RESEARCH ARTICLE OPEN ACCESS

Design And Analysis Of Trapezoid Ring Microstrip Patch Antenna For Lower Band 5G Application.

*Mukul Jain[1], Sarika Jain[2]
[1]*(Department of Electronics and Communication Engineering, Maharana Pratap University of Agriculture and Technology, India*
Email: mukuljain02@gmail.com)
[2]*(Department of Computer Science and Engineering, Institute of Technology and Management, India,*
Email: sarikajain03@gmail.com)
*India Corresponding author: *Mukul Jain*

ABSTRACT
In 5G Technology, Lower Frequency 5G Band range from 3.4GHz to 3.6GHz (in India). Now days a lot of research is going on in the field of designing of 5G microstrip antenna. In this paper, a trapezoid ring microstrip antenna is designed and analysed its parameters for 5G Application. The dielectric material FR4 has been employed as a substrate material for designing the proposed antenna having thickness 1.6mm with relative permittivity (εr) of 4.3 with loss tangent (δ) 0.025. The microstrip line feeding technique with patch insertion has been used to feed the power to the antenna with proper impedance matching of 50Ω so maximum power can transfer. The trapezoid ring microstrip antenna performance has been analysed in terms of return loss (dB), gain (dBi), directivity (dBi) and VSWR, etc. The Computer Simulation Technology (CST) Studio Suite 2017 has been used for the analysis and simulation of trapezoid ring microstrip antenna.

Keywords:- Lower Frequency 5G Band; trapezoid ring; Microstrip Antenna; FR4; Computer Simulation Technology (CST)

Date of Submission: 02-10-2017 Date of acceptance: 23-10-2017

I. INTRODUCTION

Communication between humans was first by sound through voice. With the desire for slightly more distance communication came, devices such as drums, then, visual methods such as signal flags and smoke signals were used. These optical communication devices, of course, utilized the light portion of the electromagnetic spectrum. It has been only very recent in human history that the electromagnetic spectrum, outside the visible region, has been employed for communication, through the use of radio. One of humankind's greatest natural resources is the electromagnetic spectrum and the antenna has been instrumental in harnessing this resource [2].

A microstrip antenna consists of conducting patch on a ground plane separated by dielectric substrate. This concept was undeveloped until the revolution in electronic circuit miniaturization and large-scale integration in 1970 [2].

An antenna is a device that is made to efficiently radiate and receive radiated electromagnetic waves. There are several important antenna characteristics that should be considered when choosing an antenna for your application as follows: Antenna radiation patterns, Return Loss, Gain, Directivity, and Polarization [2].

In this paper, a trapezoid ring microstrip patch antenna is designed and simulated its parameter using CST Studio Suite 2017. The calculation of Length and Width of proposed antenna is done by using rectangular microstrip patch antenna transmission line model equations.

There are several techniques available to feed or transmit electromagnetic energy to a microstrip patch antenna. The role of feeding is very important in case of efficient operation of antenna to improve the antenna input impedance matching. In microstrip patch antenna, different types of feed technique are available according to their requirement such as microstrip line feed, coaxial feed, aperture coupled feed etc [3]. For proposed antenna, microstrip line feed technique is used.

Substrates use in microstrip patch antenna varies from $2.2 \leq \varepsilon \leq 12$. Lower the permittivity of dielectric material larger the size of the antenna but it achieves better efficiency and larger bandwidth. The ε_r is limited by radio frequency or microwave circuit connected to antennas [4]. In trapezoid ring microstrip patch antenna, FR4 dielectric material is used which has $\varepsilon_r = 4.3$ with loss tangent (δ) 0.025.

II. ANTENNA DESIGN

A rectangular microstrip patch antenna shown in fig. 1 consists of rectangular patch which has length L and Width W which can be calculated by using transmission line model equations:

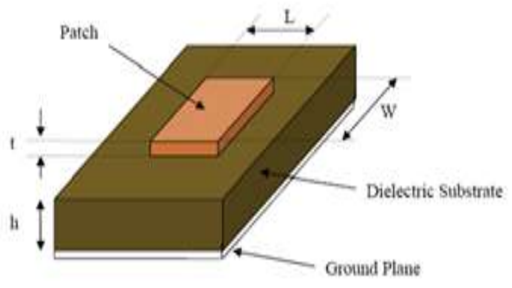

Fig.1 Rectangular microstrip patch antenna

For efficient radiation, the width W is given by Bahl and Bhartia [5] as:

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

Where, c = Speed of light, f_0= Resonant frequency, E_r = Dielectric constant

The expression for *εreff* is given by Balanis [1] as:

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}} \quad (2)$$

Where, *εreff* = Effective dielectric constant, *εr* = Dielectric constant of substrate, *h* = Height of dielectric substrate, *W* = Width of the patch

For a given resonant frequency f_o, the effective length is given by [1] as

$$L_{eff} = \frac{c}{2f_o\sqrt{\varepsilon_{reff}}} \quad (3)$$

Where, c = Speed of light, f_0= Resonant frequency, *εreff* = Effective dielectric constant

In proposed antenna which is shown in fig. 2, the height of substrate is 1.6mm and dielectric material used is FR4 which has Ɛr = 4.3 with loss tangent (δ) 0.025. The thickness of copper conducting material is 0.035 mm from which patch and ground of proposed antenna designed. The Table 1 show all the parameters used for designing of trapezoid ring microstrip patch antenna.

SR.NO.	Parameter Name	Designed Values
1	Resonant Frequency, F_0	3.5GHz
2	Dielectric Constant, E_r	4.3
3	Trapezoid Patch Length, L	16 mm
4	Trapezoid Patch Lower Width, W	30 mm
5	Trapezoid Patch Upper Width, Wa	20 mm
6	Substrate &Ground Length, Lg	32 mm
7	Substrate &Ground Width, Wg	50 mm
8	Length of Inner Trapezoid, L_b	2 mm
9	Upper Width of Inner Trapezoid, W_b	2 mm
10	Lower Width of Inner Trapezoid, Wc	4 mm
11	Length of Feed Line, F_h	8 mm
12	Length of Insert Feed, Fi	4.8 mm
13	Width of Feed Line, Fw	2.748mm

1. Table

In proposed antenna, microstrip line feed technique is used in order to transmit electromagnetic energy to proposed microstrip patch antenna. The length of feed line is 8mm and width is 2.748 mm. In proposed antenna, feed insert is also used in order to match the impedance to 50 ohm in order to transfer maximum power. The 3D view of trapezoid ring microstrip patch antenna is shown in fig. 2.

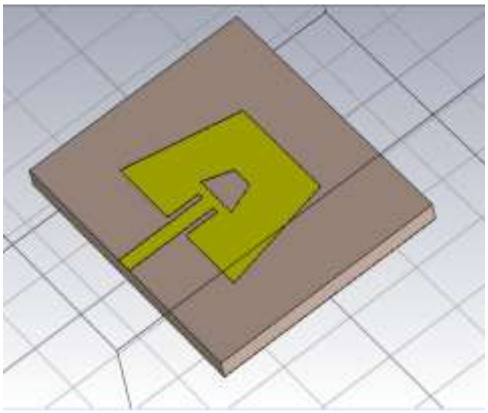

Fig.2 3D view of Trapezoid Ring microstrip patch antenna

The proposed antenna along with designed parameters which is mentioned in Table-1 is shown in fig. 3.

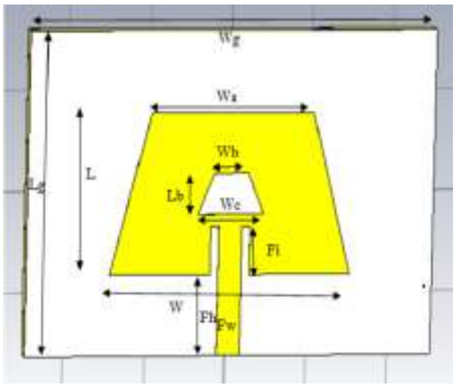

Fig.3 2D view of Trapezoid Ring microstrip patch antenna with designed parameters.

III. SIMULATION RESULT

The trapezoid ring microstrip patch antenna simulated and analysed using Computer Simulation Technology (CST) Studio Suite 2017. The return loss is -45.975db at 3.498 GHz shown in fig. 4 which is approximately the central frequency of lower frequency 5G band which range from 3.4 GHz to 3.6 GHz.

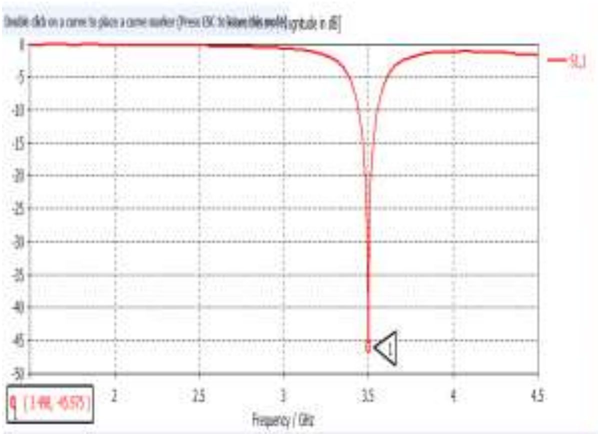

Fig.4 Return loss of proposed antenna at 3.498 GHz

The VSWR of proposed antenna is 1.01 at 3.498 GHz. Generally, VSWR of an antenna should be in range from 1 to 2. The fig. 5 shows the VSWR characteristics of proposed trapezoid ring microstrip patch antenna. The Z impedance of the proposed antenna is 50.01 ohm which is very good in order to transfer the power efficiently to antenna which is shown in fig. 6.

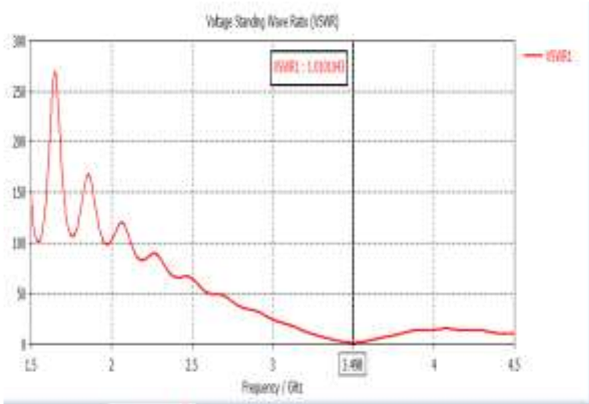

Fig.5 VSWR of proposed antenna at 3.498 GHz

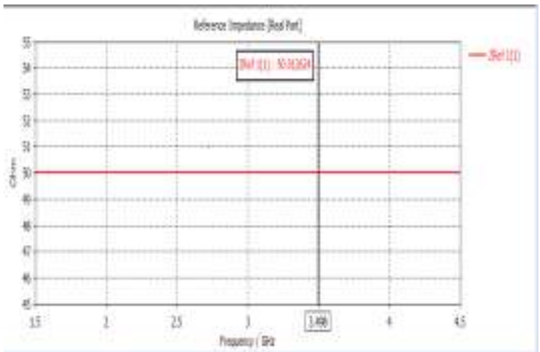

Fig.6 Z impedance of proposed antenna

The trapezoid ring microstrip patch antenna beamwidth (3 db) is 106.2 degree which is shown in fig. 7. The directivity of proposed antenna is 6.107 dbi as per fig 8. The radiation pattern of designed antenna is analysed by using fig. 8.

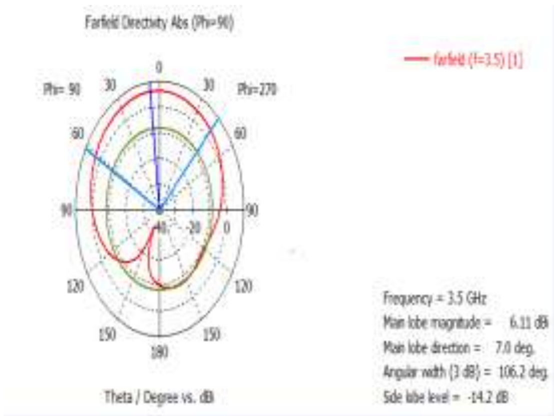

Fig.7 Polar chart of Designed antenna

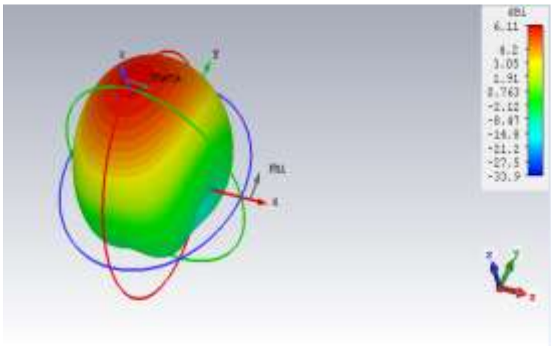

Fig.8 3D view of radiation pattern of designed antenna

As per fig. 9, the overall gain of proposed antenna is about 1.95 dbi.

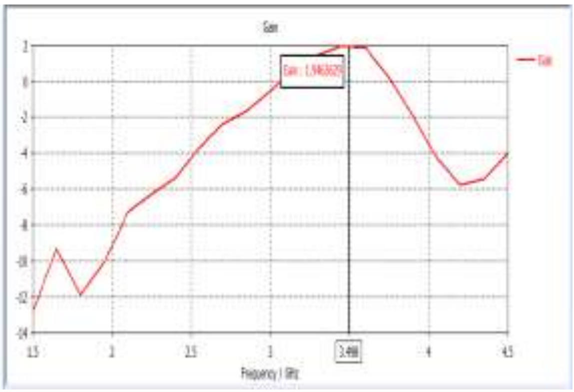

Fig.9 Overall gain of proposed antenna

The performance parameters such as Beamwidth, Return loss (db), Overall Gain, Directivity and VSWR for trapezoid ring microstrip patch antenna have analysed using CST studio suite 2017.

IV. CONCLUSION

This paper presents the design of trapezoid ring microstrip patch antenna for lower frequency 5G band which range from 3.4 GHz to 3.6 GHz. It can be concluded from the above discussion that performance parameters of antenna are suitable for 5G lower frequency band applications.

The proposed antenna having a gain of maximum 1.95 dBi and directivity of maximum 6.107dBi at resonant frequency of 3.498 GHz with minimum return loss of - 45.975dB, respectively. The Designed antenna covers 3.2% of bandwidth which is almost cover the 5G lower frequency band range.

REFERANCES

[1]. Constantine A. Balanis "Antenna Theory Analysis and Design," 2nd Edition, Wiley India (p.) Ltd., 2007.

[2]. C. Vishnu Vardhana Reddy, Rahul Rana, *Design Of Linearly Polarized Rectangular Microstrip Patch Antenna using IE3D/PSO*, Bachelor Thesis, National Institute of Technology , Rourkela, India, 2009.

[3]. Anushi Arora, Aditya Khemchandani, Yash Rawat, Shashank Singhai, Gaurav Chaitanya, "Comparative Study of Different Feeding Techniques for Rectangular Microstrip Patch Antenna," International Journal Of Innovative Research in Electrical, Electronics, Instrumentation And Control Engineering, vol.3, issue 5, May 2015.

[4]. Kiran Jain, Keshav Gupta, "Different Substates Use in Microstrip Patch Antenna-A Survey," International Journal Of Science and Research, vol.3, issue 4, May 2014.

[5]. R. Garg, P. Bhartia, I. Bahl and A, Ittipiboon, "Microstrip Antenna Design Handbook," Artech House, 2000.

[6]. Constantine A. Balanis "Advanced engineering electromagnetic," Wiley India (p.) Ltd., 1989.

[7]. Yi Huang and K. Boyle, "Antenna from Theory to Practice," John Wiley & Sons, 2008.

[8]. W. F. Richards, Y. T. Lo, D. D. Harrison, "An Improved Theory of Microstrip Antennas with Applications," IEEE Trans. Antennas and Propagation vol AP-29, pp. 38-46, Jan. 1981.

[9]. P. V. Subbaiah, R.S. Rao, "Microstrip (2001) and Slot Antennas, Handbook of Antennas and Wave Propagation," Scitech Publications pvt. Ltd India, pp. 10.4-10.8.

[10]. David M. Pozar, Susanne M. Voda, A Rigorour, "Analysis of a Microstrip line fed patch antenna," IEEE Transaction on Antenna and Propogation, vol.35, no.12, pp. 1343-1350, 1987.