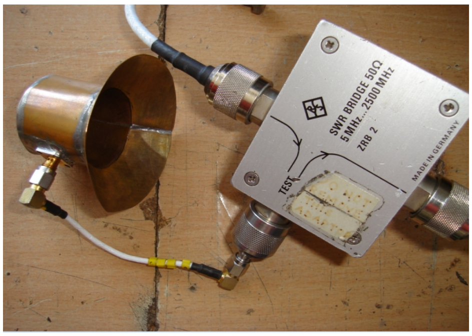

Fig.5 VSWR measurement set up for horn antenna

We have observed the results of Horn with dish and Horn without disc is very much impressive by former case. As we can see from Table 1, Gain enhancement was very much by horn feed reflector antenna. Here as far as feed point is concern we had taken impedance matching techniques and by trial and error we got feed point. There may be chance of improvement of feeding techniques by taking help of CAD software for High Frequency like HFSS or CST.This is not discussed and used in this design. We can see Fig 6 is two dimensional decibel plots.. It is the snap shot of vector analyzer results at frequency 5.35 GHz. Fig.6 provides results of E-plane and H-plane, which very much important to understand orientation of antenna. As you can see E-plane provides an output is smooth than H-plane. Fig.7 provides a final product ready for installation for wireless communication work. A especially it is useful for mobile networks.

Horns are used at microwave frequencies where moderate gains are sufficient. They are used as feed elements. They are often used in laboratories for the measurement of different antenna parameters Accurate antenna gain measurements are important in a wide range of applications such as satellite communications, remote sensing, electromagnetic compatibility measurements, and radar. To evaluate the gain of an antenna, it is customary to compare its performance against a well calibrated “standard.” So-called standard-gain horns are used for this purpose the most common type of horn used as a standard-gain horn is the pyramidal horn shown in Fig 1.

TABLE I Results

Sr. No.	Freq GHz f	Wave length (mm) λ	FSL (dB) 20log 4πr/ λ	Gains for different feed lengths (Horn with Dish)
1	5.2	57.69	52.78	30.92
2	5.3	56.6	52.94	32.08
3	**5.35**	**56.07**	**53.03**	**30.17**
4	5.4	55.55	53.11	30.25
5	5.5	54.54	53.27	30.4

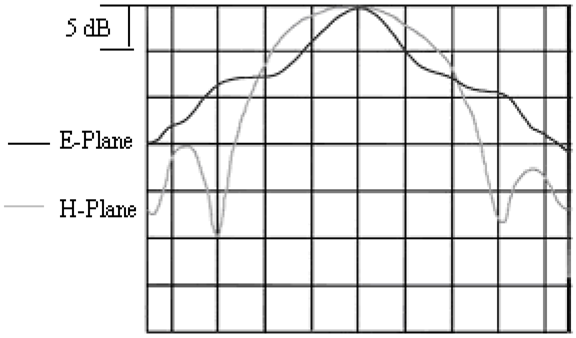

Fig.6 E-Plane & H-Plane

The rectangular geometry of this horn enables easy manufacture and results in a low-cost antenna. Conical horns can also be used as standard-gain horns where the antenna gain, *G*dBi >15 dBi. Often overlooked is the conical corrugated horn as a standard-gain horn when *G*dBi >12 dBi. In calculating the gain of all of these horns it is assumed that the aperture terminates in an infinite flange. In practice, of course, horns have a finite flange, often just the thickness of the metal wall, and this leads to some inaccuracy in the calculated gain. The calculated results for the corrugated horn will, in principle, be more accurate since flange effects are far less severe for this type of horn (at least for large aperture horns considered here when *G*dBi >12 dBi) than for the other horn types. This is a consequence of the electromagnetic field in the corrugated horn becoming zero, or close to zero, as the aperture edge is approached, which in turn will minimize any flange effects. This aspect is also largely the case with the dual-mode horn but only over a much reduced bandwidth around the center design frequency [9].

fig.7 reflector Antenna with Mounted Horn Feed

IV. Conclusion

Parabolic dish antenna is the most commonly and widely used antenna in communication field mainly in satellite and radar communication. The feed designs for the parabolic dishes are having their own advantages over conventional feed. Horn feed designed for frequency range of (4.8 GHz to 5.9 GHz) is having maximum attainable gain of 16 dB (without reflector) and 32 (dB with reflector). Even its dimensions are too small that blocking due to feed will be very low. Its mounting arrangement and design of horn are very easy and accomplished at a very low cost. VSWR for the antenna is less than 2.5.

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