Australian Journal of Basic and Applied Sciences, 5(7): 188-192, 2011
ISSN 1991-8178

Numerical Study of the effects of the Struts in a Parabolic Reflector Antenna

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Abstract: This paper investigates the impact of strut geometry, location and number of struts on gain and radiation pattern of parabolic reflector antenna at Ku band. The analysis has been carried out using GRASP software and is valid for perfectly conducting circular struts. The choice of optimal focal length was decided before carrying out any analysis. Judicious choice for position and radius of struts can lead to good Side Lobe Level (SLL) and gain. The choice of inside single strut leads to SLL of 29.5 dB below the peak with gain reduction of 0.07 dB (Gain & SLL of reflector without struts is 37.77 dB & 31 dB), while outside four struts resulted in SLL of 20.5 dB below the peak with gain reduction of 2 dB. Struts are required to support antenna feed or sub-reflector and have a serious impact on antenna radiation pattern if the geometry and placement are not optimally selected. The analysis suggests that outside single strut can be used for antenna operating in conditions not requiring high mechanical strength e.g. static platform with radom without significant effect on gain and 1.5 dB rise in SLL, while inside four struts geometry is suitable for harsh environment (high wind velocity/pressure) like that on aerodynamic mobile platform application where high mechanical strength is essential due to severe loading and vibration but noticeable loss in gain (2 dB) and significant rise in SLL (10.5 dB) occurs.

Key words: component; Strut Analysis

INTRODUCTION

Struts are the part of many reflector antennas and are used to support feed in the centre feed reflector antenna or for supporting sub-reflector in dual reflector configuration. Struts are usually made up of metal and are connected between feed and reflector rim or on the surface of the reflector. Struts thus cause blockage and scattering, which in turn result in deviation in the mathematical properties of parabolic reflector antenna and deterioration in the far field radiation pattern of the antenna (efficiency and cross-polarization is degraded and the sidelobe level is degraded). Judicious choice of strut parameters (no. of struts, radius of struts and location of the struts on the reflector), thus play vital role in designing of good reflector antenna from radiation as well as structural stability's point of view. The analysis has been carried out for 0.6 m centre feed parabolic reflector antenna with focal length of 0.3 m at Ku band using GRASP (General Reflector Antenna Software Package), with PO/PTD (Physical Optics Theory) chosen for analysis. The analysis has been performed for various geometries of struts structure and for different radii of the struts.

Strut Scattering Mechanism:

The three most important mechanisms by which the strut scattering influences the antenna radiation are described below and shown in Figure 1.1:

1. Illumination of the struts by the reflected field from the main reflector.
2. Shadowing and changes of the main reflector currents caused by direct feed illumination of the struts.
3. Reflection in the main reflector of the scattered field from the struts, where the incident field on the strut comes from the main reflector.

The degradation of the peak gain (efficiency) is mainly due to the effects (1) and (2) of which (2) is only important in a system where the struts are not supported by the outer edge of the main reflector as in Figure 1.1:

The side-lobes will mainly be affected by the strut scattering (1') and (3) where (3) is only important in a configuration as shown in Figure 1.2. Although these scattering effects are illustrated for a single reflector system they will also be the dominant effects in a dual reflector system where the feed is replaced by the sub-reflector. [1]

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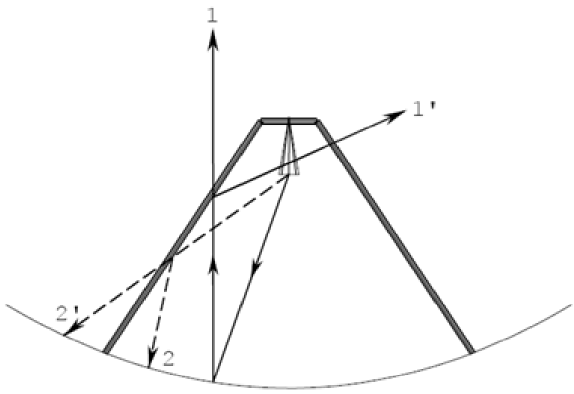

Fig. 1.1: Strut scattering of type 1 and 2

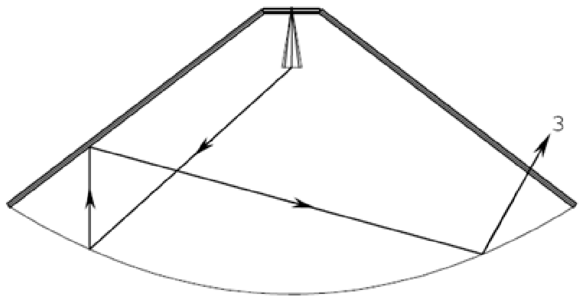

Fig. 1.2: Strut scattering of type 3

Strut Calculation Steps:

Below are the steps respectively in which struts calculations are carried out in GRASP software:

Illumination of struts by direct feed, often referred to as Spherical Wave Scattering. Strut scattering mechanism 1.

↓

Illumination of reflector by direct feed & illumination from struts (currents on struts generated in last step).Referred to as plane wave scattering. Strut scattering mechanism 2.

↓

Re-illumination of struts from reflector (currents on reflector generated in last step), referred to as plane wave scattering. Strut scattering mechanism 2.

Flow Chart 1.1

Strut Scattering:

Scattering and blockage of the radiation field can be easily seen in blow picture, which has been simulated in GRASP for symmetrical arrangement (120^0 separated) of three strut on the rim of the reflector for 0^0 -45^0 in theta with 10 rays.

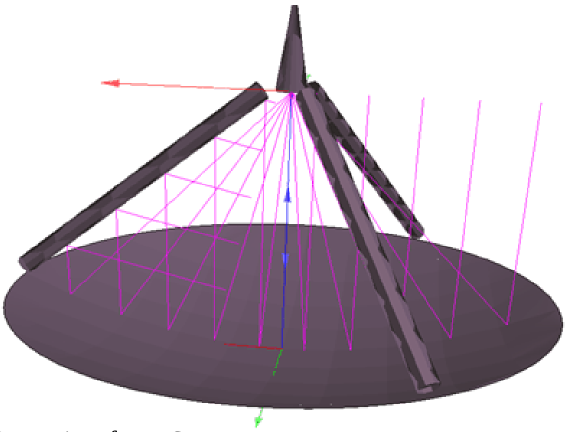

Fig. 1.3: Blockage and Scattering from Struts

Radiation Pattern Analysis:

The nominal radiation pattern (radiation pattern for the reflector without struts) depicts a gain of 37.77 dBi and a Side Lobe Level (SLL) of 31.02 dBi as shown in the graph below.

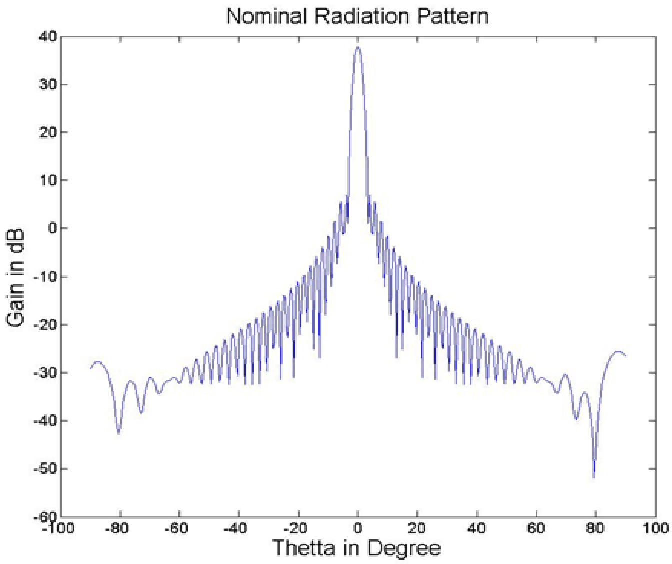

Fig. 1.4: Nominal Radiation Pattern

The analysis has been carried out for circular struts for two different radii (0.535 cm, quarter wave length and 1.07 cm, half wave length). The analysis has been carried out for single strut and three struts with two different locations (on rim and on surface of the reflector at half of the radius), results of which are given as under:

Table 1.1: Comparing Single Strut Scattering Effects

		Comparing Single Strut Scattering Effects			
Geometry	Nominal	Inside Single Strut (0.535)	InSingleStrut1.07	OutSingleStrut0.535	OutSingleStrut1.07
Gain (dB)	37.77	37.71	37.53	37.70	37.58
SLL Below Peak (dB)	31.02	29.46	26.78	28.70	25.98

Table 1.2: Comparing Three Struts Scattering Effects

		Comparing Three Struts Scattering Effects			
Geometry	Nominal	In3Struts0.535	In3Struts1.07	Out3Struts0.535	Out3Struts1.07
Gain (dB)	37.77	37.14	36.36	37.36	36.87
SLL Below Peak (dB)	31.02	21.14	17.86	25.61	19.07

Table 1.3: Comparing Four Struts Scattering Effects

		Comparing Four Struts Scattering Effects			
Geometry	Nominal	In4Struts0.535	In4Struts1.07	Out4Struts0.535	Out4Struts1.07
Gain (dB)	37.77	36.94	35.76	37.20	36.45
SLL Below Peak (dB)	31.02	24.14	18.46	24.95	22.70

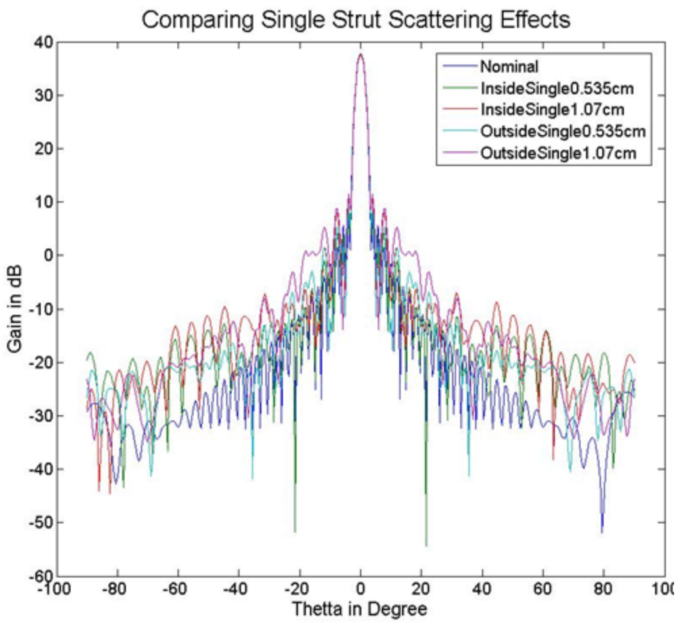

Fig. 1.5: Comparing Single Strut Scattering Effects

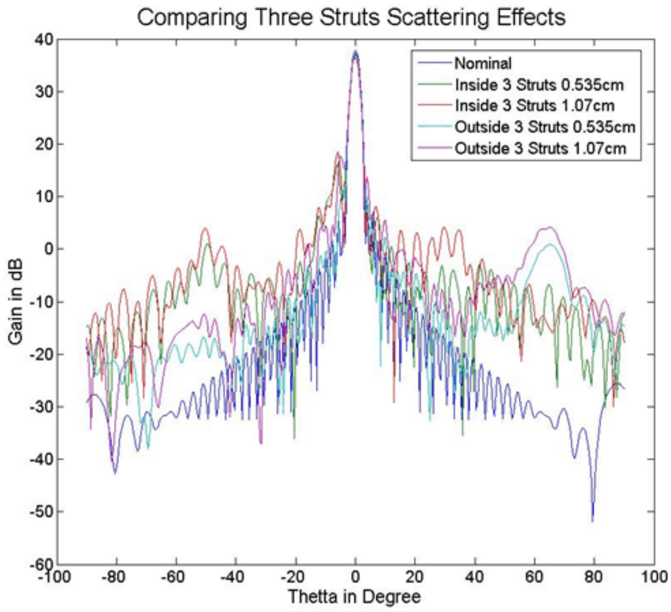

Fig. 1.6: Comparing Three Strut Scattering Effects

Conclusion:

It can be concluded on the basis of the above analysis that increasing the thickness of the struts results in over all increase in the side lobe level with the reduction in peak gain. It can also be concluded that inside arrangement of the struts result in more blockage of the radiated field than the struts on the rim of the reflector for the same struts of same radius.

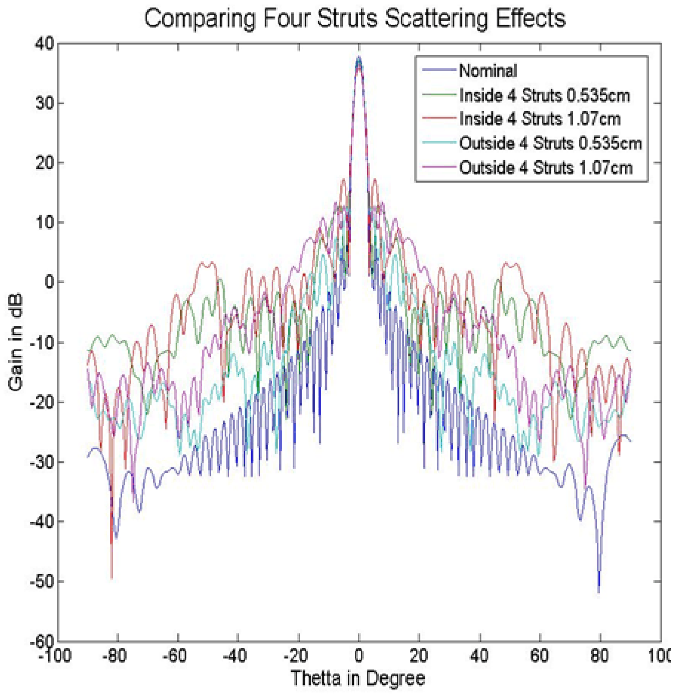

Fig. 1.7: Comparing Four Struts Scattering Effects

Future Work:

The analysis has been carried out for struts, made of metal (perfectly conducting) and for circular struts. The analysis should be carried out for polygonal struts, with dielectric as the material of the struts.

ACKNOWLEDGMENT

This is the extended version of our own paper presented and published as Conference proceedings in "International Conference on Computers & Emerging Technologies" (ICCET 2011) held on 22-23 April 2011 at Shah Abdul Latif University, Khairpur, Sindh, Pakistan.

REFERENCES

Chang, Y., H. Morrison, 1986. Rudduck. A hyrid approach for the strut analysis of reflector antennas. Antennas and propagation society international symposium., 24.

Hsi-Tseng Chou, Shih-Chung Tuan, Hsi-Hsir Chou. Time-domain analysis on the Scattering from a reflector antenna based on high frequency approximations. 2010 Electromagnetic compatibility (APEMC), Asia pacific symposium. ISBN: 978-1-4244-5621-5.

Krzysztofik, 2010. Wojciech J. Small offset parabolic reflector antenna design and analysis. 2010 antenna and wave propagation (EuCAP) proceedings of the fourth European Conference. ISBN: 978-1-4244-6431-9

Mathieu Reil, Yan Brand, Yves Cassivi, Yves Demers, Peter De Maagt. Design of low scattering struts for center-fed reflector antennas. Antennas and Propagation (EuCAP). 2010 proceedings of the fourth European Conference.ISBN: 978-1-4244-6431-9.

Nader farahat, Raj Mittra, Jesus Sanchez. Numerical Analysis of large reflector system used as a ground station antenna. 2007 Microwave and optical technology letters. 47: 3.

Nend-Tien Huang. Mittra, R. Hay.s. 2010. Numerical Study of the effect of the struts in a reflector antenna system by using the parallelized FDTD-based solver Gems. Antennas and propagation society international symposium (APSURSI), IEEE. ISBN: 1522-3965.

Rudduck, R.C., 1994. Teh-Hong Lee Jo-Yu Wu. Analysis of secondry scattering for strut lobes in reflector antenna. Antenna and Propagation society international symposium. ISBN: 0-7803-2009-3.