Bandwidth enhancement of patch antenna with anisotropic substrate using inset L-shaped feed and L slots on ground plane

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Abstract—in this paper, an inset L-shaped feed rectangular patch antenna with dual L slots etched on the ground plane is proposed and analysed for increasing band width of microstrip patch antenna. The results in terms of return loss and radiation pattern are given. The results show that dual wide bands are achieved and a better impedance matching for the upper and lower resonances are obtained.Simulation results for the effect of uniaxial substrate on the return loss and bandwidth of the rectangular patch antenna using inset L-shaped feed with dual rectangular slots on the ground plane are also presented. Our results of return loss using Ansoft HFSS are compared with those available in the literature which shows a good agreement.

Index Terms—Wide band antenna, rectangular patch, anisotropic substrate, modified ground plane.

I INTRODUCTION

The development of modern wireless communication leads to the need for broadband antennas found a wide spread application in the wireless communication industry because of their attractive features such as easy fabrication, cost, linear and circularly polarized radiation characteristics. Because of these attractive features of the broadband antennas are used in many wireless applications such as Wi-Fi, Bluetooth, GSM and GPRS.

The rectangular and circular patches are extensively used radiators which have very limited bandwidth [1]. These limits the applications in several practical cases, and the narrow bandwidth of the microstrip antenna can be widened. Recently, most of the research on microstrip antennas focused on methods to increase their bandwidth [2-10]. Several patch designs with single feed, dual frequency operation have been proposed recently [3-10]. When a microstrip patch antenna is loaded with reactive elements such as slots, stubs or shorting pin, it gives tunable or dual frequency antenna characteristics [8]. Since the slots are cut at an appropriate position inside the patch, they neither increase the patch size nor largely affect the radiation pattern of the patch [9]. These slots can take different shapes like, rectangular or square slot, step slot, tooth-brush shaped slot, V-slot, U-slot, etc [9]. The slot adds another resonant mode near the fundamental mode of the patch and realizes dual frequency response [9].

The study of anisotropic substrate is interesting since it has been found that the use of such materials may have a beneficial effect on circuit or antenna [2]. However, the designers should carefully check for the anisotropic effects in the substrate materials with which they will work.

In this paper, a novel wide band rectangular patch antenna printed on isotropic or uniaxial anisotropic substrate is designed by using inset L-shaped feed with dual L slots on the ground plane. The proposed antenna provides a significant size reduction and can completely increase the band width. In this paper the performance analyses of the proposed antenna are presented using Ansoft HFSS software, which is based on Finite Element Method, different parametric studies will be allowed and the effect of the various antenna parameters on the return loss and the radiation of the proposed antenna will be presented, also we will present the effect of the uniaxial substrate on the band width and the return loss with lower and upper resonant frequencies.

II ANTENNA DESIGN

A Simple rectangular patch antenna

The proposed structure of inset L-shaped feed with dual L slots on the ground plane given in this study to increase the band width, based on the simple rectangular microstrip patch which is designed first in order to compare it with the proposed structure.

The geometry for the simple rectangular microstrip patch of dimension W × L (see Figure 1) printed on the grounded substrate, which has a uniform thickness of h and having a relative permittivity εr and the dielectric material is assumed to be nonmagnetic with permeability μ_0.

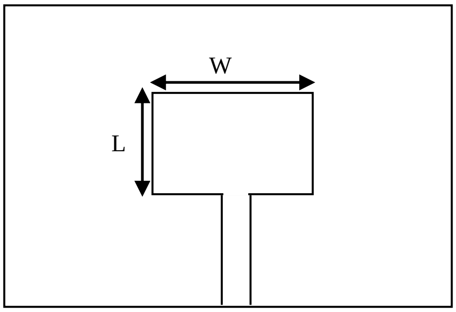

Figure 1 Geometry of a simple rectangular patch antenna

Table 1 shows the different parameters of the simple rectangular patch antenna.

TABLE 1
Design parameters of a simple rectangular patch antenna

Parameters	Value
W	15.8 mm
L	8 mm
h	1.6 mm
Relative permittivity	ε_r=4.5
Ground plane	34*20 mm^2

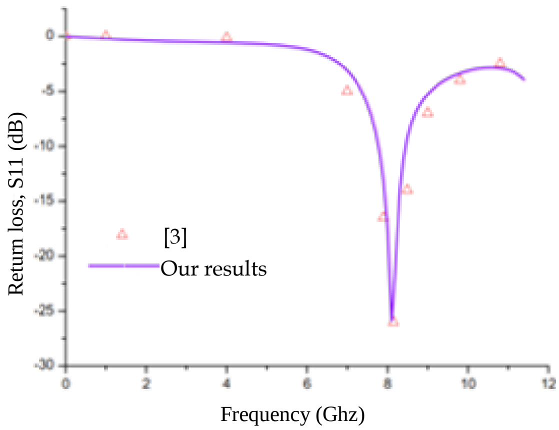

Figure 2 Simulation of return loss S11 of a simple rectangular patch antenna

Figure 2 shows the frequency response of the simple rectangular patch antenna.

B Rectangular patch antenna using inset L-shaped feed and L slots in the ground plane

The geometry for the proposed antenna based on the previous simple rectangular patch is shown in figure 2, in this case two L-shaped slots with the same dimensions are etched on the ground plane and the feeding is accomplished with inset L-shaped feed.

TABLE 2
Design parameters of the rectangular patch antenna usingin-set L-shaped feed with dual L slots on the ground plane

Parameters	Value
W	15.8 mm
L	8 mm
h	1.6 mm
Microstrip feed line	2.8 mm
$H_s=H_{FI}$	6 mm
$W_{FI}=H_{FL}$	0.5mm
$W_L=W_{FL}$	2mm
$W_s=H_L$	12 mm
Relative permittivity	4.5
Ground plane	34*20 mm^2

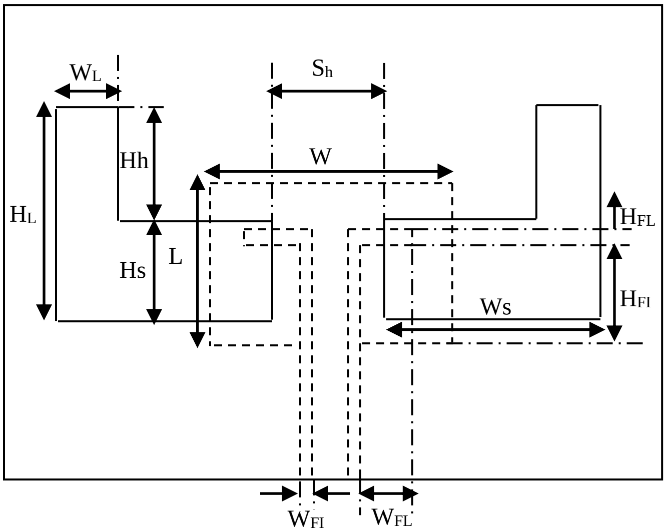

Figure 3 Geometry of inset L-shaped feed with L-slots in the ground plane

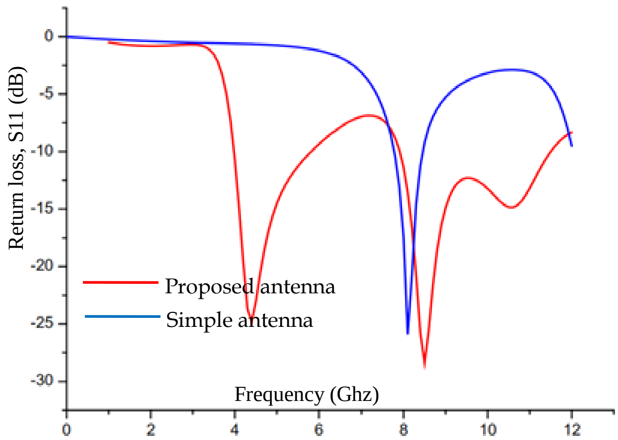

Figure 4 Comparison of return loss and bandwidth between the

proposed structure and the simple rectangular patch antenna

It is clear that dual frequencies with a very significant improvement in the bandwidth of the proposed rectangular patch using inset L-shaped feed with dual L slots on the ground plane are obtained compared to the simple rectangular patch antenna.

C Different parametric study

The parameters given in Table 2 are fixed; we varied W_L to 2mm, 4mm and 6mm. Variation of return loss as a function of frequency for different value of slot width of the L slot etched on the ground plane W_L is shown in figure 5, also it is worth noting that a comparison study on the return loss S11 between the structure with the dual L slots on the ground plane and the structure with dual rectangular slots on the ground plane which is obtained by taking the parameter Hh of the L slot on the ground plane equal zero is given.

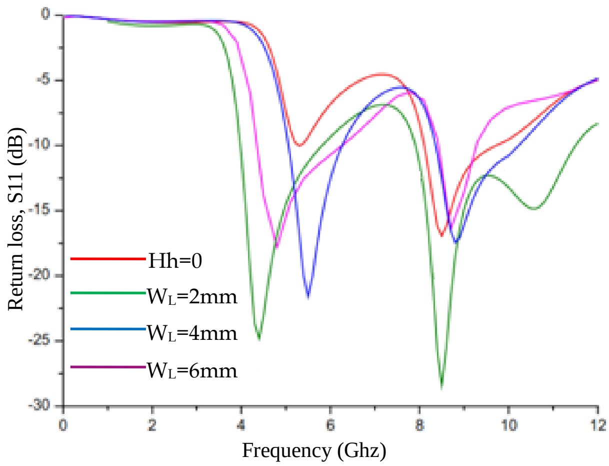

Figure 5 Comparison of return loss of the structure with (Hh=0) and the structure with Hh=6mm, with three values of W_L (mm)

It is clear that a significant improvement in the bandwidth of the proposed antenna using inset L-shaped feed with dual L slots on the ground plane are obtained compared to the rectangular patch using inset L-shaped feed with rectangularslots on the ground plane in the case with Hh =0, Also we can see clearly that for the parameter (W_L = 2 mm) we have a wider band width with an optimum matching.

The radiation patterns for upper resonant frequency for different value of slot width of the L slot etched on the ground plane W_L of our proposed structure using inset L-shaped feed with dual L slots on the ground plane compared with the radiation pattern of a simple rectangular patch antenna are illustrated by the figures below (Fig 6 and 7).

The rectangular patch using an insef L feed with a dual rectangular slots on the ground plane is obtained when the parameter Hh of the proposed structure given by Figure 3 is taken equal zero (Hh=0), because this structure is simpler than the previous one we will give some results pertaining to this case in the next figures (8 and 9).

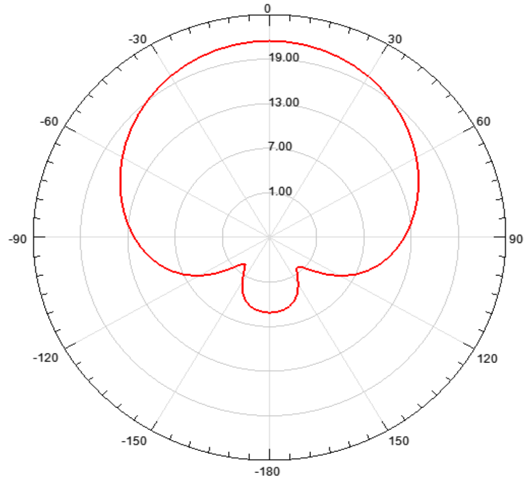

Figure 6 Radiation pattern of a simple rectangular patch

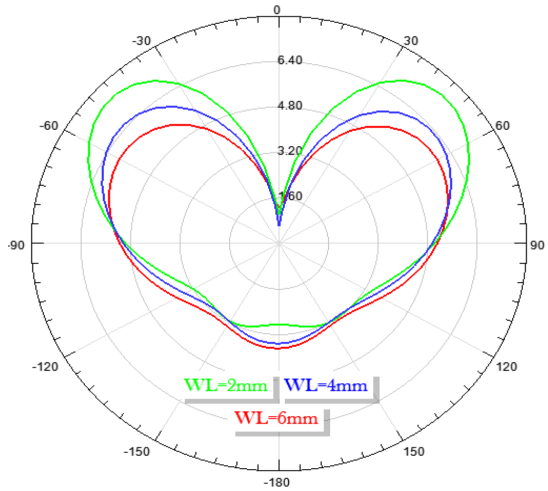

Figure 7 Radiation pattern of the rectangular patch antenna using inset L-shaped feed with dual L slots on the ground plane

The parameters given in Table 2 are fixed, variation of return loss as a function of frequency for different value of the length notch of the inset L-shaped feed W_{FL} is shown in figure 8.

In the case of Figure 9, the rectangular patch using an inset L feed with dual rectangular slots on the ground plane is also studied; the patch is embedded in a substrate containing anisotropic materials with the optical axis normal to the patch and has a uniform thickness h. The relative permittivity in this casecan be presented by a tensor with the relative permittivity in the direction perpendidicular to the optical axis denoted ε_x (with $\varepsilon_x = \varepsilon_y$) and the relative permittivity in the direction of the optical axis denoted ε_z as given by [2, 11].

It is worth noting that the results of figures 5and 8 agree very well with those obtained by S.Satthamsakul et al. [3].

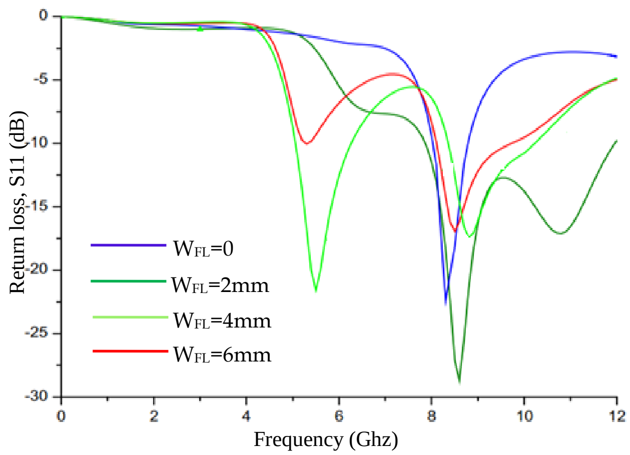

Figure 8 Variation of return loss as a function of frequency for different value of the length notch of the inset L-shaped feed W_{FL} for (Hh=0)

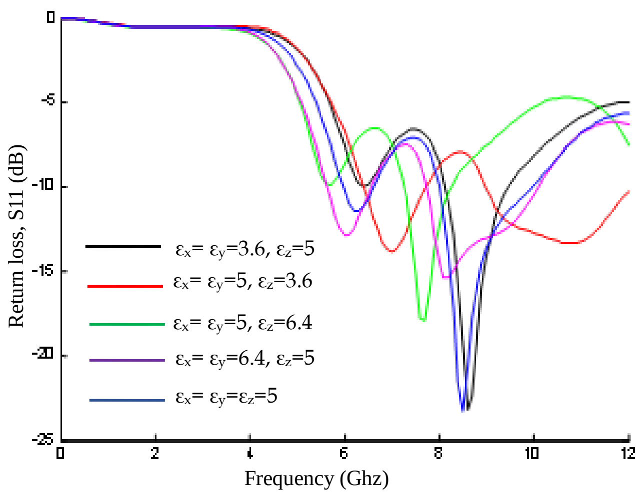

Figure 9 Effect of the uniaxial anisotropic substrate on the band width and the return loss of the rectangular patch using an insef L feed with dual rectangular slots on the ground plane

From figure 9, the obtained results show that a significant improvement in the bandwidth is achived for the anisotropic ratio AR>1, it is worth noting that ($AR=\varepsilon_x/\varepsilon_z$).

III CONCLUSION

In this paper, analysis of inset L-shaped feed rectangular patch antenna with dual L slots etched on the ground plane has been studied. From the analysis it is found that a large band width can be achieved by this novel structure and consequently this antenna is very suitable for many applications especially for applications in the access points of wireless communications.

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