A Review on Dual-Band Circularly Polarised Dielectric Resonator Antenna

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Abstract - *Antennas are an indispensible part of any wireless communication systems. DRA in comparison to other printed antennas it possess absence of metallic losses, wider impedance bandwidth, ease of excitation, better radiation efficiency as well as ease to create diversified far-field characteristics. This article gives a review about dual band circularly polarised dielectric resonator antenna. The main objective of this paper is to underline different techniques by different researchers used to generate circular polarisation in DRA.*

Key Words: circular polarisation, dielectric resonator antenna, Dual band

1. INTRODUCTION

As the demand of wireless and mobile communications are increasing day by day, the need for advanced antennas has also becomes increasing. There are many antennas that can be used for wireless communications but dielectric radiator as a resonator has more advantages over other conventional metallic antennas. High impedance bandwidth, Low metallic losses, High radiation efficiency , No surface wave losses, Low dissipation at higher frequency are some of the features of dielectric resonator antenna[1]. One of the main advantages of a DRA technology is that various feeding techniques can be used to excite the radiating modes of a dielectric resonator

Polarization of an antenna is generally determined from the electric field orientation, it can be either linearly or circularly polarized. Linearly polarized antennas can radiate only one plane (vertical or horizontal) in the direction of wave propagation. Circularly polarised antennas have several important advantages compared to linearly polarised antennas and are becoming a key technology for various wireless systems including satellite communications, mobile communications, global navigation satellite systems (GNSS), wireless sensors, radio frequency identification (RFID), wireless power transmission, wireless local area networks (WLAN), wireless personal area networks (WPAN), Worldwide Interoperability for Microwave Access (WiMAX) and Direct Broadcasting Service (DBS) television reception systems. In circular polarization the antenna radiates electromagnetic energy in a circular spiral pattern which covers horizontal, vertical and all the planes in-between them. For generating CP waves by a DRA several methods are adopted to excite a pair of orthogonal modes. The orientation of the antenna in circular polarisation are not important as the circular pattern of the transmitting and/or receiving antenna will always matches the incoming signal. Another advantage of CP antennas is rejection of multipath propagation, which leads to interference of signal in linear polarization.

2. DIELECTRIC RESONATOR ANTENNA

Dielectric resonator antenna was first introduced by Richtmyer in 1939[2] that an unmetalized dielectric object can behave like a metallic cavity resonator, and it was given the name of dielectric resonator (DR). The size of the DRA is proportional to $\lambda 0/\sqrt{\epsilon r}$ with $\lambda 0 = c/f0$ being the free-space wavelength at the resonant frequency $f0$ and where ϵr denotes the relative permittivity of the material forming the radiating structure[3]. The DRAs are characterized by high radiation efficiency because of the absence of conducting material when a low-loss dielectric material is chosen. This characteristic makes them suitable for applications at very high frequencies. .

Mainly there are four feeding techniques used in DRA that is probe-fed DRA, coplanar waveguide-fed DRA, microstrip transmission line-fed DRA and slot-fed DRA[3]. In a probe-fed DRA the dielectric resonator is disposed directly on ground plane and the excitation is given through a coaxial feed into the substrate. Feed is given through printed transmission lines in a microstrip-fed DRA. Slot-fed DRA, the feed is given through a slot on ground plane, this is also called aperture coupling. Coplanar waveguide circular loop network is used to feed the antenna structure in a coplanar waveguide-fed DRA. DRAs can be distinguished by a large impedance bandwidth if the dimensions of the resonator and the material dielectric constant are chosen correctly. Different techniques can be used in DRAs for excitation. The gain enhancement, bandwidth enhancement, and polarization characteristics of a DRA can be easily controlled using different design techniques.

3. DUAL BAND CIRCULARLY POLARISED DIELECTRIC RESONATOR ANTENNA

Some of the dual band circularly polarised dielectric resonator antenna proposed by different researchers are discussed in this paper. A dual-band hybrid DRA/patch omnidirectional CP antenna [5] shown in fig.1 has been found that the patch and the DRA are responsible for the lower and upper bands, respectively. The antenna geometry is fed by a coaxial probe centrally of length and radius .The two bands radiate circularly polarised fields with different senses. Here, the patch convert the LP wave radiated by the DRA into a CP wave, it also makes another resonance mode for a dual-band operation. From the design, the two bands can be independently controlled by the dimensions of DR and patch, respectively.

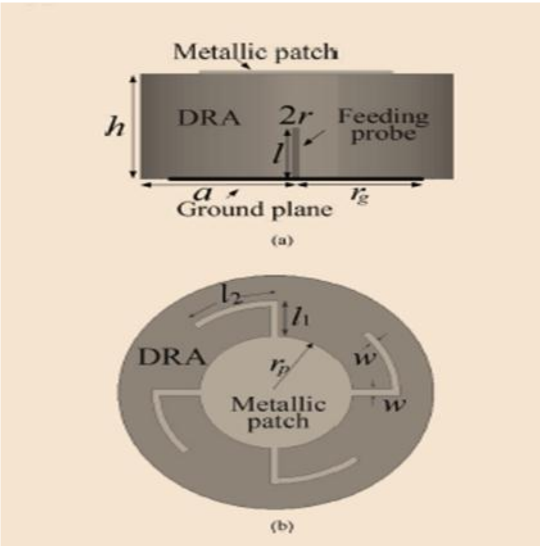

Fig -1: Dual-band dual-sense omnidirectional CP DRA/ patch hybrid antenna. (a) Front view. (b) Top view [5]

Dual C-shaped patch loaded Z-shaped CDRA [7] as shown in fig. 2 with same dielectric constant. Offset is imparted between upper and lower CDRAs to reduce the quality factor. Offset distance is that field lines between upper and lower CDRAs maintain a phase shift of π/2 at 8.0 GHz frequency band. Dual C-shaped patch behaves like a radiator and also used to excite TE01δ mode.

In another antenna, geometry as shown in fig. 3, the CP wave in first band is achieved due to generation of nearly degenerated modes while 40º rotated triangular ring-shaped aperture is accountable for the CP wave generation in the second band. The microstrip line with triangular ring-shaped aperture feeding structure and parasitic strip creates dual radiating modes in the RDRA[8]. The left-hand circular polarization(LHCP) and right-hand circular polarization (RHCP) of this antenna can be managed by triangular ring-shaped aperture and parasitic strip by taking mirror image.

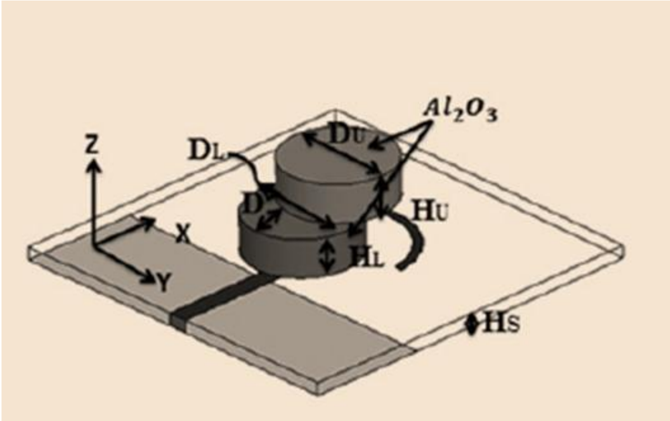

Fig -2: Dual C-shaped patch loaded CDRA [7]

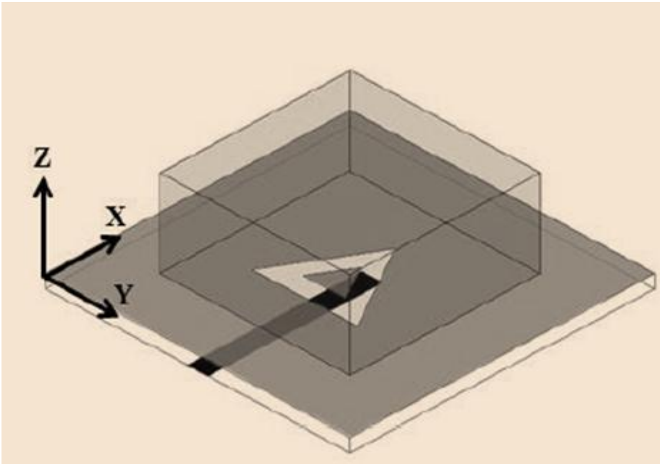

Fig -3: Configuration of the RDRA[8]

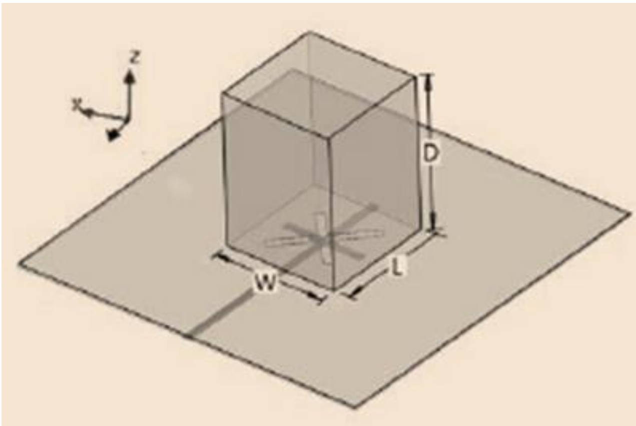

Fig -4: Geometry of the RDRA[9]

A cross-slot-coupled dual-band circularly polarized rectangular dielectric resonator antenna (RDRA) [9] is shown in fig. 4. Cross slot is used to feed the RDRA with a square cross section to achieve single-feed dual-band CP performance. The width of the DR plays a vital role in tuning the resonant frequencies of the two bands, whereas the higher band is mainly determined by the height of the DR. The size of the cross slot is crucial in the excitation of the near-degenerate modes and the AR optimization of the two bands.

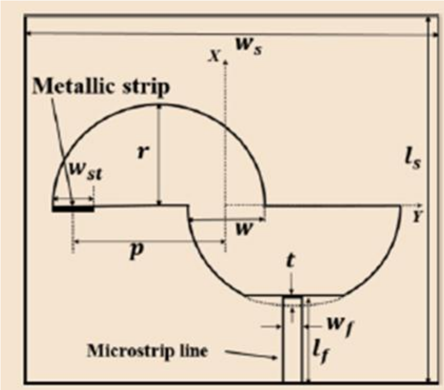

Fig -5: Antenna geometry of multiband DRA[10]

A multiband DRA as shown in fig. 5 with inverted-sigmoid shaped DR providing the dual band CP response. A metallic strip is applied at DR is responsible for the dual band CP response [10]. Due to its specific geometry the fundamental and higher order hybrid modes have been excited in the antenna structure. The reported 3-dB AR bandwidth is of 19.98% in the lower band and 3.07% in the upper band. The upper 3-dB AR passband has been tuned in different 10-dB impedance passbands by altering the location and size of the metallic strip. The reported peak gain [10] of 4.85 and 6.38 dBi in the lower and upper CP bands, respectively. In fig. 6 an asymmetrical swastik-shaped aperture coupled cylindrical dielectric resonator antenna [11]. Here stub adding with rectangular aperture is used for generation of degenerated orthogonal modes which result in CP waves.

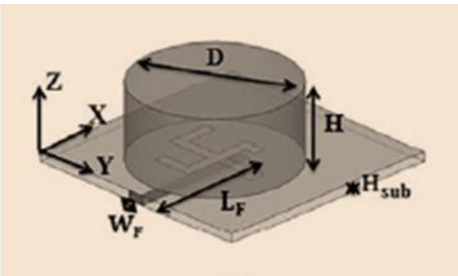

Fig -6: Asymmetrical Swastik-shaped aperture coupled cylindrical dielectric resonator antenna[11].

A summary of the results generated by the above papers are illustrated in table 1. The feed type used in the above structures and the reported axial ratio, operating frequencies are shown in the table 1.

Table -1: Summary of results of different antenna geometries

DR shape	Frequency (GHz)	Feed Type	AxialRatio Bandwidth (%)	References
Patch hybrid	1.93, 2.5	Probe	2.64, 5.06	[5]
Cylindrical	1.32, 2.68, 3.64, 5.28, 8.0	Strips	9.23,11.76,18.18,11.85,16.56	[7]
Rectangular	3.5, 5.26	Slot	2.29, 3.09	[8]
Rectangular	1.26, 1.56	Cross-slot	2.1, 2.2	[9]
Inverted-sigmoid	5.96, 11.95	Strips	19.98, 3.07	[10]
Cylindrical	2.4, 3.3	Aperture	10.75, 16.79	[11]

4. CONCLUSIONS

In this paper, some methods and designs for generating dual band circularly polarised dielectric resonator antenna are studied. Different antenna structures by different researchers are discussed along with the techniques they adopted for creating circular polarisation for dual band operation. Circularly Polarised waves are originated inside any radiating structure by generation of degenerated orthogonal modes inside antenna and 90º phase shift between these modes.

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REFERENCES

[1] R. K. Mongia and P. Bhartia, "Dielectric resonator antennas—a review and general design relations for resonant frequency and bandwidth," Int. J. Microw. Millimeter-Wave Comput. Eng., vol. 4, no. 3, p. 230–247, Mar., 1994.

[2] R. D. Richtmyer, "Dielectric Resonators," J. Appl. Phys., Vol. 10, June 1939, pp. 391-398.

[3] S. Keyrouz, D. Caratelli, "Dielectric Resonator Antennas: Basic Concepts, Design Guidelines, and Recent Developments at Millimeter -Wave Frequencies", International Journal of Antennas and Propagation, vol. 2016, Article ID 6075680, 20 pages, 2016.

[4] B. Y. Toh, R. Cahill, and V. F. Fusco, "Understanding and Measuring Circular Polarization," IEEE Trans. Educ., vol. 46, no. 3, p. 313–318, Aug., 2003.

[5] Y. M. Pan, S. Y. Zheng and W. Li, "Dual-Band and Dual-Sense Omnidirectional Circularly Polarized Antenna," in IEEE Antennas and Wireless Propagation Letters, vol. 13, pp. 706-709, 2014.

[6] Petosa A. Dielectric Resonator Antenna Handbook. Norwood, MA: Artech House; 2007.

[7] A. Sharma and R. K. Gangwar, "Circularly polarised hybrid Z-shaped cylindrical dielectric resonator antenna for multiband applications," in IET Microwaves, Antennas & Propagation, vol. 10, no. 12, pp. 1259-1267, 17 9 2016, doi: 10.1049/iet-map.2016.0035.

[8] A.Gupta and R. K. Gangwar, "Dual-Band Circularly Polarized Aperture Coupled Rectangular Dielectric Resonator Antenna for Wireless Applications," in IEEE Access, vol. 6, pp. 11388-11396,2018.

[9] X. Wang, L. Sun, X. Lu, S. Liang and W. Lu, "Single-Feed Dual-Band Circularly Polarized Dielectric Resonator Antenna for CNSS Applications," in IEEE Transactions on Antennas and Propagation, vol. 65, no. 8, pp. 4283-4287, Aug. 2017.

[10] G. Varshney, S. Gotra, V. S. Pandey and R. S. Yaduvanshi, "Inverted-Sigmoid Shaped Multiband Dielectric Resonator Antenna With Dual-Band Circular Polarization," in IEEE Transactions on Antennas and Propagation, vol. 66, no. 4, pp. 2067-2072, April 2018.

[11] A. Sharma, D. K. Tripathi, G. Das, and R. K. Gangwar, "Novel asymmetrical Swastik-shaped aperture coupled cylindrical dielectric resonator antenna with dual-band and dual-sense circular polarization characteristics," Microw. Opt. Techn. Lett., vol. 61, no. 2, pp. 405-411, 2019.

[12] Z. Zhao, J. Ren, Y. Liu, Z. Zhou and Y. Yin, "Wideband Dual-Feed Dual-Sense Circularly Polarized Dielectric Resonator Antenna," in IEEE Transactions on Antennas and Propagation,2019.