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Analysis of Compact Patch Antenna for 5G Applications

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Abstract: ***This paper represents design of a simple, small, microstrip rectangular patch antenna for 5G application. Today, the requirement of antenna for such application should have higher bandwidth, low cost, low profile and smaller in size. The dimension of antenna are length and width of 2.59 mm and 3.65 mm respectively and height of this antenna is 0.4 mm. This antenna is designed by using thin and easily available substrate is used i.e., FR4 epoxy (εr= 4.4) to achieve compactness and high gain which will improve antenna performance. This antenna is wideband antenna means it covers a large bandwidth which includes 23.9 GHz frequency and our VSWR is improved from the base paper i.e., from 1.7483 to 1.0759. The simulation results of return loss, VSWR, gain and radiation pattern of the proposed antenna have been presented and discussed. Measured results are also presented and they are in good match with simulated results. The simulation results are obtained through HFSS 14 software.***

Keywords – Microstrip Antenna, 5G, Rectangular Patch, VSWR, Wideband.

1. INTRODUCTION

An antenna is a device which is used to transmit and receive signal, which give some information. Generally, antenna application includes various of example like Radio broadcast, Navigation system, vehicles system, flush mounted, Global Positioning System (GPS), Satellite communication and many more. The Large Area Synchronized Code Division Multiple Access and UWB(Ultra-wideband) promoted fifth – generation wireless network [1-5]. 5G has higher bandwidth spectrum for future uses in many applications. The spectrum of 5G comes under millimeter wave (mm-wave) band [6]. The antenna used in the mobile communication has high and low data rate services which increases the capacity and complexity decreases. 5G help to interconnecting the world, it can transfer voice and video signal with high speed and with high accuracy. The 5G has one best feature is that low latency which is used in live video streaming, cloud gaming and many more. For 5G application, the best choice is Microstrip Patch Antenna which has various of features like low profile, compatibility, ease of fabrication. The MPA has low profile which has various of advantages for fast moving vehicles like spacecrafts, rocket and airline.

2. DESIGN CONFIGURATION

Firstly, a ground layer is designed with the dimension 6.19 mm X 7.25 mm. The antenna thickness depends upon the relative permittivity of the substrate. The ground layer and second layer attached together. The third layer of antenna is radiating patch which is most effective layer of antenna. Microstrip patch antenna uses simplest feeding technique. The design is fabricated of the dimension 6.19 mm X 7.25 mm and the thickness of the substrate is 0.6mm. In this antenna we are using FR4 epoxy substrate with the dielectric constant 4.4. The tangent of dielectric loss is 0.02 and the dimension of patch 2.59 mm X 3.65mm is engrave on the substrate. The feeding line of Microstrip Patch Antenna dimension is 1.7 mm X 0.33 mm. The different feeding technique is available but we had choose inset feed because it is simple and easiest technique for fabrication of antenna. Fig 1(a) shows the top view of designed antenna where Lg is the length of ground, Wg is the width of the ground, Lp is the length of patch and Wp is the width of patch and their value mentioned in the Table 1. For the design of microstrip patch

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antenna for rectangular patch, we had chosen HFSS (High Frequency Structural Simulator) software. This software is a high-performance full-wave EM field simulator.

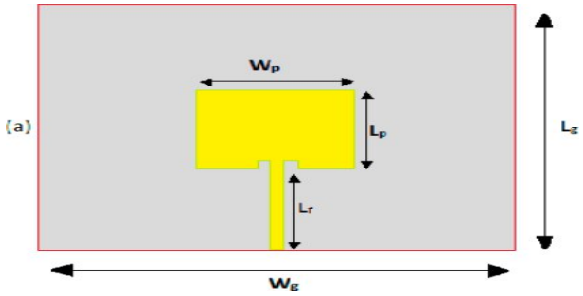

Fig. 1(a) The top view of designed antenna.

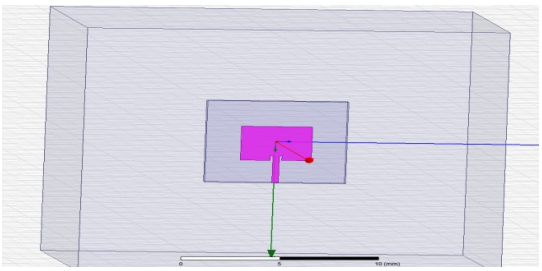

Fig 1(b) represents the top view of antenna design in HFSS software.

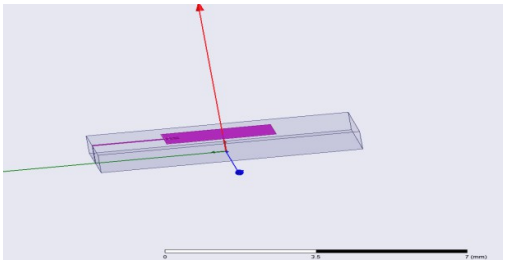

Fig. 1(c) represents the side view of antenna design in HFSS software.

Table1 Design parameter of implantable rectangular patch antenna

Parameter	L_g	L_s	L_p	Lf	h	W_g	W_f	W_p	W_f
Value (mm)	6.1949	6.1949	2.59	1.505	1.05	7.2514	7.2514	3.65	0.334

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3. ANTENNA PERFORMANCE

Here we have used Ansys HFSS v.14.0 software to create this design. The result obtained on the higher frequencies. In this microstrip patch antenna the designed antenna should be placed in a body model. For this we can use the skin, fat, muscle, etc. The substrate used is of FR4 epoxy with a dielectric constant of 4.4 and loss tangent of 0.02.

3.1 Characteristics of return loss

The multiband rectangular antenna has been simulated inside muscle model.The return loss for the frequencies 23.9 and 35.3 is -26.7205 and -16.9. as we can see in the following figure.

The S11 parameter represent how much power is radiated from the antenna, so the S11 parameter is known as reflection coefficient or return loss of antenna. So according to power radiated if S11 is 0 dB then it means 100% reflection, no power into the antenna means all power gets reflected. On the other hand, if S11 is 10 dB it means 90% of available power is already delivered to antenna and 10% gets reflected back which is best for antenna. Here the graph shows the values from 22 GHz to 40 GHz under -10 dB, which represents that at least 90% input power is delivered to device and reflected power is less than 10%, which shows this value is sufficient for many applications. And here in this range it covers two bands one is at 23.9GHz and second is 35.3 GHz which is used for 5G applications.

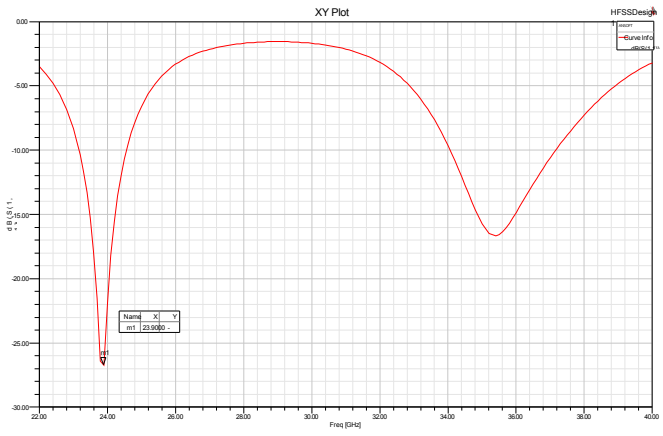

Fig.3 S11 parameter of antenna

3.2 Voltage Standing Wave Ratio

The VSWR describes the amount of mismatch between antenna and feed line connected to it. VSWR have value in the range of 1 to infinity. The value of VSWR is 1 when return loss is infinity. I Fig you can see that the value lies between 1 dB to 4 dB. The VSWR of this antenna is shown in Fig. 4. As we can see in the given figure that at 23.9GHz VSWR value is 1.0759 dB.

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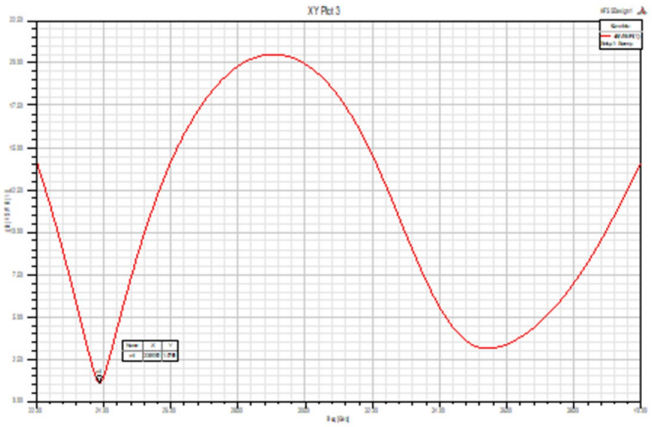

Fig. 4. VSWR of the antenna

3.3 Radiation Pattern

The 3D Pattern describes the gain of an antenna in electric and magnetic fields. The distance of radiations from the origin represents the strength of radiation emitted in that direction. The power transmitted along z axis is maximum. The simulated radiation characteristics for designed frequencies is illustrated in the E and H plane as shown in Fig 5.

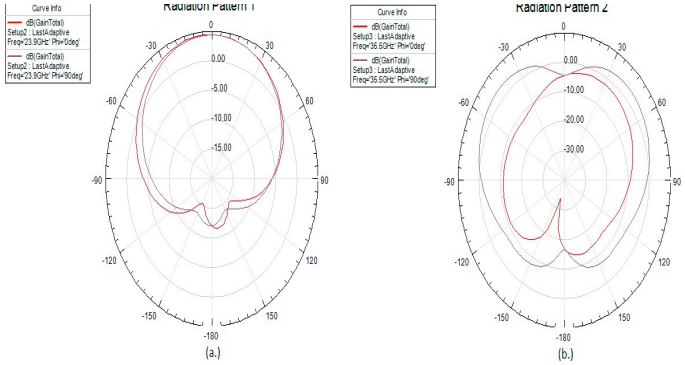

Fig.5 Radiation pattern sweep in 360^0angle

As E plane and H plane are basically the principal planes for the propagation of waves or radiation fields, where E-plane means the plane containing the electric field and H-plane means plane containing magnetic field. Co-polar means when polarization of both the transmitting and receiving antenna is same and cross polarization means when polarization of transmitting and receiving antenna are different. We simulate our antenna at two frequency that is 23.9 GHz and 35.5 GHz.

Fig 6(a) Gain of frequency 23.9GHz

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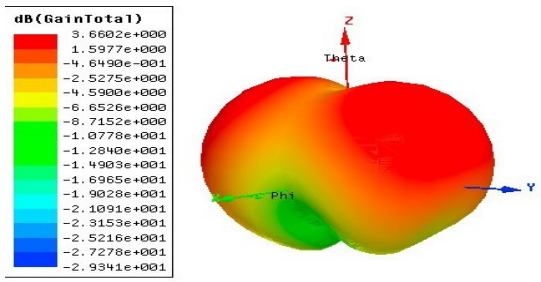

Fig 6(b) Gain of frequency 35.5GHz

3.4 Gain of Antenna

The gain of the antenna for the frequency 23.9 and 25.5 are 5.9825 and 3.6602 as we can see in the fig 6(a) and 6(b) respectively. Here in this gain result justified the application in 5G communications.

4. CONCLUSION

The antenna is fabricated on FR4 substrate having height 0.4mm. This paper emphases on the analysis and investigation of a rectangular patch antenna. There are many applications like Radio broadcast, Navigation system, vehicles system, flush mounted, Global Positioning System (GPS), Satellite communication and many more and the proposed antenna is designed precisely for these applications. The antenna resonates at three frequencies. 23.9GHz of frequency finds application in space applications such as radio astronomy and satellites. The calculation is based upon 25GHz but in this result the antenna resonant and 23.9GHz and 35.5 for multiband and our VSWR is improved from the base paper i.e., from 1.7483 to 1.0759. The gain of the antenna is also high which is 5.9825.

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