Design and simulation of Rectangular Microstrip Patch Antenna for wireless applications

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***Abstract*- The design of microstrip rectangular patch antenna is investigated for studying the view of vital parameters as mentioned below: VSWR, axial ratio, bandwidth & operating frequency, beamwidth.The antenna is studied by using "Cadfeko software" which is more easy for calculation in the design of microstrip rectangular patch antenna and analysis is done for the effect of various design parameter like dimensions (L & W) and substrate of antenna. The improvement of the results has been utilized in the design.**

Keywords—Standing Wave Ratio (SWR), Gain, Length L, Width W, S parameter.

I. INTRODUCTION

Fundamentally, a Microstrip Rectangular Patch antenna has a radiating patch on one side of a dielectric substrate & a ground plane on the other side .The radiating patch & feed line is photo etched on the dielectric substrate. Microstrip patch antennas radiate primarily because of the fringing fields are generated between the Patch edge and the ground plane. A thick dielectric substrate having a low dielectric constant which is desirable for good antenna performance, hence provides better efficiency, larger bandwidth and better radiation. Due to their low-profile structure, microstrip rectangular patch antennas are increasing popularity for use in wireless applications.

II. DESIGN OF ANTENNA

ELEMENTS Design Specifications

The three important parameters for the Microstrip rectangular Patch Antenna is as follows:

Frequency of operation (f_o): The frequency of resonance of the antenna must be selected appropriately. The Mobile Communication Systems utilizes the frequency range from 2100-5600 MHz Hence it is desired that the designed antenna must be able to operate in this range of frequency. The frequency of resonance selected for my design is 2.4 GHz.

Dielectric constant for substrate (ε_r): The dielectric material selected for our design is RT Duroid of dielectric constant 2.45. Since to reduce the dimensions of the antenna, substrate, a high dielectric constant is selected.

Height of dielectric substrate (h): For the microstrip rectangular patch antenna which is to be used in cellular phones, it is essential that the antenna should not bulky. So, the height of the dielectric substrate is considered as 1.58 mm. Hence, the required parameters for the design are as:

f_o = 2.4 GHz
ε_r = 2.45
h = 1.58 mm

Step 1: Width Calculation (W):
The width of the Microstrip rectangular patch antenna is given as:

$$W = \frac{C}{2 f_o \sqrt{\frac{\varepsilon_r + 1}{2}}}$$

Putting, c = 3.00e+008 m/s, ε_r = 2.45 and f_o = 2.4 GHz, we obtained: W = 0.0475 m = 47.5 mm

Step 2: Calculation for Effective dielectric constant (ε_{reff}):
The effective dielectric constant is:
Putting ε_r = 2.45, W = 47.5 mm & h = 1.58 mm, we derive: ε_{reff} = 2.3368.

Step 3: Calculation for the Effective length (Leff):
The effective length is as:

$$L_{eff} = \frac{c}{2 f_o \sqrt{\varepsilon_{reff}}}$$

By substituting ε_{reff} = 2.3368, c = 3.00e+008 m/s & f_o = 2.4 GHz, we can get: L_{eff} = 0.0406 m = 40.625 mm

Step 4: Calculation of the length extension (ΔL): The length of extension is: d

By substituting ε_{reff} = 2.3668, W = 47.5 mm & h = 1.58 mm we got: L = 0.81 mm

Step 5: Calculation of actual length of patch (L): The actual length is obtained by

$$\Delta L = L_{eff} - 2$$

By substituting Leff = 40.625 mm & L = 0.81 mm. we got: L = 39 m = 39 mm.

Step 6: Calculation for the ground plane dimensions (W_g & L_g):

The transmission line model is only applicable for infinite ground planes. However, it is essential to have a finite ground plane for practical considerations. It has been proved by that similar results for infinite as well as finite ground plane can be obtained, if the size of the ground plane is greater than the patch dimensions by approximately six times than the substrate thickness. Therefore, for this design, the ground plane dimensions are given as:

$$L_g = 6h + L = 6(1.5) + 39 = 48 \text{ mm}$$
$$W_g = 6h + W = 6(1.5) + 47.5 = 56.5 \text{ mm}$$

III .DEVELOPMENT MODEL

Case I: Resonant frequency**:** We can calculate the resonant frequency for Microstrip Rectangular Patch antenna, using its parameters like length (L), width (W), permittivity of the substrate (ε_r) and height (h) of the substrate. We have applied Particle Swarm Optimization technique for optimization of ΔL. The resonant frequency of rectangular Microstrip patch antenna is calculated by using optimized ΔL.

Case II: Feed point calculation: The input impedance of Microstrip rectangular patch antenna is a vital parameter which decides the amount of input power delivered to the antenna. Thus, it reduces the coupling effect for the RF signal to the nearby circuits. The calculation of an exactly 50 ohms input impedance of a rectangular Microstrip patch antenna becomes very difficult when the antenna size is drastically small.

$R_{in}(y = y0) = R_{in}(y = 0)$ cos4(π*y0/L) Using these two cases, we can obtain an approximated optimization values as:

L = 39.4 mm

W = 46.9 mm

y_0 = 13.2 mm

We have to use the above values to verify the final optimization results.

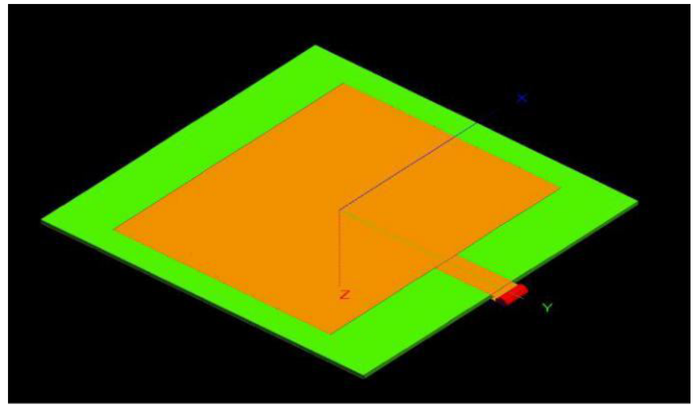

Fig (a): 3D view of microstrip rectangular patch antenna

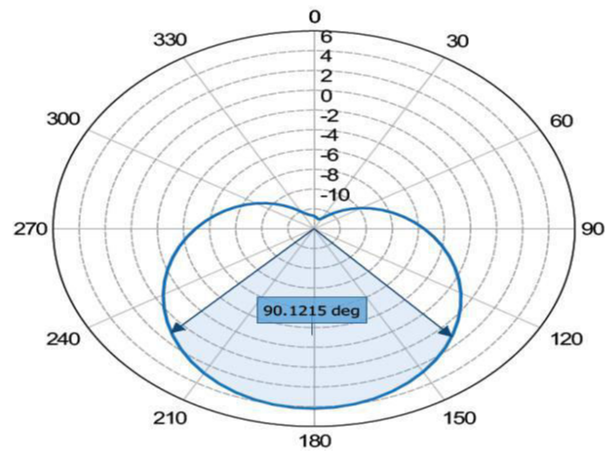

Fig (2): Total gain [dBi] (frequency=2.4GHz, Phi=0 deg)

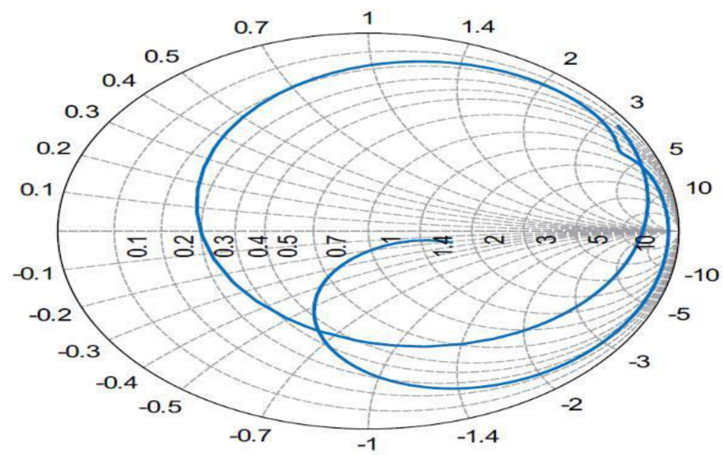

Fig. (3): S-parameter

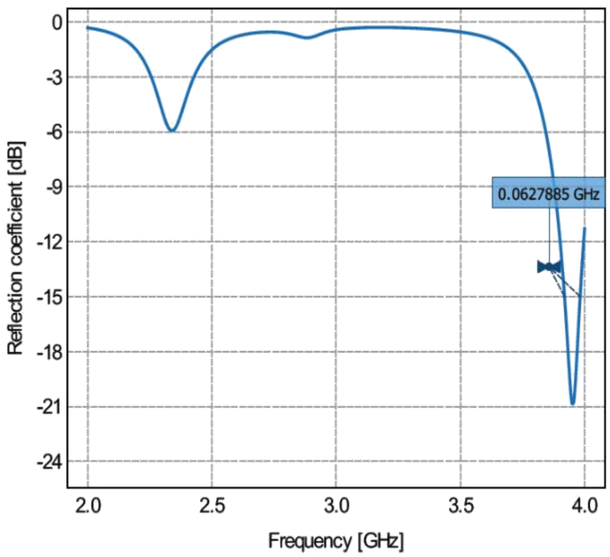

Fig. (4): Reflection coefficient magnitude [dB]

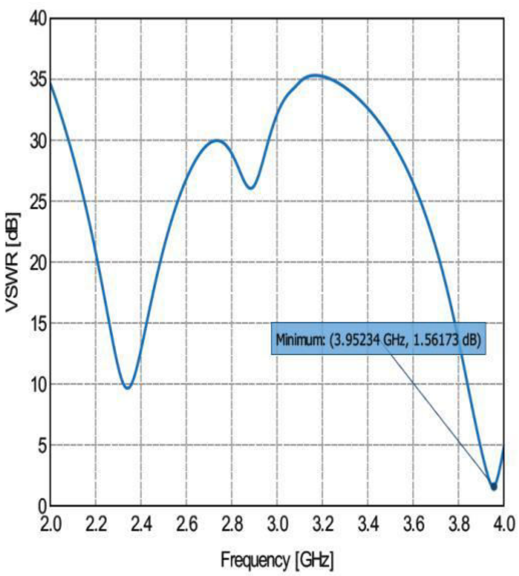

Fig. (5): VSWR [dB]

IV. CONCLUSION

The present state of work includes the design procedure of microstrip rectangular patch antenna using CADFEKO which shows the large bandwidth then the conventional results, the gain is high and the s parameters graphical results shows the increase in the efficiency and wide radiation patterns detailed experimental studies can be taken up at a later stage to find out a design procedure for balanced amplifying antennas.

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