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Design and Analysis of Double O-slot microstrip patch antenna for mobile communication at 60 GHz

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***Abstract*—**In this paper our aim is to design a Double O slot microstrip patch antenna for applications operating at 60 GHz with maximizing the antenna gain and minimizing the radiation loss using high frequency structure simulator (HFSS).We will use Rogers RT/duroid 5880 as substrate due to its suitable mechanical and insulating properties. Resonant frequency used will be 60 GHz and height will be 1.6 mm. The patch antenna has wide range of advantages as it is small in size, cheaper cost, easy to fabricate and integrate. This work proposes a slotted patch antenna design applicable to the 5th Generation. The 5G application works on millimeter frequencies and it is known that there has been great development in WLANs.The performance depend on the shape and size of the antenna. . The feedline given is 50 ohm on the radiating patch shape and size of the antenna. The millimeter frequency used is 60 GHz. The future aim of wireless communication is to provide data with high speed data range even in harsh geographical areas.

***Keywords*-**Micro strip Patch antenna, Substrate, Dielectric constant, millimeter frequency, wireless application

I. INTRODUCTION

The patch antenna has wide range of advantages as small in size cheaper cost, easy fabrication and integration. The work shows microstrip patch antenna with slot which is applicable in 5th Generation. The 5G application works on millimeter frequencies. The huge development in the field of wireless local area network**.** Microstrip patch antenna are increasingly use for commercial purpose[1-5]. It is very easy in fabrication and comfortable with curved paths of device. Therefore easy integration with microwave integrated circuits (MICs They are light weight, small size and therefore end up with small device. It can be of various shape rectangular, circular, elliptical etc. We choose the shape which is best suitable for the device application. The resonant frequency 60GHz is reserved band for millimeter frequency according to the Federal Communication system (FCC)[6].The antenna comprised of three main parts ground, substrate and patch at the top. The ground plane is bottom most layer with negligible thickness. Substrate used will be Rogers RT/duroid 5880 for its suitable mechanical and insulating properties height of the substrate is 1.6 mm. At the top there is a patch with particular dimensions in terms of length and width indicated as L and W, respectively. A Double O-slot is made in the patch and with the help of microstrip feed is provided. The slot made is in order to produce maximum gain and minimum radiation in order to make efficient working of antenna. The matching impedance is 50 Ohm. So we will analyze the reflection coefficient, radiation pattern that occur internally. The parameters of the antenna are computed on resonant frequency 60 GHz. analyze the return loss, radiation pattern that occur internally. We use 60GHz as the resonant frequency. This frequency come under millimeter wave frequency. This frequency can replace traditionally used fiber optics technique and now a days 5th Generation is based on it that is IEEE 802.11ad, high definition videos, satellite communication, automobile communication[7-9]. For security purpose this frequency is used in body scanners. Also it can also be used in motion sensors, collision avoidance, automatic doors, and detection of speed in vehicles. Millimeter frequencies have higher bandwidth due to which data rate is also high. It can achieve up to 10gbps data rate. Microstrip line feed is given to it with the help of lumped port. Simulation will be done with the help of HFSS software. We will analyze the S11 graph that is return loss of the antenna at 60GHz.The gain should be maximum and return loss should be minimum at the resonant frequency[10-13].

II. DESIGN AND CONFIGURATION OF ANTENNA

Here we show a simulated design of the antenna. The aim is to design the antenna with proper feed. In this we use microstrip feeding technique is used. In this we will discuss about patch antenna designed and simulated on the software - High Frequency Structure Simulator (HFSS). [2]

Geometrical specification of single patch antenna-

$$W = \frac{1}{2fr\sqrt{\mu_\circ \varepsilon_\circ}} \sqrt{\frac{2}{\varepsilon_{reff}+1}}$$

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}$$

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$$L = \frac{1}{2f_r\sqrt{\varepsilon_{reff}}\sqrt{\mu_\circ\,\varepsilon_\circ}} - 2\Delta_l$$

$$\frac{\Delta_l}{h} = 0.412\frac{(\varepsilon_{reff} + 0.3)(\frac{W}{h} + 0.264)}{(\varepsilon_{reff} - 0.258)(\frac{W}{h} + 0.8)}$$

The substrate used will be Rogers RT/duroid 5880 with ε_r = 2.2 with 1.6 mm thickness. With the help of these formulas we design the substrate having dimension 6 x 6 x 1.6mm^3.
In this W is the width of the patch. ε_r is the dielectric constant. μ_0 is permeability. ε_0 is the permittivity. ε_{reff} symbolizes the effective dielectric constant. 'L' is the length of the patch. The resonant frequency is f_r. The performance parameters are [1]:

1. Directivity

In antenna, the ratio of radiation intensity in a direction to that of radiation intensity averaged in all direction.

$$D = \frac{4\pi U}{P_{rad}}$$

2. Gain

The ratio of radiation intensity of the antenna in a particular direction to the total input power fed to the antenna is termed as gain of the antenna.

$$G = 4\pi\frac{Radiation\ intensity}{Total\ input\ power}$$

3. Bandwidth

Bandwidth of an antenna is defined as the particular set of frequencies or frequency band in which the antenna operates. It can be on either side of the central frequency. There are two types of bandwidths - narrow and broad.

$$B.W = f_h - f_l$$

4. Return loss

Return loss is the reflection of the signal power from insertion of a device. It is expressed in dB.

$$R.L = 10\,Log\,\frac{P_r}{P_i}$$

Design of series feed antenna array:

Parameters	Dimensions (in mm)
Wg	6
Lg	6
Wg1	4
Lg1	4
Wg2	2
Lg2	2.4
Wg3	0.5
Lg3	0.6
T1	0.1
T2	0.2

Table 1. Antenna design parameters

The antenna design parameters of the proposed design are shown in Table 1. The parameters are obtained with the help of the calculations made with the help of substrate, height values and resonant frequency.

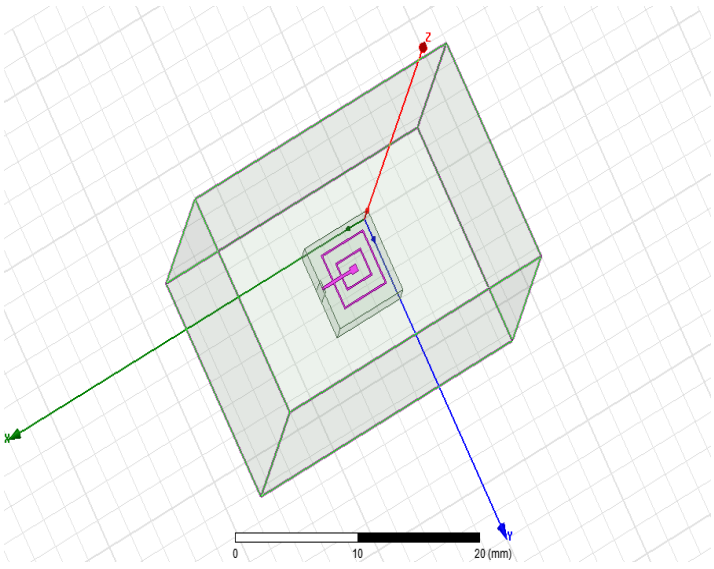

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Fig 1.Model of the proposed design

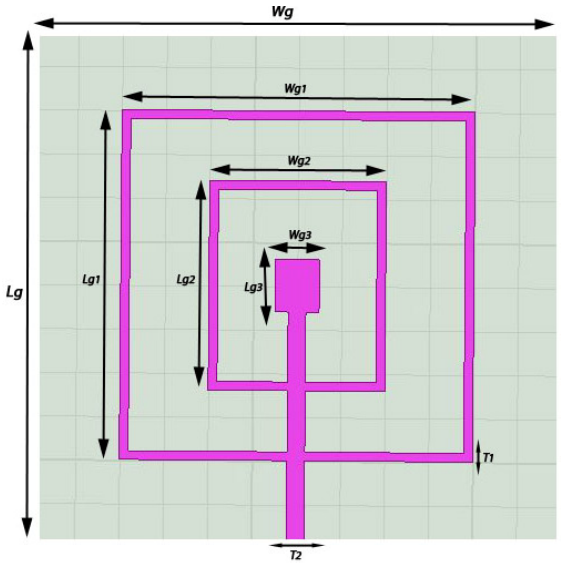

Fig 2. Dimensions of the proposed design

The overall dimension of the patch antenna i.e. substrate is 6 x 6 x 1.6 mm^3. The magnitude of Lg is 6 mm and Wg is 6 mm. Height of substrate is 1.6 mm. The true length and width of the patch are equal, 4mm each. The dimensions of the O-slot patch which is left inside is 0.5 mm and 0.6 mm respectively. 0.2mm the width a of the of the feeding strip. A ground patch on which a substrate of same dimension is placed.

III. RESULTS

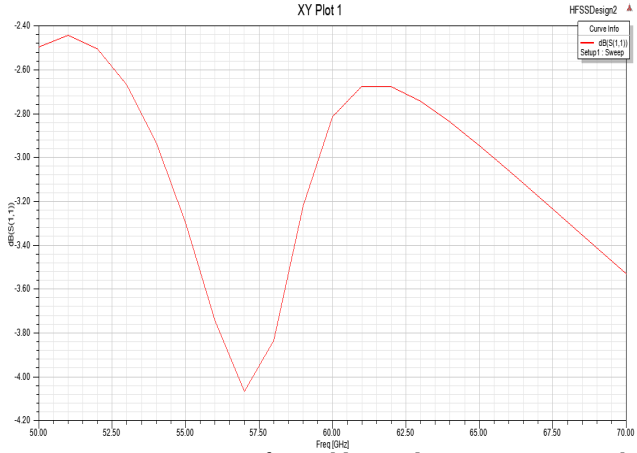

Fig 3. Return Loss of Double O-slot microstrip patch antenna

The graph of S11 that is the return loss graph shows minimum loss of -2.824 dB at resonant frequency 60GHz in case of Double O-slot microstrip patch antenna.

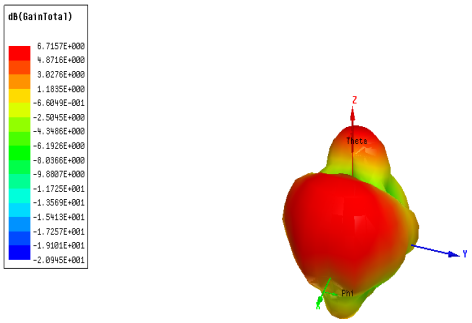

Fig 4. Gain of Double O-slot microstrip patch antenna

While finding the maximum gain of antenna in case of Double O-slot microstrip patch antenna is 6.7157 dB which is at 60Ghz frequency. Therefore overall the return loss is -2.824dB and gain is 6.7157dB. So, the antenna can work efficiently at resonant frequency

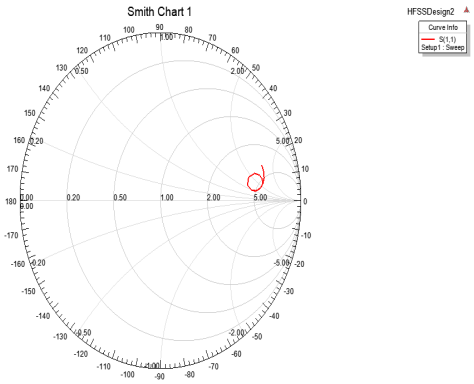

Fig5.Smith chart of the Double O-slot microstrip patch antenna

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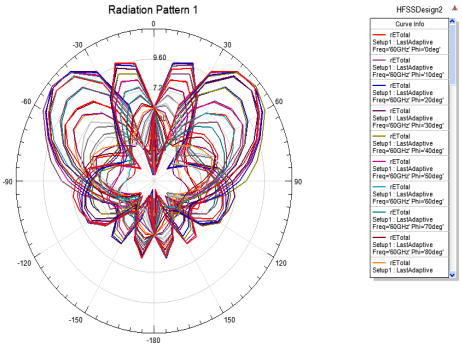

Fig 6.Radiation pattern of the Double O-Slot microstrip patch antenna

Function	**Double O-slot microstrip patch antenna**
Gain	6.7157 dB
Return Loss	-2.824 dB at 60 GHz Frequency

Table2. Results of the Double O-slot microstrip patch antenna

IV. CONCLUSION

After that simulation has done for the antenna which has been designed with the parameters 6 x 6 x 1.6mm^3 for the Double O-slot microstrip patch antenna which make it suitable to provide data with high speed data range even in harsh geographical areas. It is observed that the designed array antenna has showed increment in gain as 6.7157 dB. This gain is obtained in compensation with return loss. The designed double O-slot patch antenna operates at a resonant frequency of 60 GHz.

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