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Conformal Patch Fed Stacked Triangular Dielectric Resonator Antenna for WLAN Applications

Runa Kumari, Kapil Parmar and S K Behera
Department of Electronics and communication
National Institute of Technology, Rourkela, India
runakumari15@gmail.com
kapilparmar54@yahoo.com
skbehera@ieee.org

Abstract— **A Stacked triangular dielectric resonator antenna (DRA) fed by a conformal patch is proposed for WLAN applications. In this paper, triangular shaped three resonators with same dielectric constant and different sizes are stacked to improve the gain, bandwidth and radiation performances of DRA. An increase in bandwidth is further achieved by using air gaps. This Stacked DRA is excited by a conformal patch connected to a microstrip line which is an effective feed mechanism to obtain wideband operation and is more efficient in energy coupling than other types of feeding techniques. This stacked triangular DRA is simulated using a CST microwave studio suite^{TM} 2010. The simulated results show that the proposed DRA achieves an impedance bandwidth of about 41% for VSWR less than 2, covering a frequency range from 4.0 GHz to 6.02 GHz. Its maximum gain is 7.98 dBi. The proposed antenna is suitable for wireless local area networks (WLAN) applications in 5-6 GHz frequency range. This stacked DRA exceeds the bandwidth requirements for the IEEE 802.11a wireless local area network (WLAN) applications (in the frequency range 5.15-5.35 GHz and 5.725-5.825 GHz) within a 2:1 VSWR. Parametric studies of the antennas with CST microwave based design data and simulated results are presented here.**

Keywords- Dielectric Resonator Antenna (DRA); Stacked DRA; Conformal patch fee; CST Microwave Studio suite^{TM} 2010; WLAN.

I. INTRODUCTION

Wireless communications have grown at a very rapid pace across the world over the last few years, which provide a great flexibility in the communication infrastructure of environments such as hospitals, factories, and large office buildings. While WLAN standards in the 2.4-GHz range have recently emerged in the market, the data rates supported by such systems are limited to a few megabits per second. By contrast, a number of standards have been defined in the 5-6 GHz range that allow data rates greater than 20 Mb/s, offering attractive solutions for real-time imaging, multimedia, and high-speed video applications. To achieve the necessary applications a high performance wide band antenna with excellent radiation characteristics are required.

Dielectric Resonator Antennas (DRA) possess some peculiar properties which render them very promising, especially for millimeter wave applications. DRAs can be designed with different shapes to accommodate various design requirements. DRAs can also be excited with different feeding methods, such as probes, microstrip lines, slots, and co-planar lines [1]. As compared to the microstrip antenna, the DRA has a much wider impedance bandwidth due to their many advantageous features. These include their compact size, light weight, the versatility in their shape and feeding mechanism, simple structure, easy fabrication and wide impedance bandwidth [2]. Operating bandwidth of DRA is varied by choosing different dielectric constant of resonator material. DRA requires adhesive to mount the DR over the ground plane and more manual effort in the alignment of the DRA with the feeding structure [2].

Bandwidth enhancement is becoming the major design considerations for most practical applications of Dielectric resonator antennas [3]. Several bandwidth enhancement techniques have been reported on modified feed geometries and changing the shape of the DRA (including conical, tetrahedron, ring, triangular etc) [4]. The gain, bandwidth and radiation performances of DRA can further be modified by using stacked or stair shaped DRA instead of a single DRA [5-6]. Stacking of DRAs is an efficient technique to improve the gain, bandwidth and radiation performances [7-8]. Tayeb *et al.* had introduced an L-shaped DR antenna with the two equiangular triangles [9], which achieves an impedance bandwidth of 38%. It is discussed that an introduction of air gap between the dielectric resonator and the ground plane can improve the impedance bandwidth of the antenna significantly.

In this paper, we have designed stacked triangular DRAs for WLAN applications. To enhance the impedance bandwidth, we have introduced an air gap between the DRA's and the ground plane [10]. In this design, a conformal patch connected to microstrip line is used as a feeding technique to obtain wideband operation [11]. The CST microwave studio suite^{TM} 2010 software has been used to analyze the performance of the designed antenna such as return loss, radiation patterns and gain. The design methodology of the stacked DRA using conformal patch feed technique is discussed and the detail results of the proposed antenna are presented in this paper. Stacked DRA offers continuous operation from 5 to 6 GHz bandwidth. Thus it is the smart choice for WLAN operation.

II. ANTENNA DESIGN

The geometry of the proposed dielectric resonator antenna is shown in Fig. 1. We refer to this antenna as a triangular shaped stacked DRA. The DRA stacked configuration contains three equiangular-triangle shaped resonators with same dielectric constant and different sizes vertically stacked one atop of the other.

The resonance frequency of the TM_{mnl} mode in an equilateral-triangular DR on a ground plane is approximately given by [2]

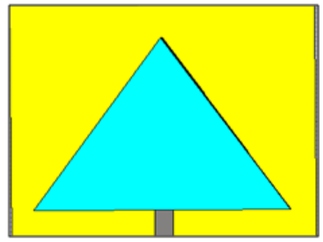
$$f_{mnl} = \frac{1}{2\sqrt{\varepsilon\mu}}\left[\left(\frac{4}{3a}\right)^2(m^2+mn+n^2)+\left(\frac{1}{2h}\right)^2\right] \quad (1)$$

where a is the length of each side of the triangle and h is the height of the resonator. The indices m, n and l should satisfy the condition $l+m+n=0$ but they all cannot be zero simultaneously. For low profile resonators where $a >> h$, this expression can be further simplified as

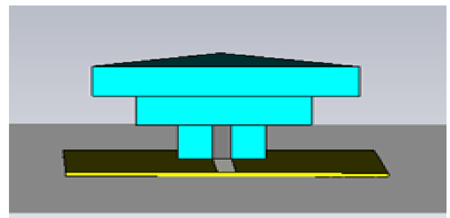
$$f_{mnl} = \frac{1}{4h\sqrt{\varepsilon\mu}} \quad (2)$$

In this design we used three dielectric resonators having same dielectric constant 9.8 with different size. The stacked DRA is excited by a conformal patch located at center of one side of small equiangular triangle which is connected to microstrip line feed. The stacked dielectric resonators are supported by a square substrate having relative permittivity constant ε_{r2}= 2.94 with dimensions ($L_S \times W_S$) 50mm×50mm and height h_s=0.762 mm. The dimensions of the ground plane are ($L_g \times W_g$) 50mm×50mm. Here the stacked DRA consists of three equiangular triangle where the lower layer resonator is with height h_1= 6.375 mm and sizes a_1= 13.86 mm, middle layer resonator is with height h_2= 6.375 mm and sizes b_1= 27.72 mm and the dimensions of upper layer resonator are height h_3= 5.575 mm and sizes c_1= 41.56 mm. As microstrip line feeding offers the advantage of easy and cost-effective fabrication of DRA, so to achieve a cost effective wideband operation the proposed DRA is excited via a conformal patch connected to a microstrip line which is an effective feed mechanism to obtain wideband operation [12]. Here, the dimensions of the microstrip feed line are ($L_f \times W_f$) 30mm×3mm.

Fig. 2 shows the schematic view of the equiangular-triangular shaped stacked DRA. The proposed DRA is designed to provide wireless local area networks (WLAN) applications.



Top view
Fig.1. The proposed stacked Dielectric Resonator Antenna



Front view
Fig.1. The proposed stacked Dielectric Resonator Antenna

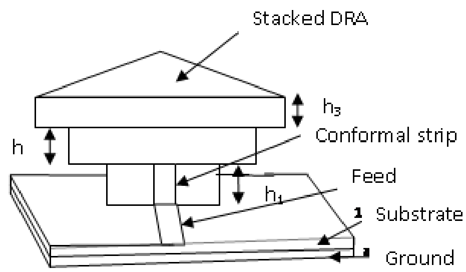


Fig.2 Schematic view of Stacked DRA

III. PARAMETRIC STUDY

Some characteristics of stacked DRA are described and Parametric study of the dielectric resonator antenna is carried out by using Computer Simulation Technology (CST) microwave studio suite™ 2010. As discussed in previous section the gain, bandwidth and radiation performance of DRA can be modified by using stacked DRA instead of single DRA. Thus, by stacking dielectric resonators we found wide impedance bandwidth in comparison to a single DRA, which is shown in Fig. 3. From the simulated results, it was observed that the impedance bandwidth of stacked DRA is 41% whereas in case of single dielectric resonator antenna design only 11% of impedance bandwidth was found. Furthermore, to achieve wideband operation, the stacked DRA is excited by using a conformal patch connected with microstrip line feed which is an effective feed mechanism. In this type of feeding technique by altering the height of the conformal patch, we have observed a bandwidth variation in simulated results. A parametric study is carried out by varying the height of the conformal patch of the stacked DRA to achieve optimum antenna performances. Fig. 4 shows the simulated return loss for different heights of conformal patch such as 5.375 mm, 6.375 mm and 7.375 mm. For the case h = 6.375 mm, a wide bandwidth with good return loss is observed.

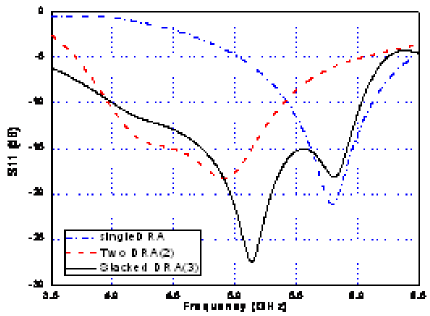


Fig 3. Comparison of return loss plots of a single DRA, stacked DRA with two resonators and stacked DRA with three resonators.

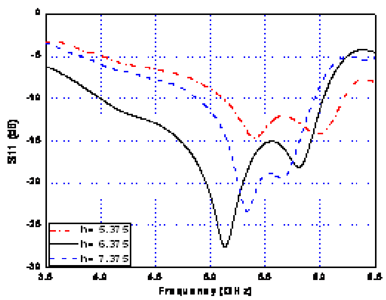


Fig. 4 Simulated return loss with different values of height of conformal patch.

IV. Results and Discussion

A triangular shaped stacked DRA for 4-6.02 GHz bandwidth has been designed and analyzed using CST Microwave studio suite™ 2010. Fig 3, 4, 5 shows the simulated results obtained for the return loss parameters. In Fig 3, we observed that the bandwidth of the DRA directly influenced by the number of resonators used. Compared with the bandwidth of single DRA, stacked DRA with three resonators is giving wide bandwidth result. From Fig 4, it is notable that with 5.375 mm height of conformal patch the DRA did not show a performance as good as with height 6.375 mm and 7.375 mm. Thus, the final simulated return loss of three resonators stacked DRA with 6.375 mm height of conformal patch, plotted against frequency is shown in Fig.5. The simulation results of proposed log periodic DRA was also showing very good radiation patterns and VSWR over the entire frequency range. It was found that VSWR values are less than 2 over the entire bandwidth.

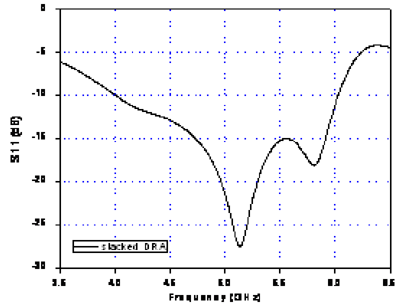


Fig 5. Simulated return loss plot of the Stacked DRA

Fig. 6 plots the simulated gain versus frequency of the proposed stacked DRA, where the peak gains are about 6.363 - 7.98 dBi across the entire operating bandwidth. The simulated peak directivity varies from 5.03 dBi to 6.7 dBi over the entire band. The directivity versus frequency plot is shown in Fig 7. The simulated far field radiation patterns of the proposed DRA are almost same for all frequencies. Fig. 8 shows the simulated radiation patterns at different frequencies (5.0 GHz, 5.2 GHz, 5.5 GHz and 5.8 GHz). It is observed that the E plane radiation patterns are in broadside direction against frequency.

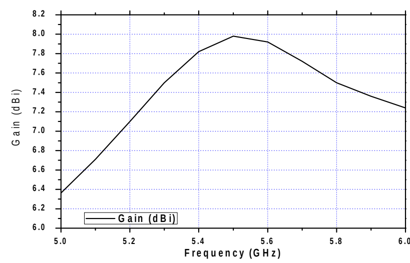


Fig 6. Simulated Gain versus Frequency of the Stacked DRA

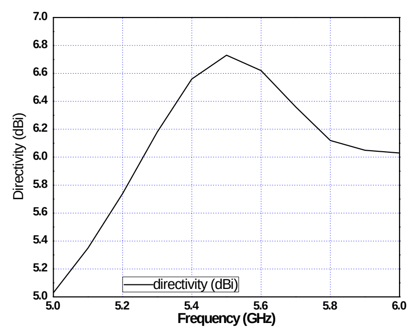
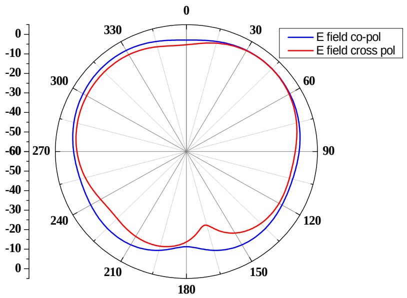
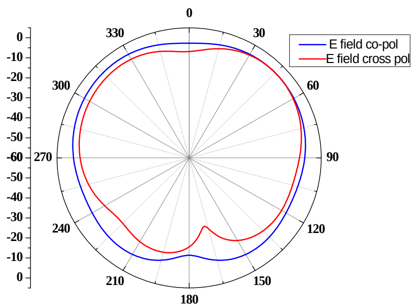


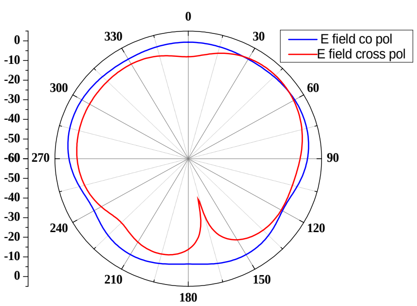
Fig. 7. Simulated Directivity versus Frequency.



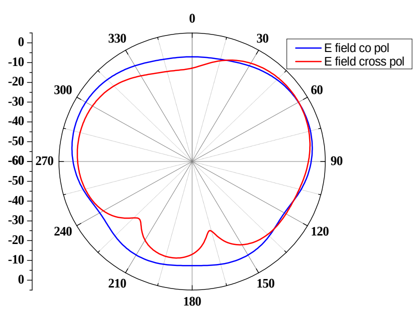
(a) E Field at 5 GHz



(b) E Field at 5.2 GHz



(c) E Field at 5.5 GHz



(d) E Field at 5.8 GHz

Fig. 8. Simulated E plane radiation patterns of stacked DRA at (a) 5 GHz , (b) 5.2 GHz, (c) 5.5 GHz and (d) 5.8 GHz

IV. CONCLUSION

A stacked triangular shaped dielectric resonator antenna is presented to improve the impedance bandwidth of the DRA for WLAN applications. It was found that due to introduction of air gap between DRAs and ground there is a significant change in the result. The simulated results show that the proposed antenna offered more than 41% impedance bandwidth, covering the frequency range from 4.0 to 6.02 GHz and a stable radiation with a gain range of 6.36 to 7.98 dBi across the operating band. This antenna is designed to satisfy 5.0-6.0 GHz wireless LAN application. In this case an excellent bandwidth enhancement was found by stacking the DRAs in comparison to use a single DRA. Fabrication of the proposed antenna will be carried out in future.

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