DESIGN OF UWB MONOPOLE BASED FRACTAL BINARY TREE ANTENNA FOR WIRELESS COMMUNICATION DEVICES

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Abstract—Due to two primary considerations, Ultra-Wideband (UWB) Antennas are becoming more and more popular and desirable in current and next wireless communications systems. First off, the demand for wireless transmission rates is rising, and UWB features like fast data rates, low power consumption, and low cost are giving UWB antennas a tremendous push. Second, as more and more wireless transmission functionalities and operating bands are required by portable wireless devices, designing antennas may become more difficult due to issues such antenna size constraints and multi-antenna interference, among other things. Multi-narrow-band antennas can be replaced by UWB antennas, potentially reducing the overall number of antennas. A Compact Dual Microstrip-Fed UWB Monopole Antenna with a Parasitic Patch is designed and simulated over HFSS in this proposed work, and the simulation results are presented and discussed in comparison with the results that were actually obtained in order to verify and support the results generated by simulation. In order to attain a passband frequency of 2.45 GHz for Bluetooth application without sacrificing the UWB antenna efficiency, a fractal binary tree is introduced. Over the specified frequency band, the suggested antenna exhibits a consistent radiation pattern with group delay fluctuation of less than 1 ns. The gain varies for the Bluetooth band from 1-1.5 dB and for the UWB application from 2.5–6 dB. According to the results, the antenna performed well in terms of gain, bandwidth, VSWR, return loss, radiation patterns, and other criteria. The antenna's operating frequency of 9.21 GHz makes it a strong contender for systems that combine Bluetooth and UWB. In order for the antenna to be used in real-time applications, the VSWR must be less than 2 and the return loss must be less than -10 dB at this frequency.

Index Terms—UWB Technology, Monopole Antenna, Wireless Communication, Bluetooth, fractal

I. INTRODUCTION

Wireless communication devices are getting more and more common these days. To meet the greater resolution and data rate needs, wireless communication technologies must be further developed. Due of this, systems for ultra-wideband (UWB) communications, which operate between 3.1 and 10.6 GHz and were approved by the FCC in 2002, are now being developed. Different wideband antennas have been investigated for communications and radar systems for a long time. Wideband antenna design is a challenging undertaking, particularly for hand-held terminals where a balance between simplicity, cost, and size must be struck. One of the main challenges in UWB communication systems is designing a small antenna that can nevertheless provide wideband characteristics across the whole working spectrum. Wideband monopole configurations in the shapes of circles, squares, ellipses, pentagons, and hexagons have all been suggested for use in ultra wideband (UWB) applications due to their appealing characteristics of wide bandwidth, simplicity of structure, unidirectional radiation pattern, and ease of construction. However, because they lack planar structures, they cannot be integrated with printed circuit boards. The low profile, cheap cost, and light weight of a microstrip-fed monopole antenna make it an appealing candidate for integration with a hand-held terminal.

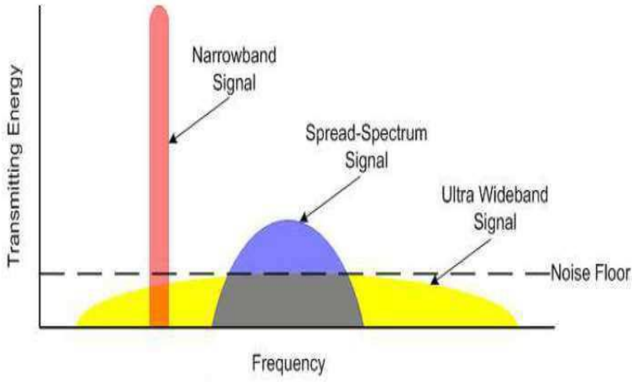


Figure 1: UWB communications' Broad Frequency range

Numerous alternatives have been put up as the demand for high-data-rate wireless communication grows more critical. The benefits of ultra-wide band (UWB) radio over other candidate technologies include greater data rates, good immunity to multi-path cancellation, a potential boost in operational security for communications, and less interference with existing systems. Antennas are a particularly difficult feature of UWB technology since they need to be compact and have relative bandwidths. The IEEE 802.11 a frequency range (5.15–5.825 GHz), which is also a low-power technology, is included in the Federal Communications Commission's (FCC) version of UWB radio's spectrum (3.1–10.6 GHz). As a result, both the IEEE802.11a and high-performance radio local area network (HIPERLAN) technologies may be considered to be interfered with by FCC UWB. Different UWB antennas with multi-notch band stop characteristics have been studied as a solution to this issue. Ultra-wideband (UWB) systems' impending widespread commercial deployment has reignited interest in the topic of ultra-wideband antennas. Every dB counts in a UWB system as much as if not more than in a typical narrowband system due to the power levels permitted by the FCC. As a result, the design of a UWB system as a whole must include an effective UWB antenna. In this study, the desired stop-band properties are obtained using a fractal binary tree. Because the fractal can be replicated and completely compressed within the existing footprint of a typical UWB antenna, it can be used more effectively with less area.

II. ANTENNA DESIGN

Figure 2 depicts the geometry of the suggested antenna, which is implemented on a FR4 substrate with a 1.6 mm thickness. The substrate's dimensions are 33.3 mm x 24.4 mm (Lsub x Wsub). Here, a large circle radius of 9.5 mm is chosen because it results in a lower resonance frequency of 4 GHz with the successful coupling in the higher frequency range. Since a large portion of the electric currents are centered at the restricted area of the radiator, an annular shape can reduce the overall size of the printed UWB antenna. In addition, the primary patch is electromagnetically connected to a circular parasitic patch that in the substrate backed and employed as an auxiliary resonator.

The proposed antenna has a double-fed configuration and is fed via a 50 microstrip line. The innovative feeding method enhances the polarization properties and impedance bandwidth by ensuring only vertical currents and preventing horizontal currents. An ideal value of 4 mm is selected for appropriate matching purposes because when the length of the rectangular strip changes, the matching likewise changes. The antenna gain is influenced by the matching qualities over the band, which is indicated by the width of the ground plane (Wg). The matching concerning over the band gets better as the ground plane's breadth widens, indicating increased antenna gain. If a ground plane width of 14 mm is taken into account, a compromise between antenna size and gain can be reached.

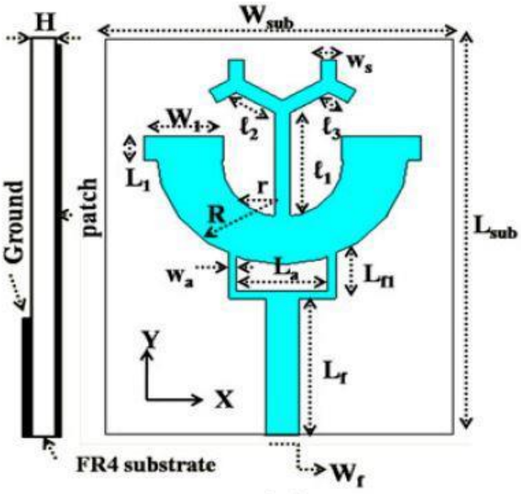
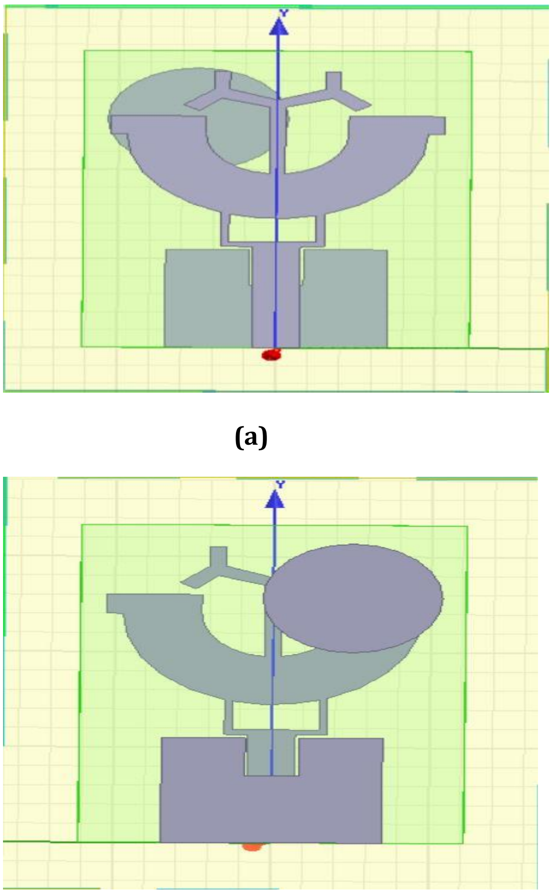


Figure 2: The geometry of UWB Monopole Antenna

a) **Simulation Using HFSS**:

The above antenna design is simulated and studied using HFSS (High-Frequency Simulation Software) version 13.0 software as shown below in Fig.3



(a)

(b)

Figure 3:UWB Monopole Antenna Design using HFSS
a) Front View **b)** Top View

III. Fabrication Model of Proposed Antenna

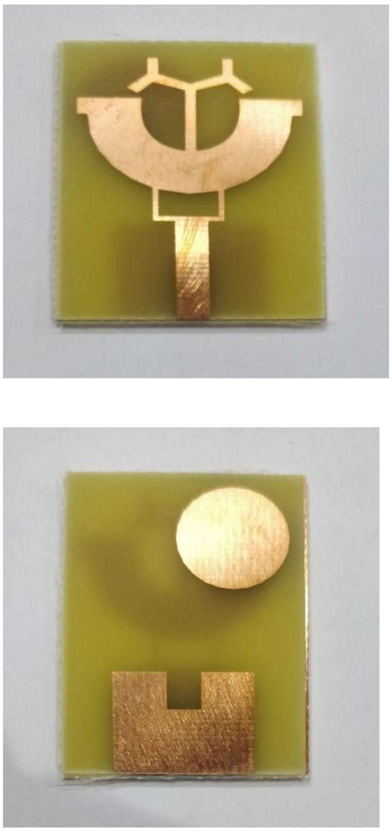


Figure 4: Fabricated UWB Monopole Antenna
a) Front View **b)** Back View

IV. Simulated & Measured Results

a) S11 (Reflection Coefficient)

Figure 5 displays the return loss for the UWB monopole antenna with the fractal binary structure that was created in HFSS and corresponds to Figure 3. The Reflection Coefficient is seen to be -23.96 at the operating frequency of 9.2 GHz and less than -10dB with a bandwidth of 7.5 GHz from this measurement.

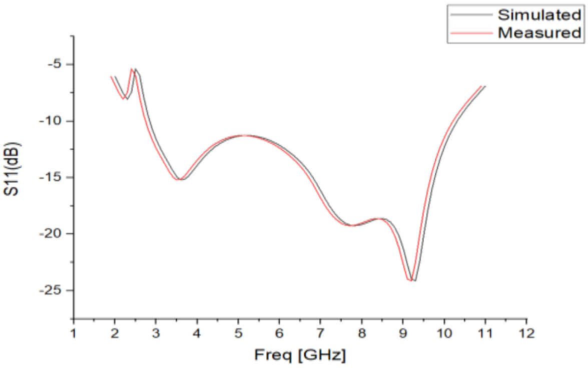


Figure 5: S11 for UWB Monopole Antenna

b)VSWR

A perfect match requires a VSWR of no less than unity. Figure 6 displays the VSWR of the UWB monopole antenna with a fractal binary structure created in HFSS and similar to Figure 3. The ideal range for practical applications is between 1 and 2. The VSWR at 9.2 GHz is observed to be 1.1126, and the associated bandwidth is below -10 dB.

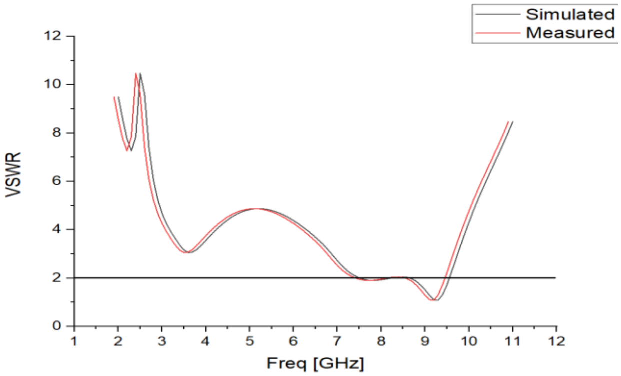
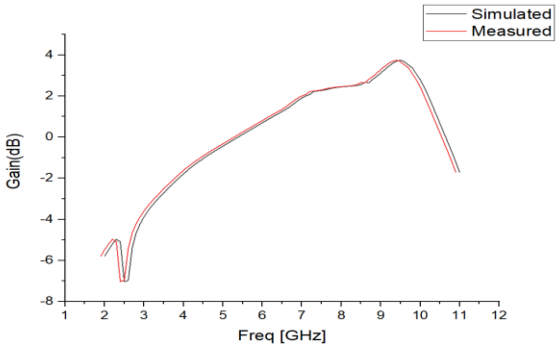


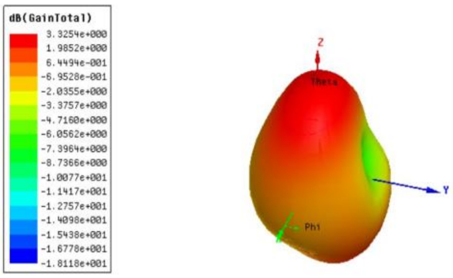
Figure 6: VSWR of UWB Monopole Antenna

c) Gain

Gain is nothing more than the amount of power that is sent per solid angle. Figure 7 displays the gain of the UWB monopole antenna created in HFSS and similar to figure 3. 3.46 dB of gain has been measured for this antenna.



(a) Graphical



b) polar

Figure 7: Gain for UWB Antenna (a) graphical b) polar

d) Radiation Pattern

A fluctuation in an antenna's power as a function of the direction it is facing away from the antenna is known as a radiation pattern. In the far-field of the antenna, this power variation as a function of the arrival angle is seen. Figure 8 depicts the radiation pattern of a dual-band CPW fed antenna developed in HFSS that corresponds to Figure 3.

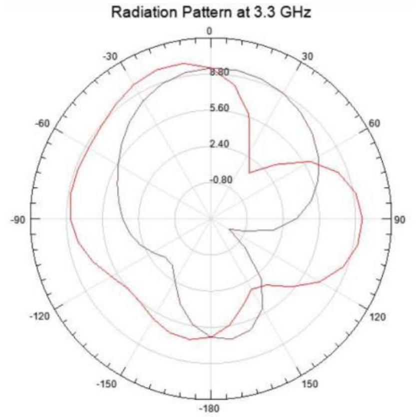


Figure 8: Radiation pattern of UWB Monopole Antenna (a) at 5.4 GHz

V RESULT ANALYSIS

Ref	Antenna size (mm)	S11 (dB)	No of Bands	Gain (dB)
1	47 X 47 X 1.6	-37,-47	2	3.4
2	18 X 12 X 1.6	-21,-29	2	3.1
3	26 X 16 X 1.6	-35	1	3.07
4	42 X 46 X 1.6	-27,-30	1	1.7
5	28X 33 X 1.6	-24,-16	2	3.23
*	33 X 24.4 X 1.6	-23.96	1	3.46

* Proposed Work

The reference papers are related to UWB Antenna for Wireless Communications and above result analysis, compared the size of an antenna, return loss, VSWR and Antenna Gain. Antenna gain is more in proposed work when compared to UWB Antennas which taken the reference.

VI. CONCLUSION

A promising technology for offering wireless communications ease and mobility to high-speed interconnectivity in devices throughout the digital home and office is ultra-wideband technology. In this project, a novel semi-arc monopole with fractal binary tree shape, overlapped circular slots, and rounded edges is designed and simulated over HFSS. The simulation results are presented and discussed in comparison with the results that were actually obtained in order to verify and justify the results produced by simulation. According to the results, the antenna performed well in terms of gain, bandwidth, VSWR, return loss, radiation patterns, and other criteria. The antenna has two working resonance frequencies of 2.5 GHz and 3.3 GHz, encompassing the Bluetooth/Wi-Fi band as well as the majority of the 3G, 4G, and an anticipated 5G spectrum in the future. When operating in real-time applications, the antenna's VSWR and return loss are obtained to be less than 2 and -10 dB, respectively, at these frequencies.

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