

Analysis of Characteristic Behavior of Rectangular Dielectric Resonator Antenna

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Abstract: In this paper effects of coaxial probe feeding position and its penetration inside the radiating structure of an antenna has been presented in detail. For this purpose, a Rectangular Dielectric Resonator Antenna (RDRA) has been synthesized and analyzed. There effects on the characteristic behavior of antenna have been obtained. Optimized condition is established and relation between probe dimensions and probe separation from the axial point of DR has been sorted out upon which the characteristics of the RDRA such as bandwidth, radiation pattern and gain of antenna depend. Parametric variations of different parameters for the RDRA are simulated and bandwidths exceeding 45% is achieved. Theoretical performance of the antenna is verified by full-wave simulations and experimental data obtained from a prototype. The obtained performance of proposed design, confirms the practicability of antenna in different indoor/outdoor wireless applications.

Keywords: Rectangular dielectric resonator antenna, coaxial Probe, feeding position, bandwidth, gain, radiation pattern

I. Introduction

Modern communication system uses different kinds of antenna; among the many, antennas made from dielectric material are well seen in the devices and dielectric antenna has been the interest of researchers from the past few decades. Dielectric Resonator Antenna is well explained [1]. These antennas come in different shapes and dimensions as per the requirement by the device or the locality where it has to be installed. There are many research papers and journals which have been published, which shows the works and findings of researchers about different characteristics and behavior of the dielectric antennas [2-7]. The antenna uses different feeding mechanism for their excitation such as probe feed; lumped port feed, excitation by different fields and many more techniques are there by which an antenna system is excited [8-9]. But there are rare publications on the experimental detail about the characteristics and behavior of the antenna depending upon the relative position of the feed point in the antenna and the type of excitation used to excite the antenna. This paper presents the detailed finding of the behavior and characteristics of the Rectangular Dielectric Resonator Antenna (RDRA) depending upon the position of the excitation point and penetration of the co-axial probe inside the dielectric material of the antenna system.

II. Antenna Design

The design opted for the study of RDRA characteristics are of rectangular shape, of dimension 24 mm X 24 mm X 12 mm. It is excited by a co-axial probe of radius 0.8mm. The proposed design is shown in fig. 1. In the fig. l_1 denotes the probe penetration inside the dielectric material, l_2 denotes the position of the center of the probe from the origin lying in XY plane.

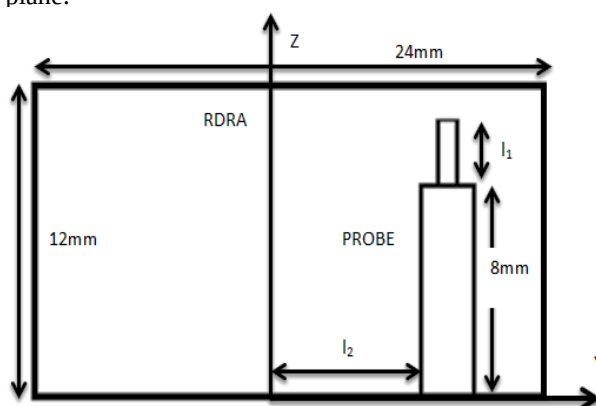


Fig. 1 Proposed Geometry of the Antenna System

III. Parametric Study

In this antenna design, l_1 and l_2 as discussed in Section II (shown in Fig. 1), are set as project variables to parametrically study its effect on the RDRA characteristics and behavior. The study has been done in two phase

A. Variation in length, l_1

First, l_1 was varied from 1 mm to 3 mm (step size of 0.5mm) to get the optimum condition, good bandwidth and most importantly, focus was set to keep the antenna resonant frequency low so that a low profile antenna can be made.

B. Variation in length, l_2

As the optimum position of l_1 is found, then the adjustment in the position of the center of probe, l_2 is done. Position of the center is varied from 12 mm to 9 mm (in step size of -1 mm).

IV. Simulation Result

Five different penetration length of probe inside the RDRA were simulated on HFSS V10 and results obtained are shown in Fig. 2. When l_1 is 1mm about 13.8 % bandwidth was obtained at S_{11} of about -10 dB in the frequency band of 17.06 – 19.55 GHz. When l_1 was increased by step size of 0.5 mm, the bandwidth of the antenna increased by 88% in the frequency band of 2.20 - 3.59 GHz and the best matching frequency observed is 3.15 GHz in this frequency band (shown in fig. 2). This increase in the bandwidth at lower frequency suggested that a still larger value should be tried and so l_1 was varied from 1.5 mm to 3 mm in step size of 0.5 mm but this time the result obtained was not fruitful, as there is decrease in the bandwidth of the antenna and moreover, the matching frequency shifted to much larger value. This is presented in tabulated form in Table I.

Table I. Variation of Length, l_1

Value of l_1 (mm)	Low Freq. (GHz)	High Freq. (GHz)	Resonant Freq. (GHz)	Band-width (%)	Max. Return Loss (-dB)
1	17.06	19.55	18.37	13.80	20.61
1.5	2.20	3.59	3.15	48.01	16.53
2	14.06	18.28	16.87	26.09	21.74
2.5	16.20	19.55	19.00	18.74	25.25
3	18.73	19.32	20.55	3.10	27.79

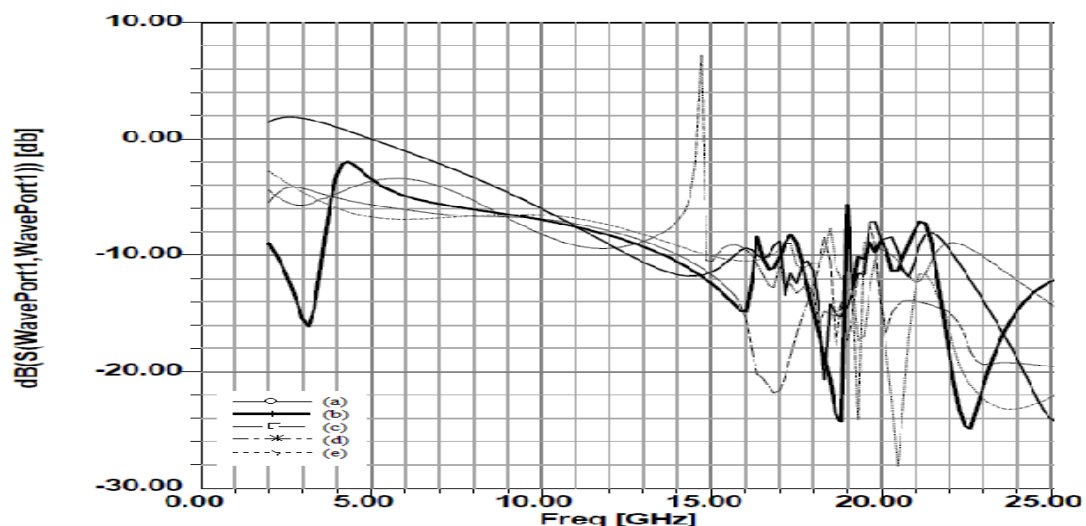


Fig. 2 Shows the S_{11} (dB) Vs Frequency (GHz) curve of parametric variation of length l_1 (a) 1mm (b) 1.5mm (c) 2mm (d) 2.5mm (e) 3mm, when $l_2 = 11$ mm

As the optimum value of l_1 is obtained, then as discussed in Section II, parametric study of l_2 is done. To perform this, different position of the center of the co-axial probe from the center of the RDRA in XY plane was tried to find the best working condition for the RDRA without compromising the low profile characteristics of the RDRA. It is shown in fig. 3, that as the position of the center increases there is decrease in the return loss, moreover the matching frequency also goes very high, which is not much desirable. So, it is found that length, l_2 should be decreased (probe should be brought far from the center of RDRA). Further, on simulation it is found

that the practical return loss of more than -25 dB is obtained but the matching frequency goes very high. The detailed parametric study of variation in position of the probe's center is given in Table II.

Table II Variation of Length, l_2

Value of l_2 (mm)	Low Freq. (GHz)	High Freq. (GHz)	Resonant Freq. (GHz)	Band-width (%)	Max. Return Loss (-dB)
9	16.33	19.18	18.50	16.05	28.44
10	18.01	19.91	19.05	10.02	17.29
11	2.20	3.59	3.15	48.01	16.53
12	21.81	25.03	21.99	13.76	16.24

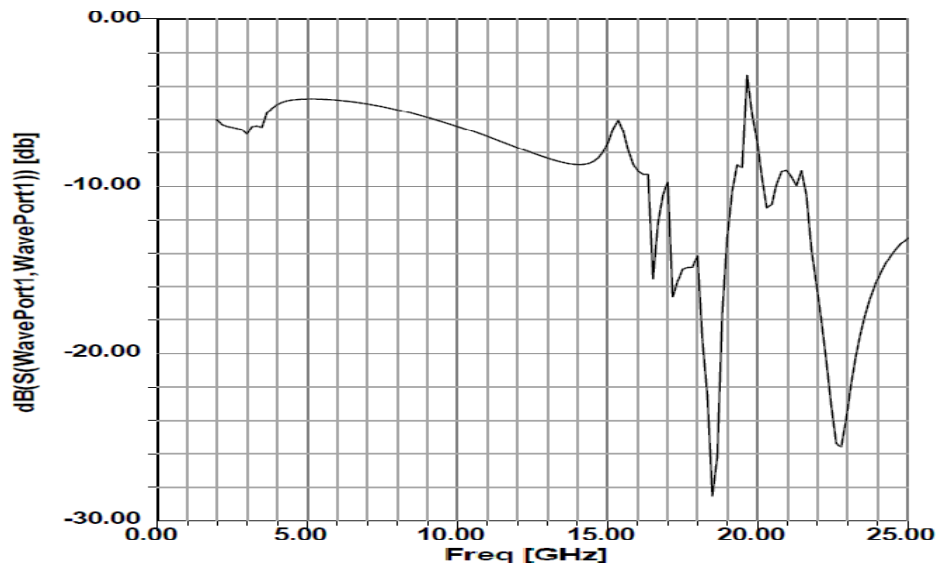


Fig. 3(a) Shows the S_{11} (dB) Vs Frequency (GHz) curve of parametric variation of length $l_2 = 9$ mm, length, $l_1 = 1.5$ mm

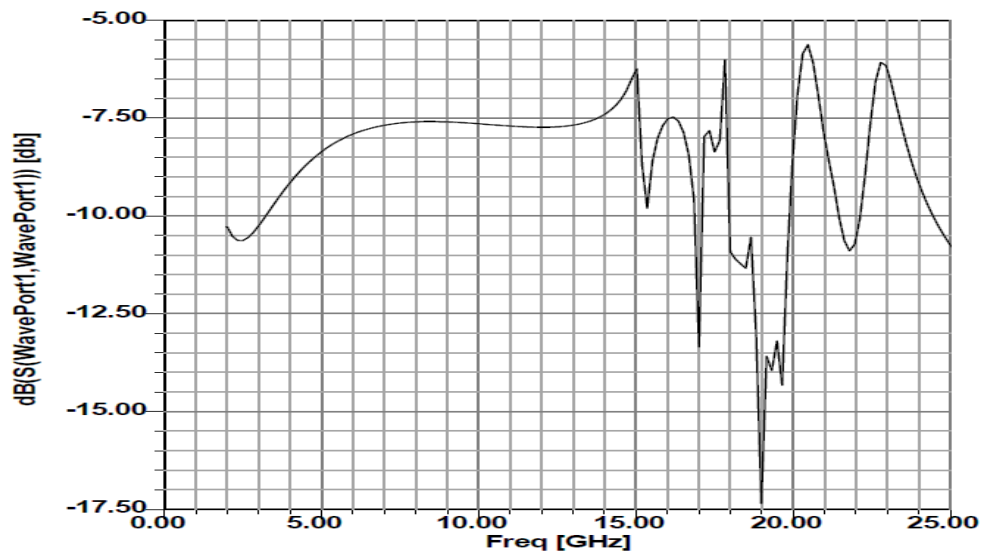


Fig. 3(b) Shows the S_{11} (dB) Vs Frequency (GHz) curve of parametric variation of length $l_2 = 10$ mm, length, $l_1 = 1.5$ mm

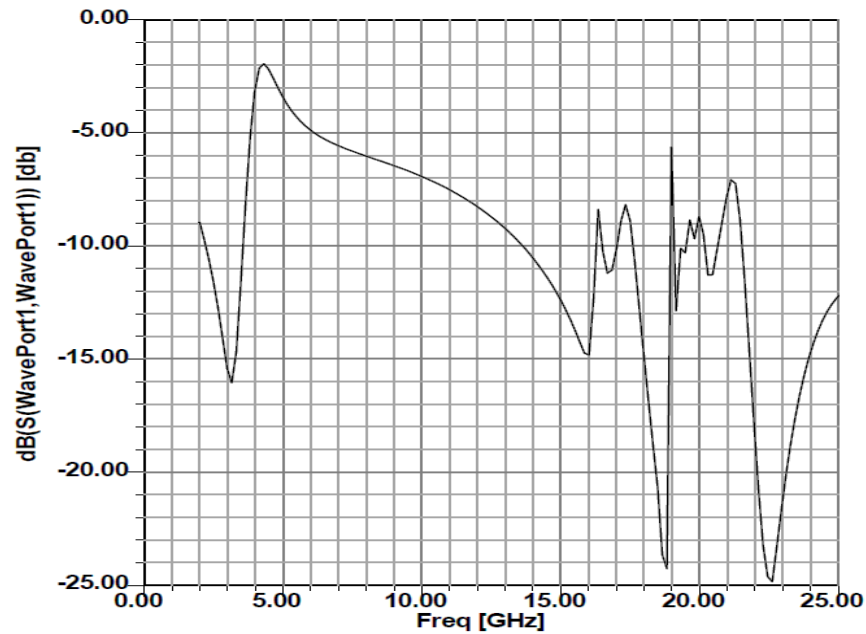


Fig. 3(c) Shows the S_{11} (dB) Vs Frequency (GHz) curve of parametric variation of length $l_2 = 11\text{mm}$, length, $l_1 = 1.5\text{mm}$

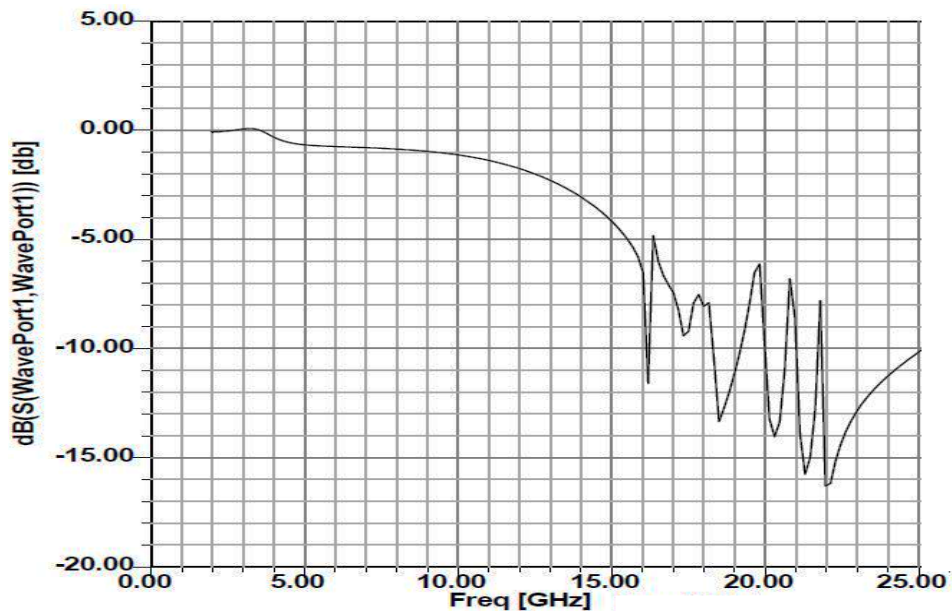


Fig. 3(d) Shows the S_{11} (dB) Vs Frequency (GHz) curve of parametric variation of length $l_2 = 12\text{mm}$, length, $l_1 = 1.5\text{mm}$

V. Conclusion

In this study the dependence of the band width on the coaxial probe penetration length (l_1) and its separation (position of the feeding point) from the axial point of radiating structure (l_2) has been obtained. It is found that ratio of l_1 to h (height of radiating element) and l_2 to L (length of radiating element) should be 12.50% and 45.83% respectively. The experimental graph has been prepared and verified by theoretical calculations. It has been shown that the impedance band width, return loss and the resonant frequency are highly dependent on the geometry parameters of the DRA. This analysis helps in realization of optimization condition of RDRA.

VI. References

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