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Design of a Wide Slot Antenna for Bandwidth Enhancement for Wireless Communication Application

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Abstract-In this paper we are proposing a brief description about Microstrip printed wide slot antenna with a fork like tuning stub for bandwidth enhancement. By applying fork like tuning stub to the microstrip wide slot antenna instead of line feed, it is experimentally found that operating bandwidth can be enhanced. Experimental results indicate that the impedance bandwidth, defined by -10Db return loss, of the proposed wide slot antenna can reach operating bandwidth of 3.1 GHz at operating frequency about 2GHz which is 6 times greater than conventional wide slot antenna. A comprehensive parametric study has been carried out to understand the effects of various dimensional parameters and to optimize the performance of the designed antenna.

Keywords— Fork like tuning stub, Bandwidth enhancement, wide-slot antenna

I. INTRODUCTION

High bandwidth, small size, simplicity, and compatibility to the rest of the RF front-end are desirable factors of an antenna. Enormous effort has been invested on designing frequency independent or very wide band antennas. In these antenna designs, different geometries are introduced to obtain wide impedance bandwidth, such as a square-ring slot [1], E-slot [2], a rectangular notch [3], wide rectangular slot [4],

and open L-slot [5]. In applications where size, weight, cost, performance, ease of installation, and aerodynamic profile are constrains, low profileantennas like microstrip and printed slot antennas are required.Microstrip-line-fed printed wide slot antennas have received much attention because of their comparably wider operating bandwidth. In order to enhance the bandwidth of a patch antenna, several approaches have been proposed, such as using an impedance matching network [6], thick substrates with low dielectrics constant and multiple resonators [7], [8], parasitic patches stacked on the top of the main patch or close to the main patch in the same plane [9], reactive loading using a U-shaped slot [10], lossy materials [11], a capacitively probe-fed structure [12], L-probe feeding [13], a combined use of both U-slot loaded patch and L-probe feeding [14], and a three-dimensional transition microstrip feed line [16]. By applying fractal geometry in microstrip antennas significance properties of antenna can be improved, such as smaller size, multiband operation, wide bandwidth and low mutual coupling in array structure [1-19].

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In recent years several fractal geometries have been designed for various antenna applications. Some of these geometries have been particularly useful in reducing the size of the antenna [17]. In [18], microstrip line fed printed wide slot antenna with rectangular fractal shaped was introduced and it achieved very good bandwidth at 3rd iteration. By rotating the slot around the centre of the slot [19], bandwidth can be enhanced but in this technique the optimization of rotating angle is required, which is somewhat difficult. Several fractal antenna configurations have been reported in recent years. The fork-like tuning stub studied here is all positioned within the slot region in the opposite side of the printed wide slot. Through proper selection of the parameters of the fork-like tuning stub, it can be expected that the coupling between the microstrip line and the printed wide slot can be controlled more effectively, which makes possible significant bandwidth enhancement of the printed wide-slot antenna. With the development of communication and integration circuit technologies, size reduction and bandwidth enhancement are becoming important design considerations for practical applications of microstrip antennas.This paper introduces wide slot antenna with fork like tuning stub. In this paper the proposed design is fed by fork like tuning stub instead of simple line feed. The feeding mechanism is called fork like tuning stub because shape of feed is look like fork.

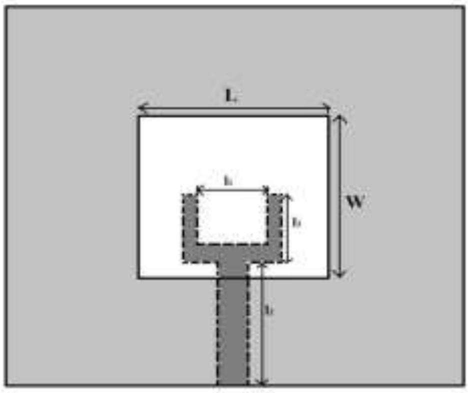

Fig. 1 Geometry of the proposed microstrip printed wideslotantenna with fork like tuning stub

II. DESIGN

Wide-slot antennas have different slot shapes such as rectangular, square, circular; and various feed shapes such as T, cross, fork-like, bow-tie, radial stub, pi, double-T, circular, and rectangular [1]–[6].

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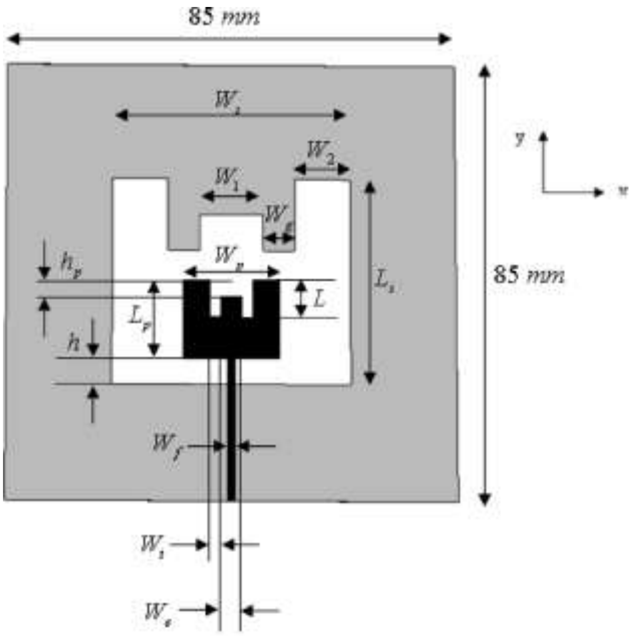
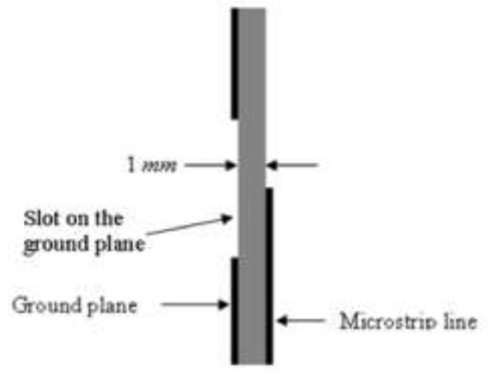
The antenna used in this study employs an E-shaped patch feed to excite the E-shaped slot on the ground plane. This combination is chosen because of its wide impedance bandwidth and good radiation characteristics. In order to achieve wide operating bandwidth and good radiation patterns, we choose an E-shaped feed and similar slot shape. The width and length for the feed is about one third of the slot size and its length is close to, but less than, the quarter wavelength computed at the lower frequency edge. The length is shorter than a printed monopole at the same frequency, because the slot edge acts as a capacitive load to the monopole. an E-shaped patch feed to excite the E-shaped slot on the ground plane. This combination is chosen because of its wide impedance bandwidth and good radiation characteristics.



(a)



(b)

Fig. 2. Configuration of proposed antenna fed by a 50 microstrip line. (a)Top view. (b) Side view.

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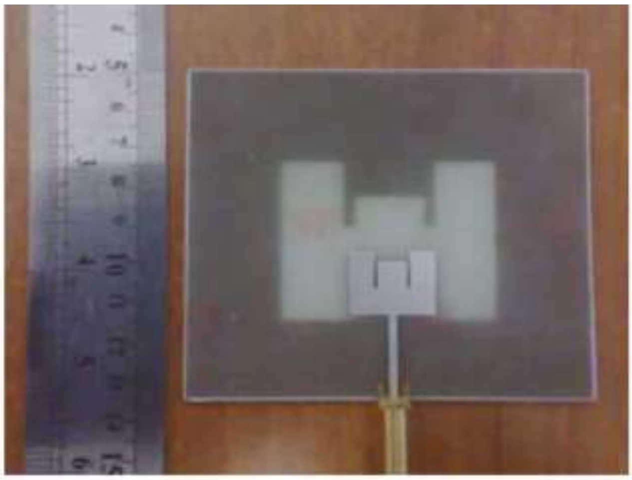
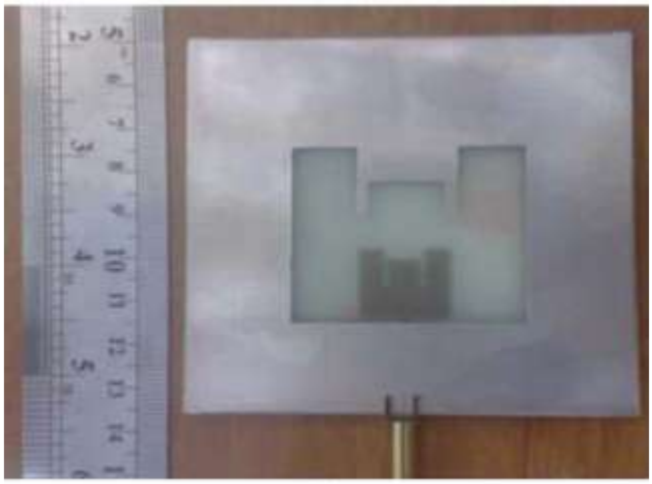


(a)



(b)

Fig. 3. photograph of the fabricated antenna. (a) Top view. (b) back view.

III. ANTENNA CONFIGURATION

The configuration of proposed antenna is shown in figure 1. The proposed wide slot has dimension of L □ W and is printed on a substrate of thickness h and relative permittivity =4.4. The printed wide slot is etched on ground substrate. The wide slot is fed by a 50- microstrip line with a fork-like tuning stub, which is printed on the opposite side of the microwave substrate and placed symmetrically with respect to the centerline (y axis) of the wide slot. The original wide slot is chosen to be square in order to excite two modes with close resonant frequency. The dimension of ground plane is 110 mm x 110mm. The basic rectangular slot microstrip-line-fed printed wide-slot antenna design-1 is shown in Figure 1. Where c is the speed of light in the air, is theeffective relative permitti ity and L is the length of the square slot. The fork-li e tuning stub is composed of a straight section of lengt h l_2 and two branch sections of equal lengths l_3, and the spacing between the edges of the two branch sections is l_1 . The widths of these sections are all the same and equal to that of the 50- microstrip line. By selecting proper dimensions of the fork-like tuning stub, good impedance matching of the printed wide-slot antenna across a much enhanced bandwidth can be obtained. For design simplicity, the width of the tuning stub is chosen to be the same as that of the 50 Ω microstrip line.

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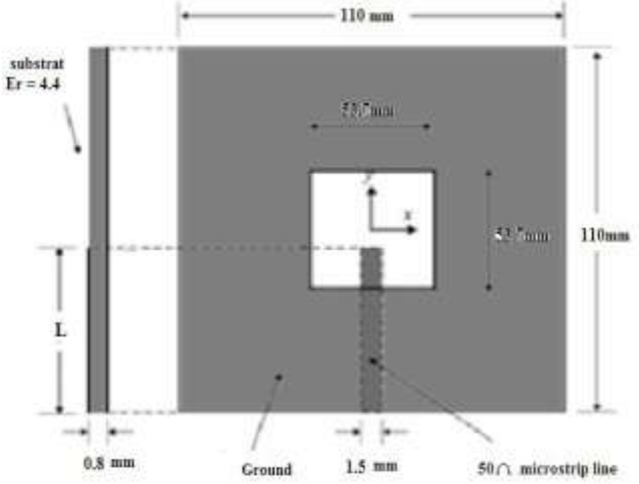

Fig. 4. Geometry of the microstrip printed wide-slot antenna with simple tuning stub

From the simulation it is observed that conventional square slot antenna gives good result for tuning stub length L = 53mm. The dimensions of the references antenna are same as the proposed antenna in [21]. The references antenna is shown in the figure 4.

IV. PARAMETRIC STUDIES

A parametric study is investigated and it demonstrates that the following parameters influence the performance of the designed wide-slot antenna most effectively.

A. FEED AND SLOT SHAPES

In order to achieve a high level of electromagnetic coupling to the feed line, a large slot is used in a wide-slot antenna. Therefore, varying the feed shape or slot shape will change the coupling property and thus the operating bandwidth is limited by matching between the feed shape and the wide slot on the ground plane. On the other hand, for optimum performance the feed and slot shapes should be similar and the feed should occupy an area of about one third of the slot size.

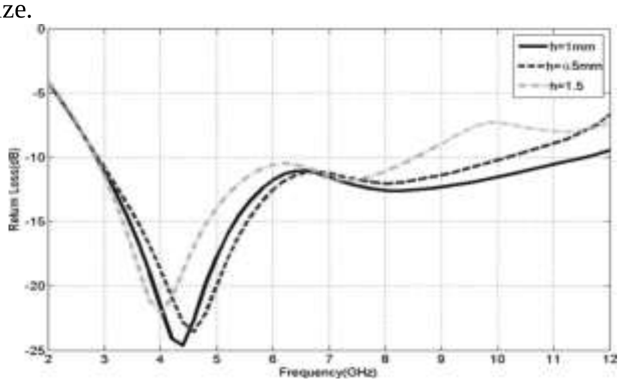

Fig. 5. Simulated return losses of antenna for various feed gaps.

Although a wide-slot antenna provides wide operating bandwidth, generally its operating bandwidth is limited due to the degradation of the radiation patterns at the upper edge of the impedance bandwidth. Through the study of different slot shapes, it is found that currents flowing on the edge of the slot will increase the cross-polarization component in the –plane and cause the main beam to tilt away from the broadside direction in the -plane.

B. EFFECT OF FEED GAP (h)

The feed gap determines the matching between the feed-line and the wide-slot antenna. In [20] the feed gap effect on the impedance matching is investigated. It is found that good impedance matching can be obtained by enhancing the coupling between the slot and feed. When the coupling is increased to a certain value, an optimum operating bandwidth can be obtained. However, if the coupling is further increased more than this value, the impedance matching will deteriorate, showing that over coupling can also degrade the impedance matching as did under coupling. Fig. 8 shows the simulated return losses of the proposed antenna with feed gaps of 0.5, 1, and 1.5 mm. It can be observed that the frequency corresponding to the lower edge of the bandwidth is clearly independent of the feed gap , but the frequency corresponding to the upper edge is heavily dependent on it.

C. C. EFFECT OF [Wg]

This parameter changes the electric field distribution on the wide slot, and reduces the slot size and effective radiation area at the same time. This parameter, as is shown in Fig. 9, can obviously affect the high frequency performance but the low frequency performance of the proposed antenna is clearly independent of the Wg.

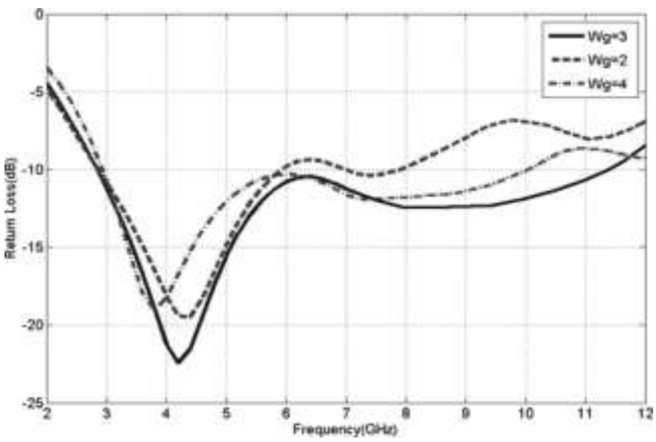

Fig. 6. Simulated return losses of antenna for various Wg.

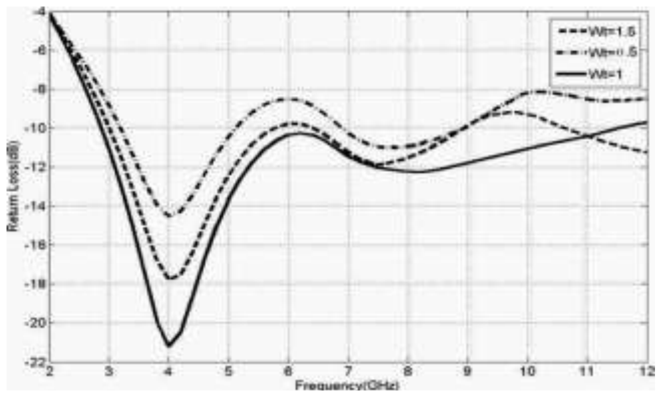

Fig. 7. Simulated return losses of antenna for various Wt.

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4.4. EFFECT OF [Wt]

This factor affects the performance of the proposed antenna most effectively. Fig. 10 shows the relationship of Wt versus return loss. As shown in this figure, the return loss deteriorates within the whole band as Wt changes. The best value for Wt in the designed antenna is 1 mm.

V. CONCLUSION

In this paper, a printed wide slot antenna fed by a forklike tuning stub has been demonstrated. Experimental results indicates that impedance bandwidth of the printed wide slot antenna can be significantly improved by applying fork like tuning stub to wide slot in the ground plane. For the optimal results the impedance bandwidth determined by -10 dB reflection coefficient can reach 3.1 GHz for the proposed design at operating frequency around 2 GHz which is about 6 times than conventional printed wide slot antenna. It was found that by choosing suitable combinations of feed and slot shapes and tuning their sizes, an optimum operating bandwidth can be obtained. Based on these characteristics, he proposed wide-slot antenna can be useful for wideband satellite and communication applications.

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