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An Ultra Wideband Vertical Slotted Orthogonal Semi Elliptical Sheets Monopole Antenna with Finite Ground Plane

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Abstract— The paper presents UWB monopole antenna having Slotted orthogonal vertical semi elliptical sheets with finite ground plane. The simulated return loss, VSWR, input impedance and radiation pattern are discussed in this paper. The results show that the voltage standing wave ratio is less than 2 (VSWR< 2) and return loss (S_{11}) is less than -10 dB along the operation bandwidth of 4.5 GHz to 13.8 GHz. The asymmetry in the feed position results in increase of the band width but degrades the radiation pattern.

Index Terms— Ultra wideband (UWB), Vertical semi elliptical sheet, Voltage standing wave ratio (VSWR), Return loss (S_{11}), Radar technology.

1 Introduction

Bandwidth is a very critical parameter in any communication system. There always seems to be a position when a trade-off needs to be affected between the system bandwidth and various other system parameters like latency, power consumption etc. when bandwidth maximization is to be done. Higher bandwidth is vital in many applications such as vehicular radar systems, imaging systems, wall-imaging systems, ground penetrating systems, medical systems, through-wall imaging systems, communications, measurements systems, etc. In order to increase the range of the operating frequency, the front end of the communication system (i.e. antenna) must be able to radiate efficiently over a wider bandwidth. The FCC affirmation for the commercial use of UWB frequencies in 2002 has attracted an increasing interest in the antenna design for this new communication standard [1]. Commercial UWB systems require small low-cost antennas with larger bandwidth and non-dispersive behaviour [2]. By means of UWB antennas, high data rate transmission can be obtained in short-range local networks and short-duration pulses. UWB is also used for real-time location systems; the precision capabilities and low power making it well-suited for radio-frequency-sensitive environments (e.g. hospitals). Another plus point of UWB antenna system is its short broadcast time.

Planar antennas are the ones that are mainly used for UWB communications. Planar antennas are widely used in the literature [3],[4],[5],[6],[7] due to their wide bandwidth, simple structure and low cost. To design a single antenna with small electrical dimensions and broadband characteristics is a covetable feature in the high-speed data communication systems. Most of the antennas used for UWB communication involve complex calculation and sophisticated fabrication process.

In this paper, a simpler design of UWB antenna having two vertical semi elliptical metal sheets with vertical slots is proposed. The simulated return loss, VSWR, input impedance and radiation patterns of the antenna are discussed.

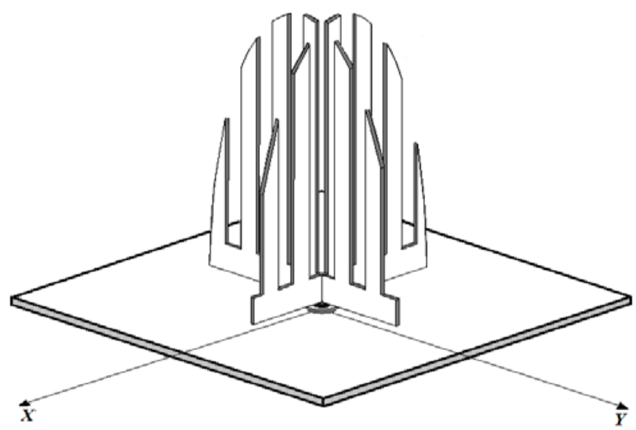

Fig.1 Geometry of the proposed antenna

2 Design Parameters and Dimensions for the Proposed Antenna

The geometrical structure of the proposed antenna is shown in Fig.1. The Vertical Slotted Orthogonal Semi Elliptical Sheets Monopole Antenna consists of two vertical semi elliptical metal sheets connected to a SMA connector with their base. Both sheets are considered as positive and connected to the inner pin of SMA connector while the finite ground plane is connected to its outer. The antenna lies in the XZ-plane and YZ-plane. The radius of minor axis of semi elliptical metal sheets

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is 30 mm along the X and Y direction as indicated in Fig.2 and its radius of major axis is fixed at 75.0 mm along the Z-direction. It has been studied that the performance of gain and return loss is affected by the radius of minor axis of semi elliptical sheet, the radius of major axis of semi elliptical sheet, feeding position, width of these slots, length of ground plane, width of ground plane and number of vertical slots, which are shown in Fig. 2.

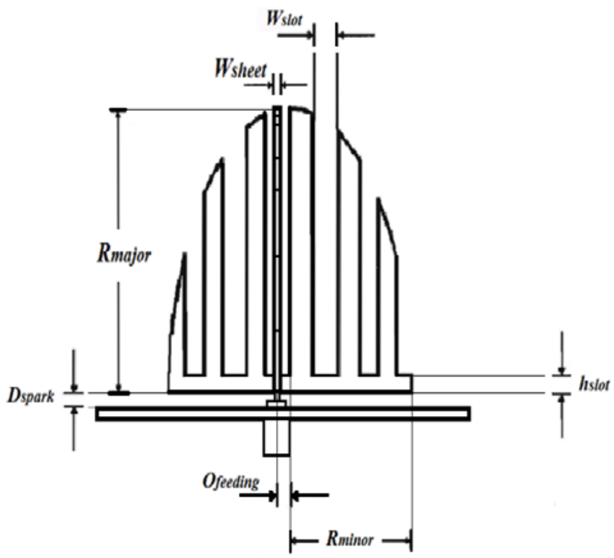

Fig.2 (a) Front view of the proposed antenna

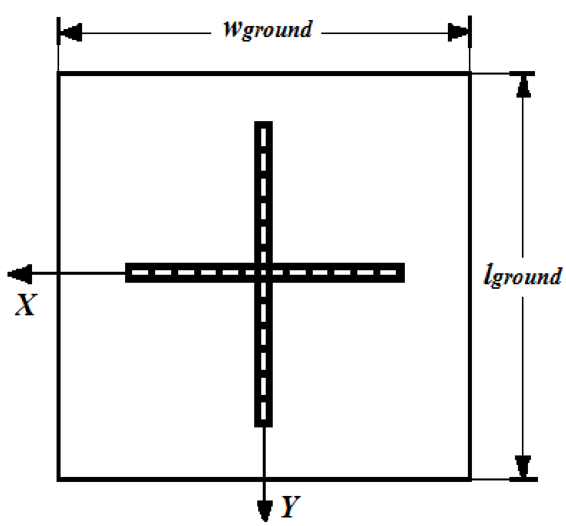

Fig.2 (b) Top view of the proposed antenna

To get ultra wideband characteristics from 4.5 GHz to 13.8 GHz the width of slots has been taken as ratio of the diameter of minor axis of semi elliptical sheet metal sheet to n, where

$$n = (2 \times number\ of\ slots)$$

The diameter of minor axis is a very critical parameter to acquire UWB characteristic and higher gain performance. To get ultra wideband characteristics, feeding is offset by 5.0 mm in positive X-direction and positive Y-direction along the base of semi elliptical metal sheets. The gap between positive and ground plane has been taken as 2.0 mm. The antenna is fed by co-axial cable having SMA connector. Depth of the semi elliptical metal plate has been taken as 1 mm. Finally, the overall physical dimensions of the proposed antenna for optimized performance are given in Table 1.

TABLE I
DESIGN PARAMETERS OF THE PROPOSED ANTENNA

Design Parameters	*Optimized values (mm)*
R_{minor}	30.0
R_{major}	75.0
W_{slot}	5.0
D_{spark}	2.0
W_{sheet}	1.0
$O_{feeding}$	5.0
h_{slot}	7.0
$l_{grouond}$	100.0
w_{ground}	100.0

3 RESULTS AND ANALYSIS

The performance of the proposed antenna was simulated using a full-wave solver. This section discusses simulated return loss, VSWR, input impedance and the radiation patterns for various frequencies over operation bandwidth.

Fig. 3 shows that the simulated return loss is less than -10 dB over the entire operation bandwidth (4.5 GHz to 13.8 GHz).

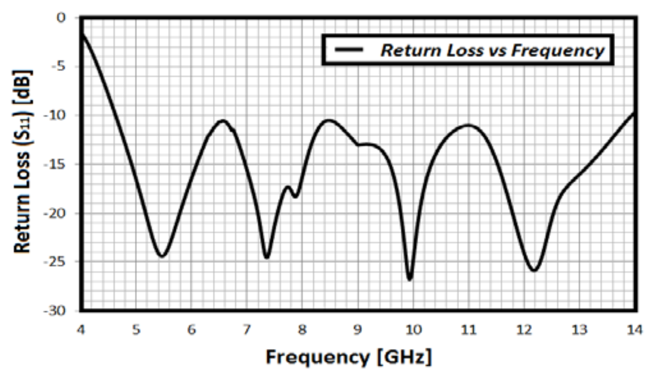

Fig. 3 Simulated return loss of the proposed antenna

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Fig. 4 shows that the simulated VSWR for proposed antenna is less than 2 (VSWR < 2) over entire operation bandwidth which is very good characteristic as an UWB antenna.

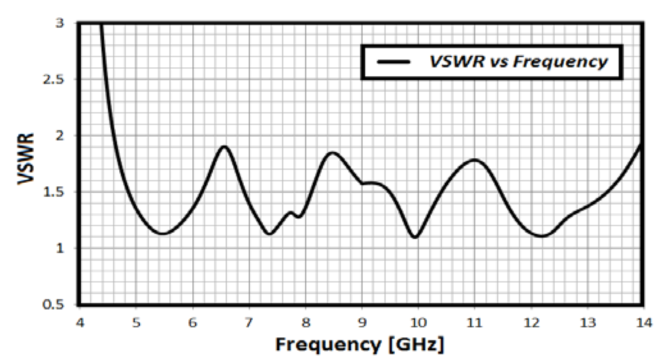

Fig. 4 Simulated VSWR of the proposed antenna

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Fig. 5 shows that the real part of the input impedance varies between 25Ω to 72 Ω whereas the imaginary part varies between -20 Ω to 43 Ω.

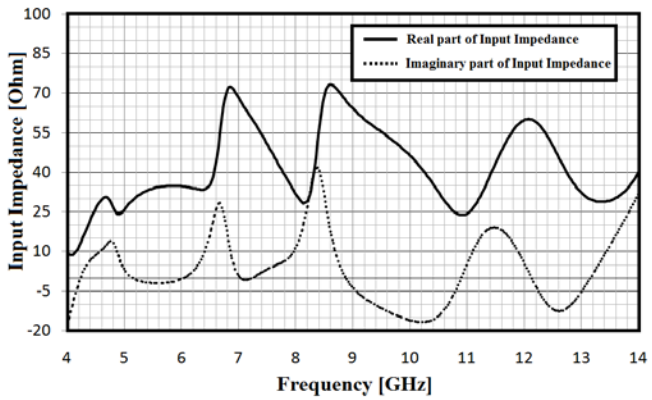

Fig. 5 Real and imaginary part of input impedance

Fig. 6 (a), 6 (b) and 6 (c) shows the simulated radiation pattern of the proposed antenna in XY plane (horizontal plane), XZ plane (vertical plane) and YZ plane (vertical plane) respectively. The radiation patterns are shown at 6 GHz, 8.5 GHz and 12 GHz. The asymmetrical geometry is used to increase the bandwidth but results in the degradation of the radiation pattern. The asymmetry of the radiation pattern is caused mainly by the asymmetry of the feed configuration.

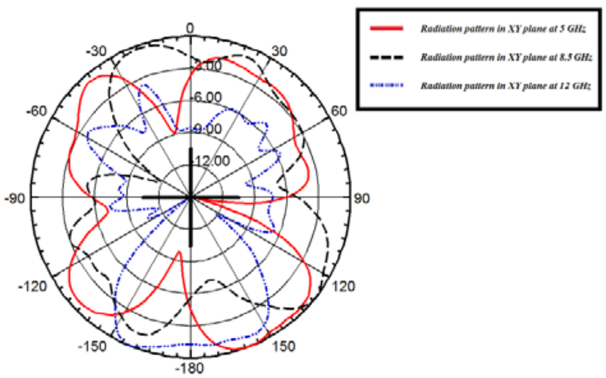

Fig. 6 (a) Simulated radiation pattern of the proposed antenna at 5 GHz, 8.5 GHz and 12 GHz in XY plane (Horizontal plane)

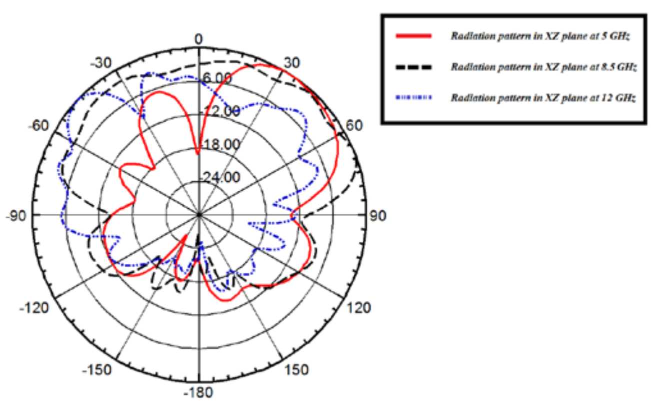

Fig. 6 (b) Simulated radiation pattern of the proposed antenna at 6GHz, 8.5 GHz and 12 GHz in XZ plane (Vertical plane)

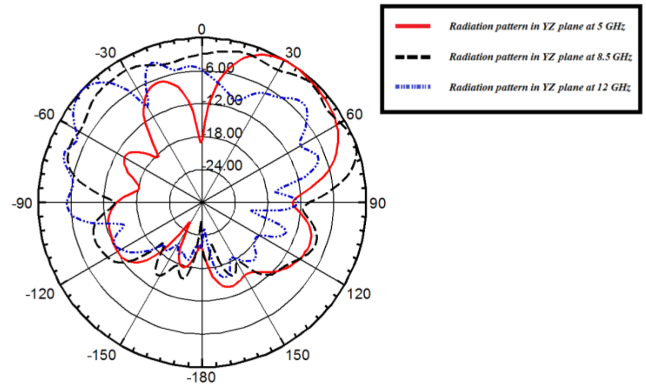

Fig. 6 (c) Simulated radiation pattern of the proposed antenna at 6 GHz, 8.5 GHz and 12 GHz in YZ plane (Horizontal plane) with reflector

The proposed antenna has a directive radiation pattern in Z-direction. In order to use this antenna as directional antenna even in any other direction one can use a reflector at one side of the antenna but addition of reflector may result in change in the return loss bandwidth.

4 Conclusions

In this paper, an Ultra Wideband Vertical Slotted Orthogonal Semi Elliptical Sheets Monopole Antenna with finite ground plane has been proposed for the UWB communication and the narrow pulsed systems. The antenna operates from 4.5 to 13.8 GHz. The simulated return loss, VSWR, input impedance and radiation patterns are presented in this paper. The antenna is suitable for use in UWB applications as it has the operating bandwidth of 9.3 GHz i.e. 102 % fractional bandwidth. It can be very useful in radar communication, for military application, bio-medical technology and space communication through satellite where high performance UWB antennas are required.

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