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Microstrip Patch Antenna for WiFi Applications

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A B S T R A C T

In this paper, a rectangular microstrip patch antenna for wifi applications, operating at 2.4 GHz is presented. The antenna is designed on FR-4 substrate with a thickness of 1.6 mm and dielectric constant εr=4.4.The patch antenna is designed and simulated using HFSS software. The return loss of the designed antenna is –22.28 dB at 2.4 GHz. The bandwidths obtained for the antenna is 60 MHz. The antenna has a very good radiation pattern with a very low back radiation.

Keywords: Antenna, WiFi, Microstrip, Rectangular Patch.

INTRODUCTION

Microstrip patch antennas are low profile antennas. It consists of a metal patch on top of the dielectric substrate and a metallic ground below the substrate. The patch is the radiating element which is connected to the feed line and are constructed by the photo-etching process on the dielectric material. The patch can be square, circular or rectangular in shape for the ease of analysis and fabrication. The patch is generally made of conducting material such as copper or gold. The relative permittivity of the dielectric substrate plays a very important role in the calculations of the antenna dimensions. A thick dielectric substrate with a low dielectric constant is desirable for good antenna performance, since it provides better efficiency, larger bandwidth and better radiation. Microstrip antenna produces maximum radiation in the broadside direction (θ = 0), with ideally no radiation along the substrate edges (θ = 90°).

The following image shows a micro-strip or patch antenna.

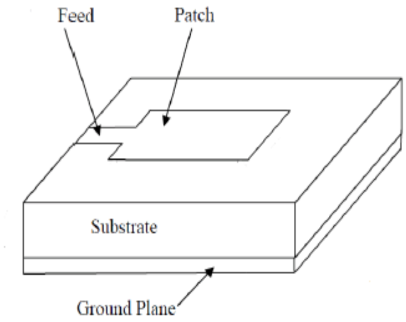

Fig 1. 3D view of Microstrip Patch Antenna

Microstrip patch antennas have the advantages of lighteweight, low cost and ease of installation.

Antenna Design: In this article two antennas for wifi application are proposed which are designed to resonate at frequencies 2.4GHz and 5.0 GHz. In the designing of these anennas FR4 substrate material with relative permittivity ε_r = 4.4 and thickness = 1.6 mm is used. The dimensions of the patch antennas are calculated using the following formulas.

Width of the Patch:

$$W = \frac{C_0}{2f_r}\sqrt{\frac{2}{\varepsilon_r + 1}}$$

Where, W = Width of the patch

C_0= Speed of light

ε_r = relative dielectric constant of the substrate

The value of the effective dielectric constant (ε_{eff}) is calculated using the following equation:

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

Due to fringing effect, electrically the size of the antenna is increased by an amount of (ΔL). Therefore, the actual increase in length (ΔL) of the rectangular patch is calculated using the following equation:

$$\frac{\Delta L}{h} = 0.412\frac{\left(\varepsilon_{reff} + 0.3\right)\left(\frac{W}{h} + 0.264\right)}{\left(\varepsilon_{reff} - 0.258\right)\left(\frac{W}{h} + 0.8\right)}$$

Where 'h'= height of the substrate

Now, the length (L) of the patch antenna is calculated using the following equation:

$$L = \frac{C_0}{2f_r\sqrt{\varepsilon_{reff}}} - 2\Delta L$$

The length and width of the substrate and the ground plane are equal. So, the length of the ground plane (Lg) and the width of the ground plane (Wg) are calculated using the following equations:

$$L_g = 6h + L$$
$$W_g = 6h + W$$

ANTENNA DESIGN

Using the above mentioned equations, a rectangular microstrip patch antenna is designed at resonant frequency of 2.4 GHz. The length (L) and width (W) and of the patch at a resonant frequency of 2.4 GHz is found to be 24.9 mm and 36 mm respectively, The height of the substrate is 1.6 mm. The length (Lg) and width (Wg) of the ground plane is taken as 60 mm and 60 mm respectively. For feeding the microstrip patch antenna, inset feed technique is used having an inset length of 30 mm and width 3mm. The simulations are carried out in High Frequency Structure Simulator (HFSS) Student Version software.

Figure-2 and Figure-3 show the frequency vs gain pattern of the antenna in the farfield. The direction of the maximum gain of the antenna is vertically above the patch (i-e, in the direction of theta), while minor lobes are on the opposite side.

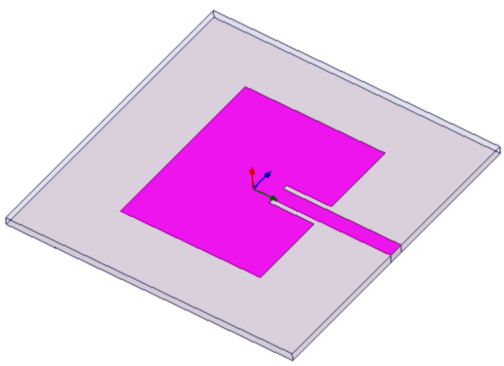

Fig 2. Antenna Geometry

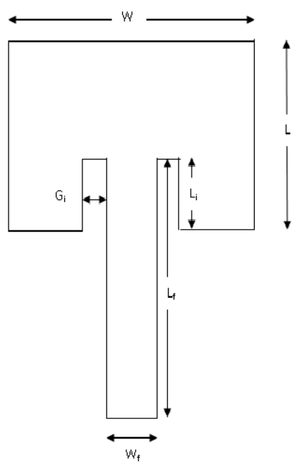

Fig 3. Geometry of Inset fed Rectangular Patch Antenna

3. FEEDING METHOD

There are differnt ways to feed microstrip patch antennas. These feeding methods can be put in the categories of contact feeding and non-contact feeding. The feeding techniques have influences in the polarization mechanisms and the input impedance of the desired antenna. Three feeding techniques are most commonly used. They are (i) coaxial probe feed, (ii) microstrip line feed, and (iii) aperture coupled feed. Microstrip line feeds are more suitable for the patch antennas as compared to other feeding techniques, because it has the advantages of easy fabrication and lower costs. In our antenna designs, we have used microstrip line feeding (inset feed) technique to radiate the power.

4. RESULT AND DISCUSSION

Figure-4 and Figure-5 show the return loss and 3D view of radiation pattern of the antenna respectively. The maximum gain of the antenna with resonant fequency 2.4 GHz is -22.28 dB. The proposed antenna has an excellent radiation pattern with negligible back radiation. It has a bandwidth of 60 MHz at 2.4 GHz.

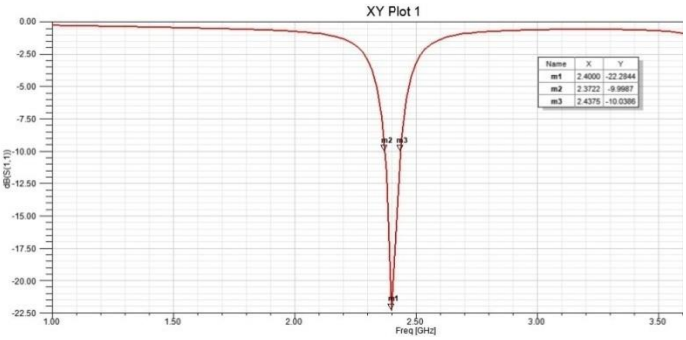

Fig 4. Frequency response of the Antenna at 2.4 GHz

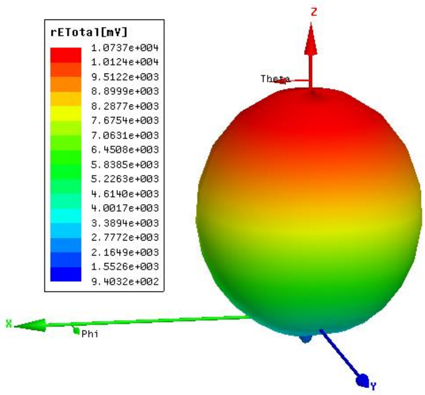

Figure 5. 3D Radiation Pattern of the proposed Antenna

5. CONCLUSION

A simple and compact inset fed microstrip antenna has been designed, simulated and studied in this paper. The main objective of this work is to design microstrip patch antennas for wifi applications. The proposed antenna is showing good response with a bandwidth of 60MHz at the resonant frequency of 2.4 GHz. The radiation pattern shows excellent response of the antenna with negligible back radiation. The designed antenna is very simple and efficient. This antenna is very light weight and low cost antenna as FR4 is used as substrate. So, this antenna is very much useful for low cost wifi applications.

References:

1. Jyoti Yadav, Suman Sharma, Mukesh Arora, "A paper on microstrip patch antenna for 5G applications", Materials Today: Proceedings, Volume 66, Part 8, 2022, Pages 3430-3437, ISSN 2214-7853, https://doi.org/10.1016/j.matpr.2022.06.123.

2. Rajesh Kumar Devi Charan Dhubkarya , "UWB Compact Microstrip Patch Antenna with High Directivity Using Novel Star-Shaped Frequency Selective Surface," Progress In Electromagnetics Research C, Vol. 119, 255-273, 2022. doi:10.2528/PIERC22030307, http://www.jpier.org/PIERC/pier.php?paper=22030307

3. Aboualalaa, M., Abdel-Rahman, A. B., Allam, A., Elsadek, H., & Pokharel, R. K. (2017). Design of a Dual-Band Microstrip Antenna with Enhanced Gain for Energy Harvesting Applications. *IEEE Antennas and Wireless Propagation Letters*, *16*, 1622-1626. [7820049]. https://doi.org/10.1109/LAWP.2017.2654353

4. Kumar, C., M. I. Pasha, and D. Guha, "Defected ground structure integrated microstrip array antenna for improved radiation properties," IEEE Antennas and Wireless Propagation Letters, Vol. 16, 310-312, 2017.
5. Chatterjee, A. and S. K. Parui, "Performance enhancement of a dualband monopole antenna by using a frequency-selective surfacebased corner reflector," IEEE Transactions on Antennas and Propagation, Vol. 64, No. 6, 2165-2171, 2016.
6. Tahir, F. A., T. Arshad, S. Ullah, and J. A. Flint, "A novel FSS for gain enhancement of printed antennas in UWB frequency spectrum," Microwave and Optical Technology Letters, Vol. 59, No. 10, 2698-2704, 2017.
7. Kundu, S., A. Chatterjee, S. K. Jana, and S. K. Parui, "A compact umbrella-shaped UWB antenna with gain augmentation using frequency selective surface," Radioengineering, Vol. 27, No. 2, 448-454, 2018.
8. Mondal, R., P. S. Reddy, D. C. Sarkar, and P. P. Sarkar, "Compact ultrawideband antenna: Improvement of gain and FBR across the entire bandwidth using FSS," IET Microw. Antennas Propag., Vol. 14, No. 1, 66-74, 2019.
9. Alsath, M. G. N. and M. Kanagasabai, "Compact UWB monopole antenna for automotive communications," IEEE Transactions on Antennas and Propagation, Vol. 63, No. 9, 4204-4208, 2015.
10. Zhou, Z. L., L. Li, and J. S. Hong, "Compact UWB printed monopole antenna with dual narrow band notches for WiMAX/WLAN bands," Electronics Letters, Vol. 47, No. 20, 1111-1112, September 29, 2011.