INTERNATIONAL JOURNAL OF
INNOVATIVE RESEARCH & DEVELOPMENT

ISSN 2278 – 0211 (Online)

A Survey on Microstrip Patch Antenna Using Shape of Patch Antenna

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Abstract:
Antennas have a big role in wireless communications. Patch Antenna is very significant role in wireless communication, due to its simple characteristics, many applications in communications need very broadband bandwidth, but the narrow bandwidth of a microstrip antenna is one of the most important features that restrict its wide usage. Therefore the main motto of this paper is to increase the bandwidth of microstrip antenna by using various bandwidth increasing techniques. So to enhance the bandwidth and overcome this difficulty we have design different shape patch antenna such as Microstrip Stacked patch antenna, S-shaped patch antenna, Y-shaped patch antenna and W-slotted patch antenna and concluded that Microstrip Stacked patch antenna presents improved bandwidth at centre frequency of 2.4GHz,which is over 15% for $|S_{11}| \leq 10$ *dB ranging from 2.314 to 2.677GHz rather than other microstrip Patch Antenna.*

1. Introduction

Basic Antenna Theory In this section, basic antenna theory is discussed, followed by an understanding on the basics of microstrip line and microstrip antenna. It is important to understand this basic knowledge before proceeding to a more in-depth understanding of how microstrip antennas operate.

Antenna is the interface between transmitter lines and space. The basic concept to understand the antennas is that they are passive devices where they require no supply voltage to operate. Besides that, they do not alter nor process RF signals especially to amplify the energy of RF signals. In the other words, an antenna only converts an electromagnetic signal to an electrical signal at a receiver or electrical signal to an electromagnetic signal at a transmitter.

If they are 100% efficient, they radiate no more power than is delivered to their input terminal. This is because all the energy of the signal is absolutely absorb. Antenna can be defined as a conductor. Here the system of conductors used for radiating electromagnetic energy into space or for collecting electromagnetic energy from space.

A Microstrip Patch Antenna consists of a very thin patch that placed a small fraction of a wavelength above a conducting ground plane. The patch and the ground plane are separated by a dielectric. The patch conductor is normally copper and can assume any shape but for this project half rectangular patch is used and this simplifies the analysis and performance prediction. The patches are usually photo etched on the dielectric substrate and the substrate is usually non-magnetic. The relative permittivity of the substrate is an important parameter to consider. It is because relative permittivity will enhances the fringing fields that account for radiation. This type of antenna is characterized by its length L, width w, and thickness h,

2. Literature Survey

The use of microstrip structures to radiate electromagnetic waves was contemplated in the 1950’s. The earliest form of antennas was developed by Deschamps [1]. Later it was formally introduced by Munson as planar antennas on missiles. By early 1970’s, the importance of microstrip radiators was realized when researchers noted that almost half of the power in a microstrip radiator escapes as radiation. Thus, a microstrip radiating patch with considerable radiation loss was defined as microstrip antennas. Later, it was proved that this radiation mechanism was arising from the discontinuities at each end of the microstrip transmission line. At the time of its inception microstrip antennas were associated with many disadvantages, such as low efficiency, lower power, high Q, poor polarization purity, poor scan capability, and very narrow bandwidth.

With the evolution of design technology, microstrip antennas have achieved higher bandwidth, mechanical robustness and versatility with respect to resonant frequency, improved polarization pattern and wider impedance bandwidth. Since printed circuit technology is currently widely used to provide smaller and low profile antennas for personal and mobile communication devices, this research study will embark on designing a microstrip antenna for specified bandwidth purposes. The broadband microstrip patch antennas are finding increasing applications in satellite communications, GPS, Wimax [1], WLAN and commercial usages especially as base station antennas, antennas for access point. But before these antennas can be designed to meet our desired requirements, the basic theory associated with the technology needs to be understood.

3. Methodology

The methodology for designing an antenna is as follows:

- Design a Broadband Microstrip Patch Antenna to operate at centre frequency of 2.4GHz and 4.5GHz.
- Design of Stacked Patch Antenna at center frequency of 2.4GHz with impedance bandwidth of 15.95%.
- Design of Y-shaped Patch Antenna at center frequency of 2.4GHz with impedance bandwidth of 13%.
- Design of S-shaped Patch Antenna at center frequency of 4.5GHz with impedance bandwidth of 12%.
- Design of W-Slotted Patch Antenna at center frequency of 4.5GHz with impedance bandwidth of 22%.
- Study the effect of antenna dimensions Length (*L*), Width (*W*) and substrate parameters relative dielectric constant (ε_r), substrate thickness (*h*) on the radiation parameters of bandwidth.
- Simulate and optimize the designed broadband microstrip patch antenna using IE3D software.
- FEEDING TECHNIQUES IN MICROSTRIP ANTENNA

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)

3.1. E-Shaped Microstrip Patch Antenna

The geometry of the proposed antenna is shown in figure 1. Two parallel slots are incorporated in the rectangular microstrip antenna such that it closely resembles a slotted E shape. It consist of rectangular patch of dimensions *L* x *W* separated from the ground plane using foam substrates of thickness h.The E-shape is located in the center of the patch.

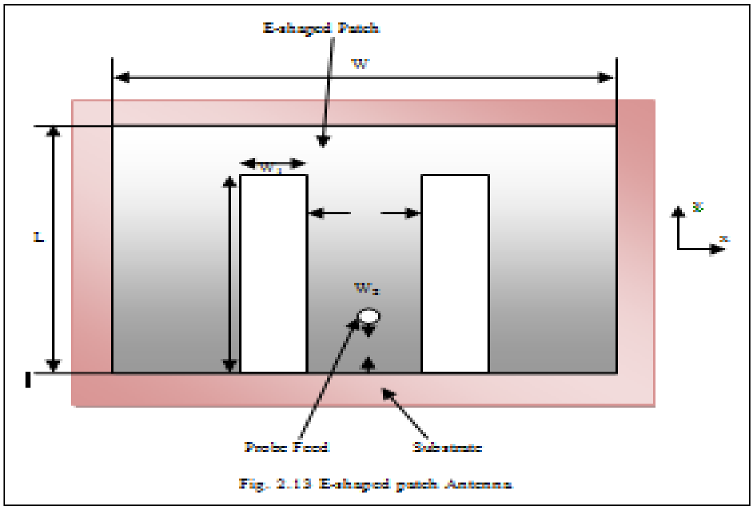

Figure 1

The location of the slots on the patch can be specified by parameter W_2. The width and length of the slots are denoted by W_1 and *l*. The rectangular patch is fed using 50Ω coaxial probe with inner diameter of 0.6mm. The slots play an important role to control the broadband behavior of the E-shaped patch antenna [2]. There are three parameters to characterize the slots, namely slot length, slot position, and slot width.When the slot length is small, the antenna only has one resonant frequency. When the slot length increases, another lower resonant frequency appears. In brief, the slot length is an important parameter to characterize the resonant frequencies of the E-shaped patch antenna. When slot position is small, the S_{11} at lower frequencies does not match well. When becomes larger, the two resonant frequencies become distinct and a broadband match is obtained [5]-[7]. In order to evaluate the performance of the proposed antenna, the antenna is simulatedthrough the simulation tool IE3D software. This antenna presents two distinct resonant frequencies as shown in figure 2, one is 2.12GHz and the other is 2.66GHz. The antenna frequency band covers the range of 2.05–2.64GHz and achieves a bandwidth of 32.3%.

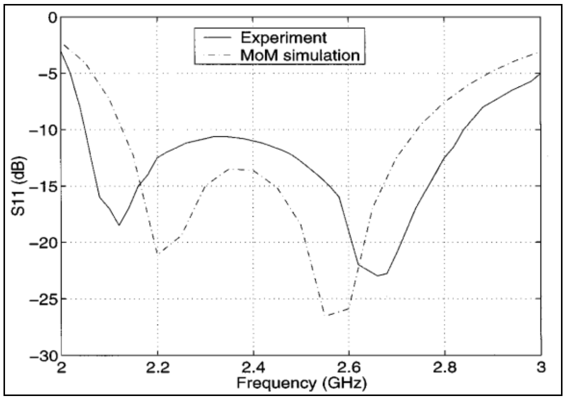

Figure 2

3.2. U-Slotted Microstrip Patch Antenna

The geometry of U-slotted patch antenna along with dimensions is depicted in figure 3. The antenna has a single patch of length *L*, width *W* and infinite ground plane separated by substrate of single dielectric materials. Foam is used here as a dielectric substrate of height h. The radiating patch is fed by a coaxial probe at a position (X_f, Y_f) for proper excitation of the antenna over a broad bandwidth. First rectangular microstrip patch antenna is designed than U-slot is cut inside the patch, which is symmetrical to center of patch.

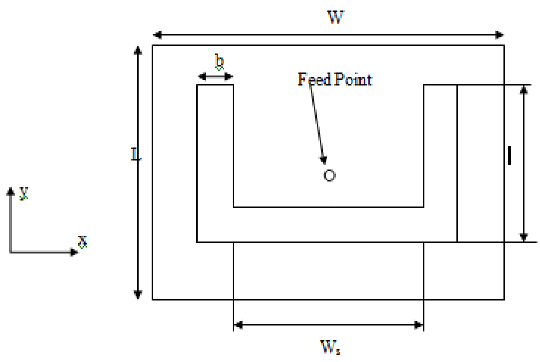

Fig. 2.15 U-slotted Patch Antenna

Figure 3

Rectangular Microstrip antennas without U-slot have large inductive reactance in the input impedance of patch, due to thick substrate. So U-slot introduces a capacitive component in the input impedance that compensates for the inductive component of the coaxial probe [2] & [3]. The simulation has been done by varying feeding positions in all direction over the microstrip patch antenna and s-parameter (S_{11}) is studied. The enhanced bandwidth for U-slotted microstrip patch antenna is obtained as 25.84% [4] is shown in figure

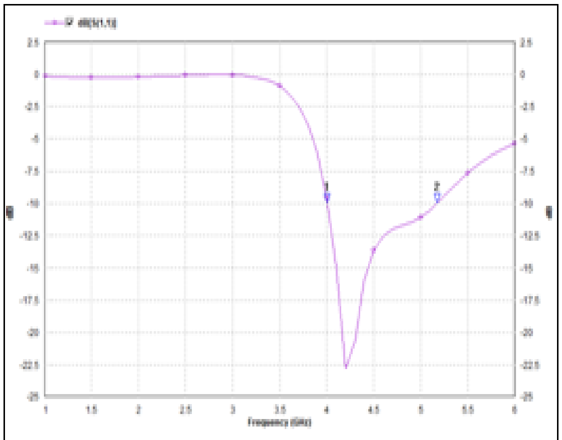

Fig. 2.16 Return loss of U-slotted patch Antenna

Figure 4

After extensive literature review and study the research was carried out in specific tasks of defining the width and length of patch first, then design the patch using different substrate and finally simulates the structure of antenna.

3.3. Microstrip Y-shaped Patch Antenna

A microstrip Y-shaped patch antenna fig 4 is fabricated on a FR4 substrate with thickness 1.524mm and relative permittivity is 4.4. It is mounted above the ground plane at height of 6mm. In this work, coaxial feeding technique is used because its main advantage is that, the feed can be placed at any place in the patch to match with its input impedance (usually 50Ω). The software used to model and simulate the Y-shaped patch antenna was IE3D, it can be used to calculate and plot return loss, VSWR, radiation pattern, smith chart and various other parameters

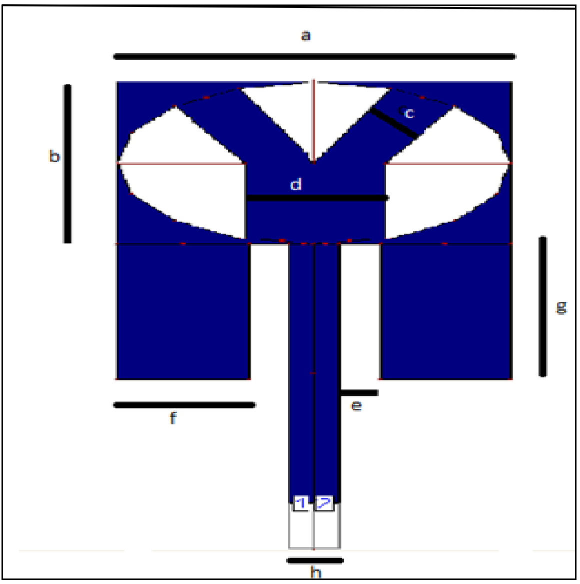

Figure 4: Y-shaped Patch Antenna

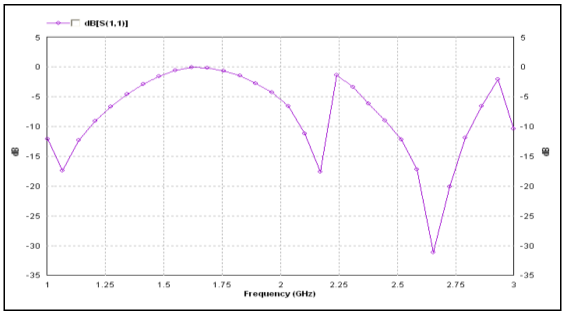

Figure 5: Return loss v/s. Frequency

3.4. Microstrip W-Slotted Patch Antenna

The geometry of W-slotted patch antenna is depicted in figure 6. The antenna has a single patch of length *L*, width *W* and infinite ground plane separated by substrate of two dielectric materials. First layer is consisting of foam as dielectric substrate of height 3.4mm and its relative permittivity is 1.07. Second layer is consisting of FR4 material as a dielectric substrate of height 1.6mm and its relative permittivity is 4.4. The radiating patch is fed by a coaxial probe at position (-12, 10) for proper excitation of the antenna over a broad bandwidth. I also checked feeding at a position (12, 10), then found the same result at both feeding point, this is because of W-slot is symmetrical to center of patch. Centre frequency chosen for this proposed antenna is 4.5GHz. First I designed a rectangular microstrip patch antenna than cut W-slot the inside the patch. A microstrip antenna without W-slot has large inductive reactance in the input impedance of patch, due to thick substrate. So W-slot introduces a capacitive component in the input impedance that compensates for the inductive component of the coaxial probe.

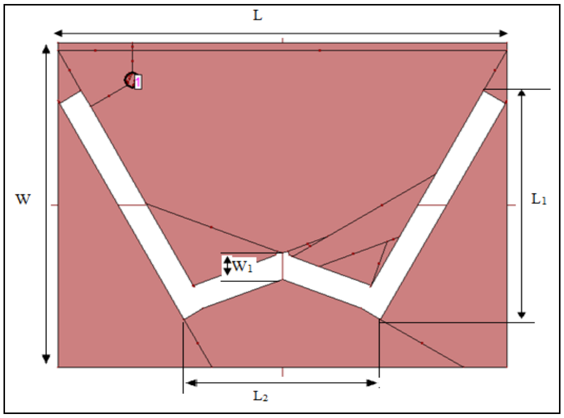

Figure 6

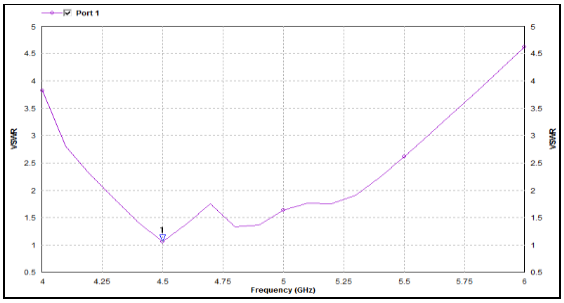

Figure 7: return loss vs. frequency

3.5. Microstrip Stacked Patch Antenna

The proposed antenna (fig 8) has a simple configuration, consisting of square patch and coaxial feeding is used for excitation. This multilayer antenna comprises three layers each of thickness 4mm. The first layer above the ground plane is consist of foam as a dielectric substrate with thickness 4mm, whose dielectric constant (ε_r) is 1.07 and a patch of size 54.5mm × 60mm is implemented on this layer. It is fed by coaxial probe feeding at position (15.7, 0). The middle layer is air gap positioned between bottom layer and top layer. The top layer also consist of foam as a dielectric substrate with thickness 4mm, whose dielectric constant is 1.07, beneath this layer another patch of size 40mm × 60mm is implemented. The designing of microstrip patch antenna mainly depends upon three parameters, namely dielectric substrate and its dielectric constant, height of the substrate and resonant frequency. In this dissertation the selected three parameters are:

- Resonant Frequency (f_r) = 2.4GHz,
- Dielectric constant (ε_r) = 1.07 &
- Height of the dielectric substrate (h) = 4mm.

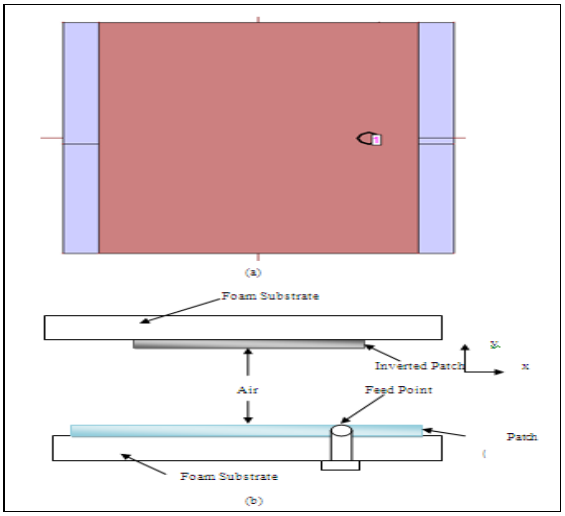

Figure 8: Microstrip Stacked Patch antenna

The bandwidth is a range of frequencies over which return loss is less than -10dB [2]. The S_{11} scattering parameter (return loss) of microstrip stacked patch antenna is shown in figure 9 and measured return loss is -22.78dB at resonant frequency 2.4GHz. The measured impedance bandwidth of the antenna is 383MHz, which is over 15.95% for $|S_{11}| \leq 10$dB ranging from 2.286 to 2.670GHz.

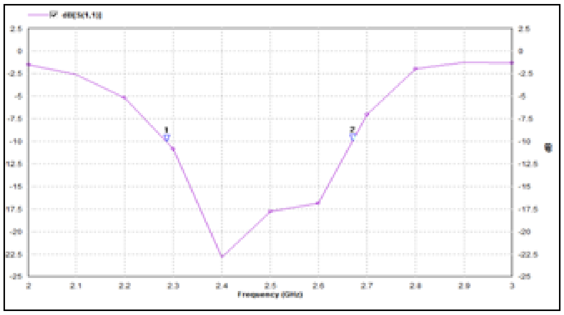

Figure 9: Return loss vs Frequency

4. Conclusion

From the work conducted on broadband microstrip patch antennas it is apparent the feasibility of microstrip patch antennas for use in broadband wireless communication systems utilizing the 2.45GHz ISM band and 4.5GHz UWB. Though the disadvantages often limit antenna performance and efficiency, it is however possible to overcome the difficulties of the antennas to suit the specifications. The 2.45GHz ISM band spans from 2.4GHz up to 2.5 GHz and UWB from 4.4GHz to 4.5GHz, offering a total active bandwidth of 100MHz. As a result the antennas were required to possess a minimum bandwidth of 100MHz. The antennas presented in this dissertation, they have bandwidth more than 100MHz.

The broadband antennas were successfully implemented results in terms of broadband performance.. Themicrostrip stacked patch antennawhich enhance the bandwidth and it attained a bandwidth of 363MHz with return loss of -22.78dB at resonant frequency 2.4GHz. The microstrip Y-shaped patch antenna demonstrated the impedance bandwidth of 380MHz about 13.4% with return loss of -31.98dB at resonant frequency 2.67GHz. The microstrip S-shaped patch antenna attained a bandwidth of 526MHz about 12% with return loss of -20dB at resonant frequency 4.3GHz. The Microstrip W-slotted Patch Antenna. It shows the good enhance impedance bandwidth of 1025MHz about 22.74% at resonant frequency 4.5GHz. Its return loss was -31.27dB. Overall all these four antennas are well suitable for wireless communication systems.

5. Future Scope

Design of antennas employing foam substrates to improve the bandwidth.,Design of slot antennas, Further array investigation onCircularly polarized antennas.It is expected however further work is required in order to improve the current broadband antennas. The following sections suggest a few issues to consider, if further attempts are made to improve the existing broadband antennas

6. References

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