Sudhir Bhaskar & Sachin Kumar Gupta / International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com
Vol. 2, Issue 1, Jan-Feb.2012, pp. 334-338

Bandwidth Improvement of Microstrip Patch Antenna Using H-Shaped Patch

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ABSTRACT

Despite the many advantages of microstrip patch antennas, they do have some considerable drawbacks. One of the main limitations with patch antennas is their inherently narrowband performance due to its resonant nature. With bandwidth as low as a few percent; broadband applications using conventional patch designs are limited. So for the antenna miniaturization and bandwidth improvement H-shaped microstrip patch antenna used.

In this paper, authors cover two aspects of microstrip antenna designs. The first is the analysis of single element narrowband rectangular microstrip antenna which operates at the central frequency of 3.3 GHz. The second aspect is the analysis and design of slot cut H-shaped microstrip antenna. The simulation process has been done through high frequency structure simulator (HFSS). The properties of antenna such as bandwidth, S parameter, VSWR has been investigated and compared between a single element rectangular and H-shaped microstrip antenna.

Keywords –MSA, HFSS, Bandwidth

I. INTRODUCTION

The need for antennas to cover very wide bandwidth is of continuing importance, particularly in the field of electronic warfare and wideband radar and measuring system. Although microstrip patch antennas have many very desirable features, they generally suffer from limited bandwidth. So the most important disadvantage of microstrip resonator antenna is their narrow bandwidth. To overcome this problem without disturbing their principal advantage (such as simple printed circuit structure, planar profile, light weight and cheapness), a number of methods and structures have recently been investigated. In this regard we can mention multilayer structures [1], broad folded flat dipoles [2], curved line and spiral antennas [3], impedance matched resonator antennas [4], resonator antennas with capacitive coupled parasitic patch element [5], log periodic structures [6,7], modified shaped patch antenna (H-shaped [8]). In the present paper H-shaped microstrip patch antenna analyzed and compared with rectangular patch antenna.

The H-shaped patch antenna here has a size about half of the rectangular patch antenna with larger bandwidth. The larger bandwidth is because of a reduction in the quality factor (Q) of the patch resonator, which is due to less energy being stored beneath the patch. Consider figure 1 below, which shows a rectangular microstrip patch antenna of length L, width W resting on a substrate of height h. The co-ordinate axis is selected such that the length is along the x direction, width is along the y direction and the height is along the z direction.

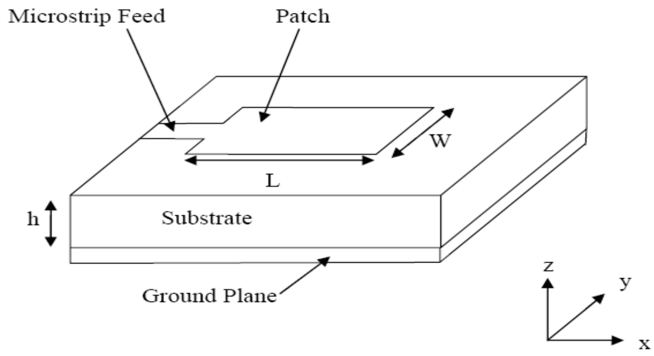

Fig1. Microstrip patch antenna

II. ANALYSIS METHOD FOR MICROSTRIP ANTENNA

The preferred models for the analysis of microstrip patch antennas are the transmission line model, cavity model, and full wave model (which include primarily integral equations/Moment Method). The transmission line model is the simplest of all and it gives good physical insight.

I. TRANSMISSION LINE MODEL

This model represents the microstrip antenna by two slots of width W and height h, separated by a transmission line of length L. The microstrip is essentially a nonhomogeneous line of two dielectrics, typically the substrate and air.

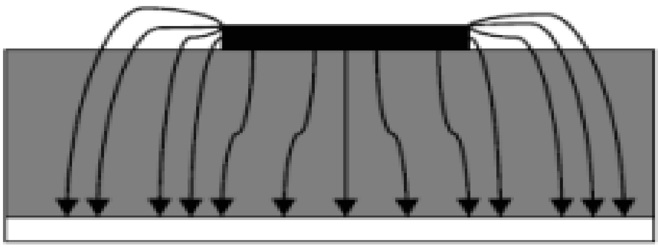

Fig.2 Electric field lines between patch and ground plane.

Hence, as seen from figure 2 most of the electric field lines reside in the substrate and parts of some lines in air. As a result, this transmission line cannot support pure transverse electric- magnetic (TEM) mode of transmission, since the phase velocities would be different in the air and the substrate. Instead, the dominant mode of propagation would be the quasi-TEM mode. Hence, an effective dielectric constant (ε_{re}) must be obtained in order to account for the fringing and the wave propagation in the line. The value of ε_{re} is slightly less than ε_r because the fringing fields around the periphery of the patch are not confined in the dielectric substrate but are also spread in the air as shown in Figure above. The expression for ε_{re} is

$$\varepsilon_{re} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left(1 + \frac{12h}{W}\right)^{-0.5}$$

………………. (1)

Where ε_{re} = Effective dielectric constant

ε_r = Dielectric constant of substrate

h = Height of dielectric substrate

W =Width of the patch

In order to operate in the fundamental TM_{10} mode, the length of the patch must be slightly less than λ/2 where λ is the wavelength in the dielectric medium and is equal to $\lambda o/\sqrt{\varepsilon_{reff}}$ where λ_o is the free space wavelength. The TM_{10} mode implies that the field varies one λ/2 cycle along the length, and there is no variation along the width of the patch [9]. In the fig.3 shown below, the microstrip patch antenna is represented by two slots, separated by a transmission line of length L and open circuited at both the ends. Along the width of the patch, the voltage is maximum and current is minimum due to the open ends. The fields at the edges can be resolved into normal and tangential components with respect to the ground plane.

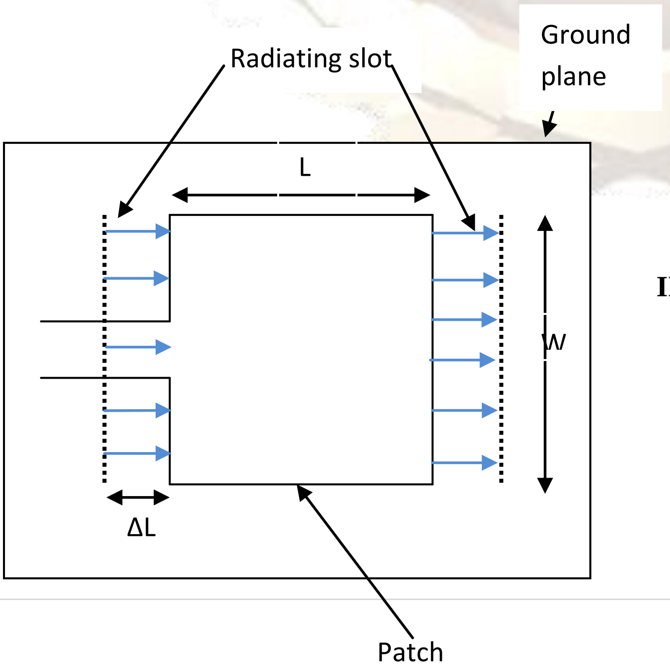

Fig. 3 Top view of microstrip antenna

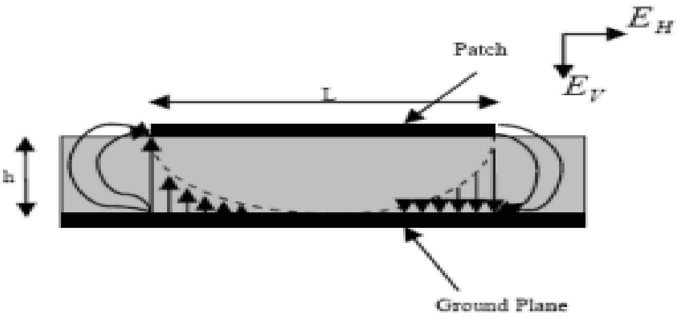

Fig. 4 Side view of patch antenna

It is seen from figure 4 that the normal components of the electric field at the two edges along the width are in opposite directions and thus out of phase since the patch is λ/2 long and hence they cancel each other in the broadside direction. The tangential components (seen in figure 4), which are in phase, means that the resulting fields combine to give maximum radiated field normal to the surface of the structure. Hence the edges along the width can be represented as two radiating slots, which are λ/2 apart and excited in phase and radiating in the half space above the ground plane. The fringing fields along the width can be modeled as radiating slots and electrically the patch of the microstrip antenna looks greater than its physical dimensions. The dimensions of the patch along its length have now been extended on each end by a distance ΔL, which is

$$\Delta L = 0.412h\frac{\varepsilon_{re} + 0.30}{\varepsilon_{re} - 0.258}\left(\frac{W/h + 0.264}{W/h + o.813}\right)$$

…………………. (2)

The effective length of the patch L_{eff} now becomes

L_{eff} =L+2Δ ……………..….. (3)

For a given resonance frequency f_0, the effective length is

The width W *is*

$$W = \frac{c}{2f_r}\left(\frac{\varepsilon_r + 1}{2}\right)^{-0.5}$$

………..………. (4)

III. DESIGN OF RECTANGULAR MICROSTRIP PATCH ANTENNA

A single element of rectangular patch antenna, as shown in figure 5, can be designed for the 3.3 GHz resonant frequency using transmission line model (equations 2, 3 and 4)

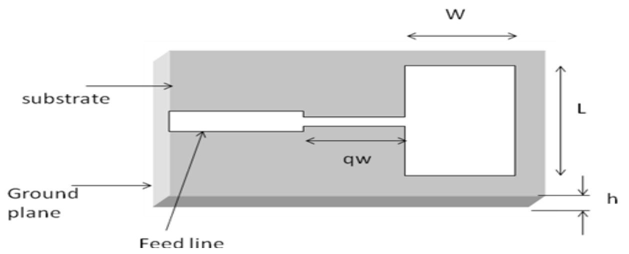

Fig. 5 Typical rectangular patch antennas

In the typical design procedure of the microstrip antenna, the desired resonant frequency, thickness and dielectric constant of the substrate are known or selected initially. In this design of rectangular microstrip antenna, glass epoxy dielectric material is selected as the substrate with 1.6 mm height. Then, a patch antenna that operates at the specified resonant frequency (3.3 GHz) can be designed by the using transmission line model equations [10].

As shown in figure 5, microstrip line type feeding mechanism used. It is also possible to determine the length and width of quarter wave length long line (branch line) of the patch and the main feed line's length and width to ensure matching. The main feed line is of 50Ω characteristic impedance. The quarter wave length long line is used between main feed line and patch for impedance matching. The characteristic impedance of branch line is calculated as

$$Z_{\lambda/4} = \sqrt{Z_0 Z_e} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Z_0 – characteristic impedance of main feed line (50Ω)
Z_e – impedance at patch edge
So for the rectangular microstrip patch antenna the parameters are
Resonating frequency f_r = 3.3 GHz
Patch width W = 27.8 mm
Patch length L = 21.42 mm
Branch line length qw = 11 mm
Substrate height h = 1.6 mm
Relative permittivity ε_r = 4.5
Width of main feed line = 3 mm

IV. DESIGN OF AN H-SHAPED MSA

The H-shaped microstrip antenna [8] consists of an H shaped patch; supported on a grounded dielectric sheet of thickness h and dielectric constant ε_r. An H-shaped microstrip patch antenna, shown in figure 6 is obtained by cutting equal rectangular slots along both the non radiating edges of the rectangular MSA.

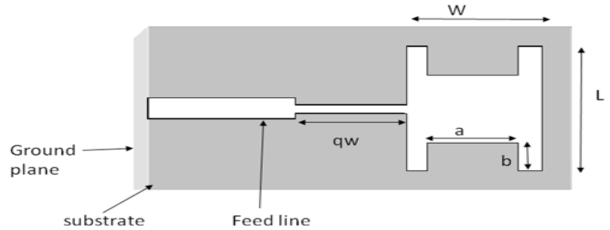

Fig. 6 H-shaped patch antennas

The H-shaped patch antenna [8] reported here has a size about half that of the rectangular patch, with larger bandwidth. The H-shaped microstrip patch antenna, because of its considerably smaller size, could replace the rectangular patch at UHF frequencies. When they are applied in the frequency range below 2 GHz, the sizes of conventional rectangular microstrip patches seem to be too large.
Design parameters of H-shaped patch antenna

The length *L* and width *W* of the patch are given by:
L = 14.1mm; W = 18.6mm; f_r = 3.3 GHz
The chosen substrate is glass epoxy relative permittivity ε_r =4.5 and height h = 1.6mm
Branch line length qw = 13mm
Rectangular slot dimensions (a*b) = 9.6mm*4.3mm

V. RESULTS

The simulated result of S_{11} scattering parameter (return loss) of single element rectangular microstrip antenna is presented in figure 7. From the figure, the antenna has almost 3.3GHz resonant frequency and it has 120MHz bandwidth at 10 dB (the difference of 3.42 GHz and 3.3 GHz). In percentage, the bandwidth of the antenna is 3.5%.

The simulation results for VSWR for the frequency range from 2.74 to 3.55 GHz is shown in the figure 8. The value of VSWR can be seen to be within 1 to 2 in the operating range. This Patch Antenna is simulated by HIGH FREQUENCY STRUCTURE SIMULATOR (HFSS) software.

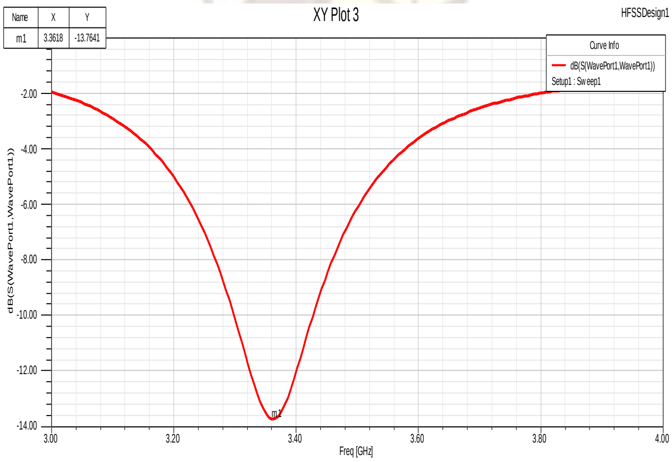

Fig. 7 Return loss of rectangular MSA

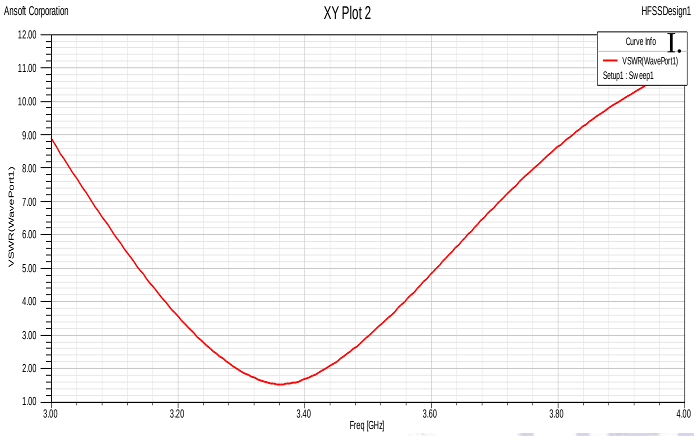

Fig. 8 VSWR of rectangular MSA

The simulated result of S_{11} scattering parameter of single element H-shaped microstrip antenna is presented in figure 9. From the figure, the antenna has almost 3.34GHz resonant frequency and it has 320MHz bandwidth at 10 dB (the difference of 3.52 GHz and 3.2 GHz). In percentage, the bandwidth of the antenna is 9.5%. The simulation results for VSWR for the frequency range from 2.6 to 4 GHz is shown in the figure 10. The VSWR bandwidth is the value of frequency range that is below 2, that is also 9.5%.

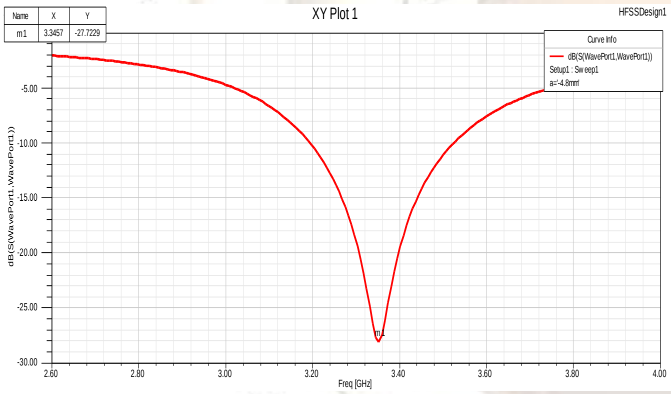

Fig. 9 Return loss of H-shaped MSA

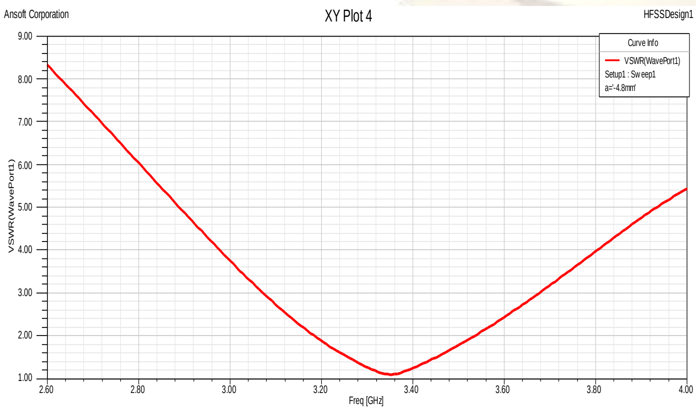

Fig 10 VSWR of single element H-shaped MSA

I. COMPARISION OF RECTANGULAR MSA AND H-SHAPED MSA

In last section rectangular MSA presented with glass epoxy substrate and thickness h=1.6mm and got return loss bandwidth 3.5%. In slot cut H-shaped MSA with same substrate presented and got 9.5% bandwidth. So by using H-shaped MSA instead of rectangular MSA we can get bandwidth improvement that is presented in figure 11.

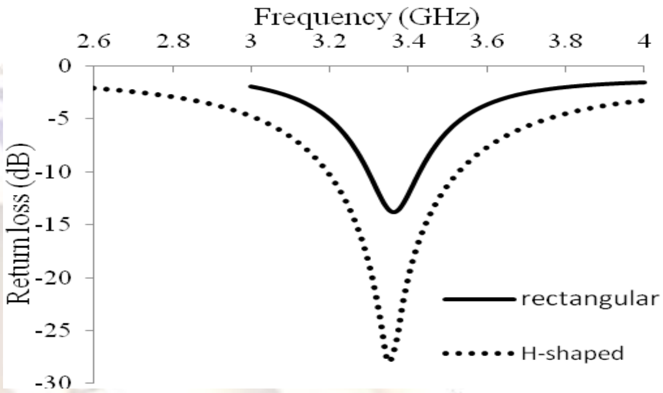

Fig. 11 Bandwidth comparison of rectangular and H-shaped MSA

Antenna type Properties	Rectangular MSA	H-shaped MSA
Resonant frequency	3.36 GHz	3.34 GHz
Bandwidth	3.5 %	9.5 %
Patch size (mm*mm)	(20.13*26.30)	(14.1*18.6)

Table1. Comparison between rectangular and H-shaped MSA

VI. CONCLUSION

Two aspects of microstrip antennas have been studied. The first aspect is the design of typical rectangular microstrip antenna and the second is the design of slot cut H-shaped microstrip antenna. A simple microstrip line type feed mechanism with quarter wavelength Long Branch line used to energized patch. The main concern is to study the bandwidth improvement of the microstrip antenna. Rectangular microstrip antenna and H-shaped microstrip antenna have been designed and simulated using high frequency structure simulator (HFSS). H-shaped microstrip antenna produced reduction in size and higher bandwidth (9.5%) in comparison to rectangular microstrip antenna (3.5%).

REFERENCES

[1]. Hall, P. S. Wood, C and Garrett, C, "Wide bandwidth microstrip antennas for circuit integration", Electron. Lett. , 15, pp. 458-460, 1979.

[2]. Dubost, G., Nicolas, M. and Havot, H. "Theory an applications of broadband microstrip antennas", Proceedings of the 6th European Microwave Conference, Rome, pp. 21S—219, 1976.

[3]. Wood, C,"Curved microstrip lines as compact wideband circularly polarised antennas", IEE J. Microwaves, Opt. & Acoust, 3, pp. 5-13, 1979.

[4]. Van De Capelle, A., De Bruyne J., Verstraete, M., Pues, H. and Vandensande J. "Microstrip spiral antennas", Proceedings of the International IEEE Symposium on Antennas and Propagation, Seattle, pp. 383-386, 1979.

[5]. Pues H. F. and Van De Capelle A. R. "Impedance-matching of microstrip resonator antennas" Proceedings of the North American Radio Science Meeting, Quebec, p. 189, 1980.

[6]. H. Pues, Ir., J. Bogaers, Ir., R. Pieck, Ir. and A. Van de Capelle, Dr. Ir. "Wideband quasi-log-periodic microstrip antenna", IEE PROC, Vol. 128, Pt. H, No. 3, , pp. 159-163, June 1981.

[7]. V. B. Romodin, V. I. Oznobikhin and V. V. Kopylov, "Log Periodic Microstrip Array", IEEE - Russia Conference, Mia-Mep9, 1999.

[8]. Ravi Kant and D.C.Dhubkarya, "Design & Analysis of H-Shape Microstrip Patch Antenna", publication in the "Global Journal of Research in Engineering", Vol. 10 Issue 6 (Ver 1.0), pp. 26-29, Nov. 2010.