

# Designing of Microstrip Patch Antenna for X-Band Applications

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**Abstract.** *This study introduces a microstrip patch antenna that contains radiating patch of FR-4 substrate material on the one side of microstrip antenna with dimensions 30mm×50mm×2mm, dielectric constant =4.4 and excited by microstrip line feed. HFSS is used in this research. This antenna composes of rectangular slots to improve gain and cylindrical shorted pins to enhance performance of antenna in desired band. Return loss -20.17dB, -17.82dB, -25.19dB at 8.36GHz, 9.30GHz, 11.30GHz respectively, radiation efficiency 73.6% and gain 5.9dBi in desired band*

**Keywords:** Return loss, gain, FR-4 substrate, X band, Radiation efficiency.

## 1. Introduction

Microstrip patch antenna execution is very important in wireless communications systems, it increases the demand of the upcoming generation to fulfill their requirements by using Antenna Technology. Microstrip patch antennas are used widely to enhance their performance and efficiency because they are easy to design and low in weight. It is easy to fabricate and can be easily integrated with the circuits easily. As they are multitasking and easy to use in communication systems because of these behaviors, they are being used in daily life [8]. Due to all these properties of microstrip antennas, various multi and wideband antennas are being designed for various purposes. There are various antennas that are being designed for different bands as it is important to design a single antenna that operates at various frequencies for many applications. There are many types of multiband or wideband antennas which are being improved daily as growing demands for a mobile communication gadget which have the capability to merge one communication standard into a one system. The improvement in range of frequency can be achieved by cutting the slots (of any shape) in ground and patch of microstrip antenna of acceptable width and length [7]. X-band is very useful in several applications because of high frequency ranges by providing high transmission rate and short range features.

## 2. Antenna Design

The proposed multiband microstrip patch antenna is designed on FR-4 substrate material in such a way that one side is patch and ground is on opposite side. There are two rectangular slots in the patch at the center which are in opposite directions and shorting pins in design at different positions. Antenna is excited by microstrip line feed. The fabrication of proposed multiband microstrip patch antenna is done with following dimensions.

Substrate thickness = 2 mm

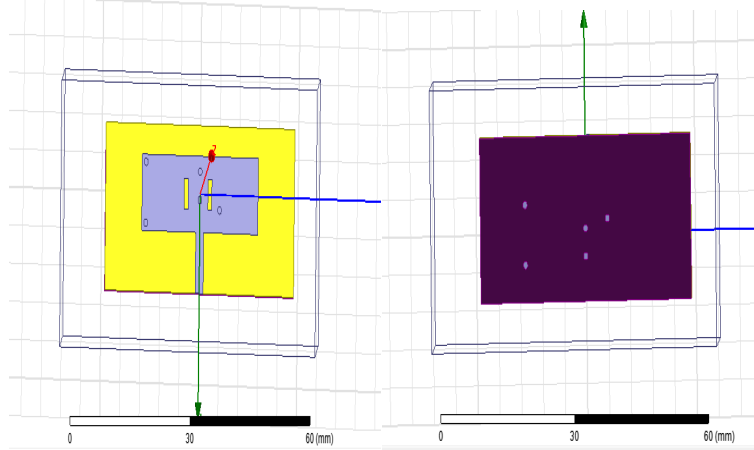
Physical dimension = 30 × 50 mm<sup>2</sup>

Component	Dimensions (mm)	Material
Patch	L=10 W=29.5	Copper
Substrate	L=30 W=50 H=2	FR4 epoxy
Ground	L=30 W=50	
Shortened Pins	R=0.5 H=2	Copper
Rectangular Slot	L=4 W=1	

**Table 1** Dimensions of the simulated antenna

### 3. SIMULATION AND RESULTS

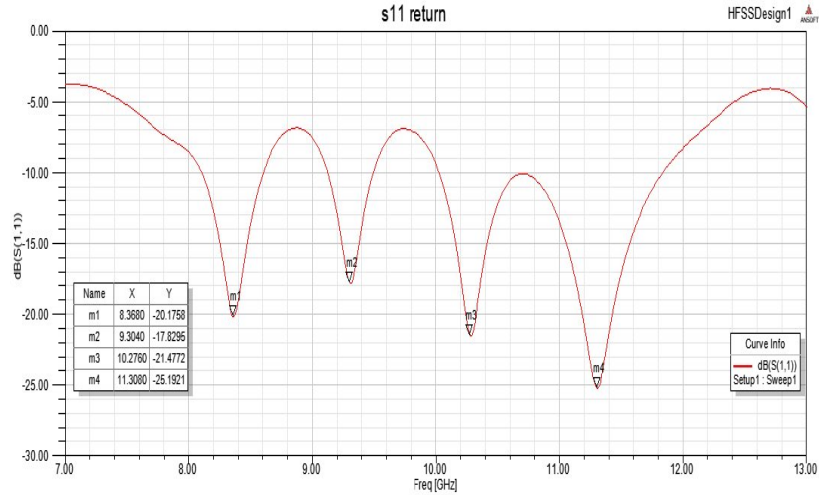
Fig 1 shows the top and bottom view design of simulated antenna which is being designed by using HFSS.



**Fig 1** Top view and bottom view of simulated antenna

#### 3.1 Return loss (S11)

S11 represents how much power is returned from the antenna, so it called reflection coefficient (written as gamma or return loss). From fig 2 one can easily conclude that proposed antenna resonates at three frequencies 8.3GHz, 9.3GHz, 10.2GHz, and 11.3GHz. From s11 graph return loss is calculated, return loss should be -10dB.

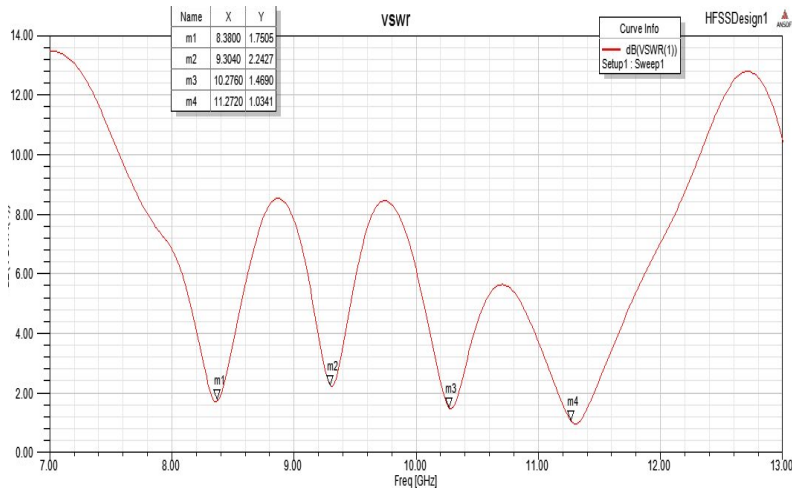


**Fig. 2** S11 (dB) of the Simulated Antenna

### 3.2 Voltage Standing Wave Ratio

VSWR is amount of mismatch impedance between an antenna and connector connecting at input port. VSWR represents how much power reflected back to the source of antenna after mismatching of impedance. Ideal value of VSWR should be 1. Practically, value of VSWR is considered between 1 and 2. In proposed design at resonating frequencies value of VSWR is 1.7, 2.04, 1.4, and 1.5.

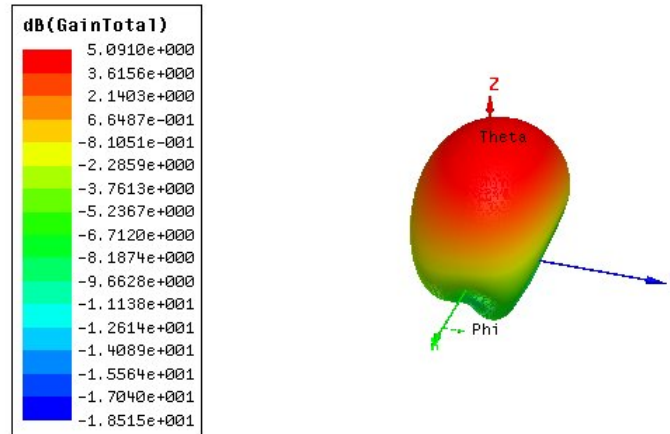
$$VSWR = V_{max} / V_{min}$$



**Fig. 3** VSWR of the Simulated Antenna

### 3.3 Gain

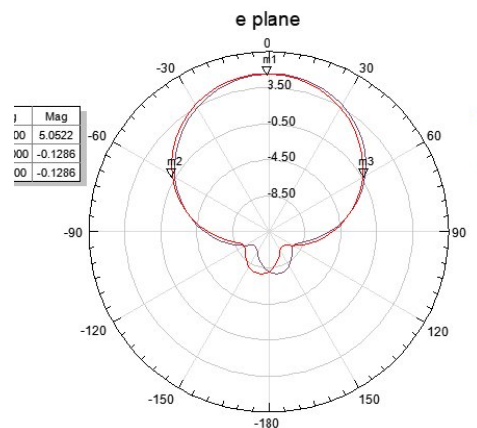
Antenna gain is a main parameter which unites the directivity and electrical efficiency of antenna. Gain denotes how much designed antenna radiates in particular direction with respect to isotropic antenna. Gain of antenna should be positive. The gain of designed antenna is 5.9 dB.



**Fig. 4** Gain of the Simulated Antenna

### 3.4 E-plane

The E-plane can act as reference plane for antennas and other microwave devices. E plane includes E – field and direction of maximum radiation.



**Fig. 5** E-plane of the Antenna

### 3.5 H-plane

The H-plane can act as a reference plane for antennas and other devices. H plane have H- field (magnetic field) and direction of maximum radiation.

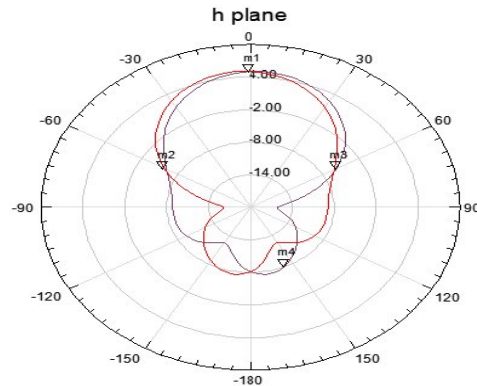


Fig. 6 H-plane of the Antenna

### 3.6 Smith Chart

It is a graphical instrument or alignment chart developed for electrical and electronics engineers specially used in radio frequency engineering to facilitate in solving problems of transmission lines and matching circuits. It is used for conceptualizing the impedance of a transmission line and antenna system as a function of frequency.

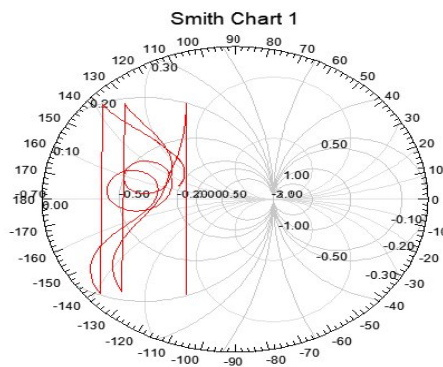
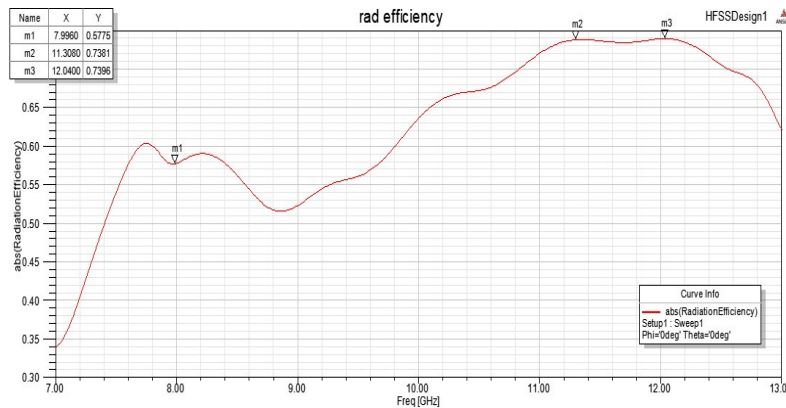


Fig. 7 Smith Chart of the Antenna

### 3.7 Radiation efficiency

It is defined as the ratio of the power of radiation emitted in an antenna to the total power received by the antenna. The radiation efficiency of designed antenna is 78.6%.



**Fig. 8** Radiation Efficiency of the Simulated Antenna

## 4. Conclusion

This paper includes the analysis which shows that the Multiband microstrip patch antenna with microstrip line feed at rectangular patch with ground plane by using FR-4 substrate material is used. This Antenna is designed, simulated, and can be used for various applications under X band frequency (8 – 12) GHz.

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