DESIGN OF BROADBAND MICROSTRIP PATCH ANTENNA FOR 5G APPLICATIONS

[1]Mr.R. Veeramani, [2]Mr.J. Rameshkumar, [3]S.Gowrimanohari
[4]M.Jayaprakash, [5]D. Monisha, [6]M.Tamilarasu
Department of Electronics and Communication Engineering,
K.S.R College of Engineering,
Namakkal,India
[1]ksrrvmksr@gmail.com, [2]rameshatrs@gmail.com, [3]gowrimanohari.sekar@gmail.com
[4]jpmurugeasan@gmail.com, [5]ksrcemonisha@gmail.com, [6]tamilarasu.m2332@gmail.com

Abstract

The fields of IoT and smart city have been demanding high data rate and quality of service that push toward the fifth generation (5G) mobile networks. Effective antenna systems and designs are necessary for these kinds of communication systems. In this research, a novel broadband microstrip antenna design for usage in 5G systems is presented.A Slot loaded inset feed microstrip patch antenna is proposed which can be employed in the LMDS (local multipoint distribution service) and has a central operating frequency of 28 GHz. The HFSS software has been used to design, model and analyze the antenna systems

Keywords:
5G, LMDS, microstrip, patch, HFSS.

I.INTRODUCTION :

To meet the growing demand in telecommunications, IoT and Smart City sectors, new technology being developed. With the advent of Fifth-generation (5G) wireless networks which enables the development of “smart cities” and the Internet of Things (IoT). Each new technology will have a lot of advantages and some disadvantages includes the implementation of the new technology, designing components for such services etc. On the other hand, widespread use of 5G networks requires the development of new technological advances and antenna infrastructure. In addition to antennas for mobile devices, there will be a substantial count of antennasinstalled in large constructions, especially public utility places.

5G technological prerequisites include increased data throughput (Data rate of 1Gbps), unlimited connectivity, availability, and better efficiency. The use of a given band is determined by its characteristics, which are primarily determined by radio signal propagation and the availability of spectrum resources. Because of its better gain,bandwidth and efficiency, it chose a microstrip patch antenna that resonates ranges from 28to32 GHz.

In today's wireless communication, the most important antenna criterion is low profile. The difficult problem for handheld devices is undoubtedly the development of antennas that provide continuously improving performance in a smaller package. Microstrip antennas are most likely the popular and widely used antennas due to their ease of circuit integration.

This paper mainly contains sections describing design equations for rectangular patch, slot analysis to optimize bandwidth, theoretical calculation of return loss and VSWR analysis.

II.DESIGN EQUATIONS OF MICROSTRIP ANTENNA

To make microstrip antennas, a thin metal strip or patch is adhered, with the necessary grounding, to a dielectric substrate. The microstrip patch antennas shape can be square, circular, triangular, rectangular, fractal or any other shape.For designing antennas, the material's dielectric constant should range between 2.2 to 12 [1]. In this antenna design FR4 material is used as dielectric substrate which has dielectric constant of 4.4. The substrate's height is selected that h<< λ0 [1] (where, λ0 is the operational wavelength). The height of the substrate is chosen as 1.6 mm. The patch antenna length (L) and the patch antenna width (W) are the design variables for microstrip patch antennas for rectangular patches (W). The height of the substrate enhances the bandwidth of the antenna. The material's dielectric constant and the resonant frequency are the dependent parameters of patch length and width. Inset feed is preferred for proper impedance matching [2][3].

The primary radiating component of Microstrip antenna is the patch. When a rectangular patch is used, its width (W) is determined by the material's dielectric constant (r) and resonance frequency (f_r), which are both given by [1] Eq.(1)

$$W = \frac{1}{2f_{r\sqrt{\mu_0\varepsilon_0}}}\sqrt{\frac{2}{\varepsilon_{r+1}}} \quad (1)$$

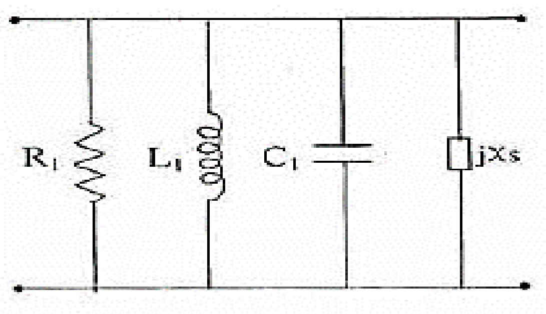

Fig-1:Slotted Rectangular Microstrip PatchAntenna

Because some waves travel in the substrate and others in the air, the effective dielectric constant is introduced to account for the fringing effect.

For$W$/h>1,the effective dielectric constantEq.(2) is

$$\varepsilon_{reff} = \frac{\epsilon_{r+1}}{2}+\frac{\epsilon_{r+2}}{2}[1+12\frac{h}{W}]^{-1/2} \quad (2)$$

Due to the fringing effect Eq.(3), a patch's electrical length is greater than the physical length. If the patch length's extended dimension is L, then

$$\frac{\Delta L}{h} = 0.412\frac{(\varepsilon_{reff}+0.3)(\frac{W}{h}+0.264)}{(\varepsilon_{reff}-0.258)(\frac{W}{h}+0.8)} \quad (3)$$

Thus, the patch's real length is Eq.(4),

$$L = \frac{1}{2f_r\sqrt{\epsilon_{reff}}\sqrt{\mu_0\varepsilon_0}} - 2\Delta L \quad (4)$$

III.PATCH ANTENNA WITH SLOT LOADED ANALYSIS

A. ANALYTICAL CALCULATIONS OF SLOT

In this section a slot loaded microstrip patch antenna is analyzed. From figure 1, the rectangular slot, which has the dimensions length L and width w, is introducedin the radiating patch in a typical Microstrip antenna. Each slots have equivalent circuit and input impedance. If the slots are properly loaded to optimize the radiating performance of the antenna.

The efficiency of the antenna is affected by the slots loaded on the patch. The rectangular microstrip patch antenna with a slot loaded in it can be considered of as a parallel combination of capacitance C1 Eq. (5), inductance L1 Eq. (6), resistance R1 Eq. (7), and resistance of the patch [4].

$$C_1 = \frac{\epsilon_{eff}\,\varepsilon_0 LW}{2h}\cos^{-2}\left(\frac{\Pi z_0}{L}\right) \quad (5)$$

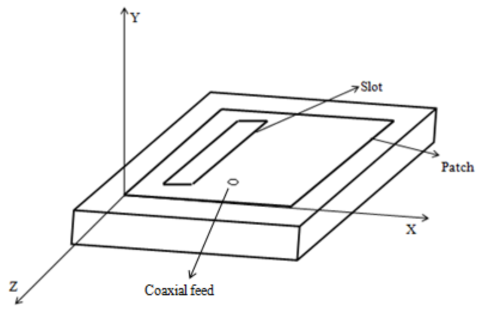

Fig-2. Equivalent Circuit of Slotted Rectangular Microstrip Patch Antenna

$$L_1 = \frac{1}{C_1\omega_r^2} \quad (6)$$

$$R_1 = \frac{Q}{\omega_r C_1} \quad (7)$$

h=Thickness of substrate

ξ_{eff}=Effective dielectric cconstant

ξ_0=Permittivity of frees pace

Z_0= Feed point location along z-axis

The input impedance(Z_{in}) of the above excluding slot can be expressed as,

$$Z_{in} = \frac{1}{\frac{1}{R_1} + j\omega\, C_1 + \frac{1}{j\omega\, L_1}} \qquad (7)$$

Then above expression can be expressed as,

$$Z_{ins} = R - jX$$

The input impedance of slot loaded on patch is Eq. (8)

$$Z_{ins} = \frac{X.X_s + jR.X_s}{R - j\,(X - X_s)} \qquad (8)$$

$$\text{Reflection Co efficient, } \Gamma = \frac{Z_o - Z_{ins}}{Z_o + Z_{ins}} \qquad (9)$$

$$\text{Return loss} = 20 \log |\Gamma| 0$$

$$VSWR = \frac{1+|\Gamma|}{1-|\Gamma|} \qquad (10)$$

As a result, the position on the patch has an impact on return loss and VSWR Eq.(10). The return loss and VSWR plot affect bandwidth. Therefore, the slot on the patch also affects bandwidth.

IV. ANTENNA DESIGN

The choice of substrate material and substrate thickness constitute the antenna design. The 1.6mm thick substrate for 5G's 28GHz band is made of the FR4 material [5-11]

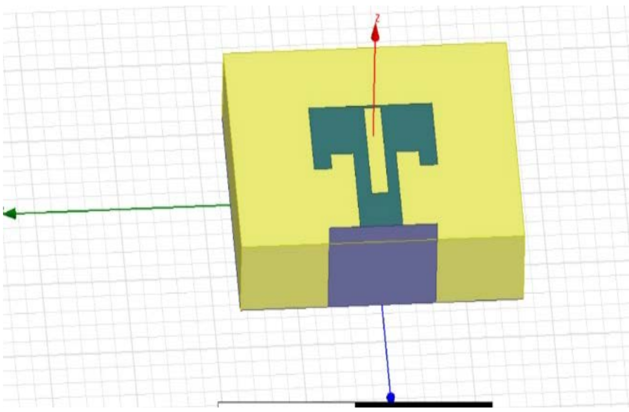

Fig .3. Proposed Slotted Microstrip Patch Antenna

TABLE.I

Antenna Components	Dimensions (mm)
Ground plane width	8.4
Ground plane length	6.8
Substrate thickness	1.6
Patch width	3.6
Patch length	1.24
Feed width	1.26
Feed length	3.1
Inset feed width	0.68
Inset feed length	0.5
Waveport width	3.2
Waveport length	2
Slot width	0.5
Slot length	3

a.Slotted Microstrip Patch Antenna Dimensions

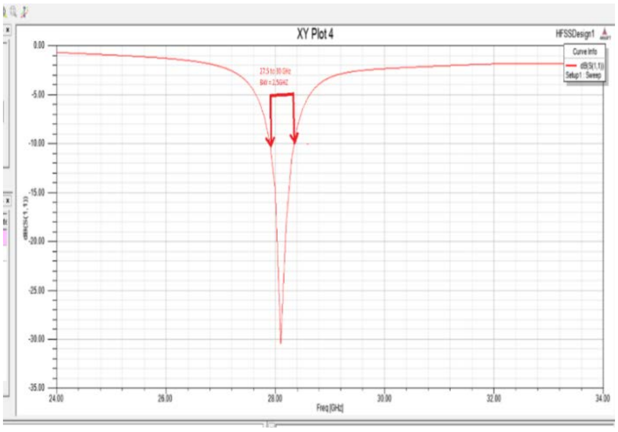

Fig -4 : Reflection Coefficient andBandwidth

Slot loaded microstrip antenna radiates effectively between 27.5 GHz to 30 GHz with overall bandwidth of 2.5 GHz. The reflection coefficient value ranges upto -31 db. The VSWR values plotted in fig .4. This proposed antenna is well suited for 5G LMDS applications.

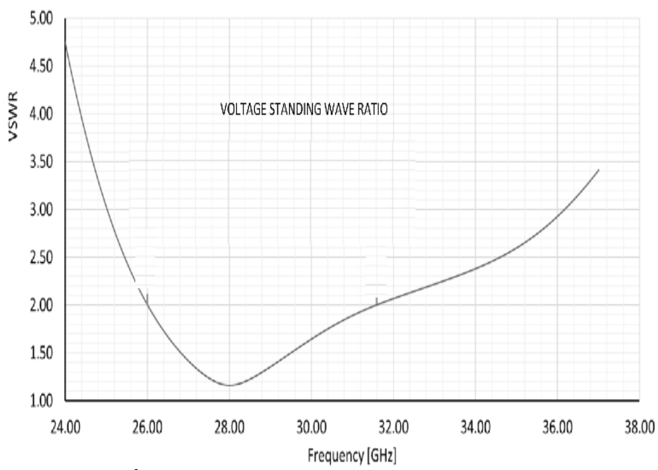

Fig .4. VSWR Measurement

V. CONCLUSIONS

Introducing therectangular slot in rectangular microstrip patch antenna reduces the resonant frequency while increasing antenna bandwidth

ISSN (PRINT): 2393-8374, (ONLINE): 2394-0697, VOLUME-10, ISSUE-4, 2023
DOI:10.21276/ijcesr.2023.10.4.6

by nearly 50%. When compared to a patch without a slot, the resonant frequency varies slightly. For a given slot length, the bandwidth also increases with slot width. The S_{11} value of the proposed antenna is nearly – 30dB at the resonant frequency. The suggested antenna would be an excellent choice for 5G LMDS applications.

REFERENCES:

[1] Constantine A.Balanis, "Antenna Theory-Analysis and Design", 4th Edition, February 2016.

[2] M.A.Matin, A. I. Sayeed, "A Design Rule for Inset-fed Rectangular Microstrip Patch Antenna", WSEAS Transactions on Communications ,vol. 9, pp. 63-72, January 2010.

[3] Girish Kumar, K.P.Ray, "Broadband Microstrip Antennas", Artech House.

[4] Shivnarayan, Shashank Sharma, Babau R Vishvkarma, "Analysis of slot loaded microstrip patch antenna", Indian Journal of Radio and space Physics, vol. 34, pp. 424-430, December 2005.

[5] Ranjan Mishra, Raj Gaurav Mishra, Piyush Kuchhal, "Analytical Study on the Effect of Dimension and Position of Slot for the Designing of Ultra Wide Band (UWB) Microstrip Antenna", Intl. Conference on Advances in Computing, Communications and Informatics (ICACCI), pp. 488-493, September 2016.

[6] Kaeib, A.F.; Shebani, N.M.; Zarek, A.R. Design and Analysis of a Slotted Microstrip Antenna for 5G

[7] Communication Networks at 28 GHz. In Proceedings of the 2019 19th International Conference on Sciences and Techniques of Automatic Control and Computer Engineering (STA); Institute of Electrical and Electronics Engineers (IEEE), Sousse, Tunisia, 24–26 March 2019; pp. 648–653.

[8] Teresa, P.M.; Umamaheswari, G. Compact Slotted Microstrip Antenna for 5G Applications Operating at 28 GHz. IETE J. Res.2020.

[9] Ulas Keskin, Bora Doken, Mesut Kartal, "Bandwidth improvement in microstrippatch antenna", 8th International Conference on RecentAdvances in Space Technologies (RAST),IEEE Conference, pp. 215- 219,June 2017.

[10] Kin-Lu Wong, "Compact and Broadband Microstrip Antennas", A Wiley Inter science Publications.

[11] Design of Slotted microstrip patch antenna for 5G. Nikita M. Tarpara1, Raju R. Rathwa2, Dr. Nirali A. Kotak "Microstrip patch Antenna for 5G Application", International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056, Volume: 05 Issue: 04 , Apr-2018.