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 the most 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 in the industry worldwide. Recently, the Federal Communication Commission (FCC) ’s assignment of the frequency band 3.1-10.6 GHz for commercial use has sparked attention on ultra-wideband (UWB) antenna technology to the industry and academia.

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

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.

![Geometry of antenna structure](image)

**Fig.1. Geometry of antenna structure.**

**TABLE I Optimum dimensions of dual band-notch UWB Antenna**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value (mm)</th>
<th>Parameters</th>
<th>Value (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>6</td>
<td>Q</td>
<td>1.8</td>
</tr>
<tr>
<td>B</td>
<td>4.8</td>
<td>H</td>
<td>1</td>
</tr>
<tr>
<td>C</td>
<td>2.5</td>
<td>P</td>
<td>0.5</td>
</tr>
<tr>
<td>D</td>
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<tr>
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<td>0.8</td>
</tr>
<tr>
<td>F</td>
<td>3</td>
<td>SW</td>
<td>1</td>
</tr>
<tr>
<td>S1</td>
<td>7.5</td>
<td>θ</td>
<td>180°</td>
</tr>
<tr>
<td>S2</td>
<td>8.5</td>
<td>L</td>
<td>35</td>
</tr>
<tr>
<td>W</td>
<td>30</td>
<td>L1</td>
<td>13.4</td>
</tr>
</tbody>
</table>

![Fig.2 shows the evolution of band-notch UWB antenna geometry. Case 1 is simple UWB antenna. Case 2 shows the geometry of high frequency band rejection in the Wi-Max range [3.3-3.7GHz] is obtained by embedding the C shaped circular slot in the main radiator. Case 3 shows the Split Ring Resonator (SRR) is a type of metamaterial embedded near the feed line structure, results in the rejection of WLAN band 5.1-5.8 GHz.](image)

![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](image)

**III. SIMULATION RESULT AND ANALYSIS:**

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

**A. EFFECT OF Θ ON S-PARAMETERS**

Fig.4 shows the variations in return loss S11 with change in angle of rotation (θ). As θ increases return loss S11 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 become 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](image)

**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 S1 on Return Loss](image)

**Fig.5 Effect of S1 on Return Loss**

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 εeff 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 S11 with respect to frequency plot is shown in Fig.3.

\[
f = \frac{c}{2\sqrt{\varepsilon_{eff} f_r}}
\]  

(1)
C. EFFECT OF W1 ON $S$-PARAMETERS:

Fig. 6 shows the variations in $S_{11}$ with circular slot width (SW). $S_1$ 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](image)

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 suppresses 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](image)

E. EFFECT OF 'B' ON $S$-PARAMETERS:

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.

![Fig.8 Effect of 'b' on Return Loss](image)

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.

![Fig.9 Surface Current distribution at, (a) 3.5 GHz, (b) 5.5 GHz](image)

IV. 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](image)

![Fig.11 Simulated and Measured S-Parameters](image)
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.

![Radiation Patterns](image)

**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 characteristic, rectangular slot is etched on the radiator. Band-notch 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.

**REFERENCES:**


3) Yan Zhang, Wei Hong, Xu Yu, Zhen-Qi Kuai, Yu-Dan Don, and Jian-Li Zhou, “*Ultrawideband Antennas With Multiple Notched Bands Based on Etched Slots on the Patch and/or Split Ring Resonators on the Feed Line*”, IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, VOL. 56, NO. 9, pp. 3063 - 3068 SEPTEMBER 2008.


9) IE3D Release 14.0, Zeal land Software Inc. Fremont, USA.