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A HIGH GAIN DUAL STACKED APERTURE COUPLED MICROSTRIP ANTENNA FOR WIDEBAND APPLICATIONS

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Abstract—This paper presents the design of a dual stacked microstrip antenna over the frequency range of 9.5–16 GHz. Investigations show that in the new structure the impedance bandwidth of the antenna is increased to 44% and the thickness of the antenna decreases to 0.14λ. Furthermore, the gain bandwidth of the antenna (above 8 dB) is increased to 5.1 GHz (40%).

1. INTRODUCTION

Increasing impedance and gain bandwidth and decreasing dimensions of microstrip antennas are primary goals of researchers. Methods such as using parasitic patches, multilayer structures, materials with low dielectric constants and air gap between layers have been reported for increasing impedance and gain bandwidth [1–22]. A structure with two rectangular patches placed in different layers above a rectangular slot, on the ground plane was presented in [23]. Although using two patches instead of one patch [24, 25] will increase impedance bandwidth and gain of aperture coupled microstrip antennas, it will also increase the thickness of this type of antenna. Decreasing the thickness of dielectric layers in microstrip antennas results in less impedance bandwidth [23].

This paper presents an investigation into the effects of, dielectric position on top layer, the location of the patches, dimensions and position of the slot and the length of the top patch. Using the results of this investigation, the thickness of the antenna decreases to 0.14λ and the gain bandwidth (above 8 dB) increases to 40%, centered at 12.8 GHz.

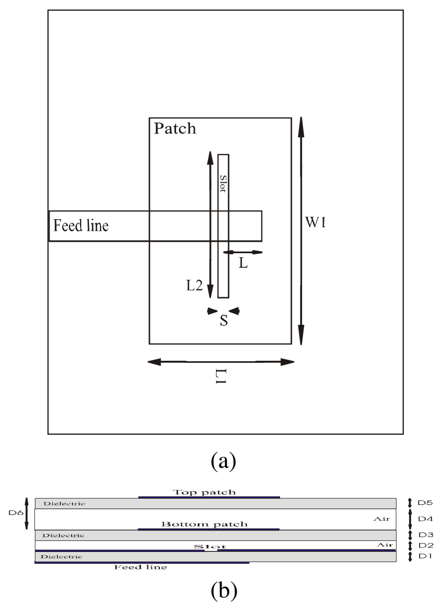


Figure 1. (a) Top view of the first antenna, (b) Side view of the first antenna. Parameters of the antenna: $D1 = D3 = D5 = 0.38$ mm, $D2 = 0.5$ mm, $D6 = 1.6$ mm, $S = 0.4$ mm, $W1 = 10$ mm, $L = 2$ mm, $L1 = 8$ mm, $L2 = 7$ mm.

2. ANTENNA STRUCTURE

In the antenna structure shown in Figs. 1(a) and (b) two rectangular patches are placed on top of the slot and are separated by materials with low dielectric constants and air gaps. In this structure there are two air gaps ($D2$, $D4$) and three substrates ($D1$, $D3$, $D5$) made of the same material with equal relative permittivity of 2.2 and thicknesses of 0.38 mm. There is a 50Ω feed line under the first dielectric layer ($D1$) while a 0.38 mm thickness slot is located above it. In Fig. 2 curve 1 shows that the antenna has low impedance bandwidth (24%) due to low thicknesses of dielectrics ($D2$, $D3$, $D4$, $D5$).

Figure 2 shows the effect of dielectric position on the top layer. The separation between patches ($D6$) is fixed to 1.6 mm. Curve 1 is VSWR of the structure which is shown in Figs. 1(a) and (b). By

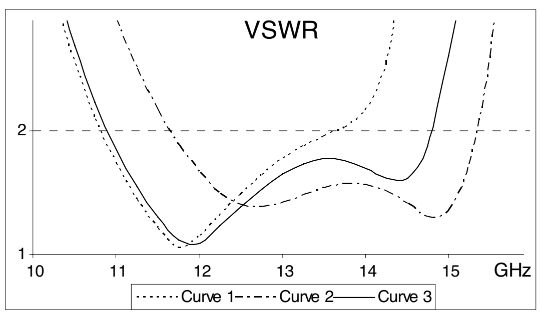


Figure 2. Effect of dielectric position on top layer. Curve 1: dielectric is under the upper patch, Curve 2: without dielectric on the top layer, and Curve 3: dielectric is on top of the upper patch.

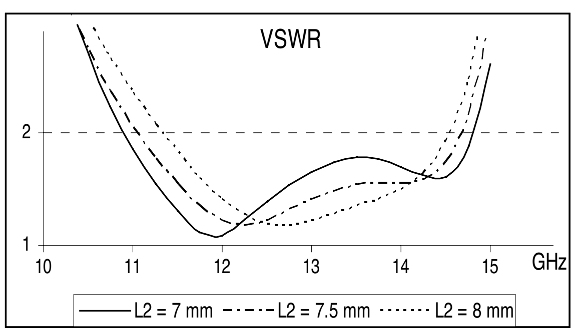


Figure 3. Effect of the slot's length ($L2$).

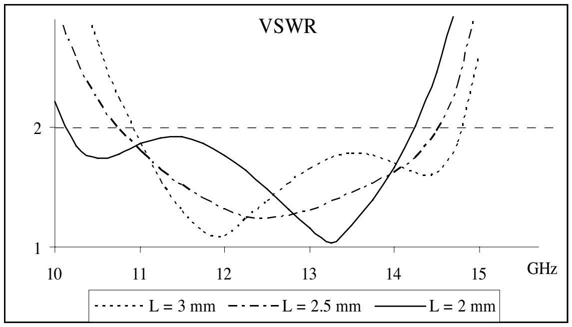


Figure 4. Effect of the slot's position on the feed line (L).

eliminating the dielectric on the top layer ($D5$) and increasing the top air gap from 1.22 mm to 1.6 mm the impedance bandwidth (curve 2) and the gain of the antenna will increase since the average relative permittivity of dielectric between patches decreases. By adding a dielectric with a thickness of 0.38 mm ($D5$) on top of the upper patch, the resonant frequencies of the antenna will decrease (curve 3).

Figure 3 shows the effect of the slot's length ($L2$). Although increasing the slot's length results in better impedance matching at the middle of the bandwidth, the impedance bandwidth will decrease. Moreover, by decreasing the slot's length to less than 6.5 mm a dual band antenna is obtained. In this step, 7 mm is an appropriate choice.

Effect of slot's position on the feed line (L), on VSWR of the antenna is shown in Fig. 4. It is clear that the resonant frequencies of the antenna depend on L. For $L = 2$ mm, the antenna has a better impedance bandwidth (34%).

Fig. 5 shows that changing the positions of the patches horizontally causes an increase in the impedance bandwidth of the antenna. By moving the bottom patch 1.5 mm to left, the VSWR of the antenna changes to curve 2, and also by changing the location of the top patch 1 mm to right side, the impedance bandwidth of the antenna increases to 44% (curve 3).

Effect of the length of top patch ($W2$) on VSWR of the antenna is shown in Fig. 6. By increasing $W2$ from 10 mm to 14 mm, better impedance matching will be obtained especially at lower frequencies. In this case 14 mm is an appropriate choice for the length of the top patch.

Figure 7 illustrates the dimensions and the structure of the final antenna. The total thickness of the antenna is 3.24 mm (0.14λ). Fig. 8 shows the simulated gain of the final design. The maximum gain of the

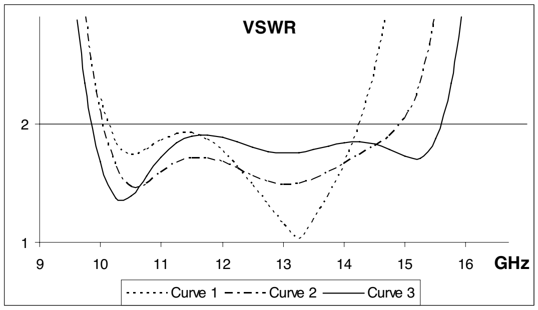


Figure 5. Effect of changing the position of patches in horizontal axis, curve 1: without changing the positions of patches, curve 2: moving the location of bottom patch 1.5 mm to left. Curve 3: moving the location of top the patch 1 mm to right.

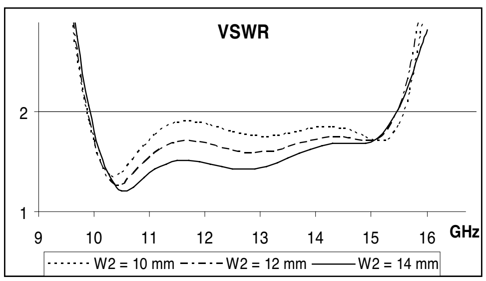
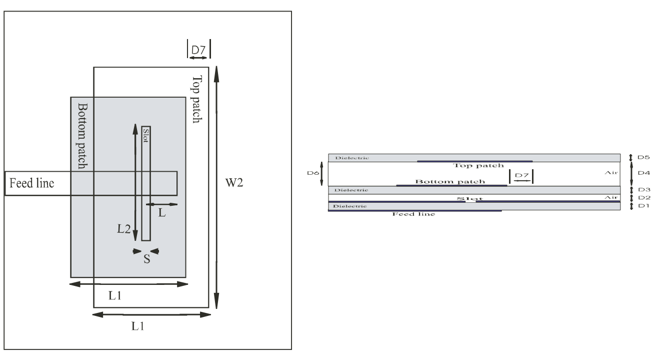


Figure 6. Effect of the length of the top patch ($W2$) on VSWR of the antenna.



(a) (b)

Figure 7. (a) Top view of the final antenna, (b) Side view of the final antenna. Parameters of the antenna: $D1 = D3 = D5 = 0.38$ mm, $D2 = 0.5$ mm, $D6 = 1.6$ mm, $D7 = 2.5$ mm, $S = 0.4$ mm, $W1 = 10$ mm, $W2 = 14$ mm, $L = 2$ mm, $L1 = 8$ mm, $L2 = 7$ mm.

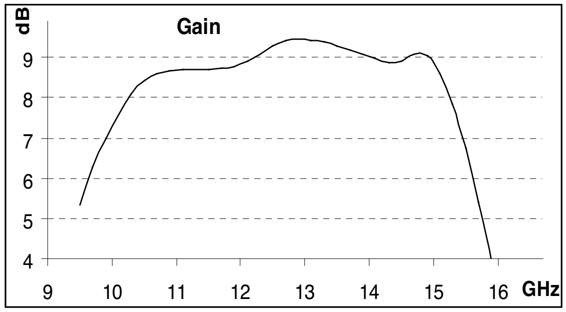


Figure 8. Gain of the final antenna.

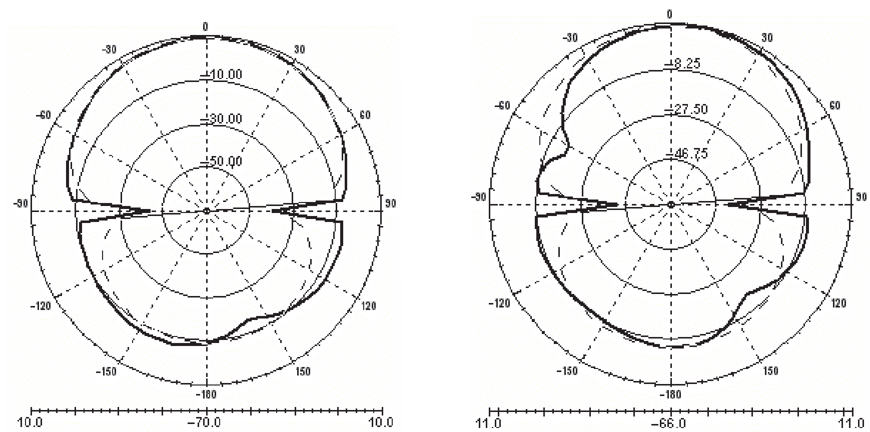


Figure 9. Radiation pattern of the final antenna at (a) 11 GHz, (b) 14 GHz, solid lines are for $\varphi = 0$ deg and dotted lines are for $\varphi = 90$ deg.

antenna is 9.5 dB at 13 GHz and the gain bandwidth of the structure is 40% centered at 12.5 GHz. The radiation pattern of the antenna at 11 GHz and 14 GHz are presented in Fig. 9. The radiation pattern of the antenna is stable across the band pass.

3. CONCLUSION

The goal of the paper is to increase the gain bandwidth and decrease the thickness of a structure with two rectangular stacked patches. To achieve this purpose, a numerical study is presented on the effects of, dielectric position on top layer, changing the positions of patches horizontally, length and position of the slot, and the length of the top patch. Results show that the thickness of the antenna decreases to 0.14λ and the gain bandwidth (above 8 dB) increases to 40%.

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