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NOVEL SLOTTED HEXAGONAL PATCH ANTENNA FOR SUB-6 GHZ 5G WIRELESS APPLICATIONS

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Abstract

Antenna is the key component in every wireless communication system. 5G becomes the latest technology trend and requires high performance antennas for efficient utilization. In this paper a novel slotted hexagonal patch antenna for 3.5GHz Sub-6 GHz 5G wireless applications is presented. The proposed antenna has novel slotted radiator along with modified ground plane with 25*20mm^2 overall dimension. The proposed antenna developed on the FR4 substrate with dielectric permittivity of 4.4 and height of the substrate is 1.6 mm and loss tangent of 0.002 to achieve better performance. The proposed antenna simulated in an integral based solver simulation software called CST Microwave studio v2020 and obtained results such as VSWR 1.01, return loss -42.18dB with bandwidth of 130MHz, gain of 3.93dBi, Efficiency of 96.65%. This novel slotted hexagonal patch antenna is suitable for Sub-6 GHz 5G wireless applications which uses 3.5GHz resonant frequency.

Keywords:

Sub-6 GHz 5G Antenna, Novel Patch Antenna, Modified Ground

1. INTRODUCTION

5G is not only important because it has the potential to support millions of devices at ultrafast speeds, but also because it has the potential to transform the lives of people around the world. Therefor in this paper a novel slotted hexagonal patch antenna for 3.5 GHz Sub-6 GHz 5G wireless applications is presented. The frequency bands for 5G networks come in two sets. Frequency range 1 (FR1) is from 450 MHz to 6 GHz, which includes the LTE frequency range. Frequency range 2 (FR2) is from 24.25 GHz to 52.6 GHz. The sub-6 GHz range is the name for FR1 and the millimeter wave (mm Wave) spectrum is the name for FR2. In this research work FR1 is considered.

A patch antenna is a type of radio antenna with a low profile, which can be mounted on a flat surface. It consists of a flat rectangular sheet or "patch" of metal, mounted over a larger sheet of metal called a ground plane [1]. The software used in this work is CST microwave studio v2020. The CST microwave studio selected based on its user interface, which is very simple and has the capability of simulating complex structures. The proposed antenna has a novel slotted radiating patch in the top and modified ground plane at the bottom for resonating in 3.5 GHz frequency. The literature review consists of the basics of micro patch antennas [1]-[3], 3D printing based selective ink deposition technique enabling complex antenna and RF structures for 5G applications up to 6 GHz is presented in [4].

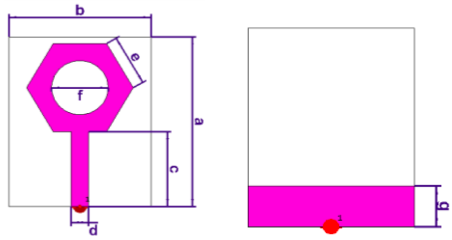
A multi-band 10-antenna array working at the sub-6-GHz spectrum (LTE bands 42/43 and LTE band 46) for massive multiple-input multiple-output (MIMO) applications in future 5G smartphones is proposed in [5]. A novel patch antenna for 2.4 GHz WLAN applications presented in [6]. A compact, broadband, planar array antenna with omnidirectional radiation in horizontal plane is proposed for the 26 GHz fifth generation (5G) broadcast applications in [7]. A cross dipole antenna for 4G and Sub-6 GHz 5G base station applications presented in [8]. A Ka-band inset-fed microstrip patches linear antenna array is presented for the fifth generation (5G) applications in different countries in [9]. A new type of broadband magnetoelectric dipole antenna is investigated and implemented for millimeter-wave applications, particularly for new fifth-generation (5G) applications in [10]. A multiple-input–multiple-output dielectric resonator antenna with enhanced isolation is proposed in this letter for the future 5G millimeter (mm)-wave applications in [11]. Metamaterial antenna for 2.4 GHz WiFi applications presented in [12]. A multiple-input–multiple-output (MIMO) antenna for 5G base stations is manufactured utilizing three-dimensional (3D) printing technology in [13]. A circularly polarized magnetoelectric dipole antenna with high efficiency based on printed ridge gap waveguide is presented in [14]. A modified circular patch antenna is presented for 4.8 GHz Wi-Fi applications in [15]. A dual-polarized patch antenna element fed by a pair of antisymmetric L-shaped probes is proposed in [16]. Broadband proximity-coupled microstrip planar antenna array for 5g cellular applications discussed in [17]. Different antennas available in literature for 5G wireless communication applications which are of larger size and having restricted performance in the literature.

The need for small antennas with the improved performance is still exists therefore in this paper a novel slotted hexagonal patch antenna for the Sub-6 GHz 5G wireless applications is presented which uses 3.5 GHz resonant frequency.

The organization of this paper includes the introduction section as first part followed by design methodology followed in the progress of the proposed antenna and the next section consists of results and discussion section and finally conclusion and future works completes the paper.

2. ANTENNA DESIGN

The novel slotted hexagonal patch antenna for 3.5 GHz Sub-6 GHz 5G wireless applications is shown in Fig.1. The overall dimension of the proposed antenna consists of length *a* which is 25 mm and width *b* is 20 mm dimension.

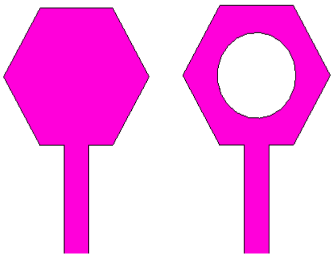


(a) Top View (b) Bottom View

Fig.1. Proposed Antenna

The Fig.1(a) shows the top view of the proposed antenna which consists of novel slotted radiating structure which obtained from modifying the normal hexagonal shaped patch and the circular slot introduced in the center of the patch is responsible for the generation of the resonating frequency 3.5 GHz.

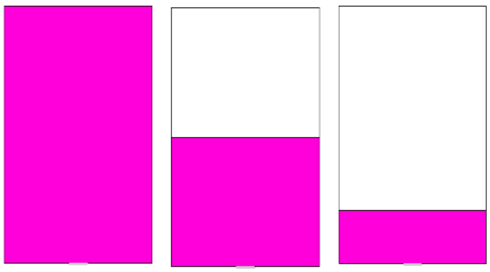
The Fig.1(b) shows the bottom view of the proposed antenna which consists of modified ground structure which is responsible for the impedance matching. The dimensions of the antenna finalized after several iterations to meet the requirements of the sub-6 GHz 5G wireless standards. The proposed antenna developed on FR4 Substrate with permittivity of 4.3 and thickness 1.6 mm. The patch designed in copper material having electrical conductivity of $5.8e^7$ with a thickness of 0.035mm. The process of designing novel slotted patch antenna is shown in Fig.2.



(a) Step 1 (b) Step 2

Fig.2. Design Process in Top View

The top view consists of slotted hexagonal patch in which the slot is introduced in the hexagonal structure with the dimension of 8 mm.



(a) Step 1 (b) Step 2 (c) Step 3

Fig.3. Design Process in Bottom View

The next step in the design process consists of modification of ground plane. In this step the parametric study is conducted by varying the length of the ground plane.

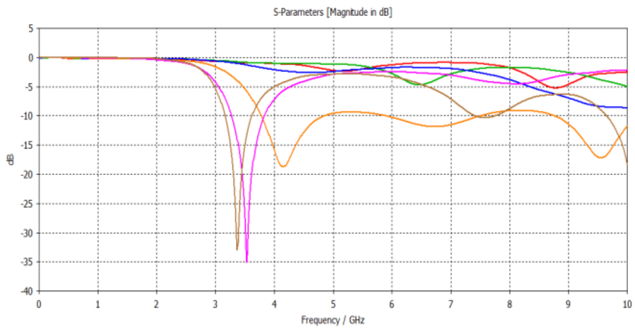


Fig.4. Variation of Return loss

The variation of return loss observed during the simulation process for finalizing the modified ground plane dimension is shown in Fig.4. From the variation of return loss plot it is observed that the resonant frequency 3.5GHz is obtained at parameter *g* at 5 mm. The Table.1 shows the parameters used in the dimensions of the proposed antenna.

Table.1. Dimensions

Parameter	Dimension (mm)
a	25
b	20
c	11
d	2.5
e	7.5
f	8
g	5

3. RESULTS AND DISCUSSION

In this section the results and discussion presented. The design and simulation of a novel slotted hexagonal patch antenna for 3.5 GHz Sub-6 GHz 5G wireless applications done using CST microwave studio v2020 and its results such as return loss, VSWR, farfield radiation, surface current, gain and efficiency discussed below.

3.1 RETURN LOSS

Return loss is the loss of power in the signal returned/reflected by a discontinuity in a transmission line. The minimum return loss at 3.5 GHz is -42.18 dB for the proposed antenna shown in Fig.5. The -10 dB Bandwidth obtained at 3.5 GHz is 550 MHz.

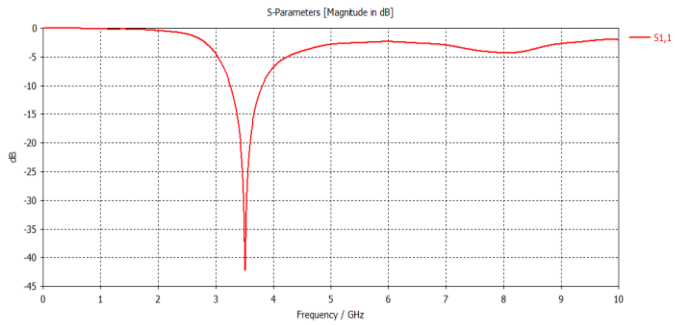


Fig.5. Return loss

3.2 VSWR

VSWR stands for Voltage Standing Wave Ratio, and is also referred to as Standing Wave Ratio (SWR). VSWR is a function of the reflection coefficient, which describes the power reflected from the antenna. The minimum Voltage Standing Wave Ratio (VSWR) obtained at 3.5GHz is 1.01 for the proposed antenna which given in Fig.6. The VSWR value must be from 1 to 1.5 for the perfect antenna and the proposed design achieves the value of 1.01 is best of possible to the perfect value.

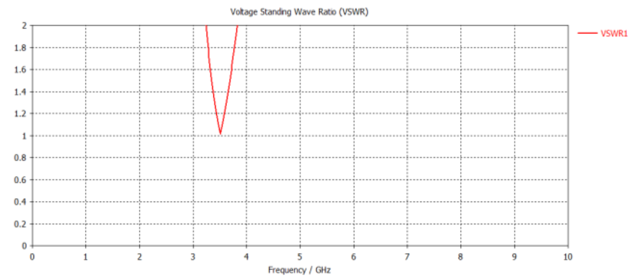


Fig.6. VSWR

3.3 SURFACE CURRENT DISTRIBUTION

Surface current distribution is a useful tool for analyzing the performance of the antenna design. The Fig.7 shows the surface current distribution obtained at 3.5 GHz resonant frequency. The maximum current distribution observed at the novel slot region in the radiating patch designed on the proposed antenna. The current flow starts from the feeding point equally distributed over the radiating patch and the modified ground region.

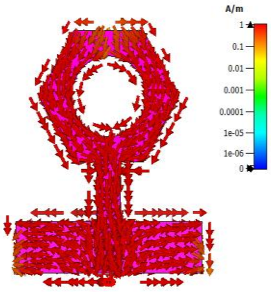


Fig.7. Surface Current Distribution

3.4 FARFIELD ANALYSIS

The 3D pattern in Fig.8 shows the distribution of the power radiated by an antenna as a function of the direction away from the antenna. The maximum gain obtained at 3.5GHz is 4.42dBi.

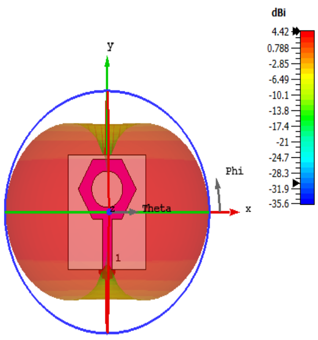


Fig.8. Farfield at 2.4 GHz

3.5 EFFICIENCY

The maximum radiation efficiency obtained at 3.5GHz is 96.67% and the total efficiency is 96.65% for the proposed antenna.

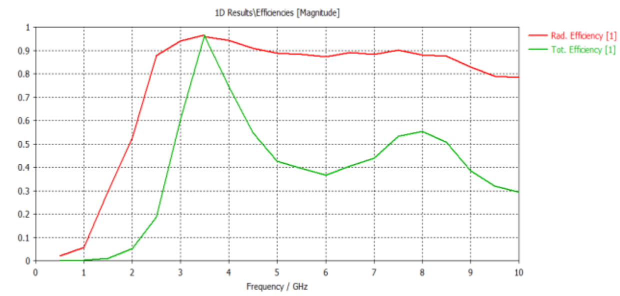


Fig.9. Efficiency

3.6 ELEVATION AND AZIMUTH PATTERN

The Fig.10- Fig.13 shows the radiation patterns obtained from the simulation of the proposed antenna is E field is like the dipole radiation pattern and the *H* field azimuth pattern of radiation which follows the omnidirectional pattern which clearly shows that the proposed antenna has better radiation characteristics to support sub-6 GHz 5G applications at 3.5GHz resonant frequency. The Table.2 summarizes the overall results obtained by the proposed novel slotted hexagonal patch antenna for 3.5GHz Sub-6 GHz 5G wireless applications.

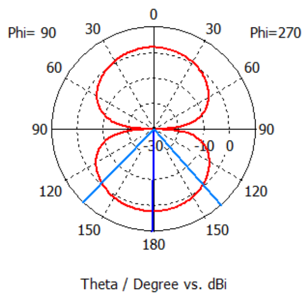


Fig.10. Elevation Pattern

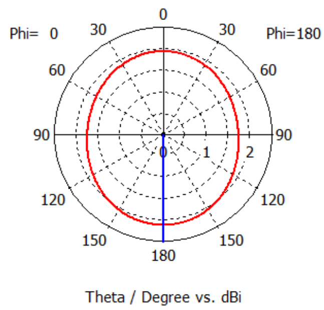


Fig.11. Azimuth Pattern

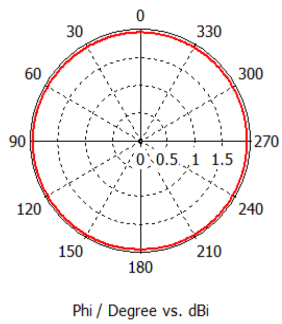


Fig.12. Radiation Pattern at π=0°

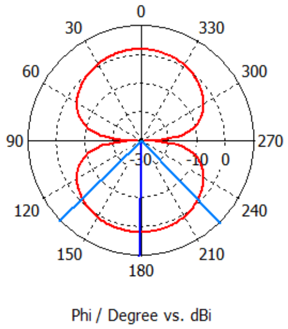


Fig.13. Radiation Pattern at θ=90°

Table.2. Overall Results

Parameter	Value
Frequency	3.5 GHz
Return Loss	-42.18 dB
VSWR	1.01
Gain	4.42 dBi
Efficiency	96.65 %
Bandwidth	550 MHz

4. CONCLUSION AND FUTURE WORK

A novel slotted hexagonal patch antenna for 3.5 GHz sub-6 GHz wireless applications is discussed in this paper. The proposed antenna is simulated in CST Microwave Studio V2020 and its results such as return loss of -42.18dB, VSWR 1.01, gain 4.42dBi and bandwidth 550MHz are following the guidelines for operating sub-6 GHz wireless communication. The proposed antenna has compact dimensions when compared to the works listed in literature and its performance parameters were suitable for operating sub-6 GHz wireless communication.

The future work will be focusing on development of its array and improvement of its gain and other performance parameters.

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