HCTL Open International Journal of Technology Innovations and Research (IJTIR)
http://ijtir.hctl.org
Volume 21, Issue 2, August 2016
e-ISSN: 2321-1814, ISBN (Print): 978-81-932623-1-3

An Overview of Microstrip Antenna

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Abstract

An astonishing growth in the area of broadband communication has been opened a access in the wide extent research and application of microstrip antenna. The adaptability of microstrip antennas added new aspect to it. The research article presents an introduction and overview of the Microstrip antenna. The features, advantages, limitations and the different types of feeding techniques are also discussed. The methods for the modelling of the microstrip antenna are also conversed. It also presents idea about the classification of antennas.

Keywords

Microstrip Antenna; Feeding techniques; Introduction; Overview.

Introduction

The magic and mystery of Radio waves have captured imaginations from the earliest speculations of thinkers [1] to the present day. The marvel of Radio is taken for granted in the world of pervasive and instantaneous wireless communications. All around us quiver vibrations in the conveying voices, images, data and information. The magic of radio plucks these vibrations out of air and recover the original data. The wand responsible for this wizardry is the antenna. An antenna makes a Radio wireless device possible. A transmit antenna takes signal from a transmission line, converts them into electromagnetic waves, and broadcasts them into free space. On the other end of the link, a receive antenna collects the incident electromagnetic waves and converts them back to the signals.

Overview

An antenna can be classified in number of ways [2]. The simplest of the antenna configuration is the wire antenna. This oldest structure is regarded as the simpler and cheaper. It is also the most versatile antenna for many applications.

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Classification in Terms of Wire Structure

In wire antenna there are three further classifications.

i. **Dipole or Linear Wire Antenna** - An antenna in the form of straight wire is termed as dipole or linear wire antennas.

ii. **Loop Antenna** - An antenna where the single wire is used to form a loop it is termed as loop antenna. The loop can take any form, but generally circular and square loop is mostly used for the ease of analysis and construction.

iii. **Helical Antenna** - An antenna where the wire is bend in a helical shape. It is also termed as helix antenna.

Classification in Terms of Aperture

One more classification is based on the aperture antenna, where the surface is a two dimensional one. The different antenna comes under it are as follows:

i. **Horn Antenna** - An antenna constructed from the waveguides are termed as horn antenna. A waveguide is a hollow metallic tube used. The shape of the horn antenna depends on the cross section of this waveguide through which the waves propagates when one end of the waveguide is trapped to a large opening and its acts as an antenna. The shape of the antenna is either rectangular or circular in shape.

ii. **Parabolic Disc Antenna** - An antenna having a shape of parabolic or disc shape. It is mostly used for very long distance reception or space reception. They are also termed as reflector antenna.

iii. **Microstrip Antenna** - An antenna having radiating patch etched on the substrate. The other side of the substrate is a metallic ground plane.

iv. **Array Antenna** - An antenna formed by multi elements. They are used at times when a single element is unable to give the desired features. The desired features can be achieved by using multi-element in the antenna structure.

Classification in Terms of Frequency

An antenna is also classified in terms of frequency, aperture, polarization and radiation. Out of these classes the frequency is the most important one. Therefore in term of frequency specific class, the antenna classification is as follow:

i. **Very High Frequency (VHF) & Ultra High Frequency (UHF) Antennas**: Yagi-Uda antennas, log periodic antennas, Helical antennas, Panel antennas, Corner reflector antennas, parabolic antennas, discone antennas are some of the antenna who are operating in this frequency. The range of VHF is from 30

Volume 21, Issue 2, August 2016
e-ISSN: 2321-1814, ISBN (Print): 978-81-932623-1-3

MHz to 300 MHz, and that of UHF is from 300 MHz to 3 GHz.

ii. **Super High Frequency (SHF) & Extremely High Frequency (EHF) Antennas**: In this range the frequency is in excess of 3 GHz. They are also called microwave antenna. The different antenna covers are parabolic antenna, pyramidal horn antennas, discone antennas, monopoles and dipoles antennas, microstrip patch antennas, fractal antennas.

Microstrip Antenna

Microstrip antenna (also known as a patch antenna) is one of the latest technologies in antennas and electromagnetic applications. It is widely used now days in the wireless communication system due to its simplicity and compatibility with printed circuit technology. Microstrip geometries which radiate electromagnetic waves were originally contemplated in the 1950s.

The concept of microstrip antenna was first proposed by Deschamps [3] in the year 1953. Gutton and Baissinot presented a patent in on the microstrip in the year 1955. Early microstrip lines and radiators were specialized devices developed in laboratories. No commercially available printed circuit boards with controlled dielectric constants were developed during this period. So this antenna didn't become practical till 1970s when it was developed further by Robert E. Munson [4, 5].

Development during this decade was accelerated by other researchers’ by the availability of low-loss tangent substrate materials. Others factors for the development include improved photo-lithographic techniques, better theoretical modelling and attractive thermal and mechanical properties of the substrate. The first practical antenna was developed by Munson [6] and Howell [7]. Since then extensive research and development of microstrip antennas and their arrays have led to diversified application within the broad field of microwave antennas.

Microstrip or printed patch antennas are used in almost all wireless systems with recent advancements in printed circuit technology. The purpose of microstrip or patch antenna is to radiate and receive electromagnetic energy in microwave range and it plays an important role in wireless communication applications. The performance and operation of a microstrip antenna is dependent on the geometry of the printed patch [8] and the material characteristics of the substrate onto which the antenna is printed.

Characteristics of Microstrip Antenna

The Microstrip antenna has proved to be an excellent radiator for many applications because of its several advantages [9] as compared to conventional microwave antennas. This result its many applications over the broad frequency range from around 100 MHz to 100 GHz.

Some of the principal advantages are:

i. They are light in weight.
ii. They occupy low volume.
iii. They are of low profile planer configuration.
iv. They can be made conformal to planar and non-planar surfaces.
v. Their ease of mass production leads to a low fabrication cost.
vi. They are easy to implement on the device.
vii. They are easier to integrate with other MICs on the same substrate.
viii. They allow both linear polarization and circular polarization with simple feed.
ix. They can be made compact for use in personal mobile communication.
x. They allow for dual- and triple-frequency operations.
xi. They act as an efficient radiator.
xii. They have low scattering cross section.
xiii. They are mechanically robust when mounted on rigid surfaces.
xiv. They are Resistant to shock and vibration.
xv. They are well compatible for embedded antennas in handheld wireless devices.
xvi. The feed line can be easily fabricated at the same time on the substrate.

However, these antennas also have some limitations as compared to conventional ones. These are:

i. They have narrow bandwidth.
ii. The efficiency is low.
iii. They have low gain.
iv. They have low power handling capacity.
v. They have low isolation between radiating elements and feed.
vi. Complex feed structure required for high performance arrays.
vii. Large ohmic loss in the feed structure of arrays.
viii. Extraneous radiation from feed and junctions.
ix. Excitation of surface waves.

Size of microstrip antenna comes in both advantages and disadvantages but there are some applications where the size of microstrip antenna is outsized for any use. The size of a microstrip antenna is inversely proportional to its frequency. At frequencies lower than microwave, microstrip patches don't make sense because of the sizes required. The narrow bandwidth is one of the main drawbacks of these types of antennas. A straight forward method of improving the bandwidth is increasing the substrate thickness [10]. However, surface wave power increases and radiation power decreases with the increasing substrate thickness, which leads to poor radiation efficiency. Therefore various other techniques are presented to provide wide-impedance bandwidths of microstrip antennas. Some of the techniques in principle are suitable feeding techniques and impedance matching networks, insertion of slot, slit and notches on the microstrip antennas. Feeding technique has a large number of adjustable parameters like length, width and shape. Other ways to overcome these limitations are decreasing dielectric constant of the substrate, increasing thickness of the substrate and width of the patch. Another problem to be solved is the low gain for conventional microstrip antenna element.

Cavity backing and lens covering [11] are the two ways to improve the gain. Cavity backing has been used to eliminate the bidirectional radiation and thereby providing higher gain compared with conventional microstrip antenna. The integrated lens microstrip antenna can be treated as composite antenna combined by microstrip radiator elements and dielectric lens, which is very useful for high frequencies applications. Antenna array [12] is another effective means for improving the gain of the microstrip antennas.

Applications of Microstrip Antenna

Numerous commercial requirements are fulfilled by the use of microstrip or printed patch antenna. Out of many shapes, rectangular shaped patch antennas are the most widely used antennas. Microstrip patch antenna fulfils most requirements for mobile and satellite communication system [13] and many kinds of microstrip antennas is designed for this purpose. Air-craft, spacecraft, satellite, and missile are others dominant applications, where the use of microstrip antenna is most suitable due to its size, weight, cost, performance, ease of installation, and low-profile nature. Also, there are other government and commercial applications in the area of mobile radio and wireless communications where the requirement of this antenna is suitable.

Some notable applications for which microstrip antennas are developed and found suitable are:

i. Satellite Communication Direct Broadcast Service.
ii. Mobile Communication Systems.
iii. Doppler and other Radars.
iv. Missile and Telemetry.
v. Remote Sensing and Environmental Instrumentation.
vi. Satellite Navigation Receivers.
vii. Radio Altimeter.
viii. Biomedical Radiators and Intruder Alarms.
ix. Personal Wireless Communication Systems and Service.

A large number of commercial needs are met by the use of these antennas [14]. The various application include the ubiquitous Global Positioning System (GPS), ZigBee, Bluetooth, WiMax, Wireless Fidelity (WiFi) and wireless communication systems. Navigational applications, such as asset tracking of vehicles as well as marine uses, have created a large demand for antennas. It finds extensive use in radio frequency identification (RFID) and radar system [15] in the area of manufacturing, transportation and medical. In short, microstrip antennas fulfil the demands of a flexible, less weight antenna system. In recent years printed monopole microstrip antenna finds use in Satellite Digital Audio Radio Services which is an alternative to audio commercial broadcasts in automobiles. The advantages of using antennas in communication systems will continue to generate new applications which require their use. They are the device which enables all the wireless systems that have become so ubiquitous in our society. The material costs for wired infrastructure also encourage the use of antennas in many modern communication systems. With the increase in the awareness of the possibilities of Microstrip antenna [16], particularly due to its radiation mechanism and functional performance, the number of applications will continue to grow. Wide bandwidth is required for certain applications in communications, electronic support and counter measures, radar and radiometry [17].

Structure of Microstrip Antenna

Most commonly used microstrip antenna is the rectangular and circular patches. These patches can be used for the simplest and the most demanding applications. For example, characteristics such as dual-frequency operations, circular and dual polarizations, broad bandwidth, beam scanning and so on are easily obtained in these patches. Any new numerical or analytical technique is standardized by first applying to these geometries. Undoubtedly the simplest microstrip antenna configuration is rectangular microstrip patch antenna. Hence this article deals with rectangular microstrip antenna.

The most basic form, of a Microstrip patch antenna consists of a radiating patch [18] on one side of a dielectric substrate; it has a ground plane on the other side as shown in Figure 1.

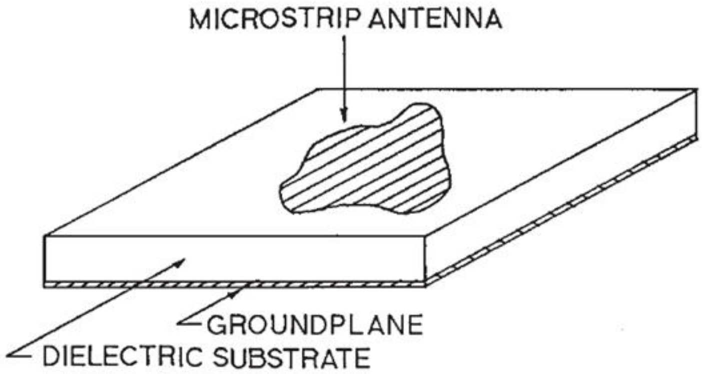

Figure 1: Geometry of a Microstrip Antenna

In its simplest form a microstrip antenna is a dielectric substrate panel sandwiched [19] in between two conductors. The lower conductor is called ground plane and upper conductor is known as patch. Commonly used frequencies for microstrip antenna is in between 1 GHz to 100 GHz. The patch is selected to be very thin. Patches are normally made of material such as gold or copper and design in to any shapes. These conducting metals are the main choice because of their low resistivity, resistance to oxidation, and ease in soldering and adhere well to substrate. The feed line and radiating patch is etched on the dielectric substrate. The radiating patch can be design in various shapes according to the desired characteristics but circular, square and rectangular shapes are common due to ease of fabrication and analysis. Their radiation characteristics are similar, despite the difference in the geometrical shape, because they behave like a dipole. If the thickness of the dielectric substrate is large the surface waves and spurious feed radiation increases, this will reduce the bandwidth of the antenna The feed radiation also leads to undesired cross polarized radiation.

Microstrip patch antennas radiate chiefly due to the fringing fields between the edges of the patch and the ground plane. A thick dielectric substrate with low dielectric constant is desirable for a better performance. This will delivers better efficiency and radiation. But this property has a tendency towards increasing the size of the antenna. For the design of a compact shape, substrate dielectric constants should be high. However such design will be less efficient and has narrower bandwidth. Impedance matching is required between antenna and feed line to ensure the maximum transfer of energy from source to radiating elements. An approximately selected port location will provide matching between antenna and feed line.

Through decades of research it was identified that the performance and operation [20] of a microstrip antenna is driven mainly by the geometry of the printed patch and the material characteristics on to which the antenna is printed. The patch geometries are generally rectangular but square, circular and triangular patches are also possible. Depending upon the characteristics of the transmitted electromagnetic energy, the radiating element may be square, rectangular, triangular elliptical or circular in shape and must be separated by a finite distance from the ground plane. A sheet of dielectric substrate is introduced between these two conducting layers.

Feeding Techniques for Microstrip Antenna

The feed guides the electromagnetic energy from the source to the region under the patch. Some of this energy crosses the boundary of the patch and radiated into space. The signal in a microstrip patch antennas is fed by a variety of methods. The methods of feeding are categorized into two categories namely contacting and non-contacting. In the contacting method, the input radio frequency power is fed directly to the patch by a connecting element such as a microstrip line. In the non-contacting scheme, often regarded as indirect one, electromagnetic field coupling is done to transfer the power between them microstrip line and the radiating patch.

The four most popular feeding techniques are the microstrip line feed, coaxial feed, aperture coupling feed, proximity coupled microstrip feed, and coplanar waveguide feed. Different feeding methods influence different antenna properties such as bandwidth, radiation pattern, polarization, gain and impedance. In practice, the coaxial and microstrip feed is the most commonly used feeding method. Matching is usually required between the antenna and the feed lines because input impedance differ from customary 50 ohm line impedance. An appropriately selected port location will provide matching between the antenna and its feed line. A brief description of each of these feeding methods is given in the section below.

Microstrip Line Feed

In this type of feed technique, as shown in Figure 2, a conducting strip is connected directly [21] to the edge of the Microstrip patch. The conducting strip is smaller in width as compared to the size of the patch.

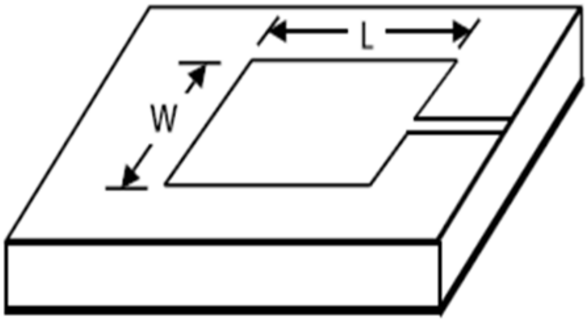

Figure 2: Microstrip Antenna fed by Microstrip Line Feed

This method is the easiest to fabricate as this feeding arrangement and radiating patch can be printed on same dielectric substrate. This arrangement provides a planar structure. Due to this advantage a large arrays may be designed using edge-fed patches. The drawback is the radiation from the feed line, which leads to an increase in the cross-polar level. Also, in the mm wave region of spectrum, the dimension of the feed line is equivalent to the dimension of the patch size, leading to increased undesired radiation. The feed arrangement to the patch may also have an inset cut in the patch. 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. This is an easy feeding scheme, because it provides ease of fabrication and simplicity in modelling as well as impedance matching.

Coaxial Probe Feed

The coaxial feed or probe feed [22] is the most common techniques used to feed printed patch antennas. It is shown in Figure 3. This feed can be given at any desired location within the patch to achieve impedance matching. 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.

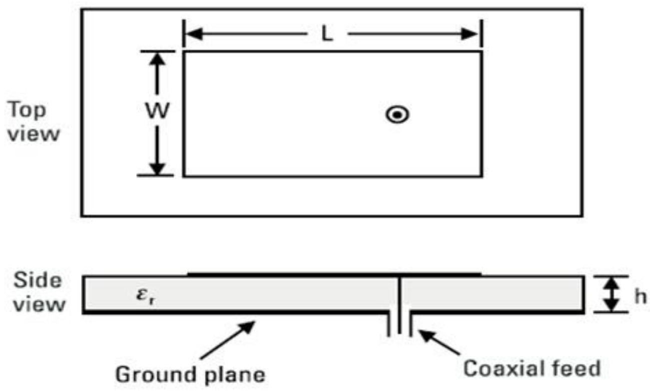

Figure 3: Microstrip Antenna fed by Coaxial Probe Feed

The coaxial feed or probe feed method gives low radiation loss. The main advantage of this feed is that it can be placed at any desired location inside the patch 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 gives less bandwidth and is not so easy to use since a hole has to be introduced into the dielectric substrate. Also the hole has to be drilled in the substrate and that the connector protrudes outside the bottom ground plane. It is not completely planar and this feeding arrangement makes the configuration asymmetrical. For thicker dielectric substrates, the increased coaxial feed or probe feed length gives the input impedance more inductive, resulting impedance matching problems. For thick substrates, which are generally employed to achieve broad band both the above methods of direct feeding the microstrip antenna have problems. In the case of a coaxial feed, increased probe length makes the input impedance more inductive, leading to the matching problem. For the microstrip feed, an increase in the substrate thickness increases its width, which in turn increases the undesired feed radiation. In large thickness dielectric substrate the microstrip line feed and the coaxial feed suffer from problem with probe reactance and surface wave excitation. The indirect feed, as discussed below solves these problems.

Aperture Coupled Microstrip Feed

In an aperture coupling [23] the field is coupled from the feed line to the resonating patch through slot in the ground structure, which is placed in between the two substrate. On bottom substrate feed line is there and on top substrate radiating patch. In the aperture-coupled microstrip antenna configuration, the field is coupled from the microstrip line feed to the radiating patch through an electrically small aperture or slot cut in the ground plane, as shown in Figure 4. The coupling aperture is generally centred under the patch. This help in lowering the cross-polarization because of configuration symmetry.

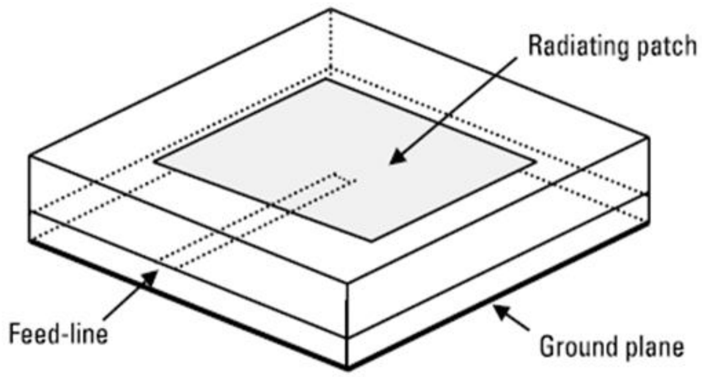

Figure 4: Microstrip Antenna fed by Aperture Coupled Microstrip Feed

The amount of coupling from the feed line to the patch is decided by the shape, size and location of the aperture. The slot aperture can be either resonant or non-resonant. The resonant slot provides another resonance in addition to the patch resonance thereby increasing the bandwidth, but this lead to an increase in back radiation too. As a result, a non-resonant aperture is normally used. The performance is moderately insensitive to small errors in the alignment of the different layers. Different substrate parameters can be chosen for the two layers for getting an optimum antenna performance. This feeding method gives increased bandwidth.

Proximity Coupled (Electromagnetically) Microstrip Feed Technique

A configuration of this non-contacting microstrip feed used two-layer substrate with the microstrip line on the lower layer and the patch antenna on the upper layer as shown in Figure 5. This feeding method [24] contains two dielectric layers i.e. one is a radiating patch layer and on lower layer feed line is fabricated with a ground plane on back side. The two substrates are separated by a common ground plane. The microstrip feed line on the lower substrate is electromagnetically coupled to the patch through a slot aperture in the common ground plane. The slot can be of any shape or size and these parameters can be used to improve the bandwidth. The radiation from the open end of the feed line does not interfere with the radiation pattern of the patch because of the shielding effect of the ground plane.

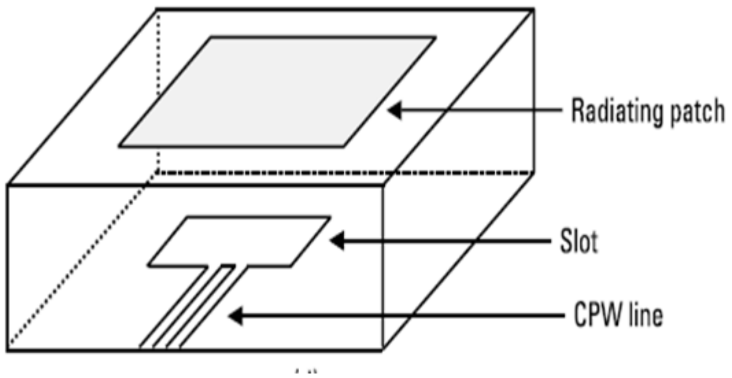

Figure 5: Microstrip Antenna fed by Proximity Coupled Microstrip Feed

This feature also improves the polarization purity [25]. The coupling aperture is usually centred under the patch, leading to lower cross polarization due to symmetry of the configuration. 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. The notable feature of this feed configuration is wider bandwidth, which is primarily because of an inclusive increase in the thickness of the microstrip patch antenna. This technique has the provision of choosing separate substrate for the patch and the feed line in order to achieve an optimize performances. The major drawback of this method is difficulty in fabrication due to multiple layers which need proper alignment. Also in this method the thickness of the antenna increases.

Coplanar Wave Guide Feeding (CPW)

The coplanar waveguide feed [26] has also been used to excite the Microstrip antenna. In this method, the coplanar waveguide is printed on the ground surface of the patch as shown in Figure 6. The line is excited by a coaxial feed and is terminated by a slot whose length is nearly one quarter of the slot wavelength.

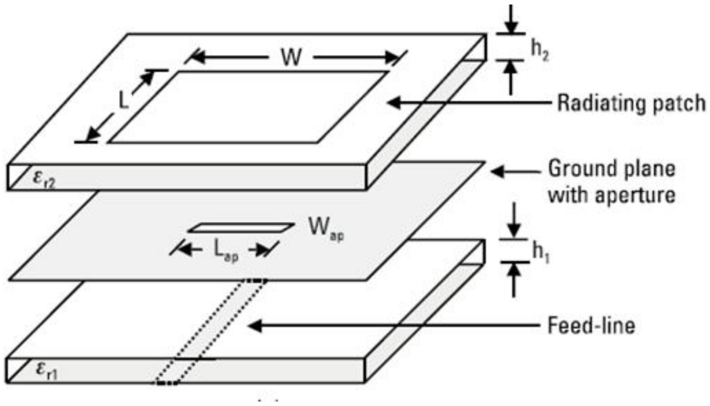

Figure 6: Microstrip Antenna fed by Coplanar Wave Guide Feed

This feeding method has been widely used for wireless communications due to its many features such as wide band width, simple structure, a single metallic layer, less numbers of soldering points, and easily compatible with other circuits etc. The main disadvantage of this method is the high radiation from the relatively longer slot. This can be better by reducing the slot dimension and adjusting its shape in the form of a loop.

A comparison between various types of feeding techniques [27] is made and shown in the Table 1.

Characteristic	Microstrip feed line	Co-axial Feed	Aperture coupled feed line	Proximity coupled feed	CPW feed
Spurious feed radiation	More	More	Less	Minimum	Less
Reliability	Better	Poor	Good	Good	Good
Ease of fabrication	Easy	Difficult	Difficult	Difficult	Difficult
Impedance matching	Easy	Easy	Easy	Easy	Easy
Bandwidth achieved	2-3%	2-3%	3-5%	15%	3%

Table 1: Comparison of Different Types of Feeding Techniques

Analysis of Rectangular Microstrip Antenna

The microstrip antenna has a thin dielectric substrate in between a two dimensional radiating patch and a ground plane. For analysis purposes [28]it is categorized as a two-dimensional planar component. The analysis method is divided into two groups. In the first group of method, the analysis is done on the basis of equivalent current distribution around the edges of the radiating patch. In this group the two widely used analytical techniques are the transmission line model and the cavity model. This group presents more physical insight but less accuracy. In the second group, the analysis is based on the distribution of the electric current distribution in between the radiating patch and the ground plane. This group is analysed by numerical methods based on the Method of Moments (MoM) and the Finite Element Method (FEM). This group requires more rigorous analysis and hence takes longer simulation time, but they give a more accurate result. Besides these to popular methods other methods such as Finite Difference Time Domain (FDTD) Method, Finite Integration Technique (FIT), Green Function Methods, etc. are also well used for the analysis.

Transmission Line Model

This model is simple in analysis and also presents a good physical insight. It is helpful in understanding the basic performance of the microstrip antenna. In this model [29] the radiating patch element is viewed as a transmission line resonator without any transverse field variations. The variation of the field is taken along the length. The radiating patch is represented by two slots separated by the length of the resonator. Fringing fields at the open circuited ends is the main source for the radiation. Originally this model was proposed for rectangular patches but later on it has been extended for all generalized shape of the patch. It is also most suitable for rectangular microstrip antenna. The drawback of this model is its accuracy. It is less accurate. Although it is easy to use, but in this case all types of configurations can't be analyzed as it does not take care of field variation in the orthogonal direction of propagation. In this approach, the microstrip antenna is represented as parallel plate transmission line, with no transverse field variation, and connected by two radiating slot of dimension *W* and height *h*. The slots are represented high impedance terminations of the transmission line. When excited, the two open ends which are normal to the direction of propagation radiates only. The resonant characteristic of it depends on the length *L* of the patch. The direction of the propagation of the electromagnetic wave is along the z-direction. A representation of this structure is shown in the Figure 7.

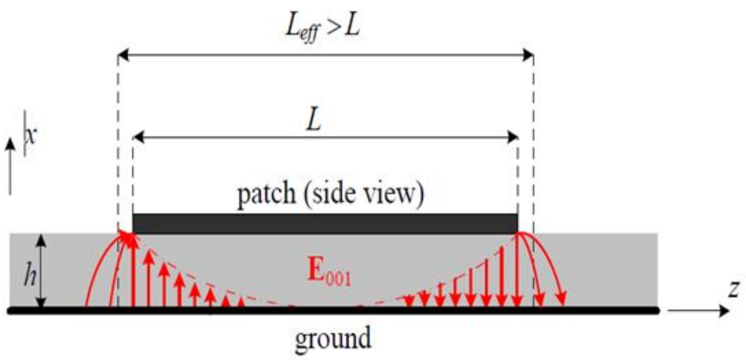

Figure 7: Representation of Microstrip Antenna using Transmission Line Model

Fringing effect accounts for the radiation from the edge of the patch. The resonant length is more than the physical length due to this fringing. The resonant length or the effective length of the patch is represented as L_{eff} .The electric field distribution along the patch is shown in the Figure 8along with the two lengths stated.

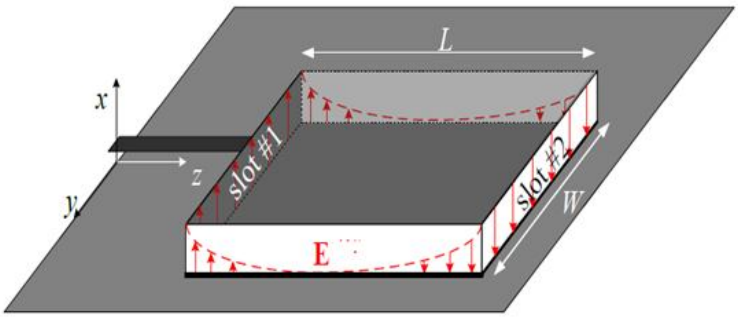

Figure 8: Electrical field Distribution in Microstrip Antenna using Transmission Line Model

Cavity Model

This model [30] gives more accurate result as compared to transmission line mode. It also gives good physical insight of the behaviour of the field on the radiating patch. Here the portion in between the radiating patch and the ground plane is treated as a cavity. The cavity is surrounded by magnetic walls around the periphery and from the top and bottom side it is enclosed with the electric walls. The field inside the cavity is uniform since the thickness of the substrate is small. The field underneath the radiating patch is expressed as a sum of the various resonant modes of the two-dimensional resonator. The fringing fields occurred around the periphery. The fringing fields and the radiated power are not enclosed inside the cavity but they are distributed at the edges of the cavity. The radiation loss from the antenna, the conductor loss, loss due the loss tangent of the dielectric substrate and sky wave loss are responsible for the total radiation of the antenna. The radiated power in the far field is computed from the magnetic current around the periphery. An alternate way of computing the radiation effect [31] is the introduction of the impedance boundary condition at the walls of the cavity. The only drawback of this model is its complex analyses. The Transmission line method is inadequate in its description of the real processes when a patch is excited. It takes into account only the modes where the energy propagates only in the longitudinal z- direction. The field distribution along the x- and y- axes is assumed uniform. Though the dominant is prevalent but the performance is also exaggerated by higher-order modes. The cavity model is a more common model [32] in analyzing the microstrip antenna, which imposes open-end conditions at the side edges of the patch. Here the patches are represented as a dielectric-loaded cavity with the electrical walls at the top and bottom of the cavity and the magnetic wall is around the periphery of the patch. A schematic diagram of the patch using this model is shown in the Figure 9.

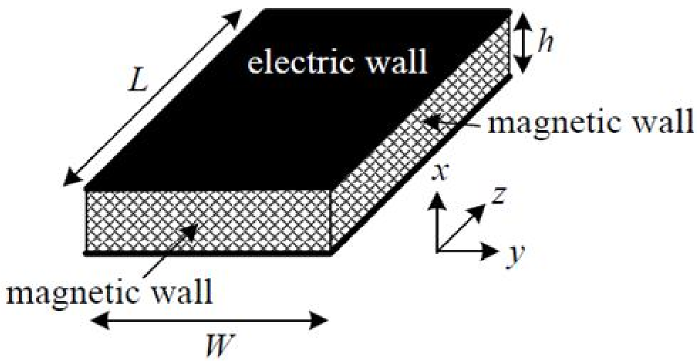

Figure 9: Representation of Microstrip Antenna using Cavity Model

In a magnetic wall the *H*-field is purely normal and *E*-field is purely tangential. The thickness of the substrate is assumed to be very small in this method of analysis. The waves generated and propagated below the patch experience considerable reflection at the edges of the patch. Merely a small fraction is being radiated. This model assumes that the *E*- field is purely tangential to the slots formed between the ground plane and the edges of the patch. Moreover, it considers only modes with no *H*- field component. Assuming the material of the substrate is truncated and limited to the periphery of the patch, the four side walls represent four narrow slots, and the radiation takes from these slots. Here the field inside the cavity is assumed to be zero, and the influence of the field in the outside infinite region is represented by the surface currents. These currents are on the surface of the cavity. The field is concentrated under the patch region as the height of the substrate is very small. The current density of the patch is maximum at its edges. The equivalent magnetic current density for the dominant TM_{001} is shown in the Figure 10. It reveals that the magnetic current densities are co-directed and are of equal magnitudes at slot no 1and 2. They are also of constant values along x-direction and y-direction. There are electrical walls at x = 0 and x = h. so at these two points the tangential Electric field components are zero.

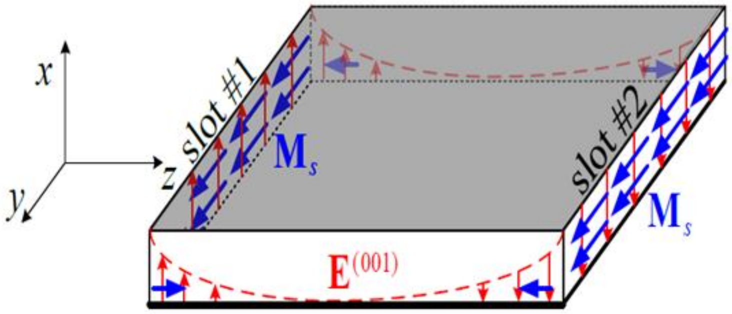

Figure 10: Magnetic Field Distribution in Microstrip Antenna using Cavity Model

In the case of Microstrip antenna, the dominant mode is the mode with the lowest resonant frequency. Since, the length of the patch is lower than the width of the patch i.e. *L* < *W*. Hence, the lowest resonant frequency mode is TM_{001}. This is the same mode resulted in the both the transmission line model and cavity model. The resonant frequency, *f*, for any given substrate of permittivity $\mathcal{E}_r$, corresponding to this is given as: $f = \frac{c}{2L.\varepsilon_r}$

Conclusion

The article is a concise summary of the antenna in general and microstrip antenna in particular. It briefly describes the microstrip antenna advantages and disadvantages in a crisp manner, the various techniques used in the feeding from the source. Along with the description of the feeding technique; a small note on the analysis method is also cited.

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