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# Design of Rectangular Patch Antenna for Multi Band Applications

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***Abstract***

*This paper presents a detailed explanation on slot loaded Microstrip rectangular patch antenna for dual and multi frequency applications. The antenna operates in C, X and Ku Bands. The antenna has been designed and simulated on a Rogers RT Duroid 5880 substrate with dielectric constant of 2.2 and thickness of 1.575 mm. In clear this paper proposed two design models. first design is rectangular microstrip patch antenna for dual band applications and the second one is that, the design of rectangular microstrip patch antenna (MPA) for multi band applications. The simulated return losses obtained for model 1 are -26.66dB at 6 GHz (C Band), -20.08 at 10.6 GHz (X Band), obtained VSWR (Voltage Standing Wave Ratio) value is 1 at 6 Ghz, 1.72 at 10.6 Ghz and the gain value are 8.47 dB at 6GHz, 9.44 at 10.6 GHz. The simulated return losses for model 2 are -31.12 dB at at 6 GHz, -20.46 at 10.69 GHz and -35.20 at 14.10 GHz, obtained VSWR values for model 2 are 1.07, 1.21 and 1.07 and the gain values are 8.39 dB, 9.50 dB and 8.16 respectively. The obtained VSWR values are <2 (ideal case is 1). The design is analysed by Finite Element Method based HFSSSimulator Software (version 14.0), the simulated results shown that the proposed antenna provides good performance in term of return loss, VSWR and gain for dual and multi frequency applications.*

***Key words***- *Microstrip antenna, Slot, Dual, Multi Frequency, HFSS, Return Loss.*

## I. INTRODUCTION

Antennas are the most significant parts in current correspondence frameworks to make a correspondence connect. Microstrip Antennas are appropriate for aviation and versatile applications in light of their position of safety, light weight and low force dealing with limit. They can be planned in an assortment of shapes so as to get upgraded addition and data transfer capacity. The proposed models are the double and multi recurrence rectangular fix radio wire stacked with spaces, with microstrip feed. It very well may be worked at C-band (4 to 8) GHz, X-Band (8 to 12) GHz and in Ku-Band (12 to 18) GHz.

By quick development in remote correspondence frameworks, requirement for low profile multiband antennas has expanded. Prerequisite for Wireless gadgets supporting more than one system, having diverse working frequencies and synchronous transmission of sound, video and information has expanded. In this paper we have one such antenna which satisfies the need of satellite based convenient specialized gadgets, particularly climate radar, surface boat radar, and a few interchanges satellites.

## II. DESIGN CONSIDERATIONS

Design considerations and formulas for the MSPA are as follows

### A. Frequency of Operation

The Satellite communication systems uses the C-Band, X-band and Ku band with frequency range from 4GHz - 8GHz, 8GHz to 12 GHz and 12GHz to 18 GHz [1]. Hence the operating frequency selected for the design are 6 GHz, 10.6 GHz and 14.10 GHz.



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B. Dielectric Constant of Substrate

The dielectric material selected is Rogers RT Duroid 5880 which has a dielectric constant of 2.2. low dielectric constant is selected since it gives better gain [1].

C. Height of Dielectric Substrate

As thickness of substrate expands, surface waves are incited inside the substrate. Surface waves brings about undesired radiation, diminishes recieving wire productivity and presents deceptive coupling between various circuits or Radio wire components, Hence the tallness of the substrate is viewed as 1.575 mm [2].

D. Length and Width of the Dielectric Substrate

Both the length and width of the substrate are taken as λ [3].

E. Slot

The dimensions of the slots and their respective positions are considered in such a way that the antenna can resonate at the required frequencies.

F. Dimensions of the Patch

The length and width of the patch are 16 mm×21mm, which are calculated using the formulae [1].

$$W = \frac{C}{2f_0\sqrt{\left(\frac{\varepsilon_r + 1}{2}\right)}}$$

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{w}\right]^{-\frac{1}{2}}$$

$$L_{reff} = \frac{C}{2f_o\sqrt{\varepsilon_{reff}}}$$

$$\Delta L = 0.412h\,\frac{(\varepsilon_{reff} + 0.3)(\frac{W}{h} + 0.264)}{(\varepsilon_{reff} - 0.258)(\frac{W}{h} + 0.8)}$$

$$L = L_{eff} - 2\Delta L$$

## III. DESIGN OF PROPOSED ANTENNAS

The above parameters are analysed and used in designing MPA in HFSS simulator, PEC is been used as material for the patch and microstrip feed is been used for feeding the antenna, initially with the feed alone, the antenna is resonating at only one frequency (6 GHz) then the slots are been placed in the patch, by varying the position of the slots in both x and y directions with a step size of 0.05mm we are able to achieve dual and multi frequency of operation (6 GHz, 10.6 GHz and 14.10 GHz) at the optimal position. It is observed that by varying the position of the slot with respect to the position of the microstrip feed and by varying the dimensions of the slots we can achieve the dual and multi frequency of operation. The below figures can represents the antenna design model for dual and multi band antenna



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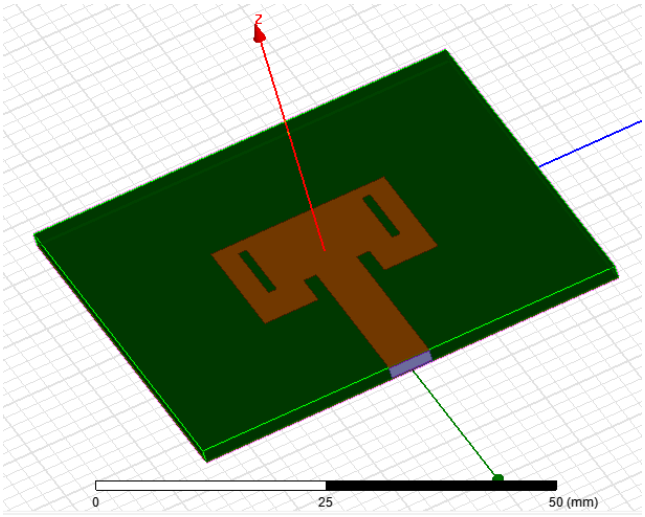


Fig. 1 Slotted rectangular patch antenna for dual and multi band

Tabel 1 Antenna Parameters

| **Parameter** | **Dimension** |
|---|---|
| Substrate Dimension | 50 mm × 50 mm × 1.575 mm |
| Patch Dimensions | 16 mm × 21 mm |
| Slot Dimensions | 9 mm × 1 mm |

## IV. RESULTS

***Design-1: Dual Band***

Obtained dual-frequency of operations at 6 GHz and 10.6 GHz with a peak gain of 8.47 dB and 9.44 dB.

*A. Return Loss*

Obtained return loss of -26.66 dB at 6 GHz and -20.08 dB at 10.6 GHz .



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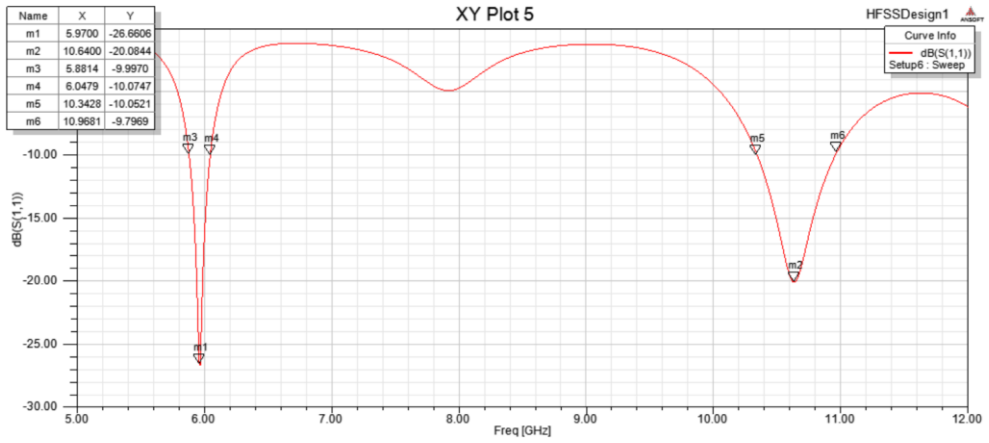


Fig. 2 Return loss

*B. VSWR:*

The figure below demonstrations the VSWR plot, observed a good VSWR of ~1 and 1.72 at 6 GHz and 10.6 GHz.

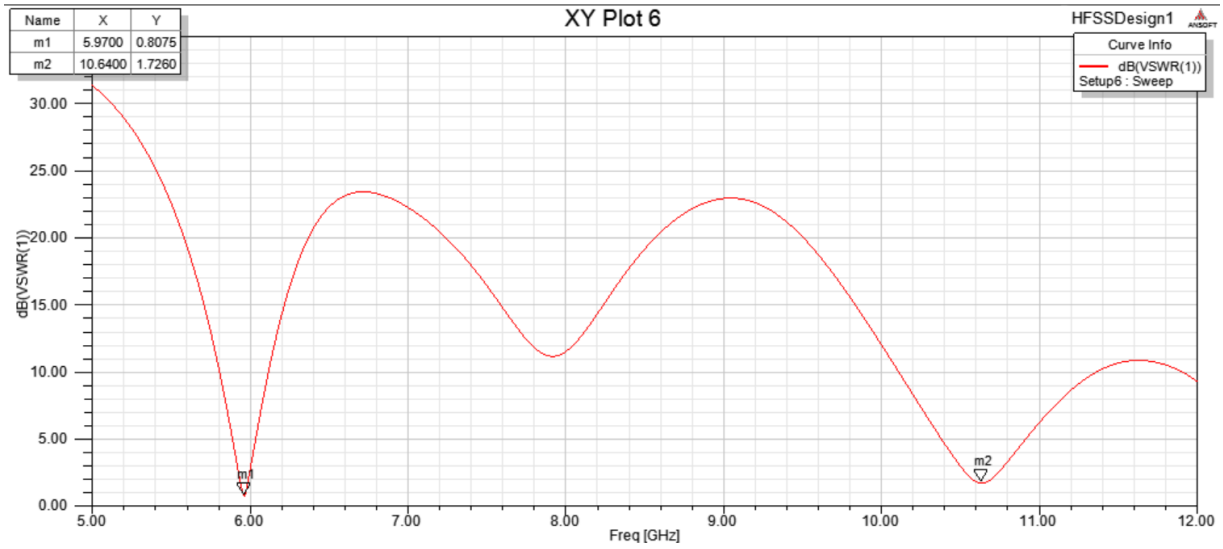


Fig. 3 VSWR

*C. 3D Polar plot*

The 3D polar plot below shows the gain of the antenna at both the operating frequencies, achieved a gain of 8.5 dB at 6 GHz and 9.44 dB at 10.6 GHz.



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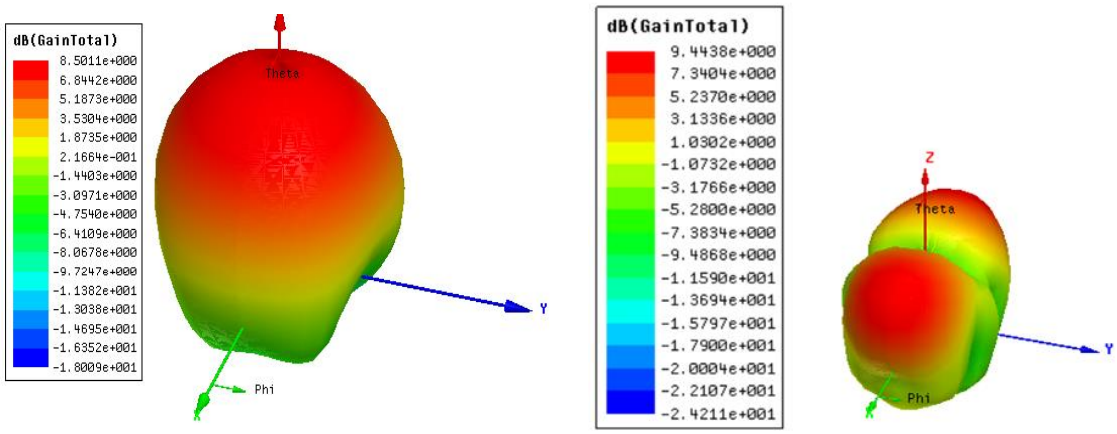


At 6 GHz At 10.69 GHz

Fig. 4 3D Polar Plots

***Design-2: Multi Band***

Obtained multi frequency of operation at 6 GHz, 10.6 GHz and 14.10 GHz with a peak gain of 8.39 dB, 9.5 dB and 8.16 dB.

*A. Return Loss*

Obtained return loss of -16.69 dB at 6 GHz and -19.50 dB at 10.6 GHz.

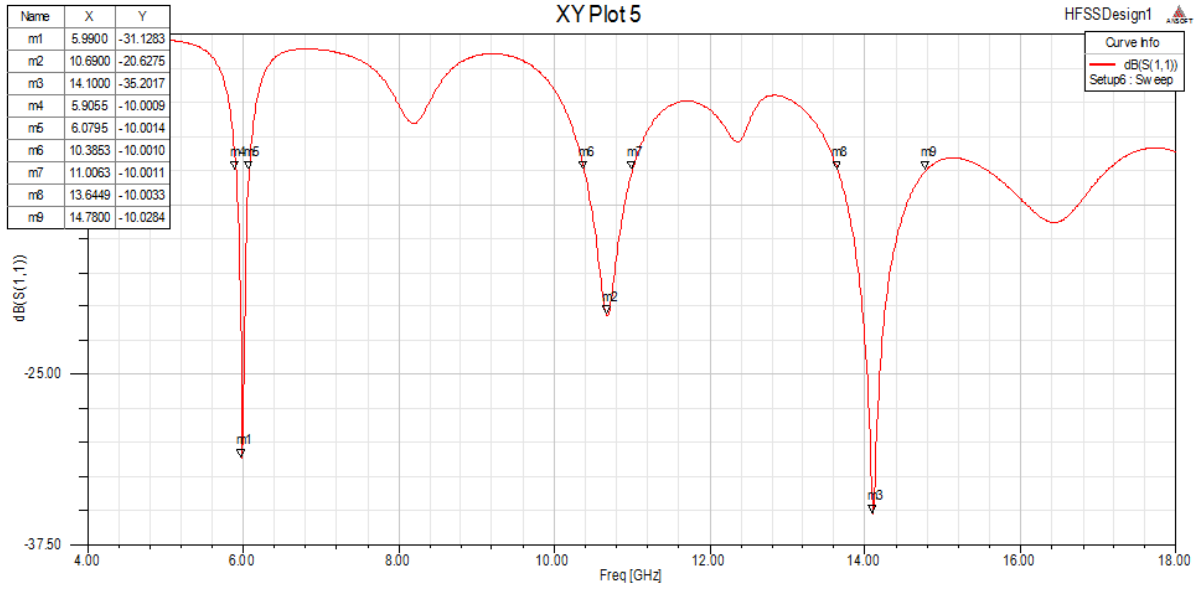


Fig. 5 Return loss

*B. VSWR:*

The figure below shows the VSWR plot, observed a good VSWR of 1.07, 1.21 and 1.07 at 6 GHz, 10.6 GHz and 14.1 GHz.



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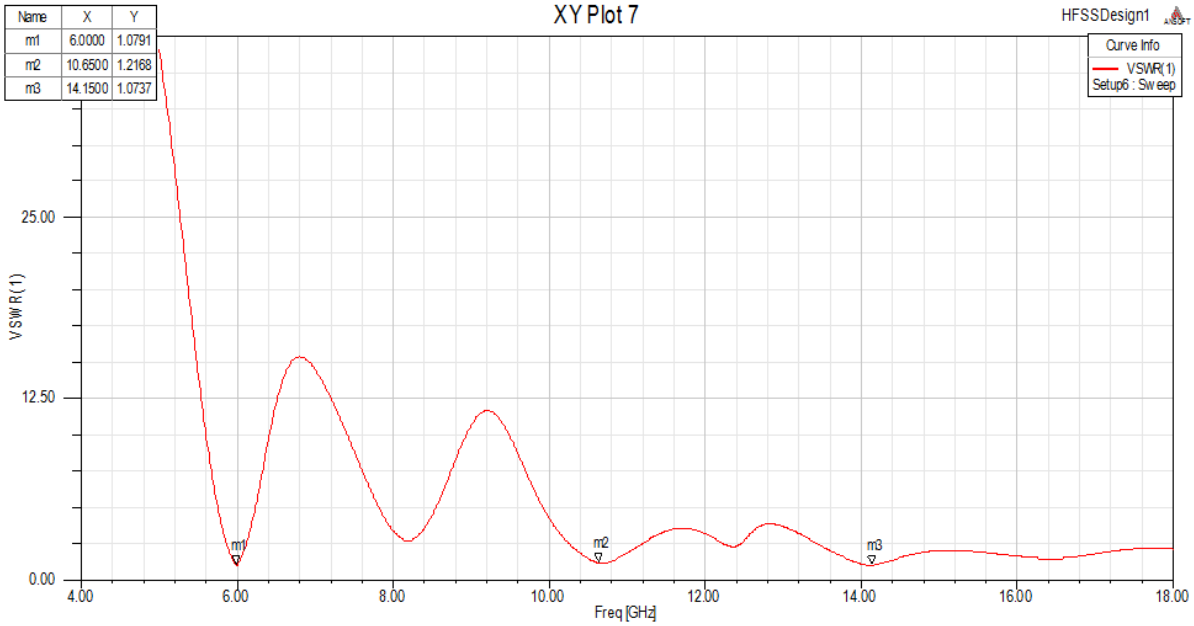
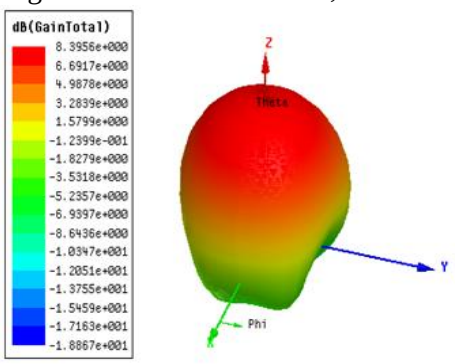
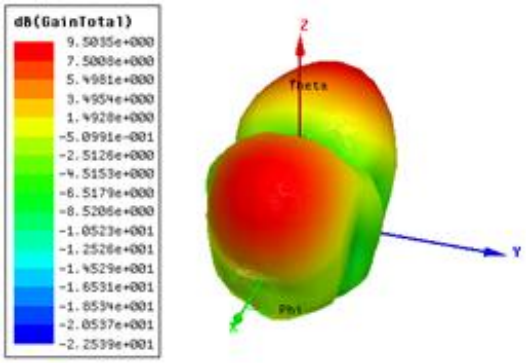



Fig. 6 VSWR

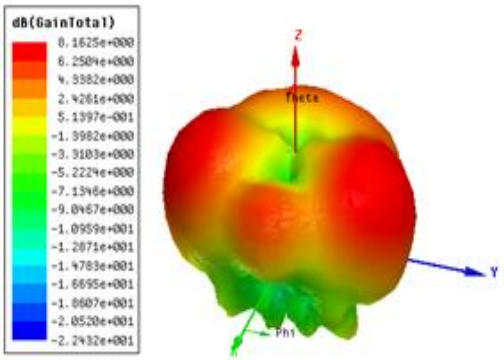
*C. 3D Polar plot*

The 3D polar plot below shows the gain of the antenna at both the operating frequencies, achieved a gain of 8.39 dB at 6 GHz, 9.50 dB at 10.69 GHz and 8.16 dB at 14.1 GHz.




At 6 GHz At 10.69 GHz




At 14.10 GHz

Fig. 7 3D Polar Plot

## V. CONCLUSION



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After analysis, the characteristics of the proposed antennas are given as follows, Obtained dual band at 6 GHz and 10.6 GHz frequencies with a gain of 8.47 dB and 9.44 dB, return loss of -26.66 dB and -26.68 dB, and VSWR values are 1 and 1.72. Similarly

Obtained multi band at 6 GHz, 10.6 GHz and 14.10 GHz frequencies with a gain of 8.39 dB, 9.50 dB and 8.16 dB, return loss of -31.12 dB, -20.62 and -35.20 dB, and VSWR values are 1.07, 1.21 and 1.07 respectively. So it is clear that this antenna models are perfect for C-Band X-band and Ku-Band applications such as Weather radar, surface ship radar, Tracking Data Relay Satellite, broadcasting and some communications satellites. The resonance frequency and impedance matching depends on the position of microstrip feed, position of the slots and its dimensions.

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