International Journal of Engineering & Technology, 7 (4.38) (2018) 1448-1450

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

A Circularly Polarized Rectangular Dielectric Resonator Antenna Excited by E-Shaped Feed

1J. Iqbal, 1U. Illahi, 1M.I. Sulaiman, 2M.Alam, 4MS. Mazliham,

1Universiti Kuala Lumpur, British Malaysian Institute, batu 8, Jalan Sungai Pusu, 53100 Gombak, Selangor Malaysia
2Institute of Business and Management (IoBM), Korangi Creek, 74900 Karachi, Pakistan
4Malaysia France Institute (MFI) Universiti Kuala Lumpur, Bander Baru, 43650 Bangi, Malaysia
**Corresponding author E-mail: Javed_iqbal55546@yahoo.com*

Abstract

This research article present designing and analysis of a novel E shaped feed, which is consisted of seven optimized metallic strips that have been used to excite Rectangular dielectric resonator antenna (DRA) and generate wideband circular polarization. The novel feed has provided a 10-dB impedance matching bandwidth of ~ 7.85% and 3-dB Axial-ratio (AR) bandwidth of ~8.12 % in the broadside direction.The proposed DRA attained high gain and beam width i.e. 5.4 dB and 45° respectively over the same frequency range. The model has been simulated in computer simulation technology (CST) software by using the transient solver, based on the finite integration technique (FIT) and thoroughly validated through another computational technique i.e. finite element method (FEM), where a significant trend resemblance can be seen between the results of both solvers.

Keywords: *Dielectric Resonator Antenna, Cross Polarization, Bandwidth, E-shaped feed.*

1. Introduction

Dielectric resonators (DR) were initially proposed in microwave (μw) circuits as an oscillator and/or filters. The DR overcome metallic waveguide cavities because of several qualities such as wide bandwidth, high radiation efficiency, lightweight, small size, high Q-factor, low cost, temperature control, and capability to resonate in several shapes (E. H. Lim, 2008).

By fixing on top of a metallic ground plane, DR emits energy effectually and because of this quality, it is used as an antenna. The most common methods used to excite a DRA are conformal feeding, aperture coupling, probe coupling, and microstrip line coupling (Long, 1983). The dimension of the feed, its location and the way it is coupled will define which mode(s) will be excited. In the end, the efficiency of the DRA is depended upon feeding, the shape of the antenna, permittivity, and size of the antenna.

On the other hand, typical microstrip antennas have minimal radiation efficiency, more conduction losses, and narrow bandwidth. To cover these concerns, DRA provides the best and suitable option for engineers in wireless communication systems (Petosa A, 2010) (Chaudhary, 2013).

Nowadays, circular polarization (CP) has got great attention because of its advantages, e.g. better mobility, reduced multipath of the signal and weather penetration in recent wireless communication systems i.e. Radar and satellite, (Leung,2003). The feeding of the DRA has been split into two categories; single feeding and double feeding technique.

Several single feed CP DRA designs have been published in the literature, for example, a rectangular DRA fed by a single-slot attained circular polarization bandwidth of 1.8% (Oliver, 1995) and in (A. A Kishak, 2003) an elliptical DRA obtained CP of 3.5%.single-slot attained circular polarization bandwidth of 1.8% (Oliver, 1995) and in (A. A Kishak, 2003) an elliptical DRA obtained CP of 3.5%.

A rectangular DRA that is excited using an outer-fed square spiral strip and a hemispherical DRA fed by a parasitic patch reported 6.7% and 2.4% CP Bandwidth respectively (Sulaiman, 2010), (Leung, 2003). Moreover, 3-dB axial ratio bandwidth of 5.71% is achieved in semi eccentric annular DRA which is feed through single vertical coaxial feed (jmai, 2014).

In this research article, a single fed technique has been used to achieve wideband circular polarization, excited through E shaped feed and the results show that wide bandwidth has been achieved through a novel feed which is comparatively wider than the other single feed DRA's stated in the literature.

2. Problem Statement

One of the major issues to work on, in today modern wireless communication systems are demands of electronic systems of high efficiency, wide bandwidth and reduced equipment size. Meeting these demands in the RF and a wireless domain is a major challenge since it involves designing an antenna to be embedded into wireless products. Dielectric resonator antenna (DRA) is the most appropriate option especially at mm-wave due to the absence of conductor or surface wave losses which effect other types of antennas. (Ittipiboon 1994, Almpanis 2006).

Additionally, problems of polarization of mismatch and diminish multipath interference effects antenna efficiency.In order to overcome such issues, circularly polarized (CP) antennas has been widely used in communication systems (Oliver 1995, Wong 2001). Latest research work on CP Dielectric Resonator Antennas (DRA's) has emphasized their reasonable broader bandwidth and better gain for CP which simply other antenna don't have i.e. microstrip antennas. (A. Petosa,2005)

3. The Aim of Research

The main aim of this research is to implement new E shaped feed to excite rectangular Dielectric resonator antenna to get cross-polarization with the broader bandwidth and high gain. Furthermore, the simulated results will be validated with another computational technique.

4. Method of Research

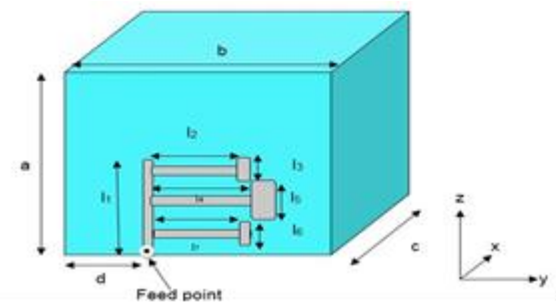

Figure 1. Geometry of the Rectangular DRA fed by a E shaped

Fig. 1 shows the geometry and 3-D view of a projected antenna of proposed Rectangular DRA excited with E shaped feed. In the projected design, a rectangular DRA prototype with a relative permittivity of alumina (εr=9.3) has been simulated. The dimensions of the DRA are a=25.4 mm, b=26.1mm and c=14.3mm which is similar to the one used in (Sulaiman, 2010). The proposed roman three type feed is made up of seven metallic individual strips. After numerous simulations of varying the parameters of the antenna, the optimum dimension of the feed are found to be l1=8.75mm, l2 and l7=8.0mm, l4=9mm,l3 and l6 1.5mm and l5=2.5mm.

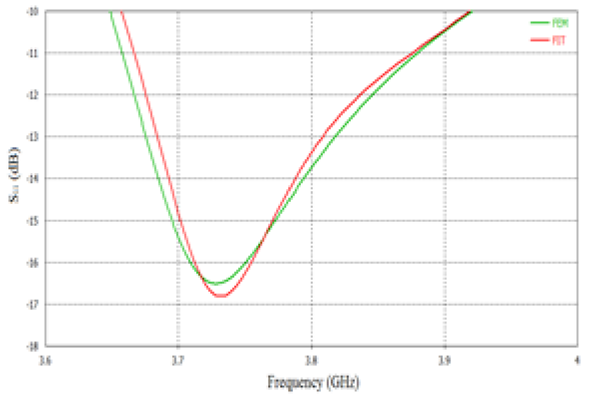

Figure 2 (a): Return losses of a RDRA fed using E-shaped feed

To simulate the effect of infinite ground plane, the boundary condition of Zmin is set to be ET=0. A discrete edge port is used to excite proposed feed. Mashed properties like lines per wavelength are 60 while lower mesh limit = 35, Mesh line ratio limit is =50 for the proposed Antenna and finally, mesh cells for the DRA is 5, 38,625.
Hexahedrons meshing is used to simulate the optimized design. Through parameter sweep, the feed position is shifted on the surface of the DRA along the y-axis and the optimized position of the feed is found to be at the Y= -4.5mm of the DRA surface. In order to validate the proposed antenna, the projected design has been simulated by using another computational technique. Good agreement between the results have been witnessed and hence validated the design.

5. Analysis and Discussion

A Prototype antenna has been simulated and optimized with CST. Fig. 2(a)–(b) illustrates the simulated results. The validation of the proposed antenna design was performed using FEM. Fig. 2(a) shows the results of both computational techniques for the proposed antenna, where small discrepancies mismatch between results of AR is because of a small size of a different domain (Jmai, 2014).

With reference to the Fig. 2(a) the proposed antenna shows validated results for 3-dB axial-ratio bandwidth and S11 impedance matching bandwidth. Through FIT, the proposed antenna matching impedance (S11) is ranging from 3.65 GHz to 3.94 GHz, representing the bandwidth of 7.85 % with minimum frequency attained at 3.70 GHz.While on the other side, FEM technique validates the CST results and over the minimum frequency 3.72 GHz show matching impedance (S11) of 7.60 %.Overall trend shows the validation of the results as well.
It is clearly seen in Fig 2(b) that 3-dB axial-ratio bandwidth has been achieved and validated over both computational techniques almost at same minimum frequency i.e.3.70 GHz & 3.71Ghz.Through FIT 3-dB axial-ratio bandwidth is 8.12% and over the same minimum frequency through FEM 3-dB axial-ratio bandwidth achieved is 8.33%. In the broadside direction (θ = 0, φ = 0)
Gain and Beamwidth of the proposed DRA can be observed from Figure c-d. Fig 2 (C) shows that gain is 5.30 dBi when computed through FIT Technique At the minimum AR frequency (~3.70 GHz), further the gain rase to 5.35 dBi when the proposed DRA is computed through FEM technique. The antenna offers the gain of almost 5.40 dBi across the whole operating bandwidth.
As shown in Fig 3 (d) useful beamwidth of 45° in the φ = 0 plane is achieved for cross polarization DRA which is reasonable enhanced comparatively.

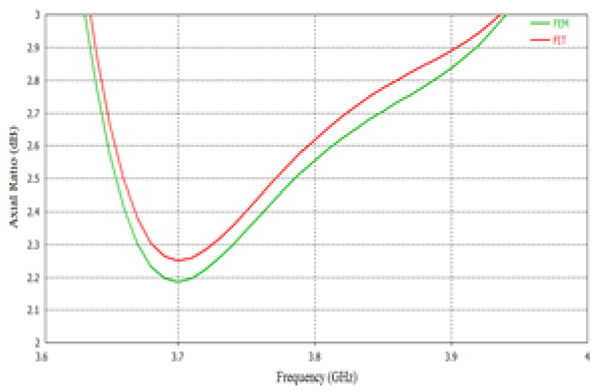

Figure 2 (b): 3- Axial ratio of a RDRA fed Using E-shaped feed

(LHCP) fields are dominant than the right-hand CP (RHCP) by approximately, around
20 dB and 22 dB in the boresight direction in the ϕ=00 & ϕ=900 plane, respectively.
Conclusion
A Wideband Circularly Polarized Rectangular- Dielectric Resonator Antenna Excited by new E-shaped feed has been investigated by using CST simulator. Based on the results obtained i.e. 10-dB impedance bandwidth of 7.85% and 3-dB AR bandwidth of 8.12 % in the broadside direction, a wideband CP DRA design has been achieved. The design has been validated through FEM computational technique and a good agreement has been
Observed and additionally, achieved high Gain and beamwidth of 5.40 dBi and 45° respectively.

Acknowledgment

The authors would like to acknowledge the Research and Innovation Department of British Malaysian Institute (BMI) for providing the peacefull environment for research and Gomal University, Pakistan for granting oversea study leave for Ph.D.

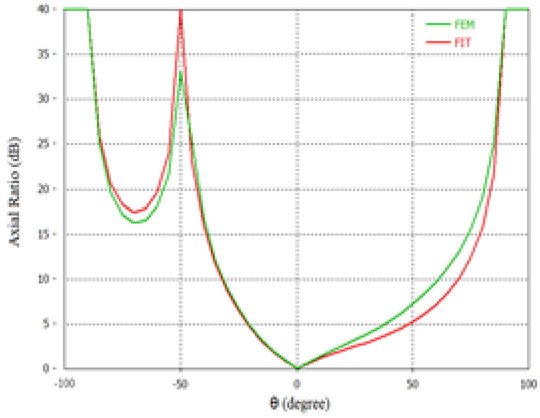

Figure 2 (c). Beamwidth of the RDRA fed by a E shaped feed

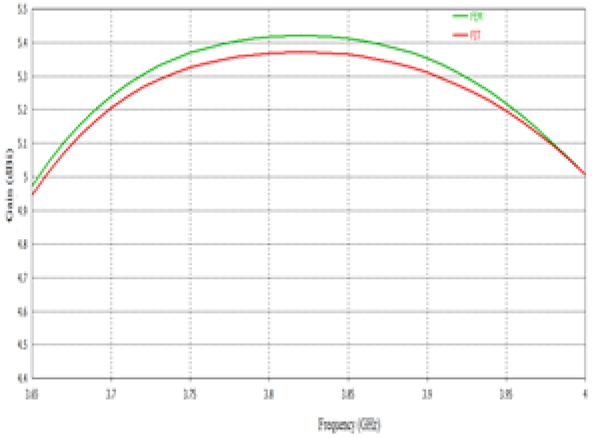

Figure 2 (d). Gain of the RDRA fed by a E shaped feed

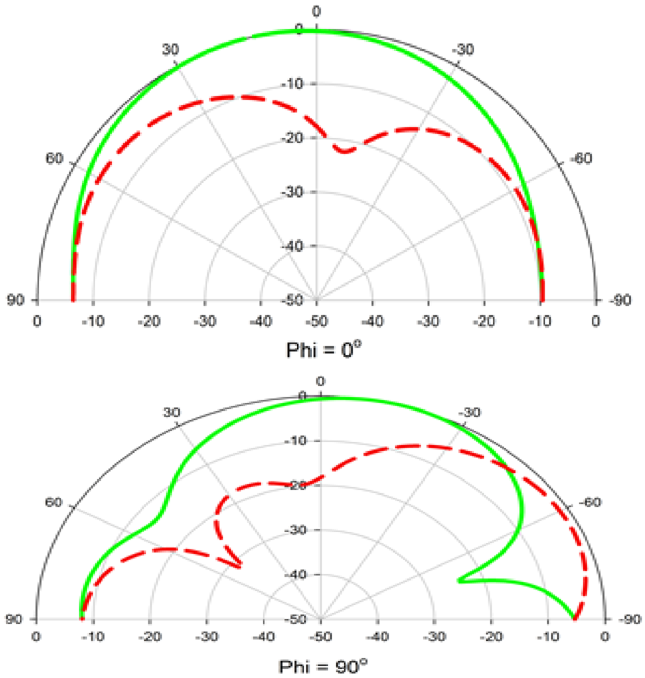

Figure 2 (e). Radiation pattern of the RDRA at ϕ=00 and ϕ=900

References

[1] Lim, E. H., & Leung, K. W. (2008). Use of the dielectric resonator antenna as a filter element. IEEE Transactions on Antennas and Propagation, 56(1), 5-10.

[2] Ittipiboon, A., Roscoe, D., Mongia, R., & Cuhaci, M. (1994, August). A circularly polarized dielectric guide antenna with a single slot feed. In Antenna Technology and Applied Electromagnetics [ANTEM 1994] Symposium on (pp. 427-430). IEEE.

[3] Almpanis, G., Fumeaux, C., & Vahldieck, R. (2006). Offset cross-slot-coupled dielectric resonator antenna for circular polarization. IEEE microwave and wireless components letters, 16(8), 461-463.

[4] Oliver, M. B., Mongia, R. K., & Antar, Y. M. M. (1995, June). A new broadband circularly polarized dielectric resonator antenna. In Antennas and Propagation Society International Symposium, 1995. AP-S. Digest (Vol. 1, pp. 738-741). IEEE.

[5] Petosa, A., Thirakounc, S., Zuliani, M., & Ittipiboon, A. (2005, July). Comparison between planar arrays of perforated DRAs and microstrip patches. In Antennas and Propagation Society International Symposium, 2005 IEEE (Vol. 2, pp. 168-175). IEEE.

[6] Wong, W. C., & Leung, K. W. (2001). Circularly polarized dielectric resonator antenna excited by dual conformal strips of unequal lengths. Microwave and Optical Technology Letters, 29(5), 348-350. 5 (2001):348-35

[7] Long, S., McAllister, M., & Shen, L. (1983). The resonant cylindrical dielectric cavity antenna. IEEE Transactions on Antennas and Propagation, 31(3), 406-412

[8] Petosa A and Ittipiboon, , 2010. Dielectric resonator antennas: A historical review and the current state of the art. IEEE Antennas and Propagation magazine, 52(5), pp.91-116.

[9] Chaudhary, R.K., Kumar, R. and Srivastava, K.V., 2013. Wideband ring dielectric resonator antenna with annular-shaped microstrip feed. IEEE Antennas and Wireless Propagation Letters, 12, pp.595-598.

[10] Leung, K.W. and Ng, H.K., 2003. Theory and experiment of circularly polarized dielectric resonator antenna with a parasitic patch. IEEE Transactions on Antennas and Propagation, 51(3), pp.405-412.

[11] Oliver, M.B., Antar, Y.M.M., Mongia, R.K. and Ittipiboon, A., 1995. Circularly polarised rectangular dielectric resonator antenna. Electronics letters, 31(6), pp.418-419.

A. A Kishak, 2003 An elliptic dielectric resonator antenna designed for circularly polarisation with single feed Micro Opt Technol lett,Vol 37,pp.454-456.

[12] Sulaiman, M.I. and Khamas, S.K., 2010. A singly fed rectangular dielectric resonator antenna with a wideband circular polarization. IEEE Antennas and Wireless Propagation Letters, 9, pp.615-618.

[13] Leung, K. W., & Ng, H. K. (2003). Theory and experiment of circularly polarized dielectric resonator antenna with a parasitic patch. IEEE Transactions on Antennas and Propagation, 51(3), 405-412.

[14] Jmai, B., Rajhi, A., & Gharsallah, A. (2014, December). Software comparative study for RF power coupler. In Microwave Symposium (MMS), 2014 14th Mediterranean (pp. 1-6). IEEE.