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Dual Band Dielectric Resonator Antenna for Wireless Application: Review

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Abstract: The technique which is introduced here is the combination of a aperture antenna and a dielectric resonator antenna (DRA). It is designed without accommodation of miniaturization and efficiency. It has been observed that aperture and DRA may be integrated to utmost wide bandwidth above it the radiation pattern and antenna polarization are protected. Here the study shows that the impact of aperture size on the radiation pattern of Dielectric Resonator Antenna. Here for the performance evaluation Ansoft HFSS Software is used. In this article the simulated and measured results are shown after completion. It has been presented that the shape aperture can exceptionally impact the radiation phenomena of the antenna excellent accordance between the simulated and measured results.

Keywords: DRA, Microstrip patch antenna, Return loss, Slot antenna, S-Parameters.

I. INTRODUCTION

The main component of wireless communication is antenna for transmitting/ receiving the radio waves. Now a days, as the size of mobile devices reduces day by day so we have to design low profile antennas. , the size of the communication device reduced to the size further and made it a hand held device. Hence, it was now easier for every member of the fighting unit to carry a hand held communication device making the unit highly mobile and communication link reliable. Further, to make the device light weight and to integrate the antenna within the device microstrip antenna may be in use. In the journey of transformation of the communication equipment from the four wheels of a vehicle to hand held equipment, the research and development of the components used has played a vital role. One of the components that is used in the communication equipment and that plays a vital role in determining the overall size of communication device is the antenna. If size of the Microstrip antenna, which may be used in the hand held communication device, can be reduced then the overall size of the device may be reduced further. Compact hand held communication devices are also in demand in the civilian market. It is due to the microstrip antenna integration into the cellular phones that has made the manufacturing of light weight cellular handsets possible. If compact microstrip antenna may be designed, then this will also help to reduce the size of communication devices meant for the civilian use. In these days achievement in the study of DRA is great rather than conventional antenna. DRA gives us better benefit and great potential. In this generation the size of mobile devices reduces day by day in forth coming days next generation needed a miniaturized and high data rate being developed along with mobile and cellular communication technology. In forth coming days the next generation needed a miniature device and high data rate device. Wi-Fi and wimax are both has been developed for the same purpose. Useful and smaller antenna wireless antenna has significant role in our life. For the same purpose portable antenna technology is being developed along with mobile and cellular communication technology. DRA have several features like low profile and low cost shows that DRA is useful for WLAN and wimax application system. DRA has a small size, high radiation efficiency, weightless. In the last few there is a drastic changes and growth in the development of wireless communication[1]-[3].We have noticed that after passing a long time each technological advancement rely on the other technological development. Size of mobile handset is necessary for mobile communication. Shape of this mobile handset was also rely on the form of antenna being used with other component. These antenna formerly used for bigger size of antenna because they had to place on large objects. Due to place occurrence of microstrip patch antenna and other evolutions the size of mobile devices could be reduced and became truly handheld because of their light weight, low cost and high frequency, it is derived from micro strip circuit.MPA is made up of quite thin layer of metal both layer have different characteristics one is radiating layer, second layer act as ground plane. Usually size is big while thickness is less of microstrip patch antenna that is why conformal to the surface. It is derivate of microstrip circuit they have good harmony. Other than communication it has been using in missile system, Radar, Body worm antenna troop. Advantage of microstrip antenna is low cost and weight less etc. But the main disadvantages of microstrip antenna are its narrow bandwidth, high metallic losses and surface wave loss [4]. To overcome the drawback of microstrip antenna, dielectric resonator antenna has been developed. DRA are the energy storage devices.

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Dielectric resonators are usually surrounded by metallic plate in order to prevent radiation. If the metallic plate is removed, a dielectric resonator radiates the energy and then it works as an antenna. There are lots of advantages of DRA such as low metallic losses and also avoid surface waves due to which we get higher efficiency. Another important feature of DRA is that it gives higher bandwidth as compared to microstrip antenna [5].

DRAs rely on radiating resonators that can transform guided waves into unguided waves (RF signals). In the past, these antennas have been mainly realized by making use of ceramic materials characterized by high permittivity and high factor (between 20 and 2000). Currently, DRAs made from plastic material (Polyvinyl Chloride (PVC)) are being realized. The main advantages of DRAs are summarized as follows:

1) The size of the DRA is proportional to with being the free-space wavelength at the resonant frequency and where denotes the relative permittivity of the material forming the radiating structure. As compared to traditional metallic antennas whose size is proportional to , DRAs are characterized by a smaller form factor especially when a material with high dielectric constant is selected for the design.
2) Due to the absence of conducting material, the DRAs are characterized by high radiation efficiency when a low-loss dielectric material is chosen. This characteristic makes them very suitable for applications at very high frequencies, such as in the range from 30 GHz to 300 GHz. As a matter of fact, at these frequencies, traditional metallic antennas suffer from higher conductor losses.
3) DRAs can be characterized by a large impedance bandwidth if the dimensions of the resonator and the material dielectric constant are chosen properly.
4) DRAs can be excited using different techniques which is helpful in different applications and for array integration.
5) The bandwidth, gain and polarization characteristics of a DRA can be easily controlled using different design techniques.

Types of DRA: Various types of DRA shown in figure 1[11].

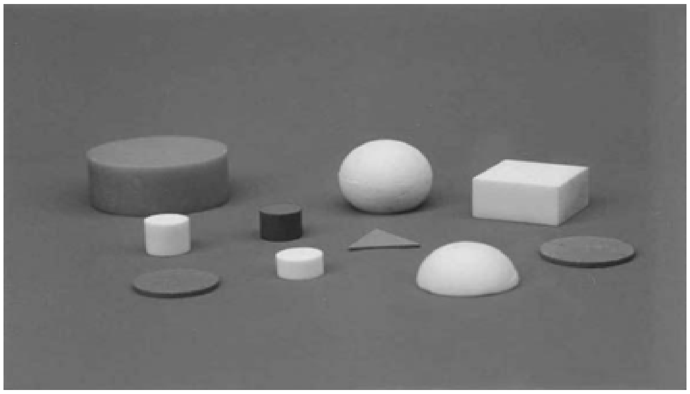

Fig.1. various shapes of DRA

II. LITERATURE REVIEW

Yao-Dong et al. [3] presented a new single-fed wide dual-band circularly polarized (CP) dielectric resonator antenna (DRA).. The antenna in this article the simulated and measured consequences are shown after completion. In the current age of cellular communication, the research is widely focused on dual polarized DRA because these radiators are insensitive to the orientation and multipath interferences between transmitter and receiver antennas. Numerous researchers have been established various techniques to create CP characteristics in DRA like diversified feeding mechanism and shapes of DRA (semi-eccentric DRA, staked rectangular DRA as well as hybrid cylindrical DRA). Though the beneath rectangular aperture the DRA is excited and its HE_{111} and $HE_{11\delta}$ (2 <; δ <; 3) modes are used for the dual-band design. To achieve CP fields, two notches are shortened from the cylindrical DRA at $\varphi = 45^{\circ}$ and 225. In this article the simulated and measured consequences are shown after completion. Halappa Gajera et al. [3], presented a New Technique of Dielectric Perturbation in Dielectric Resonator Antenna to Control the Higher Mode Leading to Reduced Cross-Polar Radiations , in the same manner, dual band DRA is also very important concept because the single radiator can work efficiently for two different wireless applications. Debatosh Guha et al. [4], presented a Cross-Polarized Radiation in a Cylindrical Dielectric Resonator Antenna, Dielectric Resonator Antenna (DRA) is one of the important radiators due to its number of attractive features such as negligible metallic loss, high radiation efficiency, diversified radiation pattern (according to the mode excited in DRA), ease of excitation and so-on. DRA can be available in different shapes and sizes but three elementary shapes of DRA are hemispherical, cylindrical and rectangular. Out of these elementary shapes, cylindrical DRA is highly used because of its

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extensive commercial obtainability and diversified radiation patterns. Debatosh et al. [5] proposed two low-profile variants of Microstrip patches and dielectric resonators (DRs). Though DRA is recently developed and still passing through advancement both variants have same features. This article we considered for purposeful relative study, where we have thought All commonly used feed mechanisms such as coaxial probe, microstrip line, and rectangular aperture for both antennas operating near the same frequency. Circular geometry, i.e., cylindrical DRA (CDRA) and circular microstrip patch antenna (CMPA), have been chosen, and a systematic investigation based on thorough experiments has been executed. Multiple sets of prototypes have been fabricated and measured at 4 GHz. All available data have been furnished and compared, indicating relative advantages and disadvantages. This comparative study should provide qualitative and quantitative instructions to a designer for choosing the right element and corresponding feed based on design requirement and feasibility. There are three different techniques available to generate dual band characteristics in DRA i.e. (i) parasitic resonating element loaded DRA [7] (ii) hybrid DRA (combination of two or more elements with DRA) [8-9] (iii) higher order mode generation in DRA along with fundamental mode [10]. Third technique is quite effective but it is not easy to create higher order radiating mode in DRA.

III. MATHEMATICAL MODELING AND DESIGNING METHOD

In the process of design we needs to calculate some parameters for subtract and the ground and which will be easily calculated by formulas discussed below:-

To calculate width of the dielectric subtract,

$$w = \frac{1}{f_r\sqrt{\mu 0 \varepsilon 0}}\sqrt{\frac{2}{\varepsilon r + 1}} \qquad (1)$$

Where f_r is the resonance frequency, $\mathcal{E}r$ is dielectric constant of the substrate & μ_0 and $\mathcal{E}_0$ are the permeability and permittivity of free space respectively.

$$w = \frac{v0}{f_r}\sqrt{\frac{2}{\varepsilon r + 1}} \qquad (2)$$

Where v_0 shows the velocity of wave in free space. Now after calculating width of dielectric next is dielectric constant which we have to calculate and the formulas used to calculate dielectric constant is given by,

$$\varepsilon r = \frac{\varepsilon r + 1}{2} + \frac{\varepsilon r - 1}{2\sqrt{1 + \frac{12h}{w}}} \qquad (3)$$

Here we considers effective length instead of original length because the Microstrip antenna looks longer as only because of fringing effect and the effective length of the antenna is differ by ΔL from the physical length. This extension in length is simply the ratio of width to the height and $\mathcal{E}_{reff}$ which is given by below formula

$$\frac{\Delta Leff}{h} = 0.412\frac{(\varepsilon reff + 0.3)(\frac{W}{h} + 0.264)}{(\varepsilon reff - 0.258) + (\frac{W}{h} + 0.8)} \qquad (4)$$

Now the original length is given by

$$L - \frac{1}{2fr\sqrt{\varepsilon reff\sqrt{\mu 0}}} - 2\,\Delta L \qquad (5)$$

After calculating all these we have to calculate the dimension of the ground plane which will be varied for same antenna in some amount and this relation is given by

$$Lg \geq \left(\frac{\lambda eff}{4}\right) * 2 + L \qquad (6)$$

$$Wg = \geq \left(\frac{\lambda eff}{4}\right) * 2 + W \qquad (7)$$

Electric and Magnetic Field Pattern**:**-For the microstrip antenna, the x-plane θ=90º, 0<ϕ<90º and 270<ϕ<360º is the principal E-plane which is given by

$$E_\phi^t = +j\frac{k_0 W V_0 e^{-jrk_0}}{\pi r}\left\{\frac{\sin(\frac{k_0 h}{2}\cos\phi)}{\frac{k_0 h}{2}\cos\phi} * \cos(\frac{k_0 L_e}{2}\sin\phi)\right. \qquad (8)$$

Similarly, the x-plane=0º, 0< θ <180º is the principal H-plane which is given by using following formula

$$E_\phi^t \approx +j\frac{k_0 W V_0 e^{-jrk_0}}{\pi r}\left\{\frac{\sin(\frac{k_0 h}{2}\sin\theta)}{\frac{k_0 h}{2}\sin\theta}\frac{\sin(\frac{k_0 W}{2}\cos\theta)}{\frac{k_0 W}{2}\cos\theta}\right\} \qquad (9)$$

Bandwidth and Antenna Efficiency:-The fractional bandwidth of the antenna is always be inversely proportional to the Q_t of the antenna and it is defined by

$$\frac{\Delta F}{F_0} = \frac{1}{Q_t} \qquad (10)$$

Where,

Q_t = Total quality factor of microstrip antenna

Modified form of the above equation that takes into account the impedance matching is given by,

$$\frac{\Delta F}{F_0} = \frac{VSWR - 1}{Q_t\sqrt{VSWR}} \qquad (11)$$

By below flow chart it is very clear that the calculations of patch parameters like length, width and feeding point all are calculated with the help of MATLAB tool using special function with high accuracy, for this in very first step antenna working frequency is selected, now dielectric material chosen to work on given frequency. Now optimum height of the substrate is inserted in the next step and the desired parameters are calculated. Here all parameters which we get are simulation result of our MATLAB code. It gives us the flexibility to change our input frequency, height of subtract at run time and the time which is required for simulation is also very less.

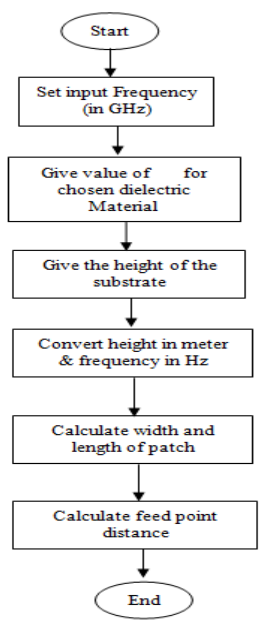

Figure 2: Flow Chart for Patch Parameter Calculation.

IV. CONCLUSIONS

Dielectric Resonator Antenna has broad spectrum of dielectric materials to be used for intended application. This paper presents the review on past done work in the field of Dielectric Resonator Antenna. After study of various research papers it concluded that by choosing proper structure for DRAs we can easily increase the bandwidth. Many different excitation schemes are available which helps to have greater efficiency and high directivity. Moreover, DRA doesn't have metallic loss, so low-loss dielectric material can be useful for high radiation efficiency.

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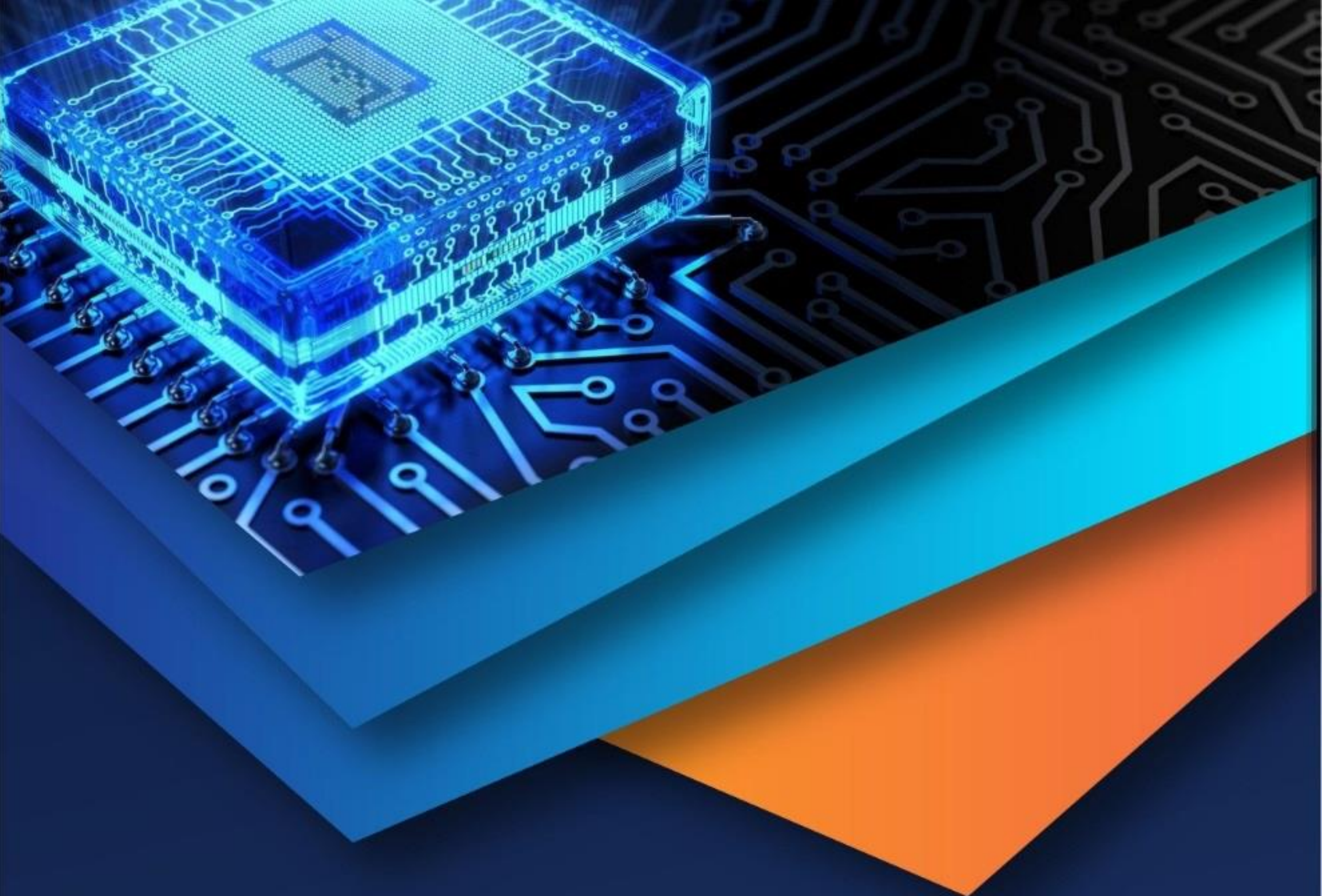

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