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High Gain Inset Fed Rectangular Patch Antenna Design for Sub6 Ghz Application

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Abstract

This research presents a straightforward rectangular microstrip patch antenna for Sub-6 GHz 5G applications. And proposed structure has a volume of 30x40x1.6mm3 and is made of a FR4 substrate material. The suggested inset-fed antenna at 4.5 GHz exhibits strong impedance matching, good return loss of -19.5 dB, high gain of 5 dB, and a VSWR of 1.2 thanks to the inset feed approach with the entire ground. All findings are also calculated using the HFSS simulation.

Keywords: Patch antenna, inset feed, HFSS software, Gain

Introduction

In the modern era, wireless technology plays a crucial function in each commerce. Sub-6 GHz to mm waves is shielded by the 5G band. The 5G frequency band below 6 GHz offers better coverage, but millimetre waves can provide a faster data rate. ranges of frequencies [1]. The transition from second-generation communications systems to fifth- generation radio communication systems has been fast developing in this decade, necessitating thedevelopment of small, miniature antennas with appropriate performance. The antenna is a very important device for wireless communication [2-3]. The antennas used for this need to be compact, lightweight, and simple to manufacture. Engineers now have to configure dimensioned electronicstructures due to advancements in the communication sector, which has given us the capability tohandle both embedded applications and patch-antenna development. Because of their various benefits, including their low price, low weight, and compact design, microstrip antennas are ideal for use in contemporary applications. [4-6]. The primary drawback of a conventional patch antennais its limited bandwidth range and poor stable gain. Thus, these antennas are appropriate for applications in the current world. Some of the methods that researchers have suggested for enhancing the functionality of microstrip patch antennas. IUT has been assigned primarily two bands for 5G technologies: The sub-6 GHz band (3.4 to 3.6Ghz & 5 to 6Ghz), and an mm-wave band (24 to 66Ghz to 76Ghz, 37 to 40.5Ghz, & 30 Ghz bands). The sub-6Ghz band has been more successfully implemented with 5Gpicked as the location for the base station [7]. The sub-6 band span may vary depending on the region, for example, the N77 band's frequency range is between 3.3 and 4.2 GHz, the N78 band's frequency range is between

3.3 and 3.8 GHz, and the N79 band's frequency range is between 4.4 and 5.0 GHz. The

(3.4 - 3.6) GHz frequency range has previously been assigned to the UK. It ranges from 3.6 to 3.8 GHz for Hungary, Romania, Spain, Italy, and. However, the 3.4 to 3.8 GHz frequency band is now being used as the Sub-6 band in Switzerland, Finland, Greece, Ireland, Greece, and Sweden. The 3.3 to3.6 GHz and 4.8 to 5.0 GHz bands are officially used in China for 5G applications. The 3.6 to

4.2 GHz and 4.4 to 4.9 GHz bands are legal for use in Japan.[8]. Researchers in antenna has created

a variety of different types of antennae to fulfill the high data interchange conditions for upcominggeneration telecommunication. Microstrip patch antenna (MPA) is the most favored among themdue to its inexpensive price, low weight, steady radiation pattern, and good gain [8]. To enhance an antenna's functionality, many feeding strategies are used, such as coaxial wire feed, inset-fed, aperture-fed, CPW-fed, imperfect ground, DGS (slots) on the ground surface, and dissimilar formslotted patches [9-10].

[11] described slotted ground MPA. A working range of 4.775 to 5.049 GHz only covers the N79 range, not the N77 or N78 range. The antenna's gain of 5.49 dB is fairly respectable. The outcome is obtained using the CST- MWS programme. [12] studies a tiny monopole patch antenna. The antenna's reflection coefficient of -50dB offers very good frequency spectrum coverage for the sub-6 GHz range (3 –7) GHz. The proposed tri-band patch antenna has a volume of (44X 70X 0.1)mm^3[13]. A dual-band antenna with frequencies between 3.29 and 3.63 GHz and 4.3 and 5.2 GHzis shown in [14] and has a high gain of about 7.17 db. The suggested antenna can be used for applications in the N77 range and N79 range. For WLAN and Sub-6 band communications, a Coplanar waveguide feed-fed hexagonal antenna is studied. The antenna's strength is inadequate (1.5 dB), yet it has high efficiency (>85%) [15]. A slotted slot antenna with a very good radiation efficiency of 97.6% & 88.5%, correspondingly, operating at 3.0 GHz and 3.3 GHz has been examined in [16]. It is described in compact MPA. The square antenna has a bandwidth of between

3.4 and 3.6 GHz. The antenna is used for the N78 frequency range having good efficiency of 98%[17]

This article analyses briefly the compact dimensions (40 40 1.575 mm3), relatively good gain (4.0dB), and reflection coefficient. The construction details of the inset-fed antenna are shown in Section 2. Section 3 & section 4 of the offered material critically evaluate each of the simulation results.

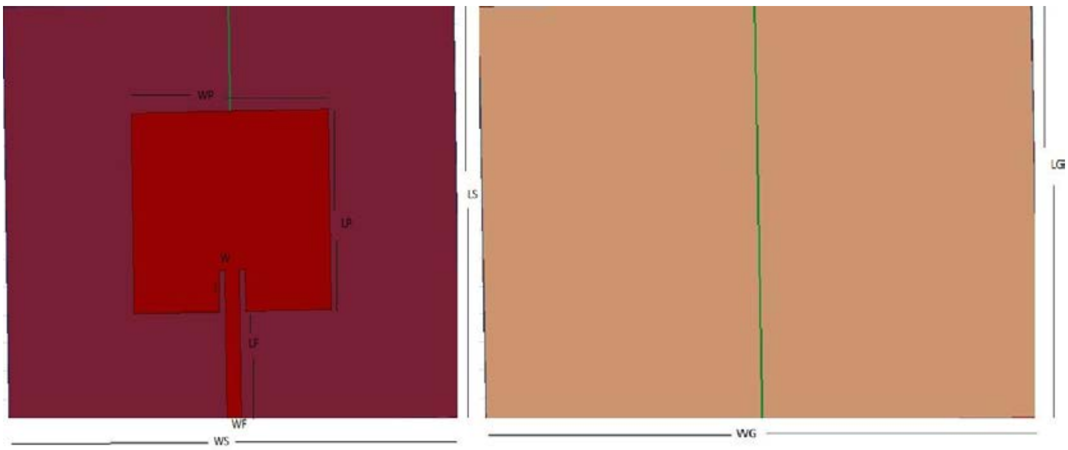

Figure 1. *(a) A Front view of antenna (b) A Bottom View of the antenna*

1. *Composition Of Inset-Feed Compact Microstrip Patch Antenna's*

This work proposes the geometrical design of an inset-fed tiny rectangular microstrip patch antenna with a full ground for applications in the sub-6 GHz frequency region. One of the work's advantages is the simplicity of the design. FR4 is utilized for the dielectric layer. The dimension of the antenna is 30x40x1.6mm^3. The ground and patch of the antenna are both equipped with copper material.

Fig. 1 shows the antenna's top and back representations. A Length of the patch is 19.88 mm and 24.5mm in width. This model makes advantage of the inset feeding approach. It utilizes the feed’s lumped port location and impacts the antenna's performance and its proper impedance matching. HFSS software is used to construct and simulate the structure. A dimension of the proposed structure is given the table1.

Table 1. *A Dimension of the proposed structure*

S.NO	Parameter	Value(mm)
1	LS	30
2	WS	40
3	LP	19.88
4	WP	40
5	LF	8
6	WF	1.3
7	L	4
8	W	2.16
9	WG	30
10	LG	40

2. *Simulation Result*

HFSS software is utilized to lay out and analyze the suggested antenna, which has a 4.5 GHz resonance. Figure 2 depicts the design's inset-fed RMPA's simulated S11- parameter (scattering parameter), with the suggested antenna's suggested reflection coefficient being -19 dB. The planned design has a good frequency range and covers some of the sub-6 GHz spectrum. Figures 4 & 5 depict the purposed antenna's 3D gain as well as radiation pattern. The simulated 2d gain at 4.5 GHz frequency yields a high result of 5 dB. Major findings of the performances parameter ofthe antenna are shown in the table 2.

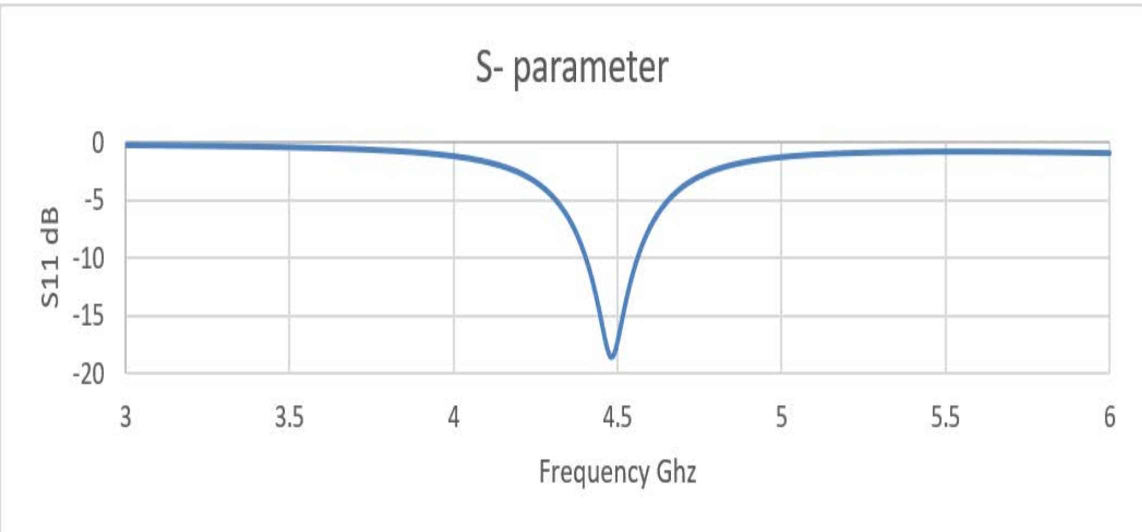

Figure 2. *A “ S” parameter of the proposed antenna*

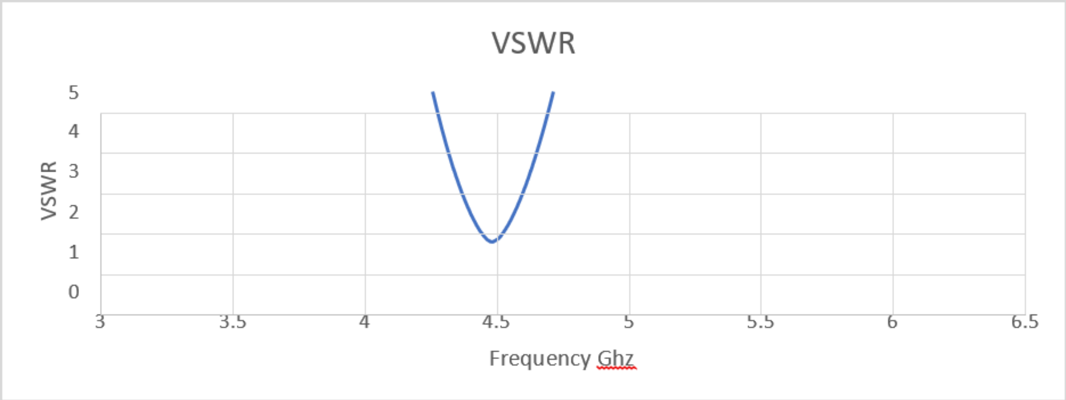

Figure 3. *VSWR of the suggested antenna*

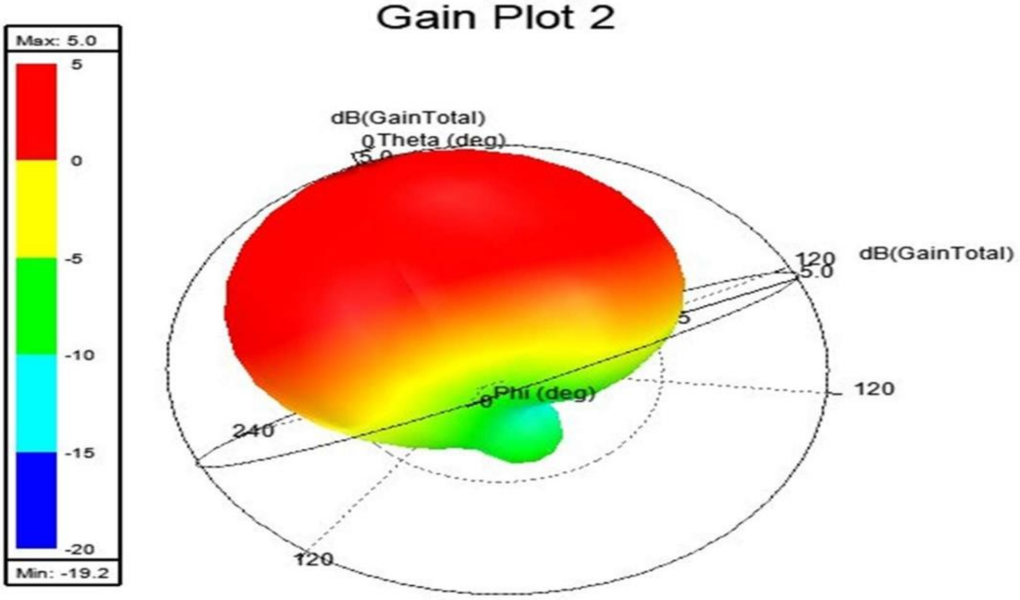

Figure 4. *3D Gain of the Suggested Antenna*

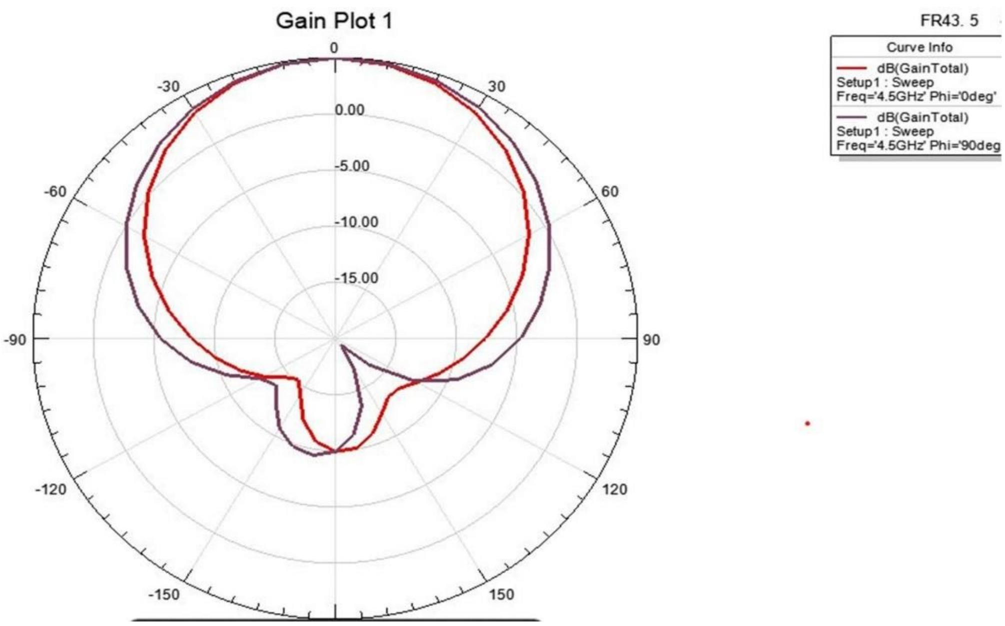

Figure 5. *A Radiation pattern of the suggested structure*

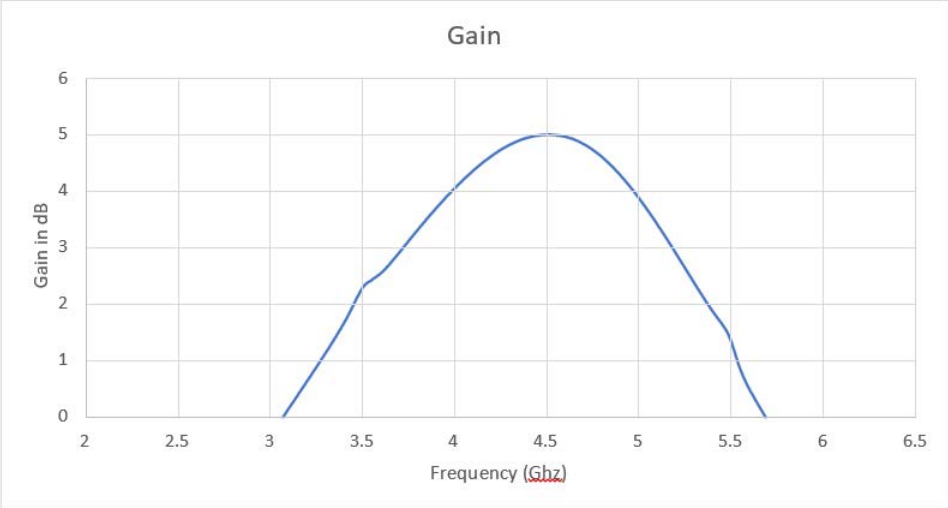

Figure 6. *2-D Gain of the planned antenna*

Table 2. *Finding results of the planned design*

S.No.	Performance Parameter of theantenna	Value
1	Reflection coefficient	19.5 dB
2	VSWR	1.2
3	Gain	5 dB

Table 3. *A comparison results of suggested patch antenna with the previous result*

Reference	Gain (dB)	VSWR	Reflection Coefficient(dB)	Substrate Material
[18]	2.3	-	-25	Fr4
[19]	2.6	-	-32	Fr4
[12]	3	1.5	-23	Fr4
Proposed Study	5	1.2	-19.5	Fr4

In Table 3, a comparison between the planned Sub-6 GHz inset-fed antenna and a few previouslypublished Sub-6 GHz MPAs is given. Despite the suggested antenna in the table indicating improved gain above earlier research, compared to our antenna, its operational band is a relativelysmall antenna. Compared to the other mentioned articles in Table 3, our antenna has a good return loss profile, good gain, and VSWR. The simplicity of the proposed design's structure is another major asset. As a result, the suggested antenna would be an appropriate structure for the Sub-6 GHz range.

Conclusion

With a high gain of 5 dB at 4.5 GHz, an inset-fed microstrip patch antenna is proposed to be utilized in the sub-6 GHz range. With S11 reaching up to -19.55dB, the antenna's performance is ideally suited for sub-6 GHz frequency applications. An antenna structure has a volume of 30x40x1.6 mm3 and is composed of FR4; it was simulated using HFSS software. The value ofVSWR is less than 2which is equal to 1.2. The proposed antenna achieves high gain and excellent impedance matching with the employment of the inset feed technique. Construction is quite simpleand low volume using Fr4 with dimensions30x40x1.6mm^3. This means that the recommended antenna can be applied to sub-6 GHz wireless communication systems.

References

Explaining 5G: Millimeter wave, sub-6, low band and other terms you need to know," https://www.androidcentral.com/explaining-5gmillimeter-wave-sub-6-low-band-and-other-terms-you-need-know, [Accessed 25 April 2020]

5G spectrum: public policy position," https://www-file.huawei.com/-/media/CORPORATE/PDF/publicpolicy/public-policy-position_5g_spectrum.pdf" [Accessed 25
April 2020].

"Global update on spectrum for 4G & 5G," https://www.qualcomm.com/media/documents/files/spectrum-for-4gand-5g.pdf, [Accessed 25
April 2020].

Olawoye, Taiwo O., and Pradeep Kumar. "A high gain microstrip patch antenna with slotted ground plane for sub-6 GHz 5G communications." *2020 International Conference on Artificial Intelligence, Big Data, Computing and Data Communication Systems (icABCD)*. IEEE, 2020.

Balanis, Constantine A. "Antenna theory analysis and design, A JOHN WILEY & SONS." *Inc., Publication* 811 (2005).

Mak, Ka Ming, Hua Wah Lai, and Kwai Man Luk. "A 5G wideband patch antenna with antisymmetric L-shaped probe feeds." *IEEE Transactions on Antennas and Propagation* 66.2 (2017): 957-961.

Azim, R., et al. "Circular patch planar ultra-wideband antenna for 5G sub-6 GHz wireless communication applications." *Journal of Optoelectronics and Advanced Materials* 23.March-April 2021 (2021): 127-133.

Azim, Rezaul, et al. "A multi-slotted antenna for LTE/5G Sub-6 GHz wireless communication applications." International Journal of Microwave and Wireless Technologies 13.5 (2021): 486-496.

Huang, Bei, et al. "A compact slotted patch hybrid-mode antenna for sub-6 GHz communication." *International Journal of Antennas and Propagation* 2020 (2020).

Paul, Liton Chandra, et al. "A Compact Slotted Circular Patch Antenna for 5G Applications." *2021 International Conference on Electronics, Communications and Information Technology (ICECIT)*. IEEE, 2021.

Olawoye, Taiwo O., and Pradeep Kumar. "A high gain microstrip patch antenna with slotted ground plane for sub-6 GHz 5G communications." *2020 International Conference on Artificial Intelligence, Big Data, Computing and Data Communication Systems (icABCD)*. IEEE, 2020.

Tang, X., Jiao, Y., Li, H., Zong, W., Yao, Z., Shan, F., ... & Gao, S. (2019, September). Ultra-wideband patch antenna for sub-6 GHz 5G communications. In *2019 International Workshop on Electromagnetics: Applications and Student Innovation Competition (iWEM)* (pp. 1-3). IEEE.

Kamran, Areeba, et al. "A bus shaped tri-band antenna for Sub-6 GHz 5G wireless communication on flexible PET substrate." *2019 22nd International Multitopic Conference (INMIC)*. IEEE, 2019.

Ishteyaq, Insha, Issmat Shah Masoodi, and Khalid Muzaffar. "A compact double-band planar printed slot antenna for sub-6 GHz 5G wireless applications." *International Journal of Microwave and Wireless Technologies* 13.5 (2021): 469-477.

Ullah, Shakir, et al. "Hexagonal shaped CPW feed based frequency reconfigurable antenna for WLAN and sub-6 GHz 5G applications." *2020 International Conference on Emerging Trends in Smart Technologies (ICETST)*. IEEE, 2020.

Amjad, Qudsia, et al. "Design and characterization of a slot based patch antenna for Sub-6 GHz 5G applications." *2019 Second International Conference on Latest trends in Electrical Engineering and Computing Technologies (INTELLECT)*. IEEE, 2019.

Murugan, S. "Compact Square patch antenna for 5G Communication." *2nd International Conference on Data, Engineering and Applications (IDEA)*. IEEE, 2020.

Paul, Liton Chandra, and Md Islam. "A Super Wideband Directional Compact Vivaldi Antenna for Lower 5G and Satellite Applications." *International Journal of Antennas and Propagation* 2021 (2021).

Azim, Rezaul, et al. "A multi-slotted antenna for LTE/5G Sub-6 GHz wireless communication applications." *International Journal of Microwave and Wireless Technologies* 13.5 (2021): 486-496.