Novel Printed Circular Disc Microstrip Line Fed Monopole Antennas for UWB Applications

Ramu PILLALAMARRI, G. SASI BHUSHANA RAO
and S SRINIVASA KUMAR

Abstract *- In this paper we have investigated printed Circular disc monopole antenna, which is basically printed microstrip antenna with etched ground plane for UWB applications. In particular we have simulated circular disc monopole antenna with etched ground plane. Simple rectangular microstrip line is used for feeding the printed monopole antenna and which is having impedance of 50 Ohms. This designed circular disc UWB monopole antenna works well for the whole UWB frequency band 3.1-10.6GHz.*

Key Words *- UWB, Microstrip, circular disc, printed monopole.*

1. INTRODUCTION

Ultra-Wideband (UWB) commonly refers to signal or system that either has a large relative bandwidth (BW) or a large absolute bandwidth [1]-[4]. 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 [5]-[6]. Most of the UWB monopole antennas are investigated till today is non-planar as in [2]-[4] 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 Circular disc UWB antenna, which is basically a printed microstrip antenna with etched ground plane [6]-[8]. First we will investigate in depth the circular disk printed monopole antenna with etched ground plane as shown Fig. 1(a) for UWB applications. We have used conventional rectangular microstrip lines as feed lines for printed UWB antennas which are properly matched to the antenna impedance [9]-[10]. And also we maintained some gap “g” between the circular patch and the ground plane in order to get proper impedance matching as well as huge bandwidth, simply saying that it was a one of the design parameter of proposed antenna in order to meet UWB applications. In future we will also investigate other broadband matching techniques to further improve the UWB performance of the printed monopole antenna.

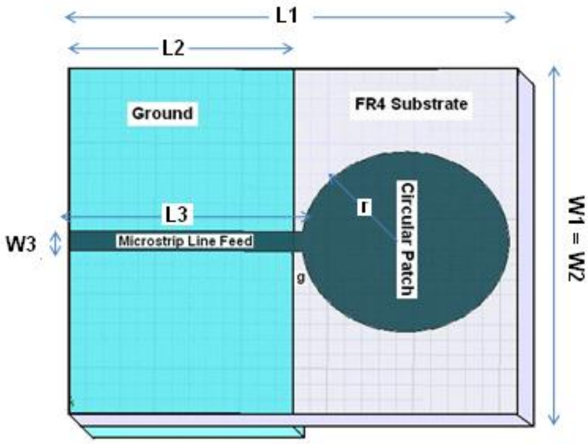

Fig. 1(a). Geometry of Circular UWB Antenna.

2. GEOMETRY OF PRINTED UWB MONOPOLE ANTENNAS AND SIMULATION RESULTS

2.1. Printed Circular disc UWB Monopole Antenna

The UWB antenna is designed on a substrate with 4.4 relative permittivity and 1.6 mm thickness and simple Microstrip line is used for feeding. Real part of antenna impedance is exactly 50 Ω at 3GHz, and 7.9GHz where the imaginary part of the antenna impedance equals zero as depicted in Fig. 1(c). Throughout the bandwidth of the UWB antenna, the

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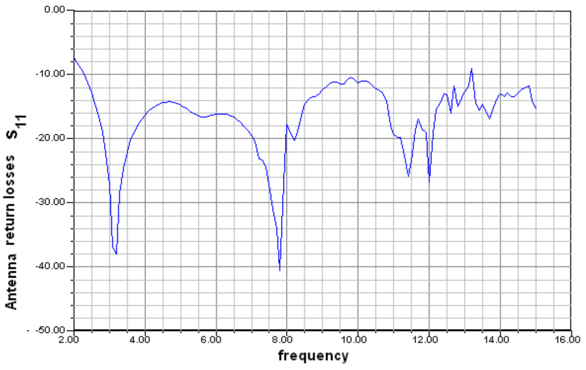

Fig. 1(b). s_{11} versus frequency plot (BW is from 2.3GHz to 13.2 GHz).

real part of the antenna impedance varies from 25 Ω to 90 Ω whereas the imaginary part of the antenna impedance is in the range -32 Ω to +30 Ω that is not a major variation of the antenna impedance. The final dimensions of the UWB antenna after doing an extensive simulation study are:

Dimensions of Circular Patch:

Radius (r) = 12 mm and metal thickness= 0.035mm.

Dimensions of Substrate: W1 = 46 mm and L1 =52 mm

Dimensions of Ground: W2 = 46 mm and L2 =26mm.

Microstrip line: W3=2.6mm and L3=27.5mm.

"g" is gap between the ground plane and patch.

For different values of g, the antenna impedance, bandwidth (f_{low} is the lower start frequency of the antenna BW, f_{high} is the higher end frequency of the antenna BW and antenna BW is considered for those frequency range where the s_{11} is below -10dB) and radiation efficiency are tabulated. Here the gap (g) between the circular patch and the ground plane below is the most crucial parameter for getting a broad BW. The other two are proper impedance matching in order to get the antenna impedance equal to 50 Ω and maximize the antenna radiation efficiency.

TABLE I.

g mm	F_{low} GHz	F_{high} GHz	Antenna Impedance Ω	P_{acc} W	P_{rad} W	Max U W/Sr	Peak Gain	η %
1	2.3	13.2	50	0.97	0.87	0.14	1.86	88.0

As we can see from Table I, the 'g' value is fixed at 1mm. The value of 'g' is very crucial for 50Ω impedance matching. The width of the ground plane also is an important factor in the antenna impedance and consequently the frequency BW. Wider ground plane means longer input microstrip line and higher inductance and it affects the antenna fundamental resonant frequency and harmonic frequencies. Note the UWB performance of the monopole antenna is due to such closely resonating fundamental and harmonic frequencies. The first resonant frequency of the monopole antenna is determined by the diameter of the circular disc.

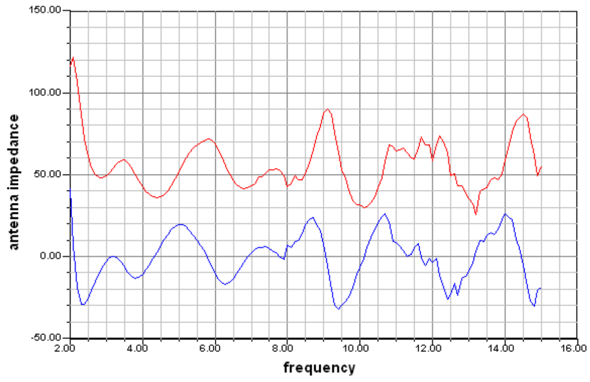

Fig. 1(c). Antenna impedance versus frequency (real part → red color and imaginary part → blue color) of circular disc UWB monopole Antenna.

The E-plane and H-plane radiation patterns of the circular disc UWB monopole antenna at 3, 5, 7.5, 10.6and 12 GHz are shown in Fig. 1(d) and 1(e). It can be observed that the E-plane radiation pattern is in the shape of 8 at 3GHz and it is in 8 shapes at the higher frequencies. It has maximum directivity at - 18^0 and -180^0 at 3 GHz and at the frequency 10.6 GHz, it has been tilted to 10^0 and -19^0, as frequency increases it is slightly titled with 5^0 to 10^0. The H-plane radiation pattern on the other hand is purely omni-directional pattern throughout ultra wideband.

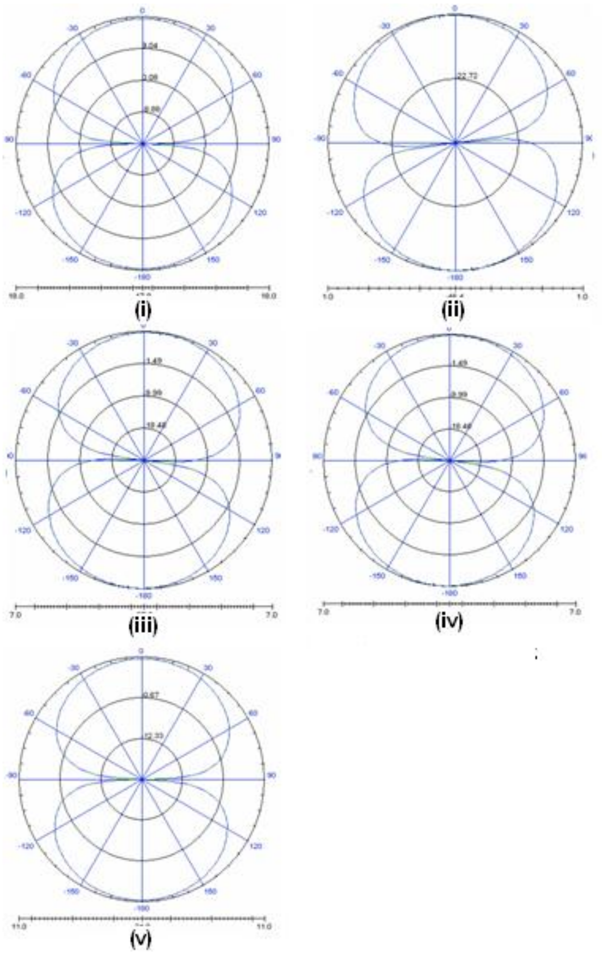

Fig. 1(d). E-plane radiation patterns at **(i)** 3 GHz, **(ii)** 5GHz, **(iii)** 7.5GHz , **(iv)** 10.6 GHz, **(v)** 12GHz.

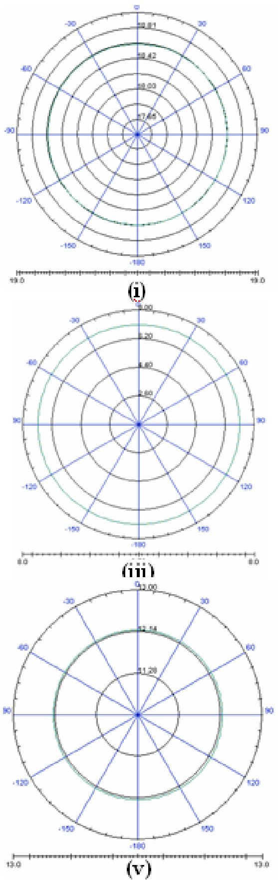

Fig. 1(e). H-plane radiation patterns at **(i)** 3GHz, **(ii)** 5GHz, **(iii)** 7.5GHz, **(iv)** 10.6 GHz, **(v)** 12GHz.

The simulated 3D radiation patterns of the proposed antenna at 3, 5, 7.5, 10.6 and 12 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 and 12 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 behavior 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.

The simulated current distribution patterns of the UWB antenna at different resonances are depicted in the Fig.1(g). It can be observed from the figure that the current distribution at 3GHz is indicating a first order harmonic, at 5GHz its indicating second harmonic. As

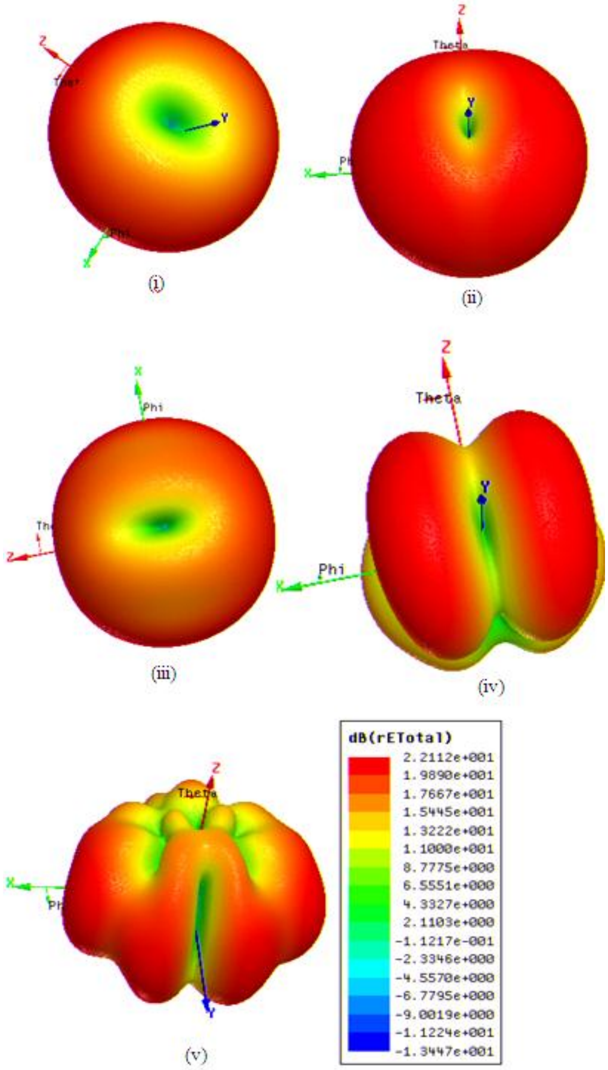

Fig. 1(f). 3D Radiation Plots at **(i)** 3GHz, **(ii)** 5GHz, **(iii)** 7.5GHz, **(iv)** 10.6 GHz, **(v)** 12GHz.

frequency increases the current distribution becomes more complicated indicating to a third order harmonic at 10.6GHz and fourth order harmonic at 12GHz.

At the first resonance the current is oscillating and having a pure standing wave pattern along most part of the edges of the patch. So the patch acts as oscillating monopole, but the variation of current becomes more complicated at higher frequencies. The antenna operates in a hybrid mode of traveling waves and standing waves at higher frequencies, but the ground plane on the other side of the substrate cannot form good slot with the patch to support traveling waves. Therefore the impedance matching becomes worse for the traveling wave dependent modes at higher frequencies.

3. CONCLUSION

In this paper, we have investigated printed Circular disc UWB monopole antenna, which is basically a printed microstrip antenna with the etched ground plane. Printed UWB monopole antennas are less

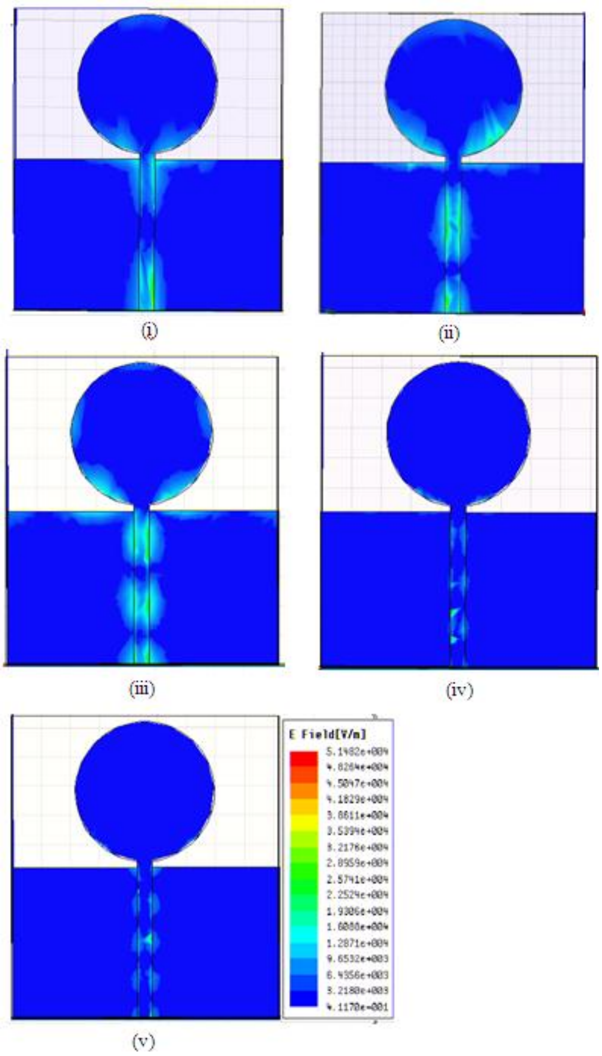

Fig. 1(g). Current distribution plots at **(i)** 3GHz, **(ii)** 5GHz, **(iii)** 7.5GHz, **(iv)** 10.6 GHz, **(v)** 12GHz.

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 compact UWB monopole antenna namely circular disk printed monopole antenna. The proposed antenna is compact and has higher efficiency as well as huge BW than present existed UWB frequency regulations. The E-plane radiation patterns of the monopole antenna are 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 from the CAD-FEKO simulation results.

4. ACKNOWLEDGMENTS

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Ramu PILLALAMARRI
Prof. S. SRINIVASA KUMAR
Radio Frequency and Microwave Laboratory
Dept. of Electronics and Communication Engineering
Jawaharlal Nehru Technological University Kakinada
Andhra Pradesh, India
E-mail: ramu06410230@gmail.com

Prof. G. SASI BHUSHANA RAO
Andhra University
Visakhapatnam-530003
E-mail: sasi_gps@yahoo.com

Mr. Ramu Pillalamarri received his B.Tech. degree in Electronics and Communication Engineering from Adam’s Engineering college, affiliated to Jawaharlal Nehru Technological University, Hyderabad in 2005. He did his M.Tech. degree in the specialization of Digital Signal Processing under the department of Electronics and Communication Engineering from Indian Institute of Technology, Guwahati, India in 2008.
Since 2008 he is a Research scholar and pursing PhD degree in the field of “UWB communication and Systems” under the department of Electronics and Communication Engineering from Jawaharlal Nehru Technological University, Kakinada, India. He has strong knowledge in field of RF and Microwave Antenna Design for Wireless

Communication Environment and His research interests include the design of Broadband, Multiband and UWB Antennas for wireless and mobile communication.

Prof. (Dr.) G. Sasi Bhushana Rao is presently working as **Professor** in the Department of Electronics & Communication Engineering, Andhra University Engineering College, Visakhapatnam. He has 22 years of experience in R&D, Industrial and Teaching. He published **125 research papers** in various reputed International/National Journal/Conferences including IEEE AES journal. He received "**Best Researcher Award**" and **Dr. Survepalli Radhakrishnan Award for Best Academician** during 75th Convocation Platinum Jubilee Celebrations-2008 of Andhra University held on 16th January 2008 and 5th Sept. 2008 respectively. He is a reviewer for IEEE AES proceedings, IEEE Communication Letters, GNSS, IETE, Indian Academy of Sciences Journals etc.,. He is a Senior Member of IEEE, Fellow of IETE, Member of IEEE Com Society, IGU and Member of International Global Navigation Satellite System (IGNSS), Australia. Also, he is a Member of International Civil Aviation Organization (ICAO) GNSS WG Panel for drafting the SARPS for Ionospheric effects on GNSS Signal. His area of research includes INS, GNSS Signal Processing, Ionospheric modeling, RADAR and SONAR signal modeling. Presently, he is handling three Govt. of India research projects from DRDO, CSIR, UGC and MHRD.

Prof. S. Srinivas Kumar is currently Professor in ECE Department, JNTU College of Engineering, Kakinada, AP, India. He received his M.Tech from Jawaharlal Nehru Technological University, Hyderabad, India. He received his Ph.D. from E&ECE Department, IIT, Kharagpur. He has twenty years experience of teaching undergraduate and post-graduate students and guided number of post-graduate theses. He has published 14 research papers in National and International journals. Presently he is guiding five Ph. D students in the area of Image processing. His research interests are in the areas of digital image processing, computer vision, and application of artificial neural networks and fuzzy logic to engineering problems.