Crown Planar Antenna Element for KA Band Satellite Applications

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Abstract. This article presents a new design of planar satellite antenna for Ka-band applications, where the effectiveness of the triangular planar antenna shape is investigated to get Crown shape; This analysis will be carried out by the simulation of planar antenna element with CST Microwave Studio ®, where numerical simulation with 5.35 dBi of antenna gain at 28.32 GHz and return loss less than −10 dB at all a frequency band between [27–29.5 GHz], can be exploited to develop the next generation of small communication satellite.

Keywords: Planar antenna · Ka-band intelligence · Satellite · Gain

1 Introduction

The development of telecommunications in recent years requires the realization of equipment increasingly efficient and less expensive. This evolution appears in many telecommunications systems. In the microwave domain, previously the circuits were heavy and their design was impressive but in recent years circuits responding to electrical performance increasingly ambitious were realized.

The patch antennas are a device that is very developed and also usable. Due to the ease of manufacture and creation of the new models.

Our goal is to create a new design of a satellite antenna that radiates in the Ka-band in the best way. In order to achieve satisfactory simulation results, we are directed to available commercial software which is CST MWS, which is a specialized tool for three-dimensional electromagnetic simulation of high frequency component and microwave applications.

To meet these requirements; several techniques have been developed which have proved their efficiency for planar antennas (Balanis 2012; Garg et al. 2001). Where we can found among the various methods (Yahya and Debidni 2011; Kil et al. 2007) to increase the gain is to put a patch element in an array configuration that can be a useful technique to improve the characteristics of planar antennas.

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This article focuses on the design of a new design of antenna element for Ka-band satellite applications; where we aim to reduce the weight and ensure the rigidity of the structure. A parametric study by a variation on substrates heights for new antenna structures for Ka-band applications where we present graph comparison of the reflection coefficient, the VSWR and the gain of this polygonal patch antenna.

2 Antenna Design Procedure

Triangular patch antenna shapes are currently considered very promising, especially for the design of compact antennas. It's designed to improve the performance of planar antennas such as bandwidth, multi-frequency resonance, and gain.

Basing on the theoretical analysis in (Chan 2002; Lin et al. 2005) proposed antenna has a regular crown shape with microstrip fed substrate permittivity of 4.3 will be presented in Fig. 1; and the antenna dimension are given in Table 1.

Table 1. Polygonal antenna parameters

Parameters	Dimensions (mm)
Patch length (Lg)	4.95
Patch width (Wg)	8.58
Substrate length (Ls)	20
Substrate width (Ws)	10
Microstrip feed length (Lt)	14
Microstrip feed width (Wt)	1

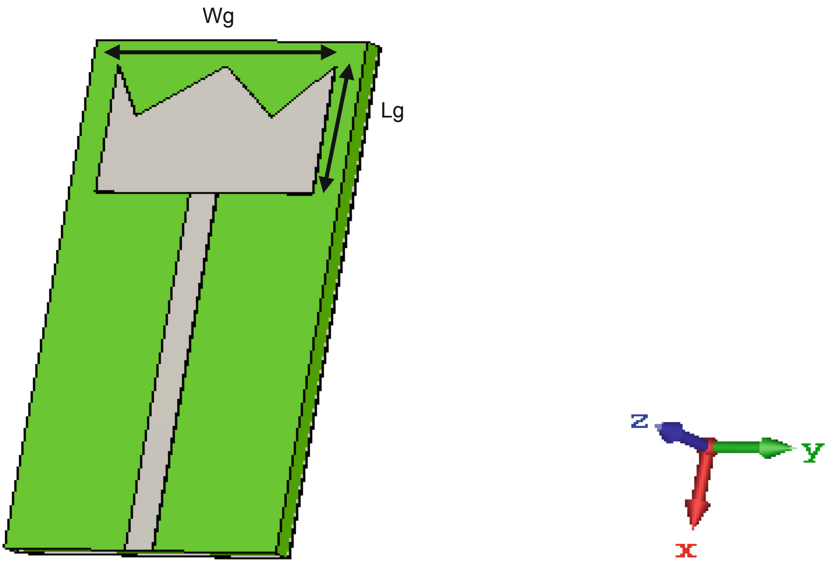

Fig. 1. Polygonal antenna with micro-strip feed.

3 Parametric Study

In this section, a parametric variation analysis of the substrate heights with commercial software of the proposed antenna is presented. This study aims to exploit the radiation characteristics of this antenna to operate in Ka band.

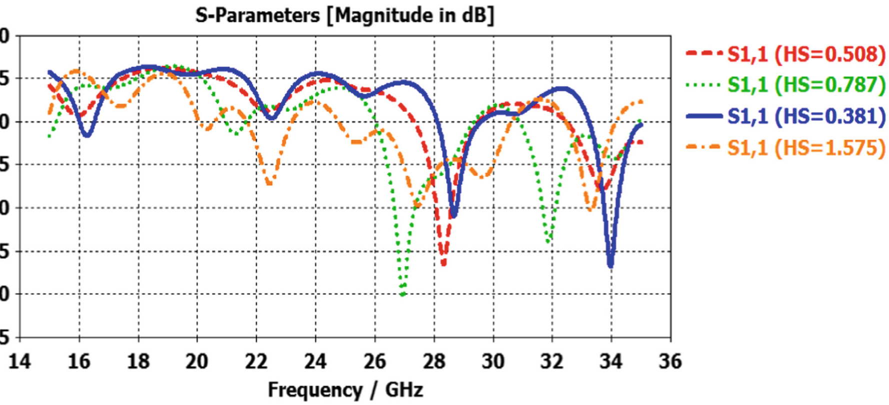

Fig. 2. The comparison results of the input return loss (S11).

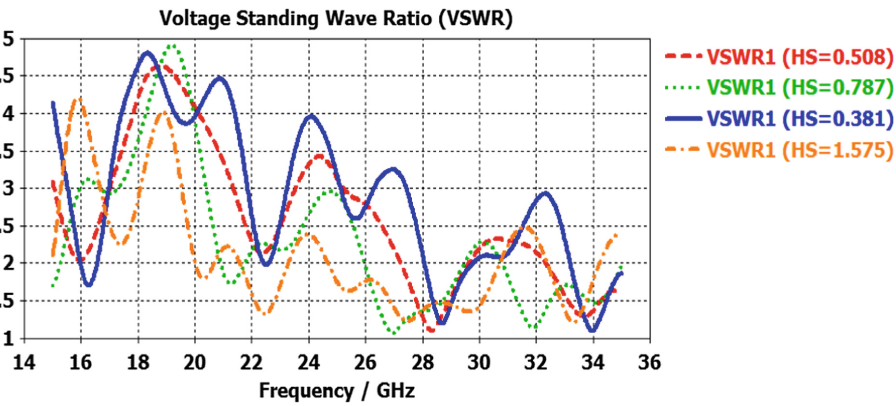

Fig. 3. The comparison results of the VSWR

The analysis results of the substrate height variation are given by the comparison in the return losses (Fig. 2), ensuring the adaptation conditions; and also given by the graph of comparison for VSWR values (Fig. 3).

It is well shown that for a height of 0.508 mm the return loss value is minimum, it is −26.58 dB for a resonance frequency of 28.32 GHz and this can also show in the value of the corresponding VSWR where it is 1.1 also less than 1.5.

Table 2 summarizes the values of the main characteristics of the proposed antenna for a frequency of 28.32 GHz. And it is clear that the value of the gain of the planar antenna is greater than 3 dBi for the different values of the substrates.

Table 2. Comparison of return loss and gain for different substrates heights at 28.32 GHz.

Substrate thickness (mm)	Return loss (dB)	Gain (dBi)	VSWR
1.575	−14.67	3.82	1.45
0.787	−15.92	4.14	1.38
0.508	−26.58	5.35	1.1
0.381	−12.92	4.76	1.58

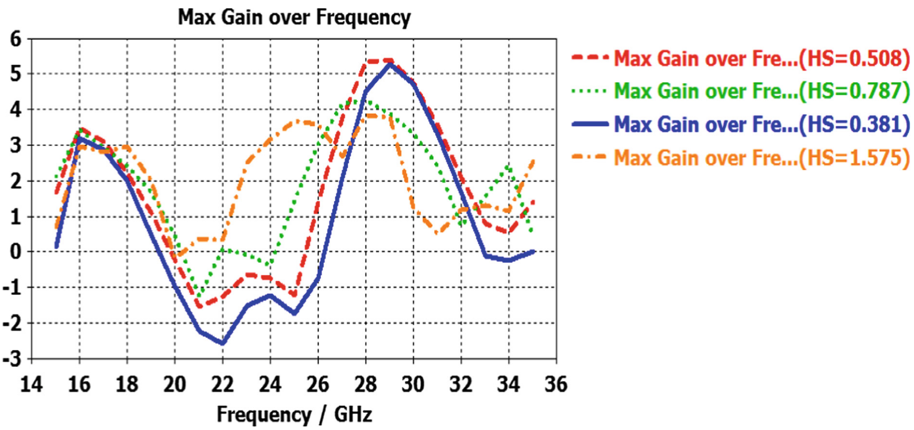

Fig. 4. Antenna gain variation comparison.

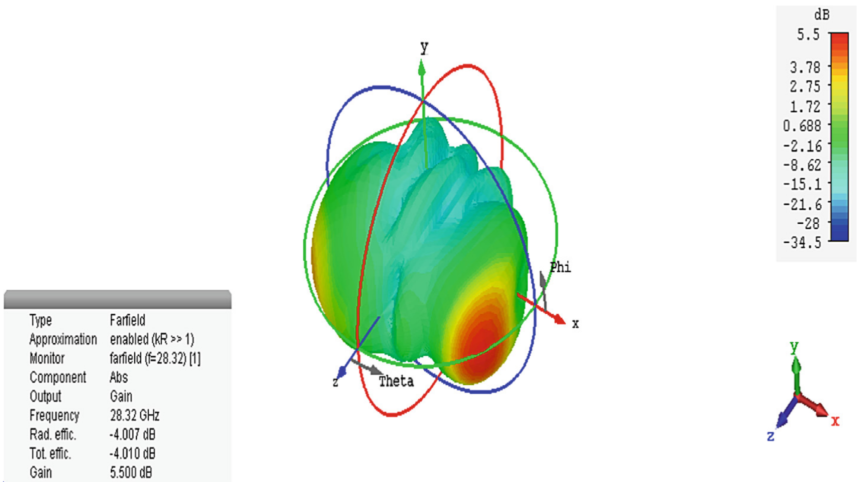

Fig. 5. 3D antenna pattern for resonance frequency of 28.32 GHz and h = 0.508 mm.

Although the return loss is −31.18 for h = 1.575 mm but the gain is low compared with h = 0.787 mm where the gain is 7.1 dBi that we bring to use this height since the value of the return loss is less than −10 dB and the VSWR value is acceptable for resonant frequency 24.804 GHz.

Figure 6 shows the variation of gain versus frequency when it is reached more than 5 dBi for a frequency range between 27.97 and 29.54 GHz (Fig. 4).

For the same dimension of the antenna cited in Table 1 and for the height h = 0.508 mm, Fig. 5 illustrates the 3D radiation pattern in resonant frequency of 28.32 GHz and Fig. 6 shows a 2D plot of the radiation pattern to describe the energy distribution of the proposed antenna (Fig. 5).

It is clear in 2D the radiation pattern of the proposed polygon antenna around 28.32 GHz for variation in the Phi angle; the energy is concentrated in a direction of an aperture of 51.8 at −3 dB.

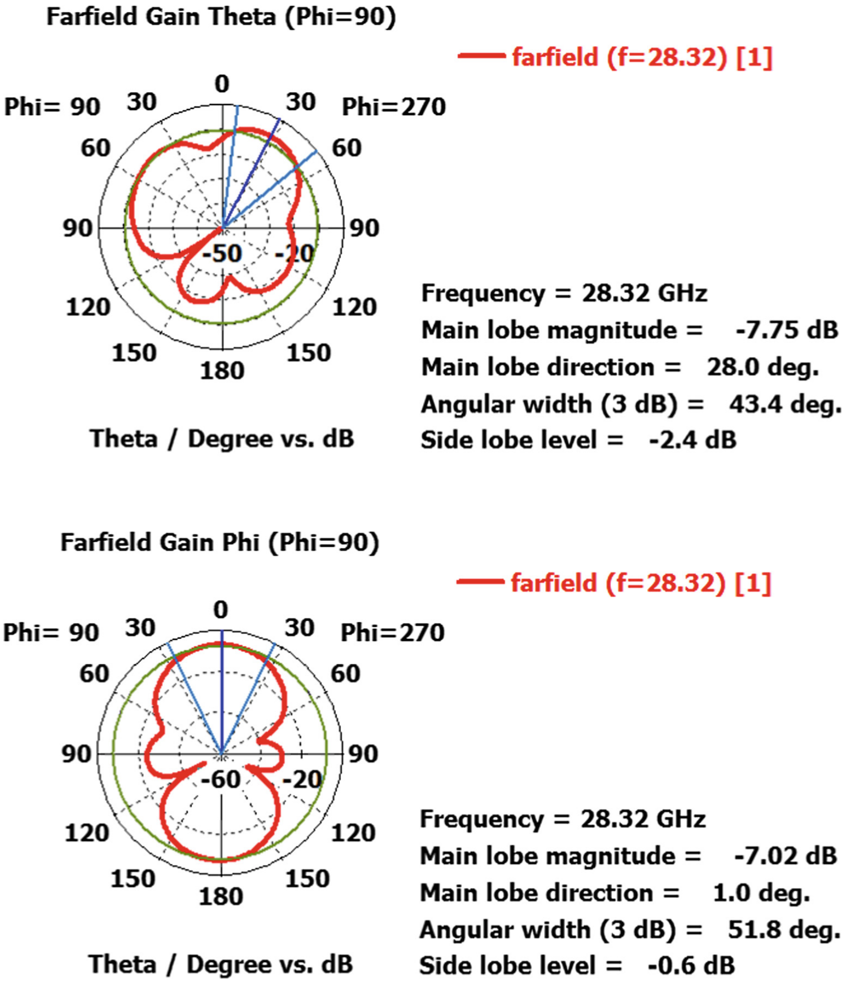

Fig. 6. 2D pattern: (a) for Theta, (b) for Phi

4 Conclusion

The parametric study presented in this analysis for a new design of a patch antenna for a Ka band applications, shows us that the characteristics of the antenna are improved for the smaller thickness, which present the efficiency to use a this antenna to meet specific needs at these substrate heights.

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