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# A Study on Microstrip Antenna for Badwidth Increment

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***Abstract:*** ***Wireless communication using multiple-input multiple-output (MIMO) wireless links has recently emerged as one of the most significant technical breakthroughs in modern communications. It has emerged as a new paradigm in rich multipath environment. All radiocommunications systems as like 3GPP UMTS or WLAN, provides higher data rates.As compared to conventional methods, high data rates can be achieved by employing higher modulation techniques and this can be achieved by deploying MIMO system .A MIMO system is able to provide improved power and bandwidth efficiencies without use of extra bandwidth. Spatial Diversity and Spatial Multiplexing define the MIMO system. Spatial Diversity is very efficient in reducing fading in multipath environment. Besides the advantages of spatial diversity in MIMO systems, they can also offers a remarkablygain in terms of information rate or capacity. MIMO systems enable high spectral efficiency at lower required energy per information bit. The channel capacity can increase by increasing signal to noise ratio (SNR) in case of Spatial Multiplexing and it can use efficiently with or without the knowledge of channel information at transmitter side. Spatial Multiplexing can also be combined with precoding when channel is known and with diversity coding when decoding reliability is in trade-off. The channel capacity of a multiple antenna system with transmit and receive antennas can be increased by the factor of without using additional transmit power or spectral bandwidth. The main aim of MIMO system is to increase the diversity gain and range of system. The capacity of a fading channel depends on CSI present at either of the side of communication link. Capacityincreases linearly with signal-to-noise ratio (SNR) at lowSNR, but increases logarithmically with SNR at highSNR. In this thesis, the channel capacity increases or decreases due to varying parameters such as increasing number of antennas, increasing SNR values has studied. The ergodic, outage capacity of the system, and the correlation effects on capacity has analyzed. If value of correlated fading parameter increases, the ergodic and the outage capacity decreases. When CSI is known to the transmitter capacity increases as compared to that when it is unknown is shown through simulation.***

***Keywords: MIMO channel capacity, deterministic capacity, Ergodic capacity, CSI, Correlation, ZF, MMSE-SIC.***

## I. INTRODUCTION

In recent years, the current trend in commercial and government communication system has been to develop low cost, minimal weight, low profile antennas that are capable of maintaining high performance over a large spectrum of frequencies. This technological trend has focused much effort in to the design of microstrip (Patch) antennas. With a simple geometry, patch antenna offer many advantages, not commonly exhibited in other antenna configurations. For example these are extremely low profile, lightweight, simple and inexpensive to fabricate using modern day printed circuit hoard technology, compatible with microwave and millimeter – wave integrated circuit(MMIC), and have the ability to conform to planar and non-planar surfaces. In addition, once the shape and operating mode of the patch are selected, designs become very versatile in the terms of operating frequency, polarization, pattern and impedance. The variety in design that is possible with microstrip antennas probably exceeds that of any other type of antenna element.

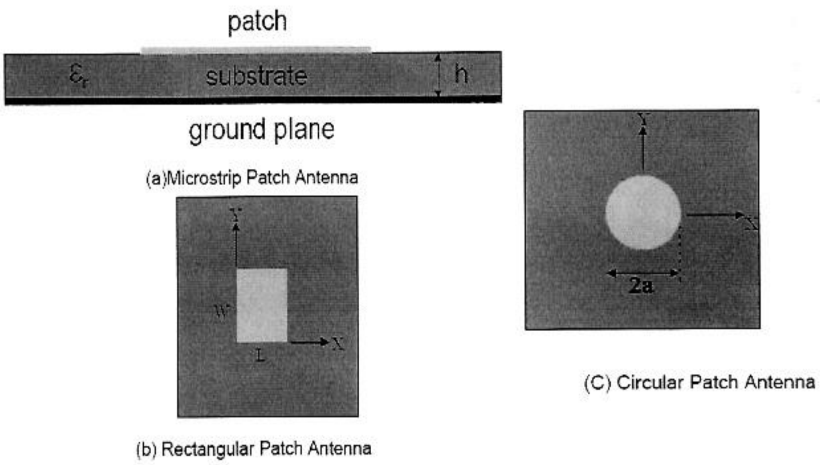


Fig.1 Rectangular& Circular Patch Antenna

 

Microstrip antennas arc among the most widely used types of antennas in the microwave frequency range, and they are often used in the millimetre-wave frequency range as well [1, 2, 3]. (Below approximately I GHz, the size of a microstrip antenna is usually too large to be practical, and other types of antennas such as wire antennas dominate). Also called patch antennas, microstrip patch antennas consist of a metallic patch of metal that is on top of a grounded dielectric substrate of thickness h, with relative permittivity and permeability Cr and gr as shown in Figure (usually pr-1). The metallic patch may be of various shapes, with rectangular and circular being the most common, as shown in Figure 1.

Most of the discussion in this section will be limited to the rectangular patch, although the basic principles are the same for the circular patch. (Many of the CAD formulas presented will apply approximately for the circular patch if the circular patch is modelled as a square patch of the same area). Various methods may be used to feed the patch, as discussed below. One advantage of the microstrip antenna is that it is usually low profile, in the sense that the substrate is fairly thin. If the substrate is thin enough, the antenna actually becomes "conformal," meaning that the substrate can be bent to conform to a curved surface (e.g., a cylindrical structure). A typical substrate thickness is about 0.02 $\lambda 0$. The metallic patch is usually fabricated by a photolithographic etching process or a mechanical milling process, making the construction relatively easy and inexpensive (the cost is mainly that of the substrate material). Other advantages include the fact that the microstrip antenna is usually lightweight (for thin substrates) and durable.

Disadvantages of the microstrip antenna include the fact that it is usually narrowband, with bandwidths of a few percent being typical. Some methods for enhancing bandwidth discussed later, however. Also, the radiation efficiency of the patch antenna tends to be lower than some other types of antennas, with efficiencies between 60% and 90% being typical.

### 1.1 Applications

Vertical polarization is most often used when it is desired to radiate a radio signal in all directions such as widely distributed mobile units. Vertical polarization also works well in the suburbs or out in the country, especially where hills are present. As a result, nowadays most two- way Earth to Earth communications in the frequency range above 30 MHz use vertical polarization.

Horizontal polarization is used to broadcast television in the USA. Some say that horizontal polarization was originally chosen because there was an advantage to not have TV reception interfered with by vertically polarized stations such as mobile radio. Also, manmade radio noise is predominantly vertically polarized and the use of horizontal polarization would provide some discrimination against interference from noise.

## II. 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 3.1. 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 planner structure.

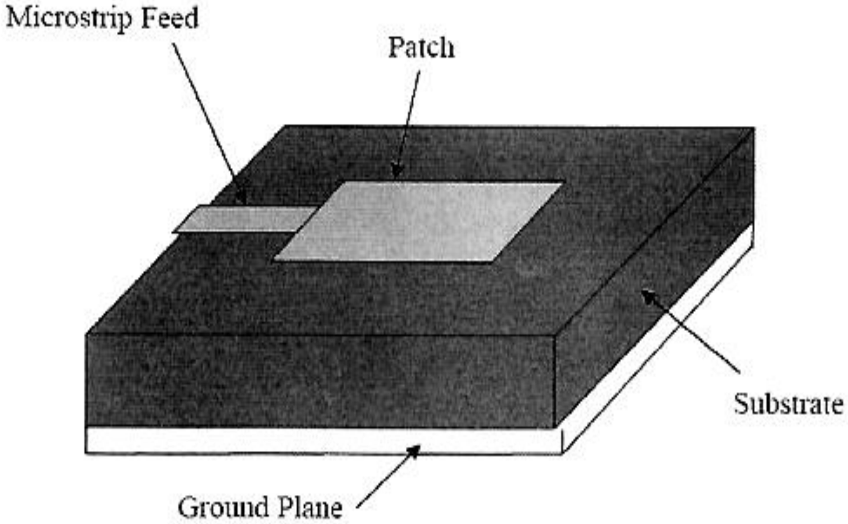


Fig.2 Microstrip Line Feed

The purpose of the inset curt 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. The feed radiation also leads to undesired cross polarized radiation.

 

## III. COAXIAL FEED

The Coaxial feed or probe feed is a very common technique used for feeding Micro strip patch antenna. As seen from Figure 3, 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.

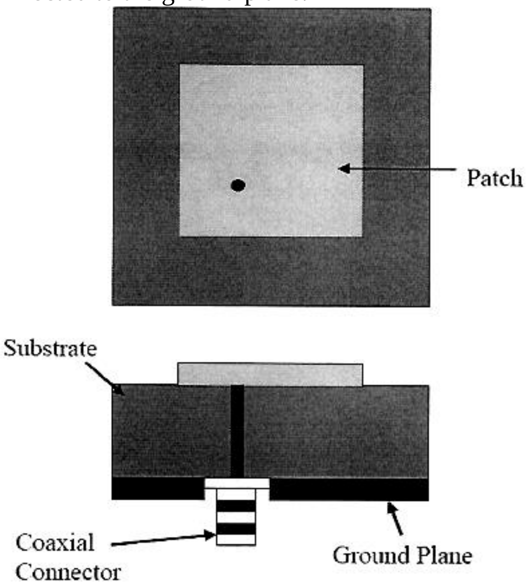


Fig.3 Probe Fed Microstrip Patch Antenna

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 how long spurious radiation. However, a 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 ($h > 0.02\lambda_0$).

Also, for thicker substrates, the increased probe length makes the input impedance more inductive, leading to matching problems. 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.

## IV. TRANSMISSION LINE MODEL

This model represents the microstrip antenna by two slots of width W and height h, separated by a transmission line of length L. The microstrip is essentially a non-homogeneous line of two dielectrics, typically the substrate and air.

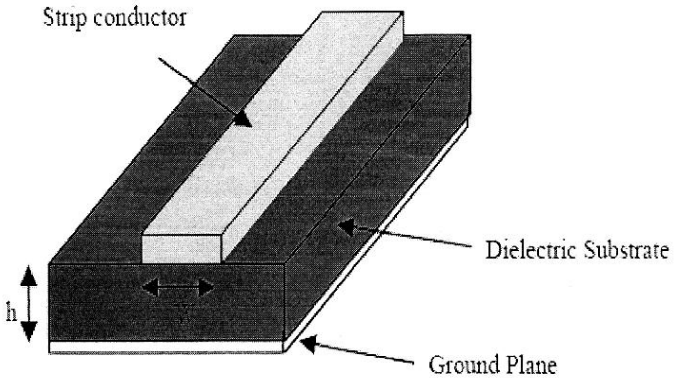


Fig.4 Microstrip Line

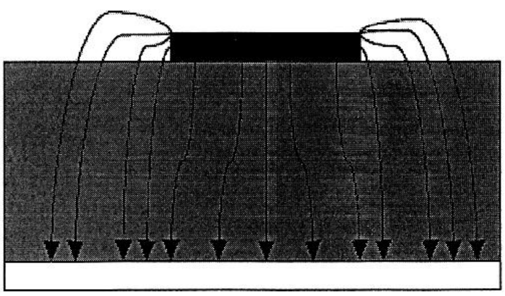

Fig.5 Electric Field Lines

 

Hence, as seen from Figure, most of the electric field lines reside in the substrate and parts of some lines in air. As a result, this transmission line cannot support pure transverse-electric-magnetic (TEM) mode of transmission, since the phase velocities would be different in the air and the substrate. Instead, the dominant model of propagation would be the quasi-TEM mode. Hence, an effective dielectric constant ($\varepsilon reff$) must be obtained in order to account for the fringing and the wave propagation in the line. The value of $\varepsilon reff$ is slightly less than $\varepsilon r$ because the fringing fields around the periphery of the patch are not confined in the dielectric substrate but are also spread in the air as shown in Figure 4.2 above. The expression for $\varepsilon reff$ is given by Balanis as:

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{1/2}$$

Where

| | | |
|---|---|---|
| $\varepsilon reff$ | = | Effective dielectric constant |
| $\varepsilon r$ | = | Dielectric constant of substrate |
| h | = | Height of dielectric substrate |
| W | = | Width of the patch |

Consider Figure below, which shows a rectangular microstrip patch antenna of length L, width W resting on a substrate of height h. The co-ordinate axis is selected such that the length is along the x direction, width is along the y direction and the height is alone the z direction.

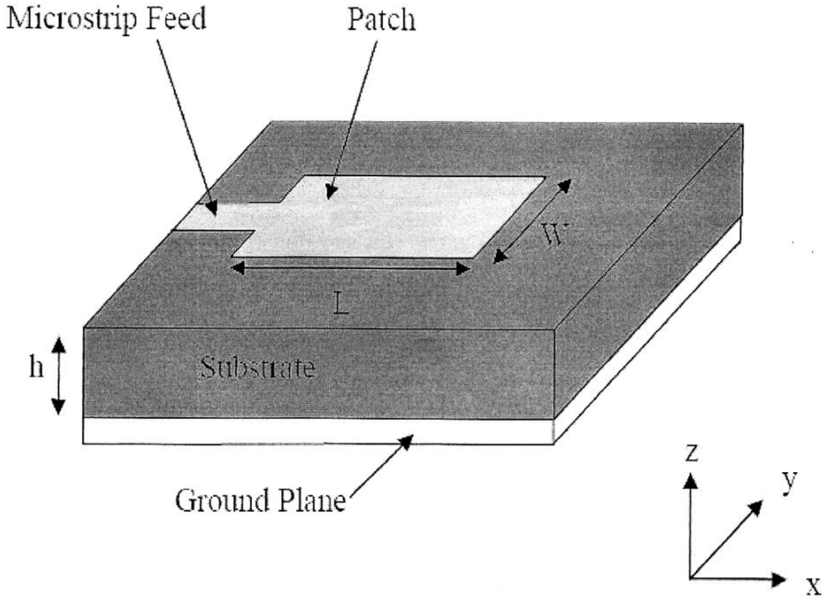


Figure 6 Microstrip Patch Antenna

## V. DESIGN OF MICROSTRIP ANTENNA USING TRANSMISSION LINE MODEL

The three essential parameters for the design of a rectangular Microstrip Patch Antenna are:-

- **Frequency of Operation (f0):** The resonant frequency of the antenna must be selected appropriately. The Personal Communication System (PCS) uses the frequency range from 1850-1990 MHz. Hence the antenna designed must be able to operate in this frequency range. The resonant frequency selected for our design is 1.5 GHz.

- **Dielectric constant of the substrate ($\varepsilon r$):** The dielectric material selected for our design in FR4 which has a dielectric constant of 4.2. A substrate with a high dielectric constant has been selected since it reduces the dimensions of the antenna.

- **Height of dielectric substrate (h):** For the microstrip patch antenna to be used in cellular phones, it is essential that the antenna is not bulky. Hence, the height of the dielectric substrate is selected as 1.67 mm.

## VI. PROCESS FLOW CHART

Figure 7 shows detail flow chart for design of a insect feed microstrip patch antenna using Transmission line model method. The design procedure starts with selection of shape to be used for the antenna design.

 

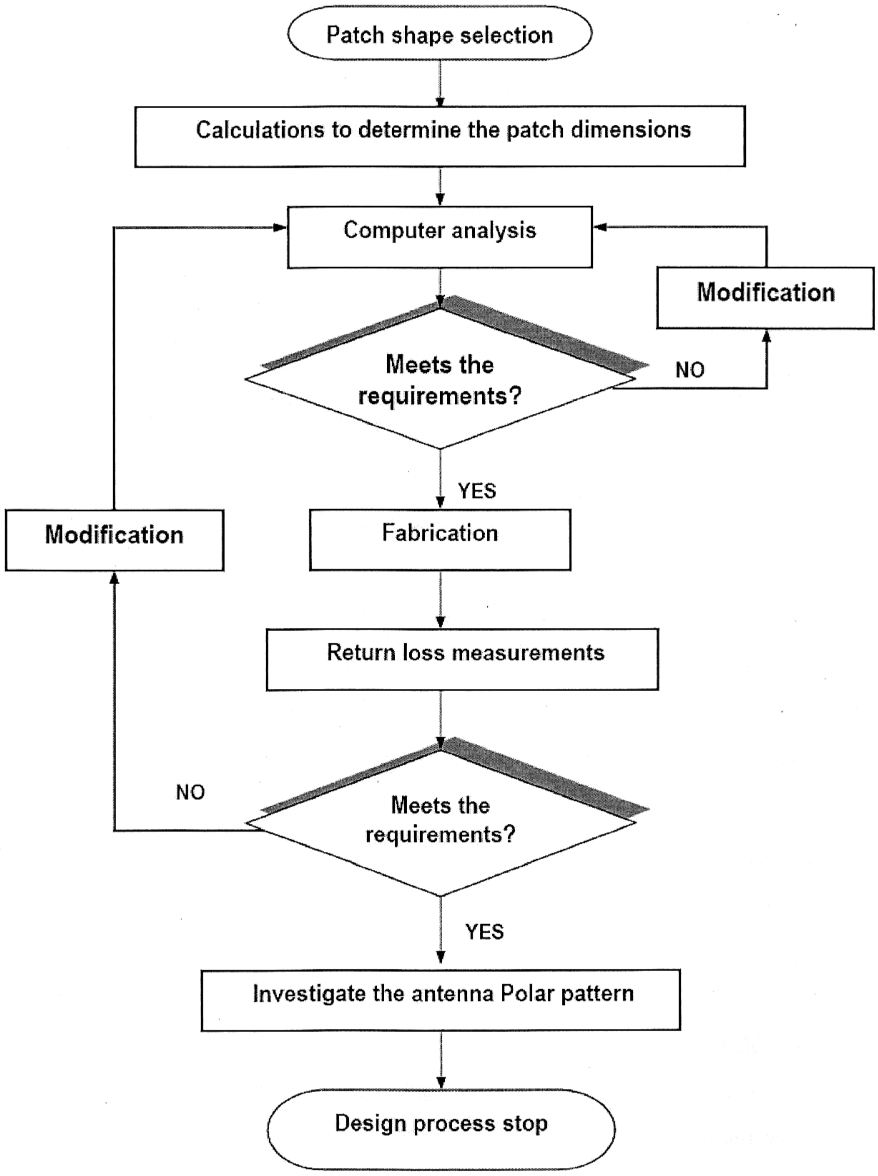


Fig. 7A flow chart for Design of microstrip antenna

**The major Advantages:**

- 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 (MICs).
- Capable of dual and triple frequency operations.
- Mechanically robust when mounted on rigid surfaces.

**Disadvantages such as:**

- 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.

## VII. SCOPE OF PRESENT WORK

In the present project work the following aspects of the Microstrip patch antenna has been studied in details.

a) Design calculation for a Microstrip patch antenna using transmission line model has been carried out to determine necessary dimensions of the antenna for simulation and fabrication of its proto-type development.

b) A simulation study of the MSA has been done in Zealand Ines IE3D Software [4]. It is an integrated full wave electromagnetic and simulation package based on method of moments for analysis and design of planner Antennas. It can be used to calculate and plot Radiation Pattern, Return Loss, VSWR, Smith Chart and various other parameters. The characteristics parameters of a MSA such as are determine through simulation and it is observed that these parameters lie in described /practical range.
c) A proto type laboratory model of the designed MSA has been fabricated and tested for its detail performance analysis _High frequency performance of developed MSA has been carried out using Network analyzer.

## VIII. CONCLUSION AND FUTURE PROSPECTUS

The technique for enhancing bandwidth of the Microstrip antenna has been shown and it can be used for WLAN applications as it fully utilizes the entire 1.5 GHz to 1.7 GHz band. As mentioned, this technique has its advantages such as it does not increase the lateral size of the microstrip antenna and disadvantages such as it increases the height of the microstrip antenna. Therefore, trade-off issues need to be considered in this design.

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