Design of h-Slotted Microstrip Patch Antenna with Enhanced Bandwidth for C-Band Application

Pritam Singha Roy, Samik Chakraborty

***Abstract:** In this paper a compact h- shaped slotted microstrip patch antenna has been proposed for C-band applications. The antenna parameters such as Return loss, Bandwidth, Gain, VSWR are improved .The comparison between measured and simulated results for unslotted and h-slotted microstrip patch antenna has been discussed . The proposed antenna has been fabricated and tested in laboratory .The measured and simulated results are exhibits good agreement. The proposed antenna achieved 16.6% of bandwidth at centre frequency of 7.52 GHz with VSWR ≤ 2 and gain is 6.46dBi. The return loss of -27.97 dB is obtained for h-slot microstrip antenna with dielectric substrate (Glass PTFE ε_r =2.55) of thickness (h) =1.6 mm. The proposed antenna is simulated with IE3D® software.*

***Keywords:** Bandwidth ; Gain;h-slot;Microstrip antenna; Return loss.*

I. INTRODUCTION

The microstrip patch antenna has been used in many wireless applications due to its various advantages such as light weight, low profile, easy fabrication and low cost. Therefore, this problem has been addressed by researchers and many configurations have been proposed for band width enhancement [1-3].Microstrip antenna The most common technique to design a microstrip antenna DGS and slot on the patch[4]. Most microstrip-fed structures of the printed slot antenna have been used by using the microstrip-fed structures [5] across the center of slot [6], [7].It has been used in large applications such as radar, missiles, aircraft, satellite communications etc.In the present work, a h- slot patch antenna is proposed with improved bandwidth and reduced size of antenna .The designed antenna resonates at a7.52GHz frequencies with an improved impedance bandwidth of 16.6%.

II. ANTENNA GEOMETRY AND DESGN

A. Geometrical study of proposed antenna:

Geometry of proposed antenna is shown in Fig. 1, where a coaxial fed is used over a Woven Glass PTFE substrate of thickness of h=1.6 mm and permittivity ε_r = 2.55.The patch

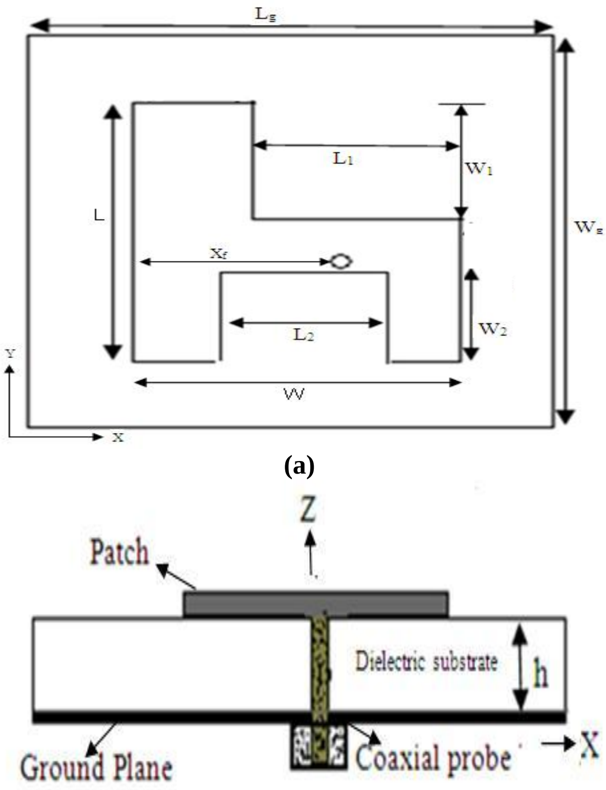

Fig.1 Geometry of proposed h-slot Microstrip antenna (a) Top view; (b) Cross section view

has the dimension of 32 mm × 43 mm.Two rectangular slots are cut from the patch and obtained a h- shaped slotted microstrip patch which is mounted over the ground plane $L_g \times W_g$ = 43 mm × 58 mm, shown in Fig 1(a).The coaxial probe feed of radius is 0.6 mm and feed of (2.5,0) with respect to the centre(0,0).

For a given resonance frequency (f) and dielectric substrate (ε_r) the parameters of proposed antenna are expressed [8-10] as follows:

$$W = \frac{c}{2f\sqrt{\frac{(\varepsilon_{r+1})}{2}}} \quad (1)$$

$$L = L_{eff} - 2\Delta L \quad (2)$$

Where e_{ff} and ΔL are the effective and extended length of patch and expressed as:

$$L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{reff}}} \quad (3)$$

$$(\Delta L) = 0.412h\,\frac{(\varepsilon_{reff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{W}{h} + 0.8\right)} \quad (4)$$

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ε_r is the effective dielectric constant of substrate is expressed as:

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}} \quad (5)$$

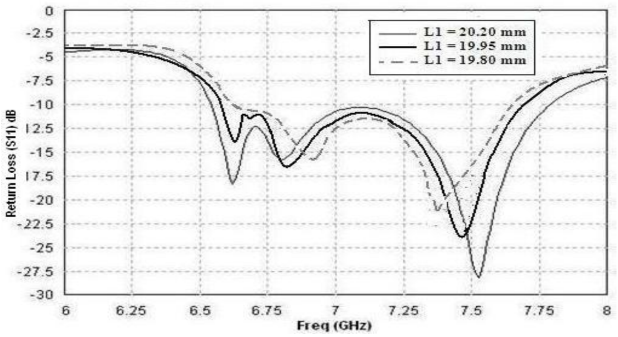
Hence for this design the ground plane length (L_g) and width (W_g) would be given as:

$$L_g = 6h + L \quad (6)$$
$$W_g = 6h + W \quad (7)$$

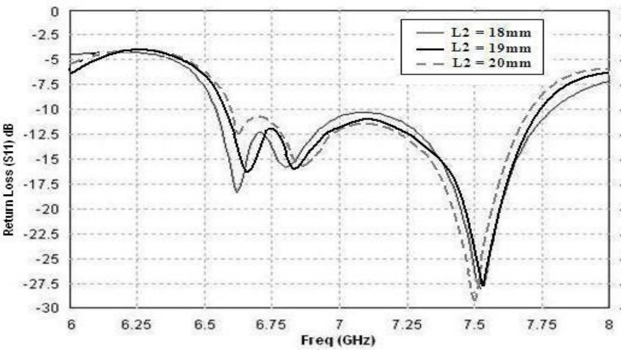
Where "h" is the thickness of substrate (in mm).

Table1. Optimal parameters specification of antenna

Parameter	L	W	L_g	W_g	L_1	L_2	W_1	W_2
Values(mm)	32	43	43	58	20.2	18	13.6	19



(a)



(b)

Fig.2 Simulated Return loss (S_{11}) (a) Variation of L_1 , while all other parameters in Table 1 are fixed; (b) Variation of L_2 , while all other parameters in Table 1 are fixed.

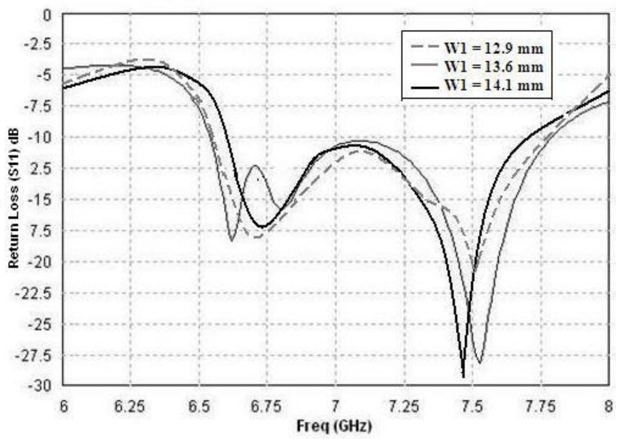


Fig 3. Simulated Return loss (S_{11}): Variation of W_1 , while all other parameters in Table 1 are fixed.

B. Parametric analysis of proposed antenna:

In this antenna the resonance frequency and Return loss are affected by the following parameters as L_1 , L_2 , W_1 and W_2 .It is observed that the resonance frequency (f)and return loss are increased with increase the value of L_1(Other parameters are constant) shown in Fig2(a) referred to the Table 2. But the resonance frequency is decreased with increased the value of L_2 and return loss is increased slowly is shown in Fig 2(b).referred to the Table 3.

Also it is observed that the resonance frequency is decreased with increased the value of W_1 but at same time the return loss is increased when all other parameters in Table 1 are fixed shown in Fig. 3.referred to the Table 4. Hence the parameters L_1 , L_2 , W_1 and W_2 are responsible for variation of simulated results.

Table 2. Parameters for different values of L_1
(L_2=18 mmW_1=13.6 mm, W_2=19 mm, Feed point=2.5)

L1 mm	Frequency Ghz	Return Loss	Gain dBi	BW Ghz	Vswr
20.2	7.52	-27.97	6.46	1.249, (16.60%)	0.685
19.9	7.47	-23.28	6.40	1.143 (15.31%)	1.21
19.8	7.33	-21.01	6.38	1.05 (14.32%)	154

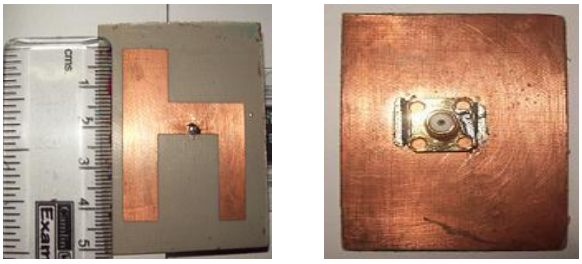
Table 3. Parameters for different values of L_2
(L_1=20.2 mmW_1=13.6 mm, W_2=19 mm, Feed point=2.5)

L2 mm	Frequency Ghz	Return Loss	Gain dBi	BW Ghz	Vswr
18	7.52	-27.97	6.46	1.249, (16.60%)	0.685
19	7.51	-28.31	6.34	1.212 (16.13%)	0.653
20	7.50	-29.14	6.24	1.163 (15.50%)	0.606

Table 4. Parameters for different values of W_1
(L_1=20.2 mm, L_2=18 mm .W_2=19 mm, Feed point=2.5)

W1 mm	Frequency Ghz	Return Loss	Gain dBi	BW Ghz	Vswr
13.6	7.52	-27.97	6.46	1.249 (16.60%)	0.685
14.1	7.48	-29.35	6.42	1.02 (13.63%)	0.495
12.9	7.51	-21.34	6.51	1.15 (15.31%)	1.38

III. EXPERIMENTAL RESULTS AND DISCUSSION



(a) (b)

Fig 4.Fabricated proposed antenna (a) Front view and (b) back view

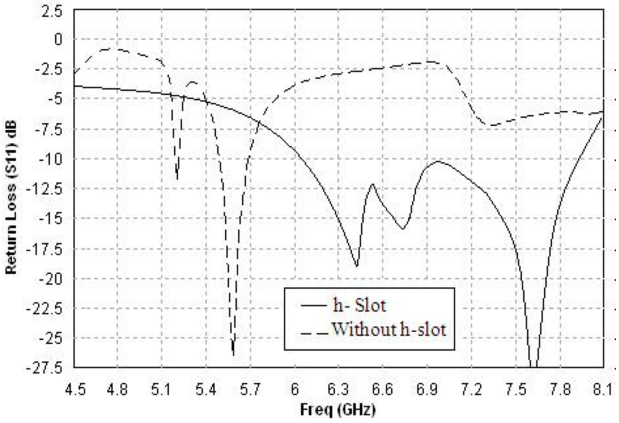
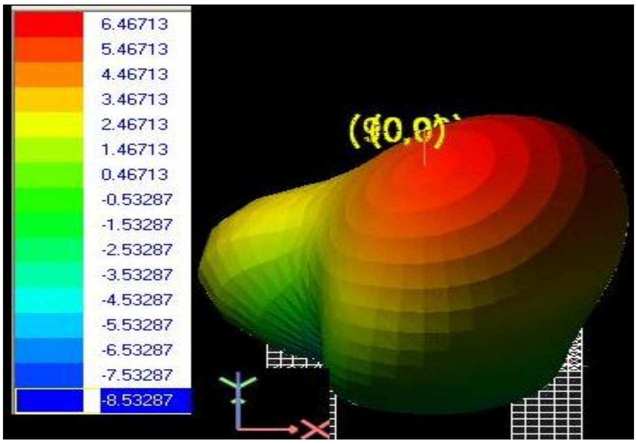


Fig 5.Simulated results (S_{11}) of proposed h-slot and without slot.

Table 2. Bandwidth of proposed antenna

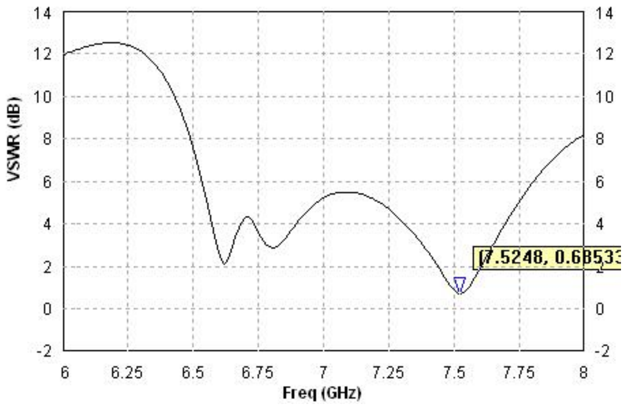
Bandwidth	IE3D	Measured
Without h- slot	4.21% (5.687-5.492)GHz	3.88% (5.547-5.385)GHz
With h- slot	16.60 % (7.792-6.543)GHz	15.56% (7.534-6.025)GHz

The proposed antenna is tested and fabricated on dielectric PTFE 2.55 and found the measured results referred to the Table 2.The gain is achieved 6.467dBi using simulation. The antenna operating with VSWR is 0.685 shown in fig 7, which improves to 16.6% of bandwidth.



(a)

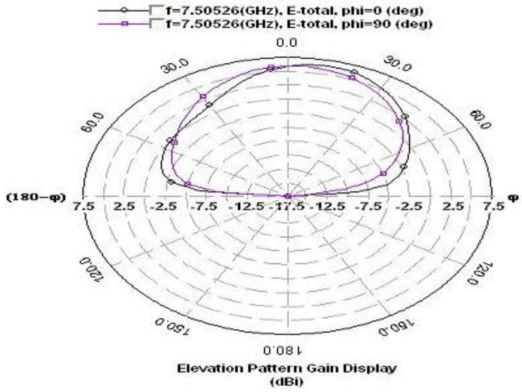
Fig 6.gain of proposed antenna simulated result.



(a)

Fig 7.The VSWR of proposed antenna simulated result

The microstrip patch antenna radiates to its patch surface. So the elevation pattern gain for phi =0 and phi = 90 degree are most important for the measurements of antenna characteristics. The fig 8. Shows the simulated radiation pattern at 7.505 GHz.



(a)

Fig 8.Radiation pattern of proposed antenna (a) simulated view

In this proposed antenna the bandwidth is affected by the following parameters as L_1, L_2 , W_1.It is observed that the resonance bandwidth is increased with increase the value of L_1(Other parameters are constant, referred to Table 1) shown in Fig9. Where as the bandwidth is increased with decrease the value of L_2 and return loss is increased slowly is shown in Fig 10.

Also it is observed that the bandwidth is increased with increased the value of W_1 shown in Fig.11.Hence the parameters L_1 ,L_2 and W_1 are responsible for variation of Bandwidth of proposed microstrip patch antenna.

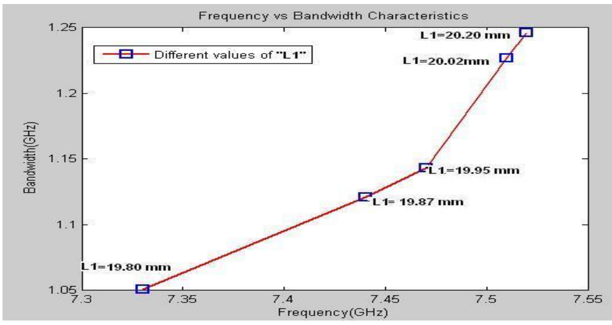


Fig.9 Simulated Bandwidth with Variation of L_1 while all other parameters in Table 1 are fixed

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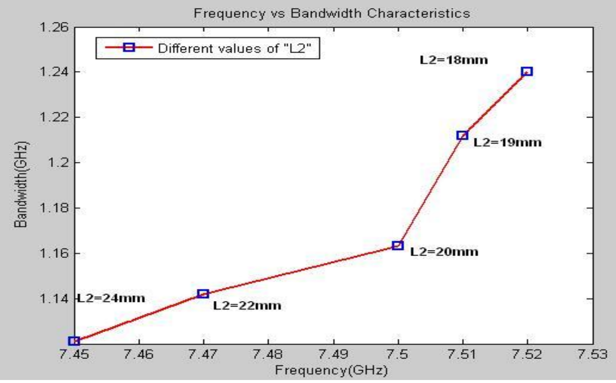

Fig.10 Simulated Bandwidth with Variation of L_2, while all other Parameters in Table 1 are fixed

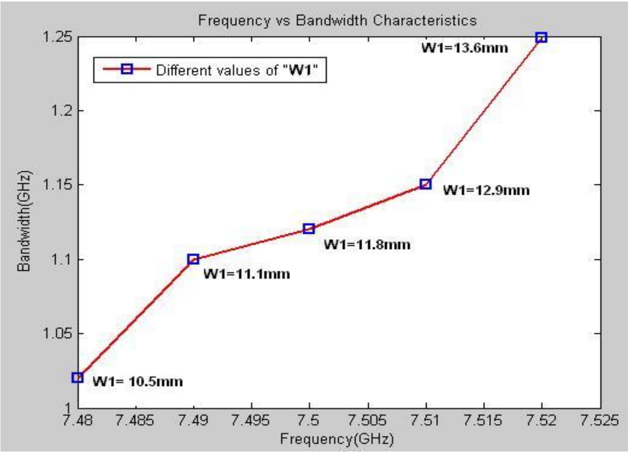

Fig.11 Simulated Bandwidth with Variation of W_1, while all other Parameters in Table 1 are fixed

Fig 12 shows the impedance (49.67Ω) locus of the h-slotted shaped microstrip patch antenna at resonance frequency of 7.52GHz.

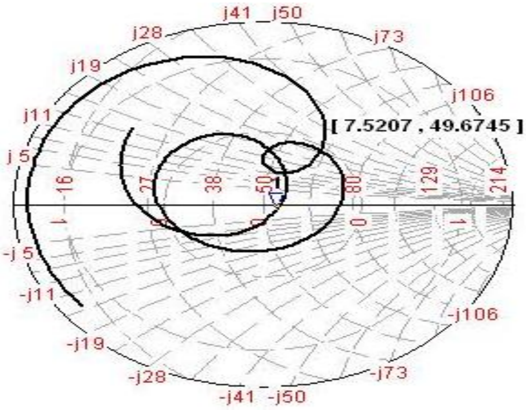

Fig 12.Smith Chart Display for proposed antenna at 7.52GHz.

IV. CONCLUSION

Proposed antenna for achieve the bandwidth of a microstrip patch antenna has been developed successfully. The proposed microstrip patch antenna can be achieving improved bandwidth. This paper presents a novel structure of Fork shaped antenna with dual frequencies of operations .The antenna has improved good performance in terms of VSWR, current distribution, gain, return loss.

REFERENCES

1. N. G. Alexopoulos, D. R. Jackson., "Fundamental superstrate (cover) effects on printed circuit antennas," IEEE Trans. Antennas Propagat., vol. 32, 1987, pp. 807–815.
2. M. K. Meshram, B. R. Vishvakarma, "Gap-coupled microstrip array antenna for wide-band operation," International Journal of Electronics, vol. 88, 2001, pp. 1161-1175.
3. J-S. Row, K. L, Wong, "'Resonance in a superstrate-loaded rectangular microstrip structure," IEEE Trans. Antennas Propagat, vol. 29, 1993, pp. 1349–1355.
4. T.K.Lo and Y.Hwng, "Microstrip antennas of very high permitivity using iris,"Electron Lett., vol.40 no. 12, pp.718-719,Jun .2004
5. T. M. Au , K.F. Tong and K.M. Luk, "Analysis of offset dual- patch microstrip antenna," IEE Proc. Microwave. Antennas Propagat., Vol.141, No.6, 1994, pp. 523-526.
6. A. Axelrod, M. Kisliuk and J. Maoz, "Broadband microstrip-fed slot radiator," Microwave J., June 1989, pp. 81-94.
7. M. Kahrizi, T.K.Sarkar and Z.H.Maricevic, " Analysis of a wide radiating slot in the ground plane of a microstrip line," IEEE Trans. Microwave Theory Tech. , Vol. MTT-41, Jan. 1993, pp.2937.
8. R.A. Sainati CAD of micro strip antenna for wireless applications. Artech House, Inc 1996
9. D.M.Pozar,"Microstrip Antennas,"Jhon Wiley and ons,Hoboken,1995,pp.79-81
10. R. Garg, P. Bhartia, I. Bahl, and A. Ittipiboon, Microstrip Antenna Design Handbook, ArtechHouse, 2001.