Dual-Polarized Dielectric Resonator Antenna excited in $HEM_{12\delta}$ mode with Enhanced Port-to-Port Isolation

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***Abstract*—** In this paper, a dual linearly polarized cylindrical dielectric resonator antenna excited in higher-order $HEM_{12\delta}$ mode is presented. The proposed design makes use of annular current sheet in conjunction with 50Ω microstrip line to excite $HEM_{12\delta}$ mode. The antenna operates at 10.04 GHz and exhibits an impedance bandwidth of 1.3% (9.98-10.11 GHz) for both horizontal and vertical polarizations. The isolation between the ports is better than 30 dB over the operating bandwidth. The peak gain of the proposed antenna is 9.45 dBi at the operating frequency for both horizontal and vertical polarizations. Diversity performance is evaluated in terms of envelope correlation coefficient and its value is below 0.0007 throughout the bandwidth. The proposed antenna could be suitable for polarimetric synthetic aperture radar, 5G communication system and other X-band applications.

Keywords-dielectric resonator antenna, polarization diversity, higher order mode, 5G communication system

I. Introduction

Cylindrical dielectric resonator has been studied systematically by Long *et. al.* as an efficient radiator way back in 1983 [1] and since then, it became the most celebrated structure in the DR antenna community. During that time, several modes have been investigated for isolated CDR [2] but only two of them *i.e.* $HEM_{11\delta}$ and $TM_{01\delta}$ have been particularly utilized for radiation purpose. The former one provides the broadside radiation whereas the latter one provides monopole-type radiation. Later, the $TE_{01\delta}$ mode has been utilized to generate broadside radiation in half split cylindrical dielectric resonator antenna (DRA) [3]. Recently, the higher order $HEM_{12\delta}$ mode has been excited and examined as another radiating mode with high-gain broadside radiation [4].

In the last few years, dual-polarized antennas have gained much more attention in both modern wireless communication systems and radar systems [5]-[8]. The polarization diverse system improves channel capacity and combat multipath fading problem. Moreover, in polarimetric radar systems such as polarimetric synthetic aperture radar and polarimetric phased array radar, the polarization diversity is sometimes required as it enhances the information content by providing both co-polar and cross polar scattering data.

DRAs have gained widespread attention due to their attractive advantages such as small size, low loss, high radiation efficiency (due to lack of surface wave and conductor losses), relatively wide bandwidth etc [9]. Moreover, different modes with diverse radiation characteristics can be excited within a single DRA which makes it a potential candidate for diversity applications.

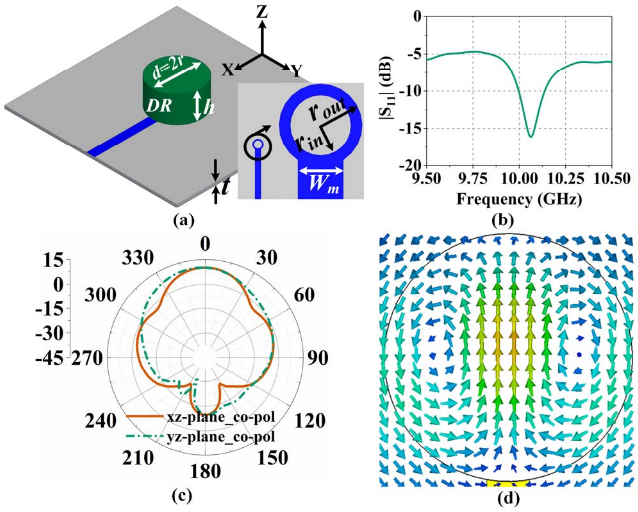

Figure 1 (a) Geometry of ACS fed DRA (r=7, h=7.65, r_{in}=1.8, r_{out}=2.2, t=0.787, all dimensions are in mm) (b) simulated response (c) simulated radiation pattern (d) electric field distribution on top surface

In this paper, a dual linearly polarized cylindrical dielectric resonator antenna excited in higher-order $HEM_{12\delta}$ mode is presented. All the simulations are done using the transient solver of CST Microwave Studio.

II. Antenna Design

In [4], it was suggested that a linearly polarized current sheet in the form of non-resonant patch can be used to excite $HEM_{12\delta}$ mode without destroying the necessary boundary condition. There the authors have used circular current sheet (CCS) which is excited using co-axial probe. However, in this paper a planar feed consisting of an annular current sheet (ACS) in conjunction with a 50Ω microstrip line is used to excite the $HEM_{12\delta}$ mode. The use of ACS instead of CCS will be clear later on.

Figure 1(a) shows the schematic of cylindrical DR placed symmetrically over the ACS which is connected to the 50Ω microstrip line. The feeding structure is printed on a low permittivity substrate of dielectric constant 2.2 and dimensions 50×50×0.787 mm^3. The cylindrical DR is made of RT/Duriod

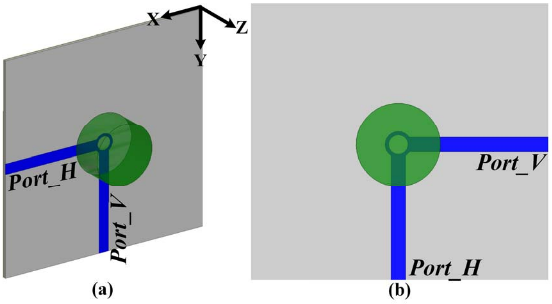

Figure 2 Geometry of the proposed dual-polarized DRA

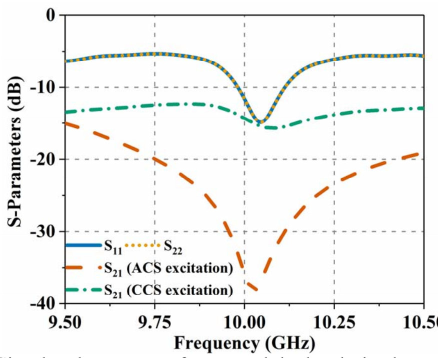

Figure 3 Simulated response of proposed dual-polarized DRA

6010 of relative permittivity 10.2 and has dimensions: radius *r* and height *h*. Figure 1(b) depicts the simulated response of the ACS fed cylindrical DRA. It is observed that antenna operates at 10.06 GHz with impedance bandwidth of 1.5% (9.99-10.14 GHz). As predicted in [4], the antenna is radiating in broadside direction with high gain as depicted in Figure 1(c). The modal electric field distribution portrayed in Figure 1(d) resembles to $HEM_{12\delta}$ mode [2], [4].

The dual-polarized cylindrical DRA fed by two orthogonal 50Ω microstrip line connected to ACS is shown in Figure 2. With the reference to the coordinate system shown in Figure 2, the antenna exhibits linear horizontal polarization when excited through *Port_H* whereas it exhibits linear vertical polarization when excited through *Port_V*.

The simulated scattering parameters of the proposed antenna are presented in Figure 3. The antenna operates at 10.04 GHz and exhibits an impedance bandwidth of 1.3% (9.98-10.11 GHz) for both the polarizations. Over the operating bandwidth, the isolation between the input ports is better than 30 dB and at the operating frequency its value is 37 dB. It is worth mentioning that the isolation between the ports is improved by almost 22 dB at the operating frequency when excited by ACS instead of CCS.

Figure 4 depicts the normalized radiation pattern in xz- and yz-plane at *Port_H* and *Port_V*, respectively. For both polarizations, the simulated peak gain is 9.45 dBi at the operating frequency.

III. Envelope Correlation Coefficient

Diversity performance of the proposed antenna is evaluated in terms of envelope correlation coefficient (ECC). ECC measures the correlation between the communication channels.

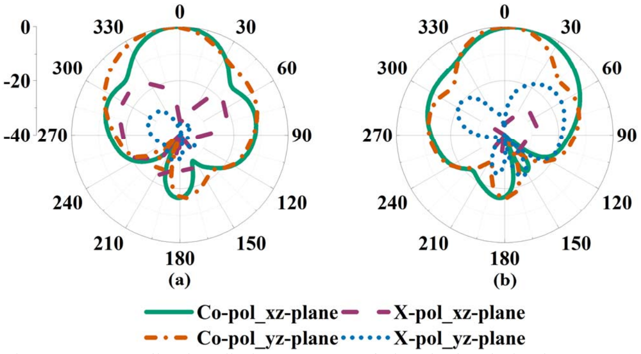

Figure 4 Normalized radiation pattern of the dual-polarized DRA (a) *Port_H* (b) *Port_V*

Assuming the uniform propagation scenario, the ECC between the i^{th} and j^{th} elements can be computed from the 3D far field radiation pattern of the antenna [10]. The computed ECC is below 0.0007 over the entire operating band, which lies within the acceptable limit (ECC<0.3 [10]), indicating effective diversity performance.

IV. Conclusion

A dual linearly polarized cylindrical dielectric resonator antenna has been proposed using higher-order $HEM_{12\delta}$ mode. The proposed antenna exhibits an impedance bandwidth of 1.3% for both horizontal and vertical polarizations and the port to port isolation < 30 dB has been achieved over the bandwidth. At the operating frequency, the peak gain of 9.45 dBi has been achieved. The antenna shows a good diversity performance with ECC below 0.0007 throughout the operating band. The proposed antenna could be suitable candidate for polarimetric radar systems, 5G communication system and other X-band applications.

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