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Research Article

Design and Analysis of E- Patch Microstrip Antenna for S Band

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Abstract

*E - Patch Microstrip antenna with slot is propose for S Band on wireless application like radar, satellite communication. The propose patch is design to operate at S Band frequency range 2-4 Ghz with HFSS simulation software .The structure is fed by 50 ohm coaxial probe feed with the dimensions of 44mm*44mm*1.57mm and dielectric of the substrate is 2.2.coaxial probe feed has advantage that it can be placed anywhere in the patch ,low spurious radiation and easy to fabricate.The different antenna parameters effect such as VSWR ,Return loss ,Radiation Pattern, Impedence are also analized.*

Keywords: *E- patch microstrip antenna, Coaxial probe feed, VSWR, Return loss, Radiation pattern, Impedance .*

1. Introduction

Microstrip patch antenna plays an important role in S Band. It has various applications such as in radar for military application, satellite communication, mobile broadcasting, and remote sensing and in bio medical application. Micro strip patch antenna contain a dielectric substrate on ground plane which is advantageous for configuration of low profile, low manufacturing cost ,less weight and is capable of integrate with micro wave integrated circuit technique. Not only in single frequency operation but also capable to operate in dual and triple frequency operation. Beside these advantages it has a major problem of narrow bandwidth which can be retrieved with several techniques like by increasing the thickness of substrate or modify by E shape and U slot patch antenna.

In present scenario technology have focus on E- patch microstrip patch antenna designing with a slot and using coaxial probe feeding techniques. As E shaped patch antenna is less vulnerable to interference while several antenna element are placed adjacent to each other to form an array in multiple antenna system.

1.1 Feed Techniques

Microstrip patch antenna can be fed by a various feed technique such as Microstrip line feed, Co-axial feed, Aperture coupling, Proximity coupling.

Microstrip line and coaxial probe feeds are contacting scheme where as Proximity and Aperture coupled feeds are non contacting. In contacting RF power directly given to the radiating patch where as in non-contacting electromagnetic field coupling is done by transfering power between the microstrip line and the radiating patch. Feeding techniques are governed by many factors like their impedance matching, efficient transfer of power between the radiation structure and feeding structure. These techniques helps in design parameters of an antenna and their effect on VSWR return losses , bandwidth and resonant frequency.

1.1.1 Co Axial Feed Technique

In this type of feed technique used for the feeding of the Microstrip patch antennas through a probe. In coaxial the outer conductor is connected to the ground plane and the inner conductor of the coaxial connector extends through the dielectric and is soldered to that of the radiating patch. The coaxial probe in this feed would be an inner conductor of the coaxial line or this can be used as the power transfer from the strip line to the Microstrip antenna from the slot in the ground plane.

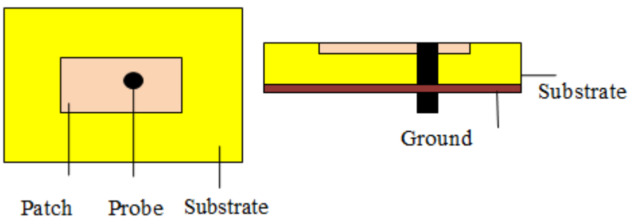

Fig 1 Probe Fed Rectangular Microstrip Patch Antenna

Advantage

- Flexibility to place the feed anywhere in the inside the patch in order to match the input impedance.
- Easy fabrication

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- Low spurious radiation.

Disadvantage

- Gives a narrow bandwidth
- Difficulty in putting hole in the model.

2. Design Equation

The E-shaped microstrip patch antenna is designed by calculating the length(L) and width (W) from the given equation

$$W=\frac{c}{2f_0\sqrt{\frac{\varepsilon_r+1}{2}}} \quad (1)$$

$$L= L_{eff} -2\Delta L \quad (2)$$

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\,[1+12\,\frac{h}{W}\,]^{-1/2} \quad (3)$$

The effective length is given by

$$L_{eff}=\frac{c}{2f_0\sqrt{\varepsilon_{reff}}} \quad (4)$$

The length extension is expressed by

$$\Delta L=0.412h\frac{(\varepsilon_{reff}+0.3)(\frac{W}{h}+0.264)}{(\varepsilon_{reff}-0.258)(\frac{W}{h}+0.8)} \quad (5)$$

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

$$W_g= 6h+W \quad (7)$$

$$Z_0=\frac{120\,\pi}{\sqrt{\varepsilon_{reff}}[\left(\frac{W}{h}\right)+1.393+\frac{2}{3}\ln\left\{\left(\frac{W}{h}\right)+1.449\right\}]} \quad (8)$$

3. Designing procedure

Simulation of design is being done using HFSS software.

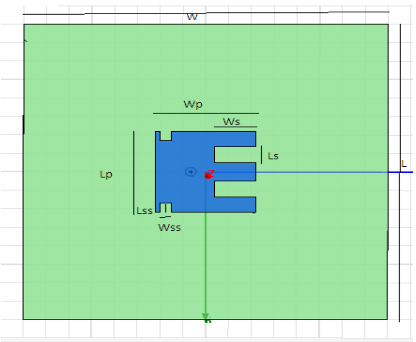

Fig .2 E Patch Microstrip Antenna with Coaxial Feed

E patch micro strip antenna has following substrate dimensions 160mm*160mm*1.57mm and material used as substrate is Duroid with dielectric constant 2.2. Further patch is formed by copper with size 44mm*44mm*0.035mm. The patch is being formed by cutting the slots so that the required design can be formed and the desired characteristics.

W- width of ground and Substrate
L-Length of substrate and ground
Lp- Length of Patch
Wp- Width of Patch
Ls- Length of slot
Ws –Width of slot
Lss- Length of side slot
Wss- Width of side slot

Table 1 Parameters of E Patch Microstrip Antenna

Freq	2.4
L	160
W	160
H	1.57
Lp	44
Wp	44
Ls	8.8
Ws	18
Lss	5
Wss	5
ε_r	2.2

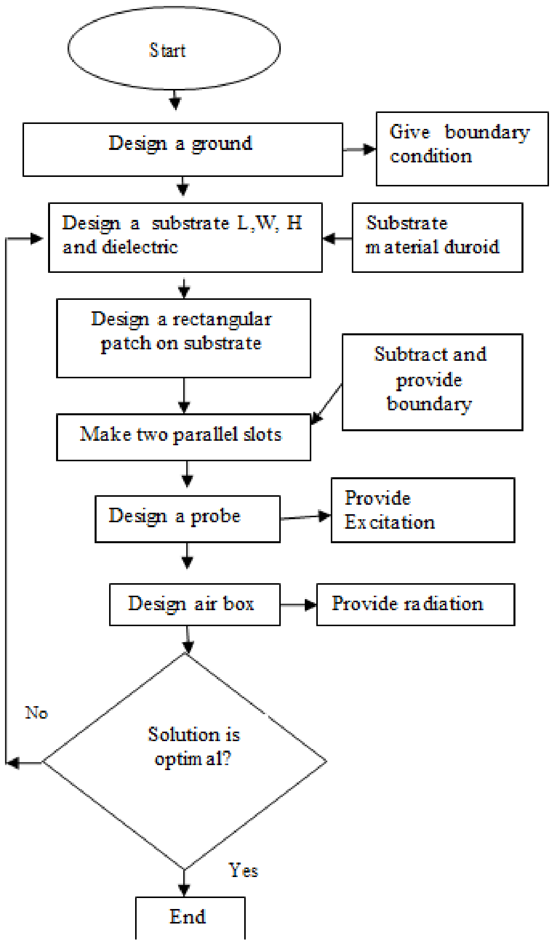

Fig. 3 Flow chart of design procedures

4. Simulation Results and Discussion

The software used to model and simulate the rectangular microstrip patch antennae is High Frequency Simulation

Software. 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.

4.1 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

$$RL = -20 \log |\Gamma| \text{ (dB)} \tag{9}$$

To obtain perfect matching between the feeding system and the antenna,

$\Gamma = 0$ RL = ∞ no power is reflected back.

$\Gamma = 1$, RL = 0 dB, all incident power is reflected.

For practical applications return loss of 9.54 dB is acceptable ,it is achieved -16.2439 as shown in Fig 4 .

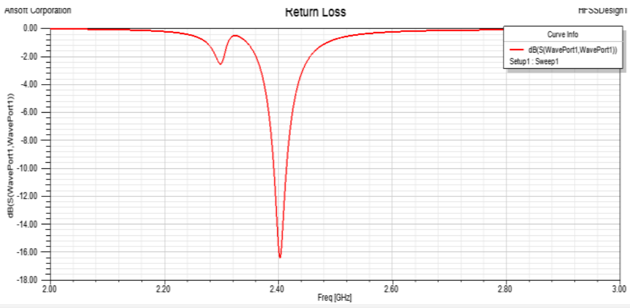

Fig .4 S- parameter plot for Return Loss v/s frequency

4.2 VSWR

VSWR function of the reflection coefficient, which describes the power reflected from the antenna. The smaller the VSWR is, the better the antenna is matched to the transmission line and the more power is delivered to the antenna. The minimum VSWR is 1.0 and should not be greater than 2. In this case, no power is reflected from the antenna.

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

$$VSWR=\frac{1+|\Gamma|}{1-|\Gamma|} \tag{10}$$

$$\Gamma = \frac{V_r}{V_i} = \frac{Z_{in}-Z_s}{Z_{in}+Z_s} \tag{11}$$

It can be observed in fig 5that VSWR is 1.38 ie close to ideal condition.

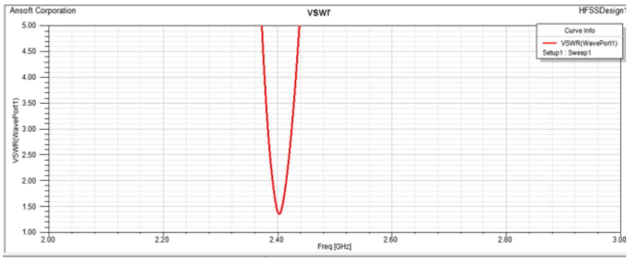

Fig.5 VSWR versus Frequency plot

4.3 Smith Chart

It can be clearly observed from fig 6.normalized impedance has obtained .9987. which is closely to normalized impedance 1, that means 50 ohm resistance so it can say value of proper impedance matching achieved hence proper transmission will be occur.

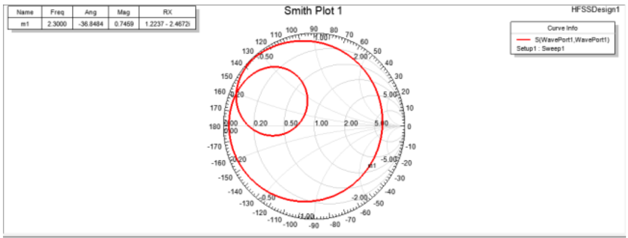

Fig. 6 Smith Chart

4.4 Radiation Pattern

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 7 and figure 8 shows the gain plot for line feed technique

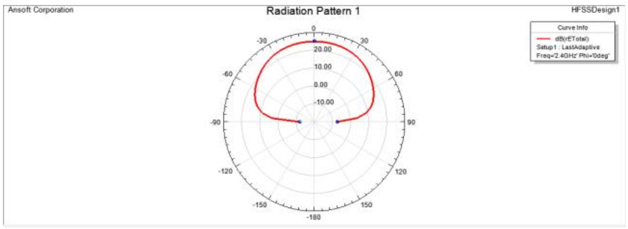

Fig. 7 Radiation Pattern at ϕ = 0.

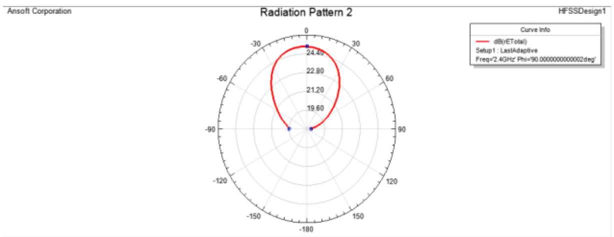

Fig.8 Radiation Pattern for total gain at ϕ = 90

The Radiation Pattern is omni directional. That radiates electromagnetic wave uniformly in one direction. Two types of radiation pattern are measured like E-Plane radiation pattern and H-Plane radiation pattern. E-Plane radiation pattern has circular and Omni directional radiation pattern that means it has a perfect circle. Gain is improved of the frequency range 2.4 GHz is by using the coaxial feed patch antenna

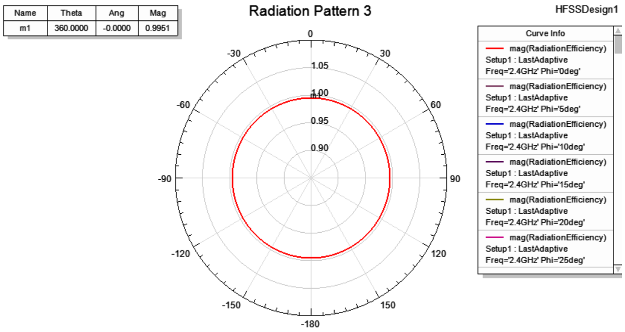

Fig 9, Radiation Pattern of gain v/s frequency plot for different value of phi.

3D gain clearly showing in fig 10 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.

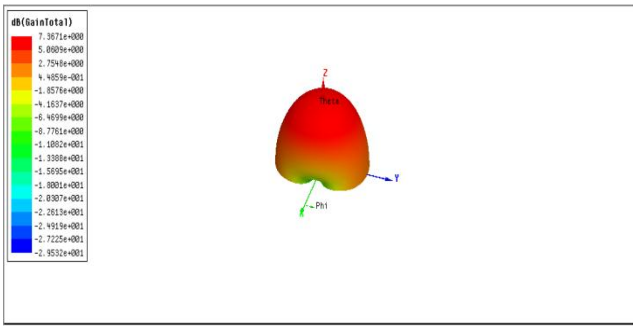

Fig. 10 3D plot Gain

4.5 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 11 shows impedance plot for the coaxial feed.

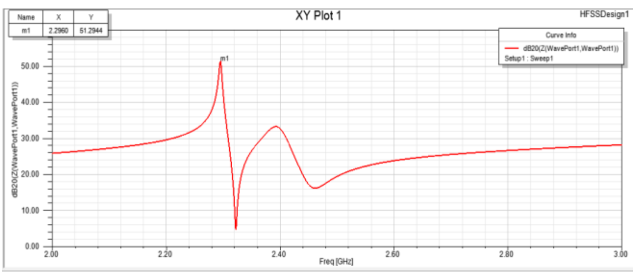

Fig. 11 Impedence versus frequency plot

Conclusions

This paper present designing and analysis of E patch micro strip antenna done using Ansoft HFSS simulation software. The radiation pattern is Omni-directional ,voltage standing wave ratio for E patch micro strip antenna is 1.38 which is close to 1 , is good hence proves that the mismatch will be too less where as return loss is -16.2439dB that state that the losses are minimum during transmission and gain obtained is also 7.3671dB which is also acceptable, when fed by coaxial feed technique

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