Irregular Pentagon Monopole Structured Antenna for Ultra-wideband Communication Systems

Mostafa A. Abdel Fattah, A. M. M. A. Allam, Shoukry I. Shams
German University in Cairo (GUC), Egypt
mostafattah@gmail.com

Abstract—In this paper a novel antenna design is proposed for ultra-wideband (UWB) communication systems. The antenna consists of irregular pentagon monopole structured section with a 50Ω microstrip feeding structure. The simulation results show that the antenna's operating bandwidth from 3.1 to 12.9 GHz which is suitable for indoor high-data rate applications. The antenna provides omni-directional radiation patterns due to its symmetrical geometrical structure. The antenna has an overall size 44mm X 30mm. The antenna is fabricated on FR4 substrate with relative permittivity of 4.4 and thickness of 1.5mm and the measured results are in a good agreement with the simulated ones.

Index Terms——Printed antennas, ultra-wideband (UWB), ultra-wideband antennas, monopole antennas.

I. INTRODUCTION

Ultra-wideband technology has been receiving increased interest as a promising solution for high data rate communication systems. Many articles were published concerning ultra-wideband antennas [1], [2], [3], [4], [5]. The Federal Communication Commission (FCC) adopted ultra-wideband (UWB) for extremely high data rate short range wireless peer-to-peer indoor communication applications. Ultra-wideband systems is defined as any radio system that occupies a bandwidth of more than 20% of its center frequency, or more than 500MHz. The spectrum from 3.1 to 10.6 GHz is allocated for unlicensed UWB measurements and indoor communication applications which represents a fractional bandwidth of 110%. The antenna presented in this article is covering this operating bandwidth.

The printed ultra-wideband antennas contains one or more layers of radiator and ground planes separated by dielectric material. The performance of the printed ultra-wideband antenna is significantly affected by the shape and size of the radiator as well as the ground plane in terms of the operating frequencies, bandwidth, and radiation patterns of the antenna. The increased interest in printed antennas is due to their compactness which is suitable for integration in smaller communication based devices. The antenna presented in this article is simulated and fabricated as a printed ultra-wideband antenna with FR4 dielectric separating the radiator and the ground planes.

In this article a new antenna design is proposed for ultra-wideband (UWB) communication systems. The antenna consists of irregular pentagon monopole structured section with a 50Ω microstrip feeding structure. The antenna has an overall size 44mm X 30mm. The simulation results show that the antenna achieves operating bandwidth from 3.1 to 12.9 GHz which is suitable for indoor high-data rate applications. The antenna is fabricated on FR4 substrate with relative permittivity of 4.4 and thickness of 1.5mm and the measured results are in a good agreement with the simulated ones. The antenna provides omni-directional radiation patterns due to its symmetrical geometrical structure. The proposed antenna is simulated by a finite-element software.

The proposed design is fabricated and a comparison between the simulated results and the measured results will be discussed in the coming sections.

II. PROPOSED ANTENNA GEOMETRY AND DESIGN

In this section, the proposed antenna geometry will be discussed as well as the effect of the antenna dimentions change on its performance.

Figure 1 shows the geometry of an UWB irregular pentagon structured antenna. The antenna consists of irregular pentagon shaped monopole section with 50Ω microstrip feeder where the antenna has a symmetrical structure. The antenna is simulated on a FR4 substrate with 4.4 relative permittivity and thickness 1.5mm.

The height and the width of the monopole section are $L_a$ and $W_a$ respectively, where the ground length of the feeding
The monopole section and the feeding section are separated by a gap \( b \). The radiation bandwidth mechanism of the antenna is described according to the simulated return loss. The antenna is simulated by a finite-element software.

The effect of the antenna length change \( L_a \) on the antenna’s return loss is shown in Figure 2. This change in length changes the electrical length of the sides of the pentagon shape of the antenna. The results show the increase of the antenna height result in antenna lower cutoff shifts towards the lower frequencies. Decreasing the antenna height, the antenna lower cutoff shifts towards the higher frequencies.

Figure 3 shows the antenna’s return loss results with gap between the feeding section and the monopole section change \( b \). This changes the coupling between the ground plane and the monopole section which results in changing the antenna bandwidth. The change in the gap’s dimension also changes in the input impedance of the monopole section.

### III. RESULTS AND DISCUSSION

The final dimensions for the proposed antenna are shown in Table I. Figure 4 illustrates the simulated frequency response of the return loss for the proposed antenna. Figure 4 shows the return loss results where the operating frequency band for the

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>( L_a )</td>
<td>16.1mm</td>
</tr>
<tr>
<td>( W_a )</td>
<td>23mm</td>
</tr>
<tr>
<td>( L_g )</td>
<td>7.8mm</td>
</tr>
<tr>
<td>( b )</td>
<td>0.75mm</td>
</tr>
</tbody>
</table>

Table I

**OPTIMUM DIMENSIONS OF THE PROPOSED ANTENNA.**

Figure 5. The fabricated proposed antenna.

Figure 6. Measured and simulated return loss of the proposed antenna.
antenna is from 3.1 to 12.9 GHz which satisfies ultra-wideband bandwidth indoor communication applications requirements.

A photo of the fabricated antenna is presented in Figure 5. The fabricated antenna measured using a network analyzer. The simulated and measured return loss for the modified antenna are illustrated in Figure 6. Its observed that the measured results are in a good agreement with the simulated results. The antenna operates at the band from 3.1 to 12.9 GHz.

Figure 7, shows the 3-D radiation pattern of the proposed antenna at 3.1 GHz. It is noticed that the radiation pattern has a donut shape which makes the antenna omni-directional radiator. Figures 8, 9, 10 and 11 illustrate the co and cross-radiation patterns in red and purple colours respectively in the $\varphi = 0^\circ$ plane at 3.1, 5, 7 and 9 GHz respectively of the proposed antenna, where the radiation patterns of the proposed design are omni-directional due to the antenna’s symmetrical structure.

IV. CONCLUSION

A printed ultra-wideband antenna has been proposed and analyzed. The proposed antenna has an irregular pentagon monopole structure with overall size of the antenna is 44mm×30mm which is suitable for mobile ultra-wideband applications. The simulated and measured return loss over bandwidth from 3.1 to 12.9 GHz are presented. The measured
and simulated return loss are in a good agreement. The antenna provides omni-directional radiation pattern due to its symmetrical geometric structure.

REFERENCES


