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Novel superman-diamond inspired DRA for X band applications

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Abstract

Exploiting advantage of Dielectric Resonator Antennas (DRA), in this dissemination a novel superman-diamond inspired shaped DRA has been proposed for X-band applications. Furthermore, possibilities of Multiple Input Multiple Output (MIMO) DRA explored using proposed novel shaped DRA and a two-element MIMO DRA has also been proposed for X-band applications. Proposed DRA made up of anisotropic composite ceramic material with dielectric constant 10 has been placed on the substrate with dielectric constant 3.55 and thickness 20 mil. Proposed DRA and MIMO DRA have demonstrated 11.7% and 9.5% impedance bandwidths, respectively. Other performance characteristics of MIMO DRA such as mutual coupling, isolation between ports, ECC, TARC have also been examined. To validate the performance of proposed DRA, simulated performances have been compared between two electromagnetic simulator solvers.

1 Introduction

In the last few decades, Dielectric Resonator Antennas (DRA) immensely contributed in various wireless applications owing to its numerous advantages: no surface wave losses, no ohmic losses, high radiation efficiency, dimensional freedom and ease of excitation [1, 2]. By utilizing dimensional freedom provided by DRAs, different shaped DRAs has been proposed in the literature [6, 7, 3, 4, 8, 5]. Advent of Multiple Input Multiple Output (MIMO) technology opened very high speed data transfer functionality in different wireless applications. Such single element DRA has been appreciated which can be utilized in their MIMO DRA version with ease. In [9], a comprehensive review of recent MIMO DRAs covered which confirmed the potential of DRAs in MIMO applications. In this dissemination, a novel superman-diamond inspired DRA is proposed for X-band applications. Furthermore, a two-element MIMO DRA has also been proposed using diamond-shaped DRA for X-band applications.

2 Antenna Design

The proposed diamond-shaped DRA is constructed with anisotropic composite ceramic material having dielectric constant (ε_r=10) and it is mounted on a RT Duroid RO4333C substrate having dielectric constant (ε_r=3.55). The desired anisotropic property of material can be achieved by additive manufacturing techniques and composite ceramics. Geometry of proposed DRA is shown in Fig. 1. Design parameters are shown in Table-1.

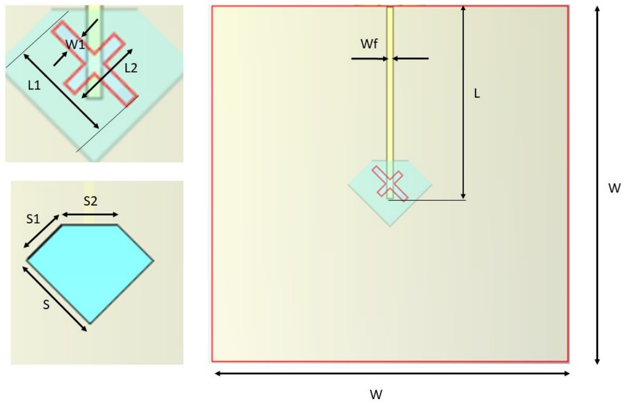

Figure 1. Geometry of the Antenna

Table 1. Design Parameters

Parameter	in mm	Parameter	in mm
W	60	L	32.5
Wf	1.15	L1	7.5
S	10	S1	5.66
S2	6.14	L2	5.16
W1	1	d	1
Wm	75	thickness of substrate	0.508
		height of DRA	19.3

MIMO technology becomes essential in present times to achieve higher data rates in wireless data transfer which is only possible with the application of efficient MIMO operable antennas. In pursuit of exploring possibilities of designing MIMO DRA using proposed DRA, a dual-port, dual-element MIMO DRA has been designed with much ease without introducing complexities to achieve higher isolation and radiation efficiency. It also confirmed that further multiple port MIMO DRA can be designed by proposed DRA without difficulties. Figure 2 shows geometry of proposed MIMO DRA.

3 Result Analysis

Detailed simulation analysis of the proposed DRA and MIMO DRA have been performed in commercial electromagnetic (EM) simulator CST (v2021) which is based on finite-difference time-domain (FDTD) technique. To validate results second EM simulator Ansys HFSS (v19.3)

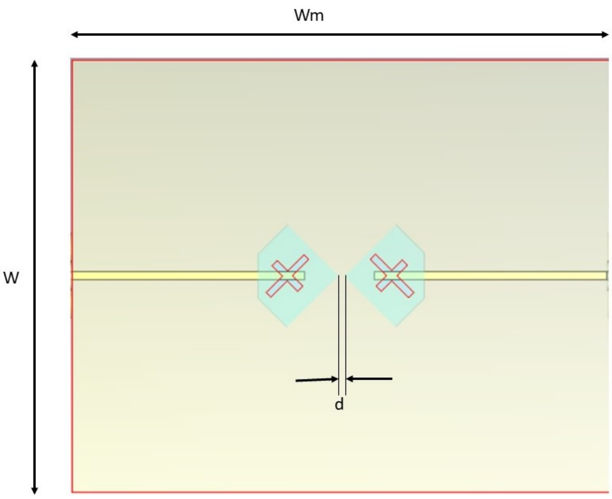

Figure 2. Geometry of the MIMO DRA

which is based on finite element method (FEM) technique, has been used. Figure 3 shows a comparison of S_{11} parameters obtained from both the solvers for the proposed DRA. The simulated impedance bandwidth of the proposed DRA is 8-9 GHz (11.7%), simulated gain in broadside direction at center frequency 8.5 GHz is 6.93 dBi and radiation efficiency is above 90% throughout the operating bandwidth. Figure 4 illustrate comparison of S_{11} and S_{12} parameters obtained from both the solvers. Since, MIMO DRA is a symmetrical structure, so only S_{11} and S_{12} parameters have been illustrated in Fig. 4 and their counterparts S_{22} and S_{21} parameters have not been shown. The impedance bandwidth squeezed and became 9.5% around center frequency but minimum isolation between ports obtained -15 dB which is achieved without applying complex techniques to enhance isolation, making design simpler. Other MIMO performance parameters e.g. total active reflection coefficient (TARC), envelope correlation coefficient (ECC), and directive gain (DG) have also been calculated as mentioned in [10, 11, 12] and found within acceptable limits of MIMO operation and not shown here for brevity. Radiation efficiency has also been observed above 90% throughout impedance bandwidth of MIMO DRA.

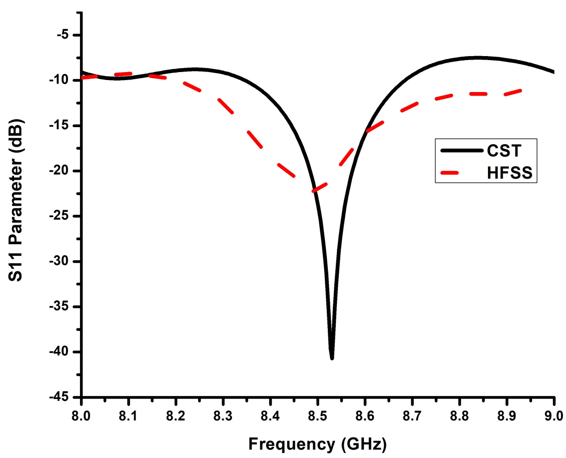

Figure 3. Comparison of S_{11} Parameters of DRA in HFSS and CST solvers

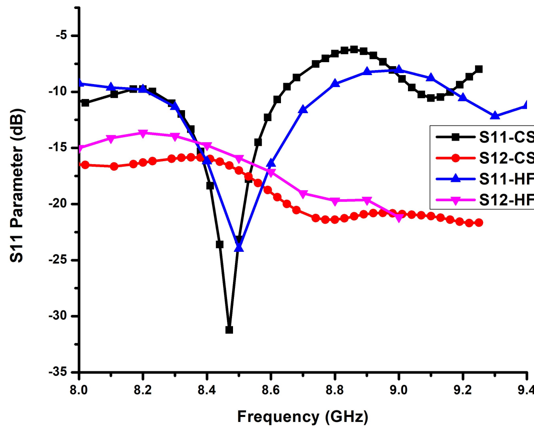

Figure 4. Comparison of S_{11} and S_{12}Parameters of MIMO DRA in HFSS and CST solvers

4 Conclusion

In this paper, a novel superman-diamond inspired shaped DRA and MIMO DRA have been proposed for X-band applications. Simulation analysis have been performed on two EM solvers to validate the results. The proposed DRA demonstrate 11.7% impedance bandwidth and 6.93 dBi simulated gain at 8.5 GHz. A dual-port MIMO DRA has also been proposed without opting complex techniques, using novel diamond shaped DRA. MIMO performance parameters have been found in acceptable limits and validated by two EM solvers.

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