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A Compact Printed Monopole Single Notch Ultra-Wideband Antenna

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Abstract: A simple, low cost and compact printed planer monopole Ultra-WideBand (UWB) antenna with single band notch characteristics is proposed. The antenna consists a semi-circular radiating patch, a modified ground plane and has a small size of 52.25×42×1.57 mm^3 designed on a Rogers RT/Duroid 5870 substrate. A circular slot has introduced in the semicircular patch for achieving the stop band at 4 GHz C band frequency range. The antenna operates from 1.5-15 GHz with a single frequency band-stop performance of 3.58-4.92 GHz. The proposed antenna is successfully simulated, prototyped and measured. Fairly good agreements between the simulations and measurements have been achieved.

Key words: Low, semi-circular, band, range, antenna

INTRODUCTION

In order to cover more wireless communication services, there is an increasing demand for antennas capable of operating at an extremely wider frequency band like Ultra-WideBand (UWB). UWB communication technology has been regarded as one of the most promising technologies in the wireless world because of their attractive features, including high speed data rate, extremely low spectral power density, precision, high precision ranging, low complexity and low cost, robustness to multi-path fading and very low interference, since the Federal Communications Commission (FCC) has allocated 7.5 GHz of the spectrum from 3.1 GHz to 10.6 GHz for UWB radio applications from February 2002 (FCC, 2002). UWB also have wide applications in short range and high speed wireless systems, such as ground penetrating radars, medical imaging system, high data rate Wireless Local Area Networks (WLAN), communication systems for military and short pulse radars for automotive even or robotics (Allen *et al*., 2006; Islam *et al*., 2015a, b; Klemm *et al*., 2008).

Different methods have already been proposed to design UWB antennas with band-notch characteristics. These include embedment of different types of slots on the radiating patch or on the ground plane, use of parasitic elements/patches, etchingof split-ring resonators, use of tuning stubs, meandering of ground plane, use of folded strips, use of resonated cells on the coplanar waveguide, embedment of strip lines and use of electromagnetic band-gap structure (Azim *et al*., 2013a, b, 2011; Dorostkar *et al*., 2013; Wang *et al*., 2012; Liu *et al*., 2010; Islam *et al*., 2015c). For example, a compact slot antenna is proposed (Azim *et al*., 2013a, b) for UWB applications. To filter out the WiMAX band, an angle-shaped parasitic slit is asymmetrically etched out along with the tuning stub, while two symmetrical parasitic slits are placed inside the tapered slot to create another notch band for WLAN. The proposed antenna can achieve UWB band with dual notched bands of 3.35-3.8 and 5.12-5.84 GHz. A compact planar slot antenna with a notched band at 5.5 GHz is proposed (Azim *et al*., 2013a, b) for UWB applications. Two symmetrical parasitic slits are etched in the slot of the ground plane to create the desired notch band. By adjusting the size and position of the strips the proposed antenna achieved an ultra-wide operating band with a notched band of 5.1-5.81 GHz. The antenna exhibits symmetric radiation characteristics with good gain, except at the notched band. A super wide band fractal antenna based on circular-hexagonal geometry with an electrical dimension $0{:}33\lambda\times0{:}23\lambda\times0{:}18\lambda$ is proposed (Dorostkar *et al*., 2013). The iterations of a hexagonal slot inside a circular metallic patch with a transmission line helps to achieve super wide impedance bandwidth. By inserting an Archimedean spiral slot into themicrostrip-slot-line transition, the antenna with an overall dimensionof 50×50 mm achieved UWB performance with a notched band of 4.6-6.2 GHz. In

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(Wang *et al*., 2012), a printed UWB antenna was prototyped on a 32×28 mm^2 FR4 dielectric substrate. The dual notched bands centered at 3.5 and 5.5 GHz were achieved by putting two C-shaped slots and a U-shaped slot into the patch. In (Liu *et al*., 2010), a planar monopole antenna with standard band-notched characteristics was proposed. A coupling strip was placed at the center of the slot patch to generate a notch frequency band of 5.12-6.08 GHz. A technique to enhance the bandwidth of a microstrip-fed planar monopole antenna has been proposed (Azim *et al*., 2011). The monopole antenna fed by a 50Ùmicrostrip feed line is fabricated on the FR4 substrate. To improve the bandwidth, the top side of the partial ground plane has been modified to form a saw-tooth shape and by this modification it is found that, the bandwidth is enhanced by 43.6% compared the initial design. The proposed antenna is easy to be integrated with microwave circuitry for low manufacturing cost.

In this study a novel compact printed microstrip-fed UWB monopole antenna with single band notched characteristics is designed. The proposed antenna operates in the frequency range 1.5-15 GHz bandwidth with rejecting the spectrum of C-band (3.48-4.92 GHz). To achieve these properties a circular slot with radius r_2 is etched out. The simulations were carried out using HFSS and CST simulator and comparison between simulated and experimental results are presented.

MATERIALS AND METHODS

The proposed UWB monopole single notch antenna geometry layout is shown in Fig. 1. The proposed antenna consists of a partial circle radiating patch in top surfaces of the substrate and a trapezoid shape ground plane on the bottom side of the substrate. The size of the antenna is 52.25×42 mm^2. The antenna is designed on Rogers RT/Duroid 5870 substrate with dielectric constant of 2.33, loss tangent of 0.0012 and a thickness of 1.575 mm. The monopole partial circle with maximum radius r_1 and width e from the centre is fed by a tapered microstrip feeding line in the middle of the ground plane. The band notch characteristics are achieved by incorporating a circular slot with radius r_2 from the main radiating circular patch. The band notch characteristics are controlled by changing the size of circle and the ground plane is a part of the impedance matching network. The top rounded corner of the proposed trapezoid ground plane minimizes the sensitivity to fabrication tolerances and help to

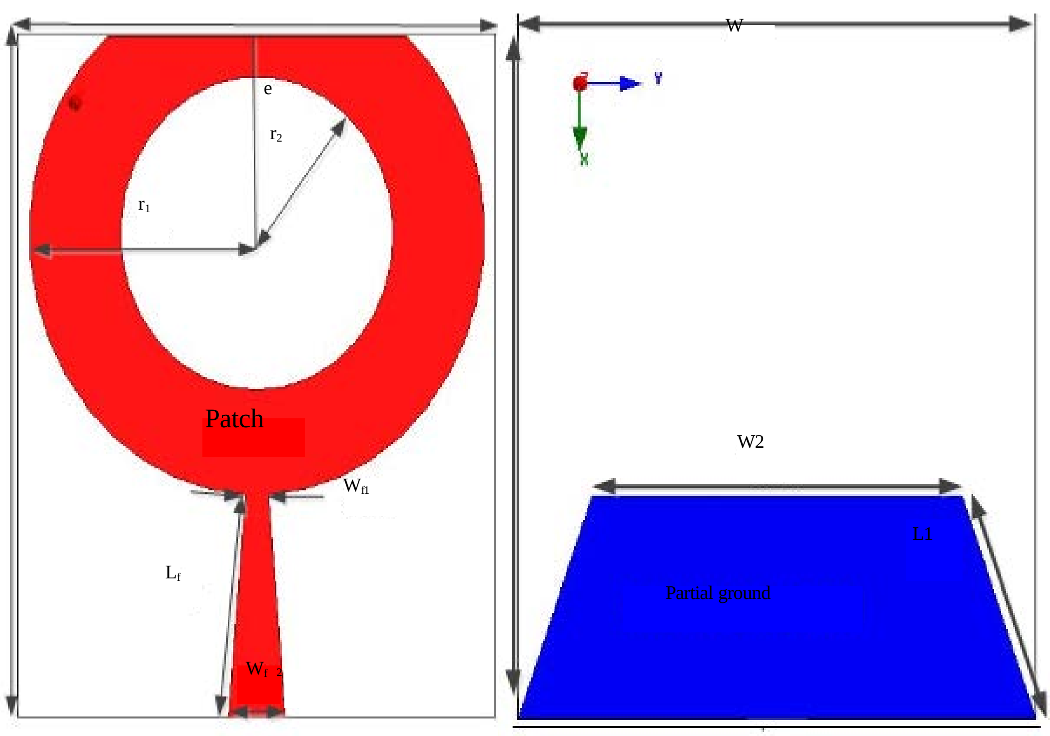

Fig. 1: The proposed antenna: a) Top layer; b) Bottom layer (dimensions are in mm)

Table 1: Optimized dimension of the proposed antenna

Parameter	Value (mm)	Parameter	Value (mm)	Parameter	Value (mm)
W	42.00	W_2	30.00	r_1	20.000
W_{f1}	1.97	L	52.25	r_2	12.000
W_{f2}	5.00	L_1	17.56	e	15.250
$W_1 = W$	42.00	l_f	17.09	h	1.575

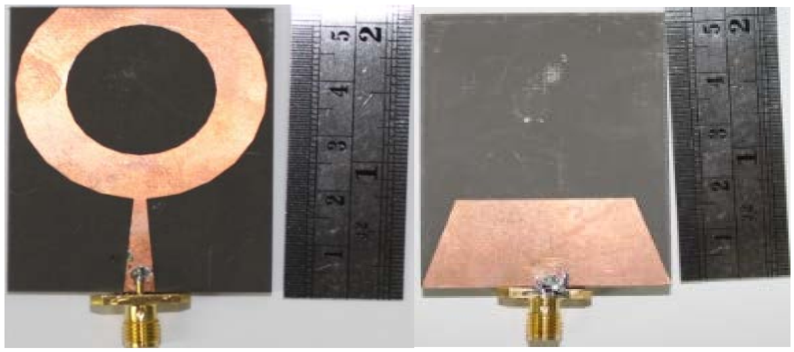

Fig. 2: Photographs of the fabricated UWB band notched antenna: a) Top layer; b) Bottom layer

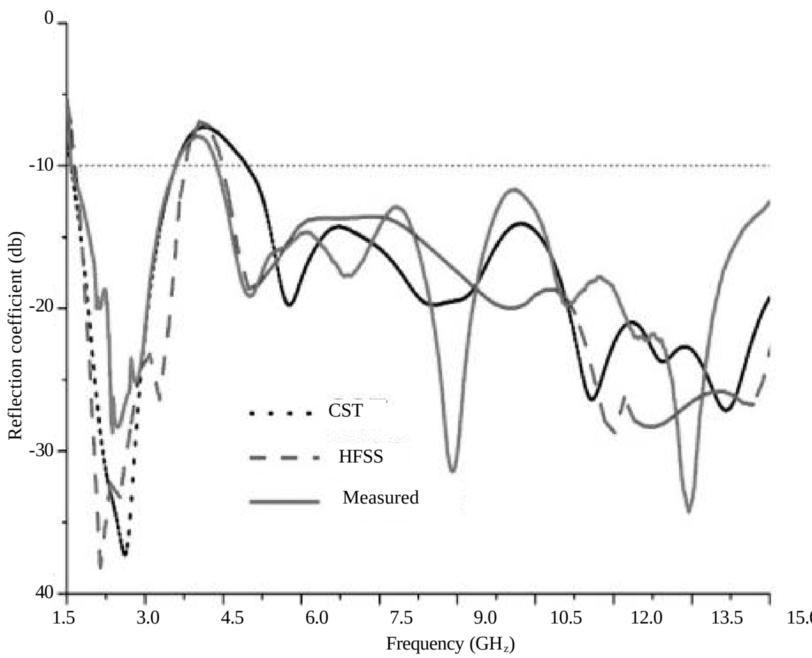

Fig. 3: Simulated and measured reflection coefficient of the proposed antenna

RESULTS AND DISCUSSION

The performance of the proposed antenna has been analysed and optimized using the finite element method based high frequency 3D full-wave electromagnetic simulator Ansoft's HFSS and efficient computational 3D simulation software CST for electromagnetic designand analysis. Simulation results are plotted using scientific graphing and data analysis software Origin Pro. The photograph of the proposed antenna prototypeis shown in Fig. 2. The measured results were obtained using the Agilent E8362C vector network analyzer and Satimo near field anechoic chamber. Figure 3 illustrates the simulated and experimental reflection coefficient against frequency of the antenna. The measured results show a slight shift in the notch band which may be due to the tolerances at the feed point during the fabrication process. The simulated result show that the proposed antenna covers

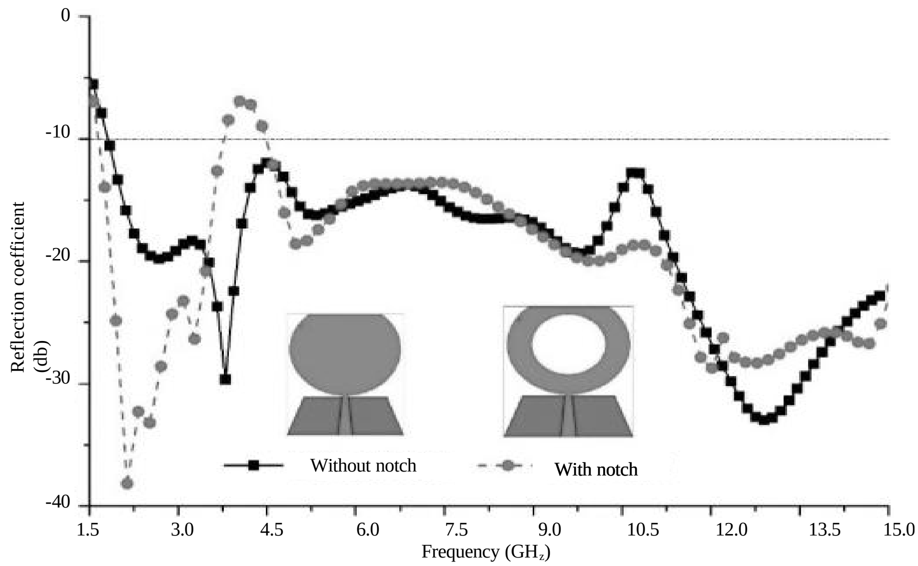

Fig. 4: Comparative graph of the proposed antenna with and without notch

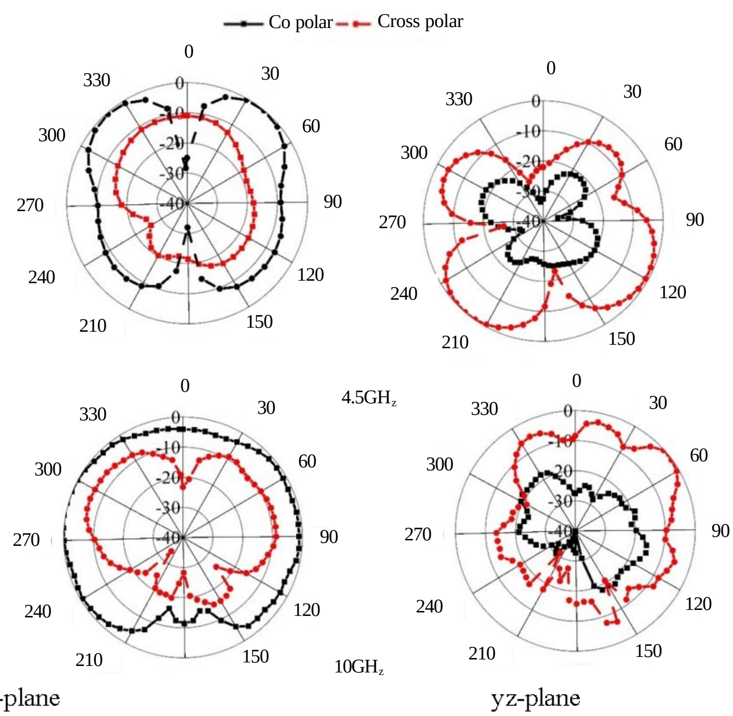

Fig. 5: Measured radiation pattern at different frequencies cross-polarization and co-polarization

the frequency range from 1.5-15 GHz and giving the notch characteristics in the frequency range 3.81-4.51 GHz in HFSS and in CST, it reject 3.58-4.92 GHz. In measurement value, it notched the 3.58-4.38 GHz C band. The comparative graph of the proposed antenna with and without notch is shown in Fig. 4. Practical requirements of notched frequency bands can easily be achieved and controlled by adjusting the sizes and locations of the resonating elements.The measured radiation pattern, including the cross-polarization and co-polarization of the fabricated antenna at frequencies 4.5 and 10 GHz in two principle planes yz-(E) and xz-(H) planes are shown in Fig. 5. It can be seen that the radiation patterns of proposed antenna in xz plane (H plane) exhibits nearly

Table 2: Comparison of proposed antenna with some existing antenna in the literature

Band-notch antennas	Dimensions (mm^2)	Band width (Ghz)	Notched band (Ghz)
Dual band-notch UWB slot antenna Azim *et al.* (2013a, b)	22×24	3.04-10.88	3.5-3.95
Tapered slot antenna Liu *et al.* (2010)	50×50	2.4-11.2	4.6-6.2
Compact monopole antenna Islam *et al.* (2015c)	35×30	3.05-11.15	5.12-6.08
Proposed	52×42	1.5-15	3.58-4.92

omnidirectional for two frequencies. The performance of the proposed antenna is compared with the existing antennas in the literature in terms of size and notch-band characteristics presented in Table 2.

CONCLUSION

In this study, a compact printed monopole antenna with single notch characteristics has been proposed for UWB applications. The band notch characteristic is obtained by incorporating a circular slot on the circular disk. The fabrication antenna has frequency band 1.5-15 GHz with rejection band around 3.58-4.92 GHz. Current distribution and radiation pattern are also presented in this research. The proposed antenna has a good simple configuration, smaller in size and good operation characteristics. Experimental results show that the proposed antenna could be good candidate for various UWB applications.

REFERENCES

Allen, B., M. Dohler, E. Okon, W. Malik, A. Brown and D. Edwards, 2006. Ultra Wideband Antennas and Propagation for Communications, Radar and Imaging. John Wiley and Sons, New York, ISBN: 9780470056820, Pages: 508.

Azim, R., A.T. Mobashsher and M.T. Islam, 2013a. UWB antenna with notched band at 5.5 GHz. Electr. Lett., 49: 922-924.

Azim, R., M.T. Islam and A.T. Mobashsher, 2013b. Design of a dual band-notch UWB slot antenna by means of simple parasitic slits. IEEE Antennas Wireless Propagation Lett., 12: 1412-1415.

Azim, R., M.T. Islam and N. Misran, 2011. Design of a planar UWB antenna with new band enhancement technique. Applied Comput. Electr. Soc. J., 26: 856-862.

Dorostkar, M.A., M.T. Islam and R. Azim, 2013. Design of a novel super wide band circular-hexagonal fractal antenna. Progr. Electr. Res., 139: 229-245.

FCC., 2002. Revision of part 15 of the commission's rules regarding ultra-wideband transmission systems. First Report and Order FCC 02, V48, Federal Communications Commission (FCC), April 2002.

Islam, M.M., M.T. Islam, M. Samsuzzaman and M.R.I. Faruque, 2015a. A negative index metamaterial antenna for UWB microwave imaging applications. Microwave Optical Technol. Lett., 57: 1352-1361.

Islam, M.M., M.T. Islam, M. Samsuzzaman and M.R.I. Faruque, 2015b. Five band-notched ultrawide band (UWB) antenna loaded with C-shaped slots. Microwave Optical Technol. Lett., 57: 1470-1475.

Islam, M.M., M.T. Islam, M. Samsuzzaman, M.R.I. Faruque and N. Misran, 2015c. Microstrip line-fed fractal antenna with a high fidelity factor for UWB imaging applications. Microwave Optical Technol. Lett., 57: 2580-2585.

Klemm, M., I.J. Craddock, A. Preece, J. Leendertz and R. Benjamin, 2008. Evaluation of a hemi-spherical wideband antenna array for breast cancer imaging. Radio Sci., Vol. 43. 10.1029/2007RS003807

Liu, H.W., C.H. Ku, T.S. Wang and C.F. Yang, 2010. Compact monopole antenna with band-notched characteristic for UWB applications. IEEE Antennas Wireless Propagation Lett., 9: 397-400.

Wang, C., Z.H. Yan, B. Li and P. Xu, 2012. A dual band-notched UWB printed antenna with C-shaped and U-shaped slots. Microwave Optical Technol. Lett., 54: 1450-1452.