Abstract- Microstrip antennas are well suited for wireless and mobile application due to their low weight, low volume and low sensitivity to manufacturing tolerance. In this paper we analyze the properties and design method of Microstrip antenna and then design the Microstrip antenna with MATLAB using cavity model method and simulate it with IE3D based on MOM method. At last, we compared the simulated and theoretical results.

Index Terms- Bandwidth, Directivity, Microstrip Antenna, Method of Moment (MOM).

I. INTRODUCTION

With the development of MIC and HF semiconductor devices and printed circuits have drawn the maximum attention of the antenna community in recent years. In spite of its various attractive features like light weight, low cost, easy fabrication, conformability on curved surface and so on, the Microstrip element suffers from an inherent disadvantage of narrow impedance bandwidth and low gain. In principle, bandwidth enhancement can be achieved by several approaches [1]. In this paper coaxial feed technique is used as they occupies less space and have low spurious radiations by using Teflon connector. The Method of Moment (MOM) is used to discuss the electromagnetic radiation characteristic of the Microstrip antenna [2].

II. ANALYSIS OF MICROSTRIP PATCH ANTENNA

Microstrip patch antenna can be designed by using a cavity model [3] suitable for moderate bandwidth antennas. The lowest order mode, TM10, resonates when effective length across a patch is half of wavelength. Radiations occur due to fringing field.

1) Resonance Frequency

The resonance frequency \( f_{mn} \) depends on the patch size, cavity dimensions, and the filling material dielectric constant, as follows:-

\[
  f_{mn} = \frac{k_{mn} \cdot c}{2\pi \sqrt{\varepsilon_r}}
\]

Where \( m, n = 0, 1, 2 \ldots \) \( k_{mn} \) = wave number at \( m, n \) mode, \( c \) is the velocity of light, \( \varepsilon_r \) is the dielectric constant of the substrate, and

\[
  k_{mn} = \sqrt{\left(\frac{mn}{W}\right)^2 + \left(\frac{mn}{L}\right)^2}
\]

For TM01 mode, length and width of non-radiating rectangular patch’s edge at a certain resonance frequency and dielectric constant is given by:

\[
  L = \frac{c}{2f_r \sqrt{\varepsilon_r}}
\]

\[
  W = \frac{c}{f_r \sqrt{\varepsilon_r + 1}}
\]

Where \( f_r \) is the resonance frequency at which the rectangular Microstrip antenna is to be designed. The radiating edge \( W \), patch width is usually kept such that it lies within the range \( L \leq W \leq 2L \) for efficient radiation. The ratio \( W/L \approx 1.5 \) gives good performance according to the side lobe appearances. The actual value of resonant frequency is slightly less than \( f_r \) because fringing effect causes the effective distance between the radiating edges of the patch to be slightly greater than \( L \). By using the above equations we can find the values of actual length of the patch as:

\[
  L = \frac{c}{2f_r \sqrt{\varepsilon_{eff}}} - 2\Delta l
\]
Transmission line model ignores field variations along the radiating edges. This disadvantage can be overcome by using cavity model in which interior region of dielectric substrate is modeled as cavity bounded by electric walls on the top and bottom. The basis for the assumption is the following observations for thin substrate. Since the substrate is thin; the field in interior region do not vary much in Z direction, that is normal to the path.

2) Cavity Model

Consider Figure 2, when the microstrip patch is provided power, a charge distribution is seen on the upper and lower surfaces of the patch and at the bottom of the ground plane. This charge distribution is controlled by two mechanisms—an attractive mechanism and a repulsive mechanism. The attractive mechanism is between the opposite charges on the bottom side of the patch and the ground plane, which helps in keeping the charge concentration intact at the bottom of the patch. The repulsive mechanism is between the like charges on the bottom surface of the patch, which causes pushing of some charges from the bottom, to the top of the patch. As a result of this charge movement, currents flow at the top and bottom surface of the patch. The cavity model assumes that the height to width ratio (i.e. height of substrate and width of the patch) is very small and as a result of this the attractive mechanism dominates and causes most of the charge concentration and the current to be below the patch surface. Much less current would flow on the top surface of the patch and as the height to width ratio further decreases, the current on the top surface of the patch would be almost equal to zero, which would not allow the creation of any tangential magnetic field components to the patch edges. Hence, the four sidewalls could be modeled as perfectly magnetic conducting surfaces.

III. DESIGN PARAMETERS OF PROPOSED ANTENNA

The various design parameters of antenna which are calculated using the standard equations (1-7) are as follows:-

- Substrate material used is glass epoxy.
- Thickness of dielectric substrate $h = 1.6$mm
- Relative permittivity of substrate $\varepsilon_{rr} = 4.2$
- Design frequency $f = 2.5$ GHz
- Step size $\Delta = 0.2$
- Width of patch $W = 37$mm
- Length of patch $L = 29$mm

IV. SIMULATION AND RESULT ANALYSIS

By using MATLAB [4], we find the values of $S_{11}$ mode and VSWR on feeding points (1, 1) and (2, 2) and also simulate the proposed antenna with IE3D [5]. Finally compared output of simulated and theoretical results with the support of various graphs and charts. All the antenna parameters are firstly calculated and plotted by using MATLAB coding and then simulated by IE3D based on Method of Moment.

Simulated Results At Feed Point (1, 1)

![Figure 3. Antenna shape with feed point](image-url)
Figure 4. Total Field Directivity versus Frequency curve.

Figure 5. Efficiency versus Frequency Curve.
Figure 6. Total Field Gain versus Frequency curve.

Figure 7. Smith Chart
Figure 8. S-Parameter curve

Figure 9. VSWR Curve.

Simulated Results At Feed Point (2, 2)
Figure 10. Antenna shape with feed point at (2, 2)

Figure 11. Total Field Directivity versus Frequency curve.
Figure 12. Efficiency versus Frequency Curve

Figure 13. Total Field Gain versus Frequency curve
Figure 14. Smith Chart.

Figure 15. S-Parameter curve.
V. CONCLUSION

Based on the theoretical, simulated and analysis of the microstrip antenna, we have discussed the size and design parameters. Then we simulated the antennas that can run at 2.5 GHz frequency and calculated its reflection coefficient $S_{11}$ by using IE3D based on Method of Moment. Through theoretical and simulated analysis, we observe the bandwidth increases when resonance frequency is greater than working frequency.

VI. ACKNOWLEDGMENT

We would like to thanks Dr. Deepak Nagaria, Department of Electronics and Communication Engineering, B.I.E.T Jhansi, (U.P) India for his full support and guidance.

VII. REFERENCES

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