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DESIGN AND FABRICATION OF A COMPACT WIDEBAND MONOPOLE ANTENNA FOR 5G WIRELESS APPLICATIONS

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Abstract : A compact Two-port multi-input, multi-output (MIMO) antenna with good isolation is proposed for sub-6 GHz and Internet of Things (IOT) applications. The wideband characteristics and the required frequency band are achieved through the Fractal-shaped structure and with proper placement of the slots on the resonator. The proposed antenna consists of a dual fractal patch etched on jeans substrate with 50Ω feed line. The proposed antenna has a dimension of 30 × 20 × 1.6 mm3.The impedance bandwidth obtained by the proposed antenna is about 94% between the frequency range of 3.1 GHz to 7.25 GHz, thus providing a wideband antenna characteristic covering sub-6 GHz 5G bands (from 3.4 to 3.6 GHz and 4.8 to 5 GHz), the WLAN band (5.2 GHz), and ISM band (5.8 GHz), respectively. The interconnected ground plane provides good isolation of less than -20 dB between the ports, and the maximum gain is 3.9 dBi. As the proposed design is compact and low profile, this antenna could be a suitable candidate for 5G and IoT Wireless Applications.

I. INTRODUCTION

An Antenna is a transducer, which converts electrical power into electromagnetic waves and vice versa. An Antenna can be used either as a transmitting antenna or a receiving antenna. In the field of communication systems, whenever the need for wireless communication arises, there occurs the necessity of an antenna. Antenna has the capability of sending or receiving the electromagnetic waves for the sake of communication, where we cannot expect to lay down a wiring system. The evolution of wireless technology has made this whole process very simple. Antenna is the key element of this wireless technology.

- A transmitting antenna is one, which converts electrical signals into electromagnetic waves and radiates them.
- A receiving antenna is one, which converts electromagnetic waves from the received beam into electrical signals.
- In two-way communication, the same antenna can be used for both transmission and reception.

Antenna can also be termed as an Aerial. Plural of it is antennae or antennas. Now-a-days, antennas have undergone many changes, in accordance with their size and shape. There are many types of antennas depending upon their wide variety of applications. The sole functionality of an antenna is power radiation or reception. Antenna (whether it transmits or receives or does both) can be connected to the circuitry at the station through a transmission line. The functioning of an antenna depends upon the radiation mechanism of a transmission line. A conductor, which is designed to carry current over large distances with minimum losses, is termed as a transmission line.

II. LITERATUREREVIEW

In literature, several antennas proposed with novel techniques for Sub- GHz 5G bands as follows a High-gain DGS antenna is discussed. C-shaped slot etched on a radiating patch to operate at multiple frequencies for commercial WLAN, WIMAX, and radar applications. X-shaped slot incorporated on rectangular patch antenna and itis fed with proximity coupled feed to excite the antenna to operate at WLAN applications. Three open-end slots are incorporated on patch elements to maintain

-10 dB (return loss) bandwidth from 3 GHz to 5.64 GHz. A pentagon slot is inserted in the ground plane to obtain wider bandwidth at the sub- 6GHz band. A 50-ohm feed line is aligned at the Vertex and side arm of the pentagon to find good impedance matching. Due to increasing the utilization of smart phones, mobile phones, and portable devices wireless technology needs high data rates and stable connections. 5G/6G technology is mobile networks' radio access technology; new 5G technology offers two bands. The first band is Frequency range 1 (FR1-410 MHz to 7125 MHz). This band is called asub-6 GHz (LTE) frequency band. The second band is Frequency Range 2 (FR2- 24.25 GHz to 52.6 GHz). This band is called a millimeter-wave (mm-Wave) spectrum. Monopole antennas became very popular for 40 years. They became popular as they can be easily fabricated. They are low profile. These are lightweight and low volume. They can be printed directly on printed circuit boards. 5Gtechnology requires a compact antenna with significant antenna parameters to offer a high data rate, less fading, and better coverage during all the atmospheric conditions

A circular slot etched on a hexagonal patch element to cover 5G Wireless applications. This antenna has a compact size because of its defected ground structure. This monopole antenna covers frequencies from 3.3 GHz to 3.8GHz with 500 MHz bandwidth which operates at one band insub-6 GHz in the FR1 band.

The design of an antenna for sub-6 GHz started with a circular patch antenna with a full ground plane. In the second stage; it is converted into a monopole antenna. In the third stage, a semi-circular patch antenna with different shapes of slots is analyzed to achieve antenna performance at sub-6 GHz for 5G networks. A fractal- based antenna designed with five circles as a radiator initially. Stared cutting of inner and outer circles radius to achieve the resonating band for sub 6 GHz band in. An SRR-inspired compact monopole antenna is presented for WLAN, Wi-MAX, and X-band applications. The paper explained the slots at the corners of the radiating patch added capacitance to the input impedance of the antenna. The neutralization of effect of capacitive and inductive nature is discussed. The review of the wearable antenna applications is discussed, and Artificial Intelligence-based antennas for the 5^{th}generation are discussed with multiple antennas.

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Table 1.1. Literature summary of reported antennas for 5G application

References	Operating band (GHz)	Dimensions (mm^3)	Gain (dBi)	Substrate	Efficiency (%)
[1]	2.02-2.77	58×58×1.6	3.6	FR-4	95
[7]	3.28-7.45	25×25×1.6	4.2	FR-4	85
[9]	3.10-7.10	32×22×0.8	3.1	FR-4	82
[10]	3.15-5.55	20×30×1.5	2.6	FR-4	79.6

III. PROPOSED DESIGN AND ITS EVOLUTION

The ultimate aim of this work is to design a novel symmetrical L-slotted compact patch antenna for 5G applications in the sub-6 GHz band. This antenna includes a symmetrical L-slotted radiating element, DGS with symmetrical subs, and a 50-ohm feed line. It covers the LTE bands of 22/42/43/46 and N77 to N79 for 5G wireless applications at the sub-6 GHz band

3.1 SIMULATION METHODOLOGY

A well-designed antenna can improve communication links and device performance, but designing an antenna is not a trivial task CST Microwave studio offers a complete design solution for antenna engineers, to be as efficient as possible at every stage of the antenna design process, from initial concept exploration to final antenna integration. But the integration of the antenna and the

CubeSat together is not an easy task to be modeled only with CST, so we provide CST with a 3D model file from external software but using the import command.

The advanced modeling interface allows us to not only create fully parametric antenna models, but also to integrate them with geometries from a wide range of imported CAD formats. This enables us to create any shape of the antenna by using modeling software and integrate them with CST simulation, Note: just by assigning the materials the software can apply the Electrical and Mechanical properties of that part to the model.CST Microwave studio is a tool used for simulating 3D structures at high frequency devices such as antennas, filters, couplers, planar and multi-layer structures and we can choose the most appropriate method for the design and optimization of devices operating in a wide range of frequencies.

3.2 DESIGN APPROACH

The use of low-profile, size, cost, performance, weight, ease of installation and an aerodynamic profile are the most important aspects to be satisfied in high performance spacecraft, missiles and satellite. To meet these requirements a microstrip patch antenna can be used, which can be compatible with Monolithic Microwave Integrated Circuit (MMIC) designs and at the same time mechanically efficient and rigid over a surface. Patch antennas are low profile, conformable to various different shapes and most importantly simple and inexpensive to manufacture (depending upon the materials involved).

This methodology would help us customize the antenna by studying the different iteration and implementing changes to make it radiate at a given frequency.

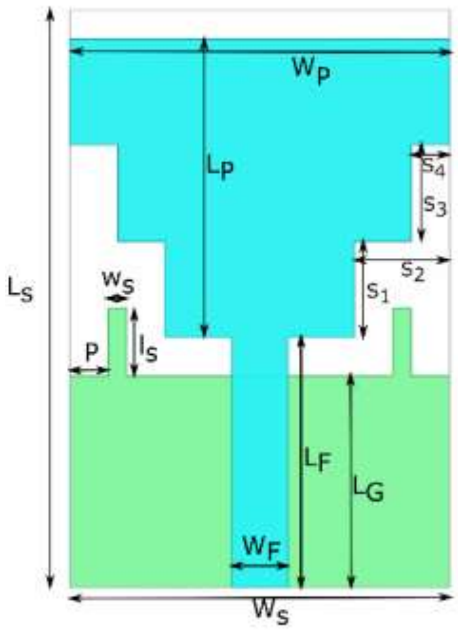
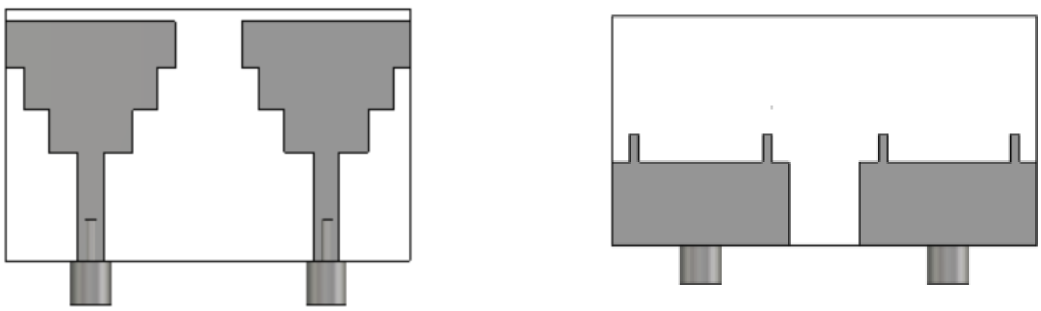


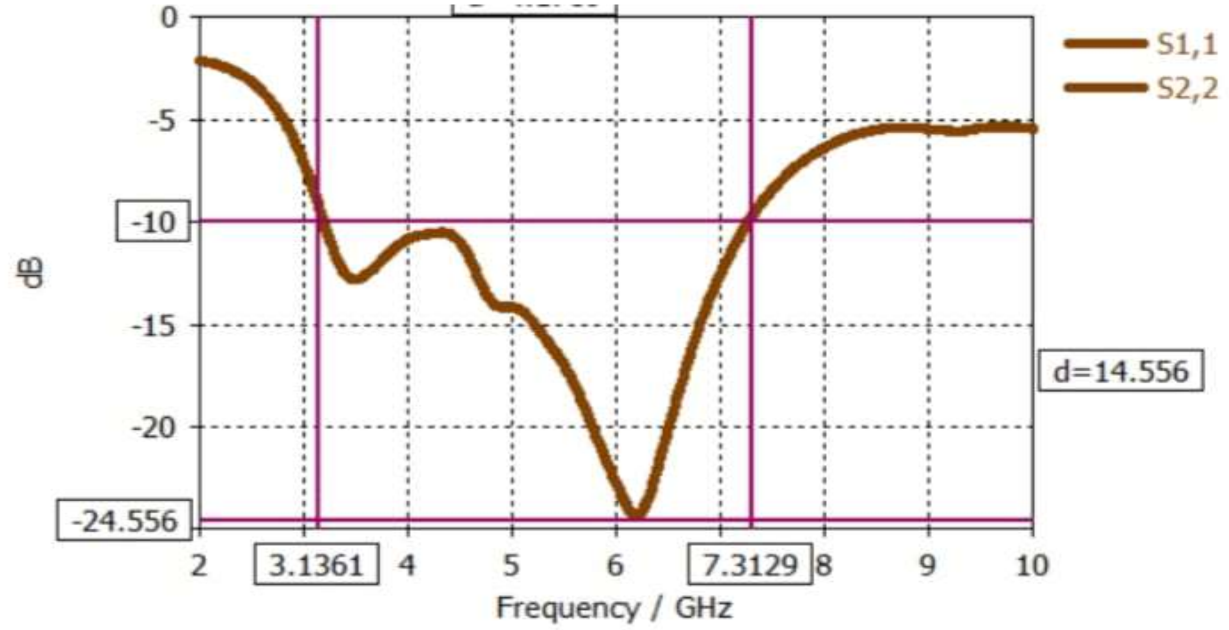
Fig. 3.1 The proposed L-slotted monopole antenna

In Fig. 3.1, the violet and greyish region is the copper patch, ground and the white region is the FR4 substrate having the relative dielectric constant 4.3 and a thickness of 1.6 mm.

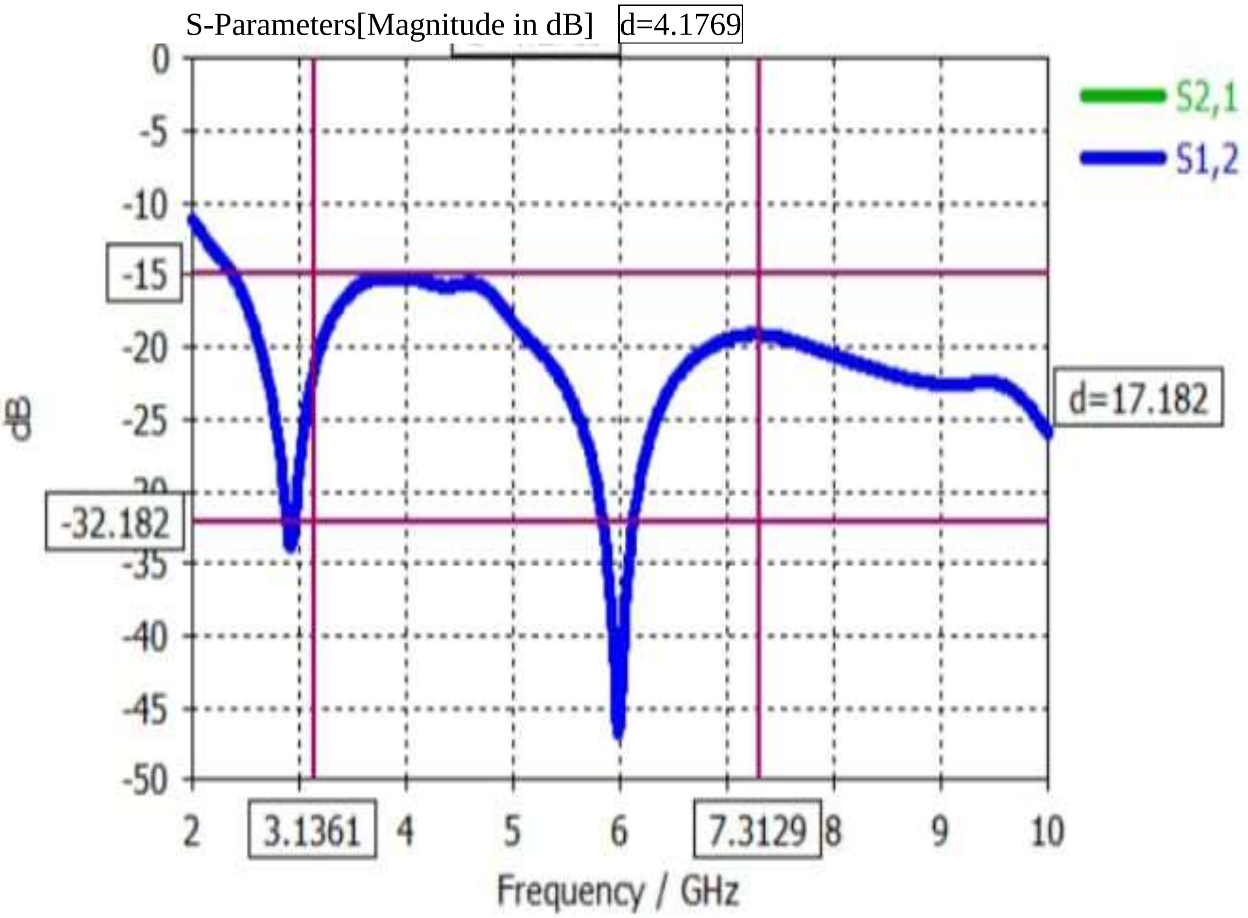


(a) (b)

S-Parameters[Magnitude in dB] d=4.1769



(c)



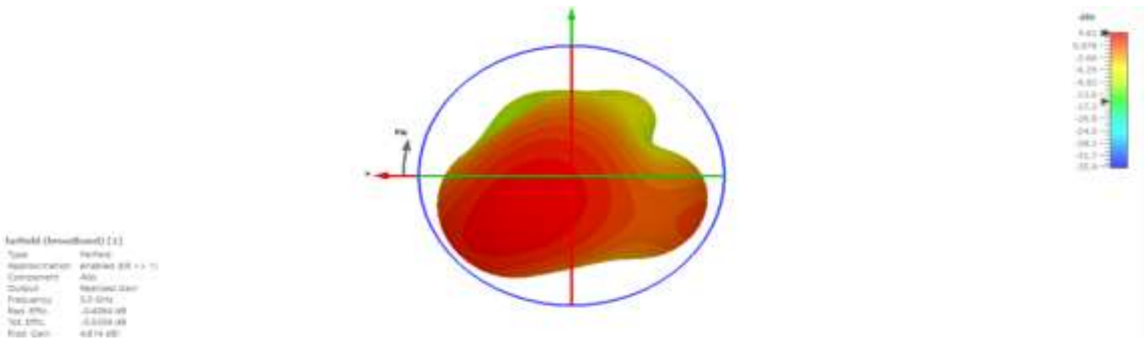
(d)

Fig. 3.2 Final proposed dual MIMO antenna, (a) top-layer, and (b) bottom-layer, and (c) its S parameter results (c) S_{11}& (d) S_{21}

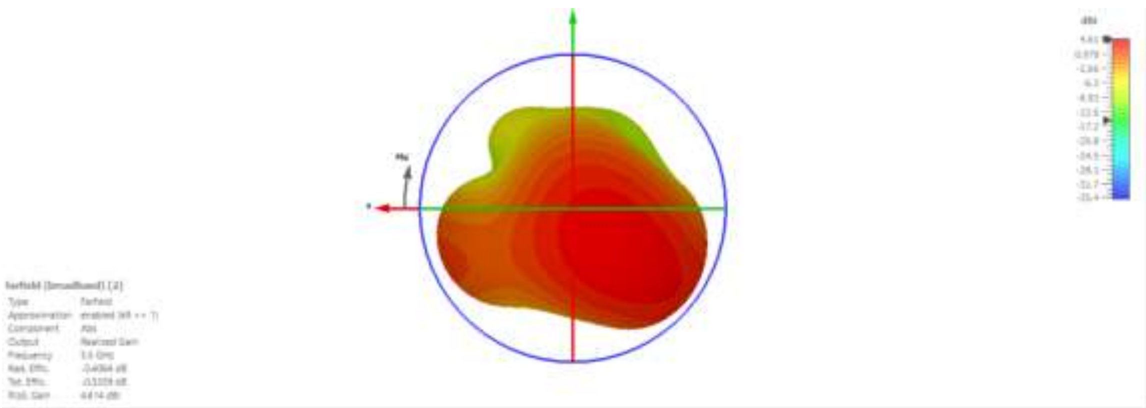
IV. RESULTS AND DISCUSSIONS

4.1 FREE SPACE RESULTS

In this chapter the antenna radiation characteristics are discussed to comprehend the far-field nature of the designed antenna. The radiation parameters of symmetrical L-slotted antenna are obtained in terms of radiation patterns at 3.6 GHz frequencies result from the CST MWS as shown in fig 4.1 and 4.2. The radiation pattern is a function of elevation and azimuth angles (θ, Φ).

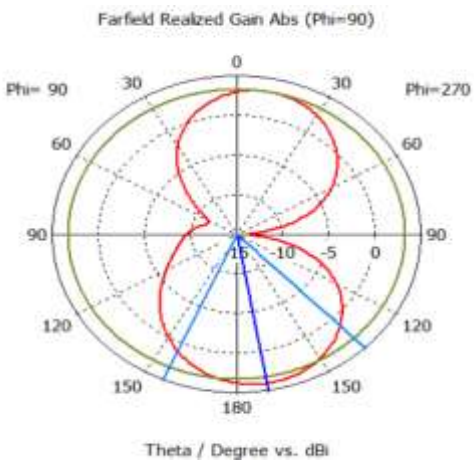


(a)

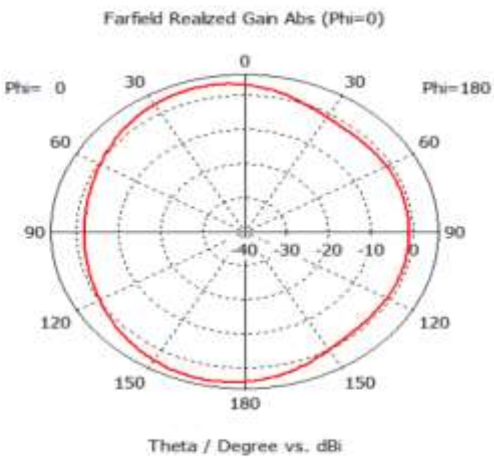


(b)

Fig 4.1 3D radiation characteristics of dual MIMO antenna (a) element 1 (b) element2

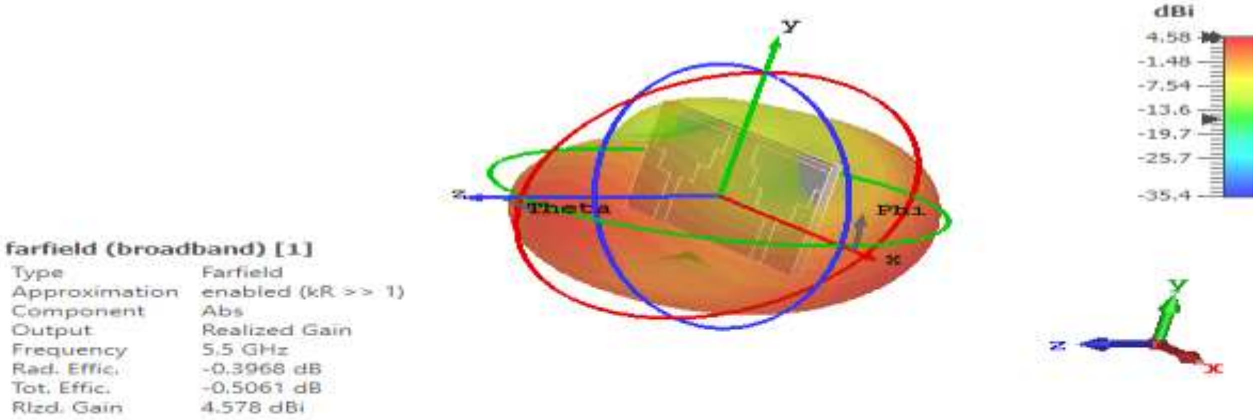


(a)

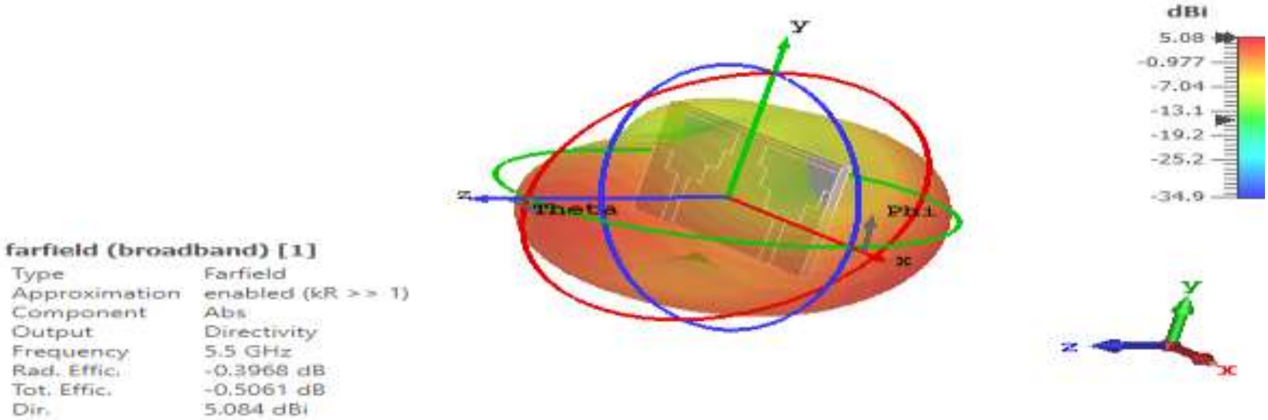


(b)

Fig. 4.2 1D radiation plots (a) E-Plane (b) H-Plane



(a)

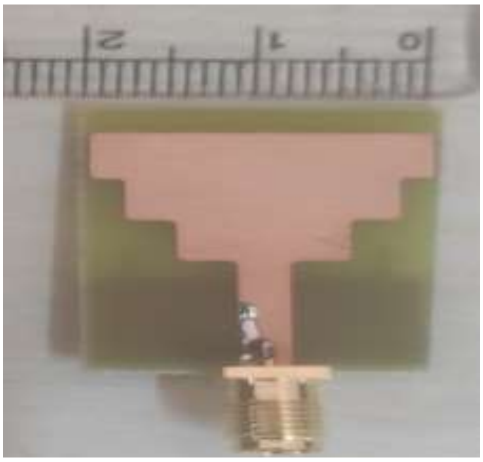


(b)

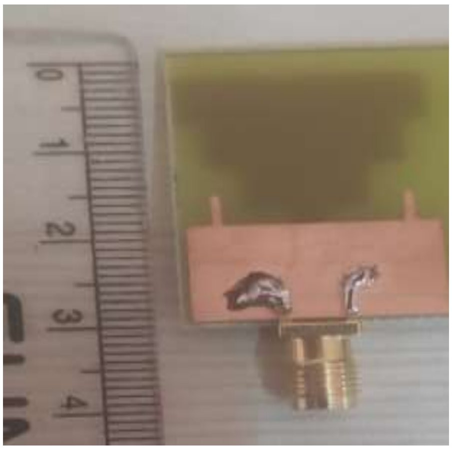
Fig. 4.3 Max.Gain and directivity plots (a) Gain (b) Directivity at 5.5 GHz

4.2 FABRICATION AND MEASUREMENT RESULTS

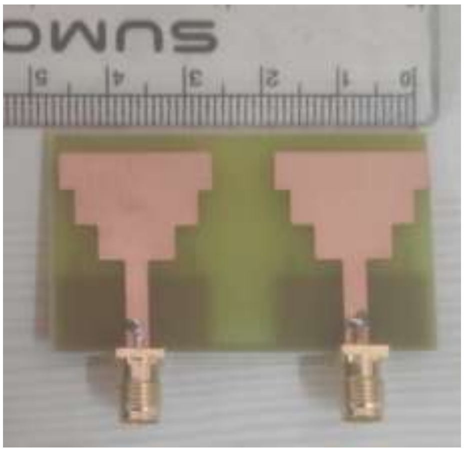
High-isolation with more than -20 dB mutual coupling has been obtained for the fabricated sample. In addition, compared with the simulations, it can be confirmed that there is a good agreement between them.



(a)



(b)


(c)

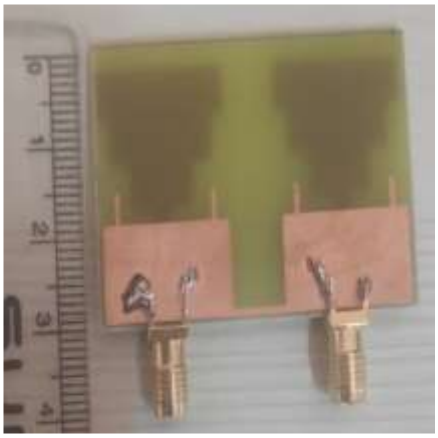

(d)

Fig. 4.4 fabricated antenna, single-element (a) top view and (b) bottom view, dual-element (c) top view and (d) bottom view

4.3 PERFORMANCE COMPARISION

In literature, different novel techniques are used to design and operate for sub-6 GHz 5G wireless applications. In this work, novel symmetrical L-shaped slots and stubs at the ground plane are used to achieve high gain and radiation efficiency at the sub-6 GHz band.

Table 4.1: Comparative Analysis of the proposed antenna with the reported antennas

Ref.	**Operating band (GHz)**	**Bandwidth (GHz)**	**Dimensions (mm^3)**	**Gain (dBi)**	**Efficiency (%)**
[1]	2.02-2.77	0.75	58×58×1.6	3.6	95
[9]	3.10-7.10	4	32×22×0.8	3.1	82
[10]	3.15-5.55	2.4	20×30×1.5	2.6	79.6
Proposed	**3.13-7.31**	**4.18**	**20×30×1.6**	**4.58**	**90.1**

V.CONCLUSION

This chapter concludes the proposed work with the research findings. A novel symmetrical L-slotted compact patch antenna is presented for 5G wireless applications at the sub-6 GHz band. The proposed antennas consist of simple slots and stubs to attain wider bandwidth of 4.18 GHz (3.13 GHz –7.31 GHz) for sub-6 GHz bands. The overall size of the FR4is 30 x 20 mm^2 along with a thickness of 1.6 mm, and ϵr =4.3, and $tan\delta$ = 0.02. The proposed symmetrical L-slotted antenna is simulated in the CST tool. This antenna offers a stable radiation pattern over the -10 dB bandwidth, high efficiency (90%), and its maximum gain is 4.58 dBi. This antenna offers stable omni directional radiation patterns over the sub-6 GHz band. It can be effectively used for newly existing 5G applications.