DUAL-BAND-NOTCHED UWB PRINTED MONOPOLE ANTENNA

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ABSTRACT:

This paper analyzed the band-notch UWB antenna and the effect of band-notch filter parameters on notch function. Two band-notch filters are added for Wi-MAX (3.2 – 3.6 GHz) and WLAN (5.15- 5.85 GHz). The dual band notch antenna is realized on FR-4 substrate with relative permittivity 4.4, thickness 1.59 mm and loss tangent 0.002. The first notch is introduced for band rejection at Wi-MAX band with the help of C-shaped circular slot on radiator with slot width SW and angle of rotation θ. The second notch is introduced for band rejection at WLAN band with SRR like structure near the feed line. The proposed structure is fabricated and tested. Simulated and measured results are close agreement with each other. Antenna has stable radiation pattern.

KEYWORDS: Monopole, Ultra-wide band (UWB) antenna, Circular Monopole, band-notch, Rectangular slot, WLAN.

I. INTRODUCTION:

UWB technology has been rapidly advancing as a promising high data rate wireless communication technology for various applications. The emergence and acceptance of the ultra wideband (UWB) impulse radio technology in the USA [1], there has been considerable research progress put into UWB radio technology worldwide. Recently, the Federal Communication Commission (FCC)'s allocation of the frequency band 3.1–10.6 GHz for commercial use has sparked attention on ultra-wideband (UWB) antenna technology in the industry and academia.

UWB Monopole Antenna with Two Notched Bands Based on the Folded Stepped Impedance Resonator is proposed in [2]. Planar Ultra-wideband Antennas with Multiple Notched Bands Based on Etched Slots on the Patch and/or Split Ring Resonators on the Feed Line is proposed in [3]. Three types of ultra-wideband (UWB) antennas with triple notched bands are proposed and investigated for UWB communication applications. Two split ring slots are used to generate notched bands with central frequency of 2.4 and 3.5 GHz, couple arc slots with the same radius are corresponding to the notched band centered on 5.8 GHz. Compact SRR Loaded UWB Circular Monopole Antenna with Frequency Notch Characteristics [4]. In this using CPW fed with SRR Circular Monopole Antenna designed. Multiple resonance frequency with multiple pairs of SRR loading with varying geometrical dimensions can be employed to achieve multi notch characteristics in the antenna design for three different frequency 3.1GHz, 6.38GHz and 10 GHz.

Planar Monopole Antenna With Dual Interference Suppression Functionality [5]. A compact microstrip-fed ultra wideband (UWB) printed monopole antenna is described that possesses attributes of dual notched functionality, wide impedance bandwidth (IBW), and circular polarization (CP). Band-Notched UWB Printed Monopole Antenna with a Novel Segmented Circular Patch [6]. The band-notched characteristic in the 5.7-GHz WLAN band is obtained by segmenting a circular monopole patch into three parts. Practically, the side patches function as two parasitic elements and work as band stop filters. The segmenting method that brings on band-notched function is easy to accomplish.

5.8-GHz Notched UWB Bidirectional Elliptical Ring Antenna Excited by Circular Monopole with Curved Slot [7]. The antenna structure consists of two parts, a circular monopole with curved slot and an elliptical ring, a curved slot on circular monopole provides the band-notched characteristic. An elliptical ring is used for controlling bidirectional pattern, thus the gain can be improved. Parasitically Loaded CPW-Fed Monopole Antenna for Broadband Operation is proposed in [8].

The proposed antenna in this paper covers the commercial UWB frequency range (i.e., 2.44–10.44 GHz), while rejecting the limiting band (i.e., 5.15–5.825GHz) to avoid possible interferences with existing communication systems running over it. The band rejection of the antenna is provided by etching the rectangular slot on the radiator. Effect of the parameters of this rectangular slot like slot length and slot width on performance of antenna have also been studied. Performance simulations of the antenna were performed with IE3D software, which is based on the method of moment. The remaining of this paper organized as follows. Section II presents the design of the antenna. Parametric study of our proposed antenna is presented in Section III. Simulation results accompanied with some discussions are presented in this section. Finally, Section IV concludes the paper.

II. ANTENNA DESIGN

Fig.1 shows the geometry of band-notch UWB antenna. The dual band notch antenna is realized on FR-4 substrate with relative permittivity 4.4, thickness 1.59 mm and loss tangent 0.002. The first notch is introduced for band rejection at Wi-MAX band with the help of C-shape circular slot on main radiator with slot width SW and angle of rotation θ. The second notch is introduced for band rejection at WLAN band with SRR like structure near the feed line. The simulation results were obtained using IE3D

14.1 Zeland simulator. The optimum dimension of proposed geometry is listed in Table. 1.

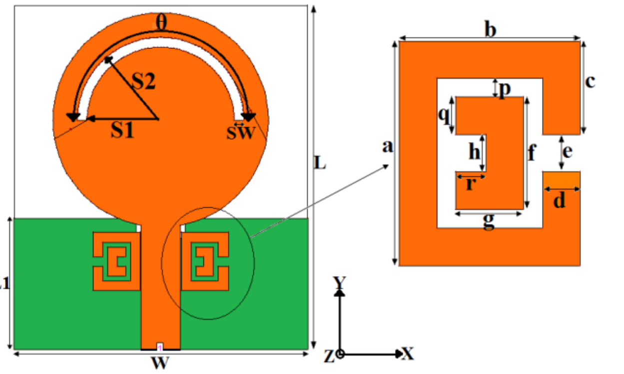


Fig.1. Geometry of antenna structure.

TABLE I Optimum dimensions of dual band-notch UWB Antenna

Parameters	Value(mm)	Parameters	Value(mm)
A	6	G	1.8
B	4.8	H	1
C	2.5	P	0.5
D	1	Q	1
E	1	R	0.8
F	3	SW	1
S1	7.5	Θ	180°
S2	8.5	L	35
W	30	L1	13.4

Fig.2 shows the evolution of band notched UWB antenna geometry. Case 1 is simple UWB antenna. Case 2 shows the geometry of high frequency band rejection for the Wi-Max range [3.3-3.7GHz] is obtained by embedding the C shaped circular slot in the circular radiator. Case 3 shows the Split Ring Resonator (SRR) is a type of meta-material embedded near the feed line structure, results in the rejection of WLAN band at 5.8 GHz.

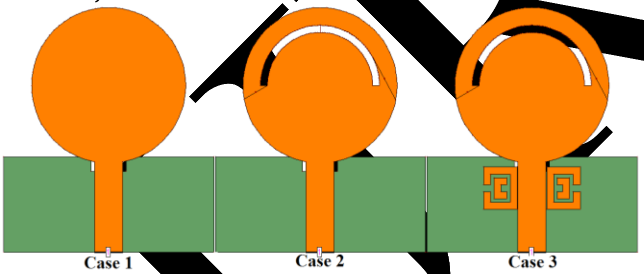


Fig.2 Antenna geometry: Case 1) simple UWB antenna, Case 2) UWB with Wi-Max band notch resonator, Case 3) UWB with WLAN band notch resonator

The notch frequencies for higher (5.4 GHz) and lower (3.5 GHz) bands are calculated using the relation given in Eq.1. Where *c* is the speed of the light, *L* is the length of the notch element and ε_{eff} is the effective dielectric constant of the substrate. SRR (Symmetry Split Ring Resonator) structure is introduced on the radiator near the feeding strip. It acts as an electric meta-material that suppress the incident electric fields. A specific band of frequencies have rejected due to the introduction of SRR [5.15-5.88 GHz]. The S_{11} with respect to frequency plot is shown in Fig.3.

$$f = \frac{c}{2\sqrt{\varepsilon_{eff} f_r}} \quad (1)$$

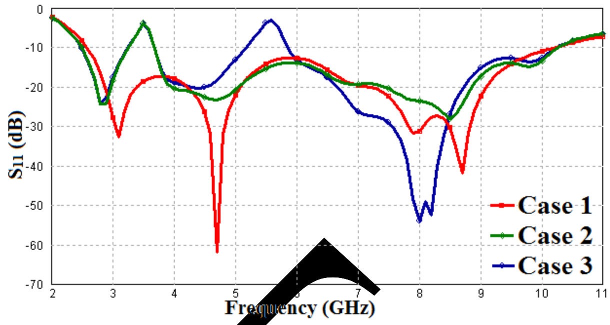


Fig.3 Return Loss

III. SIMULATION RESULT AND ANALYSIS:

In this section, effect of different parameters of structure on performance of antenna are investigated.

A. EFFECT OF θ ON S-PARAMETERS

Fig.4 shows the variations in S_{11} with change in angle of rotation (θ). As θ increases return loss S_{11} increases. There is a decrease in Lower resonance and higher resonance frequency as angle of rotation increases. Circular slot on radiator is responsible for the band-notch at Wi-Max band. At lower frequency the impedance become more capacitive while at higher frequency impedance becomes more inductive with increase in θ. The optimum value of θ is 180° for required band notch frequency and bandwidth.

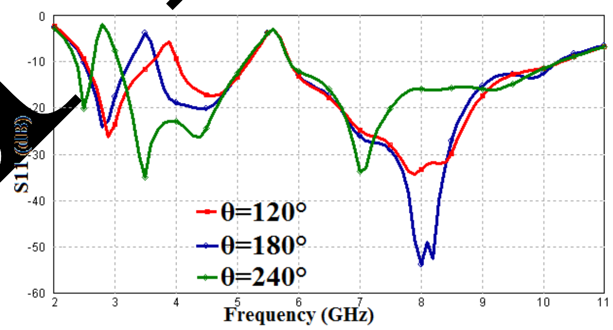


Fig.4 Effect of θ on Return Loss

B. EFFECT OF S1 ON S-PARAMETERS

Distance of circular slot from centre of circular monopole radiator (S1) also shows the same effect as like θ.

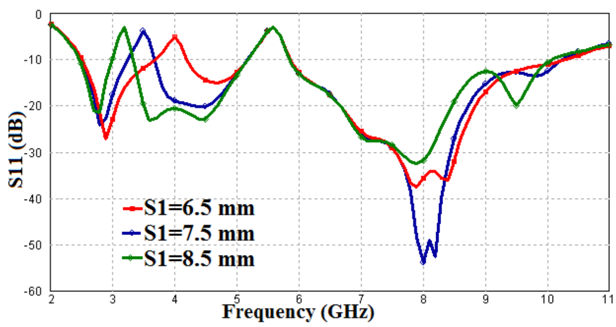


Fig.5. Effect of S1on Return Loss

Fig.5 shows the variations in S_{11} with S1. As S1 increases return loss S_{11} increases. The optimum value of S1 is 7.5 mm for required band notch frequency and bandwidth.

C. EFFECT OF W1 ON S-PARAMETERS:

Fig.6 shows the variations in S_{11} with circular slot width (SW). S1 does not show the major effect on the band-notch function. Return loss increases at higher frequency with increase in slot width. The optimum value of SW is 1 mm for required band notch frequency and bandwidth.

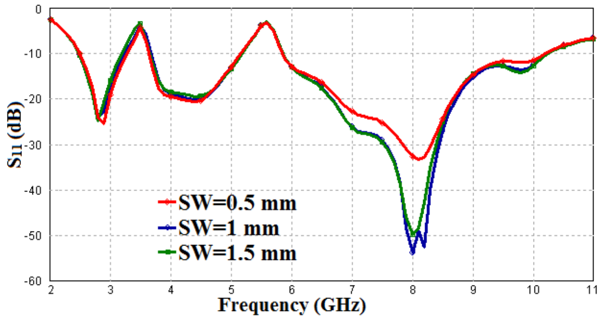


Fig.6 Effect of SW on Return Loss

D. EFFECT OF 'A' ON S-PARAMETERS:

SRR (Symmetry Split Ring Resonator) structure is introduced on the radiator near the feeding strip. It acts as an electric meta-material that suppress the incident electric fields. A specific band of frequencies have rejected due to the introduction of SRR [5.15-5.88 GHz]. Fig.7 shows the variations in S_{11} with SRR length 'a'. As 'a' increases S_{11} improves at higher frequencies and WLAN notch frequency shifted towards the higher value. There is negligible change in lower resonance frequency but higher resonance frequency changes with increase in the 'a'. The optimum value of 'a' is 6 mm for required band-notch frequency and bandwidth.

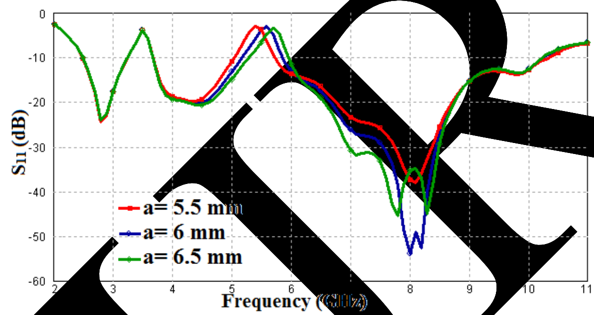


Fig.7 Effect of 'a', on Return Loss

E. EFFECT OF 'b' ON S-PARAMETERS:

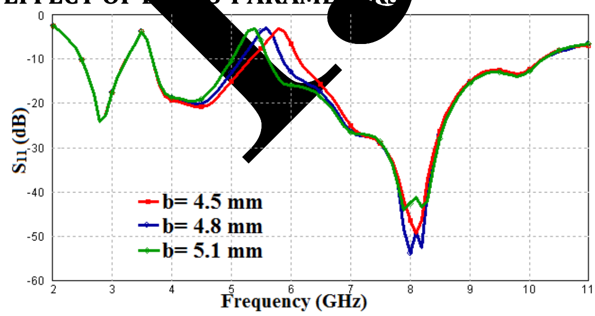
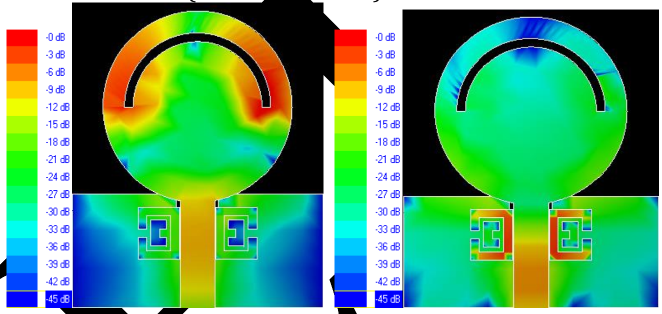


Fig.8 Effect of 'b' on Return Loss

Fig.8 shows the variations in S_{11} with SRR width 'b'. As 'b' increases S_{11} degrades. There is negligible change in lower resonance frequency but higher resonance frequency decreases with increase in the ground plane width W. The optimum value of 'b' is 4.8 mm for required band notch frequency and bandwidth.

F. SURFACE CURRENT DISTRIBUTION:

Fig.9 (a) shows the surface current distribution at frequency 3.5 GHz which is the notch frequency. Circular slot on the radiator blocks the current at notch frequency and return loss degrades below the -4 dB (Fig.3). Fig.9 (b) shows the surface current distribution at frequency 5.5 GHz which is the notch frequency of WLAN band. SRR structure near the feed line is acts as a parasitic element and suppresses the current at notch frequency and return loss degrades below the -4 dB (Fig.3). Hence we get band notch at WLAN (5.15 – 5.88 GHz) band.



(a) (b)

Fig.9 Surface Current distribution at, (a) 3.5 GHz, (b) 5.5 GHz

G. EXPERIMENTAL RESULTS AND DISCUSSIONS:

The proposed antenna is fabricated and tested as shown in Fig.10. The antenna performance was measured using the 9916A Agilent network analyzer. For measurements one port is excited while other port is terminated with 50 Ω loads. Simulated and measured S-parameters are shown in Fig.11. It is observed that the measured results are in good agreement with the simulated results.

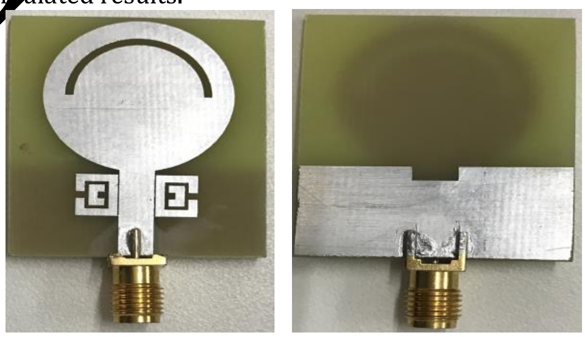


Fig.10 Fabricated structure

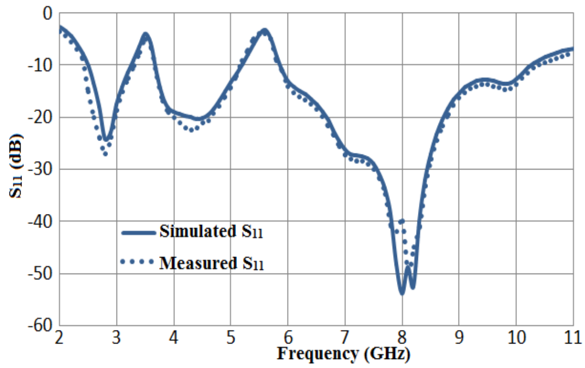
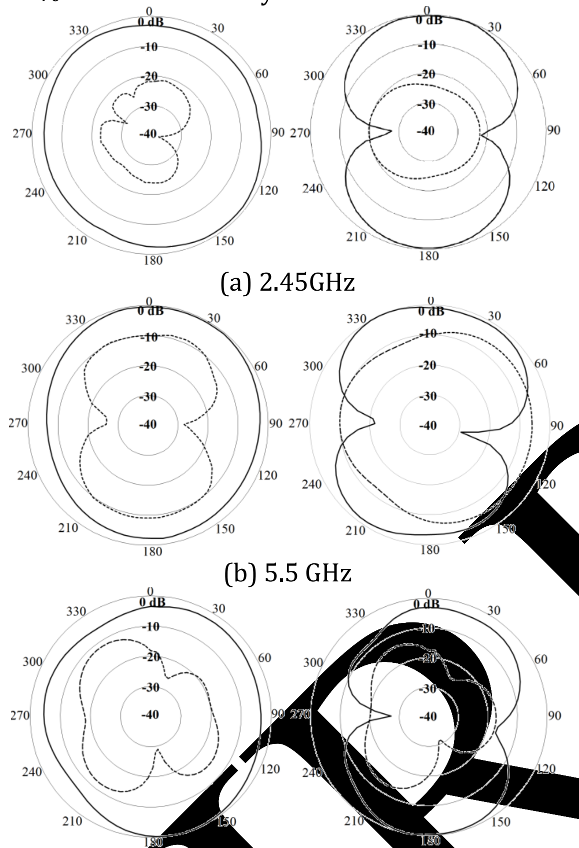


Fig.11 Simulated and Measured S-Parameters

The measured radiation patterns of the prototype MIMO antenna at three resonating frequencies viz., 3.3 GHz, 6.2 GHz and 9.6 GHz at φ =0˚ (X-Z plane) and φ=90° (Y-Z plane) are shown in Figure 12. Over lower frequencies the antenna exhibits a stable omnidirectional radiation pattern whereas it deteriorates at higher frequencies, because the equivalent radiating area changes with frequency over UWB. The radiation patterns tends to become directive in positive x directions due to asymmetry in the structure. The antenna has < 3 dB gain variation over the two bands. The proposed antenna provides more than 85% antenna efficiency.



(a) 2.45GHz

(b) 5.5 GHz

(c) 8 GHz

Fig. 12 Measured Radiation Patterns

V. CONCLUSION:

A band-notched ultra wideband rectangular slot antenna is proposed in this paper. In order to obtain band notch characteristics, rectangular slot is etched on the radiator. Band-notched characteristics can be controlled by adjusting rectangular slot length and width parameters. Parametric studies of antenna are presented. The proposed antenna design with optimal dimensions is simulated. The simulation shows that VSWR is below 2 within the desired frequency bandwidth from 2.44 GHz to upper 10.44 GHz, whereas a notched bandwidth of 5-6.15 GHz is obtained. Current distributions, radiation patterns, and gain of the antenna are also studied in this paper.

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