AN UWB CIRCULAR PATCH ANTENNA WITH SLOTTED GROUND PLANE FOR BODY-CENTRIC COMMUNICATION

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Abstract—The performance of a circular patch antenna with slotted ground plane for body centric communication mainly in the health care monitoring systems for On-body application is researched. The CP antenna is intended for utilization in UWB, body centric communication applications i.e. in between 3.1 to 10.6 GHz. The proposed antenna is CP antenna of (30 x 30 x 1.6) mm. It is simulated via CST microwave studio suite. This CP antenna covers the entire ultra wide frequency range (3.9174-13.519) GHz (9.6016) GHz with the VSWR of (3.818 GHz-13.268 GHz). Antenna's group delay is to be observed as 3.5 ns. The simulated results of antenna are given in terms of $S_{11}$, VSWR, group delay and radiation pattern.

Keywords—UWB, Body Worn Antenna, Body-Centric Communication.

I. INTRODUCTION

Wearable antenna and the body centric communication have gotten much consideration in the course of recent years in medical services observing applications [1] [2]. Progresses in microelectronics and the remote correspondences have empowered an approach to make little and light weight observing gadgets which consumes less (ultra-low) power. Such shrewd checking gadgets can be prepared together to shape the body area network (WBAN). WBAN assemble data on substances of enthusiasm by various appropriated sensor components, put in, or on human body to screen health condition unavoidably and pervasively [3] [4]. Ultra-wideband (UWB) technology, standardized by IEEE 802.15.6 TG-6, is the fastest anticipating technology for such short range communication system [5]. With a very low range of effective isotropic radiating power (EIRP) emission density, less than-41.3 dBm/MHz, longer battery life for wearable and implanted health monitoring devices can be achieved. Moreover, the lesser EIRP value results in low level of interference which allows it to coexist with other system [6] [7]. Also it provides resistant against multi-path and potential application dependent higher data transmission rate varies from few Kbps to Mbps. Federal communication commission has authorized the UWB band which ranges from 3.1 to 10.6 GHz occupying a bandwidth of 7.5 GHz [8] [9].

In this paper, we present circular Patch (CP-UWB) antenna for wireless body centric communication. We have used the concept of slotted ground plane and feed gap to enhance antenna bandwidth. Here by choosing appropriate feed gap, an optimum operating frequency bandwidth can be achieved. The rest of paper is as follows. The CP-UWB antenna design and its geometry is given in section II. The result discussions are provided in section III. Finally in section IV, we present conclusion of results.

II. ANTENNA DESIGN

![Fig. 1. Geometry of CP-UWB Antenna](image-url)
The proposed geometry of CP-UWB antenna is shown in fig 1 and different antenna parameters and its values are given in the table 1. The dimension of the antenna is 30mm x 30mm x 1.6mm. The radiating patch and ground plane are placed on opposite sides of dielectric substrate (FR-4) having the loss tangent of 0.025 \([10]\). The circular radiating patch of diameter 11 mm is fed by a micro strip line of width 2 mm. The feed gap between patch and ground plane is 1mm. The length of ground plane is 11.5 mm. The material which is used in the CP-UWB antenna at the ground plane and circular patch is copper annealed. Simulations of this antenna have been done by using CST (Computer Simulation Technology) microwave studio suite.

### Table 1 Proposed Antenna Parameters

<table>
<thead>
<tr>
<th>Antenna Parameters</th>
<th>Values (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substrate Length((L_{sub}))</td>
<td>30</td>
</tr>
<tr>
<td>Substrate Width ((W_{sub}))</td>
<td>30</td>
</tr>
<tr>
<td>Width Of Feed ((W_f))</td>
<td>2</td>
</tr>
<tr>
<td>Feed Gap ((h))</td>
<td>1</td>
</tr>
<tr>
<td>Length Of Ground Plane ((L_g))</td>
<td>11.5</td>
</tr>
<tr>
<td>Diameter Of Circular Patch ((d_c))</td>
<td>11</td>
</tr>
<tr>
<td>Width Of Slot ((W_s))</td>
<td>4</td>
</tr>
<tr>
<td>Length Of Slot ((L_s))</td>
<td>2</td>
</tr>
</tbody>
</table>

The proposed geometry of CP-UWB antenna is shown in fig 1 and different antenna parameters and its values are given in the table 1. The dimension of the antenna is 30mm x 30mm x 1.6mm. The radiating patch and ground plane are placed on opposite sides of dielectric substrate (FR-4) having the loss tangent of 0.025 \([10]\). The circular radiating patch of diameter 11 mm is fed by a micro strip line of width 2 mm. The feed gap between patch and ground plane is 1mm. The length of ground plane is 11.5 mm. The material which is used in the CP-UWB antenna at the ground plane and circular patch is copper annealed. Simulations of this antenna have been done by using CST (Computer Simulation Technology) microwave studio suite.

### III. RESULT AND DISCUSSIONS

The feed gap between the radiating patch and the ground plane is required to achieve the impedance bandwidth. Here authors have taken four different values of the feed gap (0mm, 0.5mm, 1mm, 1.5mm) in order to determine the optimal size of the feed gap.

Fig 2 shows the simulated return loss \((S_{11})\) curves for different feed gaps. Fig 2 and Table 2 shows the change of absolute fractional band width with the variation of feed gap. The optimal feed gap from the simulated result is found to be 1.5mm with the fractional bandwidth of 110.13\%. When the feed gap is 0.5mm, it will degrade the impedance bandwidth but when feed gap is kept less than or equal to 1. The fractional bandwidth of CP-UWB antenna does not offer much deviation.

### Table 2 Simulated -10dB Bandwidth of Proposed Antenna for Different Feed Gap Values

<table>
<thead>
<tr>
<th>Feed gap(mm)</th>
<th>(f_L) (GHz)</th>
<th>(f_U) (GHz)</th>
<th>Absolute Bandwidth(GHz)</th>
<th>Fractional Bandwidth(%)</th>
<th>(f_c) (GHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 mm</td>
<td>4.5096</td>
<td>13.561</td>
<td>9.0514</td>
<td>100.17</td>
<td>9.0353</td>
</tr>
<tr>
<td>0.5 mm</td>
<td>4.2558</td>
<td>12</td>
<td>7.7442</td>
<td>95.27</td>
<td>8.1279</td>
</tr>
<tr>
<td>1 mm</td>
<td>4.1712</td>
<td>13.251</td>
<td>9.0798</td>
<td>104.23</td>
<td>8.7111</td>
</tr>
<tr>
<td>1.5 mm</td>
<td>3.9174</td>
<td>13.519</td>
<td>9.6016</td>
<td>110.13</td>
<td>8.7182</td>
</tr>
</tbody>
</table>

The VSWR for proposed antenna is plotted for different feed gaps. At 0 mm feed gap, the VSWR is acceptable in the frequency range 4.4585 GHz- 9.1366 GHz, for 0.5 mm feed gap the VSWR is found to be good in the frequency range 4.1256 GHz- 12.477 GHz, at 1 mm feed gap the VSWR is observed in the frequency sweep of 3.9727 GHz- 12.831 GHz.
and at last for 1.5 mm feed gap the VSWR is found to be optimum in the frequency range 3.818GHz-13.268 GHz. The VSWR, for proposed antenna gives the best result at the feed gap of 1.5 mm. This observation shows that antenna is perfectly matched and it suffers less mismatch loss. As the feed gap of antenna varies, simulated VSWR changes accordingly. However, as the feed gap is taken below 1 mm the VSWR suffers drastically.

The elevation pattern for the antenna is simulated at the H-plane (ϕ = 0, yz-plane) and E-plane (ϕ = 90, xy-plane). The E-plane pattern is the radiation plot which is measured in a plane containing excitation, and the H-plane pattern is the radiation plot in a plane orthogonal to the E-plane.

The group delay of CP-UWB antenna is observed at different feed gaps, the evaluating values are at 0 mm feed gap group delay is 6.2 ns, at 0.5 mm it is 0.46 ns, for 1 mm feed gap it is calculated as 0.58 ns and at 1.5 mm feed gap it comes out to be 3.5 ns. Therefore, from the above graph it has been observed that with feed gap 0 mm the antenna suffers maximum delay at 6.2 ns however the optimum results are obtained, if feed gap is taken as 1.5 mm.
The elevation pattern for CP-UWB antenna is plotted for different frequencies 4GHz, 6GHz and 8 GHz along with different feed gaps 0mm, 0.5mm, 1mm and 1.5mm. The radiation pattern of CP-UWB antenna comes out to be an omni directional radiation pattern. The simulation results of E-plane radiation pattern shows that it becomes smaller as the frequency increases.

IV. CONCLUSION

In this research endeavor we present a novel CP-UWB antenna over the frequency span of 3.9174 GHz to 13.519 GHz. We optimized the antenna design by parametric study on the basis of feed gaps and compare the antenna performance in terms of return loss, voltage standing wave ratio, group delay and radiation pattern. The optimum range of return loss is observed at 1.5 mm feed gap having the frequency span of 3.9174 GHz to 13.519 GHz and for 1.5 mm feed gap VSWR is optimum in the frequency range of 3.818 GHz to 13.268 GHz. The optimum value of the group delay is 3.5 ns.

V. REFERENCES

AUTHOR’S BIOGRAPHY

Divya Pahariya was born in Kanpur, UP, India, in 1990. She received Bachelor of Technology degree in Electronics & Communication Engineering from UPTU, Lucknow, India. She joined M.Tech in Electronics & Communication Engineering from Dr. A.P.J. Abdul Kalam Technical University, Lucknow, India, in 2014.

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