A Novel Compact UWB Not-Concentric Split Ring Resonator Patch Antenna For UWB Wireless Communications

Iman Ben Issa* and Mohamed Essaaidi**

*Information and Telecommunications Systems Laboratory, Electronics and Microwaves Group. Abdelmalek Essaadi University, Faculty of Science, Tetuan, P. O. Box 2121, Tetuan, Morocco
**ENSIAS, Mohammed V University, Rabat, Morocco
e-mail: benissa.iman@hotmail.com, m.essaaidi@ieee.ma

Abstract-A new ultra-wideband (UWB) patch antenna is proposed, based on two not-concentric split ring resonator with the ground plane printed on the same substrate face, the radiation elements of the proposed antenna are electromagnetically fed by a microstrip line with rectangular slot printed on the opposite face of the substrate. The antenna is operating the frequency band ranging from 3.56 GHz up to 16 GHz. The radiation pattern plots are also presented and discussed in this paper. The entire antenna occupies only a small volume of 30 mm x 31.5 mm x1.5 mm. A prototype of the optimized antenna was fabricated and measured. Measurement and simulation results show a very good agreement.

Index Terms-Antennas, Compact, Split ring resonator, Ultra wideband.

I. INTRODUCTION

Microstrip antennas are superior to conventional antenna due to their low profile, compact, and conformable structure. But some of the shortcomings such as narrow bandwidth and low efficiency restrict its practical applications in microwave technologies. A number of papers have presented different techniques to overcome these shortcomings based on the use of aperture coupling feeding [2], parasitic elements [3], and different kinds of slots in the radiating patch [4,5]. The stacking of fed patch and using different shapes of radiating patches also improve the antenna bandwidth [6,7]. Furthermore, the size of the patch antenna sometimes restricts its wide application, therefore, several techniques have been proposed to reduce the size of the antenna such as using high dielectric constant materials [8], shorting walls, and shorting pins [9,10].

In this paper, a new ultra-wideband (UWB) patch antenna is presented. A two not-concentric split ring resonator with the ground plane onto the same substrate face. The radiation elements of the proposed antenna are electromagnetically coupled to a microstrip feed line with a rectangular slot printed in the opposite face of the substrate. The operating frequency band of this antenna ranges from 3.56 GHz to 16 GHz. Section II discusses the details of the antenna design. In section III, the different geometrical parameters effects on the antenna performances are discussed. Numerical and experimental results related with return loss and radiation pattern are presented and discussed in section IV. A final conclusion is drawn in section V.

II. ANTENNA CONFIGURATION

Fig.1 shows the geometry of the proposed antenna which consists two not-concentric split ring resonator with the ground plane printed onto the same face of a dielectric substrate and a microstrip feed line with a rectangular slot is printed on the backside of the substrate. The centers and radii of inner ring is noted by (O1, a1, a2) and outer ring is noted by (O2, b1, b2), the distance between centers of inner ring and outer ring is denoted by S=O1O2. A rectangular slot is cut in the microstrip feeder, the dimensions of the rectangular slot are w2 x l2. The width w1 and the length l1 of the microstrip feeder are 3 mm x
19.5 mm with 50 Ω characteristic impedance. The proposed antenna is printed on FR-4 substrate with a thickness of 1.5 mm and a relative dielectric constant εr = 4.4, and a loss tangent of 0.02. The total dimension of the antenna is (W x L x h) = 30 x 31.5 x 1.5 mm³. The Design Parameters of the UWB antenna are given in Table 1.

![Fig. 1. Configuration of proposed antenna](image)

The substrate’s in white color, and copper thickness 0.035mm in gray color.

**Table 1: Design Parameters of the UWB Non-Concentric Split Ring Resonator Patch Antenna.**

<table>
<thead>
<tr>
<th>Antenna Parameters</th>
<th>Values /mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substrate plan length L</td>
<td>31.5</td>
</tr>
<tr>
<td>Substrate plan length W</td>
<td>30</td>
</tr>
<tr>
<td>Radius of inner ring : a1, a2</td>
<td>4 and 7.2</td>
</tr>
<tr>
<td>Radius of outer ring : b1, b2</td>
<td>9.8 and 13.5</td>
</tr>
<tr>
<td>Gap of inner ring g1</td>
<td>2</td>
</tr>
<tr>
<td>Gap of outer ring g2</td>
<td>2</td>
</tr>
<tr>
<td>Distance between centers of inner ring and outer ring S = O1O2</td>
<td>1</td>
</tr>
<tr>
<td>Radius which cuts the ground R</td>
<td>13.8</td>
</tr>
<tr>
<td>Truncation for ground d1</td>
<td>3.5</td>
</tr>
<tr>
<td>Width of ground d</td>
<td>7</td>
</tr>
<tr>
<td>Feedline length l1</td>
<td>19.5</td>
</tr>
<tr>
<td>Feedline width w1</td>
<td>3</td>
</tr>
<tr>
<td>Slot Feedline length l2</td>
<td>5</td>
</tr>
<tr>
<td>Slot Feedline width w2</td>
<td>2</td>
</tr>
<tr>
<td>Substrate material</td>
<td>FR-4(εr = 4.4)</td>
</tr>
<tr>
<td>Substrate thickness, h</td>
<td>1.5</td>
</tr>
</tbody>
</table>

III. EFFECTS OF KEY PARAMETERS

In order to get adequate information of the antenna operation mechanics, the effects of geometric parameters on antenna bandwidth are investigated. The parameters S, R, d1, l2, g1 and g2 are selected in the parametric study. To accurately understand the influence of these parameters on its impedance bandwidth, only one parameter is studied at each time while others are kept constant.

Some important observations have been made during the design concerning the variation of several parameters. These parameters contribute largely in achieving the UWB behavior. The effects of each parameter are shown in fig. 2, 3, 4, 5 and 6.

Fig.2 shows the return loss of the antenna with different values of S. It is clearly seen that this parameter affects the whole frequency range. When S is equal to 0 or 2mm, the antenna has a multiband frequency response. When S= 1mm, the matching is improved in all the frequency band, and an ultra-widthband behavior is achieved.

Fig.3 shows the return loss of the antenna with different values of R. It can be noted that when R= d1= 13.5mm the antenna has a dual band behavior, on account of the absence of the spacing between the outer ring and the ground. The presence of the spacing or the coupling...
between these two changes the antenna behavior, which becomes UWB for a value of \( R = 13.8 \text{mm} \).

the ultra wideband operation is possible for \( g_1 = 2 \text{mm} \) and \( g_2 = 2 \text{mm} \).

Fig. 2. Simulated return loss versus frequency for different \( S \) values (\( R = 13.8 \text{mm}, d_1 = 3.5 \text{mm}, l_2 = 5 \text{mm}, g_1 = g_2 = 2 \text{mm} \)).

Fig. 3. Simulated return loss versus frequency for different \( R \) values (\( S = 1 \text{mm}, d_1 = 3.5 \text{mm}, l_2 = 5 \text{mm}, g_1 = g_2 = 2 \text{mm} \)).

Fig. 4. Simulated return loss versus frequency for different \( d_1 \) values (\( S = 1 \text{mm}, R = 13.8 \text{mm}, l_2 = 5 \text{mm}, g_1 = g_2 = 2 \text{mm} \)).

Fig. 5. Simulated return loss versus frequency for different \( l_2 \) values (\( S = 1 \text{mm}, R = 13.8 \text{mm}, d_1 = 3.5 \text{mm}, g_1 = g_2 = 2 \text{mm} \)).

Fig. 6. Simulated return loss versus frequency for different \( g_1 \) and \( g_2 \) values (\( S = 1 \text{mm}, R = 13.8 \text{mm}, d_1 = 3.5 \text{mm}, l_2 = 5 \text{mm} \)).
IV. RESULTS AND DISCUSSION

In this section the comparison between measured and simulated frequency responses of return loss, radiation patterns of the proposed antenna are presented and discussed. The fabricated antenna prototype is shown in Fig. 7.

![Photograph of the fabricated prototype](image)

(a) Top face

(b) Bottom face

Fig. 7. Photograph of the fabricated prototype.

A. Reflection coefficients

The measured and simulated of Return Loss of the proposed UWB patch antenna are shown in Fig. 8 where a 127.19% fractional bandwidth is obtained. Thus, this antenna is very suitable for operation UWB wireless technology systems.

B. Radiation Patterns

Fig. 9 illustrates the measured and simulated radiation patterns at 3.56 GHz, 9.78 GHz and 16 GHz. In E-plan Phi=0°, as shown in Fig. 9(a) and 9(b), the radiation pattern is nearly omni-directional. However, in Fig. 9(c) the radiation pattern is multi-directional. In E-plan Phi=90°, as shown in Fig. 9(a) the radiation pattern is bidirectional. In Fig 9(b) and Fig. 9(c), the radiation patterns are multidirectional.

V. CONCLUSION

A new compact ultra-wideband (UWB) patch antenna is presented in this paper. A 127.19 % fractional bandwidth compact not-concentric split ring resonator patch antenna is designed, and characterized in details. A prototype of the proposed antenna is being designed and tested. The good agreement between simulation and measurement is obtained. It can be applied to modern UWB very high speed wireless communication technologies in the frequency band ranging from 3.56 GHz to 16 GHz.
REFERENCES


Fig. 9. Measured and simulated radiation patterns of proposed antenna (a) 3.56GHz, (b) 9.78GHz, (c) 16GHz.