Microstrip Antenna Design for Ultra Wideband Application by Using Two Slots

N. Ghassemi[1], **J. Rashed-Mohassel**[2], **and M. H. Neshati**[1]

[1]Electrical Engineering Department, Sistan and Baluchistan University, Zahedan, Iran
[2]Center of Excellence on Applied Electromagnetic Systems, University of Tehran, Tehran, Iran

Abstract— This paper presents a multiresonator microstrip antenna using a rectangular patch located on top of two slots, with different lengths and excited by a U-shaped feed line. The patch and slots are separated by a substrate with low dielectric constant and an air gap. The results show that the bandwidth of the antenna increases by using two slots. Finally an antenna with VSWR < 2 from 9.8 GHz to 22 GHz and 6.1 GHz (42%) gain bandwidth (above 7 dB) is obtained. The simulated gain of the antenna is over 5 dB from 9.8 GHz to 19 GHz and with a maximum gain of 9.16 dB at the frequency of 14 GHz.

1. INTRODUCTION

Increasing the gain and impedance bandwidth of microstrip antennas has been a primary goal of researches in this field [1–3]. For this purpose, techniques such as using multilayer structures, low dielectric constant and air gap between layers have been reported in literature [1–6]. Characteristics of microstrip antennas is closely related to their feeding method and substrate materials. Strip line coupled to the patch through an aperture would be a good choice, especially at higher frequencies, because of the advantages such as: 1) radiation of feed network and radiating elements and design flexibility [6], and 2) avoidance of a coaxial feed and soldering problem [3, 6]. One way of widening the impedance bandwidth of aperture coupled microstrip antennas is to utilize a U-shaped feed line [1, 7].

In this paper a multilayer multiresonator aperture coupled microstrip antenna with a U-shaped feed line and two slots is investigated, based on Method of Moments (MoM). There is a rectangular patch above the slots. The patch and slots are separated by an air gap and a substrate with low dielectric constant, from each other. It is shown that using two slots increases the impedance and gain bandwidth of the structure. An antenna with VSWR < 2 from 9.8 GHz to 22 GHz and 6.1 GHz (42%) gain bandwidth (above 7 dB) is obtained. The simulated gain of the antenna is over 5 dB from 9.8 GHz to 19 GHz and the maximum gain is 9.16 dB at 14 GHz.

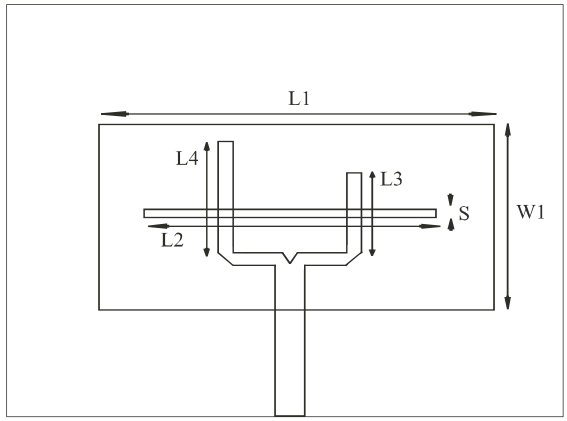
2. ANTENNA MODEL

Figures 1(a) and (c) shows an antenna structure with one slot, which is a sandwich of three dielectric layers. D_1 and D_3 are made from a material with the relative permittivity of 2.2. Under the first dielectric layer (D_1) there is a 50 Ω microstrip feed line which is divided into, two 100 Ω feed line, with different lengths, by a two-way microstrip power divider. Between D_1 and D_3 there is an air gap with 2 mm thickness (D_2) and a patch is placed on top of the third dielectric layer (D_3). As it is shown in Fig. 2 the impedance bandwidth of the antenna with one slot is 4.1 GHz (34.5%) and the gain bandwidth is 3.2 GHz (26%).

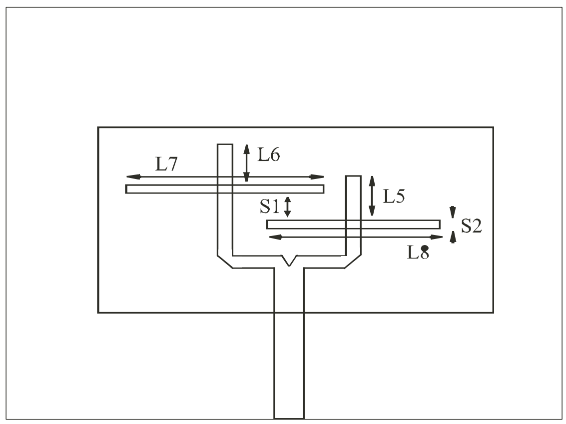
As it is shown in Fig. 1(b), without changing the dimensions of the patch and feed lines, by using two slots and decreasing the thickness of D_2 and D_3 a new structure is achieved. In the second structure there is one slot above each of the 100 Ω feed lines. The structure has three resonant frequencies. The distance between the slots (S_1), their positions (L_5 and L_6) and their lengths (L_7 and L_8) and the lengths of feed lines (L_3 and L_4) have an important effect on the resonant frequencies and the impedance bandwidth of the antenna. By changing these parameters one can set the resonant frequencies by each other to increase the impedance and gain bandwidth of the antenna. All dimensions of the antenna are shown in Table 1.

Table 1: Dimensions of the Antenna.

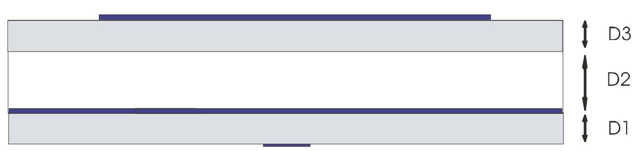
W	S, S_2	S_1	L_1	L_2	L_3	L_4	L_5, L_6	L_7	L_8
7 mm	0.2 mm	1 mm	16 mm	9.7 mm	4 mm	5 mm	2.5 mm	8 mm	8.5 mm



(a)

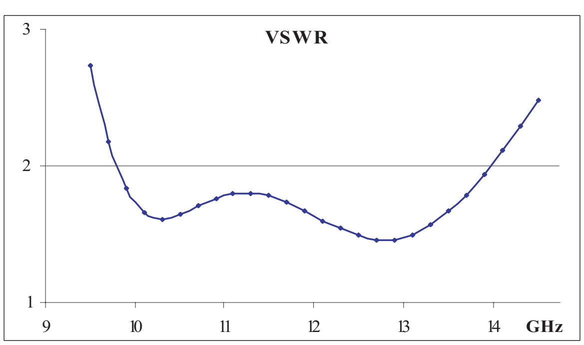


(b)

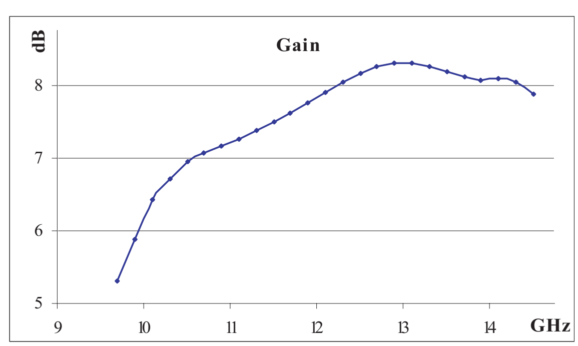


(c)

Figure 1: Antenna structure: (a) Top view of the antenna with one slot, (b) Top view of the antenna with two slots, (c) Side view of the antenna.



(a)



(b)

Figure 2: (a) VSWR, (b) Gain of the antenna with one slot.

Figure 3 shows VSWR and gain of the antenna with two slots. It is clear that the antenna has VSWR < 2 from 9.8 GHz to 22 GHz and 6.1 GHz (42%) gain bandwidth (above 7 dB). The simulated gain of the antenna is over 5 dB from 9.8 GHz to 19 GHz and maximum gain is 9.16 dB at the frequency of 14 GHz. By comparing Figs. 2 and 3 one can understand that, using two slots increase the impedance and gain bandwidth of the antenna.

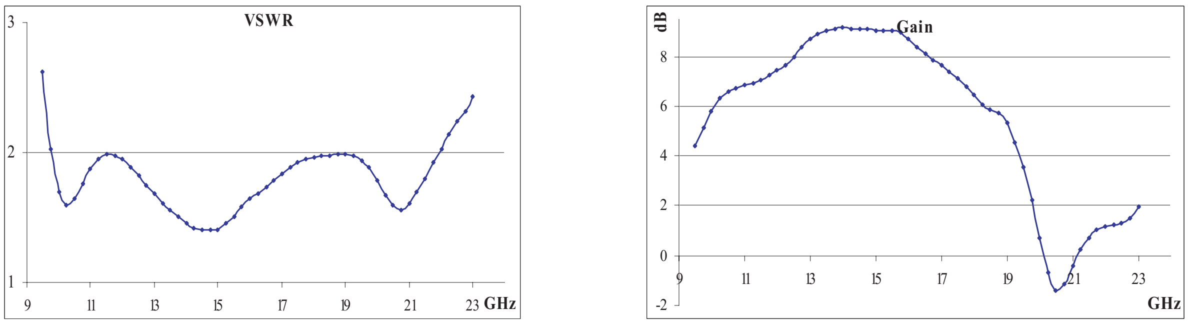


Figure 3: (a) VSWR, (b) Gain of the antenna with two slots.

3. CONCLUSIONS

This paper presents the design of an ultra wideband multilayer microstrip antenna by using two slots. In this structure there is a rectangular patch and a U-shaped feed line. The slots and patch are separated by a substrate with low dielectric constant and an air gap. This paper shows that using two slots can increase impedance and gain bandwidth of the antenna. Finally an antenna with VSWR < 2 from 9.8 GHz to 22 GHz and 6.1 GHz (42%) gain bandwidth (above 7 dB) is obtained. The simulated gain of the antenna is over 5 dB from 9.8 GHz to 19 GHz and maximum gain is 9.16 dB at the frequency of 14 GHz. However, an optimization procedure is needed to consider other characteristics of the structure such as radiation pattern of the antenna.

ACKNOWLEDGMENT

The authors would like to thank Iran Telecommunication Research Center (ITRC) for its financial supports.

REFERENCES

1. Kumar, G. and K. P. Ray, *Broadband Microstrip Antennas*, Artech House, Boston, 2003.
2. Wong, K. L., *Compact and Broadband Microstrip Antenna*, John Wiley & Sons, New York, 2002.
3. Chai, W, X. Zhang, and J. Liu, "A novel wideband antenna design using U-slot," *Progress In Electromagnetics Research Symposium Proceedings*, 1292–1295, Beijing, China, March 26–30, 2007.
4. Ray, K. P., S. Ghosh, and K. Nirmala, "Multilayer multiresonator circular microstrip antennas for broadband and dual-band operation," *Microwave and Optical Technology Letters*, Vol. 47, No. 5, 489–494, December 2005.
5. Zehforoosh, Y., C. Ghobadi, and J. Nourinia, "Antenna design for ultra wideband application using a new multilayer structure," *Progress In Electromagnetics Research Symposium Proceedings*, 2225–2231, Beijing, China, March 26–30, 2007.
6. Lee, K. F. and W. Chen, *Advances in Microstrip and Printed Antennas*, John Wiley & Sons, New York, 1997.
7. Targonski, S. D., R. B. Waterhouse, and D. M. Pozar, "Design of wide-band aperture-stacked patch microstrip antennaa," *IEEE Transmision on Antennas and Propagation*, Vol. 46, No. 9, 1245–1251, September 1998.
8. Denidni, T. A. and L. Talbi, *High Gain Microstrip Antenna Design for Broadband Wireless Applications*, 511–517, Wiley Periodicals Inc, 2003.