A Notched Chamfered Rectangular Dielectric Resonator Antenna Array for Wireless Applications

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***Abstract*— Design of Notched Chamfered Rectangular shaped two elements Dielectric Resonator Antenna (DRA) array is presented for wireless (WLAN and WiMAX) applications. In this paper, the DRA array is excited by conformal patch connected to microstrip line which is an effective feed mechanism and more efficient in energy coupling than other types of feeding techniques. Simulation results show, the proposed antenna achieves an impedance bandwidth from 2.18 to 3.75 GHz and 4.84 to 5.14 GHz covering 2.4, 3.6 and 5 GHz WLAN bands and 3.4 to 3.7 GHz WiMAX bands. Comparison is done among various shapes of the rectangular DRA arrays (Simple Rectangle, chamfered and chamfered with notched). A parametric study is carried out by varying the ground plane's dimension of the final design. The proposed antenna gives the appreciable gain and radiation pattern at the resonant frequencies.**

Keywords- Notched Chamfered Rectangular DRA array, Dielectric Resonators, Conformal patch feed, WLAN, WiMAX.

I. INTRODUCTION

In wireless communication, antenna plays a vital part in transmitting the signal. In recent years, the DRA has been widely studied due to its several advantages. It offers very wide design flexibility including wide range of permittivity from 8 to 100. It is possible to design different shaped DRA which can be excited by using various feeding methods [1], [2]. DRAs can provide wide bandwidths, low dissipation loss at high frequencies, high radiation efficiency due to the absence of conductors and surface wave losses, high permittivity, light weight and ease of excitation [3]. In many cases with a single element DRA, desired specifications cannot be achieved. For example a high gain, high efficiency, directional radiation pattern cannot be synthesized with a single DRA of any shape. In these applications, a DRA array with appropriate element arrangement and modified feed configurations can be used to provide desired specifications [4]-[9]. The Q-factor can be lowered and bandwidth can be improved by removing the central portion of the dielectric resonators (by introducing a central notch in resonators) [10]. Further the resonant frequency of the DRA can be improved by chamfering the four corners of the resonators.

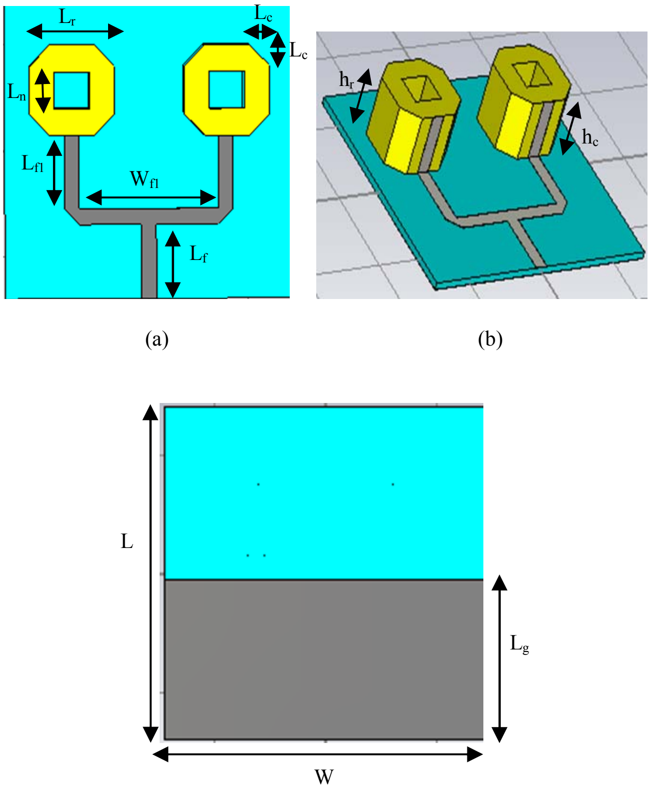
In this paper, we presented a notched chamfered rectangular dielectric resonator antenna array fed by microstrip line for wireless (WLAN covering 2.4, 3.6 and 5 GHz bands and WiMAX covering 3.4 to 3.7 GHz frequency band) applications. These are limited by IEEE 802.11 and IEEE 802.16 standards, which overlap with each other. The central portion of the dielectric resonators of the DRA array is removed (notched) and the four corners are chamfered for lowering the Q-factor and to increase the bandwidth and to get the desired resonant frequencies. In this design, a conformal patch is connected to microstrip line used as a feeding technique to obtain the desired performance. The antenna is simulated to analyze the performance of the designed antenna array such as S-parameters, radiation patterns and realized gain. The design methodology of this DRA array is discussed and the detail results of the proposed antenna are reported in this paper.

II. ANTENNA DESIGN

The geometry of the proposed DRA array has been shown in Fig.1, where rectangular shaped two element dielectric resonators having same dielectric constant 9.8, are placed over the substrate having dielectric constant 4.4. The thickness of the substrate is 1.6 mm.

The dimension of the substrate is 58×56 mm^2 (W×L). The ground plane is dimensioned as 58×27 mm^2 (W×L_g). Partial ground plane is used to further enhance the bandwidth of the DRA. The DRA array consists of two rectangular shaped dielectric resonators, where the resonators having height h_r = 13.5 mm and sides L_r = 17 mm. The four corners of the rectangular resonator is chamfered with L_c = 4 mm. The central portion of the resonators are removed i.e. rectangular notches are introduced in the centers with side L_n = 7 mm. The chamfered and notched techniques are used to enhance the performance of the antenna. Proper spacing between the two resonators is maintained to avoid mutual coupling. The conformal strips are adopted as an excitation mechanism which is attached on one side of the dielectric resonator and connected to a microstrip feed line. The conformal strip has height h_c = 13.45 mm and width W_c = 3 mm. The microstrip feed line is etched on FR4 substrate with width W_f = 3 mm, W_{f1} = 28 mm, and length L_f = L_{f1} = 14 mm which is connected by a SMA connector.

This design of the proposed DRA array is useful for multi-frequency operations [11], [12]. The multi-frequency technique is another alternative way to overcome narrow band limitations [13].By comparing the three designs i.e. a simple rectangular DRA, a rectangular DRA with chamfered corners and a notched chamfered rectangular DRA, we observed that the DRA array with notched chamfered resonators give better results and desired resonant frequencies than the former two designs.



(a) (b)

(c)

Fig.1 (a) Front view (b) Perspective view and (c) Rear view of the Notched chamfered Rectangular shaped Dielectric Resonator Array

III. PARAMETRIC STUDY

Parametric study is carried out by comparing different designs of the rectangular DRA array to achieve good antenna performances. Fig.2 shows the simulated S-parameter for different designs of rectangular DRAs. For the case of notched chamfered rectangular DRA array widest bandwidth with good return loss is perceived.

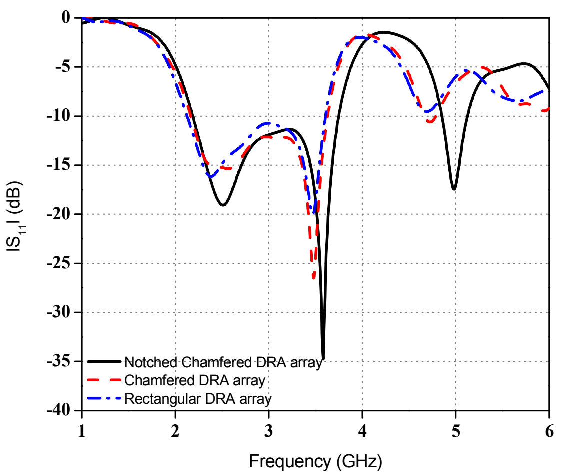


Fig.2 Comparison of S-parameter of different shapes of DRAs

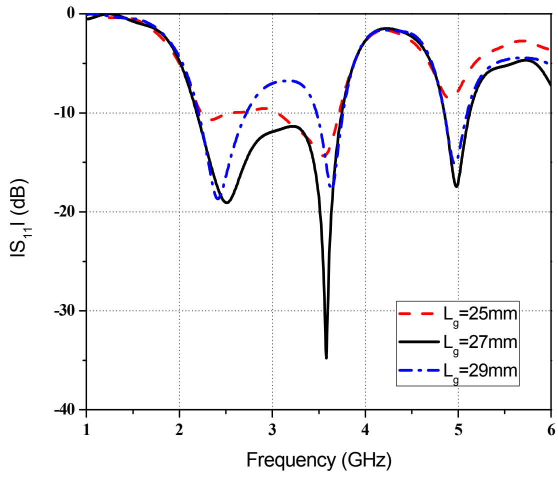


Fig.3 Comparison of S-parameter by taking different L_g values

A bandwidth from 4.84 to 5.14 GHz, covering the 5 GHz resonant frequency is also observed only in case of notched chamfered DRA. Simulated result shows the DRA array with the rectangular resonators having central notches and chamfered corners has a better resonant frequency, S-parameters and bandwidth for dielectric resonator's height h_r = 13.5 mm and conformal patch height h_c = 13.45 mm.

Another parametric study is carried out by varying the ground plane's dimension of the antenna which is shown in Fig.3. By taking different heights of the ground plane i.e. L_g = 25, 27 and 29 mm, it has been observed that L_g = 27 mm gives multi-band characteristics and covers the desired 2.4, 3.6 and 5 GHz resonant frequencies, while for other values of L_g the desired results are not obtained.

IV. RESULTS AND DISCUSSION

A modified rectangular shaped DRA array for wireless band has been designed and analyzed. Fig.2 shows the simulated S-parameter of the final design. In Fig.2 we observed that the resonant frequency, bandwidth and S-parameters of the DRA array are directly influenced by changing the shape of the dielectric resonators. It has been noticed that with a rectangular central notch and chamfered sides, the DRA achieves better bandwidth where the S-parameter is showing good performance as compared to other designs of rectangular DRAs. From Fig.3 it has been observed that by setting the ground plane L_g = 27 mm, better results compared to other values are achieved. Conformal strip feeding technique is used with a 50 Ω transmission line to get multi-band frequency response.

A. Gain Characterestics

Fig.4 plots the simulated gain versus frequency of the proposed DRA array, where the gain is 3.44 dB at 2.4 GHz, 5 dB at 3.6 GHz and 7.8 dB at 5 GHz. The gain of the DRA is improved by using array method. The DRA also gives a VSWR value less than 2 over the entire frequency range.

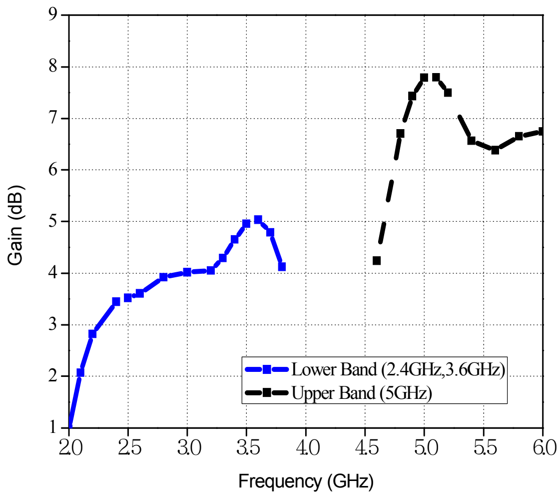
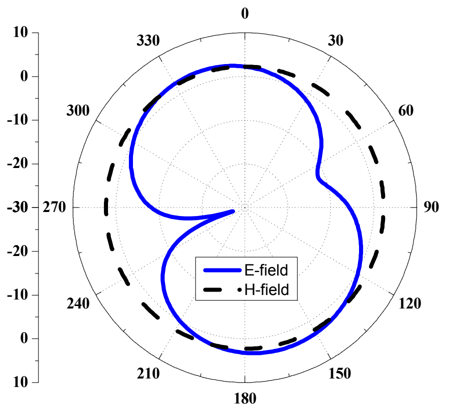
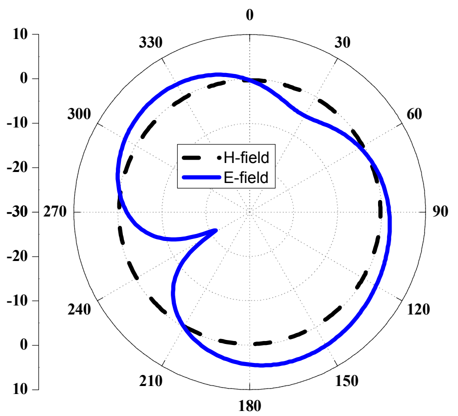


Fig.4 Simulated gain versus frequency curve for 2.4, 3.6 and 5 GHz

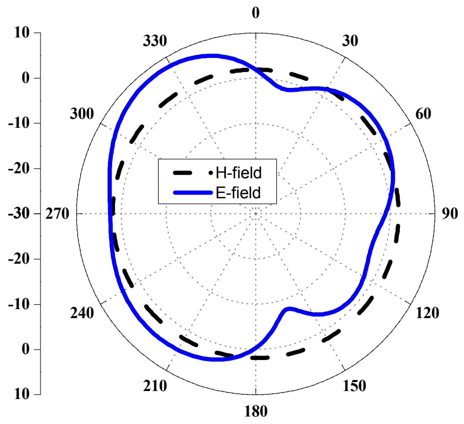
B. Radiation Pattern Characteistics



(a) At 2.4 GHz



(b) At 3.6 GHz



(c) At 5 GHz

Fig.5 Simulated radiation pattern of proposed DRA array at

(a) 2.4 GHz (b) 3.6 GHz and (c) 5 GHz

The simulated far field radiation patterns of the proposed two elements rectangular shaped DRA array is shown in Fig.5. It shows the simulated radiation patterns at desired resonant frequencies (2.4 GHz, 3.6 GHz & 5 GHz). It has been observed that the E plane radiation patterns are in broadside direction against frequency and in H plane omnidirectional radiation patterns are found.

V. CONCLUSION

In this paper, a chamfered rectangular shaped dielectric resonator antenna array with central notch is presented for wireless applications. The proposed DRA array consists of two rectangles of equal sides which are excited by conformal patch fed connected to microstrip line. The simulated results show the designed antenna covers the desired frequencies at 2.4 GHz, 3.6 GHz and 5 GHz, which covers several important application bands in current wireless communication systems. The presented multi-band DRA array is suitable for WLAN and WiMAX applications.

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