International Journal of Innovation Scientific Research and Review
Vol. 06, Issue, 05, pp.6335-6337, May 2024
Available online at http://www.journalijisr.com
SJIF Impact Factor 2023: 6.599

ISSN: 2582-6131

Research Article

A MULTI-INSET MICROSTRIP PATCH ANTENNA FOR 5G WIRELESS COMMUNICATIONS

***Alaa Alqthami and Adnan Affandi**

School of Electrical and Computer Engineering Jeddah, Saudi Arabia.

Received 05th March 2024; Accepted 06th April 2024; Published online 25th May 2024

ABSTRACT

This paper presents a low-profile multi-inset patch antenna for long-term evolution (LTE) and fifth-generation (5G) communication applications. The antenna is fabricated on an FR4 substrate with a relative permittivity of 4.3 and a thickness of 1.5mm. The simulated and measured results are in good agreement, which validates the design. The insertion of the inset enhances the capacitive effect and helps the prototype antenna achieve an operating bandwidth ranging from 2.373368 to 2.430401 GHz. The performance of the antenna has been analyzed in terms of resonant frequency, return loss (S11), gain (dB), directivity (dBi), and percentage bandwidth. The proposed antenna has a measured directivity of 7.186 dBi at a resonating frequency of 14.23 GHz. The wide band antenna presented in this paper offers Omni-directional stable radiation patterns, good gains, and efficiency with a compact size which makes this design an ideal contender for wireless fidelity (WiFi), wireless local area network (WLAN), LTE, and sub-6 GHz 5G communication applications.

Keywords: antenna, multi-insect, micro-strip, phantom, non-invasive.

INTRODUCTION

In the modern era, a huge evolution has taken place in the field of wireless and mobile communication technology. The 5G mobile communication system has become more efficient and their demand has increased due to many significant advantages like high data rate, higher data handling capacity, and low latency. So, this requires the utilization of a 5G frequency b and (around 3.4GHz) considering one solution [1].

The 5G has a great impact on the application of high data transfer speed, wide band width, and stable gain. With the continuous advancement in the development of mobile communication technology, mobile communication generations are shifting to 5G technology due to user demand. After adding the Internet of Things (IoT), the main aim of the future 5G research is to enhance the spectrum-related issues, seamless wide-coverage area (100 Mbps user experienced data rate), and super high- density control [2]. Microstrip Patch Antennas find extensive application in lower 5G scenarios, Wi-Fi, and Wi MAX owing to their compact size and directional pattern. Additionally, they are recognized for their efficiency in supporting substantial band width, maintaining stable gain, and achieving high overall efficiency [3].

In recent years, t years, a huge evolution has taken place in wireless and mobile communications technology. As an example, the continuous mobile users' demands forced the 4G system to evolve into 5G system [4]. Accordingly, this requires the utilization of new frequency bands with much higher frequencies than microwave frequency bands used for 3G and 4G applications. The use of the sub-6 GHz frequency b and (around 3.5G Hz) represents one solution trend, but it is widely investigated. Therefore, most recent research works focus on developing 5G antennas at mm-Wave frequency bands. In wireless technology, antennas are the key element to setting up a communication link [5].

***Corresponding Author: Alaa Alqthami,**
School of Electrical and Computer Engineering Jeddah, Saudi Arabia.

Researchers worldwide are actively engaged in the exploration and development of diverse antenna designs. Among these, micro strip patch antennas have gained wide spread popularity due to their significant features. These antennas are renowned for their simplicity, robustness, compatibility for integration, cost-effectiveness, energy efficiency, light weight construction, and ease of fabrication. The distinctive characteristics of microstrip patch antennas (MPAs) render them highly sought-after in Sub-6GHz wireless communication. Researchers in the present era are actively exploring various independent designs to meet specifics ability and requirements, contributing to the continuous evolution of these antennas. Various approaches are employed in the design of a Microstrip Patch Antenna(MPA), and among them, the use of Defected Ground Structure (DGS) stands out as a popular strategy to improve the antenna's radiation characteristics [6].

ANTENNA DESIGN

The antenna comprises a multi-slotted radiating element and a partial ground plane, featuring a simple design without any lumped elements and a 3D structure. The Rectangular Micro strip Patch Antenna has been designed for Mobile Applications with a frequency range [2.373368 to 2.430401GHz] (ISM-Band) resonating at 2.4 GHz in the CST Studio Suite Software. The Antenna dimension that has been designed in this paper is in the table and the radiating patch of the Antenna was fed by a feed line, which is rectangular in size.

Table 1 Dimensions Of The Proposed Antenna

Parameter	(mm)	Parameter	(mm)
L	80	W	80
WL	30.02	Wp	47
F	13.02		

The single element of the array is designed by obtaining the dimension of the Width and length of the Microstrip Patch Antenna from the Microstrip Patch calculator. The dimension of the patch is 30mm*40.562mm. The antenna structure is a Micro strip Patch and is designed on FR-4 substrate having a thickness of 1.6 mm and the patch is made up of copper material with 0.05 mm thickness. The permittivity of the FR-4 substrate is 4.08 and the permeability of the FR-4 substrate is 1.

The design of a patch antenna is based on the requirements

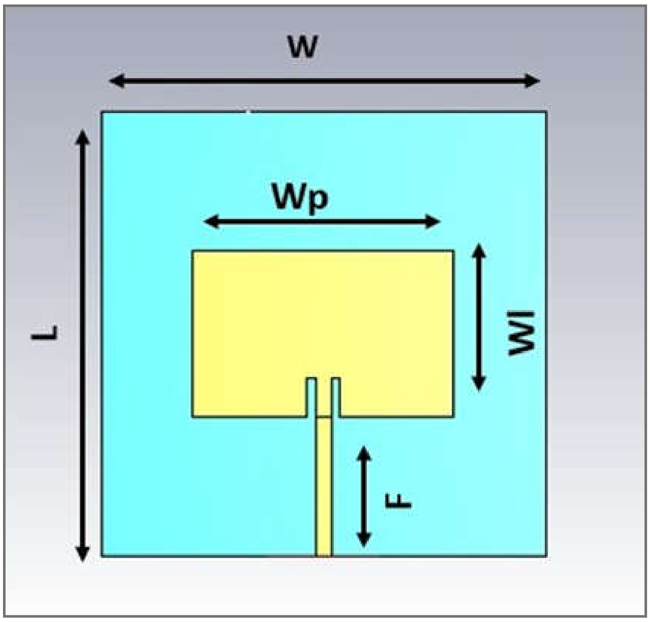

Fig.1. Antenna Design Dimensions

of the application, such as its resonance frequency, operating range, bandwidth, impedance matching, and radiation pattern. The resonating frequency of the antenna is 2.4 GHz, The ISM frequency band is usually included in the band employed when performing microwave propagation since it guarantees good penetration and resolution [18]. The dimension of the antenna is chosen so that it can resonate in the ISMB and. A variation of the Microstrip line width changes the line impedance of the transmission line. In this way, the input impedances of the antennas are adjusted. For good broad band behaviour, two transformers are used. The Microstrip patches and their characteristic transformer lines are connected with s 50 Ohm feed line.

RESULTS AND DISCUSSION

S-parameters, also known as scattering parameters, play a crucial role in characterizing the transmission of energy within an electrical network. They are employed to delineate the connection between various ports, particularly in situations where it is essential to articulate the network about amplitude and phase frequencies, rather than voltages and currents. S-parameters describe the input-output relationship between ports (or terminals) in an electrical system.

The scattering parameters of the Microstrip patch and the related impedance trans former were analyzed individually in CST Micro wave Studio (CST-MWS). S11 represents the power reflected from Port1 and it is known as reflection co-efficient or return loss. The maximum reflection coefficient is -41.234 dB at 2.4 GHz frequency. The range of frequencies constituting a band with a Band within that -10 dB points in S-Parameters can betermedas-10dBB and width band.

Fig. 2. Power Reflection Coefficient–S1,1 of Antenna

The Z-Parameter is also termed as open-circuit impedance parameters as they are calculated under open-circuit conditions. It is termed as the input impedance at the input of the port. The Z1, 1 at the resonating frequency of 2.4GHz is 49 Ohm.

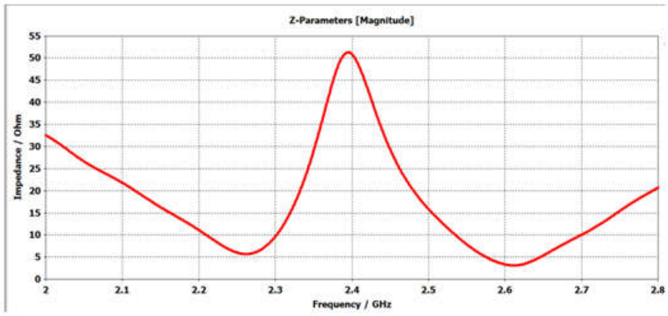

Fig.3. Impedance of the Antenna

A graphical representation of the angular function within the field expression of an antenna is referred to as a radiation pattern. There are a variety of ways to get this information, and you will come across most of the mat some point. The electromagnetic field (EMF) surrounding an object, such as a transmitting antenna, or the effect of radiation scattering off an object is referred to as the near field and far field, respectively.

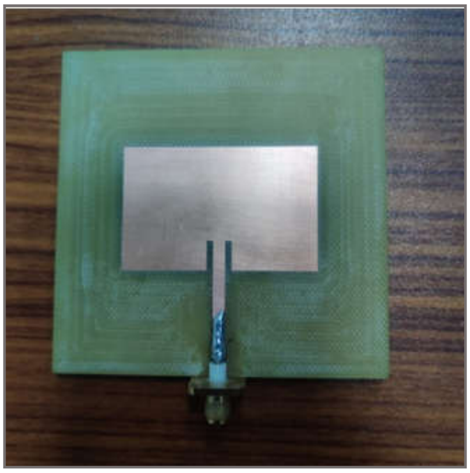

Fig. 4. Fabricated Antenna

Close-field non-radiate behaviors predominate near the antenna or scattering object, while far-field electromagnetic radiation behaviors predominate at greater distances. The most important antenna properties are related to the radiation behavior, including the antenna pattern, polarization of the radiated waves, the axial ratio, and its beam-forming capabilities.

Directivity is a parameter of an antenna or optical system that measures the degree to which the radiation emitted is concentrated in a single direction. Some measured antenna properties are summarized to gain insight into the behavior over the frequency range from 3.53-3.58GHz, which represents the working frequency range of the antenna. The directivity of the antenna is 7.186 dBi at the resonating frequency.

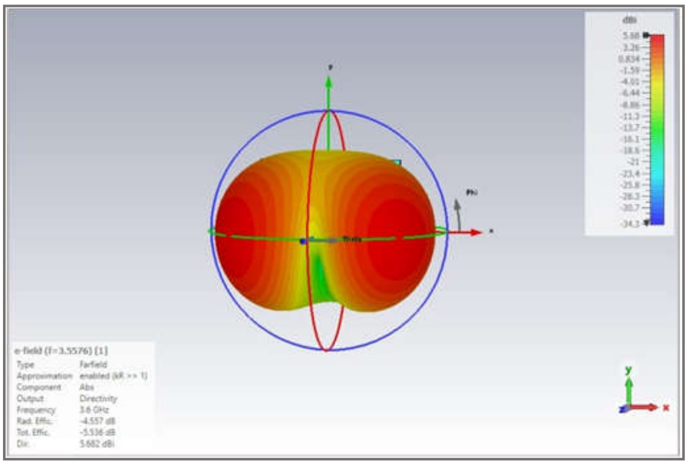

Fig.5. Directivity Pattern of the antenna

The broadside radiation pattern of the directivity is 7.186 dBi in the main lobe direction of-90 degrees. The Side Lobe Levels remain at the same good level as for the center frequency and is smaller than-1.1dB.

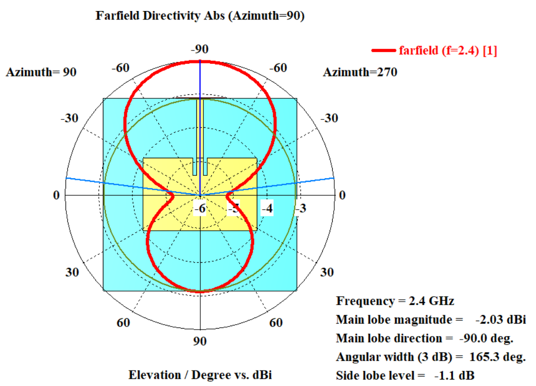

Fig.6. Far-Field Directivity (Azimuth=90)

The Gain of an antenna stands out as a critical performance metric that integrates both the antenna's directivity and radiation pattern. It represents the maximum radiation intensity generated by the antenna in comparison to that of a loss less isotropic radiator provided with an equivalent power level. The Gain pattern of the Antenna Array is the following:

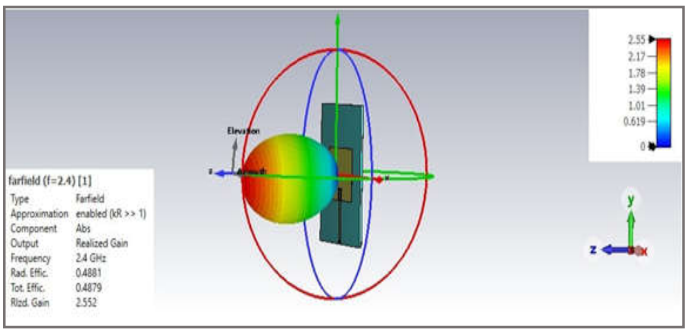

Fig.7.Gain PATTERN

CONCLUSION AND FUTURERE COMMENDATION

It can be seen from the comparison result analysis that a low-profile multi-inset patch antenna for long-term evolution (LTE) and fifth-generation (5G) communication applications. The antenna comprised a stepped patch and aground plane. To attain the required operating band, many slots have been inserted within the patch. The insertion of the slots enhances the capacitive effect and helps the prototype antenna achieve an operating band ranging from 2.373368 to 2.430401 GHzGHz (S11 is less than-10dB). The antenna presented in this paper offers Omni-directional stable radiation patterns, good gains, and efficiency with a compact size which makes this design an ideal contender for wireless fidelity (Wi-Fi), wireless local area network (WLAN), LTE, and sub-6GHz 5G communication applications.

REFERENCES

[1] S.K. Patel, J. Surve, V. Katkar, J. Parmar, Machine learning assisted meta material based reconfigurable antenna for low-cost portable electronic devices, Sci.Rep.12(12354) (2022) 1–13.

[2] M.Agiwal, A.Roy, N.Saxena, Next generation 5G wireless networks: a comprehensive survey, IEEE Commun. Surveys Tutorials 18 (3) (2016)1617–1655.

[3] M. Shafi, et al., 5G: a tutorial overview of standards, trials, challenges, deployment, and practice, IEEE J. Sel. Area. Commun. 35 (6) (2017)1201–1221.

[4] Noor,S.K., Ismail, A.M., Yasin, M.N.M., Osman, M.N., Ramli, N. (2022, August). Orbital angular momentum vortex waves generation using textile antenna array for 5g wearable applications. In 2022 IEEE Symposium on Wireless Technology Applications (ISWTA) (pp. 7-12). IEEE.

[5] Qualcomm. Global Update on Spectrum for 4G and 5G; White Pap.; QualcommInc.: SanDiego, CA, USA, 2020; pp.1–21. Available online: https://www.qualcomm.com/media/documents/files/spectrum-for-4g-and-5g.pdf

[6] Paul,L.C.; Das,S.C.; Rani,T.;Muyeen, S.M.; Shezan,S.A.; Ishraque, M.F. Aslottedplus-shaped antenna with a DGS for 5G Sub-6GHz/Wi MAX applications. Heliyon2022, 8, e12040.

****