Design of Microstrip Patch Antenna with improved characteristics and its performance at 5.1GHz for Wireless Applications

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Abstract. Despite the many advantages of microstrip patch antennas, they do have some considerable drawbacks. One of the main limitations with patch antennas is their inherently narrowband performance due to its resonant nature. With bandwidth as low as a few percent; broadband applications using conventional patch designs are limited. The paper presents a broadband microstrip patch antenna for wireless communication. In its most basic form, a microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side. The patch is generally made of conducting material such as copper or gold and can take any possible shape. A rectangular patch is used as the main radiator. There are several advantages of this type of broadband antenna, such as planar, small in size, simple in structure, low in cost, and easy to be fabricated, thus attractive for practical applications. This rectangular microstrip patch antenna is designed for wireless communication application that works at 2.4 GHz with gain 11 dB for outdoor place. It also has a wide angle of beam in its radiation pattern. The results obtain that microstrip patch antenna can be used as client antenna in computer and workable antenna for wireless fidelity.

Keywords: Microstrip Antenna, Wireless Fidelity, Frequency

1. Introduction

One of types of wireless communication at 2.4 GHz is Wireless Fidelity (WiFi). A WiFi enabled device such as a personal computer, video game console, smartphone or digital audio player can connect to the Internet when within range of a wireless network connected to the Internet [1]. The coverage of one or more (interconnected) access points (hotspot) can round up an area as small as a few rooms or as large as many square miles. With the development of MIC and high frequency semiconductor devices, microstrip has drawn the maximum attention of the antenna community in recent years. In spite of its
various attractive features like, light weight, low cost, easy fabrication, conformability on curved surface and so on, the microstrip element suffers from an inherent limitation of narrow impedance bandwidth [2, 13].

2. Methodology Adapted

2.1 Antenna Shape
In its most basic form, a Microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side as shown in Figure 1. The patch is generally made of conducting material such as copper or gold and can take any possible shape. The radiating patch and the feed lines are usually photo etched on the dielectric substrate. Microstrip patch antennas radiate primarily because of the fringing fields between the patch edge and the ground plane. For good antenna performance, a thick dielectric substrate having a low dielectric constant is desirable since this provides better efficiency, larger bandwidth and better radiation [3].

Figure 1. Structure of Microstrip Patch Antenna

Consider Figure 2, below, which shows a rectangular microstrip patch antenna of length L, width W resting on a substrate of height h. The co-ordinate axis is selected such that the length is along the x direction, width is along the y direction and the height is along the z direction.

Figure 2. Microstrip Patch Antenna
An antenna is an electrical conductor or system of conductors. Transmitter Radiates electromagnetic energy into space. Receiver—Collects electromagnetic energy from space. The IEEE definition of an antenna as given by Stutzman and Thiele is, “That part of a transmitting or receiving system that is designed to radiate or receive electromagnetic waves”. The major parameters associated with an antenna are defined in the following sections.

2.2 Antenna Gain
Gain is a measure of the ability of the antenna to direct the input power into radiation in a particular direction and is measured at the peak radiation intensity. Consider the power well as gain at various points in space. It serves as the signature of an antenna and one look at it is often enough to realize the antenna that produced it. Density radiated by an isotropic antenna with input power $P$ at a distance $R$ which is given by $S = P / 4\pi R^2$. An isotropic antenna radiates equally in all directions, and its radiated power density $S$ is found by dividing the radiated power by the area of the sphere $4\pi R$. An isotropic radiator is considered to be 100% efficient. The gain of an actual antenna increases the power density in the direction of the peak radiation:

2.3 Antenna Efficiency
The surface integral of the radiation intensity over the radiation sphere divided by the input power $P$ of the elative power radiated by the antenna, or the antenna efficiency.

2.4 Effective Area
Antennas capture power from passing waves and deliver some of it to the terminals. Given the power density of the incident wave and the effective area of the antenna, the power delivered to the terminals is the product.

2.5 Directivity
Directivity is a measure of the concentration of radiation in the direction of the maximum.

2.6 Path Loss
We combine the gain of the transmitting antenna with the effective area of the receiving antenna to determine delivered power and path loss.
2.7 Return Loss
It is a parameter which indicates the amount of power that is “lost” to the load and does not return as a reflection. Hence the RL is a parameter to indicate how well the matching between the transmitter and antenna has taken place. Simply put it is the S11 of an antenna. A graph of s11 of an antenna vs frequency is called its return loss curve [4]. For optimum working such a graph must show a dip at the operating frequency and have a minimum d B value at this frequency. This parameter was found to be of crucial importance to our project as we sought to adjust the antenna dimensions for a fixed operating frequency (say 5.1GHz). A simple RL curve is shown in figure 4.

![RL curve of an antenna](image)

**Figure 4.** RL curve of an antenna

2.8 Radiation Pattern
The radiation pattern of an antenna is a plot of the far-field radiation properties of an antenna as a function of the spatial co-ordinates which are specified by the elevation angle (θ) and the azimuth angle (φ). More specifically it is a plot of the power radiated from an antenna per unit solid angle which is nothing but the radiation intensity. It can be plotted as a 3D graph or as a 2D polar or Cartesian slice of this 3D graph. It is an extremely parameter as it shows the antenna’s directivity as

![Radiation Pattern 7](image)

**Figure 5.** Antenna parameter

![Radiation Pattern 6](image)

**Figure 6.** Design parameter
Applications of Microstrip Patch Antennas

Microstrip patch antennas are increasing in popularity for use in wireless applications due to their low-profile structure. Therefore, they are extremely compatible for embedded antennas in handheld wireless devices such as cellular phones, pagers etc. The telemetry and communication antennas on missiles need to be thin and conformal and are often microstrip patch antennas. Another area where they have been used successfully is in satellite communication.

Feed Techniques

Microstrip patch antennas can be fed by a variety of methods. These methods can be classified into two categories - contacting and non-contacting. In the contacting method, the RF power is fed directly to the radiating patch using a connecting element such as a microstrip line. In the non-contacting scheme, electromagnetic field coupling is done to transfer power between the microstrip line and the radiating patch. The four most popular feed techniques used are the microstrip line, coaxial probe (both contacting schemes), aperture coupling and proximity coupling (both non-contacting schemes).

Microstrip Line Feed

In this type of feed technique, a conducting strip is connected directly to the edge of the microstrip patch. The conducting strip is smaller in width as compared to the patch and this kind of feed arrangement has the advantage that the feed can be etched on the same substrate to provide a planar structure.

Coaxial Feed

The Coaxial feed or probe feed is a very common technique used for feeding Microstrip patch antennas. The inner conductor of the coaxial connector extends through the dielectric and is soldered to the radiating patch, while the outer conductor is connected to the ground plane.

Aperture Coupled Feed

In this type of feed technique, the radiating patch and the microstrip feed line are separated by the ground plane coupling between the patch and the feed line is made through a slot or an aperture in the ground plane.
The most common type of microstrip antenna is the patch antenna [5-6]. Antennas using patches as constitutive elements in an array are also possible. A patch antenna is a narrowband, wide-beam antenna fabricated by etching the antenna element pattern in metal trace bonded to an insulating dielectric substrate, such as a printed circuit board, with a continuous metal layer bonded to the opposite side of the substrate which forms a ground plane. Common microstrip antenna shapes are square, rectangular, circular and elliptical, but any continuous shape is possible. Some patch antennas do not use a dielectric substrate and instead are made of a metal patch mounted above a ground plane using dielectric spacers; the resulting structure is less rugged but has a wider bandwidth. Because such antennas have a very low profile, are mechanically rugged and can be shaped to conform to the curving skin of a vehicle, they are often mounted on the exterior of aircraft and spacecraft, or are incorporated into mobile radio communications devices. Another type of patch antenna is the Planar Inverted-F antenna (PIFA) [7] The PIFA is common in cellular phones (mobile phones) with built-in antennas. The antenna is resonant at a quarter-wavelength (thus reducing the required space needed on the phone), and also typically has good SAR properties. This antenna resembles an inverted F, which explains the PIFA name. The PIFA [8] is popular because it has a low profile and a unidirectional pattern. These antennas are derived from a quarter-wave half-patch antenna. The shorting plane of the half-patch is reduced in length which decreases the resonance frequency. Often PIFA antennas have multiple branches to resonate at the various cellular bands. On some phones, grounded parasitic elements are used to enhance the radiation bandwidth characteristic. The folded inverted conformal antenna (FICA) [9-11] has some advantages with respect to the PIFA, because it allows a better volume reuse.

3. Testing and Results
In testing, microstrip patch antenna is used as a substitute for external omnidirectional antenna from wireless LAN card in Ad-hoc mode. In a wireless computer network, ad-hoc mode is a method for wireless devices to directly communicate with each other. Operating in ad-hoc mode allows all wireless devices within range of each other to discover and communicate in peer-to-peer fashion without in to broadband wireless routers.)
A computer is used as a producer of wireless signals, while other computers installed microstrip patch antenna as of omnidirectional antenna. In wireless card will be used as testing of microstrip patch antenna radiation pattern by detecting the signal strength of wireless signal sources.

Signal strength information is recorded in the table. After that, micro strip patch antenna is shifted by 5, and then the signal strength is displayed on the computer recorded back in the table. This is done repeatedly for every different angle to 360°. When omnidirectional antennas are connected to the wireless LAN card, we obtained by the same signal strength to all direction of -50 dBm. If the data in the table plotted in polar coordinates, it will be obtained microstrip patch antenna radiation pattern of microstrip patch antenna. Radiation pattern of microstrip patch antenna.

3.1 Advantages and Disadvantages of Patch Antennas:

Some of their principal advantages of microstrip patch antennas are given below:

- Light weight and low volume, Low profile planar configuration which can be easily made conformal to host surface, Low fabrication cost, hence can be manufactured in large quantities, Supports both, linear as well as circular polarization.
- Can be easily integrated with microwave integrated circuits (MICs) and Capable of dual and triple frequency operations and Mechanically robust when mounted on rigid surfaces.
Microstrip patch antennas suffer from a number of disadvantages as compared to conventional antennas. Some of their major disadvantages are given below:

- Narrow bandwidth, Low efficiency and Low Gain in and Extraneous radiation from feeds and junctions
- Poor end fire radiator except tapered slot antennas, Low power handling capacity and Surface wave excitation.

3.2 Apparature coupled feed for microstrip antennas

Microstrip patch antenna is connected to the wireless LAN card in the computer via cable RG-58 which has a characteristic impedance of 50Ω. Signal strength information is recorded in the table. After that, the microstrip patch antenna is shifted by 5, and then the signal strength is displayed on the computer recorded back in the table [12]. This is done repeatedly for every different angle to 360°. When omnidirectional antennas are connected to the wireless LAN card, we obtained by the same signal strength to all direction of -50 dBm. If the data in the table plotted in polar coordinates, it will be obtained microstrip patch antenna radiation pattern of microstrip patch antenna.

4. Conclusion

A theoretical survey on microstrip patch antenna is presented in this paper. After study of various research papers, it concluded that wide bandwidth and low power handling capacity can be overcome through an array configuration and slotted patch. Some characteristics of feeding technique and various antenna parameters are discussed. Particular microstrip patch antenna can be designed for each application and different merits are compared with conventional microwave antenna and wireless communication.

References

[1] Constantine J and Balanis A 1997 Antenna Theory, Analysis and Design John Wiley & Sons Inc. 2nd edition.
[2] Garg R, Bhartia P, Bahl IJ and Ittipiboon A 2001 Microstrip antenna design handbook Artech house.
[3] Ramesh GP 2020 Microstrip Patch Antenna for Peripheral Arterial Disease Diagnosis In Recent Trends and Advances in Artificial Intelligence and Internet of Things 241-251.
[4] Nakar PS 2004 Design of a compact microstrip patch Theantenna for use in wireless/cellular devices Master’s thesis, Florida State University.
[5] Pendem S and Ramesh GP 2020 75 GHz 5G Frequency Spectrum Analysis InRecent Trends and Advances in Artificial Intelligence and Internet of Things 165-176.
[6] Kraus JD 1988 Antennas and analysis 2nd Edition. Mc Graw Hill International.
[7] Flashy AM and Ramesh GP 2020 Multi Band Antenna System for Quality Evaluation Application of Apple Fruit In Recent Trends and Advances in Artificial Intelligence and Internet of Things 199-206.
[8] Lee KF and Man LK 2011 Microstrip Patch Antennas World Scientific 8-12.
[9] Yang F, Zhang XX, Ye X and Rahmat-Samii Y 2001 Wide-band E-shaped patch antennas for wireless communications IEEE transactions on antennas and propagation 49 1094-100.
[10] Rosu I 2011 PIFA-Planar Inverted F Antenna YO3DAC/VA3IUL, RF Technical Articles.
[11] Di Nallo C and Faraone A 2005 Multiband internal antenna or mobile phones Electronics Letters 41 514-515.
[12] Meade RD, Winn JN and Joannopoulos JD 1995 Photonic crystals: Molding the flow of light Princeton Univ. Press.
[13] Subramani P, Rajendran GB, Sengupta J, Pérez de Prado R and Divakarachari PB 2020 A Block Bi-Diagonalization-Based Pre-Coding for Indoor Multiple-Input-Multiple-Output-Visible Light Communication System Energies 13 3466.