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A Miniaturized Ultra Wideband (UWB) Antenna Design for Wireless Communications

Zuhura Juma Ali *

Institute of Antenna and Microwave Techniques, Tianjin University of Technology and Education,
Tianjin, China 300222

Abstract- This paper presents a miniaturized planar circular disc UWB antenna design for wireless communications. Printed on a dielectric substrate and fed by 50Ω microstrip line with truncated ground plane, the proposed antenna has been demonstrated to provide an ultra wide 10dB return loss bandwidth with satisfactory radiation properties. The special structure reduces the spatial volume and it is used to realize the miniaturization of the antenna. Ansoft High Frequency structure Simulator (HFSS) software tool has been employed for obtaining the simulation results. The return loss, voltage standing wave ratio (VSWR), radiation patterns and current distributions of the antenna are discussed.

Index Terms- Ultra wide band (UWB), miniaturization, planar antennas, microstrip line-fed.

I. Introduction

The development of radio frequency technology and ultra wide band (UWB) equipment, there has been considerable research effort put into UWB antenna. In recent years, monopole antennas are the focus of UWB antenna. Several broadband monopole configurations, such as circular, square, elliptical, pentagonal and hexagonal have been proposed so far [1-4]. However, they are not planar structures as the ground planes are perpendicular to the radiators.

A suitable UWB antenna should be capable of operating over an ultra wide bandwidth as allocated by the Federal Communications Commission. At the same time, reasonable efficiency and satisfactory radiation properties over the entire frequency range are also necessary. Another primary requirement of the UWB antenna is a good time domain performance, i.e., a good impulse response with minimal distortion [5].

In this paper, a miniaturized planar circular disc monopole antenna fed by microstrip line is proposed. The radiator, ground plane and the feeder equipment of the antenna are placed on the same plate. This reduces the spatial volume to great degree. The outline of this paper is as follows. Section II describes the previous work; the design of the proposed antenna is described in section III. Simulation results are presented in Section IV and the conclusions are summarized in Section V.

II. Previous Work

Qurratulain, Neela Chattoraj, design a tapered U slot UWB printed monopole microstrip antenna for wireless applications. To miniaturize the UWB antenna, tapering and ground plains are used. The UWB antenna is etched on $24x36mm^2$ FR4 epoxy substrate having relative permittivity of 4.4 and a substrate height of 1.6mm, by 20% reduced size, it has achieved impedance (S_{11}< -10dB) bandwidth over 3.4GHz to 14GHz [7].

Kasi, Ping, Chakrabarty, proposed the design of compact microstrip-fed patch antenna for UWB application. The design is etched on FR4 substrate with the overall size of 28mm x 29mm, dielectric constant of 3.38 and a thickness of 1.6mm. The size of the antenna is reduced by beveling the patch with rectangular slot and partial ground plane. It has achieved impedance (S_{11}< -10dB) bandwidth over 3.8GHz to 12GHz [8].

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III. THE PROPOSED ANTENNA DESIGN

Fig.1 illustrates the geometry and configuration of the proposed antenna, which is etched on the Taconic RF-30(tm) substrate with a thickness of 1.6mm and dielectric constant of 3. A 50Ω microstrip line fed on the same side of a dielectric substrate.

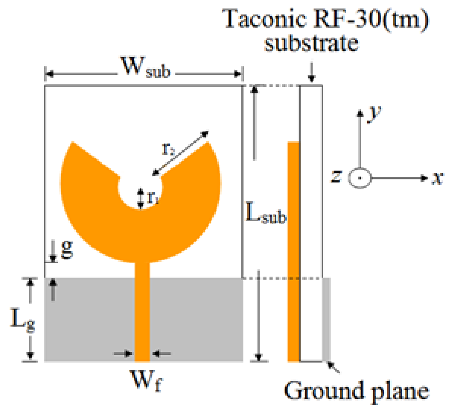


Fig.1 The geometry of the proposed antenna.

W_f is the width of the microstrip feed line that is fixed at 3mm in order to obtain 50Ω impedance. The circular patch is printed on the front surface of the substrate. W_{sub} and L_{sub} represent the width and length of the dielectric substrate, L_g represent the length of ground. The initial parameters of the circular patch before reducing its size are determined from the equations 1 and 2 reported in [2]. To reduce the overall size of the proposed antenna and obtain a good impedance matching over a broad bandwidth, the circular patch is notched. The optimized parameters are summarized in Table1.

$$f_L(GHz) = \frac{30 \times 0.24}{(l+r)\sqrt{\varepsilon_{reff}}} \quad (1)$$

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} \quad (2)$$

where,

f_L	=	the frequency corresponding to the lower edge of the bandwidth
l	=	the height of the cylindrical wire which is the same as that of planar configuration height
r	=	the equivalent radius of the cylindrical wire
ε_{reff}	=	effective relative permittivity of the substrate
ε_r	=	relative permittivity of the substrate

Table 1 The optimized parameters of the proposed antenna design

Dimension	**Length(mm)**
W_{sub}	50mm
L_{sub}	50mm
r_1	1.9mm
r_2	13.5mm
L_g	20.2mm
W_f	3mm
g	5.8mm

IV. SIMULATION RESULT AND DISCUSSION

A miniaturized UWB antenna was simulated using Ansoft High Frequency Structure Simulator (HFSS) software [6]. The simulated return loss (S_{11}) of the proposed antenna is shown in **Fig.2**. It is found that the -10dB return loss bandwidth of the antenna is approximately 6.3GHz (2.7GHz-9.0GHz) and the antenna shows stable behavior over the band. The simulated return loss shows that the antenna is capable of supporting multiple resonance modes, which are distributed across the spectrum. There are three resonance modes formed by the antenna. Their values are 3.2GHz, 6GHz and 8.1GHz respectively. Therefore, the overlapping of these resonance modes leads to the UWB characteristics. It was discovered that the VSWR of the optimized parameters of the proposed design is less than 2, this can be seen in **Fig.3**. According to **Fig.4**, The radiation patterns show omnidirectional characteristics at H-plane for 6GHz and 7.2GHz and changes in shape for 4.5GHz and 9.2GHz. It has been observed that a typical monopole like pattern in E-plane at 6GHz, but it is in distorted in shape at other frequencies. The simulated current distributions of the proposed antenna are shown in **Fig.5**. It has been observed that, the current is mainly concentrated around the edges of the patch, at the upper part of the ground plane and there is some less intense type of current concentration on the edge of the cutout. This is expected because the cutout edge represents a discontinuity for the surface currents on the patch.

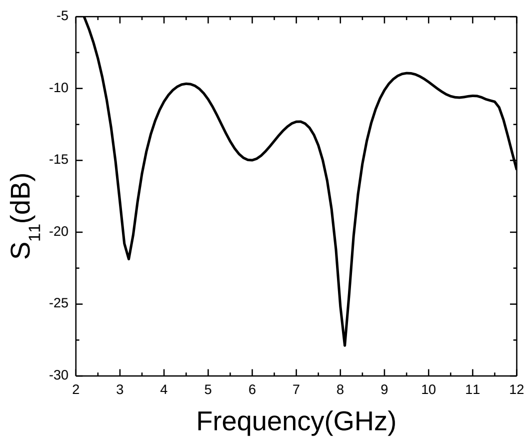


Fig.2 The simulated return loss of the proposed antenna

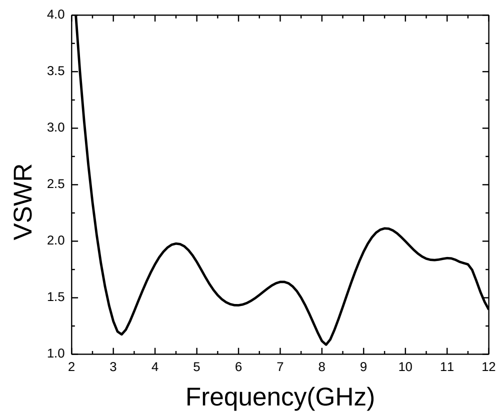
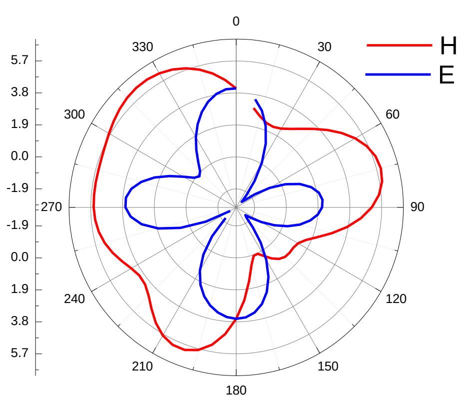
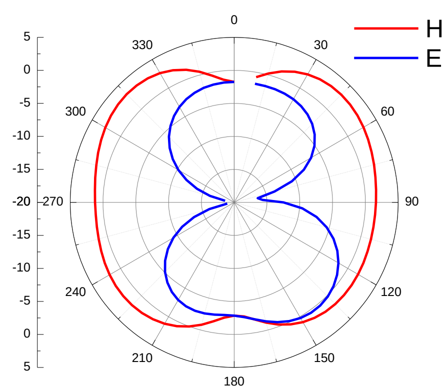


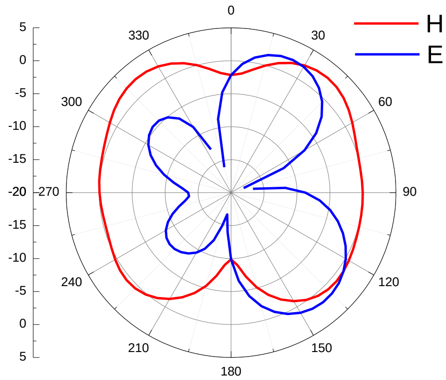
Fig.3 The simulated VSWR of the proposed antenna



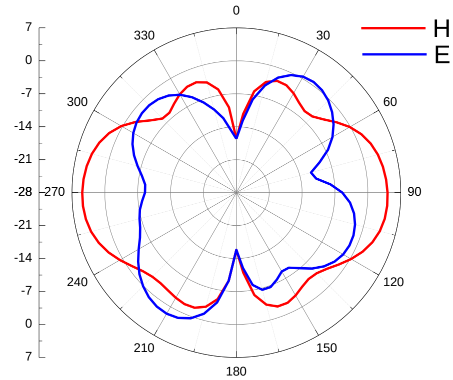
(a) at 4.5GHz



(b) at 6GHz

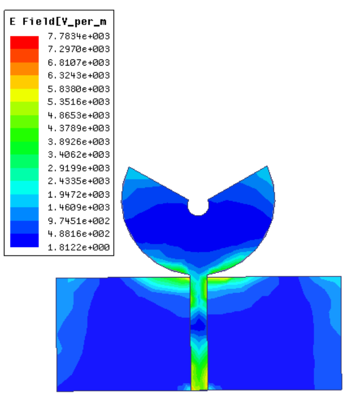


(c) at 7.2GHz

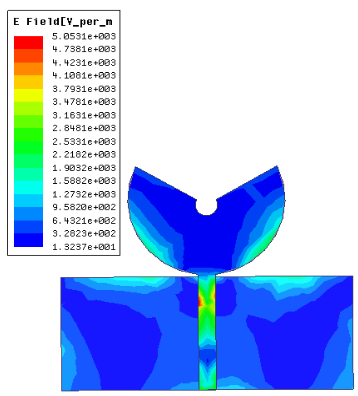


(d) at 9.2GHz

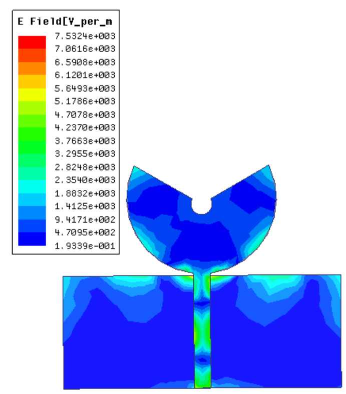
Fig.4 The simulated radiation patterns at E-plane and H-plane of the proposed antenna at (a) 4.5GHz, (b) 6GHz, (c) 7.2GHz and (d) 9.2GHz



(a) at 4.5GHz



(b) at 6GHz



(c) at 9.2GHz

Fig.5 The current distribution of the proposed antenna at (a) 4.5GHz, (b) 6GHz and (c) 9.2GHz

V. CONCLUSION

A miniaturized UWB circular disk antenna design is investigated in this paper. The operating bandwidth (S_{11} <-10dB) achieved was 6.3GHz (2.7GHz-9.0GHz). The proposed antenna is capable of supporting multiple resonance modes, at 3.2GHz, 6GHz and 8.1GHz which are distributed across the spectrum. The antenna exhibited near omnidirectional patterns at H-plane. As a result of notching the patch, the size of the antenna is reduced and has lighter weight, which is very desirable from miniaturization point of view. More degree of freedom in design and possibly less conductor losses are achieved. Due to its very wide bandwidth, the antenna can be considered as a potential candidate for UWB wireless communication applications.

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AUTHORS

First Author
Zuhura Juma Ali received her B.Sc degree in Electronics and Communication Engineering from Yildiz Technical University, Istanbul, Turkey in 2006. She worked as instructor at Karume Institute of Science and Technology, Zanzibar, Tanzania. She is now doing her M. Sc degree in Electronics Engineering from Tianjin University of Technology and Education, Tianjin, China. Her research areas of interest include microwave and wireless technology, antenna design and digital communication.
E-mail: zuhuratha@hotmail.com
Phone: +8615002271477