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A Singly fed Circularly Polarized Rectangular Dielectric Resonator Antenna excited by T-Shaped Conformal Metal Strip

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Abstract: A unique conformal feed comprising of T-shaped metal strips has been used to excite the rectangular dielectric resonator antenna (DRA). By using this single excitation technique the circular polarization (CP) has been achieved. A 3dB axial ration with a bandwidth of ~8.4% along an impedance matching bandwidth of ~8.9% has been achieved. A successful overlapped bandwidth of ~7.2% has been provided by the antenna. The antenna designing and simulation has been done using computer simulation technology (CST). The antenna formulation and calculation has been done using Finite Integration Technique (FIT) and the results of FIT has been validate using finite element method (FEM). A good resemblance has been observed among the results of FIT and FEM.

Keywords: Dielectric resonator antennas (DRAs), circular polarization (CP), T-shaped antennas, finite integration technique (FIT), finite element method (FEM), wide-band antennas.

1.0 INTRODUCTION

From the last few decades the antenna researchers are focusing more on DRAs because of their significant features like flexible design, wider bandwidth, no metallic losses etc. The circularly polarized systems are much more popular as compared to linearly polarized systems in terms of reliability and performance. The CP of DRAs can be achieved by single and dual feeding mechanisms. Dual feeding technique has been explained in [1, 2]. But the single feeding technique is more preferable because of simplicity and reduced size. Several singly fed circularly polarized DRAs has been reported in literature. A 3dB axial ration (AR) bandwidth of 7% of a rectangular DRA has been achieved by conformal strip [3]. A hook-shaped feed has been used to achieve CP bandwidth of 8.3% of a rectangular DRA and 9.8% of a cylindrical DRA as reported in [4, 5]. An AR bandwidth of 2.4% of a hemispherical DRA and 2.7% of a rectangular DRA has been achieved by parasitic patch [6, 7]. An AR bandwidth of 9% of a hollow cylindrical DRA has been achieved by a unique conformal strip [8]. A single-slot feed has been used to achieve 1.8% CP bandwidth of a rectangular DRA [9]. In all these articles good impedance matching bandwidth has been achieved over same frequency range.

In this article the CP of rectangular DRA has been achieved using T-shaped conformal metal strip. The feed parameters are optimized to achieve 3dB AR bandwidth of 8.4% and impedance matching bandwidth of 8.9% along with a useful overlap of 7.2%.

2.0 MATERIALS AND METHODS

A rectangular DRA excited by T-shaped feed has been presented in Fig. 1. The antenna prototype has been designed in CST. The band of frequency has been set at 2 to 6 GHz. The infinite ground plane effect has been used by setting the boundary conditions of Z_{min} at Electric (E_t = 0). The hexahedral meshing has been used for design simulation. A rectangular DRA with a permittivity, ϵ_r = 10 has been modeled. The dimensions of the dielectric block has been chosen from literature [5]: a = 26.1 mm, b = 25.4 mm and c = 14.3 mm. The mashing has been done by setting the cells per wavelength = 40, similarly the cells per max model box edge = 19. And the number of Cells = 562,212 has been used. Two individual lengths has been used to build the T-shaped feed. In simulation the model has been excited by the discrete edge port. The various simulations with the aid of different parameter sweeps has been used to optimize the lengths and widths of metal

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strips. Accordingly the transform command along with parameter sweeps has been used to find the optimal feed position.

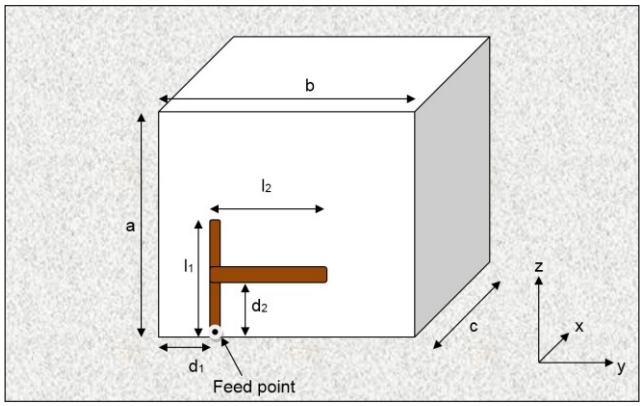

Fig. 1: Rectangular DRA excited by conformal T-shaped feed

The antenna simulation has been accomplished using time domain solver FIT and the results have been validated by using frequency domain solver FEM.

3.0 RESULTS AND DISCUSSION

The unique T-shaped feed position and parameters are optimized after running numerous simulations and optimized measurements of position, lengths and widths are d_1=5.0 mm, d_2=5.0 mm, l_1=11.0 mm, l_2=11.0 mm, width of l_1 is 1.0 mm and l_2 is 1.5 mm. The Input impedances and return losses of the rectangular DRA has been demonstrated in Fig. 2 and Fig. 3 respectively. It can be observed that $|S_{11}| \leq 10$ dB bandwidth of 9% has been achieved. The minimum value of S_{11} is found to be at 3.80 GHz in FIT and at 3.76 GHz in FEM this small negligible difference proves the validity of proposed design.

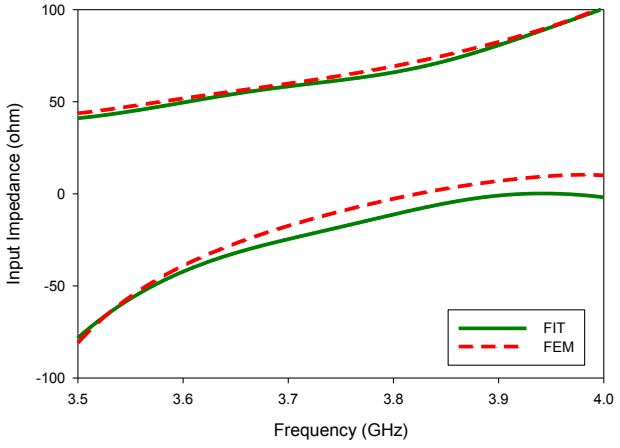

Fig. 2: Input impedance of the rectangular DRA excited by conformal T-shaped feed

The Fig. 4 represents the bore-sight axial ratio of the DRA. The AR bandwidth of 8.4% has been achieved as demonstrated in the result. Moreover the minimum point of AR i.e. 1.9921 dB has been computed at 3.8 in FIT and 1.9516 dB at 3.79 GHz in FEM. A useful overlap of 7.23% between S_{11} and CP bandwidths over same frequency range has been achieved.

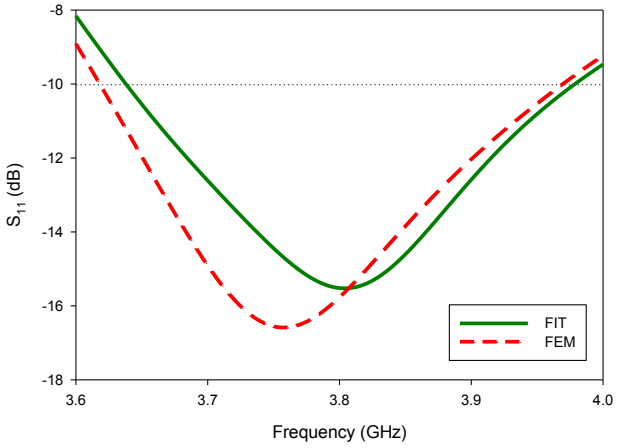

Fig. 3: Return losses of the rectangular DRA excited by conformal T-shaped feed

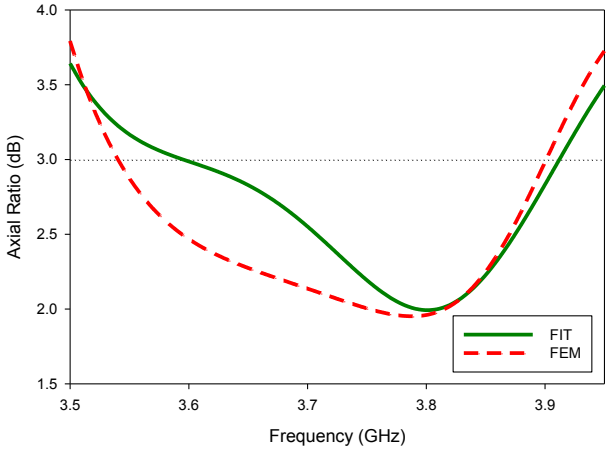

Fig. 4: Axial ratio of the rectangular DRA excited by conformal T-shaped feed

The radiation patterns of the antenna has been presented in Fig. 5. Left hand circular polarization has been achieved as the left hand field component more than 20 dB greater than right field component at minimum AR frequency i.e. 3.8 GHz in bore-sight direction. The Fig. 6 represent the beamwidth of the rectangular DRA. The antenna provides CP with a successful beamwidth of 37° in

the $\phi = 0^o$ plane which is comparable to those discussed in [10].

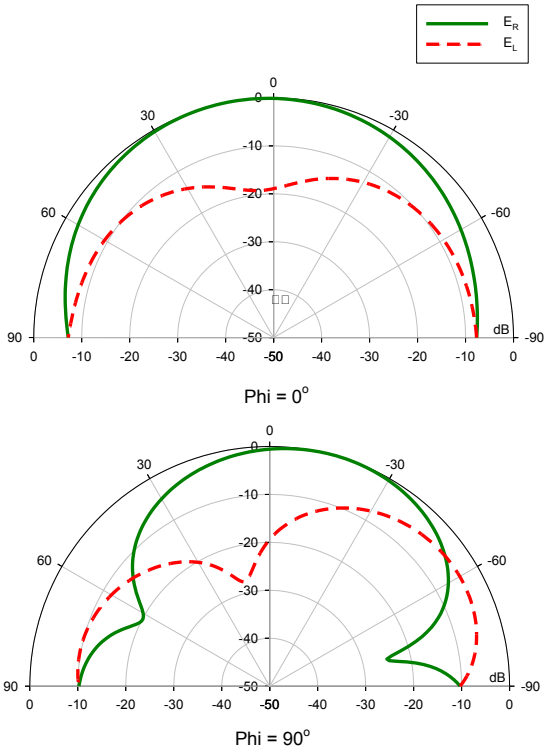

Fig. 5: Radiation patterns of the rectangular DRA excited by conformal T-shaped feed

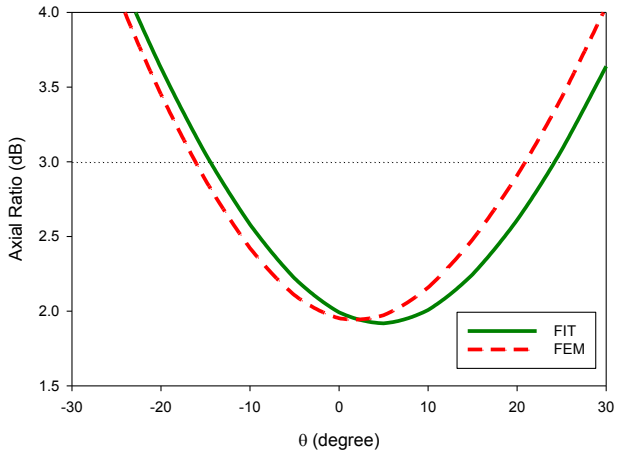

Fig. 6: AR beamwidth of the rectangular DRA excited by conformal T-shaped feed

In Fig. 7 the gain of the antenna has been presented. A useful gain of 5.4-6 dBi has been provided by the antenna throughout the bandwidth of circular polarization. The gain of the antenna has been computed and presented in both FIT and FEM. A close resemble has been found between the results of both techniques the small marginal difference is due to two different simulation environments.

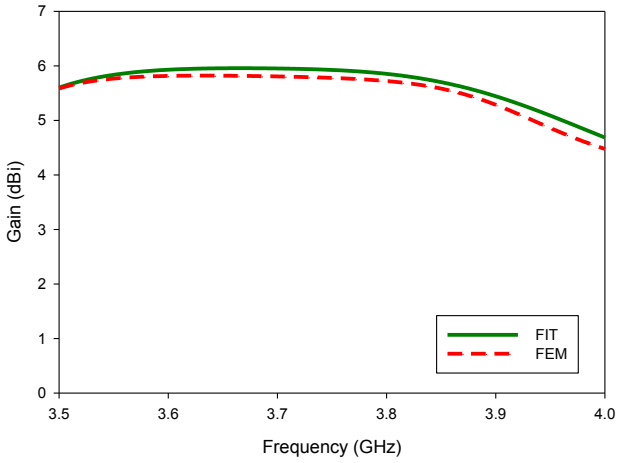

Fig. 7: Gain of the rectangular DRA excited by conformal T-shaped feed

4.0 CONCLUSION

A rectangular DRA has been successfully excited by a conformal T-shaped metal strip. The circular polarization bandwidth of ~ 8.4% along with impedance matching bandwidth of ~ 8.9% has been achieved. The useful overlapped bandwidth of ~ 7.2% has been offered by the antenna which is considerable contribution to that reported in literature. A wider beamwidth of 37° has been achieved as confirmed from far field patters. A high gain between 5.4-6 dBi has been offered by the antenna. A good agreement between the results from both FIT and FEM has been observed.

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