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Performance Characterization of Dual-band Microstrip Fractal Antenna

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ABSTRACT

This paper presents the design and performance characterization of dual-band (2.41-2.57 GHz) and (3.90-4.11 GHz) fractal microstrip antenna. Fractal antenna geometry is designed using different sizes of the 'X' slots. This antenna is designed and fabricated on 1.6 mm thick FR4 glass epoxy substrate with dielectric constant $\varepsilon_r = 4.4$. The radiating patch of antenna is about 35.4 mm × 27.82 mm with feed width, length is about 16.4 mm and 2.6 mm respectively. Results of the antenna are validated using Ansoft HFSS (High-Frequency Structured Simulator) software as return loss, radiation patterns and gain of the antenna.

Keywords: *FR4 glass epoxy, fractal antenna, performance, hfss*

1. INTRODUCTION

In wireless communication microstrip fractal antenna [1] development increases rapidly because it allows dual frequency band operation with small size antennas. IEEE S-band [2] covers the radio wave frequencies of 2 to 4 GHz and IEEE 802.11 WLAN (Wireless Local Area Network) works on 2.4 GHz (2.4 –2.484 GHz) ISM frequency band. A dual frequency antenna is required for simultaneous transmission and receiving of the signal at two different frequency bands. This paper presents the design of 'X' shape slotted dual-band fractal antenna which works at resonant frequency of 2.49 and 3.98 GHz. The performance parameters of antenna are compared with different dual-band WLAN antennas.

This paper is organized in 8 sections, section 2 highlights the previous work done in the field of WLAN antennas. Section 3 depicts the design of antenna. Section 4 presents the simulated results of antenna. Section 5 and 6 presents the fabrication of antenna and its measured results respectively. Section 7 shows performance comparison with other antennas and section 8 concludes the paper.

2. RELATED WORK

A number of antenna designs are developed for the operation of WLAN. In 2011, Agarwal et al. [3] presents stack notched rectangular patch antenna, Yeh et al. [4] presents F-shaped monopole antenna designed using horizontal and vertical metal lines for 2.4 and 5.2 GHz frequency bands, Hilbert curves based antenna for 2.45/5.35 GHz band [5], In 2015 Clarissa et al. [6] characterize UWB elliptical monopole antenna, r-shaped wideband antenna [7], L-shaped narrow slotted antenna with reduced size [8], Hong et al. [9] designed a fork monopole and rectangular ring based rectangular patch fractal antenna, Gas coupling based square fractal antenna for bandwidth enhancement [10], Kailas et al. [11] designed a CPW (co-planar waveguide) fed configured fractal antenna for ultra-wideband from 3.1 to 10.6 GHz, In 2012, Ambresh et al. [12] designed a dual-band slot etched antenna which achieves 28% compactness [12], G-shaped monopole dual-band printed antenna [14].

3. DESIGN OF 'X' SHAPE SLOTTED FRACTAL ANTENNA

The 'X' shape slotted fractal antenna [15] is designed using 1.6 mm thick FR4 glass epoxy substrate with dielectric constant $\varepsilon_r = 4.4$. The radiating patch size of antenna is about 35.4 mm × 27.82 mm. Line feed is used at the input port of antenna with length and width of 16.4 mm, 2.6 mm respectively.

The dimensions of antenna are presented in figure 1 are optimised as follows: L = 40 mm, W = 40 mm, L_1 = 35.4 mm, W_1 = 27.82 mm, L_2 = 16.4 mm, W_2 = 5mm, W_3 = 2.6 mm.

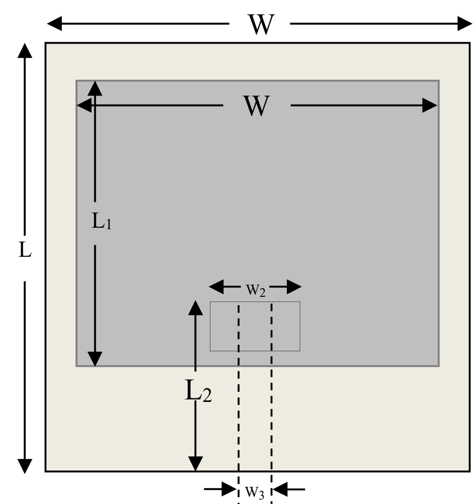

Figure 1: Antenna dimensions

4. SIMULATION RESULTS

This section presents the simulation results of the antenna parameters. Ansoft HFSS simulator is used to analyze and present the simulated results of 'X' shape slotted antenna.

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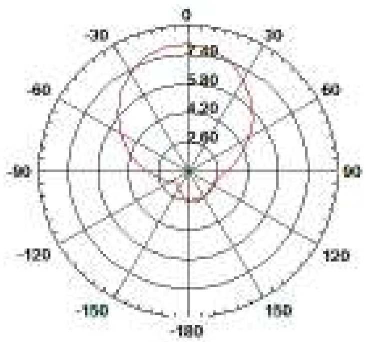
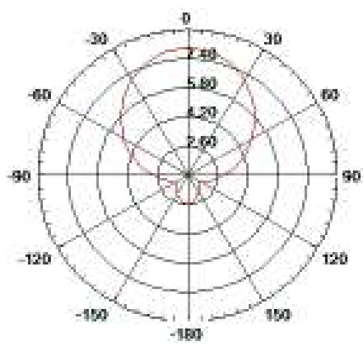
A. Radiation Pattern

In far field reports, radiation patterns of antenna plotted on X-Y plane at resonant frequency of 2.49 and 3.98 GHz.

Figure 2(a) and 2(b) plots the radiation pattern of 2.49 GHz band with (**θ** = all degrees, **φ** = 0) and (**θ** = all degrees, **φ** = 90) degrees.



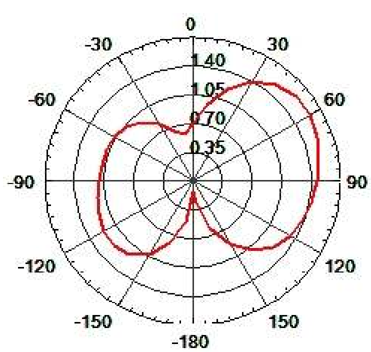
(a)



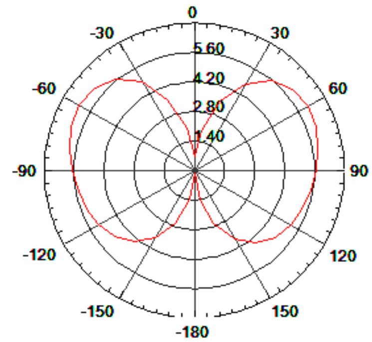
(b)

Figure 2: Radiation pattern at 2.49 GHz resonant frequency (a) ***φ*** = 0 degree (b) ***φ*** = 90 degree

Figure 3(a) and 3(b) observes radiation pattern of 3.98 GHz frequency with (***θ*** = all degrees, ***φ*** = 0) and (***θ*** = all degrees, ***φ*** = 90) degrees.

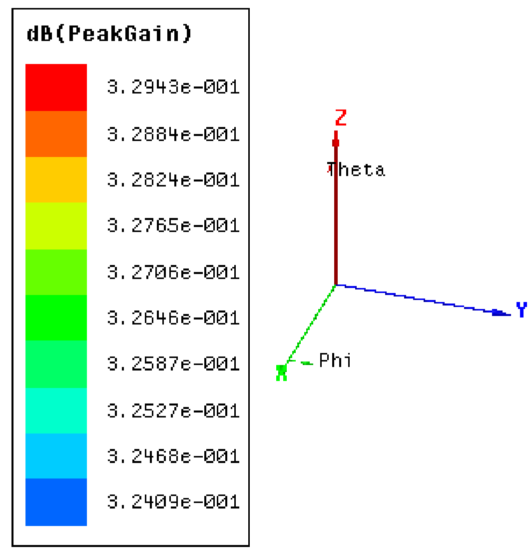


(a)

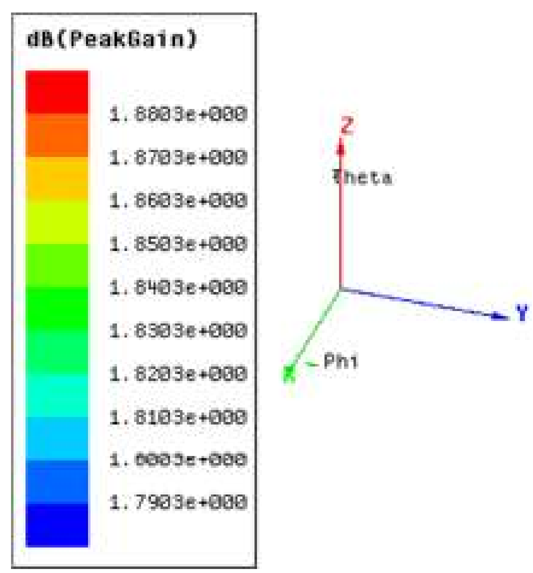


(b)

Figure 3: Radiation pattern at 3.98 GHz resonant frequency (a) ***φ*** = 0 degree (b) ***φ*** = 90 degree



(a)



(b)

Figure 4: Peak antenna gain at resonant frequencies (a) 2.49 GHz (b) 3.98 GHz

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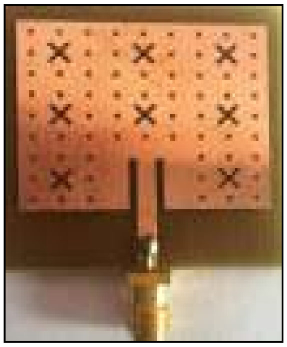
B. Antenna Gain

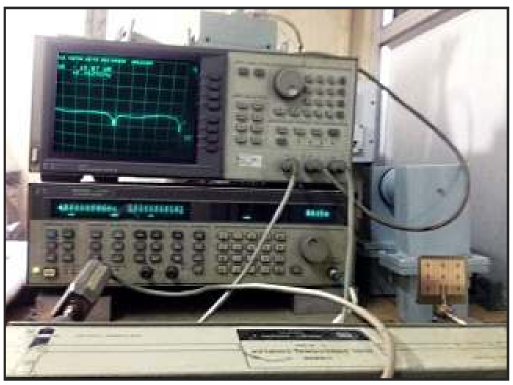
The simulated peak antenna gain is presented in figure 4(a) and 4(b). Antenna achieves gain of 3.29 dB and 1.88 dB at 2.49 GHz and 3.98 GHz resonant frequencies respectively.

4. FABRICATION OF ANTENNA

Fabricated antenna is designed with different size of the 'X' shape slots [15]. The sizes of slots are 0.707 mm, 3.476 mm and 0.353 mm, 1.006 mm width and length respectively.



(a)



(b)

Figure 5: (a) Fabricated antenna (b) Antenna testing setup

Figure 5 shows the fabricated 'X' shape slotted antenna with connector and experimental setup for testing of antenna using VNA (Vector Network Analyzer).

5. MEASURED RESULTS

VNA (Vector Network Analyzer) is used to measure the return loss (S11) results of the fabricated antenna.

A. Return Loss (S11)

'X' shape slotted antenna resonates at two frequency bands (2.41 - 2.57 GHz) and (3.90 - 4.11 GHz). Measured and simulated analysis of return loss (S11) parameter of dual-band antenna is presented in figure 6. For practical application, the value of return loss should of -10 dB for operation of an antenna. Measured and simulated return loss results of antenna are plotted as -29 dB, -20 dB and -26 dB, -18 dB for 2.46 GHz, 3.96 GHz and 2.49 GHz, 3.98 GHz resonant frequencies respectively.

Return loss result confirms the acceptability of the antenna.

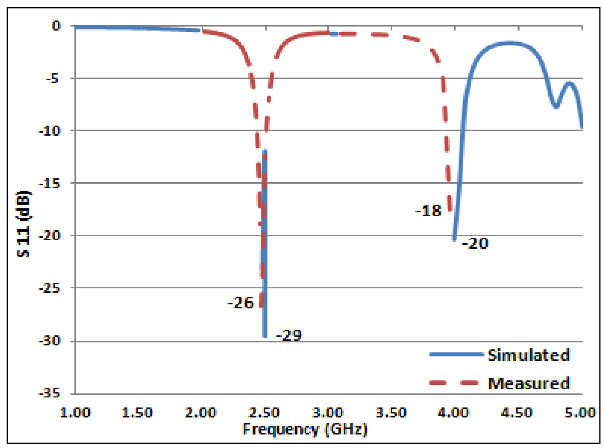


Figure 6: Simulated and measured return loss (S11) results

Table 1: Performance Comparison of WLAN Antennas

Antenna Type	Frequency Band (GHz)		Return Loss (dB)				Simulated Gain (dB)	
			Simulated	Measured	Simulated	Measured		
L-shaped	2.3 - 2.69	4.8 -5.4	- 23	- 23	- 39	- 31	1.8	2.5
G-shaped	2.25 - 2.62	4.09 - 6.0	- 35	- 21	- 30	- 20	2.39	3.43
Hilbert Curve antenna	2.42 - 2.51	5.2 – 5.5	- 27	- 19	- 36	- 26	3.24	1.12
F-shaped	2.18 - 2.75	5.1 – 5.3	- 18	- 13	- 27	- 23	2.0	2.7
'X' shape Slotted	2.41 - 2.57	3.9 – 4.11	- 29	- 26	- 20	- 18	3.29	1.88

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6. PERFORMANCE CHARACTERIZATION

For characterization of antenna performance, the results of 'X' shape slotted fractal antenna are compared with L-shaped [8], G-shaped [14], Hilbert Curve antenna [5] and F-shaped [4] dual-band WLAN antennas are presented in table 1.

Table 1 shows that the antenna results are better as compared to other WLAN fractal antennas which validate the usefulness and operation of the antenna for WLAN frequencies.

7. CONCLUSIONS

This paper presented the performance analysis of 'X' shape slotted dual-band microstrip fractal antenna. The antenna operates on (2.41-2.57 GHz) and (3.90-4.11 GHz) as lower and higher frequency bands respectively. Simulated and measured return loss results of the antenna are noted as -29 dB, -26 dB and -20 dB, -18 dB at 2.49 GHz and 3.98 GHz resonant frequencies respectively. This antenna achieves simulated peak gain of 3.29 dB and 1.88 dB. The performance comparison of 'X' shape slotted antenna with other dual-band WLAN antennas presented in table 1 confirms its suitability for WLAN applications.

REFERENCES

[1] K. Singh, V. Grewal, R. Saxena, Fractal Antennas: A Novel Miniaturization Technique for Wireless Communications, *Int. J. Recent Trends in Engineering* 2: 172−176, 2009.

[2] C. -A. Balanis, Antenna Theory: Analysis and Design, John Wiley & Sons. 2005.

[3] A.-K. Agarwal, S.-S. Pattnaik, S. Devi, and J.G. Joshi, Broadband and High Gain Microstrip patch antenna for WLAN, *Indian J. Radio & Space Physics* 40: 282−286, 2011.

[4] S.-H. Yeh, K.-L. Wong, Integrated F-shaped monopole antenna for 2.4/5.2 GHz dual-band operation, *Microwave and Optical Technology Letters* 34: 24−26, 2002.

[5] S.-S. Bor, T.-C. Lu, J.-C. Liu, B. H. Zeng, Fractal monopole-like antenna with series hilbert-curves for WLAN dual-band and circular polarization applications, *Microwave and Optical Technology Letters* 34: 876−880, 2009.

[6] L.-N. Clarissa de, R.-M. daSilva, H. P. F. daSilva, D. G. Assuncao, Experimental characterization of FSS for WLAN applications with low-cost UWB elliptical microstrip monopole antennas, *Microwave and Optical Technology Letters,* 56: 1331−1333, 2014.

[7] M.-A. Dorostkar, R. Azim, M.-T. Islam, "A Novel T Shape Fractal Antenna For Wideband Communications", Proceedings of 4th International Conference on Electrical Engineering and Informatics (ICEEI), December 2013.

[8] Y. F. L. Lin, H.-D. Chen, H.-M. Chen, A dual-band printed L-shaped monopole for WLAN applications, *Microwave and Optical Technology Letters* 37: 214−216, 2003.

[9] X. He, S. Hong, H. Xiong, Q. Zhang, E.-M. Tentzeris, Design of a novel high-gain dual-band antenna for WLAN applications, *IEEE Antennas and Wireless Propagation Letters* 8: 798−801, 2009

[10] A. Khanna, D.-K. Srivastava, J.-P. Saini, Bandwidth enhancement of modified square fractal microstrip patch antenna using gap coupling, *Int. J. Engineering Science and Technology*, 18: 286−293, 2015.

[11] K.-S. Kailas, C.-R. Suthikshn, CPW fed hexagonal microstrip fractal antenna for UWB wireless communications, *Int. J. Electronics and communications* 69: 31−38, 2015.

[12] P.-A. Ambresh, P.-M. Hadalgi, P.-V. Hunagund, Compact dual band slotted patch antenna for wireless systems, *Indian J. Radio & Space Physics* 41: 372−376, 2012.

[13] F.-L. Yi, H.-D. Chen, H. M. Chen, A dual-band printed L-shaped monopole for WLAN Applications, *Wiley Microwave and Optical Technology Letters* 37: 214−216, 2003.

[14] C.-Y. Pan, C.-H. Huang, T.-S. Horng, A new printed G-shaped monopole antenna for dual-band WLAN, *Wiley Microwave and Optical Technology Letters* 45: 295−297, 2005.

[15] R. Krishan, V. Laxmi, 'X' Shape Slot-Based Microstrip Fractal Antenna for IEEE 802.11 WLAN, Advances in Intelligent Systems and Computing 553: 135-143, 2017.

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Ram Krishan obtained his Ph.D in Computer Science and Engineering from Guru Kashi University, Talwandi Sabo in 2017 and M.Tech in Computer Engineering from Punjabi University, Patiala in year 2009. Presently he is working as Assistant Professor in Department of Computer Science, Punjabi University Guru Kashi College, Talwandi Sabo, Bathinda (Punjab), India. His research areas include wireless communication and antenna design.