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Exploring the Multiband Functionality of a Fractal Antenna Modeled After a Tree's Structure

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Abstract*: This article presents the design and analysis of a tree-shaped fractal antenna featuring U-shaped and W-shaped slots. The analysis of the proposed antenna is conducted using FR4 substrate material. In the ultra-wide band region, the proposed antenna demonstrates multiband characteristics. In order to acquire the path that radiates through the superposition of rectangular patches and a multiple-band operating frequency, the U-shaped and W-shaped openings on the patch must be enlarged. Utilizing a defected ground structure (DGS) on the ground plane so as to encompass the UWB application frequency range (3.1-10.6GHz) permits an enhancement in the impedance characteristics between adjacent frequencies.*

Keywords: Tree-shaped antenna, Fractal antenna design, Multiband characteristics.

I. INTRODUCTION

Modern wireless communication systems need antennas. Small antennas are popular due to their conformability, affordability, flexibility, and mobility. Tiny strip antennas offer these advantages but also disadvantages including low gain, narrow band width, and surface wave excitation. Micro strip arrays are proposed to solve poor gain. This approach may increase an antenna's planned emission pattern, high gain, and desired orientation. Using [1] antenna array Increased antenna gain and band breadth. Different antenna array topologies may yield radiation patterns: same amplitude and variable phase difference, varied amplitude and same phase difference, and changing amplitude and fluctuating phase difference. It is easy to make uniform arrays [2], [4]. UWB systems feature a broad operating band width to enable significant gain and directivity in the required directions. In [5], microstrip antenna array dual polarization is explored for WLAN applications. A CPW-fed four-element linear antenna array for wireless applications and surveillance radar is simulated and studied in this research One component connects to the 1x4 feeding networks. Adding and removing "U"-shaped slots from the radiating element's surface changes the impact. A careful review of each model's data determines the optimal model for production. The manufactured antenna is checked using a combinational analyzer to ensure simulation and measurement agreement [6-7]. Slot antennas have improved by changing slot size and shape. This means the antenna's operational frequency range and impedance bandwidth will grow. Slot antennas are simpler and more durable [9–12]. The radiation pattern may be determined by antenna size and shape. L-shaped, U-shaped, rectangular, and circular slot antennas with stubs were tried before the literature review, but they were difficult and had a restricted bandwidth. Multiple layers in printed slot antennas create alignment challenges. Thus, we employed single-layer CPW feed line technology [13–15]. CPW loses less than micro strip. A fiber optic system is easier to integrate with a CPW slot antenna. Instead of microstrip feed, CPW feed line may help match impedance at these ranges [16–21]. CPW's ground is on the patch's plane, making its construction simple with one metallic layer. This article introduces a novel, tiny CPW-fed with W- and U-shaped slots. Multiband features are shown by the planned ultrawide band antenna. The proposed antenna is studied using ANSYS HFSS 17. The recommended antenna and its results are discussed below.

Antenna design

A 23mm*30mm compact tree-shaped fractal is drawn on a FR4 substrate with a loss tangent of 0.02 and a dielectric constant of 4.4. The fractal is analyzed utilizing the commercially available electromagnetic desktop 17 (ANSYS).

Table 1: Design Parameters of Proposed Antenna (All are in Mm)

W	L	Wf	Lf	C	D	Ts	l1	l2	L3	L4	L5	W1
23	30	2	9.1	8	12	0.15	8.5	8.2	4.5	3.5	2.5	5.9
W2	W3	W4	Wg1	Lg1	ws	ls	Lg2	h				
3	2	2	5.6	8	2.7	6.5	5	1				

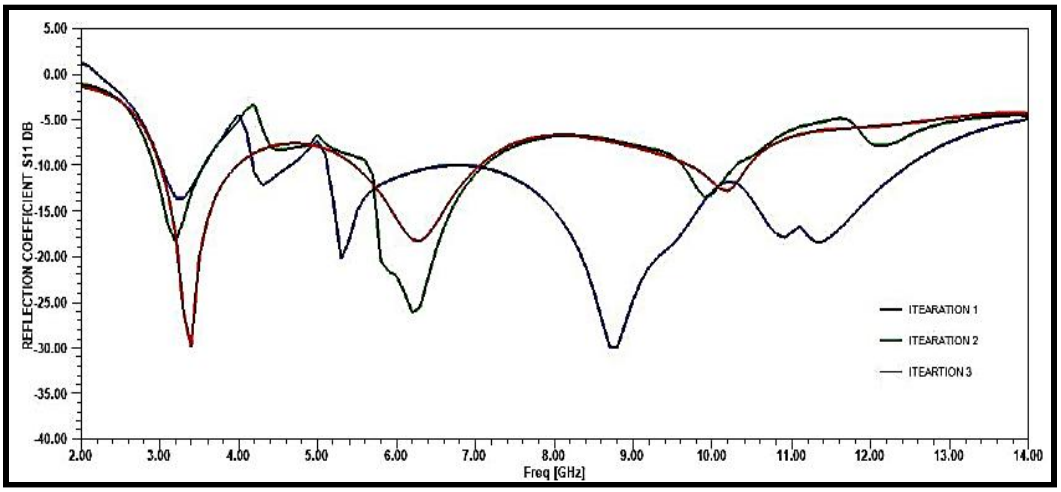

Fig. 2: Reflection Coefficient of Three Iterations of the Antenna.

The recommended antenna's parameters are tabulated after study. The scaling factors are 0.5 for b and 0.7 for a. Each iteration was tested on a 1 mm thick FR-4 substrate (W×L) with a relative permittivity (εr) of 4.4 and a loss tangent (δ) of 0.02.Wf and Lf are the antenna's feedline width and length. DGS-structured ground planes improve UWB band impedance. DGS ground plane has six symmetric corners and a rectangular gap on a Ls×Ws rectangular ground plane. Two ts-wide U-shaped gaps are regularly placed on the patch to prevent interference from WLAN (5.7GHz), weather radar (4GHz), and another X-band application. Simulations were done utilizing the antenna's performance at different iteration stages with a U-shaped slot without DGS and an inverted U-shaped slot (the suggested model) with DGS to determine how fractal iteration lengths affect antenna performance.

The DGS covers the ground plane's U-shaped slot, which is critical to the antenna's performance due to capacitance in the rectangular gap. The first antenna model iteration has one notch, whereas the second has two. The third antenna has dual-notch band characteristics. This study divides rectangular gap with U-shaped slot sizes into many groups. The antenna's impedance matching may be improved by 5.6 mm length and 2.7 mm breadth.

This study indicates that changing the U-Slot gap and Inverted U-shaped slot may affect the operating bandwidth's reflection coefficient. At minimum, each association must mention the author's country and the company. Email is needed to contact the author.

From the three fundamental iterations, the proposed antenna model has been modified by appending a U-shaped slot and a W-shaped slot. As a consequence of these structural modifications, multiband characteristics have been achieved in the ultrawideband region. In Figure 4, the outcomes of the proposed model are illustrated. The frequency range in which the maximum return loss is observed for the proposed antenna is 8.9 GHz.The antenna under consideration finds utility in WLAN, weather radar systems, and X-band frequency bands.

II. RESULTS AND DISCUSSIONS

Return loss, or reflection coefficient (S11), is the signal power discontinuity caused by an impedance mismatch. The antenna's center frequency is 8.9GHz with a maximum return loss of -28dB. This shows that 11.6GHz loses the least power. Gain represents antenna radiation efficiency and directivity. The gain factor may be used to calculate dB gain. The antenna design's lowest and highest gain values are 0.5 and 6 dB.G dBi = 10log 10 (G), where G is the antenna's

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gain factor. Measure and average gain across all directions to get the antenna's normal maximum gain. At 8 GHz, the maximum gain is 5.2dB, showing the widest notch band. The proposed model's notch band implies negative peak gain (-6dB).

The recommended antenna's radiation pattern and efficiency are achieved at different frequency ranges by adjusting gain to space radiation. We won. 3.8GHz and 5GHz (the "notch bands") have quasi-omni directional radiation patterns, whereas 4.3GHz, 5.6GHz, and GHz have omni directional patterns. The antenna's radiation efficiency decreases at the three notch bands but maintains practically constant within the operating band.

Parametric study

Which depict the effects of altering the width and length of the ground ws and ls. The triple notch characteristics are observed at a wavenumber of 4.9mm.

III. CONCLUSION

Using the ANSYS EM tool, a rectangle fractal antenna with u and w-shaped openings that exhibits multiband characteristics is designed and characterized. Multiple resonant frequencies are attained due to the presence of U-shaped and W-shaped apertures. The incorporation of U-shaped and inverted resonances into the proposed model has yielded novel outcomes. By implementing the Defected ground structure in the ground plane that proposes UWB operation (6.4-12.4GHz), impendence characteristics are enhanced. Multiband band characteristics acquired through the utilization of an inverted U-shaped slot are implemented in WLAN and weather forecasting RADAR systems, among other X-band applications. There is a -6dB decrease in gain at the notch band, while the working band (4GHz) exhibits a strong correlation between the working and notch bands. The suggested antenna exhibits broad applicability across a multitude of ultrawide band contexts.

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