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An Overview of Design and Simulation of Microstrip Rectangular Patch Antenna

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Abstract–This paper provides a glimpse of the development of microstrip patch antennas over the years. The concept of the microstrip patch antenna originated in the 1950's, but significant research carried out in this field only in the 1970's. From then there has been thousands of papers written and published on this type of antennas. It is impossible to include all noteworthy developments here but the several topics like defect structures, defect ground plane including simulation softwares, feeding methods, polarization, reconfigurable designs, and size-reduction techniques described in this paper..

Index Terms–Microstrip, planar, patch antenna, high frequency structure simulator, IE3D.

1. INTRODUCTION

In high-performance spacecraft, aircraft, missile and satellite applications, where size, weight, cost, performance, ease of installation, and aerodynamic profile are constraints, low profile antennas may be required. Presently, there are many other government and commercial applications, such as mobile radio and wireless communications that have similar specifications. To meet these requirements, microstrip antennas can be used [1]. These antennas are low-profile, conformable to planar and non-planar surfaces, simple and inexpensive to manufacture using modern printed circuit technology, mechanically robust when mounted on rigid surfaces, compatible with MMIC designs, and when particular patch shape and mode are selected they are very versatile in terms of resonant frequency, polarization, pattern, and impedance.

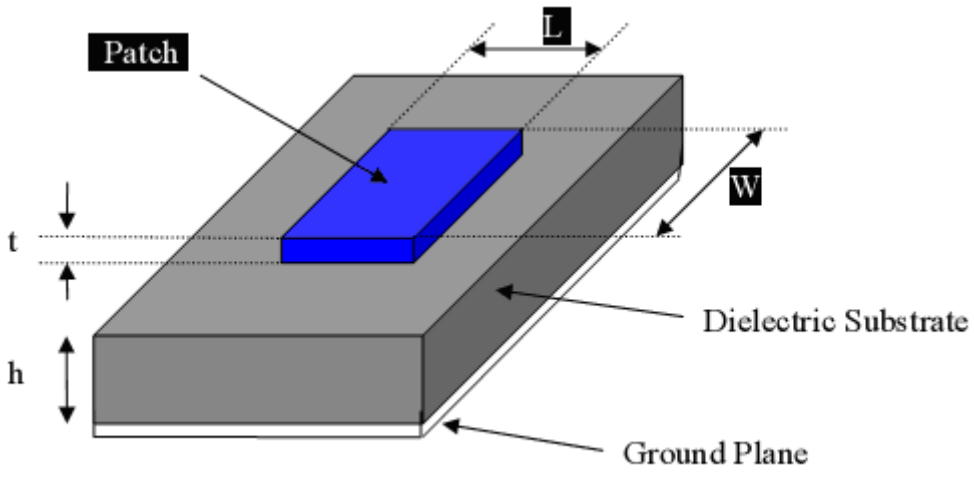


Fig-1: Typical structure of a microstrip patch antenna

In addition, by adding loads between the patch and the ground plane, such as pins and varactor diodes, adaptive elements with variable resonant frequency, impedance, polarization, and pattern can be adjusted [2]. Often microstrip antennas are also referred to as patch antennas because of the radiating elements(patches) photoetched on the dielectric substrate. In this work, rectangular

microstrip antennas are the ones under consideration. The patch dimensions of rectangular microstrip antennas are usually designed so its pattern maximum is normal to the patch [3]. Because of their narrow bandwidths and effectively operation in the vicinity of resonant frequency, the choice of the patch dimensions giving the specified resonant frequency is very important [4]. 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 [5].

2. SHAPE OF PATCH ANTENNA

In order to simplify analysis and performance prediction, the radiating patch is generally square, rectangular, circular, triangular, elliptical or some other common shape as shown in Figure 2. Microstrip patch antennas radiate primarily because of the fringing fields between the patch edge and the ground plane [6].

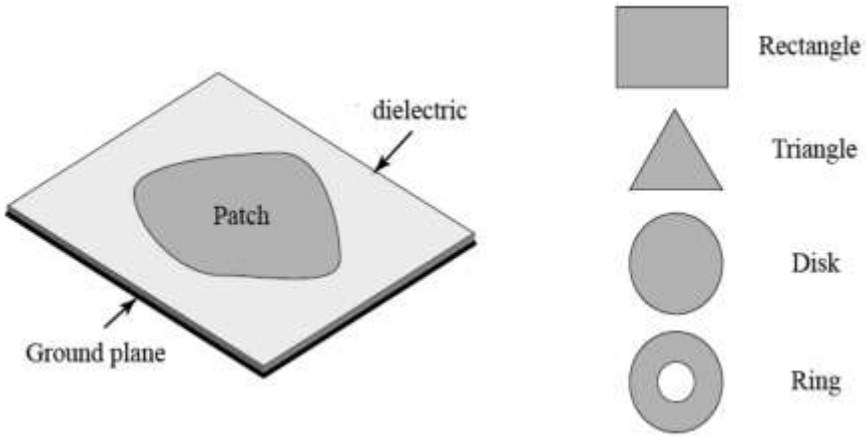


Fig-2: Basic shapes of patch antenna

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 [7]. However, such a configuration leads to a larger antenna size. In order to design a compact Microstrip patch antenna, higher dielectric constants must be used which are less efficient and result in narrower bandwidth. Hence a compromise must be reached between antenna dimensions and antenna performance [8].

3. PATCH ANTENNA FEEDING METHODS

Microstrip patch antennas, which are the most common printed-board radiating elements at RF and microwave frequencies, have two basic models to explain electromagnetic working: (i) transmission line; (ii)cavity. Both of them give good physical insight; however, the cavity model is more accurate, and at the same time more complicated [9][10]. Later a full-wave analysis has been developed including primarily the integral equations/moment methods to treat accurately single elements as well as finite and infinite arrays, stacked elements, arbitrary shaped elements, and coupling. In recent decades, neural network models have been developed especially for the calculation of resonant frequencies for the various shapes of antennas such as equilateral triangular, circular, and rectangular microstrip antennas, respectively [11].

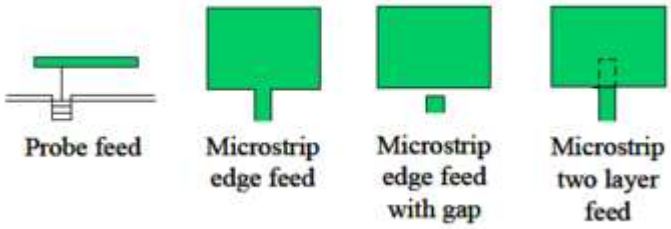


Fig-3: Various widely used feeding methods

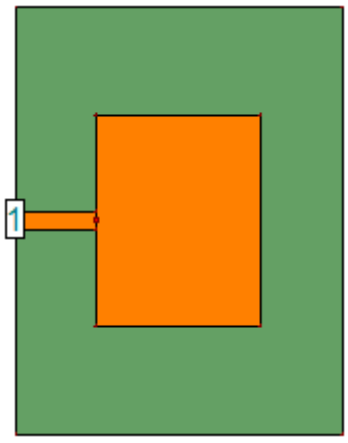
Micro strip printed antenna is operated by distinct feeding mechanisms such as micro strip line feeding, proximity coupled feeding, coaxial feeding, and aperture coupled feeding as shown in figure 3. Among all the feeding mechanisms the micro strip line feeding is considered as the most easiest one to operate the antenna.The following table gives a clarity about the various feeding methods.

4. DESIGN METHODOLOGY OF A PATCH ANTENNA

The rectangular microstrip antennas are made of a rectangular patch with dimensions width, *W,* and length, *L*, over a ground plane with a substrate thickness *h* and dielectric constants ε_r. Dielectric constants are usually used in the range $2.2 \leq \varepsilon_r \leq 12$. However, the most desirable ones are the dielectric constants at the lower end of this range together with the thick substrates, because they provide better efficiency and larger bandwidth, but at the expense of larger element size [12-15]. The three essential parameters for the design of a rectangular microstrip patch antenna are:

- Operating frequency of the antenna must be selected appropriately
- Dielectric constant of the substrate.
- The dielectric material should be selected as required

For the following design which has a dielectric constant of 4.4. A substrate with a high dielectric constant has been selected since it reduces the dimensions of the antenna. Height of dielectric substrate for the microstrip patch antenna is 1.6 mm with 1.5 GHz as the frequency of operation.



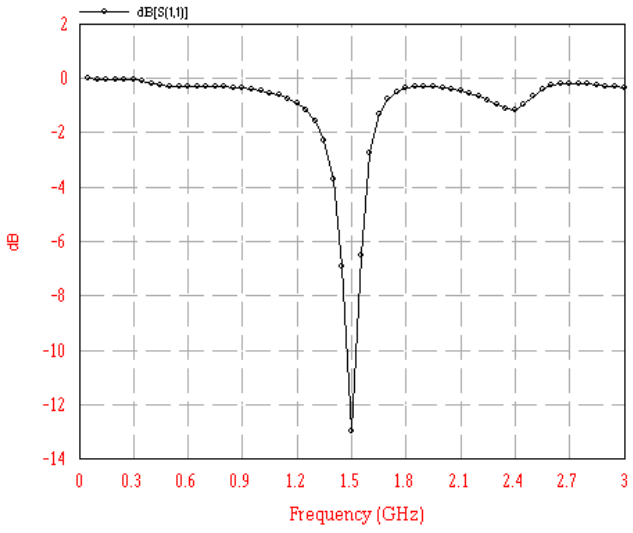


Fig-4: Conventional Patch Antenna **Fig-5:** Return Loss of the Patch Antenna for 1.5 GHz

Now we can calculate the length and width of patch using the above relations mentioned in the literature [16]. Length and width of the patch for 1.5 GHz frequency calculated as,

L = 47.4 mm
W = 61 mm
Microstrip Line Feed Width = 2.9 mm
Microstrip Line Feed Length = 12 mm

Now we can determine the position of feed point by using IE3D electromagnetic simulator, which provides the resultant graph between return loss and frequency as shown in figure 4 and figure 5.

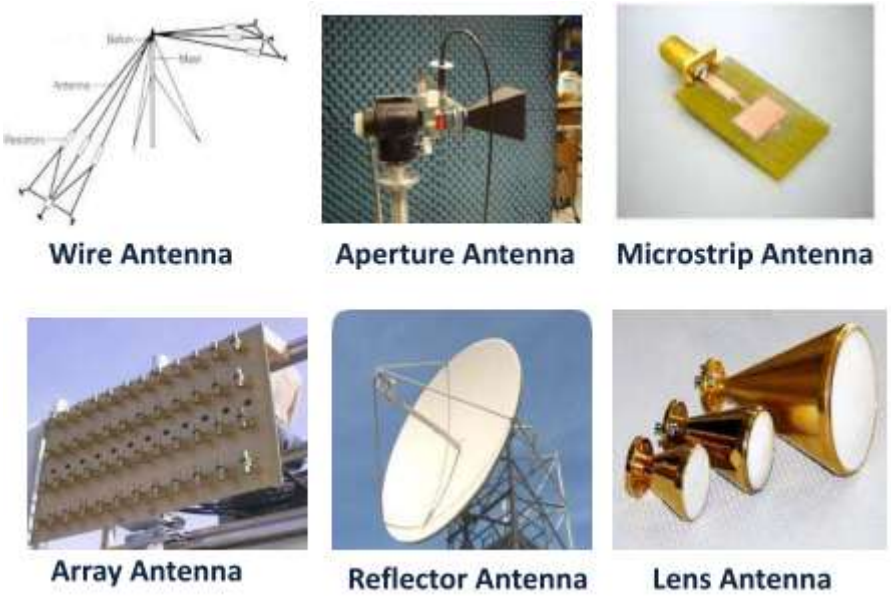


Fig-6: Applications of antennas in various microwave applications

An antenna is an electrical device which converts electric currents into radio waves and vice versa. It is usually connected with a radio transmitter or radio receiver. The first antennas were built in 1888 by german physicist Heinrich Hertz to prove existence of electromagnetic waves [17-19].

Microstrip antenna was invented by Bob Munson in 1972. It has multiple advantages like light weight and low volume, low profile planar configuration which can be easily made conformal to host surface [20]. It also has low fabrication cost, hence can be manufactured in large quantities using conventional printed circuit board technique. It supports both linear as well as circular polarization. It can be easily integrated with microwave integrated circuits (MICs). It has capability of dual and triple frequency operations. It is mechanically robust when mounted on rigid surfaces [21]. Certain limitation of these structure are narrow bandwidth, low efficiency, low gain, extraneous radiation from feeds and junctions, low power handling capacity and surface wave excitation.

5. CONCLUSION

In this paper various features and facts associated with a microstrip patch antenna have been discussed. As per our survey, generally the microstrip patch antenna provides low bandwidth, low gain and thereby it provides low efficiency. So in order to improve these characteristics there are certain bandwidth and efficiency enhancement methods like defected microstrip patch, defected ground structure techniques, making slots in the ground, slicing the corners of patch have been employed successfully over the years.

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