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A CASE STUDY

Circular antennaUWB microstrip line feeding planar modified

■ **LAXMAN PILLALAMARRI**

ABSTRACT

In this paper we have investigated compact printed semicircular disc monopole antenna, which is basically printed microstrip antenna with etched ground plane for UWB applications. In particular we have simulated very compact semicircular disc monopole antennas for UWB communication. Simple rectangular microstrip line is used for feeding the printed monopole antenna and its frequency bandwidth under -10dB return loss is ranging from 3GHz to 11.6 GHz. This compact printed monopole antenna works well for the whole UWB frequency band 3.1-10.6GHz.

KEY WORDS : UWB, Semicircular, Printed monopole antenna, Microstrip line

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INTRODUCTION

Ultra-wideband (UWB) commonly refers to signal or system that either has a large relative bandwidth (BW) or a large absolute bandwidth (Schantz, 2005; Aiello and Rogerson, 2003; Allen *et al.*, 2007 and Pozar, 2005). Such a large BW offers specific advantages with respect to signal robustness, information content and/ or implementation simplicity. But such systems have some fundamental differences from the conventional narrowband systems. The federal communications commission (FCC) has designated the 3.1 to 10.6 GHz band with effective isotropic radiated power (EIRP) below -40dbm/kHz for UWB communications. Some UWB antennas are much more complex than other existing single band, dual band and multi-band antennas (Pillalamarri and Kshetrimayum, 2007 and Kshetrimayum and Pillalamarri, 2009). Most of the UWB monopole antennas are investigated till today is non-planar as in (Pillalamarri and Kshetrimayum, 2007) and due to its protruded structure they cannot be integrated with integrated circuits and they are fragile. Few researchers have also studied printed monopole Antennas.

In this paper, we will investigate UWB antenna, which is basically a printed microstrip antenna with etched ground plane. First we will investigate in depth the semicircular disk printed monopole antenna for UWB applications. For getting compactness, we have etched the half of the part of circular patch without disturbing the bandwidth as well as antenna parameter. We have used conventional rectangular microstrip lines as feed lines for printed UWB antennas which are properly matched to the antenna impedance. In future we will also investigate other broadband matching techniques to further improve the UWB performance of the printed monopole antennas (Liang *et al*., 2004; Agrawall *et al.*, 1998; Hammoud *et al.*, 1993). CAD-FEKO simulation software has been employed for obtaining the simulation results.

Geometry of the UWB monopole antenna and the simulation results:

Very compact semi-circular UWB-monopole antenna :

This modified UWB monopole antenna is designed directly from the circular disc UWB-monopole antenna with some modifications in the patch shape as shown in Fig. 1(a). We have used the same FR4 substrate with 4.4 relative permittivity and 1.6 mm thickness. The real part of antenna impedance is exactly 50 Ω at 8.5GHz and 10.8 GHz when the imaginary part of antenna impedance cross zero. The final optimal dimensions of the UWB-monopole antenna are:

Dimensions of patch : Radius (r) = 12 mm and metal thickness = 0.035 mm, Dimensions of substrate: W1 = 34 mm and L1 = 50 mm, Dimensions of ground: W2 = 34 mm and L2 = 26 mm.

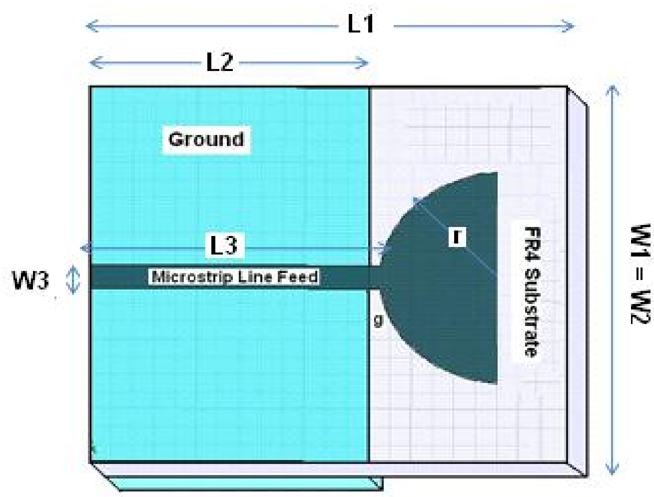

Fig. 1a: Geometry of circular UWB antenna

Microstrip line: W3=2.6mm and L3=27.5mm.where "g" is gap between the ground plane and patch.

After doing an extensive simulation study, we have fixed the dimensions of UWB monopole antenna and the value of "g" as 1mm. The antenna impedance, f_{low}, f_{high} and radiation efficiency are tabulated in Table 1. Note that proposed semicircular disc monopole antenna is more compact and high efficient antenna for UWB applications. It has maximum directivity at - 26^0 and -180^0 at 3 GHz and at the frequency 10.6 GHz, it has been tilted to 10^0 and -26.4^0 as frequency increases it is slightly titled with 5^0 to 10^0. The H-plane radiation pattern on the other hand is purely

Table 1 : Parameters of the circular disc UWB monopole antenna

g mm	F_{low} GHz	F_{high} GHz	Antenna impedance Ω	P_{acc} W	P_{rad} W	Max U W/Sr	Peak gain	η %
0.8	3.2	11.5	50	0.98	0.88	0.13	1.69	89.6
1	3	11.6	50	0.97	0.87	0.13	1.64	89.3

omni-directional pattern throughout the band of frequencies.

The simulated 3D radiation patterns of the proposed antenna at 3.1, 5, 8, 9, 10.6 and 11.2 GHz are shown in the Fig. 1 (g). The radiation pattern looks like a doughnut, similar to that of a dipole pattern, at the first resonant frequency *i.e.* 3GHz. At the second resonant frequency *i.e.* at 5GHz and the third resonance frequency *i.e.* at 8GHz the radiation pattern is somewhat like pinched doughnut (*i.e.* omni directional). As the frequency moves toward the upper end of the bandwidth the radiation pattern is some what slightly distorted as it reaches higher frequencies (*i.e.*10.6GHz

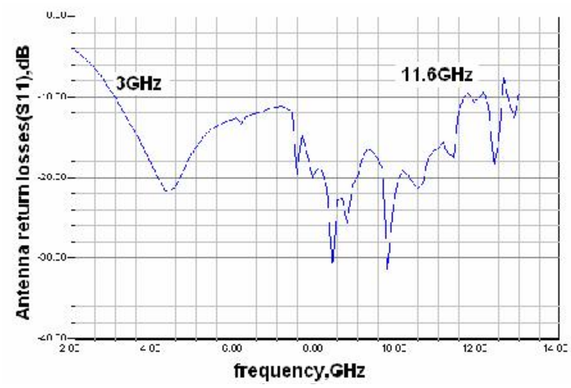

Fig. 1b: s_{11} **versus frequency plot (BW is from 2.3GHz to 13.2 GHz)**

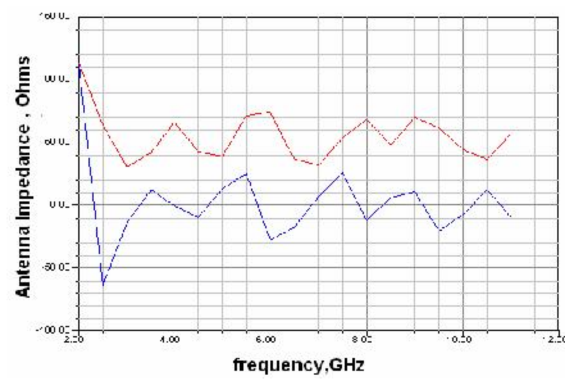

Fig. 1c: Antenna impedance versus frequency (real part → red colour and imaginary part → blue colour) of circular disc UWB monopole antenna

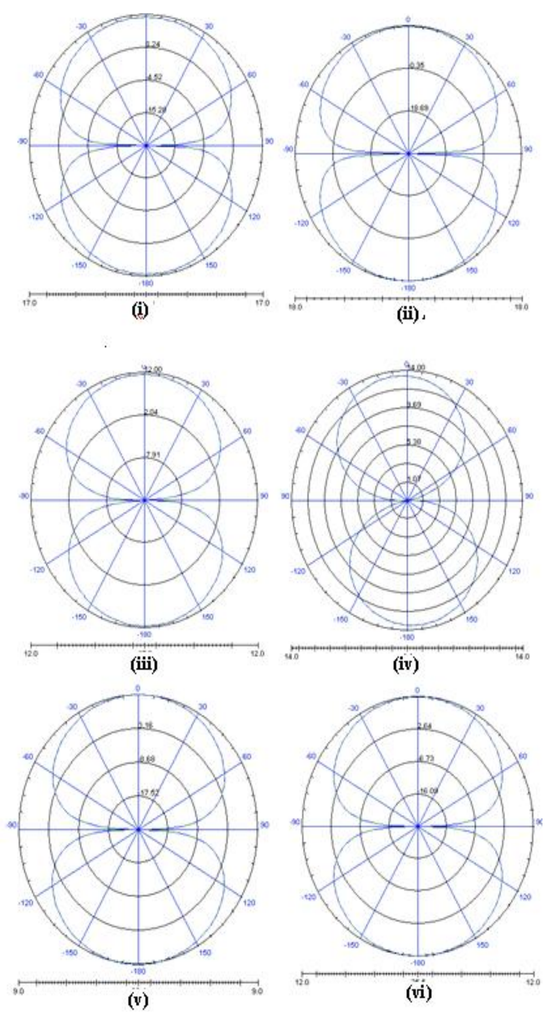

Fig. 1d: E-plane radiation patterns at (i) 3.1GHz, (ii) 5GHz, (iii) 8GHz, (iv) 9GHz, (v) 10.6 GHz and (vi) 11.2GHz

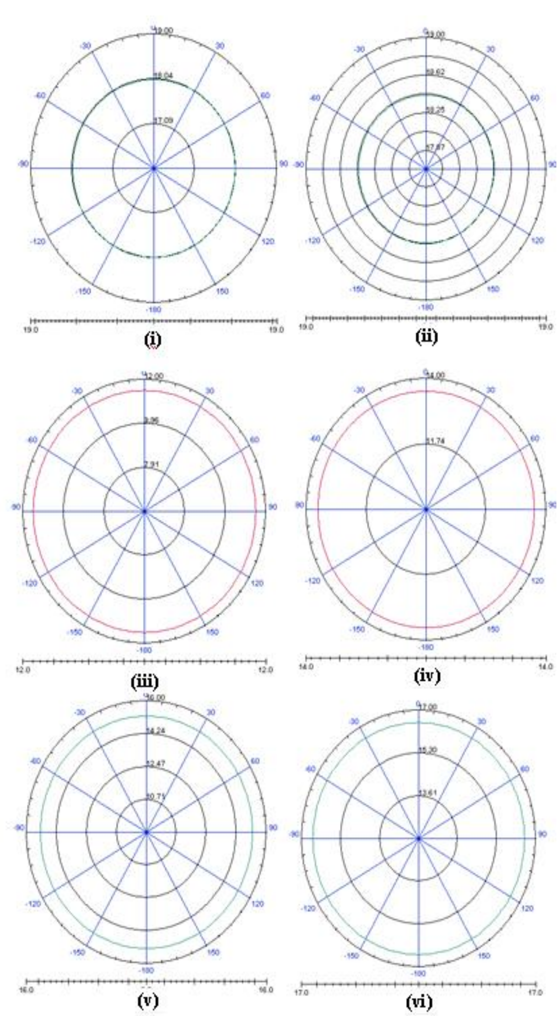

Fig. 1e: H-plane radiation patterns at (i) 3.1 GHz, (ii) 5 GHz, (iii) 8 GHz, (iv) 9GHz, (v) 10.6 GHz and (vi) 11.2GHz

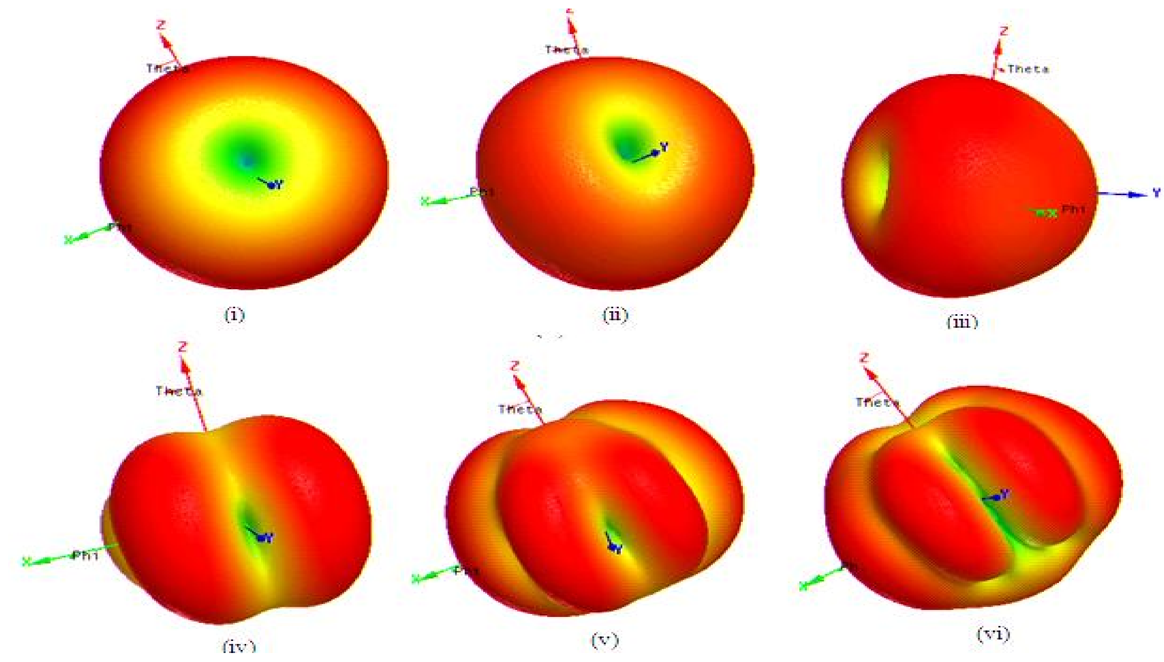

Fig. 1f: 3D Radiation plots at (i) 3.1 GHz, (ii) 5 GHz, (iii) 8 GHz, (iv) 9GHz, (v) 10.6 GHz and (vi) 11.2GHz

and 11.2 GHz.).

The transition of the radiation patterns from a simple doughnut at the lower frequencies to the slowly distorted radiation patterns at the higher resonances indicates that this antenna must have gone through major changes in its behaviour but it had omni directionality, this was possible because of the partial ground plane *i.e.* 'g' the gap between the ground plane and the patch which was a major factor for perfect impedance matching of the antenna, due to the proper impedance matching the antenna has very less reflections. As the impedance matching was good the radiation power and radiation intensity were very high.

Conclusion :

In this paper, we have investigated printed semicircular disc UWB monopole antenna with huge bandwidth, which is basically a printed microstrip antenna with the etched ground plane. Printed UWB monopole antennas are less fragile, planar and can be integrated with the integrated circuits unlike monopole antennas which have non-planar or protruded structures above the ground plane. In particular, we have simulated very compact UWB monopole antenna and it has higher efficiency. The E-plane radiation the printed monopole antenna is in the form of 8 shapes and it is slightly tilted at higher frequencies. The H-plane radiation pattern has omni-directional patterns throughout the frequencies of the BW. It has been observed that such monopole antennas are suitable for UWB operations.

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AUTHOR FOR CORRESPONDENCE

Laxman Pillalamarri

Department of Electronics and Communication Engineering, Radio Frequency and Microwave Laboratory, IIT, HYDERABAD (TELANAGANA) INDIA Email: laxmanpillalamarri85@gmail.com