

T-STRIP-FED HIGH-PERMITTIVITY RECTANGULAR DIELECTRIC RESONATOR ANTENNA FOR BROADBAND APPLICATIONS

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ABSTRACT: A rectangular low-density, high-permittivity dielectric resonator antenna (DRA) excited by T-shaped microstrip feed offering a 2:1 VSWR bandwidth of $\sim 22\%$ at 2.975 GHz is reported. The design methodology and experimental results of the antenna are discussed. The excellent gain and radiation performance of the proposed antenna projects it as a potential candidate for telecommunication applications.

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Key words: dielectric resonator antennas; T-feed; bandwidth enhancement; $\text{Ca}_5\text{Nb}_2\text{TiO}_{12}$ ceramics

1. INTRODUCTION

Dielectric resonator antennas (DRAs) have become well known in recent years due to their inherent merit of high efficiency, since conduction loss is absent in the system. Due to the same reason, such antennas have been suggested and developed for use in microwave and millimetre-wave frequency bands [1]. Compared with microstrip patch antennas (MPAs), DRAs offer several potential advantages such as smaller size, higher radiation efficiency, wider bandwidth, and so forth. In addition, DRAs possess the advantages of mechanical simplicity, simple coupling schemes to nearly all commonly used transmission lines, and generation of different radiation characteristics using different modes of the resonator. Moreover, the operating bandwidth of a DRA can be varied by suitably choosing the dielectric constant of the resonator material and its dimensions. Recently, a microstrip-energised, high-permittivity ($\epsilon_{dr} = 48$) rectangular DRA with wideband was reported [2]. Further enhancement of the bandwidth of a DRA was done using L-shaped feed [3, 4].

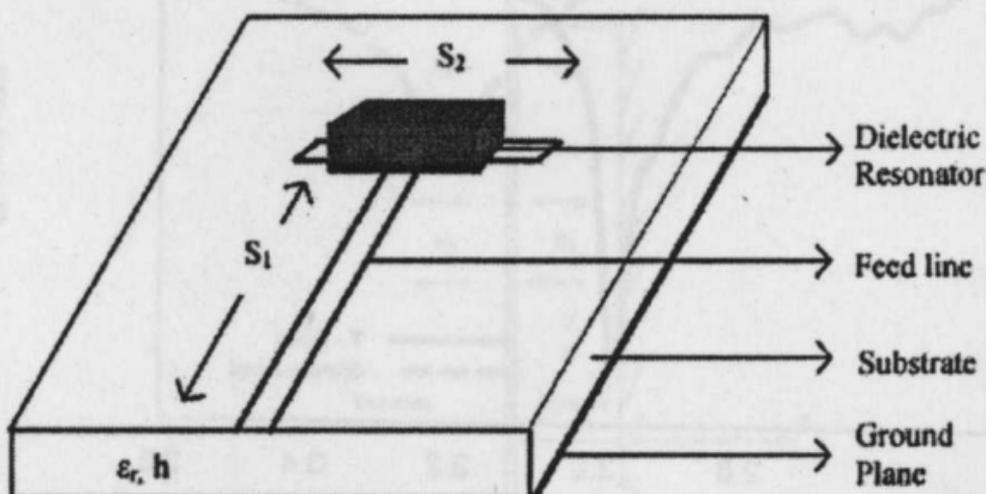


Figure 1 Geometry of the proposed T-fed rectangular dielectric resonator antenna

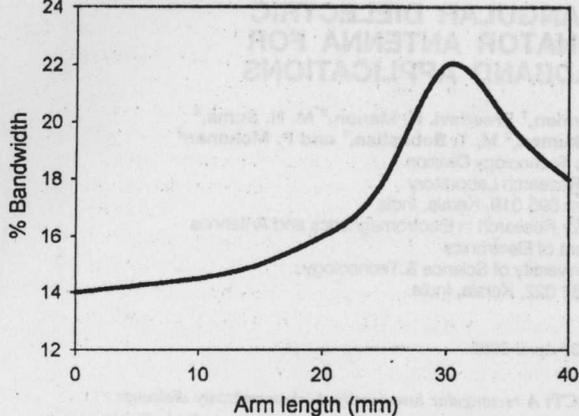


Figure 2 Variation of % bandwidth with arm length (S_2) in the T-fed rectangular DRA ($\epsilon_r = 4.28$, $h = 1.6$ mm, $\epsilon_{dr} = 48$, $l = 22.5$ mm, $b = 11.90$ mm, and $h = 5.55$ mm)

The purpose of this paper is to investigate the effect of T-shaped feed-line excitation in order to further enhance the bandwidth of operation. The design methodology, measured gain, bandwidth, and radiation performance of a rectangular DRA operating at 2.975 GHz are described in this paper.

2. FORMULATION

The configuration of the T-strip-excited rectangular DRA is shown in Figure 1. High-dielectric-constant, low-loss $\text{Ca}_5\text{Nb}_2\text{TiO}_{12}$ [3] ceramic dielectric-resonator material is prepared in a single phase via solid-state ceramic technology. $\text{Ca}_5\text{Nb}_2\text{TiO}_{12}$ has a low density of 4.05 g/cm^3 , dielectric constant $\epsilon_{dr} = 48$, $Q_u \times f > 26,000$ at 4 GHz, and temperature coefficient of the resonant frequency $\tau_f = 40 \text{ ppm/}^\circ\text{C}$. A rectangular DR of $\text{Ca}_5\text{Nb}_2\text{TiO}_{12}$ material with length $l = 22.50$ mm, breadth $b = 11.90$ mm, and height $h = 5.55$ mm was prepared via solid-state ceramic technology. The DR is energized by a 50Ω T-shaped microstrip line printed on a substrate of thickness $h = 1.6$ mm and dielectric constant $\epsilon_r = 4.28$. The feed length S_1 is fixed at 50 mm and the arm length S_2 is varied from 0 to 40 mm. The position of the DR on the feed line is optimized to provide coupling between the microstrip line and

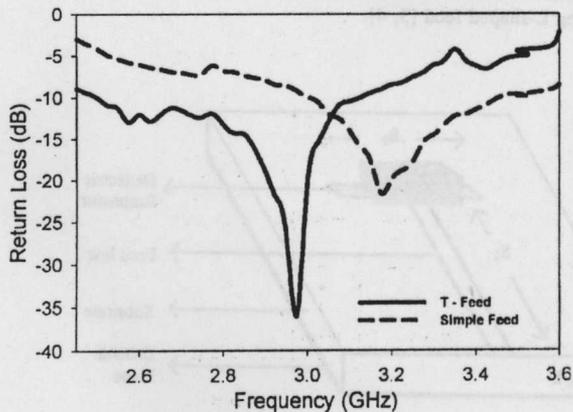


Figure 3 Variation of S_{11} with frequency of the rectangular DRA ($\epsilon_r = 4.28$, $h = 1.6$ mm, $\epsilon_{dr} = 48$, $l = 22.5$ mm, $b = 11.90$ mm, and $h = 5.55$ mm)

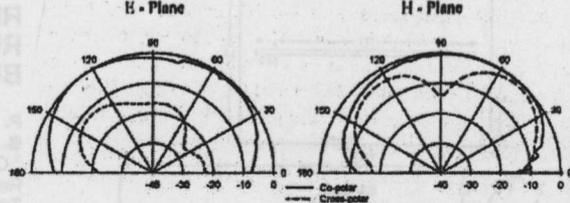


Figure 4 Radiation patterns of the T-fed rectangular DRA at the centre frequency of the operating band ($\epsilon_r = 4.28$, $h = 1.6$ mm, $\epsilon_{dr} = 48$, $l = 22.5$ mm, $b = 11.90$ mm, and $h = 5.55$ mm)

the rectangular DR, hence achieving maximum matching at the desired frequency. Excellent matching was observed when the DR was placed at the junction ($S_1 = 50$ mm) of the branched T-feed line with its length exactly over the arm length (S_2) direction, as depicted in Figure 1. For optimum arm length and position on the feed line, the DR was glued to the substrate over the feed line. The glue had a negligible effect on the frequency of operation, but was found to improve the coupling slightly.

3. RESULTS AND DISCUSSION

The antenna was characterized using an HP 8510C Vector Network Analyser. The variation of % bandwidth with the arm length of T-feed line is illustrated in Figure 2. The bandwidth increased with the arm length, reached a maximum at $S_2 = 30$ mm, and then decreased. This was taken as the optimum feed-length dimension and all the antenna characteristics were measured after fixing the DR over the feed line in the optimised position. Figure 3 shows the variation of S_{11} of the rectangular DRA, with the DR at the optimised position. The measured frequency is 2.975 GHz, which is slightly less than that of the simple microstrip-excited DRA. At the optimised position of the DR, the measured bandwidth is 635 MHz (2.49–3.125 GHz) at 2.975 GHz.

The radiation pattern of the antenna at the centre frequency of the operating band is shown in Figure 4. The cross-polarization of the antenna is better than -15 dB. The gain of proposed rectangular DRA is shown in Figure 5. The average gain of the antenna in the band is nearly 8.8 dBi. Moreover, the gain curve confirms that the antenna radiation has the same polarization in the entire operating band.

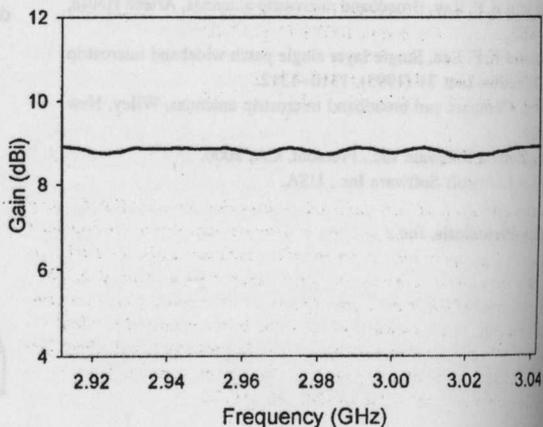


Figure 5 Gain of the proposed T-fed rectangular DRA ($\epsilon_r = 4.28$, $h = 1.6$ mm, $\epsilon_{dr} = 48$, $l = 22.5$ mm, $b = 11.90$ mm, and $h = 5.55$ mm)

The proposed DR antenna has wide bandwidth with enhanced gain. The experimental density of the DR material used in the proposed rectangular DRA is only 4.04 g/cm^3 . Hence, the weight of newly constructed antenna is also comparatively low. Moreover, the high-dielectric-constant material ($\epsilon_r = 48$), has given an additional one-third reduction in area to the DRA, compared with the corresponding microstrip-patch antenna.

4. CONCLUSION

A novel rectangular DRA excited by T-shaped microstrip-transmission feed line has been studied. The antenna, with a bandwidth of 635 MHz at 2.975 GHz was found to exhibit excellent radiation performances. The measured properties of the rectangular DRA indicate that this antenna is more advantageous than other antennas currently being used in many respects and is desirable for applications in millimetre and microwave frequencies throughout the communications field.

ACKNOWLEDGMENT

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REFERENCES

1. S.A. Long, M.W. McAllister, and L.C. Shen, The resonant cylindrical dielectric cavity antenna, *IEEE Trans AP* 31 (1983).
2. P.V. Bijumon, S.K. Menon, M.T. Sebastian, and P. Mohanan, Enhanced-bandwidth rectangular dielectric resonator antenna using microstrip feed, *Proc APSYM*, 2002.
3. S.K. Menon, B. Lethakumary, P. Mohanan, P.V. Bijumon, and M.T. Sebastian, Wideband cylindrical dielectric resonator antenna excited using an L-strip feed, *Microwave Opt Technol Lett* 42 (2004).
4. S.K. Menon, B. Lethakumary, P. Mohanan, P.V. Bijumon, and M.T. Sebastian, L-strip-fed wideband rectangular dielectric resonator antenna, *Microwave Opt Technol Lett* (2005).