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A COMPREHENSIVE REVIEW ON BASIC CONCEPTS AND DESIGN OF THE DIELECTRIC RESONATOR ANTENNAS (DRA)

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Abstract

An up-to-date literature overview on relevant approaches for controlling circuital characteristics and radiation properties of dielectric resonator antennas (DRAs) is presented. The main advantages of DRAs are discussed in detail, while reviewing the most effective techniques for antenna feeding as well as for size reduction. Furthermore, advanced design solutions for enhancing the realized gain of individual DRAs are investigated. In this way, guidance is provided to radio frequency (RF) front-end designers in the selection of different antenna topologies useful to achieve the required antenna performance in terms of frequency response, gain, and polarization. Particular attention is put in the analysis of the progress which is being made in the application of DRA technology at millimetre-wave frequencies.

Keywords: *Antenna Survey, Dielectric Resonator Antennas, Different Applications, DRA, Microwaves.*

I. INTRODUCTION

In recent years, the dielectric resonator antenna, commonly known as DRA or sometimes DR antenna, has brought remarkable attention across the globe. Richtmyer1 developed the concept of the dielectric resonator as a high Q-factor material in 1939, but it was used as an efficient electromagnetic radiator in 1983 [1][2]. The versatility of the 3-dimensional architecture depends on the respective fundamental shapes regulating parameters such as hemispherical shape radius, cylindrical shape height to radius ratio, and rectangular shapes' depth/width ratio as well as length/width ratio [3]. Several other shapes shown in Figure 1 are also used now-a-days to meet various electrical and physical requirements [4].

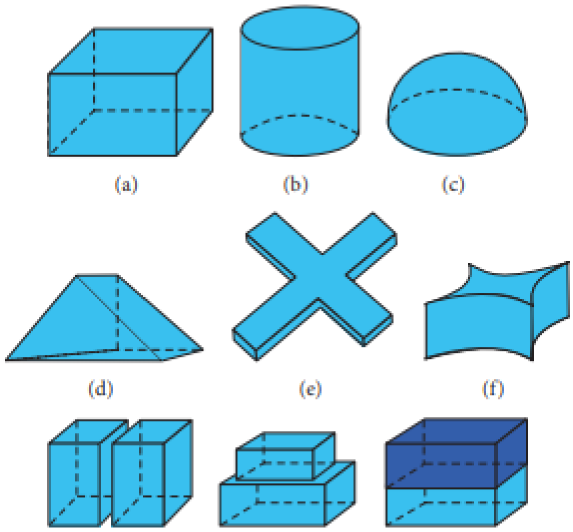

Fig. 1 Illustrates certain geometrical forms of DR antennas

Hence, different ways of reviewing the DRAs have been proposed in last two decades but an application oriented survey/review has not been carried out by anyone and in authors' opinion this type of survey/review article is equally important to the antenna researchers as well as antenna designers before designing any DRA for any specific application [5]. From a research point of view, innovation is very significant, but without real field application, it is cognitively incomplete. To this end, researchers often strive to materialise their definition, which is well represented in the history of DRAs, in order to be well viewed. While the invention of DRAs was in the early 1980s, it began in the 2000s with rapid growth and implementation [6].

The width W of the DRA antenna can be determined by utilizing the following equation.

$$w = \frac{c}{2\, f_r \sqrt{\frac{(\varepsilon_r + 1)}{2}}}$$

Where
f_r denotes the resonant frequency, and
r represents substrate dielectric constant

The effective dielectric constant (ε_{reff}) of DRA antenna is derived by using the following equations.

$$\varepsilon_{reff} = \frac{(\varepsilon_r + 1)}{2} + \frac{(\varepsilon_r - 1)}{2} \sqrt{\left(1 + 12\frac{h}{W}\right)}$$

Where h denotes the height of the antenna and W denotes the width.

The length of the antenna may be measured by applying the following equation.

$$L = \frac{c}{2\, f_r \sqrt{\varepsilon_{reff}}}$$

The antenna length extension is calculated by applying the equation below.

$$\Delta L = 0.412\, h\, \frac{\left(\varepsilon_{reff} + 0.3\right)\left(\frac{W}{h} + 0.246\right)}{\left(\varepsilon_{reff} - 0.258\right)\left(\frac{W}{h} + 0.8\right)}$$

Here W represents the width and h denotes the height.

The real length (L_{eff}) of the antenna can be calculated by using the following formula.

$$L_{eff} = L + 2\Delta L$$

II. LITERATURE REVIEW

A research on the circularly polarised microstrip patch antenna was performed by Kumar et al. A triple-frequency single-feed S-shaped circularly polarised microstrip antenna with a minimal frequency ratio has been proposed for mobile communication and GPS applications. An S-shaped slot is removed in the centre of a square patch of 84.5 to 84.5 mm2 for multi-band service. A single microstrip line with an aperture-coupled feeding structure consists of the proposed antenna geometry. The simulation results show that the proposed antenna can be used for multi-band operation with an effective return loss of -34.34 dB, -18.23 dB and -24.75 dB at 1.193 GHz, 1.454 GHz and 1.615 GHz, respectively [7].

Borakhade et al. conducted a research on pentagon slot resonator frequency reconfigurable antenna for wideband reconfiguration. The need for compact multiband, multifunctional and cost-effective antennas is growing with the developments in the field of communication and the current state of affairs in the development of antennas. In recent years, the study of reconfigurable antennas has made tremendous progress. They are lighter in weight, smaller in size and smaller in cost. Again, the reconfigurable antennas can give a variety of features, such as resonant frequency shift in operation, polarisation, and pattern of radiation [8].

III. DISCUSSION AND CONCLUSION

In this survey, recent advances in millimetre-wave DRA technology were described and discussed in depth. In addition, RF front-end designers have been provided with useful design guidelines to monitor the circuital characteristics and radiation properties of this type of antennas. Different feeding strategies were first developed for DRAs, while the related benefits and drawbacks were highlighted. In addition, design techniques useful for achieving DRA size reduction have been addressed in depth. One may make DRAs considerably smaller by using high permittivity materials or by placing conducting plates along unique symmetry planes of the resonator body. On the other hand, either by exciting the related higher-order modes (electrically large DRAs), or by combining horn-like structures, the gain of a DRA can be increased. Finally, progress has been made in implementing DRA technology at millimetre-wave frequencies and the most recent implementation of on-chip DRAs and off-chip DRAs has been tested. DRAs realised on silicon substrates with standard CMOS processes have been shown to be characterised by good efficiency and gain, demonstrating the good potential for such applications of dielectric resonator antennas.

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