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Compact Tri-band Loaded Antenna for wireless Communication and Fifth generation Applications

Journal of Electrical Systems

Abstract: - The tri-band antenna proposed for wireless applications. The proposed antenna with a low profile and compact-T shaped. Two circular rings are connected with stub different pole sizes is shown in this article. The proposed work is carried out using CST Microwave Design Studio on FR-4 substrate with a thickness of 1.6 mm. The suggested antenna works cover all commercial and C band applications in the frequency range of 1 to 6 GHz. It gives triple band at 2.5 GHz for (EBS), 3.5 GHz for 5G band or C-band and 5.8 Ism band for wireless and Wifi Max ,5G applications. An impedance bandwidth of the 15%(2.45 to 2.6),17%(3.32 to 3.6GHz) and 25%(5.5 to 5.8 GHz is obtained. A good conjunction between the simulation and measured results is inferred from design analysis.

Keywords: Triple Band,Fr-4,C-band ,CST Studio,.5G applications.

I. INTRODUCTION

Monopole antennas are more significant in commercial wireless communication applications, and ultra wideband technology, which has a frequency band of 1.5–10.6 GHz, has received significant support from academics and industry. When combined with microwave integrated circuits, these structures provide a challenge since they lack planarity.[1-3] Therefore, variations in printed monopole designs are favoured. Radiating patch shapes that are most commonly used in UWB antenna design include rectangular, circular, triangular, sectoral, arc, and their modified variants. There is great appreciation for coplanar waveguides Modern multifunctional wireless communication

Systems benefit from the use of multiband antennas because they minimise the requirement for several antenna elements in a communication device by resonating at different frequencies.[4-7] Many academics have had the chance to investigate a broad variety of potential solutions due to the challenging issue of designing tiny multiple resonant antennas. One common multiband technique involves stimulating the antenna using various feeds, [7] including microstrip and coaxial probes. Modifying the geometry of the ground and patches, such as the ground plane's splits or gaps Applications for dual frequency antennas include synthetic aperture radar,[8-10] satellite communications, global positioning systems, and personal communications systems.[11] In order for multiband antennas to work with monolithic microwave integrated circuits, coplanar waveguide must be used as the antenna feed. Many benefits come with coplanar waveguides, including low frequency dispersion, ease of integration with both active and passive components, additional design flexibility due to the ability to adjust the phase constant and characteristic impedance by varying the slot and strip widths, and avoidance of the extremely thin and delicate substrates found in micro strip lines[15-16].

There are several different dual and multiband antennas described in the literature [17]. The triple band operation in [18] is achieved by combining two L-shaped strips. The size of the antenna, measuring 33 x 28 mm2, is a significant disadvantage. To achieve triple band functioning, a 38 × 25 mm2 two self-identical ring radiator was constructed in [19]. Even for little devices, its antenna size is considerable. In their proposal, Li et al. [20] used inverted T-shaped stubs and L-strips to create a rectangular ring monopole antenna that operates in three bands. A 30 × 42 mm2 substrate with L-shaped strips is utilised in [21] to achieve tri-band functioning. A comparatively bigger CPW fed slotted antenna has also been proposed in [22]

UWB antennas operate above the two wide frequencies of the upper band, which extends from 5.85 to 10.6 GHz, and the lower band, which runs from 3.1 to 5.1 GHz. The next wave of wireless systems, which includes 6 GHz (WiFi-6E) and 5G (B5G)/6G wireless sensor technologies, is now being developed by top wireless

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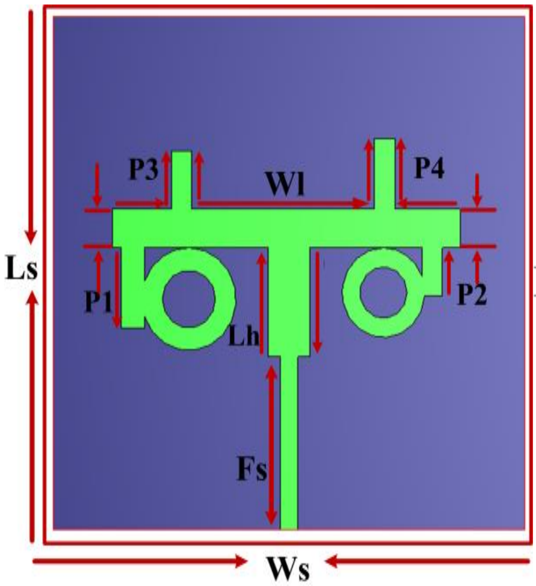
technology firms.3,4. Representatives of the Federal Communications Commission (FCC), who decided to vote in favor of using 6 GHz for Wi-Fi despite the 1.2 GHz spectrum5,6, will leave a lasting legacy for GHz Wi-Fi in the annals of wireless technology history.

II. ANTENNA DESIGN

The T-shaped proposed antenna has two distinct stub lengths connecting its circular rings, as well as a monopole impedance converter. The FR-4 substrate is etched with a feed line with a 50-ohm characteristic impedance, and a rectangular ground plane is attached to the rear of the dielectric substrate. With a dielectric loss tangent of δ (0.02), the FR-4 substrate's relative permittivity is adjusted at 4.4.The CST Microwave Studio simulates and tests the suggested antenna using precise parameters.

The Proposed antenna designed for 5G wireless applications, the proposed antenna dimension 80mmx40mm and designed in FR-4 Substrate and 1.6mm thickness and 3mm feed and input impedance 50-Ωohms. A rectangular parasitic patch with slots and strips is put above the conductor to produce the capacitive coupling effect. We have noticed multiband resonance as a result of this design process.



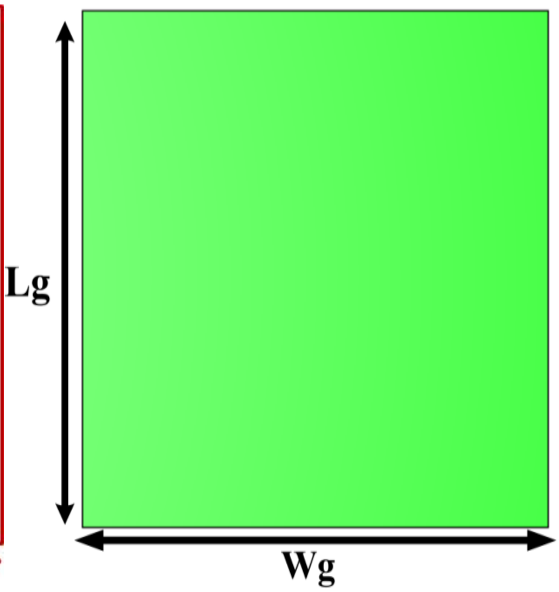


Fig.1. front side of the Antenna front side Fig.2 back side of the antenna

Table.1. Antenna parameters

S.No.	Parameter	Size(mm)
1.	hs	80mm
2.	ws	40mm
3.	fd	3mm
4.	p1,p3	1.5mm
5	P2,p4	2mm
6.	fd	3mm
7	gw	40mm
8	gh	64MM
7.	Electrical permeability	4.3

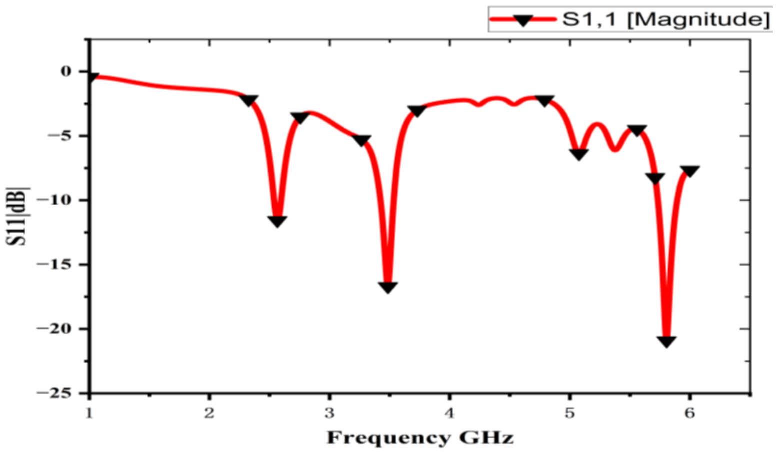


Fig.3. reflection coefficient of present antenna

The refection coefficients of present antenna return loss at different frequencies,2.5GHz,3.4GHz, 5.8 GHz at higher return loss power -11dB,-16dB,-20dB gaining respectively. Using a waveguide port, the antenna is energised. An antenna functions more efficiently when it is stimulated in the right location. It also lowers the antenna's reflection coefficient S11.

$$l = \lambda/4$$

In each resonant frequency (fr), λ represents the guided wavelength and is determined by

$$\lambda_{f_r} = \frac{c}{f_r \sqrt{\varepsilon_r}}$$

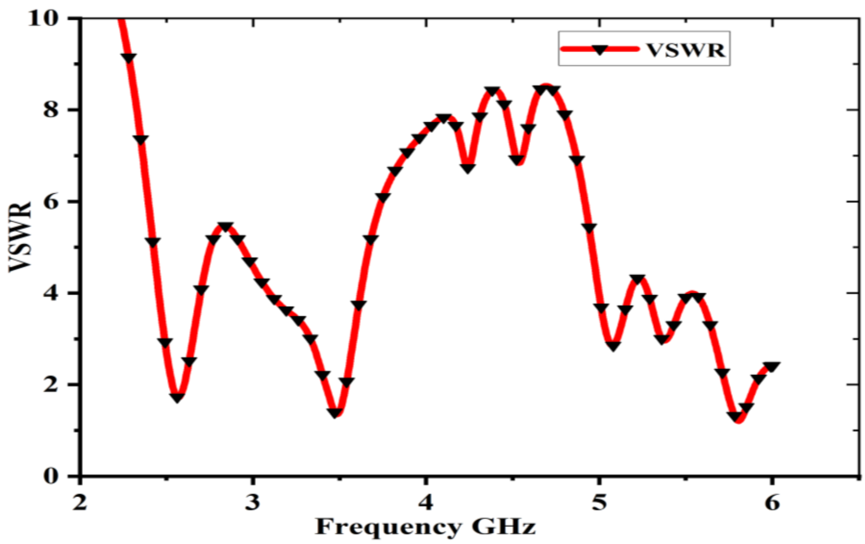


Fig.4 VSWR

Voltage Standing Wave Ratio (VSWR) is another name for Standing Wave Ratio (SWR). The power reflected from the antenna is expressed by the reflection coefficient, which establishes the voltage spread ratio. If s11, the reflection coefficient, or return loss supply the reflection coefficient, the VSWR is calculated using the following formula.

$$\text{VSWR}=\frac{1+|\Gamma L|}{1-|\Gamma L|}$$

Present antenna VSWR has simulated results present frequencies reflected power -10 dbi,-12dbi,-14dbi.

There are three iteration of the present antenna development

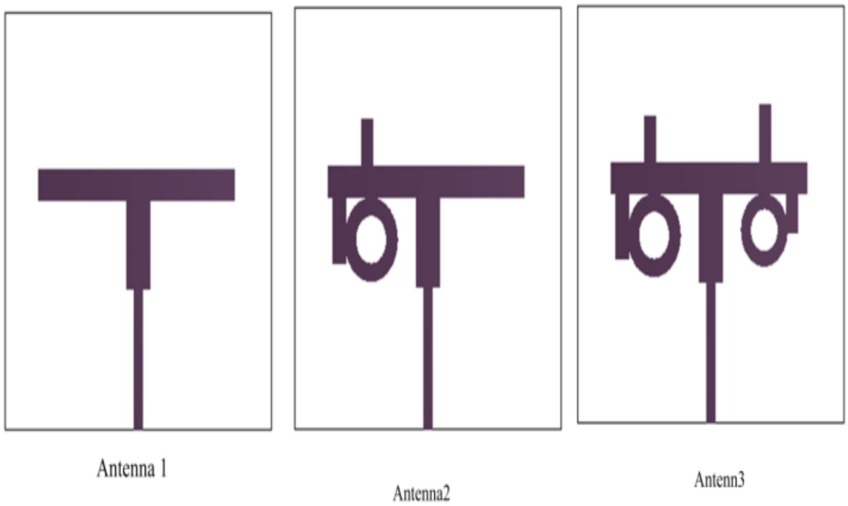


Fig.4.Antenn development Antenna1

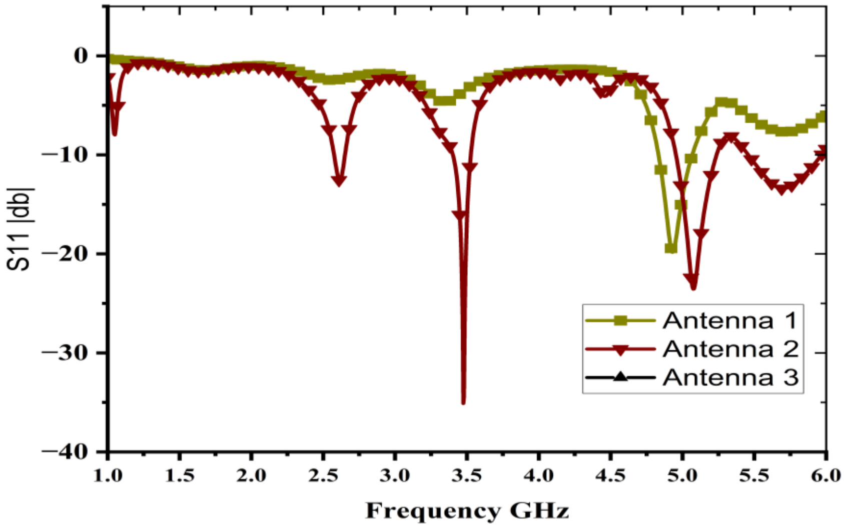


Fig.5.S11 parameters of the three iterations of the present antenna

The iteration of the Antenna 1 shows in figure.5. it a T- shaped design operating frequency 2.5 GHz and higher band width and gain presented . Iteration 2. Of the antenna shows that figure 4. Stub connected with circle ring is gives higher impedance bandwidth for C- band applications. Iteration 3. Antenna shows that in figure 4.t-shapped antenna connected with circle ring with different length from the second antenna improved higher impedance bandwidth and directivity. Its measured antenna results also matching simulation results.

The antenna gives low radiation compact low profile with in expensive with FR-4 substrate is available in the market and copper material using for higher conductivity.

$$W = \frac{c}{2f_r}\sqrt{\frac{2}{\epsilon_r+1}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{w}\right]^{-1/2} \ldots\ldots \quad (2)$$

$$L1=0.25\lambda + n\lambda \qquad L2=\frac{\lambda}{4} + m\lambda/2 \ldots\ldots\ (3)$$

L1&L2 are stub length; m and n are non-negative integers

Other circle ring stub are different lengths tuned stub attached with antenna

Area of the circle ring $= \pi(R^2 - r^2)$

Perimeter circle ring $=2\pi(R + r)$ difference of the both circumference of both rings $=2\pi R - 2\pi r$ where R radias of bigger ring, r is radius of smaller ring.

$$\text{Difference between two rings} \quad Lr = \frac{R1-R2}{r1+r2}$$

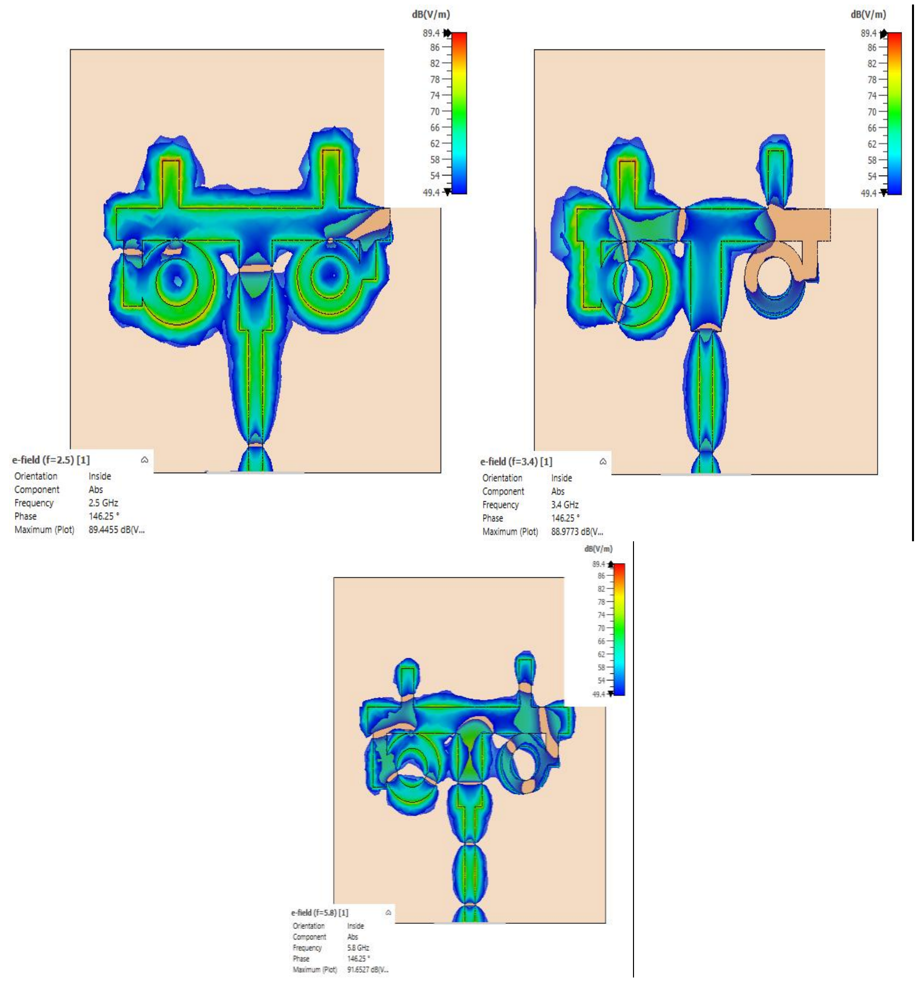


Fig.6.(a).Surface current Distribution @2.5 GH z Fig.6.(a).@3.4 GHz Fig.6. (a)@ 5.8 GHz of frequency

III.Antenna Simulated far filed results

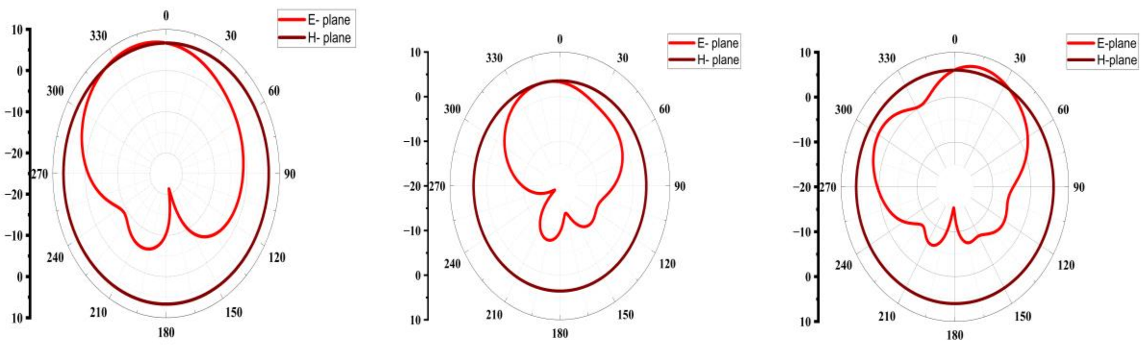


Fig7. Far filed results 2.5 GHz. 3.4 GHz. 5.8 GHz

Table.2.Comparison of Proposed antenna with recent related research works

Ref	Resonant Frequency(GHz)	Bandwidth(MHz)	Maximum Gain(dBi)
R(18)	2.4-2.7GHz,3.34GHz,4.23-6.85GHz	120/220	3.5
R(19)	2.4GHz to 3.6GHz	70/390	4.1
R(20)	2.4 to 6 GHz	120/220	4.1
R(21)	2.4 to 2.7GHz ,3.4to 3.8GHz,5.17 to 6.45GHz	34.% ,19.7%	3dbi
R(22)	433MHZ to 868MHz	54%	2bi
Present Antenna	2.5 to 5.8 GHz	500/900	10dBi

IV. Antenna Measured Results

Fig.8.Fabricated antenna

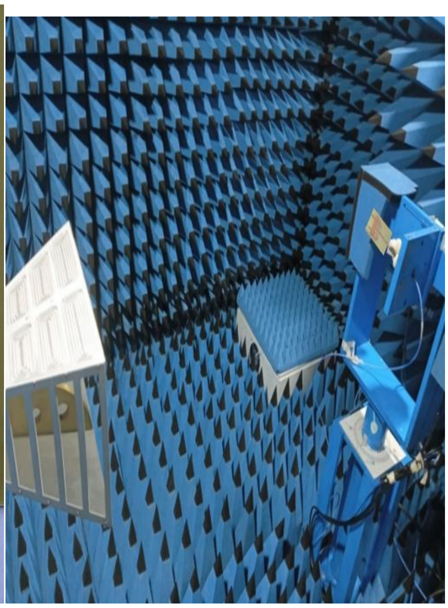


Fig.9. VNA testing machine connected to antenna

The suggested antenna design tests are carried out using an Agilent N5230A vector network analyser (VNA). Figure 8 demonstrates that the differences between the simulated and measured findings are negligible.

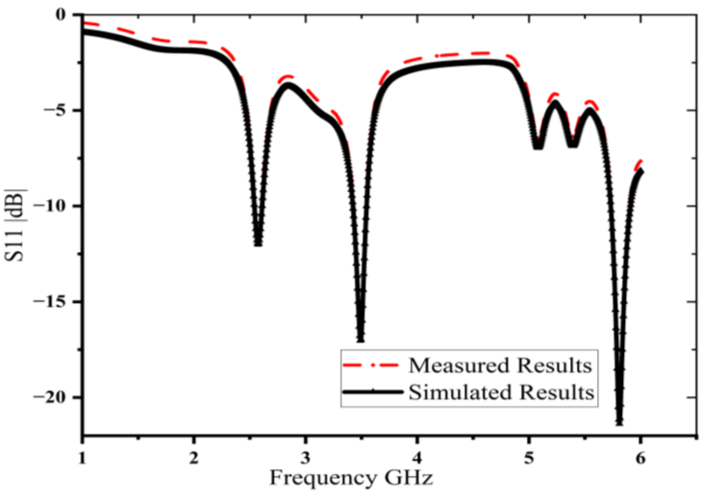
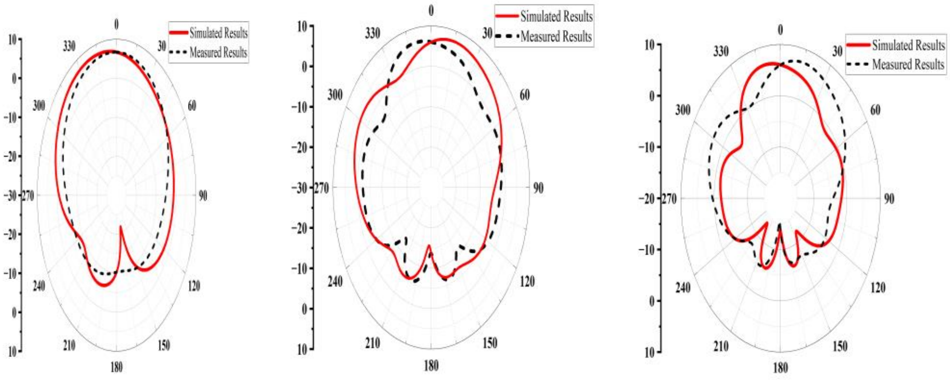


Fig.10. S11 Simulated and Measured Result

The suggested antenna has three frequency bands of coverage: 2.5 GHz, 3.4GHz, and 5.8 GHz. This is one of its main advantages. Because of this, the antenna is appropriate for a range of uses in which a multiband antenna is necessary. Additionally, the suggested antenna has a greater gain of 10 dBi at 2.5 GHz, which is advantageous for receiving signals in areas with low signal strength and long-range communication.



2.5 GHz Far filed 3.4GHz, 5.8 GHz Far filed Results

Fig.11.Simulated and Measured Results

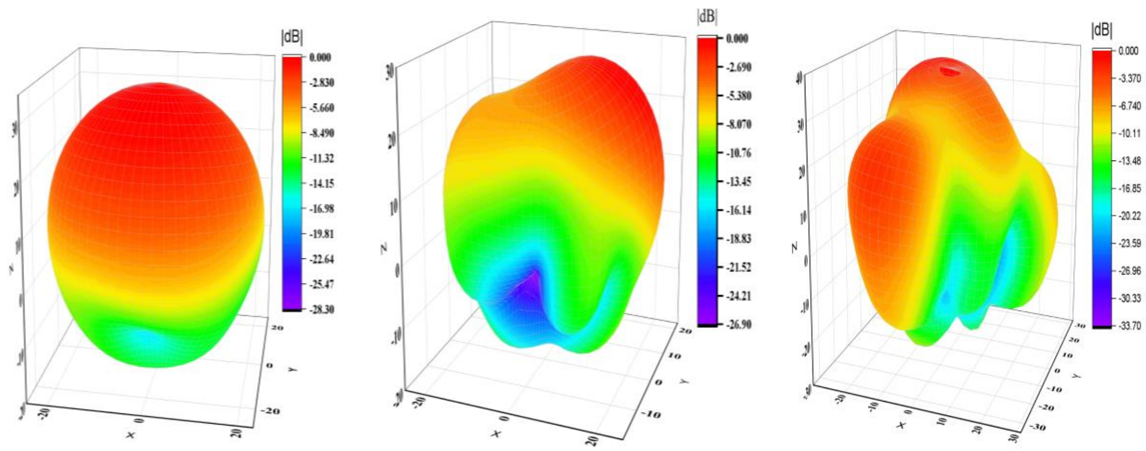


Fig.12. (a).2.4 GHz Fig 12(b).3.4GHz Fig.12© 5.8 GHz

Fig.12. Radiation pattern of the Antenna

V.CONCLUSION

This article proposes a small tri-band antenna. The suggested design has a low profile and is tiny, measuring 64 x 32 x 1.6 mm. Triple band functioning is demonstrated by the printed T-shaped antenna, supporting fifth generation applications including WiMAX in wireless networks. The antenna design achieves a high gain and bandwidth, and when tested and simulated, equivalent measurable findings are obtained. Adopting the suggested antenna for real-time wireless applications would be simple.

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