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A survey on rectangular patch antenna using a various shaped patch antenna

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ABSTRACT

Microstrip patch antennas are most commonly used in dense, conformal and low- cost wireless applications because of the advantages over the traditional antenna. In this paper, the small introduction of microstrip antenna along with various patch shapes are discussed in detail. Numerous techniques are used to improve the parameters such as bandwidth, return loss, gain, and efficiency of the antenna. In this paper, different feeding techniques such as coaxial cable, line feed, Aperture coupled and proximity coupled feeding techniques along with their advantages and disadvantages are discussed. The formulas used for calculating length and width of patch and ground antennas are provided. The antennas with different slots on patch such as Triangular slot, E shape, Single U shape, Double U shape, fractal techniques are discussed.

Keywords: *Microstrip patch antenna, U slot, E shape, HFSS, IE3D, Feeding techniques*

1. INTRODUCTION

The idea of microstrip patch antenna came from the use of Printed Circuit Board (PCB) not only in the electronic components but also in the transmitting or receiving circuits. The general structure of microstrip patch antenna is shown in figure 1[1].

It is mainly comprised of three layers namely, ground, substrate, patch. Patch is a metallic layer that is fabricated on the substrate layer and excited by the feed line. The patch is available in any shape as shown in figure 2. It may be rectangular, square, circle, Triangle and ring [2].

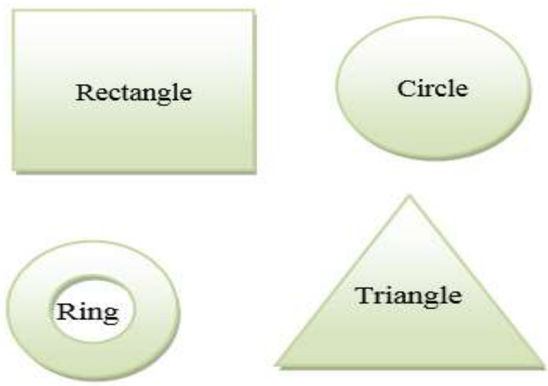

Figure 2: Different shapes of patch

Table -1: Advantages and disadvantages of microstrip patch Antenna

Advantage	Disadvantage
Low weight and low volume	Narrow bandwidth
Less costly when fabricated in large amount.	Lower gain as compared to other microwave antennas
Support both linear as well as circular polarization.	Low efficiency
Mechanically robust when mounted on a rigid surface	Low power handling capacity
Required no cavity backing	Excitation of surface wave
Ease of installation	Extraneous radiations from feeds and junctions
Capable of dual and triple frequency operation	
They use simple feeding techniques	

2. FEEDING TECHNIQUES USED IN MICROSTRIP PATCH ANTENNA

In microstrip patch antenna mainly four microstrip patch antennas are used named as Line feed, Co-axial cable, Aperture coupled and proximity coupled. Microstrip line feed is directly attached with the patch of the MPA. In coaxial feed, the inner conductor is connected to the patch whereas outer conductor is connected to the ground of the patch [3]. The advantages and disadvantages of feed lines are defined in the table below:

Table -2: Advantages and disadvantages of microstrip patch antenna [4]

Feed line Method	Advantages	Disadvantages
Coaxial feed	Matching is easy	Inductance is large for thick substrate
	Spurious radiation is less	Need soldering
Microstrip line	Use Monolithic technology	Spurious radiation from the feed line
	Fabrication is easy	
	Matching is easy by using controlling insert location	
Proximity Coupled	No direct contact between the feed line and patch	Required multilayer fabrication
	Used high dielectric substrate for the patch and low substrate for feed	
Aperture Coupled	Avoids deleterious effect of high dielectric constant and thus increased bandwidth and efficiency.	Required multilayer fabrication
	Indirect contact between feed and patch thus avoid probe reactance. No indirect radiations as a ground plane separate feed line from the radiating patch	Back lobe radiation is high

3. METHODS TO CALCULATE PATCH AND GROUND LENGTH & WIDTH IN PATCH ANTENNA

Line calculation for patch antenna in terms of length 'L' and width 'W' for center frequency 'fo' is determined by using the following formulas:

$$\Delta L = 0.412h \frac{(\in_{reff} + 0.3)\left(\frac{w}{h} + 0.264\right)}{(\in_{reff} - 0.258)\left(\frac{w}{h} + 0.8\right)}$$

Let the length of the patch is given by equation 1.5 [5].

$$Leff = L + 2\Delta L$$

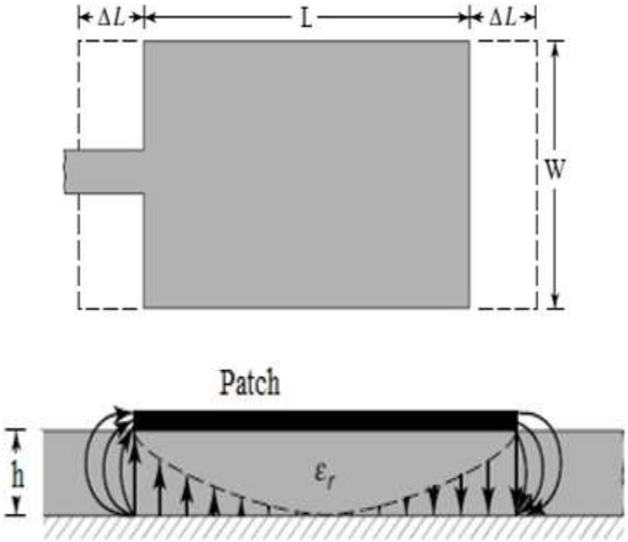

Figure 3: Physical and Effective Length of Microstrip Antenna

For a particular resonant frequency, the effective length of the patch is given by:

$$Leff = \left[\frac{c}{2 f_0 \sqrt{\in_{reff}}}\right]$$

$$W = \frac{c}{2f_o\sqrt{\frac{(\epsilon_r + 1)}{2}}}$$

$$L = L_{eff} + 2\Delta L$$

Ground length and width can be calculated as below:

$$L_g = 6h + L$$

$$W_g = 6h + W$$ [6]

4. PARAMETERS USED

To determine the performance of patch antenna a number of parameters are measured some of them are described below:

- **Return Loss:** This is the most commonly used parameters in antenna design. It is used to measure the mismatching of the feed line and patch. It is measured in dB. It is also known as reflection coefficient. If return loss gets zero, then all power will get reflected from the antenna and nothing will be radiated. It is expressed in dB and must be less than -10 dB. It can be explained in terms of incident power and reflected power as by equation defined below.

$$RL(dB) = -10\log_{10}\left[\frac{P_r}{Pi}\right]$$

Here P_i is incident power and P_r is reflected power and RL is return loss [7].

- **Voltage Standing Wave Ratio:** It is used to know the matching impedance of the transmission line in which the antenna is connected. It is the ratio of maximum voltage to minimum voltage in the transmission line and the equation associated with it is defined below

$$VSWR = \frac{(1+K)}{(1-K)}$$

- **Radiation Pattern:** Radiation pattern is a graphical representation of antenna radiation properties as a function of space coordinates. There are different shapes that radiation pattern can have like pencil beam and fan beam pattern. The radiation pattern is a graphical description of the relative field strength transmitted from or received by the antenna [8].

- **Gain:** Gain is defined as the ability of the antenna to concentrate radiated power in a given direction or to absorb incident power from that direction. Antenna gain is defined as the ratio of maximum radiation intensity in given direction of test antenna to that of maximum radiation intensity from that of an isotropic antenna.

- **Bandwidth:** Bandwidth of antenna is defined as the range of frequencies over which antenna can operate correctly. In other words, bandwidth can be considered to the range of frequency on either side of resonance frequency where antenna characteristics like gain, directivity, return loss, impedance, and polarization and radiation efficiency are within acceptable values as those at center frequency [9].

5. RELATED WORK

In this section, the design, substrate, software used, advantages/applications and outcomes are discussed that are obtained in the existing work. The existing Microstrip patch antennas find applications in WI-Max, wireless, WLAN, multiband and wideband applications.

6. CONCLUSION

This study provided an overview of microstrip patch antenna. In the last couple of years number of researchers tries to improve the performance of Microstrip patch antenna. They increased the performance parameters by changing the shape of the patch antenna like by inserting U- slot, V-slot, E slot or by using Defected Ground Structure (DGS) on the ground of the patch antenna. The maximum bandwidth up to 46 % has been improved along with 96 % of antenna efficiency.

Table 3: Comparative analysis of rectangular patch antenna

References	Design	Substrate	Software	Advantages/application	Outcomes
[10]	Triangular patch antenna	FR4 of thickness .6mm with ϵ_r	Ansoft version 2.2.0	The proposed antenna can be used for a Wi-MAX wireless communication system. Design is simple Cost is low	The parameters named as gain, return loss, and bandwidth is measured. The return loss up to -26 dB has been obtained at a resonant frequency of 2 GHz.
[11]	E shaped microstrip patch antenna has been designed	A substrate of dielectric permittivity 2.2 and thickness of 3.2 mm is used.	HFSS (High-Frequency Structure Simulator)	Find application in WLAN (Wireless Local Area Network) Large bandwidth Size of the antenna is small due to low dielectric constant	Antenna covers frequency ranges from 5.05 to 5.88GHz. The maximum gain of 7.5 dB
[12]	U slot rectangular patch antenna	The dielectric constant of the substrate is 2.33 and fed through the coaxial probe.	The 3-Dimensional EDTD method has been used to analyze the performance of the designed antenna	Low Profile Increase the quality factor of the antenna	Up to 27% of maximum bandwidth has been achieved. The computed gain is about 6.5dB.
[13]	E- shaped patch antenna	FR4 substrate	HFSS 13.0	The proposed antenna find application in cognitive radio	The frequency ranges from 1.6 GHz to 3.8 GHz has been covered. The radiation efficiency up to 96% has been obtained.
[14]	Fractal-based microstrip patch antenna	FR4 of thickness 1.58mm	HFSS	Used in Ultra Wide Band (UWB) applications	The proposed antenna resonate at 12 frequencies ranges from 1 to 10 GHz with a maximum return loss of -23.41 at 7.03 GHz.

[15]	U shaped parasitic patch antenna	FR4	HFSS	The size of the proposed antenna is very small (25 ×30mm) and hence it can be used for condensed transreceiver. Also used in commercial and industrial applications.	The bandwidth impedance of up to 27% has been achieved.

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