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# Wideband High Gain Dielectric Resonator Antennas

Shailashree S, Mallikarjun S.L., Hadalgi P.M.
Department of PG Studies and Research in Applied Electronics,
Gulbarga University, Gulbarga - 585106. India

***Abstract*—This paper presents a method for increasing the bandwidth and gain of an antenna. The bandwidth and radiation performance of the antenna is studied by increasing the thickness of the dielectric resonator and it is observed that by increasing the thickness bandwidth and gain can be improved. Experimentally measured results and design considerations are presented and discussed. These antennas may find application in modern wideband wireless communication system and in radar systems.**

***Index Terms***—**DRA, Microstrip antenna, bandwidth, gain.**

## I. INTRODUCTION

Dielectric resonator antennas (DRAs) have been widely used in the microwave and millimeter frequency bands due to their attractive radiation characteristics. They offer several potential advantages such as small size, light weight, high radiation efficiency, wide bandwidth, low loss, and no excitation of surface waves [1–4]. Different shapes of DRAs such as cylindrical, hemispherical, elliptical, pyramidal, rectangular, square and triangular have been presented in the literature. The square-shaped DRAs offer practical advantages over cylindrical and hemispherical ones in that they are easier to fabricate and have more design flexibility. DRA is fabricated from low-loss and high relative dielectric constant material of various shapes whose resonant frequencies are functions of the size, shape and permittivity of the material. The bandwidth of DRA depends on parameters such as the excitation method, shape, dimensional parameter & dielectric constant of DRA material. Bandwidth enhancement is one of the major design considerations for most practical applications of Dielectric resonator antennas. By considering this aspect a study is carried out by increasing the thickness of dielectric resonator and studied few antenna parameters and presented in this paper.

## II. DESIGN CONSIDERATIONS

Figure 1 shows the geometry of square DRA. An optimized square DR of dimension $L_{dr}= W_{dr} = 2.2$cm ($\lambda_0/3.8$), $h_{1dr}= 0.15$cm ($\lambda_0/560$) with dielectric constant $\varepsilon_r = 15$ is placed on the rectangular microstrip patch of dimension L =1.38 cm and width W = 2.24 cm. Microstrip patch is etched on a low cost glass epoxy substrate material with dielectric constant $\varepsilon_r = 4.2$ and thickness h= 0.16 cm. A 50 Ω microstrip feed line with $L_f = 0.61$ cm and $W_f = 0.32$ cm with quarter wave transformer with length $L_t = 0.72$ cm and width $W_t = 0.82$ cm is taken in terms for matching impedance. At the tip of microstrip feed line, a 50Ω coaxial SMA connector is connected for feeding microwave power [5].

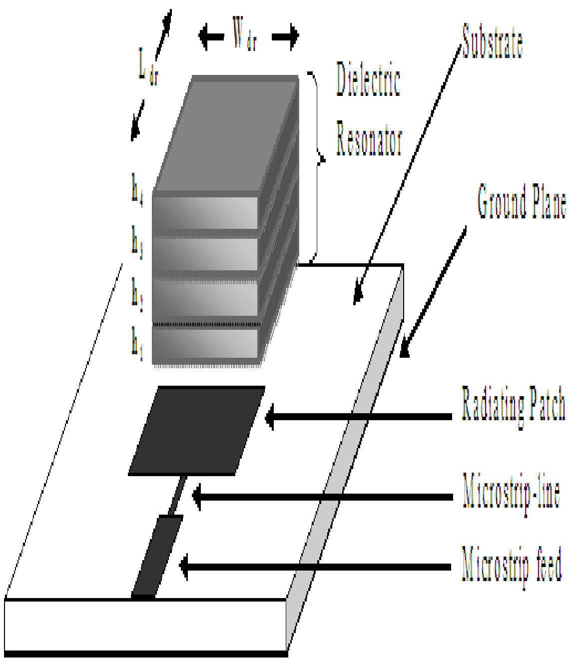


**Fig. 1-Antenna configuration**

## III. RESULTS AND DISCUSSION

The experimental study is carried out by varying the thickness of dielectric resonator as $h_1$, $h_2$, $h_3$ and $h_4$, where $h_1$ is 0.15 cm, $h_2$ is 0.3 cm, $h_3$ is 0.45 and $h_4$ is 0.6 cm. DR is placed at the center of the rectangular patch in order to achieve maximum impedance bandwidth. The impedance bandwidth over reflection coefficient less than –10 dB for the proposed antennas is measured. The resonant properties of the proposed antennas are experimentally measured on Vector Network Analyzer (Rohde and Schwarz, Germany make ZVK model 1127.8651). Figure 2 to Figure 5 show the reflection coefficient versus frequency graph of DRA with thickness $h_1$ to $h_4$. From these figures the impedance bandwidth is calculated by using the equation [6];

$$BW = \frac{f_H - f_L}{f_c}$$

where $f_H$ and $f_L$ are higher and lower cut-off frequencies of the band, respectively, and $f_c$ is the center frequency.

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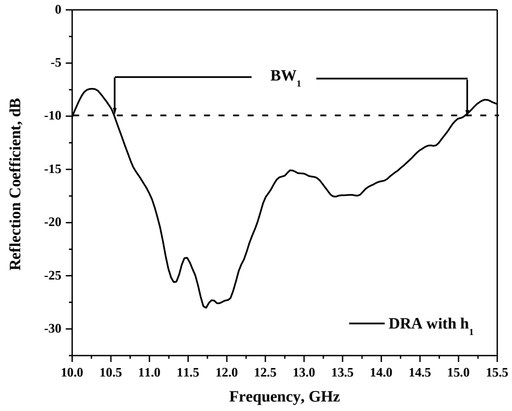


**Fig. 2-Reflection coefficient versus Frequency graph of DRA with thickness $h_1$**

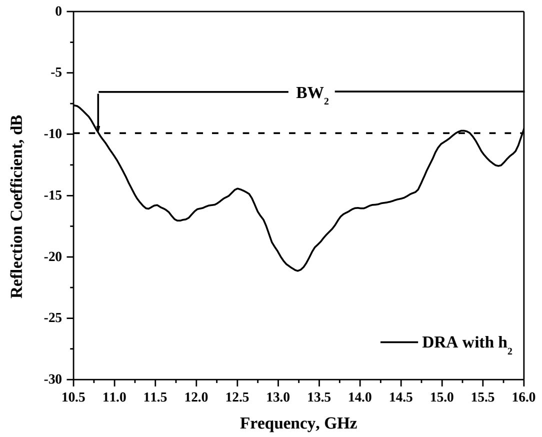


**Fig. 3-Reflection coefficient versus Frequency graph of DRA with thickness $h_2$**

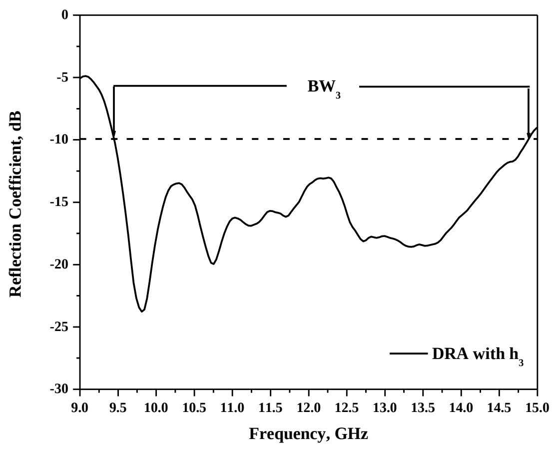


**Fig. 4-Reflection coefficient versus Frequency graph of DRA with thickness $h_3$**

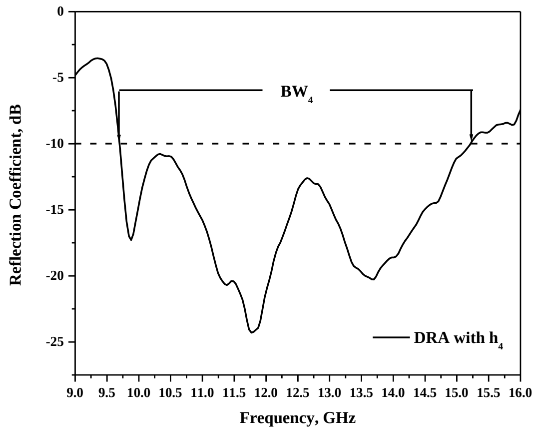


**Fig. 5-Reflection coefficient versus Frequency graph of DRA with thickness $h_4$**

From Figures 2, 3, 4 and 5 it is observed that DRA with thickness $h_1$, $h_2$, $h_3$ and $h_4$ offers single wide band. $BW_1$ at 11.73 GHz, with a magnitude of 4590 MHz (35.76%), $BW_2$ at 13.24 GHz, with a magnitude of 5180 MHz (38.71%), $BW_3$ at 9.81 GHz, with a magnitude of 13934 MHz (44.53%) and $BW_4$ at 11.77 GHz, with a magnitude of 14300 MHz (44.61%) respectively. The minimum reflection coefficient for DRA with $h_1$, $h_2$, $h_3$ and $h_4$ are found to be -12.25 dB, -21.13 dB, -23.76 dB and -24.30 dB respectively. VSWR of the antennas is also measured using VNA and are found to be 1.14 for DRA with thickness 0.15 cm, 1.197 for DRA with thickness 0.3 cm, 1.137 for DRA with thickness 0.45 cm and 1.083 for DRA with thickness 0.6 cm. Co-polar and cross-polar radiation patterns of the proposed antennas are measured at their resonating frequencies and are shown in Figure 6 to Figure 9. From the pattern it is observed that all antennas show omni-directional patterns except the one with thickness $h_1$ which is nearly omni-directional.

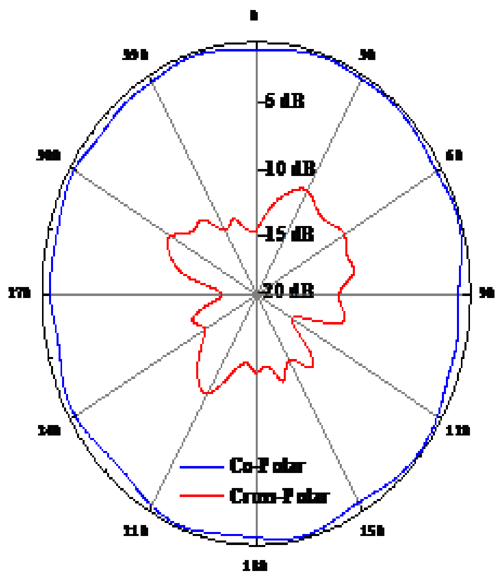

**Fig. 6-Radiation Pattern of DRA with $h_1$ at 11.73 GHz**

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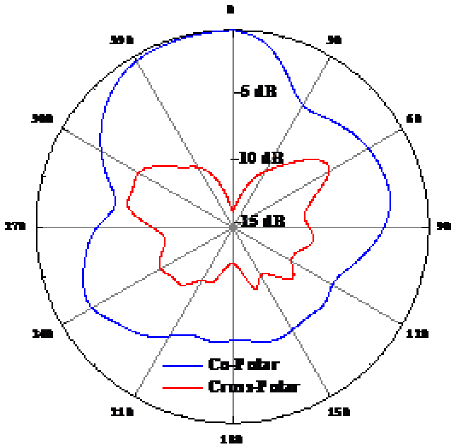


**Fig. 7-Radiation Pattern of DRA with $h_2$ at 13.24 GHz**

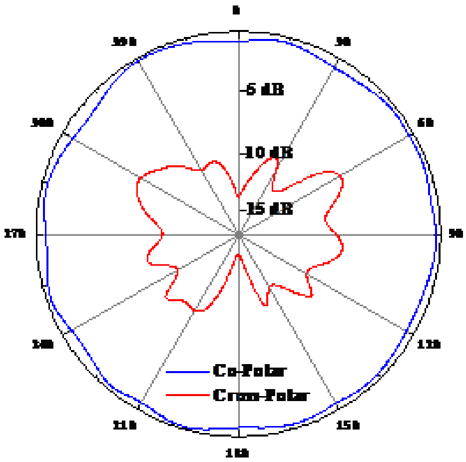


**Fig. 8-Radiation Pattern of DRA with $h_3$ at 9.81 GHz**

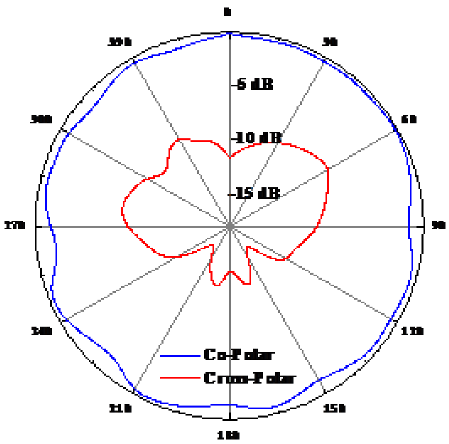


**Fig. 9-Radiation Pattern of DRA with $h_4$ at 11.77 GHz**

Gains of the proposed antennas are measured using gain-comparison method and are found to be 6.42 dB for DRA with thickness 0.15 cm, 9.74 dB for DRA with thickness 0.3 cm, 11.20 dB for DRA with thickness 0.45 cm and 9.60 dB for DRA with thickness 0.6 cm. Figure 10 shows the Smith chart of DRA with thickness 0.45 cm as when compared with all the proposed antennas, the antenna with thickness 0.45 cm shows better result in terms of bandwidth and gain.

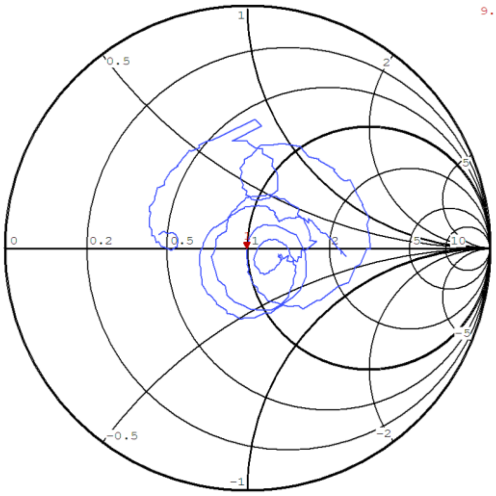

**Fig. 10-Smith Chart of DRA with Thickness 0.45 cm**

## IV. CONCLUSION

From the detailed study, it is clear that the proposed antennas are quite simple in design and fabrication and good in enhancing the impedance bandwidth. A wide bandwidth is obtained by increasing the thickness of dielectric resonator placed at the center of rectangular microstrip patch. The experimental results show that among the proposed antennas, DRA with $h_4$ (thickness of 0.6 cm.) offers maximum bandwidth of 44.61% with omni-directional radiation characteristics at the resonating frequency. Hence it is observed that by increasing the thickness bandwidth and gain can be improved. The proposed antennas are useful for X- and Ku-band modern broadband wireless communication systems and radar applications also.

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## AUTHOR'S PROFILE

**Smt. Shailashree S.** received her M.Sc. Applied Electronics degree from Gulbarga University, Gulbarga in the year 2000. She is pursuing her Ph.D degree in Dept. of Applied Electronics, Gulbarga University, Gulbarga in the field of Microwave Electronics. Her area of interest include DRA.

**Dr. Mallikarjun S. L.** received his M.Sc., M.Phil. and Ph.D. degree in Applied Electronics from Gulbarga University, Gulbarga in the year 2005, 2007 and 2011 respectively. He is working in Dept. of Applied Electronics, Gulbarga University, Gulbarga. He is an active researcher in the field of Microwave Electronics. His area of interest includes microstrip antenna, arrays and dielectric resonator antenna. He has more than 70 publications in reputed International/National Journals and in conference and symposia.

**Dr. Hadalgi. P. M.** Received his M.Sc., and Ph.D., degree in Electronics from Karnataka University, Dharwad. He is working as Professor in Dept. of Applied Electronics, Gulbarga University, Gulbarga. He is an active researcher in the field of Microwave Electronics. His area of interest includes waveguide antenna, microstrip antenna, DRA and instrumentation. He has more than 150 publications in reputed International/National Journals and in conference and symposia.