L-STRIP-FED WIDEBAND RECTANGULAR DIELECTRIC RESONATOR ANTENNA

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ABSTRACT: *In this paper, the advantages of using L-shaped microstrip feed to excite a rectangular dielectric resonator antenna (DRA) by electromagnetic coupling are presented. This feeding technique enhances the bandwidth and gain of the antenna without affecting its size. The experimental results are validated using Fidelity software based on the finite-difference time-domain (FDTD) method.* Microwave Opt Technol Lett 45: 227–228, 2005; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.20778

Key words: *L-strip feed; rectangular dielectric resonator antenna (DRA); bandwidth*

1. INTRODUCTION

Ceramic dielectric resonator antennas (DRAs) have become increasingly popular in microwave and millimeter-wave applications, as they are free from conductor loss. The development of ceramic materials with a low-temperature frequency coefficient has led to high-frequency stability for the dielectric resonator (DR). DRAs also radiate in different directions, depending on the proper excitation of different modes. DRAs with high permittivity can greatly reduce the size characteristic; thus, low-loss, high-permittivity DRs can be highly effective radiators. A high-dielec-

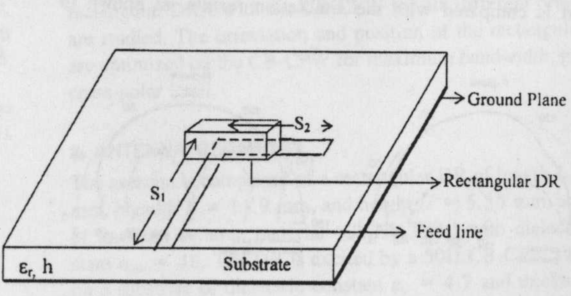

Figure 1 Geometry of the L-strip-fed rectangular DRA

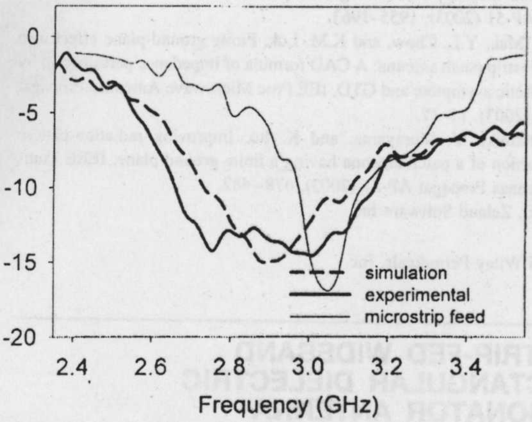

Figure 2 Variation of return loss vs. frequency of the rectangular DRA with L-strip feed (ε_r = 4.28, h = 1.6 mm, and $L \times B \times H$ = 22.5 × 11.9 × 5.55 mm^3, ε_{dr} = 48, S_1 = 5 cm, S_2 = 3.5 cm)

tric-constant (ε_{dr} = 48), low-loss single-phase ceramic material, $Ca_5Nb_2TiO_{12}$, which is prepared via solid-state ceramics, has been reported as the best method for achieving bandwidth enhancement by loading over microstrip patch antennas [1]. Recently, an L-shaped microstrip feed has been successfully used to enhance the bandwidth of microstrip antennas [2].

In this paper, an L-strip feed is employed to energize a rectangular DRA made of low-loss ceramic material ($Ca_5Nb_2TiO_{12}$) with permittivity ε_{dr} = 48. The experimental results are verified using Zeland's Fidelity simulation software based on the finite-difference time-domain (FDTD) method.

2. ANTENNA GEOMETRY

The antenna is comprised of a rectangular DR of length L = 22.5 mm, breadth B = 11.9 mm, and height H = 5.55 mm made of low-loss ceramic material ($Ca_5Nb_2TiO_{12}$) with dielectric constant ε_{dr} = 48. The DR is excited by a 50Ω L-strip feed fabricated on a substrate of dielectric constant ε_r = 4.28 and thickness h = 1.6 mm. The geometry of the proposed rectangular DRA with an L-strip feed is shown in Figure 1.

3. EXPERIMENTAL AND SIMULATED RESULTS

A rectangular DR is loaded on an L-shaped feed with feed length S_1 = 5 cm. The feed segment of length S_2 is varied from 0.5 to 4 cm and the position of the DR is optimized experimentally for maximum bandwidth. The maximum bandwidth was obtained for the rectangular DRA when the feed-segment length S_2 = 3.5 cm. The reflection characteristics of the DRA obtained at the optimized position is compared with the simulation results, as shown in Figure 2. Experimentally, the antenna resonates at 2.9125 GHz with an impedance bandwidth of 16.99% while theoretically, it is found that the antenna resonates at a frequency of 2.92 GHz with 12.33% bandwidth. The variation of the percentage bandwidth of the rectangular DRA versus feed-segment length S_2 is shown in Figure 3.

At the optimized position, the gain of the DRA is measured using the gain-transfer method. The DRA is found to have a gain of 9.1 dBi at the resonant frequency. The radiation patterns of the antenna at the centre frequency for the optimized feed parameters are shown in Figure 4. The HPBW of the antenna in the E-plane and H-plane are 92° and 66°, respectively, at the resonant frequency. The cross polarization of the antenna is better than −30 dB along the bore-sight direction.

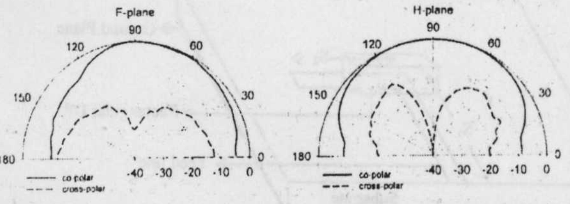

Figure 3 Variation of % bandwidth of the DRA vs. feed segment length S_2 of the L-strip feed DRA (ε_r = 4.28, h = 1.6 mm, and $L \times B \times H$ = 22.5 × 11.9 × 5.55 mm^3, ε_{dr} = 48)

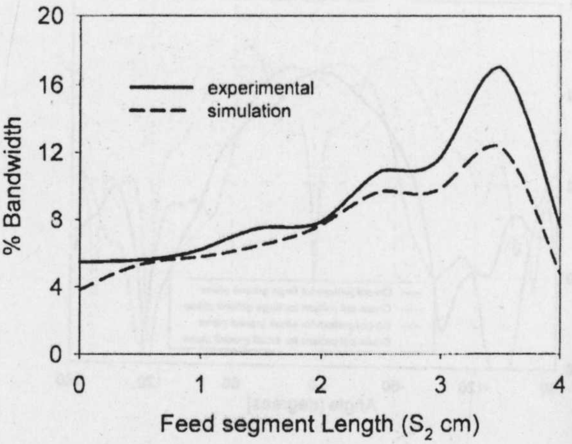

Figure 4 Radiation pattern of the rectangular DRA with L-strip feed at centre frequency (ε_r = 4.28, h = 1.6 mm, $L \times B \times H$ = 22.5 × 11.9 × 5.55 mm^3, ε_{dr} = 48, S_1 = 5 cm, S_2 = 3.5 cm)

4. CONCLUSION

A rectangular DRA excited using an L-shaped feed has been studied in detail. The experimental and simulated results of the DRA confirm that a wide bandwidth is obtained for the configuration. The antenna offers nearly 17% bandwidth with a peak gain of 9 dBi.

REFERENCES

1. P.V. Bijumon, S.K. Menon, M.T. Sebastian, and P. Mohanan, Enhanced bandwidth microstrip patch antennas loaded with high-permittivity dielectric resonators, Microwave Opt Technol Lett 35 (2002), 327–330.
2. B. Lethakumary, S.K. Menon, C.K. Aanandan, K. Vasudevan, and P. Mohanan, L-strip excited wideband rectangular microstrip antenna, Microwave Opt Technol Lett 42 (2004), 173–175.

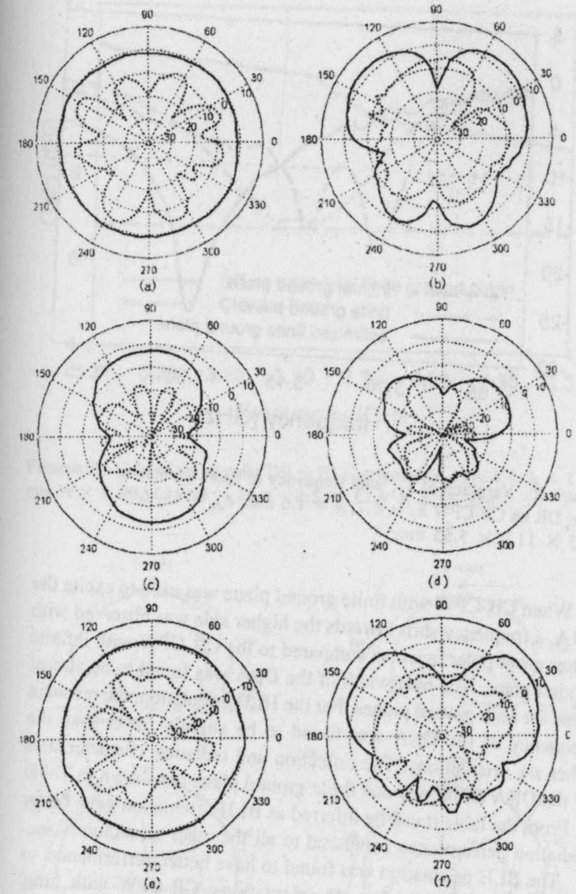

Figure 4 Measured radiation patterns for antenna B: (a) x–y plane (4 GHz); (b) x–z plane (4 GHz); (c) x–y plane (5.6 GHz); (d) x–z plane (5.6 GHz); (e) x–y plane (7 GHz); (f) x–z plane (7 GHz). Solid line: co-polarized; dashed line: cross-polarized

REFERENCES

1. H.M. Shen, R.W.P. King, and T.T. Wu, V-conical antenna, IEEE Trans Antennas Propagat 36 (1988), 1519–1525.
2. K.Y.A. Lai, A.L. Sinopoli, and W.D. Burnside, A novel antenna for ultra-wide-band applications, IEEE Trans Antennas Propagat 40 (1992), 755–760.
3. N.P. Agrawall, G. Kumar, and K.P. Ray, Wide-band planar monopole antenna, IEEE Trans Antennas Propagat 46 (1998), 294–295.
4. M.J. Ammann, Square planar monopole antenna, IEE Natl Conf Antennas Propagat, 1999, pp. 37–40.
5. A. Kerkhoff and H. Ling, Design of a planar monopole antenna for use with ultra-wideband (UWB) having a band-notched characteristic, IEEE Antennas Propagat Soc Int Symp, Columbus, OH, 2003, pp. 830–833.
6. H.G. Schantz, G. Wolence, and E.M. Myszka, Frequency notched UWB antennas, Proc IEEE Conf Ultra-Wideband Syst Technologies, Reston, VA, 2003, pp. 214–218.
7. Y. Kim and D.H. Kwon, CPW-fed planar ultra wideband antenna having a frequency band notch function, Electron Lett 40 (2004), 403–404.