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A Review: Microstrip Antenna

Dilip Gupta[1], Ashish Duvey[2], Shweta Agrawal[3]

[1]M.Tech Scholar, Dept. of Electronics & Communication, SRCEM Banmore, M.P, India
[2,3]Assistant Professor, Dept. of Electronics & Communication, SRCEM Banmore, M.P, India

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Abstract - *In present scenario wireless communication is growing very fast, this communication is possible because of antennas. The performance of antenna plays vital role in communication systems. In wireless communication microstrip patch antennas are used as their results are very appreciable. This paper presents an over view of microstrip patch antenna, its uses, merits and demerits, common shapes of microstrip patch elements. Here important parameters of Microstrip patch antennas are explained that are essential for communication system.*

Key Words: wireless communication, microstrip patch antenna

1. INTRODUCTION

The antenna is defined by IEEE, Stutzman and Thiele [1] "That part of a transmitting or receiving system that is designed to radiate or receive electromagnetic waves".

Figure 1 shows the basic form of a Microstrip patch antenna that consists of a radiating patch on one side of a dielectric substrate and having a ground plane on the other side. Copper and gold is mainly used as conducting material used for patch making and of any shape. The radiating patch and the feed lines are usually photo etched on the dielectric substrate.

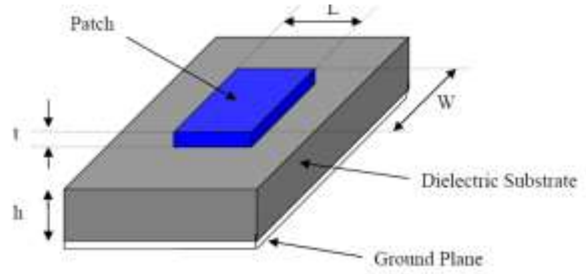

Fig.1 Structure of a Microstrip Patch Antenna

For simply analysis and performance calculation, the patch is of square, rectangular, circular, triangular, elliptical or other common shape as shown in Figure 2.

For a rectangular patch, the length L of the patch is usually $0.3333\lambda_0 < L < 0.5\,\lambda_0$, where λ_0 is the free-space wavelength. The patch is selected to be very thin such that $t << \lambda_0$ (where t is the patch thickness). The height h of the dielectric substrate is usually $0.003\,\lambda_0 \le h \le 0.05\,\lambda_0$. The dielectric constant of the substrate (ε_r) is typically in the range 2.2 ≤ ≤ 12 ε_r.

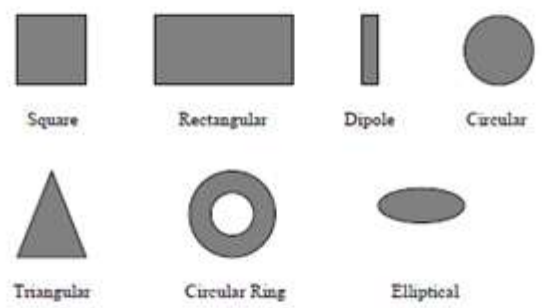

Fig-2: Common shapes of microstrip patch antenna

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 [2]. 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.

1.1 Advantages and Disadvantages

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. Some of their principal advantages discussed by [2] and Kumar and Ray [3] 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

• Capable of dual and triple frequency operations.

• 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 discussed by [3] and Garg et al [4] are given below:

• Narrow bandwidth

• Low efficiency

• Low Gain

• Extraneous radiation from feeds and junctions

• Poor end fire radiator except tapered slot antennas

• Low power handling capacity.

• Surface wave excitation

1.2 Uses of Microstrip Antennas

With remarkable research being completed on microstrip antennas, nowadays the benefits of microstrip antennas surpasses far more than its shortcomings. Primarily the uses of microstrip antennas were restricted to classifications such as rockets, aircrafts, shrewd weapons, missiles and satellites. In the present day, because of remarkable comfort in manufacture process and accessibility of worthy substrates these antennas find applications in commercial uses and are projected to substitute customary antennas in most of uses. The significant uses of microstrip antennas are as follows:

1.2.1 Mobile and Satellite Systems Applications

The practical application of mobile communications involves portable handheld equipment such as pagers, hand telephones, man pack radars, in automobiles like motor cars, vessel navigations and airplanes etc. Patch antenna arrays have also been designed for vehicles accidents minimizing systems, marine radars, altimeters, proximity fuses, telemetry, intruder alarms and secondary surveillance radars. In satellite applications the required beam shaped patterns such as fan beam and sector beam can be easily produced by microstrip antennas thereby decreasing the weight and cost of satellites.

1.2.2 Global Positioning Systems (GPS) Applications

It is expected that several GPS receivers will be used by living beings to determine accurately the positions of motor vehicles, ships and airplanes etc. The GPS has a combination of 24 satellites orbiting around earth every 12 hours at a height of 20,200 Km. A combination of 3 any four satellites are used to determine the position of an object with precision. The required receiving antennas need to be circularly polarized, low gain and small size operating at L Band. Hence some patch antennas with all mentioned requirements has been designed for GPS applications and are found to be most suitable.

1.2.3 Direct to Home (DTH) Applications

DTH has been providing television services to people at large. A traditional parabolic antenna is used as a receiver wherein the gain of about 33 dB is required at 11.5 GHz-12 GHz frequency range. However, this antenna is not only bulky but suffers severely from environmental causations like rain and snow. Hence, patch antennas arrays are a suitable replacement because these antennas take less space and even can be hanged on walls of building, less effected by environmental factors and cheap as compared to traditional parabolic antennas.

1.2.4 Patch Antenna Applications

In Medicine Exposure to microwave radiations in medical area can cause hyperthermia while treating infectious tumor. Hence the radiator used in treatment must be conformal to the surface, light weight and easy to handle. Earlier traditional radiators were used in medical fields but now flexible microstrip radiators have offered a suitable choice. The applications of microstrip antennas mentioned here are not at all complete because advantages continue to grow with time.

2. DIFFERENT MICROSTRIP ANTENNAS CONFIGURATIONS

A comprehensive list of various microstrip antennas being used is given in some references [8]. Microstrip antennas have a large number of variable parameters then that of conventional antennas. Broadly speaking microstrip antennas may be categorized into microstrip patch antenna, microstrip slot antenna, microstrip dipoles and microstrip travelling wave antennas.

2.1 Microstrip Patch Antenna (MPA)

MPA consists of a conducting patch of some flat or non-flat geometry on any side of substrate. A conducting ground plane is used on the opposite side of a substrate. Usually a patch antenna has a gain around 5 dB and 3-dB beam width around 70°-90°. Commonly used patch geometries are rectangle, triangle, ellipse, ring and disk however other geometries are 4 also used like elliptical ring, semi ring, ring-sector, pentagon, hexagonal with inner circle, eccentric circular ring H-shape, U-shape, L-shape, rectangular ring, rectangular ring with inner circle, isosceles triangle, cross-junction, T-shape and trapezoidal etc. Radiations phenomenon in patch antennas is due to fringing fields generated amid the edges of patch and ground plane. A simple co-axial feed antenna is shown in Figure 1.1.

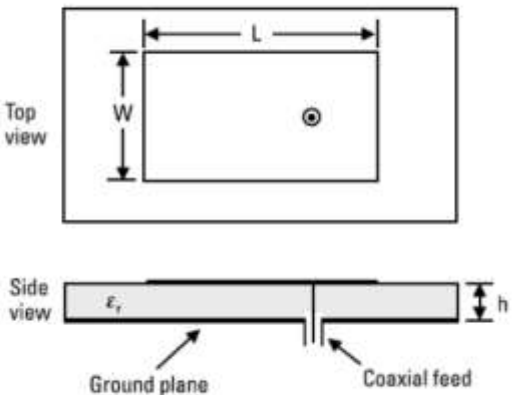

Fig.3 Upper and side view of coaxial feed antenna

2.2 Microstrip Slot Antennas

Produced slot antennas have a space in the ground plane backed by dielectric substrate. The slot may be a printed slot, rectangular slot, annular slot, tapered slot or annular ring slot. These antennas can be microstrip feed or CPW feed and have a bidirectional radiation pattern but with a reflector it can be made unidirectional. A combination of strips and slots helps in achieving a circular polarized antenna. Printed slot antennas can produces end fire radiation pattern, wide bandwidth and low cross polarization which is not possible in microstrip patch antenna.

2.3 Microstrip Travelling wave Antennas

These antennas consist of a long microstrip periodic structure terminated with resistive loads to suppress standing waves. The width of microstrip should be enough to support Transverse Electric modes. These antennas can be designed such that the main lobe can be moved in some direction from the broadside to end-fire.

3. 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 [2]. 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 Microstrip Line Feed

In this type of feed technique, a conducting strip is connected directly to the edge of the microstrip patch as shown in Figure 4.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. The purpose of the inset cut in the patch is to match the impedance of the feed line to the patch without the need for any additional matching element. This is achieved by properly controlling the inset position. Hence this is an easy feeding scheme, since it provides ease of fabrication and simplicity in modeling as well as impedance matching. However as the thickness of the dielectric substrate being used, increases, surface waves and spurious feed radiation also increases, which hampers the bandwidth of the antenna [2]. The feed radiation also leads to undesired cross polarized radiation.

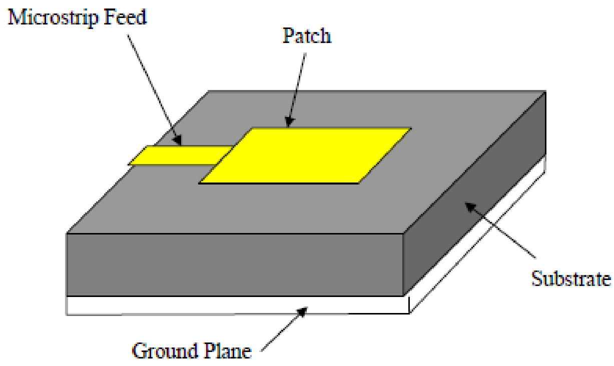

Fig.4 Microstrip Line Feed

3.2 Coaxial Feed

The Coaxial feed or probe feed is a very common technique used for feeding Microstrip patch antennas. As seen from Figure 5, 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. The main advantage of this type of feeding scheme is that the feed can be placed at any desired location inside the patch in order to match with its input impedance. This feed method is easy to fabricate and has low spurious radiation. However, its major disadvantage is that it provides narrow bandwidth and is difficult to model since a hole has to be drilled in the substrate and the connector protrudes outside the ground plane, thus not making it completely planar for thick substrates ($h > 0.02\lambda o$). Also, for thicker substrates, the increased probe length makes the input impedance more inductive, leading to matching problems [3]. It is seen above that for a thick dielectric substrate, which provides broad bandwidth, the microstrip line feed and the coaxial feed suffer from numerous disadvantages. The non-contacting feed techniques which have been discussed below, solve these problems.

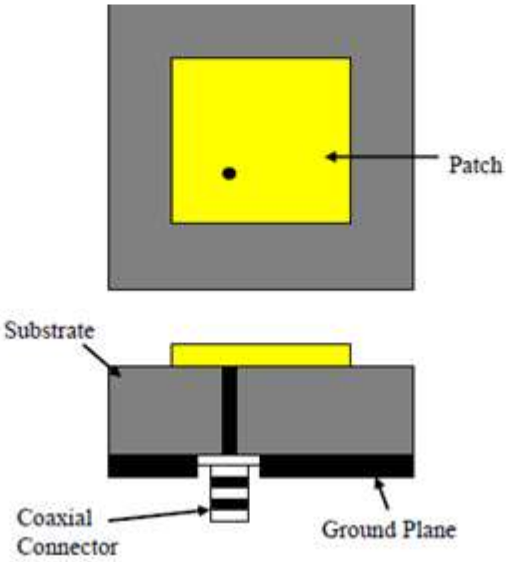

Fig. 5 Probe feed rectangular Microstrip patch Antenna

3.3 Aperture Coupled Feed

In this type of feed technique, the radiating patch and the microstrip feed line are separated by the ground plane as shown in Figure 6. Coupling between the patch and the feed line is made through a slot or an aperture in the ground plane. The coupling aperture is usually centered under the patch, leading to lower cross polarization due to symmetry of the configuration. The amount of coupling from the feed line to the patch is determined by the shape, size and location of the aperture. Since the ground plane separates the patch and the feed line, spurious radiation is minimized. Generally, a high dielectric material is used for the bottom substrate and a thick, low dielectric constant material is used for the top substrate to optimize radiation from the patch [2]. The major disadvantage of this feed technique is that it is difficult to fabricate due to multiple layers, which also increases the antenna thickness. This feeding scheme also provides narrow bandwidth.

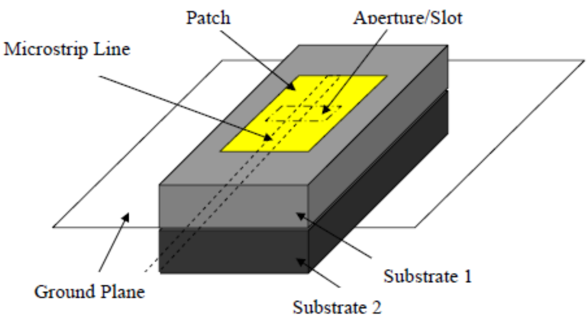

Figure 3.5 Aperture-coupled feed

Fig. 6 Aperture –coupled Feed

3.4 Proximity Coupled Feed

This type of feed technique is also called as the electromagnetic coupling scheme. As shown in Figure 7, two dielectric substrates are used such that the feed line is between the two substrates and the radiating patch is on top of the upper substrate. The main advantage of this feed technique is that it eliminates spurious feed radiation and provides very high bandwidth (as high as 13%) [2], due to overall increase in the thickness of the microstrip patch antenna. This scheme also provides choices between two different dielectric media, one for the patch and one for the feed line to optimize the individual performances. Matching can be achieved by controlling the length of the feed line and the width-to-line ratio of the patch. The major disadvantage of this feed scheme is that it is difficult to fabricate because of the two dielectric layers which need proper alignment. Also, there is an increase in the overall thickness of the antenna.

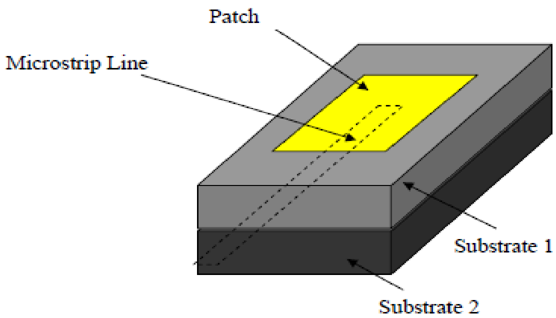

Figure 3.6 Proximity-coupled Feed

Fig. 7 Proximity –coupled Feed

4. CONCLUSION

From the above discussed applications, merits and demerits it is clear that microstrip antenna is very useful in wireless communication system. Here Feeding techniques are also explained that depends on the requirement of our designing of antenna and desired results. It also explains the different types of shapes of microstrip patch antenna that helps in designing different antenna of different frequency.

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