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DESIGN AND ANALYSIS OF U-SLOT MIRCOSTRIP PATCH ANTENNA FOR MOBILE COMMUNICATION AT 60 GHz

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Abstract: A low loss and high gain millimeter wave microstrip patch antenna has been proposed in this paper. The antenna is designed by cutting a U-slot on the patch and it is excited by microstrip feed line. The advantages of this design are high gain and low fabrication cost. Their performances depend on the shape and size of the antenna. The future aim of wireless communication is to provide data with high speed data range even in harsh geographical areas. Here aim is to design a U-slotted patch antenna at a frequency of 60GHz with maximum antenna gain and minimum 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 0.508 mm.
Keywords: Microstrip Patch antenna, Substrate, Dielectric constant, millimeter frequency, ISM band, resonant frequenc

INTRODUCTION

Most promising technology WiGig technology which delivers multigigabit throughput in mobile communication. Digitized data which is not compressed, video and voice contents could be transmitted in the space with very short distance and the rate is 8gbps at resonant frequency 60 GHz. FCC (Federal *Communications Commission)* has assigned 57 to 64 GHz unlicensed frequency for high data rate. Microstrip patch antenna are increasingly use for commercial purpose. It is very easy in fabrication and comfortable with curved paths of device.

Therefore easy integration with microwave integrated circuits (MICs)[I-V]. 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).

The antenna comprised of three main parts ground, substrate and patch at the top[VI]. 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 0.508 mm. There is a metal patch on top with dimensions L and W representing length and width, respectively.

A U shaped slot is cut into the patch and excited by microstrip feed line. 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. This frequency can replace traditionally used fiber optics technique and now a day's 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 [VII-X].

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. Simulations are carried out in HFSS software. The S11 graph showing return loss of the proposed antenna design at 60GHz will be analyzed here. The resulting gain is also analyzed.

The patch antenna has wide range of advantages as small in size cheaper cost, easy fabrication and integration. The antenna is efficient if it will show maximum gain and minimum loss at the resonant frequency [XI-XIII].

ANTENNA CONFIGURATION AND DESIGN

We use microstrip feeding technique is used. Simulations are carried out in the software - High Frequency Structure Simulator (HFSS). A microstrip patch antenna is designed and simulated here. The aim is to design the antenna with proper feed. [II]

—Geometrical specification of single patch antenna-

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

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

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

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

These formulas are used and the substrate having dimension 7.50 x 9.50 x 0.508 is designed. The substrate used will be Rogers RT/duroid 5880 with $\varepsilon_r = 2.2$ with 0.508 mm thickness. ε_{reff} symbolizes effective dielectric constant. 'L' is the length of the patch. f_r is the frequency at which the antenna resonates.

The performance parameters are width of the patch represented by 'W'. ε_r represents dielectric constant. μ_0 is permeability. ε_0 is the permittivity [I]

Directivity

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

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

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.

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

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.

$$B.W = f_h - f_l$$

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:

The data above 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.

Table 1. Parameters of the designed antenna

Parameters	Dimensions (in mm)
Lg	7.5
Wg	9.5
Lp	1.5
Wp	1.48
Ls	0.6
Ws	0.5
Wq1	0.2
Lq2	2.63
Wq2	0.5

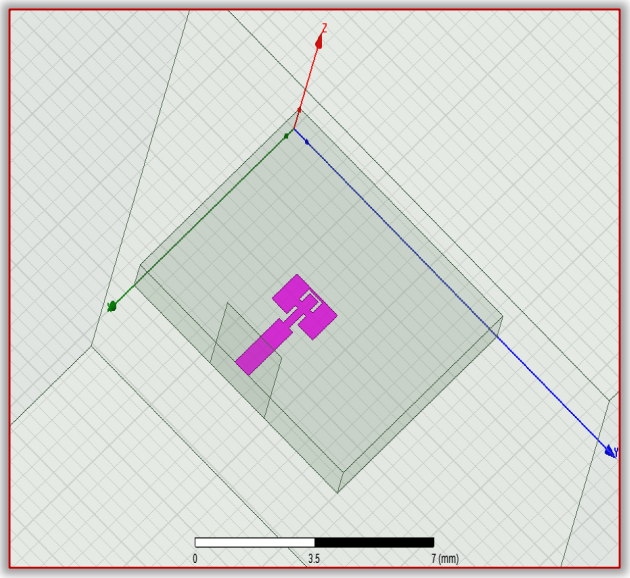
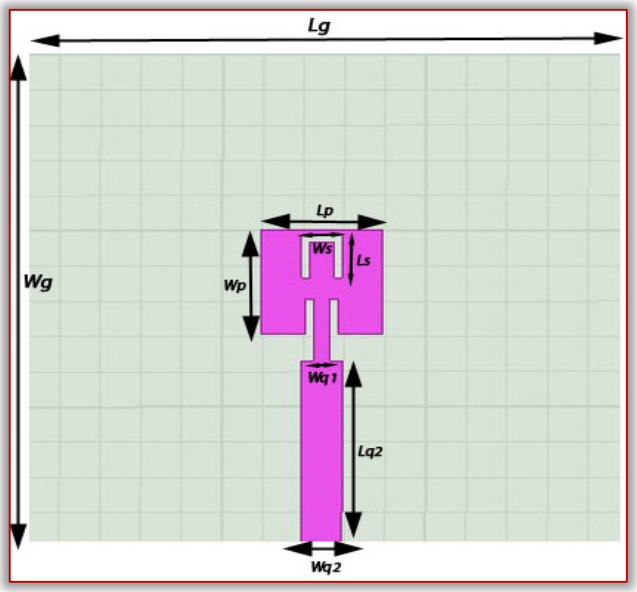


Figure 1. Model of proposed antenna design



Figue 2. Dimensions of proposed antenna design

The overall dimension of the patch antenna i.e. substrate is 7.5 x 9.5 x 0.508mm^3. The magnitude of Lg is 7.5mm and Wg is 9.5mm.Height of substrate is 0.508mm. 1.5mm and 1.48mm are the true length and width, respectively, of the patch.

First there is a ground patch on which a substrate of same dimension is placed. The excitation used is Lumped port. The dimension of the U-slot which is cut out is Ls and Ws with 0.6mm and 0.5mm respectively.Wq2 and Lq2 are the width and length of the of the feeding strip.

RESULTS

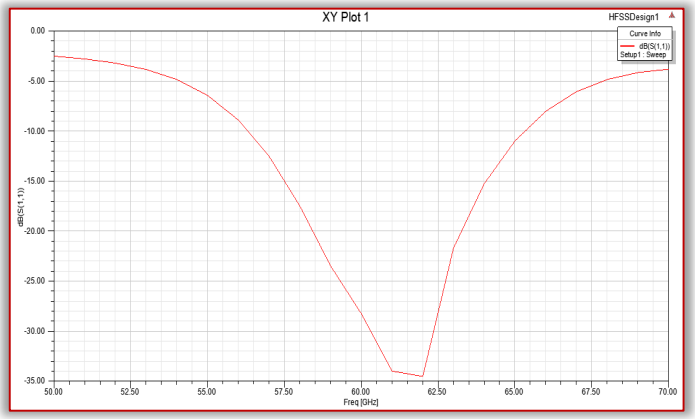


Figure 3. Return Loss graph of proposed antenna design

The S11 parameters or Return loss graph shows minimum loss of -28.3633 dB at frequency 60GHz in case of U-slotted patch antenna at 60GHz

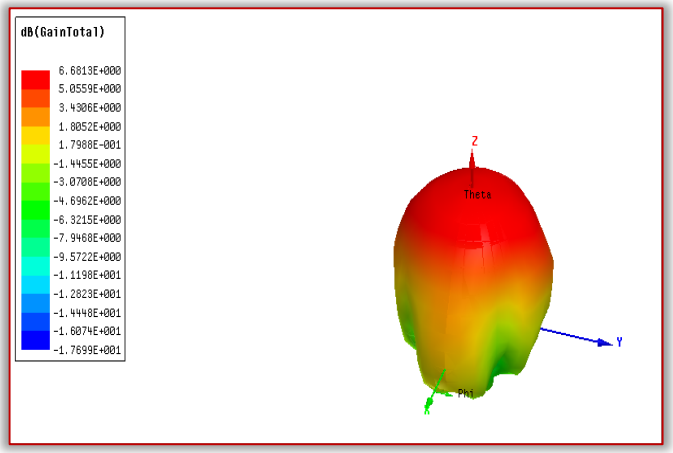


Figure 4. Gain of proposed antenna design

Overall the return loss is -28.3633dB and gain is 6.6183dB.so, the antenna can work efficiently. While finding the maximum gain of antenna in case of U-slot microstrip patch antenna is 6.6183 dB which is at 60GHz frequency.

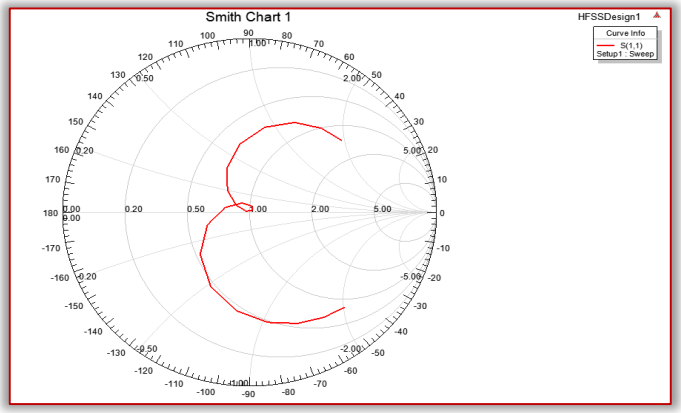


Figure 5.Smith chart of proposed antenna design

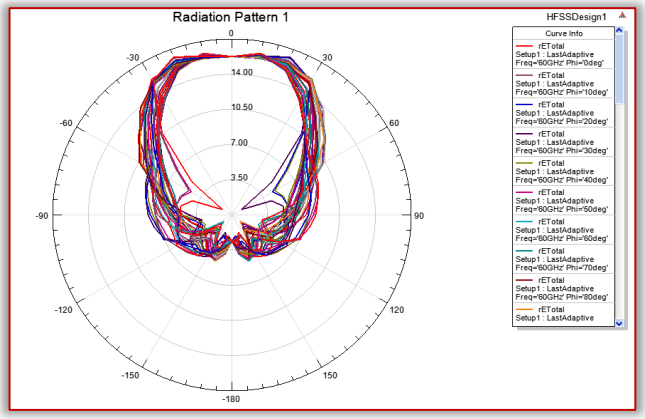


Figure 6. Radiation pattern of proposed antenna design

Table 2. Results of proposed antenna design

Function	U-slot microstrip patch antenna
Gain	6.6183 dB
Return Loss	-28.3633 dB at 60 GHz Frequency

CONCLUSION

A design and after that simulation has done for the antenna which has been designed with the parameters 7.50 x 9.50 x 0.508mm^3 for the U-slot microstrip patch antenna. It is observed that the designed array antenna has showed increment in gain as 6.6183 dB.

This gain is obtained in compensation with return loss. This U-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 patch antenna finds potentially high applications in millimeter-wave frequency in wireless communication.

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