UWB Microstrip-Fed Monopole Antenna With Single And Dual Band Notch Characteristics

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ABSTRACT: A planer monopole ultra wideband (UWB) antenna with single and dual band notched characteristics are presented in this article. Proposed antenna consists of simple rectangular shaped patch with sequential notches which is inserted in two lower corners. In order to obtain band notched properties ‘U’ shaped conductor backed plane (CBP) is embedded. Multiple ‘U’ shaped CBP can realize multiple frequency band notched characteristics. To validate this concept two prototypes are designed, simulated and fabricated for single and dual band notched UWB Antenna. Notched band can be controlled by adjusting the parameters of U shaped CBP. Proposed antennas exhibit almost Omnidirectional radiation pattern over an operating bandwidth of (2.62 - 11) GHz.

Key words: Band notch characteristics, conductor backed plane, ultra wideband antenna.

INTRODUCTION:
Ultra wideband (UWB) technology is expanding rapidly in wireless communication systems covering the frequency range from 3.1-10.6 GHz allocated by The Federal Communication Commission (FCC) [1]. Several monopole Antenna configuration have been designed so far for UWB operation[2-5]. However in practical application WIMAX(3.3-3.6 GHz),WLAN(5.15-5.825 GHz), C band satellite communication service (downlink: 3.7-4.2GHz, uplink:5.9-6.4GHz) and X band satellite communication service ( 7.25-8.39 GHz) are also operating in the UWB frequency range. Therefore UWB communication systems may generate interference with these bands. So it is desirable to design the UWB monopole antenna with multiple band stop characteristics. Different techniques for band rejection have been adopted such as embedding of slots on patch[6] or ground plane[7], or insertion of tuning stubs in ground plane.[8]. Another approach to realize the band notch function by the insertion of H shaped [11] or I shaped [12] parasitic element on the rear side of the substrate. In this article the simple monopole UWB antenna with a smaller size (24mm×24 mm×1.6 mm) is proposed. The realization of single or dual band notched features can be achieved by introducing a single or a pair of ‘U’ shaped parasitic elements. Two prototypes are designed and measured to confirm single and dual band notch response to verify the proposed antennas. Both simulated and measured results of VSWR and radiation pattern are presented and discussed.

DESIGN OF MONOPOLE UWB ANTENNA WITH SINGLE BAND-NOTCHED CHARACTERISTICS

The geometry of Proposed UWB antenna with single band-notched characteristics is illustrated in fig 1 which is constructed with a substrate made of FR4 with permittivity 4.4 and thickness 1.6 mm. The width of microstrip feed line is fixed at 2 mm to achieve 50Ω characteristic impedance. The length of ground plane is 6 mm printed on the back surface of the substrate along with a ‘U’ shaped conductor backed plane (CBP). CBP acts as a half wavelength parasitic element. At the notch frequency the current flows are more dominant around the parasitic element create attenuation. The rectangular patch dimension is (12 × 15.5) m.m² with two pairs of notches on the patch surface. Each notch of size (1 × 2) m.m². The sequential discontinuities due to the notches on the patch generate several resonances which adjust the impedance band width over UWB frequency band and on the other hand at notch frequency, large impedance mismatch.
is produced which leads to the better band notch performance as well as small increment in rejection bandwidth. Optimum gap between the radiator and the ground plane is kept at 2 m. m. Notched band can be controlled by varying the parameters of ‘U’ shaped CBP, which is characterized by \( W_i, W_o, D \) and \( d \), while the width of ‘U’ shaped CBP is 0.5 m. m. The notch frequency where maximum VSWR is obtained is given as

\[
f_n = \frac{c}{2L_n \sqrt{\varepsilon_{\text{eff}}}}, \quad \varepsilon_{\text{eff}} = \frac{\sqrt{\varepsilon_r + 1}}{2}
\]

\( L_n = \frac{\lambda_0}{2} \) and \( c \) = speed of light, \( L_n \) is optimized length in this design where \( L_n = (D-d) + W_i/2 \) for \( W_i \geq W_p \) —— (i) and \( L_n = (D-d) + W_o/2 \) for \( W_i < W_p \) —— (ii) where \( W_p \) is the patch width fixed at 12 m.

**RESULTS AND DISCUSSION OF MONOPOLE UWB ANTENNA WITH SINGLE BAND-NOTCHED CHARACTERISTICS**

Simulation results of proposed antenna obtained by Ansys HFSS™ simulator[13]. From simulated results in fig 2 it is clearly seen that impedance bandwidth improves and covers the range from 2.62 - 11 GHz (VSWR<2) and on the other hand at rejection band peak VSWR increases with the insertion of the pair of notches with patch. From the simulation result in fig 3 it is observed that band notched frequency varies with the variation of \( D \). The results predicted by HFSS simulator are compared to the ones calculated by equation (i) and (ii) as shown in fig 4(a) and 4(b) for different value of \( W_i \). It is seen that nature of slopes in the two sets of results are almost similar against the frequency.

**Fig 1: Geometry of proposed antenna with single band notch characteristics**

**Fig 2: VSWR characteristics with notch effect**  
**Fig 3: VSWR characteristics for various D**
Fig 4: Comparison of calculated and predicted length of D against the frequency

DESIGN AND SIMULATION OF MONOPOLE UWB ANTENNA WITH DUAL BAND-NOTCHED CHARACTERISTICS

The dual notched band design can be realized by providing additional half wavelength U shaped CBP. Second CBP is closed placed above the existing one as shown in fig 5. The newly added CBP works independently to achieve another notched-band. Geometry of the patch remains same. Two notched-band can be controlled by independently varying the parameters of two CBP. CBP1 is responsible for the rejection of WLAN bands (5.15 – 6.2 GHz) and CBP2 is responsible for the rejection of X band satellite communication service (6.75 – 8.37 GHz). Simulated VSWR curves with different value of $D_1$ and $D_2$ shown in fig 6a and 6b. Which indicates that they do not affect the notched frequency of the other CBP if the parameter of one CBP varied. The surface current distribution at each notch frequency for the proposed dual notch is shown in fig 7a and 7b. It is seen that surface current mainly concentrated at the corresponding CBP at each notch frequency for both case. It is clear that neighboring CBP has the little mutual effect to the other in band notch performance.

Fig 5: Geometry of proposed antenna with dual band notch characteristics
Fig 6: Simulated VSWR characteristics for various length of D₁ and D₂

Fig 7: Current distribution of dual CBP for (a) 5.5 GHz and (b) 7.3 GHz

EXPERIMENTAL RESULTS AND DISCUSSION

Optimized parameters are summarized in Table 1 and according to which prototypes of both the antennas are fabricated (as shown in fig 8) and measured. For single band notched antenna, UWB covers the range from 2 to 11 GHz with rejection band between 4.8 - 5.87 GHz for WLAN system as shown in fig 9 and for dual band notched antenna UWB covers the range from 2.67 - 11 GHz with rejection band from 5.16 – 6.28 GHz for WLAN system and 6.75 - 8.37 GHz for X band satellite communication service as shown in fig.10

Fig 8: Prototypes of proposed antenna
Table 1: Optimized parameters of proposed antenna

<table>
<thead>
<tr>
<th>Parameter of Dual notched band design</th>
<th>$L_{sub}$</th>
<th>$W_{sub}$</th>
<th>$L_p$</th>
<th>$W_p$</th>
<th>$L_f$</th>
<th>$W_f$</th>
<th>$L_1$</th>
<th>$W_1$</th>
<th>$L_2$</th>
<th>$W_2$</th>
<th>$D_1$</th>
<th>$d_1$</th>
<th>$W_{ll}$</th>
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<th>$D_2$</th>
<th>$d_2$</th>
<th>$W_1$</th>
<th>$W_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimension(m.m)</td>
<td>24</td>
<td>24</td>
<td>15.5</td>
<td>12</td>
<td>8</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>6</td>
<td>0.5</td>
<td>15</td>
<td>16</td>
<td>5.5</td>
<td>1</td>
<td>13</td>
<td>14</td>
</tr>
</tbody>
</table>

**RADIATION PATTERN:** The normalized radiation patterns of the proposed single band notch and dual band notch UWB antennas at 7 GHz and 10 GHz are displayed in Fig.11. It exhibits quasi-omnidirectional pattern in H plane (xz-plane) and typical monopole like pattern in E plane (yz-plane) at these frequencies for both antennas.
CONCLUSION: A new approach to create multiple stop bands in UWB antenna is proposed. Stop band characteristics can be adjusted by various parameters of U shaped parasitic elements. In order to obtain the UWB and improved peak VSWR at notch frequency two pairs of rectangular notches are embedded at patch. Proposed designs are able to achieve desired band rejection characteristics for WLAN and X band for satellite communication along with good UWB performance. Good Omni directional radiation pattern over the entire operating band from 2.6 GHz to 11 GHz makes the antenna suitable for UWB application.

REFERENCES:
13. ANSYS® HFSS 13.0.1.2