Tuijin Jishu/Journal of Propulsion Technology
ISSN: 1001-4055
Vol. 44 No. 5 (2023)

Design of Micro Strip Patch Antenna For 5G Wireless Communication Applications at 26 GHz

[1] Dr.RajalakshmiM.C., [2] Pallavi J, [3] Dr.RaghuJayaramu, [4] Guruprasad A M

[1] Department of Electronics and Communication Engineering
Vidya Vikas Institute Engineering and Technology
Mysuru, KA, India
[2] Department of Electronics and Communication Engineering
Vidya Vikas Institute Engineering and Technology
Mysuru, KA, India
[3] Department of Electronics and Communication Engineering
The National Institute Engineering of Engineering
Mysuru, KA, India
[4] Department of Electronics and Communication Engineering
Maharaja institute of technology Thandavapura
Mysuru, KA, India

Abstract—The purpose of this paper is to design and simulate a micro strip antenna for the future fifth generation (5G) wireless applications. The antenna structure is built on a low loss substrate with relative permittivity of 3.0 and fed by a 50Ω micro strip line. The proposed antenna provided a high gain of -7.68 dB at 26 GHz band, with a minimum reflection coefficientof-24.3dB, a very wide band width of 2.5GHz and the radiation pattern was mostly omnidirectional. The thickness of the substrate has been changed; the resonant frequency can be at 20/26 GHz depending on the value of thickness. Both of these frequencies are the proposed bands for5G.In this paper, all simulations have been performed using industry standard software CST Microwave Studio.

Index Terms—Micro strip antenna, 5G wireless applications, Omnidirectional pattern, Reflection coefficient.

1. Introduction

Over the last few decades, the wireless industry has changed and grown, time and time again. This industry as a whole shifted from1G for analog to digital phones 2G(SMS Short Message Services and voicemail),then from 2Gto3G, 3.5G networks, which came with the mobile broad band internet connections that enabled the smart phone revolution, to 4G and 4G–LTE (Long Term Evolution) which had high data rate cellular network .Future fifth-generation wireless communication networks (5G) [1], [2] will make an important difference and will add more services and benefits to the world over 4G. The fifth-generation, or 5G, is the new technological standard for the next generation of wireless networks.

Some requirements were given in the literature [1] for themain technical objectives for 5G systems: extremely high datarates per device (multiple tens of Gbps), high data rates per area and massive amounts of connected devices; ultra low latency (less than a microsecond), especially for multimedia, interactive 3Dvideo/Virtual Reality (VR) applications and ultra-reliable to support various critical applications, such as vehicle-to-vehicle (V2V)communications, industrial control, healthcare ,etc. Thus, the interference among transmitters should be minimized. Besides, the 5G technologies will make it most powerful and in huge demand in the future that it has never achieved before. However, the major difference between 4G and 5G techniques in the eyes of users is increasing data rate and less power consumption with better coverage. The 5G communications may take the wireless signals to a higherfrequency range of 30–300 GHz, which means they will use millimeter-wave (mmWave) frequencies. But it will also give some challenges to the designer. Two of the major challengesare increasing the frequency of the higher band and the shorterdata transmission range. Therefore, the performance of a 5Gnetwork can be increased to more than 20 times that of 4G–LTE.

There are a lot of candidate frequencies for 5G wireless technologies where mmWave frequency spectrum around 26GHz is receiving important considerations. The purpose of a communication system is to transmit or receive information using electromagnetic waves. And this system uses antenna for radiating or receiving radio waves. In other words, the antenna is the transitional structure between free-space and a guiding device. Micro strip antennas have received considerable attention starting in the 1970s, although the idea of a micro strip antenna was invented in 1953 and a patented in1955. These antennas can be used in many other governmental and commercial applications, such as mobile radio and wireless communications like in high-performance aircraft, spacecraft, satellite, and missile applications, among others. These antennas are low-profile, low-cost, smallsize, light weight, and easy to fabricate. Major operational disadvantages of micro strip antennas are their low gain, low power, spuriousfeed radiation, and very narrow frequency bandwidth. These antennas have many different geometrical shapes such as rectangular, square, triangular, trapezoidal, circular, elliptical, and annular ring. Besides, the micro strip patch antennas can be made to conform to planar and non-planar surfaces.

Micro strip patch antennas area promising alternative to the future wireless technologies (5G). Several designs have already been carried out on this field achieving good per-formance in mmWave frequency band. The geometry of a micro strip antenna consists of a dielectric substrate of certain

Thickness h_s, having a complete metallization on one of its surfaces and of a metal"patch"on the other side. The substrate is usually thin ($h_s << \lambda$). A dielectric substrate has a lowdielectric constant which is desirable for good performance, larger bandwidth, better radiation, and better antenna efficiency. The metal patch on the front surface can have various shapes, although a rectangular shape is commonly used. Fourmost popular configurations can be used to feed micro strip antennas: the micro strip line, coaxial probe, aperture coupling, and proximity coupling. The key point of the present paper is to propose a micro strip patch antenna to achieve a high gainand a wide impedance bandwidth for the 26 GHz application.On the other hand, the thickness of the substrate of micro strip patch antennas has been changed to investigate the effect of dimensions on micro strip patch antennas resonance frequency.The proposed antenna had a simple architecture and an almost omnidirectional radiation pattern and low fabrication cost.

This paper is outlined as follows. In Section II, the antenna dimensions and design are described in detail. Simulation results and discussions are presented in Section III. Finally, some conclusions are discussed in Section IV.

2. Antenna Geometry And Design

In general, the dimensions of the micro strip antenna are calculated by using the micro strip antenna's equations as given in [3]. In this paper, the optimization of the antenna dimensions is equired to achieve some goals.Fig.1shows the geometry of the designed antenna; it includes a top view and aside view. The proposed antenna has used the 50 Ω micro strip line feeding technique because the micro strip feed line is also a conducting strip, usually of much smaller width compared tothe patch. The micro strip-line feed is easy to fabricate, simpleto match by controlling the inset position and rather simple to model [3].

The antenna is designed on a high-frequency ceramic-filled flame element composite dielectric substrate by Fr-4with a dielectric constant of 4.3, loss-tangent of 0.413439, and thickness of 1.6 mm. fr-4 high-frequency circuit materials are flame element composites intended for use in a commercial microwave and RF (radio frequency) applications. Fr-4 sub-strate is the favorite for mmWave. It is very suitable for UHF (ultra-high frequency) because of its low dielectric loss and its low dispersion. The proposed micro strip patch antenna can take a variety of substrate thickness.

It istypically composedof a radiatingpatch onone sideof a dielectric substrate and a ground plane on the other side.The designed antenna's patch is made of copper material. Thedetailed physical dimensions for each part of the proposed antenna configuration are given in Table I, where h_p is patch thickness,h_s is substrate thickness.Finally,the resulting antenna was simple to design, fabricate and had a low profile

3. Results And Discussion

In this paper, the proposed antenna is designed and simulated using Computer Simulation Technology (CST) Mi- Crowave Studio (CSTSuite2021).The major simulation results (i.e., reflection coefficient, gain, bandwidth, radiation patterns) of the designed antenna are given in this section. First, the results of the proposed antenna with its dimensions as tabulated in Table I and with substrate thickness h_s= 1.6mm, are discussed. One important antenna parameter is the reflection coefficient (or S_{11}) defining the bandwidth and the impedance matching characteristic. The simulated results of the S_{11} parameters for the proposed antenna are shown in Fig. 2. Fig.2 reveals that the antenna can covert the mmWave bands (K and Ka) of 22/30 GHz for S_{11}<10dB as -10 dB istaken as the base value for mobile communication. The single patch resonates at 26.484GHz with a reflection coefficient of -6.5173dB with a bandwidth of 22GHz where as at 30GHz; it resonates with a reflection coefficient of -23.7 dB and a bandwidth of around 2 GHz. On the other hand, the antenna resonated at 25.836 GHz belonged to the proposed band of 26GHz for the future 5G application.

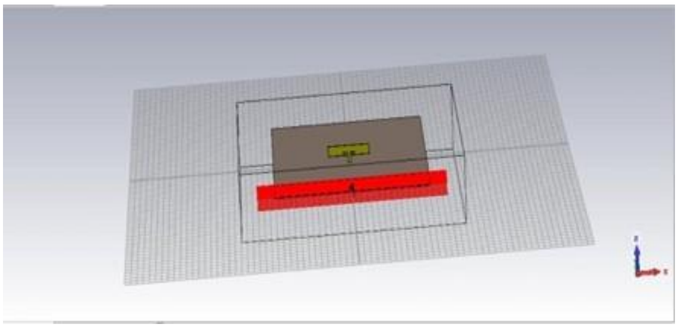

Fig.1: The geometrical structure of the proposed micro strip patch antenna.

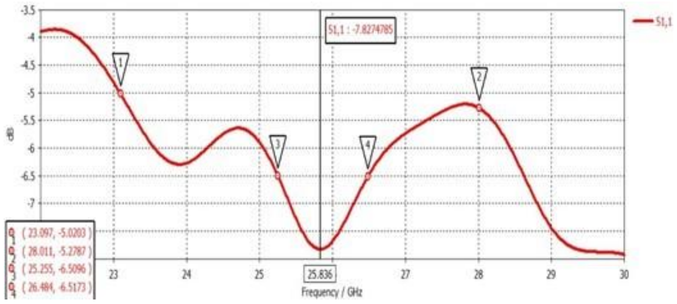

Fig.2: The plot of S_{11} parameters for the proposed antenna at 26GHz.

The simulated radiation 3D and 2D patterns of the designed patch at25.836GHz is shown in Fig.3 and Fig.4, respectively.The antenna achieved a high gain of 5.51 dB and has almost omnidirectonal patterns.

Table II presents a comparison between the proposed antenna and other references in terms of the overall size and simulated values of resonant frequencies, gain, return loss as well as bandwidth.

It is noticeable from this comparison, at the related bands the proposed antenna size is reduced of 47% compared to [7],64% compared to [6], 89% compared to [5], 61% compared to[4].From TableII, at28GHz bands, it can be seen that its S_{11}

Table I: Proposed Microstrip Patch Antenna Structural Parameters.

Name	Wg	Lg	Hs	Wp	Fi	Gpf	Lf	Wf	Lg	Wg
Unit(mm)	13.144	11.367	1.6	3.509	0.972	0.022	4.8	1	11.731	13.144

Table II: Comparison Between The Proposed Microstrip Patch Antenna And Other References At

Frequency Bands 26ghz.

References	**Size** (mm^3)	**Resonant Frequency**(GHz)	**Gain** (dB)	$S11$ (dB)	**Bandwidth** (GHz)
[4]	20.000×5.500×0.254	28.00 38.00	5.20 5.90	-25.00 -29.00	0.450 2.200
[5]	19.000×19.000×0.708	10.10 28.00	5.51 8.03	-27.50 -24.50	0.278 1.000
[6]	14.710×7.900×0.254	27.91	6.69	-12.59	0.582
[7]	10.000×7.900×0.500	28.10	7.50	-17.17	1.600
Proposedwork	11.367×13.144×1.600	25.83	5.51	-7.688	2.000

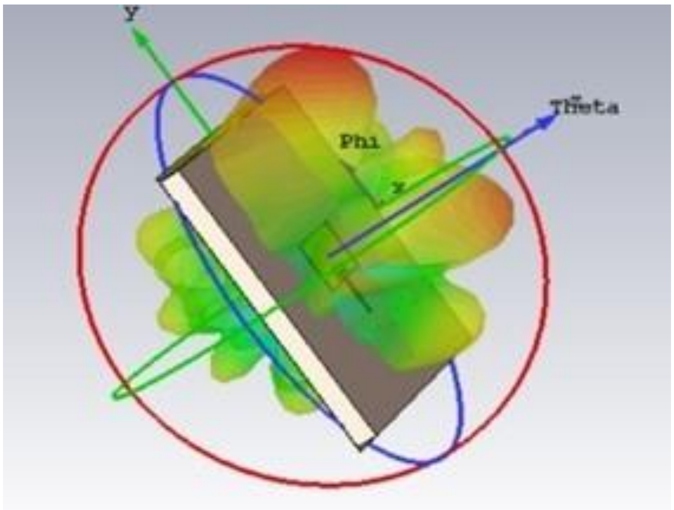

Fig.3: The 3D directivity patterns the proposed microstrip patch antenna at 25.836GHz.

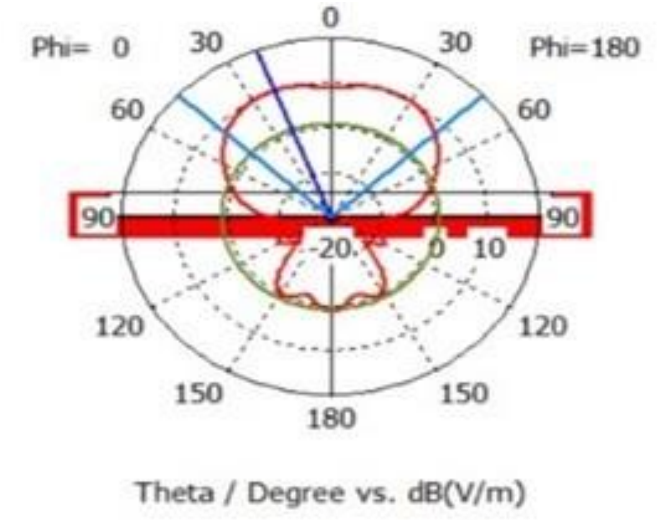

Fig.4: The 2D directivity patterns the proposed microstrip patch antenna at 25.836 GHz.

Parameter is higher compared to that of [6],[7]and almost the same as that of [4], [5] and bandwidth is broader when compared with other antennas. The designed antenna has ahigher gain compared to [4] but a lower gain in comparison with [5][7].Therefore, the proposed antenna has better results than others at 28GHz frequency bands. Impedance matching is a very important parameter for any antenna. Maximum matching means maxpower transfer or low reflection coefficient. It is found that patch antenna characteristics are affected by antenna dimensions [8].In this work; four different substrate thickness h_s are simulated and compared. The result of theS_{11}parameter, VSWR of the antenna obtained are shown in Fig.5 and Fig.6, respectively.

The results inFig.5 show when the thickness is lower (h_s=0.09mm; 0.1mm; 0.125mm) the S_{11} parameters are decreased (-25.1dB,-26.3dB, 28.8dB, respectively) at resonant frequency band 38GHz when the thickness is upper (here in,h_s=0.5mm) theS_{11}parameters had value around-24.2 dB at resonant frequency bands 28 GHz. The acceptable value of VSWR for wireless application should be less than2 and as seen inFig.6, the VSWR of this patch antenna is around1.1for all these cases. Therefore, the designed antenna can be working at frequency bands 28GHz or38GHz if only to change its substrate thickness.Fig.7shows the simulated radiation patterns of proposed 5G antenna atfrequency 38 GHz, the antenna achieved a high gain of 6.01dB.It is obvious in Fig. 5 and Fig. 6 that there is also good performance in terms of reflection coefficient and VSWR atresonant frequencies around 26 GHz, which is in K-bands,with $S11$ parameters of -7.82 dB and bandwidth of 2 GHz.Hence,the results can be considered using another application.

4. Conclusion

In this paper, a micro strip patch antenna has been proposed for5G wireless communication. The single patch antenna resonated at 25.836 GHz with a reflection coefficient of -7.82dB and a wide bandwidth of 2GHz.The achieved gain of the designed antennais5.51dB and its directivity pattern is almost omnidirectional.The designed antenna is a very low-profile structure with dimensions 11.36713.1441.6mm^3. Therefore, it is easy to integrate into devices with spaceconstraints. The simulated results, which have been taken withdifferent thicknesses of the substrate, are given to show thatthe antenna resonates at 26 GHz bands or 38 GHz with areflection coefficient around -7.82 dB. Besides, in all cases of the thickness of the substrate, the antenna also resonated at 23.53 GHz with good performance in the terms of S_{11}andVSWR parameters. Therefore, the proposed microstrip patch antenna is a good candidate for applications in 5G wireless technology.

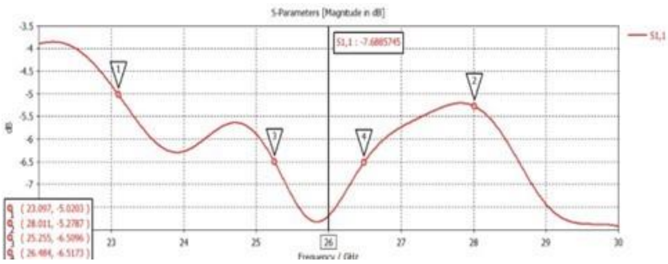

Fig.5: Simulated S-parameters of different substrate's thickness h_S.

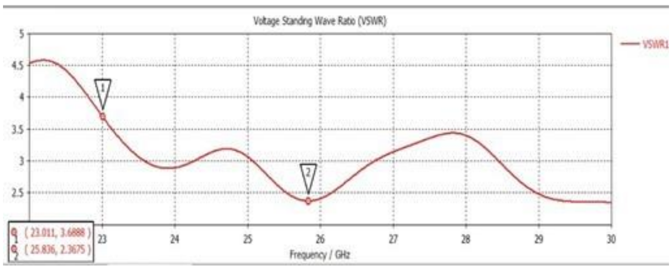

Fig.6: Simulated VSWR-parameters of different substrate's thickness h_S.

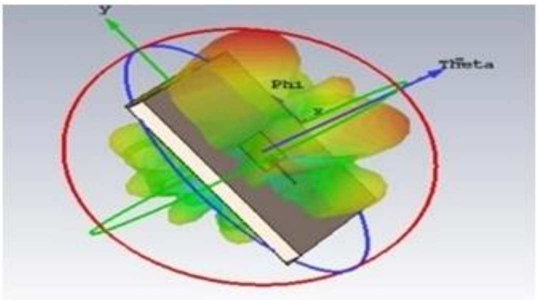

Fig.7: Simulated directivity patterns of proposed micro strip patch antenna at 38GHz

References

[1] A.Morgado,K.M.S. Huq, S.Mumtaz, and J. Rodriguez,"Asurveyof5gtechnologies:regulatory,standardizationandindustrial perspectives," *Digital Communications and Networks*,vol.4,no.2,pp.8797,2018.[Online].Available:https://www.sciencedirect.com/science/article/pii/S2352864817302584

[2] T. S. Rappaport, Y. Xing, G. R. MacCartney, A. F. Molisch, E. Mellios,and J. Zhang, "Overview of millimeter wave communications for fifth-generation (5g) wireless networks—with a focus on propagation models,"*IEEE Transactions on Antennas and Propagation*, vol. 65, no. 12, pp.6213–6230,2017.

[3] C. A. Balanis, *Antenna theory: analysis and design*.John wiley& sons,2016.

[4] N.Ashraf,O.Haraz,M.A.Ashraf,andS.Alshebeili,"28/38-ghzdual-bandmillimeterwavesiwarrayantennawithebgstructuresfor5g applications," in *2015 International Conference on Information andCommunicationTechnologyResearch(ICTRC)*,2015,pp.5–8.

[5] Y. Jandi, F. Gharnati, and A. Oulad Said, "Design of a compact dual bandspatch antenna for 5g applications," in *2017 International Conference onWireless Technologies, Embedded and Intelligent Systems (WITS)*, 2017,pp.1–4.

[6] D.MungurandS.Duraikannan,"Microstrippatchantennaat28ghzfor 5g applications," *Journal of Science Technology Engineering andManagement-Advanced Research & Innovation*, vol. 1, no. 1, pp. 20–22,2018.

[7] A.S.e.S.Neto,M.L.deMacedoDantas,J.dosSantosSilva,and H. C. C. Fernandes, "Antenna for fifth generation (5g) using a ebgstruc-ture,"in*NewContributionsinInformationSystemsandTechnologies*, A. Rocha, A. M. Correia, S. Costanzo, and L. P. Reis, Eds.Cham:SpringerInternationalPublishing,2015,pp.33–38.

[8] J. L. Li, M. H. Luo, and H. Liu, "Design of a slot antenna for future 5gwireless communication systems," in *2017 Progress In ElectromagneticsResearchSymposium-Spring(PIERS)*,2017,pp.739–741.

.