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Multiband Microstrip Antenna with Multiple Rectangular Slots

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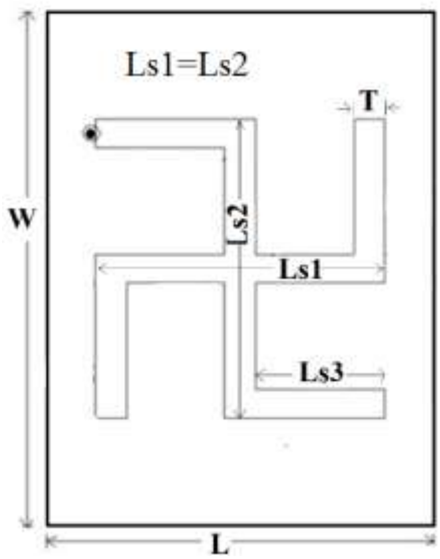
ABSTRACT
A dual polarized triple band microstrip antenna with symmetrical multiple rectangular slots has been studied. First, the rectangular patch has been fed at a fixed point and the effect is noted. Further, a symmetric plus-shaped slot has been inserted onto the patch and its effect is studied. The length of the plus shaped slot is increased and its effect on the lower order modes is observed. Next, the feed-point location is changed to obtain optimum radiation pattern. The operating frequency range of the antenna is from 0.2-1.5Ghz.

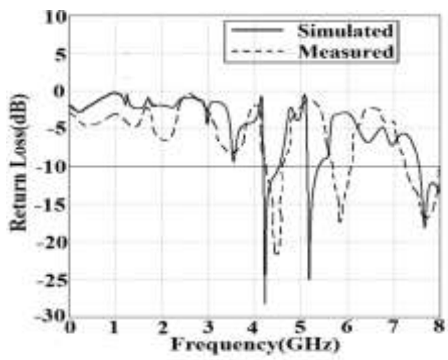
Keywords
Triple band microstrip antenna, dual polarized antenna, rectangular slots

1. INTRODUCTION
Various applications such as wireless communication see the need for dual polarized operating antenna in dual polarized antenna excitation of two orthogonal modes which in turn lead to generation of vertically and horizontally polarized E (Electric) field. Therefore, dual polarized antennas add to the body of information by providing two co-polarizations and two cross-polarizations [2].Advantages of dual polarized antenna are the reduction of multi path fading seen during transmission of a signal and also increase of channel capacity for a particular frequency. Some of the several attributes of the MSA such as its light weight and size that make it compatible for using in our hand held devices like cell phones, conformability to integrated circuits make it a good candidate for dual polarization.The basis of the paper lies in the study conducted in [1]. The configuration under consideration was a plus shaped asymmetrical slot antenna with multiple rectangular slots. The antenna showed multiband response operating in the frequency range 0.2-8GHz. In this paper, a fabricated antenna in with the same patch dimensions is considered. The slot dimensions are considered to be symmetric and a detailed analysis of lower order modes such as the fundamental modes TM_{01} and TM_{10} and also the mode TM_{11} is done. The antenna shows a triple band response for the lower frequency range. Hence, a comprehensive parametric study of varying slot lengths is conducted. The current distributions at all frequencies for different slot lengths are studied and the identified modes are tabulated. All antennas have been initially analyzed using IE3D software [3] using glass epoxy substrate (ε_r = 4.3, h = 1.6 mm, tan δ = 0.02).

2. ANTENNA GEOMETRY
The following are the dimensions of the reported antenna. The length of the patch is L=72.33 and width is W=86.60mm.The feed point is located at (-30.55, 26.28). The reported slot dimensions are Ls1=51.7mm, Ls2=57.6mm and Ls3=23.1mm and T=5.4mm. These are the dimensions of the fabricated antenna reported in [1]. Maintaining the patch dimensions constant, the slot dimensions are made symmetrical by taking L_{S1}=L_{S2}=50mm, L_{S3}=25mm and T=5mm. The operating frequency range of the antenna is from 0.2-1.5Ghz. The fabricated prototype of the antenna is shown in Fig 1(b). The simulated and measured resonance frequency and return loss plots are given in Fig 1 (c) and (d) respectively. From the figure 1 (b), the observed bandwidth for the three peaks are 0.2GHz, 0.3GHz, and 0.5GHz.



(a)



(b)

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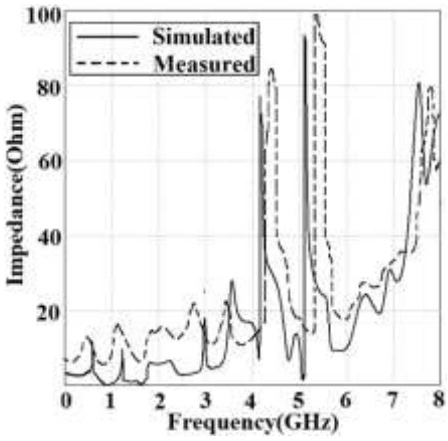


(c)

Fig 1(a): Geometry and (b) Return loss plot of and (c) Resonance curve of fabricated prototype

3. PARAMETRIC ANALYSIS

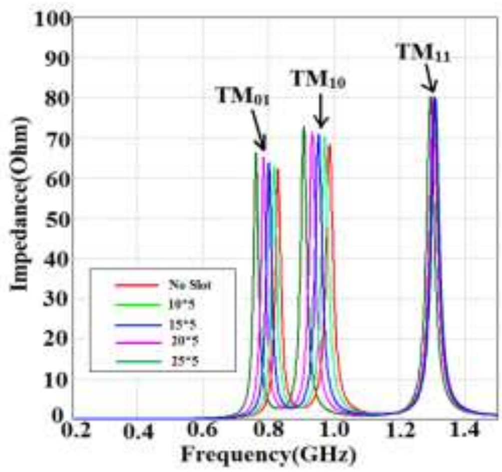
The analysis of the antenna began by conducting a parametric study of the symmetric slot. The first step involved only the study of the RMSA without slot at the feed point location mentioned above. The next step included increasing the plus shaped slot dimensions in steps of 5mm i.e. variation from 10mm to 50mm. Once this study was piloted, variations along the perpendicular arms of the plus shaped slot was carried out i.e. variation from 5 to 25mm in steps of 5mm. The current distribution at all frequencies for different slot lengths are studied and the identified modes are tabulated in table 1 and 2.

Table 1: TM Modes for various slot dimensions

MODES	NO SLOT	10*5	15*5	20*5	25*5
01	0.827	0.816	0.799	0.783	0.760
10	0.984	0.97	0.952	0.933	0.907
11	1.307	1.309	1.307	1.302	1.293

Table 2: TM Modes for various slot dimensions (contd.)

MODES	30*5	35*5	40*5	45*5	50*5
01	0.736	0.708	0.673	0.645	0.601
10	0.877	0.844	0.808	0.78	0.733
11	1.276	1.249	1.208	1.161	1.086



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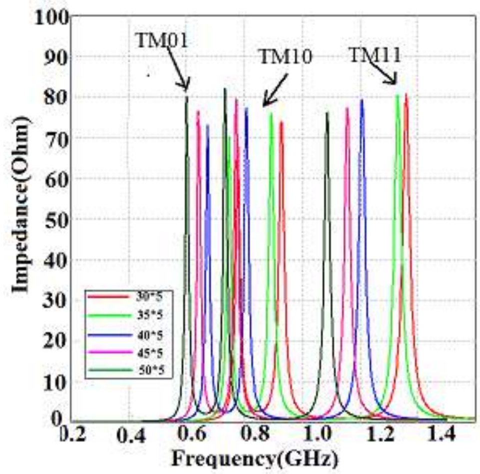
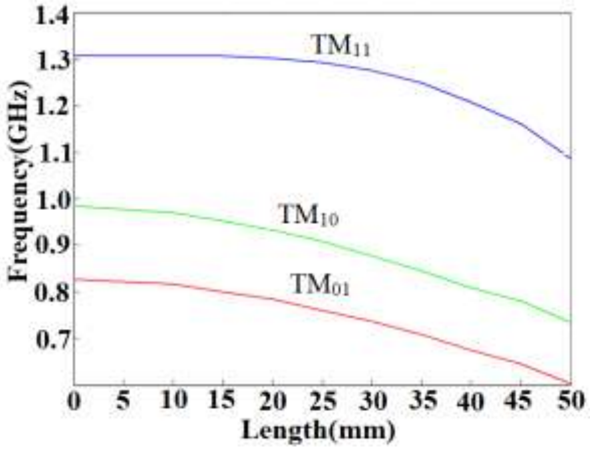


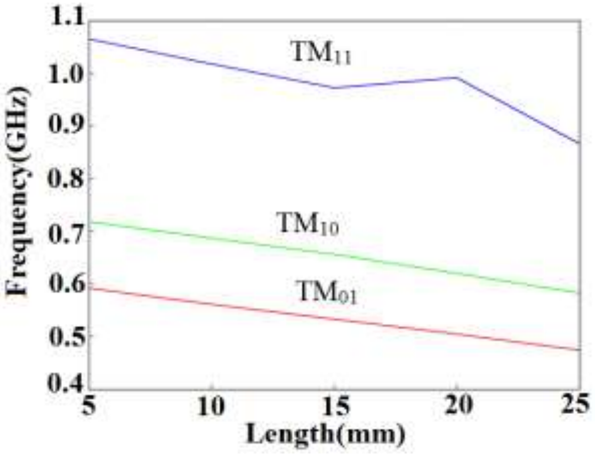
(b)

Fig 2: Resonance frequency plots for slot lengths varying from (a) L=0 and (b) L=50mm

It can be clearly observed from the graphs that as the length of the slots is increased, there is a slight decrease in impedance which results in better impedance matching. The result of the occurring TM modes corresponding to the length is plotted in the graphs as shown in the figures below.



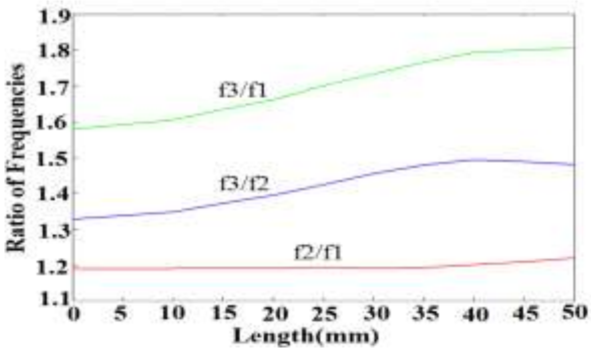
(a)



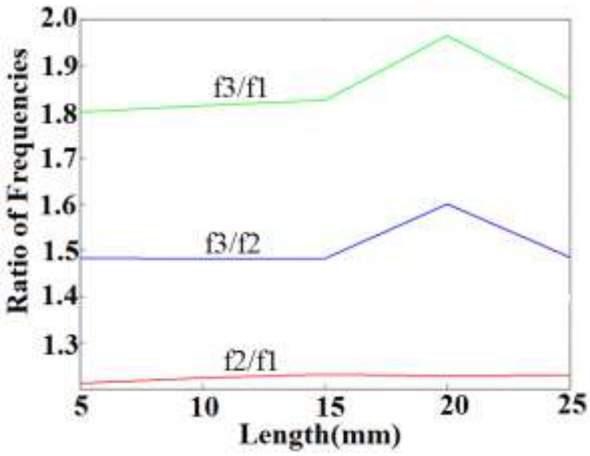
(b)

Fig 3. Frequency Vs Length for TM modes plot for (a) varying slot lengths (b) varying perpendicular edges lengths

Further, the graphs of f2/f1, f3/f1 and f3/f2 have been plotted to understand the tunability of this antenna. Here f1, f2 and f3 correspond to frequencies from modes TM_{01}, TM_{10} and TM_{11} respectively.



(a)



(b)

Fig 4. Tunability plot for (a) varying slot lengths (b) varying perpendicular edges lengths

The graph of ratio of frequencies versus length shown in the fig 4(a), (b) is for variation along plus shaped slot and along the perpendicular edges respectively. For f3/f2 and f3/f1, the graph is a gradually rising graph for increasing frequencies. For f2/f1, it can be noted that as lengths increase, the graph remains constant. The reason for this is as frequencies corresponding to TM_{01} increase, TM_{10} decrease at a constant rate and hence the effect is balanced and a constant graph is obtained. For a constant f2/f1 ratio, the tunability is said to be better because the changes in both TM modes is same and hence, the effect is same. Thus, this ratio of f2/f1 amongst the three plotted in the graph above provides the best tunability.

4. CONCLUSION

Thus, we have studied a symmetric slot and conducted a parametric study to analyze the lower order modes. Also, tunability was studied in order to understand how a band of frequency can be adjusted in terms of another band of frequency. We came to the conclusion that since f2/f1 is constant, it offers the best tenability. The future scope of this antenna’s tenability can be used in WAN, WLAN, Mobile TV, RFID, etc.

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