

# Analysis of L-Slot Loaded Rectangular Patch Antenna for Dual Band Operation

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**Abstract**—In this paper, a dual-band rectangular patch antenna is analysed and the results in terms of return loss and radiation pattern are given. It is observed that various antenna parameters are obtained as a function of frequency for different value of slot length, width and feed point; it is easy to adjust the upper and the lower band by varying these different antenna parameters. In the present work variation of substrate permittivity is also studied.

**Index Terms**—L-shaped, Slot, patch, antenna, dual band.

## I. INTRODUCTION

Today, the state of the art antenna technology allows the use of different types and models of antennas, depending on the area of application considered. Microstrip antennas have its remarkable advantages over conventional antennas and have attracted a lot of attention due to rapid growth in wireless communications area, due to their compactness, economical efficiency, light weight, low profile and conformability to any structure. However, microstrip patch antenna is limited by its inherent narrow bandwidth. Therefore, this problem has been addressed by researchers and many configurations have been proposed for band width enhancement [1-3]. Several patch designs with single feed, dual frequency operation have been proposed recently [4-7]. When a patch antenna is loaded with reactive elements such as slots, stubs or shorting pin, it gives tunable or dual frequency antenna characteristics [5]. A rigorous solution to the problem of a rectangular microstrip antenna which is the most widely used configuration because its shape readily allows theoretical analysis [8]. Also it is found that the substrate permittivity is a very important factor to be determined in microstrip antenna designs [9]. In the present work variation of substrate permittivity will be studied. In this paper, a rectangular microstrip patch antenna with a pair of L-shaped slots is presented. The proposed antenna can completely cover two bands. The proposed antenna provides a significant size reduction. Dual frequency is tuned by changing the dimensions of the slots. This paper is organized as follows. Section 2 describes the proposed rectangular patch antenna with a pair of L-shaped slots. Section 3, details the simulation resultants and the performance analyses using Matlab, different parametric studies have allows and the effect of the various antenna parameters on the return loss and the radiation of the proposed antenna are given. Finally Section 4 concludes the paper.

## II. ANTENNA DESIGN

The geometry for the rectangular microstrip patch antenna with a pair of L-shaped slots is shown in Fig. 1. The rectangular patch of dimension  $W \times L$  printed on the grounded substrate, which has a uniform thickness of  $h$  and having a relative permittivity  $\epsilon_r$  and the dielectric material is assumed to be nonmagnetic with permeability  $\mu_0$ . The patch is fed by a probe coaxial ( $50\Omega$ ).

The dual L-shaped slots, having a narrow width of  $W_n$  are placed parallel to the center line of the rectangular patch and faced to each other with distances of  $d$  and  $S$ , (see Fig. 2).

The L-shaped slot in a rectangular patch can be analysed by assuming it as a combination of horizontal slot Along X-axis denoted as “ $L_n$ ” and vertical notch Y-axis denoted as “ $L_s$ ” (see Fig. 2), when the notch is incorporated in the rectangular patch. Feeding is accomplished with a probe coaxial located on the axial of symmetry of the antenna in the point of coordinates  $x_0$  and  $y_0$ .

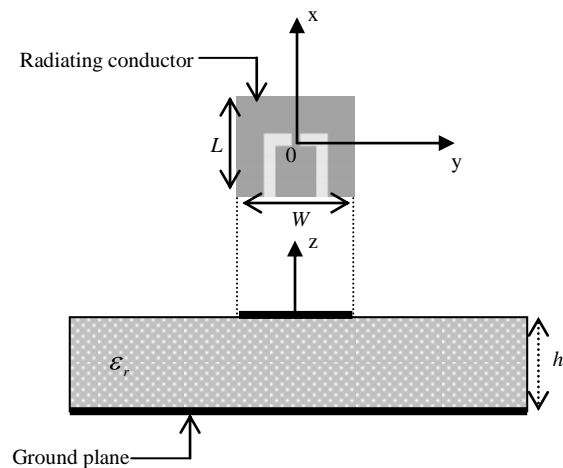


Fig. 1. Geometry of L-shaped slot loaded rectangular patch antenna

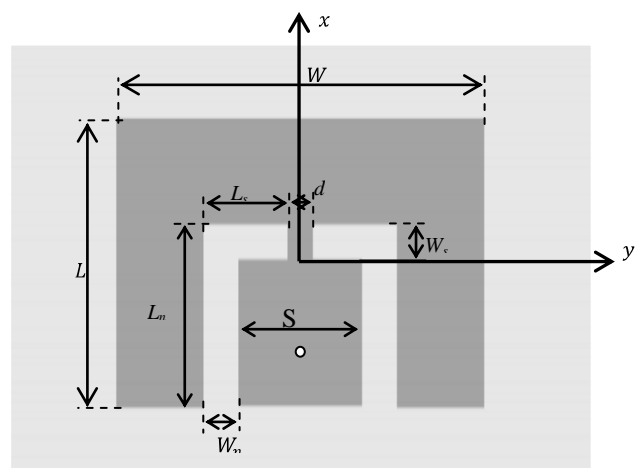


Fig. 2. Dimensions of L-shaped slot in a rectangular patch

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III. RESULTS AND DISCUSSION

Table 1 shows the different parameters (value, mm) of this proposed rectangular microstrip patch antenna with a pair of L-shaped slots, the simulation is done through programs in Matlab.

The following figures show the variation of return loss S11 with frequency and the effect of the different physical parameters on the return loss S11, the resonant frequencies and the band widths of the proposed L-shaped slot loaded rectangular patch antenna.

From Fig. 3 it is clear that the antenna resonates at two frequencies ( $F_{r1} = 2.45\text{GHz}$  and  $F_{r2} = 5.1\text{GHz}$ ) with two bandwidths. The -10dB bandwidth of lower and upper resonance frequency is respectively 19.56 % and 11.76 %.

The variation of return loss S11 according to  $\epsilon_r$  is shown by Fig.4, it is observed that the increase of the dielectric constant of substrate  $\epsilon_r$ , decreases both the lower and the upper resonance frequencies, it is found that the variation of the upper resonance is more significant than the lower resonance.

Figure. 5 shows the variation of S11 according to  $W_s$ , it is observed that both the resonance frequency are inversely depend on slot width ( $W_s$ )

From Fig. 6, the variation of S11 according to the slot length  $L_s$  is shown, it is observed that the resonant frequencies decrease slightly with increasing value of slot length ( $L_s$ ), whereas it is further observed that at both the lower and upper resonance frequencies it is almost constant.

Figure 7 shows the variation of S11 according to  $W_n$ , it is clear that the increase of the value of notch width ( $W_n$ ) decreases both the lower and the upper resonance frequencies.

For the variation of S11 according to the notch length  $L_n$  shown by Fig. 8, it is observed that both the lower and the upper gap of the resonance frequencies decrease with increasing value of the notch length  $L_n$ . It can be seen clearly that the notch length ( $L_n$ ) has a stronger effect on the resonance frequencies than the length slot  $L_s$  for both lower and upper resonant frequencies; also it is observed that the notch length ( $L_n$ ) has a stronger effect on the resonance frequencies than the notch width ( $W_n$ ) for the lower resonant frequency.

Table 1: Design parameters of proposed antenna

W	L	d	$W_s$	$L_s$	$W_n$	$L_n$	h	$\epsilon_r$	$(x_0, y_0)$
24	32	2	1	9	1	18	3.2	1	(0,-10)

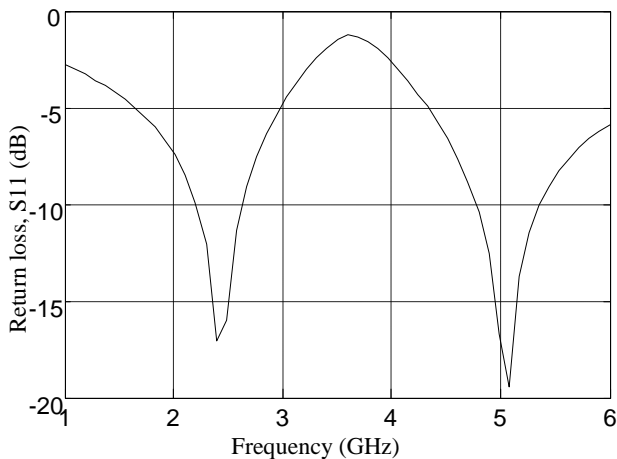


Fig. 3. Variation of return loss S11 with frequency.

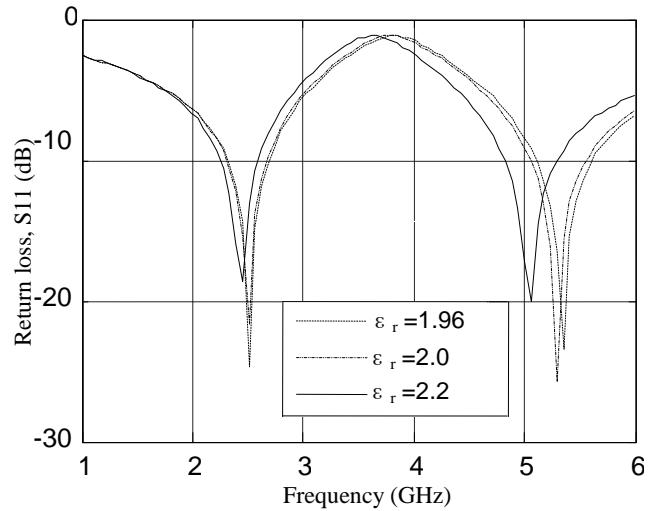


Fig. 4. Variation of return loss S11 with frequency for different substrate permittivity  $\epsilon_r$

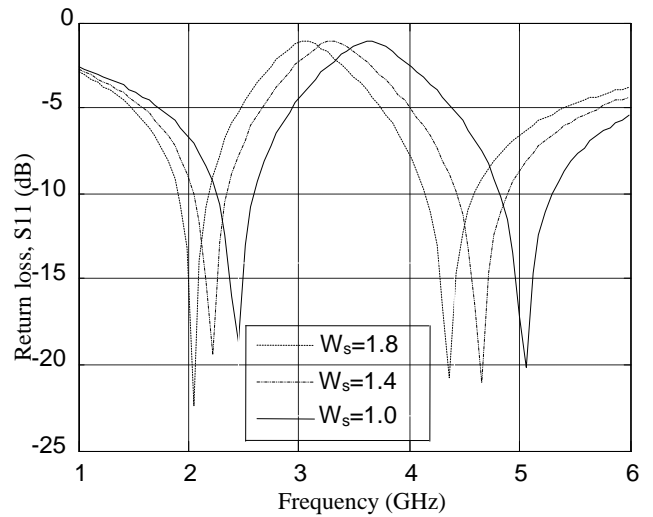


Fig. 5. Variation of return loss S11 with frequency for different value of slot width  $W_s$  (mm).

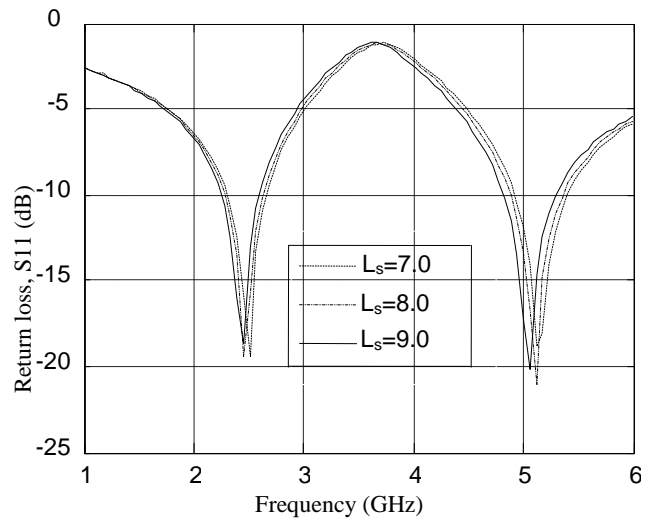


Fig. 6. Variation of return loss S11 with frequency for different value of slot length  $L_s$  (mm).

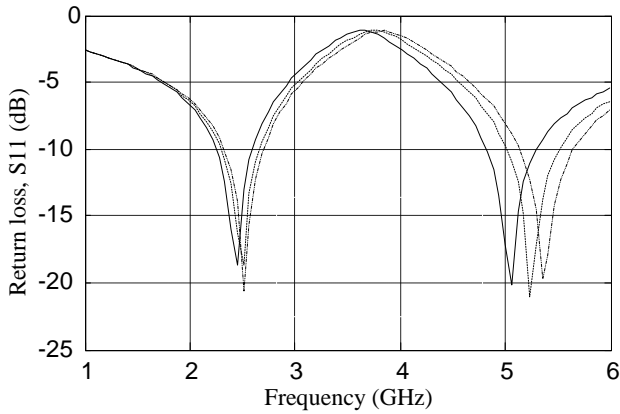


Fig. 7. Variation of return loss S11 with frequency for different value of notch width  $W_n$  (mm).

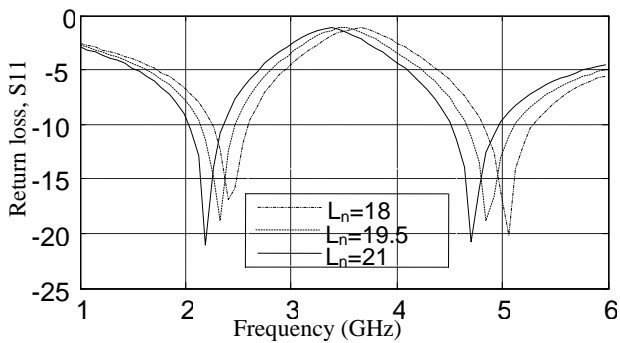


Fig. 8. Variation of return loss S11 with frequency for different value of notch depth  $L_n$ .

The variation of S11 according to  $y_0$  is shown in Fig. 9. The obtained results show that the lower and the upper resonance frequencies increase with increasing value of  $y_0$ . The maximum increase of both resonance frequencies is obtained in the centre of the axle of symmetry of structure. Also it should be noted that the feeding coordinates points has a stronger effect on the resonant frequencies as well as on the band widths, also the obtained results show that the upper resonant frequency varies more significantly when the  $x_0$  change compared to the other physical parameters of the proposed antenna.

Radiation pattern of the antenna is shown in Fig. 10 and 11 for both upper and lower resonance. It is found that radiated power at lower resonance frequency is higher than the upper resonance frequency. These figures show also that the radiation pattern is unidirectional in both principal planes E and H.

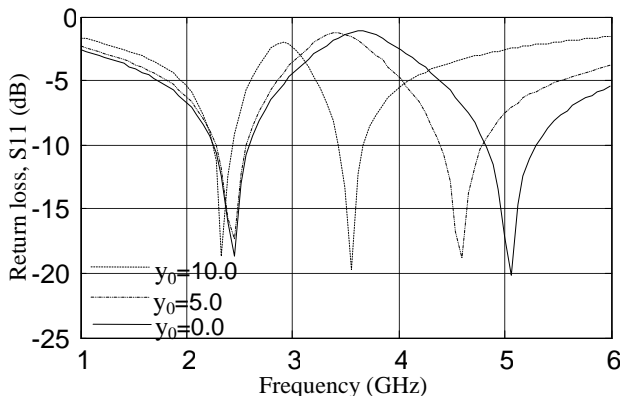


Fig. 9. Variation of return loss S11 with frequency for different feed locations  $y_0$  (mm).

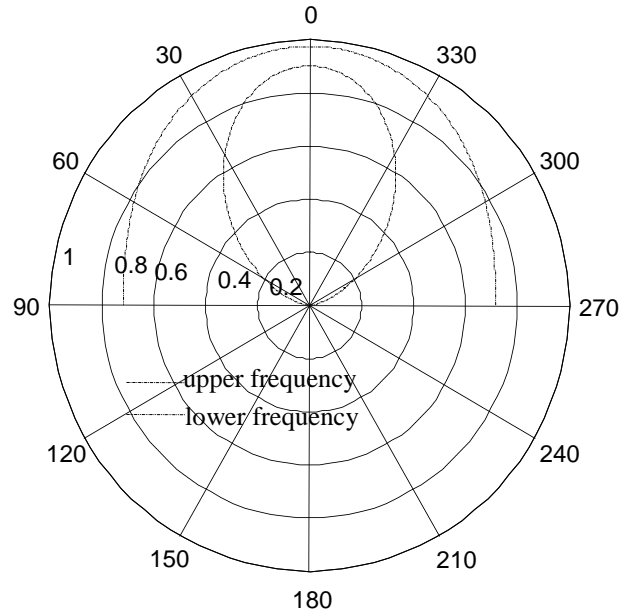


Fig. 10. Radiation pattern of L-shaped slot loaded rectangular patch antenna for both upper and lower resonant frequencies at E plane

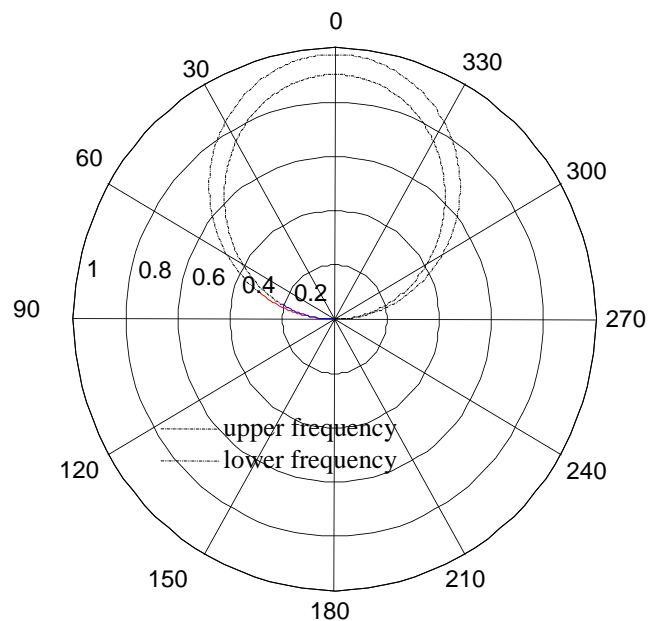


Fig. 11. Radiation pattern of L-shaped slot loaded rectangular patch antenna for both upper and lower resonant frequencies at H plane

#### IV. CONCLUSION

The L-shaped slot loaded rectangular patch has been treated in this paper, it is found that this structure can operate at two resonance frequencies and consequently this antenna can be used for dual band operation, also the effects of different physical parameters on the characteristics of this structure are investigated.

Numerical results indicate that both the upper and lower resonant frequencies and the band widths depend on the size of slot and highly dependent on the notch dimensions as well as feed locations. Also the radiation pattern of both upper and lower resonant frequency of the proposed antenna is presented in the principal planes E and H.

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