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Research Article

Design Characterization of Rectangular Microstrip Patch Antenna for Wi-Fi Application

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Abstract

The main aim of the paper is to design and simulate an inset fed rectangular microstrip patch antenna and study the effect of antenna dimension Length (L), Width (W), substrate parameter relative dielectric constant (ε_r) substrate thickness (h) and radiation parameters. The result is performed by thickness of 1.57mm of substrate and Rogers RT/duroid 5880 (tm) with dielectric constant of 2.2, S- band frequency 2.4GHz have observed the better result. In the recent years the development in communication systems requires the development of low cost, minimal weight, low profile antennas that are capable of maintaining high performance over a wide spectrum of frequency. This technological trend has focused much effort into the design of a Microstrip patch antenna. The proposed antenna design on different resonant frequencies and analyze the result of all operating frequency between 1GHz to 10GHz, when the proposed antenna designs 2.4GHz operating frequency. At 2.4GHz the verified and tested result has done in Ansoft HFSS version 11.It has observed the Return loss = -30.8 dB, VSWR =1.05 and Directivity = 6.732 dB in this paper. An omnidirectional radiation pattern and stable gain are observed.

Keywords: *HFSS, Impedance, Radiation Pattern, Return Loss, Smith chart, VSWR.*

1. Introduction

There is an increase in demand for microstip antennas with improved performance for wireless communication applications are widely used for this purpose because of their planer structure, low profile, light weight moderate efficiency and ease of integration with active device. Almost all the important wireless applications lie in the band starting from 900 MHz to 5.8 GHz. Broadband microstrip patch antennas for the 2.45 GHz ISM band and possible implementation using adhesive copper tape in research scenarios. In the course of the project, two broadband microstrip patch antennas were manufactured to adequately cover the 2.4- 2.5 GHz frequency band.

The mechanism of coupling energy, equivalent circuit diagram and relative merits are discussed in this paper as shown in fig 1..Feeding Techniques are govern by many factors like efficient transfer of power between the radiation structure, feeding structure and their impedance matching . Along with impedance matching are stepped impedance bends, stub function, transition which removes spurious radiation & surface wave loss. These radiations may increase the side lobe & cross polarization amplitude of radiation pattern. Most important factor is to remove the spurious radiation and it effect on radiation pattern is use to evaluate feed. Some feed structures are tends to better performance because of the large no of parameters available. In modern wireless communication systems, Worldwide Interoperability for Microwave Access (WIMAX) has been widely applied in mobile devices such as handheld computers and intelligent phones. This gives users the mobility to move around within a broad coverage area and still be connected to the network.

1.1 Feed Techniques

Microstrip patch antennae can be fed by a variety of different methods. The four most popular feed techniques used for the microstrip patch are

- Microstrip line feed
- Co-axial feed
- Aperture coupling
- Proximity coupling

Microstrip line and coaxial probe feeds are contacting scheme, in which RF power directly to the radiating patch. Proximity and Aperture coupled feeds are non contacting schemes, in which electromagnetic field coupling is done to transfer power between the microstrip line and the radiating patch. Feeding techniques are govern by many factors like efficient transfer of power between the radiation structure, feeding structure and their impedance matching .These techniques give a better understanding of design parameters of an antenna and their effect on return losses ,bandwidth ,VSWR and resonant frequency .

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1.1.1 Microstrip Line Feed

In this type of feeding technique, a conducting strip connected directly to the edge of the microstrip patch. The conducting strip is smaller in width as compared to the patch and this kind of feed arrangement has the advantage that the feed can be on the same substrate to provide a planar structure. This is an easy feeding scheme, since it provides ease of fabrication and simplicity in modeling as well as impedance matching. However as the thickness of the dielectric substrate being used, increases, surface waves and spurious feed radiation also increases, which hampers the bandwidth of the antenna. The feed radiation also leads to undesired cross polarized radiation.

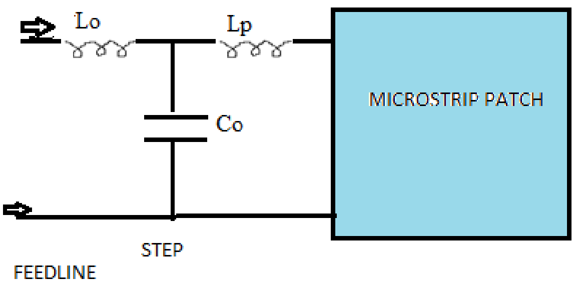
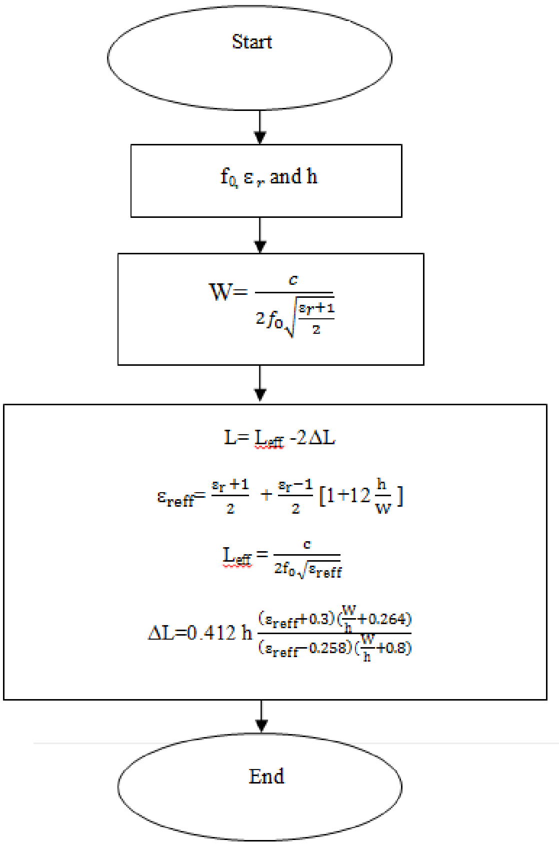


Fig 1 Circuit Diagram of Microstrip Feed

2 Design Considerations for Rectangular Micro Strip Patch Antenna



Calculation of the ground plane dimensions (L_g and W_g):

$$L_g = 6h + L \quad (1)$$

$$W_g = 6h + W \quad (2)$$

2.1 Characteristics impedance (Z_0)

When W/h ≥1

$$Z_0 = \frac{120\,\pi}{\sqrt{\varepsilon_{reff}}\left[\left(\frac{W}{h}\right)+1.393+\frac{2}{3}\ln\left\{\left(\frac{W}{h}\right)+1.449\right\}\right]} \quad (3)$$

2.2 VSWR (Voltage Standing Wave Ratio)

The VSWR is basically a measure of the impedance mismatch between the feeding system and the antenna. The higher the VSWR the greater is the mismatch. The minimum possible value of VSWR is unity and this corresponds to a perfect match

$$VSWR = \frac{1+|r|}{1-|r|} \quad (4)$$

$$r = \frac{V_r}{V_i} = \frac{Z_{in}-Z_s}{Z_{in}+Z_s} \quad (5)$$

Z_{in} = Input impedance of the antenna,
Z_s = Source impedance,
r = reflection coefficient,
Vr = Amplitude of the reflected wave,
Vi = Amplitude of the incident wave

2.3 Return Loss

RL is a parameter similar to the VSWR to indicate how well the matching is between the feeding system, the transmission lines, and the antenna. The RL is

$$RL = -20 \log |r| \text{ (dB)} \quad (6)$$

To obtain perfect matching between the feeding system and the antenna, Γ = 0 is required and therefore, from equation (6), RL = infinity. In such a case no power is reflected back. Similarly at Γ = 1, RL = 0 dB, implies that all incident power is reflected. For practical applications a VSWR of 2 is acceptable and this corresponds to a return loss of 9.54 dB.

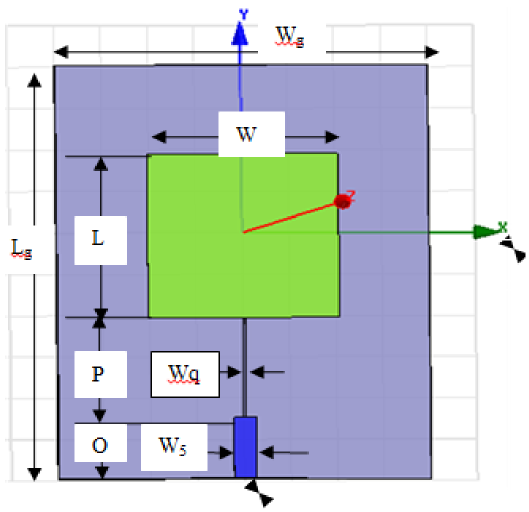


Fig: 2 Rectangular Microstrip Patch Antenna with Line Feed

RMSA i.e. Rectangular microstrip patch antenna is designed in HFSS vs. 11.0 on basically available Rogers RT/duroid 5880 (tm) Substrate of size 100mm X 80mm X 1.57mm and having dielectric constant of 2.2 and loss tangent (tan δ) = 0.02.in fig 2 shows that radiating copper patch are taken to be 39.56mm X 41.08mm .thickness of copper material is taken as .035mm which is negligible in comparison with 1.57mm thickness of Rogers RT/duroid 5880 (tm) substrate material. Dimension of 50 ohm line are 15mm X 4.84mm X.035mm.dimensions of quarter wavelength line are 24.05mm X .52mm X .035.

Table 1

S.N	Parameters	Parameters value
1.	Patch Length (L)	41.36
2.	Patch Width (W)	49.41
3.	Length of ground (L_g)	80
4	Width of ground (Wg)	100
5	Feed Length (O)	15
6	Feed Width (W_{50})	24.05
7	Quarter length (P)	4.84
8	Quarter width (W_q)	0.52
9	Height (h)	1.57

3. Simulation Results and Discussion

The software used to model and simulate the rectangular microstrip patch antennae is High Frequency Simulation Software – version 11.0. It has been widely used in the design of RF/wireless antennae, waveguide designs and filters. It can be used to determine and plot the reflection parameters, Voltage Standing Wave Ratio (VSWR), Impedance as well as the radiation patterns. Figure 1 shows the line rectangular feed microstrip patch antenna designed using HFSS version 11.0.

3.1 Return Loss

A frequency range of 2-4 GHz is chosen as the resonant frequency which is suitable for S-band applications. Figure 2 S- parameter plot for Return Loss v/s frequency. From the figure it is clear that the return loss at the resonant frequency 2.4 GHz is -30.7991dB.

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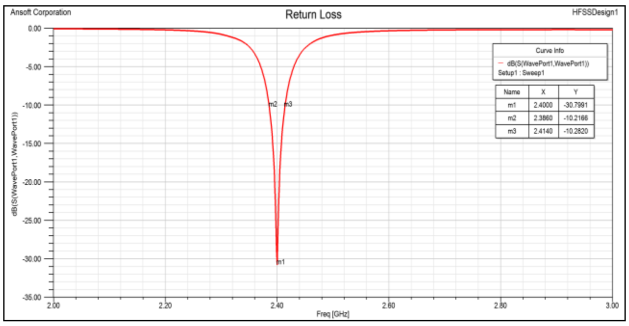

Fig 3: S- parameter plot for Return Loss v/s frequency

3.2 Radiation Pattern Plots

Since a microstrip patch antenna radiates normal to its patch surface, the elevation pattern for φ = 0 and φ = 90 degrees would be important. Figure 3 and figure 4 shows the gain plot for line feed technique.

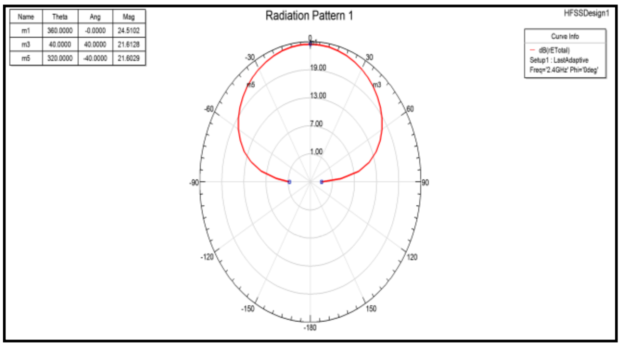

Fig 4 Total gain frequency 2.4 GHz Phi=0 deg

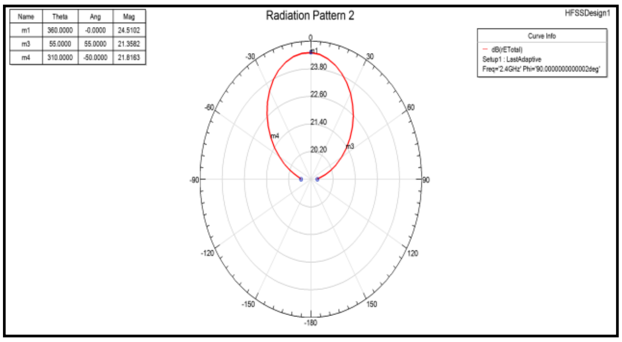

Fig 5 Total gain frequency 2.4 GHz Phi=90 deg

Figure 6, 3D gain clearly showing the peak value of gain of antenna for strip feed 6.7324e+000 dB. Basically for appropriate design antenna gain should lie in the range of 6 -8 dB.

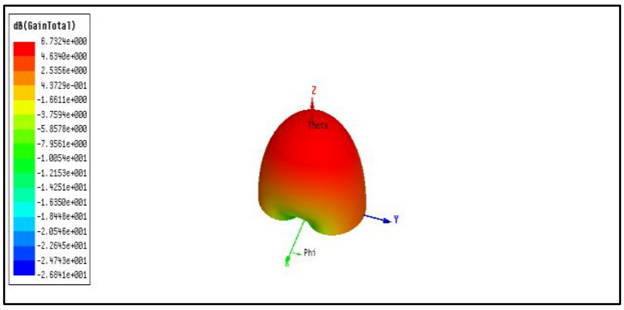

Fig 6 The 3 D Radiation pattern of RMPA

3.3 Impedance

The theory of maximum power transfer states that for the transfer of maximum power from a source with fixed internal impedance to the load, the impedance of the load must be the same of the source. The following are the impedance plot. Figure 7 shows impedance plot for the line feed.

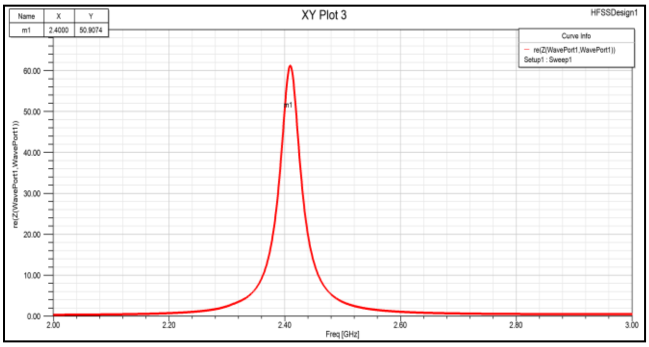

Fig 7 Impedence versus frequency plot

3.4 VSWR

When a transmitter is connected to an antenna by a feed line, the impedance of the antenna and feed line must match exactly for maximum possible energy transfer from the feed line to the antenna. When an antenna and feed line do not have matching impedances, some of the electrical energy cannot be transferred from the feed line to the antenna. Energy not transferred to the antenna is reflected back towards the transmitter. It is the interaction of these reflected waves with forward waves which causes standing wave patterns. Ideally, VSWR must lie in the range of 1-2.

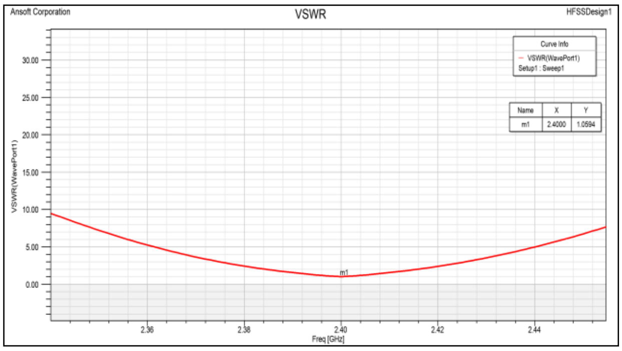

Fig 8 VSWR v/s frequency plot of Rectangular Microstrip Patch Antenna

Figure 9 shows the omnidirectional radiation pattern of patch.

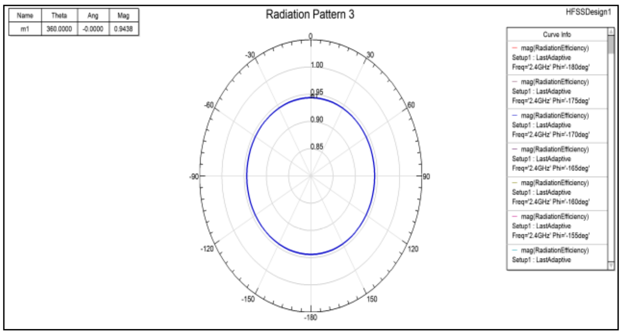

Fig 9 gain v/s frequency plot for different value of phi.

3.5 Smith Chart

Figure 10 clearly shows that normalized impedence has obtained 1.0027. which is closely to normalized impedence 1, that means 50 ohm resistance.It can be observed from this value the proper impedance matching obtained ,so it can say that proper transmission will be occour.

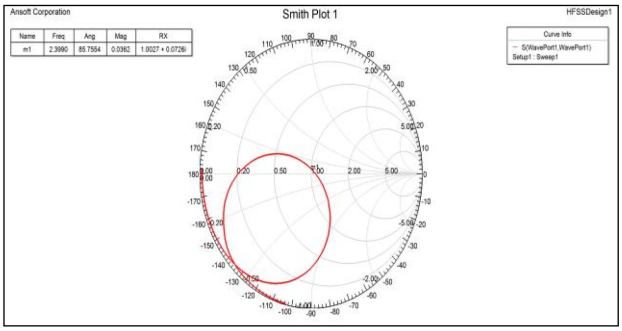

Fig 10 plot of smith chart

Conclusions

1) In this work different parameters such as return loss, VSWR, input impedance, radiation pattern and smith chart have been studied in the rectangular microstrip patch antenna operating in 2.4 GHz.
2) Incident power must be 10mW to 20mW input impedance of antenna should be 50ohm.This work suggests that the proposed antennas configurations provide a light-weight, compact, low cost and better signal strength in horizontal direction compared to the regular microstrip patch antenna.
3) These antennas present an excellent candidate for emerging wireless communications at 2.4 GHz frequency that require a transfer of amount of data in rapid bursts, which include Bluetooth and Wi-Fi (802.11) .
4) In the design the RL is -30.0294 dB in Microstrip feed line technique.
5) The VSWR for the design performed in the project has a good value of 1.05 (Microstrip feed line) as we can say the level of mismatch is not so high.
6) Taking all this in to consideration we can say that there are many aspects that affect the performance of the antenna. Dimensions, selection of the substrate, feed technique and also the Operating frequency can take their position in effecting the performance.

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