A Comparison between Different Shapes of MSPA for LTE Applications

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Abstract – *Microstrip patch antennas are found in different shapes for different applications. LTE is a developing technology and it needs low cost and small size antennas for communication. The patch antenna gained a lot of attention because of their benefits. Microstrip antennas can attain any shape according to the application. Different shapes gives different gain and directivity for the same application and the better one has to choose based on higher gain, low return loss and high bandwidth. The proximity feeding method is used in designing of three different shapes of antenna for an LTE band 1690MHz to 2200MHz. This paper discusses three different shapes like triangular, circular and rectangular patch antenna and their results.*

Key Words: Long Term Evolution (LTE), Microstrip Patch Antenna (MSPA), Proximity Feeding, Return Loss, Gain, Bandwidth.

1. INTRODUCTION

Antennas are most important elements in any wireless communication. Antennas are the last element at the transmitting side and first element at the receiving side. An LTE is a high speed data transmission application which needs a better antenna which can transmit data at a higher rate. The microstrip patch antennas have plenty of advantages such as low profile [3] [7], low cost, low power consumption etc. One major advantage of MSPA is that, it can be designed in any shape according to the application demand. It is very easy to design different shapes using MSPA. In this work three different shapes of patch antennas are designed for 1690GHz to 2200GHz LTE application. The substrate used for antenna design is FR4 epoxy which is cheap material and it has zero water absorption capacity. This material is mostly used in MSPA design because of its availability. The height of the substrate [5] is taken as h=1.6mm with a dielectric constant ε_r=4.4. Different feeding methods are used to feed the antenna based on the compatibility and requirements. In this paper proximity feeding is used to feed the antenna. This method is easy to design and gives more bandwidth. Proximity feeding is an indirect feed method where feedline and the patch are in different layers. The simulation results are obtained using the IE3D software and discussed the differences between triangular, circular and rectangular patch antennas.

1. DESIGN CONSIDERATION

In the following section the design of triangular, circular and rectangular patch antennas are discussed using the relevant design equations. The values of different parameters are listed in table I. The antennas are feed by using proximity feeding and the length of feedline is given by L_f and the width is given by W_f. The antennas consist of dielectric substrates with a ground plane and patch material [2].

1.1 Triangular Patch Antenna

The equilateral triangle is designed using the following equations (1) to (4) [6]. The length of the sides of triangular patch [4] antenna is calculated using the equation (4). The angle between each side is 60˚ for an equilateral triangle as shown in fig. 1. The outputs are dependent on the length of the side of triangular patch.

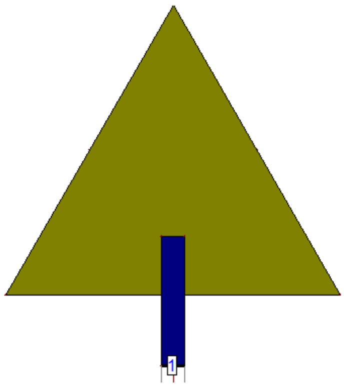

Fig -1: Triangular patch antenna with proximity feed

$$f_r = \frac{C.kmn}{2.\Pi} \times \frac{1}{\sqrt{\epsilon_r}} \quad (1)$$

$$k_{mn} = \frac{4.\pi}{3.a} \times \sqrt{m^2+n^2+mn} \quad (2)$$

Where, m=0 and n=1 for a fundamental resonant mode.

$$f_r = \frac{2.C}{3.a.\sqrt{\epsilon_r}} \quad (3)$$

$$a = \frac{2.C}{3.fr} \times \frac{1}{\sqrt{\epsilon_r}} \quad (4)$$

1.2 Circular Patch Antenna

The circular patch antenna [1] is designed by using the following formulas (5) to (8) [6]. The outputs can be controlled by varying the effective radius of a circular patch antenna. Fig. 2 shows the circular patch antenna with proximity feeding.

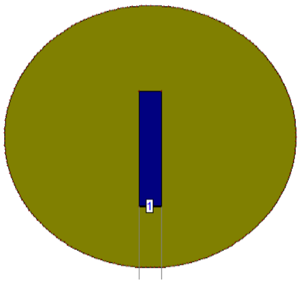

Fig -2: Circular patch antenna with proximity feed

$$a = \frac{F}{\sqrt{\{1+\frac{2.h}{\pi.\epsilon_r.F}[\ln\left(\frac{\pi.F}{2.h}\right)+1.7726\}}} \quad (5)$$

$$F = \frac{8.791\times10^9}{f_r\times\sqrt{\epsilon_r}} \quad (6)$$

Effective dielectric constant is given by eq. (7)

$$\varepsilon_{eff} = \frac{1}{2}\times(\epsilon_r+1)+\frac{1(\epsilon_r-1)}{4.\sqrt{(1+\frac{12.h}{a})}} \quad (7)$$

The effective radius of a circular patch is given by eq. (8)

$$a_e = \frac{1.8412\times c}{2.\pi.f_r.\sqrt{\epsilon_r}} \quad (8)$$

1.3 Rectangular Patch Antenna

The various parameters of a rectangular patch antenna are designed using the equations (8) to (12) [6]. The characteristics of a rectangular patch can be controlled by varying the length and width of the patch. The fig. 3 shows rectangular patch antenna with proximity feeding.

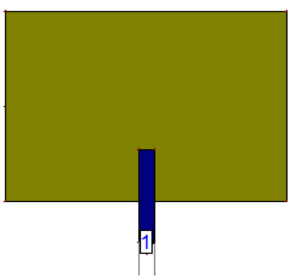

Fig -3: Rectangular patch antenna with proximity feed

The width of a rectangular patch is given by eq. (9).

$$W = \frac{c\sqrt{2/(\varepsilon_r+1)}}{2f_r} \quad (9)$$

Effective dielectric constant is given by eq. (10).

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}(1+10\,(h/w))^{-0.555} \quad (10)$$

The increase in resonant length us given by eq. (11)

$$\Delta L = 0.412h\times\frac{(\varepsilon_{eff}+0.3)}{(\varepsilon_{eff}-0.258)}\times\frac{(w/h+0.264)}{(w/h+0.813)} \quad (11)$$

The actual length of patch is given by eq. (12)

$$L = \frac{c}{2.f_r\sqrt{\epsilon_{re}}} - 2\Delta L \quad (12)$$

Table -1: Design parameters and values

Design Parameters	Values
Height of the substrate, h	1.6mm
Dielectric constant, ε_r	4.4
Side length of the triangular patch, a	49.02mm
Radius of circular patch, a_e	21.54mm
Width of the rectangular patch, W	46.93mm
Length of rectangular patch, L	36.45mm
Length of feedline L_f	18.96mm
Width of the feedline, W_f	3.4mm

3. RESULTS AND DISCUSSION

Based on the above design, different results are obtained and are compared for three different shapes. Table II shows the values obtained from three different shape antennas. The results like impedance matching, return loss, VSWR and gain are discussed.

3.1 Impedance Matching

The impedance of the patch antenna must be matched to 50Ω. Fig. 4, 5 and 6 shows smith chart for triangular, circular and rectangular patch antennas respectively. All three antennas are matched to 50Ω at their resonant frequencies.

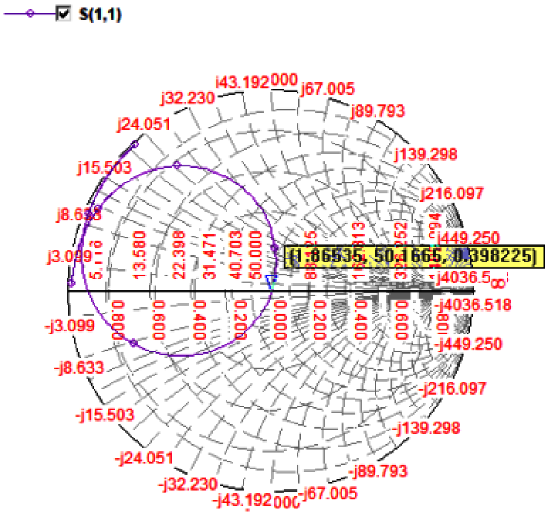

Fig -4: Smith chart for triangular patch antenna

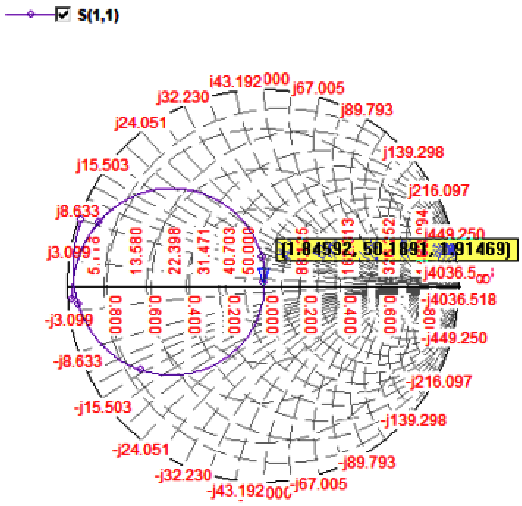

Fig -5: Smith chart for Circular patch antenna

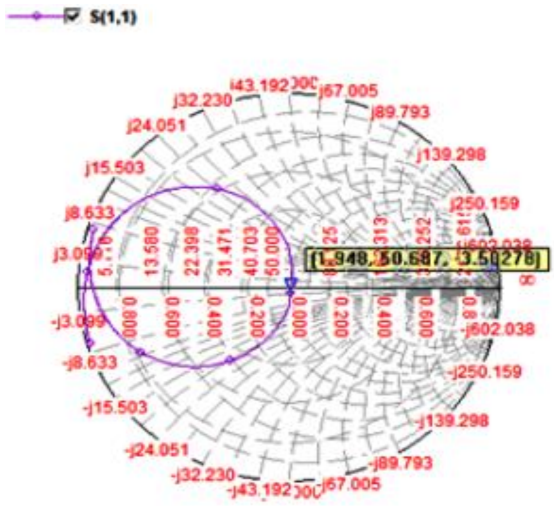

Fig -6: Smith chart for rectangular patch antenna

3.2 Return Loss and Bandwidth

Fig. 7, 8 and 9 shows the graphs for triangular, circular and rectangular patch antennas respectively. The circular patch antenna gives better return loss. Rectangular patch antenna gives more bandwidth than other two antennas.

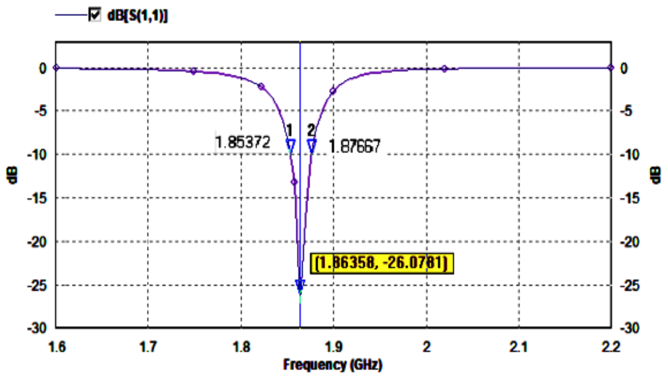

Fig -7: Return loss for triangular patch antenna

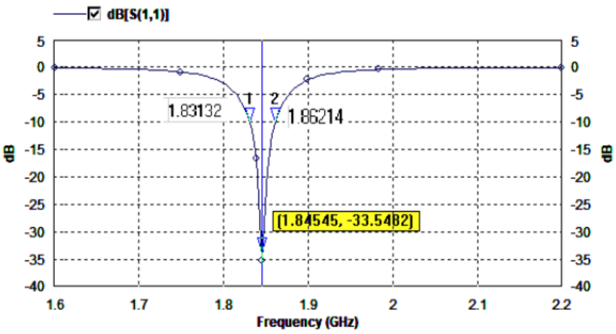

Fig -8: Return loss for Circular patch antenna

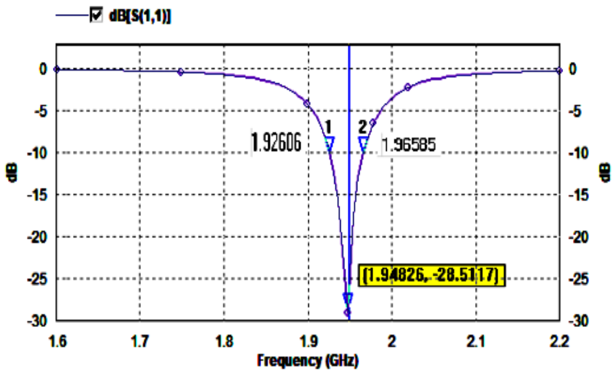

Fig -9: Return loss for rectangular patch antenna

3.3 VSWR

The VSWR of the patch antenna must be in between 1 and 2. Fig. 10, 11 and 12 shows smith chart for triangular, circular and rectangular patch antennas respectively. The circular patch antenna gives better VSWR values.

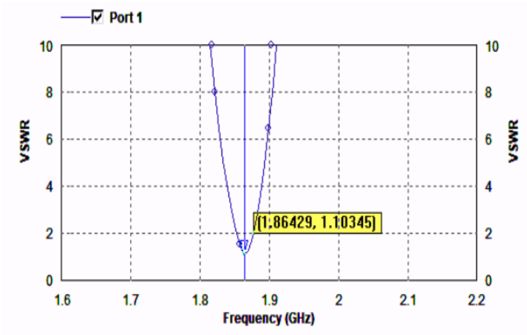

Fig-10: VSWR for triangular patch antenna

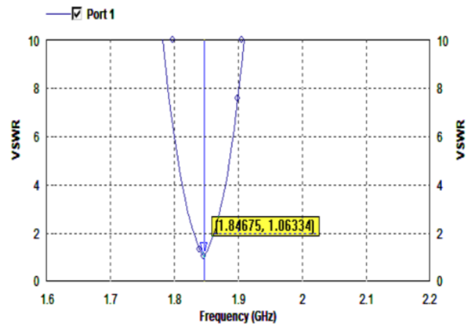

Fig -11: VSWR for Circular patch antenna

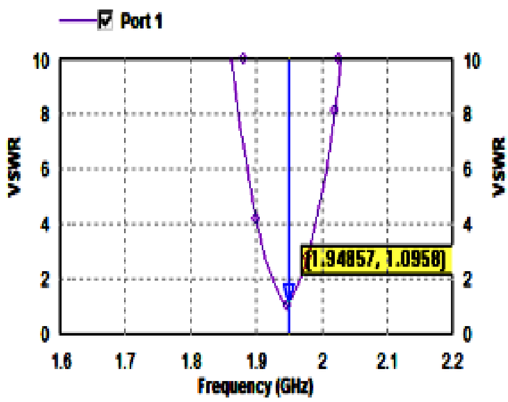

Fig -12: VSWR for rectangular patch antenna

3.4 Gain

The gain is an important parameters parameter to be considered while designing any antenna. Fig. 13, 14 and 15 shows the graphs for triangular, circular and rectangular patch antenna respectively. The rectangular patch antenna gives more Gain values compared to other two antennas.

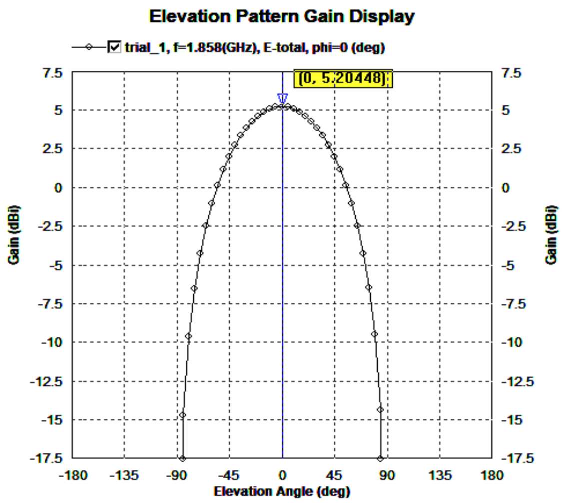

Fig -13: Gain for triangular patch antenna

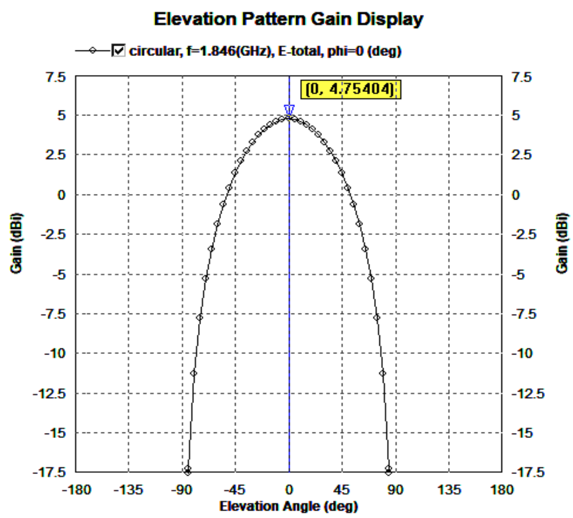

Fig -14: Gain for circular patch antenna

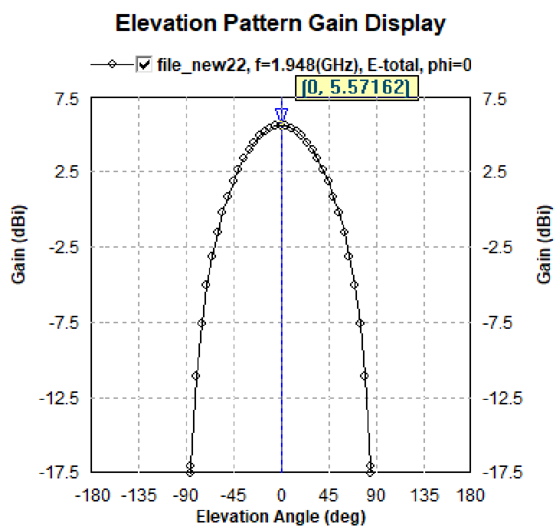

Fig -15: Gain for rectangular patch antenna

Table -1: Output parameters and values

Parameters	Triangular Patch	Circular Patch	Rectangular Patch
Resonant Frequency	1.864GHz	1.846GHz	1.948GHz
VSWR	1.103	1.06	1.09
Gain	5.2dBi	4.75dBi	5.57dBi
Return Loss	-26.07dB	-33.54dB	-28.51dB
Bandwidth	22.95MHz	30.82MHz	39.79MHz

4. CONCLUSION

The microstrip patch antennas are very easy design with any desired shapes. From the above discussion and the results obtained, it is clear that the rectangular shape patch antenna is best suited for high gain and higher bandwidth applications. All the three shape antennas give better impedance matching value at their resonant frequencies and also good VSWR values. The rectangular patch antenna gives more gain and high bandwidth compared to triangular and circular patch antennas so it is better to choose rectangular shape antenna for any type of applications.

REFERENCES

[1] Arnab Nandi Ashim Kumar Biswas, "Suppression of cross polarized radiation for circular patch antenna using different substrate and defected ground structure", Proceedings of 2017 Asia Pacific Microwave Conference , 978-1-5386-0640-7/17$31.00

[2] Raja Rashidul Hasan, Sujan Howlader, Md. Azad Hossen Shanto and Sharmin Jahan, "A novel design miniaturization of scalp implantable circular patch antenna at ISM band for biomedical application", Intelligent Systems Conference 2017, 7-8 September 2017 | London, UK.

[3] Nouman Ashraf, Bilal Ijaz and Khurram Saleem Alimgeer, "Compact microstrip triangular patch antenna with meandered ground plane for GPS and CNSS applications ", 978-1-4673-7441-5 /15/$31.00 ©2015 IEEE.

[4] Jinpil Tak and Jaehoon Choi, "Reconfigurable single port triangular patch antenna with polarization diversity", The 2015 International Workshop on Antenna Technology.

[5] Vijayalaxmi S W and Dr. A Sreenivasan, "Design and simulation of ircular microstrip patch antenna", International Conference on Innovative Mechanisms for Industry Applications (ICIMIA 2017).

[6] R. Kiruthika and Dr. T. Shanmuganantham, "Comparison of different shapes in microstrip patch antenna for X-band applications", 2016 International Conference on Emerging Technological Trends [ICETT].

[7] Chandrahasa R. Salian, Santhosh B. and Sandeep Vedagarbham, "A review on design and development of low cost 5GHz microstrip patch array antenna", International Conference on Innovative Mechanisms for Industry Applications (ICIMIA 2017).

[8] Constantine A. Balanis, Antenna Theory, Analysis and Design, 3rd ed., John Wiley & Sons, 2005, pp. 811-819.