

PERFORMANCE ENHANCEMENT OF MICRO STRIP PATCH ANTENNA FOR WIRELESS APPLICATIONS

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Abstract: The availability and growth in development of low cost, less weight, highly reliable antennas are required for wireless communication, it poses new challenges for the design of antenna in wireless communication. The micro strip patch antenna used for these communication, because they will provide high frequency and less bandwidth. This paper presents a design and simulation of rectangular micro strip patch antenna at 2.5 GHz compare with 4.8 GHz and 7.8 GHz frequency range for wireless communication that provides a radiation pattern along a wide angle of beam. The designing process uses the Rogers RT/duriod 5880 material is used as the substrate and coaxial probe feed method is used to gives the excitation value of the antenna. This antenna has many practical applications like WLAN, WI-FI etc. so the HFSS software will be used to design and implement the antenna.

Keywords: Micro strip patch antenna, Radiation pattern, Ansoft HFSS (High Frequency Structural Simulator).

1. Introduction

In the world the communication needs starts with the basic need of an antenna. In recent years there is a need for more compact antennas due to the communication devices sizes are decrease rapidly. So we need the antennas in the size of small and less in weight. Antenna is usually a metallic device (as a rod or a wire) used for radiating or receiving electromagnetic waves. The radio frequency power developed at the final stage of a transmitter is delivered through cables or feeders, without themselves consuming any power to the transmitting antenna. This travels in the free space in the form of radio waves (electromagnetic waves). The receiving antenna picks up the radio waves and delivers useful signal at the input of a receiver for reception of signals. The transmitting and receiving antennae are reciprocal in the sense, any characteristics of the antenna in general applies equally

to both. The micro strip antenna is one of the small size antennas and is printed directly on the printed circuit board. Micro strip antenna is a narrow band and wide beam antenna element pattern in a metallic trace bounded in dielectric substrate. These antennas are mostly used for the wireless applications. They are small in size, low cost, less weight to handle, simple to manufacturing, reliable and they are available in different shapes and ranges such as square, rectangular, dipole, circular, triangular, circular ring, elliptical and any other shapes. The antenna characteristics like the radiation pattern, gain, directivity and polarization are found by using the Ansoft HFSS simulator tool.

2. Antenna Structure

Micro strip patch antenna consists of a radiating patch on one side of the dielectric substrate which has a ground plane on the other side and the patch is from the top side. The micro strip patch antenna consists of three layers these are the bottom layer, which constitutes the ground plane, the middle layer which shows the substrate and finally the top layer which shows the patch. The patch is generally made of conducting material such as copper or gold and can take any possible shape which will be said in above. The general structure of the micro strip patch antenna was shown in figure 1.

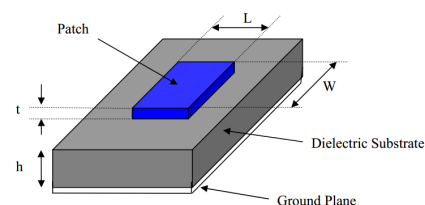


Figure.1 Structure of Micro strip patch antenna

3. Micro Strip Patch Antenna Design and Considerations

The Micro strip antenna was designed by using the Ansoft HFSS. It is one of the designing tools of antenna. The Ansoft HFSS is an easy and low cost tool which has the simple procedures to design the antenna in a very efficient way. By using this software the antenna should be designed and simulated. By simulating this antenna we can get the frequency response, gain, directivity and radiation pattern.

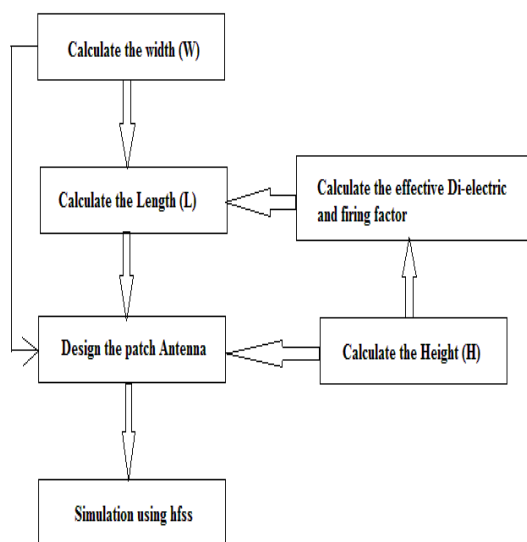


Figure.2 Design flow of Micro strip patch antenna

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a. Calculation for the Antenna Width (W)

The Width of micro strip patch antenna is given by eqn (1)

$$W = \frac{C}{2f_0 \sqrt{\frac{\epsilon_r + 1}{2}}} \quad (1)$$

Where, C is velocity of light, f_0 is a resonant frequency and ϵ_r is a relative die electric constant. Other widths are also chosen but for the higher widths the radiation efficiency is lower in manner and for the lower widths the radiation efficiency is larger in resulting values, in this equation we substituting $C=3 \times 10^{11}$ mm/s, $\epsilon_r = 2.2$ and $f_0 = 3.8$ GHz, 4.8GHz and 7.8GHz frequency, finally by solving this equation we get the width value as 31.57mm for 3.8GHz, 24.68mm for 4.8GHz and 15.40mm for the 7.8GHz.

b. Calculating the Height of the Antenna

The height (H) of the antenna is given by eqn (2) and is written as

$$H = \frac{0.3C}{2\pi f_0 \sqrt{\epsilon_r}} \quad (2)$$

By substituting all the values and solving the equation we get the height of the antenna as 3.4mm for 3.8GHz, 2.26mm for 4.8GHz and 9.1mm for 7.8GHz or the standard height of the micro strip patch antenna 3.2mm is used for the simulation.

c. Calculating the Antenna Length (L)

Calculating the length of the micro strip antenna follows the several steps which should be have four steps these as follows as

1) Effective Die Electric Constant

Before calculating the length of the antenna we must calculate the several other computations, the first we would find the effective die electric constant of the substrate which is much greater than the unity value. The effective die electric constant value is much closer than the die electric constant of the substrate. The effective die electric constant value is given in eqn (3)

$$\epsilon_{re} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[1 + 12 \frac{h}{w} \right]^{-\frac{1}{2}} \quad (3)$$

By substituting all the values and solving the equation we get the effective die electric constant value as 1.2mm for 3.8GHz, 1.76mm for 4.8GHz and 3.6mm for 7.8GHz.

2) Extensive Length

The tangential fields of an antenna are in phase and combine they will produces the maximum radiation pattern along with its two sides of the antenna. The micro strip antenna are looks larger in size when compared to its actually size due to its fringing fields so the length of the antenna was extended by its two sides along a path distance of ΔL and it is given in eqn (4)

$$\Delta L = 0.412h \frac{(\epsilon_{re} + 0.3)(\frac{w}{h} + 0.264)}{(\epsilon_{re} - 0.258)(\frac{w}{h} + 0.8)} \quad (4)$$

By substituting all the values and solving the equation we get the extensive length of the antenna as 1.2mm for 3.8GHz, 1.7mm for 4.8GHz and 1.39mm for 7.8GHz.

3) Effective Length of the Antenna

The effective length of the of antenna is given eqn (5) and which helps to find the original length of the rectangular micro strip patch antenna and it is written as

$$L_{eff} = \frac{C}{2f_0 \sqrt{\epsilon_{re}}} \quad (5)$$

This should be calculated for the narrow bandwidth of the antenna structure and various parameters of the antenna.

By substituting all the values and solving the equation we get the effective length of the antenna as 36.18mm for 3.8GHz, 23.67for 4.8GHz frequency range and 10.12mm for 7.8GHz.

d. Actual Length of the Antenna

The actual length of the antenna should be calculated by substituting the effective length and the extensive length of the antenna is given in eqn (6)

$$L = L_{eff} - 2\Delta L \quad (6)$$

By substituting all the values and solving the equation we get the length of the antenna as 33.78mm for 3.8GHz, 20.27mm for 4.8mm and 7.34mm for 7.8GHz.

4. Roger RT/DURIOD 5880(TM)

The Roger material has the die-electric constant value as 2.2 which will be mostly recommended material for the designing of the micro strip patch antenna [1]. By using these materials the designing parameters values are get reduced and the size of the antenna was almost in small range and which will produce the maximum radiation pattern along its transmission side of the structure. By using these materials the entire structure of the antenna gets minimized, cost of the designing procedure is getting reduced and the same time we get output of the micro strip patch antenna in a good and accurate manner.

5. Software Tool

The software used for the simulation and modeling of the antenna is HFSS (High Frequency Structural Simulator). It is one of the antenna designing tools and it is a high performance full-wave electromagnetic (EM) field simulator for the 3D volumetric passive device. It has simple procedure for the designing of the micro strip patch antenna structure and also it is low cost, high performance and easily understandable software for everyone.

6. Simulations and Results

The design and analysis of the rectangular micro strip antenna was designed at a frequency range of 2.5GHz, 4.8GHz and 7.8GHz. The rectangular antenna has a maximum advantage than other types because they have easily designed structure and have positive radiated edges on the both sides of the antenna. The three dimensional view of the simulated micro strip patch antenna was shown in figure3. The radiation pattern of the antenna is shown in figure4 for 2.5GHz, figure5 for 4.8GHz, figure6 for 7.8and figure 7, 8 and 9 are 2.5GHz, 4.8GHz and 7.8GHz is the frequency response from these above results will show the improved radiation pattern and the frequency response of the antenna.

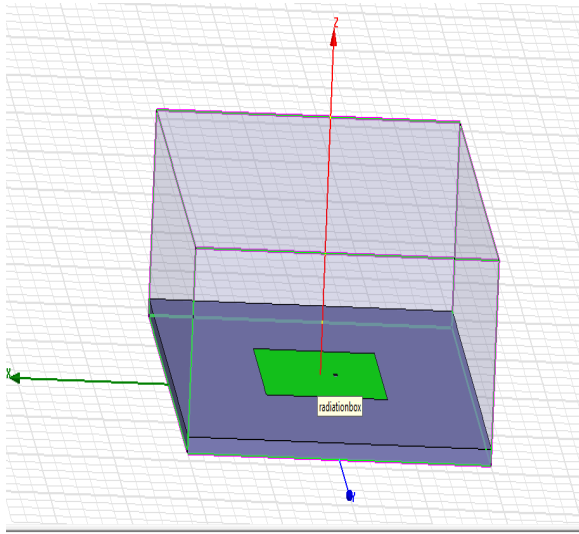


Figure.3 Three dimensional view of antenna

The radiation pattern is nothing but the directional dependence of the strength of the signal or the strength of the electromagnetic waves.

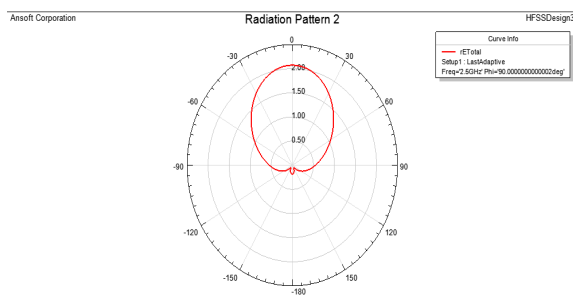


Figure 4. Radiation pattern for theta=90 deg. For 2.5GHz)

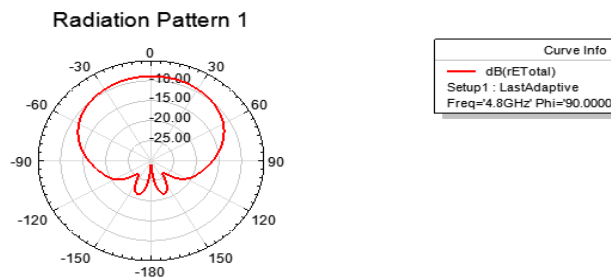


Figure 5. Radiation pattern for theta=90 deg. For 4.8GHz

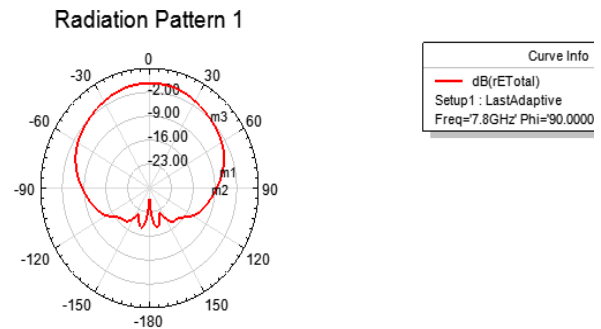


Figure 6. Radiation pattern for theta=90 deg. For 7.8GHz

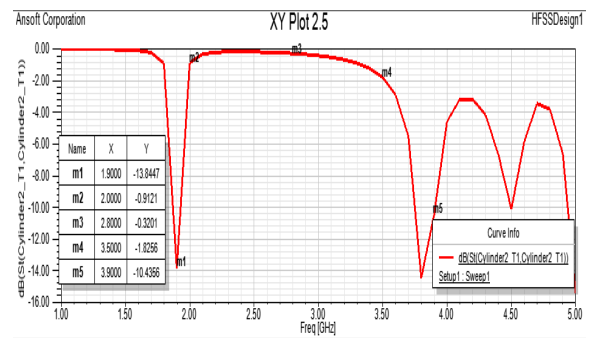


Figure 7. Frequency Response for 2.5GHz.

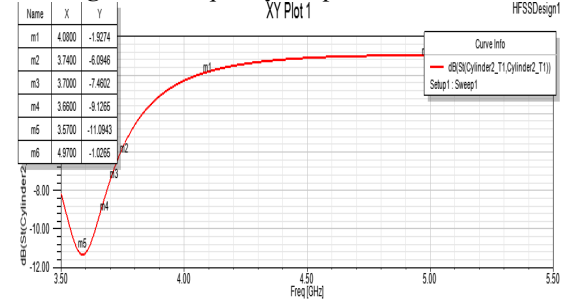


Figure 8. Frequency Response for 4.8GHz

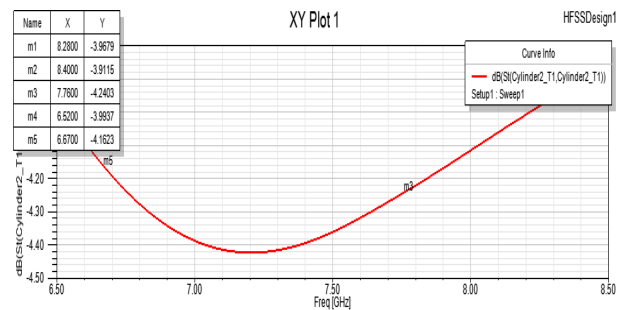


Figure 9. Frequency Response for 7.8GHz

The gain of an antenna is defined as the ratio between the maximum radiation intensity in a given direction to the maximum radiation intensity from a reference antenna in the same direction, the achieved gain of the micro strip patch antenna is 9.8475 dB for 2.5GHz, 6.6505 dB for 4.8GHz and 7.1754 dB for 7.8GHz, where the figure 10, figure 11 and figure 12 shows the gain of the antenna.

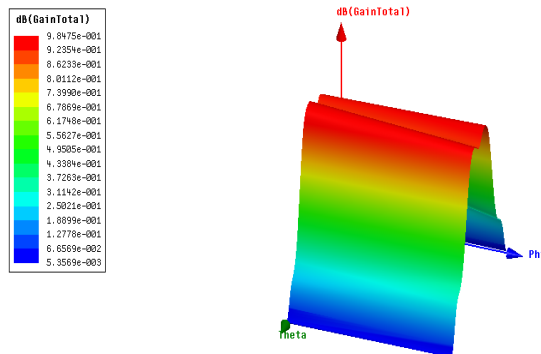


Figure 10. Gain for 2.5GHz

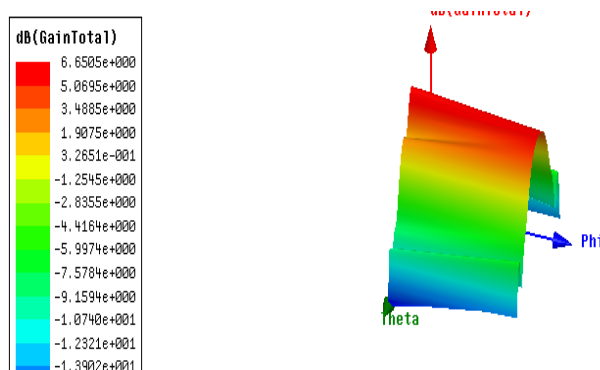


Figure 11. Gain for 4.8GHz

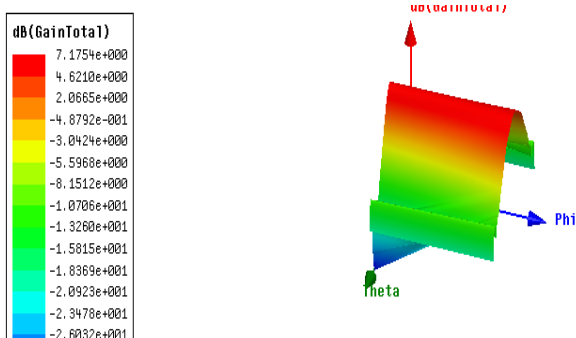


Figure 12. Gain for 7.8GHz

The figure 13, figure 14 and figure 15 shows the directivity of the antenna it is defined as the ratio between the maximum radiation intensity to the average radiation intensity of the antenna, the achieved directivity of the micro strip patch antenna is 9.3172 dB for 2.5GHz, 6.4569 dB for 4.8GHz and 7.0304 dB for 7.8GHz.

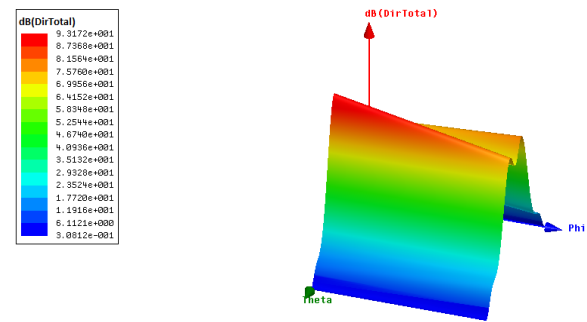


Figure.13 Directivity for 2.5GHz

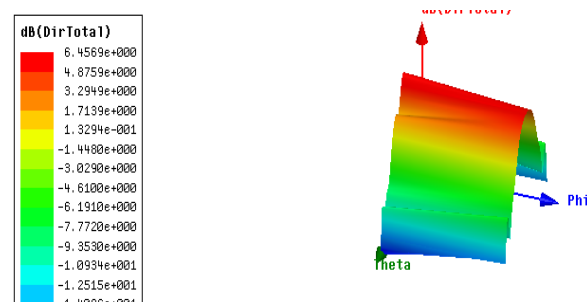


Figure.14 Directivity for 4.8GHz

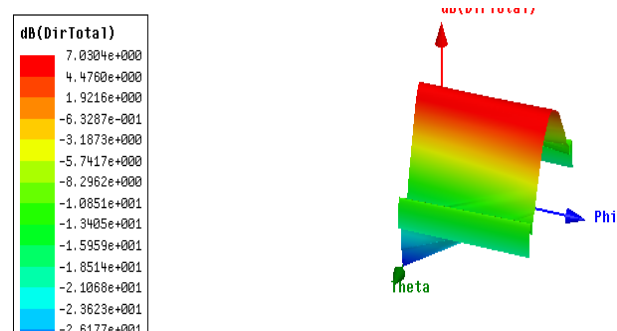


Figure.15 Directivity for 7.8GHz

The polarization of an electric field is defined in terms of the direction of its electric field vector. If the electric field vector is always in one plane, then it is said to be linearly polarized.

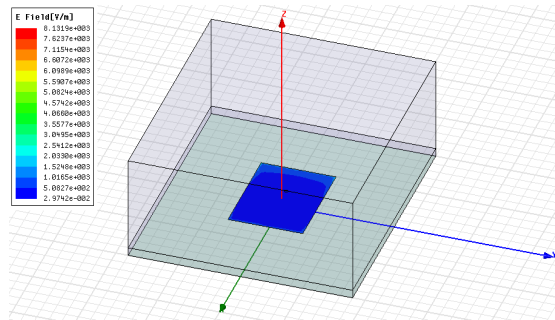


Figure.16 Polarization of MSA

Table 1. Micro strip patch antenna parameters for 2.5GHz, compare with 4.8GHz and 7.8GHz Frequency range

7. Conclusion

The rectangular micro strip antenna was designed and analyzed with a frequency range of 7.8 GHz is simulated

Frequency (GHz)	Gain (dB)	Directivity (dB)	Realized Gain (dB)	Peak Gain (dB)	Peak Directivity (dB)
2.5	9.8475	9.3172	7.3693	9.3108	9.3947
4.8	6.6505	6.4569	4.3542	5.6923	5.4236
7.8	7.1754	7.0304	5.5268	6.2569	6.1253

by using the Ansoft HFSS software. The frequency response, radiation pattern are obtained, the designed antenna gain value is 7.1754 dB optimized to meet the best possible results the RT/Rogers duroid 5880 substrate was used. The polarization of the antenna is linearly polarized antenna for both the frequency ranges. This designed antenna is suitable for WLAN and WI-FI application.

References

- [1] Constantine A. Balanis, antenna theory analysis and design, 2nd edition, John Wiley & sons, Inc., 1997
- [2] John D. K. Karus, antennas 2nd edition, McGraw-Hill Company, 1998
- [3] Pardeep Kumar, Neha Thakur, Aman Sanghi, "Micro Strip Patch antenna for 2.4 Ghz wireless application", in IJETT volume 4, issue 8- august 2013
- [4] B.SaiSandeep, S.SreenathKashyap, "design and simulation of micro strip patch array antenna for wireless communication at 2.4 GHz", in IJSER volume 3, issue 11-November 2012
- [5] RajuVerma, NamrataDewangan "Equilateral triangular micro strip patch antenna using different substrates," in JAFRC volume 1, issue 3 – march 2014.
- [6] Chandrasekhar Rao, A.TathaBabu, S.Haritha, K.Suresh, Gopi, "Performance analysis of slotted rectangular patch antenna using co-axial and strip line feed" in IJREAT volume 1, issue 3 – July 2013.
- [7] Kin – Lu Wong, compact and broadband micro strip antennas, Jon Wiley & sons, Inc., 2002.
- [8] Atinder pal singh, Ravinder Kumar, HatejSingh Dadhwal,"Design of edge fed rectangular micro strip patch antenna for WLAN applications using Ansoft HFSS" in VSRD – IJEECE, volume 2, Issue 4 – April 2012.
- [9] Severn Shelly, Joseph Costantine, Christos G, Christodoulou, Dimitris E. Anagnostou, James C.Lyke "IEEE antennas and wireless propagation letters" volume9, 2010.
- [10] W. S. Chen, K. L.Wong, and C. K. Wu, "Inset Microstrip line-fed Circularly Polarized Micro strip Antennas," IEEE Transactions on Antennas and Propagation, AP-48, 8, August 2000, pp. 1253- 1254.
- [11] D. Sievenpiper, L. Zhang, R.F.J. Broas, N. G: Alexopolous, E. Yablonovitch, High-Impedance Electromagnetic Surfaces with a Forbidden Frequency Band, IEEE Transactions on Microwave Theory and Techniques, Vol. 47, No. 11, November 1999.
- [12] A. Chen, Y. Zhang, Z. Chen, S. Chao, A Ka-Band High Gain Circularly Polarized Micro strip Antenna Array, IEEE Antennas and Wireless Propagation Letters, Vol. 9, 2010.
- [13] A. Chen, Y. Zhang, Z. Chen, C. Yang, Development of a Ka-Band Wideband Circularly Polarized 64-Element Micro strip Antenna Array With Double Application of the Sequential Rotation Feeding Technique, IEEE Antennas and Wireless Propagation Letters, Vol. 10, 2011.

