A COMPACT WIDEBAND FILLED OMEGA UWB ANTENNA

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ABSTRACT

This paper presents antenna design and analysis for UWB applications. A novel planar ultrawideband (UWB) antenna consists of an omega-shaped radiating patch and a partially ground plane is proposed. With this design, the return loss achieved i.e lower than -10 dB in 3.1–10.6 GHz frequency range and the radiation pattern is highly similar to the monopole antenna. This antenna has been designed and simulated on HFSS 12.0 and has given wide impedance bandwidth from 2.4 to 11.7 GHz , which covers both UWB and Bluetooth antenna with a stable radiation pattern and constant gain from 3 to 6dBi.

Index Terms: Microstrip Antenna, CPW, UWB, Monopole, Radiation Bandwidth

I. INTRODUCTION

Wireless multimedia systems are receiving increasing research and application interests, but the improvements are still required to provide higher data-rate links, for instance, the transmission of video signals. For the transmission of higher data rate signal we need to have higher bandwidth in the system. In order to achieve higher data rate, Ultra-Wideband (UWB) communication systems, which according to FCC ranges from 3.1-10.6 GHz is currently being investigated. For this high frequency communication there is need of a compact wideband antenna. Earlier microstrip patch antennas were basically low profile and narrow bandwidth antenna. In order to overcome the inherently narrow bandwidth of microstrip antennas, various techniques have been developed to cover the entire UWB bandwidth, such as L-/F-shaped probe to feed the patch, triangular patch, U-/V-slot monopoles, among others.

Here the focus is on UWB antenna design and analysis. Studies have been undertaken covering the areas of UWB fundamentals and antenna theory. Extensive investigations were also carried out on different types of UWB antennas.

The type of antenna proposed in this paper is an Omega shape monopole antenna. The vertical disc monopole originates from conventional straight wire monopole by replacing the wire element with a disc plate to enhance the operating bandwidth substantially. This vertical monopole is fed by a micro-strip line. The proposed antenna has been successfully designed and simulated and showing broadband matched impedance, stable radiation patterns and constant gain. The following design has been proposed after extensive study of different types of monopoles in UWB was considered. Among these antenna configurations, omega-shape monopole features simple structure, easy fabrication, wide frequency bandwidth and satisfactory radiation patterns [1, 2].

The UWB antennas studied in the open literature were mainly slot and monopole antennas. Printed wide slot antennas have an attractive property of providing a wide operating bandwidth, especially for those having a modified tuning stub, such as the fork-like stub [4]–[7], the rectangular stub [8], [9], and the circular stub [10] inside the wide slot. Broadband planar monopole antennas have received considerable attention owing to their attractive merits, such as ultra wide frequency band, good radiation properties, simple structure and the ease of fabrication.

The typical shapes of these antennas are half-disc [11], circle, ellipse [12], [13], and rectangle [14]. Despite the approval of the FCC for UWB to operate over 3.1 to 10.6 GHz, The antenna structure is simple and the aperture size is compact. Broad impedance bandwidth and stable radiation patterns are obtained, whereas the ground plane dimension is a bit large. In practice, when integrated with the system board of different ground plane size, the antenna might need a retuning for the optimized dimensions.

In [14] the authors propose a new ultra wide band antenna for UWB applications. The proposed antenna consists of a rectangular patch with two steps, a single slot on the patch, and a partial ground plane Compact size but the gain is not constant

This antenna yields an impedance bandwidth of 3.1–10.6 GHz with VSWR ≤ 2, The stable radiation patterns and constant gain are also obtained.

II. PROPOSED ANTENNA DESIGN

The antenna is Simulated on an h=1.5mm FR4 epoxy substrate with dielectric constant ε_r=4.4 and loss tangent (tan ∂=0.02). As shown in the Fig. 1, a rectangle radiator is fed by a 50 Ω CPW transmission line which is terminated with a subminiature A (SMA) connector for measurement purpose. Since both the antenna and the feeding are implemented on the same plane, only one layer of substrate with single-sided metallization is used, and the manufacturing of the antenna is very easy and extremely low cost. Both the radiating patch and the ground plane are bevelled, which results in a smooth transition from one resonant mode to another and ensures good impedance match over a broad frequency range.

The optimize dimensions of the antenna are:

Table 1: Proposed Antenna Dimensions

Dimension	Size
L	35mm
W	24mm
L_1	13.4mm
g	1.5mm
L_2	2mm
R	18mm
W_1	18mm

These parameters were found out mathematically. First of all Design of a 50Ω CPW line on a substrate with permittivity εr. Therefore the effective permittivity ie ε_{reff} using

$$\varepsilon_{eff} = \frac{\varepsilon_{r+1}}{2} \qquad 1$$

Ground plane plays a major role in determining the first and second resonances. The dimensions of the ground plane are calculated as follows:

$$L = (\ 0.8 \times \lambda_c\ ) \qquad 2$$

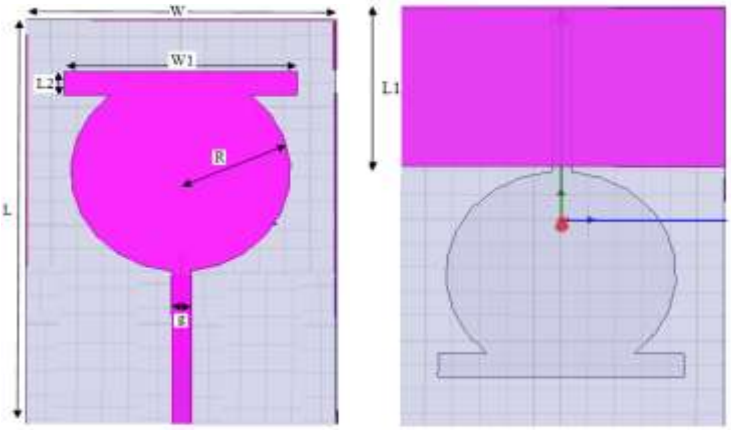
$$W = (0.55 \times \lambda_c\ ) \qquad 3$$

$$L1 = (0.3 \times \lambda_c\ ) \qquad 4$$

Where λc is the wavelength corresponding to centre frequency of the operating band. Sides of the Rectangle L2 and W1 are calculated using

$$L2 \leq \frac{120 \times h \times \pi}{Zo \times \varepsilon_r^{1/2}} \qquad 5$$

$$2R = W1 = (0.41 \times \lambda_c\ ) \qquad 6$$



(a) **(b)**

Fig. 1 Geometry and configuration of purpose antenna.

(a) Top view (b) Back view.

As shown in Fig. 1, a omega-shape radiating patch with radius of R is selected as the radiator and mounted vertically above a rectangular copper ground plane. *W* and *L1* denote the width and the length of the ground plane, respectively. A 50Ω coaxial probe connects to the bottom of the patch through the ground plane via an SMA connector. *h* is the height of the feed gap between the feed point and the ground. Fig 2 shows the fabricated antenna.

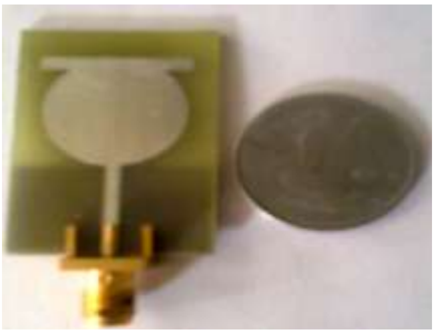


Fig. 2- Fabricated Antenna

III. RESULTS

The first parameter that we take in to account for our design is the VSWR of the antenna. The VSWR is a way of calculating how well two transmission lines are matched. The number for the VSWR ranges from one to infinity, with one meaning that the two transmission lines are perfectly matched. In regards to antenna design, a

VSWR that is as low as possible is desired because any reflections between the load and the antenna will reduce the effectiveness of the antenna.

Fig 3 shows the stimulated response of the return loss with frequency range 2.45- 11.7 GHz as the UWB applications.

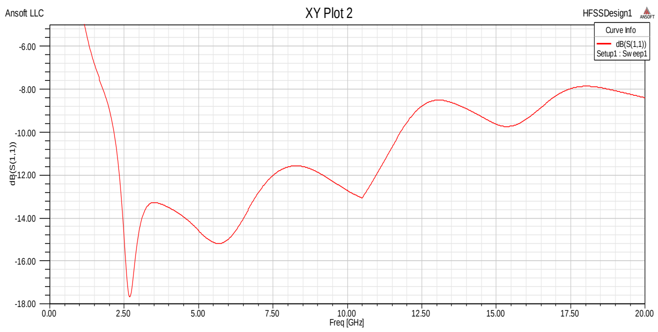


Fig. 3- Stimulated Return loss of antenna

Fig.3 presents the simulated gain for the proposed antenna. The antenna gain in the UWB band is about 3–6 dBi.

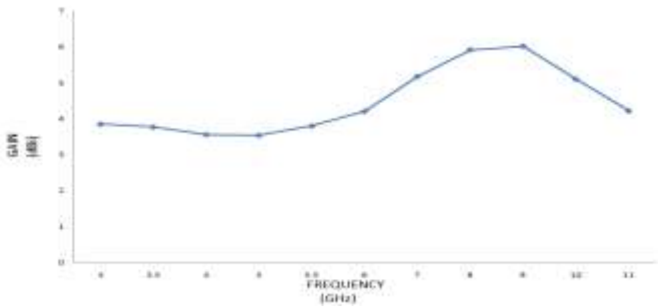
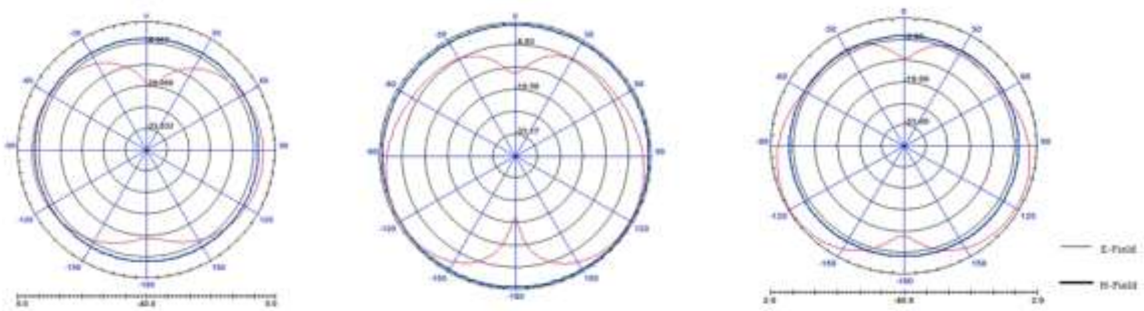


Fig. 4- Simulated Gain of Antenna

It is assumed that the antenna is receiving a signal in the direction of maximum gain. It is also common for the gain to be expressed in decibels and referenced to an isotropic source (G = 1), as shown.

The simulated radiation patterns of the antenna in E-plane (xz-plane) and H-plane (yz-plane) for three different frequencies 3, 8 and 10 GHz are shown in Figs. 5 (a-c). The patterns in the H-plane are quite omnidirectional as expected. In the E-plane, the radiation patterns remain roughly a dumbbell shape like a small dipole leading to bidirectional patterns.



(a) at 3GHz **(b) at 8 GHz** **(c) at 10 GHz**

Fig. 5- Simulated Radiation Patterns of Antenna for E-Field and H-Field at (a)3 GHz (b) 8 GHz (c)10 GHz

It has been seen that this antenna has the nearly Omni-directional radiation pattern like normal monopole antennas. However, the Omni-directional radiation properties have a little deterioration as frequency increases. Over the entire bandwidth, it's similar to a conventional wideband monopole antenna.

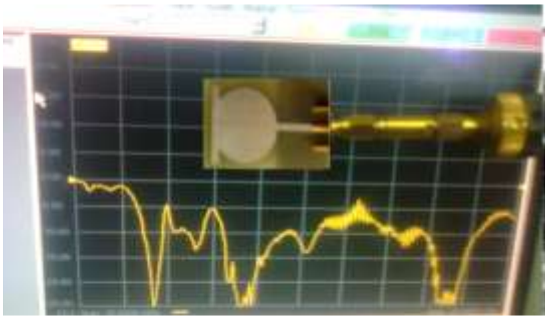


Fig. 6- Setup of Measurement on VNA

Vector network analyzer or VNA is a device which is used to measure both magnitude and phase of the response, from which all of the important other data formats can be mathematically calculated. VNA is used to measure the S –Parameters as S-parameters work by characterizing a network, in this case an antenna or RF system, through the use of matched loads instead of open and/or short circuit conditions. It is much simpler to characterize a resistive load across a wide range of frequencies than it is to accurately represent a true open or short circuit condition.

The comparison between measured and simulated result of S_{11} is done. In entire BW of UWB (3.1-10.6GHz) the measured result of S_{11} shows the perfect impedance matching except notch frequency band

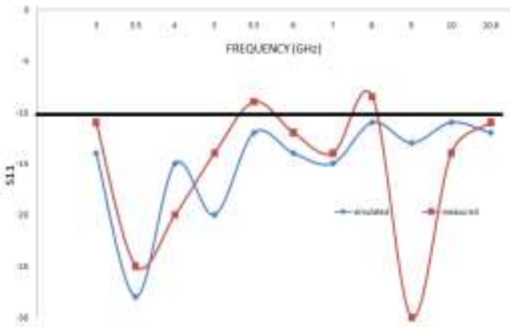


Fig. 7- Simulated and Measured Return Loss of Antenna with Optimal Dimensions

Fig. 7 shows the characteristics of the simulated and measured return loss of antenna. It is found that the input impedance of the antenna is well matched as the bandwidth covers the entire UWB band (3.1–10.6 GHz) and goes beyond the required 10.6 GHz with ($S11 \leq -10$dB).

IV. CONCLUSION

In wireless communications, ultra wideband has many advantages. This paper introduces the design of UWB antenna to minimize the potential interferences between the UWB system and the narrowband systems, a compact microstrip line-fed planar UWB antenna with omega – shape. It has been designed and analysed. And the results like VSWR, Return Loss, Stable radiation patterns and constant gain in the UWB band are obtained and discussed. The simulation results of the proposed antenna show a good agreement in term of the VSWR, antenna gain and radiation patterns. Accordingly, this antenna is expected to be a good candidate in various UWB systems.

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