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Miniature Multi Band Monopole Antenna for Fifth-Generation Wireless Networks

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Abstract: The multi band monopole antenna is high demand on wireless applications with multi frequency bands. This work describes the design, implementation, and performance analysis of a fixed Multi monopole antenna. Two etched monopoles of varying lengths printed on the same side of an electrically thin substrate. The monopoles are linked by a series microstrip line with a tuning stub. The substrate used in this design is FR4 with thickness of 1.6 mm. The antenna performing at three operating bands at center frequencies: 1.8, 2.4, and 4.5 GHz. The multi band antenna for all 2G-5G communication applications A numerical approach called FDTD (Finite Difference Time Domain) is used to simulate the proposed antenna. The gain is approximately 3.4 dBi across the two operating bands. A low-loss and compact multi monopole antenna having measurements 75 × 45 mm suitable for GSM, WLAN and 5G applications are realized. The modeling and measurement results for the reflection coefficient and radiation pattern are compared.

Keywords: *Monopole antenna, Multi Band, Compactness, 5G, Wireless Applications.*

1. Introduction

The development of dual-band and tiny antennas is becoming more and more important due to the expansion of wireless telecommunication services and related applications. Numerous communication arrangements, including mobile, satellite communications, and others, can be produced by telecom operators and equipment manufacturers [1].These systems all operate over several frequency bands. In order to serve customers, each system must have an antenna that functions in the frequency band required by that system.[2]One antenna was typically utilized for each system in the past, however this practice is expensive and wasteful in terms of space utilization [4].The multiplicity of communication methods indicates that dual-band antennas are required. Currently, there are quite a few methods for achieving dual band operation using microstrip and monopole antennas [7]. By using two [8] or more [9] radiating elements on the similar substrate, each of which supports robust currents and radiation at the resonance as the another design category, the dual-band operation can also be accomplished. Additionally included in this category are multi-layer stacked patches on multiple substrates [10], which permit the usage of patches in a variety of geometries

The proposed Design size and cost , performance ,aerodynamic profile are constraints for high performance are considering with traditional antennas. most of the time multi band antennas are high performance antennas for space ,aircraft ,missile and satilite applications. Other government and commercial applications, like mobile radio and wireless communications, also have similar requirements.[5].The best choice to satisfy these requirements is a microstrip antenna. There are currently several antenna designs on the market that may successfully match the needs. Since microstrip antennas are designed with a limited bandwidth, bandwidth expansion is frequently needed. Additionally, lower size antennas are typically needed for today's wireless communication systems. As a result, for microstip antennas, size reduction and bandwidth expansion are now crucial design factors. Because of this, research into making microstrip antennas operate compactly and broadly has significantly risen.

2. Antenna Design

Antenna Geometry and Structure

The antenna is made up of two etched monopoles of varying lengths printed on the same side of an electrically thin substrate. A tuning stub and a series microstrip line are used to link the monopoles. This design makes advantage of the reasonably priced substrate FR4.A ground plane is printed on the back of the substrate, its length matching the length of the microstrip feedline and its width matching the width of the substrate. The antenna at the center of the two monopoles is fed by a 50 Ω microstrip wire with a tuning stub. When a 50 SMA connector would be a more useful feed, the antenna is excited for modeling purposes using an edge port. Simulations using the Finite Difference

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Time Domain (FDTD) numerical approach and CST MWS were run to validate the proposed antenna.

This antenna operates on two different bands thanks to its two monopole elements, each of which is of a different length. A dual-resonance mode of operation is created by the difference in lengths, which results in two distinct current paths. The lower band of operation is controlled by the longer monopole element, while the upper band is controlled by the shorter monopole element. In order to maintain a good impedance match in the two operating bands, it was discovered that the length of the tuning stub was a very effective way to manage the electromagnetic energy connection from the microstrip feed line to the strip monopole antenna. At the two design frequency bands, the antenna has a bandwidth of more than 9%.

As illustrated in Figures 1 and 2, an antenna with monopole elements of different lengths structure has been built. Table 2 displays the antenna's dimensions. The antenna's overall measurements are 75 × 45 × 1.6 mm.

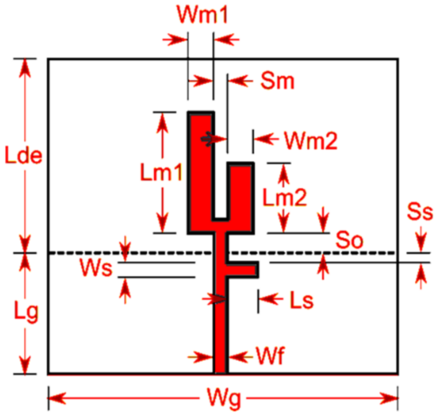

Fig. 1 Top View of proposed antenna

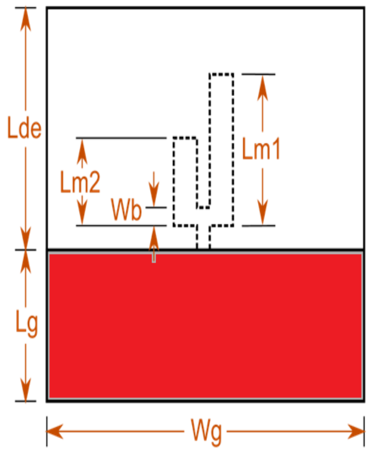

Fig.2. Back View of proposed antenna

Table 1. Proposed antenna's dimensions

Name	***Description***	***Value***
Lg	Length on the ground	20 mm
Lde	Height of Dielectric above the ground plane edge	75 mm
Wg	Ground-plane width	45 mm
Wf	Feed-line width	3 mm
Wm1	Monopole width 1	5.363 mm
Wm2	Monopole width 2	5.363 mm
Lm1	Monopole length 1	32.00 mm
Lm2	Monopole length 2	20.33 mm
Ls	Stub's Length	4.360 mm
Ws	Stub width	3 mm
So	Monopole offset from the ground plane edge	2.3 mm
Ss	Stub offset from the ground plane edge	-60.52 µm
Sm	Spacing between the monopole elements	934.2 µm
Wb	Monopole base width	1.707 mm
ε_r	Relative permittivity	4.3
H	Substrate height	1.6 mm

3. Results and Discussion

The CST MWS FDTD is used to design and test the proposed antenna's specifications. Line width at the feed line and radiating patch junction have provided an abrupt change in geometry that creates discontinuity for the electric and magnetic fields, resulting in the desired radiation pattern.

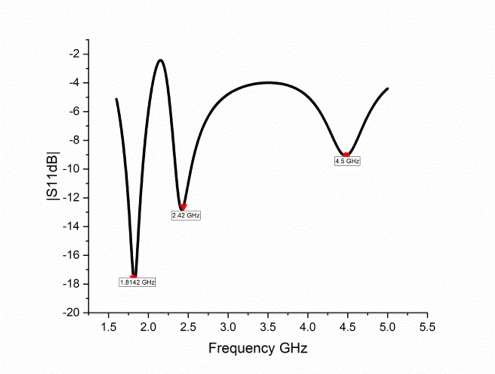

Fig. 3. $S_{11}$of the proposed antenna

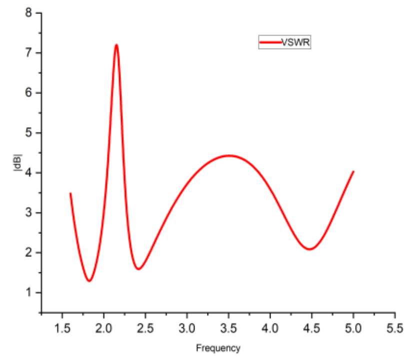

Fig.4. VSWR

Figure 4 depicts the simulation's return loss characteristic, which relates the maximum power transfer ability and antenna impedance matching. The antenna efficiently resonates between 1.8, 2.4 and 4.5 GHz and has an impedance bandwidth of 3.1 GHz. The frequency range where the return loss magnitude is less than - 10 dB and the reflected wave is smaller than the incident wave is known as the antenna bandwidth. This indicates that the antenna and its feed line have acceptable impedance matching. This low and negative reflection coefficient demonstrates that the antenna is active and capable of delivering power from the source.A reference level of -6 dB for S_{11} is used to specify the frequency bands that are covered by adesign.

Antenna characteristics like antenna directivity and radiation pattern are the only ones that are examined in the far field, where the radiation effect is strong. It is also defined as the zone where the outgoing wave front is planar and the antenna radiation pattern shows polar variation that is independent of antenna distance. Figure 4, 5, 6 depicts the antenna's radiation pattern behaviour at 1.8, 2.4 and 4.5 GHz. The suggested antenna has a directed pattern in both the electric and magnetic planes, with 2.3, 2.7 and 4.6 dBi, respectively. Figure 7 depicts the of directivity. The directivity of the antenna's radiation at various frequencies observed that the antenna's directivity increases at higher frequencies.

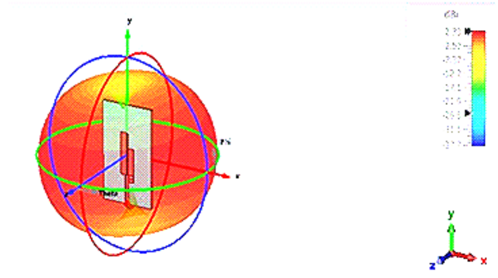

Fig. 5 The proposed antenna's far field plot (f=1.8 GHz)

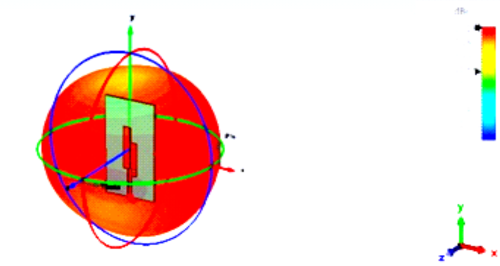

Fig. 6 The proposed antenna's far field plot (f=2.4 GHz)

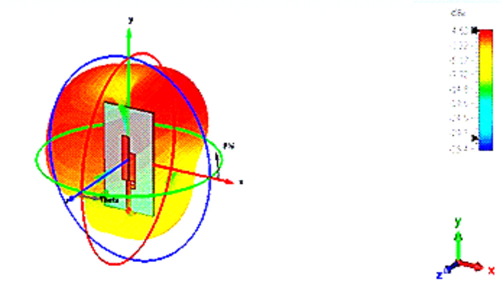

Fig. 7. The proposed antenna's far field plot (f=4.5 GHz)

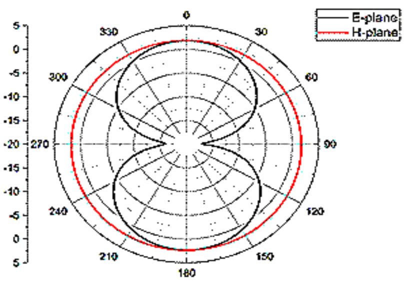

Fig.8. 1.8 GHz Frequency

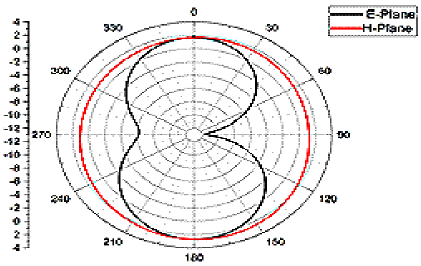

Fig.9. 2.4 GHz Frequency .

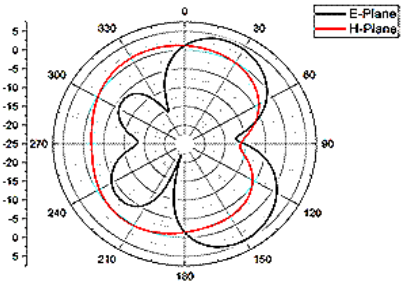

Fig.10. 4.5 GHz Frequency

4. Prototype Antenna

The antenna was created using traditional printed circuit board technologies on a FR4 substrate. The prototype is depicted in Fig.8 below.

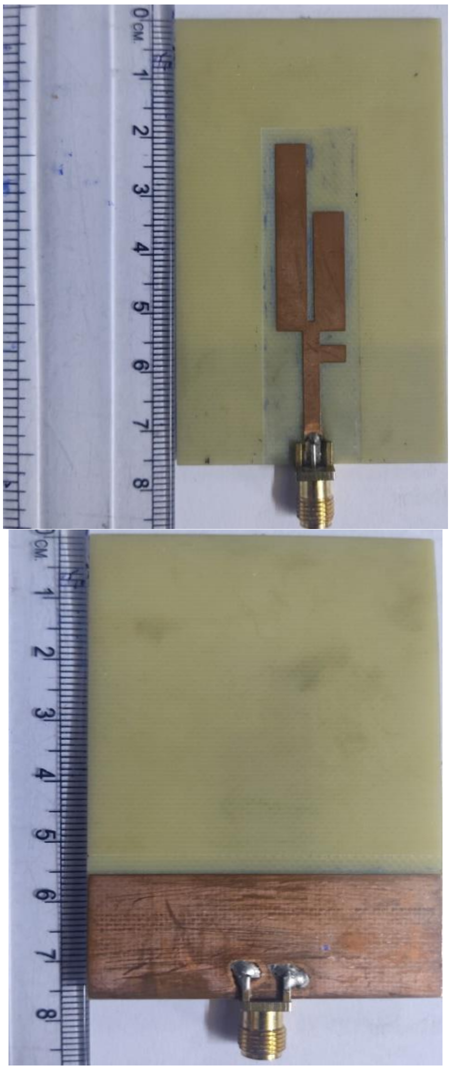

Fig. 11.Top and bottom view of prototype antenna

The constructed structure was put to the test in the anechoic chamber seen in Fig. 9, and the results are as follows:

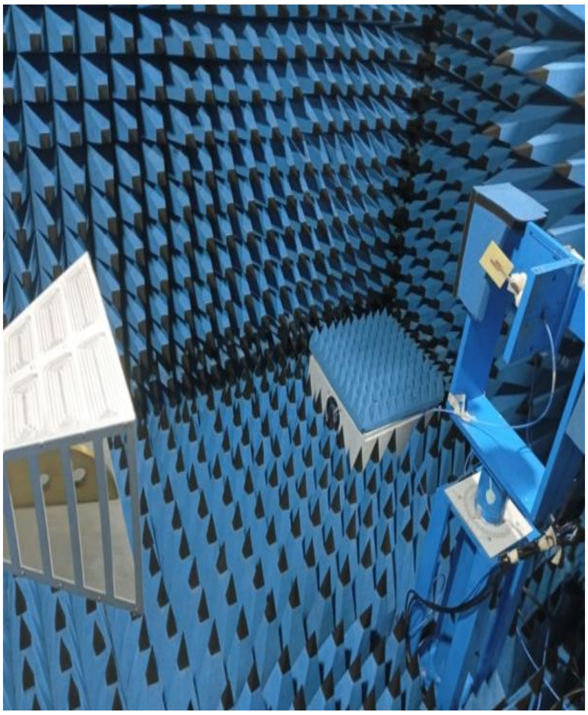

Fig. 12.Measurement setup of the prototype antenna

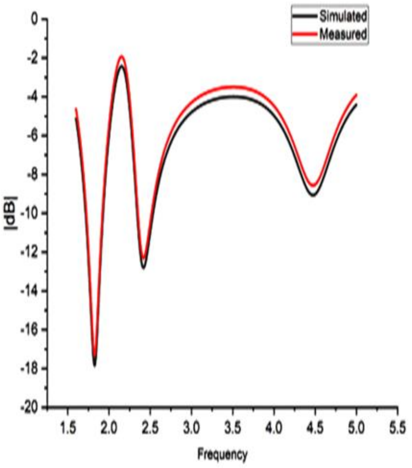

Fig. 13. S_{11}Parameter of fabricated antenna measured using VNA

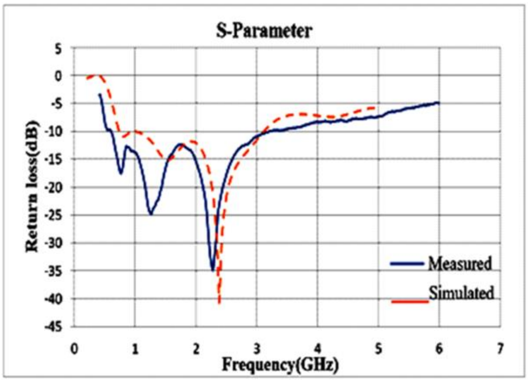

Fig. 14..Return loss of fabricated antenna measured using VNA

The proposed antenna is shown in Fig. 13. and is constructed to function at the desired frequency. Whereas the measured impedance bandwidth for $|S_{11}|$ was covering all the bands. In this plot, the simulated and measured outputs are similar to each other and VSWR value lies between 1 to 1.7. Results from simulations and measurements coincide rather well, though few inconsistence are observed in the results due to the fabrication tolerance.

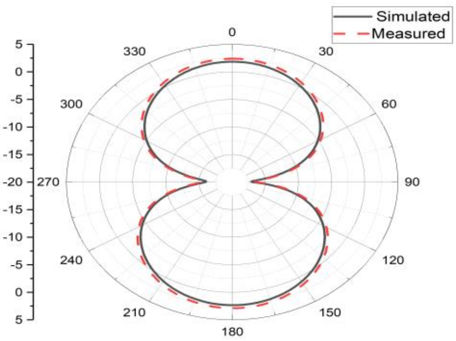

Fig.15. Result of E-plane 1.8GHz

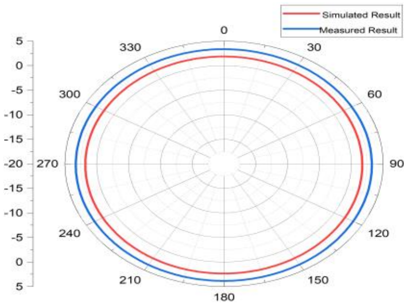

Fig. 16. Result of 1.8Hz H-Plane

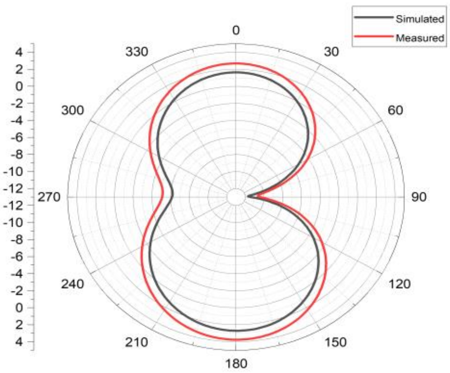

Fig 17. Result of E-plane. 2.4 GHz

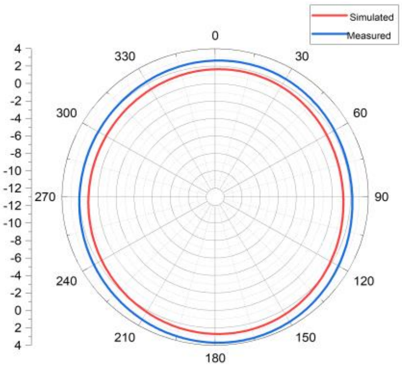

Fig 18. Result of H-plane. 2.4 GHz

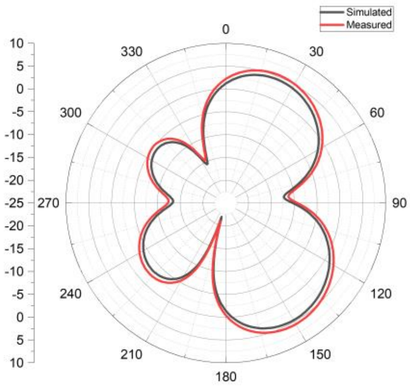

Fig 19. Result of E-plane. 4.5 GHz

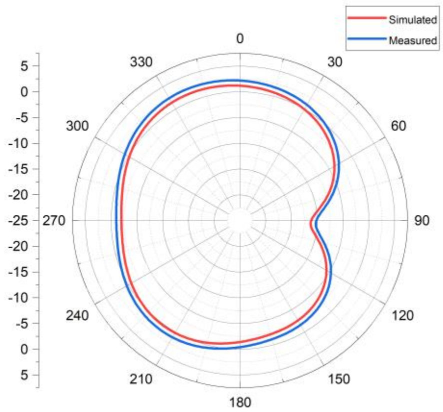

Fig.20 Result of H-plane. 4.5 GHz

Fig.15 to 20. displays the antenna's simulated and measured farfiled radiation patterns. The proposed antenna achieved bi-directional radiation patterns at φ = 90◦ (E-Plane) and directional radiation patterns at φ = 0◦ (H-Plane). The fabrication tolerances, measurement, and mesh size modeling of the antenna in the tool are the main factors that contribute to the variations between the simulated and measured patterns.

5. Conclusion

The Suggested article The Multi band monopole antenna is made up of two etched monopoles of various lengths that are manufactured on the parllel face of an electrically thin substrate. The monopoles are linked by a series microstrip line with a tuning stub. The simulation findings show that the resonance at 1.8 GHz is essentially unpretentious, whereas the higher bandwidth is extended owing to the slotted monopolar's TM02 mode resonance. The antenna has been constructed and measured, and it decides well with the simulation results. At 1.8 GHz and 2.4, 4.5 GHz, omnidirectional radiation with a gain of 2.3 dBi and broadside radiation with a gain of 4.2 dBi are produced, respectively. Because the suggested antenna has various radiation properties at different bands with a noticeable return loss, three resonant frequencies are achieved. It is versatile and suitable for a wide range of wireless communication technologies. The omnidirectional antenna design reduces the size of the antenna and is ideal for wifi, WiMAX, and WLAN applications.

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