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Comb Shaped Triple Band Microstrip Antenna for Wireless Communication

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ABSTRACT

A comb shaped microstrip antenna is designed by loading rectangular slots on the patch of the antenna. The antenna resonating at three different frequencies f_1 = 5.35 GHz, f_2 = 6.19 GHz and f_3= 8.15 GHz. The designed antenna is simulated on High Frequency Structure Simulator software [HFSS] and the antenna is fabricated using substrate glass epoxy with dielectric constant 4.4 having dimension of 8x4x0.16 cms. The antenna shows good return loss, bandwidth and VSWR. Experimental results are observed using Vector Analyzer MS2037C/2.

Key words: Comb shaped, glass epoxy, triple band and HFSS.

1. INTRODUCTION

Microstrip antenna consists of patch on one side and a ground on the other side separated by a dielectric material. The microstrip antenna is known as printed antenna. Printed antenna is extensively used in many applications because of its low profile, less cost easy fabrication. Printed antenna has some limitations such as narrow band low gain and so on. These limitations can be overcome by introducing different techniques like slot loading, meandering edges of the patch, shorting embedding DGS, using FSS structures, and many more. Loading slots on the patch creates reactance and increases the current distribution of the antenna**.**

Priyanka Jain designed a comb shaped antenna with rectangular and circular slits with DGS structure. Antenna is resonating at dual band 2.4GHz and 4.4GHz frequencies with good return loss. When DGS is loaded it is observed that the return loss shows improvement from 21.31dB to 37.28 dB for 2.4 GHz and 30.76 dB to 33.87 dB at 4.4 GHz.

Angelina Markina presented a tooth shaped microstrip antenna. The variation of length and width of the teeth with respect to reflection coefficient is analyzed. Using recession model the numerical values for the S11 are calculated and it is found that two frequencies is best suited.

Kaushik Mandal proposed comb shaped microstrip antenna resonating for seven bands from 1.56 GHz to 6.02 GHz. Using coaxial probe feed the antenna is analyzed for different slot length.

Hussein H. M. Ghouz analyzed the microstrip antenna with triangular patch having elliptical shape resonator in embedded on the FR4 substrate. The antenna shows larger bandwidth 230 % with gain of 6.75dBi and average efficiency 75%, the antenna found wide band application.

Chong-Zhi Han, Guan-Long Huang, Tao Yuan designed a microstrip antenna suitable for millimeter wave using a coplanar fed structure and also the antenna is further studied by embedding eight element array to meet the be forming for 5G communication.

Ruipan Zhang presented a microstrip antenna is analyzed using multilayer structure having cross slots on the ground with the microstrip line feed shows application in Ka-band from 25 to 36.58 GHz and AR bandwidth from 30.80 to 36.13 GHz with high gain over 5 dBi.

Bo Cheng proposed a multimode microstrip antenna, it consists of grid slotted patch with vertical grounded balun feeding structure the TM10, TM12, and antiphase TM22 modes are excited simultaneously with the bandwidth 26.2%.

Fajar Wahyu Ramadhan designed a microstrip antenna for multiband application in the S and C band radar. The is designed for three iterations by embedding fractal. The antenna is working at three different frequencies 2.24 GHz, 3.46 GHz, and 4.86 GHz with return loss -15.7 dB. -14.06 dB and -38.2dB respectively.

It is observed from literature review the microstrip antenna with slot loading, defective ground structures with multilayer substrates bandwidth can be increased. Compare to the previous research papers proposed slot loading is one of the simplest design to obtain good bandwidth.

In this paper a comb shaped microstrip antenna is designed using rectangular slots is presented. The conventional antenna parameters are enhanced by loading rectangular slots on the II and III quadrant of the patch and it is observed that by introducing the slots the current path of the antenna increases and results in increase in bandwidth

2. Microstrip Antenna Design

A conventional microstrip antenna is designed for center frequency 3.5 GHz over glass epoxy substrate having dielectric constant 4.2 (loss tangent 0.02). The rectangular patch dimensions' width and length are calculated using the equations (1-7).

1.1. Width of the patch antenna.

$$w = \frac{c}{2fr} \times \sqrt{\frac{2}{\epsilon r+1}} \text{ --------- } 1$$

1.2. Effective dielectric constant

$$\epsilon eff = \frac{\epsilon r+1}{2} + \frac{\epsilon r+1}{2\sqrt{1+12\frac{h}{w}}} \text{ ---------} 2$$

1.3. Length extension ΔL on each side is

$$\Delta L = 0.41\,h \times \frac{(\epsilon eff+0.3)}{(\epsilon eff-0.258)} \times \frac{(\frac{w}{h}+0.264)}{(\frac{w}{h}+0.8)} \text{ ------- } 3$$

1.4. Effective length of the patch

$$L_{eff} = \frac{c}{2fr\sqrt{\epsilon eff}} \text{ ------------ } 4$$

1.5. Actual length of the patch

$$L = L_{eff} - 2\Delta L \text{ ------------ } 5$$

1.6. Ground plane dimensions

$$L_g = 6h+L \text{ -------------- } 6$$
$$W_g = 6h+w \text{ ------------- } 7$$

Figure 1 shows the geometry of the conventional microstrip antenna. And the figure 2 is the fabricated conventional microstrip antenna using low cost material FR_4 as a substrate. The detailed dimensions of antenna parameters are tabulated in table 1.

Table 1. Dimensions of the conventional antenna.

Parameters	Dimensions
Width of the patch Wp	2.64 cms
Length of the patch Lp	2.04 cms
Width of the feed line Wf	0.3 cms
Length of the feed line Lf	2.18 cms
Width of the quarter wave transformer feed Wtf	0.05 cms
Length of the quarter wave transformer feed Ltf	1.09 cms
Length of the ground	8 cms
Width of the ground	4 cms

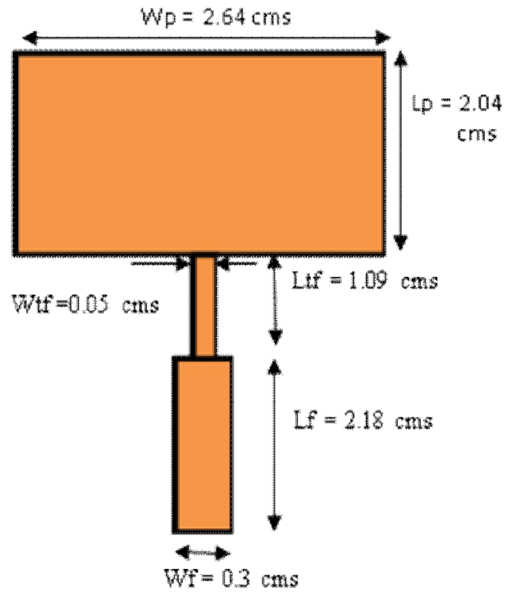


Figure 1. Geometry of conventional microstrip antenna.

Figure 2. Fabricated Conventional Microstrip Antenna.

3 Proposed Antenna Design

3.1 Comb shaped microstrip antenna design

To improve the gain and bandwidth of the antenna the study is carried out by loading Rectangular slots in the form of comb shape, on the conventional microstrip antenna. The dimensions of the slot S_l has a length 1.6 cms with the width S_W = 0.15 cms is loaded. Slots (R_1-R_9) are embedded with length 1 cms having width (P_1-P_9) = 0.1cms. Figure 4 gives the geometric structure of the comb shaped microstrip antenna with detailed dimensions of each slot length and width. Figure 3 is the fabricated comb shaped microstrip antenna using quarter wave transformer feed. Rectangular slots on the II and III quadrant of the patch is loaded. Loading slot means adding reactance which results in performance improvement in terms of bandwidth, gain and the number of bands.

Fig 3.Fabricated comb shaped microstirp antenna

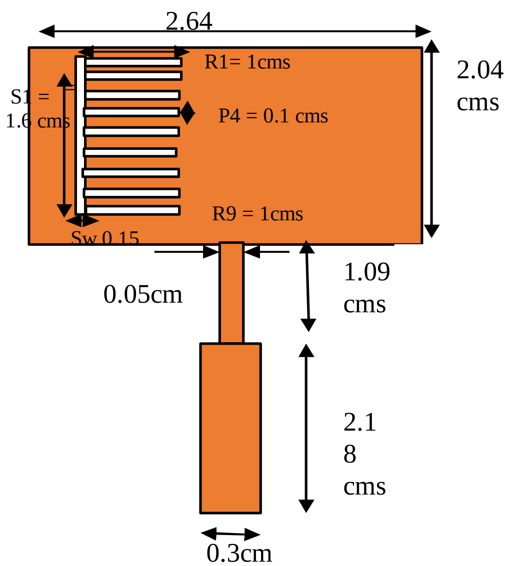


Fig 4. Geometry of comb shaped microstrip antenna.

4. Result and Discussion

Conventional microstrip antenna is designed for the center frequency 3.5 GHz and simulated using HFSS software. The parameters of the antenna are measured using Vector Analyzer MS2037C/2. Figure 5 shows the simulated and the measured reflection coefficient graph. The simulated results show antenna resonating at 3.4 GHz with return loss -15.83 dB having Bw = 2.64 % and measured antenna is resonating at 3.29 GHz with return loss -14.88 having Bw =2.73 %.

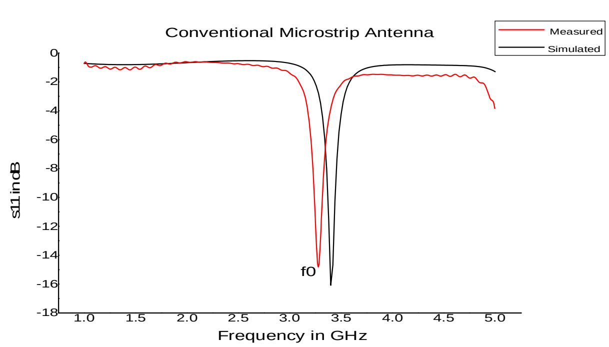


Figure 5. Frequency versus Reflection coefficient for conventional microstrip antenna.

Rectangular slots in the form of comb results in triple band in nature. The comb shaped antenna is resonating at three different frequencies f_1 = 5.35 GHz, f_2 = 6.19 GHz and f_3= 8.15 GHz measured with return loss rl1 = -11.33 dB, rl2 = -19.56 dB and rl3 = -21.08 dB and f_1 = 5.5 GHz, f_2 = 6.05 GHz and f_3 = 8.02 GHz with return loss rl1 = -25.41 dB, rl2 = -11.31 dB and rl3 = -22.05 dB simulated results respectively. The comb shaped microstrip antenna is compared with the conventional antenna as shown in figure 6.

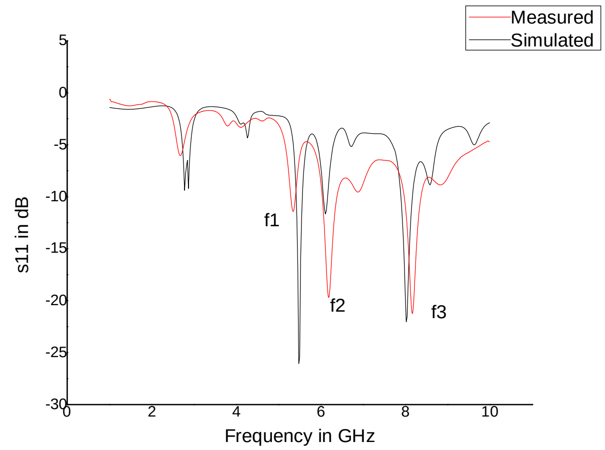


Figure 6. Frequency with reflection coefficient for comb shaped antenna.

It is observed in the figure 6 that without slot the bandwidth is 2.73 % The bandwidth of microstrip antenna for three resonating frequencies are Bw1 = 2.24 GHz Bw2 = 5.49 GHz Bw3 = 4.78 GHz. As compared to the conventional microstrip antenna the comb shaped microstrip antenna shows the better return loss, bandwidth and gain because when slots are loaded on the patch the current gets multiple paths which gives rise to more number of bands. Figure 7 show the compared VSWR plot for both simulated and measured results. It is observed that the values of VSWR for both measured and simulated are less than 1.85.

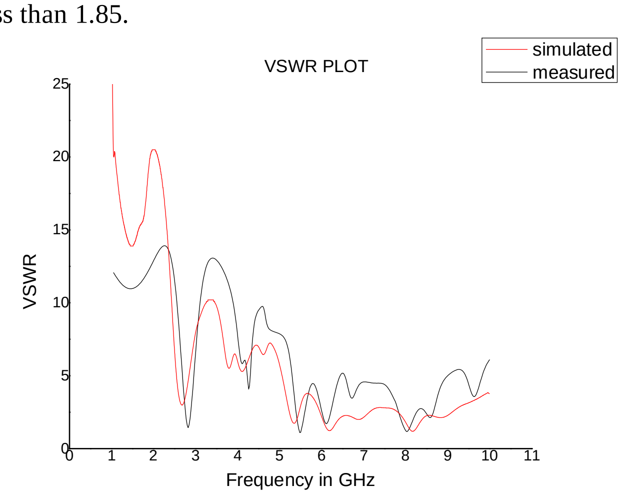
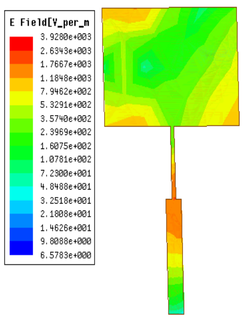
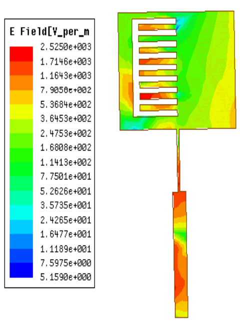


Figure 7. Frequency with VSWR plot.

The current distribution of conventional microstrip antenna is compared with the comb shaped microstrip antenna. It is observed in the figure 8 that the current distribution without slot loaded antenna shows current distribution near the radiating edge. When the slots are loaded the current distribution increases and it is observed both near feed line as well as near the slots.

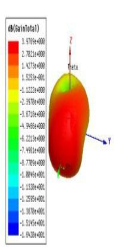


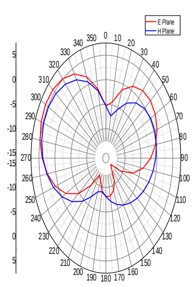
(a)



(b)

Figure 8. (a) Current Distribution for Conventional Microstrip Antenna (b) Current Distribution for comb shaped microstrip antenna.





(a) (b)

Figure 9. (a) 3D polar Plot Antenna (b) Radiation Pattern

Radiation pattern of the microstrip antenna with slot loaded and the 3D polar plot gain is shown in the figure 9. A gain of 3.13 dB and the radiation pattern for the first resonance 5.35 GHz is observed.

5. CONCULSION

The microstrip antenna with comb shaped slot is designed using low cost substrate FR4. The proposed prototype is resonating at three different frequencies f_1 = 5.35 GHz, f_2 = 6.19 GHz and f_3= 8.15 GHz with good return loss -11.33, -19.56 and -21.08 having bandwidth Bw1 = 2.24 GHz, Bw2 = 5.49 GHz and Bw3 = 4.78 GHz and VSWR less than 1.85. Since the microstrip antenna is resonating from 5.35 GHz to 8.15 GHz is found application in WLAN, C and X band.

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