Wideband Microstrip fed Stacked Rectangular Dielectric Resonator Antenna for WLAN application

G.D. Makwana, K.J. Vinoy
Microwave Laboratory, ECE Department, IISc, Bangalore, India
gmakwana@gmail.com, vinoykj@gmail.com

Abstract

This paper presents a microstrip fed stacked rectangular dielectric resonator antenna (RDRA) operating at 5.2 GHz for wireless local area network (WLAN) applications. The proposed antenna consists of two rectangular slabs of microwave dielectric materials with dielectric constants of 32 and 10.2 stacked vertically to obtain improved bandwidth. Antenna has been fed with a 50Ω microstrip transmission line printed on a grounded substrate. Physical parameters of stacked RDRA have been optimized by extensive numerical simulations using HFSS. The experimental results agree with simulation.

Key words: Stacked rectangular dielectric resonator antenna, WLAN application.

1. Introduction:

Although microstrip patch antennas are popular for microwave applications, these have disadvantages including wide beam width, narrow bandwidth (1 to 6%), surface wave excitation (which distorts the radiation pattern and increase power loss), high fabrication tolerances sensitivity and conductor losses (which increase dramatically with frequency). Attempts to reduce these negative effects have proven to achieve limited success, since an improvement in one aspect usually comes with degradation in another factor. In this context, Dielectric Resonator Antennas (DRAs) have been suggested for various applications as these offer several advantages, such as high efficiency, large bandwidth, low profile, ease of fabrication, and low production cost. The resonant frequency of a DRA is predominantly determined by its size, shape, material relative permittivity $\varepsilon_r$, and mode of operation [1]. DRAs are usually made of low-loss microwave dielectric materials with high dielectric constants. They have high radiation efficiency typically greater than 95% due to absence of conductor and surface losses. These advantages make DRA a candidate for emerging wireless and mobile communication systems where radiator area is an important factor. DRAs can be excited using probe, direct microstrip coupling, microstrip slot, and coplanar waveguide coupling [4, 5, and 6].

Several DRAs with standard shapes (hemispherical, cylindrical, and rectangular) are reported in literature [1, 2, and 3]. Rectangular DRAs are easy to fabricate and offer more design flexibility compared to other shapes, since two of its dimensions can be independently varied for a fixed resonant frequency and known dielectric constant. The mode degeneracy of the RDRA can be avoided by properly choosing the three dimensions of the resonator [2]. Hence, we chose the rectangular dielectric resonator for our investigation in this paper. Kishk et al [7] showed experimentally that stacking two different DRAs results in larger bandwidth than conventional homogeneous DRA. This paper investigates stacked rectangular DRA which consists of two different microwave materials with different dielectric constants. A microstrip transmission line is used to excite the stacked RDRA. Measured results are compared against the simulated results obtained from the EM Simulation software, HFSS. The proposed stacked RDRA has wide bandwidth suitable for WLAN applications.
2. Antenna Geometry:

Figure 1 shows the geometry of the proposed stacked rectangular DRA. As shown in Figure 1, a 50Ω microstrip line having width of 4.45 mm and length of 45 mm is printed on top of the substrate (dielectric constant of 2.5, thickness of 1.56 mm, and loss factor of 0.0017) and bottom of the substrate is ground plane. Two rectangular DRAs are used with same cross sectional area but different heights \( h_1 \) and \( h_2 \) to form a stacked RDRA. Table 1 lists the design parameters of the proposed stacked RDRA. The slab 1 is placed above the microstrip line for coupling, whereas the slab 2 is placed above the slab 1 for electromagnetic coupling. The total height, \( h \), of stacked RDRA is 4.56 mm. The size of ground plane is 80*50 mm².

<table>
<thead>
<tr>
<th></th>
<th>Dielectric constant (( \varepsilon_d ))</th>
<th>( w ) (mm)</th>
<th>( d ) (mm)</th>
<th>Height (mm)</th>
<th>Loss factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slab 1</td>
<td>32</td>
<td>17.0</td>
<td>7.0</td>
<td>3.00</td>
<td>0.0011</td>
</tr>
<tr>
<td>Slab 2</td>
<td>10.2</td>
<td>17.0</td>
<td>7.0</td>
<td>1.56</td>
<td>0.0017</td>
</tr>
</tbody>
</table>

Figure 1: Proposed stacked RDRA

3. Results and Discussion

Based on extensive simulation studies, microstrip line fed stacked RDRA is fabricated with the overall size of 17*7*4.56 mm³. Slab 2 is made of two layers of microwave material with dielectric constant of 10.2 and thickness of 0.78 mm. The photograph of fabricated stacked RDRA is shown in Figure 2. The return loss characteristic of stacked RDRA is measured by N5230A PNA series network analyzer. The measured and simulated return loss characteristics are shown in Figure 3. Table 2 lists measured and simulated performance of the proposed stacked RDRA. Measured results are in good agreement with simulated results. The fabricated stacked RDRA has a 10 dB return loss bandwidth of 6.11% at its resonant frequency of 5.23 GHz. The radiation patterns of antenna are measured in an anechoic chamber. The co- and cross- polarization patterns in the E-plane and H-plane of the antenna are presented at resonant frequency in Figure 4 and Figure 5 respectively. The antenna shows a cross polarization level better than -20 dB at the resonant frequency.
Figure 2: Fabricated stacked RDRA

Figure 3: Measured & simulated S11

Table 2 Performance of the proposed stacked RDRA

<table>
<thead>
<tr>
<th>Fr. (GHz)</th>
<th>S11 (dB)</th>
<th>BW (MHz)</th>
<th>%BW</th>
<th>Gain (dB) At bore site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stacked RDRA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simulated</td>
<td>5.21</td>
<td>-28.54</td>
<td>307</td>
<td>5.90</td>
</tr>
<tr>
<td>Measured</td>
<td>5.23</td>
<td>-22.90</td>
<td>320</td>
<td>6.11</td>
</tr>
<tr>
<td>Slab 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simulated</td>
<td>5.39</td>
<td>-15.75</td>
<td>210</td>
<td>3.89</td>
</tr>
</tbody>
</table>

Figure 4: Measured E plane radiation patterns
4. Conclusion:

Efficient antenna designs are needed in the frequency band of 5.15 GHz to 5.35 GHz for high speed data transfer for WLAN applications. In this paper, we have proposed a microstrip fed stacked rectangular DRA with 6.11% 10-dB return loss bandwidth. Due to the absence of conductor loss, the proposed antenna has high radiation efficiency. And due to the stacked it shows wideband operation. Due to these advantages, the antenna is proposed for WLAN application. This type of antenna also has a potential in wireless application such as cellular phones, MIMO wireless systems, WLAN, Wi-Fi, and GPS systems.

REFERENCE: