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Design of I-Slot Cut Rectangular Patch Microstrip Antenna for L-band Application

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Abstract: In this paper, a design of I-slot cut rectangular patch microstrip antenna for L-band applications is proposed. The antenna is designed using FR4 glass epoxy as a substrate with permittivity 4.4 and thickness 1.6 mm. The designed antenna has a resonating frequency of 1.57 GHz. The proposed antenna based on co-axial feed configuration has reflection coefficient (return loss) -17.03 dB, gain 5.14 dBi, VSWR 1.32 and cross polarized value (XP) is -40.2 dB over the span of $\pm 50^0$. Good return loss, antenna gain and radiation pattern characteristics are obtained in the frequency band of interest. Structural dimensions of the proposed antenna are optimized by using HFSS simulator.

Index Terms - Co-axial feed, HFSS, Microstrip patch antenna (MPA), return loss(S_{11}), VSWR.

I. INTRODUCTION

Antenna plays a major role in wireless communication, due to its vast use in devices like mobile phones, GPS systems, mp3 players etc. The antenna is a radiating element used for efficient transmission and reception of electromagnetic waves. Depending upon the use, the antenna can operate in different frequency bands. Many research is going on microstrip antenna among the different types of antennas, because of its advantages like low cost, lightweight, compatibility for an embedded antenna in handheld wireless devices and high performance [1-2]. The MPAs are having some limitations like very narrow bandwidth, low gain, high cross polarized (XP) fields, low isolation etc. To overcome these limits many techniques have been implemented [3]. The different shapes of DMS also reported and implemented like bent slots [4], square slots [5], cross slot [6], circular slot [7] etched in the patch of an MPA and are used for different purposes like dual band, miniaturization, multiband, wideband, frequency tuning [8].
In this paper, a I-slot cut rectangular patch microstrip antenna is designed with low cross polarized radiation (XP) in L-band. L-band is essential like in satellite communication, vehicular and mobile service, satellite navigation, telecommunication uses such as GSM phones, digital audio broadcasting used by military for telemetry and astronomy.

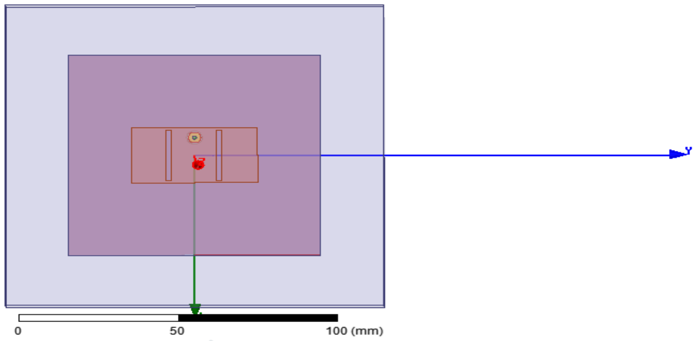
II. ANTENNA CONFIGURATION

A probe feed rectangular microstrip patch antenna (RMPA) is designed using Transmission Line Model (TLM) to resonate at 1.57 GHz using the FR4 dielectric substrate with $\varepsilon_r = 4.4$ and $h = 1.6$ mm as per the design guidelines given in [1-3]. Fig.1 shows the proposed antenna geometry consisting of dielectric substrate, I-slot cut patch as well as co-axial feed. The rectangular patch is separated from the ground plane with FR4 Dielectric substrate, with the below shown dimensions. While table 1 shows the respective design parameter values of the proposed antenna.

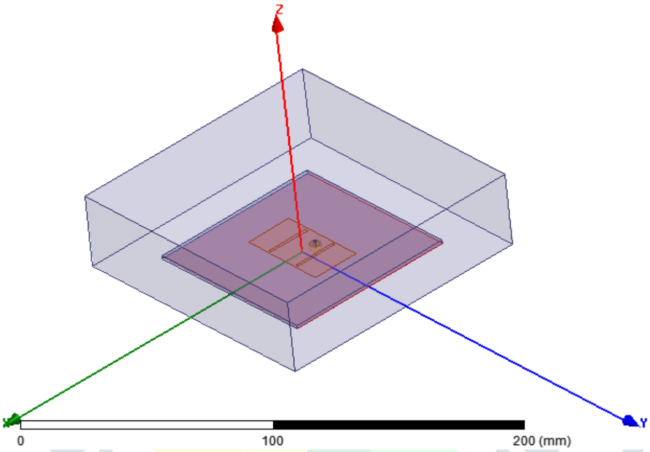
Table 1: Design parameter of Microstrip Patch Antenna

Parameter	**Designed values**
Operating Frequency	1.57 GHz
Substrate	FR4 glass epoxy
Dielectric constant of substrate	4.4
Height of substrate	1.6 mm
patch width	58 mm

Patch length	45 mm
I-Slot length	40 mm
I-Slot width	1.5 mm



(a)



(b)

Figure 1. Schematic diagram of a probe fed rectangular microstrip patch antenna, (a) Top view of proposed MPA, (b) side view of proposed MPA.

III. ANALYSIS AND DESIGN EQUATIONS

All the dimensions of the MPA shown in the table 1 were calculated by using the rectangular patch design equations as shown below

1. Width of Patch (W) = $$\frac{c}{2f_0\sqrt{\frac{\varepsilon_r+1}{2}}} \tag{3.1}$$

2. Effective dielectric = $$\varepsilon_{reff}=\frac{\varepsilon_r+1}{2}+\frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{w}\right]^{\frac{1}{2}} \tag{3.2}$$

3. Effective Length = $$L_{eff}=\frac{c}{2f_0\sqrt{\varepsilon_{reff}}} \tag{3.3}$$

4. Fring factor = $$\Delta L=0.412h\frac{\left(\varepsilon_{reff}+0.3\right)\left(\frac{w}{h}+0.264\right)}{\left(\varepsilon_{reff}-0.258\right)\left(\frac{w}{h}+0.8\right)} \tag{3.4}$$

5. Length of Patch (L) = L_{eff} - 2ΔL (3.5)
6. Length of Substrate (L_S)= 6h + L (3.6)
7. Width of Substrate (W_S)= 6h + W (3.7)

IV. SIMULATION RESULTS AND DISCUSSIONS

The software used to model and stimulate the MPA is HFSS [13]. HFSS is a high performance full wave electromagnetic field simulator. It integrates simulator, visualizaalisation, solid modeling and Automation in an easy to learn environment where soltion of 3D EM problem is quickly and accurately obtained. Ansoft HFSS can be used to calculate paramteres such as return loss, gain ,bandwidth and VSWR etc [9].

4.1 Return Loss

Power will not deliver to the load and is return of the power that is called loss and this loss that is returned is called return loss. Return loss is shown in figure 2.figure shows that microstrip antenna resonate at 1.57 GHz having returnloss of – 17.03 dB.

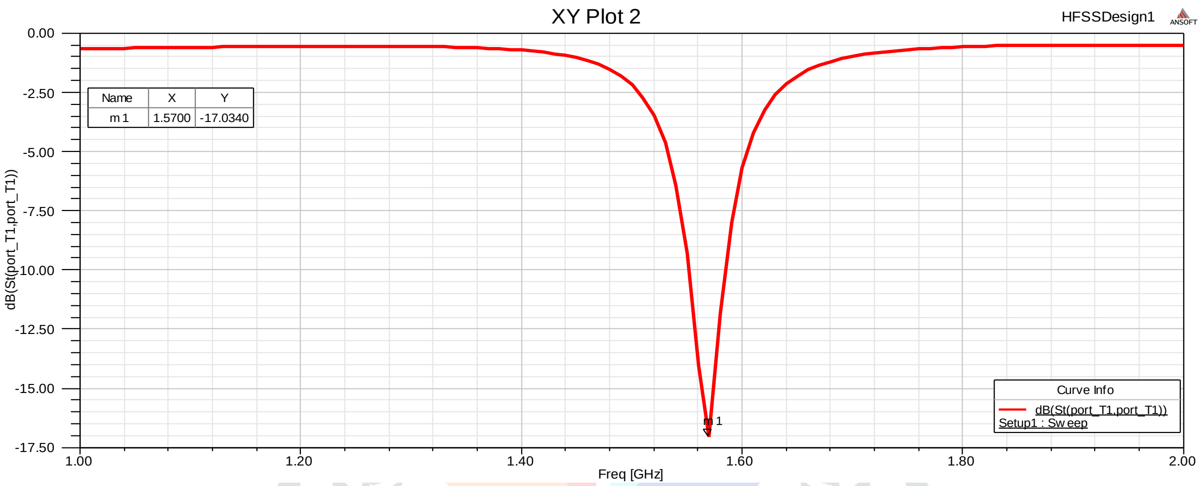


Figure 2: Return loss (S_{11}) of MPA

4.2 Radiation Pattern

The radiation pattern of microstrip Patch Antenna is radiated or received by the antenna. The Fig.3 shows comparison of H-plane and E-plane radiation patterns of proposed MPA configurations, the plot shows a peak gain of 5.14 dBi and the cross-polarization (XP) value of -40.21dB. The proposed configuration gives large XP suppression without affecting the co-polarized radiations in both the principal planes. The XP value of -40.21dB is symmetric with broadside.

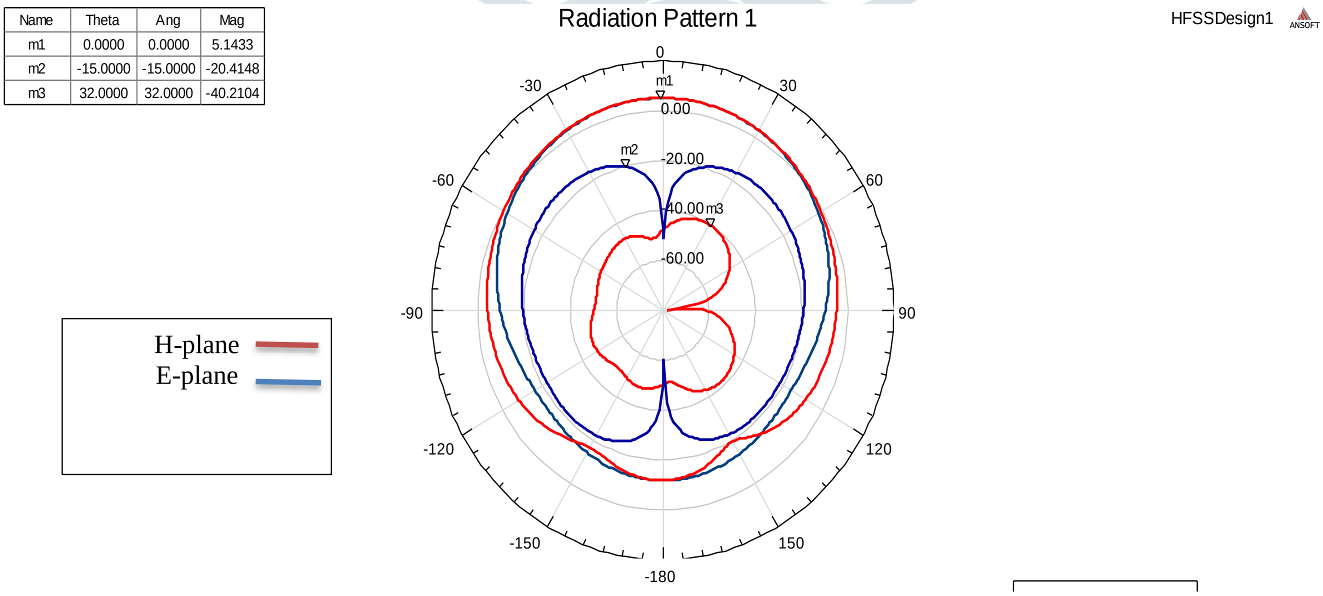


Figure 3: shows the radiation pattern for the proposed MPA

4.3 Voltage Standing Wave Ratio (VSWR)

VSWR measures how well an antenna is matched to the cable impedance where the reflection = 0.This means that all power is transmitted to the antenna and there is no reflection. Figure 4 shows result of VSWR = 1.32.

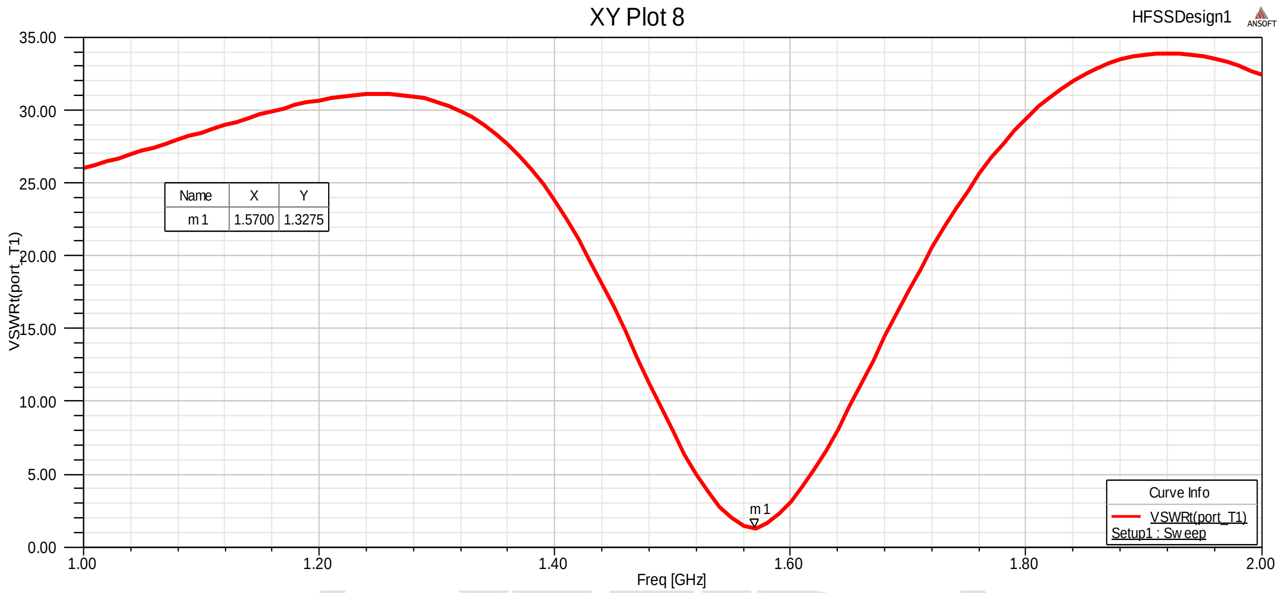


Figure 4. VSWR plot for the designed antenna

V. CONCLUSION

A Microstrip patch Antenna has been successfully designed according to its designed specifications, simulated and analyzed. The performance paramteres was achieved returned loss in the operating frequency 1.57 GHz is equal to -17.03 dB ,VSWR is 1.32 and Antenna gain is 5.14 dBi. The proposed antenna covers the L band with good percentage gain, return loss and efficiency. Hence the proposed antenna has many applications such as mobile service, satellite navigation, telecommunication uses such as GSM phones, aircraft surveillance such as Automatic dependent surveillance-broadcast, amateur radio, digital audio broadcasting used by military for telemetry and astronomy.

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