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A Rectangular Microstrip Antenna Loaded with Log-Periodic Stubs for Tri-Bands Operation

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Abstract

In this paper, a rectangular microstrip antenna loaded with two log periodic stubs is proposed. The antenna geometry is fed with a microstrip line which is tapered at the connection point. The proposed geometry is designed on easily available FR4_epoxy dielectric material and the dimensions of the dielectric substrate used are of 48 mm x 36 mm x 1.6 mm. Antenna geometry?s performance is investigated in the frequency range between 2 GHz to 20 GHz. The geometry exhibits resonances at 7.76GHz, 11.27GHz, and 16.22GHz which lie in the C, X, and Ku bands. To validate the design, proposed geometry was fabricated and tested. Measured results fairly agree with the simulated data.

Index terms— planar antennas, rmsa, stub loading, triple band antennas.

1 Introduction

og-periodic dipole antennas (LPDAs) were first reported by Rumsey's. Later, LPDA geometries for practical applications were developed by DuHamel, and Isbell [1]. After this, R. Carrel [2] reported mathematical analysis of LPDA and computed its various parameters like radiation patterns and input impedance. However, in modern wireless applications planar (2D) antennas are preferred over 3D antennas. Among planar antennas, microstrip antennas are most preferred ones because of their light weight, small size, low cost, and ease of fabrication and integration [3][4][5][6].

In order to increase the density and to reduce the size/volume the concept of substrate integrated circuits, particularly the laminated waveguide [6][7][8][9] and the substrate integrated waveguide (SIW) [10][11][12][13][14][15][16][17][18][19], has been proposed as a promising technology for microwave and millimeter-wave components & systems which helps in achieving low cost, planar, compact, and high-density integration.

However, most of these geometries are complicated as whole geometry design depends on the log-periodic structure. In this work a simple rectangular microstrip antenna loaded with logperiodic stubs has been investigated thoroughly for exciting triple bands [20] with a very high gain of 10dB (conventional MSAs offer 5 to 6dB) and above at resonances. It should be noted that only stubs Although, the proposed geometry exhibits multiple S11 bands, only three resonances are useful as gain is positive at these frequencies.

Antenna geometry is presented in Section 2. Section 3 presents geometry optimization procedure. Experimental results and discussions are covered in Section 4. Finally, the work is concluded in Section 5.

2 II.

3 Antenna Design

The geometry of rectangular microstrip antenna loaded with log periodic stubs is shown in Figure 1 and its optimized dimensions are listed in Table 1. Log periodic stubs are added to excite the multiple resonances and to enhance bandwidth & gain of each resonance bands. The geometry was fed with the microstrip line which is tapered at the feed end for proper impedance matching. The proposed geometry was designed and optimized on easily available FR4_epoxy substrate with dielectric constant of 4.4 and thickness of 1.6 mm. The geometry was simulated with an Ansoft's high frequency structure simulator (HFSS) v.13 [21] which is electromagnetic simulation software. Section 3 gives the details of optimization procedure of the proposed antenna. L Abstract- In this paper, a rectangular microstrip antenna loaded with two log periodic stubs is proposed. The antenna geometry is fed with a microstrip line which is tapered at the connection point. The proposed geometry is designed on easily available FR4_epoxy dielectric material and the dimensions of the dielectric substrate used are of 48 mm x 36 mm x 1.6 mm. Antenna geometry's performance is investigated in the frequency range between 2 GHz to 20 GHz.

The geometry exhibits resonances at 7.76GHz, 11.27GHz, and 16.22GHz which lie in the C, X, and Ku bands. To validate the design, proposed geometry was fabricated and tested. Measured results fairly agree with the simulated data.

follow the LPDA technique whereas the base is a simple rectangular microstrip antenna (RMSA).

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5 Geometry Optimization

In this section parametric study is carried out for optimizing the proposed antenna geometry. Parameters chosen for optimization are position of right log arm (RLA), tapering length (TL), and feed arm width (W). Effect of all these parameters on antenna performance are investigated thoroughly and presented in the following sub-sections.

6 a) Variation of Position of Right Log Arm (RLA)

In this study right log arm (RLA w. r. t. right edge of rectangular base) position is varied from in steps of 2 mm and keeping all other parameters remains constant. The simulated results of reflection coefficient (S11) and gain of antenna are shown in Figure **??** (a) and (b) respectively. From the study of simulated reflection coefficient characteristics, gain of the antenna is optimum at RLA-1. (Note: RLA is the position of right log arm from edge of rectangular base and left movement is indicated by -ve sign and right movement is indicated by +ve sign).Parameter L 1 L 2 L 3 L 4 W 1 W 2 W 3 W 4 D 1 D 2 D 3 D 4

Values (mm) 4 2.6 1. The proposed antenna is excited through microstrip line. However, for proper matching, the point at which the line is joined to antenna geometry is tapered. The tapering length (TL) at the connection point is varied in steps of 0.25 mm from 7mm to 8mm and keeping all other parameters constant. It is interesting to note that the geometry offers optimum results at TL = 7.95mm. The simulated results of reflection coefficient (S11) and gain of antenna are shown in Figure 3 (a) and (b), respectively. From the study of simulated reflection

7 c) Variation of Feed Arm Width (W)

In another effort, the width of microstrip feed line was varied to investigate its effect on antenna performance. The feed arm width (W) from 3.5mm to 4.5mm in steps of 0.25 mm and keeping all other parameters constant. The results (S11 and gain vs. freq) are presented in Figure 4 (a) and (b), respectively. From Figure 4 it may be noted that the optimum results can be obtained for W=4mm. In order to understand the effect of individual stub, we used one at a time i.e., one arm is kept and other is removed. Also, the single arm effect was observed by keeping it at the center of the antenna geometry (Figure 5). However, no significant change in the results was observed (pl. ref. Figure **??**).

8 Experimental Validation of the Geometry and Discussions

The proposed geometry shown in Figure 1 with its optimized dimensions listed in Table 1 is fabricated on FR4_epoxy substrate having dielectric constant of 4.4 and thickness of 1.6 mm. The photograph of fabricated prototype is shown in Figure **??**. In Figure **??**, the setup of measurement of reflection coefficient of antenna is shown. Reflection coefficient characteristics of measured results are compared with simulated values in Figure **??**. From Figure **??** it may be noted that measured results fairly match with simulated data. Radiation patterns at all three resonances are plotted in Figure 10. From these plots it may be noted that the radiation characteristics are stable across the frequencies of operations.

9 Conclusions

In this paper, a rectangular microstrip antenna loaded with two log periodic stubs is proposed. The proposed geometry is fed with a microstrip line which is tapered at the connection point for proper impedance matching. The proposed geometry is designed on easily available FR4_epoxy dielectric material and log periodic stubs are added to excite the multiple resonances and to enhance bandwidth of each resonance bands. Besides multiple resonances, the antenna offers high gain of greater than 10dB at the operating frequencies. The future work includes bandwidth enhancement of individual bands and possible investigation of excitation of four bands. [1] [2]

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Figure 1: FFigure 1 :

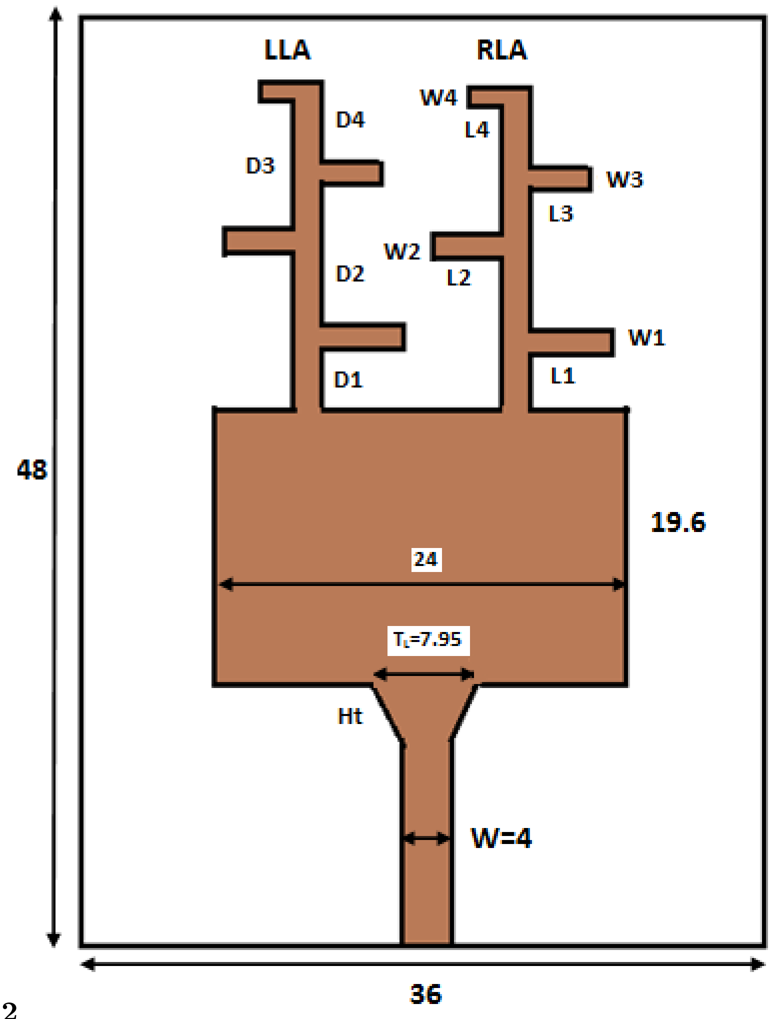

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Figure 2: 2 FeFFigure 2 :

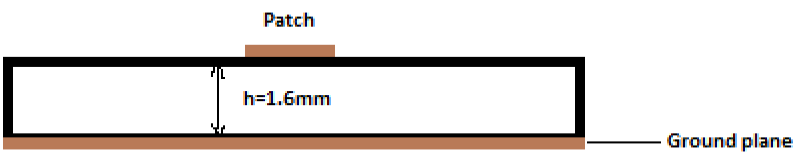

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Figure 3: Figure 3 :

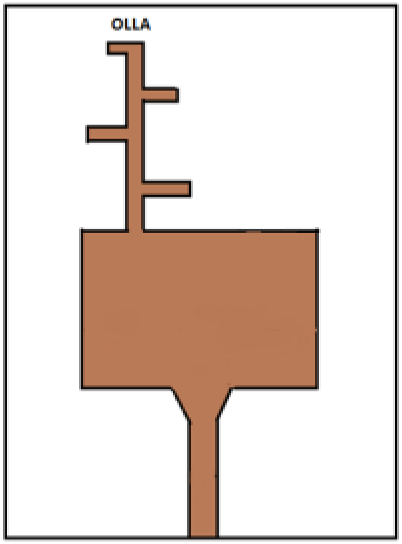

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Figure 4: Figure 4 :

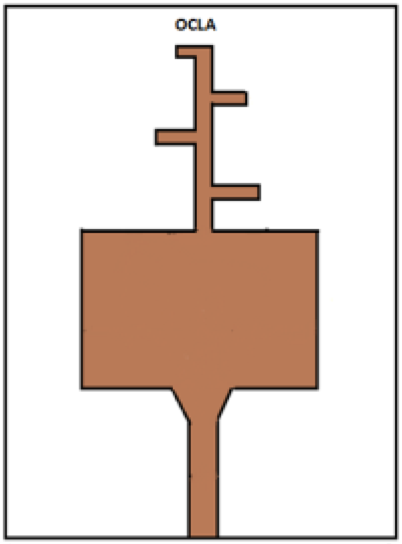

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Figure 5: Figure 5 :

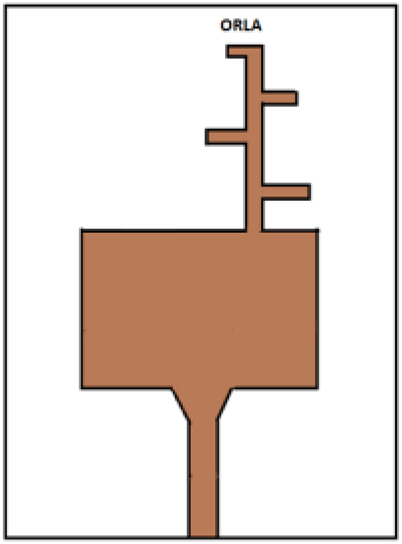

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Figure 6: Figure 6 :Figure 7 :FFigure 8 :Figure 9 :

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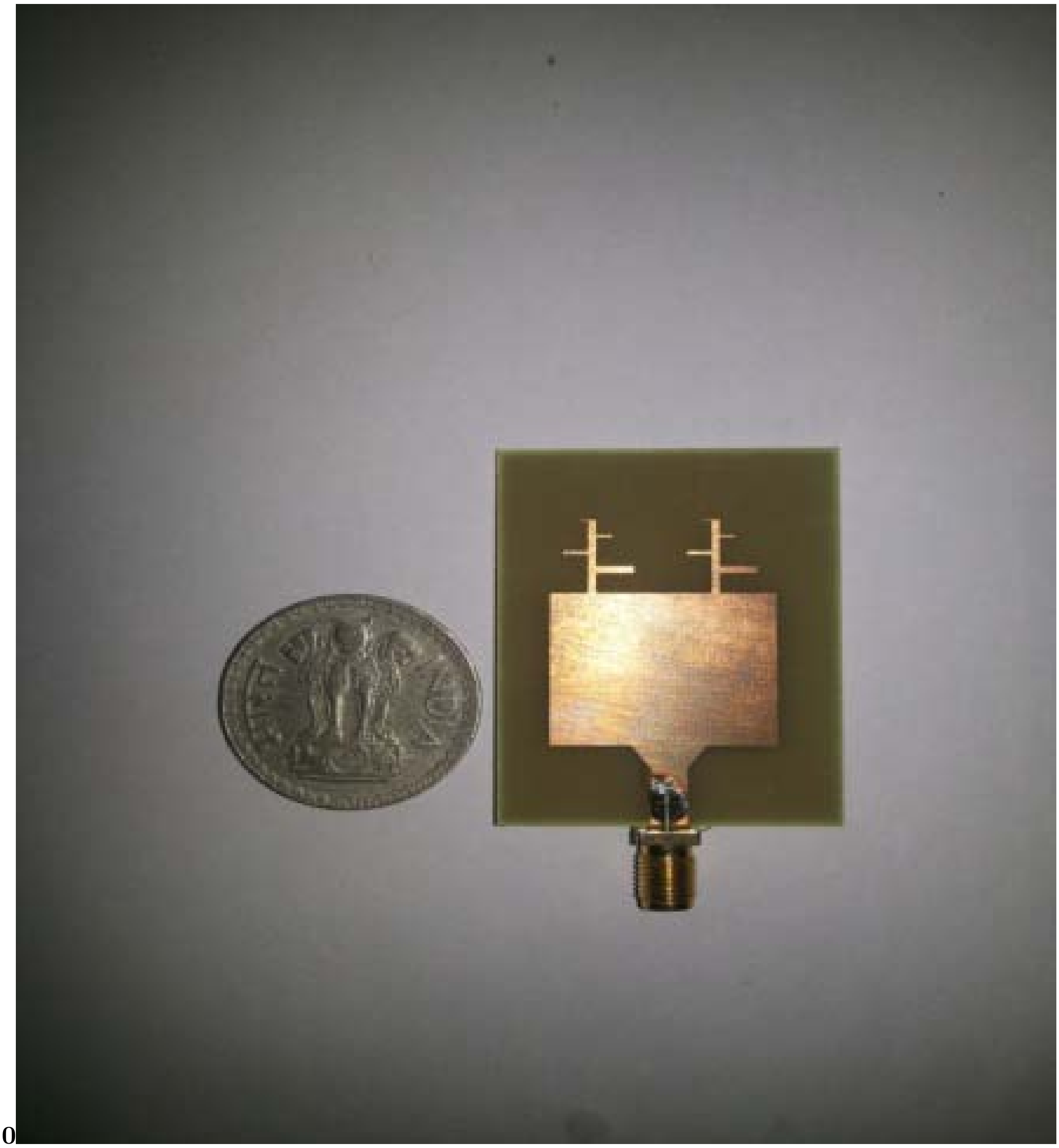

Figure 7: Figure 10 :

1

Figure 8: Table 1 :

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