MAT JOURNALS

Journal of Telecommunication Study
Volume 3 Issue 2

Design of Low Cost 2×2Microstrip Patch Antenna Array for LTE Applications

[1]SunitaNarasagond, [2]Mr. Jayanth C, [3]Mr. Sandeep Vedagarbham
[1]M.Tech Student, [2]Assistant Professor
Department of Telecommunication
DSCE, Bangaluru
[3]Chief Technical Officer(RFDivision), Lambdoid Department Wireless Communication, Bengaluru
***Email:** sunita.jn1008@gmail.com, C.jayanth@gmail.com, Sandeep@lambdoid.net*

Abstract

This paper concentrates on the design of low cost microstrip patch antenna array for LTE application. Array is a bunch of identical antennas which is designed for enhancing the gain and also directivity in the particular application. LTE is the communication standard for the transfer of data in a higher speed. MIMO technology is the basic for designing an antenna array for LTE application. Variety of antennas is used for the exchange of data but choosing an antenna for the communication must possess small structure with less cost. The patch antenna offers a very low cost and also very simple for construction of an array

***Keywords**: Long Term Evaluation, Antenna Array, Microstrip Patch Antenna, Antenna Stacking*

INTRODUCTION

It is very difficult to imagine communication without antennas. Many researches are carrying out in designing the best suitable antennas for different applications which must be economic, reliable, provides high gain with a least amount of return loss. The patch antenna is one which satisfies all these requirements compared to other antennas. Patch antennas can be found in plenty of unique shapes like triangular, circular and rectangular etc. and dimension of the antennas depends on frequency of a particular application. Nowadays people rely on internet for their daily activities therefore high speed data transformation is very much essential. LTE provides higher data rates [9] for users and there is a high demand for such antenna is increasing for an LTE application. The concept of Multiple Input Multiple Output (MIMO) is a technique which is widely used in designing LTE antennas. The design of antenna demands different structure, feeding method, polarisation and also unique shape for the required application. Here different designs of antenna array of patch antenna are considered with their performance. The LTE is best suited for portable devices like mobile phones, tablets and computers. The proposed 2×2 patch antenna is designed using IE3D software and fabricated using photoengraving and chemical etching method.

LITERATURE SURVEY

Wen-Shan Chen, Yun Chi and et.al.,[1] presented a paper on couple fed LTE antenna for tablet application. Here the antenna is designed for three bands and they are LTE700, LTE2300 and LTE2500. It is suitable for tablet and computer application. This approach reduces the size of an antenna and also the return loss occurred is -6dB. The disadvantage of this method is that it very difficult to design an antenna for LTE700 band due to some physical limitations.

Mohammad H Haroun, Hussam Ayada and et.al.,[2]presented a paper on slot antenna which fed by the line with a tuning stub for a directional radiation. The slot antenna is designed for a three frequency bands of LTE. This approach gives a better result for return loss. As the frequency increases the antenna becomes more directional [2].

Leonardo Lizzi and Andrea Massa [3] presented a paper on dual band fractal monopole antenna for LTE application. The two frequency bands used in the antenna design are 700MHz and 2200MHz with 24% size reduction. The special type shape is designed in this paper called as sierpinski fractal. Standard quarter wave resonant feeding method is used for designing of monopole antenna.

A.A. Asaker, R. S Ghoname and et.al.,[4] presented a paper on MIMO antenna for LTE application. By using the etched slot at antenna patch the bandwidth can be increased. The four element antenna is fabricated using the thin film and the photolithographic technique. This antenna structure is designed to produce an orthogonal polarisation and avoid the problem of narrow bandwidth.

F.N.M Redzwan, M.T. Ali and et.al.,[5] Presented a paper on inverted F shape antenna for LTE application. The antenna is designed for a single band and the size of the antenna too small so that it can be mounted on a mobile phone. This structure can give a bandwidth of 120MHz with a substrate height 4mm and 4.9dB gain can be obtained. By inserting the parasitic element near the main radiating element, the antenna can be designed for dual and tri bands.

Abdul Aziz Reguna, Tommihariyadi and et.al.,[6] presented a paper on omnidirectional MIMO antenna for LTE application which is designed at 1.8GHz. The 2×2 array is developed with a return loss 0f -30dB and gain is 7dB. The pattern obtained is omnidirectional pattern.

Kai Yu, Yingsong Li and et.al.,[7] presented a paper on E shaped patch antenna for LTE application which is operated in triple bands. This antenna is fed by the coaxial probe. Two shorted pins of metal are used to join the E shaped patch antenna. This design covers three bands of LTE with good impedance matching.

DESIGN CONSIDERATION

An array is a bunch of similar elements which are arranged in a regular fashion. The microstrip patch antenna [8] is very easy to design and the design procedure includes design of a stacked single patch antenna, 1×2 patch antenna array and finally 2×2 patch antenna array.

ANTENNA STACKING

The antenna stacking is performed in the microstrip patch antennas to increase the bandwidth of operation. Here different layer patch antenna has different frequency. In this work two layers are used to increase the bandwidth. The air gap of 5mm is introduced to between the ground plane and the FR4 substrate. The total height of two substrates and effective dielectric constant of both materials is considered in the design of 2×2 patch antenna array. The dielectric constant of air is 1 and the dielectric constant of FR4 material is 4.4. The effective dielectric constant of these materials is 2.9. The height of the air gap is taken as 5mm and height of FR4 is considered as 0.6mm. The total height of the substrate material is 5.6mm.

DESIGN FORMULAS

The main parameters required to design a microstrip patch antenna are based on the materials used to design an antenna and the frequency of the application. The main three parameters are:

1. Frequency of operation f_r= 2.35GHz.
2. Dielectric constant of the material used ε_r=2.9.
3. Height of the substrate h= 5.6mm

By considering these parameters the

different parameters of rectangular patch antenna are calculated from the below equations.

i. Width of a Rectangular Patch antenna is calculated from the equation 1.

$$W=\frac{C}{2.fr}\times\sqrt{\frac{2}{\epsilon r}} \qquad (1)$$

Where, C= 3×10^{8}m/s

ii. Effective dielectric constantis calculated from equation 2.

$$\in eff=\frac{\epsilon r+1}{2}+\frac{\frac{\epsilon r-1}{2}}{\sqrt{\frac{12h}{W}+1}} \qquad (2)$$

The effective diectric constant for two materials is considered in the calulation i.e. ε_r=2.9.

The increase in resonant length

$$\Delta L=0.412h\times\frac{(\epsilon eff+0.3).\left(\frac{W}{h}+0.264\right)}{(\epsilon eff-0.258).\left(\frac{W}{h}+0.8\right)} \qquad (3)$$

The effective length of patch is calculated from the equation 4.

$$Leff=\frac{C}{2.fr.\sqrt{\epsilon eff}} \qquad (4)$$

The resonating length of the patch is calculated from the equation 5.

$$L=Leff-2\Delta L \qquad (5)$$

The wavelength is calculated from equation 6.

$$\lambda=\frac{C}{fr} \qquad (6)$$

The guided wavelength is calculated from equation 7.

$$\lambda_g=\frac{\lambda}{\sqrt{\epsilon eff}} \qquad (7)$$

The length of feedline is obtained from equation 8.

$$Lf=\frac{\lambda g}{4} \qquad (8)$$

The width of the feedline is taken approximately $\lambda_g/20$. All the parameters and the their vqlues are listed in table I.

Table 1. *Patch Antenna Parameters*

Parameters	**Values**
Operating Frequency	2.35GHz
Height of the Substrate	5.6mm
Dielectric Constant of two Substrate	2.9
Patch Width	53mm
Patch Length	40mm
Wavelength	127.6mm
Guided Wavelength	79.47mm
Length of Feedline	19.86mm
Width of Feedline	3.97mm

The Wilkinson power divider is used to isolate the power between all the antennas. Equal amount of power is supply to each antenna through Wilkinson power divider.

RESULTS AND DISCUSSION

The antenna is designed using IE3D software and the antenna prototype is tested by scalar network analyser. The simulation results are obtained from IE3D software and the fabrication testing results are obtained from scalar network analyser.

SIMULATION RESULTS

Below figures depicts the various results which are obtained from IE3D simulator. Figure 1 shows the 2×2 array antenna designed for LTE application using IE3D. In this section all results are explained in detail.

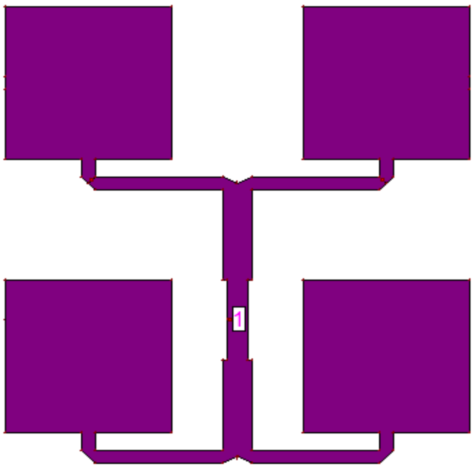

Fig. 1: *2×2 Antenna Array*

Impedance Matching: The figure 2 shows the smith chart for 2×2 patch antenna array which shows the impedance matching of an array with the transmission line. It is important to match the impedance of an array to the impedance of transmission line i.e. to 50Ω. The impedance of an array is matched to 50Ω at 2.346GHz.

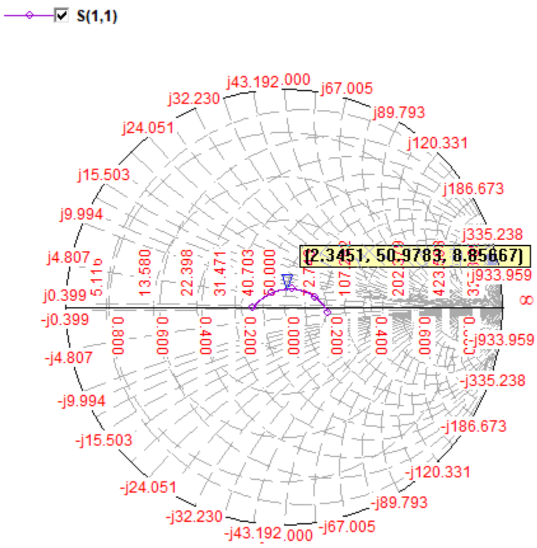

Fig. 2:*Impedance Matching*

Return and Bandwidth: The return loss indicates that how much energy is radiating back to the transmitter. The return loss must be below -10dB [10] for better performance of an antenna. The designed microstrip patch antenna array gives a return loss of -20.54dB and the bandwidth of 100MHz.

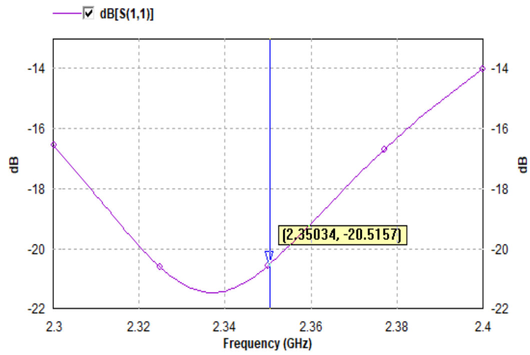

Fig. 3:*Return Loss and Bandwidth*

*VSWR:*The VSWR is a measure of voltage signal returned to the transmitter to the voltage transmitted by it. For the better performance of an antenna the VSWR must in between 1 and 2. The design array gives a VSWR of 1.2 which satisfies the requirement.

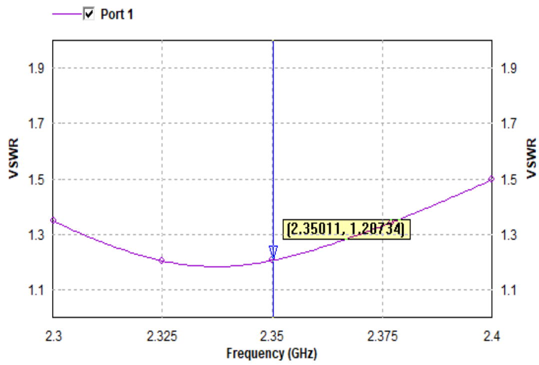

Fig. 4: *VSWR Pot*

Gain: The gain is most concerned parameter of an antenna. Every antenna is design to get more gain. The figure 5 shows the 2D gain plot of an antenna array which indicates that the designed array is giving 13.89dBi. The figure 6 shows the 3D radiation pattern in which it is clear that the radiation of an array is directional and there are minor side lobes in the pattern.

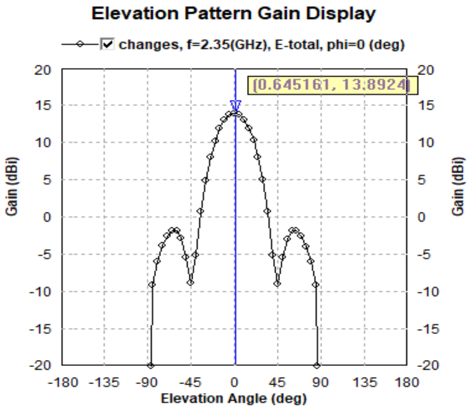

Fig. 5: 2D Gain

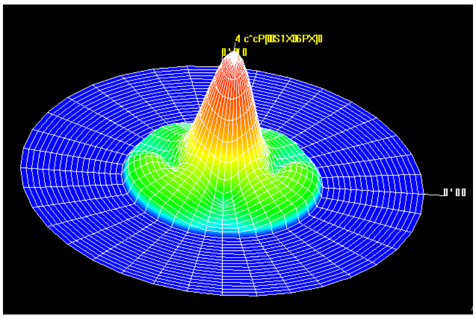

Fig. 6: 3D Gain

Efficiency: The figure 7 shows the efficiency Vs frequency plot for 2×2 patch antenna. The developed antenna array gives 92% of efficiency.

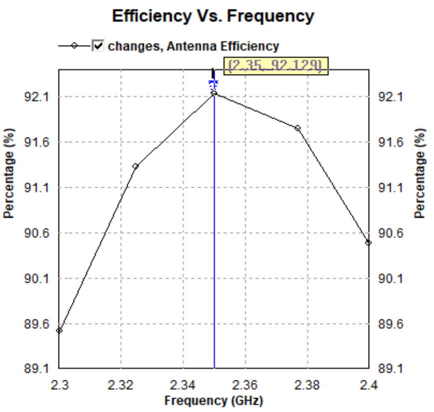

Fig. 7: Efficiency Plot

FABRICATION RESULTS

The antenna array which is designed using IE3D software is fabricated using photoengraving and chemical etching method. In figure 8 the prototype of 2×2 antenna array.

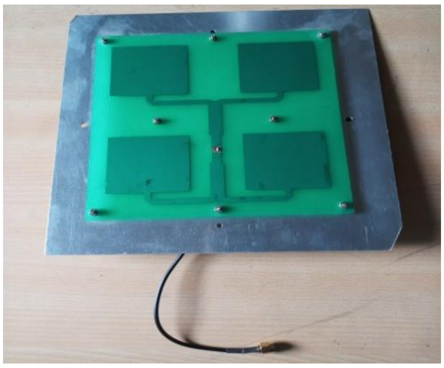

Fig. 8: 2×2 Antenna Array Prototype

The antenna prototype is tested using scalar network analyser (SNA). The figure 9 and 10 show the VSWR and return loss plots obtained from SNA. The VSWR obtained is 1.33 and also the return loss obtained is -16.93dB.

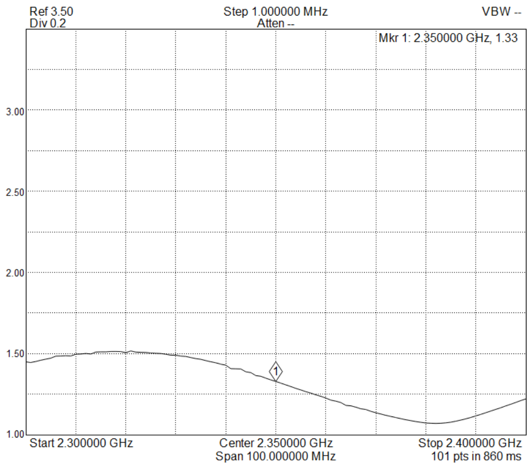

Fig. 9: VSWR obtained from SNA

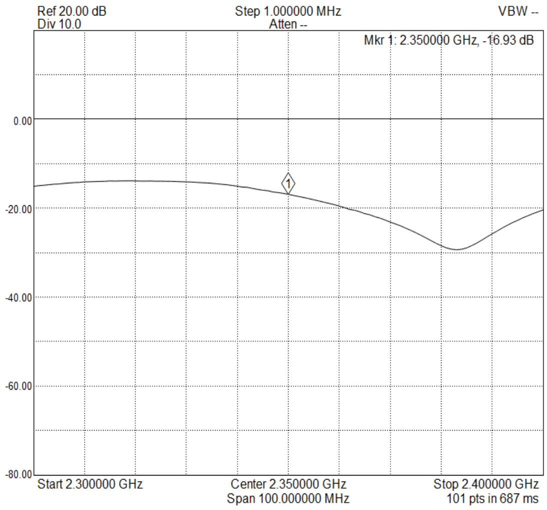

Fig. 10: *VSWR obtained from SNA*

CONCLUSION

The 2×2 stacked patch antenna array for LTE applications is designed using IE3D. The designed antenna array met all the specifications. The maximum gain up to 14dBi is achieved. The antenna prototype is tested using SNA and results shows that the designed array satisfies the requirements of LTE application. The VSWR obtained from SNA is 1.33 and return loss obtained is -16.93dB. All the simulated and tested results prove that the designed antenna works better with LTE applications.

REFERENCES

1. Wen-Shan Chen, Yun Chi, Fa-Shian Chang and Chia-Yao Hsu "Coupled-fed LTE Antenna Design for Tablet Applications" , 2016 IEEE 5th Asia-Pacific Conference on Antennas and Propagation (APCAP).
2. Mohammad H. Haroun, HussamAyad, Jalal Jomma "Design of Tri Band Microstrip Slot Antenna for LTE Applications", ISBN: 978-4799-4129-2, 2015 IEEE.
3. Leonardo Lizzi and Andrea Massa "Dual-Band Printed Fractal Monopole Antenna for LTE Applications", IEEE Antennas and Wireless Propagation Letters, VOL. 10, 2011.
4. A.A. Asaker, R.S. Ghoname and A.A. Zekry, "Design of a Planar MIMO Antenna for LTE-Advanced", International Journal of Computer Applications (0975 – 8887) Volume 115 – No. 12, April 2015.
5. F. N. M. Redzwan, M.T. Ali, M.N. Md. Tan, NF. andMiswadi, "Design of Planar Inverted F Antenna for LTE Mobile Phone Application", 2014 IEEE Region 10 Symposium, IEEE, 2014.
6. Abdul Aziz Reguna, TommiHariyadi, Arjuni B. Pantjawati and Enjang A. Juanda, "Design and Simulation of Omnidirectional MIMO Microstrip Antenna at 1.8 GHz for LTE Applications", 2016 International Conference on Radar, Antenna, Microwave, Electronics, and Telecommunications.
7. Kai Yu, Yingsong Li, XianpingLuo and Xiaomin Liu, "A Modified E-Shaped Triple-band Patch Antenna for LTE Communication Applications", 978-1-5090-2886-3, IEEE, 2016.
8. Constantine A. Balanis, *Antenna Theory, Analysis and Design*, 3rd ed., John Wiley & Sons, 2005, pp. 811-819.
9. I. Islam, M.F. Jamlos and N.A. Rahman, "A High Gain Double-Sided Array Antenna for LTE and WLAN Applications", 2015 IEEE International RF and Microwave Conference (RFM 2015), Riverside Majestic Hotel, Kuching, Sarawak on December, 14 - 16, 2015.
10. A. Osman, Alaa A. Yassin, B.Ali, H.Ahmed and S.Noor, "Design and Simulation of High Performance Half wave-dipole Antenna for L TE Applications", International Conference on Computing, Control, Networking, Electronics and Embedded Systems Engineering, 2015.