Microstrip Patch Antenna at Ku Band

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***Abstract*- In the following paper a microstrip patch antenna with a slot is designed on Fr4 substrate which has a dielectric constant 4.4. This antenna operates in ku band (12-18 GHz). The operating bandwidth of antenna is 12.029-13.255 GHz. The resonant frequency is 12.64GHz. This antenna is simulated on CST software. The maximum gain of antenna is 4.82 dBi with directivity 7.10 dB. The VSWR is 1.10.**

Keywords– bandwidth; ku band; Gain; VSWR etc.

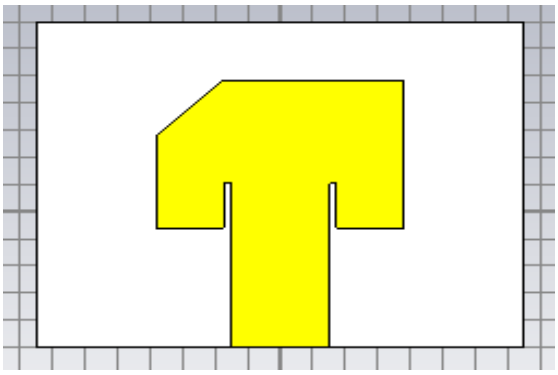
1. INTRODUCTION

The ku band ranges between 12-18GHz. Ku bands is mainly used for satellite communication. Mostly the downlink frequency is used by direct broadcast satellite for broadcasting on satellite TV'S. It is also used in many specific services for example International Space Station (ISS) communications uses NASA'S tracking data relay satellite & SpaceX star link Satellites. Some frequencies of the band are used in radar guns to identify speed of vehicles, especially in Europe region.

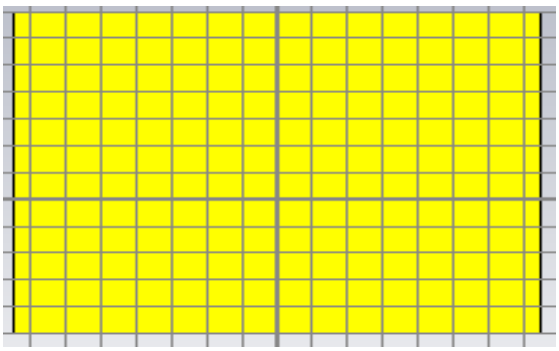
After going through some literature review, we have prepared the paper. [1-3 and 7] shows the single antenna designs and variations in size with gain, in paper [3], frequency is 13.6-27.2GHz having gain 2.28dBi and the antenna is circular antenna. And in [1-2] the gain increases and size is also increased. In [1] frequency ranges between 11.2-14GHz having gain about 4.65dBi and size is 9x12.75x1.6 mm^3. In [2], frequency ranges 15.27-16.51GHz having gain about 4.45dBi and antenna size is 17x17x1.07 mm^3. In paper [7], antenna works in between 12-18GHz and size is 30x30x0.5 mm^3. This antenna can be used for satellite applications when it will be modified as array. In paper [4 and 6] there are many changes in the design of the antenna, slots in antenna and some defects in the ground. Both design shows that antenna resonates at multiple frequencies and multiple bands, antenna of [4] resonant at 15 GHz with return loss of -50dB & with an average gain of 6dB and basic size is 5.5x5x1.6 mm^3 and this antenna shows multiple resonance frequencies. Apart from basic antenna this antenna has modifications with a C slot design. [6] Shows an antenna with U slot on the patch with defected ground. [6], antenna works at dual band 12/32GHz. This antenna has a 5.42dBi gain and antenna dimensions are 25x35x1.6 mm^3. Till now, antennas with single design are discussed but there is need of more complex antennas according to applications. [5] Shows an array of antenna. In research paper [5], frequency range is in between 12.2-13.1GHz with gain about 12dBi and size of array antenna is 2x2 and the single element can be used for 11.2-12.7 GHz frequencies.

2. ANTENNA DESIGN

The size of antenna is 15x14x1.6 mm^3.Fr4 substrate is used here because of easy availability having height h=1.6mm and ε_r=4.4. The dimension that is length and the width of the antenna is 15x14 mm^2. Here ground and substrate are- of same length & width. The dimensions of patch are 7.60x5.3 mm^2 with a feed of 3.05x6.84 mm^2.



(a)Front side view



(b)Back side view

Figure 1- Microstrip patch antenna

2.1 Design Parameters of Antenna

Parameters to design the antenna are calculated by using the formula's given below.

$$W = \frac{C}{2f_r}\sqrt{\frac{2}{\varepsilon_r+1}} = 7.60\text{mm}$$

Here f_r = Resonate frequency

ε_r = Dielectric constant

C= speed of light ($3x10^8$m/sec)

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[\frac{1}{1+12\left(\frac{h}{w}\right)}\right]^{1/2}$$

$$= 3.60mm$$

$$\Delta L = 0.412h\left[\frac{\varepsilon_{reff}+0.300}{\varepsilon_{reff}-0.258}\right]\left[\frac{\frac{W}{h}+0.264}{\frac{W}{h}+0.813}\right] = 0.69\text{mm}$$

$$L = \frac{1}{2f_r\sqrt{\varepsilon_{reff}}\sqrt{\mu_0\varepsilon_0}} - 2\Delta L = 5.30mm$$

$$\lambda_0 = \frac{C}{f} = 25\text{mm}$$

The table shows the design parameters of the antenna

Table 1- Antenna Parameters

Design Parameters	Readings(mm)
ground & substrate length	15
ground & substrate width	14
patch length	7.60
Patch width	5.31
Feed length	3.05
Feed width	6.84
Substrate height	1.6

2.2 Antenna design Results

The antenna is designed in the 12-18 GHz frequency range. The reflection coefficient of the antenna is -37.03 dB at frequency 12.64 GHz. Reflection coefficient shows how much power is consumed and how much power is reflected towards the source of power. Figure 2 shows the S11 results of antenna at 12.64 GHz. S_{11} is also known as return loss that describes the amount of power reflected from the antenna in graphical form. VSWR of this antenna is 1.02 at 12.64 GHz. VSWR results are shown in Figure 3 at resonant frequency. VSWR is the standing wave ratio of antenna and shows the amount of mismatch between the antenna and its connecting feed line. The gain of antenna i.e. 4.83 dBi showed in figure 4 and its shows amount of radiation with respect to the ideal antenna and the directivity is 7.11 dB at 12.64 GHz and tells how much radiation in any particular direction. Figure 5 shows the radiation patterns of antenna in the H-Plane and the E-Plane. E-plane shows the direction of electric field and propagation and H-plane shows direction of magnetic field and propagation. These provide details of main lobe magnitude, direction and angular width etc.

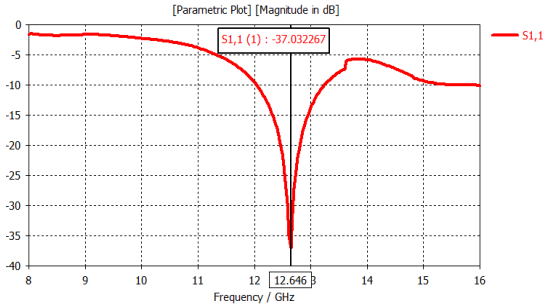


Figure 2: S-parameters

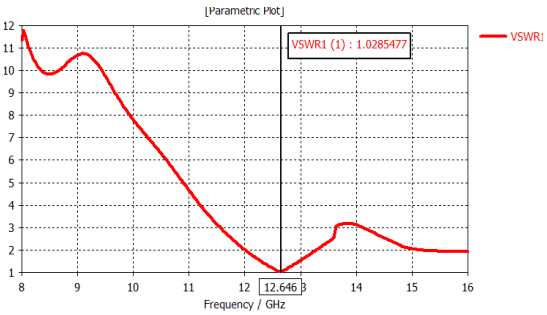
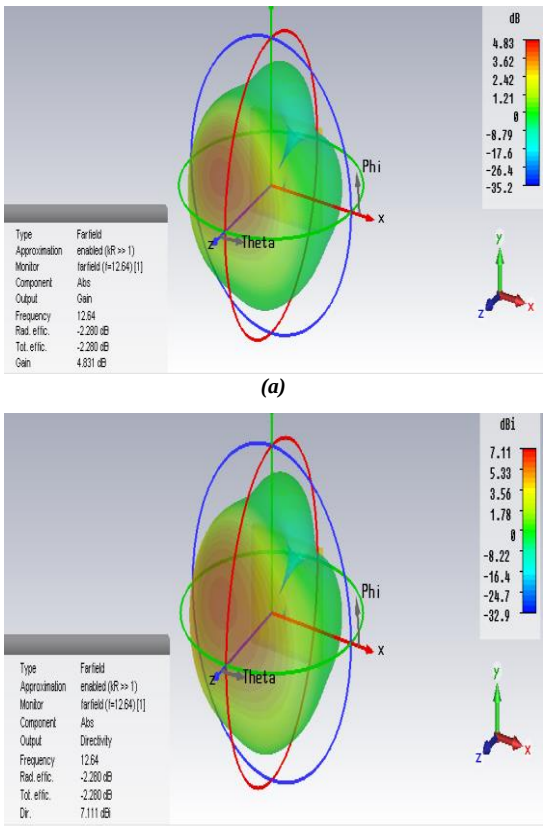


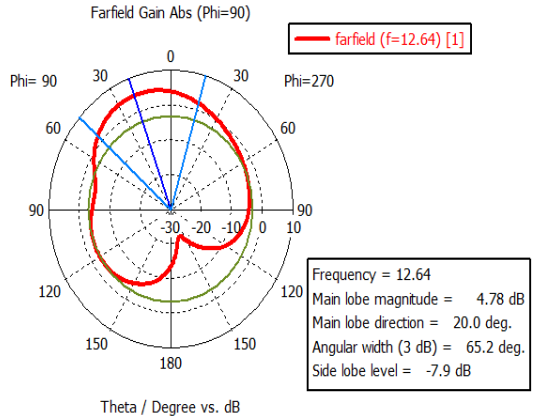
Figure 3: VSWR



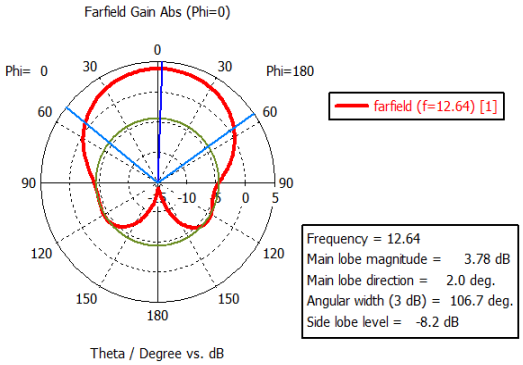
(a)

(b)

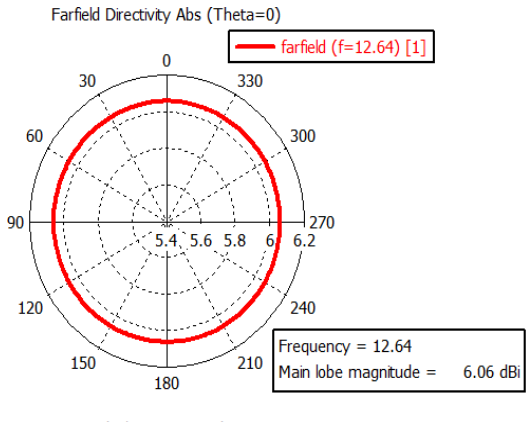
Figure 4: (a) Gain & (b) Directivity



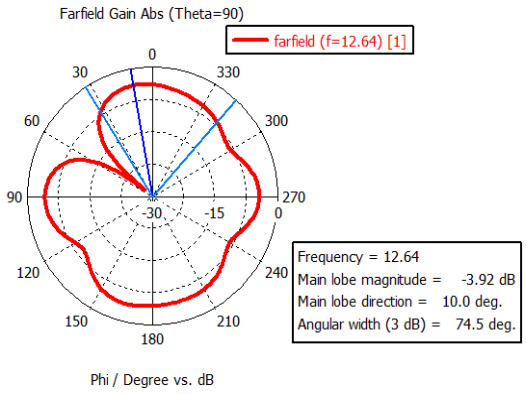
(a) Radiation pattern for E-Plane



(b) Radiation pattern for E-Plane



(c) Radiation pattern for H-Plane



(d) Radiation pattern for H-Plane

Figure 5- Radiation Patterns

3. RESULTS OF ANTENNA

The final results are tabulated in tsegments of gain, operating frequency, VSWR etc.

Table 2- Final results

Antenna Design	Frequency range (GHz)	Operating frequency Bandwidth	Gain(dBi) & Directivity	VSWR Ratio
Proposed Antenna	12-18	12.029 - 13.255 GHz	G=4.83dB at 12.64 GHz Directivity= 7.11dB at 12.64 GHz	1.02

3. CONCLUSION

A microstrip patch antenna for 5G applications is designed with a slot operates in the range of 12-18GHz frequency. The antenna size is 15x14x1.6mm^3. The gain of the antenna is 4.82dBi. The S parameters are below -15dB which are required for better operating of antenna. The VSWR ratio is 1.02 for working of antenna. All the results are in operating range for efficient use of antenna.

REFERENCES

[1] A Novel Ku-band Microstrip Antenna https://ieeexplore.ieee.org/document/7016793?arnumber=7016793
[2] Wide Ku Band Microstrip Patch Antenna Using Defected Patch and Ground https://ieeexplore.ieee.org/abstract/document/ 7012794
[3] Design of Compact Microstrip Patch Antenna for K Band and Ku Band Applications https://ieeexplore.ieee.org/document/9262349
[4] Design of Compact Ku Bnad Microstrip Antenna for Satellite Communication https://ieeexplore.ieee.org/document/6577042
[5] Ku Band Slotted Rectangular Patch Array Antenna Design. https://ieeexplore.ieee.org/abstract/document/7129855
[6] A Novel Dual Band Microstrip Patch Antenna for Ku/Ka Band Wireless Applications. https://ieeexplore.ieee.org/document/9344739
[7] Performance Analysis of Novel Design and Simulation of a Microstrip Patch Antenna for Ku Band Satellite Communications https://ieeexplore.ieee.org/document/9392467
[8] Dual Band X Shape Microstrip Patch Antenna for Satellite Applications https://www.sciencedirect.com/science/article/pii/ S2212017313004714
[9] Design of High Gain Broadband Microstrip Patch Antenna for UWB/X/KU Band Applications https://www.sciencedirect.com/science/article/abs/pii/S1434841121003022
[10] Design of a Microstrip Patch Antenna for Ku Band Applications https://www.sciencedirect.com/science/article/pii/S2214785321005368