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DESIGN OF A CONICAL HORN ANTENNA FOR ULTRA-WIDEBAND APPLICATIONS

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Abstract

Due to rapid development in wireless technologies, ultra-wideband antennas are becoming increasingly important nowadays to cover many bands of frequencies and to support different applications by using single antenna. This paper outlines the design of an ultra-wideband conical horn antenna, which covers the range of frequencies from 6GHz to 18GHz with high gain, i.e., 23dB. This antenna can be effectively used for satellite communication and terrestrial broadcasting.

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1. Introduction

An antenna is a transducer which truncates abruptly to transfer guided electromagnetic waves into free space radiated electromagnetic waves. Due to advances in technologies, the radio band has become increasingly crowded. In such cases, if a device supports more than one application, it will be more useful. Nowadays, this can be achieved by using the concept of ultra-wideband (UWB) antennas. On February 14th, 2002, the Federal Communications Commission (FCC) amended the Part 15 rules which govern unlicensed radio devices to include the operation of UWB devices. The FCC also allocated a bandwidth of 7.5GHz, i.e., from 3.1GHz to 10.6GHz for UWB applications [1].

The first application a horn antenna can be traced back to the beginning of the radio [3]. Each size of horn antenna has specific features. First, the small-aperture size is used as a feed to a large aperture size, while the large aperture size is used as a medium gain antenna. Second, it can deal with a different polarization or combination of polarizations. Conventional horn antennas have a limited bandwidth [2]. Horn antennas are used in cases where high gain is required. When the gain of the dish antenna is required, the solution is often to use a horn antenna. In addition, it is used in several RF antenna applications without having to be added to another antenna, such as short-range radar systems for automotive speed enforcement [4]. When a horn antenna is used as a parabolic reflector feeder, its radiation is orientated towards the surface of the parabolic reflector to produce a logically uniform illumination of the surface without passing radiation to avoid the reflector. This leads to an increase in the overall efficiency of the antenna. Another feature of using a horn antenna is minimizing the signals that come from the side loops of the parabolic reflector antenna [4].

A series of studies has been focused on horn antenna. For example, Priyanka and Teena [5] gave an overview for different techniques of the conical horn at 3GHz with 12dB of gain and they provided a reference bank for horn antenna, while Nafati et al. [6] provided a method to compute E and

H far field radiation accurately for CHA using diffraction theory and geometrical optics. Gurpinder and Deepinder [7] have designed CHA for Ku bands, obtaining 18.4dB to 20.2dB of gain, 18.4dB to 19.4dB of directivity and VSWR < 1.14 using HFSS software. Daniyan et al. [8] represented design considerations and concepts of a CHA at L-band frequency, while Min Huang et al. [9] designed a CHA for generating electromagnetic field with orbital angular momentum. Korrapati [10] has studied the conical antenna in terms of far field area coverage based on port potential. He made an analysis to the response of the far field coverage of the antenna based on a numerical methodology. The analysis has showed that the far field potential increases as the port potential increases. Rohini et al. [11] designed a CHA with coaxial feeding using CST software for X-band frequency (8GHz to 12GHz), while Mridula [12] designed a varied slot pattern rectangular corrugated horn antenna using CST software. This antenna works on an X-Ku band. The simulation results show less cross polarization, less return losses and a good VSWR pattern at central 15.83GHz. As well as, in the Ku band, it has a mode conversion, which contains matching and varied slot pattern mode converters.

There are different types of horn antennas available. In this paper, a CHA is designed using CST Microwave Studio. Aluminum metal has been used to create the antenna with no dielectric loading. In general, the typical gain of the horn antenna is in the range of 10-20dB, but under some special cases, it can be extended up to 25dB too. Due to high directivity, horn antennas can be used where high power is needed.

The paper is arranged as follows: Section 2 provides a short description theory about CHA, Section 3 presents the antenna design and geometry, Section 4 explains the antenna simulation procedure and represents the results with corresponding discussions, and finally, in Section 5, conclusions are made.

2. Conical Horn Antenna (CHA)

Horn antennas are suitable for frequencies between 300MHz to 3GHz. They have a directional radiation pattern proportional with frequency [5]. CHA is constructed with a short length of cylindrical metal tube, which is closed at one end and a conical shape with an open end [7], as illustrated in Figure 1. The dimensions of CHA are related to wavelength which adjusts the radiation characteristics [7]. The modes traveling have been computed using Bessel and Legendre functions [13]. The optimum diameter of cylindrical (*d*) is represented in equation (1):

$$d = \sqrt{3\lambda L}, \tag{1}$$

where λ is the wavelength and L is the slant length of the cone from the apex. Equation (2) represents the conical horn gain (G) as below:

$$G = \left(\frac{\pi d}{\lambda}\right)^2 Ea, \tag{2}$$

where d is the aperture diameter and Ea is the aperture efficiency.

3. Antenna Design

The conical antenna is depicted in Figure 1. It is designed to operate at a frequency band of 6GHz to 18GHz for satellite communication. Aluminum material is used to design this antenna. The antenna dimensions are shown in Table 1.

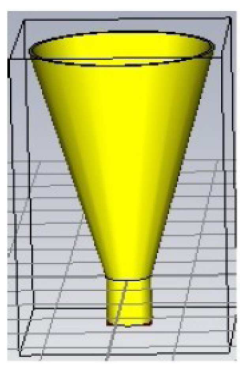

Figure 1. Ultra-wideband CHA.

Table 1. Dimensions of cone

Description	Size in mm
Bottom radius	15
Top radius	70
Cone height	200
Thickness of cone	3
Height of cylinder	40

4. Antenna Simulation and Results

This CHA with coaxial feeding is built and simulated using CST Microwave Studio software.

4.1. Return loss

$$\sin\alpha \pm \sin\beta = 2\sin\frac{1}{2}(\alpha \pm \beta)\cos\frac{1}{2}(\alpha \pm \beta).$$

Transient time domain solver mode is used to simulate with an accuracy of 40dB. Corresponding results are shown below where Figure 2 gives the details of return loss using reflection coefficient vs. frequency graph.

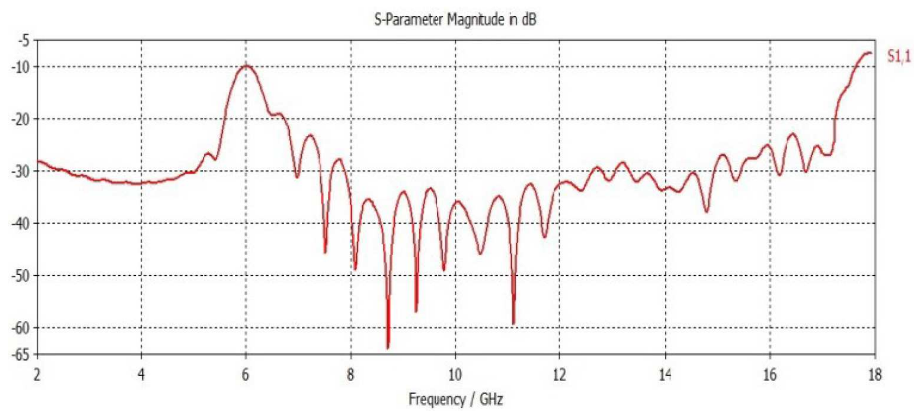

Figure 2. $|S_{11}|$ vs. frequency.

From Figure 2, the return loss is less than 10dB for the frequency band of 6GHz to 18GHz, i.e., the energy is properly radiated into free space without reflecting.

4.2. VSWR plot

From Figure 3, the VSWR plot shows that throughout the frequency ranges the value of VSWR is less than two which is quite good for meeting practical standards.

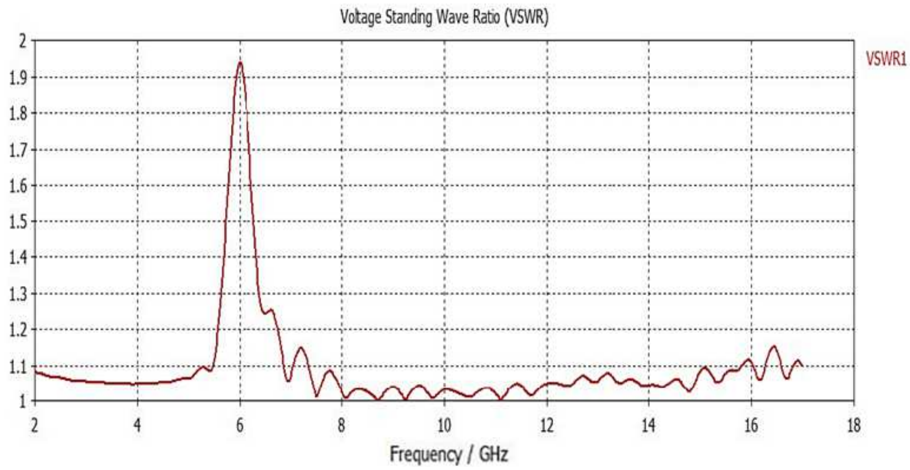

Figure 3. VSWR vs. frequency.

4.3. Far field broadband radiation pattern

For horn antennas, the gain typical range is 10-20dB. Figure 4 shows that this CHA has good gain of 26dB with high radiation efficiency.

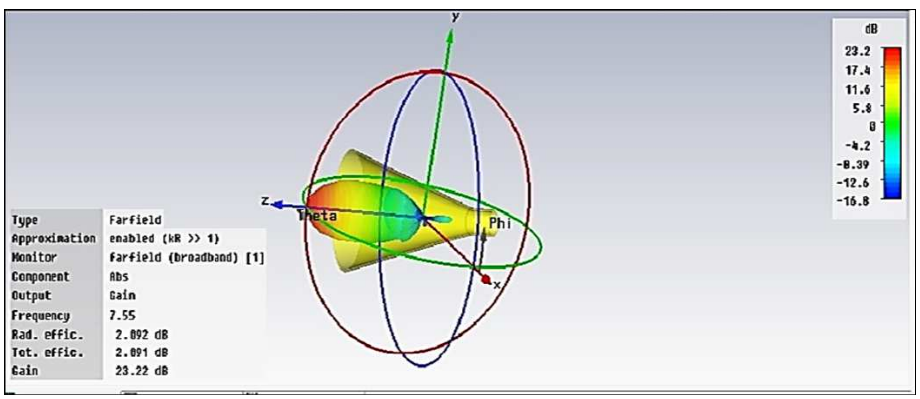

Figure 4. Far field radiation pattern.

5. Conclusions

This study demonstrates that the designed CHA is suitable for a variety of applications within the 6GHz to 18GHz frequency band, particularly in satellite and terrestrial communications, due to its high directivity of 26dB. Currently, the fabrication of the antenna is underway, and once completed, a comparison between the simulated and measured results will be possible. Additionally, work is ongoing on the design of a corrugated conical horn antenna, intended to operate across the L, X, K, and Ku bands.

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