International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 09 | Sep 2020 www.irjet.net p-ISSN: 2395-0072

T-slotted ultra wide band Microstrip Patch Antenna for 5G Communication

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Abstract - *In proposed research work, a compact planar T- slotted ultra wide band microstrip patch antenna for 5G Wireless communication at millimeter wave frequency is presented. The antenna is simulated Using CST software. We will evaluate the S11 parameters which are the antenna's return loss, VSWR, Radiation pattern and its gain. To increase the antenna bandwidth, a slotted T-shaped is added in patch. The calculated results indicate that the bandwidth of antenna is 6.22 GHz from (46.00 GHz - 52.22 GHz) frequency. This bandwidth of antenna covers Ultra wide band (3.1GHz to 10.6GHz) range. Lowest return loss of -14.617dB at 48.72 GHz. Antenna gain is 6.177 dB at 50 GHz. And the voltage standing wave ratio (VSWR) is 1.456 at 48.72 which makes the antenna a good choice for very high speed WLAN and 5 G communications applications.*

Key Words: Slotted patch antenna, Microstrip line feed, ultra wide band, 5G Wireless communication, CST Software

1. INTRODUCTION

Microstrip antenna plays a vital role in the fastest growing wireless communications industry and we can't think of any advancement in wireless communication without improvements in Microstrip antenna technology. In order to create communication between wireless devices on higher frequency bands such as millimetre wave bands, we need antennas that are conformal, small and lightweight, cheap and simple to produce so that printed antennas are favoured because of their advantages over other radiating antennas. By building patch antennas with slotted configuration, antenna bandwidth and efficiency can be improved and propagation loss in 5 G system can occur as a result of atmospheric absorption of mm waves. To accomplish this, various miniaturization techniques such as slotting techniques[1-2] have been used.

This In electromagnetic spectrum, the frequency spectrum band for millimetre wave falls between 30GHz and 300GHz. For 5 G networks, the frequency bands come in two types. Frequency range 1 (FR1) ranges from 450 MHz to 6 GHz, including the frequency range for the LTE. Frequency range 2 (FR2) is between 24.25GHz and 52.6GHz. The range sub-6 GHz is the name of FR1 and the spectrum of millimetre wave (mmWave) is the name of FR2. The peak data rates for a fully operational 5 G network are theoretically 20 Gb / s downlink and a 10 Gb / s uplink, as defined by the International Telecommunications Union. The free space wavelength in this band is in the range of 1 mm to 10 mm so this band enables the use of smaller antennas. The path loss is proportional to the frequency square, such that the path loss at this high frequency band is high[3].

UWB structures, which were characterised by FCC in 2001, cover 3.1GHz to 10.6GHz bands[4].This paper describes a T slot microstrip antenna built and simulated to achieve the compact and ultra wide WiMax middle band as Ultra wideband (UWB) systems are gaining growing interest in a broad range of applications. Miniature antennas for wireless communication systems are also well needed.. Therefore as bandwidth enhancement and size reduction become significant design requirements for realistic applications and our design fulfil both criteria with better efficiency as well[5-6].

The antenna comprised of three main parts ground, substrate and patch at the top[7]. The ground plane is with marginal thickness at the bottom of most plate. The substrate used would be Rogers RT / duroid 5880 because the height of the substrate is 1.57 mm for its appropriate mechanical and insulating properties. Substrate that is easily available and demonstrate strong high frequency behaviour. There is a metal patch with length and width dimensions. T slot is made in the patch and supplied with the help of microstrip feed. The slots are made with the goal of generating maximum gain and minimal radiation to make antenna work efficiently. 50 Ohm is used as an impedance matching[8-9].Millimeter frequencies have a larger bandwidth, which also makes the data rate high. It can attain data rate of up to 10gbps. It's fastest-growing technology in this decade[10-11].

2. ANTENNA CONFIGURATION AND DESIGN

Microstrip patch antenna configuration and design is accomplished with the help of CST, Software. I build and model a T-slotted microstrip patch antenna here. The goal is to design the antenna with proper microstrips feed line[12].

2.1 Geometrical specification of T-Slotted patch antenna-

Width of microstrip patch antenna

$$W = \frac{c}{f_0}\sqrt{\frac{2}{\epsilon_r + 1}}$$

Length of microstrip patch antenna

$$L = L_{eff} - 2\Delta L$$

Where L_{eff} can be determined by formula as started below

$$L_{eff} = \frac{C}{2f_0\sqrt{\epsilon_{reff}}}$$

ϵ_r: Dielectric constant of the Rogger substrate.

$$\epsilon_{reff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \times \sqrt{\left(1 + \left(\frac{12h}{w}\right)\right)}$$

ΔL (Extension length)

$$\Delta L = 0.412 \times h \times \frac{(\epsilon_{reff} + 0.3)\left(\frac{w}{h} + 0.26\right)}{(\epsilon_{reff} + 0.253)\left(\frac{w}{h} + 0.8\right)}$$

The above formulas we used to find the dimensions 5 × 5 × 1.57mm3.The substrate used would be Rogers RT/duroid 5880 with ε_r = 2.2 with 1.57 mm thickness. Where C = 3 × 108 m/sec is velocity of light, f0 is resonant frequency, h is the height and W is the width of the patch.

ε_r is the dielectric constant. ε_{reff} symbolizes the effective dielectric constant. 'L' is the length of the patch. The performance parameters are. [1].

1. Directivity

The ratio of radiation intensity in one direction to that of radiation intensity was combined in all directions in the antenna.

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

2. Gain

The ratio of the antenna's radiation intensity in a specific direction to the total input power supplied to the antenna is called antenna gain.

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

3. Bandwidth

An antenna bandwidth is known as the unique set of frequencies or frequency bands the antenna operates in. There are two types of bandwidths-narrow and broad-on each side of the central frequency.

$$B.W = f_h - f_L$$

4. Return loss

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

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

Following figure 1.1 shows the Dimensions of T-slotted ulta wideband microstrip patch antenna.Numerical values of these mentioned parameters are listed in the Table.1

The parameters are obtained with the help of the calculations made with the help of substrate, resonant frequency and height values.

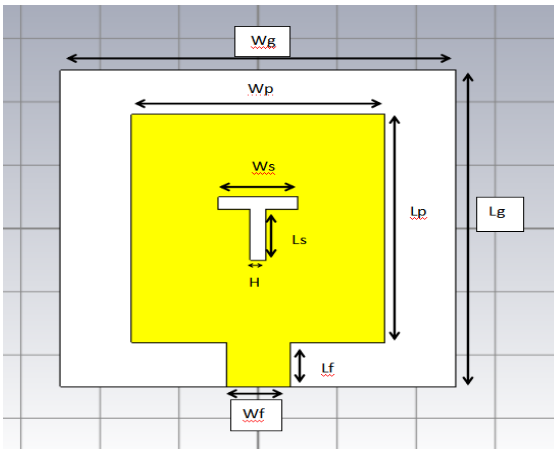

Fig -1: Dimensions of the T-slotted patch antenna

Parameters	Value (mm)
Width of ground,Wg	5.0
Length of ground,Lg	5.0
Width of patch,Wp	3.2
Length of patch,Lp	3.6
Width of slot,Ws	1.0
Length of slot,Ls	0.8
Thikness of slot,H	0.2
Width of feed,Wf	0.8
Length of feed,Lf	0.7
Thickness of substrate	1.57

(h)	
Dielectric constant of subsrate (ε_r)	2.20
Loss tangent	0.0009

Table -1: Optimized geometrical parameters

3. IMPLEMENTATION THROGH SIMULATION

The design is simulated in CST software in frequency range of 30 to 60GHz under suitable boundary conditions. First all parameters are calculated using formula denoted by equations and further optimized to get desired outcomes. The geometrical layout of antenna is shown in Fig. 1 with all dimensions of proposed antenna and CST layout of antenna shown in Fig.2

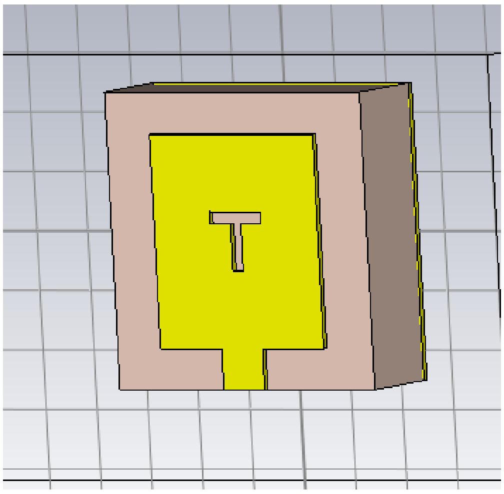

Fig -2: CST layout of T-slotted antenna. of the T-slotted patch antenna

4. RESULT DISCUSSION

The simulated reflection coefficient (S11) of the antenna is shown in Figure 3. The antenna resonates at 48.72 GHz with return loss of -14.617dB. Figure 4. is presented the simulated Radiation pattern(3D), Figure 5. is presented the polar plot of designed T-slot antenna that shown the main lobe magnitude 8.66.1dBi, main lobe direction 41.0deg, angular width (3dB) 54.1 deg. and the side lobe level -4.5dB when phi=90 at 50 GHz and the Directivity is 8.658 at 50 GHz and the maximum Gain value at 50 GHz is 6.177 dB. And the voltage standing wave ratio (VSWR) is 1.456 at 48.72 Figure shows the simulated Gain and VSWR Fig. 6, and Fig. 7 Correspondingly.

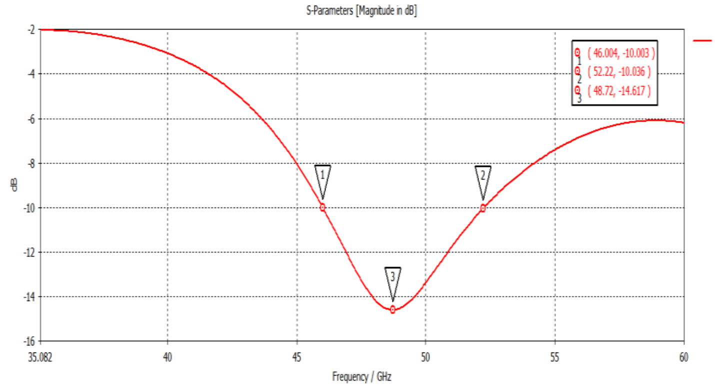

Fig -3: Return Loss

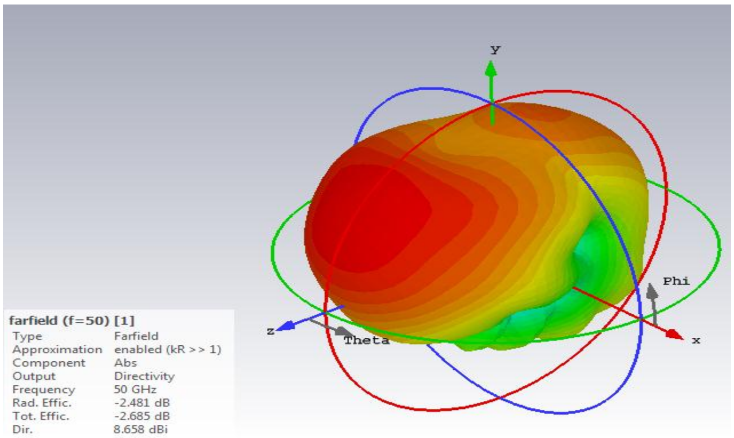

Fig -4: Radiation Pattern (3D)

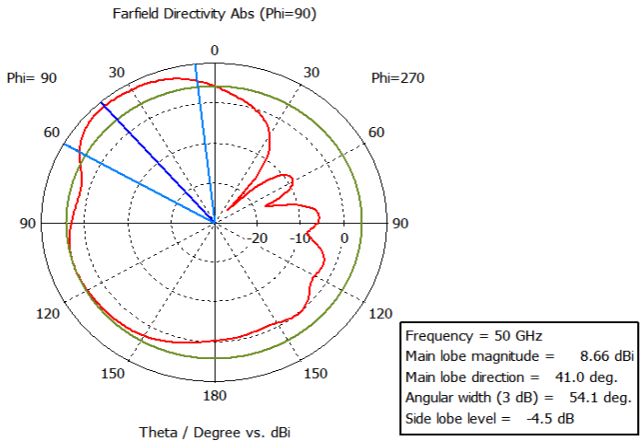

Fig -5: Polar Plot

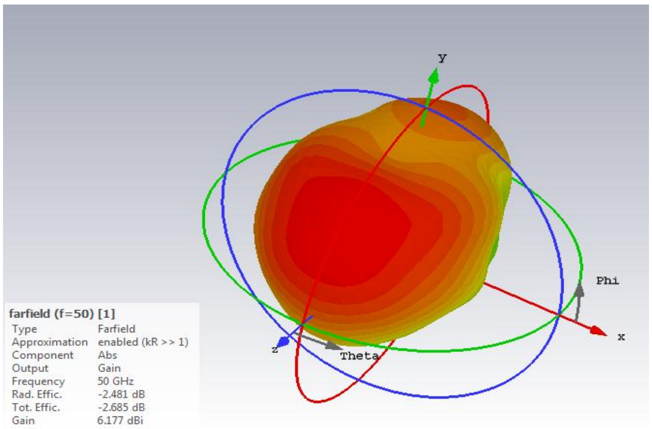

Fig -6: Gain

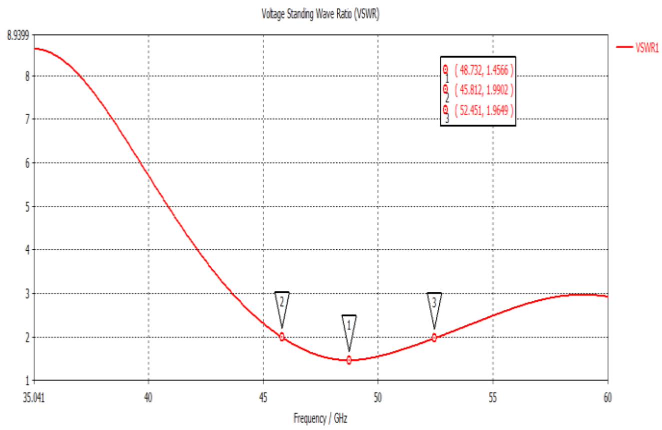

Fig -7: VSWR

5. CONCLUSIONS

The T slotted ultra wideband microstrip patch antenna is introduced in this proposed design for 5G communication. Simulated result obtained from the proposed designed antenna the reflection coefficient from 46.00 GHz to 52 .22 GHz is below -10dB. The antenna covers a 6.22GHz Ulta wide band from the frequency range 46.00 GHz to 52.2 GHz.The maximum antenna gain at 50GHz is 6.177 dB. At the same time the antenna is small and compact with the use of roger substrate material with low dielectric constants. The antenna shows omni directional patterns of radiation which are the specifications for 5G applications. Future wireless 5 G technology with a higher data rate is anticipated.

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BIOGRAPHIES

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