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A Microstrip Patch Antenna Design using HFSS for Wireless Local Area Network (WLAN) Applications at 2.4GHz Frequency

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Abstract:

Here, a microstrip patch antenna(MPA) is calculated and intended for the applications of Wireless Local Area Network (WLAN) using HFSS. The designed antenna will be capable of operating at 2.4 GHz frequency and hence can be implemented in Wireless Local Area Network (WLAN) applications. The proposed calculation and design use a FR-4 dielectric material whose dielectric constant is Ɛr = 4.4 with a thickness of 1.5mm. The entire designing of the antenna is carried out using HFSS software. Since the proposed antenna design is simple and of a very low profile, it can be used easily in Wireless Local Area Network (WLAN) applications.

Keywords - High Frequency Structure Simulator (HFSS); Micro Strip Antenna (MSA); Wireless Local Area Network (WLAN); Return Loss; Patch; dielectric.

I. INTRODUCTION

In 1950s only, Micro strip antennas are initially developed. Though, the methodology of Printed Circuit Board (PCB) was then familiarized after 1970s.Consequently, MSA had developed as a very communal antenna taking on varied range of technologies and methodological applications owing to their low cost, low profile, less weight, planar configuration and numerous added applications.[1] Micro Strip Antennas(MSA) are extensively applied in Radio Frequency Identification (RFID) Devices and its applications, Broadcast Radio Devices and its applications, Mobile Devices and its applications, Global Positioning Systems (GPS) and its devices, Satellite Communication Devices and its applications, Television Devices and its applications, Multiple-Input Multiple Output (MIMO) Devices and its applications, vehicle collision avoidance Devices and its applications, surveillance Devices and its applications, direction finding devices, radar Devices and its applications, remote sensing Devices and its applications, missile guidance devices, and so on [2]. Antennas are transducers designed, scrutinized and then fabricated to transmit and receive electromagnetic waves. Microstrip antennas are mostly picked instead of conventional microwave antennas in abundant practical applications because of their superior advantages [15]. An elementary microstrip antenna's arrangement is shown in Fig1, which comprises of the following. (i.e.) on upper end a radiating patch is added and on the lower end a ground plane is added and in-between a dielectric substrate with Ɛr ≤10 is present.

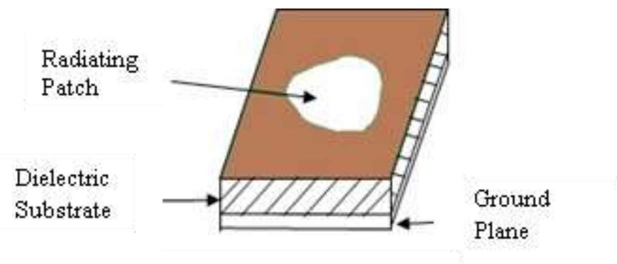
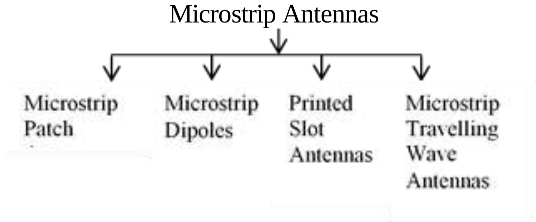


Fig1: Configuration of Microstrip Antenna

The physical aspects and features characterized in microstrip antennas are enhanced when compared with conventional microwave antennas. So, it is easy to design, examine and fabricate microstrip antennas in numerous geometric forms and magnitudes [10]. Fundamentally the microstrip antennas are classified into the following four categories.

Microstrip Antennas



II. Geometry of Microstrip Patch Antenna

Microstrip patch antenna(MPA) encompasses of a conducting patch (mostly planar or non-planar design) which is on the upper end of the dielectric material substrate and has a ground plane on the lower end. Let us consider an illustration, for narrow-band microwave wireless links we require a printed resonant antenna with a semi-hemispherical coverage or directivity. Because of its planar formation and alignment, it offers easiness for incorporating with microstrip Methodology, also MPA are greatly dependable and are now customarily used as elements for an array. So far, a vast amount of MPAs is designed, examined and deliberated to till date. The exclusive list of geometries with their configurations and features is presented in [13]. The microstrip antennas that are most frequently used are the rectangular patch and circular patch antennas, which are also the basic configurations of the same. For most of the anticipated solicitations one of these patches are used widely. The rectangular patch geometries are easy to analyze and are easily separable, while the circular shaped patch geometries produces symmetrical radiation pattern. A simplest form of MPA is shown in figure 2.

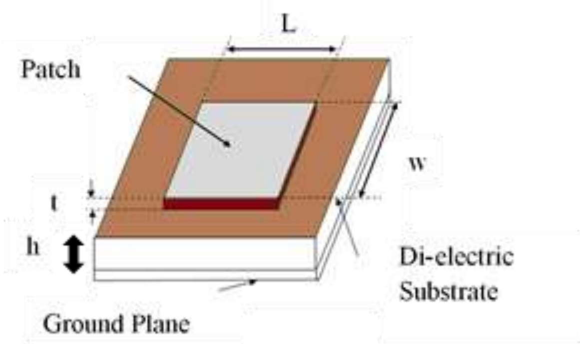


Fig2: Microstrip Patch Antenna Structure

A Comparison Table (Table I) described below shows the Characteristics of Printed Dipole Antenna, the Microstrip Slot Antenna and the Microstrip Patch Antenna.

Table- I: Comparison of Antenna Characteristics

S. No	**Characteristics**	**Printed Dipole Antenna**	**Microstrip Slot Antenna**	**Microstrip Patch Antenna**
1	Profiles	Slim	Slim	Slim
2	Shapes	Rectangular and Triangular	Rectangular and Circular	Any Shape
3	Fabrication	Simple	Simple	Very Simple
4	Polarization	Linear	Linear and Circular	Linear and Circular
5	Bandwidth	≥30%	5-30%	2-50%
6	Dual-Frequency Operation	Obtainable	Obtainable	Obtainable
7	Radiation	Exists	Exists	Exists

Here, we are going to calculate and design a rectangular microstrip patch antenna whose patch is of rectangular shape with L1 as length and W1 as width. The antenna designed will be able to operate at 2.4 GHz frequency and hence find its application in Wireless Local Area Network (WLAN)[16]. The proposed antenna uses a FR-4 dielectric material whose dielectric constant value is $\varepsilon r = 4.4$ and thickness value is 1.5mm.

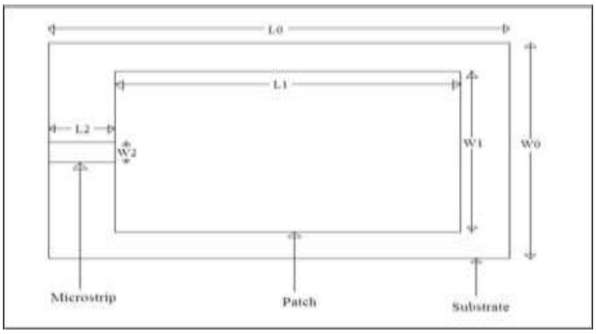


Fig3: Microstrip Patch Antenna Geometry

Fig3. represents the microstrip patch antenna structure comprising a patch of rectangular shape, a dielectric substrate and a feed line which is microstrip one. The rectangular patches and its ground planes are separated by FR4 substrate.

Table II shows the parameter values of the designing antenna which comprises of rectangular patch, dielectric substrate and microstrip feed line.

Table- II: Design Structure values of MPA

List of Structures	Value (mm)
Substrate Thickness	1.5
Substrate Length	47.044
Substrate Width	38.484
Patch Length	38.044
Patch Width	29.484
Microstrip Length	5.21
Microstrip Width	1.0

Microstrip patch antennas find its applications in all grounds and areas due to their low cost for the materials that are used as substrate and also has a very low cost for fabrication. The applications were the conventional antennas so far used are gradually been replaced by microstrip patch antennas. Based on the research, microstrip antennas can be fabricated for all the applications at low cost with better efficiency when a comparison is done with the conventional antennas. Though the demerits (can be minimized) are for microstrip patch antennas, based on the study they are much better in many aspects compared with conventional antennas.

III. Analysis and Design Equations

The various design equations and formulas are shown as below.

1. $$\text{Width of Patch } (W) = \frac{c}{2f_r\sqrt{\frac{(\varepsilon_r+1)}{2}}}$$
2. $$\epsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+\frac{12h}{W}\right]^{-\frac{1}{2}}$$
3. $$L_{eff} = \frac{c}{2f_r\sqrt{\varepsilon_{eff}}}$$
4. $$\Delta L = 0.412h\frac{(\varepsilon_{eff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{eff}-0.258)\left(\frac{W}{h}+0.8\right)}$$
5. $$\text{Length of Patch (L)} = L_{eff} - 2\Delta L$$
6. $$\text{Length of Substrate } (L_g) = 6h + L$$
7. $$\text{Width of Substrate} (W_g) = 6h + W$$

With the above seven steps we can calculate both the patch and substrate's length and width, patch thickness, resonance frequency, dielectric constant value. The MPA width is given by

$$W = \frac{C}{2f_r\sqrt{\frac{(\varepsilon_r+1)}{2}}}$$

The effective length can be calculated using the formula

$$L_{eff} = \frac{C}{2f_r\sqrt{\varepsilon_{eff}}}$$

After calculating, the design is executed using HFSS software.

IV. Antenna Design and Results Using HFSS

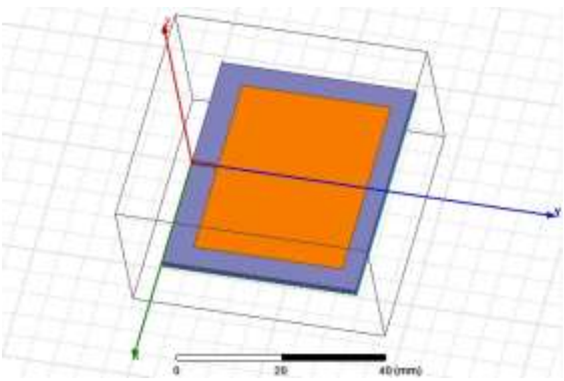


Fig4: Microstrip Patch Antenna design using HFSS

Microstrip patch antenna calculation is then analyzed with High Frequency Structure Simulator (HFSS) and then finalized. The simulated results of MPA designed comprises of return loss (S11 parameter), Voltage Standing Wave Ratio (VSWR), 2-Dimensional and 3-Dimensional radiation patterns are also examined.

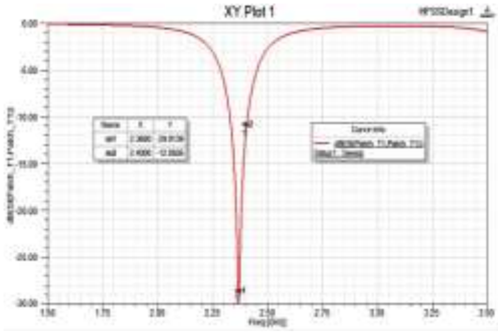


Fig5: Return Loss

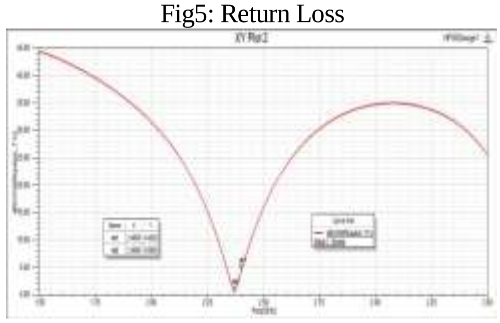


Fig6: Voltage Standing Wave Ratio (VSWR)

Radiation pattern can be defined as the direction of the electromagnetic (EM) waves that will radiate away from the antenna. Here, for the antenna which is calculated and designed, we optimize it for 2.4GHz frequency with 15 adaptive solutions as maximum whose delta value S will be 0.02. The designed antennas radiation pattern is omnidirectional and hence the antenna can be fabricated and implemented for WLAN application.

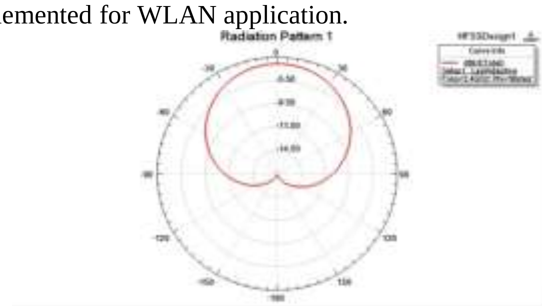


Fig7: 2D Radiation Pattern

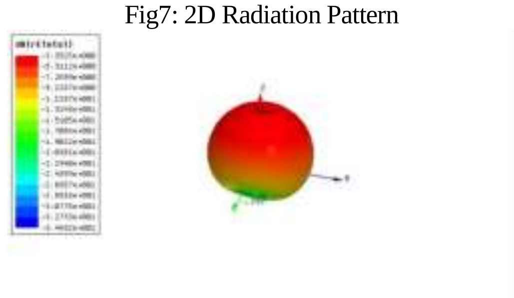


Fig8: 3D Radiation Pattern

V. Conclusion

The designed antenna is radiating with a return loss whose value is of -12.0505 dB at 2.4GHz. Here we use the HFSS simulation software to design the MPA. Also, designed antenna has an adequate bandwidth which is supplied through microstrip feed line and hence the optimized resonance 2.4GHz frequency is easily accomplished. As stated overhead the designed MPA is improved using various optimization techniques so that it can be implemented in all the WLAN frequency applications. The designed antenna has very low-profile and therefore they are simple and compact, making them to fabricate easily and are also their feed can be a simple microstrip feed line and hence can be implemented and used for WLAN applications.

REFERENCES

[1] Tanish Narang; Shubhangi jain; "Microstrip Patch Antenna- A Historical Perpective of the Development",Conference on Advances in Communication and Control Systems 2013 (CAC2S 2013)..

[2] [16] Ogunlade Michael Adegoke; Ismael Saad Eltoum; "Analysis and Design of Rectangular Microstrip Patch Antenna AT 2.4GhzWLAN Applications", International Journal of Engineering Research &Technology (IJERT) ISSN: 2278-0181Vol. 3 Issue 8, August – 2014.

[3] J. R. James, P.S. Hall. Handbook of microstrip antennas, I.E.E. Electromagnetic Waves Series 28- Peter Pereginus LTD, 1989.

[4] C. A. Balanis, "Antenna Theory-Analysis and Design," 2nd ed., J. Peters, John Wiley and Sons, pp. 728-730. [5] Girish Kumar, K.P. Ray, "Broadband microstrip antennas", Aretch House 2003.

[5] R.J. Mailloux, J.F. Mcllvenna and N.P. Kemweis-Microstrip Array Technology IEEE Transactions on Antennas and Propagation, Vol. 29, No.1, January 1981.

[6] Ansoft Corporation, HFSS User's Guide, version 10 &12, Ansoft Corporation, Pittsburgh, CA, 20

[7] Nandini Ammanagi, Rahul Khadilkar, Akash Harwani, Disha Budhlani, Disha Dembla; "Comparison of the performance of Microstrip Antenna at 2.4GHz Using Different Substrate Materials", International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958, Volume-3, Issue-4, April 2014.

[8] Wentworth M. Stuart (2005), ''Fundamentals of Electromagnetic with Engineering Applications'', pp 442-445, John Wiley & Sons, NJ, USA.

[9] J. D. Kraus, R. J. Marhefka, "Antenna for all applications" 3rd Ed., McGraw- Hill, 2002.

[10] Ramesh Garg, Prakash Bartia, Inder Bahl, Apisak Ittipiboon, ''Microstrip Antenna Design Handbook'', 2001, pp 1-68, 253-316 Artech House Inc. Norwood, MA.

[11] C.A. Balanis, "Antenna theory: analysis and design", 2nd ed., John Willey and & Son, Inc., 1997.

[12] Robert A. Sainati, CAD of Microstrip Antennas for Wireless Applications, Artech House Inc, Norwood, MA, 1996.

[13] James j., and P.S. Hall (Eds), Handbook of microstrip antenna, Peter Peregrinus, London, UK, 1989.

[14] Y T Lo and S W Lee, editors, ''Antenna Handbook Theory, Applications & Design'', Van Nostrand Rein Company, NY, 1988.

[15] Peter K.J., Glory G.G.S., Arumugam S., Nagarajan G., Devi V.V.S., Kannan K.S., "Improving ATM security via face recognition", ICECT 2011 - 2011 3rd International Conference on Electronics Computer Technology, Pages 373-376, 2011

[16] Deepa S., Marimuthu C.N., Dhanvanthri V., "Enhanced Q-LEACH routing protocol for wireless sensor networks", ARPN Journal of Engineering and Applied Sciences, Volume 10, Issue 9, Pages 4036-4041, 2015