# Design of Rectangular Patch Antenna: Analysis with Different Feed Positions and Bandwidth Improvement

**P.Bharghava, M.Pachiyaannan**

***Abstract***— ***This letter describes that analysis of rectangular micro strip patch antenna with different feeding positions & bandwidth improvement. The design of the proposed antenna is performed with FR4-epoxy dielectric substrate material with variable thickness. It is observed that the position of feeding can be taken symmetrically by changing feeding locations. Different thickness of substrate (h=2, 3, 4, 5, 6 mm) have been taken to increase the bandwidth. The simulated results for height h=4mm have bandwidth=113MHz. The proposed rectangular micro strip antenna is at the operating frequency of 2.4GHz. The configurations proposed are simulated & analysed by Ansoft HFSS. The VSWR, gain pattern and return loss performance are used for the analysis of the configuration.***

***Keywords***— ***Bandwidth, Dielectric Substrate, Rectangular patch, Return Loss***

## 1. INTRODUCTION

A micro strip patch antenna does have the advantage of low price, less weight and less profile planner configuration. The disadvantage of rectangular micro strip patch antennas is low operating bandwidth [1-2]. The bandwidth can be improved in such a way that the increased substrate thickness or the reduced dielectric constant. The range of the dielectric constant is usually in ($2.2 \le \varepsilon r \le 12$) [3-4]. The coaxial probe feed is used for the rectangular patch micro strip antenna operating at resonant frequency of 2.4GHz of $TM_{10}$ mode. By choosing the proper feed position the antenna is matched [6].

The rectangular micro strip patch antenna is described using its width W, length L and thickness h. The substrate should be of narrow thickness h ($h \ll \lambda_O$, regularly $0.003 * \lambda_O \le h \le 0.05 * \lambda_O$) where $\lambda_O$ is indicating wavelength of free space on the ground plane [7].

## 2. DESIGN OF RECTANGULAR PATCH ANTENNA

The care has to be taken in the selection of resonant frequency of the antenna.The range of frequencies from 2-3 GHz is utilized for the WIFI applications. The resonant frequency $f_O$ 2.4GHz is selected for this design. The FR-4 Epoxy is selected as substrate material for the design which contains a dielectric constant $\varepsilon_r$ of 4.4

The dielectric substrate height (h) is chosen as 4 mm.

The elements for the design are: $f_O$= 2.4GHz, $\varepsilon_r$= 4.4 (FR4-Epoxy), loss tangent=0.02 and h=4mm.

The coaxial feeding is used for the antenna to get excitation. The advantage is no further impedance matching network is required in case of coaxial feeding. The radii of outer cylinder, inner cylinder are 1.6mm and 0.6mm. The radius of substrate is 0.6mm. The height of the cylinder used in the substrate is 4mm that is the heights of the substrate cylinder and substrate are same.

### *2.1 Calculation of width (W)*

The calculation of width of patch at $f_O$=2.4GHz with $\varepsilon_r$ = 4.4 as

$$Wp = \frac{Co}{2fo\sqrt{\frac{\varepsilon r+1}{2}}} \quad \text{--------- (1)}$$

W=38mm.

### *2.2 Determination of effective dielectric constant ($\varepsilon_{eff}$)*

The calculation of $\varepsilon_{eff}$ with $\varepsilon_r$= 4.4 and $f_O$=2.4GHz can be calculated as

$$\varepsilon effe = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2}\sqrt{\frac{1}{1+10\frac{h}{wp}}} \quad \text{--------- (2)}$$

$\varepsilon_{eff}$= 3.7

### *2.3 The extension of length calculation ($\Delta L$)*

The calculation of length extension with $\varepsilon_{eff}$=3.7, $f_O$= 2.4GHz, W=38mm and h=4mm as

$$\Delta L = 0.412h\frac{(\varepsilon effe+0.3)(\frac{wp}{h}+0.264)}{(\varepsilon effe-0.258)(\frac{wp}{h}+0.813)} \quad \text{--------- (3)}$$

$\Delta$L=2.44mm

### *2.4 Determination of the effe length*

The effe length can be determined with $\varepsilon_{eff}$ = 3.7and $f_O$ = 2.4GHz

$$Leffe = \frac{Co}{2fo\sqrt{\varepsilon effe}} \quad \text{--------- (4)}$$

$L_{eff}$ =32.5mm.

### *2.5 Determination of physical length of patch (L)*

The physical length is calculated as

$$Lp = Leffe - 2\Delta L \quad \text{--------- (5)}$$

Lp =27.6 mm.

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*2.6 Determination of ground plane's dimensions (Lground and Wground) by equations as*

For $L_p$ =27.6mm, $W_p$= 38mm and h =6 mm

$L_{ground}$ = $L_p$+6h

$L_{ground}$ = 63.60mm.

$W_{ground}$ =$W_P$ +6h

$W_{ground}$ =74.0 mm.

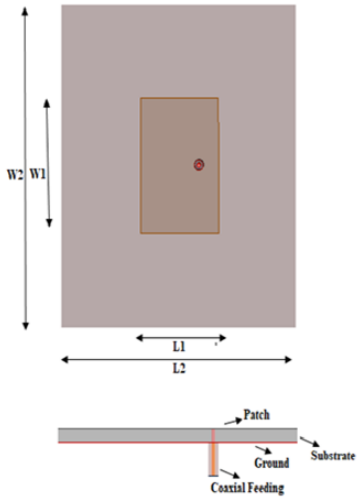


**Fig- 1. Geometry of the antenna proposed.**

**Table-1: Lengths & widths of patch antenna**

| S.NO. | Parameter | Size in mm |
|---|---|---|
| 1 | Lp | 28 |
| 2 | Wp | 38 |
| 3 | Lg | 64 |
| 4 | Wg | 74 |

## 3. RESULTS

Return loss is the parameter by which we can indicate the reflection of signal due to impedance mismatch. Return loss for proposed patch antenna which is in rectangular shape is about -30dB when height of the substrate is 4mm. In this case, the higher cut off frequency is 2.46GHz and the lower cut off frequency is 2.3463GHz as given in Figure-2. The higher and lower cutoff frequencies have to be taken at the value of -10dB of return loss. The bandwidth is given by difference of higher cutoff frequency and lower cut off frequency. The resulted bandwidth is 113MHz.

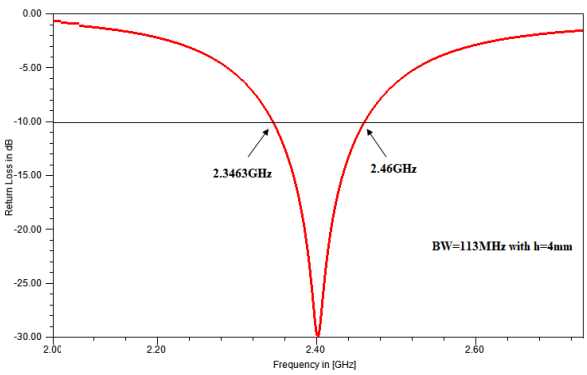


**Fig-2. Frequency Vs Return Loss curve**

By changing the height of substrate the bandwidth can be changed. The change of height of substrate h(mm) from 2mm to 6mm along with the changes of $s_{11}$ and bandwidth are given in Table-2. At the height of substrate h=4mm, the $S_{11}$ is equal to -30 and bandwidth is equal to 113MHz. This is acceptable one.

**Table-2. Comparision table of h, S11 and BW**

| S.NO. | h(mm) | W(mm) | L(mm) | $S_{11}$ | BW(MHz) |
|---|---|---|---|---|---|
| 1 | 2 | 38 | 28.20 | -31 | 68 |
| 2 | 3 | 38 | 27.75 | -36 | 86 |
| 3 | 4 | 38 | 27.00 | -30 | 113 |
| 4 | 5 | 38 | 26.25 | -16 | 111 |
| 5 | 6 | 38 | 27.10 | -14 | 86 |

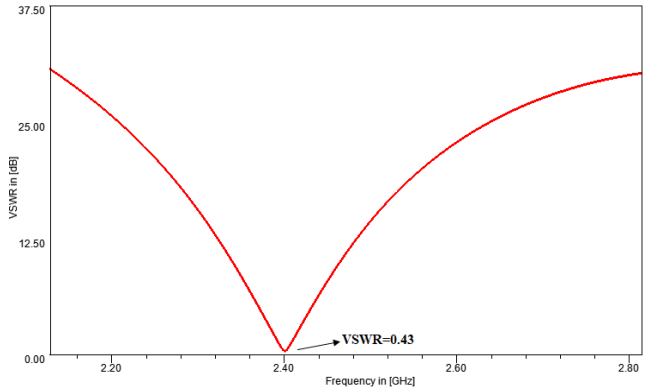


**Fig-3. Frequency Vs VSWR curve**

The VSWR for the proposed patch antenna is 0.43 at 2.4GHz which is given in Figure-3. The vector current distribution for the considered antenna at required frequency is indicated in Figure-4. The gain pattern is available in Figure-5.

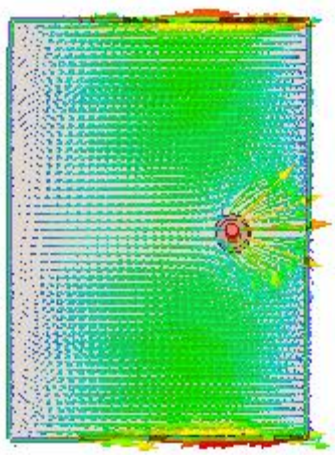

**Fig-4. Vector Current Distribution**



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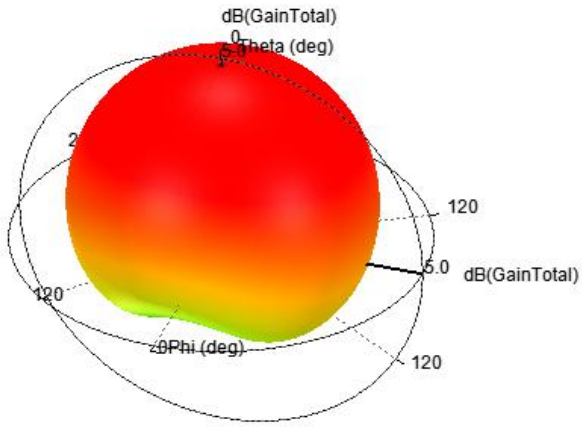


**Fig-5. Gain Pattern**

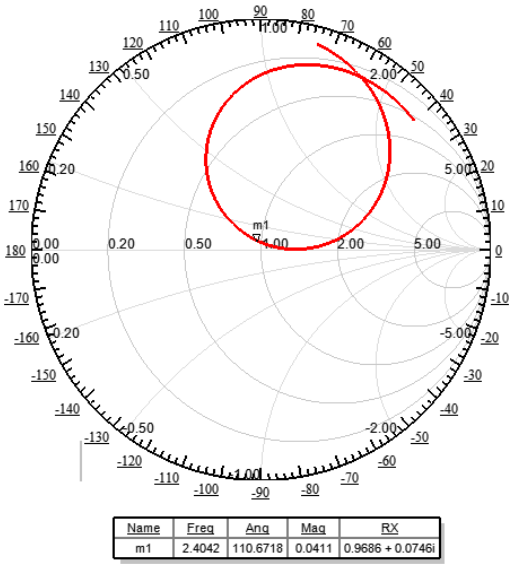


**Fig-6. Smith Chart Curve**

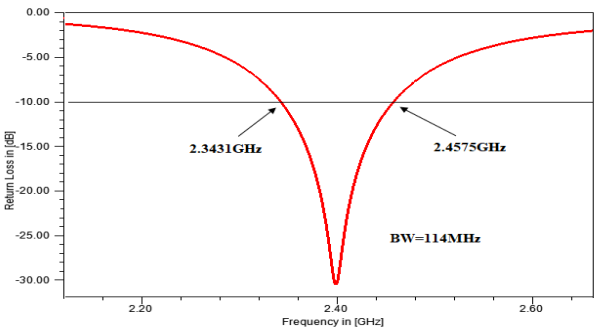


**Fig-7. Return Loss when feeding is on left side symmetrically**

As impedance is symmetrically distributed from centre of the patch towards the edges that is from 0 ohms to maximum resistance value, the feeding can be given on left side symmetrically. Even the feed point location is changed symmetrically the return loss and VSWR are not altered that can be seen in the figure-7 and figure 8. The geometry of micro strip antenna by taking feed point on left side symmetrically is shown in figure-9.

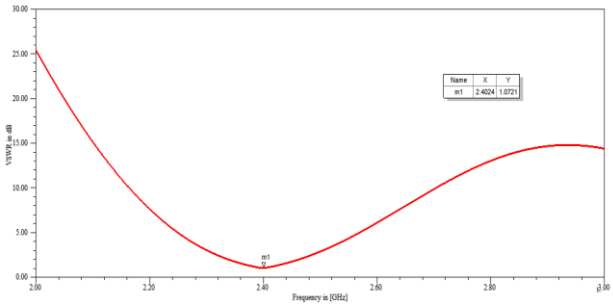

**Fig-8. VSWR curve when feeding is on left side symmetrically**

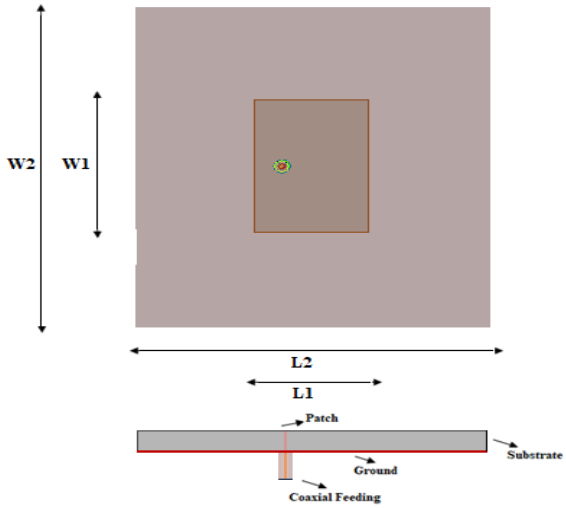


**Fig-9. Geometry of micro strip antenna by taking feed point on left side symmetrically**

## 4. CONCLUSION

The bandwidth of rectangular micro strip patch antenna is improved by increasing and setting the height of substrate up to 4mm and the bandwidth is around 113MHz. By symmetrical distribution of impedance it was proved that giving feed point location on left and right sides from the middle point does not alter the execution of the patch antenna

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