A TRIPLE BAND HYBRID MIMO RECTANGULAR DIELECTRIC RESONATOR ANTENNA FOR LTE APPLICATIONS

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ABSTRACT

A Triple band Multiple-Input Multiple-Output (MIMO) Rectangular Dielectric Resonator Antenna (RDRA) is designed using hybrid techniques for Long Term Evolution (LTE) applications was investigated and presented. In recent years, Dielectric Resonator Antenna (DRA) has been rapidly used in RF designs due to small size, light weight, high radiation efficiency, small conductive loss, and ease of excitation and fabrication which is suitable to fulfil current needs in RF design, especially for 5G applications. The Rectangular DRA consists of rectangular dielectric resonator with relative dielectric constant ϵr. The main advantage of Rectangular DRA is that it is characterized by three independent geometric dimensions a, b and d (width x length x height) this offers more design flexibility and low cross polarization levels as compared to other DRA’s.

The proposed MIMO Antenna can transmit and receive data independently by covering LTE Band 8 at 0.9GHz, LTE Band 3 at 1.8GHz and LTE Band 40at 2.3GHz. Hybrid technique is adopted in this design by combining a meander line antenna with an RDRA to realize multiband operation. In this regard it is convinced that proposed MIMO antenna can be a good candidate for LTE applications.

Keywords- Hybrid technique, LTE, Meander line, MIMO, Rectangular DRA.

INTRODUCTION

Wireless Communication have been part of human life where people communicate everywhere and anywhere in the world with high-speed data rates. Mobile communication technology have moved from 1G,2G and 3G to now 3.5G which is long term evolution (LTE). LTE was standardized by 3rd Generation partnership project in order to satisfy market demands which enables exiting range of wireless Communication [1]. The operating frequency of LTE ranges from 400 MHz to 4 GHz [2]. Multiple-Input Multiple-Output (MIMO) technology has been developed to provide excellent channel capacity and high data rates in wireless communications [3]. It is implemented by utilizing multiple antennas at the transmitting and receiving ends of the communication system [4]. As compared to microstrip antennas, DRAS are widely used in the electromagnetic field due to their superior characteristics such as low metallic losses, high efficiency, high gain at high frequencies flexibility in their shapes and excitation mechanisms [5]. Additionally, DRAS provide a wider impedance bandwidth [6]. Meanwhile, meander line antenna has been proposed to achieve a size reduction in the antenna instead of having the long vertical microstrip feeding line [7]. In the recent era of wireless communication, a multiband antenna is desirable because each nation or wireless carrier uses different frequency bands [8]. A rectangular shape is chosen because it provides one more degree of freedom than cylindrical DRAS and hemispherical DRAS [9]. It can be used to control impedance bandwidth by adjusting the ratios of length-height and width-height [10].

ANTENNA DESIGN AND ANALYSIS

SINGLE PORT HYBRID DRA

A rectangular dielectric resonator (DR) antenna and a meander line are coupled through microstrip feed line on 90[L] × 45[WG] mm2 of FR4 substrate (εr = 4.6) with a thickness of 1.6 mm. the volume of DRA at 1.8 GHz is 29[a]×29[b]×11.4[d] mm3 with relative permittivity (εr) of 30 and loss tangent (tan δ) of 0.019. Meanwhile, the meander line which is resonating at 0.9 GHz, has an overall feeding length (ML2) of 74.9 mm, feeding width (MW1) of 3 mm, width (W1) of 35 mm, and length (W2) of 3 mm. The same left and right widths (W3 and W5) and gaps (W2 and W4) of the meander line antenna ate 4.5 mm and 1mm respectively. In this work,50[LG]×45[WG] mm2 of a partial ground plane is used instead of full ground because it gives the widest impedance bandwidth at 1.8 GHz

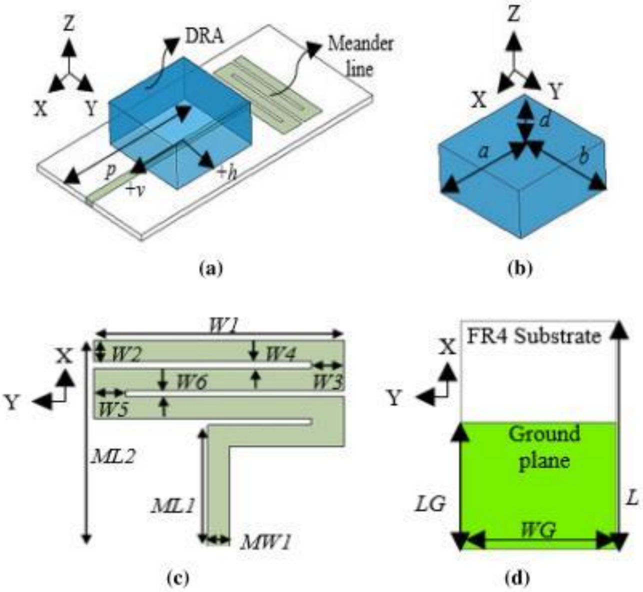

FIGURE 1. Single port hybrid DRA geometry (a) Overall 3D view (b) 3D view of DRA (c) Front view without DRA (d) Back view.

Parameter	Value (mm)	Parameter	Value (mm)
a	29	*W2*	3
b	29	*W3*	4.5
d	11.4	*W4*	1
h	0	*W5*	4.5
L	90	*W6*	1
p	50.2	*LG*	50
v	9.3	*WG*	45
W	107.8	*ML1*	62.9
Y	62.8	*MW1*	3
W1	35	*ML2*	74.9

Where LG = Length of the ground
WG= Width of the ground / substrate
L= Length of the substrate
a,b,c are length, breadth and thickness of RDRA
ML1, ML2 are the lengths of the meander line
W1,W2,W3,W4,W5,W6 are widths of the meander Line.

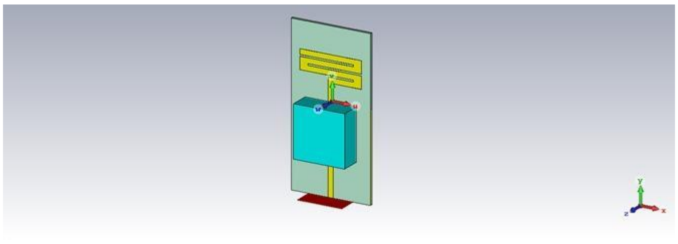

Fig. Design of single port hybrid DRA in CST

Single Port hybrid DRA Simulated Return Loss(S11)

The frequency vs. return loss graph plotted is called Impedance Bandwidth of the antenna. Bandwidth is taken as the range of frequencies over which the return loss is less than - 10dB.

The bandwidth of a rectangular DRA using CST designed to resonate is shown in the below figure. The designed antenna resonates at three frequencies which are 0.9GHz,1.8GHz and 2.3GHZ and return losses are -24.412dB, -28.016dB and - 14.81dB respectively.

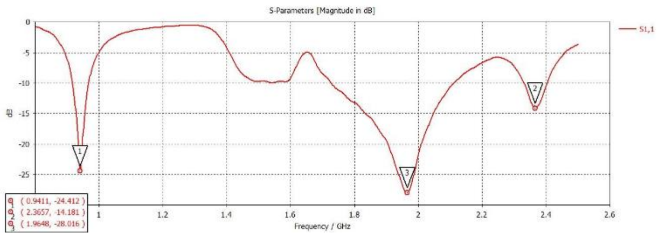

Fig. S-parameters of single port hybrid DRA

Voltage Standing Wave Ratio (VSWR) of Single port hybrid DRA

The ratio of the maximum voltage to the minimum voltage in a standing wave is known as voltage standing wave ratio. The term, which indicates the impedance mismatch, is VSWR. The higher the impedance mismatch, the higher will be the value of
VSWR. The ideal value of VSWR should be 1:1 for effective radiation.

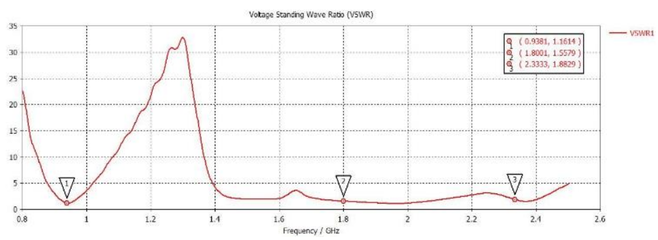

Fig. VSWR of single port hybrid DRA

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Results and analysis of single port hybrid DRA

	0.9GHz	1.8GHz	2.3GHz
RETURN LOSS	-24.41dB	-28.01dB	-14.81dB
VSWR	1.16	1.55	1.54
DIRECTIVITY	1.785dB	4.58dB	4.95dB

TWO PORT MIMO HYBRID DRA

In order to increase channel capacity and data rates, which are highly demanded by users, the MIMO technology is implemented. In this work, a parallel excitation scheme is used by duplicating a single port
hybrid DRA with a separation length between two ports (Y) along the y-axis and Y= 62.8.

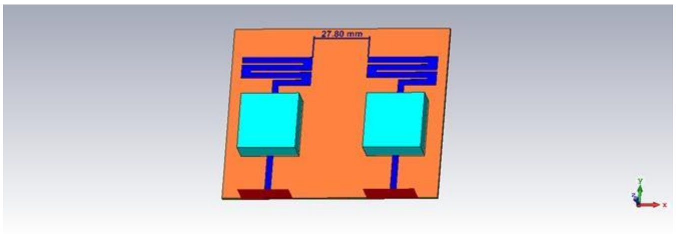

Fig. Design of two port MIMO hybrid DRA in CST

Two port MIMO hybrid DRA S-parameters

The impedance bandwidth of a rectangular DRA using CST designed to resonate is shown in the below figure. The designed antenna resonates at 0.9GHz, 1.8 GHz and 2.3GHz and return losses are-33.47 dB, -25.56 dB and -14.19 dB respectively.

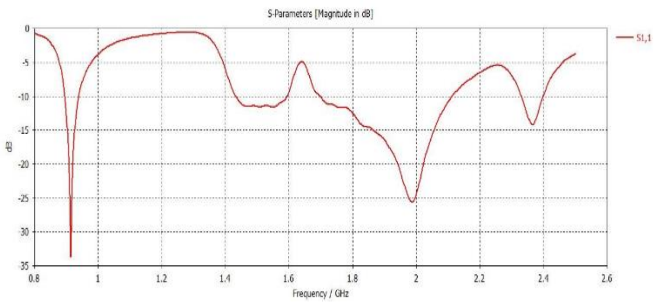

Fig. S-parameters of two port MIMO hybrid DRA

Voltage Standing Wave Ratio(VSWR) of two port MIMO hybrid DRA

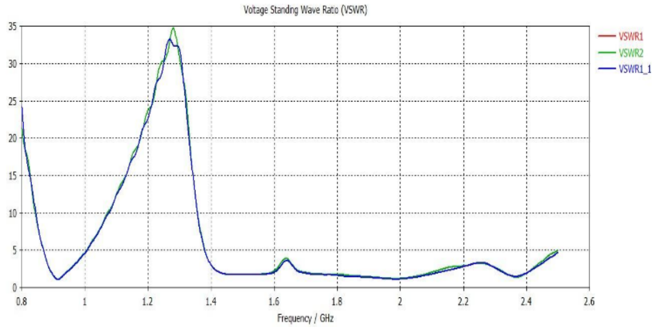

Fig. VSWR of two port MIMO hybrid DRA

Envelope Correlation Coefficient(ECC) of Two port MIMO hybrid DRA

Envelope Correlation Coefficient tells us how independent two antenna's radiation patterns are. So if one antenna was completely horizontally polarized and the other was completely vertically polarized, the two antennas would have a correlation of zero.

For good antenna 0.5 value of ECC is considered and 0.3 or less is considered pretty good for MIMO applications.

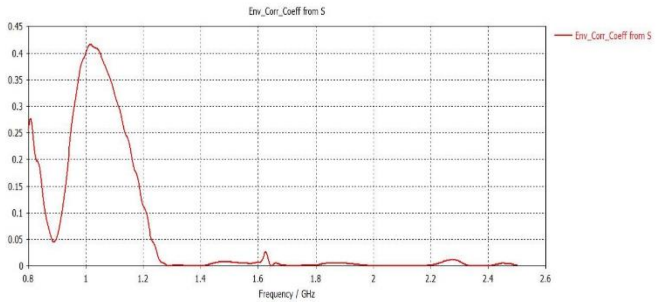

Fig. Envelope Correlation Coefficient (ECC) of two port MIMO hybrid DRA

Diversity Gain (DG) of two port MIMO hybrid DRA

Diversity gain is the gain in the reception quality of a signal when the signal is received from multiple channels. The multiple channels can be in frequency,
time and space.For good MIMO antenna it should be close to 10dB.

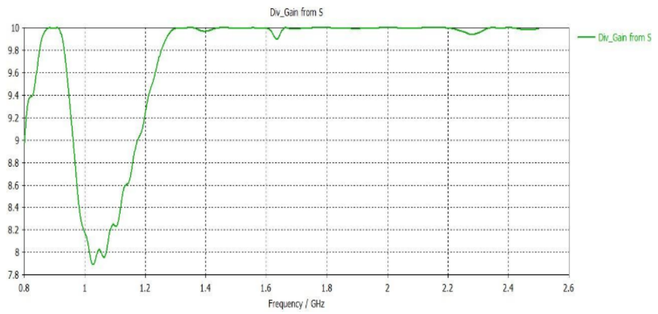

Fig. Diversity gain of two port MIMO hybrid DRA

Results and analysis of two port MIMO RDRA

	0.9GHz	1.8GHz	2.3GHz
RETURN LOSS	-33.74dB	-25.56dB	-14.19dB
VSWR	1.11	1.77	1.75
DIRECTIVITY	3.30dB	5.20dB	5.429dB
ECC	0.0011	0.0003	0.0014
DIVERSITY GAIN	9.994dB	9.999dB	9.97dB

FOUR PORT MIMO HYBRID DRA

In order to improve the channel capacity, data rates and performance of the antenna MIMO is designed using four ports. In this we used parallel scheme of excitation to design four port RDRA. For RDRA centre to centre distance is taken as 62.8mm and total substrate of length 233.4mm and breadth 90mm.

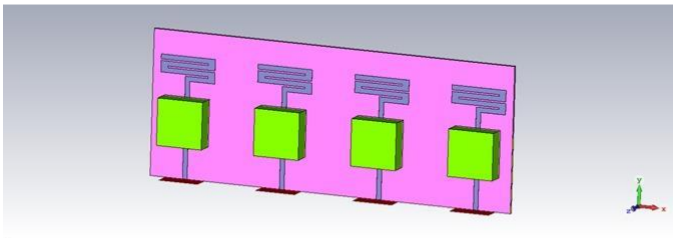

Fig. Design of four port MIMO hybrid DRA in CST

Four port MIMO hybrid DRA S-parameters

The obtained return loss values for four port RDRA using CST are -33.61dB, -13.34 dB and 14.10dB at 0.9GHz,1.8GHz and 2.3 GHz respectively.

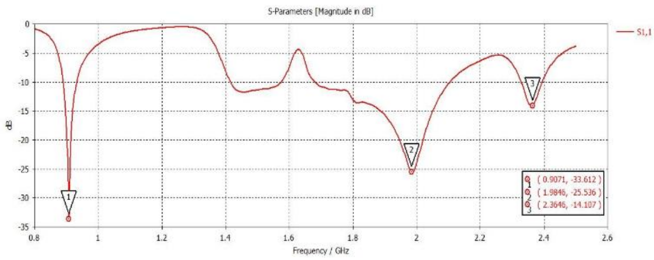

Fig. S-Parameters of four port MIMO hybrid DRA

Voltage Standing Wave Ratio (VSWR) of Four port MIMO hybrid DRA

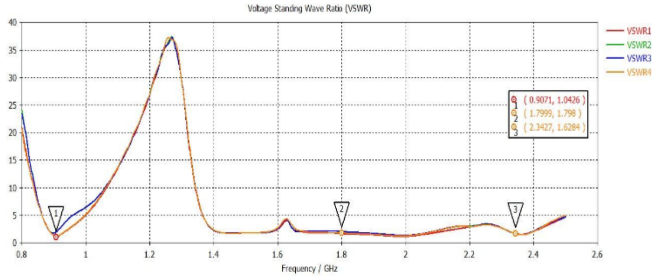

Fig. VSWR of four port MIMO hybrid DRA

Envelope Correlation Coefficient (ECC) of four port MIMO hybrid DRA

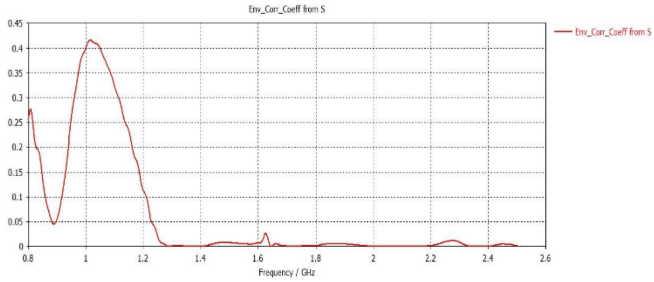

Fig. ECC of four port MIMO hybrid DRA

Diversity Gain (DG) of four port MIMO hybrid DRA

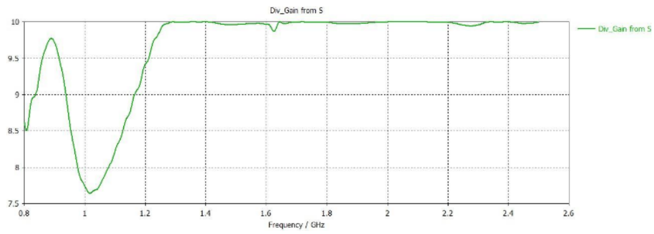

Fig. DG of four port MIMO hybrid DRA

Result and Analysis of Four Port RD

	0.9GHz	1.8GHz	2.3GHz
RETURN LOSS	-33.61dB	-13.34dB	-14.10dB
VSWR	1.04	1.79	1.62
DIRECTIVITY	4.02dB	5.09dB	5.37dB
ECC	0.04	0.0013	0.0016
DIVERSITY GAIN	9.772dB	9.993dB	9.995dB

EIGHT PORT MIMO HYBRID DRA

In order to improve the performance of antenna we designed eight port MIMO hybrid DRA.

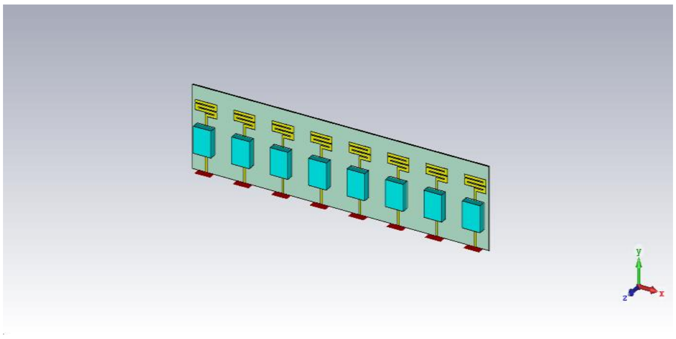

Fig. Design of eight port MIMO hybrid DRA

Return loss(S11) of Eight Port MIMO hybrid DRA

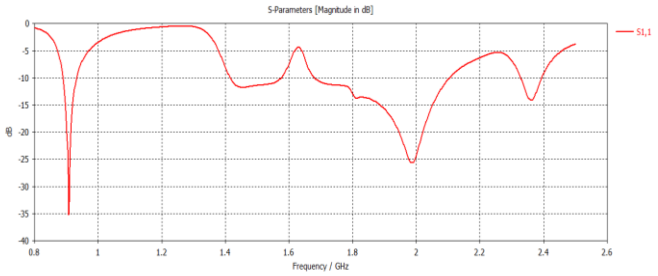

Fig. Return loss of eight port MIMO hybrid DRA

VSWR of Eight port MIMO hybrid DRA

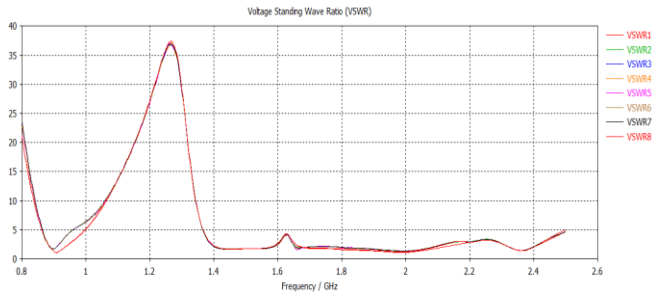

Fig. VSWR of eight port MIMO hybrid DRA

Envelope Correlation Coefficient(ECC) of Eight Port MIMO hybrid RDRA

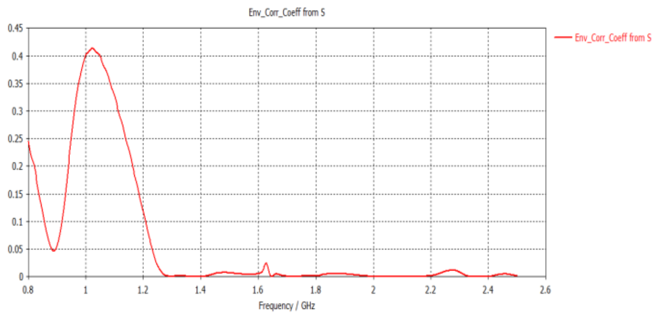

Fig. ECC of eight port MIMO hybrid DRA

Diversity Gain of Eight Port MIMO RDRA

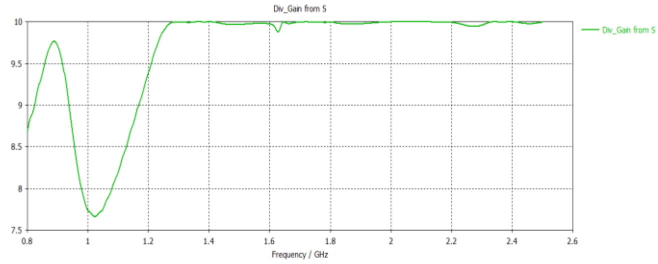

Fig. DG of eight port MIMO hybrid DRA

Results and analysis of eight port MIMO RDRA

	0.9GHz	1.8GHz	2.3GHz
RETURN LOSS	-35.12	-25.641	-14.10
VSWR	1.88	1.57	1.53
DIRECTIVITY	6.50	4.49	5.339
ECC	0.04	0.0007	0.0015
DG	0.887	9.996	9.997

SINGLE PORT HYBRID DRA WITH ROGGERS TMM4 SUBSTRATE

In order to improve the performance of the antenna, Roggers TMM4 substrate is used which has the relative permittivity of 4.7.

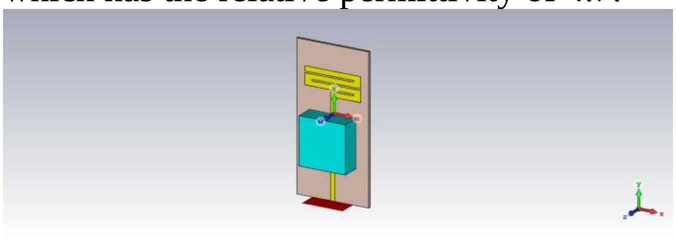

Fig. Design of single port RDRA using Roggers TMM4 substrate

RESULT AND ANALYSIS:

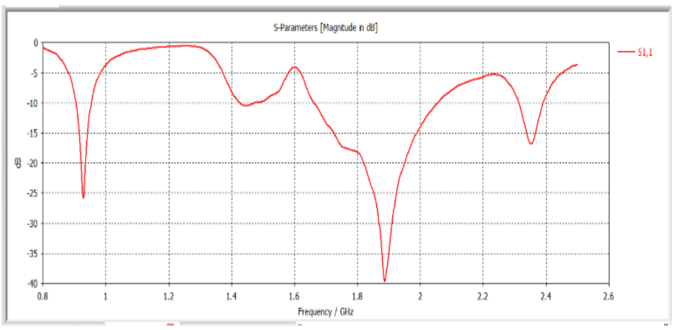

Fig. Return Loss(S11) of Single port RDRA with Roggers TMM4 substrate

Return losses are improved at 0.9GHz, 1.8GHz and 2.3GHz frequencies by using Roggers TMM4 substrate than FR-4 substrate.

CONCLUSION

The simulated results show that the designed triple band multi-input multi output rectangular dielectric resonator antenna is suitable for LTE applications. The designed MIMO manages to achieve -10 dB on return loss for impedance bandwidth at three different low, middle and higher frequency bands those are 0.9GHz,1.8GHz and 2.3 GHZ. There is a good agreement between the measured and simulated CST results in terms of S- parameters, radiation efficiency and radiation pattern. Moreover, the measured values of ECC less than 0.5, the measured values of diversity gain is around 10 dB. From the above simulated results we have observed that double port hybrid RDRA gives low losses, high gain, more radiation efficiency and high directivity. However, with four port RDRA the directivity is increased. Even though it has good performance in all the cases, it can be impedance matching values, gain and directivity. conclude that the designed antenna is well suited for LTE band application with an appreciable impedance matching values, gain and directivity.

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REFERENCES

[1] S. F. Roslan, M. R. Kamarudin, M. Khalily, and M. H. Jamaluddin,''An MIMO rectangular dielectric resonator antenna for 4G applications,''*IEEE Antennas Wireless Propag. Lett.*, vol. 13, pp. 321–324, 2014.

[2] 1. Messaoudene, T. A. Denidni, and A. Benghalia, "CDR antenna with dual-band 1.9/2.7 GHz for MIMO-LTE terminals," Microw. Opt. Technol. Lell, vol. 57, no. 10, pp. 2388-2391, 2015.

[3] Y. M. Pan, K. W. Leung, and K. M. Luk, "Design of the millimeter-wave rectangular dielectric resonator antenna using a higher-order mode," IEEE Trans. Antennas Propag., vol. 59, no. 8. pp. 2780-2788,Aug. 2011.

[4] Y. Ding, Z. Du, K. Gong, and Z. Feng, ''A novel dual-band printed diversity antenna for mobile terminals,'' *IEEE Trans. Antennas Propag.*, vol. 55, no. 7, pp. 2088–2096, Jul. 2007.

[5] S. F. Roslan, M. R. Kamarudin, M. Khalily, and M. H. Jamaluddin, ''An MIMO F-shaped dielectric resonator antenna for 4g applications,'' *Microw. Opt. Technol. Lett.*, vol. 57, no. 12, pp. 2931–2936, 2015.

[6] M. H. Jamaluddin, N. A. Mohammad, and S. Z. Naqiyah, "Size reduction of mimo dielectric resonator antenna for LTE application," in Proc. IEEE Asia-Pacific Conf. Appl. Electromagn. (APACE), Langkawi, Malaysia,Dec. 2016, pp. 286-290.

[7] Y. Torabi and R. Omidi, "Novel metamaterial compact planar MIMO antenna systems with improved isolation for WLAN application." Wireless Pers. Commun., vol. 102, no. 1, pp. 399-410, 2018.

[8] Y. Hong, J. Tak, J. Back, B. Mycong, and J. Choi, "Design of a multiband antenna for LTE/GSM/UMTS band operation." Int. J. Antennas Propag.. vol. 2014, Jul. 2014. Art. no. 548160.

[9] K. M. Luk and K. W. Leung, Eds., Dielectric Resonator Antennas. London, U.K.: Research Studies Press, 2003.

[10] N. Suleman and Rahmat, "Design of multiband MIMO 2*2 microstrip antenna with multi-slot method," Int. J. Appl. Eng. Res., vol. 12, no. 19, pp. 8125 8130, 2017.