Development of Feed for Parabolic Reflector Antenna

Jagdish. M. Rathod, Member, *IACSIT* and Y.P.Kosta, Senior Member IEEE

***Abstract*—Reflector antennas are widely used antenna in the communication world for numerous applications like radio astronomy, microwave communication, satellite tracking, and radar applications. These applications resulted in spectacular progress in the development of sophisticated analytical and experimental techniques in shaping the reflector surface and optimizing illumination over their apertures so as to maximize the gain. We have designed the feed antenna for parabolic dish. That is used for both rec eption and transmission purpose. This different frequency band performance having horn feed and it 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.**

***Index Terms*—Beamwidth, Gain, Feed, VSWR**

I. INTRODUCTION

The success in the exploration of outer space has resulted in the advancement of antenna theory. Because of the need to communicate over great distances, sophisticated forms of antennas had to be used in order to transmit and receive signals that had to travel millions of miles. A very common antenna form for such an application is a parabolic reflector shown in Fig. 1 Antenna of this type has been built with diameters as large as 305 m. Such large dimensions are needed to achieve high gain required transmit or receive signals after millions of miles of travel 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 scientist of India Jagadis Chandra Bose in 1897 is pyramidal horn [2] Most common features of a Dish are Parabolic or dish antennas are NOT frequency dependant, Dish antennas are NOT all the same shape, Wind loading, beamwidth, and Dish size When excited with a circular waveguide carrying TE_{11} mode wave, the electric field distribution at the aperture is as shown by arrows [2]

We can see the typical reflector configurations in Fig.1. 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].

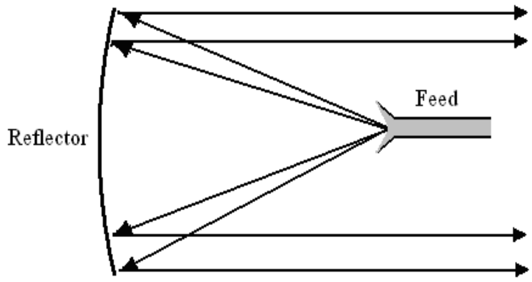

Fig.1 Typical reflector configuration

The parabolic reflector antenna is one of the most widespread of all the microwave antennas, and is the type 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]. Parabolic dish feed geometries for feeding parabolic dish antennas, regardless of which form of radiator (horn, dipole, etc.) is normally, use. We have used conical horn as a feed for reflector antenna. We see the method in which the radiator element is placed at the focal point, and a waveguide (or transmission line) is routed to it. This method is used in low-cost installations such as home satellite TV receive-only (TVRO) antennas [8].

II. GEOMETRY OF HORN FEED FOR PARABOLIC REFLECTOR

Suppose that we have a point source and that we wish to produce a plane wave front over a large aperture by means of a sheet reflector. Referring to Fig.2, it is then required that the distance from the source to the plane wave front via path 1 and 2 be equal. Followings are equation for the required surface contour. It is the equation of a parabola with the focus at F. The basic property of the parabolic reflector is that it converts the spherical wave irradiating from a point source placed at the focus into a plane wave.

Manuscript received March 11, 2009. This work was supported by SICART and B V M Eng College-V V Nagar-India.
Jagdish. M. Rathod is with, Department of Electronics Engg, B V M Engg College, V V Nagar-Gujarat-India,
Y.P.Kosta is with, Charotar Institute of Technology, Changa-India

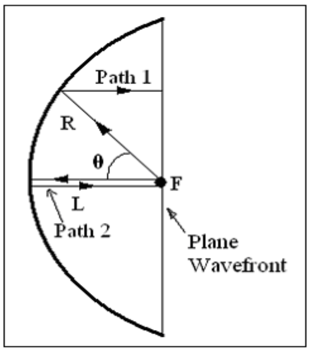

Fig. 2 Parabolic reflector geometry

$$2L = R(1 + \cos q) \quad (1)$$

$$R = \frac{2L}{1 + \cos q} \quad (2)$$

Conversely all the energy received by a dish from the distance source is reflected to a single point at the focus of the disc In Fig.3 parabolic dish parameter is mentioned and the position of the focus or focal length is given by:

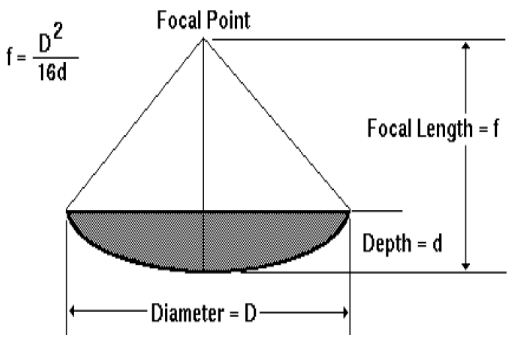

Fig. 3 Parabolic dish parameter

The size of the dish is the most important factor since it determines the maximum gain that can be achieved at the given frequency and resulting beam width. The gain and beam width obtained are given by:

$$G = \frac{(p \times D)^2}{l^3} \times h \quad (3)$$

and

$$BW = \frac{70\,l}{D} \quad (4)$$

Where D =dish diameter

η = efficiency

The efficiency is determined by the effectiveness of illumination of the dish by the feed, but also by the other factors. Each time the diameter of the dish is doubled, the gain is four times or 6 dB, greater. If both stations double the size of the dishes, signal strength can be increased of 12 dB, a very substantial gain. An efficiency of 50% can be assumed when hand building the antenna.

The ratio f/D (focal length/diameter of dish) is the fundamental factor governing the design of the feed for a dish. The ratio is directly related to the beam width of the feed necessary to illuminate the dish effectively. Two dishes of the same diameter but different focal lengths require different design of feed if both are to be illuminated efficiently. The value of 0.25 corresponds to the common focal plane dish in which the focus is in the same plane as the rim of the dish. The lower the f/D ratio, the lower the side lobes, because the feed is more protected from stray rays. Side lobes can also be reduced by means of additional shielding on the rim of the parabolic reflector (skirt).

A horn antenna can be used to feed the parabolic dish. It is radiating element which has the shape of horn. A horn antenna may be regarded as a flared out (or opened out) waveguide. The function of the horn is to produce a uniform phase front with a larger aperture than that of the waveguide and hence greater directivity. A waveguide, when excited at one end and open at the second end, radiates. However, radiation is poor and nondirective pattern results because of the mismatch between the waveguide and free space. The mouth of the waveguide is flared out to improve the radiation efficiency, directive pattern and directivity. If in a design of horn, the walls of a circular waveguide are flared out, a conical horn is obtained.A conical horn is shown in Fig.4 [5].

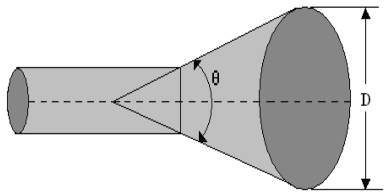

Fig.4 Conical horn

Parameters Given Frequency of operation: 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 = 0.445Actual 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]. Fig.5 is the photograph of final Antenna prototype known as a conical horn feed with its connector for parabolic reflector antenna.

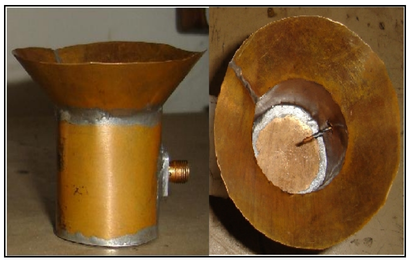

Fig.5 Horn antenna with connector and feed.

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.Fig.6 by which we can understand the horn feed position with respect to disc.

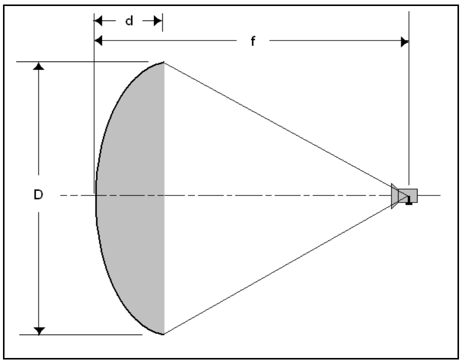

Fig. 6 Horn feed position with respect to disc

VSWR for the antenna is less than 2.5. We have dimensions are too small that blocking due to feed will be very low. It's mounting at 13mm.

Our objective is to design a conical horn feed for the parabolic dish at an operating frequency of 5.35 GHz and the frequency band over which the antenna should work efficiently is 4.8 to 5.9 GHz

III. Design Calculation

Parameters are Frequency of operation: 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.

$$\frac{f}{D} = \frac{\text{focal length}}{\text{Diameter of dish}} \qquad (5)$$

$$= \frac{270 \text{ mm}}{600 \text{ mm}}$$

$$\frac{f}{D} = 0.45$$

Circular Waveguide Dimension Calculation: 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. For both mode calculation of λ_c. Actual dish diameter is 600 mm but the diameter of the illuminated area is 432.66 mm (shown as shaded region). 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.From Fig.7 the value of θ can be calculated from simple trigonometric equation.

$$q = \tan^{-1}\left(\frac{BC}{AB}\right) \qquad (6)$$

$$\therefore q = \tan^{-1}\left(\frac{216.33}{187}\right)$$

$$= 49.15^0$$

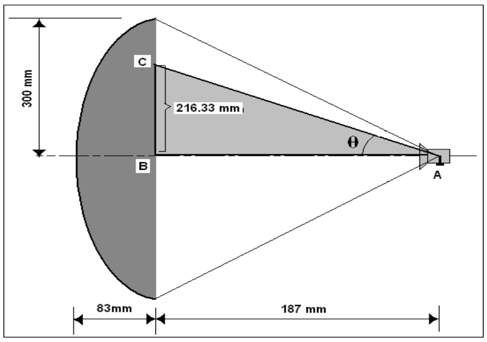

Fig.7.Aperture angle calculations

For the ease of designing & calculation taking θ ≈ 50º, see in below Fig.8.

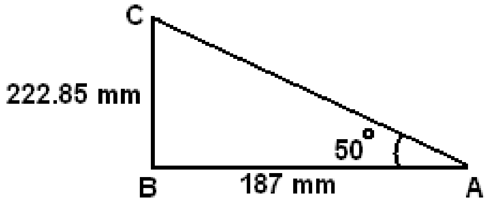

Fig.8.Geometry for angle

$$\therefore \tan 50 = \frac{BC}{AB}$$

$$\therefore BC = \tan(50°)\times AB$$

$$\therefore BC = 222.85 \; mm$$

$$G = \left(\frac{pD}{l}\right)^2 \qquad (7)$$

If aperture is not uniformly illuminated, illumination efficiency (η) must be introduced.

$$G = h\left(\frac{pD_a}{l}\right)^2 \qquad (8)$$

Generally η is of the order of 60%.

$$G = 6\left(\frac{D_a}{l}\right)^2$$

Where, G is the power gain ration, not the decibel power gain. The beam width of an ideal paraboloid uniformly illuminated is given by,

$$BW = \frac{70l}{D_a} \qquad (9)$$

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

Ideal paraboloid with uniform illumination and no losses is given BW which is

BW = 7.291^0

IV. Results & Discussions

Finally results mentioned are of 13mm.Fig.9 is the snap shot of gain from spectrum analyzer.

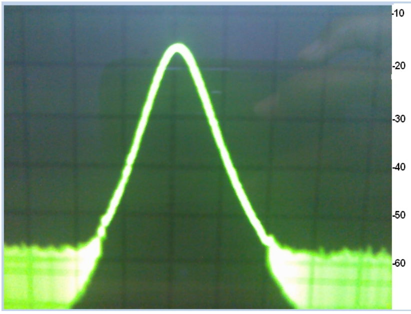

Fig. 9 Gain for horn antenna with centre frequency of 5.35 GHz

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.See in Table-1 the different reading which is measured on spectrum analyzer. This shows how conical horn feed can improve the performance of parabolic reflector antenna.

TABLE 1 OBSERVATION OF FEED AND WITHOT FEED

Freq (GHz)	Received Gains for different feed lengths (Horn with Dish)				Received Gains for different feed lengths (With Horn only)			
f	Feed wire length 12mm		Feed wire length 13mm		Feed wire length 12mm		Feed wire length 13mm	
	Level	Gain (dB)	Level	Gain (dB)	Level	Gain (dB)	Level	Gain (dB)
5.1	22	25.75	19	28.75	38	9.75	37	10.75
5.2	17	30.92	17	30.92	35	12.98	34	13.92
5.3	16	32.03	16	32.08	32	16.02	33	15.08
5.35	18	30.17	18	30.17	34	14.17	35	13.17
5.4	19	29.25	18	30.25	34	14.25	36	12.25
5.5	22	26.41	18	30.4	38	10.41	37	11.41
5.6	19	29.56	22	26.56	38	10.56	38	10.56

V. CONCLUSION

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. We have enhances the gain by almost double by using horn feed parabolic reflector antenna then without horn feed parabolic reflector antenna. 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).

ACKNOWLEDGMENT

The Authors thanks to Principal & H.O.D, Electronics Department of B.V.M.Engg.College, V.V.Nagar-Gujarat-India for their support and Encouragements, V.V.Nagar and Twin Engineers, Baroda for given testing and development facility for this work.

REFERENCES

[1] Constantine. A. Balanis "Antenna Theory: Analysis and Design" (2nd Ed.)
[2] J.D. Kraus & Ronald J.Marhefka "Antenna for all applications " (3rd Ed.)
[3] M.L.Sisodia and Vijay Laxmi Gupta 'Microwaves: Introduction to Circuits, Devices and Antennas" (1st Ed.)
[4] Kennedy Davis "Electronic communication system " (3rd Ed.)
[5] G.S.N.Raju "Antennas and wave propagation " (1st Ed.)
[6] Rajeshwari Chatterjee "Antenna Theory and Practice" (1st Ed.)
[7] B Paul Wade "Electromagnetic horn antennas"1994, 1998
[8] Joseph J. Carr" Practical Antenna Handbook "Fourth Edition

Jagdish M.Rathod He is born in 1972 at Mumbai-India.He has received his Bachelor of Engg & Master of Engg in 1995 & 2005 with respectively in Electronics & Communication engg.He is working as a lecturer in B V M Engg College since 1997.He got a Fourteen years of experience as a lecturer. He is pursuing his PhD since Oct-2006 in Electronics & Communication from S P University under the kind support of Dr.Y.P.Kosta, CIT, Changa-Gujarat. He is a Life member of I.E.T.E & IE (I) & I.S.T.E., IACSIT, BES etc official organization He has published a Twenty-four number technical and fundamental research papers in national and International journals and conferences till this date.

Dr. Yogesh Kosta He has Received his M.Tech & PhD in Electronics and Telecommunicationin1991 and1998 w.r.t.He than joined I S R O Ahmedabad, where he designed & developed the Ku –band transponder 3D Satellites. He also worked as a faculty in United Nation's PG Program on SATCOM. He later joined Teledyne Wireless at Mt.View, California as a senior design engineer. He designs MMIC-Power Amplifier Chipsets for commercial and military applications.. He is senior member of IETE, IEEE, and M-TTS.He has published and presented more than a Thirty Five technical and fundamental research papers in national and International journals and conferences till this date.