International Journal of
Innovative Research

International Journal of Innovative Research 1(1):19–23, 2016
ISSN: xxxx-xxxx (online)
www.irsbd.org

RESEARCH PAPER

A compact single notch printed antenna for UWB applications

Md. Zulfiker Mahmud[1], Mohammad Tariqul Islam[1], Md. Samsuzzaman[2*]

[1]Department of Electrical Electronic and Systems Engineering, Universiti Kebangsaan Malaysia, Malaysia.
[2]Dept. of Computer and Communication Engineering, Patuakhali Science and Technology University, Dumki, Patuakhali, Bangladesh

ARTICLE HISTORY

Received: June 1**6**, 2016
Revised : July **20**, 2016
Accepted: July 28, 2016
Published: August 31, 2016

*Corresponding author:
sobuz@pstu.ac.bd

ABSTRACT

A simple, low cost and compact printed planer monopole ultra-wideband (UWB) antenna with single band notch characteristics is proposed. The antenna consists of 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 been introduced in the semicircular patch for achieving the stop band at 4 GHz C band frequency range. The antenna operates from 1.5 to 15 GHz with a single frequency band-stop performance of 3.58 – 4.92 GHz. The proposed antenna are successfully simulated, prototyped and measured, and fairly good agreements between the simulations and measurements have been achieved.

Key words: Single notch antenna, optimized dimension, ultra-wideband.

Introduction

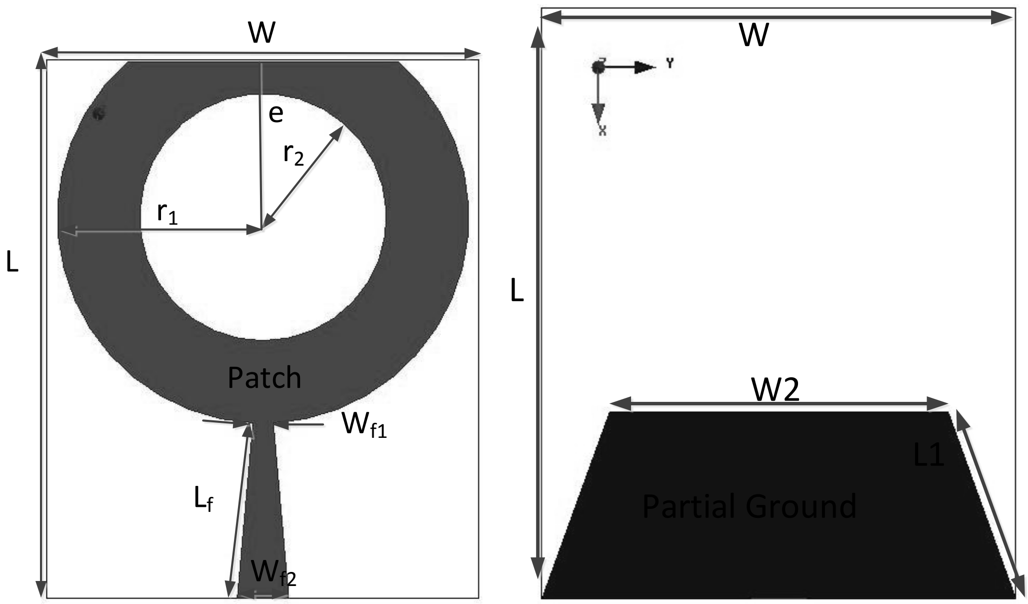
In order to cover more wireless communication services, there is an increasing demand for antennas capable of operating at an extremely wider frequency band like Ultra-wideband (UWB). UWB communication technology has been regarded as one of the most promising technologies in the wireless world because 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 has 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 or even robotics (Allen et al., 2006; Fear & Stuchly, 2000; Jafari et al., 2007; Klemm et al., 2008). Since the transmission power cannot be readily increased due to the sizeof portable devices, a large frequency bandwidth seems to be the proper solution to achieve a high data rate. With the increasing demand for high data transmission rate, broadband and multiband antennas play vital roles in the wireless communication system (Azim et al., 2013a).

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, etching of 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., 2013b; Azim et al., 2013c; Dorostkar et al., 2013; Lee et al., 2012; Wang et al., 2012; Liu et al., 2010; Azim et al., 2011; Ojaroudi et al., 2012; Azim et al., 2011b). For example, a compact slot antenna is proposed (Azim et al., 2013b) 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., 2013c) 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. The symmetric radiation patterns and stable gain make the proposed suitable for being used in various wireless applications such as ISM (2400-2483 MHz), Wi-Fi (2400 MHz), GPS (2400 MHz), Bluetooth (2400-2500 MHz), WLAN (2.4-2.48 GHz, 5.15-5.85 GHz) and UWB (3100-10600 MHz). A tapered slot antenna with a band-notched function was proposed in (Lee et al., 2012). By inserting an Archimedean spiral slot into the microstrip-slot-line transition, the antenna with an overall dimension of 50 × 50 mm achieved UWB performance with a notched band of 4.6–6.2 GHz. In 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., 2011a). The monopole antenna fed by a 50Ω microstrip 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 to 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.

Antenna design

The proposed UWB monopole single notch antenna geometry layout is shown in Figure 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 acquire a better impedance bandwidth. The width (W_{f2}) of the microstrip feed in starting position is 5 mm, corresponding to a characteristic impedance of near about 50 Ω, and the field width (W_{f1}) of the bottom line is 1.97 mm, corresponding to a characteristic impedance of 71 Ω. The proposed tapered feeding line gradually transforms the impedance from 50 to 71Ω and provide best impedance performance than rectangular microstrip feed. An SMA connector is connected to the port of the microstrip line. The antenna has an overall dimension of $L \times W \times h mm^3$. The trapezoid ground plane has an area $\frac{1}{2} \times L1 \times (W + W2)\ mm^2$. The details of the optimized design parameter are summarized in Table 1.



(a) (b)

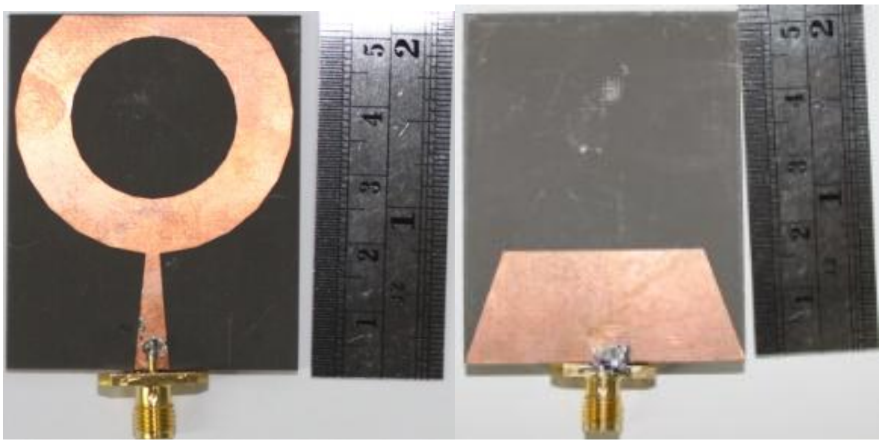
Figure1. The proposed antenna (a) Top layer (b) Bottom layer (all dimension are in mm)

Table 1. Optimized Dimension of the proposed antenna

Parameter	Value (mm)	Parameter	Value (mm)	Parameter	Value (mm)
W	42	W_2	30	r_1	20
W_{f1}	1.97	L	52.25	r_2	12
W_{f2}	5	L_1	17.56	e	15.25
$W_1 = W$	42	l_f	17.09	h	1.575

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 design and analysis. Simulation results are plotted using scientific graphing and data analysis software Origin Pro. The photograph of the proposed antenna prototype (top and bottom view) is shown in Figure 2. The measured results were obtained using the Agilent E8362C vector network analyzer and Satimo near field anechoic chamber (UKM StarLab). Fig. 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 shows that the proposed antenna covers the frequency range from 1.5 - 15 GHz and gives the notch characteristics in the frequency range 3.81- 4.51 GHz in HFSS and in CST, it rejects 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 Figure 4. Practical requirements of notched frequency bands can easily be achieved and controlled by adjusting the sizes and locations of the resonating elements



(a) (b)

Figure 2. Photographs of the fabricated UWB band notched antenna: (a) top layer (b) bottom layer

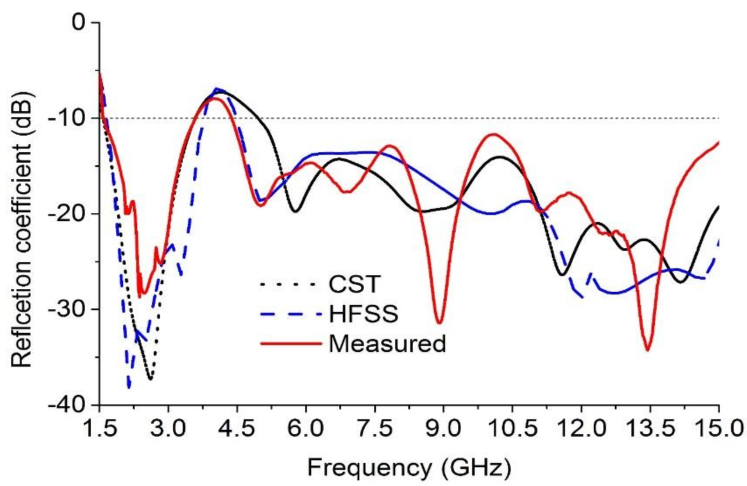


Figure 3. Simulated and measured reflection coefficient of the proposed antenna

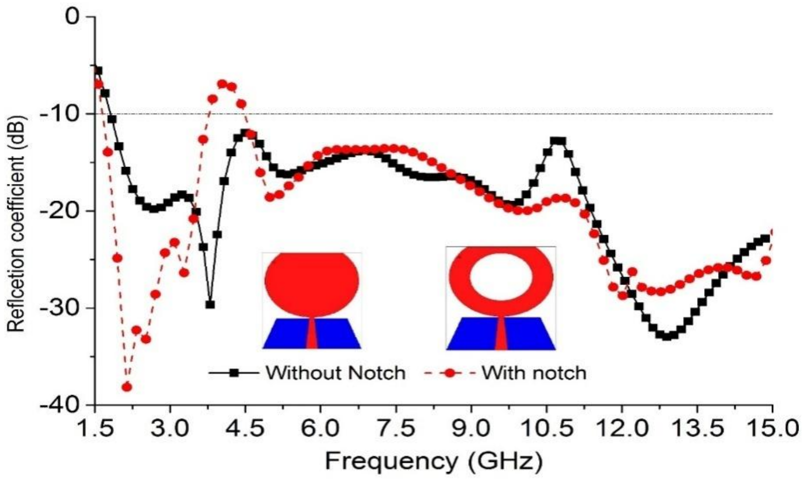


Figure 4. Comparative graph of the proposed antenna with and without notch

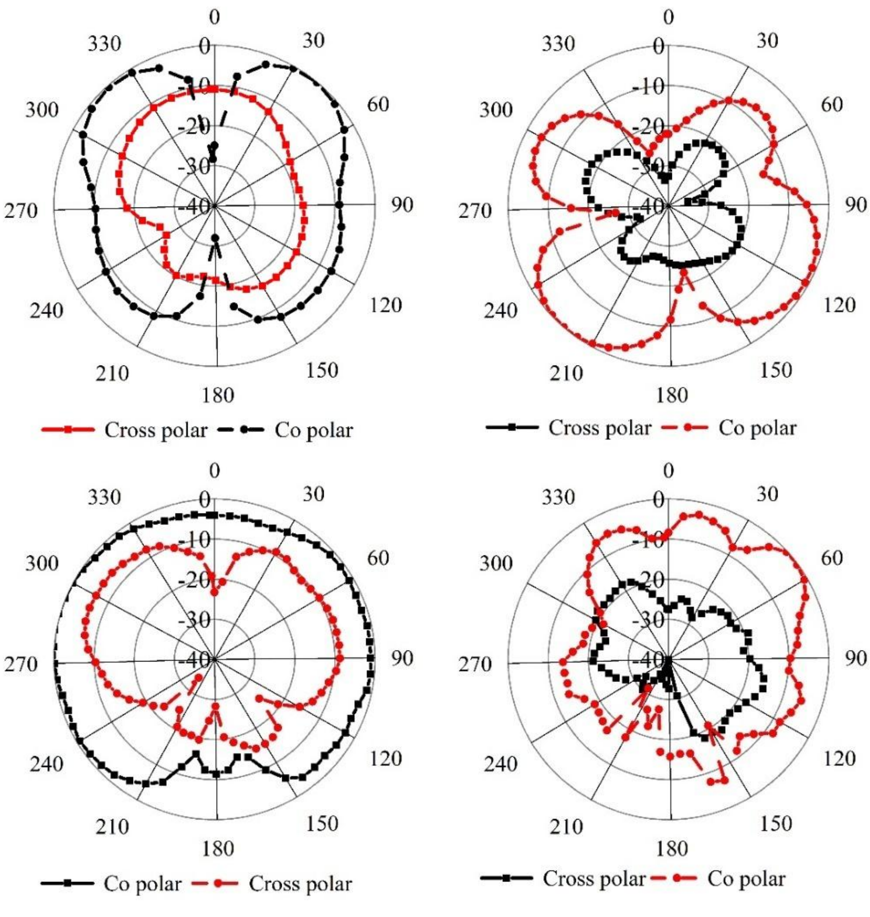


Figure 5. Measured radiation pattern at different frequencies cross-polarization and co-polarization.

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 Figure 5. It can be seen that the radiation patterns of proposed antenna in *xz* plane (H plane) exhibits nearly 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.

Table 2. Comparison of Proposed Antenna with some Existing Antenna in the Literature

Band-Notch Antennas	Dimensions (mm^2)	Bandwidth (GHz)	Notched Band (GHz)
Dual Band-Notch UWB Slot Antenna [Azim et al., 2013b]	22× 24	3.04 - 10.88	3.5 – 3.95
Tapered Slot Antenna[Lee et al., 2012]	50×50	2.4 - 11.2	4.6 – 6.2
Compact Monopole Antenna[Liu et al., 2010]	35×30	3.05 - 11.15	5.12 – 6.08
Proposed	52×42	1.5 - 15	3.58 – 4.92

Conclusion

In this article 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 work. The proposed antenna has a good simple configuration, smaller in size and good operation characteristics. Experimental results show that the proposed antenna could be a good candidate for various UWB Applications.

References

Allen B, Dohler M, Okon E, Malik W, Brown A, Edwards D (2006) Ultra wideband antennas and propagation for communications, radar and imaging: John Wiley & Sons.

Azim R, Islam MT, Misran N (2011a) "Design of a Planar UWB Antenna with New Band Enhancement Technique," *Applied Computational Electromagnetics Society Journal*, 26:856-862.

Azim R, Islam MT, Misran N (2011b) "Compact tapered-shape slot antenna for UWB applications," Antennas and Wireless Propagation Letters, *IEEE*, 10:1190-1193.

Azim R, Islam MT, Misran N (2013a), "Microstrip line-fed printed planar monopole antenna for UWB applications," *Arabian Journal for Science and Engineering*, 38: 2415-2422.

Azim R, Islam MT, Mobashsher AT (2013b) "Design of a dual band-notch UWB slot antenna by means of simple parasitic slits," *Antennas and Wireless Propagation Letters, IEEE,* 12: 1412-1415.

Azim R, Mobashsher AT, Islam MT (2013c) "UWB antenna with notched band at 5.5 GHz," *Electronics Letters*, 49: 922-924.

Dorostkar MA, Islam MT, Azim R (2013) "Design of a novel super wide band circular-hexagonal fractal antenna," *Progress In Electromagnetics Research,* 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, April*.

Fear E, Stuchly M (2000) "Microwave detection of breast cancer," *Microwave Theory and Techniques, IEEE Transactions on,* 48:1854-1863

Jafari HM, Deen MJ, Hranilovic S, Nikolova NK (2007) "A Study of Ultrawideband Antennas for Near-Field Imaging," *IEEE Transactions on Antennas and Propagation*, 55: 1184-1188

Klemm M, Craddock I, Preece A, Leendertz J, Benjamin R (2008) "Evaluation of a hemi-spherical wideband antenna array for breast cancer imaging," *Radio Science,* 43:1-15.

Lee DH, Yang HY, Cho YK (2012) "Tapered slot antenna with band-notched function for ultrawideband radios," *Antennas and Wireless Propagation Letters, IEEE*, 11: 682-685

Liu HW, Ku CH, Wang TS, Yang CF (2010) "Compact monopole antenna with band-notched characteristic for UWB applications," *Antennas and Wireless Propagation Letters, IEEE,* 9: 397-400

Ojaroudi N, Ojaroudi M, Ghadimi N (2012) "UWB omnidirectional square monopole antenna for use in circular cylindrical microwave imaging systems," Antennas and Wireless Propagation Letters, *IEEE*, 11:1350-1353.

Wang C, Yan ZH, Li B, Xu P (2012) "A dual band-notched UWB printed antenna with C-shaped and U-shaped slots," *Microwave and Optical Technology Letters,* 54: 1450-1452

*Int J Inno Res*1(1):19–23, 2016