Effect of Slot Length On Microstrip Antenna for Triple Band Application

Mamatha A G and Dr. Pradeep M Hadalgi

Abstract— A rectangular slot loaded microstrip antenna is designed to analyze the performance of antenna by varing length of the slot. the designed antenna has FR4 as a substrate with the height of 0.16 cms at 6 GHz frequency is simulated using HFSS software. the antenna shows the single, double and triple bands in nature for different slot dimensions and it is observed that as the length of the slot increases the virtual size of the antenna decreases. For slot length 0.05 cms peak gain is 2.91 dB with -18.68 dB return loss and the virtual size reduction of 15 % is obtained. The length of rectangular slot is increased by 0.05 cms in each step and for slot length 0.05 cms the antenna exhibits 30% virtual size reduction with good return loss, radiation pattern and VSWR.

Index Terms—Rectangular slot, FR4, HFSS, Triple band and Virtual Size Reduction

1 Introduction

Microstrip antenna has many applications in wireless communication, aeronautical, satellite application and military application because of its light weight, compact in size, less cost etc. Microstrip antenna has main drawback i. e its narrow bandwidth and less gain hence many techniques are used to overcome the drawbacks such as loading slot, truncating edges, using defective structures, adding metamaterials, multilayer substrates and EBG structures etc. [1,2].

Junho Yeo designed the microstrip antenna with very thin rectangular slot near the radiating edge to get a high permittivity with two resonant frequencies for higher sensitivity [3].

Tilak Sarmah proposed the microstrip antenna by introducing a diagonal slit on the patch at frequency 2.4GHz using HFSS. He loaded a slit at an inclination of 45 degrees and achieved a dual band in nature [4].

Sai Radavaram analyzed the microstrip antenna using two inverted U shaped slots which gives rise to wide band with Peak gain of 9.6 dBi and 6 dBi is obtained at the TM_{01} and TM_{02} modes [5].

Aarti G Ambekar designed using circular microstrip antenna, where the slits are loaded on the patch results in multiband response and also shows degeneration of matched input impedances at some modes to get dual polarization multiband antenna [6].

Ajay Thatere analyzed the patch antenna loading a defective ground structure of I shape, which results in 35% increase in bandwidth as compared to the rectangular microstrip antenna [7].

Anıl Elakaş designed a microstrip antenna with triangular shaped slits on the corners of the patch. The antenna is simulated using Sonnet Suites with air thickness 10 mm and achieved 9.68 dB gain at 9.5 GHz [8].

Jafar Khalilpour proposed a microstrip antenna with slits loaded on the patch results in 32 % of bandwidth improvement and also 44 % of size reduction. The microstrip antenna also exhibits cone pattern with circular polarization [9].

Ramesh Kumar Verma designed a microstrip antenna by loading slots and notch using IE3D simulation software for Bluetooth application shows triple band in nature [10].

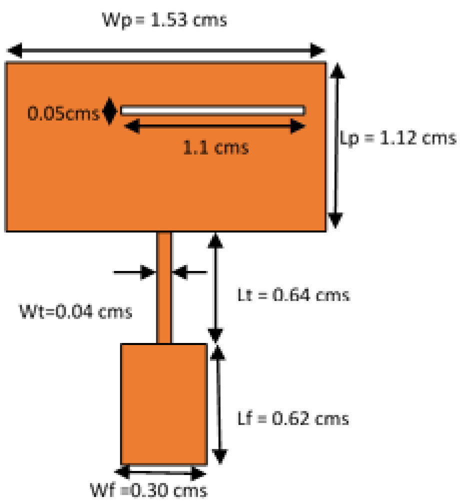
In this article a rectangular slot loaded patch antenna at 6GHz is designed and its performance is analyzed for different slot length by increasing in step of 0.05 cms. The proposed antenna characteristics peak gain, radiation pattern, VSR (virtual size reduction) and return loss results are being analyzed with the basic microstrip antenna.

2 Antenna Design and Simulation Result

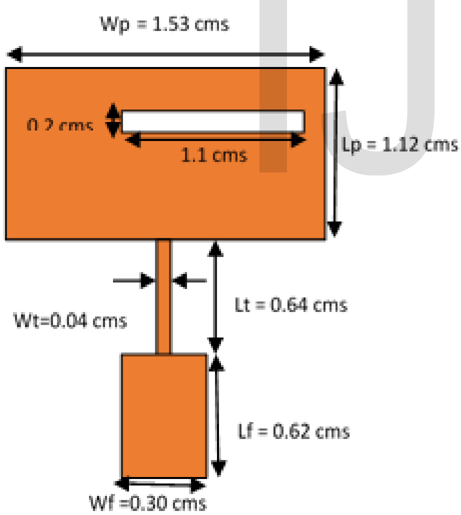
The conventional microstrip antenna is designed for 6 GHz using FR_4 substrate with dielectric constant 0f 4.4 and thickness of 0.16 cms. The designed antenna is resonating and 5.85 GHz frequency with the peak gain of 2.89 dB. The proposed microstrip antenna is designed using the slot loaded technique. The slot length nearly equal to 1/4 of wavelength is considered. The length of the slot is varied and for each increase in length of the rectangular slot on the microstrip patch is analyzed and performance of microstrip antenna is observed

2.1 Keeping Width of the slot W = 1.1 cms as constant

The microstrip antenna is loaded with slot L_1 = 0.05 cms length. The antenna is resonating at two different frequencies f_1 = 5.07 GHz and f_2 = 8.42 GHz with peak gain of 2.91 dB and 3.52 dB is obtained respectively. The length of the slot is increased in step of 0.05 cms up to 0.5 cms and the effect of slot in each step on the microstrip antenna characteristics is observed. As the length of the slot is increased the virtual size reduction decreases. The geometry of microstrip antenna of slot length for L_1 = 0.05 cms, L_4 = 0.2 cms, L_7 = 0.35 cms and L_{10} = 0.5 cms is showed in the figure (1) and fig (2).

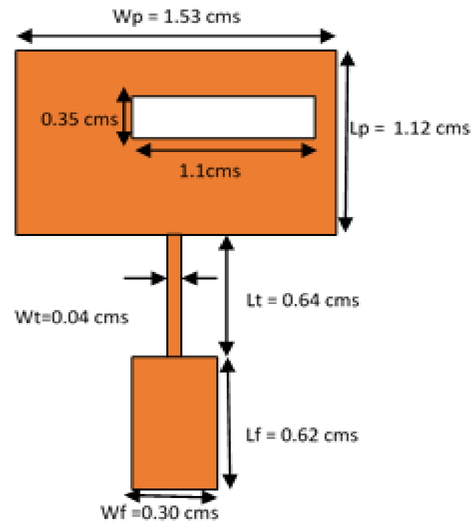


(a)

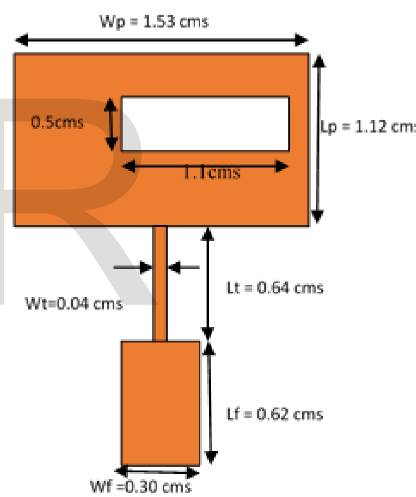


(b)

Fig 1. Rectangular slot loaded antenna having L1 = 0.05 cms and L4 = 0.2 cms



(c)



(d)

Fig 2. Rectangular slot loaded antenna having L7 = 0.35 cms and W = 0.5 cms

2.2 Current Distribution

The current distribution for change in slot length at each step is observed and analyzed. The current distribution is shown in figures 3 & 4 below (a, b, c and d). The accumulation of charge carriers near the slot loaded microstrip antenna is more as compared with the conventional microstrip antenna (fig a). The slot with length 0.05 cms, 0.2 cms and 0.5 cms is shown in below figure 3. The current distribution near the slot for slot length 0.5 cms is more because the slot width has increased the electrical path as compared with other dimensions of slots. Hence the antenna shifted to lower value frequency

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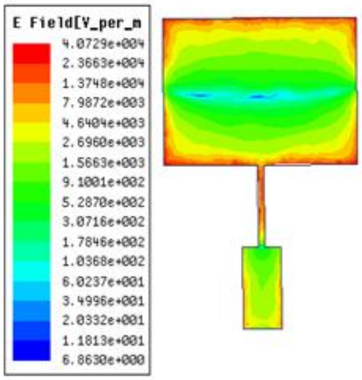
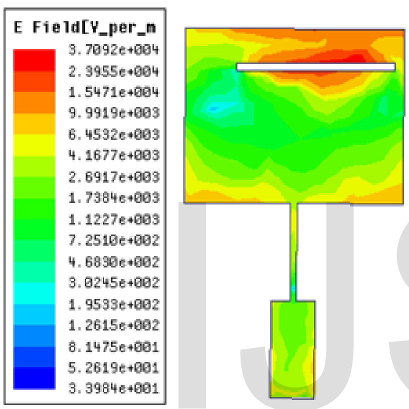
and also results in reduction of size up to 30 %.

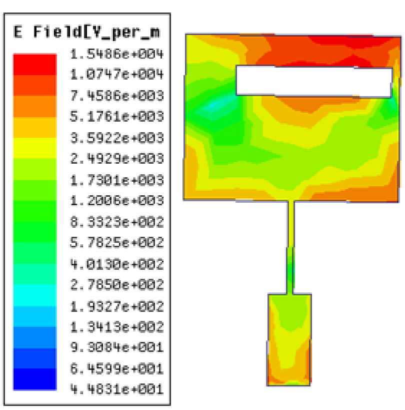


(a)



(b)

Fig 3 : current distribution of (a) conventinal antenna and (b) slot with 0.05 cms length



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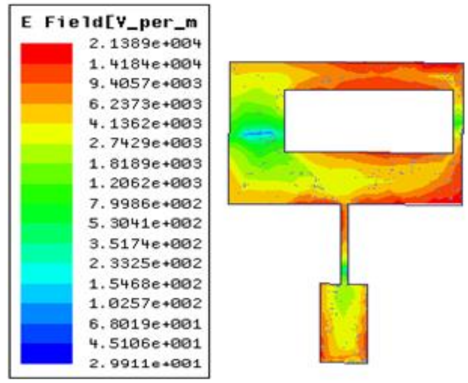
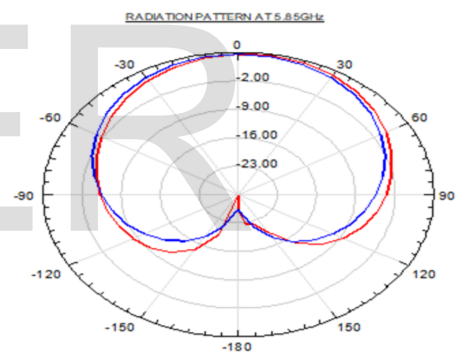


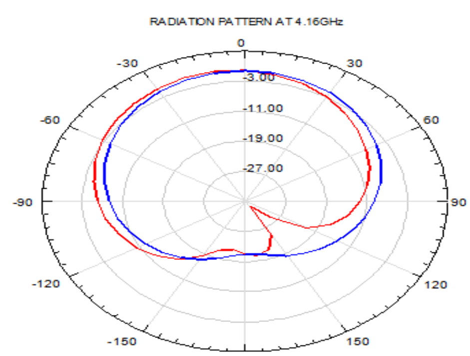
(d)

Fig 4 : current distribution of (c) slot with 0.35 cms length (d)slot with 0.5 cms length.

The conventional microstrip antenna radiation pattern is compared with the slot loaded microstrip antenna where the length of the slot is L = 0.5 cms at frequency 4.16 GHz. The antenna with the slot loaded shows broadside radiation pattern as shown in fig 5.



(a)



(b)

Fig 5. Radiation pattern with E and H plane
(a) conventional microstrip antenna at 5.85 GHz
(b)For slot length L_{10} = 0.5 cms loaded microstrip antenna at 4.16 GHz

Table 1
Parameters of Microstrip antenna with variation of slot length.

Width of the Slot in cms	Resonating Frequency	S11 Value	Virtual Size Reduction
L_1 = 0.05	f_1 = 5.07 GHz	-18.68 dB	15.5 %
	f_2 = 8.42 GHz	-16.02 dB	
L_2 = 0.1	f_1 = 4.9 GHz	- 60.79 dB	18.3%
	f_2 = 8.48 GHz	-23.49 dB	
L_3 = 0.15	f_1 = 4.71 GH	-19.79 dB	21.5%
	f_2 = 8.67 GHz	-14.74 dB	
	f_3 = 10.24GHz	-10.78 dB	
L_4 = 0.2	f_1 = 4.65 GHz	-23.16 dB	22.5%
	f_2 = 8.83 GHz	-10.80 dB	
L_5 = 0.25	f_1 = 4.46 GHz	-23.48 dB	25.6%
L_6 = 0.3	f_1 = 4.38 GHz	- 22.89 dB	27%
L_7 = 0.35	f_1 = 4.30 GHz	-22.89 dB	28%
L_8 = 0.4	f_1 = 4.30 GHz	-15.08 dB	28%
	f_2 = 8.28 GHz	-10.21 dB	
L_9 = 0.45	f_1 = 4.21 GHz	-17.68 dB	29.8%
	f_2 = 8.42 GHz	-10.05 dB	
	f_3 = 10.9 GHz	-11.34 dB	
L_{10} = 0.5	f_1 = 4.16 GHz	-14.73 dB	30.6%
	f_2 = 8.42 GHz	-10.91 dB	
	f_3 = 11.28 GHz	-19.72 dB	

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3 Conclusion

The microstrip antenna is designed for 6 GHz and a rectangular slot of different length is varied and analyzed in each step. The microstrip antenna shows better performance for the slot length L_{10} = 0.5 cms with broadside radiation pattern and 30.6 % virtual size reduction is achieved and also exhibits triple band in nature. Hence the antenna found application in multiband.

- *Author Mamatha A G is currently pursuing PhD degree program inDepartment of Applied Electronics, Gulbarga University Kalaburagi,India electric power engineering in University, Country, PH-01123456789. E-mail: mamathaprashanth80@gmail.com*
- *Co-Author Prof. Dr. Pradeep M Hadalgi is Professor in Department of Applied Electronics, Gulbarga University Kalaburagi, India. E-mail: pm_hadalgi@rediffmail.com*

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