International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 4 Issue 05, May-2015

Bandwidth Improvement of Microstrip Patch Antenna using Partial Ground Plane

Siju J Thomas
Department of Electronics & Communication Engineering
Sagar Institute of Research, Technology and Science
Bhopal, India.

Mehajabeen Fatima
Department of Electronics & Communication Engineering
Sagar Institute of Research, Technology and Science
Bhopal, India.

Abstract **— Microstrip patch antennas are of high demand for its light weight, cheap manufacturing, small size, high gain, high directive gain and also offers circular polarization apart from linear polarization. But it also has narrow bandwidth operation due to its resonant nature, which is a disadvantage for its class. Huge research is being conducted on it for its possible improvement in its performance in the near future. A large number of methods have been suggested, which can reduce the limitations of the antenna, thus improving the performance, with no deviations in the basic advantages of the antenna. The area of research interests are like changing the geometrical dimensions of the antenna, especially changing the dimensions of the ground plane of the antenna. This paper provides a comparison of the work done, by changing the ground plane to partial ground plane and getting an enhanced bandwidth value.**

Keywords—: microstip antenna, narrowband,circular polarization, enhanced bandwidth, high return loss.

I. INTRODUCTION

Microstrip or patch antennas are becoming increasingly useful because they can be printed directly onto a circuit board. Microstrip antennas have spread within the mobile phone market, as it has small size, low cost for manufacturing, high gain, have a low profile and are easily fabricated (1). Apart from these all benefits, the microstrip antenna has some limitations too, that is, they suffers from narrow bandwidth operation, low efficiency, surface wave excitations and poor end fire radiations. The Q-factor of the antenna can be improved by considering a thick substrate, but that will lead to more power delivered to the surface waves, which results in unwanted power losses.

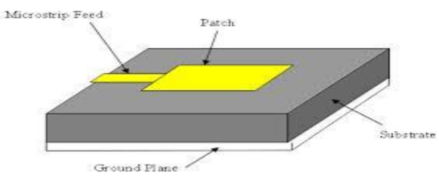

Fig 1.). Microstrip patch antenna

There are two types of feeding techniques in Microstrip antenna:-
(A) Contacting type feeding technique in which power is feed to patch through the micro strip line. Micro strip line and coaxial probe are examples of this type technique.
(B) Non contacting type feeding technique in which electromagnetic coupling is uses for transferring power between patch and micro strip line. Aperture coupling, proximity couplings and coplanar wave guide feed are e proximity couplings and coplanar wave guide feed are examples of this type technique. (1)

II. TRANSMISSION LINE MODEL

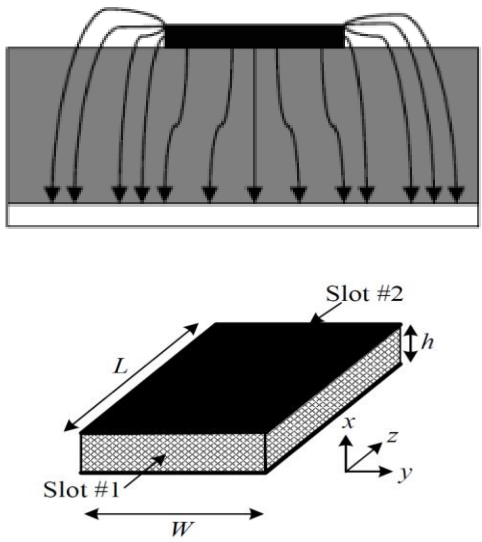

Fig 2). Electric field between patch and ground.

The TL model is the simplest model representing the rectangular patch as a parallel plate transmission line connecting two radiating slots (apertures), each of width W and height h. It gives a relatively good physical insight into the nature of the patch antenna and the field distribution for all TM00n modes.

The slots represent very high impedance terminations from both sides of the transmission line (2).

Thus, we expect this structure to have highly resonant characteristics depending crucially on its length L along z. The resonant length of the patch, however, is not exactly equal to the physical length due to the fringing effect. The fringing effect makes the effective electrical length of the patch longer than its physical length.

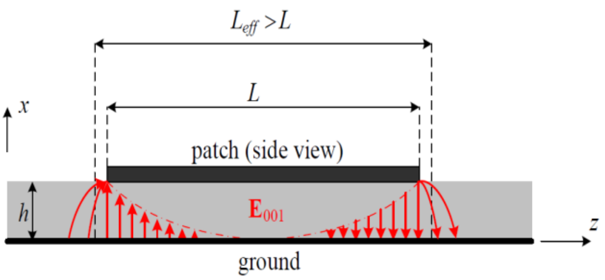

Fig. 3.) Side view of the Excitations in the Antenna

An effective dielectric constant (Ɛre) must be obtained in order to account for the fringing and the wave propagation in the line. The value of Ɛre is slightly less than Ɛr because the fringing fields around the periphery of the patch are not confined in the dielectric substrate but are also spread in the air (2).

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

Where ε_{re} = Effective dielectric constant, ε_r = Dielectric constant of substrate, h = Height of dielectric substrate, W =Width of the patch.

A). Computing the effective patch length :

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

Then the effective length will be given as,

$$L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{reff}}}$$

For a given resonance frequency f_r, the effective length of the width w is,

$$w = \frac{c}{2\,f_0\sqrt{\frac{\varepsilon_r + 1}{2}}}$$

III. ANTENNA DESIGN

Based on the equation, on calculation, the length (L) of the patch is obtained as 23.4 mm and width (W) of the patch as 30.4 mm. The length of the Ground plane will be 32.92 mm and width will be 39.92 mm, based on the calculations. The length and width of the substrate will be same as that of the length and width of the ground plane. The substrate material is chosen as RO 4003C, whose dielectric constant value is 3.48. Here, arrow-headed triangular slot is given for good production of circular polarization waves. As the triangular slot is placed in first quadrant, only in one diagonal direction, therefore, the antenna structure can be termed as Asymmetric or unbalanced.

Based on the above design parameter values of the Antenna, the antenna was designed on Ansoft HFSS Software. And then the antenna was analyzed, the Return loss parameter, VSWR parameter and the Y-parameter were studied.

The schematic diagram of the Antenna can be given as :

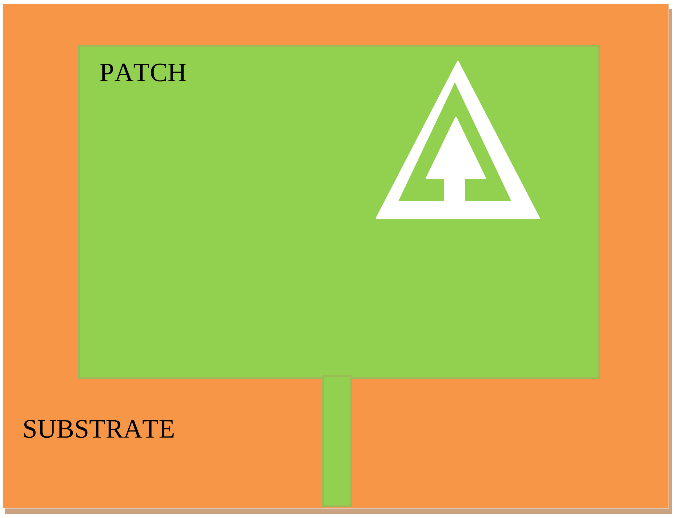

Fig. 4). Schematic Diagram of the Antenna

Here as its shown in the Schematic diagram, the patch contains arrow-head triangular slot, to whom the input excitation is given via the microstrip transmission line, via Lumped port.

The Antenna structure has values of x = 32.92 mm and y = 39.92 mm, which corresponds to the size of Ground plane and the Substrate material. Thus the design on HFSS Software will be like given below :

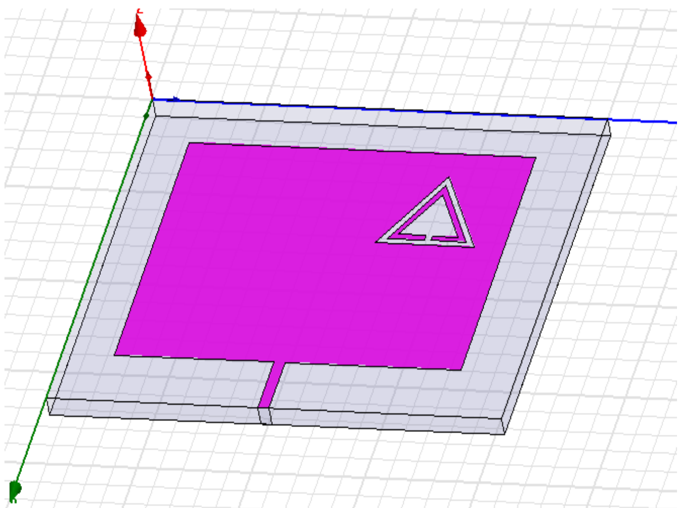

Fig 5). Proposed Antenna Structure

On analyzing the antenna, the corresponding Rectangular Plot was obtained, from which, it was found that the antenna gave a Bandwidth of 230 MHz.

The Rectangular Plot for the Return loss value of the antenna is given below :

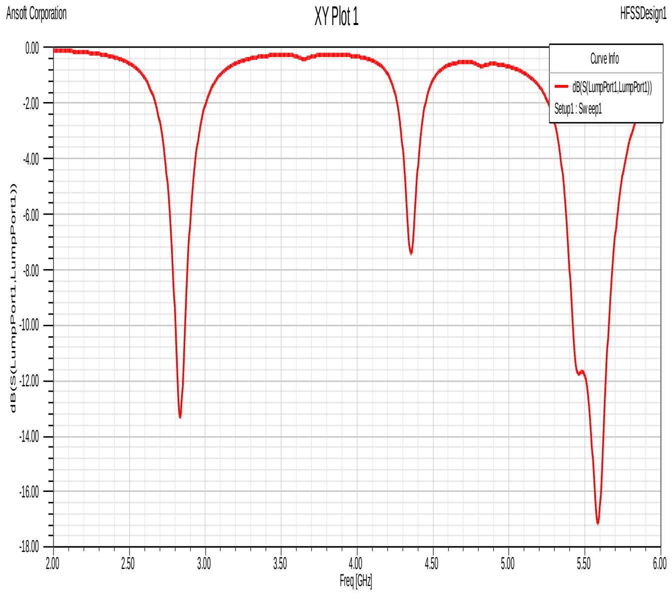

Fig. 6). Return loss plot

To study the Reflection Coefficient of the Antenna, another parameter called Voltage Standing Wave Ratio (VSWR), is studied. It describes the power reflected by the antenna during its operation.

$$VSWR = {1+\Gamma}/{1-\Gamma}$$

Here, Γ stands for Reflection Coefficient. It is determined from the Voltage being measured along the transmission line leading towards the antenna. VSWR is the ratio of peak amplitude of a standing wave to the minimum amplitude of a standing wave. The VSWR Plot for the Antenna is given below :

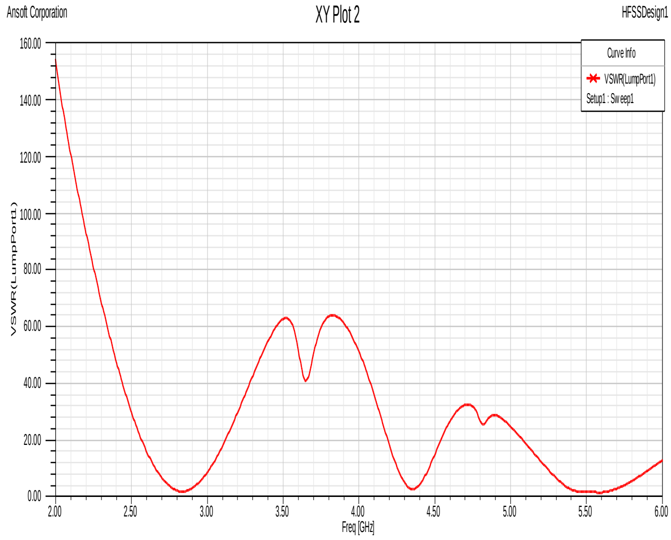

Fig 7). VSWR Plot

Also, the antenna is analysed for the Y-parameter plot, by which the value of the Impedence Matching of the antenna with the corresponding input signal at the transmission line can be obtained. The Y-Parameter plot for the antenna is given below :

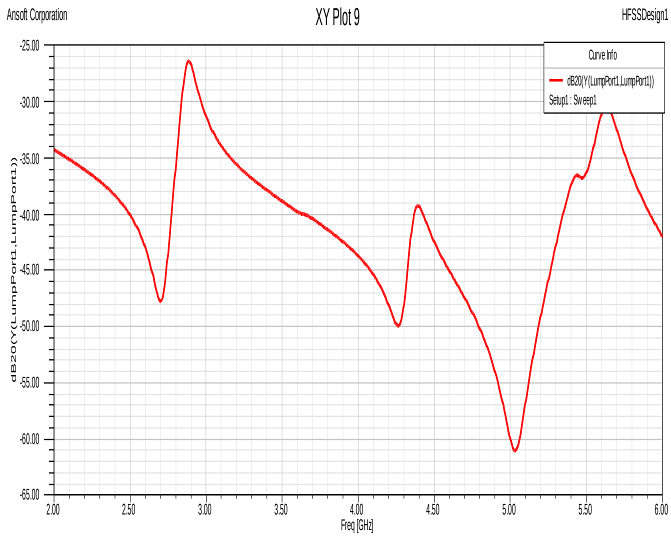

Fig 8). Y-Parameter

These were the results of the Original Antenna, when it was designed and analyzed on HFSS software.

Now, the antenna will be examined based on replacing its ground plane with partial ground plane.
The Schematic diagram for the Antenna with Partial Ground plane is given below :

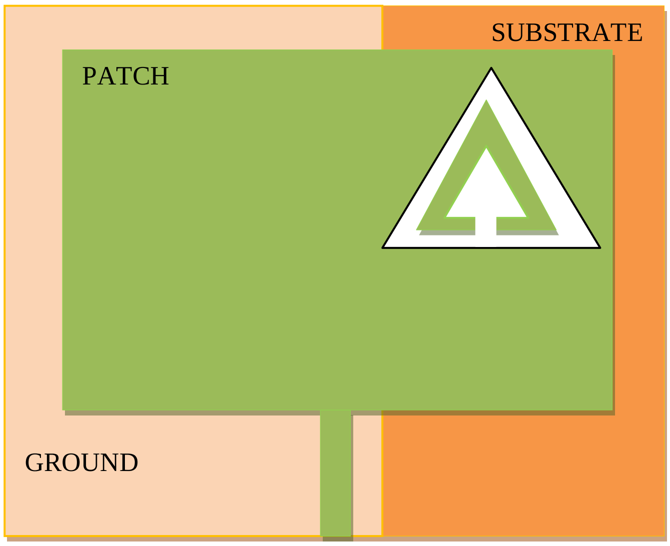

Fig 9). Schematic Diagram of antenna with Partial Ground Plane

It is evident from the Schematic diagram shown above, that the ground plane of the antenna is replaced by the Partial Ground Plane.

Now this structure will be designed on the HFSS Software, with the Partial ground plane values as x = 15 mm and y = 39.92 mm. Then the antenna will be applied for analysis, from which the Return loss plot, VSWR Plot and Y-Parameter plot will be studied.
The structure of the antenna with partial ground plane when designed on HFSS is shown below :

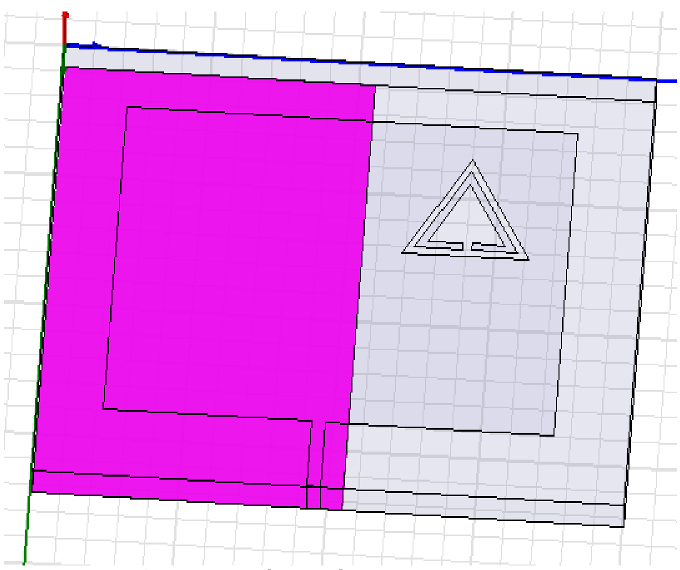

Fig 10). Antenna with ground x = 19.91mm,y=39.92mm

Now the antenna is applied with excitation, to study parameters like Return loss plot, VSWR Plot and Y-Parameter plot. Firstly, the antenna is analyzed for Return loss Parameter. The plot for the Return loss parameter is shown below :

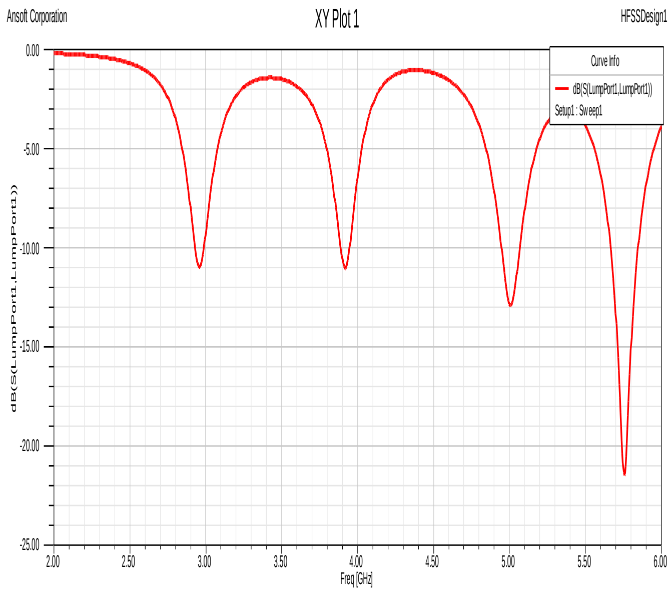

Fig. 11). Rectangular Plot for Return loss

From the plot for the Return loss, it is evident that the antenna gave a better Bandwidth value, that is 400 GHz, double value than the bandwidth of the antenna having full ground plane.

Also, the antenna was analyzed for the VSWR (Voltage Standing Wave Ratio), and the corresponding plot for the same was obtained as shown below :

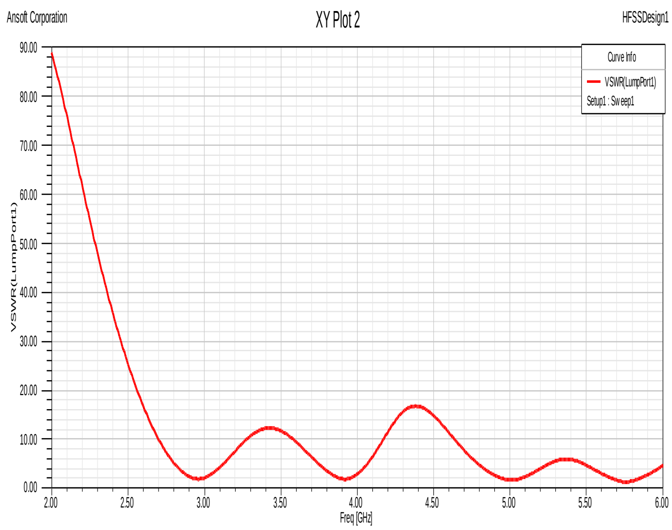

Fig 12). VSWR Plot

Also, the antenna is studied on the basis of Y-Parameter, which is an essential method for the calculation of the Impedence Matching of the Antenna with the Corresponding input at the Transmission line. The plot for the Y-Parameter of the antenna is shown below :

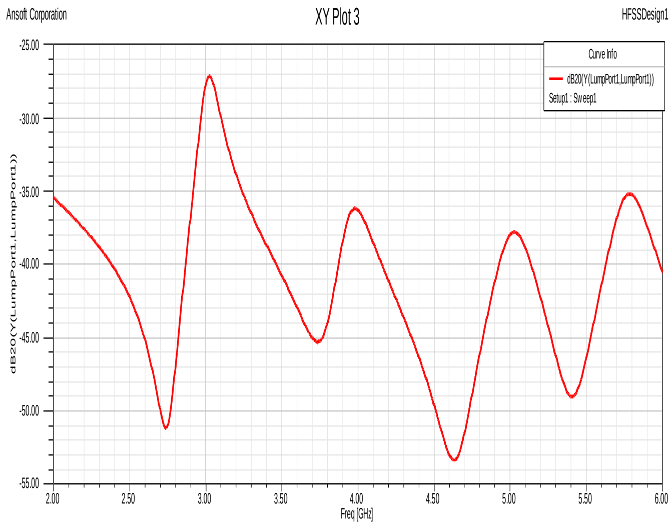

Fig 13). Y-Parameter

Thus by reducing the ground plane to partial ground plane, the Bandwidth has been doubled in value and there is also an increase in the Return Loss value.

IV. CONCLUSION

Bandwidth Improvement of Microstrip Patch Antenna using Partial Ground Plane is studied here. The overall size of the Antenna is 32.92 x 39.93 x 1.5mm^3 and it gave a Bandwidth of 230 MHz. The proposed antenna's ground plane was varied as x = 15 mm and y = 39.92 mm, it gave a Bandwidth of 400 MHz, showing an increase in the value of Bandwidth.

REFERENCES

[1] Sunil Singh, Neelesh Agarwal, Navendu Nitin, Prof. A.K. Jaiswal, "Design consideration of Microstrip Patch Antenna", *International Journal of Electronics and Computer Science Engineering*, pp. 1-4,2013.

[2] C. Vishnu Vardhana Reddy, Rahul Rana, Prof. S.K. Behara, "Design of Linearly Polarized Rectangular Patch Antenna using IE3D/PSO",*Ethesis NIT Rourkela*,pp. 24-27,2009.

[3] Junho Yeo and Jong-Ig Lee," Modified Series-Fed Two-Dipole-Array Antenna With Reduced Size," IEEE Antennas Wireless Propag. Lett, Vol. 12, 2013.

[4] Y.-K. Jung and B. Lee, "Dual-band circularly polarized microstrip RFID reader antenna using metamaterial branch-line coupler," *IEEE Trans. Antennas Propag.*, vol. 60, no. 2, pp. 786–791, Feb. 2012.

[5] H.-D. Chen, C. Sim, and S.-H. Kuo, "Compact broadband dual coupling- feed circularly polarized RFID microstrip tag antenna mountable on metallic surface," *IEEE Trans. Antennas Propag.*, vol. 60, no. 12, pp. 5571–5577, Dec. 2012.

[6] S. Maddio, A. Cidronali, and G. Manes, "A new design method for single-feed circular polarization microstrip antenna with an arbitrary impedance matching condition," *IEEE Trans. Antennas Propag.*, vol. 59, no. 2, pp. 379–389, Feb. 2011.

[7] X. Chen, G. Fu, S.-X. Gong, Y.-L. Yan, and W. Zhao, "Circularly polarized stacked annular-ring microstrip antenna with integrated feeding network for UHF RFID readers," *IEEE Antennas Wireless Propag. Lett.*, vol. 9, pp. 542–545, 2010.

[8] Nasimuddin, Z. N. Chen, and X. Qing, "Asymmetric-circular shaped slotted microstrip antennas for circular polarization and RFID applications," *IEEE Trans. Antennas Propag.*, vol. 58, no. 12, pp. 3821–3828, Dec. 2010.

[9] Z. N. Chen, X. Qing, and H. L. Chung, "A universal UHF RFID reader antenna," *IEEE Trans. Antennas Propag.*, vol. 57, no. 5, pp. 1275–1282, May 2009.

[10] Q. Li and Z. Shen, "An inverted microstrip-fed cavity-backed antenna for circular polarization," *IEEE Antennas Wireless Propag. Lett.*, vol. 1, pp. 190–192, 2002.