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Designing Optimized Cassegrain with Balanced Feed

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ABSTRACT

Cassegrain Reflector Antenna Design consists of various effects caused by blockage and its effect on overall performance. The design for minimum blockage condition results in geometry that offers lower amount of blockage and increased spillover past the subreflector. To avoid this, optimized design of the antenna results in geometry that offers lower amount of spillover past the edges of the main reflector and increases some percentage of blockage. The design of feed elements for Cassegrain antennas is considered in the following section. It includes the design of conical corrugated horn antenna having throat section. Throat section is used for the purpose of achieving match between input waveguide and horn thereby maintaining low VSWR. The Scalar Horns are used to obtain identical performance in both the principal planes. The dual reflector design is simulated on the 'Induced Current Analysis of Reflector Antenna' software. Ansoft HFSS is used to obtain the radiation characteristics of the Corrugated Horn.

General Terms

Cassegrain dual reflector design, Feed design for Cassegrains, Design approaches

Keywords

Conical Corrugated horn, Scalar horn, Sidelobe reduction, Cross-polarization reduction

1. INTRODUCTION

The endeavours of synthesizing, analyzing and designing reflector antennas of different configurations did not really emerge until a number of radar applications evolved to satisfy growing technical demands. A large number of demands of reflectors for satellite communications and tracking, microwave communications, radar applications and point-to-point communications have resulted in the development of both the complicated reflector configurations and analytical and practical design techniques. To meet the specifications like off-axis beam, contour beams, multiple beams, different new configurations of reflector antennas are investigated. Many radio frequency communication antennas use only one polarization and reasonable specification for isolation between orthogonal polarization and the desired polarization is specified. Nevertheless to use the available frequency spectrum effectively, the antennas are designed for operating with dual polarizations at the same operating frequency. They require tighter constraints on cross-polarization performance and isolation between two operating polarizations. For producing a pencil beam with significantly low side lobe levels, the paraboloid[7] is the most suitable type when used with a feed element that can produce the desired pattern on the reflector. For applications in terrestrial communication systems, front-fed geometry offers ease of construction. Cassegrainian systems[1] may succeed over the front–fed configuration at the cost of economy. Considerable improvement in efficiency can be achieved by shaping of reflector profiles. Most of the earth-station antennas use these techniques.

The feed elements used may be pure mode circular waveguides and conical horns, rectangular horn antennas, hybrid mode corrugated waveguides and conical corrugated horns depending upon the requirement. Since metallic surface having corrugations is the most suitable type of the surface for meeting the anisotropic conditions, hybrid mode waveguides or horns are widely used as feed elements. Large reflector antennas designed for operating with different frequency bands employ cluster of feeds that may include simple hybrid mode horn antennas as well as lens corrected horn antennas designed for various frequency bands. It can also be considered as an example of movable feed elements.

2. DESIGN APPROACHES

2.1 The Minimum Blockage Condition

The minimum blockage condition[1] offers smaller size of the subreflector and reduced amount of sidelobes. If the overall diameter of the feed is Df, the condition for minimum blockage

$$\frac{F}{2f} = \frac{d}{Df} \tag{2.1}$$

As mentioned earlier the diameter for minimum blocking condition is given by,

$$Dbmin = \sqrt{\frac{2}{k}F\lambda} \tag{2.2}$$

It shows that the shadows created by feed aperture and the hyperboloid are nearly equal and they contribute to the aperture blockage. If the distance of the subreflector from feed is reduced(i.e. L_s in the figure), the blocking offered by feed would be greater. If the phase centre of the feed is known then it should be coincided with the real focal point and the Minimum Blockage Condition becomes,

$$\frac{F}{2f - Dpc} = \frac{d}{Df} \tag{2.3}$$

The blockage loss for d/D < 0.1 or 1% area blockage is less than 0.1 dB, but increases rapidly above 1% blockage.

If the focal length of the paraboloid is an integral number of half wavelengths i.e. F = mλ/2, the back lobe of the primary pattern is 180 deg. out of phase with the main lobe. If the focal length is adjusted F = (2m +1)λ/4 (where m is an integer), the back lobe and the main lobe of the primary radiation are in phase and the back lobe adds to the gain. If these requirements are not satisfied exactly, the feed should be located at the point, nearer to the focus, at which the value of F satisfies the above mentioned criteria. Deviations from the constant phase of the aperture should be kept within λ/8 and certainly should not exceed λ/4.

Two factors contribute to the phase error.

- Distortion of paraboloid surface.
- Deviation of the primary wavefronts from spherical waves.

The first criterion is identical to surface irregularities and it can be considered as a tolerance that is acceptable in constructing the reflector. The latter criterion defines the feed as a point source cone. The angular aperture of the main reflector should be included within the point source cone. Addition of hyperboloid shifts the phase center of a spherical wave from the real focal point to the virtual focal point. It reduces the edge taper on the subreflector and also reduces the taper of the diffracted beam. Hence, for the given subreflector size, if the focal length to diameter ratio (i.e. F/D ratio) is increased, the illumination taper is reduced, spillover at the main reflector and the subreflector is increased and the subreflector blockage is reduced. The blockage effects are negligible for smaller subreflector size. The antenna efficiency is affected by the illumination efficiency and the spillover. Clearly, if the illumination efficiency is increased, the spillover efficiency reduces.

2.2 Design Tips

- Focal length to diameter ratio is taken in the range 0.25 and 0.55.
- To reduce the diffraction losses, subreflector diameter should be >> 5λ.
- It should be kept less than 10% of main reflector diameter for >> 99% blockage efficiency and lower secondary radiation.
- The distance of the subreflector from the feed is selected on the basis of feed pattern. Efforts should be carried out to reduce the feed aperture phase error.
- The feed may be located behind the main reflector (i.e. for negative value of Lm) if the feed support is creating mechanical problems. The feed location is affected by the dimensions of the feed support cone, inclusion of polarization diplexers, lateral dimensions of the feed and the space available behind the paraboloid.
- The included angle of the subreflector should be selected in a way that minimizes the spillover. Usually, -10 dB to -15 dB edge taper is adjusted on the subreflector.

2.3 The Optimized Design of the Cassegrainian System

Even though the Optimized Design of the Cassegrainian System allows some percentage of blockage thereby increasing the size of the subreflector, it offers reduced amount of spillover past the edges of the main reflector. Hence it is preferred in most of the cases.

Including the effect of center blockage, subreflector diffraction and blockage from subreflector, the following equations can be written[4][6].

The relation between blockage parameter and diffraction parameter is given by

$$C_d = \left(\frac{1}{\pi}\right)\frac{[\cos(\frac{\psi}{2})]^2}{\sqrt{\sin(\theta_0)}}C_b \qquad (2.4)$$

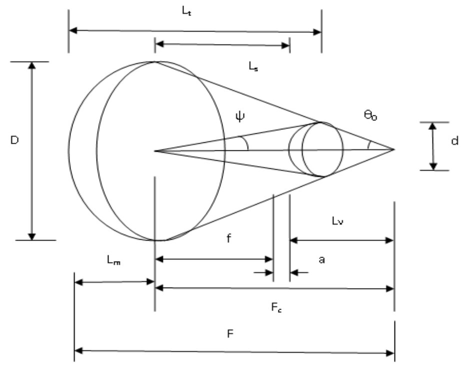

Figure 1. Classical Cassegrain Geometry

For most of the antennas the subtended angle by the main paraboloid reflector is close to 90 deg. and that by the subreflector is small.

$$C_d \approx \frac{C_b}{\pi} \qquad (2.5)$$

The overall aperture efficiency is defined as the product of the following terms[6],

$$\eta_a = \eta_f \eta_i \qquad (2.6)$$

The feed efficiency is given by,

$$\eta_f = \frac{2[1 - A_0]^2}{-\ln A_0} \qquad (2.7)$$

It indicates that feed efficiency is mainly dependent on the illumination taper. The overall interference is indicated by η_i.

The blockage parameter is given by,

$$C_b = \frac{-\ln A_0}{[1 - A_0]} = \pi C_d \qquad (2.8)$$

It is desired to maximize the aperture efficiency w.r.t. d. Hence the resultant d/D ratio is given by the following equation.

$$\frac{d}{D} = \left[\frac{1}{(4\pi)^2}\frac{[\cos(\frac{\psi}{2})]^4}{\sin\theta_0}{A_0}^2\frac{\lambda}{D}\right]^{1/5} \qquad (2.9)$$

From the above equation, it is clear that d/D ratio is more dependent on the edge taper on the subreflector. So, in addition to $\cos^n\psi$, other distributions (e.g. Gaussian) can also be launched.

From the geometry of the figure, following equations can be written.

$$\tan\left(\frac{\theta_0}{2}\right) = \pm\frac{1}{4}\frac{D}{F} \quad (2.10)$$

The positive sign in the above formula applies to the Cassegrain forms, and the negative signs to Gregorian forms.

$$\frac{1}{\tan(\theta_0)} + \frac{1}{\tan(\psi)} = \frac{2Fc}{d} \quad (2.11)$$

$$1 - \frac{\sin\frac{1}{2}(\theta_0 - \psi)}{\sin\frac{1}{2}(\theta_0 + \psi)} = \frac{2Lv}{Fc} \quad (2.12)$$

The parameters D, F, Fc and ψ may be determined by considerations of antenna performance and space limitation; θ_0, Ds and Lv would then be calculated from the above formulae. ψ may be determined independently of the shape factor.

The contour of the main dish is given by the equation,

$$x_m = \frac{{y_m}^2}{4F} \quad (2.13)$$

The contour of the subdish is given by,

$$x_s = a\left[\sqrt{1 + (\frac{y_s}{b})^2} - 1\right] \quad (2.14)$$

where

$$e = \frac{\sin\frac{1}{2}(\theta_0 + \psi)}{\sin\frac{1}{2}(\theta_0 - \psi)} \quad (2.15)$$

$$a = \frac{Fc}{2e} \quad (2.16)$$

$$b = a\sqrt{e^2 - 1} \quad (2.17)$$

The parameters e, a and b are the parameters of the hyperbola, a is the half traverse axis, and b is half the conjugate axis.

The magnification M is given by,

$$M = \frac{F_e}{F} = \frac{e+1}{e-1} \quad (2.18)$$

For the analysis of the radiation pattern of reflector antennas, the widely used techniques are PO (Physical Optics) and PTD. Also, to obtain the wide angle secondary radiation characteristics, the GTD (Geometrical Theory of Diffraction) is considered as a versatile tool. Since the reflectors have larger aperture dimensions, MoM and FEM methods are not economic. Restriction on the wave order can be determined with the help of powerful spherical wave theory. It involves the use of elemental wave functions and determination of spherical wave suit to the desired illumination.

The Classical Cassegrainian System for satisfying the following performance parameters of a radar antenna is considered next.

2.3.1 Design Specifications

Following performance specifications are taken into account to design Classical Cassegrain Antenna. The antenna is to be designed for cloud radar operating at 34.86 GHz.

Frequency	34.86 GHz
Gain	> 54 dB
Half Power Beamwidth	0.3 deg. x 0.3 deg.
Side-lobe level	Less than 26 dB
Intrinsic Cross-polarization	Minimum
Maximum Unambiguous Range	15 km
Polarization	In both the planes

2.3.2 The Optimized Design for Specified Parameters

Following design procedure yields optimized design of Cassegrain antenna. It takes care of reduction in aperture efficiency caused by the scatter from the subreflector.

Since side-lobe requirement is < -26 dB, 12 dB Edge Taper (ET) on Subreflector is required. (Since subtended angle by hyperboloid is within 30 deg. in most of the applications, Space Attenuation is usually neglected i.e. ET ≈ FT, where FT stands for Feed Taper.)

Taper in dB = $-20logA_0$

$$-0.6 = log_{10}A_0$$
$$A_0 = 0.25$$

The blockage parameter is given by (2.8),

$$C_b = 1.85$$

The diffraction parameter is given by (2.5),

$$C_d = \frac{C_b}{\pi} = 0.59$$

Taking the main reflector diameter

D = 200λ

For focal length to diameter ratio F/D =0.3

F_m = 1.72 * 0.3 = 0.516 m = 516 mm

$$\tan\left(\frac{\theta_0}{2}\right) = \pm\frac{1}{4}\frac{D}{F} = 0.83$$

$$\theta_0 = 39.81^0 \times 2 = 79.61^0$$

For F_e/D ratio of, F_e/D = 1.5

Magnification is given by,

$$M = \frac{F_e}{F} = \frac{1.5D}{0.3D} = 5 \quad M = \frac{F_e}{F} = \frac{1.5D}{0.3D} = 5$$

$$\frac{2e}{2} = \frac{M+1}{M-1}$$

Therefore,

e = 3/2 = 1.5

Alternatively, from (2.15)

$$e = \frac{\sin\frac{1}{2}(79.61 + 18.96)}{\sin\frac{1}{2}(79.61 - 18.96)} = 1.5$$

$$a = \frac{Fc}{2e} = \frac{0.1854}{2 \times 1.5} = 0.0618\, m$$

$$b = 0.0618\sqrt{e^2 - 1} = 0.0618\sqrt{(1.5)^2 - 1}$$
$$= 0.069\, m$$

$$\tan\psi = \frac{1}{2\frac{F_c}{d} - \frac{1}{\tan\theta_0}}$$

$$2\frac{F_c}{d} = \frac{1}{\tan 18.96} + \frac{1}{\tan 79.61} = 3.09$$

Therefore

$$\frac{F_c}{d} = 1.545$$

The depth of the main reflector is given by,

$$depth = \frac{D^2}{16F} = 0.3583\, m = 358.3\, mm$$

The subreflector diameter can be found as [from (2.9)] ,

$$\frac{d}{D} = \left[\frac{1}{(4\pi)^2}\frac{[\cos(9.48)]^4}{\sin 79.61}(0.25)^2\frac{1}{200}\right]^{1/5} = 0.07$$

Now, D = 200λ gives d = 0.12 m.

Feed Efficiency, as mentioned earlier in (2.7)

$$\eta_f = \frac{2[1 - 0.25]^2}{-\ln(0.25)} = 0.81$$

The overall interference (including center blockage, spillover and neglecting strut blockage)

$$(\eta_i)_{max} \approx \left[1 - C_b\left(1 + 4\sqrt{1 - \left(\frac{d}{D}\right)}\right)\left(\frac{d}{D}\right)^2\right]^2$$
$$= 0.92$$

Aperture efficiency is given by,

$$\eta_a = \eta_f \times \eta_I = 0.81 \times 0.92 = 0.7452$$

Gain of the Cassegrainian system is given by,

$$G = \epsilon_{ap}\, \pi^2 \frac{(D - d)^2}{\lambda^2}$$
$$= 0.7452 \times (\pi)^2 \times \frac{(200\lambda - 14\lambda)^2}{\lambda^2}$$
$$= 252672.14$$

G = 2.52 * $(10)^5$ =54.03 dB

The distance of subreflector from the main reflector focal point can be found as

$$1 - \frac{\sin\frac{1}{2}(79.61 - 18.96)}{\sin\frac{1}{2}(79.61 + 18.96)} = \frac{2Lv}{0.1854}$$

$$L_v = \frac{0.335 \times 0.1854}{2} = 0.031\, m = 31\, mm$$

Hence, the subreflector should be located 31 mm away from the focal point of the main reflector. The half-angle subtended by the subreflector is found as 18.96 degree. Conical Corrugated horn having aperture diameter 4.09λ i.e. aperture diameter of 0.035174 m (35.174 mm) and 15^0 flare angle is used as the feed element. Detailed design of conical corrugated horn is described in the next section.

The far-field radiation pattern is obtained using ‘Induced Current Analysis of Reflector Antenna Software’ that works on PO and PO/PTD principles.

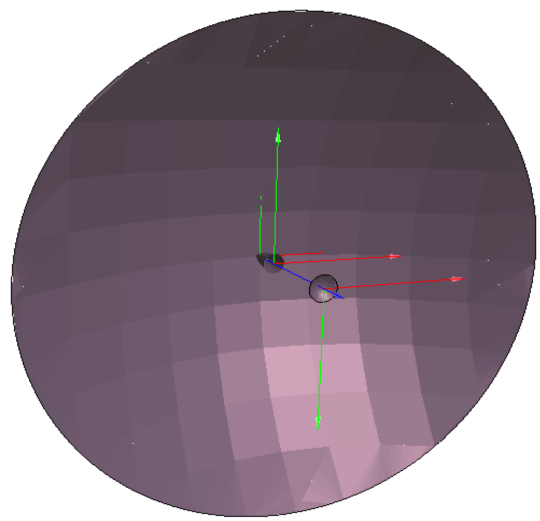

Figure 2. Cassegrain Antenna Geometry (Solid Metallic Surface)

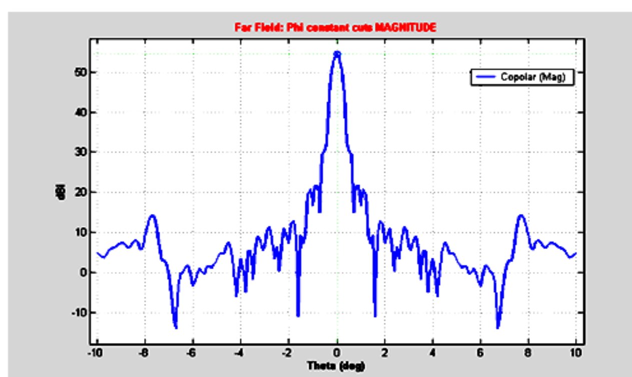

Figure 3. Far Field Phi Constant Cuts (Co-polar Magnitude)

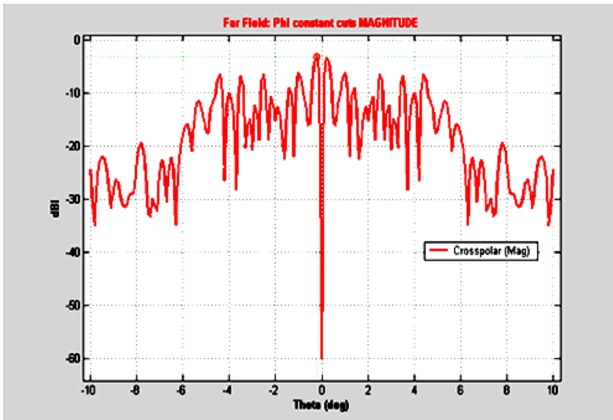

Figure 4. Far Field Phi Constant Cuts (Crosspolar Magnitude)

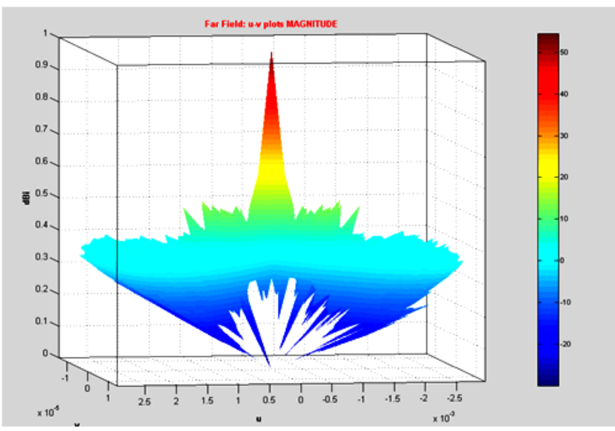

Figure 5. Co-polar Magnitude

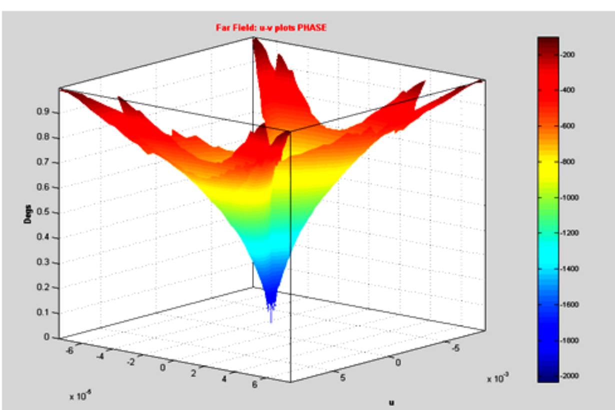

Figure 6. Co-polar Phase

The aperture (i.e. target) is divided into 13 rings and 1014 patches for simulation. Same discretization is also used for subreflector. The $\cos^n\psi$ type feed is used to illuminate the subreflector. From radiation diagram, it can be observed as the gain obtained with this system is 54.5439 dBi. The spillover estimation from feed is 0.283 dB. The simulation results show Fraunhofer region radiation characteristics.

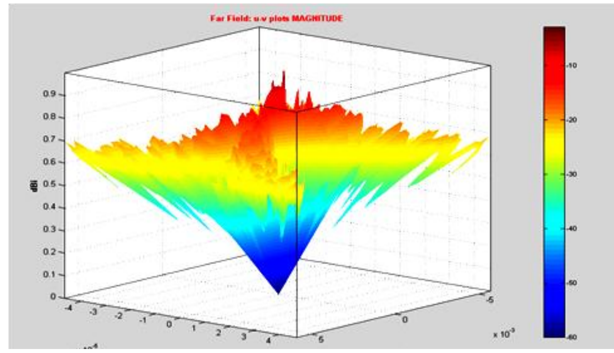

Figure 7. Crosspolar Magnitude

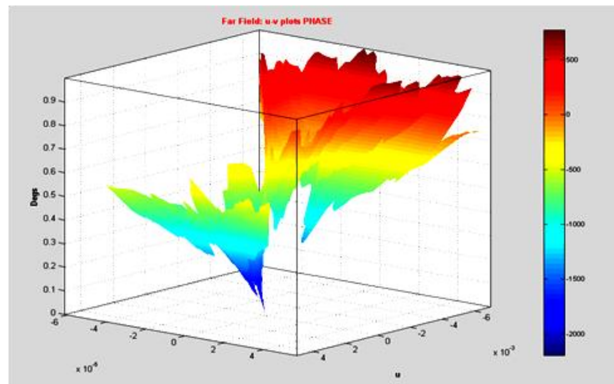

Figure 8. Crosspolar Phase

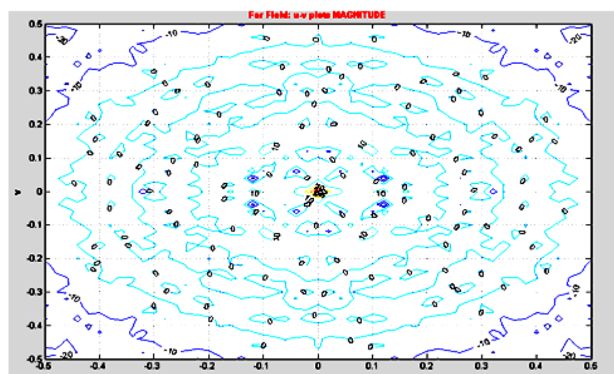

Figure 9. Co-polar Magnitude Contours

3. DESIGN OF FEED ELEMENTS

3.1 Feed Design Tips

Feeds are the most critical parts of the reflector antennas. Most widely used feed components include conical corrugated horn antennas involving throat section, the scalar feed, conical corrugated horn antennas having ring-loaded slots and mode-converters[2]. Following are some design tips from which most of the corrugated horn feeds are designed. Let,

- D'/ λ = normalized diameter of the feed, s/ λ = normalized slot-depth, b/ λ = normalized slot-width, t/b = ratio of ridge width to slot width
- Slot widths are varied between 0.1λ and 0.3λ. Ridge width to slot width ratios are taken between 0.1 to 1.

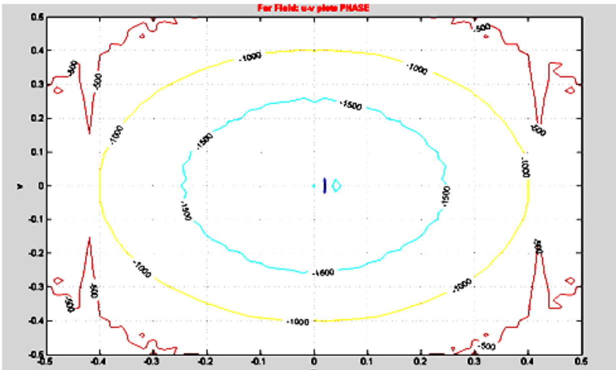

Figure 10. Co-polar Phase Contours

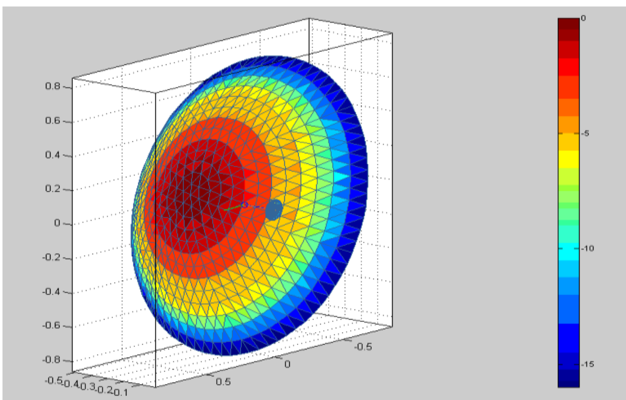

Figure 11. Fed Surface

- Ratio of 0.1 is taken for narrow ridge and 1 is taken for equal slot/ridge width. It covers the range between 2 slots per wavelength and 9 slots per wavelength.
- For designing the horn, charts for slot depth/ λ i.e. s/ λ and normalized diameter i.e. D'/ λ having t/b ratio as a parameter for constant slot width should be considered[5].
- For a constant t/b ratio, curves for s/ λ and D'/ λ for which parameter is slot width/ λ i.e. b/ λ should be considered[5].
- For small horn apertures slot depth is always deeper than for large aperture diameters. For aperture diameters under 2 λ, the slot depth to produce balanced-hybrid conditions is much deeper than the normalized quarter wavelength slot.
- The ratio t/b is more important than the b/λ ratio i.e. normalized slot width. Small values of t/b require deeper slots when the slot and ridge have equal width.
- Slots which are relatively wide, for example 0.3λ, more difference between the t/b ratios exists. The design parameters for most of the corrugated horn antennas are located at, t/b ≈ 0.5, D'/ λ > 0.3, b/ λ < 0.2 on the chart.
- The central slot depth is considered as the electrical depth in almost all the cases. Sometimes in the cases of larger flare angles, a mean depth is selected.
- The depth at the centre is used in the case when the slots are cut perpendicular to the horn axis.
- A value about 20% less than the slot depth is selected when the slots are machined perpendicular to the horn flare. For determining cross-polar bandwidth, charts for peak cross-polar power (dB) as a function of f/f0 (where $f_0 f/f_0$ is the mode balance frequency) should be considered[5].
- The theoretical percentage bandwidth should be decided from the peak cross-polar level i.e. it should be maintained below -30 dB or -40 dB for achieving better performance.
- The Space-Harmonic Model is more useful than the Surface-Impedance Model for the cross-polarization characteristics of the feed.

The mode-balance frequency f_0 is determined by the geometry of the corrugations. When channel bandwidth is narrower than the bandwidth determined by the cross-polar level, the geometry of the corrugations is not vituperative. For almost all the cases the slot depth is taken as 0.25λ. In practice, ridge width to slot width ratio is selected between 0.5 and 1.0. Ten slots per wavelength are sufficient to provide the required performance when the operating frequency is chosen in the range of few Gigahertz. But at higher frequencies (i.e. in the range of hundreds of Gigahertz), fabricating two slots per wavelength becomes ambitious. No tight constraint is specified on the choice of t/b ratio > 0.5. In the case of narrow-band horns, the flare angle should be selected in such a way that the length of the horn is reduced thereby reducing the cost of manufacture i.e. horn is designed for 10 deg. to 15 deg. flare angle. On the other hand when wide band horn antennas are considered, a semi-flare angle as small as practicable should be selected e.g. 5 deg. The next step is to design the junction and throat section of the corrugated horn. The radiation diagram of a conical horn is usually required to have perfect symmetry and zero cross-polarization. It requires a balanced (γ =1) HE_{11} mode radiating from a horn having circumferential corrugations. To achieve the longitudinal impedance X infinite, the slot depths near the horn aperture are chosen to be electrically quarter a wavelength deep. However, as the frequency starts to depart from the slot resonant frequency, γ will deviate from unity. This change depends both on the slot parameters and the horn aperture size. To maintain the radiation diagram symmetry of the horn antenna with aperture size less than 8, the corrugations should be extended into the aperture plane. The mode-content factor γ is defined as the ratio of the longitudinal fields of the TE_{mn} and TM_{mn} components. When the two components are in phase then γ = +1 is taken and when the two components are out of phase γ = -1 is taken.

3.2 Design of Throat Section

The design procedure mentioned in [5] is used for designing the throat of the Conical Corrugated Horn Antenna. When tapering of the slots is stopped, the guide wavelength starts to decrease towards free space wavelength. Throat section is used to match the smooth wall circular waveguide to the corrugated waveguide. The mode conversion along the horn is more influenced by the longitudinal geometry of the slots. In the vicinity of the throat, it is better to have a large number of slots per wavelength. At millimeter wavelengths it is impractical to fabricate ten slots per wavelength.

3.3 Conical Corrugated Horn Antenna Feed

For the given design, to achieve the required edge taper requirement on the subreflector, conical corrugated horn antenna having aperture diameter 4.09 λ should be used.

Horn aperture diameter = 4.09 λ = 4.09 * 0.0086 = 0.035174 m = 35.174 mm

Horn flare angle: 15 deg.

As recommended by EIA standard, for frequency range of 28.30-38.80 GHz WC28 waveguide is used for the design frequency of the reflector antenna.

Characteristics of WC28 waveguide:

- Inside diameter (cm) : 0.714 cm
- Cutoff-frequency : 24.620 GHz

For corrugated horn design, following parameters are used.

- t = ridge width = 0.906 mm, b = slot width = 2 mm
- ridge width/slot width ratio = t/b = 0.453

$$s = \frac{a^2}{2\lambda l} = \frac{(2.045\lambda)^2}{2\lambda \times 7.9\lambda} = 0.265$$

Slant radius,

$$l = \frac{a}{\sin 15^0} = \frac{2.045\lambda}{\sin 15^0} = 0.06794\, m = 67.94\, mm$$

The dimensions of the designed horn are specified in Table 1.

3.4 The Scalar Feed Design

An ideal feed horn for paraboloid reflectors for many applications is one which combines low spillover, nearly uniform aperture illumination, equal E and H plane patterns and wide frequency bandwidth, as well as a well defined phase centre. For pattern symmetry, it is necessary that the same boundary conditions should exist inside the horn in the E and H planes. A metallic surface corrugated with many closely spaced, parallel, transverse grooves presents a reactive boundary which approaches the same boundary condition for TM(Transverse Magnetic) and TE(Transverse Electric) waves at grazing incidence. If the grooves are made deep enough so that the surface reactance is capacitive, surface waves cannot be supported. A horn antenna having wide flare angle and lined with such a reactive surface thus has the same boundary conditions for both polarizations. Hence the type of the feed is known as 'Scalar Feed'. It has essentially the same pattern for both E and H planes.

For better performance 10 slots are required per wavelength[2]. Hence, for the given design frequency, 63 slots are sufficient for designing the horn.

The slot width b is taken in the range, $b < \lambda/10$.

And the ridge width is taken in the range, $t \leq b/10$.

For accommodating the required number of slots in the distance,

$$\left(\frac{0.01759}{\sin 15}\right) - \left(\frac{0.00357}{\sin 15}\right) = 54.13\, mm$$

following parameters need to be considered. Ridge width to slot width ratio, t/b = 0.1. It gives, b = slot width = 0.7811 mm, t = ridge width = 0.07811 mm, d_n = slot-depth = 2.15 mm. The Scalar Horn geometry is shown in Figure 17.

For simulating Conical Corrugated Horn antenna, software that supports Mode-Matching Techniques plus Method of Moments is considered as an accurate software. Some authors have suggested the use of Ansoft HFSS for obtaining the radiation diagram. HFSS works on Finite Elements Method.

The 3D Modeler Window shows the horn geometry in HFSS. PML (Perfectly Matched Layer) is used around the horn structure. Several layers of specialized materials that can absorb the outgoing waves construct PML. Driven model solution is used for the simulation.

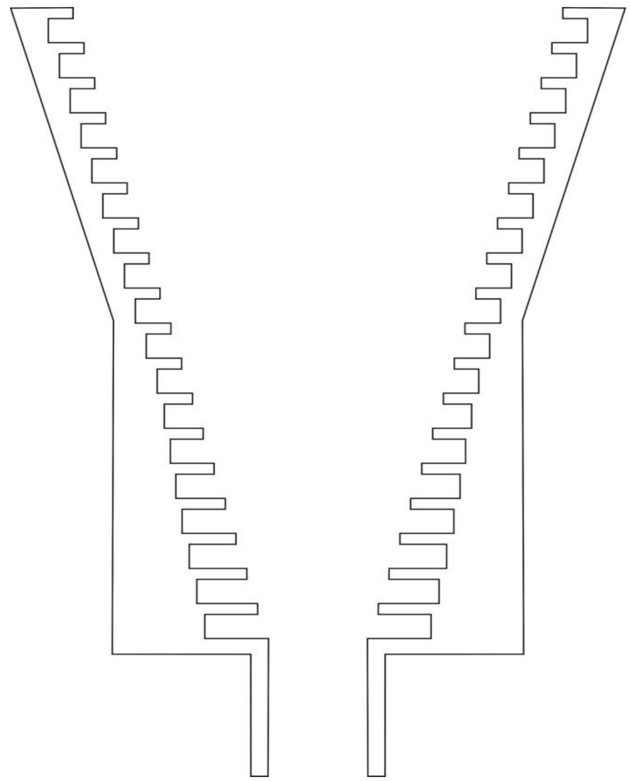

Figure 12. Conical Corrugated Horn involving Throat Region

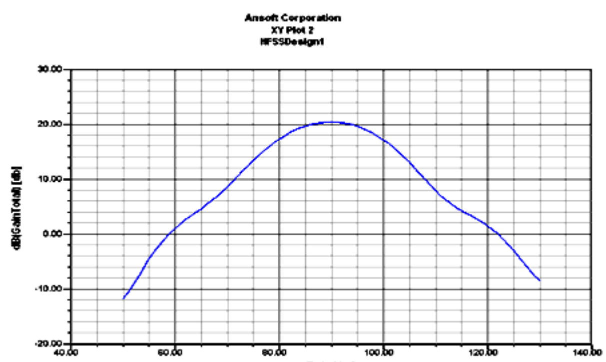

Figure 13. E-plane Radiation Diagram

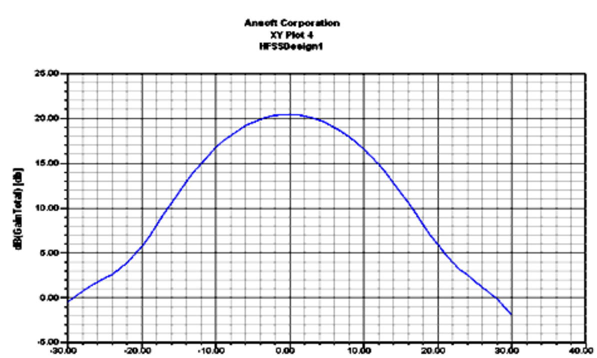

Figure 14. H-plane Radiation Diagram

Table 1. Dimensions for the designed Conical Corrugated Horn

Slot Depth, D_n	Slot depth in mm	Inner radius(r_1)	Inner radius (mm)
0.5λ	4.3	0.415λ	3.57
0.476λ	4.09	0.506λ	4.349
0.45λ	3.87	0.596λ	5.128
0.42λ	3.6	0.686λ	5.907
0.38λ	3.268	0.777λ	6.686
0.335λ	2.88	0.868λ	7.465
0.297λ	2.55	0.9586λ	8.244
0.265λ	2.28	1.05λ	9.023
0.265λ	2.28	1.139λ	9.802
0.265λ	2.28	1.23λ	10.581
0.265λ	2.28	1.32λ	11.36
0.265λ	2.28	1.41λ	12.139
0.265λ	2.28	1.5λ	12.918
0.265λ	2.28	1.59λ	13.697
0.265λ	2.28	1.68λ	14.476
0.265λ	2.28	1.774λ	15.255
0.265λ	2.28	1.86λ	16.034
0.265λ	2.28	1.955λ	16.813
-	-	2.04λ	17.592

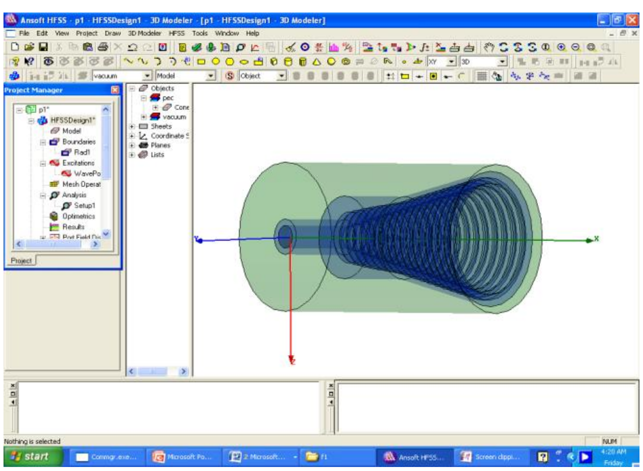

Figure 15. Horn geometry in 3D modeler window

The gain obtained from the feed system is nearly 21 dB in both the planes. Perfect Electrical Conductor (PEC) is selected for constructing the horn walls in the simulation. For the specified horn dimensions, a larger mesh is required at the solution frequency. The coordinate system is shifted at the horn aperture for obtaining the radiation diagram in both the planes.

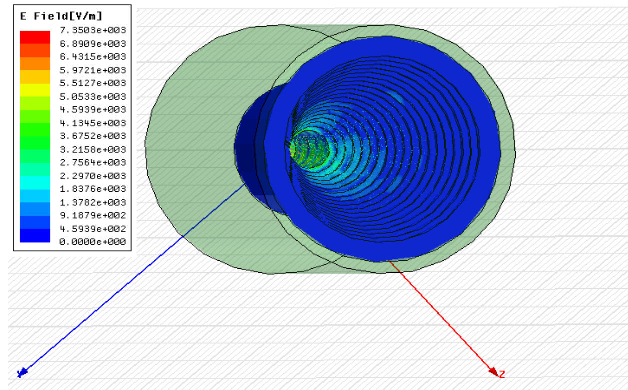

Figure 16. E-field within the Horn

For designing both the horn antenna feeds Kelleher's Horn equation is used to determine the radiation diagram requirements and aperture dimensions of the feeds. The distribution provided by both the horn feeds is $\cos^{24.5}\psi$.

4. CONCLUSION

The Cassegrain dual reflector geometry supersedes the front – fed configuration. Following benefits outline the performance of the Cassegrainian Systems. In the applications of satellite receivers(considering front-fed operation), it is not suitable to locate the bulky low-noise receiver close to the feed in front of the main paraboloid reflector. It also increases the attenuation of the signal propagating along the feed-line and noise-power. These difficulties are removed in the dual reflector system, wherein the low-noise receiver can be located behind the feed The antenna designer has the option of using the variety of feed-subreflector pairs. In the front-fed configuration the blockage resulting from the feed increases the wide-angle sidelobes. In addition the ground-coupling inserts the noise-power into antenna. The dual-reflector geometry employs subreflector of relatively larger diameter in terms of λ. Hence noise resulting from spill-over from the feed can be reduced. Also the transreflector from hyperboloid to the main paraboloid removes the possibility of ground-coupling. Using transreflectors and twistreflectors, either the feed or the subreflector can be made invisible. Movement of one of the surfaces in the dual-reflector system allows the broadening of the beam. Also, the larger equivalent focal length can be achieved as compared with the total length. State-of-the art design techniques of hybrid-mode feeds minimize the intrinsic cross-polarization and improve the return-loss characteristics. Hence isolation between two orthogonal polarizations can be maintained. By selecting the proper ET on the subreflector, the sidelobe control can be achieved. With the help of other techniques like 'Hooding Techniques', Polarization-Twisting, serrating the edges of the main reflector; pattern control of the Cassegrain is obtained. Feed components with polarization diplexers allow frequency reuse techniques. The softwares used here provide the designer an extra degree of freedom for altering the dimensions of the design as per the given specifications.

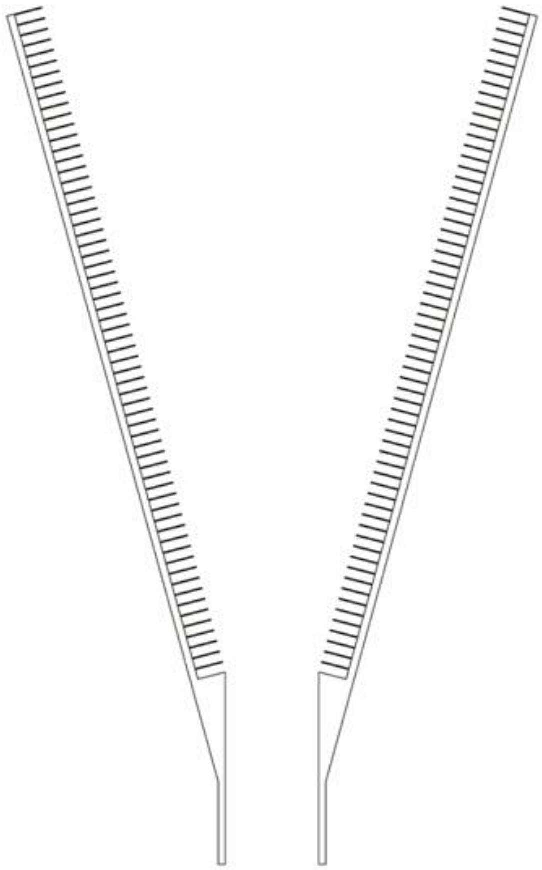

Figure 17. The Scalar Horn Geometry

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