

A compact slot antenna with improved bandwidth and gain for wireless applications

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Abstract

A wide-slot antenna is investigated to achieve a bandwidth of about 162%. The ground plane includes a rectangular slot with dual SRR and two semicircular defects in the bottom side of the rectangular slot. A fork like feed-line with two parasitic stubs to increase the bandwidth is used to feed the slot. 37*37*0.8 mm³ is the size of the proposed antenna and the dielectric substrate used is FR4. The measured bandwidth ranges from 1.8-17.5 GHz which is approximately 162%. Significant improvement in gain for the frequency range of 1.8-6.1 GHz is observed. The proposed antenna has radiation patterns that are stable and omnidirectional in both E and H planes in all the six frequency points for entire frequency range. The simulated and measured results are in good agreement.

Keywords: SRR; Semicircular Slots; Bandwidth Enhancement; Fork like Fed-Line

1. Introduction

In the new information era wideband wireless communication technology has become a necessity. As the number of users is increasing rapidly the technologies that are wide in bandwidth and have high data rate are required. Ultra-wideband (UWB) could be one of such technologies developing in recent years. It is a short range high rate technology. It is a technology that is developed to transfer data at a fast rate over a short range (less than 10m). It can provide a data rate of hundreds of mega bits per seconds which is required for video communication in local applications like home networking. It is also a low cost and low power system which is suitable for ad-hoc sensor networks. It has a frequency band of 3.1-10.6 GHz and a spectrum band of 7500 MHz. It must have a bandwidth greater than the 20% of the centre frequency [1-2].

The designing of metamaterial structure is effective technique to improve the gain and bandwidth but to make their product constant. To get the negative value of ϵ and μ , split ring resonators (SRR) are designed [3]. The loop between the SRR creates capacitive and inductive effect in the circuit and due to this, resonance is created [4]. In the metamaterials, non-magnetic structures help to obtain resonant magnetic responses. These structures are designed as very small resonators with distributed capacitive and inductive elements [5-6].

In recent years, printed slot antennas have become really popular since their wide frequency bandwidth, ease of integration, and low profile nature make them a popular choice. In slot antennas bandwidth is enhanced by using a fork-like feeding stub as it enhances the coupling between the wide-slot and the feed-line [7]. Rotating the slot at a proper angle or the fractal shaped geometry introduces a new resonant mode that increases the bandwidth [8-9]. Introducing a patch at the slot provides additional surface current path creating more resonance and improving the bandwidth [10].

In this paper, a slot antenna is proposed based on the work of [11]. Off-set feed line [12-15] is used to reduce the size of the antenna

and to enhance the bandwidth further improvement in the bandwidth is observed by using dual SRR and semicircular slots in the ground plane. The size and the position of these structures are optimized to increase the coupling between the ground plane and the feed-line. The antenna is fabricated and it is observed that there is a close agreement between the simulated and measured results. The measured bandwidth is found to be 162% ranging from 1.8-17.5 GHz. The improvement in gain for the range of 1.8 - 6.1 GHz is observed and the radiation patterns are observed at six different frequency points.

2. Antenna design

The front and the back view of the proposed wide-slot antenna are shown in Fig. 1. The front side consists of a fork-like feed-line with two parasitic rectangular stubs and the back side consists of the ground plane with a rectangular slot and a displaced Dual SRR structure. At the bottom side of the rectangular slot two semicircular slots are placed. A dielectric substrate (FR4) of 0.8 mm thickness is used with a relative permittivity of 4.4 and a tangent loss of 0.02. The area of the antenna is controlled by using off-set feed-line and displaced patch thus reducing the size of the antenna to 37 mm * 37 mm. The antenna impedance is controlled by the semicircular slots, dual SRR and the off-set feed-line.

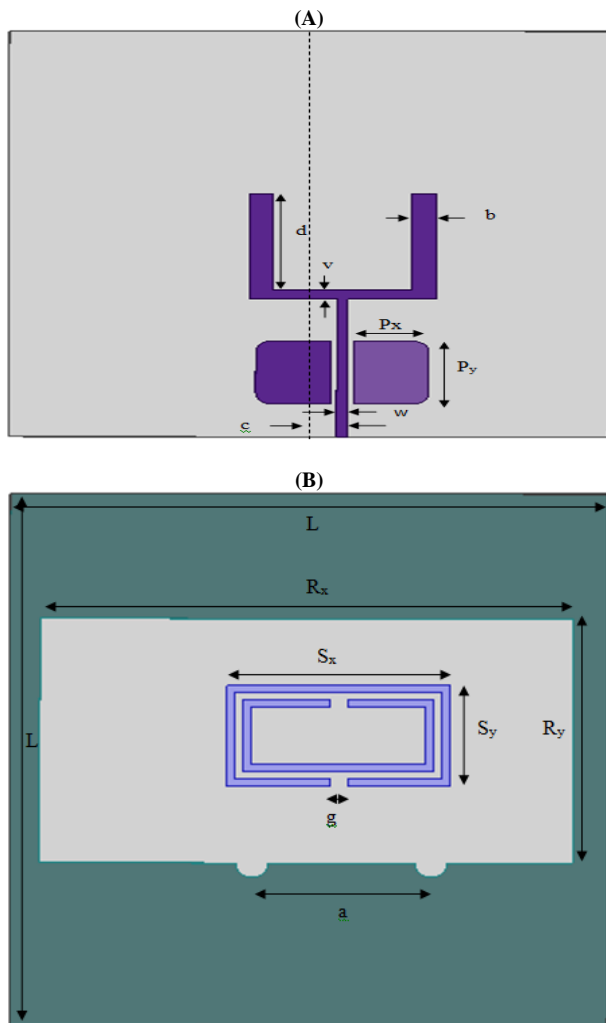


Fig. 1: Proposed Antenna Design A) Top View B) Bottom View.

The feed-line is displaced by $c = 2.05$ mm from the centre of the patch towards the right. The Dual SRR structure is also displaced by an amount of 1.85 mm in the X-direction and by 1.35 mm in the Y-direction. The distance between the centre of two semicircular slots is $a = 11.1$ mm. The proposed antenna has the following dimensions as shown in Tab. 1.

Table 1: Dimensions of the Proposed Antenna.

Parameters	Dimensions (mm)
L	37
B	1.5
D	8.8
V	0.8
W	0.7
P_x	4.6
P_y	5.75
R_x	33
R_y	17
S_x	13.8
S_y	7
G	1.1

3. Results and discussion

The proposed antenna is fabricated as depicted in Fig. 2. The simulated and measured reflection coefficients are compared in Fig. 3. It is clear that measured results are similar to simulated results. The simulated impedance bandwidth is 158% from the frequency range of 2.28- 18.9 GHz while the measured impedance bandwidth ranges from 1.8-17.5 GHz which is approximately 162%. Here is a small frequency shift in the simulated and measured results which may have occurred due to the fabrication errors.

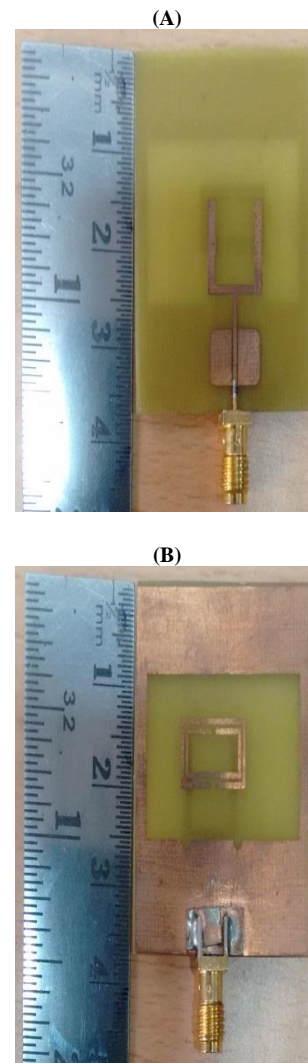


Fig. 2: Fabricated Model of the Proposed Antenna with A) Top View B) Bottom View.

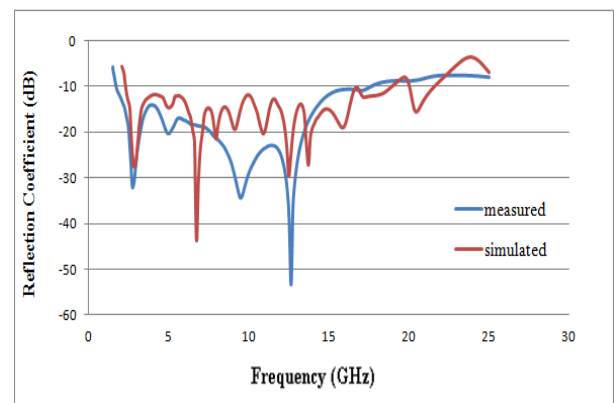


Fig. 3: Comparison of Measured (Blue) and Simulated Values (Red) Of Reflection Coefficient (S_{11}) for the Fabricated Antenna.

The comparison between the simulated and measured VSWR is compared and shown in Fig. 4. VSWR plots also show the similar results when compared to reflection coefficient plot. Thus a good percentage of bandwidth enhancement is obtained by using Dual SRR and modified ground. The semicircular slots in the ground plane are very useful in improving the bandwidth of the slot antenna. In addition to the semicircular slots the Dual SRR structure also improves the bandwidth further.

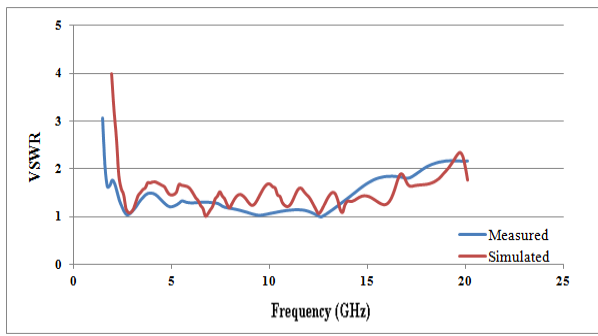


Fig. 4. Comparison between Measured (Blue) and Simulated Values (Red) Values of VSWR for the Proposed Antenna.

The measurement of gain is performed in the anechoic chamber. The dual ridge horn antenna is used as a reference antenna. Fig. 5 represents the comparison between the simulated and measured gain of the fabricated antenna. The gain is improved as compared to the reference antenna [11] for the frequency range of 1.8-6.1 GHz. The measured gain varies from 3.3- 8.25 dB with a maximum value of 8.25 dB at 10.5 GHz.

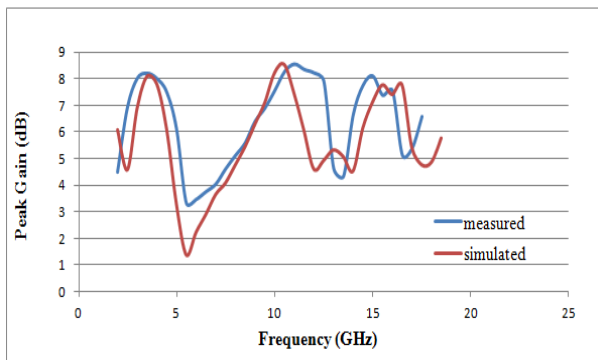


Fig. 5. Comparison of Measured (Blue) and Simulated Values (Red) of Peak Gain for the Fabricated Antenna.

The radiation patterns of the fabricated antenna are also measured in the anechoic chamber at six different frequencies over the entire frequency range. Measured results are shown with blue color and simulated radiation pattern are indicated with red color. It is seen that the simulated and measured results are very close. The radiation patterns thus obtained over the entire frequency range are omni-directional in characteristic. The simulated and measured radiation patterns of the fabricated antenna are represented in Fig. 6.

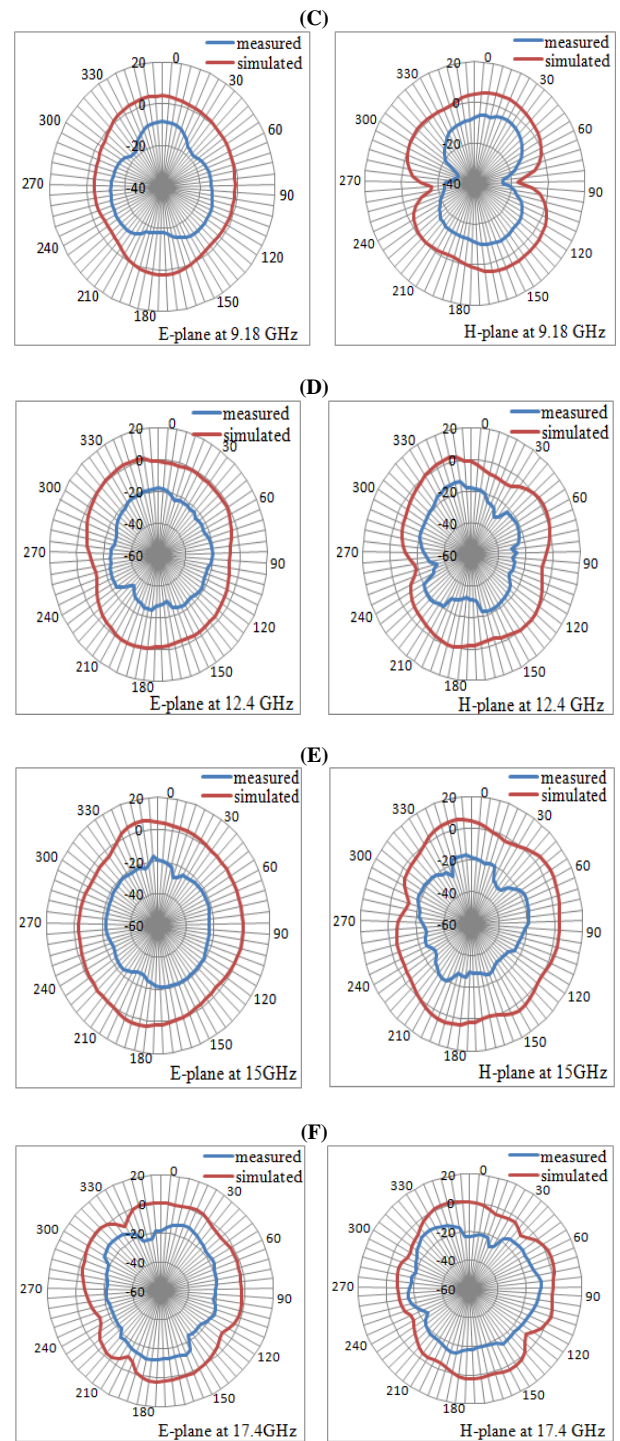
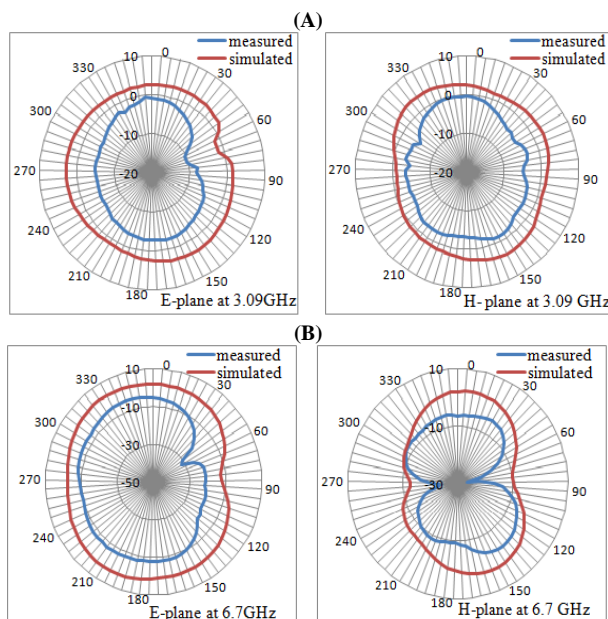


Fig. 6. Simulated (Red) and Measured Values (Blue) of Radiation Patterns of the Proposed Antenna at Frequency (A) 3.09 GHz, (B) 6.7 GHz, (C) 9.18 GHz, (D) 12.4 GHz, (E) 15 GHz, (F) 17.4 GHz.

4. Conclusion

A wide-slot antenna with dual SRR and semicircular slot at the bottom edge of the rectangular slot is proposed and investigated. This antenna consists of a fork-like feed-line with two parasitic rectangular patches. It is observed that the simulated and measured results are in good agreement. The measured bandwidth of the antenna ranges from 1.8-17.5 GHz which is about 162%. The gain of the proposed antenna is improved in the lower frequency range of 1.8-6.1 GHz as compared to the reference antenna. The gain varies from 3.3- 8.25 dB with a highest value of 8.25 dB at 10.5 GHz. The radiation patterns obtained over the entire frequency range are also omni-directional in characteristic. Thus the antenna proposed has a wider bandwidth, improved gain in the lower frequency range and reduced size.

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