

# 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  $\epsilon_r = 2.55$ ) of thickness ( $h$ ) = 1.6 mm. The proposed antenna is simulated with IE3D® software.

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

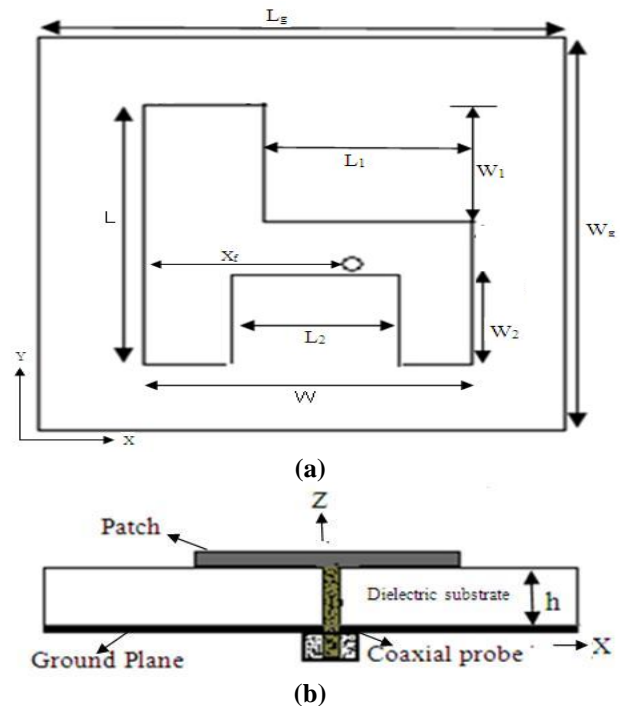
## I. INTRODUCTION

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 a 7.52GHz 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  $\epsilon_r = 2.55$ . 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 ( $\epsilon_r$ ) the parameters of proposed antenna are expressed [8-10] as follows:

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

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

Where  $e_{ff}$  and  $\Delta L$  are the effective and extended length of patch and expressed as:

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

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

$\epsilon_r$  is the effective dielectric constant of substrate is expressed as:

Manuscript published on 30 August 2016.

\*Correspondence Author(s)

Pritam Singha Roy, Department of Electronics, Govt. College of Engineering & Textile Technology, Berhampore, Murshidabad-742165. (West Bengal), India.

Samik Chakraborty, Department of Electronics & Communication, Indian Maritime University, Taratala, (Kolkata). India.

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$$\epsilon_{r,eff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[ 1 + 12 \frac{h}{W} \right]^{-\frac{1}{2}} \quad (5)$$

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

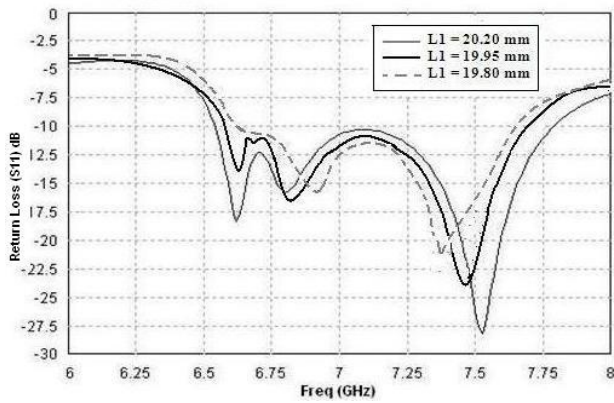
$$L_g = 6h + L \quad (6)$$

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

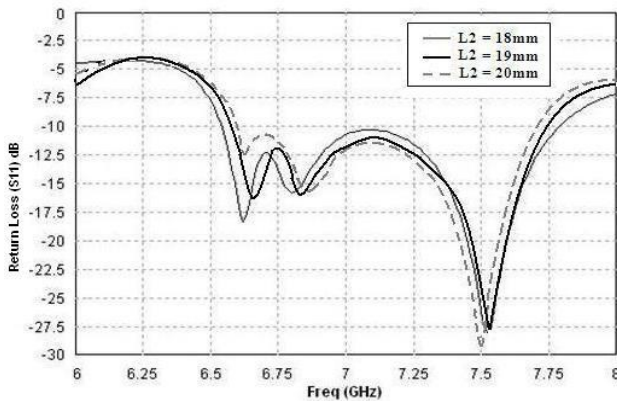
Where “h” is the thickness of substrate (in mm).

**Table 1. 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

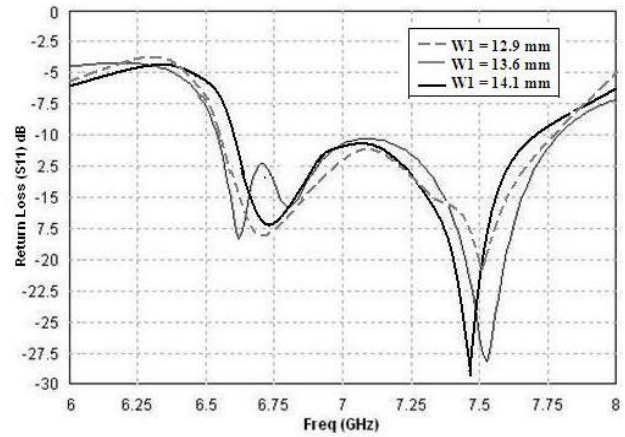


(a)



(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 Fig 2(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  $L_1$**   
( $L_2=18$  mm  $W_1=13.6$  mm,  $W_2=19$  mm, Feed point=2.5)

$L_1$ 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

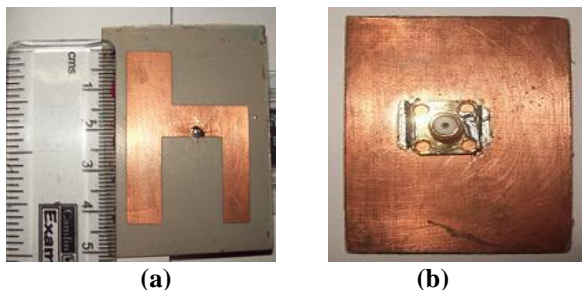
**Table 3. Parameters for different values of  $L_2$**   
( $L_1=20.2$  mm  $W_1=13.6$  mm,  $W_2=19$  mm, Feed point=2.5)

$L_2$ 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

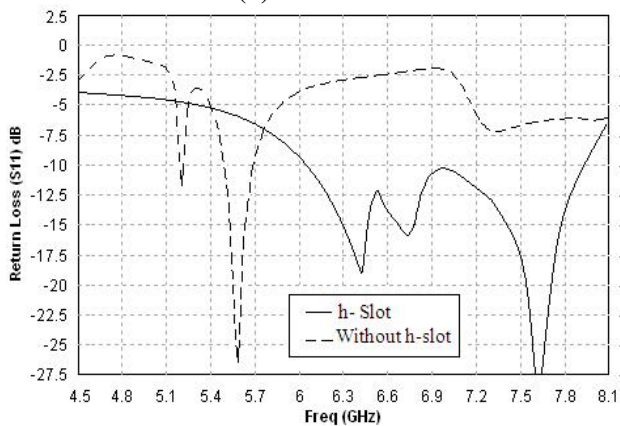
**Table 4. Parameters for different values of  $W_1$**   
( $L_1=20.2$  mm,  $L_2=18$  mm,  $W_2=19$  mm, Feed point=2.5)

W1 mm	Frequency Ghz	Return Loss	Gain dBi	BW Ghz	Vsw r
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**



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

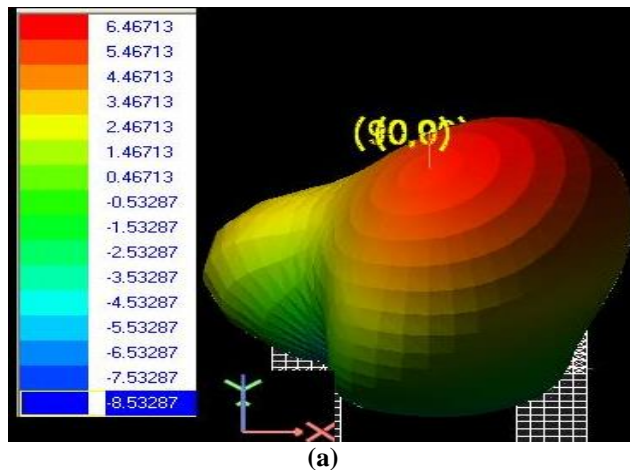


**Fig 5. Simulated results ( $S_{11}$ ) of proposed h-slot and without slot.**

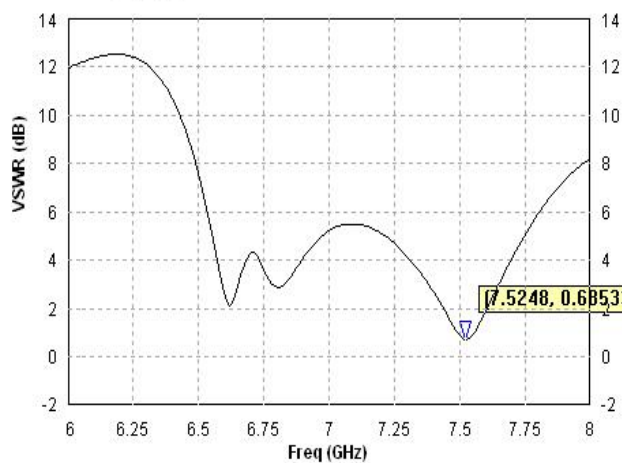
**Table 2. Bandwidth of proposed antenna**

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

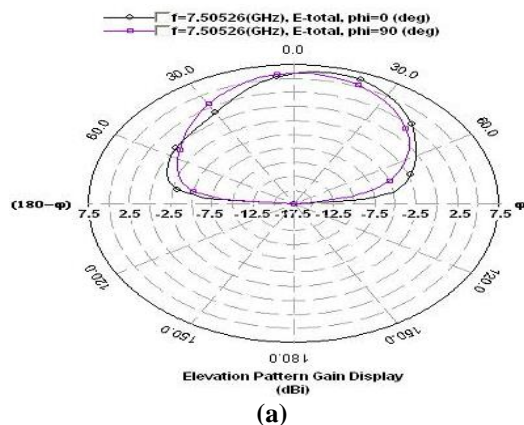
The proposed antenna is tested and fabricated on dielectric PTFE 2.55 and found the measured results referred to the Table 2. The gain is achieved 6.467dBi using simulation. The antenna operating with VSWR is 0.685 shown in fig 7, which improves to 16.6% of bandwidth.



**Fig 6. gain of proposed antenna simulated result.**



**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.



**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.

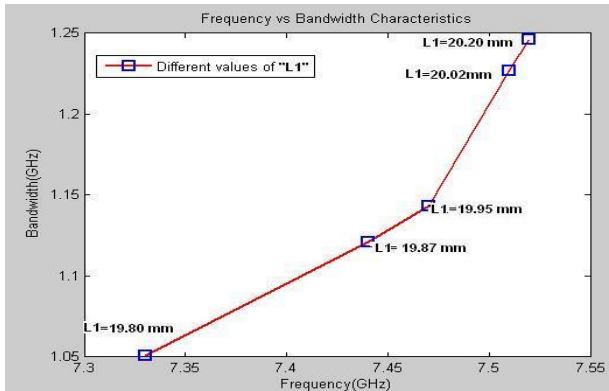




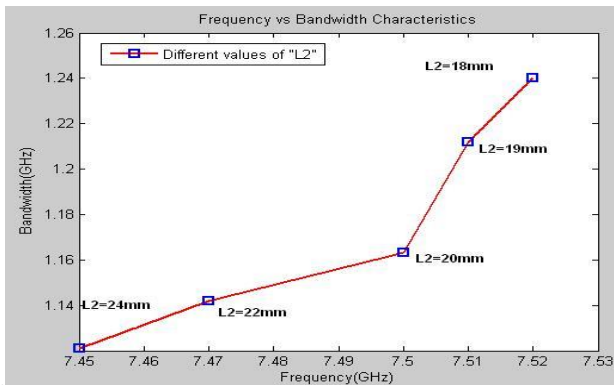
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Where as the bandwidth is increased with decrease the value of  $L_2$  and return loss is increased slowly is shown in Fig 10.

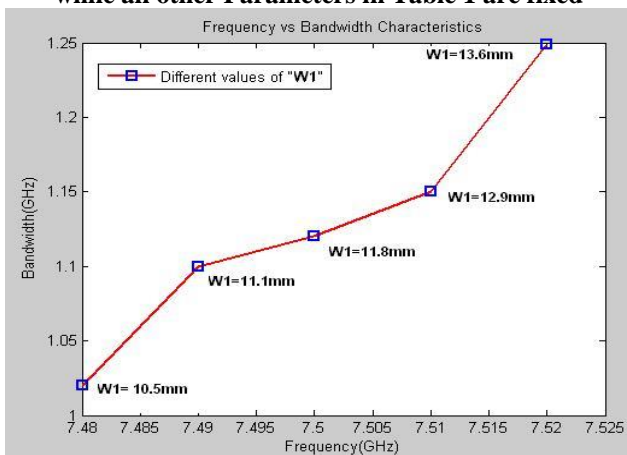
Also it is observed that the bandwidth is increased with increased the value of  $W_1$  shown in Fig.11.Hence the parameters  $L_1$ ,  $L_2$  and  $W_1$  are responsible for variation of Bandwidth of proposed microstrip patch antenna.



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

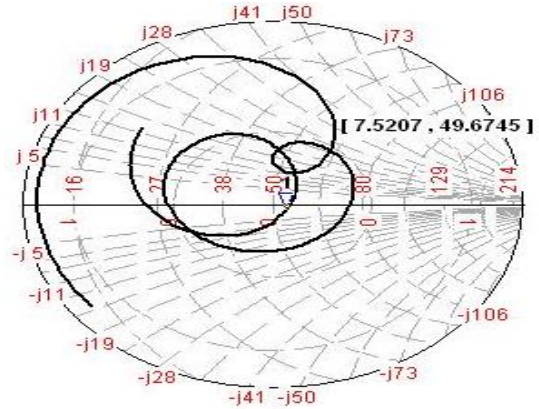


**Fig.10 Simulated Bandwidth with Variation of  $L_2$ , while all other Parameters in Table 1 are fixed**



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

Fig 12 shows the impedance ( $49.67\Omega$ ) 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.

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