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Inset Fed Horizontal wide U-Shaped Slotted Microstrip Antenna for Multi-band Operation

Neelesh Agrawal, Jamshed A. Ansari, Navendu Nitin, Devesh Tiwari, Abhishek Kumar Saroj

Abstract*-- A multi-band horizontal wide U-slotted patch antenna is proposed for wireless communication. Along with the horizontal wide U-slot, the proposed antenna also consists of four truncated corners along with inset feeding for proper antenna matching. The proposed antenna design has three distinct simulated resonating frequencies i.e., 4.7 GHz, 6.8 GHz and 9.8 GHz having -10 dB return loss band width as 111.1 MHz, 245.1 MHz, 998.6 MHz respectively while measured resonating frequencies are observed as 4.75 GHz, 7.1 GHz and 10.2 GHz having -10 dB return loss band width as 539.1 MHz , 410.6 MHz , 2.0834 GHz respectively . The proposed antenna results are examined using High frequency structure simulator tool and then verified through measured results . Thus, the proposed antenna is applicable for frequency bands like S band, C band and X band .

Keywords* : *Wide U-slot, truncated corners , inset feed, multi-band, microstrip antennas (MSA).

I. INTRODUCTION

Now a days , microstrip antennas (MSA) are used in almost all wireless communications since it can be embedded to the printed circuit board. It has one major limitation in all wireless communication devices that is; there is a requirement of two or three antennas for different applications such GSM, GPRS, Bluetooth, Wi-Fi, etc.. So an antennas is required that can be utilized for multi band applications. Multi-band antennas are antennas the can work simultaneous on different applications. Because of this various researchers and scientists worked on the different multi-band microstrip patch antennas such as a half U-Slot on a patch which is semi-circular in shape to generates two resonance frequencies[3,7], a shorted patch antenna loaded with half U-slot to get broad band resonance [4,7], stacked U-slot MSA to get broadband operation [5,7],Truncated corners U-slot MSA to get broadband operation [11,7], a circular dish patch antenna loaded with triple U- Shaped slots produces dual resonance[2], Multiband resonance structures such as a disk MSA with Quad c – slots and also by using multiple narrow slits [1,10], U shaped feeding strip having unequal arm to get high gain [6,7], MSA with U-Shaped parasitic elements for wideband operation [9,7].

In above used techniques of U-shaped patch the researchers achieved dual band, broadband and wide band applications. They were not able to achieve multi-band (more than two bands) operations for S, C, and X bands by above reported techniques. The main objective of the paper is that to achieve multi-band operation with novel design technique for MSA [8]. A novel design MSA has been proposed which contains horizontal wide U-slot on a rectangular radiating patch having four truncated corners and excited by inset line feeding. The detail analysis of the antenna design and operation is discussed in next section.

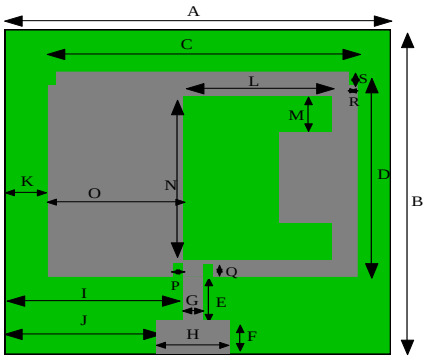

Fig. 1.Structure of the horizontal wide U slotted MSA

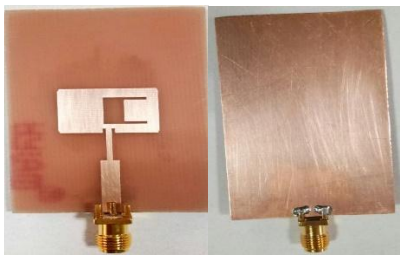

Fig. 2.Photograph of the fabricated horizontal wide U slotted MSA

II. ANTENNA DESIGN

The simulated horizontal wide U slotted MSA design is revealed in Fig 1. Proposed antenna structure is simulated and designed on HFSS. A dielectric substrate FR4 of thickness 1.6 mm is considered in the proposed model. The horizontal wide U slotted MSA is designed with a 50 Ω microstrip feed line for excitation.

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The length and width of microstrip line feed are characterized as F and H respectively . A quarter wave length transformer has been used with microstrip line feed for proper matching. The length and width of a quarter wave length transformer are represented as E and G respectively. Table-1 listed below shows different dimensions of the proposed MSA. The fabricated horizontal wide U slotted MSA is represented in Fig.2 .

TABLE-1. Antenna Parameters

Antenna Parameters	Size in (mm)
(B) represents the Ground plane Length	58.94
(A) represents the Ground plane Width	35.9
(D) represents the Patch Length	12.56
(C) represents the Patch Width	17.56
(E) represents the Quarter wave transformer Length	8.294
(G) represents the Quarter wave transformer Width	0.723
(F) represents the Microstrip Line Feed Length	14.896
(H) represents the Microstrip line Feed Width	3.059
(I)	17.6335
(J)	16.4205
(K)	9.17
Length of the horizontal arms of Wide U slot (L)	8
Width of the vertical & horizontal arms of Wide U slot (M)	1
Length of the vertical arm of Wide U slot (N)	8
(O)	7.78
Length of Inset Feeding (Q)	1.2
Width of Inset Feeding(P)	0.9
(S) represents the Truncated corners Length	0.5
(R) represents the Truncated corners Width	0.2

III. RESULTS AND DISCUSSIONS

The simulated & measured results of proposed antenna are revealed in Fig. 3. It has been observed that antenna resonates at three distinct frequencies. The three resonating frequencies obtained are due to following reasons :- (a) microstrip line of quarter wavelength, (b) horizontal wide U-shaped slot on a rectangular patch and (c) four truncated corners. All these combine techniques help in achieving triple band frequencies. It is observed that the simulated resonating frequencies are obtained at 4.7, 6.8 and 9.8 GHz having peak return loss up to -13.6699 dB, -22.0876 dB and -23.6923 dB respectively while the measured resonating frequencies are 4.75, 7.1 and 10.2 GHz having return loss up to -24.3844, -19.8713, -32.7160 respectively .

Fig. 4. shows simulated & measured -10dB return loss band width for the proposed MSA. The simulated (-10 dB return loss) bandwidth for frequencies 4.7, 6.8 and 9.8 GHz are 111.1 MHz ,245.1 MHz , 998.6 MHz respectively. The measured(-10 dB return loss bandwidth) for frequencies 4.75, 7.1 and 10.2 GHz are 539.1 MHz , 410.6 MHz , 2.0834 GHz respectively. A decent resemblances between the measured and simulated results has been attained but the dissimilarities in resonating frequencies between the measured and simulated results are may be because of various limitations in simulated design .

For frequencies 4.7, 6.8 and 9.8 GHz the simulated VSWR are 1.5229, 1.1707, 1.1399 respectively while measured VSWR for frequencies 4.75, 7.1 and 10.2 GHz are 1.1285, 1.2259, 1.0474 respectively as revealed in Fig. 5.

From Fig. 6, it is observed that proposed antenna has broadside radiation pattern at all resonating frequencies. The maximum radiation intensity for frequency 4.7 GHz is 1.0287dB (for Φ=90˚& Θ= -10˚) and 0.7606 dB (for Φ=0˚& Θ= 0˚) while for frequency 6.8 GHz maximum radiation intensity is 2.0047 dB (for Φ=90˚& Θ= 0˚) and 3.0436 dB (for Φ=0˚& Θ= 20˚) and for frequency 9.8 GHz maximum radiation intensity is 2.5861 dB (for Φ=90˚& Θ=-50˚) and 1.8246 dB (for Φ=0˚& Θ= 10˚).

Simulated 2D gain for frequencies 4.7, 6.8 and 9.8 GHz are shown in Fig. 7. Simulated 3D gain for frequencies 4.7, 6.8 and 9.8 GHz are represented in Fig. 8.The maximum gain of the antenna is 3.4378 dB, 5.3859 dB and 5.2190 dB for 4.7, 6.8 and 9.8 GHz respectively. It has been noticed that antenna gain is maximum at higher resonance frequency.

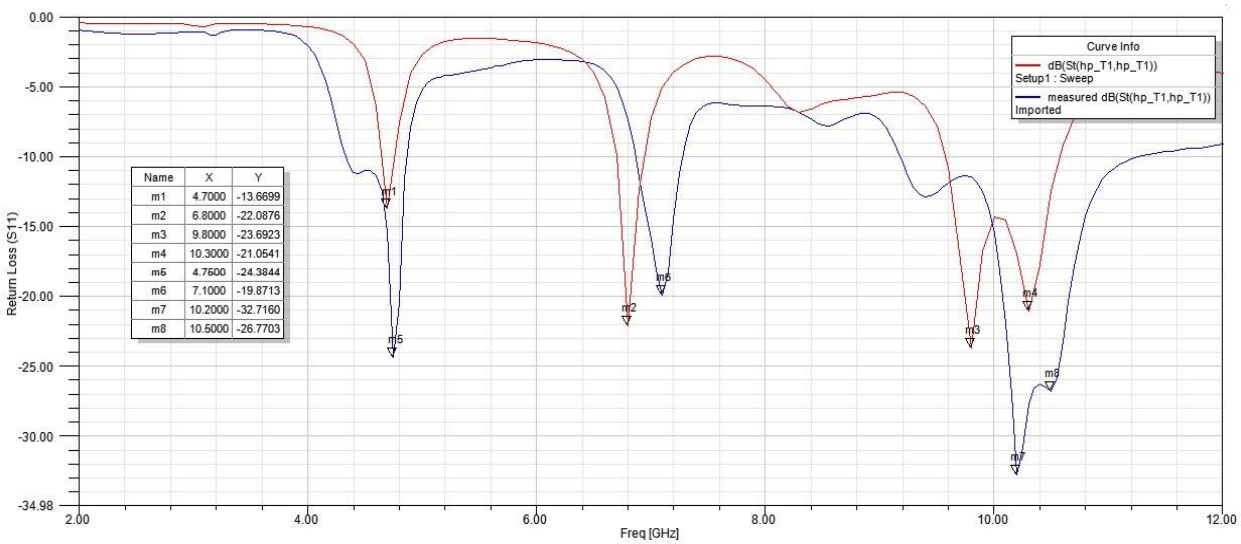


Fig. 3.Simulated & measured return loss vs frequency.

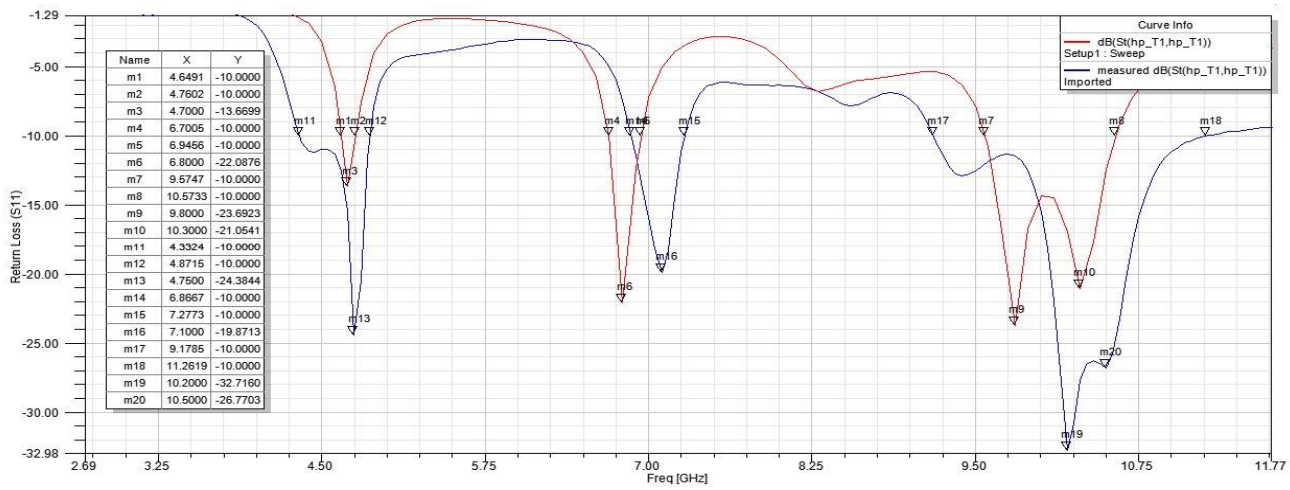


Fig. 4.Simulated & measured (-10 dB return-loss) bandwidth vs frequency

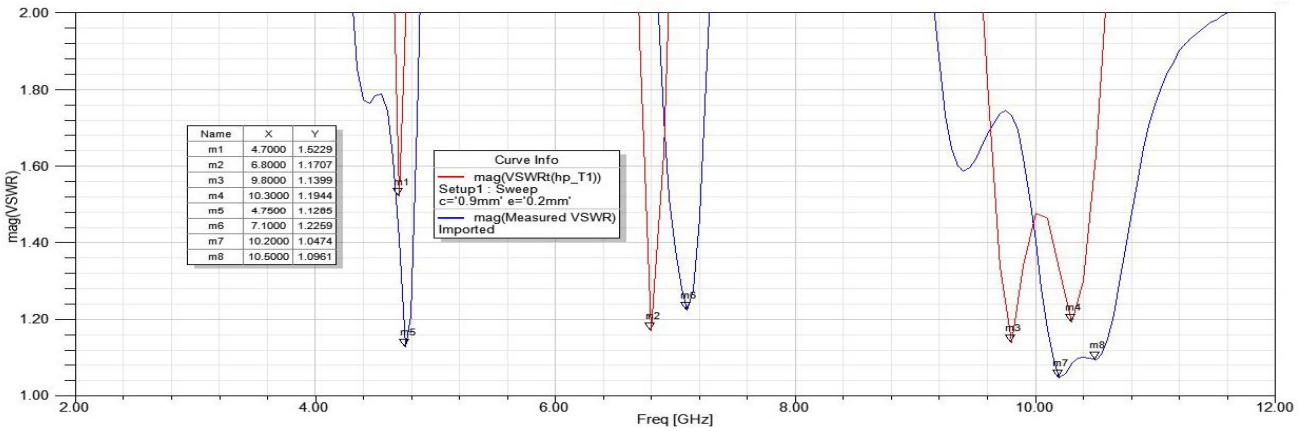
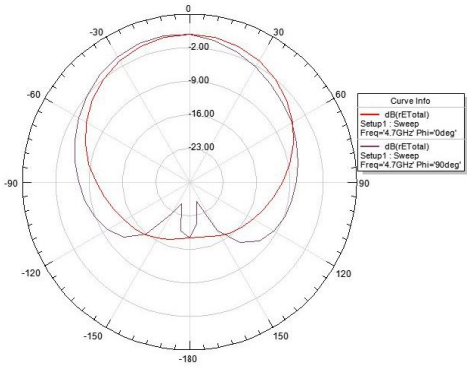
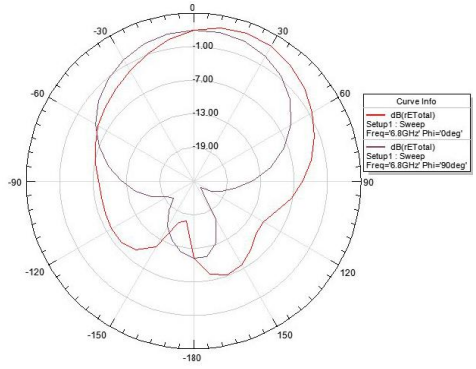


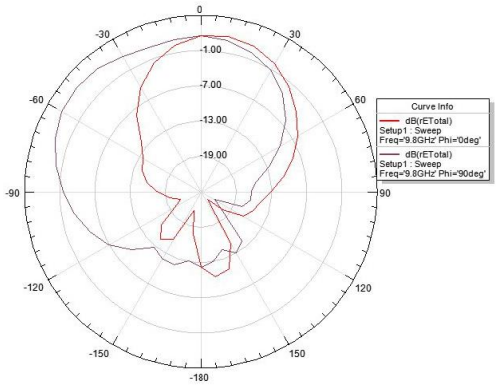
Fig. 5.Simulated & measured VSWR vs frequency .



(a)

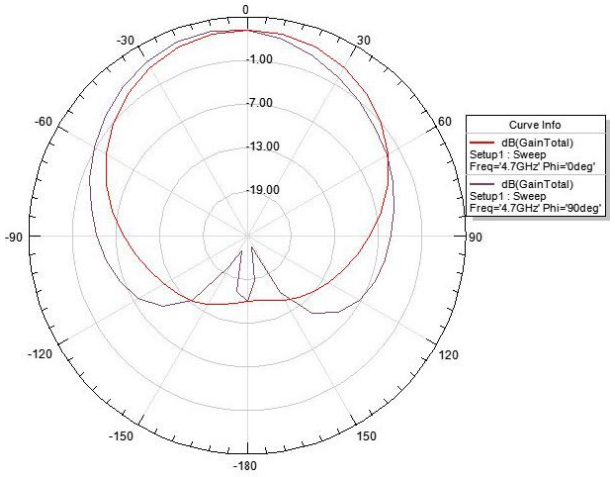


(b)

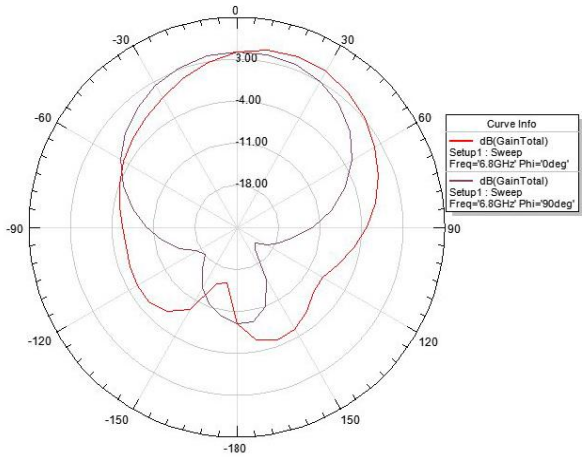


(c)

Fig. 6.Simulated radiation pattern at frequencies (a) 4.7, (b) 6.8, and (c) 9.8 GHz



(a)



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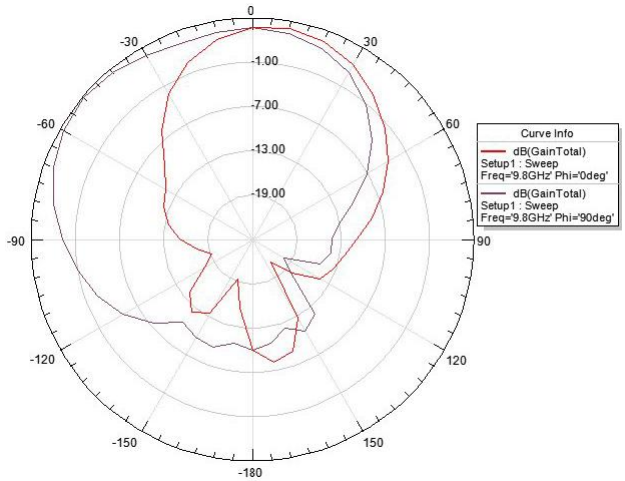
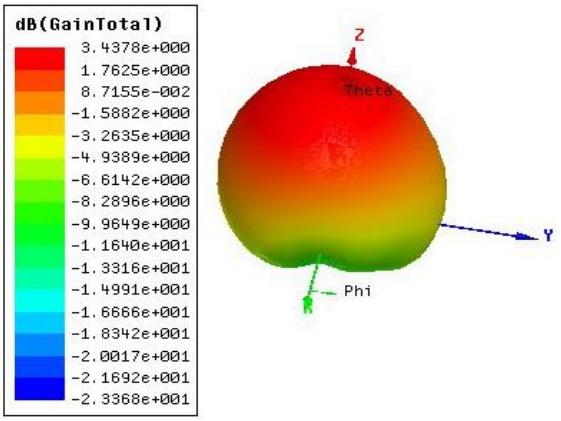
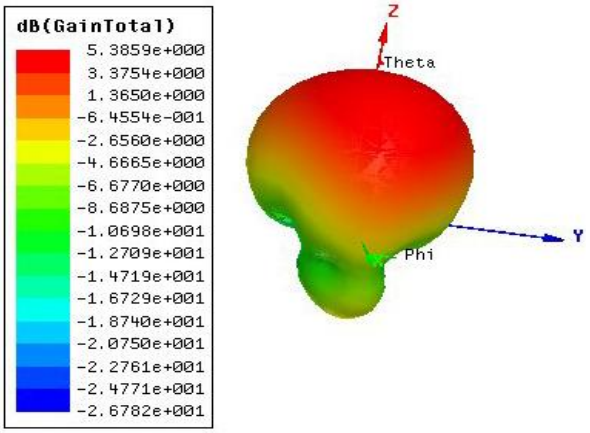


(c)

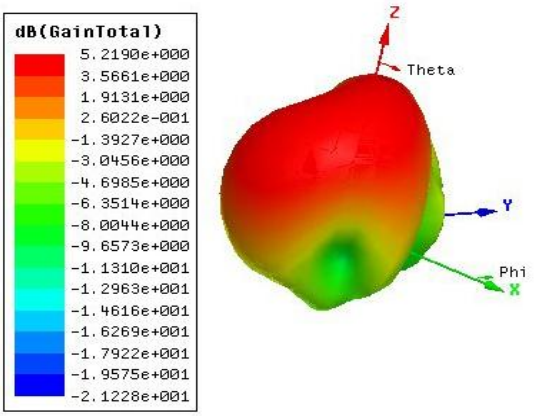
Fig. 7.Simulated 2D gain at frequencies (a) 4.7, (b) 6.8, and (c) 9.8 GHz



(a)



(b)



(c)

Fig. 8.Simulated 3D gain at frequencies (a) 4.7, (b) 6.8, and (c) 9.8 GHz.

IV. CONCLUSION

Inset fed horizontal wide U slotted MSA has been successfully presented for multi-band operation. From the results it was observed that antenna has shown good performance at higher resonating frequency having maximum simulated -10 dB bandwidth of 998.6 MHz at 9.8 GHz while measured -10 dB bandwidth of 2.0834 GHz at 10.2 GHz and maximum simulated gain of 5.3859 dB at 6.8 GHz . As well as radiation pattern is broadside at higher frequency. Thus, presented antenna can be useful for multiband operation in wireless communications.

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