Ultra Wideband Stacked Z-shaped Dielectric Resonator Antenna

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***Abstract* – In this paper, a hybrid Z-shaped dielectric resonator antenna (DRA) design is proposed. Conformal strip feeding is utilized to feed the antenna. It is observed that by use of two different DRA materials, Q-factor can be reduced and in turn ultrawide bandwidth (UWB) can be achieved. A rigorous parametric study is carried out to optimize the bandwidth of proposed antenna while maintaining its compactness. The proposed antenna was fabricated and tested. Measured impedance bandwidth of about 114.5% (-10 dB reference) covering entire C- and X-band (3.56 GHz-13.1 GHz) is achieved which is in close agreement to simulated bandwidth. Average gain of about 6 dBi is achieved over the entire band of interest.**

***Index Terms* — Dielectric resonator antenna (DRA), conformal feed, ultrawideband (UWB) antenna.**

1. Introduction

In the recent years, DRAs have gained much attraction from the researchers world over as they provide several advantages over conventional microstrip patch antennas. DRA offers the benefit of wide bandwidth, high radiation efficiency, high gain, wide range temperature stability, and compatibility with different excitation mechanisms [1]. DRAs are best suited for high gain and wideband applications as no conduction losses prevail, while in case of microstrip patch antenna, conduction losses are very high [2].

Over the years, many bandwidth enhancement techniques have been proposed. In [3], A. Kishk, has proposed a truncated tetrahedron shaped DRA to achieve about 40% bandwidth. Rao et al. [4] have used the concept of stacking two different permittivity tetrahedrons and achieved about 60% bandwidth. Liang et al. [5] have proposed H-shaped DRA design to achieve about 62% bandwidth. T. Denidni et al. [6] have proposed wideband Z-shaped DRA. The authors have used air gap between ground plane and DRA to achieve wideband. However, air gap insertion between ground plane and DRA lead to stability issues when used for practical applications. Moreover, the radiation patterns suggest that the antenna is broadside for low frequency while it is in endfire mode for high frequencies. Thus, radiation pattern is not uniform. In this paper, instead of using air gap, the authors have used two different permittivity materials to reduce effective permittivity which in turn provides ultrawide bandwidth. Moreover, uniform radiation pattern over the entire frequency band is achieved. About 107% simulated bandwidth has been achieved with frequency range from 3.94-13 GHz, while measured results provide even better bandwidth of about 114.5%.

The antenna geometry, and design parameters are discussed in Section 2. Section 3 covers the discussion on simulated and measured results. Finally, the conclusions are summarized in Section 4.

2. Antenna Geometry and Design

Fig. 1 shows the geometry of hybrid Z-shaped DRA. The dielectric resonator (DR) is placed on a 100 X 80 mm^2 FR4 substrate having relative dielectric constant of ε_r = 4.4. The Z-shaped DRA can be considered to be a combination of 3 parts namely, the lower arm residing on the substrate, the central heighted portion, and the upper arm. Each portion comprises of Rogers RO3010 (ε_{r1} = 10.2) and Teflon (ε_{r1} = 2.1) material stacked together. The DR is excited by a hexagonal shaped conformal strip feed. Initially, gradual flaring is given to the vertical portion of the feed. The flaring extends till the width of DR and then the vertical feed is extended parallel to the DR surface. This gradual flaring helps in controlling the excitation of higher order modes while the parallel portion of height h_6 helps in coupling more energy to the DR. Thus, hexagonal shaped conformal feed is more efficient in comparison to conformal trapezoidal feed. Upon parametric analysis of the proposed design using Ansoft HFSS 2014, the optimal design parameters obtained are as follows: L = 100 mm, W = 80 mm, l = 50 mm, l_1 = 40 mm, l_2 = 8 mm, l_3 = 2 mm, w = 2 mm, w_1 = 5 mm, w_2 = 9.5 mm, h_1 = 5.1 mm, h_2 = 7.6 mm, h_3 = 12 mm, h_4 = 15.8 mm, and h_5 = 6.36 mm.

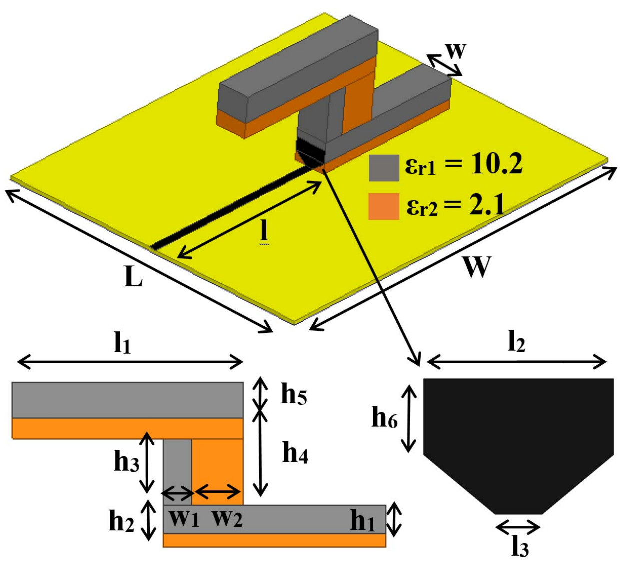

Fig. 1. Geometry of hybrid Z-shaped DRA.

3. Results and Discussion

Low permittivity Teflon is taken as the base of lower arm as impedance matching of the conformal feed-line with low permittivity material is more efficient. Effect of changing the width (l_2) of conformal strip on the performance of DRA has been studied. It has been found that as the width of strip increases from 2mm to 8mm, impedance matching improves and in turn simulated bandwidth increases from 77% to 107%. The length of the arms of DRA, play a crucial role in improving the bandwidth of DRA. As the arm length of the proposed antenna increases, the effective electrical path length increases. This makes the antenna to radiate at low frequencies and in turn provide wider bandwidth. As the permittivity of the hybrid DRA material increases, the bandwidth improves. Upon parametric analysis, it has been found that as the permittivity of material used with Teflon increases from 4.4 to 10.2, simulated bandwidth improves from 62.57% to 107%.

Fig. 2 shows the photographs of proposed antenna taken from various angles. The return loss performance of fabricated antenna was tested using Vector Network Analyzer. Fig. 3 shows the comparison between simulated and measured return-loss performance of the proposed antenna. About, 114.5% measured impedance bandwidth is achieved which is better than simulated bandwidth of 107%. Fig. 4 shows the simulated co- and cross-polarized radiation patterns in E- and H- planes at 5.2, and 11.5 GHz, respectively. The proposed antenna has good separation between co- and cross polarization levels.

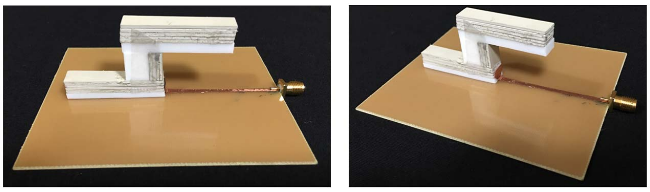

Fig. 2. Photographs of fabricated hybrid Z-shaped DRA.

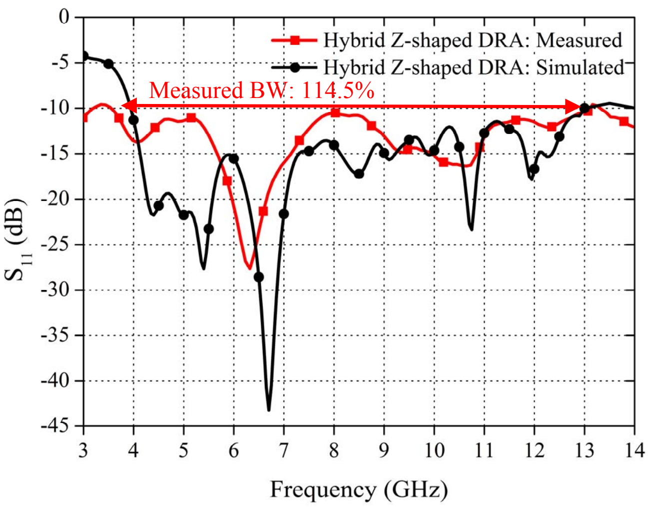

Fig. 3. Comparison of simulated and measured return-loss performance of Hybrid Z-shaped DRA.

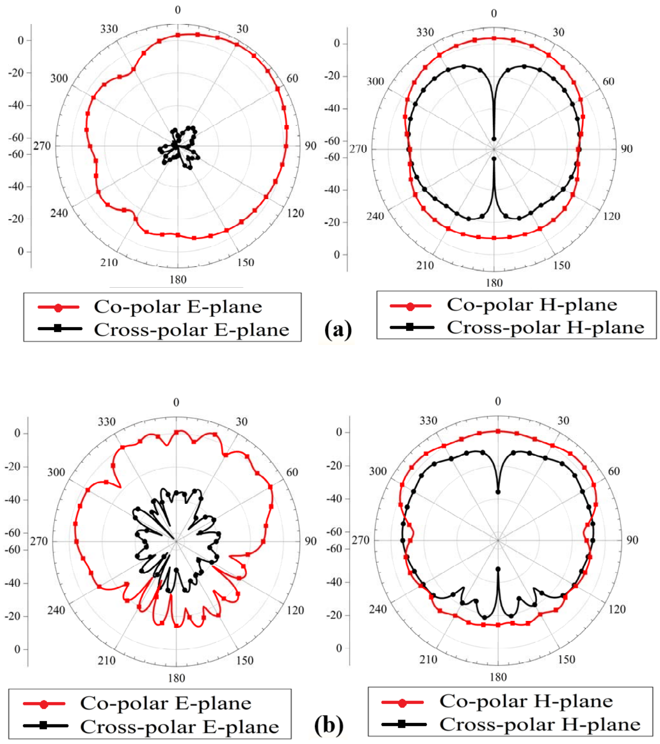

Fig. 4. Simulated co- and cross-polarized radiation patterns of proposed antenna at (a) 5.2 GHz, and (b) 11.5 GHz.

4. Conclusion

Hybrid Z-shaped DRA with UWB characteristics is proposed in this paper. It is shown that bandwidth can be improved by use of different permittivity materials as hybrid structures help in reducing Q-factor. About 114.5% bandwidth covering entire C- and X- band is achieved with an average gain of 6 dBi over the entire band of interest.

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