Ultra Wideband CPW Antenna With Single Frequency Notch For EMI Reduction

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Abstract

An ultra wideband slot antenna using coplanar waveguide (CPW) feed is proposed in this letter. Presented antenna consists of a conventional rectangular shaped ground slot and a 50Ω feed line. A rectangular notch of 4.9 mm × 1.6 mm is embedded in the feed line which increases the electrical size of the antenna. This improves input impedance matching, thereby resulting in ultra wideband nature. An L-shaped grounded metallic strip is protruded into the rectangular slot for introducing a frequency rejection band from 4.5 GHz - 5.7 GHz, thereby reducing the interference between unlicensed ISM band and the downlink satellite communication spectrum.

1. Introduction

Ultra wideband antenna utilizes a wide portion of spectrum and provides high bandwidth communication along with high data rate. In this modern day communication system, device compactness has triggered the use of a single ultra wideband antenna for different frequency applications. But this results in interference between different bands which can be avoided by incorporating frequency notches as required. Split ring resonators are majorly used to incorporate frequency notches, whose precise positioning is an essential requirement for achieving frequency notches which is a difficult task and also performance of the antenna becomes sensitive to resonator positioning. In [1] a differential coplanar waveguide ultra wideband antenna is proposed with tapered slot and controllable frequency notch, in [2] a modified Sierpinski square fractal antenna is proposed having ultra wideband nature along with frequency notch characteristics, in [3] another ultra wideband antenna has been studied which uses split ring resonator to achieve desired frequency notch, in [4] a CPW fed ultra wideband antenna with frequency notches is realized using split ring resonator and metallic shunt strips, ultra wideband antenna loaded with parasitic slit for achieving frequency notch has been studied in [5]. These techniques are either associated with the compactness issues of the antenna or the use of complex resonator circuits.

2. Antenna Design And Analysis

In this letter an ultra wideband planar antenna using CPW feed is presented. Proposed antenna consists of a conventional rectangular ground slot on FR4 epoxy of thickness 1.6 mm. The proposed antenna covers the entire ultra wideband frequency range with a single frequency notch at lower frequency. The schematic view of the proposed antenna is illustrated in fig. 1 along with its geometrical dimensions (mm) displayed in Table I.

TABLE I: Geometrical Dimensions (mm)

<table>
<thead>
<tr>
<th>l₁</th>
<th>l₂</th>
<th>l₃</th>
<th>l₄</th>
<th>l</th>
<th>w</th>
<th>w₉</th>
<th>w₅</th>
<th>f</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.8</td>
<td>7.0</td>
<td>4.9</td>
<td>23</td>
<td>35</td>
<td>35</td>
<td>11.1</td>
<td>10.5</td>
<td>24.6</td>
</tr>
</tbody>
</table>
2.1 Prototype analysis and surface current

![Antenna 1 and Antenna 2](image1)

**Figure 2.** Steps for improvement of antenna

![Antenna 3 and Antenna 4](image2)

**Figure 3.** Surface current density distribution at 7.0 GHz

Hierarchical steps involved for antenna improvement are illustrated in Fig. 2 using antenna prototypes and the corresponding value of return loss is depicted in Fig. 4. Antenna design initiates with etching a rectangular slot in the ground plane and introducing a feed line, as depicted by antenna I. Antenna resonance is improved by protruding the 50Ω feed line into the slot, as a wide impedance bandwidth is observed in Fig. 4 by the blue curve. Electrical size of the antenna is increased by etching a rectangular notch in the feed line for improving the input impedance matching, depicted by antenna III. Finally, a frequency notch is introduced in the resonating band by the introduction of an L-shaped grounded metallic strip (antenna IV), confirmed by the black curve in Fig. 4. Surface current density distribution with advancing time at 7.0 GHz is plotted in Fig. 3, illustrating the antenna regions responsible for dominant antenna radiations. From the current density distribution plot it can be concluded that the ground plane also behaves as a radiator which is responsible for high antenna gain.

![S11 of antenna prototypes](image3)

**Figure 4.** $S_{11}$ of antenna prototypes

2.2 Effect of L-shaped grounded strip

![Top view of antenna with and without grounded strip](image4)

**Figure 5.** Top view of antenna with and without grounded strip

![Effect of grounded strip on S11](image5)

**Figure 6.** Effect of grounded strip on $S_{11}$

An L-shaped grounded metallic strip has been protruded into the ground slot with an aim of introducing the frequency notch between WiMAX and WLAN band. Fig. 5 illustrates the schematic view of the proposed
antenna with and without grounded strip. Effect of grounded strip can be studied in fig. 6 which confirms the introduction of frequency notch because of L-shaped structure.

2.3 Effect of Rectangular notch

Impedance matching at the feed port is improved by etching a rectangular notch of 4.9 mm × 1.6 mm in the feed line. Schematic view of proposed antenna with and without rectangular notch is depicted in fig. 7 and its effect on $S_{11}$ is depicted in fig. 8.

Table II: Comparison Table

<table>
<thead>
<tr>
<th>Reference Ultra Wideband Antenna</th>
<th>mm×mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>[3]</td>
<td>50×50</td>
</tr>
<tr>
<td>[4]</td>
<td>50×50</td>
</tr>
<tr>
<td>[6]</td>
<td>50×70</td>
</tr>
<tr>
<td>[7]</td>
<td>40.4×40.2</td>
</tr>
<tr>
<td>Proposed Antenna</td>
<td>35×35</td>
</tr>
</tbody>
</table>

3. Result And Discussions

Return loss of the antenna is shown in fig. 9 which confirms the ultra wideband nature of the antenna with single frequency notch. Antenna matching is illustrated by the VSWR plot depicted in fig. 10 which confirms excellent antenna matching with single rejection band. Smith chart plot for input impedance matching is depicted in fig. 11. Normalized radiation patterns at 3.3 GHz and 10 GHz are plotted in fig. 12 and fig. 13, which illustrates stable monopole pattern for entire resonating band.
5. References


4. Conclusion

An ultra wideband antenna with single frequency notch using coplanar waveguide has been studied in this letter. The antenna consists of a rectangular ground slot and an extended feed line. A rectangular notch has been embedded in the feed line for improving the impedance matching and obtaining ultra wideband nature. Grounded metallic strip is protruded into the ground slot for controlling the rejection band. The proposed antenna reduces interference between the unlicensed band and the downlink satellite communication spectrum, thereby assisting EMI reduction.