Rectangular Vs Circular Microstrip Patch Antenna Design & Comparison

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Abstract— This paper presents design procedure for Rectangular and Circular microstrip patch antenna. These microstrip patch antennas are compact and low profile. FR4_epoxy dielectric substrate used for calculation. These antennas designed for 2.4GHz operating frequency and compared for various parameters.
Key words: Microstrip Antenna, Rectangular Patch, Circular Patch, Return Loss, VSWR, Gain

I. INTRODUCTION

Microstrip patch antennas are commonly used due to their size and performance. Microstrip patch antenna has advantage of low cost, smaller size and easy to fabricate. This paper describes different parameter and design consideration of rectangular and circular microstrip patch antenna. This paper also summarizes comparison statement of both design technique. Microstrip patch antenna has metallic sheet placed above ground plane which is separated by dielectric substrate placed in between. Microstrip patch antennas are commonly used in communication field. In microstrip antenna design rectangular patch and circular patch are mostly used.

II. RECTANGULAR MICROSTRIP PATCH ANTENNA

Design procedure of rectangular microstrip patch antenna:
Calculation are done for fr=2.4GHz
(Consider c=3 x 10^8 m/s, Ɛ r=4.4, h=1.6mm)

a) Calculate wavelength (**λ**):

$$\lambda = \frac{c}{fr}$$

Where fr=2.4GHz

b) Calculate patch width (W):

$$W = \frac{\lambda}{2}\sqrt{\frac{2}{\varepsilon r + 1}}$$

c) Calculate effective dielectric constant (Ɛe):

$$\varepsilon e = \frac{\varepsilon r + 1}{2} + \frac{\varepsilon r - 1}{2}\sqrt{\frac{1}{1 + 12\frac{h}{w}}}$$

d) Calculate effective length extension:

$$\Delta L = 0.412 \text{ x } h\left[\left(\frac{\varepsilon r + 0.3}{\varepsilon e - 0.258}\right)\left(\frac{\frac{w}{h} + 0.264}{\frac{w}{h} + 0.8}\right)\right]$$

e) Calculate actual length of patch (L):

$$L = \frac{\lambda}{2\sqrt{\varepsilon e}} - 2\Delta L$$

f) Calculate feed width for 50**Ω** impedance:

$$Z_{50\Omega} = \frac{377}{\sqrt{\varepsilon r}\left(\frac{w}{h} + 2\right)}$$

g) Calculate length of feed:

$$L = \frac{\lambda}{4\sqrt{\varepsilon r}}$$

Calculation done using these equations to obtain different design parameters considering FR4_epoxy substrate.

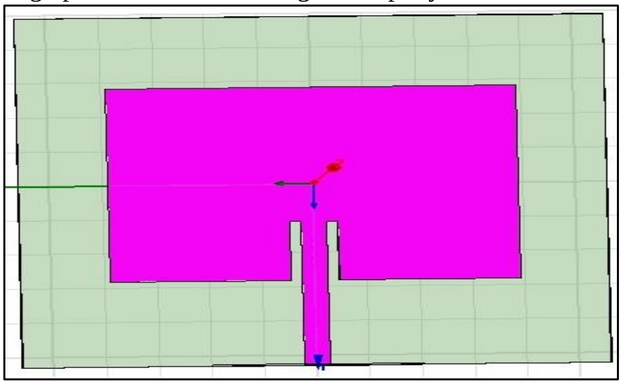

Fig. 1: Rectangular Microstrip Patch Antenna

A Simple Design of rectangular microstrip patch antenna is shown in fig.1. FR4_epoxy used as substrate because light weight and cheap.

III. SIMULATION RESULT OF RECTANGULAR MICROSTRIP PATCH ANTENNA

Simulation is carried out in HFSS software. The simulation result of simple rectangular microstrip patch antenna are shown in fig. 2, 3, 4 and 5. This shows return loss -14.59dB, VSWR 1.46, gain 2.79dB and directivity 3.75dB at 2.4GHz frequency.

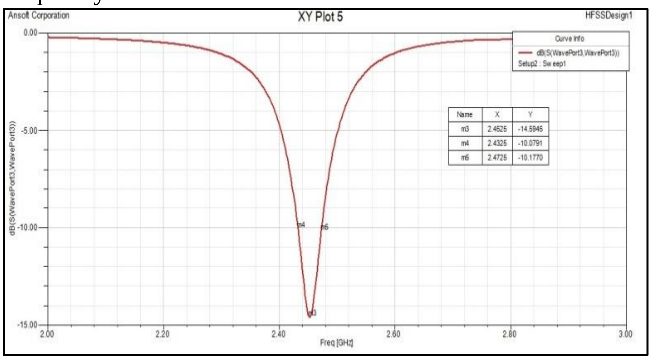

Fig.2. Return Loss

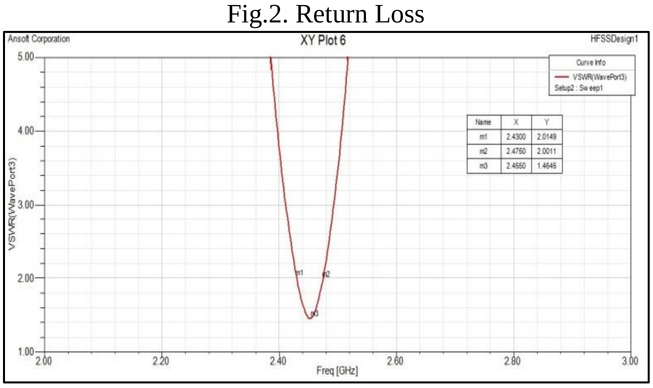

Fig.3. VSWR

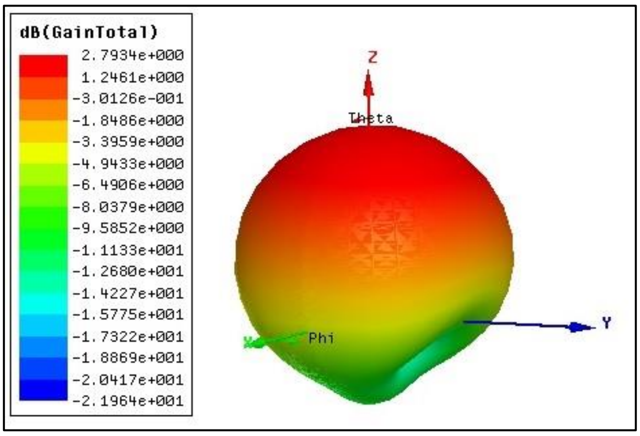

Fig. 4: Gain

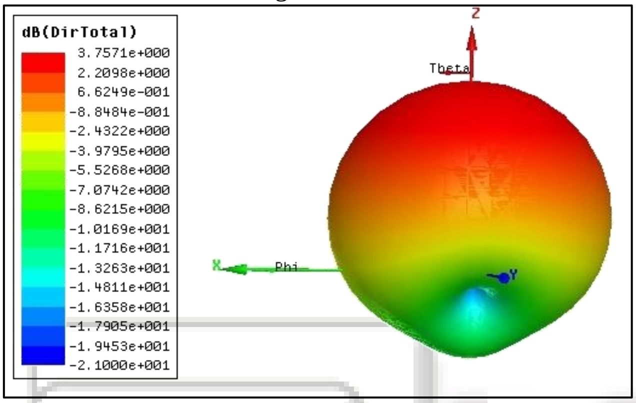

Fig. 5: Directivity

IV. CIRCULAR MICROSTRIP PATCH ANTENNA

Design procedure of Circular microstrip patch antenna:

– Calculation are done for fr=2.4GHz
– (Consider c=3 x 10^8 m/s, Ɛ r=4.4, h=1.6mm)

a) Calculate wavelength (**λ**):

$$\lambda = \frac{c}{fr}$$

Where fr=2.4GHz

b) Calculate radius of patch (a):

$$a = F\left\{1 + \frac{2h}{\pi F \varepsilon_r}\left[\ln\left(\frac{\pi F}{2h}\right) + 1.7726\right]\right\}^{-1/2}$$

Where,

$$F = \frac{8.791 \times 10^9}{f_r\sqrt{\varepsilon_r}}$$

c) Calculate actual length of patch substrate:

Ls = 4a

Ws = 4a

d) Calculate feed width for 50**Ω** impedance:

$$Z_{50\Omega} = \frac{377}{\sqrt{\mathcal{E}r}\left(\frac{w}{h} + 2\right)}$$

e) Calculate length of feed:

$$L = \frac{\lambda}{4\sqrt{\mathcal{E}r}}$$

Calculation done using these equations to obtain different design parameters considering FR4_epoxy substrate.

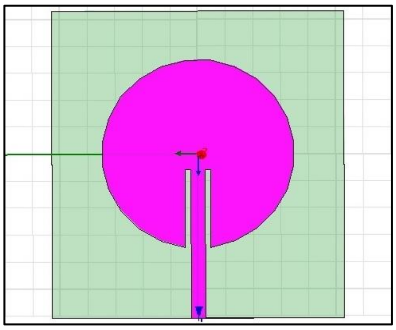

Fig. 6: Circular Microstrip Patch Antenna

V. SIMULATION RESULT OF CIRCULAR MICROSTRIP PATCH ANTENNA

Simulation is carried out in HFSS software. The simulation result of simple circular microstrip patch antenna are shown in fig. 7, 8, 9 and 10. This shows return loss -16.54dB, VSWR 1.34, gain 3.41dB and directivity 3.98dB at 2.4GHz frequency.

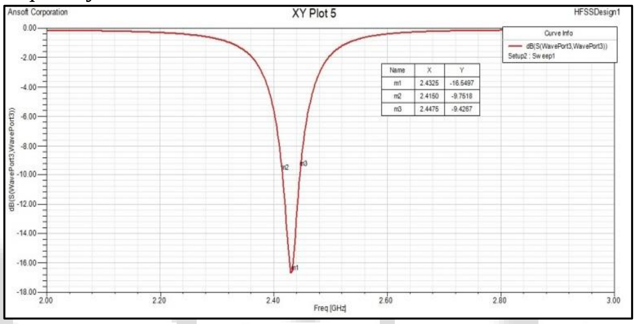

Fig.7. Return Loss

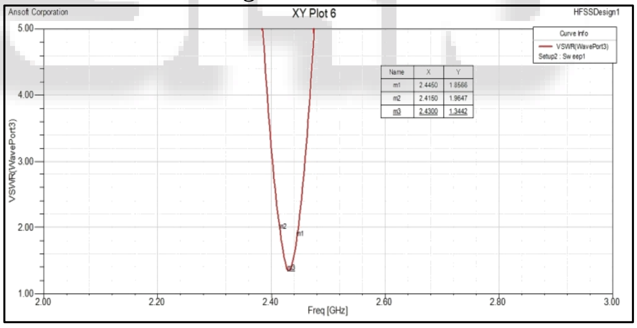

Fig.8. VSWR

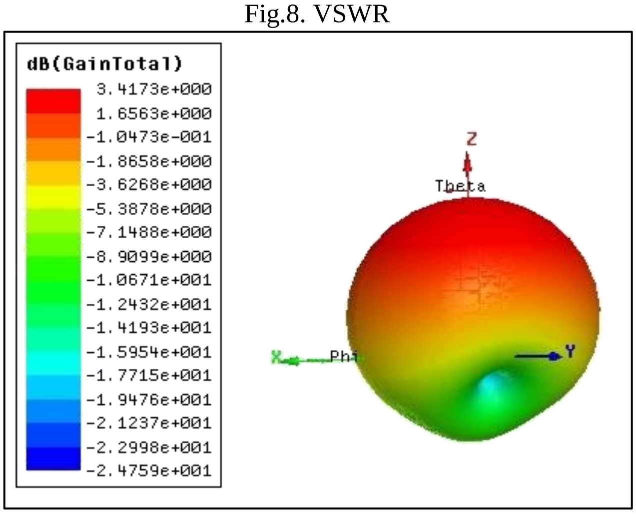

Fig. 9: Gain

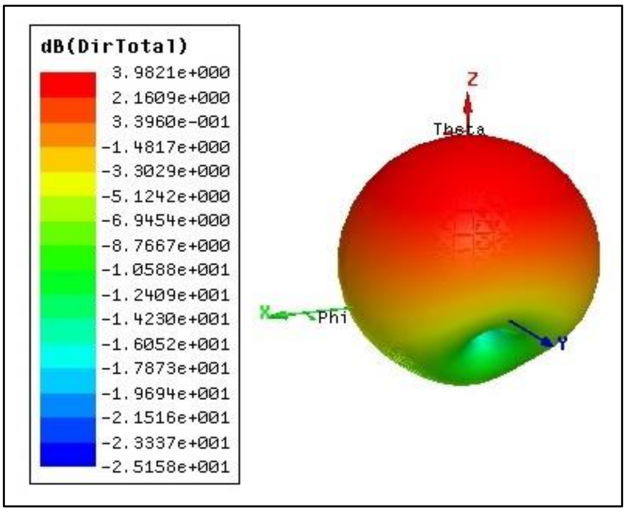

Fig. 10: Directivity

VI. Comparison Table

Patch	Return Loss (dB)	VSWR	Gain (dB)	Directivity (dB)
Rectangular	-14.59	1.46	2.79	3.75
Circular	-16.54	1.34	3.41	3.98

Table 1:

VII. Conclusion

In this paper, a novel technique for the design of rectangular and circular microstrip patch antenna has been proposed and demonstrated. The comparison table of rectangular vs circular microstrip patch antenna shows that circular microstrip patch antenna has improved antenna parameters than rectangular microstrip patch antenna.

The proposed rectangular and circular microstrip patch antenna are in small size and is applicable to WLAN band at 2.4GHZ.

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