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A UWB Aperture Coupled Microstrip Antenna for S and C Bands

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***Abstract*- This paper presents a multilayer aperture coupled microstrip antenna with a non symmetric U-shaped feed line. The antenna structure consists of a rectangular patch which is excited through two slots on the ground plane. A parametric study is presented on the effects of the position and dimensions of the slots. Results show that the antenna has VSWR < 2 from 2.6 GHz to 5.4 GHz (70%) and the gain of the structure is more than 7 dB from 2.7 GHz to 4.4 GHz (48%).**

I. Introduction

Microstrip antennas have been used widely because of their advantages such as; light weight, low cost and easy to fabricate by using printed circuits technology. But they suffer from disadvantages like low gain and narrow bandwidth [1-5]. Techniques such as using multilayer structure, materials with low dielectric constants and utilizing stacked patches have been reported in literature for increasing gain and impedance bandwidth [1-10]. For increasing impedance bandwidth a structure with a U-shaped feed line has been reported [11-14]. An aperture coupled microstrip antenna with a non symmetric feed line and two slots on the ground plane operated at X and Ku bands [15], and C and X bands [16] are reported with ultra wideband impedance and gain bandwidth. In this paper, a similar idea is used for S and C bands presenting an antenna structure with a rectangular patch which is excited through two slots on the ground plane. An investigation is presented on the effects of the dimensions and positions of the slots on the ground plane for these frequency ranges. Finally an antenna with VSWR < 2 from 2.6 to 5.4 GHz is obtained (70%). The maximum gain of the antenna is 9.5 dB at the frequency of 3.5 GHz and the gain of the antenna is more than 7 dB for 2.7 – 4.4 GHz (48%).

II. Antenna Structure

Fig. 1 shows the antenna structure with a rectangular patch and two slots on the ground plane which was designed and used in this research. The shape of this antenna is similar of the one in [16]. However, with changing the dimensions, the properties of the antenna have been changed. The patch and ground plane are separated with air gap (D2) and a material with relative permittivity of 2.2. D1 and D3 are made from the same material and the same thickness. In microstrip antennas the thickness and relative permittivity of dielectrics and the thicknesses of air gaps, have an important effect on the characteristics of this type of antennas [11, 17]. Under the first dielectric layer there is a 50 Ω feed line which is divided into two 100 Ω feed lines with different lengths.

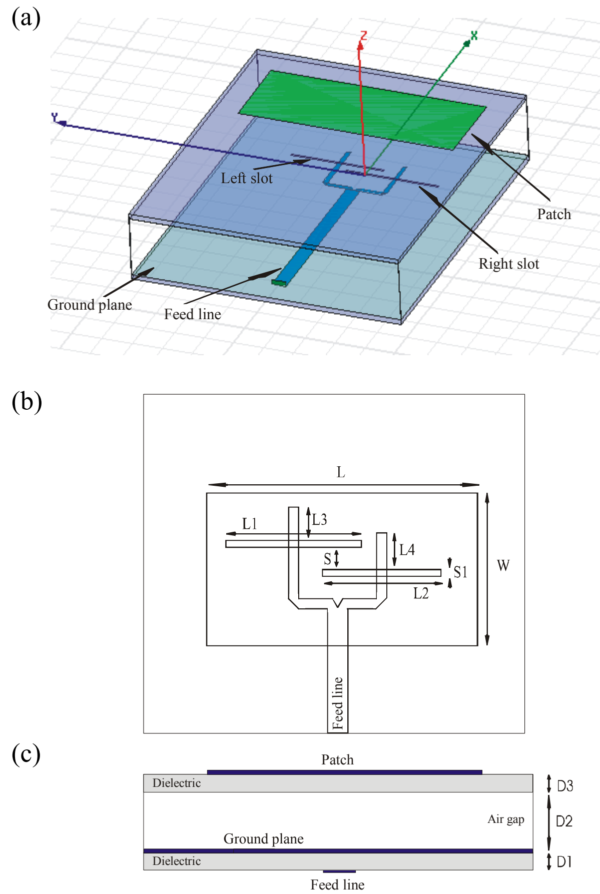

Figure 1: (a): The antenna structure, (b): Top view, (c): Side view, Dimensions for S and C bands: D1 = D3 = 1.6 mm, D2 = 7 mm, L3 = 9.5 mm, L4 = 10.5 mm and W = 27 mm.

III. Parametric Study

Dimensions and locations of the slots on the ground plane have a crucial effect on the characteristics of the antenna. Fig. 2 shows VSWR and gain of the antenna for

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three different lengths of the left slot (L1). By increasing the length of L1 from 26 mm to 36 mm, the antenna will have better impedance matching at the frequency of 2.7 GHz and 4 GHz, and at 3.2 GHz by decreasing the length of L1 better impedance matching will be obtained. Fig. 2 illustrates that the length of the left slot does not have an important effect on resonant frequencies of the antenna at high frequencies – more than 4.5 GHz - but it has a crucial effect on the VSWR plot at low frequencies.

(a)

(b)

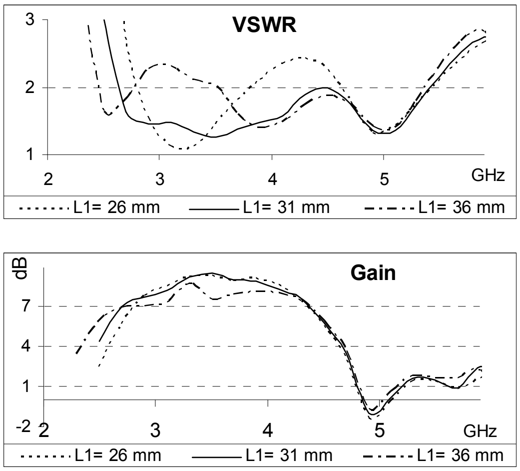


Figure 2: The effect of length of the left slot on, (a): VSWR and (b): gain of the antenna

Fig. 3 shows the characteristics of the structure for three different values for the length of the right slot (L2). By increasing the length of L2 from 26 mm to 36 mm, better impedance matching will be obtained at high frequencies – more than 4.5 GHz. At low frequencies – less than 3.5 GHz – the effect of increasing the length of L2 is similar to increasing the length of L1. Although for L2 = 26 mm and L2 = 31 mm the same impedance bandwidth is obtained, but the antenna has better gain for L2 = 31 mm.

(a)

(b)

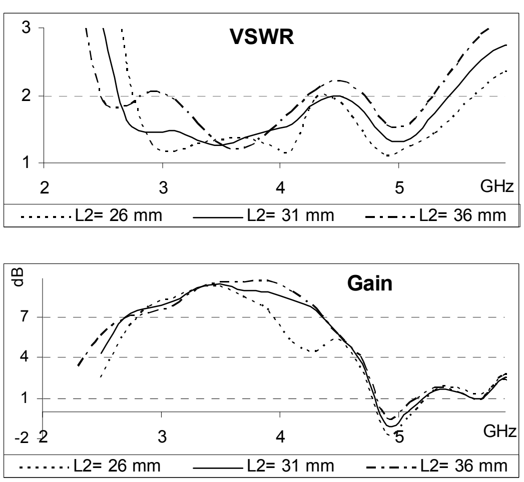


Figure 3: The effect of length of the right slot on, (a): VSWR and (b): gain of the antenna

Fig. 4 (a) illustrates that by changing the separation between slots, the VSWR plot will change over the entire bandwidth. By increasing the separation between the slots, better impedance matching will be obtained at the last resonant frequency. For S = 6 mm the impedance bandwidth and gain of the antenna is similar to S = 4 mm. Fig. 4 (b) shows that S does not have a significant effect on gain of the structure.

(a)

(b)

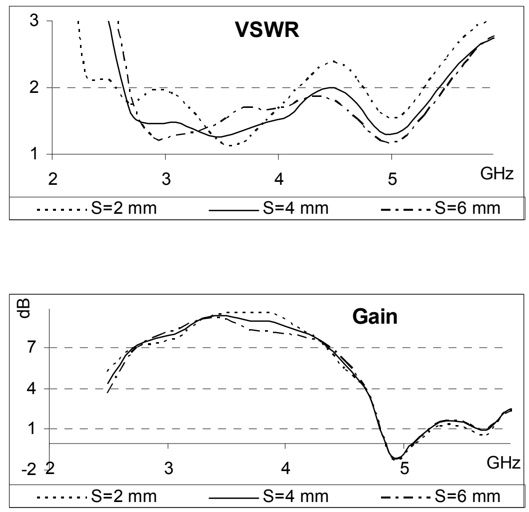


Figure 4: The effect of separation between the slots on, (a): VSWR and (b): gain of the antenna

IV. Simulation Results

The dimensions of the antenna structure are shown in Table 1. Fig. 5 shows the Smith chart plot of return loss of the antenna. The return loss of the antenna is less than -10 dB from 2.6 – 5.4 GHz and the simulated gain bandwidth (over 7 dB) of the antenna is 1.7 GHz (48%). The impedance bandwidth of the antenna (VSWR < 1.5) is 1.2 GHz (36%). The maximum gain of the antenna is 9.5 dB at the frequency of 3.5 GHz. Fig. 6 illustrates the radiation pattern of the antenna at 3, 4 and 5 GHz. It is clear that at the frequency of 5 GHz, the gain of the antenna is about 5 dB at 45 and -45 degree.

TABLE I

The Dimensions of the Antenna for S and C bands

L	L1 = L2	L3	L4	W
72 mm	31 mm	9.5 mm	10.5 mm	27

S	S1	D1	D2	D3
6 mm	0.8 mm	1.6 mm	7 mm	1.6 mm

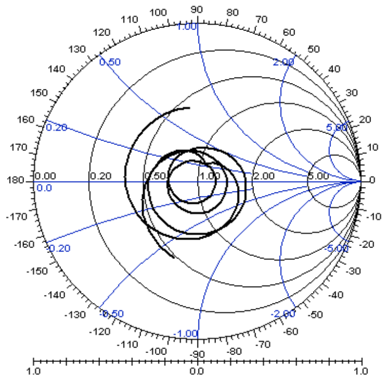
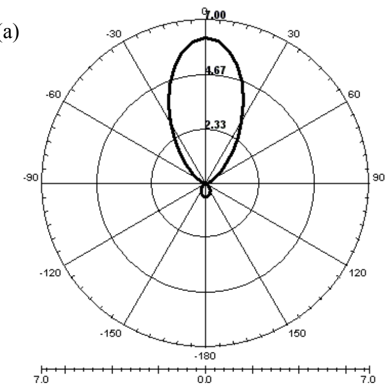
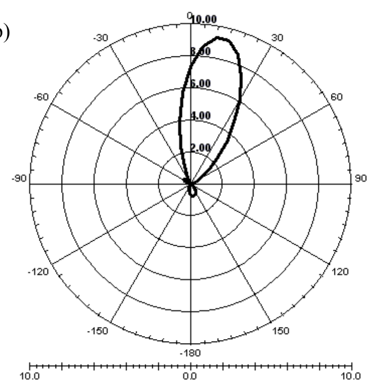


Figure 5: The Smith chart of return loss of the antenna

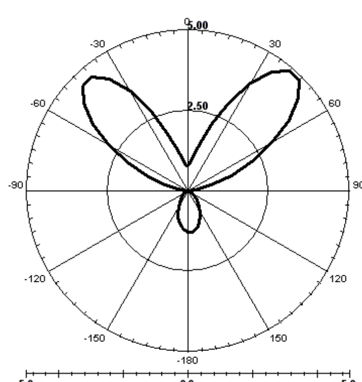
(a)



(b)



(c)



(d)

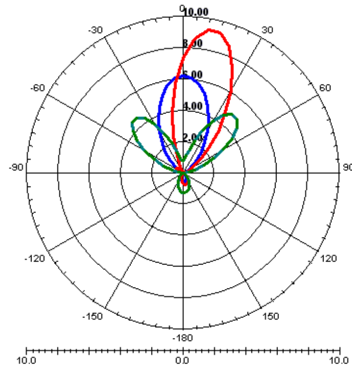


Figure 6: The radiation pattern of the antenna at (a): 3 GHz (b): 4 GHz (c): 5 GHz (d): 3, 4 and 5 GHz

V. CONCLUSIONS

This paper presents an antenna structure with a rectangular patch and two slots on the ground plane. The patch and slots are separated by an air gap and a substrate with low dielectric constant. Under the ground plane there is a 50 Ω feed line which is divided into two 100 Ω feed lines by a two way microstrip power divider. A numerical investigation is presented on the effects of positions and dimensions of the slots. Simulation results show that the antenna has VSWR < 2 from 2.6 – 5.4 GHz and gain bandwidth (over 7 dB) of the antenna is 1.7 GHz (48%). However an optimization procedure is needed to consider other characteristics of the antenna such as radiation pattern.

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REFERENCES

[1] T. A. Milligan, *Modern antenna design*, John Wiley & Sons, Hoboken, New Jersey, 2005.

[2] R. Garg, P. Bhartia, I. Bahl and A. Ittipiboon, *Microstrip antenna design handbook*, , Artech House, Boston, London, 2001.

[3] K. L. Wong, *Compact and broadband microstrip antenna*, John Wiley & Sones, New York , 2002.

[4] G. Kumar, and K. P. Ray, *broadband microstrip antennas*, Artech House, USA, 2003.

[5] N. Ghassemi, M. H. Neshati, J. Rashed-Mohassel, "Investigation of multilayer probe-fed microstrip antenna for ultra wideband operation," Proceeding's of *Asia Pacific Microwave Conference(APMC 2007),* pp. 2135-2138, Bangkok, Thailand, Dec. 11-14, 2007.

[6] T. Kim, J. Choi, and J. S. Jeon, " Design of a wideband microstrip array antenna for PCS and IMT-2000 service, " *Microwave and Optical Technology Letters.*, vol. 30, No. 4, pp. 261-265, Aug. 2001.

[7] Tayeb A. Denidni and Larbi Talbi, "High gain microstrip antenna design for broadband wireless applications," *Wiley Periodicals, Inc.*, pp. 511-517, 2003.

[8] N. Ghassemi, M. H. Neshati, J. Rashed-Mohassel, "A Multilayer Multiresonator Aperture Coupled Microstrip Antenna for Ultra Wideband Operations," *in Proc. IEEE Applied Electromagnetic Conference 2007,* Kolkata, India, December 19-20, 2007.

[9] K. F. Tong, K. M. Luk, and K. F. Lee, " Wideband II-shaped aperture-coupled U-slot patch antenna, " *Microwave and Optical Technology Letters.*, vol. 28, pp. 70-72, Jan. 2001.

[10] W. X. Zhang, C. S. Pyo, S. I. Jeon, S. P. Lee and N. H. Myung, " A new type of wideband slot-fed U-slotted patch antenna, " *Microwave and Optical Technology Letters*, vol. 22, No. 6, pp. 378-381, Sep. 1999.

[11] S. D. Targonski, R. B. Waterhouse, and D. M. Pozar, " Design of wide-band aperture-stacked patch microstrip antenna," *IEEE Trans. Antennas Propagat.*, vol. 46, pp. 1245-1251, Sep. 1998.

[12] F. Y. Zulkifli, F. Narpati, and E. T. Rahardjo, "S-shaped patch antenna fed by dual offset electromagnetically coupled for 5-6 GHz high speed network," *PIERS Online*, Vol. 3, No. 2, pp. 163-166, 2007.

[13] B. L. Ooi, E. S. Siah and P. S. Looi, "A novel microstrip-fed slot-coupled self-complementary patch antenna," *Microwave and Optical Technology Letters*, Vol. 23, No. 5, December 1999, pp. 284-289.

[14] G. Sorbello, M. Pavone and L. Rassello, "Numerical and experimental study of a rectangular slot antenna for UWB comunications," *Microwave and Optical Technology Letters*, Vol. 46, No. 4, Aug. 2005, pp. 315-319.

[15] N. Ghassemi, J. Rashed-Mohassel, and M. H. Neshati, "Microstrip antenna design by using two slots," *Progress in Electromagnetic Research Symposium (PIERS 2008),* Hangzhou, China, March 24 – 28, 2008.

[16] N. Ghassemi, J. Rashed-Mohassel, M. H. Neshati, and M. Ghassemi, "Slot coupled microstrip antenna for ultra wideband applications in C and X bands," *Progress in Electromagnetic Research M (PIER M),* Vol. 3, 2008.

[17] K. P. Ray, 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, December 2005, pp. 489-494.