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# Design and analysis of T-slot mircostrip patch antenna for mobile communication at 60 GHz

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**Abstract-** Microstrip patch antenna with T-slot which finds application in WLANs. It also includes 5G application. The microstrip patch antenna is simulated with the help of HFSS (High frequency simulator software). We will analyze the S11 parameters that are return loss of the antenna and its gain. The aim of this work is to design a T-slotted patch antenna at a frequency of 60 GHz with maximum the antenna gain and minimum 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. 1.57mm is kept the height of the substrate and antenna resonates at a frequency of 60GHz. 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, WiGig technology that is IEEE 802.11ad, high definition videos, satellite communication, and automobile communication. 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.
**Keywords**- Resonant frequency, Microstrip Patch antenna, Substrate, Dielectric constant, millimeter frequency, 60GHz.

## I. INTRODUCTION

Microstrip patch antenna has been playing vital role in the mobile communication which is growing at very fast rate. The patch antennas are feasible where our traditional antennas doesn't show feasibility. The small in size results in overall smaller size of the antenna. The fabrication is quite simple and easily etched on any printable circuit board. These are much comfortable at the curved path of the designs are increasingly use for commercial purpose[1-5]. It is very easy in fabrication and comfortable with curved paths of device. These are compatible for many shapes such as circle, rectangle, oval, triangle square etc. We choose the shape which is best suitable for the device application. Mass manufacturing is done due to cheaply available. These support dual polarization that is circular and linear also multiband can be used. The resonant frequency 60GHz is reserved band for millimeter frequency according to the Federal Communication system (FCC).The antenna comprised of three main parts ground, substrate and patch at the top[6]. 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 1.57 mm. Substrate which is easily available in the market and show good behavior at high frequencies. There is a metal patch with dimensions length and width. Two E and one H slot is made in the patch and with the help of microstrip feed is provided. The slots are made is in order to produce maximum gain and minimum radiation in order to make efficient working of antenna. 50 Ohm is used as the matching impedance[7-9]. So we will analyze the return loss, radiation pattern that occur internally. 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. In this decade it is fastest growing technology. In this paper we will make a microstrip patch antenna ground sheet on the base, put a substrate material on it .a patch is created and two E and one H slot is made. Microstrip line feed is given to it with the help of lumped port. Simulation will be done with the help of HFSS software[10-13].

## II. ANTENNA CONFIGURATION AND DESIGN

The configuration and design of the microstrip patch antenna is with the help of High Frequency Structure Simulator (HFSS) Software**.** A microstrip patch antenna is designed and simulated here. The aim is to design the antenna with proper microstrip line feed. [2]

**Geometrical specification of single patch antenna-**

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

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

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

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

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The above formulas we used to find the dimensions 5 x 5 x 1.57mm$^3$. The substrate used will be Rogers RT/duroid 5880 with $\varepsilon_r = 2.2$ with 1.57 mm thickness.

H is the height and W is the width of the patch. $\varepsilon_r$ is the dielectric constant. $\mu_0$ is permeability. $\varepsilon_0$ is the permittivity. $\varepsilon_{reff}$ 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.

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

### 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.

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

**Design of series feed antenna array:**

| Parameters | Dimensions (in mm) |
|---|---|
| Wg | 5 |
| Lg | 5 |
| Wg1 | 3.2 |
| Lg1 | 3.6 |
| H | 0.2 |
| Tx | 1 |
| Ty | 0.8 |

Table 1. Parameters of the designed antenna

Following table shows the parameters of the designed antenna .The parameters are obtained with the help of the calculations made with the help of substrate, resonant frequency and height values.

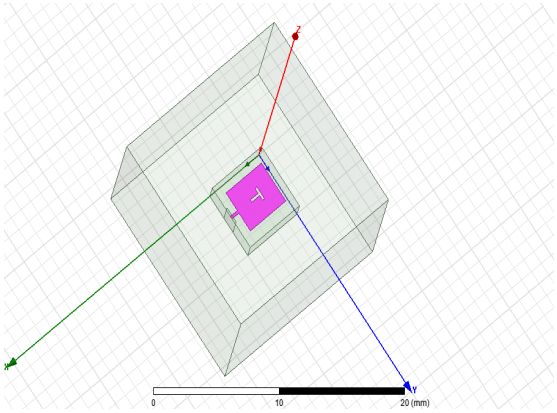

Fig 1.Model design of the proposed antenna

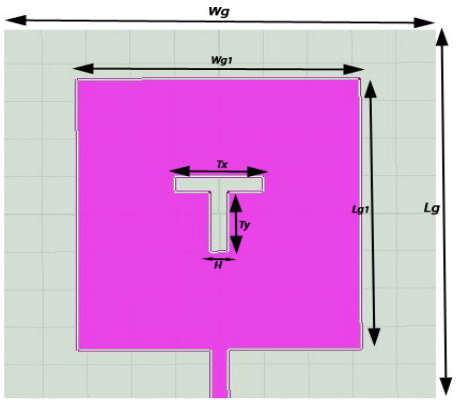


Fig 2. Dimensions of the T-slotted patch antenna

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Overall dimensions of substrate of the antenna are 5 x 5 x 1.57 $mm^3$. The measure of L is 5 mm and W is 5 mm. Height of substrate is 1.57 mm. Ground patch is built on which a substrate of same dimension is placed.. 3.2 mm and 3.6 mm are the true length and width, respectively, of the proposed design. The excitation used is Lumped port. The dimensions of the T-slotted patch left inside are 1 mm and 0.8 mm, respectively. 0.2 mm the width of the feeding strip.

## III. RESULTS

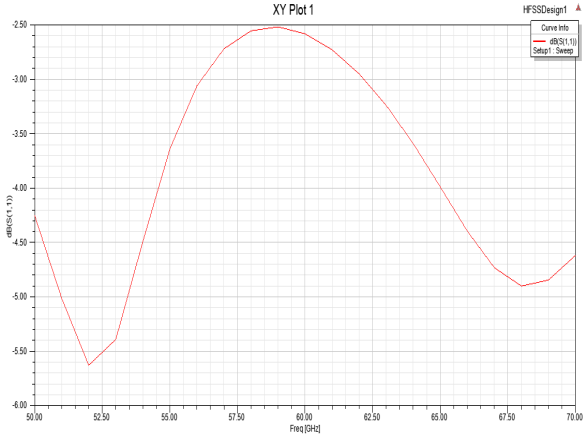


Fig 3. Return Loss graph of T-slotted proposed antenna

Figure 3 shows return loss graph of the T-slotted antenna which a minimum loss of -2.6048 dB at 60GHz.

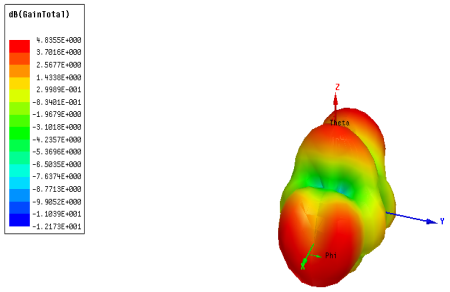


Fig 4. Gain of T-slot microstrip patch antenna

The maximum gain of antenna is 4.8355 dB which is at 60GHz frequency. Therefore overall the return loss is -2.6048dB and gain is 4.8355dB. So, the antenna can work efficiently.

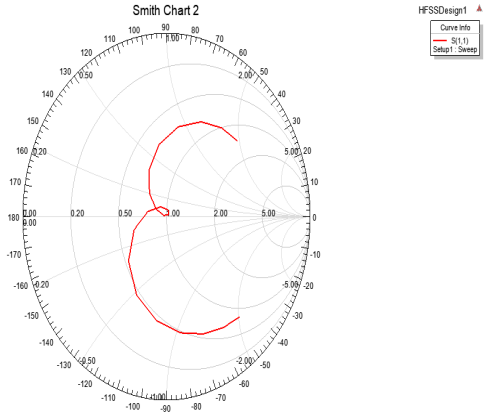


Fig5.Smith chart of proposed antenna design

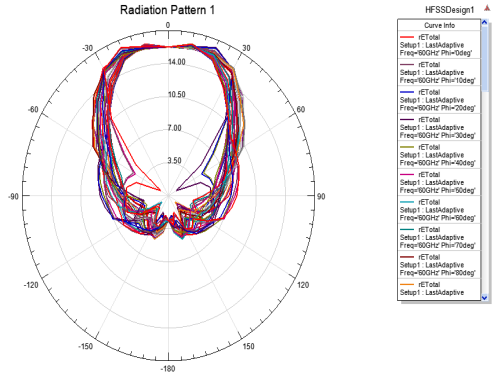


Fig 6.Radiation pattern of the proposed antenna design

| Function | T-slot microstrip patch antenna |
|---|---|
| Gain | 4.8355dB |
| Return Loss | -2.6048 dB at 60 GHz Frequency |

Table2. Results of the proposed antenna design

## IV. CONCLUSION

After that simulation has done for the antenna which has been designed with the parameters 5 x 5 x 1.57$mm^3$ for the T-slotted patch antenna. It is observed that the designed array

antenna has showed increment in gain as 4.8355 dB. This gain is obtained in compensation with return loss. This T-slot microstrip patch antenna operates at 60 GHz resonant frequencies which make it suitable to provide data with high speed data range even in harsh geographical areas .The small in size results in overall smaller size of the antenna. The fabrication is quite simple and easily etched on any printable circuit board. These are much comfortable at the curved path of the designs are increasingly use for commercial purpose.

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