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# A Star Shaped Dielectric Resonator Antenna for ISM band Applications

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**Abstract:** A microstrip fed Star shaped Dielectric Resonator Antenna (DRA) for ISM frequency is proposed. Star shaped DRA is implemented by modifying Triangular DRA for 2.45 GHz resonant frequency. The radiated power is almost same as accepted power impedance matching between dielectric resonator and feed line is achieved. It is observed that Triangular DRA exhibits a radiated power of 0.9033W with respect to 1W incident power and maximum gain of 5.3866dBi, while Star DRA exhibits a exhibits a radiated power of 0.8758W with respect to 1W incident power and maximum gain of 5.9572 dBi. It can be used for a variety of ISM band applications.
**Keywords:** Star Dielectric Resonator Antenna, Triangular DRA

## Introduction

The DRA has become the area of interest because of their attractive features such as compact size, light weight, low metallic losses, high radiation efficiency, wide bandwidth, and low cost. DRAs are available in different shapes [2]-[3]. Triangular DRA (TDRA) have some advantages like simple comprehensive design, smaller area than any other DRA for given resonant frequency and variable aspect ratios. In addition to this, there is no conducting material excluding feed line, so negligible metallic (conducting) losses exist [4]-[7].

In this paper, Triangular shaped DRA at 2.45 GHz resonant frequency is presented. Star DRA is converted from two Equilateral Triangle shaped Dielectric Resonators (DR) at same resonant frequency with improved gain by minor increasing in effective area of the DRA. All simulations in this study have been performed using the commercial FEM solver Ansoft HFSS.13.

## Design and Configuration

The design for the proposed antenna has been undertaken in two parts. In first part, the Triangle DRA is designed. To design the TDRA, The resonant frequency of Equilateral Triangle Shape DR at TMmnl mode can be calculated by following equation-1 [4]:

$$f_r = \frac{1}{2\sqrt{\varepsilon\mu}}\left[\left(\frac{4}{3a}\right)^2 (m^2 + mn + n^2) + \left(\frac{l}{h}\right)^2\right]^{\frac{1}{2}} \quad (1)$$

Where a is the side length of Triangular DRA, h is two times of the height and l=1 for fundamental mode. The three integers l, m, and n have the relation of l+ m + n=0 but not zero simultaneously.

The TDRA is implemented as shown in Fig.1 for 2.4 resonant frequency. From the equation-1, the calculated side length of TDRA (a) = 36.17 mm by taking height of DR (h) = 26.155 mm and Dielectric constant ($\varepsilon_r$) =9.8 (Alumina ceramic material) for fundamental mode ($TM_{101}$).

The TDRA is implemented on FR402 substrate (dielectric constant = 4.25). The dimensions of substrate is 53 X 63 mm$^2$ with 1.51 mm thickness.

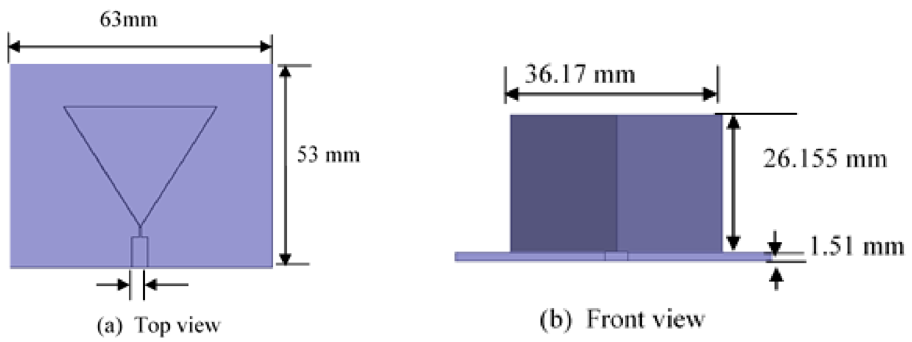


Fig.1: The Triangular DRA structure: (a) Top view. (b) Side view.

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The coplanar loop feeding is designed on FR402 substrate as shown in fig.2 to excite TDRA. After optimization for better impedance matching, the final dimensions of coplanar feeding line are mentioned in fig.2.

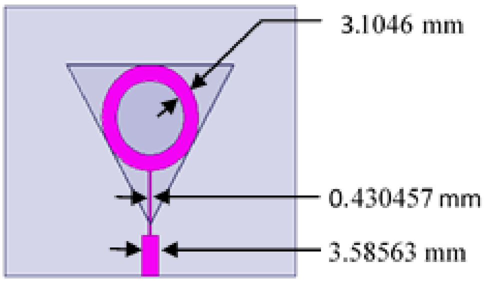
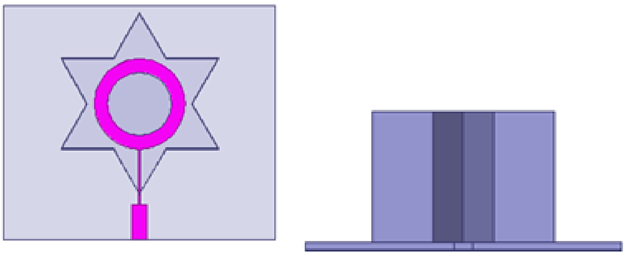



Fig.2: co planar feeding line structure of TDRA.

In second part, another inverted triangle with same size is to be placed on it to get star shape DRA. Fig.3 shows the geometry of star DRA excited by same coplanar microstrip feeding that is supported by a 53 X 63 $mm^2$ substrate (FR402) with a dielectric constant ($\varepsilon_r$)=4.25 and thickness of 1.51 mm which is same as substrate of TDRA.



(a) Top view (b) Front view

Fig.3: The geometry of Star DRA: (a) Top view. (b) Front view.

**Parametric Study**

Based on investigation of the DRA's characteristics, parametric studies were accomplished by using Ansoft HFSS.13. Fig.4 and Fig.5 show return loss (S11) vs frequency plot for TDRA and star DRA respectively. It is observed that return loss for TDRA is -27.22 dB at resonant frequency of 2.45 GHz and, while return loss for star DRA is -35.92 dB at 2.43 GHz resonant frequency and gain is 5.9572dBi.

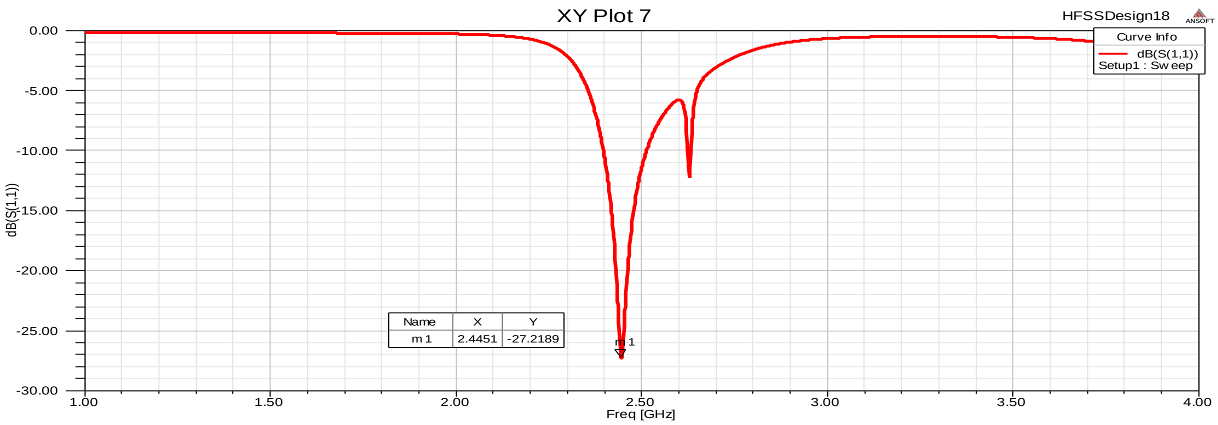



Fig.4 Return loss vs Frequency plot for proposed TDRA.

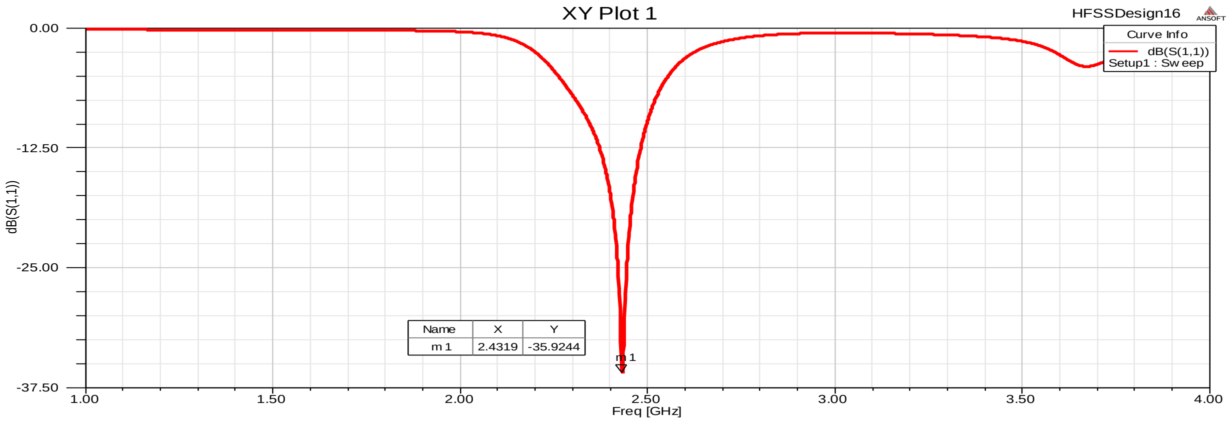


Fig.5 Return loss vs Frequency plot for proposed Star DRA.

Fig.6 and Fig.7 show the simulated radiation pattern at 2.45 GHz frequency of proposed antenna. It is cleared that radiation is obtained along the broadside direction of the antenna because of counteracting in y-z and z-x plane within the elements of the proposed antenna. The overall gain of TDRA is 5.3866 dBi which is higher than that of previous designed TDRA [4], [7] and the overall gain of Star TDRA is 5.9572 dBi.

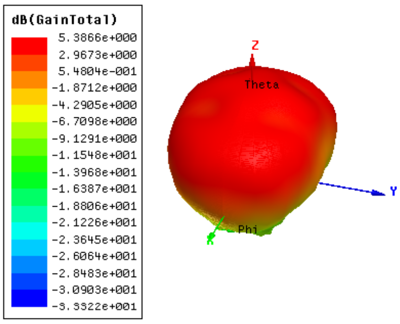


Fig.6 The 3D Radiation pattern of the TDRA.

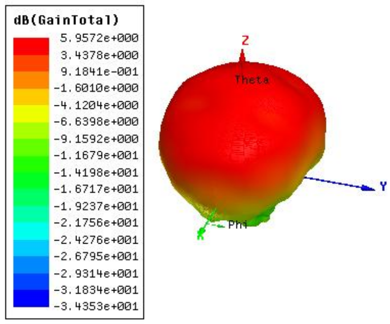


Fig.7 The 3D Radiation pattern of the star DRA.

The radiation patterns (both co-polar and cross-polar) of the proposed antenna for ϕ=0 (x-z plane or E plane) and ϕ=90 (y-z plane or H plane) at 2.45 GHz are simulated here. The co-polarized (desired polarization component) and the cross polarized (undesired polarization component) for both E- and H- planes are presented here in fig. 8 and fig.9. The cross polarized power level shows how many decibels down power level with the desired polarized power level.

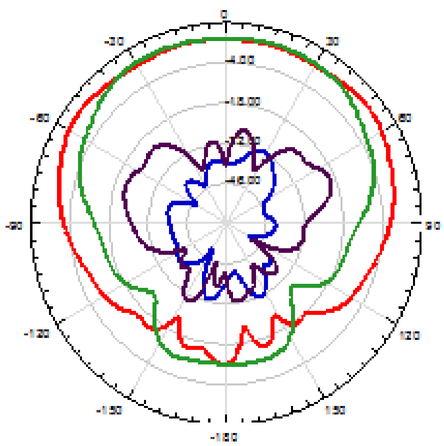


Fig.8 The Radiation patterns of the proposed TDRA

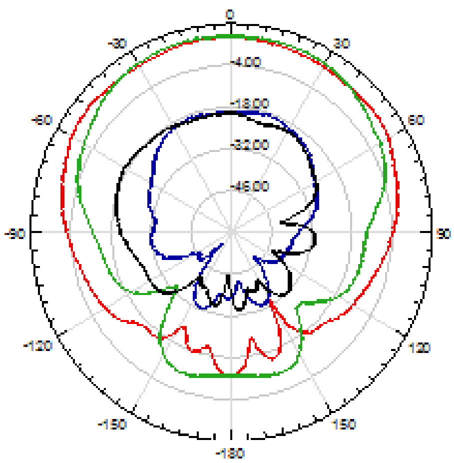


Fig.9 The Radiation patterns of the proposed Star DRA.

**Parametric Study**

From the parametric studies, it is observed that the gain increases from 5.3866 dBi to 5.9572dBi when DRA is modified from TDRA to Star DRA. The impedance matching is achieved here as accepted power of TDRA is 0.9973w for 1w incident power and that of Star DRA is 0.9924w for 1w incident power. The radiated power of TDRA is 0.9033w with respect to 1w incident power, while radiated power of Star DRA is 0.8758w with respect to 1w incident power. The comparison of other parameters are shown in table-I. The discrimination between co-polar and cross-polar components of x-z plane and y-z plane obtained are reasonably good for practical applications.

TABLE I. SIMULATED RESULTS FOR TDRA AND STAR DRA

| Antenna → <br> Parameters ↓ | TDRA | Star DRA |
|---|---|---|
| Gain | 5.3866 dBi | 5.9572 dBi |
| Directivity | 5.8165 dBi | 6.5 dBi |
| Return loss | -27.2189dBi | -35.9244 dBi |
| Radiation efficiency | 90.57% | 88.25% |
| Resonant Frequency | 2.45 GHz | 2.43 GHz |
| Impedance Bandwidth | 4.73% <br> (2.3961-3.512 GHz) | 6.22% <br> (2.3455-2.4967 GHz) |

**Conclusion**

An investigation on equilateral Triangular dielectric resonator antenna with coplanar microstrip fed is carried out theoretically using Ansoft HFSS.13.TDRA is modified to Star DRA and designed for gain enhancement. Parametric studies are carried out to investigate the different antenna design parameters. It is observed that the overall gain increases from 5.3866 dBi to 5.9572 dBi and the bandwidth increases from 4.73% (2.3961- 2.512 GHz) to 6.22% (2.3455-2.4967 GHz). The overall gain is high enough to use the antenna in wireless applications at resonant frequency.

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