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Bandwidth Enhancement of a Microstrip Patch Antenna with Square Shaped Parasitic Element

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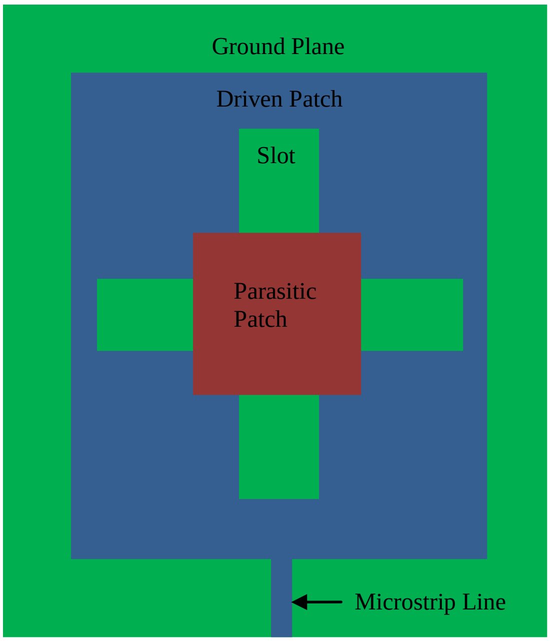
Abstract— ***A new, compact, simple and slotted wideband microstrip patch antenna with stacked configuration is presented in this paper. The antenna is printed on a dielectric substrate, and directly fed from a 50 Ω microstrip line. Using IE3D software package of Zeland, according to the set size, the antenna is simulated. The composite effect of integrating these techniques and by introducing the novel slotted patch offers a low profile, wide bandwidth, high gain and compact antenna element. The computer simulation results show that the antenna can realize wide band characters. The results were validated by measurements in the laboratory. With adjusted parameters, it exhibits a broad impedance bandwidth (VSWR ≤ 2) of about 62.69% (1.394 GHz – 2.667 GHz).***

Keywords— ***Microstrip antenna, wideband, stack, slot, microstrip line, IE3D.***

I. INTRODUCTION

The rapid development of wireless communication systems has increased the demand for compact microstrip antennas with high gain and wideband operating frequencies. Microstrip patch antenna has advantages such as low profile, conformal, light weight, simple realization process and low manufacturing cost. However, the general microstrip patch antennas have some disadvantages such as narrow bandwidth etc. Enhancement of the performance to cover the demanding bandwidth is necessary [1]. There are numerous and well-known methods to increase the bandwidth of antennas, including increase of the substrate thickness, the use of a low dielectric substrate, the use of various impedance matching and feeding techniques, and the use of multiple resonators [2-15]. To overcome the above problem, a multi-layer microstrip antenna structure with two rectangular slots on the rectangular patch which results in a typical mathematical plus symbol is proposed. This paper is a modification of [16] in which the feed was simple coaxial probe. An impedance bandwidth of 15% was investigated. In this paper a printed wide-band stacked patch antenna for enhancing the bandwidth is presented. The lower plus shaped slotted driven patch is fed by a microstrip line and the upper square shaped parasitic patch is electromagnetically coupled. The antenna is simulated using IE3D, 12.32 version of Zealand. Good agreement is obtained between the simulated and experimental results.

II. ANTENNA DESIGN



(a) Top view of the antenna.

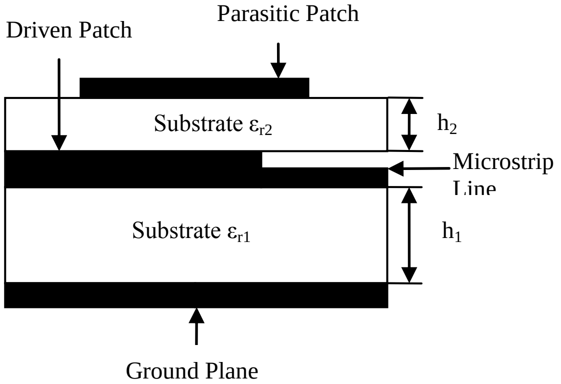
The dielectric constant of the substrate is closely related to the size and the bandwidth of the microstrip antenna. Low dielectric constant of the substrate produces larger bandwidth, while the high dielectric constant of the substrate results in smaller size of antenna. A trade-off relationship exists between antenna size and bandwidth [17]. The resonant frequency of microstrip antenna and the size of the radiation patch can be similar to the following formulas [18].

$$f \cong \frac{c}{2L\sqrt{\varepsilon_r}} \quad (1)$$

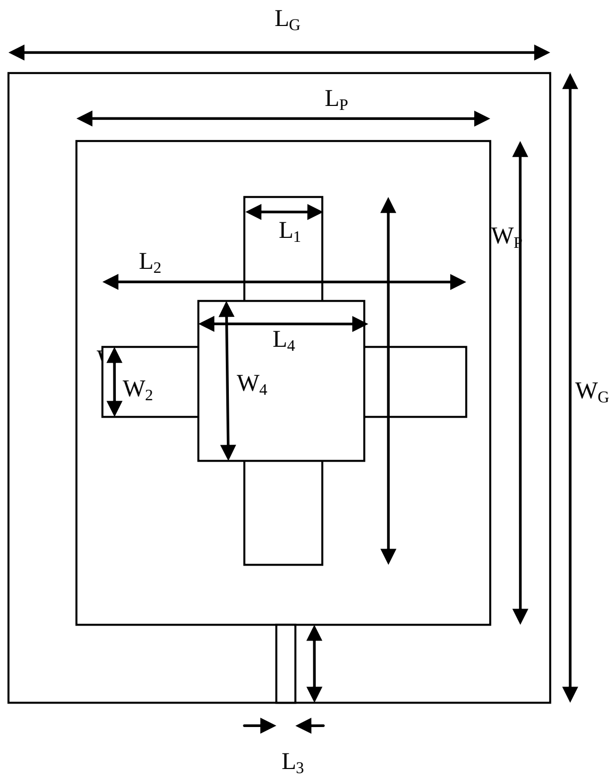
$$W = \frac{2}{f_r}\left(\frac{\varepsilon_r + 1}{2}\right)^{\frac{1}{2}} \quad (2)$$

$$L = \frac{c}{2 f_r \sqrt{\varepsilon_r}} - 2\Delta l \quad (3)$$

Where f is the resonant frequency, c is the free space velocity of the light, L is the actual length of the current, ε_r is the effective dielectric constant of the substrate and Δl is the length of equivalent radiation gap.



(b) Side view of the antenna.



(c) Dimensions of the antenna.

Fig.1. Geometry of the proposed antenna.

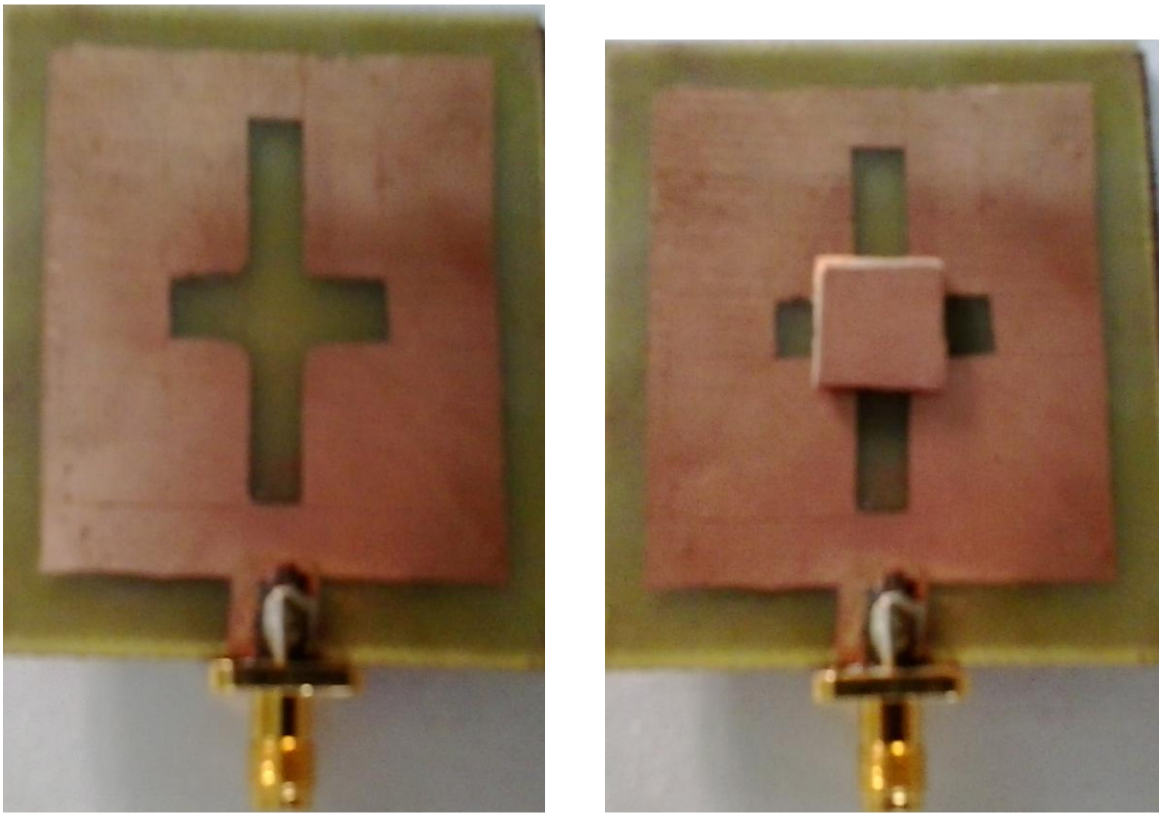
The geometries of the proposed patch antenna are shown in figure 1. The antenna is built on a glass epoxy substrate with dielectric constants $\varepsilon_{r1} = \varepsilon_{r2} = 4.2$ and heights $h_1 = h_2 = 1.6$ mm. The geometry of the top view and side view of the proposed antenna is shown in figure 1 (a) and (b) respectively. The detailed dimensions of the slotted patch are shown in figure (c). Table 1 shows the optimized design parameters for the proposed antenna. Reducing the size of the antenna is one of the key factors to miniaturize the wireless communication devices. However, reducing the antenna size will usually reduce its impedance bandwidth as well. Therefore designing a small antenna operating with a wide impedance bandwidth which satisfies future generation wireless application is a challenging work, especially having stable radiation patterns across the operating frequency band [19-20]. In this paper microstrip line feeding, slot on the patch provide the wide bandwidth enhancement.

Table 1. The proposed patch antenna design parameters.

Parameter	Value [mm]	Parameter	Value [mm]
W_G	50	L_2	20
L_G	50	W_3	5
W_P	40	L_3	7
L_P	40	W_4	10
W_1	30	L_4	10
L_1	5	h_1	1.6
W_2	5	h_2	1.6

III. RESULTS AND DISCUSSIONS

The proposed antenna was first simulated and optimized by IE3D software and was then fabricated and measured. In this section, experimental and simulation results are presented. The pictures of the proposed fabricated antenna fed by a Microstrip line are shown in figure 2. This was used to calculate the return loss, impedance bandwidth and radiation pattern. The simulated and measured return loss of the proposed antenna is shown in the figure 3. The results show that the simulated and measured impedance bandwidths at -10 dB return loss are about 62.69% (1.394 to 2.667 GHz) and 57.73% (1.444 to 2.616 GHz) respectively.



(a) (b)

Fig. 2. Picture of the fabricated antenna. (a) Without parasitic patch. (b) With parasitic patch.

This large enhancement in bandwidth is obtained by selecting suitable slot shape and proper feeding technique. There is a good agreement between the simulated and the experimental results. The VSWR is shown in figure 4. The simulated radiation patterns of the elevation and azimuth of the proposed antenna are shown in figure 5.

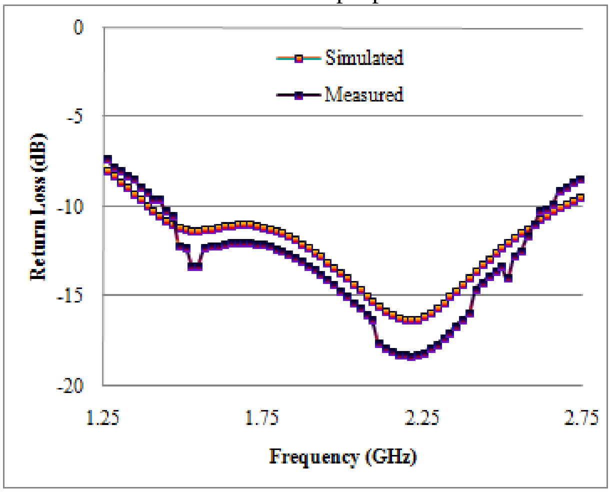


Fig. 3. Simulated and measured return loss of the proposed antenna.

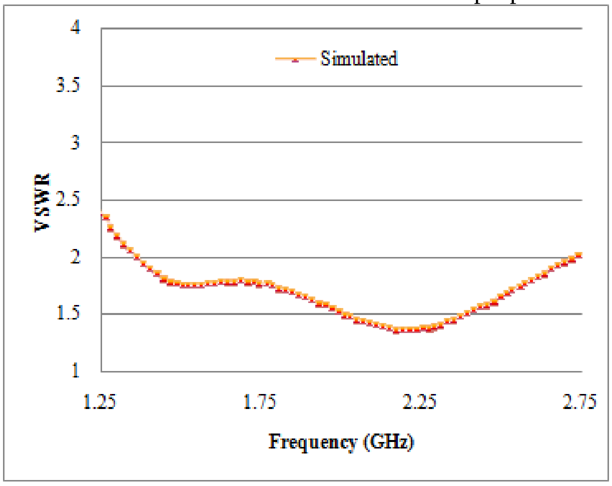
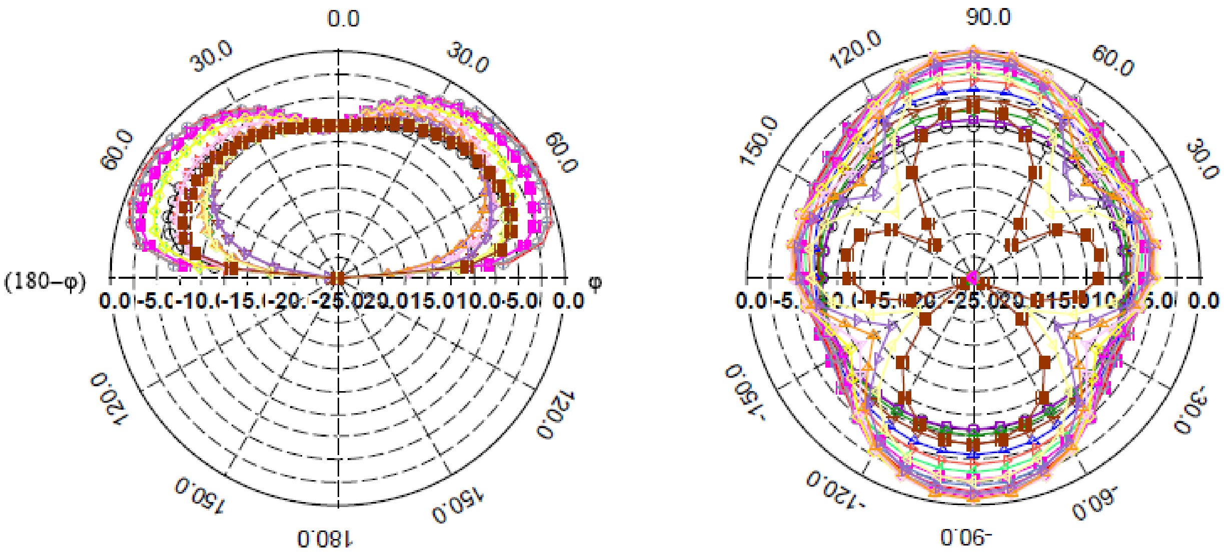


Fig.4. Simulated VSWR of the proposed antenna.



(a) (b)

Fig. 5. Simulated radiation pattern of the proposed antenna. (a) Elevation pattern. (b) Azimuth pattern.

IV. CONCLUSION

A compact, slotted and stacked microstrip patch antenna for enhancing the bandwidth has been designed, simulated and measured successfully. Simulation results of a wideband microstrip patch antenna covering 1.394 GHz to 2.667 GHz frequency have been present. With the use of 50 Ω microstrip line feed the proposed microstrip patch antenna achieves an impedance bandwidth of 62.69% at -10 dB return loss. Good antenna performance and impedance matching can be realized by adjusting the length and width of microstrip line. It can be concluded from the results that the designed antenna has satisfactory performance covering the frequency bands of UMTS (1.92-2.17 GHz), WLAN (2.40–2.48GHz).

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