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METHODOLOGY FOR DESIGN AND DEVELOPMENT OF MICROSTRIP PATCH ANTENNA

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Abstract: A microstrip patch antenna is a type of radio antenna that can be mounted on a lower surface. The microstrip patch antennas are widely used in low cost wireless communication applications because they have distinct several benefits as compared to the traditional antennas. In this paper, the design and development methodology of microstrip patch antenna having H-shaped and using the FR4 substrate with 1 mm thickness has been discussed. The antenna parameters such as gain, bandwidth, return loss, and radiation pattern has been analysed on LED3 software. Other types of microstrip patch antennas can be designed using this methodology and the performance can be evaluated as required for a specific application.

Keywords- **Antenna, Aperture, Microstrip Patch Antenna, Wireless Communications**

I. INTRODUCTION

An antenna is a transducer for transmission and reception of electromagnetic waves from a transceiver employed in any wireless communication system. This is the basic and the most essential component of any wireless communication system. There are many performance parameters such as antenna gain, aperture, effective length, bandwidth, polarization, etc. There are several types of antennas that include wire, reflector, microstrip patch, etc. [1].

Microstrip patch antenna primarily consist of conducting path having either non-planar or planar geometry [2]. The conducting path known as patch and ground plane exist on either side of dielectric substrate, as depicted in Fig. 1.

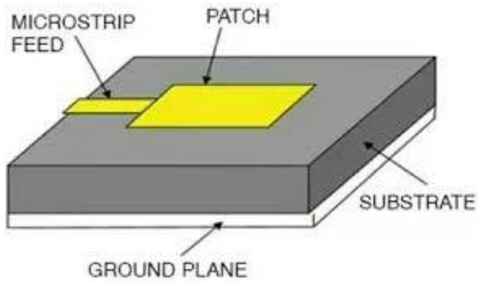

Fig. 1. Basic Structure of Microstrip Patch Antenna

Microstrip antennas, in general, can be categorized as Microstrip travelling antenna, printed dipole antenna and microstrip patch antenna. The first two types can have circular, rectangular, triangular, or elliptical shape only whereas there is no constraint on any specific geometrical shape for design of microstrip patch antenna. Moreover, they are very light in weight, have planar structure, has economic efficiency and are suitable for both planar and non-planar surfaces for installation purpose. They find applications in aircraft, satellites and missile systems. Its narrower operating bandwidth and lower gain, there are restrictions in its use in conventional wireless systems. Typical applications of various wireless networks and communication systems that deploy microstrip patch antennas are given in Table I [3].

TABLE I. APPLICATION AREAS OF MICROSTRIP ANTENNA

Wireless Standards	Frequency
1G Analog Cellular Standard	824 - 849 MHz; 869 - 895 MHz
2G GSM Standards	890-915 MHz and 935-960 MHz
PCS	1.85 - 1.99 GHz; 2.18 - 2.2 GHz
Cellular Video	28 GHz
Wireless LAN	2.40 - 2.48 GHz; 5.4 GHz band
Wide Area Wireless Networks	60 GHz

Direct Broadcast Satellite (DBS)	11.7 - 12.5 GHz band
Global Positioning System (GPS)	1575 MHz band; 1227 MHz band
Collision Avoidance Radar System	60, 77 and 94 GHz bands
Paging	931-932 MHz
Automatic Toll Collection System	905 MHz; 5 - 6 GHz

With the rapid growth of telecommunication engineering, the requirement of wider bandwidth and smaller size of the patch radiator are the need of the hour for most of the wireless communication applications. Sometimes the antenna size does not match with the available space in the device. The methods to reduce the antenna size include Defected Ground Structure (DGS) which is considered to be the best one. Another method is use of Planar Inverted F Structure (PIFA). The reduction in antenna size leads to improvement in various performance determining parameters including antenna gain and return loss. [4] [5]

Substrate is important in the design of antenna and selection of appropriate substrate is vital because it has an affect over the electrical performance. Also it gives the required mechanical support to antenna. Table II presents commonly used layer material in microstrip patch antenna [6].

TABLE II. LAYER MATERIAL IN MICROSTRIP ANTENNA

Type of Layer	**Type of Material Used**
Microstrip Line	Copper
Patch	Copper
Substrate	Dielectric substrate material
Ground plane	Copper

Certain properties of substrate which are to be kept in mind while designing microstrip patch antenna are its thickness, chemical stability, flexibility and loss tangent. In microstrip patch antenna, if the substrate thickness is less, then it implies less transmission loss but less power signal will be sent. This is due to requirement of thin transmission in order to ensure proper impedance matching. And if the substrate thickness is more than the thickness of the strip line, then it will result into impedance mismatching [5].

II. RELATED LITERATURE

In this section we will study about the literature review of microstrip patch antenna. The microstrip patch antenna exhibits many advantages which makes it a good choice. Some of these advantages are planar configuration, low profile, economical, light in weight, easy to manufacture and integrate with external circuitries etc. [5-6]. These antennas have application in radars and communication system because of their good properties. But somewhere it suffers from some disadvantages too which are narrow bandwidth and its low gain which create a negative impact in the antenna efficiencies. To improve its narrow bandwidth substrate thickness can be increased but it has disadvantage of decrease in efficiency due to higher dissipation of input power is dissipated in the resistor. This results into reduction in available power to antenna for radiation. [6-7]

The basic structures of microstrip patch antenna are comparatively easy to fabricate. This has led to extensive research interest in analysis of microstrip antennas. Due to exponential growth of wireless technologies, there is need of compact in size, low-profile and broadband antennas such as microstrip patch antenna [7].

III. MICROSTRIP PATCH ANTENNA FEEDS

There are several methods for feeding the signal into microstrip patch antennas. Let the conducting patch be a rectangular one which exists on one side of the dielectric substrate. Let `$L$' represents length and `W' represents width of a rectangular conducting patch. The microstrip substrate has dielectric constant, denoted by ε_r and thickness, h. The antennas feed can be either contacting type in which RF signal is directly fed through the contacting element like coaxial cable, or it may be non -contacting type in which the RF signal is transferred through electromagnetic coupling [8].

There are a lot of techniques of feeding the RF signal into microstrip patch antenna but four techniques are very popular, that is, microstrip line feed, coaxial line feed, proximity coupling field, aperture coupling feed. The distinct feature of each one of these types is briefly described below.

Microstrip Line Feed: A narrow width conducting strip is directly connected at one edge of the patch. This enables to etch the microstrip line feed on the substrate itself that results into planar type of structure. [9].

Co-axial Feed: This technique is very common. The inner conductor of the coaxial cable is welded to the radiating element of the antenna after penetrating it through the dielectric substrate on the opposite end of the substrate. Whereas the outer conductor of the coaxial cable is directly connected with the ground plane. [10]. This technique has an advantage of placing the feed at convenient place on any point on the patch so as to achieve impedance matching of coaxial cable with that of antenna input port.

Proximity-coupling Feed: The feed line is placed in between two dielectric substrates. The upper dielectric substrate also supports the radiating. [11]. This helps in reducing spurious radiations significantly and thereby providing extremely high bandwidth.

Aperture-coupling Feed: An aperture is used in the ground plane for providing the coupling between the microstrip patch and the feed line. It implies that the ground plane separates aperture coupling feed and the radiating patch. [12]

IV. DESIGN METHODOLOGY

The following steps are proposed to be used while designing and developing a microstrip patch antenna. [13].

- Step I. Calculation of the width (W) of the microstrip patch

$$W = \frac{c}{2 f_0 \sqrt{\frac{\varepsilon_r + 1}{2}}} \quad (1)$$

Where c denotes the velocity of electromagnetic waves, ε_r represents the dielectric constant, f_0 represents the centre frequency.

- Step II. Effective dielectric constant, ε_{eff}

$$\epsilon eff = \frac{\epsilon r+1}{2} + \frac{\epsilon r-1}{2}\left[\frac{1}{\sqrt{1+12\frac{h}{w}}}\right] \quad (2)$$

- Step III. Effective length, L_{eff}

$$Leff = \frac{c}{2fo\sqrt{\epsilon eff}} \quad (3)$$

- Step IV. Extension length, ΔL

$$\Delta L = 0.412h\frac{(\epsilon eff+0.3)\left(\frac{w}{h}+0.264\right)}{(\epsilon eff-0.258)\left(\frac{w}{h}+0.8\right)} \quad (4)$$

- Step V. Actual length of the microstrip patch

$$L = L_{eff} - 2\Delta L \quad (5)$$

A modified microstrip-fed monopole antenna which has planar structure and different frequency band notch function for ultra-wideband (UWB) application is proposed here.

In this design, two slots were inserted on either side of the feed line which exists on the ground plane. It enables to enhance the bandwidth of microstrip patch antenna.

During the development phase of microstrip patch antenna, the patch had been cut into H-shape. By introducing DGS, the inductance and capacitance get changed which simultaneously increases the antenna bandwidth. In this antenna FR4 substrate is used with thickness of 1mm and with dielectric constant of 4.4, as shown in Fig. 2. [14]

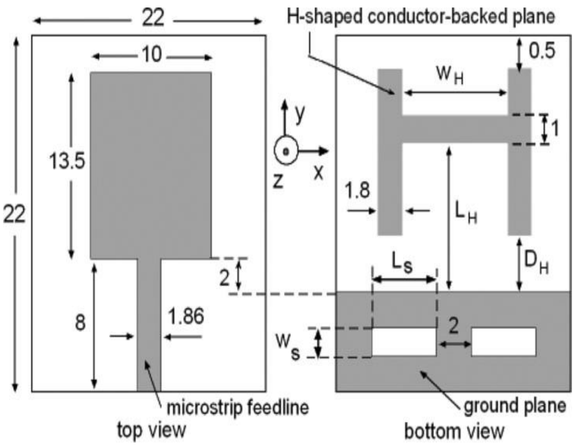

Fig. 2. Geometry of Planar Monopole Antenna

The patch length which is just opposite to the feed line restores with Murkowski geometry. In the 1st iteration various parameters like return loss, gain and radiation pattern was calculated and the centre part of the line gets removed (Refer Fig. 3a). The same process was repeated in the 2nd iteration and the shape became as shown in Fig 3(b) [14].

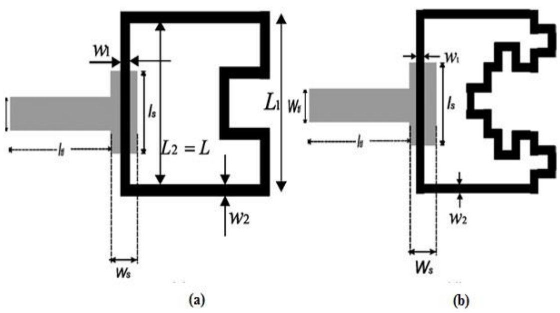

Fig. 3 Antenna design with 1st and 2nd iteration fractal

This antenna was designed using LED3 software material used is aluminium and the dimension of the ground plane was kept as 20 x 20 cm^2. With two iterations, it is observed that the bandwidth increases, as depicted in Fig. 4 [12-14].

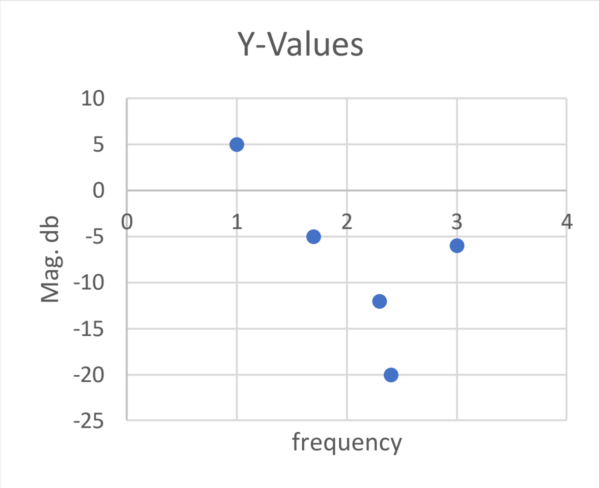

Fig. 4. Bandwidth and return loss of H-shaped antenna using FR4 substrate.

It is seen that the 3 dB bandwidth for FR4 category substrate is calculated to be (2.49 - 2.41 =) 0.08 GHz and the return loss was -20.1 dB.

V. CONCLUSION

In this paper we studied about the design methodology of a microstrip patch antenna using a particular shape H. The methodology for design and development of microstrip patch antenna depends on various techniques used to simulate different parameters of the antenna. The proposed antenna was designed using FR4 substrate. The major performance parameters such as antenna gain, bandwidth and return loss were observed. The simulation was performed using LED3 software. The results indicate significant improvement in the desired performance parameters. The performance can be further improved for target parameters depending on the application.

VI. REFERENCES

[1] Meena M., and Kannan P. (2018). Analysis of microstrip patch antenna for four different shapes and substrates. ICTACT Journal on Microelectronics, Vol. 4, Issue 1.

[2] Singh D., Thakur A., Srivastava V. M. (2018). Miniaturization and Gain Enhancement of Microstrip Patch Antenna with Defected Ground and EBG, Journal of Communication (JOCM), Vol. 13, No. 12, pp. 730-736.

[3] Singal T. (2012). Analog and Digital Communications, First Edition, Tata McGraw Hill Education.

[4] Panda S. et. al. (2019). An Extensive Judgment of Rectangular Microstrip Patch Antenna with Flexible Substrates. International Journal of Recent Technology and Engineering (IJRTE), ISSN: 2277-3878, Vol. 8, Issue 2.

[5] Sona O., (2002). Development and analysis of compact microstrip antennas, Department of Electronics Faculty of Technology, Cochin University of Science and Technology Cochin, India.

[6] Singal T. (2013). Issues of interoperability among heterogeneous wireless communication networks, International Journal of Computing and Business Research, Vol. 4, Issue 2, pp. 1-10.

[7] Hasan R. H., et. al. (2015). Designing and Analysis of Microstrip Patch Antenna for Wi-Fi Communication System Using Different Dielectric Materials. American Journal of Engineering Research, Vol. 4, Issue 10, pp-118-126.

[8] Singh D., and Srivastava, M. (2018). Comparative Analyses for RCS of Patch Antenna using Shorted Stubs Metamaterial Absorber, Journal of Engineering Science and Technology (JESTEC), Vol. 13, No. 11, pp. 3532-3546.

[9] Vishwakarma B., (2008). Analysis of compact H shaped Microstrip antenna. International Conference on Recent Advances in Microwave Theory and Applications, Jaipur, India.

[10] Qais S., (2013). Thesis of miniaturization of patch antenna using DGS.

[11] Khan W. M., and Gulhane S. M., (2015). Related Review on Microstrip patch antennas. International Journal of Industrial Electronics and Electrical Engineering, ISSN: 2347-6982, Vol. 3, Issue 1.

[12] YongLiu, et. al., (2012). Some Recent development of Microstrip antenna, International Journal of Antennas and Propagation, Article ID 428284.

[13] Sudarshan A., and Prabhu A. (2017). Design and development of microstrip patch antenna, International Journal of Antennas, Vol. 3, No. 1.

[14] Werfelli H., et. al. (2016). Design of Rectangular Microstrip Patch Antenna. 2nd International Conference on Advanced Technologies for Signal and Image Processing, Jaipur, India.