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A Comparative Analysis of Microstrip Patch Antenna of Different Shapes for Wi-Fi Applications

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Abstract
Modern communication devices need conformal, planar, high gain, high bandwidth, and miniaturized antennas for their operation. These days Microstrip antennas due to their low-profile structure and due to their achievable high gain and bandwidth are very commonly used antennas for the purpose of communication. In this research the effect of varying the shape of radiating patch on the performance parameters of patch antenna is investigated. The radiating patch considered in this research includes rectangular and circular patch.
Index Terms— Patch antenna, Gain, Radiation pattern

Introduction
Microstrip Patch Antenna is conformal and planar structure antenna which consists of metallic patch, substrate, ground plane and feeding part. The metallic patch in patch antenna can be of different shape and depending upon the shape of patch we can classify patch antenna. Although there can be large number of patch shapes but generally rectangular and circilar patch shape is most commonly used. Accordingly patch antennas are classified as square parch antenna and circular patch antenna as shown in Fig (1) and Fig (2). Operative frequency of patch is decided by the Dielectric constant of substrate, and height of substrate. The width of patch antenna dictates the efficiency of antenna.

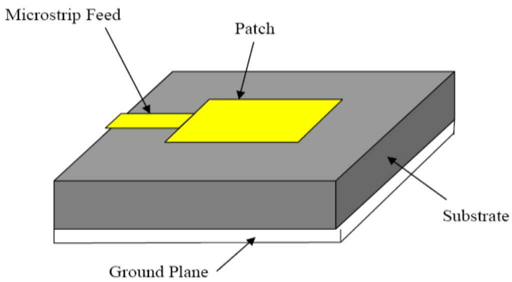

Figure 1 Rectangular Patch Antenna

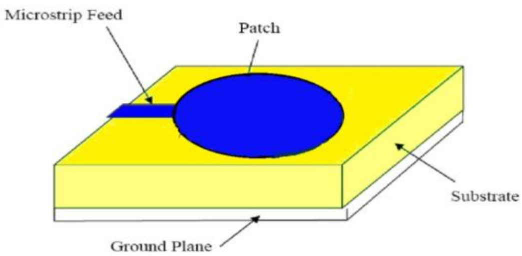

Figure 2 Circular Patch Antenna

The optimized length and width of rectangular patch antenna as proposed in [1-7] is given by

$$w = \frac{C}{2f\sqrt{\frac{\epsilon_{eff} + 1}{2}}} \text{-------------} (\mathbf{1})$$

Here C is the velocity of light and ϵ_{eff} is the effective permittivity of the substrate which is given by expression

$$\varepsilon_{eff} = \frac{\varepsilon + 1}{2} + \frac{\varepsilon - 1}{2}\sqrt{1 + 12\frac{h}{w}} \text{-------} (\mathbf{2})$$

Here ε is the dielectric constant of substrate and h is the thickness of the substrate
The patch length is given by the expression

$$L = \frac{C}{2f\sqrt{\epsilon_{eff}}} \text{---------------} (\mathbf{3})$$

For circular patch antenna
Radius of the circular patch is given by

$$a = \frac{F}{[1 + \frac{2h}{\pi F \varepsilon_r}(\ln\{\frac{\pi F}{2h}\} + 1.7726)]^{0.5}}$$

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

ε_r= Dielectric constant of substrate

Length and width of the substrate can be calculated by

Substrate length, $L_{sub} = 2 \times 2a$
Substrate width, $W_{sub} = 2 \times 2a$

In this research we had designed the rectangular and circular microstrip patch antenna for 2.4 GHz. The designed antennas are compared in terms of performance parameters which includes input impedance, scattering parameters, Voltage standing wave ratio, and Radiation Pattern. High Frequency Structure Simulator is used to simulate the structures.
The Dimensions and parameters of substrate in designing Rectangular and circular Patch antenna are mentioned in Table 1 and Table 2.

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Table 1 Rectangular Patch antenna design parameters

S. No.	Name of Parameter	Value
1	Resonant Frequency	2.4 GHz
2	Patch Length	5 Cm
3	Patch width	.10 cm
4	Substrate Material	Duriod
5	Substrate height	.16 cm
6	Feed width	.493 cm
7	Feed Length	6.15 cm

Table 2 Circular Patch antenna design parameters

S. No.	Name of Parameter	Value
1	Resonant Frequency	2.4 GHz
2	Patch radius	2.5 Cm
3	Substrate Material	Duriod
4	Substrate height	.16 cm
5	Feed width	.493 cm
6	Feed Length	6.15 cm

Results and Discussion

The structure of Rectangular Patch antenna designed using High Frequency Structure Simulator for 2.4 GHz is shown in Fig (3).

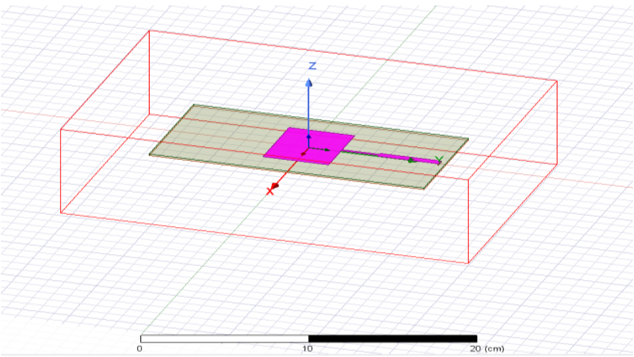

Figure 3. Structure of Rectangular Patch antenna

Input Impedance of designed antenna is shown in Fig (4). Obtained Input impedance is 42.65 Ω.

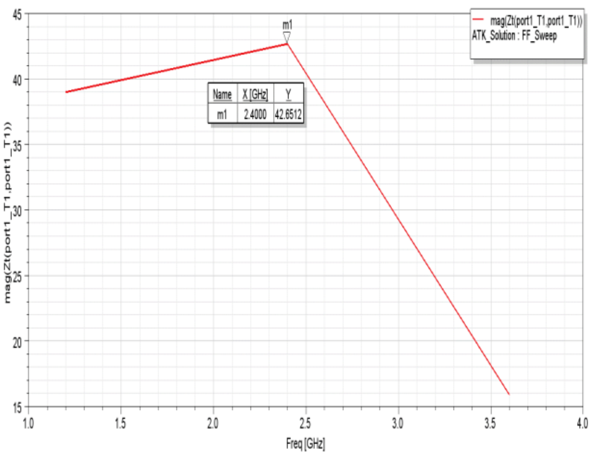

Figure 4. Input impedance of Rectangular Patch antenna

The scattering parameter at Port 1 is measured to be -3 db. and is shown in Fig (5). This indicates a good matching between source and antenna.

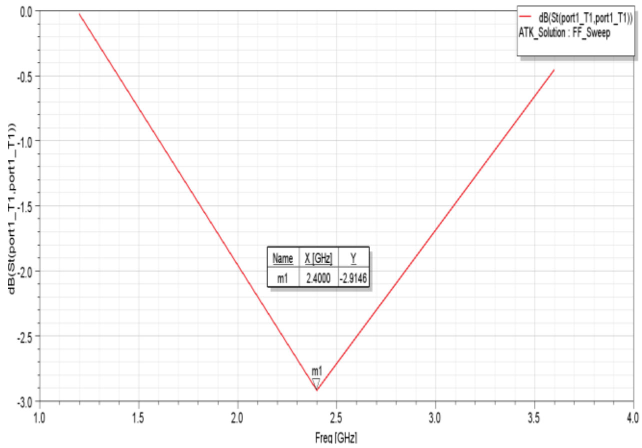

Figure 5. S_{11} graph of Rectangular Patch antenna.

VSWR of designed dipole antenna is shown in Fig (6). Obtained VSWR is around 6 which indicate good matching between source and load.

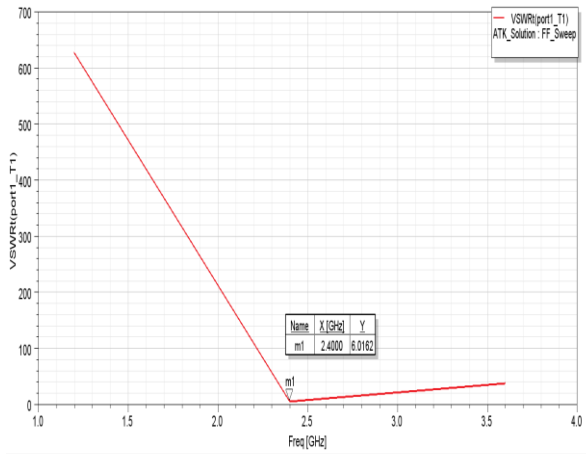

Figure 6.VSWR graph of Rectangular Patch antenna.

The Radiation Pattrn of designed dipole antenna is shown in Fig (7). A gain of 7 dB is achievable from designed dipole antenna.

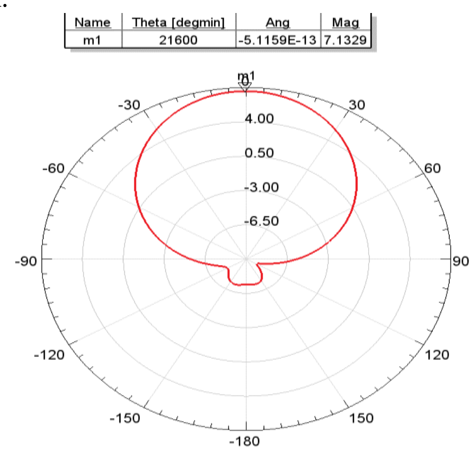

Figure 7. Radiation Pattern of Rectangular Patch antenna.

The structure of Circular Patch antenna designed using High Frequency Structure Simulator for 2.4 GHz is shown in Fig (8).

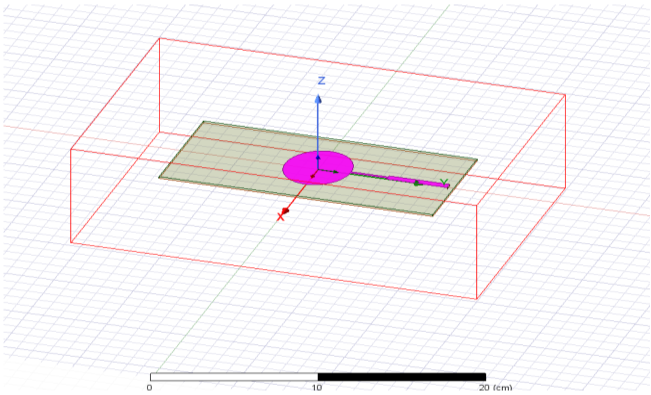

Figure 8. Structure of Circular Patch antenna

Input Impedance of designed antenna is shown in Fig (9). Obtained Input impedance is 50 Ω.

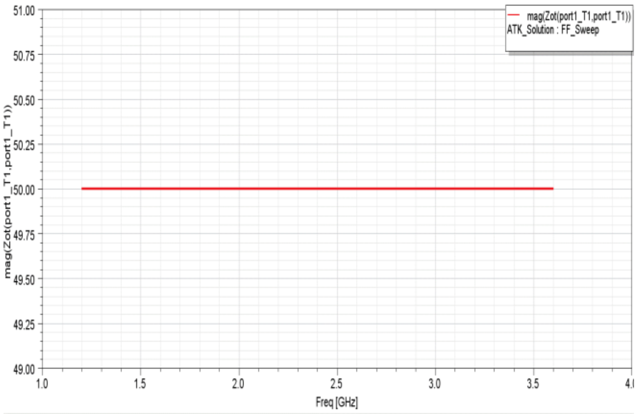

Figure 9. Input impedance of Circular Patch antenna

The scattering parameter at Port 1 is measured to be -.43 db. and is shown in Fig (10).

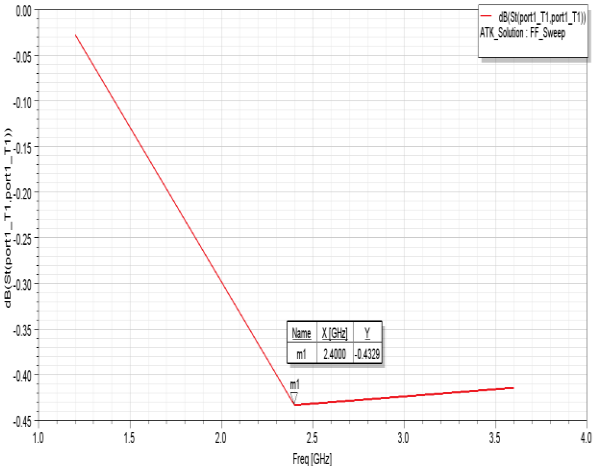

Figure 10. S_{11} graph of Circular Patch antenna.

VSWR of designed Circular Patch antenna is shown in Fig (11). Obtained VSWR is around 40.

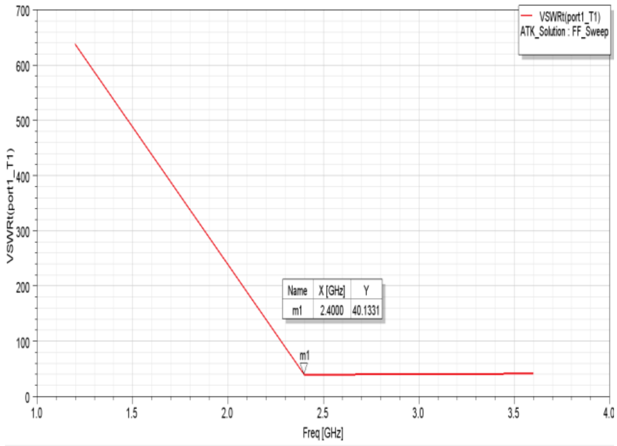

Figure 11. VSWR graph of Circular Patch antenna.

The Radiation Pattrn of designed Circular Patch antenna is shown in Fig (12). A gain of dB is achievable from designed dipole antenna.

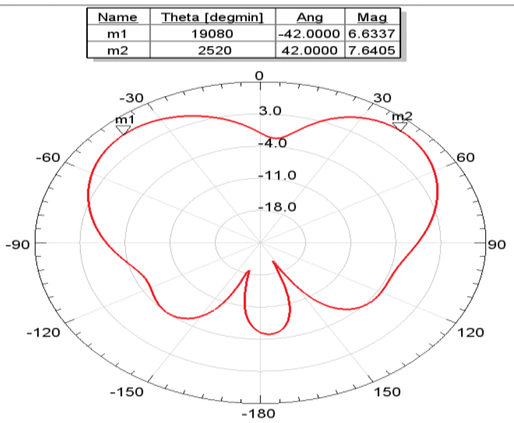

Figure 12. Radiation Pattern of Circular Patch antenna

Conclusion

Rectangular and Circular Patch antenna is designed in this research. A comparison of these antennas is presented below

Table 3.

S.No.	Performance Parameter	Rectangular Patch antenna	Circular Patch antenna
1	Input Impedance	42.65 Ω	50 Ω.
2	VSWR	6	40
3	S_{11}	-3 dB	-.43 dB
4	Gain	7 dB	7.6 dB

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