

Enhancement of Micro-strip performance with improvement of antenna gain and feeding technique

Pawan Kumar Nishad, Ashish Suryavanshi

Department of Digital Communications
School Of Engineering and Technology, Vikram University Ujjain

Abstract-The goal of this observed is to design and analysis the Microstrip Patch Antenna which covers the Ultra Wide Band 3.1 to 10.6 GHz. This synopsis covers study of basics and fundamentals of microstrip patch antenna. A series of parametric study were done to find that how the characteristics of the antenna depends on its various geometrical and other parameters. The various geometrical parameters of the antenna are the dimensions of the patch and ground planes and the separation between them and it also includes the dielectric constant of the substrate material. The parametric study also contains the study of different techniques for optimizing the different parameters of antenna to get the optimum results and performance. This is a simulation based study. The design and simulation of the antenna is carried out using microwave Studio simulation software. Four antennas with different types of shapes were designed which cover the entire UWB range. The First designed antenna has two half circular patches which are overlapped to each other. A narrow rectangular slit is added to the patch to improve the performance of antenna.

Keywords- Polyimide Film, Antenna, FR4, Microstrip.

I. INTRODUCTION

Applications that require low-profile, light weight, easily manufactured, inexpensive, conformable antennas often use some form of a microstrip radiator. The microstrip antenna (MSA) is a resonant structure that consists of a dielectric substrate sandwiched between a metallic conducting patch and a ground plane. The MSA is commonly excited using a microstrip edge feed or a coaxial probe. The canonical forms of the MSA are the rectangular and circular patch MSAs. The rectangular patch antenna in Figure 1 is fed using a microstrip edge feed and the circular patch antenna is fed using a coaxial probe.

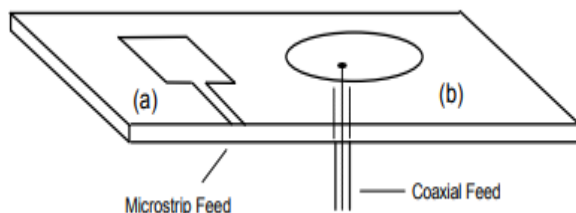


Fig.1. (a) A rectangular patch microstrip antenna fed with a microstrip edge feed.
(b) A circular patch microstrip antenna fed with a coaxial probe feed.

The patch shapes in Figure 1 are symmetric and their radiation is easy to model. However, application specific patch shapes are often used to optimize certain aspects of MSA performance. The earliest work on the MSA was performed in the 1950s by Gutton and Baissinot in France and Deschamps in the United States. [1] Demand for low-profile antennas increased in the 1970s, and interest in the MSA was renewed. Notably, Munson obtained the original patent on the MSA, and Howell published the first experimental data involving circular and rectangular patch MSA characteristics. [1] Today the MSA is widely used in practice due to its low profile, light weight, cheap manufacturing costs, and potential conformability. [2] A number of methods are used to model the performance of the MSA.

The simplest model of the MSA is the transmission line model, developed in the 1970s by Munson. [1] The radiating edges of the patch, located at and opposite the feed edge, are modeled as a pair of transmission lines excited 180° out of phase. [1] This method neglects field variations along the radiating edge, and feed effects. Another disadvantage is that an empirically determined correction factor is required to account for fringing fields at the edges of the patch. [1] Despite these assumptions, the transmission line model provides a useful zeroth order approximation to the behavior of the rectangular patch MSA. However, it is not applicable to the circular patch MSA or patches of arbitrary shape.

A more rigorous solution to MSA behavior is the magnetic cavity model. The MSA is modeled as a resonant TM_{mn} cavity with perfect electrically conducting (PEC) top and bottom surfaces and a perfectly magnetically conducting (PMC) ribbon around the edge. [4] The fields in the antenna are derived by solving for TM_{mn} modes in the cavity. The radiation is accounted for using a loss tangent in the material, or a reflection coefficient at the PMC ribbon. Within the cavity, the TM₀₀ mode represents static capacitance and loss in the conductors. The TM₁₀ and higher modes are radiative. [1] The magnetic cavity model works well for cavities of simple shape, such as the rectangular and circular patch MSA.

However, derivation of the TM_{mn} modes in an arbitrarily shaped cavity is often tedious. For patch antennas of arbitrary shape, numerical methods are used to solve the integral equations. The Finite Difference Time Domain (FDTD) method and the Method of Moments (MoM) are both applied in practice.

The greatest disadvantage of the MSA is narrow impedance bandwidth. Also, losses in the conductors and substrate cause reduced radiation efficiency. Finally, the classic resonant patch length is on the order of $\lambda/2$. This length is restrictive when applications require a compact antenna design.

The magic and mystery of Radio waves have captured imaginations from the earliest speculations of thinkers [1] to the present day. The marvel of Radio is taken for granted in the world of pervasive and instantaneous wireless communications. All around us quiver vibrations in the conveying voices, images, data and information. The magic of radio plucks these vibrations out of air and recover the original data. The wand responsible for this wizardry is the antenna. An antenna makes a Radio wireless device possible. A transmit antenna takes signal from a transmission line, converts them into electromagnetic waves, and broadcasts them into free space. On the other end of the link, a receive antenna collects the incident electromagnetic waves and converts them back to the signals.

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II. PROBLEM STATEMENT

Microstrip antenna (also known as a patch antenna) is one of the latest technologies in antennas and electromagnetic applications. It is widely used now days in the wireless communication system due to its simplicity and compatibility with printed circuit technology. Microstrip geometries which radiate electromagnetic waves were originally contemplated in the 1950s. The concept of microstrip antenna was first proposed by Deschamps [3] in the year 1953. Gutton and Baissinot presented a patent in on the microstrip in the year 1955. Early microstriplines and radiators were specialized devices developed in laboratories. No commercially available printed circuit boards with controlled dielectric constants were developed during this period. So this antenna didn't become practical till 1970s when it was developed further by Robert E. Munson [4, 5].

Development during this decade was accelerated by other researchers' by the availability of low-loss tangent substrate materials. Others factors for the development include improved photo-lithographic techniques, better theoretical modelling and attractive thermal and mechanical properties of the substrate. The first practical antenna was developed by Munson [6] and Howell [7]. Since then extensive research and development of microstrip antennas and their arrays have led to diversified application within the broad field of microwave antennas.

However, these antennas also have some limitations as compared to conventional ones. These are:

- i. They have narrow bandwidth.
- ii. The efficiency is low.
- iii. They have low gain.
- iv. They have low power handling capacity.
- v. They have low isolation between radiating elements and feed.
- vi. Complex feed structure required for high performance arrays.
- vii. Large ohmic loss in the feed structure of arrays.
- viii. Extraneous radiation from feed and junctions.
- ix. Excitation of surface waves

III. SOLUTION TO THE CHALLENGES

Various types of feeding techniques are available to feed microstrip antenna and resolve the problem of radiation feed. Each of them has their own merits or demerits. A number of factors are used to choose which type of feeding is suitable for the designed antenna. The main consideration is effectual power transfer from feed line to the antenna radiating element that is proper matching between the feed and antenna. Various techniques like impedance transformer, stubs are used for impedance matching. Feed structure should like that these matching

structure could be fabricated with radiating element easily. Spurious feed radiation and surface wave losses are also the major factors which depend on the feeding methods which affects the antenna characteristics. Surface waves decrease the efficiency of antenna and spurious feed radiation results in undesired radiation which will give rise to side lobe level and also increases level of cross polarization. Another main feature is that feed network should be well-suited to make an array, feeding methods can be divided into two categories: one is contacting feeds and the other is non-contacting feeds or electromagnetic coupled feed. In contacting feeds, the feed line is directly connected to the radiating element. The main drawback of contacting feeds is that it shows inherent asymmetry which produces the higher order modes that lead to an increase in cross polarization level. To minimize these non-contacting feeds are used. Microstrip line feed and coaxial probe feeding are two mainly used direct contact feedings and aperture coupled and proximity coupling are two non-contacting couplings which are described in brief below.

1. Microstrip line feeding

In this type of feeding, the radiating patch is directly fed by the microstrip feed line. It has a narrow width as compared to the patch. It is the simple and mostly used feeding method. Because the microstrip line can be treated as an extended part of the radiating patch and fabricated on the same substrate on the board. This feeding is simple to fabricate and it's easy to implement impedance matching techniques are very compatible with this type of feed. But this feed also has some drawbacks, suffers from spurious feed radiation and surface wave losses also has low bandwidth.

2. Coaxial probe feed

One of the widely used feeding for microstrip antenna. In this type of feeding, the core of the coaxial cable is directly connected to the patch using soldering and the outer cable is connected to the ground. The core conductor is inserted in the substrate via a hole. The main advantage of this feeding is that we can directly feed or connect the inner conductor to the feed point where the input impedance is equal to the characteristic impedance of the feed line.

As communications are growing day by day, the need for portable devices which can be carried everywhere is also increasing. To make the communication device easily portable and light weight, the microstrip antenna plays an important role. Our main aim is to design a microstrip antenna which is of 2.5 GHz frequency (ISM Bands) which is a free unlicensed band.

This 2.4 GHz frequency band which we are using can be used by any device for any application without any restriction. The great advantage of this antenna is it is thin and easy to manufacture. Patch antennas are planar antennas used in wireless links and other microwave applications. The drawback of MPA, it has narrow bandwidth and for practical application bandwidth

enhancement is necessary, so for extending the bandwidth many approaches have been utilized. The proposed in this paper is to design an antenna which overcomes the disadvantages. The different multiband techniques studied for converting single band to multiple bands are U, E and H patch over the substrate. The E-shaped patch antenna provides the highest bandwidth followed by U-shaped patch antenna and H-shaped patch antenna. E slot is used when the frequencies chosen are from different bands. But in this project, the frequencies for the proposed antenna are close together. E slot is formed by using 2 U-slots; hence it can lead to overlapping of the U-slots which can cause wrong radiation patterns. U-slots can also be designed to perform a number of functions including wideband, dual- and triple-band operations with small and large frequency ratios, as well as for circular-polarization applications. Though with reduction in the size of rectangular patch, resulting in asymmetric U-slot patch antenna fed with thicker probe, broadening the operating bandwidth is possible.

IV. LITERATURE SURVEY

Madhusudhana et al. [1] In this article, a rhombus-shaped fractal microstrip frequency reconfiguration patch antenna is presented. The proposed antenna depends upon the capacitance value of the varactor diode resonates at ten distinct frequencies as follows: 1.375GHz, 1.525GHz, 1.725GHz, 2.45GHz, 3.45GHz, 4GHz, 5.3GHz, 5.45GHz, 5.5GHz and 5.825GHz. Design and optimization of microstrip antenna with analysis for different capacitance values of varactor diode is carried out using IE3D simulation tool. The proposed design is realized using FR4 (Dielectric constant $\epsilon_r = 4.4$) substrate with dimension $(41 \times 41 \times 1.6)$ mm³. A single varactor diode inserted upon the slot is used to switch the operating frequency. The proposed design of antenna, both simulated and fabricated, is seen to have close agreement, and is appropriate to be used in L, S and C band applications.

Guizhi Xu et al. [2] With the rapid development of flexible/stretchable electronics, wireless technology for wearable systems starts to gain momentum. Here, a class of stretchable microstrip antennas composed of serpentine mesh layouts in both the patch and ground plane is designed.

Parismita A. Kashyap et al. [3] Structural modifications on microstrip patch antenna design for performance enhancement offer improvements and advantages only up to a certain limit. However, with the use of novel material in the patch area, the performance of a microstrip patch antenna can further be enhanced in terms of gain and bandwidth. In this paper, a nanomaterial-based slotted rectangular microstrip patch antenna is proposed for gain and bandwidth enhancement in Wireless Local Area Network (WLAN) applications.

M. Kamran Shereen et al. [4] This paper discusses a review of frequency configurability through switches for 5G applications. A new switching technique (varying values of lumped parameters) for frequency reconfiguration is analyzed and validated by investigation a difference between a simple (no reconfigurable) and a reconfigurable antenna for 60 GHz resonant frequency.

Saktioto et al. [5] A metamaterial is any material engineered with a property not discovered in naturally occurring materials. Its existence is important in the development and application of modern technology in this century. Furthermore, Its characteristics such as high sensitivity and gain can be potentially applied in antenna technology. In this research, the metamaterial implementation was used to improve low-profile microstrip antennas as ultra-wideband (UWB) applications. The proposed metamaterial consists of variations of one to four hexagonal shape split ring resonator (SRRH) elements.

This study was carried out through simulation and experiments which were operated in the frequency range 0.05–9 GHz. Based on the results, the proposed antenna with the variation of the SRR-H elements provides increased performance than the without SRR-H. The highest double negative (DNG) metamaterial characteristic of the SRR-H four-element structure provides the highest antenna performance compared to others. The given working frequency occurs at 5.98 GHz with an increase in bandwidth of 47.49% from without SRR-H. The antenna metamaterial structure also responds by providing an ultimate gain radiation pattern of 5.97 dBi at a 45-degree angle in the Quadrant II region. Thus, the performance of the proposed antenna shows the potential for use in UWB technology.

Mouaaz Nahas et al. [6] The microstrip patch antenna has been successfully used in modern wireless communication systems including the fifth generation (5G) applications. The focus of this paper is on the high-band millimeter waves of the 5G, particularly the 26 and 28 GHz as widely used frequency bands. The main goal of this study is to provide a significant improvement in the microstrip patch antenna gain by adding slots with L and I shapes to a single rectangular patch, being very common structure used in 5G antennas.

Wa'il A. Godaymi Al-Tumah et al. [7] A novel double annular-ring microstrip antenna, split into six sectors, is proposed to achieve multiband operation with high gain and impedance bandwidth. The gaps on the driven and parasitic patches excite resonant frequencies that are located in the Ku-, K, and Ka-bands thus making the antenna capable of these multiband applications. The present design is numerically and experimentally investigated. This investigation indicates that the suggested antenna achieves four operating bands, with

impedance bandwidths of 1.72 GHz (12.16–13.88 GHz), 2.04 GHz (19.28–21.32 GHz), 1.54 GHz (24.04–25.58 GHz), and 1.97 GHz (27.37–29.34 GHz) which correspond to the resonant frequencies of 13.10 GHz, 20.72 GHz, 25.00 GHz, and 28.85 GHz, respectively. Also, the new design achieves good values of gain (6.11–8.31) dB and a return loss of between 16.14 dB and 21.52 dB. The commercial tool Ansoft high frequency structure simulator is used to simulate the designed antennas and it compared with the obtained measurement data. The comparison shows close agreement between the simulations and measurements.

Wireless communications applications continue to grow very rapidly. These growing applications call for the continued miniaturization of the antennas, particularly as mobile devices become smaller or more densely packed with features. Compact and multiband antennas are needed to meet these size reduction requirements. This integration of compact antennas in small packages often calls for the use of multiple resonances and impedance matching methods. Therefore, compact and multiband antennas are of considerable interest in the research and application communities. Research into these antennas has been mostly concerned with the use of multiple resonance approaches [1–6]. While maintaining good radiation features and reduction of the antenna size are among the most pressing problems in modern wireless systems, arguably, one of the most important features of continuing wireless communication systems research is the incorporation of broadband and multi-band performance in compact systems [7,8].

V. RESEARCH DESIGN

Stages of the research –

- Identification of problem and selection of research area
- Collection of facts through literature surveys
- Designing the model of a framework which could act as a solution to the defined problem.
- Analysis of result by implementing the execution engine.

VI. CONCLUSION AND FUTURE WORK

This work describes seven different microstrip patch antenna designs with different shapes. Four of them are designed for use in UWB application without any band notches and three of them are designed to work in UWB with different band notches for different applications like (WiMAX) operating in 3.3-3.7 GHz, (WLAN) for IEEE 802.11a 5.15-5.825 GHz, Downlink X-band satellite communication systems in 7.25 - 7.75 GHz, 4.5- 4.8 GHz INSAT / Super-Extended C-Band (Indian National Satellite systems). The easiest and most common method to achieve a band notch is making a narrow slot of different shapes into the radiating patch of the antenna, will affect the current flow in the patch, different type of

shapes is used to make the slots are used to get the band-notched in the desired frequency band. These proposed antenna structure's simulation is carried out using the CAD software Microwave Studio in Computer Simulation Technology Simulator (CST), one commercial 3-D full-wave electromagnetic simulation software. The Simulated results are presented, shows the usefulness of the proposed antenna structure for UWB applications. The simulation results of band notch antenna indicate that the proposed antenna fulfils the excellent triple band notch characteristics for various frequency bands and showing the good return loss and radiation patters in the interested UWB.

New techniques should be explored to reduce the size of the UWB antennas to suit more practical applications. Metamaterial is a promising candidate since it can reduce the size greatly. Some optimization techniques should be used to optimize the optimum results like PSO, Genetic algorithm.

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