

# A Dual Band Rectangular Patch Notched Antenna with T- and E-Slots



Eshita Gupta and Anurag Garg

**Abstract** Due to the demand of communication systems increases, here we introduce a dual band antenna with T- and E-shaped slots. This introduced antenna has small radiating rectangular patch with dimension  $13 * 16 \text{ mm}^2$ . The antenna is resonating at two different frequencies, i.e., 4.8325 and 7.9375 GHz with very substantial gain. At these resonating bands, the antenna has voltage standing wave ratio (VSWR) less than 2 and return loss less than  $-10$ . This type of antenna is suitable for C-band wireless applications. The antenna is simulated by using CST suite to get optimize results.

**Keywords** Rectangular radiating patch · Slots · Dual band

## 1 Introduction

From last couple of years, the development of wireless communication has increasing exponentially, and it also increases the demand of antenna because communication is quite impossible without the antenna [1], due to which the demands like ability of multi-function, light weight, and small size from a single device also increase. For these reasons, microstrip patch antenna comes in demand [2, 3]. So, to fulfill these points, many experiments with different geometry of microstrip slot and monopole antennas are observed, and many different methods and strategies are also developed to improve the ability and functionality of the antennas.

In the field of communication, the first band of frequency which was commercially allocated for telecommunication via satellite is 'C-band' [4]. The C-band has frequency range from 4 to 8 GHz and is used in many satellite communication transmissions, in some Wi-Fi, cordless telephones, etc. It is also used in weather and surveillance radar systems. Operating frequency for different devices uses different

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[5] bands of frequency and that is why the demand of imprinted notched microstrip antenna increased because it has several features such as it is small in size, light weighted, cost effective, easy to fabricate, and many more.

Number of techniques has been introduced to obtain dual band antennas [6], they are loading slit technique, loading the patch with sorting pins [7], use slots in the patch, and using stacked patches [6–8]. Here, a new configuration of rectangular microstrip patch antenna is presented in which T- and E-shaped slots are cut inside the radiating patch. This antenna is also known as dual band antenna because it resonates at two different frequencies. The antenna is simulated by using CST Studio Suite 2014 to get the optimized results.

## 2 Designing of Antenna

The antenna configuration will consist of a ground plane, substrate, rectangular patch containing slots, and microstrip feedline. The rectangular patch is printed on one side of the substrate which is feed by microstrip line of  $50 \Omega$  and slightly small ground plane on the contrary side of the substrate. The antenna is engraving on Roger RT5880 (lossy) substrate of height 1.6 mm, having loss tangent 0.0009 and permittivity 2.2.

Steps of designing

- (i) Specify some parameters, i.e., dielectric constant ( $\epsilon_r$ ) = 2.2, resonant frequency ( $f_r$ ) = 7.2412 GHz, height of substrate = 1.6 mm, height of copper ground and patch = 0.035 mm. Now, we have to determine width and length of the patch.
- (ii) To find the practical width, we use the formula which is described in Eq. (1):

$$W = \frac{1}{2fr\sqrt{\mu_0\epsilon_0}} \sqrt{\frac{2}{\epsilon_r + 1}}$$

$$W = 16 \text{ mm} \quad (1)$$

- (iii) Now, we determine the effective dielectric constant ( $\epsilon_{\text{reff}}$ ) of the antenna by using Eq. (2)

$$\epsilon_{\text{reff}} = \frac{\epsilon_{r+1}}{2} + \frac{\epsilon_{r+1}}{2} \left( 1 + 12 \frac{h}{W} \right)^{-0.5}$$

$$\epsilon_{\text{reff}} \approx 2.173 \quad (2)$$

- (iv) The calculation of effective length ( $L_{\text{eff}}$ ) can be calculated by using Eq. (3)

$$L_{\text{eff}} = \frac{c}{2f_o\sqrt{\epsilon_{\text{reff}}}} \quad (3)$$

where  $c$  = speed of light.

$$L_{\text{eff}} \approx 14.1 \text{ mm.}$$

- (v) Total or active length of patch is obtained by Eq. (4)

$$L = L_{\text{eff}} - 2\Delta L \quad (4)$$

$$L \approx 13 \text{ mm}$$

where

$$\Delta L = 0.412h \frac{(\epsilon_{\text{reff}} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\epsilon_{\text{reff}} - 0.258)\left(\frac{W}{h} + 0.8\right)}$$

$$\Delta L \approx 0.809 \text{ mm}$$

After calculating all the parameters, we will design it in the CST software and then simulate it. After simulating the design, we analyze the results like s-parameter, VSWR, radiation parameter, gain plot, etc.

- (vi) The antenna will resonate at two different frequencies due to the presence of slots on the rectangular radiating patch.

The geometry of antenna, i.e., its front view and back view design, is demonstrated in Figs. 1 and 2. The parameters of antenna were defined in Table 1. The length of the antenna is represented by variable 'X', and width of the antenna is represented by variable 'Y'.

### 3 Result and Discussion

After simulating, the design which is introduced in this paper will operate/resonates at two different bands which means it can work on these two frequency ranges one at a time or simultaneously which depend upon the ability of the antenna. Dual band antenna is very useful in communication field due to one of its biggest advantage, i.e., it is capable to provide stable and strong wireless connection to the location which is difficult to reach.

So, this antenna is very beneficial because it resonates at two different frequencies, i.e., 4.8325 GHz (4.7945–4.8692 GHz) and 7.9375 GHz (7.8365–8.0319 GHz), and the bandwidth achieved is 74 MHz and 195.4 MHz, respectively, with reference to –10 dB line. The return loss characteristic of the suggested antenna with reference to –10 dB line is shown in Fig. 3.

The voltage standing wave ratio (VSWR) of the antenna is also less than 2 at the resonant bands and is demonstrated in Fig. 4.

Fig. 1 Front view

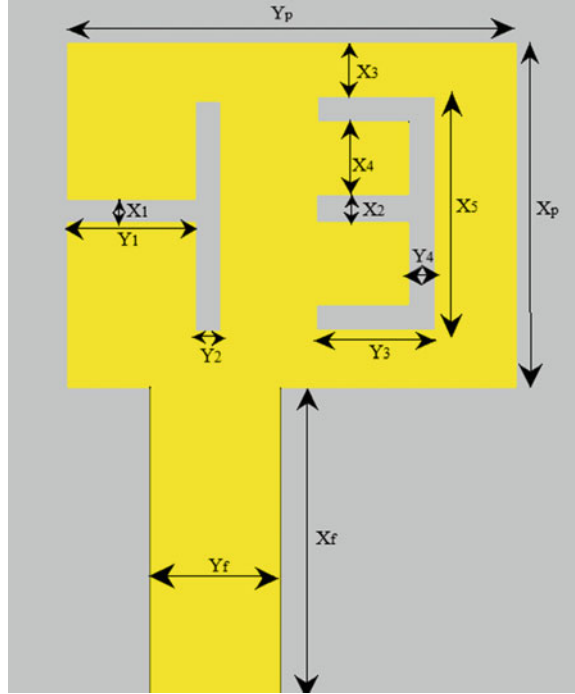
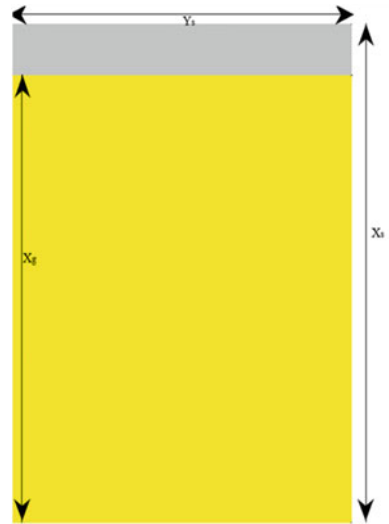
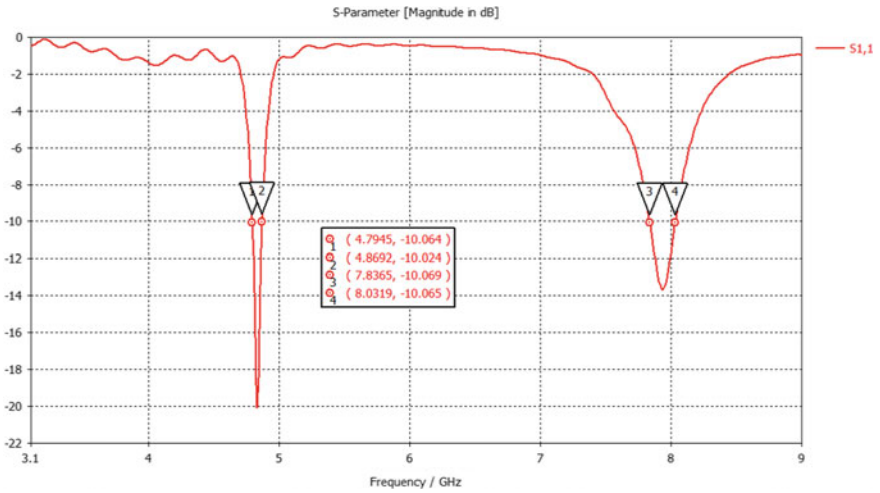


Fig. 2 Back view

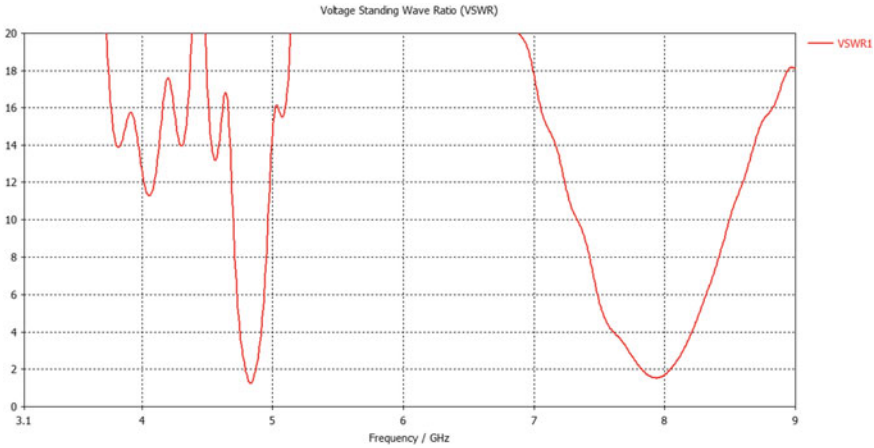


**Table 1** Dimensions of antenna

Parameters	Variables	Dimensions (mm)
Patch and slots	$X_p$	13
	$Y_p$	16
	$X_1$	1
	$X_2$	1
	$X_3$	2
	$X_4$	3
	$X_5$	9
	$Y_1$	5
	$Y_2$	1
	$Y_3$	4
	$Y_4$	1
Feed line	$X_f$	10
	$Y_f$	4.971
Roger RT5880	$X_s$	20
Substrate	$Y_s$	24
Ground	$X_g$	20
	$Y_g$	22



**Fig. 3** Return loss plot



**Fig. 4** VSWR plot

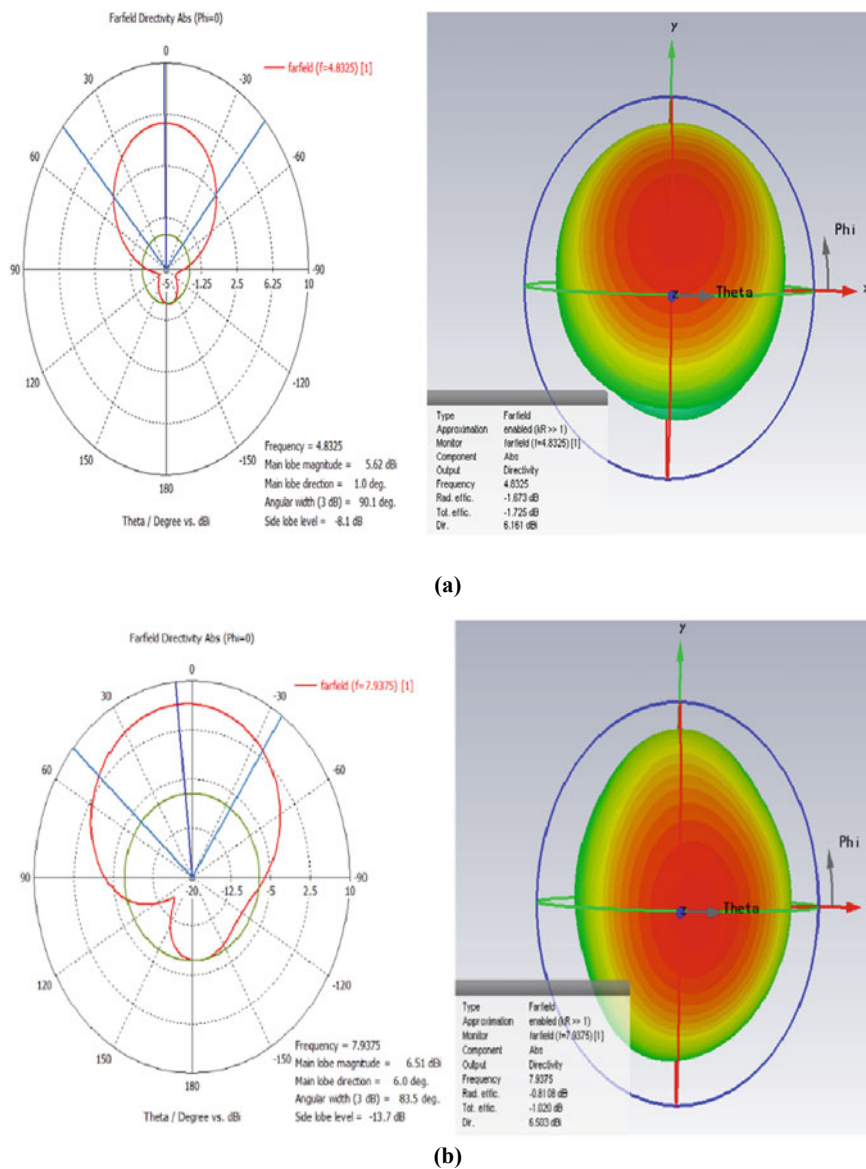
The antenna is resonating at two different bands, first at 4.8325 GHz with directivity 6.161 dBi and second at 7.9375 GHz with directivity 6.503 dBi. The radiation pattern for these two resonating bands is highly directional, i.e., the main lobe is in one direction only and the directivity at both resonating bands is high.

Figure 5a, b signifies the radiation pattern at two different resonant frequencies in 2-dimension as well as in 3-dimension.

Gain plot of the antenna is demonstrated in Fig. 6. The gain at resonant frequency 4.8325 GHz is approximately 5.2506 dB, and at resonant frequency 7.9375 GHz, the gain is approximately 5.6871 dB. This antenna has substantial gain.

## 4 Conclusion

The introduced antenna is a dual band antenna because it resonates at two different frequencies, i.e., 4.8325 GHz and 7.9375 GHz, with reference to  $-10$  dB line and VSWR less than 2. The gain of the antenna is also high. At frequency 4.8325 GHz and 7.9375 GHz, the gain is 5.2506 dB and 5.6879 dB, respectively. The radiation pattern at these frequencies is directional, and this antenna is suitable for many C-band wireless applications.



**Fig. 5** Radiation pattern in 2D and in 3D at resonant frequency **a** at 4.8325 GHz and **b** at 7.9375 GHz

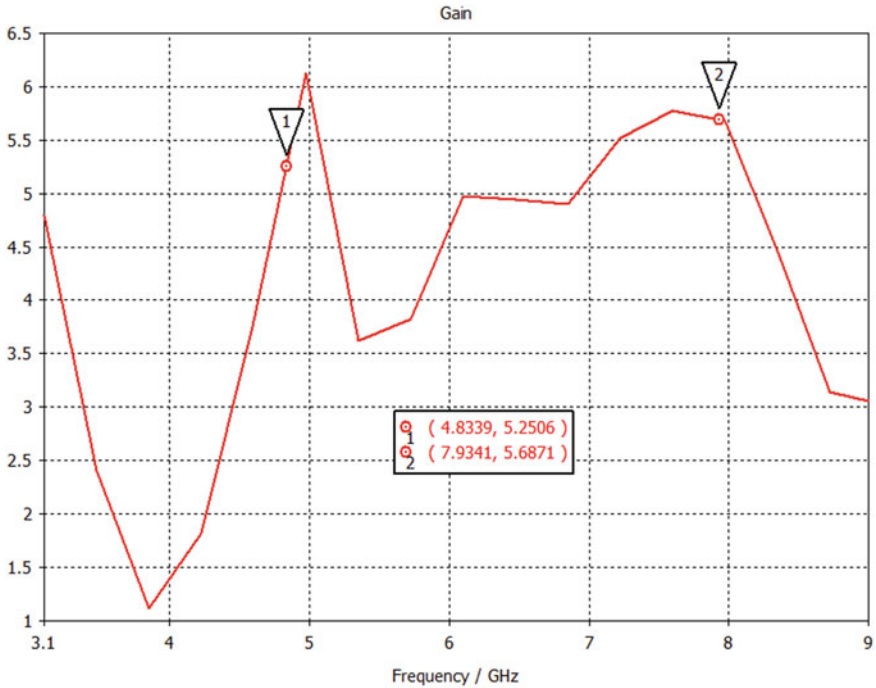


Fig. 6 Gain plot

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