Design, simulation, optimization and fabrication of patch antenna by analyzing different shapes of Patch

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Abstract— ***Now a days, wireless communication is integral part of society and antenna plays an important role in wireless communication. Due to this, selection and design of antenna is a crucial process. Before fabrication, it is first simulated and optimized to get best performance. Using Ansoft HFSS version 10.0.0 four different shapes such as rectangle, circle, square and meander microstrip patch antennas are simulated. These antenna shapes are then fabricated using FR4 material with dielectric constant 4.4 and thickness 1.5 mm. Their performances are compared using parameters like return loss, gain, VSWR, radiation pattern and impedance. The operating frequency is chosen as 2.4 GHz and coaxial feed method is used to fed antennas. It is summarized that rectangular microstrip patch antenna has better results at 2.4GHz frequency compared to all other shapes.***

Keywords—Microstrip patch antenna, Comparison, return loss, VSWR, Radiation pattern.

I. INTRODUCTION

In satellite, spacecraft, aircraft,and missile applications where high performance is required, in terms of cost, performance, weight, size, aerodynamic profile and ease of installation. These specifications similarly found in various government and commercial applications like wireless communication and mobile radio. To fulfill these requirements, microstrip antennas can be preferred.

Microstrip antennas are suitable to planar and non-planar surfaces, low profile, easy to design and inexpensive to manufacture using modern PCB design technology and are physically robust when mounted on rigid surfaces, consistent with Monolithic microwave integrated circuit(MMIC) designs. When any shape and mode is selected, they are unique in terms of polarization, resonant frequency, impedance, and radiation pattern.

Microstrip antenna which is also known as Printed antenna, are widely used at microwave frequencies and radio frequencies. These antennas consist of Patch on surface and ground plane at other side separated by dielectric substrate. Microstrip transmission lines or coaxial probe feed are used to connect antenna to transmitter or receiver . The ground plane excite high-frequency electromagnetic fields and electromagnetic waves radiate in outward direction through the gap between the patch around the ground plane.

II. LITERATURE SURVEY

From frequency spectrum, operating frequency had selected. ISM band 2.4GHz is selected as it is freely available for Industrial, Scientific and Medical purpose. In various applications compact size and wide bandwidth are constraints for an antenna design. To achieve this constraints there are many methodologies. There are number of substrates available to achieve widen bandwidth and low reflection loss. The performance of the substrate is depends on dielectric constant. The substrate with less dielectric constant and low loss gives better performance as compare to those having higher values.

III. DESIGN CALCULATIONS

A. Rectangular Patch Antenna

f_r= 2.4 GHz ,h= 1.6 mm, ε_r=4.4.

$$W = \frac{1}{2 fr\sqrt{\mu 0 \varepsilon 0}}\sqrt{\frac{2}{\varepsilon r+1}}$$

$$= \frac{1}{2\left(2.4\times 10^{9}\right)\sqrt{8.854\times 10^{-12}\times 1.25\times 10^{-6}}}\sqrt{\frac{2}{4.4+1}}$$

$$= 0.0968 \text{ cm}$$

$$\varepsilon_{reff} = \frac{\varepsilon r+1}{2}+\frac{\varepsilon r-1}{2}\left[1+12\frac{h}{w}\right]^{-1/2}$$

$$= \frac{4.4+1}{2}+\frac{4.4-1}{2}\left[1+12\frac{0.16}{0.0968}\right]^{-1/2}$$

$\varepsilon_{reff} = 3.072$

B. Circular patch antenna

fr= 2.4 GHz , h= 1.6 mm, εr=4.4

$$F = \frac{8.791\times10^{9}}{fr\sqrt{\varepsilon r}}$$

$$F = \frac{8.791 \times 10^{9}}{2.4 \times 10^{9}\sqrt{4.4}}$$

$F = 1.7462$

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

$$= \frac{1.7462}{\left\{1+\frac{2\times0.16}{\pi\times4.4\times1.7462}\left[\ln\left(\frac{\pi\times1.7462}{2\times0.16}\right)+1.7726\right]\right\}^{1/2}}$$

a = 1.69492 cm

C. Square patch antenna

fr= 2.4 GHz , h= 1.6 m, ε_r= 4.4

W = L

$$W = \frac{1}{2fr\sqrt{\mu0\varepsilon0}}\sqrt{\frac{2}{\varepsilon r+1}}$$

$$W = \frac{1}{2(2.4\times10^{9})\sqrt{8.854\times10^{-12}\times1.25\times10^{-6}}}\sqrt{\frac{2}{4.4+1}}$$

W = 0.0968 cm, *L = 0.0968 cm*

D. Meander Patch Antenna

s = 0.102 λg
d = 0.046 λg
w = 0.013 λg

Where, λg = guided wavelength.

Hence we get,

s =7mm
d =1.2mm
w =0.8mm

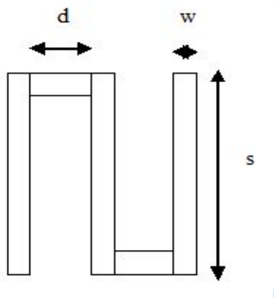


Fig. Dimensions of Meander antenna

IV. Simulation Results

A. Rectangular patch antenna

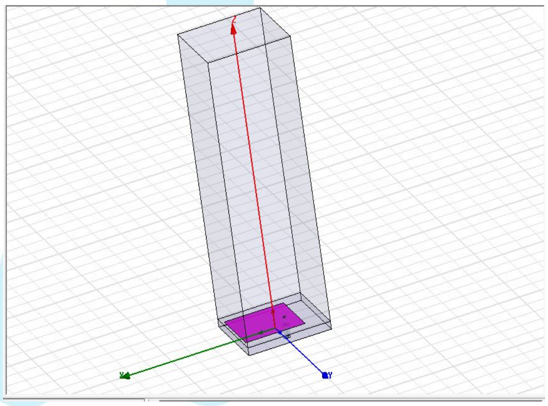


Fig.1 Rectangular Patch Antenna

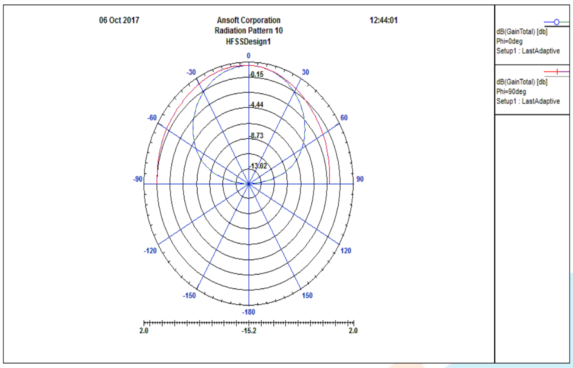


Fig.2 Radiation Pattern

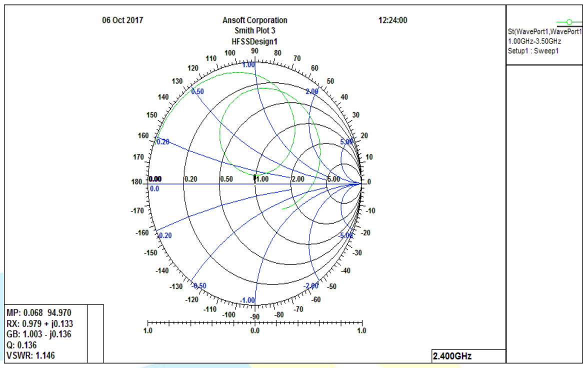


Fig.5 Impedance & VSWR

B. Circular patch antenna

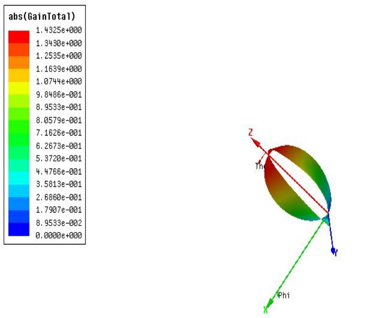


Fig.3 Polar Plot

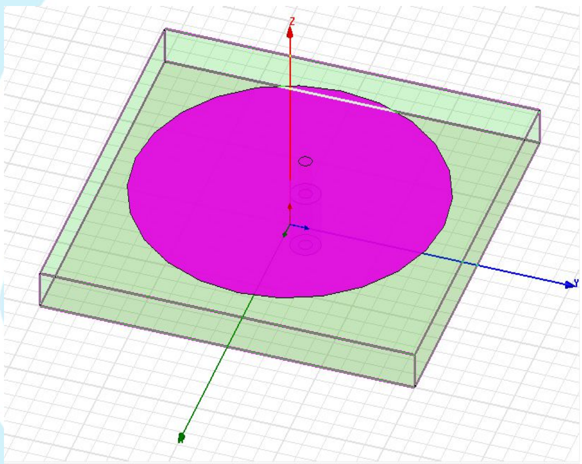


Fig.1 Circular Patch Antenna

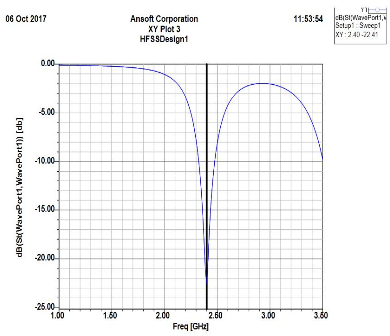


Fig.4 Return Loss

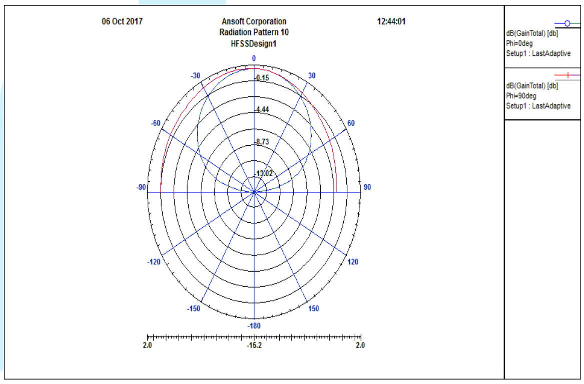


Fig.2 Radiation Pattern

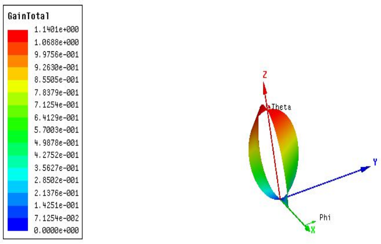


Fig.3 Polar Plot

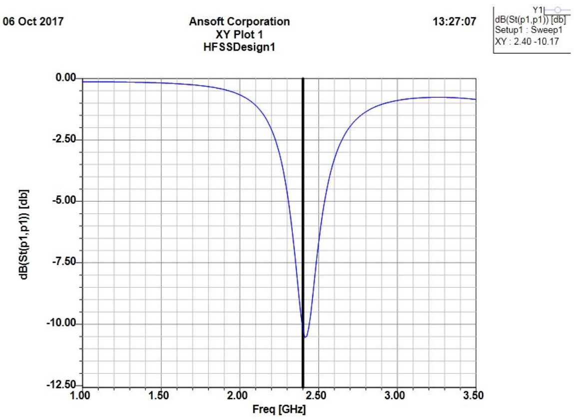


Fig.4 Return Loss

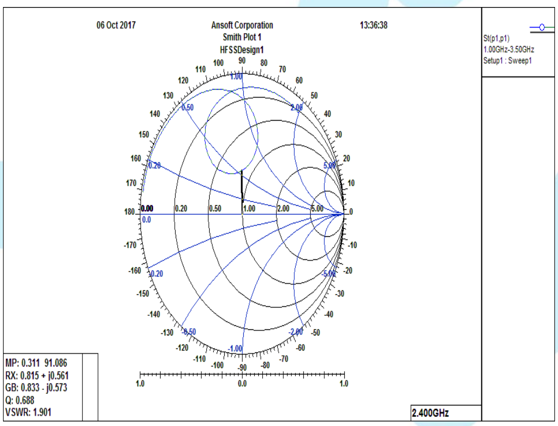


Fig.5 Impedance & VSWR

B. Square patch antenna

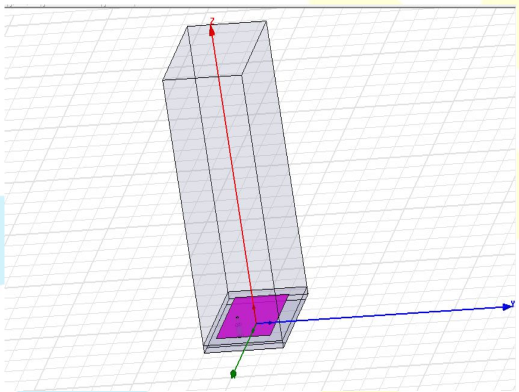


Fig.1 Square Patch Antenna

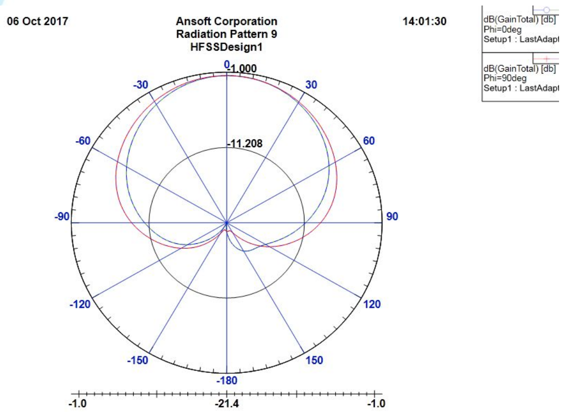


Fig.2 Radiation Pattern

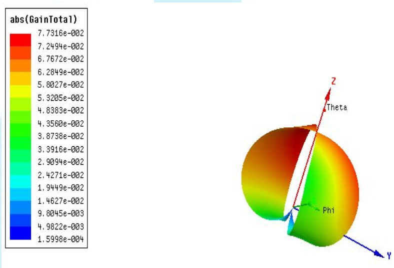


Fig.3 Polar Plot

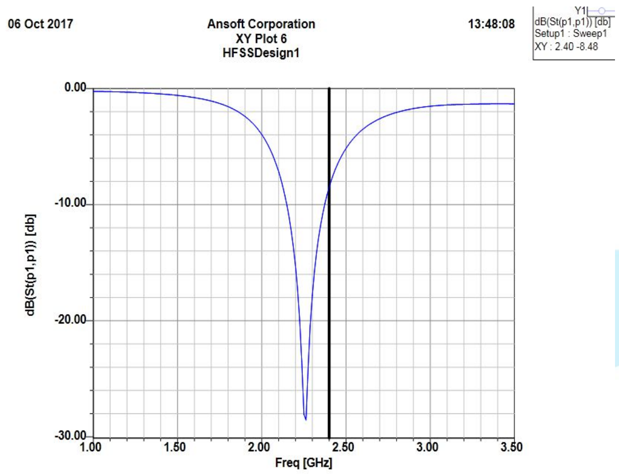


Fig.1 Meander Patch Antenna

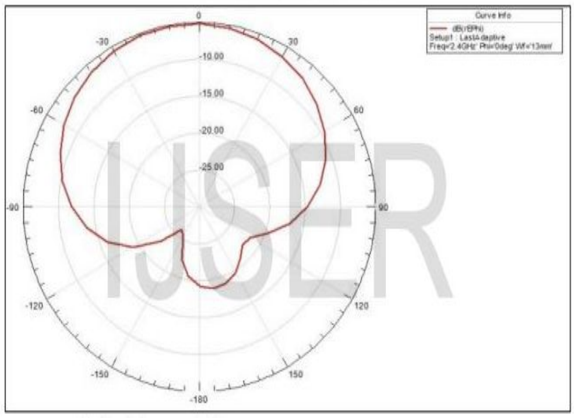
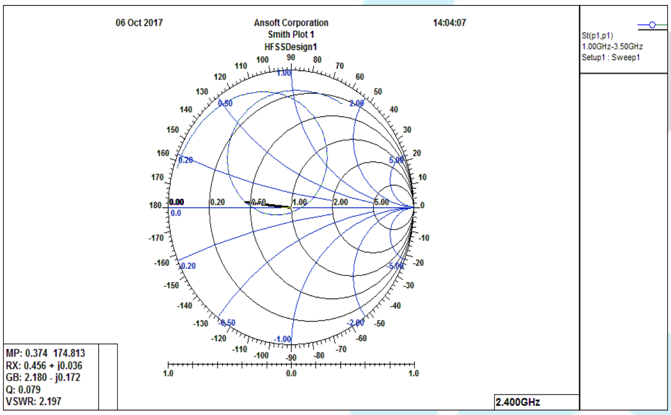


Fig.4 Return Loss



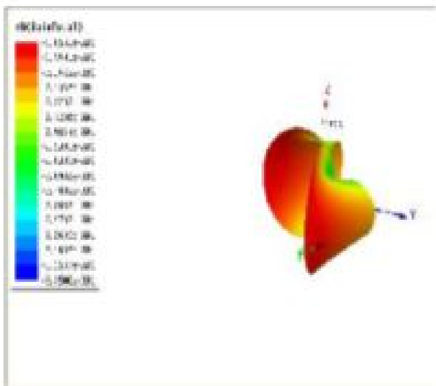


Fig.5 Impedance & VSWR

D. Meander patch antenna

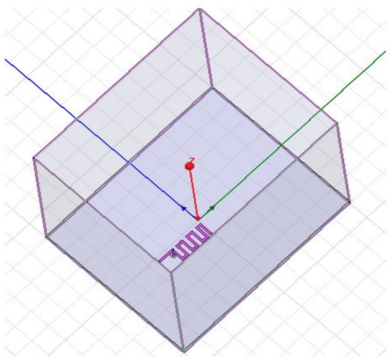


Fig.2 Radiation Pattern

Fig.3 Polar Plot

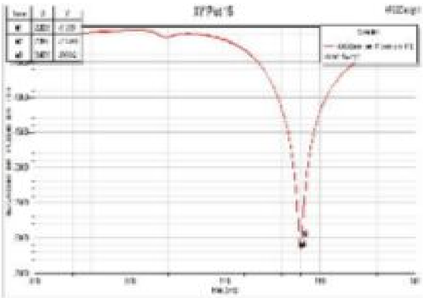


Fig.4 Return Loss

V. RESULT AND DISCUSION

Shape	Parameters			
	Gain	Return loss	VSWR	Impedance
Rectangular	1.56	-22.41	1.146	48.95+j6.65
Circular	0.47	-10.17	1.901	40.75+j28.05
Square	-1.46	-8.48	2.197	22.8+j1.8
Meander	-0.9	-9.2	1.8	49.3+ j3.88

The motive of this paper is to design different microstrip antennas with operating frequency 2.4 GHz from ISM band which is allotted for commercial applications. By comparing the results it is easy to find performance of all above four antennas. For rectangular antenna, the gain is higher that is 1.56 with VSWR is nearly equal to 1 and the return loss is low than other shapes at 2.4 GHz frequency. Hence from above comparison, it shows that rectangular antenna gives better results.

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