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Circularly Polarized 2X2 Array Antenna with Matching Network for LTE Applications

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Abstract*: A model of circularly polarized 2 X 2 array structure antenna is designed to operate at 2.34 GHz band LTE applications. Designed antenna is incorporated with inset fed of 50-ohm impedance proper matching network. The total area of the antenna is around 13.5X13.7 cm on FR4 substrate material with dielectric constant of 4.4. The proposed antenna is providing left hand circular polarization gain of 11.1 dB and right-hand circular polarization of gain 11.9 dB with total gain of 14.34 dB. The axial ratio is less than 3 dB and the S_{11} are less than -10 dB at the operating frequency band. Designed antenna will be well suited for LTE i.e. 4G communication applications with good radiation characteristics.

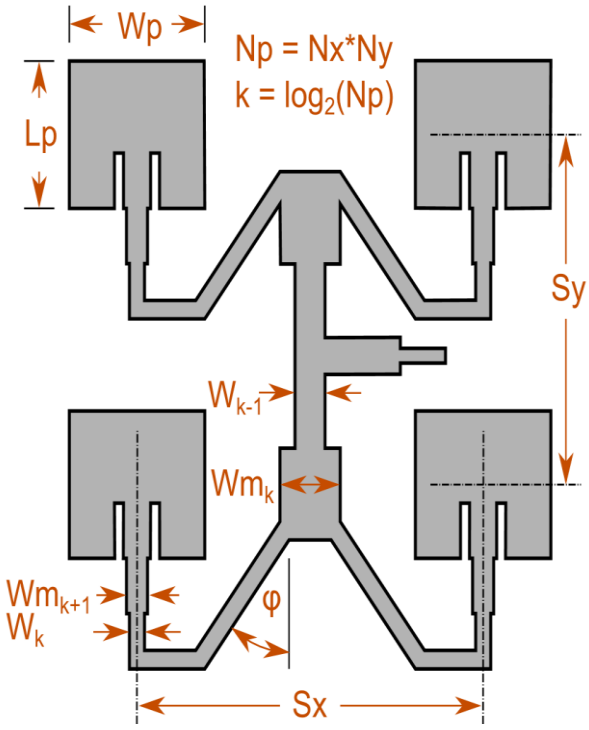
***Index Terms*: Array Antenna, Axial Ratio, Circular Polarization, Matching Network**

I. INTRODUCTION

In the modern communication systems presently there is a lot of demand for high gain circularly polarized antennas for their wide applications [1-4]. Researchers are designing novel and compact antennas to fit them in to the real time applications with moderate gain and bandwidth [5-8]. There is some gap between the high gain antennas and the compact dimensions because of structural dissimilarities and frequency of operation. The gain improvement can be done with large aperture antennas but fitting in to them in compact communication modules will raise the challenge [9-14]. The total area of the antenna and the frequency of operating band are inversely proportional and similarly the dielectric constant and the performance is also inversely proportional [15-18]. The improvement in the gain leads to decrement in the bandwidth and increment in the size of the antenna structure. To overcome such problems, people are designing novel structures with defected grounds, metamaterials, artificial magnetic conductor structures and frequency selective surfaces [19-24]. The frequency range for an application is very crucial in the design of the antennas and after that incorporating different structures in the antenna geometry to tune the model as per the specification is hectic task [25-26]. This article provides the design with development of high gain array antenna to cater the need of long-term evolution technology (4G) with respect to bandwidth and the gain. The design specification, simulation characteristics and their analysis is presented in the subsequent sections in detailed technical manner.

II. ANTENNA STRUCTURE

The proposed 2X2 square truncated inset fed array antenna is designed on FR4 substrate of dielectric permittivity 4.4 and loss tangent 0.25. Power divider is used in the feeding network to distribute the power equally to all the radiating elements through special type of feeding. The basic 2X2 array antenna structure is provided in Fig 1 with corporate feeding and half cutting dimensional view. Fig 2 shows the dimensional parameters of the power divider. The dimensional characteristics can be observed from Table 1 to 4 for the basic array antenna with special feeding.



(a)

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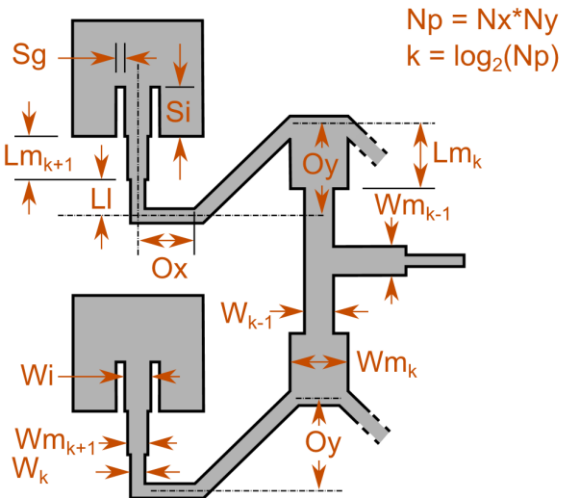


(b)

Fig 1. 2X2 Array antenna, (a) Array with corporate Feeding, (b) Half cutting dimensional view

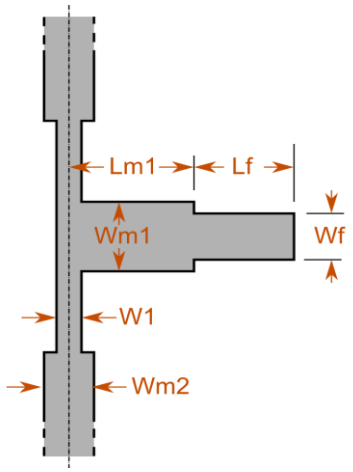


Fig 2. Power divider dimensional parameters

Name	Description	Value
Nx	Number of patches in X-direction	2 patches
Ny	Number of patches in Y-direction	2 patches
Wp	Patch width	48.49 mm
Lp	Patch length	40.59 mm
Sx	Patch spacing between patch centres in the X-direction	87.44 mm
Sy	Patch spacing between patch centres in the Y-direction	87.44 mm
Ox	X-offset of patch element	24.24 mm
Oy	Y-offset of patch element	22.80 mm
H	Substrate height	1.575 mm
εr	Relative permittivity	2.2

Table 1. Antenna's Dimensions-1

Name	Description	Value
tanδ	Loss tangent	0
Lm1	Matching line 1 length	22.83 mm
Lm2	Matching line 2 length	23.18 mm
Lm3	Matching line 3 length	4.235 mm
Lm4	Matching line 4 length	23.55 mm
Lm5	Matching line 5 length	23.55 mm
Lm6	Matching line 6 length	23.55 mm
Lm7	Matching line 7 length	23.55 mm
Wm1	Matching line 1 width	4.853 mm
Wm2	Matching line 2 width	2.784 mm

Table 2. Antenna Dimensions-2

Name	Description	Value
Wm3	Matching line 3 width	1.412 mm
Wm4	Matching line 4 width	1.412 mm
Wm5	Matching line 5 width	1.412 mm
Wm6	Matching line 6 width	1.412 mm
Wm7	Matching line 7 width	1.412 mm
W1	Network line 1 width	1.412 mm
W2	Network line 2 width	1.412 mm
W3	Network line 3 width	1.412 mm
W4	Network line 4 width	1.412 mm
W5	Network line 5 width	1.412 mm

Table 3. Antenna's Dimensions-3

Name	Description	Value
W6	Network line 6 width	1.412 mm
Ll	Network line length	4.710 mm
Lf	Feed line length	4.710 mm
Wf	Feed line width	4.853 mm
Si	Feed inset from edge of patch	11.01 mm
Wi	Width of patch feed line	1.412 mm
Sg	Spacing between feed line and patch	1.719 mm

Table 4. Antenna's Dimensions-4

Fig 3 shows the proposed antenna model with corner truncated structure. The designed model dimensions can be observed from Table 5. The overall size and the angle of diagonal lines can be observed from the given table.

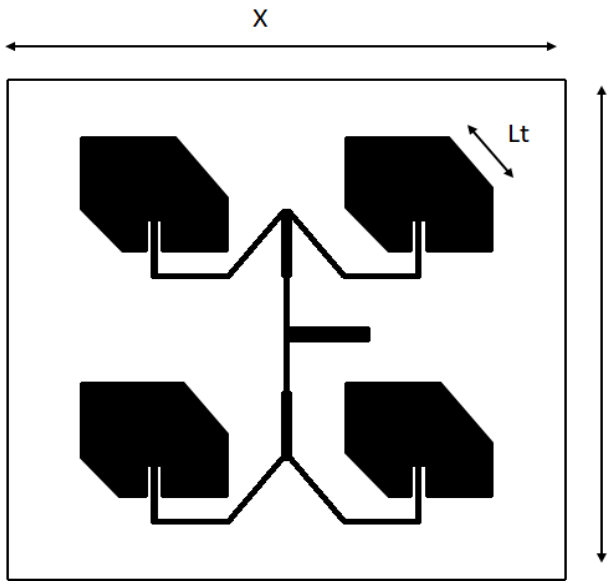


Fig 3. Proposed circularly polarized antenna

Name	Description	Value
X	Device X-dimension	135.9 mm
Y	Device Y-dimension	137.7 mm
Z	Device Z-dimension	1.575 mm
φ	Angle of diagonal lines	39.46 °

Table 5. Antenna Dimensions-5

III. RESULTS WITH ANALYSIS

The performance characteristics about the designed antenna analysis is done using antenna magus electromagnetic tool. The simulation characteristics are analyzed and presented in this section with respect to impedance, S_{11}, VSWR and radiation patterns. Figure 4 showing the impedance curve of the antenna and it has been observed an impedance of 50 ohms at operating frequency.

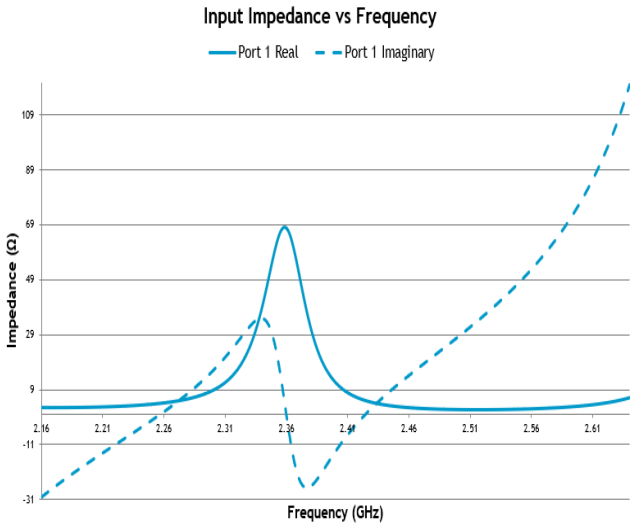


Fig 4. Impedance vs Frequency

The reflection coefficient of below -10 dB with good impedance characteristics and voltage-standing-wave-ratio value of less than 2 in the operating frequency band and can able to observe from Figure 5 and 6.

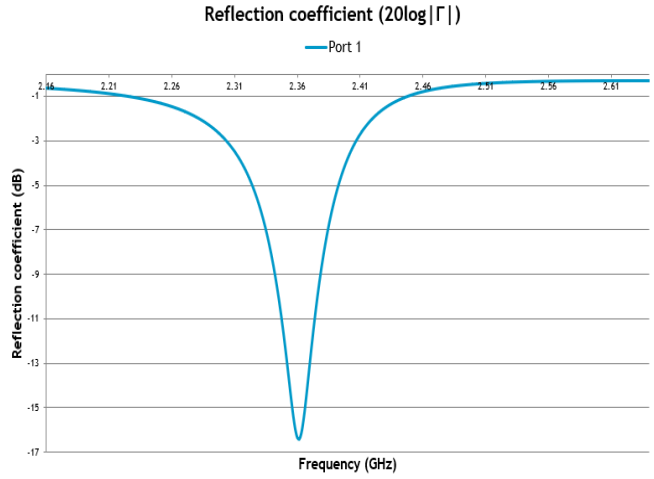


Fig 5. Reflection Coefficient vs Frequency

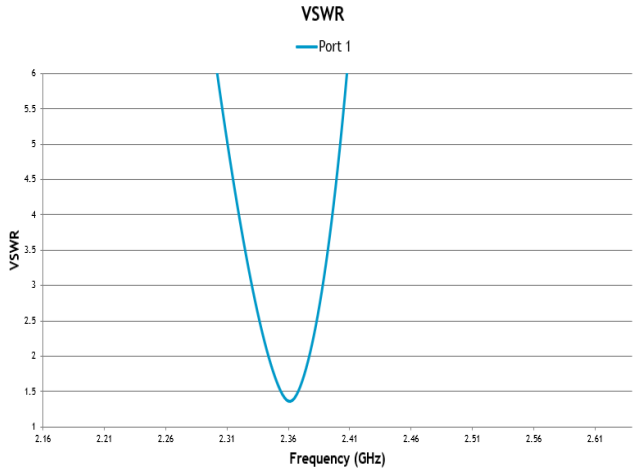


Fig 6. VSWR vs Frequency

The radiation pattern is providing the main information regarding the radiation mechanism of the antenna and its performance with respect to gain. Figure 7 shows the gain total at 2.3 GHz in two dimensional, Figure 8 shows the radiation at 2.3 GHz in polar coordinates.

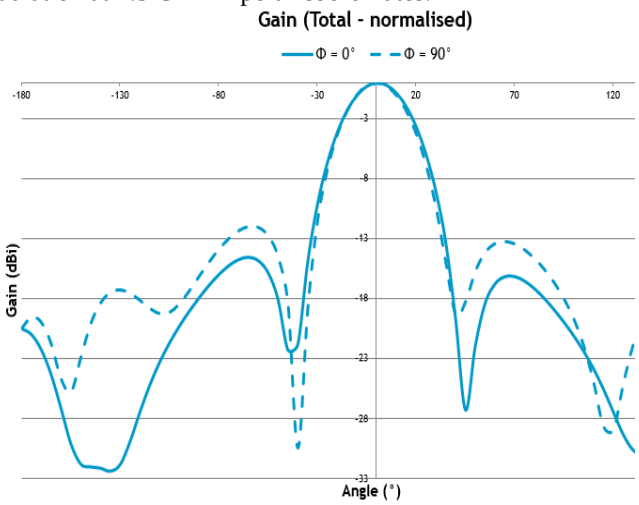


Fig 7. Gain total at 2.3 GHz

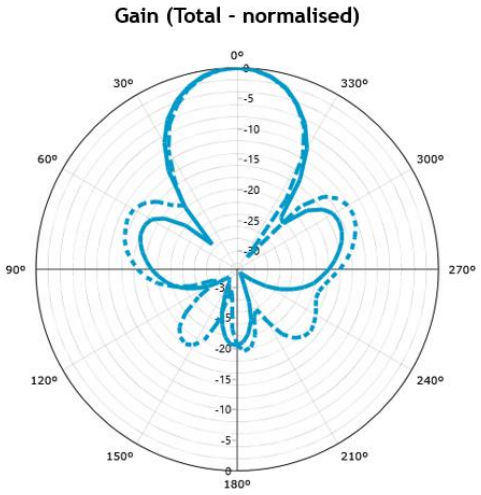


Fig 8. Gain in polar at 2.3 GHz

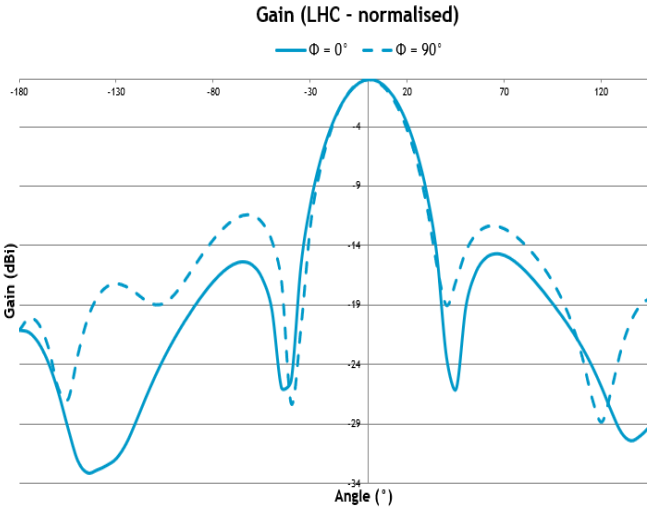


Fig 9. Left Hand Circular Polarization in 2D at 2.3 GHz

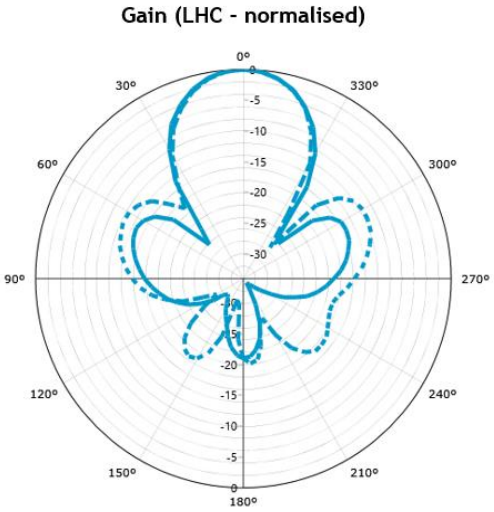


Fig 10. Left Hand Circular Polarization in polar at 2.3 GHz

Figure 9 shows the left hand circular polarization of the antenna and Figure 10 is also conveying the same in polar view. Figure 11 shows the right hand circular polarization in 2D and Figure 12 shows the same in polar coordinates for better understanding.

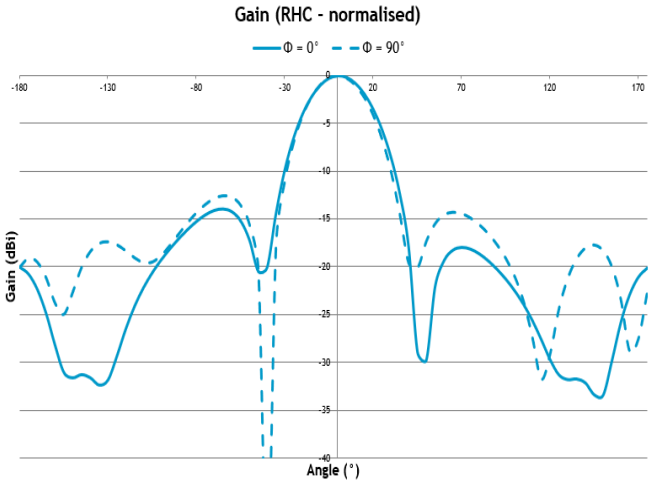


Fig 11. R H C P in 2D at 2.3 GHz

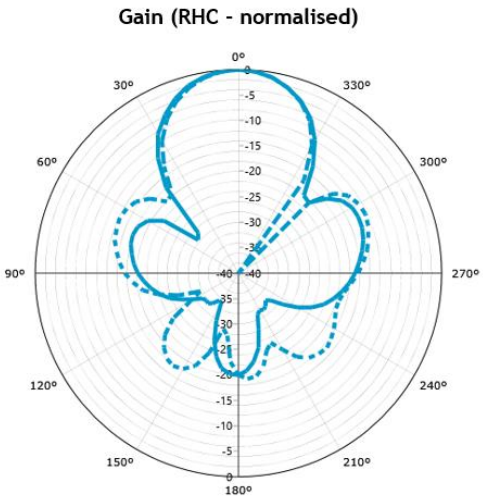


Fig 12. R H C P in polar at 2.3 GHz

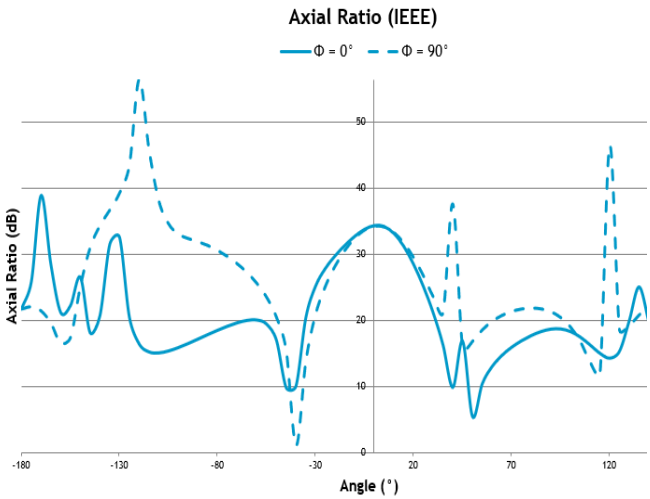
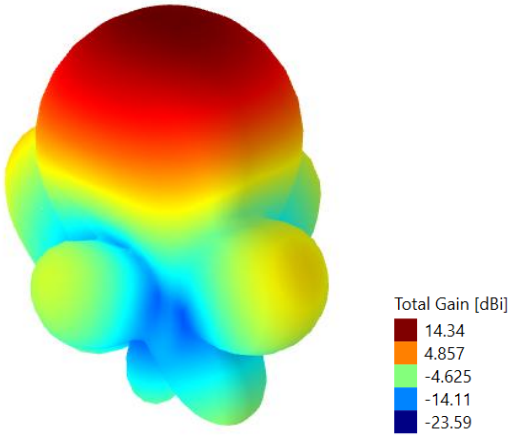
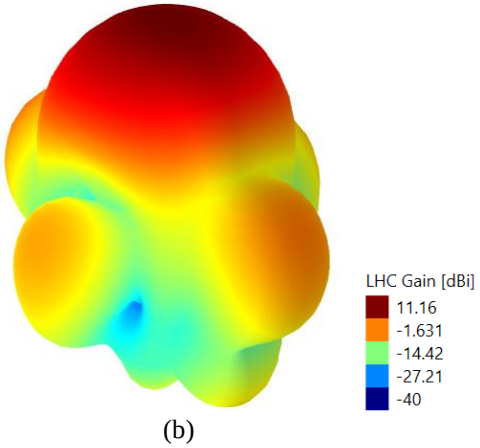


Fig 13. Axial ratio (IEEE)

The axial ratio less than 3 dB will provide evidence to circular polarization and here the Figure 13 is giving the information regarding axial ratio and axial ratio bandwidth. Fig 14 shows the total gain, LHC and RHC gain in three dimensional view. The maximum gain of 14.34 dB is attained and LHC and RHC peak gain values of 11.1 dB and 11.4 dB are attained.



(a)



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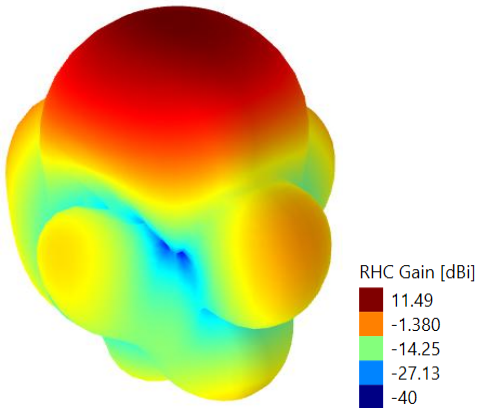

(c)

Fig 14. 3D View of Radiation, (a) Total Gain, (b) Left Hand Circular Gain, (c) Right Hand Circular Gain

IV. CONCLUSION

A CP-Antenna is proposed in this work for high gain applications. The proposed model of the antenna is able to provide maximum gain of 14.4 dB gain with more than 11 dB gain in left and right circular polarizations. The AR is less than 3 dB, S_{11} less than -10 dB and VSWR less than 2 in the operating band. The operating band is from 2.32 to 2.38 GHz and the bandwidth of 6 MHz and impedance bandwidth of 2.5%. The axial ratio bandwidth of 5 MHz and excellent radiation characteristics making this model for most suitable device in LTE applications.

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