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SLOT COUPLED MICROSTRIP ANTENNA FOR ULTRA WIDEBAND APPLICATIONS IN C AND X BANDS

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Abstract—This paper presents an aperture coupled microstrip antenna with a rectangular patch which is located on top of two slots on the ground plane. The patch and slots are separated by an air gap and a material with low dielectric constant. There is a $50\,\Omega$ feed line which is divided into two $100\,\Omega$ feed lines by a two way microstrip power divider under the ground plane. Using a parametric study on the effect of the position and dimensions of the feed line the impedance bandwidth of the antenna (VSWR < 2) is increased to 7.9 GHz (86%) centered at 9.25 GHz and the gain of the structure is more than 7 dB from 5.4 GHz to 8.8 GHz (48%).

1. INTRODUCTION

Microstrip antennas have several advantages like: low cost, easy fabrication and light weight. But they suffer from disadvantages like low gain and narrow impedance bandwidth [1–5]. Materials with low dielectric constants, multilayer structures and utilizing air gaps between layers can increase impedance bandwidth and gain of microstrip antennas [1–31]. It has been reported that using U-shaped feed line can increase impedance bandwidth in aperture coupled microstrip antennas [32–37]. A slot coupled patch antenna with two slots on the ground plane and a non symmetric U-shaped feed line is reported at the frequency range of 10–22 GHz (75%) [38]. In this paper a similar idea is used for C and X bands presenting an antenna structure with a rectangular patch. By using a numerical investigation on the effects of the dimensions and positions of the feed line the impedance bandwidth (VSWR < 2) of the structure is increased to 86% (5.3–13.2 GHz). The antenna has 48% (5.4–8.8 GHz) gain bandwidth (above 7 dB) and 0.15λ thickness which is less than many previous works [5–10, 32, 33].

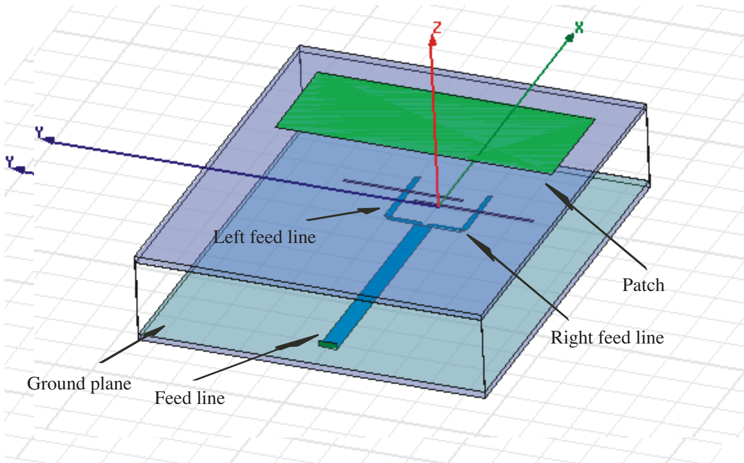
2. ANTENNA STRUCTURE

Figure 1 shows an antenna structure with a rectangular patch which is excited through two slots on the ground plane. The patch and ground plane are separated with a material (D3) with a relative permittivity of 2.2, and an air gap (D2). D1 and D3 are made from the same material with the same thickness. There is a $50\,\Omega$ feed line which is divided into two $100\,\Omega$ feed lines with different lengths under the first dielectric layer (D1).

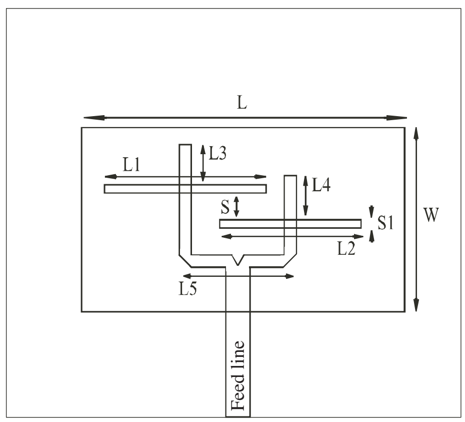
3. PARAMETRIC STUDY

Dimensions and location of the feed line have a crucial effect on the impedance bandwidth of the antenna. Fig. 2 shows VSWR of the antenna for three different separations between $100\,\Omega$ feed lines (L_5). At 7 GHz and 10 GHz by decreasing the length of L_5 from 12 mm to 8 mm better impedance matching will be obtained and by increasing the length of L_5 from 8 mm to 12 mm, the antenna will have better impedance matching at the frequency of 9 GHz. Simulation results show that the characteristics of the feed line do not have an important effect on the gain of the antenna.

Figure 3 shows the VSWR of the structure for three different lengths of the right feed line (L_4). By increasing the length L_4 from



(a)



(b)

(c)

Figure 1. (a) Antenna structure, (b) top view, (c) side view, dimensions for C and X bands: $D_1 = D_3 = 0.8\,\text{mm}$, $D_2 = 3.4\,\text{mm}$, $L = 36\,\text{mm}$, $W = 14\,\text{mm}$ and $L_1 = L_2 = 15.5\,\text{mm}$.

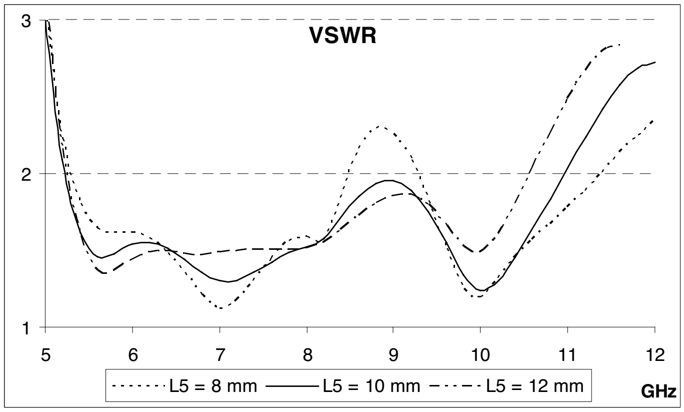


Figure 2. Effect of separation between 100 Ω feed lines on the VSWR of the antenna.

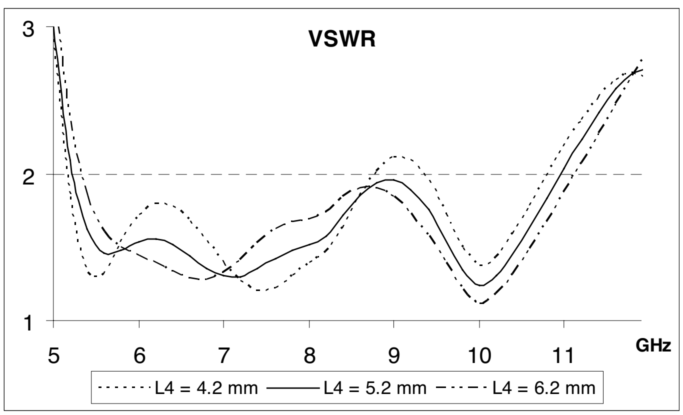


Figure 3. Effect of length of the right feed line on VSWR of the antenna.

4.2 mm to 6.2 mm, better impedance matching will be obtained at the last resonant frequency and at the frequency range of 5.8–7 GHz. By decreasing the length of the right feed line from 6.2 to 4.2 mm a better impedance matching is concluded at the frequency range of 7–8.5 GHz.

Figure 4 illustrates that by increasing the length of the left feed line (L_3) better impedance matching is obtained at high frequencies (more than 9 GHz). By increasing the length of L_3 from 4.8 mm to 5.8 mm, a resonant frequency of 12.5 GHz is created and the impedance bandwidth of the antenna is increased to 86%.

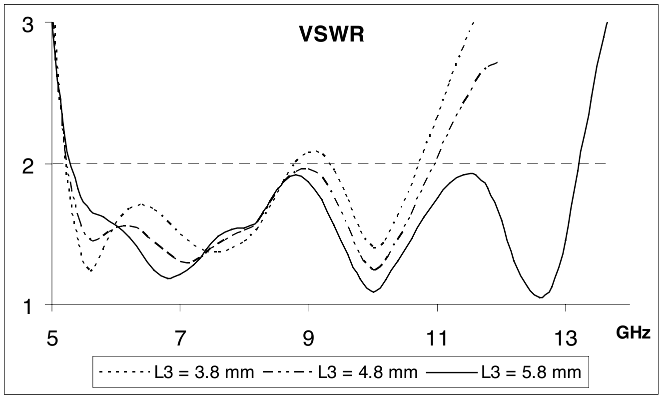


Figure 4. Effect of length of the left feed line on VSWR of the antenna.

4. RESULTS

All dimensions of the antenna structure are shown in Table 1. The total thickness of the antenna is 5 mm (0.15λ) and less than many previous works [5–10, 32, 33]. As it is shown in Fig. 4, the VSWR of the antenna is less than 2 from 5.3–13.2 GHz and the simulated gain bandwidth (over 7 dB) of the antenna is 3.4 GHz (48%). The maximum gain of the antenna is 9.5 dB at the frequency of 6.8 GHz. Fig. 5 shows the gain of the antenna at 0 degree. Fig. 6 illustrates the radiation pattern of the antenna at 6, 8, 10 and 12 GHz. It is clear that at the frequency of 8 GHz, the gain of the antenna is 9.6 at 15 degrees and at the frequency of 10 GHz the gain of the antenna is about 5 at 45 and −45 degrees. Fig. 7 shows the Smith chart plot of return loss of the antenna.

Table 1. Dimensions of the antenna for S and C bands.

L	$L_1 = L_2$	L_3	L_4	L_5
36 mm	15.5 mm	5.8 mm	5.2 mm	10 mm
S	S_1	$D_1 = D_3$	D_2	W
2 mm	0.4 mm	0.8 mm	3.4 mm	14 mm

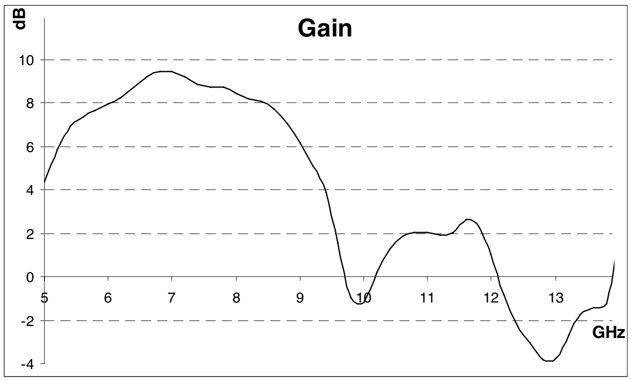


Figure 5. Gain of the antenna at 0 deg.

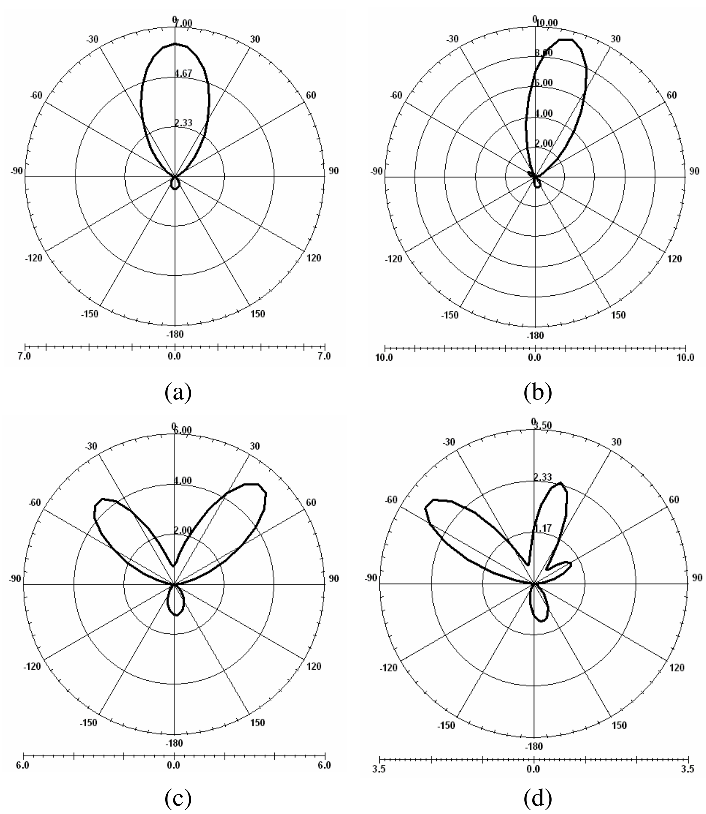


Figure 6. Radiation pattern of the antenna at (a) 6 GHz, (b) 8 GHz, (c) 10 GHz, (d) 12 GHz.

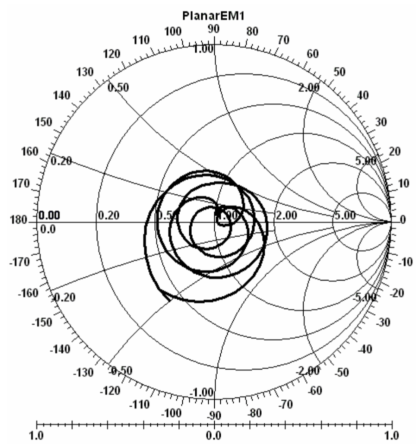


Figure 7. Smith chart of return loss of the antenna.

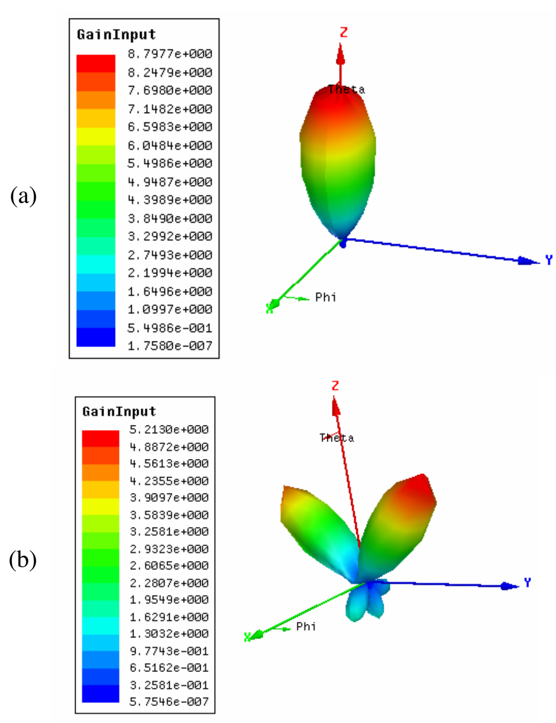


Figure 8. 3D polar plot of radiation pattern of the antenna at (a) 7 GHz and (b) 10 GHz.

5. CONCLUSION

This paper presents an antenna structure with a non-symmetric, U-shaped feed line and a rectangular patch which is excited through two slots on the ground plane. The patch and the ground plane are separated by a material with low dielectric constant and an air gap. A numerical investigation is presented on the effects of position and dimensions of the feed line. Simulation results show that the antenna has VSWR < 2 from 5.3–13.2 GHz and gain bandwidth (over 7 dB) of the antenna is 3.4 GHz (48%) and the antenna has 0.15λ thickness which is less than many previous works [5–10, 32, 33]. However an optimization procedure is needed to consider gain and radiation patterns of the antenna at higher frequencies.

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