Dual Band Dielectric Resonator Based Metamaterial Antenna

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***Abstract*—A dielectric resonator based metamaterial antenna is presented for dual band operations. The hybrid design uses the dielectric resonator (DR) and split ring resonator (SRR) to radiate two resonant modes. The antenna has a compact size of 40 × 40 mm². The peak realized gain of 6.24 dBi and 6.04 dBi is obtained at 5.5 GHz and 5.8 GHz respectively. Also a peak efficiency of 94% is obtained across the covering frequency. The antenna has potential applications for WiMAX (5.5 GHz) and WLAN (5.8 GHz) operations**

Keywords*—*dielectric resonator (DR); dual band; metamaterial (MTM); split ring resonator (SRR);

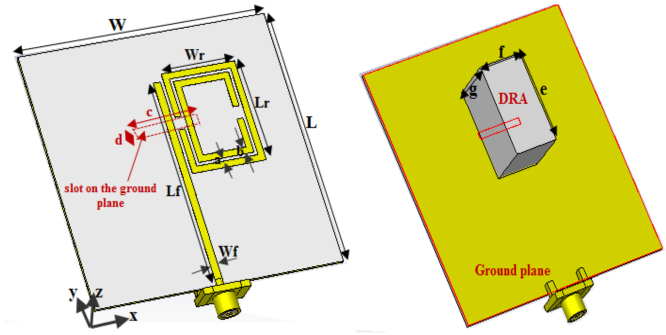
I. INTRODUCTION

With the recent developments in wireless communications, devices are becoming smaller and supporting multiple operations. Therefore, dual band antennas with good isolation and radiation characteristics are needed in this regard. Primarily, dielectric resonators (DRs) are integrated and employed to design antennas with good radiation characteristics [1]. But in order to obtained multiband operations, the shaped of the DR need to be modified and this has led to serious problems regarding configuration analysis, fabrication and implementation of the design. Metamaterials (MTMs) on the other hand, are notable for their unusual electromagnetic properties not readily found in conventional materials [2]. Although few works on dielectric resonator antennas (DRA) based on the concept of MTM has been investigated in [3]–[5], but is worth noting, that the existing schemes features the application of DR to leaky-wave antennas (LWA).

In this paper, dual band dielectric resonator based MTM antenna is proposed. A 50Ω microstrip transmission line is use to excite both the DR and SRR. Two independent resonant modes are obtained; resonant modes at 5.5 GHz and 5.8 GHz due to DR and the SRR respectively. Good isolation is obtained between the two resonant modes despite their closeness. The antenna is suitable for WiMAX (5.5 GHz) and WLAN (5.8 GHz).

II. ANTENNA DESIGN

The configuration of the proposed antenna is shown in Fig. 1. The DR is fed by a 50 Ω transmission line via an aperture coupled slot on the ground plane. To prevent unwanted spurious radiation, the DR is place on the ground plane. The SRR is gap coupled fed by the transmission with the slit aligned to the aperture slot for impedance matching. The antenna is designed on Rogers's substrate of permittivity 3.2, loss tangent of 0.0018 and thickness of 0.5 mm. The DR has dimension of 14 × 8 × 8 mm³ with the permittivity of 10.2. Table 1 shows the dimension of the proposed antenna. Computer simulation technology CST® 2013 microwave studio is use for the simulation.



(a) (b)

Fig. 1. Geometrical configurations of Antenna 1 (a) Front view (b) Back view

III. EXPERIMENTAL RESULTS AND DISCUSSION

Fig. 2 shows the reflection coefficients of the conventional aperture coupled DRA and proposed DR based MTM antennas (DRBMA). The conventional DRA resonates at 5.6 GHz with single $TE^{x}_{\delta 11}$ mode. But when coupled with SRR, the DRBMA resonates at 5.5 GHz and 5.8 GHz. The two resonant modes are verified in Fig. 3. The simulated surface current distributions at 5.5 GHz and 5.8 GHz are obtained with high concentrations of current on the SRR (Fig. 3(b)). This shows the dependence of the resonance frequency of the SRR. But the E-field distributions of the DR at 5.5 GHz are verified as shown in Fig. 4 proves that $TE^{x}_{\delta 11}$ is excited inside DR. This also indicates that, the DR resonates at 5.5 GHz. The simulated radiation patterns for the DRBMA at the two resonant modes are shown in Fig. 5. At 5.5 GHz, a side lobe of -14.7 dB is obtained as expected for ordinary DRA and improved to -5.5 dB at 5.8 GHz with SRR. The peak realized gain of 6.24 dBi and 6.04 dBi is obtained respectively at 5.5 GHz and 5.8 GHz. Also radiation efficiency of 94% and 81% are obtained at 5.5 GHz and 5.8GHz respectively.

TABLE I. Dimensions (mm) of the proposed DRBMA

L	W	Lr	Wr	Lf	Wf	a
40	40	16	12	32.3	1.18	0.5
b	**c**	**d**	**e**	**f**	**g**	
1.0	8.3	1.0	14	8.0	8.0	

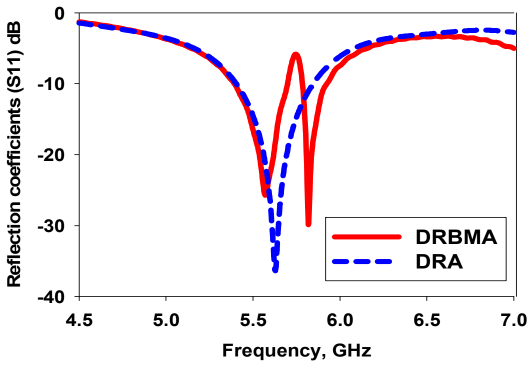
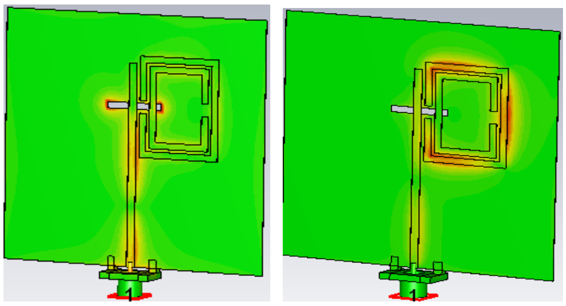
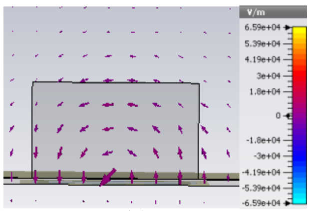


Fig. 2. Simulated reflection coefficients of DRBMA and DRA Antennas



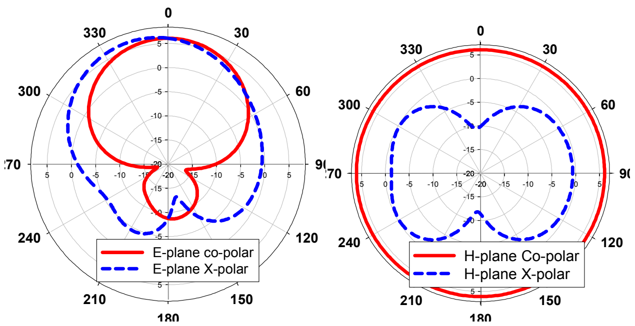
(a) (b)

Fig. 3. Simulated surface current distributions at (a) 5.5 GHz (b) 5.8 GHz.

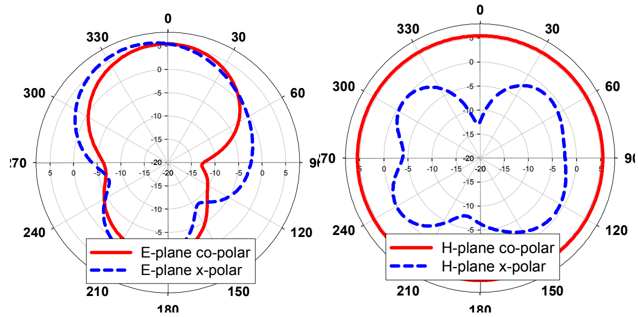


(c)

Fig. 4. E-field distribution across the DR at 5.5 GHz



(a) (b)



(c) (d)

Fig. 5. Simulated radiation patterns for DRBMA at (a) 5.5 GHz (E-plane), (b) 5.5 GHz (H-plane), (c) 5.8 GHz (E-plane), (d) 5.8 GHz (H-plane)

IV. Conclusion

A dual band dielectric resonator based metamaterial antenna has been presented. The hybrid antenna uses DR and SRR as the main radiating elements. The resonance frequency at 5.5 GHz and 5.8 GHz are independently excited by the DR and SRR respectively. The antenna has a compact size of 40 x 40 mm^2. The peak realized gain of 6.24 dBi and 6.04 dBi are obtained at 5.5 GHz and 5.8 GHz respectively. Also an efficiency of 94% and 81% are obtained at 5.5 GHz and 5.8 GHz respectively. The antenna has potential applications for WiMAX (5.5 GHz) and WLAN (5.8 GHz).

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