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A BROADBAND BICONICAL ANTENNA FOR WIDE ANGLE RECEPTION

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Abstract

A broadband Biconical antenna has been designed for the interception of electromagnetic waves in the frequency band of 2-12 GHz. The aim of the design is to miniaturize the size of the Biconical antenna as much as possible without affecting the electrical performance of the antenna like VSWR, radiation pattern and gain. These types of broadband antennas are widely used for ESM applications. The designed antenna has return loss better than 10 dB across the frequency band with omnidirectional pattern. The omnidirectional pattern helps in achieving almost 360° of azimuth coverage along with some degree of coverage in elevation plane. Such antenna can be used for the direction finding which can be further translated into angle of arrival (AOA) measurement of enemy targets. A CAD model has been designed and simulated by using CST microwave studio for the EM analysis. The simulated results like three dimensional radiation pattern, VSWR, Return loss and gain plots have been presented for discussion.

Index Terms: *Biconical antenna, EM analysis, AOA and Omni-directional.*

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1. INTRODUCTION

Federal Communication Commission (FCC) defined the term Ultra Wide Band (UWB) in terms of the percentage bandwidth with respect to the centre frequency. An antenna is termed as UWB if it satisfies the following condition:

$(f_H – f_L)/f_C > 0.2$ … (1)

And $(f_H – f_L) > 500$ MHz … (2)

Where,

f_L = lowest frequency of operation

f_H = highest frequency of operation

f_C = centre frequency of operation = $(f_H + f_L)/2$

Antenna is one of the most important components of UWB communication. Biconical antenna was first introduced by Schelkunoff [1]. Biconical antenna is a broadband antenna which can operate over large bandwidth. Biconical antenna consists of two conical conductors, which are driven by alternating EM field. In a typical Biconical configuration, both the conical conductors have common axis and the feed is provided along this axis. In other words, a Biconical antenna is a broadband version of a simple dipole antenna which exhibits bandwidth 3 octaves or more. It is described that thickening the arms of dipole or

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monopole antenna results in increased bandwidth because the current distribution remains no longer sinusoidal and therefore influences the input impedance of the antenna. Theoretically, an infinite Biconical antenna is a frequency independent antenna but for finite Biconical antenna both input impedance and radiation pattern changes with frequency of operation. A Biconical antenna is a broadband radiator with omnidirectional pattern in one plane and limited coverage in other plane. The impedance of the feeding point of Biconical antenna is generally chosen to be 50Ω because most of the coaxial connectors have 50Ω impedance. The impedance of a Biconical antenna depends upon its conical geometry and impedance decreases with increase in conical geometry. In most of the Biconical antennas, the impedance varies between 50-75Ω based on the cone angle.

The input impedance of a Biconical antenna with conical length (l) and cone angle (α) is given by Papas and King [2] as:

$Z_{in} = Z_o (1-\beta/\delta)/ (1+\beta/\delta)$ … (3)

Where,

Z_o = characteristic impedance= 60 ln cot (α/4) … (4)

The equation (4) suggests a relationship between the cone angle/flare angle and the characteristic impedance of a Biconical antenna.

2. BROADBAND BICONICAL ANTENNA

A Biconical antenna has been design and simulated to operate in 2-12 GHz frequency range with maximum VSWR 2.5:1 and Omni-directional pattern in Azimuth plane. As shown in Fig-1, the important parameters of a Biconical antenna are cone angle (α), radius of the cone (r), gap between the cones (g) and the conical length (l). These parameters were taken as variables and optimized using the CST Microwave Studio to obtain the desired results.

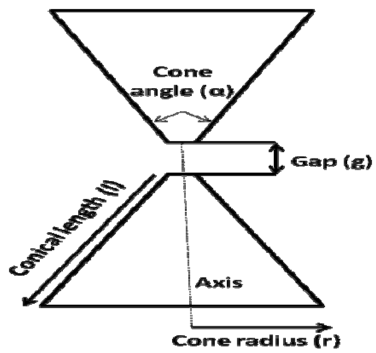

Fig -1: Biconical antenna geometry

The parameters like conical length (l) or cone angle (α) can be derived from each other if other parameters like cone height (h) and cone radius (r) are defined. Based on the trigonometry, a relationship between cone height (h), cone angle (α) and cone radius (r) is given as:

$\tan(\alpha/2) = r/h$ … (5)

The other important design parameters have been optimized and their final values are given in Table-1 for reference.

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Parameter Name	**Optimized value**
Gap (g)	4 mm
Cone Radius (r)	30 mm
Cone Angle (α)	100^{0}
Cone Height (h)	25 mm
Conical Length (l)	39 mm

Table -1: Design Parameters

Based on the optimized design parameters, a Biconical antenna has been modeled in CST Microwave Studio as shown in Fig-2. The modeled Biconical antenna is excited by a 50Ω coaxial connector. It shows that the two metallic cones are separated from each other with the help of connector dielectric which maintains the gap [3] [4]. The conic sections are hollow and have a thickness of 1 mm.

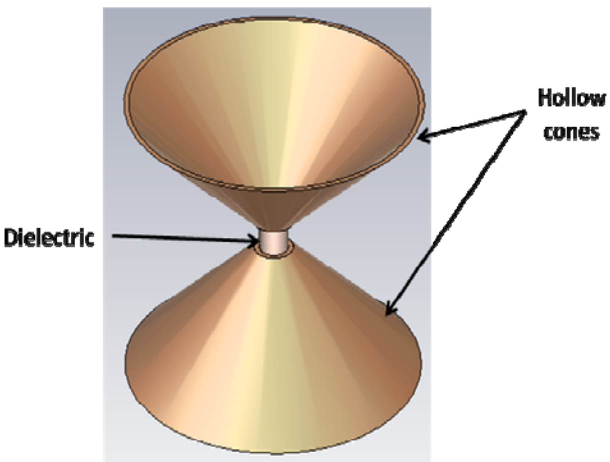

Fig -2: Bi-conical antenna model

The modeled antenna has been analyzed by using the CST Microwave Studio for obtaining the electrical performance parameters like return loss, VSWR, radiation Pattern and gain of the designed Biconical antenna.

The return loss plot, as shown in Fig-3, suggests that the antenna is well matched with 50Ω coaxial connector in the frequency range of 2-12 GHz. Moreover, it also recommends that the same feeding can be used for achieving larger bandwidth at different centre frequency.

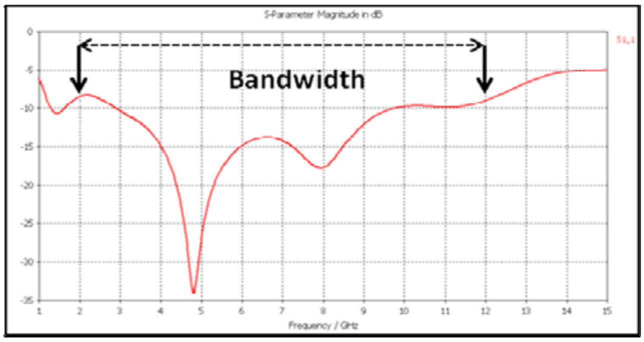

Fig -3: Return Loss of Biconical Antenna

The VSWR of the designed antenna is well within the desired range i.e. 2.5:1 for the 6:1 bandwidth. VSWR plot for the Biconical antenna has been presented in Fig-4.

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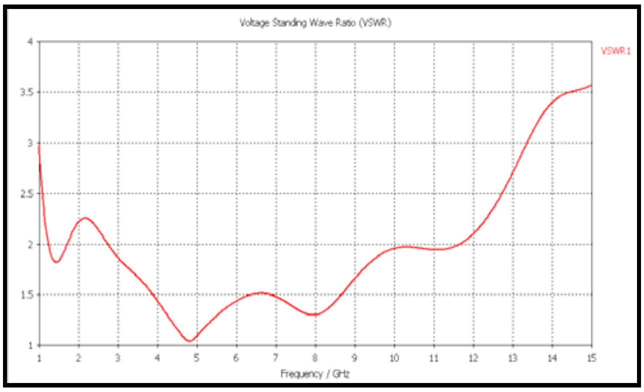

Fig -4: VSWR of Biconical Antenna

The radiation pattern of the antenna at 2 GHz is presented in Fig-5. It is clear that if the antenna is kept in vertical polarization, it provides 360° azimuth coverage. This property is extremely useful when antenna is used as a sensing element for enemy radars. EM wave from any direction in azimuth plane is well intercepted by such antennas due to omnidirectional pattern.

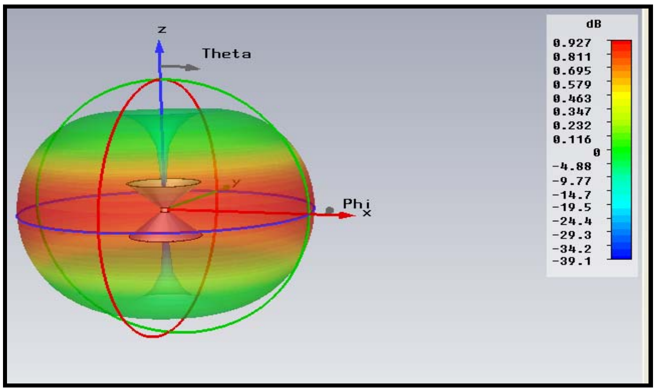

Fig -5: Radiation Pattern of Biconical Antenna

The half power beam width (HPBW) in elevation plane at different frequencies is tabulated under Table-2. It can be concluded that the designed Biconical antenna can intercept the threat in ± 30° in elevation plane for a maximum loss of 3 dB.

Frequency (GHz)	**HPBW**
2	100°
4	125°
6	90°
8	83°
10	97°
12	66°

Table -2: HPBW in elevation plane

The Biconical Antenna offers moderate gain in the entire frequency range. The simulated gain for the proposed Biconical antenna is presented in Fig-6. It is evident from the gain plot that the gain increases linearly with the frequency with some exception.

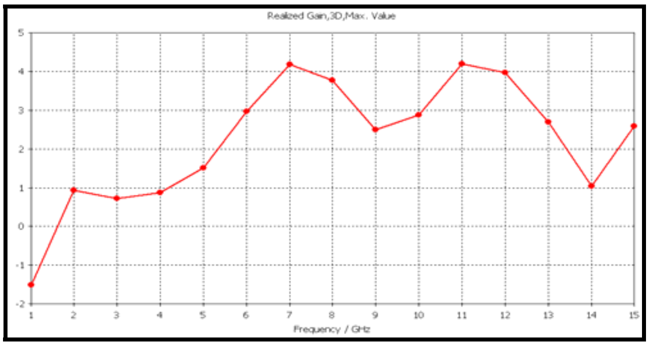

Fig -6: Biconical Antenna Gain Plot

The exceptions in the antenna gain appear due to the increase in HPBW of the antenna in elevation planes. If we compare Table-2 and Fig-6, it is clear that the frequency spots where the gain falls, the HPBW increases. It is a common phenomenon in a broadband antenna and cannot be just controlled by design parameters.

3. CONCLUSION

A broadband Biconical antenna has been reported in this paper. The simulated result suggests that the antenna performs well within the frequency range of 2-12 GHz. The antenna can intercept enemy radar signals in 360° azimuth plane along with ± 30° coverage in elevation plane. The antenna also exhibits moderate gain ranging between 2-4 dB which helps in improving the received signal strength. The mechanical dimensions of the antenna are kept as small as possible to make it compact and hollow conic section makes it light weight and extremely useful for those platforms where volume is a constraint. The proposed design can be further optimized to achieve larger bandwidth i.e. 1-18 GHz with omnidirectional radiation pattern.

4. ACKNOWLEDGEMENTS

The author would like to thank Director, DARE for his continuous support and encouragement for this work.

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